Atmospheric response to Arctic sea ice: the importance of the background state

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1. Experiments:
   • 1979 to 2009 (30 years)
   • Control: observed sea ice concentration
   • Perturbed: reduced Arctic sea ice
   • 10 ensemble members
   • AMIP – observed SSTs
   • CPLD – upper 200m of ocean free
   • AMIP_CPLD – repeat AMIP but with CPLD SST bias

2. Temperature response:
   • Larger response in CPLD
   • Surrounding ocean warms
   • Can reach the tropics

3. Mean sea level pressure response:
   • AMIP: “heat low” in all seasons
   • Positive NAO in DJF
   • CPLD: negative NAO in DJF

4. AMIP_CPLD response:
   • Add CPLD SST bias to AMIP
   • Reproduces negative NAO
   • Background state is key

5. Planetary waves:
   • Decrease in upward EP flux at surface 50-60°N in all experiments
   • Consistent with reduced baroclinicity (weaker Equator to pole temperature gradient)

6. Explanation:
   • Easier to consider increased Arctic sea ice (increased upward EP flux)
   • Response of Atlantic jet depends on propagation of EP fluxes
   • More equatorward propagation leads to interaction with jet
   • EP flux divergence/convergence on poleward/equatorward side of jet
   • Jet shifts polewards (i.e. positive NAO for increased Arctic ice)
   • Response depends on background refractive index

7. Real world response:
   • Cannot be diagnosed from regression
   • Possibility of “emergent constraint” but must be based on the underlying physical cause of model spread (i.e. the refractive index)

8. Summary:
   • Sign of NAO response to Arctic sea ice depends on the background state
   • Upward planetary waves from the surface are reduced when Arctic sea ice is reduced, consistent with reduced equator to pole temperature gradient and reduced baroclinicity
   • NAO response depends on propagation of planetary waves, which is controlled by the refractive index of the background flow
   • Real world response cannot be diagnosed from regression
   • “Emergent constraint” might be possible
   • Need coordinated multi-model experiments → please contact Doug Smith (doug.smith@metoffice.gov.uk) if you are interested in participating