Effect of the East Asian Marginal Sea SST variability on the North Pacific atmospheric circulation – East / Japan Sea case study

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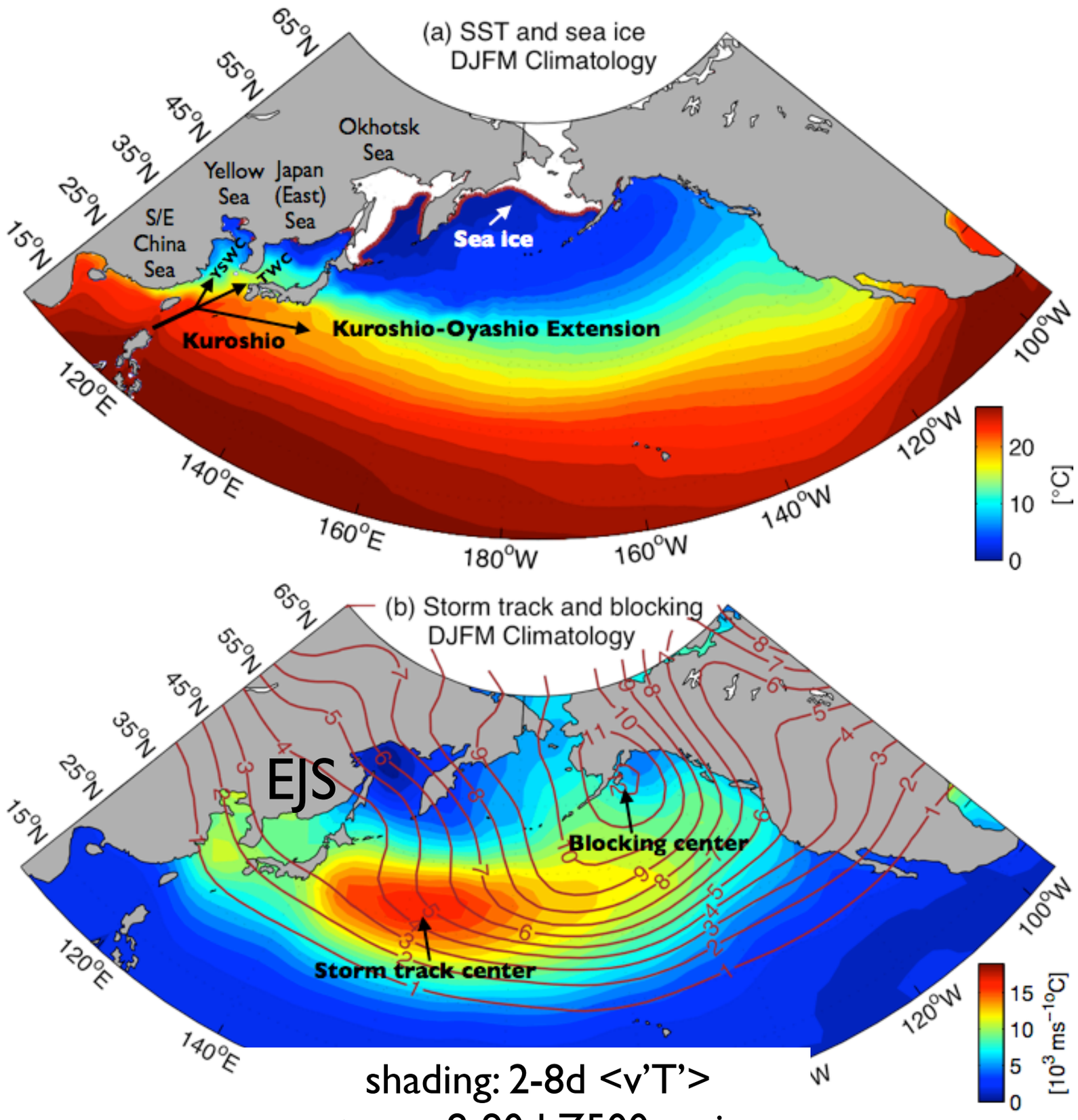
East Asian Marginal Seas in the Northwest Pacific



shading: 2-8d <v'T'>
contours: 8-90d Z500 variance

- Sites of strong heat and moisture flux and air-mass modification process.

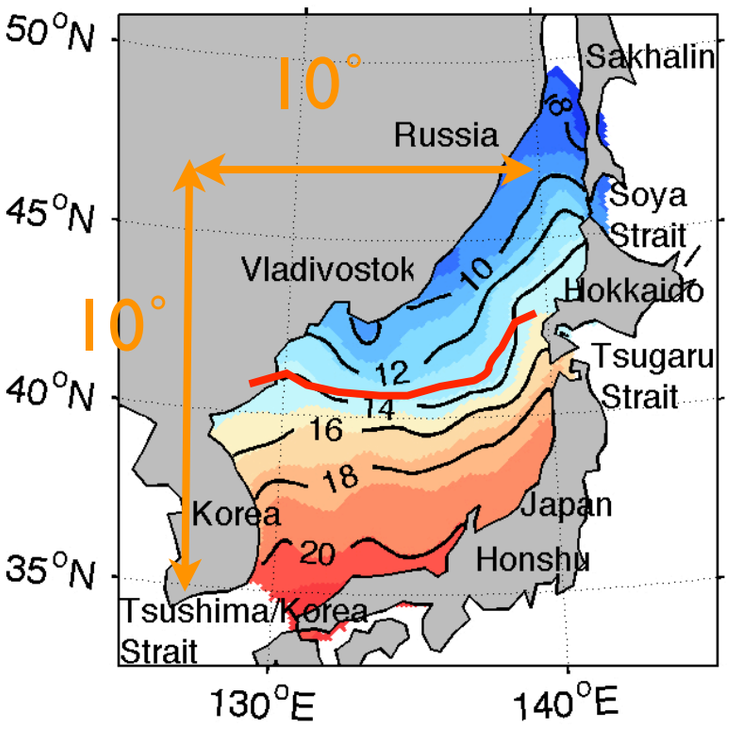
- Proximate to the North Pacific storm track, the marginal seas may influence the downstream KOE process

→ A unique process not found in the North Atlantic.

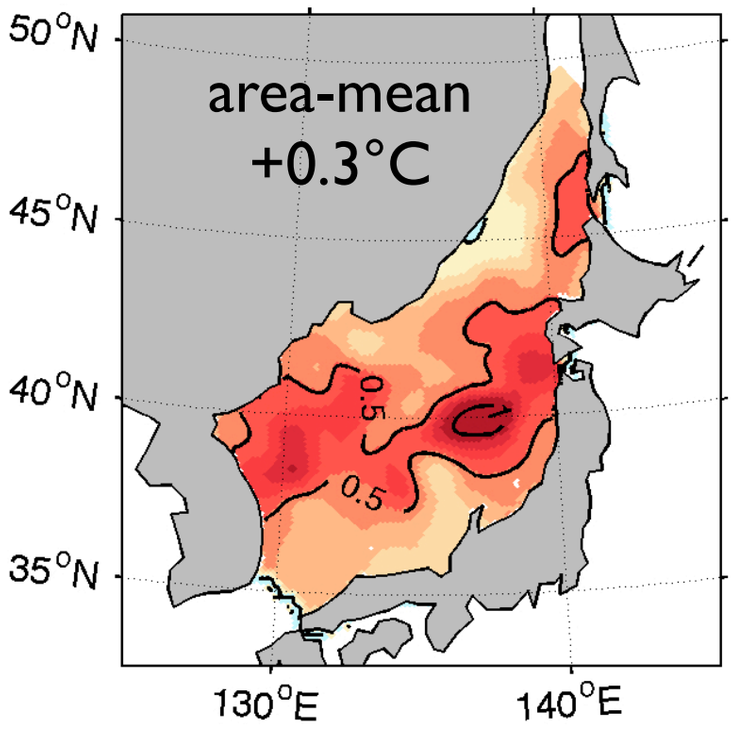
- Focus on the EJS located just upstream of the NP storm track

EJS SST and regional weather variability

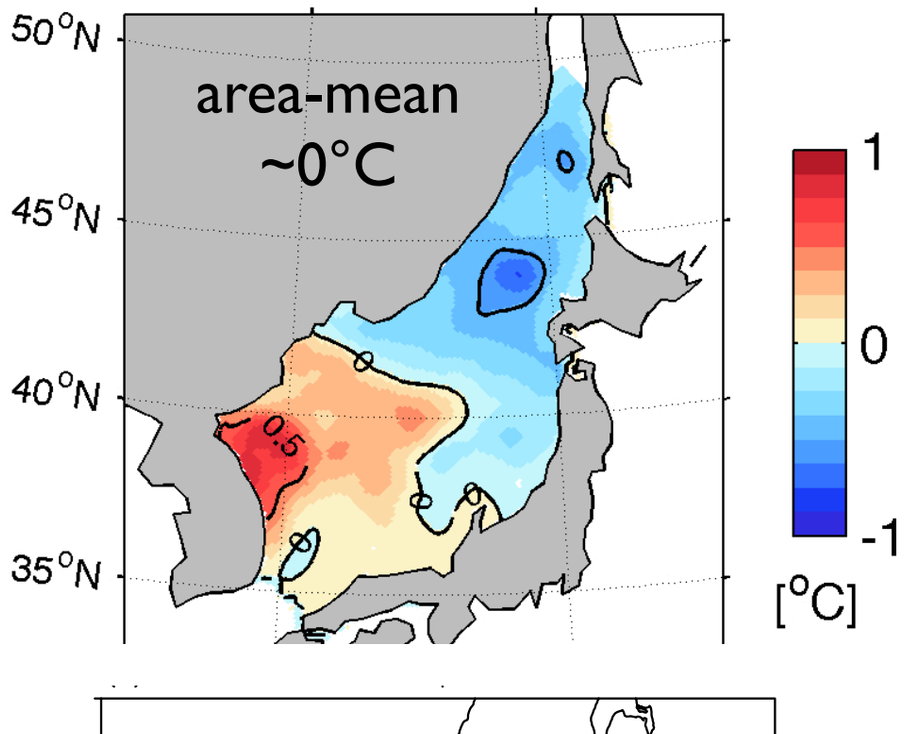
Winter SST climatology



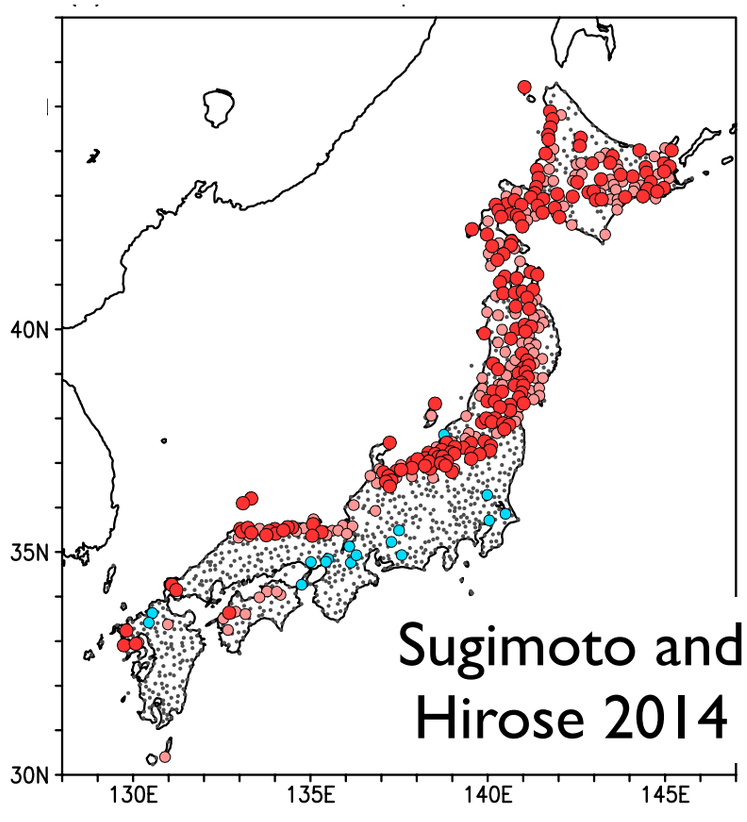
EOF1 42%



EOF2 18%



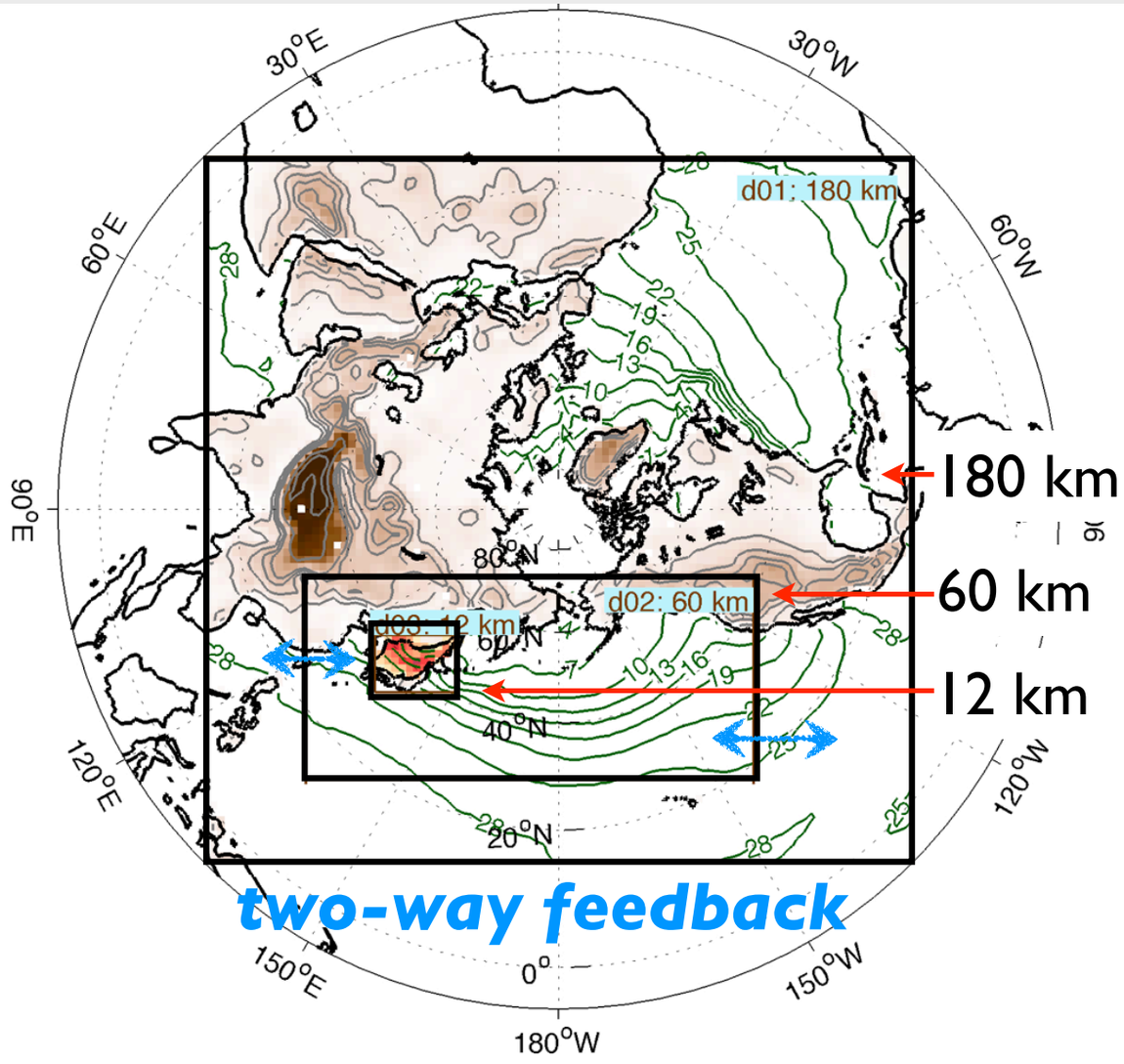
Correlation
EJS SST and precipitation



EJS SSTs important for regional weather and climate

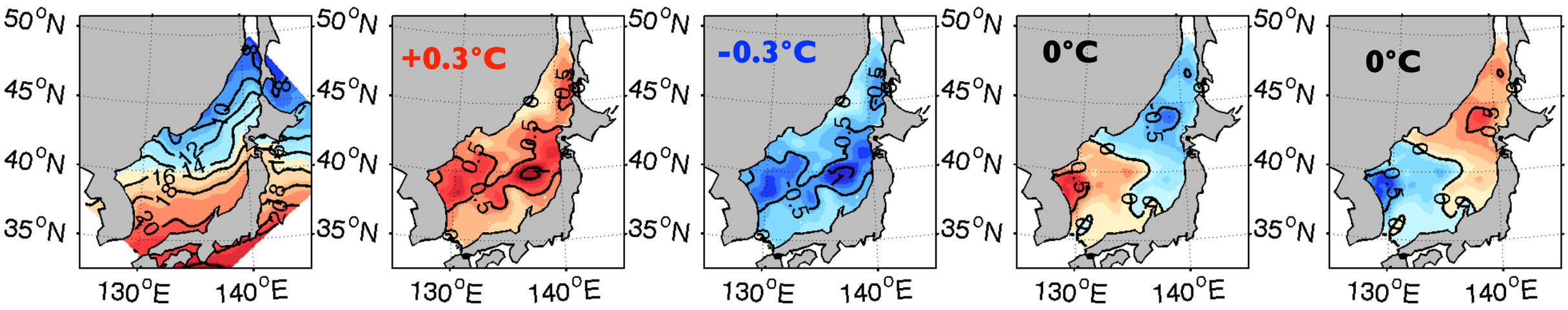
Do EJS SSTs induce any remote atmospheric influence?

Hemispheric-scale WRF with two-way nested feedbacks to capture multi-scale-interaction

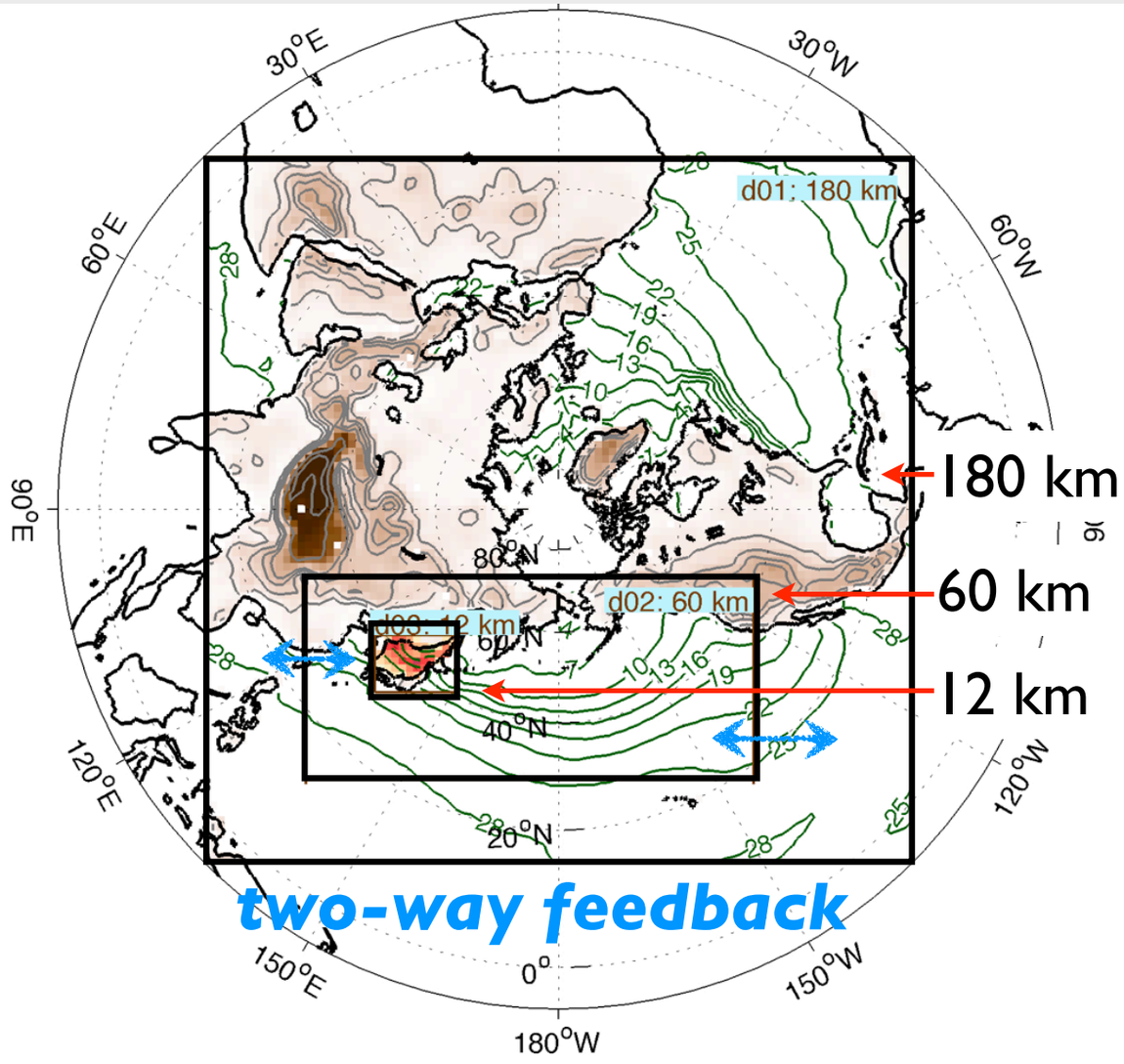


- Five sets of 6-month (Nov-Apr)
- 40 ensemble simulations
- Climatological SST outside the EJS
- ±SSTA to assess symmetricity

Response: EOF1P(N) minus CTL



Hemispheric-scale WRF with two-way nested feedbacks to capture multi-scale-interaction



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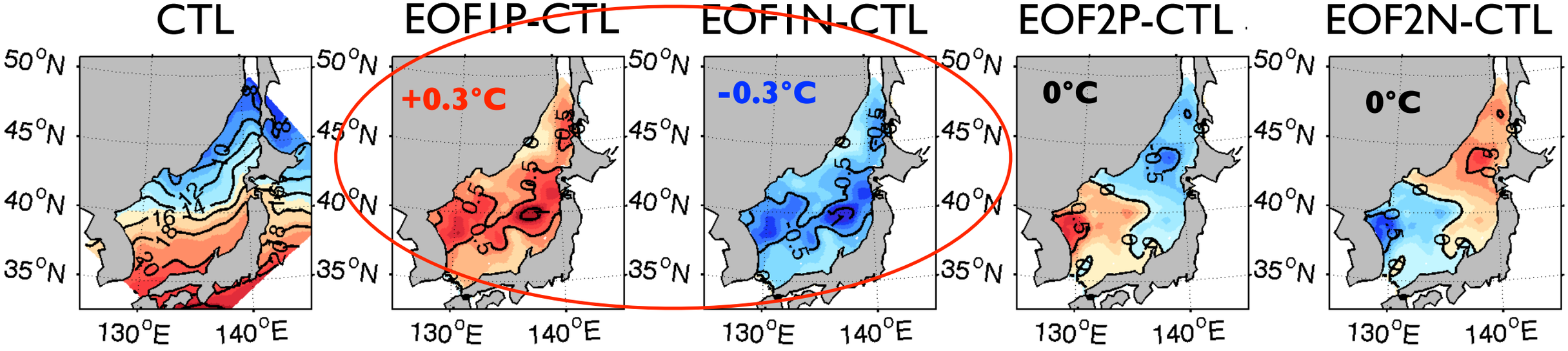
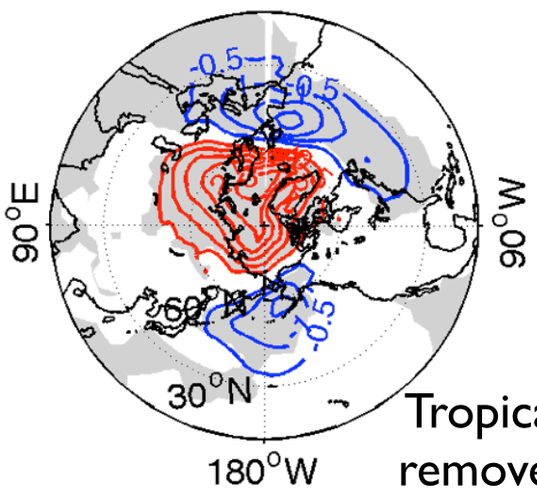
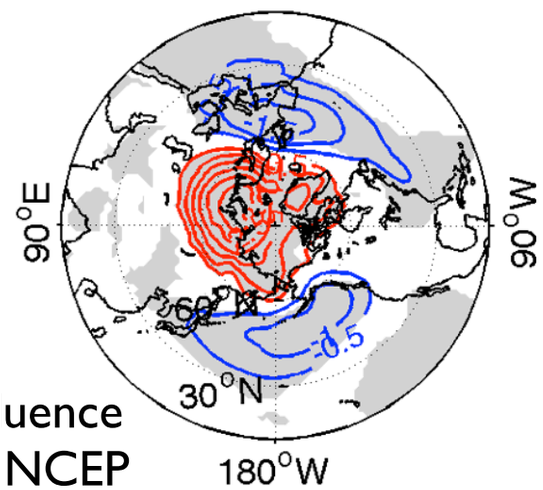


Dominant modes of internal variability in CTL

EOF1 NCEP SLP 34%

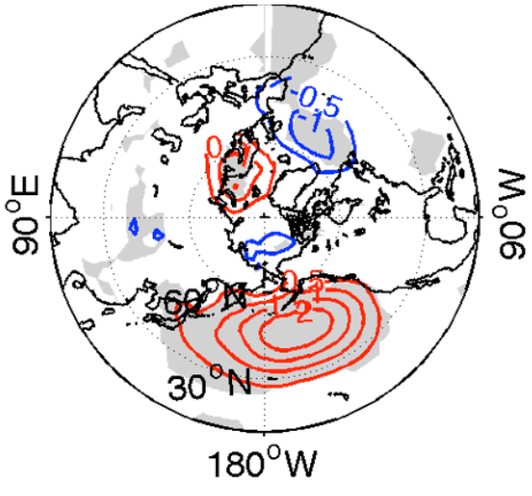


EOF1 CTL SLP 34%

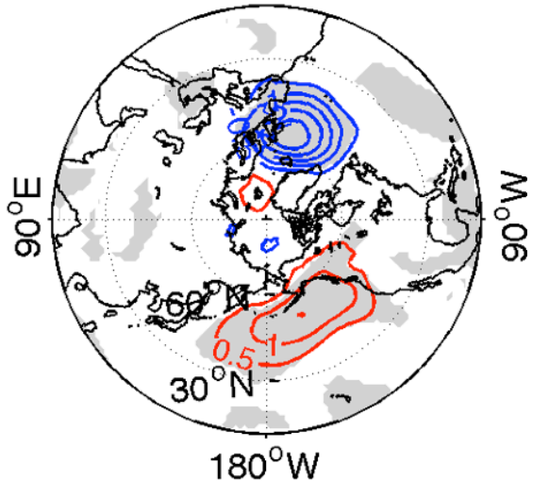


Tropical influence removed in NCEP

EOF2 NCEP SLP 14%



EOF2 CTL SLP 15%

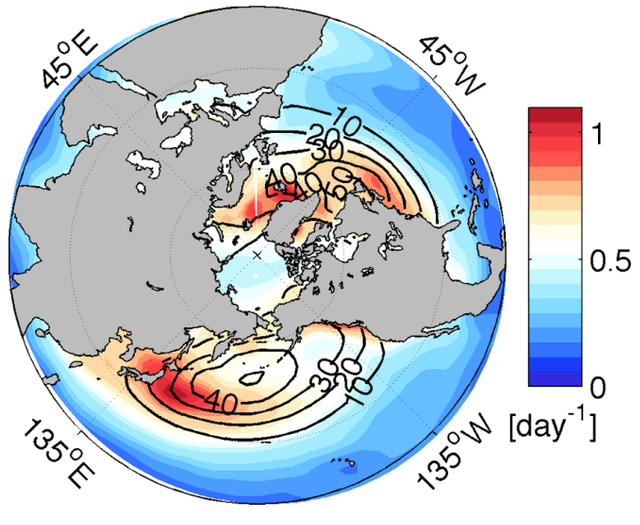


- Atmospheric response to extra-tropical SSTA is projected onto dominant modes of model's intrinsic variability.
- 1st mode: AO
- 2nd mode: AL

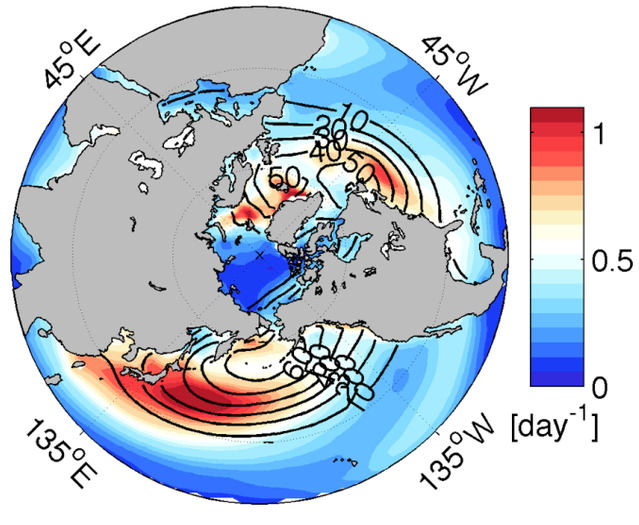
- The simulated mean σ and storm track (2-8d SLP variance).

Eady growth rate $\sigma = 0.31 f \left| \frac{\partial \vec{v}}{\partial z} \right| \frac{1}{N}$,

NCEP σ



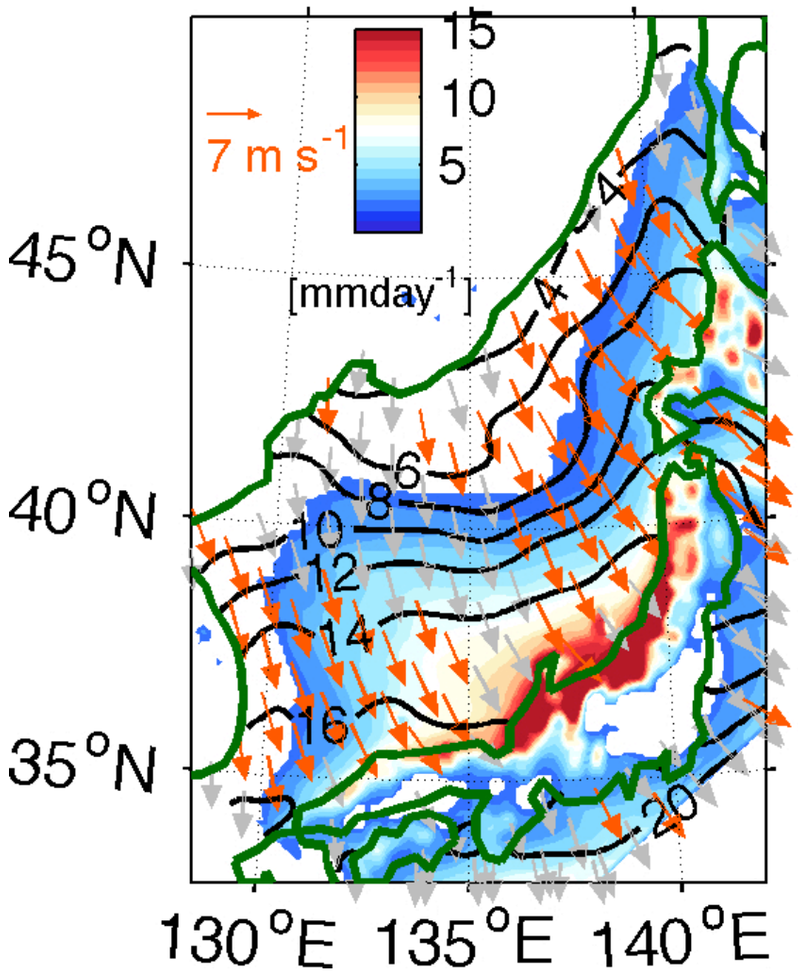
CTL σ



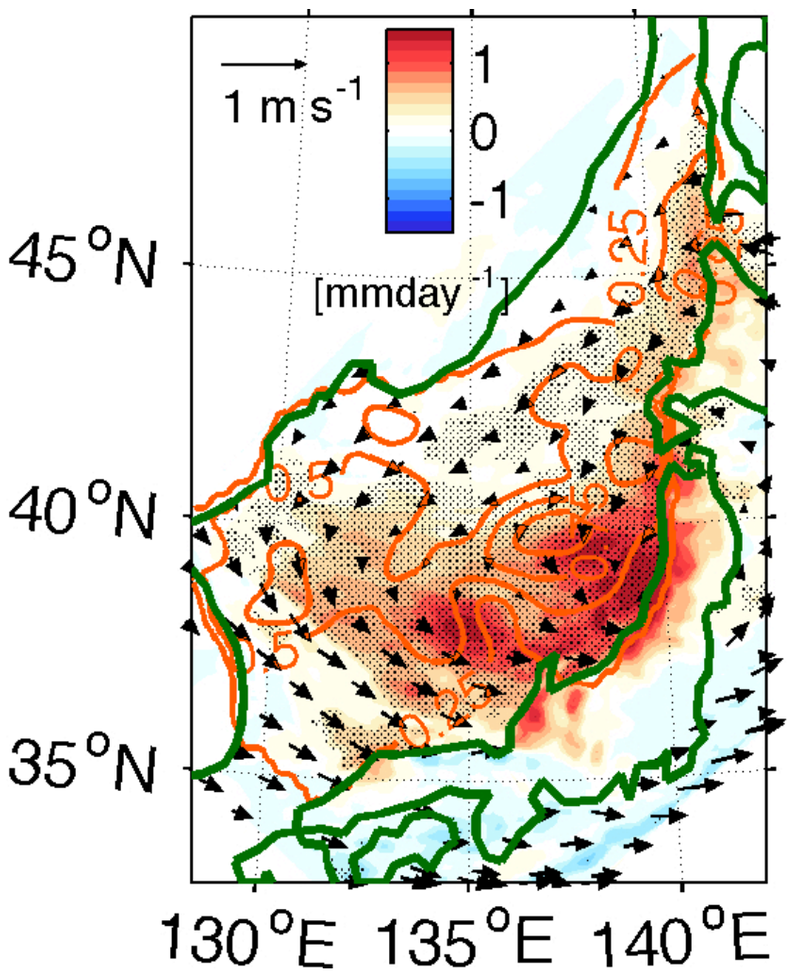
Local atmospheric response is linear:
Intra-basin SST pattern critical to local weather

Response in time-mean precipitation and wind

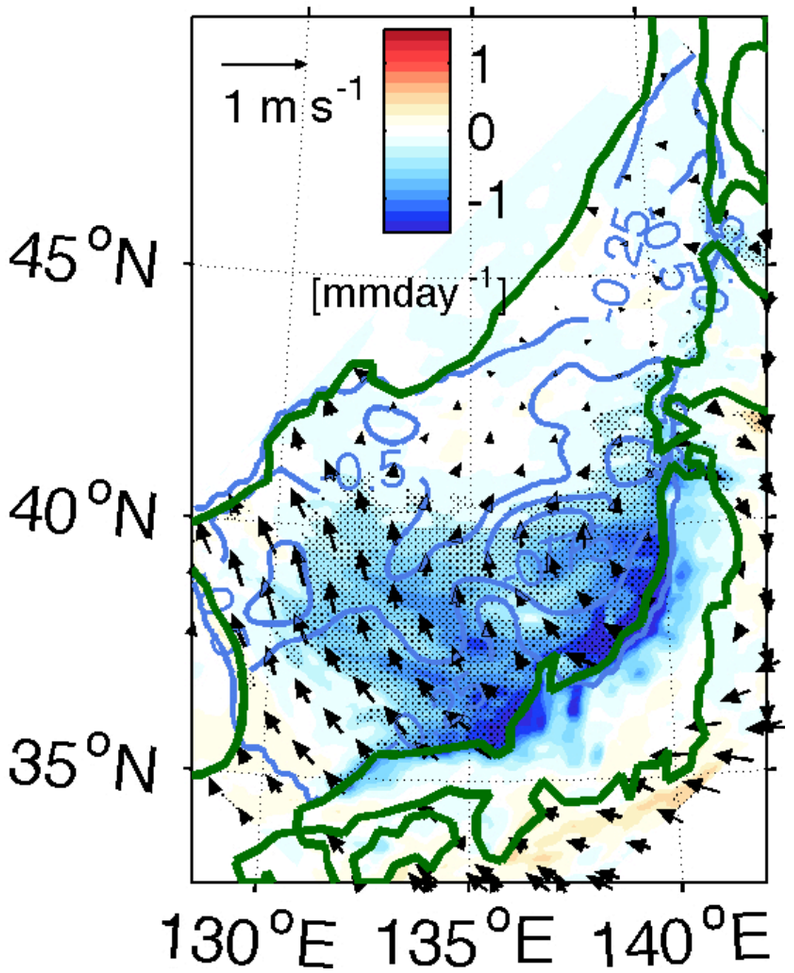
NDJ CTL



EOF1P-CTL



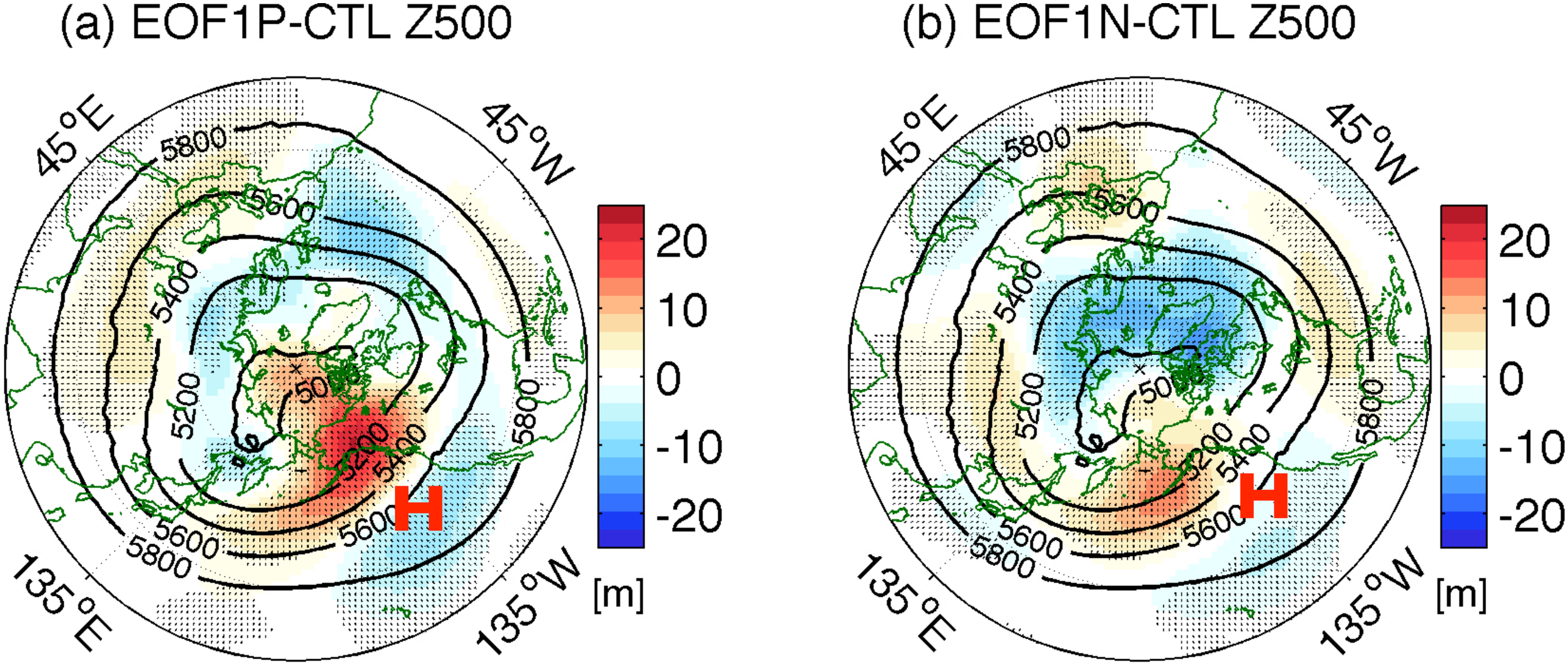
EOF1N-CTL



A symmetric response with respect to the sign of SSTA

Downstream and remote response is *NOT* linear!

Response in time-mean Z500

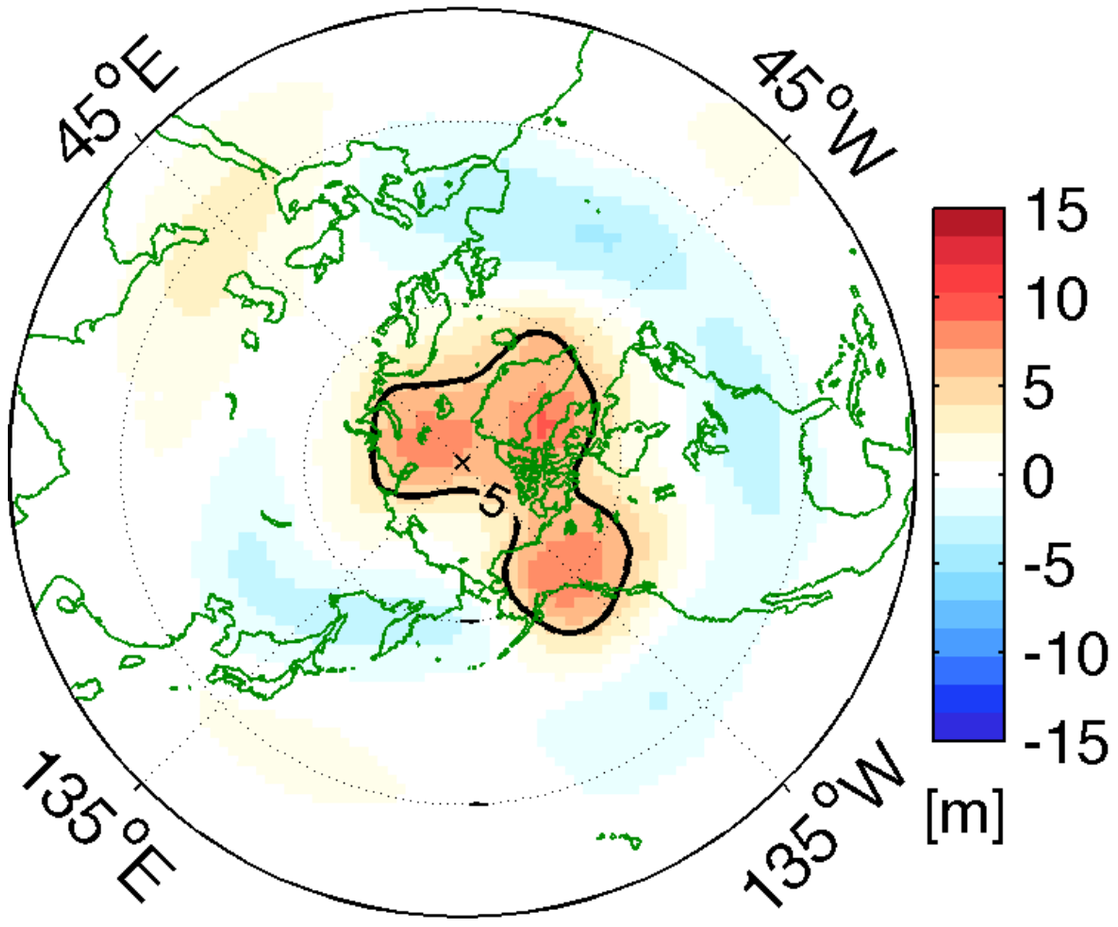


Anomalous ridge a common downstream response independent of SSTA.

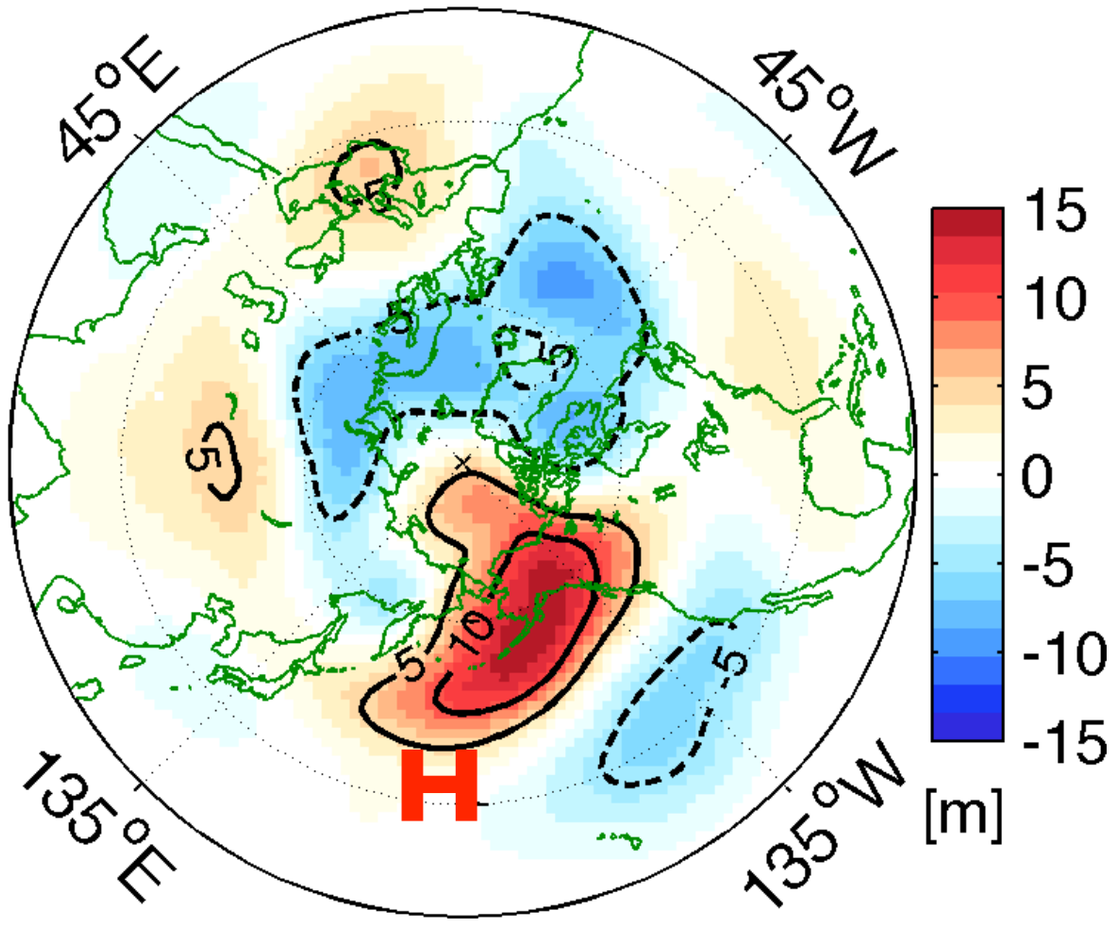
Confirming that the downstream ridge is a nonlinear response

Symmetric = ½ × (EOF1P - EOF1N)
Anti-symmetric = ½ × [(EOF1P-CTL) + (EOF1N-CTL)]

Symmetric Z500



Anti-symmetric Z500

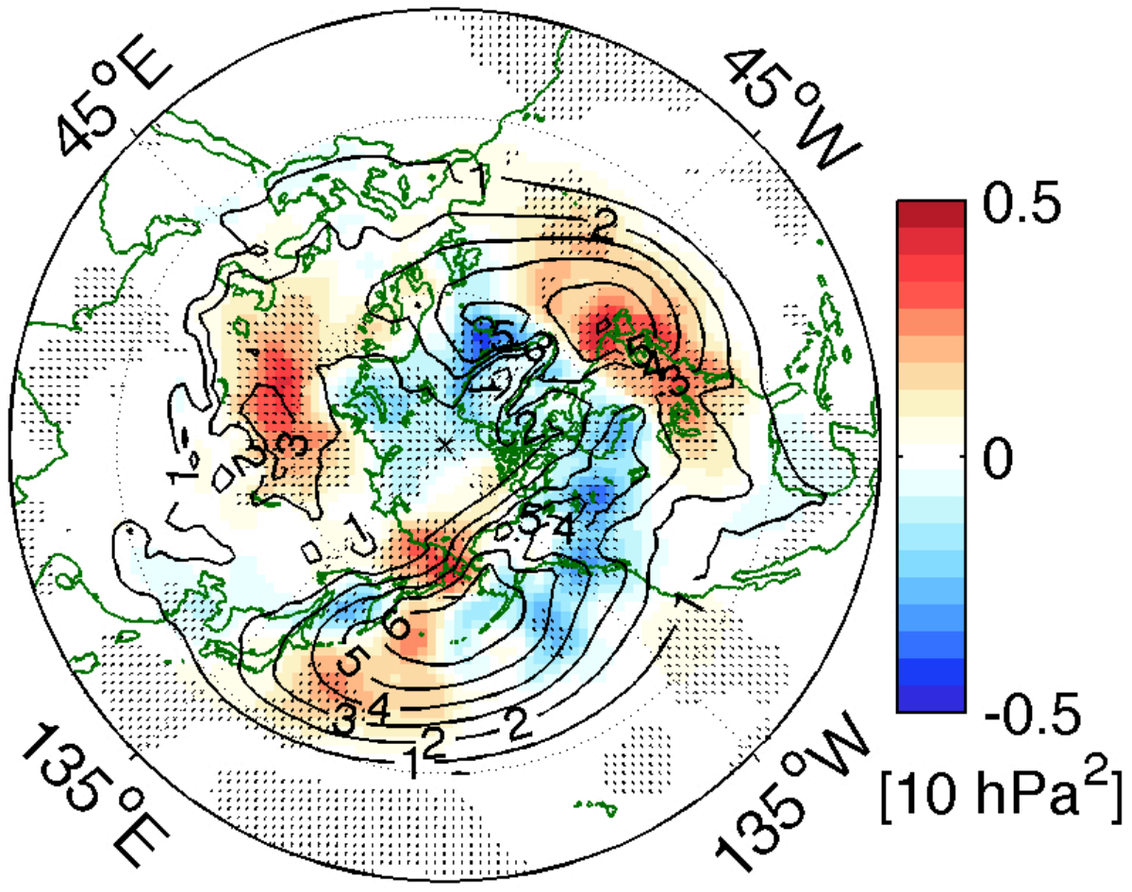


A downstream ridge response independent of sign of upstream SSTA
Dominant time-scale of 8-90 days with an equivalent barotropic vertical structure

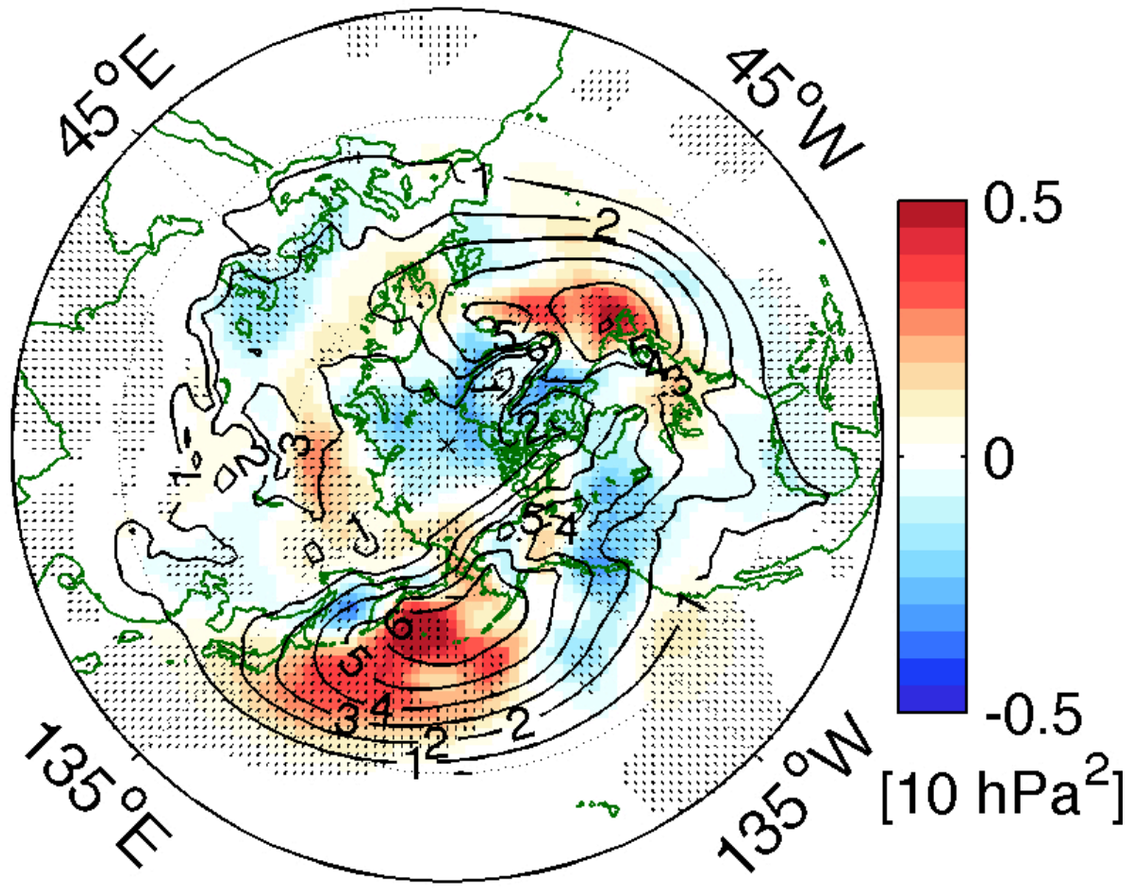
The downstream blocking response is accompanied by the strengthened storm track variability in the upstream

Response of 2-8 day SLP variance

(a) EOF1P-CTL 2-8 day SLP Var



(b) EOF1N-CTL 2-8 day SLP Var



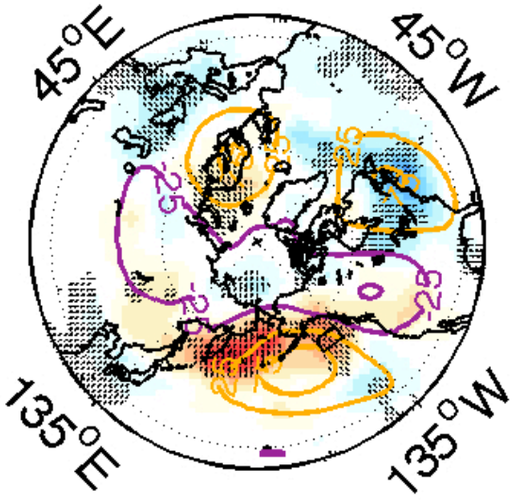
What is the connection between the upstream storm track response and the downstream blocking response?

Intensified storm track activity prior to the onset of GoA blocking

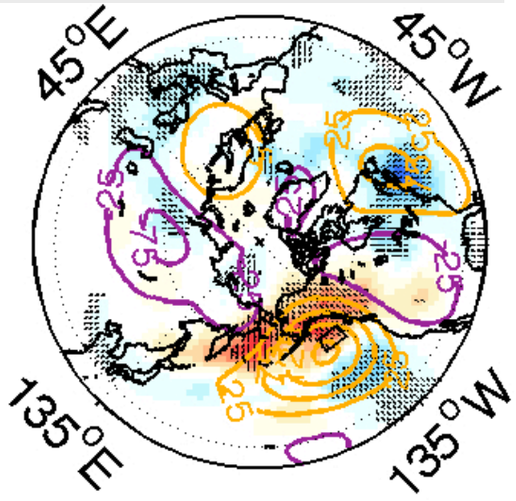
Composite evolution of synoptic & intraseasonal variability against the GoA blocking index

EOF1P-CTL

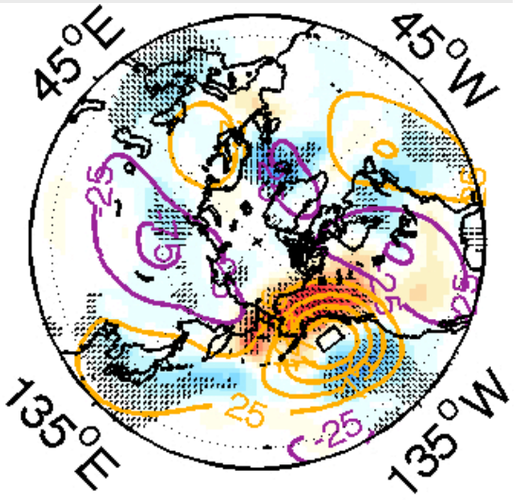
Day-2



Onset of blocking

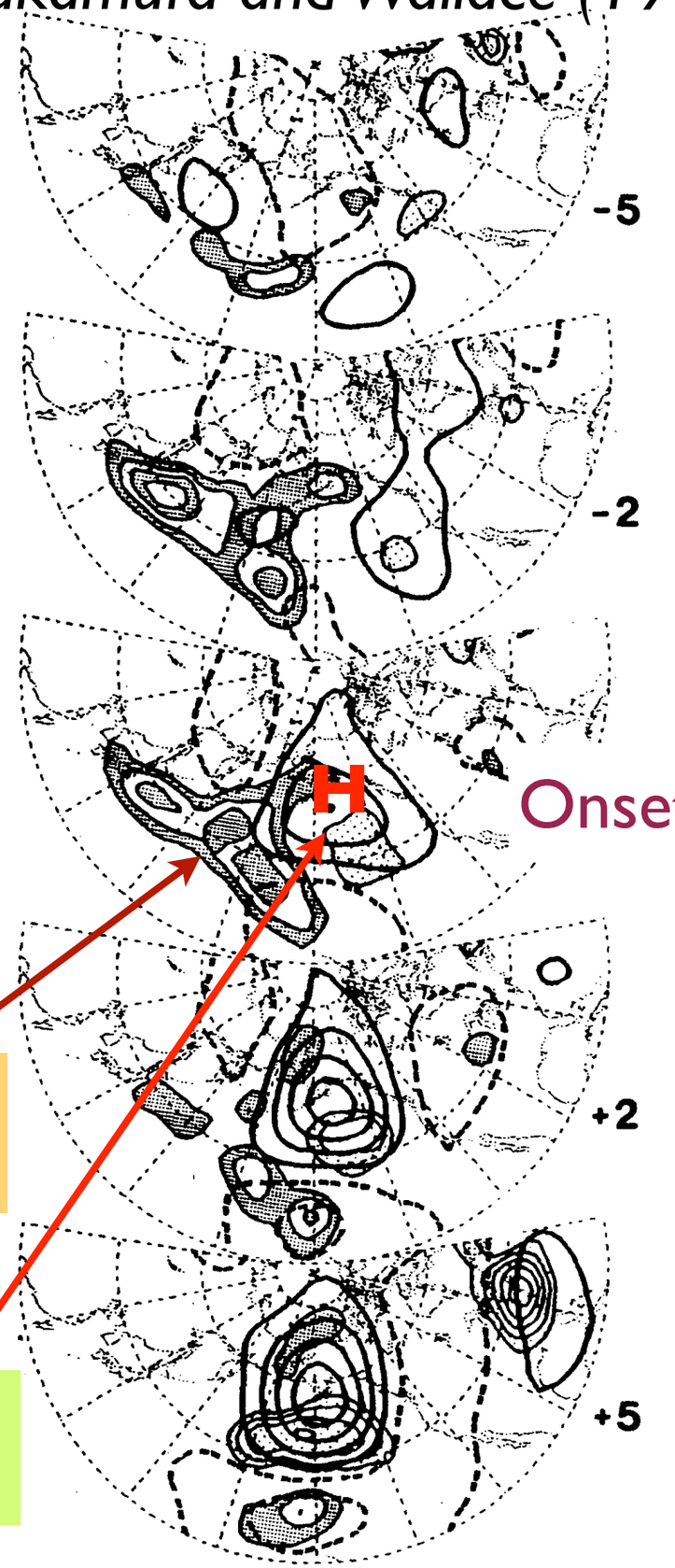


Day+2



- Enhanced baroclinic wave activity preceding the blocking ridge.
- The onset of a block is sandwiched by amplified (suppressed) baroclinic wave activity in the north (south).

Nakamura and Wallace (1990)



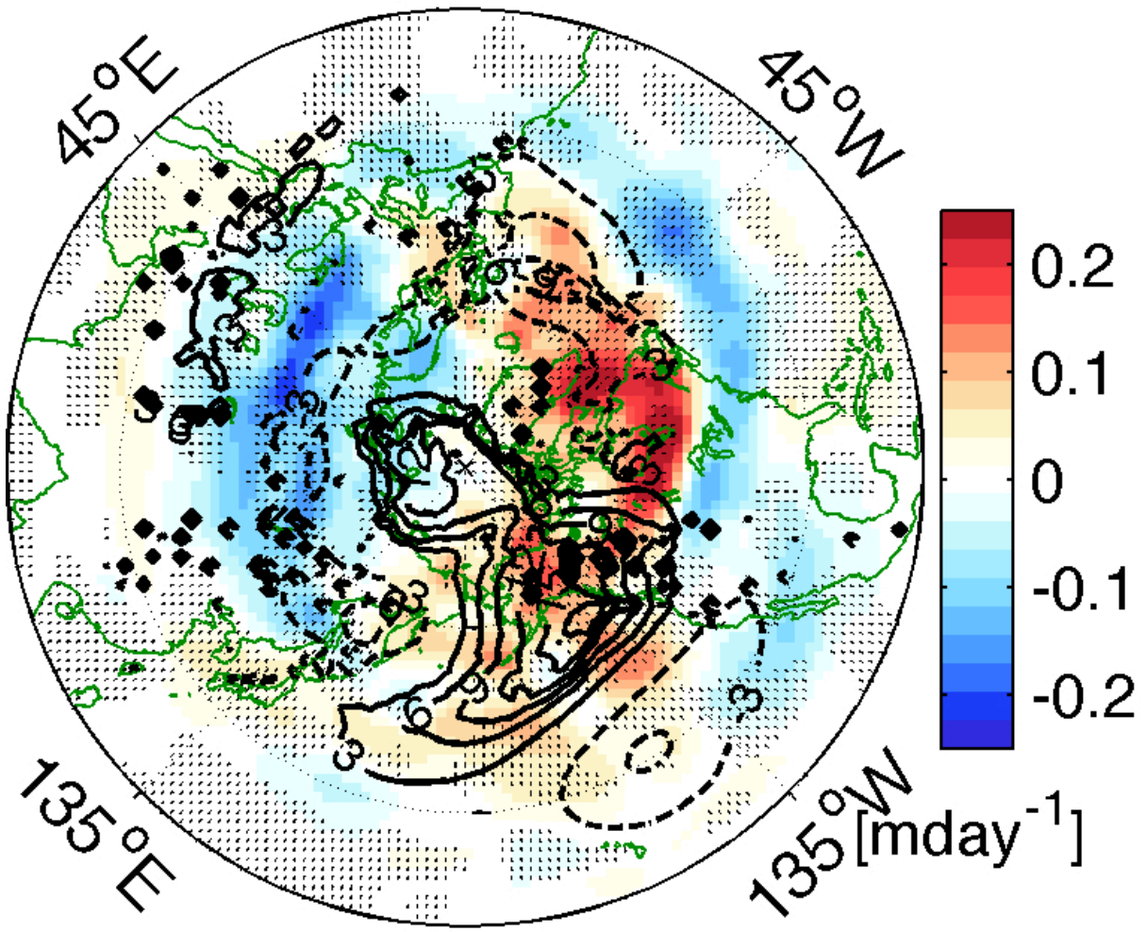
Enhanced synoptic SLP

intraseasonal Z500

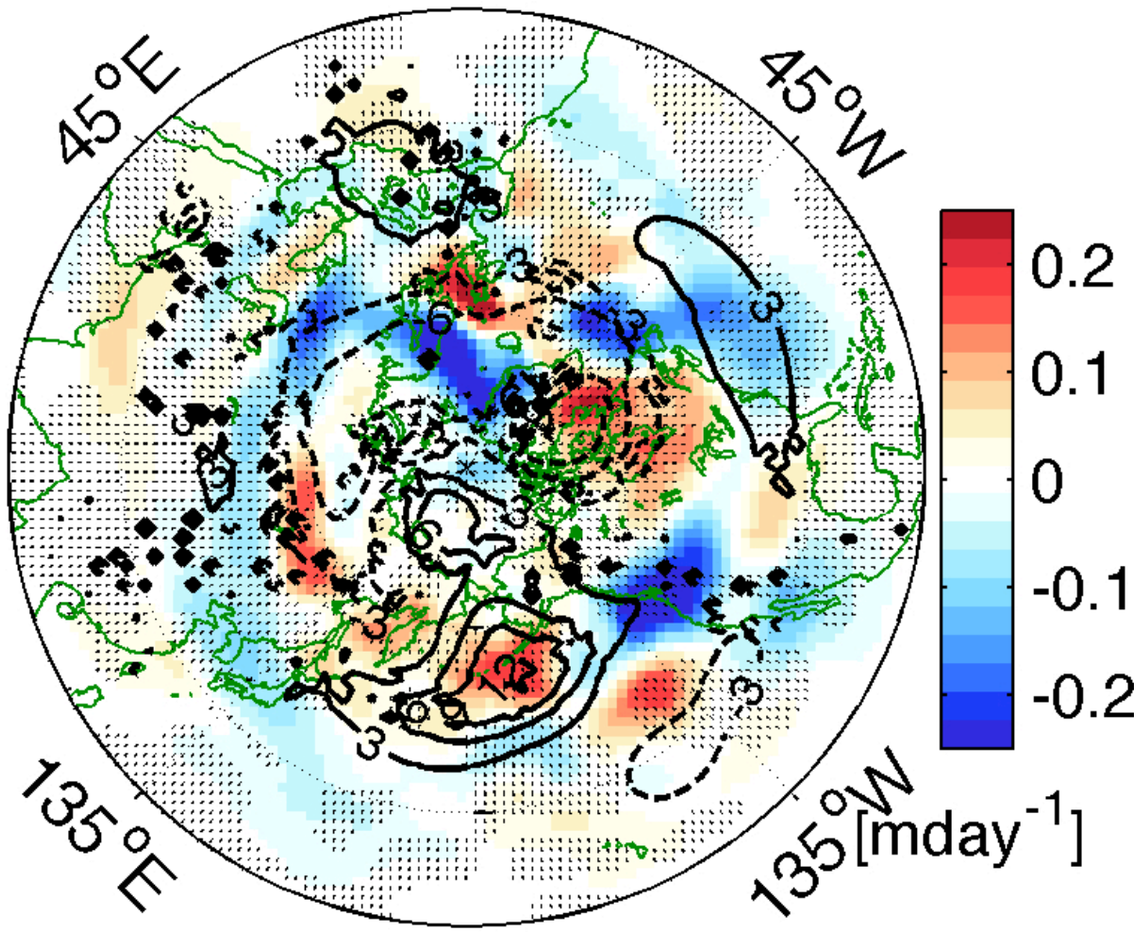
Synoptic eddy vorticity flux reinforcing the blocking ridge response

$$\partial Z/\partial t = (f/g)\nabla^{-2}\left[-\nabla(\overline{v'\zeta'})\right]$$ Column-integrated height tendency due to eddy vorticity flux convergence

EOF1P-CTL ∂Z/∂t and mean Z



EOF1N-CTL ∂Z/∂t and mean Z



shading: Zt due to eddy flux
contour: time-mean Z response

- Z_t spatially well corresponds to low-frequency blocking circulation.

Summary

Q: What is the *characteristic atmospheric response pattern* to a small extent/amplitude SSTA and the *generating mechanism*?

Local response: linear and symmetric wrt sign and pattern of SSTA.

A critical role of the intra-basin SSTA for the regional weather and climate

Anomalous transient eddy vorticity flux
a direct linear baroclinic response → an equivalent barotropic ridge anomaly

Remote response: highly nonlinear independent of SSTA.

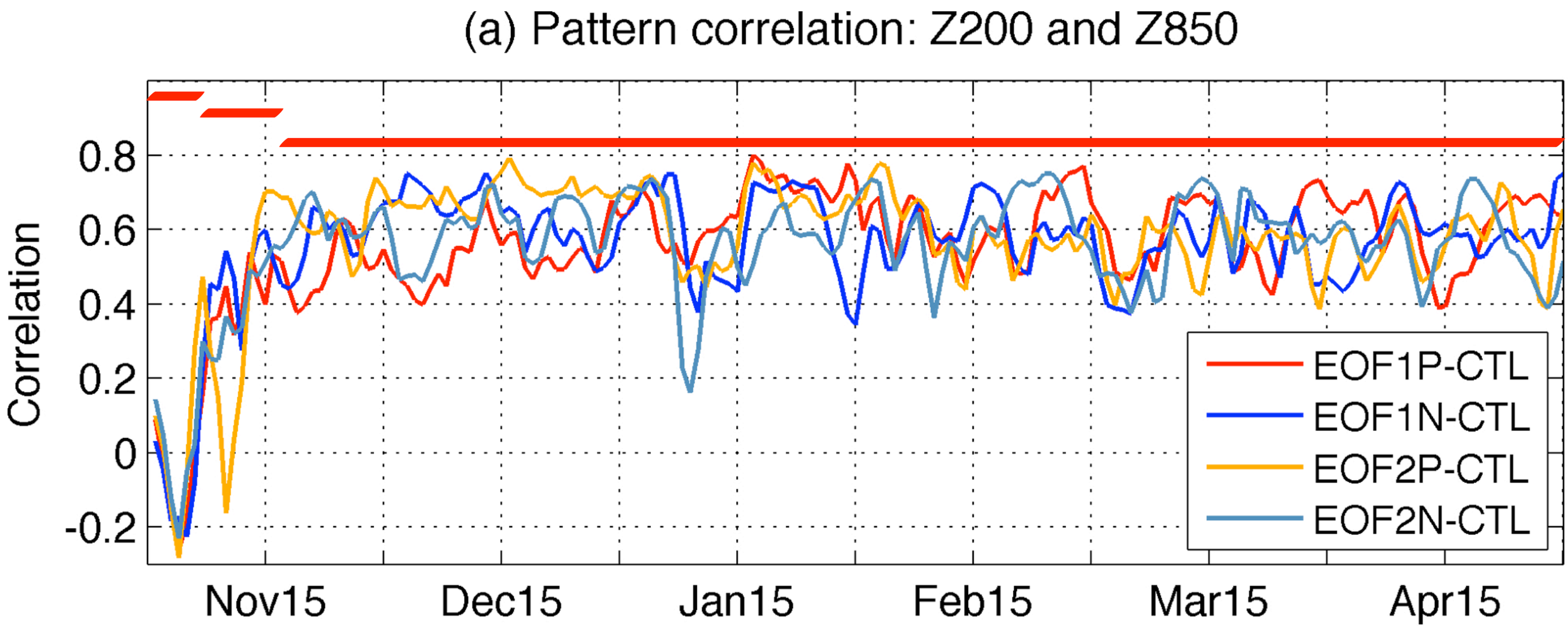
East Asian Marginal Seas an important element for the North Pacific climate variability?

Thanks

hseo@whoi.edu

Seo et al. 2014: On the effect of the East/Japan Sea SST variability on the North Pacific atmospheric circulation in a regional climate model. *JGR-Atmos*., 119, 418-444

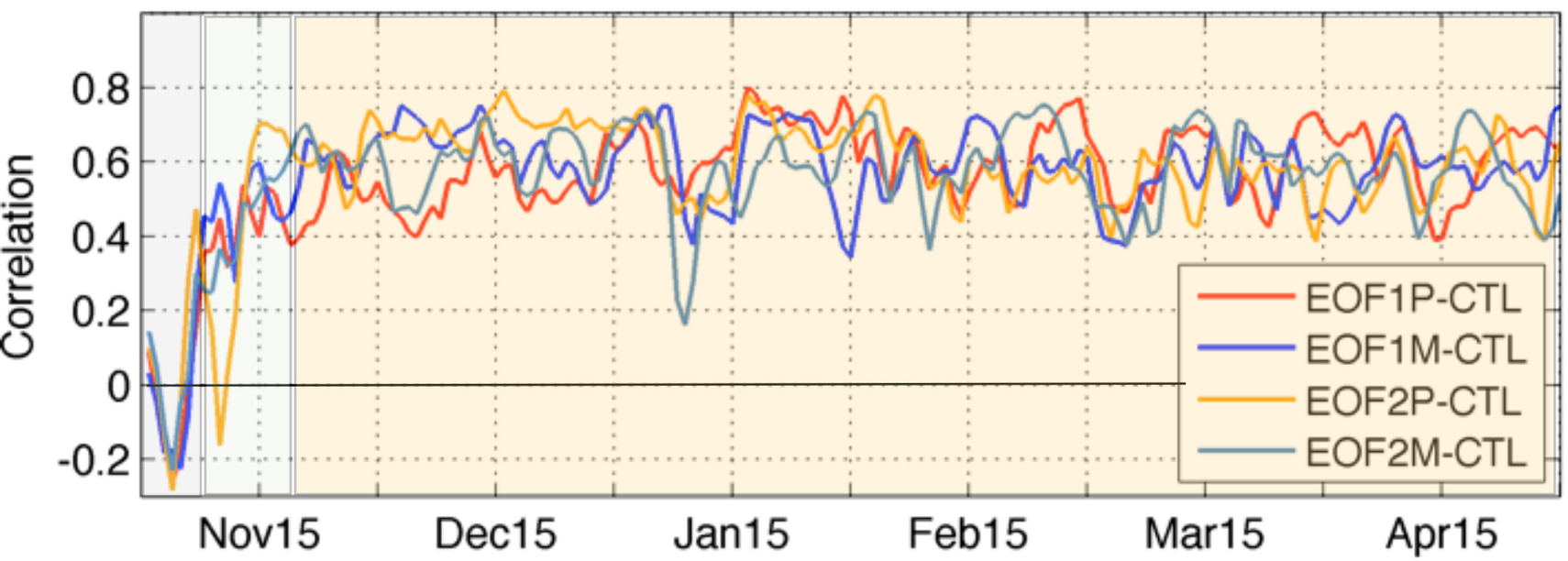
Equilibrium response with an equivalent barotropic structure



- Initial response: short-lived (~5 days) and baroclinic
- A rapid transition (1-2 weeks) to a positive correlation
- A quasi-equilibrium response with an equivalent barotropic structure
- Has a dominant time-scale of 8-90 days ~ blocking

Equilibrium response with an equivalent barotropic structure

Time-series of pattern correlation of Z200 and Z850



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(b) Z200 EOF1P-CTL (c) Z500 EOF1P-CTL (d) Z850 EOF1P-CTL