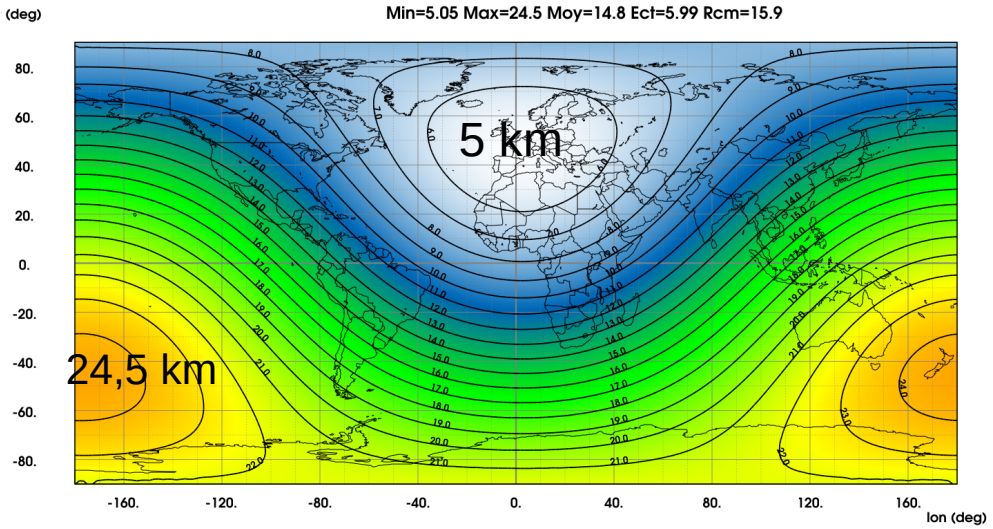
Surface Scheme at Météo-France

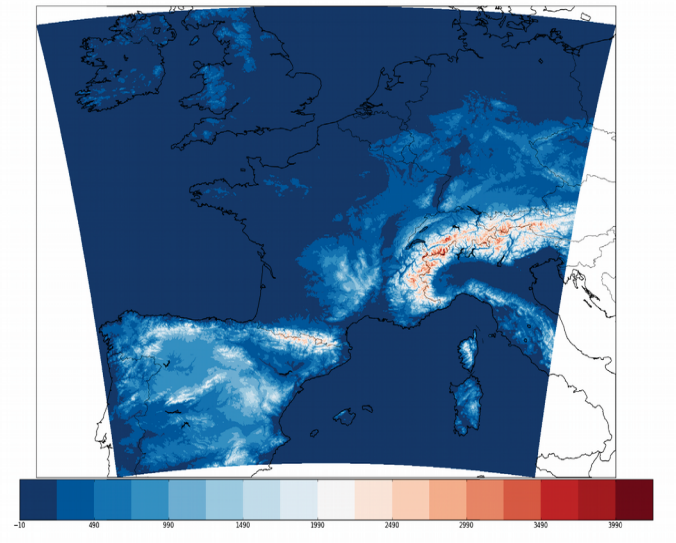
Nadia Fourrié, Camille Birman

Outline

- Introduction
- Surface model
- Surface analysis
- LDAS (Land Data Assimilation System)
- Perspectives.

Introduction : NWP systems at Météo-France





- **Global Model ARPEGE**

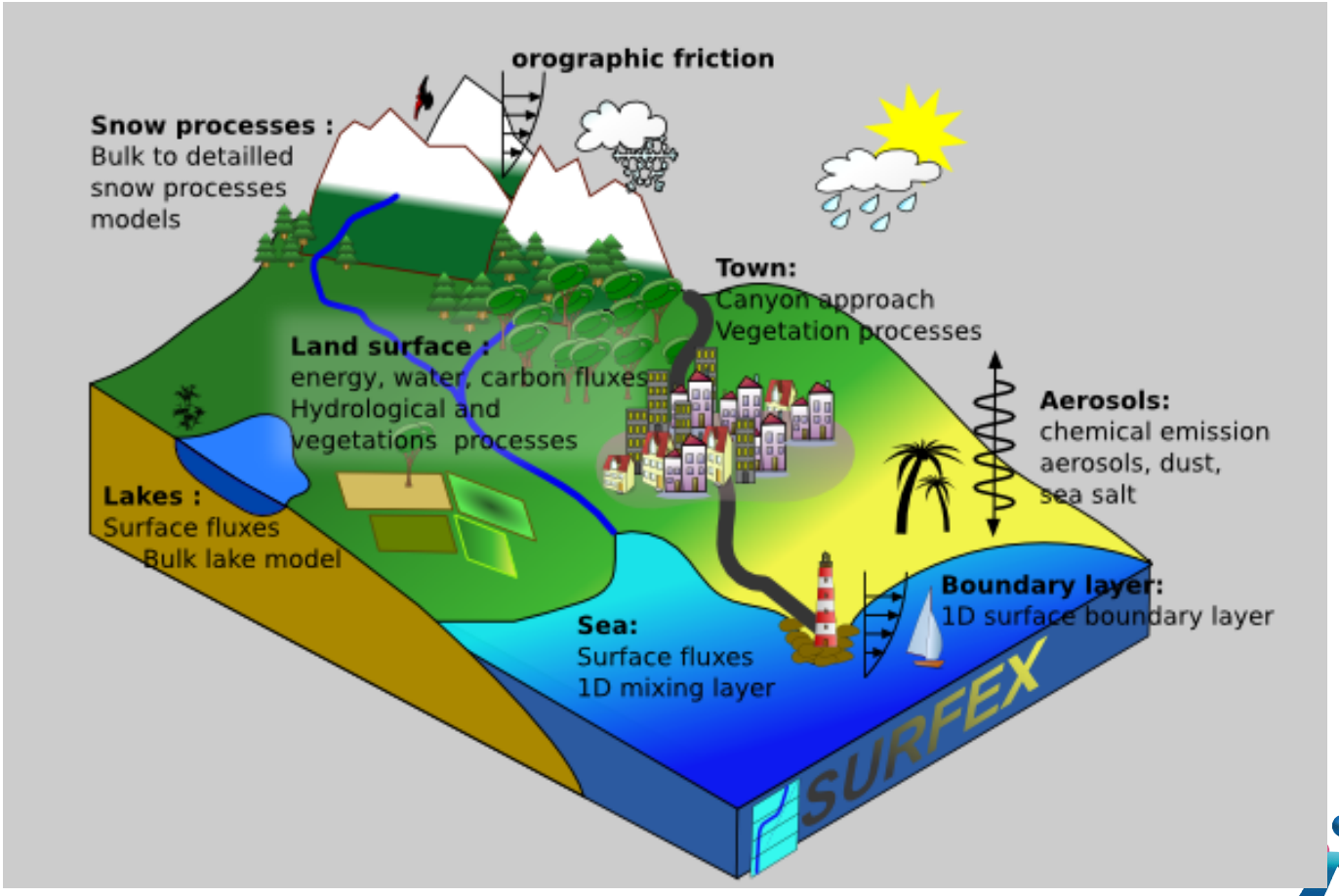
- Spectral model with variable resolution: T_L1798c2.2L105
- Δx from 5 to 24,5 km
- 105 vertical levels from 10 m to 0.1 hPa
- Incremental 4D-Var assimilation (6-h window and 30 min time-slots)
- Forecast (cut-off and ranges): from 60 to 114 h

- **Limited area model AROME**

- Spectral limited area non-hydrostatic model with explicit moist convection
- Δx = 1.3 km
- 90 vertical levels from 5 m up to 10 hPa
- 3D-Var assimilation (1-h window)
- Coupling files : hourly forecasts from global model ARPEGE
- Forecast range : from 7 to 48 hours (8 times a day)

Surface modelling platform SURFEX

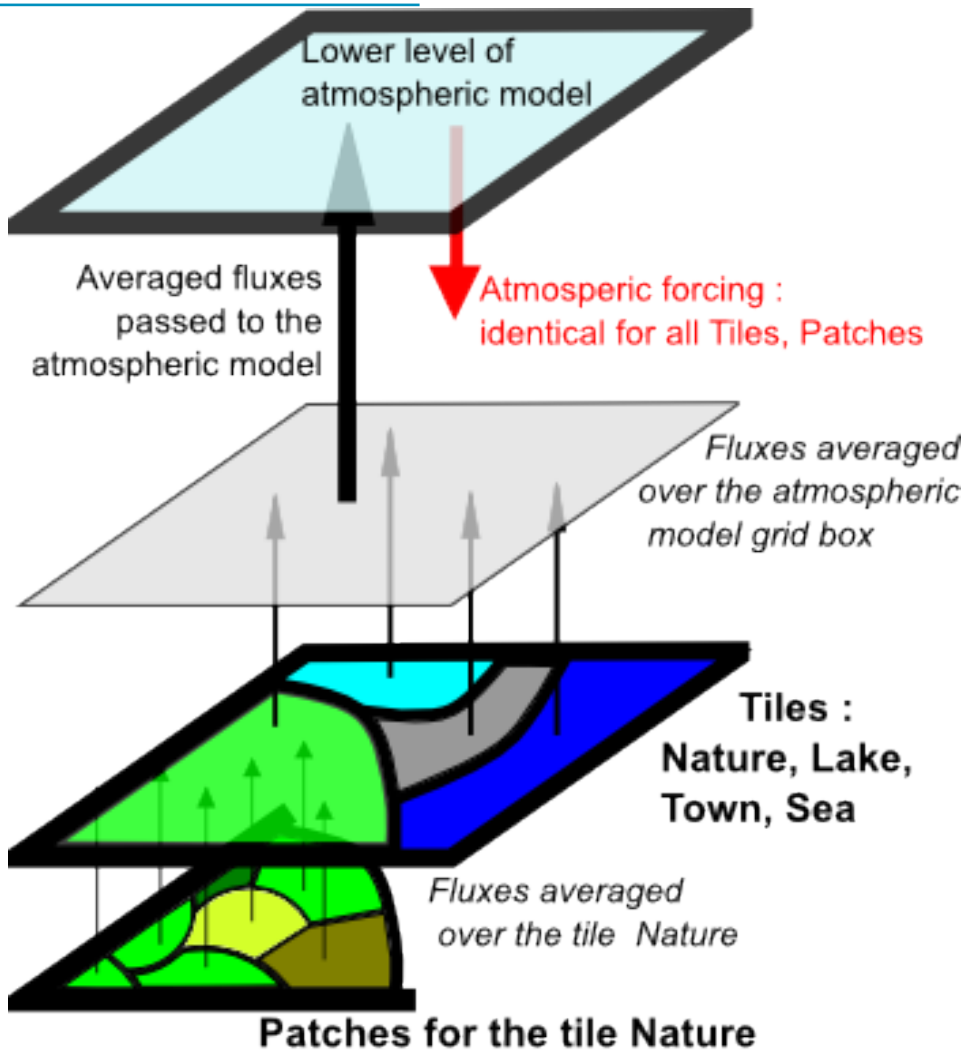
- SURFEX platform to modelise the exchanges of water and energy between land surface and atmosphere.
- Several schemes available for nature, sea, lake and town
  Masson, V., et al. "The SURFEXv7. 2 land and ocean surface platform for coupled or offline simulation of earth surface variables and fluxes." (2013). https://hal.archives-ouvertes.fr/hal-00968042/



Surface modelling platform SURFEX

- **Atmospheric forcing** (air temperature, specific humidity, wind components, pressure, rain rate, snow rate, CO2, chemical species, aerosol concentration)
  and radiative forcing (solar radiation, infrared radiation)

- **Surface radiative properties** (albedo, emissivity, surface radiative temperature) and surface fluxes (momentum, sensible heat, latent heat, CO2, chemical species, aerosols)



SURFEX tiling and coupling with an atmospheric model

Use of SURFEX in Surface schema @MF

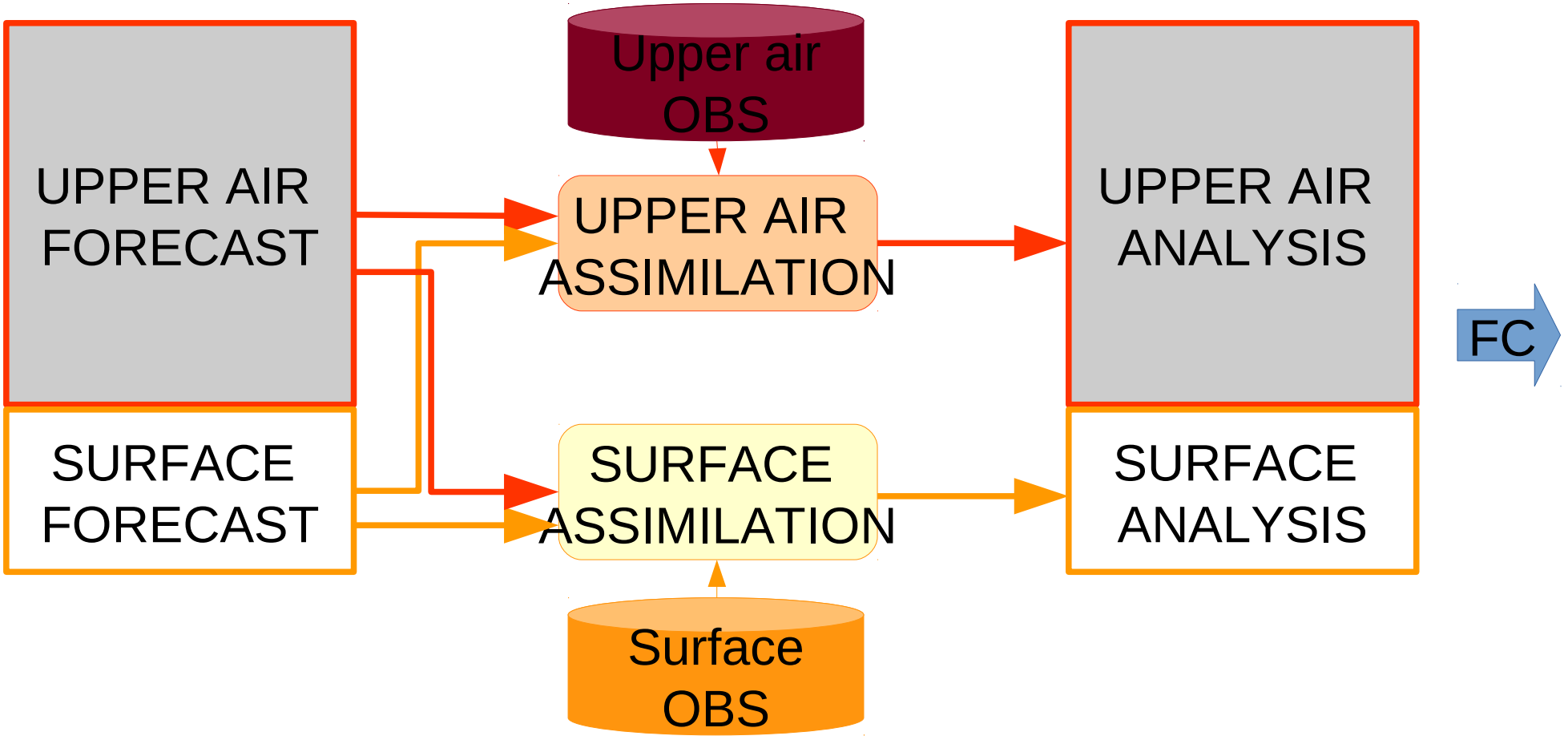
Now

	Nature	Lake	Sea	Town
ARPEGE	ISBA-3L	OSTIA	OSTIA+clim for sea ice	rock
AROME	ISBA-3L	OSTIA	OSTIA	TEB

In the near future

	Nature	Lake	Sea	Town
ARPEGE	ISBA-DIF +Explicit Snow	Flake	OSTIA +GELATO-1D	rock
AROME	ISBA-DIF +Explicit Snow	Flake	OSTIA +GELATO-1D	TEB

Surface modelling platform SURFEX



Land surface assimilation system

- The 4 tiles have their own prognostic variables (and analysed variables):

  - Nature: ISBA-3L (3 layers) for NWP (Noilhan and Mahfouf, 1996; Boone et al., 1999), prognostic variables in the three superficial layers (liquid and solid fractions for soil water content, SWE for snow on the ground) → : T_s, T_2, T_3, w_g, w_2, w_3.

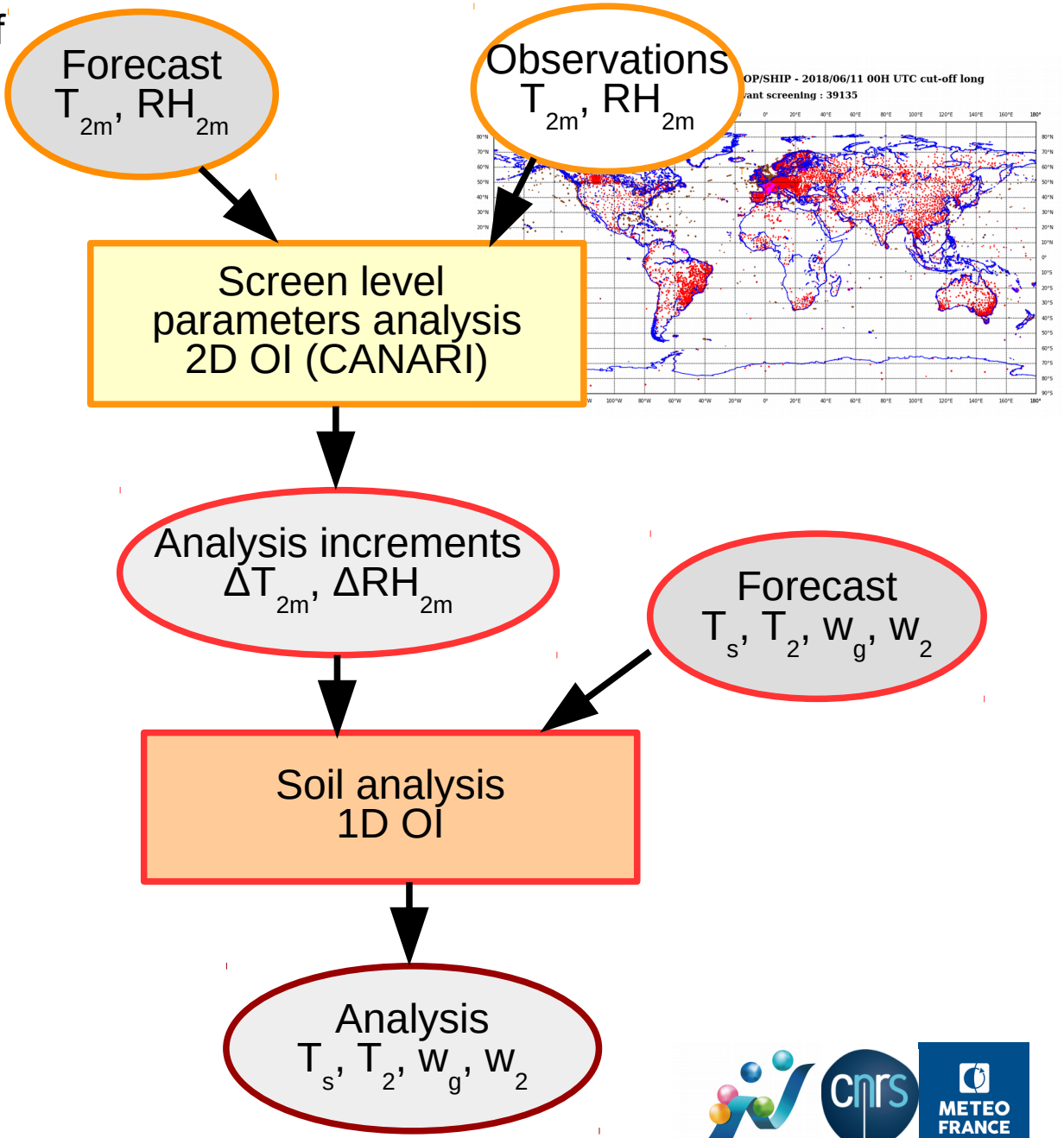
  - Town: TEB (Masson, 2000) → T_{roof}, T_{wall}, T_{road}

  - Lake → LST

  - Sea → SST

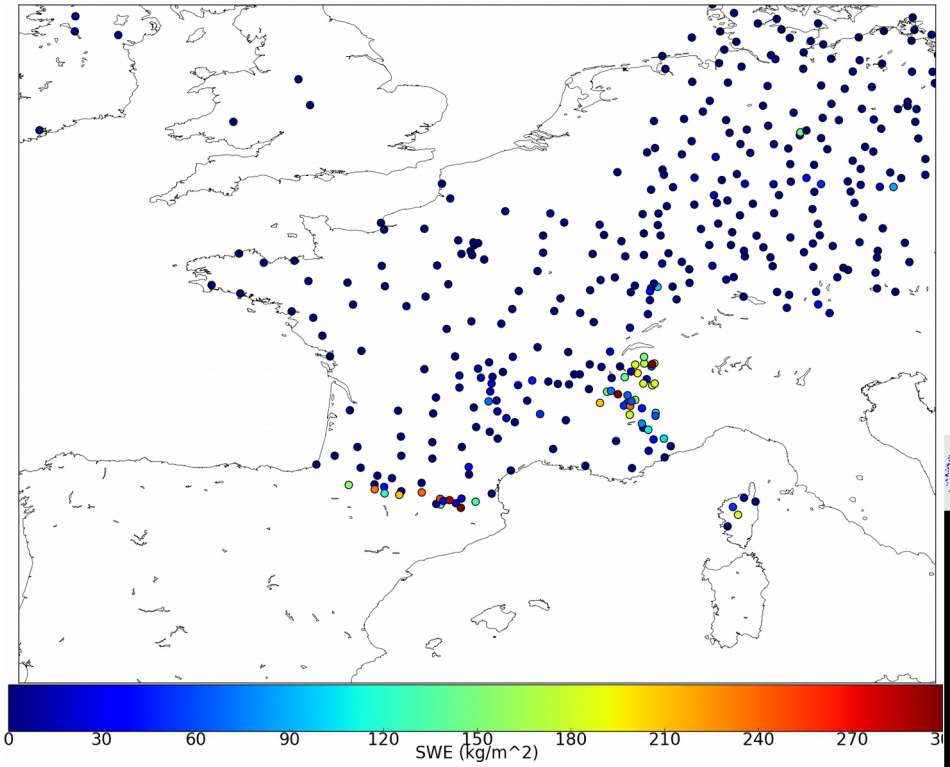
Land surface assimilation system

- We use screen level observations of T_{2m} and RH_{2m} to compute gridded analysed fields using 2D Optimal Interpolation (OI) (CANARI)
- 1D OI scheme using the increments of T_{2m} and RH_{2m} (Giard and Bazile, 2000) to obtain increments of soil temperature and moisture T_s, T_2, w_g, w_2.
  - $\Delta T_s = \Delta T_{2m}$
  - $\Delta T_2 = \Delta T_{2m}/2\pi$
  - $\Delta w_g = \alpha_1 \Delta T_{2m} + \beta_1 \Delta RH_{2m}$
  - $\Delta w_2 = \alpha_2 \Delta T_{2m} + \beta_2 \Delta RH_{2m}$



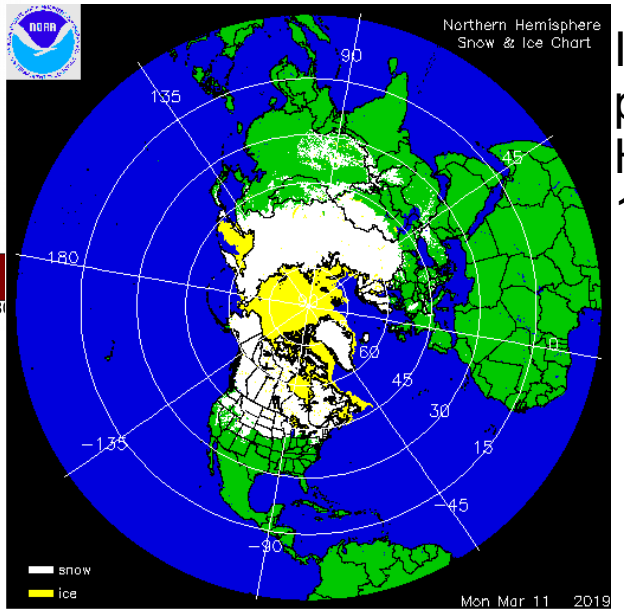
Current studies : Snow analysis

- Snow analysis over plains: necessary to correct for insufficient snow melt in the model



Snow depth observations over the AROME-France domain

- Heterogeneous observation network over the globe and the AROME-France domain
- Snow analysis performed using CANARI 2D OI
- Use of satellite data (snow cover) for the snow analysis

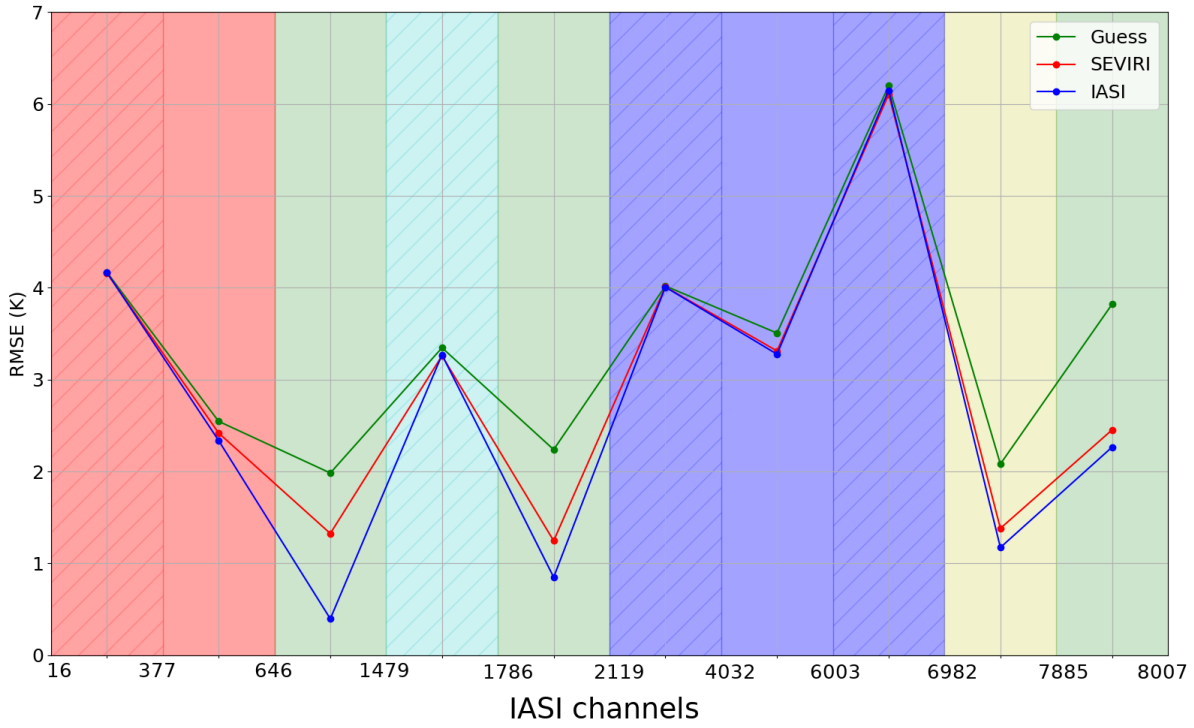


IMS snow and ice product over Northern Hemisphere on March 11, 2019

See Camille Birman's talk on Wednesday

Current studies : land surface temperature retrieved from satellite observations

- A realistic land surface temperature is crucial for the assimilation of surface sensitive channels in the infrared bands.
- Retrieval of the land surface temperature from a window channel for the simulation of other channels in the variationnal assimilation.
  - Comparison of the retrieved surface temperature from SEVIRI with in-situ observation and with the surface temperature retrieved from IASI
  - Simulations of IASI and SEVIRI channels using different surface temperatures (model temperature, temperatures retrieved from SEVIRI and IASI window channels)

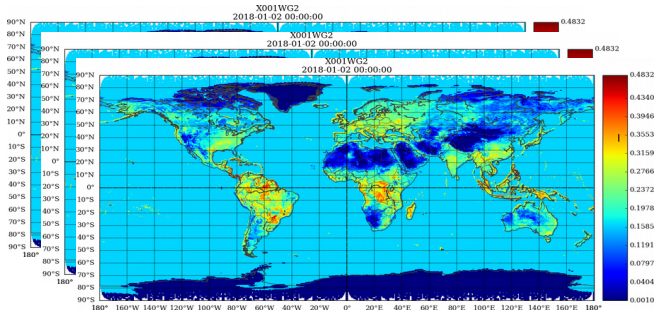


Night-time root mean square errors related to simulations of IASI brightess temperatures using model LST, SEVIRI LST and IASI LST. Hatched channels present very small sensitivity to LST (Fig. Zied Sassi)

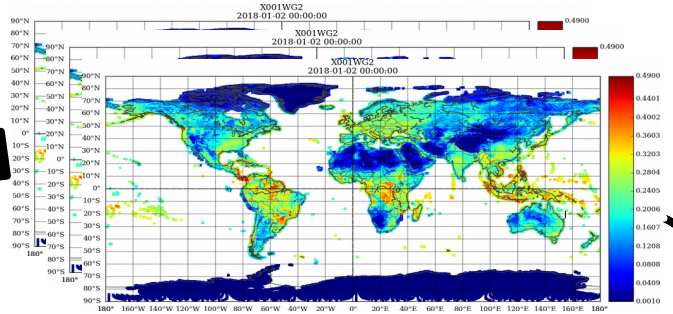
See Zied Sassi's talk this afternoon

Current studies: Diagnostics using ARPEGE EDA for surface analysis

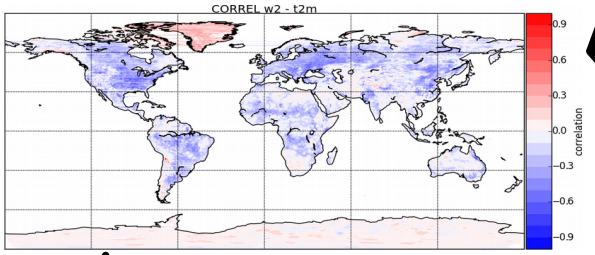
- Optimal interpolation coefficients: constant coefficients
- Use of Ensemble Date Assimilation (AEARP, 50 members) to compute standard deviations and covariances between surface variables and observed variables. Statistics of the day varying in space and time



Surface fields at **low resolution** from EDA (50 members)



Surface fields at **high resolution** (50 members)



Correlations and standard deviations at **high resolution**

Soil analysis

See Camille Birman's talk on Wednesday

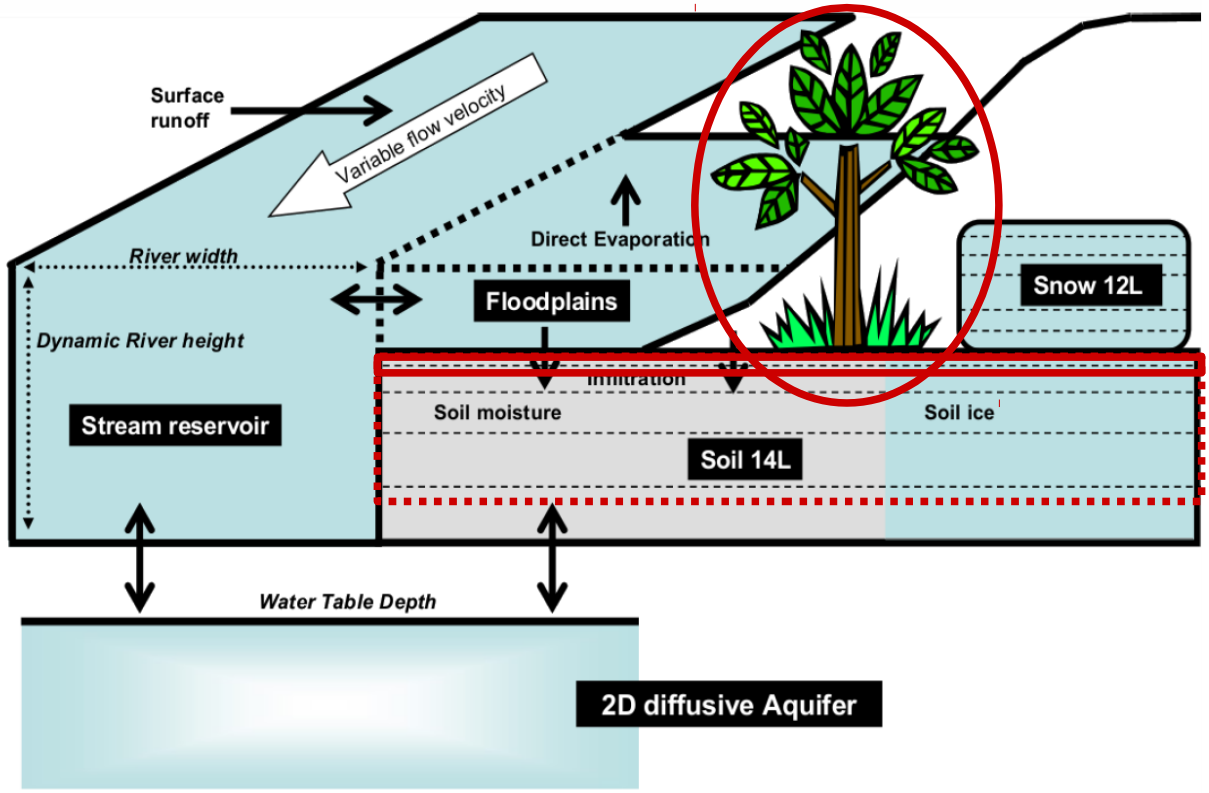
Data assimilation in LDAS-Monde

- **LDAS-Monde:** Offline global capacity integration of satellite observations into a land surface model fully coupled to hydrology
- **LDAS-Monde involves:**
  - Land surface model: **ISBA** (Interaction Soil-Biosphere-Atmosphere)
  - River routing system: **CTRIP** (CNRM version of Total Runoff Integrating Pathways)
  - Data assimilation routines
- **Observations assimilated:**
  - Surface Soil Moisture (SSM)
  - Leaf Area Index (LAI)
- **Data Assimilation schemes:**
  - Simplified Extended Kalman Filter (SEKF)

    [Mahfouf et al., 2009]
  - Ensemble Square Root Filter (EnSRF)

    [Whitaker and Hamill, 2002]

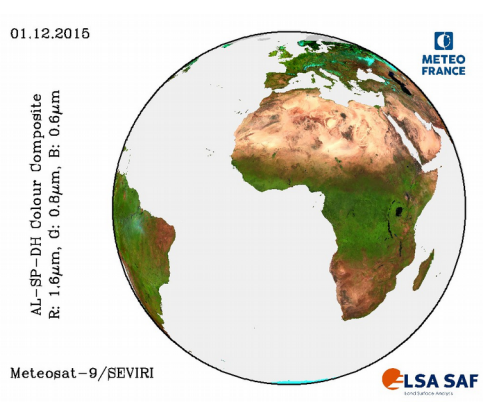
    [Fairbairn et al., 2015]

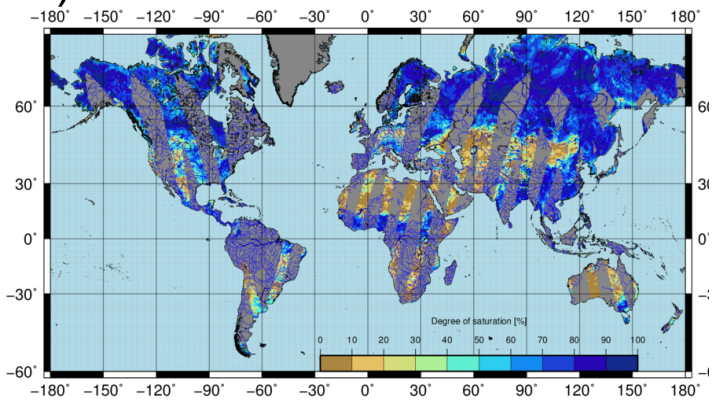


See Clement Albergel 's presentation on Tuesday

Conclusions and future work

- Analysis of surface parameters:
  - snow depth,
  - surface temperature
  - improvement of analysis techniques, in particular in areas of complex orography (MESCAN)
- Improvement of the land surface data assimilation system: use of atmospheric ensembles produced by ensemble data assimilation systems (AEARP → global model ARPEGE, AEARO → limited area model AROME)
- Assimilation of satellite products :
  - for snow (snow cover products Nesdis-IMS/H-SAF product/Modis?)
  - for albedos (products from LSA-SAF)
  - for soil moisture (soil moisture product from ASCAT, and/or from L-band sensors SMOS/SMAP)





Thanks for your attention !