Supplemental Information for "Extreme vertical drafts in the polar summer mesosphere: A mesospheric super bore?"

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1. Figures S1 to S3.
2. Movies S1 and S2.
3. Description of datasets.

Additional Supporting Information (Files uploaded separately)

1. Movie S1.
2. Movie S2.

Introduction

In this document we present supplemental material aimed to complement the information and results presented in the article.

Supporting Figures

Figure S1 shows horizontal wind profiles obtained a specular meteor radar located also in Andoya (e.g., Chau et al., 2017). Horizontal wind vector components are obtained assuming a homogeneous wind inside the illuminated area, i.e., a circle of approximately 400 km diameter at 86 km altitude.

Figure S2 shows the PDF of w for the DNS under study, i.e., with $Fr0.08$ that is characterized by a kurtosis $K_w = 6.6$.

Figure S3 shows the impacts on ice particles located at three selected altitudes at the beginning of the extreme event, that have been calculated using expected temperature and pressure profiles from empirical models (Picone et al., 2002) as well as the observed vertical drafts. We have used published vapor pressures (Murphy & Koop, 2005), a water vapor volume mixing ratio of 3 ppmv and assuming that the particles experienced the observed vertical velocities for 3 min. In the case of ice particles experiencing the extreme updrafts (pink) they could be transported up more than 8 km in less than 5 min, their temperature could decrease more than 50 K, but their particle radius does not change since there are less water molecules available at these altitudes than lower down. On the other hand, those experiencing downdrafts (green), go down 3–4 km in less than 10 min their temperature increases more than 50 K, and their particle radius could decrease significantly (more than 15 nm in a few minutes), depending on the initial temperature. In Figure S3d, estimations for three different background temperatures with respect to the empirical model are estimated and marked with different line styles. Note that these are approximate values, since we are not using the exact spatial and temporal information of the vertical velocity.

Supporting Movies

Movie S1 shows a temporal animation of the PMSE 2D spatial cuts in Figure 2. Instead of the color bar, a cut at 87 km is included.

Movie S2 shows a temporal animation of DNS results show in Figures 3a, 3b and 3c.

Description of datasets

The data used in the plots presented in this article can be found at `https://www.radar-service.eu/radar/en/dataset/RDOybenOQktKPLsT?token=MIPFqNPRJYOxNGsasNXi`.

We present three types of files:

- Spectra and spectra moments of PMSE echoes in IDL sav format (*pmse_spectra* directory).

- Three dimensional PMSE brightness as function of frequency for each time interval in HDF5 format. The metadata of all imaging files is included in metadata.h5 (*pmse_imaging* directory).

- Winds from a closely located specular meteor radar (*smr_winds* directory)

References

Chau, J. L., Stober, G., Hall, C. M., Tsutsumi, M., Laskar, F. I., & Hoffmann, P. (2017). Polar mesospheric horizontal divergence and relative vorticity measurements using multiple specular meteor radars. *Radio Science*, *52*(7), 811–828. doi: 10.1002/2016RS006225.

Murphy, D. M., & Koop, T. (2005). *Review of the vapour pressures of ice and supercooled water for atmospheric applications.* doi: 10.1256/qj.04.94

Picone, J. M., Hedin, A. E., Drob, D. P., & Aikin, A. C. (2002, 12). NRLMSISE-00 empirical model of the atmosphere: Statistical comparisons and scientific issues. *Journal of Geophysical Research: Space Physics*, *107*(A12), 15–1. Retrieved from `http://doi.wiley.com/10.1029/2002JA009430` doi: 10.1029/2002JA009430

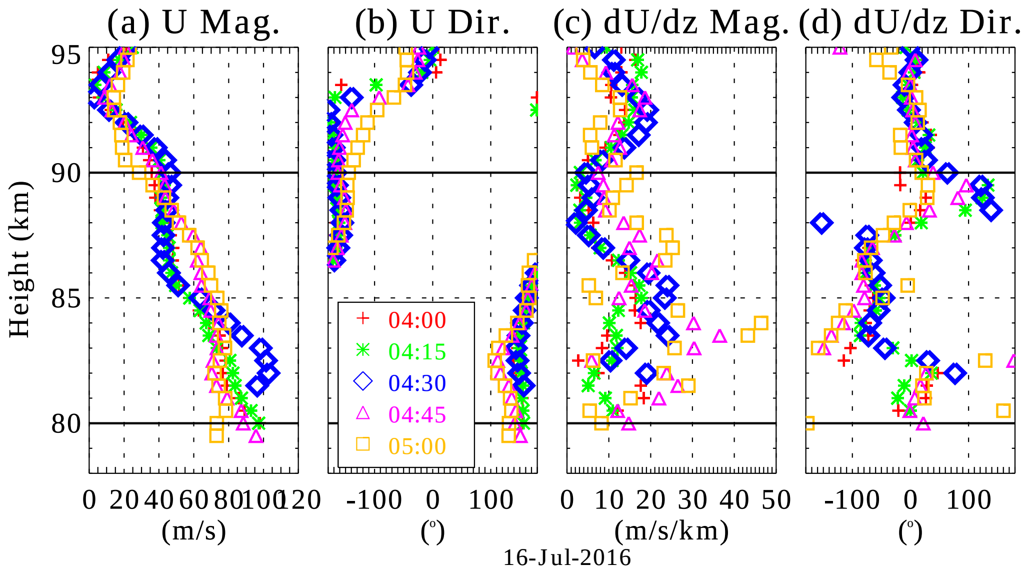

Figure S1. Horizontal winds profiles obtained with a collocated radar that observe specular meteor echoes around 04:30 UT on July 16, 2016: horizontal wind magnitude and direction with their respective vertical gradients. The direction is with respect to x, positive anti-clockwise. The colors indicate time in minutes with respect to 04:30 UT. The central time values are marked with black diamonds.

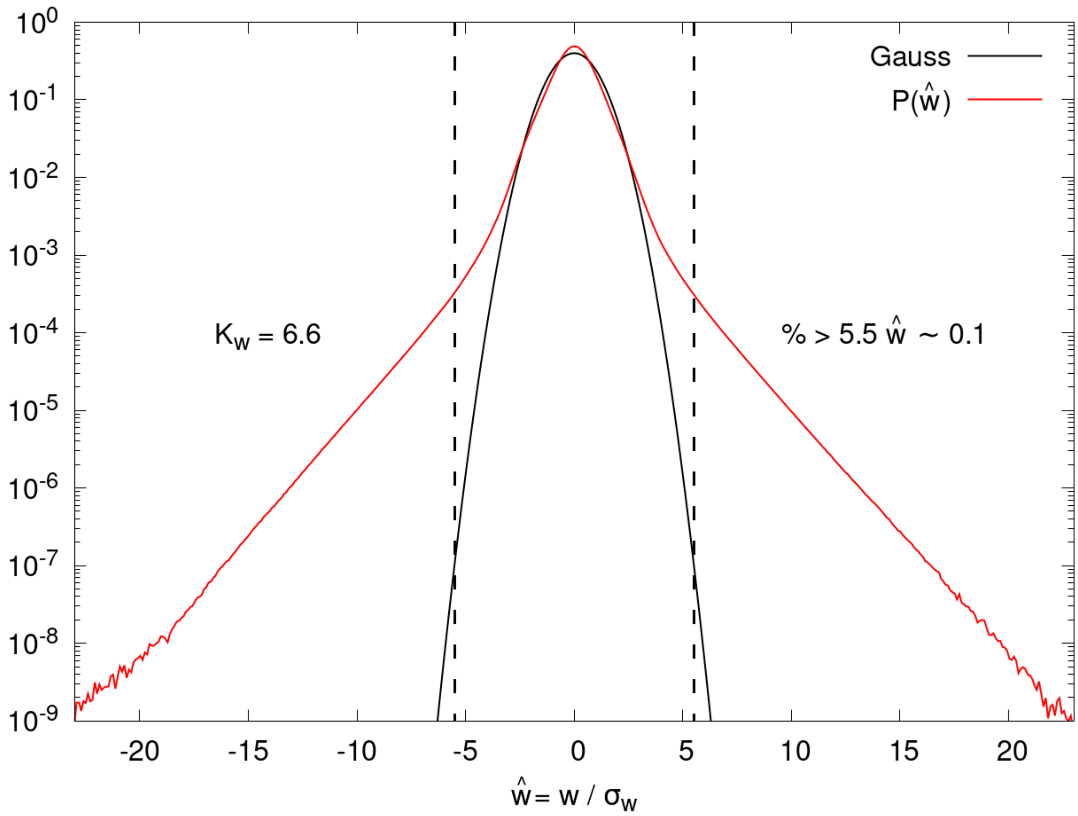

Figure S2. Probability density function of the standardized Eulerian vertical velocities $\hat{w} = w/\sigma_w$ from the DNS of a stably stratified Boussinesq flow with Froude number ~ 0.08, thus compatible with the MLT values (red). In black, a Gaussian distribution with comparable standard deviation is indicated as a reference, the dashed lines indicating $\pm 5.5\sigma_w$. Note that the probability to observe vertical velocities larger than $|5.5\sigma_w|$ is found in this run to be $\sim$0.1%, i.e., 1 in 1000.

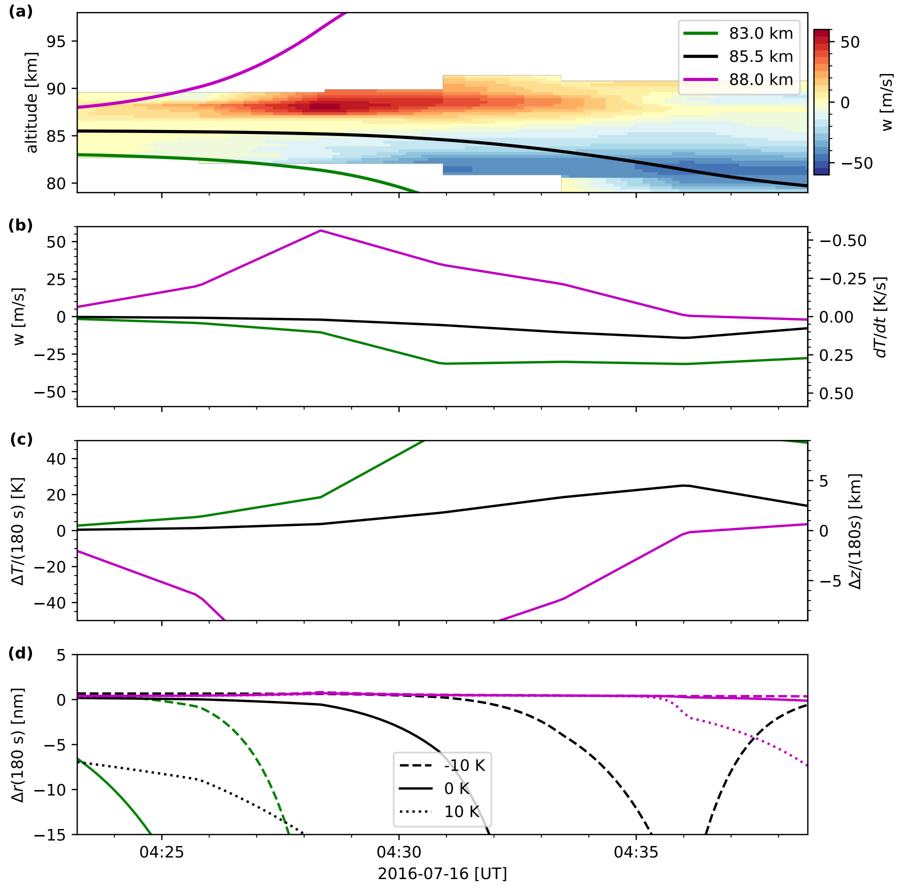

Figure S3. Effects of observed vertical drafts on airparcels located at three different altitudes: (a) observed vertical velocities and particle position, (b) vertical velocities and changes of temperatures for three altitudes, (c) changes of temperature and altitude for airparcels exposed 180 sec to the observed velocities, (d) changes of ice particle radius for three different background temperatures. Line colors correspond to the legend in panel (a).