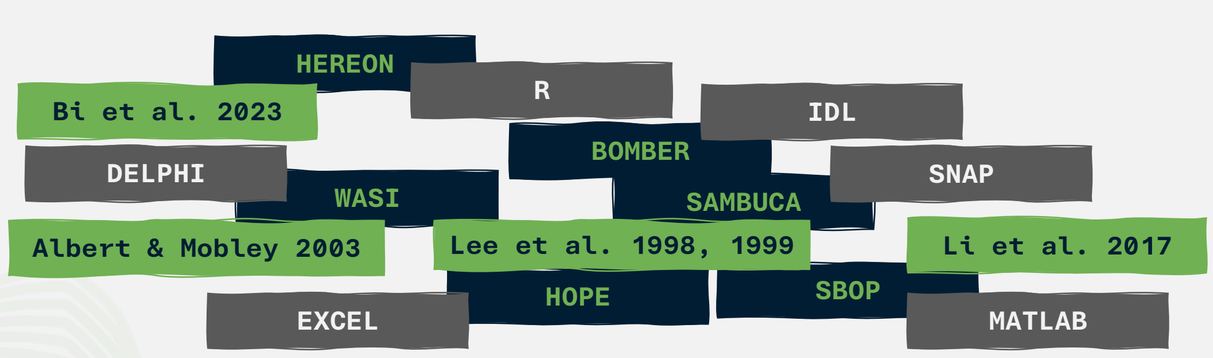
A modular open-source bio-optical Python framework for forward and inverse modeling

Marcel König[1,2], Kelly L. Hondula[2], Phillip Noel[2], Nicholas R. Vaughn[2], Dagmar Müller[1], Kerstin Stelzer[1], Carsten Brockmann[1], Gregory P. Asner[2,3]

[1] Brockmann Consult GmbH, Hamburg, Germany
[2] Center for Global Discovery and Conservation Science, Arizona State University, Tempe, AZ, USA
[3] School of Ocean Futures, Arizona State University, Hilo, HI, USA

Why did we reinvent the wheel?

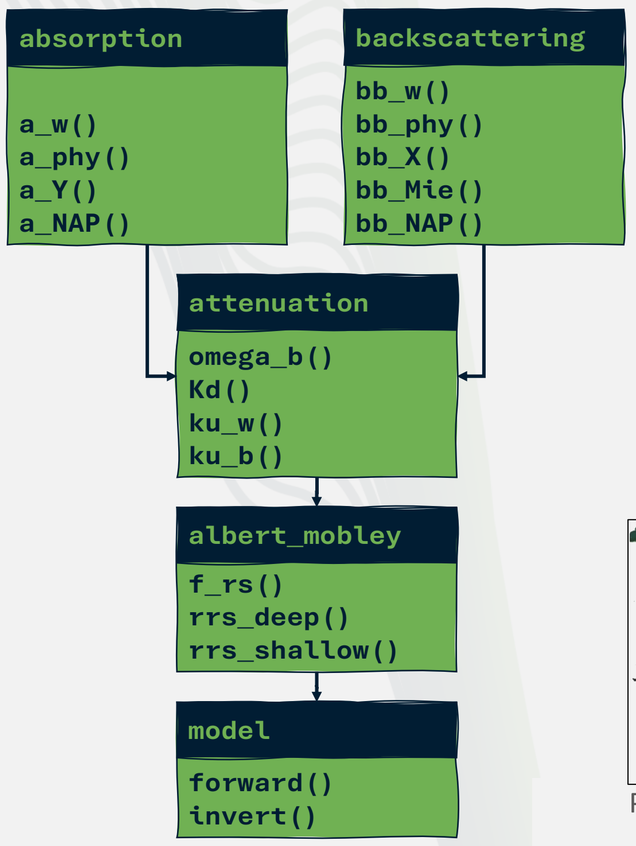
- There are **many great algorithms and** pieces of **software** out there
- **BUT few are easily accessible** and **full control** over single parts **is often limited**
- This **complicates** further **development and integration** into larger processing chains
- and results in **wasting time** by **recoding** and **debugging**



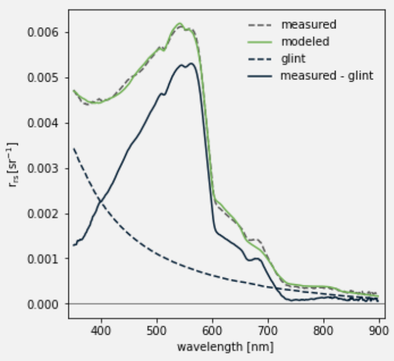
The bio_optics Python package

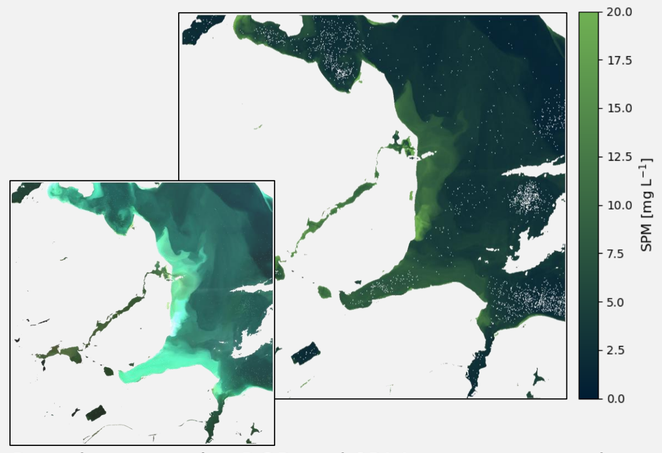
- **Modular architecture** to maximize **user control** and enable **construction** of new algorithms
- **Lower-level functions** (e.g., `a_Y()`) can be **run stand-alone** or **combined to build higher-level algorithms**
- **Functions** can be **replaced** by **measurements**
- **Analytical models** for **optically deep and shallow water** (e.g., Albert & Mobley 2003; Lee et al. 1998, 1999; Bi et al. 2023) as well as **water surface reflectance / glint** models (e.g., Gege 2012; Lin et al. 2023)
- **Forward** and **inverse methods** available
- **Collection of empirical and semi-analytical models** (e.g., HICO algorithms for CHL, CDOM and Turbidity; Jiang et al. 2021 algorithm for SPM, and many more)
- Built on **established Python packages** (numpy, scipy, pandas, lmfit)
- Additional **functions to ease** data **workflows** (e.g., spectral resampling, find the closest band, OWTs, Forel-Ule scale, QWIP, OPSHAL, and many more)

An example for how lower-level functions and modules can be combined to build higher-level algorithms.



Example application of the 4C glint correction on field spectroscopy data.

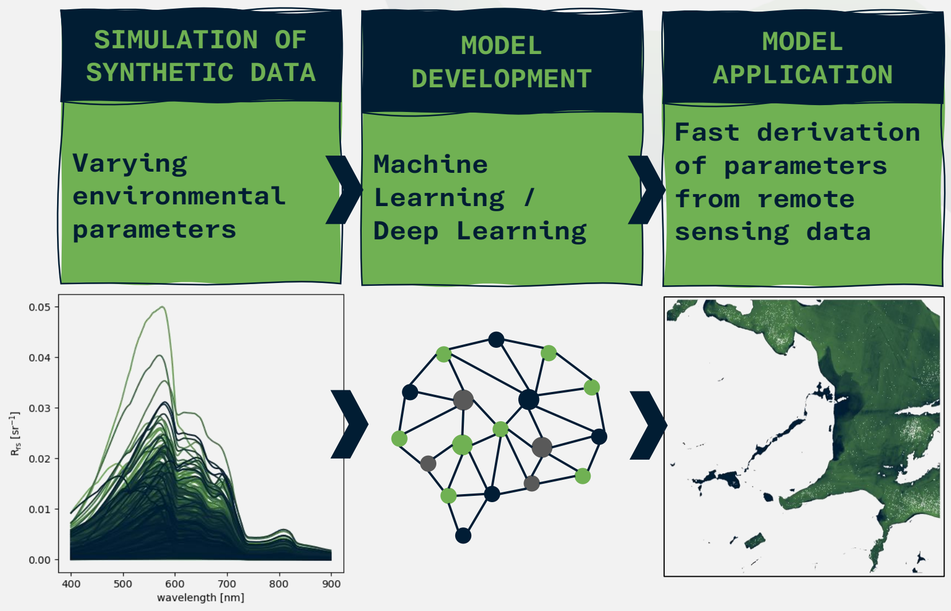




Pseudo true-color RGB and SPM map generated using `spm.jiang(Rrs, wavelengths)`

What's next?

- Integration of **analytical partial derivatives** and **Optimal Estimation** (OE) for rigorous **uncertainty estimation**
- Extension with **machine learning** and **deep learning** techniques and **spectral-spatial** approaches
- Continuous **integration** of **existing and novel algorithms**
- Continuous **consolidation** in terms of **documentation**, **naming conventions**, bugfixing, and **performance improvement** (e.g., through parallelization and vectorization)
- Enhanced **collaboration** with the bio-optical **community**
- Application in **teaching** and **training**?



SCAN ME!

Contact | Marcel König
E-Mail | marcel.koenig@brockmann-consult.de
Tel | +49 (0)40 69 63 89 – 300
www | https://www.brockmann-consult.de
LinkedIn | https://www.linkedin.com/company/brockmann-consult/

Center for Global Discovery and Conservation Science
Arizona State University

bio_optics is **freely available** at **https://github.com/CMLandOcean/bio_optics**

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