Thank You!!! Happy Retirement!

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Diurnal cycle of clouds from satellite data and climate models

(very preliminary results)

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Collaborators: Chris Golaz (GFDL, now at LLNL), Ming Zhao, Yi Ming, Huan Guo, Hailey Shin (all GFDL)

Support: NOAA MAPP project

NOAA MAPP Project:

Diurnal Metrics for Evaluating GFDL and Other Climate Models

Aiguo Dai (SUNY Albany), Chris Golaz (GFDL, now at LLNL), Junhong Wang (SUNY Albany), Ming Zhao (GFDL), Yi Ming (GFDL)

Motivation:

1. Diurnal cycle is not well simulated in GFDL and other models for Tas, P and other fields;
2. Physical processes underlying the diurnal cycle can be used to diagnose deficiencies in model physics

Objectives:

- To develop a new set of constructive diurnal metrics that can guide modelers to identify problems in simulating certain physical processes in their models
- To improve our understanding of the physical processes underlying major diurnal variations.

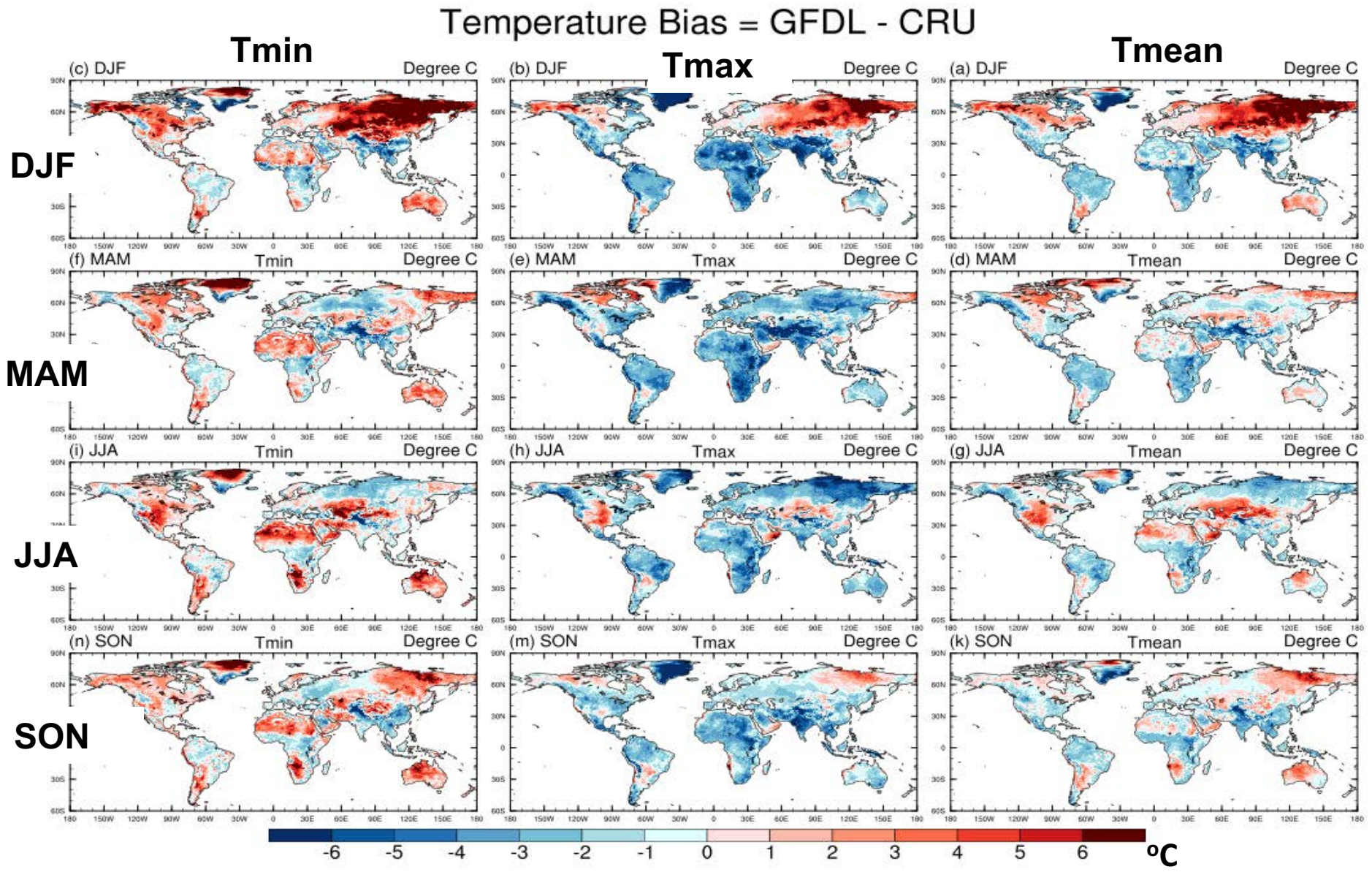
AM4 prototype: AM4g5

- **Physical Parameterizations:**
  - **convection:** double plume
  - **cloud microphysics:** Rotstayn-Klein
  - **planetary boundary layer:** Lock scheme
- **Resolution:**
  - **horizontal:** 0.625 X 0.5 degree
  - **vertical:** 32 layers (from sfc to 1 hPa)
- **Temporal:** hourly 2006-2010

Ref: Zhao, M., et al., The GFDL Global Atmosphere and Land Model AM4.0/LM4.0: Documentation with Prescribed SST Simulations, *to be submitted to JAMES*

Diurnal metrics data

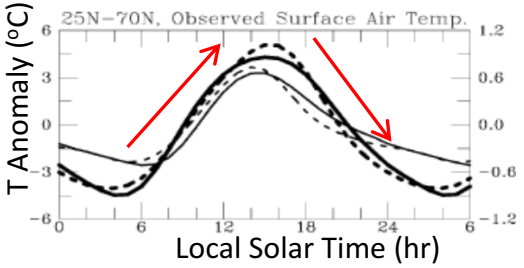
Dataset name	Source data	Metric data
GFDL-am4 V1	0.625X0.5 Hourly (3-hrly for clouds) 2006-2010	0.625 x 0.5 hourly
ISCCP-D2	280km equal-area-grid monthly-averaged 3-hrly 1994-2009	0.625x0.5 3-hourly
Surface observation	Station 3-Hourly 1976-2005	0.25 x 0.45 3hrly
ERA-Interim	0.5X0.5 6-hourly 1997-2010	--
MERRA-2	0.67x0.5 Hourly 1980-2009	5x4 3-houly



- **Cold biases in daily maximum T (Tmax), except DJF central and northern Asia and JJA central U.S.**
- **Mostly warm biases in daily minimum T (Tmin)**
- **Cold biases in daily mean T (Tmean), except DJF central and northern Asia and JJA central U.S.**

Processes Controlling Tmin, Tmax and DTR

(Dai et al. 1999, *J. Clim*; Dai & Trenberth 2004)

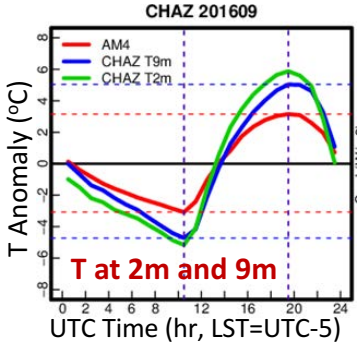


1. Tmax and (Tmax – Tmean):

Sfc solar heating: surface and atmospheric albedo (snow/ice, clouds), atmospheric absorption (H2O, aerosols)

Evaporative cooling: soil moisture, near-surface wind speed and RH

Tmax decreases with height



2. Tmin and (Tmean-Tmin):

Surface LW cooling: surface T gradient (Ts-Tas), near-surface water vapor, low-cloud fraction

3. DTR (=Tmax–Tmin):

Surface solar heating: low solar heating→ low Tmax and low DTR

Surface evaporative cooling: too much LH flux→ low Tmax and low DTR

Smoothed terrain: low elevation→ lower nighttime LW cooling and lower DTR

LW affects both Tmin and Tmax and thus has relatively small effects on DTR.

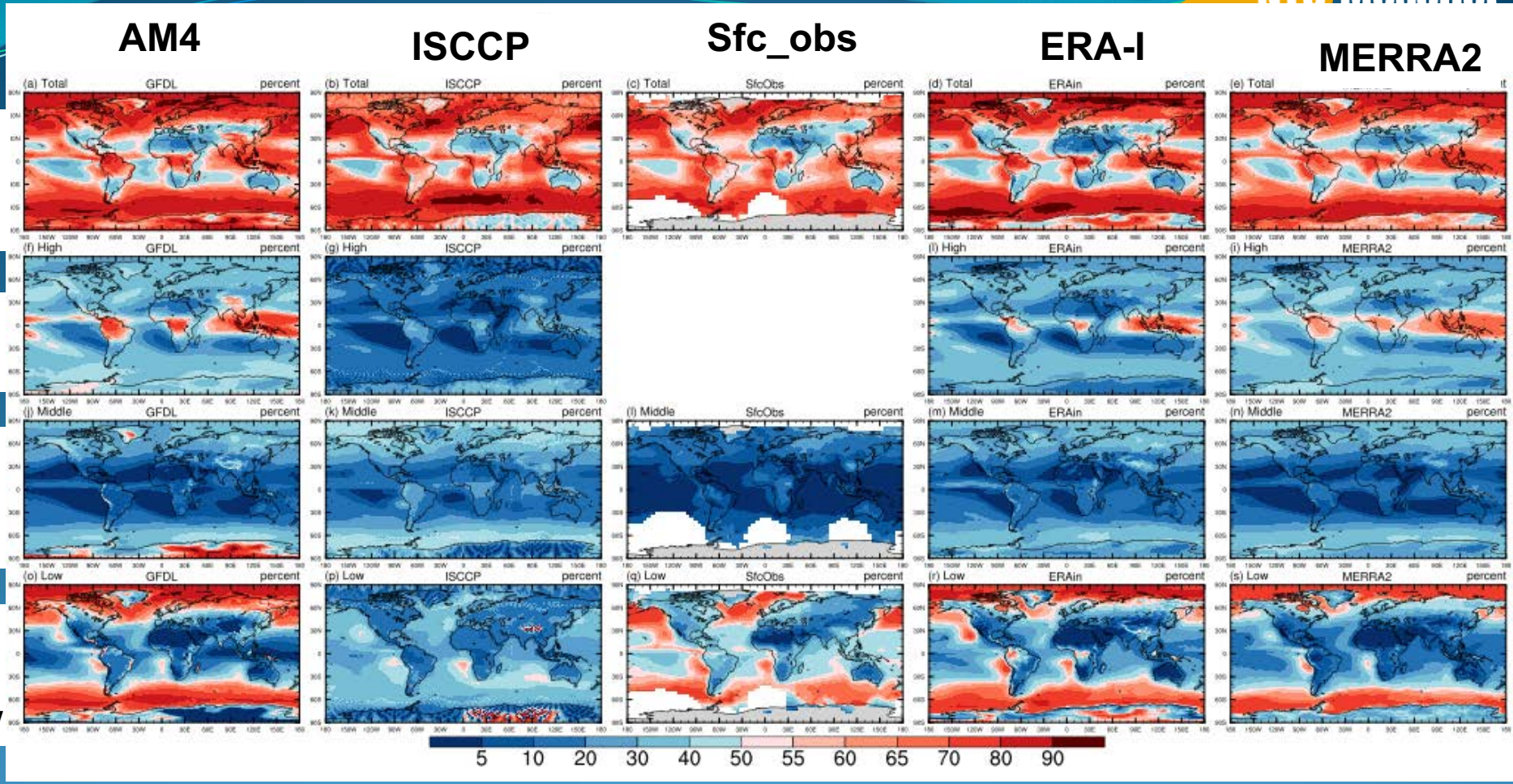
The diurnal temperature range in the CMIP5 models

Jenny Lindvall and Gunilla Svensson
Climate Dynamics (2014)

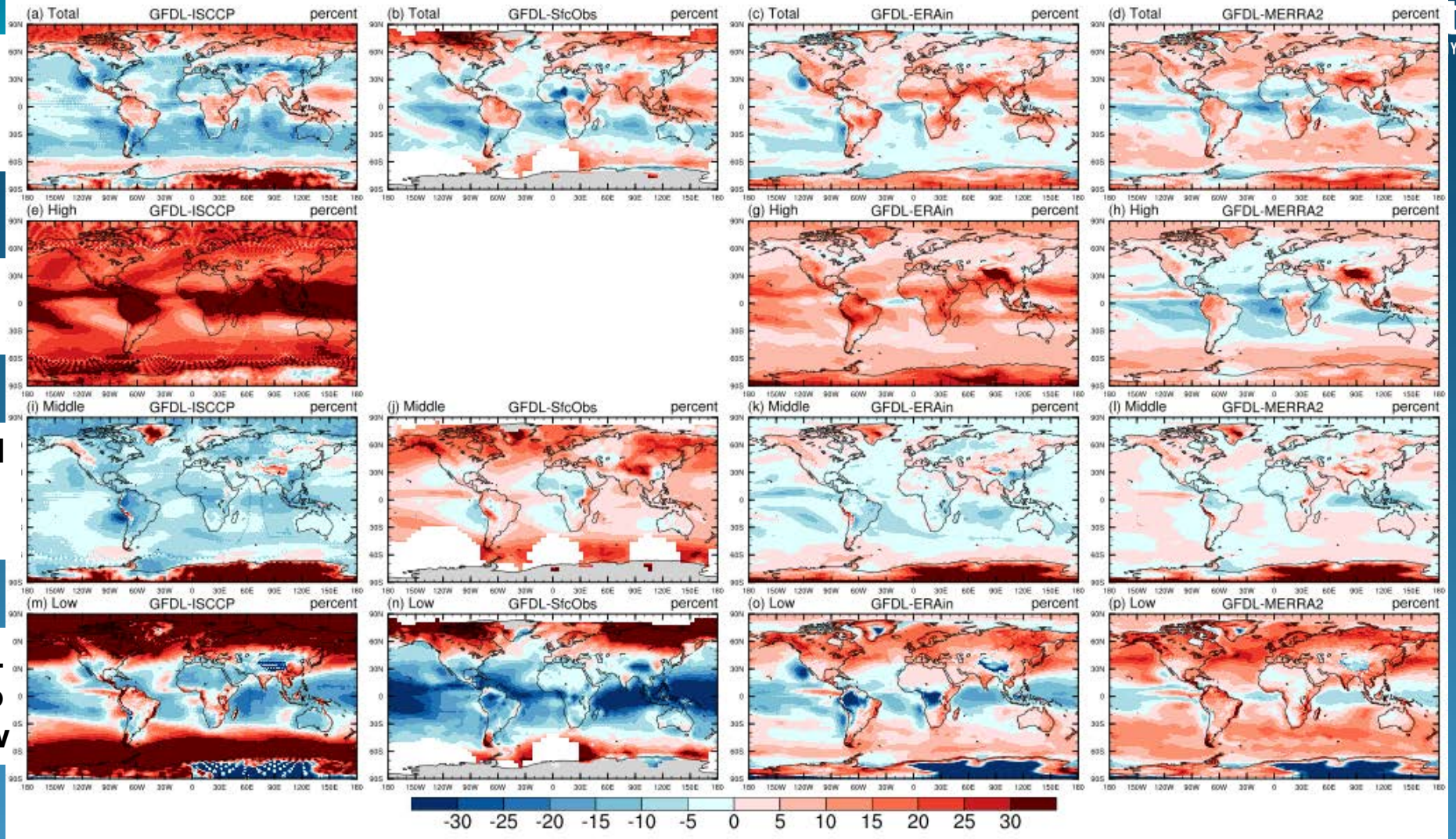
- The DTR varies substantially between different CMIP5 models, particularly in the subtropics, and is generally underestimated.

- The DTR integrates many processes and neither the model differences in the DTR nor in the change in DTR can be attributed to a single parameter. Which variables that impact the model discrepancies vary both regionally and seasonally. However, **clouds seem to matter in most regions and seasons and the evaporative fraction is important in summer**.

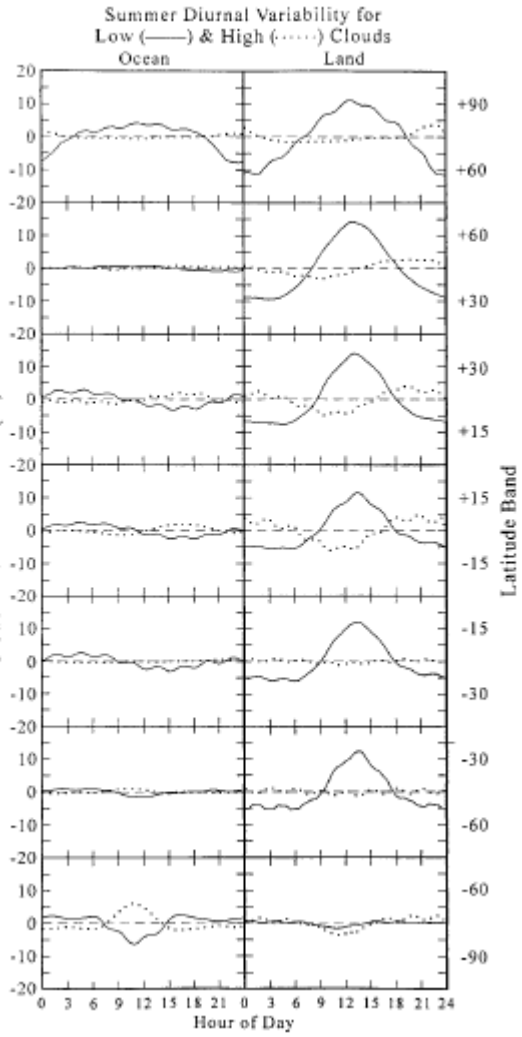
Annual Mean Cloud Amount



- General agreements in total cloud amount
- Less ISCCP high clouds, esp in tropical land areas
- Less Sfc obs middle clouds
- Less ISCCP low clouds in higher latitudes

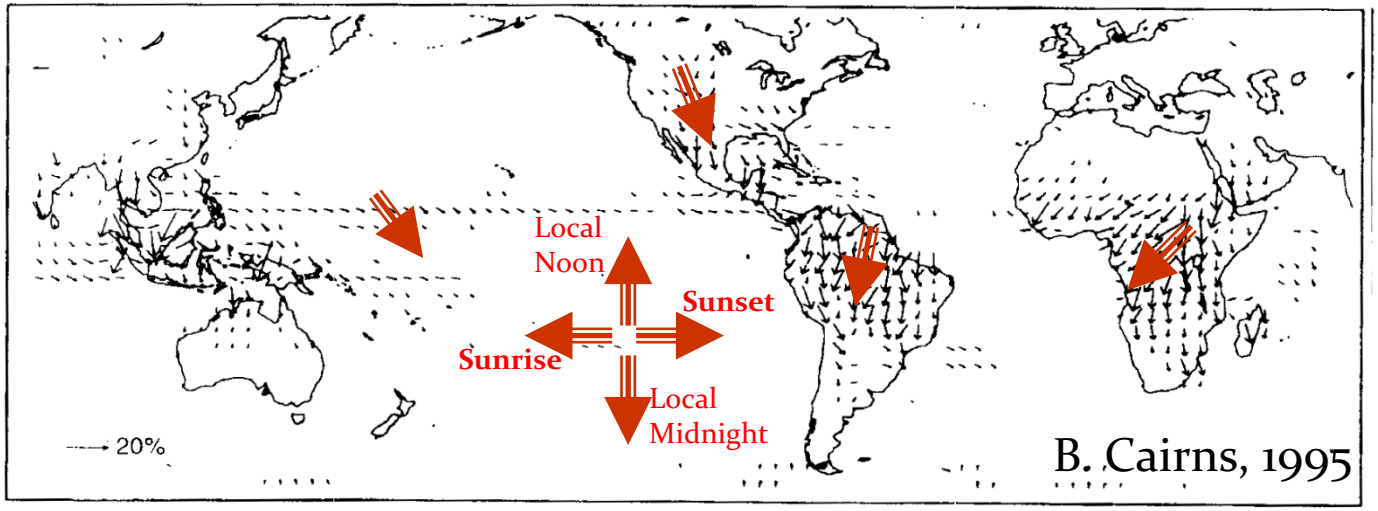


- Overestimate total clouds over land, but underestimate over ocean
- Overestimate high clouds esp over land
- Underestimate low clouds in low latitudes
- Better agreements with RAs

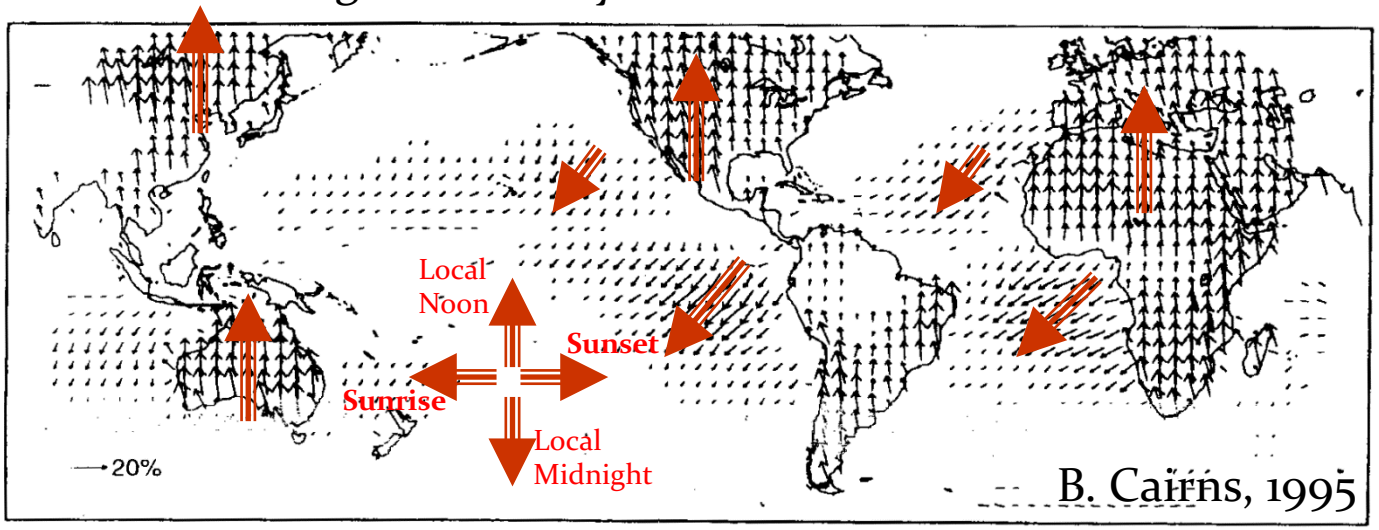


Rossow & Schiffer (1999)

Average Diurnal Cycle of High Clouds

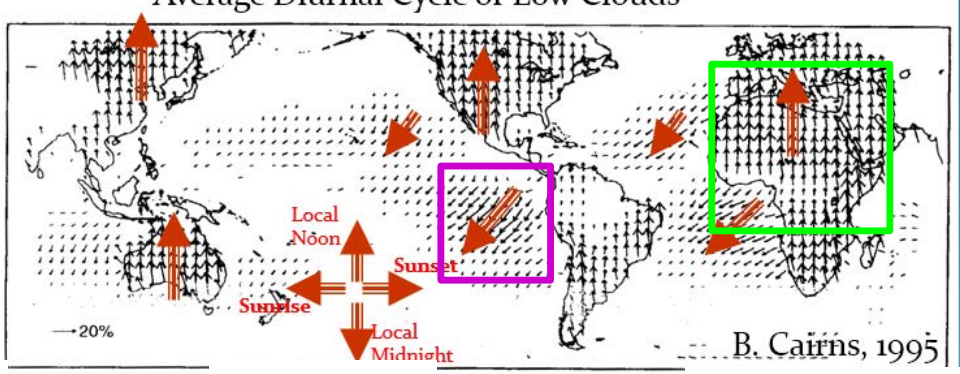


Average Diurnal Cycle of Low Clouds



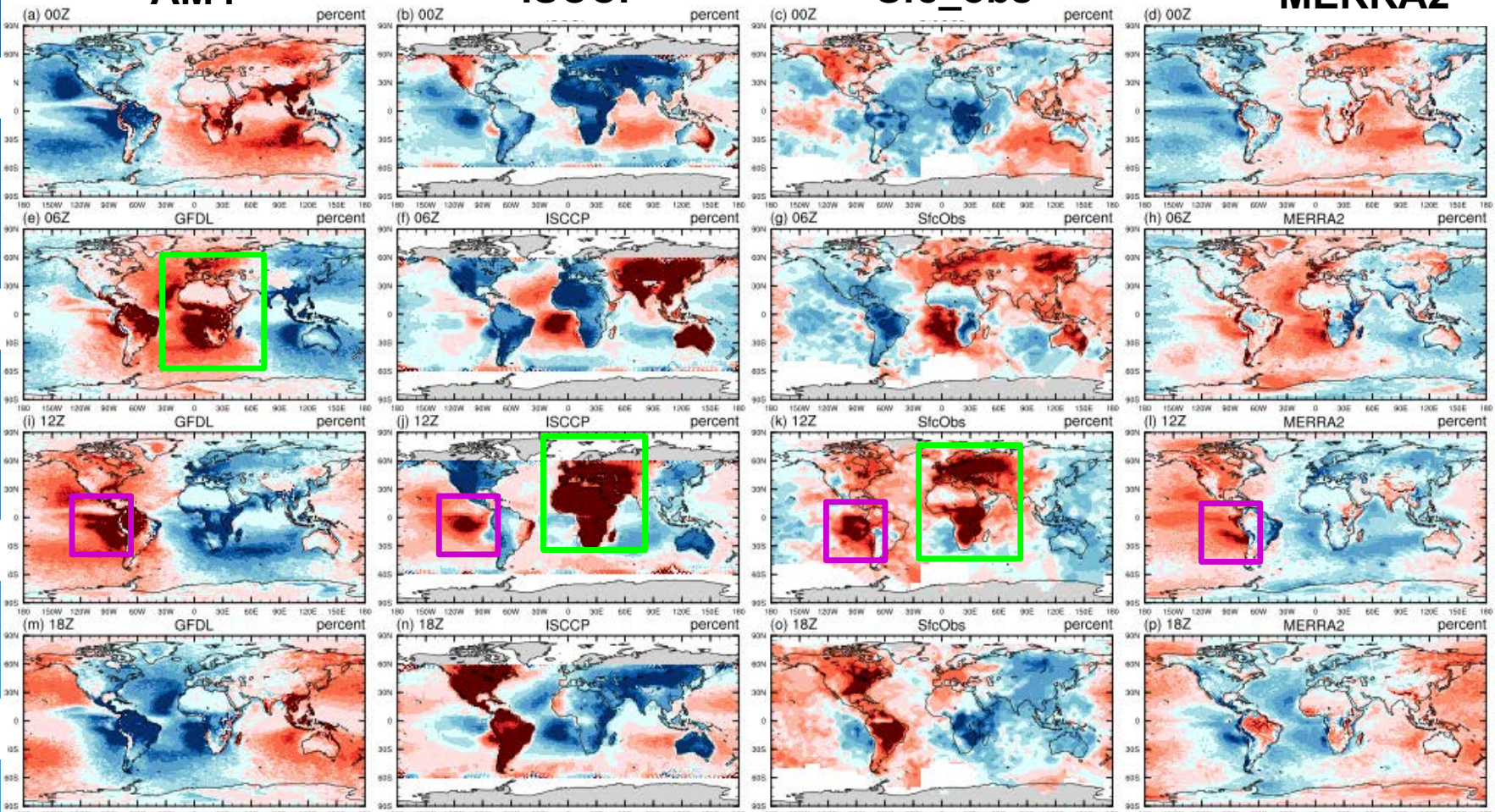
Low Cloud

- Good agreements over ocean
- AM4 peaks earlier over land
- smaller magnitude in MERRA2 over land



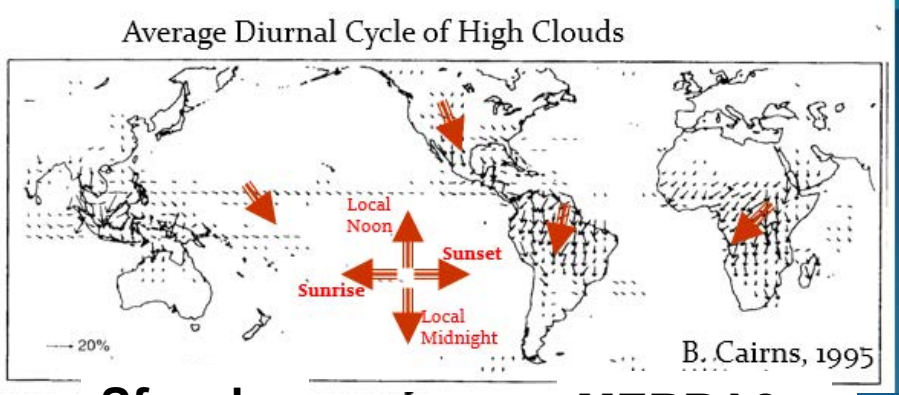
AM4 | ISCCP | Sfc_obs | MERRA2

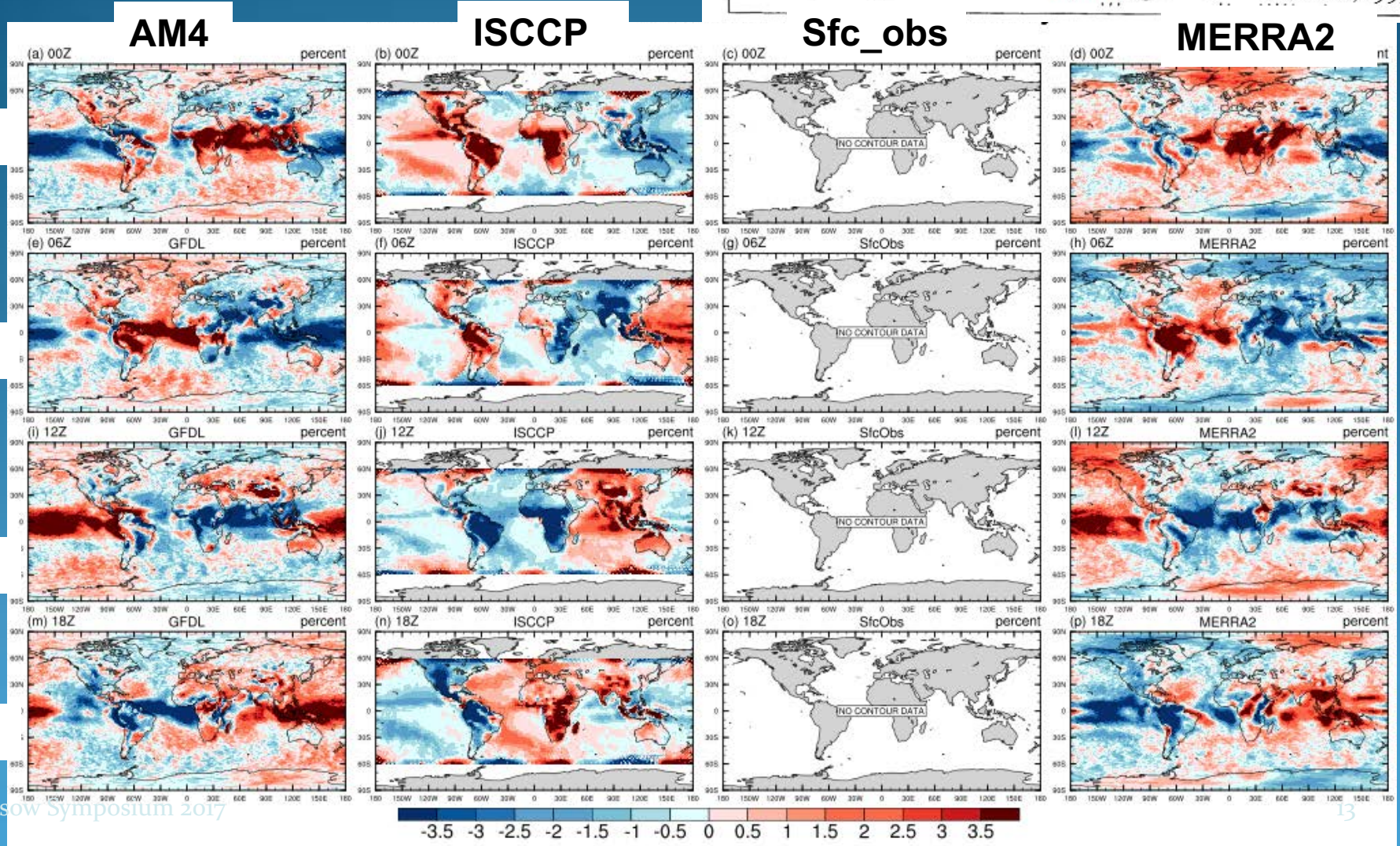
00Z | 06Z | 12Z | 18Z



High Cloud

- Similarity between AM4 & MERRA2, with larger magnitude in tropics
- Larger magnitudes over land










2016
New York State Mesonet
NATIONAL WEATHER SERVICE





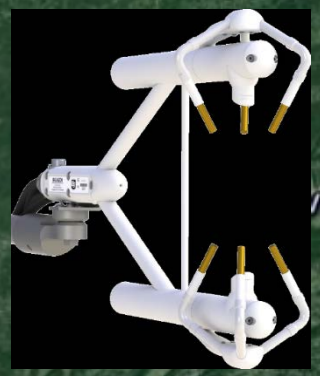


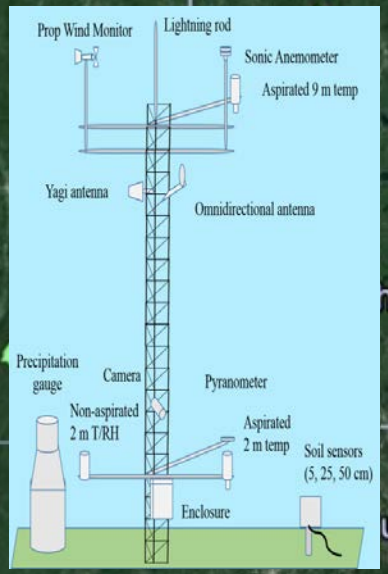


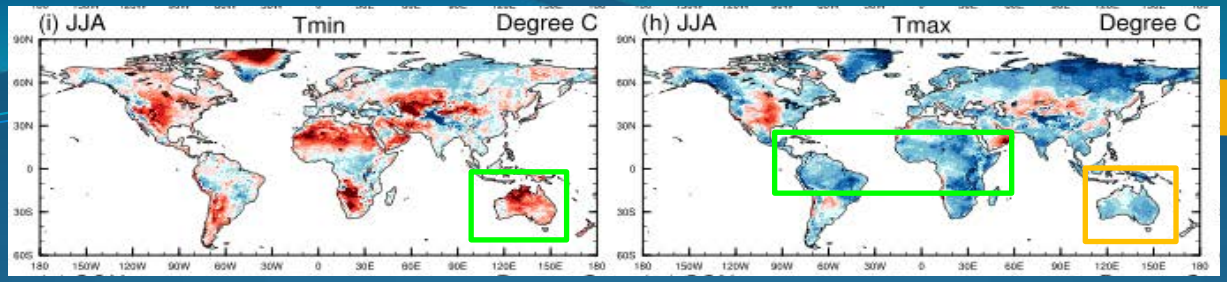

Batavia, NY


NY State Mesonet

- 126 Sites
- Spaced ~19 miles apart
- Reports every 5 minutes







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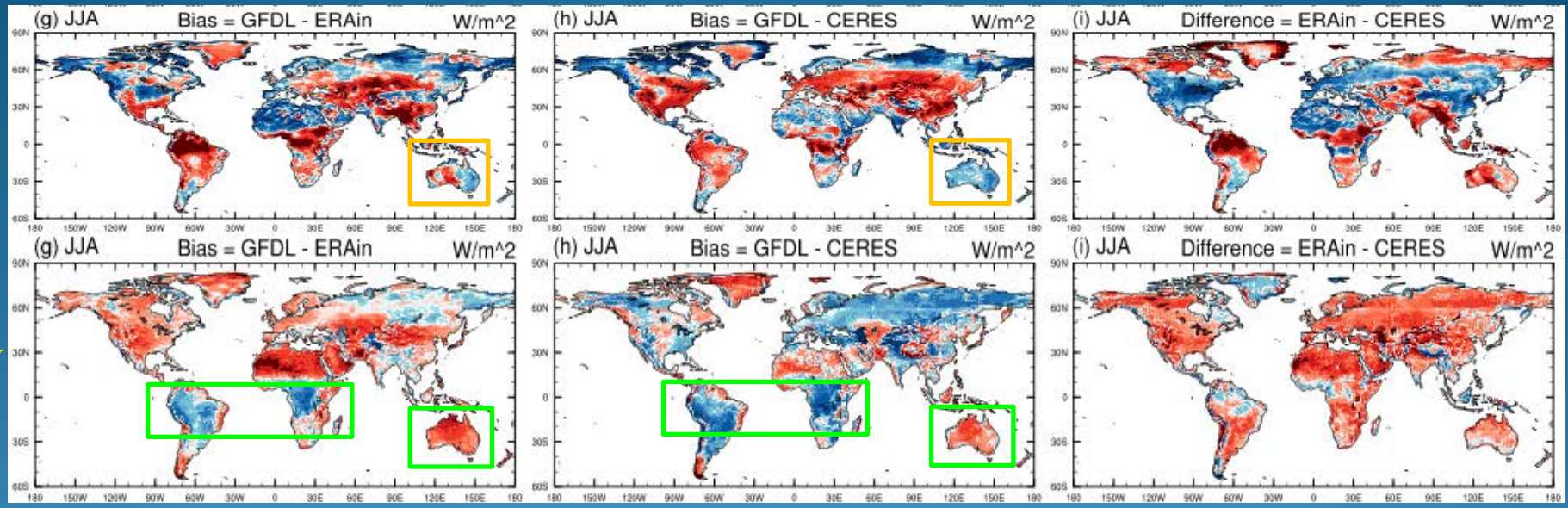
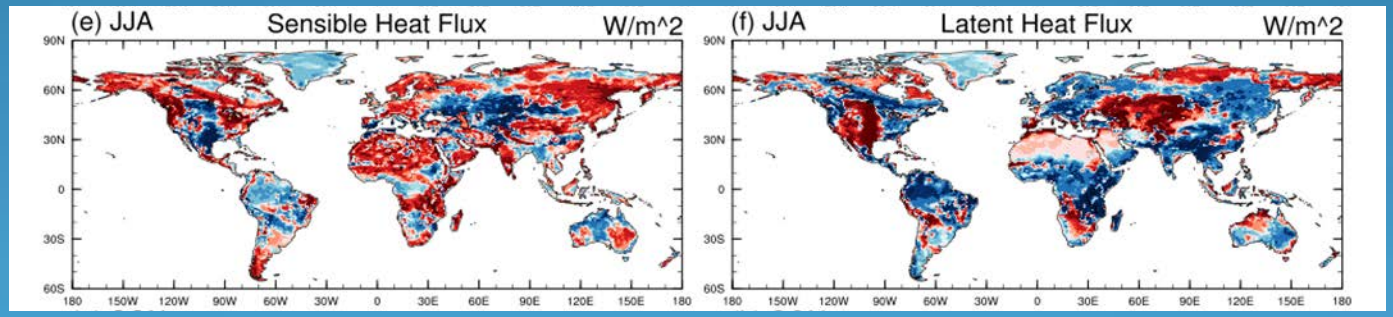
Net SW

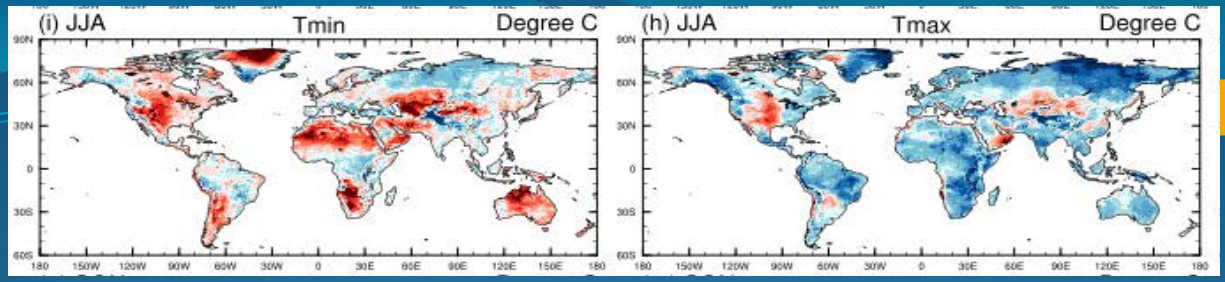


↓ LW

SH
LH



- SW not a cause of the cold Tmax bias in most areas except Australian;
- LW↓ contributes to the cold Tmax biases over S.A. and central Africa & warm bias in Au
- LH contributes to the cold biases in Tmax in general



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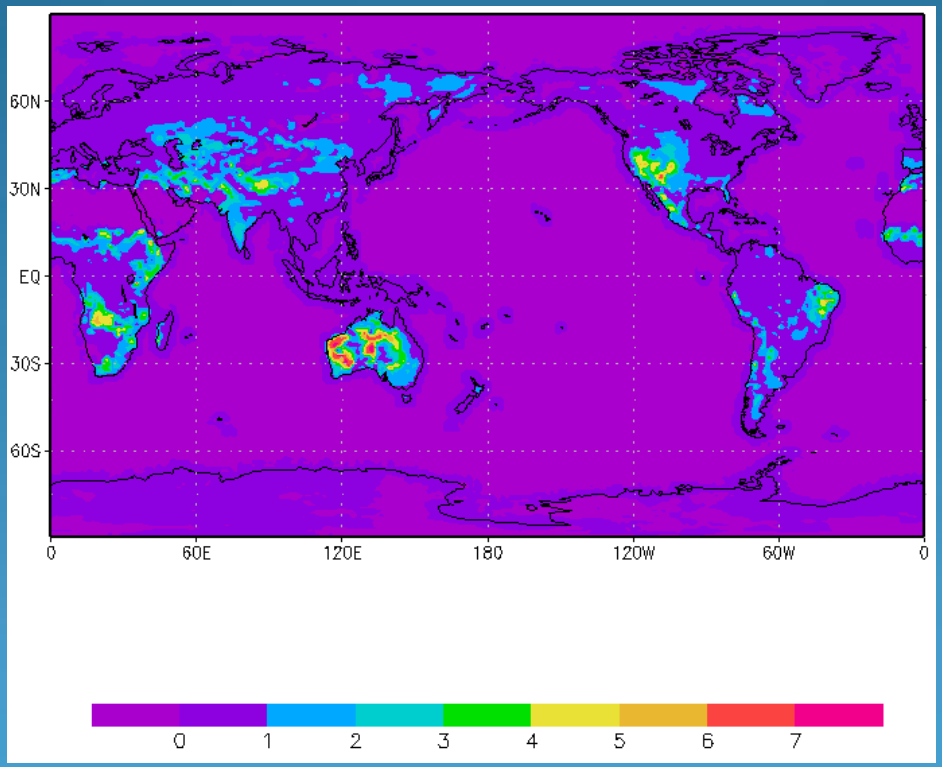
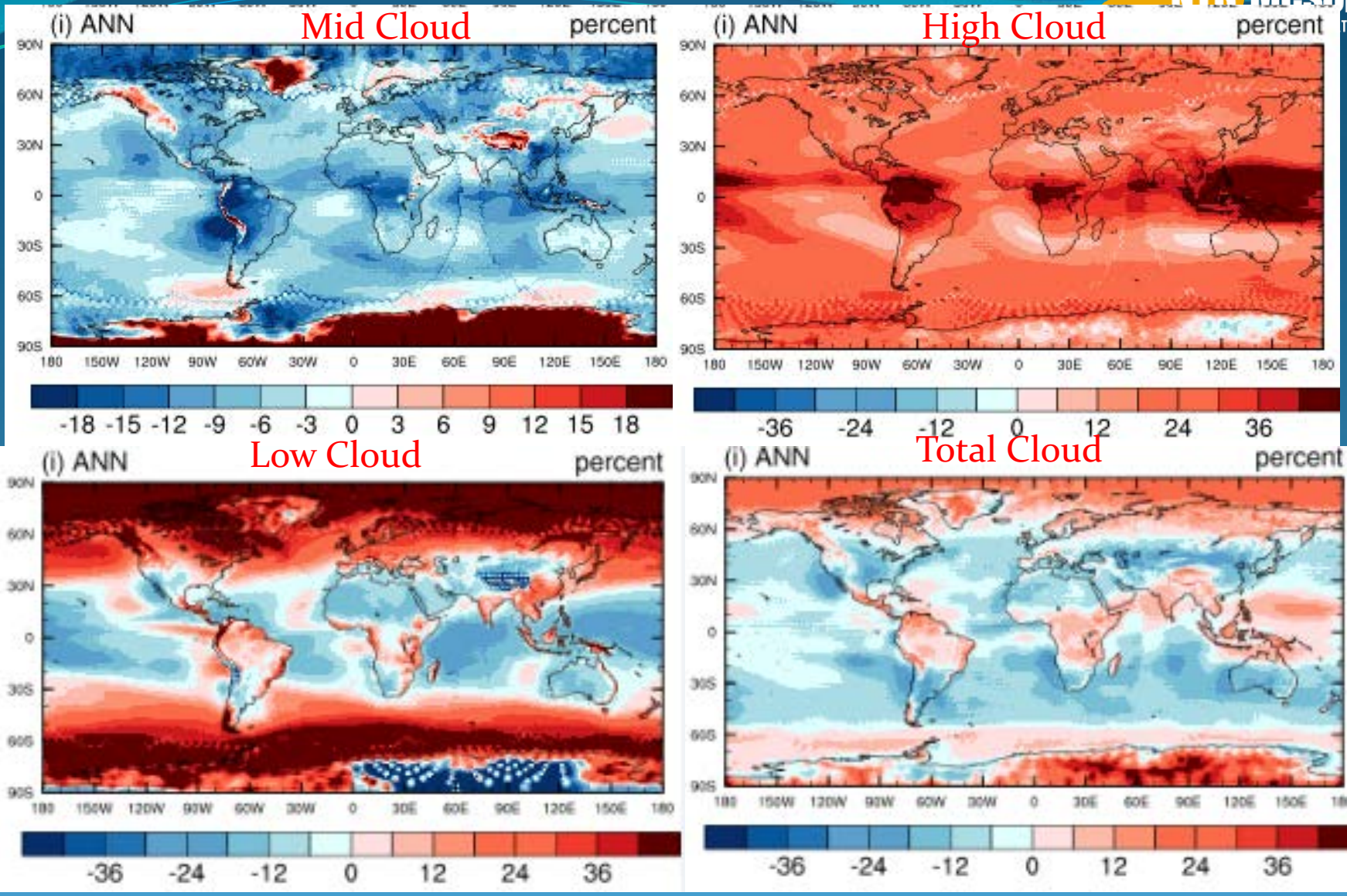
T2 (using T_{sfc}) minus T2 (using T_{ca})



Annual Cloud Amount: GFDL AM4 - ISCCP



- Overestimate high clouds at all latitudes
- Overestimate low clouds in mid-high latitudes, underestimate low clouds in low latitudes
- Underestimate middle clouds (in much smaller magnitude)

Outline

1. Data and analysis method
2. Annual and seasonal cloud amount comparisons
3. Diurnal cycle of cloud amount comparisons
4. Linkage between diurnal biases in surface temperature and cloud amount