The water budget of the uppermost tropical troposphere

Patrick Eriksson, Mattias Ekström and Bengt Rydberg
Chalmers University of Technology, Gothenburg, Sweden
Contact: Patrick.Eriksson@chalmers.se

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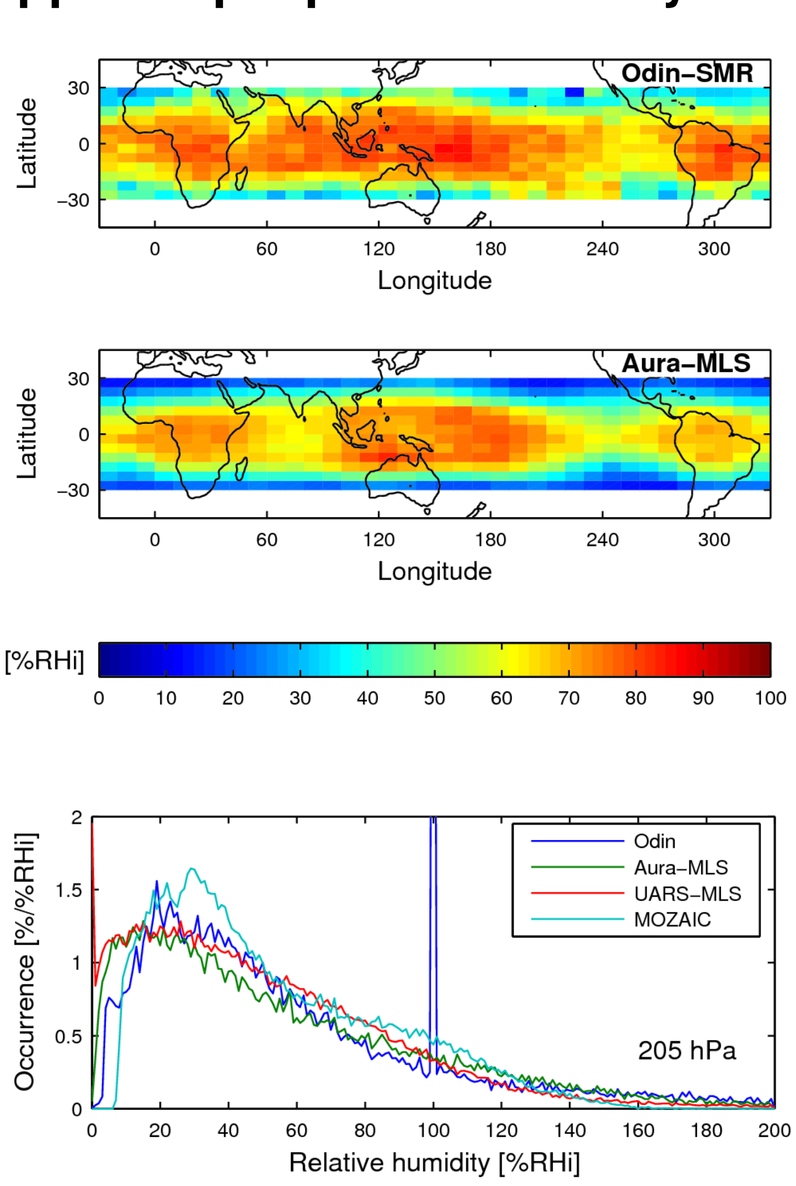
Summary and conclusions

The exact nature of the processes responsible for the moistening of the upper tropical troposphere is still uncertain. This problem is partly explained by the poor performance of older instruments in the upper parts of the tropical troposphere, but some recent microwave instruments have the potential of providing improved global measurements of both water vapour and cloud ice mass. Data from Odin-SMR, UARS/Aura MLS, CloudSat and MOZAIC have been compared to evaluate the accuracy of the satellite retrievals. The results point towards that the average tropical humidity in considered altitude range can now be measured from satellites, by MLS and SMR, with a systematic error < 15 %. Much higher differences were found between CloudSat, MLS and SMR cloud ice mass estimates. Both MLS and SMR retrievals can be improved with respect to cloud inhomegenity effects, and the CloudSat data should be most accurate at this stage.

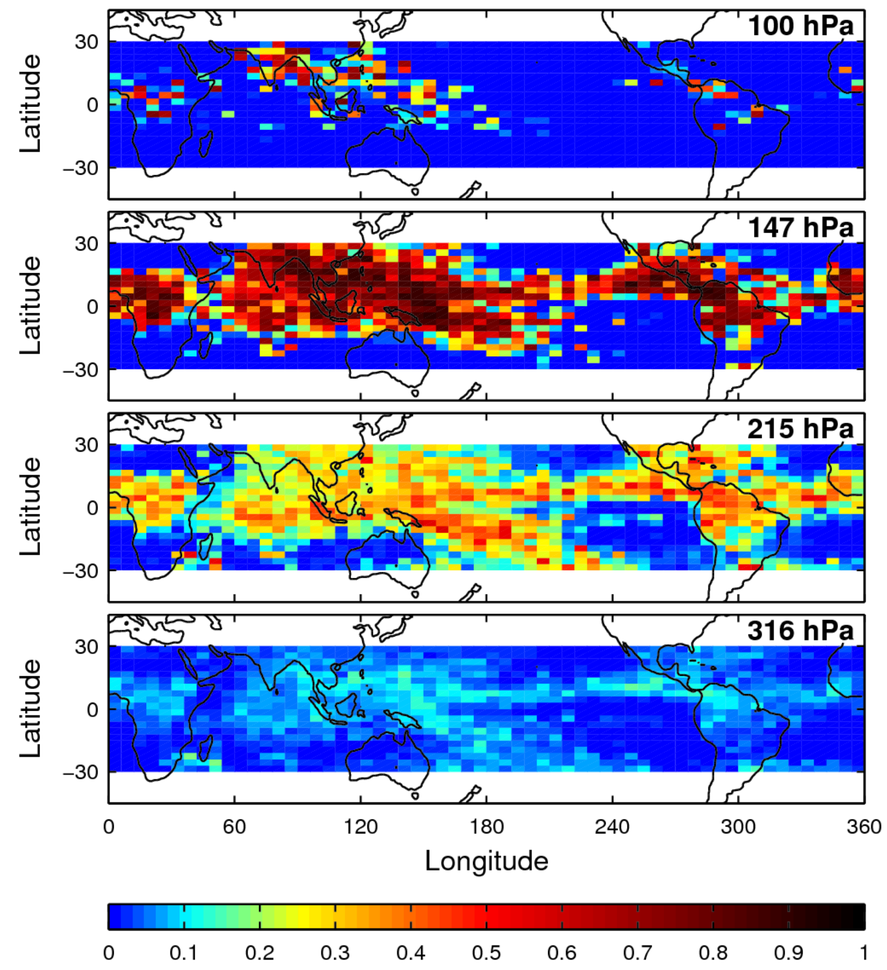
Aura MLS humidities and cloud ice from CloudSat have been used to investigate the ratio of ice mass to total water. The ice-fraction derived is normally less than 10 % around 10 km and outside regions of deep convection in the altitude levels above. On the other hand, the ice-fraction can be significant at higher altitudes in regions of deep convection, reaching values of around 80 %. Below the TTL, ice and water vapour distributions have similar spatial patterns indicating that water in both phases is transported up to the upper troposphere by the same processes. The ice fraction is locally high in the TTL, but the dissimilar patterns of ice and water vapour could be interpreted as that the cloud ice gives a limited final moistening effect.

Measurements of upper tropospheric humidity

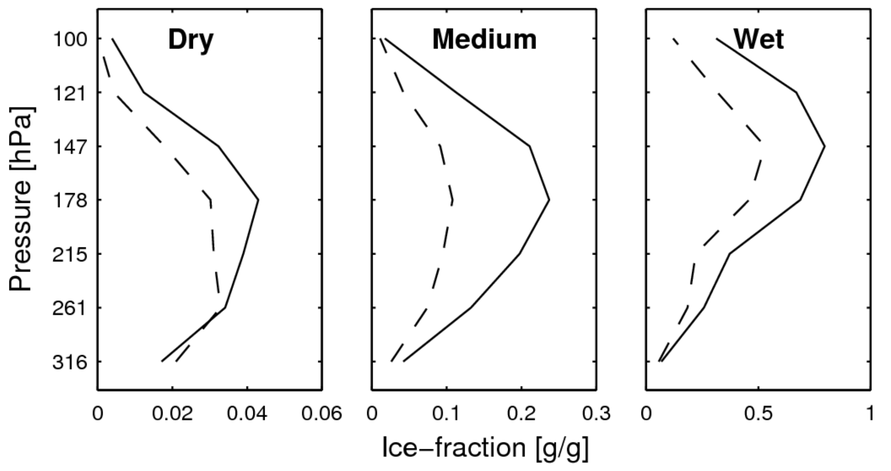
A first algorithm to retrieve tropical UT water from Odin-SMR observations has been developed, providing RH_i for two layers (12 and 15 km). SMR and MLS mean values around 12 km are shown in the top figure, while the lower figure compares PDFs for data inside the MOZAIC flight corridors [1]. A high agreement is in general found, and the comparison suggests low systematic retrieval errors for all three involved satellite datasets. Disagreements are partly caused by the fact that the SMR retrieval sets the RH_i to 100% if cloud scattering is strong, and can not handle cases with low tropopause at the edges of considered latitude range.



Cloud ice mass fractions

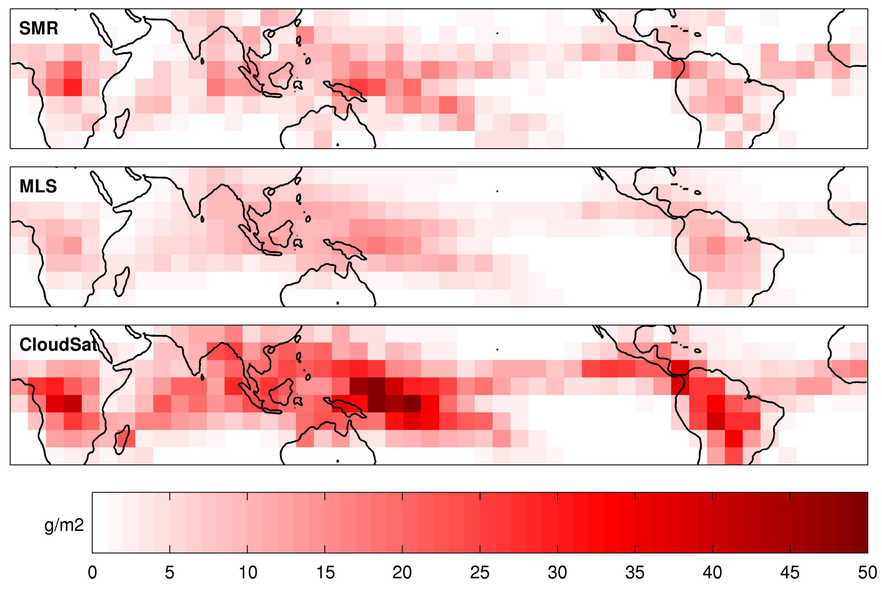


The ratio $m_{ice}/(m_{gas}+m_{ice})$ where m_{ice} is the cloud ice mass [g/m^3] provided by CloudSat (R04) and m_{gas} is the mass of water in gas phase derived from Aura MLS (v2.2) VMR data and ECMWF temperatures [2].



Vertical profiles of ice mass fractions for 3 different regions [2]. Dashed lines indicate the uncertainty.

Cloud ice mass measurements



Cloud ice mass above about 12 km [3]. Data from the first SMR cloud ice retrieval are here compared to (integrated IWC) data from MLS (v2.2) and CloudSat (R04). The datasets differ substantially and several possible error sources were identified.

Results and figures from

[1] Ekström, Eriksson, Read and Murtagh, Comparison of satellite limb-sounding climatologies of the uppermost tropical troposphere, ACP, 2008.
[2] Ekström and Eriksson, Altitude resolved ice-fraction in the tropical upper troposphere, GRL, 2008.
[3] Eriksson, Ekström, Rydberg, Wu, Austin and Murtagh, Comparison between early Odin-SMR, Aura MLS and CloudSat retrievals of cloud ice mass in the upper tropical troposphere, ACP, 2008.