Soil moisture analysis at DWD

Experiences from operations and ELDAS

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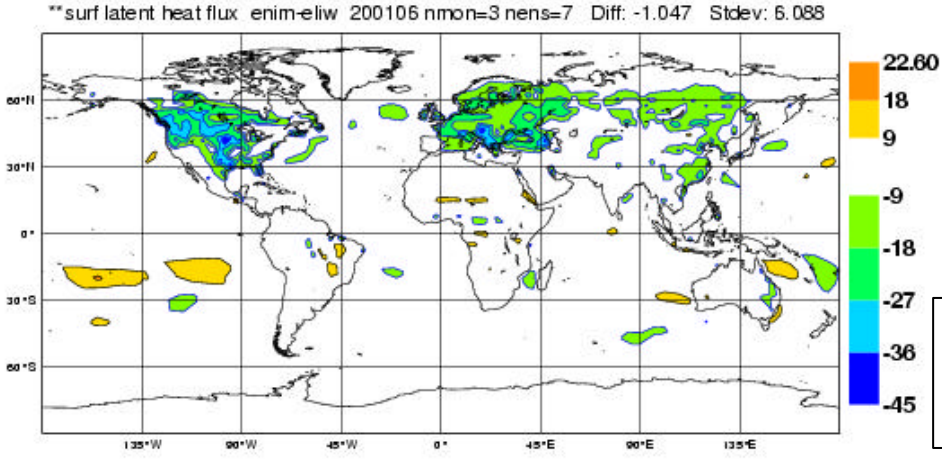
DWD

LM(E) user meeting, Langen 2006

Outline

- Motivation for soil moisture analysis
- The method
- Experiences with LM(E)
- Results from Eldas
- Conclusions

(E-TESSEL) – TESSEL: JJA

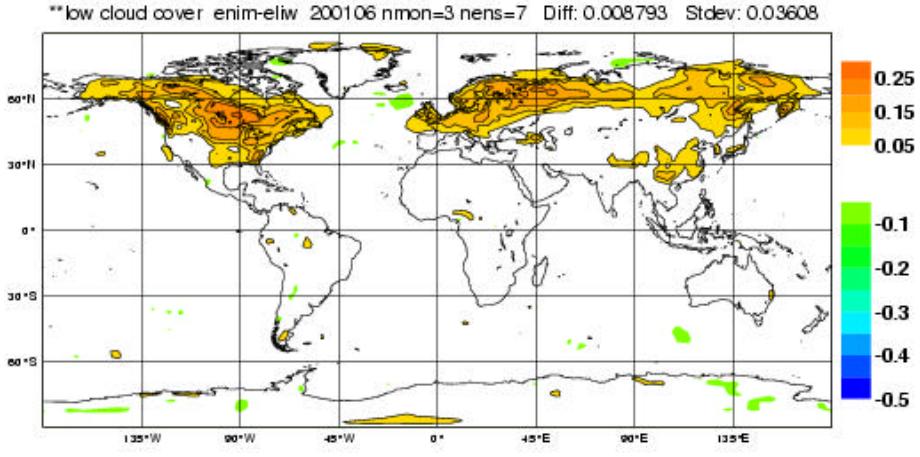


Increased

Latent heat flux (Wm^{-2})

Due to:

Lower canopy resistance



increased

Low cloud cover

Small impact on

High cloud cover

Medium cloud cover

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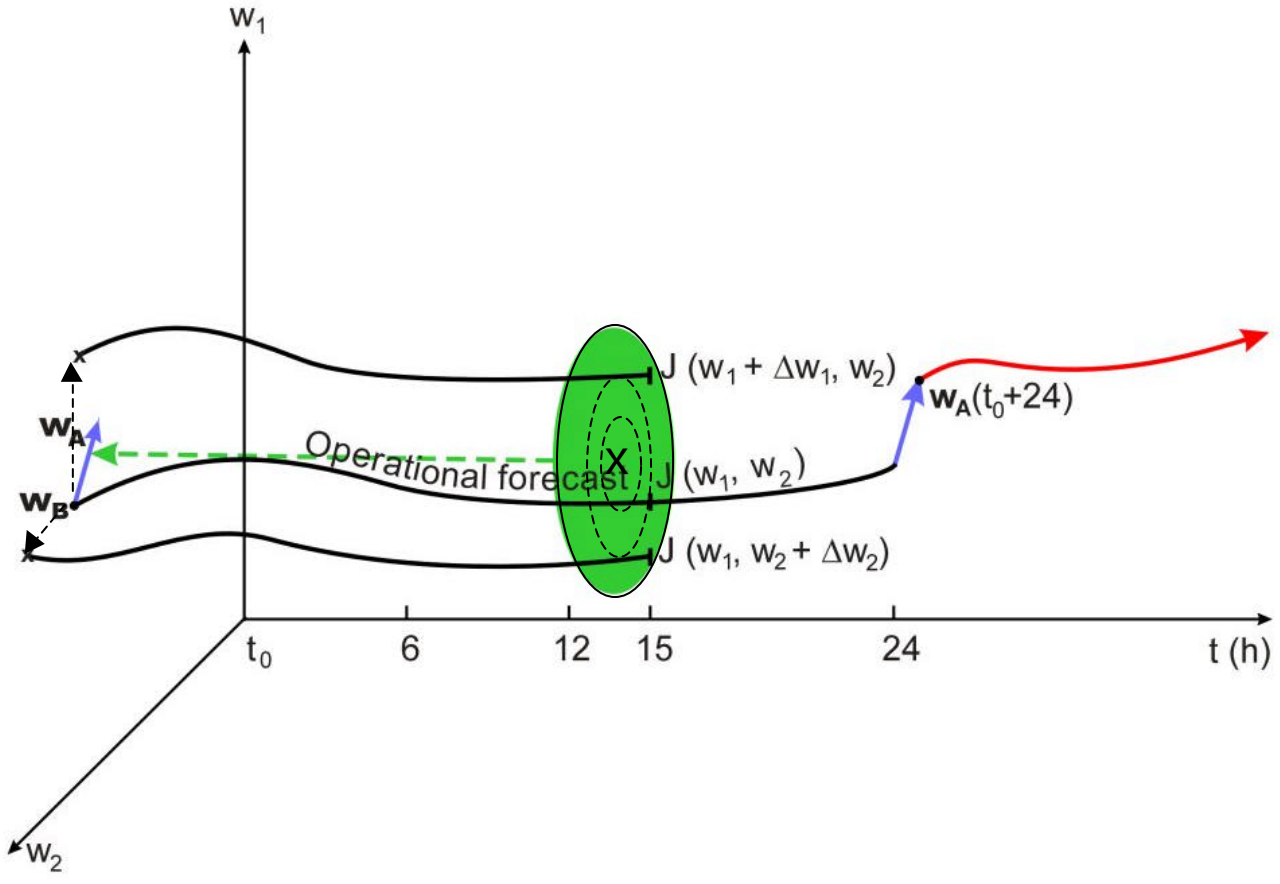
Concept of the Variational Soil Moisture Assimilation



2d var (z,t) soil moisture analysis

Cost function penalizes deviations from observations and initial soil moisture content

$$J = (h - h_b)^T B^{-1} (h - h_b) + (T_{2m} - T_{2m}{}^{obs})^T O^{-1} (T_{2m} - T_{2m}{}^{obs})$$

Assumption: Linearity between variation of T2m and wb

$$T_{2m} = T_{2m}(h_b) + \Gamma_{T2m}(h - h_b), \quad \Gamma_{T2m} = dT_{2m}(12:00, 15:00) / dwb(0:00)$$

Calculate minimum of cost function analytically

$$\nabla J = 0$$

$$h_{ana} = h_b + (\Gamma_{T2m}{}^T O^{-1} \Gamma_{T2m} + B^{-1})^{-1} \Gamma_{T2m}{}^T O^{-1} (T_{2m}{}^{obs} - T_{2m}(h_b))$$

Analysis error and update of Background error covariance matrix:

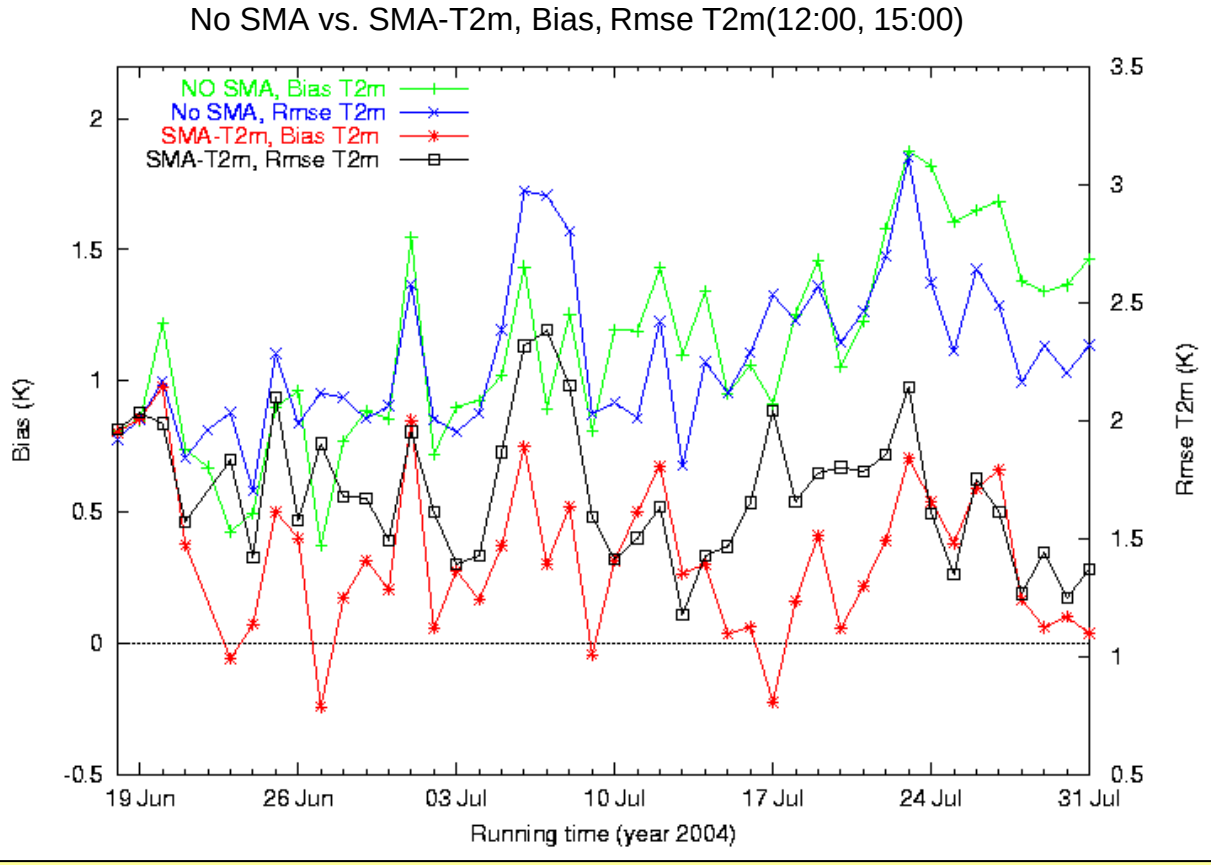
$$A = \nabla^2 J = (\Gamma_{T2m}{}^T O^{-1} \Gamma_{T2m} + B^{-1})^{-1}$$

$$B^{t+1} = MAM^T + Q$$

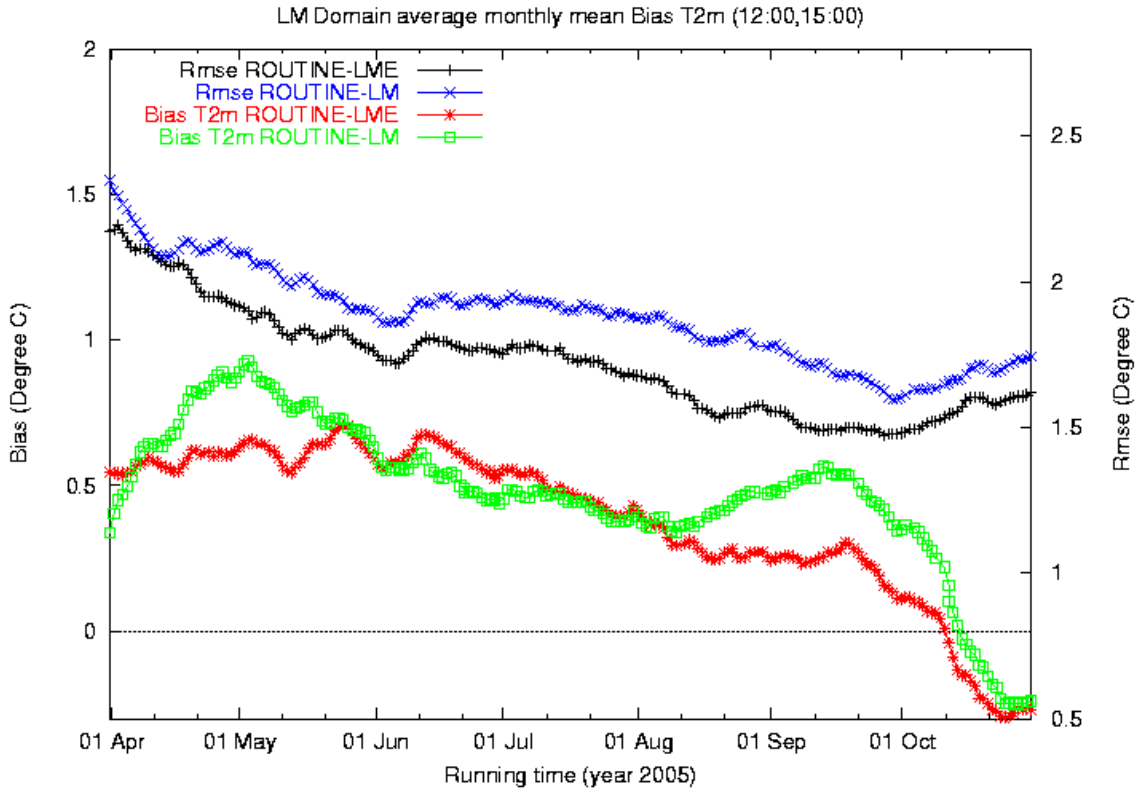
Experiences from operations

- LME: SMA against No SMA
  Six week Test Period June/July 2004
- LME vs. LM
  Parallelsuite April-November 2005
- Climatology of soil moisture increments

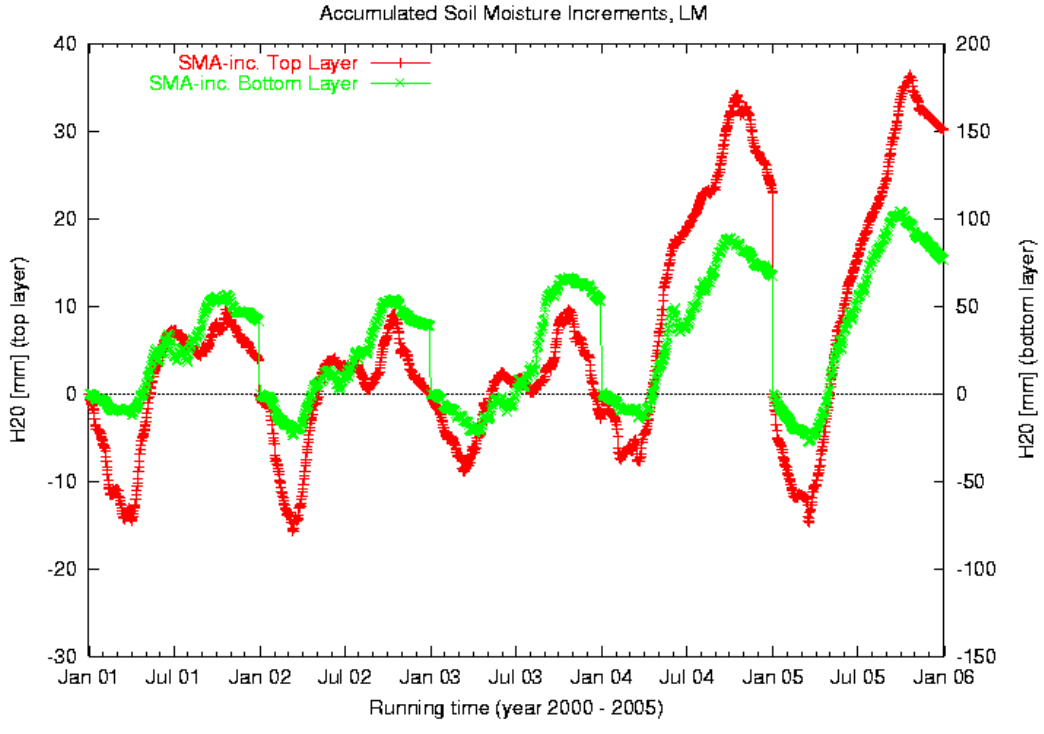
SMA (T2m) reduces effectively Bias and Rmse of T2m in LME



SMA-T2m: LME beats LM

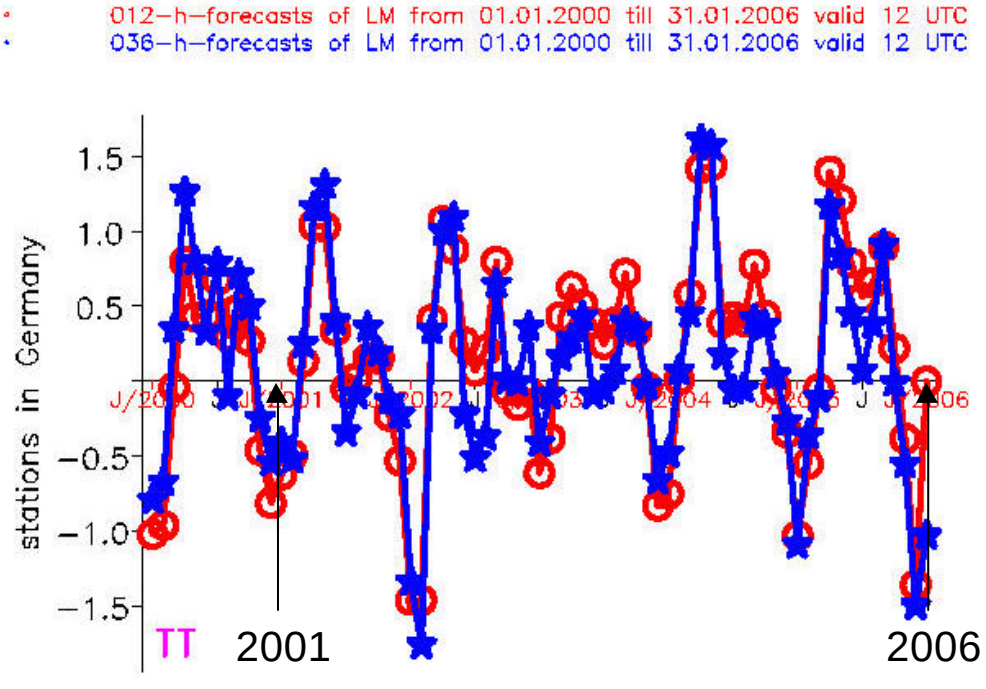


Hydrological annual budget of SMA far from being closed



Large positive bias for T2m in 2004, 2005

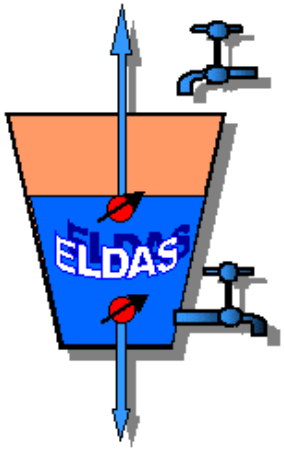
in spite of soil moisture analysis



Results of verification of forecasts for local weather elements at surface stations
frequency bias for cloud covers (–: 0–2/8, – –: 7–8/8), gusts
and precipitation T–6 till T, mean error for other elements

Eldas

Development of a European Land Data Assimilation System to predict droughts and floods



- Combine european expertise in soil moisture assimilation to build and implement a soil moisture assimilation system at a number of european weather centers.
- Build a demonstration database covering at least one seasonal cycle.
- Validate the soil moisture fields against independent observations.
- Assess the added value of soil moisture assimilation to predict the hydrological cycle on the continental scale with focus on prediction of droughts and the risk of floodings.

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Eldas model experiments covering the period April 15 – December 31 2000

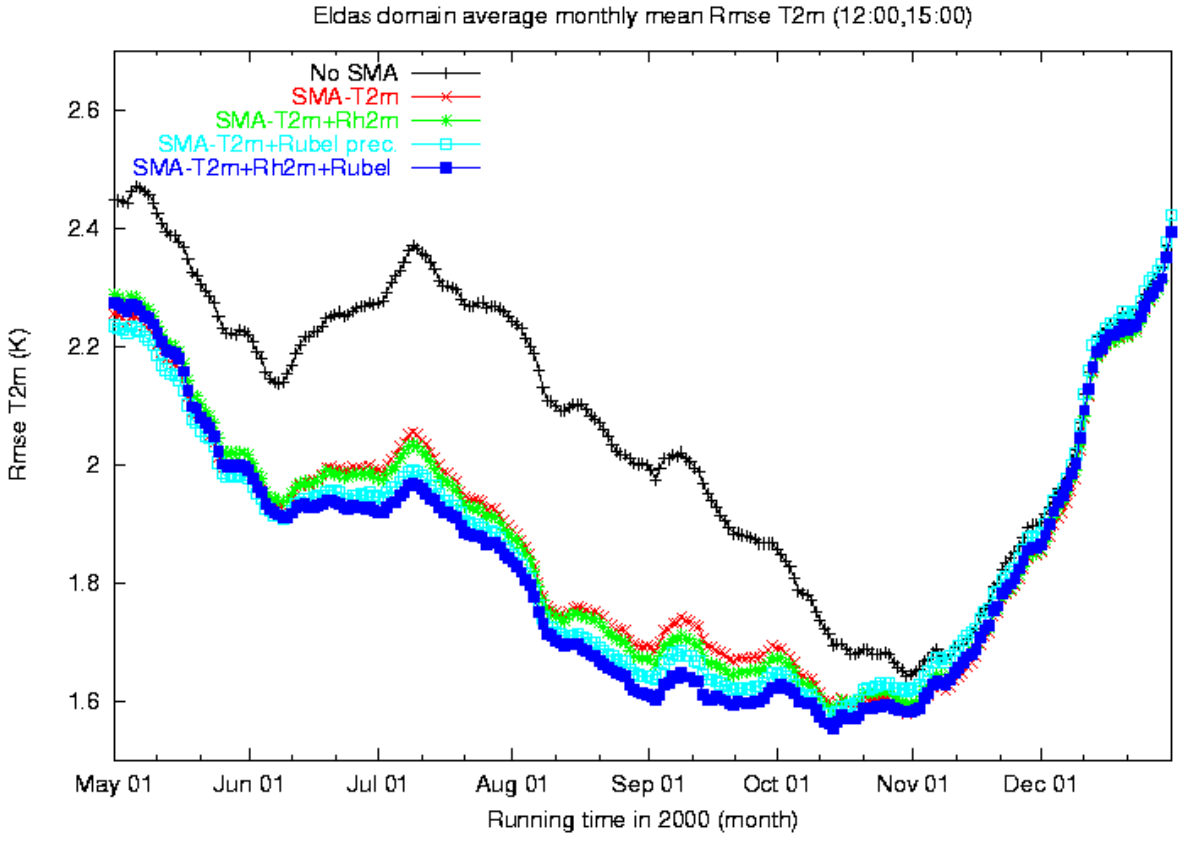
Experimental setup

Model base	Eldas Domain	Grid	Land surface scheme	Soil moisture assimilation system	External forcing	Physiografic data (LAI, plcov, zgeo…)
GME / LM	Europe	LM rotated (0.2° x 0.2°)	TERRA (2 layers)	SMA (T2m, Rh2m) depending on experim.	3 hourly Precipitation data	Ecoclimap

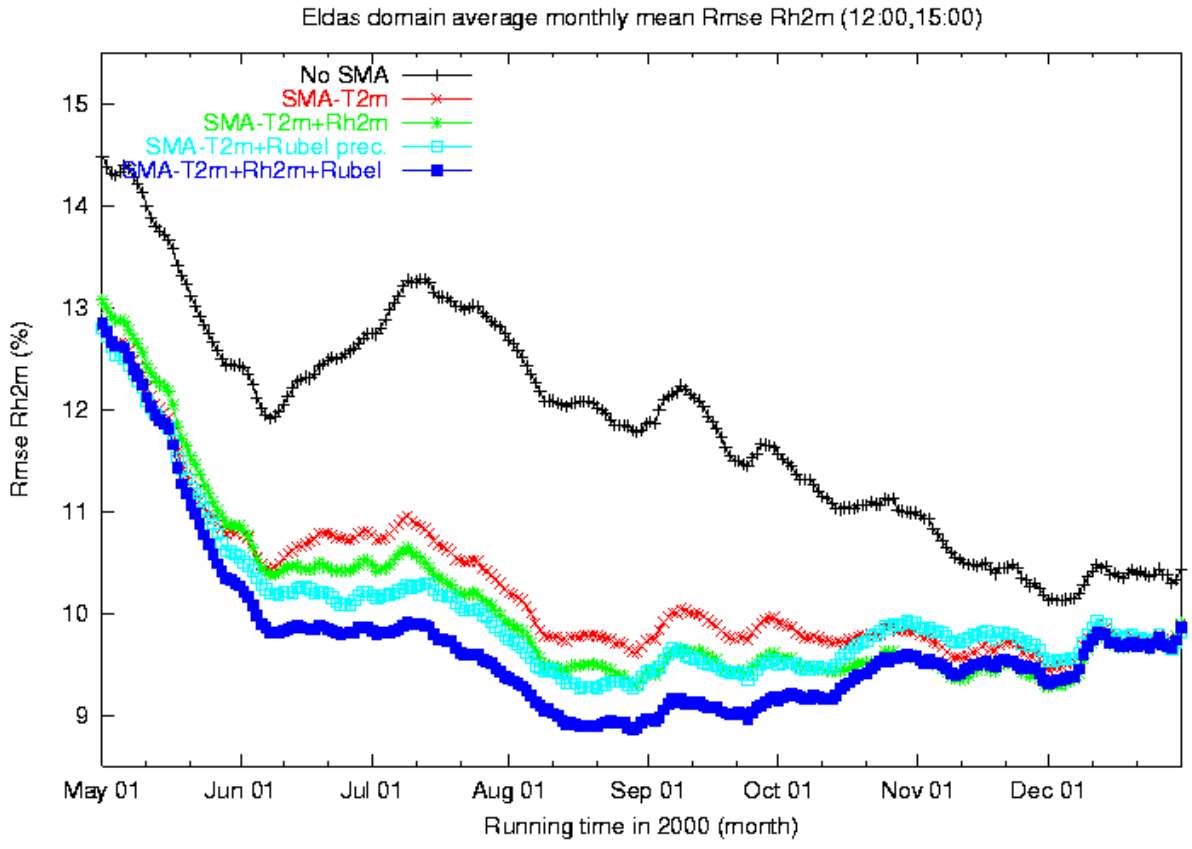
Model experiments

Used Observations	SMA–T2m	SMA-T2m+Rh2m	SMA-T2m+Precip.	SMA-T2m+Rh2m+Precip.	No SMA (Soil moisture from previous forecast, Initial data from SMA-T2m)
T2m	+	+	+	+	
Rh2m		+		+	
Precipìtation forcing			+	+	

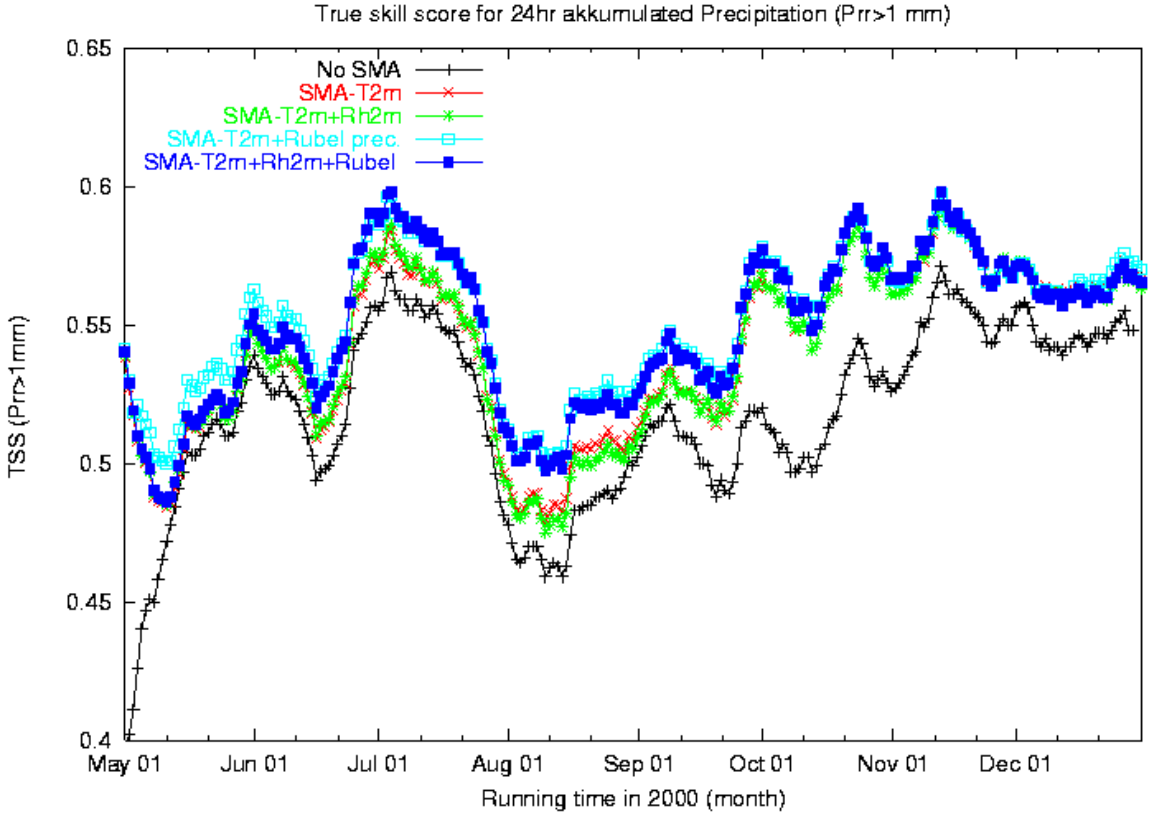
Significant impact on T2m with analysed precipitation, small effect with Rh2m in SMA



Positive Impact on Rh2m even more pronounced.
Again higher impact from analysed precipitation data.

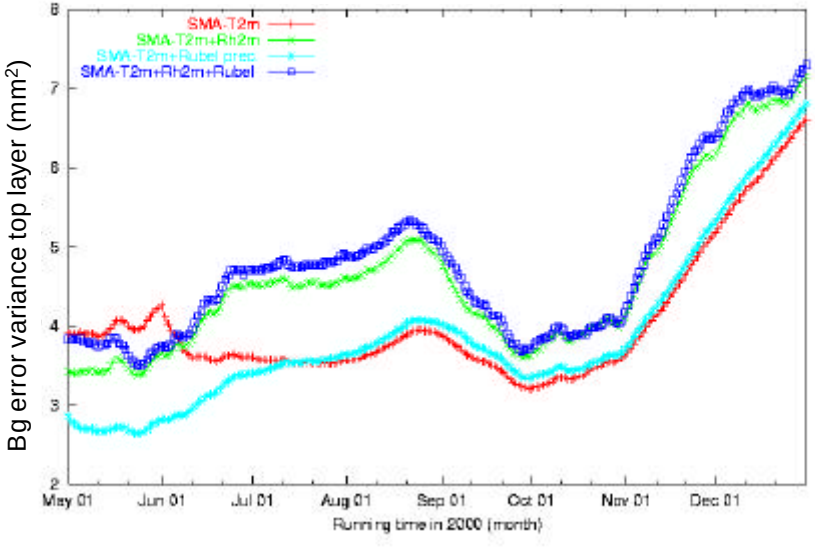


Improvement of 24 hr precipitation forecast with precipitation forcing

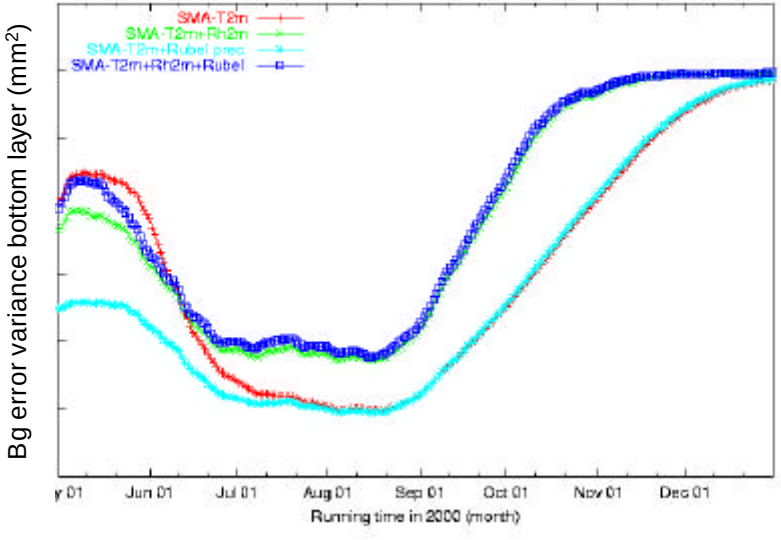


Confidence in soil moisture Analysis best during vegetation period for the bottom layer in top layer highest before and behind the vegetation period.

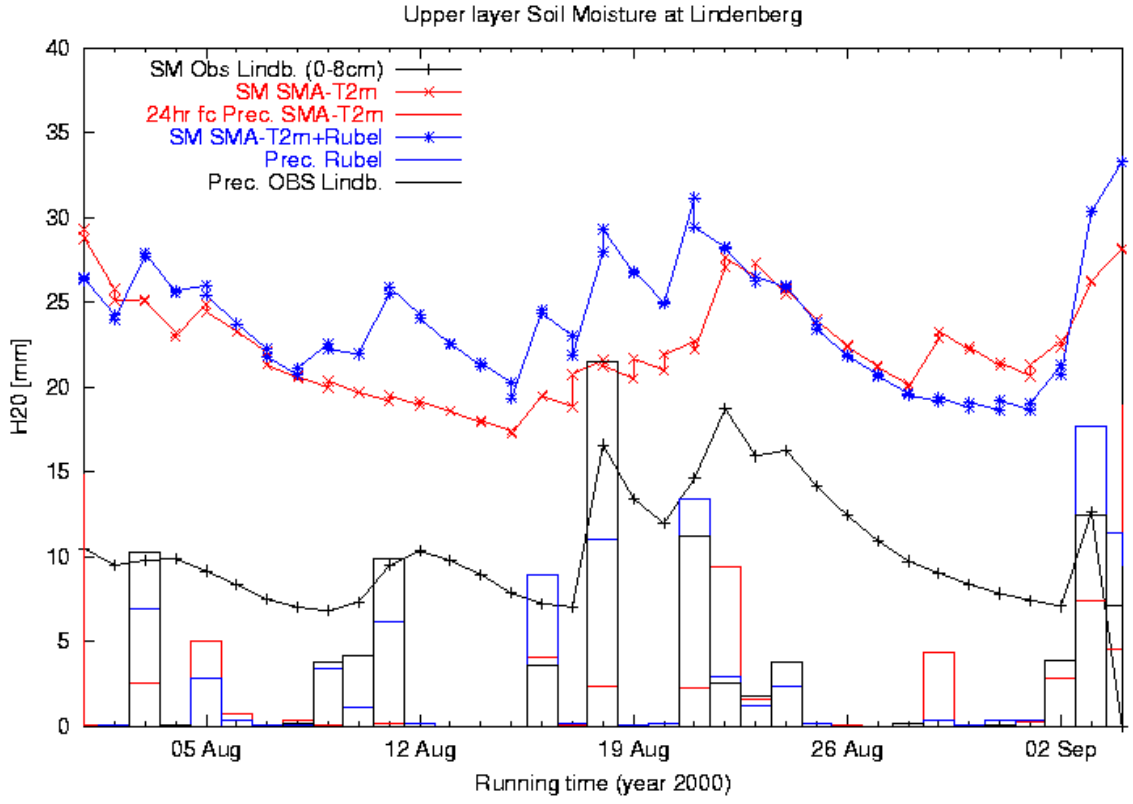
Eldas domain average daily background error variance top layer (mm^2)



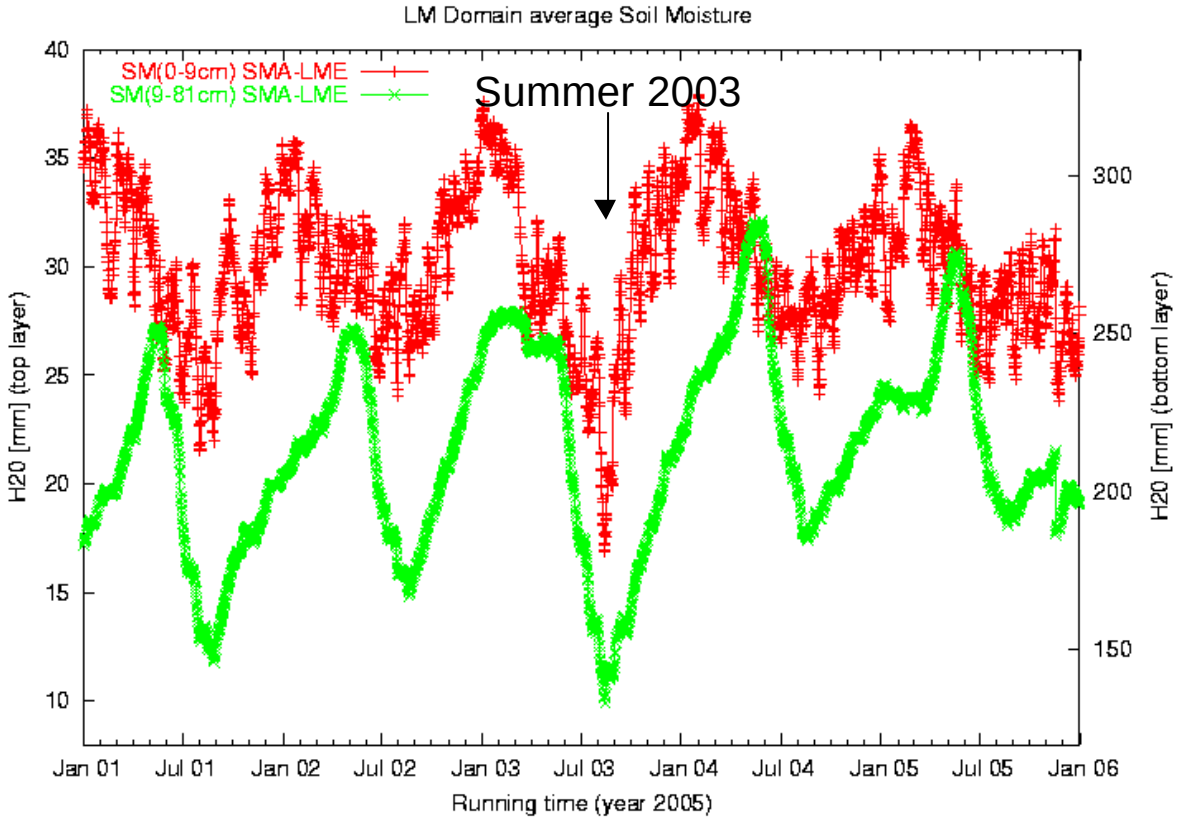
Eldas domain average daily background error variance bottom layer (mm^2)



Gridpoint validation of soil moisture at Lindenberg
Using analysed precipitation in the LM forecast



Soil moisture is climate monitor



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Conclusions

- SMA improves the forecast of screen level parameter and precipitation. Using analysed precipitation has strongest positive impact. A high qualityprecipitation product at analysis time therefore would be very much appreciated.
- SMA compensates for deficits in the flux parameterisation. This prevents from recovering errors in the land surface scheme during operations and leads to drifts in the soil moisture content.
- The interdisciplinarity between modellers, validators, hydrologists and agronoms should be enforced to come to more realistic soil moisture values applicable for flood and drought prediction.
- Future satellite informations on soil moisture content and heating rates available from microwave and thermal infrared radiation data should be used in the analysis. Resources are necessary to realise this!

Thanks to …

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- Ulrich Damrath for verification results.