



Variational soil assimilation at DWD

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- Description of the 2D-Var scheme
- Performance since introduction
- Efforts in ELDAS

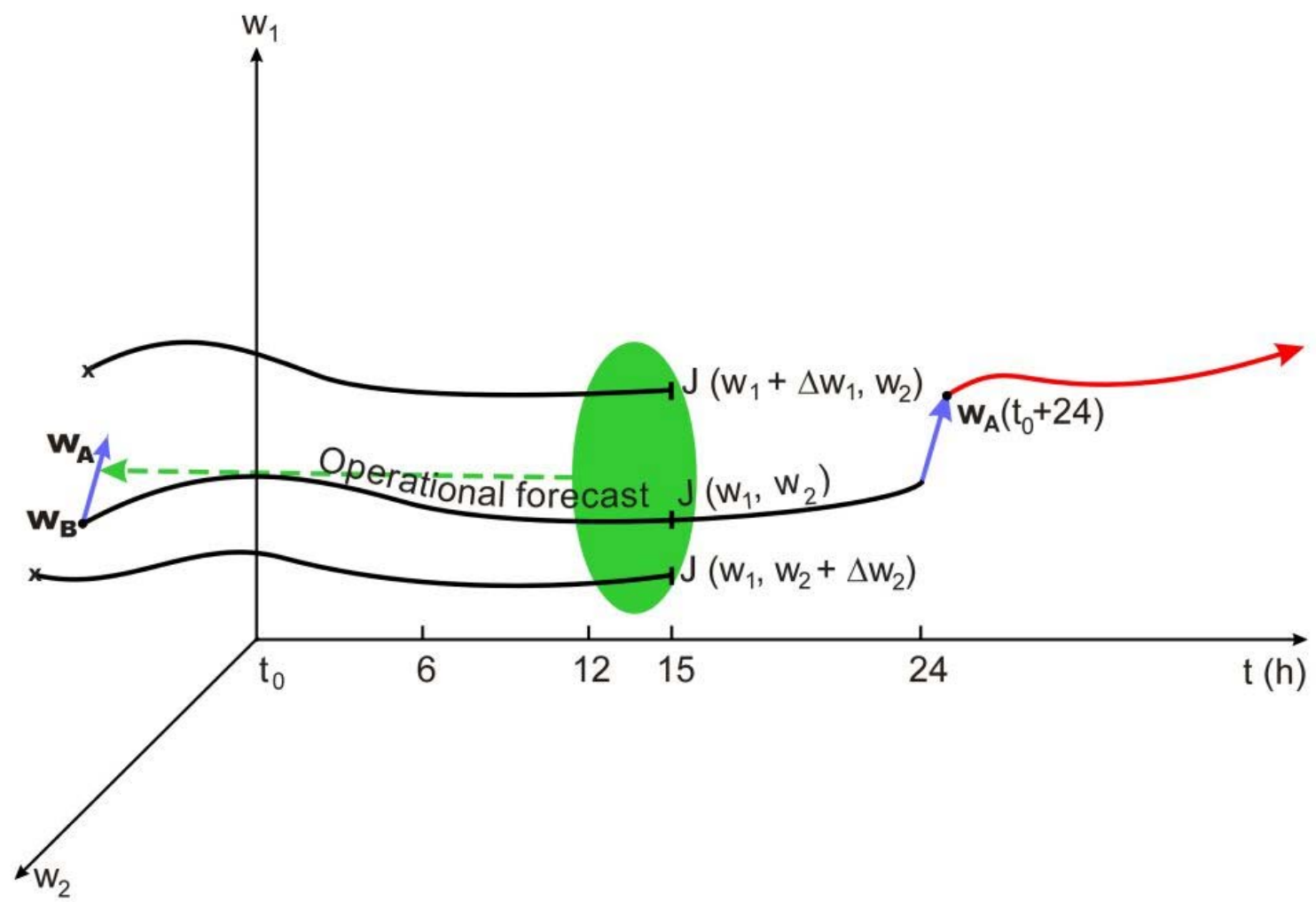
The soil moisture assimilation scheme (SMA) at DWD

- 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

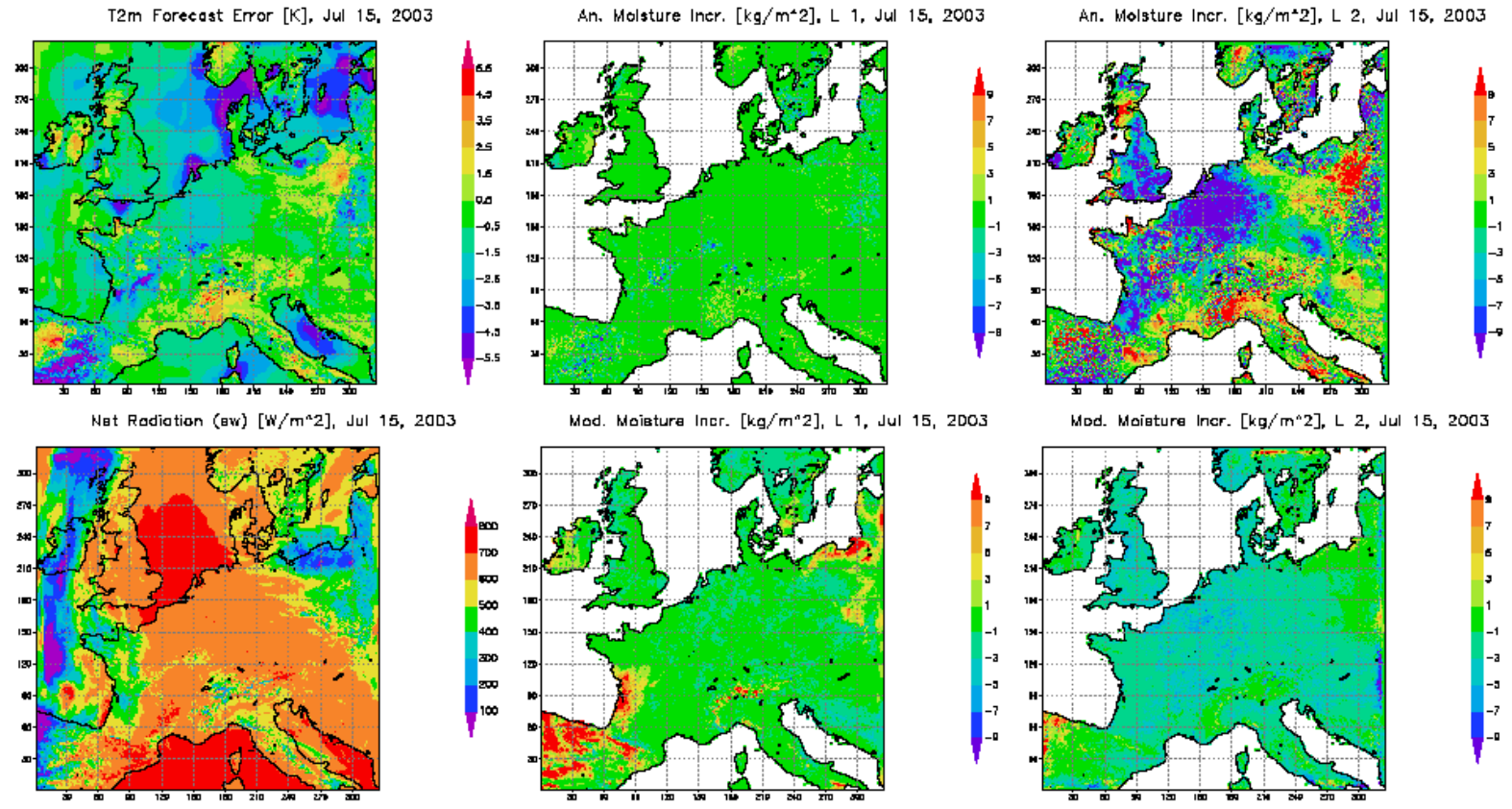
Technical details

- $I \times J$ 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

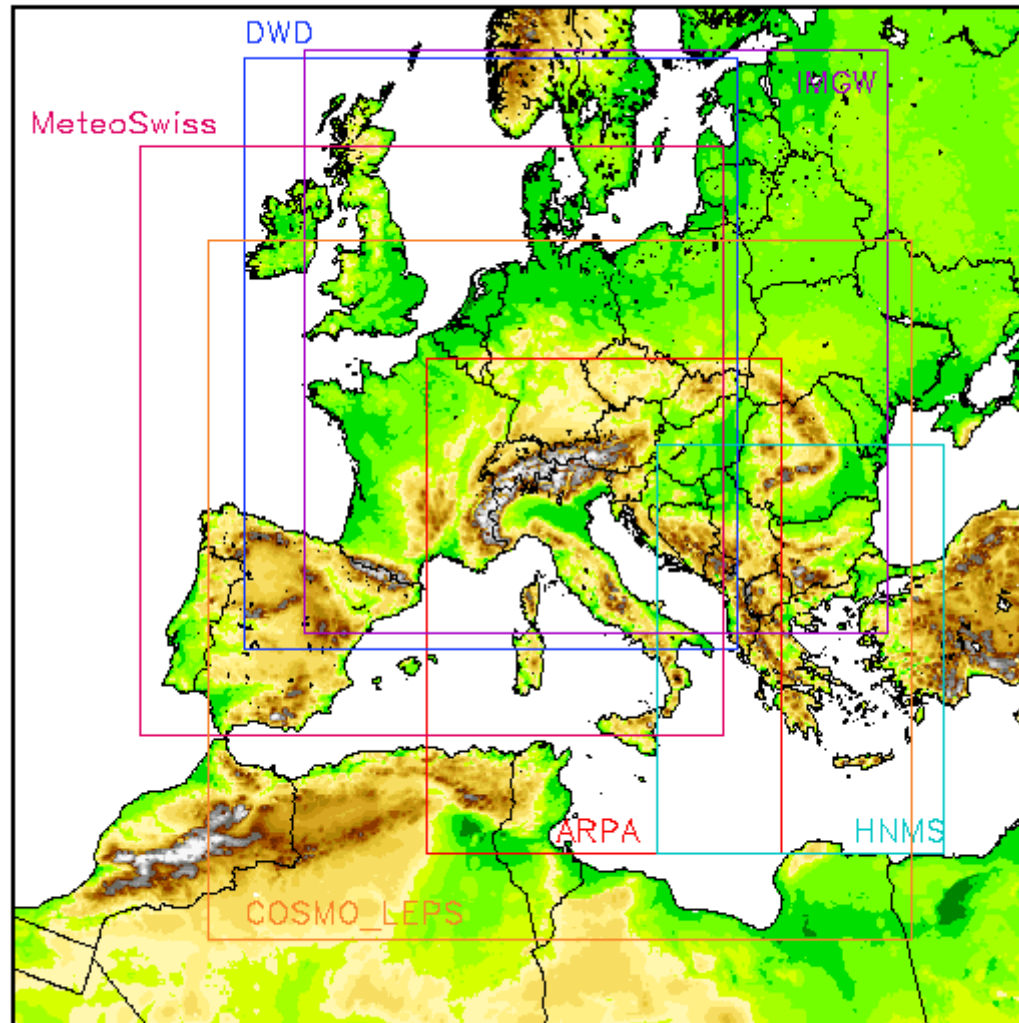
Concept of the Variational Soil Moisture Assimilation



Increments on a radiation day



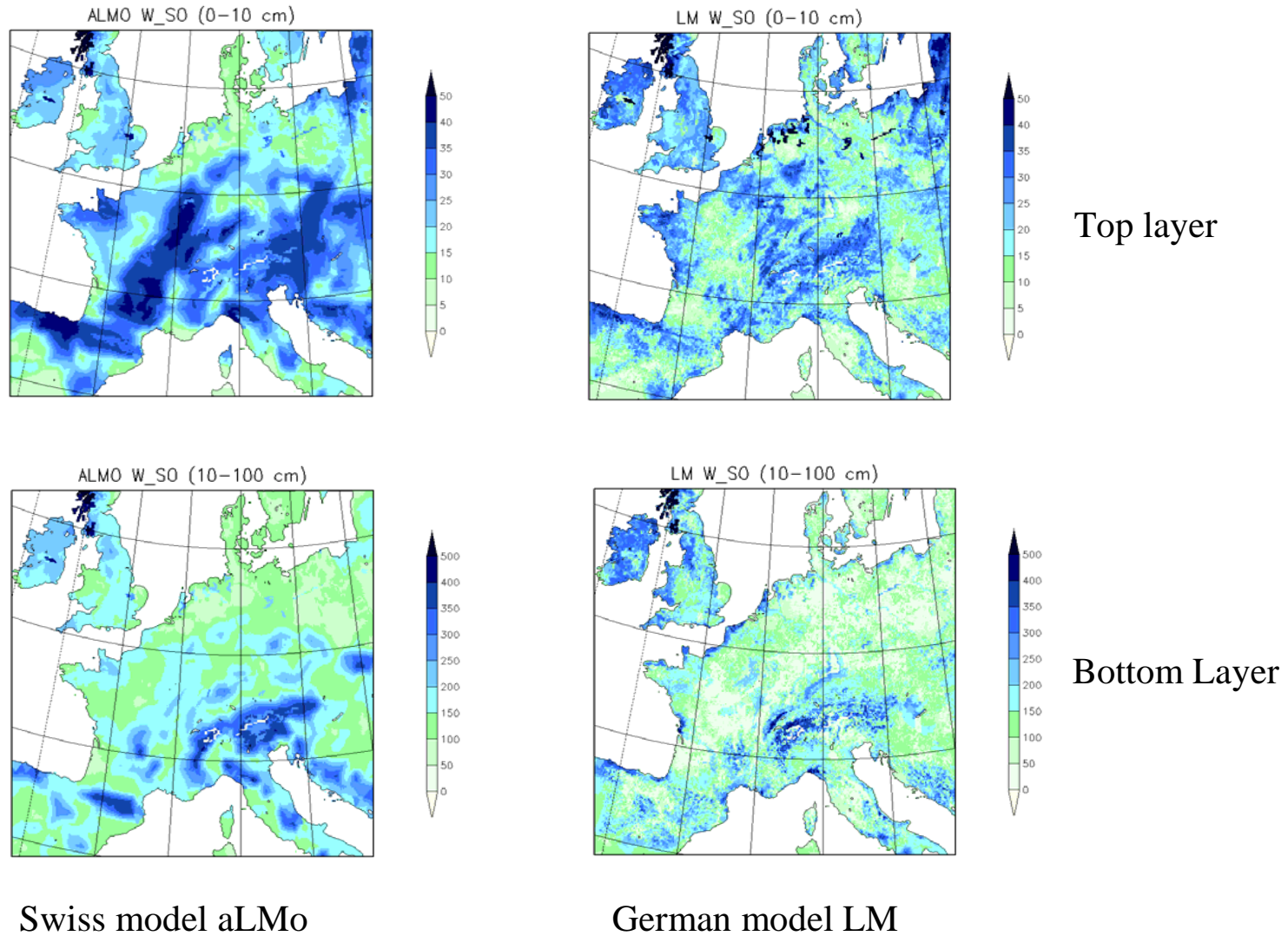
LM versions run in COSMO



Experiences from COSMO

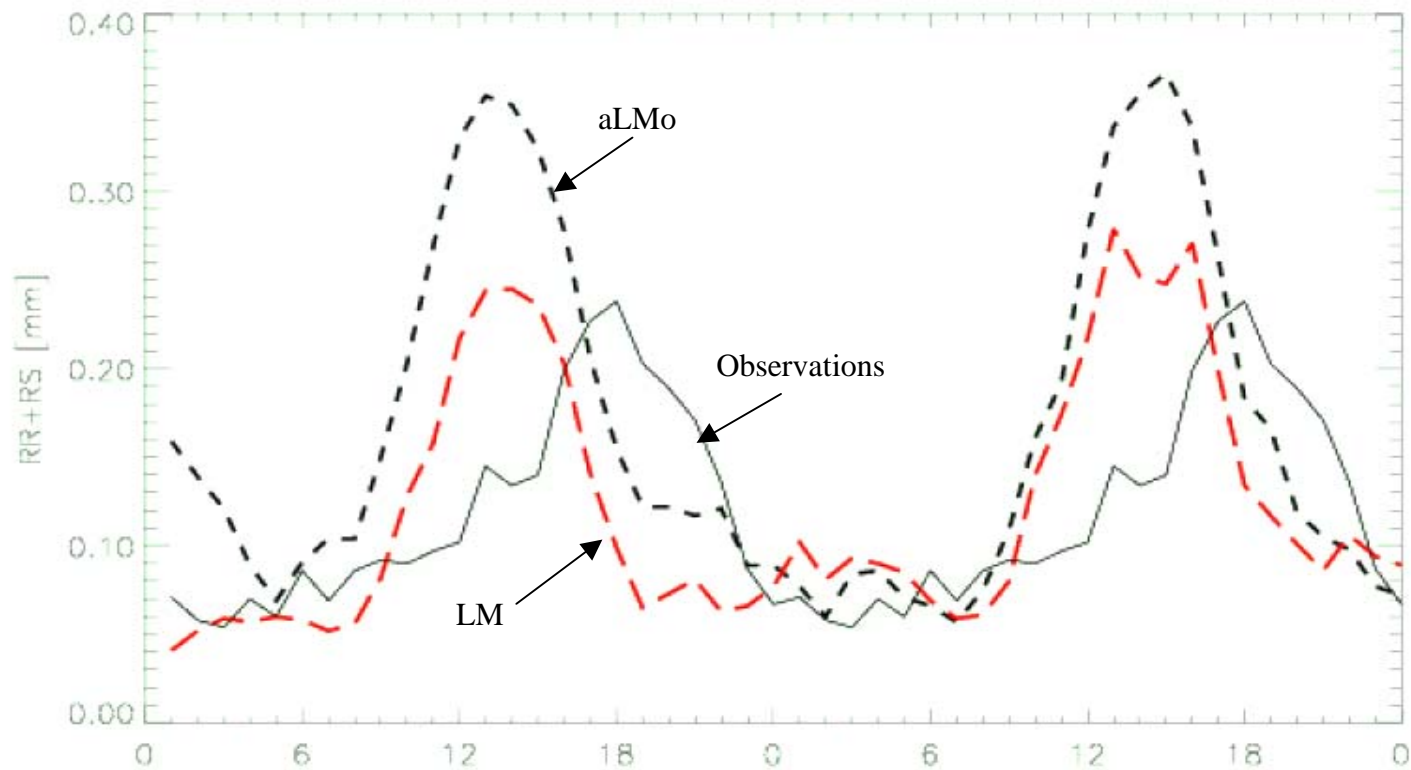
- LM is run operationally in Switzerland, Italy, Greece, Poland and Germany
- Only DWD applies a soil moisture assimilation
- Comparison between Meteo Swiss and DWD results for summer 2003
- Boundary data for Global Model GME of DWD
- Models LM (DWD) and aLMo (Meteo Swiss) identical, except
 - Soil moisture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



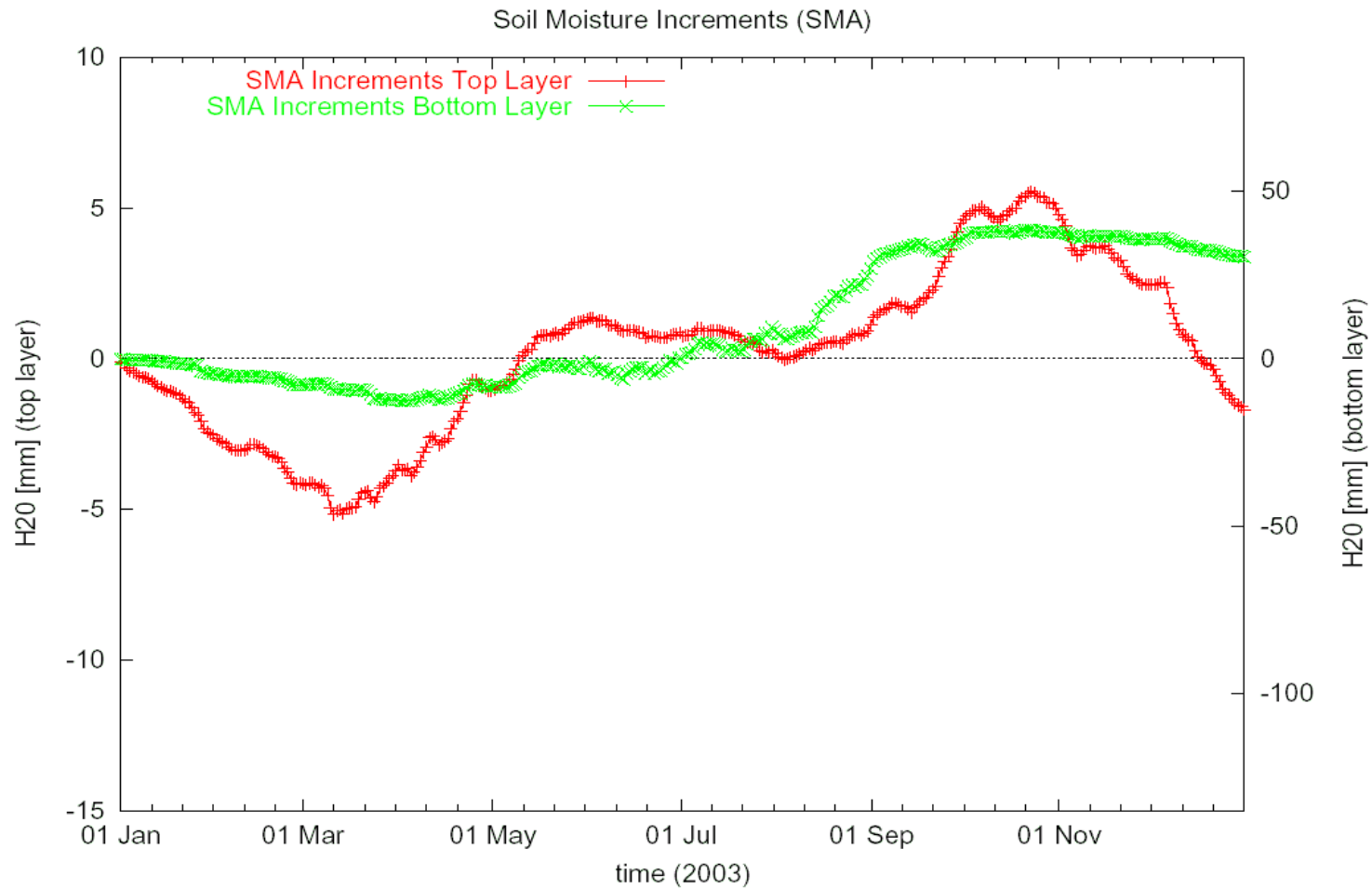
Precipitation over Switzerland Summer 2003

Precipitation

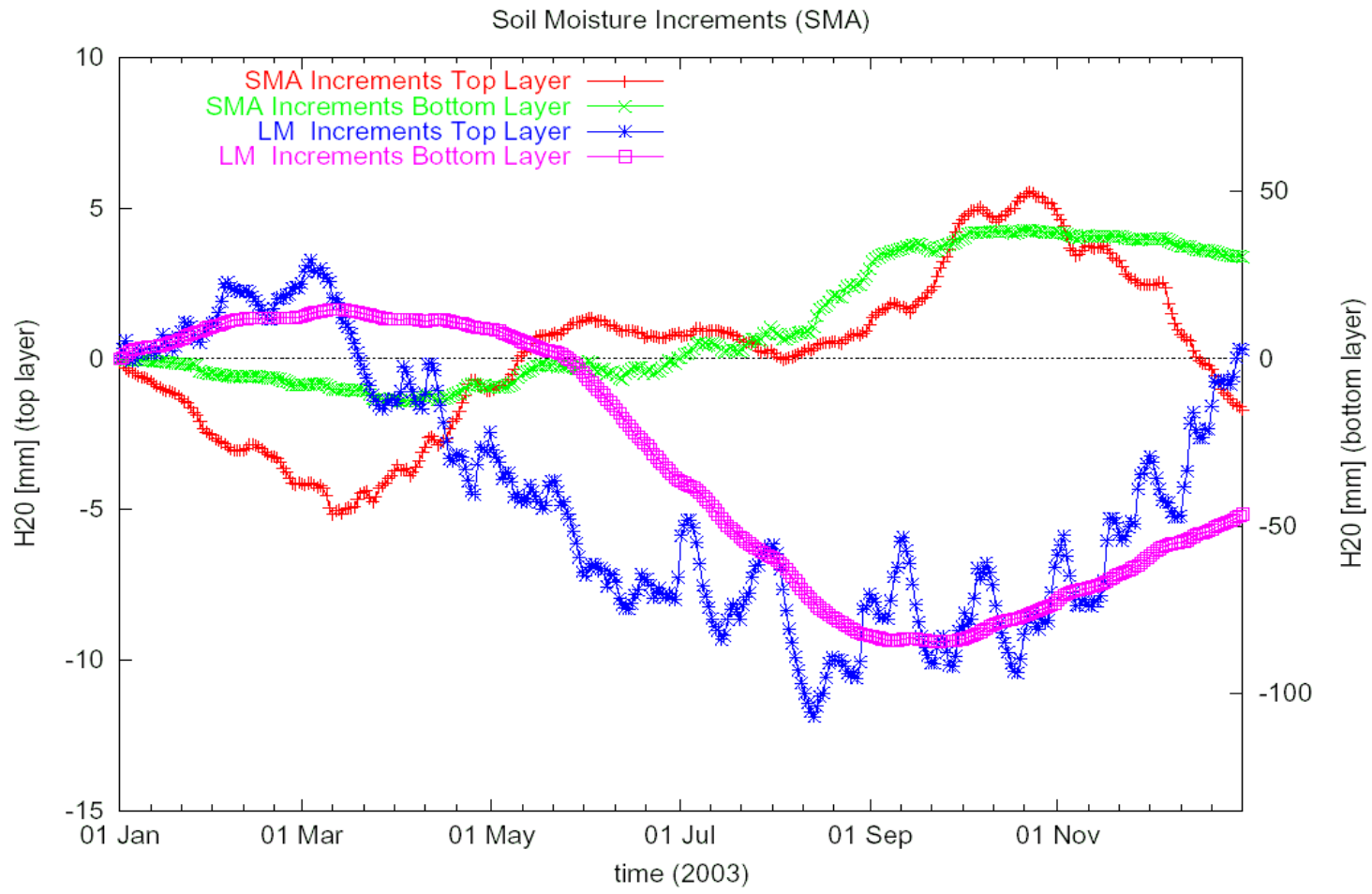


From Schubiger, 2003

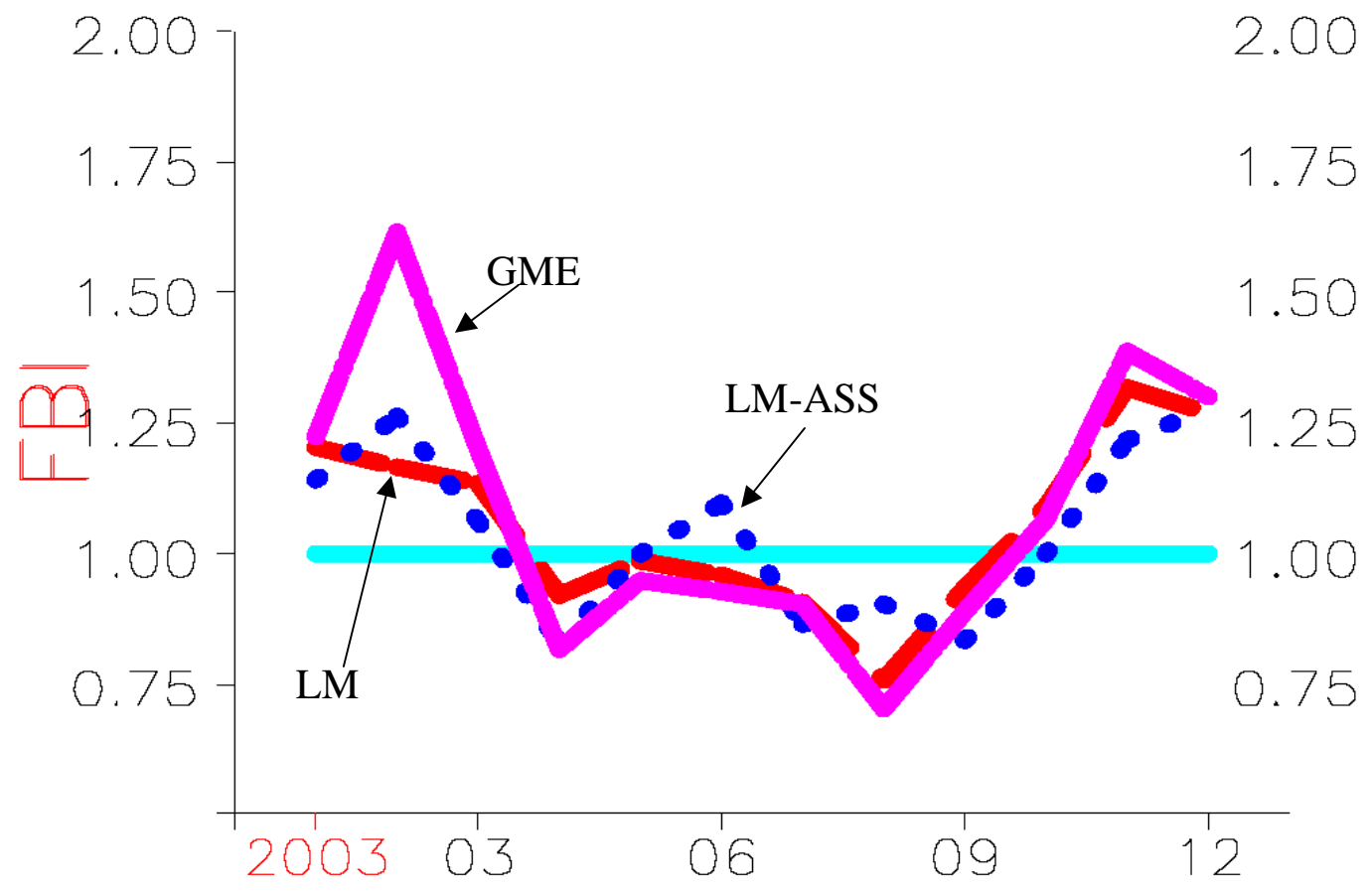
Accumulated assimilation increments



Assimilation incr. < Model increments?

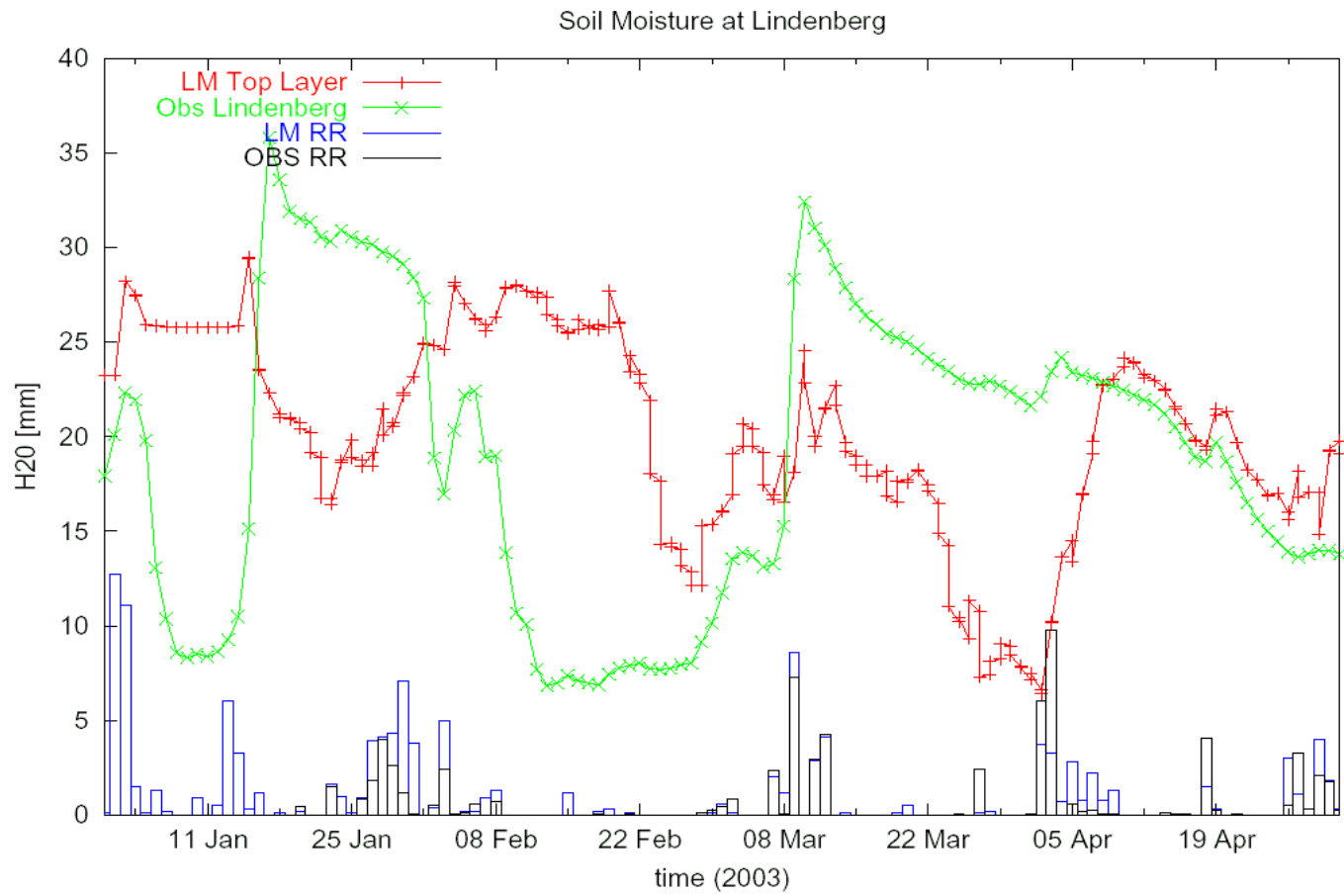


Frequency bias in precip. (Germany)



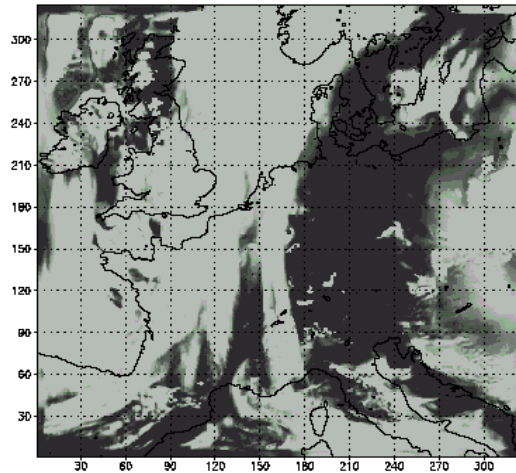
Schwelle: 0 mm/24h

Verification at Lindenberg

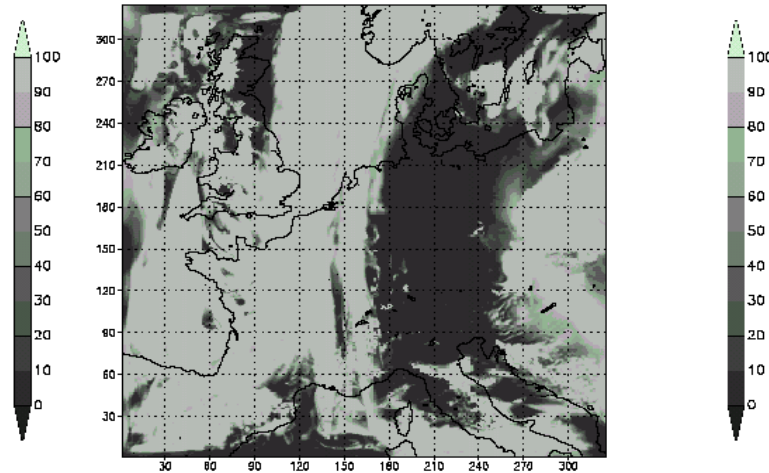


Operational SMA diagnostics

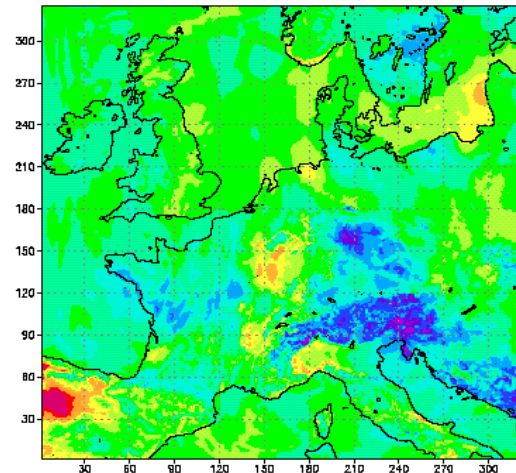
Tot. Cloud Cov. [%], 12 UTC, Feb 9, 2003



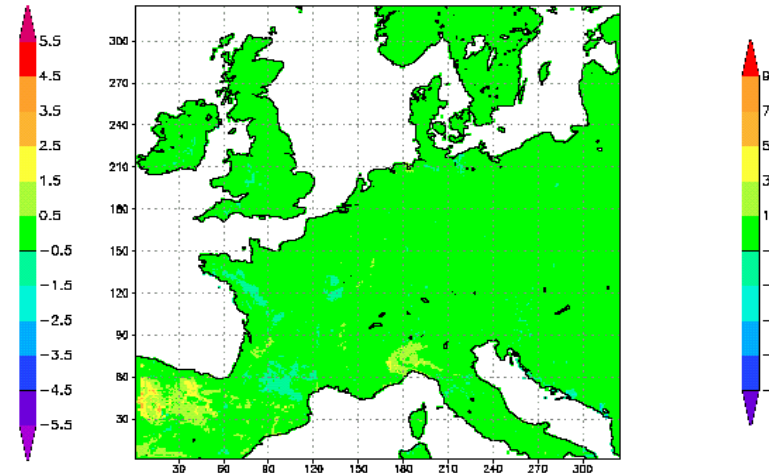
Tot. Cloud Cov. [%], 15 UTC, Feb 9, 2003



T2m Forecast Error [K], Feb 9, 2003



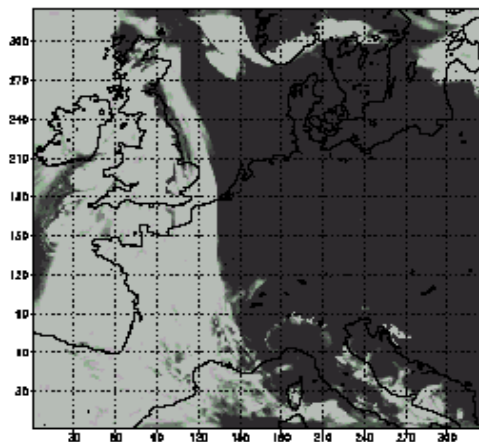
An. Moisture Incr. [kg/m^2], L 1, Feb 9, 2003



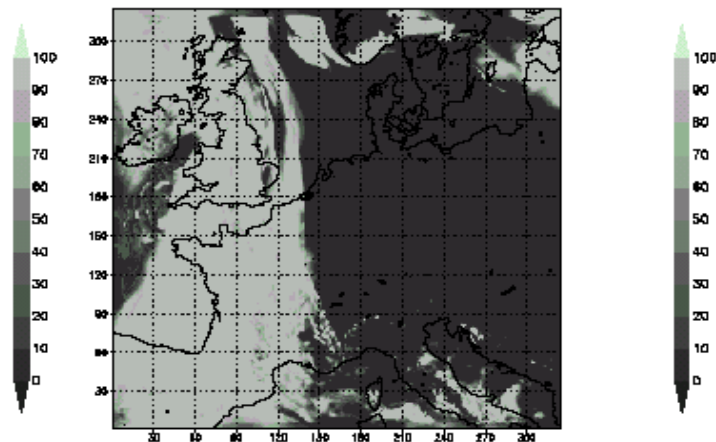
Adobe
Acrobat-Dokument

Operational SMA diagnostics

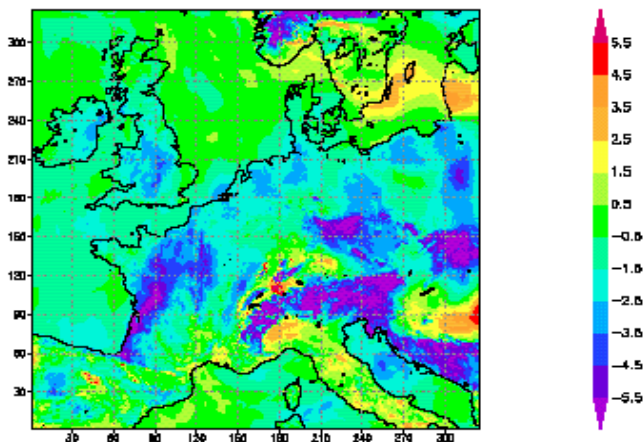
Tot. Cloud Cov. [%], 12 UTC, Feb 23, 2003



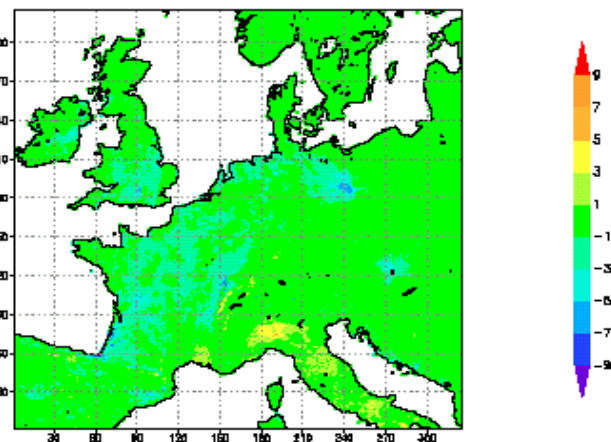
Tot. Cloud Cov. [%], 15 UTC, Feb 23, 2003



T2m Forecast Error [K], Feb 23, 2003



An. Moisture Incr. [kg/m²], L 1, Feb 23, 2003



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

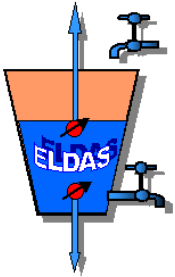
Conclusions from operations

- 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
- No. 1 priority is the improvement of the precipitation input

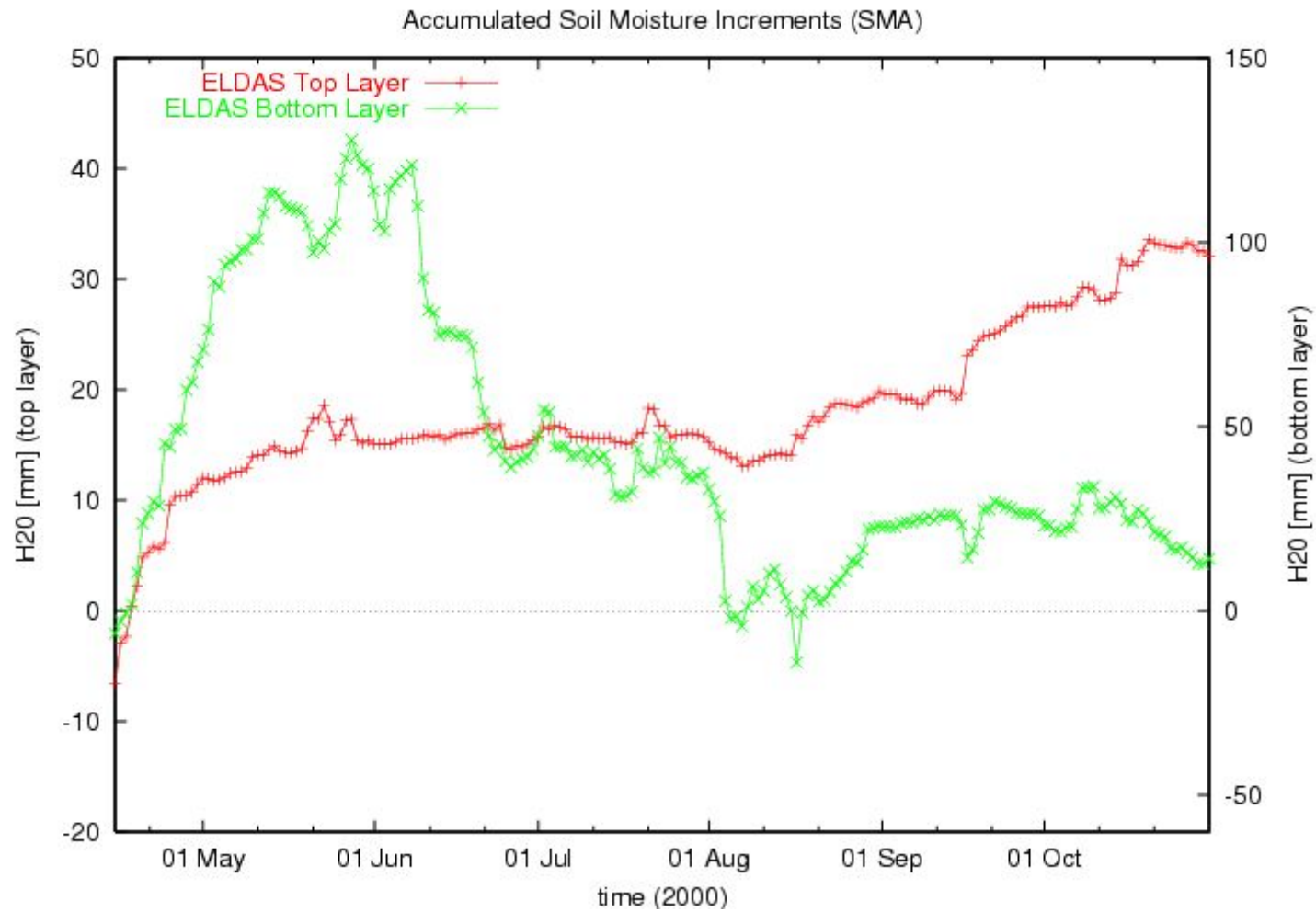


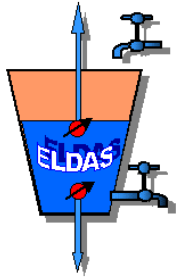
ELDAS assimilation

- 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

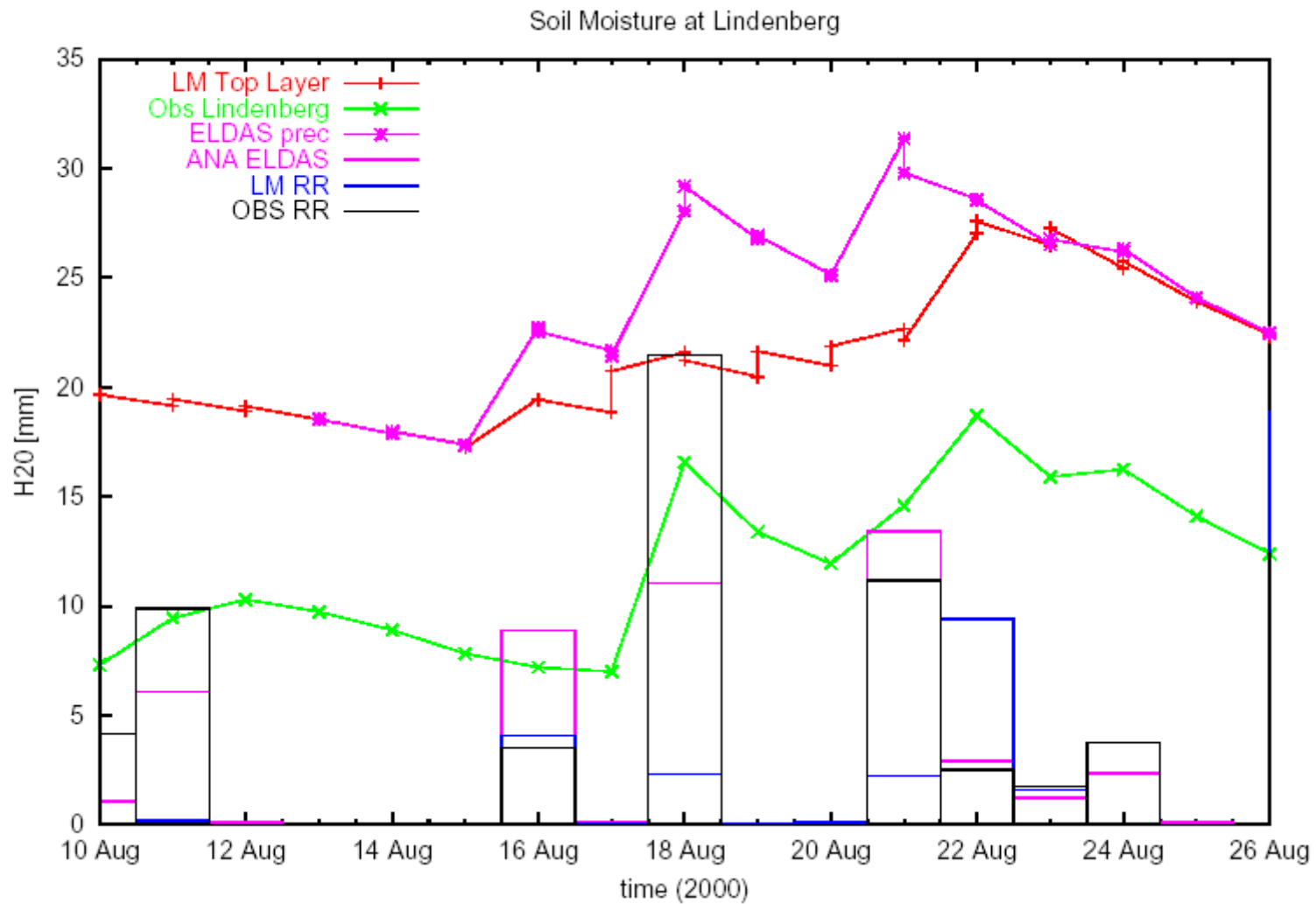


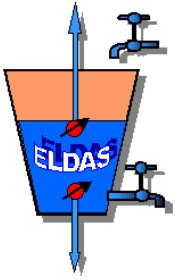
Accumulated SMA Increments



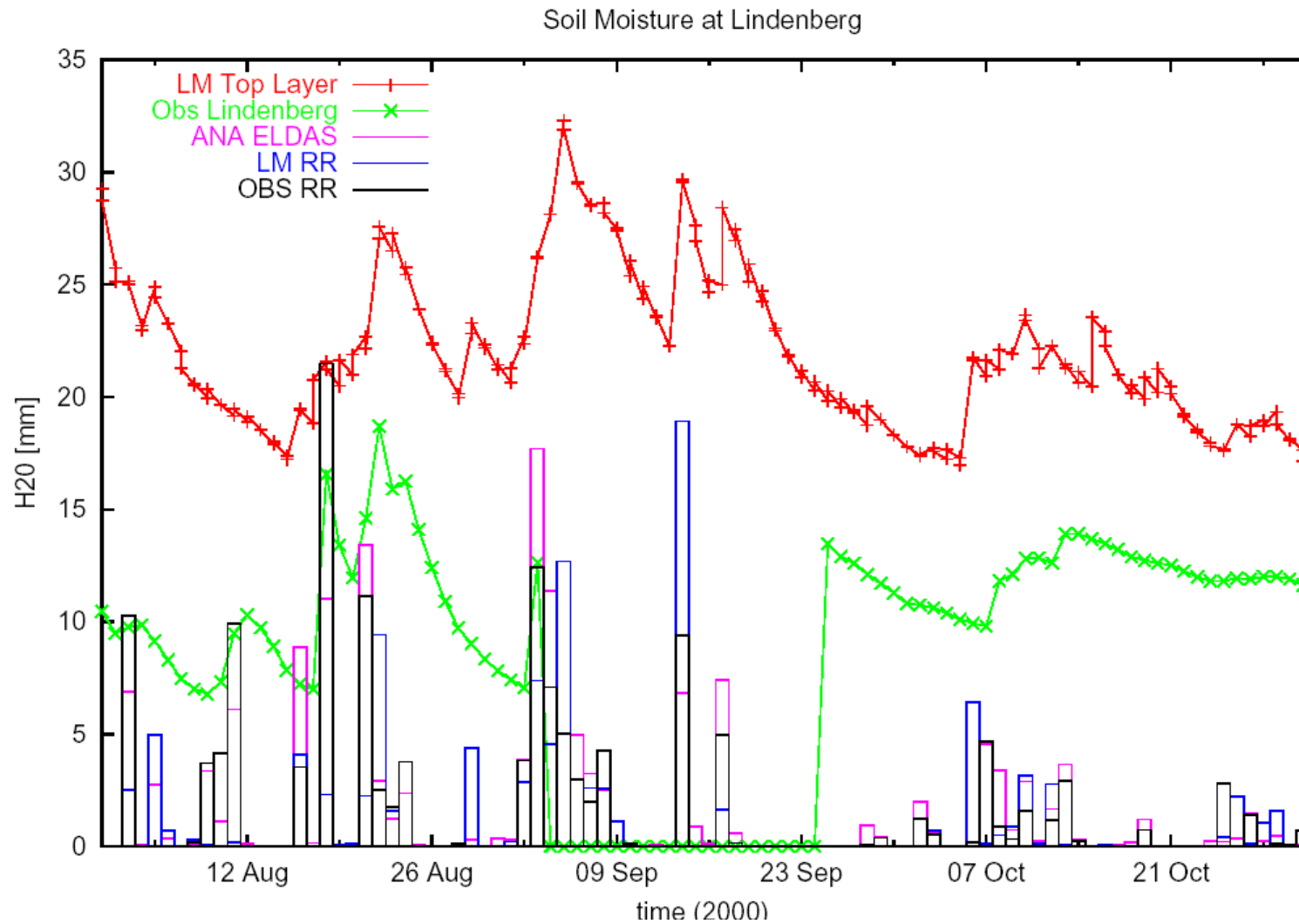


Effect of using observed precip





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
- Gerd Vogel and Wolfgang Adam (DWD Observatory Lindenberg) provided validation data
- Erdmann Heise (DWD) for numerous discussions
- Cor Jacobs (Alterra) for early validation results