Correction of Cloud Contamination on AMSU Measurements

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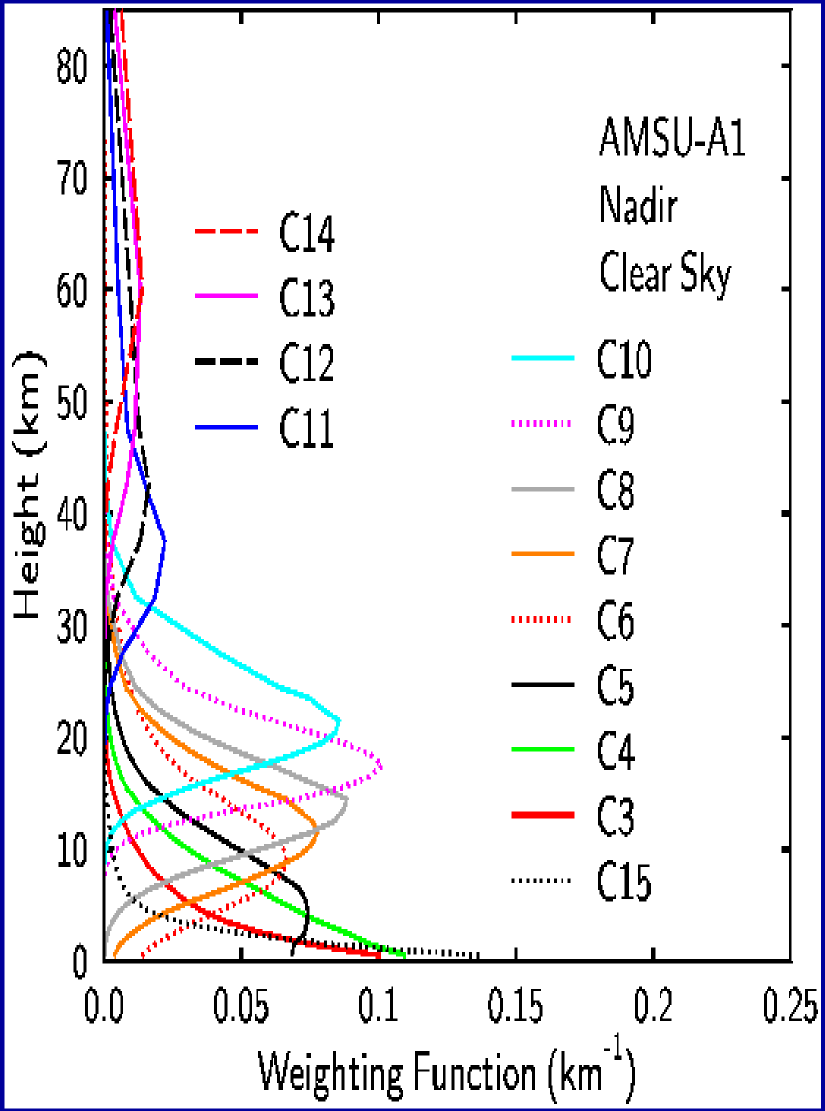
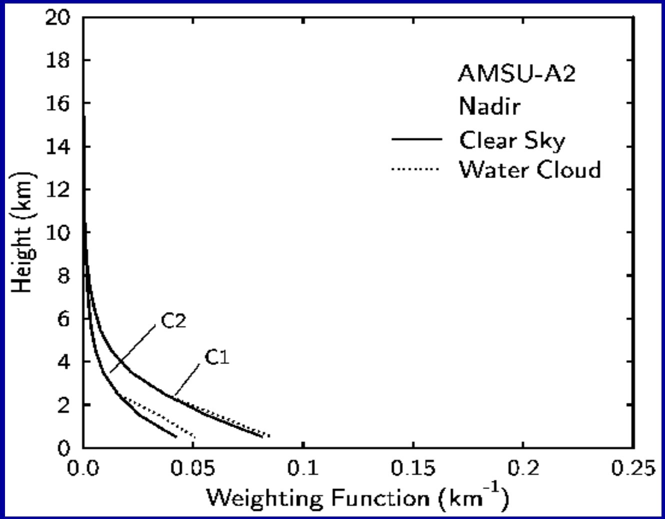
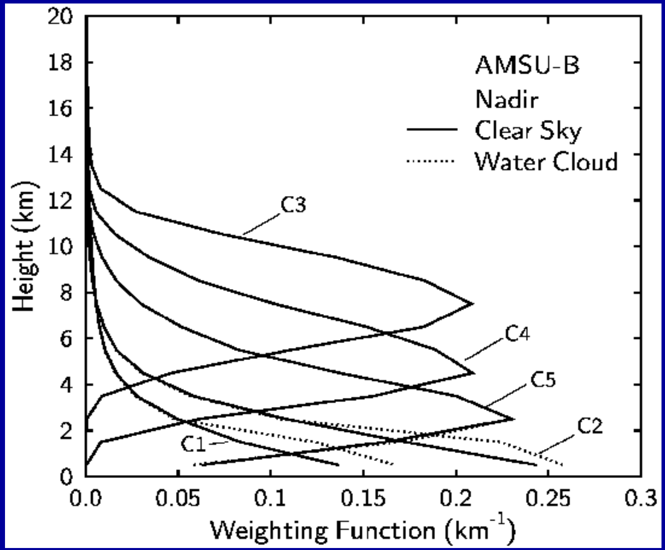
AMSU Weighting Functions



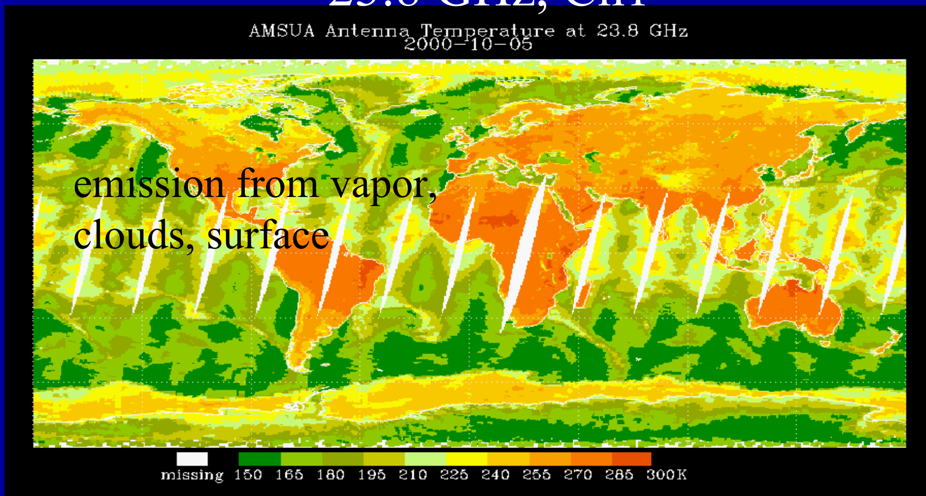




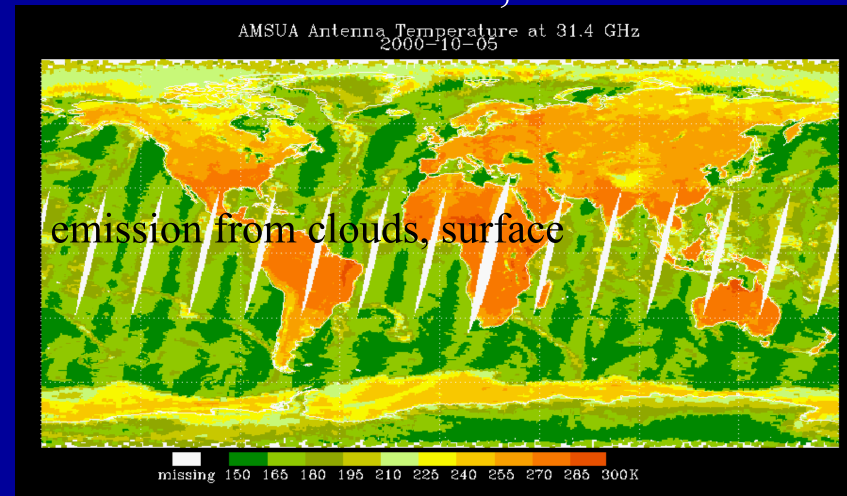
Advanced Microwave Sounding Unit

Imaging and Temperature Sounding Channels

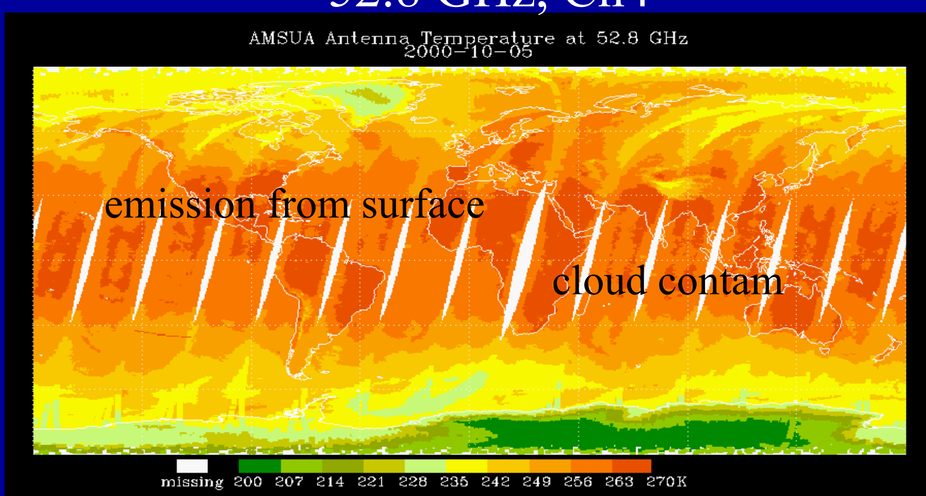
23.8 GHz, Ch1



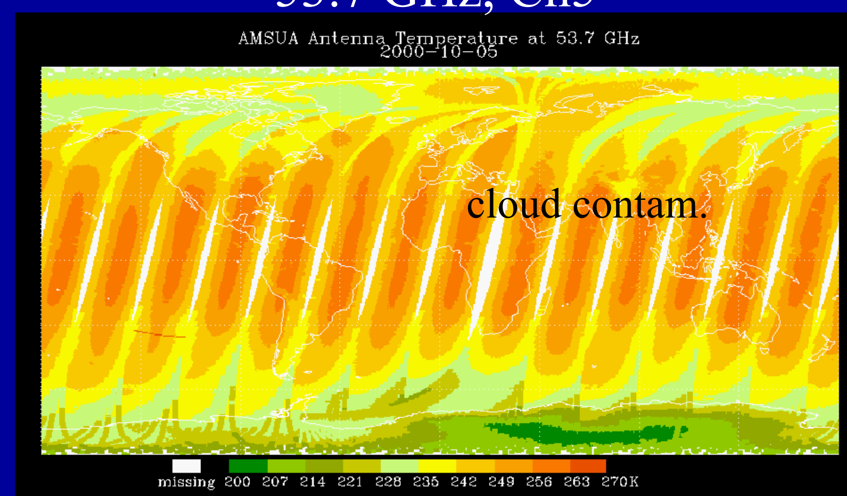
31.4 GHz, Ch2



52.8 GHz, Ch4



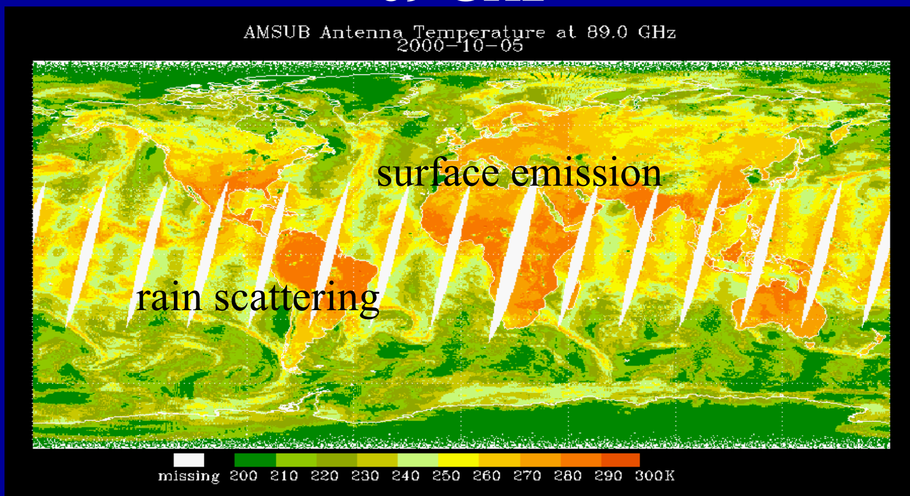
53.7 GHz, Ch5



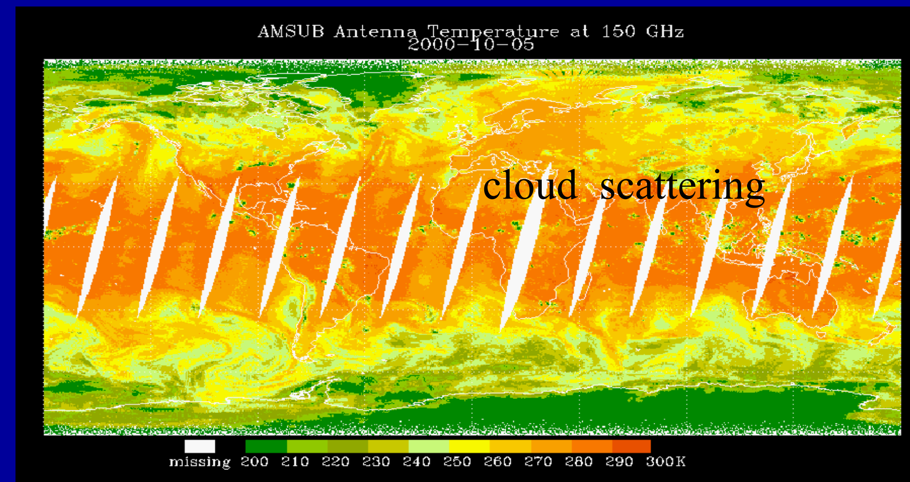
Advanced Microwave Sounding Unit

Imaging and Moisture Sounding Channels

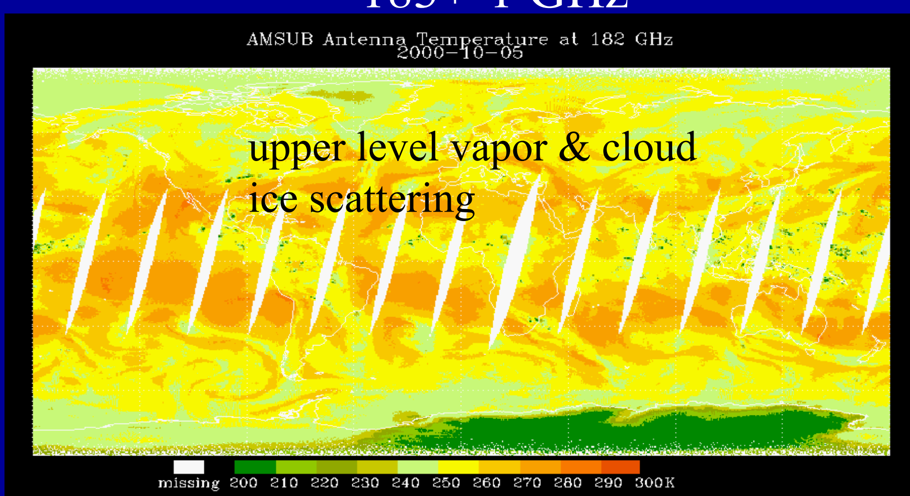
89 GHz



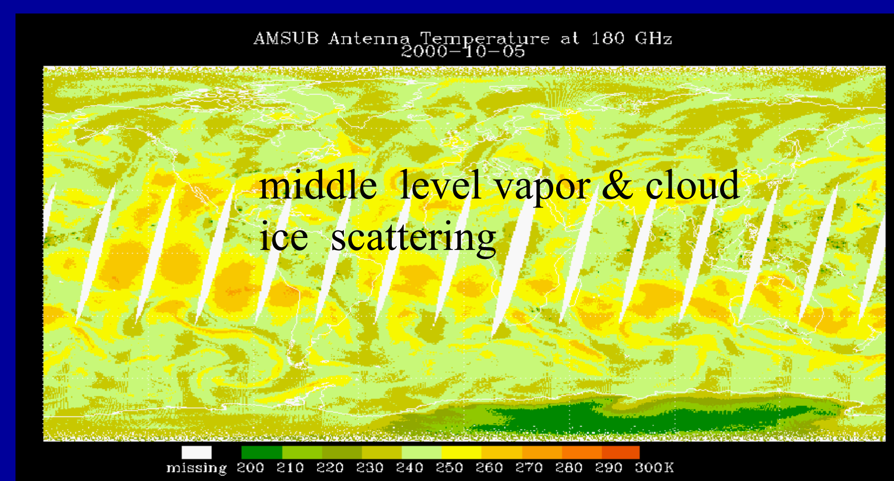
150 GHz



183+-1 GHz



183+-3 GHz



Motivation

- Investigate the effects of precipitating clouds on AMSU sounding channels using cloud resolving model outputs,
- Correct the cloudy AMSU radiances to the clear ones so that vertical temperature and moisture profiles are retrieved.

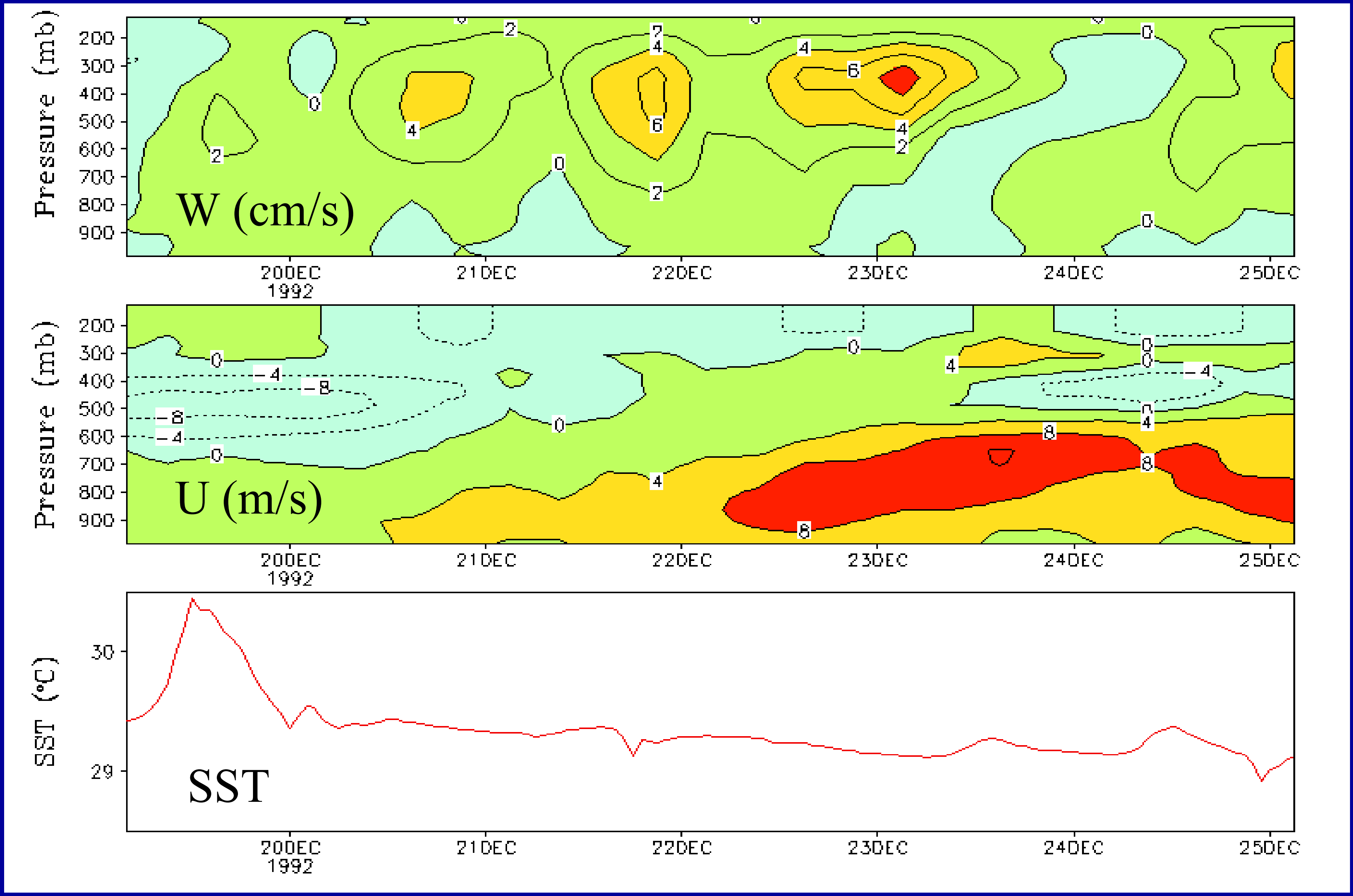
Cloud Resolving Model

- Non-hydrostatic and Anelastic (Tao and Simpson 1993)
- Prognostic equations for T, qv, qc, qr, qi, qs, qg
- Radiation (Chou and Suarez 1994, Chou et al. 1998)
- Cloud Microphysics (Rutledge and Hobbs 1983 1984, Lin et al. 1983, Tao et al. 1989, Krueger et al. 1995)
- Turbulence Closures
- Imposed spatial-uniform large-scale vertical velocity, zonal wind, SST, horizontal temperature and moisture advections

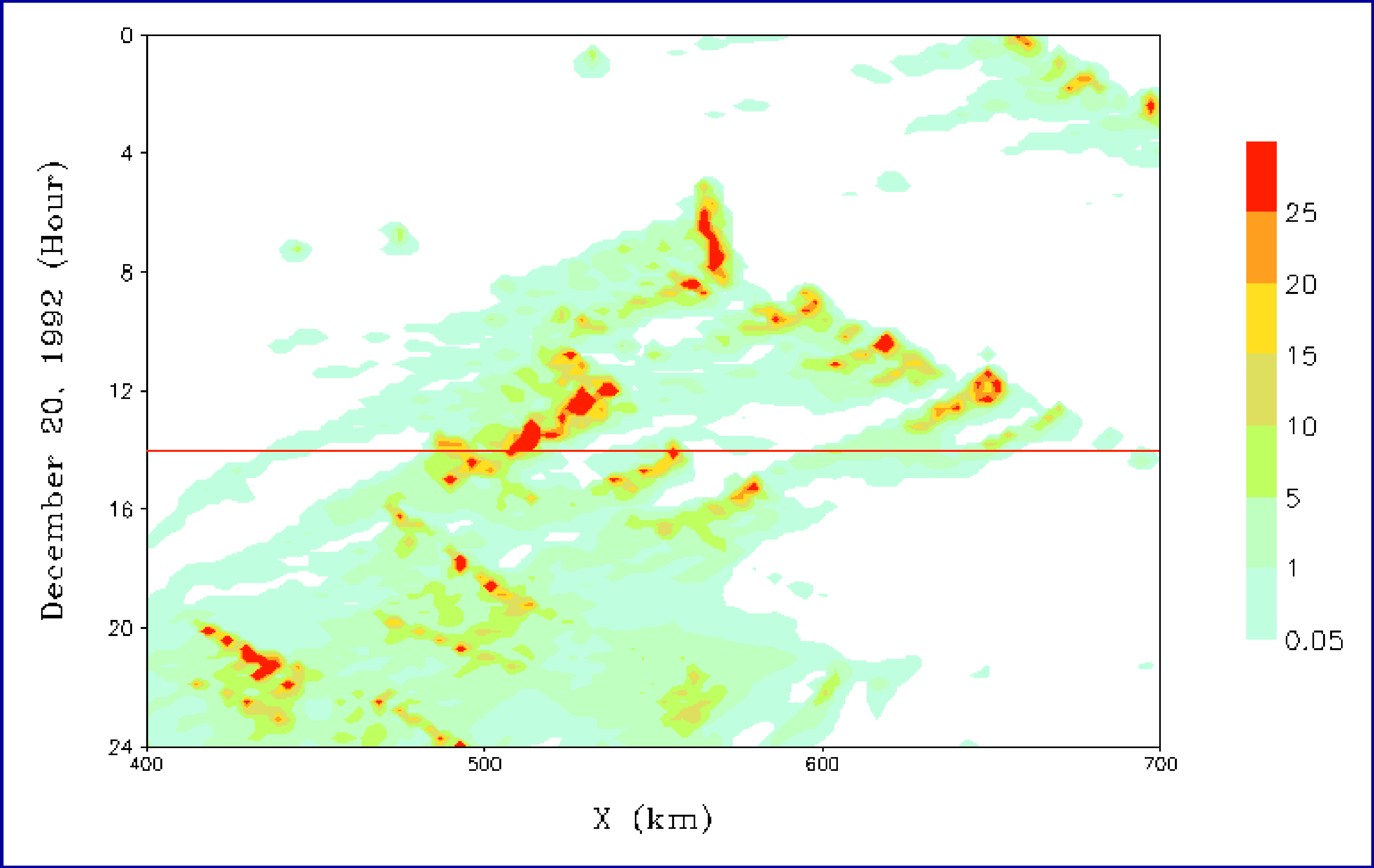
Cloud Resolving Model

- Two dimension: x-z
- Domain: 768 km
- Horizontal Resolution: 1.5 km
- Vertical resolution: 200 m near surface to 1 km above 15 km
- Time step: 12 Seconds

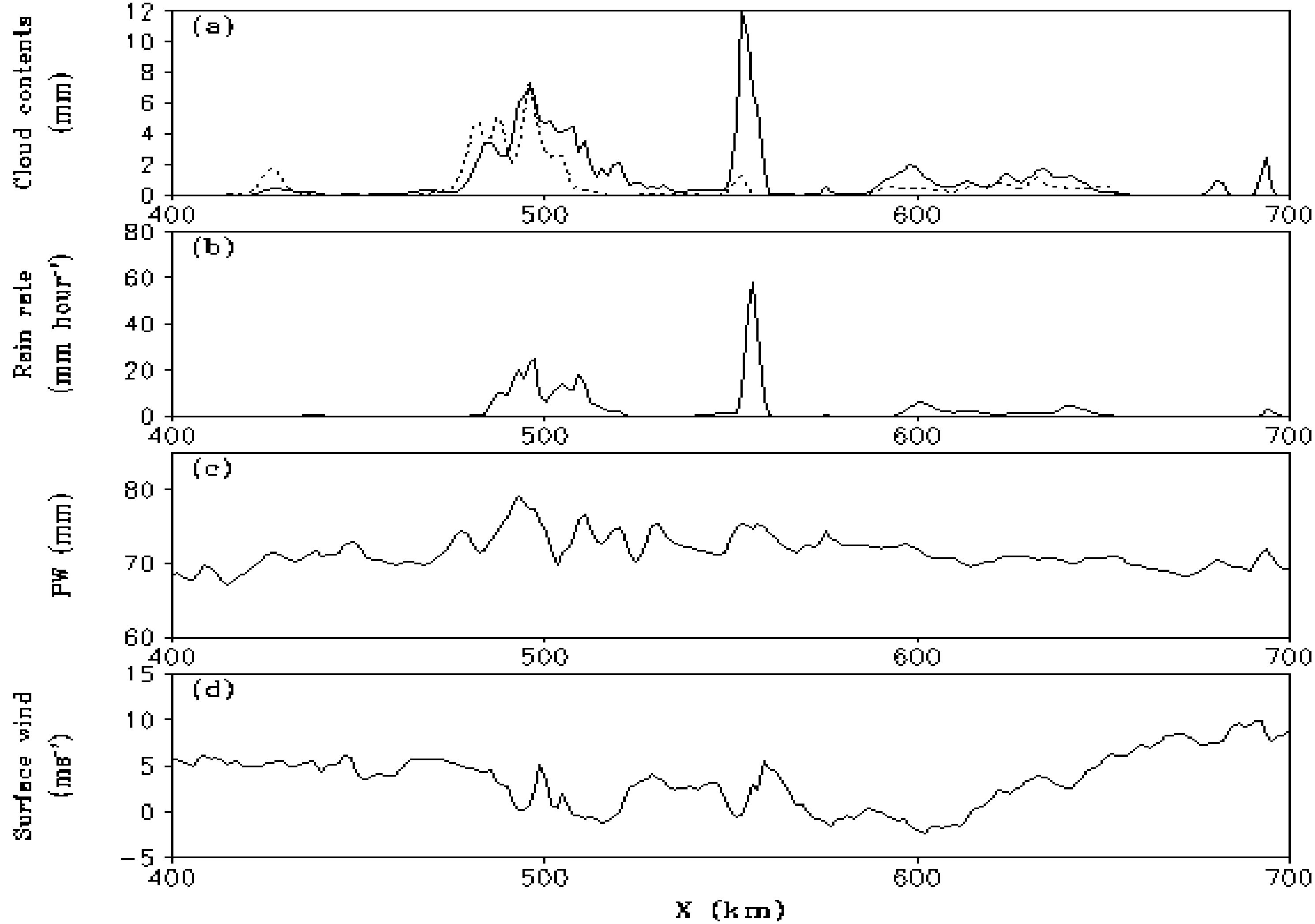
Model Initial Fields



Simulated Surface Rain Rate

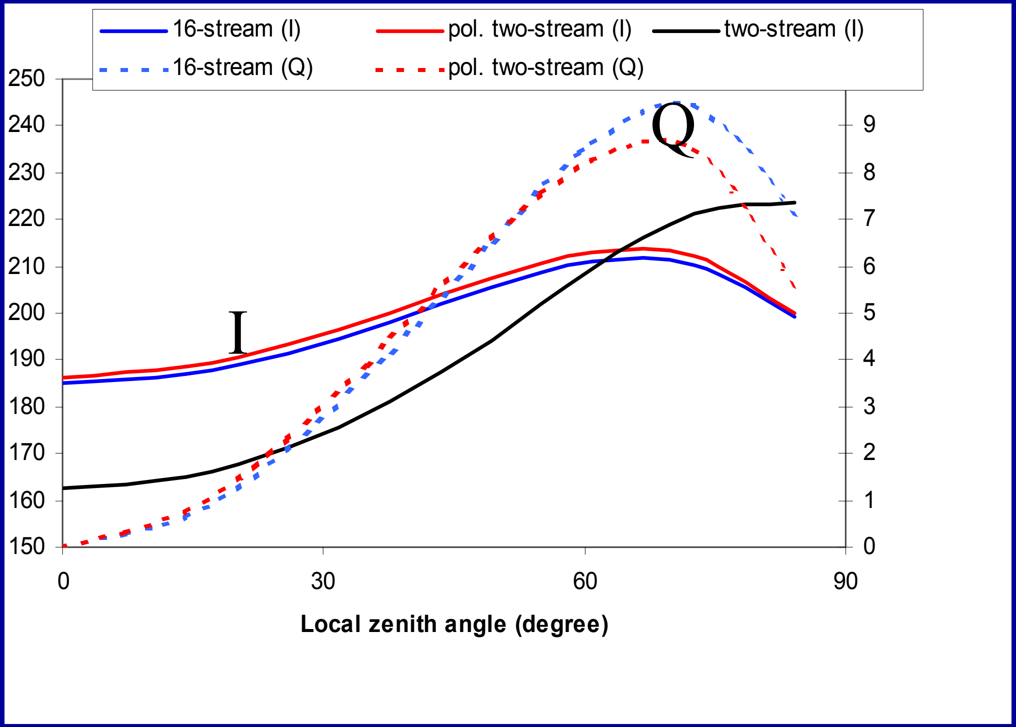


Cloud Model Outputs



Radiative Transfer Modeling

Fast Atmospheric and Surface POlarimetric Radiative Transfer Model (FASMPORT) (Liu and Weng, 2002; JAS)

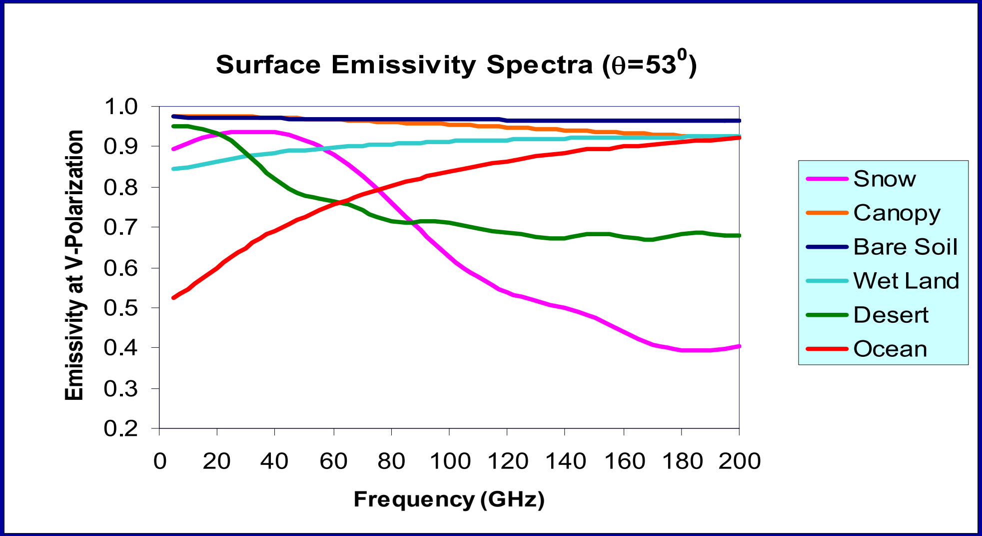


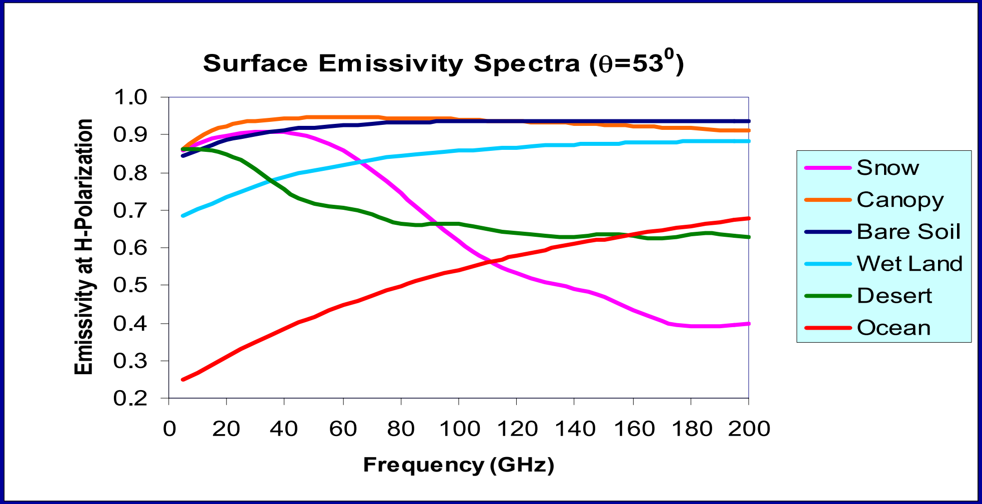
- Atmosphere:
  - Gaseous constituents
  - Hydrometeors
- Surface:
  - Coherent media: new sea ice, smooth bare soil
  - Clustering media: canopy
  - Random media: snow, desert
  - Rough surface: ocean

- Polarimetric two-stream
- Various surface & atmospheric components

Microwave Emissivity Model
(Weng et al, 2001; JGR)

- **Open water** – two-scale roughness theory
- **Sea ice** - Coherent reflection
- **Canopy** – Four layer clustering scattering
- **Bare soil** – Coherent reflection and surface roughness
- **Snow/desert** – Random media





Scattering and Emission Processes

Phenomenology.

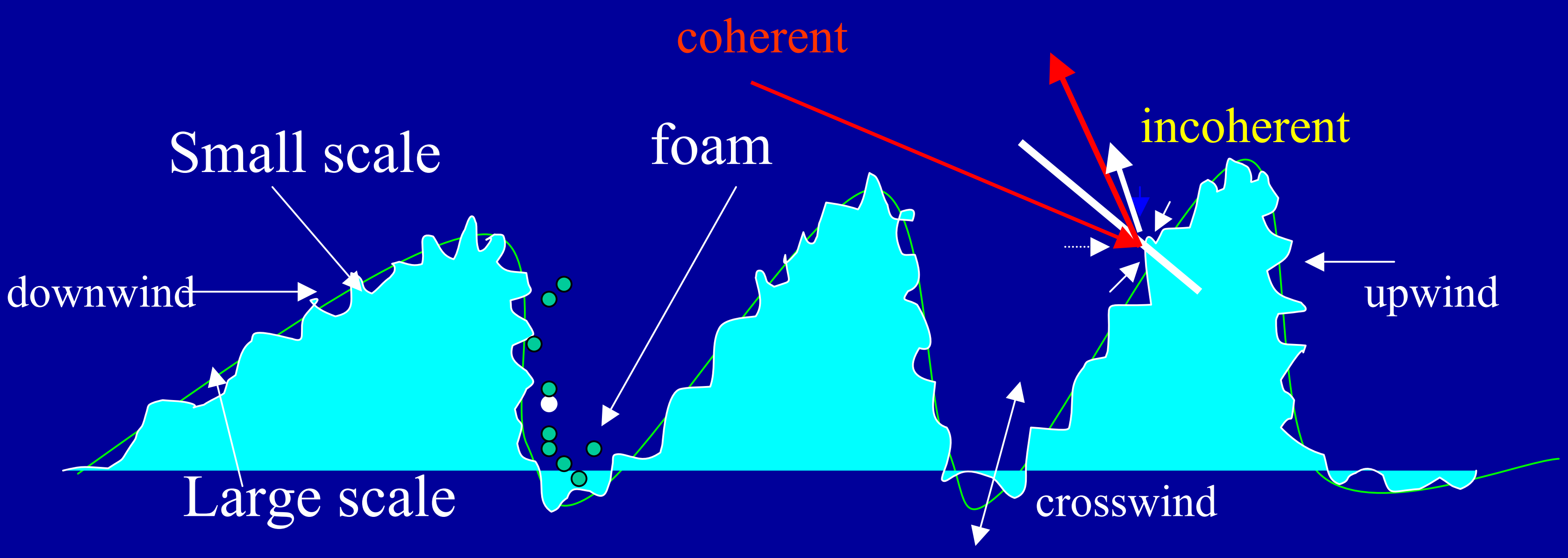
- Large gravity waves, whose wavelengths are long compared with the radiation wavelength.
- Small capillary waves, which are riding on top of the large-scale waves, and whose RMS height is small compared with radiation wavelength.
- Sea foam, which arises as a mixture of air and water at the wind roughened ocean surface, and which leads to a general increase in the surface emissivity.

Methodology: two-scale model

- Large-scale wave is simulated as an ensemble of tilted facets each acting as an infinitely large specular surface
- Small scale-wave is approximated by small perturbation theory

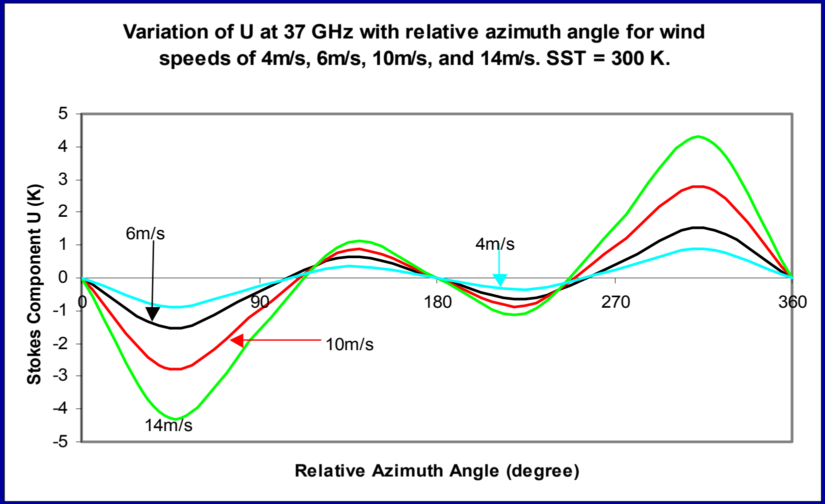
Ocean Roughness Model

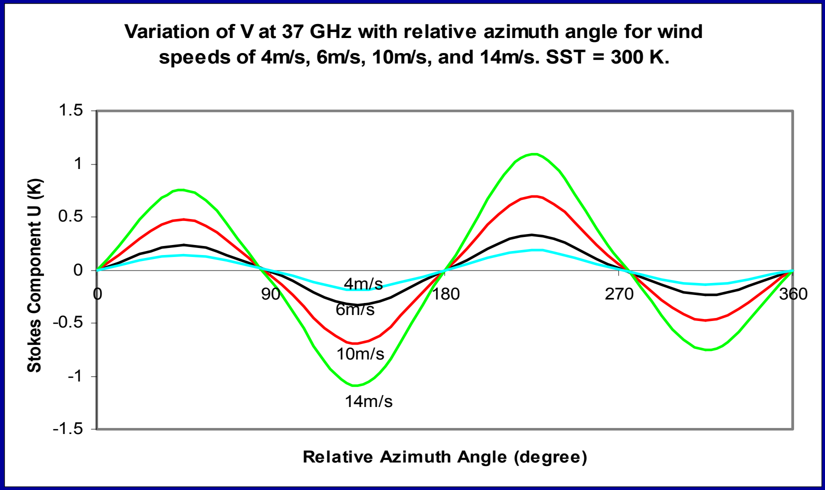
Large-scale roughness is dependent on gravity waves whereas small scale irregularities are affected by capillary waves. There are coherent reflection and incoherent scattering associated with the waves in both scales



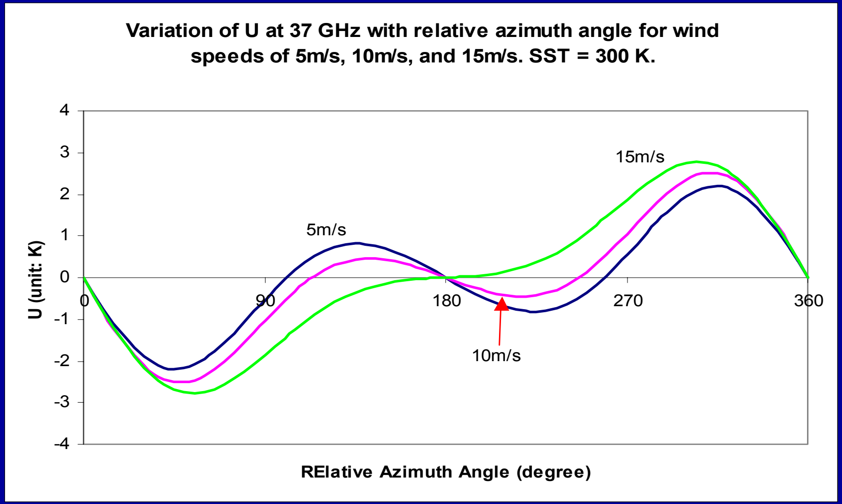
Oceanic Emissivity

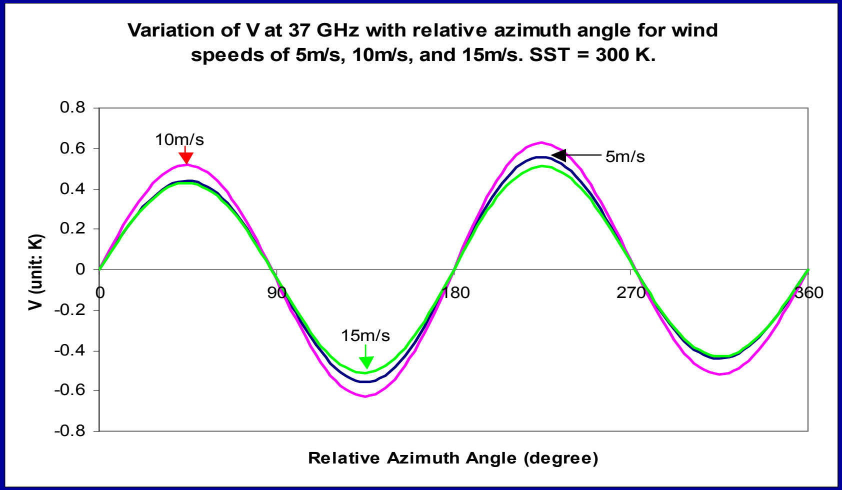
Two-scale Simulations



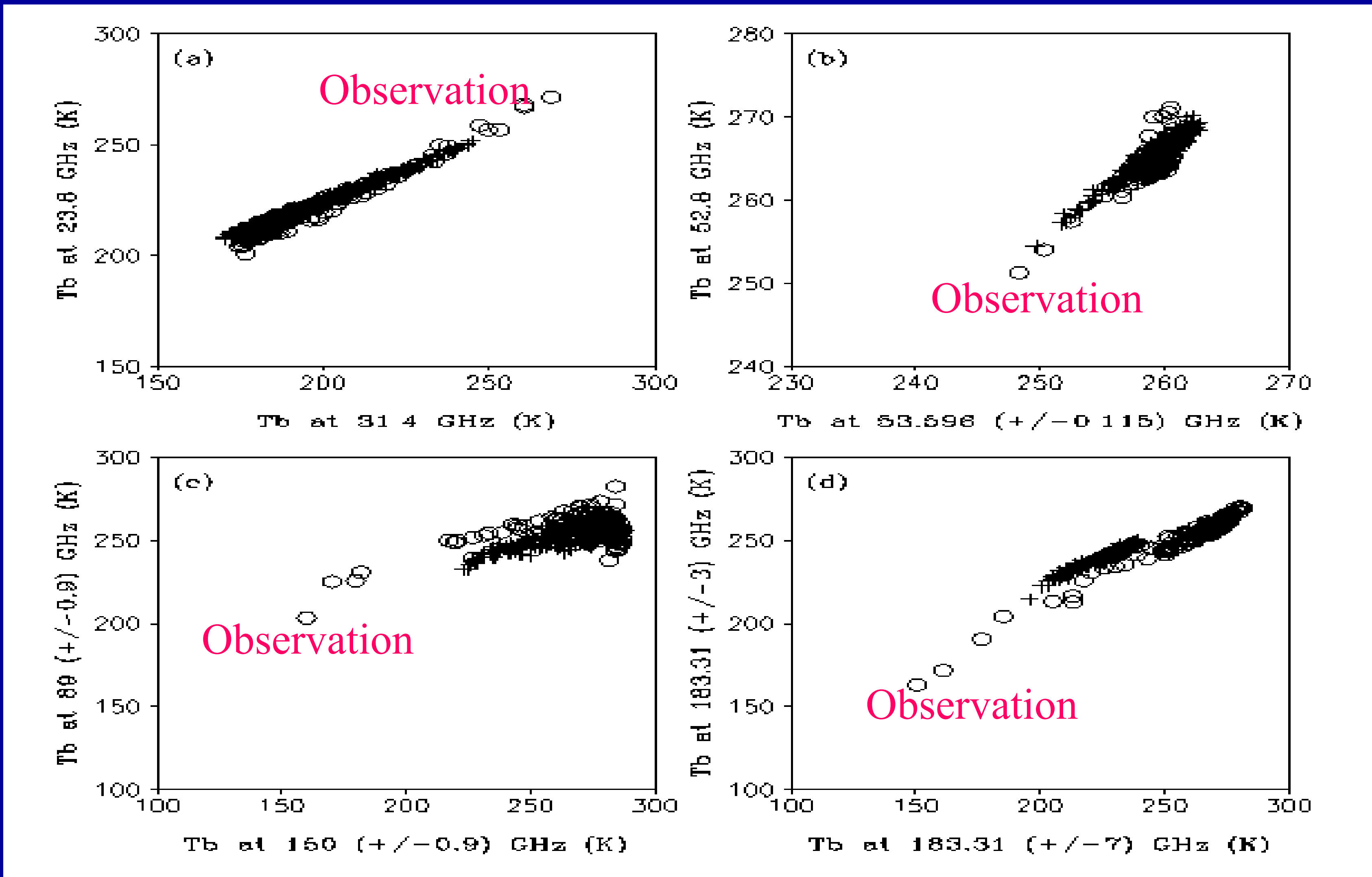


NRL Measurements

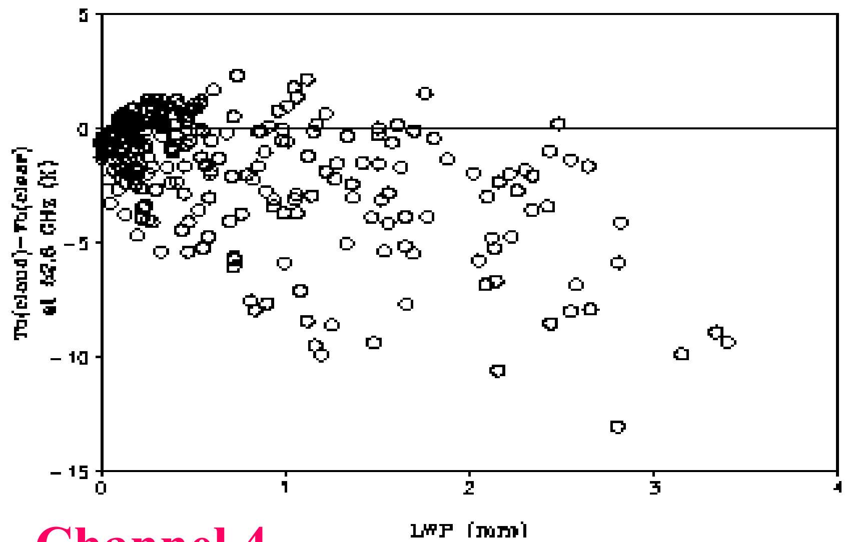


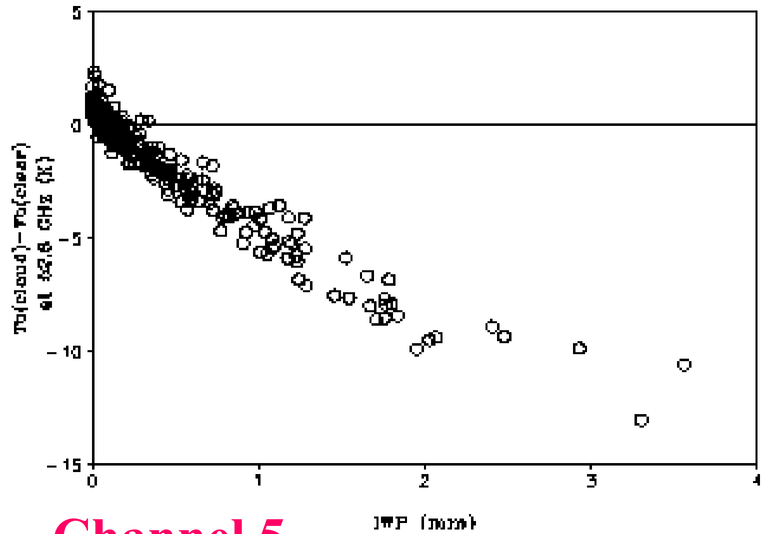


Channel Correlation from Simulation and Measurements



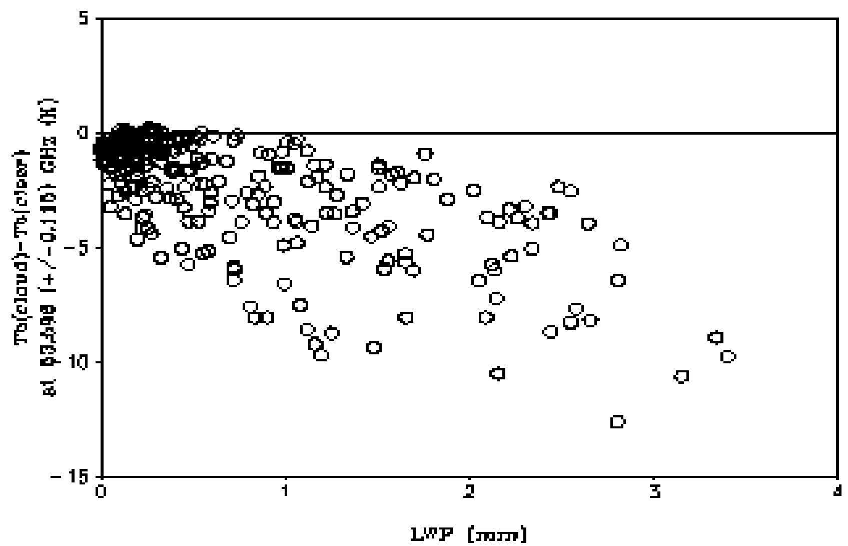
Cloud Effects on AMSU-A Sounding Channels

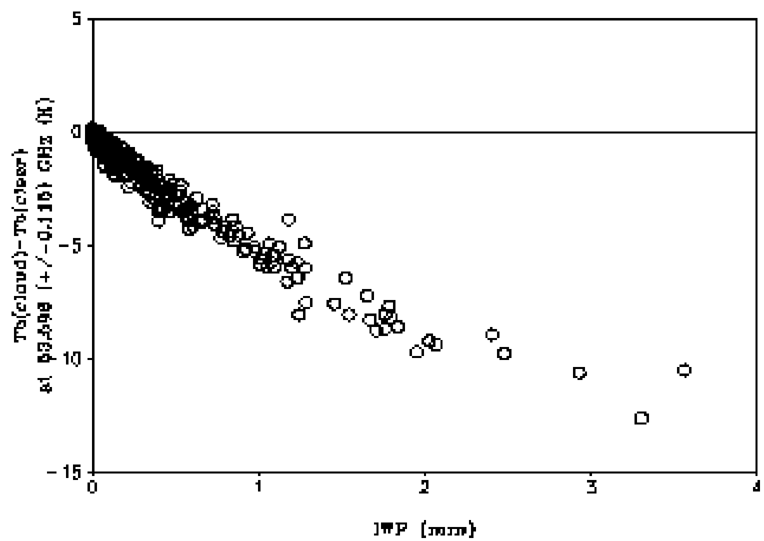




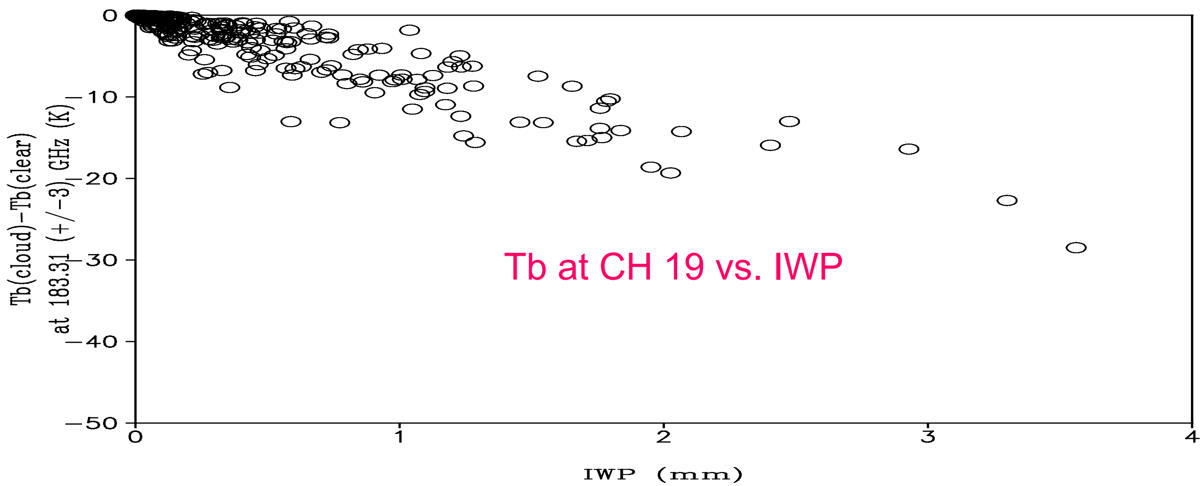
Channel 4

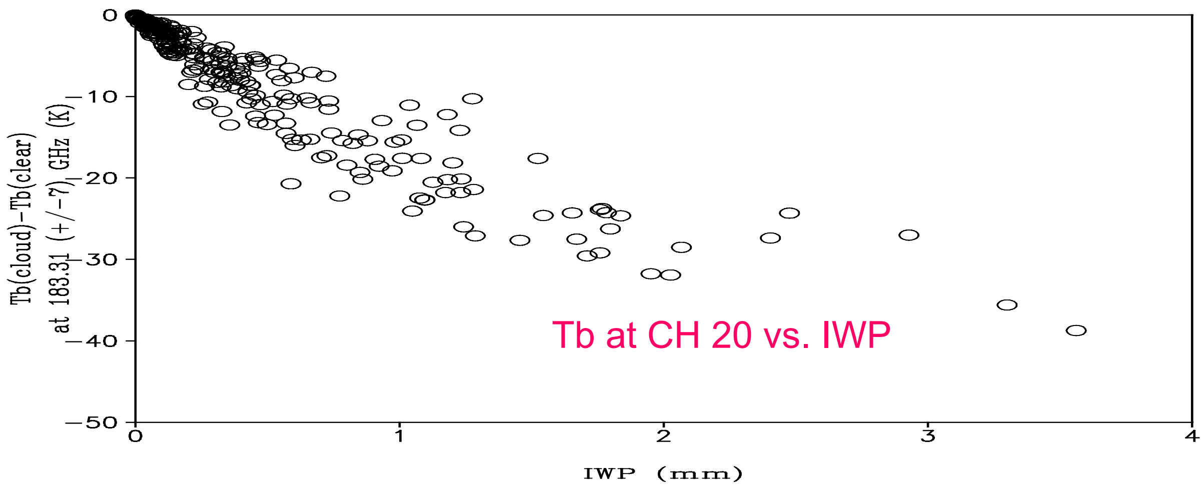
Channel 5



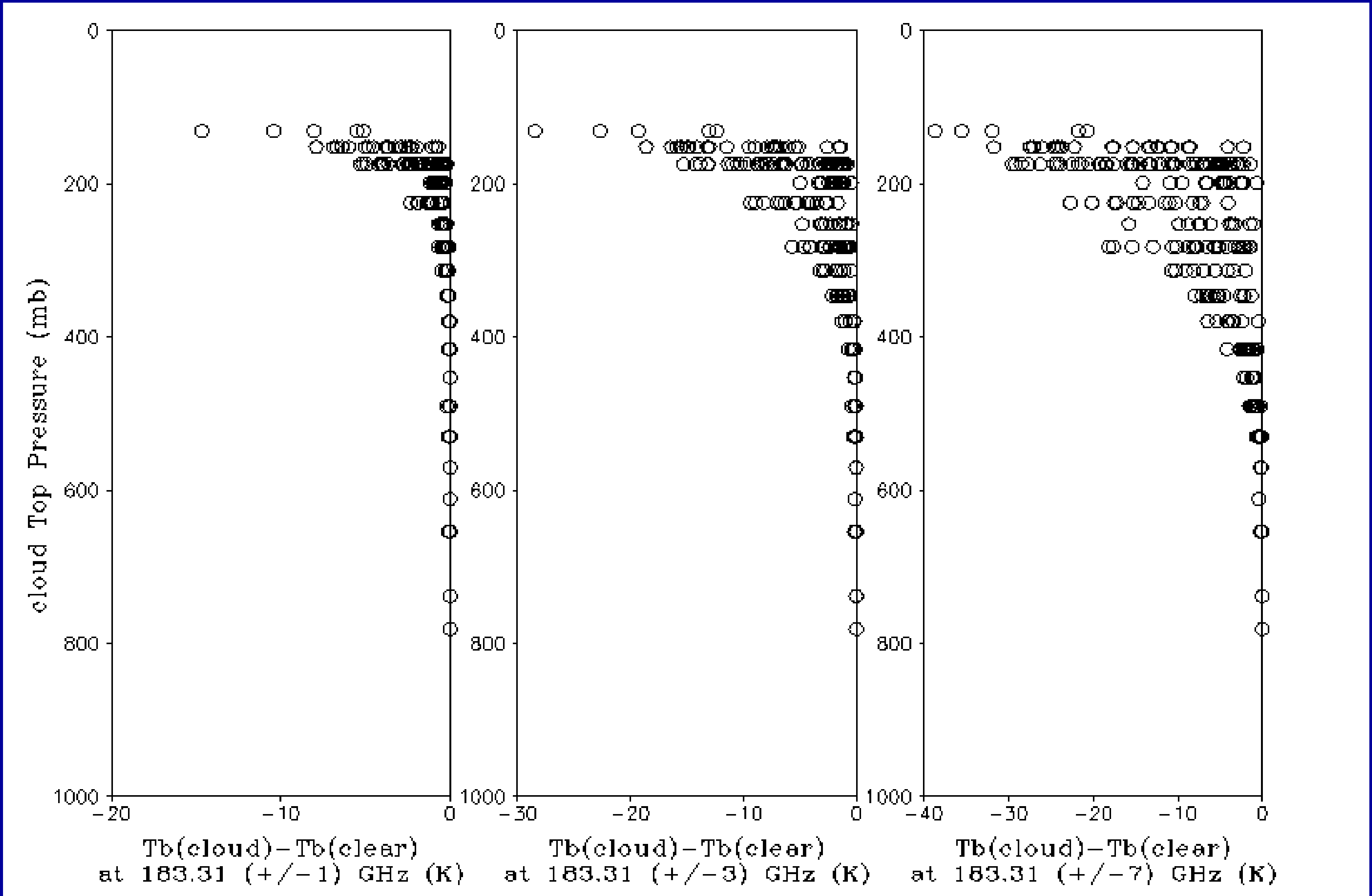


Cloud Effects on AMSU-B Sounding Channels

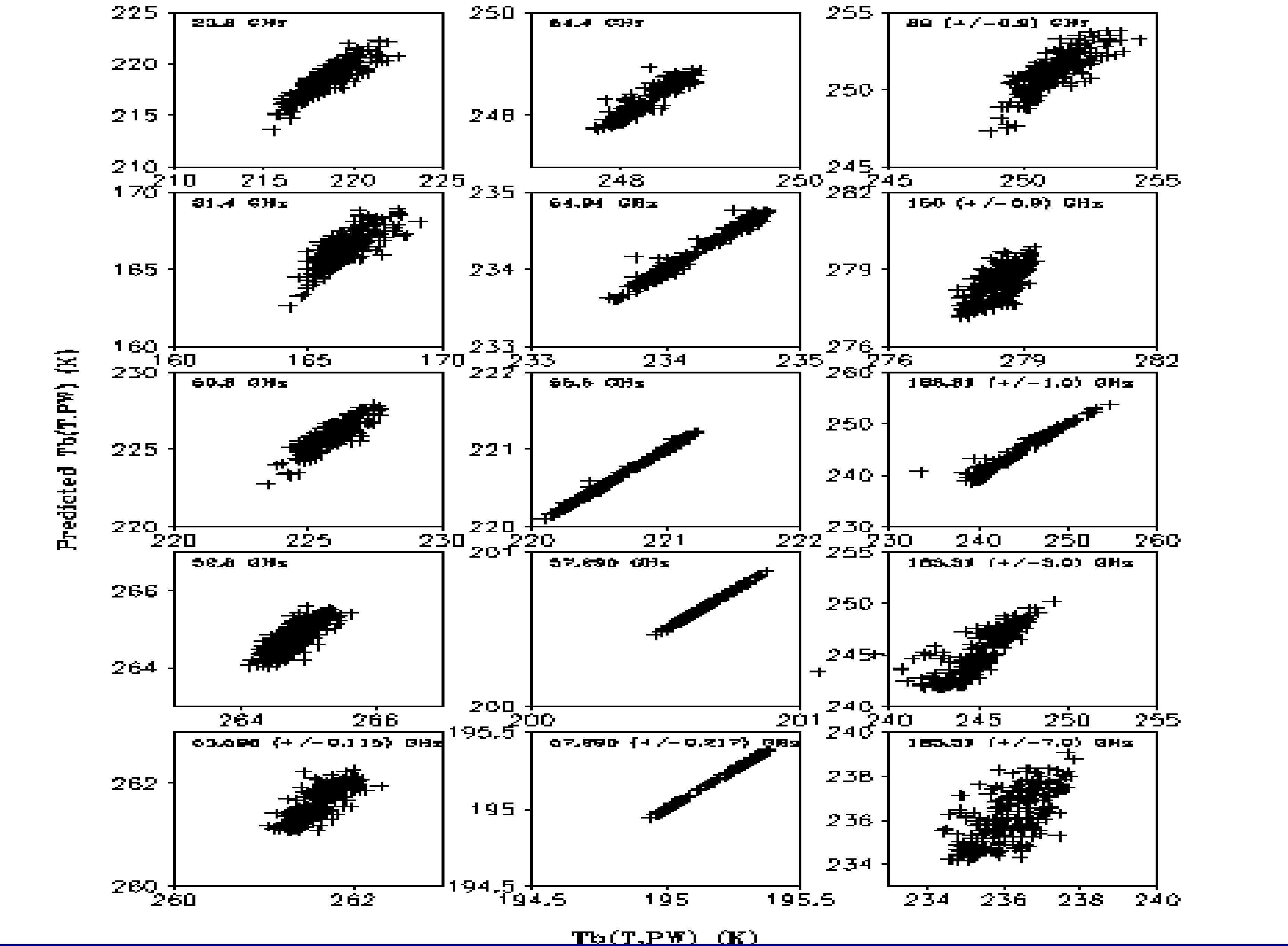




Effects of Cloud Top



Correction to Cloudy TB



Summary and Conclusions

- AMSU sounding channels are sensitive to precipitating clouds,
- The brightness temperature depression is highly correlated with cloud ice water path than cloud liquid water path,
- Thus, the correction is best made with cloud ice and liquid water paths if both are required at a sufficient dynamic range.