Issues in Satellite and Land Surface Model Soil Moisture Validation

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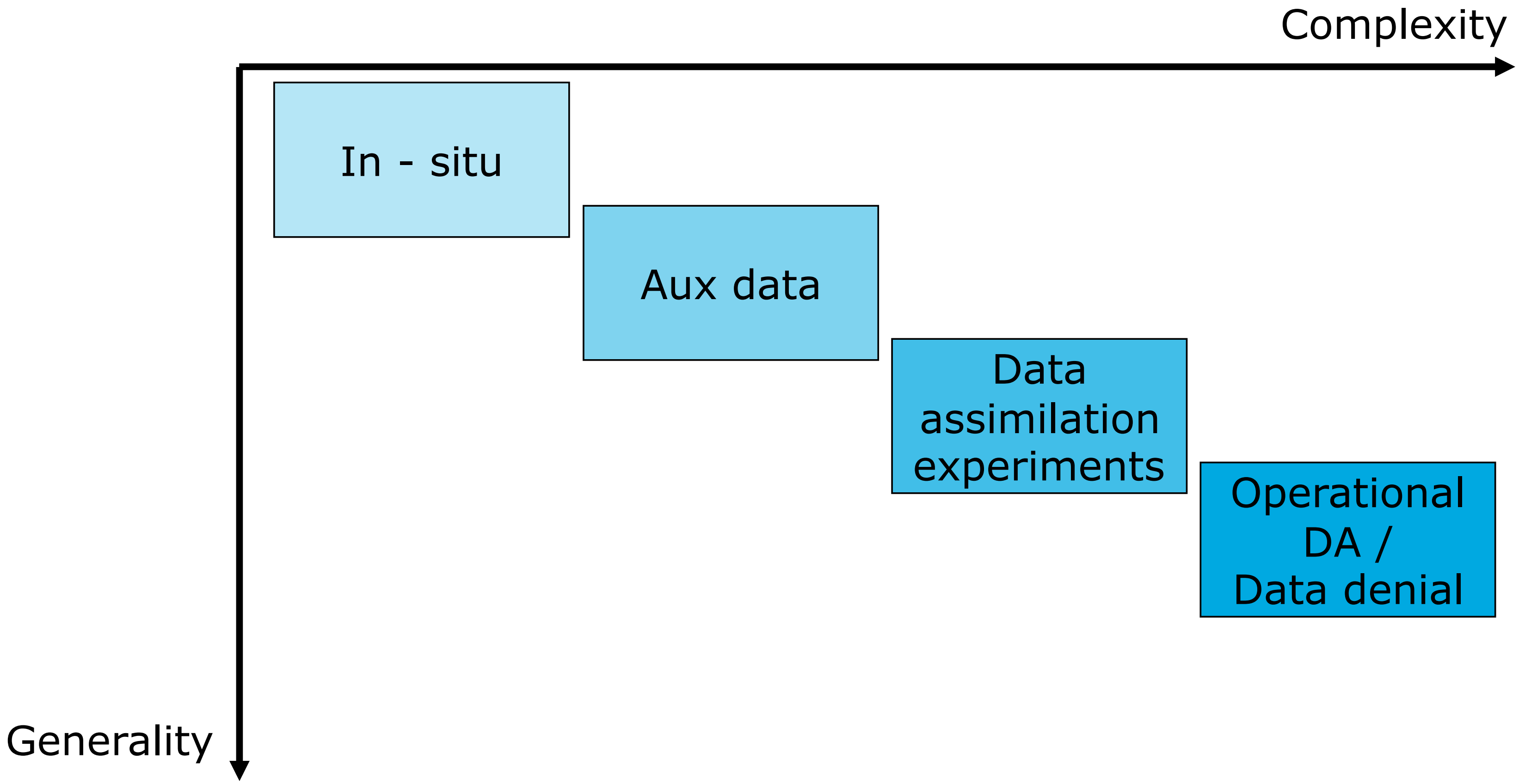
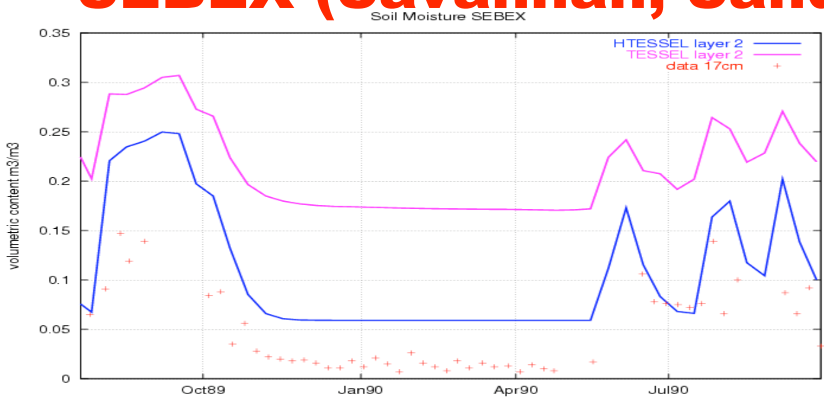
Soil Moisture Validation Strategy

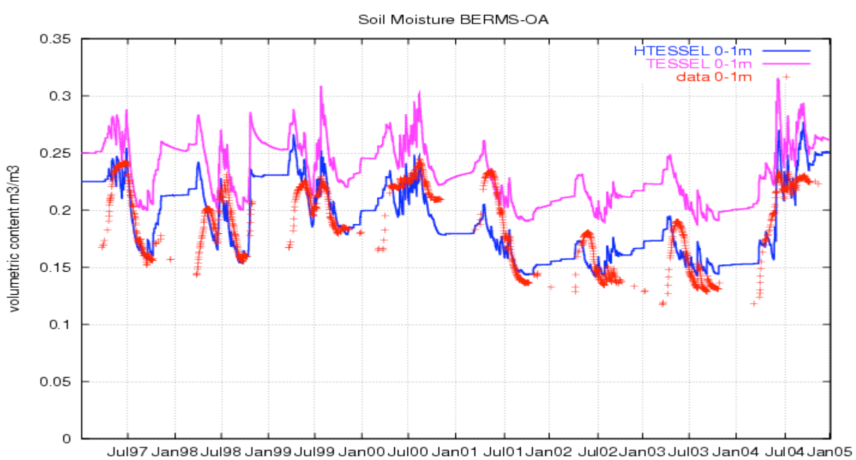


In-situ - Revision of TESSEL

SEBEX (Savannah, Sandy soil)



BERMS (Boreal Forest)



HTESSEL improves soil moisture and marginally evaporation with respect to TESSEL in dry climates and leads to a better represented soil moisture inter-annual variability in continental climate

Balsamo et al. 2010

Mismatch in horizontal resolution

- in-situ observations represent the point scale

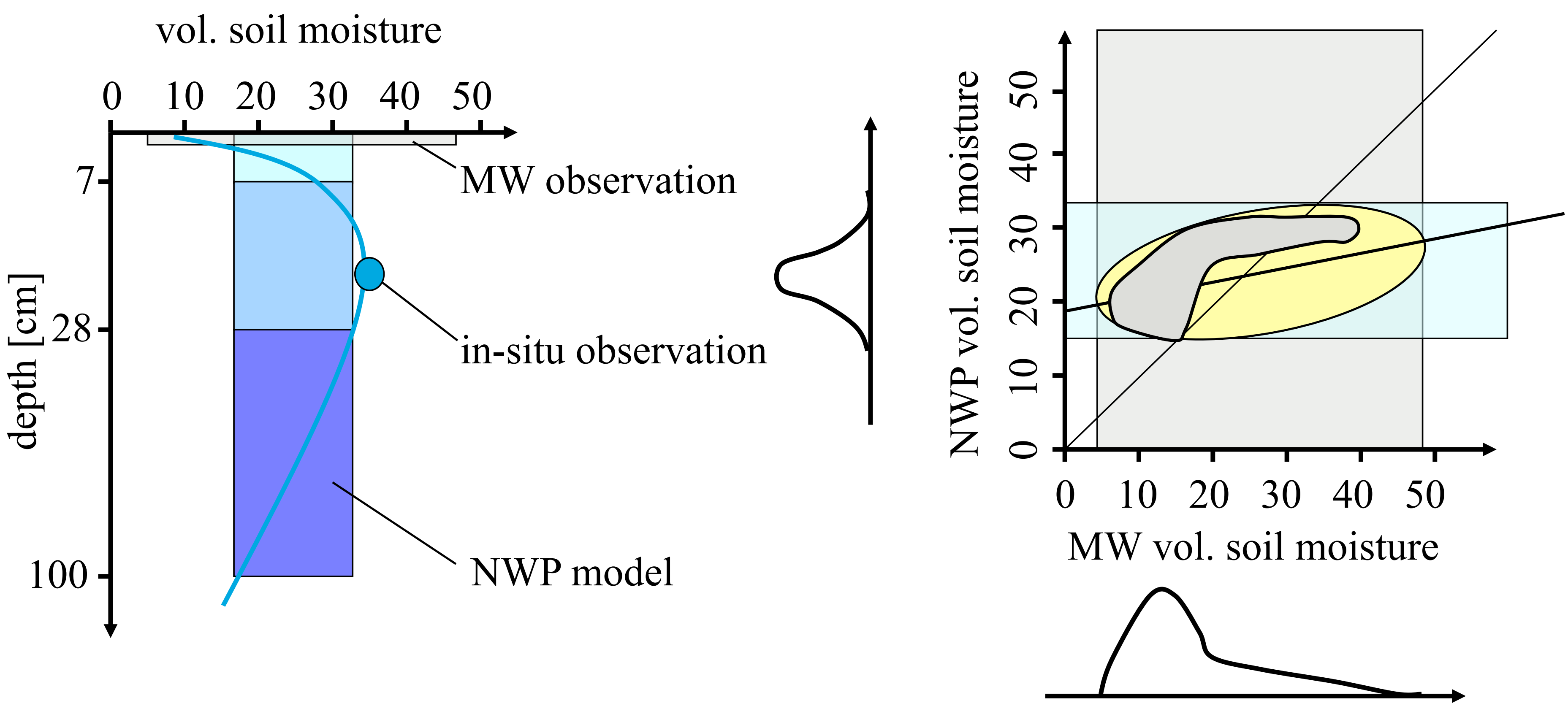
- up-scaling is difficult (presentation W. Crow et al.), there is no preferred strategy

- antenna gain, the exact shape of the footprint, and non-linearities in the radiative transfer models should be considered (for satellite observations)

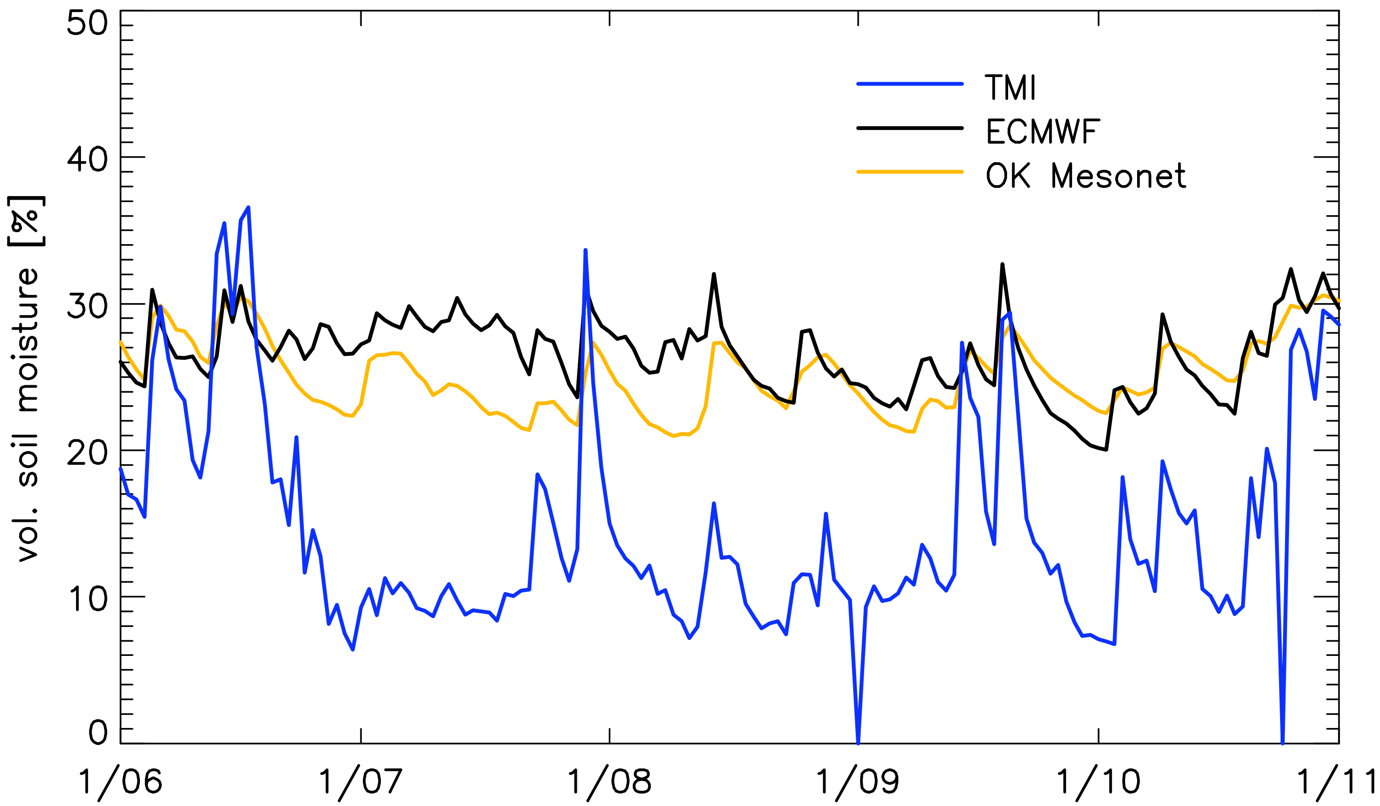
- large systematic differences in the in-situ observations on comparably small scales exist (presentation by A. Robock)

- one model will be operated at different spatial resolutions (e.g. for deterministic forecasts, ensemble forecasts, short-range forecasts, seasonal forecasts, …)

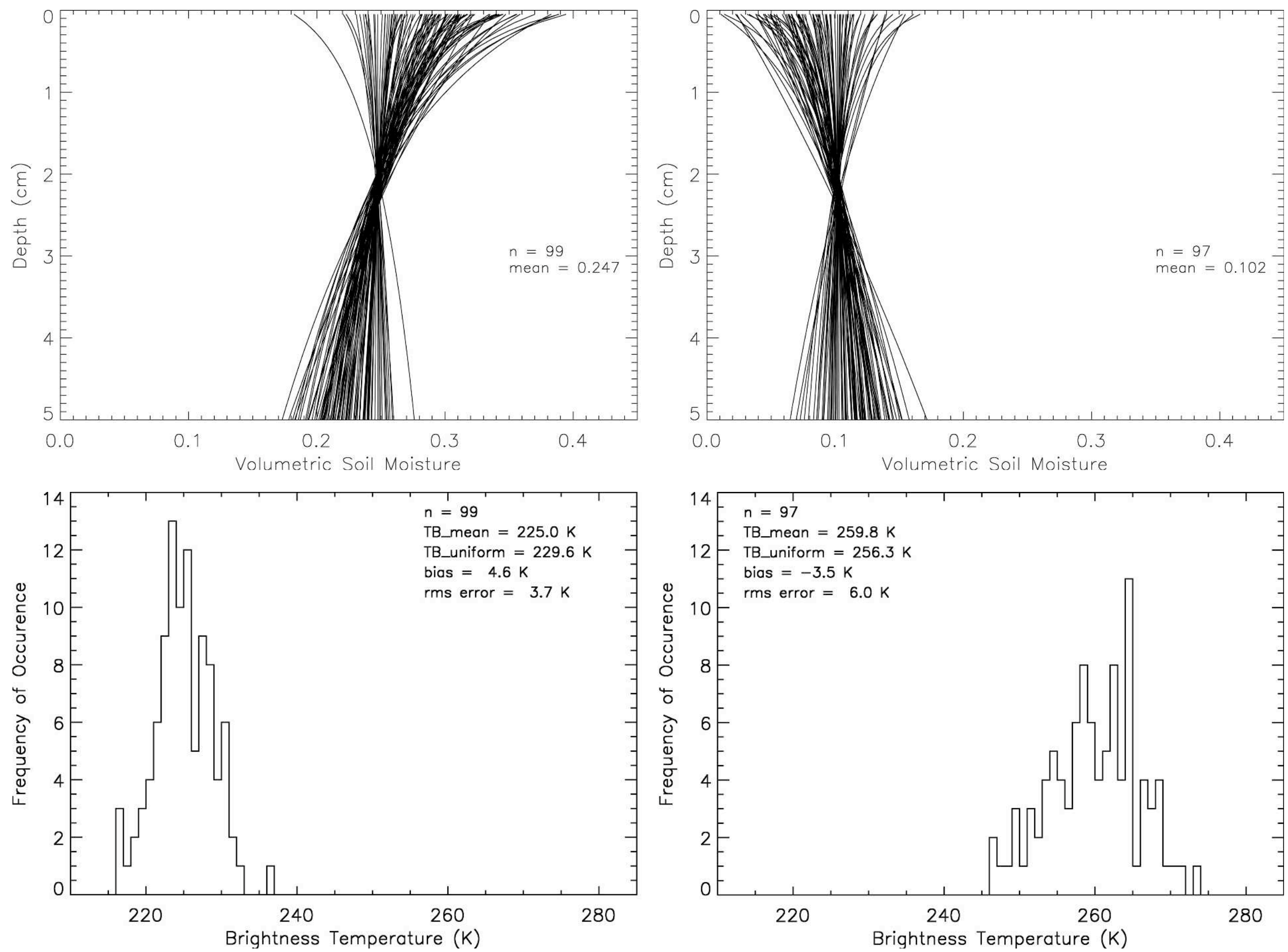
Mismatch in vertical resolution



Oklahoma Data 2002



Mismatch in vertical resolution



Wilker et al. 2006

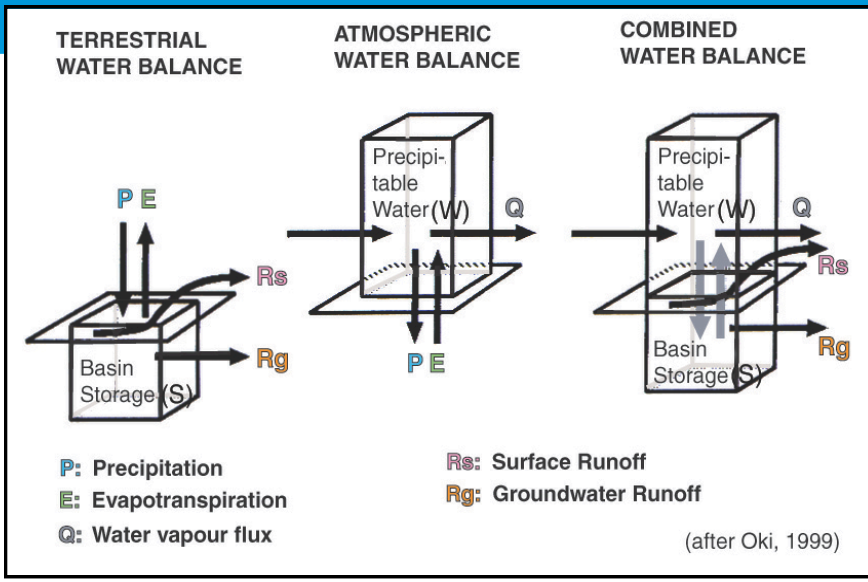
- methods and skill scores for the evaluation of the satellite product or model forecast / analysis need to be established

- uncertainties of the (aggregated) in-situ observations need to be defined

- biases and systematic differences between data sets need to be quantified and minimized prior to data assimilation applications and inter-comparisons (e.g. triple collocation)

- bias correction can be done “off-line”, e.g. CDF matching, or within the DA scheme, e.g. through VarBC (Auligne et al. 2007) or Particle Filters (Montzka et al. 2011)

Combined Water Balance Approach (using model data)



- **Terrestrial water balance:**

$$\frac{\partial S}{\partial t} = (P - E) - R_s - R_g$$

- **Atmospheric water balance:**

$$\frac{\partial W}{\partial t} = -\nabla_H \vec{Q} - (P - E)$$

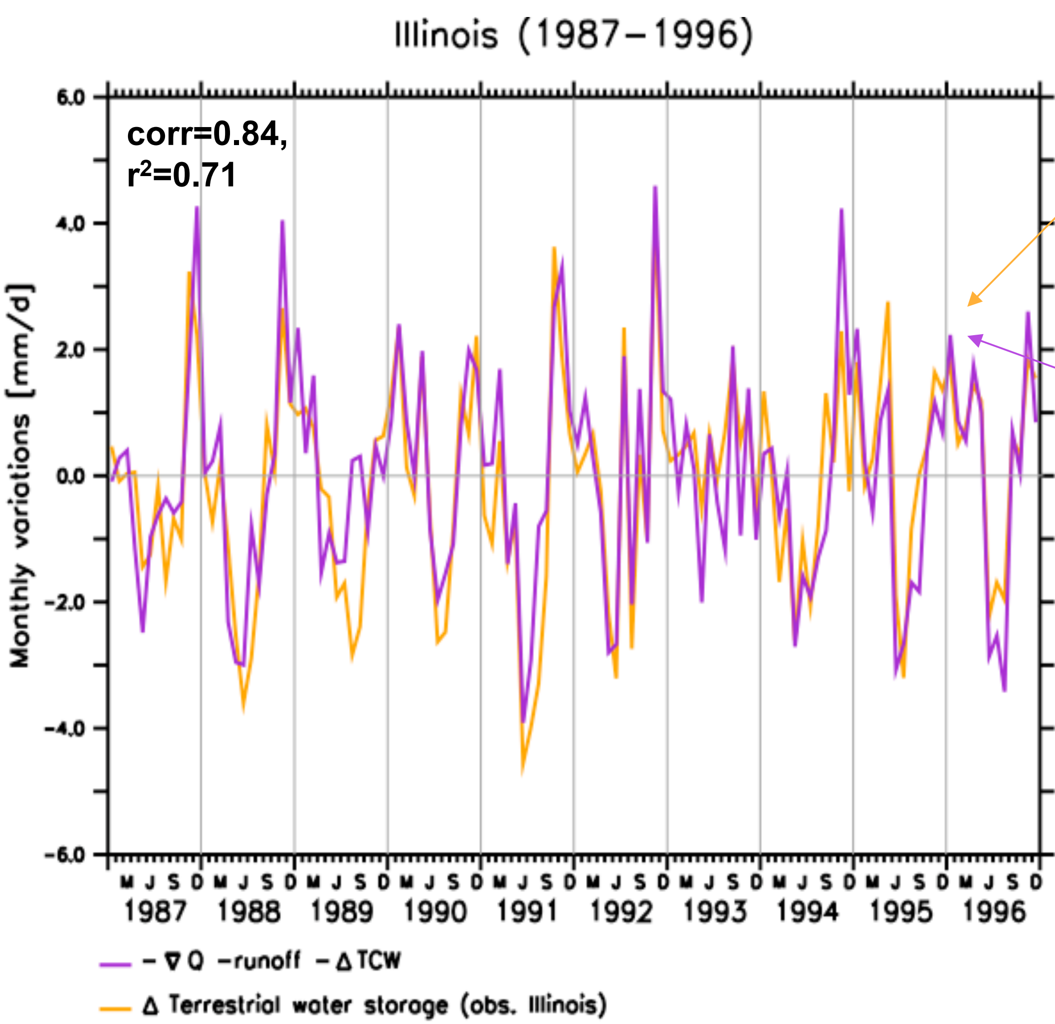
- **Combined water balance:**

$$\frac{\partial S}{\partial t} = -\nabla_H \vec{Q} - \frac{\partial W}{\partial t} - R$$

reanalysis data (ERA-40)

measured streamflow (R_s+R_g)

Case Study: Mississippi & Illinois



Water-balance Estimates

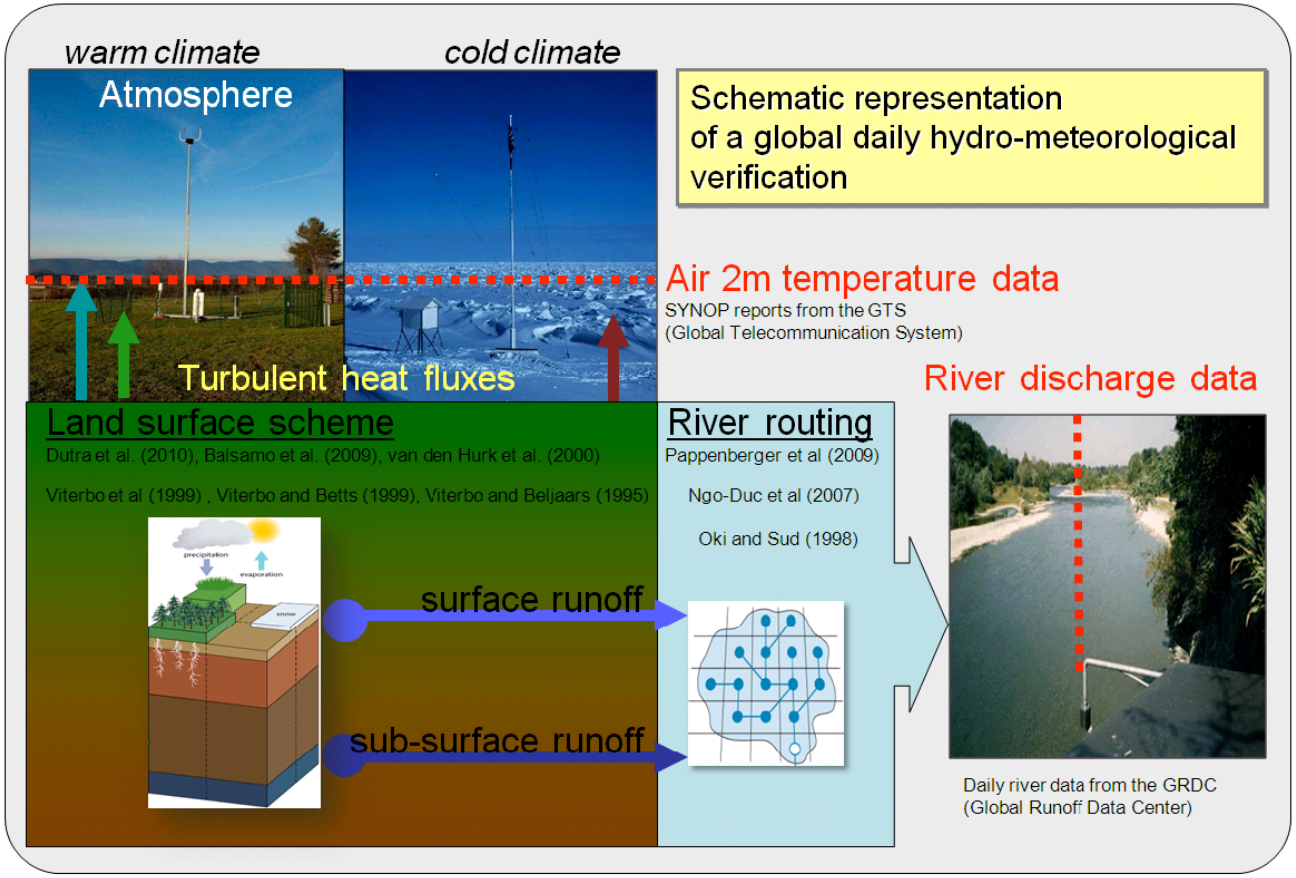
$$\frac{\partial S}{\partial t} = -\nabla_H \vec{Q} - \frac{\partial W}{\partial t} - R$$

Observations

(soil moisture+ groundwater+snow)

[Seneviratne et al. 2004]

HTESSEL verification



If we consider 3 model versions:

- SNOWHTESSEL
- HTESSEL
- TESSEL

[G. Balsamo et al. 2010]

HTESSEL verification

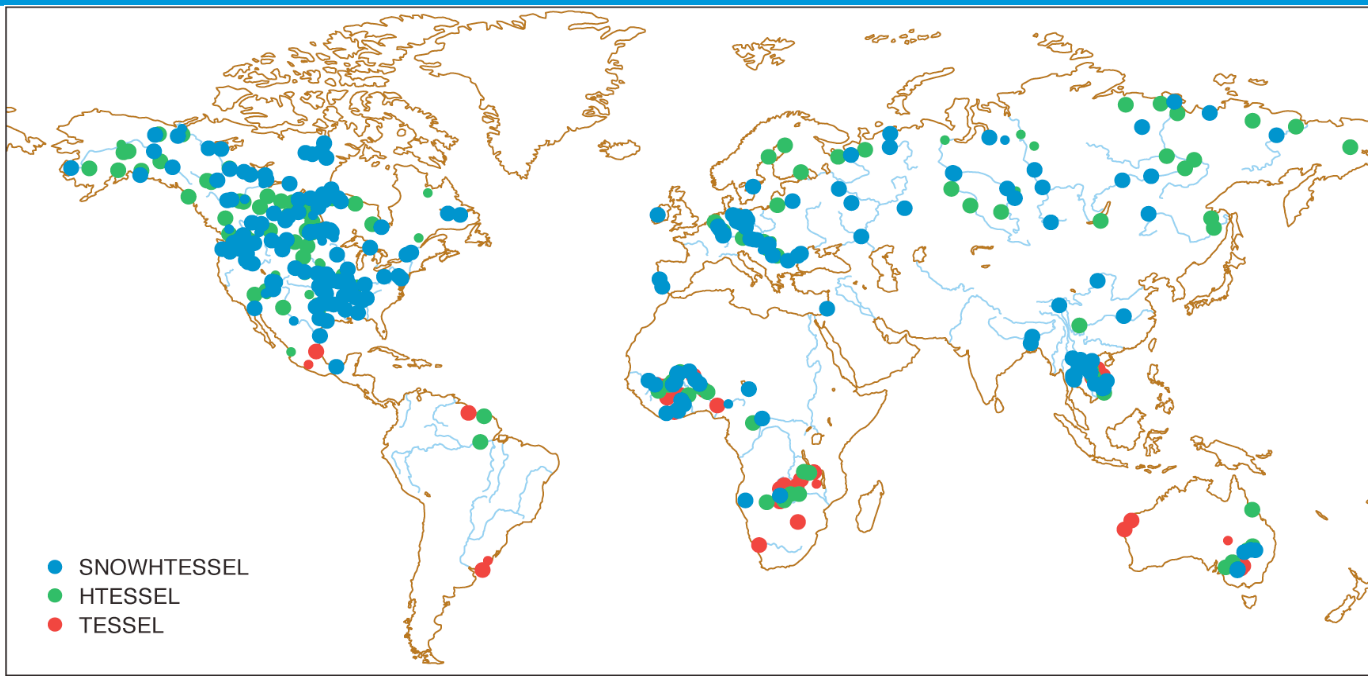
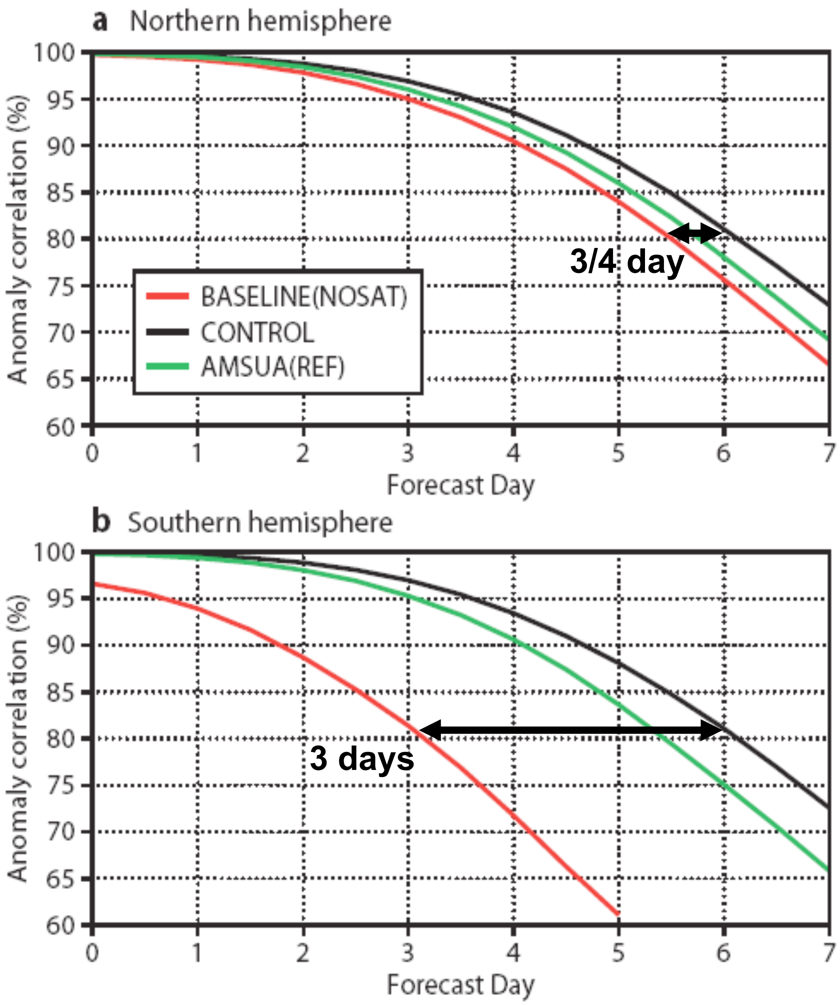


Figure 7: Indication of best correlated modelled and observed river discharges. Models include SNOWHTESSEL (blue), HTESSEL (green), and TESSEL (red). Large circles indicate the best performing scheme is <u>significantly better</u> than the others at a 5% significance level, while small circle indicate non-significant improvements<u>. All river discharges plotted have positive correlation significantly different from zero</u>.

	<u>Correlation of daily river discharges</u>	**<u>Number of river gauges (out of 211)</u>**
SNOWHTESSEL	**0.33**	**116 best correlate rivers**
HTESSEL	**0.25**	**81**
TESSEL	**0.09**	**14**

NWP Skill Scores



[Bauer/ECMWF, 2010]

EUCOS Observing System Experiments (OSEs):

- 2007 ECMWF forecasting system,
- winter & summer season,
- different baseline systems:
  - no satellite data (NOSAT),
  - NOSAT + AMVs,
  - NOSAT + 1 AMSU-A,
- general impact of satellites,
- impact of individual systems,
- all conventional observations.

← 500 hPa *geopotential height* anomaly correlation

Summary

- Comparisons against in-situ observations are very useful and the most direct source of independent information, but a range of performance indicators / skill scores should be established (Entekhabi et al 2010.). Accuracy goal of 4 % is too vague, hard to verify and not even traceable to the scientific objectives of a mission.

- Uncertainty estimates should be established at the relevant model / satellite spatial resolution.

- Biases and systematic differences can probably not be avoided and should be quantified and minimized prior to analyses.

- OSSEs, data assimilation experiments and data denial experiments can only give indirect estimates of the skill of a product but can contribute to quality assurance.

- Modelling and DA communities should be involved in mission evaluation.

THANK YOU

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