ACCORD

A Consortium for COnvection-scale modelling Research and Development

Summary of EWGLAM Data Assimilation Session

26th EWGLAM 31st SRNWP meeting, 30 September-3 October 2023, Prague, Czech Republic

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Contents

Parallel session

- High Resolution Variational Data Assimilation over the Copernicus Arctic Regional Reanalysis Second Generation(CARRA2) region (Swapan Mallick)
- Pierre BROUSSEAU: A 4DEnVar scheme for Arome-France (Pierre BROUSSEAU)
- Discussion

Plenary session

- Algorithmic developments in ACCORD (Antonín Bučánek)
- Advances in the use of observations in ACCORD (Benedikt Strajnar:)
- A Review of WCSSP SE Asia Model Initialization Methods: Comprehensive Comparison of Warm Start and 4DVar with Large-Scale Blending (Dingmin Li)
- News on KENDA (Christoph Schraff)
- Discussion

Posters+ elements of DA in other sessions

Agenda for parallel session on data assimilation

Wednesday 2 October, 8.30-10.30 CEST

Presentations

- High Resolution Variational Data Assimilation over the Copernicus Arctic Regional Reanalysis Second Generation(CARRA2) region (Swapan Mallick)
- A 4DEnVar scheme for Arome-France (Pierre BROUSSEAU)

Some discussion points

1. Flow-dependent DA techniques, status and current challenges
2. Use of host-model information in DA
3. Key observation usage and observation handling aspects
4. Foreseen Role of AI/Machine Learning
5. Status of reconstruction work towards object oriented user friendly DA (OOPS, JEDI, KENDA, ..)
6. Verification: How to objectively evaluate/show benefit from km-scale data assimilation and modelling (scores, methods, events etc)
7. Data assimilation for km-scale re-analysis
8. Views on useful focus areas for knowledge exchange/enhancements and cooperation during coming years and form of cooperation

What is main interesting topic to cooperate on between consortia and how?

High Resolution Variational Data Assimilation over the Copernicus Arctic Regional Reanalysis Second Generation(CARRA2) region

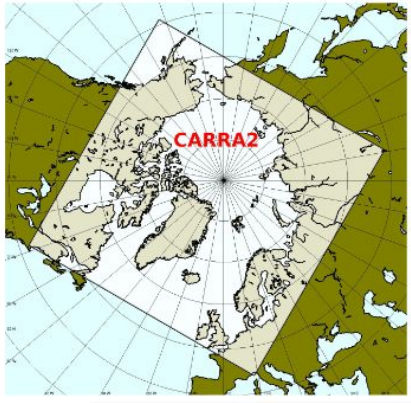
Climate Change

Copernicus Arctic Regional Reanalysis (CARRA-2)

Concept: Reanalysis is a method of reconstructing past atmospheric states by using historical observations in conjunction with a weather forecasting model. CARRA-2 reanalysis is a high-quality climate data product by assimilating long time series of observations into Harmonie model and 3D-VAR data assimilation system to provide the best estimate of the atmospheric state.

HARMONIE-AROME	Cy46h1
Horizontal resolution	2.5 km
Number of grid points	2880 x 2880
Number of vertical levels	65
Model dynamics	Hydrostatic
Surface scheme	12-layer soil + 14-layer snow diffusive scheme
Upper-air data assimilation	3D-Var
Surface data assimilation	Simplified Extended Kalman Filter
Assimilation frequency	3-hourly, **6-hourly (for Ensemble)**
Output frequency	3-hourly analyses and hourly forecasts (3h after the 6h forecast range)
Forecast lengths	18h from 00 UTC and 12 UTC and 3h otherwise
Time coverage	September 1985 - December 2025 (timely updates are planned)
When data available	Full time series expected to be available spring 2026

New generation Arctic reanalysis CARRA2: pan-Arctic extension



https://climate.copernicus.eu/copernicus-arctic-regional-reanalysis-service

ECMWF Copernicus European Commission

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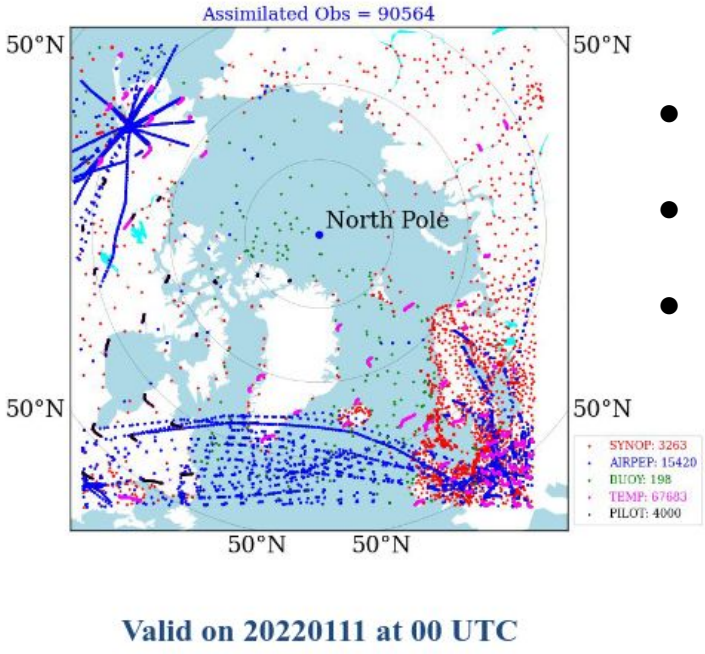
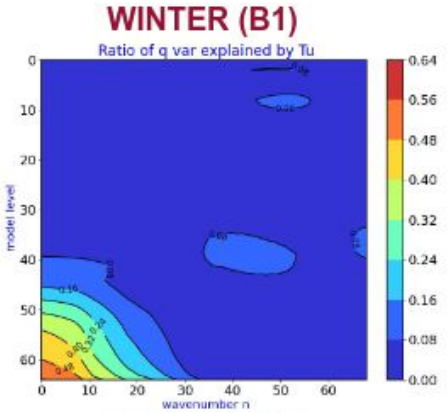
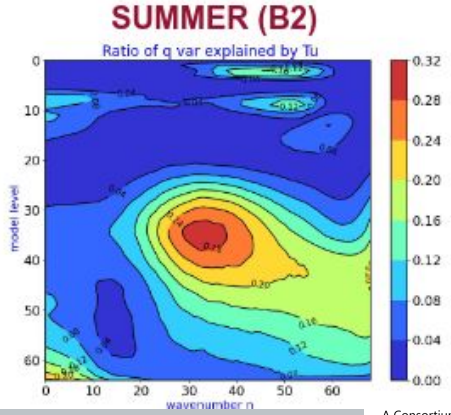
High Resolution Variational Data Assimilation over the Copernicus Arctic Regional Reanalysis Second Generation(CARRA2) region



- Uneven obs distribution (left)
- Identification of Biases
- Need for climatologically varying B matrix (right)





Percentage of the variance of specific humidity that is explained by unbalance temperature (Tu) as a function of height and wave number.

Discussion on regional re-analysis presentation

Presentation

- High Resolution Variational Data Assimilation over the Copernicus Arctic Regional Reanalysis Second Generation(CARRA2) region (Swapan Mallick)

Takeaway and main Triggered Discussion/Questions

1. Uneven distribution of observations of Arctic domain. Challenges related to that.
2. Biases identified in horizontal zonal wind and humidity.
3. Perturbation techniques for ensemble members used for deriving uncertainty,
4. How to optimally blend host model information for such a large resolution domain with much coarser resolution ERA 5 on lateral boundaries.
5. Special needs requirements for reanalysis and how shared?
6. Clear Differences in B matrices between different seasons and need to handle.

A 4DEnVar scheme for Arome-France: presentation and evaluation

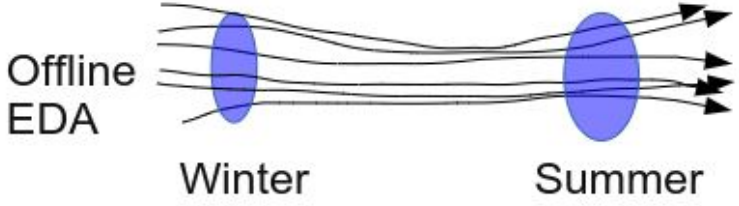
Towards a 4D scheme

3D-Var/3DEnVar : $J(\delta\mathbf{x}) = \frac{1}{2}(\delta\mathbf{x})^T\mathbf{B}^{-1}(\delta\mathbf{x}) + \frac{1}{2}(\mathbf{d}-\mathbf{H}\delta\mathbf{x})^T\mathbf{R}^{-1}(\mathbf{d}-\mathbf{H}\delta\mathbf{x})$

4DEnVar : $J(\underline{\delta\mathbf{x}}) = \frac{1}{2}(\underline{\delta\mathbf{x}})^T\underline{\mathbf{B}}^{-1}(\underline{\delta\mathbf{x}}) + \frac{1}{2}(\underline{\mathbf{d}}-\underline{\mathbf{H}\delta\mathbf{x}})^T\underline{\mathbf{R}}^{-1}(\underline{\mathbf{d}}-\underline{\mathbf{H}\delta\mathbf{x}})$ (Desroziers et al. 2014)

$$\underline{\delta\mathbf{x}} = \begin{pmatrix} \delta\mathbf{x}_0 \\ \delta\mathbf{x}_1 \\ \vdots \\ \delta\mathbf{x}_K \end{pmatrix} \qquad \underline{\mathbf{B}} = \underline{\widetilde{\mathbf{B}}^{\mathrm{e}}} = \begin{pmatrix} \widetilde{\boldsymbol{B}}^{\mathrm{e}}_{0,0} & \widetilde{\boldsymbol{B}}^{\mathrm{e}}_{0,1} & \cdots & \widetilde{\boldsymbol{B}}^{\mathrm{e}}_{0,K} \\ \widetilde{\boldsymbol{B}}^{\mathrm{e}}_{1,0} & \widetilde{\boldsymbol{B}}^{\mathrm{e}}_{1,1} & & \widetilde{\boldsymbol{B}}^{\mathrm{e}}_{1,K} \\ \vdots & & \ddots & \\ \widetilde{\boldsymbol{B}}^{\mathrm{e}}_{K,0} & \cdots & & \widetilde{\boldsymbol{B}}^{\mathrm{e}}_{K,K} \end{pmatrix}$$

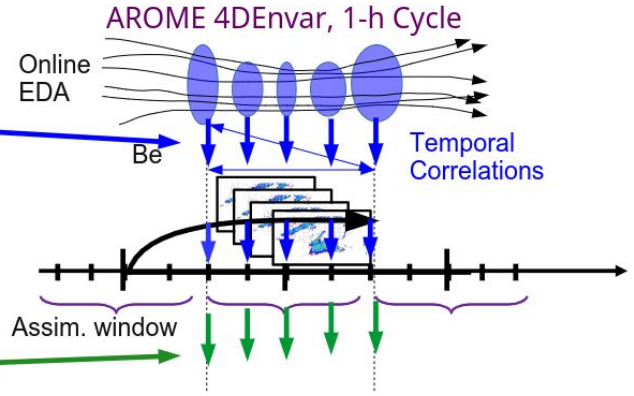
Provided by an EDA



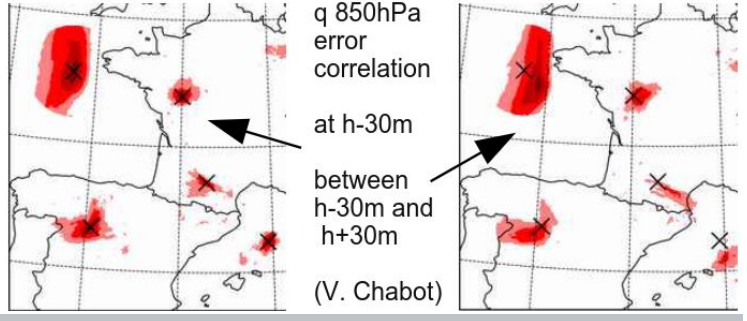
A 4DEnVar scheme for Arome-France: presentation and evaluation

Towards a 4D scheme : 2 challenges

How the temporal error correlations are able to manage the temporal information along the assimilation window ?



How should we use the 4D increment to start the new forecast ?



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Discussion on 4DEnvar presentation

Presentation

- A 4DEnVar scheme for Arome-France (Pierre BROUSSEAU)

Takeaway and Triggered Discussion/Questions

1. 3denvar operational at Meteo France next month, while 4denvar is suggested for e-suite and evaluation.
2. Temporal background error covariances important improvement for 4D. Demonstrated noticeable in high impact events.
3. Ensemble size matters like for 3denvar.
4. Is there difference in required ensemble size for 4denvar as com 3denvar?
5. Observations with high density in time and space play important role (radar).
6. Further potential optimisation and tuning of localisation.
7. Observation error correlation handling
8. Where to start the forecast from 4D state?
9. Functionality and limitations in case of few observations
10. Computational cost and memory requirements

Discussion on Cooperation

1. Area of cooperation: very high resolution (DA) modelling and spin-up, flow dep, crowd sourced observations, qc, radar polarimetric observations
2. Form of cooperation: interchange of information, studies of common interests, presentations
3. Next step is to call for meeting on cooperation topic and forum.

Summary

Main session

- Algorithmic developments in ACCORD (Antonín Bučánek)
- Advances in the use of observations in ACCORD (Benedikt Strajnar:)
- A Review of WCSSP SE Asia Model Initialization Methods: Comprehensive Comparison of Warm Start and 4DVar with Large-Scale Blending (Dingmin Li)
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Move to new more flexible systems. Flow dep DA methods. RADAR data and towards use of OPERA NIMBUS and satellite all-sky. Improved use of screen level data.

Crowd-sourced observations, what hampers more use of it?

Summary

Posters + elements of DA in other sessions

- LAM 4D-Var improvements at Met Office (simplified physics improvements+move to JEDI), T2m, RHm pseudo-observations.
- HIRLAM move towards flow depend DA and OOPS system, ways to evaluate quality, ML.
- ECMWF improved T2m assimilation and improved low peaking channel sat usage over sea ice, coupled upper-air/surface DA through trajectories, surface asscat forward model.
- The E-AI EUMETNET Programme (ML for DA components and entire educational DA system).
- DWD surface parameter estimation using DA
- Status and Plans for evaluation of Harmonie-AROME cy46 data assimilation tunable settings (Jana Sanchez-Arriola et al.)
- Rapid update cycle at SHMU (Michal Nestiak et al.)
- Potential for use of data assimilation framework for verification (Eoin Whelan et al.)

Crowd-sourced observations, what hampers more use of it?