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Assimilation of Doppler Radar Radial Winds in the HARMONIE-AROME model configuration run at AEMET

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1.Introduction

HARMONIE-AROME (Bengtsson et al., 2017) operational suite in AEMET that runs on the Nimbus supercomputer:

- The model runs at 2.5 horizontal resolution and 65 vertical model levels extending up to 10 hPa, over a geographical domain centered on thIberian Peninsula that includes the Balearic Islands.
- 3DVar data assimilation with a 3h cycle
- Large scale mixing for all variables (including humidity) activated.
- Observations assimilated: SYNOP, SHIP, DRIBU, AMDAR, and TEMP reports, GNSS ZTD data, ATOVS satellite radiances from AMSUA and AMSUB/MHS instruments, ASCAT, 2 meter temperature and relative humidity assimilated in upper air and radar reflectivity from 40 radars from three countries: Portugal, Spain and France.

The introduction of the radar reflectivity in AEMET operational HARMONIE-AROME system in 2019 has demonstrated to be beneficial, and to complement other humidity data assimilated from GNSS ZTD, ATOVS and Radiosonde observations. It produced a positive impact on HARMONIE forecasts, especially on precipitation. This improvement was mainly associated to a decrease of the False Alarms ratio. The assimilation procedure for radar reflectivity and some results can be found in Sánchez-Arriola et al. (2019).

The process followed to assimilate Doppler radial winds (DRWs) data processed and disseminated by OPERA, and the results obtained with respect to the current AEMET operational NWP run configuration are explained here. **For more details** see ALADIN-HIRLAM Newsletter N16 2021 ,p65-76.

2. Radar observations assimilated

Currently, the AEMET HARMONIE-AROME operational run assimilates **reflectivity data** from Portuguese (2), Spanish (15) and French (23) weather radars (Sánchez-Arriola et al., 2019). In this study, the **additional DRWs** observations that have been assimilated come only from the Spanish and French networks. The OPERA data received in AEMET has been preprocessed and quality controlled by **BALTRAD software** (Michelson et al.,2018). Some minor changes have been needed to adapt the reference cycle 40h.1.1 HARMONIE-AROME code to the operational context in AEMET to be able to assimilate these observations. The HARMONIE preprocessing of this data includes:

- Creation of **Super observations (SO)** to reduce their spatial density (Ridal et al., 2017).
- Radial winds are selected only if they are accompanied by a **co-located reflectivity observation** and **Nyquist velocity** exceeds 30 m/s. This is the case of DRWs from the Spanish and French radars.
- HARMONIE only use wind information for observations with an **elevation angle higher than 1 degree**.

Figure1 and **2** show the distribution of Doppler winds and Relative Humidity at Minimization from radars for the cycle 2020 03 16 00UTC around 3000m.

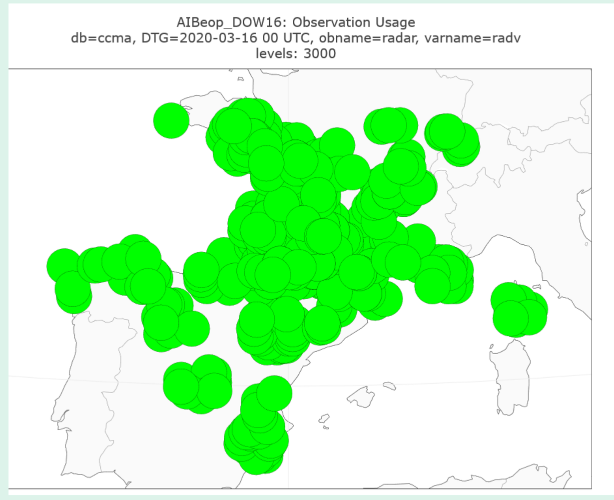

Figure 1: DOWS obs for 16 march 2020, at 00h

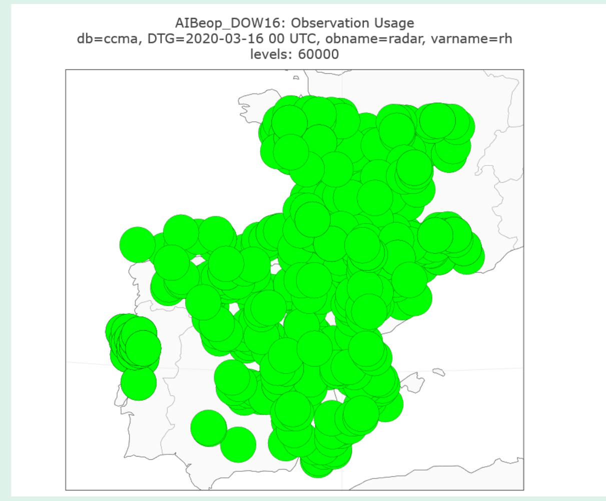

Figure 2: RH obs for 16 march 2020, at 00h

3. Data Assimilation experiments

Several parallel experiments have been carried out to test the assimilation of over **one month long period**: from **1st to 31 March 2020**. It should be noticed that during the last week of this period the number of available aircraft observations dropped drastically due to the reduction in flights caused by the COVID pandemic.

- The **CONTROL (AIBe)** experiment run for this study is the operational suite based on **HARMONIE-AROME cycle40h1.1**.
- **PRELIMINARY EXPERIMENT** over March 2020, **default values** in the HARMONIE-AROME code for relevant parameters for the assimilation of DRWs were kept.

- Rejection limit for DRWs innovations in the first guess check a value of **20m/s**

- DRWs **thinning** whithin **15 × 15 km2 boxes**.

- Observation error standard deviation is formulated following a linear increase with distance to radar. With the default formulation, it oscillates between **1m/s and 2m/s at 120km.**

DIAGNOSTIC of the PRELIMINARY experiment

Figure 3 , first guess departures of observations having gross errors according to Andersson and Järvinen (1999). The transformed histogram of innovations (right) reveals that the rejection limit value used for DRW observations in these experiments (the threshold where innovations apart from Gaussian) **should be** more restrictive

At **Figure 4**, The Desroziers technique (Desroziers et al., 2005) was applied to obtain the horizontal error correlation of DWRs.

Figure 5 shows that the observation error assigned to Doppler winds is much lower than the one assigned to radiosonde and aircraft winds.

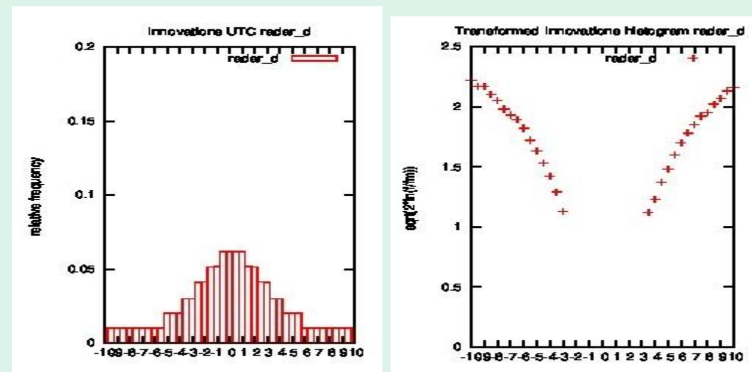

Figure 3: *Histogram (left) and transformed histogram (right) of all innovations of DRWs.*

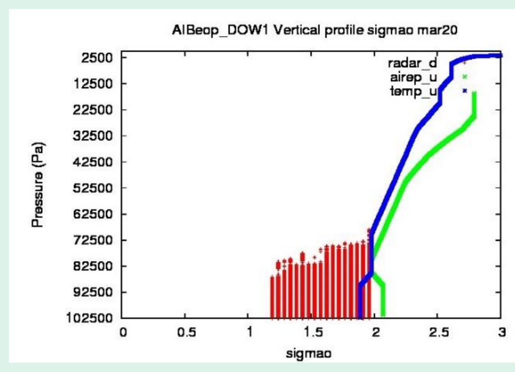

Figure 5: *Vertical profile of ob error standard deviation values for wind observations from DRW (only up to 700hPa), AIREP and radiosondes.*

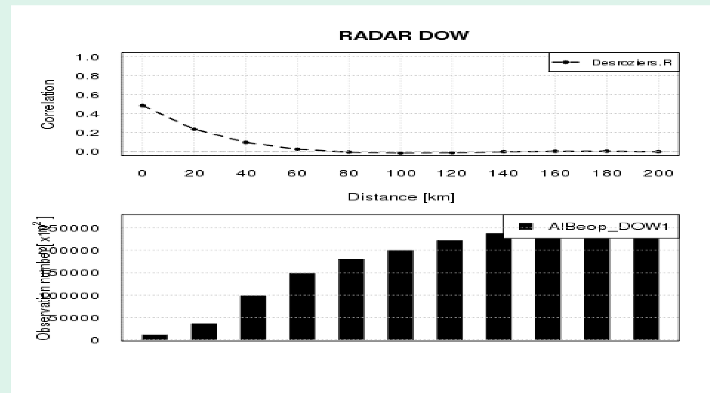

Figure 4: *Estimation of horizontal error correlations based on Desroziers et al.(2005) (top) and the number of collocations (bottom)*

DESIGN of a REFINED DATA ASSIMILATION of Doppler radar radial winds

This new experiment modifies the default setup in respect to:

- The **first guess check limit** has been set to **5m/s**
- The **thinning distance** has been increased to **25km**
- **Observation error standard deviation** has been increased ranges to **3-4m/s** at 120km .

4. RESULTS: Impact on forecast

ASSESSMENT

The impact of the assimilation of Doppler radar radial winds has been assessed by means of the objective verification of model forecasts against SYNOP and TEMP observations over the four weeks period of study.

The **figures 6 and 7** display verification scores reached by the two experiments described in the text: CONTROL (AIBe, in red) and the REFINED DATA ASSIM experiment of DRWs (AIBeop_DOW16, in green).

At **Figure 6**, the Kuiper Skill Score for 10meter winds, and 12h accumulated precipitation is shown. It can be seen how the **skill of 10meter wind** forecasts clearly improves for AIBop_DOW16 experiment for the stronger wind speed intervals. In case of **precipitation**, a positive impact is found for the largest precipitation amounts at the different accumulation intervals. A decrease of 2 meter temperature forecast bias has also been found.

Figure 7 displays the vertical profiles of forecast bias and error standard deviation for (a) wind speed and (b) relative humidity. The overall impact is neutral, but wind speed bias is slightly larger at 700 and 500 hPa which will be further investigated in a future work. On the other hand, a small positive impact is found for relative humidity at 850-700hPa, at all forecast lengths. This improvement in humidity is more noticeable the last week of the period, when the number of aircraft data decreased drastically (not shown).

The observation fit to first guess and to the analysis for RS wind and radial wind at around 600hPa is shown at **Figure 8** for the REFINED DATA ASSIM experiment. It can be observed the similar size of innovations for both observation types, and a closer fit of radiosonde wind to the analysis.

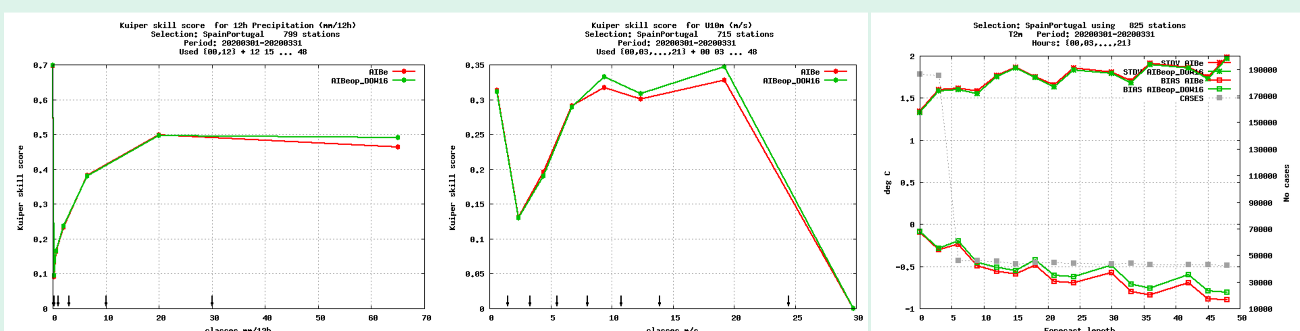

Figure 6: *Verification of CTRL (red) vs AIBeop_DOW16 (green) forecasts. (a) KSS of 10m wind, (b) KSS of 12h accumulated precipitation,* ***(c) STDV and BIAS T2m.***

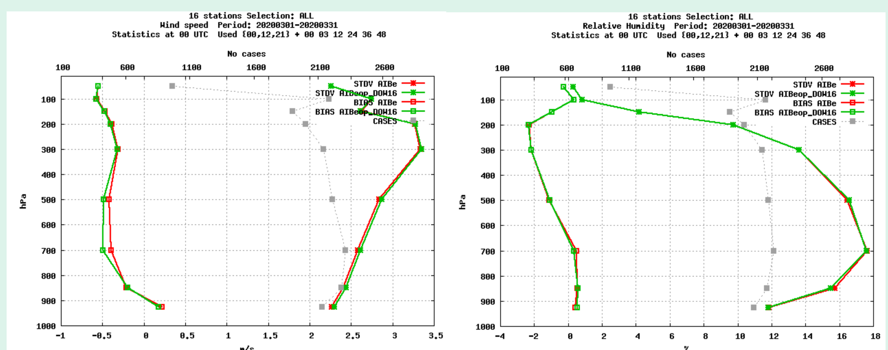

Figure 7: *Vertical profile of verification scores (bias and standard deviation) obtained by CTRL (red) and AIBeop_DOW16 (green) forecasts using radiosonde observations: wind speed (left), relative humidity (right).*

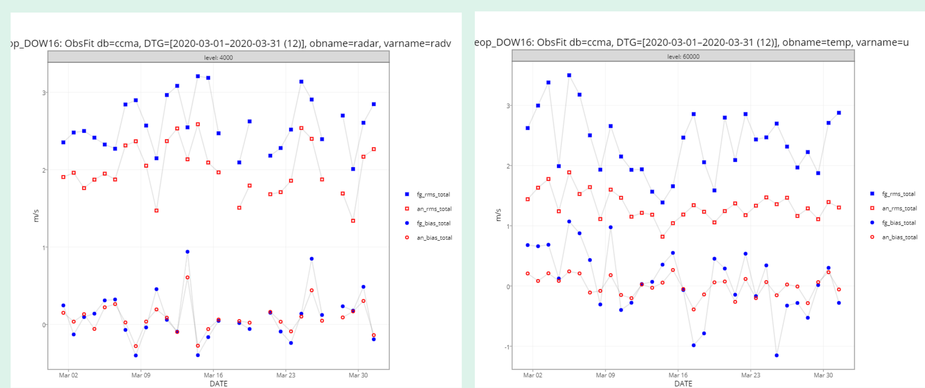

Figure 8: *Obsfit for DRW (left) and for TEMP u observations (right).*

5. Conclusions &Future work

Doppler radar radial winds (together with reflectivities) from the Spanish and French weather radars have been assimilated by two experiments parallel to the HARMONIE-AROME run operational in AEMET over one month long period (March 2020).

- **The preliminary experiment** conducted to assimilate these new radial winds data with the default settings in cycle40h1.1 of HARMONIE presented very high radial wind innovations. Some tuning of first guess check limits has allowed to filter them, but active assimilation of the rest of DRWs data produced a **negative impact** on some forecasted parameters.
- **The revised DRWs assimilation** has been conducted after a **Diagnostics** of the data assimilation and have led to a larger revision of **quality control** and data **thinning** parameters. **Observation error standard deviation** for these data has been also empirically inflated, after comparing it against that of other observation types.

And this revised DRWs assimilation shows to **improve surface wind speed and precipitation forecasts in high impact weather conditions.**

Although the results finally found are rather promising, **additional work** is required to better understand the source of high innovations of DRWs, to tune the quality control of these data, to advance in characterizing its error(Waller et al., 2019) ,to improve the construction of the Super Observation SO, in connection with the data thinning strategy.

Besides, **the background error covariance B matrix** used by the assimilation algorithm when assimilating these observations having a high spatial density is also of paramount importance (Bojarova and Gustafsson, 2019). These experiments have used a B matrix calculated with downscaled ECMWF Ensemble Data Assimilation (EDA) members. Work is ongoing to do these experiments with another calculated by BRAND (B-randomization) and HARMONIE EDA methods.

Currently there is a **parallel run** to the AEMET HARMONIE operational one (that also assimilates IASI radiances since mid December 2020) that includes Doppler radar radial winds.

REFERENCES

Bengtsson, L., Andrae, U., Aspelien, T., Batrack, Y., Calvo, J., de Rooy, W., Gleeson, E., Hansen-Sass, B., Homleid, M., Hortal, M., Ivarsson, K.-L., Lenderink, G., Niemelä, S., Nielsen, K. P., Onvlee, J., Rontu, L., Samuelsson, P., Muñoz, D. S., Subias, A., Tijm, S., Toll, V., Yang, X., and Køltzow, M. Ø., 2017: The HARMONIE-AROME Model Configuration in the ALADIN-HIRLAM NWP System,Monthly Weather Review, 145, 1919-1935 doi: 10.1175/MWR-D-16-0417.1

Bojarova,J., Gustafsson N., 2019: Relevance of climatological background error statistics for mesoscale data assimilation, Tellus A: Dynamic Meteorology and Oceanography, Volume 71,1, 1615168 doi: 10.1080/16000870.2019.1615168

Desroziers, G., L. Berre, B. Chapnik, and P. Poli, 2005: Diagnosis of observation, background and analysis-error statistics in observation space. Quart. J. Roy. Meteor. Soc., 131, 3385–3396, https://doi.org/10.1256/qj.05.108.

Michelson, D, et al. 2018 BALTRAD Advanced Weather Radar Networking. Journal Journal of Open Research Software, 6: 12. DOI: https://doi.org/10.5334/jors.193

Ridal, M., and M. Dahlbom, M., 2017: Assimilation of Multinational Radar Reflectivity Data in a Mesoscale Model: A Proof of Concept. Journal of Applied Meteorology and Climatology, 56(6), 1739-1751

Sánchez-Arriola J., Navascués B., Calvo J., 2019: Radar Reflectivity Impact study with HARMONIE-AROME in AEMET. ALADIN-HIRLAM Newsletter No.12, 112-118

Waller, J. A., and coauthors, 2019: Observation Error Statistics for Doppler Radar Radial Wind Superobservations Assimilated into the DWD COSMO-KENDA System. Mon. Wae. Rev., 147, 3351-3364, https://doi.org/10.1175/MWR-D-19-0104.1