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Atmospheric Measurement Techniques Discussions

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Interactive comment on "Performance Evaluation of THz Atmospheric Limb Sounder (TALIS) of China" *by* Wenyu Wang et al.

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1 General Comments

This paper describes the performance of a proposed instrument. If flown, the instrument will make an important contribution to monitoring the chemistry of the middle atmosphere, particularly in view of the fact that EOS MLS on NASA's Aura satellite will inevitably cease operation in the next few years, and no similar instrument other than TALIS is planned to continue the EOS MLS record. The paper should be made available to the public in some way for that reason. I am not entirely convinced that it deserves to be published in AMT, though, and certainly not as it stands. The reason for this is that the proposed instrument is quite close to being a carbon copy of the EOS

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Discussion paper

MLS instrument. EOS MLS has been in flight for 15 years, now, and its performance and limitations have been studied and reported in enormous detail. A simulation of the performance of an instrument which is very similar to EOS MLS provides only a very small advance in knowledge.

Where the two instruments differ is in the spectrometers used. EOS MLS has old-fashioned filter banks, whereas TALIS will use FFT spectrometers with many more channels. For this paper to demonstrate any novelty, it needs to show how the coverage of the TALIS spectrometers differs from that of the MLS filter banks, and to demonstrate the extent to which the improved coverage leads to improved quality of retrieval products. This would involve simulating retrievals with the two sorts of spectrometers, with all other factors kept identical.

The simulation reported has a number of failings. The most serious of these are the failure to properly consider the vertical resolution of the instrument, and the failure to describe the antenna characteristics assumed; these characteristics are the main factor limiting the vertical resolution of the instrument. For the paper to be published, the antenna characteristics should be described, and the inevitable tradeoff between resolution and precision considered properly. Another problem is the failure to address how information on the geometrical tangent height is to be incorporated into the retrieval of temperature and tangent pressure.

The paper is generally presented adequately for the most part. The standard of written English is rather variable, but is such that the authors' meaning is always clear. The figures are of a good standard in most respects, but I make some suggestions for improvement below.

2 Specific comments

- Page 1 line 18: In “high single scan retrieval precision of 1 – 50%”, remove the word “high”. 1% can be considered high precision in this context, but 50% is not high precision in any context. I suppose you could replace “high” with “relatively high”.

- Page 1 line 25–27: It seems odd to talk of this instrument as a “Terahertz limb sounder” when its highest frequency is 0.6 THz and its lowest frequency is below 0.2 THz.

- Page 3 lines 5–7: The double sideband nature of both UARS MLS and Aura MLS has been a considerable nuisance to the instrument team, especially when attempting to obtain results in the important 300 hPa – 60 hPa range. It was a technological limitation at the time EOS MLS was built, which would have been too expensive to work around. Modern mm-wave technology includes sideband-separating receivers. As TALIS appears still to be in the design phase, the authors might like to consider whether this technology would be appropriate.

- Page 3 line 14: “TALIS covers most spectral bands of EOS MLS and extends them.” It would perhaps be worth adding some sort of diagram with the EOS MLS and TALIS spectral bands overlaid on each other, so that the reader can quickly see by how much the TALIS coverage extends that of EOS MLS. The should also be a statement that EOS MLS had a band at 2.4 THz which TALIS will lack — there is no need of a diagram to show this.

- Page 3 line 15: “... and lower noise of TALIS”. The authors should probably state the T_{sys} values of the EOS MLS bands so that the reader can easily see how much lower the noise level of TALIS will be. A cross-check against Waters et al. (2006) (see Table 1) indicates that the TALIS T_{sys} values are either effectively the same as those of EOS MLS or are about 30%–50% better. This is unlikely

Table 1. System temperature values for TALIS and EOS MLS

Band	T_{sys} (TALIS)	T_{sys} (MLS)
118 GHz	800	1200
190 GHz	1000	900 – 1100
240 GHz	1000	1300 – 1300
643 GHz	3000	4000 – 4400

to be sufficient to allow easy measurement of a species which EOS MLS can not measure. If TALIS can really do a better job than EOS MLS, it is likely to be on account of the bandwidth and resolution of the spectrometers rather than because of the slightly better measurement noise.

- Page 4 Line 10: It is worth pointing out that the only SO_2 which is observable by instruments like EOS MLS and TALIS comes from volcanic eruptions.

- Page 4 Lines 12–13: "...MLS demonstrated that SO_2 can be measured by 240 GHz radiometer cooperated with 190 GHz radiometer ...". What I actually said in Pumphrey et al. (2015) is that MLS measures SO_2 from three radiometers: 190 GHz, 240 GHz and 640 GHz. The radiometers are not combined with each other. Rather, a separate SO_2 product is produced from each radiometer. Only the 240 GHz SO_2 product is recommended for general use.

- Page 4 line 14: "NO_2 is a unique species not covered by EOS MLS". This is entirely true. The authors should perhaps explain whether TALIS's ability to measure this species is due to improved bandwith, resolution or radiometer noise. Figure 3 suggests that the measurement will be very difficult.

- Page 8 line 5: This formula defines the Planck brightness temperature. It is not uncommon in microwave remote sensing (especially in limb sounding) to work with the Rayleigh-Jeans brightness temperature because it is proportional to the radiance. The authors should be clear which brightness temperature they intend to use.

- Page 10 section 4.1: This section omits a number of important items. Firstly, it does not state what antenna pattern is assumed when applying equation (5). This is important because the antenna pattern is the main limitation on vertical resolution. The pattern does not always vary with frequency in the way one would naively expect. The 640 GHz band of EOS MLS has better vertical resolution than the 190 GHz band, but nowhere near the three times better that you would expect from Rayleigh's criterion. This is because the 640 GHz radiometer does not view the full aperture of the antenna. Secondly, nothing is said about the specific problem of temperature/pressure retrieval. We usually have two sources of information about where the antenna is pointing: pressure information that comes from the radiance measurements, and geometric height information which comes from the satellite navigation system and the antenna view angle. These two pieces of information are linked by the hydrostatic equation, which itself depends on the temperature profile. For the temperature retrieval precisions presented to be credible, the reader needs to know how the geometric tangent height information was incorporated, and how precise it was assumed to be.

- Page 14ff, figures 6–10: The precision becomes very much poorer very suddenly at a height of 25 km. The authors should explain why this is. The figures make it appear as if the retrieval grid changes vertical resolution at this point from a grid which is coarser than the achievable vertical resolution to one which is finer than the achievable vertical resolution. This will inevitably make the retrieval precision appear far worse below 25 km, but this does not mean that the performance of the instrument itself is far worse below 25 km. The authors should perhaps try showing averaging kernels calculated for a far finer grid, so that the true vertical resolution of the instrument can be assessed. They could then choose a retrieval grid which matches the achievable resolution better.

- Page 23 figure 12: The mixing ratio of CO changes over a very large range. In my experience, the only way to show a vertical profile over the 10 km–90 km range is to use a logarithmic mixing ratio scale.

3 Technical corrections

- Page 2 Line 2: "Earth' " should be "Earth's".
- Page 2 line 28: "Spectrum resolution" should be "spectral resolution".
- Page 3 line 12: "criterions" should be "criteria". Although there is a trend in modern English away from using Greek or Latin-derived plurals, "criteria" is in very general use, but nobody says "criterions".
- Page 5, figures 1 – 4: The different lines on these figures can be quite hard to distinguish and to match up with the legend. It would help if the authors were to make the lines slightly thicker and to ensure that they choose strongly-contrasting colours. (They should continue to avoid pure yellow (#ffff00) and pure green (#00ff00) as these colours can be hard to see on a white ground.) The vertical scale currently goes from 1 K to 1000 K, but the data do not cover this entire range. If the software used will permit, the vertical scale should be reduced to cover 2 K to 300 K
- Page 4 line 16: "as more spectral" should be "as many spectral"
- Page 4 lines 24–25 and throughout the paper: in LaTeX, use a non-breaking thin-space (`\,`) between a number and its unit in order to avoid a line break at that point. Here, write `635.87\,GHz`.
- Page 8 line 3: T should be in math mode so that it comes out in math italic (T). In LaTeX, write `$T$`, not `T`.

- Diaeresis out of position over de la Nöe's name. Also, “la” does not have a capital letter.