IPMA Instituto Português do Mar e da Atmosfera

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Local AROME surface Data Assimilation: status and plans

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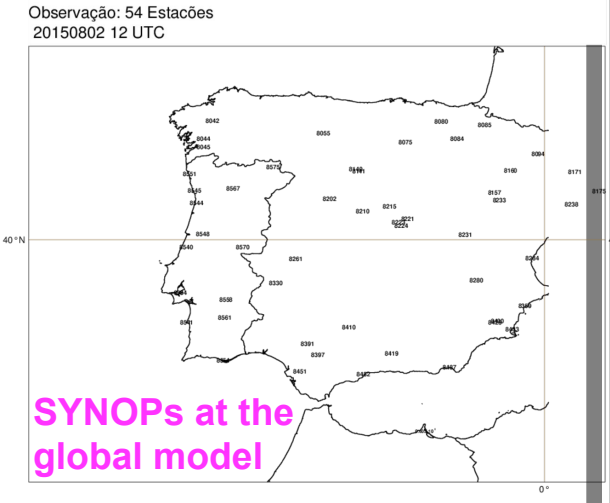
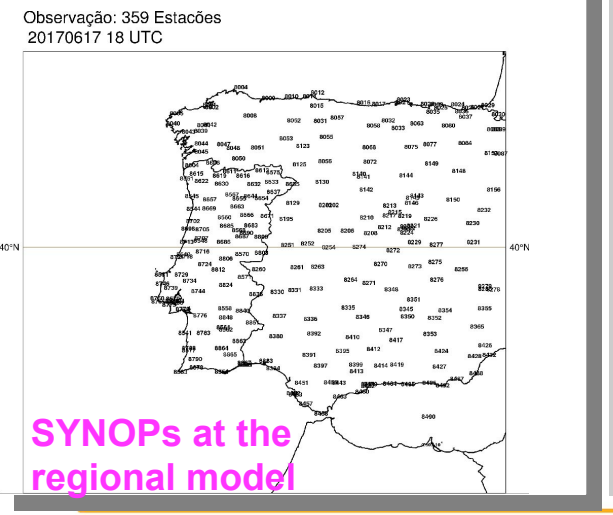
Outline

1. Motivation
2. AROME surface DA scheme
3. Local surface DA implementation
4. Preliminary scores & diagnostics
5. Conclusions & future outlook

Motivation





1. IPMA runs in operations a local version of the convention-permitting model AROME (Piet et al., 2018) in a limited area over Iberia with a 2.5 km resolution -> AROME_PT2

2. AROME was designed to solve deep convection and to simulate very localised atmospheric phenomena with a short living cycle, specially on the PBL, with high-impact on the human activities

3. Up to now the model was initialised by dynamical adaptation of the global model ARPEGE and does not contains the information on the atmospheric short-scales

4. Over the Iberian Peninsula there is a relatively dense network of hourly surface observations which is maintained by the national met. services and data is shared in quasi real-time

5. A Data Assimilation system aims at combining a short-range numerical forecast with available observations to provide the model with the best image a model may have in its initial time, for the atmospheric scales it was designed

AROME surface DA scheme - CANARI_OI-MAIN/ SURFEX

Optimum Interpolation: implementation in the CANARI software (I)

1) Optimum Interpolation of T_{2m} and RH_{2m} using 2m observations interpolated at the model grid-point by a 2m analysis (2-D CANARI OI)

$$\Delta T_{2m} = T_{2m}^{a} - T_{2m}^{b} \qquad \Delta RH_{2m} = RH_{2m}^{a} - RH_{2m}^{b}$$

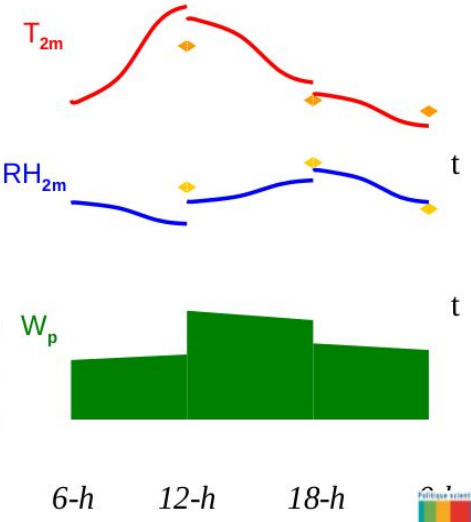
2) Correction of 4 surface parameters (T_s, T_p, W_s, W_p) using 2m increments between analysed and forecasted values.

$$T_p^{a} - T_p^{b} = \Delta T_{2m} / 2\pi \qquad T_s^{a} - T_s^{b} = \Delta T_{2m}$$

$$W_s^{a} - W_s^{b} = \alpha_{WsT} \Delta T_{2m} + \alpha_{WsRH} \Delta RH_{2m}$$

$$W_p^{a} - W_p^{b} = \alpha_{WpT} \Delta T_{2m} + \alpha_{WpRH} \Delta RH_{2m}$$

Sequential analysis



OI coefficients

$$\alpha_{W_s pT} = \frac{\sigma^{b}_{W_s p}}{\Phi \sigma^{b}_{T2m}} \left\{ \left[1 + \left(\frac{\sigma^{a}_{RH2m}}{\sigma^{b}_{RH2m}} \right)^2 \right] \rho_{T2m,W_s p} - \rho_{T2m,RH2m} \rho_{RH2m,W_s p} \right\}$$

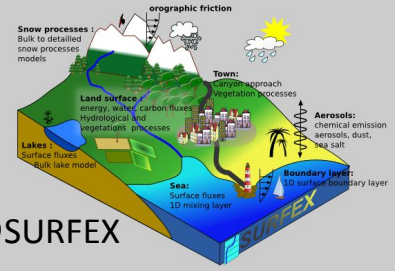
$$\alpha_{W_s pRH} = \frac{\sigma^{b}_{W_s p}}{\Phi \sigma^{b}_{RH2m}} \left\{ \left[1 + \left(\frac{\sigma^{a}_{T2m}}{\sigma^{b}_{T2m}} \right)^2 \right] \rho_{RH2m,W_s p} - \rho_{T2m,RH2m} \rho_{T2m,W_s p} \right\}$$

$$+ \left(\frac{\sigma^{a}_{T2m}}{\sigma^{b}_{T2m}} \right)^2 \left[1 + \left(\frac{\sigma^{a}_{RH2m}}{\sigma^{b}_{RH2m}} \right)^2 \right] - \rho^{2}_{T2m,RH2m}$$

- Very strong dependency of these background error statistics to **physiographic** properties and **meteorological conditions.**

@Rafiq, 2018

1. Surface mass and energy forcing to AROME is provided by SURFEX



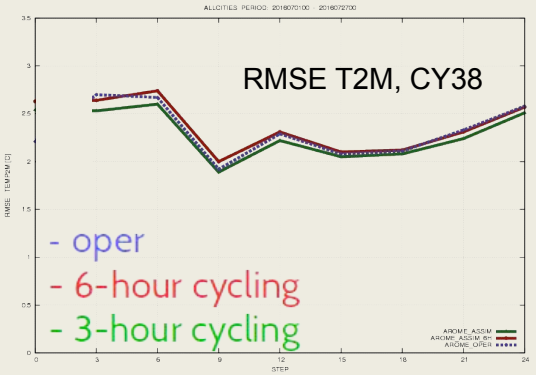
@SURFEX

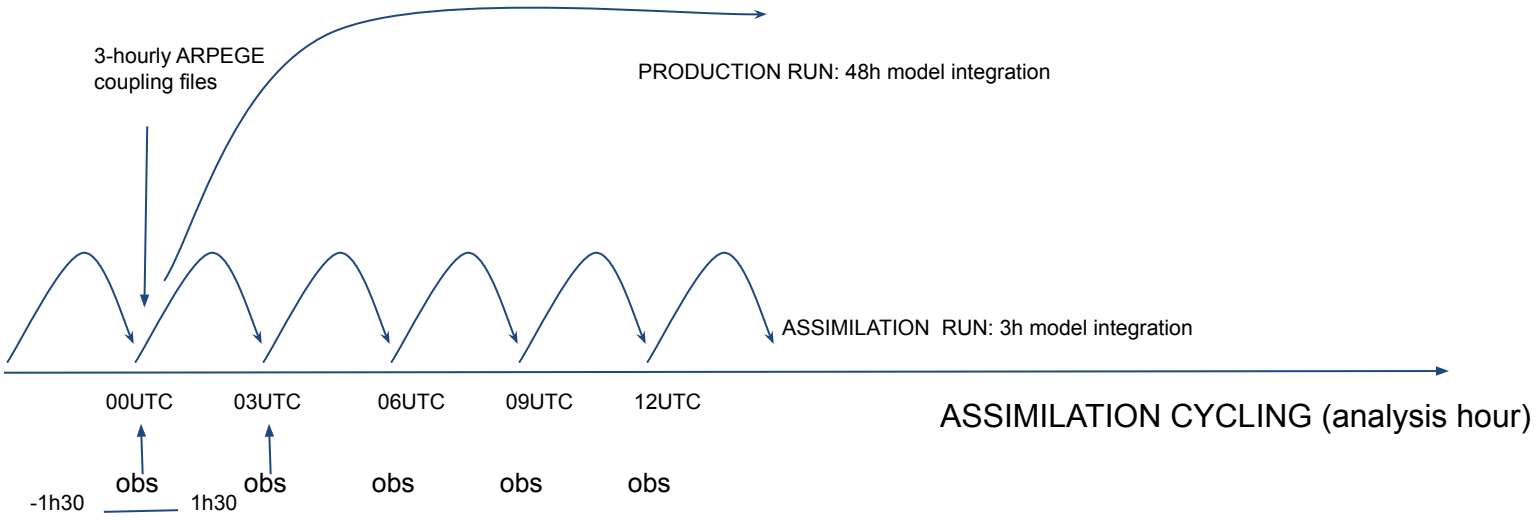
2. The surface DA scheme of AROME follows the ideas of Giard et Bazile (2000) to refresh the soil and deep soil temperature and moisture, from near surface parameters (T2M, RH2M) and uses SURFEX to produce a more realistic initial forcing to the AROME model

Local surface DA implementation - I

AROME_PT2 (Iberia)

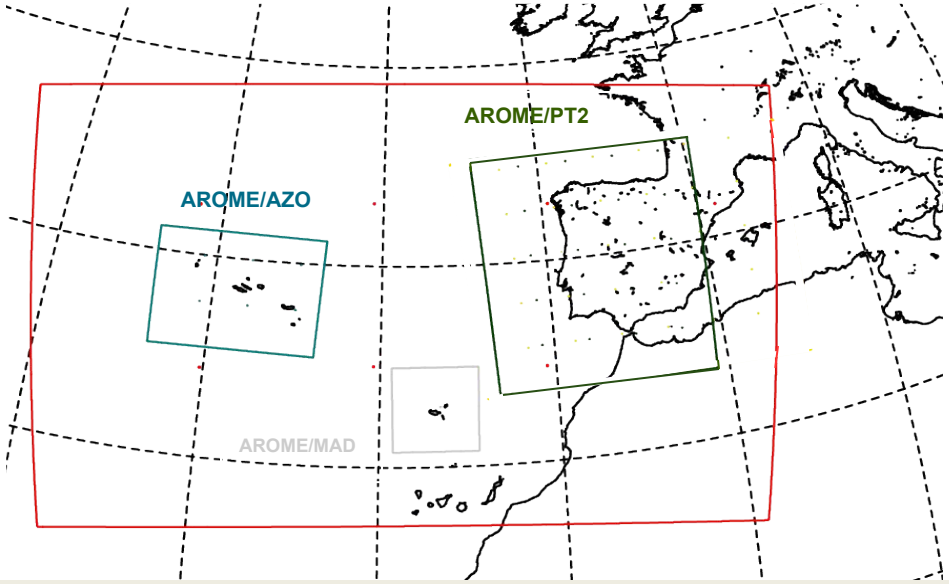
Resolution: 2.5km
Observations: regionally shared Iberian SYNOP
Upper-air analysis: none
Surface analysis: CANARI_OI-MAIN
Cycling frequency: 3 hours
Coupling model: 3-hour frequency ARPEGE forecasts (~9km)
Production time: 00UTC (for the time being)
Computing platform: HPC ECMWF
Scripting system: ARSO_IPMA (ecflow)
Programme: DAsKIT (ACCORD WP8; ALADIN DAsKIT); CY43T2 T-codes from ALADIN system





Local surface DA implementation - II

Local operations (IBM_p7+ (9 nodes)):



February 2020
DynAD CY40T1_L60,2.5km,ARPEGE coupling (export version)
AROME/PT2 + AROME/MAD + AROME/AZO (48-hour prognostics)

September 2018
SurfDA CY38T2_L46 for AROME/PT2 (used for hourly diagnostics) -> DAsKIT set

outlook: new local HPC in 2022

Ported @ ECMWF & NEW developments:

Daily archiving
Local ARPEGE couplings
GTS & local observations under GTS WMO BUFR format
Local OIFS HDF5 radar observations

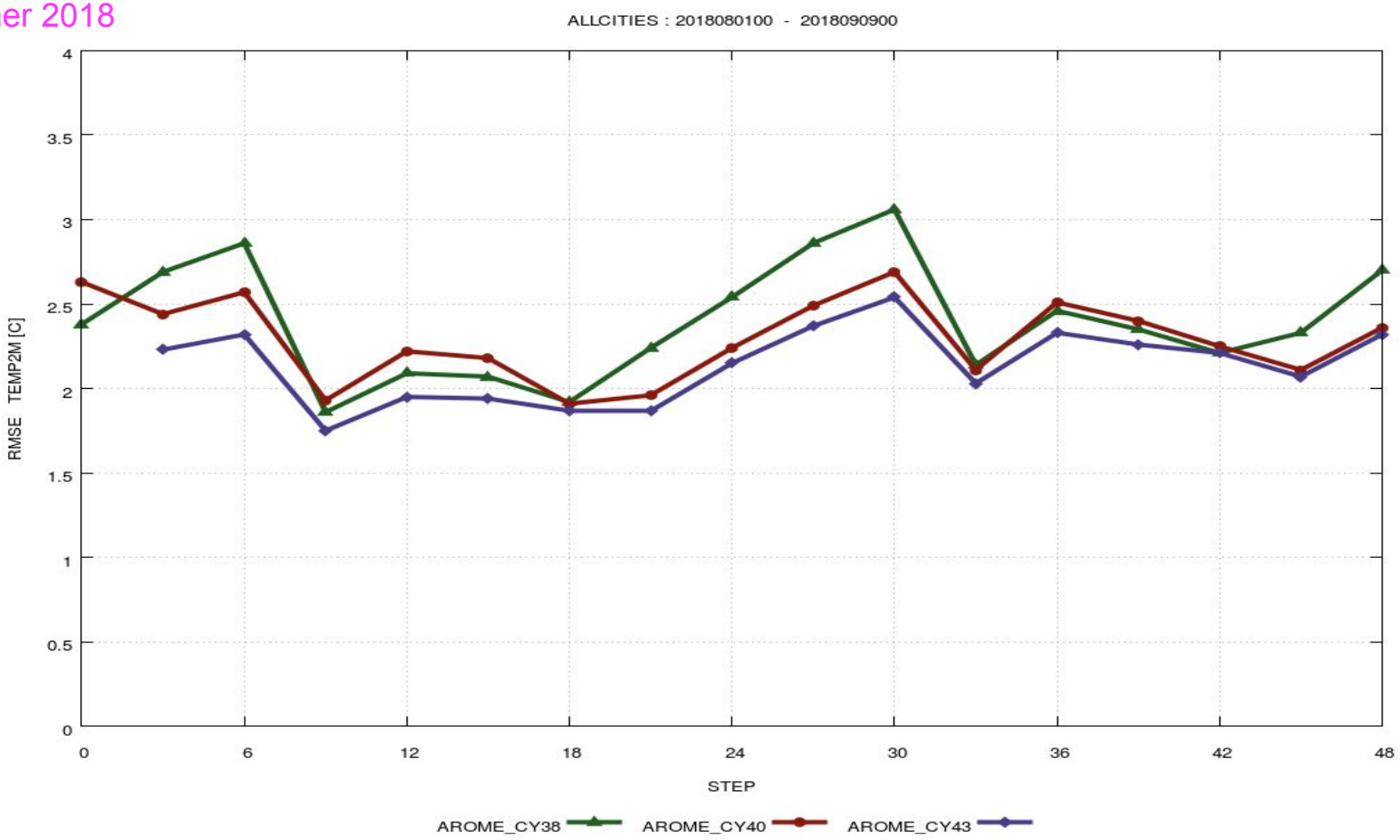
Missing the DA implementation over Azores !

AROME CY43T2_bf10 (3-hour cycling since 19 July 2021)

DynAD:	AROME/**PT2_L60,2.5km**	AROME/**MAD_L60,2.5km**	AROME/**AZO_L60,2.5km**
SurfDA:	AROME/**PT2_L60,2.5km**	AROME/**MAD_L60,2.5km**	**Issues during integration**
CombDA:	AROME/**PT2_L60,2.5km**	AROME/**MAD_L60,2.5km**	**None**

Preliminary scores & diagnostics - I

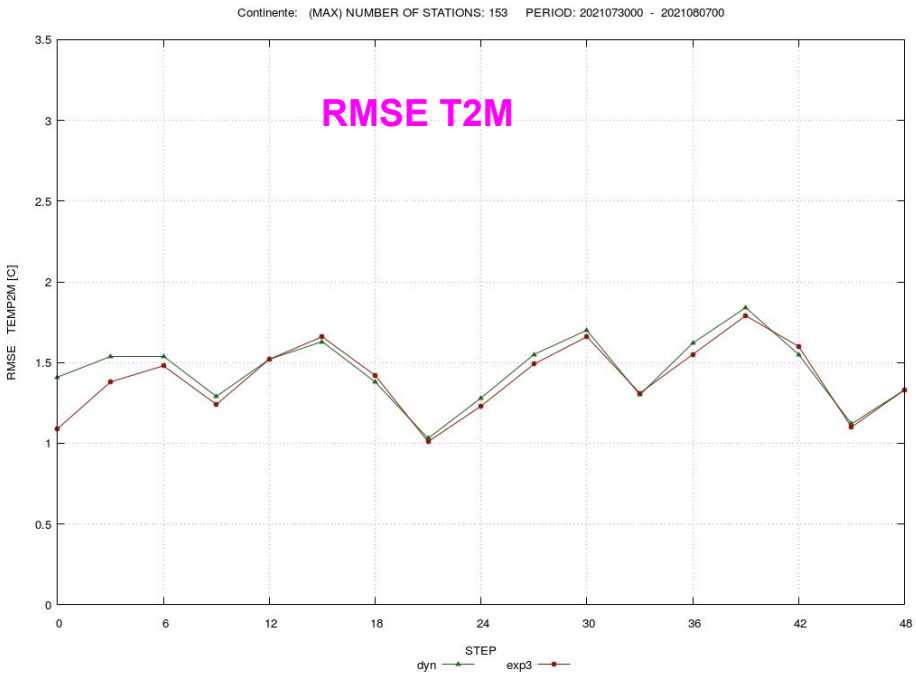
Summer 2018

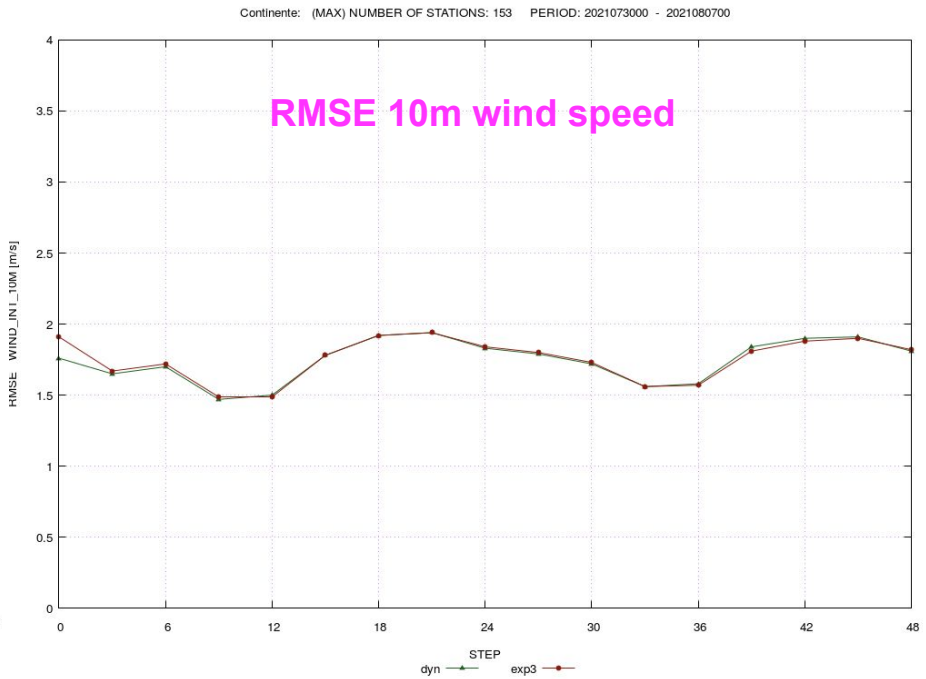


FIRST STEP: Validation of the dynamical adaptation configuration over the three domains (Rio et al, 2021)

Preliminary scores & diagnostics - II

Sampling period 20210730-20210807: 00UTC run; PT2 domain, up to 153 weather stations (after 10 days cycling)



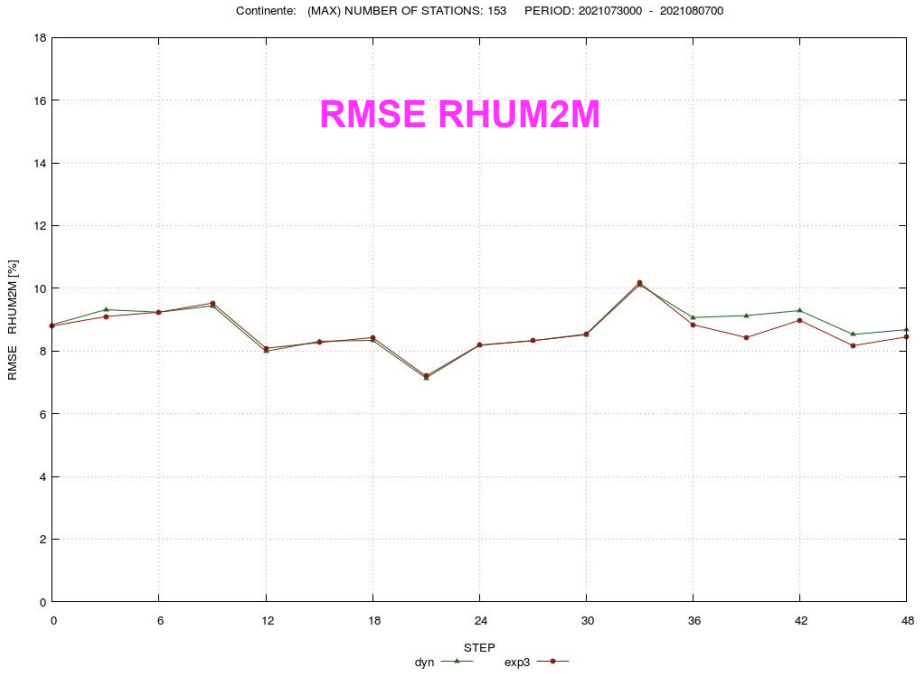


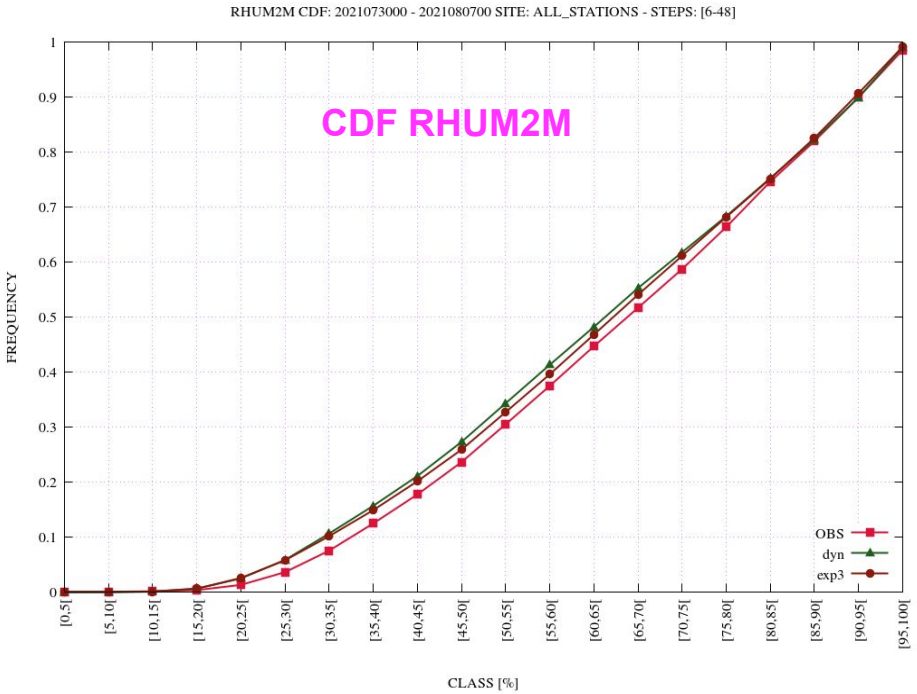
dyn **surfDA**

Initialisation by surface DA: improvement in TEMP2M; neutral for 10m wind speed

Preliminary scores & diagnostics - III

Sampling period 20210730-20210807: 00UTC run; PT2 domain, up to 153 weather stations (after 10 days cycling)

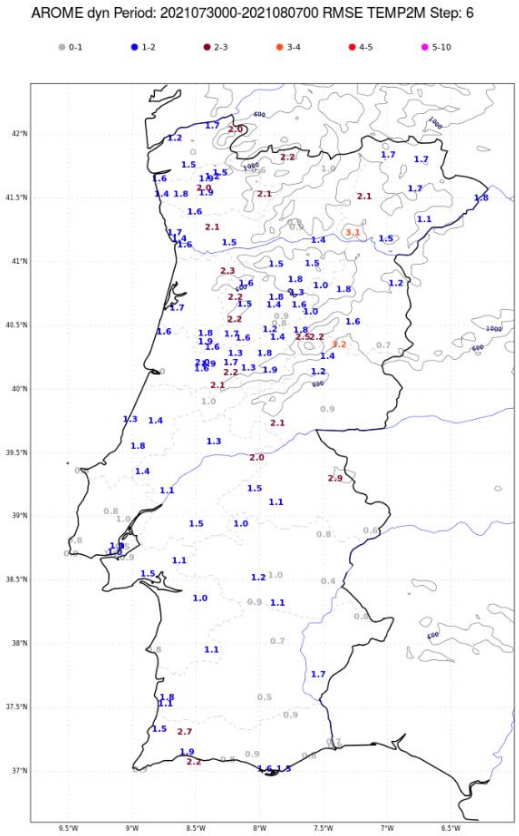




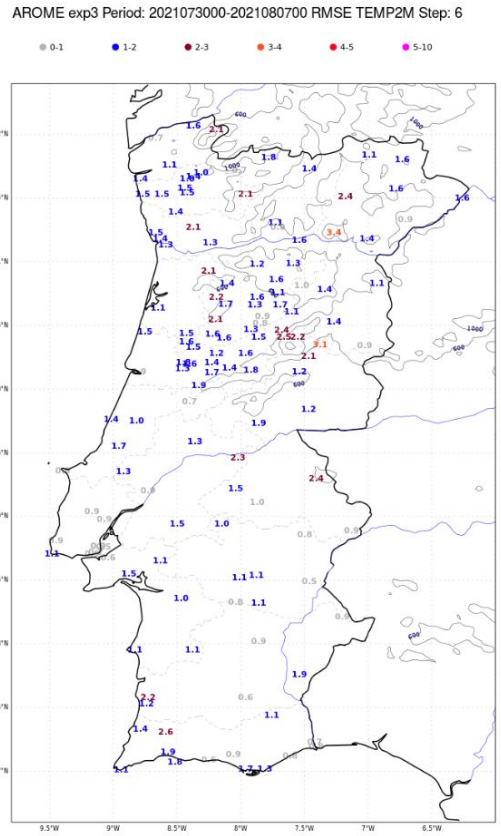
dyn surfDA obs

Initialisation by surface DA: improves the match for the RH2M

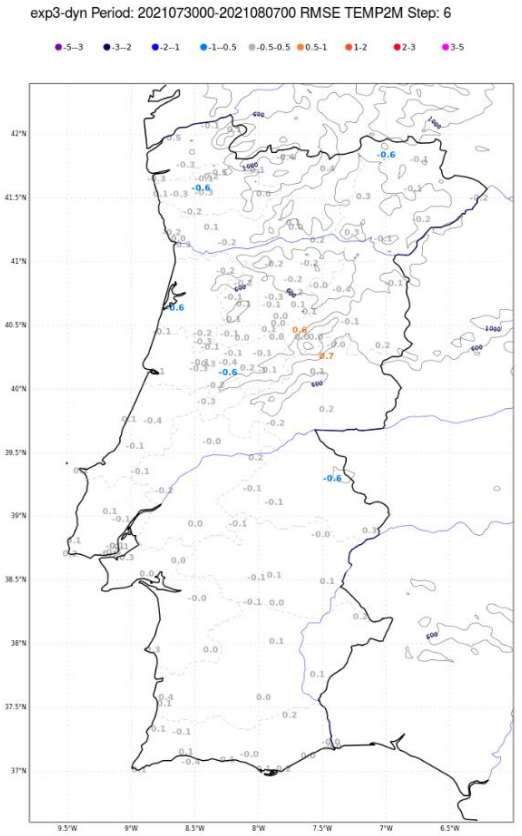
Preliminary scores & diagnostics - IV



RMSE TEMP2M dyn



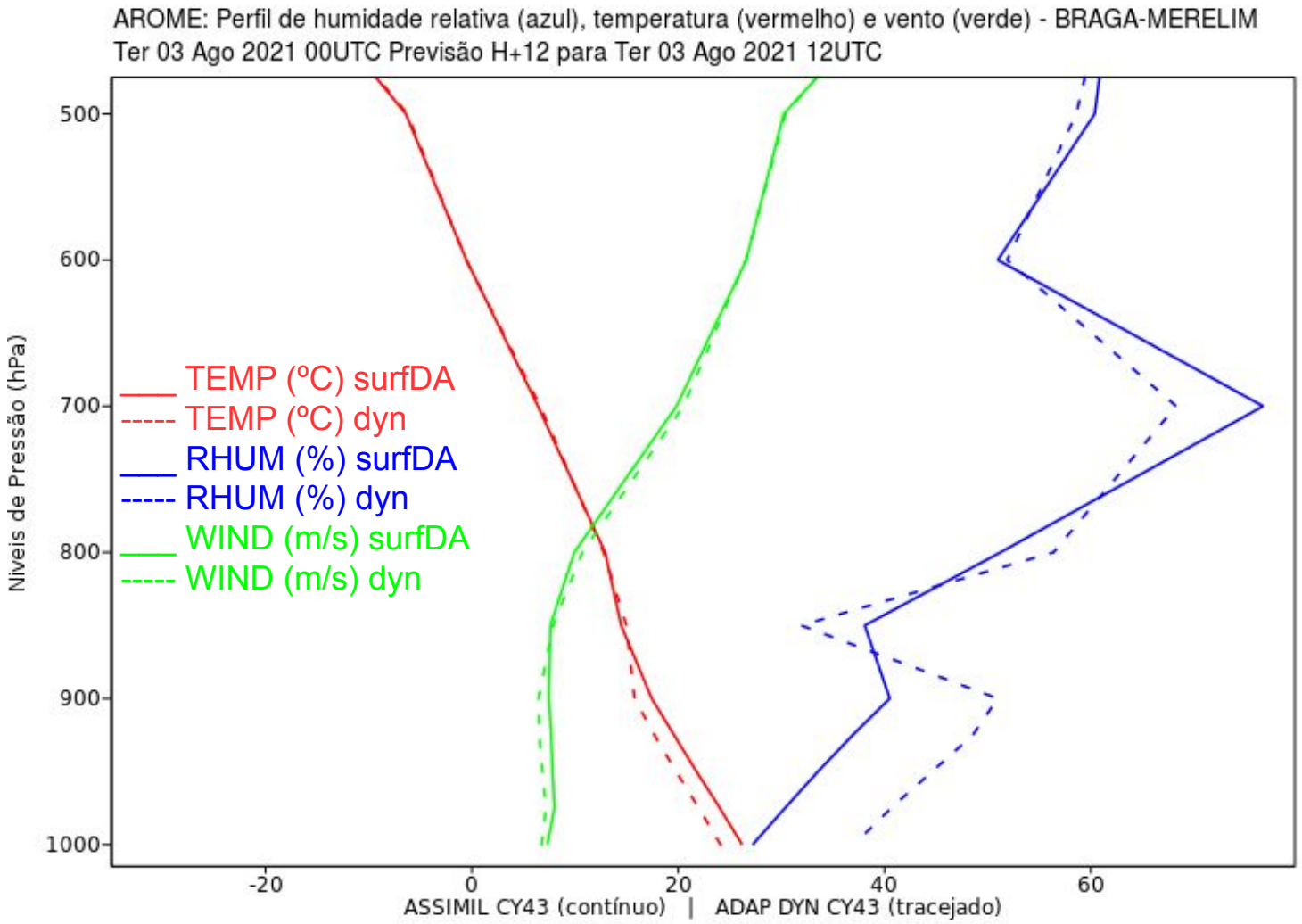
RMSE TEMP2M surfDA



RMSE TEMP2M surfDA-dyn

Preliminary scores & diagnostics - V

AROME_PT2 (2021.08.03, H+12) atmospheric profile



Conclusions & future outlook - I

- Iberian surface observational network has the potential to add value to the initial lower conditions of the convective-permitting model AROME

- IPMA has a cheap surface DA tool suitable for operational implementation and uses surface Iberian observations to include small-scales atmospheric information on the lower initial conditions of the local AROME model, with the potential to add value the near surface meteorological forecasts

- The tool, associated to the DAsKIT effort - on which Portugal participated - is being jointly assembled, maintain and validated under the synergies of the partners of the ACCORD consortium (former ALADIN+LACE+HIRLAM)

- It is based on a combination of an horizontal Optimal Interpolation analysis algorithm of T2M an RH2M, and a vertical, flow dependent (ISBA sense), linear extrapolation providing a refreshment to the soil and deep soil temperature and moisture (SURFEX)

- The tool is now under validation and tuning on the latest (export) cycle of the ALADIN-HIRLAM system and the preliminary results are promising

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Conclusions & future outlook - II

- **Foreseen & on-going developments in the short-term (operational implementation) will include:**
  - inclusion of Alqueva on the CY43T2 climatologies (not included yet on any version ecoclimap_v1 - used in operations; may be included in ecoclimap_v2 or ecoclimap-SG ?)
  - further tuning of the structure functions on the OI algorithm (determination of the characteristic length-scale - L; MESCAN with and without isotropic characteristics)
  - revisiting the Zenith Solar Angle impact on the vertical extrapolation coefficients
  - a brief seasonal validation once stabilised the tool
  - investigation of of the surface Iberian (SYNOP) observations added value when assimilated by a combination of the surface with an upper-air (3D-Var) algorithm
  - extend the system to an Atlantic area covering Madeira
  - test the surface DA over the Azores

- **Foreseen & on-going developments in the longer-term (I&D) will include:**
  - application to the assimilation of four 'mobile' weather stations strategically placed on hilly mountains (Lousã & Seia), to investigate its added on lower level inversion simulation (with high-impact on wildfire propagation) -> FireStorm project (FCT)
  - assimilation of LST on the surface scheme (Météo-France)
  - the investigation of the added value of an EKF in comparison to the OI scheme in operations (OMZS)

Thank you for your attention !

Termonia, P., Fischer, C., Bazile, E., Bouyssel, F., Brožková, R., Bénard, P., Bochenek, B., Degrauwe, D., Derková, M., El Khatib, R., Hamdi, R., Mašek, J., Pottier, P., Pristov, N., Seity, Y., Smolíková, P., Španiel, O., Tudor, M., Wang, Y., Wittmann, C., and Joly, A.: *The ALADIN System and its canonical model configurations AROME CY41T1 and ALARO CY40T1*, Geosci. Model Dev., 11, 257–281, https://doi.org/10.5194/gmd-11-257-2018, **2018**.

SURFEX: https://www.umr-cnrm.fr/surfex/

Giard, D., et Bazile, E.: *Implementation of a New Assimilation Scheme for Soil and Surface Variables in a Global NWP Model*, Monthly Weather Review, 128, 997-1015, **2000**.

Rafiq, H.: *Review of surface data assimilation in ALADIN/HIRLAM*, 2018 DAsKIT Working Days, Romania, 19-21 September, **2018**, available from: http://www.umr-cnrm.fr/aladin/IMG/pdf/hamdi_surface_da.pdf.

Rio, J., Lopes, M.J., Monteiro, M. and Lopes, N.: Validation of AROME CY43T2 configurations at IPMA, ACCORD Newsletter 1, **2021,** available from: http://www.umr-cnrm.fr/accord/IMG/pdf/accord-nl1.pdf.