Semi-automatic tuning procedure for a GCM targeting continental surfaces: a first experiment using in situ observations

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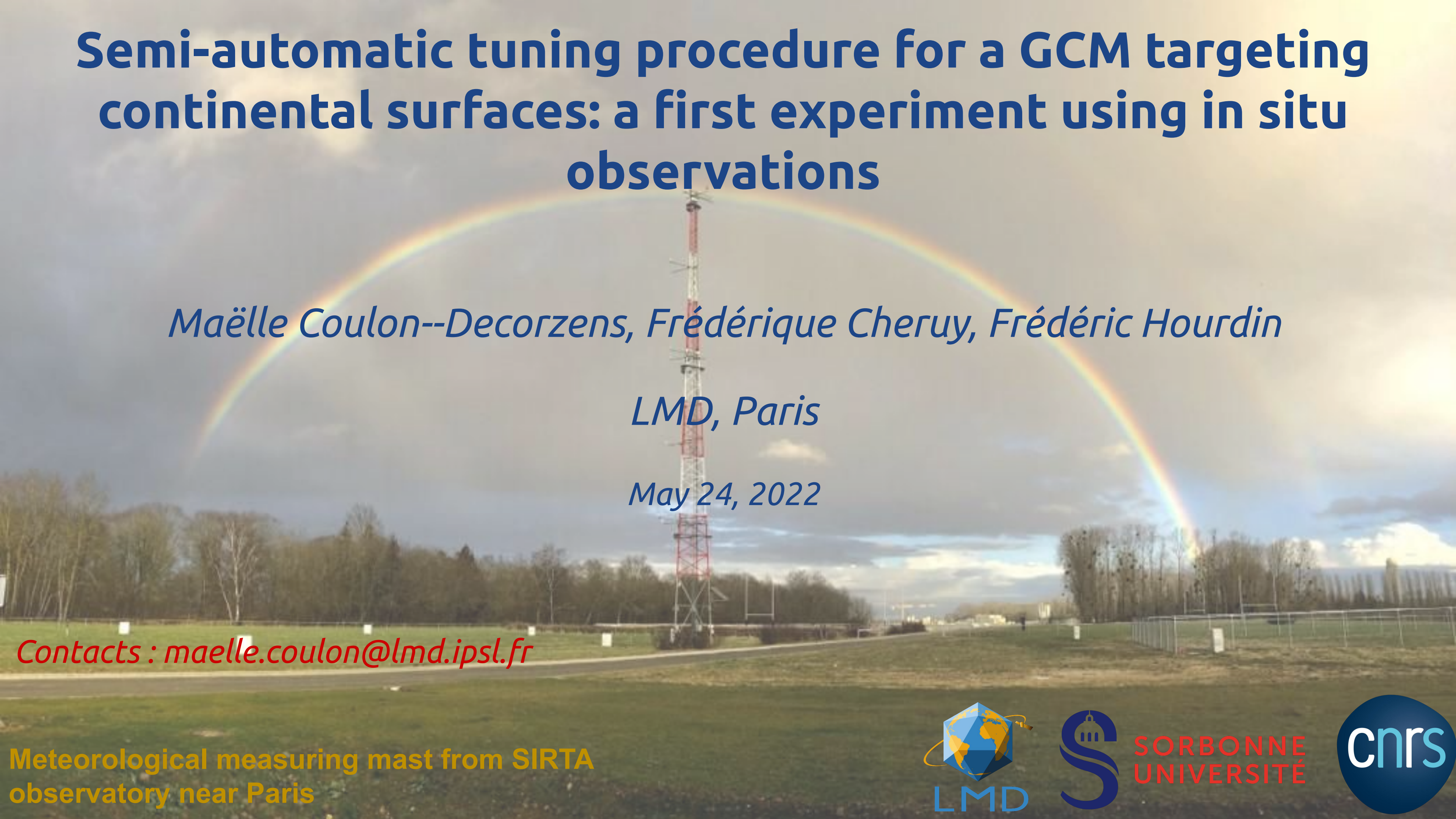

Meteorological measuring mast from SIRTA observatory near Paris

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Context and objective

Tuning / calibration of LMDZ-ORCHIDEE model (atmospheric and land surface IPSL model)

- **HighTune explorer :** a statistical tool based on **history matching** (uncertainty quantification and machine learning)

- **Two step in the current tuning :**

1. **Single Column test cases vs Large Eddies Simulations :** *(Couvreux et al, 2021)*
   process oriented metrics
   shallow convection and stratocumulus over land and ocean

2. **AMIP runs vs Satellite products** *(Hourdin et al, 2021)*
   radiative metrics at the top of the atmosphere + precipitations

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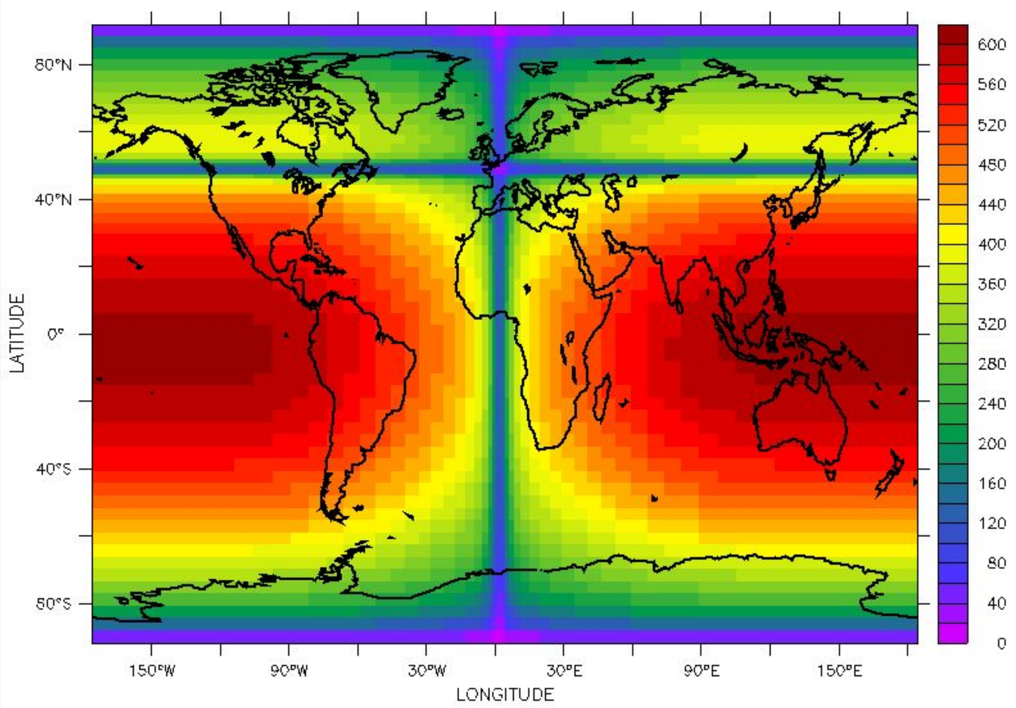
Add a step targeting the continental surfaces

- **biaises** remain over land surfaces (ex : surface radiations and near-surface temperature in summer) *(Cheruy et al, 2014)*
- add a step **less computationally costly** than global AMIP runs
- take advantage of **in situ observations** : hourly joint colocated data + radiations from the surface

Tuning toward the SIRTA observations

Configuration : global runs **nudged in wind** toward reanalysis and zoomed over SIRTA observatory for **hourly comparison** between observations and simulations

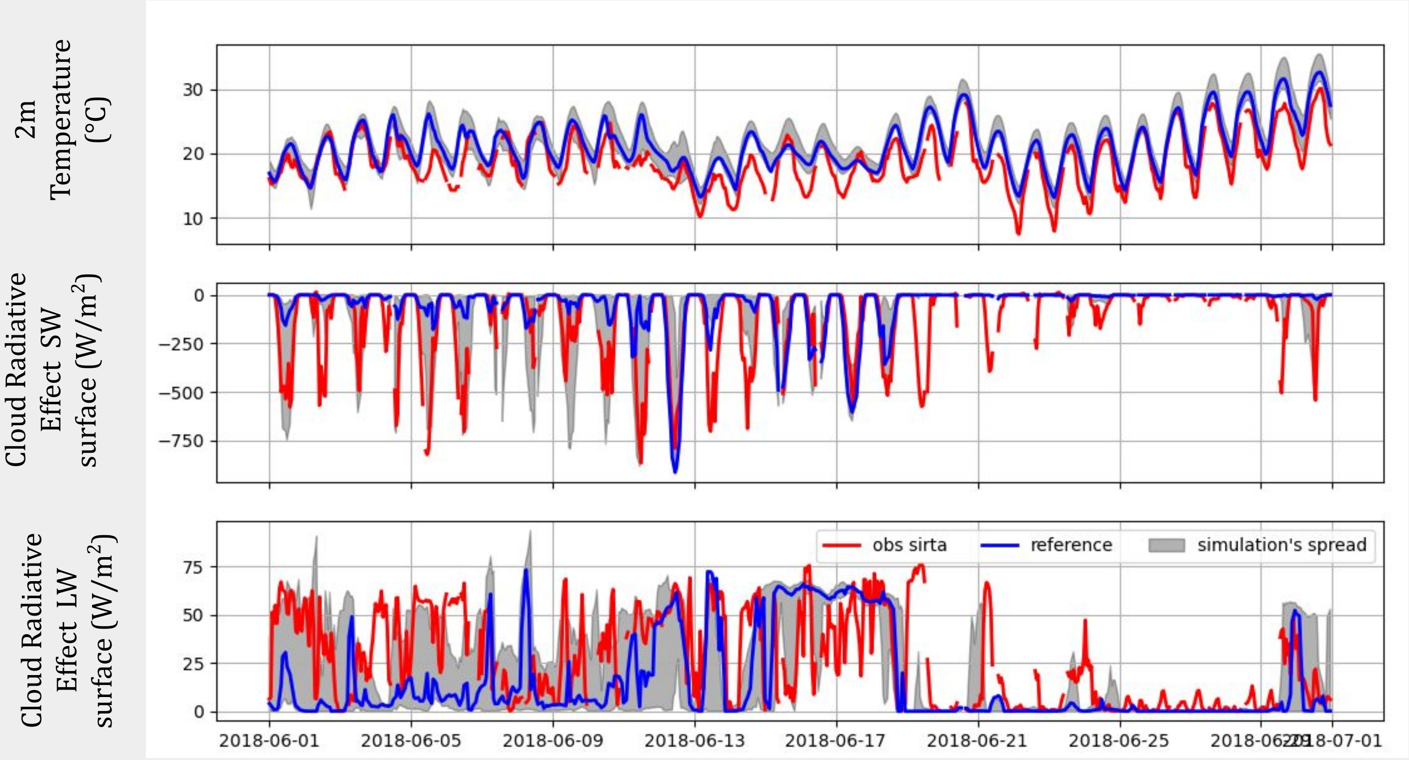


Grid mesh size in km

Tuning toward the SIRTA observations

Configuration : global runs **nudged in wind** toward reanalysis and zoomed over SIRTA observatory for **hourly comparison** between observations and simulations

Spread of an ensemble of 180 simulations, obtained by randomly sampled the parameter space that is not ruled out by the step 1, compared to SIRTA's observations and our reference simulation for june 2018 (hourly outputs)



Metrics and results

Metrics : Precipitations, Cloud radiative effect in SW and LW at the surface, averaged over two periods of may and june (not enough clouds, with or without precipitations)
→ Constrain the **first order of water and energy balance** at the surface
→ be as independent as possible of the **representativeness of the measurement site**

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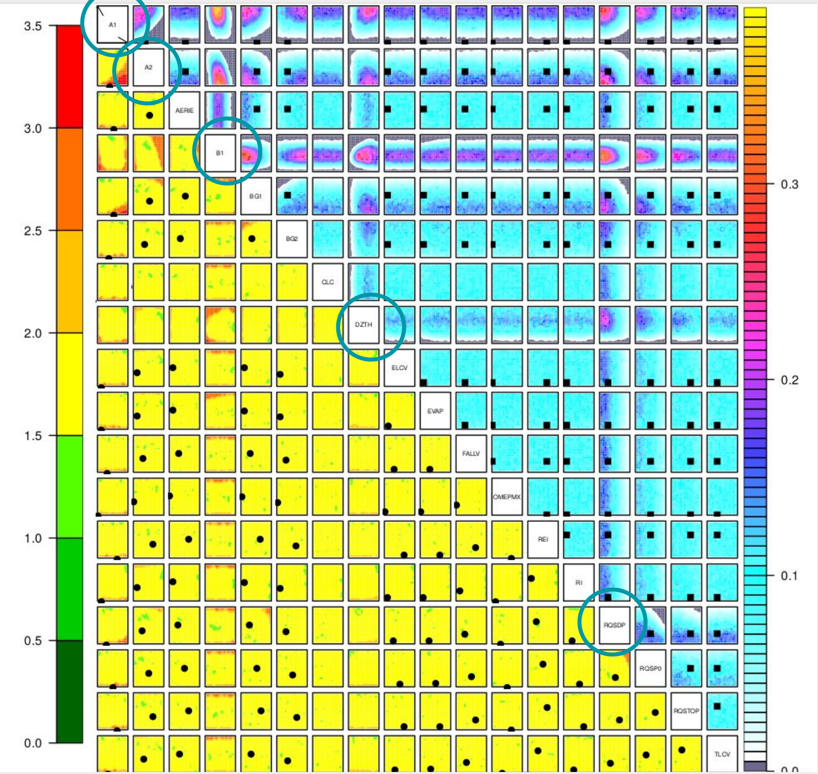
Results : Implausibility matrix at the end of the **first** tuning step
Grey = none of the parameters allow to satisfy the constraints given an uncertainty

free parameters constrainted by the **first** step : involved in **shallow convection**, **water vapor sub-grid scale distribution**



Metrics and results

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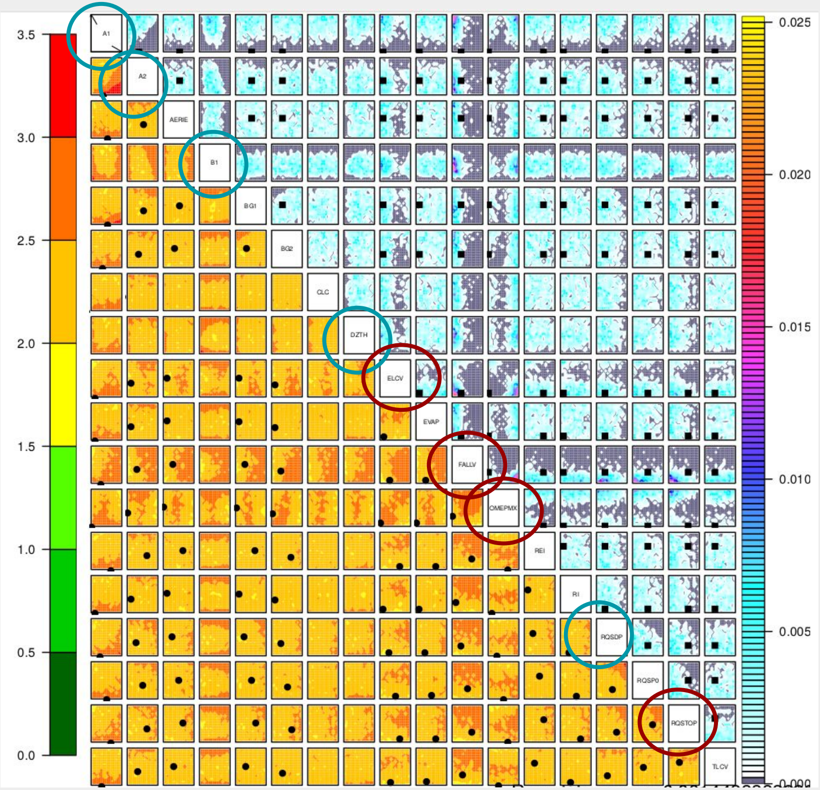
Results : Implausibility matrix at the end of the **new** tuning step
Grey = none of the parameters allow to satisfy the constraints given an uncertainty



free parameters constrainted by the **first** step : involved in **shallow convection**, **water vapor sub-grid scale distribution**

free parameters constrainted by the **new** step : involved in **deep convection**

Conclusions and outlooks

Conclusions :

- Succeed in building a method to tune the model at the surface using in situ observations
- New parameters are constrained compare to the Single Column vs Large Eddies Simulation tuning

To go further :

- evaluate this results with other observations site
- work on the representativeness of the site to benefit from other observations like turbulent fluxes
- add another free parameters from land surface model to evaluate the spread of its response
- add other observations site from other climate (semi-arid, polar climate…)

Main question raised during the work :

- How to choose well the metrics and their related uncertainty ?

References :

Cheruy, F., J. L. Dufresne, F. Hourdin, and A. Ducharne (2014), Role of clouds and land-atmosphere coupling in midlatitude continental summer warm biases and climate change amplification in CMIP5 simulations, Geophys. Res. Lett., 41, 6493–6500, doi:10.1002/2014GL061145.

Couvreux, F., Hourdin, F., Williamson, D., Roehrig, R., Volodina, V., Villefranque, N., et al. (2021). Process- based climate model development harnessing machine learning: I. A calibration tool for parameterization improvement. Journal of Advances in Modeling Earth Systems, 13, e2020MS002217. https://doi.org/10.1029/2020MS002217

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