Meteorologisk institutt

SMHI

Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Infrastructuur en Waterstaat

AEMet
Agencia Estatal de Meteorología

IPMA
Instituto Português do Mar e da Atmosfera

MET éireann

Status HARMONIE-AROME 4D-Var

1st ACCORD All Staff Workshop
12-16 April 2021

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Content

- 4D-Var configuration
- sanity checks
- some results
- conclusion and outlook

Brief HARMONIE-AROME 4D-Var History

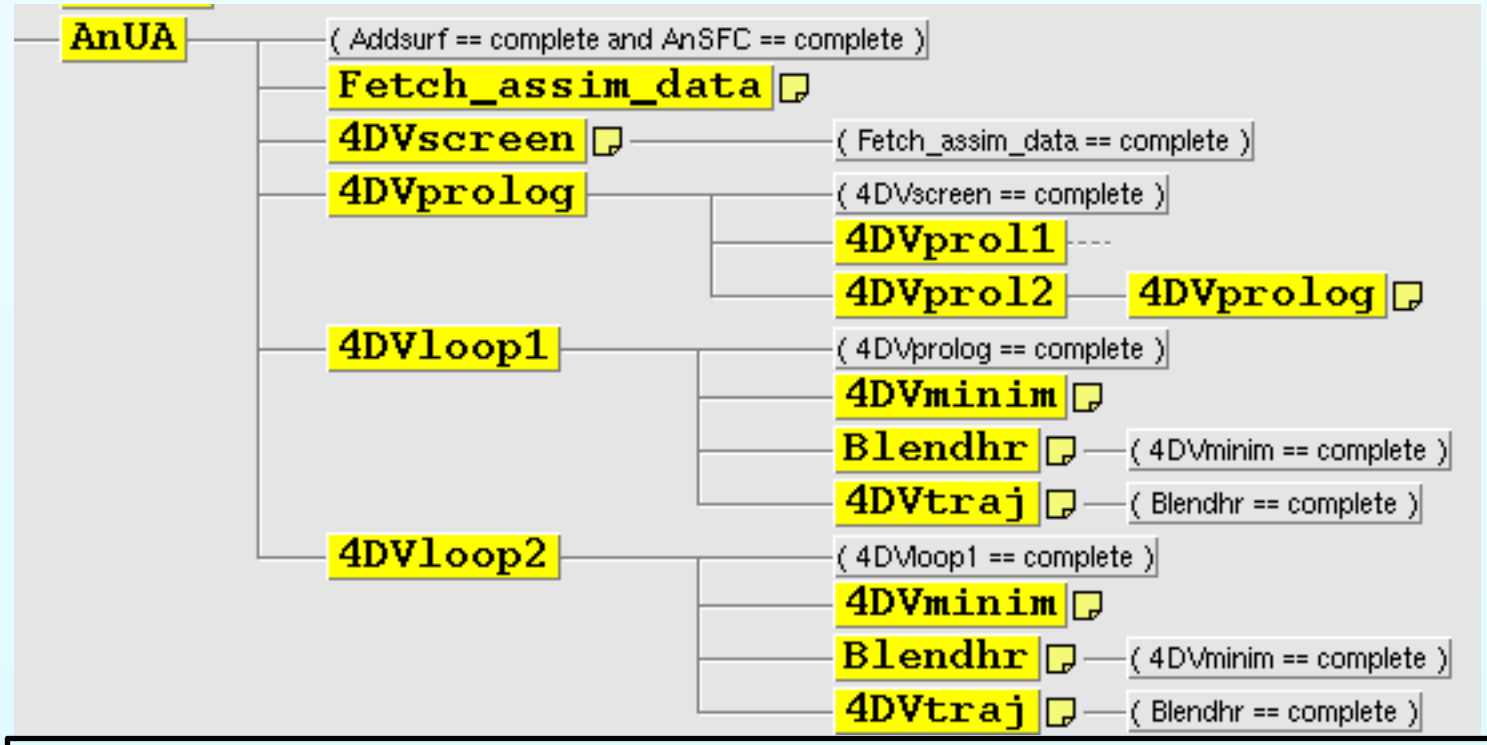
- **Nils, Magnus and Ole** visit Météo-France Dec. 8-12, 2008, to learn how Bernard Chapnik had set up first version of ALADIN 4D-Var (in OLIVE system).
- First HARMONIE 4D-Var working week at met.no June 8-11, 2009 (Nils, Magnus, Ole, **Trygve**), during which HARMONIE 4D-Var mini-SMS prototype is developed.
- 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, **Roge**r). 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**) ……

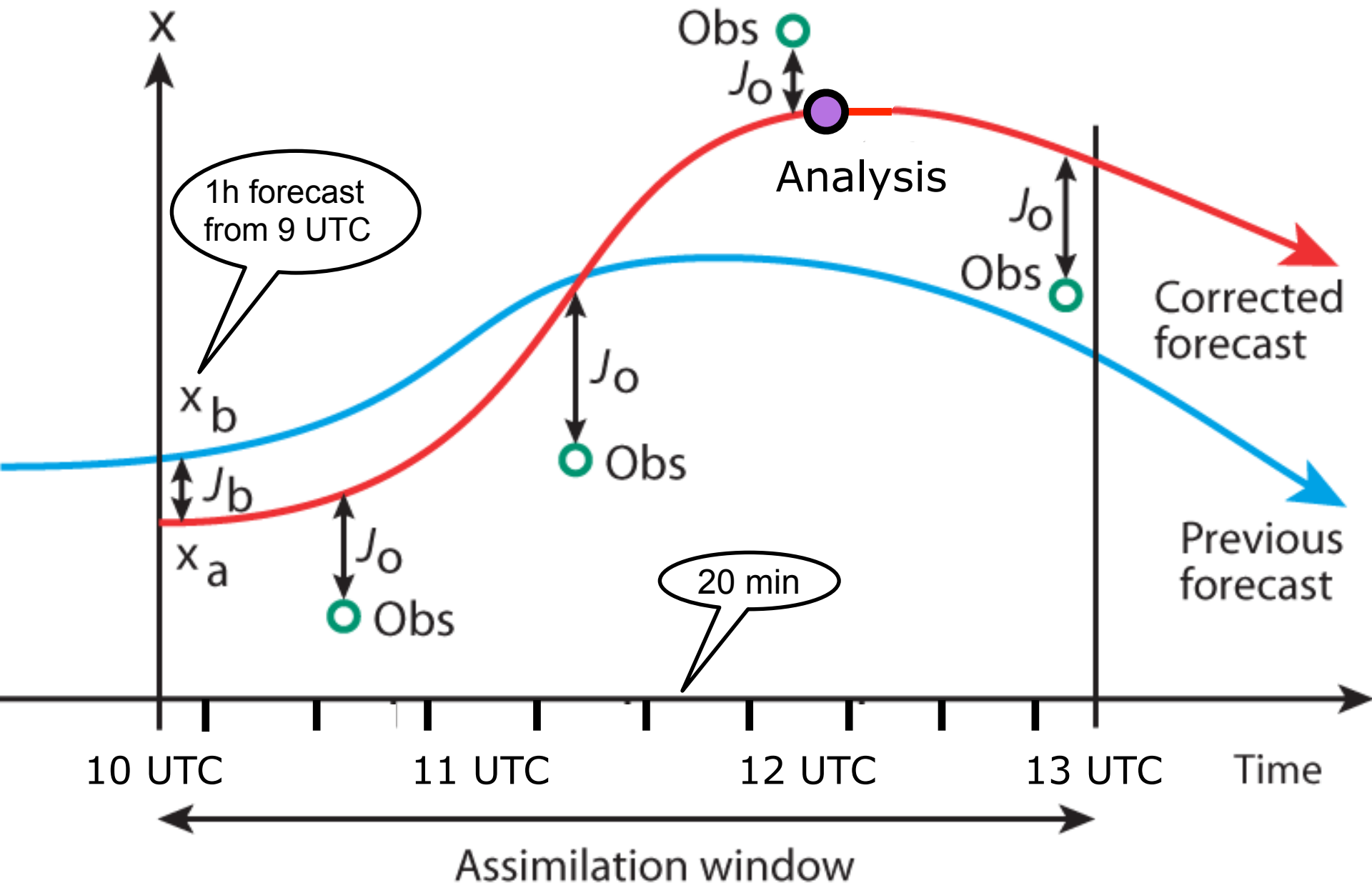
Default HARMONIE-AROME 4D-Var setup

- 3-hour observation window
- 3-hour cycling frequency
- multi-incremental approach with 1st loop @15 km and 2nd 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

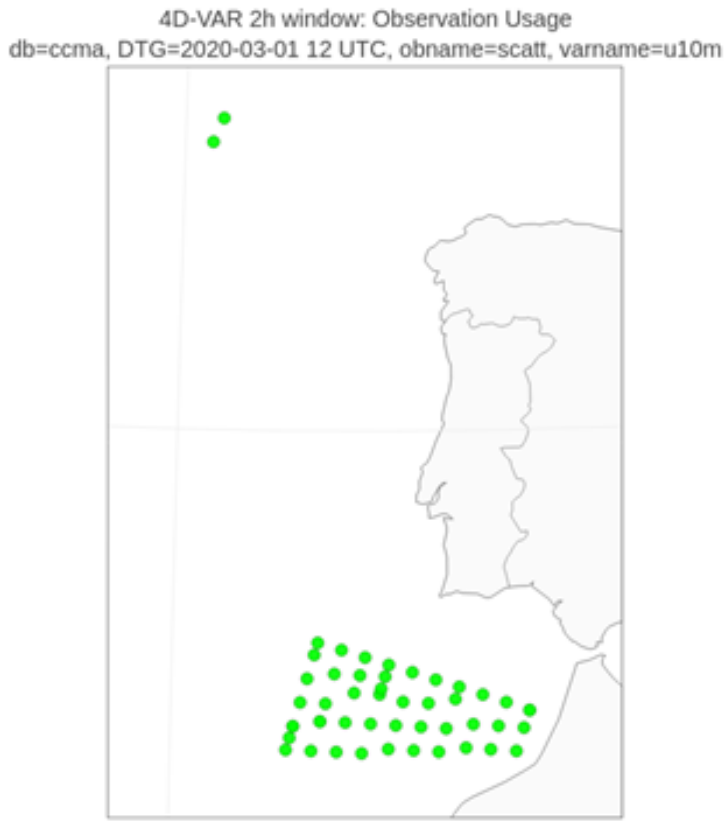
Central tasks in the 4D-Var setup

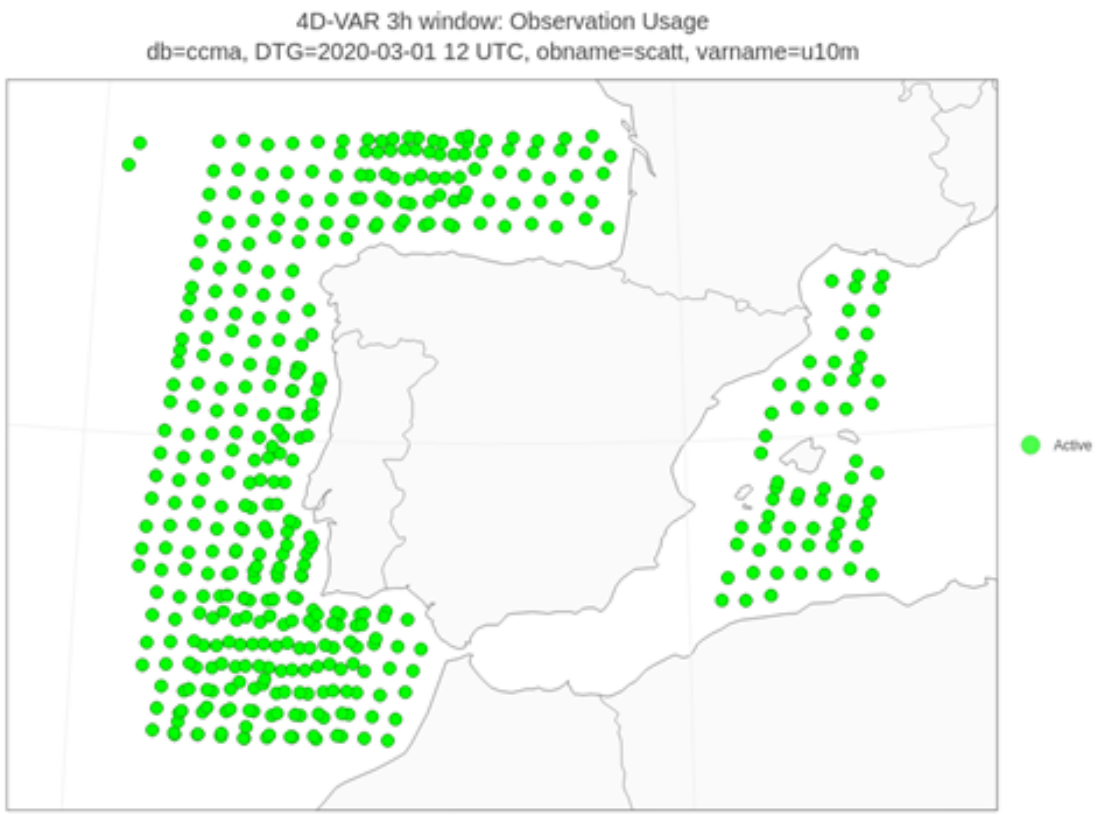


Note that 4DVscreen and 4DVtraj (2x) are 3h-forecasts with additional ODB IO.


x
Obs
J_o
Analysis
1h forecast
from 9 UTC
J_o
Obs
Corrected
forecast
x_b
J_o
Obs
J_b
x_a
J_o
Obs
20 min
Previous
forecast
10 UTC
11 UTC
12 UTC
13 UTC
Time
Assimilation window

With a 3h observation window no satellite data is left out !

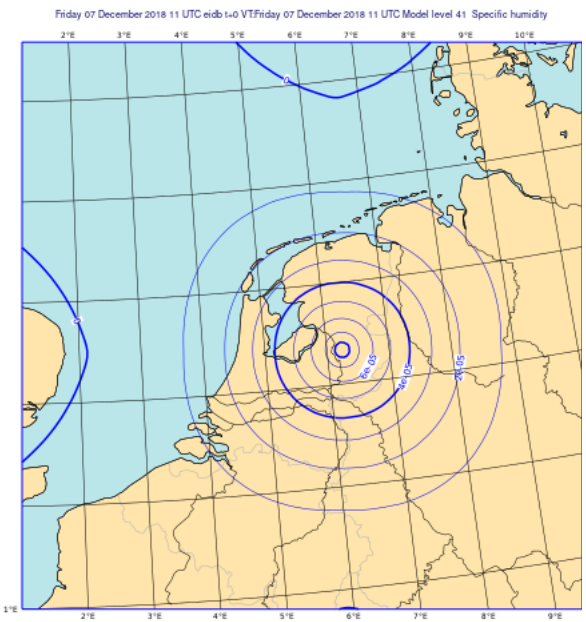




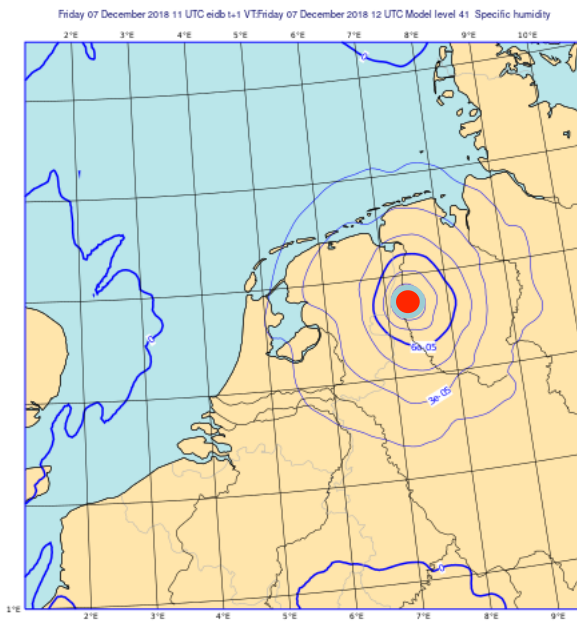
single observation experiment for a 2 hour observation window setting

specific humidity at 850 hPa and for 12UTC

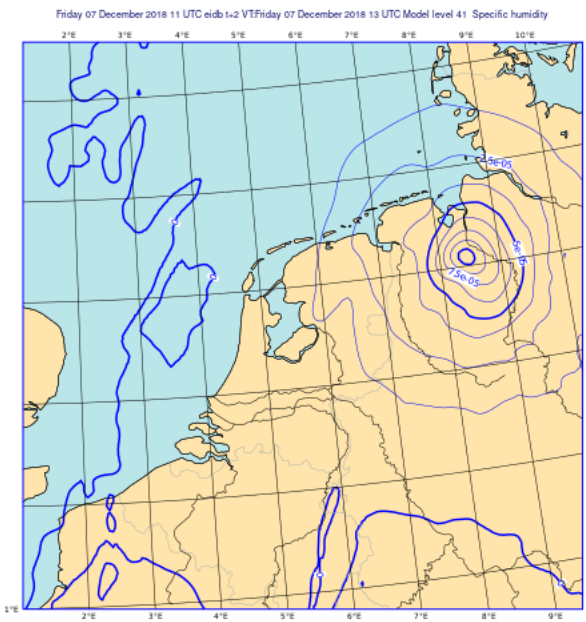
11 UTC

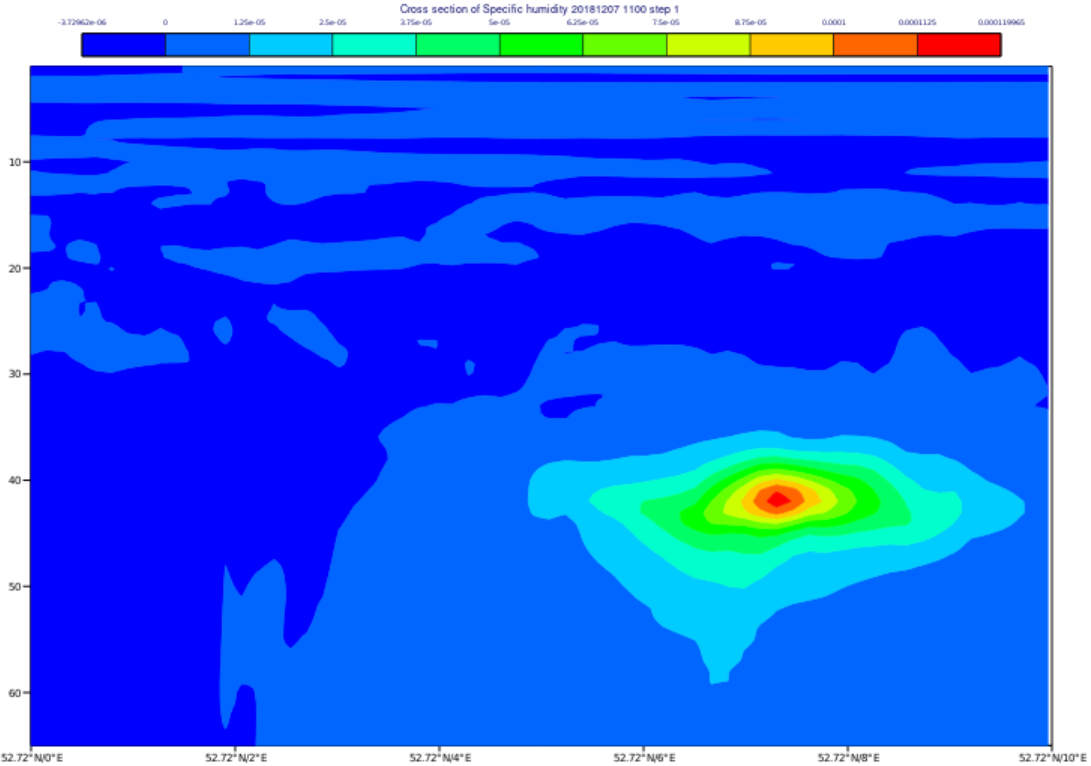


12 UTC

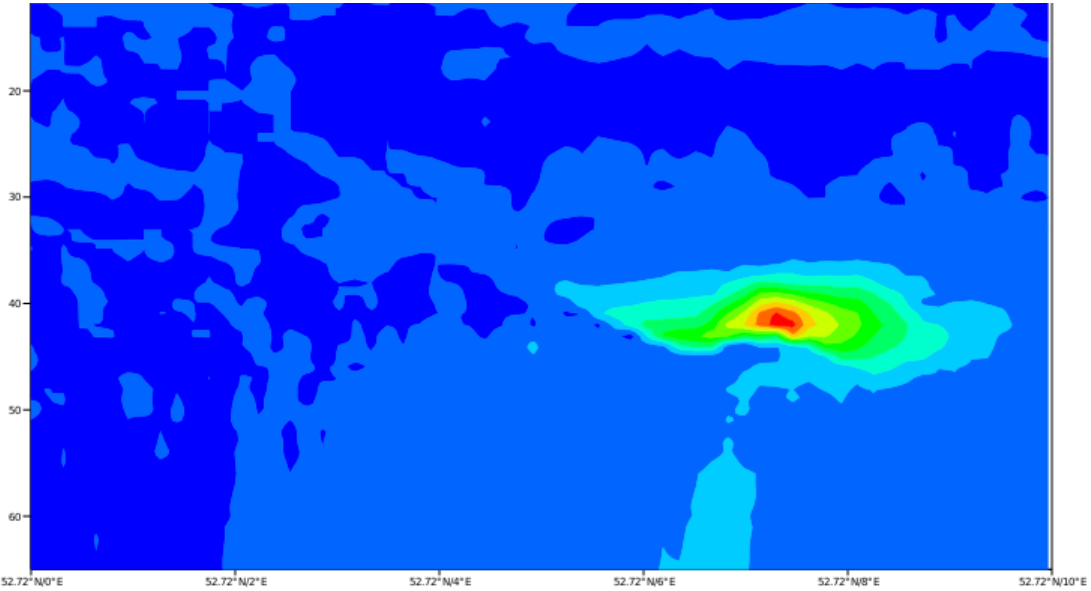


13 UTC



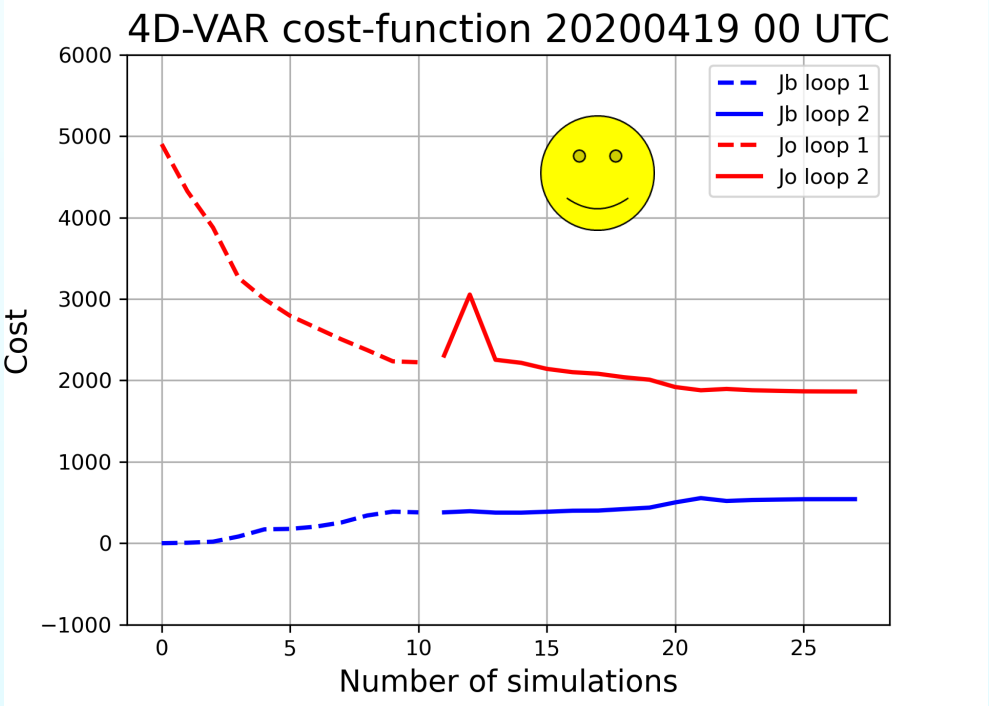


Linearly computed analysis increment (11 UTC) and linearly propagated @5km to 12 UTC



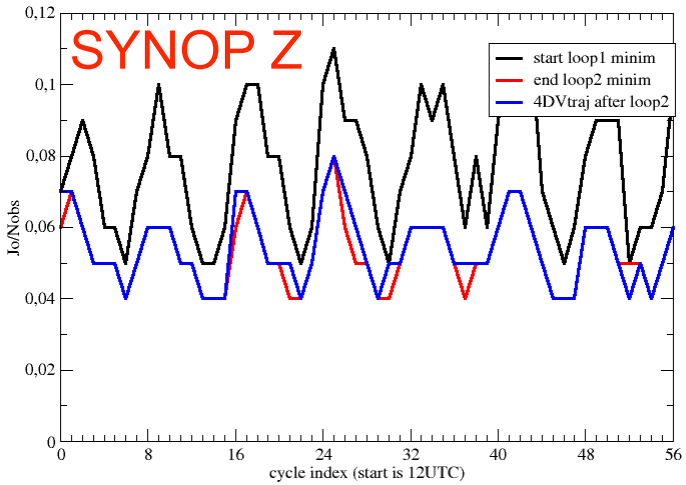
Same increment propagated from 11 UTC to 12 UTC with full physics HARMONIE@2.5km

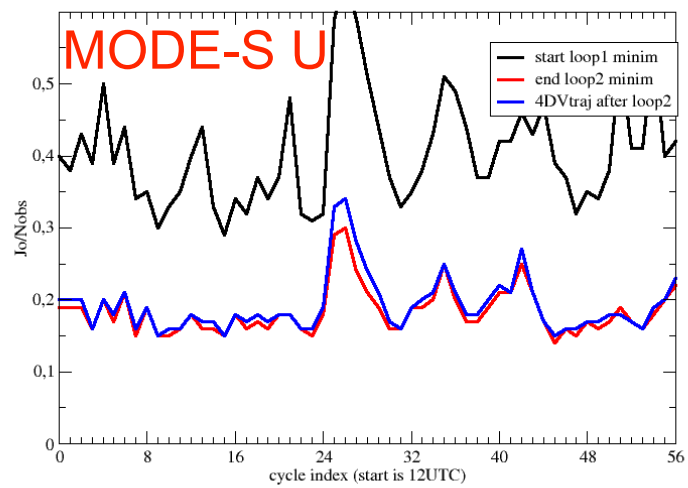
(Difference of two 4DVtraj's)

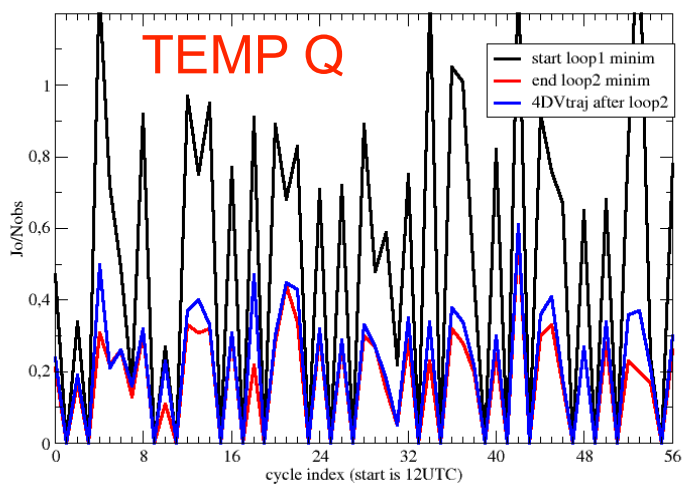


Obstype	3D-VAR	4D-Var
SYNOP	1026	2710
TEMP	23161	19900
AIREP	4161	8978
ASCAT	302	314
RADAR	1700	4871

Jo statistics during 7 days





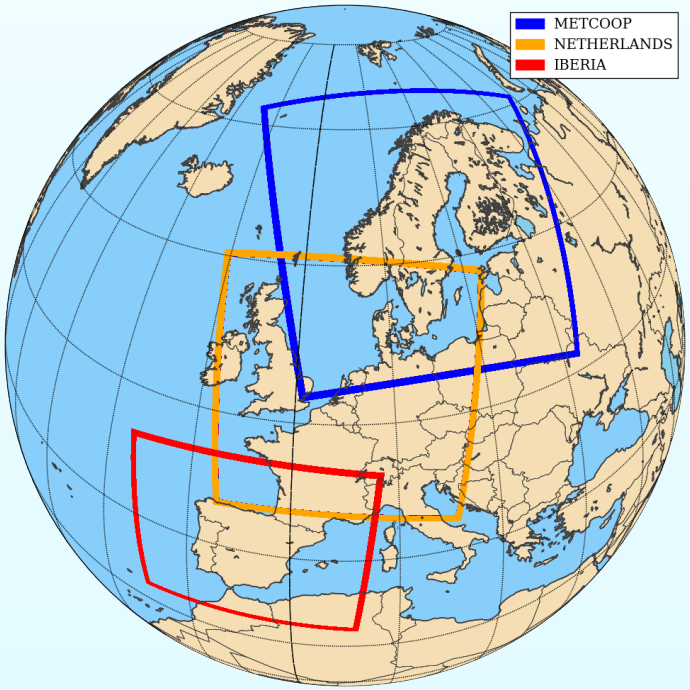


- solid decrease in obs-model distance by minimization (from black to red lines)
- good correspondence between linear and nonlinear model (red and blue lines)

Experimental setup for three domains

Common:

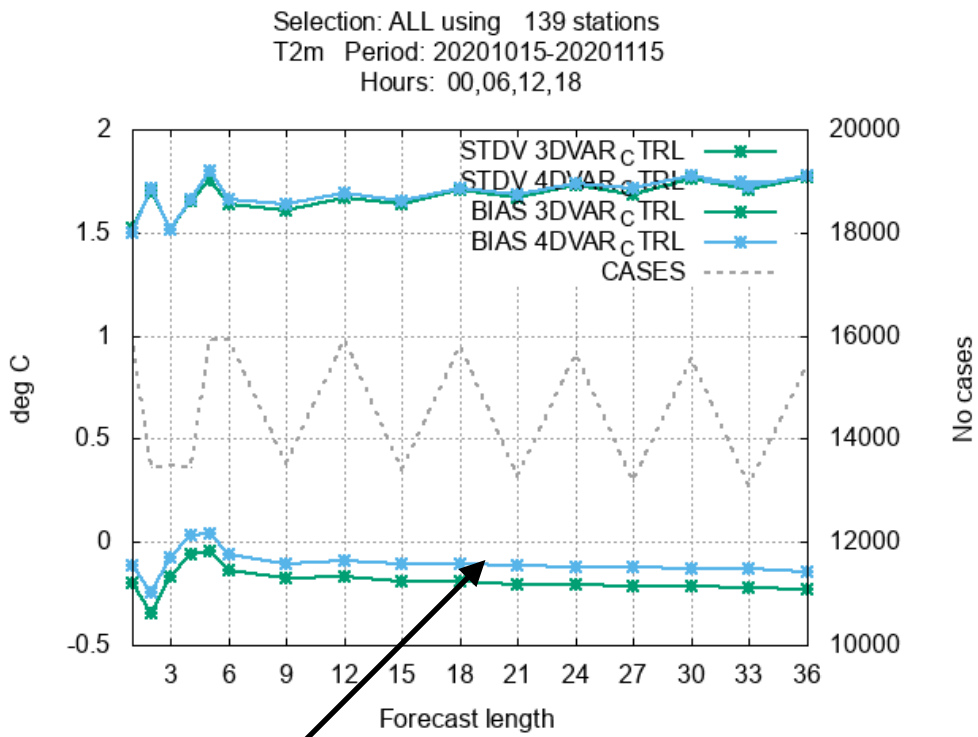
- observation window is 3 hours
- loops @15km and @7.5km
- cycling time is 3 hours



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)

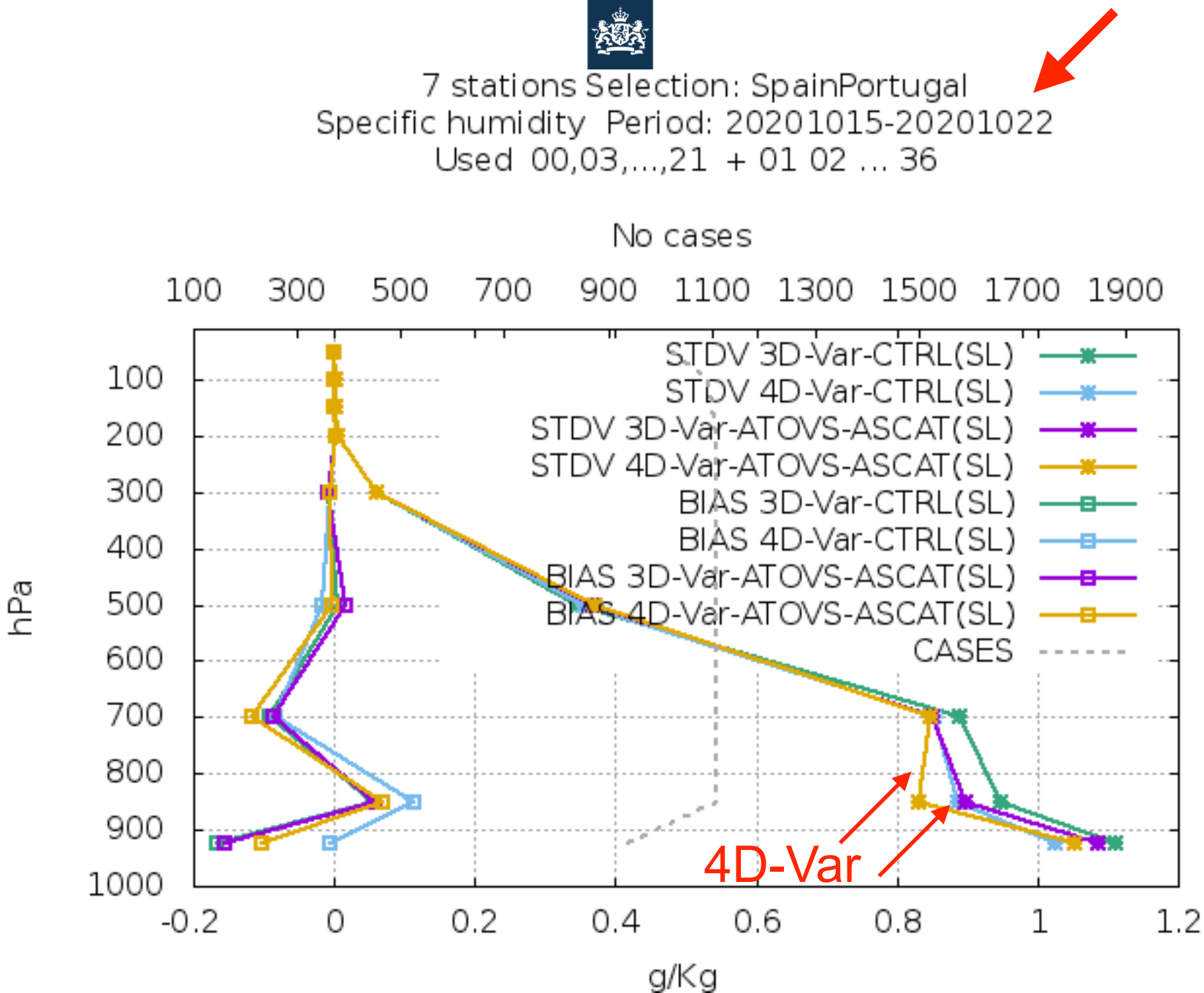
Screen Level (SL) observations (T2m and Rh2m) assimilated in upper air (and in the surface analysis) for the Iberian Peninsula.



4D-Var reduces bias

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


7 stations Selection: SpainPortugal
Specific humidity Period: 20201015-20201022
Used 00,03,...,21 + 01 02 ... 36
No cases
100 300 500 700 900 1100 1300 1500 1700 1900
STDV 3D-Var-CTRL(SL)
STDV 4D-Var-CTRL(SL)
STDV 3D-Var-ATOVS-ASCAT(SL)
STDV 4D-Var-ATOVS-ASCAT(SL)
BIAS 3D-Var-CTRL(SL)
BIAS 4D-Var-CTRL(SL)
BIAS 3D-Var-ATOVS-ASCAT(SL)
BIAS 4D-Var-ATOVS-ASCAT(SL)
CASES
hPa
100 200 300 400 500 600 700 800 900 1000
-0.2 0 0.2 0.4 0.6 0.8 1 1.2
g/Kg
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.