Closing the Gaps in Our Knowledge of the Hydrological Cycle over Land: Conceptual Problems and the Role of Data Assimilation

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1. Introduction

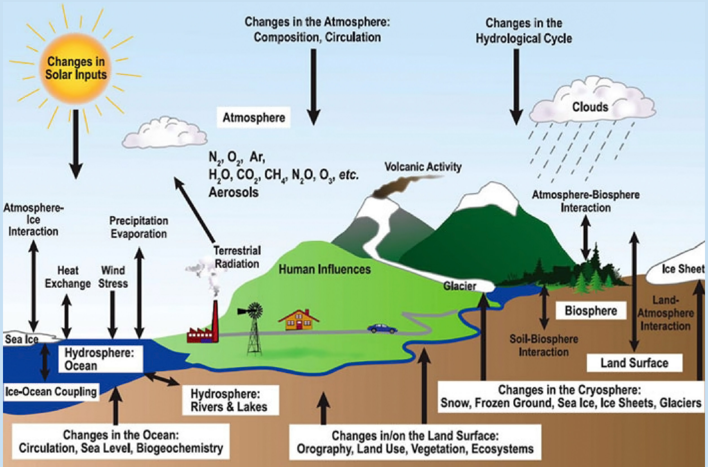

Fig. 1 (from IPCC)

Water stored on land is a key variable in the climate system *(Seneviratne et al., 2010)*. (Fig. 1).

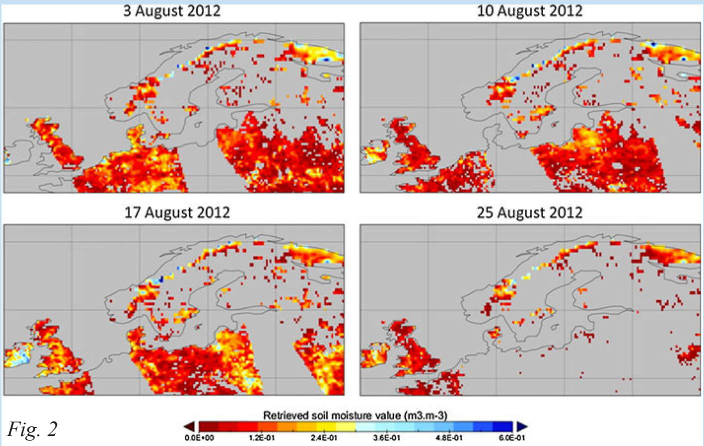

Fig. 2

Hydrological observations have errors and are discrete in space and time so that their information has gaps (SMOS soil moisture data; Fig. 2). It is desirable to fill these gaps using additional information and computational techniques. Data assimilation *(Kalnay, 2003; Lahoz et al., 2010a)* is an objective way of doing this

The main challenges for observations/models of the land surface hydrological cycle are given in ***panel 2***; the challenges for land data assimilation (DA) are given in ***panel 3***. For further details see Lahoz and De Lannoy (2013).

2. Challenges, observations/models of the land surface hydrological cycle:

Satellites observations:

- Capture land system spatio-temporal variability;
- Length of time periods should allow trend identification and bias mitigation;
- Provide uncertainty information;
- Relate observations to key land system variables.

Models:

- Models (SURFEX model; Fig. 3) to describe physical processes, including coupling land surface with more specialized modules (e.g. dynamic vegetation, snow);
- Consistent parameter datasets to limit predictive uncertainty;
- High quality forcing data, e.g., precipitation.

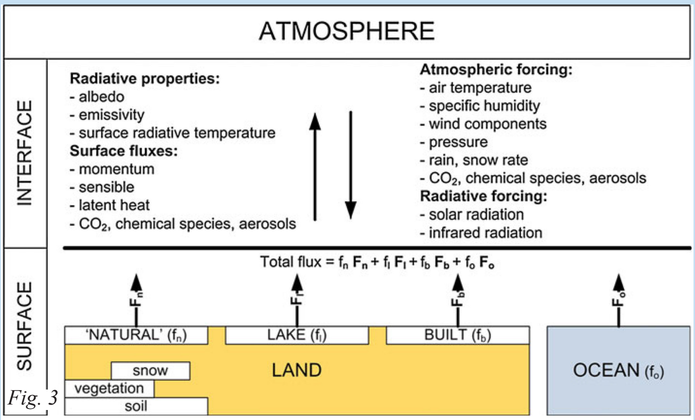

Fig. 3

Improvements in observational and model information from addressing these challenges, will improve application of DA ideas to understand the land hydrological cycle.

3. Challenges for land data assimilation:

Assimilated satellite observations include *retrievals of land surface temperature, soil moisture, snow water equivalent and snow cover area* (Lahoz *et al.*, 2010). Challenges include:

- *Disaggregate data* from large scales to small scales;
- *Radiance DA* to avoid inconsistencies between a priori information and land surface models;
- *Multiple sensors* and *new sensors*;
- *Combination* of state/forcing/parameter information;
- *Representation of observation/forecast errors*, and *specification of biases* in observational/model information;
- *Advanced DA techniques* (e.g., NILU Ensemble Kalman Filter; Fig. 4);
- Preserving *water balance*;

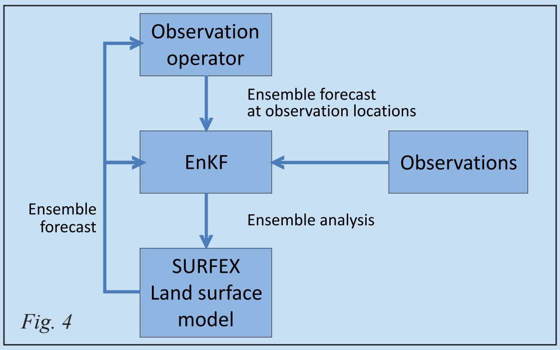

Fig. 4

4. Conclusions:

To understand the land hydrological cycle, we need *observations* and *models*. *Data assimilation* combines observational and model information. Data assimilation *adds value to observations* by filling the gaps between them and *adds value to models* by constraining them with observations.

Collectively, new satellite missions, increasing attention to forecast uncertainty due to errors in land surface models, parameters and inputs, and development of advanced assimilation techniques will *close the largest gaps* in *our understanding of the hydrological cycle over land.*

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