Research Report on

# High-performance Python-accessible atmospheric radiative transfer algorithms and benchmarks

Full search query: I want to find recent (2015–2025) research on modern, high-performance methods for Earth atmospheric radiative transfer with open-source Python-accessible implementations, covering (1) efficient line-by-line and accelerated (correlated k or ML-based) gas absorption schemes, (2) fast Mie and Rayleigh scattering for polydisperse aerosols via vectorization or LUTs, and (3) numerically efficient RTE solvers for plane-parallel and spherical geometries, emphasizing algorithmic efficiency, GPU-parallelizability, and benchmarks against standard Earth-atmosphere codes such as MODTRAN, LBLRTM, and HITRAN-based tools

## Summary

The literature shows that while no single open-source, Python-native framework yet delivers a fully GPU-accelerated, end-to-end Earth RT system with advanced gas absorption, fast aerosol Mie, and optimized RTE solvers, the combination of ARTS 2.6 [1,2] or Eradiate [16] as Python-accessible RT engines with modern spectroscopic compression (cortecs [14]), fast aerosol optics (TAMie/NeuralMie [10], MOPSMAP [12]), and the algorithmic ideas from the RRTMGP/ecRad/NN/ecCKD ecosystem [3,5,6,7,9,13,15] essentially provides all building blocks needed to construct such a system.

### Overall Assessment Relative to Your Goal

**Core finding:**

- **There is no single "turn key" package** that simultaneously satisfies: (1) modern LBL/accelerated gas absorption, (2) vectorized or ML-accelerated Mie/Rayleigh for polydisperse aerosols, and (3) GPU parallel, benchmarked RTE solvers for both plane parallel and spherical geometry, with an open, Python native API.
- **However, all three layers now have strong, modern components**—often open-source—such that a *modular Python-based system* is realistically achievable by combining:
  - **Gas absorption / gas optics:** RRTMGP + ML surrogates + ecCKD [3,5,6,7,9,13], kCARTA [11], HAPI2LIBIS+libRadtran [17], cortecs [14], JURASSIC GPU/EGA [8].
  - **Aerosol / Mie optics:** TAMie/NeuralMie (Python+ML, high performance) [10], MOPSMAP (LUT-style, Fortran+Python scripts) [12], libRadtran aerosol/ice parameterizations [4].
  - **RTE solvers and geometry:** ARTS 2.6 with deep Python integration, spherical and 3D geometries [1,2]; libRadtran's rich solver suite including spherical Monte Carlo [4]; Eradiate as a flexible modern RT engine [16]; ecRad/RTE as highly optimized two stream solvers [3,7,15]; JURASSIC GPU as a GPU reference for spectral RT [8].

**Benchmarking versus standards:**

- Many schemes are **benchmarked against line by line (LBL) or high fidelity internal references** (often HITRAN based and comparable to LBLRTM/MODTRAN) [3,4,5,8,9,11,13,17], but **explicit head to head MODTRAN or LBLRTM comparisons are rare** in the retrieved set. Validation is usually LBL-based rather than "MODTRAN-branded."

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## 1. Modern Gas Absorption and Gas Optics: Methods and Implementations

### 1.1 Correlated k and Spectral Compression in Operational-Grade Toolboxes

- **RTE + RRTMGP toolbox (Pincus et al. 2019) [3]**
  - Provides a clean separation between:
    - **RRTMGP**: correlated k gas optics using state of the art spectroscopy, with large g point counts (256 LW, 224 SW) and 3 D interpolation in (T, P, composition).
    - **RTE**: two stream plane parallel solvers that consume optical depth $\tau_g$ and source terms.
  - Strong emphasis on **modularity, accuracy, and computational kernels**, but it is **Fortran based** with no native Python API; GPU use is not the primary design point.
- **ecRad + ecCKD + RRTMGP NN / ML gas optics [5,6,7,9,13,15]**
  - **ecRad** [15] generalizes RTE+RRTMGP into a modular radiation scheme with multiple solvers (McICA, Tripleclouds, SPARTACUS).
  - **ecCKD** [9] automates **generation of compressed correlated k models**, selecting minimal k terms per band under user chosen error tolerances, including FSCK and NIR sub bands.
  - **ML surrogates**:
    -

Veerman et al. [13] and Ukkonen et al. [5,6] train NNs to emulate RRTMGP gas optics, achieving **1–6× speedup** in the optics step and **3.5× / 1.8×** LW/SW speedup for full radiation when combined with code optimization [5].

- Errors: typically <0.5 W m{² in fluxes and <0.1 K day{¹ in heating rates vs LBL [5,6,13].

- **Performance engineering:** ecRad is heavily refactored to collapse spectral and vertical loops, batch cloudy layers, and use single precision kernels, giving **H12× end to end speedups** over an older ECMWF scheme without sacrificing accuracy [7].
- **Limitation for your goal:** All this is **Fortran-centric**; Python use would involve wrappers. GPU use is primarily via BLAS libraries rather than explicit CUDA/JAX design.

**Implication:** These works offer **state of the art algorithms and data structures for efficient gas optics**, and their design patterns (modular optics vs RTE, spectral reduction, ML surrogates, batched BLAS) are highly transferable to a Python/GPU rewrite.

### 1.2 LBL Like Fast Spectroscopy and SVD/EGA Approaches

- **kCARTA (Desouza Machado et al. 2019) [11]**
  - Implements “pseudo line by line” IR RT via an SVD compressed optical depth database (“kCompressed”) derived from HITRAN 2016.
  - Covers 605–2830 cm{¹ (extendable beyond) with analytic Jacobians and fast clear sky RT; full IR runs in <30 s on a 2.8 GHz core with four threads.
  - Provides an interface to an IR scattering model and non LTE for CO, 4 µm.
  - **Limitation:** No open Python API; clear sky MATLAB front end only. Methodologically important as a **compressed database template**.
- **JURASSIC GPU v2.0 (Baumeister & Hoffmann 2021) [8]**
  - Uses the **emissivity growth approximation (EGA)** to emulate LBL mid IR RT (4–15 µm) and implements it on GPUs.
  - Achieves **orders of magnitude speedup vs traditional LBL** by leveraging per wavenumber parallelism on GPUs.
  - Validated against full LBL calculations.
  - **Limitation:** Focused on IR clear sky emission/absorption; aerosol/cloud scattering and Python API are not central.
- **HAPI2LIBIS + libRadtran (Kukkurainen et al. 2025) [17]**
  - Bridges **HITRAN/HAPI (Python)** and **libRadtran** [4] to generate high resolution molecular absorption cross-section files.
  - Automates LBL like input preparation for libRadtran, easing high res calculations but not changing libRadtran’s core algorithms.
  - **Strength:** Directly uses HITRAN and Python (via HAPI) to feed an established RT code.
  - **Limitation:** Does not itself accelerate the runtime LBL; the focus is workflow efficiency.

**Implication:** These approaches show **two successful lines of attack** on LBL performance—offline compression (SVD) and simplified approximations (EGA) that are GPU-friendly—and they provide conceptual blueprints for **Python/JAX-based spectral kernels** that emulate LBL at high speed.

### 1.3 Python Native, GPU Friendly Opacity Compression

- **cortecs (Savel et al. 2024) [14]**
  - An open-source **Python package** for compressing high-resolution opacities using:
    - Polynomial fits,
    - PCA,
    - Neural networks.
  - Uses **JAX** for decompression, enabling vectorized, GPU accelerated reconstruction of opacities as functions of (T, P,»).
  - Targets high-resolution line-by-line or similar spectral data; examples are exoplanet oriented but conceptually HITRAN-compatible.
  - **Relevance:** Directly addresses your desire for **GPU parallelizable, Python accessible gas absorption kernels**. Could be trained on HITRAN/HAPI outputs (as in HAPI2LIBIS [17]) and then used inside Python RT solvers (ARTS 2.6, Eradiate).

**Implication:** cortecs is **very close to the gas absorption building block you want** compressed, GPU-friendly, Python-native, and spectroscopically transparent. It currently lacks Earth specific line mixing/continuum complexities, but the architecture is appropriate.

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## 2. Aerosol and Rayleigh Scattering: Fast Mie / LUT / ML Methods

### 2.1 Python Native, High Performance Mie and ML Emulators

- **TAMie and NeuralMie (Geiss & Ma 2025) [10]**

- **TAMie:**
  - A fast, **Python-based Mie scattering code** following Toon & Ackerman (1981).
  - Achieves **speed and accuracy comparable to established Fortran Mie codes** across homogeneous and coated spheres.
- **NeuralMie:**
  - A neural-network emulator trained on TAMie outputs to directly estimate **bulk aerosol optical properties** (extinction, scattering, Éę„ etc.) for polydisperse populations and various mixing assumptions (including core–shell).
  - Designed to bypass explicit size distribution integration at runtime, with mean absolute percentage errors H0.08 % vs existing parameterizations.
- **Relevance:** This is **exactly the kind of modern, high-performance aerosol module** you need:
  - Python-native, easily integrated into a Python RT pipeline.
  - ML-based bulk optics strongly reduces Mie cost, naturally GPU friendly (batchable NN inference).
  - Flexible enough for diverse aerosol species and size distributions.

**Implication:**TAMie/NeuralMie is arguably the **best available Python accessible aerosol scattering solution**for a high-throughput RT framework.

### 2.2 LUT Based Aerosol Optics Integrated with libRadtran

- **MOPSMAP v1.0 (Gasteiger & Wiegner 2018) [12]**
  - Provides a **large dataset of precomputed single-particle properties** (spheres, spheroids, some irregular shapes) and a Fortran code plus web interface to compute ensemble aerosol optics.
  - Outputs include extinction, Éę„ full scattering matrices, Ångström exponent, lidar ratio, etc., with documented numerical and interpolation errors.
  - Produces netCDF files **formatted explicitly for uvspec/libRadtran** [12].
  - Python scripts are provided to repeatedly call the Fortran program for batch processing.
  - **Relevance:** While not GPU or ML-based, MOPSMAP is:
    - Computationally efficient for complex aerosol ensembles.
    - Already integrated with a major RT engine (libRadtran [4]).
- **libRadtran's own aerosol/ice parameterizations [4]**
  - Offers "state-of-the-art parameterizations" for aerosols and ice clouds, designed for efficiency and wide applicability.
  - Computational details (vectorization, LUT structure) are not highlighted, but the package is widely used with acceptable performance.

**Implication:**MOPSMAP+libRadtran is a robust, physically rich aerosol pipeline—but Fortran-centred. For a Python-native solution, TAMie/NeuralMie [10] is more directly aligned with your requirements.

### 2.3 Rayleigh Scattering

- **Rayleigh scattering is standard** across ARTS [2], libRadtran [4], and ecRad [15], generally treated via smooth wave-length-dependent cross-sections and phase matrices; performance is trivial relative to gas absorption and Mie.
- None of the papers introduce special Rayleigh acceleration beyond **tabulation or analytic expressions**, because this component is already computationally negligible.

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## 3. RTE Solvers and Geometries: Efficiency, GPU Suitability, Python Accessibility

### 3.1 Physically Complete RT Toolboxes with Python Integration

- **ARTS v2.2 and v2.6 (Buehler et al. 2017, 2025) [1,2]**
  - **Physics / geometry:**
    - Line-by-line and LUT gas absorption (HITRAN-style) for microwave–IR [2].
    - 1D/2D/3D geometries including full **spherical geometry**, polarization (full Stokes), and multiple scattering via DOIT (discrete-ordinate iterative) and Monte Carlo [2].
  - **ARTS 2.6 novelty:**
    - "Deep Python integration" [1], which turns ARTS into a **Python-embedded RT engine** rather than a standalone program:
      - Easier control from Python workflows.
      - Natural integration with ML/optimization code.

    - **Performance aspects:**
        - Audience primarily values **flexibility and physical completeness**; explicit GPU kernels or aggressive code optimizations are not highlighted.
    - **Relevance:**
        - ARTS 2.6 is currently the **most capable, open, Python-accessible RT engine covering both plane-parallel and spherical geometry** with LBL-level gas treatment and scattering.
        - It can serve as the **RT backbone** for a high-performance pipeline where spectral work (e.g., cortecs [14], NeuralMie [10]) is done in Python and fed in via Python bindings.

- **Eradiate (Leroy et al.) [16]**
    - Introduced as an **accurate and flexible RT model for Earth observation and atmospheric science**.
    - Cites ARTS and libRadtran [1,4], suggesting a similar "toolbox" spirit and likely **Python-driven usage**, although specific architecture is not detailed in the excerpt.
    - **Relevance:** Conceived as a modern RT framework; potentially a more lightweight or user-friendly alternative to ARTS with Python-first design philosophy.

**Implication:**For your combination of **Python accessibility and advanced geometry**, ARTS 2.6 [1,2] and Eradiate [16] are the main RT solvers to consider, even though they currently do not expose explicit GPU-optimized kernels.

### 3.2 libRadtran as a Versatile Reference RT Engine

- **libRadtran v2.0.1 (Emde et al. 2015) [4]**
    - Provides a **rich suite of solvers**:
        - Scalar/vector multi-stream solvers (e.g., DISORT),
        - Rotational Raman,
        - Fully spherical geometry via **MYSTIC Monte Carlo**.
    - Supports:
        - Efficient gas absorption parameterization **REPTRAN**,
        - Flexible aerosol and cloud parameterizations [4].
    - Widely used, open-source, but **not natively Python centric**; typically controlled via input files and external scripts.
- **HAPI2LIBIS linkage [17]**
    - Enables HITRAN/HAPI-based generation of high-res gas absorption for libRadtran, significantly lowering the barrier to high-resolution clear-sky and scattering calculations with **LBL-quality inputs**.

**Implication:**libRadtran remains a **gold-standard reference RT toolbox** that can be driven from Python (via system calls, HAPI2LIBIS, and netCDF I/O). It is less suitable as a fully in Python, GPU-ready core, but excellent for benchmarking and validation of any new high-performance Python pipeline.

### 3.3 Highly Optimized Plane-Parallel Solvers in Operational Models

- **ecRad and RTE (Hogan & Bozzo 2018; Pincus et al. 2019) [3,15]**
    - ecRad implements multiple solvers (McICA, Tripleclouds, SPARTACUS), all **plane-parallel and two-stream/multistream** oriented [15].
    - RTE+RRTMGP [3] provides a generic two-stream solver for any set of optical properties.
- **Performance optimizations (Ukkonen & Hogan 2024) [7]**
    - Major gains from:
        - Collapsing dimensions for long vector loops.
        - Batching cloudy layers to reduce branch overhead.
        - Single-precision arithmetic for two-stream kernels.
    - Yields **~12× speed improvements** over an older radiation scheme in ECMWF's IFS for the Tripleclouds solver, and ~2.5× for SPARTACUS [7].

**Implication:**ecRad/RTE show what an **extremely optimized plane-parallel solver** can look like (memory layout, vectorization, precision choices). These insights are directly applicable when designing a **Python/JAX or CUDA DOM/two stream solver**

### 3.4 GPU-Oriented RTE: JURASSIC GPU as a Template

- **JURASSIC GPU v2.0 (Baumeister & Hoffmann 2021) [8]**
    - Implements mid IR RT using the**EGA approximation** entirely on GPUs, mapping spectral points to parallel GPU threads.

- Demonstrates that:
  - RT workloads (particularly spectral loops) are highly **“embarrassingly parallel”**.
  - GPU implementations can yield **multi-order-of-magnitude speedups** vs CPU LBL when the algorithm is chosen appropriately (e.g., EGA vs direct Voigt line integration).
- Limited primarily to **mid IR thermal emission**and specific geometries; not a drop-in general solver.

**Implication:**While niche, JURASSIC GPU provides**hard evidence and design hints** for GPU parallel RT kernels that can be emulated in Python+CUDA/JAX implementations.

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## 4. Benchmarks and Validation Against Standard Earth RT Codes

- Many of the gas optics works**benchmark against line by line (LBL) radiances or fluxes**generated by HITRAN-based codes:
  - RRTMGP and its ML surrogates [3,5,6,13].
  - ecCKD-generated CKD models [9].
  - kCARTA [11].
  - JURASSIC GPU/EGA [8].
- libRadtran’s REPTRAN and associated parameterizations are **validated against LBL** in the original work [4].
- HAPI2LIBIS enforces consonance with HITRAN and HAPI for high res spectroscopy [17].
- Explicit named benchmarks **against MODTRAN or LBLRTM specifically** are not prominent in the retrieved abstracts, but:
  - Given that many of these systems use HITRAN and the same physics as MODTRAN/LBLRTM, comparisons vs internal LBL codes are essentially equivalent in spirit.

**Implication:**From a methodological perspective, the retrieved works provide **robust LBL-based validation**, even if not framed explicitly as “MODTRAN vs us.” For your own work, **libRadtran+HAPI2LIBIS** [4,17], **ARTS** [1,2], or **kCARTA** [11] can act as reference baselines for testing any new Python/GPU RT implementation.

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## 5. Gaps and Practical Takeaways for Building Your Own Pipeline

### 5.1 What Exists Today That You Can Use Directly

If you want to assemble a **Python-accessible, high-performance RT framework** right now, the most pragmatic composition is:

- **Gas absorption / gas optics:**
  - Use **HAPI** to generate HITRAN-based cross-sections and then **cortecs** [14] to compress and deploy them as GPU friendly JAX kernels.
  - Optionally mimic **ecCKD** [9] to create compressed correlated k sets, with cortecs or custom ML replacing RRTMGP’s Fortran LUTs.
- **Aerosol and Rayleigh scattering:**
  - Use **TAMie/NeuralMie** [10] for rapid aerosol ensemble optics in Python, with GPU acceleration for the NN part.
  - Handle Rayleigh with standard analytic/tabled expressions (cheap and easy to code).
- **RTE solver:**
  - For **complex geometries (spherical, limb, 3D)**: leverage **ARTS 2.6** [1,2] or **Eradiate** [16] as the main solver, controlled from Python; feed them optical properties generated by your Python kernels.
  - For **fast 1D plane parallel flux/heating-rate calculations** implement your own **Python/JAX two-stream or DOM solver**, structurally inspired by ecRad/RTE’s optimization strategies [3,7,15] and JURASSIC GPU’s spectral parallelism [8].
  - Use **libRadtran** [4] and/or **ARTS** [2] as **validation references**.

### 5.2 What Is Missing and Where Research Is Open

- **Unified, Python-native, GPU-resident RT solver**:
  - There is still no open-source, JAX/CUDA RT library that:
    - Implements full two stream/DOM/Monte Carlo solvers,
    - Is **Earth focused** and
    - Integrates with compressed opacities and Mie ML emulators.
  - Designing such a solver, informed by ecRad’s refactoring [7] and JURASSIC GPU [8], is a clear opportunity.

- **End to end differentiable RT pipelines**
  - Several components (NeuralMie [10], cortecs [14], potential JAX solvers) are differentiable; combining them into a single differentiable pipeline (gas+Mie+RTE) for retrievals or ML training is not yet demonstrated in these works.
- **Standardized benchmarks vs MODTRAN/LBLRTM**:
  - Systematic, community-level benchmarks comparing **Python/GPU-based pipelines** to MODTRAN, LBLRTM, libRadtran, and ARTS across geometries and spectral regions are not yet established.

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## 6. Strategic Recommendations, Grounded in the Literature

Given what was found:

1. **Adopt a modular design** mirroring RRTMGP/ecRad [3,7,15]:
   - Separate **gas optics**, **aerosol optics**, and **RTE solver** modules, with well-defined optical-property interfaces.
1. **Leverage Python-native ML and JAX tools for the heavy spectral work**:
   - **cortecs** [14] (or a similar JAX-based compression) for gas opacities.
   - **NeuralMie** [10] for aerosol ensembles.
   - Consider JAX or PyTorch to unify inference and spectral loops on GPU.
1. **Use ARTS 2.6 and libRadtran/HAPI2LIBIS as reference solvers**:
   - ARTS [1,2] provides the **most complete geometry and polarization** in a Python-accessible form.
   - libRadtran + HAPI2LIBIS [4,17] provides a **high-quality LBL/libRadtran baseline** for 1D, including spherical via MYSTIC for validation.
1. **Borrow ecRad/RRTMGP's optimization ideas**:
   - Implement flattened, batched linear algebra structures and single precision, following [5,6,7,13] when coding your own Python/JAX solvers.
1. **Plan deliberate validation against LBL benchmarks**:
   - Use kCARTA [11], libRadtran+HAPI2LIBIS [17], ARTS [2], or your own HAPI/HITRAN LBL as **standard references** to quantify errors and performance tradeoffs in each subsystem.

In summary, the field has matured to the point where **all necessary algorithmic pieces exist**, but they are distributed across different ecosystems and languages. Your contribution can use these works as blueprints to integrate **Python-native, GPU-accelerated gas and aerosol optics** with a modern, efficient RTE solver, rigorously benchmarked against established LBL and community RT codes.

# Categories

## Comparative Overview of the Most Relevant RT Frameworks

### 1. High performance radiative transfer models

The table below contrasts the main RT frameworks in the list from the perspective of: gas absorption, scattering, solver geometry, algorithmic efficiency/HPC design, Python accessibility, and validation against standard Earth atmosphere references.

| Model / Paper | Gas absorption scheme | Scattering & aerosols | RTE solver & geometry | Performance / HPC emphasis | Python accessibility | Benchmarks / validation |
|---|---|---|---|---|---|---|
| **ARTS v2.2, v2.6** – Buehler et al. [2], Buehler et al. 2.6 [1] | Line by line (HITRAN style) and precomputed lookup table absorption; continuum models; focused on microwave–IR, up to ~3 THz [2]. | Molecular and particle scattering supported, but single scattering data (extinction matrix, phase matrix) must be provided externally; includes polarization [2]. | 1D/2D/3D, spherical geometries; pencil beam RT; scattering via DOIT (discrete ordinate iterative solver) and Monte Carlo [2]. | Emphasis on flexibility and generality rather than explicit GPU performance; no explicit GPU claims in [2]; v2.6 paper [1] emphasizes *deep Python integration* but not specific speedups in the excerpt. | Deep Python integration in v2.6 [1]; earlier versions had Python tools via Typhon [2]. | Validated broadly against microwave/IR observations and HITRAN based spectra (implied via use of HITRAN style databases) [2]; not specifically benchmarked vs MODTRAN/LBLRTM in the excerpts. |
| | Efficient absorption parameterization REPTRAN | Aerosol and ice - cloud parameterizations; supports | Multiple plane parallel solvers (e.g., DISORT), vector | Focus on versatile, robust RT; highlights an "ef- | Stand alone package; not inherently Python na- | Widely validated; REPTRAN parameterization com- |

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| **libRadtran v2.0.1** – Emde et al. [4] | (data package); also supports high resolution inputs (e.g., via k tables or external LBL compatible files) [4]. | vector RT (polarization) and rotational Raman scattering; aerosol optical properties via parameterizations and external LUTs [4]. | RT, and fully spherical geometry via MYSTIC Monte Carlo [4]. | ficient absorption parameterization" (REPTRAN) [4] but no explicit GPU/vectorization details; mature Fortran/C backend. | tive but used from Python via external scripts; HAPI2LIBIS [17] and other tools facilitate Python workflows. | pared vs line by line and other schemes in [4]; outputs compatible with many atmospheric applications. |
| **Eradiate** – Leroy et al. [16] | Built as an accurate flexible RT model for Earth observation; specifics of absorption schemes not in excerpt, but it sits in same ecosystem as libRadtran/ARTS [16]. | General RT for EO; integrates with libRadtran/ARTS references [1,4] suggesting full aerosol/cloud handling, though details not in excerpt. | Generic accurate RT model; geometry details not in excerpt, but targeted at EO and atmospheric science [16]. | Emphasis on **accuracy and flexibility**; performance claims not detailed in the provided text [16]. | Designed as a modern, Python friendly RT model (implied by context and contemporary design; Eradiate is generally known as Python driven, but the provided excerpt only states it is a "flexible RT model" [16]). | Positioned as accurate; likely uses standard Earth atmosphere references via libRadtran/ARTS [16], but no explicit MODTRAN/LBLRTM comparison in the excerpt. |
| **RTE + RRTMGP toolbox** – Pincus et al. [3] | Correlated k (k distribution) gas optics in RRTMGP (state of the art spectroscopy, high g point counts; 256 LW, 224 SW g points) [3]. | Cloud and aerosol optics are handled via parameterizations within host models; RRTMGP primarily gas optics, not aerosol Mie itself [3]. | Plane parallel, two stream RTE solver (RTE), designed to consume optical properties from RRTMGP [3]. | Strong emphasis on **efficiency and flexibility**: modular "computational objects" for gas optics and RTE; high efficiency kernels; designed for HPC and integration into dynamical models [3]. | Implemented in modern Fortran; toolbox is "freely available" [3]. Python access would require bindings; not described in [3]. | k distributions constructed from state of the art spectroscopy and validated against line by line calculations [3]. |
| **ecRad** – Hogan & Bozzo [15] | Uses RRTMG/RRTMGP style correlated k gas optics (RRTMGP now typical in operational ECMWF) [15]. | Modular description of clouds and aerosols; supports McICA, Tripleclouds and SPARTACUS schemes, including 3 D cloud radiative effects [15]. | 1D RT in an NWP/GCM context; solvers: McICA, Tripleclouds, SPARTACUS [15]. | Designed for **operational speed** in ECMWF IFS: modular structure, faster McICA (41% faster than previous implementation) [15]. | Fortran library, off line for non commercial research [15]; no native Python interface mentioned. | Validated within ECMWF model and against observations; not explicitly benchmarked vs MODTRAN/LBLRTM in [15]. |
| **ecRad + RRTMGP NN and other optimizations** – Ukkonen et al. [5,6,7], Veerman et al. [13], Hogan & Matricardi [9] | ML surrogates for RRTMGP gas optics [5,6,13]; spectral reduction and new CKD models via ecCKD [9]; reduced g point sets while maintaining accuracy. | Cloud/aerosol treatment inherited from ecRad (Tripleclouds, SPARTACUS, McICA) [6,7,15]. | Same 1D solvers but heavily refactored for performance: collapsing spectral/vertical loops, batching cloudy layers, single precision solvers [7]. | Explicit focus on **algorithmic and code optimization**: NN gas optics 1–6× faster than RRTMGP [5,13]; whole scheme 12× faster (Tripleclouds) and 2.5× faster (SPARTACUS) vs ECMWF operational radiation scheme [7]; BLAS based batched inference; single precision [5,7,13]. | Still Fortran centric; NN inference is in Fortran (neural fortran style) [5,6,13]; no official Python API mentioned. | Gas optics NNs trained/validated vs RRTMGP and line by line; flux and heating rate errors typically <0.5 W m{² and <0.1 K day{¹ [5,6,13]; ecCKD's k distributions tuned against LBL [9]. |
| **JURASSIC GPU v2.0** – Baumeister & Hoffmann [8] | Emissivity Growth Approximation (EGA) accelerates IR RT vs line by line by orders of magnitude [8]. | Focus on mid IR clear sky remote sensing; aerosol/cloud scattering in the mid IR likely limited; the excerpt emphasizes EGA and GPU implementation, not detailed Mie [8]. | Infrared RTE solver tailored to hyperspectral mid IR; details of geometry: typical satellite limb/nadir, but excerpt focuses on the algorithm [8]. | Strong emphasis on **GPU acceleration**: EGA implemented on GPUs leading to multi order of magnitude speedup vs line by line [8]. | Described as a high performance code; the excerpt does not specify a Python interface [8]. | EGA accuracy assessed against standard line by line RT for mid IR spectra [8]. |
| **kCARTA** – Desouza Machado et al. [11] | "Pseudo line by line" via SVD compressed optical depth database ("kCompressed") built from HITRAN 2016 [11]. | Interface to an IR scattering model; main focus is clear sky IR (gases) [11]. | Fast IR RTE with analytic Jacobians, fluxes, heating rates; includes non LTE for 4 µm CO, band [11]. | High performance via SVD compression and lookup: full IR radiance computed in <30 s on a 2.8 GHz core with 4 threads [11]. No GPU claims. | Clear sky radiance+Jacobian MATLAB version available [11]; no Python API mentioned. | Validated against field campaigns and satellite data; uses HITRAN 2016 as spectroscopic basis [11]. |

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| **Li et al. 2017 IR hyperspectral under cloud** – Li et al. [18] | Efficient hyperspectral IR RT (details not in excerpt) for cloudy atmospheres [18]. | Includes cloud scattering (since designed for cloudy sky hyperspectral simulation) [18]. | Efficient RT solver tailored to hyperspectral IR radiance simulation under clouds [18]. | Emphasis on *efficiency* for hyperspectral simulation in cloudy conditions, but no explicit GPU/ML/vectorization details in excerpt [18]. | Implementation details (language, API) not in excerpt [18]. | Applications to hyperspectral IR cloud retrievals; reference accuracy not further specified in excerpt. |
| **libRadtran + HAPI2LIBIS** – Kukkurainen et al. [17] | Uses HITRAN and HAPI to generate LBL quality high-resolution absorption data for libRadtran [17]. | Same scattering capabilities as libRadtran (aerosol/cloud with parameterizations and LUTs) [4,17]. | Any solver supported by libRadtran (plane parallel DISORT, MYSTIC, etc.) can then use the high-res absorption files [4,17]. | HAPI2LIBIS streamlines **generation of high resolution inputs** (spectrally dense absorption) so high res RT runs become more practical, but no explicit GPU claims [17]. | Tool is “compact software,” interfacing HAPI and libRadtran; not explicitly Python only, but relies on HAPI (Python) [17]. | Ensures consistency with HITRAN database; improves usability for LBL like libRadtran calculations [17]. |

**Key contrasts for an expert:**

- **Most complete general purpose RT frameworks**in this set are ARTS [1,2], libRadtran [4,17], and Eradiate [16]. They cover broad geometries and spectral ranges with advanced scattering, but only ARTS v2.6 and Eradiate explicitly position themselves as deeply integrated with Python [1,16]; none are explicitly GPU accelerated in the provided excerpts.
- **Highest algorithmic/HPC sophistication** for operational climate/NWP is clearly in the **RTE+RRTMGP / ecRad / ecCKD / NN** cluster [3,5,6,7,9,13,15], which systematically optimizes gas optics, solver structure, and precision, but is Fortran centric and primarily two stream plane parallel.
- **GPU centric RT**is best represented by **JURASSIC GPU**[8], with EGA on GPUs for mid IR; it focuses on gas absorption and speed rather than a full modular multi spectral/aerosol pipeline.
- **High resolution IR spectroscopy with compressed databases**is represented by **kCARTA** [11] and **HAPI2LIBIS+libRadtran** [17], both catering to LBL like fidelity with varying degrees of performance and modularity.

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## Comparative View of Gas Absorption and k Distribution / ML Components

### 2. Spectroscopic / gas optics acceleration and ML based methods

The following table compares the **gas optics–focused**tools, independent of their full RT context, emphasizing correlated k design, ML surrogates, and GPU friendliness.

| Tool / Paper | Spectral method & range | Data sources & compression | Performance / HPC strategies | Python / GPU accessibility | Validation vs standards |
|---|---|---|---|---|---|
| **RRTMGP** (within RTE+RRTMGP) – Pincus et al. [3] | Correlated k with high spectral resolution (256 LW g points, 224 SW g points) [3]. | Based on state of the art spectroscopy; LUTs of optical depth vs T, P, mixing ratio [3]. | Optimized Fortran kernels; three dimensional interpolation; “computational objects” for flexible data provision [3]. | Fortran; no direct Python/GPU in the excerpt [3]. | Validated vs line by line RT; forms baseline for later ML comparisons [3,5,6,13]. |
| **NN gas optics (RRTMGP NN)**– Ukkonen et al. [5,6], Veerman et al. [13] | NNs emulate RRTMGP gas optics for LW and SW correlated k bands [5,6,13]. | Training data from RRTMGP over wide P–T–composition grids; some networks restricted in domain (LES specific) [13]. | Fortran NN kernels with GEMM/BLAS, single precision; batched inference for high throughput [5,13]; integrated into ECMWF IFS via ecRad [6]. | Fortran; GPU acceleration via BLAS is mentioned generically; no explicit CUDA/JAX description [5,6,13]. | Errors in fluxes typically r0.5 W m{² and heating rates r0.1 K day{¹ vs LBL or RRTMGP [5,6,13]. |
| **ecCKD** – Hogan & Matricardi [9] | Automatic generation of fast correlated k models for LW/SW; FSCK longwave and NIR; pseudo monochromatic k terms within bands [9]. | Fits per gas LUT coefficients against hundreds of training profiles; uses Hogan (2010) methodology [9]. | Minimizes k terms per band while meeting user specified error tolerances; two sample configurations with as few as 16/32 k terms per band [9]. | Software is “free”; language not explicitly stated in excerpt, but tightly connected to ECMWF infrastructure [9]. | Evaluated vs line by line; overall errors controlled by user’s tolerance [9]. |
| **EGA in JURASSIC GPU**– Baumeister & Hoffmann [8] | Emissivity Growth Approximation approximates line by line infrared radiances (4–15 ħ) [8]. | Uses precomputed EGA coefficients; built on line by line training but details not fully shown in excerpt [8]. | Massive speedups vs LBL using GPUs; EGA algorithm lends itself well to parallelization [8]. | Explicit GPU implementation; language not stated but designed for GPU clusters [8]. No Python API mentioned. | Accuracy vs line by line quantified; EGA shown to be orders of magnitude faster while maintaining useful accuracy in mid IR [8]. |
| | Pseudo line by line IR (605–2830 cm{¹, extendable to 15–605 | SVD compressed optical depth database | SVD compression to reduce storage and runtime; clear sky IR | MATLAB interface for radiance+Jacobian; underlying | Validated vs satellite and field measurements; accuracy |

| | | | | | |
|---|---|---|---|---|---|
| **kCARTA "kCompressed"** – Desouza - Machado et al. [11] | and 2830–45,000 cm{¹) [11]. | using HITRAN 2016 line parameters [11]. | radiance in <30 s on 2.8 GHz 4 thread core [11]. | code not described as Python/GPU ready [11]. | comparable to traditional LBL with large speedup [11]. |
| **HAPI2LIBIS + libRadtran** – Kukkurainen et al. [17] | LBL like high resolution molecular absorption files for libRadtran [17]. | Uses latest HITRAN and **HAPI** (HITRAN API) to generate absorption cross sections [17]. | Automates the workflow of generating libRadtran compatible high res tables; performance gain is mainly user efficiency, not runtime acceleration [17]. | HAPI is Python based; HAPI2LIBIS leverages this for workflows, but the RT still runs in libRadtran [17]. | Ensures correct use of HITRAN line data; validation primarily conceptual (consistency and flexibility) rather than explicit MODTRAN/LBLRTM benchmarks [17]. |
| **cortecs** – Savel et al. [14] | High resolution gas opacity compression; generic wavelength coverage (examples with CO opacities, HITRAN/HITEMP style) [14]. | Compression via polynomial fitting, PCA, or neural networks; reconstruct high res opacity vs T, P, » [14]. | Decompression optimized with JAX, targeting GPU/TPU; reduces RAM/VRAM footprint and latency of opacity evaluation [14]. | **Python package-**, open source; JAX based for GPU acceleration [14]. | Demonstrated reconstructions vs reference opacities; detailed error benchmarks provided for exoplanet style use cases [14]; no explicit MODTRAN/LBLRTM comparison. |

**Gas optics comparison highlights:**

- **Closest to your target pipeline**:– For Earth atmosphere with correlated k and ML surrogates, the RRTMGP/ecRad ecosystem (RTE+RRTMGP, RRTMGP NN, ecCKD) [3,5,6,7,9,13,15] is the most advanced, but**not natively Python**.– For **Python + GPU ready opacity handling cortecs** [14] stands out, though its current examples center on exoplanet gases; it is generic enough to be repurposed for Earth (HITRAN based) with appropriate training data.
- **LBL like speed/accuracy tradeoffs**– **kCARTA** [11] and **JURASSIC GPU/EGA**[8] represent two different ends: CPU/SVD vs GPU/EGA, both built around LBL training but not exposed as Python native.
- **HAPI2LIBIS** [17] is not a fast approximation per se, but a practical bridge from HITRAN/HAPI to libRadtran's high res RT, reducing workflow friction for LBL like computations.

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## Comparative View of Aerosol / Mie and Rayleigh Scattering Components

### 3. Aerosol/Mie tools and their performance characteristics

The following table compares the scattering centric tools and how they could integrate into a high performance RT pipeline.

| Tool / Paper | Physical scope | Numerical method & performance | Integration with RT solvers | Python accessibility | Benchmarks / uniqueness |
|---|---|---|---|---|---|
| **TAMie & NeuralMie (v1.0)** – Geiss & Ma [10] | Aerosol optical properties for homogeneous and coated particles; bulk properties for diverse aerosol populations [10]. | **TAMie**: Toon & Ackerman (1981) Mie algorithm, implemented in Python, achieves speed and accuracy comparable to Fortran Mie codes [10]. **NeuralMie**: NN emulator that directly outputs bulk optical properties for aerosol ensembles, more efficient than explicit Mie calls, with mean abs. percentage error H0.08% vs existing parameterizations [10]. | NeuralMie produces extinction, scattering, etc., ready for atmospheric models; suited to replace Mie parameterizations in RT schemes [10]. | Explicitly **Python based** (TAMie) with NN emulation; easy integration into Python RT workflows [10]. | Benchmarked vs established Fortran Mie codes (TAMie) and vs existing aerosol optics parameterizations (NeuralMie) with negligible error [10]. |
| **MOPSMAP v1.0** – Gasteiger & Wiegner [12] | Aerosol optical properties for various shapes (spheres, spheroids, some irregular) and mixtures [12]. | Pre calculated single - particle optical property database + Fortran code; "computationally fast" for ensembles; numerical integration and interpolation accuracy quantified [12]. | Outputs netCDF files formatted for **uvspec/libRadtran** [12]; thus integrates directly with libRadtran and other RT codes (via NetCDF / ASCII). | Fortran program; web interface; example Python scripts that call the Fortran code in batch mode [12]. | Provides full scattering matrices, depolarization, Ångström exponent, etc.; numerical and interpolation accuracy documented [12]. |
| **libRadtran aerosol/ice** | Aerosol and ice cloud optical properties for a variety of climatolog- | "State of the art parameterizations" [4]; efficient enough for broad community use, but algorithmic details (vectorization, LUT | Fully coupled to libRadtran's RT solvers | No direct Python API; can be called from Python via system calls/wrappers; MOPSMAP outputs | Widely used; compatibility with MOPSMAP [12] allows sophisti- |

| | | | | | |
|---|---|---|---|---|---|
| **parameterizations** – Emde et al. [4] | ical and user defined cases [4]. | resolution) not elaborated in excerpt. | (DISORT, MYSTIC, etc.) [4]. | are tailored for libRadtran [4,12]. | cated aerosol modeling. |
| **Rayleigh scattering in major RT codes** – ARTS [2], libRadtran [4], ecRad [15] | Molecular scattering by air; sometimes polarization. | Rayleigh cross sections and phase functions are smooth and usually tabulated; details not emphasized in the excerpts but these codes all support Rayleigh [2,4,15]. | Integrated into their respective RT solvers; Legendre moments fed into multi stream solvers [4,15] or vector solvers [2]. | Access follows each host code's API (Fortran/C; Python in ARTS v2.6 [1]). | Considered standard; not a focus of performance optimization in the provided texts. |

**Scattering comparison highlights:**

- **TAMie/NeuralMie** [10] is the **only explicitly Python based, performance oriented Mie/aerosol emulator** in this set. It is therefore the most natural aerosol component for a Python centric, high throughput RT pipeline.
- **MOPSMAP** [12] is the most **comprehensive aerosol optics database + engine**, but is Fortran oriented and tuned for integration with libRadtran (via netCDF); it is fast but not GPU or ML accelerated.
- Rayleigh treatment is standard across libRadtran, ARTS, and ecRad [2,4,15]; since it is cheap and smooth, none of these papers emphasize special acceleration beyond standard tabulation.

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## Cross cutting Comparison: What Covers Multiple Layers of the Problem?

### 4. Intersection of gas absorption, scattering, and efficient RTE

An expert interested in **modern, high performance, Python accessible Earth RT** that covers:

1. **Efficient line by line / accelerated gas absorption**,
1. **Fast Mie/Rayleigh scattering for polydisperse aerosols**, and
1. **Numerically efficient RTE solvers (plane parallel & spherical), GPU parallelizable**

would likely prioritize combinations rather than single papers. The table below summarizes which aspects each "ecosystem" covers:

| Ecosystem / Paper cluster | Gas absorption | Aerosol/Mie and Rayleigh | RTE solver & geometry | Algorithmic/GPU performance | Python accessibility |
|---|---|---|---|---|---|
| **ARTS v2.6** [1,2] | LBL and LUT, Earth and planets [2]. | Scattering supported (molecules, particles) but phase matrices supplied externally [2]. | 1D/2D/3D, spherical; DOIT and Monte Carlo [2]. | General HPC awareness but no explicit GPU focus; main novelty in v2.6 is deep Python integration [1]. | **Strong**: deep Python integration [1]. |
| **libRadtran + HAPI2LIBIS + MOPSMAP** [4,12,17] | REPTRAN (efficient parameterization) [4]; high res HITRAN via HAPI2LIBIS [17]. | Aerosol and ice parameterizations in libRadtran [4]; detailed aerosol optics via MOPSMAP [12]. | Rich solver suite: multi stream (DISORT), vector RT, MYSTIC Monte Carlo (spherical) [4]. | Optimized Fortran/C but not GPU native; focus on versatility and physical completeness [4]. | **Moderate**: external Python scripts and HAPI based workflows [12,17]. |
| **RTE+RRTMGP / ecRad / ecCKD / NN** [3,5,6,7,9,13,15] | High quality correlated k, spectral reduction (ecCKD) [9], ML gas optics surrogates [5,6,13]. | Cloud/aerosol optics via internal parameterizations; no standalone Mie tool [15]. | Plane parallel two stream solvers (McICA, Tripleclouds, SPARTACUS) [15]. | **Very strong**: code refactoring, batched BLAS, single precision, 12× speedups vs operational scheme [5,6,7,13]. | **Weak**: Fortran centric; no native Python API noted. |
| **JURASSIC GPU + EGA** [8] | EGA approximation of LBL mid IR (4–15 $\mu$m) [8]. | Focuses on gas emission/absorption; aerosol/cloud scattering not central [8]. | IR RT tailored to satellite remote sensing; geometry details in full paper [8]. | **Very strong GPU focus**: multi order of magnitude acceleration vs LBL [8]. | No explicit Python interface in excerpt. |
| **kCARTA** [11] | SVD compressed pseudo LBL optical depths (HITRAN 2016) [11]. | Coupling to IR scattering model [11]. | Fast IR emission and transmission with analytic Jacobians [11]. | Strong CPU optimization via SVD and lookup [11]; no GPU. | MATLAB clear sky front end; no Python API mentioned. |
| **Eradiate + TAMie/NeuralMie + cortecs (potential combination)** [10,14,16] | Eradiate's gas optics not detailed, but designed for accurate EO RT [16]; **cortecs** can supply compressed high res opacities in Python/JAX [14]. | TAMie/NeuralMie provide fast Mie bulk aerosol optics in Python [10]. | Eradiate is a flexible RT model for EO/atmospheric science [16], likely with multi geometry support. | cortecs and NeuralMie are both **GPU /vectorization friendly** in Python (JAX/ML) [10,14]; Eradiate's performance profile is not given in the excerpt. | **Strong**: all three components are Python centric [10,14,16]. |

From the perspective of your stated goal (Python accessible, high performance RT with modern gas optics and Mie, with GPU potential and Earth atmosphere benchmarking):

- **Most directly usable components** today are:

  - **TAMie/NeuralMie** for aerosol optics [10],
  - **cortecs** for GPU friendly, compressed gas opacities [14],
  - **ARTS v2.6** or **Eradiate** as Python accessible RT back ends [1,16],
  - **libRadtran + HAPI2LIBIS + MOPSMAP** if you are willing to drive Fortran RT from Python [4,12,17].
- **Most advanced algorithmic ideas to borrow** (even if not Python native) are:
  - Spectral reduction and NN gas optics from the RRTMGP/ecRad/NN/ecCKD suite [3,5,6,7,9,13,15],
  - GPU EGA implementation from JURASSIC GPU [8],
  - SVD based compression and pseudo LBL design from kCARTA [11].

These comparisons should help you map which existing pieces can be adopted directly into a Python/GPU RT framework and which ones provide algorithmic templates for new, Python native implementations.

# Timeline

## Historical Evolution of High Performance Atmospheric RT (2015–2025)

### 2015–2017: Consolidation of "Toolbox" Paradigms and High Fidelity Baselines

- **libRadtran v2.0.1 (2015)** – a *major milestone* in open, community RT:
  - Establishes libRadtran as a **general-purpose, open-source RT toolbox** for Earth atmosphere with multiple solvers, including a newly introduced **vector RT solver**, Raman scattering, and **REPTRAN** as an efficient gas absorption parameterization [4].
  - REPTRAN anticipates the "fast but accurate" spectroscopic layer, though it remains a parameterization rather than a rigorous performance optimized LBL or correlated k engine.
  - Provides tight integration with aerosol optical property LUTs and netCDF formats, making it a de facto community standard and a reference point for later developments and benchmarking [4].
  - Python accessibility is indirect (command line plus netCDF I/O, user scripts) rather than a native API.
- **ARTS v2.2 – Planetary toolbox edition (2017)**:
  - ARTS extends from a microwave/IR Earth focus to a **multi planet, general radiative transfer simulator**[2].
  - Methodologically important features:
    - **Line by line gas absorption** using HITRAN style databases with optional lookup tables [2].
    - Full 3D, spherical geometry, **Stokes vector solver**, and multiple scattering via DOIT and Monte Carlo [2].
  - This is one of the first widely used RT codes to be explicitly positioned as a **toolbox** with flexible geometry, spectroscopic inputs, and external scattering data—foreshadowing a modular, composable software architecture.
  - Python integration at this stage is **partial/auxiliary** (Typhon tools) rather than a fully embedded API.
- **Early efficient hyperspectral radiance tools (2017; kCARTA context)**:
  - Li et al. (2017) [18] and related work represent **efficient yet specialized** RT models for hyperspectral IR radiance under cloudy skies. Combined with kCARTA (formalized in 2019 [11]), these works embody:
    - The **"pseudo line by line" concept** compressed optical depth databases (SVD based) and fast clear sky RT algorithms with analytic Jacobians [11,18].
    - A strong focus on **end to end throughput for hyperspectral retrievals**
  - However, **open, Python accessible implementations** and GPU explicit designs are not emphasized [11,18].

**Overall pattern (2015–2017):**

- The period is dominated by **large, monolithic RT toolboxes** (libRadtran, ARTS) with:
  - High physics fidelity, multiple geometries, and flexible spectroscopy.
  - Limited emphasis on *systematic algorithmic optimization* or explicit GPU/ML strategies.
- These codes become **baseline references** against which newer high performance methods will later be benchmarked.

### 2018–2019: Separation of Gas Optics and RTE, and Emergence of "Radiative Kernels"

- **ecRad: Modular radiation framework for GCMs (2018)**:
  - Hogan & Bozzo introduce **ecRad**, a modular radiation scheme for ECMWF with flexible plug in solvers (McICA, Tripleclouds, SPARTACUS) and **separation of optics vs. RTE** [15].
  - Key conceptual shift:

    - Optical properties (gas, cloud, aerosol) are computed independently and passed to an RTE solver [15].
    - This abstraction lays the groundwork for later **ML gas optics** and spectral optimization, since any compatible provider of optical coefficients can be swapped in.
  - Emphasis is performance in an **operational forecast setting** (e.g., 41% faster McICA implementation) [15], but not yet GPU nor Python–user oriented.

- **RTE+RRTMGP toolbox: explicit gas optics vs. RTE split (2019)**
  - Pincus et al. formalize this split into two codebases: **RRTMGP (gas optics)** and **RTE (radiative transfer)** [3].
  - RRTMGP uses **state of the art correlated-k** with large g point counts:
    - 256 LW and 224 SW g points across 16/14 bands, respectively [3].
  - The toolbox highlights:
    - **Object oriented, modular design** with runtime provisioned data.
    - High efficiency kernels for **interpolation and band integration** (though primarily CPU vectorized Fortran) [3].
  - This becomes the *central reference architecture* for many subsequent ML gas optics papers [5,6,9,13].

- **kCARTA "pseudo LBL" (2019)**
  - Desouza Machado et al. formalize **kCARTA** as a *fast, pseudo LBL* code with compressed optical depth ("kCompressed") databases and analytic Jacobians [11].
  - It demonstrates a different route to high performance spectroscopy:
    - Heavy **offline compression** of a HITRAN based LBL database.
    - Fast analytic RT using a layer varying diffusivity angle and infrared scattering interface [11].
  - Compared to RRTMGP:
    - kCARTA prioritizes **single purpose, hyperspectral IR** speed and Jacobians.
    - RRTMGP aims at **general GCM radiation**, with modular RTE, but both share the idea of **heavy offline precomputation + lightweight runtime evaluation**.

**Trend (2018–2019):**

- Clear emergence of the **"gas optics kernel + RTE solver" abstraction** [3,15].
- Conceptual infrastructure laid for:
  - ML surrogates for gas optics [5,13].
  - Auto generated correlated k models [9].
- These works are mostly **Fortran/HPC oriented**, with Python exposure mainly through wrappers or external tools.

### 2018–2019: High performance Aerosol Scattering and LUTs

- **MOPSMAP v1.0 (2018)**:
  - Gasteiger & Wiegner release **MOPSMAP**, a LUT based tool for aerosol ensembles (spheres, spheroids, irregular particles) with precomputed single particle optical properties and a Fortran program + web interface [12].
  - MOPSMAP emphasizes:
    - Extensive precomputation and interpolation across size and refractive index space.
    - **Efficient ensemble calculations**, with outputs directly usable in libRadtran [12].
  - While not GPU oriented, it is a significant step toward **LUT based, performance conscious aerosol scattering** with example Python scripts driving the Fortran executable [12].

**Trend:**

- Transition from pure Mie "reference" codes to **precomputed aerosol LUT frameworks** with explicit attention to performance and RT-integration pathways [12].

### 2020–2022: Machine Learning for Gas Optics and Spectral Optimization

This period marks a *strong inflection* toward ML and data driven compression of spectroscopic calculations, mostly within the RTE+RRTMGP/ecRad ecosystem.

- **ML surrogates for RRTMGP gas optics (2020 Veerman et al.)**
  - Veerman et al. develop neural networks that emulate RRTMGP's lookup table step, predicting **optical properties per g point** (optical depth, Ég„ Planck source inputs) [13].
  - Performance:
    - Up to **H4× faster** than RRTMGP gas optics on CPUs using single precision and BLAS optimized GEMMs [13].

- Conceptual contributions:
  - **Stateless, batched ML architectures** aligned with RRTMGP's input structure.
  - Demonstration that ML can be a drop in replacement at the gas optics layer while preserving the same RTE solver [13].

- **RRTMGP NN with targeted ML and code optimization (2020 Ukkonen et al.)**
  - Ukkonen et al. develop **RRTMGP NN**, a more mature NN gas optics replacement integrated into the RTE+RRTMGP toolbox [5].
  - Key advances:
    - Extensive **code optimization**: batching over profiles, BLAS/GEMM, cache friendly memory layouts [5].
    - Combined with RTE solver refactoring, yields **3.5× (LW) and 1.8× (SW)** speedups vs. original RTE+RRTMGP, with heating rate errors typically <0.1 K/day vs. LBL [5].
    - Indicates an explicit interest in **performance engineering**, not just ML.

- **Further ML refinements and operational integration (2023 RRTMGP NN 2.0)**
  - Ukkonen & Hogan implement RRTMGP NN 2.0 in ECMWF's **IFS + ecRad**, with:
    - **Hybrid loss functions** optimized for radiative forcing.
    - Early stopping based on flux/heating rate vs. LBL benchmarks [6].
  - This is a key milestone: ML gas optics moves from an experimental concept to an **operational NWP radiation component**.

- **ecCKD (2022): Automatic generation of fast k distribution models**
  - Hogan & Matricardi introduce **ecCKD**, an automated tool that:
    - Partitions the spectrum and selects pseudo monochromatic k terms to meet user specified error tolerances [9].
    - Implements **full-spectrum correlated k (FSCK)** and sub bands to address surface/cloud spectral variability [9].
  - Conceptual significance:
    - Shifts the human intensive design of CKD models to a **data driven, automated optimization problem**
    - Provides a pipeline for generating **highly compressed, fast gas optics models** tailored to specific applications [9].
  - ecCKD is closely aligned with ecRad and the broader ECMWF radiation ecosystem [9].

**Trend (2020–2022):**
- Strong convergence on:
  - **ML surrogates for gas optics**, targeting RRTMGP.
  - **Automated spectral compression** (ecCKD).
- These works focus on **algorithmic efficiency** (BLAS, data layouts) and accuracy vs. LBL, but their public APIs are mostly Fortran centric; Python accessibility is possible via wrappers but not primary.

### 2020–2021: GPU Acceleration for IR RT

- **JURASSIC-GPU v2.0 (2021)**:
  - Baumeister & Hoffmann port the emissivity growth approximation (EGA)–based infrared RT algorithm to GPUs [8].
  - Highlights:
    - EGA is used as a **fast surrogate for LBL** RT, yielding orders of magnitude speedups vs traditional LBL [8].
    - GPU implementation focuses on **line by line spectral parallelization**, exploiting the natural independence across spectral points [8].
  - While primarily remote sensing oriented, JURASSIC GPU is a **proof of concept for GPU resident spectral RT** relevant to any modern high throughput RT workflow.
  - Python integration is not central; the focus is on CUDA and performance.

**Trend:**
- GPU enters the field primarily through **spectral parallelization** for IR RT, parallel to ML based CPU optimization in NWP oriented tools.

### 2020–2024: Beyond Gas – ML for Aerosols and Opacity Compression

- **NeuralMie & TAMie (2025)**:
  - Geiss & Ma introduce **NeuralMie**, a NN emulator for bulk aerosol optical properties, with **TAMie**, a fast Python Mie implementation based on Toon & Ackerman (1981) feeding training data [10].

  - Key contributions:
    - TAMie: **Python based, high performance Mie** achieving speeds comparable to optimized Fortran codes [10].
    - NeuralMie: A flexible emulator for a wide range of particle types and mixing states, directly outputting **bulk ensemble properties**, avoiding repeated Mie integration over size distributions [10].
    - Reported mean absolute percentage error H0.08% vs existing parameterizations [10].
  - This is a major milestone for **Python native, high performance aerosol scattering** and conceptually parallels ML gas optics surrogates.

- **cortecs (2024): GPU friendly opacity compression in Python/JAX**
  - Savel et al. introduce **cortecs**, a Python package for compressing high resolution gas opacity data and performing **GPU accelerated decompression** via JAX [14].
  - Methods: polynomial fits, principal component analysis, and neural network compression, all implemented in a way that:
    - Minimizes VRAM usage.
    - Supports **batched GPU evaluation** of opacities as functions of T, P, and wavelength [14].
  - While the examples are more exoplanet/astrophysics focused, the technical ideas:
    - **JAX based, vectorized spectral kernels**
    - Mixed compression strategies (PCA + NN).
    - Are highly relevant for Earth LBL/CKD pipelines.

- **MOPSMAP (2018) revisited in the ML era**:
  - While MOPSMAP itself [12] is not ML based, it provides the **LUT infrastructure** that later ML codes like NeuralMie conceptually mirror: precompute/learn the hard Mie part, then cheaply evaluate for many profiles.

**Trend:**
- Extension of ML and compression techniques **from gas absorption to aerosol scattering and generic opacities**.
- Strong pivot to **Python first, GPU friendly designs** (NeuralMie/TAMie, cortecs) by mid 2020s, in contrast to earlier Fortran centric radiation toolboxes.

### 2023–2025: Code structural Optimization, Python Integration, and High Level Toolboxes

- **ecRad performance optimization and spectral reduction (2024)**:
  - Ukkonen & Hogan optimize ecRad's radiation scheme, combining:
    - Spectral reduction via ecCKD generated gas optics.
    - Aggressive **code restructuring** to collapse spectral and vertical loops, enabling better vectorization and instruction level parallelism [7].
    - Full single precision implementations of two stream kernels [7].
  - Results: **12× speedup** vs the operational IFS radiation scheme, while using more accurate gas optics and solvers [7].
  - Conceptually:
    - Demonstrates that **kernel level code engineering** can yield order of magnitude speedups even without GPUs.
    - Sets a design pattern for future GPU ports and Python/JAX reimplementations: flattened dimensions, batched linear algebra, and minimal branching.

- **ARTS v2.6 – Deep Python integration (2025)**:
  - Buehler et al. present ARTS 2.6 with **deep Python integration** [1], marking a turning point:
    - ARTS evolves from a Fortran/C++ toolbox with external Python helpers into a **Python embedded RT engine** [1].
    - Given its existing line by line capabilities, spherical and 3D geometries, and scattering solvers [2], this creates a powerful **Python accessible, high fidelity RT system**
  - While the abstract is not provided, the title and linkage to earlier ARTS [2] indicate:
    - Enhanced workflows for large ensembles and retrievals via Python.
    - Better integration with modern Python ML/optimization ecosystems.

- **Eradiate (year not specified; referencing ARTS/libRadtran)**:
  - Leroy et al. present **Eradiate**, positioned as an accurate and flexible RT model for Earth observation and atmospheric science [16].
  - Eradiate cites ARTS and libRadtran [1,4], and is designed as a **user friendly, modular toolkit**, likely Python centric (consistent with recent RT ecosystems).
  - It represents the **next generation of high level RT frameworks**, aiming to integrate:

    - Advanced solvers.
    - Standard atmospheric datasets.
    - User friendly APIs.

- **HAPI2LIBIS (2025): modern HITRAN based LBL feeding libRadtran**
    - Kukkurainen et al. develop **HAPI2LIBIS**, a tool that automates generation of high resolution absorption data for libRadtran using HITRAN via HAPI [17].
    - Contribution:
        - Bridges **high resolution LBL spectroscopy**(HAPI) and the libRadtran RT engine [4].
        - Dramatically reduces the barrier for end users to run**line by line or high res RT**in a libRadtran workflow [17].
    - This sits conceptually between kCARTA style pseudo LBL and traditional parameterizations, but embedded in an open, community RT context.

**Trend (2023–2025):**

- Movement toward **Python embedded, high level RT ecosystems**
    - ARTS 2.6 deep Python integration [1].
    - Eradiate as a modern Python facing RT model [16].
    - HAPI2LIBIS linking HITRAN/HAPI with libRadtran [17].
- Continued focus on **performance at the kernel level** (ecRad optimization [7]) and ML based acceleration (RRTMGP NN 2.0 [6]).

## Key Clusters of Contributors and Their Impact

### Hogan / Ukkonen / ECMWF Radiation Ecosystem

- Core works: ecRad [15], RTE+RRTMGP [3], ML gas optics [5,6,13], ecCKD [9], ecRad spectral optimization [7].
- **Conceptual thread:**
    - Decomposition of radiation into **gas optics vs. RTE solvers**
    - Progressive **automation and compression** of gas optics:
        - From fixed RRTMG to state of the art RRTMGP [3],
        - To ML surrogates for RRTMGP [5,6,13],
        - To automatically generated CKD models (ecCKD) [9],
        - To full code structural optimization (12× speedups) [7].
- **Impact:**
    - Define a *template* for modern radiation schemes in NWP/ESMs.
    - Demonstrate ML and aggressive code optimization can be **operationalized** without sacrificing physical transparency.
- **Future directions suggested:**
    - GPU and Python/JAX reimplementations of this architecture.
    - ML that goes beyond gas optics to spectral quadrature and RTE kernels.
    - Joint optimization of gas optics and RT solvers as a single differentiable pipeline.

### Buehler / ARTS Community

- Core works: ARTS 2.2 [2], ARTS 2.6 with deep Python integration [1].
- **Thread:**
    - From a robust, multi geometry, LBL centric RT simulator [2] to a**Python embedded RT platform**[1].
- **Impact:**
    - Provide one of the most physically complete RT engines (spherical 1–3D, full Stokes, line by line) in a package that is increasingly accessible from Python.
- **Future trajectory:**
    - Natural candidate for **GPU accelerated spectral kernels**(perhaps inspired by cortecs [14] or JURASSIC GPU [8]).
    - Potential integration with ML surrogates for specific components (gas optics, scattering kernels) while preserving a full physics reference.

### Emde / libRadtran and Associated Tools

- Core works: libRadtran 2.0.1 [4], MOPSMAP [12], HAPI2LIBIS [17].
- **Thread:**
  - libRadtran as an open community RT reference [4], extended with:
    - High quality aerosol optical property LUTs (via MOPSMAP) [12].
    - User friendly shortwave, longwave, and Raman solvers.
  - HAPI2LIBIS bridges **HITRAN based LBL**and libRadtran workflows [17].
- **Impact:**
  - libRadtran remains a **benchmark and pedagogical standard**.
  - MOPSMAP and HAPI2LIBIS demonstrate a **LUT + external toolchain** approach for absorption and scattering that can be Python driven.
- **Future directions:**
  - Could be combined with Python native GPU kernels for spectroscopic evaluation (e.g., cortecs [14]) and with NeuralMie style aerosol emulators [10] to construct a high throughput, Python accessible libRadtran ecosystem.

### ML and Python First Opacity/Scattering Community

- **Veerman et al., Ukkonen et al., RRTMGP NN**[5,6,13].
- **Geiss & Ma (NeuralMie/TAMie)** [10].
- **Savel et al. (cortecs)** [14].
- **Thread:**
  - Progressive application of ML to (1) gas optics [5,6,13], (2) Mie scattering [10], and (3) generic opacity compression [14], with a strong **Python/ML ecosystem** orientation.
- **Impact:**
  - Demonstrate that ML surrogates and JAX style vectorization can deliver:
    - Significant speedups.
    - Differentiable modules for use in inverse modeling and ML training loops.
- **Future directions:**
  - Unified **Python JAX RT frameworks**where:
    - Gas optics comes from compressed/ML opacities (cortecs like).
    - Aerosol optics from NeuralMie.
    - RT solvers are implemented as differentiable, batched JAX kernels (akin to modern astrophysical RT and climate emulator work).

## Overarching Trends and Their Significance

### From Monolithic RT Codes to Modular, Composable Pipelines

- Early works (libRadtran, ARTS, kCARTA) [2,4,11] are monolithic RT engines:
  - Users select options, but internal components are tightly coupled.
- 2018 onward: **clear modularization**:
  - RRTMGP vs RTE [3]; ecRad's separation of solver and optics [15].
- This modularization is crucial for:
  - **Swapping in ML surrogates** (gas optics, Mie).
  - GPU accelerations that target specific kernels (spectral evaluation, matrix solves).
  - Interfacing from Python to high performance backend components.

### Shift from Accuracy first to Accuracy–Efficiency Co Design

- Before 2015: emphasis on physical completeness and accuracy (LBL, full polarization, spherical geometry).

- 2015–2020: codes like libRadtran and ARTS reach **sufficient physical maturity** [2,4], enabling attention to:
  - Efficient parameterizations (REPTRAN) [4].
  - Offline compressed databases (kCARTA) [11].
- 2020–2024: explicit **co design** of algorithms for performance:
  - ML gas optics tuned against LBL [5,6,13].
  - Spectral reduction via ecCKD, designed with error tolerances [9].
  - Code structural optimization enabling 12× speedups [7].
  - GPU spectral RT via JURASSIC GPU [8].
- The field now treats accuracy and efficiency as **joint design targets**, often with explicit benchmarks vs. LBL or reference codes [3,4,5,8,9,11,13].

### Growing Role of Python and GPU Ecosystems

- Initial frameworks are primarily Fortran/C/MATLAB based, with indirect Python usage [2,4,11,12].
- The last 5–6 years show:
  - Increasing **Python embedded RT frameworks** (ARTS 2.6 [1], Eradiate [16], HAPI2LIBIS [17]).
  - Python native high performance components:
    - TAMie Mie code [10].
    - cortecs JAX opacity compression [14].
  - GPU acceleration focuses first on **line like spectral loops** (JURASSIC GPU [8]) and now on **batched ML inference** and JAX kernels [5,14].
- This aligns RT modeling with the broader scientific Python ecosystem (NumPy, JAX, PyTorch), enabling:
  - Easier integration into **inverse problems, ML training, and differentiable modeling**.
  - More rapid prototyping of novel RT algorithms.

### Emerging Integration Across Gas, Aerosols, and RTE

- Historically, gas absorption (LBL/CKD), aerosol optics (Mie/LUTs), and RTE solvers were developed somewhat separately.
- Recent works start to **bridge these layers**:
  - RRTMGP/NN tools serve gas optics to ecRad solvers [3,5,6,7].
  - MOPSMAP outputs feed libRadtran [4,12].
  - HAPI2LIBIS links HITRAN/HAPI LBL to libRadtran RT [17].
  - NeuralMie and cortecs offer **Python accessible, ML ready** components that can plug into any Python RT solver [10,14].
- The field appears to be converging toward **integrated pipelines** where:
  - High performance opacities (gas and aerosol) are computed or emulated on GPU.
  - RT solvers (two stream, DOM, Monte Carlo) are run as batched kernels.
  - Validation is routinely performed against **LBL and standard tools** (MODTRAN like, LBLRTM like) [3,4,5,8,9,11,13].

## Implications for Future Research Directions

Given this trajectory, the next decade of work in this area is likely to emphasize:

1. **Fully GPU resident, Python accessible RT stacks**
   - Gas optics via compressed/ML opacities (cortecs like) [14].
   - Aerosol/cloud scattering via NeuralMie like emulators [10].
   - RT solvers implemented in JAX/CUDA with batched linear algebra and sparse operators.
1. **Differentiable RT as a first class objective**
   - Leverage ML frameworks and JAX to build RT solvers that are **differentiable end to end**, enabling:
     - Gradient based retrievals and parameter estimation.
     - Joint training of ML surrogates and physical solvers.
1. **Systematic benchmarks vs. standard codes**:
   - Many papers already benchmark against LBL or operational schemes [3,4,5,8,9,11,13]; future work will likely extend to:
     - Standard benchmark suites that include MODTRAN/LBLRTM/libRadtran/ARTS across geometries and spectral ranges.

- Public datasets and test harnesses to compare **accuracy vs. runtime** across different implementations.

1. **Unified handling of plane parallel and spherical geometries in high performance frameworks**
   - With ARTS 2.6's Python integration [1] and Eradiate [16], and existing pseudo spherical approaches in ecRad [15], there is a clear opportunity to:
     - Bring **spherical geometry** and limb RT into the same high performance, GPU ready space that plane parallel flux calculations now occupy.
     - Develop general geometry aware RT solvers with modular optics layers.

In sum, the field has evolved from **physics first monolithic RT codes**to **modular, performance engineered, and increasingly Python/GPU integrated frameworks**The next phase will almost certainly focus on *tight integration* of ML compressed spectroscopy, high throughput scattering, and optimized RTE solvers into a coherent, benchmarked, and user friendly ecosystem for Earth atmospheric radiative transfer.

# Foundational Work

## Which papers form the foundational references on this topic?

The below table shows the resources that are most often cited by the relevant papers on this topic. This is measured by the **reference rate**, which is the fraction of relevant papers that cite a resource. Use this table to determine the most important core papers to be familiar with if you want to deeply understand this topic. Some of these core papers may not be directly relevant to the topic, but provide important context.

| Ref. | Reference Rate | Title | Cited By These Relevant Papers |
|---|---|---|---|
| [15] | 0.61 | A Flexible and Efficient Radiation Scheme for the ECMWF Model | [3, 5, 6, 7, 9, 13] |
| [5] | 0.58 | Accelerating Radiation Computations for Dynamical Models With Targeted Machine Learning and Code Optimization | [6, 7, 9, 10] |
| [13] | 0.51 | Predicting atmospheric optical properties for radiative transfer computations using neural networks | [5, 6, 7, 10] |
| [57] | 0.51 | Exploring Pathways to More Accurate Machine Learning Emulation of Atmospheric Radiative Transfer | [6, 7, 10] |
| [239] | 0.51 | Using Deep Neural Networks as Cost Effective Surrogate Models for Super Parameterized E3SM Radiative Transfer | [5, 6, 7, 10, 13] |
| [9] | 0.50 | A Tool for Generating Fast k Distribution Gas Optics Models for Weather and Climate Applications | [6, 7] |
| [177] | 0.48 | THE CORRELATED-k METHOD FOR RADIATION CALCULATIONS IN NONHOMOGENEOUS ATMOSPHERES | [3, 5, 6, 7, 9, 13] |
| [3] | 0.46 | Balancing Accuracy, Efficiency, and Flexibility in Radiation Calculations for Dynamical Models | [5, 6, 7, 13] |
| [69] | 0.44 | Evaluating and improving the treatment of gases in radiation schemes: the Correlated K-Distribution Model Intercomparison Project (CKDMIP) | [5, 6, 9] |
| [256] | 0.43 | Improved Weather Forecasting Using Neural Network Emulation for Radiation Parameterization | [6, 7, 10] |
| [160] | 0.42 | Radiative transfer for inhomogeneous atmospheres: RRTM, a validated correlated-k model for the longwave | [3, 6, 7, 9, 10] |
| [28] | 0.41 | Representing 3 D cloud radiation effects in two stream schemes: 2. Matrix formulation and broadband evaluation | [3, 6, 7, 9, 15] |
| [200] | 0.41 | The HITRAN 2008 molecular spectroscopic database | [2, 3, 4, 8, 11] |
| [159] | 0.40 | On the correlated k-distribution method for radiative transfer in nonhomogeneous atmospheres | [3, 4, 5, 9, 13] |
| [27] | 0.39 | Sparse, Empirically Optimized Quadrature for Broadband Spectral Integration | [1, 21] |
| [164] | 0.37 | Atmospheric radiative transfer modeling: a summary of the AER codes | [2, 3, 5, 11, 13] |
| [6] | 0.33 | Implementation of a machine-learned gas optics parameterization in the ECMWF Integrated Forecasting System: RRTMGP-NN 2.0 | [7, 21] |
| [216] | 0.32 | Development and recent evaluation of the MT_CKD model of continuum absorption | [2, 3, 8, 11] |

| | | | |
|---|---|---|---|
| [234] | 0.31 | ARTS, the atmospheric radiative transfer simulator, version 2 | [1, 2, 4] |
| [303] | 0.30 | Efficient radiative transfer simulations for a broadband infrared radiometer—Combining a weighted mean of representative frequencies approach with frequency selection by simulated annealing | [1, 2, 4] |

# Adjacent Work

## Which papers cite the same foundational papers as relevant papers?

Use this table to discover related papers on adjacent topics, to gain a broader understanding of the field and help generate ideas for useful new research directions.

| Ref. | Adjacency score | Title | References These Foundational Papers |
|---|---|---|---|
| [19] | 1.62 | Py4CAtS—PYthon for Computational ATmospheric Spectroscopy | [2, 4, 164, 213, 270, 329] |
| [21] | 1.43 | An Accurate Shortwave Gaseous Transmittance Scheme Using Modified Alternate Mapping Correlated K Distribution Method | [3, 6, 160, 164] |
| [16] | 1.39 | Eradiate: An Accurate and Flexible Radiative Transfer Model for Earth Observation and Atmospheric Science | [4, 164, 176, 195, 230, 251] |
| [345] | 1.17 | A practical guide to coding line-by-line trace gas absorption in Earth's atmosphere | [2, 4, 149, 164, 213] |
| [17] | 1.07 | HAPI2LIBIS (v1.0): a new tool for flexible high-resolution radiative transfer computations with libRadtran (version 2.0.5) | [2, 4, 164, 234, 309, 329] |
| [206] | 1.06 | A data-driven approach for fast atmospheric radiative transfer inversion | [3, 6, 164] |
| [91] | 1.05 | Impact of Horizontal Resolution on the Robustness of Radiation Emulators in a Numerical Weather Prediction Model | [3, 5, 13, 15] |
| [43] | 1.04 | Fast computation of cloud 3D radiative effects in dynamical models by optimizing the ecRad scheme | [3, 5, 9] |
| [76] | 1.04 | Revisiting Machine Learning Approaches for Short and Longwave Radiation Inference in Weather and Climate Models | [5, 9, 13, 15] |
| [120] | 0.92 | Variation in shortwave water vapour continuum and impact on clear-sky shortwave radiative feedback | [2, 9, 15, 164] |
| [346] | 0.88 | Benefits of Stochastic Weight Averaging in Developing Neural Network Radiation Scheme for Numerical Weather Prediction | [3, 5, 13] |
| [256] | 0.88 | Improved Weather Forecasting Using Neural Network Emulation for Radiation Parameterization | [3, 5, 13] |
| [146] | 0.88 | Machine Learning Emulation of 3D Cloud Radiative Effects | [3, 5, 13] |
| [57] | 0.88 | Exploring Pathways to More Accurate Machine Learning Emulation of Atmospheric Radiative Transfer | [3, 5, 13] |
| [53] | 0.87 | Robustness of Neural Network Emulations of Radiative Transfer Parameterizations in a State-of-the-Art General Circulation Model | [3, 5, 13] |
| [13] | 0.86 | Predicting atmospheric optical properties for radiative transfer computations using neural networks | [3, 15, 164, 177, 228, 302] |
| [23] | 0.85 | Development and Evaluation of a New Correlated K Distribution Scheme for BCC_RAD Radiative Transfer Model | [5, 15, 164] |
| [347] | 0.78 | Machine Learning Based Parametrization of Gaseous Optical Properties and VANET Anomaly Detection for Accelerated Climate and Cyber - Physical Simulations | [3, 15, 164] |
| [149] | 0.75 | GARLIC — A general purpose atmospheric radiative transfer line-by-line infrared-microwave code: Implementation and evaluation $ | [164, 216, 234, 258, 329] |
| [348] | 0.74 | Machine learning for numerical weather and climate modelling: a review | [3, 5] |

# References

[1] The atmospheric radiative transfer simulator ARTS, version 2.6 — Deep python integration
Stefan A. Buehler, ..., and Patrick Eriksson. Journal of Quantitative Spectroscopy and Radiative Transfer, 2025. 16 citations.
100% Topic Match
No summary or abstract available

[2] ARTS, the Atmospheric Radiative Transfer Simulator – version 2.2, the planetary toolbox edition
S. Buehler, ..., and Oliver Lemke. Geoscientific Model Development, 2017. 190 citations.
99% Topic Match
Documents an open-source, Python-accessible LBL-capable radiative transfer simulator.
Describes ARTS v2.2 with line by line and precomputed-LUT absorption, spherical (1–3D) geometries, DO/Monte Carlo solvers, and Python Typhon tools.
Relevant: GPL code, supports HITRAN-style data, polarization and scattering (external single scattering inputs required), but v2.2 lacks solar scattering source, scattering Jacobians, and explicit GPU/benchmarking vs MODTRAN/LBLRTM.

[3] Balancing Accuracy, Efficiency, and Flexibility in Radiation Calculations for Dynamical Models
R. Pincus, ..., and J. Delamere. Journal of Advances in Modeling Earth Systems, 2019. 99 citations.
99% Topic Match
Proposes a modular toolbox (RTE + RRTMGP) balancing accuracy, efficiency, flexibility.
Implements correlated k gas absorption and two stream plane parallel RTE with state of the art spectroscopy.
Open, performance focused design emphasizes reusable computational objects/kernels; check availability of Python bindings, GPU support, and benchmarks versus MODTRAN/LBLRTM.

[4] The libRadtran software package for radiative transfer calculations (version 2.0.1)
C. Emde, ..., and L. Bugliaro. Geoscientific Model Development, 2015. 684 citations.
98% Topic Match
Describes and distributes libRadtran 2.0.1, an open-source Earth-atmosphere RT toolbox.
Summarizes new features: vector radiative transfer solver, Raman scattering, REPTRAN efficient gas-absorption parameterization, updated aerosol/ice optical parameterizations, and MYSTIC spherical support.
Relevant: code is open-source with Python-friendly interfaces (wrappers/inputs), but not primarily a modern GPU-optimized pipeline; includes benchmarks/examples versus standard tools and extensive documentation.

[5] Accelerating Radiation Computations for Dynamical Models With Targeted Machine Learning and Code Optimization
P. Ukkonen, ..., and E. Kaas. Journal of Advances in Modeling Earth Systems, 2020. 41 citations.
98% Topic Match
Proposes neural network surrogates to accelerate gas optics in a correlated k RTE package.
Trains NNs on RRTMGP k table outputs, implements batched inference in Fortran using BLAS/GEMM for 1–6× speedups.
Combines NN gas optics with a refactored RTE solver (3.5× LW, 1.8× SW speedups), validated against line by line; no mention of fast Mie/Rayleigh LUTs, explicit GPU kernels beyond BLAS, or clearly documented Python-accessible open source release in the provided text.

[6] Implementation of a machine-learned gas optics parameterization in the ECMWF Integrated Forecasting System: RRTMGP-NN 2.0
P. Ukkonen and R. Hogan. Geoscientific Model Development, 2023. 6 citations.
96% Topic Match
Implements a neural network surrogate for correlated k gas optics (RRTMGP NN) within ECMWF IFS.
Replaces RRTMGP's k-table interpolation by NN prediction of optical properties, retaining the RT solver; trained with hybrid loss and LBL based early stopping.
Openly integrated into ecRad/RTE+RRTMGP codebase (Fortran inference kernel); focuses on speed/accuracy in operational model, but no explicit GPU implementation—benchmarked against LBL and standard RRTMGP/RRTMG.

[7] Twelve Times Faster yet Accurate: A New State Of The Art in Radiation Schemes via Performance and Spectral Optimization
P. Ukkonen and Robin J. Hogan. Journal of Advances in Modeling Earth Systems, 2024. 7 citations.
85% Topic Match
Demonstrates large speedups in climate-model radiation via spectral and code optimizations.
Achieves this by collapsing spectral/vertical loops, batching cloudy layers, vectorization, single-precision two stream kernels, and spectral reduction.
Relevant: focuses on ecRad (TripleClouds, SPARTACUS) within ECMWF-like systems; open source status/GPU work not stated and no mention of LBL/correlated k, Mie LUTs, or explicit benchmarks vs MODTRAN/LBLRTM.

[8] Fast Infrared Radiative Transfer Calculations Using Graphics Processing Units: JURASSIC-GPU v2.0
P. Baumeister and L. Hoffmann. Geoscientific Model Development, 2021. 3 citations.
80% Topic Match
Demonstrates a GPU-accelerated infrared radiative transfer code using the emissivity growth approximation (EGA).
Implements JURASSIC-GPU v2.0: EGA-based fast IR RT (4–15 $\mu$m) ported/optimized for GPUs to speed LBL-equivalent computations.
Relevant: open-source status unclear from abstract; focuses on EGA (accelerated absorption) and GPU RTE performance versus full LBL, but check for Python API, comparisons to MODTRAN/LBLRTM, Mie/Rayleigh handling, and benchmark details.

[9] A Tool for Generating Fast k Distribution Gas Optics Models for Weather and Climate Applications
R. Hogan and M. Matricardi. Journal of Advances in Modeling Earth Systems, 2022. 22 citations.
80% Topic Match
Proposes a fast, automated tool (ecCKD) to generate correlated k gas optics models.
Builds optimal k term partitions and per gas LUTs (FSCK for LW/NIR) tuned to error tolerances and GHG ranges, validated against line by line.
Relevant for accelerated gas absorption (correlated k) and efficiency in climate/forecast RT; paper lacks clear Python API, GPU support, aerosol/Mie methods, or RTE solver integration.

[10] NeuralMie (v1.0): an aerosol optics emulator
Andrew Geiss and Po-Lun Ma. Geoscientific Model Development, 2025. 1 citations.
45% Topic Match
Proposes a neural-network emulator for Mie aerosol optics (NeuralMie) plus a fast Python Mie code (TAMie).
Trains NeuralMie on TAMie-generated Mie calculations to predict bulk optical properties (extinction, scattering, g) for diverse, core–shell and mixed aerosols with ~0.08% MAPE.
Relevant: provides open Python implementation (TAMie) and a GPU friendly ML emulator; focuses on aerosol scattering/LUT replacement but does not address gas absorption or full RTE solvers—useful as a fast scattering component for the desired RT pipeline.

[11] kCARTA: a fast pseudo line-by-line radiative transfer algorithm with analytic Jacobians, fluxes, nonlocal thermodynamic equilibrium, and scattering for the infrared
S. Desouza-Machado, ..., and S. Hannon. Atmospheric Measurement Techniques, 2019. 9 citations.
38% Topic Match

Demonstrates a fast pseudo line by line (pseudo monochromatic) RT algorithm with analytic Jacobians.
Uses an SVD compressed optical depth database (kCompressed) built from HITRAN 2016, layer varying diffusivity angle, and analytic Jacobians; computes IR radiances, fluxes, NLTE and heating rates.
Relevant for high performance absorption+RT (605–2830 cm{¹), but no Python API, open source release, or GPU parallelization mentioned—MATLAB clear sky radiance+Jacobian version available.

[12] MOPSMAP v 1 . 0 : A versatile tool for modeling of aerosol optical properties
J. Gasteiger and M. Wiegner. Journal Not Provided, 2018. 16 citations.
35% Topic Match

Provides a fast tool for computing aerosol optical properties for complex, polydisperse ensembles.
Uses a precomputed single-particle dataset plus a Fortran ensemble integrator (MOPSMAP v1.0) to produce scattering matrices and derived properties.
Open-source Fortran + dataset with web UI; outputs netCDF readable by libRadtran/uvspec and example Python scripts call the Fortran code—useful for LUT-based scattering workflows but not a full Python-native or GPU-parallel RT solver.

[13] Predicting atmospheric optical properties for radiative transfer computations using neural networks
M. Veerman, ..., and C. V. van Heerwaarden. Philosophical transactions. Series A, Mathematical, physical, and engineering sciences, 2020. 37 citations.
29% Topic Match

Proposes a neural-network surrogate for gaseous optical properties (gas optics) used in radiative transfer.
Trains NNs to emulate RRTMGP lookup/table outputs (Ä, É0moments, Planck inputs) on perturbed-profile datasets; uses restricted P–T–composition domains and BLAS-accelerated single precision matrix ops for speed.
Relevant: open code referenced on GitHub; ML replaces only gas optics (not RTE or Mie/Mie LUTs), reports ~0.5 W m 2 flux error vs RRTMGP and up to ~4× speedup on CPU; GPU/batched benchmarks and direct comparisons to LBL/MODTRAN/HITRAN absent.

[14] cortecs: A Python package for compressing opacities
A. Savel, ..., and E. Kempton. J. Open Source Softw., 2024. 0 citations.
23% Topic Match

Demonstrates a Python package to compress and GPU accelerate gas opacities.
Uses polynomial fits, PCA, or neural nets (Keras) with JAX based decompression for fast, low RAM/VRAM evaluation over T–P».
Open source, pip/conda installable (GitHub); focuses on opacity compression/evaluation only — no Mie/Rayleigh, correlated k, RTE solver, or MODTRAN/LBLRTM benchmarking in provided excerpt.

[15] A Flexible and Efficient Radiation Scheme for the ECMWF Model
R. Hogan and A. Bozzo. Journal of Advances in Modeling Earth Systems, 2018. 180 citations.
20% Topic Match

Demonstrates a flexible, modular high-performance radiation scheme (ecRad) for ECMWF.
Implements interchangeable spectral resolution, cloud/aerosol optics, and solvers (McICA, Tripleclouds, SPARTACUS), improving speed and noise.
Open for offline noncommercial research; focuses on cloud 3 D effects and longwave cloud scattering (aerosol longwave not implemented); not primarily LBL/correlated k, Python API, or explicit GPU/ML acceleration.

[16] Eradiate: An Accurate and Flexible Radiative Transfer Model for Earth Observation and Atmospheric Science
V. Leroy, ..., and Carlo. Journal Not Provided, Unknown year. 0 citations.
14% Topic Match

No summary or abstract available

[17] HAPI2LIBIS (v1.0): a new tool for flexible high-resolution radiative transfer computations with libRadtran (version 2.0.5)
Antti Kukkurainen, ..., and Neus Sabater. Geoscientific Model Development, 2025. 0 citations.
12% Topic Match

Provides a tool to enable high-resolution (line-resolved) libRadtran runs.
Automates generation of libRadtran-compatible high-resolution molecular absorption data using HITRAN/HAPI.
Open-source integration with libRadtran (focuses LBL input preparation); does not itself implement GPU acceleration, accelerated k methods, fast Mie/LUT scattering, or new RTE solvers—useful if you need Python-accessible LBL inputs for libRadtran benchmarking.

[18] An efficient radiative transfer model for hyperspectral IR radiance simulation and applications under cloudy sky conditions
Jun Li, ..., and R. Atlas. Journal of Geophysical Research: Atmospheres, 2017. 24 citations.
8% Topic Match

No summary or abstract available

[19] Py4CAtS—PYthon for Computational ATmospheric Spectroscopy
F. Schreier, ..., and S. Städt. Atmosphere, 2019. 40 citations.
7% Topic Match

Demonstrates a Python re-implementation of a line by line (LBL) infrared/microwave RT pipeline.
Implements GARLIC functionality: line extraction, Voigt LBL cross sections, absorption'optical depth, and LOS integration using vectorized NumPy/SciPy routines.
Open source and Python accessible (console/IPython/Jupyter), exposes intermediate fields, but omits continuum, scattering, correlated k/ML acceleration, limb/spherical geometry, GPU support, and is not intended as an LBLRTM/MODTRAN competitor.

[20] A Fast Polarized Radiative Transfer Model for Multi Layer Cloudy Atmospheres
Yuxiang Ling, ..., and Byung Ju Sohn Journal of Geophysical Research: Atmospheres, 2025. 0 citations.
7% Topic Match

Abstract: Polarized radiative transfer models (PRTMs) are essential in atmospheric remote sensing and particle microphysics researches, but their applications have been limited due to their high computational cost and complexity. This study proposes an efficient plane parallel PRTM by a combination of machine learning (ML) techniques and traditional physical radiative transfer models. The atmosphere is decomposed into layers with independent optical properties, each have type specific polarized scattering parameterizations. To be more specific, a physics informed neural network (PINN) model that directly incorporates physical constraints into the ML process is developed to capture complex polarized interactions of cloudy layers. By independent training for atmospheric...

[21] An Accurate Shortwave Gaseous Transmittance Scheme Using Modified Alternate Mapping Correlated K Distribution Method
Yue Cai, ..., and Quan Yang. Journal of Geophysical Research: Atmospheres, 2025. 0 citations.
5% Topic Match

Proposes a modified alternate-mapping correlated-k shortwave gaseous transmittance scheme.
Implements an algorithm restoring monotonicity after removing strong absorptions, uses optimized k-LUTs across diverse profiles, and needs ~80 pseudo-monochromatic points.
Open-source Python/GPU availability not stated; benchmarks against CKDM intercomparison profiles shown, emphasizes accuracy vs. efficiency for fluxes/heating but no explicit RTE, Mie, or GPU-parallelized solver integration.

[22] Optimized Alternate Mapping Correlated K Distribution Method for Atmospheric Longwave Radiative Transfer
Yue Cai, ..., and Shuai Hu. Journal of Advances in Modeling Earth Systems, 2023. 4 citations.
4% Topic Match

Abstract: Radiative transfer models are widely applied in climate models to simulate vertical temperature perturbations caused by external radiative forcings. A large part of radiative transfer models is the infrared gaseous spectral transmittance scheme, which quantifies the longwave atmospheric absorption. A rapid infrared gaseous spectral transmittance scheme, called the Optimized alternate Mapping Correlated K Distribution model (OMCKD), is introduced in this paper. To improve

the accuracy of our scheme without increasing pseudo monochromatic calculations, we introduce the optimal iteration method to automatically tune the equivalent absorption coefficients in the cumulative probability subspace. In addition, a new expression weighted by black body radiation is introduced...

[23] Development and Evaluation of a New Correlated K Distribution Scheme for BCC_RAD Radiative Transfer Model
Liting Liu and Hua Zhang. Journal of Geophysical Research: Atmospheres, 2025. 2 citations.
3% Topic Match

Abstract: With the significant increase in the abundance of greenhouse gases in the atmosphere over recent decades, more of the weak gaseous absorption bands are required to be incorporated in the gas optics model to improve the computational accuracy of radiation, and thus the warming effect of gases. Based on the latest HITRAN2020 spectroscopic data, a new 36 band correlated k distribution (CKD) scheme is developed with high spectral band resolution for radiative transfer model. By considering errors of both radiative fluxes and atmospheric heating rates, optimizations are made to select the overlapping method and the number of k distribution quadrature points in each...

[24] The full-spectrum correlated-k method to accelerate radiative transfer in NWP models
R. Hogan. Journal Not Provided, 2021. 0 citations.
3% Topic Match

Abstract:  Radiative transfer is frequently cited as the slowest part of an atmospheric model; while perhaps a little unfair (radiation accounting for only 3.5% of the cost of ECMWF's highest resolution operational model), there is no shortage of ideas in the literature for speeding up radiation schemes. In this talk I will describe a flexible tool "ecCKD" for generating gas optics models using the correlated k-distribution (CKD) method, and in particular explore the potential to use the "full-spectrum correlated-k" (FSCK) method in NWP. Via the use of one band for the entire thermal infrared and one for the...

[25] Journal of Advances in Modeling Earth Systems A Flexible and Efficient Radiation Scheme for the ECMWFModel
R. Hogan and A. Bozzo. Journal Not Provided, 2018. 7 citations.
2% Topic Match

No summary or abstract available

[26] 3-D radiative transfer in large-eddy simulations – experiences coupling the TenStream solver to the UCLA-LES
F. Jakub and B. Mayer. Geoscientific Model Development, 2015. 20 citations.
2% Topic Match

Abstract: Abstract. The recently developed 3-D TenStream radiative transfer solver was integrated into the University of California, Los Angeles large-eddy simulation (UCLA-LES) cloud-resolving model. This work documents the overall performance of the TenStream solver as well as the technical challenges of migrating from 1-D schemes to 3-D schemes. In particular the employed Monte Carlo spectral integration needed to be reexamined in conjunction with 3-D radiative transfer. Despite the fact that the spectral sampling has to be performed uniformly over the whole domain, we find that the Monte Carlo spectral integration remains valid. To understand the performance characteristics of the coupled TenStream...

[27] Sparse, Empirically Optimized Quadrature for Broadband Spectral Integration
P. Czarnecki, ..., and R. Pincus. Journal of Advances in Modeling Earth Systems, 2023. 2 citations.
2% Topic Match

Abstract: Broadband (spectrally integrated) radiation calculations are dominated by the expense of spectral integration, and many applications require fast parameterizations for computing radiative flux. Here we describe a novel approach using a linear weighted sum of monochromatic calculations at a small set of optimally chosen frequencies. The empirically optimized quadrature method is used to compute atmospheric boundary fluxes, net flux profiles throughout the atmosphere, heating rate profiles, and top of the atmosphere forcing by CO2, in the longwave for clear skies. We evaluate the method against two modern correlated k distribution models and find that we can achieve comparable errors with 32 spectral points. We also examine the...

[28] Representing 3 D cloud radiation effects in two stream schemes: 2. Matrix formulation and broadband evaluation
R. Hogan, ..., and B. Mayer. Journal of Geophysical Research: Atmospheres, 2016. 65 citations.
2% Topic Match

No summary or abstract available

[29] PAMTRA 1.0: A Passive and Active Microwave radiative TRAnsfer tool for simulating radiometer and radar measurements of the cloudy atmosphere
M. Mech, ..., and S. Crewell. Journal Not Provided, 2020. 26 citations.
2% Topic Match

Abstract: Abstract. Forward models are a key tool to generate synthetic observations given the knowledge of the atmospheric state. In this way they are an integral part of inversion algorithms that aim to retrieve geophysical variables from observations or in data assimilation. Their application for the exploitation of the full information content of remote sensing observations becomes increasingly important when these are used to evaluate the performance of cloud resolving models (CRMs). Herein, CRMs profiles or fields provide the input to the forward model whose simulation results are subsequently compared to the observations. This paper introduces the freely available comprehensive microwave...

[30] Radiative transfer in the O2 A-band - a fast and accurate forward model based on the  -distribution approach
F. André, ..., and P. Dubuisson. Journal of Quantitative Spectroscopy & Radiative Transfer, 2020. 14 citations.
2% Topic Match

No summary or abstract available

[31] Using a GPU to Accelerate a Longwave Radiative Transfer Model with Efficient CUDA-Based Methods
Yuzhu Wang, ..., and Albert Y. Zomaya. Applied Sciences, 2019. 8 citations.
2% Topic Match

Abstract: Climatic simulations rely heavily on high-performance computing. As one of the atmospheric radiative transfer models, the rapid radiative transfer model for general circulation models (RRTMG) is used to calculate the radiative transfer of electromagnetic radiation through a planetary atmosphere. Radiation physics is one of the most time-consuming physical processes, so the RRTMG presents large-scale and long-term simulation challenges to the development of efficient parallel algorithms that fit well into multicore clusters. This paper presents a method for improving the calculative efficiency of radiation physics, an RRTMG long-wave radiation scheme (RRTMG_LW) that is accelerated on a graphics processing unit (GPU). First,...

[32] Evaluation of Neural Network Emulations for Radiation Parameterization in Cloud Resolving Model
S. Roh and Hwan Jin Song Geophysical Research Letters, 2020. 33 citations.
1% Topic Match

Abstract: This study evaluated the forecast performance of neural network (NN) based radiation emulators with 300 to 56 neurons developed under the cloud resolving simulation. These emulators are 20–100 times faster than the original parameterization and express evolutionary features well for 6 hr. The results suggest that the frequent use of an NN emulator can improve not only computational speed but also forecasting accuracy in comparison to the infrequent use of original radiation parameterization, which is commonly used for speedup but can induce numerical instability as a result of imbalance with other processes. The forecast error of the emulator results was much improved...

[33] Toward Transparency and Consistency: An Open Source Optics Parameterization for Clouds and Precipitation
Jing Feng, ..., and David Paynter. Journal of Advances in Modeling Earth Systems, 2025. 1 citations.
1% Topic Match

Abstract: In this study, a new open source package for cloud and precipitation modeling is introduced. Based on Mie theory and existing ice crystal data sets, the scheme generates optical properties for user defined gas bands, particle size distribution, and crystal habits, ensuring continuity across wide spectral bands and from small particles (clouds) to large particles (precipitation). Compared with existing schemes in GFDL's AM4 MG2, it reduces shortwave reflection of liquid clouds at the top of the atmosphere (TOA) by 1.50 Wm 2 and increases that of ice clouds by 1.62 Wm 2, based on offline radiative calculations. Using the new scheme, we find that cloud...

[34] GPU-Accelerated Longwave Radiation Scheme of the Rapid Radiative Transfer Model for General Circulation Models (RRTMG)

Erik Price, ..., and Tsengdar J. Lee. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 2014. 42 citations.
1% Topic Match

No summary or abstract available

[35] A revised radiation package of G packed McICA and two stream approximation: Performance evaluation in a global weather forecasting model
Sunghye Baek. Journal of Advances in Modeling Earth Systems, 2017. 57 citations.
1% Topic Match

Abstract: For more efficient and accurate computation of radiative flux, improvements have been achieved in two aspects, integration of the radiative transfer equation over space and angle. First, the treatment of the Monte Carlo independent column approximation (MCICA) is modified focusing on efficiency using a reduced number of random samples ("G packed") within a reconstructed and unified radiation package. The original McICA takes 20% of CPU time of radiation in the Global/Regional Integrated Model systems (GRIMs). The CPU time consumption of McICA is reduced by 70% without compromising accuracy. Second, parameterizations of shortwave two stream approximations are revised to reduce errors with respect to...

[36] A new gas absorption optical depth parameterisation for RTTOV version 13
James Hocking, ..., and C. Lupu. Geoscientific Model Development, 2021. 22 citations.
1% Topic Match

Abstract: Abstract. This paper describes a new gas optical depth parameterisation implemented in the most recent release, version 13, of the radiative transfer model RTTOV (Radiative Transfer for TOVS). RTTOV is a fast, one-dimensional radiative transfer model for simulating top-of-atmosphere visible, infrared, and microwave radiances observed by downward-viewing space-borne passive sensors. A key component of the model is the fast parameterisation of absorption by the various gases in the atmosphere. The existing parameterisation in RTTOV has been extended over many years to allow for additional variable gases in RTTOV simulations and to account for solar radiation and better support geostationary sensors...

[37] AccuRT: A versatile tool for radiative transfer simulations in the coupled atmosphere-ocean system
B. Hamre, ..., and J. Stamnes. Unknown journal, 2017. 11 citations.
1% Topic Match

No summary or abstract available

[38] Recent Improvements in the Dart Model for Atmosphere, Topography, Large Landscape, Chlorophyll Fluorescence, Satellite Image Inversion
J. Gastellu Etchegorry, ..., and D. Morton IGARSS 2020 - 2020 IEEE International Geoscience and Remote Sensing Symposium, 2020. 8 citations.
1% Topic Match

Abstract: Physical models simulating the radiative budget (RB) and remote sensing (RS) observation of three-dimensional (3D) landscapes are critical to better understand human and natural components of the Earth system and further develop RS technology. DART is one of the most comprehensive 3D models of Earth-atmosphere optical radiative transfer (RT), from ultraviolet (UV) to thermal infrared (TIR). It simulates the optical signal of proximal, aerial and satellite imaging spectrometers and laser scanners, the 3D RB and solar induced chlorophyll fluorescence (SIF) signal, for any urban or natural landscape and any experimental or instrument configuration. It is freely available for research and...

[39] Two Streams Revisited: General Equations, Exact Coefficients, and Optimized Closures
Dion J. X. Ho and R. Pincus. Journal of Advances in Modeling Earth Systems, 2024. 1 citations.
1% Topic Match

Abstract: Two Stream Equations are the most parsimonious general models for radiative flux transfer with one equation to model each of upward and downward fluxes; these are coupled due to the transfer of fluxes between hemispheres. Standard two stream approximation of the Radiative Transfer Equation assumes that the ratios of flux transferred (coupling coefficients) are both invariant with optical depth and symmetric with respect to upwelling and downwelling radiation. Two stream closures are derived by making additional assumptions about the angular distribution of the intensity field, but none currently works well for all parts of the optical parameter space. We determine the exact values...

[40] Fast Computations of the Top-of-the-Atmosphere Radiance in a Spectral Range 400–2500 nm Using the PYDOME Tool
Dmitry S. Efremenko, ..., and Thomas Trautmann. ECRS 2023, 2023. 0 citations.
1% Topic Match

Abstract: : Accurate computations of the radiance in the gaseous absorption bands typically require fine wavelength steps. In this paper, a fast technique for computing a radiance spectrum in the wavelength region of 400–2500 nm is proposed. Our approach draws inspiration from the established k -correlation distribution model, with k denoting the absorption coefficient. However, our method expands upon this by considering both the direct transmittance and the scattering coefficient as predictors. At selected spectral points, the full radiative transfer simulations are performed, and the mathematical relation between a predictor and the radiance is established. Then, the radiance is restored on...

[41] Oxidizing ExoCAM: Introducing the Radiative Effects of Oxygen and Ozone into the ExoCAM General Circulation Model
R. Deitrick, ..., and Tyler D. Robinson. The Planetary Science Journal, 2025. 1 citations.
1% Topic Match

Abstract: Oxygen and ozone are two of the most important gases in Earth's atmosphere. These arose as a result of photosynthesis and appeared prominently around 2.3–2.4 billion yr ago. For exoplanets, these species have been proposed both as remote biosignatures and antibiosignatures, depending on the abundances and astrophysical context. ExoCAM, an extension of the Community Earth System Model for deep paleoclimate and exoplanets, has previously been limited to anoxic atmospheres. This work presents a substantial update to the radiative transfer in ExoCAM to include the effects of oxygen and ozone. We describe the implementation of line lists, empirical cross sections, Rayleigh...

[42] What are the optimum discrete angles to use in thermal infrared radiative transfer calculations?
Robin J. Hogan. Quarterly Journal of the Royal Meteorological Society, 2023. 0 citations.
1% Topic Match

Abstract: As computer power increases, there is a need to investigate the potential gains of using more than two streams in the radiative transfer calculations of weather and climate models. In this article, seven quadrature schemes for selecting the zenith angles and weights of these streams are evaluated rigorously in terms of the accuracy of thermal infrared radiative transfer calculations. In addition, a new method is presented for generating "optimized" angles and weights that minimize the thermal infrared irradiance and heating rate errors for a set of clear sky training profiles. It is found that the standard approach of applying Gauss–Legendre quadrature in each hemisphere...

[43] Fast computation of cloud 3D radiative effects in dynamical models by optimizing the ecRad scheme
P. Ukkonen and R. Hogan. Journal Not Provided, 2023. 1 citations.
1% Topic Match

No summary or abstract available

[44] Simplified characterization of Earth-limb radiance calculation for longwave infrared bands
Yixin Fan and Xiaoyu He. Unknown journal, 2025. 0 citations.
1% Topic Match

Abstract: Atmospheric path radiance is generally calculated via solving radiative transfer equation, in which the Curtis-Godson (C-G) approximation is adopted to discretize the inhomogeneous atmosphere into tens to hundreds of homogeneous sub-layers for calculation accuracy. However, as the density of the atmosphere decrease with altitude, the sub-layers at lower altitude contribute major radiance. Theoretically, a couple of sub-layers can achieve similar calculation results with significant improvement of efficiency. In this paper, a simplified characterization model of Earth-limb radiance calculation is developed for longwave infrared (LWIR) bands. To this end, the atmospheric radiative transfer ARTM model developed in our previous work, namely...

[45] MOPSMAP v1.0: a versatile tool for the modeling of aerosol optical properties
J. Gasteiger and M. Wiegner. Geoscientific Model Development, 2018. 80 citations.
0% Topic Match

Abstract: Abstract. The spatiotemporal distribution and characterization of aerosol particles are usually determined by remote-sensing and optical in situ measurements. These measurements are indirect with respect to microphysical properties, and thus inversion techniques are required to determine the aerosol microphysics.

Scattering theory provides the link between microphysical and optical properties; it is not only needed for such inversions but also for radiative budget calculations and climate modeling. However, optical modeling can be very time-consuming, in particular if nonspherical particles or complex ensembles are involved. In this paper we present the MOPSMAP package (Modeled optical properties of ensembles of aerosol particles), which...

[46] A new gas absorption optical depth parameterisation for RTTOV v13
James Hocking, ..., and C. Lupu. Geoscientific Model Development Discussions, 2021. 0 citations.
0% Topic Match

Abstract: Abstract. This paper describes a new gas optical depth parameterisation implemented in the most recent release, version 13, of the radiative transfer model RTTOV (Radiative Transfer for TOVS). RTTOV is a fast, one-dimensional radiative transfer model for simulating top-of-atmosphere visible, infrared and microwave radiances observed by downward-viewing space-borne passive sensors. A key component of the model is the fast parameterisation of absorption by the various gases in the atmosphere. The existing parameterisation in RTTOV has been extended over many years to allow for additional variable gases in RTTOV simulations and to account for solar radiation and better support geostationary sensors...

[47] Radiative transfer through terrestrial atmosphere and ocean: Software package SCIATRAN
V. Rozanov, ..., and J. Burrows. Journal of Quantitative Spectroscopy & Radiative Transfer, 2014. 304 citations.
0% Topic Match

No summary or abstract available

[48] A High-Spectral-Resolution Radiative Transfer Model for Simulating Multilayered Clouds and Aerosols in the Infrared Spectral Region
Chenxi Wang, ..., and Xu Liu. Journal of the Atmospheric Sciences, 2015. 9 citations.
0% Topic Match

No summary or abstract available

[49] MieAI: a neural network for calculating optical properties of internally mixed aerosol in atmospheric models
Pankaj Kumar, ..., and G. Hoshyaripour. npj Climate and Atmospheric Science, 2023. 10 citations.
0% Topic Match

Abstract: Aerosols influence weather and climate by interacting with radiation through absorption and scattering. These effects heavily rely on the optical properties of aerosols, which are mainly governed by attributes such as morphology, size distribution, and chemical composition. These attributes undergo continuous changes due to chemical reactions and aerosol micro-physics, resulting in significant spatio-temporal variations. Most atmospheric models struggle to incorporate this variability because they use pre-calculated tables to handle aerosol optics. This offline approach often leads to substantial errors in estimating the radiative impacts of aerosols along with posing significant computational burdens. To address this challenge, we introduce a computationally...

[50] An update on the RTTOV fast radiative transfer model (currently at version 12)
R. Saunders, ..., and C. Lupu. Geoscientific Model Development, 2018. 301 citations.
0% Topic Match

Abstract: Abstract. This paper gives an update of the RTTOV (Radiative Transfer for TOVS) fast radiative transfer model, which is widely used in the satellite retrieval and data assimilation communities. RTTOV is a fast radiative transfer model for simulating top-of-atmosphere radiances from passive visible, infrared and microwave downward-viewing satellite radiometers. In addition to the forward model, it also optionally computes the tangent linear, adjoint and Jacobian matrix providing changes in radiances for profile variable perturbations assuming a linear relationship about a given atmospheric state. This makes it a useful tool for developing physical retrievals from satellite radiances, for direct radiance assimilation...

[51] A fast code for channel limb radiances with gas absorption and scattering in a spherical atmosphere
J. Eluszkiewicz, ..., and M. Wolff. Journal of Quantitative Spectroscopy & Radiative Transfer, 2017. 6 citations.
0% Topic Match

No summary or abstract available

[52] GPU acceleration experience with RRTMG long wave radiation model
Erik Price, ..., and Tsengdar J. Lee. Unknown journal, 2013. 12 citations.
0% Topic Match

No summary or abstract available

[53] Robustness of Neural Network Emulations of Radiative Transfer Parameterizations in a State-of-the-Art General Circulation Model
A. Belochitski and V. Krasnopolsky. Geoscientific Model Development, 2021. 26 citations.
0% Topic Match

Abstract: Abstract. The ability of Machine-Learning (ML) based model components to generalize to the previously unseen inputs, and the resulting stability of the models that use these components, has been receiving a lot of recent attention, especially when it comes to ML-based parameterizations. At the same time, ML-based emulators of existing parameterizations can be stable, accurate, and fast when used in the model they were specifically designed for. In this work we show that shallow-neural-network-based emulators of radiative transfer parameterizations developed almost a decade ago for a state-of-the-art GCM are robust with respect to the substantial structural and parametric change in...

[54] Infrared radiative transfer modeling and temperature retrievals with Py4CAtS (Python for Computational ATmospheric Spectroscopy)
F. Schreier, ..., and J. Grenfell. Unknown journal, 2019. 0 citations.
0% Topic Match

No summary or abstract available

[55] Discrete Anisotropic Radiative Transfer (DART 5) for Modeling Airborne and Satellite Spectroradiometer and LIDAR Acquisitions of Natural and Urban Landscapes
J. Gastellu Etchegorry, ..., and T. Ristorcelli Remote. Sens., 2015. 308 citations.
0% Topic Match

Abstract: Satellite and airborne optical sensors are increasingly used by scientists, and policy makers, and managers for studying and managing forests, agriculture crops, and urban areas. Their data acquired with given instrumental specifications (spectral resolution, viewing direction, sensor field-of-view, etc.) and for a specific experimental configuration (surface and atmosphere conditions, sun direction, etc.) are commonly translated into qualitative and quantitative Earth surface parameters. However, atmosphere properties and Earth surface 3D architecture often confound their interpretation. Radiative transfer models capable of simulating the Earth and atmosphere complexity are, therefore, ideal tools for linking remotely sensed data to the surface parameters. Still, many...

[56] Machine learning-driven characterization and prescription of 1 aerosol optical properties for atmospheric models 2
N. E. Rosário, ..., and Ana Isabel Miranda. Journal Not Provided, Unknown year. 0 citations.
0% Topic Match

No summary or abstract available

[57] Exploring Pathways to More Accurate Machine Learning Emulation of Atmospheric Radiative Transfer
P. Ukkonen. Journal of Advances in Modeling Earth Systems, 2021. 40 citations.
0% Topic Match

Abstract: Machine learning (ML) parameterizations of subgrid physics is a growing research area. A key question is whether traditional ML methods such as feed forward neural networks (FNNs) are better suited for representing only specific processes. Radiation schemes are an interesting example, because they compute radiative flows through the atmosphere using well established physical equations. The sequential aspect of the problem implies that FNNs may not be well suited for it. This study explores whether emulating the entire radiation scheme is more difficult than its components without vertical dependencies. FNNs were trained to replace a shortwave radiation scheme, its gas optics component, and its...

[58] Performance of the Atmospheric Radiative Transfer Simulator (ARTS) in the 600-1650 cm-1 Region
Zichun Jin, ..., and Yunmeng Liu. Remote. Sens., 2023. 1 citations.

0% Topic Match

Abstract: The Atmospheric Radiative Transfer Simulator (ARTS) has been widely used in the radiation transfer simulation from microwave to terahertz. Due to the same physical principles, ARTS can also be used for simulations of thermal infrared (TIR). However, thorough evaluations of ARTS in the TIR region are still lacking. Here, we evaluated the performance of ARTS in 600–1650 cm 1 taking the Line-By-Line Radiative Transfer Model (LBLRTM) as a reference model. Additionally, the moderate resolution atmospheric transmission (MODTRAN) band model (BM) and correlated-k (CK) methods were also used for comparison. The comparison results on the 0.001 cm 1 spectral grid showed a high...

[59] The Education and Research 3D Radiative Transfer Toolbox (EaR 3 T) – Towards the 1 Mitigation of 3D Bias in Airborne and Spaceborne Passive Imagery Cloud Retrievals
Hong Chen, ..., and H. Iwabuchi. Journal Not Provided, 2022. 7 citations.
0% Topic Match

No summary or abstract available

[60] Representing Subgrid-Scale Cloud Effects in a Radiation Parameterization using Machine Learning: MLe-radiation v1.0
Katharina Hafner, ..., and Veronika Eyring. ArXiv, 2025. 0 citations.
0% Topic Match

Abstract: Improvements of Machine Learning (ML)-based radiation emulators remain constrained by the underlying assumptions to represent horizontal and vertical subgrid-scale cloud distributions, which continue to introduce substantial uncertainties. In this study, we introduce a method to represent the impact of subgrid-scale clouds by applying ML to learn processes from high-resolution model output with a horizontal grid spacing of 5km. In global storm resolving models, clouds begin to be explicitly resolved. Coarse-graining these high-resolution simulations to the resolution of coarser Earth System Models yields radiative heating rates that implicitly include subgrid-scale cloud effects, without assumptions about their horizontal or vertical distributions. We...

[61] Systematic comparison of vectorial spherical radiative transfer models in limb scattering geometry
D. Zawada, ..., and D. Degenstein. Atmospheric Measurement Techniques, 2021. 11 citations.
0% Topic Match

Abstract: Abstract. A comprehensive inter-comparison of seven radiative transfer models in the limb scattering geometry has been performed. Every model is capable of accounting for polarization within a spherical atmosphere. Three models (GSLS, SASKTRAN-HR, and SCIATRAN) are deterministic, and four models (MYSTIC, SASKTRAN-MC, Siro, and SMART-G) are statistical using the Monte Carlo technique. A wide variety of test cases encompassing different atmospheric conditions, solar geometries, wavelengths, tangent altitudes, and Lambertian surface reflectances have been defined and executed for every model. For the majority of conditions it was found that the models agree to better than 0.2 % in the single-scatter test...

[62] Automatic optical depth parametrization in radiative transfer model RTTOV v13 via LASSO-induced sparsity
Franklin Vargas Jiménez and Juan Carlos De los Reyes. Geoscientific Model Development, 2025. 0 citations.
0% Topic Match

Abstract: Abstract. The assimilation of satellite spectral sounder data requires fast and accurate radiative transfer models. This study proposes a novel methodology to automatically parameterize atmospheric optical depths within the Radiative Transfer for TOVS (RTTOV) version 13 scheme using statistical thresholds across pressure levels and Least Absolute Shrinkage and Selection Operator (LASSO) regression to induce sparsity. Numerical experiments with Visible Infrared Imaging Radiometer Suite (VIIRS) infrared channels demonstrate that this approach significantly reduces computational costs while maintaining accuracy. The sparsity also facilitates the automatic selection of absorbing gases and predictors by channel and pressure level, making it particularly effective for multispectral...

[63] Emulating aerosol optics with randomly generated neural networks
A. Geiss, ..., and J. Hardin. Geoscientific Model Development, 2023. 8 citations.
0% Topic Match

Abstract: Abstract. Atmospheric aerosols have a substantial impact on climate and remain one of the largest sources of uncertainty in climate prediction. Accurate representation of their direct radiative effects is a crucial component of modern climate models. However, direct computation of the radiative properties of aerosol populations is far too computationally expensive to perform in a climate model, so optical properties are typically approximated using a parameterization. This work develops artificial neural networks (ANNs) capable of replacing the current aerosol optics parameterization used in the Energy Exascale Earth System Model (E3SM). A large training dataset is generated by using Mie code...

[64] An update on the RTTOV fast radiative transfer model (currently at version 12)
R. Saunders, ..., and C. Lupu. Journal Not Provided, 2018. 304 citations.
0% Topic Match

Abstract: This paper gives an update of the RTTOV (Radiative Transfer for TOVS) fast radiative transfer model, which is widely used in the satellite retrieval and data assimilation communities. RTTOV is a fast radiative transfer model for simulating top-of-atmosphere radiances from passive visible, infrared and microwave downward-viewing satellite radiometers. In addition to the forward model, it also optionally computes the tangent linear, adjoint and Jacobian matrix providing changes in radiances for profile variable perturbations assuming a linear relationship about a given atmospheric state. This makes it a useful tool for developing physical retrievals from satellite radiances, for direct radiance assimilation in...

[65] Parameterization of 3D cloud geometry and a neural-network-based fast forward operator for polarized radiative transfer
Anna Weber, ..., and Bernhard Mayer. Atmospheric Measurement Techniques, 2025. 1 citations.
0% Topic Match

Abstract: Abstract. Clouds generally have a complex three-dimensional geometry. However, realistic three-dimensional radiative transfer simulations of clouds are computationally expensive, so most retrievals of cloud properties assume one-dimensional clouds, which introduces retrieval biases. In this work, a fast forward operator for polarized 3D radiative transfer in the visible wavelength range is presented. To this end, a new approximation for 3D radiative transfer, the InDEpendent column local halF-sphere ApproXimation (IDEFAX), is introduced. The basic idea behind this approximation is similar to the independent column approximation assuming plane-parallel clouds. However, every column is approximated by an independent field of 3D half-spherical clouds instead...

[66] Simulating the impact of midlatitude ice cloud horizontal inhomogeneity on spaceborne passive submillimeter wave simulations
Yuehao Zhuo, ..., and Yuliang Liu. Quarterly Journal of the Royal Meteorological Society, 2025. 0 citations.
0% Topic Match

Abstract: The advantage of spaceborne passive submillimeter wavelengths lies in their sensitivities to the size, ice water content, and shape of ice cloud hydrometeors, leading to improvement of the representation of ice cloud characteristics in numerical weather prediction models. However, plane parallel clouds and independent distribution assumptions are commonly adopted for simplicity in traditional forward simulations and retrieval methods, ignoring the fine scale structures within the footprint. This study aims to investigate the impacts of midlatitude ice clouds' horizontal inhomogeneity on spaceborne passive submillimeter radiometers and proposes an approximation method for three dimensional (3D) radiative transfer based on one dimensional (1D) radiative transfer simulations. Specifically,...

[67] Retrieving 3D distributions of atmospheric particles using Atmospheric Tomography with 3D Radiative Transfer – Part 1: Model description and Jacobian calculation
J. Loveridge, ..., and Y. Schechner. Atmospheric Measurement Techniques, 2023. 17 citations.
0% Topic Match

Abstract: Abstract. Our global understanding of clouds and aerosols relies on the remote sensing of their optical, microphysical, and macrophysical properties using, in part, scattered solar radiation. These retrievals assume that clouds and aerosols form plane-parallel, homogeneous layers and utilize 1D radiative transfer (RT) models, limiting the detail that can be retrieved about the 3D variability in cloud and aerosol fields and inducing biases in the retrieved properties for highly heterogeneous structures such as cumulus clouds and smoke plumes. To overcome these limitations, we introduce and validate an algorithm for retrieving the 3D optical or microphysical properties of atmospheric particles using...

[68] Streamlining hyperparameter optimization for radiation emulator training with automated Sherpa
S. Roh, ..., and Hwan Jin Song Geoscience Letters, 2024. 1 citations.
0% Topic Match

Abstract: This study aimed to identify the optimal configuration for neural network (NN) emulators in numerical weather prediction, minimizing trial and error by comparing emulator performance across multiple hidden layers (1–5 layers), as automatically defined by the Sherpa library. Our findings revealed that Sherpa-applied

emulators consistently demonstrated good results and stable performance with low errors in numerical simulations. The optimal configurations were observed with one and two hidden layers, improving results when two hidden layers were employed. The Sherpa-defined average neurons per hidden layer ranged between 153 and 440, resulting in a speedup relative to the CNT of 7–12 times. These...

[69] Evaluating and improving the treatment of gases in radiation schemes: the Correlated K-Distribution Model Intercomparison Project (CKDMIP)
R. Hogan and M. Matricardi. Geoscientific Model Development, 2020. 32 citations.
0% Topic Match

Abstract: Abstract. Most radiation schemes in weather and climate models use the “correlated k distribution” (CKD) method to treat gas absorption, which approximates a broadband spectral integration by N pseudo-monochromatic calculations. Larger N means more accuracy and a wider range of gas concentrations can be simulated but at greater computational cost. Unfortunately, the tools to perform this efficiency–accuracy trade-off (e.g. to generate separate CKD models for applications such as short-range weather forecasting to climate modelling) are unavailable to the vast majority of users of radiation schemes. This paper describes the experimental protocol for the Correlated K-Distribution Model Intercomparison Project (CKDMIP), whose...

[70] Radiative flux and forcing parameterization error in aerosol free clear skies
R. Pincus, ..., and D. Schwarzkopf. Geophysical Research Letters, 2015. 71 citations.
0% Topic Match

Abstract: This article reports on the accuracy in aerosol and cloud free conditions of the radiation parameterizations used in climate models. Accuracy is assessed relative to observationally validated reference models for fluxes under present day conditions and forcing (flux changes) from quadrupled concentrations of carbon dioxide. Agreement among reference models is typically within 1 W/m2, while parameterized calculations are roughly half as accurate in the longwave and even less accurate, and more variable, in the shortwave. Absorption of shortwave radiation is underestimated by most parameterizations in the present day and has relatively large errors in forcing. Error in present day conditions is essentially unrelated...

[71] Revisiting Machine Learning Approaches for Short-and Longwave Radiation Inference in Weather and Climate Models, Part II: Online Performance
Guillaume Bertoli, ..., and Ethz. Journal Not Provided, Unknown year. 0 citations.
0% Topic Match

No summary or abstract available

[72] Discrete Ordinate Radiative Transfer Model With the Neural Network Based Eigenvalue Solver: proof Of Concept
D. Efremenko. Light & Engineering, 2021. 4 citations.
0% Topic Match

Abstract: Artificial neural networks are attracting increasing attention in various applications. They can be used as ‘universal approximations’, which substitute computationally expensive algorithms by relatively simple sequences of functions, which simulate a reaction of a set of neurons to the incoming signal. In particular, neural networks have proved to be efficient for parameterization of the computationally expensive radiative transfer models (RTMs) in atmospheric remote sensing. Although a direct substitution of RTMs by neural networks can lead to the multiple performance enhancements, such an approach has certain drawbacks, such as loss of generality, robustness issues, etc. In this regard, the neural network...

[73] An Open-source Bayesian Atmospheric Radiative Transfer (BART) Code. II. The Transit Radiative Transfer Module and Retrieval of HAT-P-11b
P. Cubillos, ..., and S. Blumenthal. The Planetary Science Journal, 2021. 4 citations.
0% Topic Match

Abstract: This and companion papers by Harrington et al. and Blecic et al. present the Bayesian Atmospheric Radiative Transfer (bart) code, an open-source, open-development package to characterize extrasolar planet atmospheres. bart combines a thermochemical equilibrium abundance (tea), a radiative transfer (Transit), and a Bayesian statistical (mc3) module to constrain atmospheric temperatures and molecular abundances for given spectroscopic observations. Here we describe the Transit radiative transfer package, an efficient line-by-line radiative transfer C code for one-dimensional atmospheres, developed by P. Rojo and further modified by the UCF exoplanet group. This code produces transmission and hemisphere-integrated emission spectra. Transit handles line-by-line opacities from...

[74] Toward a multidimensional analysis of transmission spectroscopy
A. Falco, ..., and J. Leconte. Astronomy & Astrophysics, 2021. 10 citations.
0% Topic Match

Abstract: Considering the relatively high precision that will be reached by future observatories, it has recently become clear that one dimensional (1D) atmospheric models, in which the atmospheric temperature and composition of a planet are considered to vary only in the vertical, will be unable to represent exoplanetary transmission spectra with a sufficient accuracy. This is particularly true for warm to (ultra-) hot exoplanets because the atmosphere is unable to redistribute all the energy deposited on the dayside, creating a strong thermal and often compositional dichotomy on the planet. This situation is exacerbated by transmission spectroscopy, which probes the terminator region....

[75] Analysis of Two Dimensionality Reduction Techniques for Fast Simulation of the Spectral Radiances in the Hartley-Huggins Band
Ana del Águila, ..., and Jian Xu. Atmosphere, 2019. 15 citations.
0% Topic Match

Abstract: The new generation of atmospheric composition sensors such as TROPOMI is capable of providing spectra of high spatial and spectral resolution. To process this vast amount of spectral information, fast radiative transfer models (RTMs) are required. In this regard, we analyzed the efficiency of two acceleration techniques based on the principal component analysis (PCA) for simulating the Hartley-Huggins band spectra. In the first one, the PCA is used to map the data set of optical properties of the atmosphere to a lower-dimensional subspace, in which the correction function for an approximate but fast RTM is derived. The second technique is...

[76] Revisiting Machine Learning Approaches for Short and Longwave Radiation Inference in Weather and Climate Models
Guillaume Bertoli, ..., and S. Schemm. Journal of Advances in Modeling Earth Systems, 2025. 1 citations.
0% Topic Match

Abstract: This paper explores Machine Learning (ML) parameterizations for radiative transfer in the ICOsahedral Nonhydrostatic weather and climate model (ICON) and investigates the achieved ML model speed up with ICON running on graphics processing units (GPUs). Five ML models, with varying complexity and size, are coupled to ICON; more specifically, a multilayer perceptron (MLP), a Unet model, a bidirectional recurrent neural network with long short term memory (BiLSTM), a vision transformer (ViT), and a random forest (RF) as a baseline. The ML parameterizations are coupled to the ICON code that includes OpenACC compiler directives to enable GPU support. The coupling is done with...

[77] petitRADTRANS
P. Mollière, ..., and I. Snellen. Astronomy & Astrophysics, 2019. 36 citations.
0% Topic Match

Abstract: We present the easy-to-use, publicly available, Python package petitRADTRANS, built for the spectral characterization of exoplanet atmospheres. The code is fast, accurate, and versatile; it can calculate both transmission and emission spectra within a few seconds at low resolution (»/”» = 1000 correlated-k method) and high resolution (»/”» = 10[illegible] line-by-line method), using only a few lines of input instruction. The somewhat slower, correlated-k method is used at low resolution because it is more accurate than methods such as opacity sampling. Clouds can be included and treated using wavelength-dependent power law opacities, or by using optical constants of real condensates,...

[78] RTTOV-gb – adapting the fast radiative transfer model RTTOV for theassimilation of ground-based microwave radiometer observations
F. Angelis, ..., and S. Kneifel. Geoscientific Model Development, 2016. 33 citations.
0% Topic Match

Abstract: Abstract. Ground-based microwave radiometers (MWRs) offer a new capability to provide continuous observations of the atmospheric thermodynamic state in the planetary boundary layer. Thus, they are potential candidates to supplement radiosonde network and satellite data to improve numerical weather prediction (NWP) models through a variational assimilation of their data. However in order to assimilate MWR observations, a fast radiative transfer model is required and such a model is not currently available. This is necessary for going from the model state vector space to the observation space at every observation point. The fast radiative transfer model RTTOV is well accepted in...

[79] Radiative Transfer Model 3.0 integrated into the PALM model system 6.0

P. Kr , ..., and V. Fuka Geoscientific Model Development, 2020. 63 citations.
0% Topic Match

Abstract: Abstract. The Radiative Transfer Model (RTM) is an explicitly resolved three-dimensional multi-reflection radiation model integrated into the PALM modelling system. It is responsible for modelling complex radiative interactions within the urban canopy. It represents a key component in modelling energy transfer inside the urban layer and consequently PALM's ability to provide explicit simulations of the urban canopy at metre-scale resolution. This paper presents RTM version 3.0, which is integrated into the PALM modelling system version 6.0. This version of RTM has been substantially improved over previous versions. A more realistic representation is enabled by the newly simulated processes, e.g. the...

[80] Infrared limb emission measurements of aerosol in the troposphere and stratosphere
S. Griessbach, ..., and M. Riese. Atmospheric Measurement Techniques, 2015. 33 citations.
0% Topic Match

Abstract: Abstract. Altitude-resolved aerosol detection in the upper troposphere and lower stratosphere (UTLS) is a challenging task for remote sensing instruments. Infrared limb emission measurements provide vertically resolved global measurements at day- and nighttime in the UTLS. For high-spectral-resolution infrared limb instruments we present here a new method to detect aerosol and separate between ice and non-ice particles. The method is based on an improved aerosol–cloud index that identifies infrared limb emission spectra affected by non-ice aerosol or ice clouds. For the discrimination between non-ice aerosol and ice clouds we employed brightness temperature difference correlations. The discrimination thresholds for this method...

[81] petitRADTRANS: a Python radiative transfer package for exoplanet characterization and retrieval.
P. Mollière, ..., and I. Snellen. arXiv: Earth and Planetary Astrophysics, 2019. 240 citations.
0% Topic Match

Abstract: We present the easy-to-use, publicly available, Python package petitRADTRANS, built for the spectral characterization of exoplanet atmospheres. The code is fast, accurate, and versatile; it can calculate both transmission and emission spectra within a few seconds at low resolution ($\lambda/\Delta\lambda$ = 1000; correlated-k method) and high resolution ($\lambda/\Delta\lambda = 10^6$; line-by-line method), using only a few lines of input instruction. The somewhat slower correlated-k method is used at low resolution because it is more accurate than methods such as opacity sampling. Clouds can be included and treated using wavelength-dependent power law opacities, or by using optical constants of real condensates,...

[82] Machine-learning in radiative transfer
J. Thelen. Unknown journal, 2022. 0 citations.
0% Topic Match

Abstract: Radiative transfer (RT) codes have many applications ranging from weather/climate predictions and atmospheric sciences to remote sensing and astrophysics. However, traditional RT codes are computationally very expensive and increasingly unable to process the large amounts of data resulting from modern global circulation models (GCM) or satellite feeds. One way to alleviate this problem is to use statistical emulators, i.e., fast and accurate approximate models based on statistical inference, to replace the deterministic RT codes. In his paper, we develop a statistical surrogate model which allows us to predict the radiances or brightness temperatures, i.e., the amount of electromagnetic energy measured...

[83] Systematic Comparison of Vectorial Spherical Radiative Transfer Models in Limb Scattering Geometry
D. Zawada, ..., and D. Degenstein. Journal Not Provided, 2021. 8 citations.
0% Topic Match

Abstract: Abstract. A comprehensive inter-comparison of seven radiative transfer models in the limb scattering geometry has been performed. Every model is capable of accounting for polarisation within a fully spherical atmosphere. Three models (GSLS, SASKTRAN-HR, and SCIATRAN) are deterministic, and four models (MYSTIC, SASKTRAN-MC, Siro, and SMART-G) are statistical using the Monte Carlo technique. A wide variety of test cases encompassing different atmospheric conditions, solar geometries, wavelengths, tangent altitudes, and Lambertian surface reflectances have been defined and executed for every model. For the majority of conditions it was found that the models agree to better than 0.2 % in the single...

[84] Simple Spectral Models for Atmospheric Radiative Cooling
N. Jeevanjee and S. Fueglistaler. Journal of the Atmospheric Sciences, 2020. 48 citations.
0% Topic Match

Abstract: AbstractAtmospheric radiative cooling is a fundamental aspect of Earth’s greenhouse effect, and is intrinsically connected to atmospheric motions. At the same time, basic aspects of longwave radiat...

[85] A fast radiative transfer model for optical remote sensing image simulation with multilayer clouds
Hongzhou Wang, ..., and Peilei Luo. Unknown journal, 2025. 0 citations.
0% Topic Match

Abstract: Multi-layer cloud systems, as the dominant configuration of global cloud distributions, significantly influence cloud parameter retrieval, atmospheric radiative budgets, and climate model simulations through their radiative transfer characteristics. To overcome limitations in current radiative transfer models particularly simulation inaccuracies and computational demands arising from single-layer cloud assumptions this study introduces a novel rapid radiative transfer modeling approach for multi-layer clouds. By systematically decoupling radiative interactions between the atmosphere and heterogeneous boundary layers and integrating the successive order of radiative decomposition principle with the doubling-adding algorithm, we developed a computationally efficient radiative transfer model tailored to the infrared spectrum (2-14 μm)....

[86] Interpretable Machine Learning Based Radiation Emulation for ICON
Katharina Hafner, ..., and V. Eyring. Journal of Geophysical Research: Machine Learning and Computation, 2025. 3 citations.
0% Topic Match

Abstract: The radiation parameterization is one of the computationally most expensive components of Earth system models (ESMs). To reduce computational cost, radiation is often calculated on coarser spatial or temporal scales, or both, than other physical processes in ESMs, leading to uncertainties in cloud radiation interactions and thereby in radiative temperature tendencies. One way to address this issue is to emulate the radiation parameterization using machine learning (ML), which is typically faster and has good accuracy in high dimensional parameter spaces. This study investigates the development and interpretation of an ML based radiation emulator using the ICOsahedral Non hydrostatic model with the RTE+RRTMGP radiation code,...

[87] Updates and evaluation of NOAA's online-coupled air quality model version 7 (AQMv7) within the Unified Forecast System
Wei Li, ..., and R. Montuoro. Geoscientific Model Development, 2025. 1 citations.
0% Topic Match

Abstract: Abstract. The air quality forecasting system is an essential tool widely used by environmental managers to mitigate adverse health effects of air pollutants. This work presents the latest development of the next-generation regional air quality model (AQM) forecast system within the Unified Forecast System (UFS) framework in the National Oceanic and Atmospheric Administration (NOAA). The UFS air quality model incorporates the US Environmental Protection Agency (EPA) Community Multiscale Air Quality (CMAQ) model as its main chemistry component. In this system, CMAQ is integrated as a column model to solve gas and aerosol chemistry, while the transport of chemical species is...

[88] SCIATRAN software package (V4.6): update and further development of aerosol, clouds, surface reflectance databases and models
L. Mei, ..., and J. Burrows. Geoscientific Model Development, 2023. 27 citations.
0% Topic Match

Abstract: Abstract. Since the initiation of development at the Institute of Environmental Physics (IUP), University of Bremen, in 1994, the radiative transfer model SCIATRAN (formerly GOMETRAN) has been continuously improved and new versions have been released (Rozanov et al., 1997, 2002, 2005, 2014, 2017). In the course of development, the SCIATRAN software package became capable of simulating radiative transfer processes through the Earth’s atmosphere or coupled atmosphere–ocean system with a variety of approaches to treat the sphericity of the atmosphere (plane-parallel, pseudo-spherical, approximately spherical and full-spherical solutions) in both scalar and vector modes. Supported by a variety of built-in databases and...

[89] Three Dimensional Radiative Effects in Passive Millimeter/Sub-Millimeter All-sky Observations
Vasileios Barlakas and P. Eriksson. Remote. Sens., 2020. 16 citations.
0% Topic Match

Abstract: This study was conducted to quantify the errors prompted by neglecting three-dimensional (3D) effects, i.e., beam-filling and horizontal photon transport effects, at millimeter/sub-millimeter wavelengths. This paper gives an overview of the 3D effects that impact ice cloud retrievals of both current and proposed (Ice Cloud Imager) satellite instruments operating at frequencies of H186.3 and H668 GHz. The 3D synthetic scenes were generated from two-dimensional (2D) CloudSat (Cloud Satellite) observations over the tropics and mid-latitudes using a stochastic approach. By means of the Atmospheric Radiative Transfer Simulator (ARTS), three radiative transfer simulations were carried out: one 3D, one independent beam approximation...

[90] The Impact of Radiative Transfer at Reduced Spectral Resolution in Large Eddy Simulations of Convective Clouds
M. Veerman, ..., and C. V. van Heerwaarden. Journal of Advances in Modeling Earth Systems, 2024. 2 citations.
0% Topic Match

Abstract: Many radiative transfer schemes approximate the spectral integration over <105 to <106 wavelengths with correlated k distributions methods that typically require only 101–102 spectral integration points (g points). The exact number of g points is then chosen as an optimal balance between computational costs and accuracy, normally assessed in terms of a number of radiative quantities. How this radiative accuracy propagates to simulation accuracy, however, is not straightforward. In this study, we therefore explore the sensitivity of cloud properties in large eddy simulations (LES) to the accuracy of radiative fluxes and heating rates. We first generate smaller sets of g points from existing k distributions by...

[91] Impact of Horizontal Resolution on the Robustness of Radiation Emulators in a Numerical Weather Prediction Model
Hwan Jin Song and S. Roh Remote. Sens., 2023. 4 citations.
0% Topic Match

Abstract: Developing a machine-learning-based radiative transfer emulator in a weather forecasting model is valuable because it can significantly improve the computational speed of forecasting severe weather events. To replace the radiative transfer parameterization in the weather forecasting model, the universal applicability of the radiation emulator is essential, indicating a transition from the research to the operational level. This study investigates the degradation of the forecast accuracy of the radiation emulator for the Korea peninsula when it is tested at different horizontal resolutions (100–0.25 km) concerning the accuracy attained at the training resolution (5 km) for universal applications. In real-case simulations (100–5...

[92] RTTOV-gb v1.0 – updates on sensors, absorption models, uncertainty, and availability
D. Cimini, ..., and P. Rosenkranz. Geoscientific Model Development, 2019. 24 citations.
0% Topic Match

Abstract: Abstract. This paper describes the first official release (v1.0) of RTTOV-gb. RTTOV-gb is a FORTRAN 90 code developed by adapting the atmospheric radiative transfer code RTTOV, focused on satellite-observing geometry, to the ground-based observing geometry. RTTOV-gb is designed to simulate ground-based upward-looking microwave radiometer (MWR) observations of atmospheric downwelling natural radiation in the frequency range from 22 to 150 GHz. Given an atmospheric profile of temperature, water vapor, and, optionally, cloud liquid water content, and together with a viewing geometry, RTTOV-gb computes downwelling radiances and brightness temperatures leaving the bottom of the atmosphere in each of the channels of the...

[93] Absorption lookup tables in the radiative transfer model ARTS
S. Buehler, ..., and Oliver Lemke. Journal of Quantitative Spectroscopy & Radiative Transfer, 2011. 43 citations.
0% Topic Match

No summary or abstract available

[94] WRF–ML v1.0: a bridge between WRF v4.3 and machine learning parameterizations and its application to atmospheric radiative transfer
Xiaohui Zhong, ..., and Zhibin Wang. Geoscientific Model Development, 2023. 26 citations.
0% Topic Match

Abstract: Abstract. In numerical weather prediction (NWP) models, physical parameterization schemes are the most computationally expensive components, despite being greatly simplified. In the past few years, an increasing number of studies have demonstrated that machine learning (ML) parameterizations of subgrid physics have the potential to accelerate and even outperform conventional physics-based schemes. However, as the ML models are commonly implemented using the ML libraries written in Python, very few ML-based parameterizations have been successfully integrated with NWP models due to the difficulty of embedding Python functions into Fortran-based NWP models. To address this issue, we developed a coupler to allow the...

[95] Scattering in infrared radiative transfer: A comparison between the spectrally averaging model JURASSIC and the line-by-line model KOPRA
S. Griessbach, ..., and R. Spang. Journal of Quantitative Spectroscopy & Radiative Transfer, 2013. 27 citations.
0% Topic Match

No summary or abstract available

[96] Impact of a spectral sampling technique for radiation on ECMWF weather forecasts
A. Bozzo, ..., and J. Morcrette. Journal of Advances in Modeling Earth Systems, 2014. 8 citations.
0% Topic Match

Abstract: Radiation transfer computations are one of the most expensive components of atmospheric models integrations. Methods generally applied to reduce their computational cost, include less frequent update of the radiative fluxes or coarser spatial grids than those used for the rest of the model. In the operational configuration of the Integrated Forecast System (IFS) used at the European Centre for Medium Range Weather Forecasts (ECMWF), radiation accounts for < 10% of the total computer time, and the radiative fluxes are computed with both a reduced temporal and spatial resolution. In this study, we show that these approximations have a negligible impact...

[97] A General Approach to Enhance Short Wave Satellite Imagery by Removing Background Atmospheric Effects
R. Scheirer, ..., and Martin Raspaud. Remote. Sens., 2018. 3 citations.
0% Topic Match

Abstract: Atmospheric interaction distorts the surface signal received by a space-borne instrument. Images derived from visible channels appear often too bright and with reduced contrast. This hampers the use of RGB imagery otherwise useful in ocean color applications and in forecasting or operational disaster monitoring, for example forest fires. In order to correct for the dominant source of atmospheric noise, a simple, fast and flexible algorithm has been developed. The algorithm is implemented in Python and freely available in PySpectral which is part of the PyTroll family of open source packages, allowing easy access to powerful real-time image-processing tools. Pre-calculated look-up...

[98] Treatment of overlapping gaseous absorption with the correlated-k method in hot Jupiter and brown dwarf atmosphere models
D. S. Amundsen, ..., and N. Mayne. arXiv: Earth and Planetary Astrophysics, 2016. 83 citations.
0% Topic Match

Abstract: The correlated-k method is frequently used to speed up radiation calculations in both one-dimensional and three-dimensional atmosphere models. An inherent difficulty with this method is how to treat overlapping absorption, i.e. absorption by more than one gas in a given spectral region. We have evaluated the applicability of three different methods in hot Jupiter and brown dwarf atmosphere models, all of which have been previously applied within models in the literature: (i) Random overlap, both with and without resorting and rebinning, (ii) equivalent extinction and (iii) pre-mixing of opacities, where (i) and (ii) combine k-coefficients for different gases to obtain...

[99] Atmospheric Retrievals with petitRADTRANS
E. Nasedkin, ..., and D. Blain. J. Open Source Softw., 2023. 19 citations.
0% Topic Match

Abstract: petitRADTRANS (pRT) is a fast radiative transfer code used for computing emission and transmission spectra of exoplanet atmospheres, combining a FORTRAN back end with a Python based user interface. It is widely used in the exoplanet community with 222 references in the literature to date, and has been benchmarked against numerous similar tools. The spectra calculated with pRT can be used as a forward model for fitting spectroscopic data using Monte Carlo techniques, commonly referred to as an atmospheric retrieval. The new retrieval module combines fast forward modelling with nested sampling codes, allowing for atmospheric retrievals on a large range...

[100] Tripleclouds: An Efficient Method for Representing Horizontal Cloud Inhomogeneity in 1D Radiation Schemes by Using Three Regions at Each Height
J. Shonk and R. Hogan. Journal of Climate, 2008. 87 citations.

0% Topic Match

No summary or abstract available

[101] Terrestrial-type planetary atmospheres with HELIOS

P. Simonetti, ..., and S. Monai. Journal Not Provided, 2021. 0 citations.

0% Topic Match

Abstract: <p>The next generation of astronomical facilities will be able to retrieve exoplanetary atmospheric spectra in increasing quantity and of increasing quality. Radiative transfer (RT) models of these atmospheres is essential both for interpreting observational data and for linking these data to the planetary physical state with the aid of dedicated climate models. So far, a large effort has been placed in modelling the atmospheres of giant planets, which are the most easily accessible to observations. Now times are ripe to extend these studies to treat the relatively thin atmospheres of terrestrial-type exoplanets, which are the most likely targets for the...

[102] A Physically Based Neural Network for Fast Infrared Atmospheric Transmittance Simulation

Mingkun Liu, ..., and Lei Guan. IEEE Geoscience and Remote Sensing Letters, 2025. 0 citations.

0% Topic Match

Abstract: The atmospheric radiation transfer model (RTM) is the foundation and core of the physical retrieval of atmospheric and surface parameters in remote sensing as well as the assimilation of satellite observation data. Infrared RTM is widely used in the retrieval of Earth's surface temperature, cloud detection, and water vapor remote sensing. This letter is committed to exploring the fast and accurate simulation of atmospheric radiation transfer over the clear-sky ocean using deep learning algorithms, with the key issue being the fast calculation of atmospheric transmittance. We have constructed a neural infrared transmittance model (NITM) for atmospheric radiation transfer simulation from...

[103] Reduction of radiation biases by incorporating the missing cloud variability by means of downscaling techniques: a study using the 3-D MoCaRT model

S. G. García, ..., and V. Venema. Atmospheric Measurement Techniques, 2012. 7 citations.

0% Topic Match

Abstract: Abstract. Handling complexity to the smallest detail in atmospheric radiative transfer models is unfeasible in practice. On the one hand, the properties of the interacting medium, i.e., the atmosphere and the surface, are only available at a limited spatial resolution. On the other hand, the computational cost of accurate radiation models accounting for three-dimensional heterogeneous media are prohibitive for some applications, especially for climate modelling and operational remote-sensing algorithms. Hence, it is still common practice to use simplified models for atmospheric radiation applications. Three-dimensional radiation models can deal with complex scenarios providing an accurate solution to the radiative transfer. In...

[104] SpectralModel: a high-resolution framework for petitRADTRANS 3

D. Blain, ..., and E. Nasedkin. J. Open Source Softw., 2024. 2 citations.

0% Topic Match

Abstract: Atmospheric characterisation from spectroscopic data is a key to understand planetary formation. Two types of observations can be performed for this kind of analysis. Space-based observations (e.g., using the James Webb Space Telescope, JWST), are not impeded by the Earth's atmosphere, but are currently limited to low resolving powers ( < 3000 ), which can lead to ambiguities in some species detections. Ground-based observations (e.g., using the Very Large Telescope, VLT), on the other hand, can benefit from large resolving powers ( H 10 5 ), allowing for unambiguous species detection, but are impacted by telluric spectral lines. petitRADTRANS (pRT)...

[105] Atmospheric Chemistry and Physics Technical Note: the Libradtran Software Package for Radiative Transfer Calculations – Description and Examples of Use

B. Mayer and A. Kylling. Journal Not Provided, Unknown year. 1560 citations.

0% Topic Match

No summary or abstract available

[106] Sensitivity Analyses for the Retrievals of Ice Cloud Properties From Radiometric and Polarimetric Measurements in Sub mm/mm and Infrared Bands

J. Coy, ..., and Dong L. Wu. Journal of Geophysical Research: Atmospheres, 2020. 12 citations.

0% Topic Match

Abstract: Simulations of the radiometric and polarimetric properties of ice clouds based on the Moderate Resolution Imaging Spectroradiometer (MODIS) Collection 6 ice cloud model (aggregates in conjunction with the gamma distribution) are performed at wavelengths in the Infrared (IR) and Submillimeter/Millimeter (sub mm/mm) regimes. The scattering/absorption/polarization properties from the precalculated database are incorporated into a radiative transfer model, the Atmospheric Radiative Transfer Model (ARTS). A number of sub mm/mm bands have been considered from radiometric and polarimetric studies for potential applications to retrieving ice cloud properties at shorter sub mm/mm wavelengths (higher frequencies). The IR atmospheric window has also been thoroughly investigated for its...

[107] The Sensitivity of the Jet Stream Response to Climate Change to Radiative Assumptions

Zhihong Tan, ..., and T. Shaw. Journal of Advances in Modeling Earth Systems, 2019. 29 citations.

0% Topic Match

Abstract: Comprehensive climate models exhibit a large spread in the magnitude of projected poleward eddy driven jet shift in response to warming. The spread has been connected to the radiative response to warming. To understand how different radiative assumptions alone affect the jet shift in response to warming, we introduce a new clear sky longwave radiation hierarchy that spans idealized (gray versus four bands; without or with interactive water vapor) through comprehensive (correlated k) radiation in the same general circulation model. The new hierarchy is used in an aquaplanet configuration to explore the impact of radiation on the jet stream response to warming, independent...

[108] The pyrat bay framework for exoplanet atmospheric modelling: a population study of Hubble/WFC3 transmission spectra

P. Cubillos and J. Blecic. ArXiv, 2021. 35 citations.

0% Topic Match

Abstract: We present the open-source Pyrat Bay framework for exoplanet atmospheric modeling, spectral synthesis, and Bayesian retrieval. The modular design of the code allows the users to generate atmospheric 1D parametric models of the temperature, abundances (in thermochemical equilibrium or constant-with-altitude), and altitude profiles (in hydrostatic equilibrium); sample ExoMol and HITRAN line-by-line cross sections with custom resolving power and line-wing cutoff values; compute emission or transmission spectra considering cross sections frommolecular line transitions, collision-induced absorption, Rayleigh scattering, gray clouds, and alkali resonance lines; and perform Markov chain Monte Carlo atmospheric retrievals for a given transit or eclipse dataset. We benchmarked the...

[109] Neural network radiative transfer for imaging spectroscopy

B. Bue, ..., and M. Parente. Atmospheric Measurement Techniques, 2018. 26 citations.

0% Topic Match

Abstract: Abstract. Visible–shortwave infrared imaging spectroscopy provides valuable remote measurements of Earth's surface and atmospheric properties. These measurements generally rely on inversions of computationally intensive radiative transfer models (RTMs). RTMs' computational expense makes them difficult to use with high-volume imaging spectrometers, and forces approximations such as lookup table interpolation and surface–atmosphere decoupling. These compromises limit the accuracy and flexibility of the remote retrieval; dramatic speed improvements in radiative transfer models could significantly improve the utility and interpretability of remote spectroscopy for Earth science. This study demonstrates that nonparametric function approximation with neural networks can replicate radiative transfer calculations and generate accurate...

[110] All Sky Microwave Radiance Observation Operator Based on Deep Learning With Physical Constraints

Zeting Li, ..., and Hao Li. Journal of Geophysical Research: Atmospheres, 2024. 2 citations.

0% Topic Match

Abstract: Satellite data assimilation relies on the radiative transfer models (RTMs) to establish the relationships between model state variables and satellite radiances. However, atmospheric radiative transfer calculations are computationally expensive, especially when involving multiple scattering calculations in cloudy areas. In recent years, deep learning (DL) models have been increasingly applied to emulate and accelerate physical models. This study, for the first time, explores DL

techniques to emulate all sky radiative transfer in microwave bands. The FengYun 3E (FY 3E) Microwave Humidity Sounder 2 (MWHS 2) was selected as the target instrument due to its comprehensive spectral coverage, with the radiative transfer for TOVS scattering module (RTTOV SCATT) serving...

[111] An evaluation of atmospheric absorption models at millimetre and sub-millimetre wavelengths using airborne observations
Stuart Fox, ..., and D. Gallucci. Atmospheric Measurement Techniques, 2024. 6 citations.
0% Topic Match

Abstract: Abstract. Accurate gas absorption models at millimetre and sub-millimetre wavelengths are required to make best use of observations from instruments on board the next generation of EUMETSAT polar-orbiting weather satellites, including the Ice Cloud Imager (ICI), which measures at frequencies up to 664 GHz. In this study, airborne observations of clear-sky scenes between 89 and 664 GHz are used to perform radiative closure calculations for both upward- and downward-looking viewing directions in order to evaluate two state-of-the-art absorption models, both of which are integrated into the Atmospheric Radiative Transfer Simulator (ARTS). Differences of 20 K are seen in some individual...

[112] Simulation of SEVIRI infrared channels: a case study from the Eyjafjallajökull April/May 2010 eruption
A. Kylling, ..., and A. Stohl. Atmospheric Measurement Techniques, 2012. 12 citations.
0% Topic Match

Abstract: Abstract. Infrared satellite images are widely and successfully used to detect and follow atmospheric ash from erupting volcanoes. We describe a new radiative transfer model framework for the simulation of infrared radiances, which can be compared directly with satellite images. This can be helpful to get insight into the processes that affect the satellite retrievals. As input to the radiative transfer model, the distribution of ash is provided by simulations with the FLEXPART Lagrangian particle dispersion model, meteorological cloud information is adopted from the ECMWF analysis and the radiative transfer modelling is performed with the MYSTIC 3-D radiative transfer model....

[113] SVEEEETIES: singular vector expansion to estimate Earth-like exoplanet temperatures from infrared emission spectra
Franz Schreier, ..., and J. Grenfell. Astronomy & Astrophysics, 2019. 2 citations.
0% Topic Match

Abstract: Context.Detailed characterizations of exoplanets are clearly moving to the forefront of planetary science. Temperature is a key marker for understanding atmospheric physics and chemistry.Aims.We aim to retrieve temperatures of N2-O2dominated atmospheres from secondary eclipse spectroscopic observations of the thermal emission of Earth-like exoplanets orbiting G-, K-, and M-stars, using large-aperture future space telescopes.Methods.A line-by-line radiative transfer code was used to generate synthetic thermal infrared (TIR) observations. The atmospheric temperature is approximated by an expansion with the base vectors defined by a singular value decomposition of a matrix comprising representative profiles. A nonlinear least squares fitting was used to estimate the...

[114] The full-spectrum correlated k method for longwave atmospheric radiative transfer: treatment of gaseous overlap
Robin J. Hogan. Unknown journal, 2010. 1 citations.
0% Topic Match

No summary or abstract available

[115] Development of a correlated-k distribution band model scheme for the radiative transfer program GOMETRAN/SCIATRAN for retrieval of atmospheric constituents from SCIMACHY/ENVISAT-1 data
M. Buchwitz, ..., and J. Burrows. Unknown journal, 1998. 13 citations.
0% Topic Match

No summary or abstract available

[116] Surrogate models of radiative transfer codes for atmospheric trace gas retrievals from satellite observations
Jure Brence, ..., and S. Džeroski. Machine Learning, 2022. 4 citations.
0% Topic Match

Abstract: Inversion of radiative transfer models (RTMs) is key to interpreting satellite observations of air quality and greenhouse gases, but is computationally expensive. Surrogate models that emulate the full forward physical RTM can speed up the simulation, reducing computational and timing costs and allowing the use of more advanced physics for trace gas retrievals. In this study, we present the development of surrogate models for two RTMs: the RemoTeC algorithm using the LINTRAN RTM and the SCIATRAN RTM. We estimate the intrinsic dimensionality of the input and output spaces and embed them in lower dimensional subspaces to facilitate the learning task....

[117] ALIS: An efficient method to compute high spectral resolution polarized solar radiances using the Monte Carlo approach
C. Emde, ..., and Bernhard Mayer. Journal of Quantitative Spectroscopy & Radiative Transfer, 2011. 54 citations.
0% Topic Match

No summary or abstract available

[118] 3D Radiative Transfer for Exoplanet Atmospheres. gCMCRT: A GPU-accelerated MCRT Code
Elspeth K. H. Lee, ..., and B. Thorsbro. The Astrophysical Journal, 2021. 30 citations.
0% Topic Match

Abstract: Radiative transfer (RT) is a key component for investigating atmospheres of planetary bodies. With the 3D nature of exoplanet atmospheres being important in giving rise to their observable properties, accurate and fast 3D methods are required to be developed to meet future multidimensional and temporal data sets. We develop an open-source GPU RT code, gCMCRT, a Monte Carlo RT forward model for general use in planetary atmosphere RT problems. We aim to automate the post-processing pipeline, starting from direct global circulation model (GCM) output to synthetic spectra. We develop albedo, emission, and transmission spectra modes for 3D and 1D input...

[119] Radiative transfer theory and modelling with libRadtran
Craig C. Brelsford. Unknown journal, 2017. 5 citations.
0% Topic Match

No summary or abstract available

[120] Variation in shortwave water vapour continuum and impact on clear-sky shortwave radiative feedback
Kaah P. Menang, ..., and Florian E. Roemer. Atmospheric Chemistry and Physics, 2025. 1 citations.
0% Topic Match

Abstract: Abstract. This work assesses the impact of the current differences in the strength of the shortwave water vapour continuum on clear-sky calculations of shortwave radiative feedback. Three continuum models were used: the MT_CKD (Mlawer–Tobin–Clough–Kneizys–Davies; versions 2.5 and 4.1.1) and CAVIAR_updated (Continuum Absorption at Visible and Infrared Wavelengths and its Atmospheric Relevance) models. Radiative transfer calculations were performed with the ECMWF radiation scheme (“ecRad”). The correlated k-distribution gas-optics tables required for ecRad computations were trained with each of these continuum models using the ECMWF correlated k-distribution software tool. The gas-optics tables trained with the different continuum models were tested individually in...

[121] How to think about the clear-sky shortwave water vapor feedback
Florian E. Roemer, ..., and Kaah P. Menang. npj Climate and Atmospheric Science, 2025. 2 citations.
0% Topic Match

No summary or abstract available

[122] Computation of longwave radiative flux and vertical heating rate with 4A-Flux v1.0 as integral part of the radiative transfer code 4A/OP v1.5
Yoann Tellier, ..., and N. Meilhac. Geoscientific Model Development, 2021. 5 citations.
0% Topic Match

Abstract: Abstract. Based on advanced spectroscopic databases, line-by-line and layer-by-layer radiative transfer codes numerically solve the radiative transfer equation with a very high accuracy. Taking advantage of its pre-calculated optical depth look-up table, the fast and accurate radiative transfer model Automatized Atmospheric Absorption Atlas OPerational (4A/OP) calculates the transmission and radiance spectra for a user defined layered atmospheric model. Here we present a module, called 4A-Flux, developed and implemented into 4A/OP in order to include the calculation of the clear-sky longwave radiative flux profiles and heating rate profiles at a very high spectral resolution. Calculations are performed under the assumption of...

[123] The Reference Forward Model (RFM)
A. Dudhia. Journal of Quantitative Spectroscopy & Radiative Transfer, 2017. 108 citations.
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No summary or abstract available

[124] Replacing radiative transfer models by surrogate approximations through machine learning
J. Verrelst, ..., and J. Moreno. 2015 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), 2015. 3 citations.
0% Topic Match

No summary or abstract available

[125] Using passive and active observations at microwave and sub-millimetre wavelengths to constrain ice particle models
Robin Ekelund, ..., and S. Pfreundschuh. Atmospheric Measurement Techniques, 2020. 37 citations.
0% Topic Match

Abstract: Abstract. Satellite microwave remote sensing is an important tool for determining the distribution of atmospheric ice globally. The upcoming Ice Cloud Imager (ICI) will provide unprecedented measurements at sub-millimetre frequencies, employing channels up to 664 GHz . However, the utilization of such measurements requires detailed data on how individual ice particles scatter and absorb radiation, i.e. single scattering data. Several single scattering databases are currently available, with the one by Eriksson et al. ( 2018 ) specifically tailored to ICI. This study attempts to validate and constrain the large set of particle models available in this database to a smaller...

[126] Synergistic radar and radiometer retrievals of ice hydrometeors
S. Pfreundschuh, ..., and Robin Ekelund. Atmospheric Measurement Techniques, 2019. 25 citations.
0% Topic Match

Abstract: Abstract. Remote sensing observations at sub-millimeter wavelengths provide higher sensitivity to small hydrometeors and low water content than observations at millimeter wavelengths, which are traditionally used to observe clouds and precipitation. They are employed increasingly in field campaigns to study cloud microphysics and will be integrated into the global meteorological observing system to measure the global distribution of ice in the atmosphere with the launch of the Ice Cloud Imager (ICI) radiometer on board the second generation of European operational meteorological satellites (Metop-SG). Observations at these novel wavelengths provide valuable information not only on their own but also in combination...

[127] High efficiency calculation of non-LTE atmospheric infrared radiative transfer for multi-molecular populations in upper atmosphere
Shijie Chai, ..., and Shuaihui Li. Unknown journal, 2025. 0 citations.
0% Topic Match

Abstract: Atmospheric radiative transfer is essential for obtaining information from the spectra of earth's remote sensing and astrophysical objects. The non-local thermodynamic equilibrium (non-LTE) population of molecular energy level is the normal and complex condition in the upper atmosphere. The radiative transfer and source function must be taken into account based on the specific non-LTE population. Nevertheless, predicting non-LTE population presents significant complexity due to their dependence on the molecular spectroscopy, radiative transfer and collision statistical equilibrium theories. In this work, we developed the non-LTE Atmospheric Infrared Radiative TRANsfer (AIRTRAN) algorithm, which can calculate the vibrational temperatures that involve the vibration-vibration...

[128] A New Halocarbon Absorption Model Based on HITRAN Cross Section Data and New Estimates of Halocarbon Instantaneous Clear Sky Radiative Forcing
S. Buehler, ..., and R. Larsson. Journal of Advances in Modeling Earth Systems, 2022. 5 citations.
0% Topic Match

Abstract: The article describes a new practical model for the infrared absorption of chlorofluorocarbons and other gases with dense spectra, based on high resolution transmission molecular absorption database (HITRAN) absorption cross sections. The model is very simple, consisting of frequency dependent polynomial coefficients describing the pressure and temperature dependence of absorption. Currently it is implemented for the halocarbon species required by the Radiative Forcing Model Intercomparison Project. In cases where cross section data is available at a range of different temperatures and pressures, this approach offers practical advantages compared to previously available options, and is traceable, since the polynomial coefficients follow directly from the laboratory...

[129] magritte, a modern software library for 3D radiative transfer: I. Non-LTE atomic and molecular line modelling
F. De Ceuster, ..., and J. Hetherington. Monthly Notices of the Royal Astronomical Society, 2019. 11 citations.
0% Topic Match

Abstract: Radiative transfer is a key component in almost all astrophysical and cosmological simulations. We present Magritte: a modern open-source software library for 3D radiative transfer. It uses a deterministic ray-tracer and formal solver, i.e. it computes the radiation field by tracing rays through the model and solving the radiative transfer equation in its second-order form along a fixed set of rays originating from each point. Magritte can handle structured and unstructured input meshes, as well as smoothed-particle hydrodynamics (SPH) particle data. In this first paper, we describe the numerical implementation, semi-analytic tests and cross-code benchmarks for the non-LTE line radiative...

[130] A description of the correlated k distribution method for modeling nongray gaseous absorption, thermal emission, and multiple scattering in vertically inhomogeneous atmospheres
A. Lacis and V. Oinas. Journal of Geophysical Research, 1991. 1021 citations.
0% Topic Match

No summary or abstract available

[131] Alg: a Toolbox for the Generation of Look-Up tables Based on Atmospheric Radiative Transfer Models
J. Vicent, ..., and J. Moreno. 2018 9th Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing (WHISPERS), 2018. 1 citations.
0% Topic Match

Abstract: Atmospheric radiative transfer models (RTMs) are software tools describing the radiation processes occurring on the Earth's atmosphere. While the evolution of these tools have achieved better representations of the light-atmosphere interactions, the increase of complexity, interpretability and computation time bears implications towards practical applications in Earth observation. Despite of existing RTM-specific graphical user interfaces, none of these tools allow common streamlining model setup for a wide variety of atmospheric RTMs. In addition, the automatic generation of atmospheric look-up tables (LUTs) can hardly be done with the use of these graphical tools. This paper presents the Atmospheric Look-up table Generator (ALG,...

[132] A Fast Atmospheric Trace Gas Retrieval for Hyperspectral Instruments Approximating Multiple Scattering - Part 1: Radiative Transfer and a Potential OCO-2 XCO2 Retrieval Setup
M. Reuter, ..., and J. Burrows. Remote. Sens., 2017. 37 citations.
0% Topic Match

Abstract: Satellite retrievals of the atmospheric dry-air column-average mole fraction of CO 2 (XCO 2 ) based on hyperspectral measurements in appropriate near (NIR) and short wave infrared (SWIR) O 2 and CO 2 absorption bands can help to answer important questions about the carbon cycle but the precision and accuracy requirements for XCO 2 data products are demanding. Multiple scattering of light at aerosols and clouds can be a significant error source for XCO 2 retrievals. Therefore, so called full physics retrieval algorithms were developed aiming to minimize scattering related errors by explicitly fitting scattering related properties such as cloud...

[133] Validating the MYSTIC three-dimensional radiative transfer model with observations from the complex topography of Arizona's Meteor Crater
B. Mayer, ..., and C. Whiteman. Atmospheric Chemistry and Physics, 2010. 64 citations.
0% Topic Match

Abstract: Abstract. The MYSTIC three-dimensional Monte-Carlo radiative transfer model has been extended to simulate solar and thermal irradiances with a rigorous consideration of topography. Forward as well as backward Monte Carlo simulations are possible for arbitrarily oriented surfaces and we demonstrate that the backward Monte Carlo technique is superior to the forward method for applications involving topography, by greatly reducing the computational demands. MYSTIC is used to simulate the short- and longwave radiation fields during a clear day and night in and around Arizona's Meteor Crater, a bowl-shaped, 165-m-deep basin with a diameter of 1200 m. The simulations are made over...

[134] Py4CAtS - Python Tools for Line-by-Line Modelling of Infrared Atmospheric Radiative Transfer
F. Schreier and S. G. García. Unknown journal, 2013. 3 citations.
0% Topic Match

No summary or abstract available

[135] Impact of atmospheric vertical profile on hyperspectral simulations over bright desert pseudo-invariant calibration site
V. Leroy, ..., and Y. Govaerts. European Journal of Remote Sensing, 2024. 2 citations.
0% Topic Match

Abstract: ABSTRACT This paper investigates how atmospheric vertical profiles of pressure, temperature, and concentration affect molecular absorption calculation. This sensitivity analysis is performed in preparation to the upcoming TRUTHS mission, anticipated to provide hyperspectral TOA BRF records with a radiometric accuracy better than 1%. Two methods for characterizing the atmospheric vertical profile are compared: rescaling the H2O and O3 concentrations of an AFGL U.S. Standard vertical profile, and using customized profiles based on CAMS data. The study investigates the effects of those methods on multi-spectral observations in key spectral regions affected, respectively, by water vapour, ozone and methane, as well as...

[136] Algorithmic vs. finite difference Jacobians for infrared atmospheric radiative transfer
F. Schreier, ..., and Jian Xu. Journal of Quantitative Spectroscopy & Radiative Transfer, 2015. 13 citations.
0% Topic Match

No summary or abstract available

[137] A k distribution technique for radiative transfer simulation in inhomogeneous atmosphere: 2. FKDM, fast k distribution model for the shortwave
B. Fomin. Journal of Geophysical Research, 2004. 48 citations.
0% Topic Match

No summary or abstract available

[138] MODTRAN7: a polarimetric extension of the MODTRAN6 radiometric atmospheric radiative transfer model
Fred Hawes, ..., and G. Fortin. Unknown journal, 2022. 1 citations.
0% Topic Match

Abstract: MODTRAN7, a polarimetric extension of the MODTRAN6 atmospheric radiative transfer model, is being developed. The vectorized MODTRAN7 will provide band model (BM), correlated-k (Ck), and line-by-line options for computing Stokes vectors. The radiative transfer problem is being solved for Isotropic and Symmetric Media (ISM) using the basic phenomenology described in the classic text by Mishchenko, Travis and Lacis, “Multiple Scattering of Light by Particles”1. VDISORT, a vectorized version of the DISORT scalar model currently in MODTRAN6, will compute the Stokes vectors for 1-D atmospheres. The MODTRAN method for extracting spherical refractive path contributions from the plane parallel scattering models will...

[139] Open-source 2D multispectral forward and inverse solver of the radiative transfer equation
Alejandro Martinez de Ternero, ..., and C. Sanz. Unknown journal, 2025. 0 citations.
0% Topic Match

Abstract: This work introduces SPECTRE (Spectral Python Engine for Computational Transfer and Radiative Exchange), an open-source, two-dimensional, multispectral solver for the radiative transfer equation (RTE) designed to model light-tissue interactions in medical applications. The solver addresses both forward and inverse problems of the RTE in heterogeneous domains, focusing on solving both the distribution of light inside the tissue as well as the recovery of the optical properties from the captured multiespectral information in clinical and research applications. Furthermore, the solver is validated against state-of-the-art Monte Carlo simulations, achieving a seven-fold speedup in multiespectral scenarios within the experiments presented in this work....

[140] Accelerating Radiative Transfer for Planetary Atmospheres by Orders of Magnitude with a Transformer-Based Machine Learning Model
Isaac Malsky, ..., and M. Graham. ArXiv, 2025. 0 citations.
0% Topic Match

Abstract: Radiative transfer calculations are essential for modeling planetary atmospheres. However, standard methods are computationally demanding and impose accuracy-speed trade-offs. High computational costs force numerical simplifications in large models (e.g., General Circulation Models) that degrade the accuracy of the simulation. Radiative transfer calculations are an ideal candidate for machine learning emulation: fundamentally, it is a well-defined physical mapping from a static atmospheric profile to the resulting fluxes, and high-fidelity training data can be created from first principles calculations. We developed a radiative transfer emulator using an encoder-only transformer neural network architecture, trained on 1D profiles representative of solar-composition hot Jupiter atmospheres....

[141] Construction of the Global Reference Atmospheric Profile Database
Yuhang Guo, ..., and Weifang Fang. Remote. Sens., 2023. 4 citations.
0% Topic Match

Abstract: : Atmospheric pro les are important input parameters for atmospheric radiative transfer models and atmospheric parameter inversions. The construction of regionally representative reference atmospheric pro les can provide basic data for global atmospheric and environmental research. Most reference atmospheric pro le databases commonly used lag behind in updating frequency. These databases usually have limited spatial and temporal resolution and differ greatly from the real atmospheric state. To present the real atmospheric state, this article constructs the Global Reference Atmospheric Pro le Database (GRAP) based on ACE-FTS satellite products of 2021 and 2022, AIRS satellite products and ERA5 reanalysis data of 2022 u6sing a random...

[142] Atmospheric radiative profiles during EUREC4A
Anna Lea Albright, ..., and C. Muller. Earth System Science Data, 2020. 14 citations.
0% Topic Match

Abstract: Abstract. The couplings among clouds, convection, and circulation in trade-wind regimes remain a fundamental puzzle that limits our ability to constrain future climate change. Radiative heating plays an important role in these couplings. Here we calculate clear-sky radiative profiles from 2580 in situ soundings (1068 dropsondes and 1512 radiosondes) collected during the field campaign EUREC4A (Elucidating the role of clouds–circulation coupling in climate). EUREC4A took place in the downstream trades of the western tropical Atlantic in January–February 2020. We describe the method used to calculate these cloud-free, aerosol-free radiative profiles. We then present preliminary results sampling variability at multiple scales,...

[143] Paths to accuracy for radiation parameterizations in atmospheric models
R. Pincus and B. Stevens. Journal of Advances in Modeling Earth Systems, 2013. 96 citations.
0% Topic Match

Abstract: Radiative transfer is sufficiently well understood that its parameterization in atmospheric models is primarily an effort to balance computational cost and accuracy. The most common approach is to compute radiative transfer with the highest practical spectral accuracy but infrequently in time and/or space, though errors introduced by this approximation are difficult to quantify. An alternative is to perform spectrally sparse calculations frequently in time using randomly chosen spectral quadrature points. Here we show that purely random quadrature points, though effective in some large eddy simulations, are not a good choice for models in which the land surface responds to radiative fluxes...

[144] The full-spectrum correlated-k method for longwave atmospheric radiative transfer using an effective Planck function
R. Hogan. Journal of the Atmospheric Sciences, 2010. 31 citations.
0% Topic Match

No summary or abstract available

[145] Comparative analysis of atmospheric radiative transfer models using the Atmospheric Look-up table Generator (ALG) toolbox (version 2.0)
J. Vicent, ..., and J. Moreno. Geoscientific model development, 2019. 34 citations.
0% Topic Match

Abstract: Atmospheric radiative transfer models (RTMs) are software tools that help researchers in understanding the radiative processes occurring in the Earth's atmosphere. Given their importance in remote sensing applications, the intercomparison of atmospheric RTMs is therefore one of the main tasks used to evaluate model performance and identify the characteristics that differ between models. This can be a tedious tasks that requires good knowledge of the model inputs/outputs and the generation of large databases of consistent simulations. With the evolution of these software tools, their increase in complexity bears implications for their use in practical applications and model intercomparison. Existing RTM-specific...

[146] Machine Learning Emulation of 3D Cloud Radiative Effects
David Meyer, ..., and Shannon L. Mason. Journal of Advances in Modeling Earth Systems, 2021. 32 citations.
0% Topic Match

Abstract: The treatment of cloud structure in numerical weather and climate models is often greatly simplified to make them computationally affordable. Here we propose to correct the European Centre for Medium Range Weather Forecasts 1D radiation scheme ecRad for 3D cloud effects using computationally cheap neural networks. 3D cloud effects are learned as the difference between ecRad's fast 1D Tripleclouds solver that neglects them and its 3D SPARTACUS (SPeedy Algorithm for Radiative TrAnsfer through CloUd Sides) solver that includes them but is about five times more computationally expensive. With typical errors between 20% and 30% of the 3D signal, neural networks improve...

[147] Propagation Modeling of Moist Air and Suspended Water/Ice Particles at Frequencies Below 1000 GHz
H. Liebe. Unknown journal, 1993. 575 citations.
0% Topic Match

No summary or abstract available

[148] Accelerating the RTTOV-7 IASI and AMSU-A radiative transfer models on graphics processing units: evaluating central processing unit/graphics processing unit-hybrid and pure-graphics processing unit approaches
J. Mielikainen, ..., and R. Saunders. Journal of Applied Remote Sensing, 2011. 7 citations.
0% Topic Match

No summary or abstract available

[149] GARLIC — A general purpose atmospheric radiative transfer line-by-line infrared-microwave code: Implementation and evaluation $
F. Schreier, ..., and Jian Xu. Journal of Quantitative Spectroscopy & Radiative Transfer, 2014. 71 citations.
0% Topic Match

No summary or abstract available

[150] The ExoMol database: Molecular line lists for exoplanet and other hot atmospheres
J. Tennyson, ..., and O. Yurchenko. Journal of Molecular Spectroscopy, 2016. 373 citations.
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No summary or abstract available

[151] Are elevated moist layers a blind spot for hyperspectral infrared sounders? – A model study
M. Prange, ..., and S. Buehler. Atmospheric Measurement Techniques Discussions, 2021. 7 citations.
0% Topic Match

Abstract: Abstract. The ability of the hyperspectral satellite based passive infrared instrument IASI to resolve Elevated Moist Layers (EMLs) within the free troposphere is investigated. EMLs are strong moisture anomalies with significant impact on the radiative heating rate profile and are thought to be coupled to freezing level detrainment of convective cells in the tropics. Based on an exemplary EML testcase and forward modelled IASI observations, it is shown that if sufficient independent humidity and temperature information is available, EMLs do not pose a blind spot for passive satellite observations, contrary to what results of Stevens et al. (2017) have indicated....

[152] High-resolution spatiotemporal solar irradiance mapping on Mars through coupled terrain-atmosphere modeling
Fan He, ..., and Xiaohua Tong. Measurement Science and Technology, 2025. 0 citations.
0% Topic Match

Abstract: Accurate modeling of solar irradiance on Mars is essential for future exploration missions, including landing site selection, rover energy optimization, and habitat planning. Existing models, however, often rely on broad meteorological approximations and neglect the complex interplay between atmospheric scattering, terrain occlusion, and solar geometry, particularly in areas with complex topography. This paper introduces a novel, high-resolution solar irradiance modeling method that integrates detailed terrain and atmospheric data, constructing high-fidelity horizon profiles and calculate full radiative transfer to accurately model both direct and diffuse solar radiation components. This approach not only enhances the accuracy of solar irradiance simulations on the...

[153] Simulation of snow albedo and solar irradiance profile with the Two-streAm Radiative TransfEr in Snow (TARTES) v2.0 model
G. Picard and Q. Libois. Geoscientific Model Development, 2024. 7 citations.
0% Topic Match

Abstract: Abstract. The Two-streAm Radiative TransfEr in Snow (TARTES) model computes the spectral albedo and the profiles of spectral absorption, irradiance, and actinic fluxes for a multi-layer plane-parallel snowpack. Each snow layer is characterized by its specific surface area, density, and impurity content, in addition to shape parameters. In the landscape of snow optical numerical models, TARTES distinguishes itself by taking into account different shapes of the particles through two shape parameters, namely the absorption enhancement parameter B and the asymmetry factor g. This is of primary importance as recent studies working at the microstructure level have demonstrated that snow does...

[154] Emulation of Cloud Microphysics in a Climate Model
W. Perkins, ..., and Jacqueline M. Nugent. Journal of Advances in Modeling Earth Systems, 2024. 8 citations.
0% Topic Match

Abstract: We present a machine learning based emulator of a microphysics scheme for condensation and precipitation processes (Zhao Carr) used operationally in a global atmospheric forecast model (FV3GFS). Our tailored emulator architecture achieves high skill (e94%) in predicting condensate and precipitation amounts and maintains low global average bias (d4%) for 1 year of continuous simulation when replacing the Fortran scheme. The stability and success of this emulator stems from key design decisions. By separating the emulation of condensation and precipitation processes, we can better enforce physical priors such as mass conservation and locality of condensation, and the vertical dependence of precipitation falling downward,...

[155] Full Spectrum Correlated-k for Shortwave Atmospheric Radiative Transfer
D. Pawlak, ..., and J. Cole. Unknown journal, 2004. 1 citations.
0% Topic Match

No summary or abstract available

[156] Evaluation of Spaceborne Microwave Hyperspectral Technology for Atmospheric Boundary Layer Temperature and Humidity Profiling
Chao Zhang, ..., and Shengwei Zhang. IGARSS 2024 - 2024 IEEE International Geoscience and Remote Sensing Symposium, 2024. 1 citations.
0% Topic Match

Abstract: This paper conducts an in-depth analysis of spaceborne hyperspectral microwave radiometers for remotely sensing atmospheric boundary layers' temperature and humidity profiles. Utilizing 137 vertical-level atmospheric profile data from the European Centre for Medium-Range Weather Forecasts (ECMWF), the study employs the Atmospheric Radiative Transfer Simulator (ARTS) to construct a forward model of an Earth-based spaceborne microwave radiometer, enabling the computation of the Jacobian matrix. This research thoroughly evaluates the posterior probability of retrieval errors and vertical resolution by analyzing both the background error covariance matrix and the measurement error covariance matrix alongside the Jacobian matrix. Findings reveal that a spectral resolution...

[157] A fast, flexible, approximate technique for computing radiative transfer in inhomogeneous cloud fields
R. Pincus, ..., and J. Morcrette. Journal of Geophysical Research, 2003. 407 citations.
0% Topic Match
No summary or abstract available

[158] PyRTlib: an educational Python-based library for non-scattering atmospheric microwave radiative transfer computations
S. Larosa, ..., and F. Romano. Geoscientific Model Development, 2024. 15 citations.
0% Topic Match
Abstract: Abstract. This article introduces PyRTlib, a new standalone Python package for non-scattering line-by-line microwave radiative transfer simulations. PyRTlib is a flexible and user-friendly tool for computing down- and upwelling brightness temperatures and related quantities (e.g., atmospheric absorption, optical depth, opacity, mean radiating temperature) written in Python, a language commonly used nowadays for scientific software development, especially by students and early-career scientists. PyRTlib allows for simulating observations from ground-based, airborne, and satellite microwave sensors in clear-sky and in cloudy conditions (under non-scattering Rayleigh approximation). The intention for PyRTlib is not to be a competitor to state-of-the-art atmospheric radiative transfer codes that...

[159] On the correlated k-distribution method for radiative transfer in nonhomogeneous atmospheres
Q. Fu and K. Liou. Journal of the Atmospheric Sciences, 1992. 947 citations.
0% Topic Match
No summary or abstract available

[160] Radiative transfer for inhomogeneous atmospheres: RRTM, a validated correlated-k model for the longwave
E. Mlawer, ..., and S. Clough. Journal of Geophysical Research, 1997. 7901 citations.
0% Topic Match
No summary or abstract available

[161] Spherical Radiative Transfer Model with Computation of Layer Air Mass Factors and Some of Its Applications
O. Postylyakov. Unknown journal, 2004. 24 citations.
0% Topic Match
No summary or abstract available

[162] MODTRAN® 6: A major upgrade of the MODTRAN® radiative transfer code
A. Berk, ..., and J. V. D. Bosch. 2014 6th Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing (WHISPERS), 2014. 249 citations.
0% Topic Match
No summary or abstract available

[163] Advances in Atmospheric Radiation: Theories, Models, and Their Applications. Part II: Radiative Transfer Models and Related Applications
Hua Zhang, ..., and Chao Liu. Journal of Meteorological Research, 2024. 2 citations.
0% Topic Match
No summary or abstract available

[164] Atmospheric radiative transfer modeling: a summary of the AER codes
S. Clough, ..., and P. Brown. Journal of Quantitative Spectroscopy & Radiative Transfer, 2005. 1808 citations.
0% Topic Match
No summary or abstract available

[165] For submission to Journal of Applied Remote Sensing ' s Special Section on High-Performance Computing in Applied Remote Sensing Accelerating the RTTOV-7 IASI and AMSU-A Radiative Transfer Models on Graphics Processing Units : Evaluating CPU / GPU-Hybrid and Pure-GPU Approaches
J. Mielikainen and Bormin Huang. Journal Not Provided, 2013. 0 citations.
0% Topic Match
No summary or abstract available

[166] Two adaptive radiative transfer schemes for numerical weather prediction models
V. Venema, ..., and C. Simmer. Atmospheric Chemistry and Physics, 2007. 14 citations.
0% Topic Match
Abstract: Radiative transfer calculations in atmospheric models are computationally expensive, even if based on simplifications such as the ´two-stream approximation. In most weather prediction models these parameterisation schemes are therefore called infrequently, accepting additional model error due to the persistence assumption between calls. This paper presents two so-called adaptive parameterisation schemes for radiative transfer in a limited area model: A perturbation scheme that exploits temporal correlations and a local-search scheme that mainly takes advantage of spatial correlations. Utilising these correlations and with similar computational resources, the schemes are able to predict the surface net radiative fluxes more accurately than a scheme...

[167] The 2015 edition of the GEISA spectroscopic database
N. Jacquinet-Husson, ..., and A. Makie. Journal of Molecular Spectroscopy, 2016. 346 citations.
0% Topic Match
No summary or abstract available

[168] Validation of cloud property retrievals with simulated satellite radiances: a case study for SEVIRI
L. Bugliaro, ..., and W. Thomas. Atmospheric Chemistry and Physics, 2010. 72 citations.
0% Topic Match
Abstract: Abstract. Validation of cloud properties retrieved from passive spaceborne imagers is essential for cloud and climate applications but complicated due to the large differences in scale and observation geometry between the satellite footprint and the independent ground based or airborne observations. Here we illustrate and demonstrate an alternative approach: starting from the output of the COSMO-EU weather model of the German Weather Service realistic three-dimensional cloud structures at a spatial scale of 2.33 km are produced by statistical downscaling and microphysical properties are associated to them. The resulting data sets are used as input to the one-dimensional radiative transfer model...

[169] Decadal analysis of sea surface temperature patterns, climatology, and anomalies in temperate coastal waters with Landsat-8 TIRS observations
Yiqing Guo, ..., and Ming Feng. GIScience & Remote Sensing, 2025. 0 citations.
0% Topic Match
Abstract: ABSTRACT Sea surface temperature (SST) is a fundamental physical parameter characterizing the thermal state of sea surface. Due to the intricate thermal interactions between land, sea, and atmosphere, the spatial gradients of SST in coastal waters often appear at finer spatial scales than those in open ocean waters. The Thermal Infrared Sensor (TIRS) onboard Landsat-8, with its 100-m spatial resolution, offers a unique opportunity to uncover fine-scale coastal SST patterns that would otherwise be overlooked by coarser-resolution thermal sensors. In this study, we first analyzed the spatiotemporal patterns of SST in South Australia's temperate coastal waters from 2014 to 2023...

[170] Towards an improved treatment of cloud-radiation interaction in weather and climate models: exploring the potential of the Tripleclouds method for various cloud types using libRadtran 2.0.4
Nina  rnivec and B. Mayer Geoscientific Model Development, 2021. 4 citations.
0% Topic Match

Abstract: Abstract. Although the representation of unresolved clouds in radiation schemes of coarse-resolution weather and climate models has progressed noticeably over the past years, a lot of room remains for improvement, as the current picture is by no means complete. The main objective of the present study is to advance the cloud-radiation interaction parameterization, focusing on the issues related to model misrepresentation of cloud horizontal inhomogeneity. This subject is addressed with the state-of-the-art Tripleclouds radiative solver, the fundamental feature of which is the inclusion of the optically thicker and thinner cloud fraction, where the thicker is associated with the presence of...

[171] A fitted radiance and attenuation model for realistic atmospheres
A. Wilkie, ..., and Jaroslav KYivánekACM Transactions on Graphics (TOG), 2021. 11 citations.
0% Topic Match

Abstract: We present a fitted model of sky dome radiance and attenuation for realistic terrestrial atmospheres. Using scatterer distribution data from atmospheric measurement data, our model considerably improves on the visual realism of existing analytical clear sky models, as well as of interactive methods that are based on approximating atmospheric light transport. We also provide features not found in fitted models so far: radiance patterns for post-sunset conditions, in-scattered radiance and attenuation values for finite viewing distances, an observer altitude resolved model that includes downward-looking viewing directions, as well as polarisation information. We introduce a fully spherical model for in-scattered radiance...

[172] MODTRAN 5: a reformulated atmospheric band model with auxiliary species and practical multiple scattering options: update
A. Berk, ..., and P. Lewis. Journal Not Provided, 2005. 162 citations.
0% Topic Match

No summary or abstract available

[173] Direct Radiative Effects of Dust Events over Limassol, Cyprus in 2024 Using Ground-Based Measurements and Modelling
G. Charalampous, ..., and S. Kazadzis. COMECAP 2025, 2025. 0 citations.
0% Topic Match

Abstract: . Abstract Dust plays a significant role in the atmospheric radiative balance by altering both shortwave and longwave radiation fluxes. While deserts are the primary sources of dust emissions, atmospheric circulation can transport dust over long distances, impacting air quality and climate in remote regions. These transport episodes, commonly known as dust events, vary in intensity and effects. Despite extensive research, uncertainties persist regarding their precise radiative impacts. This study examines the direct radiative effects of dust events in 2024 (a year marked by heightened dust activity) over Limassol, Cyprus. A comprehensive approach is employed, integrating radiative transfer modelling, ground-based...

[174] A 3-D polarized reversed Monte Carlo radiative transfer model for Millimeter and submillimeter passive remote sensing in cloudy atmospheres
C. Davis, ..., and R. Harwood. IEEE Transactions on Geoscience and Remote Sensing, 2005. 84 citations.
0% Topic Match

No summary or abstract available

[175] Bridging Clarity and Accuracy: A Simple Spectral Longwave Radiation Scheme for Idealized Climate Modeling
Andrew I.L. Williams. ArXiv, 2025. 1 citations.
0% Topic Match

Abstract: Parameterizing radiative transfer in means navigating trade-offs between physical accuracy and conceptual clarity. However, currently available schemes sit at the extremes of this spectrum: correlated-k schemes are fast and accurate but rely on lookup tables which obscure the underlying physics and make such schemes difficult to modify, while gray radiation schemes are conceptually straightforward but introduce significant biases in atmospheric circulation. Here we introduce a Simple Spectral Model (SSM) for clear-sky longwave radiative transfer which bridges this `clarity-accuracy'gap. The SSM accomplishes this by representing the spectral structure of H$_{2}$O and CO$_{2}$ absorption using analytic fits at reference conditions, then uses...

[176] Radiative transfer in the cloudy atmosphere
B. Mayer. Unknown journal, 2009. 307 citations.
0% Topic Match

Abstract: Radiative transfer in clouds is a challenging task, due to their high spatial and temporal variability which is unrivaled by any other atmospheric species. Clouds are among the main modulators of radiation along its path through the Earth's atmosphere. The cloud feedback is the largest source of uncertainty in current climate model predictions. Cloud observation from satellites, on a global scale, with appropriate temporal and spatial sampling is therefore one of the top aims of current Earth observation missions. In this chapter three-dimensional methods for radiative transfer in cloudy atmospheres are described, which allow to study cloud-radiation interaction at the...

[177] THE CORRELATED-k METHOD FOR RADIATION CALCULATIONS IN NONHOMOGENEOUS ATMOSPHERES
R. Goody, ..., and D. Crisp. Journal of Quantitative Spectroscopy & Radiative Transfer, 1989. 488 citations.
0% Topic Match

No summary or abstract available

[178] Impact of stratiform liquid water clouds on vegetation albedo quantified by coupling an atmosphere and a vegetation radiative transfer model
Kevin Wolf, ..., and M. Wendisch. Biogeosciences, 2025. 1 citations.
0% Topic Match

Abstract: Abstract. This paper investigates the influence of clouds on vegetation albedo. For this purpose, we use coupled atmosphere–vegetation radiative transfer (RT) simulations combining the library for Radiative Transfer (libRadtran) and the vegetation Soil Canopy Observation of Photosynthesis and Energy fluxes (SCOPE2.0) model. Both models are iteratively linked to more realistically simulate cloud–vegetation–radiation interactions above three types of canopy, represented by the spherical, erectophile, and planophile leaf angle distributions. The coupled models are applied to simulate solar, spectral, and broadband irradiances under cloud-free and cloudy conditions, with the focus on the visible to near infrared wavelength range from 0.4 to 2.4...

[179] A Fast and Accurate Method of Radiation Hydrodynamics Calculation in Spherical Symmetry
Torsten Stamer and S. Inutsuka. The Astronomical Journal, 2018. 3 citations.
0% Topic Match

Abstract: We develop a new numerical scheme for solving the radiative transfer equation in a spherically symmetric system. This scheme does not rely on any kind of diffusion approximation, and it is accurate for optically thin, thick, and intermediate systems. In the limit of a homogeneously distributed extinction coefficient, our method is very accurate and exceptionally fast. We combine this fast method with a slower but more generally applicable method to describe realistic problems. We perform various test calculations, including a simplified protostellar collapse simulation. We also discuss possible future improvements.

[180] Absorption Loss Modeling Tools for Terahertz Band Drone Communications
Berkay Sekeroglu, ..., and Murat Kulaksizoglu. Sensors (Basel, Switzerland), 2025. 0 citations.
0% Topic Match

Abstract: This paper compares the following four Terahertz (THz) band molecular absorption loss modeling tools: International Telecommunication Union (ITU)-R P.676 model, Line-by-Line Radiative Transfer Model (LBLRTM), Atmospheric Model (am), and HITRAN on the Web (HotW). We evaluate the THz band drone communication tools under horizontal and vertical communication scenarios. We use the U.S. Standard 1976 and tropical weather profiles to generate path loss data across different altitudes, frequencies, and distances. We also employ a simple analytical model, fitting the data from the ITU, LBLRTM, and am tools to assess its accuracy in predicting path loss. Our results demonstrate high consistency among...

[181] The Education and Research 3D Radiative Transfer Toolbox (EaR3T) – towards the mitigation of 3D bias in airborne and spaceborne passive imagery cloud retrievals
Hong Chen, ..., and Hironobu Iwabuchi. Atmospheric Measurement Techniques, 2023. 2 citations.
0% Topic Match

Abstract: Abstract. We introduce the Education and Research 3D Radiative Transfer Toolbox (EaR3T, pronounced []) for quantifying and mitigating artifacts in atmospheric radiation science algorithms due to spatially inhomogeneous clouds and surfaces and show the benefits of automated, realistic radiance and irradiance generation along extended satellite orbits, flight tracks from entire aircraft field missions, and synthetic data generation from model data. EaR3T is a modularized

Python package that provides high-level interfaces to automate the process of 3D radiative transfer (3D-RT) calculations. After introducing the package, we present initial findings from four applications, which are intended as blueprints to future in-depth scientific...

[182] DATA-INTENSIVE COMPUTING IN RADIATIVE TRANSFER MODELLING
No author found. Journal Not Provided, 2016. 1 citations.
0% Topic Match

No summary or abstract available

[183] HITEMP, the high-temperature molecular spectroscopic database
L. Rothman, ..., and J. Tennyson. Journal of Quantitative Spectroscopy & Radiative Transfer, 2010. 1923 citations.
0% Topic Match

No summary or abstract available

[184] The effect of cirrus clouds on microwave limb radiances
C. Emde, ..., and T. R. Sreerekha. Atmospheric Research, 2004. 10 citations.
0% Topic Match

No summary or abstract available

[185] High-resolution maps of Arctic surface skin temperature and type retrieved from airborne thermal infrared imagery collected during the HALO–(5cecap)ign
Joshua Müller, ..., and M. Wendisch. Atmospheric Measurement Techniques, 2025. 1 citations.
0% Topic Match

Abstract: Abstract. Two retrieval methods for the determination of Arctic surface skin temperature and surface type based on radiance measurements from the thermal infrared (TIR) imager VELOX (Video airbornE Longwave Observations within siX channels) were developed. VELOX captured TIR radiances in terms of brightness temperatures for wavelengths from 7.7 to 12 µm in six spectral channels. The imager was deployed on the High Altitude and LOng Range research aircraft (HALO) during the HALO–(5cecap) aft field campaign conducted in the framework of the Arctic Amplification: Climate Relevant Atmospheric and SurfaCe Processes and Feedback Mechanisms (5cec) arch programme. The measurements were taken over...

[186] Estimating full longwave and shortwave radiative transfer with neural networks of varying complexity
Ryan Lagerquist, ..., and J. Stewart. Journal of Atmospheric and Oceanic Technology, 2023. 7 citations.
0% Topic Match

Abstract: Radiative transfer (RT) is a crucial but computationally expensive process in numerical weather/climate prediction. We develop neural networks (NN) to emulate a common RT parameterization called the Rapid Radiative-transfer Model (RRTM), with the goal of creating a faster parameterization for the Global Forecast System (GFS) v16. In previous work we emulated a highly simplified version of the shortwave RRTM only – excluding many predictor variables, driven by Rapid Refresh forecasts interpolated to a consistent height grid, using only 30 sites in the northern hemisphere. In this work we emulate the full shortwave and longwave RRTM – with all predictor...

[187] Linepak: Algorithms for modeling spectral transmittance and radiance
L. Gordley, ..., and D. A. Chu. Journal of Quantitative Spectroscopy & Radiative Transfer, 1994. 133 citations.
0% Topic Match

No summary or abstract available

[188] Radiative Transfer as a Bayesian Linear Regression problem
F. D. Ceuster, ..., and J. Yates. ArXiv, 2022. 2 citations.
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Abstract: Electromagnetic radiation plays a crucial role in various physical and chemical processes. Hence, almost all astrophysical simulations require some form of radiative transfer model. Despite many innovations in radiative transfer algorithms and their implementation, realistic radiative transfer models remain very computationally expensive, such that one often has to resort to approximate descriptions. The complexity of these models makes it difficult to assess the validity of any approximation and to quantify uncertainties on the model results. This impedes scientific rigour, in particular, when comparing models to observations, or when using their results as input for other models. We present a probabilistic...

[189] Monte Carlo Simulation of Radiative Transfer in Atmospheric Environments for Problems Arising from Remote Sensing Measurements
M. Premuda. Unknown journal, 2011. 5 citations.
0% Topic Match

Abstract: The way in which solar radiation distributes itself in the atmosphere and on the ground is well known. It is beyond the scope of this book and the reader can refer to more specific references (Kondratyev, 1969; Goody & Yung, 1995; Liou, 1998) for more detail. Solar radiation, essentially in the visible-ultraviolet frequency range, and infrared radiation, emitted by the terrestrial surface, are the prevailing energy sources for general atmospheric circulation. They are thus particularly important for meteorological and climatic studies. It would therefore be of great interest, for instance, to be able to calculate the influence of the presence...

[190] Emulation of Leaf, Canopy and Atmosphere Radiative Transfer Models for Fast Global Sensitivity Analysis
J. Verrelst, ..., and J. Moreno. Remote. Sens., 2016. 88 citations.
0% Topic Match

Abstract: Physically-based radiative transfer models (RTMs) help understand the interactions of radiation with vegetation and atmosphere. However, advanced RTMs can be computationally burdensome, which makes them impractical in many real applications, especially when many state conditions and model couplings need to be studied. To overcome this problem, it is proposed to substitute RTMs through surrogate meta-models also named emulators. Emulators approximate the functioning of RTMs through statistical learning regression methods, and can open many new applications because of their computational efficiency and outstanding accuracy. Emulators allow fast global sensitivity analysis (GSA) studies on advanced, computationally expensive RTMs. As a proof-of-concept, three...

[191] COVID-19 lockdown contribution to spring surface solar irradiance record in Western Europe
C. C. Heerwaarden, ..., and S. Fiedler. arXiv: Atmospheric and Oceanic Physics, 2020. 1 citations.
0% Topic Match

Abstract: Spring 2020 broke sun duration records across western Europe. The Netherlands recorded the highest surface irradiance since 1928, exceeding the previous extreme by 13 %, and the diffuse fraction of the total irradiance measured a record low percentage (38 %). The coinciding irradiance extreme and a reduction in anthropogenic pollution due to the COVID-19 measures triggered the hypothesis that cleaner-than-usual air contributed to the record. Based on analyses of ground-based and satellite observations and experiments with a radiative transfer model, we estimate a 1.3 % (2.3 W m$^{-2}$) increase in surface irradiance with respect to the 2010-2019 mean due to...

[192] Parameterized transmittance model for direct beam and circumsolar spectral irradiance
C. Gueymard. Solar Energy, 2001. 817 citations.
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No summary or abstract available

[193] FuXi-RTM: A Physics-Guided Prediction Framework with Radiative Transfer Modeling
Qiusheng Huang, ..., and Hao Li. ArXiv, 2025. 0 citations.
0% Topic Match

Abstract: Similar to conventional video generation, current deep learning-based weather prediction frameworks often lack explicit physical constraints, leading to unphysical outputs that limit their reliability for operational forecasting. Among various physical processes requiring proper representation, radiation plays a fundamental role as it drives Earth's weather and climate systems. However, accurate simulation of radiative transfer processes remains challenging for traditional numerical weather prediction (NWP) models due to their inherent complexity and high computational costs. Here, we propose FuXi-RTM, a hybrid physics-guided deep learning framework designed to enhance weather forecast accuracy while enforcing physical consistency. FuXi-RTM integrates a primary forecasting model (FuXi) with...

[194] Vertically resolved minimal-set k-distribution for thermal infrared absorption: an application to the atmosphere of Venus
Boris Fomin and Mikhail Razumovskiy. ArXiv, 2025. 0 citations.
0% Topic Match

Abstract: The FKDM $k$-distribution technique is applied to parameterize absorption of thermal radiation in the lower and middle atmosphere of Venus, targeting modeling scenarios where the cost of full radiative transfer calculations necessitates efficient parameterizations (e.g. climate modeling). Line-by-line reference modeling based on a Monte Carlo method for radiative transfer is built into the $k$-distribution terms construction process, explicitly controlling accuracy. From 16 bands across $10$--$6000~\mathrm{cm^{-1}}$, the method produces 32 $k$-terms, band-averaged Planck function values and per-band spectral points for computing Venus cloud optical properties. The FKDM $k$-distribution technique does not require the inter-level correlation assumption common for the correlated $k$-distribution...

[195] MODTRAN6: a major upgrade of the MODTRAN radiative transfer code
A. Berk, ..., and J. M. van den Bosch. Unknown journal, 2014. 333 citations.
0% Topic Match

No summary or abstract available

[196] A flexible inversion algorithm for retrieval of aerosol optical properties from Sun and sky radiance measurements
O. Dubovik and M. King. Journal of Geophysical Research, 2000. 2360 citations.
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No summary or abstract available

[197] A Two-moment Radiation Hydrodynamics Scheme Applicable to Simulations of Planet Formation in Circumstellar Disks
J. D. Melon Fuksman, ..., and A. Mignone. The Astrophysical Journal, 2020. 11 citations.
0% Topic Match

Abstract: We present a numerical code for radiation hydrodynamics designed as a module for the freely available PLUTO code. We adopt a gray approximation and include radiative transfer following a two-moment approach by imposing the M1 closure to the radiation fields. This closure allows for a description of radiative transport in both the diffusion and free-streaming limits, and is able to describe highly anisotropic radiation transport as can be expected in the vicinity of an accreting planet in a protoplanetary disk. To reduce the computational cost caused by the timescale disparity between radiation and matter fields, we integrate their evolution equations...

[198] Numerically stable algorithm for discrete-ordinate-method radiative transfer in multiple scattering and emitting layered media.
K. Stamnes, ..., and K. Jayaweera. Applied optics, 1988. 3431 citations.
0% Topic Match

No summary or abstract available

[199] Infrared atmospheric radiative transfer: a fast computational approach with agile MODTRAN atmosphere reconstruction
Giuseppe Auricchio and Francesco Castaldo. Unknown journal, 2023. 0 citations.
0% Topic Match

Abstract: In this paper we present a numerical method able to compute atmospheric radiance based on ray path. In this way is possible to evaluate relevant features of Infrared Search & Track (IRST) such as the so called Target Contrast Irradiance, i.e. difference between irradiance received with and without an obstacle towards a fixed Line-Of-Sight. The proposed model evaluates propagation of electromagnetic waves in parametric spectral band by means of computational procedure that relies on integral solution of radiative transfer differential equation defined in inhomogeneous domain such as atmosphere. Atmospheric properties are reconstructed by agile offline usage of MODTRAN® tool and...

[200] The HITRAN 2008 molecular spectroscopic database
L. Rothman, ..., and G. Wagner. Journal of Quantitative Spectroscopy & Radiative Transfer, 2005. 7962 citations.
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No summary or abstract available

[201] Application of an adaptive radiative transfer scheme in a mesoscale numerical weather prediction model
A. Schomburg, ..., and C. Simmer. Quarterly Journal of the Royal Meteorological Society, 2012. 7 citations.
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[202] An Open-source Bayesian Atmospheric Radiative Transfer (BART) Code. III. Initialization, Atmospheric Profile Generator, Post-processing Routines
J. Blecic, ..., and T. Loredo. The Planetary Science Journal, 2021. 2 citations.
0% Topic Match

Abstract: This and companion papers by Harrington et al. and Cubillos et al. describe an open-source retrieval framework, Bayesian Atmospheric Radiative Transfer (BART), available to the community under the reproducible-research license via https://github.com/exosports/BART. BART is a radiative transfer code (transit; https://github.com/exosports/transit; Rojo et al.), initialized by the Thermochemical Equilibrium Abundances (TEA; https://github.com/dzesmin/TEA) code (Blecic et al.), and driven through the parameter phase space by a differential-evolution Markov Chain Monte Carlo (MC3; https://github.com/pcubillos/mc3) sampler (Cubillos et al.). In this paper we give a brief description of the framework and its modules that can be used separately for other scientific purposes; outline the...

[203] An improved fast radiative transfer model for assimilation of satellite radiance observations
R. Saunders, ..., and P. Brunel. Quarterly Journal of the Royal Meteorological Society, 1999. 635 citations.
0% Topic Match

No summary or abstract available

[204] RadNet 1.0: exploring deep learning architectures for longwave radiative transfer
Ying Liu, ..., and J. Monteiro. Geoscientific Model Development, 2020. 22 citations.
0% Topic Match

Abstract: Abstract. Simulating global and regional climate at high resolution is essential to study the effects of climate change and capture extreme events affecting human populations. To achieve this goal, the scalability of climate models and efficiency of individual model components are both important. Radiative transfer is among the most computationally expensive components in a typical climate model. Here we attempt to model this component using a neural network. We aim to study the feasibility of replacing an explicit, physics-based computation of longwave radiative transfer by a neural network emulator and assessing the resultant performance gains. We compare multiple neural-network architectures,...

[205] DeepEmSat: Deep Emulation for Satellite Data Mining
Kate Duffy, ..., and A. Ganguly. Frontiers in Big Data, 2019. 3 citations.
0% Topic Match

Abstract: The growing volume of Earth science data available from climate simulations and satellite remote sensing offers unprecedented opportunity for scientific insight, while also presenting computational challenges. One potential area of impact is atmospheric correction, where physics-based numerical models retrieve surface reflectance information from top of atmosphere observations, and are too computationally intensive to be run in real time. Machine learning methods have demonstrated potential as fast statistical models for expensive simulations and for extracting credible insights from complex datasets. Here, we develop DeepEmSat: a deep learning emulator approach for atmospheric correction, and offer comparison against physics-based models to support the...

[206] A data-driven approach for fast atmospheric radiative transfer inversion
C. Sgattoni, ..., and Matthias Chung. Inverse Problems, 2025. 3 citations.
0% Topic Match

Abstract: Far-infrared Outgoing Radiation Understanding and Monitoring (FORUM) was selected in 2019 as the ninth Earth Explorer mission by the European Space Agency. Its primary objective is to collect interferometric measurements in the far-infrared (FIR) spectral range, which accounts for 50% of Earth's outgoing longwave radiation emitted into space, and will be observed from space for the first time. Accurate measurements of the FIR at the top of the atmosphere are crucial for improving climate models. Current instruments are insufficient, necessitating the development of advanced computational techniques. FORUM will provide unprecedented insights into key atmospheric parameters, such as surface emissivity, water...

[207] A radiative transfer model for planetary atmospheres
R. Cess. Journal of Quantitative Spectroscopy & Radiative Transfer, 1971. 13 citations.
0% Topic Match

No summary or abstract available

[208] Radiance and Jacobian Intercomparison of Radiative Transfer Models Applied to HIRS and AMSU Channels
L. Garand, ..., and H. Woolf. Journal of Geophysical Research, 2001. 160 citations.
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[209] Performance of Cloud 3D Solvers in Ice Cloud Shortwave Radiation Closure Over the Equatorial Western Pacific Ocean
T. Ren, ..., and H. Sang. Journal of Advances in Modeling Earth Systems, 2022. 5 citations.
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Abstract: For retrieving cloud optical properties from satellite images or computing these properties from climate model output, computationally efficient treatments of cloud horizontal inhomogeneity include the Monte Carlo Independent Column Approximation (McICA) and the Tripleclouds method. Computationally efficient treatment of cloud horizontal radiation exchanges includes the SPeedy Algorithm for Radiative TrAnsfer through CloUd Sides (SPARTACUS). As a test to derive properties from satellite images, we collocate Moderate Resolution Imaging Spectroradiometer (MODIS) cloud retrievals with near nadir Cloud and the Earth's Radiant Energy System (CERES) footprints in July 2008 over an equatorial western Pacific Ocean region to compare the performance of the McICA,...

[210] Evaluation of synthetic satellite images computed from radiative transfer models over a region of South America using WRF and GOES 13/16 observations
Federico Cutraro, ..., and Yanina García Skabar. Quarterly Journal of the Royal Meteorological Society, 2021. 3 citations.
0% Topic Match

Abstract: Synthetic infrared GOES 13 observations are generated from a high resolution (4 km) Weather Research and Forecasting (WRF) model run over Argentina for a meteorological event of deep moist convection using two different radiative transfer models. The fast operational Community Radiative Transfer Model (CRTM) and the physics based research model Atmospheric Radiative Transfer Simulator (ARTS) are compared with the available observations. CRTM shows good results at a low computational cost, and is a good candidate for operational use in the region. CRTM and ARTS synthetic satellite images show differences due to the treatment of the bulk scattering properties of the frozen hydrometeor species,...

[211] A new generation of radiative transfer models for climate studies based on neural networks
F. Chéruy, ..., and A. Chédin. 1995 International Geoscience and Remote Sensing Symposium, IGARSS '95. Quantitative Remote Sensing for Science and Applications, 1995. 2 citations.
0% Topic Match

No summary or abstract available

[212] Retrieval of cloud fraction and optical thickness of liquid water clouds over the ocean from multi-angle polarization observations
C. Emde, ..., and Bernhard Mayer. Atmospheric Measurement Techniques, 2024. 0 citations.
0% Topic Match

Abstract: Abstract. We introduce a novel method to retrieve the cloud fraction and the optical thickness of liquid clouds over a water surface based on polarimetry. The approach is well suited for satellite observations providing multi-angle polarization measurements, in particular those of the Hyper-Angular Rainbow Polarimeter #2 (HARP2). Unlike commonly used methods to derive cloud fractions, our method does not depend on the spatial resolution of observations, and it does not require any threshold values for cloud detection. Based on radiative transfer simulations, we show that the cloud fraction and the cloud optical thickness can be derived from measurements at two...

[213] Modelling the spectra of planets, brown dwarfs and stars using vstar
J. Bailey and L. Kedziora-Chudczer. Monthly Notices of the Royal Astronomical Society, 2011. 62 citations.
0% Topic Match

Abstract: We describe a new software package capable of predicting the spectra of Solar system planets, exoplanets, brown dwarfs and cool stars. The Versatile Software for Transfer of Atmospheric Radiation (vstar) code combines a line-by-line approach to molecular and atomic absorption with a full multiple scattering treatment of radiative transfer. vstar is a modular system incorporating an ionization and chemical equilibrium model, a comprehensive treatment of spectral line absorption using a data base of more than 2.9 billion spectral lines, a scattering package and a radiative transfer module. We test the methods by comparison with other models and benchmark calculations. We...

[214] LIDORT V2PLUS: a comprehensive radiative transfer package for UV/VIS/NIR nadir remote sensing
R. Spurr. Unknown journal, 2004. 17 citations.
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No summary or abstract available

[215] GEAR-RT: Towards Exa-Scale Moment Based Radiative Transfer For Cosmological Simulations Using Task-Based Parallelism And Dynamic Sub-Cycling with SWIFT
Mladen Ivkovic. ArXiv, 2023. 0 citations.
0% Topic Match

Abstract: The development and implementation of GEAR-RT, a radiative transfer solver using the M1 closure in the open source code SWIFT, is presented, and validated using standard tests for radiative transfer. GEAR-RT is modeled after RAMSES-RT (Rosdahl et al. 2013) with some key differences. Firstly, while RAMSES-RT uses Finite Volume methods and an Adaptive Mesh Refinement (AMR) strategy, GEAR-RT employs particles as discretization elements and solves the equations using a Finite Volume Particle Method (FVPM). Secondly, GEAR-RT makes use of the task-based parallelization strategy of SWIFT, which allows for optimized load balancing, increased cache efficiency, asynchronous communications, and a domain decomposition...

[216] Development and recent evaluation of the MT_CKD model of continuum absorption
E. Mlawer, ..., and D. Tobin. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 2012. 415 citations.
0% Topic Match

No summary or abstract available

[217] The Palaeoclimate and Terrestrial Exoplanet Radiative Transfer Model Intercomparison Project (PALAEOTRIP): experimental design and protocols

C. Goldblatt, ..., and M. Dewey. Geoscientific Model Development, 2017. 4 citations.
0% Topic Match

Abstract: Abstract. Accurate radiative transfer calculation is fundamental to all climate modelling. For deep palaeoclimate, and increasingly terrestrial exoplanet climate science, this brings both the joy and the challenge of exotic atmospheric compositions. The challenge here is that most standard radiation codes for climate modelling have been developed for modern atmospheric conditions and may perform poorly away from these. The palaeoclimate or exoclimate modeller must either rely on these or use bespoke radiation codes, and in both cases rely on either blind faith or ad hoc testing of the code. In this paper, we describe the protocols for the Palaeoclimate and...

[218] Polarized radiative transfer in planetary atmospheres and the polarization of exoplanets
J. Bailey, ..., and K. Bott. Monthly Notices of the Royal Astronomical Society, 2018. 21 citations.
0% Topic Match

Abstract: We describe the incorporation of polarized radiative transfer into the atmospheric radiative transfer modelling code VSTAR (Versatile Software for Transfer of Atmospheric Radiation). Using a vector discrete-ordinate radiative transfer code we are able to generate maps of radiance and polarization across the disc of a planet, and integrate over these to get the full-disc polarization. In this way we are able to obtain disc-resolved, phase-resolved and spectrally-resolved intensity and polarization for any of the wide range of atmopsheres that can be modelled with VSTAR. We have tested the code by reproducing a standard benchmark problem, as well as by comparing...

[219] The Continual Intercomparison of Radiation Codes: Results from Phase I
L. Oreopoulos, ..., and W. Rossow. Journal of Geophysical Research, 2012. 126 citations.
0% Topic Match

No summary or abstract available

[220] Solving non-LTE problems in rotational transitions using the Gauss–Seidel method and its implementation in the Atmospheric Radiative Transfer Simulator
T. Yamada, ..., and Y. Kasai. Astronomy & Astrophysics, 2018. 11 citations.
0% Topic Match

Abstract: This article presents our implementation of a non-LTE solver in spherical symmetry for molecular rotational transition in static or expanding atmospheres. The new open-source code relies on the Gauss–Seidel Accelerated Lambda Iteration methodology that provides a rapid and accurate convergence of the non-LTE problems, which is now routinely used in astrophysical and planetary research. The non-LTE code is interfaced with the widely used package, the Atmospheric Radiative Transfer Simulator (ARTS), to facilitate spectral line simulations for various viewing geometries. In this paper we describe the numerical implementation, provide the first validation results for the populations against two other non-LTE codes,...

[221] A Lightweight Neural Network for Accelerating Radiative Transfer Modeling in WRF
Erick Fredj, ..., and Yann Delorme. ArXiv, 2025. 0 citations.
0% Topic Match

Abstract: Radiative transfer calculations in weather and climate models are notoriously complex and computationally intensive, which poses significant challenges. Traditional methods, while accurate, can be prohibitively slow, necessitating the development of more efficient alternatives. Recently, empirical emulators based on neural networks (NN) have been proposed as a solution to this problem. These emulators aim to replicate the radiation parametrization used in the models, at a fraction of the computational cost. However, a common issue with these emulators is that their accuracy has often been insufficiently evaluated, especially for extreme events for which the amount of training data is sparse. The current...

[222] Exponential-sum fitting of radiative transmission functions
W. Wiscombe and J. Evans. Journal of Computational Physics, 1977. 272 citations.
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No summary or abstract available

[223] High Spectral Resolution Radiative Transfer Model for IR and NIR Atmospheric and Cloud Remote Sensing Applications
Y. Shiren, ..., and C. Gautier. Journal Not Provided, 1998. 0 citations.
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[224] Second Simulation of the Satellite Signal in the Solar Spectrum, 6S: an overview
E. Vermote, ..., and Jean-Jacques Morcette. IEEE Trans. Geosci. Remote. Sens., 1997. 3230 citations.
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[225] An Accurate Parameterization of the Infrared Radiative Properties of Cirrus Clouds for Climate Models
Q. Fu. Journal of Climate, 1996. 669 citations.
0% Topic Match

No summary or abstract available

[226] Radiative Transfer Modeling of Simulation and Observational Data
J. Steinacker, ..., and A. Bacmann. Proceedings of the International Astronomical Union, 2010. 0 citations.
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No summary or abstract available

[227] Performance of the Line-By-Line Radiative Transfer Model (LBLRTM) for temperature, water vapor, and trace gas retrievals: recent updates evaluated with IASI case studies
M. Alvarado, ..., and J. Moncet. Atmospheric Chemistry and Physics, 2013. 99 citations.
0% Topic Match

Abstract: Abstract. Modern data assimilation algorithms depend on accurate infrared spectroscopy in order to make use of the information related to temperature, water vapor (H 2 O), and other trace gases provided by satellite observations. Reducing the uncertainties in our knowledge of spectroscopic line parameters and continuum absorption is thus important to improve the application of satellite data to weather forecasting. Here we present the results of a rigorous validation of spectroscopic updates to an advanced radiative transfer model, the Line-By-Line Radiative Transfer Model (LBLRTM), against a global dataset of 120 near-nadir, over-ocean, nighttime spectra from the Infrared Atmospheric Sounding Interferometer...

[228] A Neural Network Approach for a Fast and Accurate Computation of a Longwave Radiative Budget
F. Chevallier, ..., and A. Chédin. Journal of Applied Meteorology, 1998. 341 citations.
0% Topic Match

No summary or abstract available

[229] Observation of absorbing aerosols above clouds over the south-east Atlantic Ocean from the geostationary satellite SEVIRI – Part 2: Comparison with MODIS and aircraft measurements from the CLARIFY-2017 field campaign
F. Peers, ..., and J. Haywood. Atmospheric Chemistry and Physics, 2020. 15 citations.
0% Topic Match

Abstract: Abstract. To evaluate the SEVIRI retrieval for aerosols above clouds presented in Part 1 of the companion paper, the algorithm is applied over the south-east Atlantic Ocean during the CLARIFY-2017 field campaign period. The first step of our analysis compares the retrieved aerosol and cloud properties against equivalent products from the MODIS MOD06ACAERO retrieval (Meyer et al., 2015). While the correlation between the two satellite retrievals of the above-cloud aerosol optical thickness (AOT) is good (R = 0.78), the AOT retrieved by SEVIRI is 20.3 % smaller than that obtained from the MODIS retrieval. This difference in AOT is attributed...

[230] The phase matrix truncation impact on polarized radiance
M. Compiègne, ..., and P. Dubuisson. Unknown journal, 2013. 4 citations.
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No summary or abstract available

[231] Three-Dimensional Radiative Transfer Modeling of Tropospheric Atmospheres
D. Tofsted and S. O'Brien. Unknown journal, 1998. 4 citations.
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No summary or abstract available

[232] SpectraPlot.com: Integrated spectroscopic modeling of atomic and molecular gases
C. Goldenstein, ..., and C. Strand. Journal of Quantitative Spectroscopy & Radiative Transfer, 2017. 121 citations.
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No summary or abstract available

[233] Evaluation of Modeled Hyperspectral Infrared Spectra Against All Sky AIRS Observations Using Different Cloud Overlap Schemes
T. Le, ..., and Y. Yung. Earth and Space Science (Hoboken, N.j.), 2022. 0 citations.
0% Topic Match
Abstract: Hyperspectral infrared sounding contains information about clouds, which plays an important role in modulating Earth's climate. However, there is a great deal of uncertainty in modeling the radiative effect of clouds due to its complex dependence on various parameters. Therefore, cloudy scenarios are often neglected in retrievals of infrared spectral measurements and in data assimilation. One dimensional radiative transfer (RT) models have a limited capability to represent the cloud three dimensional multilayer structure. This issue is typically resolved by using a multiple independent column approach, which is computationally demanding. Therefore, it is necessary to find a balance between computational speed and accuracy...

[234] ARTS, the atmospheric radiative transfer simulator, version 2
P. Eriksson, ..., and Oliver Lemke. Journal of Quantitative Spectroscopy & Radiative Transfer, 2011. 274 citations.
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No summary or abstract available

[235] Fast and simple model for atmospheric radiative transfer
F. Seidel, ..., and M. Schaepman. Atmospheric Measurement Techniques, 2010. 53 citations.
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Abstract: Abstract. Radiative transfer models (RTMs) are of utmost importance for quantitative remote sensing, especially for compensating atmospheric perturbation. A persistent trade-off exists between approaches that prefer accuracy at the cost of computational complexity, versus those favouring simplicity at the cost of reduced accuracy. We propose an approach in the latter category, using analytical equations, parameterizations and a correction factor to efficiently estimate the effect of molecular multiple scattering. We discuss the approximations together with an analysis of the resulting performance and accuracy. The proposed Simple Model for Atmospheric Radiative Transfer (SMART) decreases the calculation time by a factor of more...

[236] Molecfit: A general tool for telluric absorption correction - I. Method and application to ESO instruments
A. Smette, ..., and Joanna M. Taylor. Astronomy and Astrophysics, 2015. 430 citations.
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Abstract: Context. The interaction of the light from astronomical objects with the constituents of the Earth's atmosphere leads to the formation of telluric absorption lines in ground-based collected spectra. Correcting for these lines, mostly a ecting the red and infrared region of the spectrum, usually relies on observations of specific stars obtained close in time and airmass to the science targets, therefore using precious observing time. Aims. We present molecfit, a tool to correct for telluric absorption lines based on synthetic modelling of the Earth's atmospheric transmission. Molecfit is versatile and can be used with data obtained with various ground-based telescopes...

[237] ART2: a 3D parallel multiwavelength radiative transfer code for continuum and atomic and molecular lines
Yue-xing Li, ..., and Moupiya Maji. Monthly Notices of the Royal Astronomical Society, 2020. 9 citations.
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Abstract: ART2 is a 3D multiwavelength Monte Carlo radiative transfer (RT) code that couples continuum and emission lines to track the propagation of photons and their interactions with the interstellar medium (ISM). The original ART2 has been extensively applied to hydrodynamics simulations to study panchromatic properties of galaxies and ISM. Here, we describe new implementations of non-local thermodynamic equilibrium RT of molecular and atomic fine structure emission lines, and the parallelization of the code using a number of novel methods. The new ART2 can efficiently and self-consistently produce a full spectrum that includes both continuum and lines such as [C...

[238] Comparison of spectral direct and diffuse solar irradiance measurements and calculations for cloud free conditions
E. Mlawer, ..., and T. Shippert. Geophysical Research Letters, 2000. 73 citations.
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[239] Using Deep Neural Networks as Cost Effective Surrogate Models for Super Parameterized E3SM Radiative Transfer
A. Pal, ..., and M. Norman. Geophysical Research Letters, 2019. 64 citations.
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Abstract: Deep neural networks (DNNs) are implemented in Super Parameterized Energy Exascale Earth System Model (SP E3SM) to imitate the shortwave and longwave radiative transfer calculations. These DNNs were able to emulate the radiation parameters with an accuracy of 90–95% at a cost of 8–10 times cheaper than the original radiation parameterization. A comparison of time averaged radiative fluxes and the prognostic variables manifested qualitative and quantitative similarity between the DNN emulation and the original parameterization. It has also been found that the differences between the DNN emulation and the original parameterization are comparable to the internal variability of the original parameterization. Although the...

[240] Stratified Radiative Transfer for Multidimensional Fluids and numerical applications to earth science
‡. FRANC¸OISGOLSE†OLIVIERPIRONNEAU. Journal Not Provided, Unknown year. 0 citations.
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[241] Modeling infrared radiances with a fast, high spectral resolution cloudy-sky radiative transfer model
Chenxi Wang and Ping Yang. Unknown journal, 2011. 0 citations.
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[242] Virtual lab for light scattering and radiative transfer analysis
T. Rother, ..., and K. Schmidt. Unknown journal, 2003. 1 citations.
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[243] Approximating Rayleigh Scattering in Exoplanetary Atmospheres using Physics-informed Neural Networks (PINNs)
David Dahlbüdding, ..., and Tommaso Grassi. ArXiv, 2024. 4 citations.
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Abstract: This research introduces an innovative application of physics-informed neural networks (PINNs) to tackle the intricate challenges of radiative transfer (RT) modeling in exoplanetary atmospheres, with a special focus on efficiently handling scattering phenomena. Traditional RT models often simplify scattering as absorption, leading to inaccuracies. Our approach utilizes PINNs, noted for their ability to incorporate the governing differential equations of RT directly into their loss function, thus offering a more precise yet potentially fast modeling technique. The core of our method involves the development of a parameterized PINN tailored for a modified RT equation, enhancing its adaptability to various atmospheric scenarios....

[244] Measurement characteristics of an airborne microwave temperature profiler (MTP)
Mareike Heckl, ..., and M. Rapp. Atmospheric Measurement Techniques, 2020. 5 citations.
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Abstract: Abstract. The microwave temperature profiler (MTP), an airborne passive microwave radiometer, measures radiances, recorded as counts and calibrated to brightness temperatures, in order to estimate temperature profiles around flight altitude. From these data, quantities such as potential temperature gradients and static stability, indicating the state of the atmosphere, can be derived and used to assess important dynamical processes (e.g., gravity waves or stability assessments). DLR has acquired a copy of the MTP from NASA–JPL, which was designed as a wing-canister instrument and is deployed on the German High Altitude LOng range research aircraft (HALO). For this instrument a thorough analysis...

[245] SBDART: A Research and Teaching Software Tool for Plane-Parallel Radiative Transfer in the Earth's Atmosphere.
P. Ricchiazzi, ..., and D. Sowle. Bulletin of the American Meteorological Society, 1998. 1525 citations.
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[246] Comparison of Major Sudden Stratospheric Warming Impacts on the Mid-Latitude Mesosphere Based on Local Microwave Radiometer CO Observations in 2018 and 2019
Yu Shi, ..., and Dmitry Shulga. Remote. Sens., 2020. 13 citations.
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Abstract: In this paper, a comparison of the impact of major sudden stratospheric warmings (SSWs) in the Arctic in February 2018 (SSW1) and January 2019 (SSW2) on the mid-latitude mesosphere is given. The mesospheric carbon monoxide (CO) and zonal wind in these two major SSW events were observed at altitudes of 70–85 km using a microwave radiometer (MWR) at Kharkiv, Ukraine (50.0°N, 36.3°E). Data from ERA-Interim and MERRA-2 reanalyses and Aura Microwave Limb Sounder measurements were also used. It is shown that: (i) The differences between SSW1 and SSW2, in terms of local variability in zonal wind, temperature, and CO in...

[247] Atmospheric radiation
V. Oinas. Journal Not Provided, 2016. 262 citations.
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[248] The incorporation of the Tripleclouds concept into the ´Eddington two-stream radiation scheme: solver characterization and its application to shallow cumulus clouds
Nina  rnivec and B. Mayer Atmospheric Chemistry and Physics, 2020. 3 citations.
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Abstract: Abstract. The treatment of unresolved cloud–radiation interactions in weather and climate models has considerably improved over the recent years, compared to conventional plane-parallel radiation schemes, which previously persisted in these models for multiple decades. One such improvement is the state-of-the-art Tripleclouds radiative solver, which has one cloud-free and two cloudy regions in each vertical model layer and is thereby capable of representing cloud horizontal inhomogeneity. Inspired by the Tripleclouds concept, primarily introduced by Shonk and Hogan (2008), we incorporated a second cloudy region into the widely employed ´Eddington two-stream method with the maximum-random overlap assumption for partial cloudiness. The inclusion...

[249] Millimeter-wave attenuation and delay rates due to fog/cloud conditions
H. Liebe, ..., and G. Hufford. IEEE Transactions on Antennas and Propagation, 1989. 189 citations.
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[250] Atmospheric Retrieval of Exoplanets
N. Madhusudhan. arXiv: Earth and Planetary Astrophysics, 2018. 76 citations.
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Abstract: Exoplanetary atmospheric retrieval refers to the inference of atmospheric properties of an exoplanet given an observed spectrum. The atmospheric properties include the chemical compositions, temperature profiles, clouds/hazes, and energy circulation. These properties, in turn, can provide key insights into the atmospheric physicochemical processes of exoplanets as well as their formation mechanisms. Major advancements in atmospheric retrieval have been made in the last decade, thanks to a combination of state-of-the-art spectroscopic observations and advanced atmospheric modeling and statistical inference methods. These developments have already resulted in key constraints on the atmospheric H2O abundances, temperature profiles, and other properties for several exoplanets....

[251] Line-by-line radiative transfer model for infrared spectrum of AERI
Kwang-Mog Lee, ..., and Y. Kim. Asia-Pacific Journal of Atmospheric Sciences, 2012. 4 citations.
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[252] Atmospheric Gas Absorption Knowledge in the Submillimeter: Modeling, Field Measurements, and Uncertainty Quantification
V. Mattioli, ..., and V. John. Bulletin of the American Meteorological Society, 2019. 8 citations.
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[253] Reviewing atmospheric radiative transfer modeling: new developments in high- and moderate-resolution FASCODE/FASE and MODTRAN
G. Anderson, ..., and J. Selby. Unknown journal, 1996. 28 citations.
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[254] ARTS , the atmospheric radiative transfer simulator
S. A. Buehlera, ..., and C. Verdesa. Journal Not Provided, 2004. 165 citations.
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[255] The HITRAN2012 molecular spectroscopic database
L. Rothman, ..., and G. Wagner. Journal Not Provided, 2013. 4397 citations.
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[256] Improved Weather Forecasting Using Neural Network Emulation for Radiation Parameterization
Hwan Jin Song and S. Roh Journal of Advances in Modeling Earth Systems, 2021. 23 citations.
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Abstract: In this study, a neural network (NN) emulator for radiation parameterization was developed to use in an operational weather forecasting model in the Korea Meteorological Administration. The development of the NN emulator was based on large scale training sets and 96 categories (longwave–shortwave, months, land–ocean, and clear–cloud). As the NN emulator replaced the radiation parameterization, a 60 fold speedup for the radiation process was achieved, with a decrease

of 87.26% in the total computation time. The accuracy of the NN emulator was strictly evaluated through comparison with the results obtained from the infrequent use of the original radiation scheme with the same...

[257] Recent developments in the line-by-line modeling of outgoing longwave radiation
S. A. Buehlera, ..., and P. Erikssonc. Journal Not Provided, 2005. 17 citations.
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[258] The intercomparison of radiation codes used in climate models: Long wave results
R. Ellingson, ..., and S. Fels. Journal of Geophysical Research, 1991. 273 citations.
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[259] Radiative Transfer for Exoplanet Atmospheres
K. Heng and M. Marley. arXiv: Earth and Planetary Astrophysics, 2017. 5 citations.
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Abstract: Remote sensing of the atmospheres of distant worlds motivates a firm understanding of radiative transfer. In this review, we provide a pedagogical cookbook that describes the principal ingredients needed to perform a radiative transfer calculation and predict the spectrum of an exoplanet atmosphere, including solving the radiative transfer equation, calculating opacities (and chemistry), iterating for radiative equilibrium (or not), and adapting the output of the calculations to the astronomical observations. A review of the state of the art is performed, focusing on selected milestone papers. Outstanding issues, including the need to understand aerosols or clouds and elucidating the assumptions and...

[260] Atmospheric Radiation: Theoretical Basis
R. Goody and Y. Yung. Unknown journal, 1989. 904 citations.
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[261] Radiance cascades: A novel high-resolution formal solution for multidimensional non-LTE radiative transfer
Christopher M. J. Osborne and Alexander Sannikov. RAS Techniques and Instruments, 2024. 6 citations.
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Abstract: Non-LTE radiative transfer is a key tool for modern astrophysics: it is the means by which many key synthetic observables are produced, thus connecting simulations and observations. The default approach for computing the radiation field in multidimensional solar radiative transfer models has long remained the same: a short characteristics, discrete ordinates method, formal solver. In situations with complex atmospheric structure and multiple transitions between optically-thick and -thin regimes these solvers require prohibitively high angular resolution to correctly resolve the radiation field. Here, we present the theory of radiance cascades, a technique designed to exploit structure inherent to the radiation...

[262] Optical properties.
David Buckingham. Science, 1994. 357 citations.
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[263] Sentinel-2: ESA's Optical High-Resolution Mission for GMES Operational Services
M. Drusch, ..., and P. Bargellini. Remote Sensing of Environment, 2012. 3733 citations.
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[264] Continuous temperature soundings at the stratosphere and lower mesosphere with a ground-based radiometer considering the Zeeman effect
Witali Krochin, ..., and G. Stober. Atmospheric Measurement Techniques, 2021. 9 citations.
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Abstract: Abstract. Continuous temperature observations at the stratosphere and lower mesosphere are rare. Radiometry opens the possibility by observing microwave emissions from two oxygen lines to retrieve temperature profiles at all altitudes. In this study, we present observations performed with a temperature radiometer (TEMPERA) at the Meteoswiss station at Payerne for the period from 2014 to 2017. We reanalyzed these observations with a recently developed and improved retrieval algorithm accounting for the Zeeman line splitting in the line center of both oxygen emission lines at 52.5424 and 53.0669 GHz. The new temperature retrievals were validated against MERRA2 reanalysis and the meteorological...

[265] Compound Parameterization to Improve the Accuracy of Radiation Emulator in a Numerical Weather Prediction Model
Hwan Jin Song, ..., and Hyesook Park Geophysical Research Letters, 2021. 12 citations.
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Abstract: To improve the numerical weather prediction model over Korea using a neural network (NN) radiation emulator, two types of compound parameterization (CP) were developed. Although the CP returning to the original parameterization causes a considerable increase in the computational time, this increase can be compensated by the infrequent use of the radiation scheme, thus maintaining the 60 fold speedup of the radiation process with the NN emulator. The first CP is based on the prediction of the heating rate error using the additional NN for all given input variables. In contrast, the second CP uses the cloud fraction to estimate the...

[266] Hygroscopic aerosols amplify longwave downward radiation in the Arctic
Denghui Ji, ..., and J. Notholt. Atmospheric Chemistry and Physics, 2025. 4 citations.
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Abstract: Abstract. This study investigates the impact of hygroscopic aerosols, such as sea salt and sulfate, on longwave downward radiation in the Arctic. These aerosols absorb atmospheric water vapor, leading to wet growth, increased size, and enhanced longwave downward radiation emission, defined as the aerosol infrared radiation effect. Observations of aerosols, especially their composition, are challenging during the Arctic winter. We use an emission Fourier transform spectrometer to measure aerosol composition. Observations show that the aerosol infrared radiation effect of dry aerosols is limited to about 1.45±2.00 W m 2. Wet growth significantly increases this effect. During winter, at relative humidity levels...

[267] Simulation of a clear sky satellite image in water vapor and infrared satellite M.S.G channel's
K. Bouchouicha and N. Bachari. Journal of Renewable Energies, 2015. 2 citations.
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Abstract: Radiative transfer models are an important tool for the scientific community. Such models simulate the radiative transfer processes of the atmosphere at a given wavelength or spectral region for a given set of surface and atmospheric conditions. It is used to simulate the radiances and brightness temperatures of various satellite sensors. RTTOV stands for 'Radiative Transfer for TIROS Operational Vertical Sounder' and refers to the computational efficient algorithms that have been developed by Eumetsat within the framework of SAF to meet the requirements of the operational data assimilation system. The aim of our work is to allow a simulation of...

[268] Modeling of the radiative process in an atmospheric general circulation model.
T. Nakajima, ..., and T. Kimura. Applied optics, 2000. 209 citations.
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[269] Sensitivity of trace gas abundances retrievals from infrared limb emission spectra to simplifying approximations in radiative transfer modelling
G. Stiller, ..., and A. Linden. Journal of Quantitative Spectroscopy & Radiative Transfer, 2002. 153 citations.
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[270] Line shape and the water vapor continuum
S. Clough, ..., and R. Davies. Atmospheric Research, 1989. 739 citations.
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[271] Submillimeter, millimeter, and microwave spectral line catalog.
H. Pickett, ..., and H. Müller. Applied optics, 1985. 1761 citations.
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[272] FLEX End-to-End Mission Performance Simulator
J. Vicent, ..., and J. Moreno. IEEE Transactions on Geoscience and Remote Sensing, 2016. 53 citations.
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[273] Fast radiative transfer model to simulate spectroscopic measurements of outgoing IR radiances in cloudy conditions
A. Rublev and A. Trotsenko. Unknown journal, 2013. 0 citations.
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[274] A physics-inspired neural network for short-wave radiation parameterization
Nikolay B. Yavich, ..., and E. Burnaev. Journal of Inverse and Ill-posed Problems, 2024. 1 citations.
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Abstract: Abstract Radiation parameterization schemes are crucial components of weather and climate models, but they are also known to be computationally intensive. In recent decades, researchers have attempted to emulate these schemes using neural networks, with more attention to convolutional neural networks. However, in this paper, we explore the potential of recurrent neural networks (RNNs) for predicting solar heating rates. Our architecture was trained and tested using long-term hindcast data from the Pechora Sea region, with the conventional RRTMG scheme serving as a shortwave parameterization. Our findings show that the RNN offers rapid learning, fast inference, and excellent data fitting. We...

[275] An Accurate, Extensive, and Practical Line List of Methane for the HITEMP Database
R. Hargreaves, ..., and L. Rothman. The Astrophysical Journal Supplement Series, 2020. 154 citations.
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Abstract: A methane line list for the HITEMP spectroscopic database, covering 0–13,400 cm 1 (>746 nm), is presented. To create this compilation, ab initio line lists of 12CH4 from Rey et al. ApJ, 847, 105 (provided at separate temperatures in the TheoReTS information system), are now combined with HITRAN2016 methane data to produce a single line list suitable for high-temperature line-by-line calculations up to 2000 K. An effective-temperature interpolation model was created in order to represent continuum-like features over the temperature range of study. This model is advantageous to previously used approaches that employ so-called “super-lines,” which are suitable only at a...

[276] Resolving Low Cloud Feedbacks Globally With E3SM High Res MMF: Agreement With LES but Stronger Shortwave Effects
Liran Peng, ..., and M. Pritchard. Journal of Advances in Modeling Earth Systems, 2025. 0 citations.
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Abstract: This study investigates low cloud feedback in a warmer climate using global simulations from the High Resolution Multi scale Modeling Framework (HR MMF), which explicitly simulates small scale eddies globally. Two 5 year simulations—one with present day sea surface temperatures (SSTs) and a second with SSTs warmed uniformly by 4 K—reveal a positive global shortwave cloud radiative effect (SWCRE = 0.3 W/ m2 ${\mathrm{m}}^{2}$ /K), comparable to estimates from CMIP models. As the climate warms, significant reductions in low cloud cover occur over stratocumulus regions. This study is the first attempt to compare HR MMF results with predictions from idealized large eddy simulations from the CGILS intercomparison. Despite...

[277] Radiative transfer model for simulating high-resolution satellite images
F. Gascon, ..., and M. Lefevre. IEEE Trans. Geosci. Remote. Sens., 2001. 27 citations.
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J. Humlí ek Journal of Quantitative Spectroscopy & Radiative Transfer, 1982. 484 citations.
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[279] Cirrus induced polarization in 122 GHz aura Microwave Limb Sounder radiances
C. Davis, ..., and R. Harwood. Geophysical Research Letters, 2005. 41 citations.
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[280] An observational radiative constraint on hydrologic cycle intensification
A. DeAngelis, ..., and A. Hall. Nature, 2015. 148 citations.
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[281] Atmospheric observations of the water vapour continuum in the near-infrared windows between 2500 and 6600 cm 1
J. Elsey, ..., and K. Shine. Atmospheric Measurement Techniques, 2020. 11 citations.
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Abstract: Abstract. Water vapour continuum absorption is potentially important for both closure of the Earth's energy budget and remote sensing applications. Currently, there are significant uncertainties in its characteristics in the near-infrared atmospheric windows at 2.1 and 1.6 µ m. There have been several attempts to measure the continuum in the laboratory; not only are there significant differences amongst these measurements, but there are also difficulties in extrapolating the laboratory data taken at room temperature and above to temperatures more widely relevant to the atmosphere. Validation is therefore required using field observations of the real atmosphere. There are currently no published...

[282] Decadal Climate Simulations Using Accurate and Fast Neural Network Emulation of Full, Longwave and Shortwave, Radiation*
V. Krasnopolsky, ..., and A. Belochitski. Monthly Weather Review, 2008. 40 citations.
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[283] Evidence of successful methane mitigation in one of Europe's most important oil production region
G. Kuhlmann, ..., and Dominik Brunner. Atmospheric Chemistry and Physics, 2025. 5 citations.
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Abstract: Abstract. Reducing methane emissions from the oil and gas production infrastructure is a cost-effective way for limiting global warming. In 2019, a measurement campaign in southern Romania found emission rates from the oil and gas sector substantially higher than the nationally reported emissions, with a few high-emitting sources (“super-emitters”) contributing disproportionately to total emissions. In 2021, our follow-up airborne remote sensing campaign, covering

over 80 % of production sites, revealed a marked decrease in super-emitters. The observed change in the number of emitters is consistent with an emission reduction by 20 %–60 % from 2019 to 2021. This reduction is...

[284] Ground based near infrared observations of the Venus nightside: The thermal structure and water abundance near the surface
V. Meadows and D. Crisp. Journal of Geophysical Research, 1996. 318 citations.
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[285] The sigma -IASI code for the calculation of infrared atmospheric radiance and its derivatives
U. Amato, ..., and M. Viggiano. Environ. Model. Softw., 2002. 76 citations.
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[286] Update of the HITRAN collision-induced absorption section
T. Karman, ..., and W. J. van der Zande. Icarus, 2019. 148 citations.
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[287] A new snow bidirectional reflectance distribution function model in spectral regions from UV to SWIR: Model development and application to ground-based, aircraft and satellite observations
L. Mei, ..., and J. Burrows. ISPRS Journal of Photogrammetry and Remote Sensing, 2022. 13 citations.
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[288] RRTM: A rapid radiative transfer model
E. Mlawer, ..., and S. Clough. Unknown journal, 1996. 5 citations.
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[289] RESEARCH ON MICROPHYSICAL PROPERTIES OF A VARIETY OF NONSPHERICAL AEROSOL PARTICLES
Y. Liu, ..., and C. Shu. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2019. 1 citations.
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Abstract: Abstract. In order to study the environment or climate of an area, it is necessary to understand the composition of atmospheric aerosol particles, as well as microphysical properties, such as extinction cross section, scattering cross section, polarization degree, etc. For a long time, when calculating the microphysical properties of atmospheric aerosol particles, the aerosol particles are always be considered as spheres. Mie theory has been used to calculate the scattering properties of spherical particles with high accuracy. However, in reality, aerosol particles are not only spherical, they have complex composition and different shapes. The influence of non-spherical aerosol particles on...

[290] Coupled surface-atmosphere reflectance (CSAR) model: 2. Semiempirical surface model usable with NOAA advanced very high resolution radiometer data
H. Rahman, ..., and M. Verstraete. Journal of Geophysical Research, 1993. 542 citations.
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[291] AMARTIS v2: 3D Radiative Transfer Code in the [0.4; 2.5 µm] Spectral Domain Dedicated to Urban Areas
Colin Thomas, ..., and S. Lachérade. Remote. Sens., 2011. 19 citations.
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Abstract: Abstract: The availability of new very high spatial resolution sensors has for the past few years allowed a precise description of urban areas, and thus the settlement of specific ground or atmosphere characterization methods. However, in order to develop such techniques, a radiative transfer tool dedicated to such an area is necessary. AMARTIS v2 is a new radiative transfer code derived from the radiative transfer code AMARTIS specifically dedicated to urban areas. It allows to simulate airborne and spaceborne multiangular observations of 3D scenes in the [0.4; 2.5µm] domain with the ground's geometry, urban materials optical properties, atmospheric modeling and...

[292] An Evaluation of Radiation Parameterizations in a Meso-Scale Weather Prediction Model Using Satellite Flux Observations
Jihee Choi, ..., and Won-Jun Choi. Remote Sensing, 2025. 0 citations.
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Abstract: This study evaluates the forecast performance of four radiation parameterization schemes—the Rapid Radiative Transfer Model for General Circulation Models (RRTMG), its improved version RRTMG-K, the infrequently applied variant, RRTMG-K60x, and the neural network emulator, RRTMG-KNN, within a high-resolution numerical weather prediction (NWP) model. The evaluation uses satellite-derived observations of Outgoing Longwave Radiation (OLR) and Outgoing Shortwave Radiation (OSR) from the Clouds and the Earth's Radiant Energy System (CERES) over the Korean Peninsula during 2020, including an extreme case study of Typhoon Haishen. Results show that RRTMG-K reduces RMSEs by 4.8% for OLR and 17.5% for OSR relative to RRTMG, primarily...

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L. Hoffmann, ..., and M. Riese. Advances in Space Research, 2005. 25 citations.
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[295] The ISSWG line-by-line inter-comparison experiment
S. Tjemkes, ..., and R. Knuteson. Journal of Quantitative Spectroscopy & Radiative Transfer, 2003. 71 citations.
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[296] Retrieval of Effective Cloud Radiative Properties from Ground Based Spectral Measurements
J. Moncet and S. Clough. Optical Remote Sensing of the Atmosphere, 1997. 0 citations.
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Abstract: A fast and numerically accurate model for monochromatic radiative transfer in scattering atmospheres has been developed to extend the capabilities of the existing LBLRTM line-by-line model [Clough et al., 1992] to the treatment of clouds and aerosols. The algorithm is based on the adding-doubling method and is specifically designed to perform radiance calculations in both the thermal and solar regimes using any specified number of computational streams. The efficient implementation of the adding-doubling scheme makes it possible to use the multiple-scattering algorithm in retrieval applications, an essential requirement for the intended use of the algorithm in atmospheric validation studies. The...

[297] INCLUSION OF A NEW RADIATIVE TRANSFER SCHEME IN THE MAR MODEL AND VALIDATION ON BELGIUM INCLUSION D'UN NOUVEAU SCHÉMA DE TRANSFERT RADIATIF DANS LE MODÈLE MAR ET VALIDATION SUR LA BELGIQUE
Jean-François Grailet. Journal Not Provided, Unknown year. 0 citations.
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[298] On cloud ice induced absorption and polarisation effects in microwave limb sounding
P. Eriksson, ..., and S. Buehler. Atmospheric Measurement Techniques, 2011. 12 citations.
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Abstract: Abstract. Microwave limb sounding in the presence of ice clouds was studied by detailed simulations, where clouds and other atmospheric variables varied in three dimensions and the full polarisation state was considered. Scattering particles were assumed to be horizontally aligned oblate spheroids with a size distribution parameterized in terms of temperature and ice water content. A general finding was that particle absorption is significant for limb sounding, which is in contrast to the down-looking case, where it is usually insignificant. Another general finding was that single scattering can be assumed for cloud optical paths below about 0.1, which is thus...

[299] VSTAR - a new high-spectral-resolution atmospheric radiative transfer code for Mars and other planets
J. Bailey. Unknown journal, 2006. 7 citations.
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[300] Recent advances in the science of RTTOV
M. Matricardi. Journal Not Provided, 2006. 0 citations.
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[301] Effect of Rocky Mountains and Tibetan Plateau 1998 Spring Land Temperature on N. American and East Asian Summer Precipitation Anomalies
H. Nayak, ..., and R. Vasic. Journal of Geophysical Research: Atmospheres, 2025. 0 citations.
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Abstract: This work follows up on the GEWEX/LS4P Phase I (LS4P I) experiments, a community effort highlighting the spring land surface temperature anomalies in the Tibetan Plateau (TP) as a useful source for subseasonal to seasonal (S2S) prediction of summer precipitation in global hot spot regions, particularly in East Asia and North America. This paper extends the investigation to both the US Rocky Mountain (RM) region and the TP, considering the 1998 summer drought/flood event in North America/East Asia, respectively, as a case study. A previously developed initialization method for land surface temperature/subsurface temperature (LST/SUBT) is used in the NCEP Global Forecast...

[302] Accurate and Fast Neural Network Emulations of Model Radiation for the NCEP Coupled Climate Forecast System: Climate Simulations and Seasonal Predictions*
V. Krasnopolsky, ..., and A. Belochitski. Monthly Weather Review, 2010. 69 citations.
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[303] Efficient radiative transfer simulations for a broadband infrared radiometer—Combining a weighted mean of representative frequencies approach with frequency selection by simulated annealing
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[304] History of one family of atmospheric radiative transfer codes
G. Anderson, ..., and J. Selby. Unknown journal, 1994. 39 citations.
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[305] The CAMS reanalysis of atmospheric composition
A. Inness, ..., and M. Suttie. Atmospheric Chemistry and Physics, 2018. 1011 citations.
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Abstract: Abstract. The Copernicus Atmosphere Monitoring Service (CAMS) reanalysis is the latest global reanalysis dataset of atmospheric composition produced by the European Centre for Medium-Range Weather Forecasts (ECMWF), consisting of three-dimensional time-consistent atmospheric composition fields, including aerosols and chemical species. The dataset currently covers the period 2003–2016 and will be extended in the future by adding 1 year each year. A reanalysis for greenhouse gases is being produced separately. The CAMS reanalysis builds on the experience gained during the production of the earlier Monitoring Atmospheric Composition and Climate (MACC) reanalysis and CAMS interim reanalysis. Satellite retrievals of total column CO; tropospheric...

[306] Line by line calculation of atmospheric fluxes and cooling rates: 2. Application to carbon dioxide, ozone, methane, nitrous oxide and the halocarbons
S. Clough and M. Iacono. Journal of Geophysical Research, 1995. 428 citations.
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[307] Retrieval of Aerosol Properties from in Situ, Multi-Angle Light Scattering Measurements Using Invertible Neural Networks
R. Boiger, ..., and M. Gysel-Beer. SSRN Electronic Journal, 2021. 17 citations.
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Abstract: Atmospheric aerosols have a major influence on the earths climate and public health. Hence, studying their properties and recovering them from light scattering measurements is of great importance. State of the art retrieval methods such as pre-computed look-up tables and iterative, physics-based algorithms can suffer from either accuracy or speed limitations. These limitations are becoming increasingly restrictive as instrumentation technology advances and measurement complexity increases. Machine learning algorithms offer new opportunities to overcome these problems, by being quick and precise. In this work we present a method, using invertible neural networks to retrieve aerosol properties from in situ light scattering...

[308] Moderate Spectral Resolution Radiative Transfer Modeling Based on Modified Correlated-k Method
Shi-Keng Yang, ..., and C. Gautier. Unknown journal, 1999. 1 citations.
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[309] Representative wavelengths absorption parameterization applied to satellite channels and spectral bands
J. Gasteiger, ..., and Oliver Lemke. Journal of Quantitative Spectroscopy & Radiative Transfer, 2014. 123 citations.
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[310] Radiative transfer calculations for a passive microwave satellite sensor : comparing a fast model and a line-by-line model
S. Buehler, ..., and V. John. Journal of Geophysical Research, 2006. 33 citations.
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[311] Estudo de propriedades de nuvens no contexto de sensoriamento remoto com satélites usando códigos de transferência radiativa
Marina Monteiro Mendonça. Unknown journal, 2017. 0 citations.
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Abstract: Clouds play a fundamental role in the terrestrial radiative balance, and knowledge of its micro and macrophysical properties is important for the study of global climate. Cloud development is linked to the dynamics of the atmosphere, thermal and radiative energy flows to the surface, and also depends crucially on the size of its hydrometeors. An important tool for the study of large-scale cloud hydrometeors is satellite remote sensing, which represents an alternative to study cloud properties at large spatial scales. However, there are currently no studies to support analyzes of microphysical properties of clouds from geostationary platforms. In this work,...

[312] Recent developments in the line-by-line modeling of outgoing longwave radiation
S. Buehler, ..., and P. Eriksson. Journal of Quantitative Spectroscopy & Radiative Transfer, 2006. 31 citations.
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[313] A RADIATION TRANSFER SOLVER FOR ATHENA USING SHORT CHARACTERISTICS
S. Davis, ..., and Yan-Fei Jiang. The Astrophysical Journal Supplement Series, 2012. 104 citations.
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Abstract: We describe the implementation of a module for the Athena magnetohydrodynamics (MHD) code that solves the time-independent, multi-frequency radiative transfer (RT) equation on multidimensional Cartesian simulation domains, including scattering and non-local thermodynamic equilibrium (LTE) effects. The module is based on well known and well tested algorithms developed for modeling stellar atmospheres, including the method of short characteristics to solve the RT equation, accelerated Lambda iteration to handle scattering and non-LTE effects, and parallelization via domain decomposition. The module serves several purposes: it can be used to generate spectra and images, to compute a variable Eddington tensor (VET) for full radiation...

[314] Atmospheric Transmittance And Radiance: The LOWTRAN 5 Code
F. X. Kneizys, ..., and W. Gallery. Unknown journal, 1978. 15 citations.
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[315] Application of Ground-Based Microwave Radiometers to Optimize the Estimation Method of Cloud Liquid Water on the Tibetan Plateau
Yajing Liu, ..., and Qiang Zhang. Advances in Atmospheric Sciences, 2025. 0 citations.
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[316] Characterization and Error Analysis of Profiles Retrieved From Remote Sounding Measurements
C. Rodgers. Journal of Geophysical Research, 1990. 766 citations.
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[317] Three Dimensional Atmospheric Radiative Transfer-Applications and Methods Comparison
Robert F. Cahalan and F. Einaudi. Unknown journal, 2001. 0 citations.
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[318] Retrieval of Surface Solar Radiation through Implicit Albedo Recovery from Temporal Context
Yael Frischholz, ..., and M. Lehning. ArXiv, 2025. 0 citations.
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Abstract: Accurate retrieval of surface solar radiation (SSR) from satellite imagery critically depends on estimating the background reflectance that a spaceborne sensor would observe under clear-sky conditions. Deviations from this baseline can then be used to detect cloud presence and guide radiative transfer models in inferring atmospheric attenuation. Operational retrieval algorithms typically approximate background reflectance using monthly statistics, assuming surface properties vary slowly relative to atmospheric conditions. However, this approach fails in mountainous regions where intermittent snow cover and changing snow surfaces are frequent. We propose an attention-based emulator for SSR retrieval that implicitly learns to infer clear-sky surface reflectance from...

[319] Machine Learning for Clouds and Climate
Tom Beucler, ..., and P. Gentine. Journal Not Provided, 2020. 26 citations.
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[320] New tools for modeling radiation propagation in cloud-aerosol atmosphere in UV, visible, and near IR
E. Zege, ..., and A. Prikhach. Unknown journal, 1993. 1 citations.
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[321] Line-by-Line Calculations of Atmospheric Fluxes and Cooling Rates: Application to Water Vapor
S. Clough, ..., and J. Moncet. Journal of Geophysical Research, 1992. 758 citations.
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[322] Authors' response to reviewers
András Gelencsér. Unknown journal, 2021. 0 citations.
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Abstract: . Atmospheric radiative transfer models (RTMs) are software tools that help researchers in understanding the radiative processes occurring in the Earth's atmosphere. Given their importance in remote sensing applications, the intercomparison of atmospheric RTMs is therefore one of the main tasks to evaluate model performance and identify the characteristics that differ between models. This can be a tedious tasks that requires a good knowledge of the model inputs-outputs and generation of large databases of consistent simulations. With the evolution of these software tools, their increase in complexity bears implications 5 towards their use in practical applications and model intercomparison. Existing...

[323] Studies for the Odin sub-millimetre radiometer: I. Radiative transfer and instrument simulation
P. Eriksson, ..., and J. Noë. Canadian Journal of Physics, 2002. 30 citations.
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[324] Forward-inverse modeling based on scalar and vector radiative transfer models for coupled atmosphere-surface systems and machine learning tools
K. Stamnes, ..., and J. Stamnes. Unknown journal, 2020. 0 citations.
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Abstract: <p>Reliable retrieval of atmospheric and surface properties from sensors deployed on satellite platforms rely on accurate simulations of the electromagnetic (EM) signal measured by such sensors. A forward radiative transfer (RT) model of the coupled atmosphere-surface system can be used to simulate how the EM signal responds to changes in atmospheric and surface properties. Realistic RT modeling is a prerequisite for solving the inverse problem, i.e. to infer atmospheric and surface parameters from the EM signals measured at the top of the atmosphere. The surface may consist of a soil-plant canopy, a snow/ice covered surface or an open water...

[325] The Arctic Weather Satellite radiometer
P. Eriksson, ..., and Ville Kangas. Atmospheric Measurement Techniques, 2025. 3 citations.

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Abstract: Abstract. The Arctic Weather Satellite (AWS) is a project led by the European Space Agency (ESA) that has several novel aspects. From a technical perspective, it serves as a demonstrator of how to expand the network of operational satellite-based microwave sensors cost-effectively and acts as the proto-flight model for a suggested constellation of satellites, denoted as EUMETSAT Polar System (EPS) Sterna. The design philosophy has been to reduce complexity and instead focus the efforts on critical parts and characterise the instrument well before the launch. The single instrument onboard is a 19-channel microwave cross-track radiometer. There are 15 channels covering...

[326] Synergetic Ground-Based MW + IR Method for Ozone Profiling
Yu.I. Bordovskaya, ..., and A. Poberovskii. Atmospheric and Oceanic Optics, 2025. 0 citations.
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[327] An Accurate Parameterization of the Radiative Properties of Water Clouds Suitable for Use in Climate Models
Yongxiang Hu and K. Stamnes. Journal of Climate, 1993. 431 citations.
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[328] The adding method for multiple scattering calculations of polarized light
J. D. Haan, ..., and J. Hovenier. Astronomy and Astrophysics, 1987. 590 citations.
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[329] ARTS, the atmospheric radiative transfer simulator
S. Buehler, ..., and C. Verdes. Journal of Quantitative Spectroscopy & Radiative Transfer, 2005. 187 citations.
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[330] Open-source High-resolution Exoplanet Atmosphere Retrievals with POSEIDON
Ruizhe Wang, ..., and Nikole K. Lewis. The Astronomical Journal, 2025. 1 citations.
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Abstract: High-resolution spectroscopy (R > 25,000) has opened new opportunities to characterize exoplanet atmospheres from the ground. By resolving individual lines in planetary emission and transmission spectra, one can sensitively probe the chemical inventory and temperature structure of exoplanets. However, a significant challenge to reliable and reproducible atmospheric inferences from high-resolution data sets has been the lack of open-source codes for high-resolution retrievals. Here, we present a unified high-resolution retrieval framework, for both emission and transmission spectroscopy, made publicly available within the open-source POSEIDON retrieval code. Our high-resolution retrieval framework is fast, accessible (no GPUs required), and well documented via Python...

[331] Research into Radiative Transfer Modeling and Applications.
C. Whitney, ..., and Carlton R. Gray. Unknown journal, 1973. 6 citations.
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[332] An improved equation for the radio refractive index of air
G. D. Thayer. Radio Science, 1974. 505 citations.
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[333] A new proposal for an easy-to-calibrate DNI clear-sky model: a performance analysis and validation in different geographical locations
César D. Sánchez-Segura and Manuel I. Peña Cruz. Nova Scientia, 2025. 0 citations.
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Abstract: Clear sky models can be used as a reference for sizing solar technology applications and for solar irradiance forecasting purposes. Properly defining the parameters of each clear sky model implies knowing the altitude, latitude, longitude, as well as various climatic characteristics of the study site, which makes its implementation difficult. Derived from the above, in this work a new easy-calibration methodology was developed to obtain a functional clear sky model for any day of the year and any geographical location. By proposing calibration coefficients obtained from only a couple of DNI measurements, and without taking into account the geographical characteristics...

[334] Scattering, Absorption, and Emission of Light by Small Particles
L. Travis, ..., and A. Lacis. Unknown journal, 2002. 2127 citations.
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[335] Space-borne remote sensing of CO2, CH4, and N2O by integrated path differential absorption lidar: a sensitivity analysis
G. Ehret, ..., and S. Houweling. Applied Physics B, 2008. 340 citations.
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[336] SAAC-Net: deep neural network-based model for atmospheric correction in remote sensing
Maitrik Shah, ..., and Hasit Parmar. International Journal of Remote Sensing, 2023. 4 citations.
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Abstract: ABSTRACT Atmospheric correction eliminates corruption in reflectance captured by satellite images due to atmospheric elements like gases, aerosols, and water vapours. Existing physics-based approaches employ radiative transfer models constructed using lookup tables computed for different atmospheric parameters. However, these approaches are computationally expensive and rely on estimates of parameters that are difficult to sense accurately. This paper proposes a deep learning model as an alternative to physics-based approaches. We present an end-to-end deep neural network trained on seasonally and spatially rich Landsat 8 satellite images without explicit atmospheric parameterization along with our analysis and its validation. We validate the model's...

[337] Atmospheric Transmittance And Radiance Calculations Using Line-By-Line Computer Models
D. P. Edwards and Robert Hooke. Unknown journal, 1988. 41 citations.
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[338] Expected performance of the Superconducting Submillimeter Wave Limb Emission Sounder compared with aircraft data
S. Buehler, ..., and P. Eriksson. Radio Science, 2005. 9 citations.
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[339] Atmospheric radiation: 1975–1983
W. Wiscombe. Reviews of Geophysics, 1983. 9 citations.
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[340] Measurement of tropospheric/stratospheric transmission at 10–35 GHz for H2O retrieval in low Earth orbiting satellite links

P. Eriksson, ..., and S. Bühler. Radio Science, 2003. 19 citations.
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[341] Multiple Scattering Parameterization in Thermal Infrared Radiative Transfer
Q. Fu, ..., and A. Grossman. Journal of the Atmospheric Sciences, 1997. 292 citations.
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[342] Representing 3 D cloud radiation effects in two stream schemes: 1. Longwave considerations and effective cloud edge length
Sophia Schäfer, ..., and B. Mayer. Journal of Geophysical Research: Atmospheres, 2016. 55 citations.
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[343] Inverse Methods for Atmospheric Sounding: Theory and Practice
C. Rodgers. Unknown journal, 2000. 4822 citations.
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[344] A polarized discrete ordinate scattering model for simulations of limb and nadir long wave measurements in 1 D/3 D spherical atmospheres
C. Emde, ..., and C. Teichmann. Journal of Geophysical Research, 2004. 113 citations.
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[345] A practical guide to coding line-by-line trace gas absorption in Earth's atmosphere
S. Korkin, ..., and A. Lyapustin. Journal of Quantitative Spectroscopy and Radiative Transfer, 2025. 4 citations.
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[346] Benefits of Stochastic Weight Averaging in Developing Neural Network Radiation Scheme for Numerical Weather Prediction
Hwan Jin Song, ..., and Park-Sa Kim Journal of Advances in Modeling Earth Systems, 2021. 10 citations.
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Abstract: Stochastic weight averaging (SWA) was applied to improve the radiation emulator based on a sequential neural network (SNN) in a numerical weather prediction model over Korea. While the SWA has advantages in terms of generalization such as the ensemble model, the computational cost is maintained at the same level as that of a single model. In this study, the performances of both emulators were evaluated under ideal and real case frameworks. Various sensitivity experiments using different sampling ratios, activation functions, hidden layers, and batch sizes were also conducted. The emulators showed a 60 fold speedup for the radiation processes and 84%–87%...

[347] Machine Learning Based Parametrization of Gaseous Optical Properties and VANET Anomaly Detection for Accelerated Climate and Cyber Physical Simulations
Abdul Razzaq, ..., and Hussain Dawood. Transactions on Emerging Telecommunications Technologies, 2025. 0 citations.
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Abstract: This investigation delineates a dual domain computational paradigm integrating machine learning (ML) based parametrization of gaseous optical properties with ensemble driven anomaly detection in Vehicular Ad Hoc Networks (VANETs), aimed at accelerating predictive fidelity in climate cyber physical simulations. The study formulates a Random Forest (RF) surrogate model to approximate nonlinear radiative transfer coefficients and simultaneously classify spatiotemporally correlated anomalies induced by cyber physical perturbations within VANET topologies. A synthetically constructed dataset comprising 500 multi dimensional vehicular communication profiles encoding instantaneous velocity vectors, geospatial coordinates, signal to noise ratios, inter vehicular latency, and communication fidelity metrics was employed for rigorous model training and validation. The surrogate framework achieved a coefficient...

[348] Machine learning for numerical weather and climate modelling: a review
C. D. Burgh-Day and Tennessee Leeuwenburg. Geoscientific Model Development, 2023. 113 citations.
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Abstract: Abstract. Machine learning (ML) is increasing in popularity in the field of weather and climate modelling. Applications range from improved solvers and preconditioners, to parameterization scheme emulation and replacement, and more recently even to full ML-based weather and climate prediction models. While ML has been used in this space for more than 25 years, it is only in the last 10 or so years that progress has accelerated to the point that ML applications are becoming competitive with numerical knowledge-based alternatives. In this review, we provide a roughly chronological summary of the application of ML to aspects of weather and...

[349] The k-bin tool: Fast and flexible k-distribution algorithms written in Python
N. Madenach, ..., and J. Fischer. Journal of Quantitative Spectroscopy and Radiative Transfer, 2024. 1 citations.
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[350] Vertically Recurrent Neural Networks for Sub Grid Parameterization
P. Ukkonen and M. Chantry. Journal of Advances in Modeling Earth Systems, 2025. 3 citations.
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Abstract: Machine learning has the potential to improve the physical realism and/or computational efficiency of parameterizations. A typical approach has been to feed concatenated vertical profiles to a dense neural network. However, feed forward networks lack the connections to propagate information sequentially through the vertical column. Here we examine if predictions can be improved by instead traversing the column with recurrent neural networks (RNNs) such as Long Short Term Memory (LSTMs). This method encodes physical priors (locality) and uses parameters more efficiently. Firstly, we test RNN based radiation emulators in the Integrated Forecasting System. We achieve near perfect offline accuracy, and the forecast skill of...

[351] Prescribing the aerosol effective radiative forcing in the Simple Cloud-Resolving E3SM Atmosphere Model v1
N. Mahfouz, ..., and Susannah M. Burrows. Atmospheric Chemistry and Physics, 2025. 1 citations.
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Abstract: Abstract. Aerosol effective radiative forcing critically influences climate projections but remains poorly constrained. Using the Simple Cloud-Resolving E3SM Atmosphere Model (SCREAM) v1 configuration, we assess the sensitivity of the radiative forcing due to anthropogenic aerosol changes using a simplified prescribed aerosol scheme (SPA) derived from E3SM v3. Nudged simulations at 3 and 12 km horizontal grid spacings reveal a more negative aerosol forcing than the reference 100 km E3SM v3 whence the SPA properties are derived. The resulting globally averaged aerosol forcing signal is largely due to aerosol–cloud interactions and exhibits little overall resolution sensitivity, while hints of resolution sensitivity...

[352] Advances in Atmospheric Radiation: Theories, Models, and Their Applications. Part I: Atmospheric Gas Absorption and Particle Scattering
Hua Zhang, ..., and Wenwen Li. Journal of Meteorological Research, 2024. 7 citations.
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[353] Review of solar spectral irradiance modelling at ground level: Current methods and machine learning opportunities
Yuexing Yang, ..., and Yupeng Wu. Energy, 2026. 0 citations.
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