

Response to anonymous Referee#1

We thank the reviewer for the useful comments and suggestions which will certainly improve the manuscript. Next, general and minors comments, as well as a few technical corrections, have been answered. Besides, in most of them, we have re-written some sentences. These new sentences (in quotations) follow the answers. If accepted, the changes will be included in a revised manuscript.

Panels a and b of Figure 4 have been amended as proposed in the minor comment number 10. The Figure 4 caption has also been re-written.

General comments

In their discussion of the results, both the abstract and conclusions are vague about the size of the impact from targeted observations. Both should be re-written to be more quantitative, quoting numbers from the results section. Examples from the abstract –‘generally positive impact’, ‘the improvement is slight’, ‘the improvement is significant’.

- Following your suggestion, the second paragraph of the Abstract (P2782, L13-L19) will be re-written as:

“The results obtained show that extra radiosondes have an overall positive impact on the forecasts (average improvement of all upper air variables and vertical levels studied is 3.6%). When in addition to extra radiosonde data also enhanced satellite data are assimilated, the overall forecast skill is almost doubled. However, a distinct behaviour is found between PREVIEW and MEDEX cases. While for MEDEX cases the improvement is slight, for PREVIEW cases is significant (average improvements of 1.7% and 8.9% respectively for the experiment with enhanced satellite data). It is suggested that this is due to the location of the target areas and the spatial distribution of the composite observing system and to the different atmospheric predictability in these two periods.”

- Accordingly, in section 4.1 “Results”, the phrase (P2800, L22-23) will be re-written as:

“This benefit is larger (lower) when 2008 (2009) cases are separately considered.. While for MEDEX-DTS cases the average improvement is slight for both EXP-RS and EXP-ATOVS (1.4% and 1.7% respectively) for PREVIEW-DTS cases the average improvement is significant for EXP-RS (4.8%), but especially for EXP-ATOVS2 (8.9%).”

- In the conclusions, two of the main findings can be re-written as:

P2806, L12-14: “The forecast skill is increased when not only targeted radiosondes but also enhanced satellite radiances selected with an adaptive observations screening are assimilated (-3.6 and -6.5 % respectively).”

P2806, L18-19: “Improvements are found to be larger for PREVIEW-DTS (2008) cases than for MEDEX-DTS (2009) ones (average improvements of 1.7% and 8.9% respectively for the experiment with enhanced satellite data).”

I was confused by the discussion of the prediction of the sensitive areas in Section 3. Both SV and ETKF methods are mentioned. However, in the discussion of sensitive areas for the different cases, and the location of the targeted ATOVS data in particular, only the SV sensitive areas are mentioned. The text states several times that ATOVS data is assimilated in SV based sensitive regions (abstract, introduction, section 3.2.2 for example). Were the ETKF SAPs used to determine the sensitive regions where additional observations were added? If the ETKF information was available but they were not used, then this should be discussed.

The request of targeted radiosondes was done in real time by the “lead user”, who evaluated different objective methods, i.e. SVs and ETKF from Météo-France in both campaigns, and also ETKF from UK Met Office only in PREVIEW-DTS (unfortunately, in MEDEX-DTS ETKF from UK Met Office was not available). For several reasons, ETKF from Météo-France guidance was never taken into account by the “lead user”. In PREVIEW-DTS, the “lead user” guided his targeting decisions by SVs and ETKF-UK Met Office calculations. SVs and ETKF-UK methods often agreed, but sometimes they pointed out different sensitive regions. The “lead user” evaluated both guidances and also the location of targetable stations (compared with the sensitive regions). The final request of extra radiosondes usually agreed with SVs areas. However, in a few cases, the “lead user” selected a larger targeted area to include extra radiosondes located in not only SVs but also ETKF sensitive regions. In MEDEX-DTS, the “lead user” only used SVs calculations.

EXP-ATOVS2 was designed to increase the observations coverage over sensitive regions not properly sampled by extra radiosondes, as maritime areas (see minor comment 3). We decided to use always the same SAP method for the selection of the geographical areas with enhanced satellite data in the DA in all the PREVIEW-DTS and MEDEX-DTS cases. Using SVs method would also be more consistent with the “lead user” decisions made in the operational targeting environment during both field campaigns.

To clarify these aspects in the revised version of the paper, we propose to introduce the following changes:

- The paragraph ranged between P2792-L28 and P2793-L2 will be rewritten as:

“Once the SAPs were calculated, in the third step the “lead user” evaluated the different SAPs and decided which of the available observations would be requested. From the operational point of view in PREVIEW-DTS, SVs and ETKF from UK Met Office were used to guide the selection of targeted observations. Both methods often agreed, but in some cases they pointed out different sensitive regions. The request of targeted radiosoundings was mostly driven by SVs. Only in a few cases the “lead user” selected a large targeted area to include additional radiosondes located not only in SVs but also in ETKF sensitive regions. On the contrary, in MEDEX-DTS only SVs method was used.”

- At the beginning of section 3.2.2 (ATOVS data) at P2796-L23:

“A reduced (0.45°) satellite data thinning is applied in some regions, derived from the sensitivity maps, and a normal thinning (0.90°) in non-sensitive regions. In this experiment, SVs is used as SAP method to be consistent with the “lead user” decisions to select the extra radiosondes in the operational targeting environment.”

Minor comments:

1. P2783, L18 The statement ‘certain regions’ is rather vague. Data targeting refers to the addition of observations in regions of forecast sensitivity.

The statement “certain regions” can be replaced by “selected regions”. Thus, that phrase will be rewritten as:

“Data targeting refers to the selection of additional observations in particular regions to reduce the initial condition errors.”

2. P2783, L20-26 – It may be worth adding here that these field campaigns generally use dropsonde data from research aircraft, i.e. they are adding an extra component to the observing system. This is distinct to making better use of observations that we already have, such as by using more of already available satellite observations (which is a far more cost-effective and practical way to do data targeting).

We fully agree and thank the reviewer for this comment. We will add a couple of sentences in this sense to that paragraph:

“Many field campaigns deploy special observations to add an extra component to the observing system (e.g. dropsonde data from research aircraft), but others make use of adapted observational resources that are routinely available (e.g. additional radiosondes). This approach is far more cost-effective and a practical way to do data targeting.”

3. P2788 – For the assimilation experiments, why is the EXP-ATOVS*2 experiment using the same data as EXP-RS plus ATOVS data, rather than the same data as the control + ATOVS. The two setups will not necessarily give the same results.

The present paper deals with the impact of targeted observations on the forecast of some high impact Mediterranean events, derived from two field campaigns. Three experiments are carried out in an operational context, taking into account the existing composite observation system and the observation usage in the data assimilation systems. The main goal is to test the impact of the targeted observations available in these campaigns. In PREVIEW and MEDEX, only extra radiosondes were deployed as targeted observations. Then, initially we compared EXP-RS (control plus extra radiosonde data) with EXP (control). The number and location of extra radiosondes are rather different from case to case, and in some cases, extra radiosondes only partially sampled sensitive regions, because targetable stations were mostly located over Western and Central Europe. Sensitive regions located over Europe were correctly sampled, but this was not the case for those over oceanic regions. Due to some difficulties, ATOVS data are not assimilated over land in most operational data assimilation systems. With EXP-ATOVS2 (control plus extra radiosonde data plus extra satellite data) we seek to test the potential **additional** improvement obtained with an enhanced sampling of the sensitive regions located over the oceanic areas to complement the extra radiosondes launched in the continent and in some cases a few remote islands and ships. In any case, we agree that it would be interesting to test the single impact of the enhancement of satellite data assimilated over the sensitive sea areas with respect to control as a further step of this study.

In order to further clarify the experiments set-up, section 2.1 “Experiment Description” has been re-written as follows:

The first paragraph of section 2.1:

“Three experiments have been conducted over the two different periods of 2008 (PREVIEW) and 2009 (MEDEX) field campaigns. They are carried out in an operational context taking into account the existing composite observation system and the observation usage in the HIRLAM data assimilation system. The assimilation cycle started one week before for spin-up reasons.”

The last paragraph of section 2.1:

“The number and location of extra radiosondes were rather different from case to case during the field campaigns, and very often, they only partially sampled the sensitive regions. The third experiment, EXP-ATOVS*2, aims to investigate other data targeting strategies in HIRLAM DA, in particular a non uniform data thinning for the satellite data located in the target region, following the work of Bauer et al. (2011) with ECMWF global model. With EXP-ATOVS2 we seek to test the potential additional improvement obtained with an enhanced sampling of ATOVS data located in the sensitive regions over the ocean and sea areas to complement the extra radiosondes mostly launched in Europe. EXP-ATOVS*2 experiment assimilated the same observations than EXP-RS but, in the sensitive areas, it allowed a double density of satellite data to influence the analysis (a minimum distance of 0.45°, close to the original AMSU-A data resolution). Some changes in the screening algorithms of the DA system were implemented accordingly.”

4. P2788 – What other analyses did you use to test the effect of using a different analysis on your results? The details are rather vague – did you re-calculate your results against an independent analysis? (i.e. not from one of the experiments EXP-RS, EPS or EXP-ATOVS*2).

Results were calculated using EXP, EXP-RS and EXP-ATOVS2 as verifying analyses. Both quantitative and qualitative results were rather similar, so we did not try to use an independent analysis. For instance, mean RMSE of 500 hPa geopotential height forecast for any experiment calculated with different verifying analysis are very similar, as it can be seen in the table below. Results come from PREVIEW-DTS (2008) cases.

	EXP	EXP-RS	EXP-ATOVS2
RMSE using EXP analysis (m)	15.05	13.73	12.13
RMSE using EXP-RS analysis (m)	15.01	13.58	12.01
RMSE using EXP-ATOVS analysis (m)	15.16	13.74	12.13

5. P2789 Equation 1 and L6 – Please define DTE. In the previous paragraph, it says that EXP-RS is used as the verifying experiment, therefore in equation (1), should EXP be EXP-RS?

- Please define DTE:

We have performed three experiments: two Data Targeting Experiments (DTEs) and a control experiment. DTE refers to EXP-RS or Exp-ATOVS2, while the control

experiment is referred as EXP. As it is underlined by the referee, DTE was not defined in the manuscript, for this reason L6 (P2798) will be re-written as:

“Its interpretation is straightforward: when $REL\ RMSE < 0$, DTE (Data Targeting Experiment) forecast error is lower...”

- In the previous paragraph, it says that EXP-RS is used as the verifying experiment, therefore in equation (1), should EXP be EXP-RS?.

No. EXP-RS analyses have been used to verify all experiments: EXP, EXP-RS and EXP-ATOVS2.

6. P2791 – High resolution rain-gauge data. Typically how much data was available in each 500km x 500 km box, and how much variation was there by case? This may affect your results.

Yes, this is a point we didn't develop as it deserves, thanks for pointing it out. We will include this information, improving the last paragraph in section 2 (P2791 12-23). The corresponding changes follow here:

BEFORE:

“The SAL method compares forecasts and observations in the same grid, thus some kind of gridding method is required for the observations (Cherubini et al., 2002). Rain gauge data from the high resolution climate stations network operated by the different European NMSs have been upscaled by ECMWF to the model resolution (around 16 km) and provided to the authors for this study. These high resolution data were available for most, but not for all, the weather cases studied in this work. In particular, rain gauge data were sparse for some Eastern Mediterranean countries over the MEDEX-DTS period. SAL method should be applied in limited size geographical areas (about 20 500×500km², Wernli et al., 2009) in order to obtain clear conclusions. Because the verification areas used in these DTS field campaigns were larger than this limit, all VAs at each VT were split in several sub-areas. Every sub-domain was considered in the SAL method as a different case.”

AFTER:

“The SAL method compares forecasts (Quantitative Precipitation Forecast, QPF) and observations (Quantitative Precipitation Estimate, QPE) in the same grid, thus some kind of gridding method is required for the QPE (Cherubini et al., 2002). Moreover, SAL method should be applied in limited size geographical areas (about 500×500 km², see Wernli et al., 2009) in order to obtain clear conclusions. Because the verification areas (VAs) used in these DTS field campaigns were larger than this limit, all VAs at each VT were split in several sub-areas, considering each one in the SAL method as a different case. For the QPE, High Resolution Rain Gauge Data (HRRGD) from the climate stations network operated by the different European NMSs have been upscaled by ECMWF to the model resolution (around 16 km) and provided for this study. Spatial and temporal HRRGD variability can have an impact on the QPE consistency, and hence in the results obtained, but this is beyond the scope of this study (see, for instance, PaiMazumder and Molders, 2011). However, some indication is provided here. In some European regions HRRGD covers most of the land domain including mountains (e.g. the Alps), while in some others it is rather sparse: HRRGD density can vary in Europe from 10⁻² km⁻² to 10⁻³ km⁻². Concerning daily coverage variation, some

countries keep an almost constant number of quality-controlled daily data, but this is not generally the case (the variation in number of available daily data can range from 1% to 30%). Therefore, neither the coverage is homogeneous, nor the availability of each station data can be considered constant. In fact, HRRGD were available for most, but not for all, the weather cases studied in this work. In particular, the data were sparse for some Eastern Mediterranean countries over the MEDEX-DTS period. On average, around 1300-1400 data were daily available on each 500 x 500 km² verification domain. Within, and for daily precipitation, only those grid-boxes containing at least 2 observations were considered for the up-scaling process (the rest were neglected), improving the QPE consistency.”

PaiMazumder, D. and Mölders, N.: Theoretical Assessment of Uncertainty in Regional Averages due to Network Density and Design, J. Appl. Meteor. Climatol., 48, 1643–1666, doi: <http://dx.doi.org/10.1175/2009JAMC2022.1>, 2009.

7. Section 3 – The locations of the sensitive regions depend on some of the details of the techniques used to identify the sensitive regions. Therefore I suggest adding some more details here. For example, what kind of singular vectors and at what resolution were they calculated? How many ensemble members were used to create the ETKF and at what resolution? Did the different sensitivity techniques always agree?.

Next sentence will be added in P2792-L27:

“Details of the techniques used to identify the sensitive regions can be found in Prates et al. 2009.”

- Did the different sensitivity techniques always agree?.

In spite of some differences between SVs and ETKF-UK Met-Office for some PREVIEW-DTS cases, the “lead user” usually requested extra radiosondes guided by SVs. A comparison between different sensitive region calculations is out of the scope of the present paper.

8. Section 3.1 – The section headings refer to events c and f, but the figure caption for Figure 1 refers to individual cases, 863 and 1025, which is confusing for the reader. It would be clearer if the caption for figure 1 also specified which case belongs to event c and which case belongs to event f.

Figure caption will be re-written as:

“Fig. 1. Top: MSLP (left panel) and 500 hPa geopotential height (right panel) analyses for case 863 (event c). Bottom: like top panels but for case 1025 (event f). The analyses are derived from EXP-RS. The green box is the verification area for the corresponding cases.”

9. P2793, L5 and P2794, L21 – Are the sensitive areas referred to here SV regions? Was similar guidance provided by ETKF?

– Are the sensitive areas referred to here SV regions?

Yes, the sensitive areas referred to here are SV regions.

- Was similar guidance provided by ETKF?

For event c (P2794, L4) SV and ETKF provided similar sensitive areas, although in some cases ETKF also provided additional sensitive areas, but far upstream of the cut-off low. Probably for this reason they were not taken into account by the “lead user”. For event f, as it happened in MEDEX-DTS campaign, the sensitive areas referred always to SV regions (please see the answer to second general comment).

10. Section 3.2.3 and Figure 4 – AMDAR data, both profiles and data from cruise altitude are displayed on Figure 4 as red dots. Therefore it is difficult to see from figure 4 the density of AMDAR profiles or how it compares to radiosounding stations, because we cannot differentiate between the profiles and cruise-level data.

In Figure 4, AMDAR data are displayed in different colours depending on the pressure level. Data above 400 hPa (cruise altitude) are displayed in red dots and data below 400 hPa (profiles) are displayed in light green dots.

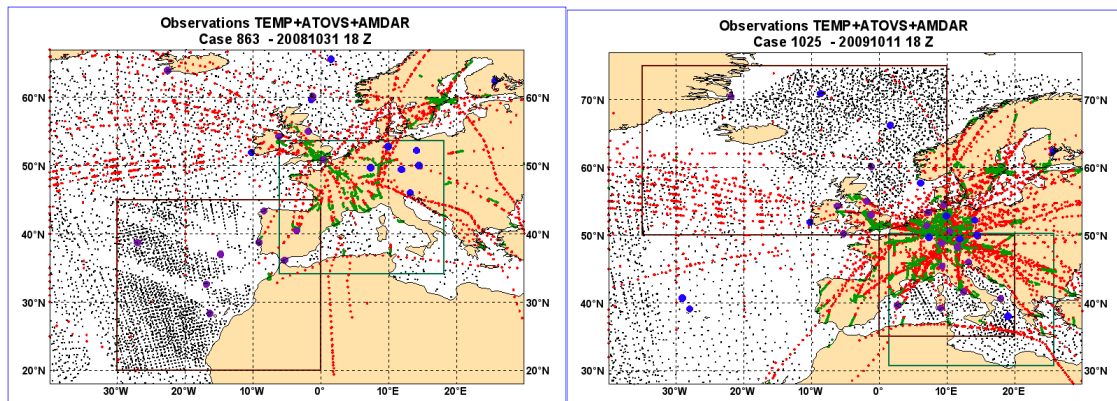


Figure caption: “Fig. 4. Different data assimilated for case 863 (a) and for case 1025 (b). ATOVS data are displayed in black points, AMDAR cruise altitude (above 400 hPa) in red points, AMDAR profiles (below 400 hPa) in light green points, operational radiosondes in blue circles, and additional radiosondes in purple circles. The verification area is marked with a green rectangle and the brown rectangles mark the targeted area used for enhanced ATOVS data.”

11. P2798 – In figure 5b, it would be helpful to point out to the reader that negative values of REL_RMSE correspond to forecast improvements.

This can be included in L20-21 as:

“For Z500 the number of improvements (negative values) is slightly larger than that of deteriorations (positive values), as improvements account for 14 of 24 cases (58.3 %) for both DTEs.”

12. P2806, L21-23. This sentence is very confusing. Please re-phrase.

The sentence can be re-phrased as follows:

“The added value per targeted radiosonde is different for each case, being more valuable the extra observations located in sparse data areas and during periods of low predictability.”

13. P2807 L26 – This is not the only study analysing targeted observations for the Mediterranean region. Please see: Garcies and Homar, 2013, Q. J. Roy. Meteorol. Soc. (at <http://onlinelibrary.wiley.com/doi/10.1002/qj.2148/abstract>)

We thank the reviewer for his comment. We did not know this potential reference at the time of submission of this manuscript to NHESS (5 April 2013). The paper Garcies and Homar, 2013 was first published online on 22 May 2013.

Garcies and Homar present a theoretical assessment of different sensitivity products that were available based on single sounding assimilation experiments over a particular case of MEDEX-2009 campaign. We have decided to make reference to their work at the end of the manuscript (Conclusions and discussion), where we state that our paper does not address how the choice of different SAP methods may influence the results. P2810, L15-16 will be re-written as follows:

“The influence of potential differences due to the application of different sensitive area calculation/prediction methods was not addressed in this study. A simultaneous work by Garcies and Homar (2013) presents a theoretical assessment of the targeting guidance provided by different sensitivity methods based on single sounding assimilation experiments over a particular MEDEX-DTS case study”. Notice that the first sentence has been re-written as suggested by referee#2.

We have also re-written sentence P2807 L26 stressing the operational context of the observing system experiments (OSEs) carried out in our study, as follows

“The present study is to our knowledge, the first one to assess the impact of targeted observations on the forecasts over the Mediterranean region in an operational environment.”

Garcies, L. and Homar, V. : Are current sensitivity products sufficiently informative in targeting campaigns? A DTS-MEDEX-2009 case study. Q.J.R. Meteorol. Soc., doi: 10.1002/qj.2148, 2013.

Technical corrections:

P2794 L21 and L15 – ‘along’ the (date) – in both cases replace ‘along’ by ‘during’.

Thank you for your suggestion. We will follow it in P2793 L21, P2794 L15 and in P2794 L13.

P2799 L1 – ‘worsening’ – ‘degradation’ is a more commonly-used term.

Thank you for your suggestion. We will follow it in P2799 L1, and in P2804 L28.