Status

HARMONIE-AROME 4D-Var

1st ACCORD All Staff Workshop
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Content

• 4D-Var configuration

• sanity checks

• some results

• conclusion and outlook
Brief HARMONIE-AROME 4D-Var History

- **Nils, Magnus and Ole** visit Météo-France Dec. 8-12, 2008, to learn how Bernard Chapnik had set up first version of ALADIN 4D-Var (in OLIVE system).

- First HARMONIE 4D-Var working week at met.no June 8-11, 2009 (Nils, Magnus, Ole, **Trygve**), during which HARMONIE 4D-Var mini-SMS prototype is developed.

- During second working week at met.no Sept. 7-11, 2009 (Nils, Magnus, Ole, Trygve). **First working version of HARMONIE 4D-Var is established.**

- Third working week at SMHI 30 Nov-4 Dec 2009, was devoted to careful testing of the HARMONIE 4D-Var components. Planning for future developments (multiple outer loop iterations, more advanced simplified physics). **HIRLAM, Météo-France and LACE participants.**

- Fourth working week at met.no 3-7 May, 2010 (Nils, Magnus, Ole, Trygve, **Roger**). Work towards introduction of satellite data and phasing to cy 36.

- Fifth working week at SMHI 22-26 November 2010. **Cleaning and various enhancements of HARMONIE 4D-Var. HIRLAM and LACE (Météo-France in teleconference part).**

- Assimilation experiments carried out during 2011 demonstrated encouraging results for HARMONIE 4D-Var using ALARO together with ISBA surface scheme.

- Sixth 4D-Var working week at Oslo, Norway, 7-11 Nov, 2011. HIRLAM staff resources put on 4D-Var decreased and focus completely on AROME 4D-Var.

- ............ **Several HIRLAM working weeks later, also with Météo-France participation (Yann Michel, Pierre Brousseau)** ............
Default HARMONIE-AROME 4D-Var setup

- 3-hour observation window
- 3-hour cycling frequency
- Multi-incremental approach with 1\textsuperscript{st} loop @15 km and 2\textsuperscript{nd} loop @7.5 km
- During minimization the Aladin/Arpège linear physics package is used
- Operational observation sets have been tested
- Spectral q
- Memory saving option for trajectory storage
Central tasks in the 4D-Var setup

Note that 4DVscreen and 4DVtraj (2x) are 3h-forecasts with additional ODB IO.
1h forecast from 9 UTC

Analysis

Corrected forecast

Prevoius forecast

20 min
With a 3h observation window no satellite data is left out!
single observation experiment for a 2 hour observation window setting

specific humidity at 850 hPa and for 12UTC
Linearly computed analysis increment (11 UTC) and linearly propagated @5km to 12 UTC

Same increment propagated from 11 UTC to 12 UTC with full physics HARMONIE@2.5km

(Difference of two 4DVtraj’s)
<table>
<thead>
<tr>
<th>Obstype</th>
<th>3D-VAR</th>
<th>4D-Var</th>
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<tbody>
<tr>
<td>SYNOP</td>
<td>1026</td>
<td>2710</td>
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<tr>
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<tr>
<td>RADAR</td>
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<td>4871</td>
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</table>
Jo statistics during 7 days

- solid decrease in obs-model distance by minimization (from black to red lines)
- good correspondence between linear and nonlinear model (red and blue lines)
Experimental setup for three domains

Common:
- observation window is 3 hours
- loops @15km and @7.5km
- cycling time is 3 hours

Large series of 1-month experiments have been performed for these domains with a selection of observations:

- Conventional
- AMSU-A and IASI
- MHS
- GNSS ZTD
- Rh2m&T2m
- SCATTEROMETER
- MODE-S EHS
- RADAR (H)
Screen Level (SL) observations (T2m and Rh2m) assimilated in upper air (and in the surface analysis) for the Iberian Peninsula.

Set-up for the Iberian Peninsula both for 3D-Var and 4D-Var: (this can be domain dependent, in particular the LSOE flag):

**LSOE=.False.:** SL obs assimilated night & day
**LDIRCLMOD=.True.:** SL H(x) from diagnosed SL forecasts SL obs assimilated only at ANTIME (00, 03, ...)
**LBLVAR=.True.:** Avoiding interpolation in critical cases with strong inversion

4D-Var reduces bias
7 stations Selection: Spain Portugal
Specific humidity Period: 20201015-20201022
Used 00,03,...,21 + 01 02 ... 36

No cases

4D-Var
CONCLUDING REMARKS

• 4D-Var has matured and performance is neutral-positive compared to 3D-Var

• Operational feasibility is being considered (thereby exploring single precision, quadratic grid, …)

• Extension of future observation set (GNSS STD, SEVIRI, AMV, CRiS, …… MTG-IRS)

• Implemented and testing planned:
  - Control of lateral boundary condition (beginning of window)
  - Larger extension zone
  - Use of model tendency as control vector

• Overlapping windows and continuous assimilation

• More diagnostics: FSOI, DFS, OBSMON, ..
For more results and information, see

- Magnus Lindskog *et al.*: Use of microwave radiances from Metop-C, FY-3C and FY-3D satellites in MetCoOp data assimilation.

- Isabel Monteiro *et al.*: Assessing the impact of ASCAT winds assimilation in HARMONIE-AROME for a domain over the Iberian Peninsula.