ACCORD

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OOPS Local Area 4DVAR

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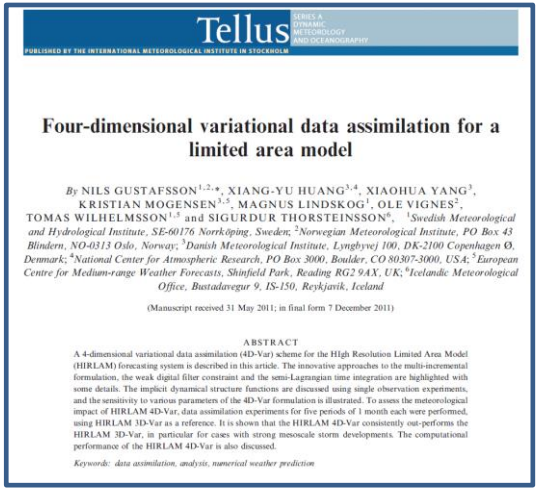
Outline

- Background & Aims
- Technical work on ECMWF HPCF and CY48T3
- Plans and further work

Background & Aims

- HIRLAM consortium developed 3D/4D Variational Systems for Data Assimilation at around 10 km grid resolution (1997-2013).



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Four-dimensional variational data assimilation for a limited area model

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ABSTRACT

A 4-dimensional variational data assimilation (4D-Var) scheme for the HIgh Resolution Limited Area Model (HIRLAM) forecasting system is described in this article. The innovative approaches to the multi-incremental formulation, the weak digital filter constraint and the semi-Lagrangian time integration are highlighted with some details. The implicit dynamical structure functions are discussed using single observation experiments, and the sensitivity to various parameters of the 4D-Var formulation is illustrated. To assess the meteorological impact of HIRLAM 4D-Var, data assimilation experiments for five periods of 1 month each were performed, using HIRLAM 3D-Var as a reference. It is shown that the HIRLAM 4D-Var consistently out-performs the HIRLAM 3D-Var, in particular for cases with strong mesoscale storm developments. The computational performance of the HIRLAM 4D-Var is also discussed.

Keywords: data assimilation, analysis, numerical weather prediction

High Resolution Hirlam Limited Area Model

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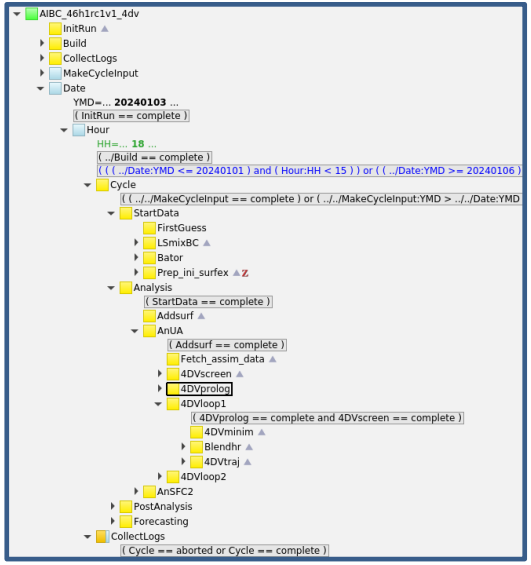
Background & Aims

- For km-scale modelling HIRLAM and ALADIN joined forces in 2005: HARMONIE
- Comparisons of HIRLAM and ALADIN 3D-Var in 2009, and at around the same time HARMONIE-AROME 4D-Var work started.
- AROME 3D-Var operational in HIRLAM since 2014.
- Météo-France prioritized to put resources into development of EnVAR in OOPS framework. First HIRLAM working version in June 2022.
- HIRLAM project will end in December 2025 and transition to UWC.
- ACCORD DA strategy for 2026-2030 is about to be formed.

Background & Aims

- KNMI and AEMET are running a 4DVAR HARMONIE parallel experiment assimilating all available operational observations (radar, seviri, iasi, scatt, amsua, amsub and conv).

- There will be a proper comparison of performances with the operational 3DVAR.



Background & Aims

- To facilitate the cooperation with ECMWF and within ACCORD we plan to port our 4D-Var LELAM developments into CY49 OOPS.

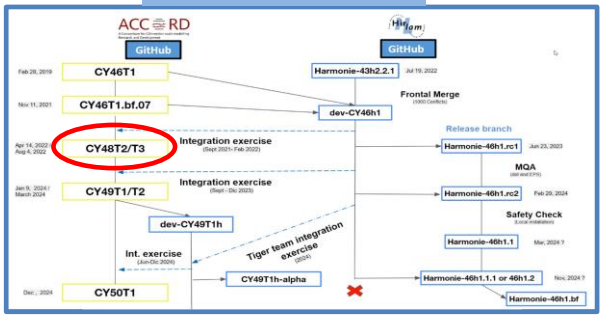
- In the current ACCORD RWP 2024 OOPS developments already play a central role in the DA section. We see possibilities to combine with machine learning and ensembles.

DA5.1	**Develop and consolidate full assimilation cycles using OOPS binaries in the OLIVE/VORTEX (MF) and in the other frameworks.** This work will require collaboration on keeping consistent solutions with unit testing (see below) and exchange of results. Regular code cycle updates.
DA5.2	**Consolidate the OOPS assimilation components as unit tests, including tests of OOPS objects.** Implement in DAVAI framework. Regular code cycle updates.
DA5.3	**Participation in C++ layer** (short term: local repositories; mid-term: managed via ECMWF repository) and provide support to scientists (for getting hand-on the OOPS system). Regular code cycle updates.
DA5.4	**OOPS: Other components or approaches:** develop large scale error constraint ; allow centred FGAT ; LAM 4DVAR (make use of DAVAI framework at ECMWF as first step).

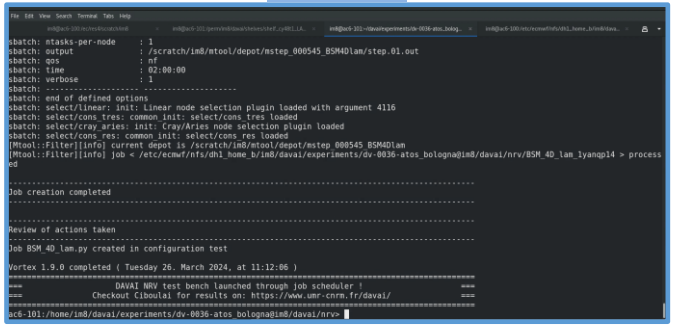
Technical work on ECMWF HPC and CY48T3

- **CY48T3** has been choosen as work release to join efforts with MeteoFrance OOPS developers and to prepare for the next CY49T1h HARMONIE release
- Although **DAVAI** is not thought for development purposes we are working with it thanks to our MF colleagues. We have needed some time to get used to it

Release History



DAVAI

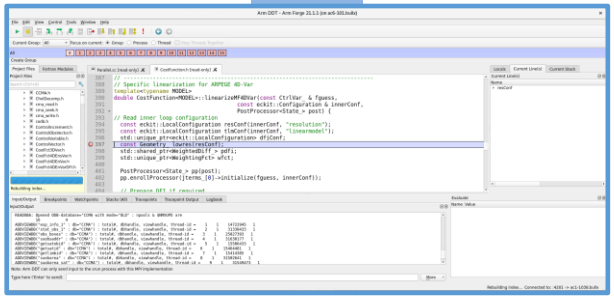


Technical work on ECMWF HPC and CY48T3

- **DDT** has become a basic tool for our development. This debugger allows to navigate the code to better understand it, using breakpoints, looking at the values of variables in runtime, etc...

- **4 diferent model configurations as references** to create our HARMONIE 4DVAR-OOPS in CY48

DDT



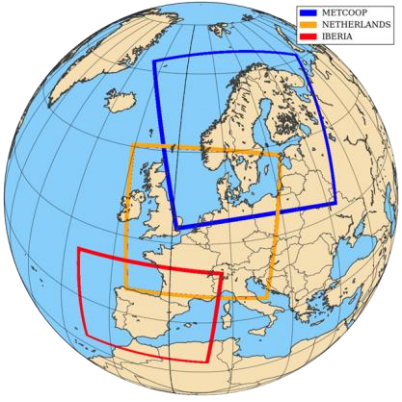
Harmonie-4dvar-CY46
Arome-3dvar-OOPS-CY48
Arpege-4dvar-OOPS-CY48
Arome-Forecast-CY48

Harmonie-4dvar-OOPS-CY48

Technical work on ECMWF HPC and CY48T3

- **Orange domain** over Netherlands is our working domain. It has 10 km resolution and 65 levels. The inner loop geometry is 20 km. We prepared all the input data for DAVAI running a corresponding MASTERODB 4DVAR in CY46 and a MASTERODB Forecast in CY48.

- Main **LELAM code modifications** are reading the boundary conditions for the trajectory computation and adaptation of SP2GP/GP2SP routines from global to local versions.



Technical work on ECMWF HPC and CY48T3

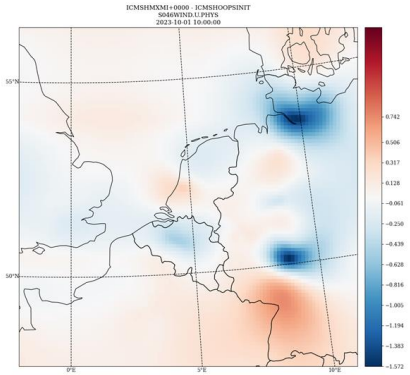
- **Two Cost Functions** are available in the OOPS code (ECMWF and MF). There are some differences between them, in particular, the trajectory for the propagation of the tangent linear model is computed at different resolutions. Our plan is to make the 2 options available for the HARMONIE-4DVAR to be able to compare its performance.

$$J(\delta\mathbf{x}) = \frac{1}{2}\delta\mathbf{x}^{\mathrm{T}}\mathbf{B}^{-1}\delta\mathbf{x} + \frac{1}{2}\sum_{i=0}^{n}(\mathbf{H}_i\delta\mathbf{x}(t_i) - \mathbf{d}_i)^{\mathrm{T}}\mathbf{R}_i^{-1}(\mathbf{H}_i\delta\mathbf{x}(t_i) - \mathbf{d}_i)$$

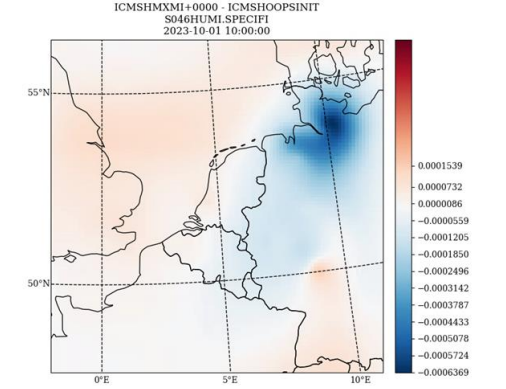
Technical work on ECMWF HPC and CY48T3

- **Preliminary results** show realistic analysis increments for wind and specific humidity. This is an indication that there are no gross errors and that the tecnhical implementation seems reasonable:

U wind increment lev46



Q increment lev46



Plans and further work

- **Merge** the **screening** and **minimization** at diferent inner resolutions in a one single 4DVAR LELAM OOPS task.
- Once the algorithm works technically, careful check of **nameslists**, input **upper air** and **surface fields**, used will be carried out.
- **Port** the **code modifications** to HARMONIE CY49T1h release.
- Proper **documentation** will be written.
- **Discuss** with our **colleagues in MF** about our implementation (next WW in Toulouse, October 2024)

Plans and further work

- The **performance tests** will be carried out with **CY49T1h release**, using the HARMONIE scripting system.
- Need to setup a **MASTERODB 4DVAR LELAM** version also in CY49T1h to compare to.
- The tests will compare the **ECMWF and MF cost functions** in the 4DVAR LELAM OOPS as well as other new features if desired.