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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Mid-winter lower stratosphere temperatures in the Antarctic vortex: comparison between observations and ECMWF operational model." *by* M. C. Parrondo et al.

M. C. Parrondo et al.

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Reply to referee #2

The authors want to thank the referee for the careful, detailed and positive review that improves significantly the paper.

Following the referee suggestion, the work of Gobiet et al. (2005) is now acknowledged in the introduction:

"Gobiet et al. (2005) find a vertical wave-like structure bias over the Antarctic latitudes more pronounced in the 2003 winter months (+- 2K) after analysing global coverage data derived by radio-occultation methods onboard the CHAllenging Minisatellite Pay-

load (CHAMP)."

Specific comments

- p7698, l25/p7699, l1: Could you be more specific here, and for instance give some values for these differences in the Southern Hemisphere (SH) polar area?

We changed the sentence to provide some quantitative information:

"Manney et al. (2003) compared six meteorological analyses for two Arctic winters finding that the area with temperatures below a PSC formation threshold commonly varies by ˜25%, with some differences larger than 50% between them. Moreover, the biases Ĕ bias is found. We are not aware on similar studies for the Antarctic. However, since fewer measurements are available for the Antarctic compared to the Arctic one can expect an even worse situation in terms of absolute area."

- p7699, paragraph that begins at line 2: similarly, what is a good agreement (less than 1-K differences?), and a clear bias?

Knudsen 2003 focuses on the analysis accuracy at PSC temperatures and does not provide actual numbers except for the year 1999-2000 (Table 1). For this year the bias (Tobs-Tecm) remains below 0.26K except at very low temperatures (T$<$Tice+2.5K) in which the bias ranges from +0.79 to -0.65 K, depending on the level. Additionally, in figure 2 a map is displayed for the years 96/97, 99/00 and 02/03 in which biases averaged to 0.5, 1.0 and 1.5K can be found. In this figure it can be seen that in years 96/97 and 99/00 biases of 0.5 K or less are dominant. Differences during year 02/03 larger than + 1.5K are common, but only over Russia where the author suggests a possible evidence of the deterioration of the Russian radiosonde network. Moreover, the figure restrict to the 30 hPa level.

We preferred to write the paragraph in a similar way as it is in the abstract of Knudsen 2003. We understand, however, that the paragraph as it stands does not help much. We changed it in the following form:

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“Moreover, the biases between analyses vary from year to year. A direct comparison between the radiosonde network in the Arctic and the ECMWF for the period 1996-2003 (Knudsen 2003) shows agreement in some years up to few tenth of K (i.e. 1996/97 and 1999/2000) while in others a bias larger than 1.5 K is found.”

- p7699 l11-14: this paragraph may better follow the first paragraph of the introduction.

The paragraph is somehow redundant with last sentence of first paragraph. We have deleted this sentence and added some of the material to the first paragraph:

“The study of processes in the lower stratosphere related to the depletion of ozone in Polar Regions such as polar stratospheric cloud (PSC) formation, chemical reaction rates or air mass trajectory calculations rely on winds and temperatures obtained from analyses and forecasts of operational meteorological models. Those models are fed in almost real time by atmospheric data of very diverse origin. In particular, temperatures in the lower stratosphere are mainly based on radiosonde and satellite data. Over the Antarctic region stations are scarce (fewer than 16 radiosonde stations report daily to ECMWF) and forecasts rely basically on satellite radiances from the Advanced Microwave Sounding Unit-A (AMSU-A).”

- Last sentence of the introduction: Rather than an enumeration, the reader would appreciate a presentation of an article plan.

We admit that the last sentence is without an end. We have reformulated to present the plan.

“The dataset produced within QUOBI over Belgrano station has been used here to carry out a comparison with data provided by the ECMWF and NCEP models. Differences in temperature are discussed in terms of their impact on the PSC area probability after rejecting the possibility of sonde calibration errors at extreme low temperatures.”

- p7700, l9: a 0.3žC (C is lacking): Corrected

- p7700, l12: a reference to ECMWF model cy25r4 is made. However, the operational

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model from April 29, 2003 onwards was cy26r1, and then cy26r3 from October 7 on. Can the authors carefully checked that point? It is furthermore said that the spatial resolution is 1.125 deg x 1.125 deg. However, ECMWF analyses can be retrieved with a 0.5 deg x0.5 deg resolution. Did the authors used any spatial interpolation in order to compare ECMWF fields with the Belgrano radiosoundings? The kind of interpolation used should be stated here.

As the referee comment, data come from runs cy26r1 until October 6 and cy26r3 onward. We corrected this.

ECMWF temperature data were extracted from NADIR (NILU's Atmospheric Database for Interactive Retrieval) where they are stored in spectral form truncated to T106 resolution (1.125 deg x 1.125 deg). Data have been used as extracted from the database without any smoothing, interpolation, etc. We noticed that this information is missing in the paper therefore we added it.

"ECMWF temperature data from cy26r1 and cy26r3 runs (ECMWF, 2005) at 12:00 UTC have been extracted from NADIR (NILU's Atmospheric Database for Interactive Retrieval)where they are stored in spectral form truncated to T106 resolution (1.125 deg x 1.125 deg)."

- p7700, l14-15: I am not sure to understand the sentence very well. Did the authors extract from the radiosounding profiles the temperature records that are the closest to the ECMWF levels, so that no vertical interpolation is performed (which, if true, should be stressed)? Furthermore, which ECMWF levels are used ("full" model levels or pressure levels)?

Yes, we searched for the radiosonde data closest in pressure to the ECMWF levels so that no interpolation is necessary. We incorporated this information in the text. We have used "full" model levels.

- p7700, l16-l20: same question for the horizontal/vertical interpolation in NCEP data

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Same answer. The following sentence is added:

“For means of comparison, the closest data to the models levels from the radiosonde temperature profiles were used without any interpolation.”

- p7701,l3:extrema rather than “singular points”. Corrected

- Section 4:pp7701,l14, the authors claim that the lowest stratospheric temperatures are found at ≈ 30-25 hPa. However, if I look at Figure 6, I am inclined to think that the real lowest temperatures are found much below in the stratosphere. I strongly suggest that the authors produce an additional figure with the averaged monthly temperature profiles at Belgrano during QUOBI (and perhaps the same for the analysis), which can be very helpful to clarify this point, and which could also emphasize the unrealistic low ECMWF temperatures at 30 hPa.

After checking temperature mean vertical profiles for July and August we find the statement correct. A plot containing monthly mean vertical temperatures plot can be added to the paper but we don’t see the improvement of such a figure since the material is already included. Temperature evolution in the levels where bias is maximum (figure 2) and differences between ECMWF and sonde temperatures versus height (figure 3).

- p7701, l13: What are the stations used, do they cover the whole Antarctica, how many profiles used?

We incorporated in station names in paragraph starting in line 24: Neumayer, McMurdo, Amundsen-Scott, Syowa, Dumont d’Urville, Belgrano, Davis, Marambio and Rothera. Stations are distributed around the whole Antarctica.

- P7701, l23: NCEP temperatures are warmer than the radiosondes by more than 1 degree C at 50 hPa and 200 hPa.

The sentence has been reformulated:

“Temperatures are always higher in the model, but differences remain below 1 degree

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C in a layer between 150 and 50 hPa”

- P7703,l22: What are the amplitudes of the differences reported by Knudsen et al. (2003)? Do they compare well with the values reported here?

As previously mentioned, Knudsen 2003 gives no numbers for year 2003. From his figure 2 it can be seen that differences in the coldest region at 30 hPa are of 1.5K which is in good agreement with the values reported taking into account that Northern Hemisphere stratospheric temperatures are warmer than Antarctica.

However, a bias comparison between Arctic and Antarctic may easily lead to a misunderstanding since temperature differences are found to be largely dependent on the temperature at certain levels. Moreover, the reported differences can be due to Russian radiosonde network degradation, as suggested by the author.

Since Knudsen paper focus on the Arctic, we preferred to avoid quantitative comparison here.

- P7704,l2: It seems to me that the results of Parrondo et al., confirm very well with those of Gobiet et al. This should be more clearly stated

We emphasized the Gobiet et al. work by adding the following:

“The Gobiet et al. (2005) global results derived by a completely independent radio-occultation method show an excellent agreement over Antarctic latitudes in magnitude and height dependence with that obtained in this work.”

And in the summary, after the second sentence

“in excellent agreement with those obtained by Gobiet et al. (2005) derived by a completely independent dataset based on radio-occultation from satellite”

- References: Gobiet et al’s mistakes: Corrected

- Figure 2: The levels reported in this figure (namely 31.9 hPa, and 25.7 hPa) are not

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the ECMWF “full”- model levels on which the prognostic variables (like T) are computed, but rather the “half”- models levels, i.e. the interface between levels. In contrast, in figure 3, there is no dot on the ECMWF curve at 31.9 hPa or 25.7 hPa. In figure 3, the dots are at the right positions (23.3 hPa, 28.9 hPa and 35.8 hPa). There is thus a clear need to clarify on which levels are the temperature extracted from the radiosoundings: on the “full” levels as it should be (in this case figure 2 has to be modified accordingly), or on the “half”-levels, wrongly, in which case the data analysis has to be reprocessed?

We strongly appreciate the referee for noticing the differences in levels between figure 2 and 3. Calculations are performed in “full”-model levels and consequently the figure 2 is wrong. By any reason an old version of the figure computed at the inter-layers was included without notice of the authors. In new figure for levels 18 (28.9 hPa) and 19 (23.3 hPa), details on bias for individual days have slightly changed but the average magnitude of the bias and its temperature dependence remains the same.

- Figure 2 legend: include “2003” before “winter”, “at Belgrano” after “radiosondes”. “In the lower stratosphere”, rather than “at the lower...” Correct the ECMWF levels if needed. Corrected

- Figure 3: The x-axis unit is lacking. The legend should state that the curve has been obtained with radiosoundings performed in several Antarctic stations. It should also state the signification of the error bars (1 standard deviation ? 2?...)

We can see the units in figure 3 x-axis (deg C). Can be a printer problem?

Obviously figure 3 caption is insufficient. Now, it stands as:

“Differences in temperature between radiosondes and operational models for Belgrano. Bars represent one standard deviation.”

- Figure 4: The legend should state whether the figure has been produced with only Belgrano radiosoundings, or with other Antarctic stations.

Corrected

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- Figure 6: The legend should read: “Left: Areas... ECMWF analysis (top) and ... Right...”

Corrected

- Figure 7: the x-axis legend should read “Day number in 2003”

Again, we can see in our copy the legend

Technical comments

All points have been corrected

Abstract last sentence has been re-written:

“Here we show the results of the comparison and discuss the potential implications that this bias might have on the ozone depletion computed by Chemical Transport Models based on ECMWF temperature fields after rejecting the possibility of a bias in the sonde data at extreme low temperatures.”

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 7697, 2006.