Second review of “Assimilating WIVERN wind pseudo-observations in WRF model: an application to the outstanding case of the Medicane Ianos” by Stefano Federico et al.

My previous concerns have been taken into account: the aims of the paper and the WIVERN instrument are now clearly introduced, the use of member 42 as reference has been clarified, and the interpretation of the results has improved, also with the inclusion of new contents. Overall, the paper quality has increased and the results are now more robust thanks to new sensitivity tests. However, inconsistencies remain in the methods and results, and further effort is needed before the paper can be considered for publication. Minor comments are listed below to help in that way.

First we would like to thank both reviewers for the careful review of this paper and for the useful suggestions that improved the quality of the paper.

l. 54 The synergy is not fully clear as the Aeolus mission is over

Right, but EPS-Aeolus, built on the success of the Aeolus mission, will fly with WIVERN. We added the link to the EPS-Aeolus web page https://www.eumetsat.int/eps-aeolus. We wrote:

“Although the Aeolus mission is over, the Eumetsat Polar Satellite Aeolus (https://www.eumetsat.int/eps-aeolus), built on the success of the Aeolus mission, will fly with WIVERN making the synergy possible.”

l. 59 formatting issue

Corrected. Thanks.

l. 60 spell out En3DVar

Done. Thanks.

l. 67 what is the difference between ETKF and EnKF?

The ETKF (Ensemble Transform Kalman Filter) is a suboptimal Kalman filter with the forecast error covariance matrix estimated by the covariance matrix of the ensemble forecast perturbations. It is faster than EnKF and the forecast perturbations are transformed in analysis perturbation through a transformation matrix. However, the sentence was deleted as it didn’t add much to the paper and going in these details is out of the scope of the paper.

Details on the ETKF can be found in:

Wang, X., and C. H. Bishop, 2003: A comparison of breeding and ensemble transform Kalman filter ensemble forecast schemes. J. Atmos. Sci., **60 ,** 1140–1158.

Wang, X., T. M. Hamill, J. S. Whitaker, and C. H. Bishop, 2007a: A comparison of hybrid ensemble transform Kalman filter–optimum interpolation and ensemble square root filter analysis schemes. Mon. Wea. Rev., **135 ,** 1055–1076.

l. 81 you may want to cite the recent paper by Miglietta et al. 2025: https://doi.org/10.1175/BAMS-D-24-0289.1
Done. Thanks.

l. 102 despite → although

Done. Thanks.

l. 135 as of September 2020 the ECMWF-ENS had horizontal resolution of ~18 km: https://confluence.ecmwf.int/display/FCST/Implementation+of+IFS+Cycle+47r1

Corrected. Sorry for the mistake.

Figure 2 typo “staring”
Corrected.

l. 161 far enough

Corrected.

l. 185 the red line in Figure 3 is hard to see; zooming in would help

Ok. In the revised version of the paper, we provided a zoom (panel b). The new figure has two panels: the Figure 3 of the previous version of the paper is panel a) and the zoom is panel b).

l. 190 as of September 2020 the ECMWF-IFS had horizontal resolution of ~9 km: https://confluence.ecmwf.int/display/FCST/Implementation+of+IFS+Cycle+47r1
Corrected. Sorry for the mistake.

Figure 4 missing time in caption and (a) (b) (c) in panels

Added.

l. 240 this sentence is awkward: (1) the vertical tilt is not shown in Fig. 1b and is a characteristic of extratropical rather than tropical cyclones; (2) the (arbitrary) swath of WIVERN is illustrated at a specific time thus cannot match the 3 hourly evolution

Yes, but Figure 1b shows the center of Ianos and the WIVERN swath used for all times. As the storm center is well inside the WIVERN swath and as the storm is in its tropical-like phase for the whole period considered, we can infer that the storm is reasonably sampled at all times. We rephrased the sentence avoiding the discussion about the tilting. We wrote:

"Figure16b) shows that the Ianos center is well inside the WIVERN swath for most of the times, so we can infer that the storm is well sampled. However, as Ianos approaches the land, its center is closer to the WIVERN swath edge and the sampling of Ianos becomes suboptimal."

l. 256 please explain

Ok. We explained better the point. We wrote:

"The observation error covariance matrix is diagonal, i.e. observation errors are assumed uncorrelated. However, observation errors are correlated, and their correlation decreases with the distance among the observations (Bennit2017, Torcasio2023). In this paper, pseudo-observations are generated at 5 km horizontal resolution and are thinned to 10 km distance to account, at least partially, for assuming a diagonal observation error covariance matrix.

l. 267 what is this radio-sounding??? it is not mentioned anywhere else in the paper

In the first review of the paper, we were asked to compare the WIVERN wind error with radio-sounding error, and we did this in Figure 5b. The radio-sounding error is that used by the WRF data assimilation software (file SOUND.txt) and it seems appropriate to use this error for comparison. We clarified better the point by rephrasing.

l. 305 reference?
We added a recent paper on this vast subject. The reference is:

Pandey, S. K. and Yadav, K.: A mathematical model for viscous flow dynamics of tropical cyclones, European Journal of Mechanics -B/Fluids, 111, 72–80, https://doi.org/https://doi.org/10.1016/j.euromechflu.2024.12.003, 2025.700

l. 307 which phase space?

We slightly changed the sentence, and the phase space is not mentioned anymore.
l. 323 far enough
Corrected. Thanks.

l. 330-331 syntax

Ok. Thank you for noticing the point.
l. 342 repetition

Thanks for noticing the point. We slightly changed the reference to Figure 10 to avoid the repetition.

372-374 as noted in my first review, Figure 11 (d) is very challenging to interpret; showing instead a zonal cross-section of the meridional wind would match the contents of panels (a-c) and be way more straightforward

Ok. We suggested to maintain our version of the figure to show the impact of WIVERN winds DA on both components of the wind, however, as suggested by the reviewer, considering only the meridional wind components is more straightforward. So, we changed the figure and the comment accordingly. The new Figure 11 is shown below:

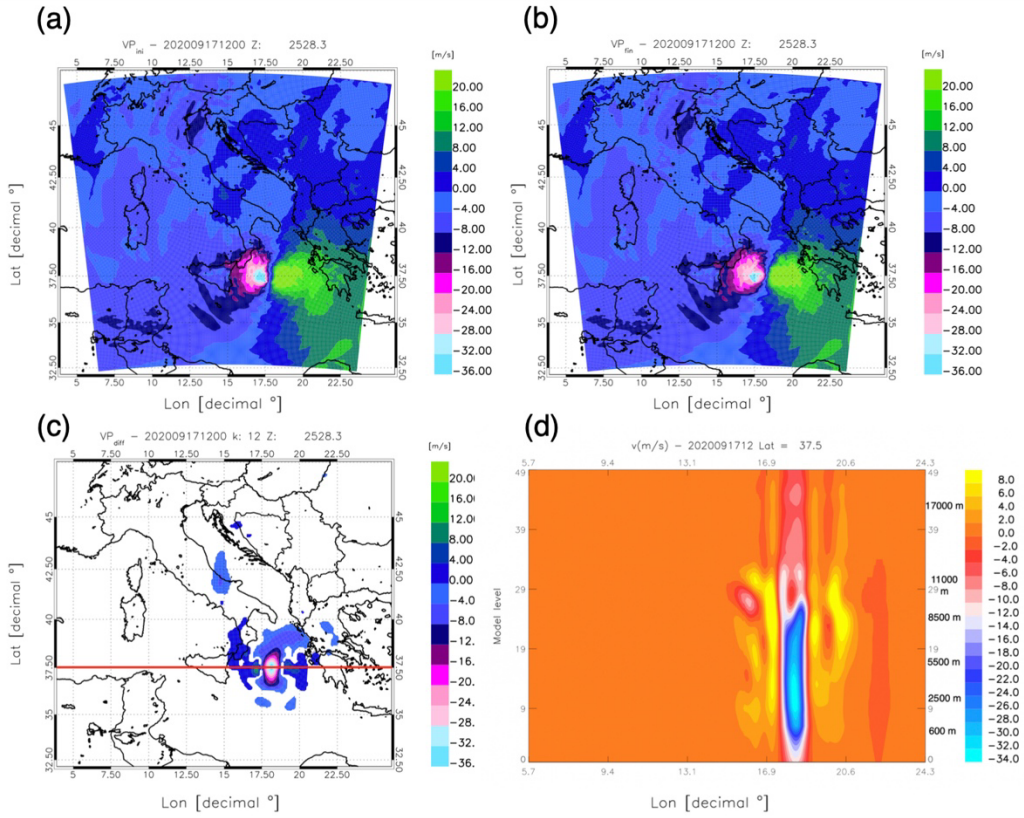

Figure 11. Analysis of wind components at 12 UTC on 17 September 2020 for member 10: a) background meridional wind component at about 2500 m a.s.l; b) analysis of the meridional wind component at about 2500 m a.s.l; c) difference between analysis and background fields of the meridional wind component (same level of panels a-b); d) cross-section of the difference between the analysis and the background of the meridional wind component along the red line of panel c). The y-axis of panel d) shows the WRF vertical levels and labels on the right y-axis correspond to the approximate heights of the levels.

l. 375 despite a decrease

Done.

l. 406-408 the average precipitation over the box (and not just over Kefalonia) should be given to better understand whether the reduction in RMSE is due to an improvement in precipitation location and/or intensity

Ok. We did this calculation. Results show a minor worsening of the bias when WIVERN DA is assimilated. Specifically, the ensembles CTRL and WIV_{24h} are overestimating the precipitation in the southern part of the red rectangle and underestimating the rainfall in the most intense part of the storm (i.e. north of the representative member trajectory). As WIV_{24h}, compared to CTRL, improves (i.e. increases) the precipitation forecast in the most intense part of the storm and tend to reduce the rainfall in the southern part of the red rectangle of Figure 14 it follows that: a) the bias is almost unchanged; b) the RMSE is notably improved. Stated in other terms, the WIVERN DA improves both the location and intensity of the precipitation forecast in the most intense part of the storm.

We wrote:

"Although the RMSE is improved by WIVERN DA, the average precipitation over the red rectangle of Figure 13 is slightly worsened. The average rainfall of the member 42, of the CTRL ensemble and of the WIV_{24h} ensemble are, respectively, 59.3 mm, 63.6 mm and 64.1 mm. This result, i.e. a notable improvement of the RMSE and a similar bias, shows that the improvement of the RMSE is determined by a better representation of the location and intensity of the rainfall in the most intense part of the storm (i.e. north of the trajectory of the representative member 42)."

Figure 12 remove "eye" (surface pressure below 975 hPa has no specific physical meaning)
Deleted. Thanks for noticing the point.
Figure 13 show the orange rectangle on all panels as they are all compared over the area

Done.
l. 414-417 comparing a number of members using an arbitrary error threshold and for a specific location without showing results is not convincing; this part requires a more systematic approach (such as the RMSE applied to precipitation over a wider area above) or must be removed altogether
Ok. We deleted the comparison of the surface wind in Kefalonia for the reasons stated by the reviewer.
l. 418 referring to the previous version of the paper is not appropriate!!!
Deleted.
l. 424 what does NMC stand for?
National Meteorological Center. Added.

l. 425-428 I do not understand how the background error matrix is computed: from two forecasts (at which lead times?) or analysis/forecast, from IFS or WRF? Please clarify
The background error matrix is computed from WRF forecasts verifying at the same time. The verifying times are 00 UTC and 12 UTC for the whole month of September 2020 and the WRF

forecasts have lead times of 12h and 24h. We rephrased the sentence to clarify the point. We wrote:

"Specifically, the background error matrix was computed from the difference of two WRF forecasts, with lead times of 12 h and 24 h, verifying at the same time, both 12 UTC and 00 UTC, for the whole month of September 2020. The WRF forecasts use the operational analysis/forecast cycle issued by the ECMWF at 00 UTC and 12 UTC on each day of September as initial and boundary conditions."

l. 440 bias: lowercase

Ok.

l. 441 what is the definition of first guess here?

Thanks. It is CTRL. Modified.

l. 446 refer to fig. 14

Done.

l. 455-460 the information is repetitive: "assimilation at 12 UTC on 16 September" = "forecast from 12 UTC on 16 September" = "assimilated 24 h after the ensemble initialization" (same for WIV12h)

To avoid repetitions, we deleted the sentence "Also, in the first experiment pseudo-observations are assimilated 24 h after the ensemble initialization, while in the second experiment WIVERN pseudo-observations are assimilated after 12 h from the ensemble initialization."

l. 473 refer to fig. 16b

Thanks. Done.

l. 528 with respect to; but the sentence is awkward as the results are preliminary and not shown here

Agree. We deleted the whole sentence.