ACCORD

A Consortium for COnvection-scale modelling
Research and Development

Algorithmic developments in ACCORD

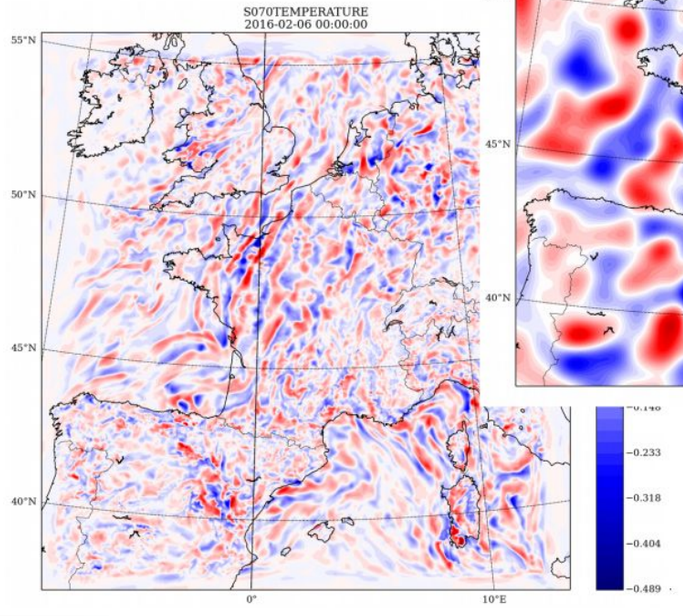
Work of numerous contributors from the ACCORD DA teams
presented by Antonín Bučánek

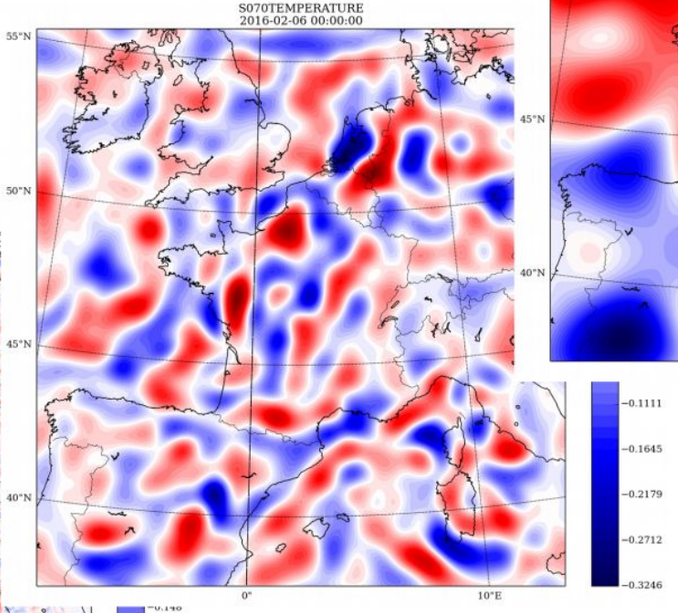
Contents

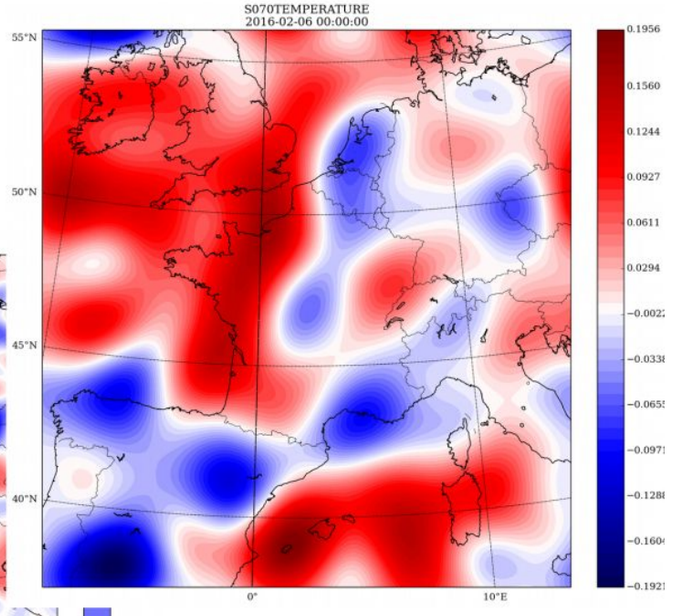
- Application and improvements of EnVar
  - 4DEnVar (talk of Pierre Brousseau)
  - Scale dependent localization for EnVar
  - Various approaches to constructing ens. perturbations for LAM EnVar
- Implementation and optimization of 4DVar
  - Implementation of LAM version in OOPS
- Initialization methods and optimizations for nowcasting
  - incremental analysis update
  - variational constraints
  - cloud assimilation
- Background errors in observations space

Scale dependent localization in Arome-France EnVar

Temperature perturbations at level 70
for member 1
at small, medium and large scales
Valid 20160206 00UTC





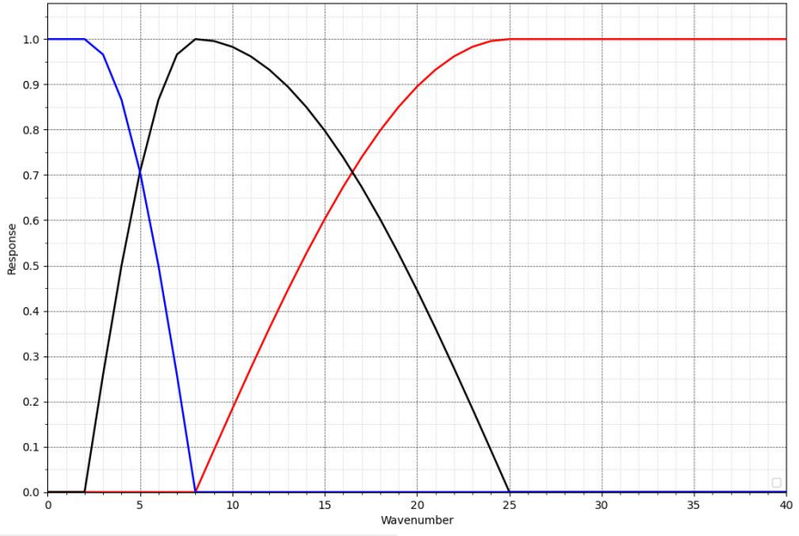


Analysis increment computed from control vector ($B^{1/2}$ preconditioning)

$$\Delta \mathbf{x}_o = \sum_k \sum_j \mathbf{e}_{k,j} \circ \left(\mathbf{L}_j^{1/2} \boldsymbol{\xi}_k \right)$$

$e_{k,j}$ is scale j of normalized member k perturbation

Filters response functions

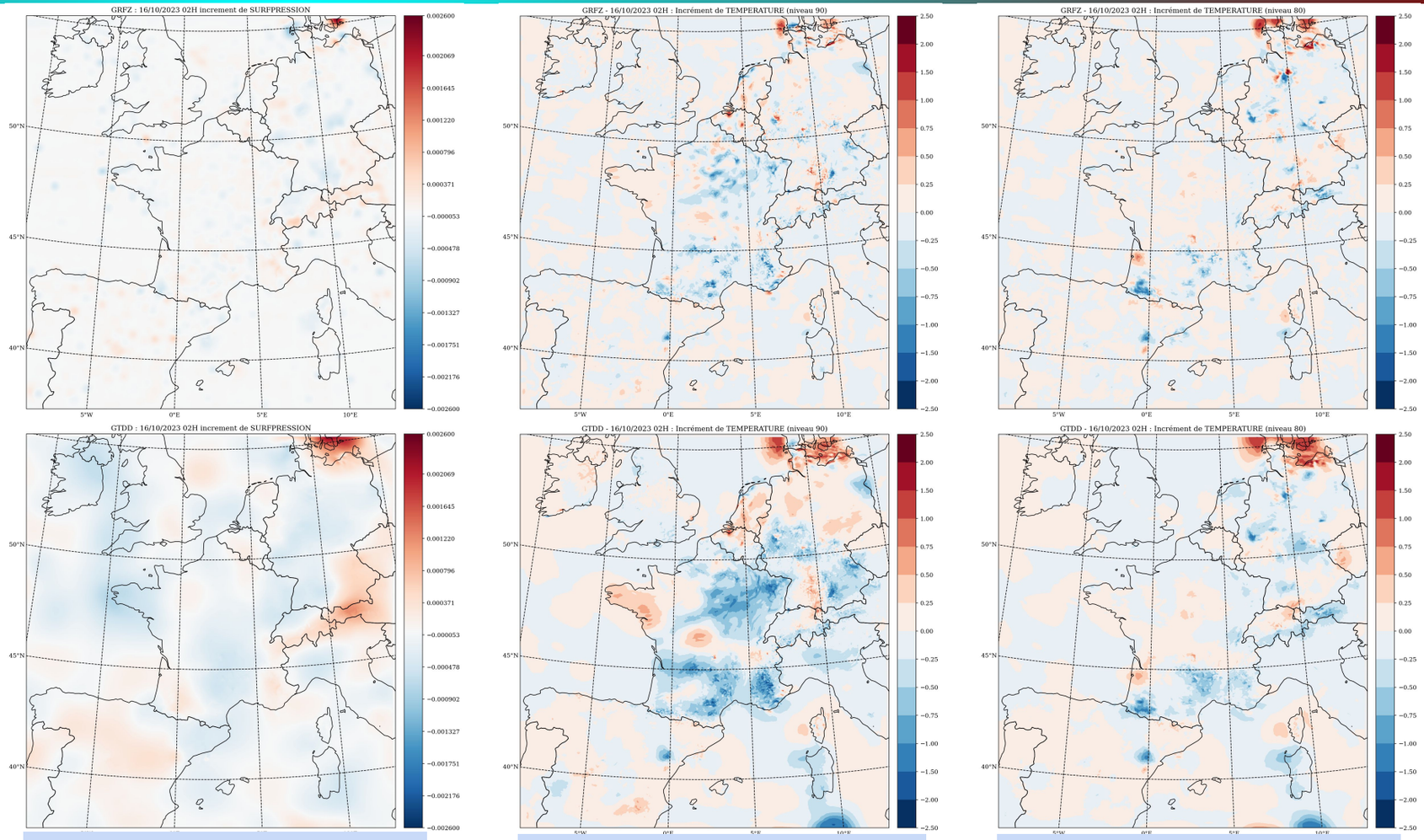


Valérie Vogt, Pierre Brousseau, Etienne Arbogast, Loïk Berre, Caron et al., 2019 (Meteo-France)

Scale dependent localization - Increments

REF 3DEnVar :
localisation length varying
from 25km at the surface
to 150km at the model top

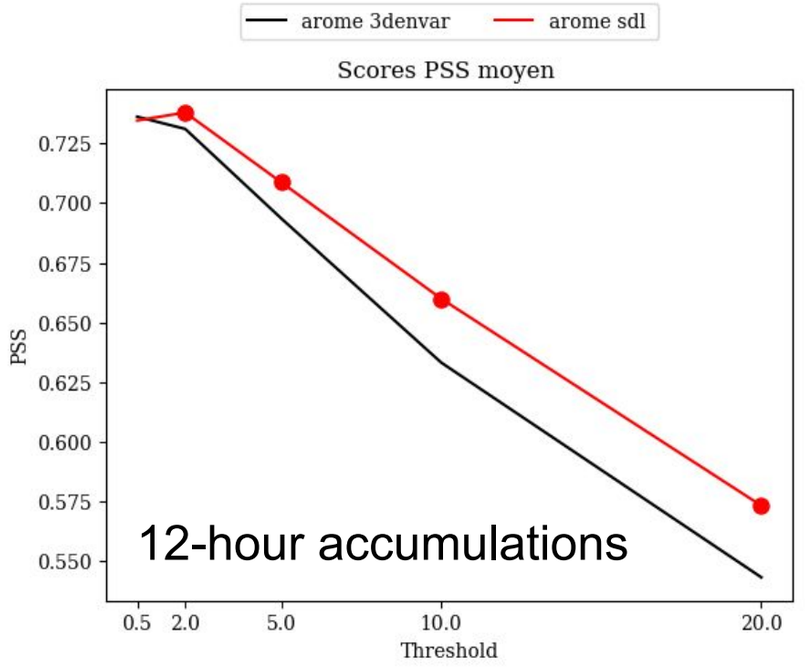
3DEnVar SDL :
localisation length
constant with height, but
varying with perturbation scale :
150 km (resp 75 and 25 km)
for low wavenumbers
(resp intermediate and high)

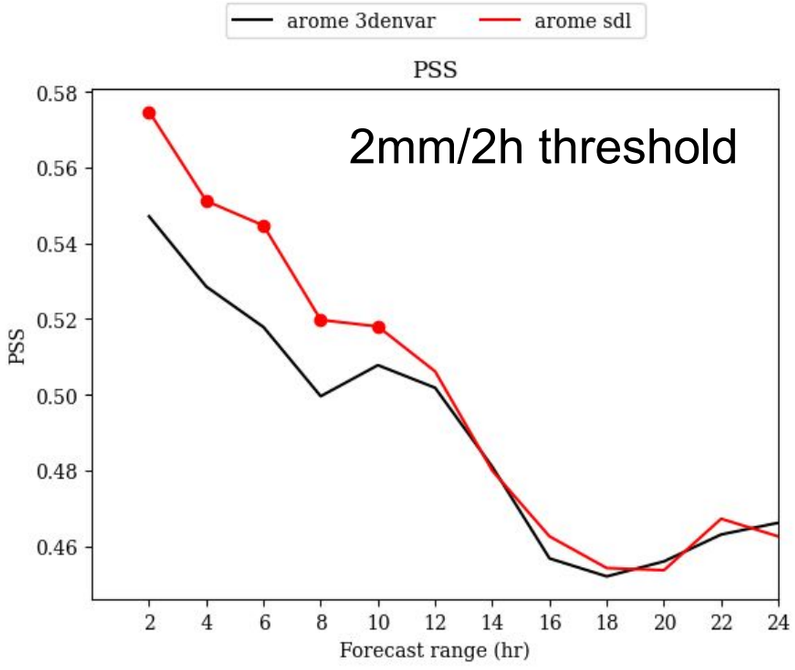


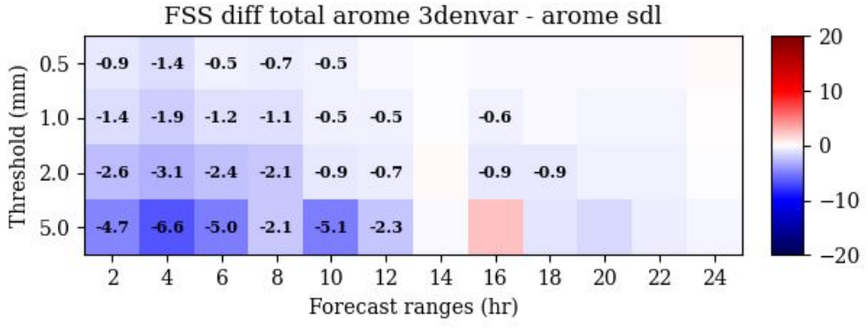
Valérie Vogt, Pierre Brousseau, Etienne Arbogast, Loïk Berre, Caron et al., 2019 (Meteo-France)

SDL 25/75/150km - Validation over 3 months against MF e-suite (Oct 2023 - Jan 2024)

- Positive impact on precipitation for all thresholds and up to 10 hours.
- Setting localization length scales becomes less critical when using SDL.
- SDL shows good complementarity with 4DEnVar and direct assimilation of reflectivity: the impact of each evolution is amplified when taken together, without retuning the localization.
- SDL is a candidate to the next e-suite in cy49t1 together with 4DEnVar (Pierre Brousseau talk) and direct assimilation of reflectivity (Maud Martet).





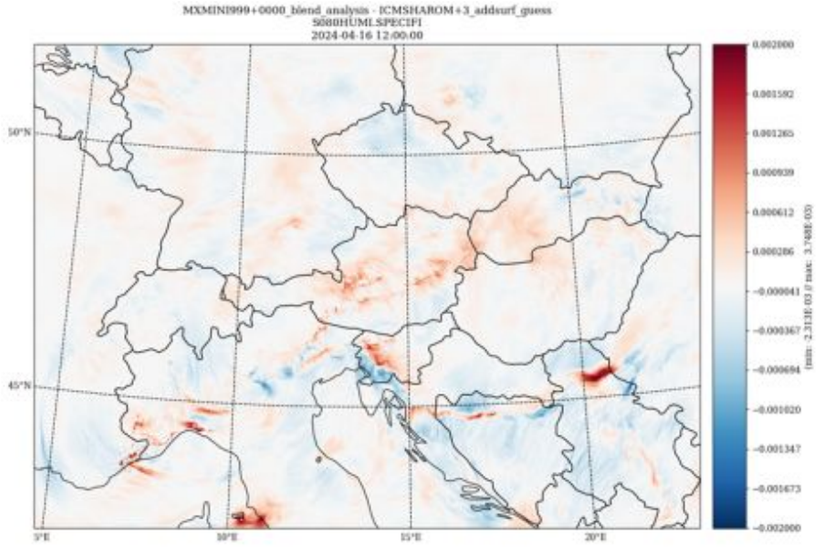


Valérie Vogt, Pierre Brousseau, Etienne Arbogast, Loïk Berre, Caron et al., 2019 (Meteo-France)

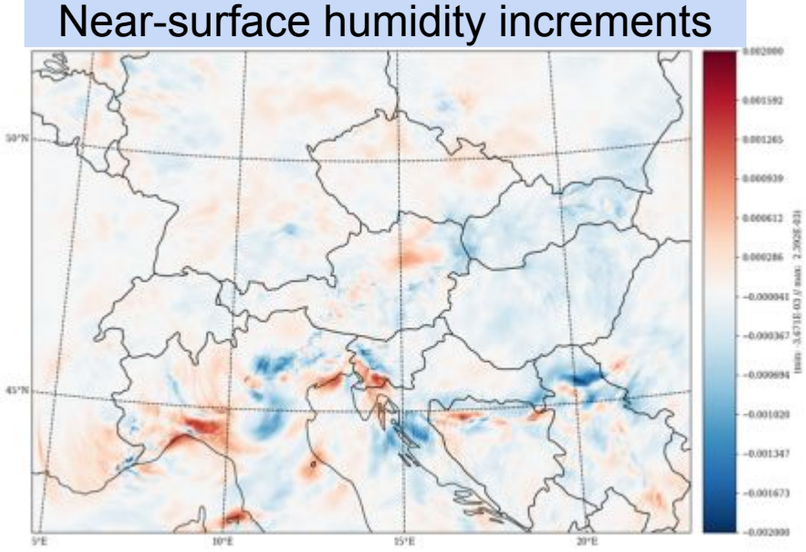
Constructing ens. perturbations for LAM EnVar

- Different ways of providing ensemble information to EnVar in the 16 member Claef-1k explored
  - LAM perturbations, including second-last run; global perturbations; mixed LAM/global perturbations
- The flow-dependency is well-captured with EnVar
- Combining LAM and global perturbation produces potentially unrealistic covariances over large areas

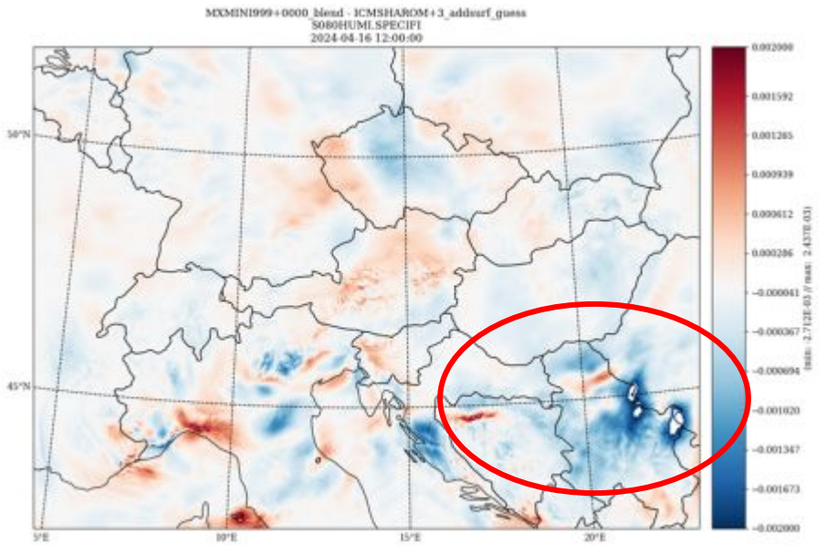
Near-surface humidity increments



50 LAM members



50 IFS member interpolated



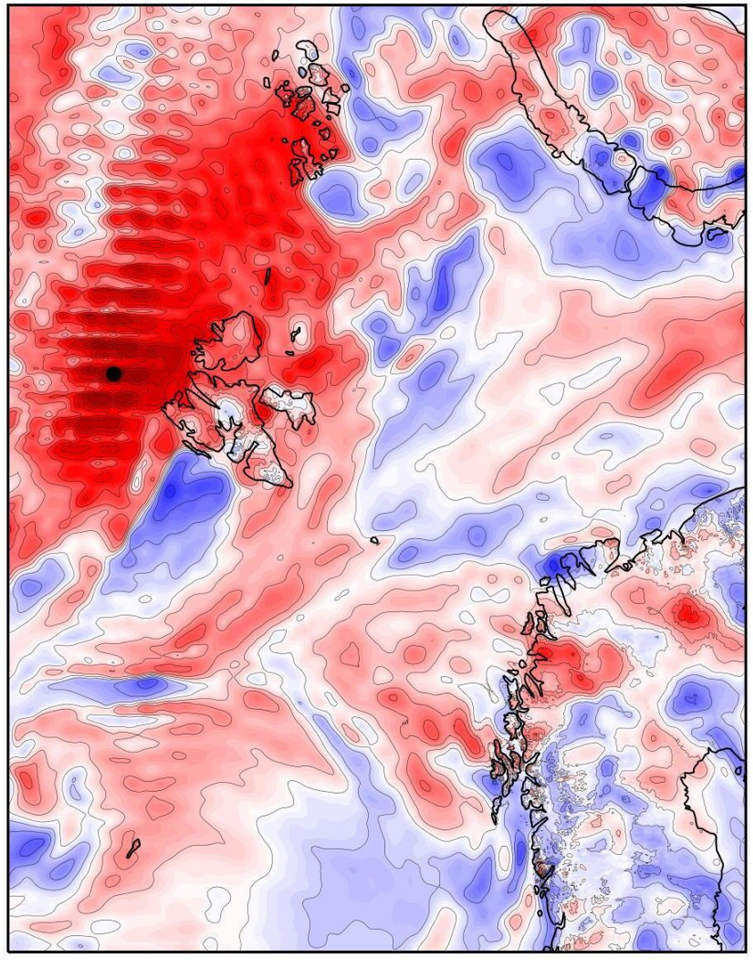
LAM/global (16+32) mixed members

Benedikt Strajnar (ARSO) and Florian Meier (GeoSphere)

Regional EnVar using ECMWF ensemble members

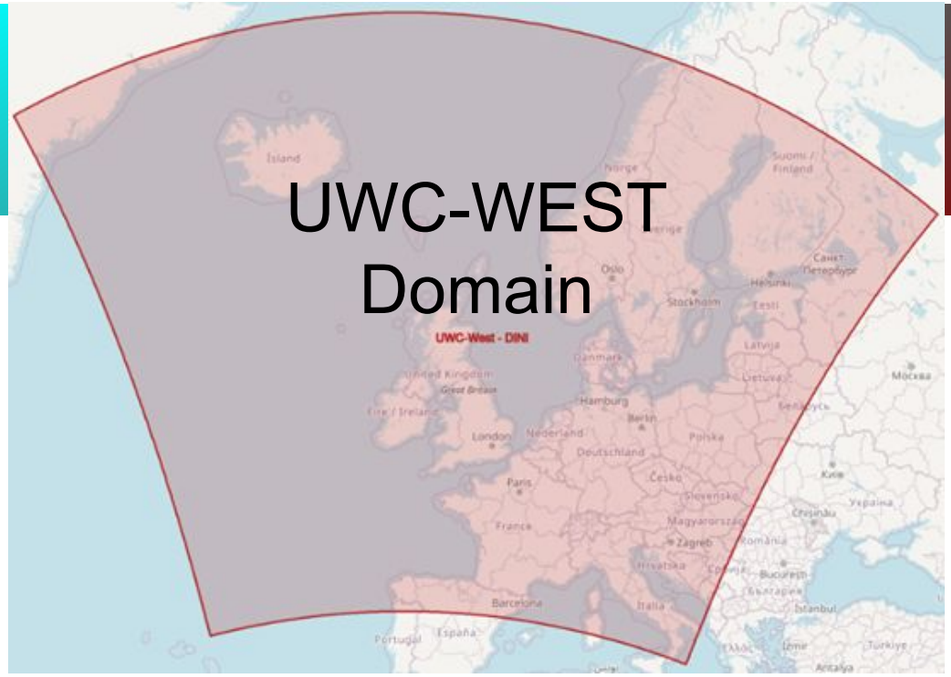
In an attempt to use ECMWF EDA ensemble members in a regional EnVar, we have found spurious ripples in the grid-point correlation field. According to Elias Holm (ECMWF), these ripples are probably due to spectral orography adjustments. These ripples make the ensemble unusable for a regional EnVar. It would be possible to filter these ripples spectrally, but this would lead to very coarse and broad increments, making the EnVar less competitive.

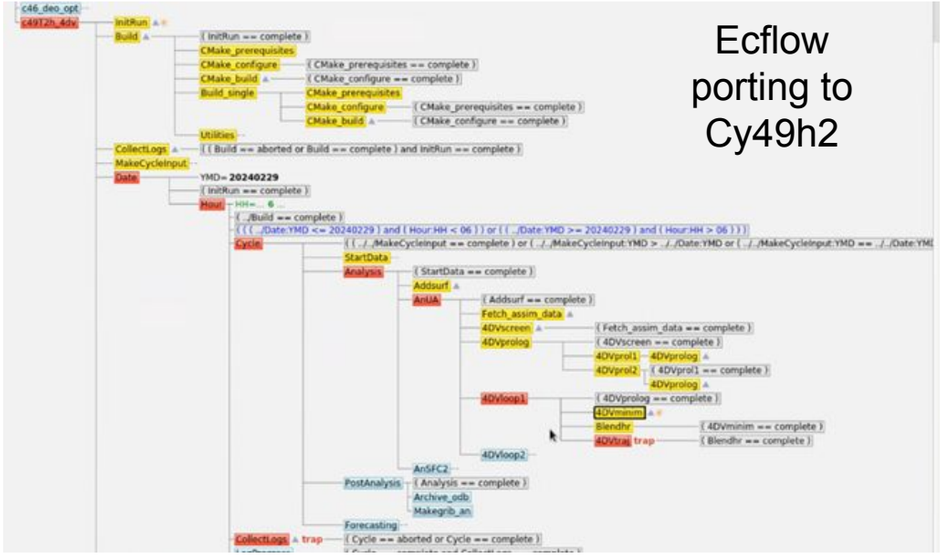
Ensemble correlation



LAM 4DVAR in MASTERODB

- **Running daily at UWCW.**
  - United Weather Centers West - Denmark, Iceland, Ireland, the Netherlands,
  - 3 parallel runs (1 hour shifted) are running daily
  - 2km resolution, 90 levels, 2outerloops
  - HARMONIE Cy43. 3-hour assimilation window.
- **AEMET, work on optimizing and tuning of 4DVAR:**
  - Observation usage and error specification of HARMONIE-AROME Cy46 ongoing.
  - Comparison of 4DVAR vs. 3DVAR and possibly new parallel tests will be performed to improve 4DVAR impact.
- **Work in porting to Cy49h2 HARMONIE repo.**
  - First developments in running the LAM 4DVAR in Cy49h2
  - Essential to compare MASTERODB vs. OOPS version in the same cycle.





Ecflow porting to Cy49h2

Chris Romick (KNMI), Isabel Monteiro (KNMI), Jan Barkmeijer (KNMI), Ole Vignes (MET Norway), Pau Escribà (AEMET), Jana Sanchez (AEMET), Magnus Lindskog (SMHI)

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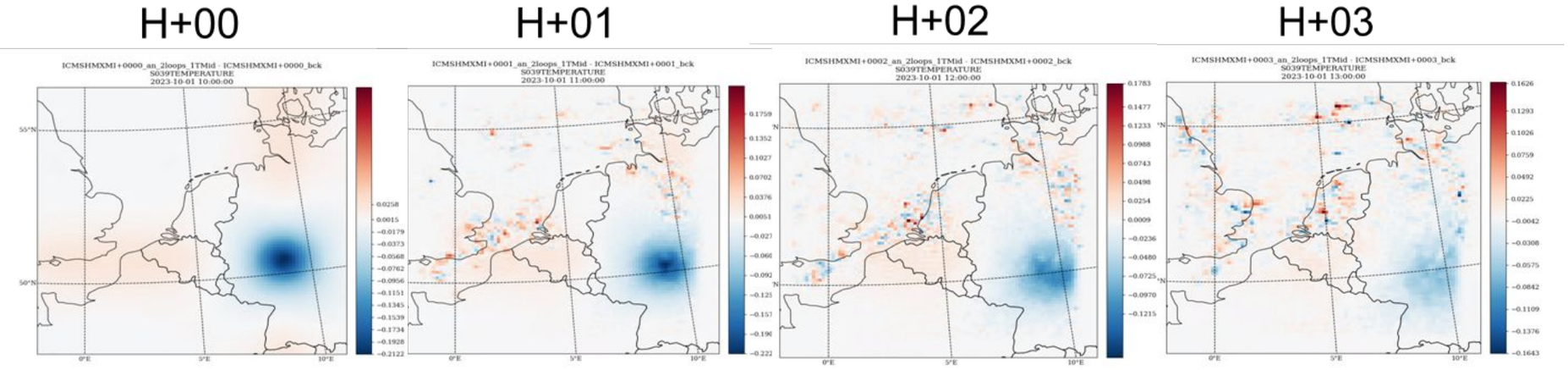
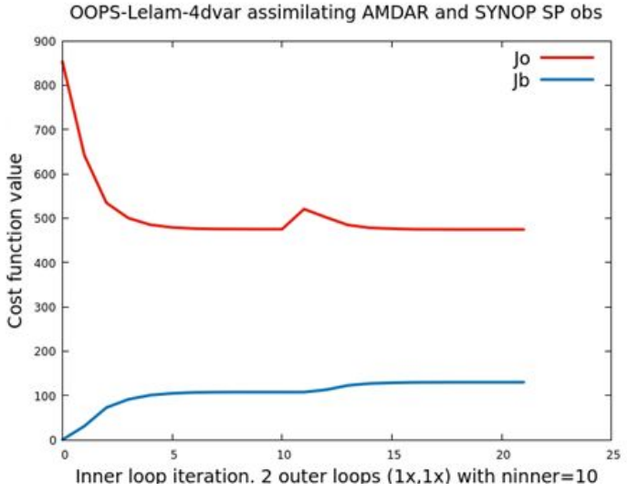
LAM 4DVAR in OOPS

LAM 4DVAR implemented in OOPS CY48T3



Temperature increment evolution within 3-hour assimilation window at model level 39 (around 800 hPa) with only single Amdar Temperature Obs. assimilated.

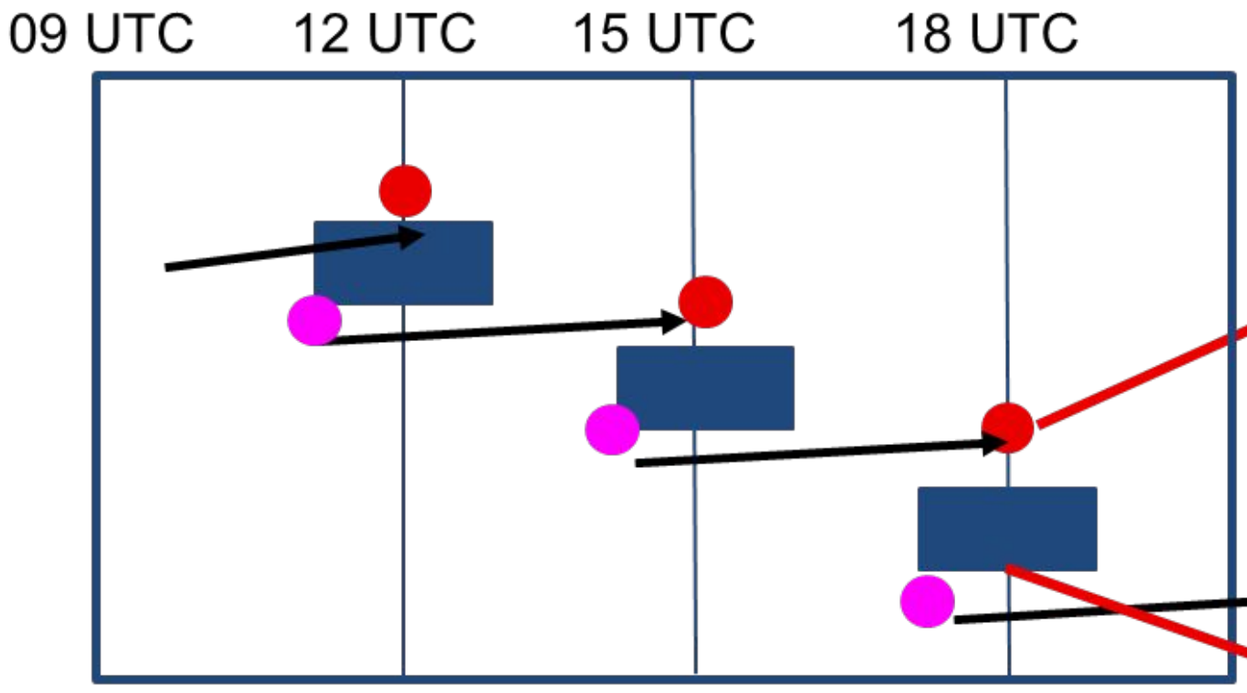


Evolution of cost functions during minimization. 2 outer loops. SYNOP, AMDAR and BUOY observation assimilated.

Coming work:
- Solve the noise problem
- Port the code modifications to HARMONIE CY49T2h release
- Carry out performance tests and compare with MASTERODB 4DVAR
- Proper documentation will be written

Pau Escribà (AEMET), Magnus Lindskog (SMHI), Jan Barkmeijer (KNMI), Roel Stappers (MET Norway), Chris Romick (KNMI), Ole Vignes (MET Norway)

Centered Incremental Analysis Updates (IAU)
A filtering procedure to mitigate spin-up



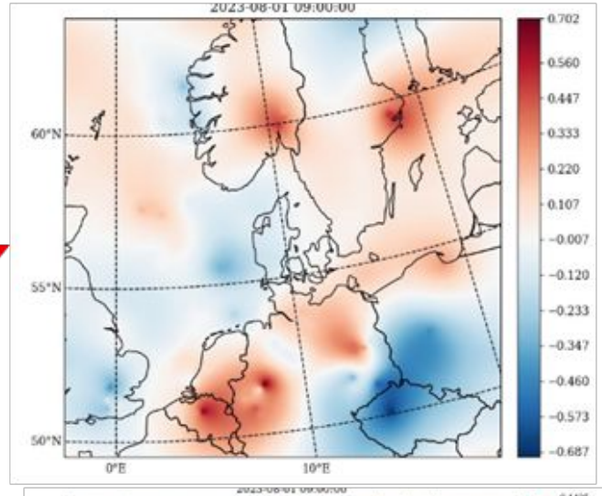
Analysis (UA)
Analysis (SU)
Forecast (UA)
Nudging period

'nudging' term

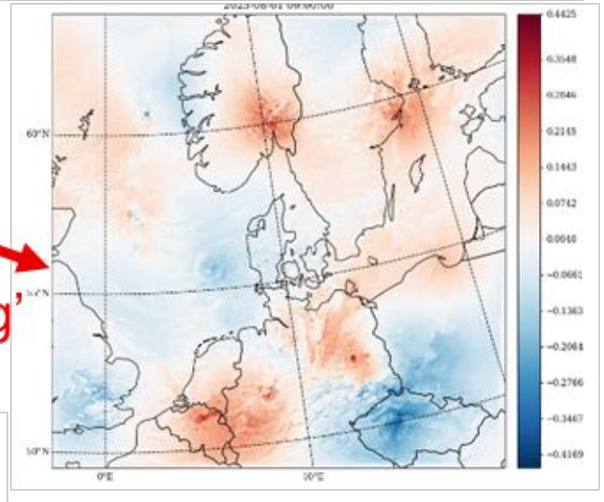
$$\left(\frac{\partial q^n}{\partial t}\right)_{\text{total}} = \left(\frac{\partial q^n}{\partial t}\right)_{\text{dynamics}} + \left(\frac{\partial q^n}{\partial t}\right)_{\text{forcing}}$$

with

$$\left(\frac{\partial q^n}{\partial t}\right)_{\text{forcing}} = \text{moist} + \text{turb} + \text{LR} + \text{SR} + \underline{\text{analysis}}.$$



3D-Var temperature increments for model level 46 (around 900 hPa)



Effect of increments on forecast after 1 hour of 'nudging'

Mats Dahlbom (DMI), Maria Diez (AEMET), Magnus Lindskog, Swapan Mallick (SMHI)

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Initialization for NWP-NWC

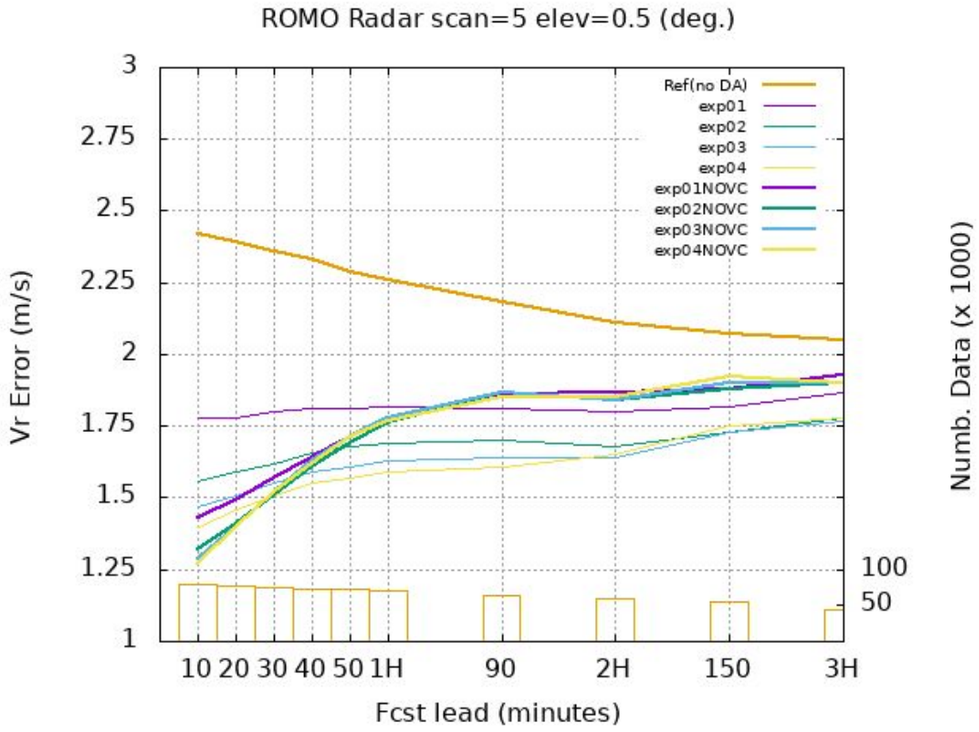
A new algorithm, **Variational Constraints (VC)** filters noise in ALADIN-NH dynamics initial conditions after 3DVar

Enables analysis of NH dynamic variables:
vertical motion and pressure departure which are not provided by current 3DVar

Minimal computational cost on top of standard 3DVar (eq. to one time step).

Potential for Rapid Refresh (RR) applications and it will be operational in AEMET Nowcasting suite (2025)

Validated and available at https://github.com/Hirlam/Harmonie (PR CY46VC#1095)



Radial wind error growth curves for RR DA experiments (10 minutes cycling) wind radar data.

The VC exps show clear smaller error growth. VC algorithm builds signal coherently from consecutive RR cycles and improves the NWC forecast skill with respect to the NO-VC exps.

Cloud Data Assimilation

Cloud data assimilation using observation operator defined by the Penalty Function

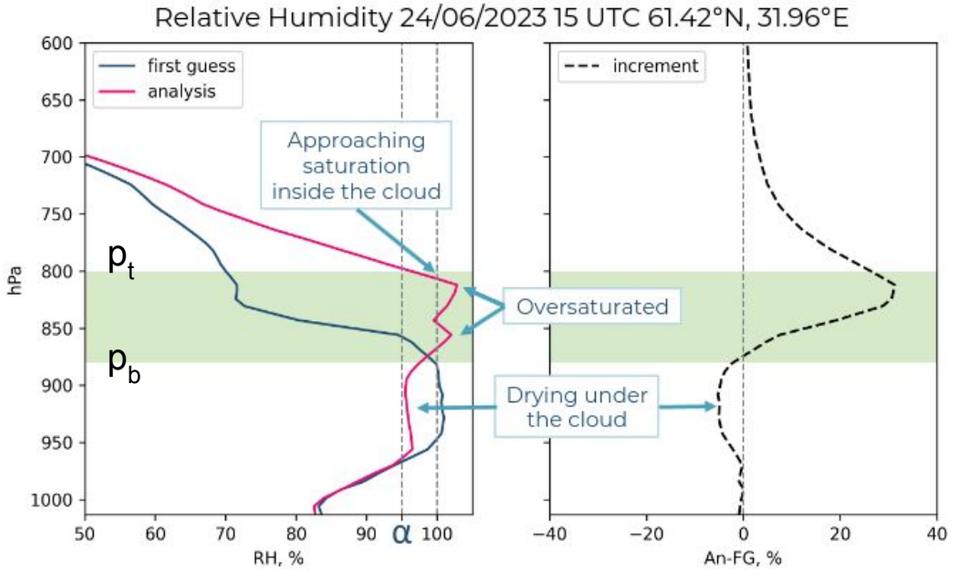
Observations:

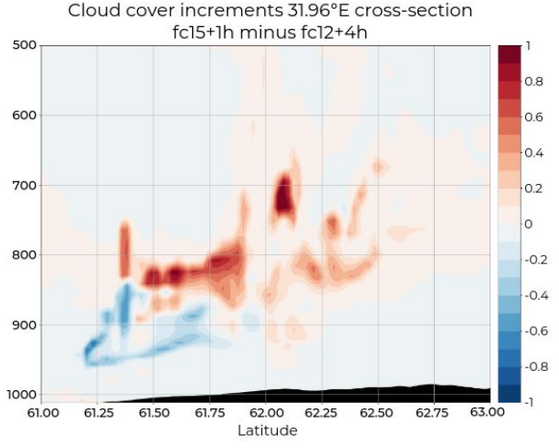
1) Ceilometer observation of cloud base altitude (p_b)
2) Satellite observation of cloud top altitude (p_t)

Penalty Function definition:

$$P(vl) = \begin{cases} RH(vl) - 1, & \text{for} \quad vl \in [p_b, p_t] \\ RH(vl) - \alpha, & \text{for} \quad vl \notin [p_b, p_t] \ \text{and} \ RH(vl) > \alpha \\ 0, & \text{for} \quad vl \notin [p_b, p_t] \ \text{and} \ RH(vl) \leq \alpha \end{cases}$$

where vl – vertical model level; $RH(vl)$ – model relative humidity ; α – threshold value





Proof of concept with pseudo-observations

- Small oversaturation is generated in the middle of the cloud layer.
- Impact on forecast visible
- The next step is to estimate cloud tops in addition to cloud base measurements with subsequent real case experiments.

Alina Lerner-Vilu (EEA), Siebren de Haan (KNMI), Aarne Männik (TalTech)

Background statistics in Observation Space (BGOS)

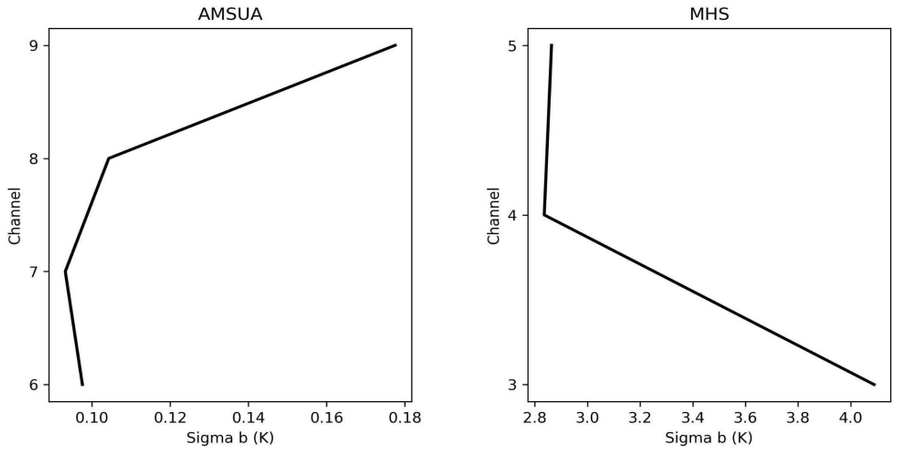
A new application has been developed in the OOPS framework to compute background error variance in observation space:

- either from an existing ensemble
- or from the static B matrix (randomization)

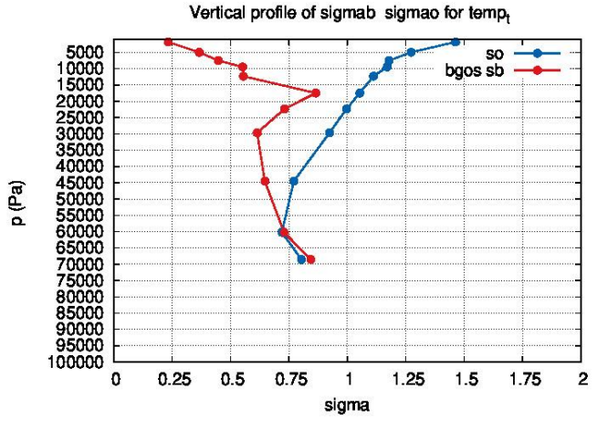
using:

- either the nonlinear observation operator,
- or the linearized observation operator.

It has been tested and validated in CY46, and will be ported to CY49 soon.



Example of standard deviation in brightness temperature space for AMSUA and MHS



Vertical profile of bgos sb and used so for TEMP T over IBERIA domain.

SEE POSTER: Jana Sanchez-Arriola, et al. **"Status and Plans for evaluation of Harmonie-AROME cy46 data assimilation tunable settings"**

Conclusions

- EnVar
  - Scale Dependent Localization amplifies impact of 4DEnVar
  - Constructing ens. perturbations for LAM EnVar is challenging
- 4DVar
  - LAM 4DVar implemented in OOPS
  - Parallel suite running in UWCW
- Initialization & NWC
  - Incremental analysis update - reduce spin-up
  - Variational Constraints alg. helps to balance NH variables
  - Innovative approach to cloud assimilation

Thank you for attention!