Response to reviews

Review n°1 by Dr John King

Dear Dr John King,

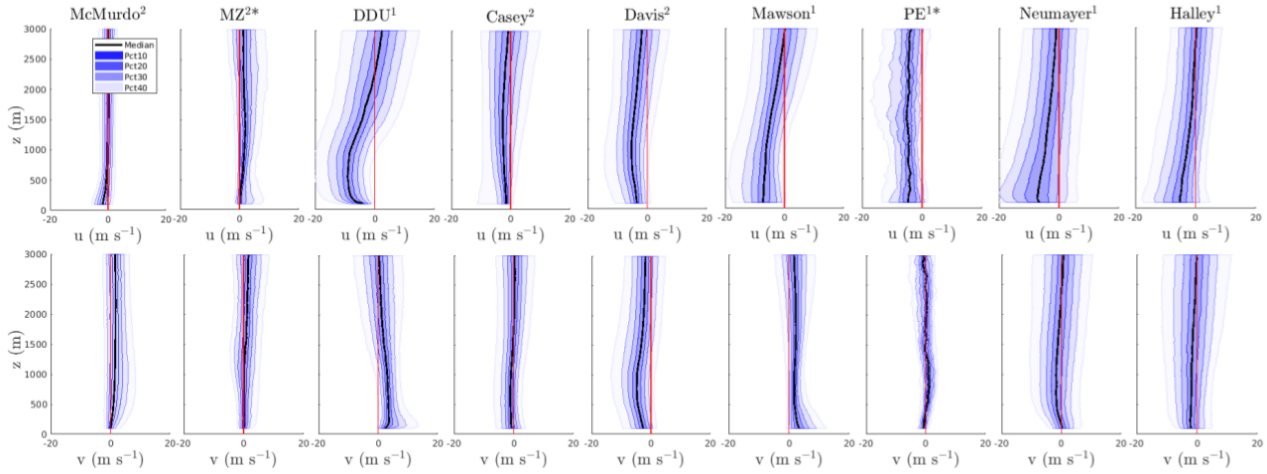
Thank you very much for having carried out a thorough review of our paper. Please find herebelow our responses to your comments.

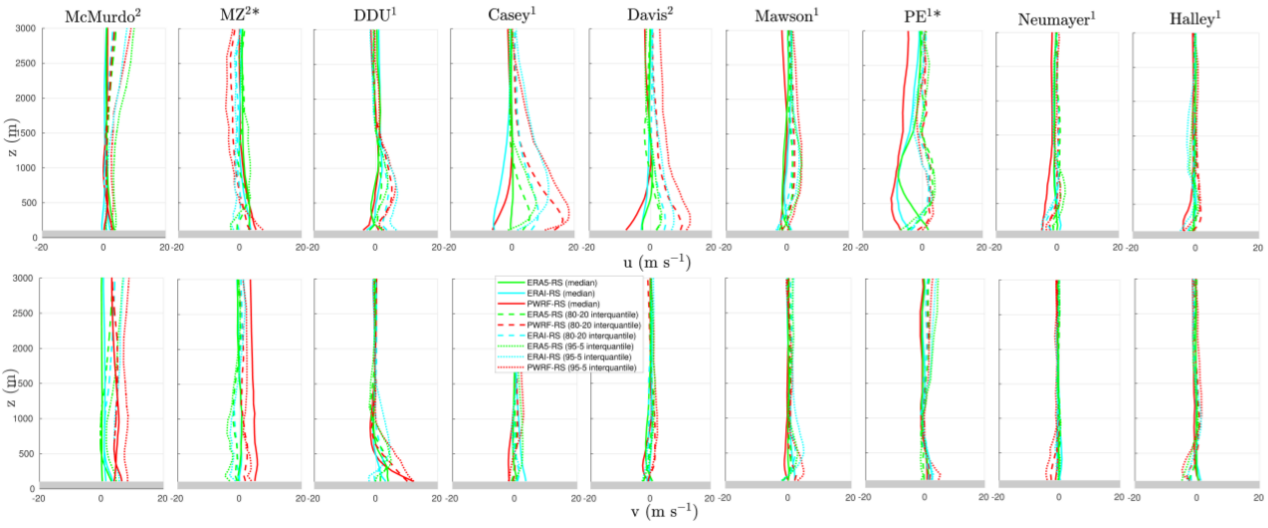
In this well-written paper, the authors develop the first ever climatology of low-level (0 –3000 m above ground level) atmospheric structure in the Antarctic coastal zone. This is an extremely important region where intense atmosphere-ocean interaction control globally-important processes such as sea ice and bottom water formation. It is thus important to understand how well atmospheric models can capture the structure of this region. Obtaining the high-resolution radiosonde data required for producing a climatology that can be used for model validation is no easy task as there is no central repository for such data and the database that the authors have put together is an achievement in itself.
The authors use their climatology to validate two reanalysis products and a high-resolution regional atmospheric simulation using the Polar WRF model. All three products produce a reasonable simulation of the Antarctic coastal atmosphere but with some notable weaknesses. In particular, the model products tend to show katabatic flow extending further offshore than is seen in reality.
The presentation of the manuscript is clear and the methodology is straightforward and sound. Careful thought has been given to the strengths and weaknesses of the data used. Conclusions are soundly based on the analysis presented. I believe that the paper is more or less suitable for publication in ACP as it stands. However, below, and in the attached annotated manuscript I have listed some points which, if addressed, could further improve the manuscript.

Thanks a lot for this comment and for supporting the publication of our article in ACP after revisions.

Major points
1. The main variables validated are temperature, relative humidity and wind speed. While characterising the wind speed profile is a useful first step, the wind direction is also important for things such as the offshore wind stress (which drives sea ice export) and the low-level atmospheric mass and moisture fluxes. It would be a straightforward extension of the validation already carried out to include some validation of the u and v components of the wind separately. Around the coast of East Antarctica the v-component corresponds closely to the offshore or downslope component, making interpretation straightforward.

Thank you for raising this important aspect. First of all we have added two figures in the supplementary materials. The first one shows the statistics of the u and v components separately from radiosonde data. The second one shows the comparison of ERA5, ERA-I and Polar WRF with observations for the u and v components separately:





As these figures are now available for the reader, we can comment more on the behavior of the zonal and meridional components of the wind and on their respective representation by the reanalyses and by Polar WRF.

At the beginning of Sect. 3.1.1 (Annual statistics) we have added the following sentence :

'The reader can refer to Fig. 2 in the supplementary materials for separate statistics for the zonal and meridional wind components and for further information about the wind direction.'

and we have added some comments about the flow direction throughout the section.
For instance for DDU, we now state :
'Moving westward (from left to right in the Fig. 2 to Adé}lie Land and DDU station, a clear katabatic layer can be pointed out in the profiles. This layer is characterized by high wind speeds (with an annual median around 10 m s^{-1} with a south-easterly direction and capped by a temperature inversion at about 1000-1500 m of altitude. Fig. 2 in the supplementary materials also evidences a clear transition from a low level easterly flow to a mid-tropospheric westerly flow at an altitude of about 2300 m.'

In Sect 3.2.1 (evaluation of the wind in ERA5, ERA-I and Polar WRF) we now specify :
'Fig. 6 in the supplementary materials also provides the comparison of the statistics for the zonal and meridional components of the wind separately.'

We have then completed our evaluation of the wind speed in Polar WRF as follows :

'In katabatic regions, Polar-WRF and reanalyses represent reasonably well the sharp increase in directional constancy from z=2000 m to z=500 m that shows the contrast between the synoptic and the katabatic flows. However significant deficiencies can be noted for the low-level wind speed, especially at DDU, Casey and Davis stations. At these three stations the median and the interquantiles are overestimated in the three data sets.
At Davis and Casey stations, the simulated median low-level flow has an excessive westward velocity while at DDU the median low-level wind has a too pronounced southward component (Fig. 6 in the supplementary materials).'

We have also added one comment for the simulation of the wind at PE :

'Note that these deficiencies are mostly due to an overestimation (in absolute value) of the westward component of the flow (Fig. 7 in the supplementary materials).'

2. It would be useful to have some additional information on the physical settings of the locations of the radiosonde stations. In particular, give the actual elevation, local terrain slope and distance from the coast for each station and the corresponding values for the model locations.

Thank you for this important comment.
Following your recommendation in the preliminary quick report, we added a paragraph before the publication of the discussion paper. The paragraph is the following :
"McMurdo station lies on the southwestern edge of the Ross Island, close to the interface between the Ross ice shelf - that extends over 900 km to the south with a slight

rise in elevation - and the Ross sea to the north. The topography of the Ross Island region is complex with steeply rising
terrain corresponding to the two main mounts: the Mount Erebus and the Mount Terror. Black Island and White Island with respective maximum elevation of 1040 m and 740 m are located 30 km south of McMurdo. The Transantarctic Mountains whose altitude can exceed 2000 m are located west of Ross island at a distance of about 80 km.
About 350 km north of McMurdo, MZ is located on the coast of Terra Nova Bay, at the northeastern side of the confluence zone of the Prietsley and Reeves glaciers and at the south of an orographic jump of more than 1200 m associated to the abrupt slopes of the Transantarctic Mountains Range. Mawson station is situated on the coast of an isolated horseshoe-shaped rocky area. The ice sheet surface steeply rises from the coastal ice cliffs surrounding the station toward the Plateau. Davis is a coastal base that lies to the east of the Amery ice shelf in the Vestfold Hills, the largest coastal ice-free area of Antarctica. The land rises progressively to the south-west towards the Plateau and a ridgeline in the ice topography is located around 60 km to the northeast of the station (Alexander and Murphy, 2015).
Casey station is located on the coast of the Wilkes Land, at 12 m of altitude. The Law Dome, which lies to the east of Casey and which rises to an altitude of 1395 m, shields the base from the easterly winds that predominate in the region. DDU station is located at 41 m of altitude on the Petrels Island, approximately 5 km off Adélie Land and the ice sheet proper. The climate at the station is very influenced by strong katabatic winds blowing from the interior of the ice sheet.
Neumayer station lies on the Ekström ice shelf, at a few kilometers from the shore line. The shelf extends more than 100 km to the south with an inclination of approximately 1 ‰. Halley station is situated towards the seaward edge of the Brunt Ice shelf, Coats Land, on the southeastern shore of the Weddell Sea at about 30 m of altitude. The Brunt ice shelf extends to the south-east of the station for over 40 km, and the uniform surface rises very gradually over this distance until the hinge zone where the land steeply rises up to the continental plateau.
Unlike all the other stations of interest here - that are located close to the coast and near sea-level - PE is 220 km far from the coast at 1382 m of altitude. The station has been built on a small granite ridge just north of the Sør Rondane Mountains in the Dronning Maud Land and it is located at approximately 1 km north of the Utsteinen Nunatak that culminates at an elevation of 1564 m."

We have also added a Table in the supplementary materials (Tab 1) that summarises the exact location, elevation and terrain-type characteristics in the ERA5, ERA-I and Polar WRF grid points (and we refer to it in the main text) :

Table 1. Geographical characteristics of the stations (indications in black font). Green, cyan and red indications correspond to the location and mean altitude of the nearest grid point in ERA5, ERA-I and in the Polar WRF simulation respectively. In the last column, the distance from the station to the nearest coast is indicated in black font and the percentage of 'land-type' surface (excluding sea-ice) is indicated for the nearest mesh in ERA5, ERA-I and Polar WRF.

station name	longitude (°)	latitude (°)	altitude (m)	distance to the coast (km) or % of land
Halley	-25.80, -25.8, -25.5, -26.00	-75.61, -75.5, -75.8, -75.68,	30, 25, 207, 74	15, 76 %, 77 %, 91%
DDU	140.00, 140.0, 140.3, 139.9	-66.66, -66.8, -66.8, -66.67	41, 302, 532, 260	0, 75%, 59%, 56%
McMurdo	166.67, 166.8, 166.5, 166.6	-77.85, -77.8, -78.0, -75.74	10 , 138, 239, 1	0, 48%, 84%, 29%
Neumayer	-7.74, -7.8, -7.5, -8.00	-70.63, -70.8, -70.5, -70.82	17, 58.18, 7, 86	5, 75%, 43%, 100%
Mawson	62.87, 62.8, 63.0, 62.75	-67.60, -67.5, -67.5, -67.62	15, 91.25, 383.4, 313	0, 21%, 52%, 69%
Casey	110.52, 110.5, 110.3, 110.7	-66.28, -66.3, -66.0, -66.32	30, 100, 109, 249	0, 36%, 22%, 73%
Davis	77.97, 78.0, 78.0, 78.42	-68.58, -68.5, -68.3, -68.47	18, 45, 142, 200	0, 27%, 24%, 69%
MZ	164.11, 164.0, 164.3, 164.40	-74.39, -74.5, -74.3, -74.67	15, 531, 828, 163	0, 88%, 81%, 62%
PE	23.35, 23.3, 23.3, 23.33	-71.95, -72.0, -72.0, -71.86	1382, 1515, 1518, 1269	220, 100%, 100%, 100%

Minor points

Please refer to the annotated manuscript. Note also throughout: "East-Antarctica" should just be "East Antarctica" (no hyphen). "Mc Murdo" should be "McMurdo" (no space)

Thank you for raising these points. The text and the figures have been corrected.

Please also note the supplement to this comment:
https://www.atmos-chem-phys-discuss.net/acp-2018-1197/acp-2018-1197-RC1-supplement.pdf

Thanks for all these detailed comments. They have all been taken into account.
In particular :

- We have added one sentence about our choice of the relative humidity rather than specific humidity for the study:
« First, the relative humidity is the variable directly measured by radiosondes. »

- We have added one sentence on the WMO guidelines about the exact time at which sounds are launched :
« *It is worth mentioning that the World Meteorological Organisation guidelines state that sondes should be launched at a time such that it reaches the tropopause at the synoptic hour (00 or 12 UTC). To achieve this in the Antarctic where tropopause height is typically 8000 to 9000 ? m, sondes are launched around 45 minutes before the targeted hour. In the lowest 3000 m a.g.l., one might expect the best comparison with model data one hour before the notional synoptic hour. However, the statistical evaluation in Sect. 3 is not appreciably sensitive to a +/- 1 hour shift in the time sampling of reanalyses and Polar WRF data sets (not shown).* »

- We noticed your comment on the size of the wind roses in Fig 3. Given that the paper is already quite long, we prefer not adding a new figure. To improve the readability, we have circled the wind rose with a blue border to increase the contrast. We have actually done the same thing for Fig 4.
To gain insights into the direction of the flow, the reader can also refer to the new figures for the u and v components that we have added in the supplementary materials to answer your first major comment.
- We have added the location of the stations in Fig 11.

We thank you again your careful review of our manuscript. We hope that our corrections will make our paper accepted for publication in ACP,

The authors of « *On the fine vertical structure of the low troposphere over the coastal margins of East Antarctica* »