P2.25 MOISTURE CORRESPONDENCE BETWEEN LOWER AND UPPER TROPOSPHERE OVER OCEANS USING AIRS OBSERVATIONS

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Abstract

This study uses AIRS level 3 moisture profile data to reveal geographical correspondences of atmospheric moisture content between lower and upper troposphere. The daily gridded AIRs atmospheric specific humidity over world oceans between 50ºS to 50ºN are used to derive three-day average vertical integrated moisture content for the two air columns: 1000mb-700mb and 700mb-500mb for the available three years time period. Then singular value decomposition analysis (SVD) is performed to identify the teleconnections among grids between these two atmospheric layers. In addition, the time series of the resulting major SVD patterns are analyzed to reveal the dominant mode of temporal variations ranging from weekly to interannual time scales. Results suggest that there is a good agreement in moisture variations between lower and upper troposphere over middle-latitude and tropical oceans in general. Exceptions are found in small areas near a landmass where moisture profile may be different from the rest of the majority oceans.

1. INTRODUCTION

The Atmospheric Infrared Sounder (AIRS) mounted on Aqua spacecraft measures vertical profiles of air temperature and humidity using both microwaves and infrared irradiances (Pagano et al. 2003; Lambrigtsen and Lee 2003; Susskind et al. 2003; Autmann et al. 2003). The AIRS' level III data that provide gridded values of 1° latitude by 1° longitude for the highest temporal resolution of twice per day became available recently (Granger et al., 2005). This level III data were derived from the Level II Version 4.0 AIRS retrieval algorithm (Fetzer et al. 2005; Ye et al. 2005). This gridded level III data set will be very valuable for the climate research community.

This study uses AIRS moisture profile data to reveal geographical correspondences of atmospheric moisture content between the lower and upper troposphere.

2. METHODOLOGY

The daily gridded AIRS atmospheric specific humidity over world oceans between 50.S to 50.N are used to derive three-day averages of vertical integrated moisture content for the two air columns: 1000mb-500mb (1000mb, 925mb, 850mb, 700mb, 600mb, 500mb) and 500mb-100mb (400mb, 300mb, 250mb, 200mb,150mb,100mb) for the six months of January to June, 2005. The vertical integration of water vapor is based on the following equation:

$$w = \int_{p1}^{p2} q_i * \Delta p_i \Big/ g$$

Then singular value decomposition analysis (SVD) is performed to identify the teleconnections among grids between these two atmospheric layers. Thus the two fields analyzed in SVD are the moisture field below 500mb and the moisture field above 500mb. The time series

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of the resulting major SVD patterns are used to reveal the dominant mode of temporal variations ranging from daily to seasonal time scales.

3. RESULTS

Six major patterns produced by SVD are analyzed. They explain about 46.8% of total variance of the two moisture fields below and above 500mb.

The time series of pattern 1 shows a strong seasonal pattern of variation: the value peaks in early February and decreases gradually for the remaining 5 months (Figure 1). The PC1 for both below and above 500mb match closely.

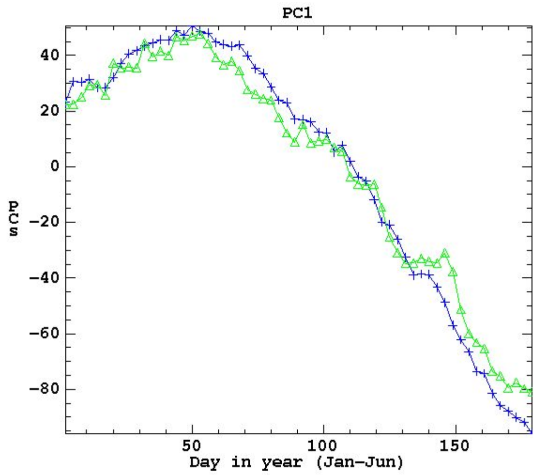
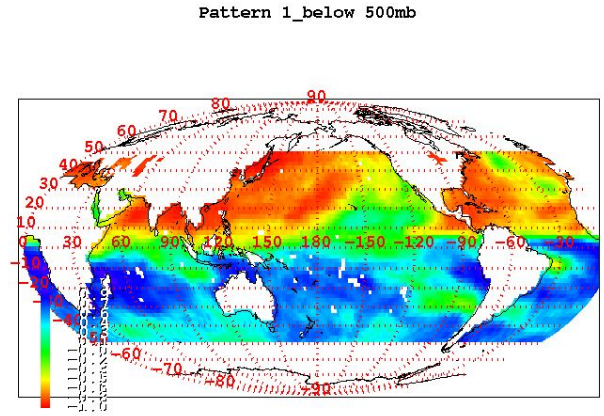


Figure 1. Time series of PC1 for below 500mb (Blue) and above 500mb (Green).

This suggests that abundant moisture over the southern hemispheric tropical ocean is decreasing while these over the northern hemisphere it is increasing starting in early February both below and above 500mb (Figure 2 and Figure 3). The correspondence between below and above 500mb for this seasonal pattern is very close except for a few areas. One of the major differences lies over 20°S in the western South Pacific Ocean, extending from east coast of Australia to about 150W. In this region, the moisture is more abundant in the lower troposphere than the upper, thus more significant seasonal variations of moisture exist in the lower troposphere. A similar pattern to this (mirror image) is evident in the North Pacific Ocean where the lower atmospheric moisture also seems to have stronger seasonal variations. This may be related to the fact that moisture is discharged into these areas constantly throughout the year from land areas over upper troposphere. This phenomenon can be seen from daily moisture changes. While over equatorial regions of eastern Pacific between 150W –120W, upper tropospheric moisture seems to have a stronger seasonal variation.



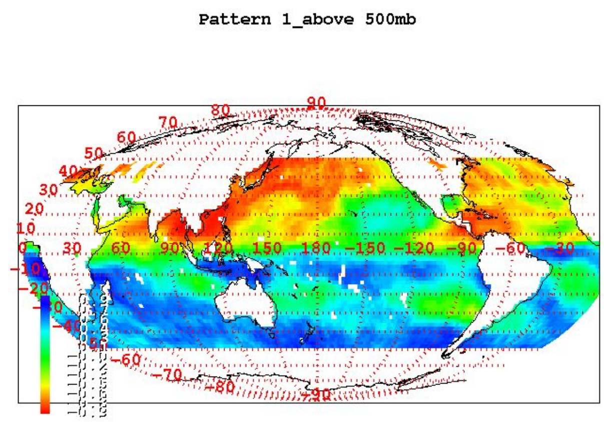


Figure 3. EOF of PC1 on moisture above 500mb.

Pattern 2 shows intraseasonal variations overlaid with a seasonal variation that peaked in early April (Figure 4). On daily scales, PC2 for lower tropospheric (Blue) moisture has slightly different values compared to the upper troposphere

(Green).

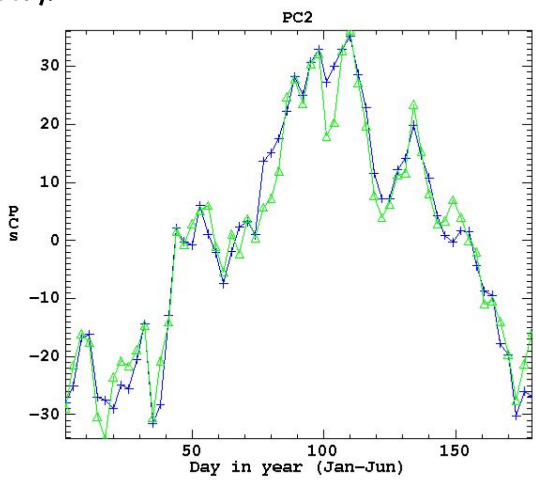


Figure 4. Time series of PC2

The major activities described by this pattern are over the eastern equatorial Pacific, the equatorial Atlantic ocean, and the southern Indian Ocean (Figure 5 and Figure 6). Variation of this pattern seems to be strong over the lower troposphere in most areas. However, in the area over the northern coast of Australia, and coast of southern Africa, the variations seem to be more noticeable on upper troposphere.

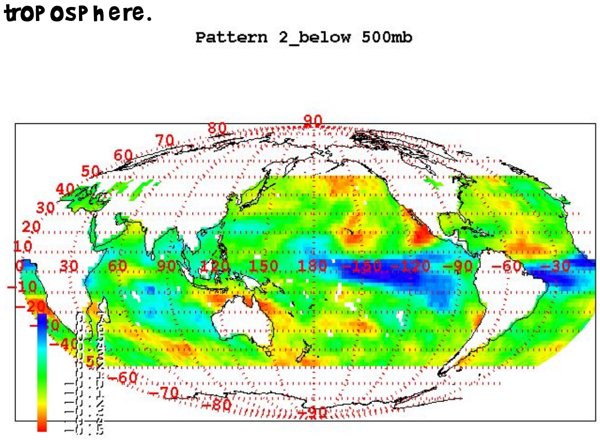


Figure 5. EOF of PC2 for moisture below 500mb.

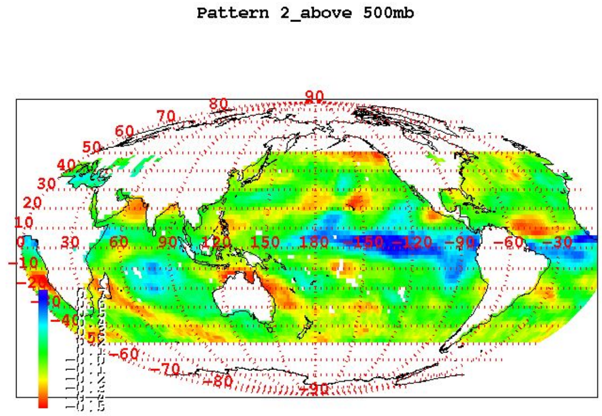


Figure 6. EOF of PC2 for moisture above 500mb.

Pattern three shows an intraseasonal variation of about 50 days with the stronger cycle occurring over February and March (Figure 7).

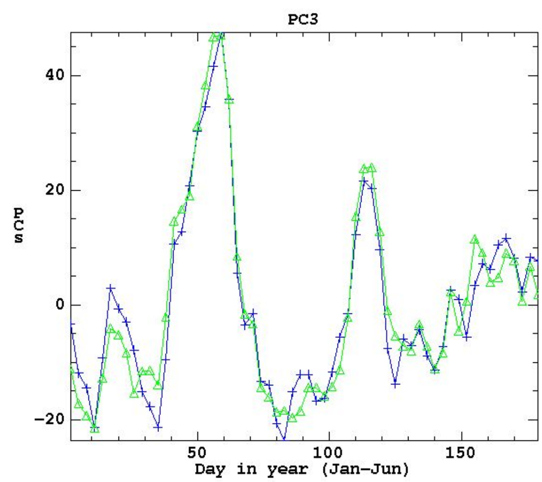


Figure 7. Time series of PC3

This pattern reveals sandwiched off-phase moisture changes over the middle and tropical Pacific Oceans. Activities seem to be of similar strengths between lower and upper troposphere, except over the western equatorial ocean where upper troposphere has a stronger variation amplitude (Figure 8 and Figure 9).

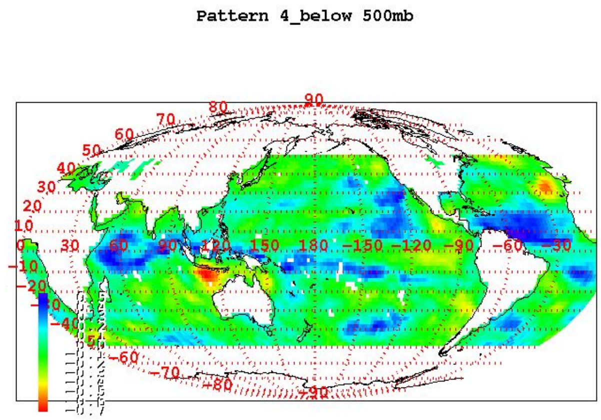


Figure 8. EOF of PC4 for moisture field below 500mb

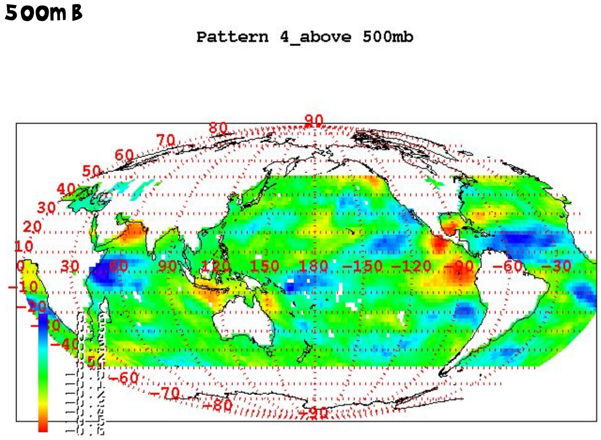


Figure 9. EOF of PC4 for moisture field above 500mb

Pattern four shows seasonal variation at about 4-month time scale with a peak in early March and late June. This pattern shows more moisture variation over the upper troposphere for certain areas (Figure 8 and Figure 9). Three major centers are (1) over the eastern tropical Pacific Ocean and the western coast of South America, (2) over the western Indian Ocean with two opposite phases between northern and equatorial areas, and (3) over the South Indian Ocean off the coast of northwestern Australia. In moisture fields below 500mb, there is an almost continuous area of active moisture variation from the equatorial Indian Ocean to the central Pacific Ocean, while this is not the case for the moisture fields above 500mb.

Pattern five shows moisture variation at a time scale of 30 days. (Figure 10). The variation is stronger during the first three month than in later months.

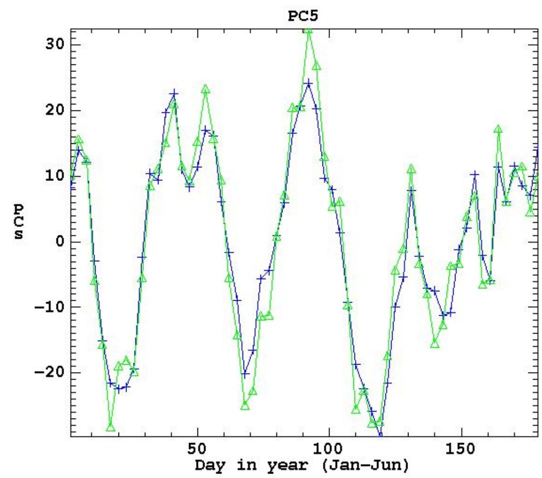


Figure 10. Time series of PC5

This pattern describes moisture activities over isolated centers almost all concentrated in the Pacific and Indian oceans (Figure 11 and Figure 12). The southwest-to-northeast orientation of these centers marks the influence of trade winds especially over the Pacific tropical ocean.

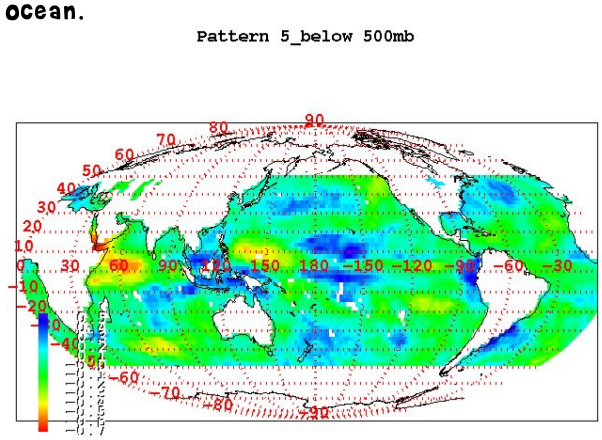


Figure 11. EOF of PC5 for moisture field below 500mb

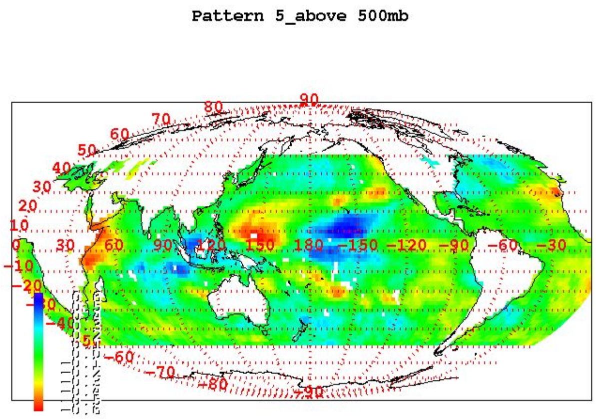


Figure 12. EOF of pattern 5 for moisture field of above 500mb

Pattern six seems to show a 10-day moisture cycle overlaid on three monthly variations (Figure 13).

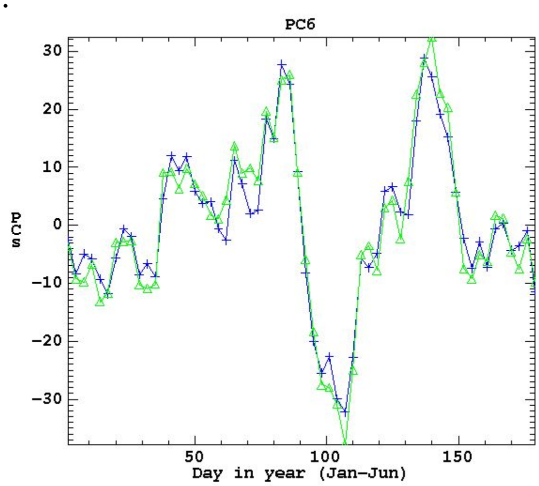


Figure 13. Time series of pattern six

Activity centers of this pattern also show a southwest-to-northeast orientation. Most interesting of these is a dry center over the western coast of South America for below 500mb corresponding to a relative wet center above 500mb (Figure 14 and figure 15).

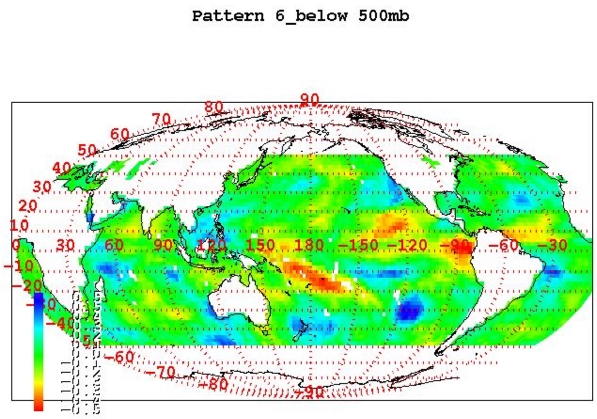


Figure 14. EOF of pattern six for moisture field below 500mb

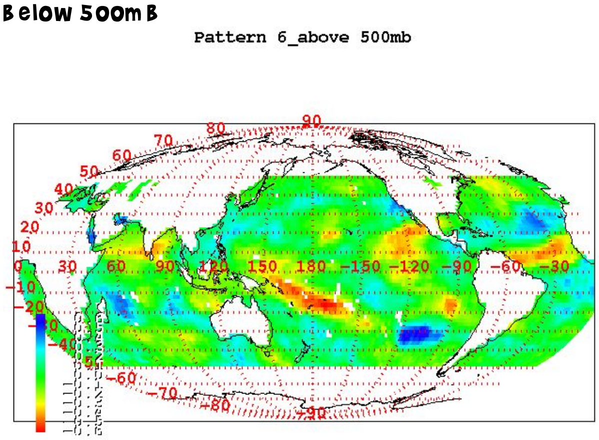


Figure 15. EOF of pattern six for moisture field above 500mb

4. CONCLUSIONS

This study analyzed connections of moisture content between the lower and upper troposphere over global middle-latitude and tropical oceans for the time period of 6 month in 2005. It is interesting to see that the dominant seasonal and intraseasonal variation patterns correspond well between lower and upper troposphere with stronger variability over the lower troposphere. As the variance of pattern decreases, poorer correspondence starts to show in some areas upper troposphere may have larger variability than lower troposphere or even no activity is found in there.

This study suggests that a universal moisture profile over oceans is in general a good assumption. Exceptions occur over certain geographical regions near to a landmass, where moisture profiles may be modified.

5. REFERENCES

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