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FOR 2131

International Max Planck Research School on Earth System Modelling

Max-Planck-Institut für Meteorologie

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Ensemble **data assimilation** of screen-level observations **across the atmosphere-land interface** enhanced by **fingerprint operators**

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Gernot Geppert, Felix Ament

In which case can we expect warmer temperature?

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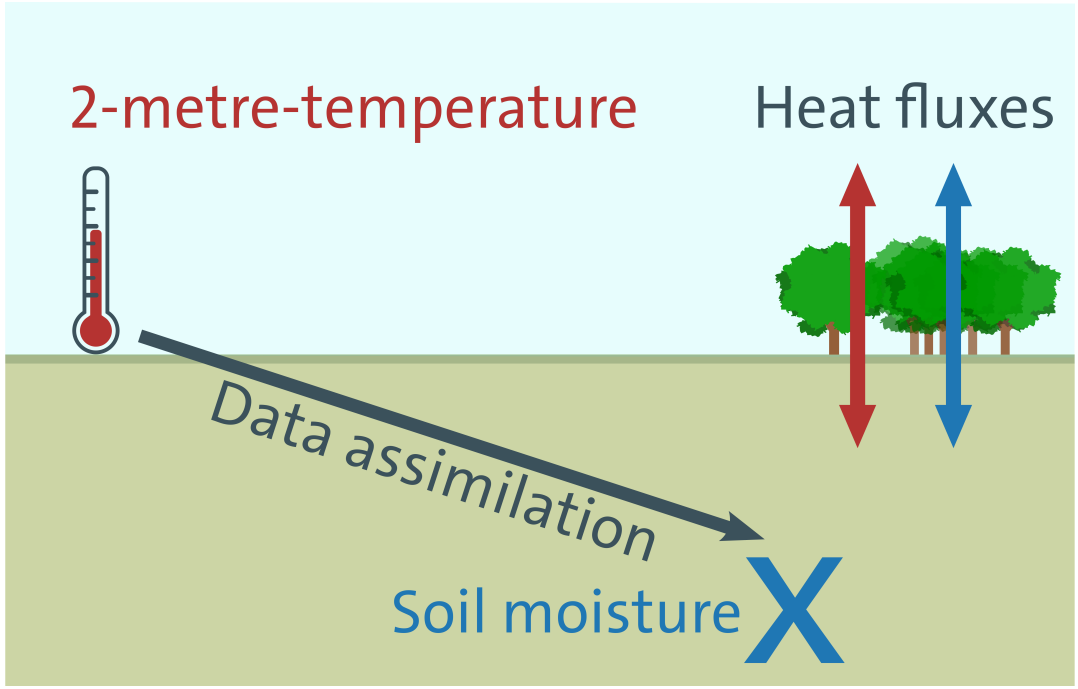
Heat fluxes couple atmospheric boundary layer to the land surface



Simplified 1D methods

(ECMWF, 2020; Gómez et al., 2020; Carrera et al., 2015)

\+ impact on boundary layer forecast

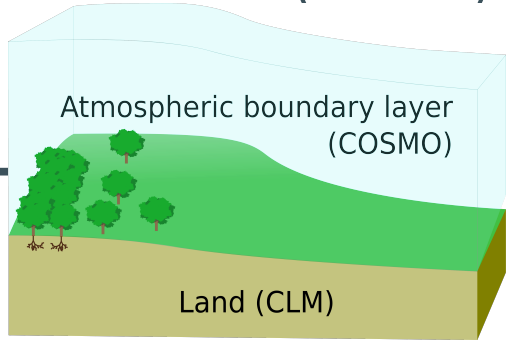
\- impact on soil moisture analysis

(e.g. Hess, 2001; Drusch and Viterbo, 2007; Carrera et al., 2019; Muñoz-Sabater et al., 2019)

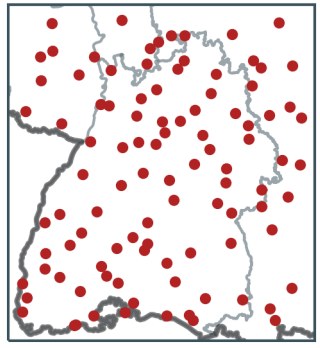
How to efficiently assimilate observations across the interface?

Idealised twin experiments for coupled atmosphere-land data assimilation

Nature run (“truth”)



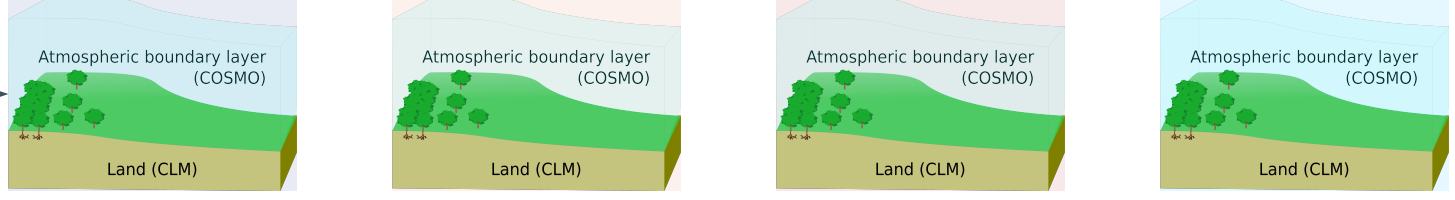
Synthetic Observations



Data assimilation

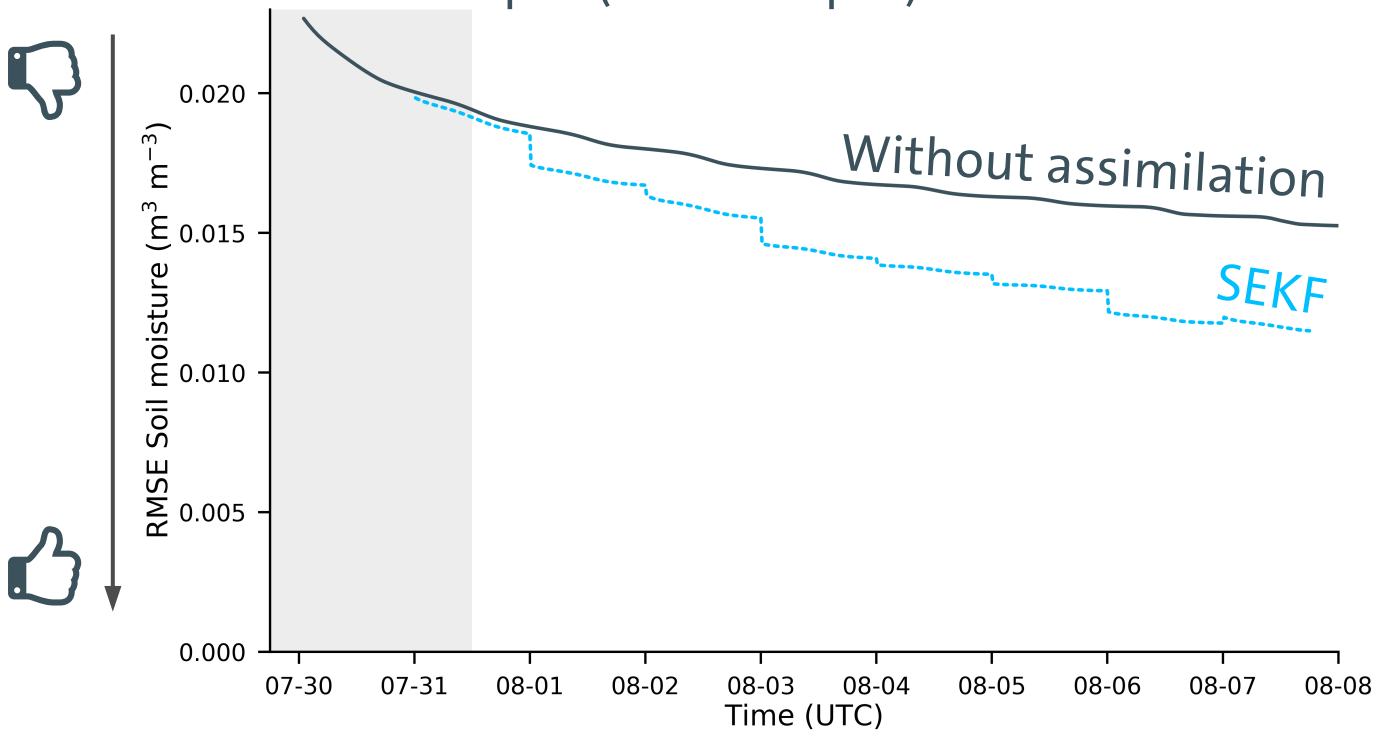
+ initial soil perturbations

Ensemble (40 simulations)



Setup works for reference data assimilation

Soil moisture in root-depth (0.21 m depth)



Simplified extended Kalman filter – 1D method
(de Rosnay et al. 2013)

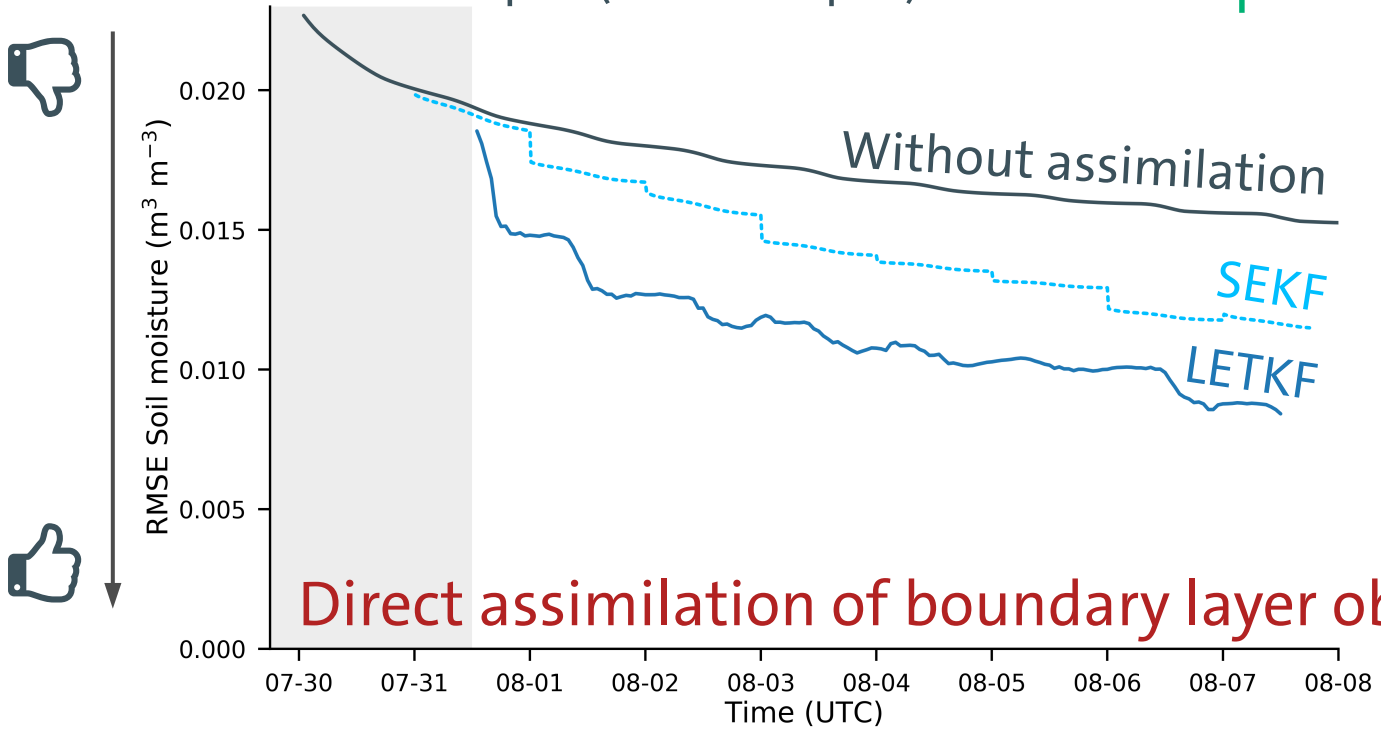
Update at 00:00 UTC

Fully-observed field at 12:00 UTC

Hourly LETKF assimilation additionally improves analysis

Soil moisture in root-depth (0.21 m depth)

↗ Improvement (SEKF): 20 %



LETKF (Hunt et al. 2007)

Hourly updates with 99 observations

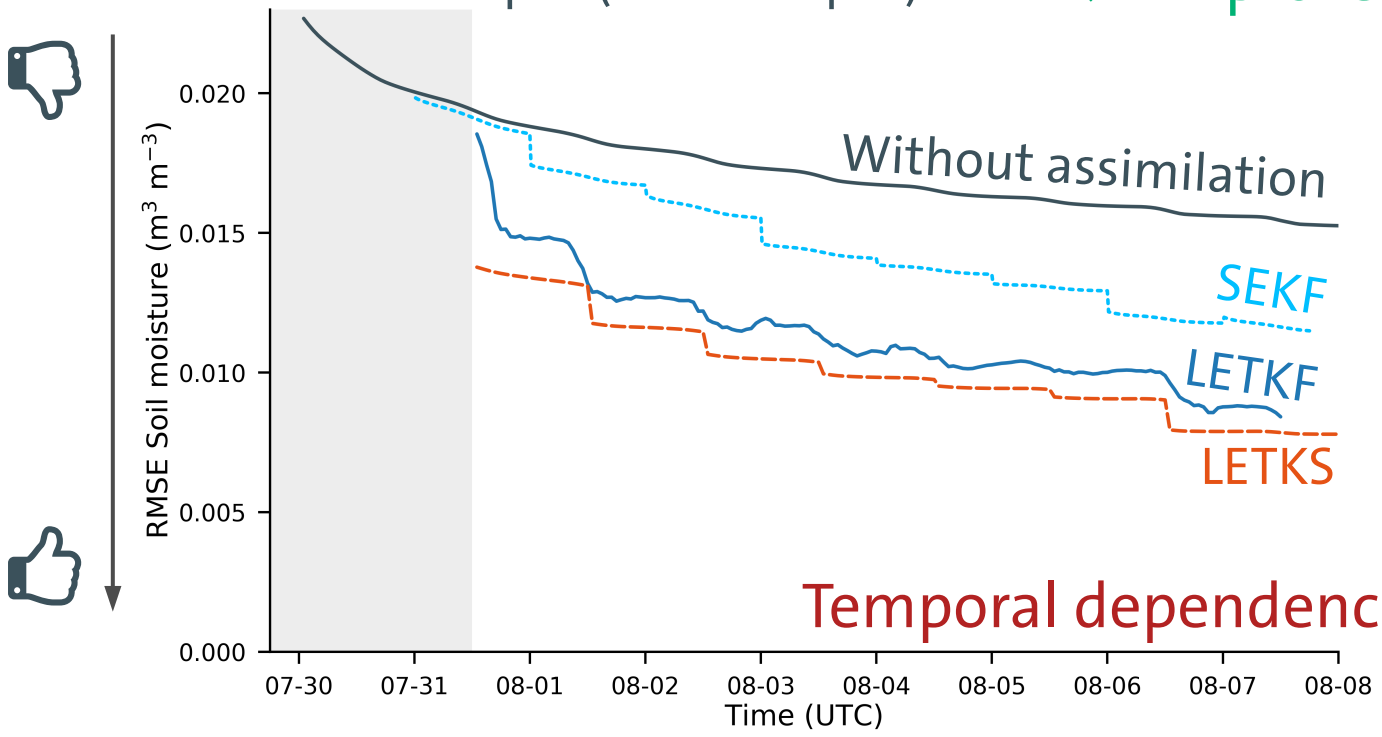
Obs. localisation (15 km) + very small inflation

Direct assimilation of boundary layer observations possible

A positive impact with a localised ensemble Kalman smoother

Soil moisture in root-depth (0.21 m depth)

↗ Improvement (LETKF): 10 %



Linearised IEnKS
(Bocquet and Sakov, 2014)

Same localisation
+ much larger inflation

24 hour window

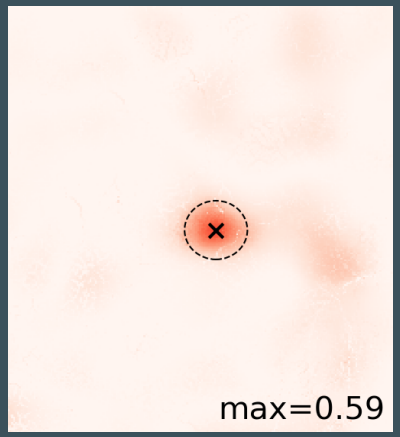
Temporal dependencies improve analysis

“Overfitting” with the ensemble Kalman smoother

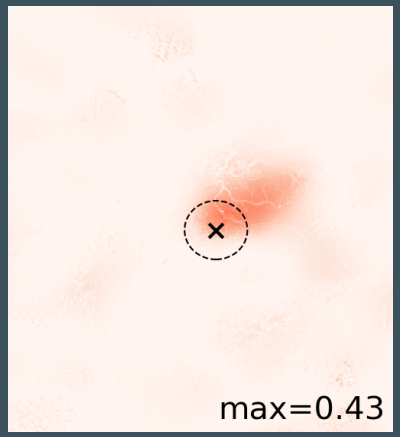
12:00 UTC

Soil moisture

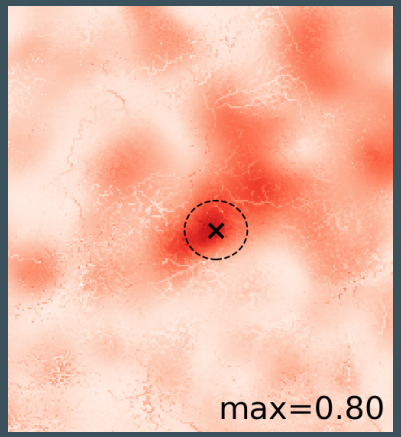
Filter

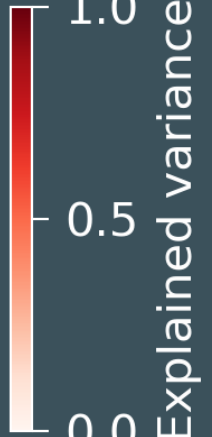


Filter



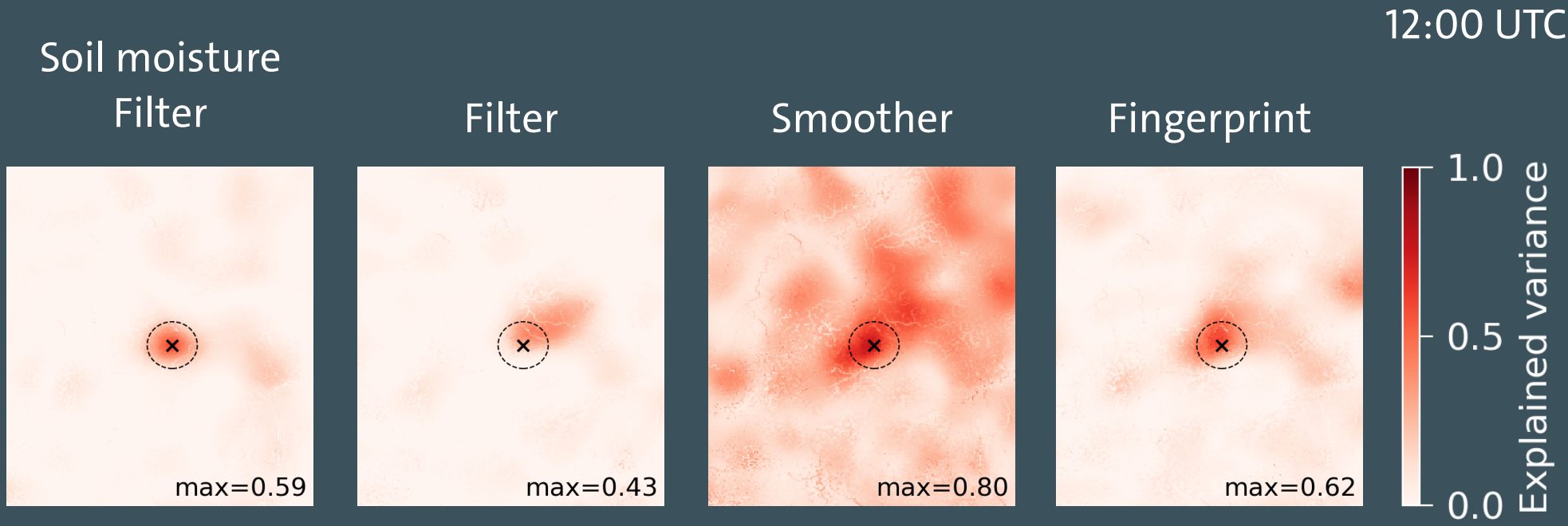
Smoother





More difficult to tune covariances with inflation and localisation

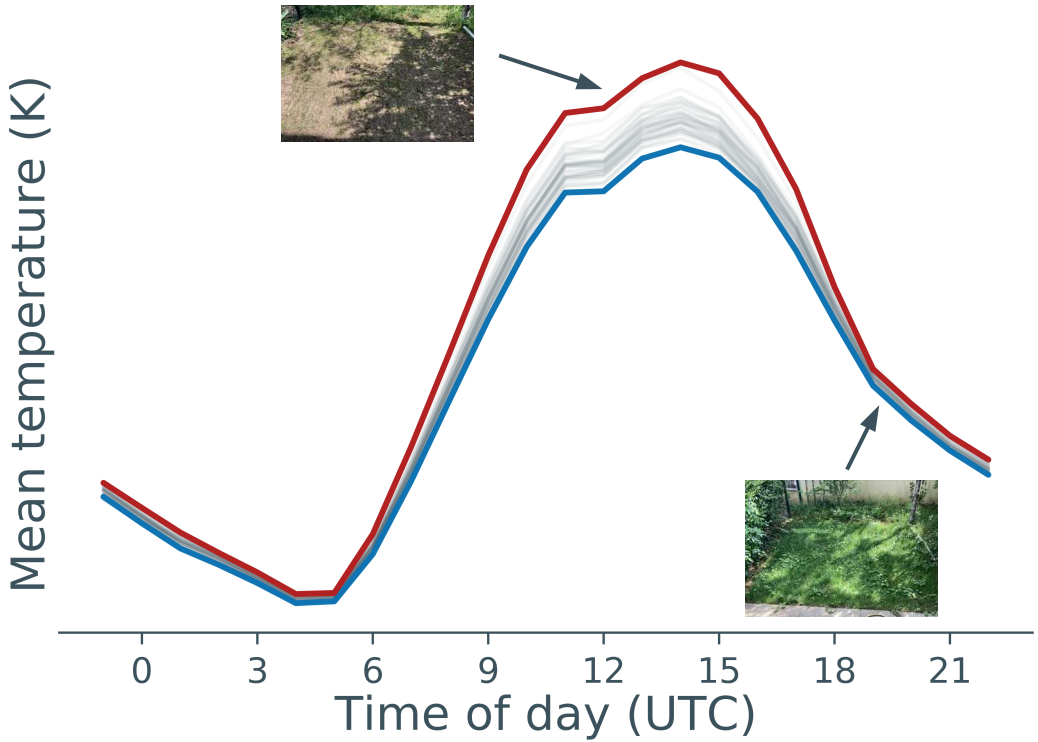
Fingerprint operators reduce this problem



What are fingerprint operators and how to construct them?

How to construct fingerprint operators for the atmosphere-land interface

Feature-based data assimilation (Morzfeld, 2018)



How to construct fingerprint operators for the atmosphere-land interface

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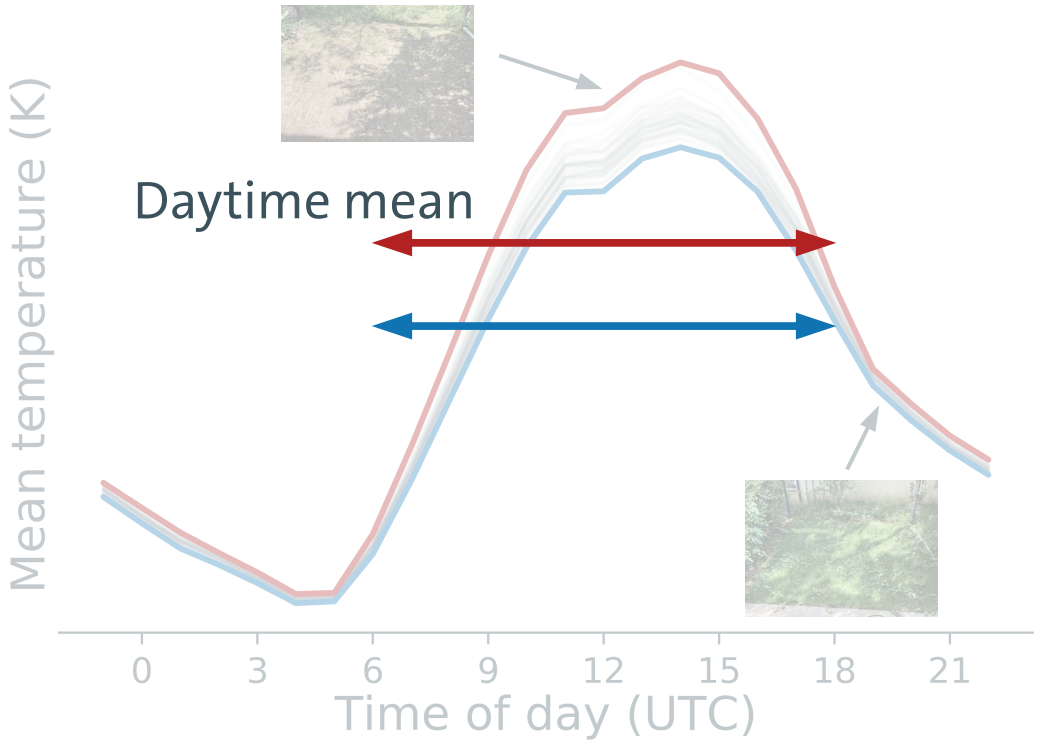
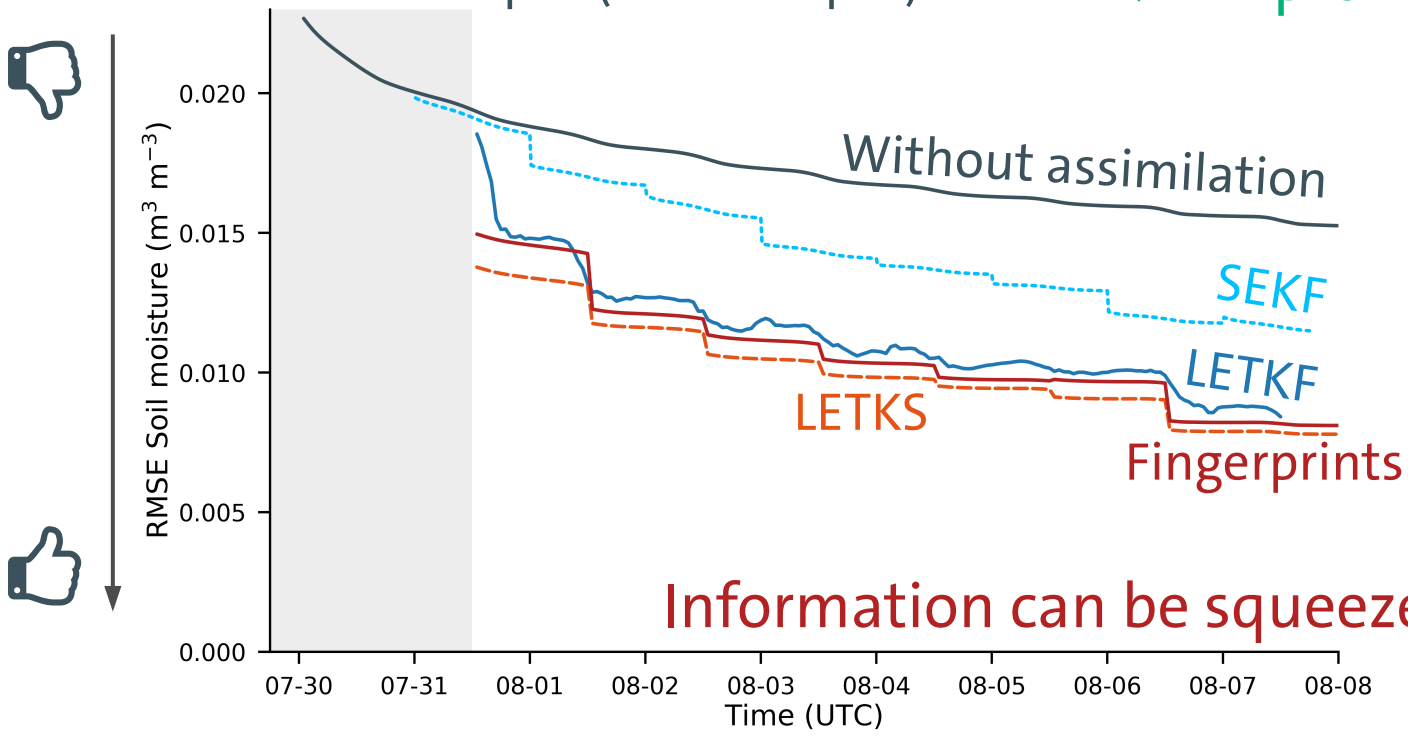


Amplitude

Almost as good as using the raw observations

Soil moisture in root-depth (0.21 m depth)

↗ Improvement (LETKF): 5 %



LETKS framework

24 hour window

Same localisation
+ small inflation

Information can be squeezed into two features

Conclusions

Emerging potential of localised EnKF framework to update soil moisture with screen-level observations

Direct assimilation of screen-level observations into the soil moisture with an hourly interval possible

Fingerprint operators allow a flexible use of observational information to make the coupled data assimilation problem easier

Do you have questions?

Feel free to write me an email: tobias.finn@enpc.fr

Or take a look at: Finn, T. S. (2022), doi:10.17617/2.3381204