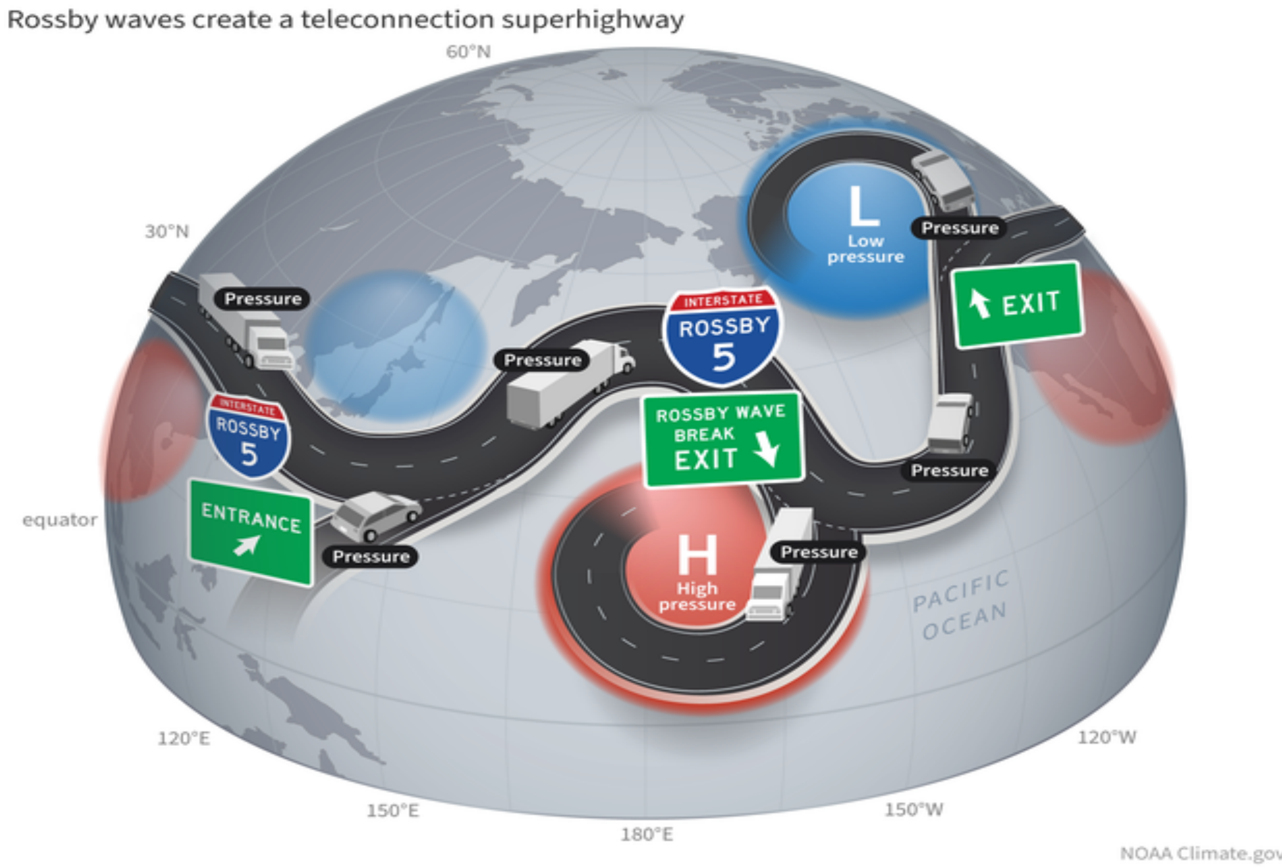
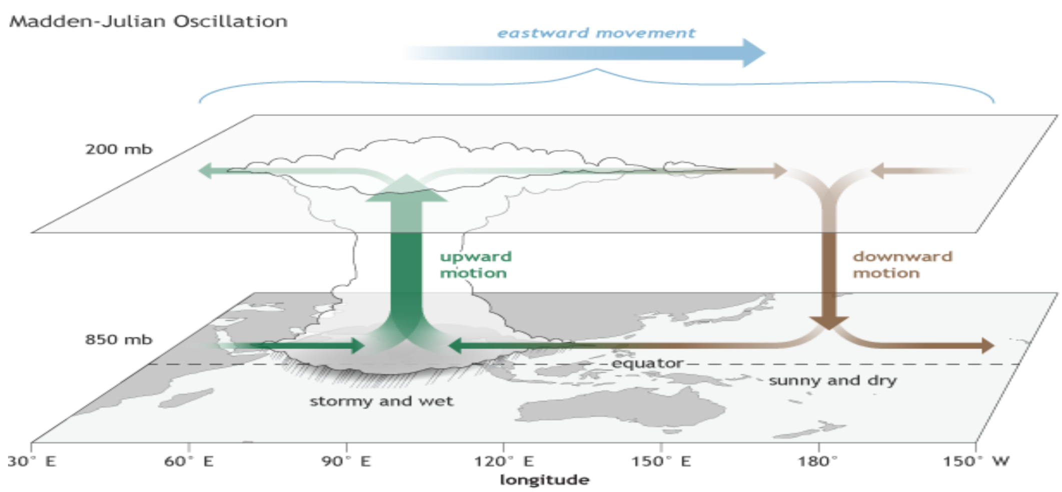
How Teleconnections Work & How Do They Relate In Winter?



For the winter season, forecasters, meteorologists, and enthusiasts alike will try to make connections between a certain phase of a teleconnection and its effect in terms of sensible weather. A certain teleconnection phase is linked with distinct weather patterns across the middle latitudes. In winter, we're at the coldest time of year; therefore, a large atmospheric process that happens across the higher latitudes for example, can essentially allow for a dislodgement of cold air to cascade southward. You need cold to increase chances for snow, right? Below we'll analyze what each teleconnection is, how it effects weather patterns, and what implications a certain phase has.

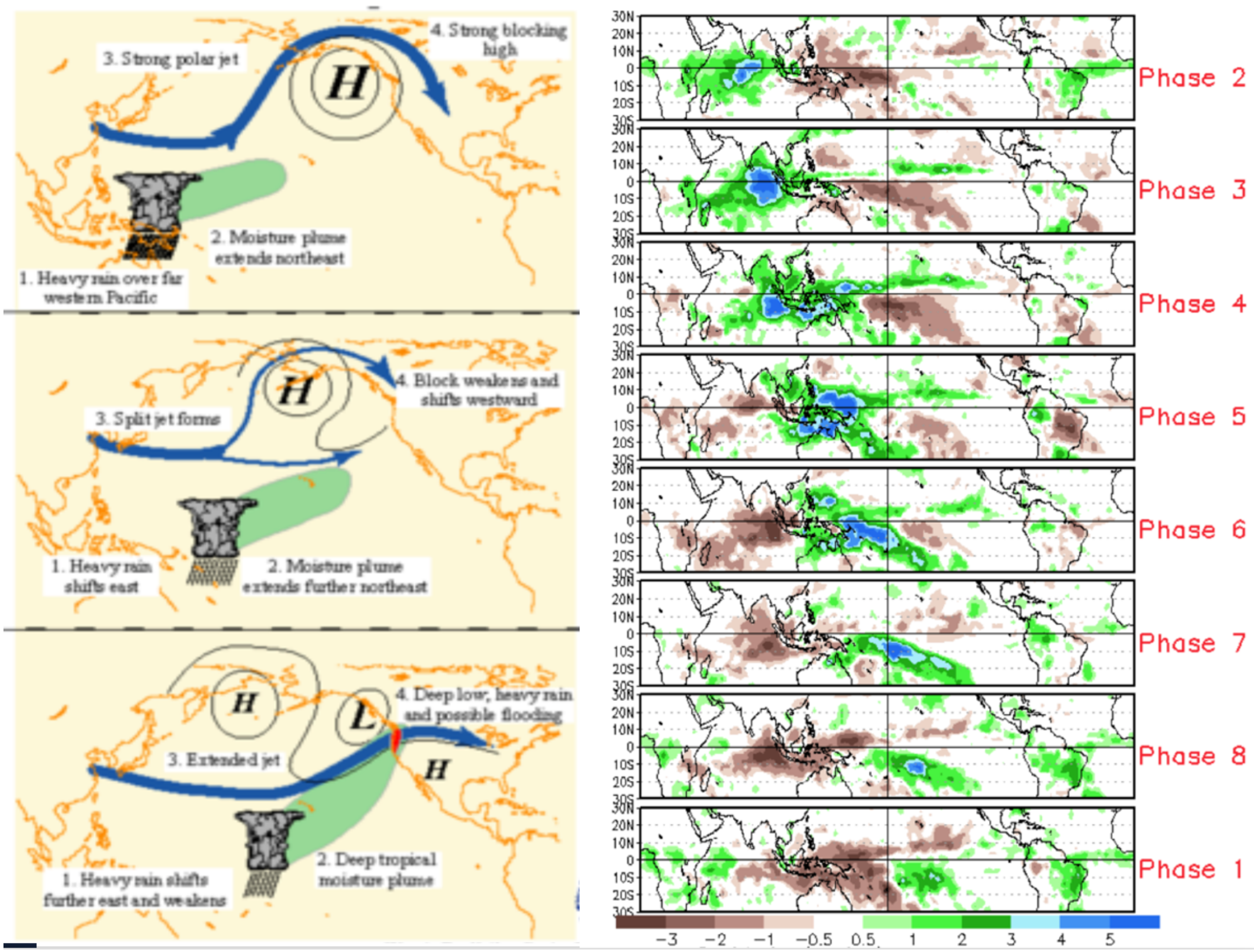
The MJO - Madden Julian Oscillation

If you're unfamiliar with the MJO, it's simply a large cluster of thunderstorms, clouds, and rain that travels eastward globally along the tropics. This tropical phenomenon has large scale impacts across the globe due changing placements of enhanced convection and rainfall and suppressed phases. We see thanks to a nice graphic by the NOAA what the MJO schematic looks like below. This large circulation typically traverses the globe on average, in a span of 30-60 days and then returns to its starting point. During the winter, there typically can be more than one MJO event.

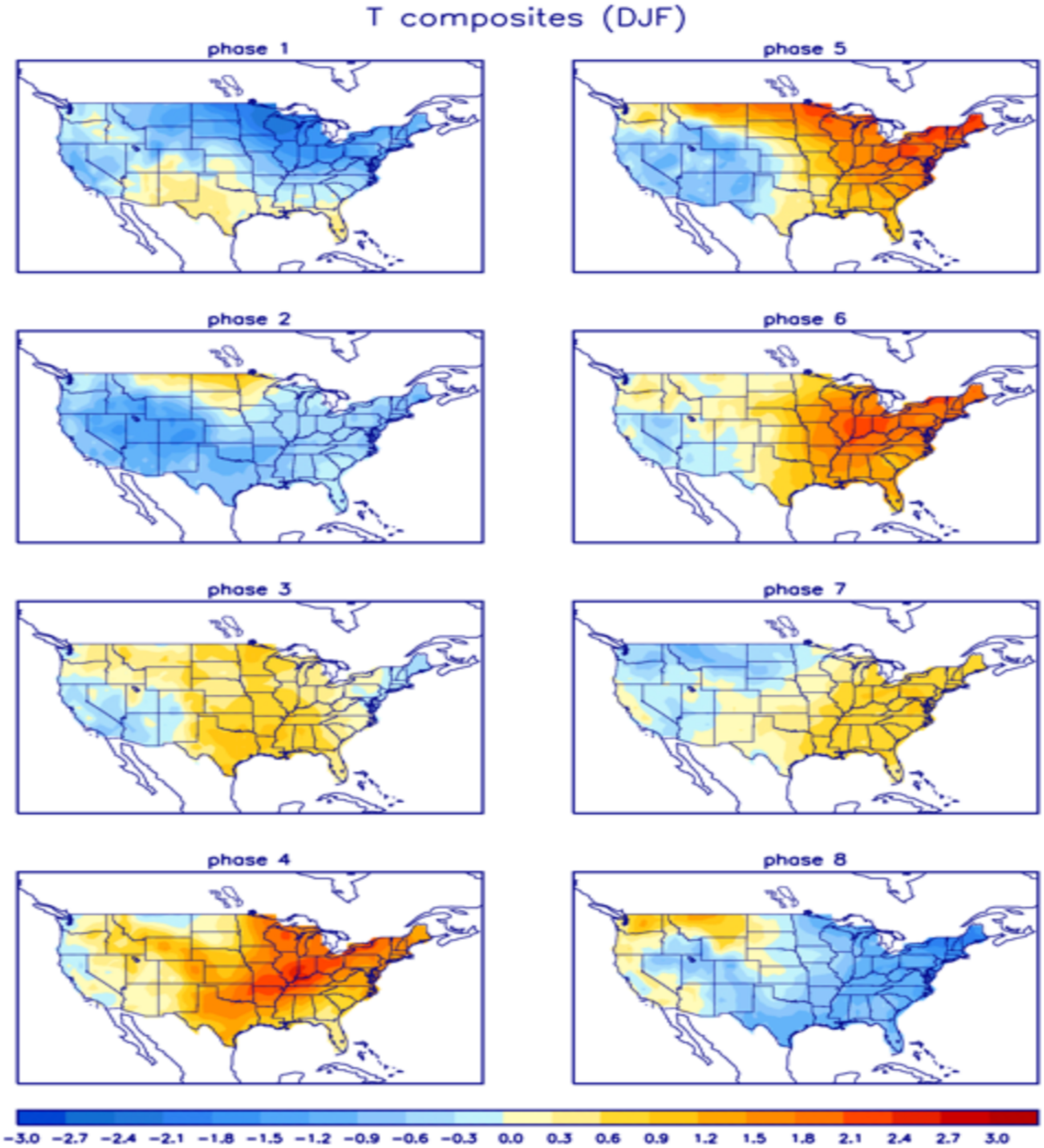


If you are familiar with the MJO, you've likely seen it associated with phases. It's important to not get it confused with parts of the MJO. Think of it as a dipole – one entity that has two opposing parts. This means there is an active part (rising motion) and suppressed part (sinking air). What is analyzed are where exactly is the placement of the rising and sinking motion along the tropics. This is now broken into 8 phases.

Here below represents the circulation along the equator as it'll typically begin across the Indian Ocean and Maritime Continent. On the left-hand side, the thunderstorms (convection) propagate eastward toward the central Pacific. As it does so, latent and sensible heat fluxes from the convection, influences other atmospheric processes that directly impacts the pacific and polar jet streams. This is nicely illustrated below. As the jet stream stretches across the Pacific, we see a plume of moisture stream toward the West Coast while large blocking highs establish themselves in certain areas. This can now influence the polar jet stream to inject arctic or cold air masses into North America. On the right-hand side, the enhanced vs suppressed envelope of the MJO are broken into the aforementioned 8 phases with blue representing rain and brown being dry air.



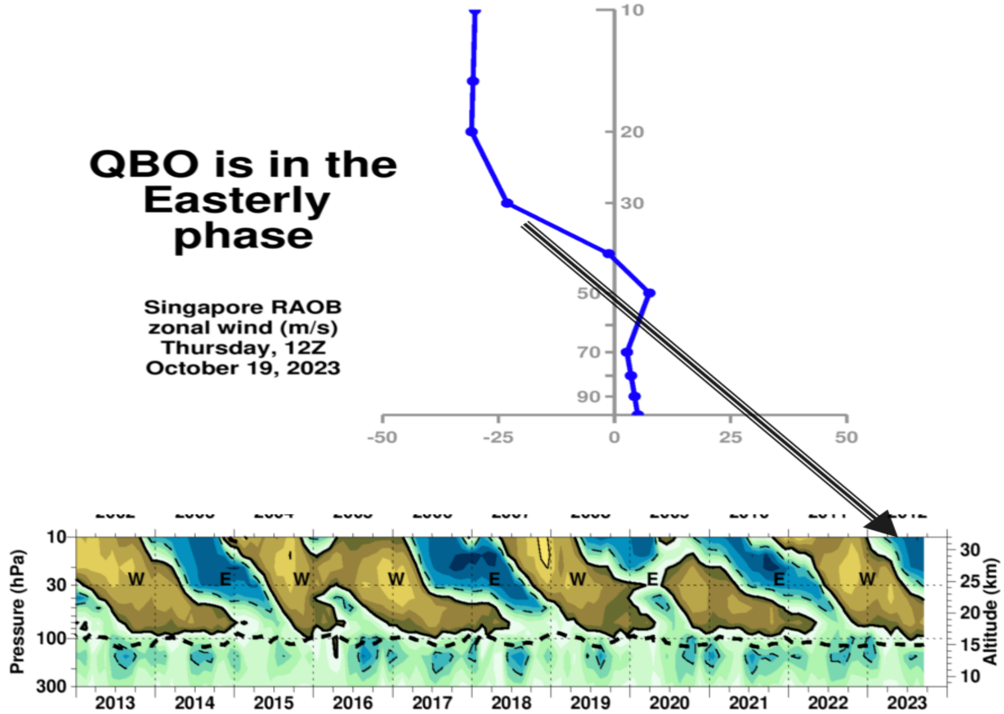
Thanks to the [CPC](), there is a correlation between the certain phase of the MJO and the temperature result across the U.S. As the tropical convection shifts into the Pacific and Western Hemisphere, it sets off a series of large atmospheric processes that ultimately can result in arctic or cold air masses that bleed into the U.S. You'll always see a reference to the phases of 8,1, and 2. It's these phases that typically correlate with more widespread colder temperatures. The only caveat is that the MJO and its downstream impacts can be influenced by different phases of ENSO, which can become more complicated. Regardless, many who do long range forecasts in the winter look at this to help give an idea in terms of temperatures. Where there is cold, likely there'll be snow!



The QBO – Quasi Biennial Oscillation

Don't be frightened by the fanciness of the term, it's simpler than you might surmise. The QBO is just a band of zonal winds in the stratosphere that are known to vary between westerly (positive) and easterly (negative) phases over the course of 12 – 24 months. These winds then descend toward the tropopause (level above the troposphere) and can influence the state of the stratospheric polar vortex.

Every 14 months, these winds reverse from easterly to westerly, and vice-versa. It's influenced from and driven from the troposphere. Significant weather cyclones that mature like in the tropics or mid-latitudes, direct energy waves vertically that reach the stratosphere. These waves "break" in fact up there, and render a force that impacts the zonal winds, which in turn now trigger them to descend to the tropopause. Once a certain phase of the winds reaches there, we see the reversal. Below represents the phase we're currently in, thanks to data from NASA. Here we're in the easterly phase. The top graphic shows zonal wind with height (measured in hectopascals so basically, it's the top of the stratosphere to the tropopause). Below shows the same thing, except it's represented in the colors of yellow and blue, with the former highlighting the westerly phase and the latter showing the easterly phase. The blue is trickling down, implying we're maturing into the easterly phase.

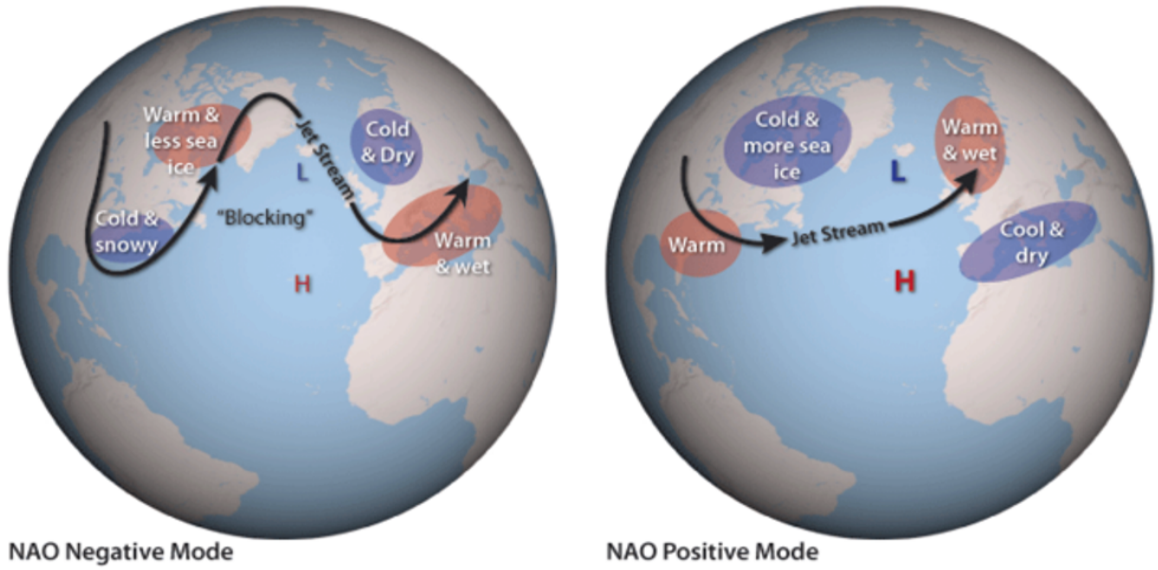


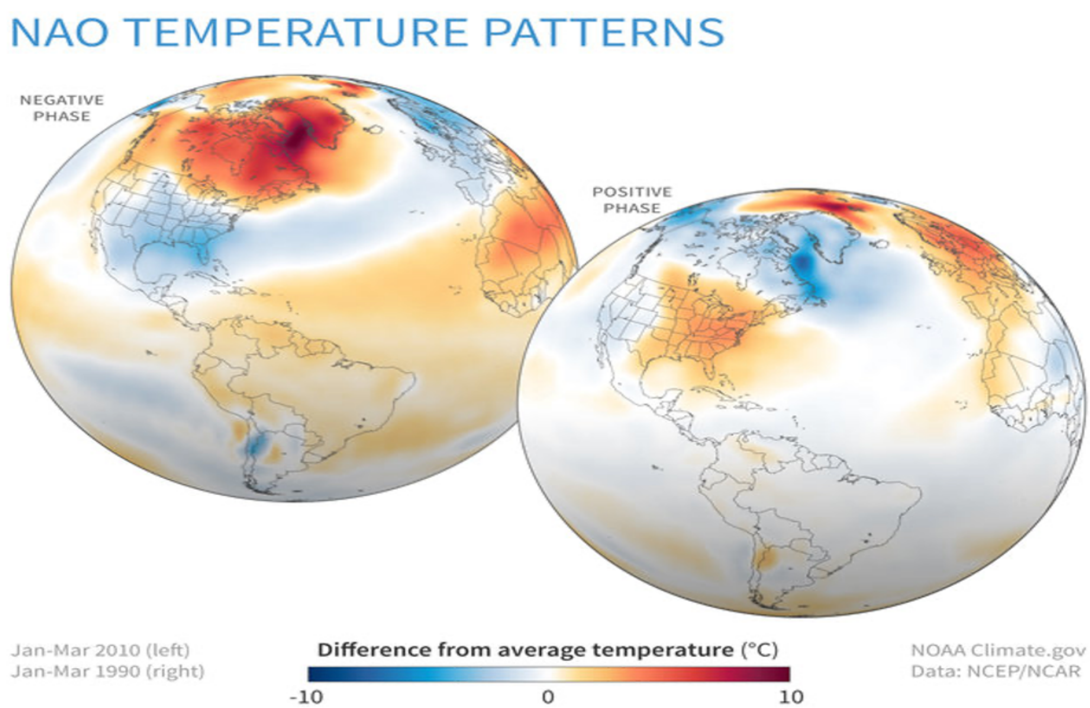
Why is this relevant? Let's analyze the differences between the westerly and easterly phases, and what they mean in terms of impacts. A negative phase (easterly winds) has shown to promote a weaker stratospheric polar vortex. This implies that it's much more susceptible to being disturbed (sudden stratospheric warming), thereby resulting in a very good chance of high latitude blocking episodes. A positive phase (westerly winds) can enhance the polar vortex. This results in less polar blocking probability, the chance of a strong jet stream in the troposphere, and ultimately more mild temperatures in the U.S.

The North Atlantic Oscillation (NAO) & Arctic Oscillation (AO)

The NAO describes a “seesaw” air pressure difference between low and high pressure between Iceland and Azores, Portugal. It’s a dipole pattern, meaning one area serves as an area of low pressure (Icelandic Low) and high pressure (Azores High). We look to North Atlantic region, specifically Greenland and Iceland to observe the type of pressure pattern that’ll occur because a specific pattern here has a strong correlation to temperatures across the Eastern U.S. and Europe.

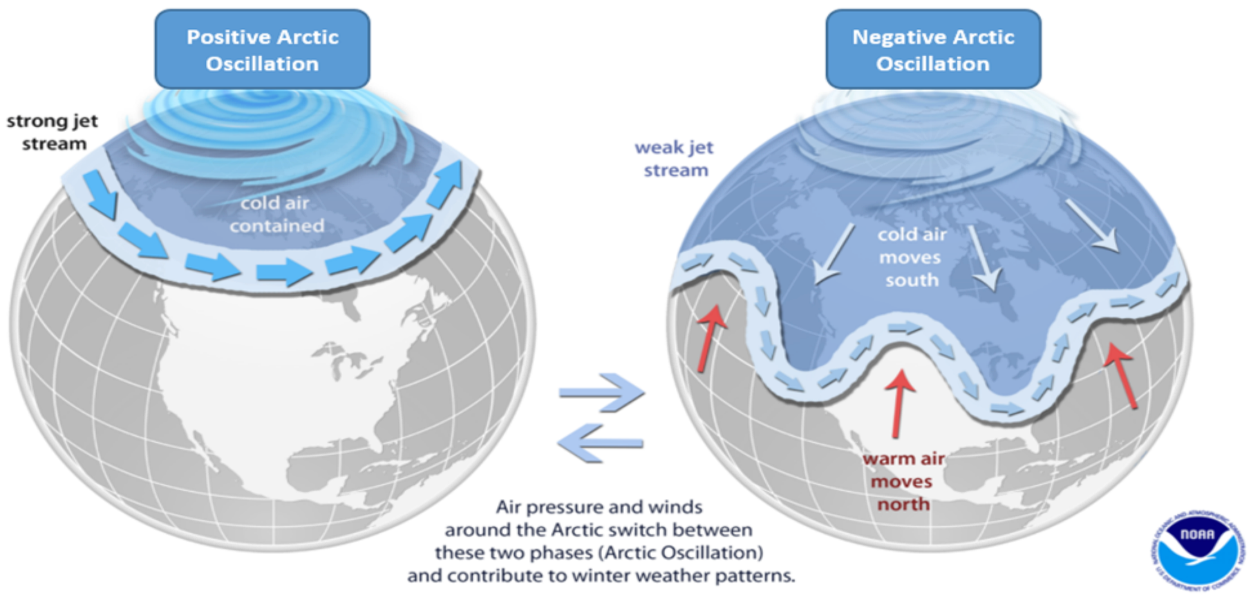
Below reveals two fantastic graphics from NOAA to help explain this seesaw pressure pattern, and how it looks in terms of the orientation of the jet stream. The NAO is quantified into two phases: positive and negative phase. The positive phase is associated with a stronger than normal low-pressure area near Iceland and Greenland, and stronger than normal high pressure over the Azores. Here, the jet stream becomes stronger and zonal resulting in milder temperatures and in general lack of snow to the mid-latitudes. Conversely, the negative phase is associated with a weaker Icelandic Low and Azores High. A negative phase implies polar high latitude blocking, where the jet stream becomes much wavier, weaker, and now can dislodge southward allowing arctic air to spill. The associated phases result in quite the sharp temperature differences as shown below, and the NAO is considered the leading mode of climate variability given how large of an influence it has.

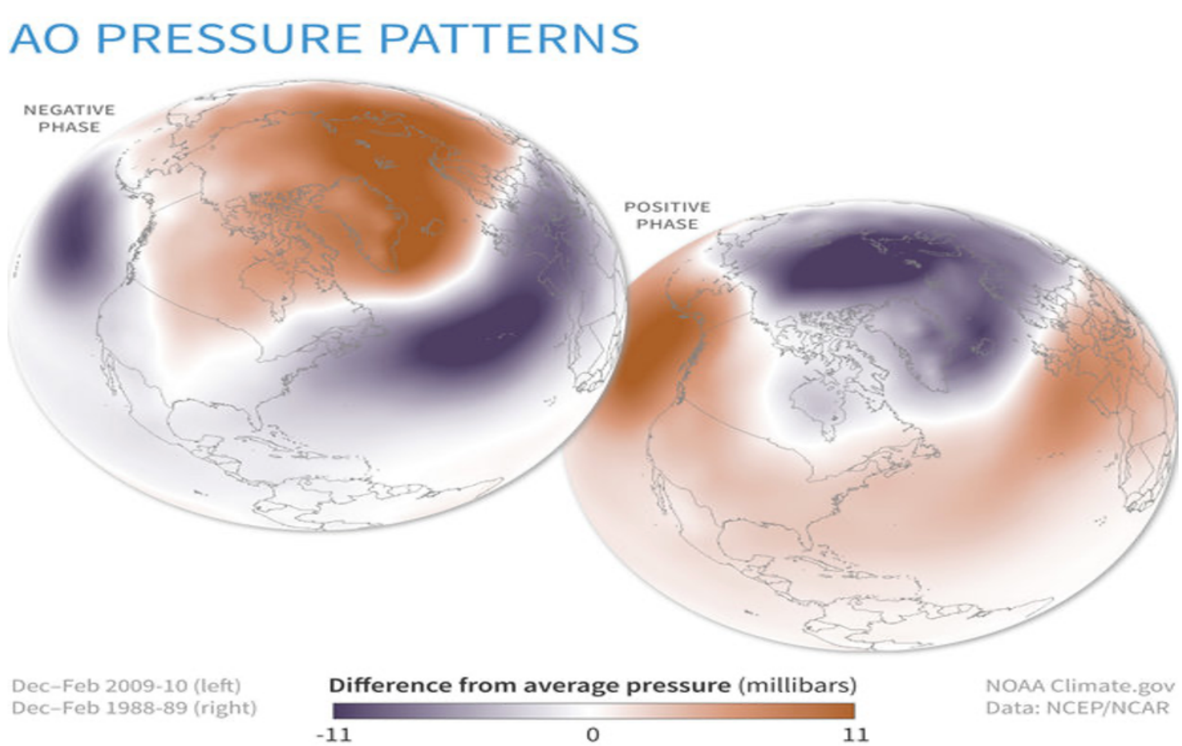




The AO is quite similar to the NAO in terms of its phases and pressure differences except it's analyzed across the high latitudes of the Arctic. When it's in the negative phase, higher-than-average pressure prevails across the Arctic. This results in a southward shifted polar jet stream as shown in the graphic below. Here, arctic outbreaks are now capable of being dislodged into the mid-latitudes as the "river" of frigid air can seep southward. This also may be referenced sometimes as high-latitude blocking as well. In fact, some scientific literature still debates whether the NAO and the AO are just "two sides of the same coin" since they're closely correlated.

The positive phase of the AO has very similar effects as the positive phase of the NAO. This is characterized by lower-than-average pressure over the Arctic, with the cold air "bottled" up in the higher latitudes. The polar jet also strengthens as a result and retreats northward. This results in milder temperatures in the mid-latitudes as well.





Continents such as North America, Europe, and Eurasia tend to be the most influenced by these teleconnections, especially the AO and NAO. It still should be stressed that the atmosphere is a fluid and chaotic. Sometimes, there aren't straight liner relationships where if "x = y", then we get that specific result. Curveballs can be thrown sometimes into any forecast by using these teleconnections because they're governed by a tumultuous atmosphere; however, research has come a long way to prove these relationships between a certain phase and the resulting pattern where it in the very least can depict a signal. These signals help point in a direction for making a type of outlook or forecast. Now you know what to look for when making a solid educational guess on what to expect for a certain timeframe during the winter months!