Satellite remote sensing of precipitation: Ongoing challenges in the context of climate research

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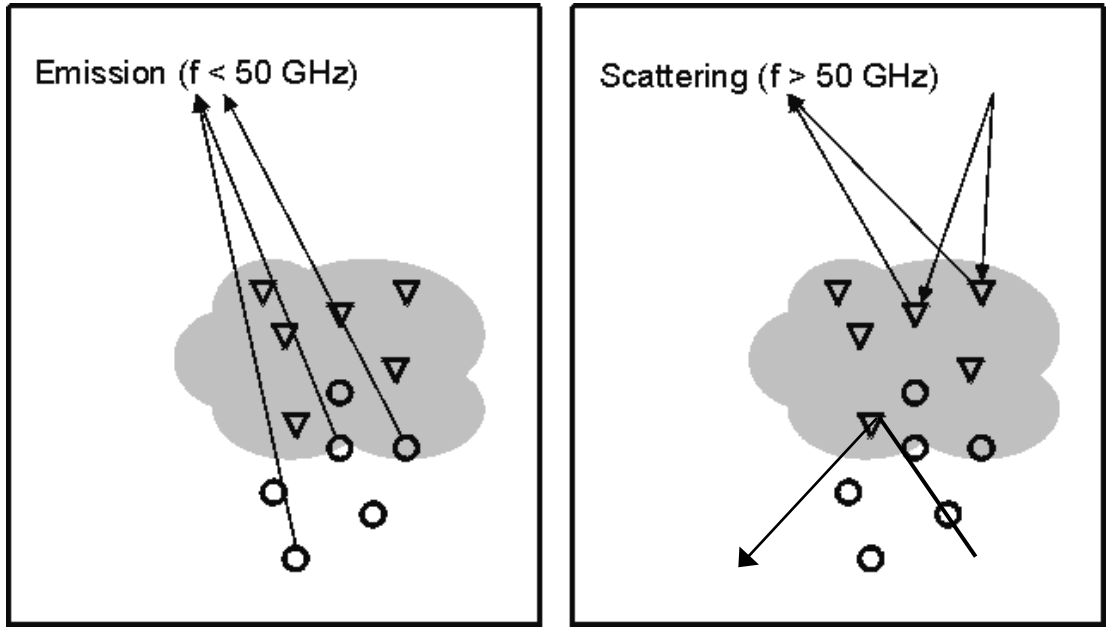
Precipitation is arguably one of the most complex processes to observe and at the same time one of the most critical parameters with immediate effects on habitability, environmental risk, etc.

Observing (?) precipitation from space

- Infrared sees cloud top. Solar sees cloud thickness, particle size. Both are correlated with rain but no direct signal.
- More direct signal of precipitation observed in the microwave, but only sensitive to the column amount of precipitation.
- Only space-borne radars come close to directly observing precipitation (but are expensive and have their own problems as well).

Passive microwave sensitivity to precipitation



- Most directly linked to surface precipitation
- Over cold (water) surfaces only

- All types of surfaces
- More indirect

A bunch of particular problems

- Accuracy and stability of long-term time series
- High-latitude precipitation
- Orographic precipitation
- Light rain
- Understanding precipitation processes

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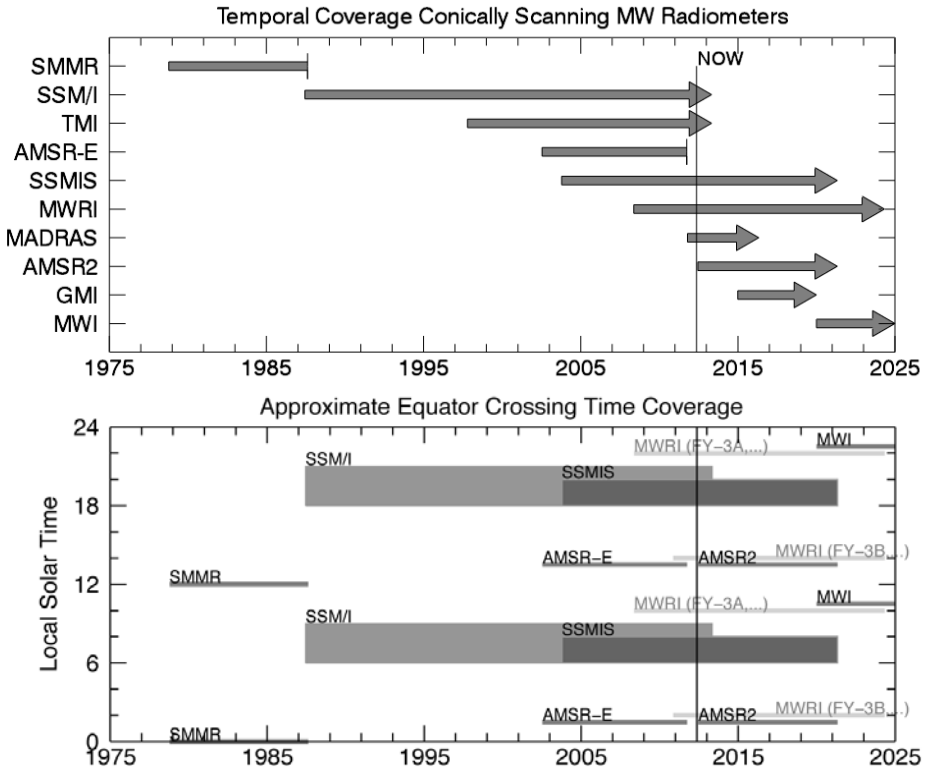
E.g. passive microwave data record

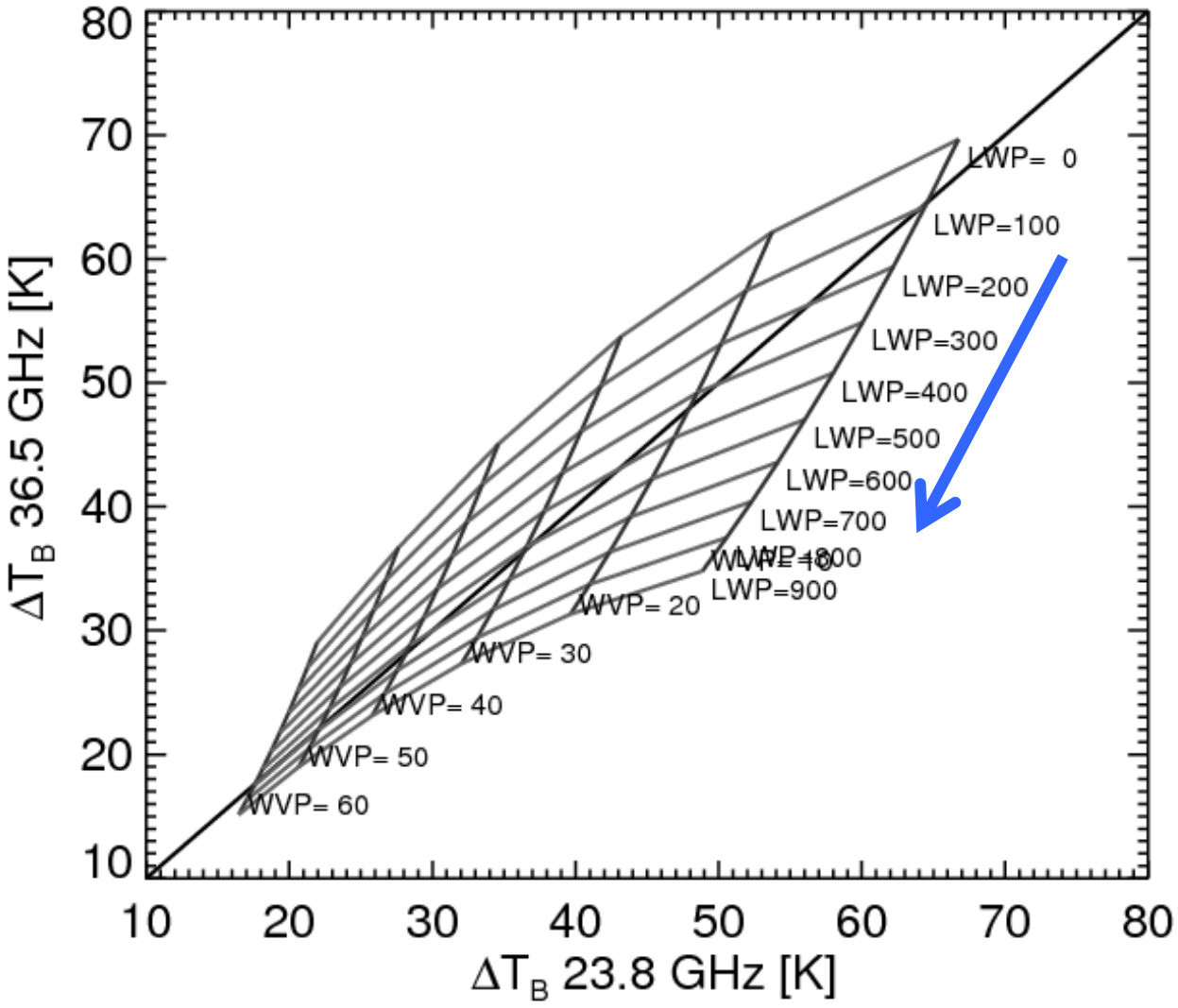


- SSM/I, SSMIS Morning/Evening Coverage since 1987
- TRMM/GPM crisscrossing in LEXT since 1997 resp 2014
- AMSR-E/AMSR-2 13:30 LEXT
- MWI on EUMETSAT/ EPS-SG early afternoon orbit

FCDRs / TDPs

- Characterization/Calibration/Intercalibration
  - HOAPS
  - RSS
  - XCAL
  - GSICS
- Geophysical parameters intercomparison projects

MW: Principle of retrieval



Comparison within G-VAP

Example from G-VAP Final Report (Schröder et al., 2016): Annual mean TCWV for 20 long-term TCWV data sets

GEWEX water vapor assessment (G-VAP)

Final Report

M. Schröder, M. Lockhoff, L. Shi, T. August, R. Bennartz, H. Brogniez, X. Calbet, R. Dirksen, S. Eikenberg, F. Fell, J. Forsythe, A. Gambacorta, K. Graw, B. Ho, H. Höschen, J. Kinzel, R. Kursinski, A. Reale, J. Roman, N. Scott, B. Sun, T. Trent, A. Walther, U. Willen, Q. Yang

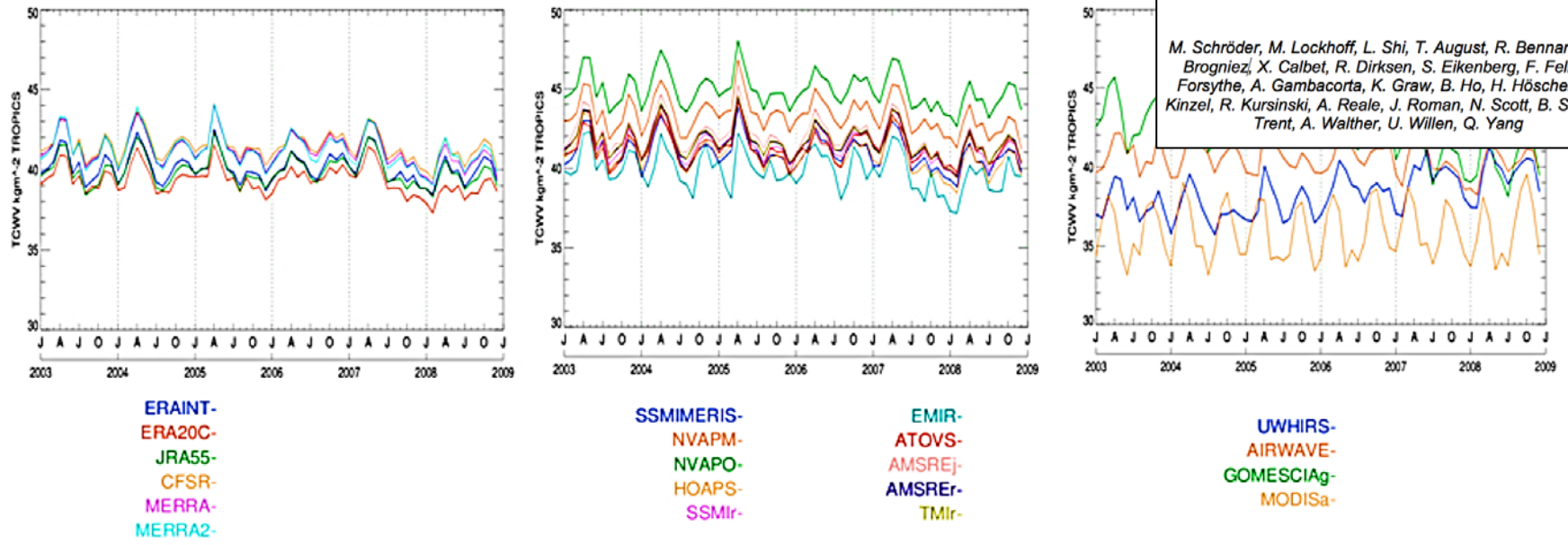


Figure 5-4: Time series (01/2003 – 12/2008) of TCWV for the tropics (±20°) over ocean for the weather type scenarios all-sky (left), cloudy-sky (middle) and clear-sky (right).

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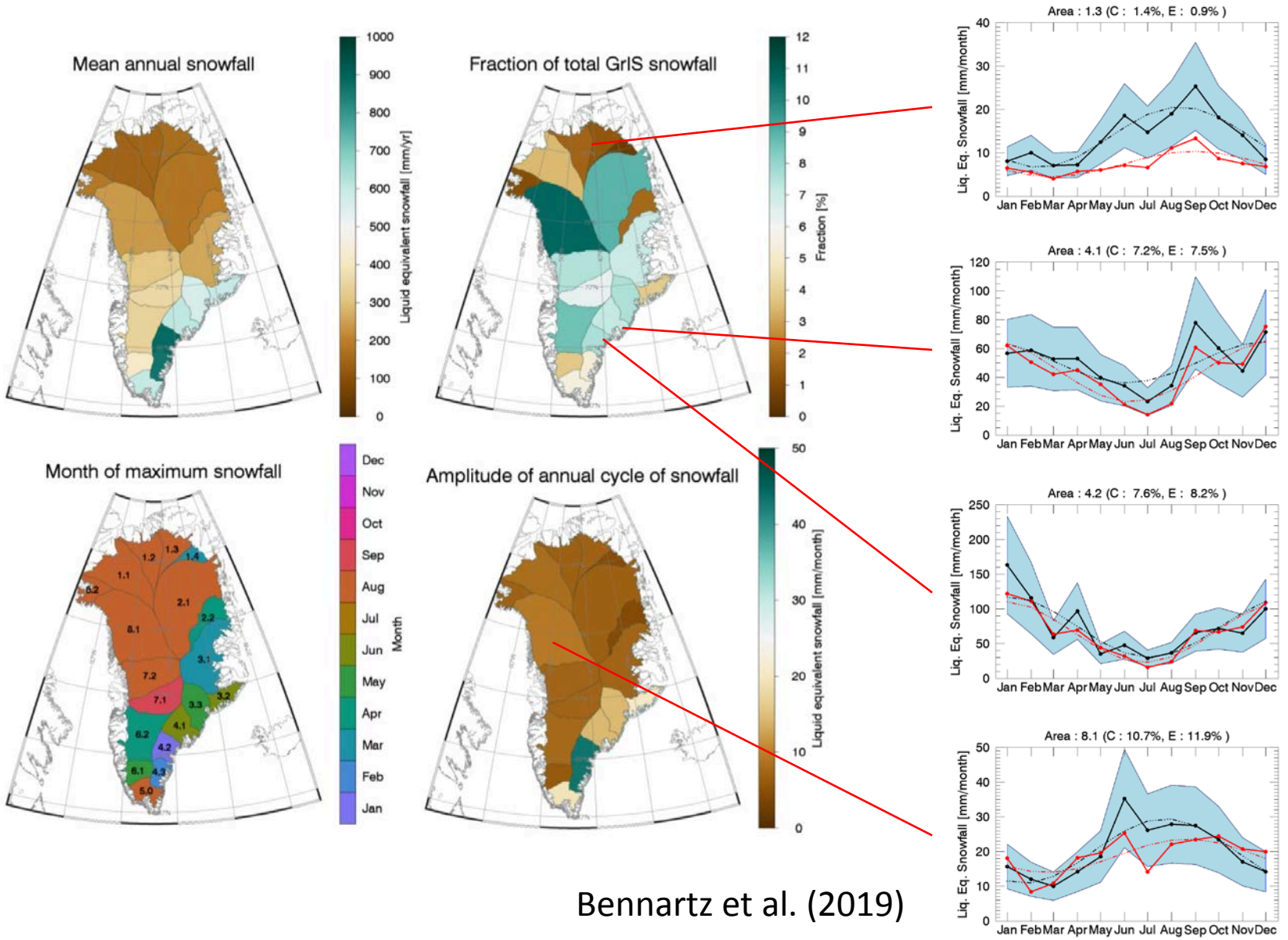
Snowfall over the Greenland Ice Sheet



Bennartz et al. (2019)

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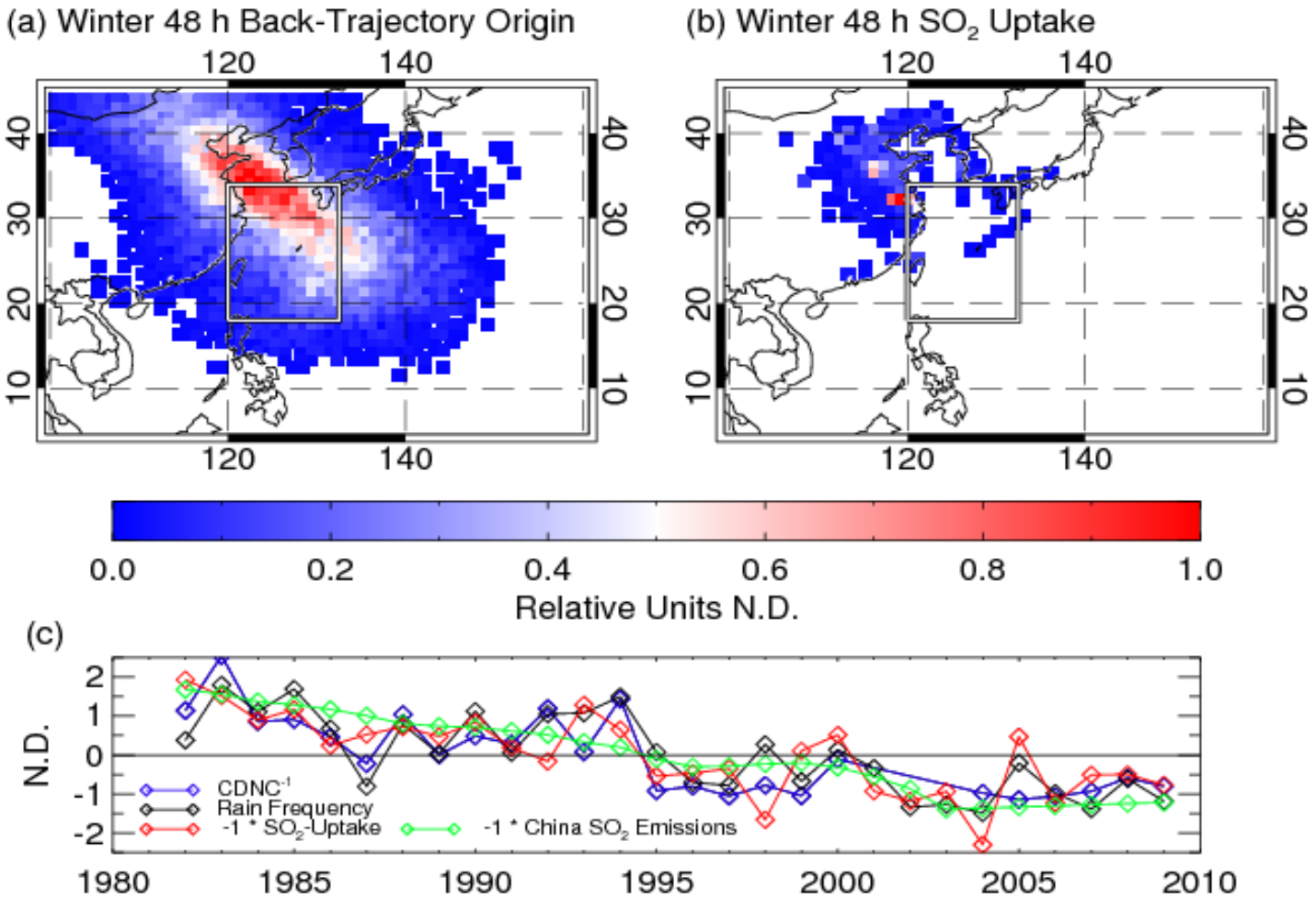
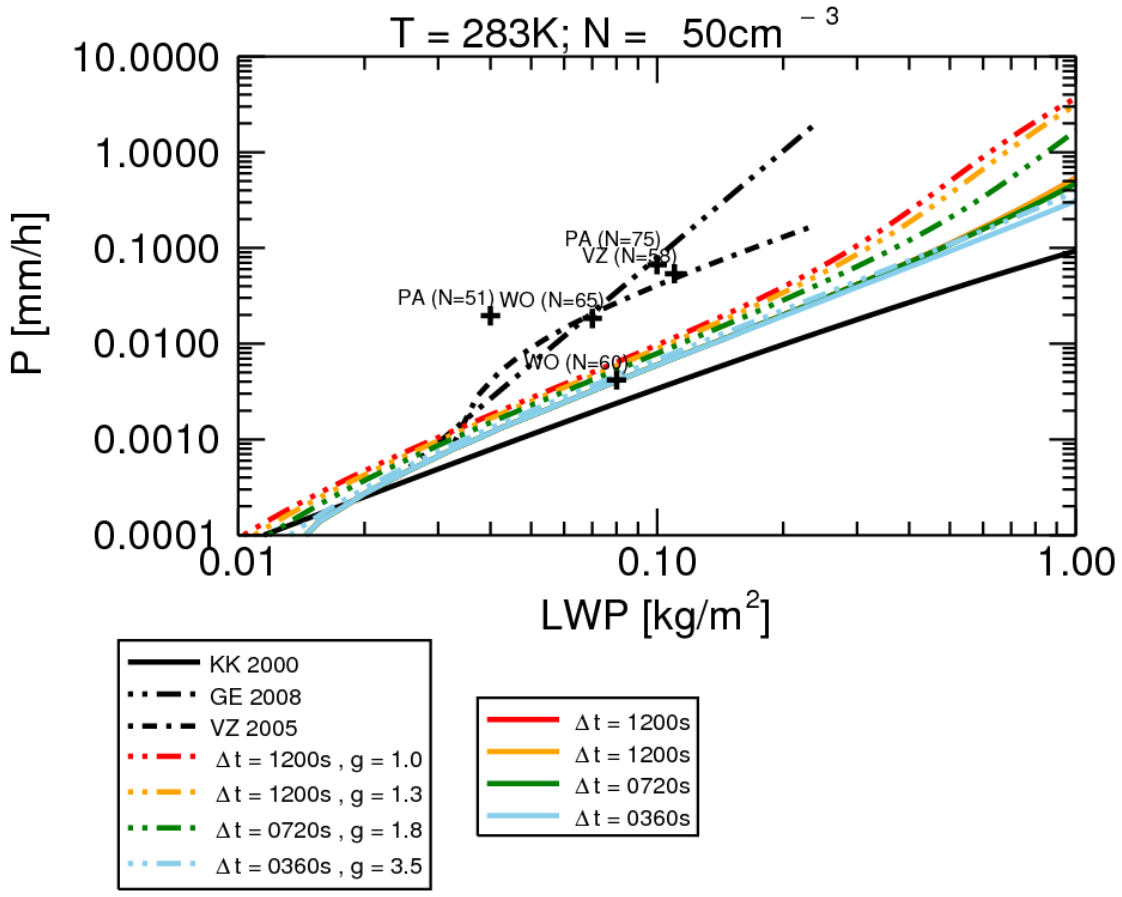
Suppression of light rain over the East China Sea due to pollution



Bennartz et al. (2011)

Constraining warm cloud microphysics



(Lauer et al. ,2011)

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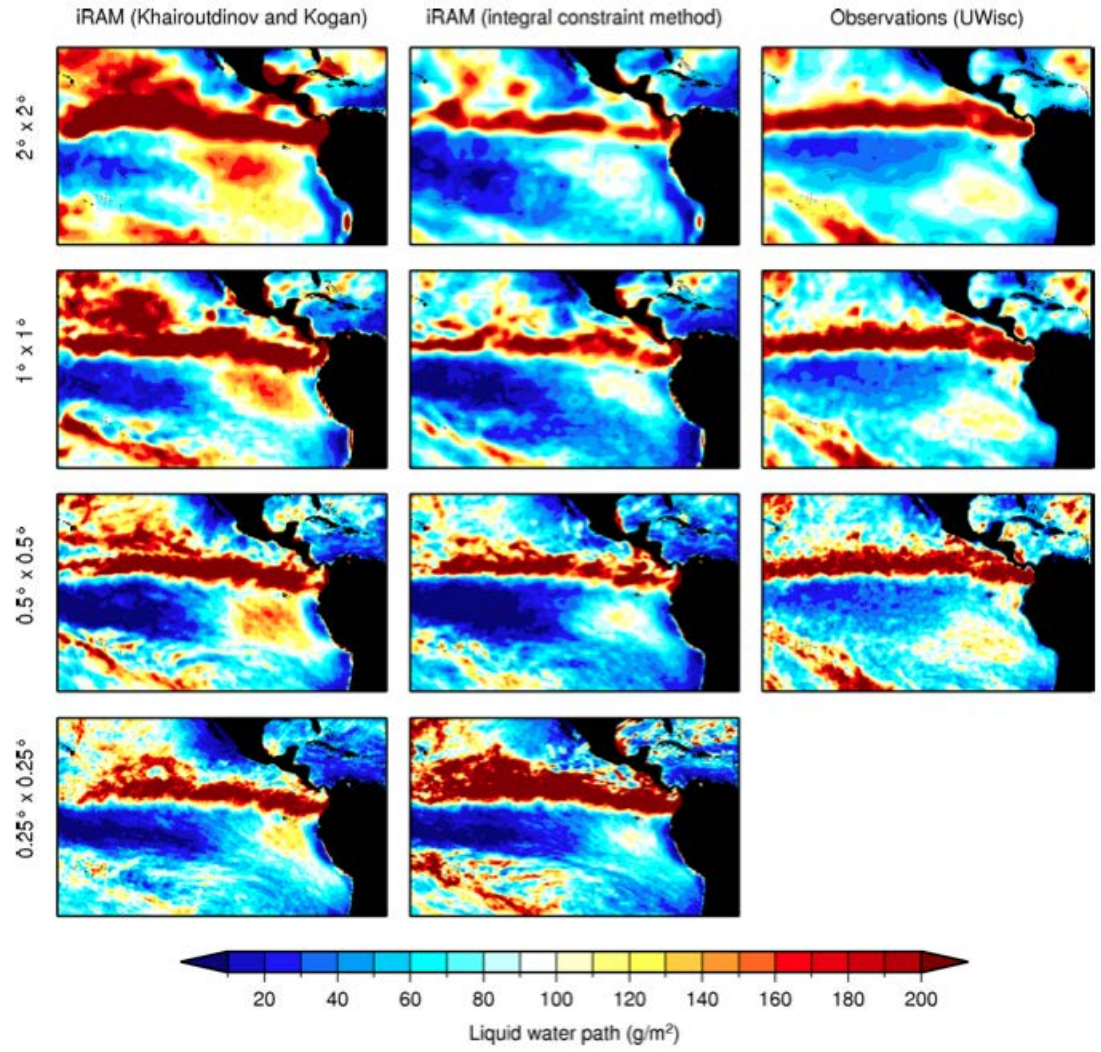

(Lauer et al. ,2011)

Conclusions

- We are dealing with a heavily under-constrained problem and indirect observations.
- Need to make sure we understand the physics of what we are observing. Process understanding must go along with advances in retrieval techniques.
- Statistical methods (e.g. machine learning) only get us so far. Simpler is often better.
- Inter-calibration (e.g. of passive microwave time series) is most crucial to successful long-term time series.
- Intercomparison/assessment efforts are of tremendous value even though there is no ultimate ground truth.