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A SIMPLE DIAGNOSIS METHOD OF MOISTURE PROFILE FROM TMI/TPW

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1. Introduction

Estimation of total precipitable water(TPW) over the globe by remote-sensing technique becomes very popular and practical. But to estimate the vertical profile of water vapor is still difficult. We will present a new relationship to estimate the vertical profile of water vapor, based on the statistical formula by Liu et. al (1991). The TPW data of the TRMM/TMI are used in this study, provided by Dr. Shibata at NASDA/EORC.

2. Relationship between surface humidity and lower TPW

Liu et. al (1991) documented that the lower TPW below 850 hPa (w*) is linearly correlated with the surface specific humidity qs. From his Fig. 10,

$$w_* = \frac{1}{g}\int_{p_*}^{p_s} q\,dp = 1.2931\times10^{-3} q_s, \quad (1)$$

Assuming the following based on Smith(1966) below 850 hPa,

$$q = q_s\left(\frac{p}{p_s}\right)^{\lambda_s}, \quad (2)$$

Here λ_s is the vertical profile parameter for specific humidity below 850 hPa.

From (1) and (2) we obtain that w_* is,

$$\frac{q_s}{g(\lambda_s+1)}\left\{p_s - p_*\left(\frac{p_*}{p_s}\right)^{\lambda_s}\right\} \quad (3)$$

Substituting p_s =1013 hPa, p*=850 hPa and g=9.8 in (1) and (2), we calculate λ_s iteratively as

$$\lambda_s = 3.099 \quad (4)$$

That is, from (2), below 850 hPa the specific humidity is proportional to the third power of the pressure.

Substituting (4) into (2), we also obtain

$$q_* = 0.5805 q_s, \quad (5)$$

This indicates that the specific humidity at 850 hPa is about 60% of the surface specific humidity.

3. Estimation of vertical profile of specific humidity

By using Liu(1986)'s regressive formula to estimate the surface specific humidity from the TPW, we first estimate the surface specific humidity from the TRMM/TMI TPW.

We also assume (2) is applicable for the upper layer above 850 hPa.

$$q = q_*\left(\frac{p}{p_*}\right)^{\lambda_*}, \quad (6)$$

Then the TPW, W, is written in the following.

$$W = \frac{p_*}{g}\left(\frac{q_*}{\lambda_*+1}\right) + w_*, \quad (7)$$

In (7), as the unknown parameter is λ* only, we can easily get λ*, where λ* is the vertical profile parameter of specific humidity in the upper troposphere. There two parameters, λ_s and λ* will give us the simple estimation/ diagnosis method of vertical humidity profile.

Figure 1 is the monthly mean vertical moisture moisture profile parameter, λs (upper) and λ*(lower) obtained from TRMM/TMI in July, 1998.

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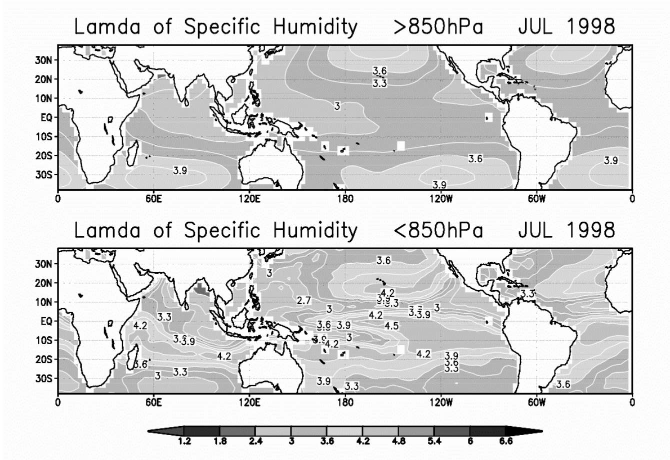

Fig. 1 Vertical Profile Parameter of specific humidity, λs (upper) and λ*(lower) from TRMM/TMI in July, 1998.

This figure shows that in the lower troposphere λs indicates homogeneous value between 3.0 and 3.9 with a slightly small number along the ITCZ and Asian Monsoon area. However, above 850 hPa the regions with larger and smaller λ* are separated. Here small λ corresponds small gradient of humidity decrease in height. In the lower figure we notice that the region with small λ* is associated with the ITCZ and the active Asian Monsoon region. The region with larger λ* may be associated with the area with cool SST over the tropics and sub tropical area.

4. Vertical Profile Parameter in Objective Analysis Data

We may estimate the vertical profile parameter in the same manner for the objective analysis data from JMA and NCEP.

Fig. 2 shows the result of JMA(a) and NCEP(b). First JMA. Comparing with Fig. 1 in the lower troposphere the value of λs is around 2, suggesting that more gradual decrease of moisture in the tropics. Also we find that large λs areas are detected off California and off North Africa. In most area λs and λ* are negatively correlated. When λ* is large, then λs is small at the same location.

NCEP in Fig. 2b has a different feature. There are large λs and small λ* regions.

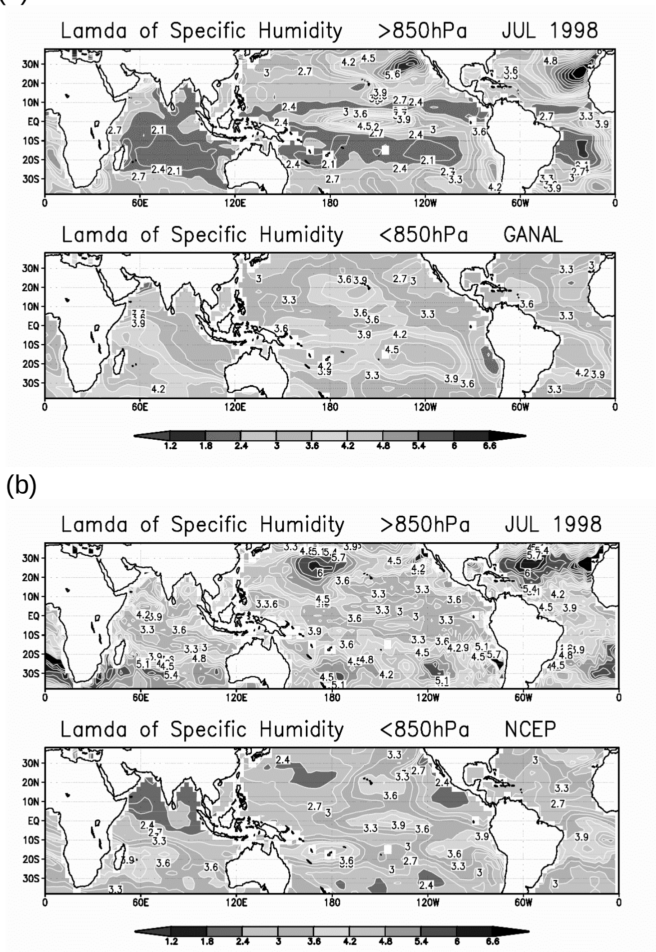

Fig. 2 Same as Fig.1, except for the objective analysis data of JMA(a) and NCEP(b).

5. Conclusion

We propose a simple diagnosis method to estimate the vertical mosture profile from the TRMM/TMI TPW data.

We found that vertical moisture profile parameter λ is small over the moisture abundant area, however, the value of λ is scattered in satellite data and objective analysis data.

References

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