High-Latitude Processes and Feedbacks Breakout

Report-out

Logistics

- Moderators: Gudrun, Wieslaw, Wilbert.
- Note-takers: Anastasia, Yannick, and Theresa.
- 22 lightning presentations
  - Slides available on Google Drive
- Two sub-breakouts
  - High/low-latitude linkages
  - High-latitude processes

Summary of Presentations (1/3)

- **Polar Amplification MIP: examining regional and global impacts of Arctic sea ice loss**
  - Gudrun Magnusdottir: How does the atmospheric response to sea-ice decline compare to the full effect of Arctic Amplification?
  - Yannick Peings: Are 100 ensemble members enough to capture the remote atmospheric response to +2°C Arctic sea ice loss?
  - Tien-Yiao Hsu: Understanding the role of ocean-atmosphere interactions on the response of large-scale climate to the loss of Arctic sea-ice using a hierarchy of simplified ocean models)
  - Alexandre Audette: Opposite responses of the dry and moist eddy heat transport into the Arctic in the PAMIP experiments
  - Robert Fajber: Latent Heating and Large Scale Transport Cause Arctic Amplification in a Model without Sea Ice.
- **Terrestrial processes**
  - Anastasia Piliouras: Arctic deltas modify riverine fluxes
  - Vladimir Alexeev: Water balance response of permafrost-affected watersheds to changes in air temperature

Summary of Presentations (2/3)

- **Atlantic Meridional Overturning Circulation**
  - Oluwayemi Garuba: The role of oceanic and atmospheric feedbacks in the response of the Atlantic Meridional Overturning Circulation to a CO2 increase.
  - Wilbert Weijer: CMIP6 Models Predict Significant 21st Century Decline of the Atlantic Meridional Overturning Circulation.
- **Studies of Arctic synoptic events**
  - Jing Zhang: Modeling Studies on Blowing Snow Processes Associated with Extreme Arctic Weather.
  - Xiangdong Zhang: An Arctic Summer Intense Storm and its Role in Accelerating Sea Ice Decrease
  - Younjoo Lee: Understanding the Evolution of Polynyas Along Northern Greenland
- **High-latitude ocean heat and freshwater transports**
  - Theresa Morrison: Transport of Heat Across the Greenland Continental Shelf by Winds and Eddies in High-Resolution Ocean-Sea Ice Simulations.
  - Jiaxu Zhang: Labrador Sea freshening linked to the Beaufort Gyre freshwater release.

Summary of Presentations (3/3)

- **Radiative effects of snow and sea ice**
  - Rudong Zhang: Unraveling driving forces explaining significant reduction in satellite-inferred Arctic surface albedo since the 1980s
  - Chad Thackeray: Assessing prior emergent constraints on surface albedo feedback in CMIP6
- **Metrics of Arctic sea ice**
  - Matthew Watts: An assessment of pan-Arctic sea ice and regional limitations in CMIP6 historical simulations.
  - Detelina Ivanova: Evaluating the sea ice volume solution in a high-resolution climate models.
- **Novel approaches to modeling and predictability of high-latitude Earth systems**
  - Milena Veneziani: An evaluation of the E3SM-Arctic Ocean/Sea Ice Regionally Refined Model.
  - Balu Nadiga: Using Machine Learning to Explore Teleconnections from Lower Latitudes to the Arctic
  - Wieslaw Maslowski: The role of sea ice physics in modeling and prediction of Arctic climate change.
  - Wieslaw Maslowski: Regional Arctic System Model: An approach for dynamical downscaling of global climate reanalyses and projections at timescales from sub-seasonal to decadal.

White Paper Discussion: Grand Challenge

Grand Challenge: *What are the roles of regional processes and feedbacks, atmospheric and oceanic coupling to lower latitudes, in shaping the high-latitude Earth system, its variability and trends and what are the consequences of high-latitude climate change for the regional and global carbon cycle and sea level rise?*

Suggestions to include:

- Impacts on lower latitudes
- Timescales of interest
- Predictability
- Land and ice
- Coastal
- Human dimension

Or, maybe just make it ***simpler***

White Paper Discussion: Short & Long Term Goals

- Improve our understanding -and model representation- of
  - Snow and sea ice effects on albedo
  - Biophysical effects of river chemistry
  - Ocean mixing
    - Changes in mixing and entrainment of Atlantic Water
    - Deep convection in sub-Arctic, impact on AMOC
  - Pathways of enhanced freshwater inputs from Greenland and impacts on AMOC
  - Impact of fisheries on lower trophic levels (e.g., whaling in the Southern Ocean)
  - Warm blob around Bering Strait
    - (remote?) drivers
    - Impacts

White Paper Discussion: Short & Long Term Goals

- Quantify high-latitude feedbacks
  - Rank feedbacks according to their importance, uncertainty
  - Search for unknown feedbacks
  - Spatial distribution
  - Seasonality
  - Mutual interactions
  - Impact of transport on feedbacks
- Develop capabilities to study feedbacks
  - Make ‘physics’ modular in ESMs, so that you can easily turn off and assess the impact of specific processes
- Quantify the pace and uncertainty of climate change
  - Natural variability vs. feedbacks and forcing

Summary: Priority Research Areas (1/4)

- There is an urgent need to better understand, quantify, and constrain *feedbacks* on amplified high-latitude change
  - Even basic feedbacks are poorly represented in models
  - Many feedbacks remain to be discovered
    - In particular related to biogeochemical and biogeophysical processes
  - Feedbacks are challenging to quantify due to their
    - spatial inhomogeneity
    - strong seasonality
    - nonlinear mutual interactions
- This is critical for improving predictions and projections of high-latitude change
  - Both in response to exogenous forcing, and internal variability

Summary: Priority Research Areas (2/4)

- There is also critical need to improve our understanding of the *exchanges* between high- and lower latitudes
  - High-latitude changes have implications for global energy budget
- Oceans are critical
  - Key drivers of high-latitude change
  - Play a critical role in global response to Arctic change
  - Large thermal inertia is source of predictability
- Challenging to model, due to importance of
  - Small-scale processes
  - Non-linear dynamics

Summary: Priority Research Areas (3/4)

- We need to improve our *numerical tools* for studying high-latitude processes.
- Critical needs are:
  - Active coupling between terrestrial and marine domains through the coastal interface
    - Rivers
    - Deltas
    - Ice sheets
  - Improvements in cloud and aerosol physics
  - Improvements in biogeochemical cycles and ecosystems modeling
    - Coupling to physical system
  - High resolution for resolving fine-scale processes in ocean and sea ice, e.g.,
    - Leads and ridges
    - River plumes
    - Cross-shelf exchange
    - Transports through narrow straits
    - Mixing and deep convection
  - Regional refinement that allows for modeling high-latitude Earth systems in global context

Summary: Priority Research Areas (4/4)

- We need to better understand how *predictable* the high-latitude Earth systems are
  - What are the main sources of predictability?
  - How can we use any predictability to make more accurate predictions?
- We need to use a hierarchy of approaches to make progress
  - Machine Learning
  - Reduced-order models
  - Comprehensive regional and global Earth system models