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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Evaluation of ECMWF water vapour analyses by airborne differential absorption lidar measurements: a case study between Brasil and Europe" *by* H. Flentje et al.

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1. General Comments

This paper presents an interesting comparison of water vapour mass mixing ratios between short-range ECMWF forecasts and new lidar measurements made from an aircraft. The paper concentrates on a region of the atmosphere that lacks routine good quality observations of water vapour of good coverage. One short flight and one long flight (the latter made in two legs) produced valuable data for two days in March 2004. The results show good agreement between the modelled and observed data, especially in the light of the difficulty of modelling and measuring water vapour

concentrations. An analysis has been made of the errors in the results.

I would recommend that the paper be published, but I would suggest that it is modified after consideration of the points that I highlight below. I raise in this section issues that I think are general, with specific points in the remaining sections.

The discussion of water vapour transport and the use of back-trajectories requires attention. In my view and as it stands, this is a weak part of the paper. It is mentioned that transport determines the water vapour fields. E.g. on P.4406, lines 10 and 14 I did not understand the statement that, "Back-trajectories reveal that the humidity fields are largely determined by transport". I took this to mean that water vapour in the regions studied behaves as a conserved tracer. This can be only sometimes true (e.g. in downward moving air), and the back-trajectories shown in Figs. 4 and 5 do not demonstrate this. In these Figs. many back-trajectories show considerable cooling (in forward time) as they arrive at their destinations, indicating that the water vapour is influenced strongly by thermodynamic processes, as would be expected. Firstly, the statement about transport should be clarified, in case the authors do not mean it in the same way that I do. Secondly, the discussion of the back-trajectories in the discussion section (P.4415) requires attention. The authors should discuss Figs. 4 and 5 in detail. This is missing and as it stands it is not clear what points are being made about the nature of water vapour processes by showing the back-trajectories. Further, there are too few back-trajectories. I would presume that many more back-trajectories have been studied, but the ones shown are representative? I was also puzzled why the Figs. 4 and 5 were arranged in the way that they are (why not all in one Fig., or three separate Figs?) and why are some back-trajectories run for 7 days and others for 9 days?

The way that many of the Figs. are discussed needs some attention, especially for Figs. 2 and 3 which have many panels. Sometimes it is unclear which panel is being discussed. Usually the reader can work out which panel is being discussed, but each point in the text should be explicitly linked to each Fig. panel to lead the reader through the discussion in a lucid way. There are other examples, e.g. in the discussion on

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P.4410,L.22, Fig. 1 is referenced, but this should actually be Fig. 1a.

The ordering of the Figs. needs to be changed. Some journals have a policy that the Figs. should be arranged in the same order that they are discussed (I would presume that APCD has this policy, but even if the journal doesn't, it is good practice anyway). In this paper (P.4411), the discussion jumps from Fig. 2 to Fig. 6, without discussing Figs. 3, 4, or 5 up to that point.

The ECMWF forecast/analysis system requires additional discussion. Of importance are the observations of water vapour that are assimilated in the upper troposphere and lower stratosphere (UT/LS). Only a brief discussion is necessary (e.g. how high radiosondes ascend, which satellite data are used, and how many humidity observations are used in one assimilation cycle). This is useful to appreciate the accuracy of the ECMWF's analysis of water vapour in the UT/LS.

2. Specific Comments

2.1. P.4406,L.4: The title of the paper refers to analyses, but the ECMWF water vapour fields used in the paper are actually forecasts from analyses. These are two different things. On my first read through the paper I thought that only a one-hour forecast was made from each analysis, which seemed strange. On reading again, I came to the conclusion that a set of forecasts were made, separated by one hour (between 0 and 5 hours I would presume). Is this correct? This should be made clearer at the earliest opportunity in the paper. In connection, the paper's title should be changed (e.g. change "analyses" to "fields"), and at other points in the paper, as this would describe what is actually being done. (In practice, I presume that a mix of forecasts and analyses are used depending upon the time of day that the measurements are made).

2.2. P.4406,L.16: The term "bias" is used without indicating clearly what is biased with respect to what. I presume that the bias refers to that of the ECMWF model fields with respect to the lidar observations. Could the author indicate, if possible, whether the

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biases shown are good, bad or average compared to other forecasting systems?

2.3. P.4406,L.19: Correlation values are quoted. Are these anomaly correlations (see also point 2.9 below).

2.4. P.4409,L.24: What are the relevant meteorological parameters that were developed along the flow? Please give an example to put this into context.

2.5. P.4410,L.9: What is a "labile" flow?

2.6. P.4411,L.17,L.18: I don't think that the word "bias" should be used in this context, as the field shown in Fig. 2d are specific differences between model and observation data. "Bias" should be changed to "difference". Bias is a quantity that is meaningful when referring to a shift between two distributions that have a similar shape. The term is therefore meaningful in the context of Fig. 6.

2.7. P.4411,L.22: In connection with the above point, please change "mean bias" to "bias".

2.8. P.4411,L.23: What is the difference between the +/- value quoted and the standard error? Are they the same? Please state what this means and how it was calculated.

2.9. P.4411,L.26: What is meant by the "linear correlation" coefficient? How was it calculated?

2.10. P.4412,L.22: See point 2.6 above.

2.11. P.4412,L.23: See point 2.8 above.

2.12. P.4412,L.26: See point 2.9 above.

2.13. P.4413,L.12: See point 2.8 above - in particular the +/- value quoted and the standard error are, unlike in previous uses, different here. What is the difference in meaning between these values?

2.14. P.4414,L.7,L.9: What do these standard deviations refer to? Are they just the

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widths of the distributions in Fig. 6?

2.15. P.12,L.24: Similar to point 2.7 above, change "mean relative bias" to "relative bias".

2.16. P.16,Fig. 1b: What do the red dots indicate in this panel? Specifically what is meant by "upper tropospheric water vapour" (an average between two layers perhaps)?

2.17. P.4421,4422, Figs. 2 and 3. I would recommend that the contours placed in panels b and c of each Fig. be removed as I can't find where in the paper they are used in the discussion. Since Figs. 2 and 3 are very similar, the caption of Fig. 3 should read something like, "As Fig. 2 but for ...".

2.18. P.4425, Fig. 6. What do the different coloured lines mean in panel b? If the measured distributions for leg 1 and leg 2 are dashed and solid respectively (both black lines), why not use dashed and solid blue lines to represent the Gaussian fits? The scale in the x-direction used in these plots make it very different to see the biases. It might be clearer to place panel b below panel a and to make each twice (or more) its current width. Also, in the caption, should "panels C" mean "panels d"?

3. Technical Corrections

3.1. P.4405, in title: Spelling mistake "Brazil".

3.2. P.4406,L.16: Change "accounts to few" to "is a few".

3.3. P.4406,L.20: PBL is used but not defined until later.

3.4. P.4407,L.13: Add "such" ie, "services such as".

3.5. P.4407,L.15: Change "e. g" to "e.g.".

3.6. P.4408,L.27: What is meant by "Other than there"? Suggest removing this.

3.7. P.4409,L.20: Change "and few 10 m" to "a few 10 m".

3.8. P.4409,L.24: Remove "following".

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3.9. P.4410,L.22: Spelling mistake "gray" to "grey".

3.10. P.4410,L.24: Opportunity to save space "Cb" instead of "Cumulonimbus".

3.11. P.4411,L.4: What does "a.g.l." stand for?

3.12. P.4412,L.4: "note that clouds are circled for security reasons". I initially interpreted this that cloud features in the Figs. had circles around them. I suggest that this is changed to, "note that, for safety reasons, clouds were circled by the aircraft", if this is what is meant.

3.13. P.4412,L.8: Suggest that "from 20N to beyond the equator" is changed to "from 20N equatorward and beyond the equator" to make this description easier to understand.

3.14. P.4412,L.11-12: Suggest that the last sentence of this paragraph be changed to, "The measurements in Fig. 3b show a layer of relatively moist air (q 0.5 g/kg) extending from 0 to 15N at about 10 km altitude above a layer of dry air (q<0.1 g/kg) at about 8 km altitude. This is similar to the situation on 10 March between -24 and -26N (Fig. 2b)." This might make the description clearer (if this is an accurate reflection of the authors' point).

3.15. P.4414,L.28: Change "Headley" to "Hadley".

3.16. P.4415,L.16: Suggest changing "observations" to "observed water vapour distribution".

3.17. P.4415,L.17: I presume that "9-d" means "9 day" (I would suggest making this change). Also, some of the back-trajectories are 7 days long, which should be mentioned here.

3.18. P.4416,L.10: Suggest changing "a hardly predictable" to "an unpredictable".

3.19. References: I would encourage the authors to check the spelling in the references. I haven't checked in detail, but I have spotted a couple of errors in the third

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reference - change "McNelly" to "McNally" and change "Thepaud" to "Thépaut".

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 4405, 2007.