A simple nudging scheme to assimilate ASCAT soil moisture data in the WRF model

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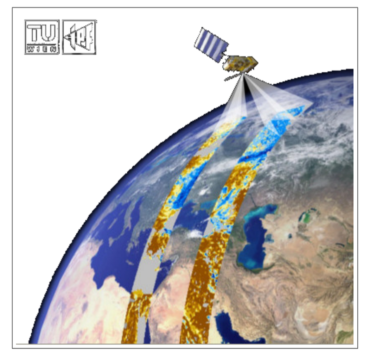
In the last years several studies dealt with the assimilation of remote sensed soil moisture data in NWP models aimed at improving soil moisture estimations and screen level variables predictions (2 meter temperature and relative humidity)

Satellite soil wetness **and** NWP model outputs



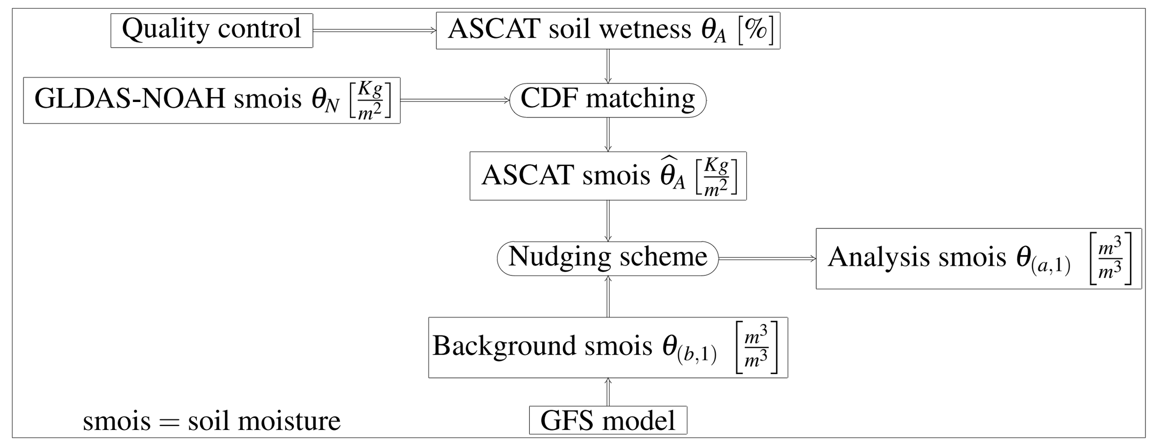
⟶ new analysis of surface soil moisture

Bibliography	Dataset	NWP model	Method
Drusch and Viterbo (2007)	TMI	ECMWF IFS	nudging
Scipal et al. (2008)	ERS	ECMWF IFS	nudging
Mahfouf (2010)	ASCAT	ALADIN model	EKF
Dharssi et al. (2011)	ASCAT	UKMO model	nudging
de Rosnay et al. (2011)	ASCAT	ECMWF IFS	EKF
Draper et al. (2011)	AMSR-E	ISBA (LSM)	EKF
Draper (2011)	AMSR-E	MOSES (LSM)	EKF

Here a simple nudging scheme is implemented in order to assimilate ASCAT surface soil wetness (Advanced SCATterometer C-band sensor on-board of the MetOp-A satellite) into the WRF (Weather and Research Forecasting) regional weather model

1. Data and Methods

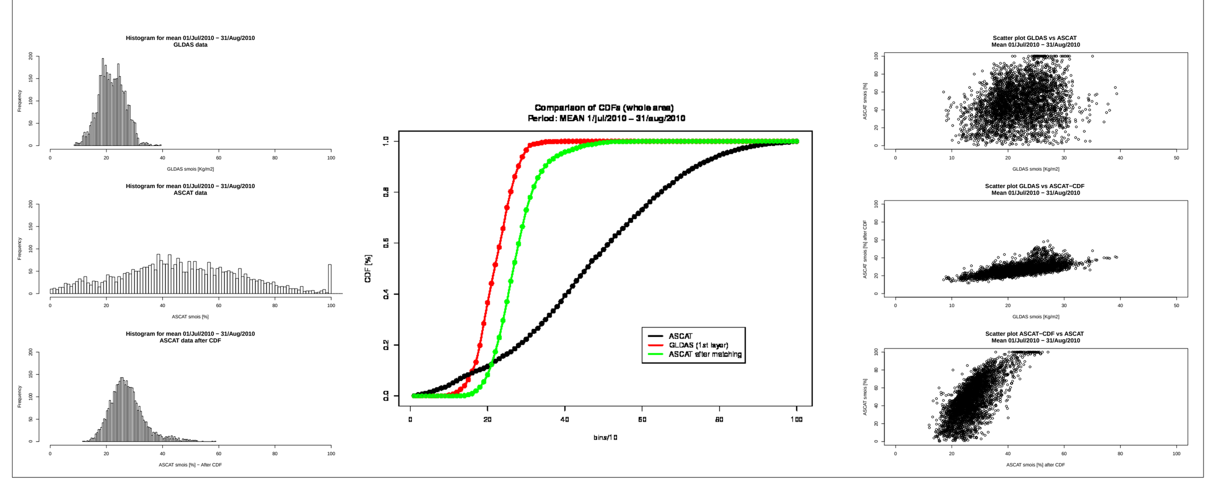
A few preprocessing steps (quality control and Cumulative Distribution Frequency matching) are needed before the assimilation



CDF matching

- $\widehat{\theta}_A = p_1 + p_2 \times \theta_A$
- ○ $p_2 = var(\theta_N)/var(\theta_A)$
- ○ $p_1 = mean(\theta_N) - p_2 \cdot mean(\theta_A)$

The effect of the CDF matching is shown below:



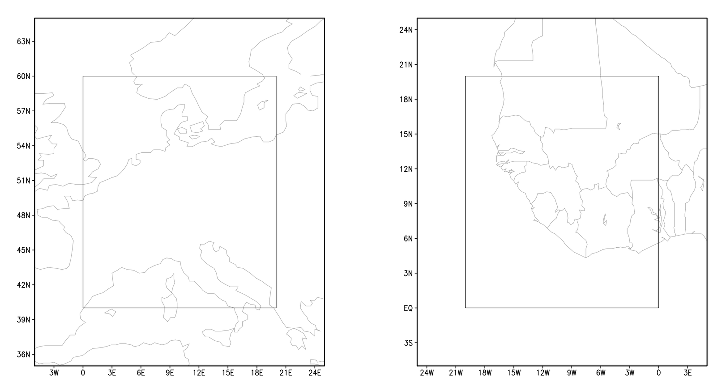
The equation of the nudging scheme is shown below:

$$\theta_{(a,l)} = \begin{cases} \theta_{(b,l)} + K(\widehat{\theta}_A - \theta_{(b,l)}) & \text{for } l = \text{0-10 cm} \\ \theta_{(b,l)} & \text{for } l \text{ below 0-10 cm} \end{cases}$$

where $\theta_{(b,l)}$ is the background soil moisture at layer l, $\widehat{\theta}_A$ is the CDF corrected ASCAT surface soil moisture and the coefficient $K = 0.2$ as in Dharssi et al. (2011)

2. WRF simulations

- EXP run: 1-month long simulation (July 2010) over Central Europe and West Africa where first level soil moisture is nudged towards ASCAT data. Other details:
  - ○ Noah land surface model
  - ○ $\simeq$12 km spatial resolution
  - ○ 140 rows×100 cols (Central Europe); 180 rows×140 cols (West Africa)
- CTR run: as in EXP but without assimilation of ASCAT data

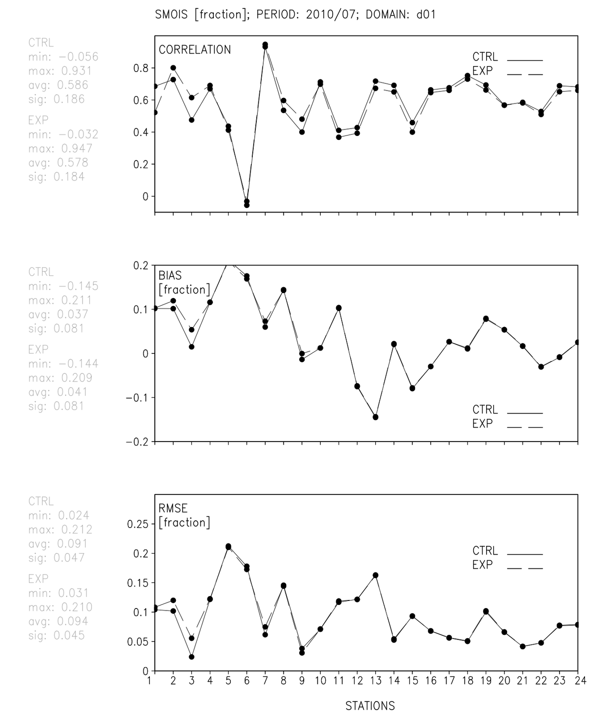


3. Results

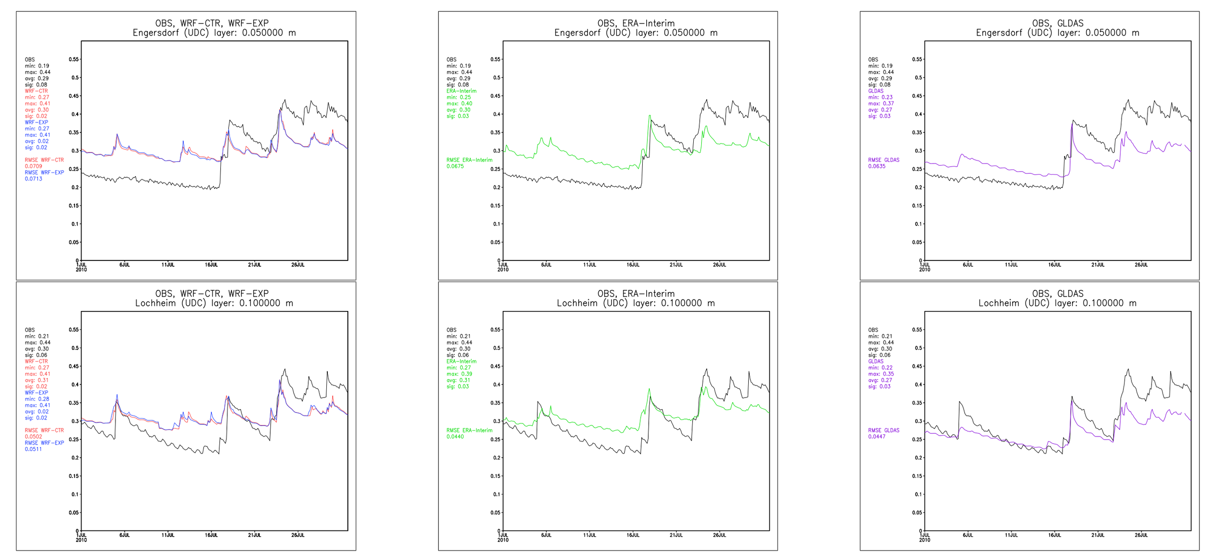
Soil moisture estimations were validated against observed data from SMOISMANIA and UDC-SMOS networks in Europe (24 stations) and from AMMA project in West Africa (1 station, Agoufou in Mali). 2-meter temperature predictions were validated against METAR reports (several stations in Europe, 19 stations in West Africa)

Central Europe

- ***Soil moisture (0-10 cm)*** - verification skills for 24 stations:



○ ***Soil moisture (0-10 cm)*** - comparisons with other datasets:



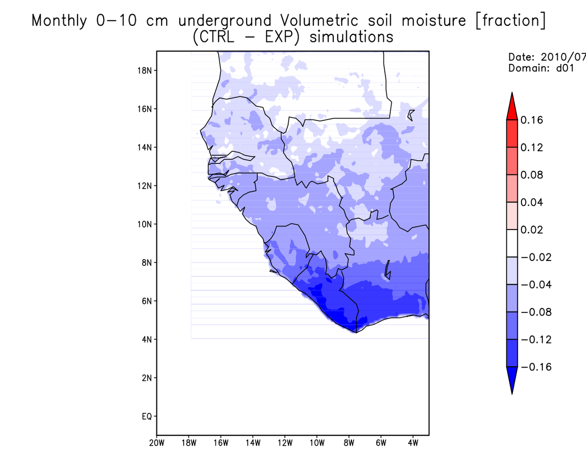
⋆ ***2 meter temperature*** - impact of ASCAT soil wetness assimilation on 2 m temperature estimations is neutral

West Africa

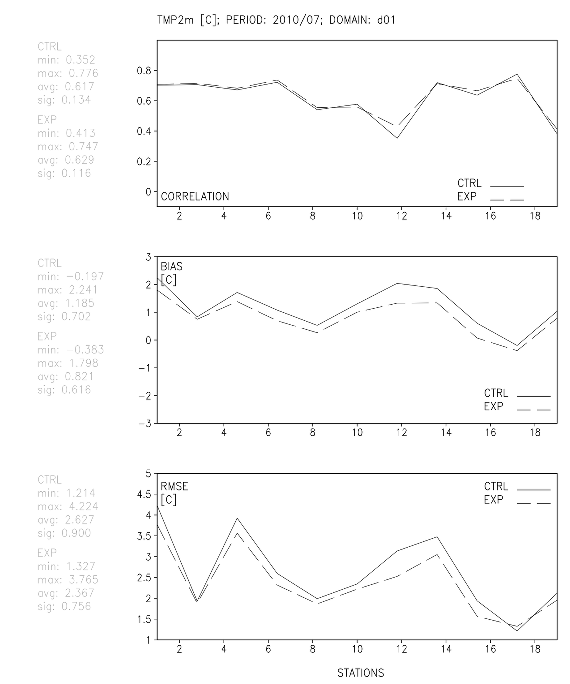
- ***Soil moisture (0-10 cm)*** - verification skills for Agoufou:

	EXP	CTR
corr	0.504	0.425
bias	-0.015	-0.029
RMSE	0.032	0.042

○ ***Soil moisture (0-10 cm)*** - diff btwn CTR and EXP:



⋆ ***2 meter temperature*** - verification skills for 19 stations:



4. Conclusions

For **Central Europe** impact of soil wetness assimilation:

- is broadly neutral or even slightly negative on soil moisture estimations (as discussed in Scipal et al. 2008)
- ○ gives results similar to bibliography/other datasets
- ⋆ is neutral on 2 m temperature predictions

For **West Africa** impact of soil wetness assimilation

- is positive for soil moisture estimates (Agoufou station)
- ○ 'adds' water to soil
- ⋆ is positive for 2 m temperature predictions

Results found demostrate the benefits of the nudging scheme of ASCAT data on soil moisture and screen level temperature estimations especially in those remote areas where the coverage of observational instruments is poor. In widely monitored areas the impact of the assimilation of ASCAT data is almost neutral.