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Influence of enhanced convection over Southeast Asia on blocking ridge and associated surface high over Siberia in winter

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Introduction

Our common view based on statistics

In La Niña winter, enhancement of Siberian high (SH) and stronger-than-normal East Asian winter monsoon are seen.

Previous studies for the ENSO impact

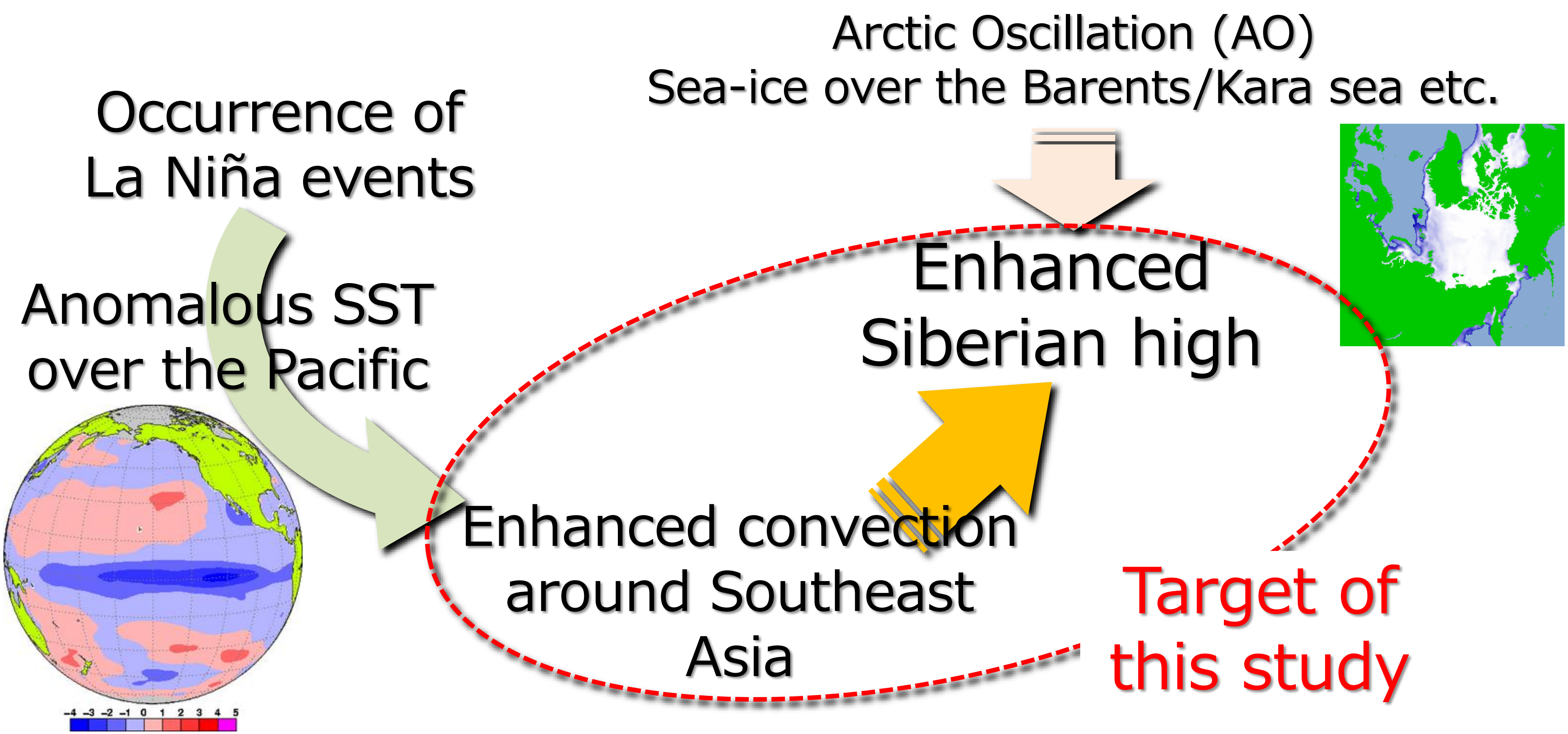
- ☐ <u>Suggestion of ENSO impact</u>
  - ✓ Zhang et al. (1997), Cheung et al. (2012), Hao et al. (2016), Kang and Lee (2017) etc.
- ☐ <u>No ENSO impact</u>
  - ✓ Yang et al. (2002), Gollan et al. (2012) etc.
- ☐ <u>ENSO impact depends on a phase of PDO</u>
  - ✓ Wang et al. (2008)

Further investigation is needed to examine the existence of the ENSO influence on the variability of SH.

Introduction

Target of this study

Dynamical impact of enhanced convection around Southeast Asia associated with La Niña events on the enhancement of SH and its mechanism.



Data and Methods

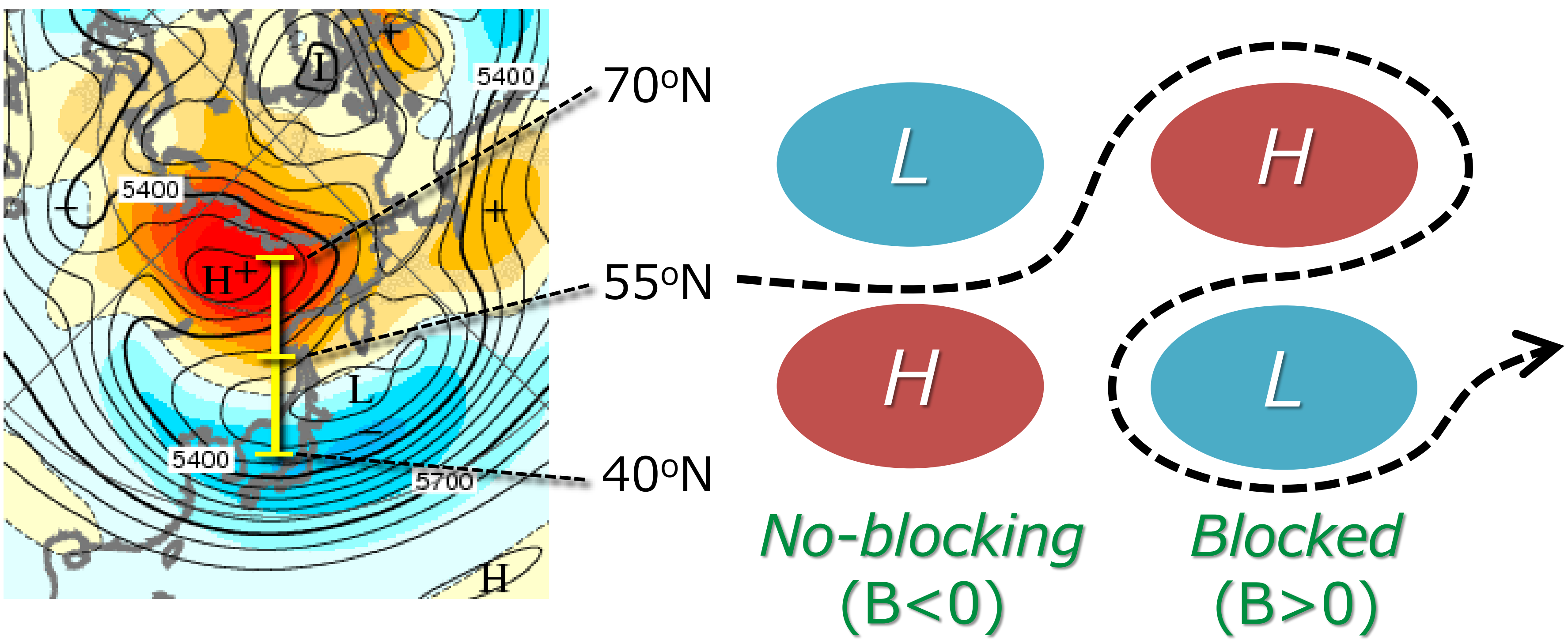
- The Japanese 55-year reanalysis dataset (JRA-55, Kobayashi et al. 2015)
- OLR dataset provided by NOAA
- “Normal” was defined as the 30-year average during the period from 1981 to 2010, and “anomaly” was defined as deviation from the normal.

Analysis Model

- Linear Baroclinic Model (LBM, Watanabe and Kimoto 2000, 2001)
- Comprising linearized primitive equation about a basic state defined as the normal.
- Resolution: T42L40 (sigma vertical coordinate)

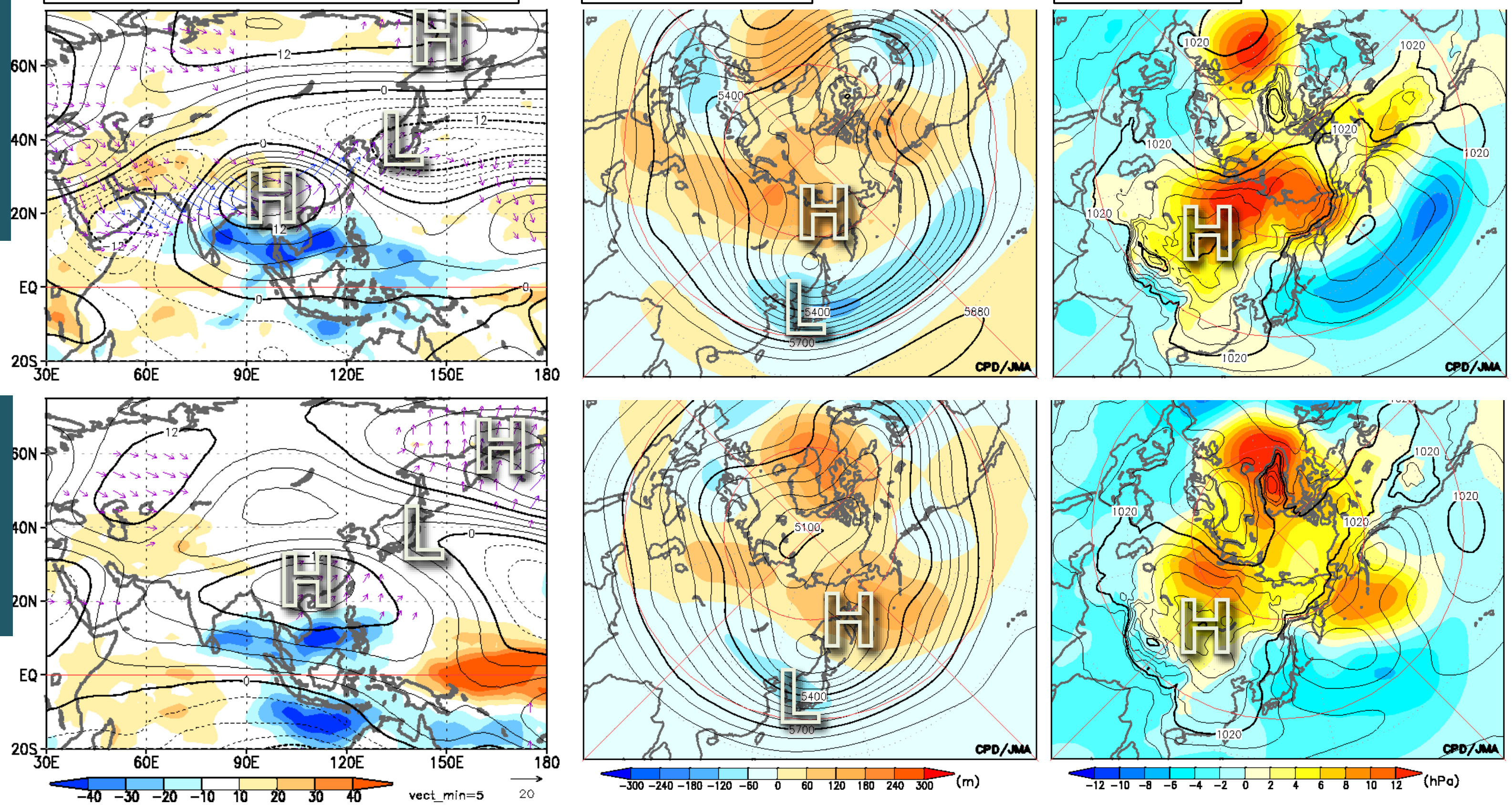
Blocking detection over Siberia

- Daily blocks over Siberia were detected with a simple blocking algorithm based on meridional reversal of 5-day running mean Z500.
- The blocking index (B) was defined as a difference of the time-filtered Z500 averaged in northern and southern areas over a central latitude of 55°N.



Case of enhanced SH in La Niña years

	ψ200 & OLR	Z500	SLP
21 Nov. –20 Dec. 2005			
1 Dec. –31 Jan. 2010/11			

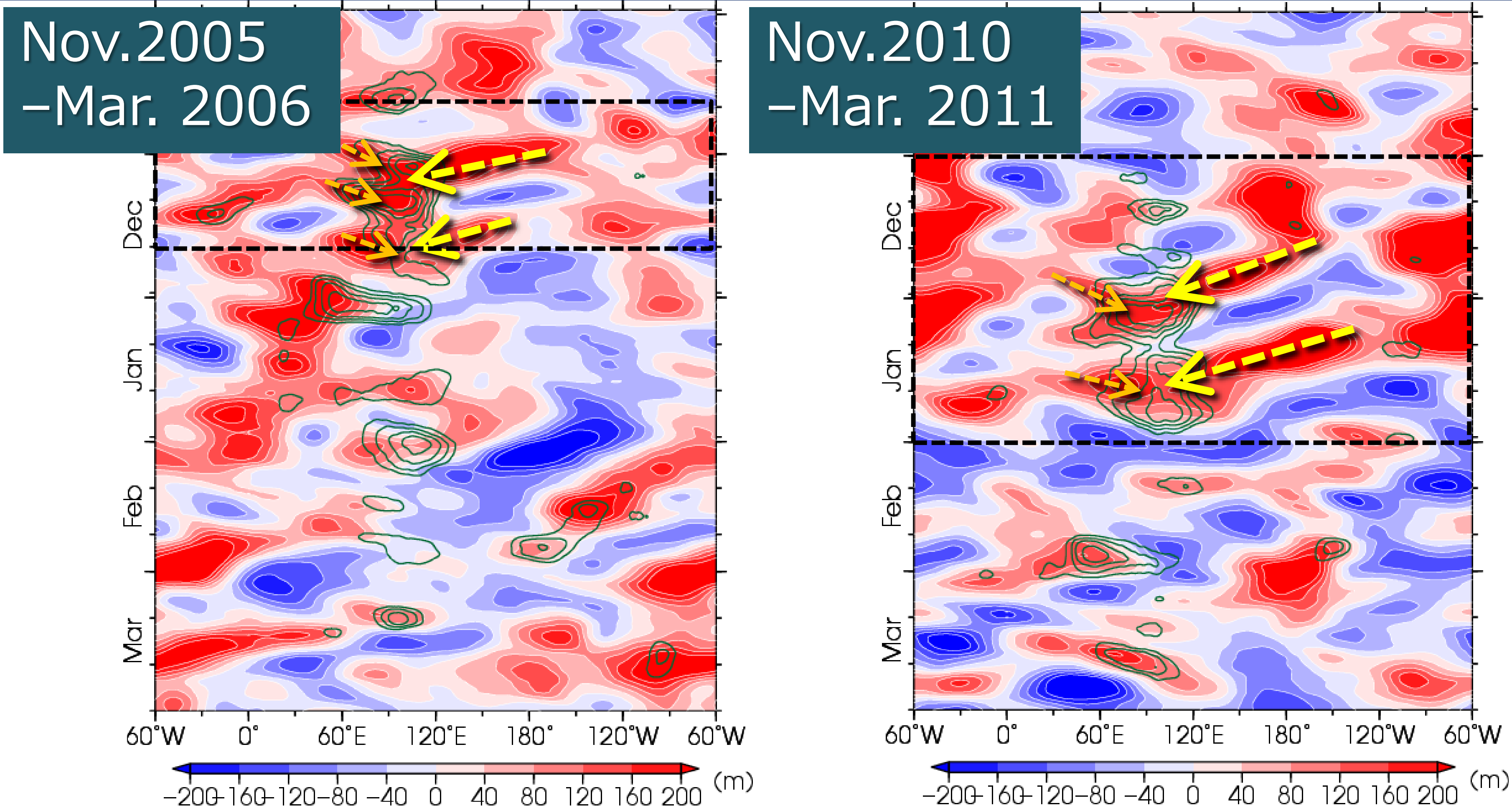


Shading: OLR anomaly
Contour: stream function anomaly

Contour: historical, **Shading**: anomaly

Enhanced convection around Southeast Asia, the associated downstream wave train and blocking over Siberia was seen.

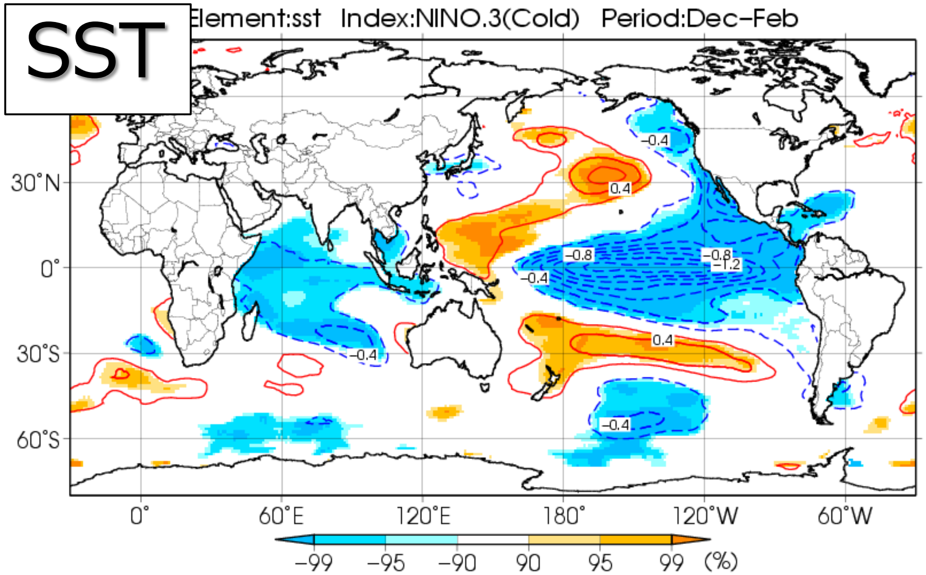
Longitude-time cross section

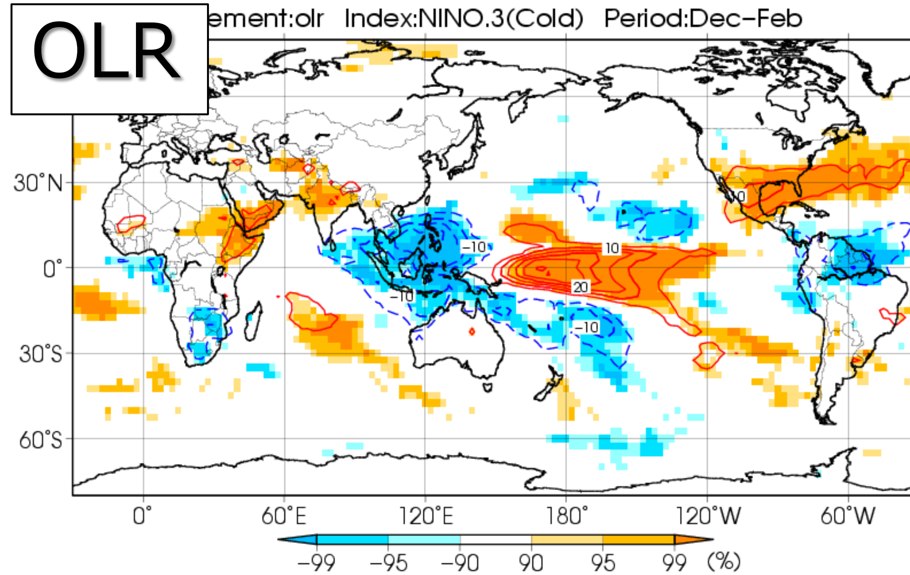


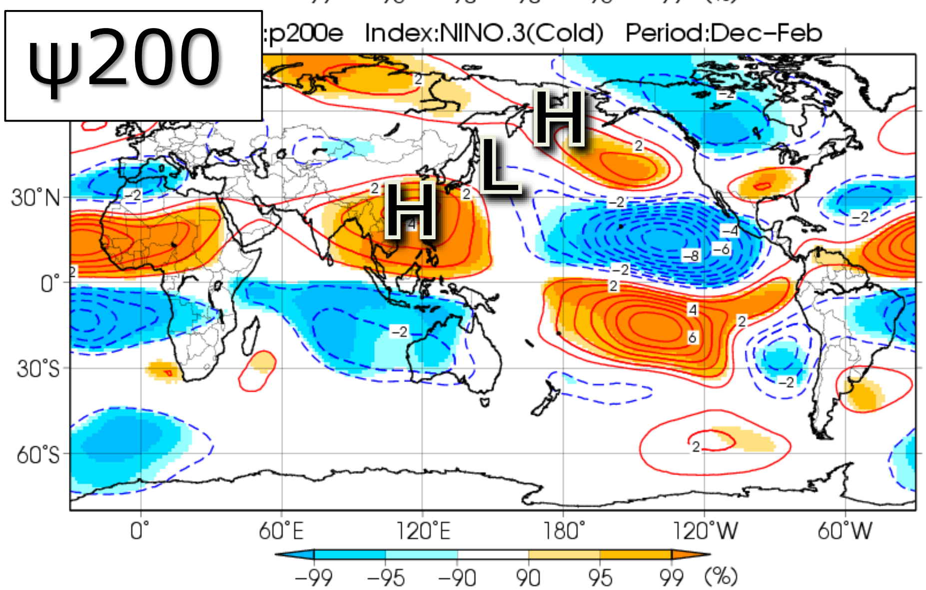
Shading: Z500 anomaly averaged over 50°–80°N, **Green lines**: SLP averaged 40°–60°N at intervals of 4hPa (shown for 1032hPa or more)

Enhancement of SH was led to a westward-moving planetary-scale wave and a eastward-moving synoptic-scale wave of positive height anomaly over Siberia.

La Niña composite anomalies in winter







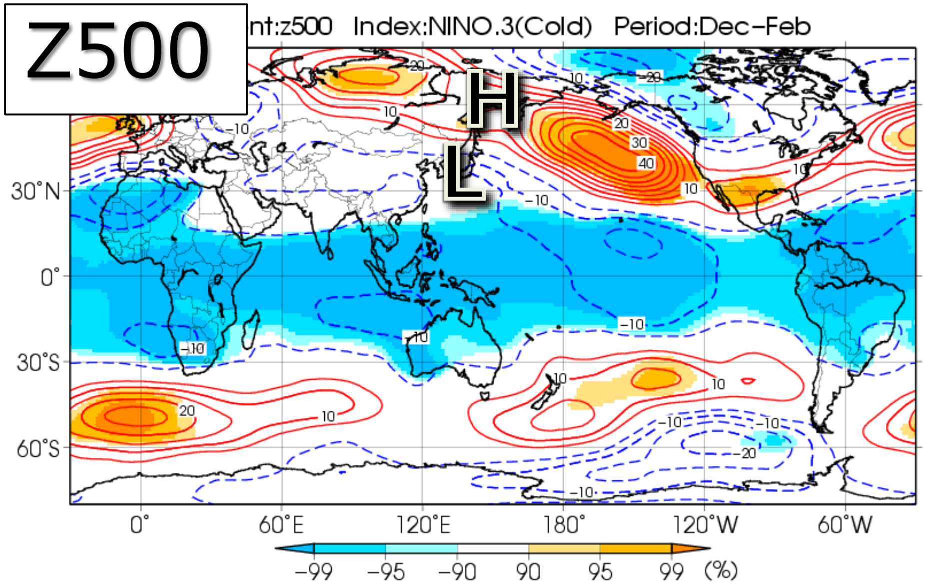
La Niña years are derived based on the JMA's definition.

Contour: Composite anomaly
Shading: Confidence level by t-test

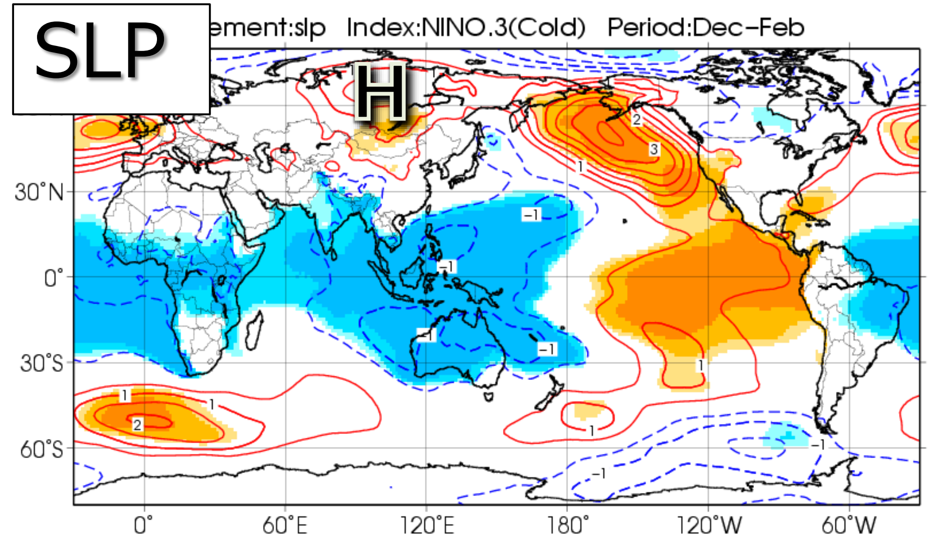
- Associated with enhanced convective activity over Southeast Asia, anti-cyclonic circulation anomaly over southeastern China and downstream wave train extending to Eastern Siberia.

La Niña composite anomalies in winter

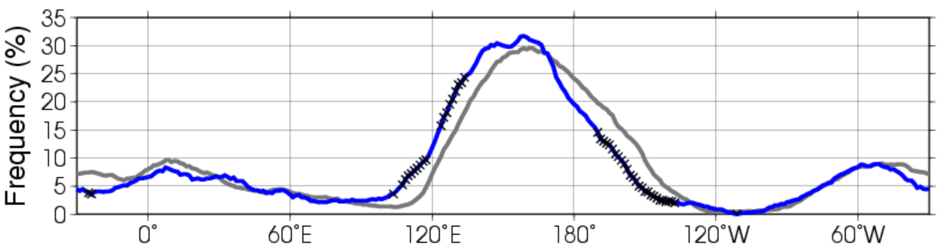
Z500



SLP



Blocking frequency

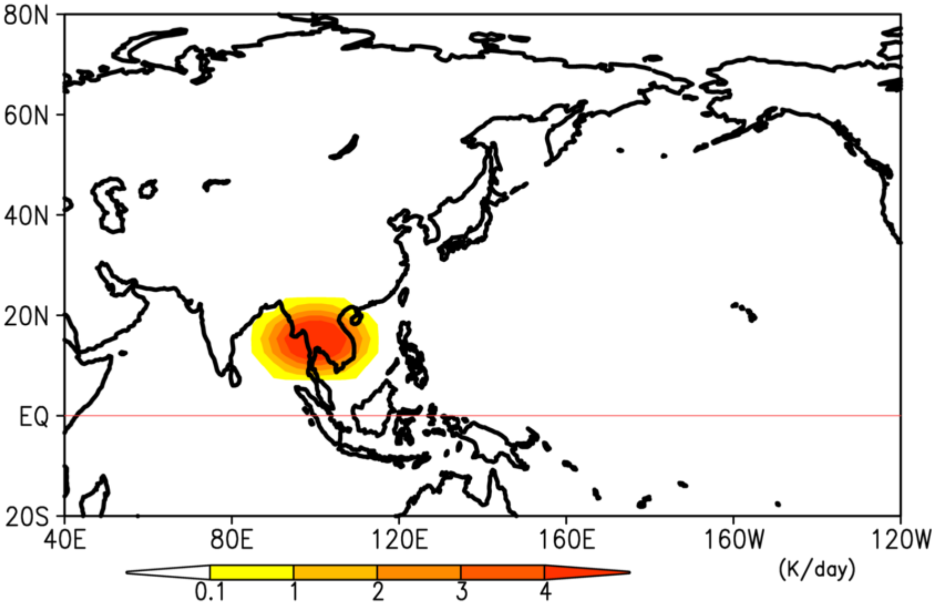


Blue (**gray**) **lines**: Composite in La Niña (no ENSO) years
"×" on the line: statistical significance at the 95% confidence level.

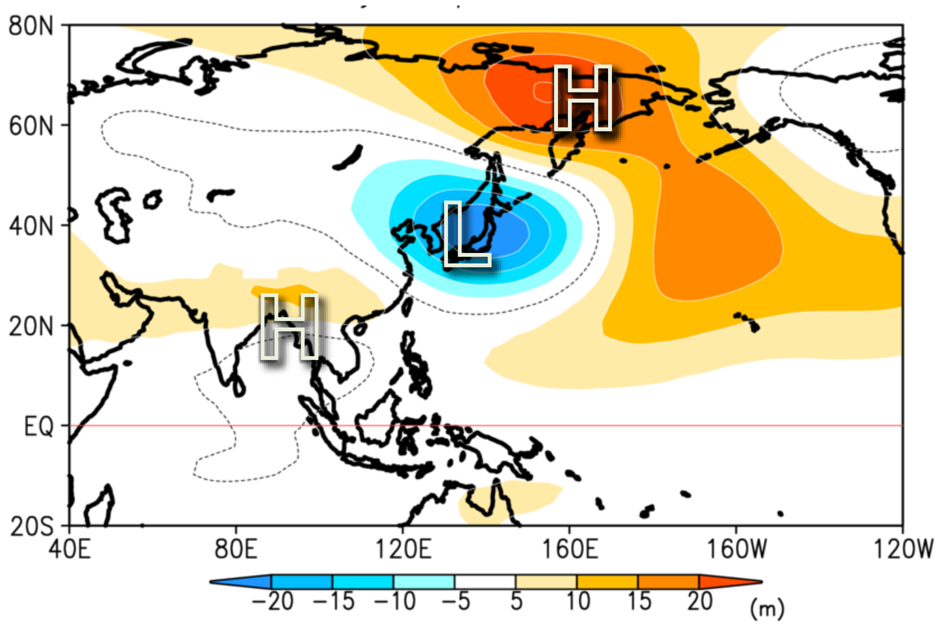
- Z500 shows positive anomaly over the area from the Bering sea to Siberia, and blocking frequency increases over Siberia, consistent with Barriopedro and Calvo (2014).
- Development of Siberian high is seen associated with positive height anomaly.

LBM response to heating around Indo-china

Heat forcing at σ≅0.45



Response of Z500

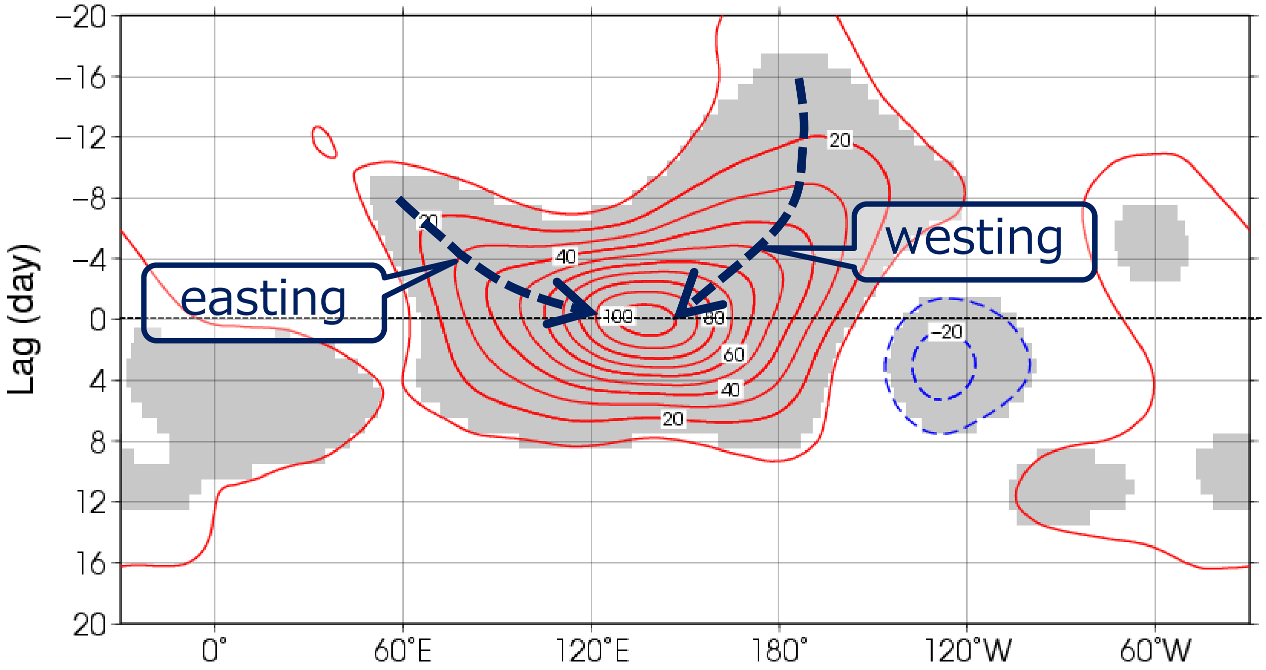


Basic state: Climatological normal in DJF mean
Heating has shape of an zonally elongated ellipse and has gamma vertical distribution with maximum amplitude of 8 K/day.

- Steady linear response of Z500 to the heating shows wave pattern over the area from southern China to Eastern Siberia, indicating one of the essential wave sources of anomaly pattern to the high-latitudes.

Retrograding of blocking ridge over Siberia

Lag-regression of blocking index



Contour:

Lag-regression of blocking indices into <u>those averaged over 120°–150°E</u>.

Gray shading:

Statistical significance at the confidence level of 99%.

Statistical period:

DJF from 1958/59 to 2012/13.

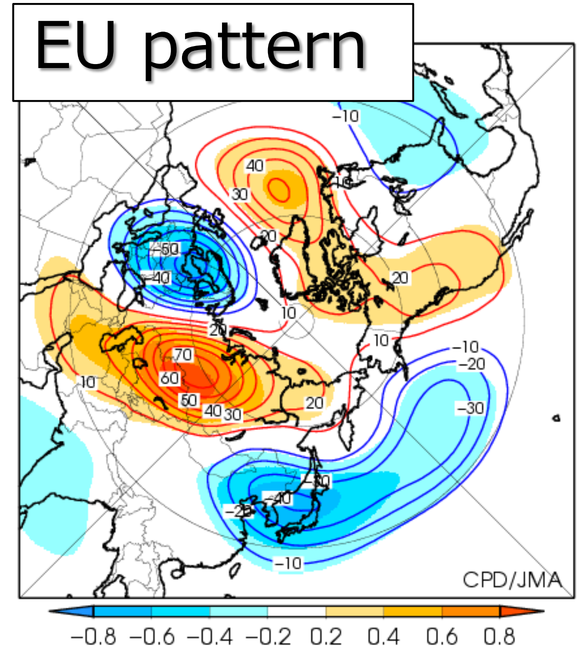
- Blocking tends to retrograde (move westward) from the dateline to Central Siberia with about ten-days, corresponding to "<u>Pacific-origin type</u>" suggested by Takaya and Nakamura (2005) (TN05).
- Eastward progression of blocking from Western Siberia is also seen, indicating a phase shift of Rossby wave.

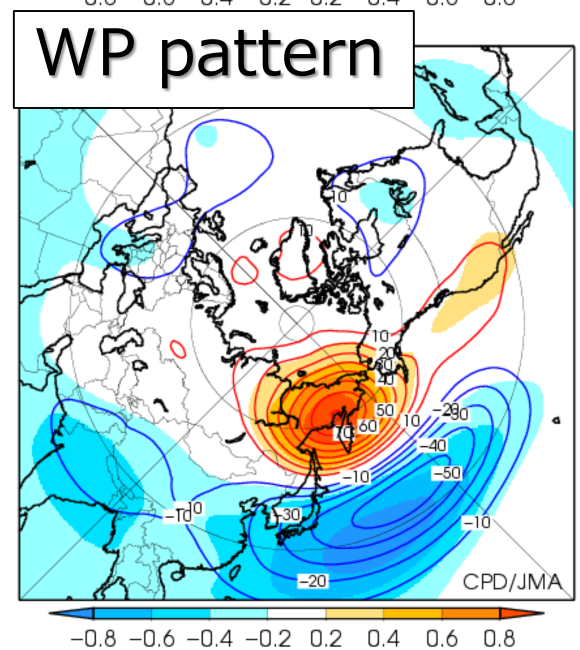
Conclusion

- In two case studies for the period when La Niña event occurred and the development of SH was seen, enhanced convection around Southeast Asia, wave train from southern China to the Bering Sea and blocking ridge over Siberia was observed.
- These characteristics are consistent with anomaly pattern statistically seen in La Niña events.
- The blocking ridges exhibited westward progression over Siberia, and it is presumed to be associated with the development of SH.
- LBM experiment indicates the contribution of enhanced convection around Southeast Asia as wave sources of anomaly pattern from southern China to the Bering Sea.

Discussion and future issues

- “Wave-train (Atlantic-origin) type” (TN05) is also important for the development of SH.
  - ✓ Does ENSO influences on the frequency of the “wave-train type” or EU (Eurasian) pattern?
- Relationship between the eastward-moving wave over Siberia and ENSO.
- Mechanism for the retrograding of blocking ridge.
  - ✓ Contribution of β-effect or vorticity advection in vorticity budget.
  - ✓ Relation to WP (Western-Pacific) pattern.





Thank you!
Any questions or comments?

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Outline of LBM

Model type	Linear, Dry model
Equation System	Comprising linearized primitive equation about a basic state defined as the climatological normal in DJF period
Resolution	T42L40 (σ vertical coordinate)
Horizontal Diffusion	4-order (bi-harmonic) e-folding time of 1-hour
Vertical Diffusion	e-folding time of 1000 days
Linear Damping	30-days (in the most of the free atmosphere) 0.5-day ($\sigma \geqq 0.94247$ and $\sigma \leqq 0.03$) 1-day (σ=0.91496 and 0.88244) 5-days (σ=0.84543 and 0.80491)