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A Consortium for COnvection-scale modelling Research and Development

ACCORD Overview of Surface activities

Patrick Samuelsson, 2024-10-01,
46th EWGLAM and 31th SRNWP Meeting in Prague

Overview outline

ACCORD surface overview covers activities at ACCORD level and in sub-organisations Météo-France, HIRLAM, LACE and individual Met services.

This year the LACE surface activities will be presented separately by the LACE project manager Martina Tudor in the surface side session.

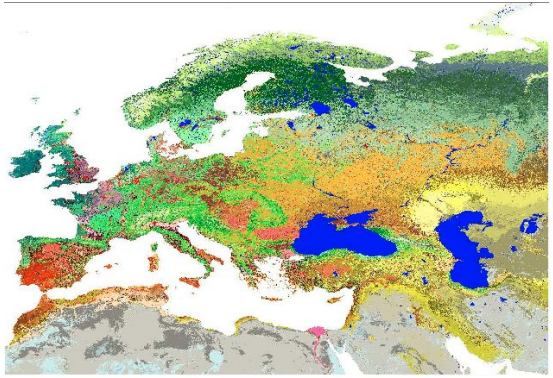
Examples of activities are given for

- **Surface physiography: Towards ML-based decametric physiography**
- **Surface processes: Multi-layer land physics and sea/ocean prognostic variables**
- **Surface Data Assimilation: 2DEnVAR, satellite LST, LETKF and ML-based observation operators**

Land cover in ACCORD

Operationally based on ECOCLIMAP 1st (1 km) and 2nd (ESA-CCI land cover 300 m) generations. Work on alternative land-cover databases are ongoing for a couple of reasons:

- **To overcome the issues with ESA-CCI land cover as already reported (e.g. too homogeneous and not representative).**
- **The need for even higher resolution O(50-100 m).**



Since last year, two different ML methods based on the agreement-based reference map building (ECOSG+) and the map translation approach (ECOSG-ML) have been released by the team. These are applied to generate ML-based physiography at 60 m resolution from a multitude of input data.

Thomas Rieutord

Geoffrey Bessardon

Ekaterina Kurzeneva

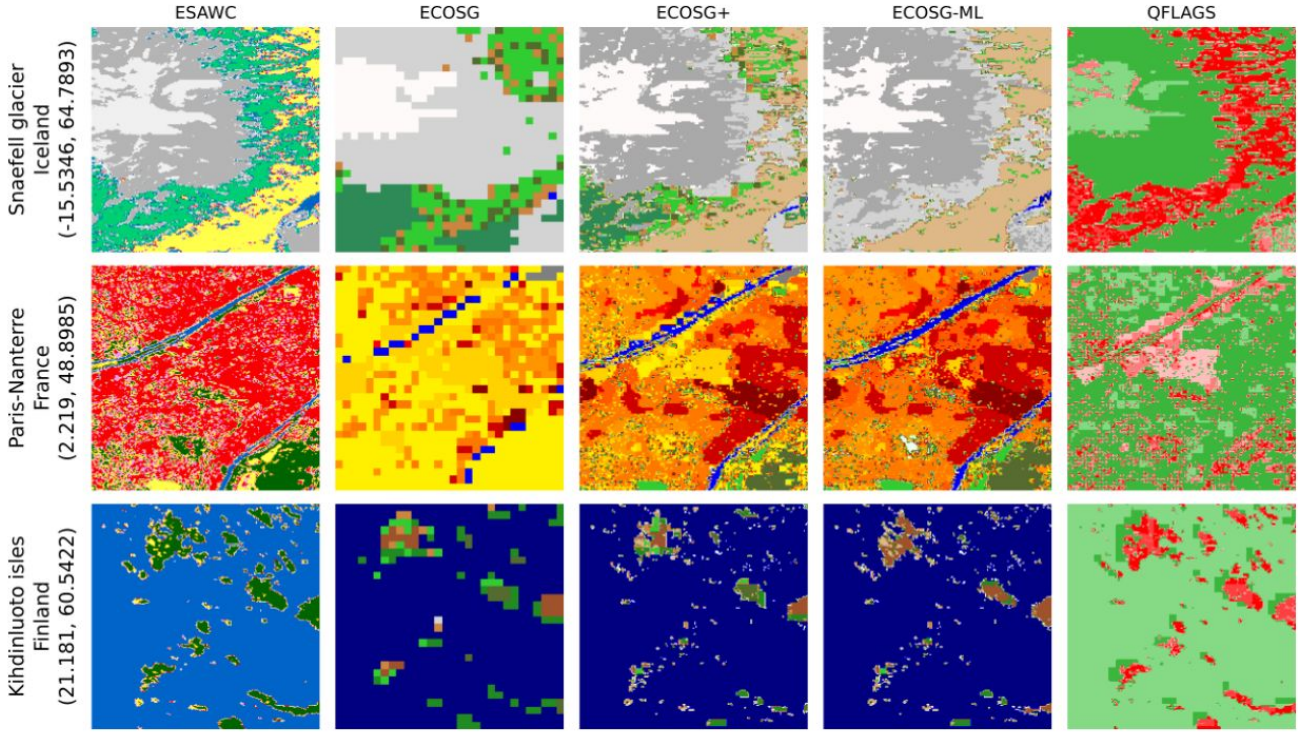
Sandro Oswald

Next generation of physiography data is based on Machine Learning

Here, physiography generated by these two methods are compared to ESA CCI landcover Word Cover map (ESAWC) and ECOSG, accompanied by quality flags (QFLAGS).

Links to documentation:
Geoffrey Bessardon et al. (2024),
doi: 10.20944/preprints202409.0953.v1
Thomas Rieutord et al. (2024),
doi: 10.20944/preprints202409.0942.v1

Work now continues at FMI by Rudolf Mård and Panu Maalampi.



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Chiara Marsigli showed this slide yesterday in her presentation about “News about C-SRNWP”

C-SRNWP 2024 – 2028 - requirements

Req no.	Requirement description	Priority
C-SRNWP_1	Ensure efficient exchange of information between Participating Members and European LAM consortia in relation to scientific, technical and operational aspects of NWP.	M
		RU
C-SRNWP_2	Ensure the maintenance of resources (e.g. existing software) and development of new resources under the EUMETNET 'umbrella' to support the NWP community, e.g. in data assimilation (DA) and parametrization.	M
		RU

- EWGLAM/SRNWP annual workshop
- Expert Teams of selected topics
- SRNWP website
- Contact with the OBS programmes -> A. Cress, DWD
- Short Term Scientific Missions -> E-WFC
- Inform about other conferences/projects
- Follow the DestinE project
- Organise thematic workshops

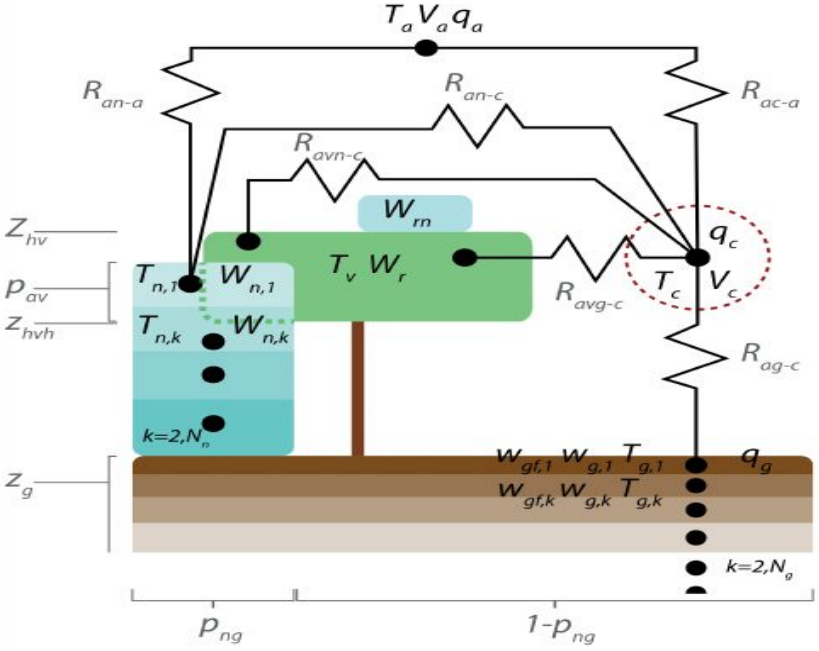
- Catalogue of resources
- Maintain and develop existing resources (Global Lake Database, SRNWP Surface Data Pool) -> new proposal from ET SURF?

New proposal from ET SURF, or actually Ekaterina, Patrick, Chiara, to be presented and discussed tomorrow at the end of the Surface side meeting:

Ekaterina Kurzeneva (FMI) and Patrick Samuelsson (SMHI): “How can the ML-based decametric physiography framework be used for C-SRNWP?”

SURFEX multi-layer land processes for NWP

- All ACCORD operational NWP systems are still running the 2-3 layers Force-Restore soil scheme together with the 1-layer D95 snow scheme.
- But we see more and more setups where the multi-layer surface physics options enter, i.e. the combination of the 14-layer diffusion soil scheme, the 12-layer explicit snow scheme and the explicit canopy (Multi-Energy Balance).
- Apart from evaluation of the multi-layer surface physics over a few ACCORD domains and for a number of Destination Earth on-demand Extremes domains we also apply this setup in a couple of projects…



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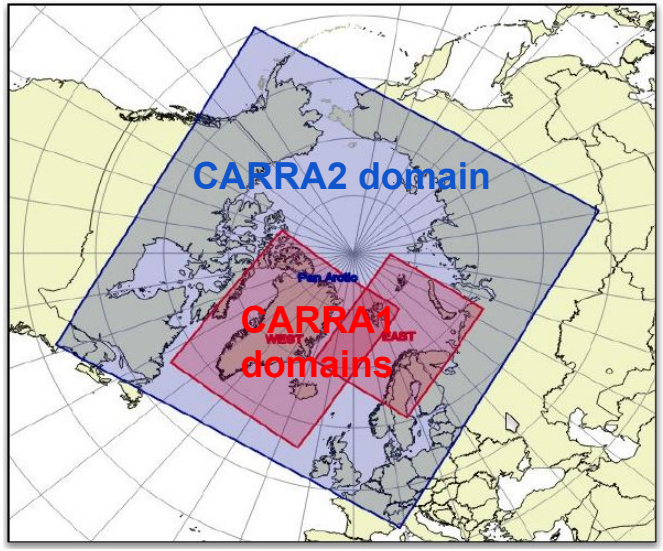
SURFEX multi-layer land processes for NWP



CARRA2 setup:

HARMONIE-AROME, cy46h1

2880x2880 grid points (2.5 km resolution)

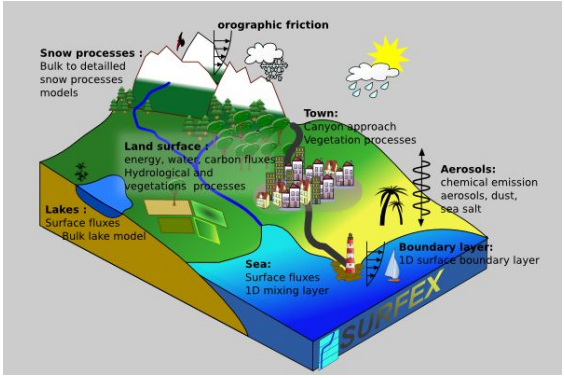
For the CARRA2 pan-Arctic reanalysis project the multi-layer surface setup is used. One motivation for this is that sparse near-surface observational data (for assimilation) asks for better description of physical processes.
Production is now running. Time period: 1985-2025.

The MASCOT project:

- **An internal Météo-France project at CNRM, between GMME and GMAP groups.**
- **The goal is to perform Offline SURFEX experiments as close as possible to the operational setups (Arpege/AROME) for testing of new configurations for the surface based on multi-layer physics, starting with the combo: Diffusion Soil, Explicit snow, Multi-patches, ISBA A-gs photosynthetic option with offensive/defensive stress.**
- **Surface assimilation will be included in a second phase of the project.**

Based on presentation by MF colleagues: Adrien Napoly, Junior Ngandjou and Antoine Verrelle

The sea/ocean surface in ACCORD LAM NWP systems



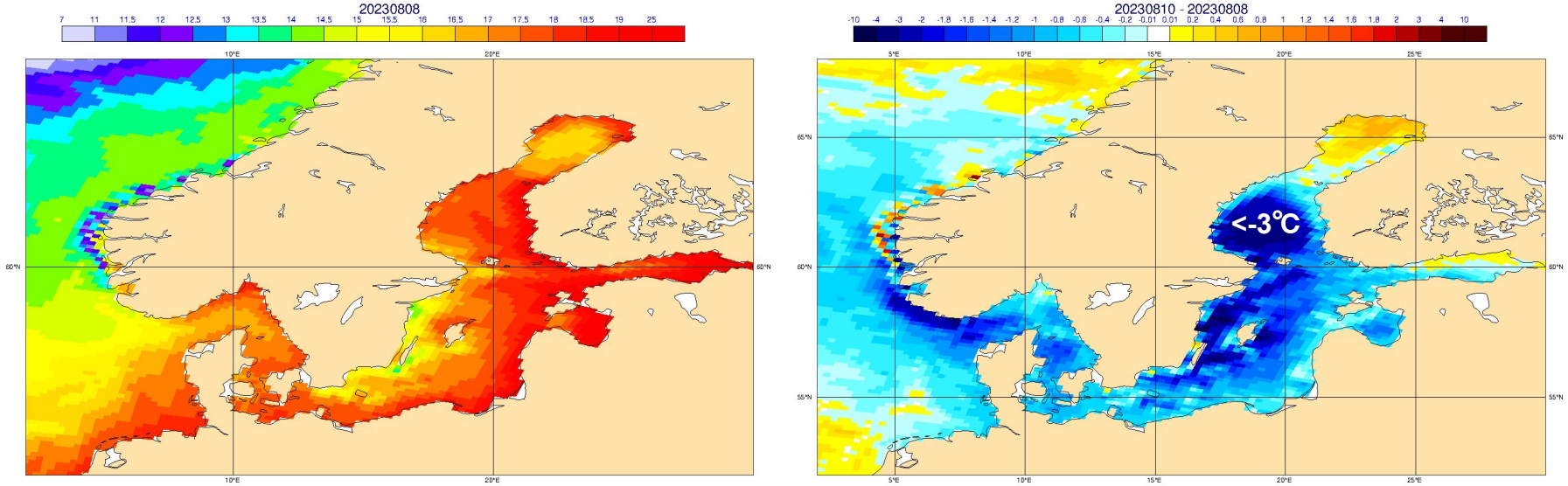
SURFEX provides a few alternatives:

- **Read in external SST and prescribe the sea tile surface temperature with this. This option is currently used in most operational setups. Sub-alternatives are to keep the SST constant during the forecast period or update it e.g. hourly.**
- **Use the 1D Ocean Mixing Layer (OML) model available as a sub-model in SURFEX. Here SST, salinity and current become prognostic variables.**
- **Couple to an 3D ocean model, e.g. NEMO, via the coupler OASIS.**
- **Also, in principle the lake model FLake could be used as done by ECWMF, i.e. in the coastal zone, although no such activity is ongoing among ACCORD institutes.**

We have examples where the air/sea interaction provided by an evolving/prognostic SST is favourable for atmospheric processes like storm developments. But, as Kristian Mogensen (ECMWF) expresses it, it is difficult to see benefits on overall standard NWP scores from prognostic SST.

Storm Hans August 2023

Slide by Kristian Mogensen (ECMWF)

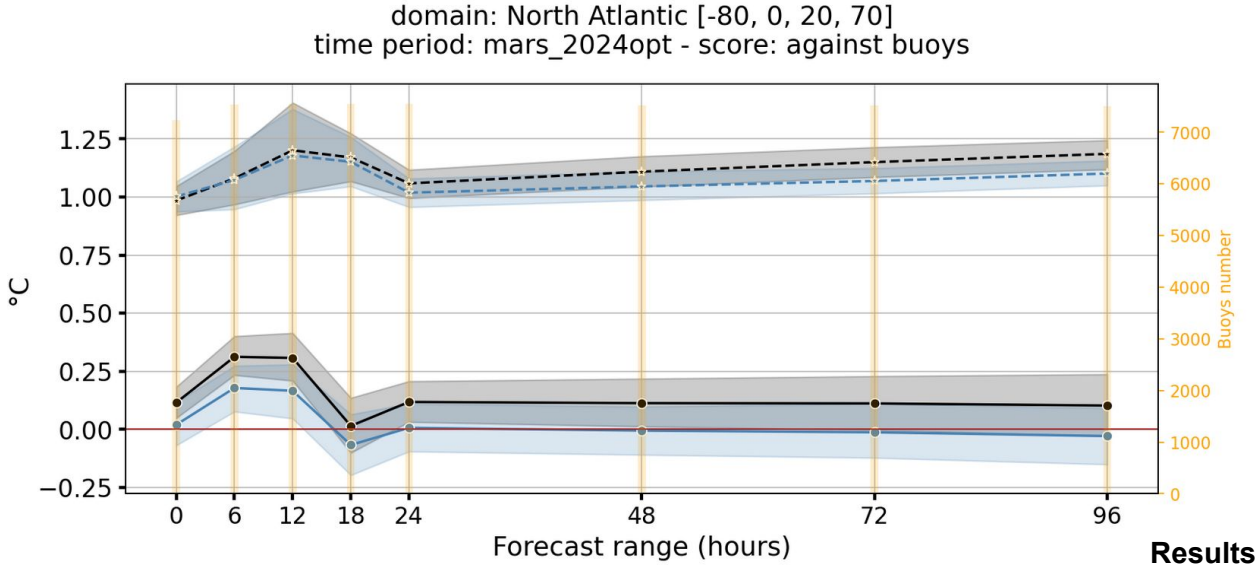


SST from ORAS5 on the 20230808 (left) and the difference in SST 2 days later showing a strong cooling in the seas around Southern Scandinavia

Comment by Patrick:
[ORAS5 is the ECMWF Ocean ReAnalysis System 5](#).

The sea/ocean surface in ACCORD LAM NWP systems

At Météo-France it is very probable that the 1D Ocean Mixing Layer (OML) model will be activated in the next global Arpege setup, cy49. The OML prognostic variables are cycled but restored towards Mercator-Ocean outputs during the surface analysis step.
Not enough time yet to validate it in LAM Arome-France configurations.



Bias and STD of OML SST against buoys in the North Atlantic during March 2024:

- **GW5C, constant SST based on Mercator+buyos**
- **GWSA, with OML prognostic SST**

As Adrien says, it is not always as good as in this picture, but on average it is better as compared to IFS analysis or radio soundings observations.

Results from Adrien Napoly, GMAP, Météo-France

ACCORD has a variety in surface data assimilation

Operationally, OI surface assimilation is still our working horse in most setups with assimilation.

Circumstances decide how short-medium term solutions beyond OI look in our consortia:

Ensemble NWP system:
OI for soil with EPS-coeff.

Ensemble NWP system:
EnKF-based solution

Deterministic and Ensemble NWP system:
(S)EKF-based solution

Crowd-sourced focus:
TITAN/gridPP spatialisation

Less weakly coupled atm-surface assimilation

Two flavours of EnKF:
- the Ensemble Square Root Filter (EnSRF)
- the Local Ensemble Transform Kalman Filter (LETKF)

Both in connection to multi-layer surface physics.

MetHungary
CARRA2

Create a good initial state for the surface (before any additional surface DA) by forcing SURFEX by optimized/analysed forcing variables.

2D-Var
2D-EnVar

Météo-France

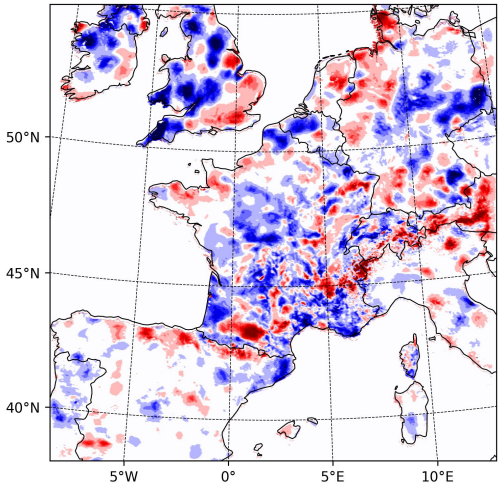
Météo France ongoing activities on surface data assimilation

(Camille Birman, Sophie Marimbordes, Zied Sassi, Nadia Fourrié...)

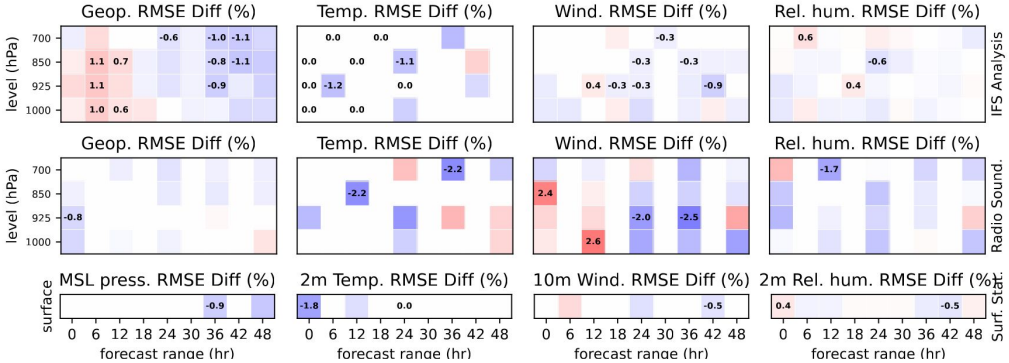
Towards a 2DEnVar for screen-level analysis (Sophie Marimbordes)

- 2DEnVar system with a fully flow-dependant B-matrix computed from AROME EDA (3h range forecasts, 50 members, 3.2 km grid-spacing)
- Localisation (length 25 km), inflation factor (by a factor 3)
  - Satisfactory 2DEnVar *(Marimbordes et al., 2024, accepted in QJRMS)*

Assimilation of satellite retrieved land surface temperature (*Sassi et al., 2023*): assimilation of SEVIRI LST in AROME (Sophie Marimbordes)



LST increments from 2DEnVar 20230526 03H UTC



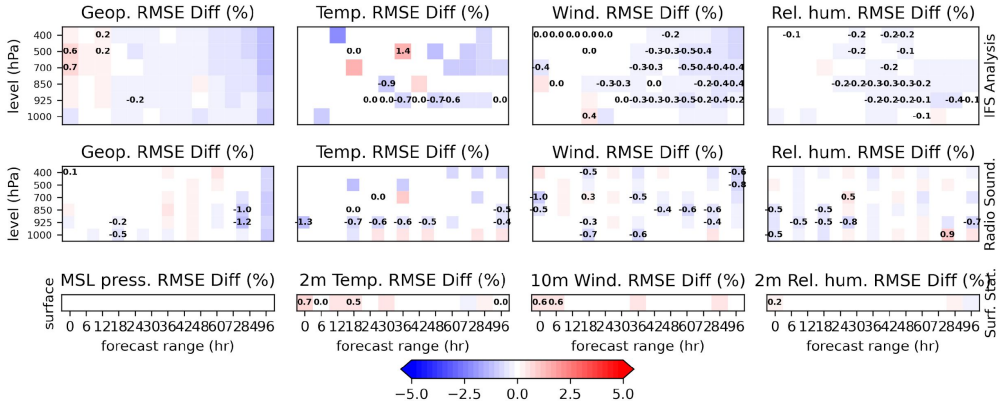
RMSE reduction over France with the assimilation of SEVIRI LST in AROME with 2DEnVar with respect to 2DEnVar without LST assimilation on 20230527-20230725 with respect to IFS analyses, radiosounding data and Synop observations (blue=improvement, **bold numbers**=significant with a 95%confidence level)

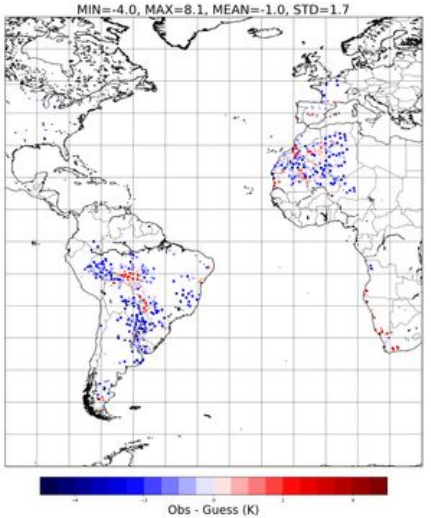
Météo France ongoing activities on surface data assimilation

(Camille Birman, Sophie Marimbordes, Zied Sassi, Nadia Fourrié...)

Assimilation of satellite retrieved land surface temperature: assimilation of IASI LST in ARPEGE (Zied Sassi)

- IASI sensor onboard Metop-B/C
- Assimilation of LST retrieved by nighttime, in clear sky conditions
- Thinning of IASI LST observations every 50 km





LST first guess departures
2023/06/16 - 00H UTC

RMSE reduction on the Northern Hemisphere with the assimilation of IASI LST in ARPEGE on 20230615-20230915 with respect to IFS analyses, radiosounding data and Synop observations (blue=improvement, **bold numbers**=significant with a 95%confidence level)

Slide by Jostein Blyverket (MetNorway)

LETKF

Courtesy of Åsmund Bakketun

Local ensemble transform Kalman filter

- A flexible DA scheme where state and observation vector can be easily extended
  - New multilayer surface models
  - Satellite observations
- Use ensemble information to distribute observed information horizontally and in state space (no optimal interpolation needed)
- **Target for surface assimilation scheme in CARRA-Land and CARRA3 coupled demonstrator (CERISE project)**

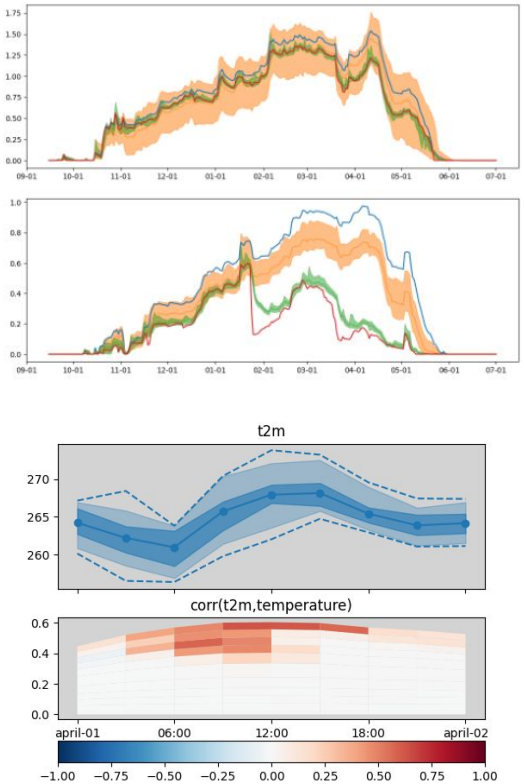


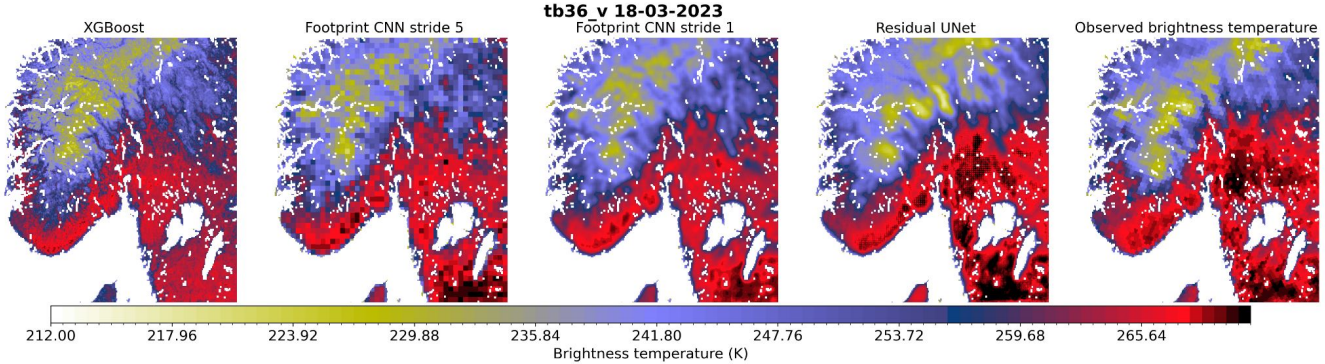
Figure xx: Top: Time-series of snow depth (truth, ctrl, openloop, assimilated) Bottom: 2m temperature and snow profile with ensemble correlation between 2m temperature and snow temperature

Funded by the European Union

Slide by Jostein Blyverket (MetNorway)

Machine learning observation operator

- Can we develop a reliable observation operator for AMSR-2 observations using machine learning?
  - Tb18 and Tb36 vertical polarization (V-pol) GHz (usually used in snow retrievals)
- Training dataset: September 2020 - May 2022, from offline SURFEX
- Three different approaches:
  - XG boost: Decision trees, no spatial context
  - **Footprint Convolutional Neural Network (CNN), learn spatial features**
  - Residual U-Net, CNN developed for the whole domain, learn spatial features at different spatial scales, domain dependent



Courtesy of Cyril Palerme

Figure xx: Example machine learning prediction of AMSR-2 Tb36 V-pol, from left, XGboost, Footprint CNN stride 5, Footprint CNN stride 1, residual U-Net, and observed brightness temperature from AMSR-2. For 18 March 2023.

Agenda of Parallel session on surface aspects

EUMETNET
EUROPEAN METEOROLOGICAL SERVICES NETWORK

Wednesday October 2nd 08:30-10:30 CEST
Green Lecture Hall - downstairs, where posters are
Webex link here for remote participants

- **Martina Tudor (DHMZ, Croatia): “LACE activities on surface”**
- **Jürgen Helmert (DWD, Germany): "Towards implementation of HiHydroSoil v2.0 in the ICON-(ART) system at DWD: Global Maps of Soil Hydraulic Properties at 250m Resolution”**
- **Jan-Peter Schulz (DWD, Germany) et al.: “A new urban parameterisation for the ICON atmospheric model”**
- **Russell Glazer (University of Reading, UK): “Evaluation of a mixed-layer height detection algorithm in the Unified Model using data from the urbisphere-Berlin field campaign”**
- **Abhishek Lodh (SMHI, Sweden): “Using Ensemble Land Data Assimilation Spread for evaluating impact of Surface Observations in the ISBA coupled Harmonie- Arome model”**
- **Patrick Samuelsson (SMHI, Sweden): “How to treat agricultural areas in our land-surface schemes with respect to evapotranspiration, vegetation cover, …”**
  - **replaced with suggestion/discussion by Ekaterina Kurzeneva (FMI) and Patrick Samuelsson (SMHI): “How can the ML-based decametric physiography framework be used for C-SRNWP?”**

schemes with respect to evapotranspiration, vegetation cover, …

In our ACCORD NWP setups with SURFEX we struggle to describe the crop-land situations illustrated below.
We have information on active-vegetation LAI based on satellite data bases, but that's it.
How to use annual variations in this LAI only to describe the situations below?
How is it done at other centres? To be discussed…

THANKS!

ACCORD Surface Working week, Kraków, May 2024