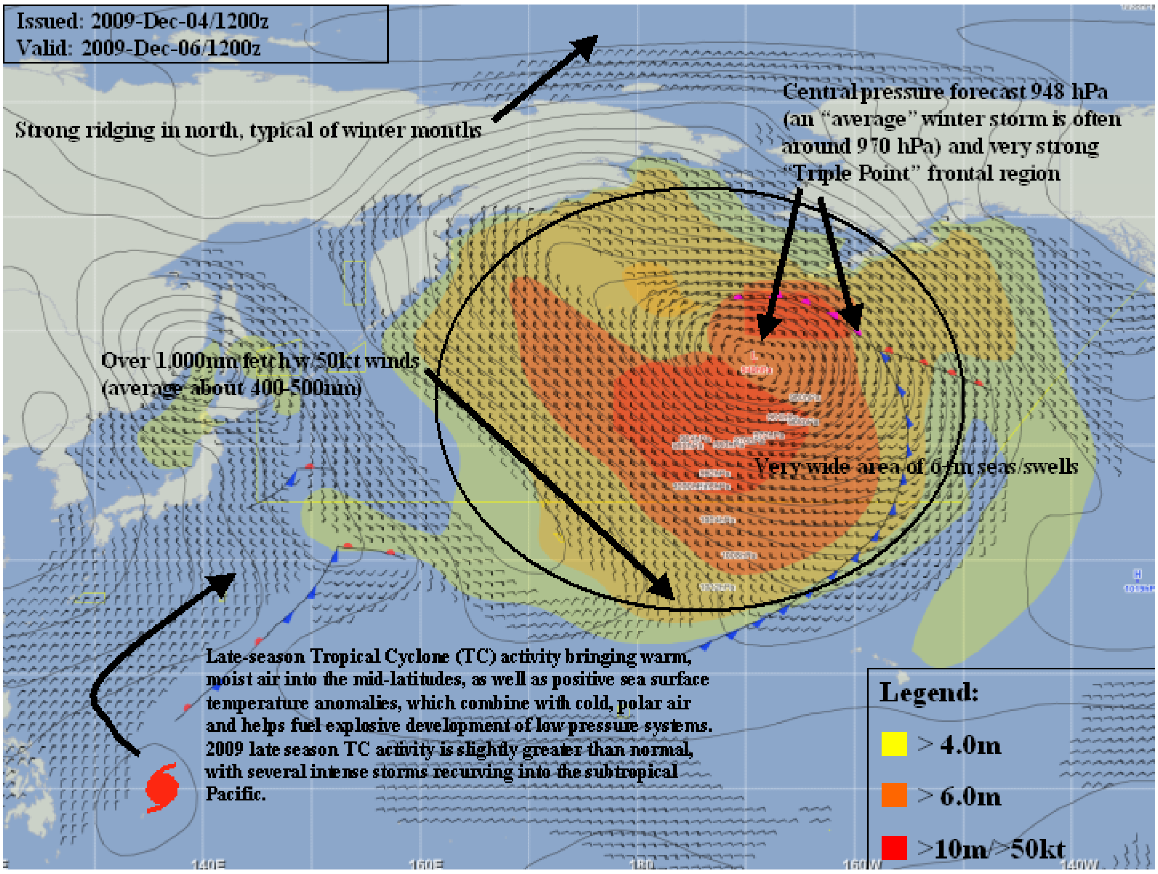
Analysis of Fall Transition Season (Sept-Early Dec) 2009

Why has the weather been so violent?

As can be seen by the following forecast map, the Fall Transition and early Winter Season of 2009 has been particularly heavy in the North Pacific, with several very deep low pressure systems, long fetches of over 1,000nm with very strong winds, and extremely wide areas of over 6m seas/swells.



Reasons for such violent weather are related to several features, including the El Niño phenomenon, sea surface temperatures, global circulation patterns and slightly higher than average tropical cyclone activity in the Northwest Pacific, many of which recurved into the subtropics, bringing warm, moist air which helps fuel explosive development of low pressure systems.

For a detailed scientific analysis of the mechanisms involved, please see the following pages.

Introduction

The Fall Transition Season of 2009 has been particularly heavy in the North Pacific – the period September through early December has boasted ten low pressure systems deeper that 970mb, four of which showed central pressures less than 955mb (Figure 1).

The presence of a moderate El Niño over the past several months (Figure 2), and its effect on Tropical Storm development, sea surface temperatures and global circulation patterns can be traced as the reason for this particularly heavy weather.

El Niño

El Niño is part of the climate phenomenon called ENSO – El Niño/ Southern Oscillation - which is a periodic change in the atmosphere and ocean of the tropical Pacific. It is defined in the atmosphere by the sign of the pressure difference between Tahiti and Darwin, Australia, and in the ocean by warming or cooling of surface waters of the tropical central and eastern Pacific Ocean. The warm phase of ENSO is known as El Niño, and the cold phase of ENSO is known as La Niña (Figure 3). ENSO events (warm or cool) do not occur with a specific period, and tend to occur every three to eight years.

The effects of ENSO are felt globally, but are felt most acutely in the Pacific Ocean, as sea surface temperature anomalies associated with ENSO can affect the circulation patterns of the basin.

During El Niño events, the atmospheric pattern is characterized by an eastward extension of the East Asian jest stream from the International Date Line to the southwestern United States, and shifting of that jet stream further south through the mid-latitudes. This results in an amplified main low track and enhanced Aleutian low (Figure 4), meaning that lows within the main low track tend to be stronger, and track further south through the basin.

Tropical Storms and Sea Surface Temperatures

The transition season of 2009 has seen 15 tropical systems (tropical storm strength and higher), which is near the average of about 13 storms of TS strength or higher for the period September-November (Table 1).

Recent research by the Weathernews Voyage Planning team indicates that El Niño typically does not have an effect on the total number of tropical systems – average number of storms remains consistent between El Niño, Neutral and La Niña years. However, there are on average 2 more typhoons per year in El Niño years than in neutral or La Niña years.

His research shows that tropical cyclones form farther south and east during El Niño event than in neutral or La Niña years (Figure 5). Forming farther south, these cyclones tend to track westward in warmer waters for longer periods of time, allowing tropical depressions to reach tropical storm strength and typhoon strength farther south and east in the basin.

Per Lance’s research, tropical cyclones tend reach higher maximum wind intensities during El Niño years (on average 10-15 knots higher than in neutral or La Niña years), and they tend to recurve slightly more often than in ENSO Neutral years and much more often than during La Niña years.

The Fall transition season of 2009 (September – early December) has seen 19 tropical systems develop, 15 of which were tropical storm strength or higher. Of those 15 systems, 7 recurved through the western ocean into the mid-latitudes of the West or Central Pacific. Four of those recurving systems (Choi-wan, Melor, Lupit and Nida) were significant Typhoons, with maximum wind speeds of 105 kt and higher recorded during their lifetimes.

The seven recurving tropical systems (as well as several tropical depressions that also recurved) during this period brought rich tropical moisture in the mid-latitudes, which helped prime the atmosphere for more violent weather during this transition season in two ways.

Firstly, recurving tropical systems bring warm, humid air to the mid latitudes. When that warm, humid air converges with cold air associated with mid-latitude systems, the warm, humid air can serve as fuel for the mid-latitude systems by providing additional latent heat energy. This allows the mid-latitude storms to deepen further, sometimes very quickly, resulting in intense storms with very heavy associated conditions. Such was the case with Typhoons Choi-wan (in Mid-September), Lupit (in late October) and Nida (in early December), each of which deepened to lows with central pressure of 967mb or lower after extratropical transition or combining with mid-latitude low.

Secondly, strong recurving tropical systems (as in the case with the four systems mentioned above) typically have strong southerly winds along the eastern side of the system. These strong winds can serve to 'push' warm surface waters northward from the tropics into the mid-latitudes. Figure 6 shows a positive sea surface temperature (SST) anomaly was present across much of the West Pacific, west of the Dateline for the period September 1- December 7. This figure shows a significantly positive anomaly between 160E-170E, 35N-40N. Positive sea surface temperature anomalies were also present east of the dateline, south of 40N.

The strong anomaly in the Western Pacific can be attributed to strong recurving tropical systems 'pushing' warm SSTs north into the mid-latitudes, effectively warming the average SST in the West Pacific by almost 2.5C in some areas.

The presence of this pool of warm water served as additional fuel for developing lows in the Western Pacific. The main cyclogenesis area of the Pacific basin is off the coast of Japan, associated with the Kuroshio current core. With warmer water present over a much larger area than normal, lows that developed off the coast of Japan stayed over these warmer waters for longer, allowing them to gain more energy than they would normally. When those lows converged with cold air as they tracked northeastward into the Bering Sea or Gulf of Alaska, this additional energy allowed lows to deepen further and more quickly than if a typical sea surface temperature distribution was present across the basin.

The PNA and El Niño

The Pacific North American (PNA) Index is a climate index that describes one of the most prominent modes of low-frequency variability in the Northern Hemisphere extratropics. The positive phase of the PNA is characterized by a stronger than normal Aleutian low, and a stronger high pressure system over the western US (Figure 7). The negative phase of the PNA is characterized by weaker than normal lows across the Aleutians/Central Pacific, but a stronger trough across the western United States.

The PNA is a natural mode of climate variability, but it tends to very strongly with ENSO events – the positive phase of the PNA is strongly correlated to El Niño events, while the negative phase is strongly correlated to La Niña events.
(Climate Prediction Center: http://www.cpc.ncep.noaa.gov/data/teledoc/pna.shtml)

The period of September-November 2009 showed an average PNA value of 0.64. The average sea level pressure anomaly for the period 1 September – 7 December (Figure 8) is in line with the characteristics of a positive PNA, with a deep anomaly over the Aleutian Islands and Gulf of Alaska.

Eight of the ten storms that were observed to have central pressures of less than 970mb occurred when the PNA Index was in a positive phase (Figure 9), meaning that the Aleutian Low, and the main low track was enhanced.

Conclusion

The presence of several recurving tropical systems over the western Pacific affected the weather pattern during the transition season in two ways. Firstly, warm, humid tropical air was carried into the mid-latitudes as these systems tracked northeastward and merged with the main low track.

Secondly, several strong recurving typhoons served to 'push' warmer tropical waters northward into the mid-latitudes, causing a warm SST anomaly to develop across the western Pacific. This allowed low pressure systems that developed off the coast of Japan to remain over warmer waters for longer; when those lows then interacted with cold air at higher latitudes, the resulting dynamics allowed lows to deepen further, and often more rapidly, than typically is expected.

Similarly, the effects of El Niño on the general weather pattern of the North Pacific, and El Niño's interaction with the Pacific/North American pattern resulted in an enhanced Aleutian low pressure system across the central Pacific and Gulf of Alaska, resulting in a more active main low track across the basin.

The enhanced main low track served to allow stronger low pressure systems to develop (in concert with the observed SST anomaly), which caused the several violent storms that were observed over the course of this transition season.

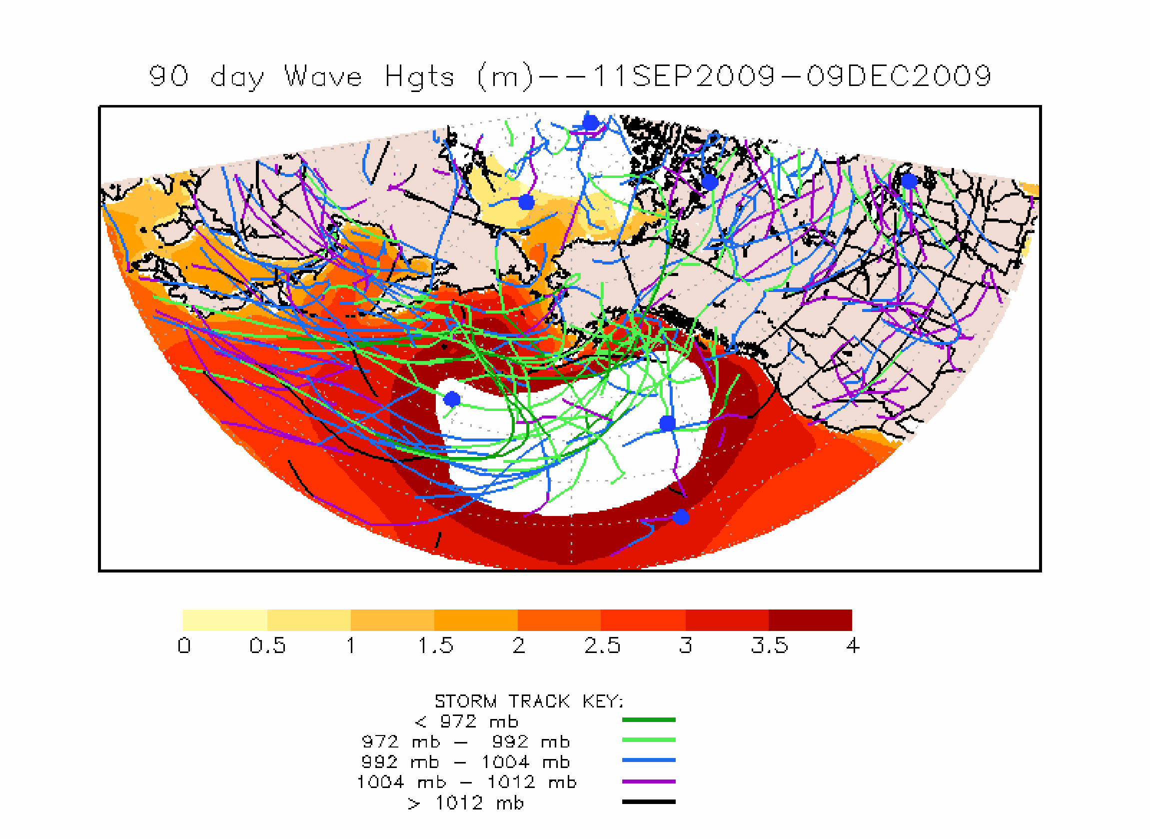


Figure 1. Ninety-day average wave heights (m) and storm tracks for the period 11 September – 09 December.

Courtesy Climate Prediction Center :

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/stormtracks/strack_alaska.shtml

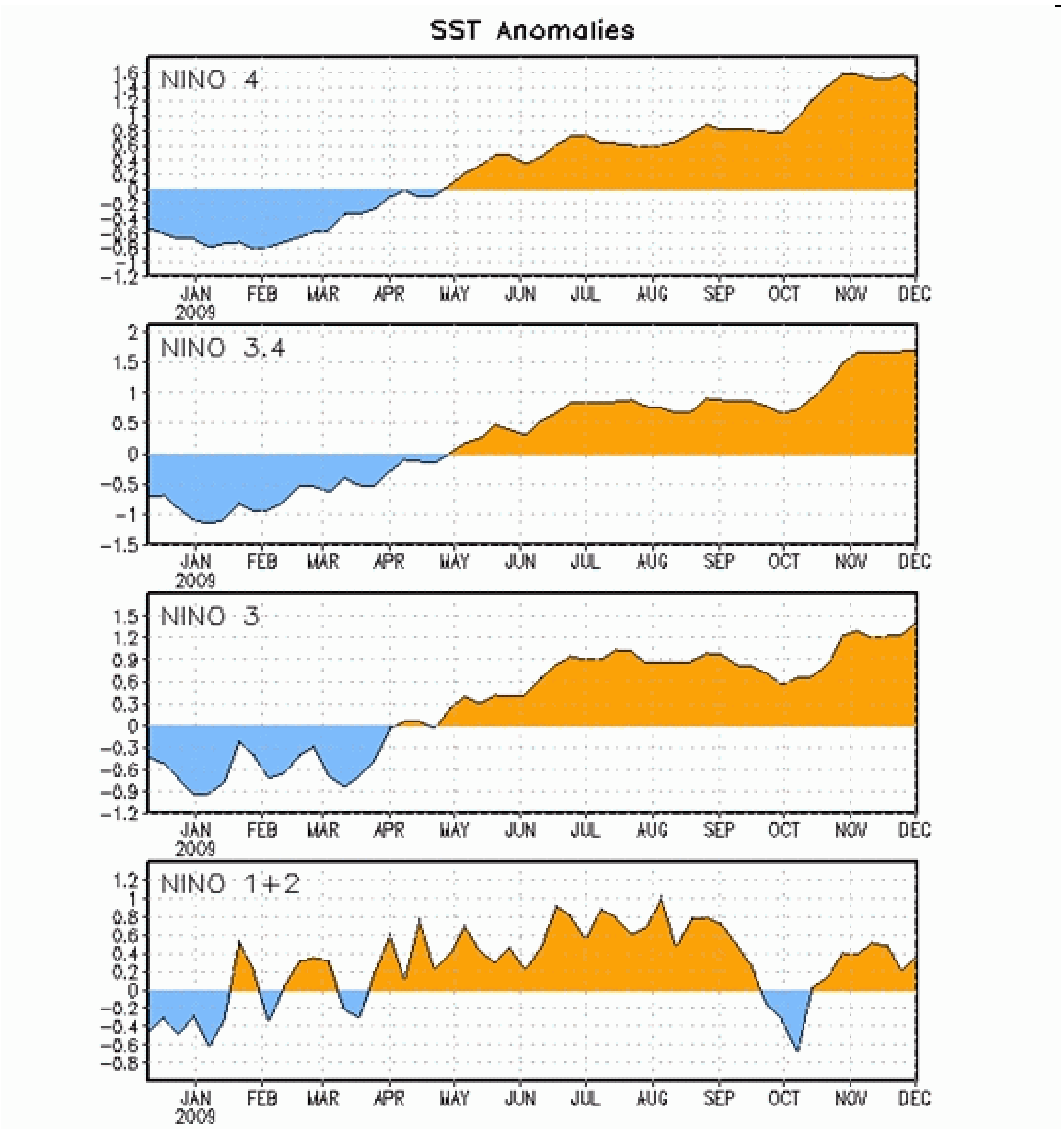


Figure 2. Time series of area averaged sea surface temperature anomalies in the Niño regions [Niño-1+2 (0-10S, 90W-80W), Niño-3 (5N-5S, 150W-90W), Niño-3.4 (5N-5S, 170W-120W), Niño-4 (5N-5S, 150W-160E)]. SST anomalies are departures from the 1971-2000 base period weekly means. (Xue et. al., 2003, *J. Climate*, **16**, 1601-1612). Graphics courtesy Climate Prediction Center.

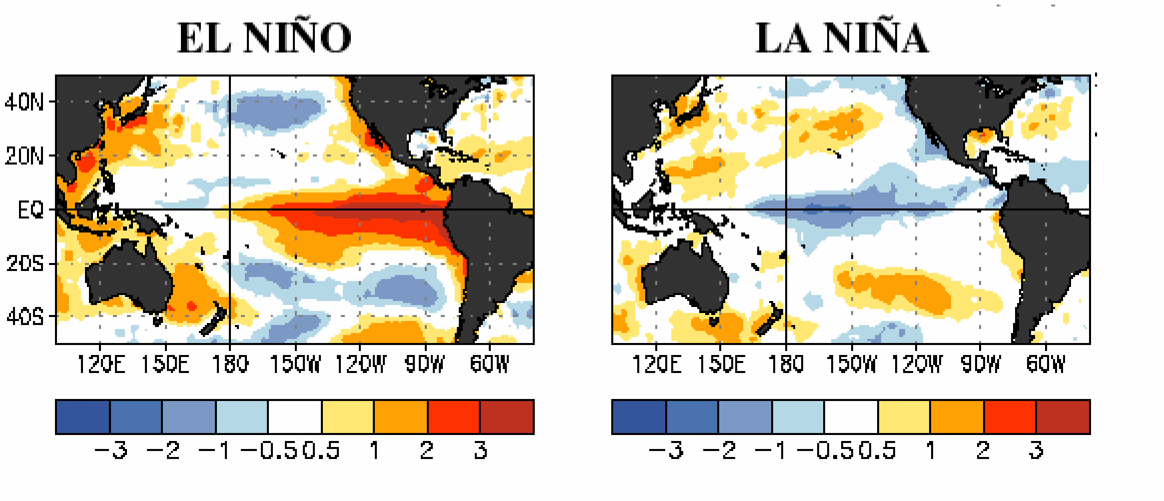


Figure 3. Typical Sea surface temperature anomaly distributions associated the warm (El Niño) phase and cool (La Niña) phase of the ENSO Cycle. Graphic courtesy National Oceanic and Atmospheric Administration.

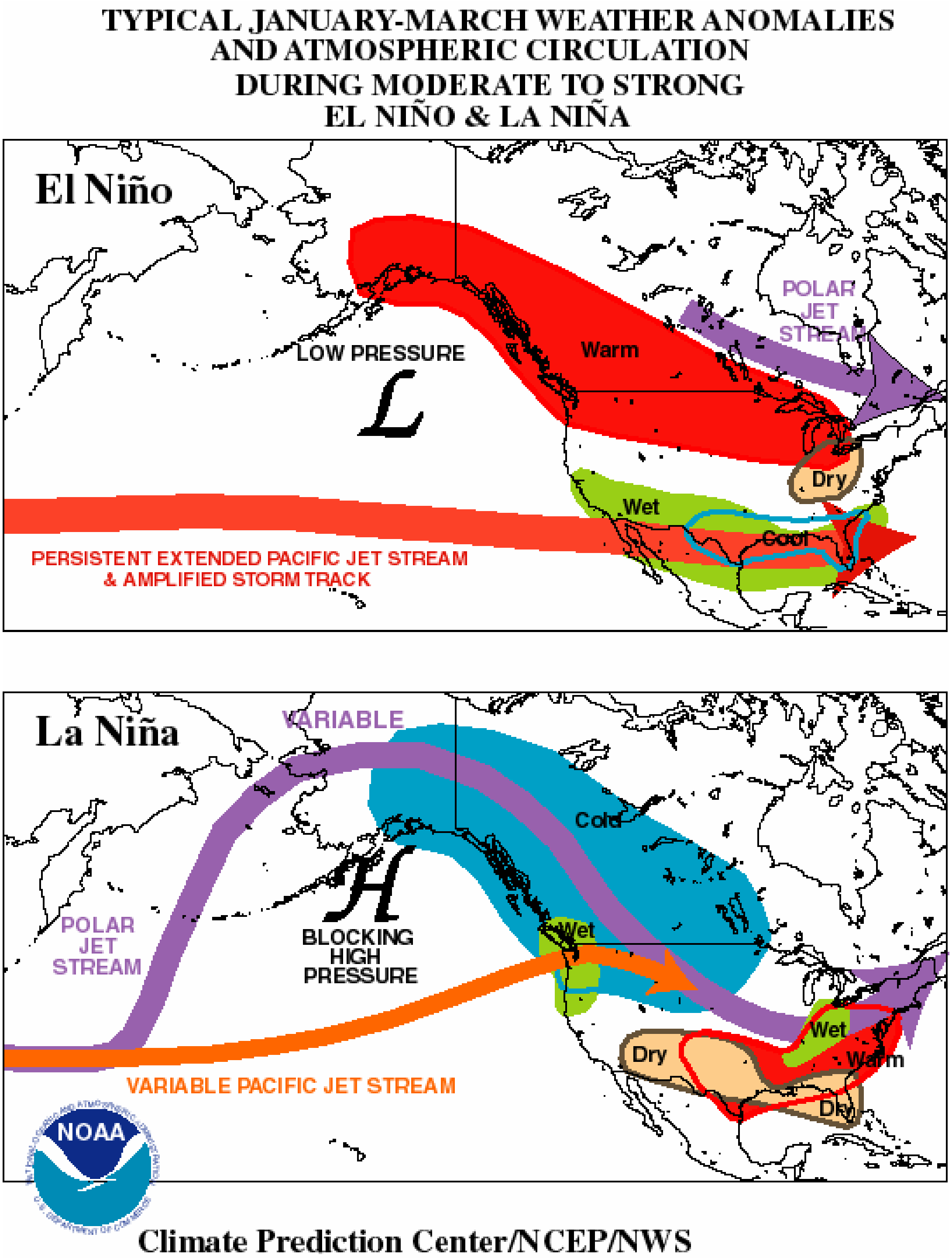


Figure 4. Typical winter weather patters during El Niño and La Niña events.

Courtesy Climate Prediction Center

(http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/nawinter.shtml)

Month	2009	Average
September	7	5.6
October	5 (plus 1 TD)	4.7
November	3 (plus 2 TDs)	2.9
December**	0 (Plus 1 TD)	1.6

Table 1. Number of tropical systems of tropical storm strength and higher in the West Pacific. This list does not include Tropical Depressions (TD). However, there have been a total of 4 TDs in the NW Pacific in Oct., Nov., and Dec. 2009, many of which have brought tropical moisture into the mid-latitudes.** As of Dec-07, 2009

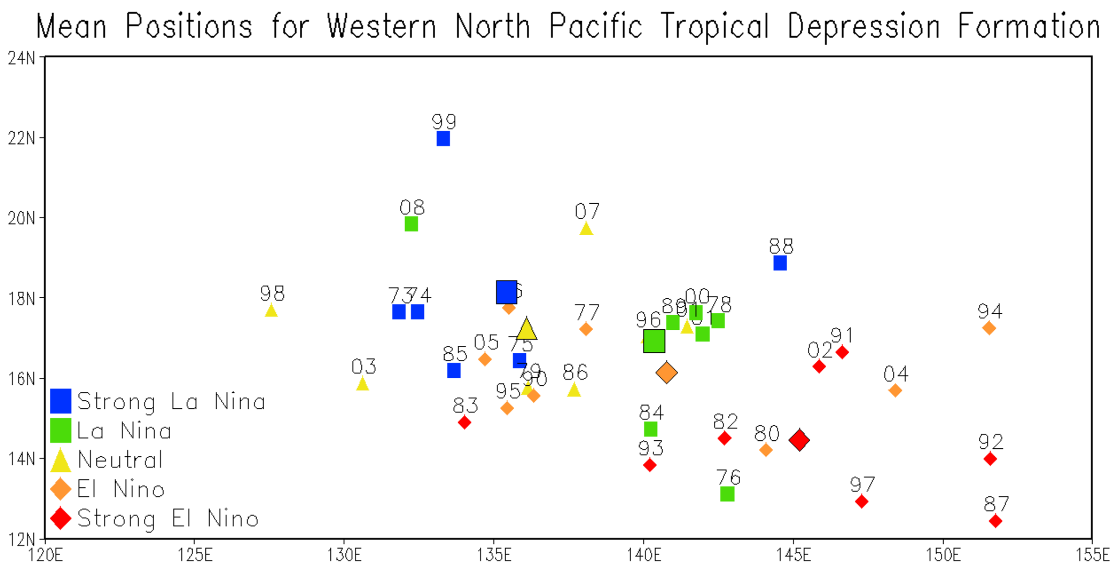


Figure 5. Mean position for tropical depression formation across the western Pacific for Strong La Niña, La Niña, ENSO Neutral, El Niño and strong El Niño events. Chart produced by the WNI-Voyage Planning team.

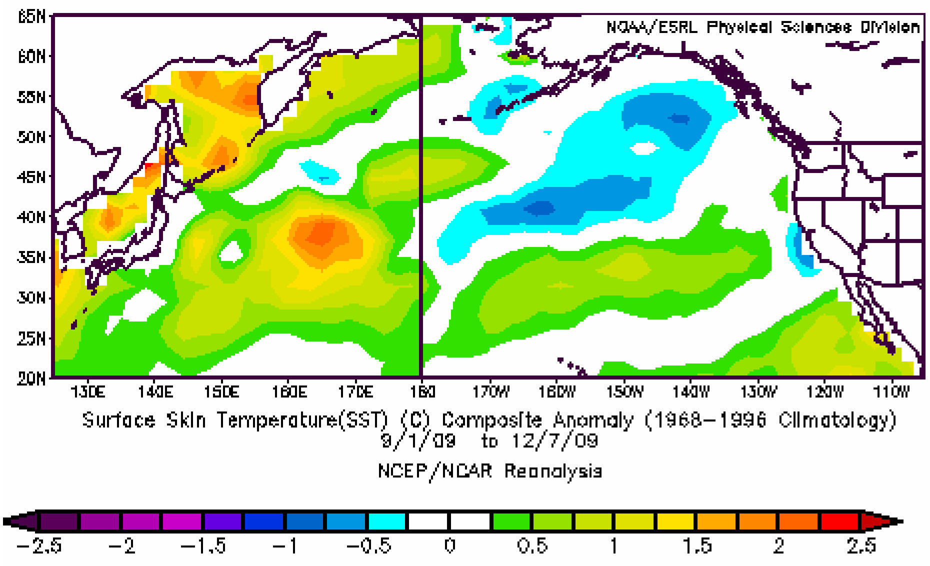


Figure 6. Average sea surface temperature anomaly (degrees C) for the period September 1 – December 7, as compared to climatogical mean 1968-1996. From NCAR/NCEP global Reanalysis Data provided by Earth System Research Laboratory.

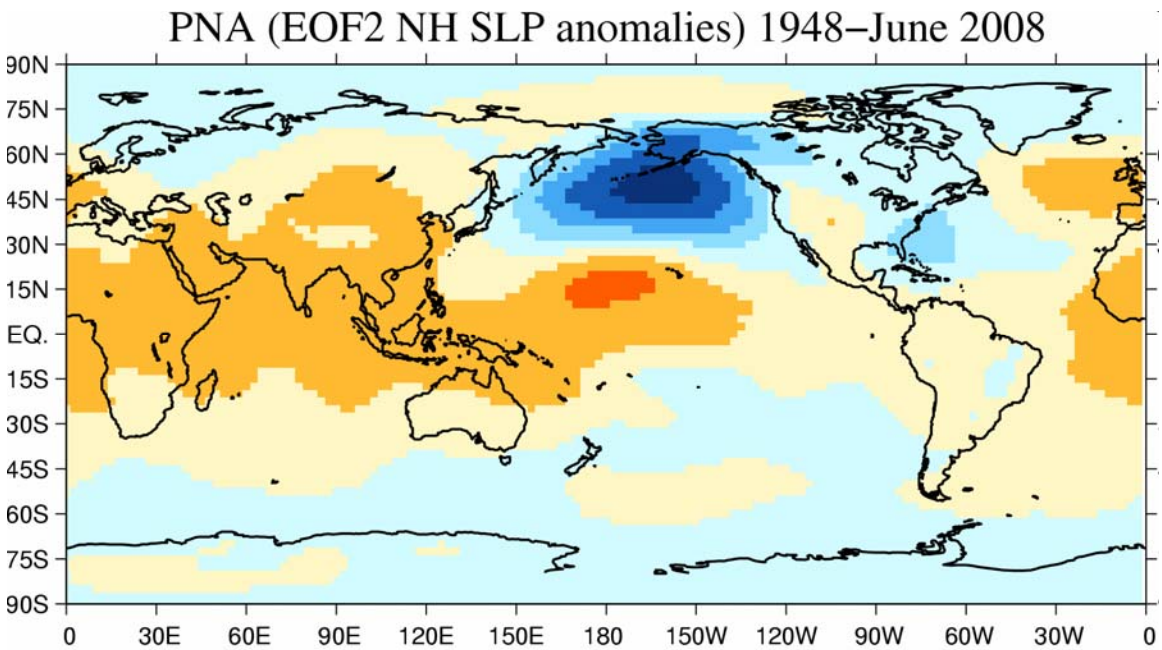


Figure 7. Empirical Orthogonal Function loading pattern for sea level pressure anomalies associated with the positive phase of the Pacific/North American Index. Courtesy Joint Institute for the study of Atmosphere and Ocean.

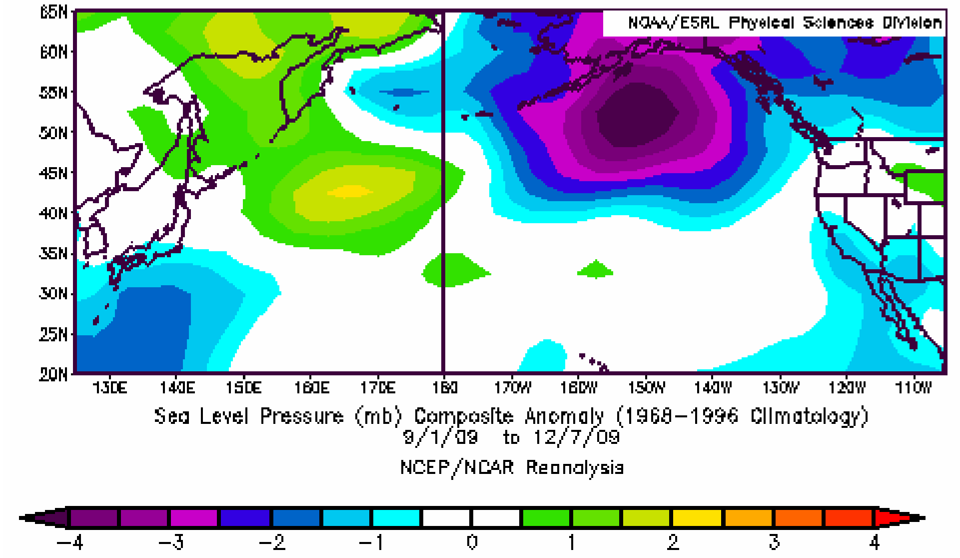


Figure 8. Composite mean Sea Level Pressure anomaly for the period September 1 – December 7, as compared to climatogical mean 1968-1996. From NCAR/NCEP global Reanalysis Data provided by Earth System Research Laboratory.

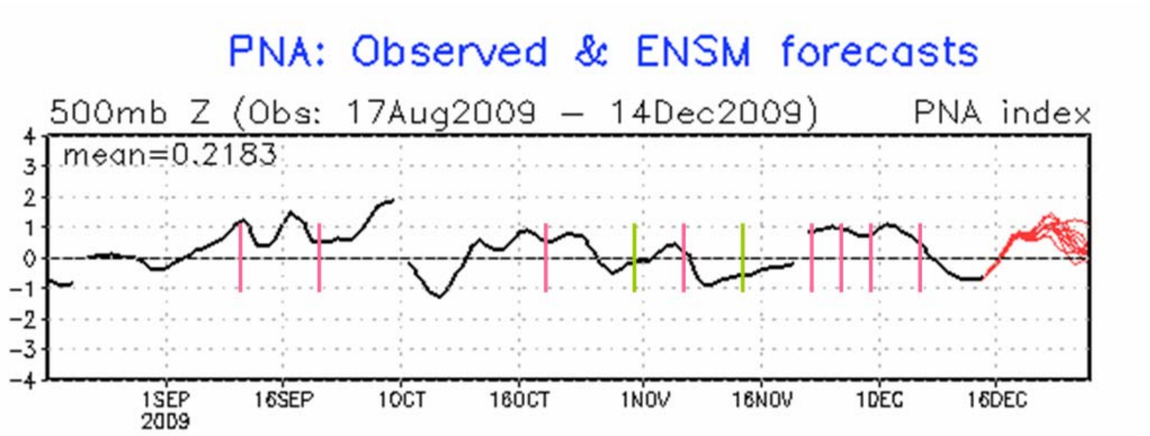


Figure 9. Observed daily PNA Index value. Vertical lines indicate the approximate date of storms that were observed to have central pressures of less than 970mb. Pink Lines indicate Positive PNA value at the time of observation and green lines indicate Negative PNA value at the time of observation.

PNA index figure courtesy Climate Prediction Center

(http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/pna.shtml)