Upper Tropospheric Humidity: Climatology and Trends

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Introduction

This study shows preliminary results from a Short-Term Scientific Mission, which is currently conducted by Kostas Eleftheratos in collaboration with Dr. Klaus Gierens in the Department of Dynamics of the Atmosphere in DLR-IPA, in the frame of Cost Action 723.

The main aims of the work in the STSM are a) to describe the natural variability of the Upper-Tropospheric Humidity (UTH) based on the longest available satellite data set of the past 20 years and b) to provide important insights into trends of UTH as well as trends in the frequency of occurrence of ice-supersaturation. The UTH data are based on the TOVS/HIRS global satellite observations for the period 3/1979-5/1998 and refer to a layer-averaged relative humidity with respect to ice from approximately 200 to 500 hPa, computed from satellite radiance observations at water vapor channels near 6.7 μm (HIRS channel 12).

State-of-the-art analysis of global UTH data is performed in order to examine the natural variability in UTH on time scales from months to years. The effect of El Nino/Southern Oscillation is examined separately and removed from the data set accordingly, based on simple regression statistical modelling as described in Zerefos et al (2003). The new data set, freed from seasonality and the ENSO fluctuation, will be used to calculate long-term changes of observed UTHi in space and time over regions with high and low air traffic. These trends will be compared with corresponding observed trends in cirrus cloud cover as given by Zerefos et al. (2003). In our approach, we will retain values of UTH in excess of ice saturation (Gierens et al., 2004). This will allow to look for trends in the occurrence frequency of ice-supersaturation as well, along major air corridors and at adjacent areas.

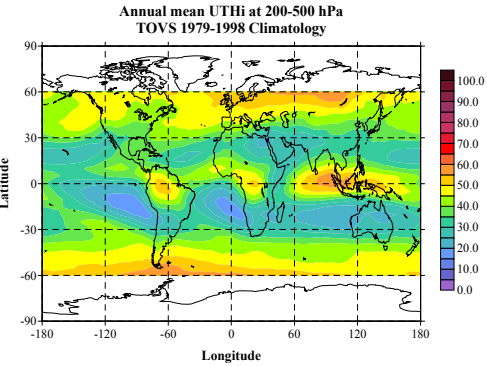

Figure 1. Latitude-longitude map of annual mean upper-tropospheric humidity (in %) from the TOVS dataset for the period 3/79-5/98. UTHi data are relative humidity data with respect to ice for the vertically averaged layer of 200-500 hPa. ***(As in Bates and Jackson, 2001)***

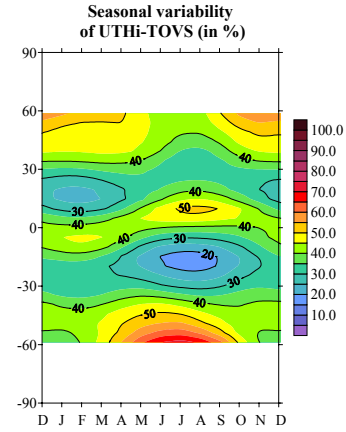

Figure 2. Seasonal averaged zonal mean distribution of UTHi (in %) for the period 3/79-5/98 from TOVS.

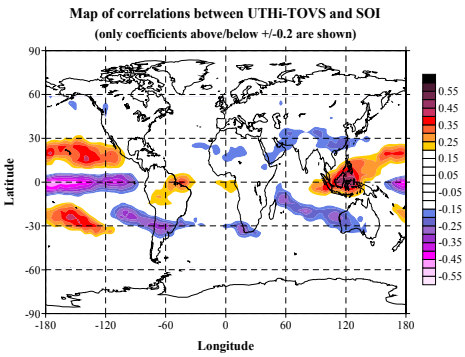

Figure 3. Latitude-longitude map of correlation coefficients between monthly mean UTHi-TOVS and the Southern Oscillation Index for the period 3/79-5/98. Only correlation coefficients above/below ±0.2 are shown. The more significant correlations are observed in the tropical regions.

Progress

The STSM has three major Tasks:

Task 1. The description of the natural variability in UTHi (seasonality, ENSO fluctuation) and its removal from the data set.

Task 2. The calculation of UTHi long-term changes over regions with high and low air traffic and comparison with corresponding trends in cirrus cloud cover.

Task 3. The calculation of trends in the frequency of occurrence of ice-supersaturation along major air corridors and adjacent areas.

Until now, Task 1 has almost been completed. Tasks 2 and 3 will constitute the subject of research for the next period.

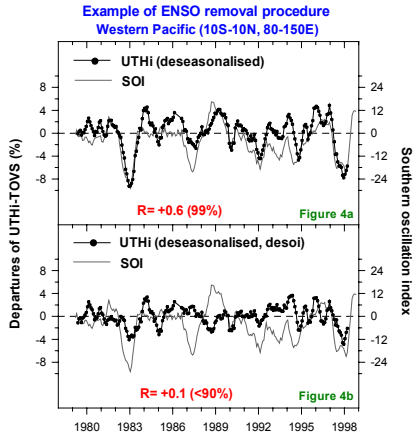

Figure 4. (a) Time series of deseasonalised UTHi-TOVS from 3/79 to 5/98 and of the Southern Oscillation Index (SOI) over the Western Pacific region (10°S-10°N, 80°E-150°E). **(b)** Same as **(a)** but after removing the effect of El Nino/Southern Oscillation from the UTHi data using the method described in Zerefos et al. (2003). R is the correlation coefficient between the two lines. Shown are the running averages of the two times series.

Results

The highest amounts of UTHi (>50%) are seen to occur over the northern and the southern middle latitudes particularly during the wintertime (Figures 1 and 2).

The lowest amounts of UTHi (<30%) are seen over the subtropics of the northern and the southern hemisphere almost throughout the year (Figures 1 and 2).

Over the deep tropics (10°S-10°N) the seasonal zonal mean UTHi reflects the seasonal shift of the ITCZ (Figure 2).

Significant correlations (up to ±0.6) between UTHi and the Southern Oscillation Index are found over regions between 30°S-30°N (Figure 3). In these regions, ENSO explains about 25-35% of the variance in UTHi.

Over regions affected from ENSO, an example of the ENSO removal procedure using the method described in Zerefos et al. (2003), shows that ENSO can be quite well removed from the UTHi data (Figure 4) before examining any trends. The model assumes a linear relation between UTHi and ENSO.

Acknowledgements

We acknowledge the assistance of Dr. Darren Jackson from ETL-NOAA for providing the UTHi-TOVS data for the period 3/79-5/98.

References

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3. Zerefos, C. S., K. Eleftheratos, D. S. Balis, P. Zanis, G. Tselioudis and C. Meleti, Evidence of impact of aviation on cirrus cloud formation, *Atmos. Chem. Phys.*, 3, 1633-1644, 2003.