Redouane Lguensat

PhD | RE | Climate Data Scientist

IPSL, Sorbonne Université
Jussieu campus, Paris, France
✉ *redouane.lguensat "at" ipsl.fr*
redouanelg.github.io

Machine Learning for Climate modeling

Research Interests

Machine Learning, Computer Vision, Numerical Modeling, Data Assimilation, Climate Change Impacts

Current Position

Since Dec 2021 **IRD Research Engineer / Statistician**,
ESPRI-MOD team at Institut Pierre-Simon Laplace / Sorbonne Université
Bias correction and downscaling of climate model simulations for climate change impact studies, with a focus on developing countries

Projects

2023-2031 **PEPR TRACCS** *PC6 and PC10*

- Co-lead of WP2 in PC10: Statistical modeling and machine learning for emulation and downscaling
- Collaborator in PC6: Surrogate modeling for climate model tuning

2022-2030 **GAIA Data** *Tasks 3.1/3.2*

- NLP-based tools for vocabulary and catalogs

PhD Thesis (10/2014 - 10/2017)

Topic **Learning from Ocean Remote Sensing data: from Analog methods to Deep Learning**

Institution IMT Atlantique (ex Télécom Bretagne) /Université Bretagne Loire

Supervisor Prof. Ronan Fablet

Committee

- Prof. Sylvie Thiria - Sorbonne Université (Chair)
- Prof. Antonio Turiel - Institut de Ciencies del Mar, Spain (Reviewer)
- Prof. Marc Bocquet - Ecole des Ponts- ParisTech (Reviewer)
- Dr. Bertrand Chapron - Ifremer
- Dr. Pierre Ailliot - Université de Bretagne Occidentale
- Dr. Clément Ubelmann - CLS

Professional Record

Mar 2020 – Sep 2021 **Machine Learning for the tuning of climate models** *Make Our Planet Great Again funded postdoc, LSCE-IPSL/ LOCEAN-IPSL, Sorbonne Université*, Paris, France
Numerical Models, Surrogate modeling, climate modeling

Dec 2019 – Feb 2020 **Separation of wave/eddy processes from SSH measurements** *CNRS Research Engineer - MEOM team; IGE; Grenoble Alpes University*, Grenoble, France
Numerical Models, Deep Learning, Computational physics

Dec 2017 – Nov 2019 **Inversion of SWOT mission data using data-driven methods** *CNES funded Postdoc researcher - MEOM team; IGE; Grenoble Alpes University*, Grenoble, France
Numerical Models, Deep Learning, Computational physics

Nov 2014 – Oct 2017 **Data-driven interpolation of geophysical dynamics using analog methods** *PhD student - LabSTICC; IMT Atlantique; Bretagne-Loire University*, Brest, France
Stochastic filtering, Analog methods, Data Assimilation, Deep Learning

Apr – May 2016 **Sea Altimetry Mapping using Analog Data Assimilation** *Visiting PhD student - Ocean University of China - MIT lab*, Qingdao, China
Analog Hidden Markov Models, Sea Level Anomalies, Multi-Scale Reconstruction.

Avr – Sep 2014 **Solving nonlinear non-convex inverse problems under sparsity constraints.** *Research intern - CEA Saclay - Cosmostat team*, Saclay, France
Convex/non-convex optimization, Sparsity, Greedy algorithms, Proximal algorithms

Jul – Aug 2013 **Study of electric vehicles charging strategies and their impact on the smart grid** *Research intern - IRISA - OCIF team*, Rennes, France
Smart grid, Game theory, Reinforcement Learning.

Awards and Grants

Nvidia Graphics Processing Unit (GPU) card grant through the Nvidia Developer GPU grant program

CNES Postdoctoral grant (2yrs) to conduct research at IGE Grenoble

EURASIP Ranked second at the "3 min thesis" competition of EUSIPCO 2016 Budapest, submitted video can be seen here `https://youtu.be/bp6mOXf7BJY`

"Norman Miller's Prize" Best Student Poster at IEEE/MTS OCEANS'16 Conference in Shanghai, China

"Morocco Science Award" 2016 Delivered by the "Moroccan Scientific Community", a science communication initiative run by a team of volunteers covering different areas of expertise. The prize was given for the category "3 min thesis"

Education

2014–2017 **Doctor of Philosophy (PhD) in Computer Vision.** *IMT Atlantique*, Brest, France
`www.imt-atlantique.fr` (formerly known as Telecom Bretagne) / Thesis supervisor: Prof. Ronan Fablet

2011–2014 **Engineer's degree, major: Image Processing and Remote Sensing.** *IMT Atlantique*, Brest, France

2013–2014 **Research master degree "Sciences, Technologies, Santé", SISEA, major: Image Processing.** *Université de Rennes I*, Rennes, France

2011–2012 **Bachelor's degree: Mathematics.** *Université de Bretagne Occidentale*, Brest, France

2009–2011 **Preparatory classes for French "Grandes Ecoles"** *CPGE Mohamed V*, Casablanca, Morocco, *MPSI/MP**

Publications (H-index: 10; >500 citations; source Google Scholar)

Review paper

- M. Sonnewald, **R. Lguensat**, Jones, D. C., Dueben, P. D., Brajard, J., and Balaji, V. (2021). "Bridging observation, theory and numerical simulation of the ocean using Machine Learning", *Environmental Research Letters*

Journal papers

- M. Sonnewald, K. Reeve, **R. Lguensat**. "The Southern Ocean supergyre: a unifying dynamical framework identified by machine learning". *Nature Communications Earth & Environment, 2023*.
- **R. Lguensat**, H. Durand, J. Deshayes, V. Balaji. "Semi-automatic tuning of coupled climate models with multiple intrinsic timescales: lessons learned from the Lorenz96 model". *Journal of Advances in Modeling Earth Systems (JAMES), 2023*.
- MCA. Clare, M. Sonnewald, **R. Lguensat**, J. Deshayes, V. Balaji. "Explainable artificial intelligence for bayesian neural networks: toward trustworthy predictions of ocean dynamics". *Journal of Advances in Modeling Earth Systems (JAMES), 2022*.
- H. Frezat, G. Balarac, J. Le Sommer, R. Fablet, **R. Lguensat**. "A posteriori learning for quasi-geostrophic turbulence parametrization". *Journal of Advances in Modeling Earth Systems (JAMES), 2022*. Editor Highlight
- M. Sonnewald and **R. Lguensat**. "Revealing mechanisms of change in the Atlantic Meridional Overturning Circulation under global heating". *Journal of Advances in Modeling Earth Systems (JAMES), 2021*.
- Y. Yang, Kin-Man Lam, X. Sun, J. Dong, **R. Lguensat**. "An Efficient Algorithm for Ocean-Front Evolution Trend Recognition". *Remote Sensing, 2021*. .
- H. Frezat, G. Balarac, J. Le Sommer, R. Fablet, **R. Lguensat**. "Physical invariance in neural networks for subgrid-scale scalar flux modeling" *Physical Review Fluids*.
- X. Sun, M. Zhang, J. Dong, **R. Lguensat**, Y. Yang, X. Lu. "A Deep Framework for Eddy Detection and Tracking From Satellite Sea Surface Height Data" *IEEE Transactions in Geoscience and Remote Sensing*, 2020.
- **R. Lguensat**, Viet, P. H., Sun, M., Chen, G., Fenglin, T., Chapron, B., and Fablet, R. "Data-driven Interpolation of Sea Level Anomalies using Analog Data Assimilation." *Remote Sensing*, 2019.
- **R. Lguensat**, P. Tandeo, P. Aillot, M. Pulido and R. Fablet, "The Analog Data Assimilation" *Monthly Weather Review*, 2017.
- R. Fablet, P. Viet, **R. Lguensat**, P-H Horrein and B. Chapron, "Spatio-Temporal Interpolation of Cloudy SST Fields Using Conditional Analog Data Assimilation" *Remote Sensing*, 2018.
- R. Fablet, P. Viet, and **R. Lguensat**. "Data-driven Methods for Spatio-Temporal Interpolation of Sea Surface Temperature Images". *IEEE Transactions on Computational Imaging*, 2017.
- Y. Yang, J. Dong, X. Sun, **R. Lguensat**, M. Jian, X. Wang. "Ocean Front Detection from Instant Remote Sensing SST Images". *IEEE Geoscience and Remote Sensing Letters*, 2016

Conference papers

- JE. Johnson, **R. Lguensat**, R. Fablet, E. Cosme, J. Le Sommer, "Neural Fields for Fast and Scalable Interpolation of Geophysical Ocean Variables". Machine Learning and the Physical Sciences workshop at NeurIPS 2022.
- H. Frezat, J. Le Sommer, R. Fablet, G. Balarac, **R. Lguensat** "A posteriori learning of quasi-geostrophic turbulence parametrization: an experiment on integration steps". Machine Learning and the Physical Sciences workshop at NeurIPS 2021.
- M. Sonnewald, **R. Lguensat**, A. Radhakrishnan, Z. Sayibou "Revealing the impact of

global warming on climate modes using transparent machine learning and a suite of climate models". Spotlight talk at "Tackling Climate Change with Machine Learning" workshop at ICML 2021.

- **R. Lguensat**, R. Fablet, J. Le Sommer, S. Metref, E. Cosme. K. Ouenniche, L. Drumetz, J. Gula. "Filtering Internal Tides From Wide-Swath Altimeter Data Using Convolutional Neural Networks". IGARSS 2020: IEEE International Conference on Geoscience and Remote Sensing, Hawai, USA.
- **R. Lguensat**, W. Jones, A. Charantonis, D. Watson-Parris. "The 2020 Climate Informatics Hackathon: Generating Nighttime Satellite Imagery from Infrared Observations". Climate Informatics Conference 2020, Oxford, UK.
- Harder et al. "NightVision: Generating Nighttime Satellite Imagery from Infra-Red Observations" Climate Change AI workshop, NeurIPS 2020. Vancouver, Canada.
- **R. Lguensat**, J. Le Sommer, R. Fablet, S. Metref, E. Cosme. "Learning Generalized Quasi-Geostrophic Models Using Deep Neural Numerical Models" Machine Learning and the Physical Sciences workshop, NeurIPS 2019. Vancouver, Canada.
- H. Chergui, K. Tourki, **R. Lguensat**, M. Benjillali, C. Verikoukis, M. Debbah, "Classification Algorithms for Semi-Blind Uplink/Downlink Decoupling in sub-6 GHz/mmWave 5G Networks." IWCMC19: International Wireless Communications and Mobile Computing Conference. Tangier, Morocco.
- **R. Lguensat**, M. Sun, R. Fablet, E. Mason, P. Tandeo, G. Chen. "EddyNet: A deep neural network for the detection and classification of ocean eddies" IGARSS 2018: IEEE International Conference on Geoscience and Remote Sensing. Valencia, Spain.
- R. Fablet, P. Viet, and **R. Lguensat**. "Data-driven assimilation of irregularly-sampled image time series" ICIP 2017: IEEE International Conference on Image Processing, Beijing, China.
- **R. Lguensat**, M. Sun, G. Chen, T. Lin, R. Fablet, Spatio-Temporal Interpolation of Altimeter-Derived SSH Fields Using Analog Data Assimilation: A Case-Study In The South China Sea. IGARSS 2017 : IEEE International Geoscience and Remote Sensing Symposium, Fort Worth, Texas, USA.
- **R. Lguensat**, R. Fablet, P. Ailliot and P. Tandeo, An Exemplar-based HMM framework for nonlinear state-space models. EUSIPCO 2016 : IEEE European Signal Processing Conference, Budapest, Hungary.
- **R. Lguensat**, P. Tandeo, P. Ailliot, B. Chaperon and R. Fablet, Using archived datasets for missing data interpolation in ocean remote sensing observation series, MTS/IEEE OCEANS'16, Shanghai, China. Best Student Poster award
- R. Fablet, P. Viet, **R. Lguensat** and B. Chapron, Exploiting ocean observation and simulation big data to improve satellite-derived geophysical products: Analog strategies. BiDS'17: Big Data from Space Conference. Toulouse, France.
- P. Tandeo, P. Ailliot, B. Chapron, **R. Lguensat** and R. Fablet, The analog data assimilation: application to 20 years of altimetric data, Climate Informatics 2015, Boulder, Colorado.
- **R. Lguensat**, P. Tandeo, R. Fablet and P. Ailliot, Non-parametric Ensemble Kalman methods for the inpainting of noisy dynamic textures. ICIP 2015 : IEEE International Conference on Image Processing, Quebec City, Canada.
- **R. Lguensat**, P. Tandeo, R. Fablet and R. Garello, Spatio-temporal interpolation of Sea Surface Temperature using high resolution remote sensing data, OCEANS'14, St. John's, Canada.
- S. Dimitrov, **R. Lguensat**, Reinforcement Learning Based Algorithm for the Maximization of EV Charging Station Revenue, Mathematics and Computers in Sciences and Industry (MCSI 2014), Varna, Bulgaria.

PhD thesis

- **R. Lguensat**, Learning from Ocean Remote Sensing Data. PhD dissertation, IMT Atlantique/Univ. Bretagne Loire, 2017.

Master thesis

- **R. Lguensat**, Nonlinear optimization under sparsity constraints: Algorithms for solving nonlinear inverse problems. Master SISEA, Universite de Rennes I, 2014.

Technical Reports

- S. Rjiba, **R. Lguensat**, E. Mason, R. Fablet and J. Le Sommer. "Convolutional Neural Networks for the Segmentation of Oceanic Eddies from Altimetric Maps", 2018.

Invited conferences and workshop talks

- Panelist at Climate Informatics conference 2023, Cambridge, UK. Panel on diversity and inclusion in climate informatics. April 2023
- Virtual seminar, Machine learning beyond buzzwords: how to collaborate efficiently between climate scientists and machine learners. AI for the study of Environmental Risks (AI4ER), UKRI Centre for Doctoral Training, Cambridge, UK. April 2023
- Virtual seminar, Machine Learning for Climate Modeling, IWRI-CRSA webinars, Université Mohamed VI Polytechnique, Benguerir, Morocco. February 2023
- Talk on Machine Learning for Climate Modeling at AI4Science workshop in Université Mohamed VI Polytechnique, Rabat, Morocco. December 2022
- Virtual webinar, Machine Learning for Climate Modeling, Leibniz-Institut für Ostseeforschung Warnemünde (IOW), Physical Oceanography Division. October 2022
- Virtual seminar: "History Matching for the tuning of climate models", French-German Make Our Planet Great Again webinar series, Jan 2022.
- Virtual seminar: "History Matching for the tuning of climate models", AI4ES seminars, Barcelona Computing Center, Feb 2021.
- Invited talk: "Physical Oceanography meets Deep Learning"; Data Science for the future, a workshop of Global Science Week 2019, Grenoble, France.
- Talk on "Hybrid ocean numerical models: Physics + Deep Learning" at AI4Climate seminar, LOCEAN lab, March 2019, Paris, France.
- Talk on "Quasi-geostrophy driven Deep learning" at the LEFE/MANU AI & Ocean Atmosphere workshop, February 2019, Rennes, France.
- Talk on "EddyNet: a deep neural network for the detection and classification of oceanic eddies" at Gdr-ISIS/CNES TSI joint meeting, October 2018, Paris, France.
- Talk on "Delving Deep in the ocean with Deep Learning" at Grenoble Data Club, March 2018, Grenoble, France.
- Talk on "Analog Data Assimilation" at Stochastic Weather Generators (SWGEN), 17 May 2016, Vannes, France.
- Talk on the use of historical datasets in geophysics at a joint Seminar between the MIT Lab and Vision Lab of Ocean University of China, 19 April 2016, Qingdao, China.

Teaching/Supervision

French "Qualification MdC" 2018, Section 61

- Teaching
  - (2021) ESIEA: Data Analysis and Estimation theory, Probability and Statistics
  - (2020-2022) Master Data Engineering EHTP (Morocco): 4h introduction to deep neural networks + 1h30 tutorial. Materials can be found here: `https://github.com/redouanelg/TeachingMaterials/tree/master/EHTP_DataEng`
  - (2015-2016) IMT Atlantique: 64h of supervised work/exercise class on Statistics, Probability, Digital communication theory, Image and signal processing.
- Summer Schools
  - Practical session about Physics-Informed AI for the ML4Ocean summer school 2022 `https://github.com/jiho/ML4Oceans`
  - Talk on Machine Learning for climate model tuning at the IPSL Virtual spring school 2022
- Supervision of several Master students:
  - LOCEAN-IPSL: Homer Durand (2021), Victor Bennini (2022), Maud Tissot (2023), Maya Janvier (2023)
  - IMT Atlantique: Hamza Ameur (2015), Mael Bompais (2016), Phi Hyunh Viet (2016), Mohamed Fannane (2017), Saifeddine Rjiba (2018)
  - Univ Grenoble Alpes: Audrey Monsimer (2019), Mickael Lalande (2019)
  - EHTP Morocco: Rania Souri and Nabila Lasri (2021)

Participation to conference committees and reviewing activities.

Workshop organisation

- **Co-convener** at EGU23. Session: "Machine learning for Earth System modelling"
- **Organizing Committee member** of AI4OAC workshop, Brest, France
- **Organizing Committee member** of the 54th International Liége Colloquium On Ocean Dynamics, Liége, Belgium.
- **Co-convener** at EGU22. Session: "Machine learning for Earth System modelling"
- **Paper Track Chair** at MoroccoAI 2021 conference. `https://morocco.ai/conf21`
- **Co-convener** at vEGU21. Session: "Machine learning for Earth System modelling"
- **Co-convener** at AGU'2020 fall meeting. Session: "Innovation and Exploration in Observed and Model Oceanographic Data Using Interpretable Machine Learning"
- **Data Challenge chair** at Climate Informatics'2020 `https://ci2020.web.ox.ac.uk/organizing-committee`
- **Co-convener** at EGU'20. Session: "Machine learning for Earth System modelling"
- **Data Challenge chair** at Climate Informatics'19 `https://sites.google.com/view/climateinformatics2019`
- **General chair** of the *IndabaXMorocco* 2019, a scientific workshop for Artificial Intelligence in Morocco `https://indabaXMorocco.github.io`.
- **Organizing Committee member** of *Data Science & Environment 2017:* IMT Atlantique, international workshop, `http://conferences.telecom-bretagne.eu/dse2017/committees/`
- Organizer of PhD students day 2015: IMT Atlantique, Signal & Communications department, `http://conferences.telecom-bretagne.eu/jdsc15`

Journal Club

- Organizer of the AI4Climate journal club since 2020

Reviewing activities

- Associate Editor of AMS journal "Artificial Intelligence for the Earth Sciences (AI4ES)" since 2023
- Journals: Nature, Nature Climate Change, Journal of Advances in Modeling Earth Systems (JAMES), Artificial Intelligence for the Earth Sciences (AI4ES), Geophysical Research Letters, IEEE JSTARS, Proceedings A, Remote Sensing of the Environment, Journal of Atmospheric and Oceanic Technology, Mathematical Problems in Engineering, IEEE Transactions on Geoscience and Remote Sensing, Earth System Science Data, Earth Space Science, Frontiers in Marine Science, etc.
- Conferences: Earthvision 2021/2023, ClimateChangeAI workshop 2021/2022/2023, ML4PS 2022, MoroccoAI 2021/2022, Climate Informatics 2019/2020, AI4EarthScience 2020, IndabaXMorocco 2019, etc.

Spoken languages

Arabic-Amazigh	Native speaker	French	Fluent
English	Fluent	Chinese	A2 level