A global radiosonde and tracked balloon archive on 16 pressure levels (GRASP) back to 1905–Part2: Homogeneity adjustments for wind data

General response.

We thank the two reviewers for their thoughtful comments. We believe they helped us considerably to improve the manuscript as well as the output netCDF file format.

Both the reviewers pointed out the importance the manuscript and recognised the big effort made in order to homogenize the available upper air wind data collected in the GRASP archive, presented in the part I of this work, already published by ESSD doi:10.5194/essd-6-185-2014. The reviewers understood the main emphasis of our homogenization is put on the early year, and no remarks about the method are advised.
The reviewers underline the paper has to be improved to meet the scientific style convention, in particular they found:

- poor quality of the language. We apologies for that and we have tried to improve the style, the grammar and we used a spell checker to eliminate the typos. Also the abbreviation, the parameters and equations were not consistent: we worked in order to make them uniform through all the paper.
- too many pictures with in some cases too small text font and, in some cases, the captions is not complete: we rearranged most of the pictures, cut some of them with redundant information, and combined some others, paying attention to carefully describe the caption and increasing the text font in the picture.
- NetCDF files not well documented and not user friendly: the file structure has been revisited and a dedicated appendix, to explain in the details the file content, has been added. The new files can be downloaded at http://doi.pangaea.de/10.1594/PANGAEA.823608?format=html (full archieve) and http://doi.pangaea.de/10.1594/PANGAEA.823609?format=html (single stations).

All the reviewers' general, detailed and technical remarks have been taken in account, and in the following part we respond point by point.

Answers to reviewers

Anonymous Referee #1

The paper presents the results of the homogenization of a new data set of wind speed and wind direction records for different pressure levels covering a significant number of stations over the world. The importance of such work can hardly be overstated.
Homogeneity breaks arisen from the changes of instruments and measurement routines, station relocation etc. can affect results of climatological studies. Therefore, such breaks have to be detected and possibly corrected before any scientific analysis. The authors of the paper did a good work deserving to be published. However, I think, the paper in the current state need to be improved before it can be accepted for publication.

We are glad that the reviewer appreciates the importance of this work and we hope that the description in the paper now meets the required standard.

First of all, English needs polishing. Sometimes it's quite difficult to understand what authors mean. The sections Abstract, Introduction and Conclusion require essential style corrections.
We tried to improve the style as far as we could and sent the manuscript to peers for proofreading before submitting it again

Secondly, all abbreviations, identifiers (like e.g. WMO identifiers) and parameters have to be explained in the text (e.g. PILOT and GRASP on p. 338, lines 4-5 or "U and V wind values" on p. 341, line 25).
We now have explained the abbreviations at their first occurrence.

Thirdly, the text is full of typos and sometimes the descriptions of a figure in the main text disagree with figure's captions or even with figure itself.
Consistency between text and figures should now be much better. We ran the text through a spell checker so that most typos should now be eliminated.

Technical notes:
1. Figures The text in some of the figures is difficult to read. The font size of the text in Figs. 1, 3-4, 6-8, 10-11 have to be increased.
We have increased the size of axis labels and other text in most figures

Also, in my mind, it would be better if the scale for the SNHT statistics in the Fig. 8 would be the same as in the Fig. 6: the increase of the homogeneity of the corrected data can be easily seen.
This has been left as it is. The scale change is, however, now mentioned in the caption.

I would also recommend to decrease the number of figures. Some of the figures can be combined (like Figs. 6-8, 12-14, 18-19, 20-21). This merging would not only decrease the figures' number but also help readers to see the clear difference between the raw and corrected data.
We have combined several figures as suggested. In particular Figs 6-8 have been condensed to one figure, now containing curves at only one pressure level instead of three.

Other figures (like Figs. 15-16 and 22-23) can be submitted as Supplemental or On-line Material.
We consider those figures as important enough to keep them in the main text, so we did not follow this suggestion.

Please, also, add the descriptions for the open circles to the captions of the Fig. 17. - done
2. Typo on p. 341, line 27 – "is is" - fixed
3. Equation on p. 342, line 10 – the sign seems to be wrong - fixed
4. On p. 349, line 19 and on p. 351, line 15 the word "Fig." is missing in "in 6" and "see 6". - fixed
5. On p. 350, line 1 – "Figure 10" has to be instead of "Figure 6" - fixed
6. On p. 350, line 11-12 – here in the text the Fig. 11 is describing as having plots for 750, 500 and 300 hPa levels, but the Fig. 11 on p. 371 shows only data for the 500 hPa level. - fixed
7. On p. 353, lines 14-15 – the descriptions of the plots shown in Fig. 22a and Fig. 22b are mixed up. – we have rewritten the relevant 2 paragraphs so this should now be fixed
8. In the Appendix A (p. 356, line 11) the Greek letter "theta" has to be changed to "phi". – dd is now used for wind direction. The issue is fixed

I strongly recommend to the authors to thoroughly re-read their text, improve its style and English, and re-check all figures and their descriptions.
As already mentioned - we tried to improve the style as far as we could and sent the manuscript around before submitting it again.

Anonymous Referee #2

The reviewed paper describes the big effort which was made to homogenize the available upper air wind data from different sources starting in 1905 as far as possible. Main emphasis was put on the early years, although there the hardest conditions occur due to low data coverage.
Unfortunately neither the paper nor the data meet the scientific style conventions. In the current state it is not recommended to publish the article.
The diction makes the paper hard to read – the authors should improve the English considerably.
Thanks for recognizing that the generation and homogenization of these early data is a big effort. We concentrated on the early years since this paper is a first serious attempt to homogenize those data using surface data only reanalysis data. We have tried to improve the language as far as we could and we invested quite some work in making the format of the published data compliant to the CF convention.

General remarks
PILOT: The format for messages from fixed land stations which contain only wind data. They are called PILOT messages (see http://www.ofcm.gov/fmh3/pdf/13-app-e.pdf); pilot ballons or pibal is used more often.
We now use the term “pilot balloons” throughout the paper.

Names and symbols should be unified through the hole paper (as well in text, formulas and figures), e.g. NOAA-20CR, NOAA 20CR, NOAA20CR, 20CR, bg or ff, WS or Φ, WD or Δ, τ or ‘an’, ‘20CR’
We now use NOAA-20CR throughout the paper and we use only one name for symbols.

Meteorological conventions should be considered, e.g. that Φ is used as symbol for geopotential (like in part1)
We now use dd instead of Φ for wind direction. Also the time indexing has been simplified.

Formula should be written like in part1: the dependence of a variable on time is easier to read in Eq 2, part 1 than in Eq. 1 of part 2
We handle the time dependency now consistently in Eq. 1 and 2.

The paper does not explain the content of the data files.
A section has been added in the appendix that describes the data files in some detail. Also the file structure itself has been simplified and better standardized.

Detailed remarks:

Page 337 Line 20: Thorne et al. (2011) does not deal with temperature biases of radiosondes or upper air temperature trends.
Thorne et al. (2005) is now cited.

Page 339 Line 11: Brönnimann et al. (2012) analyses temperatures of the arctic not for mid-latitudes like cited here…
We now refer to Compo et al. (2011) where this is better visible.

Page 340 Line 2: "data starting in 1905 at Lindenberg": Fig. 1 does not show a dot for Lindenberg for 1930-1940 and the data in the according netCDF-file 010393_t_U.nc (if the crude time axis wasinterpreted well by the reviewer) start in 1950.
We have clarified this point. Lindenberg starts in 1905 but only for temperature. There are a few stations (such as Hamburg) that start with wind measurements in 1904.

Page 340 Line 8: "Since then the network has not changed much." – This is not true as the former gaps (South America, South Africa and Pacific) are filled.
After the IGY 1958 there were only moderate changes. We have narrowed this statement to the period 1958 onward, mentioning also some notable changes, such as the reduced density in the Former Soviet Union.

Page 341 Line 10: Wrong sign, correct is: the value is corrected to value minus 360° in case of being larger than 180°.
Thanks for pointing this out. The formula is now corrected.

P 343 Line 7: N=1470 means that the chosen interval is 4 years, this contradict to page 344 line 16 where 'the intervals a, b are generally chosen longer (1-8 years)" for break adjustment. Later (page 346 Line 8) it is written that 'interval for the break size estimation has been set to 8 years'. Please, give the information in which cases N varies (as written p 342 line 17).The authors did not mention that k has to be larger than 730 and smaller than sample size – 730.
We now explain in more detail which time intervals are used for break detection and which for adjustments.

Page 343 Line 23: <Qk> should have the index tm as you have different means for 00:00 and 12:00 GMT time series.
The formula has been changed as suggested.

Page 344 Line4: It becomes not clear how the break probability was calculated, please include the conversion function.
While it would be ideal to derive the break probability using a conversion function from the SNHT value to a probability, this is hampered by various obstacles. Those are autocorrelation of the time series, missing values at some levels and the correlation between levels, which vary from station to station. The choices made are values that work well in the sense that break detection seems justified a posteriori by visual inspection and in the sense that the global trend heterogeneity is substantially reduced.

Page 344 Line 18: Should it be the standard deviation of τΦ? (instead of the mean)
No, this is meant as it is written.

Page 344 Line 18: Do the authors mean 'the vertical mean of break sizes'?
Yes, the vertical mean of break sizes.

Page 345 Line 22: Citation is missing.
Compo et al. 2011 is now cited in this paragraph.

Page 345 Line23: The quotient was calculated, not the difference.
This is now corrected.

Page 345 Line 28: 'for the scatter plot' – which scatter plot is meant?
The reference to Fig. 4a) is now more precisely given.

Page 347 Line 3: Figure A1 by Compo et al. (2011) shows low bias above 500 hPa and only for latitudes -30° to 40°N. Stickler et al (2010) only mention NOAA-20CR, but do not show or comment any data. Fig. 3 from part 1 does not show wind speeds but U and V for 150 hPa.
The wind speed bias is now described more precisely such that it corresponds to Compo et al. 2011

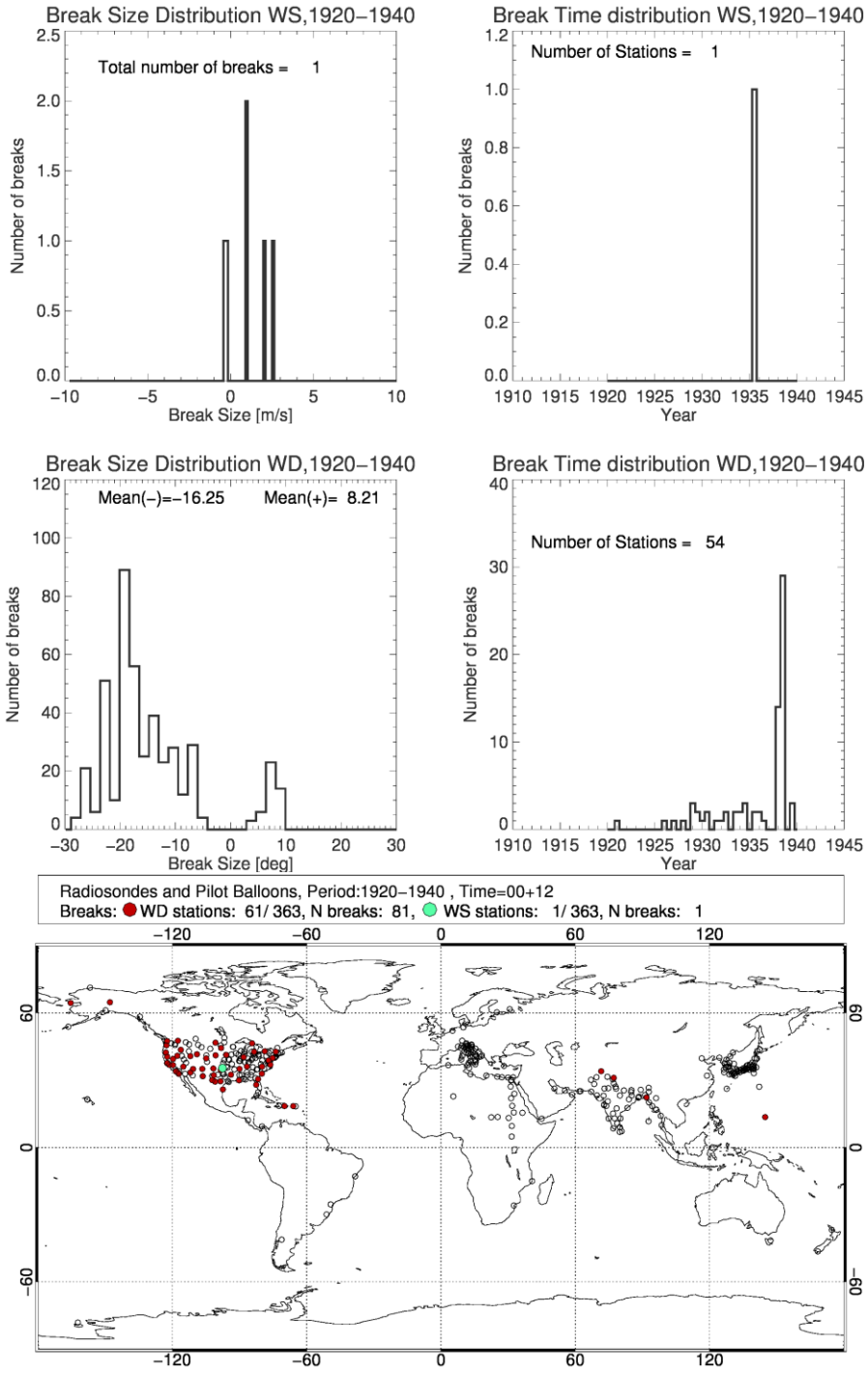
Page347 Line18: Time period is not given for Figure 4 data and Figure 4d is not mentioned. It is not clear, why data from 4a vanish during the step to 4b (as well in case 4c data below 60% vanish on the way to 4d).
Figure 4 is now described more precisely in the caption and in the text.

Page 349 Line 1: The high variability of the time series in Fig. 2 makes it hard to see any shift in the sense of the authors.
This is intended. The reader should see that it is difficult to detect breaks from the time series without a reference. The breaks are now highlighted by vertical bars and also the 700 hPa line , where the break is best visible, is now plotted last.

Page 349 Line3: 'only three pressure levels that have an almost complete time series back to 1935' – in Figure 2 only the 700-hPa-line goes back to that time.
We have reformulated this text passage.

Page 349 Line 19: 'No visible inhomogeneities remain.' As the reviewer understood all colored areas under the SNHT curve indicate inhomogenities and such areas are still visible in Fig. 8.
This formulation was indeed to strong. We have changed it accordingly.

Page 349 Line 21: The authors should provide a number of found inhomogenities in the 1930s for wind speed over US. At page 350 Line 6 they wrote 'Generally it has been found that wind speed breaks over the US are relatively rare and relatively weak'. Please, check whether the adjustments have an influence on the data Brönnimann used.



As the plots show, there are practically no wind speed breaks but several wind direction breaks, most notably in 1938, and almost exclusively over the US. The breaks act such that the difference in wind direction between mid-1930s and early 1940s shown in Fig. 3 of Brönnimann et al. (2009) is large. Had the breaks been adjusted, the difference would have been about halved, so that they are more like the differences between dry and wet years at later periods.

Page 349 Line 25: 'The breaks in the 1970s and 1980s are no longer visible in the adjusted innovation time series.' The language is not precise enough: nothing was done for wind speed at station Bismark, so SNHT is unchanged.
The wind speed change at Bismarck is indeed weak in the early 1960s and zero elsewhere. This is now clarified.

Page 350 Line 12: 1997 no break is to be seen – what is meant?
There is no break in 1997, so this year has been removed from the list in the text.

Page 351 Line 19: 'generally directed southward' is not true as the adjustment has positive and negative sign.
This has been to reformulated as: adjustments are such that winds change from westerly to more northwesterly in most cases.

Page 353 Line 6: The geographical name for the region is Antarctica.
Corrected

Page 353 Line 14: Give the time range considered (1900-2010?).
The time range is now given.

Page 354 Lines 25ff: Please explain, why known breaks (Gruber and Haimberger (2008) are not considered.
As now explained in the text, there are two reasons:

1. first, the ERA-40 used in Gruber and Haimberger (2008) has several known inhomogeneities, so that we cannot trust the wind speed breaks too much to be used as metadata in this evaluation.
2. second reason is the small variance of the background departure time series in ERA-40 (which assimilated upper air data) that allowed the detection of more breaks than is possible from the difference series from a surface data only reanalysis.

Page 355 Line 2: Dee and Uppala (2009) did not made wind bias adjustments, only surface winds were mentioned.
Right, this has yet to be implemented and tested. So we now write "future adjustment…"

Pages 361 to 383: The figures, especially the captions, suffering from inaccurateness.
We have revised almost all figures to get larger axis labels etc. and we have improved the captions. Also the panels are now labeled to make easier reference to them.

Fig. 5: Lat=45N does mean what?
We agree, the latitude is meaningless in this context and it is now omitted.

Fig. 6: The WS-Threshold is about 20, whereas it is higher than 25 in Fig. 8; the color of the triangles is not explained.
Thanks for pointing this out. The thresholds in the plots are now consistent with what is written in the text and with what was used in RAOBCORE.

Technical remarks:
Language corrections are mentioned only in exceptional case, the article has to be revised (ideally with the help of a native speaker).
P 337 Lines4-6: “they still are an essential component of the observing network” is the same as “Even then they remain an essential component of the observing network.” - fixed

P 338 Line 4: “called GASP” and “(GASP)” is one to much. - fixed
Page 342 Line 12: better: Gaussian distributed - fixed
Page 343 Line 23: Eq number and ‘with’ is missing. - fixed
Page 346 Line 1: in the range 1.0–1.2 provided assumed there - fixed
Page 346 Line 2: For easier reading, please start the sentence with ‘Beyond 1960 the mean…’ - fixed
Page 346 Line 10: It is not clear want is meant by ‘between the current break and the beginning of the time series’. (The last detected break?) - fixed
P346 Line 14: to track of the ascending - fixed
Page 347 Line 24: monthly means are shown in Fig. 5 - fixed
Page 349 Line 19: in Fig. 6 - fixed
Page 350 Line 11: No data for 700 and 300 hPa are shown. - fixed
Page 352 Line 20: Written is ‘at least 10 years’; caption of Fig 17 ‘at least 15 years’- fixed
Page 353 Line 13: Figure 22b - fixed
Fig. 1: The caption content “Between the 1960s and the 2000s the difference is relatively small.” does not belong to a caption.
This has been deleted

Fig. 2: ‘Note shifts in 1938 and 1948’ does not belong to the caption if they are not marked.
This has been deleted

Fig. 8: Changed right y-axis is not mentioned. - fixed
Fig. 9: WMO station number should be given in caption of Fig.3
This has been added

Fig. 23: Replace BeakNum by total number of breaks.
This has been changed

Technical remarks to one file out of the data set (010393_t_U.nc):
The format of the data (netCDF) is highly appreciated. But the main advantage of netCDF (self-explaining files) is not given, because the file structure is orderless, variables are unexplained, certain attributes are not used. Variables not belonging to the file (e.g. Varno_R_Humidity etc.) should be excluded from the file. Ancillary Data and Flags (http://cfconventions.org/1.6.html#ancillary-data) should be used for the variables ‚status‘ and ‘anflag’. The use of standard_names for all variables is highly recommended. unit=”” is not valid. ‘event’ is not explained. ‘sonde_type’ is set to missing value though the whole tested file. Version number of RAOBCORE is missing as well as the origin of the data. The described dataset includes the self-demand to accord the climate and forecast conventions 1.4 – this is not the case, at least in the tested case of file 010393_t_U.nc (U-wind at Lindenberg, Germany) The attribute of the variable ‘pressure-layers’ should be pascal, the valid range is certainly not 0 to 23 as given in the file. The time axis is not given properly: there are date (which should have the dimension unlimited, the numbers in the variable does not fit to the unit, _FillValue = -999 is not allowed in this case: data without time are useless), obs_time and original_time (with a wrong valid range 0 to 24 and additionally values up to 30) and index_days. Index_days starts with 18263 – if this is the content

belonging to the unit ‘days since 1900-01-01 00:00:00’ than it would mean that the data set starts in 1950 and not in 1905 as written at page 340.
The global attributes are incomplete; one should follow the recommendations of cf: http://cfconventions.org/1.6.html#identification-of-conventions
The content of the file was not checked because of the inadequate file structure.

The reviewer was right that too little care has been given to the attributes of the netCDF files. Several attributes have been added and the units as well as valid ranges have been corrected. Variables that contained only missing values have been omitted. The files are CF 1.4 compliant as has been tested by http://puma.nerc.ac.uk/cgi-bin/cf-checker.pl?cfversion=auto. The provided netcdf reading routines have been adjusted as well.