The variations of cloud liquid water amount on temperature over SHEBA site

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- **NOAA ETL cloud radar data from SHEBA data band.**

Outline

1. **Background**

   cloud temperature feedback/water clouds only -- LWP or τ

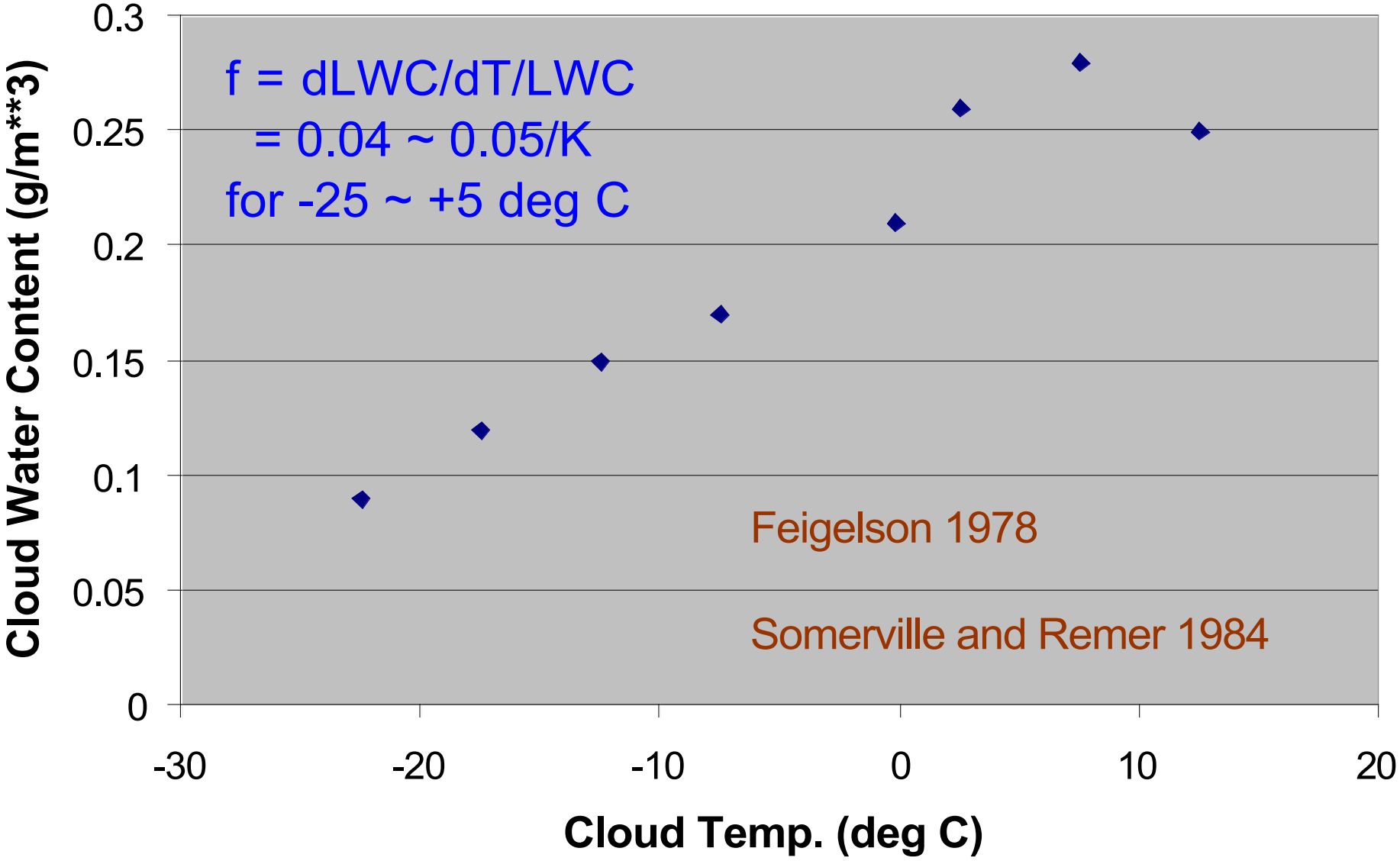
2. **SHEBA Data: AVHRR,**

3. **MWR, IRT, MMCR, ice camp meteor. obs., atmospheric. profiles**

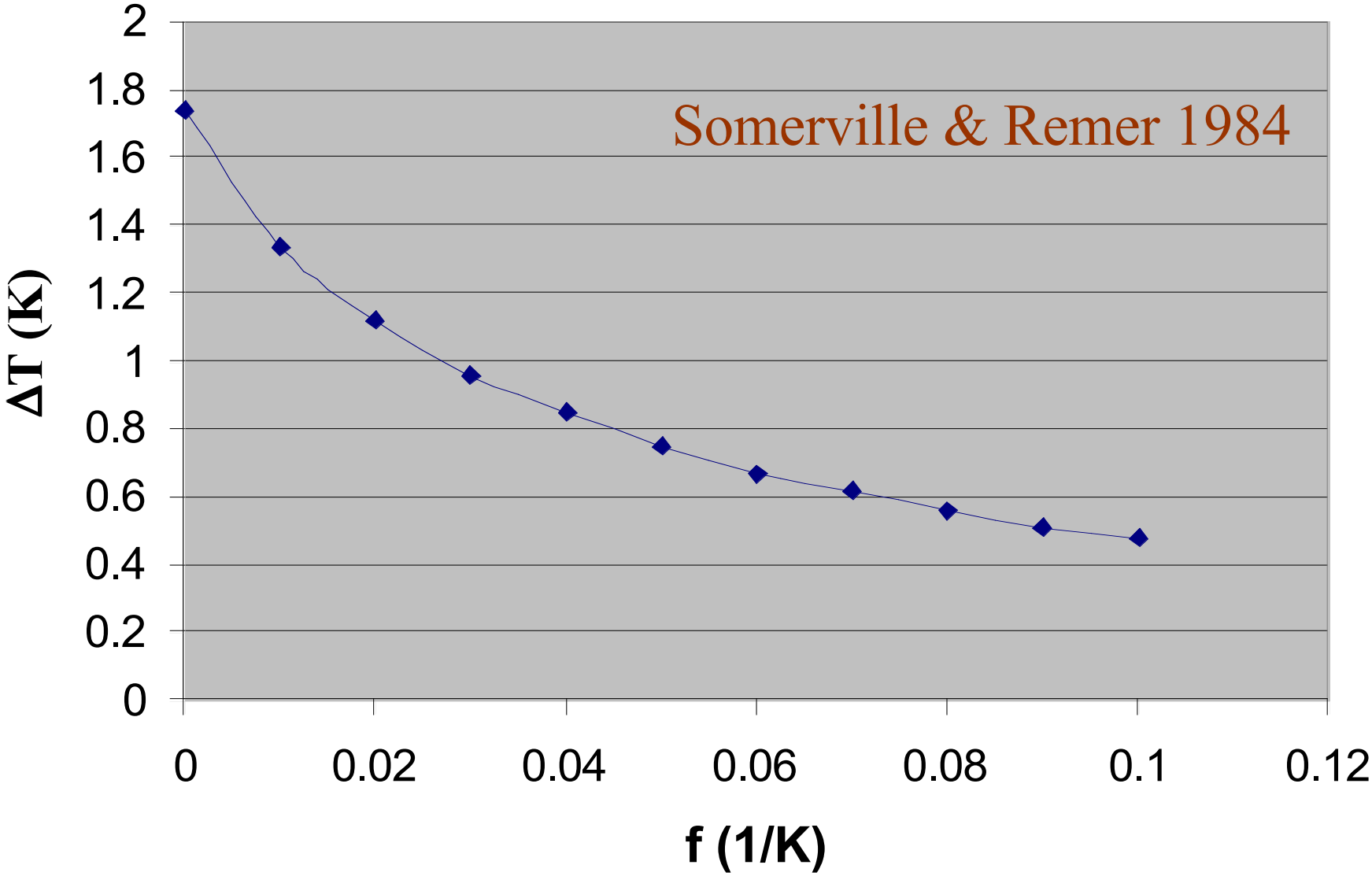
3. **Results: change rate, causes**

4. **Summary**

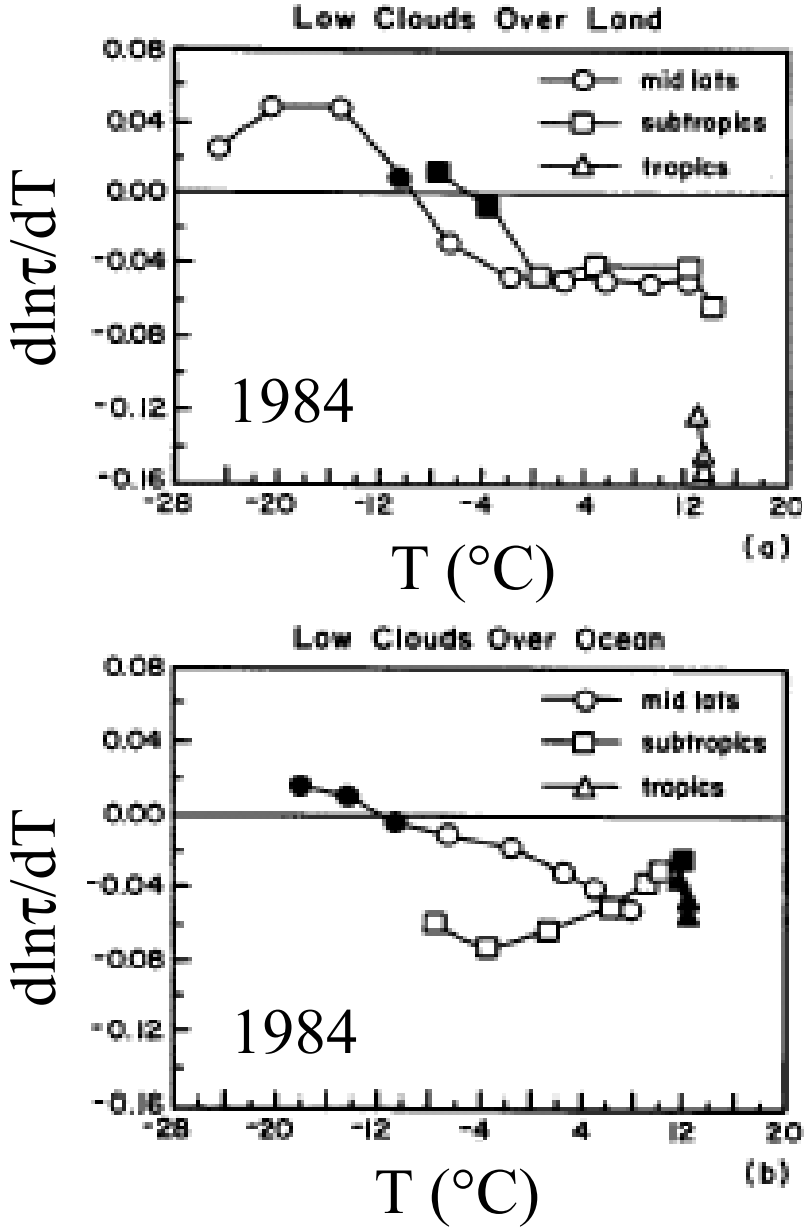
former USSR data

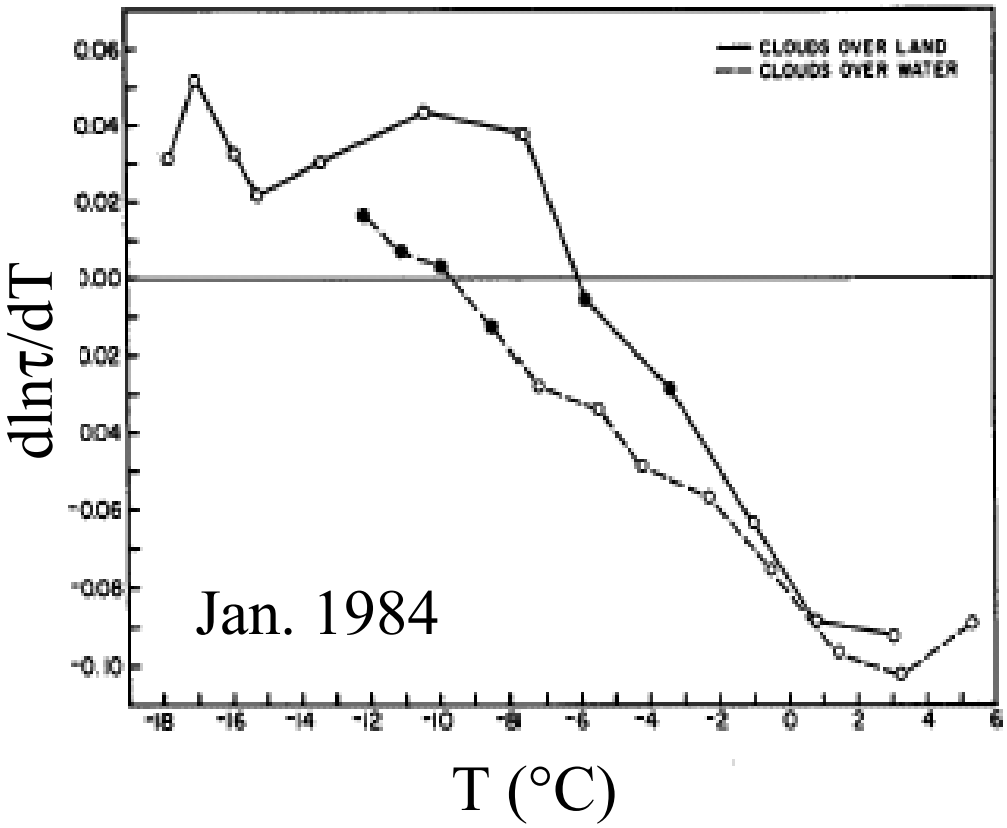


Surface Temp. Warming

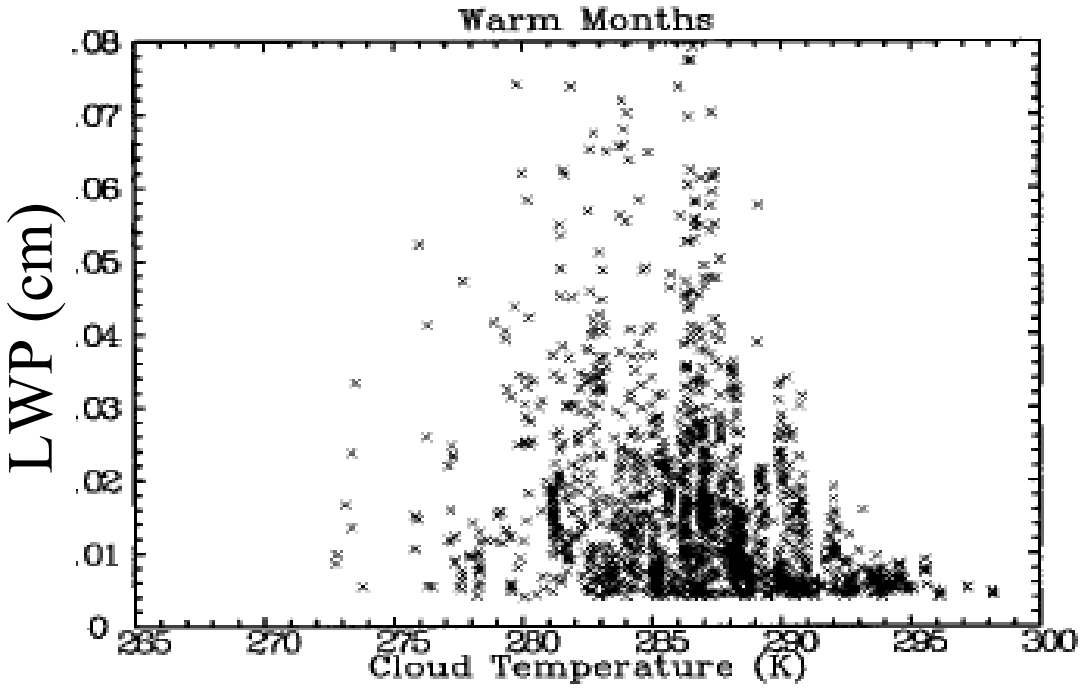


satellite optical depth



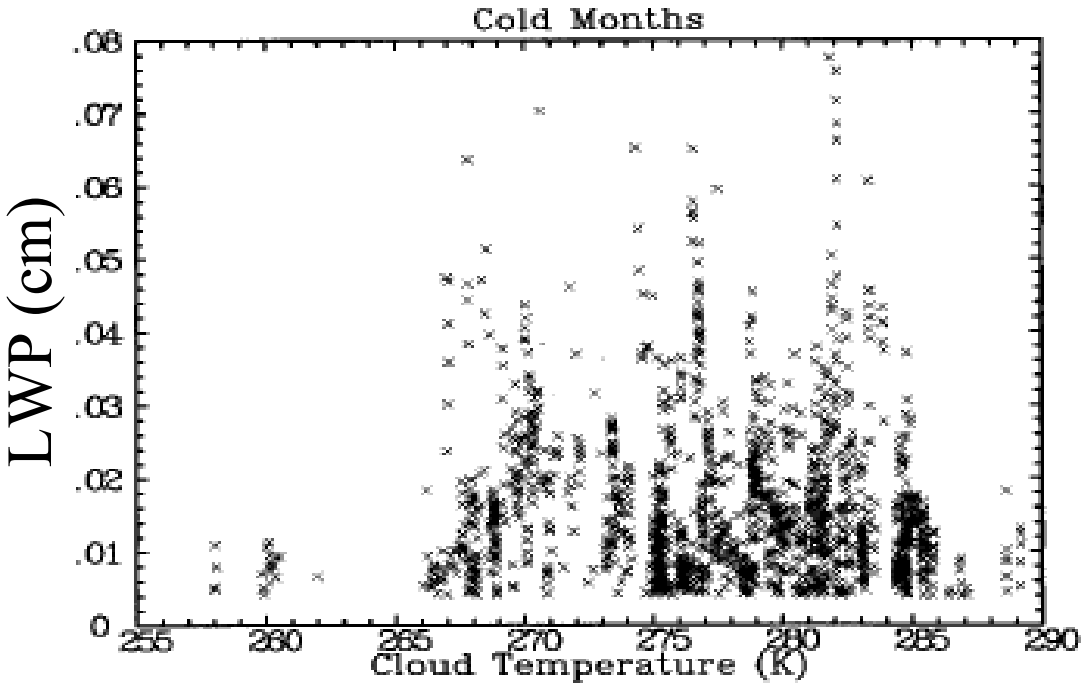


Tselioudis et al. 1992



f = -0.08/K
T > 280K

Del Genio & Wolf, 2000

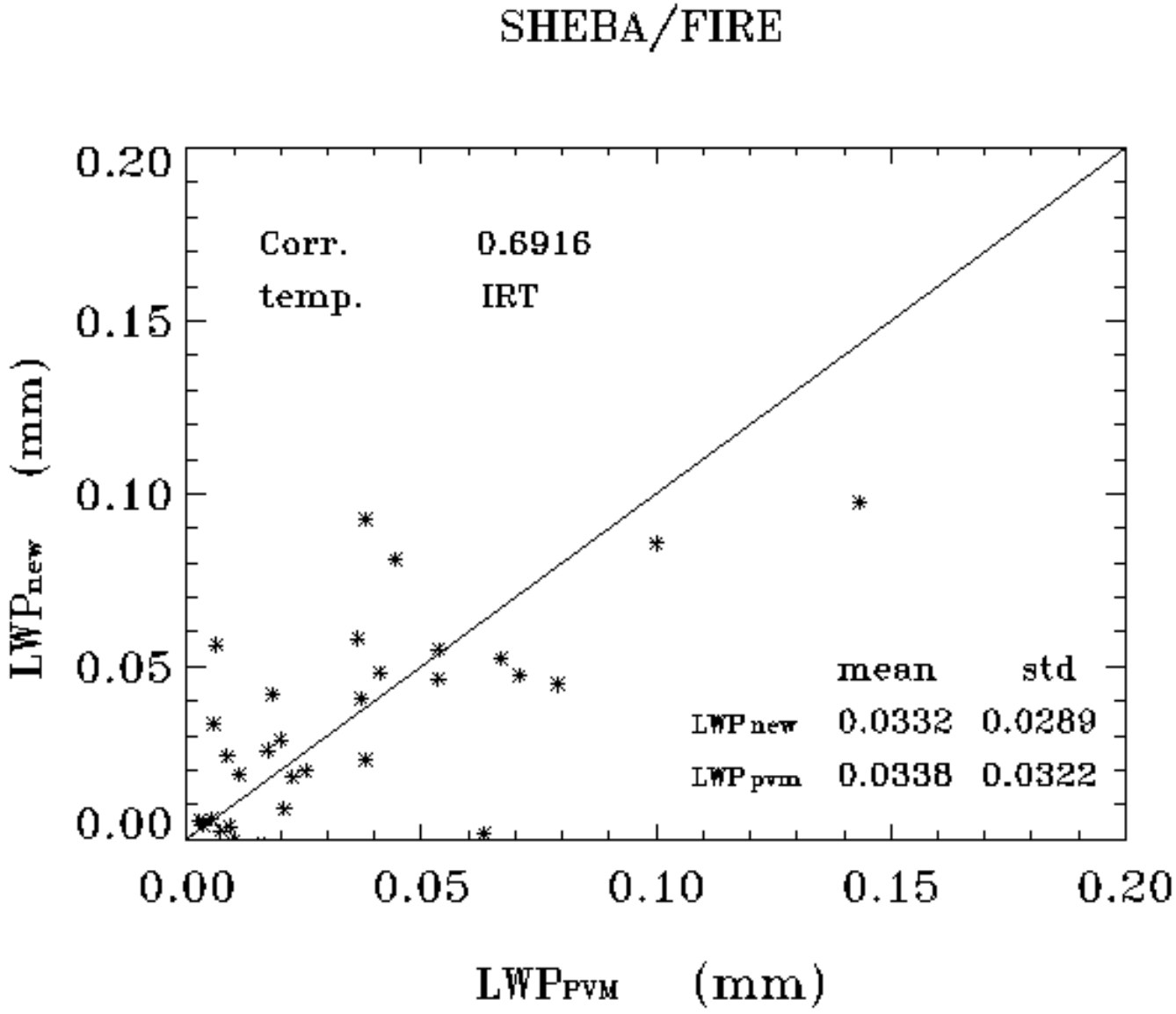


f = -0.01/K
T > 265K

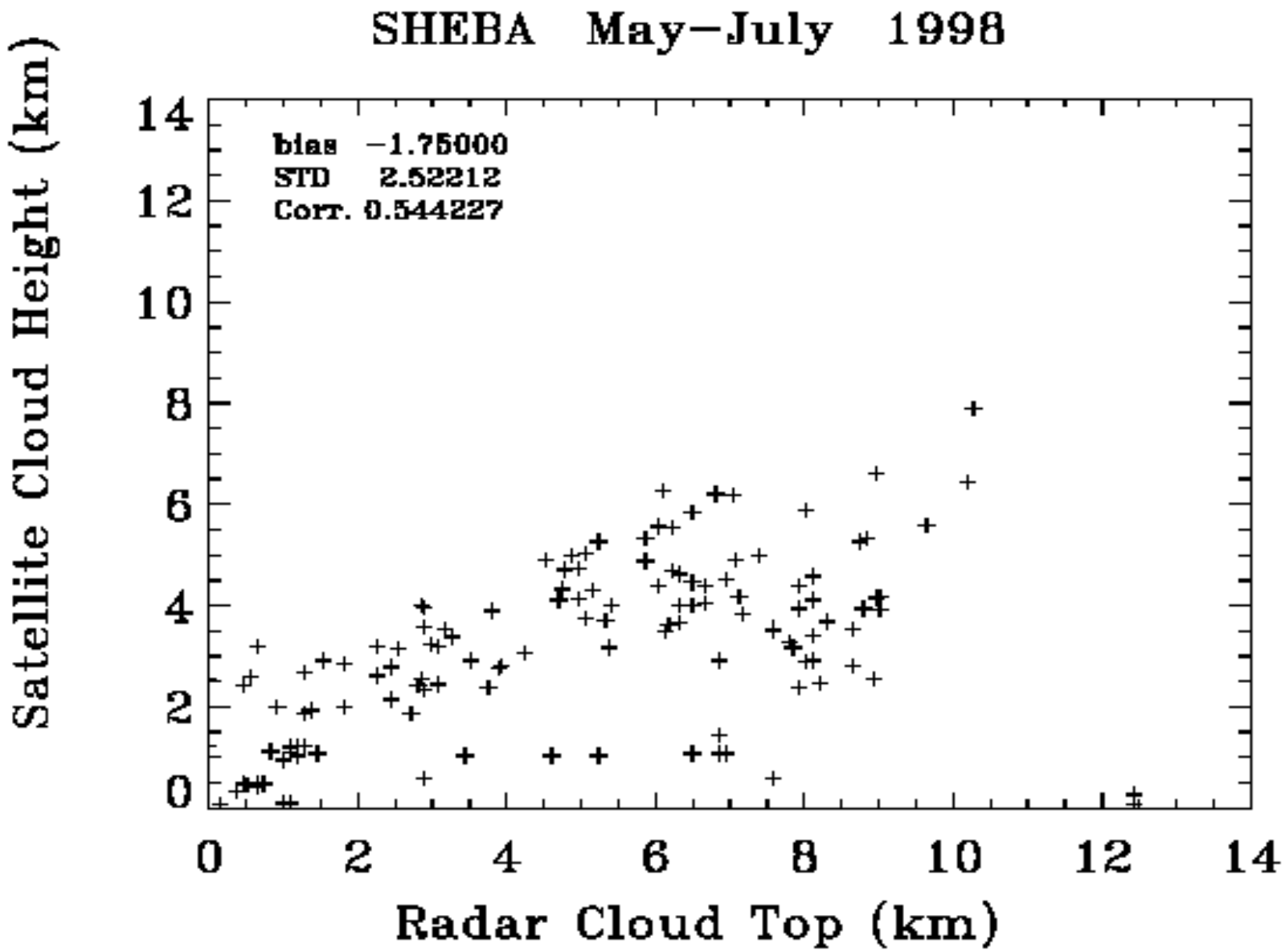
Data sets

- **SHEBA ice camp measurements:**
  - **Microwave Radiometer (MWR) LWP**
  - **Infrared thermometer (IRT)**
    cloud base temperature and height
  - **Radiosonde atmospheric profile**
  - **Meteorological measurements Ts, Ps, q_v**
  - **Millimeter Cloud Radar (MMCR) cloud height, thickness**
- **Satellite measurements:**
  - **IR cloud top temperature and height**
  - **Cloud cover**

MWR vs PVM LWP



Cloud top height



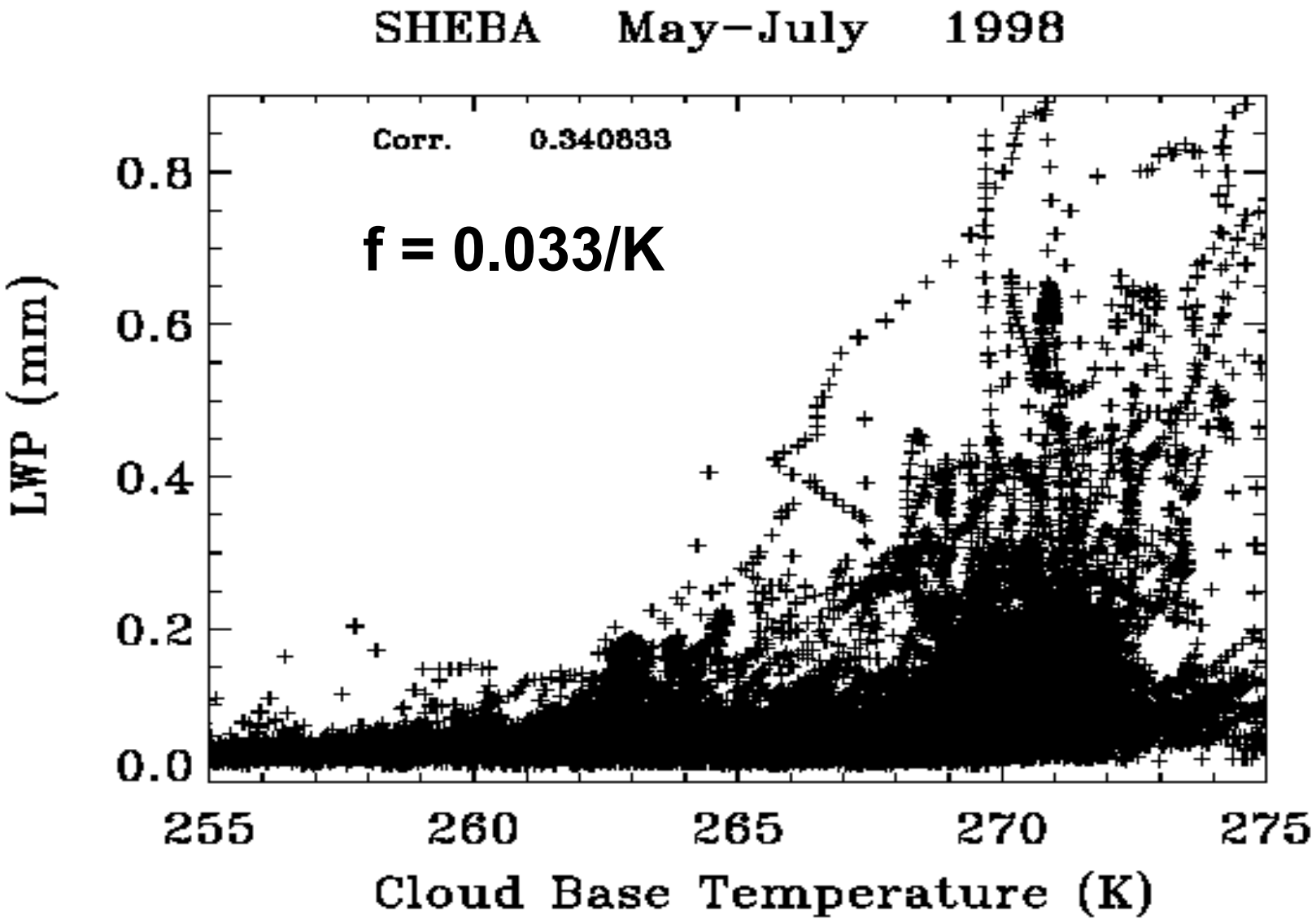
Data sets (cont.)

- Matched in 25km radius and 30 minutes
- SHEBA year November 1997 ~ October 1998
- FIRE ACE May 1998 ~ July 1998
- Analyzed LWP data: LWP > 0.02mm

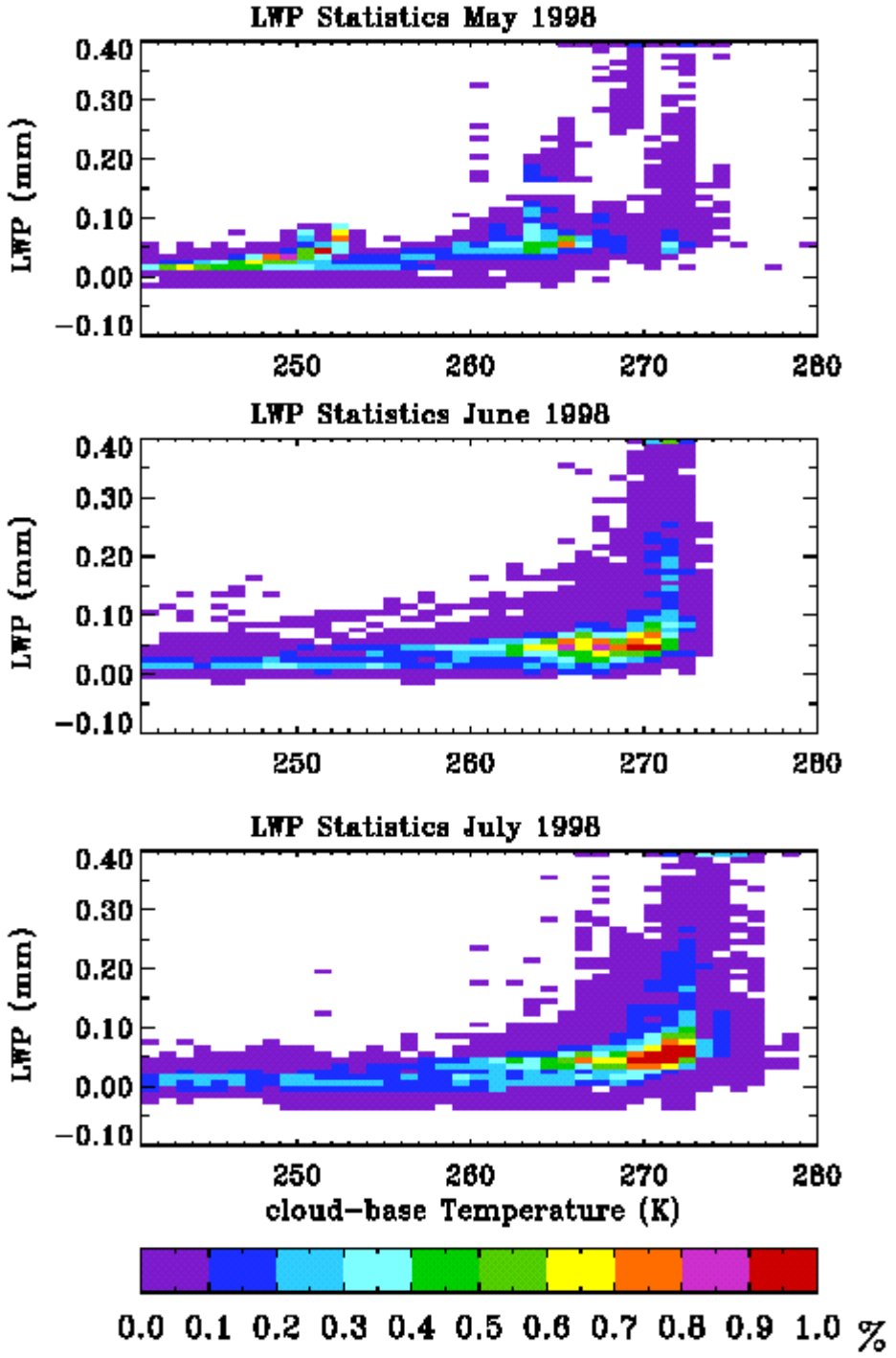
Results

- LWP vs temperature
- LWP or LWC with environmental parameters
- Relative change rate (f number)
- Determinate factor for LWP increase with temperature
  - Humidity and LCL

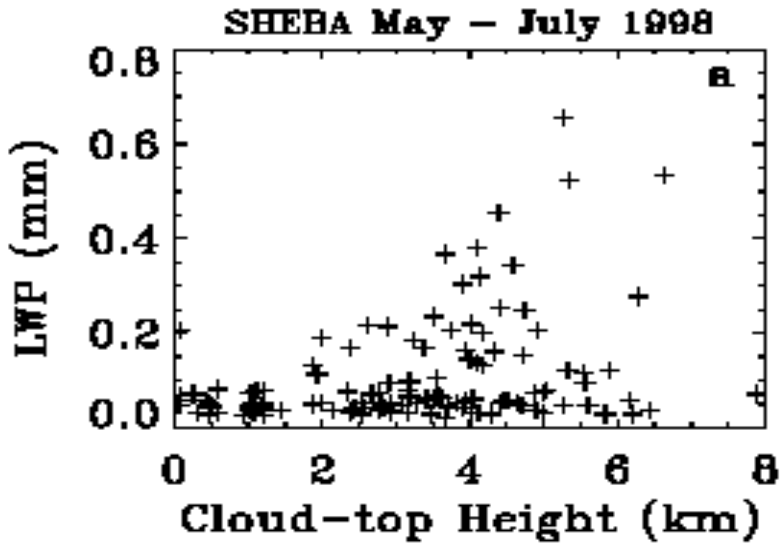
LWP vs temperature

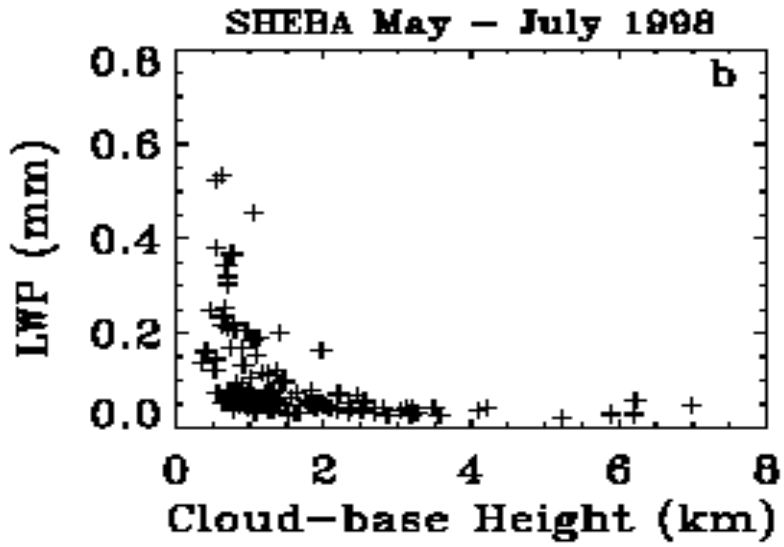


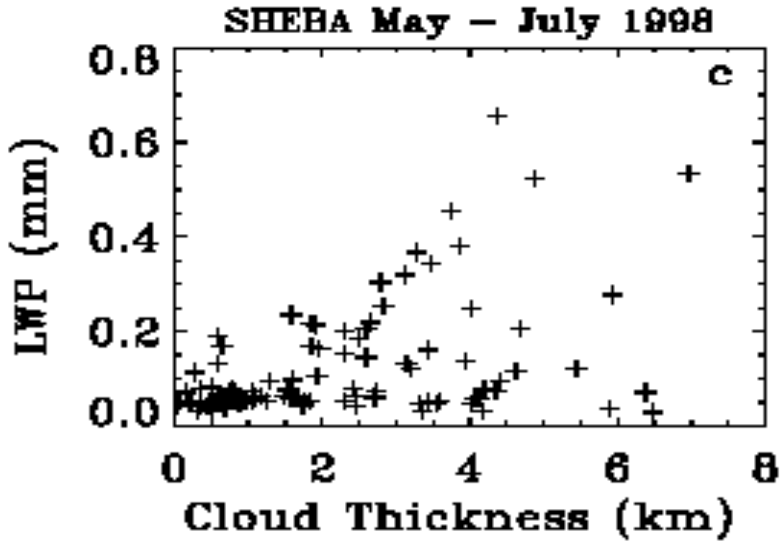
f = 0.07/K for mean LWP & T

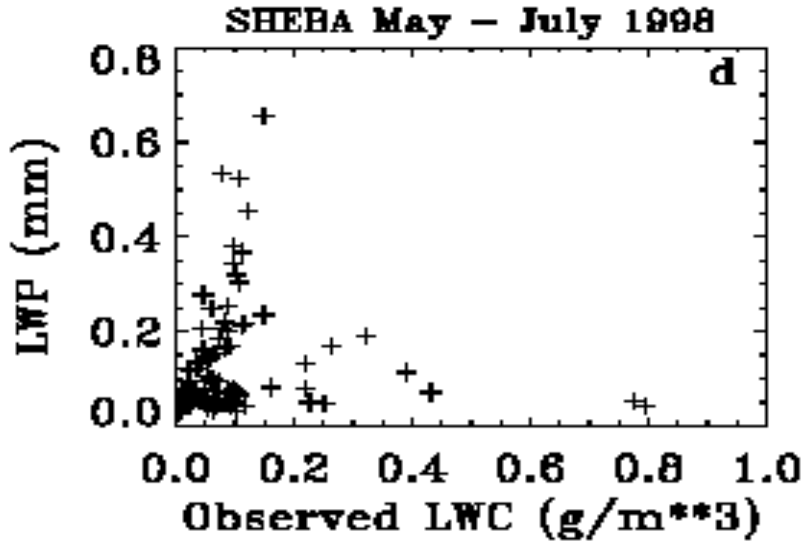


satellite-ground matched data

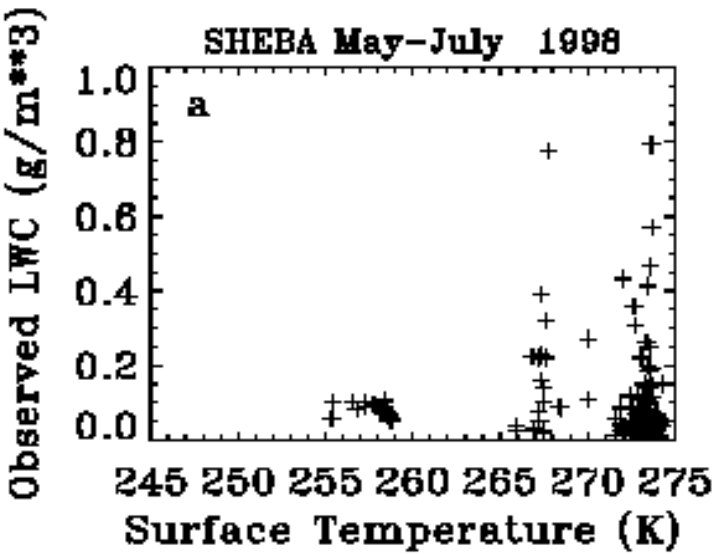


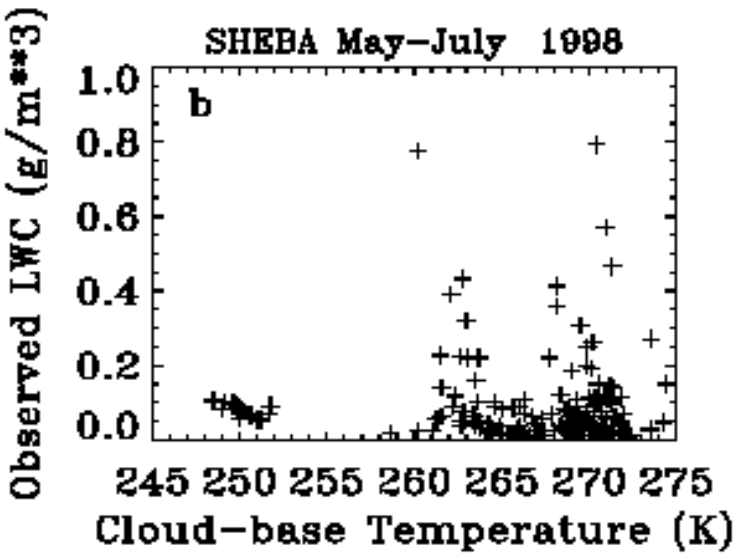


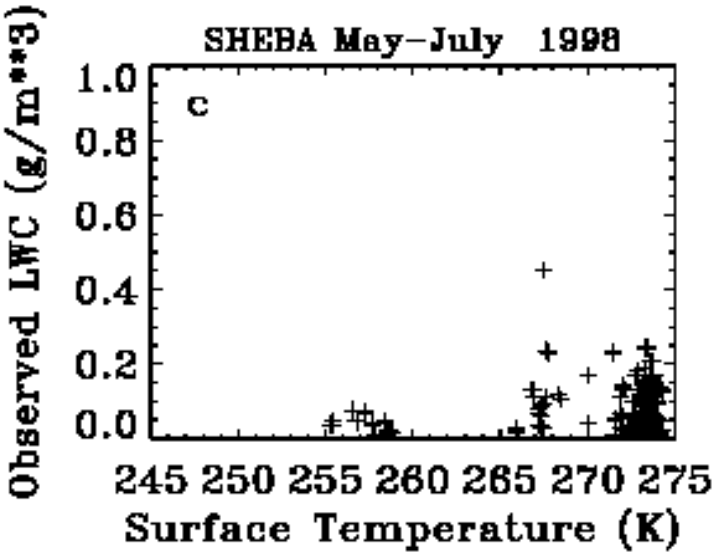


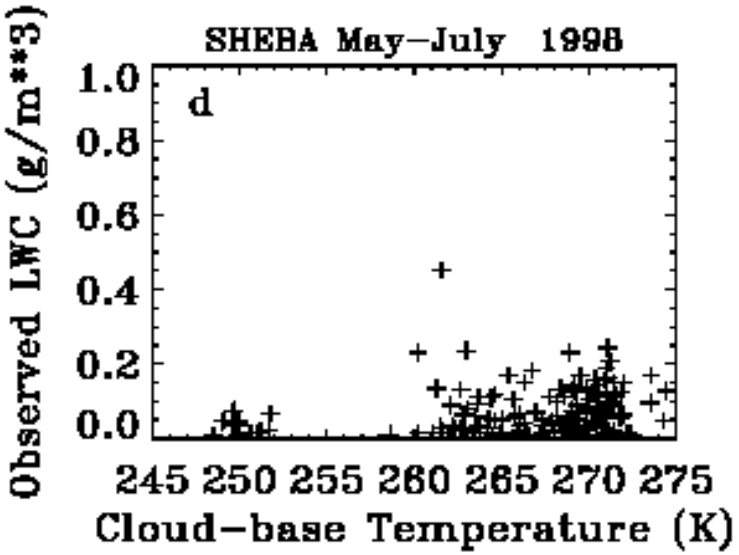


LWC vs temperature

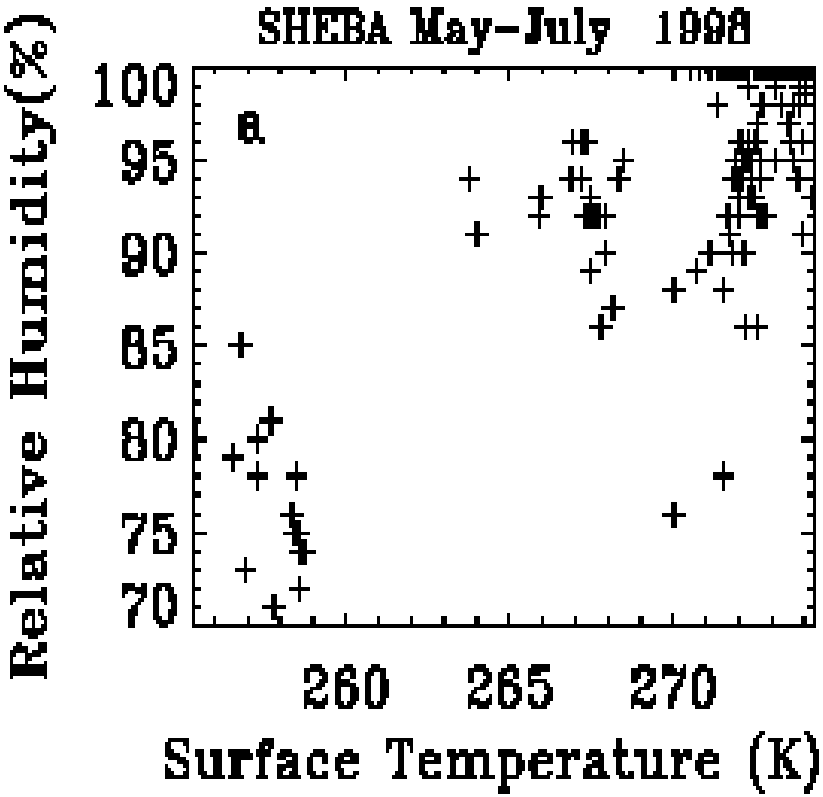


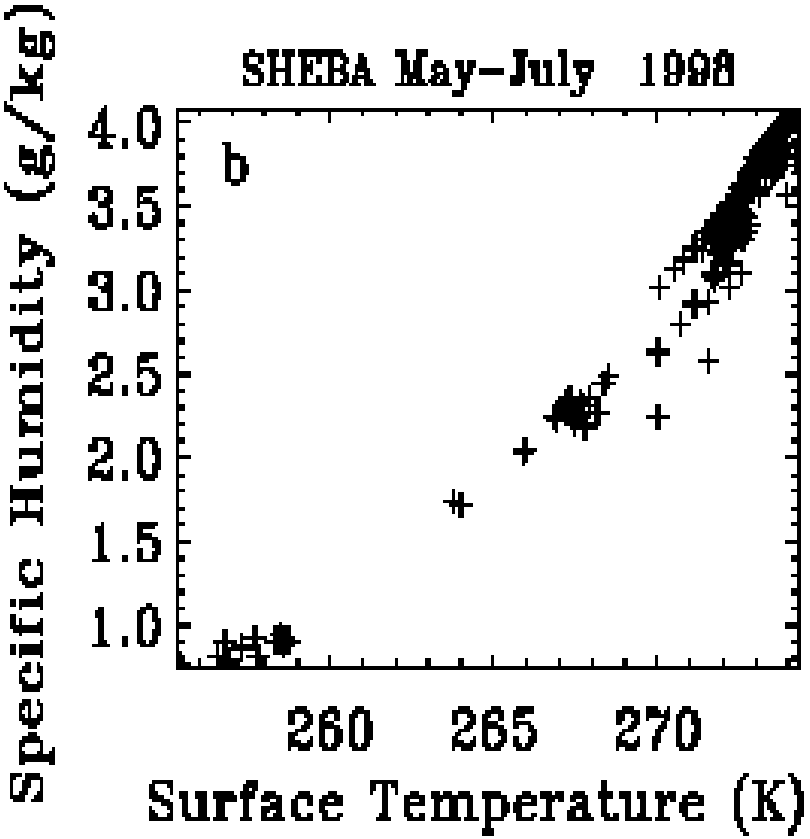




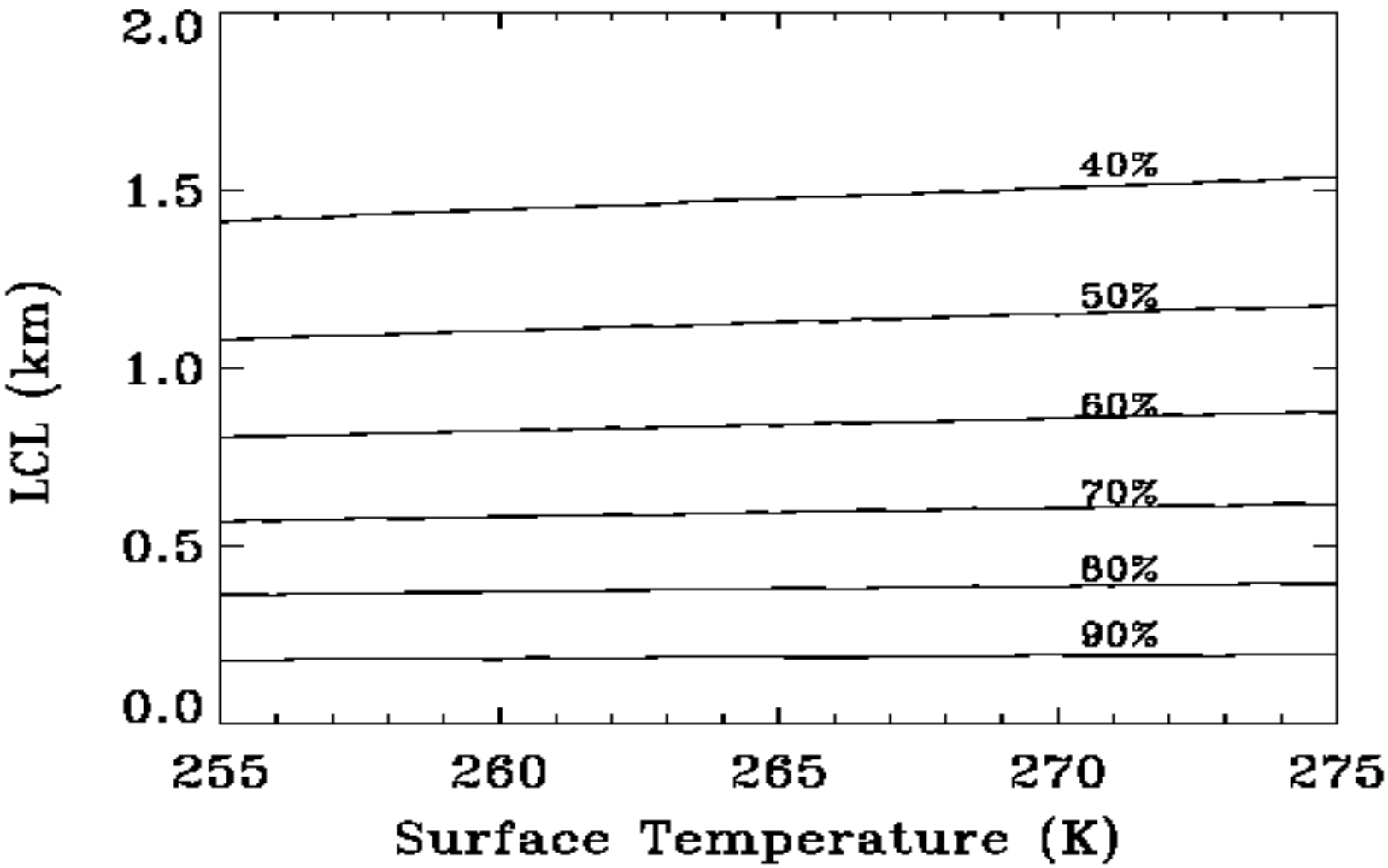


surface humidity

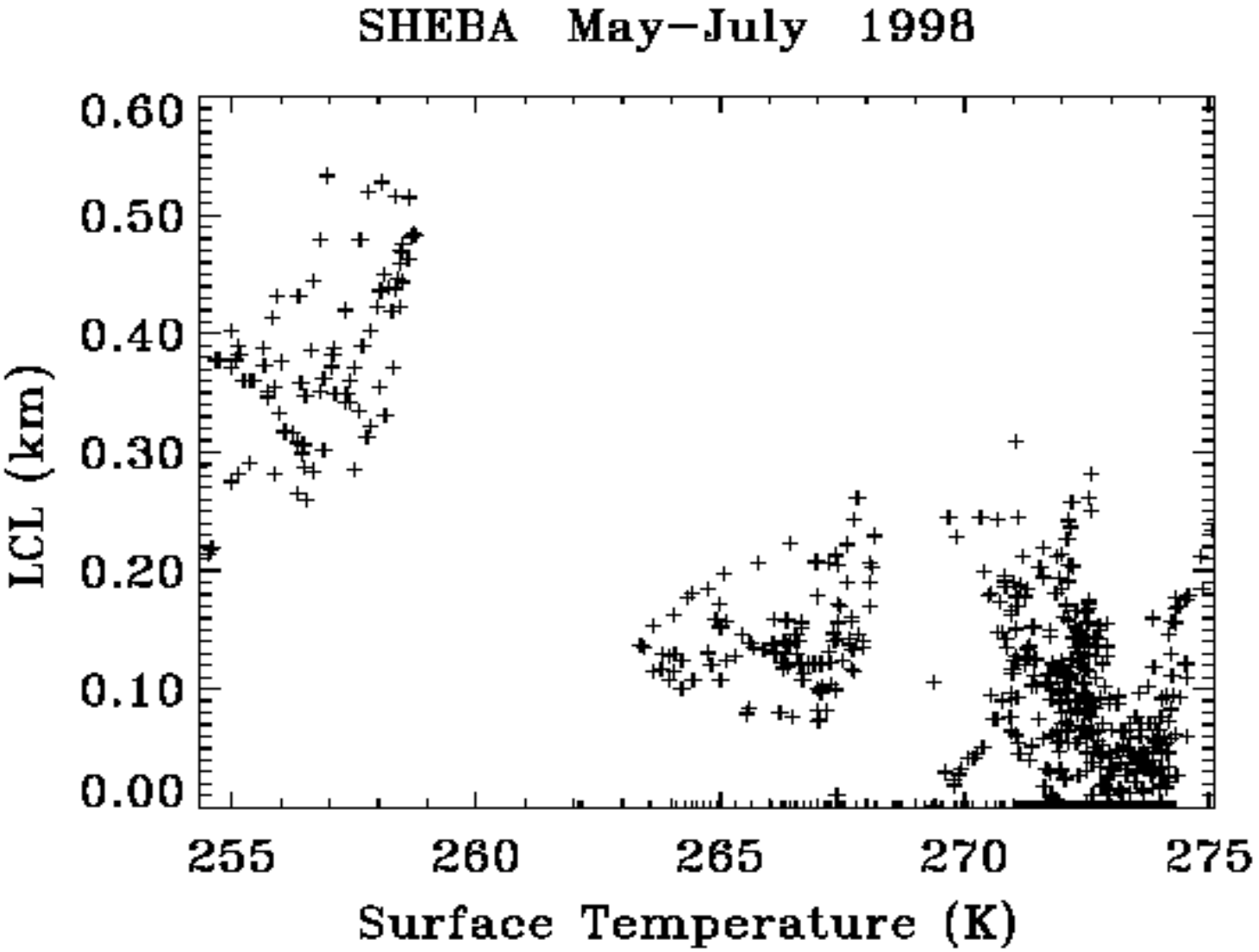




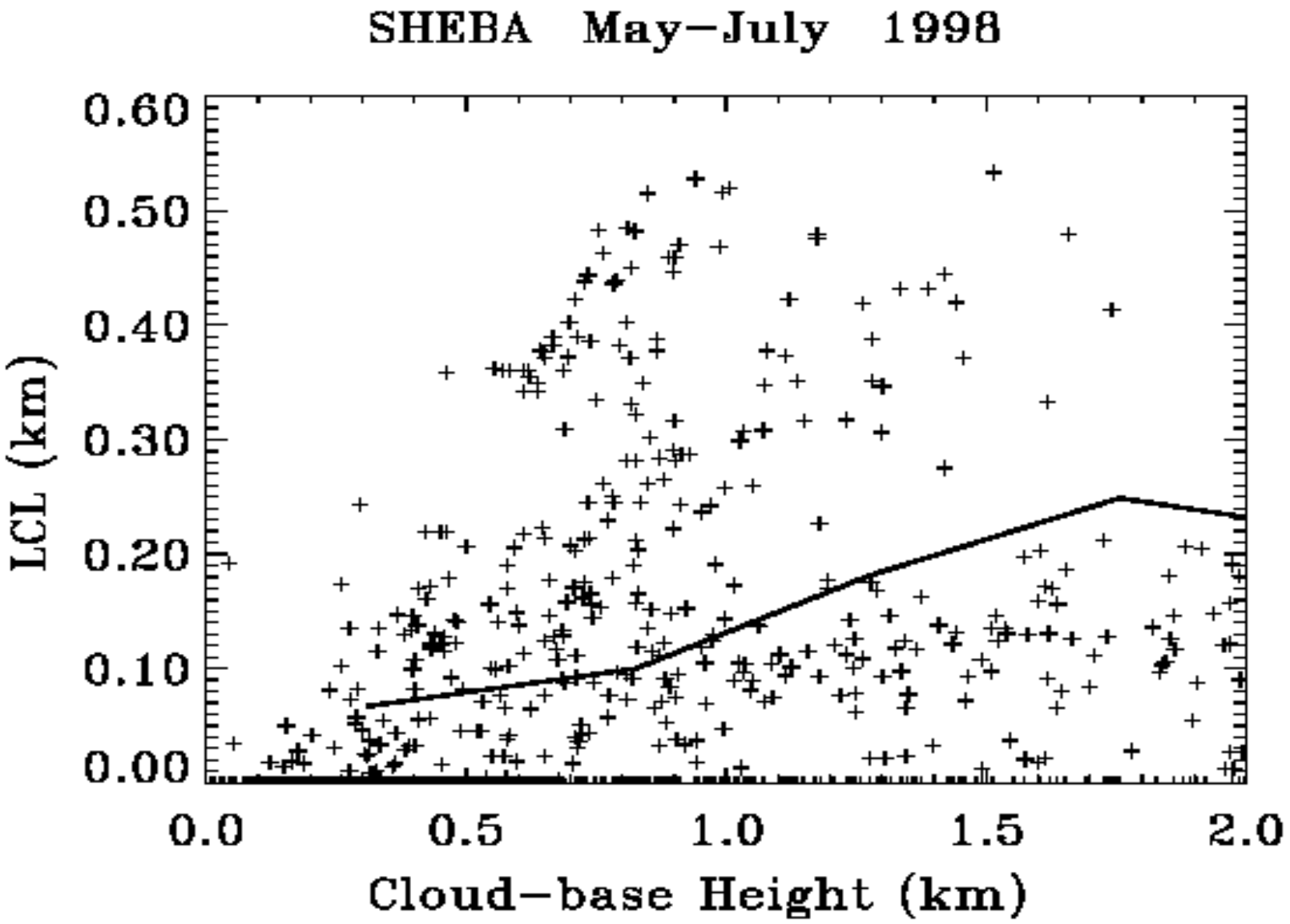
theoretical LCL



LCL vs Ts


SHEBA May–July 1998
LCL (km)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
255
260
265
270
275
Surface Temperature (K)

Cloud base vs LCL



Conclusions

- LWP increases with temperature due to cloud thickness increase

  No significant change of LWC with temperature
- Relative change rate f = 3.3%/K
- Humidity increase explains part of the cloud vertical structure change (LCL and moist static energy)
- Hope CERES/Terra or Aqua data provide large-scale & long-term LWP or τ dependence on temperature, and radiative feedback of the dependence


CERES
NASA


NASA

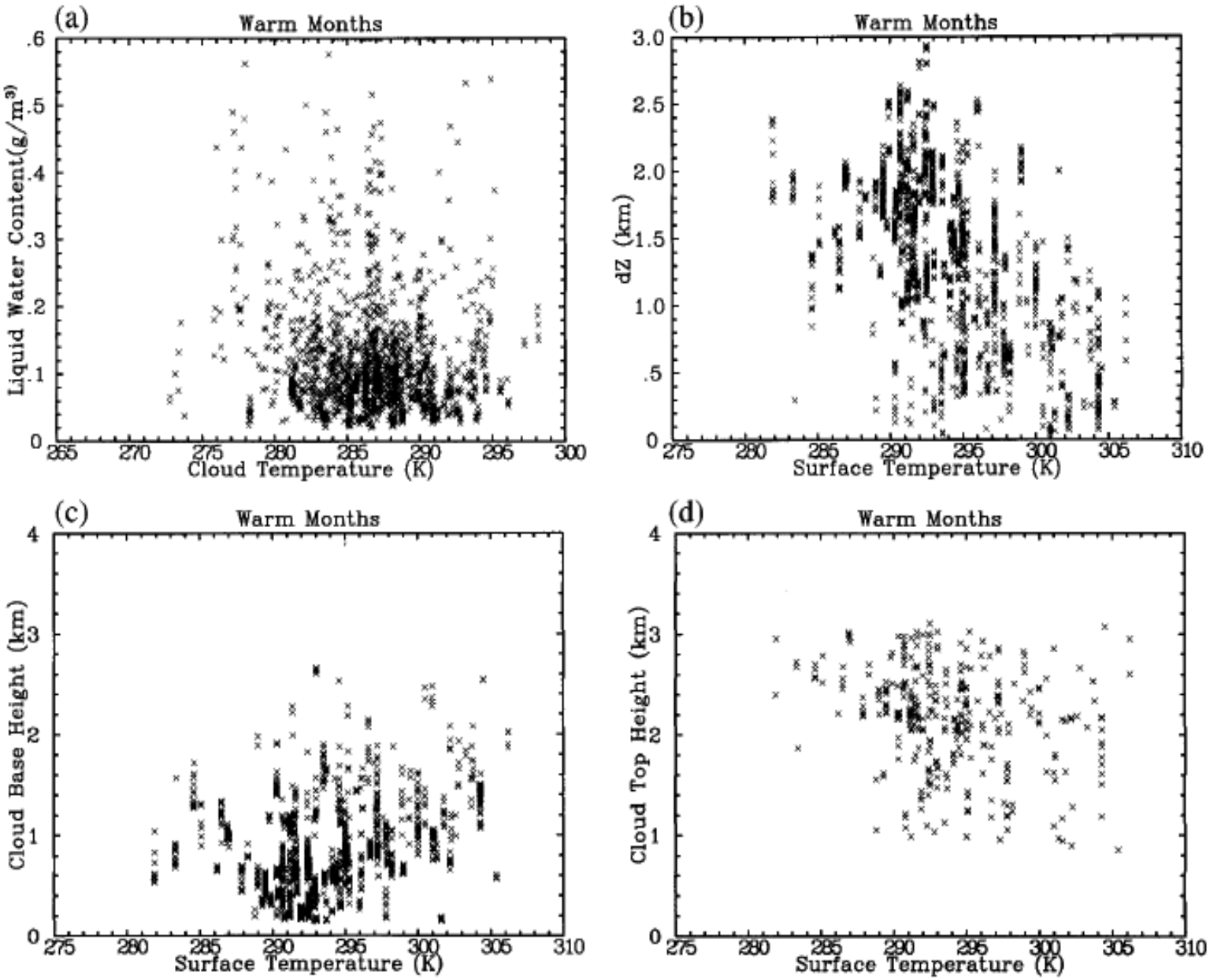
Introduction

- Cloud optical depth on temperature
  or cloud liquid water path (LWP) &
  or cloud liquid water content (LWC)

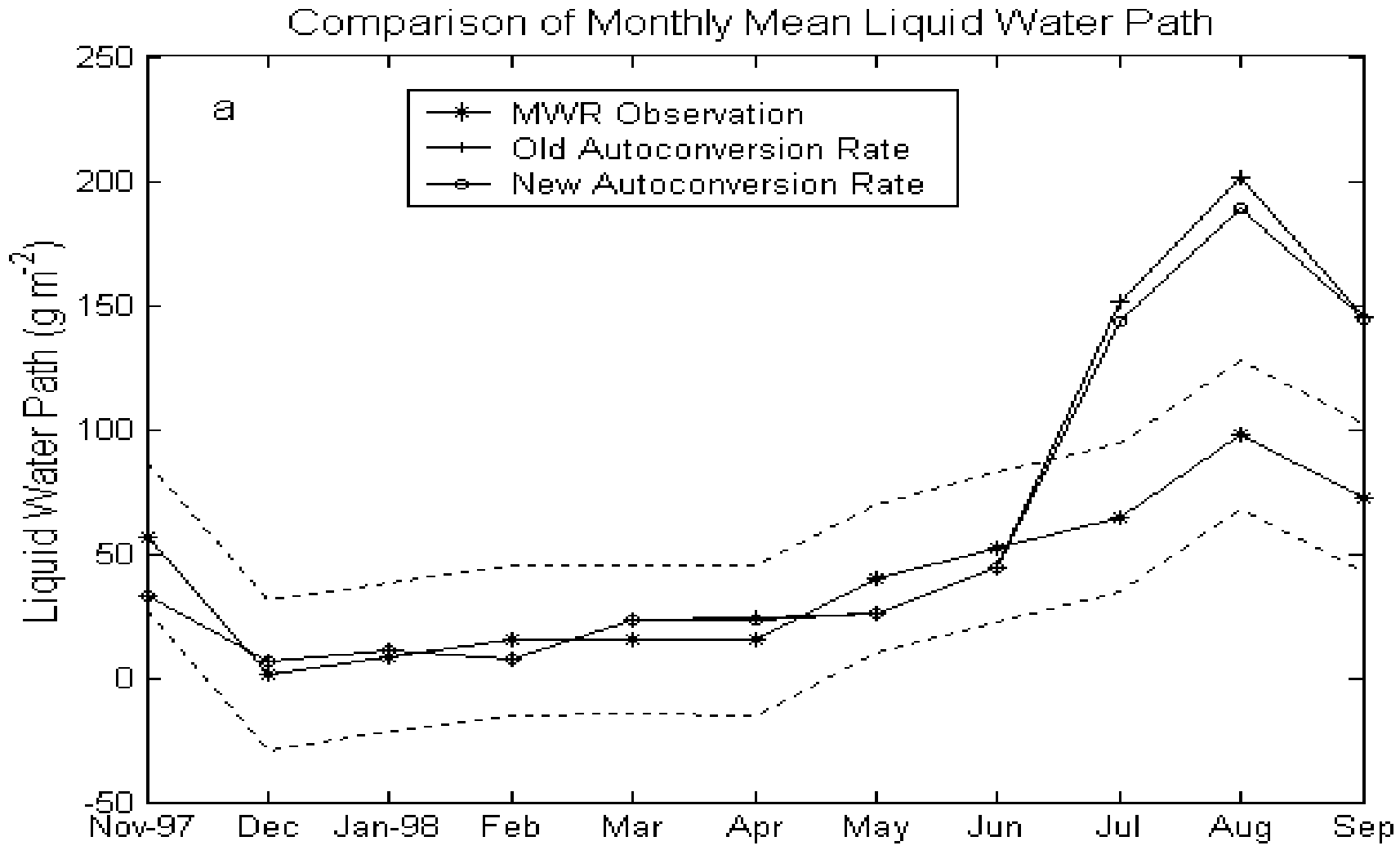
- Regional, temperature, &
  cloud type dependent:
  aircraft, satellite, and ground based observations

- Water clouds only

SGP Summer data

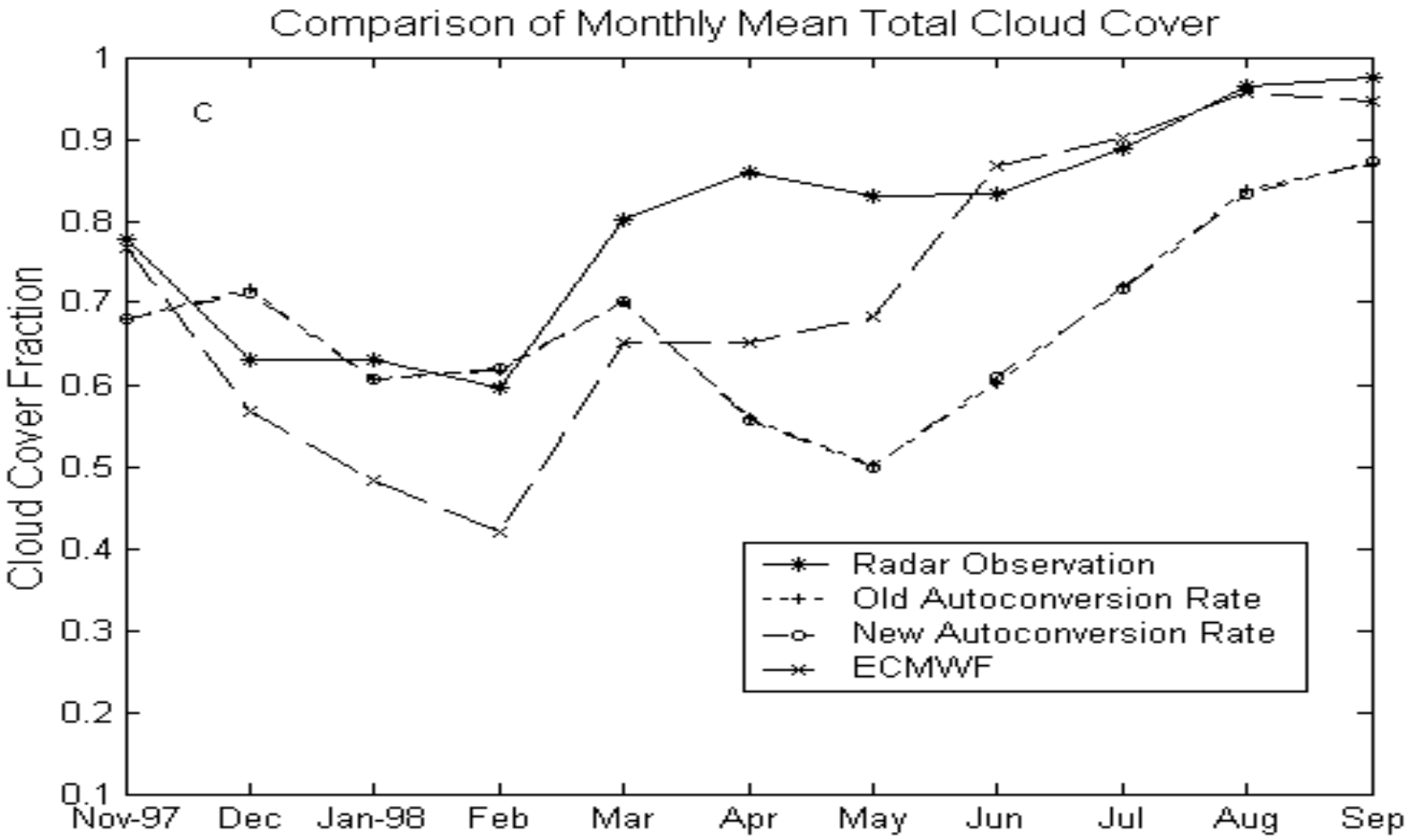


monthly SHEBA LWP



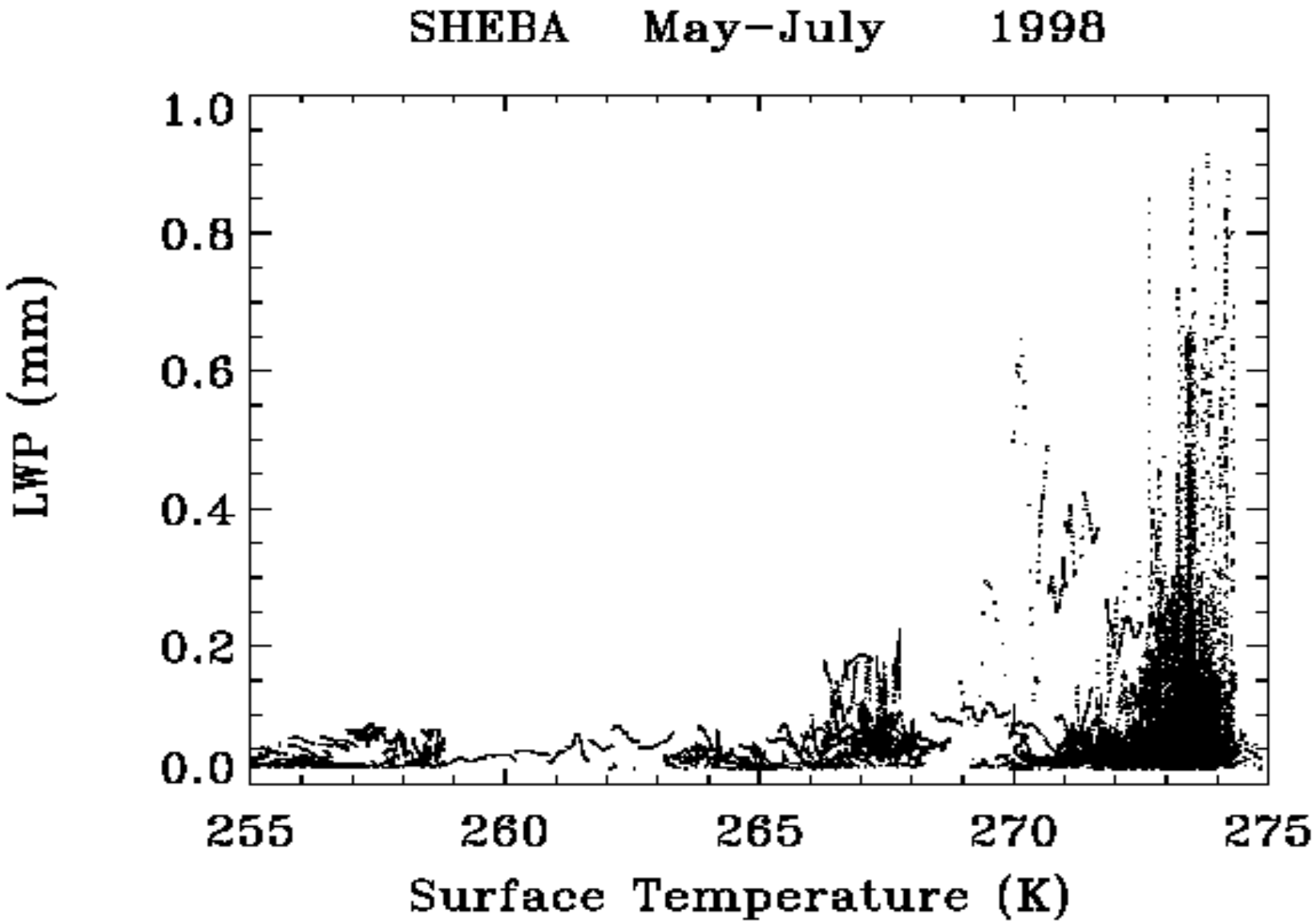
Zhang et al. 2002

monthly SHEBA cloud cover



Zhang et al. 2002

LWP vs surface temperature



relative change rate

- **Pixel level data:**

  f = dLWP/dT/LWP = 0.033/K

- **Averaged data from monthly statistics:**

  f = 0.07/K

- **For climate study, the f values from original samples may be more realistic since it is weighted by population**