Confronting Soil Moisture Dynamics from the ORCHIDEE Land Surface Model with the ESA-CCI SM Product: Perspectives for Data Assimilation

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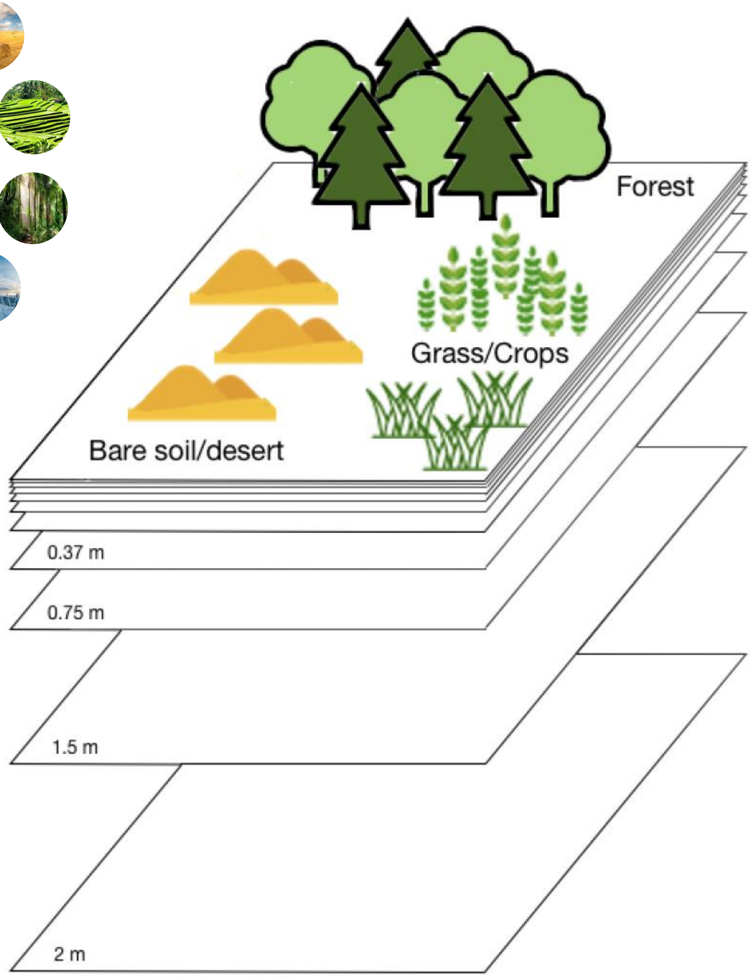
Overview of presentation

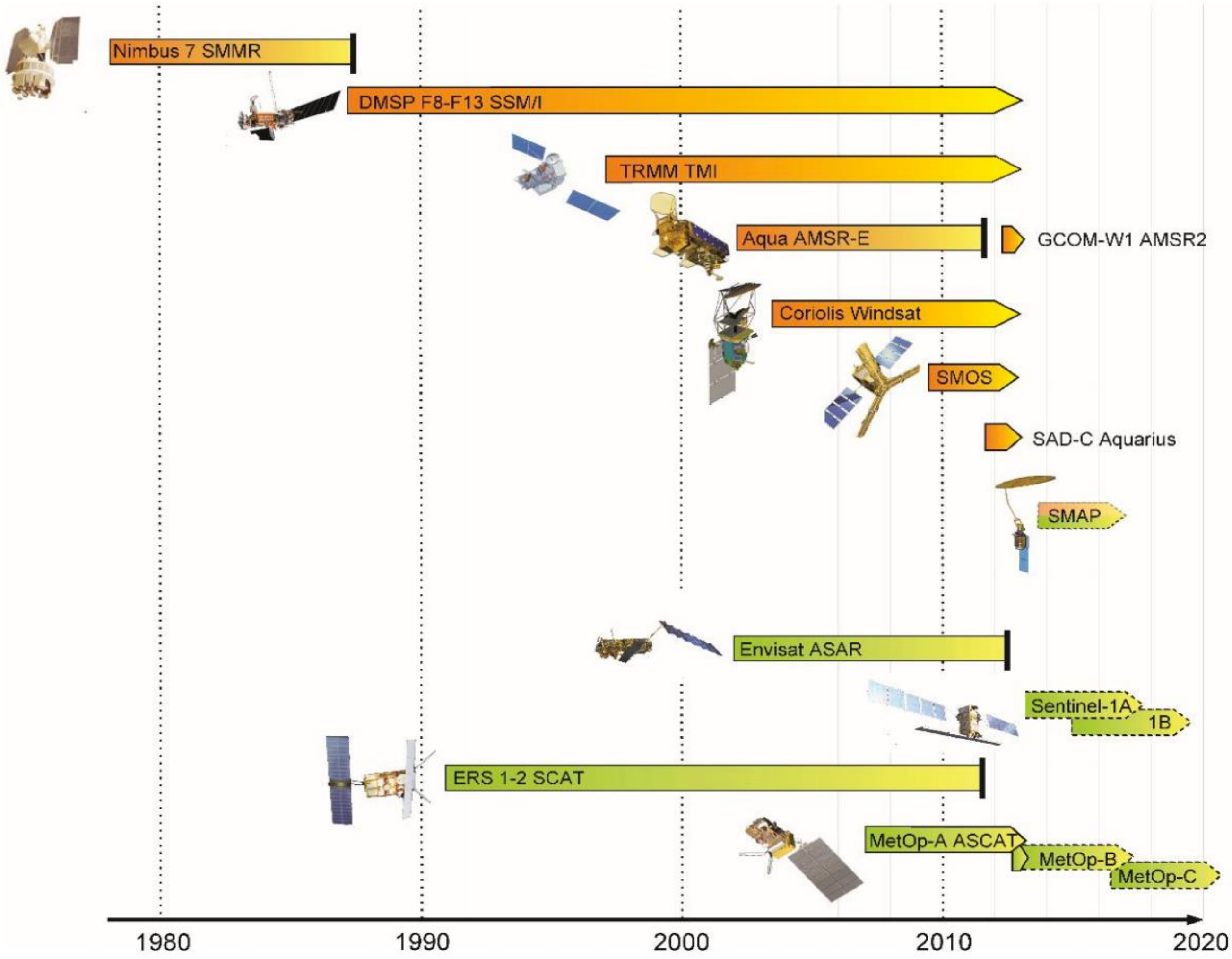
- Comparison between ORCHIDEE and ESA-CCI SM product:
  - How is soil moisture modelled in ORCHIDEE?
  - What is the ESA-CCI product and how can we use it to improve soil moisture representation in ORCHIDEE?
- Preliminary data assimilation experiments:
  - What are the key model parameters linked to the water, energy and carbon cycles?
  - What are the key properties of soil moisture dynamics we want to focus on?
- Future perspectives

Soil Moisture in ORCHIDEE



- 3 hydric budgets for soil columns associated to vegetation
- Weighted average of the 3 SM variables
- 11 layer discretization for the soil column

ESA-CCI SM Combined Product

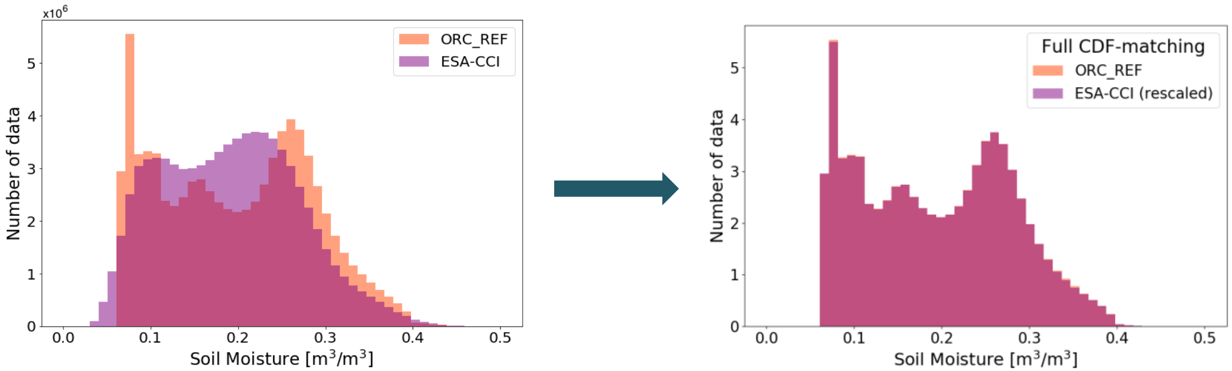


- Daily values for 37 years (1979-2016)
- Global coverage at a resolution of 0.25°
- Retrievals merged using GLDAS Noah LSM model

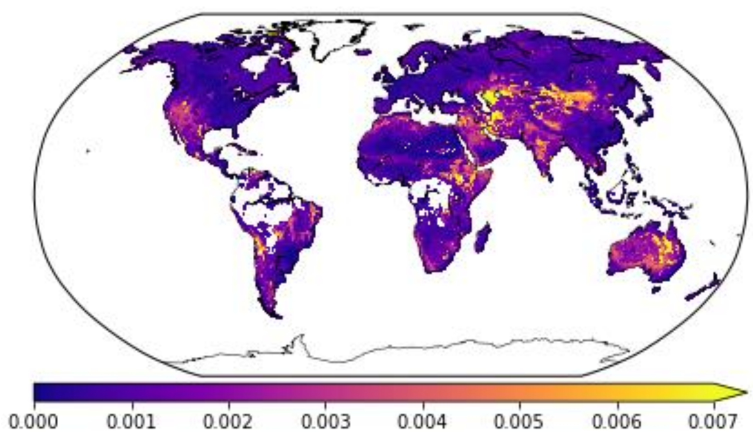
Credit: ESA-CCI, 2015

Prior steps

Bias correction



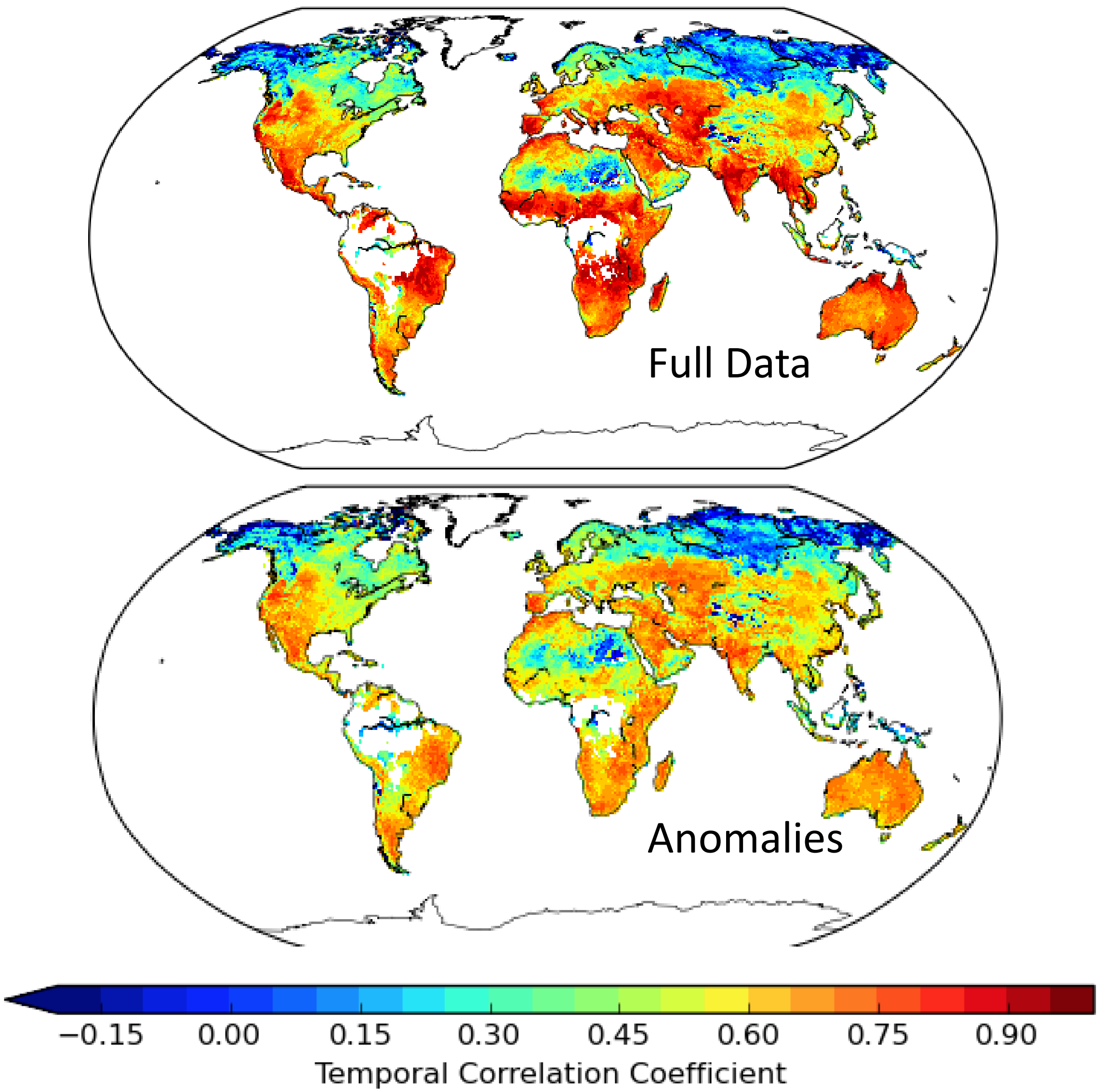
Choice of representative depth



Standard Deviation of the RMSD [m^3/m^3] calculated at each integrated depth between 4 mm and 18.6 cm

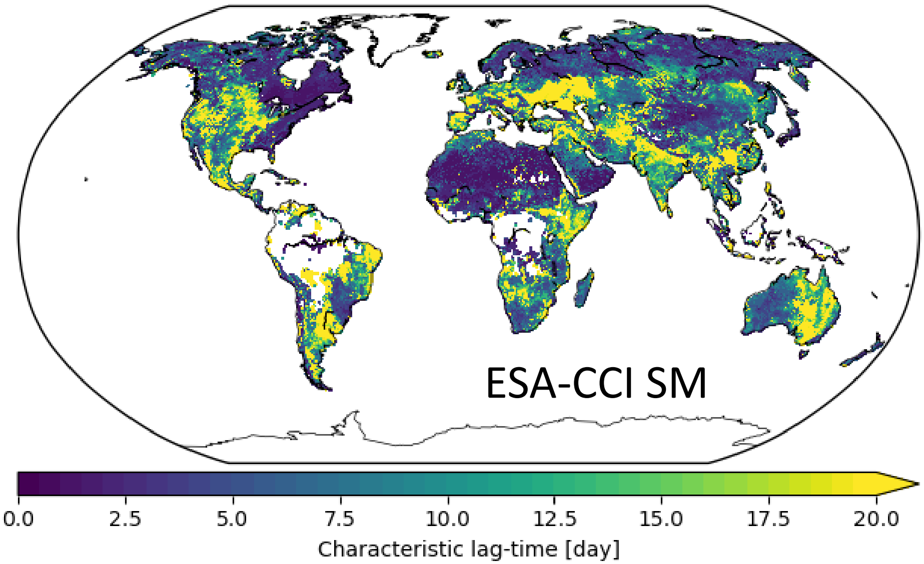
- Simple CDF matching used on all pixels over the 8 years considered
- Theoretical global mean sensing depth 2cm
- Depth 2.2cm selected (top 4 layers)

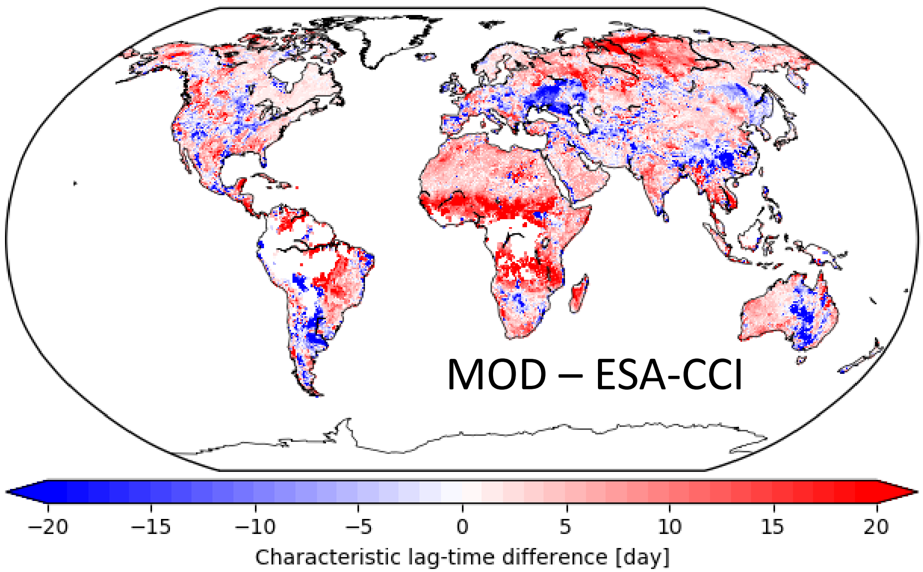
Temporal Correlations



- Generally strong correlations globally
- Poor correlations at high latitudes
- Anomalies (i.e. without seasonality) lower correlation scores
- Correlations very sensitive to forcing used

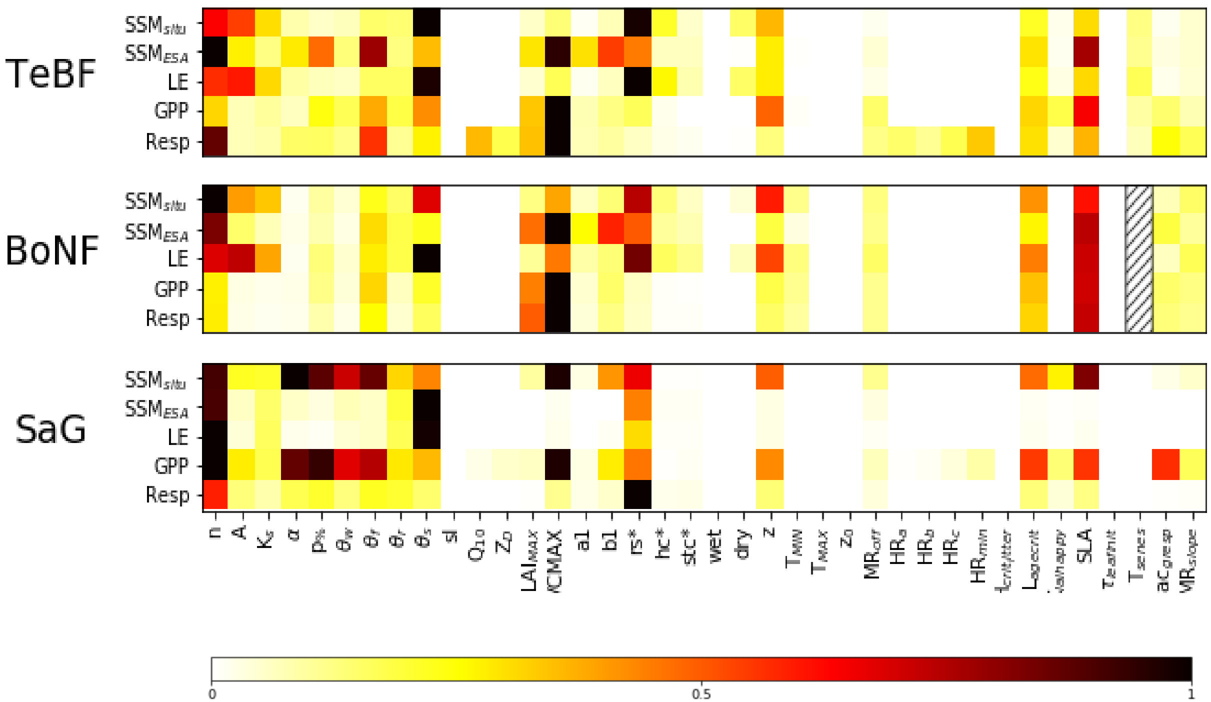
Temporal autocorrelation





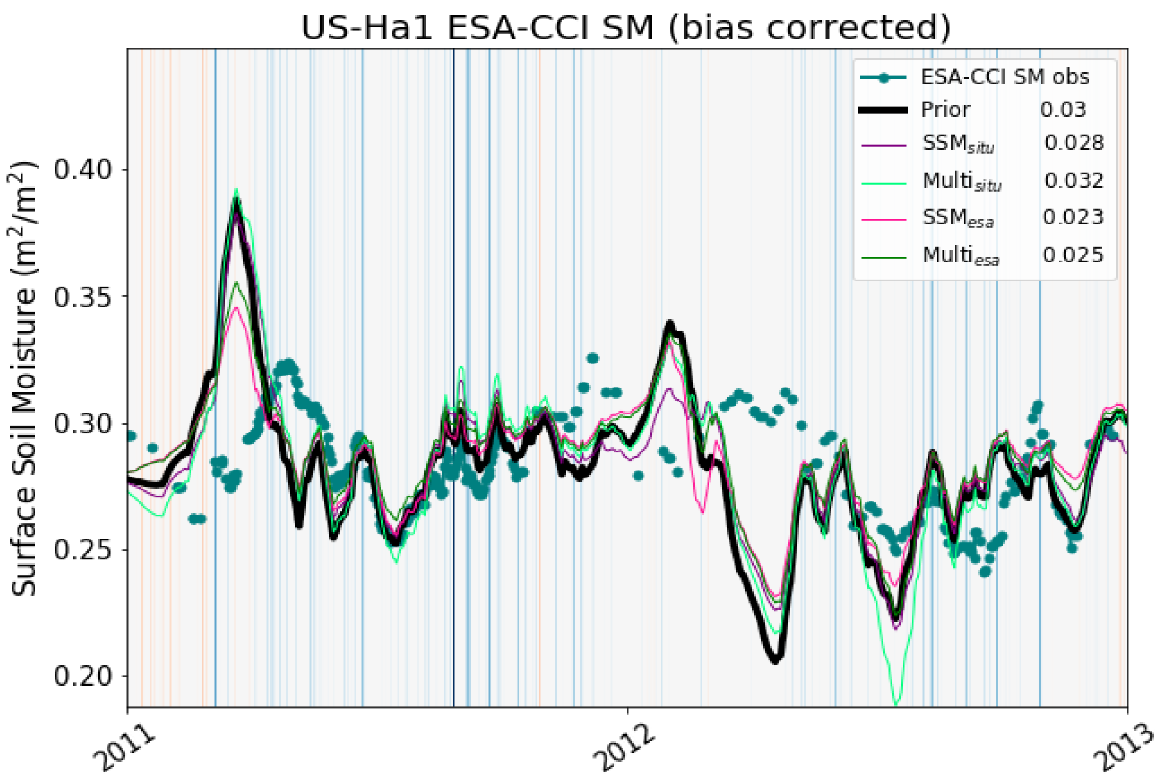
- Lag time = time after which data are no more auto-correlated
- Red areas: model auto-correlated longer then observations
- Blue areas: observations auto-correlated for longer
- Autocorrelation sensitivity to soil resistance to evaporation parameterisation

Identifying parameters



- ➢ Morris screening using 38 key parameters linked for water and carbon cycles
- ➢ Followed at Sobol analysis (not shown)

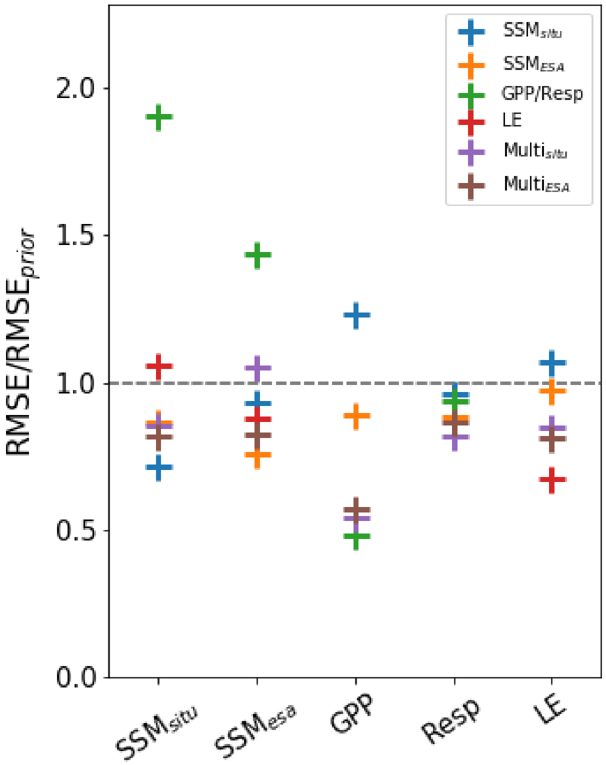
Optimisation at a site



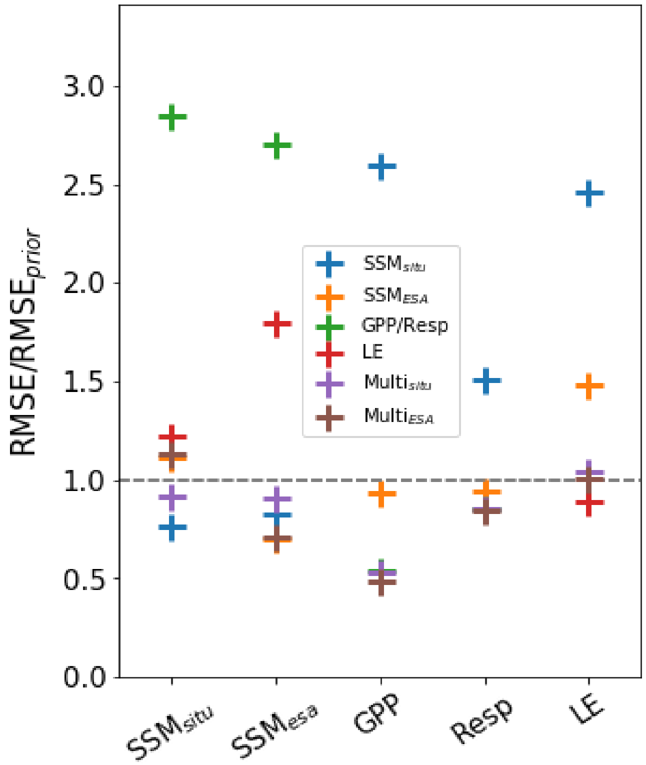
- Parameters calibrated against:
  - SSM in situ (SSM$_{situ}$)
  - SSM retrieved from ESA-CCI SM (SSM$_{esa}$)
  - GPP/Resp/LE and one of the SSM data streams (Multi$_{*}$)

- RMSE decreases in all cases except Multi$_{situ}$

RMSE over different fluxes



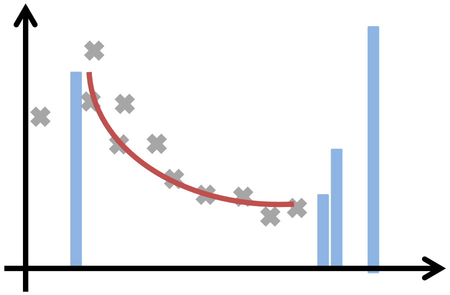
Temperature broadleaf



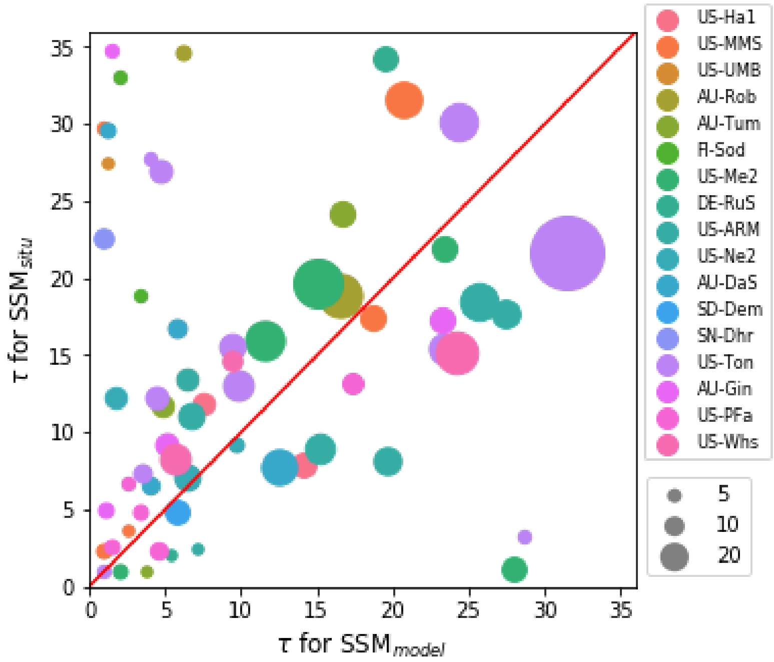
Boreal needleleaf

- Parameters found by assimilating GPP/Resp observations worsens the fit to SSM
- Best results when multiple fluxes used in assimilation

Identifying drydowns



$$\vartheta(t) = A \times \exp(-t/\tau) + \vartheta_{eq}$$



- ➢ Defined as a dry period lasting at least 5 days after a rainfall event exceeding 5mm of rain.

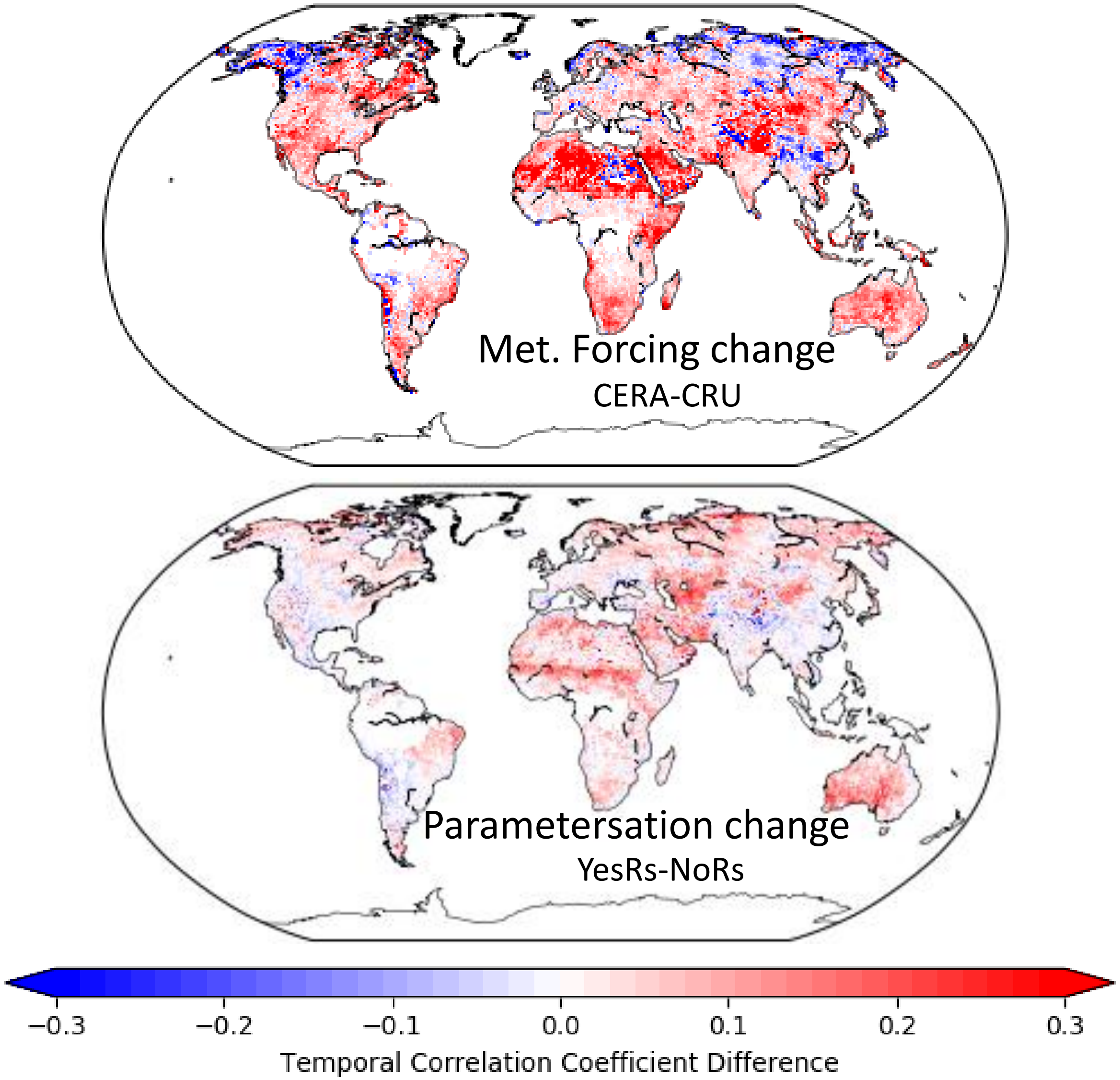
Next steps

- Identify drydowns for a number of sites globally covering a range of soil textures and vegetation types
- See how **τ** changes with parameters calibrated over the SSM data and/or vegetation observations.
- Calibrate **τ** directly

Thank you. Questions?

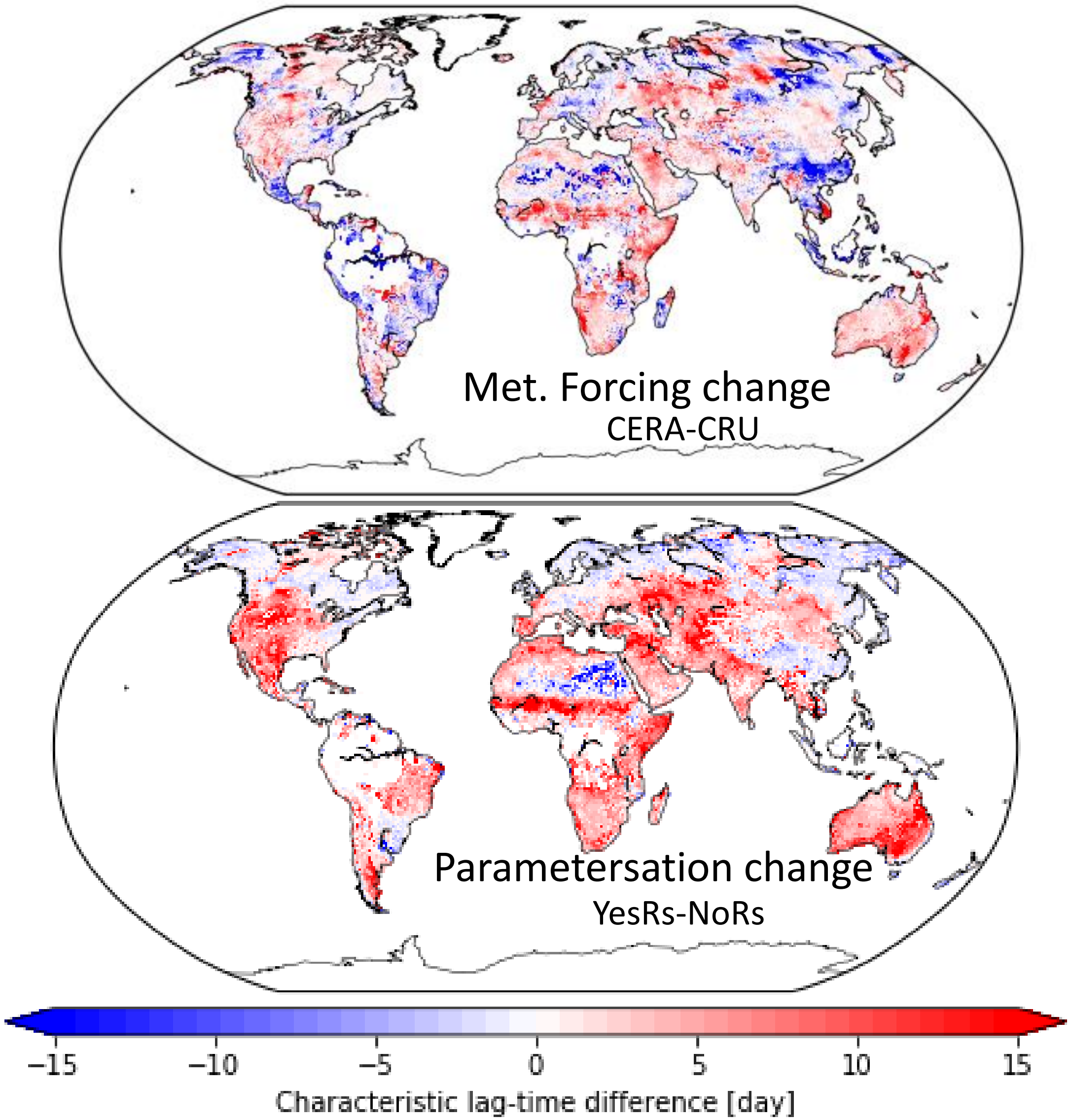
Raoult, N., et al. (2018), *Confronting Soil Moisture Dynamics from the ORCHIDEE Land Surface Model With the ESA-CCI Product: Perspectives for Data Assimilation*, Remote Sens. **2018**, 10, 1786. https://doi.org/10.3390/rs10111786

Effect of forcing data and parameterisation



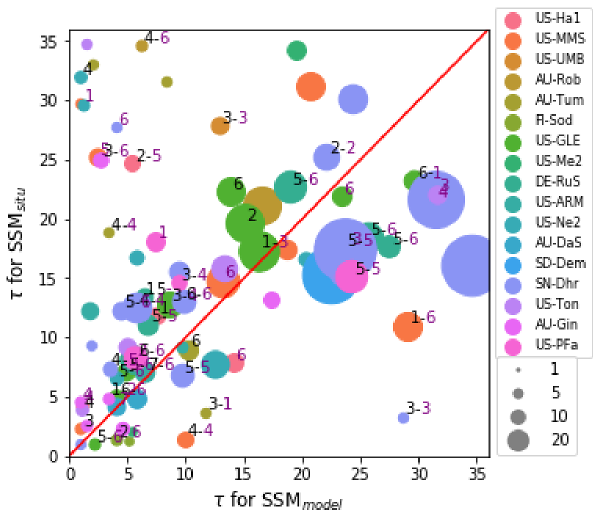
- Soil resistance is a switch is the model
- Changing the meteorological forcing impacts the correlations more than changing the soil resistance parameterisation

Effect of forcing data and parameterisation

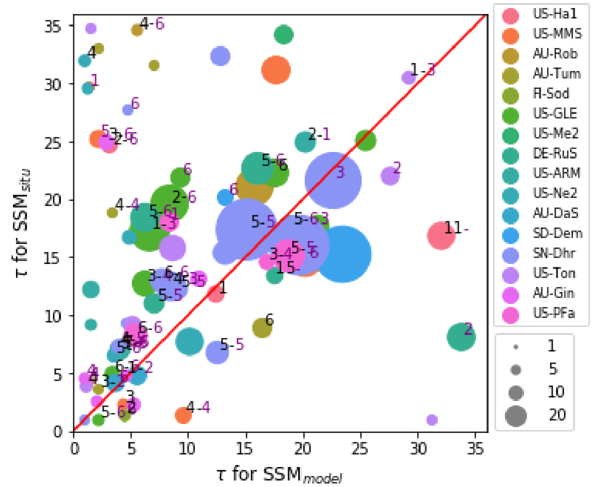


- Removing soil resistance from the model affects evapotranspiration
- Lag-time slightly more sensitive to this change of parameterisation than this change of met. forcing

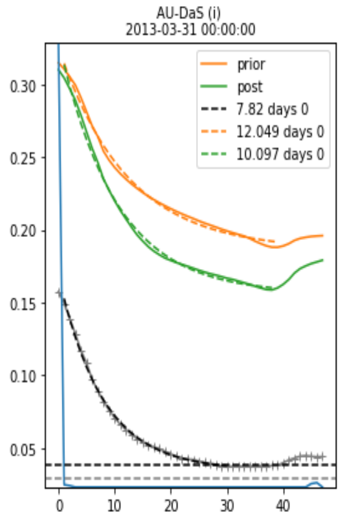
Effect of calibration on drydowns



Prior



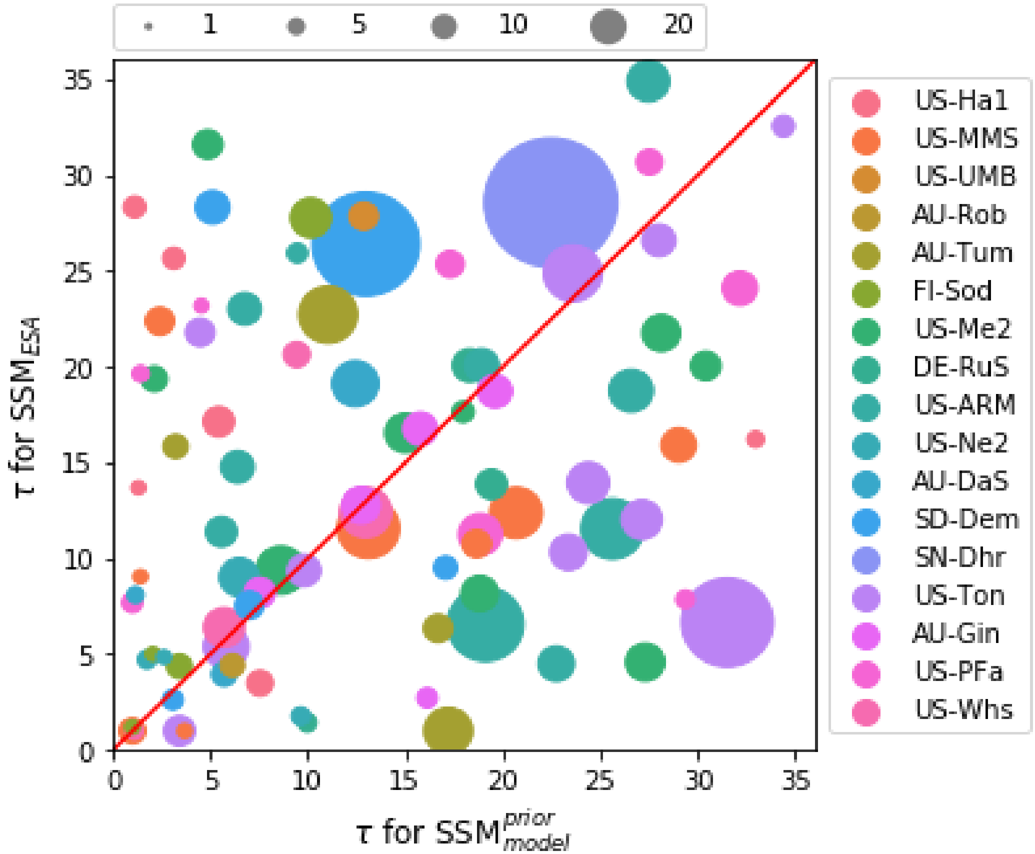
Post



Example

- The larger the value of tau the longer it takes to drydown, the curve is shallow
- Calibration using RMSE lowers tau values in the model

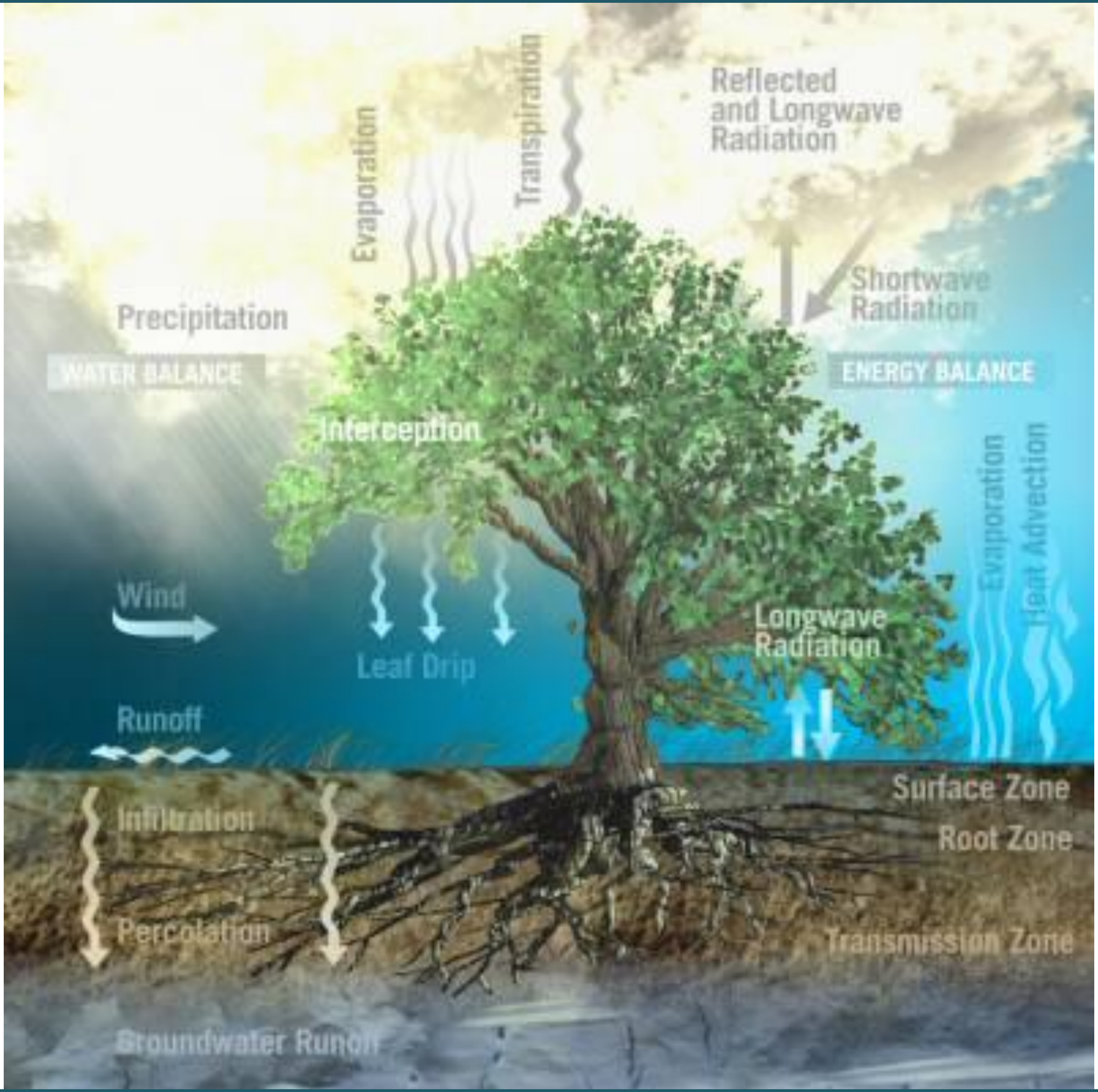
Drydowns in ESA-CCI SM



ORCHIDEE land surface model

- **OR**ganising **C**arbon and **H**ydrology **I**n **D**ynamic **E**cosyst**E**ms
- Land component of the IPSL Earth System Model
- Simulates the Energy, Water and Carbon balance

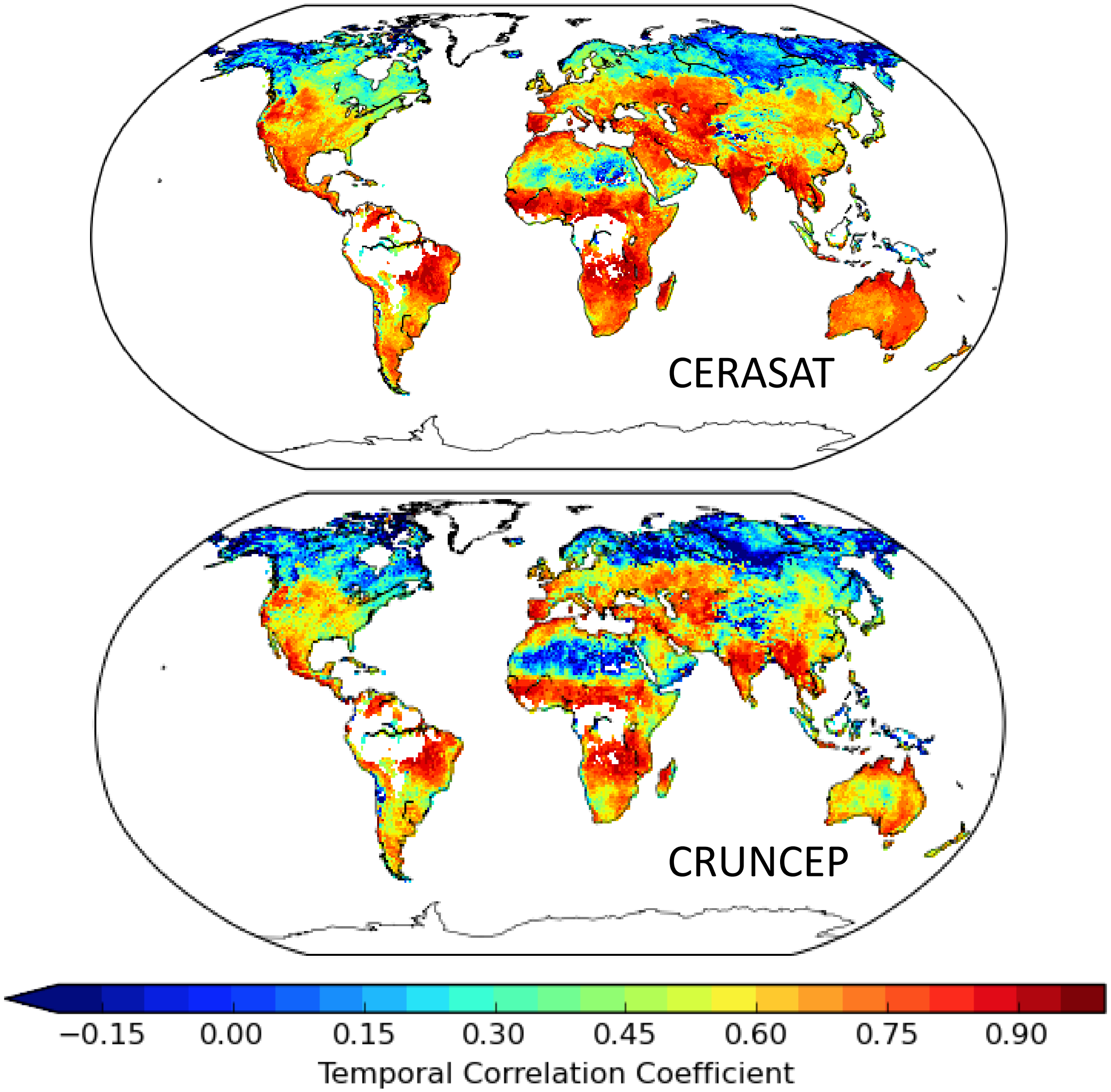
Motivation: Why Soil Moisture?



- Impacts the water, carbon and energy cycles
- Complex interactions and feedbacks
- To be used in DA experiments to improve the model

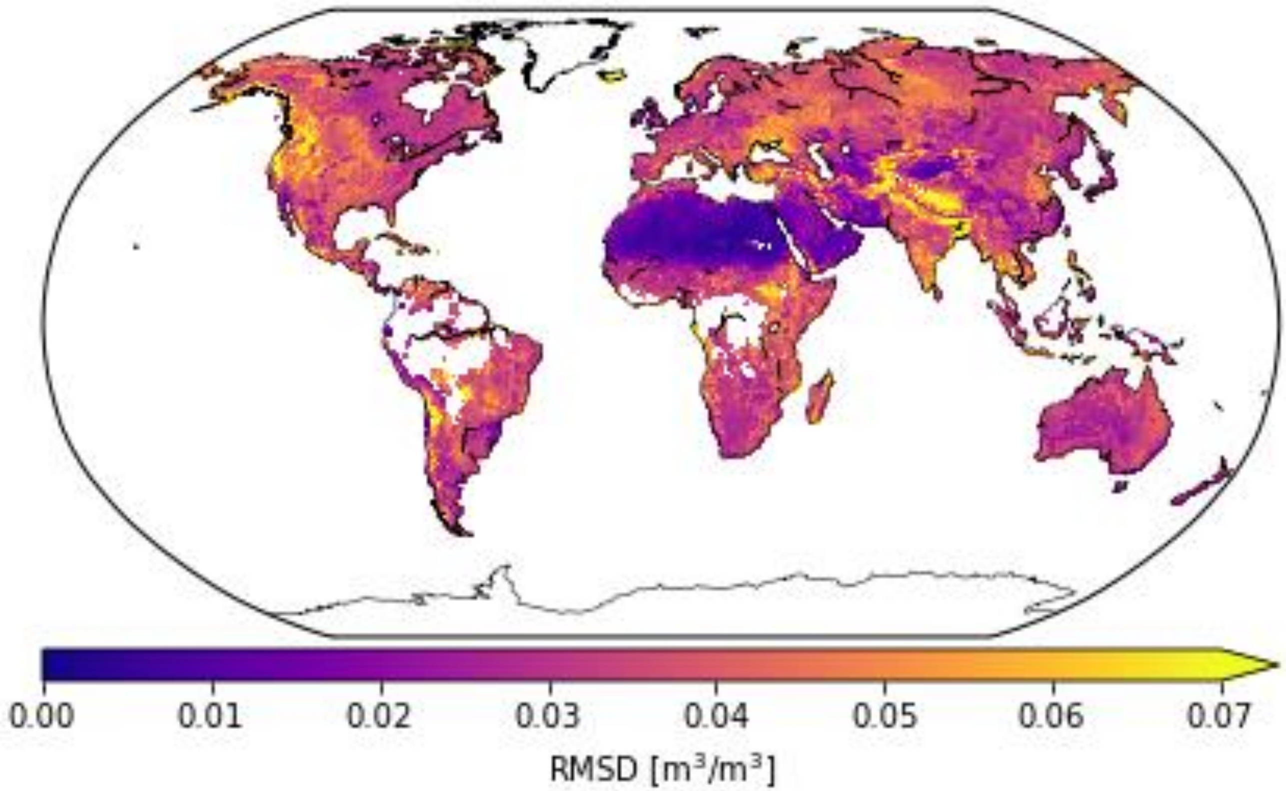
Credit: NASA

Effect of meteorological forcing data



- Meteorological forcing data controls precipitation in the model
- Stronger correlations when using CERASAT

RMSD



- Areas of dense vegetation masked and low quality time points removed
- Low RMSD values in the Sahara
- Values of SSM range 0.1- 0.4m^3/m^3, RMSD approximately 5-10% of SSM values