Uncertainty quantification of atmospheric models

Applying the EasyVVUQ framework on the DALES model

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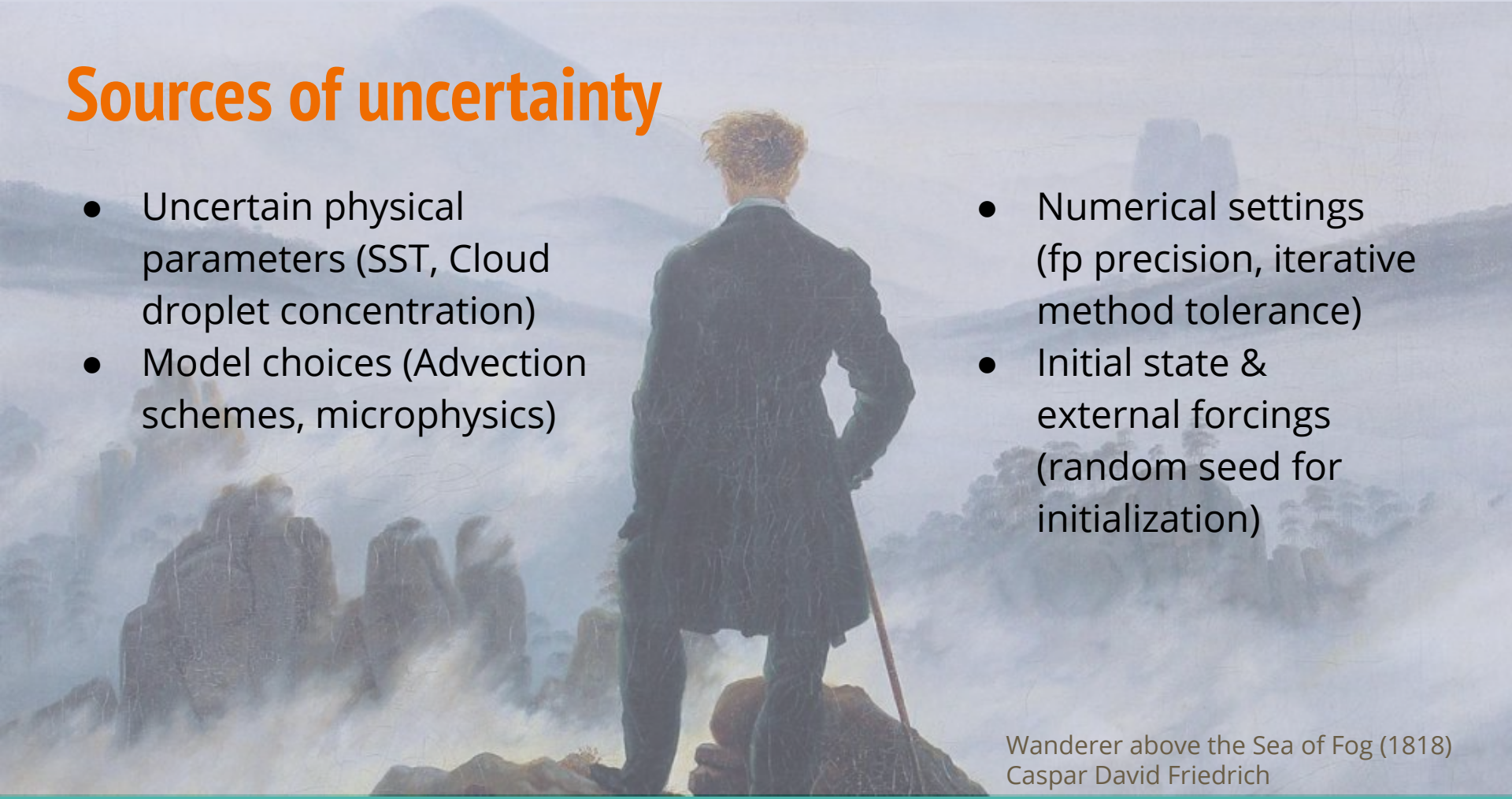
Sources of uncertainty

- Uncertain physical parameters (SST, Cloud droplet concentration)
- Model choices (Advection schemes, microphysics)
- Numerical settings (fp precision, iterative method tolerance)
- Initial state & external forcings (random seed for initialization)



Wanderer above the Sea of Fog (1818)
Caspar David Friedrich

EasyVVUQ toolkit

Verified Exascale Computing for Multiscale Applications

- verification, validation and uncertainty quantification

Open source Python framework

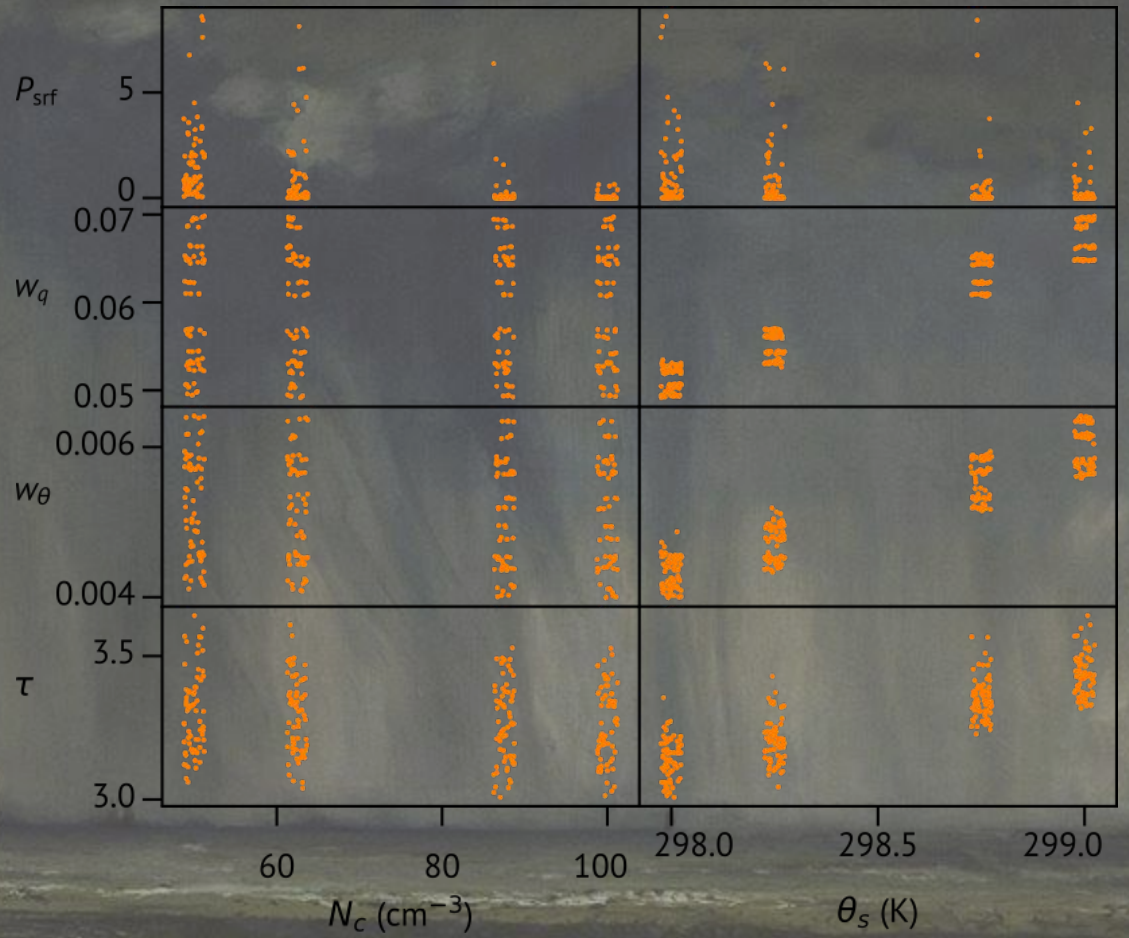
Idea: study impact of **model parameters** on **observables** (cloud cover, precipitation, vertical profiles)

Probability distributions of parameters -> probability distributions of output quantities and Sobol indices

Example: UQ of DALES

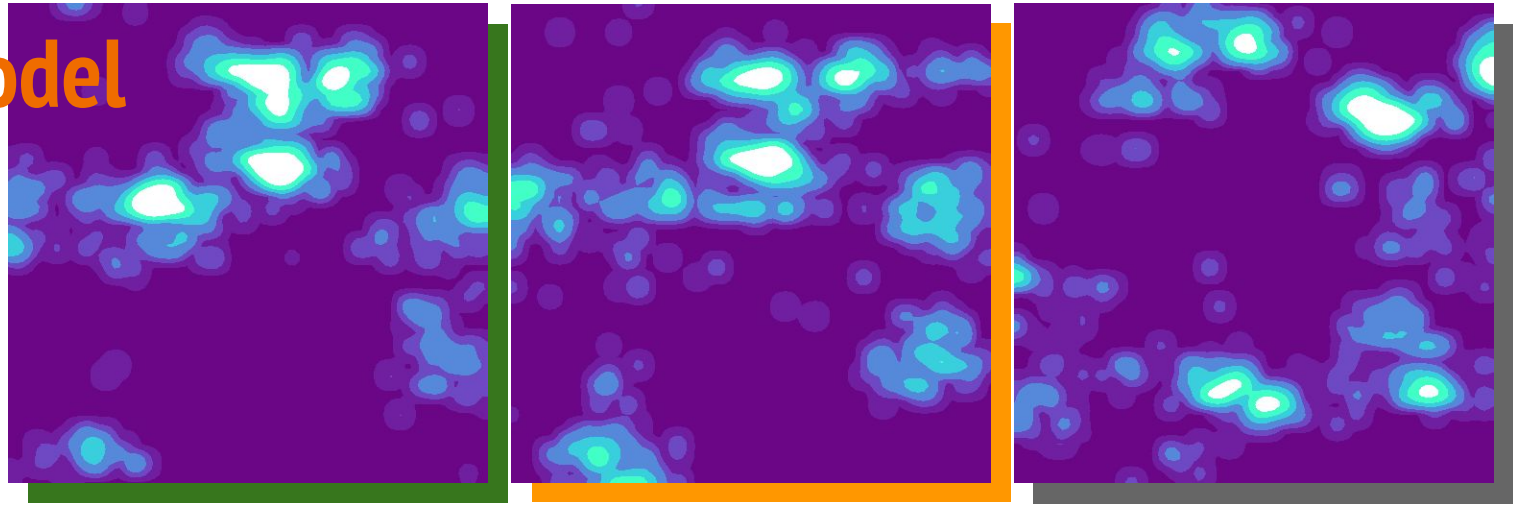
RICO case [van Zanten et al. 2010]

12.8 x 12.8 km @ 100 m resolution



Gustave Courbet, The Waterspout (1866)

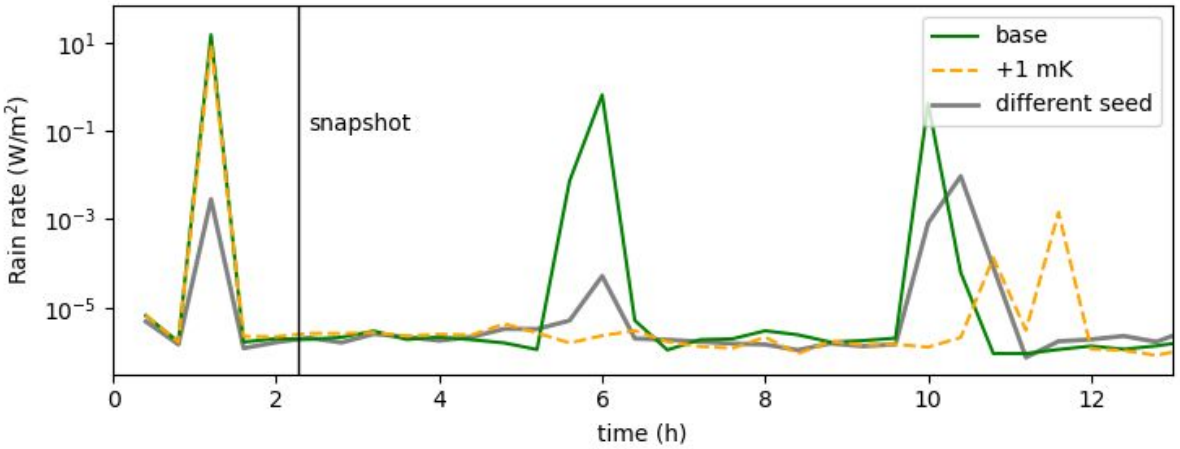
Chaotic model behavior



Any change in model parameters or initial state gives a different run, different clouds

- Look at average quantities (average over time and space)
- Run ensembles

RICO case is small: space for one rain event at once [Seifert & Heus 2013]



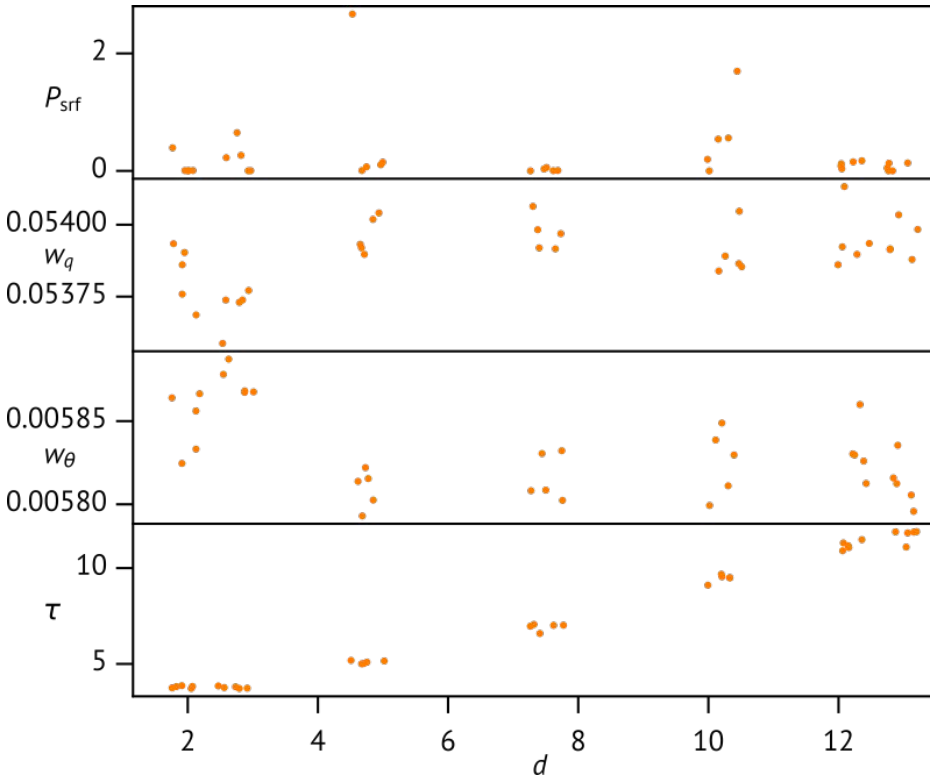
Iterative Poisson solver

ESiWACE optimization project for speeding up DALES with netherlands eScience center

- Faster for very large domains
- More flexible with boundary conditions

Tolerance parameter - how to chose it?

[iterative solver inspiration from PALM]



Solver tolerance, digits

References

DALES

Heus, T., et al: Formulation of the Dutch Atmospheric Large-Eddy Simulation (DALES) and overview of its applications, GMD, 3, 415–444, 2010.

https://github.com/dalesteam/dales

VECMA

https://www.vecma.eu/

EasyVVUQ

https://easyvvuq.readthedocs.io/en/latest/

DALES EasyVVUQ experiment setup

https://github.com/fjansson/EasyVVUQ-DALES

F. Jansson, W. Edeling, J. Attema, D. Crommelin: Assessing uncertainties from physical parameters and modelling choices in an atmospheric LES model, Submitted.

EasyVVUQ alpha users welcome! Contact me: fjansson@abo.fi