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Interactive comment on "Improving the bias characteristics of the ROPP refractivity and bending angle operators" *by* C. P. Burrows et al.

C. P. Burrows et al.

chris.burrows@metoffice.gov.uk

We would like to thank the reviewer for providing useful comments. The two points raised are addressed below.

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1 Comment 1

1.1 Reviewer's comment

The authors mention (Sec 4, page 4455, line 15) that the exponential interpolation (linear-log N) is negatively biased, without further comment. I do not think that this is systematically the case, but the sign should be related to the prevailing temperature and moisture gradients. Assuming dry air, the bias of the power law under negative temperature gradient (troposphere, mesosphere) is likely of different sign than that of the corresponding power law under positive temperature gradient (stratosphere).

1.2 Response

It is true that the sign of the correction will depend on the sign of the temperature gradient. This can be seen in equation A23 of the Discussion Paper, and is reproduced below.

$$N(x) = N_i \exp\left(-k_m\left(x - x_i\right)\right) \times \left(1 + \frac{k_m\beta}{2T_m}\left(\left(x - x_m\right)^2 - d\right)\right) \tag{1}$$

The temperature gradient, β will determine whether the corrected refractivity is larger or smaller than that calculated by assuming exponential varying refractivity. The text should be clarified to state that the 'systematic' bias depends on the sign of this gradient.

The region focussed on in this paper is the stratosphere, where radio occultation data has a large impact on NWP analyses, but where the vertical spacing of model levels is often large enough to allow these biases to have a significant impact. The two regions of negative temperature gradients mentioned by the reviewer are of less importance

in practice; In the troposphere, the model levels are usually close enough that the exponential assumption is reasonable, and in the mesosphere, the observation uncertainties are large, and hence the observations are given little weight in an assimilation context.

2 Comment 2

2.1 Reviewer's comment

The authors mostly elaborate on the issues associated with large spacing of the upper levels, where most of the problem is mathematical (the best interpolation choice for a function that is not exponential but still moderately simple, segments of power law). However, are the large moisture gradients in the low troposphere better tractable? Besides the broken linear distribution for temperature, the authors propose an exponential for moisture. But is the moisture part significantly better, or the distribution is simply too variable and the interpolation presents intrinsic limitations?

2.2 Response

The assumption of exponentially varying specific humidity is seen to give a more realistic interpolation than a linear assumption on a single-profile basis, but this doesn't rule out a more representative option existing. In the troposphere, where moisture is most prevalent, the vertical spacing of the model levels is relatively small, so to an extent the exact form of the humidity variation between model levels at these heights is not critical, and does not affect the statistics significantly (compare Figure 2 with Figure 4 and Figure 3 with Figure 8 below approximately 10 km).

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 4439, 2014.

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