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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aircraft millimeter-wave retrievals of cloud liquid water path during VOCALS-REx" *by* P. Zuidema et al.

Anonymous Referee #2

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General comments

- The paper presents airborne measurements with the GVR instruments during VOCALS-Rex. In general the paper is interesting (both for its new instrumental approach and cloud analysis) and well written, however, I have some problems with its focus. The title suggests a rather technical assessment of liquid water path (LWP) from a new airborne approach (requiring a more detailed error budget) while the introduction points more in the direction of stratocumulus process analysis. The paper starts with information on the southeast Pacific radiative environment (section 2) which contains also an instrument description before it goes on with section 3 on water vapour. It is also not logical to have the discussion on the liquid absorption properties in the water vapour section (3.2). In my view the whole section 3 only serves to give the neces-

sary information for the LWP retrievals (and the introduced uncertainty) and could be focused in this sense.

For the sake of clarity I suggest to i) change the title (either go for process studies or also include water vapour), ii) introduce a section dedicated to the accuracy of measurements/ retrievals (see also my next points) and iii) expand the introduction by formulating the research questions addressed later on.

- It is a challenge to disentangle the influence of water vapour and liquid water on the measured brightness temperatures (4 channels). Resonant emission by water vapour determines the shape of the 183 GHz line (half width approx. 3 MHz/hPa) with a significant influence of the continuum absorption at the outer wing channels. Emission by liquid water increases with frequency. Therefore a double-sideband receiver will smooth the response to liquid water. The exact mixture depends on the sideband response (should be – but isn't always 0.5) and the bandpass response of the frequency channels. The problem to account for the different influences of WV and liquid needs to be explained and a quantitative attempt to describe the uncertainty needs to be made. The values given in section 3.1 give a rough range but do not include all sources of uncertainty.

- I do not understand why the authors base their retrieval only on the +/-14 GHz channel for LWP (section 2, line 18). Including more channels should reduce the sensitivity of the retrieval to uncertainties - mostly I am worried about the variability of the boundary layer troposphere WV. I guess that there are more practical reasons for choosing this retrieval approach. In general, the information on the retrieval approach is scattered throughout the paper – the retrieval philosophy needs to be explained early on (eventually you can add a flow chart). Further, section 4 should include a summary of the uncertainty contributions.

Specific comments

- Please be consistent and give WVP always in mm or in cm.

- Page 19583. Lines 17-18: For clarity please add "..pointing upward"

- Page 19584. Line 14: Why did you choose WVP above 1370 m – not 1400 m or 1500 m?

- Page 19585. End of section 2. Say clearly how your algorithm will work and that in your approach you first need to derive WVP from the above cloud flight legs.

- Page 19585. Line 27. What is the typical standard deviation?

- Page 19586. Line 7. Why only one sonde? If their was only one good match say so.

- Page 19586. Line 13. Either explain the external calibration in detail or leave it out. What is the difference to the one done during inflight (two reference loads to calculate gain and Tsys)? "Foam of known emissivity" sounds rather vague. Did you use ecosorb or pyramidal material and at which temperature?. How do you handle the residual reflectivity?

- Page 19588. Lines 1-4. Scattering by ice crystals strongly depend on their size. You could shorten this by just referring to Bühler et al. (2007, QJRMS, Fig.3) that shows that at 183 GHz particles need to have an effective radius larger them 100 um to be effective scatterers – therefore much larger than in found in most cirrus clouds.

- Page 19590. Lines 25-28. Why is the physical retrieval scheme "more applicable to lower WVP environments"? The scheme should include the effects of non-linearities. I would guess it is more the apriori and covariances which are not matched to the pacific environment?

- Page 19591. Lines 4-7. "..by integrating the in-situ water vapor mixing ratio from flight level up to either the lifting condensation level, or, to one-half of the altitude difference up to the cloud base." I don't understand what you mean by altitude difference. Maybe an idealized sketch could help? How do you determine the cloud boundary information (refer also to othet VOCALS papers) and how accurate is it? How does this error propagate? The IR temperature might be too warm due to water vapour emission

below cloud.

- Page 19591. Lines 24-26. What is the variability of the boundary layer WVP?

- Section 5 (assessment). Out of consistency I would recommend three subsections for the three assessment approaches.

- Page 19598. Lines 7-10. Better give the instrument (radar, lidar) specifications when you introduce the cloud boundary determination.

- Fig.6 Why do you show relative humidity up to 20 km. One can't trust the RH measurement in the stratosphere - better assume a fixed concentration of about 4ppm. I would just show only the lower 15 km then one can also see the PBL height better.

- Figures – I can not distinguish purple and black on my screen.

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