Why observe temperature, water vapor, and cloud structures with high-spectral-resolution infrared observations at 1-km horizontal scales?

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What this talk is <u>not</u> about

Vertical resolution

Temporal resolution

Spatial coverage

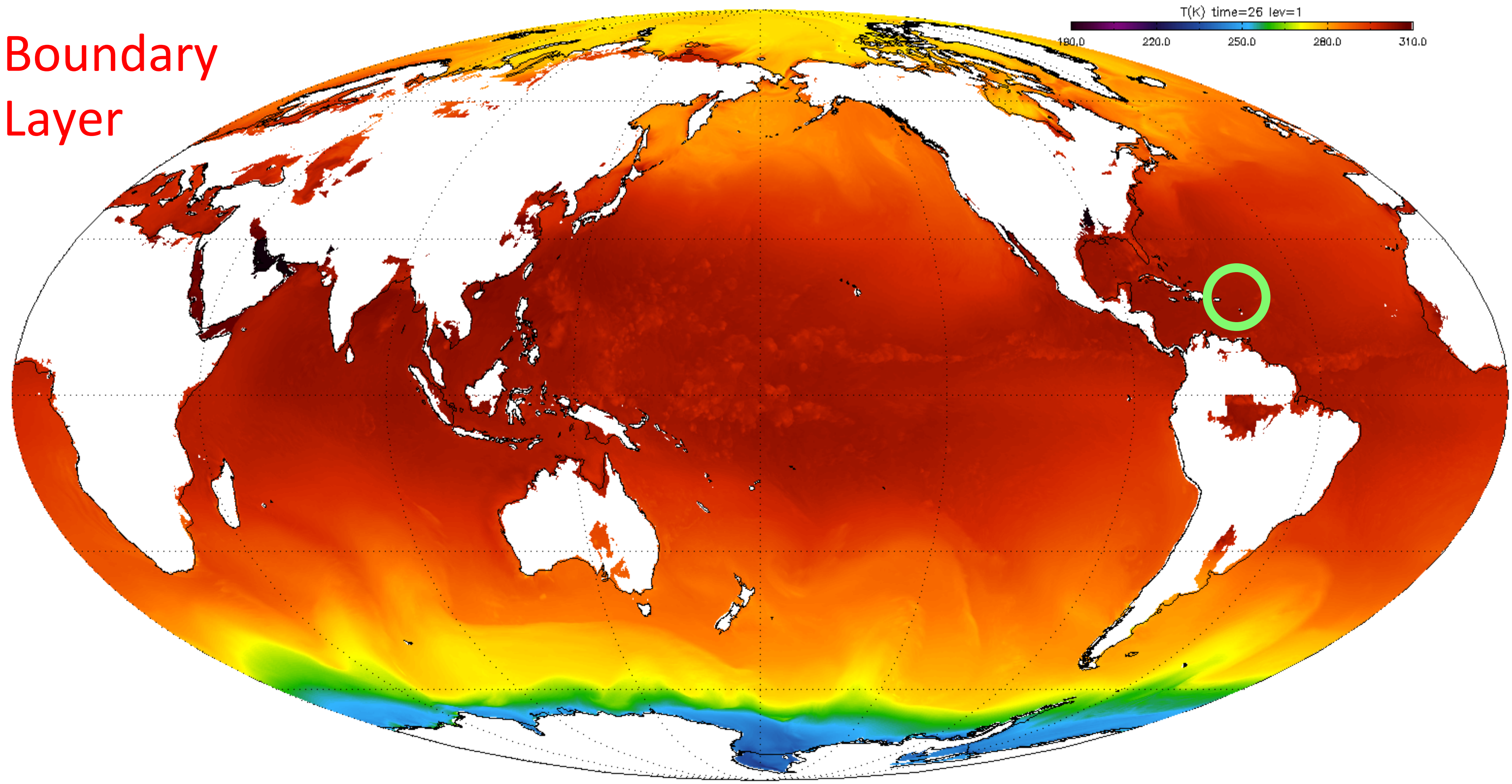
Sampling in thick/uniform clouds/precipitation

“Value tradeoffs” among these topics and with spatial resolution

Dependence of spatial variability on cloud regime

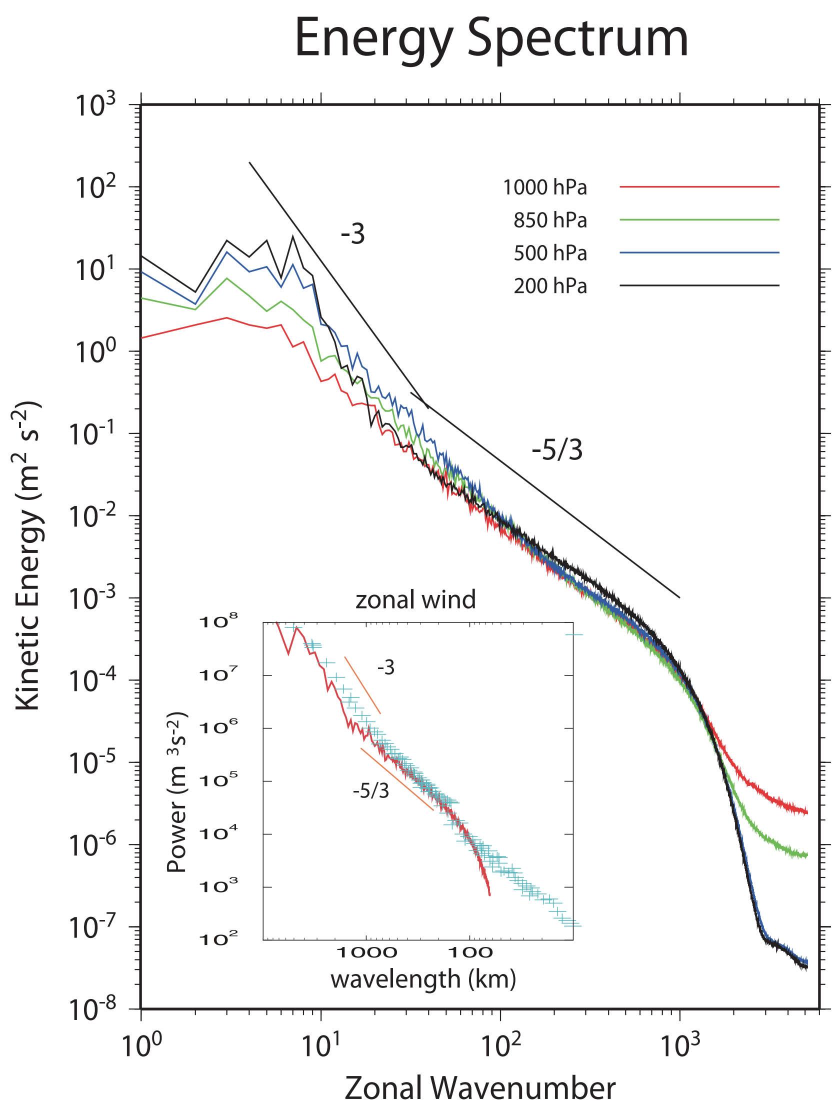
Global NICAM model (7-km resolution)

A large diversity of T structures
Scales of variability dependent on cloud regime



Kinetic energy power spectra in NICAM

Break from roughly –3 to –5/3 in mesoscale range
Diffusive behavior at smallest scales

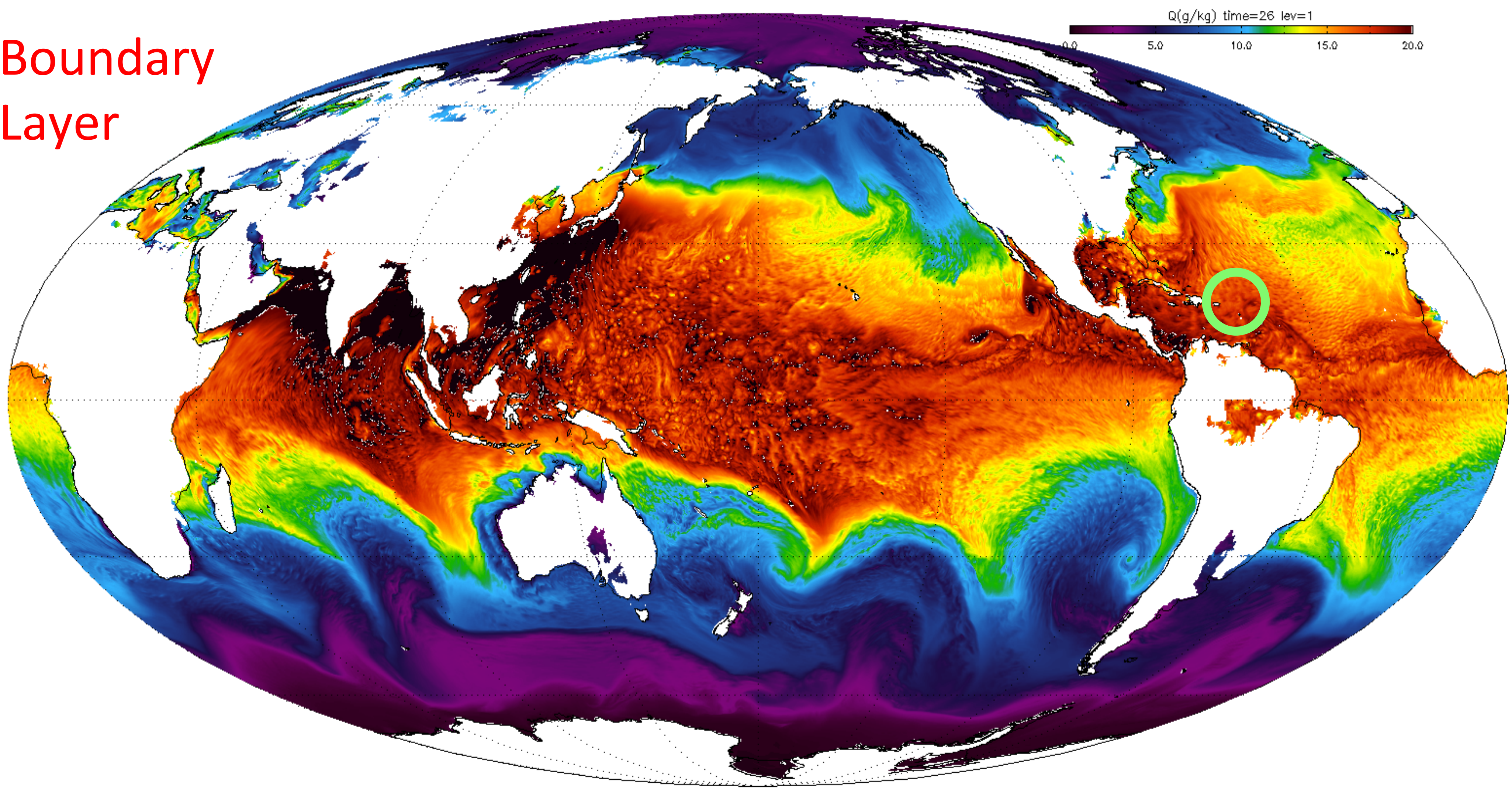


Terasaki et al. (2009), *SOLA*

Global NICAM model (7-km resolution)

Even larger variability of q compared to T
Scales of variability often inversely related to T

Boundary Layer



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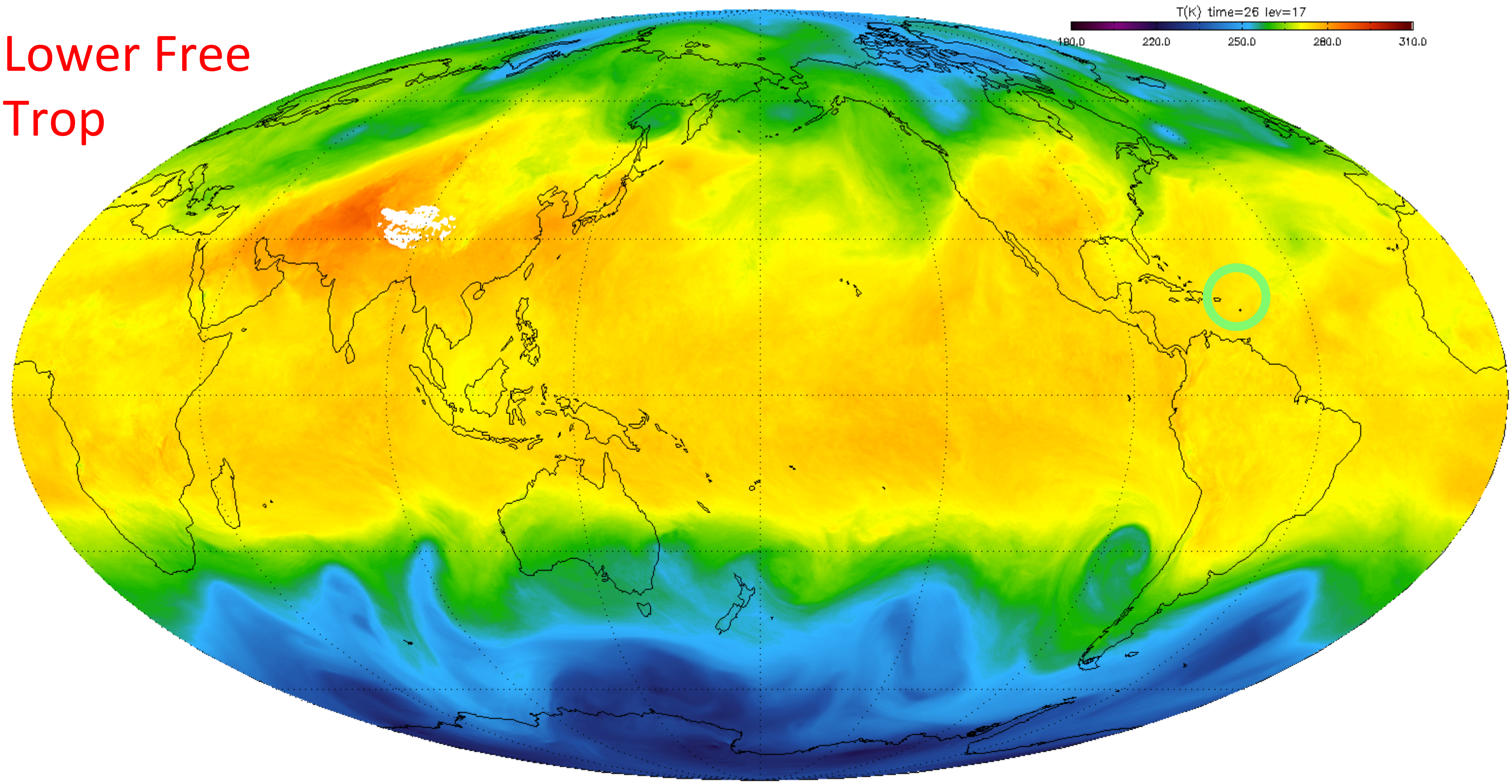
Lower Free Trop



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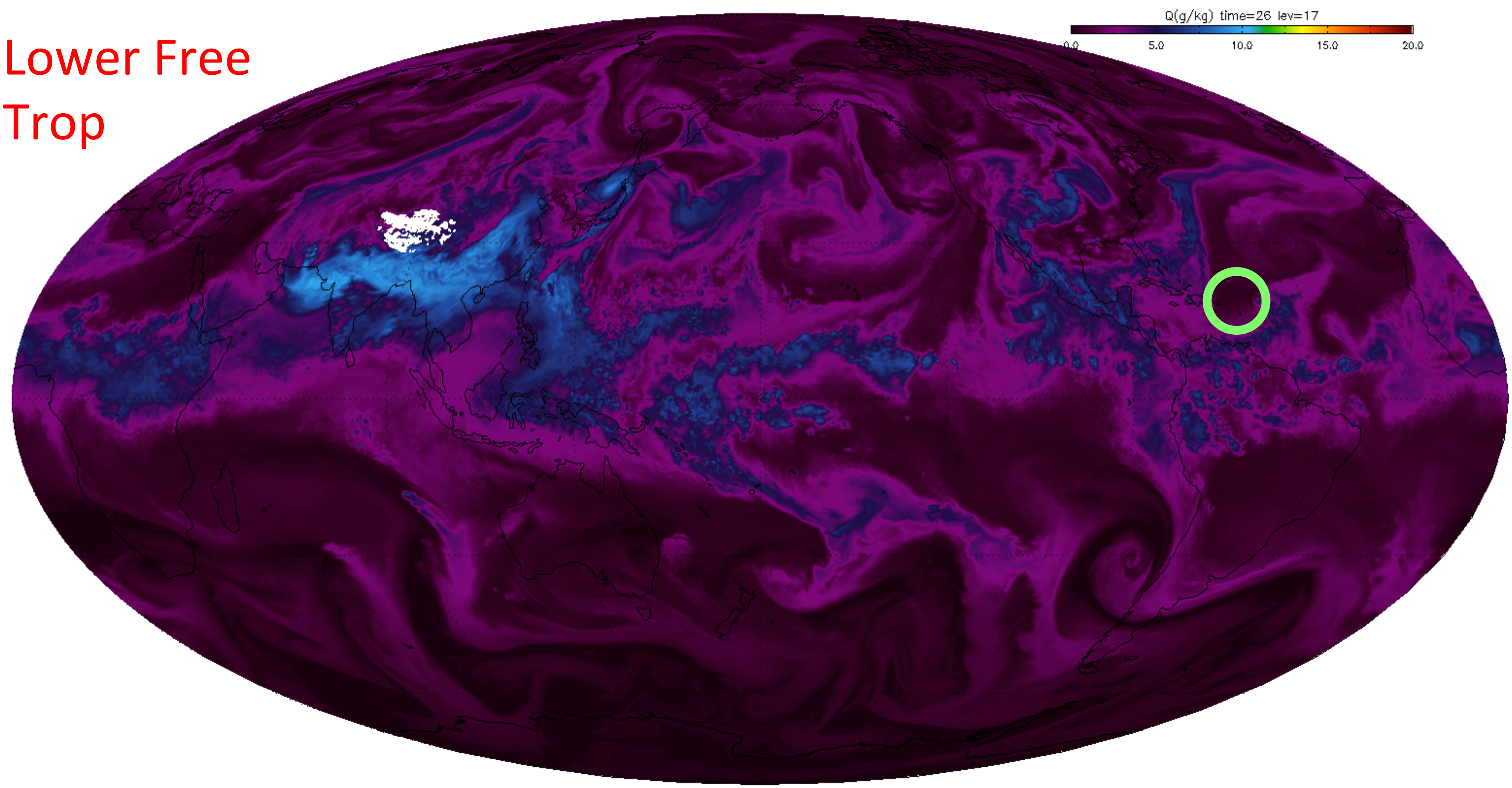
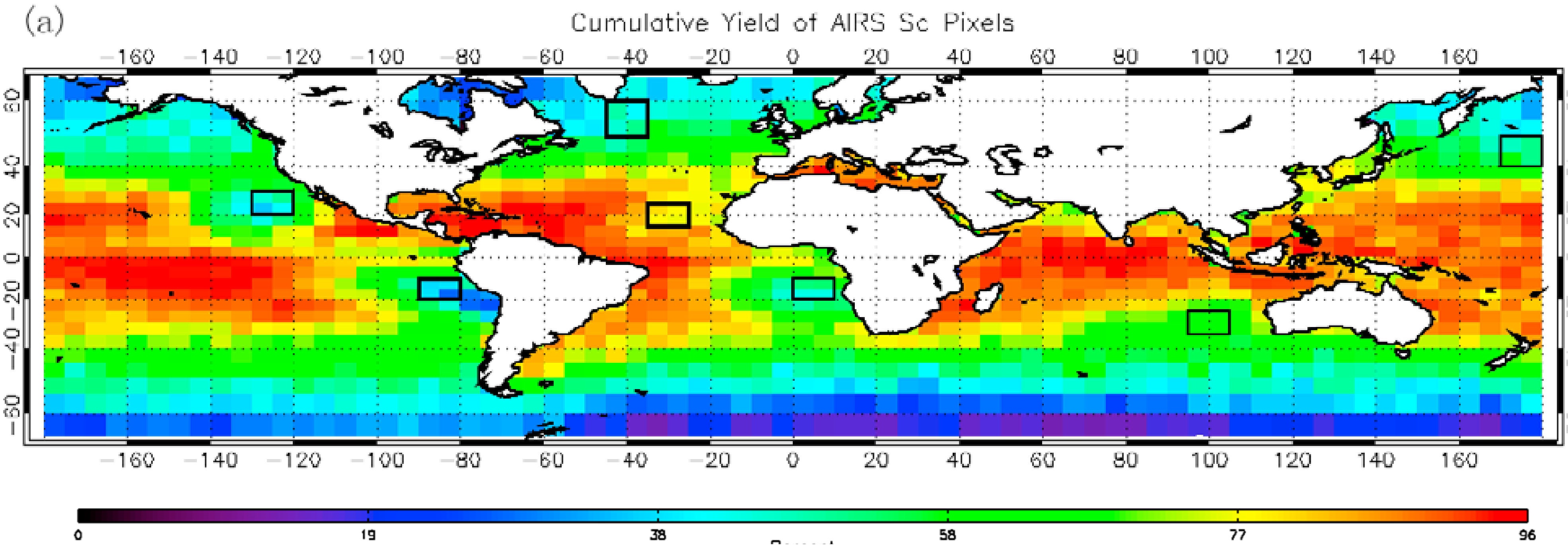


A brief focus on trade Cu regime

Greatest AIRS (IASI? CrIS?) yield in low lat oceans

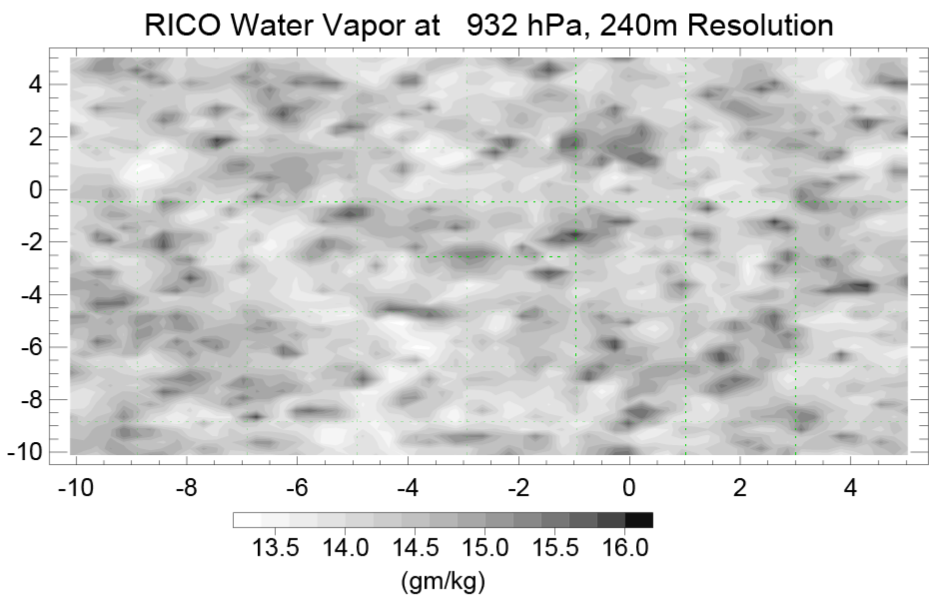
Very high skill in trade cumulus
Cloud regime very important for cloud-climate feedback

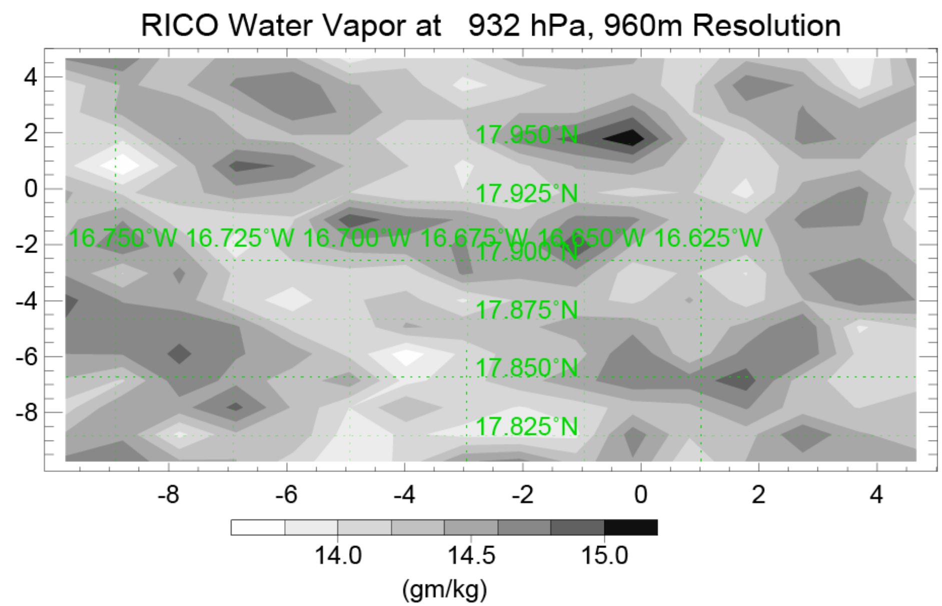


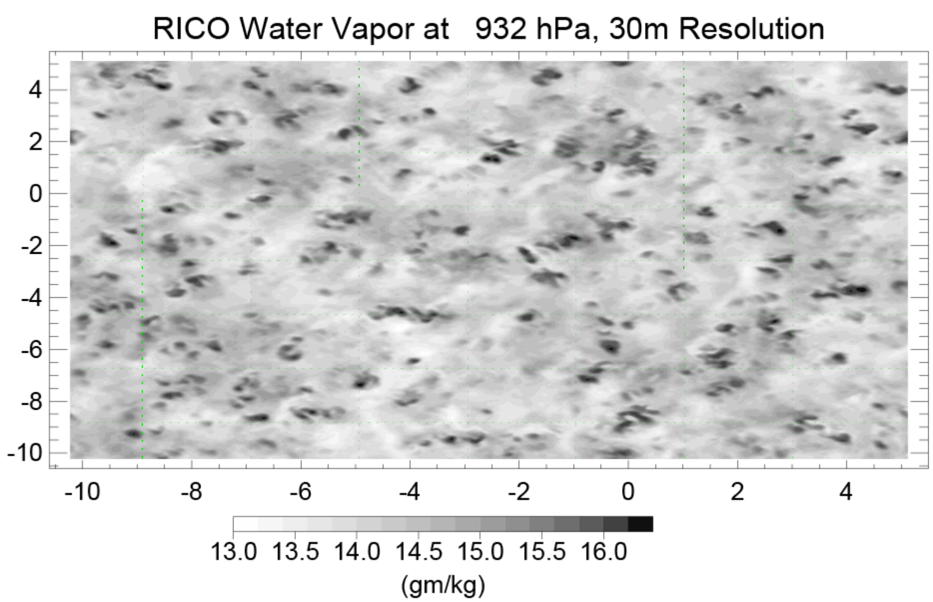
Yue et al., 2011, *J. Geophys. Res*.

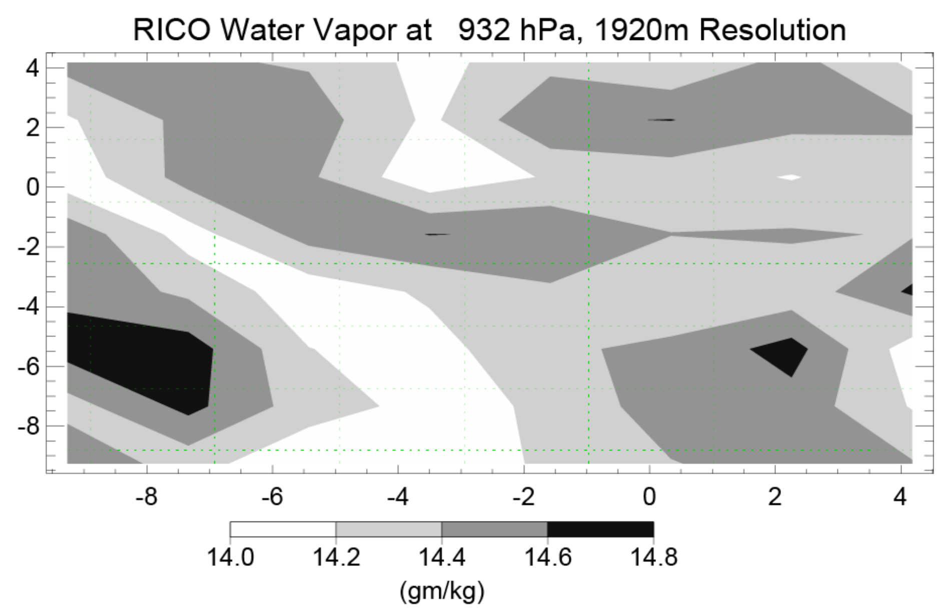
JPL-LES near Barbados during RICO campaign

q in PBL highly variable at scales < 1 km
Domain size very similar to AIRS, CrIS, and IASI FOV









Some key issues (horizontal resolution)

Climate/NWP model evaluation/parameterization

Confronting a new generation of high spatial resolution models with low spatial resolution satellite soundings

Scale-dependence of pdfs related to cloud regime, altitude, latitude, etc.

NWP model data assimilation

"Hole hunting" more successful at fine spatial resolution

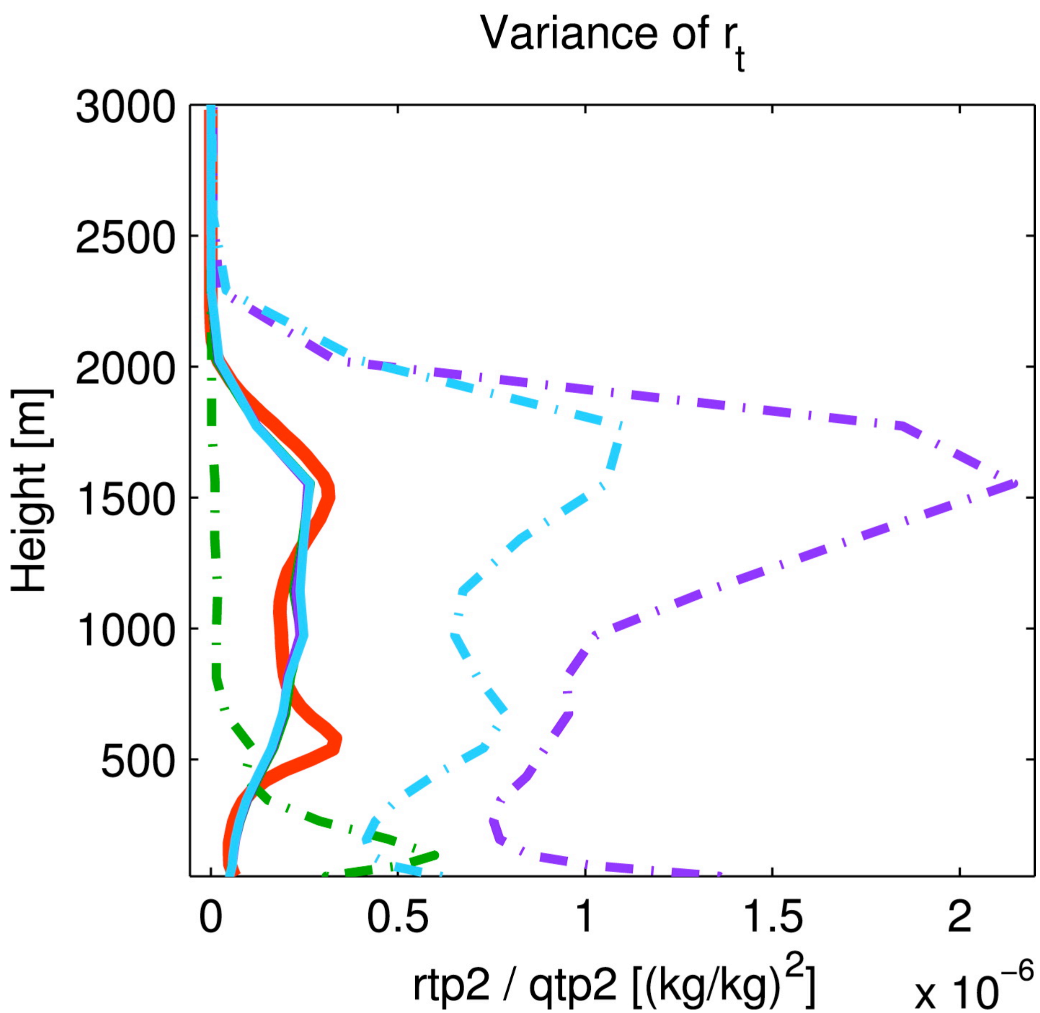
High value per pixel in cloudy scenes within large horizontal T/q gradients

Representation error of q (regime, latitude, height dependence)

(c.f., Hyoung-Wook Chun talk Thursday)

CRM + parameterization for BOMEX

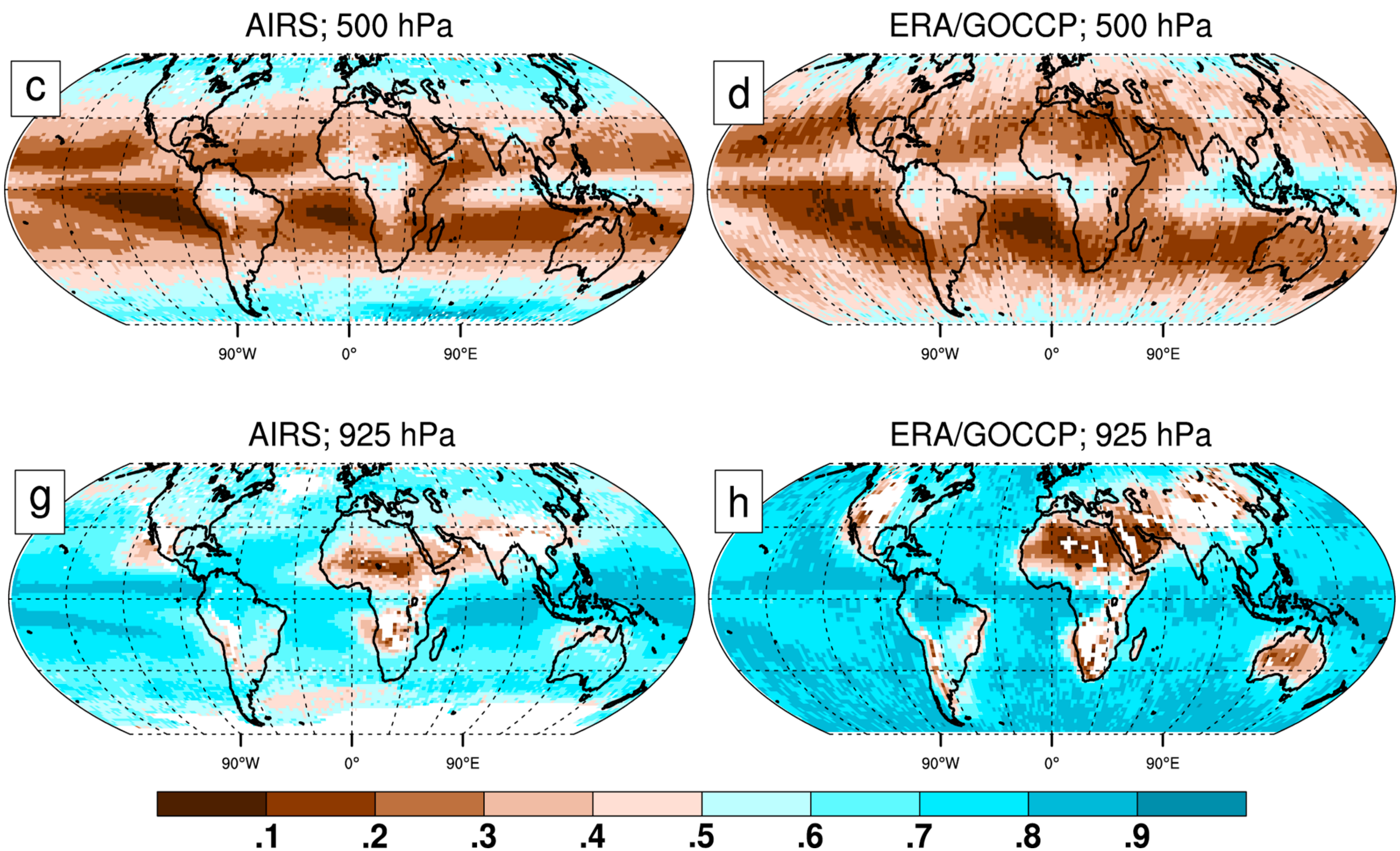
Variance depends on parameterization (CLUBB) and resolution of CRM
Total water (vapor, cloud, precip)



Larson et al., 2012, *Mon. Wea. Rev*.

Small-scale variance and critical RH in climate models: Substantial regime dependence

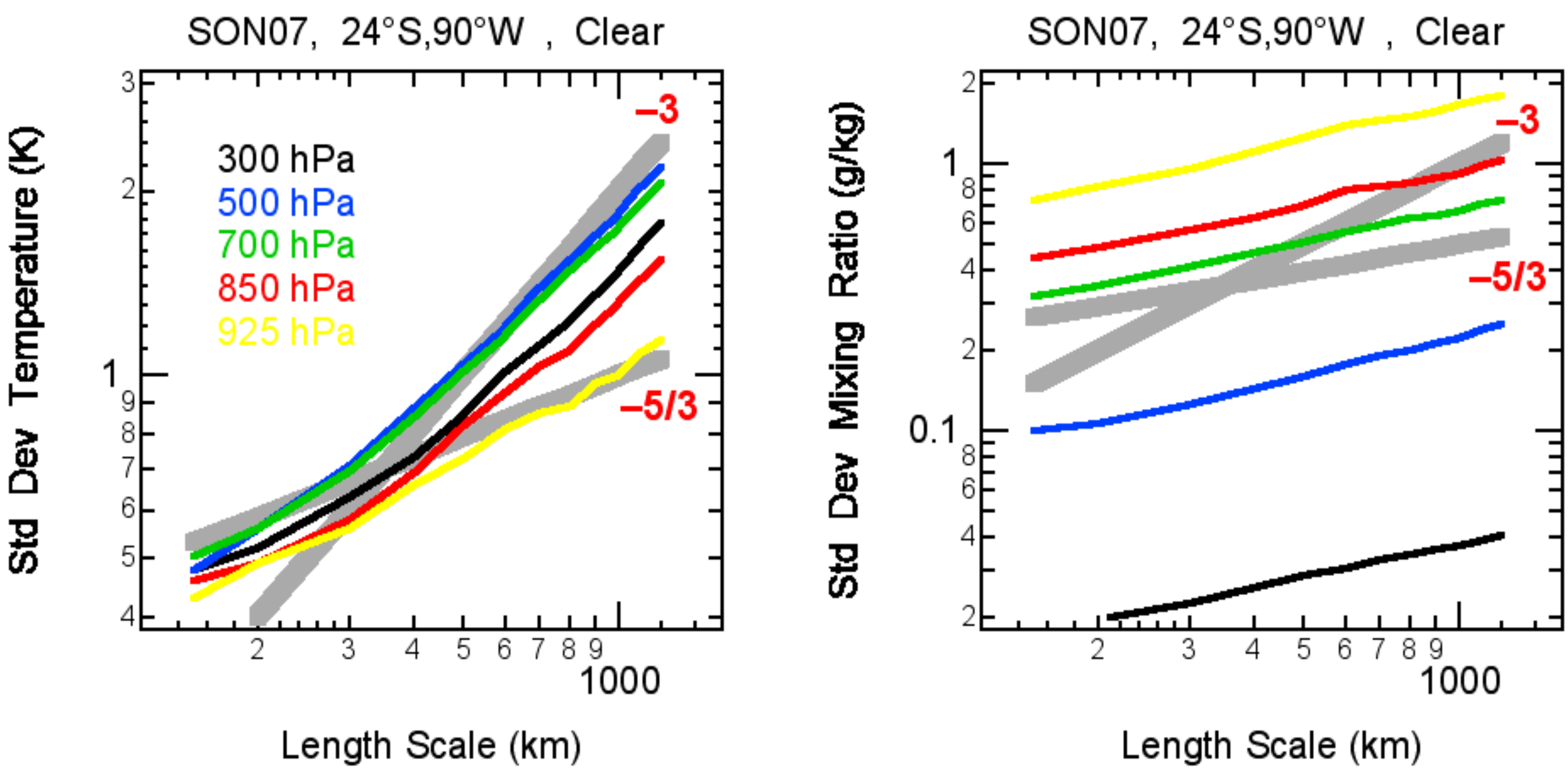
Lower critical RH suggests larger variance of T and q



Quaas (2012), *J. Geophys. Res.*

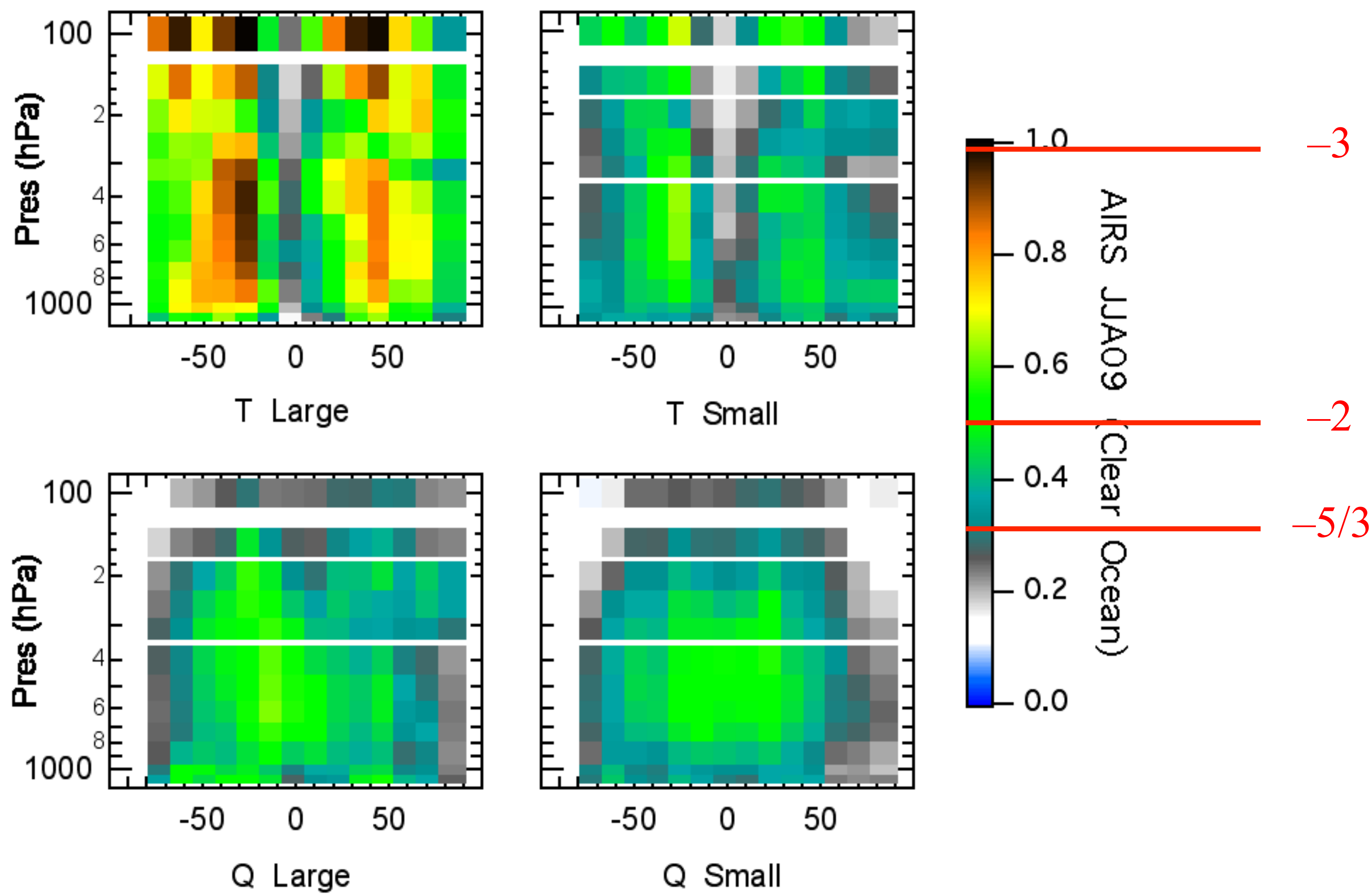
Comparing AIRS and model variance

Scaling exponents & breaks depend on altitude



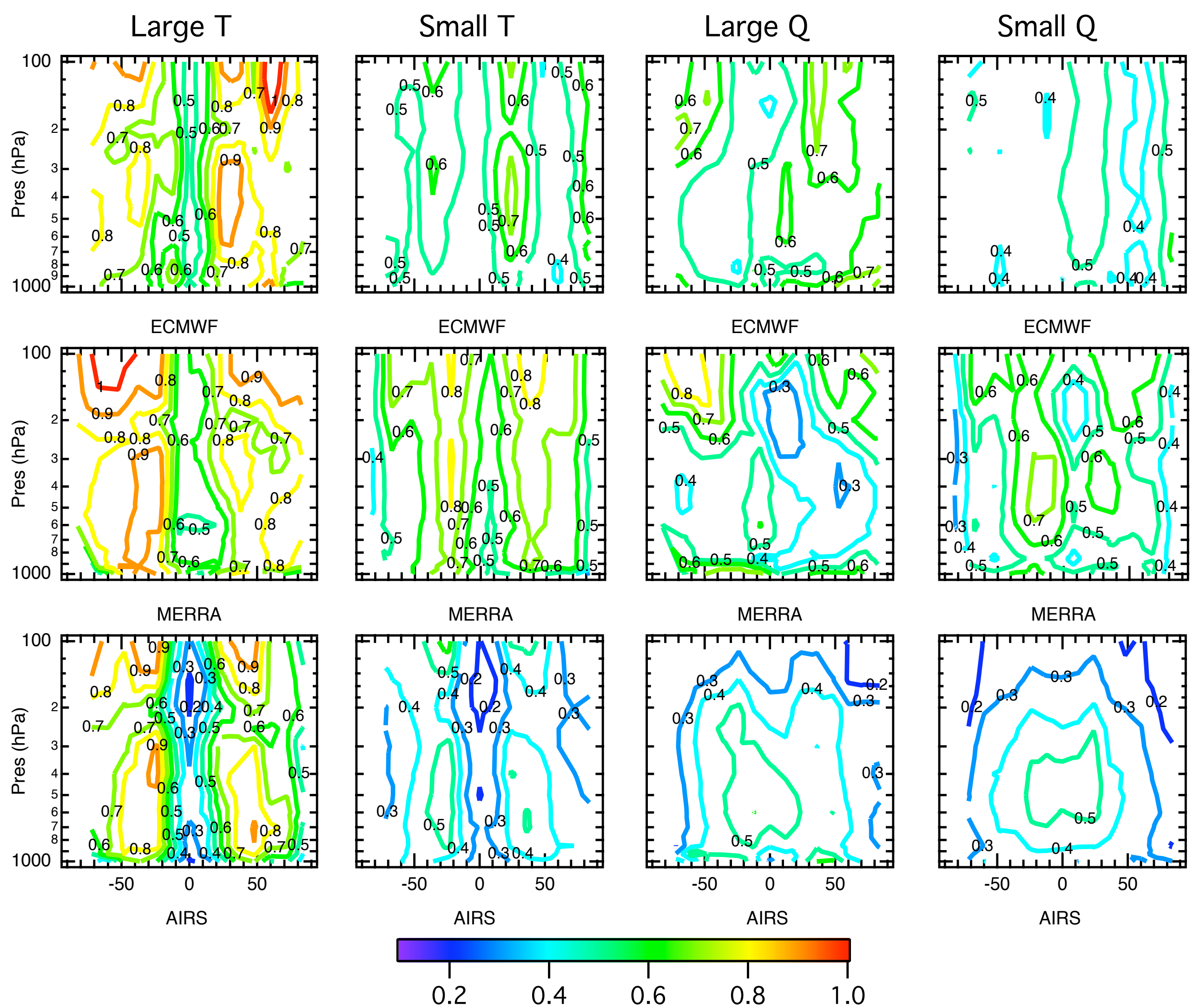
Kahn and Teixeira (2009), *J. Climate*

Mesoscale "break" in AIRS T apparent but negligible for q



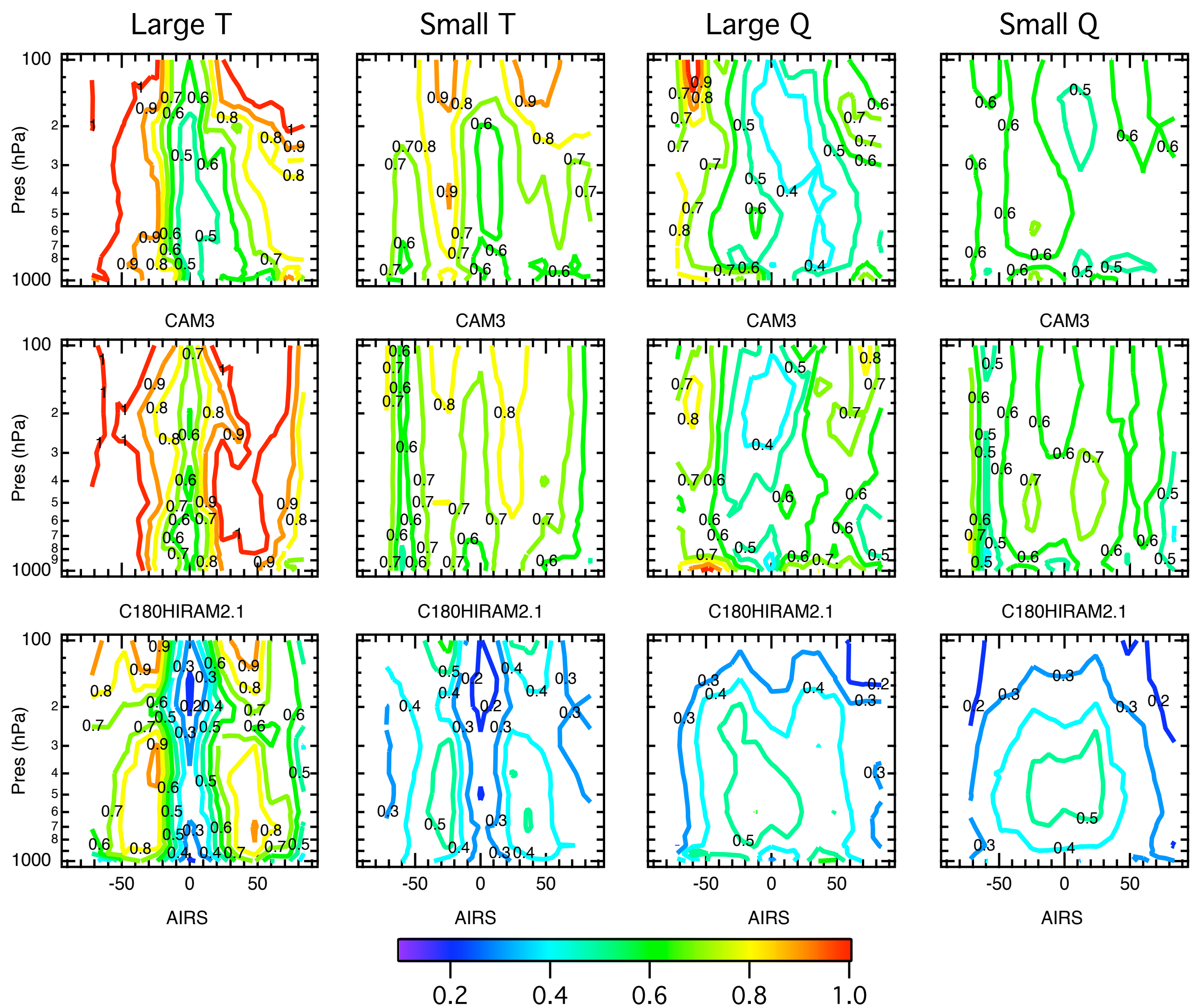
Kahn and Teixeira (2009), *J. Climate*

Models with data assimilation more comparable to AIRS



Kahn et al. (2011), *J. Atmos. Sci.*

“Free-running” models not as comparable to AIRS

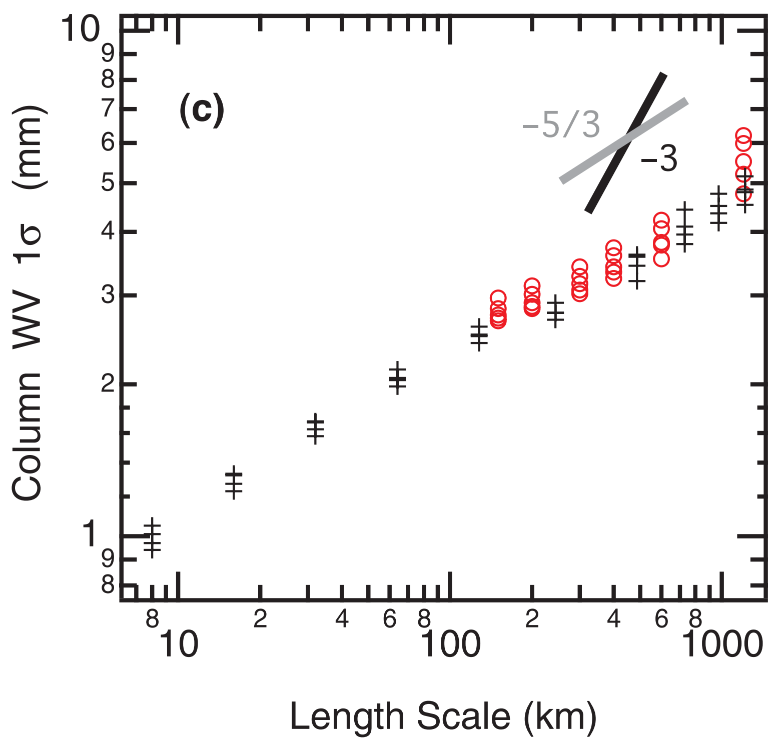


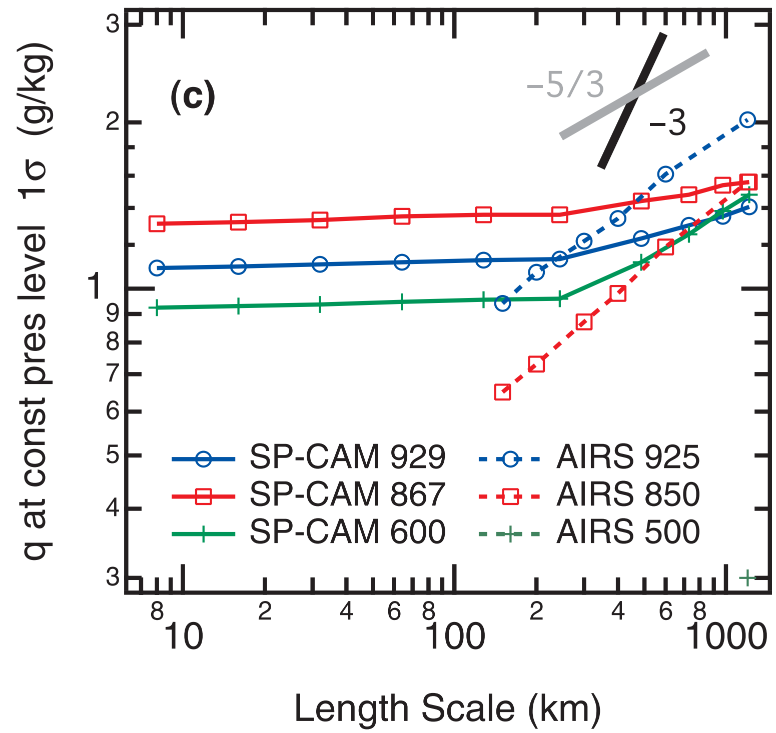
Kahn et al. (2011), *J. Atmos. Sci.*

Can we use current 1-km CWV observations to address scaling?

Ambiguity between CWV and height-resolved q

Existing 1-km resolution CWV observations <u>might</u> fall short on this issue
Scaling of CWV resembles T, height-resolved q close to –2

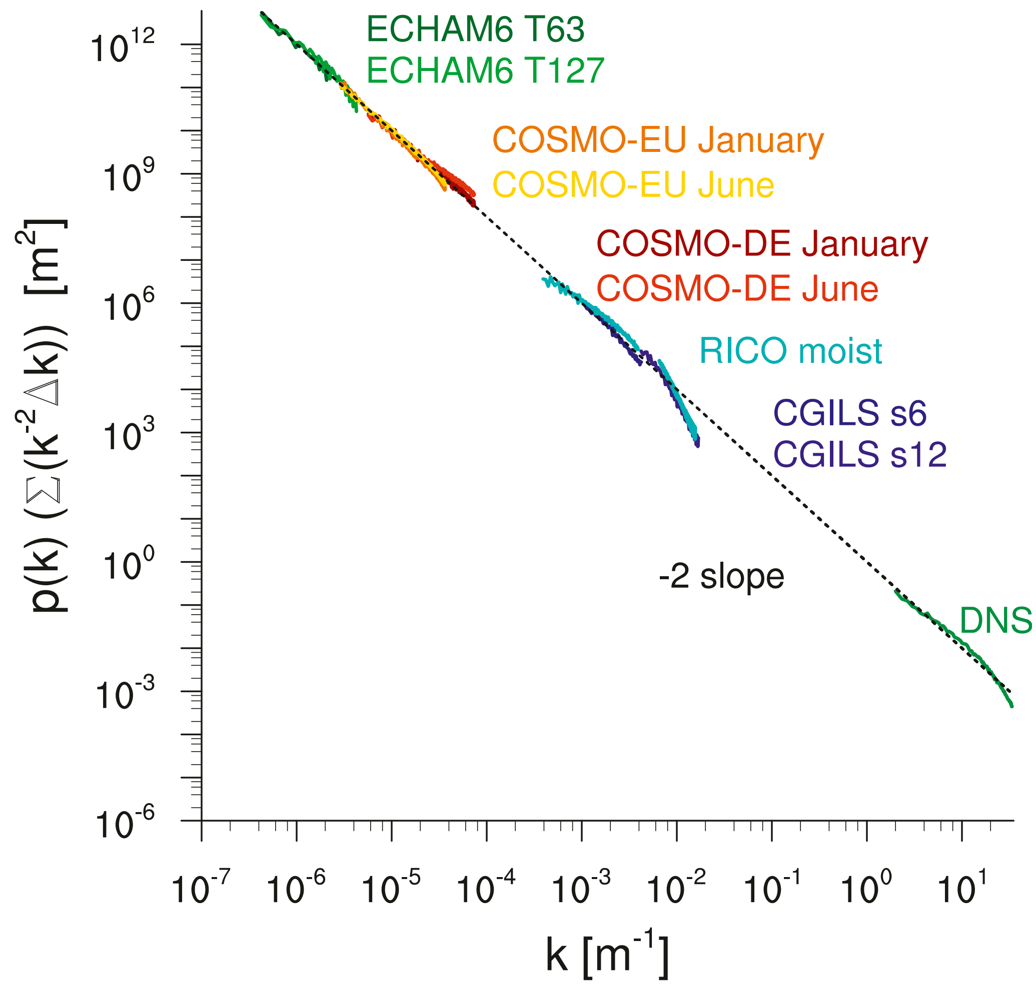




Kahn et al. (2011), *J. Atmos. Sci.*

Scaling of q_t approximately –2 at all scales

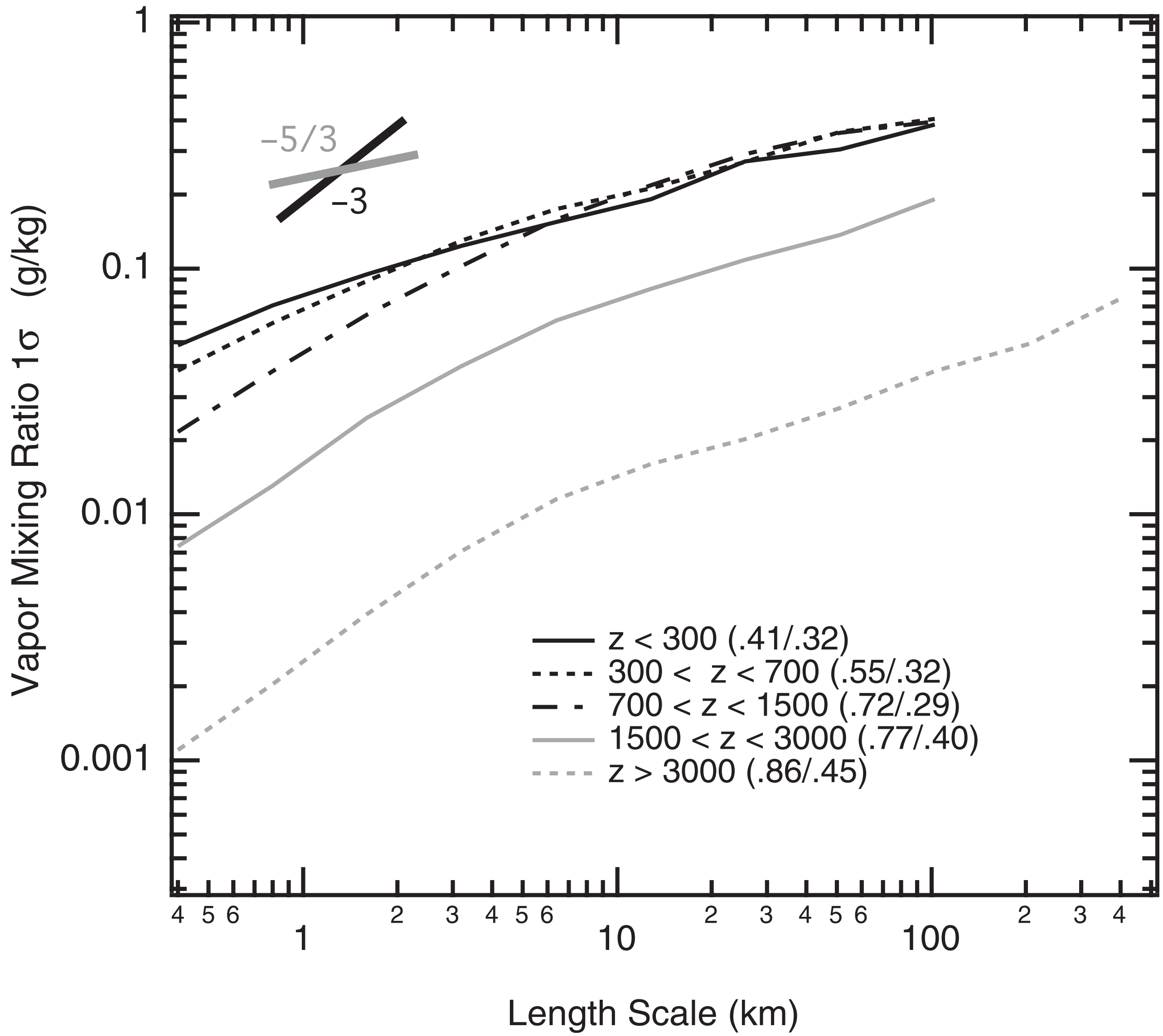
Simulations based on trade cumulus regime (RICO)
Averaged over height (column)



Schemann et al. (2013), *J. Atmos. Sci.*

Height-dependent scale break in q_v near 5–10 km

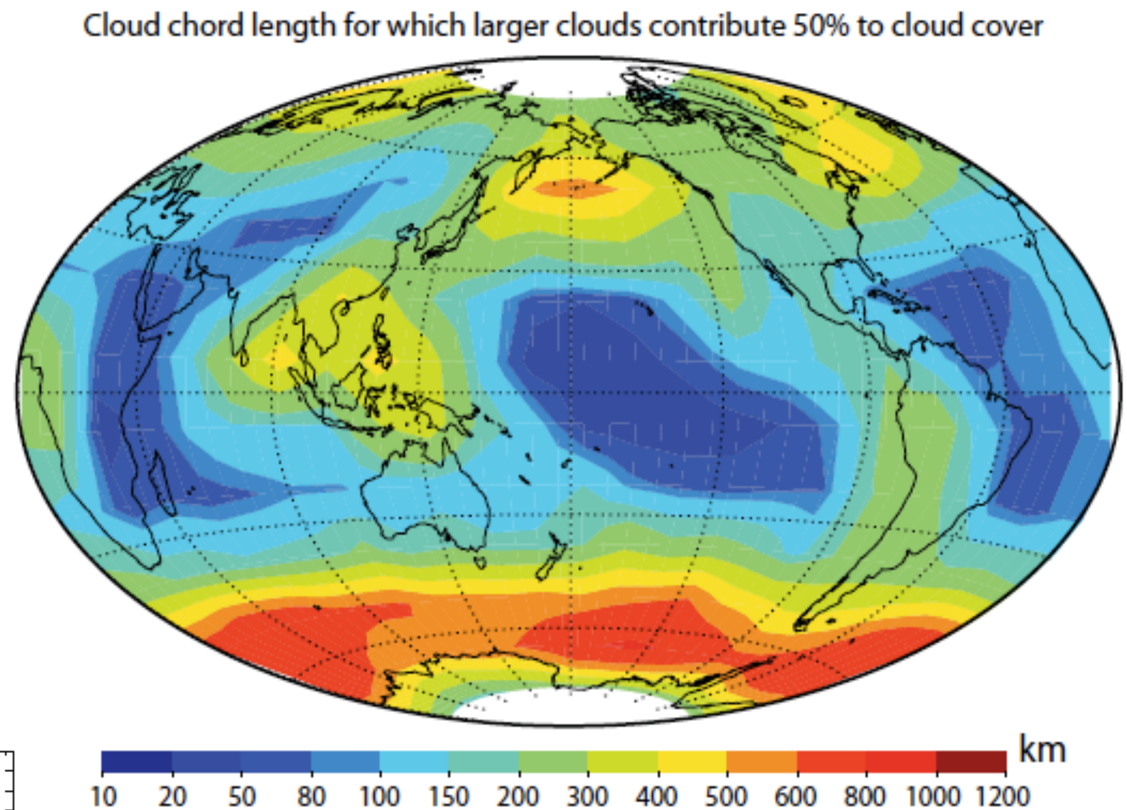
VOCALS-REx aircraft observations within/above stratocumulus

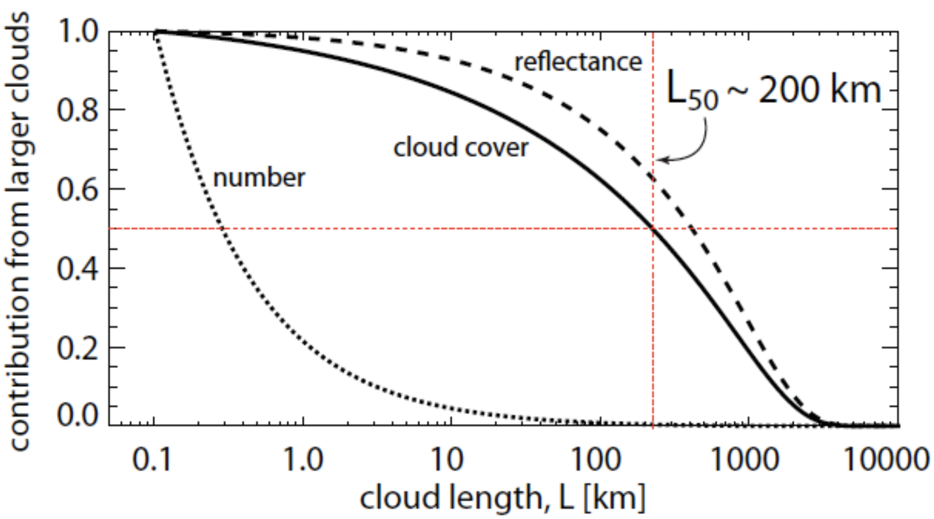


Kahn et al. (2011), *J. Atmos. Sci.*

What about clouds?

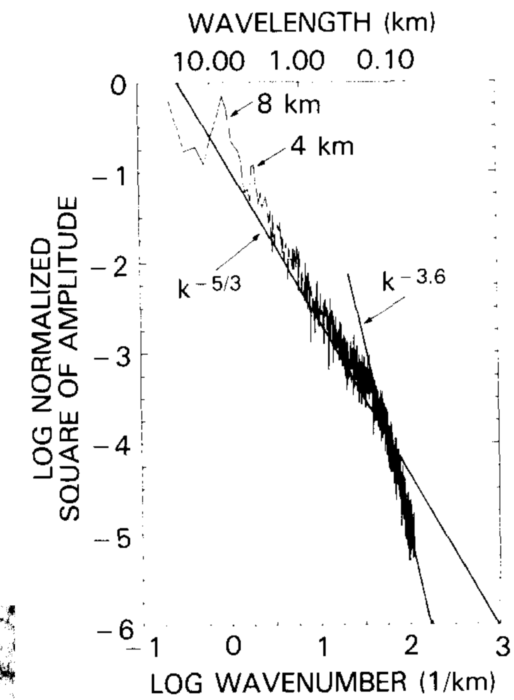
Scale dependence of cloud number, coverage, and reflectance sensitive to spatial scale

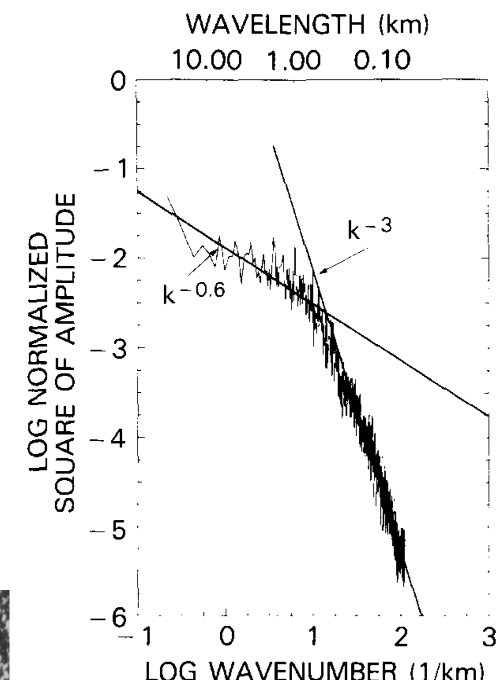


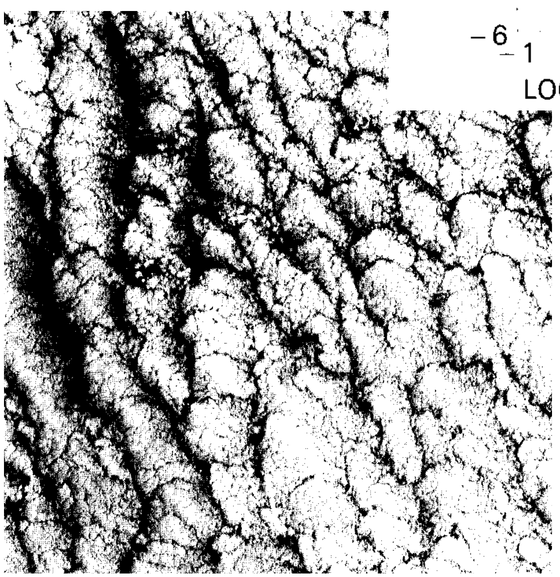


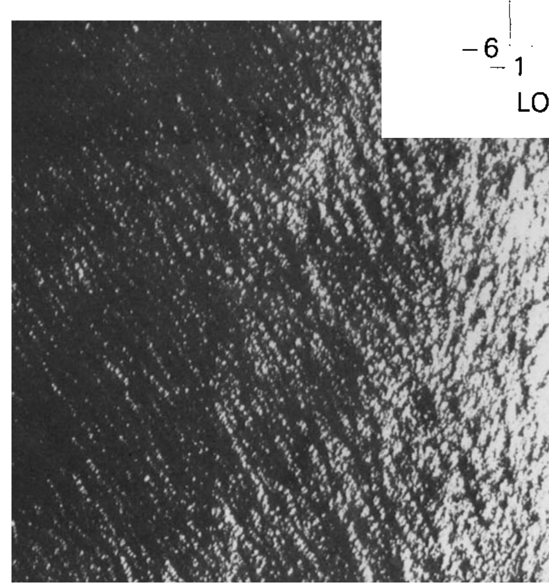
Wood and Field (2011), *J. Climate*

Scale Break at 0.5 km in Sc with Landsat's Thematic Mapper (TM) Data









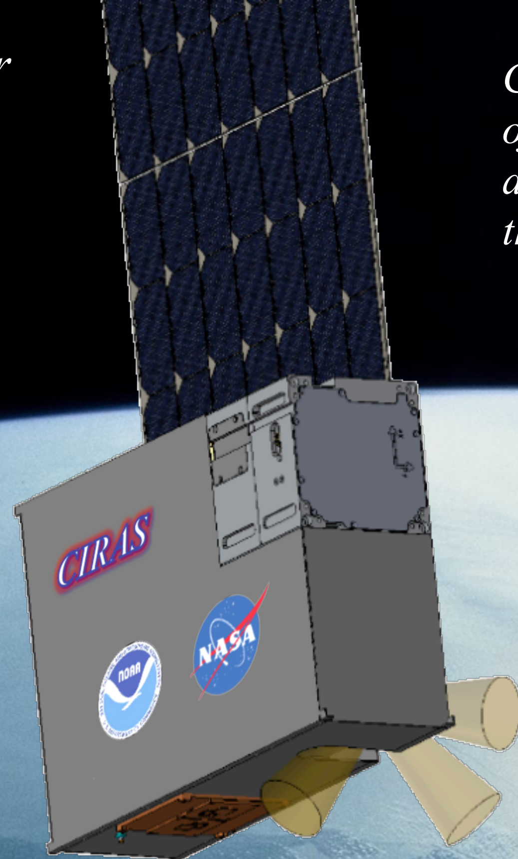
Cahalan and Snider (1989), *Remote. Sens. Env.*

What about the future?

CubeSat Infrared Atmospheric Sounder (CIRAS)

For NASA InVEST
PI: Tom Pagano (JPL)
Sponsor: NASA ESTO

CIRAS will significantly reduce the cost of atmospheric sounding in the infrared and enable improved timeliness through constellations



CIRAS Mission

- *Demonstrate Key Technologies needed for Infrared Instruments on CubeSats*
- *Demonstrate fidelity of Hyperspectral Mid IR radiance measurements to retrieve Temperature and Water Vapor Profiles*
- *Fill Coverage Gaps and Improve Timeliness of Operational IR Sounders*
- *TRL in: 5-6, TRL out: 7*
- *Build: 2016, 2017. Launch 2018 (TBD)*

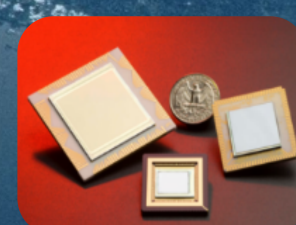
Parameter	CIRAS
Spatial	
Orbit Altitude	600-850 km
Scan Range	0.84° - 57°
Horizontal Res'n	1.6 km - 13.5 km
Spectral	
Method	Grating
Band 1	4.78-5.09 µm
Res'n / Sampling	0.5 / 0.2 cm^{-1}
Total Channels	625
Radiometric	
NEdT (@250K)	<0.25 K
Resources	
Size	6U Cubesat
Mass	8.5
Power	37.5
Data Rate	2 Mbps

CIRAS Technologies

Micro Pulse Tube Cryocooler (Lockheed Martin)

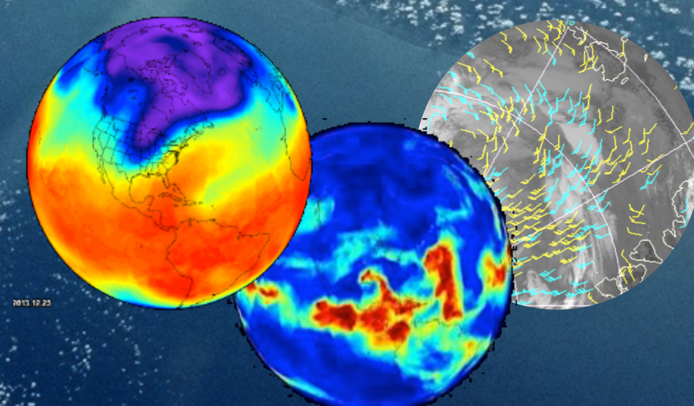
JPL GRISM Spectrometer

JPL HOT-BIRD Detector



CIRAS Measurements

- *Lower Tropospheric Temperature Profiles*
- *Lower Tropospheric Water Vapor Profiles*
- *Goal: Experimental Demonstration of 3D Winds*



*Patent Pending