Apport du ML pour la modélisation du climat

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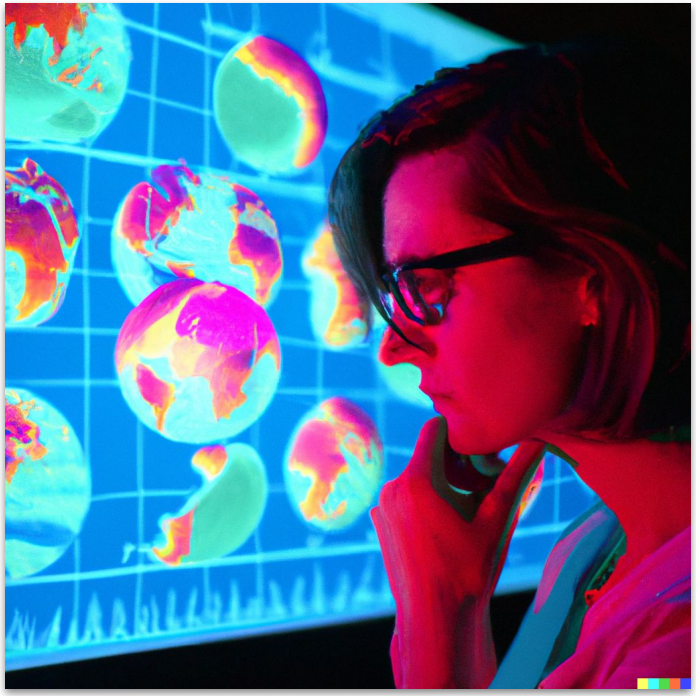
Machine Learning in Climate sciences

You probably already doing ML without knowing !

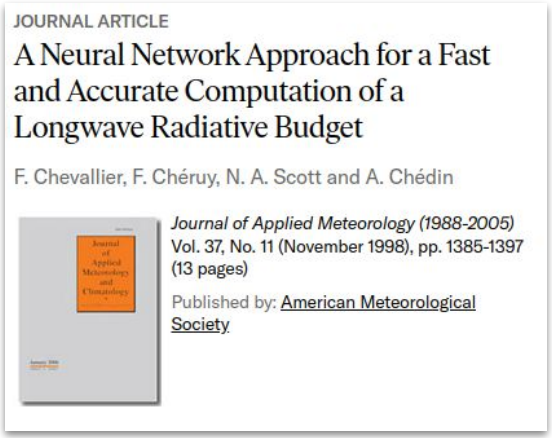
- **Linear Regression** is a ML algorithm, origins go back to works from Legendre and Gauss in the 19th century.
- **Empirical Orthogonal Functions (EOF)** is a dimensionality reduction technique invented by Edward Lorenz (a meteorologist), very popular tool in oceanography for time series analysis. Related to **Principal Component Analysis (PCA)**
- **Analogs methods** used in short term forecasting are related to **K-Nearest Neighbors**
- **Kriging** used for missing data interpolation is also called **Gaussian Process Regression**
- **Adjoint modeling** is related to the **backpropagation** algorithm used in Neural Networks



R. Lguensat and DALL.E (OpenAI)

Machine Learning in Climate sciences

ML has a long history at IPSL



JOURNAL ARTICLE

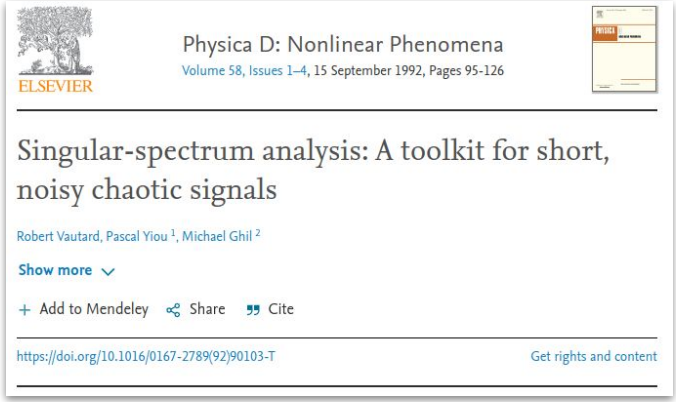
A Neural Network Approach for a Fast and Accurate Computation of a Longwave Radiative Budget

F. Chevallier, F. Chéruy, N. A. Scott and A. Chédin

Journal of Applied Meteorology (1988-2005)
Vol. 37, No. 11 (November 1998), pp. 1385-1397 (13 pages)

Published by: American Meteorological Society

Emulation of radiative transfer (1998)



ELSEVIER

Physica D: Nonlinear Phenomena
Volume 58, Issues 1–4, 15 September 1992, Pages 95-126

Singular-spectrum analysis: A toolkit for short, noisy chaotic signals

Robert Vautard, Pascal Yiou [1], Michael Ghil [2]

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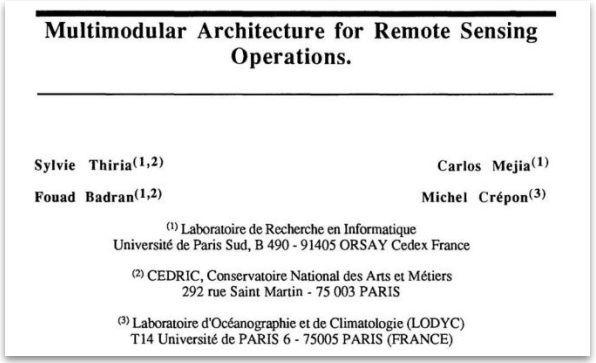
Decomposition of time series (1992)



Multimodular Architecture for Remote Sensing Operations.

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Conference paper at NeurIPS'91

Selection of ML applications in Climate Modeling

Not an exhaustive list

Subgrid Parametrization	Hot research topic, offline vs online performance, embedding ML models in Fortran codes, etc..
Emulation	Simple and fast ML based emulators, interpretable vs explainable AI
Climate Model Tuning	Surrogate modeling, History Matching, metrics for tuning, coupled model tuning
Other applications	Super-resolution / Statistical Downscaling, Model output analysis, Multi-models, etc..

Apport ML pour le modèle IPSL

Discussion

- Priorité:
  - Paramétrisation sous-maille
  - Tuning semi-automatique
  - Accélération de modèles (Emulation)
  - Correction de biais et downscaling

- Considérations:
  - Explicativité des modèles Machine Learning
  - Incorporation de contraintes physiques lors de l'apprentissage
  - Généralisation des modèles

Comment initier des collaborations ML+Climat à l'IPSL?

Rôle d'ESPRI-IA
Journée SAMA
Formation ML-IPSL
Journal club

D'autres application:

- Clustering
- Interpolation de données manquantes
- ML et Causalité
- Data Management plan: construction de dataset pour entrainement ML (ex: superresolution)
- Data assimilation
- NLP pour vocabulaire CMIP