# Atmospheric water vapor: AIRS vs. coupled climate models

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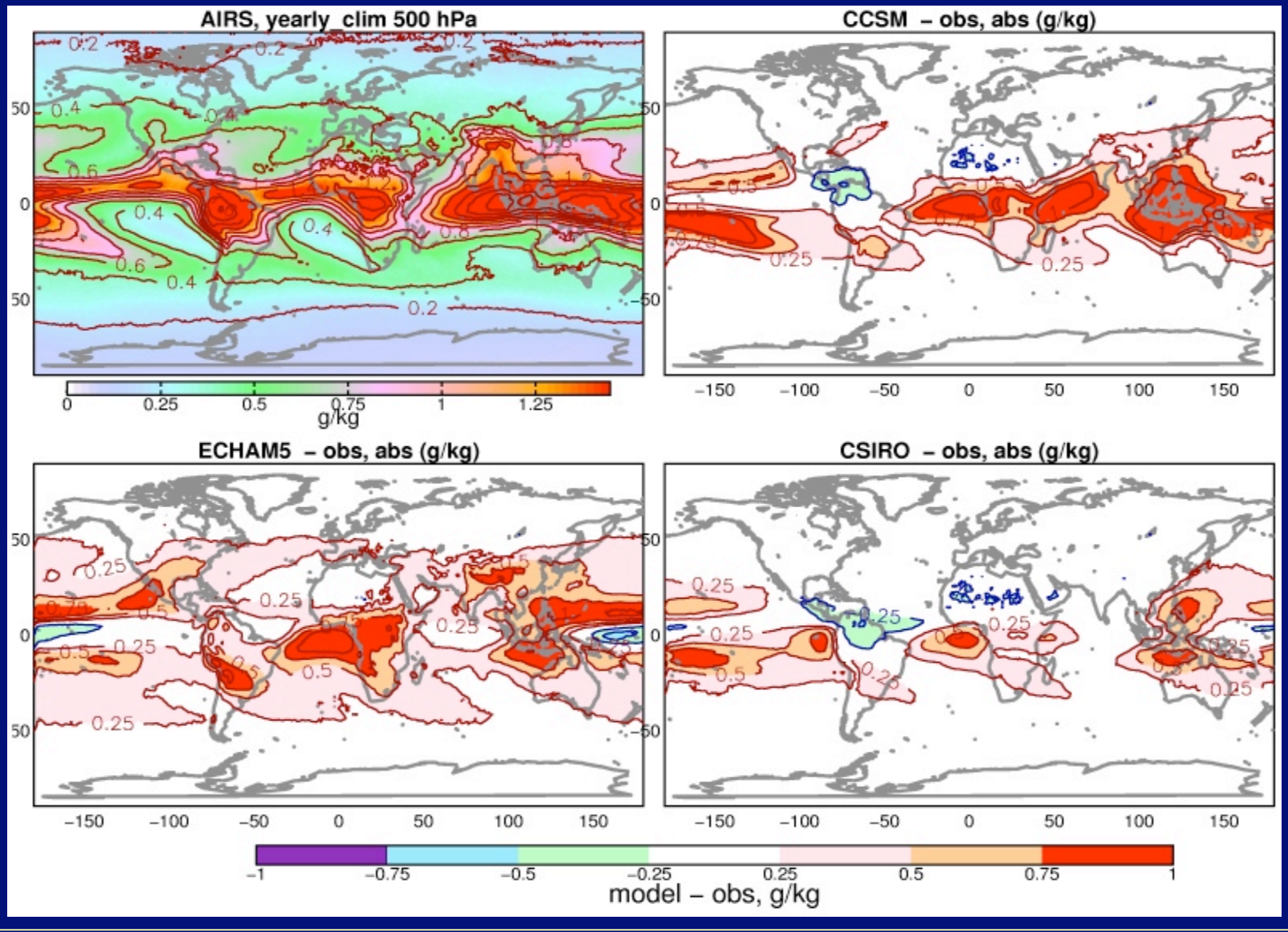
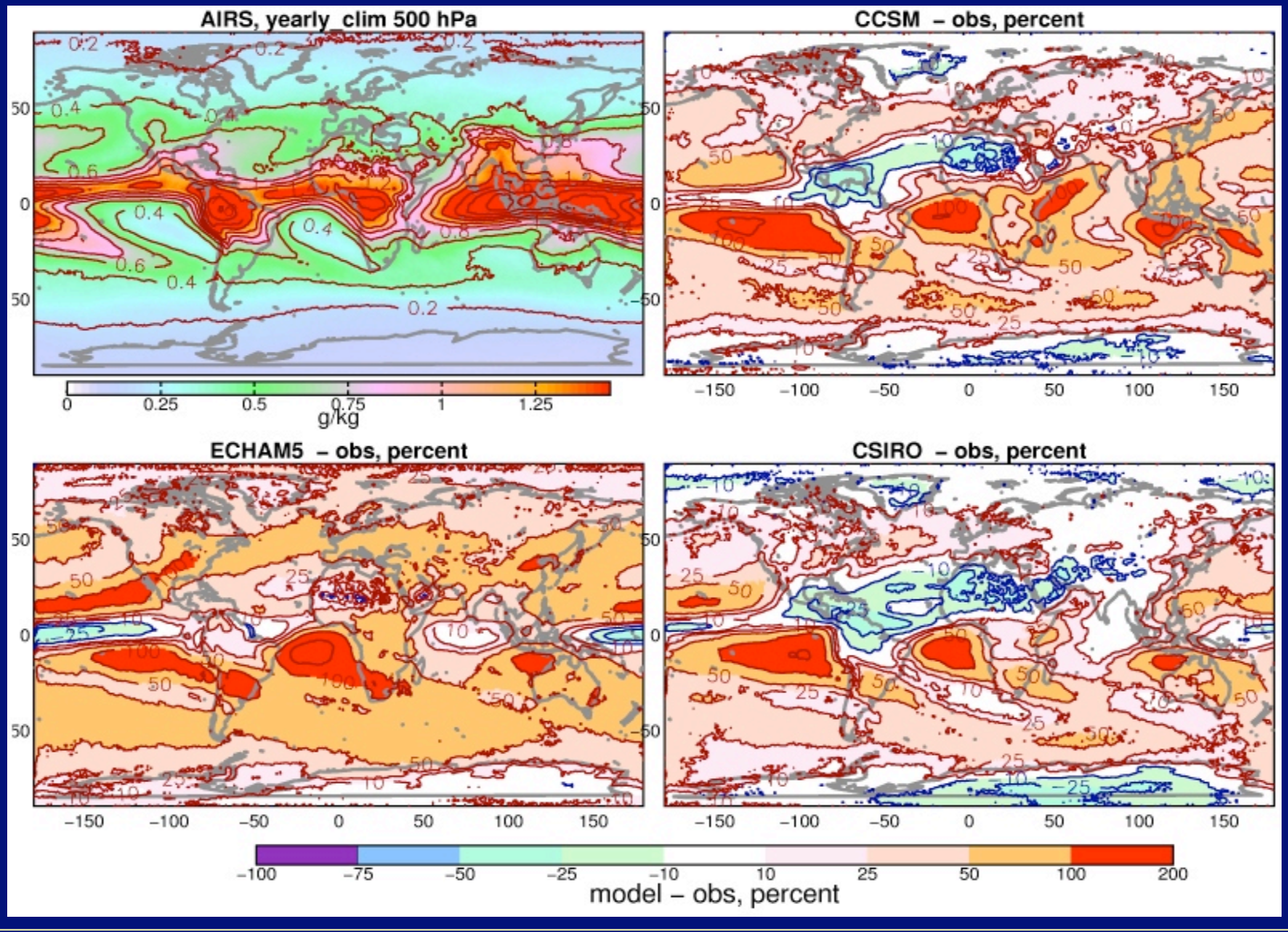
# Annual mean: models systematically differ from AIRS

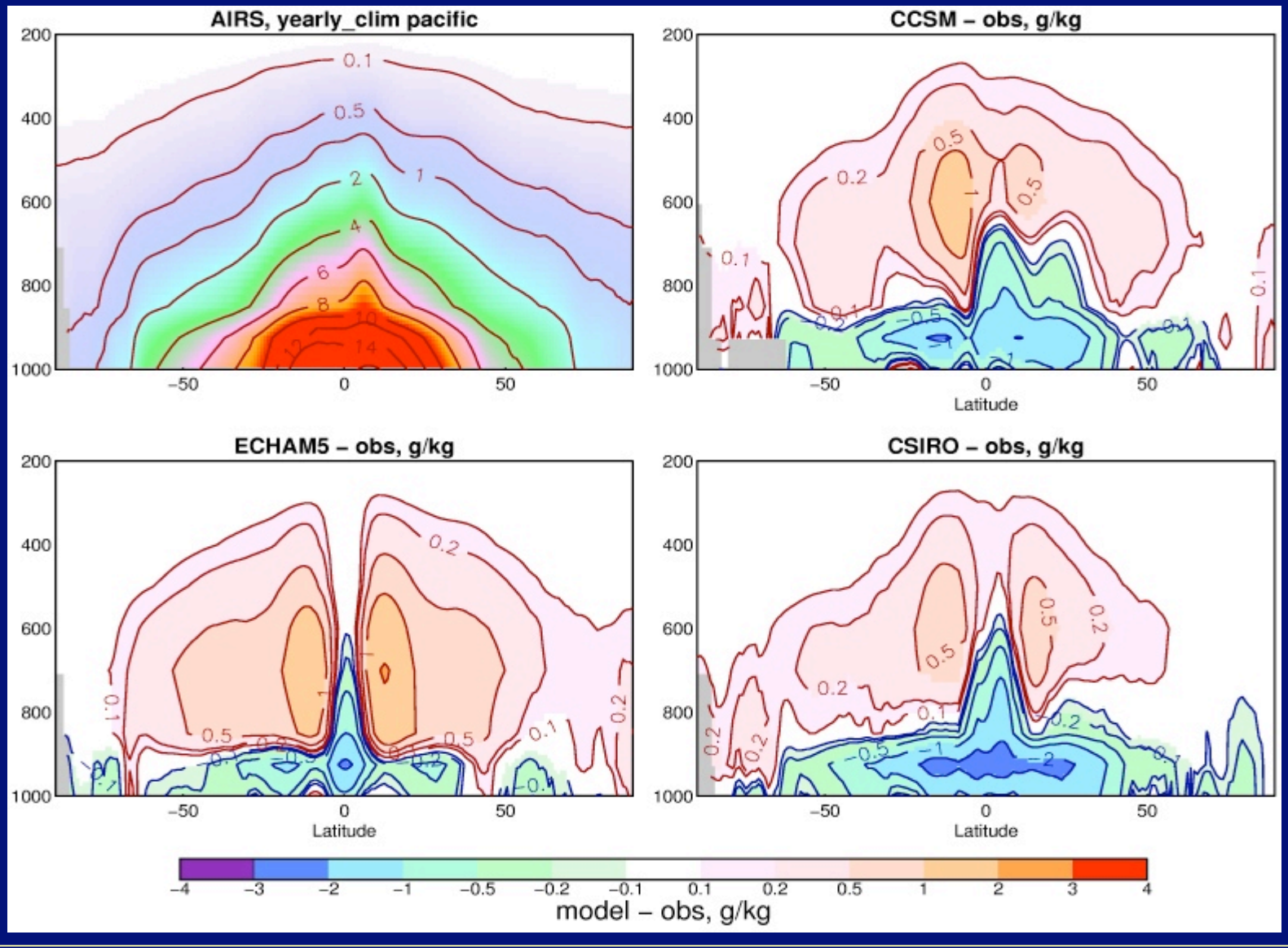


# Fractional difference 50-100% at 500 hPa

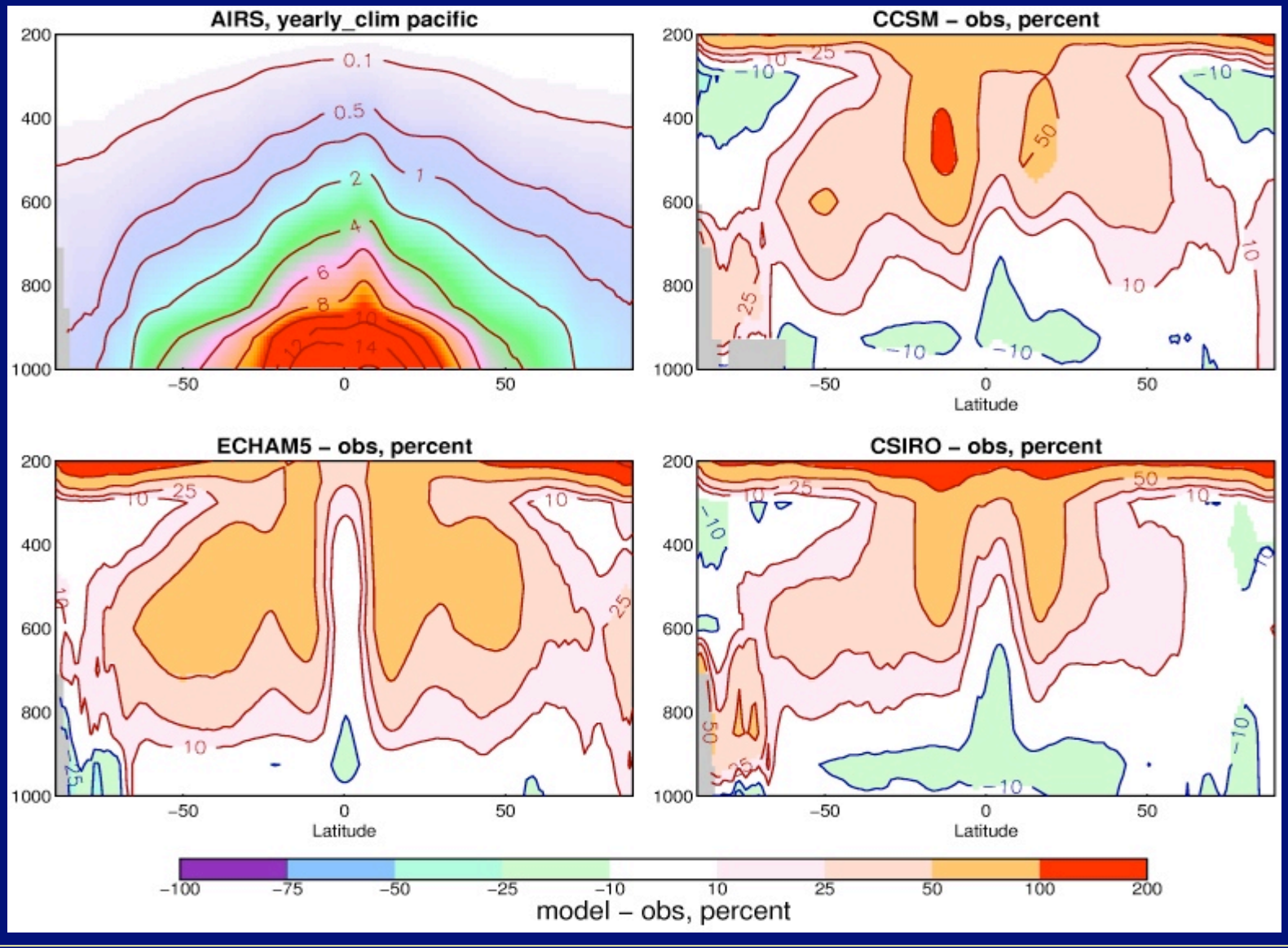


# Pacific Section: Annual mean specific humidity

## MODELS- AIRS



# Fractional differences: greater with height

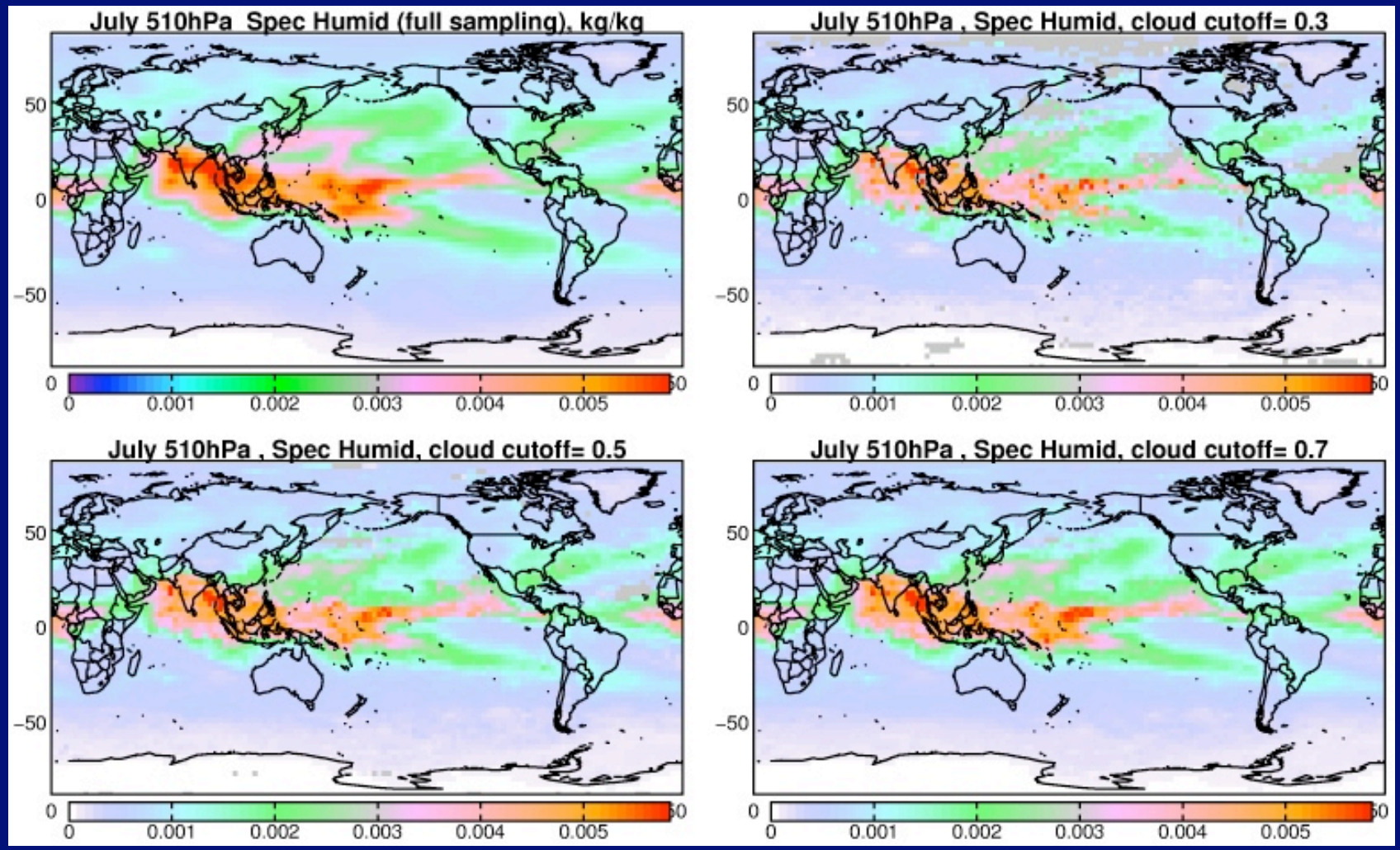


# Source of systematic model/AIRS differences?

- Cloud sampling problems? Models use *all* scenes (we are using IPCC database, can't mask by cloud fraction)
- Diurnal cycle aliasing?
- AIRS errors?
- Systematic problems with coupled climate models?

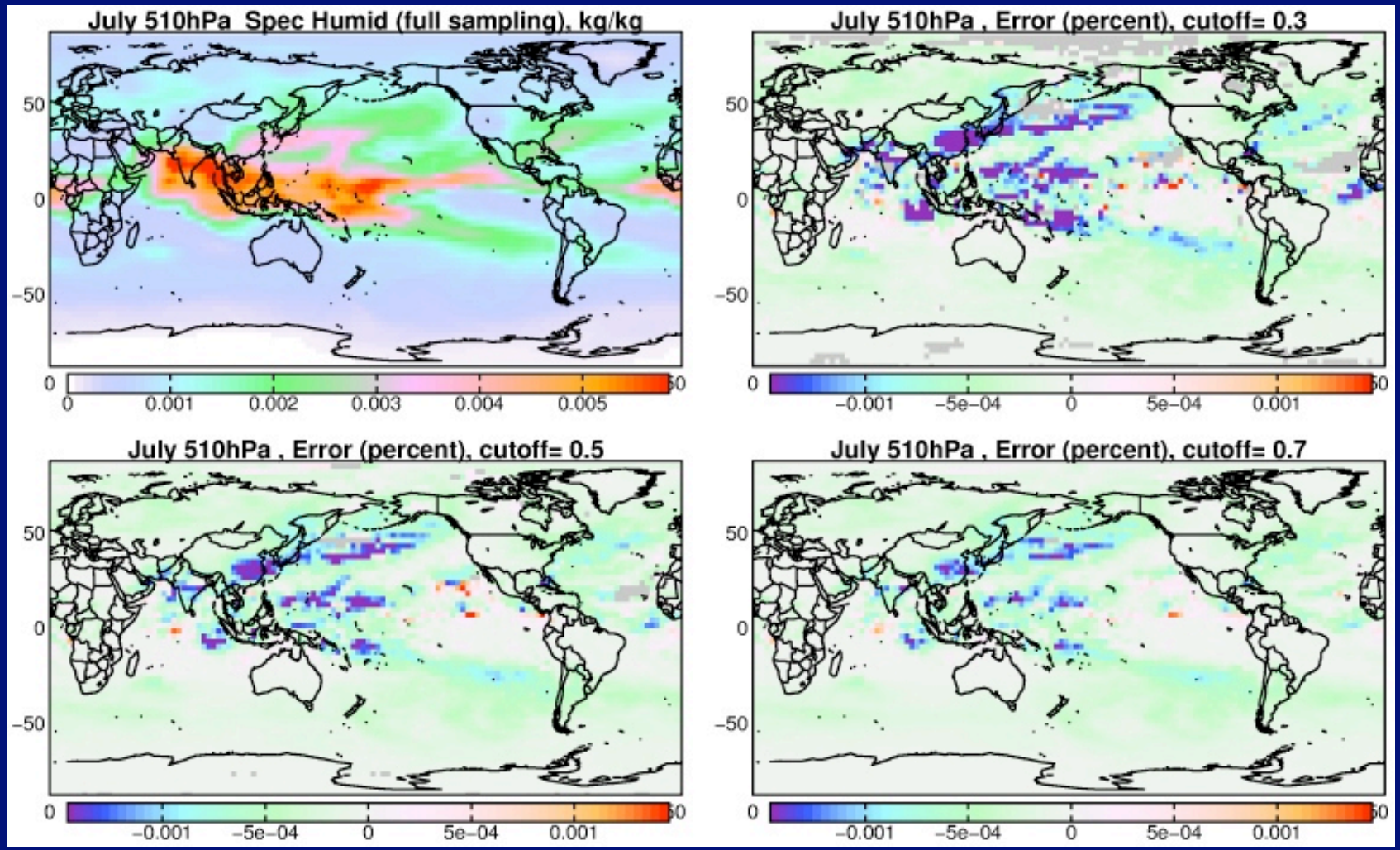
# Effect of cloud sampling (sample if C.LE.cutoff)

- Can be tested in "model world" (CCSM3). Actual units



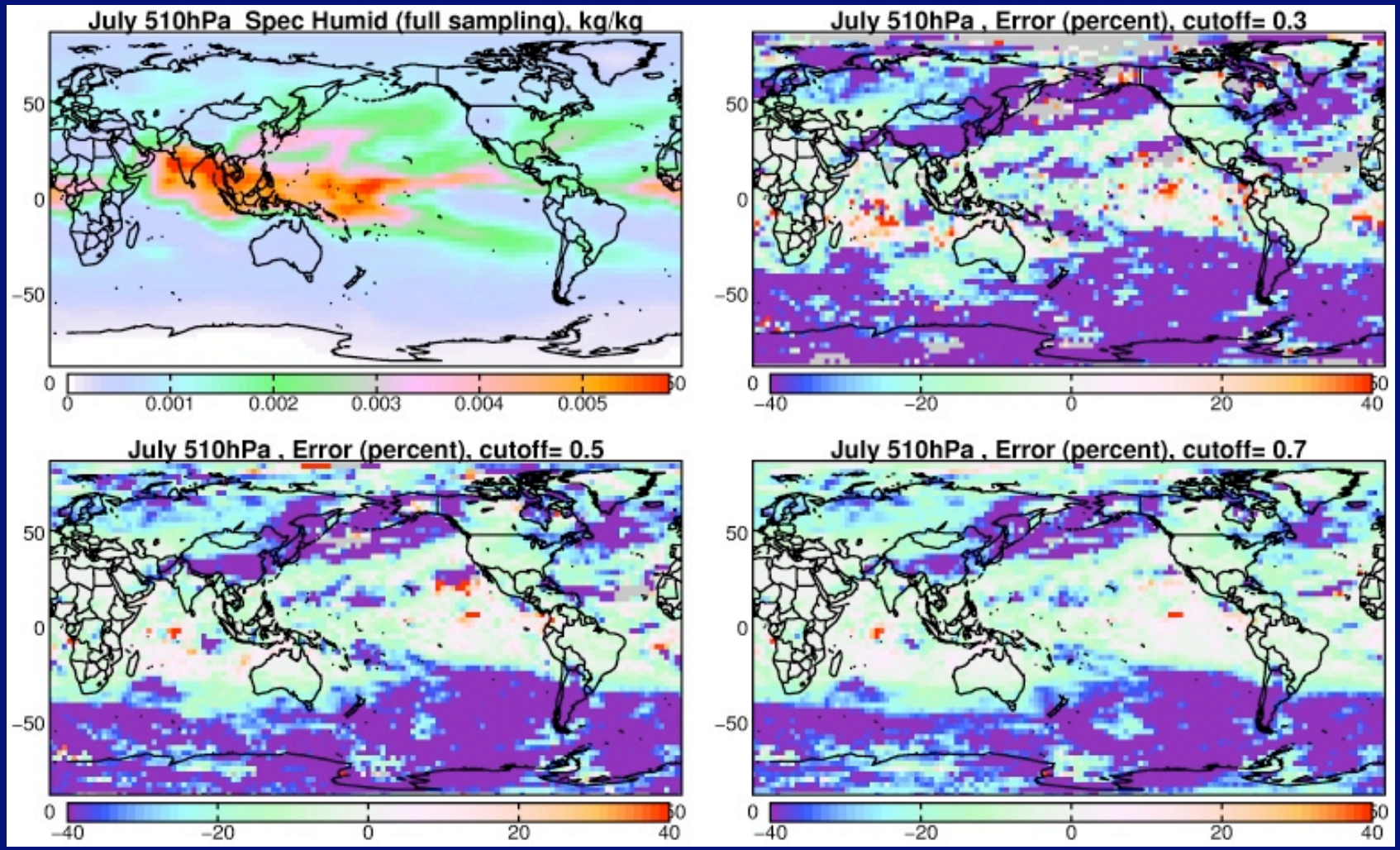
# Effect of cloud sampling

- Can be tested in "model world." Sub sampled less Full

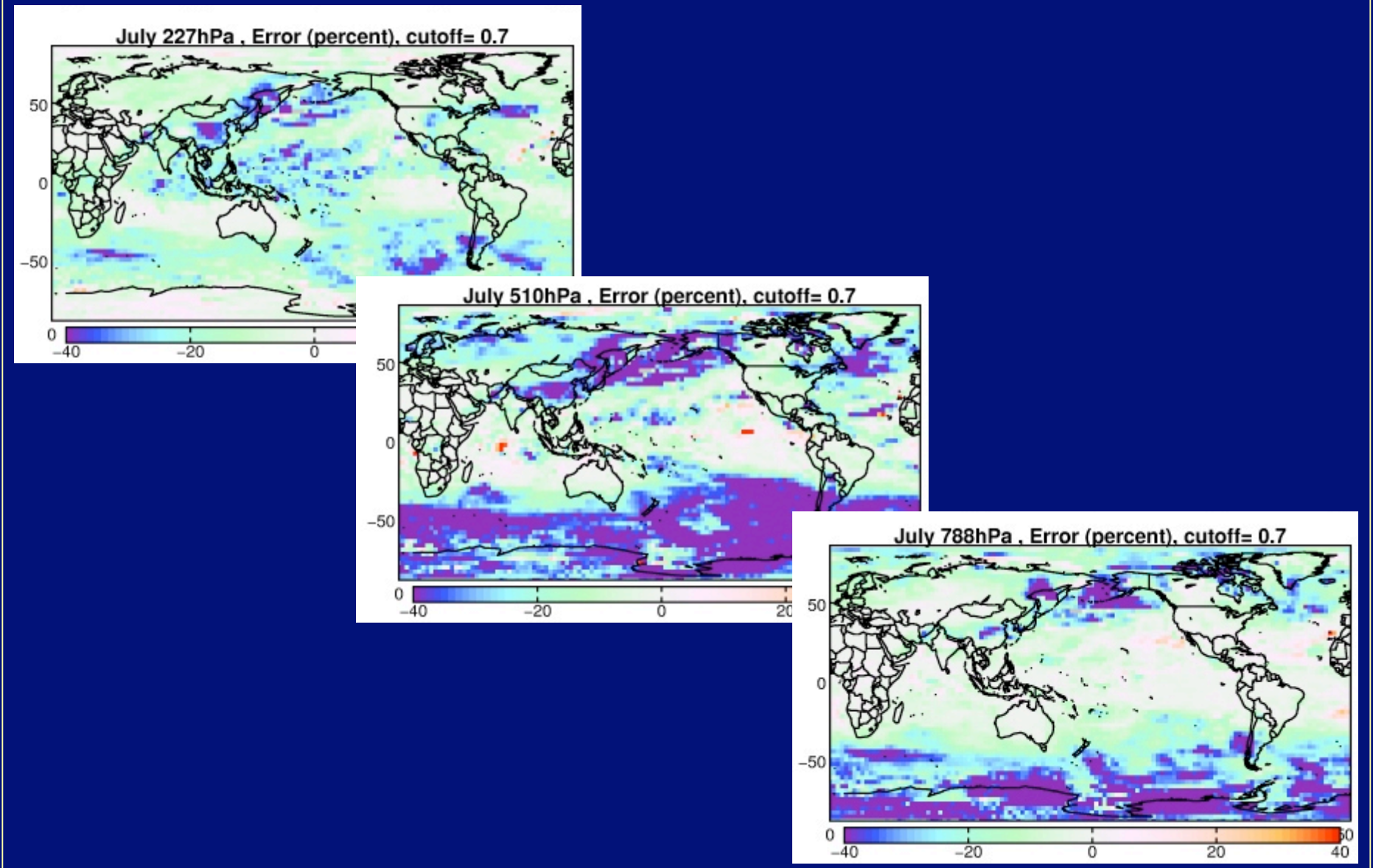


# Effect of cloud sampling

- Can be tested in "model world." Percent errors



# Midlevels are worst; isn't so bad above and below



# That was model world – what about real world?

- AIRS valid samples vs. *all* sonde data at Lihue

| Pressure layer (mb) | AIRS (g/kg) | Sonde (g/kg) | Difference (%) |
|---|---|---|---|
| 1000-925 | 11.39 | 11.18 | 1 |
| 925-850 | 8.90 | 9.16 | -2 |
| 850-700 | 3.86 | 3.47 | 11 |
| 700-600 | 1.27 | 1.13 | 11 |
| 600-500 | 0.67 | 0.71 | -6 |
| 500-400 | 0.37 | 0.41 | -10 |
| 400-300 | 0.16 | 0.17 | -8 |
| 300-200 | 0.061 | 0.058 | 5 |

Averages based on 850 AIRS and 124 sonde values; AIRS footprint within 100 km of Lihue. 12/02-01/03. Data from E. Fetzer, JPL

# Real world, continued

- AIRS valid samples vs. *all* sonde data at Nauru (ARM TWP)

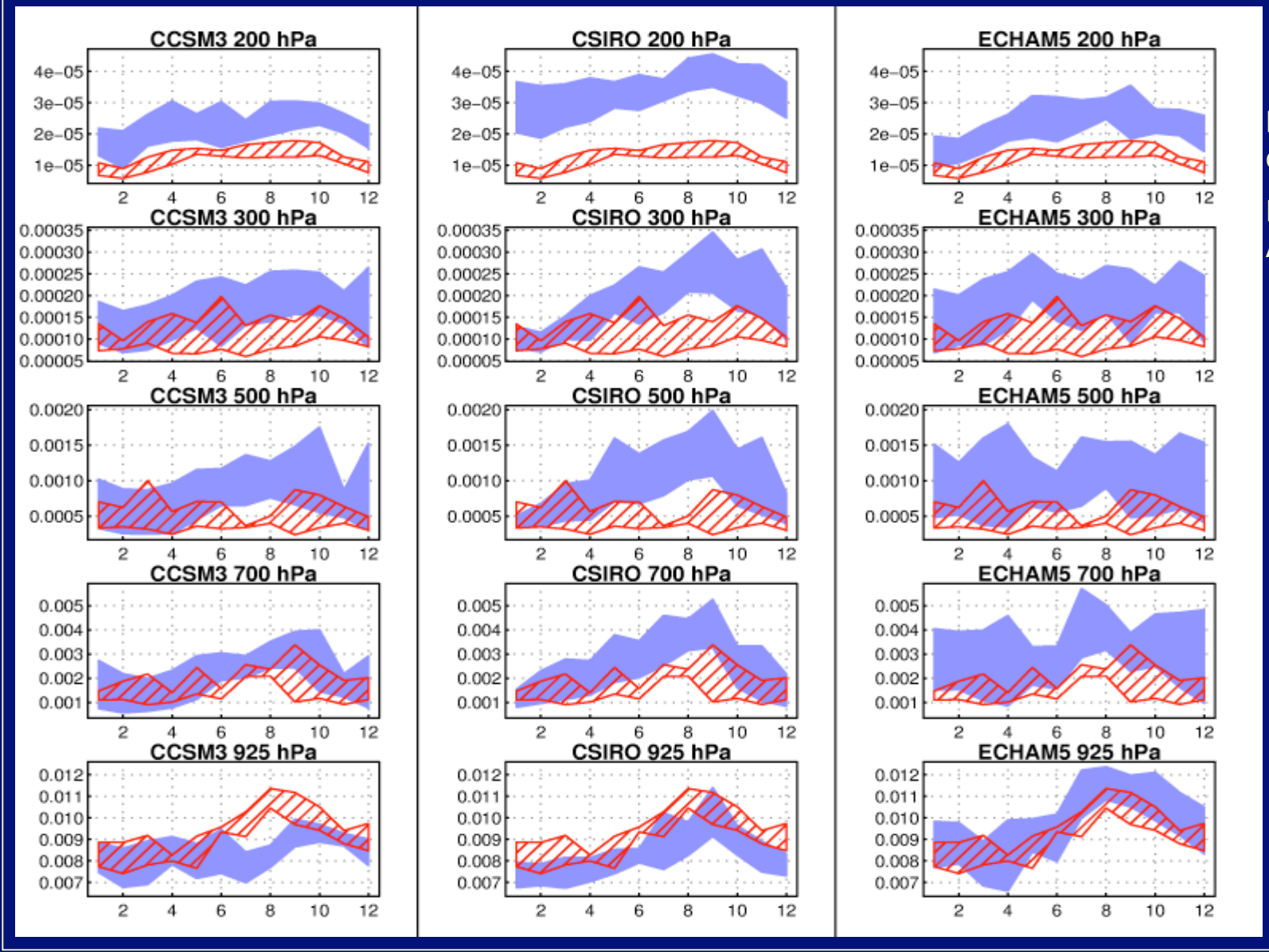
| Pressure layer (mb) | AIRS (g/kg) | Sonde (g/kg) | Difference (%) |
|---|---|---|---|
| 1000-925 | 16.79 | 17.76 | -5 |
| 925-850 | 14.09 | 13.73 | 2 |
| 850-700 | 10.05 | 9.61 | 4 |
| 700-600 | 6.81 | 6.49 | 4 |
| 600-500 | 4.40 | 4.32 | 1 |
| 500-400 | 2.47 | 2.41 | 2 |
| 400-300 | 1.00 | 0.94 | 6 |
| 300-200 | 0.31 | 0.31 | -1 |

Averages based on 851 AIRS and 71 sonde values; sonde launched when AIRS within 30 degrees. 09/02-04/03. Data from E. Fetzer, JPL

# Cloud sampling summary

- Model suggests cloud sampling biases are worst poleward of $40^{o}$, at midlevels (400-700 hPa)
- In those regions sampling only when cloud fraction < 0.7 can underestimate specific humidity by 40%
- Between $40^{o}$S to $40^{o}$N, bias generally ~5% or less
- Roughly consistent with radiosonde comparison

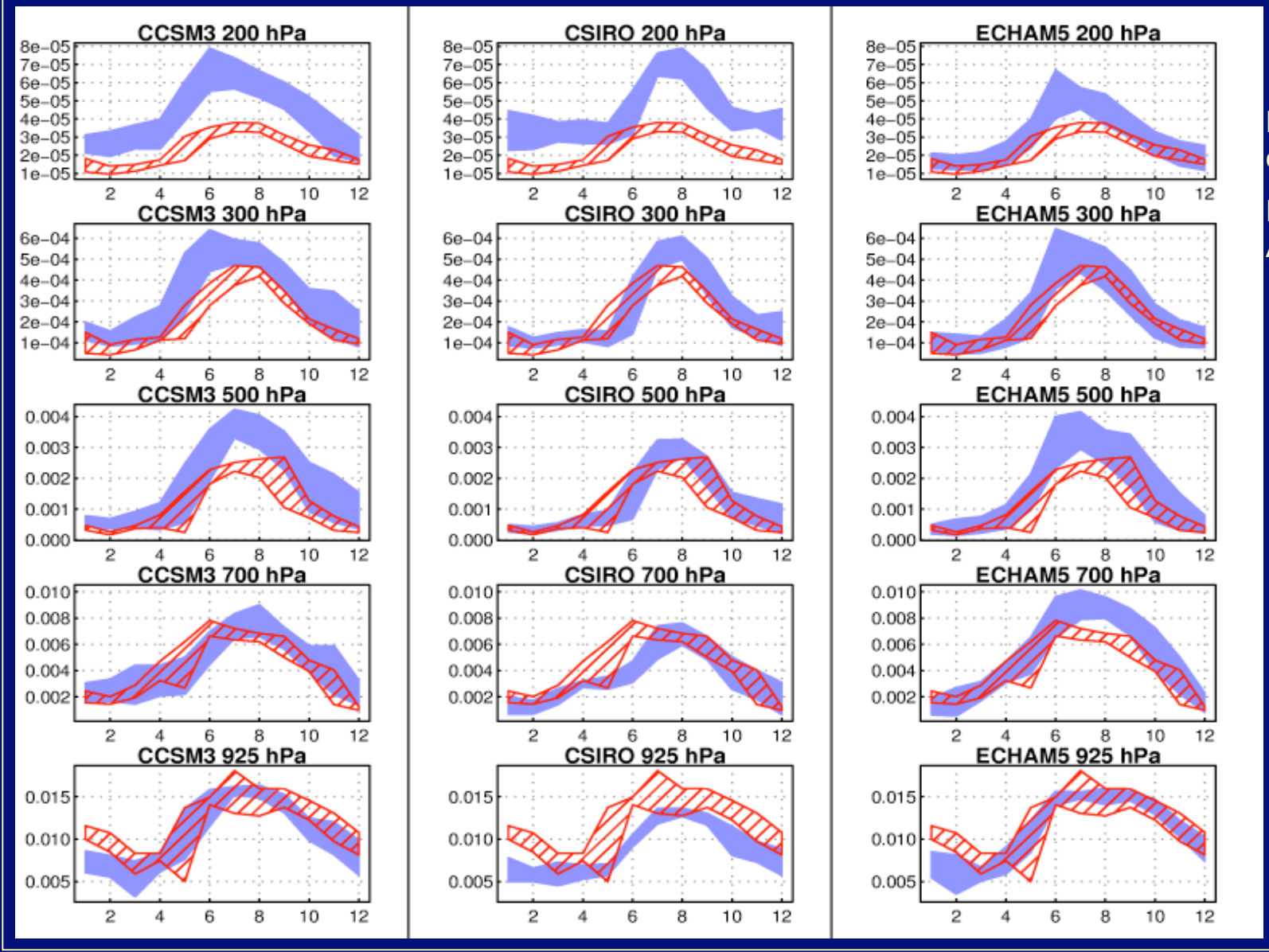
# Seasonal cycle at various locations: North Pacific




Blue = 10 yrs of model

Red = 3 yrs of AIRS

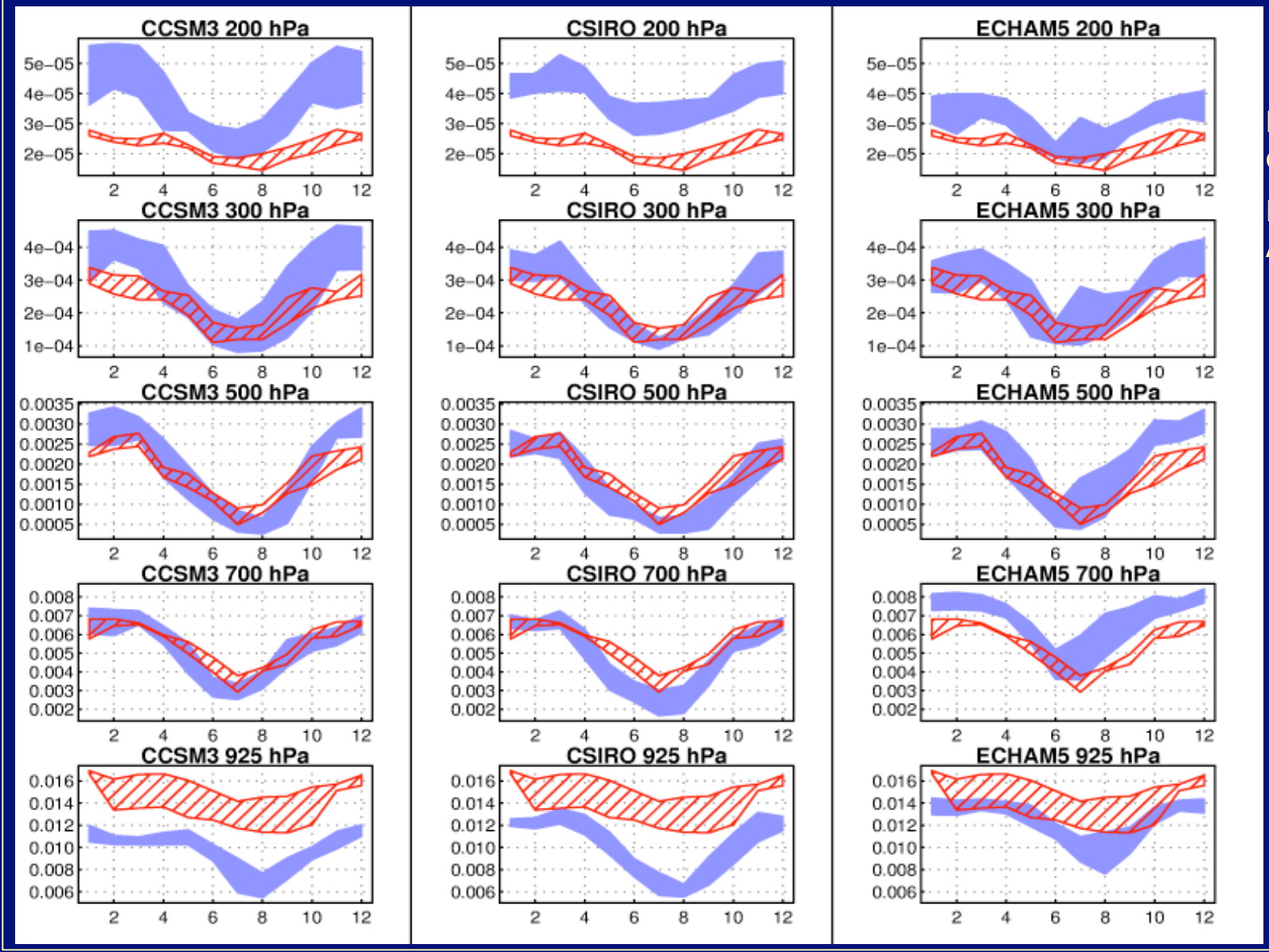
# Seasonal cycle at various locations: Central India




Blue = 10 yrs of model

Red = 3 yrs of AIRS

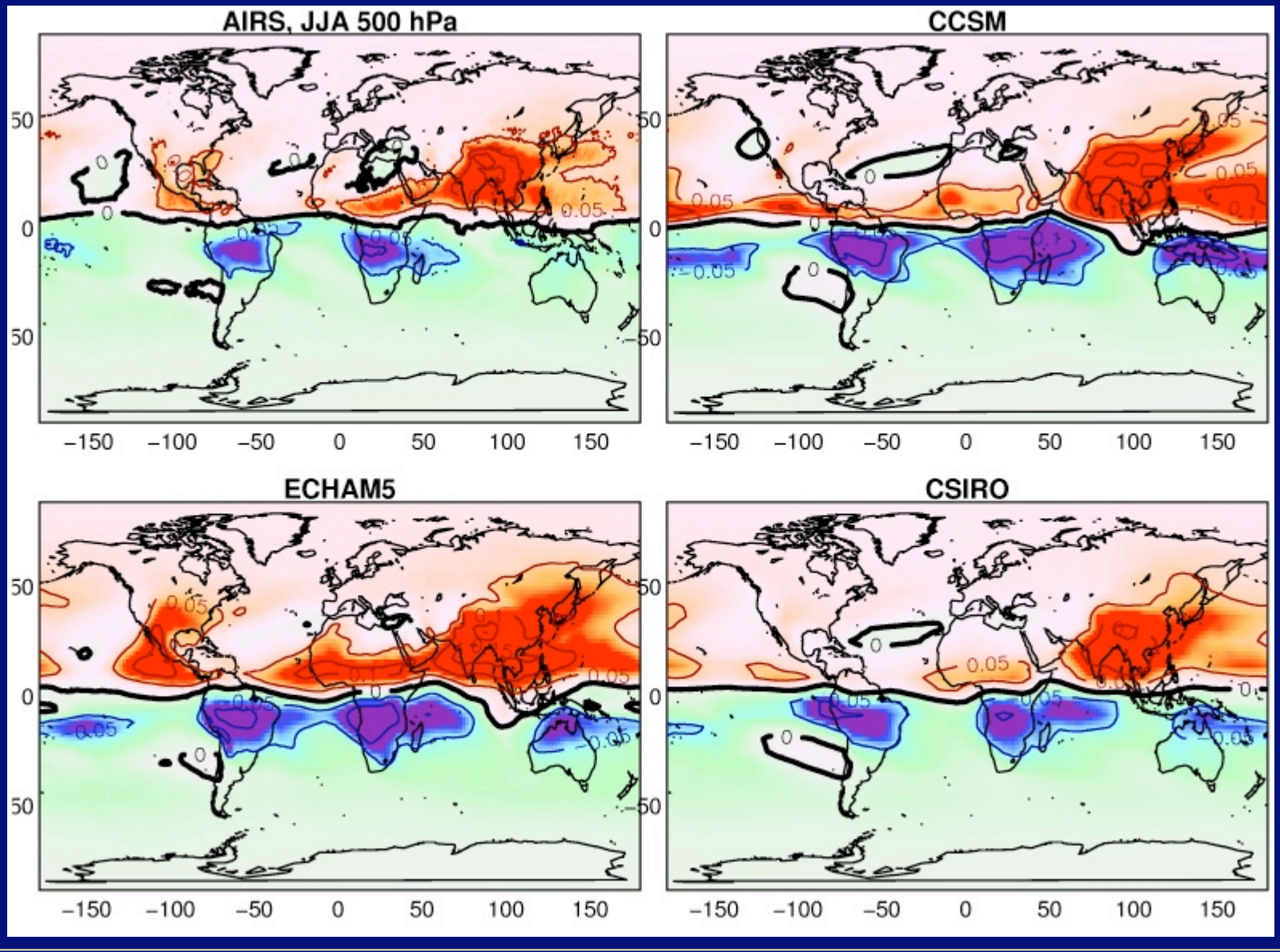
# Seasonal cycle at various locations: Amazon Basin



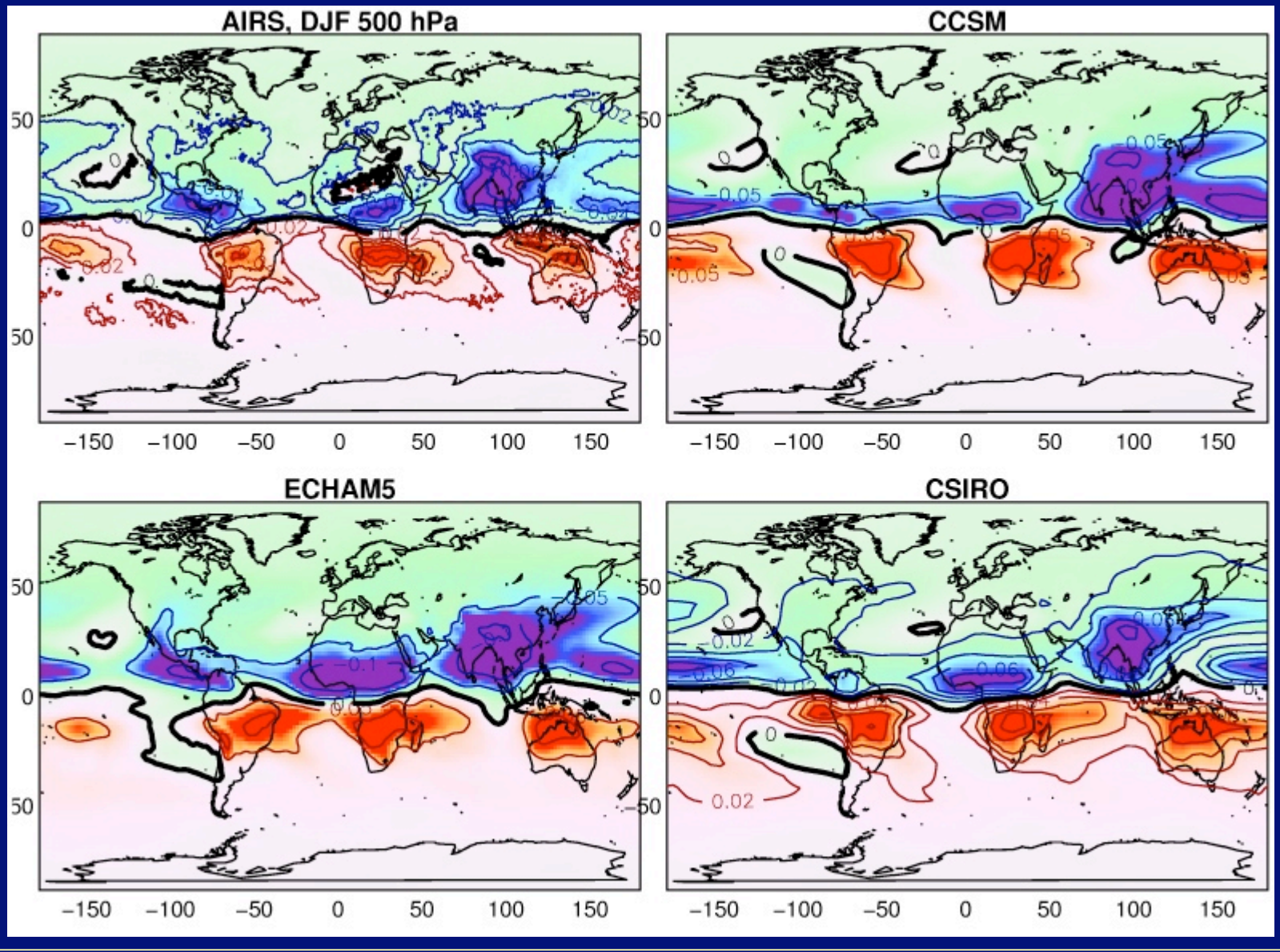

Blue = 10 yrs of model

Red = 3 yrs of AIRS

# Seasonal cycle, 500 hPa (JJA anoms from annual mean)



# Seasonal cycle, 500 hPa (DJF anoms from annual mean)



# Conclusions

- Coupled climate models show systematic moist biases compared to AIRS
- Largest biases (> 50%) tend to be at high altitudes, and between about 40°S to 40°N
- Altitude dependence argues against diurnal cycle issue
- Cloud sampling does not seem to be the cause, according to model estimates and radiosonde evaluation of sampling error
- Probably systematic coupled model errors
- Seasonal cycle *around* the (overly moist) mean not too bad, perhaps modestly too strong

# What's Next?

- Does the CGCM moist bias 'make a difference'?
- Estimate space/time sampling bias, e.g. footprint vs. point data vs. CGCM box
- Wider comparison w/ radiosondes
- Relative vs. specific humidity
- AIRS-CGCMs at interannual time scales, e.g. ENSO, PDO, …
- Moisture over western US: 2004-2006

  (Dry-Very Wet-Dry)