Cloud Ice Water Amount and Vertical Structure Observed by TRMM

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Outline

1. **Background**

   history

   VIRS: cloud cover, Tc, t, re, De, LWPv, IWPv, WPv

   TMI: LWPt, Tw, water vapor

2. **Method**

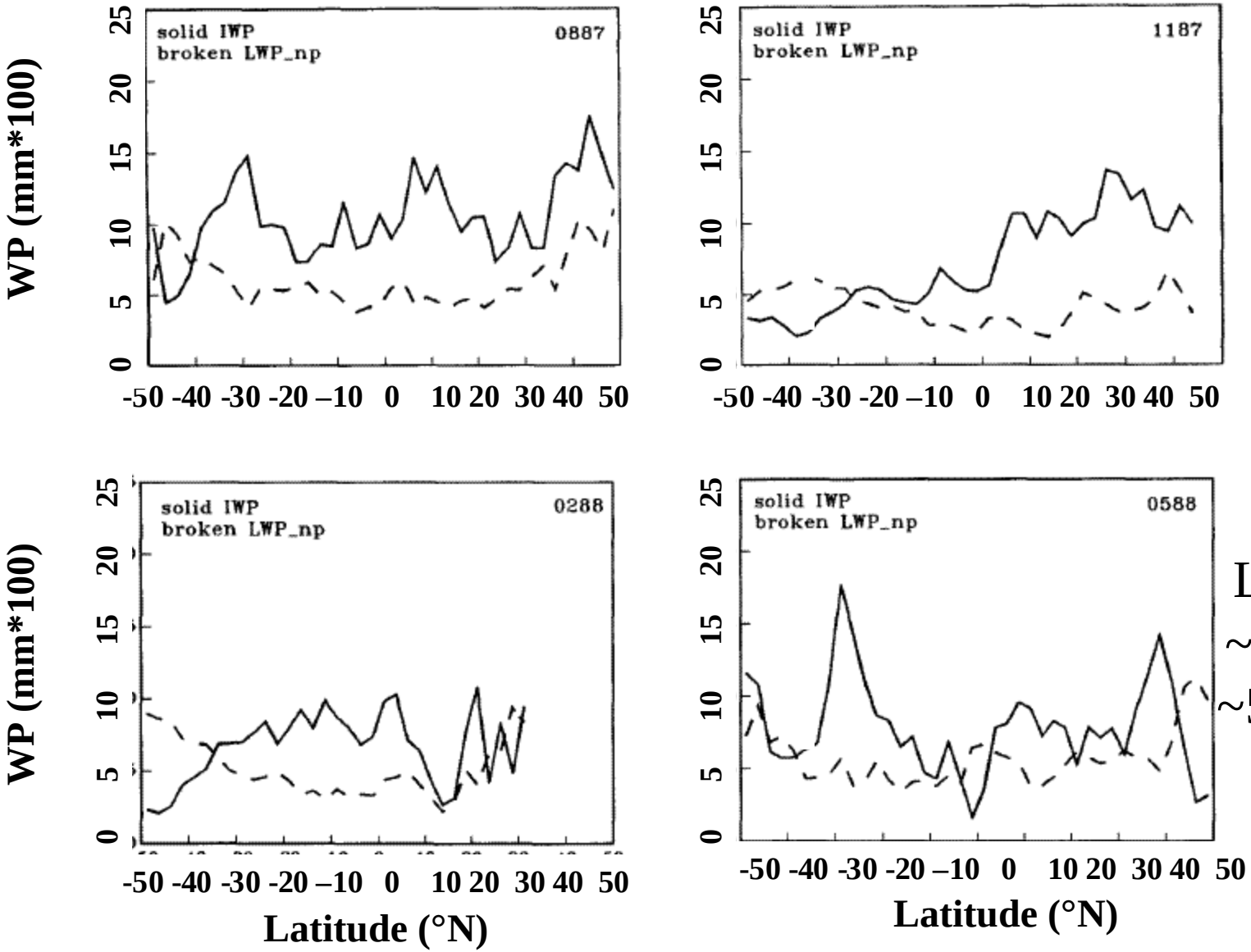
   multi-layer clouds: WPv – LWPt = IWPtv

   vertical structure: Tw – Tc

3. **Results**

4. **Summary**

history



ISCCP & SSM/I

average: 0.07mm

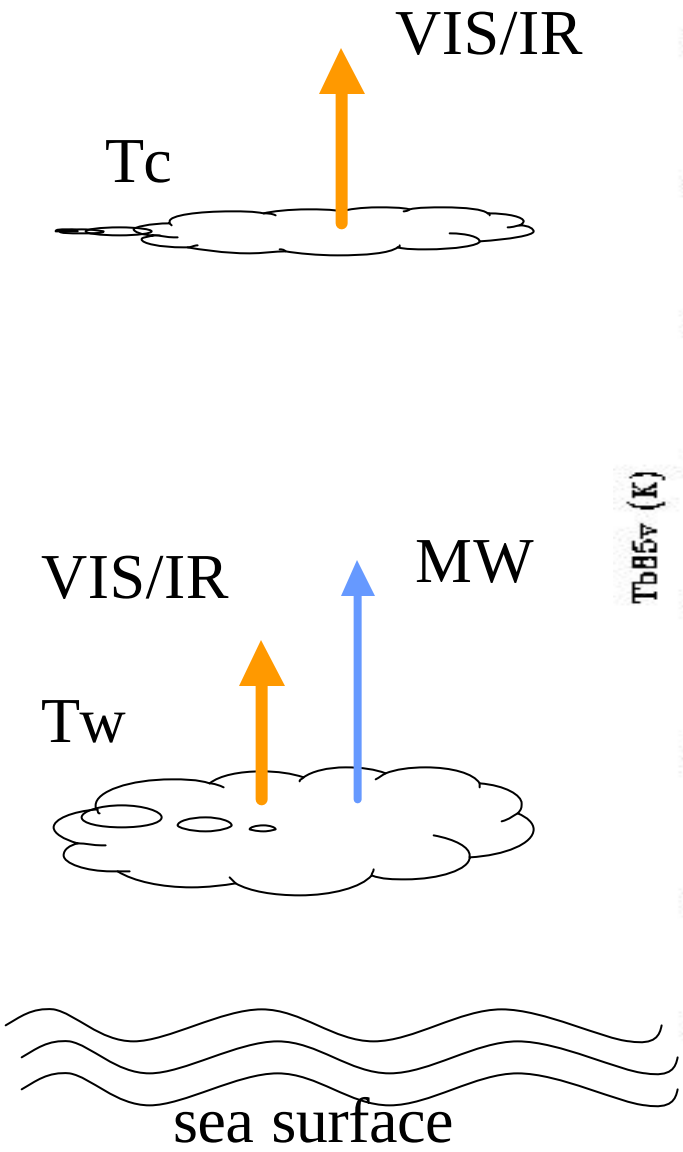
LWP/WP:
~22% trop.
~55% south

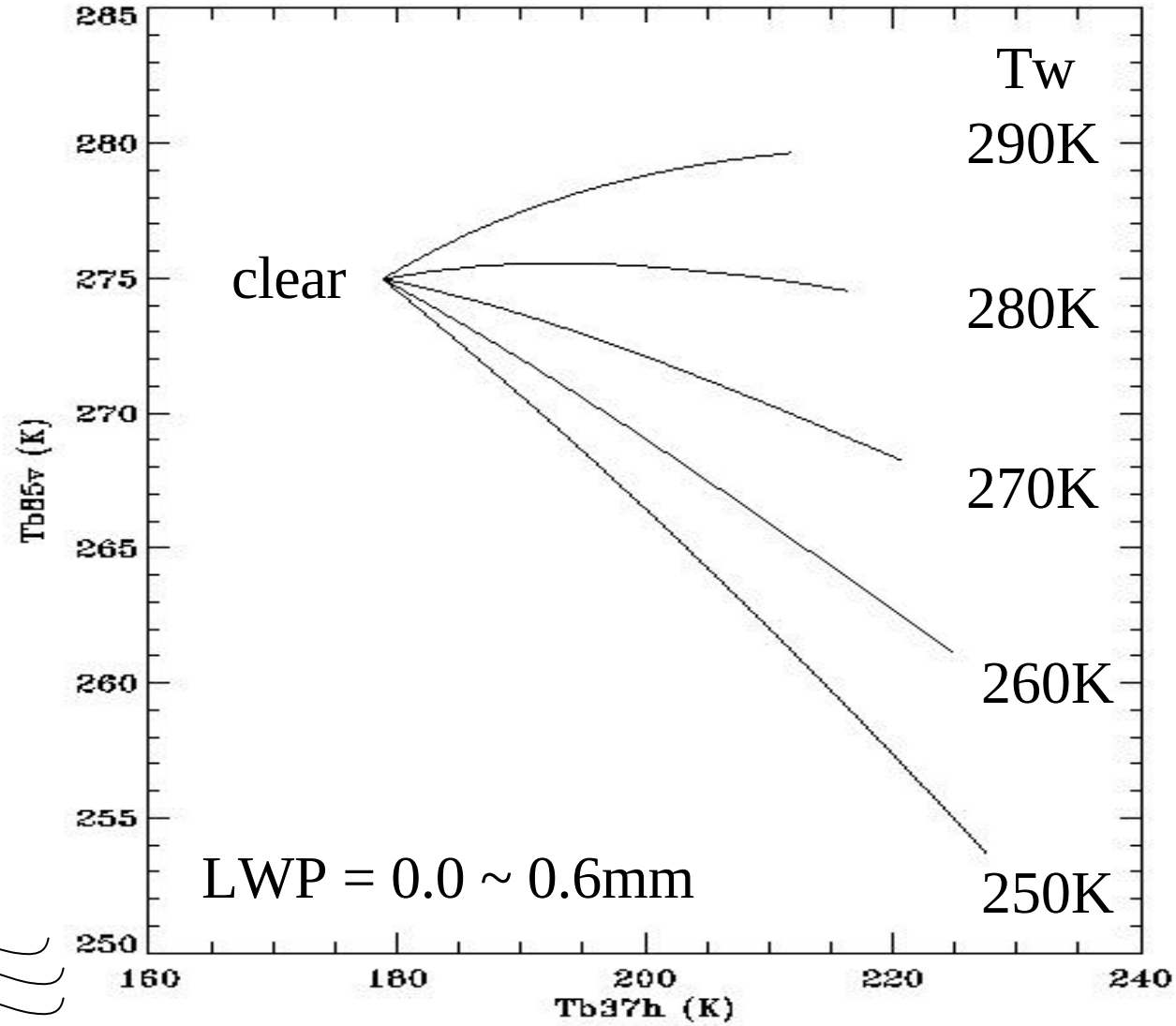
Method

- **Retrieval method: (Lin et al. 1998a & b)**
  - **microwave RT model: 2 stream**
  - **T and P dependence of vapor absorption**
  - **careful choice for water abs. coef.: Tw**
  - **e_s: CM, s (freq) & latest dielectric constant**
  - **2-D physical retrieval of LWP and Tw**
  - **clear sky calibration/validation**

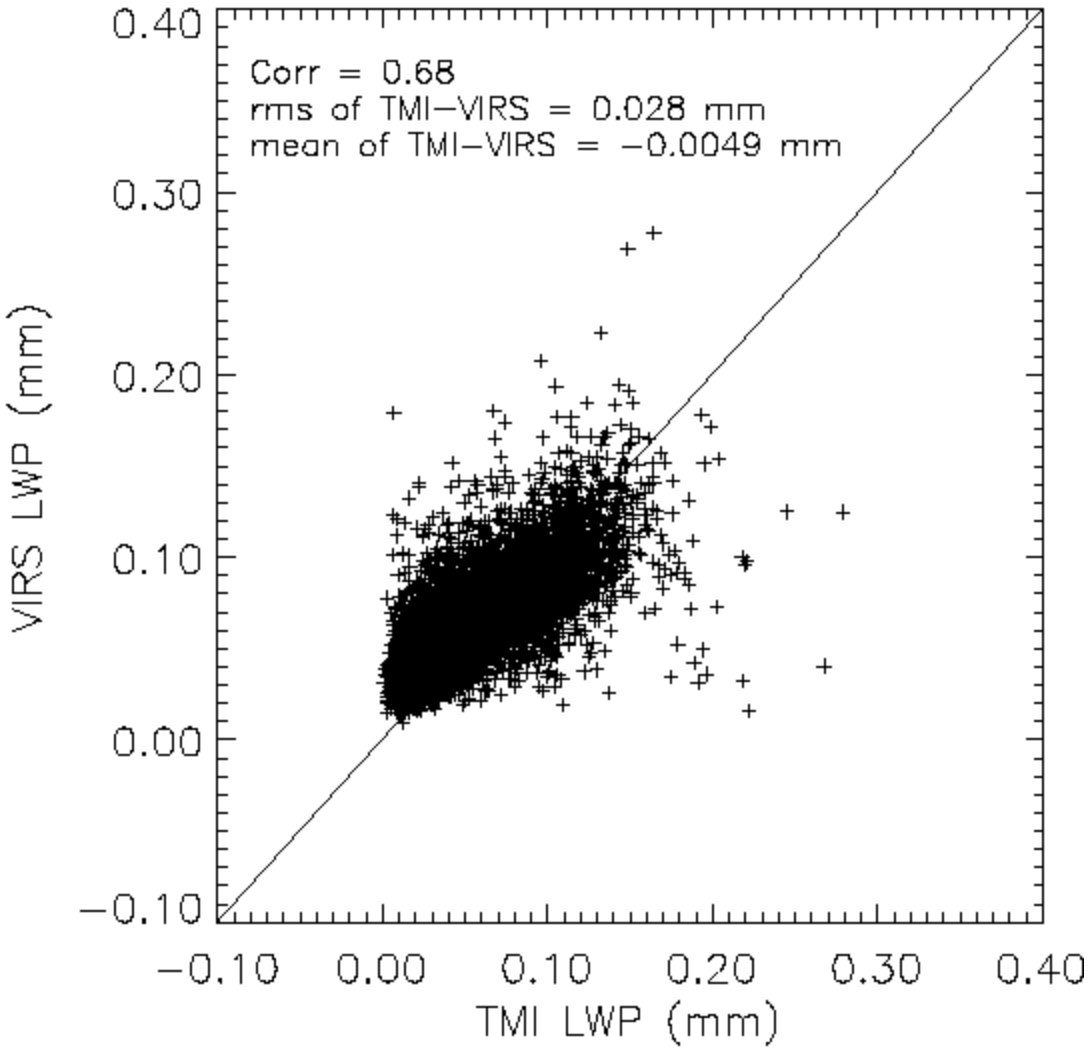
- **Data analysis:**
  - **convolute VIRS cloud products into TMI FOVs**
  - **retrievals from TMI Tb values**
  - **combined VIRS/TMI data for multilayer clouds**

detection of multilayer clouds

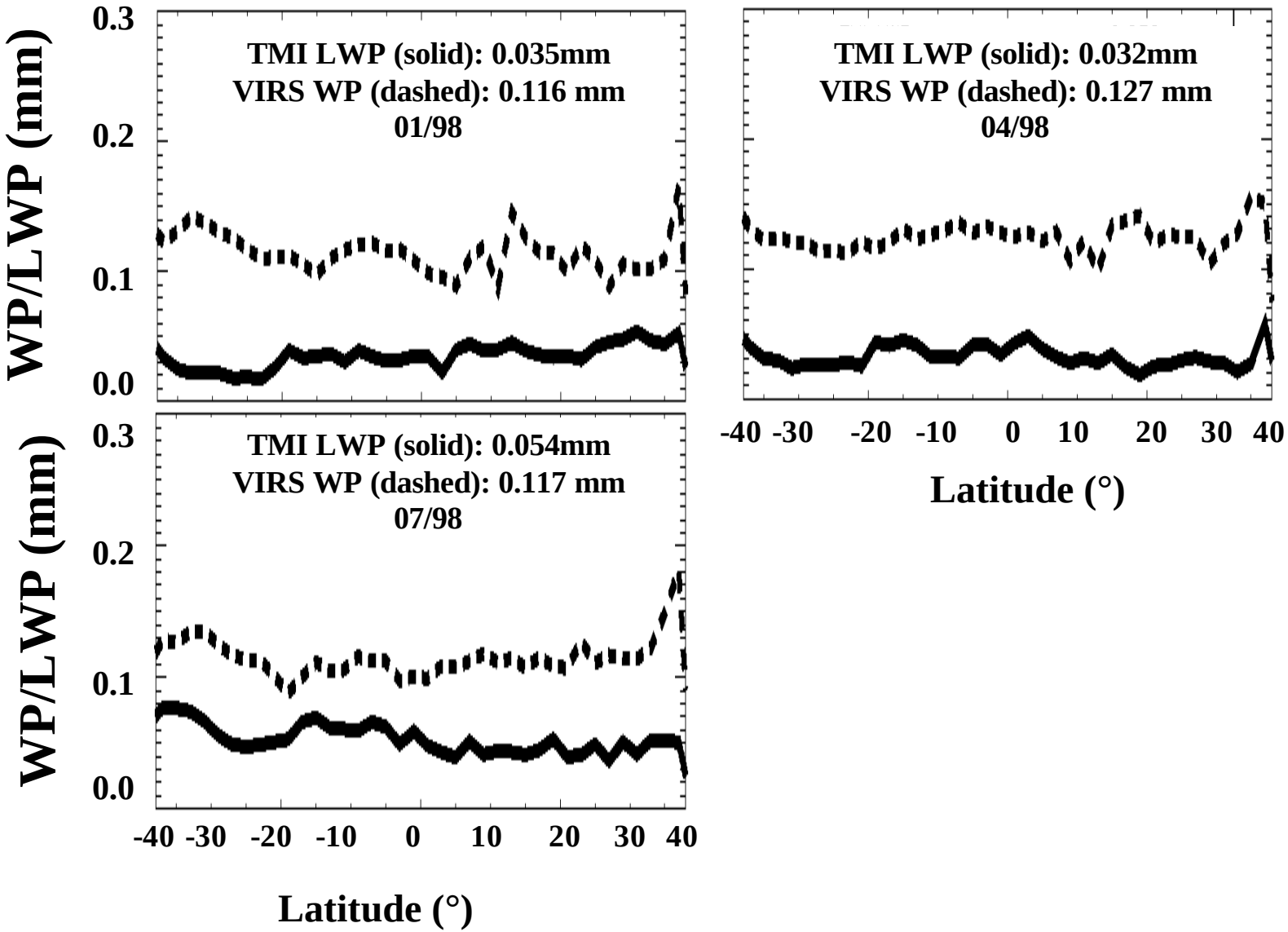




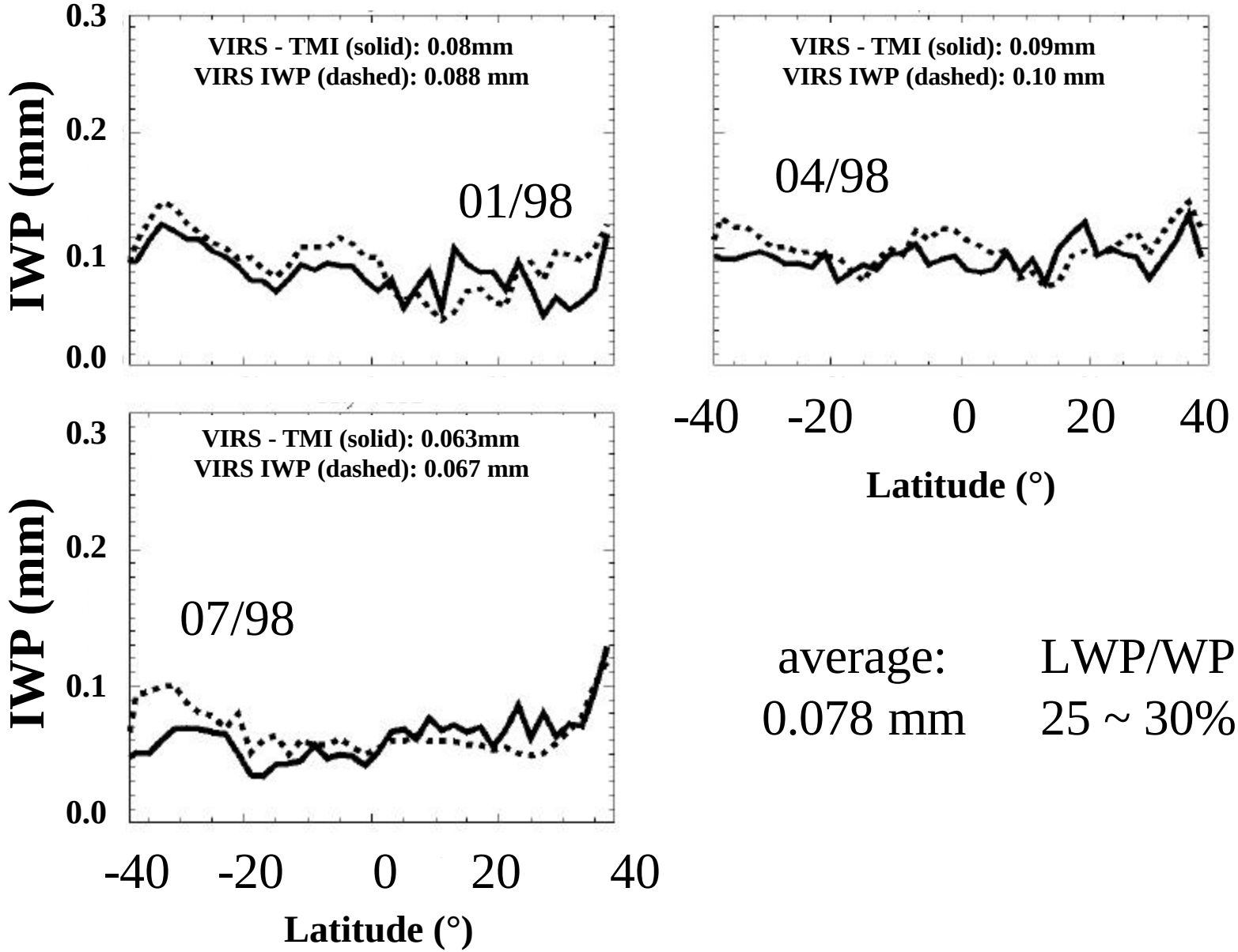
comparison of warm clouds



WP for cold clouds



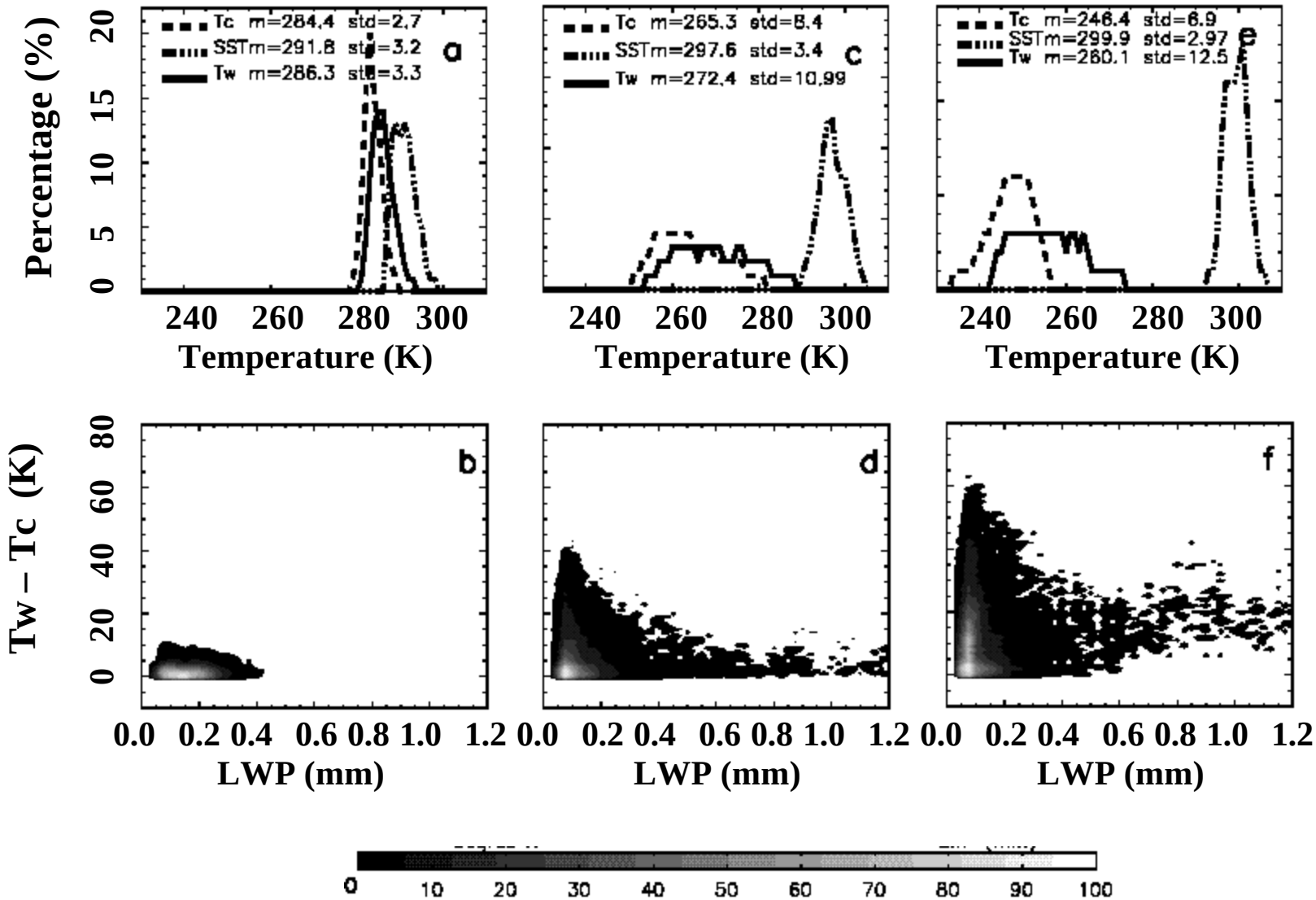
IWP from VIRS & TMI/VIRS



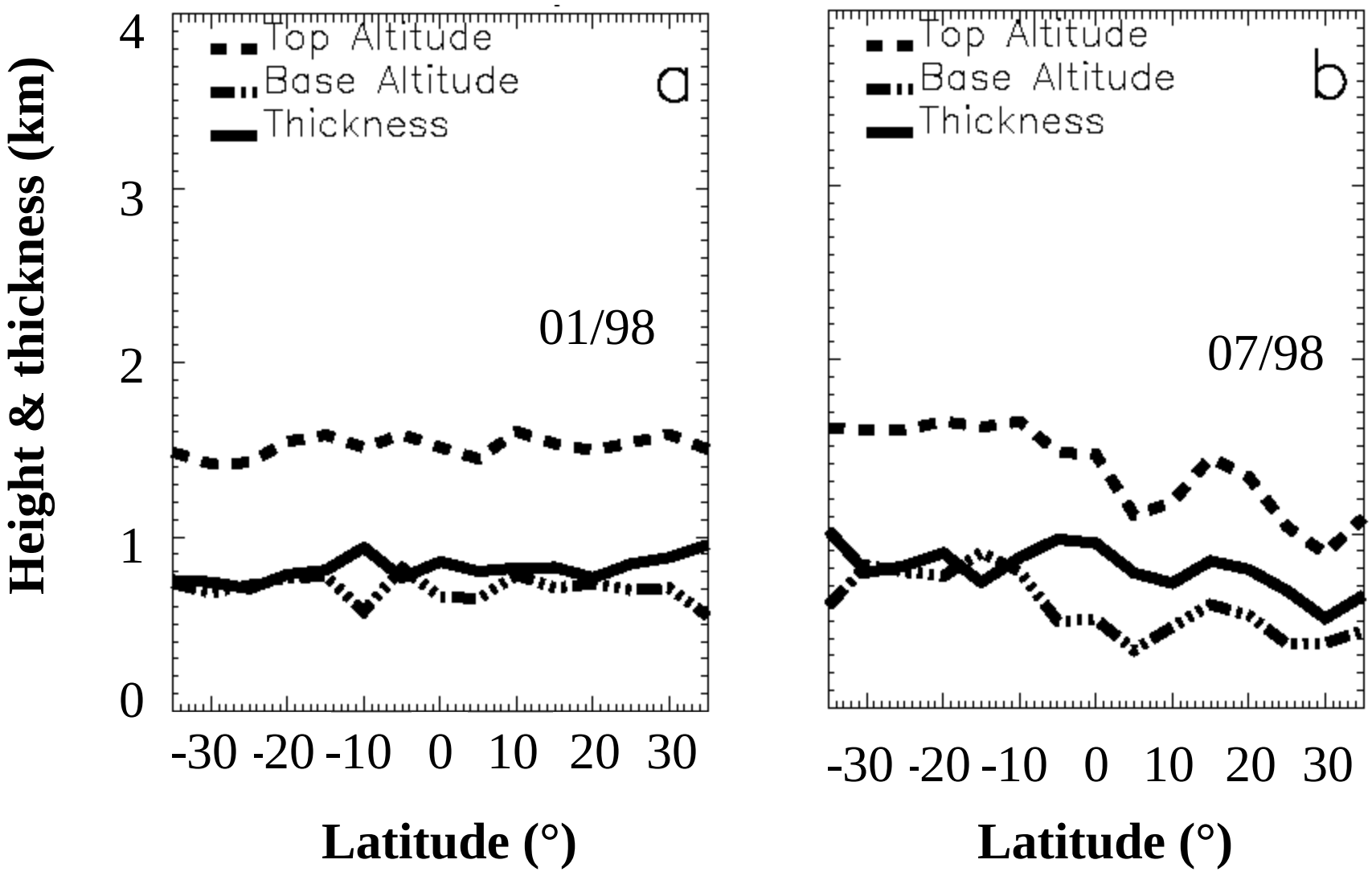
average: 0.078 mm

LWP/WP: 25 ~ 30%

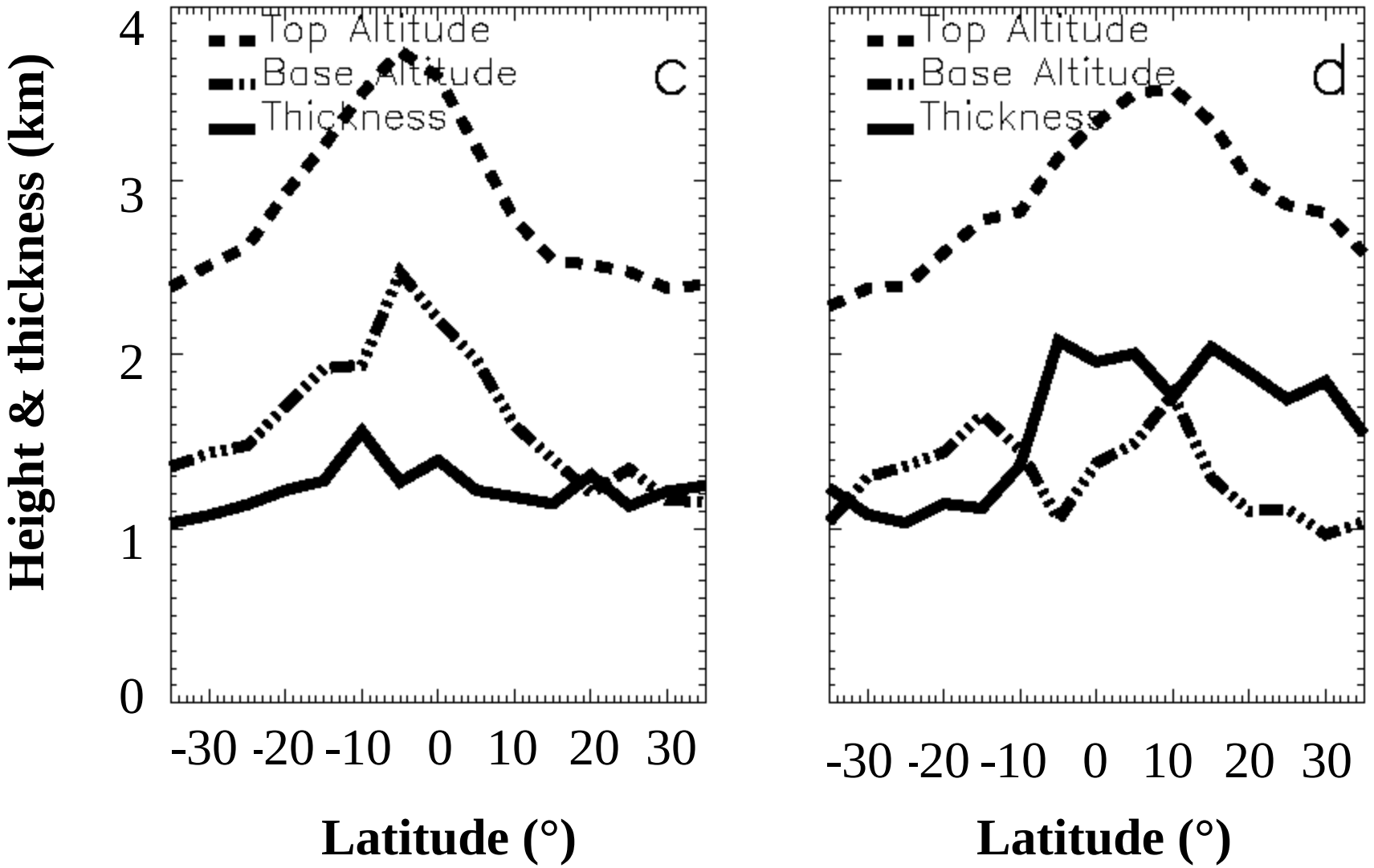
Tc, Tw & LWP distributions



low cloud thickness

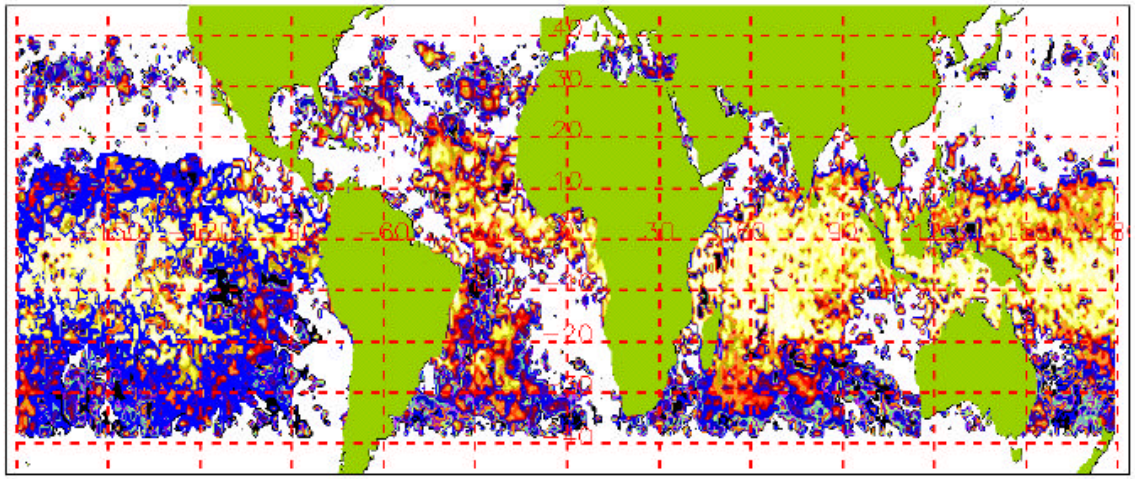


middle cloud thickness



high cloud frequency

01/98



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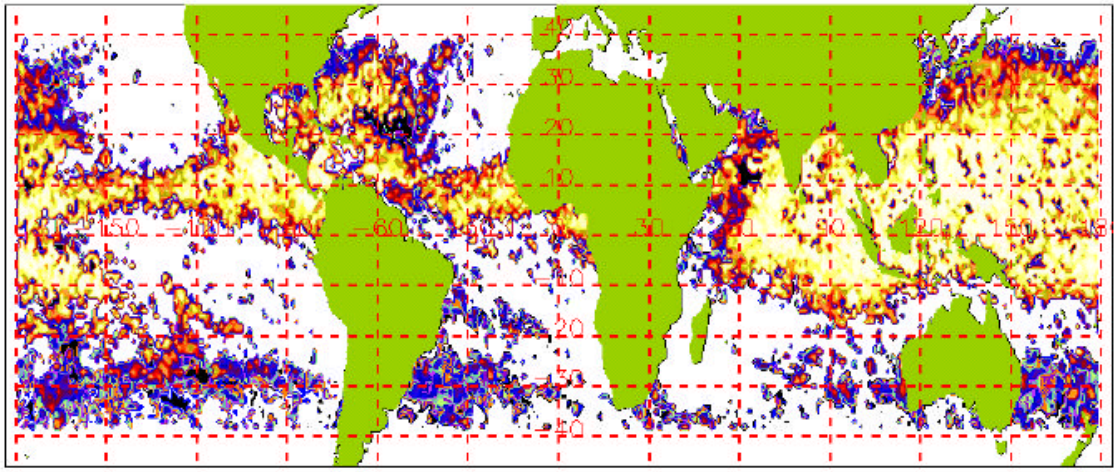

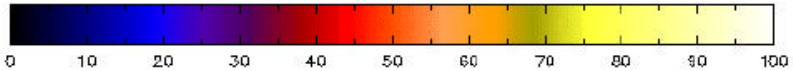

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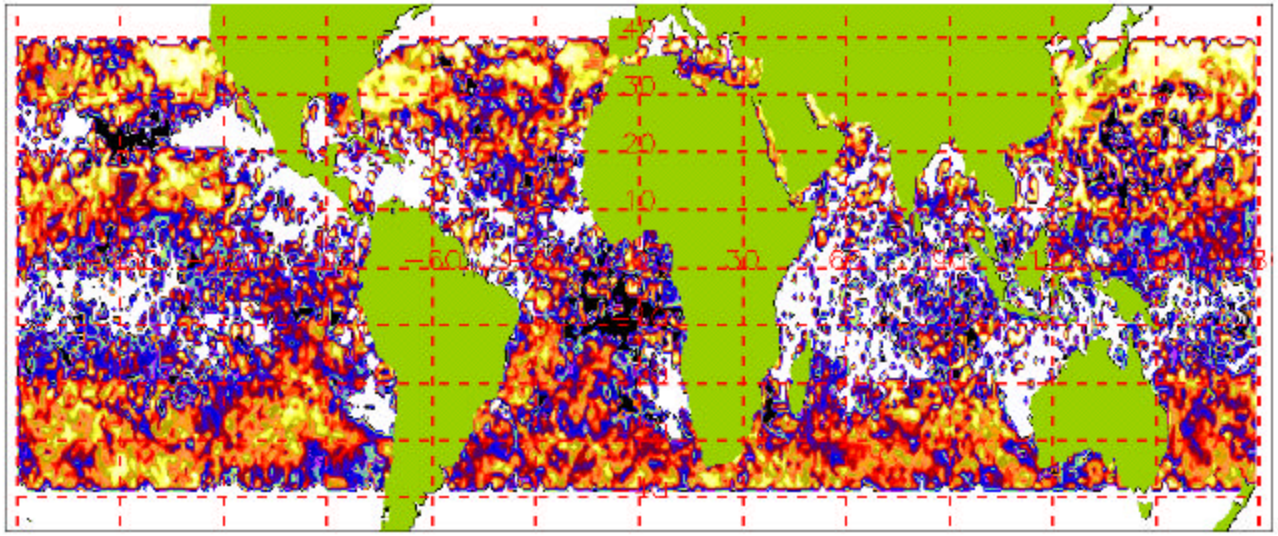

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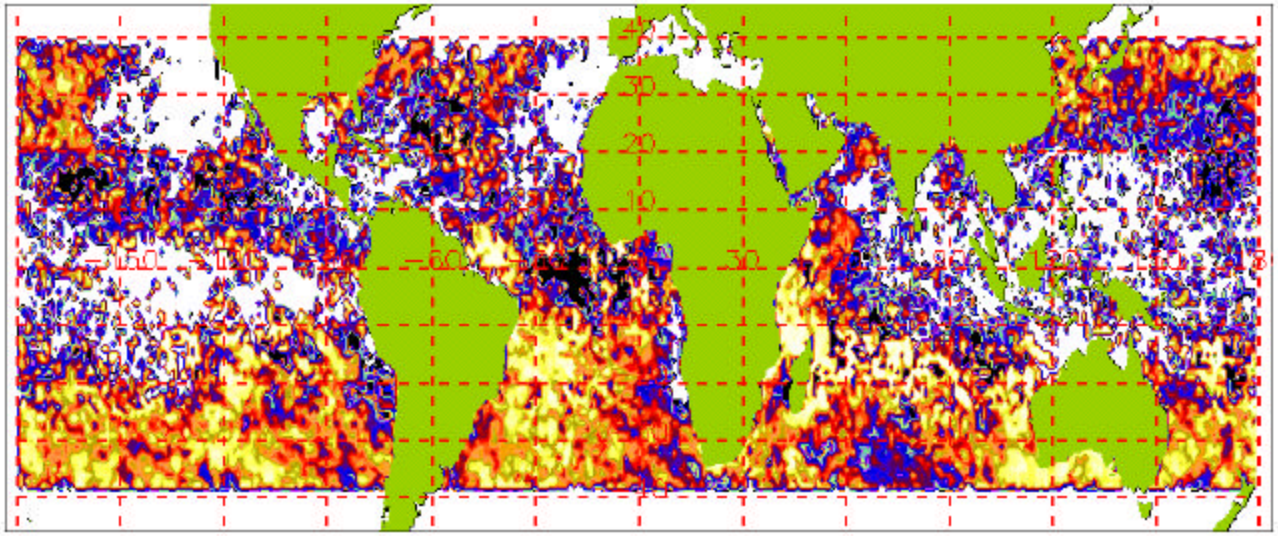
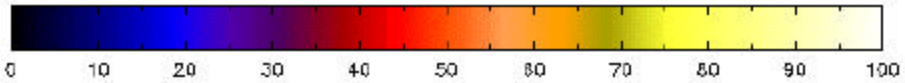
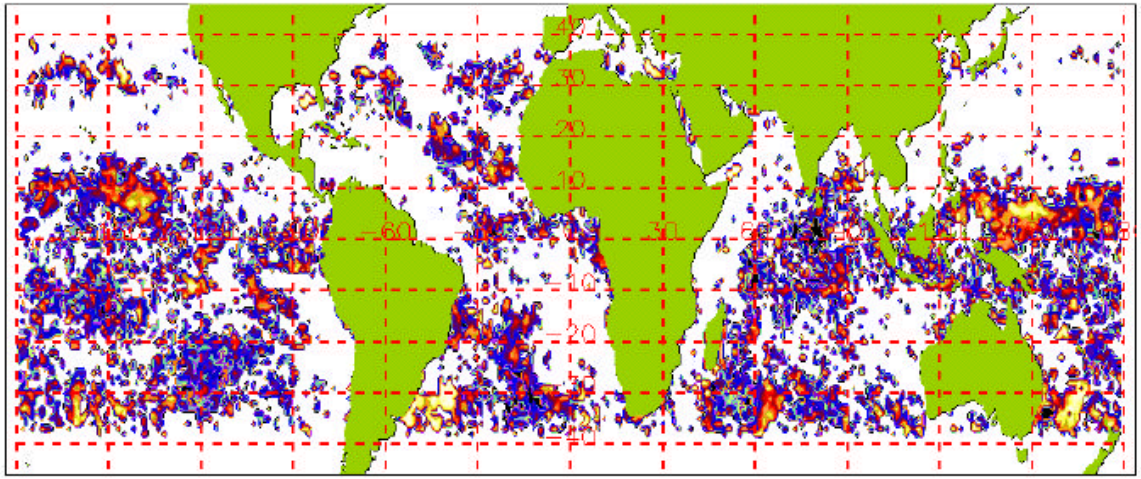




overlapping freq. (high cld)

01/98



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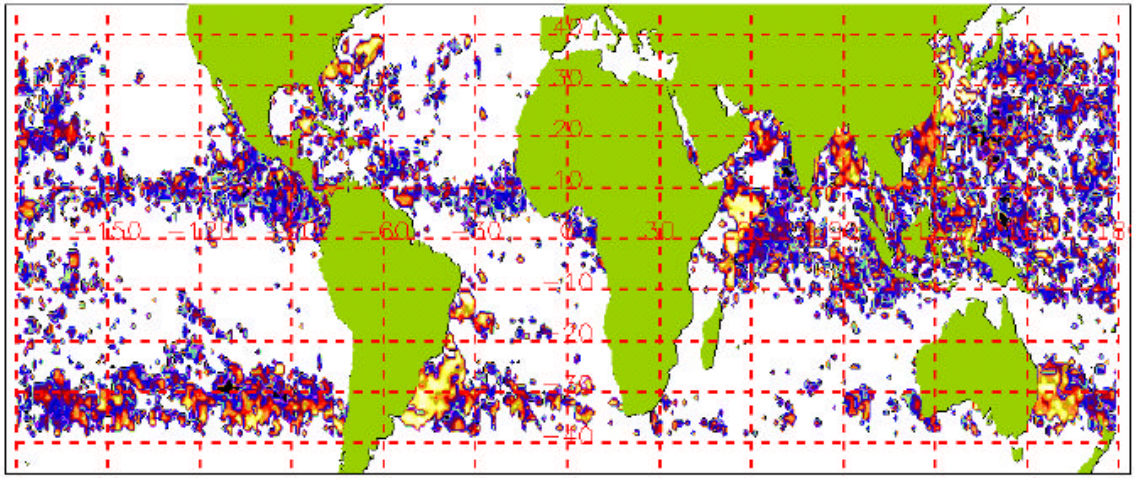
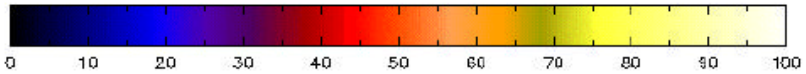
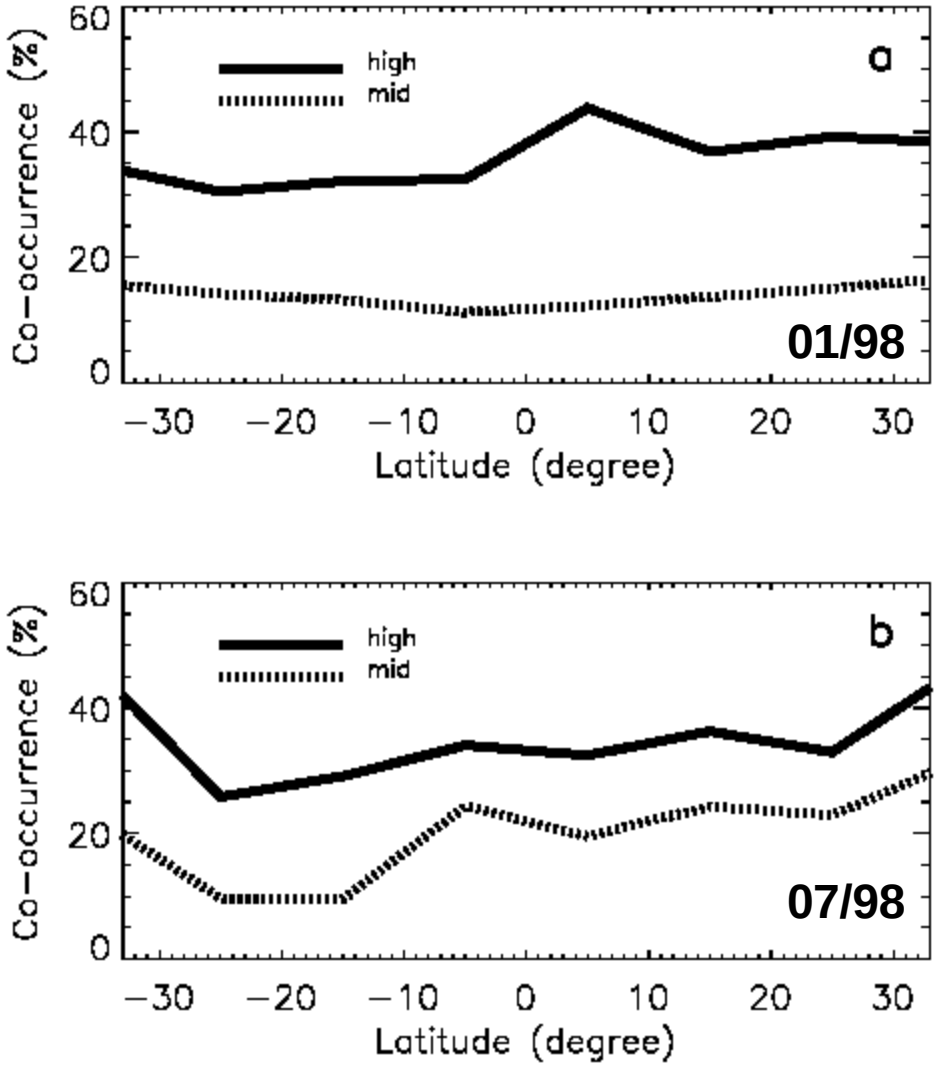




zonal mean overlap freq.



Conclusions

- Satellite observations of LWP from CERES VIRS and TMI for warm clouds are very consistent with mean difference < 0.01mm, and similar spatial variations.
- VIRS IWP may be overestimated due to low clouds underneath upper layer cirrus clouds.
- Monthly mean IWP values from combined VIRS/TMI data are about 0.07 ~ 0.09mm, which is close to previous estimations.
- Tropical cold clouds are general thicker than water clouds. Only about 25 ~ 30% of VIRS WP values is the contributed from lower layer water clouds.
- Thicknesses of low and middle clouds are ~ 0.7 and 1.1km, respectively. Middle clouds have larger variations than low clouds.
- Under high cloud conditions, the cloud overlapping frequency is about 37% over Tropics.

Acknowledgement

Many people, especially Sunny Sun-Mack and Jianping Huang, have significant contributions to this study.

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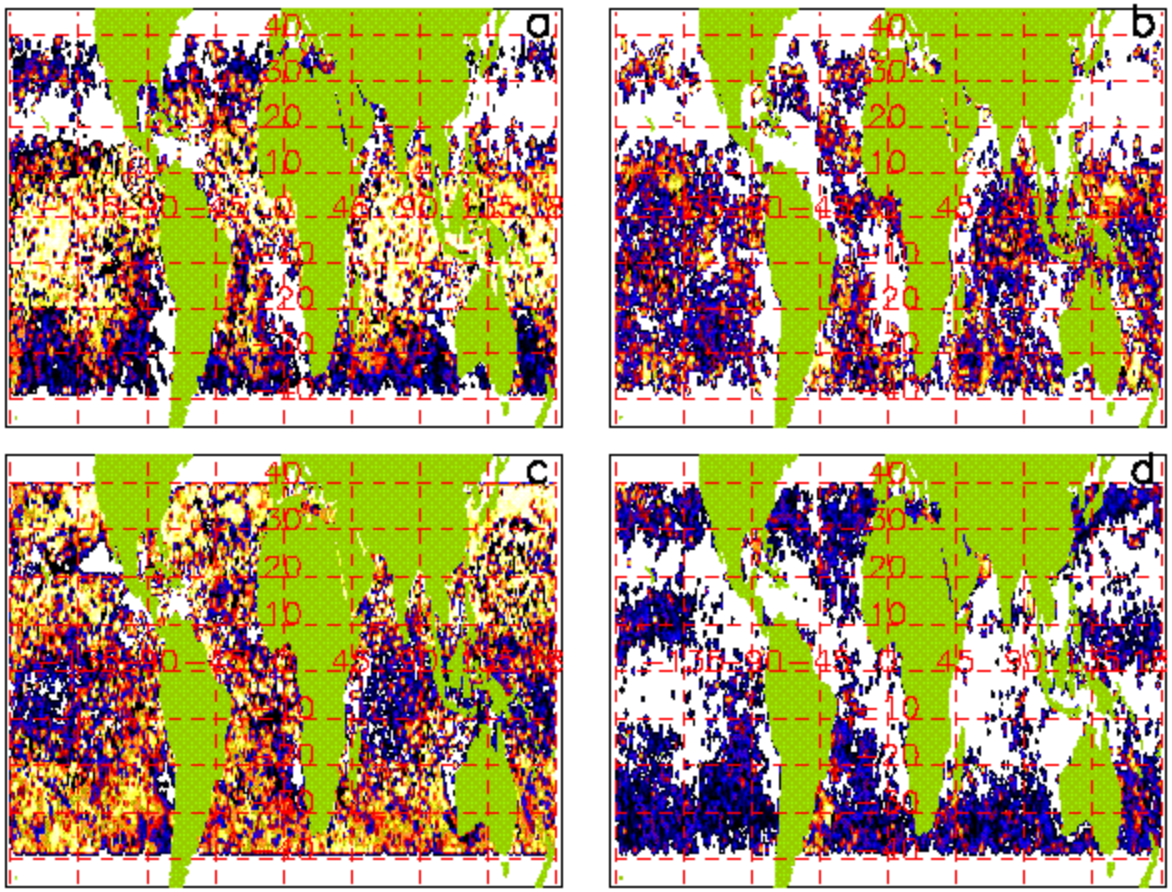
Backup Slides

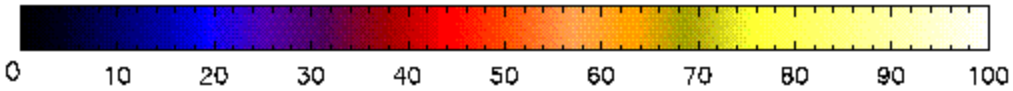
tropical cloud distribution (01/98)

occurrence | overlapping

high

middle





tropical cloud distribution (07/98)

occurrence | overlapping

high

middle