Overview of ALADIN surface activities

Patrick Le Moigne
Input from colleagues working on ALADIN, ALARO, AROME, and ARPEGE models

EWGLAM/SRNWP meeting, Sofia, 2019

Outline

ALADIN surface activity

- Surface analysis
- SURFEX physics
- Physiography
- Summary

Surface analysis

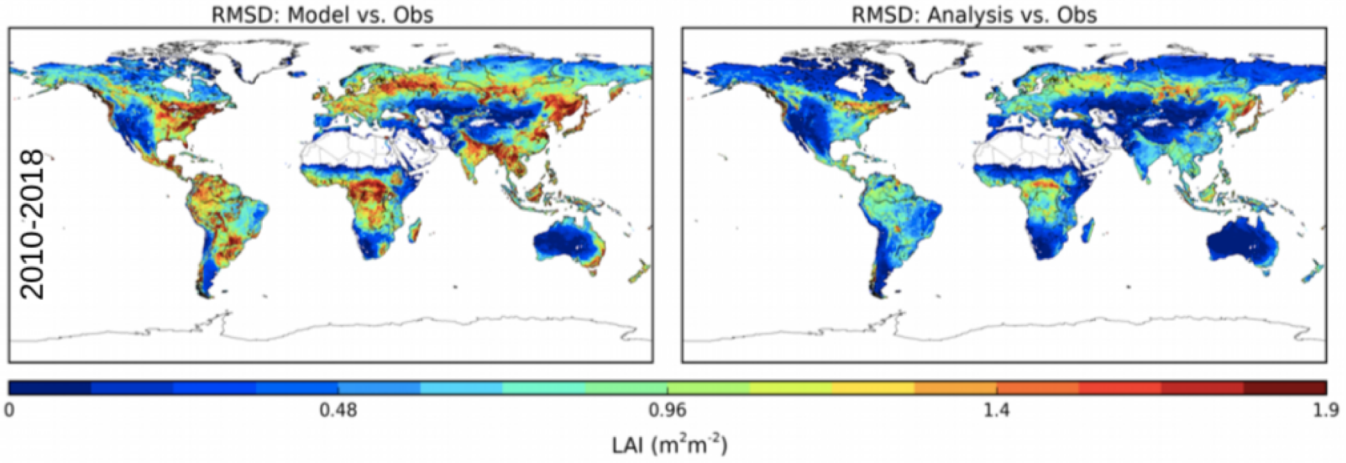
- Tests performed using MESCAN structure function for T2m in the AROME surface data assimilation (more realistic increments over mountain areas). Analysis of daily Precipitation with MESCAN (reanalysis context).
- Use of a LDAS system to assimilate LAI and SSM (MF, OMSZ)
- Use of a LDAS system (Force restore model) to assimilate T2M, RH2M. Pilot experiment (SHMU).
- Snow analysis over plains to correct insufficient snow melt in the AROME model. The snow analysis is based on CANARI while transferring the increments to SURFEX in AROME (MF).
- At IPMA (Monteiro et al., 2017) AROME surface data assimilation cycling based on Giard and Bazile (2000), showed a clear positive impact on T2M and RH2M forecast scores up to 24 hours. Assimilation of wind from ASCAT.
- 3D-var coupled to EKF (RMI, Duerinckx et al., 2017)
- Using the ARPEGE EDA for diagnostics for surface analysis (MF).
- Assimilation of (6h to 1h) conventional data over the Iberian peninsula with Canari-Arome (IPMA+INM)
- Assimilation of satellite products, in particular for surface temperature, for soil moisture (soil moisture product from ASCAT, and/or from L-band sensors SMOS/SMAP), for snow (snow cover products Nesdis-IMS/H-SAF product/Modis?) and for albedo (products from LSA-SAF) (MF)

Offline LDAS to assimilate LAI and SSM

- @MF

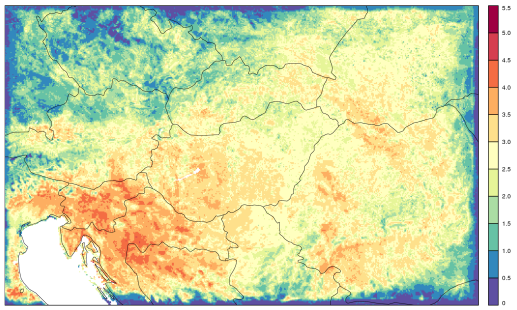
C Albergel et al.

Model	Domain	Atm. Forcing	DA Method	Assimilated Obs.	Observation Operator	Control Variables	Additional Option
ISBA Multi-layer soil model CO_2-responsive version (Interactive vegetation)	**Global (2010 – 2018)**	**ERA-5 Res.: 0.25°x0.25°**	**SEKF**	**SSM** (CGLS SWI + cdf matching) **LAI** (CGLS)	**Second layer of soil (1-4cm)** **LAI**	**Layers of soil 2 to 8 (1-100cm)** **LAI**	**Coupling with CTRIP (0.5°)**

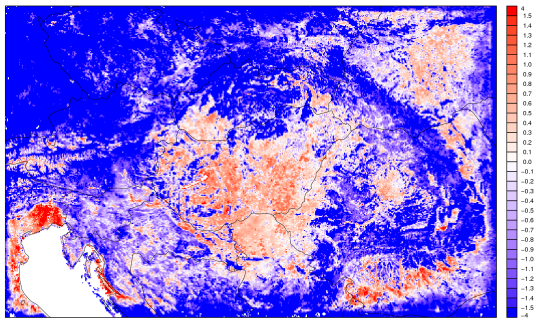


- @OMSZ: wish to introduce a daily update of LAI in operational AROME using LDAS to assimilate LAI

B Szintai et al.



LAI computed by SURFEX open-loop

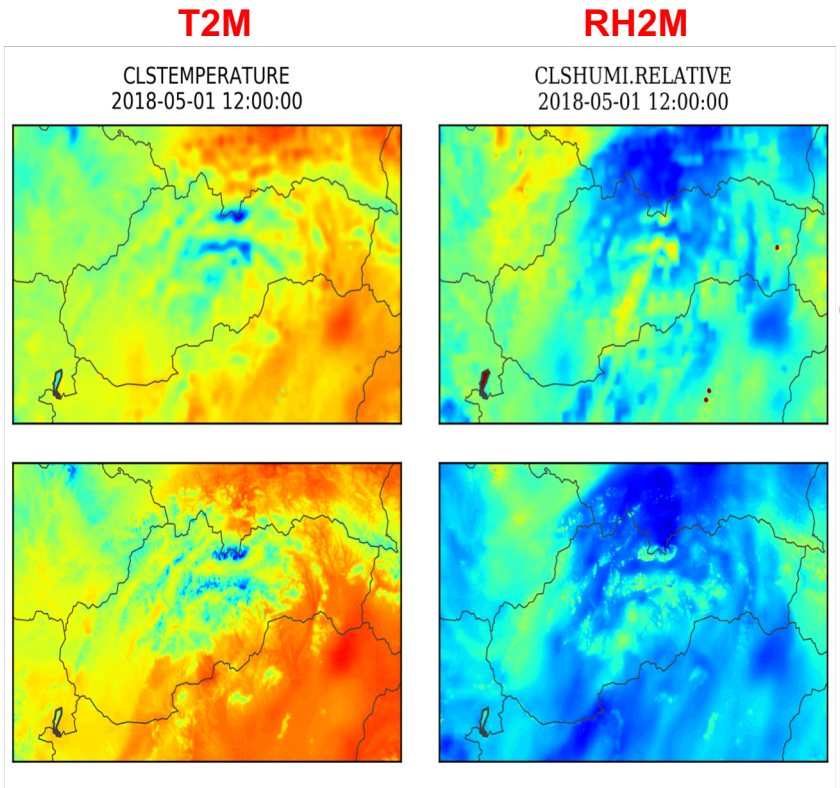


Departure to climatology

(source SHMU)

Offline LDAS to assimilate T2M and RH2M

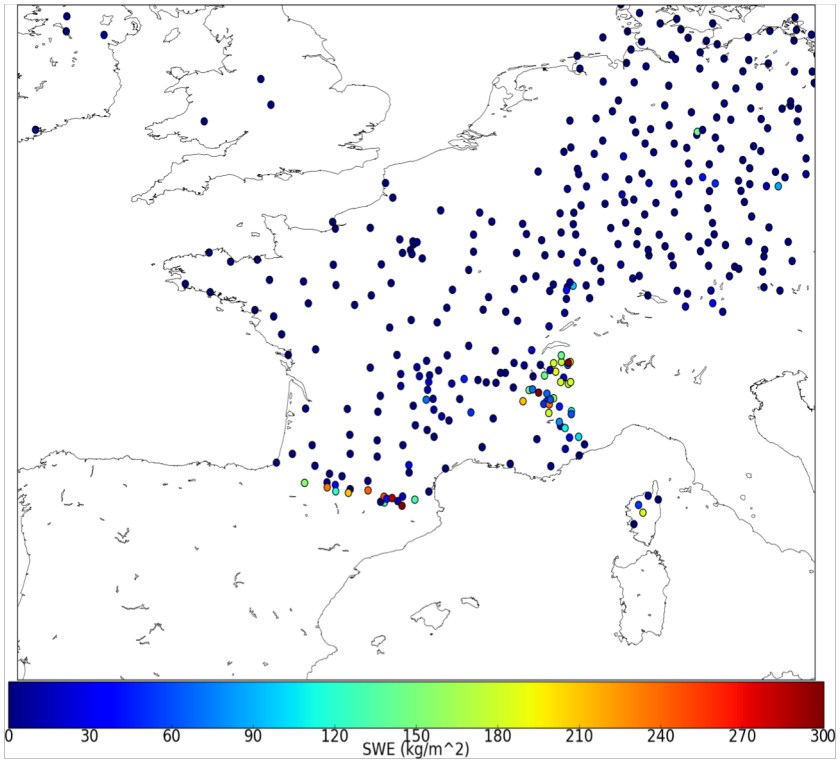
- Analysis of soil water content and temperature
- Spatial domain: INCA-SK 501 x 301 @ 1 km
- Gridded observations: CANARI analysis replaced by hi-res analysis of T2M & RH2M from INCA-SK
- Forcing: ~20m above surface, INCA-SK precipitation analysis + global radiation analysis (improved calculation of Jacobians); other fields from ALARO-SK 4.5km
- SURFEX and SODA-EKF from cy40t1 pack
- Pilot experiment based on ISBA-3L Force restore scheme, assimilation of T2M and RH2M



- Next steps:
  - Test and optimize current setup
  - Compare EKF with OI_MAIN
  - switch to SURFEX v8.1
  - Add snow cover analysis

Snow analysis with AROME

- To correct insufficient snow melt over plains in the AROME model
  - 2 periods of study: winter 2018 (February-March) and 2019 (January-April)

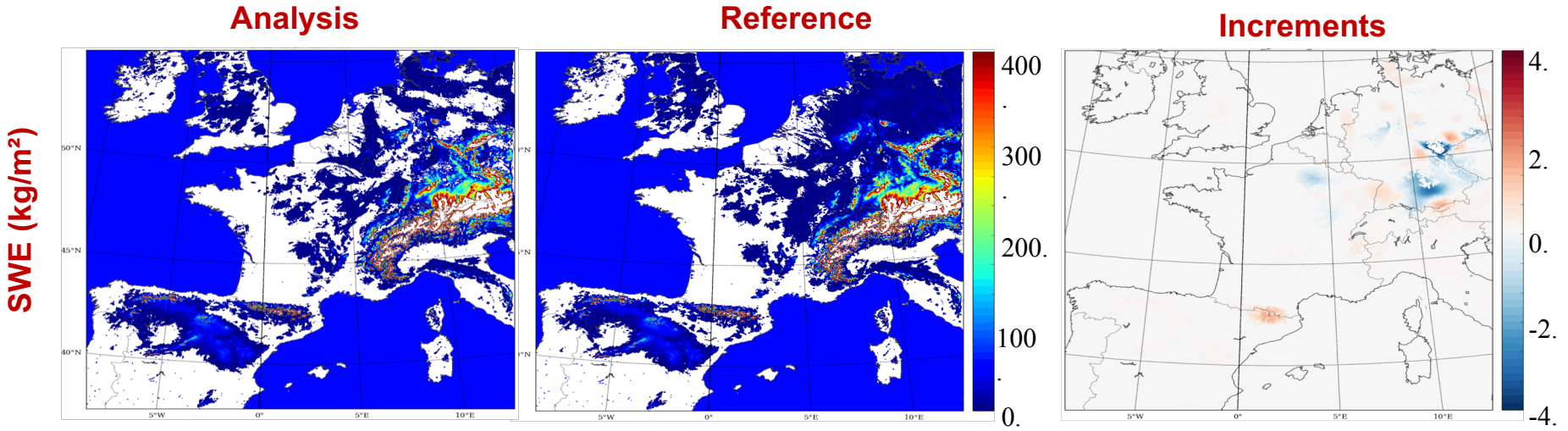


Snow depth observations over the AROME-France domain

- ✓ Heterogeneous observation network over the AROME-France domain
- ✓ Snow analysis performed using CANARI 2D OI
- ✓ Prognostic variable: **SWE** → use of model density to transform snow depth observations into snow water equivalent for the assimilation
- ✓ Tuning of observation and background errors and length scales

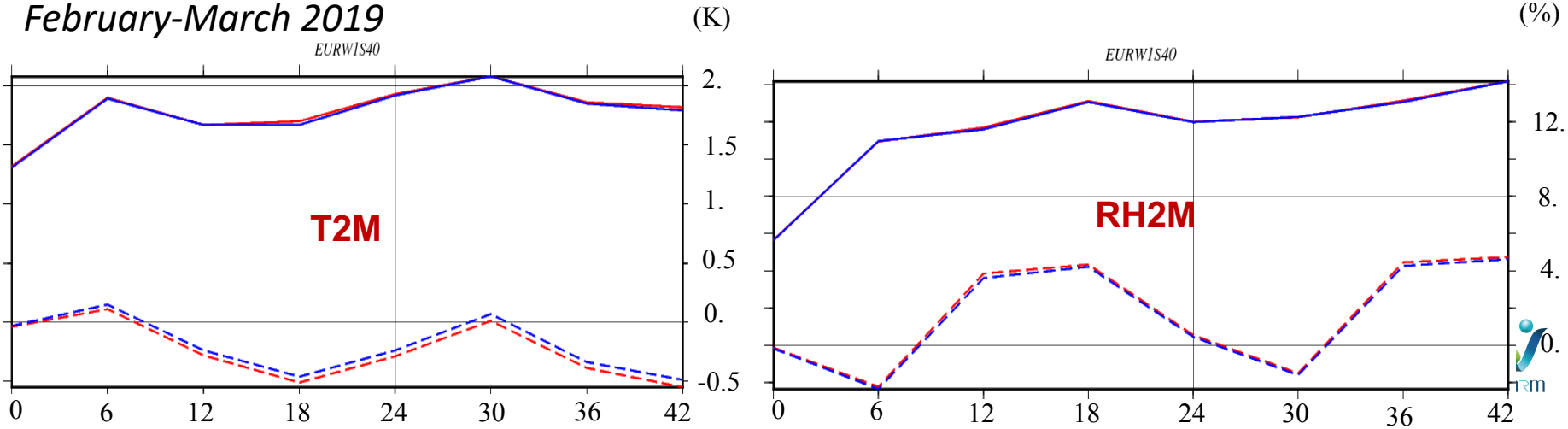
Snow analysis: case studies

20 January 2019, 12UTC



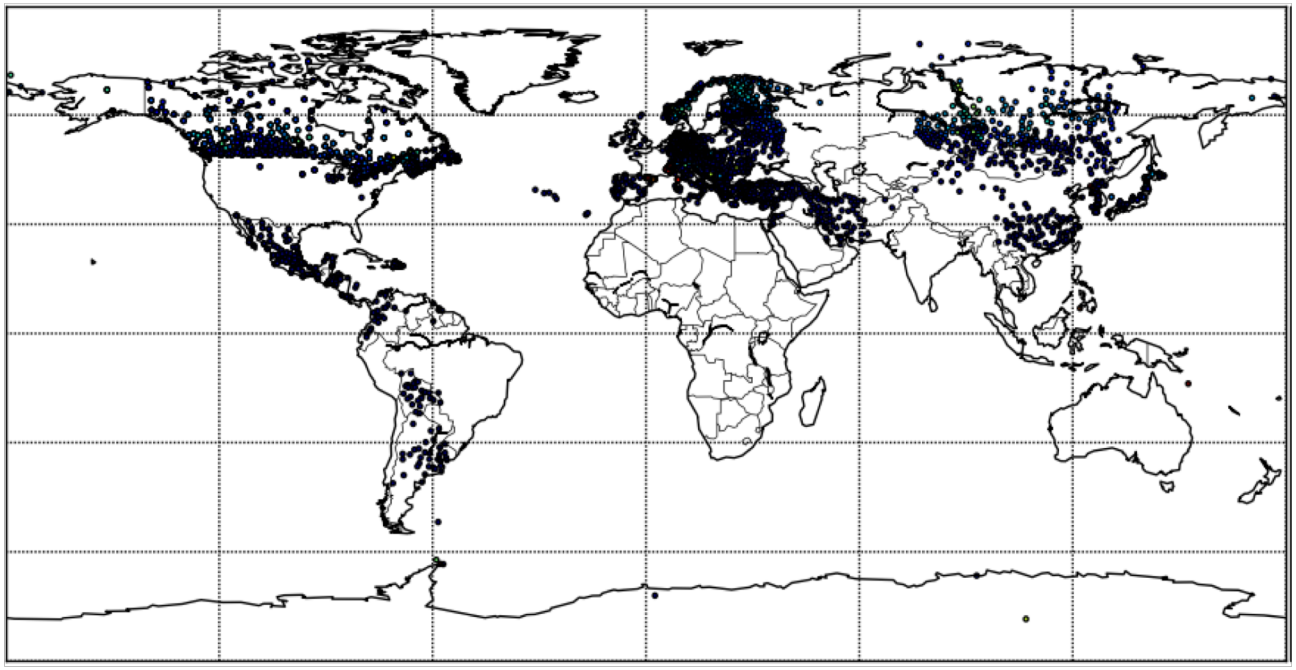
errors: σ_o= 2.5 kg/m² ; σ_b = 5.0 kg/m² ; length scale 50 km (model 1.3 km)

February-March 2019



Snow analysis in ARPEGE

- Synop stations measuring snow depth: heterogeneous coverage over the globe

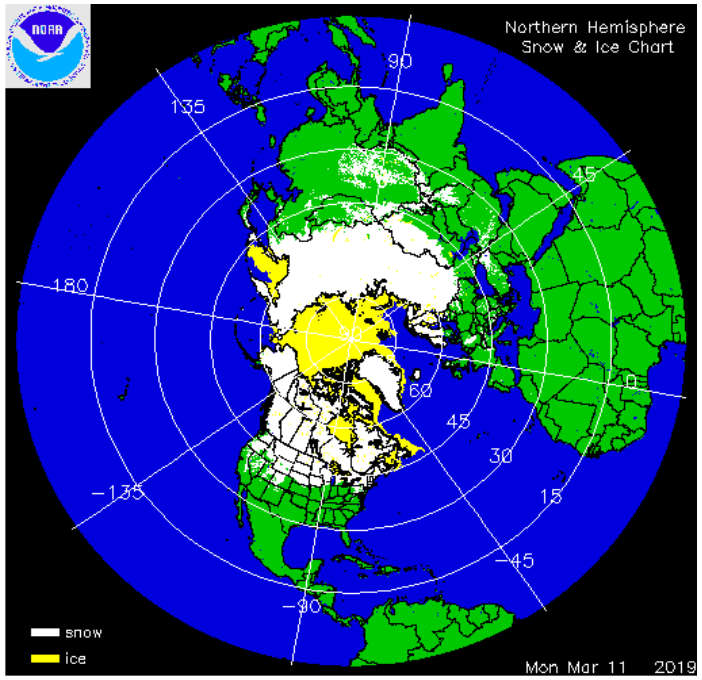


- Same principle as in AROME: 2D-OI with a struture function accounting for the distance and the difference of elevations between observation and grid point
- Tuning of observation errors and length scale:
  - σ_o = 5 kg/m², d = 100 km

C Birman et al.

Snow analysis in ARPEGE: use of satellite data

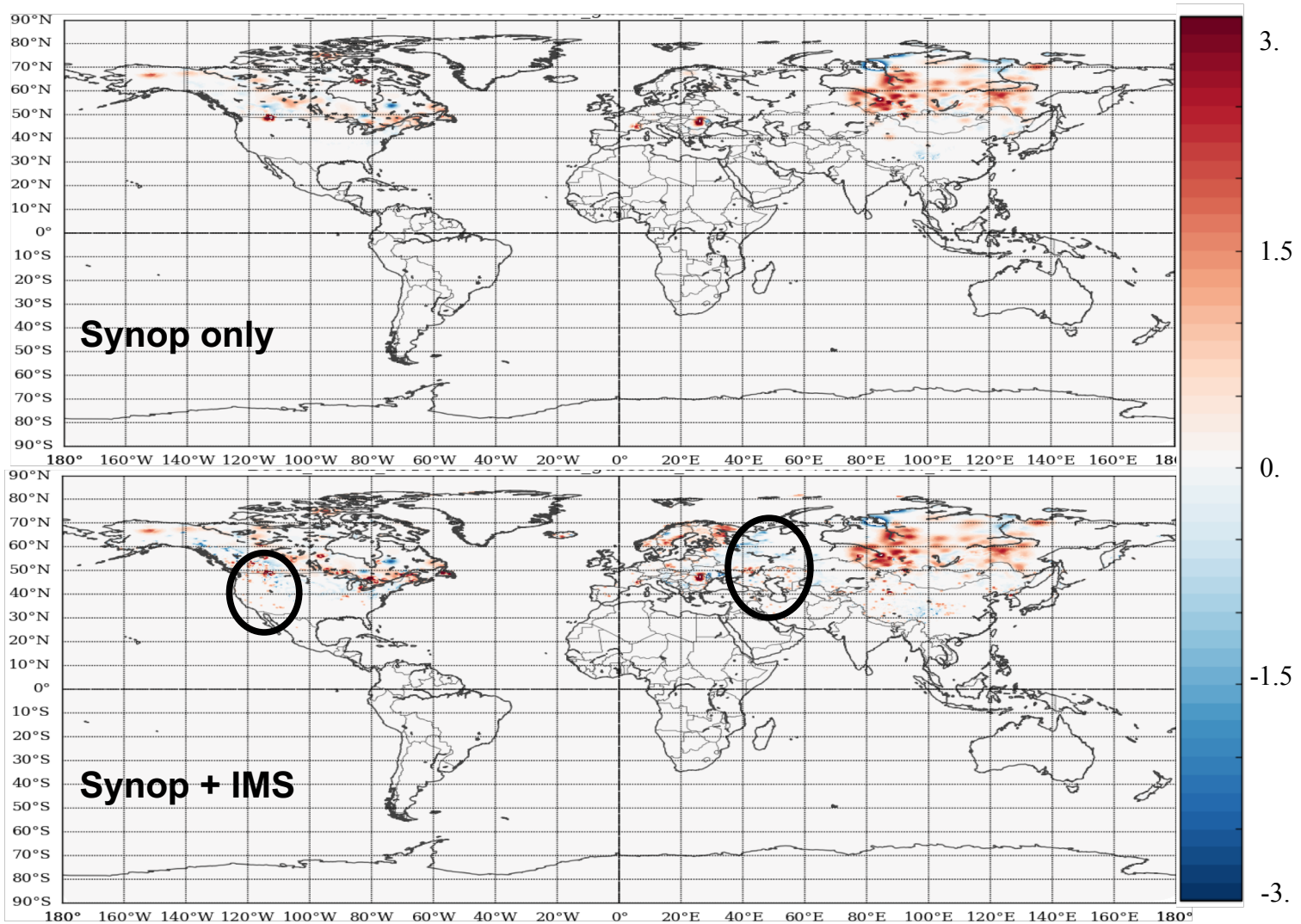
- **IMS NOAA-NESDIS** snow product over Northern Hemisphere: derived from AVHRR, AMSU, GOES/Imager, Himawari (AHI), Meteosat (SEVIRI)
- Daily product, 4 km resolution
- The snow mask (values 0 or 1) is converted into values that can be ingested in the assimilation :
  - 0 kg/m² (no snow) or 5 kg/m² (snow on the ground)
- Thinning of observations: ~1 observation every 30 km is kept
- Tuning of observation errors and length scale:
  - σ_o = 8 kg/m² (IMS) instead of 5 kg/m² (Synop)
  - d = 10 km (IMS) instead of 100 km (Synop)



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

C Birman et al.

Analysis increments of SWE (kg/m^2)



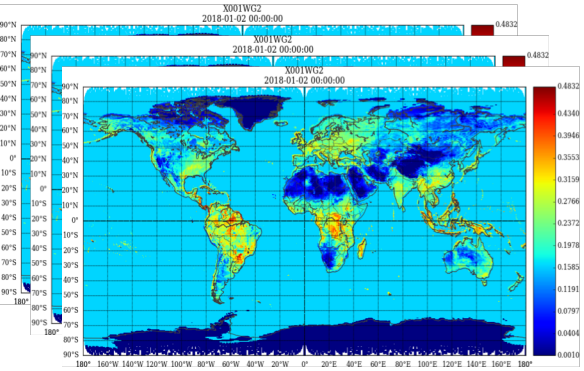
Increments in regions where there is a lack of in-situ data

C Birman, J-F Mahfouf, et al.

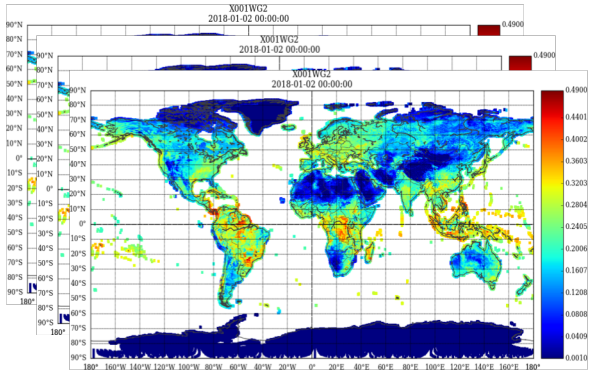
Diagnostics using ARPEGE EDA for surface analysis

- **In the OI**, the interpolation coefficients = covariances between the forecast errors of T2M and RH2M and the soil moisture values w_g and w_2
  - **constant** in space and time
  - **empirical coefficients** are applied to account for the **local conditions** (diurnal cycle, presence of wind, snow on the ground, precipitation…) and decrease the increments.

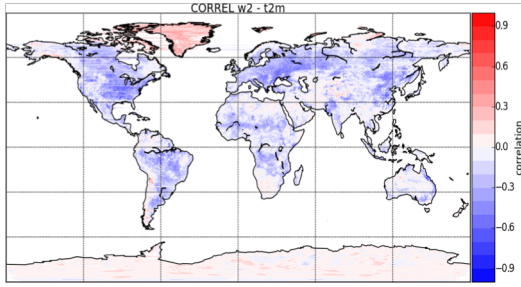
- The idea is to use the ARPEGE **Ensemble Data Assimilation** to compute covariances between soil variables (T_s, T_2, w_g and w_2) and observed variables (T2M and RH2M), and use them in the OI to replace the previous coefficients.



- Surface fields at **low resolution** from EDA (50 members) 6h forecast



- Surface fields at **high resolution**, using FULPOS (2M variables) and PREP for SURFEX fields



- Correlations and stdev (t2m/w2, t2m/wg, rh2m/w2, rh2m/wg) at **high resolution**

- **Soil analysis (OI) of w_g and w_2**

SURFEX physics

- SURFEX/CROCUS in ALADIN (Slovenia)
  - ALADIN model coupled to CROCUS compared to ALADIN forced by INCA analysis showed good agreement between the two.
  - Used for hydrological purposes and snow avalanche risk and forecasting
- SURFEX/FLake in AROME (Hungary and France)
  - Tested in AROME in Hungary
  - Ongoing tests in ARPEGE in France
- Coupling ALARO-1 to SURFEX
- SURFEX/GELATO1D in ARPEGE

Coupling ALARO-1 to SURFEX

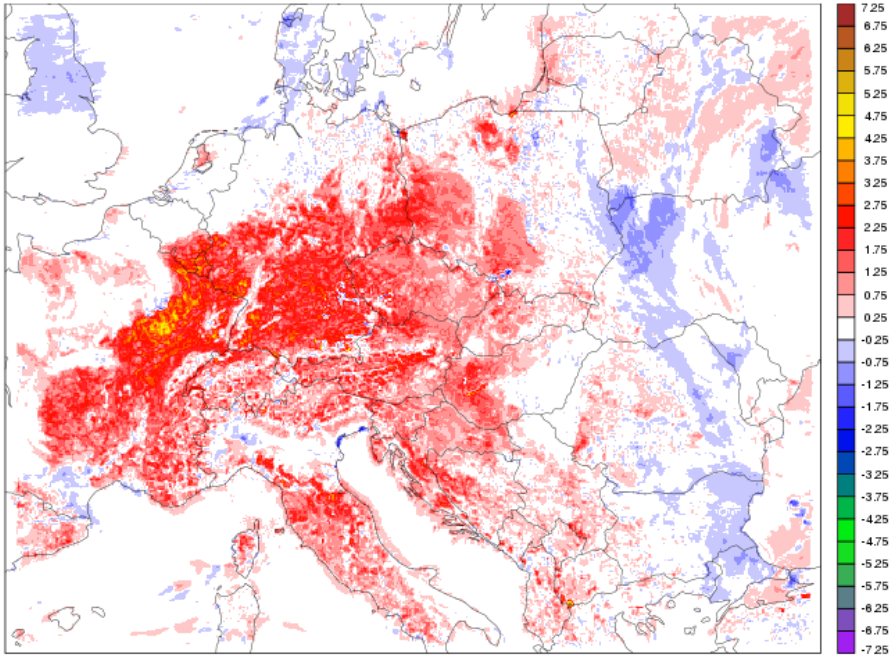
- Work has started in 2017
- The goal is to switch ALARO-1 to SURFEX scheme, offering several more advanced options relevant for NWP:
  - tiling approach
  - 3-level ISBA scheme, and explicit snow scheme (ISBA-ES)
  - town energy balance (TEB) and lake model (FLAKE) models
  - orography-radiation interaction (ORORAD)
- Comparison of ISBA-2L scheme called directly or via SURFEX to verify that results were almost the same…
  - **Several issues identified**: dynamical roughness length, setup issues, misusing of antifibrillation, inconsistency in the evaluation of TOUCANS stability functions
  - **Solutions were developed**: to account for the effect of orography on roughness length, to harmonize surface and atmospheric setup, to implement TOUCANS stability functions in SURFEX… and remove antifibrillation scheme

contribution of D. Degrauwe, M. Dian, J. Mašek, R. Hamdi, S. Panežić

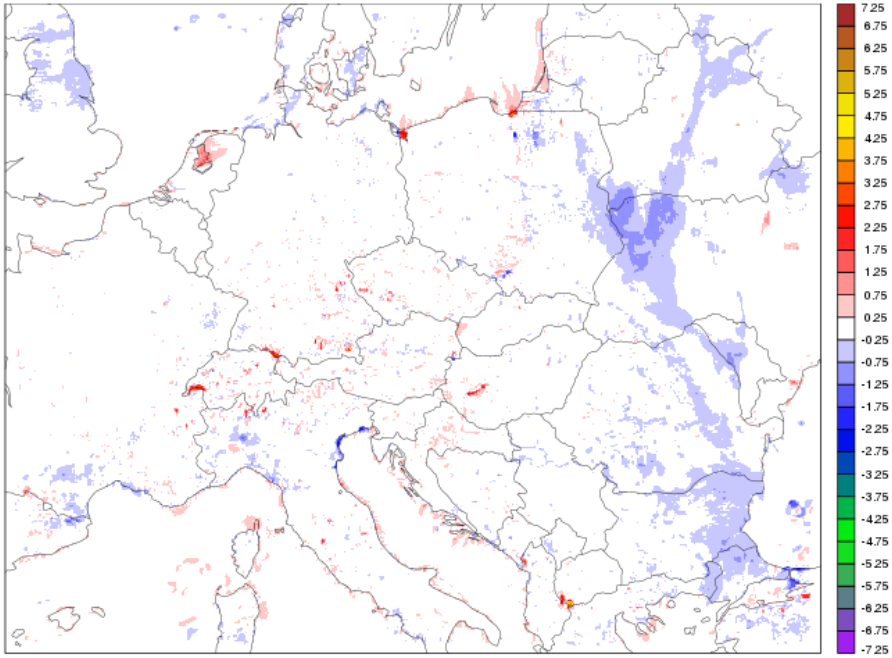
Coupling ALARO-1 to SURFEX

- T_{SURFEX} - T_{ISBA} at lowest model level, t = 6h

before



now

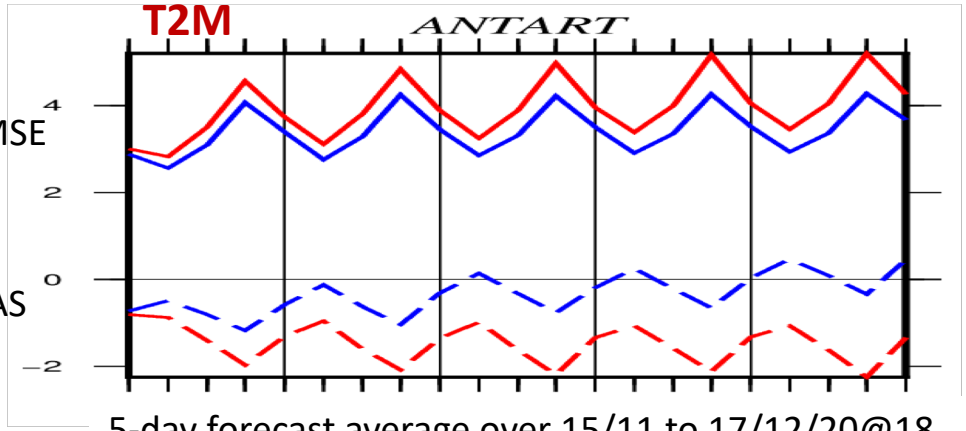


- Need to investigate more in details the differences

- Good basis for further developments

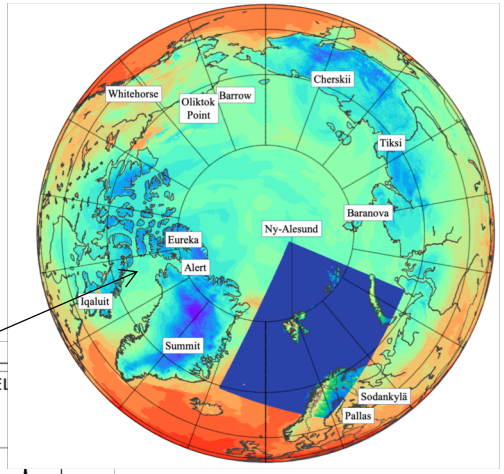
Coupling 1D sea-ice model GELATO in ARPEGE-SH

- A 4Dvar ARPEGE-SH with GELATO is running for the YOPP-SH experiment. Encouraging preliminary results.

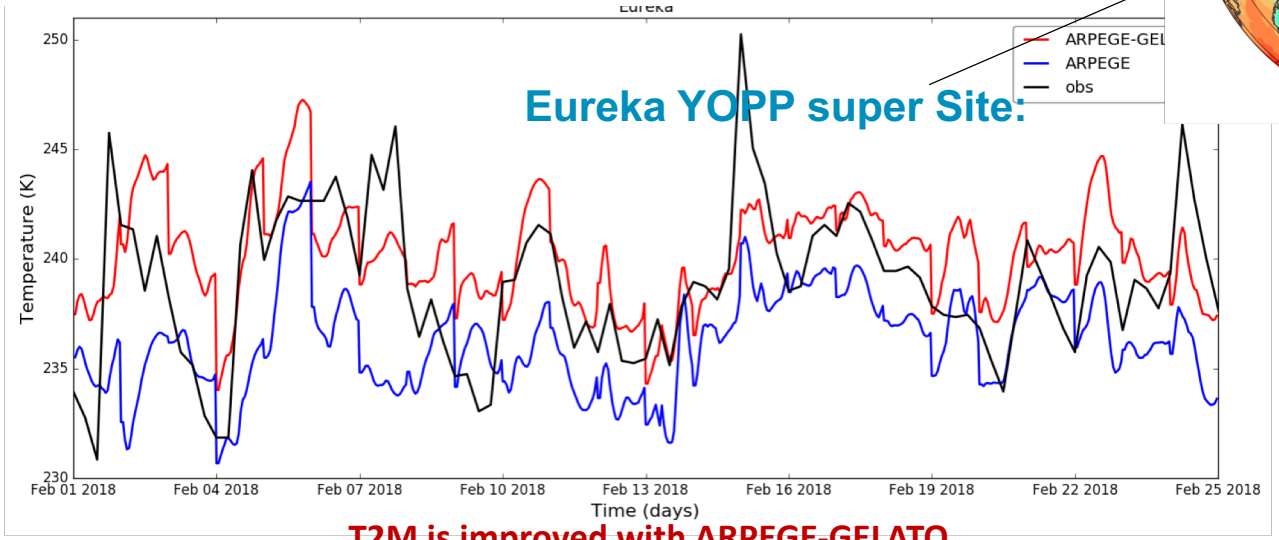


ARPEGE-SH
ARPEGE-SH-GELATO

5-day forecast average over 15/11 to 17/12/20@18



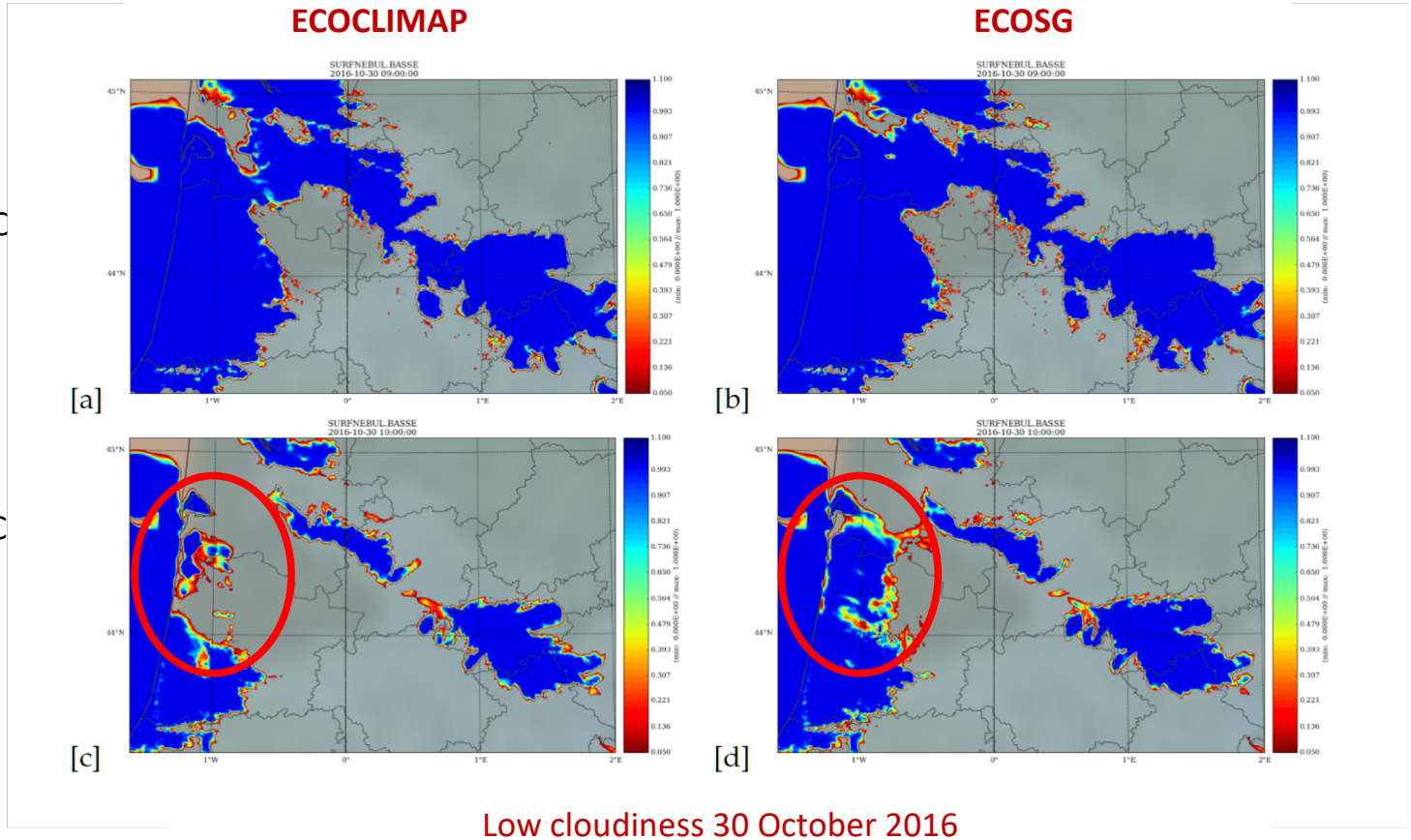
Eureka YOPP super Site:



T2M is improved with ARPEGE-GELATO

Physiography: ECOCLIMAP

- ECOCLIMAP @ IPMA (include Alqueva lake)
- ECO-SG @ MF: AROME-500m tests in fog conditions in SO France



Low cloudiness 30 October 2016

- Studied in more details during SOFOG3D field campaign

Summary

- Activity dominated by surface analysis (consistent with the graph Piet has shown on DA efforts)
- Few developments on physics, apart from ALARO-1 coupling to SURFEX (work already done in AROME, ALADIN, and ARPEGE)
- Tests of several physical options: FLake, Gelato-1D in ARPEGE, soon ISBA-DF in AROME, etc.
- Sensitivity tests with ECO-SG have started (at least at MF)