Could the western North Pacific blocking be initiated by a retrograding wave?

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Quick Summary

Motivation

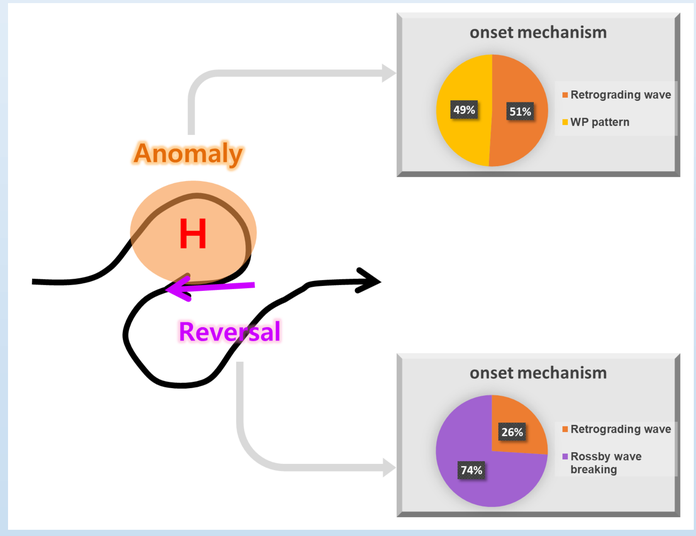
The western North Pacific (WNP) region has remarkable discrepancy in the blocking frequencies and blocking onset mechanisms depending on the type of blocking detection (anomaly vs reversal). Anomaly-type of blocking events are initiated from the eastern North Pacific (i.e., retrograding of low frequency eddies). Reversal-type of blocking capture the blocking events caused by Rossby wave breaking. Nevertheless, we still need a more detailed understanding of the WNP blocking onset mechanisms.

Objectives

We investigate the two types (anomaly vs reversal) of WNP blocking onset characteristics with or without the presence of retrograding waves.

Take-away points

- We find that 51% of anomaly-type blocking events and 26% of reversal-type blocking events are related to retrograding waves, indicating that such waves are not a prerequisite for the WNP blocking initiation. However, all types of blockings events originating from retrograding waves develop very strongly at large sizes, resulting in severe cold anomalies in North America.
- The western Pacific (WP) pattern also influences the block onset with 49% of the anomaly-type blocking events, resulting in moderate blocking anticyclone and pronounced cooling in both North America and Eurasia.
- When blocking events develop without the retrograding waves and the WP pattern, we find the weak anticyclones and weak surface impacts, with 74% of the reversal-type blocking events. The majority of these events show a cyclonic wave breaking structure.



Data

ERA5, winter (DJF) of 1979-2020

WNP domain: 120°E-180°

Blocking detection methods

1) Hybrid method (HYB, Dunn-siguon et al. 2013) captures both strong height anomalies and local reversal.

2) Large-scale reversal method (LAR, Masato et al. 2013) detects a reversal of meridional height gradient using two averaged latitudinal fields.

WNP blocking	HYB	LAR	All method
# of block onset	35	104	12
# of block onset with retrograding wave	18	27	8
# of block onset without retrograding wave	17	77	4
Ratio of block onset with retrograding wave	51.4 %	26.0 %	66.7 %

Key Results

Temporal evolution for WNP blocking events associated with retrograding wave

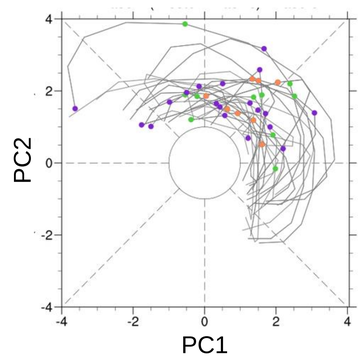
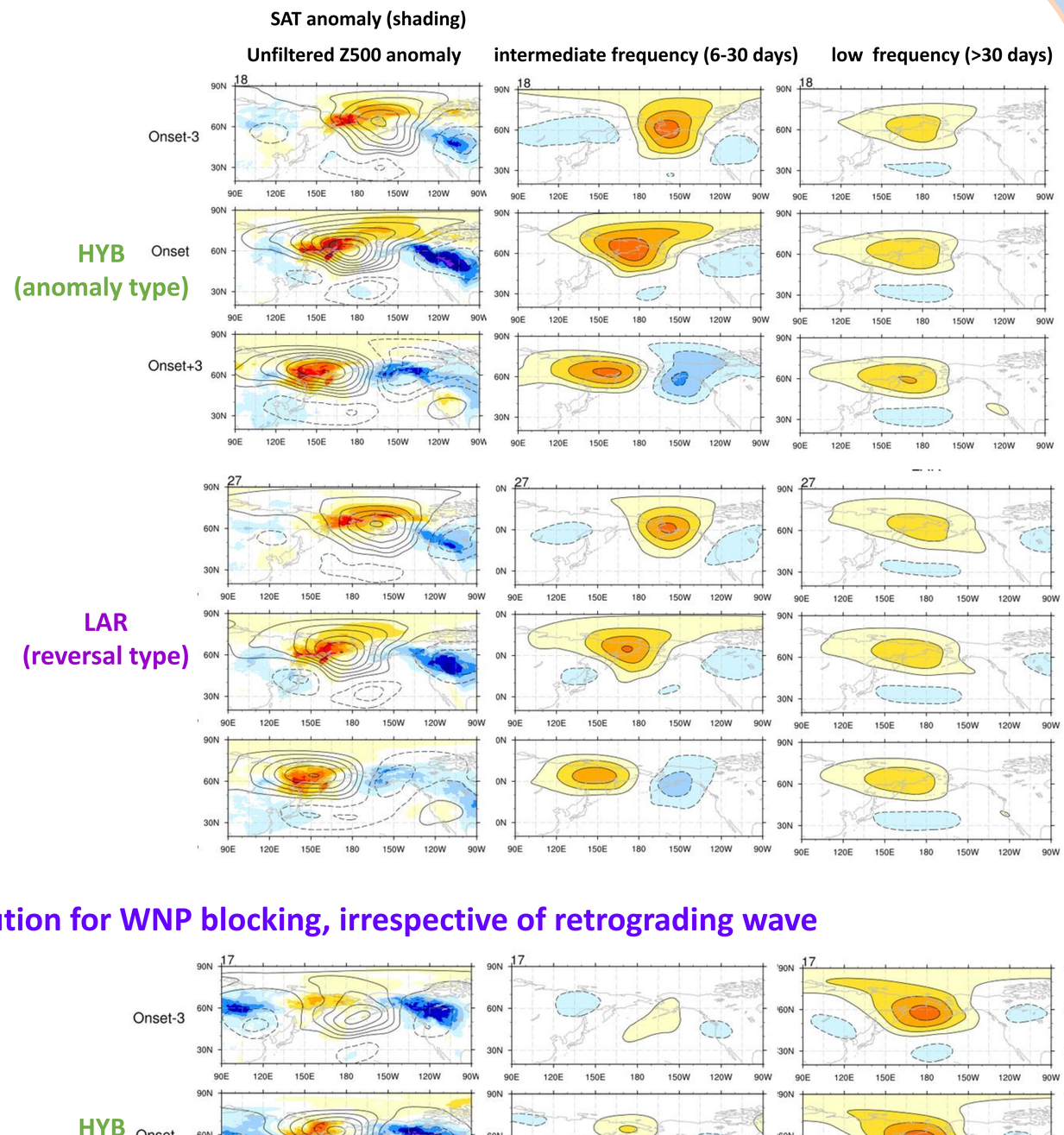


Fig. phase diagram of retrograding waves (grey lines) associated with onset dates of WNP blocking (green dot-HYB, purple dot-LAR)



- All types of blocking events show massive anticyclone and strong surface impact.
- Cross-frequency coupling between M and L is evident.
- M is dominant, and retrograding signal is clear.
- L resembles WP pattern, and is relatively weak, stationary.

Temporal evolution for WNP blocking, irrespective of retrograding wave

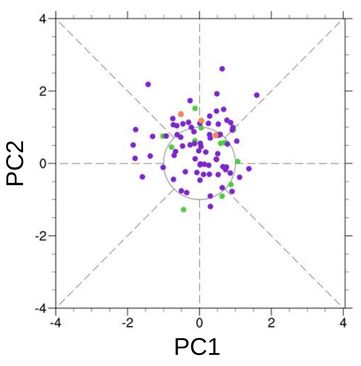
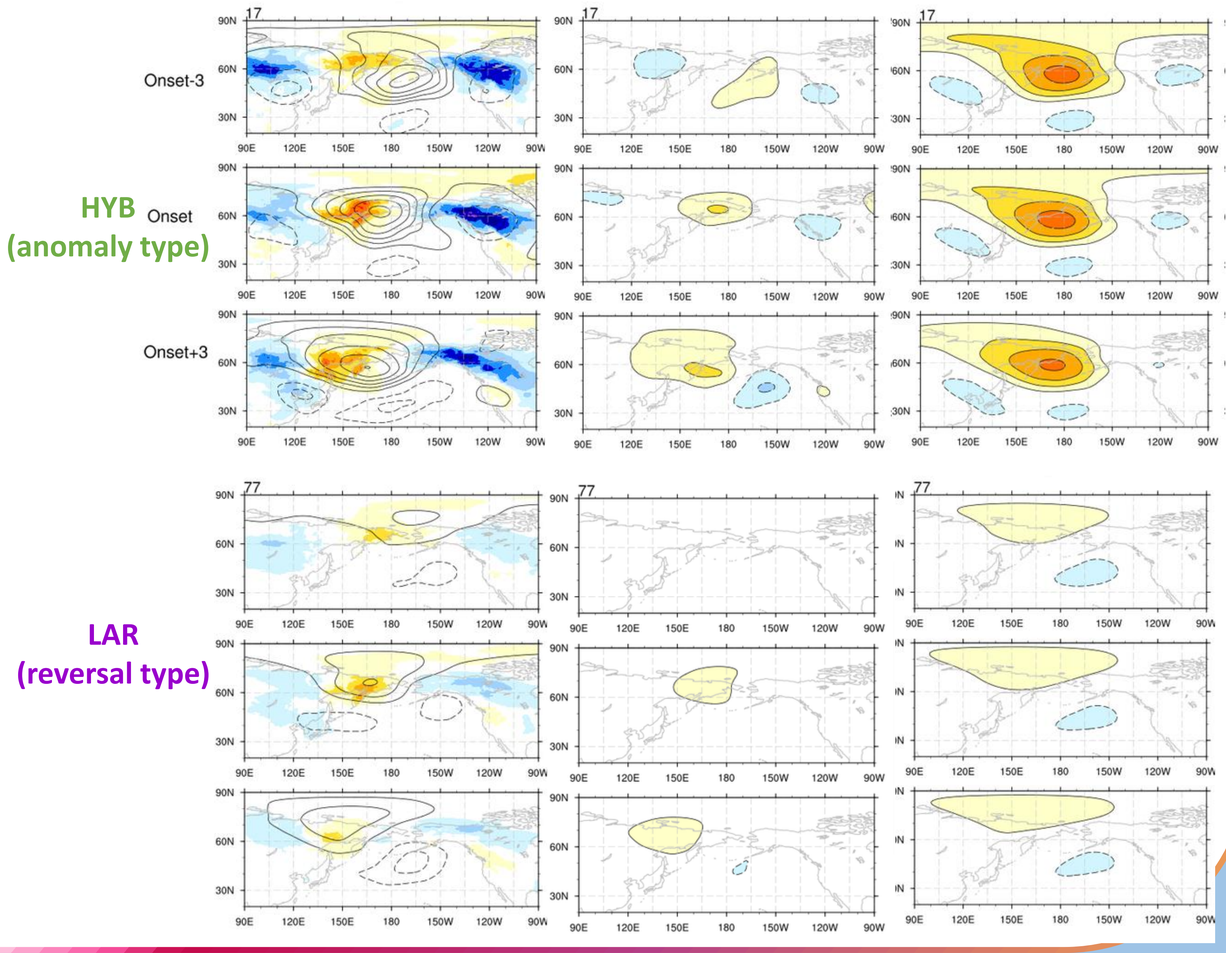
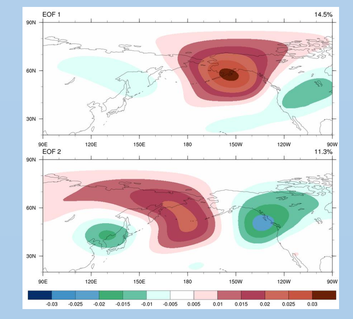


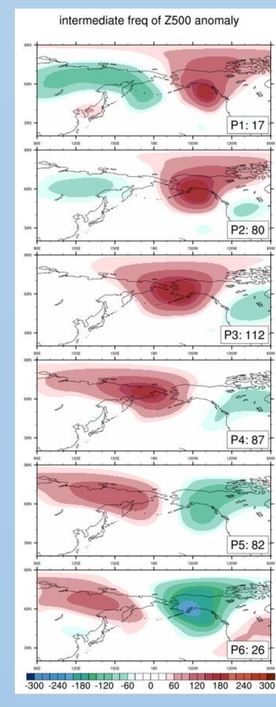
Fig. phase diagram of onset dates of WNP blocking (green dot-HYB, purple dot-LAR), regardless of retrograding wave

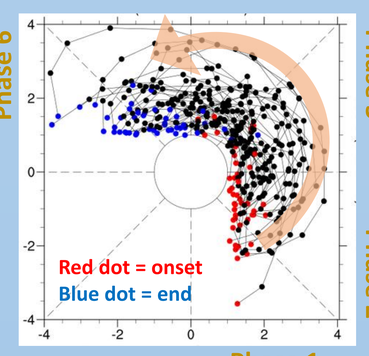


- 49% of the anomaly type shows moderate anticyclone and strong cooling in both USA and Eurasia due to WP pattern.
- 74% of reversal type shows weak anticyclone and weak surface impact due to RWB.

Retrograding wave detection







1. Consider the strong period of +EOF1 or EOF2 applied to Z500 on intermediate frequency (6-30 day filtered) over Pacific
2. Each events are collected if they exceed 1 std of PCs.
3. We can show the 2-D phase space using PCs.
4. To extract the westward moving events, we consider only events where the angular displacement from start to end position is at least +60 degree.
5. Finally, we got the westward moving, strong anticyclones over Pacific, which is refer to retrograding wave associated with blocking.

Retrograding wave	#
# of retrograding events	48
# of retrograding days	404
Ratio of retrograding days against winter days	10.7 %
Mean duration	8.4