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Introducing and Finding Tripoles: A Connection Between Central Asia and the Tropical Pacific

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From Dipoles to Tripoles

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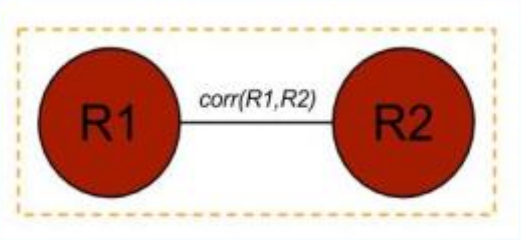
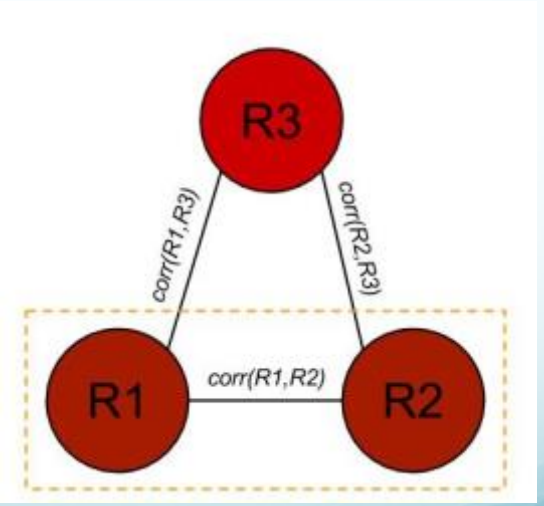
- see more details in poster
"Introducing and Finding Tripoles: A New Recurring Long Distance Pattern in Climate Science" by Saurabh Agrawal

A **dipole** involves two regions R1 and R2, such that the anomaly time series at region R2 has a strong negative correlation with that of region R1.



A **tripole** involves three regions R1, R2, and R3, such that the anomaly time series at region R3 is more strongly correlated with either addition or subtraction of **z-scored** anomaly time series observed at region R1 and region R2, as compared to that with any of the anomaly time series at region R1or R2 alone.

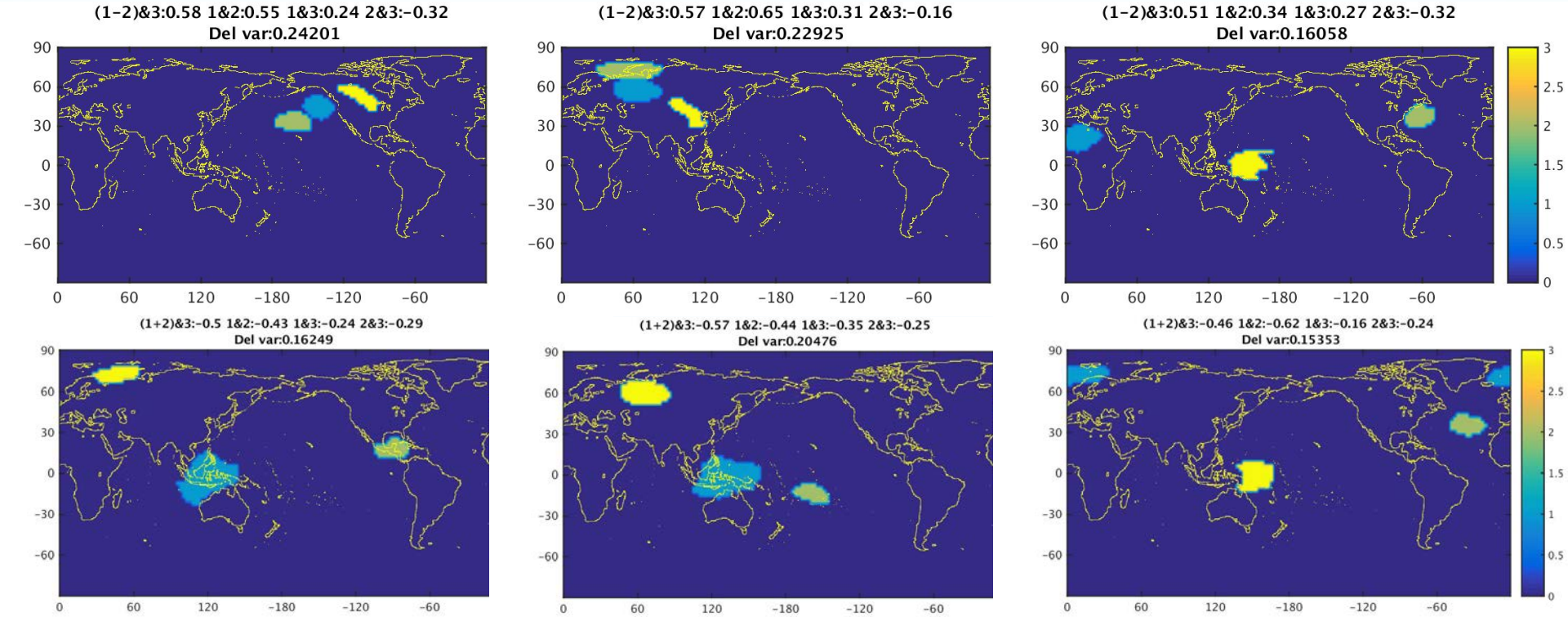


Dipoles vs. Tripoles in Climate

- The concept of a **tripole** helps to describe weak connections between remote locations that require information from **two** locations to describe a connection to a **third** location – thus more spatio-temporal influences are considered.
- An oscillation in atmosphere or ocean (=wave pattern) is rarely related to only one spatial counterpart (=**dipole**), other connections (=**tripole**) need investigation.
- El Niño/Southern Oscillation (ENSO) is an oscillation between the west Pacific warm pool and the tropical eastern Pacific – but both locations also influence other regions.
- Background state is an important factor for the ENSO strength (=amplitude).
- Pacific Decadal Oscillation (PDO) is one background state that influences frequency and strength of ENSO events (Verdon and Franks, 2006, GRL)
- We have identified an extratropical influence on the sea level pressure over the west Pacific warm pool that can be improved with information from the eastern Pacific – thus involving all **three** locations.

Examples of Tripole Patterns

Correlations between regions 1 (blue), 2 (green), and 3 (yellow):

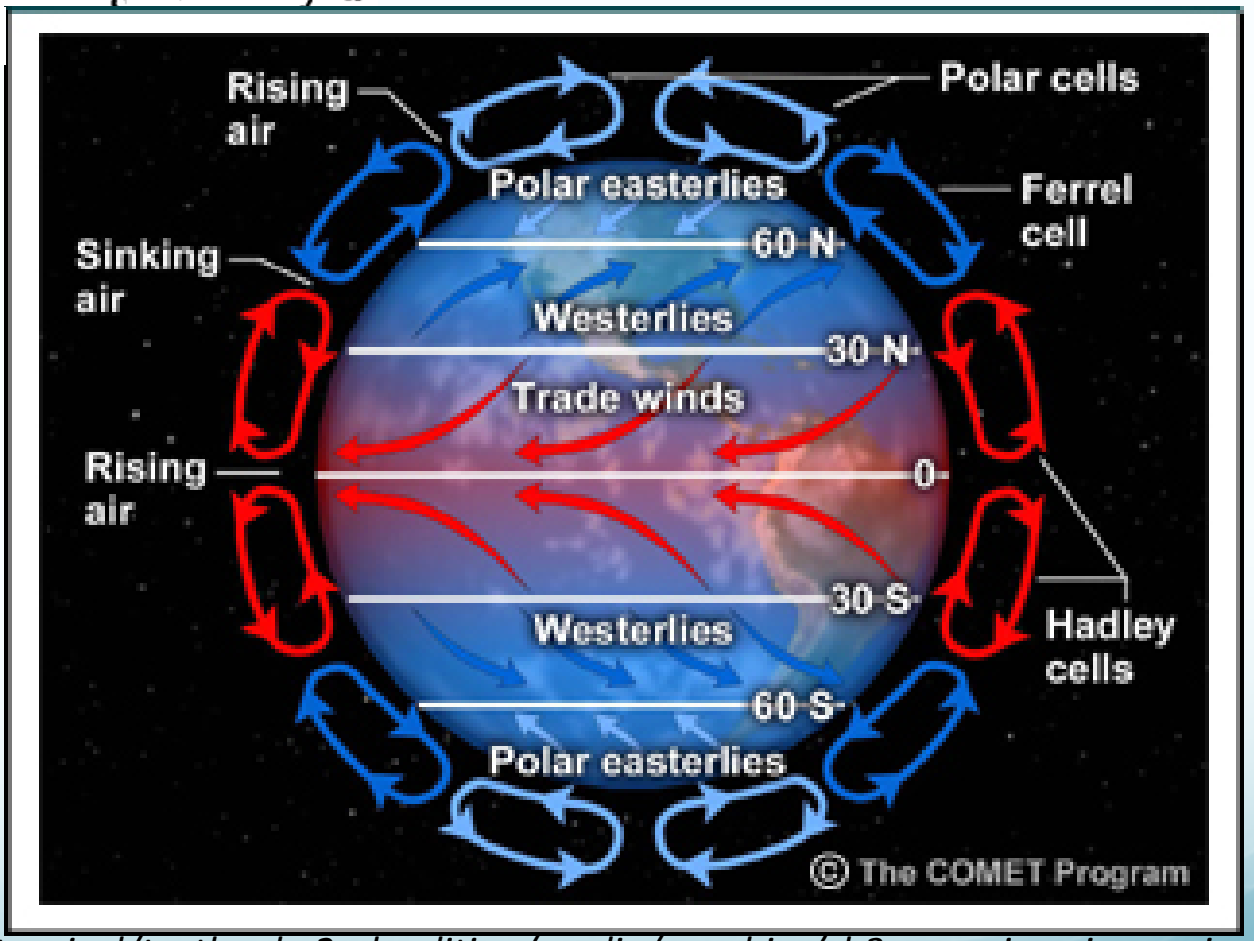


General Circulation: Regions are connected

VI. *Concerning* the Cauſe *of the* General Trade-Winds: *By* Geo. Hadley, *Eſq*; *F. R. S.*

... the N. E. and S. E. Winds within the Tropicks muſt be compenſated by as much N.W. and S. W. in other Parts, and generally all Winds from any one Quarter muſt be compenſated by a contrary Wind ...

(Hadley Phil. Trans. 1735)



http://www.meted.ucar.edu/tropical/textbook_2nd_edition/media/graphics/ch3_overview_image.jpg

Searching for *Negative Tripoles*
(All edges negative)

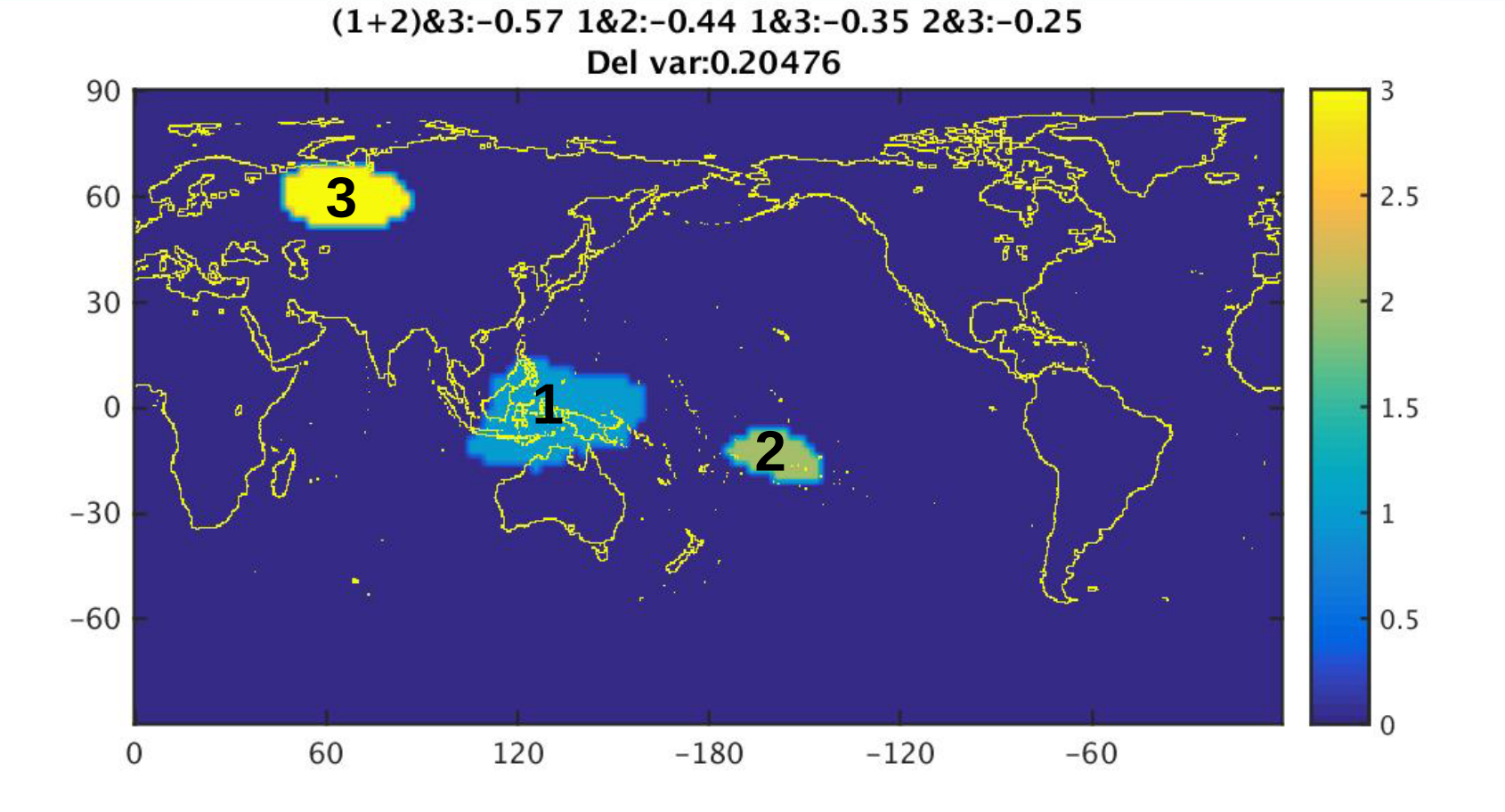
- Preprocessing
  - Compute the **z-scored** monthly anomaly time series at each location.
  - Extract the data for the winter months.
  - Finally, standardize the extracted seasonal time series.

Searching for *Negative Tripoles*
(All edges negative)

- STEP-1: Find dipoles using Shared Nearest Neighbor (SNN) approach.
  - Start with the most negative edge in the graph.
  - Create a region around each end by considering all the strong positive neighbors.
  - Discard the locations that are not negatively correlated with any location at the other end.
  - Mark the two regions as a dipole if
    - There is a strong negative correlation between the area-weighted time series of two ends
    - The regions are big enough
  - Repeat the procedure until all the negative edges (below certain threshold) are considered.

- STEP-2: For each dipole, find the regions that share negative neighbors with both ends.

Low-frequency ENSO Variability during DJF: Adding Z-scored Area-Averaged SLP for both Ends



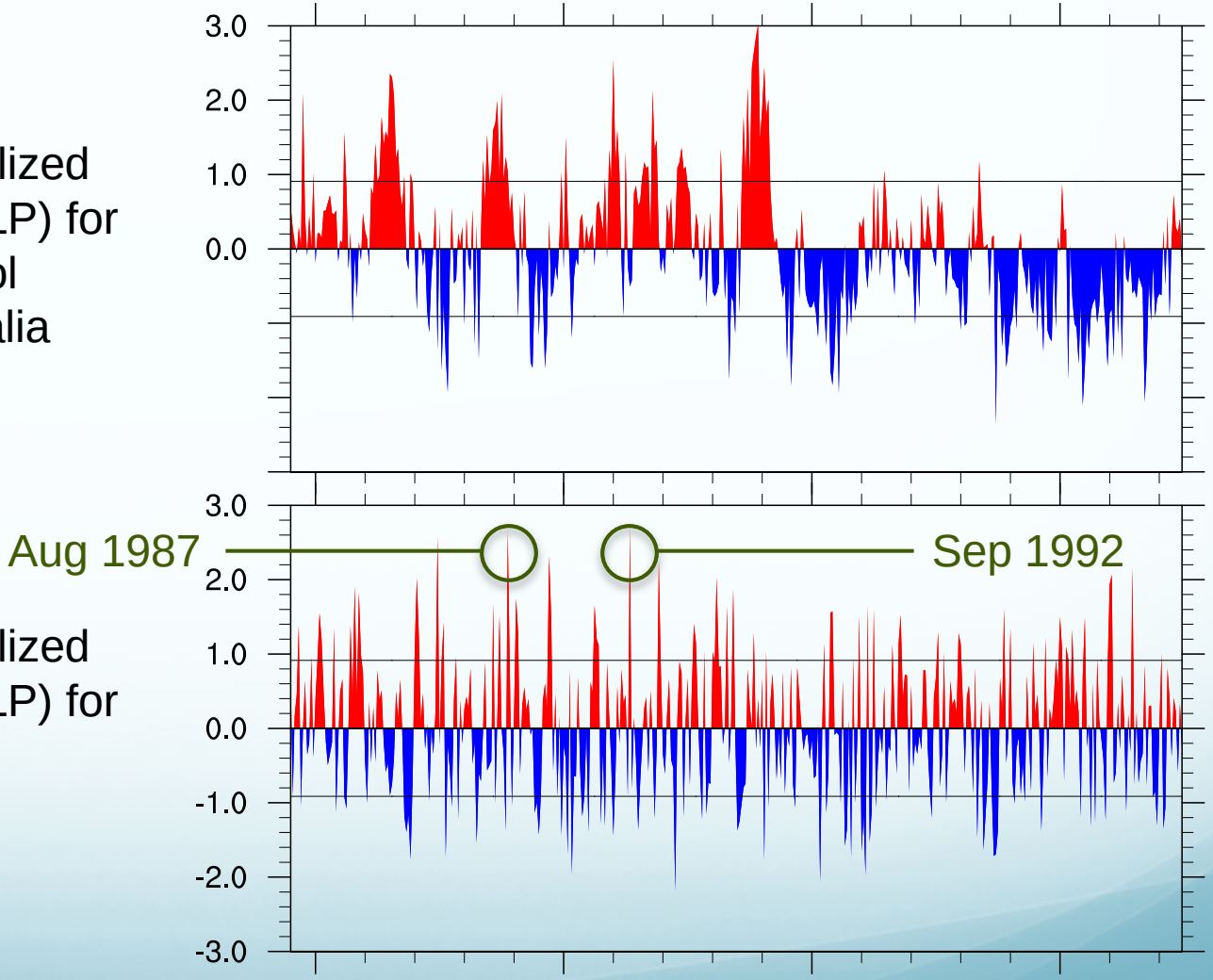
The PDO – ENSO Connection

(Deser et al. 2010, Ann. Rev.)

Influence of Northwestern Russia and Central Asia on ENSO

Area-averaged normalized sea level pressure (SLP) for west Pacific warm pool around Darwin, Australia (Region 1)

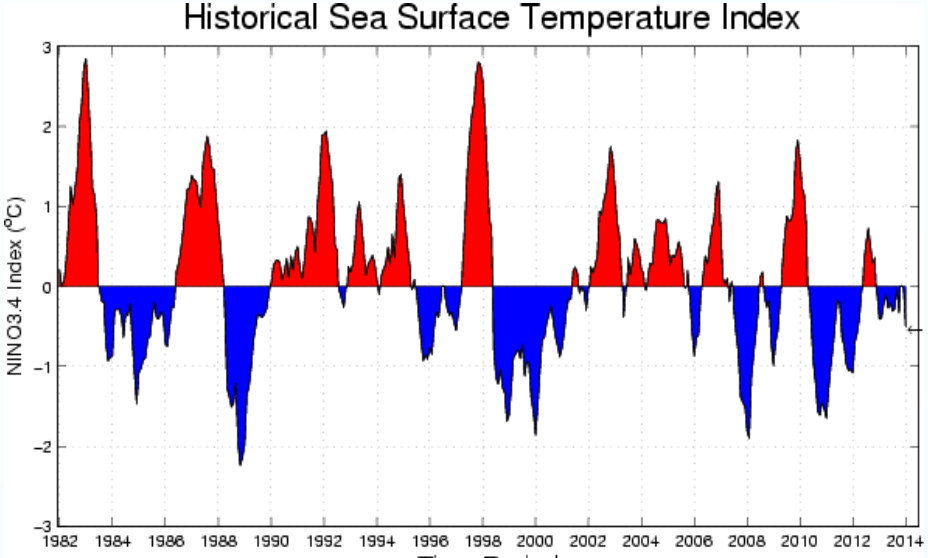
Area-averaged normalized sea level pressure (SLP) for northwestern Russia (Region 3)

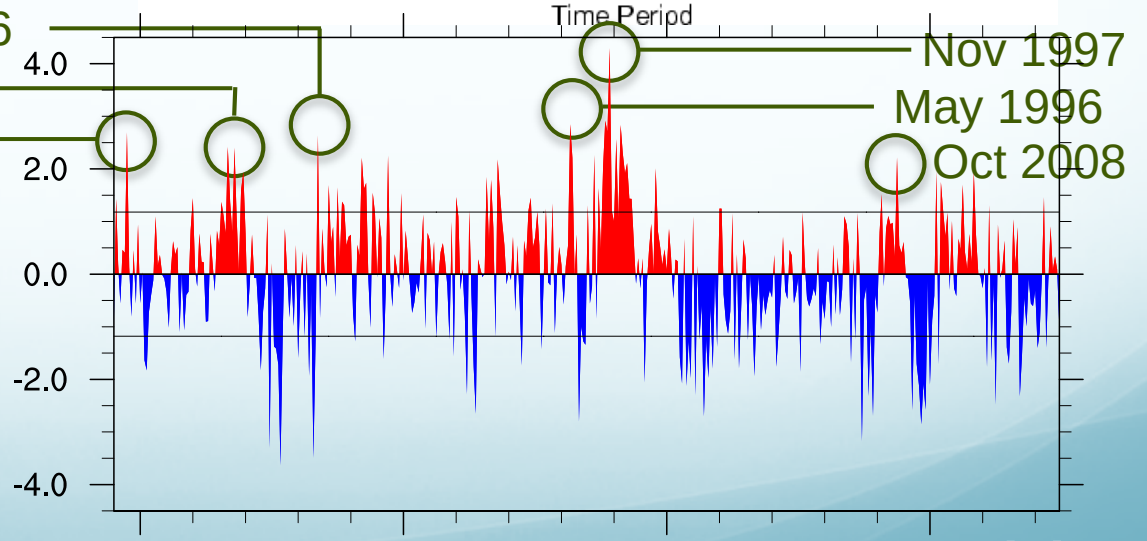


Influence of Northwestern Russia and Central Asia on ENSO

NINO3.4 SST Index (°C)

(iri.columbia.edu/our-expertise/climate/forecasts/enso/2014-february-quick-look)



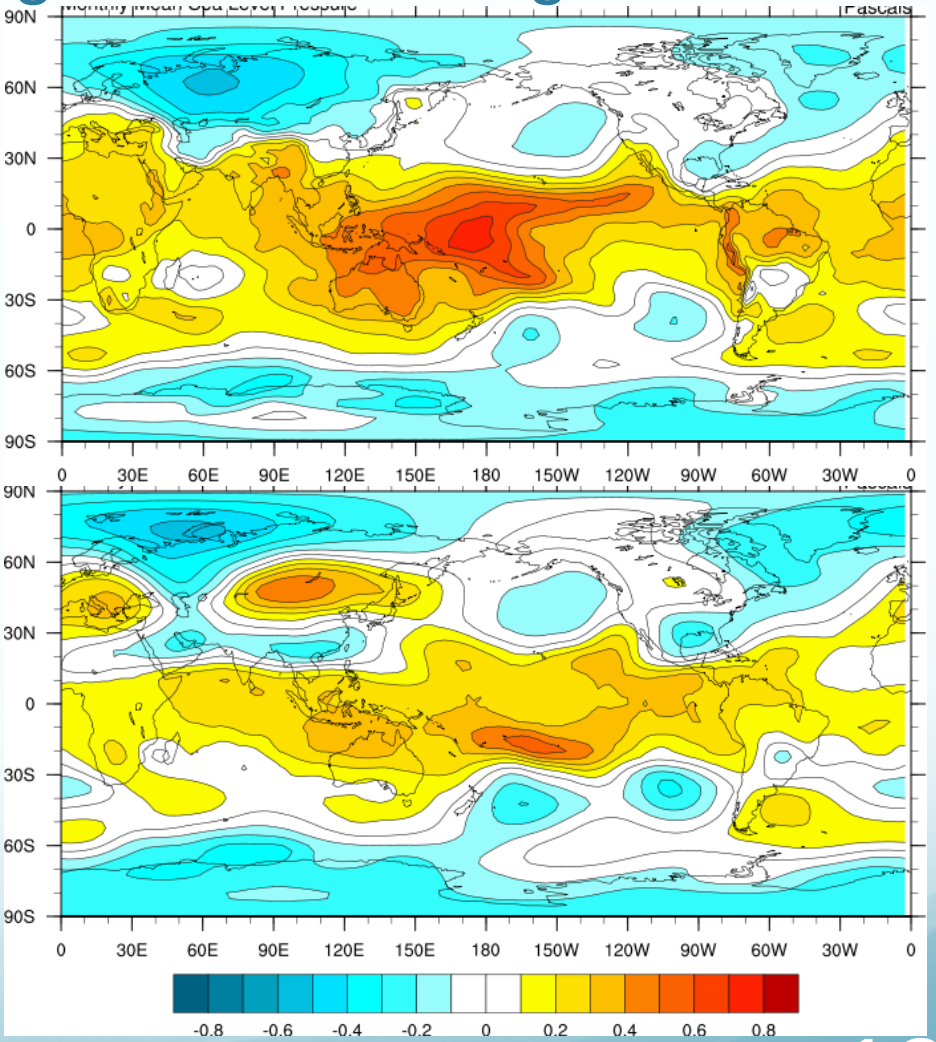


Area-averaged normalized sea level pressure (SLP) for west Pacific warm pool plus East Pacific (Regions 1+2)

Correlation of Area-averaged Normalized SLP Time Series for Regions 1+2 during DJF

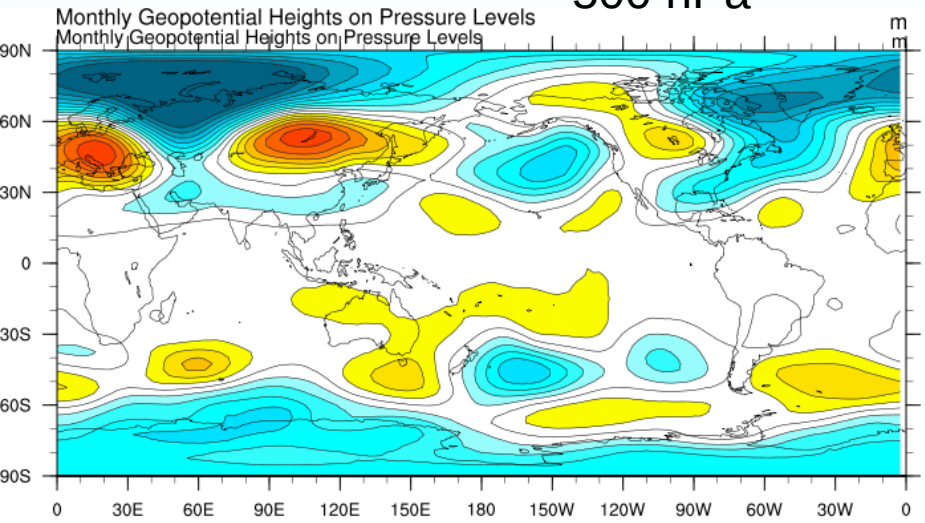
Sea level pressure

500 hPa geopotential height

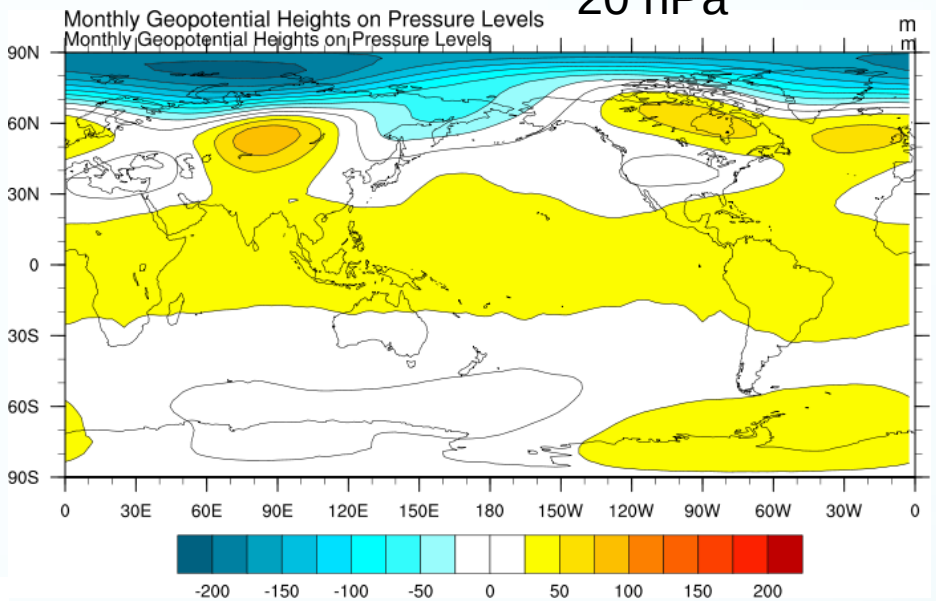


Composite Analysis (pos.-neg. phase) during DJF

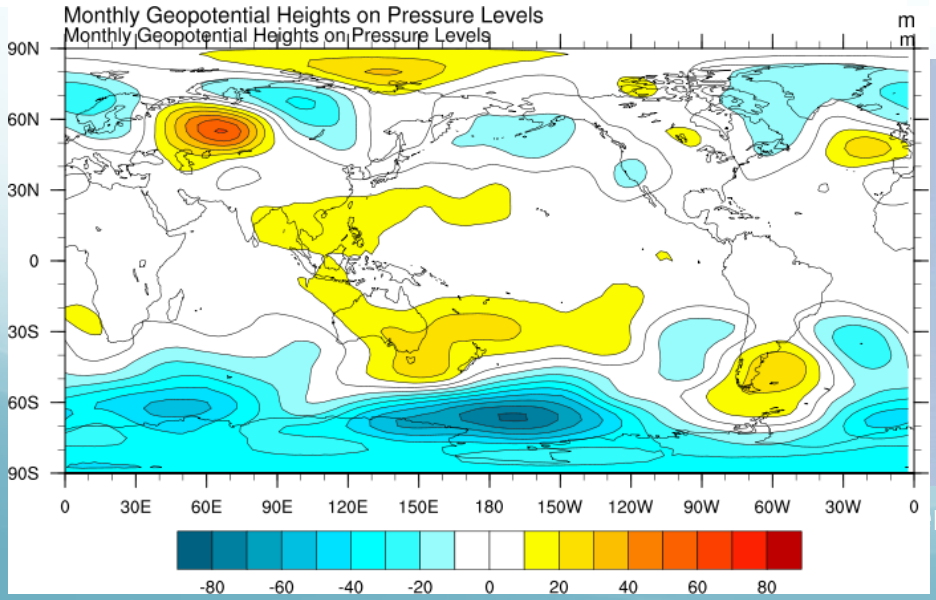
500 hPa

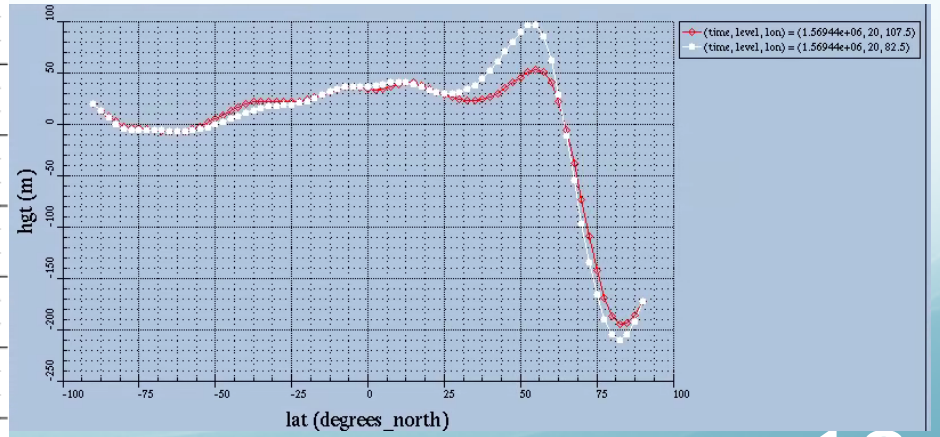


20 hPa



500 hPa during JJA

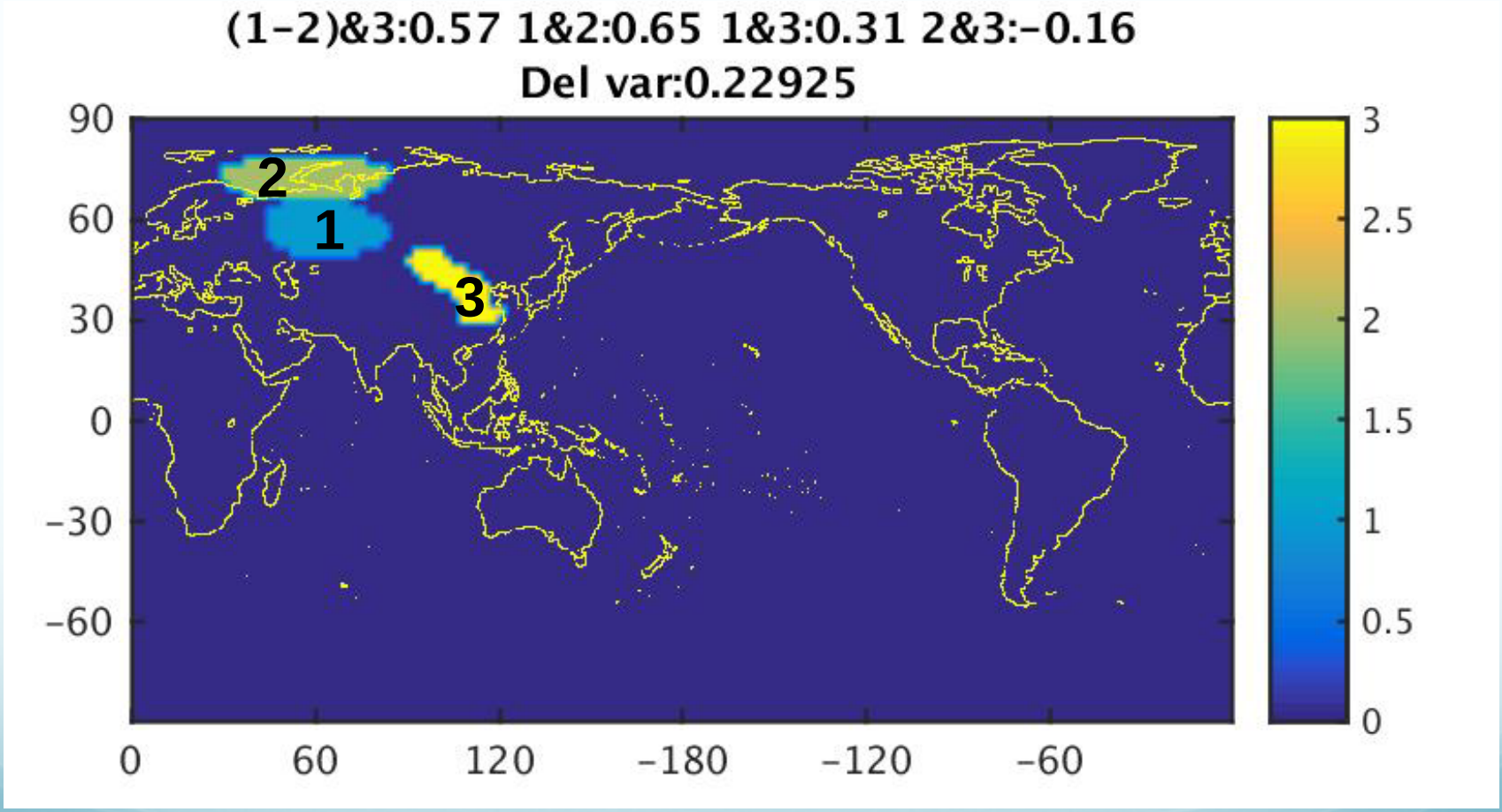




n Central Asia and Tropical Pacific

Influence of Northern Russia and Central Asia on Southern China and the Darwin Region

(Correlation between region 3 and Darwin is 0.33 in 500 hPa geo. pot. height.)



Conclusions

1. *The concept of tripole patterns helps to understand relationships between distant regions.*
2. *Weak dipoles can become important parts of tripole patterns with significant correlations.*
3. *Low-frequency ENSO variability can be explained by the area-averaged background state (Region 1+2).*
4. *Tripole patterns can be used to follow wave trains in the atmosphere.*