Land data assimilation within ALADIN

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Scientific objectives

- Provide an analysis of the soil prognostic variables in ALADIN
- Current operational status : interpolation of the global ARPEGE soil analysis (Météo-France) - ALADIN soil analysis at CHMI
- ARPEGE soil analysis : optimal interpolation using analysis increments from a 2D spatial interpolation of screen-level observations (T_{2m}, RH_{2m}) (Giard and Bazile, 2000)
- Main weakness : cannot use new observation types and new land surface prognostic variables
  - Satellite observations informative about soil conditions (AMSR-E, ERS, ASCAT, SMOS)
  - Improved radiative and precipitation fluxes
  - "Carbon version" of ISBA predicting biomass
- Proposal : Simplified Extended Kalman filter (SEKF) [Hess, 2001] within an offline version of the surface module SURFEX

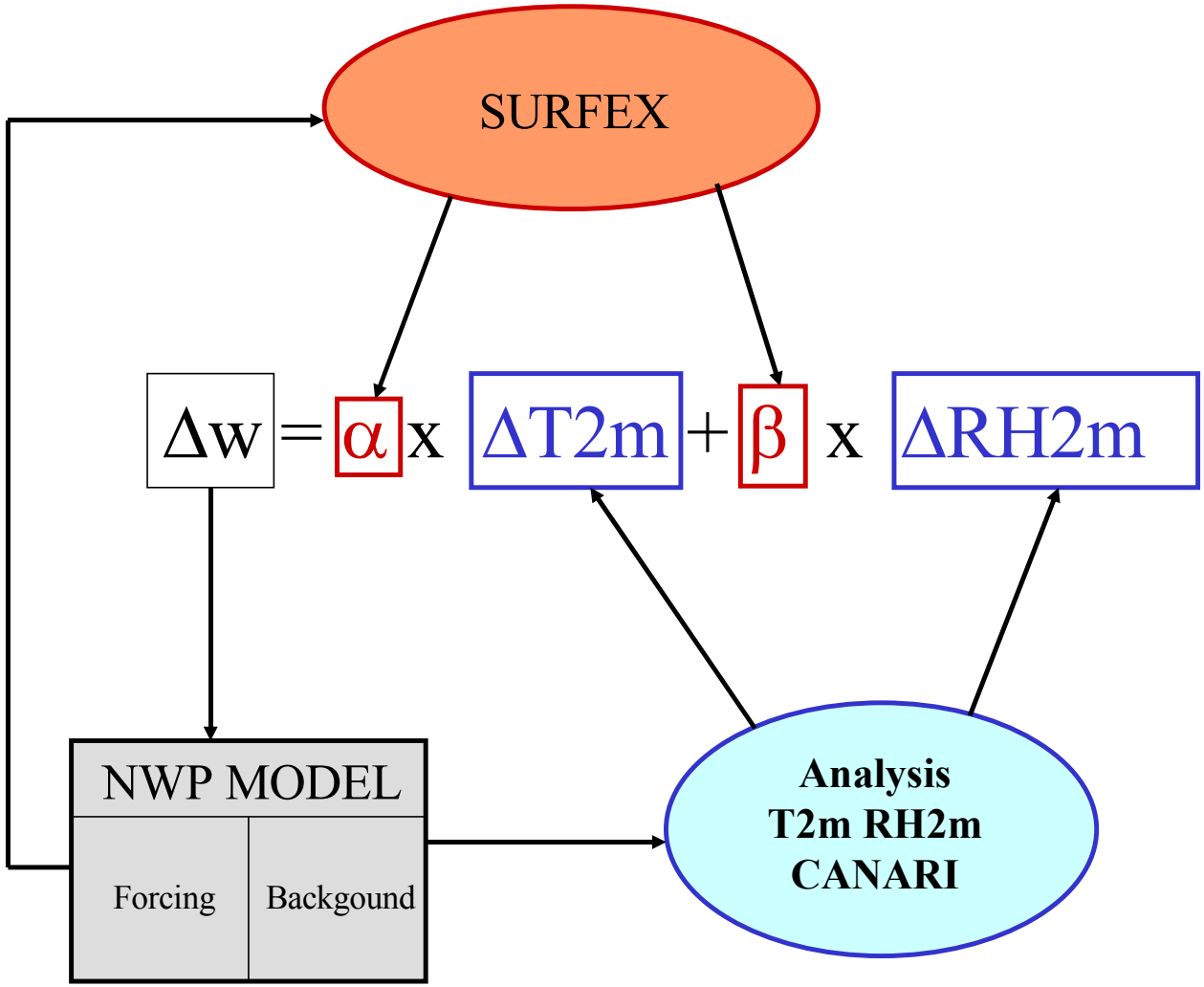
Summary of activities

- Concept developed at the Meteorological Service of Canada (2004-2006) in preparation of the HYDROS mission (Balsamo et al., 2006; 2007, *J. of Hydromet.*) following the online *simplified 2D-Var* of Balsamo et al. (2004) (ALATNET)
- Evaluation at local scale using simulated observations (Mahfouf, 2007)
  - For the assimilation of T_{2m} and RH_{2m} the soil analysis behaves very similarly for the OI approaches and the SEKF
  - The SEKF can assimilate microwave brightness temperatures in combination with screen-level observations
  - The SEKF has a similar behavior as a more expensive EnKF (less tuning parameters)
- The SEKF has been coded within SURFEX by K. Bergaoui (Tunisia) in spring 2007 and is currently under scientific evaluation at Météo-France and IRM (Belgium)

Experimental set-up

- Period : July 2006
- Domain : ALADIN-France (273x273 pts)
- Analysis : mean soil moisture content w_2
- Observations : CANARI T_{2m} and RH_{2m} analysis every 6 hours over the ALADIN-France domain
- Atmospheric forcing : hourly short-range forecasts (0-6h) over the ALADIN-France domain
- SURFEX set-up :
  - Physiographic data bases (soil-vegetation) *as close as possible* from the current ALADIN operational fields
  - Options of ISBA *as close as possible* to the ALADIN configuration
  - Initial soil conditions : ALADIN analysis (01 July 2006 00Z)

Coupling between atmospheric model and offline surface scheme



Optimum interpolation

Analytical coefficients obtained from Monte-Carlo experiments (Bouttier et al, 1993; Giard and Bazile,2000)
Strong reduction in the presence of rain, clouds, strong wind, low radiative forcing (empirical thresholds)

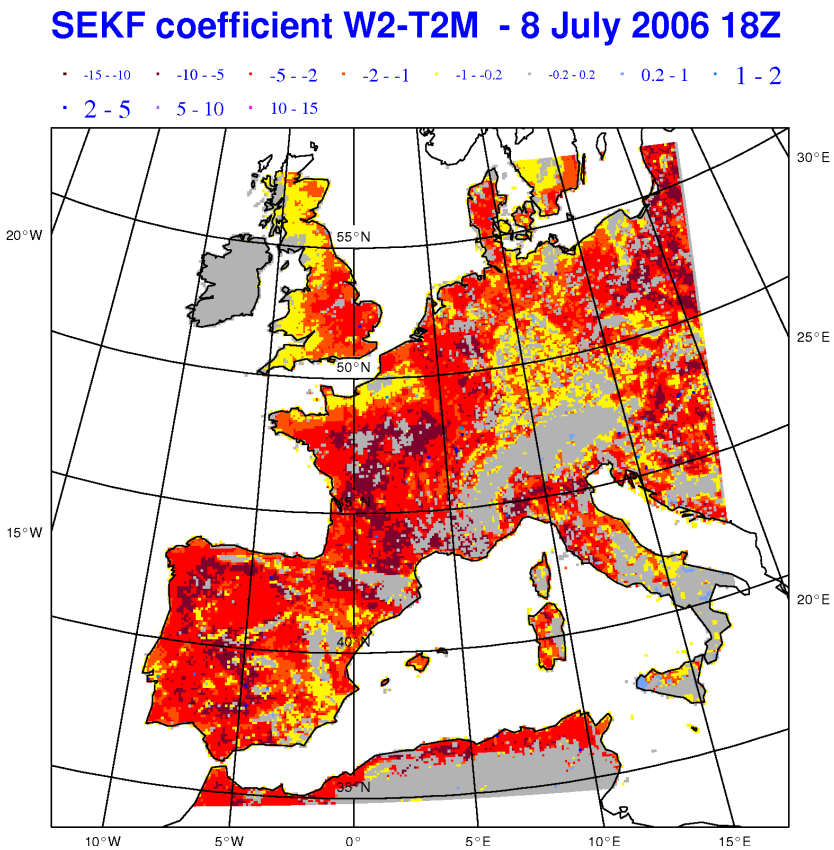
Simplified EKF

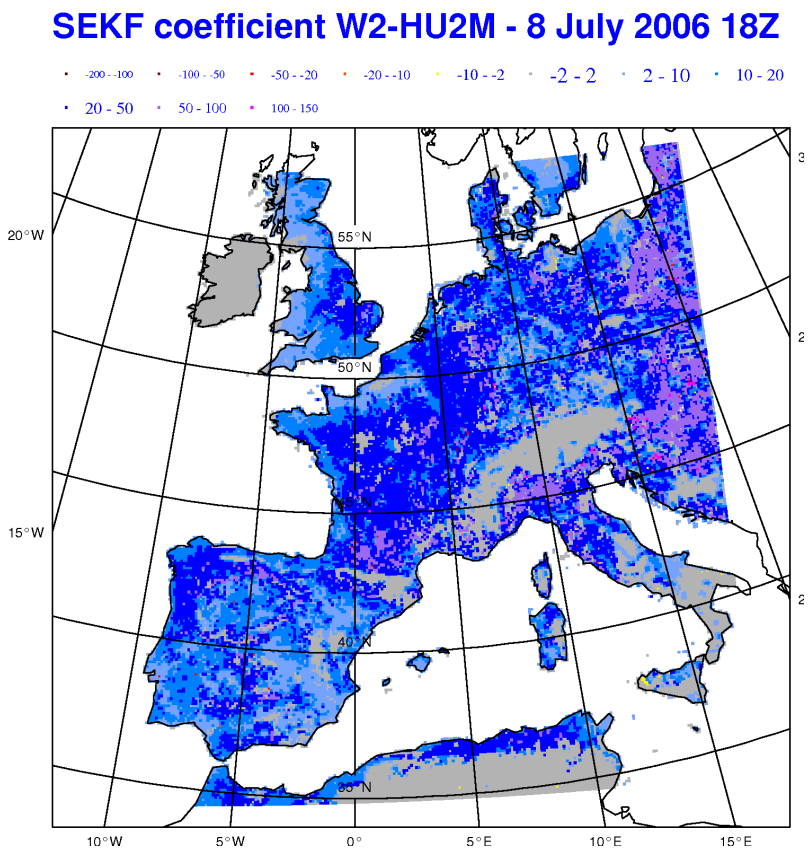
$$\mathbf{K} = \mathbf{B}\mathbf{H}^T(\mathbf{H}\mathbf{B}\mathbf{H}^T + \mathbf{R})^{-1}$$

where $\mathbf{B}$ and $\mathbf{R}$ are prescribed
The Jacobian of the observation operator $\mathbf{H}$ is obtained in finite differences (instead of adjoint code).

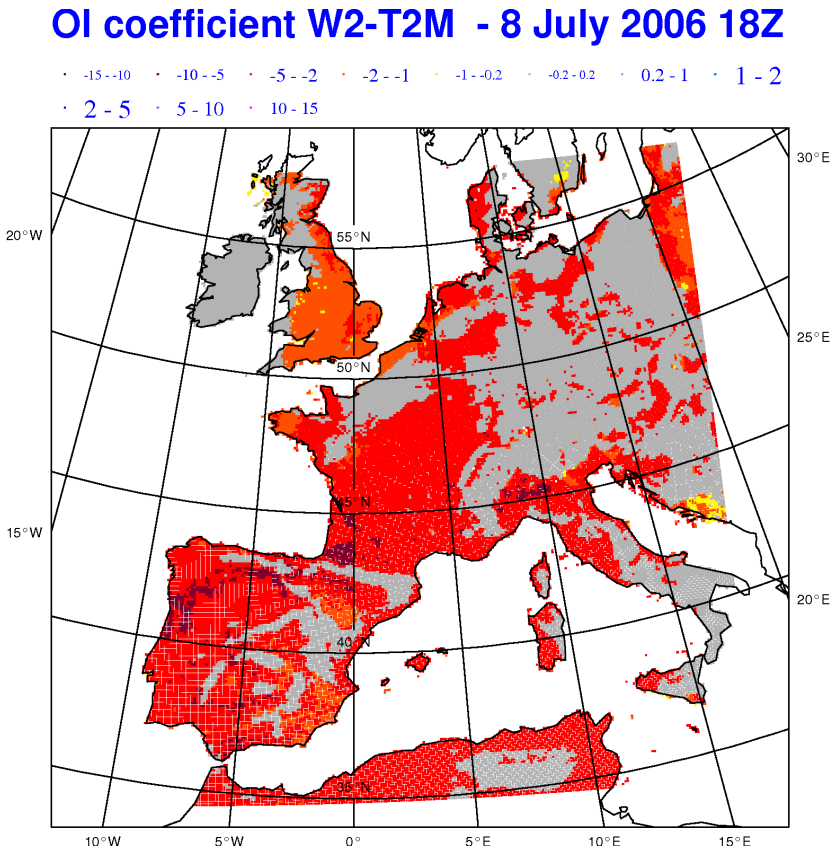
$$\mathbf{H} \approx \frac{\mathbf{y}(w_2 + \Delta w) - \mathbf{y}(w_2)}{\Delta w}$$

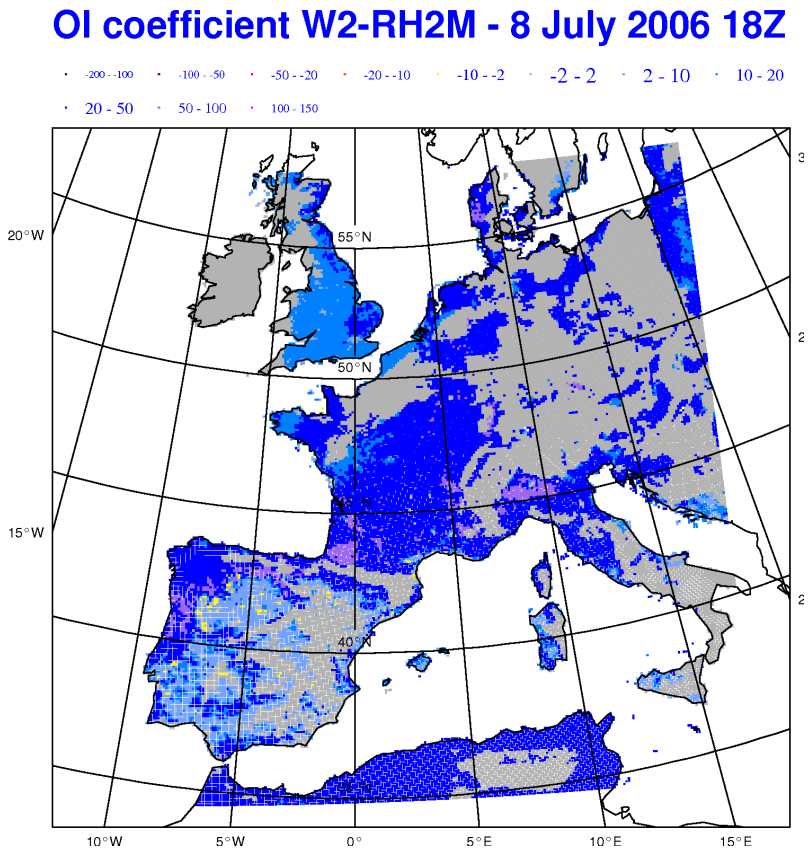
Kalman gain (Extended Kalman filter)



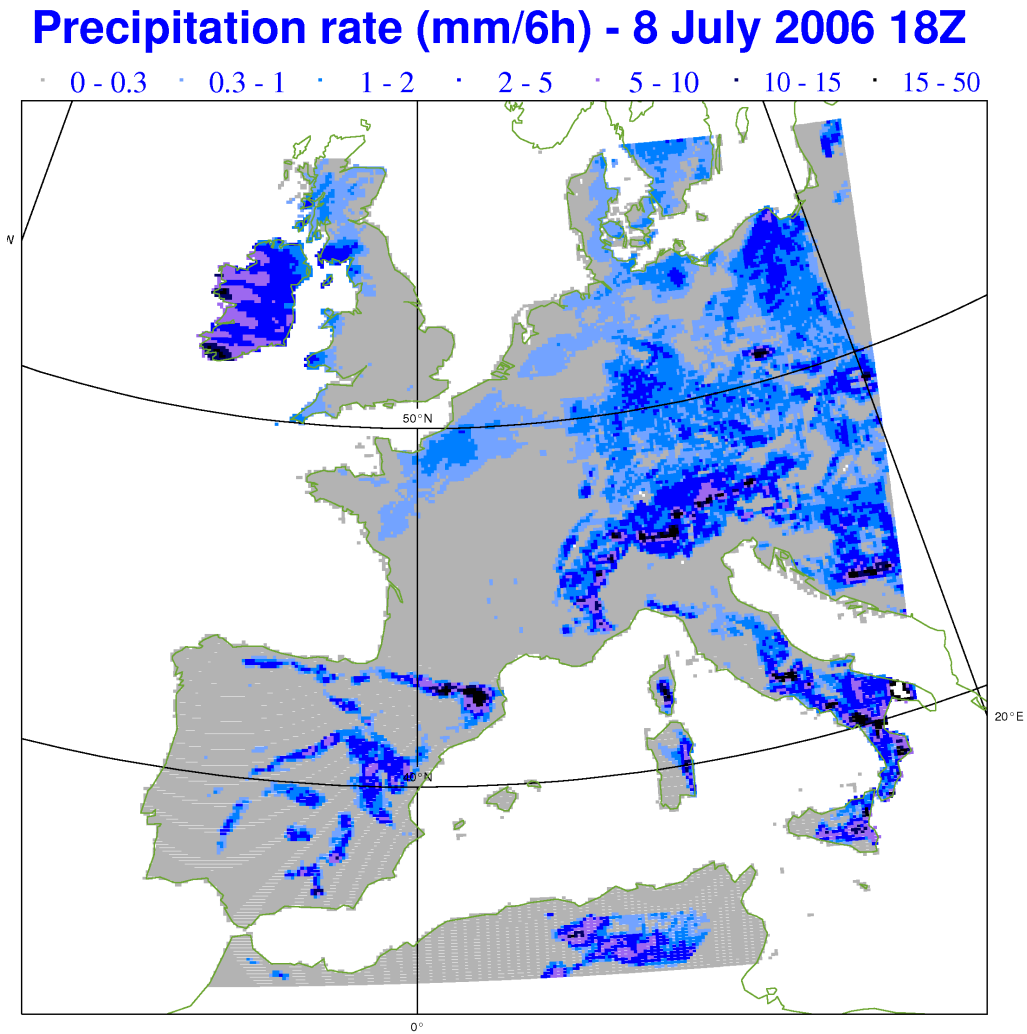


Kalman gain (Optimum interpolation)



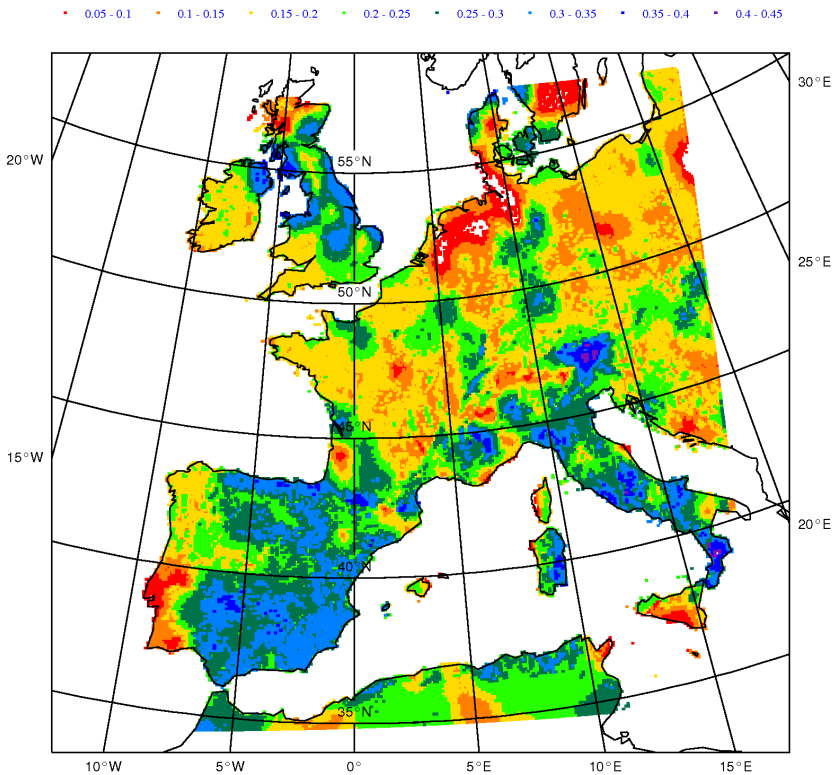


Accumulated precipitation

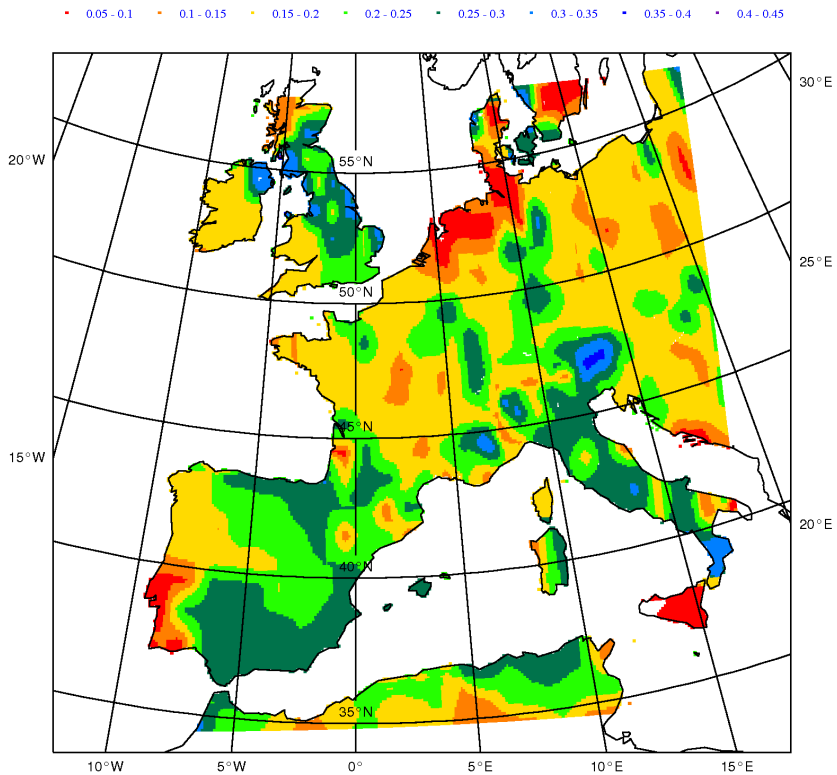


Soil moisture after 1 month of assimilation

SURFEX Mean soil moisture 30 July 2006



ALADIN Mean soil moisture 30 July 2006

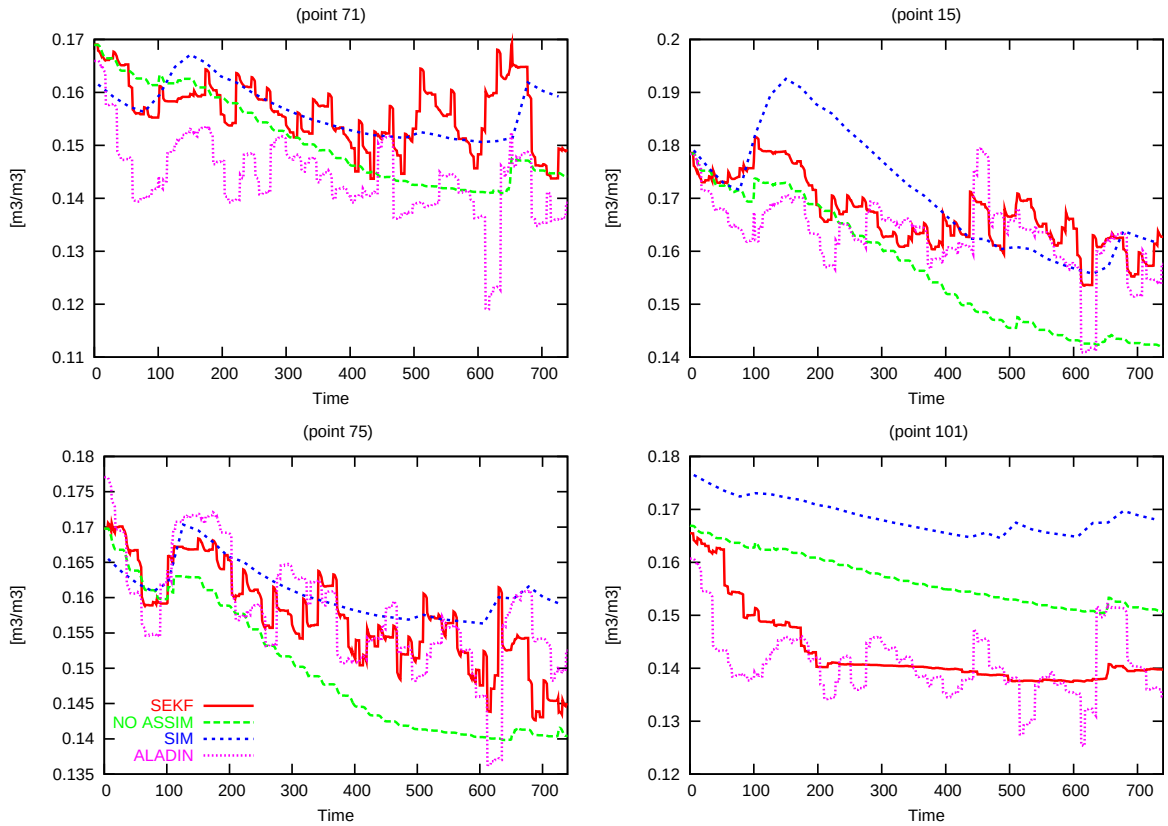


Comparison with ALADIN, SIM and NO ASSIM

ALADIN = interpolation of ARPEGE analyses

SIM = ISBA scheme forced by observed precipitation forcing over France

NO ASSIM = ISBA scheme forced by ALADIN short-range forecasts



Conclusions

- Development of a flexible tool for land data assimilation within ALADIN (geographical domain, observations to be assimilated, variables to be analysed, land surface scheme version)
- A SEKF is now available within SURFEX for the analysis of soil moisture (still relies on a 2D spatial interpolation tool)
- The first results over the ALADIN-France for summer 2006 are encouraging (proof of concept)
- Work to be done (in collaboration with HIRLAM/ALADIN partners) :
  - Reduce remaining inconsistencies between SURFEX and ALADIN-ISBA
  - Evaluate the analysis in winter periods (soil freezing)
  - Perform assimilation of surface soil moisture contents (satellite, offline hydrological model SIM)
  - Couple the soil analysis with the atmospheric analysis (to allow feedbacks)
  - Improve the efficiency of offline SURFEX version