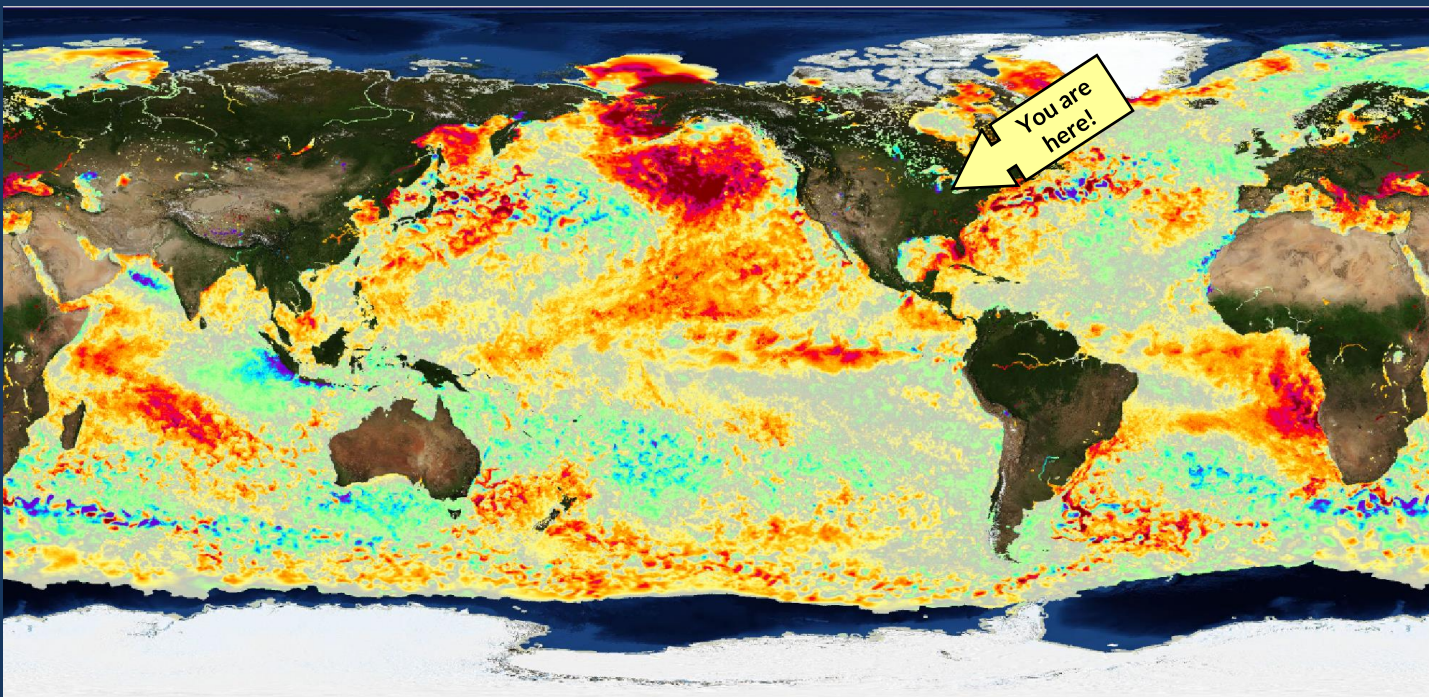




Winter Outlook for Southeast Michigan

90 Day Outlook Valid December 1, 2019 to February 28, 2020



Slide 2: Winter Outlook for Southeast Michigan
Slides 3 to 8: Technical forecast discussion



Winter Outlook for Southeast Michigan

December-January-February

December

Temperatures: Slightly warmer than normal.

Snowfall: Near normal precipitation, but below normal snowfall.

January

Temperatures: Colder than normal.

Snowfall: Normal snowfall. Potential for more snow limited by increased potential for a storm track displaced to the south.

February

Temperatures: Normal

Snowfall: Normal



Boundary Conditions: The Ocean-Atmosphere Interface

October 2019 & Indian Ocean Forcing

Top: Velocity Potential

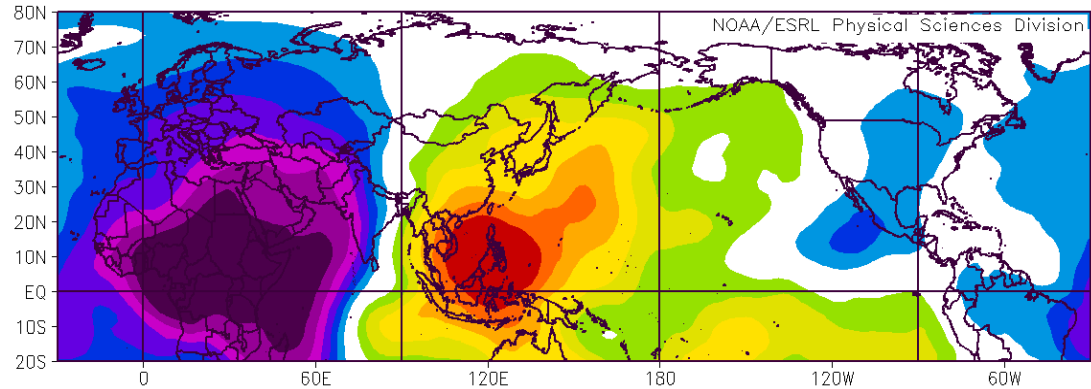
Purple (red) represents divergence (convergence). This standing pattern was dominant in October and is again dominant heading into December.

Bottom: 250mb height anomaly

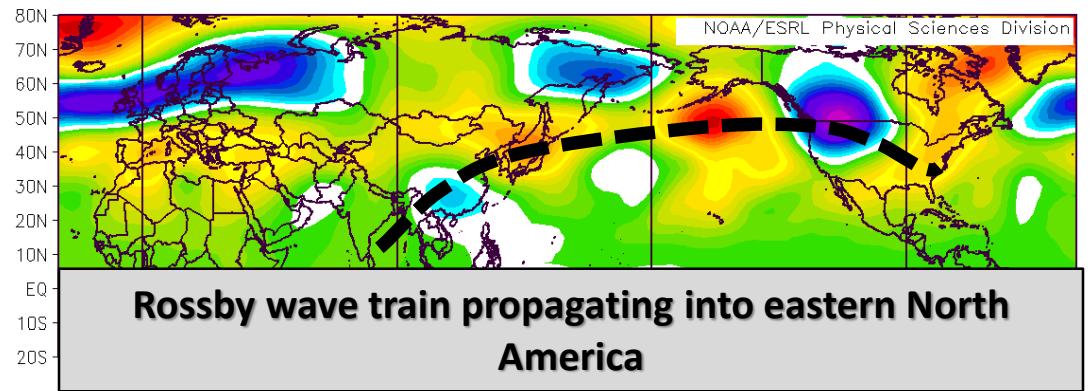
The forcing pattern anchored a well-defined Rossby wave train (RWT), connecting the Indian Ocean to eastern North America.

October in Southeast Michigan

The pattern was warm and wet with cold displaced to the northwest. However, seasonal longwave amplification will change this 'teleconnection' for Southeast Michigan by winter.



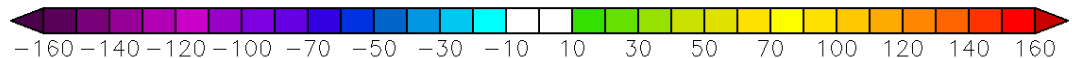
.2101 sigma Velocity Potential Composite Anomaly (1981-2010 Climatology)
9/23/19 to 10/22/19



Rossby wave train propagating into eastern North America

250mb Geopotential Height (m) Composite Anomaly (1981-2010 Climatology)
9/23/19 to 10/22/19

NCEP/NCAR Reanalysis





Boundary Conditions: The Ocean-Atmosphere Interface

November 2019 & West Tropical Pacific Forcing

Top: Velocity Potential

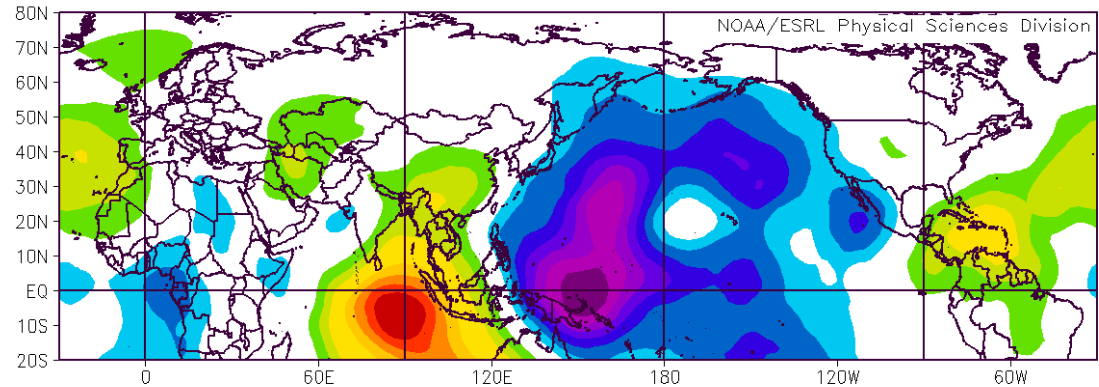
The dominant forcing mode from late October to mid-November was positioned east of the Maritime Continent, west of the classic “Nino region”, but directly impactful for Southeast Michigan nonetheless.

Bottom: 250mb height anomaly

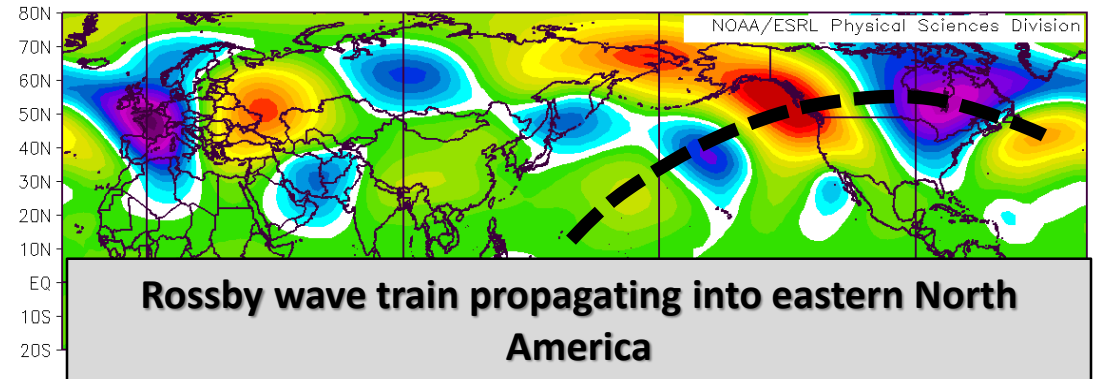
Another well-defined RWT anchored much further east than October and driven by the west tropical Pacific convection.

November in Southeast Michigan

The first 20 days of November were the coldest on record for Detroit (prev. 1976). As stated on the previous slide, the ‘teleconnection’ often changes as the cold season progresses, but it is still important to establish that the tropics have been directly driving the circulation over the North America heading into winter.



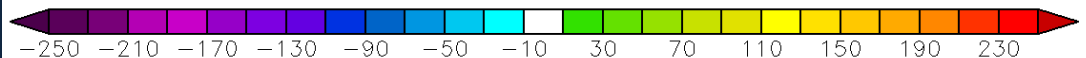
.2101 sigma Velocity Potential Composite Anomaly (1981-2010 Climatology)
10/31/19 to 11/15/19



Rossby wave train propagating into eastern North America

250mb Geopotential Height (m) Composite Anomaly (1981-2010 Climatology)
10/31/19 to 11/20/19

NCEP/NCAR Reanalysis





Modeling the Ocean-Atmosphere Interface

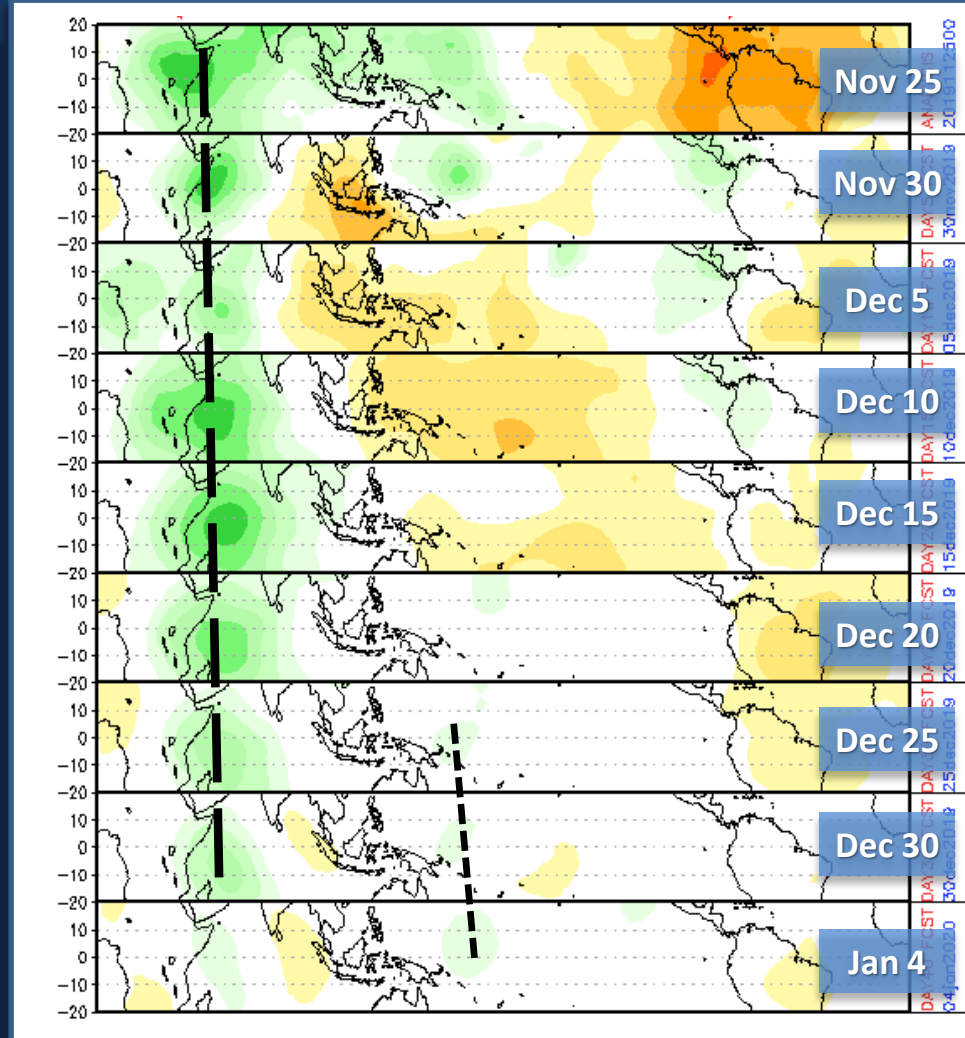
Climate Forecast System (CFS) for December into January

40-day Simulated Velocity Potential (Nov 25 to Jan 4)

The low frequency tropical forcing from Autumn is forecast to persist into mid-winter and will likely persist through winter. A slight eastward migration of the west Pacific forcing is noted (lower right panels). This is reasonable given a) potential for intraseasonal variability to cause periods of enhanced westerlies at the surface and b) warmer SST anomalies in this region remain focused near 170E

Implications for Southeast Michigan

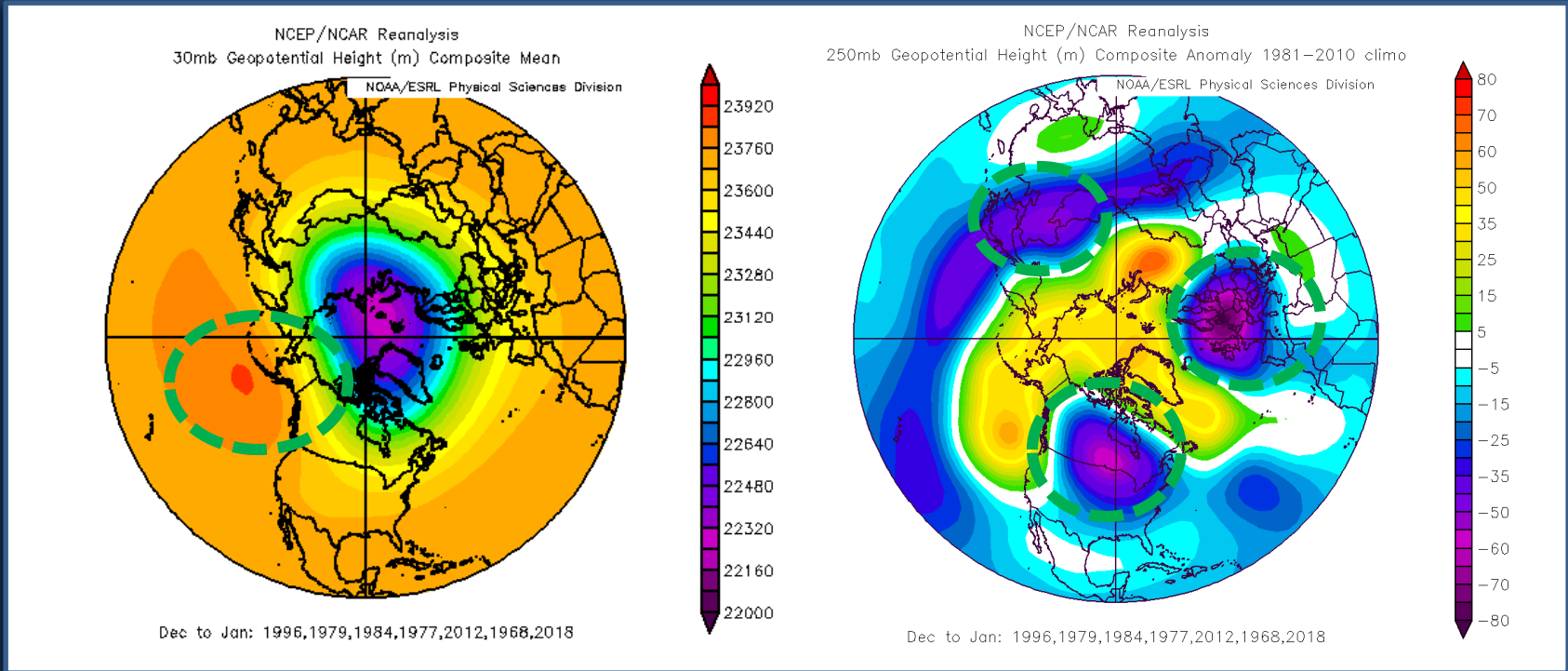
1. The teleconnection associated with western Indian Ocean forcing evolves from warm/ridging (i.e. October 2019) to cold/troughing by mid-winter concurrent with seasonal longwave amplification.
2. West Pacific convection centered along 160E becomes more favorable for a building southeast US ridge & a storm track displaced northwest of SE Michigan as troughing retracts into NW Canada. Eastward progression, as modeled, would correspond to a less retracted trough.





Boundary Conditions: Tropopause-Stratosphere Interaction

Quasi-biennial Oscillation Composites



Westerly QBO with a descending easterly shear zone for 30mb (left) and 250mb (right) for Dec-Jan

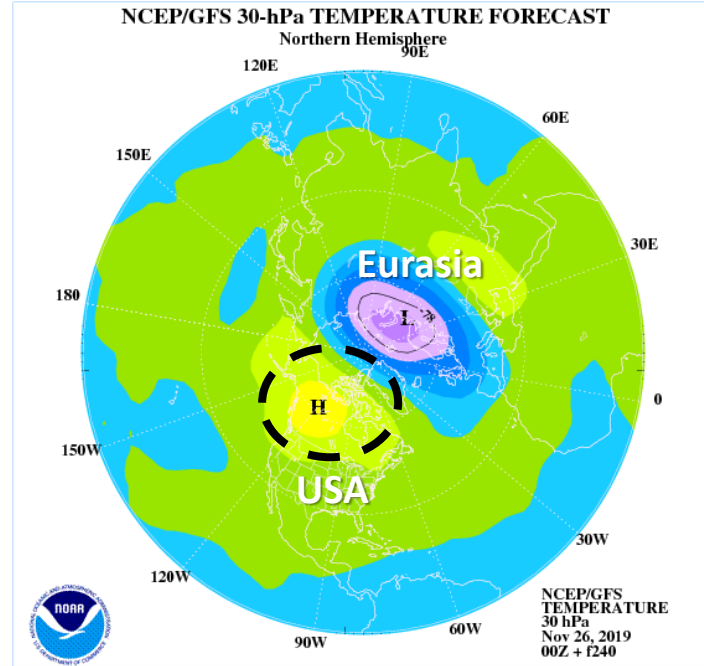
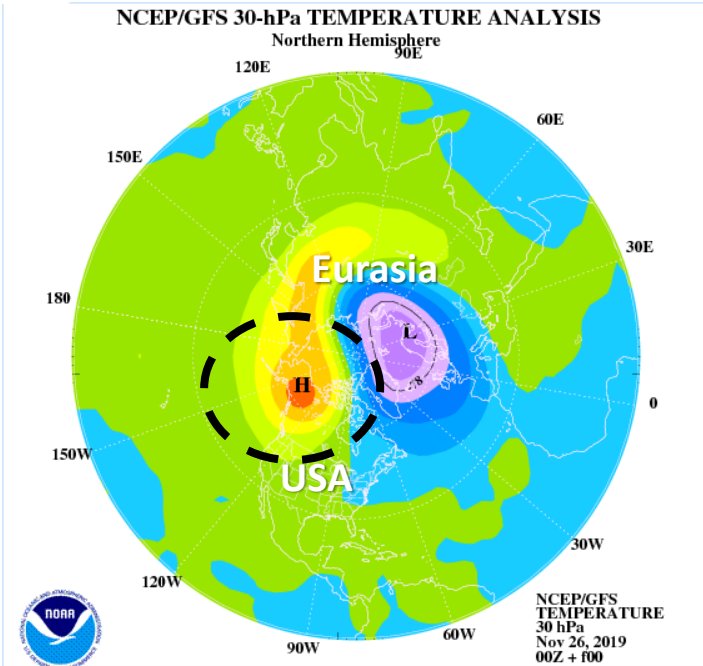
The two easterly QBO phases climatologically support a weaker PV by directing Rossby wave energy poleward while the opposite is generally true for the westerly phase. Of note in the historical composite on the left, however, is the wave 1 forcing (Aleutian high) on the PV. The tropospheric counterpart (right) indicates daughter tropospheric vortices eventually displaced off the pole. Note both the strong signal and small sample size, however. An ENSO filter has also been applied to these composites.





Modeling the Stratosphere & Implications

Probable Canadian Warming in the Stratosphere



30mb Temperature analysis for Nov 25, 2019 (left) and 10-day simulation (right)

Current analysis indicates wave 1 stress on the PV is occurring (left) and is forecast to advance (right) through medium range. Labitzke (1977a) characterized this type of event as a Canadian Warming (CW). Not to be confused with a “sudden stratospheric warming”, CWs are defined by a reversal in the temperature gradient b/t the pole and mid-latitudes caused by PV displacement and stronger forcing/warming in the lower portion of the stratosphere (i.e. 30mb vs 10mb). That criteria will either be met or nearly met during December. Given proper troposphere-stratosphere coupling, which is not a certainty, a period of weakened zonal flow and high-latitude blocking may manifest. December CWs also occurred in 1993, 81, 78, 66, 65, 59, 58, and 54 – a composite of the following Januarys favors blocking and a strong cold signal for the Great Lakes.





Technical Discussion Summary

December-January-February

Summary

Modes of tropical forcing observed during Autumn will continue. In the aggregate, they will support troughing over the Great Lakes with potential for well-defined episodes of ridging building from the southeast US. This would force the storm track over or northwest of the area. With lower confidence, modeling indicates this tendency decreasing as convection migrates east of 160°E , which could mitigate the amplitude of the southeast US ridge or even reinforce support for troughing if it makes sufficient eastward progress

Composites of the current QBO state along with observations & modeling of warming over the lower-middle Canadian stratosphere offer support for blocked flow and a southward-displaced storm track during mid-winter, but are conditional on meaningful troposphere-stratosphere coupling.

The MJO was not discussed, but it is typically more active in ENSO neutral or weak ENSO years. By constructively interfering with the low frequency state (i.e. active western Indian Ocean & western tropical Pacific convection areas) it will likely dictate the amplitude and timing of strongest tropical forcing.