Variational soil assimilation at DWD

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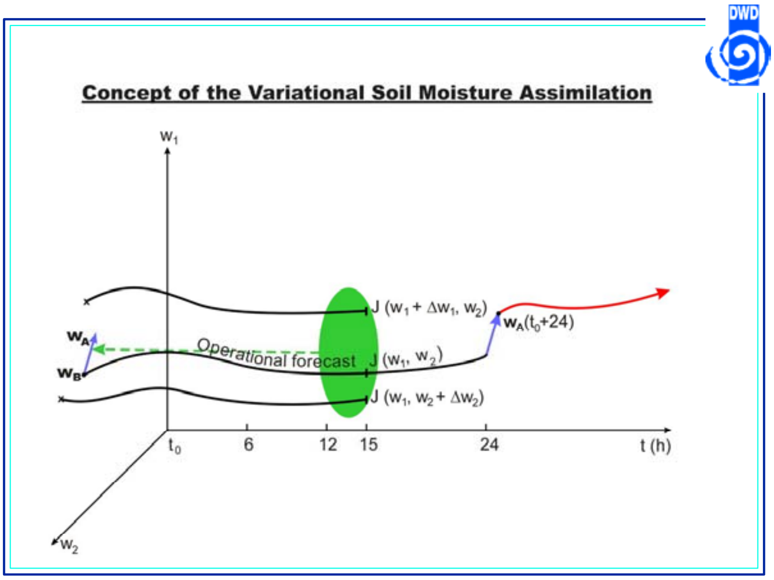
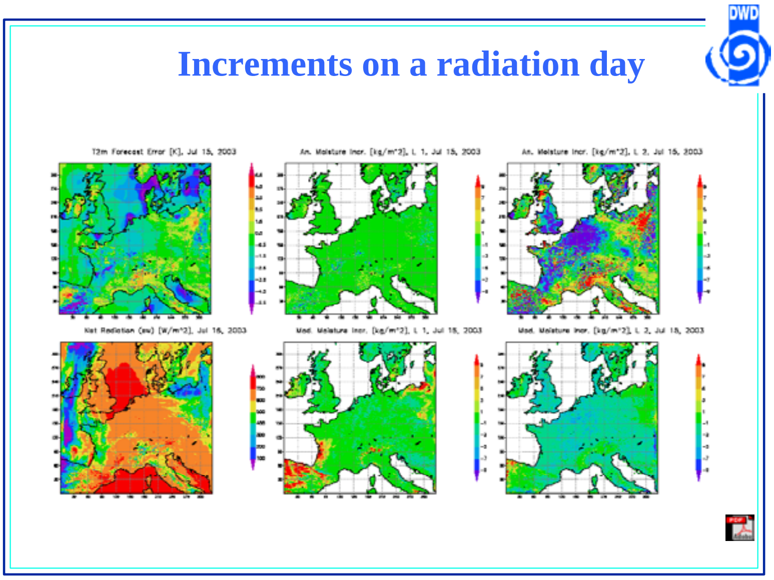
The soil moisture assimilation scheme (SMA) at DWD

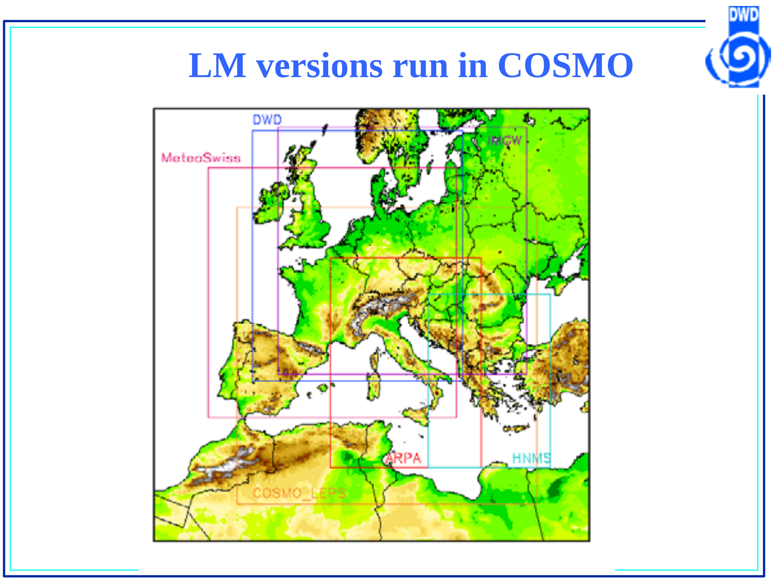
- Full description in Hess 2001, (Meteorol. Atmos. Phys., 77)
- Basic idea: Exploit information about soil wetness implicitly contained in screen level temperature and humidity
- Find soil moisture which minimizes screen level forecast errors
- Strong constraint approach: Errors in t and q at screen level only caused by initial state errors for soil wetness
- Grid points are assumed to be horizontally decoupled
- Dependence of control variables on soil wetness is linear
- Background error covariances can be advanced by persistence

Technical details

- I*J problems in 2 dimensions (soil depth, time)
- As many control variables as numbers of layers
- Perturbation method for finding gradients of cost function
- Quadratic cost function, no iterations required
- Analysis error covariance matrix can be calculated
- Kalman filter approach for advancing **B**
- Costs amount to two 15-hour forecasts
- Operational in the 'Lokal-Modell (LM)' at DWD since 14 March 2000
- Basis for assimilation schemes within ELDAS at ECMWF and Meteo France


Concept of the Variational Soil Moisture Assimilation
w_1
w_A
w_B
Operational forecast
$J(w_1 + \Delta w_1, w_2)$
$J(w_1, w_2)$
$J(w_1, w_2 + \Delta w_2)$
$w_A(t_0+24)$
t_0
6
12
15
24
t (h)
w_2

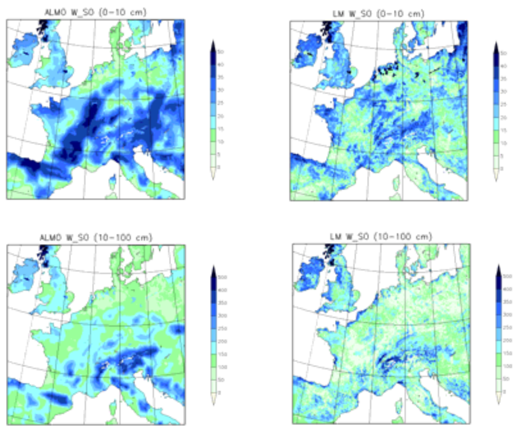

Increments on a radiation day


LM versions run in COSMO
DWD
MeteoSwiss
IMGW
ARPA
HNMS
COSMO_LEPS

Experiences from COSMO

- LM is run operationally in Switzerland, Italy, Greece, Poland and Germany
- Only DWD applies a soil moisture assimilation
- Comparison between Meteo Swiss and DWD results for summer 2003
- Boundary data for Global Model GME of DWD
- Models LM (DWD) and aLMo (Meteo Swiss) identical, except
  - Soil moisture assimilation (aLMo inserts moisture fields from free-running GME soil model)
  - Boundary layer parameterisation (minor impact)

Soil moisture in aLMo and LM, 20 Aug 2003



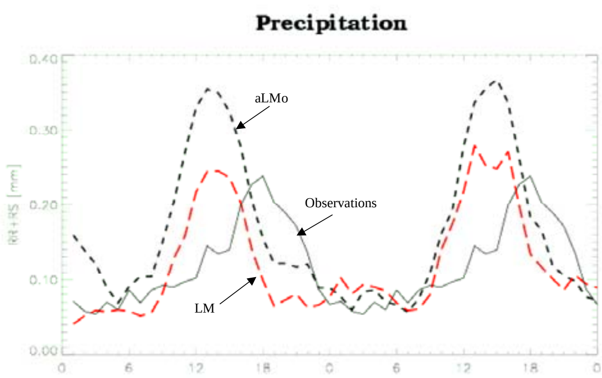
Top layer

Bottom Layer

Swiss model aLMo

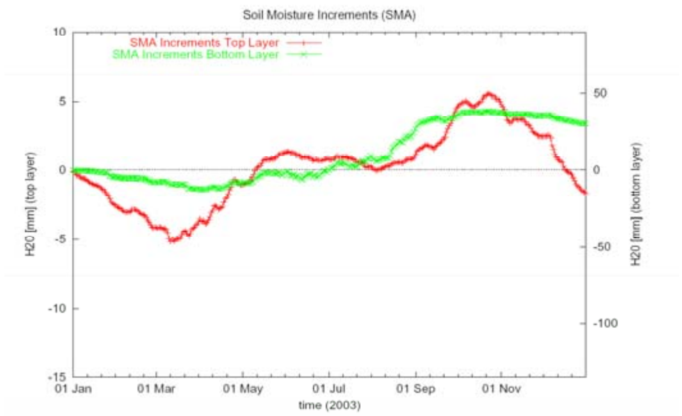
German model LM

Precipitation over Switzerland Summer 2003

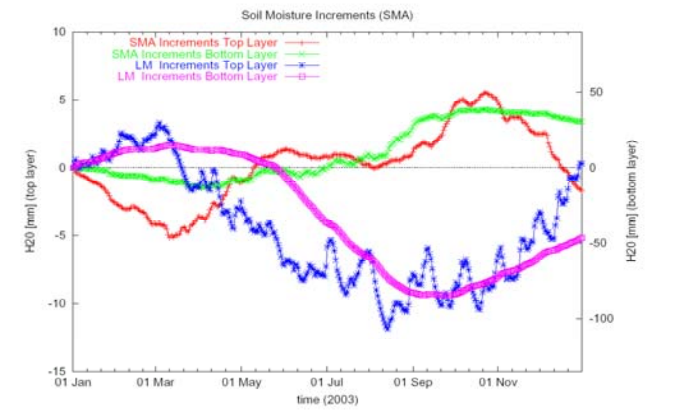


From Schubiger, 2003

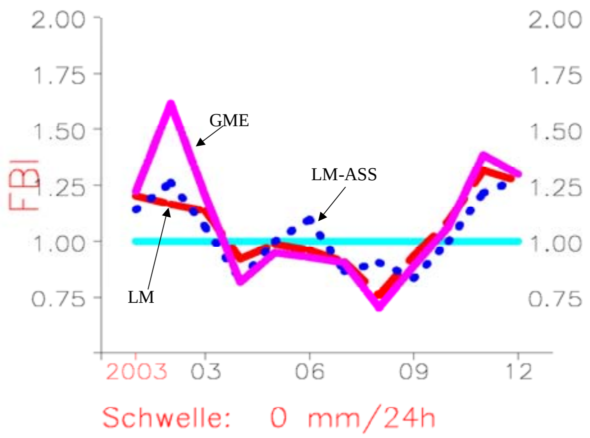
Accumulated assimilation increments



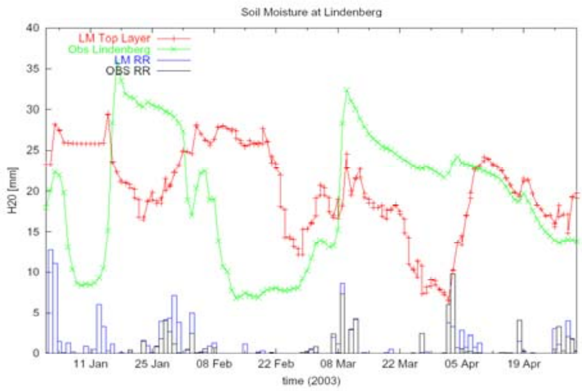
Assimilation incr. < Model increments?



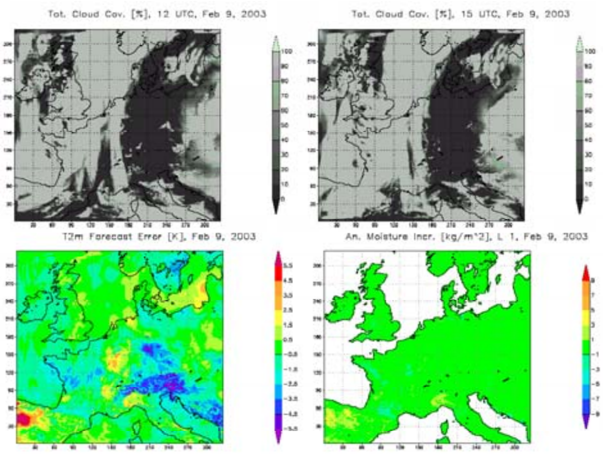
Frequency bias in precip. (Germany)



Verification at Lindenberg

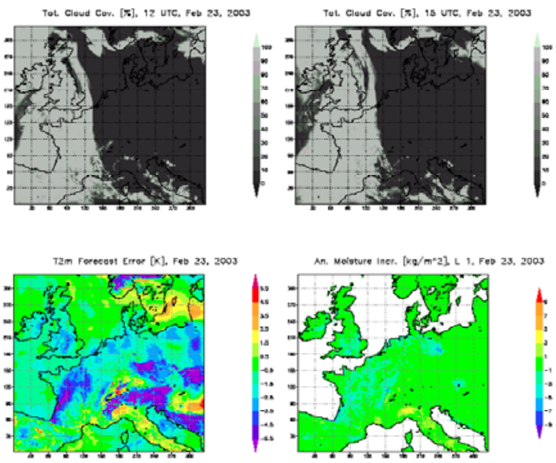


Operational SMA diagnostics



Adobe Acrobat-Dokument

Operational SMA diagnostics



Some concerns

- Strong constraints approach heavily relies on correct parameterisations (clouds, surface fluxes, ...)
- Not always the right result for the right reason
- Developments in parameterisation become more complex, as SMA and physics changes interfere
- Modelling of the background error covariance matrix **B** requires more attention

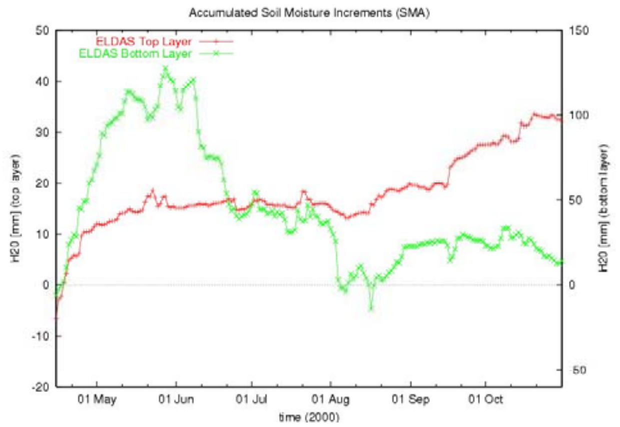
Conclusions from operations

- Soil moisture heavily influences model climate
- LM has problems in capturing the annual water (and energy) cycle
- The soil moisture assimilation is in principle capable of bringing the system closer to reality
- <u>No. 1 priority is the improvement of the precipitation input</u>

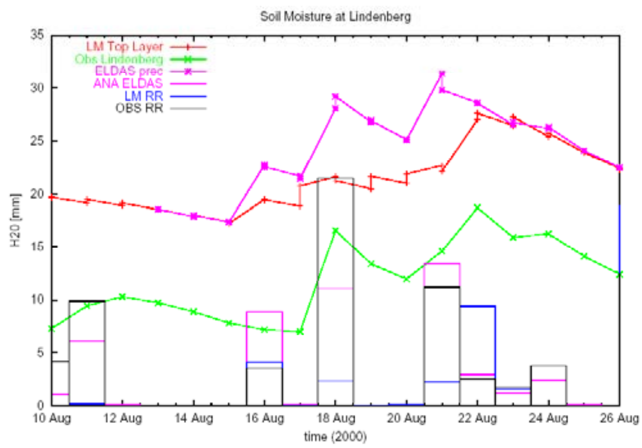
ELDAS assimilation

- New model domain and resolution for ELDAS
- External parameters (orography, soil and vegetation parameters) taken from ELDAS database
- Two assimilation from 15 April to 31 December 2000
  - Model precipitation
  - Observed precipitation from ELDAS database (Rubel et al)
- Run with observed precip. is currently re-done
- Results made available for validation
- Test runs made available early in the project for pilot studies

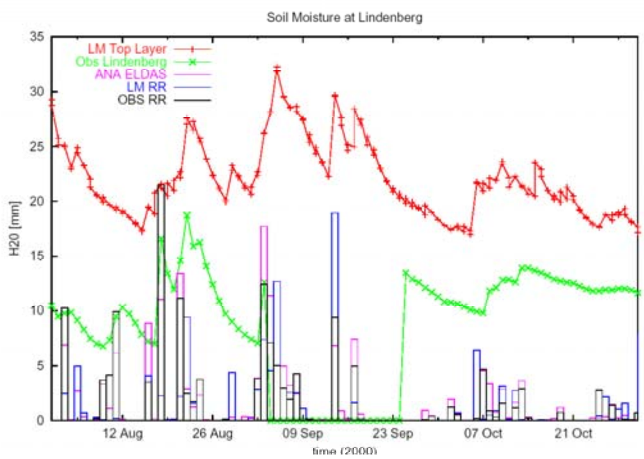
Accumulated SMA Increments



Effect of using observed precip



Verification of ELDAS results



Conclusions from ELDAS (prelim.)

- ELDAS has very ambitious goals: Improve the screen level forecasts and *at the same* time produce realistic soil moistures
- It looks like it can in principle be done, at least at the regional scale
- Results similar to operations
- More work is required
- Accuracy of precipitation input is paramount

Benefits from ELDAS

- The SMA scheme was developed within the former EU-project 'NEWBALTIC'
- New insights from fruitful discussions between the different communities
- Access to new data for validation
- Changes to operational system (GME +LM) motivated by ELDAS results
- Further changes planned (soil assimilation for GME, new soil model for LM)

Lessons learned

- Never underestimate the technical difficulties
- Be precise in technical specification
- Plan extensive monitoring tools
- Do pilot validations early in the project

Acknowledgements

- Francis Schubiger and Emanuele Zala (Meteo Swiss) provided the aLMo fields
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