Ensemble-Based Soil Initialization for Seasonal-to-Decadal Predictions

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Motivation
As the ocean, the long-term memory of the (deep) soil exhibits potential seasonal-to-decadal predictability.1) Soil temperature & moisture should be initialized as realistic as possible.

Challenge: There are no observations for the deep soil...

Approach: Ensemble-based data assimilation
- Use offline soil model (TERRA-ML from COSMO-CLM)
- Assimilate atmospheric forcing data and satellite observations
- TERRA-ML transports observational information downwards
- Achieve optimized soil initial state for predictions

Observation Simulation System Experiments

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<th>TERRA-ML</th>
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<td>Multilayer land surface scheme, default in COSMO-CLM</td>
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<td>Prognoses soil temperature &amp; moisture</td>
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<td>Offline model, driven by atmospheric forcing</td>
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Data assimilation experiment
- One vertical soil column (Lindenberg)
- Use Ensemble Kalman Filter
- Generate truth run, but initialize filter with strong bias (initial uncertainty)

Observations
Soil temperature & moisture in first layer only

Regional Data Assimilation with Real Observations

Technical setup
- Domain: Africa, decade 2001-2010, within the MiKlip-DEPARTURE project
- TERRA-ML coupled with Parallel Data Assimilation Framework (PDAF²)
- Use Local Ensemble Transform Kalman filter (LETKF³)

Methodology
- Create land surface re-analysis 1979-2010 using WATCH forcing data
- Additionally assimilate satellite soil moisture in 2000
- Initialize with soil fields from DA system at 01.01.2001 (00 UTC)

Evaluation
West African Monsoon (WAM) precipitation in three regions: Guinea Coast (GC), Western & Central Sahel (WS, CS)
- Compare new soil initialization (CCLM-SOIL) with standard initialization (= soil taken from ERA-driven historical COSMO-CLM run)

Results
Correlations with observations for all sub-periods of the decade in the 3 regions:

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<th>GC</th>
<th>WS</th>
<th>CS</th>
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Impact on Decadal Predictions

Results
Soil initialization consistently improves the predictability of sub-periods in all regions:
- WS/CS: particularly for longer periods
- GC: particularly at end of decade

Comparison with other boundary conditions
- RCMs outperform the GCM and land surface BCs in the decadal predictability
- Improved soil initialization increases skill in both regions

Conclusions and Outlook

- Soil initialization is relevant for medium-range climate
- Predictive skill can be enhanced by soil initialization with ensemble data assimilation due to long-term memory
- Limited by model & observations errors, but high potential due to improved satellite observations within past years

References

Outlook
- Further evaluation
- Use new satellite products
- Application to other predictions/models
- Exploration of parameter estimation

Presented at the 15th EMS Annual Meeting & 10th European Conference on Applications of Meteorology (ECAM) (Sofia, Sept. 2018)

Support by the MiKlip project (BMBF, Germany) is acknowledged.