P6.15 Observed 3-D Structure of Atmospheric Temperature and Moisture Associated with the Madden-Julian Oscillation

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Abstract

The Atmospheric InfraRed Sounder (AIRS)[1] is the first of a new generation of high spectral resolution infrared sounders with 2378 channels measuring outgoing radiation between 650 cm-1 and 2675 cm-1. The improved vertical resolving power of AIRS has greatly improved the accuracy of temperature (1 K/1 Km layers) and moisture soundings (15% / 2 Km layers). AIRS temperature and moisture soundings (retrievals) have vertical resolution of 1 – 2 km, compared to 3 – 5 km from current National Oceanic and Atmospheric Administration (NOAA) operational sounders - such as the High resolution InfraRed Sounder (HIRS), AMSU-A and AMSU-B. The fine vertical resolving power of AIRS provides us with an opportunity to examine the 3-dimensional structure of atmospheric temperature and moisture with improved accuracy. In NOAA/NESDIS, these AIRS-based high quality atmospheric temperature and moisture products have been produced operationally on a near real-time basis since August 2002[2]

In this paper, we will apply the NOAA/NESDIS data set to describe the 3-dimensionsal structure of temperature and moisture over the globe. Variations in atmospheric temperature and moisture associated with the Madden-Julian Oscillation (MJO)[3] over the global tropics are investigated using 2 years AIRS retrievals. First, the mean seasonal variations of 3-dimensional temperature and moisture fields are computed to document the mean atmospheric structure over the global tropics. Band pass filtering is then implemented to the original time series of the AIRS-observed temperature and moisture data to extract the components associated with variations of intraseasonal time scale (20 – 80 days). The results of these analyses provide quantitative description of the MJO with improved quality and spatial resolution compared to those based on previous satellite observations.

The AIRS Temperature and Moisture Retrievals

The AIRS retrieved temperature and moisture products are used in this study to examine the 3-dimensional structure of the atmosphere. The data set used is one of the global gridded data sets generated by NOAA/ NESDIS/ORA Near Real Time (NRT) AIRS processing system. The horizontal resolution for both the temperature and the moisture products are 2.0^o latitude x 0.5^o longitude, while vertically they are converted to 25 and 20 layers, in the temperature and moisture retrievals, respectively. Data for entire two years period from August 2003 to July 2005 are used in this study. Details of the AIRS retrieval algorithm can be found in Goldberg et al (2003)[2] and Susskind et al. (2003)[4].

Before further calculations may be conducted, daily mean temperature and moisture were computed for each grid box and for each day during the data period by averaging the values observed for the ascending and descending orbits. This time series of daily mean values are then used in the subsequent calculations to define the seasonal and intra-seasonal variations.

Mean Seasonal Variations

While a 24-month period is relatively short to define climatology of temperature and moisture with ideal quantitative accuracy and stability, we hope that seasonal mean values taken from the 2-year observations will provide us with an insight into the 3-dimensional structure of the atmosphere over the globe.

Figure 1 shows the geographic distributions of air temperature (top) and moisture (bottom) for the December/January/February (left) and June/July/August (right) periods. The air temperature are those from the 905 mb to 1013 mb layer, the moisture shown is the total precipitable water for the atmosphere above 1013 mb. The lower level atmospheric temperature is relatively uniform over the tropics and the temperature gradient is large over mid-latitude for both seasons. Blocks of air masses colder than 250 ^{o}K are observed over Siberia and Greenland during DJF, while a high temperature of above 300 ^{o}K appears over Australian Desert during the same season. The spatial distribution of moisture is characterized by the ITCZ and convection centers over tropical land masses. Maxima of water vapor are observed over Maritime continent and adjacent oceanic regions throughout the seasons, while significant seasonal variations in moisture is noticeable over Eastern Pacific with larger values appear during JJA period.

Shown in Figure 2 are height-latitude sections of seasonal mean temperature (top) and moisture (bottom) for the DJF (left) and JJA (right) periods averaged over the western Pacific [160^{o}E-170^{o}E]. While the

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temperature contours are almost parallel over the entire tropics, the moisture distribution presents a relatively large gradient with a maximum centered at the ITCZ.

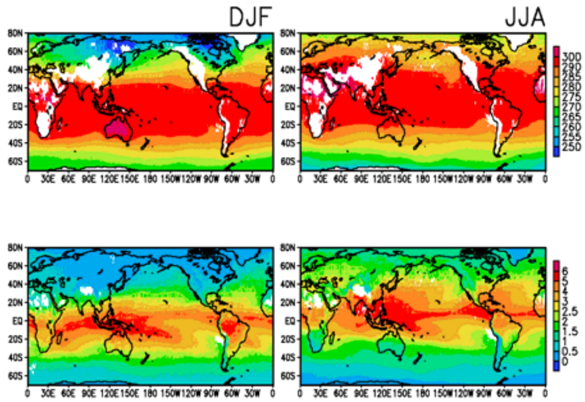

Figure 1: Geographic distributions of air temperature (top) and moisture (bottom) for the DJF (left) and JJA (right) periods. Seasonal means are calculated for a 24-month period from August 2003 to July 2005.

The precipitable water contour of 0.1 [g/cm^2] almost reaches to 400 mb over the western Pacific ITCZ region, while it reaches higher altitude during the summer season than winter season for the area toward mid-latitude.

Similar 3-dimensional structure of atmospheric temperature and moisture are observed over the eastern Pacific [Figure3, 120^{o}W-110^{o}W], though the moisture there does not reach as high as that over the western Pacific, and the gradient of moisture over ITCZ region also appears to be weaker than those from the eastern Pacific.

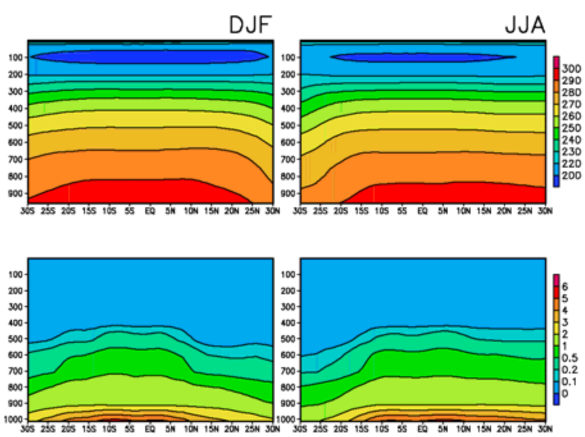

Figure 2 Height-latitude sections of seasonal mean temperature (top) and moisture (bottom) for the DJF (left) and JJA (right) periods averaged over western Pacific [160^{o}E-170^{o}E]. The temperature and moisture are printed in unit of ^{o}K and g/cm^2, respectively.

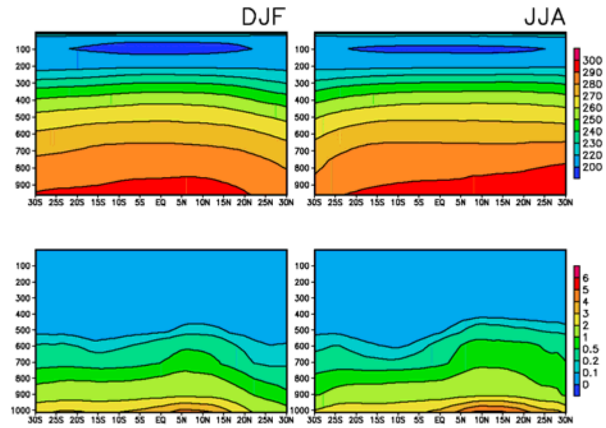

Figure 3 Same as in figure 2, except for the eastern Pacific [120^{o}W-110^{o}W].

Intraseasonal Variations

One of the major components of global climate, the intraseasonal variability, has been long examined using two dimensional OLR fields along with precipitation data. The availability of AIRS observations makes it possible to investigate the 3-dimensional structure of moisture-

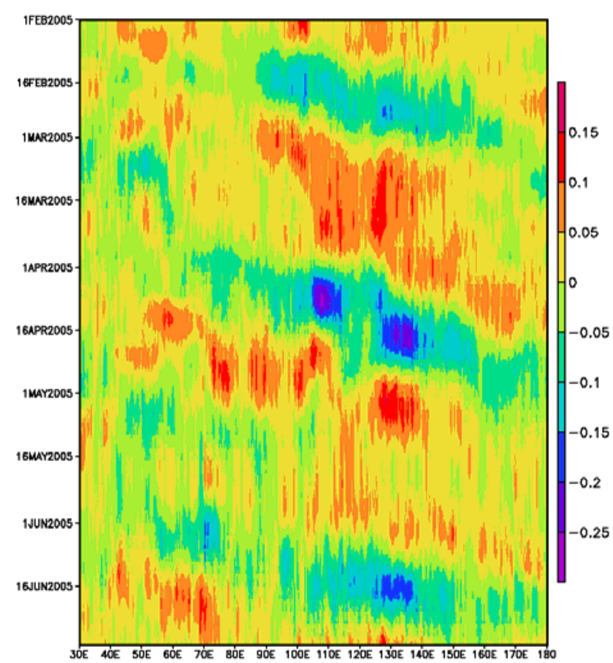

Figure 4 Time-longitude section of 20-80 day band-pass-filtered 800 mb to 900 mb layer precipitable water averaged over 5^o S-5^o N for the period from 1 February to 30 June, 2005.

variations associated with the Madden-Julian Oscillation (MJO). For this purpose, band-pass filtering is performed on the time series of the original daily observations to extract the components with time periods of 20 – 80 days. Presented in figure 4 is a time-longitude section of the band-passed moisture variations averaged over the tropical belt [5^o S-5^o N]. Eastward propagation of the moisture anomaly is apparent in the band-passed fields with a period of about 40 days. Large variations in moisture are observed over 110^o E-150^o E during this period.

The moisture variations of intra-seasonal time scale are presented throughout the troposphere (Figure 5). It is apparent that convection activities associated with the MJO play an important role in the transport water vapor from the lower atmosphere to the middle and upper troposphere.

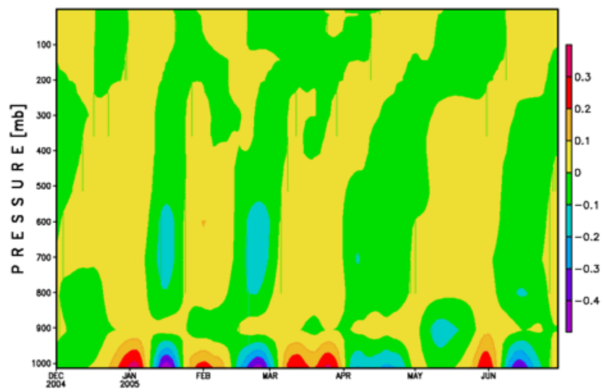

Figure 5 Time series of 20-80 day band-pass filtered moisture profiles over a 2^o latitude by 2^o longitude grid box centered at [120^oE, 0].

Summary

Preliminary work reported in this paper demonstrated the potential utility of the AIRS temperature and moisture retrievals in examining the 3-dimensional structure of mean seasonal variations and intra-seasonal variations of the atmosphere over the globe. While data for a 2 year period are used for this study, continuous accumulation of the AIRS retrievals will enable broad applications of the data set in climate analysis and model verifications.

Further work is underway to quantitatively examine the accuracy of the temperature and moisture retrievals and to apply the retrieved quantities to verify several selected re-analyses / climate model outputs.

Acknowledgements

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