OOPS Limited Area 4DVAR

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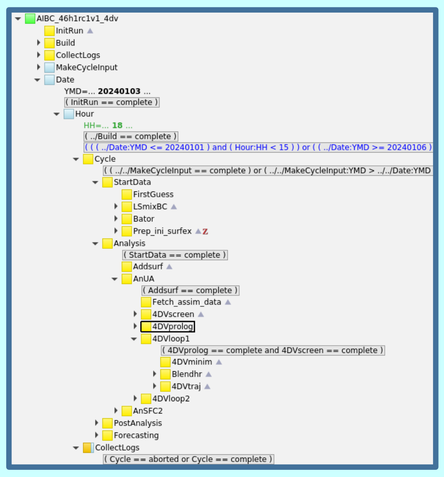
Background & Aims

A bit of background on HARMONIE 4DVAR LELAM



There is a **history of HIRLAM** in developing a 4DVAR LELAM configuration, applied also in HARMONIE-AROME.

Currently, **available in MASTERODB CY46** and being tested as a parallel run to the 3DVAR operational forecasting suites at UWCW and AEMET. It is as well used in several research ongoing projects and mentioned in research applications. Optimization of the 4DVAR LELAM is an important contribution in the ACCORD work plan.

Aims

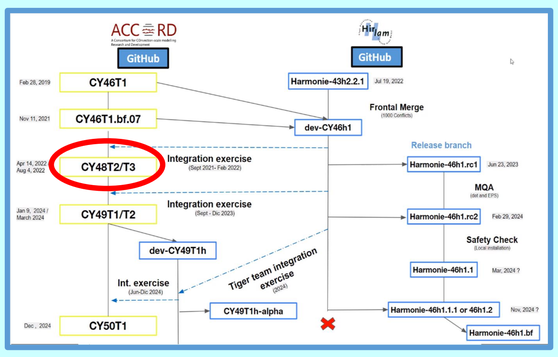
DA5.1	**Develop and consolidate full assimilation cycles using OOPS binaries in the OLIVE/VORTEX (MF) and in the other frameworks.** This work will require collaboration on keeping consistent solutions with unit testing (see below) and exchange of results. Regular code cycle updates.
DA5.2	**Consolidate the OOPS assimilation components as unit tests, including tests of OOPS objects.** Implement in DAVAÏ 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).

To facilitate the cooperation with ECMWF within ACCORD we now focus on porting our 4D-Var LELAM developments into **CY49 OOPS**.

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

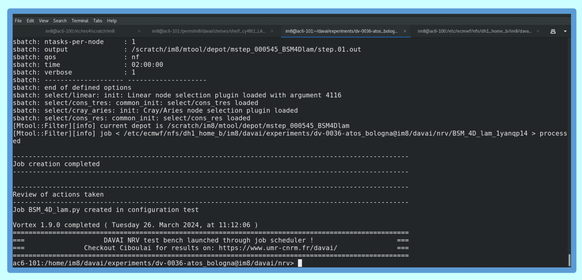
Technical work on ECMWF HPCF and CY48T3

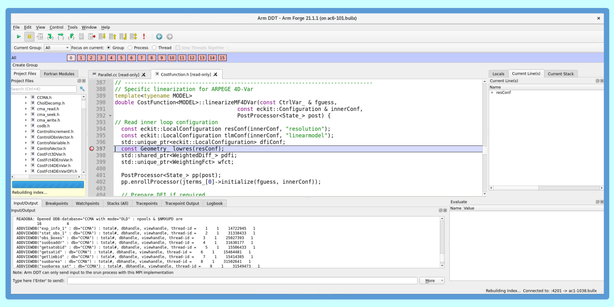
Setting up a work framework:



CY48T3 has been chosen as work release to join efforts with MF 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.





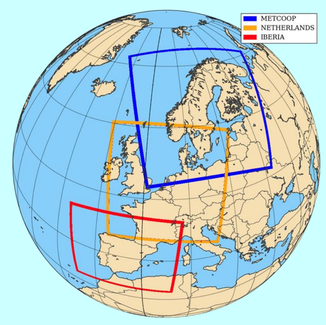
DDT has become a basic tool for our development. This debugger allows to navigate the code to better understand it, using breakpoints, looking at the values of variables in runtime, etc...

Our setup **references** are 4:

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

→ **Harmonie-4dvar-OOPS-CY48**

Our LELAM specifics



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.

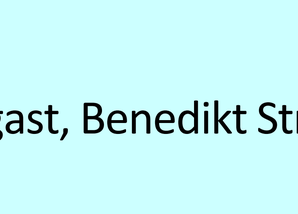
Main **LELAM code modifications** are reading the boundary conditions for the trajectory computation, adaptation of SP2GP/GP2SP routines from global to local versions and working with Lambert geometry in two different resolutions (high and low) at the same runtime.

The two 4DVAR Cost Functions in OOPS

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

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 their performances.

Status and first results



Preliminary results show realistic analysis increments. Here an example for wind and specific humidity. This is an indication that there are no gross errors and that the technical implementation seems reasonable

Plans and further work

Technical developments:

Merge the screening and minimization at different inner resolutions in a one single 4DVAR LELAM OOPS task.

Once the algorithm works technically, a careful **check** of namelists and input upper air and surface fields will be carried out.

Port the code modifications to HARMONIE CY49T1h release.

Proper **documentation** will be written. **Discuss** with our colleagues in Météo-France about our implementation.

Performance tests:

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.

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