USING CALCULATED WATER VAPOUR INDICATOR TO EXPLORE CLOUD POTENTIAL IN THE TROPICAL TROPOPAUSE LAYER DEHYDRATION

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1.0. Introduction

Both water vapour and clouds have important radiative effects which play a role in the atmospheric dynamics and the energy balance that impact the earth's climate system. The radiative effect of water vapour is most important near the Tropical Tropopause Layer (TTL) where its measurement is quite difficult due to low absolute concentration and the presence of ice.

Clouds are intimately related to the distribution of water vapour, especially in the Upper Troposphere (UT) near the TTL. Quantification of the relationship between the UT water vapour and clouds is important to understand how cloud and water vapour feedbacks will operate in a future climate (Su et al., 2006).

Introduction Cont…

Studies have revealed positive correlation between Upper Tropospheric water vapour, Cloud Ice, and Deep Convection over the tropical region (i.e. Su et al., 2006) , though not much have been done on such kind of relationship at the (TTL) which is highly dehydrated.

The TTL, a region which extends from about 14 to 18 km and surrounds the thermal tropical tropopause controls the input of water vapour into the lower tropical stratosphere, and is also the location of large sheets of Subvisible Cirrus (SVC) Clouds, which are a factor in the earths radiation budget (Pfister et al., 2006). The TTL air dehydration is suggested to be a complex mix of convective hydration or dehydration and in-situ dehydration by the SVC.

2.0. Data and Methodology

Simultaneous in-situ balloon-borne observations of relative humidity, pressure and temperature profiles derived from the tropical soundings of Southern Hemisphere Additional Ozonesondes -SHADOZ of National Aeronautics and Space Administration (NASA) network in Nairobi, Kenya (1^0S, 37^0E) for the period between 2000 to 2006 were used. These were supplemented with Radiosonde temperature and pressure profiles from Nairobi Radiosonde station for the same period. The weekly SHADOZ profiles and daily Radiosonde profiles were averaged to obtain monthly profiles up-to about 33km above the surface with a vertical resolution of about 150m.

Each monthly relative humidity profile was an average of 2-6 profiles. Shorter profiles ranging from 14-18km above the surface representing the Tropical Tropopause Layer (TTL) were then extracted from the entire profiles. The total numbers of soundings from SHADOZ used in this study were above. These were compared to the profiles from satellite-borne Halogen Occultation – HALOE TTL zonal mean measurements for the same period for both Sunrise and Sunset Occultations between the latitudes of 20^0N and 20^0S.

Area-average time series of cirrus reflectance and cloud ice optical depth from Moderate Resolution Imaging Spectroradiometer (MODIS) Level-3 products from NASA's Aqua satellite for the period from 2000 to 2006 over the region, 17E – 64E, 9S – 9N were investigated.

3.0. Discussions

Buck's formula for vapour pressure over ice was used to calculate the vapour pressure *(Buck, 1981, Buck Research Manual, 1996)*. Errors in calculating vapour pressure can result to errors in specific humidity. Zhain and Eskridge, 1997, showed that this error can be caused bias for vapour pressure caused by using mean temperature, and the magnitude of this bias is inversely proportional to the square of the mean temperature. They also pointed out that the error can be greater than 10%, and as high as 20%, at low temperatures.

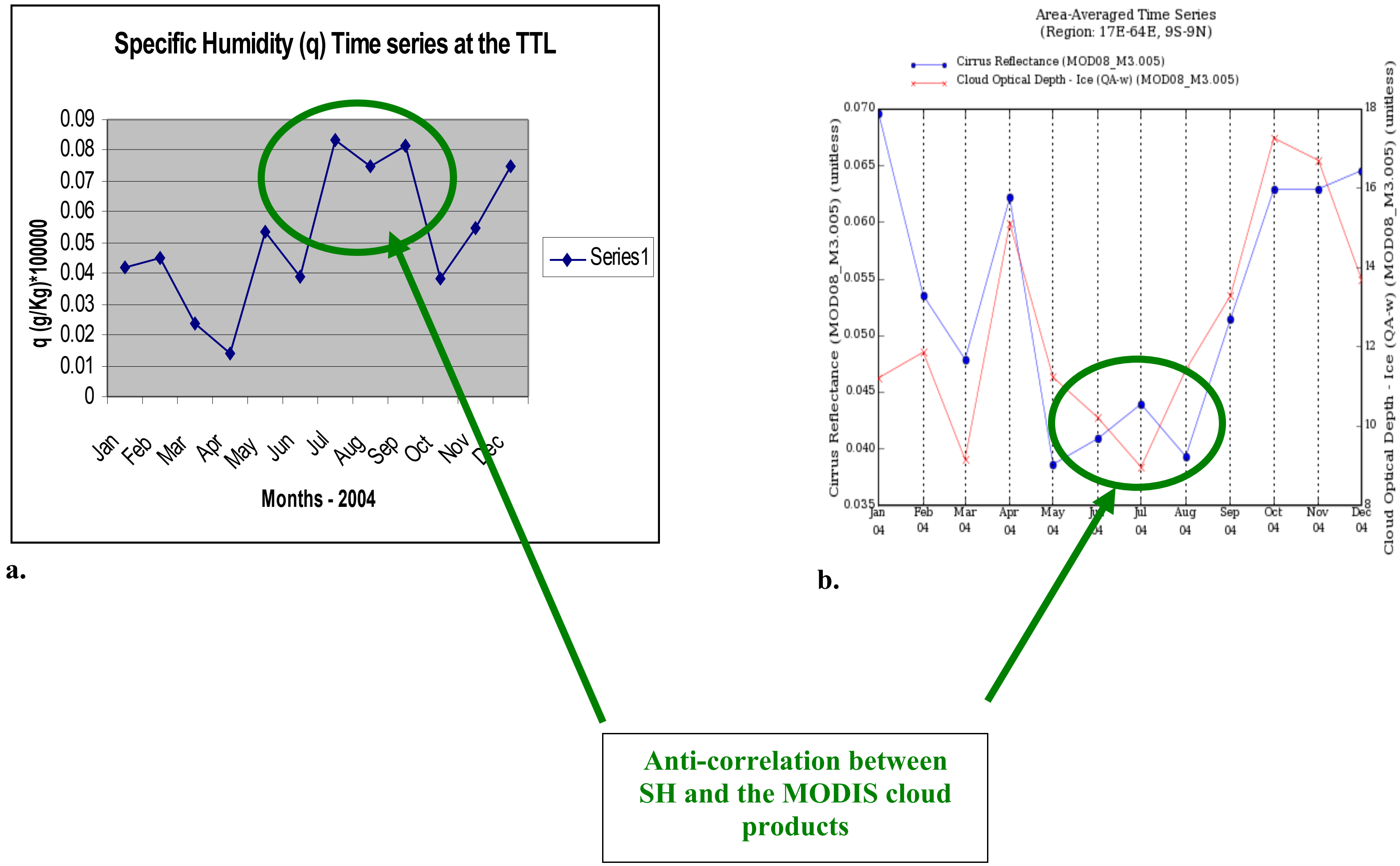
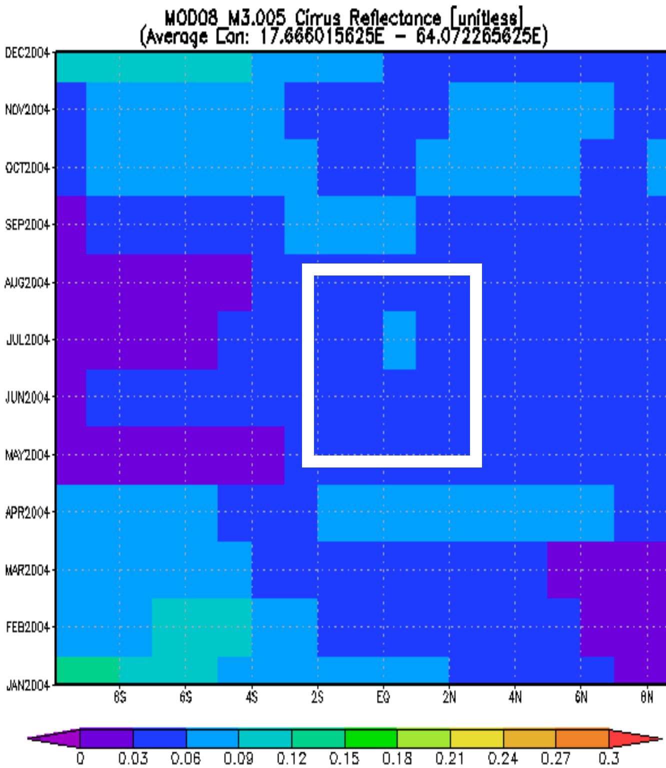
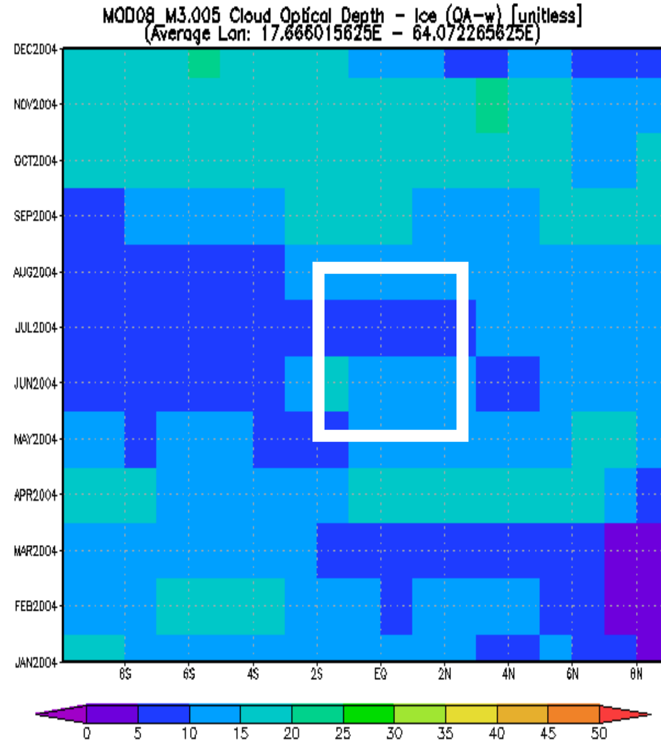


Fig. 1: Anti-correlation between the calculated time series of specific humidity (a) in the tropical tropopause layer (TTL), and the area-averaged time series of MODIS level-3 cirrus reflectance and Cloud optical depth – Ice (b) for the year 2004



a.



b.

Fig 2: Latitude- Time height of the MODIS Level-3 cirrus reflectance (a), and cloud optical depth –ice indicating the minimum values between May and August

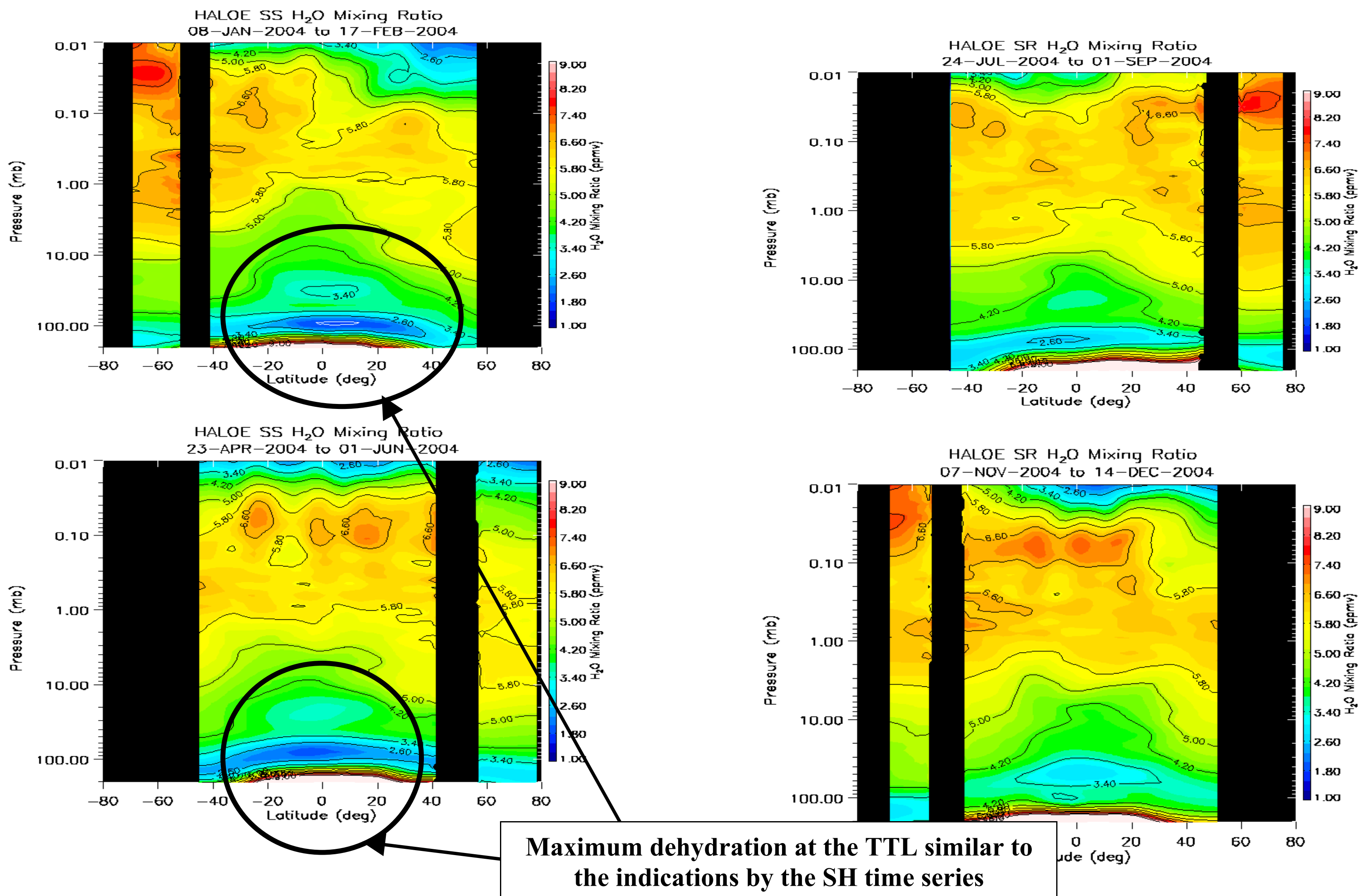


Fig3: Seasonal climatologies of water vapour from Halogen Occultation Experiment (HALOE) for the year 2004

Sublimation of detrained cloud ice contributes to the moistening of upper tropopshere, though less than the vertical transport of moisture over the deep convective regions.

Su et al., 2006 found an approximately linear relationship between log (upper troposphere water vapour) and log (cloud ice water path) and the enhancement of upper troposphere water vapour greenhouse effects by tropical deep convection and associated clouds

4.0. Conclusion

There is a negative correlation between the MODIS level-3 cirrus reflectance and cloud optical depth – ice which indicates that the Subvisible Cirrus Clouds in the tropopause plays a key role in the tropical tropopause layer water vapour budget.

The calculated specific humidity concentration as an indicator of the water vapour content used in this study shows consistency with occultation patterns from the HALOE experiment over the tropical tropopause layer.

5.0. Acknowledgement

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6.0. References

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Buck Research Manual, 1996