



High-Latitude Processes and Feedbacks Breakout

Report-out

Logistics



- Note-takers: Anastasia, Yannick, and Theresa.
- Moderators: Gudrun, Wieslaw, Wilbert.
- 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-Yao 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 processes in the Arctic: 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 assesment 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.
- **Methodological presentations about modeling and predictability of high-latitude Earth system**
 - 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

But instead, 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