

# IFS/Arpège Memorandum

**From:** Claude Fischer (Météo-France)

**To:** (ECMWF) DR, RD Division & Section Heads

**To:** (Météo-France) Arpège diffusion list

**To:** (ALADIN) Piet Termonia

**To:** (HIRLAM) Daniel Santos-Muñoz

**File:** RD17-xxx

**Subject:** Minutes of the IFS/Arpège coordination video-conference held on 21 February 2017.

## **Participants:**

**Météo-France:** Alain Joly, François Bouyssel, Claude Fischer, Karim Yessad, Ryad El Khatib, Stéphane Martinez, Alexandre Mary, Patrick Moll

**ECMWF:** Stephen English, Deborah Salmond, Peter Lean,

**ALADIN:** Piet Termonia (excused)

**HIRLAM:** Daniel Santos-Muñoz (excused)

## **1. Adoption of Agenda**

adopted

## **2. Approval of Minutes of meeting of 18 October 2016**

approved

Note: minutes from the 22 November and 12 January technical video-conferences also are available, and can be obtained from Claude.

## **3. Review of list of actions from last meeting**

1. Deborah will list those elements of F2008 that already are present in the IFS codes (usually under key-protected switches). This list could be a starting point for discussing items that could/should be accepted or be tested on various compiler versions and computer platforms.  
=> Action open. Deborah will start listing F2008 items that could be accepted (mostly

improvements of F2003 features). In addition, it seemed useful to also specifically list those features that we should NOT accept, like COARRAYS.

2. EC and MF will start checking which existing issues could be relevant for the Confluence page, and start document them. Action on both EC (Steve and Deborah) and MF (Claude, François). The content of the page will be reviewed in the forthcoming coordination meetings. => Action open. Steve and Claude to liaise in order to test the “Known Issues and Bug Fixes” Confluence page hosted at EC.
3. Deborah will provide a library-link release note for CY44\_main, in order to list the versions of OOPS, Atlas etc. that should go with IFS CY44. => Action closed. Though a debate started about which sub-libraries would become mandatory, and when and for what purpose, among the extra items listed by Deborah. Claude suggested that MF experts shall sit together first and analyse these items, then possibly get back to EC.
4. Action on Sylvie: send the technical and scientific note about the results with the mass-preserving option in IFS to MF, when ready. => Action open.
5. Peter to send information to MF about the switches and changes in the use of observations in CY43R3 (improved optimizations for CCMA, reproducible sequence numbering). => Action closed.
6. Thinning strategies and minimal distance between selected observations (Arome case). Action on Peter and Claude: to further liaise as necessary and exchange information or suggestions on the thinning method. At MF, Vincent Guidard will be kept in the loop. => Action closed.
7. Cycling strategy in 2017 (CY45, CY46). The build of the technical cycle CY45, a few weeks after CY44, was eventually retained as the best scenario, but an evaluation of whether the follow-up interim cycles (CY45R1/R2, CY45T1) and the next joint cycle (CY46) could be delayed over the autumn and the end of 2017, respectively, needs to be done. Action on Steve and Claude to check with their respective management and staff, and liaise as appropriate. => Action closed (see content and timing of cycles in Table of § 10).

*Preliminary note: the following files/slides were presented at the video-conference, and can be obtained from Claude (on demand):*

- *progress and plans at MF (by François)*
- *progress and plans at EC (by Steve) – refer to slides of 18 October meeting*
- *COPE Progress and Plans, link with OOPS (Peter)*

#### **4. MF information about progress and plans of E-suites and cycles**

François presented the ongoing porting efforts of new applications at MF, like the Arome EPS system (PEARO):

Model component:

- same as main Arome-1.3km over France
- except horizontal resolution : 2.5km
- production at 9 and 21utc (coupled to 6 and 18utc global PEARP ensemble)
- 12 members at 45-h range

Perturbations :

- initial & boundary conditions from PEARP (members selected by clustering)
- initial condition centred on interpolated Arome-1.3km analysis
- perturbed surface & model physics (SPPT stochastic scheme)

PEARO is in operational production mode since end 2016.

The current e-suite is based on CY42\_op2. The description for Arpège / AEARP (EDA) / PEARP (EPS) reads:

- **New convection scheme PCMT in Arpège and AEARP**
- **SURFEX model (surface parameterizations)**
- AEARP: resolution increase for the computation of background error variances
- AEARP: normalisation of variances induced by wavelet modelling of correlations
- VarBC on ground GPS observations
- Assimilation of 2 water vapour channels (183GHz) of GMI on GPM
- Assimilation of 3 water vapour channels (183GHz) of MWHS2 on FY3-C
- Higher density of GEORAD (from 250 to 125km)
- Assimilation of window SEVIRI channels (4, 6, 7, 8 over sea)
- 5 new channels (ozone) for IASI
- New physics in PEARP (ARPEGE EPS)
- Optimisations (new compiler version, etc.)
- New diagnostics (domain, variables, etc.)

Description for Arome :

- Same modifications as in Arpège for observations
- New version of IAU
- New cloud optical properties
- New autoconversion threshold for transformation of cloud droplets into rain
- Ocean mixing layer scheme in Arome-OM (Overseas models)
- Optimisations (new compiler version, server for production of AROME-EPS coupling files)
- New diagnostics (domain, variables, etc.)

The switch to operations was expected for end of May 2017.

The next e-suite is targeted on CY43T2, if technical validation is completed in due time. Its schedule is from autumn 2017 to mid 2018;

- Migration to VORTEX (Python toolbox) for ARPEGE 4DVar, EDA and AROME 3DVar
- Migration to GRIB2 format for post-processing (lat/lon) files and using GRIB2 encoding for historical files (model geometry) based on IFS official GRIB\_API library

- New horizontal resolutions for global systems (deterministic, EDA, EPS)
  - > ARPEGE: ~5km over France (T11598c2.4L105 or T11798c2.2L105)
  - > 4DVAR: 2 minimisations in T1224c1L105 and T1499c1L105
  - > EPS: 35 members (unchanged) at ~7.5 over France (~T11198c2.2L90) and four times per day
  - > EDA: 50 members in T1499c1L105
- Modifications in the physics: tunings in PCMT convection scheme, inclusion of prognostic graupel in Arpège's microphysics, revision of surface evaporation over sea, 1D version of GELATO sea ice scheme, Flake lake model, etc.
- European radar data in Arome, Humidity observations from aircraft, variational bias correction for aircraft data, observation correlation between infra-red channels, 2D obs operator for GPS RO data, etc.

## 5. EC information about progress and plans of E-suites and cycles

Steve gave an overview of the preparations for CY43R3 in operations (refer also to his slides from the last coordination meeting on 18 October). Among the most important changes, Steve mentioned the new aerosol climatologies, the changes in the convection schemes for the HRES and EDA systems, and the use of EDA humidity perturbations for B. A careful evaluation of the forecast behaviour in the RD e-suite with respect to observations and analyses has been undertaken. The most positive impact of the e-suite is seen with respect to observations and operational analyses and forecasts, while the evaluation with respect to the RD e-suite own analyses showed larger RMSE. The reason for this behaviour is that the RD e-suite analyses have significant differences linked to the changes in the EDA perturbations. This was especially true for humidity. The analysis is changing more than the forecast. This explains why the higher RMSE is seen in verification against own analysis, but not against operational analysis or observations.

CY43R3 is expected to become operational in June 2017.

The next plans are to build CY45R1 (end of March) and then CY45R2 which is expected to be dedicated to changes needed for implementing the overlapping 12-hour window 4D-VAR.

## 6. Updated status of build of CY44; validation of assimilation at MF in CY43

Claude gave an update of the status of validation of CY43 and pre-CY44 at MF. In CY43, the assimilation configurations are still being checked and validated. 4D-Screening and 4D-VAR minimization seem to be OK in Arpège, and a quite significant effort is now being spent for updating the CANARI OI code (Florian Suzat and Patrick Moll). Once this validation work is completed, MF intend to quickly move the set of fixes on top of CY43T2, in order to resume validation of Arpège and Arome Screening/Minimization/CANARI on that version, and prepare tests of assimilation cycles. CY43T2 remains the target version for building the next e-suite (spring/summer/autumn 2017).

The build of pre-CY44 has been resumed at MF, after EC had sent their pre-final version in the very beginning of February. So this new version now contains all scientific input of CY43T2 and CY43R3 as well as the OOPS re-factoring items intended for CY44. With the efficient help of

Aladin phasers in Toulouse, several bugs have been fixed actually very recently (mostly for LAM configurations, like in the LBC code and in CONTROL\_VECTOR) but also probably for the 601 configuration (general fix affecting all singular vector computations, for IFS/Arpège/LAM).

Claude stressed that, in the course of validation of the assimilation in CY43, especially for the minimization, a few difficult bugs had been encountered, which were pointing to very complex pieces of IFS/Arpège codes. Quite specifically, the handling of LTRAJHR is complex, and the code of LSPRT is even more difficult to understand. In addition, MF have started to investigate in detail how LSPRT works in recent cycles for the assimilation, and most likely the ongoing tests do point to actual bugs in the assimilation systems of IFS, Arpège and the LAMs.

Action on Claude: to provide EC a description of MF's tests and results with LSPRT in assimilation.

Deborah confirmed that the pre-CY44 code enabled to run simple 4D-VAR IFS from OOPS, but the only critical aspect was the humidity increment which seems wrong. We will probably get back to this item in some upcoming meetings. The option LTRAJHR=.TRUE. (the low resolution trajectory is interpolated from a outer-loop NL time stepping) is so far the only option coded for OOPS. However LTRAJHR=.FALSE. (the low resolution trajectory comes from the inner-loop NL time stepping) would be an easy modification. So far EC have been running their simple 4D-Var comparisons between IFS and OOPS with outer and inner loops at the same resolution (T159), so as yet this is not an issue. The IFS runs were done with LTRAJHR=.FALSE. so that the IFS ifsmin step started from the same state as the OOPS ifsmin step. IFS with LTRAJHR=.TRUE. saves the trajectory in the first ifstraj step and the consequent grib packing/unpacking would not give bit-reproducibility.

EC had been fixing recently problems in IFS 4D-VAR for CY44, and fixed the IFS version of the IO\_server. Furthermore, EC are working at present on a modified code for implementing the PCAPES diagnostic (formerly coded inside Full-POS). The final steps for building CY44 have been defined:

1. EC to send MF on Wed 22 Feb their already available fixes (4D-VAR, IO\_server)
2. MF to add Toulouse fixes (LAM, 601 etc.) and build a new pre-CY44 version on Wed 22 Feb (tagged as v08 in MF's GIT repository)
3. Deborah to check with Tomas about completion of new PCAPES code; plan to send this code to MF early next week (Mon 27 Feb, say)
4. MF to add whatever remaining fixes from Toulouse tests, and build a v09 on Mon 27 or Tue 28 Feb. Run final technical benchmark tests ("mitraille" for global and LAM)
5. MF to send their pre-CY44 to EC around Thu 2 March. Final check and declaration of CY44 by EC.

## 7. HIRLAM comments

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## **8. ALADIN comments**

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## **9. Specific issues:**

### **9.1. OOPS Progress**

The FORTRAN re-factoring for CY44 is almost fully on schedule. The VarBC re-factoring is presently being checked by Roel Stappers with support by Alan Geer. Roel has been pointing to a weakness in the present OOPS generic code: OOPS assumes that any piece of the control vector will be pre-conditioned by its B-matrix block, but this pre-conditioning is not optimal for the VarBC coefficients (this result goes back to Dick Dee's original papers on variational BC). EC are now working on a modification of the OOPS code in order to relax this constraint.

Deborah has made good progress with building the Trajectory object needed to run simplified physics from OOPS-IFS-VAR (key LETRAJP). She believes that the changes will also directly benefit to the Arpège version of OOPS-VAR later on. Claude suggested that Deborah's visit in March could be used to discuss the practical code details with GMAP staff. For the Trajectory, this could be Etienne, Karim and Cécile, if available on 16 March.

MF had recently managed to upgrade the Arpège OOPS/3D-VAR prototype from a code version based on CY40, to a code version based on CY43 (Etienne Arbogast). To do so, apart from CY43\_main IFS/Arpège codes, it was necessary to implement an older version of the OOPS/3D-FGAT branch from EC's GIT repository, along with the CY43 fixes needed for Arpège Screening and minimization, and a number of specific patches in order to iron out other FORTRAN aspects (some of which likely to be solved by the ongoing re-factoring). MF now plan to upgrade the LAM OOPS/3D-VAR, and test the complete set of available obs operators of CY43. Eventually, the upgraded versions can be used to resume scientific work on EnVar and test specific re-factoring codes or OOPS classes.

Claude mentioned that MF would like to better understand EC's planned work with the "alpha control vector solution" in OOPS. This work was shortly mentioned at the OOPS Board meeting. In practice, an equivalent solution already exists in the OOPS code (implemented by MF) and thus, this effort could be redefined within a collaboration between the DA groups of MF and EC. Steve will check and provide feedback to MF.

Action on Steve: to provide MF with a feedback, possibly a workplan description, about the "alpha control vector" work planned at EC.

### **9.2. Update about COPE and link with OOPS & Screening code in IFS**

Peter presented the latest plans for implementing COPE and the link with OOPS. Among other aspects, he pointed out that the intention at EC would be to run several steps of early Screening of observations, in order to make early checks of observations which would need to be removed from the assimilation process if they do not pass Screening or even cause crashes within the code. Eventually, however, there would be a full Screening step performed after cut-off time, using all observations, and which would stay in the critical path of operations. This would however remain tractable as the computational cost of a full Screening in IFS is not blocking for the timeliness of the operational system.

At code level, the plan is to first code a rather thin layer of C++ code/classes in order to enable calling Screening from within the OOPS binaries, but separate from the 4D-VAR minimization, and later to implement C++ classes required in order to enable a single execution of Screening + Minimization from within the same binary file.

### 9.3. Strategy for code updates between OOPS re-factoring and IFS-Arpège cycles

Claude explained a proposal for handling the OOPS re-factoring steps in a parallel development branch, with respect to the (more scientific and optimization oriented) R- and T-cycles. This would enable an easier exchange of codes between MF and EC, while still both sides could decide to implement features of re-factoring in any of their R- or T-cycles. Eventually, building the next common cycle then would be done in two major steps of code exchanges: (1) a step for merging the R- and T-cycles, followed by (2) a merge of the technical OOPS branch. Only the result after both steps should become a declared joint cycle.

The meeting participants agreed to this proposal, which will be adopted starting with CY45 as base version (thus, for the OOPS branch), and with CY46 as target after steps (1) and (2). See graphical overview in Appendix. It was anticipated that the build of CY46 might still be a complex one, though it might well be the last one with significant OOPS re-factoring to enter. The expectation was that the build might take about 3 or 3.5 months (see Table in §10).

## 10. Content and timing of cycles

Joint cycle	ECMWF	MF	Start of phasing	Declaration	Misc. / Oper plans
CY42				June 2015	Declared 17 June
	CY42R1		end of June 2015	July 2015	Could be implemented with resolution upgrade but not essential
	CY42R2		September 2015		
		<i>CY42T1</i>		<i>Cancelled in</i>	<i>Dropped</i>



				<i>order to prepare for CY43 which was rescheduled after the last coord meeting</i>	
		CY42_op1 / op2	March 2016	January 2017	MF E-suite version expected for operations by April/May 2017
	CY42R3				Contains re-factoring on top of R2 (only)
CY43			September 2015	February 2016	Declared 25 Feb.
	CY43R1		March 2016	June 2016	Scientific changes
	CY43R2		May 2016	?	Re-factoring for OOPS
	CY43R3		October 2016	November 2016	Model + DA
		CY43T1	April 2016	June 2016	Including Aladin and Hirlam
		CY43T2	October 2016	mid-November	Wrap-up of bugfixes from [CY40-CY42], as well as MF E-suite changes from CY42_op1/op2
CY44			mid-November 2016	End of February 2017	The build process of this cycle might be in multiple steps to accommodate necessary input for OOPS in IFS. Tbd in forthcoming video-conferences.
	<i>CY44R1</i>				<i>Dropped</i>
		<i>CY44T1</i>		<i>Cancelled in order to build the technical OOPS cycle CY45</i>	<i>Dropped</i>
CY45			March 2017	End of March 2017	MODEL object re-factoring
		CY45T1	September or October 2017	November 2017	Including Aladin and Hirlam
	CY45R1		May 2017	June 2017	Science tbc
	CY45R2		July 2017	September 2017	12h overlapping DA
CY46			End of November 2017	End of February 2018	




About CY45: Olivier Marsden will soon send a version of his Python script for implementing the Passing by Arguments (aka “SPAMing”) of MODEL variables. Contact at MF will be Alexandre. EC indicated that the actual work of the Python script would focus on the SPAMing step, while removing the USE statements would have to be done manually. This two-step strategy will prevent the code to abruptly crash or stop, with potentially a few places where the fixes might be non trivial. However, EC expected that many of the USE statements could be removed fairly quickly. MF suggested that the Python script could be complemented by a facility (in Python) for spotting duplicated variable passing (by argument and by remaining USEs) so that no duplication instance would be overseen in near future. EC will check.

## 11. AOB

None.

## 12. Next meetings

### Next technical video-conferences:

- Thursday 16 March, 14h30 CET / 1.30pm UK

### Next Coordination video conferences:

- Thursday 20 April, 10h30 CET / 9.30pm UK (Note: this date was finally decided after the meeting, and it is going to be a morning schedule unlike usual !)

### Next physical Coordination Meeting:

Monday 12 June 2017, meeting to take place in Reading

Note: followed by OOPS Board meeting on 13 June, in Reading as well.

## List of actions

1. Deborah will start listing F2008 items that could be accepted (mostly improvements of F2003 features). In addition, it seemed useful to also specifically list those features that we should NOT accept, like COARRAYS.

2. Steve and Claude to liaise in order to test the “Known Issues and Bug Fixes” Confluence page hosted at EC.
3. Action on Sylvie: send the technical and scientific note about the results with the mass-preserving option in IFS to MF, when ready.
4. Action on Claude: to provide EC a description of MF’s tests and results with LSPRT in assimilation.
5. Action on Steve: to provide MF with a feedback, possibly a workplan description, about the “alpha control vector” work planned at EC.

**Appendix: graphical overview of cycling strategy including a parallel OOPS branch**

