Arctic Climate
(from a newbie and a climate/atmosphere modeler)

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US CLIVAR Summit POS Breakout
A new DOE project “High-Latitude Application and Testing of Global and Regional Climate Models” (HiLAT)

- PIs: Jones (LANL) & Rasch (PNNL)
- Team: Burrows, Elliott, Fyke, Hecht, Hunke, Jeffery, Rowland, Urban, Urrego-Blanco, Veneziani, H. Wang, S. Wang, Weijer, Yoon
Global warming strongly affects cryosphere.
US CLIVAR Research Challenges and International CLIVAR Research Foci

- Polar climate change is one of the US CLIVAR Research Challenges.
- Regional sea-level change and Arctic is one of the International CLIVAR Research Foci.

- Link to extreme weather – Arctic-Midlatitude interaction working group

- Link to various climatic feedback processes
  - biogeochemistry feedbacks
  - Cloud/aerosol processes
  - Dynamical feedback
  - Troposphere-Stratospheric link
Various climatic feedbacks were suggested as a potential cause.

What makes difference between Arctic and Antarctic temperature trend?
**Biogeochemical feedbacks**

- **A** $T_{sfc}$ trend
- **B** ICE trend
- **C** ICE_free_days trend
- **D** CHL trend

- Warming induced sea ice melting and increasing shortwave radiation into the ocean $\rightarrow$ longer phytoplankton growing season $\rightarrow$ warming (positive feedback)

Park et al. 2015 in *PNAS*
The sensitivity of high-latitude marine ecosystems to inputs from GrIS, AIS, Arctic deltas is unknown.

- Freshwater inputs tend to reduce biological productivity
  - Stronger stratification reduces upwelling of nutrients
- Nutrient inputs tend to enhance biological productivity
  - Arctic: macronutrient input from deltas
  - Antarctic: micronutrient input from ice shelves
Greenland ice sheet evolution in a warming climate

Anthropogenic signal emerges in bimodal pattern

- enhanced precip on top
- enhanced ablation at rim

Fyke et al., 2014b, GRL
Cold winters in the US in the recent years ~ linked to Hiatus
Polar Control on Midlatitude Weather

- Explore interactions between polar climate and midlatitude weather
  - Does Arctic sea ice retreat alter midlatitude circulation patterns – a.k.a. ‘Polar Vortex’ and cause extreme winter over the U.S. and other?
  - Identify the relative contribution of the Arctic influence vs. the tropics on the past extreme winters in midlatitude (e.g., 2013/14, 14/15).

- Approach
  - Multi-ensembles of atmosphere-only simulations
  - Tag water vapor
Reducing Arctic Sea Ice can change surface energy budget and initiate teleconnection.

Through link to stratospheric circulation

Kim et al. 2014 in Nature Communications
Traditional view is teleconnection originated from the tropics.

Competing with a teleconnection pattern originated from the tropics

- Trenberth et al. 2014 Nature Climate Change
Blob and transient eddy forcing in the atmosphere

Wang et al. 2014 in GRL
California Drought Linked to Human-caused Global Warming

Objective

- Identify weather or a climate patterns that link to a recent severe California drought

Approach

- Use Community Earth System Model, a coupled climate model simulation, to identify a potential link to human-caused global warming
- Identify the “Dipole” pattern observed in CA drought
- Vary forcing agents in the Community Earth System Model (CESM) simulations to evaluate the dipole response

Impact

- The persistent dipole and the subsequent California drought is linked to El Niño’s initiation phase, rather than El Niño itself
- This link has been strengthening in recent years, likely due to increased greenhouse gases in the atmosphere

A better physics in GCM makes MJO and teleconnection toward high-latitudes more realistic.

Yoo et al. (2015) in print, JCLI
Intensive Observations are on-going by international partners:
Why an atmosphere guy cares about Arctic and Oceanic feedbacks?

In a coupled climate model, what controls the ENSO amplitude?

- A couple of parameters in the atmosphere model, especially in convection…
- An example is here (from Cecile Hannay & Rich Neale @ NCAR).

Dcs = 250 microns

Dcs = 200 microns
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![Graphs showing Dcs = 250 microns and Dcs = 200 microns with various climate model outputs and power spectra.]
Thank you!

- It is all about the coupled climate system.
Antarctic Sea Expansion

Strengthens stratification and reduces upward heat flux

- Trend in sea-ice fraction from observations (left) and a CCSM4 ensemble average (right)

Landrum et al. (2014)

Trend in sea-ice fraction from observations (left) and a CCSM4 ensemble average (right)

- Strengthens stratification and reduces upward heat flux
Rainfall extreme