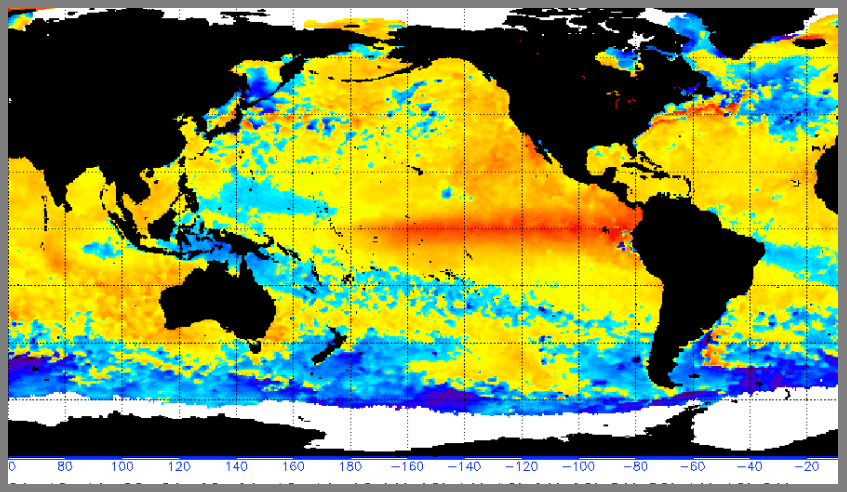
Winter Outlook 2015-2016

Southeast Lower Michigan

December through February



Slide 2: Winter Outlook for SE Michigan
Slides 3-11: Forecast Reasoning

Winter Outlook for Southeast Michigan

A break after back-to-back harsh winters

Temperature Outlook

A strong polar vortex and a strong el Nino will combine to bring warmer than normal temperatures for at least the first two months of winter. As el Nino-related processes wear on the polar vortex throughout winter, a late season return to more typical temperatures is a possibility.

December: Warmer than Normal
January: Warmer than Normal
February: Slightly Warmer Than Normal

Snowfall Outlook

Strong el Ninos are climatologically dry in the Great Lakes region. Combined with a strong polar vortex that will reinforce warm trends, snowfall – especially snowpack – is expected to be below normal through at least January. A late season shift toward more normal snowfall is a possibility.

December through January: Below normal snow and, especially, snowpack
February: Near Normal

Current Stratosphere State

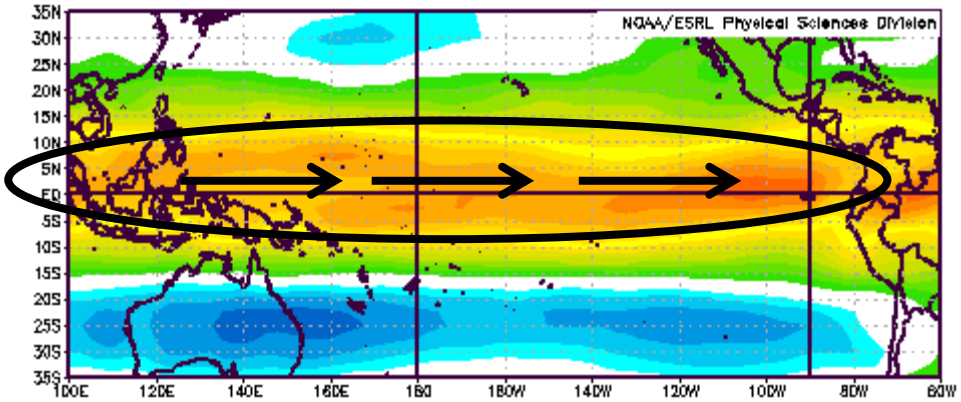
A mature westerly QBO (quasi-biennial oscillation)

Westerly winds are downwelling from the upper stratosphere (top) to the lower stratosphere (bottom). Recent indications are that the stronger westerlies will be reaching the lower stratosphere before winter begins.

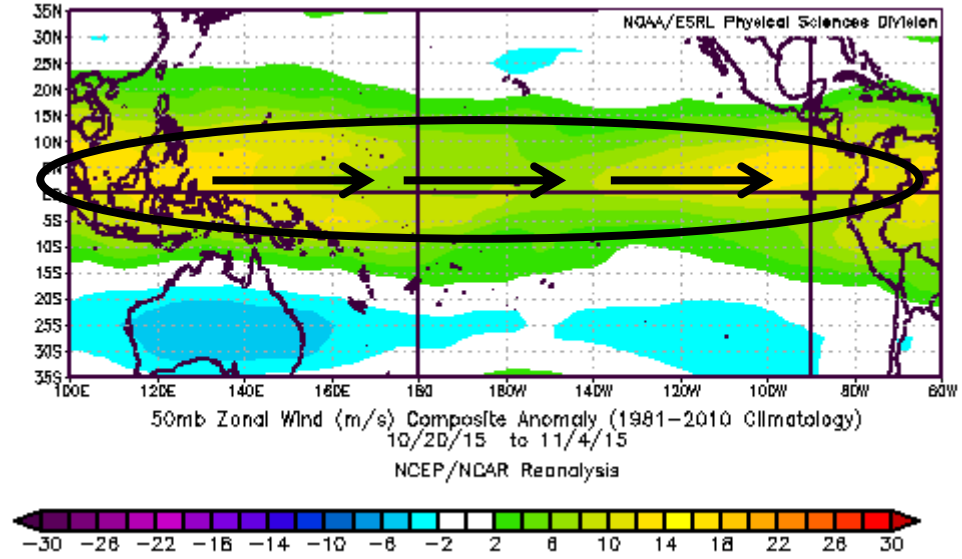
Per Baldwin et al. (2001) and Hitchman and Huesman (2008) the westerly phase reduces flow toward the wintertime northern hemisphere and inhibits poleward Rossby wave breaking. *The lack of wave breaking helps contribute to a strong polar vortex.*

Remember: A strong polar vortex tends to lock cold air up north and keep SE Michigan warmer.

Zonal Wind Anomaly at 20mb

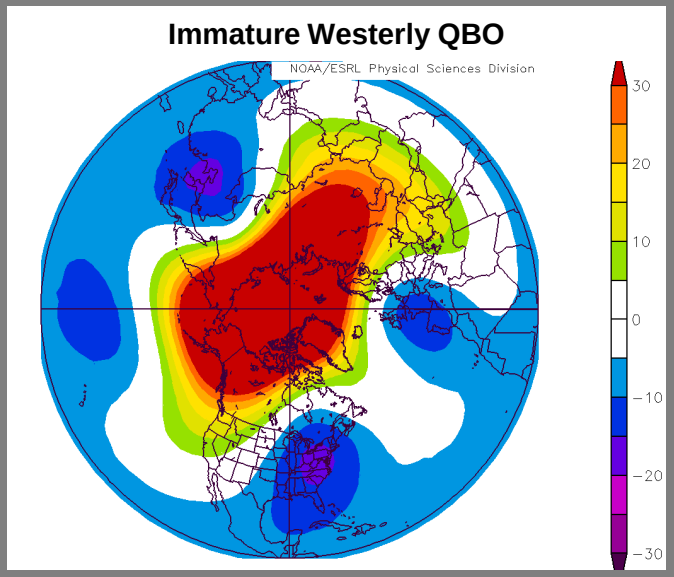


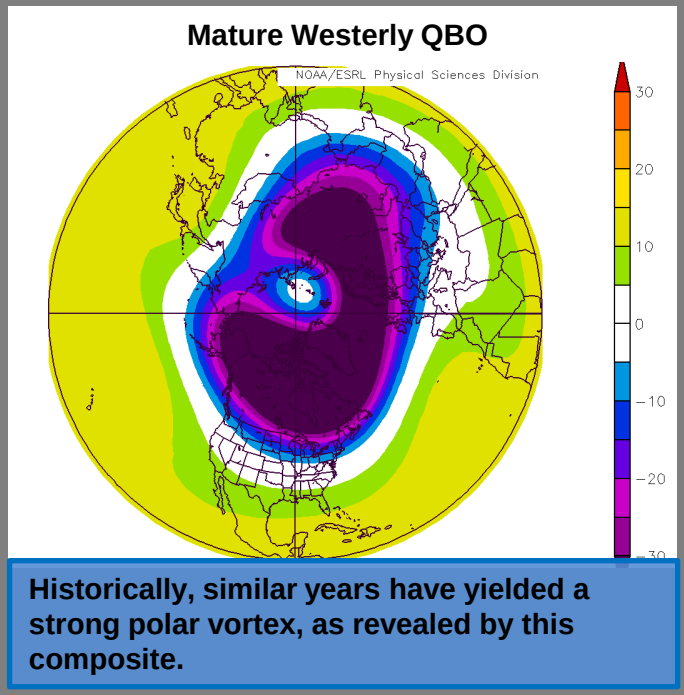
Zonal Wind Anomaly at 50mb



Current Stratosphere State
Mature Westerly QBO in Progress

Composite 50mb geopotential height anomalies for 2 different stratospheric wind scenarios



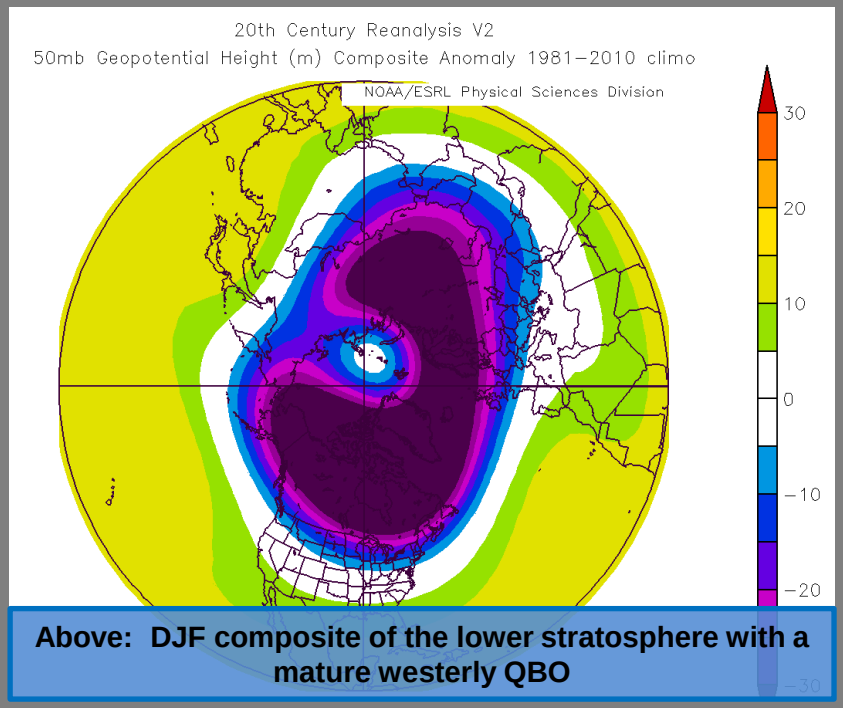


Historically, similar years have yielded a strong polar vortex, as revealed by this composite.

Left: This composite shows high lower stratospheric height anomalies for cases when the QBO was westerly during the DJF period, but the maximum was located in the upper stratosphere (i.e. an "immature" QBO). Mostly, these are cases when an easterly QBO began a transition to westerly at the onset of winter. The polar vortex is quite weak in these cases.

Right: These years feature a mature westerly QBO, which is what we will see entering this winter. The polar vortex in these cases is strong. In fact, ***a mature westerly QBO is the most favorable state for a strong* PV**, largely due to reasons mentioned on the previous slide.

Current Stratosphere State
Off to a Strong Start?

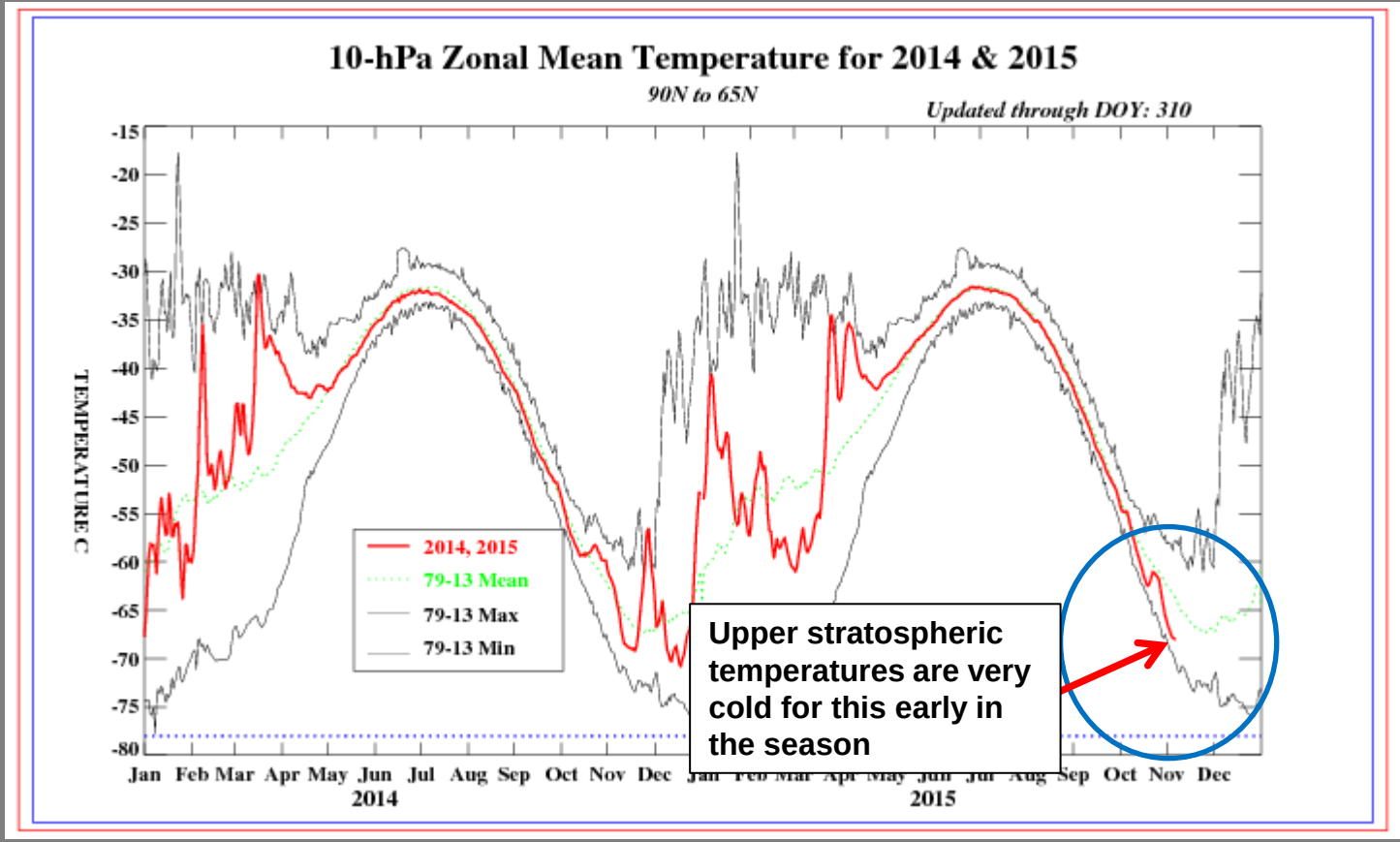


Above: DJF composite of the lower stratosphere with a mature westerly QBO

Holton & Tan (1980) and, later, HH08 confirmed that the polar night jet is the strongest when the maximum westerlies are entering the lower stratosphere (i.e. mature QBO). Their findings support the above composite, which is why years similar to this year has such a strong signal for a strong polar vortex.

Is there any data yet to support the notion that this year will be similar?

Current Stratosphere State
Observations



The expectation that the stratospheric polar vortex will be strong to begin the winter is already being borne out in the observations, which indicate that it is stronger than normal. Because the descending westerlies will provide protection to the PV against deceleration, the conclusion is that ***the polar vortex will be a strong player this winter. Specifically, it will provide strong resistance to cold air intrusions into Southeast Michigan***.

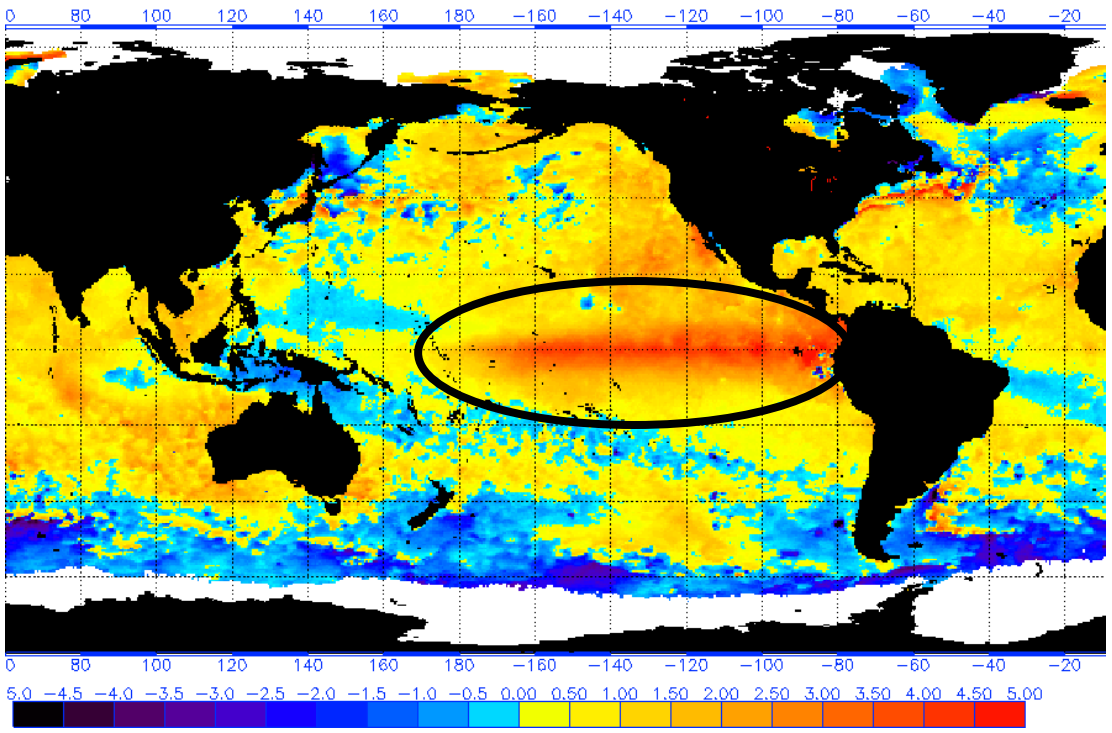
Current Tropical State
Sea Surface Temperature Anomalies

One of the strongest el Ninos on record is in full swing in the tropical Pacific.

Since June, the multi-variate ENSO index (MEI) has consistently ranked the 2015 el Nino as the second strongest on record behind the “Climate Event of the Century”, the el Nino of 1997-98.

Current forecasts suggest el Nino will remain strong through the winter.

Current Sea Surface Temperature (SST) Anomalies



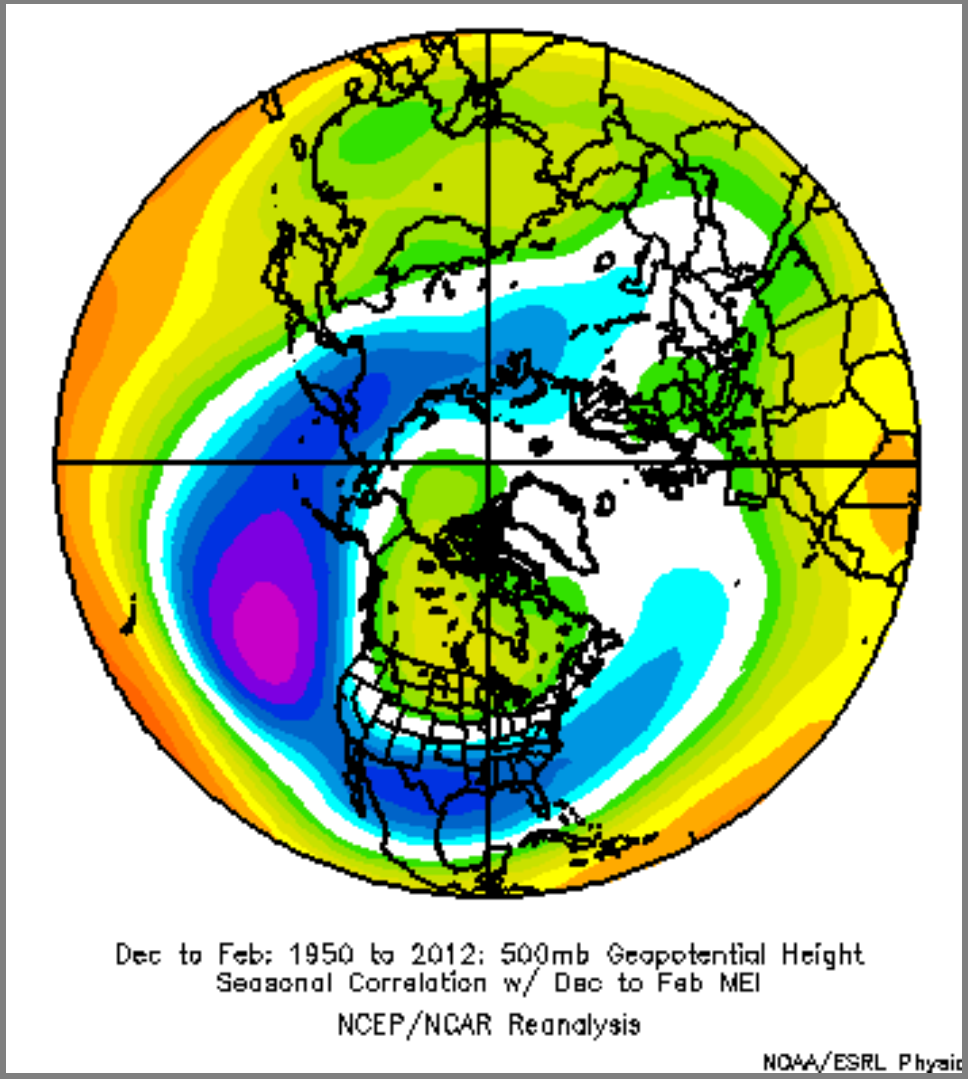
el Nino Climatology
500mb pattern correlation to el Nino

To the right is a correlation of the middle atmosphere to el Nino processes in the tropics.

el Ninos produce a strong Aleutian low off the coast of the western US and an enhanced subtropical jet that feeds into the southern US. **Warmer temperatures and drier weather dominate the Great Lakes and much of Canada.**

These features are the most pronounced and persistent when el Nino is strong.

But there are additional aspects to el Nino that may be important this year….



El Nino vs Stratosphere
Two dominant forces in opposition

1. el Ninos increase poleward transport of ozone, which helps to increase the temperature of the polar vortex and weaken it.

2. el Ninos are fundamentally a westerly momentum phenomenon. This increases wave breaking in the winter hemisphere. For this reason, ***el Ninos are known to weaken the polar night jet as winter wears on, potentially bringing colder air by winter's end.***

You'll notice that the propensity for weakening the polar vortex and increasing wave breaking are in contrast to the previous discussion on this winter's polar vortex, which is expected to be strong and somewhat resistant to such wave driving. **Thus, *two strong forces will be opposing each other by winter's end.***

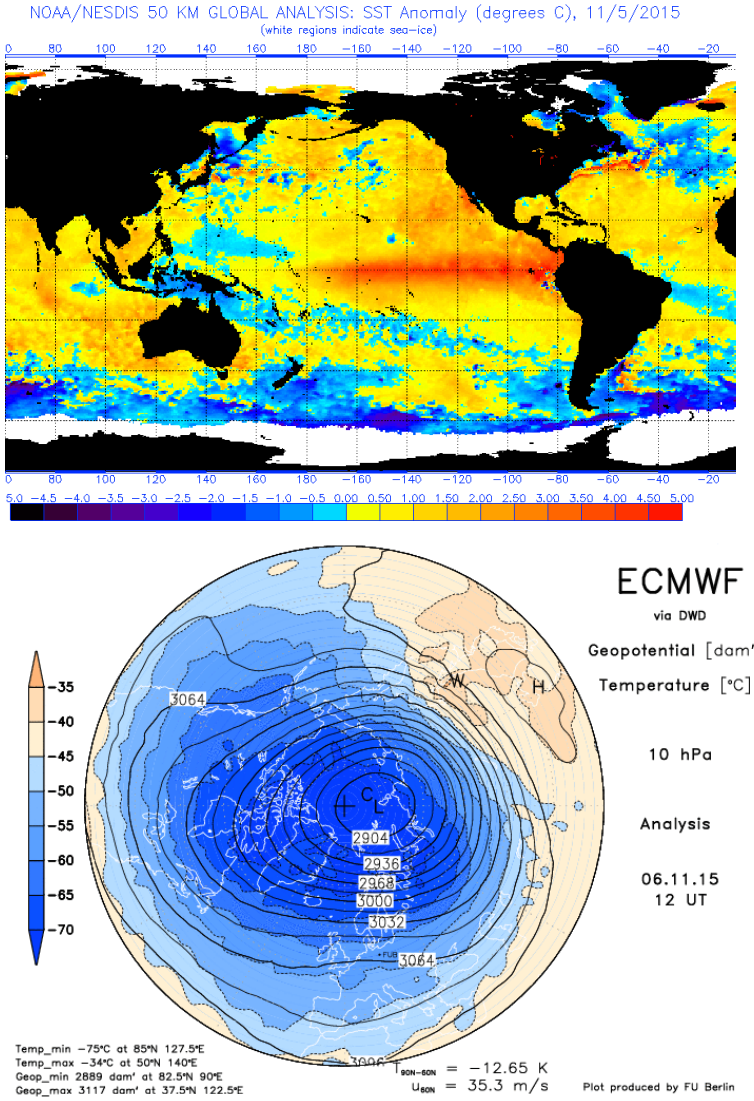
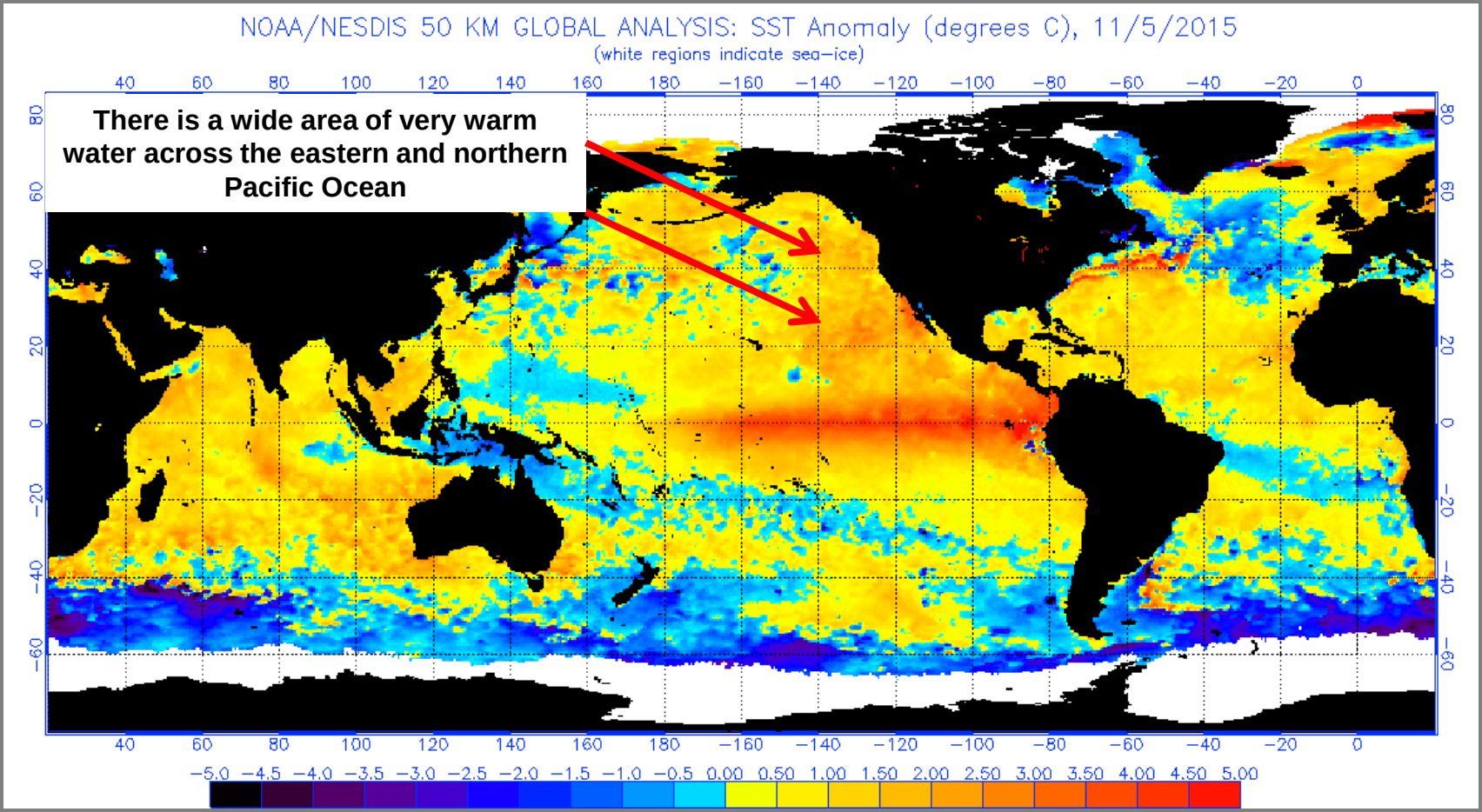


Image courtesy of Free University Berlin

The Northern Pacific
Warm Water Everywhere



A wide expanse of warm Pacific water will be a source of heat for the lower atmosphere for part or all of the winter. This may act as a partial counter to the deep Aleutian Low that el Ninos are known for. The best approach here is to look at past el Ninos that featured the most similar pattern of warm sea surface temperatures (positive PDO values that accompanied past el Ninos)

The Northern Pacific
Potentially Aiding Great Lakes Troughing

Below: A composite of el Nino years with warmer water in the east (+PDO) minus el Ninos with colder water in the east (-PDO). The map is a difference product, where the color shading represents the differences. Warm colors suggest locations of more ridging in years like this year, while cool suggests more troughing.

This is the most uncertain aspect of the winter outlook. Notice the signal for higher heights across the eastern Pacific due to a retracted Aleutian low. This can help elicit a downstream response of lower heights across Hudson Bay, which can be more favorable for troughing in the Great Lakes. This is expected to play a tertiary role behind the strong stratospheric polar vortex and the strong el Nino, but it is at least one force acting in favor of troughing in the Great Lakes. *Please refer back to Slide 2 for the SE Michigan Winter Outlook.*