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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Atmospheric Moisture Effects on Heavy Precipitation During the HyMeX IOP16 Using GPS Nudging and Dynamical Downscaling" *by* Alberto Caldas-Alvarez and Samiro Khodayar

Anonymous Referee #1

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1 General comments

The manuscript presents a study of heavy precipitation in the Mediterranean area. Different data sources are used to characterize the event in terms of moisture. Among them, COSMO-CLM runs play a central role. GPS-ZTD data are assimilated in COSMO-CLM through nudging in nested domains of 7 km and 2.8 km, respectively. The authors conclude that nudging GPS ZTD data improves the modelling of precipitation for this event.

As correctly pointed out by the authors, the role of moisture in heavy precipitation events is of great interest. Unfortunately, the discussion paper is burdened with substantial flaws.

First of all, it contains numerous purely speculative assertions that are not at all substantiated. This is reinforced by the fact that results are often given before they are demonstrated (this should be reversed). More rigorous justifications are needed to make the discussion paper a compelling study.

Second, as justly stated by the authors at the end of their concluding section, their study relies on one case only. This undermines the results concerning the sensitivity study to the assimilation of GPS ZTD data, all the more since the different runs start much earlier than the event itself. In doing so, it is difficult to link the impact of the assimilation of ZTD-GPS data to the simulated precipitation. The differences observed during the chosen event might simply be due to the chaotic nature of the atmosphere. In any case, such a configuration does not help understand where and when the assimilation of GPS ZTD data has the most impact on precipitation. For example, the authors should include some estimation of the impact duration of the GPS-ZTD data assimilation by running some free runs and determining when they converge, or start the different runs shortly before the event starts.

Third, I deem it doubtful that the "modelling experiments demonstrated the benefit of sub-hourly GPS-ZTD nudging to improve the modelling of precipitation" for the following two reasons. First, the benefit of a sub-hourly frequency versus, e.g., a hourly frequency, has not been demonstrated. Second, there is no "pure" modelling in the study since the model is constantly perturbed by the modification of its moisture field. In doing so, it is highly speculative to interpret any physical process in a consistent way. The authors should be more specific about the usefulness of continuously nudg-

ing moisture.

More details regarding these general comments are given below.

2 Specific comments

L47-49: The authors point out the interest of assimilating humidity data at sub-hourly frequencies. I suggest the authors study the sensitivity of the assimilation frequency by carrying out an additional experiment with a one-hour assimilation frequency. This would demonstrate to what extent a sub-hourly assimilation frequency is needed.

Case study and numerical set-up: Why run experiments that last several months and study one case only? The differences seen in this specific case could be caused by a lower predictability rather than to improvements in the description of the humidity field. Why is there no NDG-2.8 simulation forced by NDG-7? In theory, shouldn't this configuration yield the best results?

L246-247: Can the authors please elaborate on why, "under a weak synoptic forcing, the impact of the GPS-ZTD is larger given the strongest correction of the lower to middle tropospheric humidity"?

Section 3.3: This section contains general statements, which are true, but are not new: writing that moisture is swept by a front and/or originates from the seas and oceans is true, but it would be much more interesting to know which fraction is swept and which fraction comes from evaporation. Moreover, many statements in this section are not properly backed. The CTRL-7 simulation is validated later (that would be better here or before!), no moisture budgets are computed, some HYSPLIT backward trajectories are computed, but the underlying analyses (GDAS) are not validated. A validation against MODIS is mentioned but not

shown(?!) In addition to the lack of GDAS validation for this event, I wonder what 0.5 degree resolution parcels represent. Furthermore, I suspect that labels A and B are inverted in the lower panel of Figure 6.b. If I am wrong, it means that I don't understand this panel.

L326-328: The specific humidity in Figure 5.a is said to be in agreement with the simulated IWV in Figure 4.a. Why not compute the IWV from the radiosonde to quantify it?

L352-353: Why does this "further promote the moisture uptake form the Sea"?

L396-398: Looking only at the maximum precipitation value is not really fair because the rain gauge network is rather sparse compared to the scale of the studied phenomenon (and simulated maximum value). At first glance, I would say that CTRL-2.8 is better than NDG-2.8. A proper validation of numerical simulations against rain gauges is needed.

L400: The authors do not really assess the accuracy of model moisture outputs: since most of the radiosonde locations are near GPS receivers, they rather assess the accuracy of GPS IWV retrievals. This most certainly explains why NDG-7 and NDG-2.8 results are so close to each other. To really assess the accuracy of model moisture outputs, free runs should be evaluated.

L411: Figure 8.a shows the IWV over the CO domain, not Corsica. This is important, because the most noticeable differences among the nudging simulations may be over the sea since IWV mainly comes from GPS receivers on ground. The authors should adapt the rest of their interpretation of Figure 8.a accordingly.

L423: Where is it evidenced that the humidity reduction takes place below 500 hPa?

L429-447: A validation against radiosondes is presented. Which radiosonde profile has an impact on the event under consideration? They are all located either east,

north, or south of Corsica, while the authors showed that moisture comes from the (south-)west.

L466-467: Where is a "decrease of humidity close to ground" shown?

L469-471: A simulation nudging IWV at 2.8 km and forced by NDG-7 would be useful here.

L487: Why is the effect of the low-pressure system change exclusively seen in the 7 km simulations? Isn't the wind changed in the 2.8 km simulations, too?

L568-569: The high-temporal resolution of GPS-ZTD observations has not been shown to facilitate a better representation of the water vapour variability and a better regulation of the accumulated precipitation. To do this, different temporal resolutions should have been used.

3 Technical corrections

Title: "Effects ... using" something does not really mean anything. I suggest adding "Assessing", "Evaluating" or some other relevant term to amend it.

L68-69: What is the "location" of a convective system? In convective updrafts, saturation is likely to be reached. To make it meaningful, the sentence "Khodayar ... (HPE)." needs more context.

L130: It is already written (L100 and 103) that the GPS data come from 25 European and African networks with over 900 stations.

L217: Is it useful to describe the vertical interpolation in the nudging scheme when it comes to assimilate GPS data?

L230-231: It is unclear. What is the "iterative process"? If Eq 2 is used, it is not an iterative process, is it?

L241: It is stated that the 7 km runs are forced by ECMWF analyses. How often?

L244: The terms "large precipitation reductions" is unclear. The authors must specify which experiences they are referring to.

L254: First occurrence of "θe": it should be expanded here, not in L273.

L298: What is an "offshore-size" convective system?

L367: "Ellipse A in Fig. 7" or in Fig. 6.d?

L369: "Ellipse B in Fig. 7" or in Fig. 6.d?

L447: What is an "accuracy rate"?

L454: What does "height-surface" mean? Do the authors simply mean "vertical"?

L455: What does "vertical-horizontal direction" mean?

L476: "Wind speed" seems to refer to the horizontal wind speed. This should be specified right away.

Figure 3: SEVIRI is not a satellite, it is an instrument.

Figure 6: Units of evapotranspiration are either kgm^{-2} or mm. Over what period of time? In Figure 6.d, the two sets of trajectories cannot be distinguished. Is it possible to plot each of them with a distinct color? I suppose the lower panel is a time series. Is it possible to add labels in the x-axis?

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