Mid-latitude Ocean Influence on North Pacific Sector Climate Variability

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[2]Kiel University

suggests that daily ocean fluctuations must be

→simulated by the ocean components and

→resolved by the atmospheric components

of global climate models to enable realistic simulation of North Pacific Sector climate variability

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Background and motivation

- Latif and Barnett (1994): Extra-tropical coupled mode
- Extra-tropical SST experiences annual reemergence [Alexander et al. 1999…]
- The atmosphere responds to extra-tropical SST anomalies [Czaja & Frankignoul 1999, 2002…]
- The atmospheric response to extratropical (North Pacific) SST anomalies is highly controversial
- Response is small compared to tropical response and internal atmospheric variability [Palmer & Sun 1985; Kushnir et al. 2002…]
- But potentially persistent due to the large thermal inertia of the oceanic mixed layer [Kushnir et al. 2002…]
- Transient eddies are crucial [Peng & Whitaker 1999…]
- Oceanic fronts are important for anchoring the storm-track [Minobe et al. 2008; Taguchi et al. 2009…]

Background and motivation

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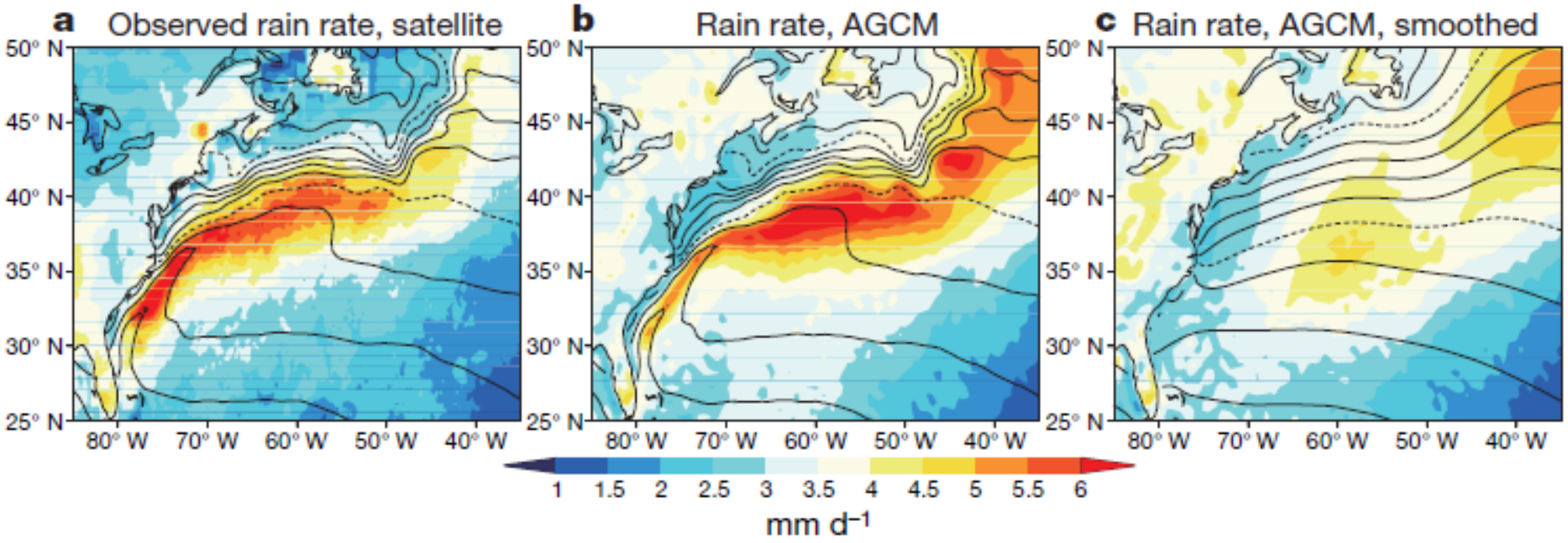
LETTERS

Influence of the Gulf Stream on the troposphere

Shoshiro Minobe[1], Akira Kuwano-Yoshida[2], Nobumasa Komori[2], Shang-Ping Xie[3,4] & Richard Justin Small[3]



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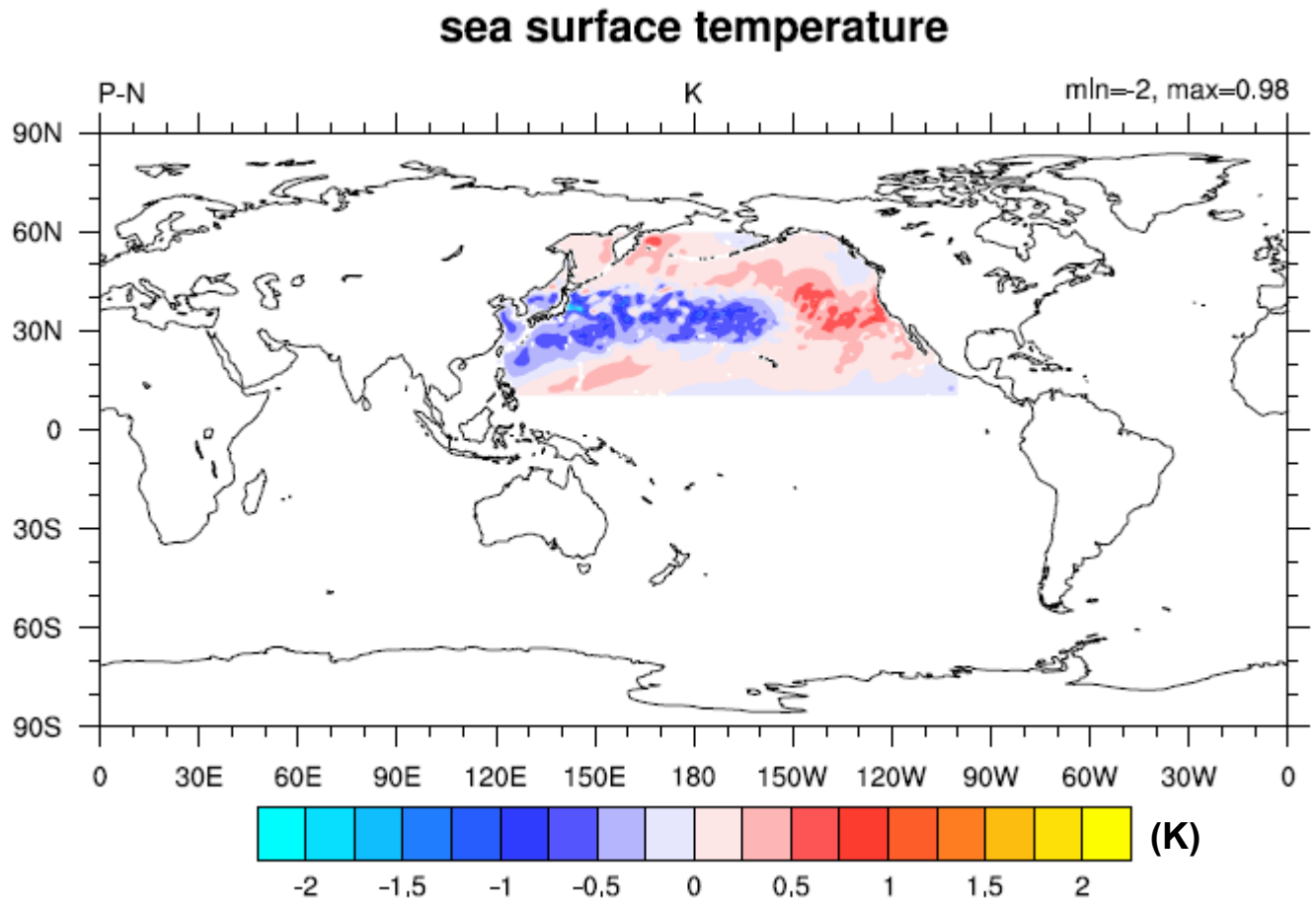
Forced experiments with the AGCM ECHAM5

➢ *Experimental design*

+ ECHAM5 integrated for 10 separate winters (NDJF 1981-1990)
+ Model forced by daily background SST ± anomalies from NOAA-OI SST
+ High resolution (T213, ~0.5°), 31 levels (lid at 10 hPa)
+ Use daily observed background SST (instead of SST climatology)
+ Results were analyzed for DJF as mean differences between ± anomaly polarities

North Pacific forcing SSTA (PDO-like) positive polarity – negative polarity, DJF



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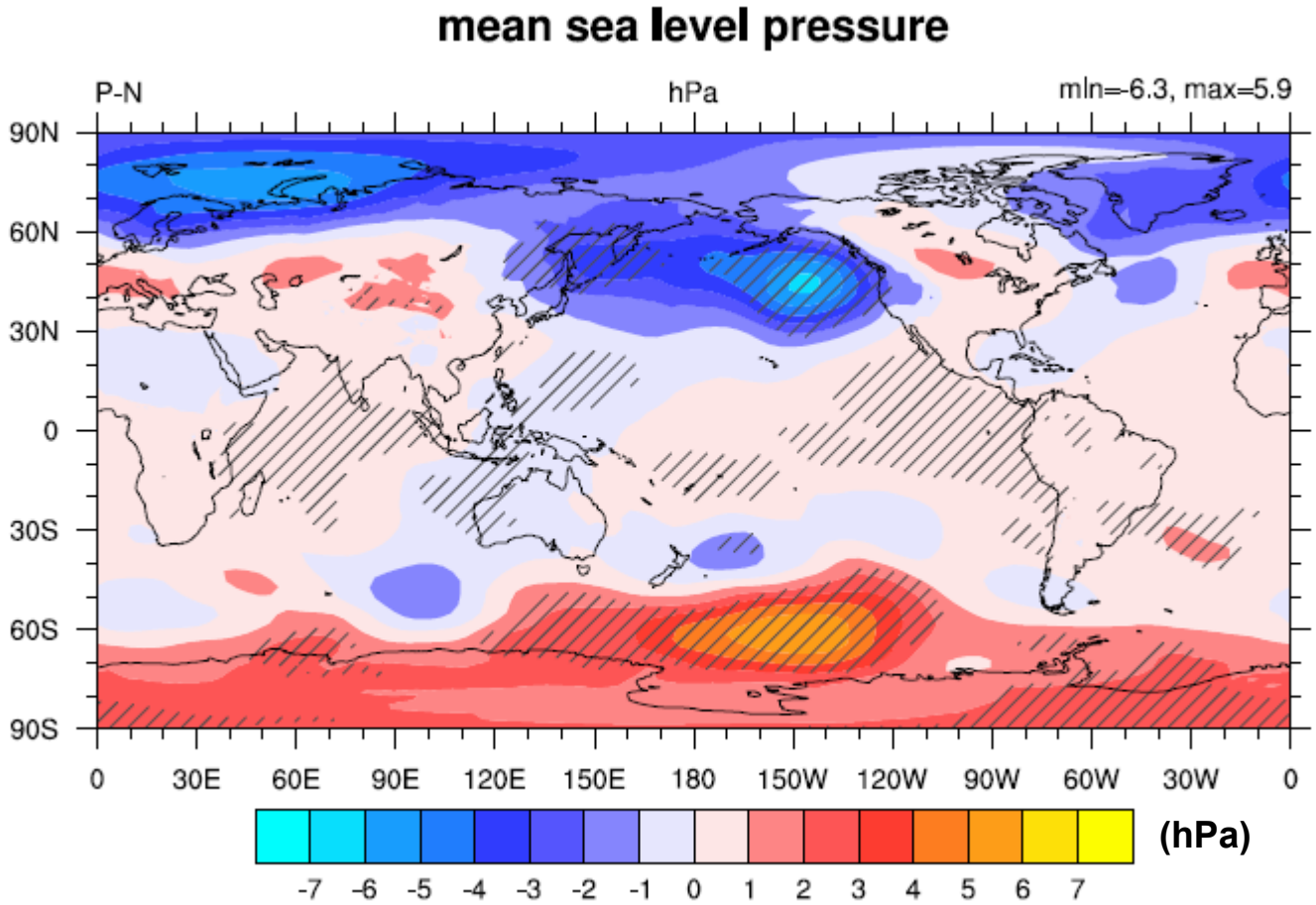
AGCM response to NP SSTA
positive polarity – negative polarity, DJF



hatching denotes 90% significance

there is a strong Southern Hemisphere response

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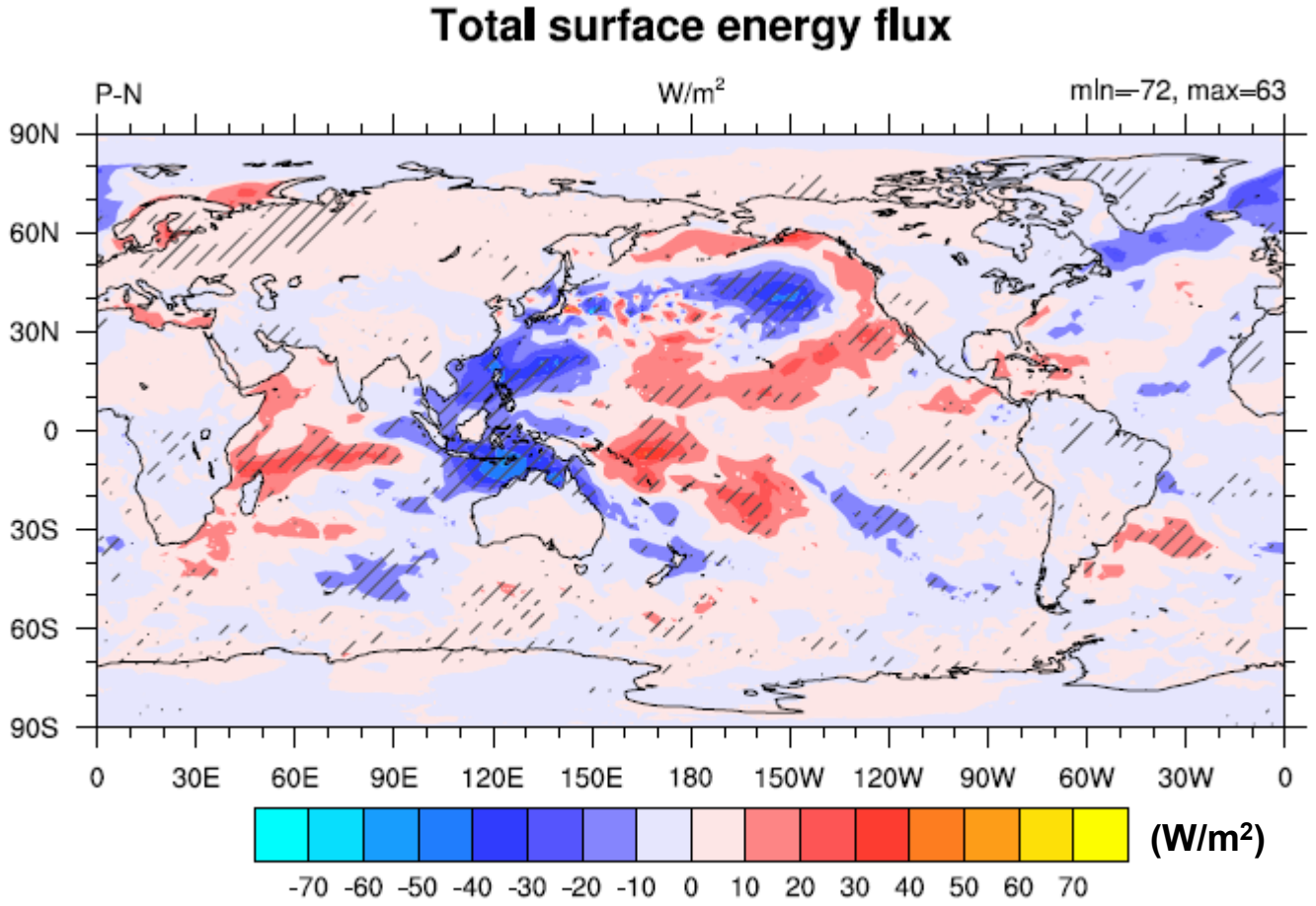

hatching denotes 90% significance

positive feedback in large regions

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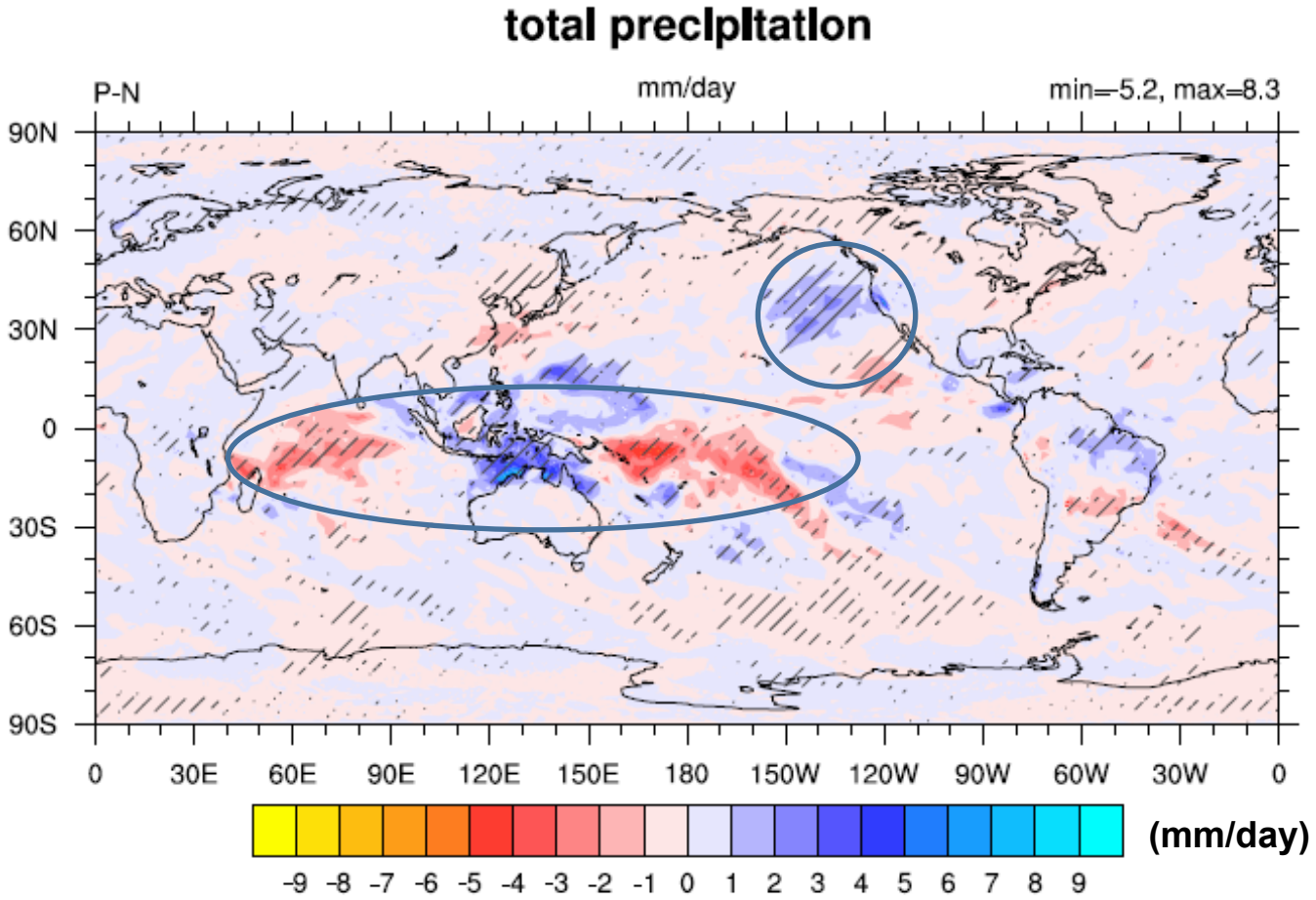

hatching denotes 90% significance

there is a strong tropical response

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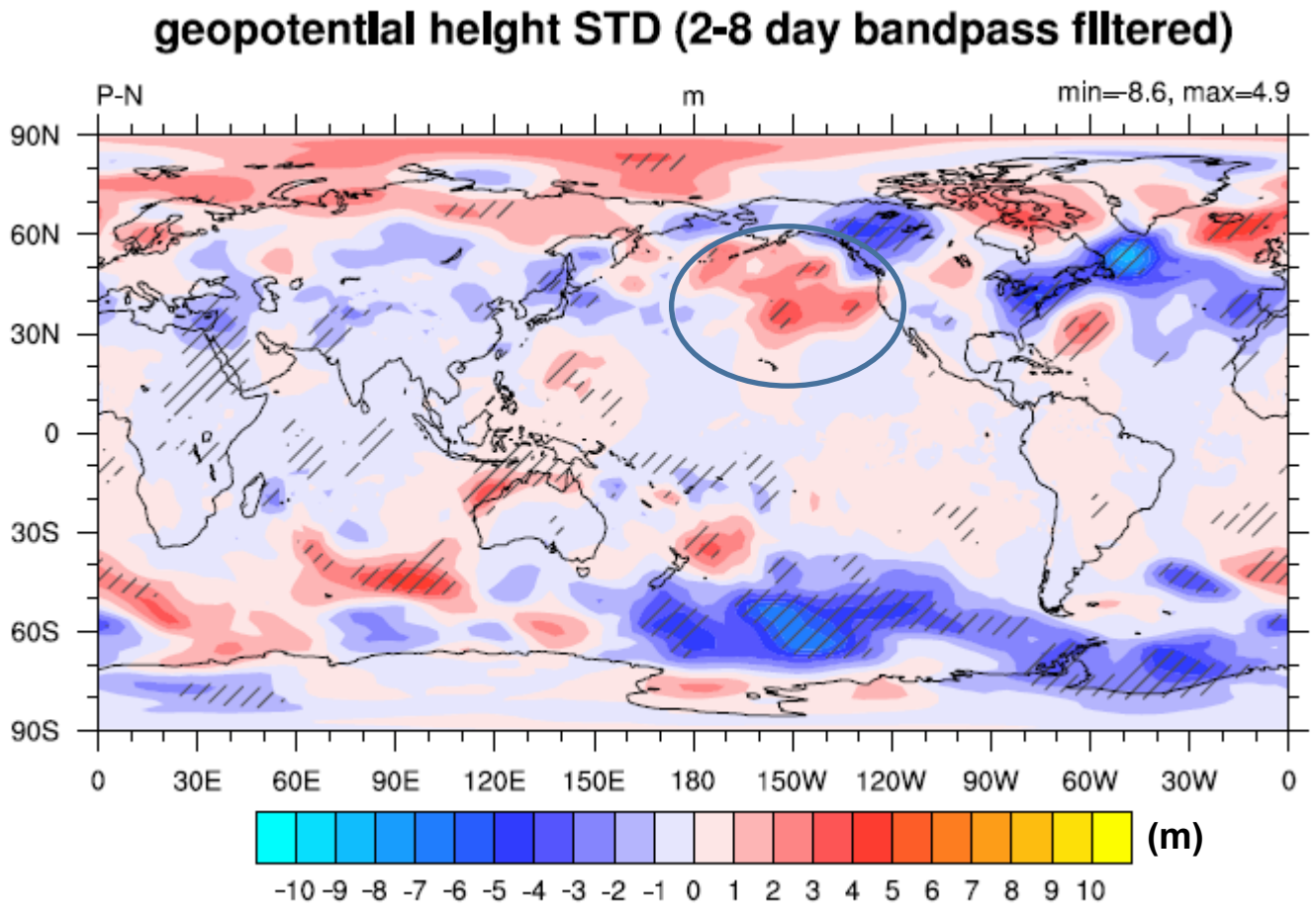

hatching denotes 90% significance

changes mostly in the eastern half of the North Pacific

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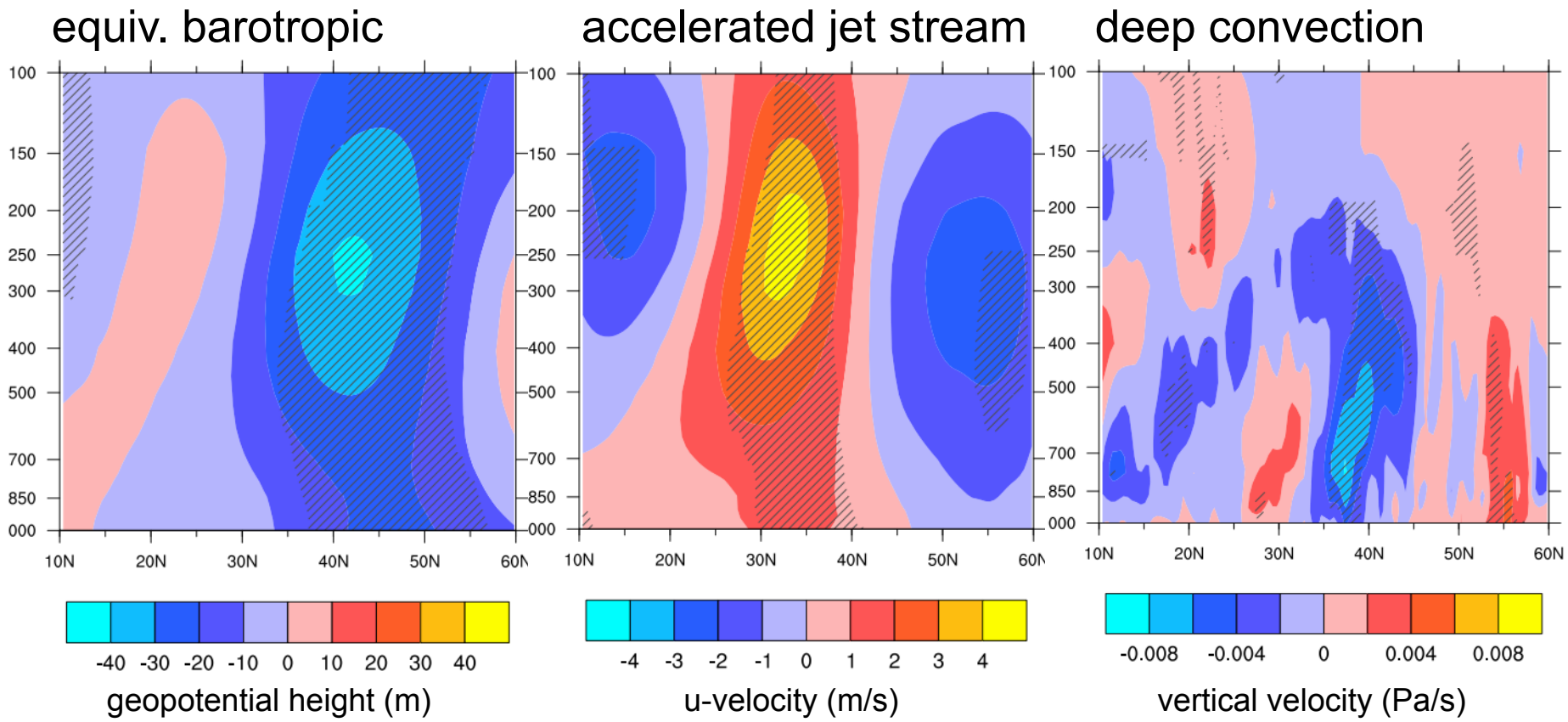
➢ *Characteristics of model response, zonal means*



ECHAM5 simulates an equivalent barotropic, eddy-driven response

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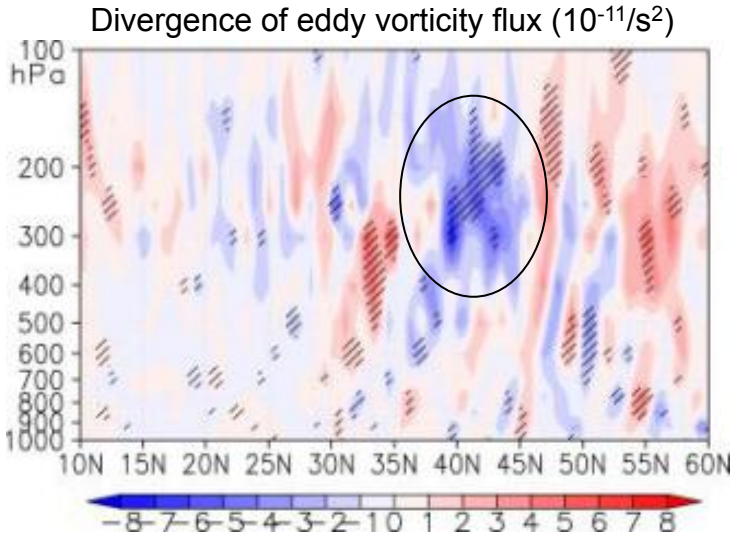
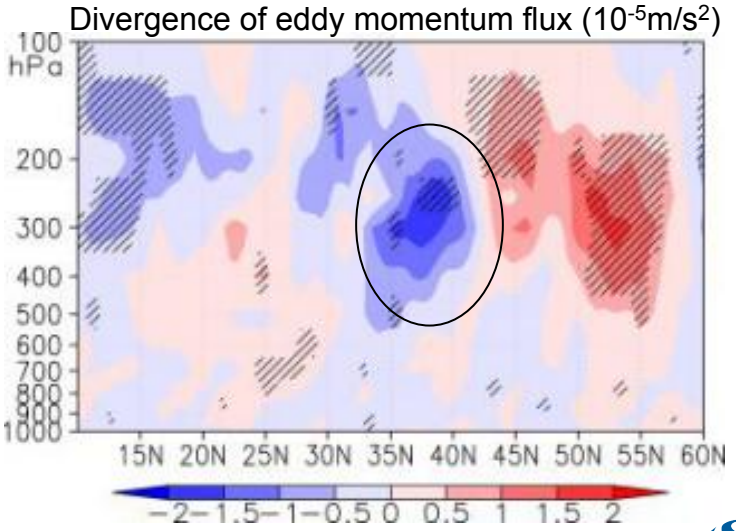
AGCM response to NP SSTA
positive polarity – negative polarity, DJF

➢ *mechanism*

confirmation of Kushnir et al 2002:

+ Eddy vorticity convergence in the upper troposphere
+ Mean flow balances vorticity import by divergence, resulting in ascending motion at lower levels
+ The associated vortex stretching produces the surface low
+ Eddy zonal momentum convergence directly accelerates the zonal flow





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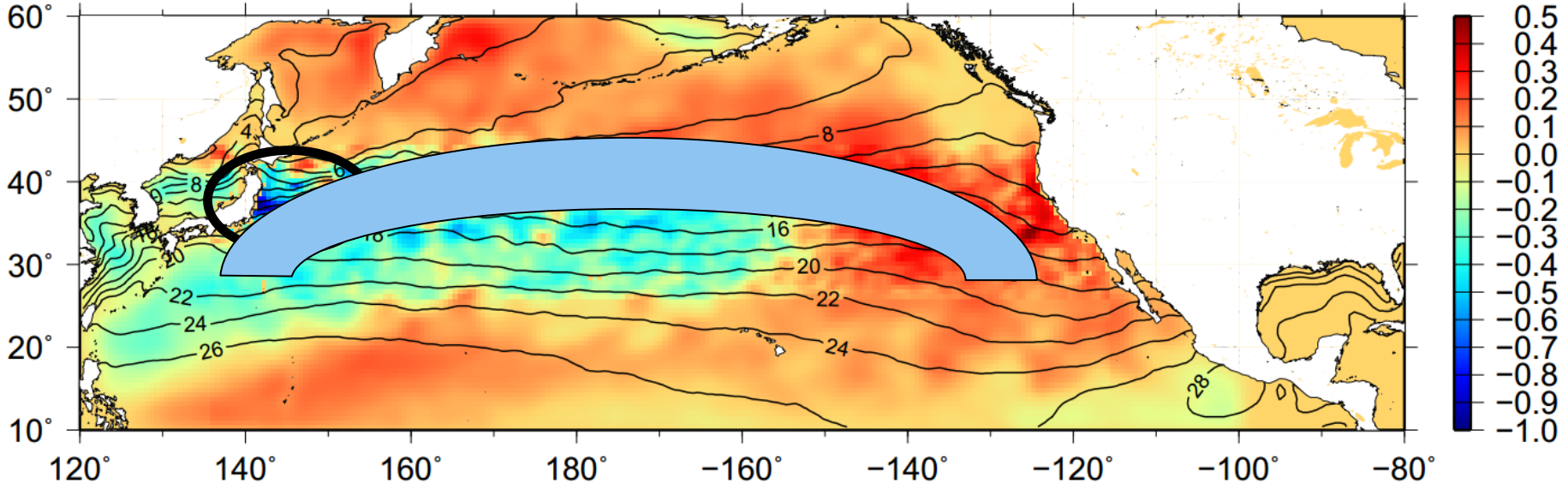
The relative position of the SST anomaly with respect to the full SST

PDO-like SSTA pattern does not strengthen the SST gradient in the west



Contour: winter-mean (DJF) climatological SST
Shading: PDO-like forcing SSTA

what about the zonal SST gradient?

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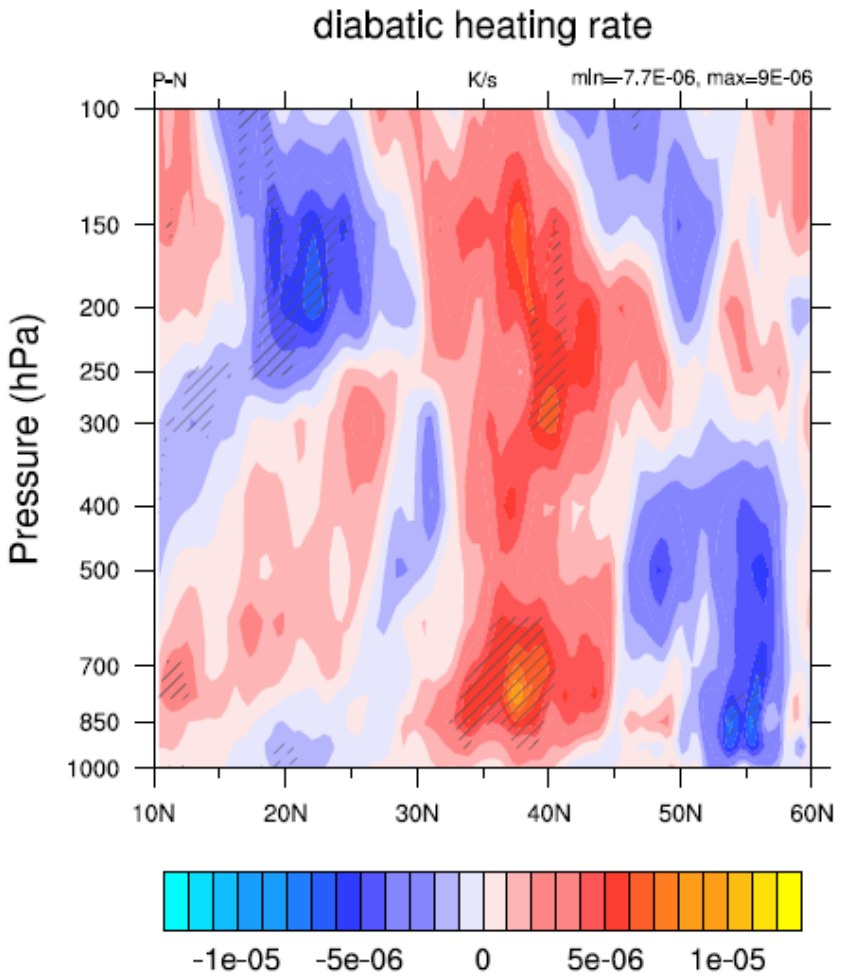
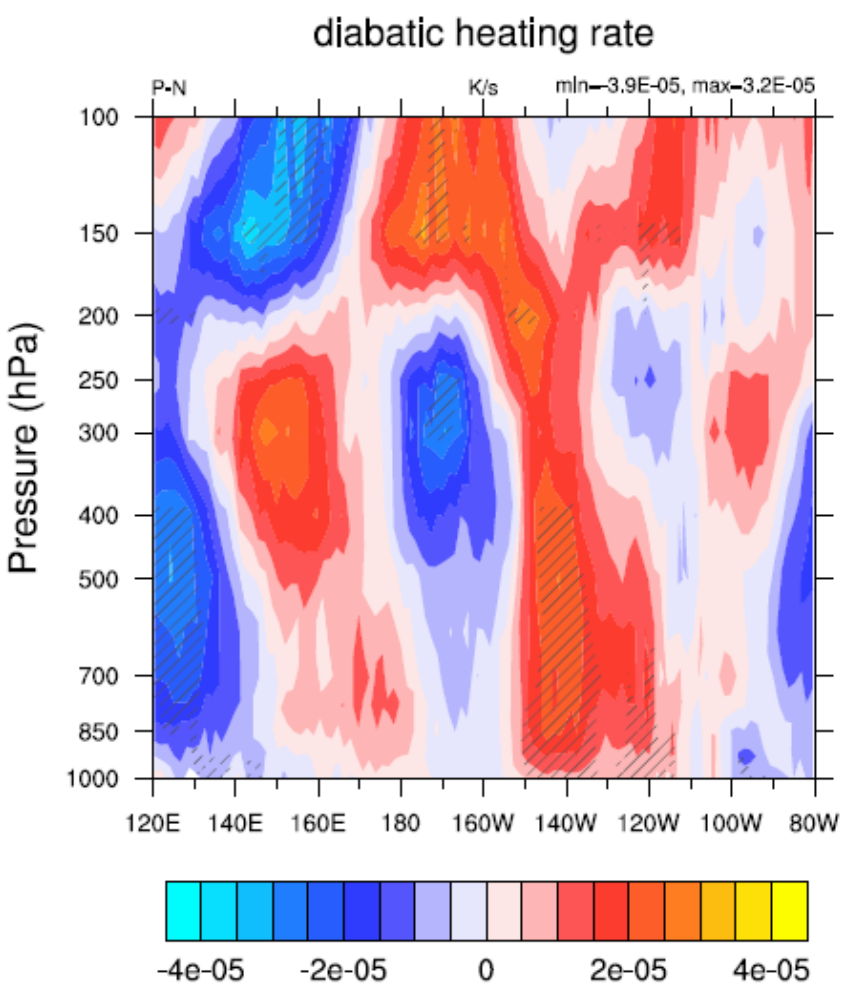
Diabatic heating

north-south section, average over NP



east-west section, 25N-40N



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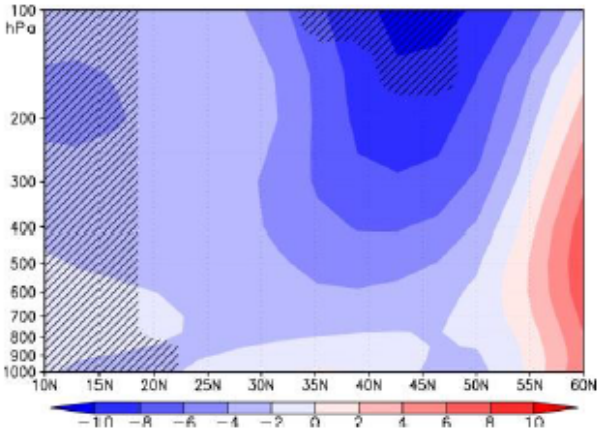
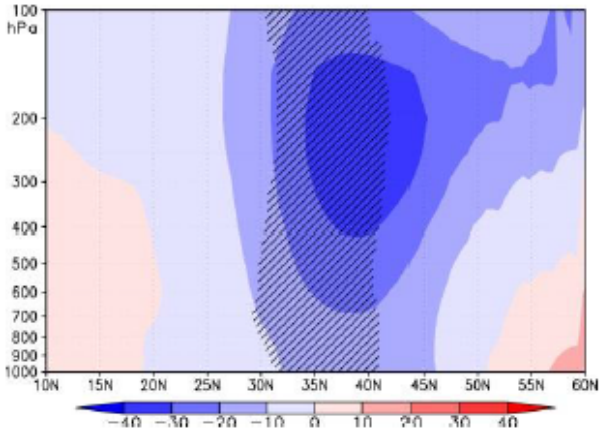
Summary sensitivity experiments

- geopotential height anomalies

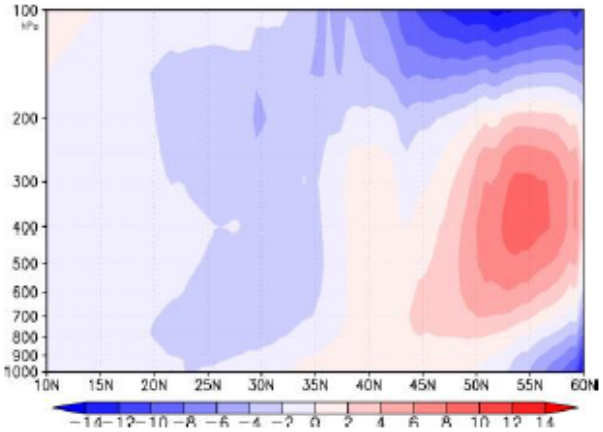
a T31 daily SST



b T213 daily SST



c T213 climatological SST



daily SST and high horizontal resolution is required to simulate a statistically significant response that is consistent with data

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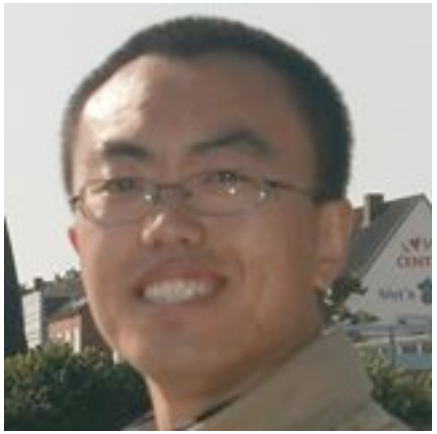
Open questions

- What is the relative role of meridional and zonal SST gradients?
- How does daily SST variability impact storm tracks
- What is the role of the tropics? Although the SST forcing is restricted to the extra-tropics

- to be continued….



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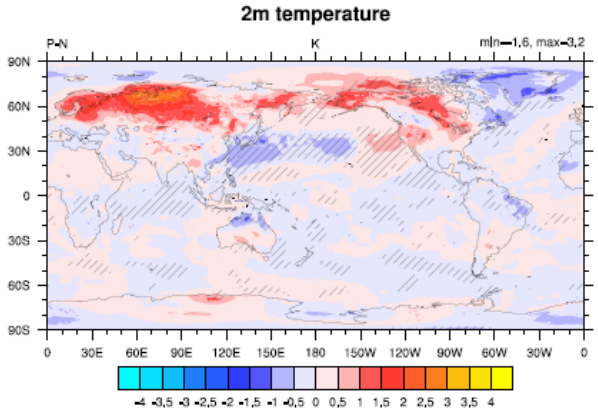
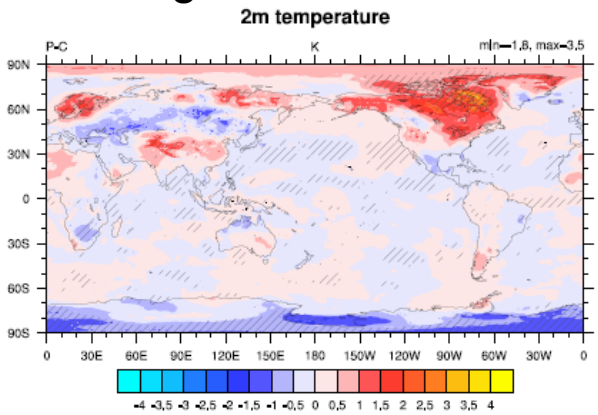
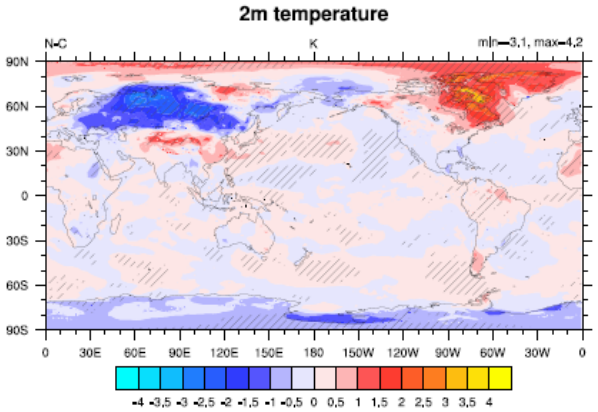
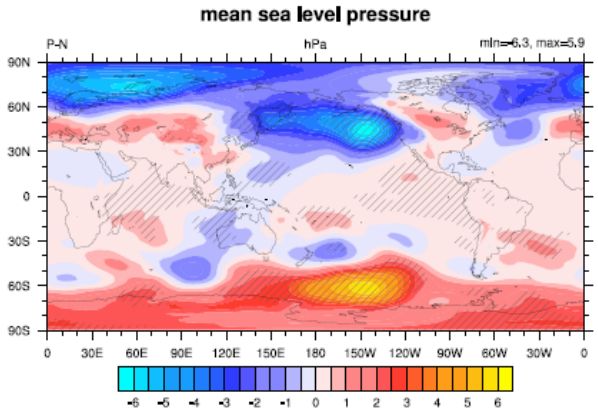
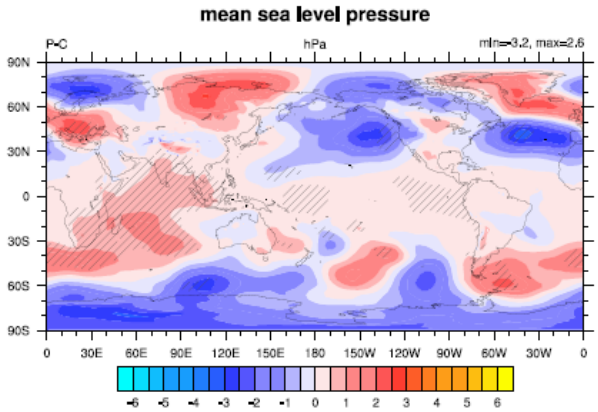
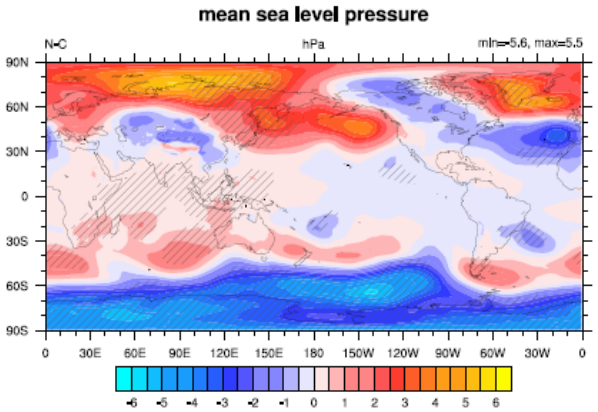
Response is nonlinear

difference



negative NP SSTA



positive NP SSTA