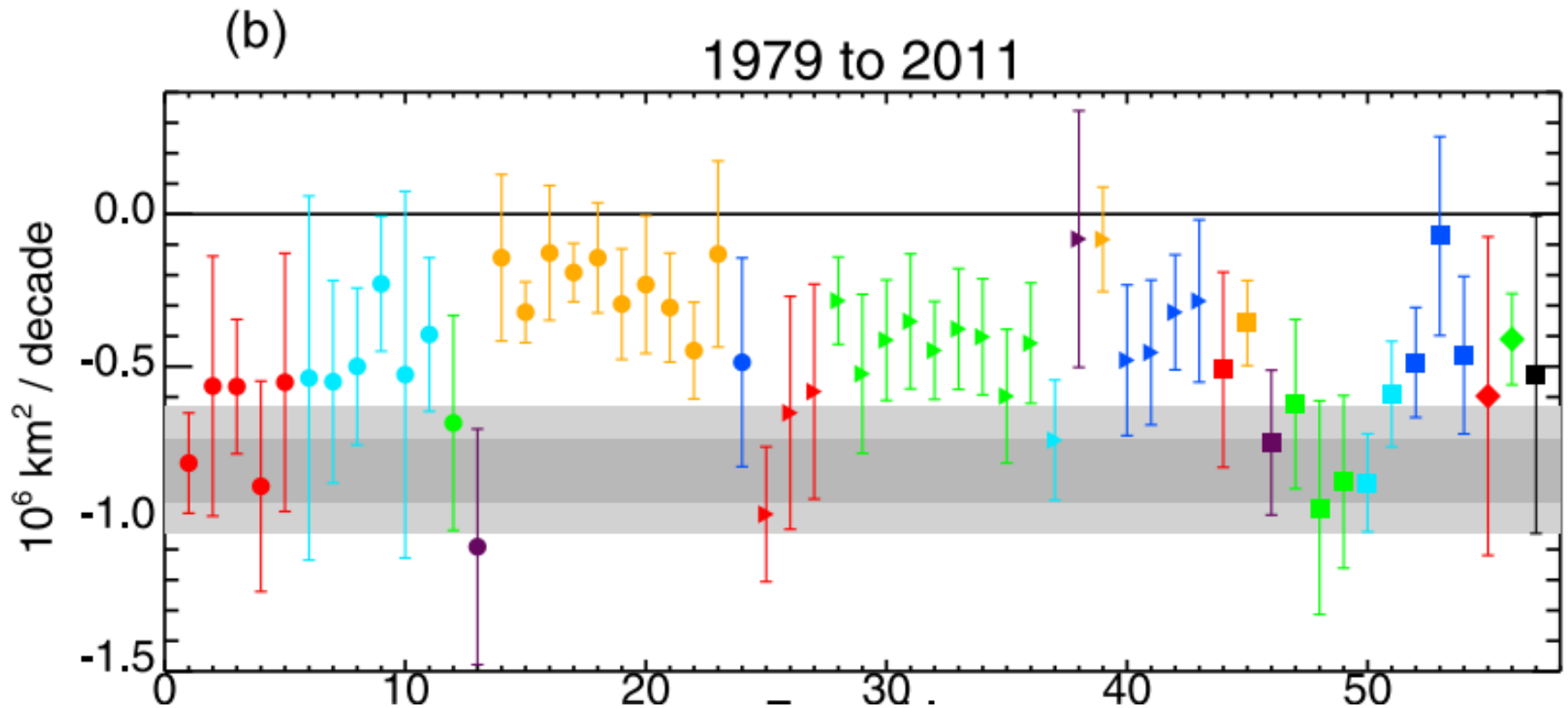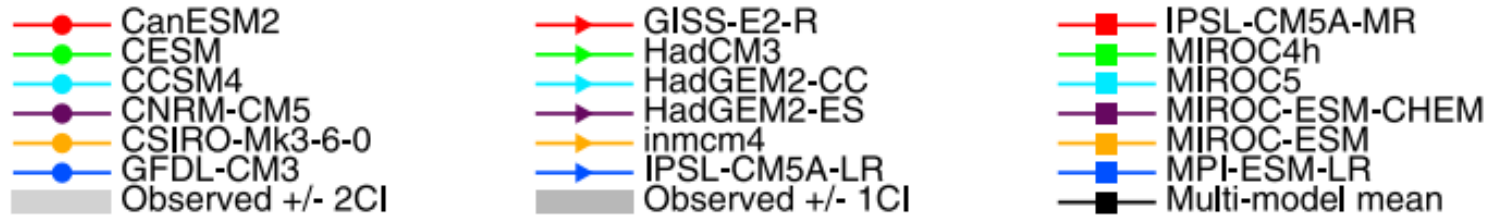# Exploring current and future Arctic TOA radiative fluxes in CMIP5 models
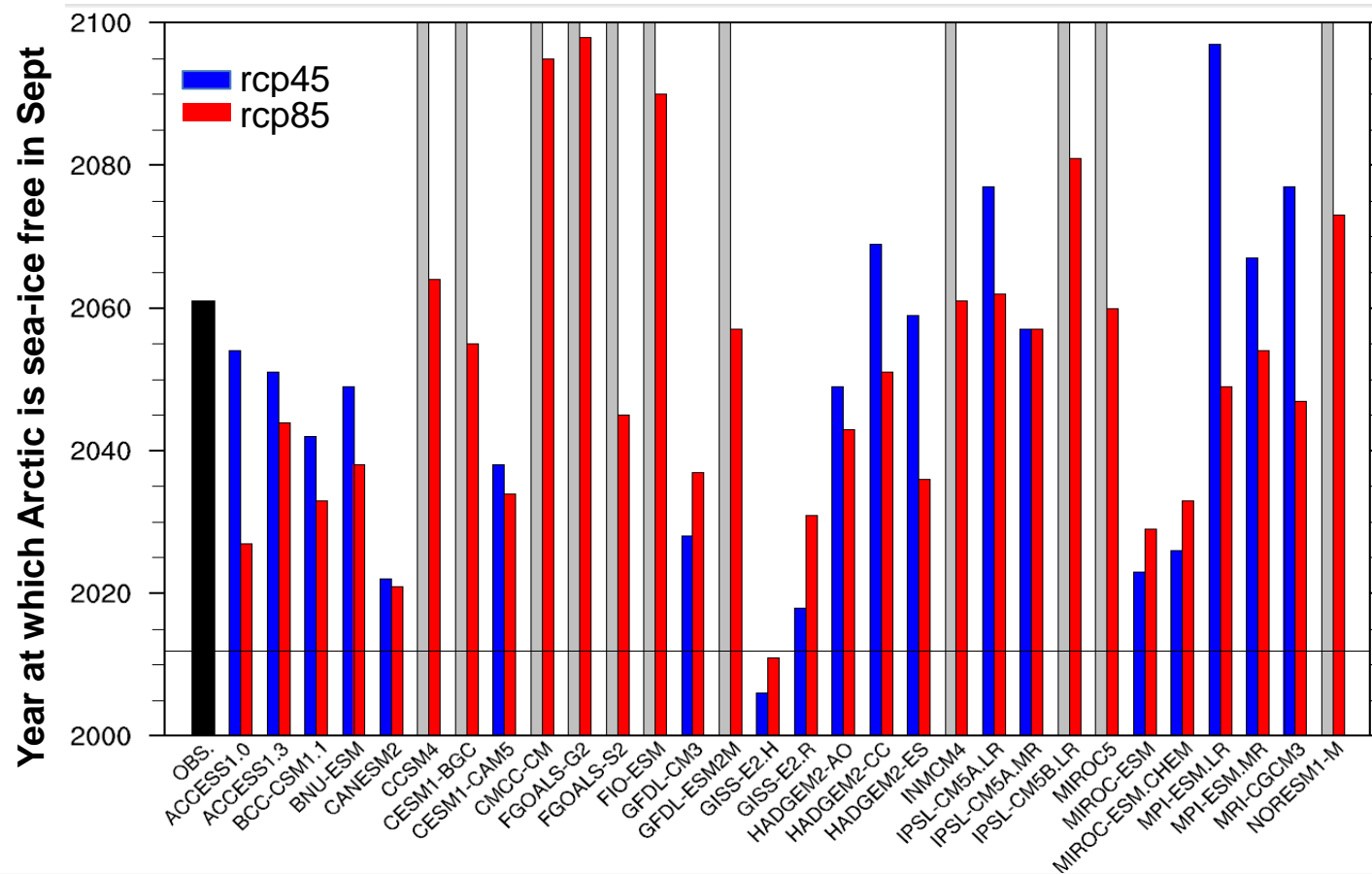
Jason M. English
LASP / University of Colorado
Jan 29, 2014

Thanks to Collaborators
Andrew Gettleman & Jen Kay

NASA MODIS image May 27, 2013

CMIP5 models underestimate observed recent sea ice loss
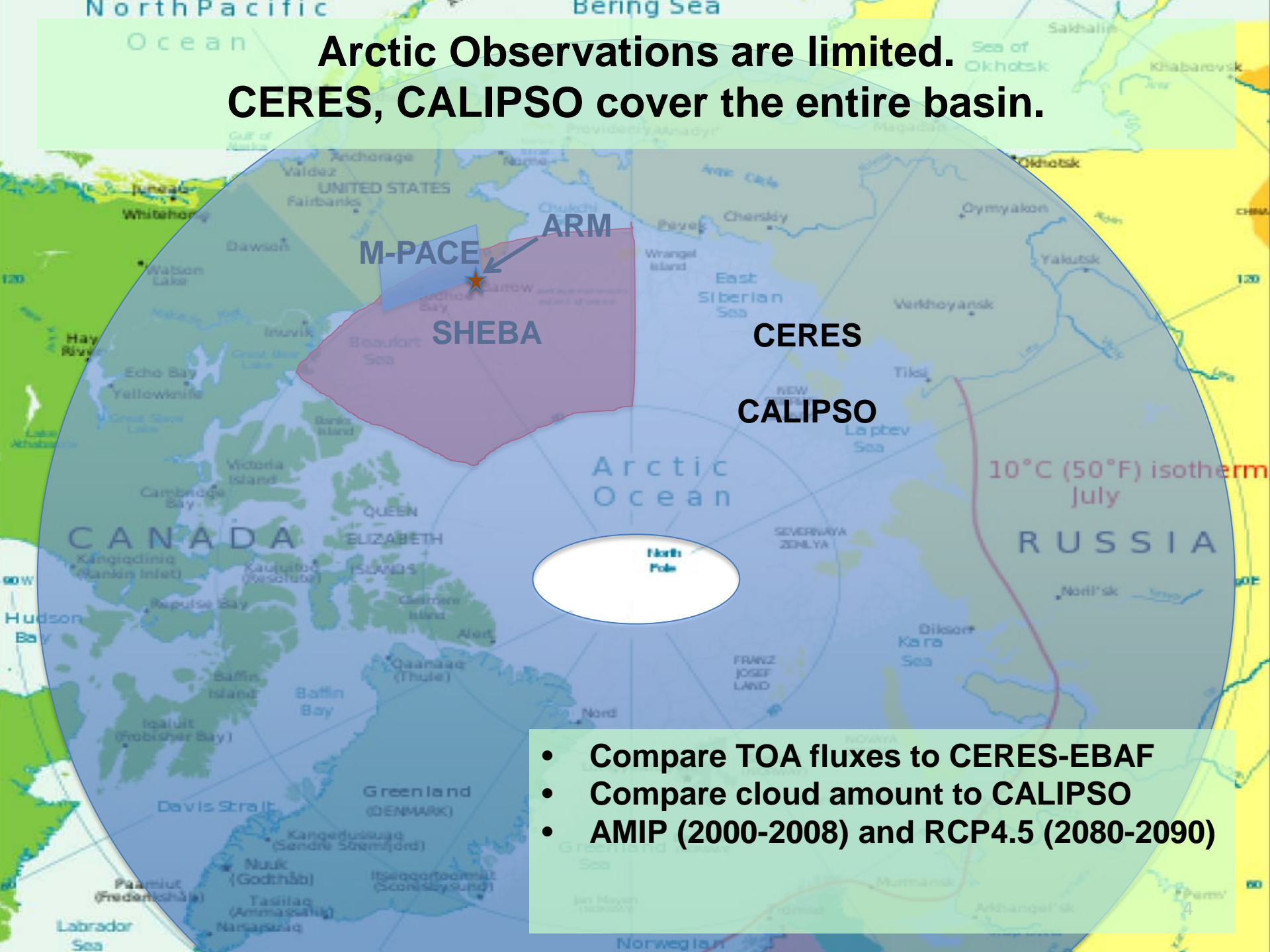

Karlsson and Svensson 2013

CMIP5 models disagree on rate of future sea ice loss


What are the contributions of clouds & radiation?
(as opposed to NHT, circulation)

Liu et al. 2013

Arctic Observations are limited.
CERES, CALIPSO cover the entire basin.

ARM

M-PACE

SHEBA

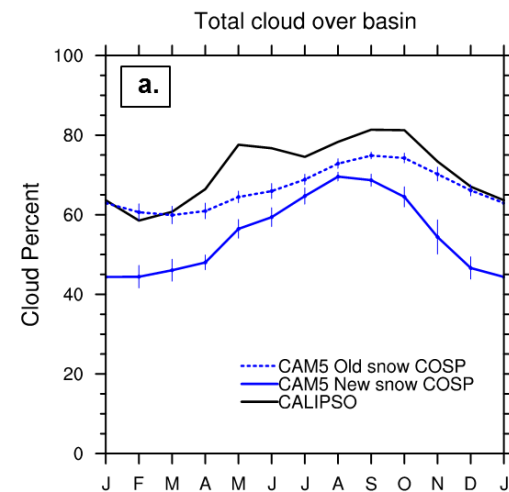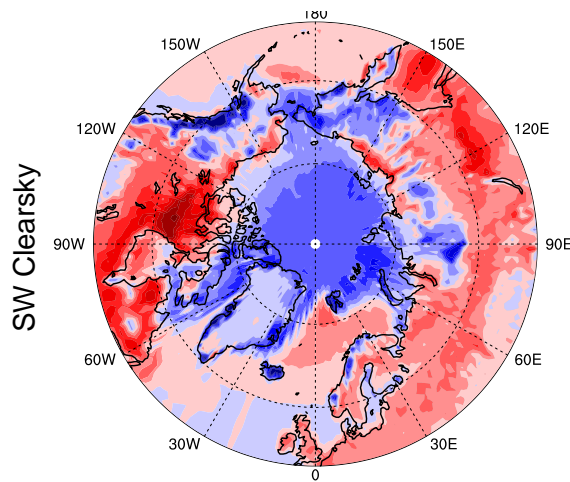**CERES**

CALIPSO

10°C (50°F) isotherm July

- Compare TOA fluxes to CERES-EBAF
- Compare cloud amount to CALIPSO
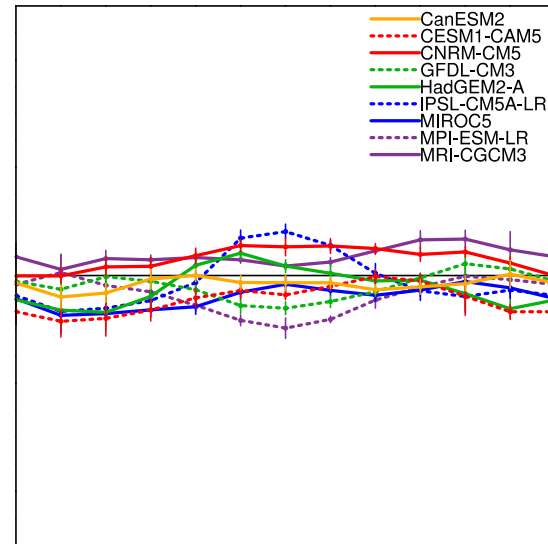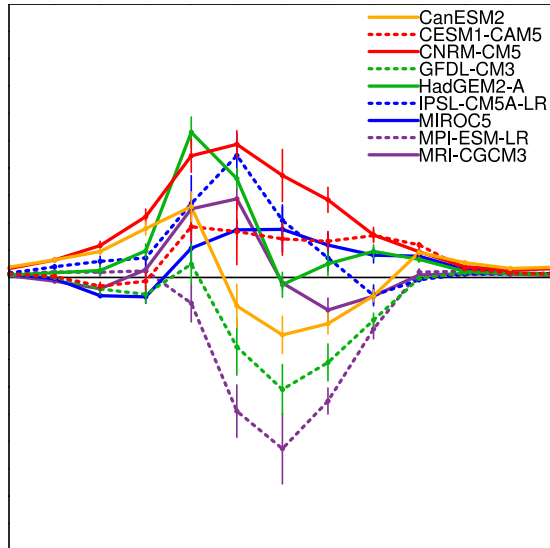- AMIP (2000-2008) and RCP4.5 (2080-2090)

CESM/CAM5 SW clearsky is too low (snow albedo)
SW cloud forcing is too high (insufficient clouds)

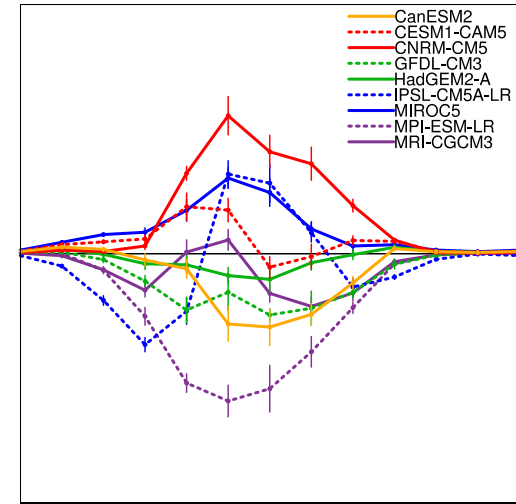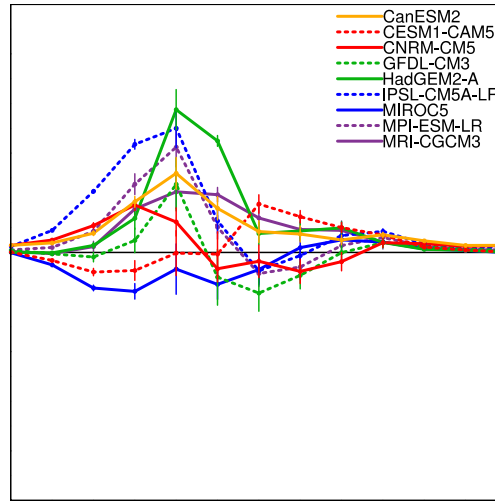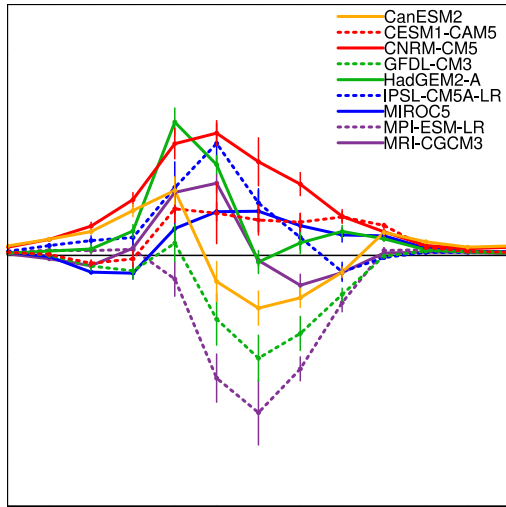English et al., under review, J. Climate, 2013

5
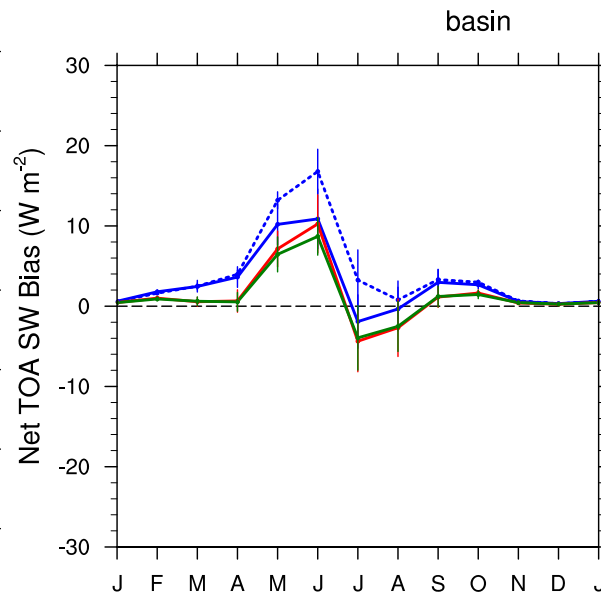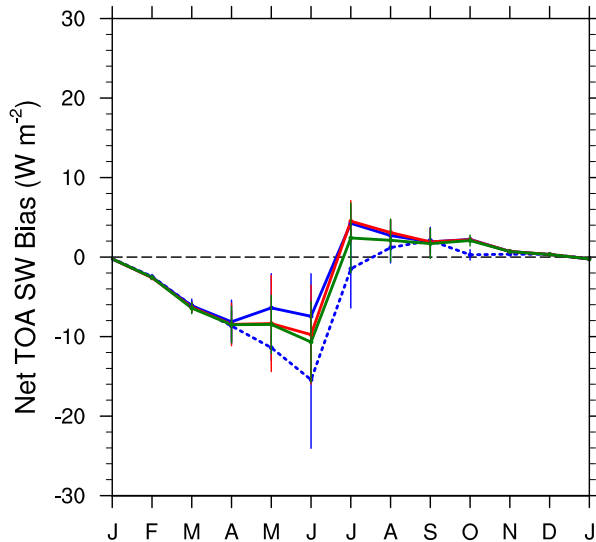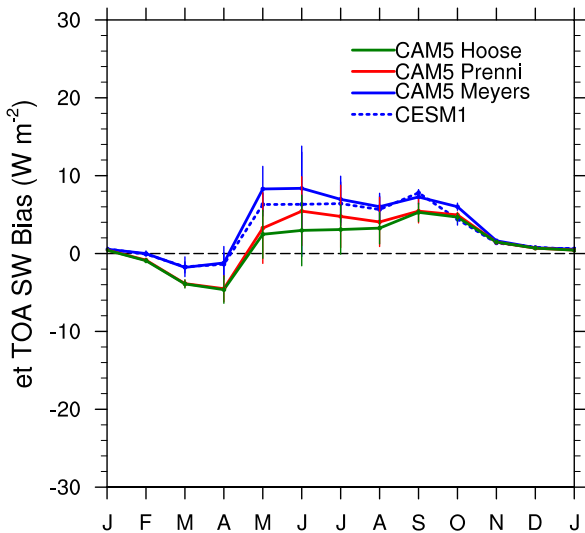
Current climate (AMIP 2000-2008): SW biases are larger than OLR biases

- SW biases skewed positive (6 models have positive bias; 3 models have negative)
- What is causing these biases? To investigate, let's compare All-sky, clear-sky and cloud-forcing
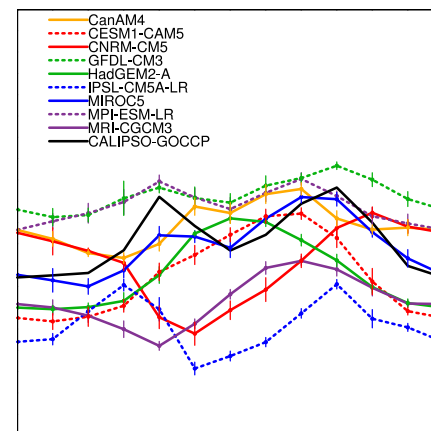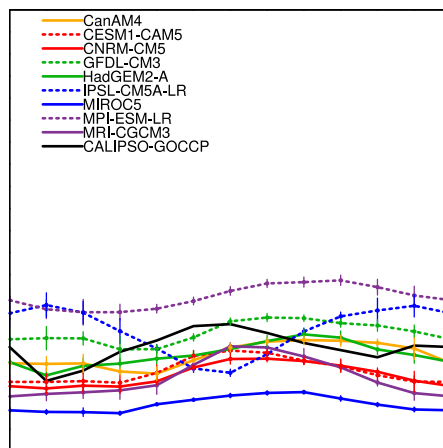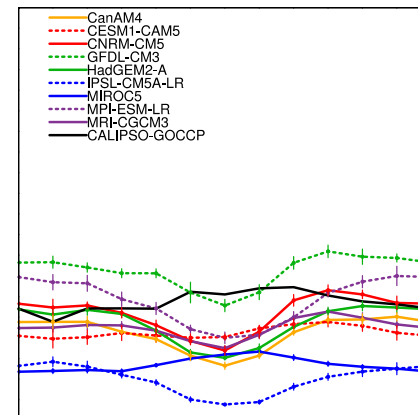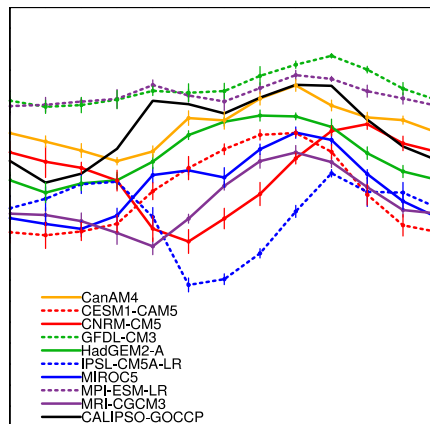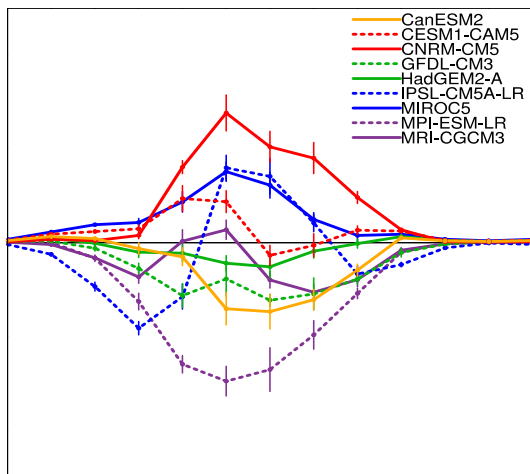
# CMIP5 models have SW Clear-sky and cloud forcing biases

SW Clear-sky: most models have positive bias in spring/early summer

SW Cloud Forcing: models vary

CMIP5 models span a large range of cloud biases; generally too low

CMIP5 SW cloud forcing biases correlated with CALIPSO cloud amount biases
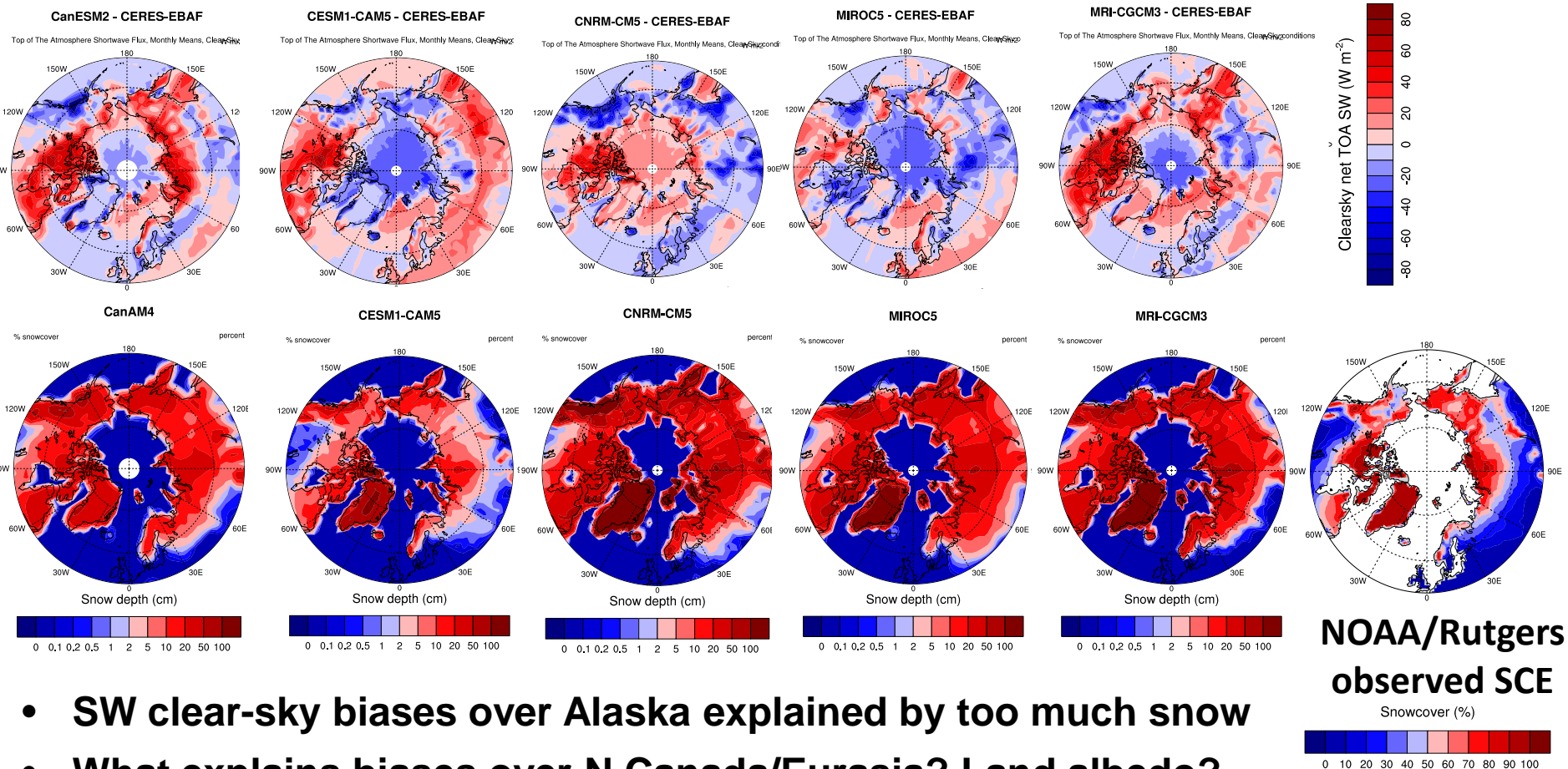

Cloud amount vs SWCF in JJA

$R^2 = 0.6179$

Cloud amount bias (CMIP5 - CALIPSO)

SW Cloud Forcing Bias (CMIP5 - CERES)
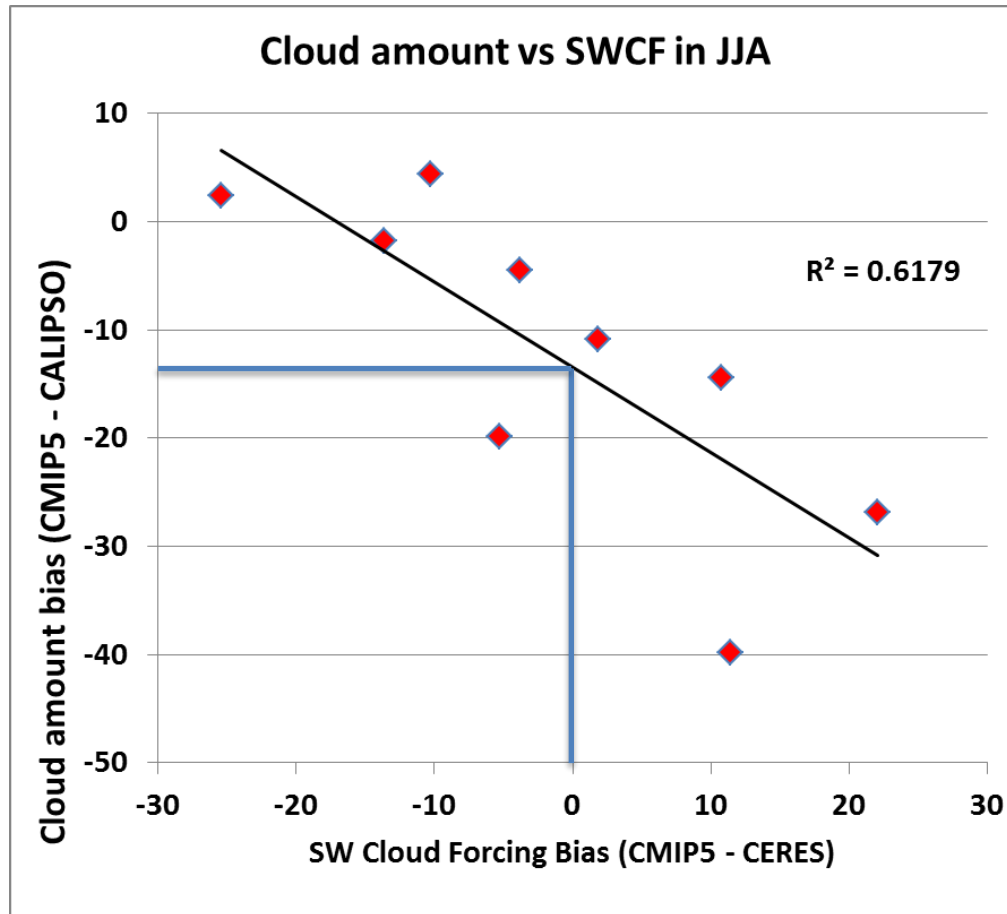
Two models are outliers (IPSL-CM5-A and MRI-CGCM3)
Why does 0 CERES bias correspond to -15 CALIPSO?
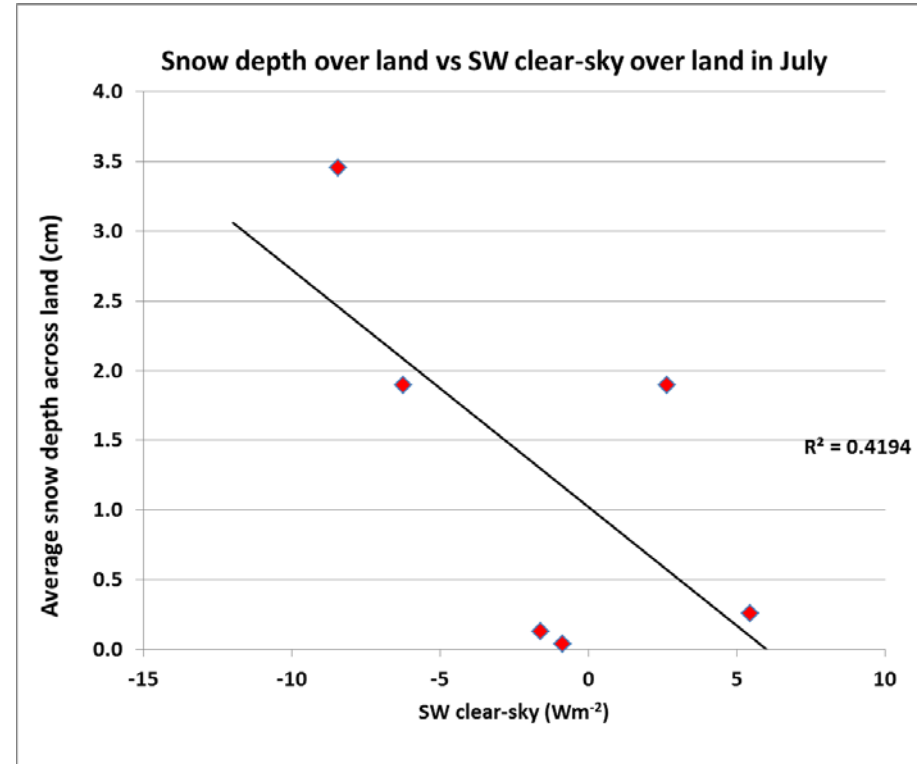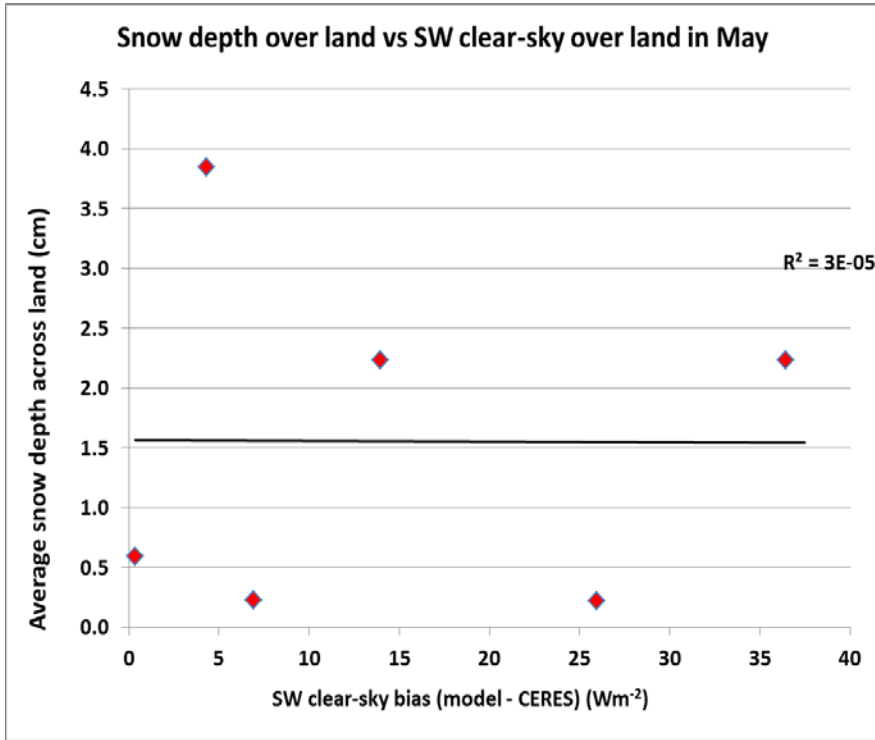
CMIP5 Spring SW Clearsky biases:

- **Too high over N Canada and Eurasia land**
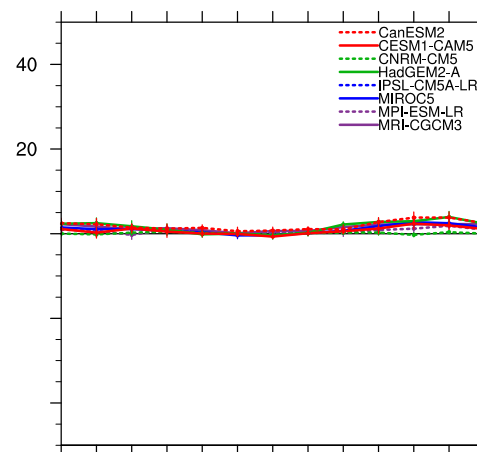- **Too low over S Alaska mountains**
- **Varies over Sea ice**

AMJ

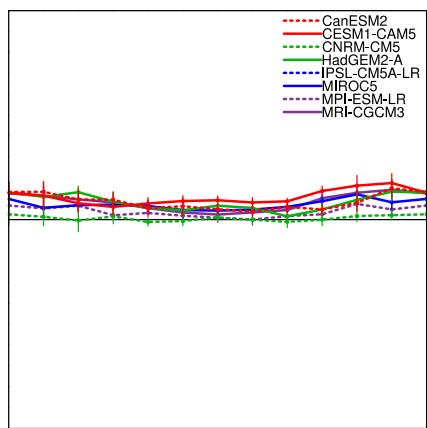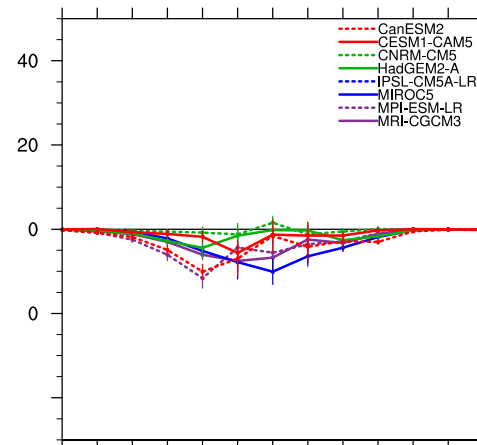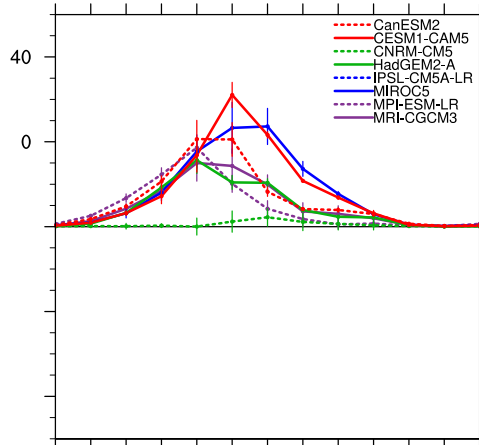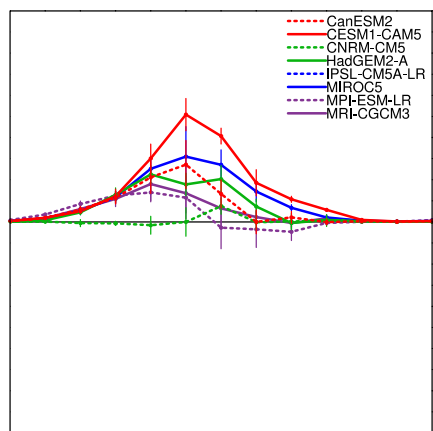- **SW clear-sky biases over Alaska explained by too much snow**
- **What explains biases over N Canada/Eurasia? Land albedo?**

Snow depth does not explain spring clear-sky biases (July is more correlated than May)

RCP4.5 projections: More net SW due to snow/ice loss and more OLR due to higher T

2080-2090 – 2000-2008
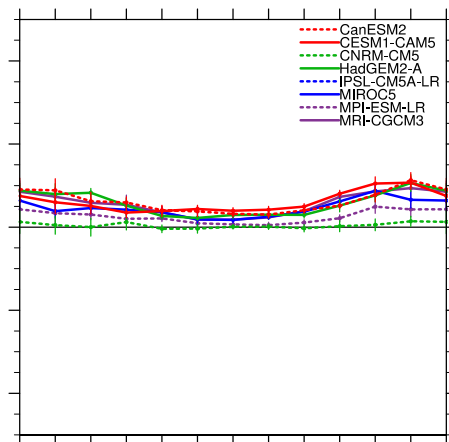
Summary

- **CMIP5 models have monthly SW biases up to 30 Wm-2 and OLR biases 10 Wm-2 vs CERES-EBAF**
- **SW clear-sky biases partly driven by insufficient snow on land and snow albedo on sea ice; other causes TBD (land model albedo?)**
- **SW cloud forcing biases driven in part by cloud amount biases**
- **CMIP5 models project more net SW and more OLR under RCP4.5**

Next Steps

- **Explore causes of too much SW over land, and variations of albedo over sea ice in CMIP5 models**
- **Compare Arctic T and sea ice projections to ability of CMIP5 models to reproduce observed recent climate change**