Soil Moisture Assimilation in the Framework of Regional Decadal Climate Predictability*

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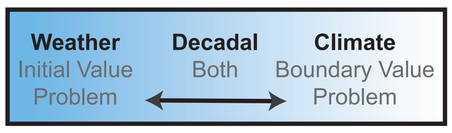
MIKLIP – DECADAL PREDICTIONS

- Aim is model system to provide reliable decadal forecasts on climate and weather
- Sub-projects DecReg and DEPARTURE assess predictability of climate predictions on regional scale for Europe and Africa
- Focus on improvement of soil initialisation for TERRA-ML SVAT model by data assimilation
- Long-term memory of deep soil is expected to be important for medium range climate predictability



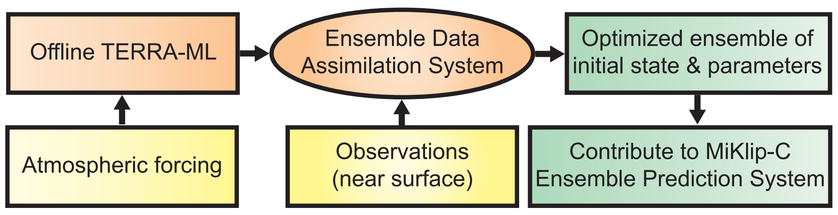


Figure 1 Work flow within the MiKlip DecReg subproject of the Goethe University Frankfurt.

DATA ASSIMILATION

- Application of sequential ensemble-based data assimilation[1] using observations of soil moisture and soil surface temperature
- Advantages of initialising deep soil state via data assimilation of near-surface observations into the soil model TERRA-ML compared to spin-up simulation:
  - Reduced calculation time due to offline soil model
  - Reduced convergence time
  - No convergence but systematic bias in spin-up run
  - Even one observation per day has large impact

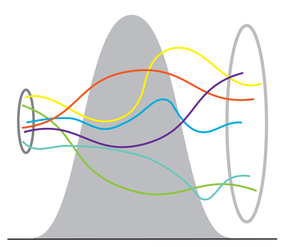


Figure 2
Sequential ensemble-based data assimilation.

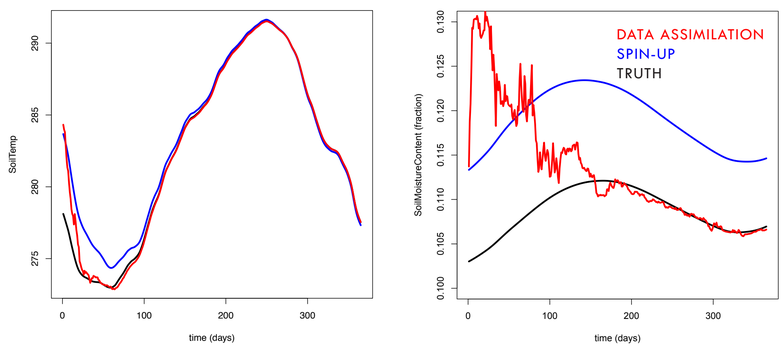


Figure 3
Convergence of TERRA soil moisture and soil temperature in 5m depth in an idealiased experiment.

SOIL MOISTURE DATA

- ESA Soil Moisture Climate Change Initiative Project (http://www.esa-soilmoisture-cci.org/)
- Merged product of six active and passive sensors over the period 1979 to 2010

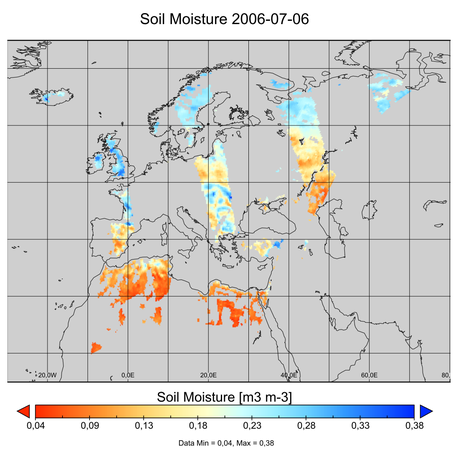


Figure 4
ESA-CCI soil moisture for 2006-07-06.

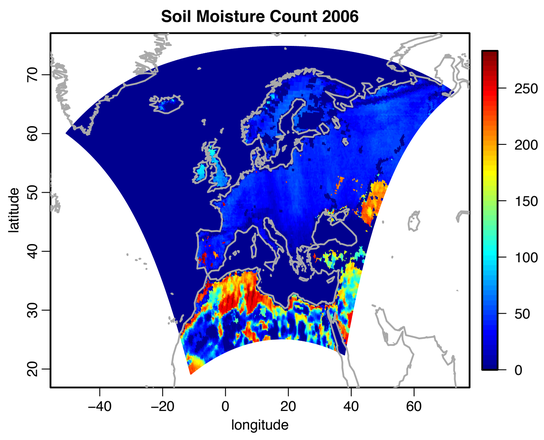


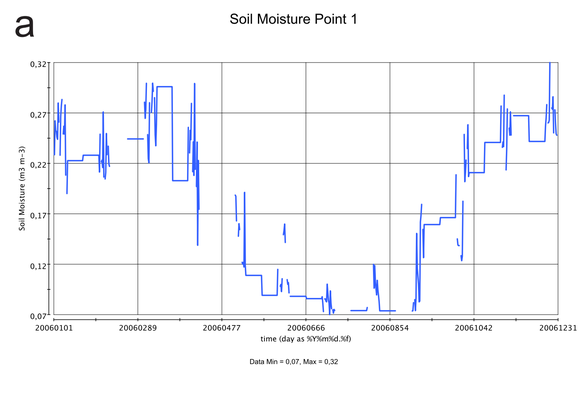
Figure 5
Number of available data points of ESA-CCI soil moisture in 2006.

*Presented at Satellite soil moisture validation & application workshop, Amsterdam, Netherlands, July 2014

GRIDPOINT DATA ASSIMILATION

Setup

- Location Point 1 = 39.97°N, 6.41°W (West Spain)
- Location Point 2 = 53.57°N, 9.95°E (Hamburg, Germany)
- Integration time range = 2006010100 - 2006123123
- TERRA = standard TERRA vertical grid (10 layers)
- Forcing = WATCH 3hrly
- Initial state: spin-up 2000-2006 to get initial state
- EnKF has initial spread given by climatological spread for each layer
- Obs-error settings were: rms_obs_tso=1.0 and rms_obs_wso=0.05
- No covariance inflation / localization
- Ensemble size = 48



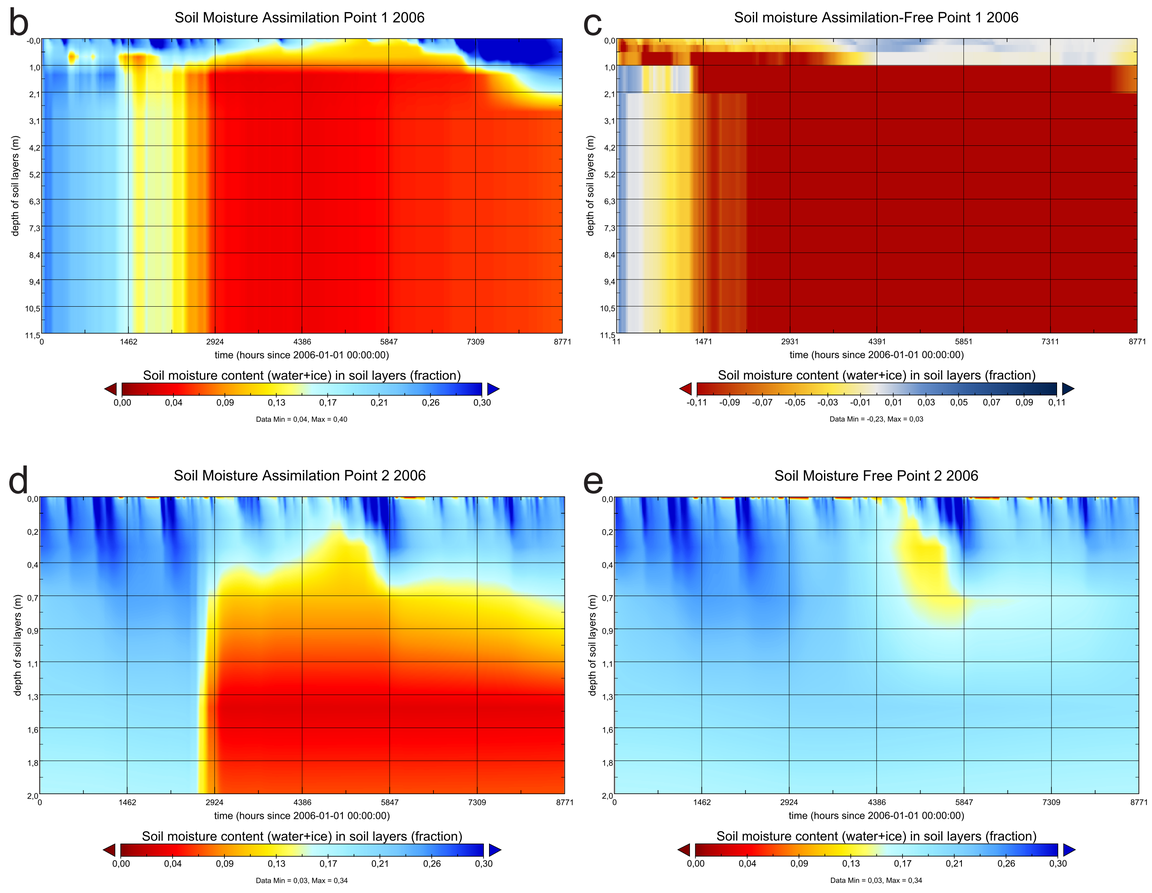


Figure 8 Soil moisture and soil surface temperature assimilation for point 1, and soil moisture only assimilation for point 2. Figure 8a shows the ESA-CCI soil-moisture for 2006 at point 1. The Figs. 8b-e show depth profile of the assimilation run and a free run without assimilation for the year 2006.

SOIL INITIALISATION

- Long-term run with offline TERRA-ML and WATCH forcing for deep soil spin-up to produce best possible soil initial fields
- Decadal prediction run with COSMO-CLM for 2001-2010 (CCLMref - Initialisation with ERA-Interim driven COSMO-CLM run, CCLMexp - Initialisation with WATCH-TERRA soil fields)

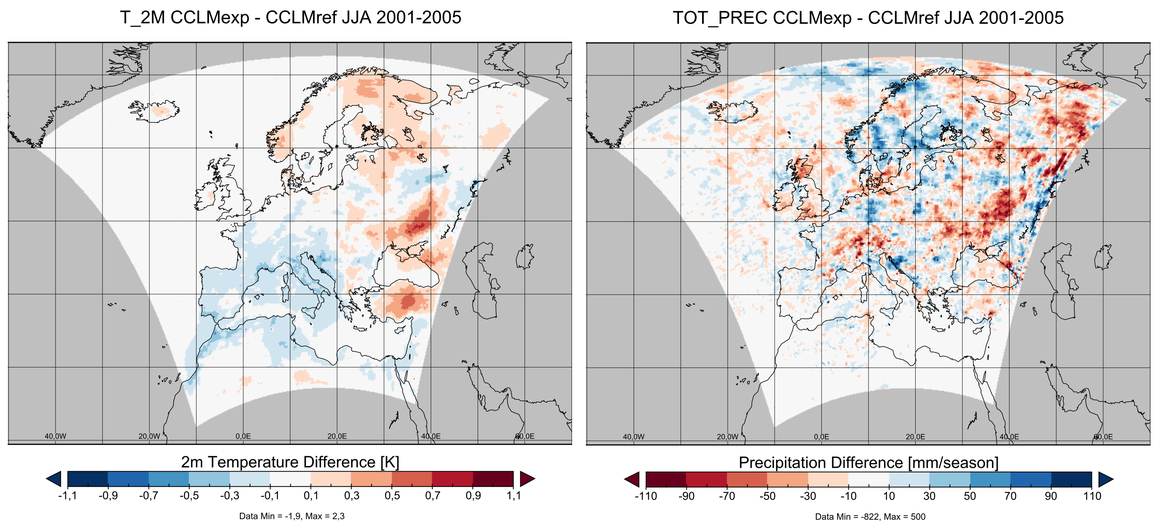


Figure 7 Difference of CCLMexp minus CCLMref 2001-2005 summer (JJA) means / mean seasonal sums of 2m temperature (left) and precipitation (right).

SUMMARY & OUTLOOK

- Deep soil state estimation with data assimilation is possible and provides advantages over spin-up run
- Soil initialisation has impact on medium range climate predictions
- Next steps: Investigation of impact of data density and uncertainty, and impact of initialisation on decadal predictability

REFERENCES

[1]Tödter, J. and B. Ahrens (2014): A Second-Order Exact Ensemble Square Root Filter for Nonlinear Data Assimilation. Submitted to Monthly Weather Review, in revision.