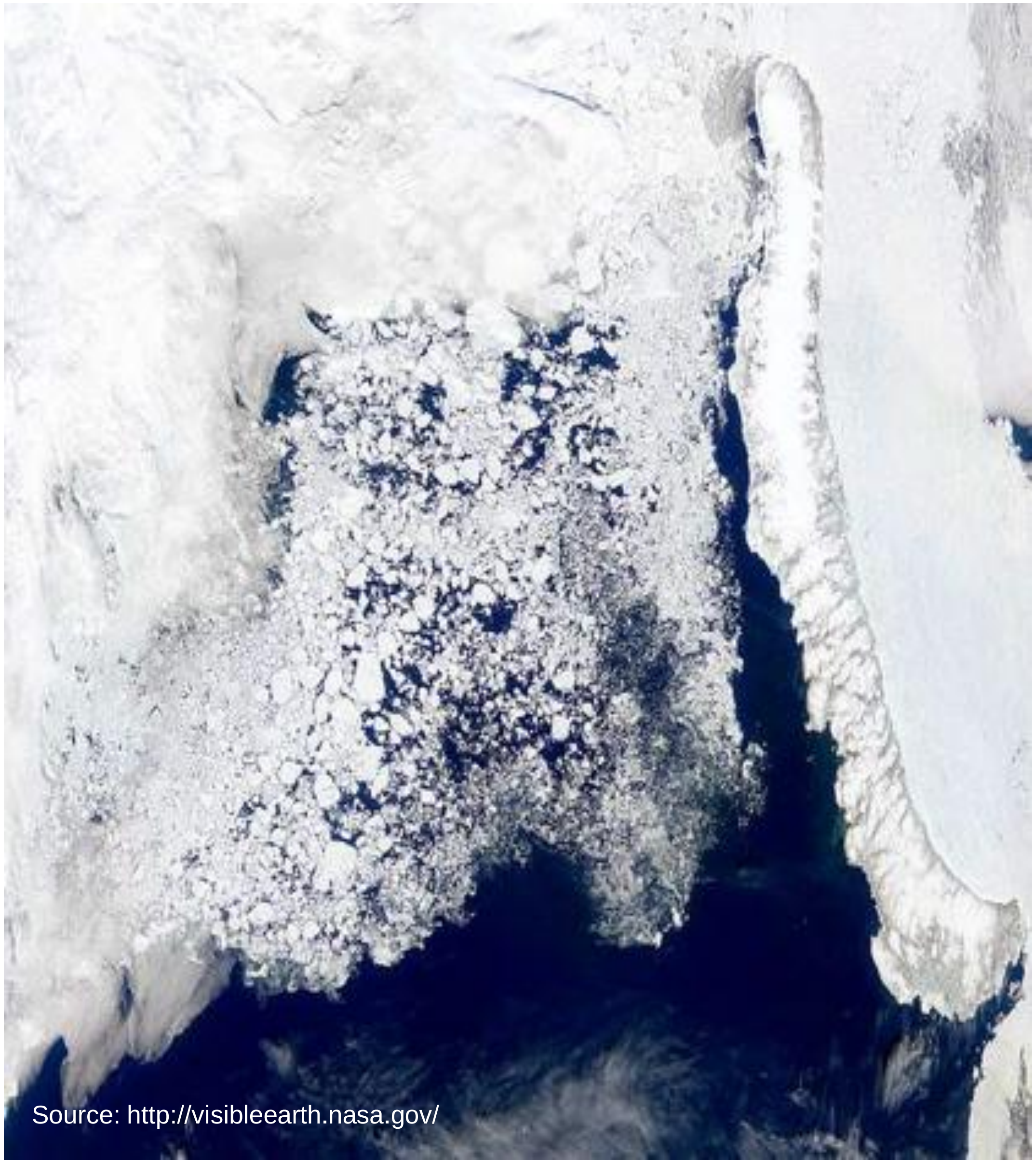
The Winter Sea Ice-Atmosphere Feedback over the Barents Sea



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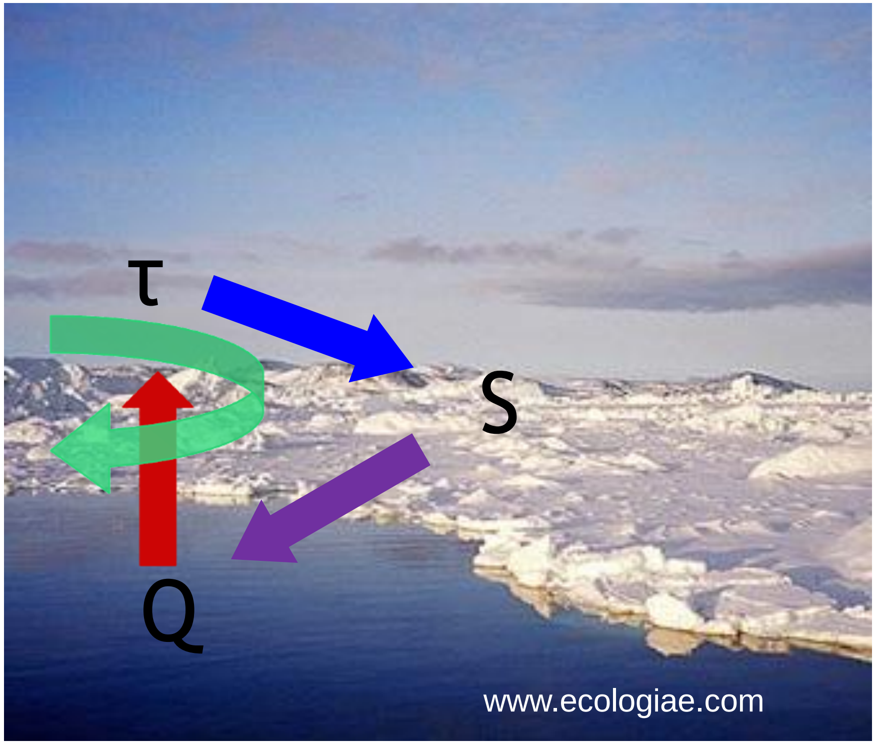
Motivation: Sea Ice-Atmosphere Feedback

- Sea ice anomalies (S) alter surface turbulent heat fluxes (Q): S->Q
- Q-driven SLP anomalies induce surface wind stress (τ) anomalies: Q->τ
- τ anomalies feed back on sea ice through changes in ice drift and temperature advection: τ->S
- Literature on Arctic sea ice-atmosphere interaction has focused on the atmospheric response to monthly sea ice anomalies (S->Q-> τ).
- Our objective is to examine the entire feedback (S->Q-> τ ->S) using a daily-to-weekly spatiotemporal scale.



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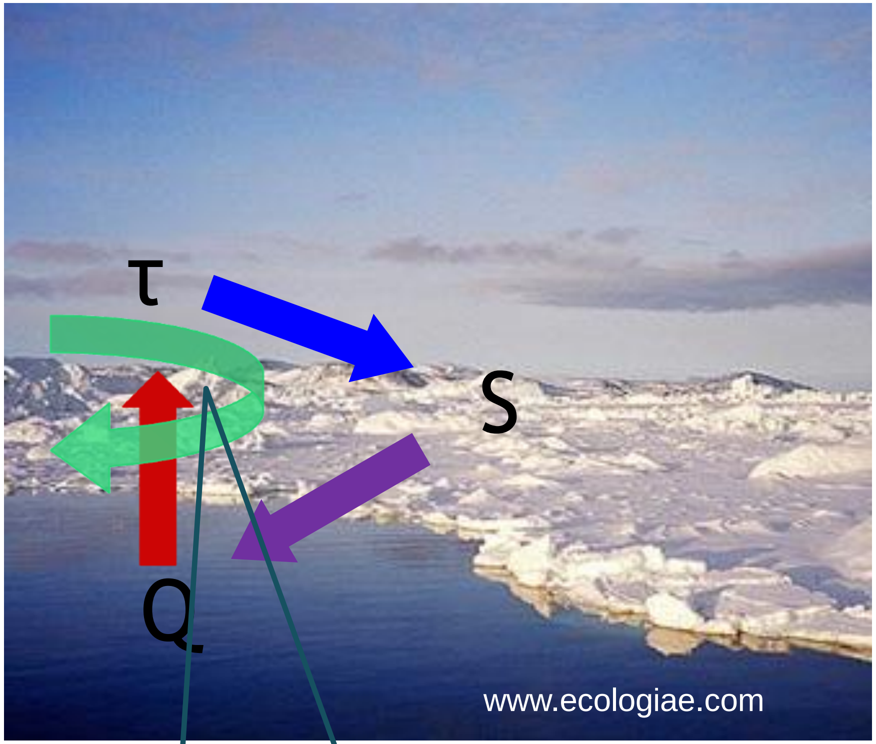


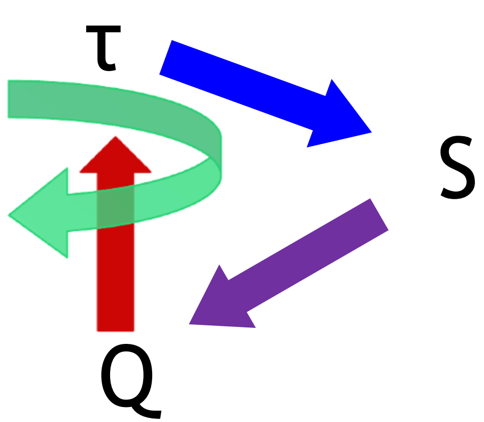
S->Q-> τ
Alexander et al. (2004)
Deser et al. (2004)
Koenigk et al. (2009)
Magnusdottir et al. (2004)
Seierstad and Bader (2009)

Experimental Design

1) Use the Community Atmosphere Model (CAM) to determine the atmospheric responses to high and low sea ice concentration (SIC) over the Barents Sea (S->Q->τ).

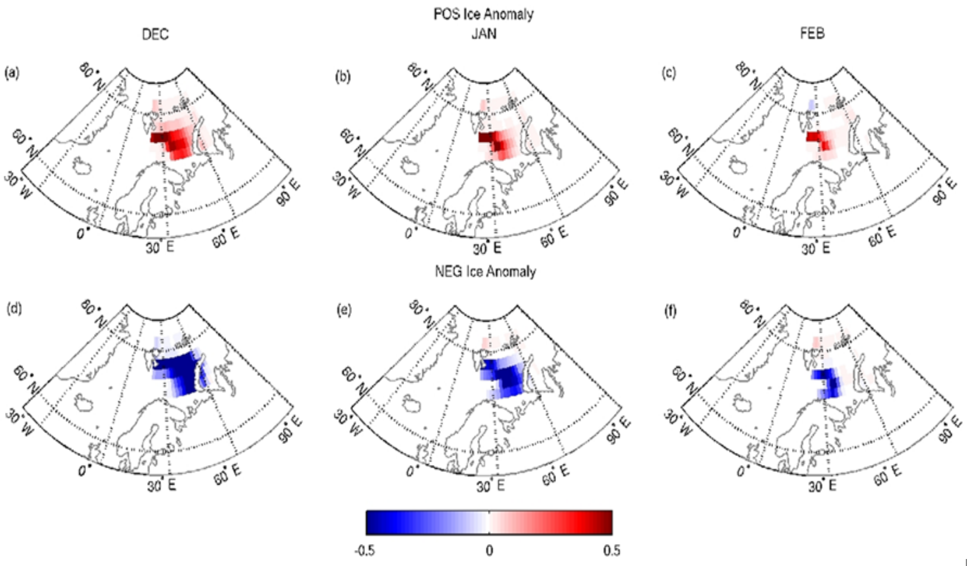
2) Force the Community Ice CodE (CICE) model with a data atmosphere using output taken from from 1) to determine SIC responses to SIC-driven wind stress anomalies (τ->S).

3) Determine effect of feedback by turning off sea ice anomaly-induced heat fluxes (i.e., eliminating S->Q) in a coupled simulation (CAM+CICE+SOM).

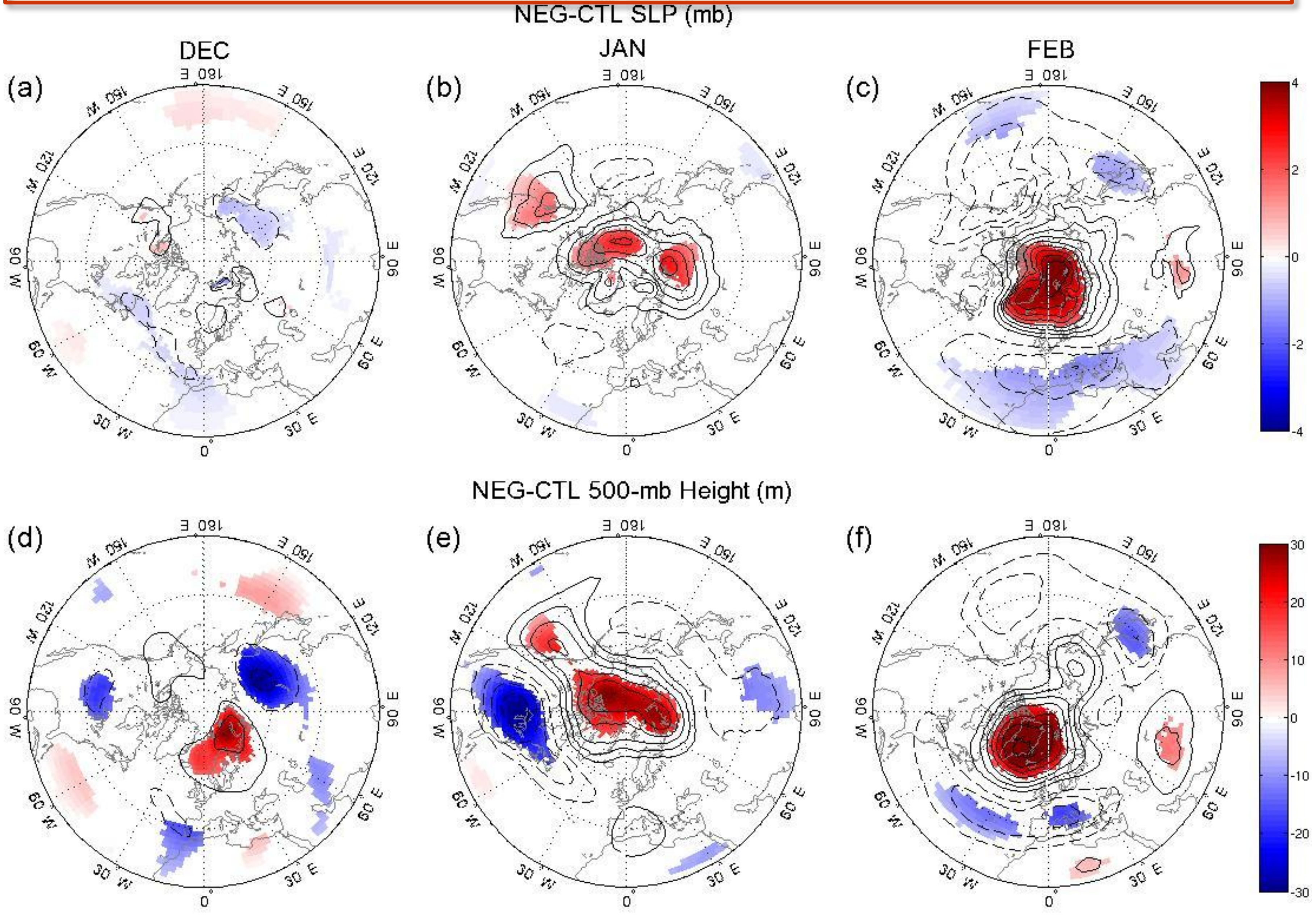


Data & Methods

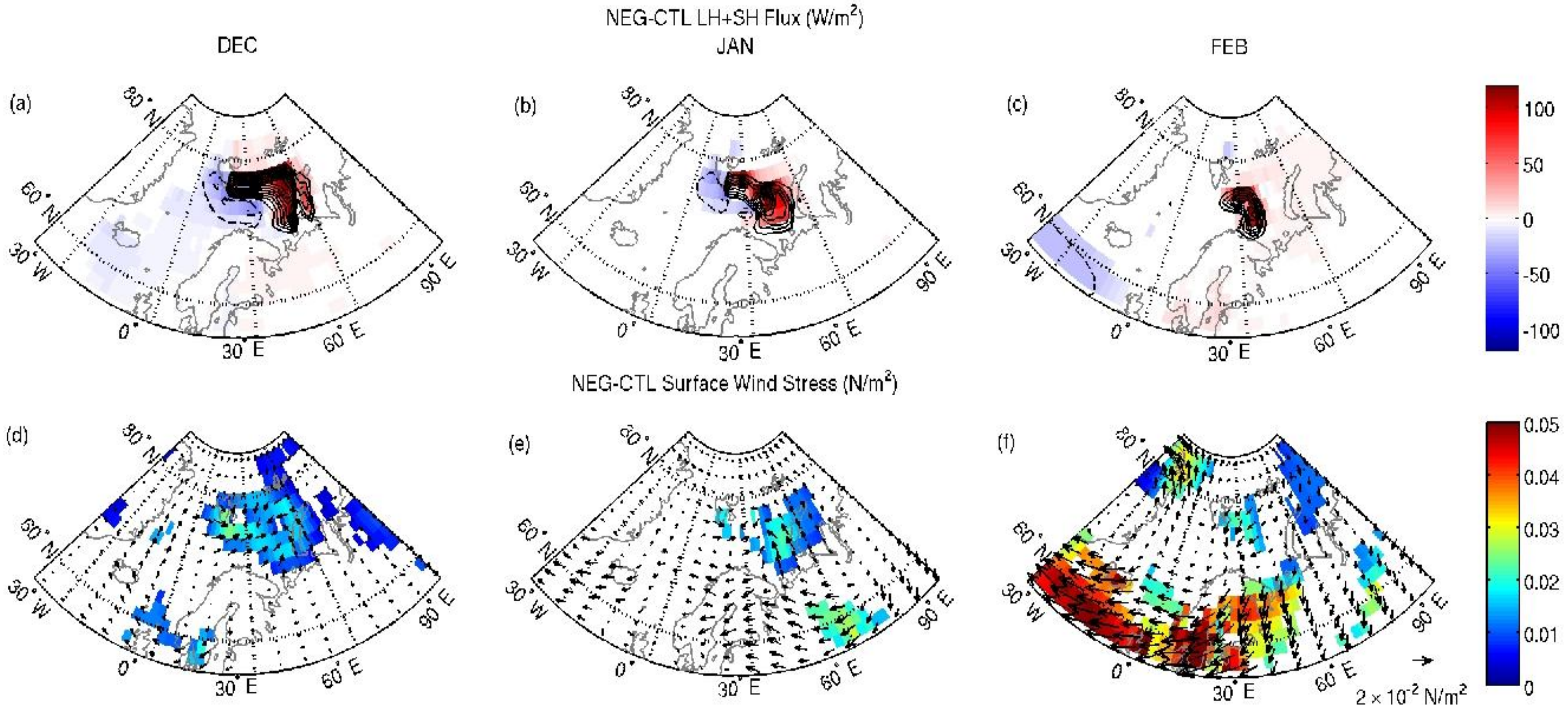
- Default monthly climatological sea ice and SSTs were used to force a 100-year continuous CAM control run (CAM100).
- 6-hourly output from CAM100 were used to force a 100-year CICE control run (CICE100).
- Daily anomalies derived from CICE100 winters (Dec-Feb) containing the most days with anomalously high and low Barents Sea (70°-82°N, 20°-65°E) SIC were superimposed on climatological SIC for the high-ice (POS) and low-ice (NEG) CAM boundary forcing experiments.
- The control run (CTL) was forced with daily climatological SIC computed from the CICE100 ensemble mean values.
- POS, NEG, and CTL were run for 100 winters each using initial conditions from CAM100.
- The CAM (v.4) was run on a 1.9°x2.5° grid with a finite volume (FV) core, and CICE model (v. 4.0) was run on a 1° displaced-pole grid (gx1v6).



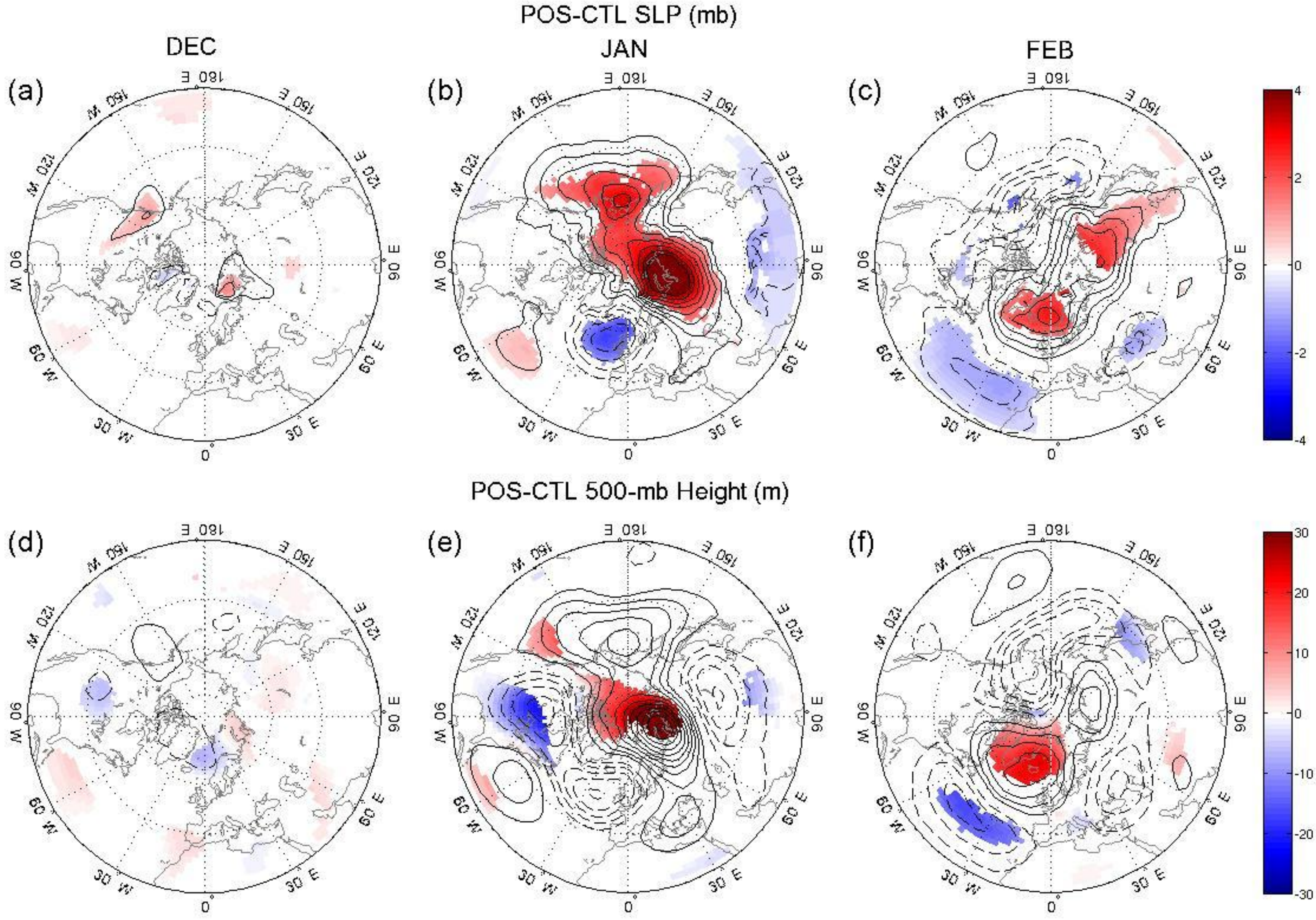
Low-Ice SLP & 500-mb Height Responses



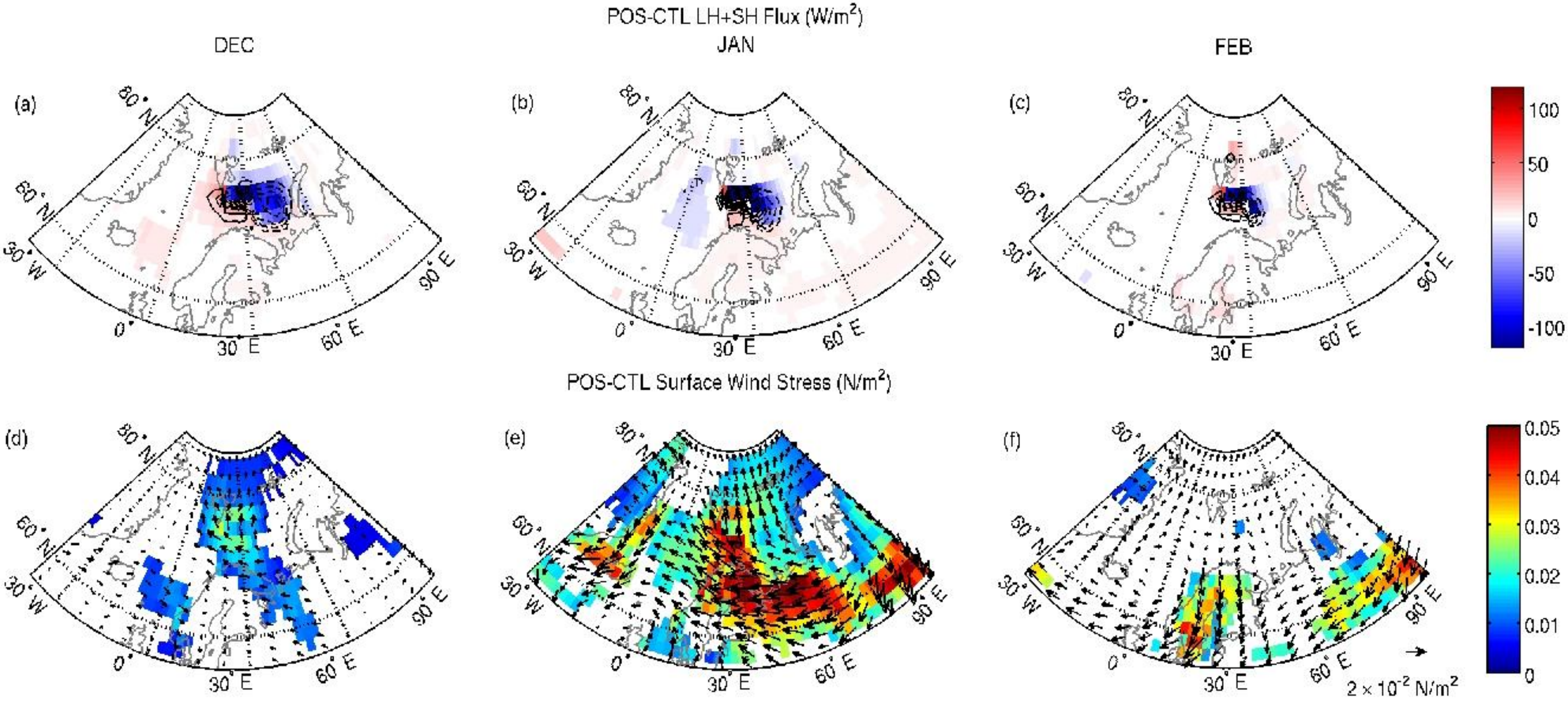
Low-Ice Surface Heat Flux & Wind Stress Responses



High-Ice SLP & 500-mb Height Responses



High-Ice Surface Heat Flux & Wind Stress Responses



Summary

- Monthly mean responses to the high- and low-ice forcing showed opposite-signed surface wind stress and turbulent heat flux anomalies.
- The large-scale high- and low-ice SLP and 500-mb responses were remarkably similar.
- Hilbert Empirical Orthogonal Functions (HEOFs) of the SLP responses show propagating features resembling the AO/NAO and wave 2 patterns.
- The feedback of the atmosphere onto the ice is currently being analyzed from CICE runs forced with output from the CAM control and experiments.
    - Preliminary results suggest the sign of the ice-atmosphere feedback depends on the sign of the ice anomaly over the Barents Sea.

Acknowledgments

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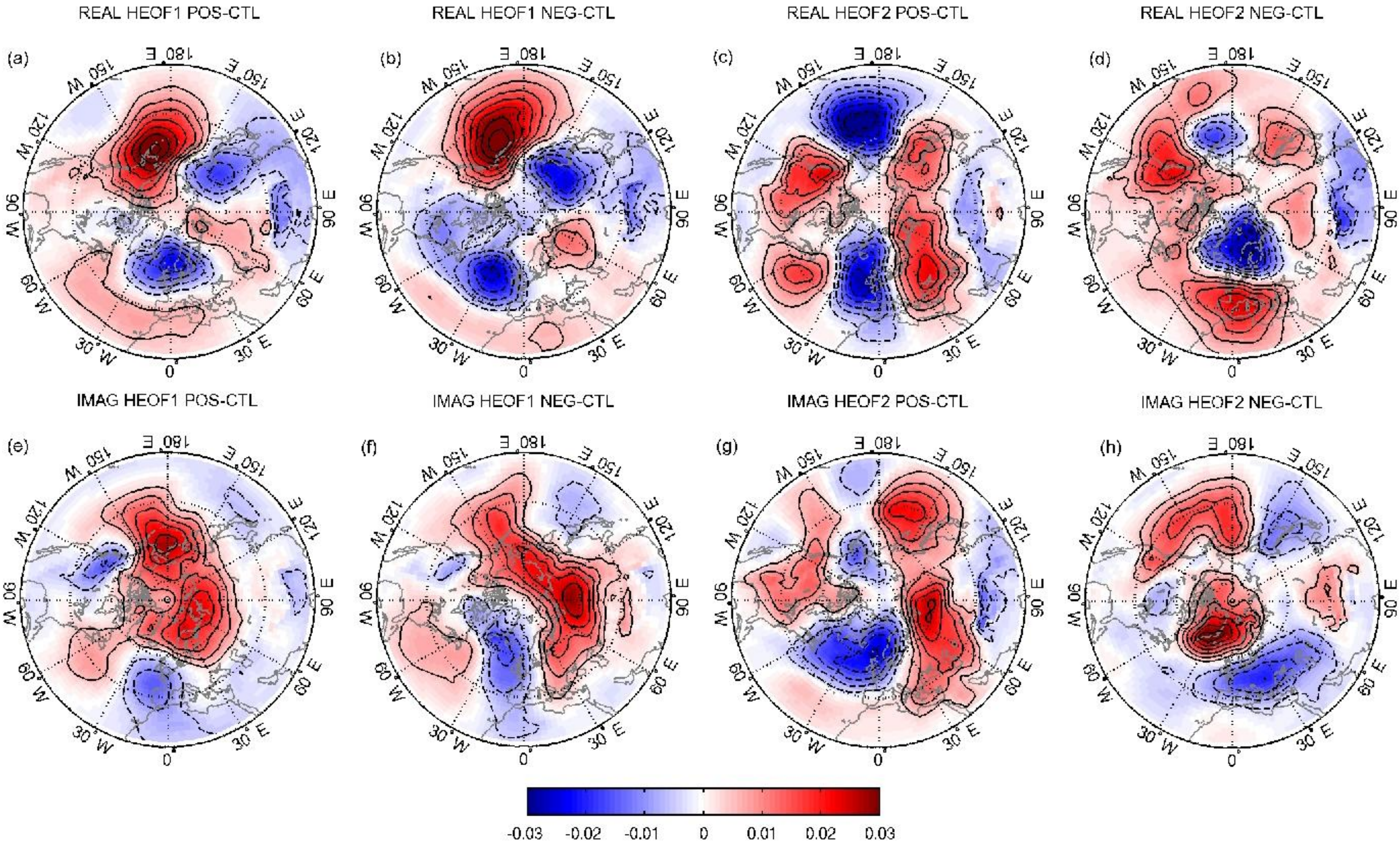
SLP HEOFs


REAL HEOF1 POS-CTL
(a)
REAL HEOF1 NEG-CTL
(b)
REAL HEOF2 POS-CTL
(c)
REAL HEOF2 NEG-CTL
(d)
IMAG HEOF1 POS-CTL
(e)
IMAG HEOF1 NEG-CTL
(f)
IMAG HEOF2 POS-CTL
(g)
IMAG HEOF2 NEG-CTL
(h)
180° E
150° W
150° E
120° W
120° E
90° W
90° E
60° W
60° E
30° W
30° E
0
-0.03
-0.02
-0.01
0
0.01
0.02
0.03

HEOF Moduli & Phase Angles