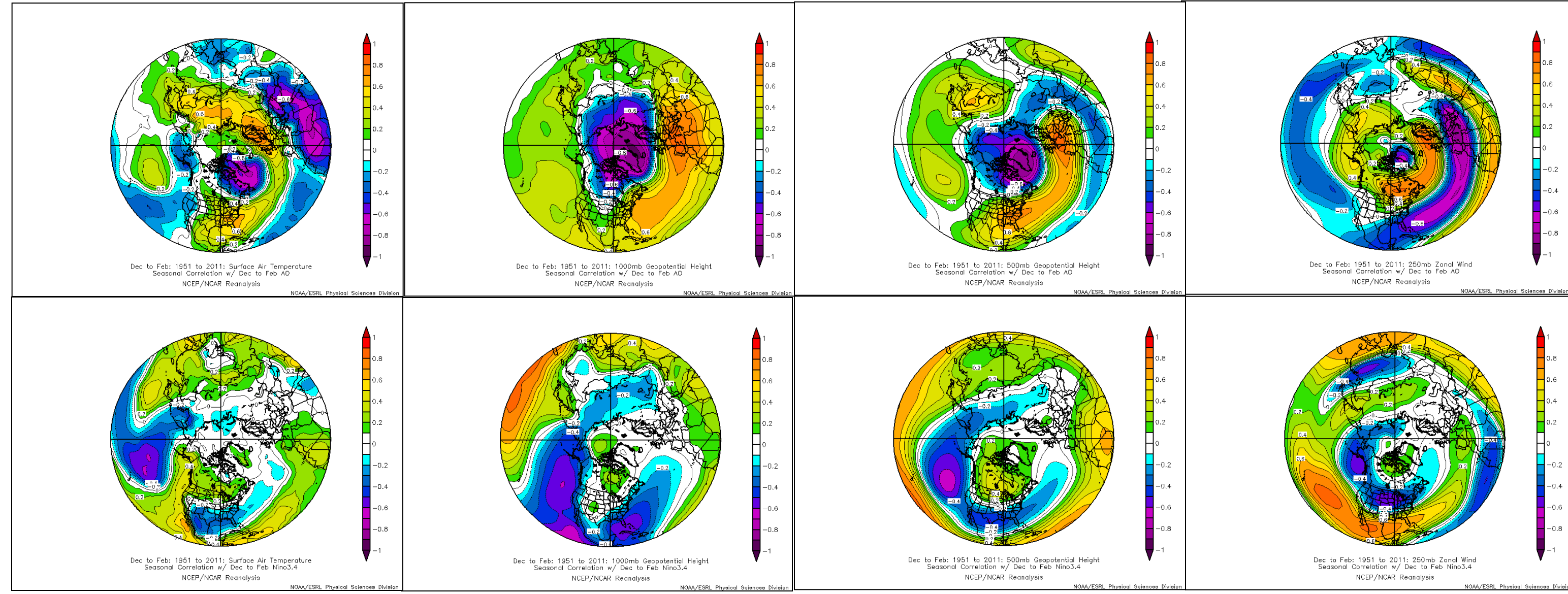


Development of Conceptual Models of the Impacts of ENSO and Arctic Oscillation Interactions on Intraseasonal Temperature Extremes During the Florida Dry Season



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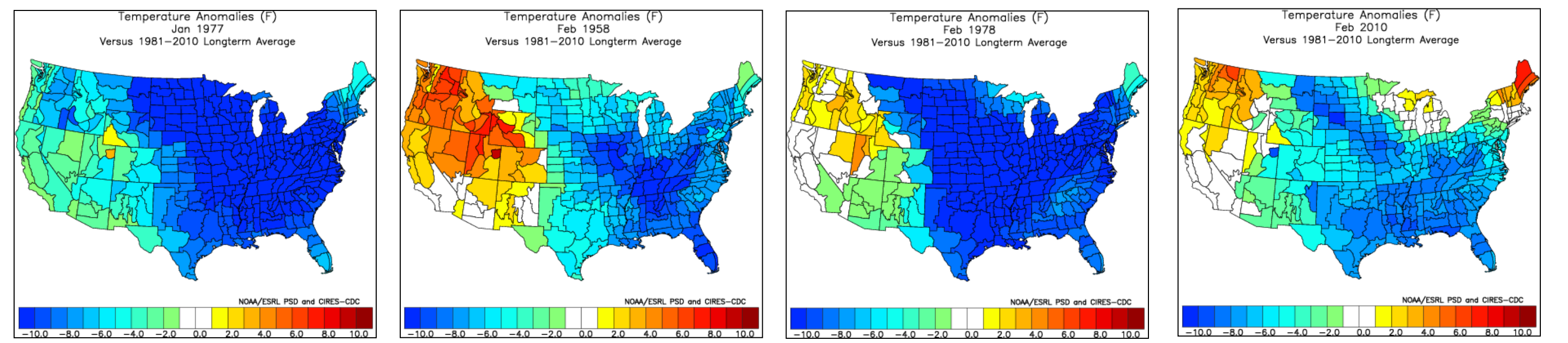
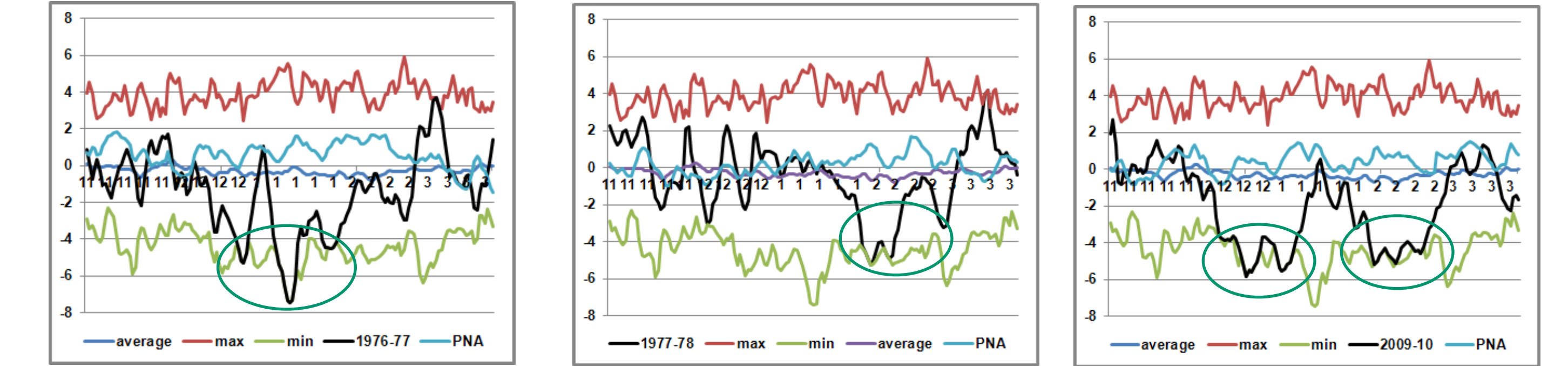
NH correlation maps of mean DJF AO and NINO 3.4 with mean air temp, 1000mb GPH, 500mb GPH, and 250mb zonal wind

Past research has shown that while the El Niño Southern Oscillation (ENSO) has the greatest impact on rainfall and storminess during the Florida dry season (November – April) – it is the Arctic Oscillation (AO) that has the greatest correlation with extremes of temperature – especially extreme low temperatures. The North Atlantic Oscillation (NAO) is the part of the AO affecting the North Atlantic basin. And, while the NAO and AO are highly correlated and often of the same sign, it is the large-scale AO pattern that has the greatest impact on Florida, especially for major intraseasonal events and on the seasonal scale. Northern Hemisphere (NH) correlation maps for winter (DJF) surface air temperature and major synoptic parameters affecting weather patterns such as 250 mb and 1000 mb/500 mb GPH with ENSO and AO show they both have significant impact on the Florida region with opposing signs. While ENSO is a factor in mean temperature, logistic regression results for Florida clearly show the impact of the AO is most significant for minimum temperature. Generally, a negative/positive AO pattern is complementary to a positive/negative ENSO (El Niño/La Niña). For example, typically AO- enhances the effect of El Niño and weakens the effect of La Niña on Florida DJF temperature and rainfall and vice versa for AO+. However, records since 1950 illustrate that both strongly negative and positive AO conditions can coexist during DJF in strong El Niños. Positive AO conditions are most likely to exist on the seasonal scale during La Niña conditions, and it becomes increasingly difficult for strongly negative AO conditions to develop during La Niñas. During DJF, strong phases of the AO are less likely during ENSO neutral conditions, but both strong AO +/- have occurred. Examples of the four extreme phases of AO and ENSO illustrate that on the seasonal scale the influence of the AO can overwhelm the expected influence of ENSO and reverse the sign and magnitude of the expected temperature and rainfall anomalies!

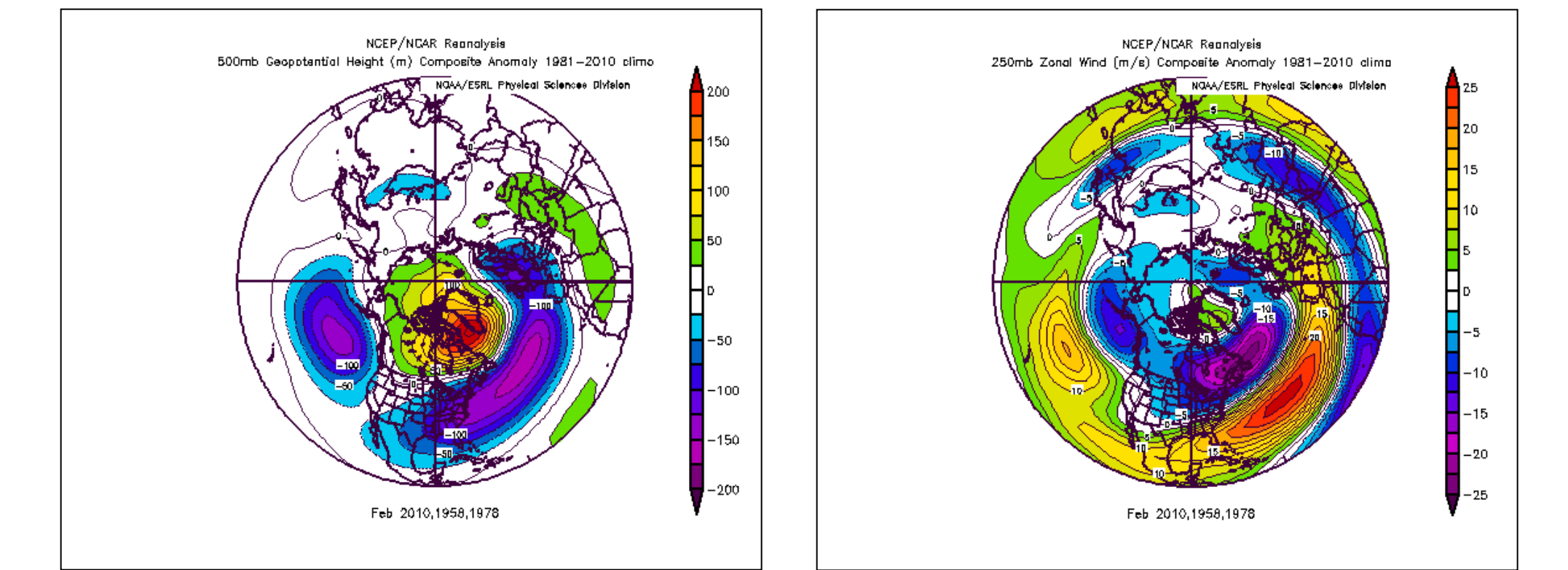
This study was designed to focus on extreme intraseasonal combinations of ENSO and AO during DJF to see if general conceptual models could be developed to better understand their interactions and be used in outreach for seasonal forecasts. The historical relationships of the influence of AO and ENSO on temperature are statistically strong, but the AO cannot be predicted reliably more than a few weeks in advance. Reliable long-range forecasts of AO persistence are not possible at this time. Nevertheless, increasing knowledge about its interaction with ENSO would be helpful as unexpected extremes of heat and cold are often incorrectly attributed to ENSO in winter. Examples of four of the most extreme intraseasonal combinations of AO and ENSO on the scale of approximately a month during DJF illustrate how profoundly the AO can influence the expected ENSO-related synoptic weather patterns and temperature of Florida and much of the nation. Generally, AO+ conditions and warmer than normal temperature have an overwhelming positive impact on the economy, although some sectors can be harmed by unusual warmth. The negative phase of the AO is most impacting to Florida and has the greatest potential for economic harm and societal disruption due to the increased potential for extreme cold and/or prolonged cold spells. The most recent extreme negative AO event during La Niña resulting in the coldest December ever in Florida in 2010 was unusual. It is the extreme negative AO combined with El Niño that is potentially most impacting and responsible for notable extreme historical cold and stormy periods during DJF – most recently during winter 2009-10.

This preliminary study revealed some important caveats that serve as a reality check in adopting any overly simplistic conceptual models of extreme events during the Florida dry season. Neutral ENSO and AO conditions remain problematic as noteworthy major freezes have occurred during these conditions, and AO- during ENSO neutral conditions have produced devastating freezes as well. Some of the most devastating freezes have not occurred during extended AO- conditions, but have been brief, singular events during the winter that were preceded by unusual warmth and, thus, more damaging. We have considered primarily extremes of temperature; however, extreme rainfall and frequent winter storms and violent deadly tornadoes are also highly impacting events during the Florida dry season, especially during moderate and strong El Niño conditions. Indications are that extremely wet and stormy dry season periods are associated with El Niños characterized by high frequency-low amplitude fluctuations in the daily AO index; i.e., progressive and stormy weather patterns. Indeed, the extended extreme negative AO event during the 2009-10 season resulted in land and water temperatures too cold to support organized severe weather outbreaks, and that was a positive benefit that helped offset the negative impacts of extreme cold weather. This study does not address the physical mechanisms of AO and ENSO interaction or their predictability, but it does highlight their importance for the future. In particular, the two extreme ENSO/AO interactions that are highly complementary and additive: positive AO and La Niña and negative AO and El Niño can result in extreme warmth and drought and extreme cold and storminess, respectively, and these are the two most significant impact scenarios during the Florida dry season.

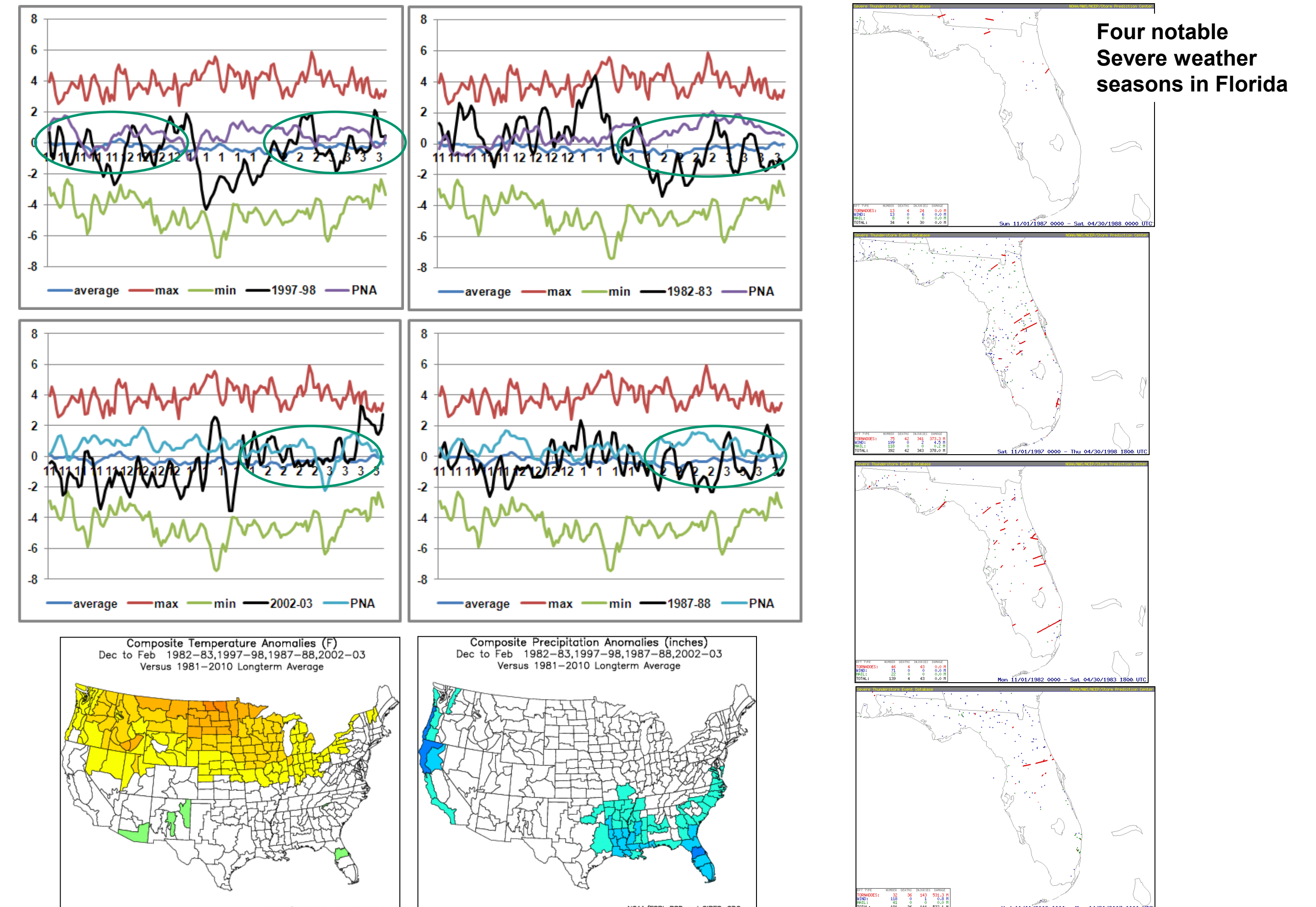
Notable El Niño AO- Cold Events



Composite 500mb GPH and 250mb zonal wind for notable February El Niño / negative AO events



Caveats – This study relates to **extreme cold weather** - extreme rainfall and severe weather outbreaks in Florida during El Niños occur more typically during high frequency, low amplitude AO periods – i.e. progressive and stormy!



DJF composite temperature and rainfall anomalies for the four seasons above.

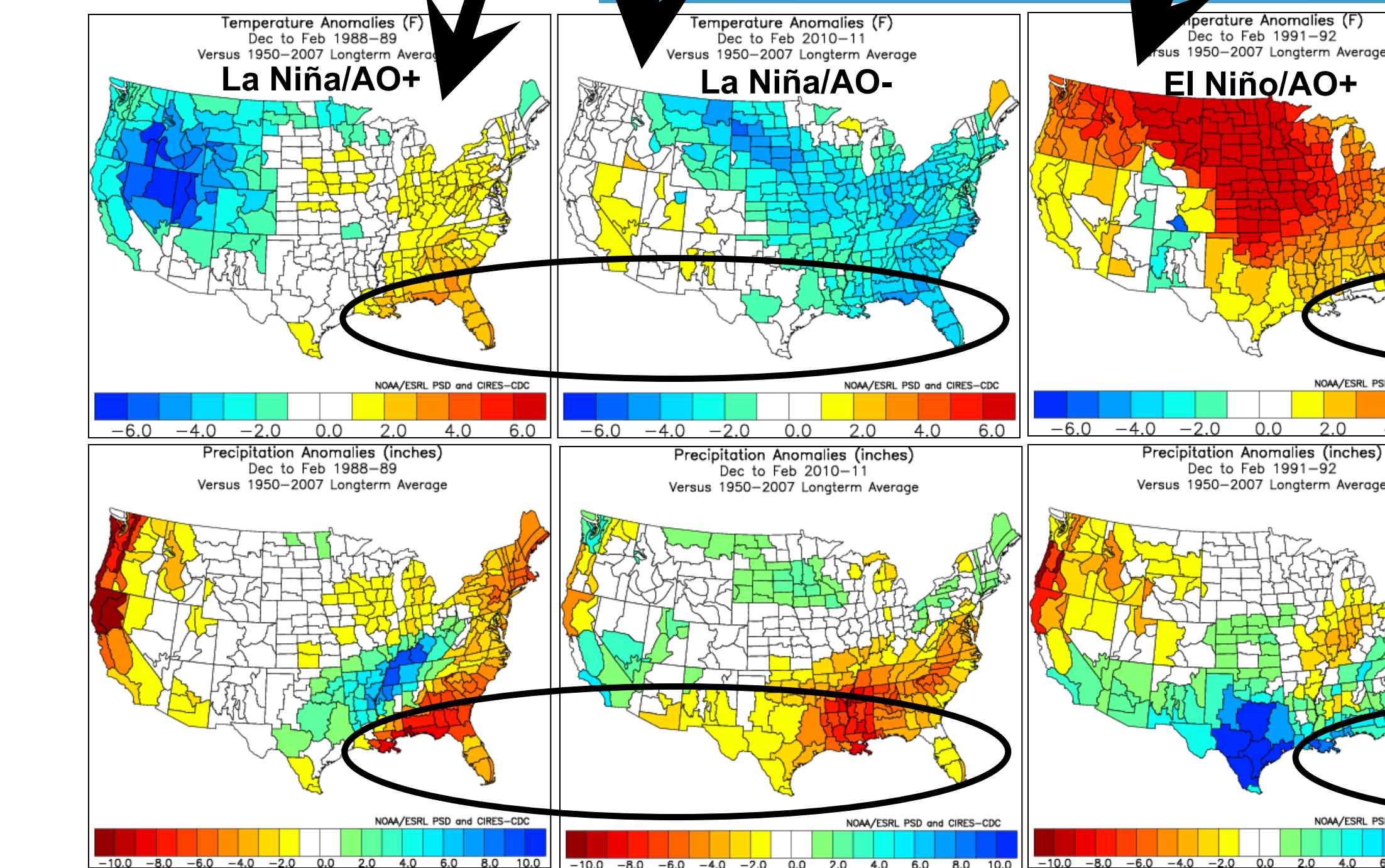
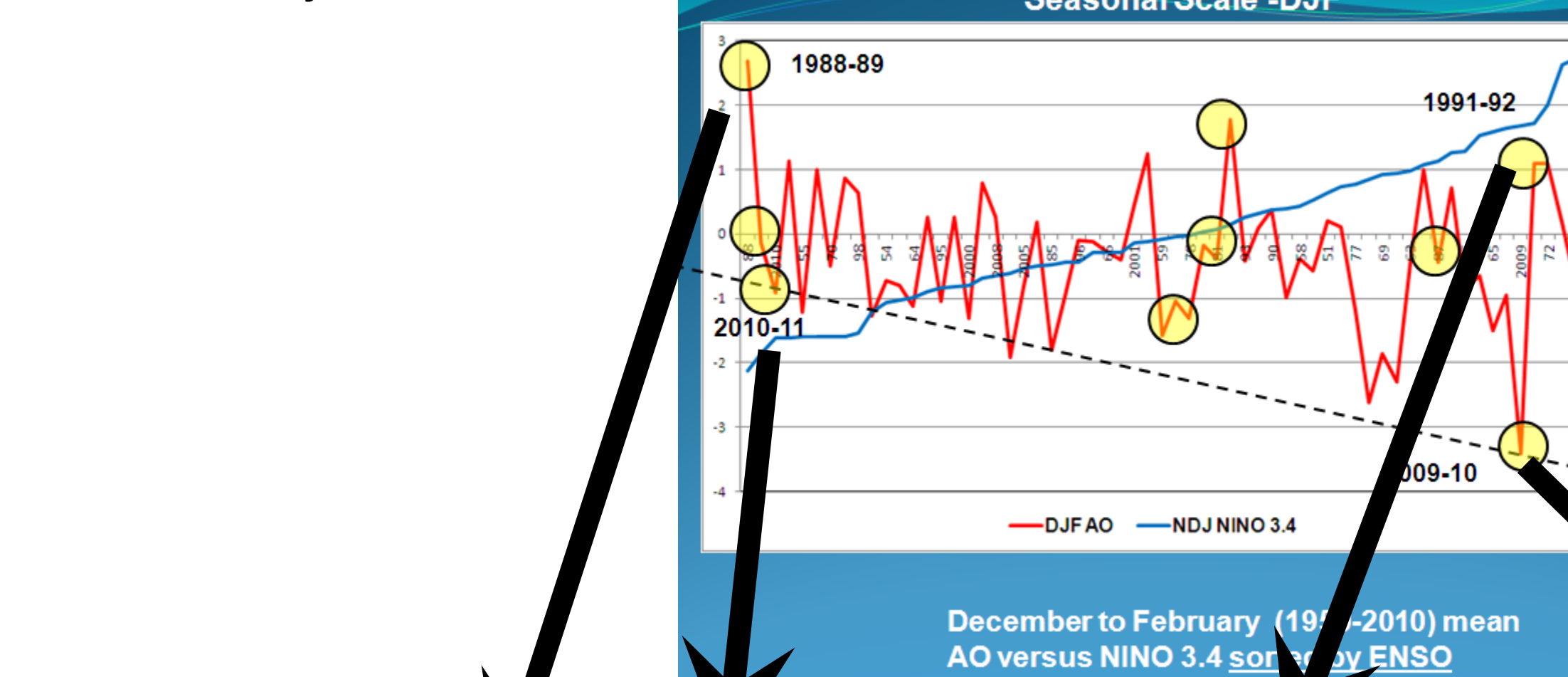
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Recorded Oral Presentation
Hagemeyer B.C. and W.A. Ulrich, 2011. The Impact of Strong Negative Arctic Oscillations on the 2009-10 and 2010-11 Florida Dry Seasons. 15th Conference on Applied Climatology Amer Meteor. Soc., Asheville, NC. P.35

Parameter	ENSO	PNA	NAO	AO	Ensl
JT STREAM	0.5	0.2	0.1	0.1	0.1
NDJ FMA	0.6	0.3	0.2	0.2	0.2
STORMS	0.4	0.1	0.1	0.1	0.1
MEAN TEMP	0.1	0.1	0.1	0.1	0.1
MIN TEMP	0.2	0.2	0.2	0.2	0.2
RAINFALL	0.3	0.3	0.3	0.3	0.3

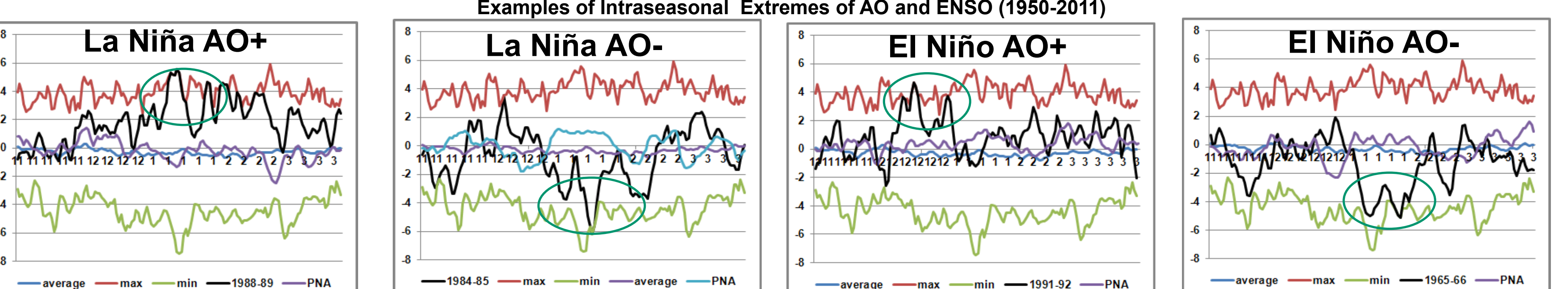
From Hagemeyer, 2007.

AO	ENSO	PNA	NAO	AO	Ensl
8.0	0.5	0.2	0.1	0.1	0.1
7.0	0.4	0.2	0.1	0.1	0.1
6.0	0.3	0.1	0.1	0.1	0.1
5.0	0.2	0.1	0.1	0.1	0.1
4.0	0.1	0.1	0.1	0.1	0.1
3.0	0.1	0.1	0.1	0.1	0.1
2.0	0.1	0.1	0.1	0.1	0.1
1.0	0.1	0.1	0.1	0.1	0.1
0.0	0.1	0.1	0.1	0.1	0.1
-1.0	0.1	0.1	0.1	0.1	0.1
-2.0	0.1	0.1	0.1	0.1	0.1
-3.0	0.1	0.1	0.1	0.1	0.1
-4.0	0.1	0.1	0.1	0.1	0.1
-5.0	0.1	0.1	0.1	0.1	0.1
-6.0	0.1	0.1	0.1	0.1	0.1
-7.0	0.1	0.1	0.1	0.1	0.1
-8.0	0.1	0.1	0.1	0.1	0.1

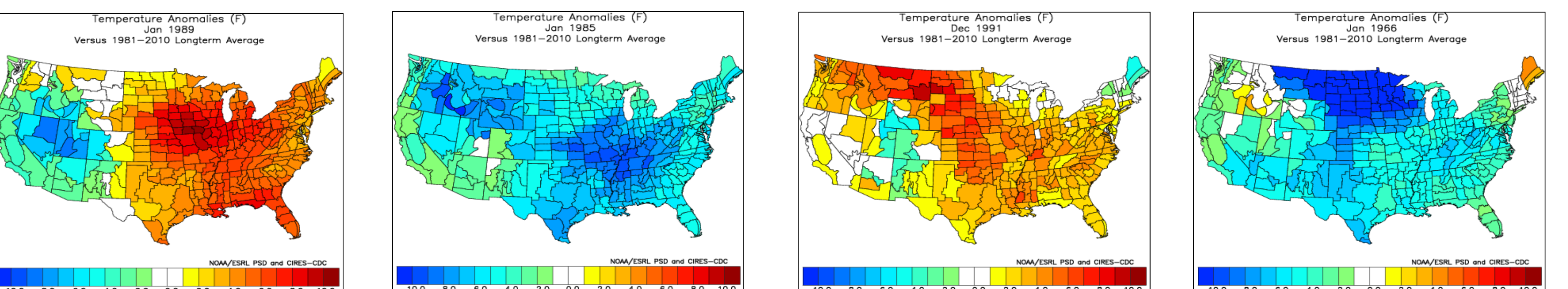
Logistic regression results for quartiles of average monthly min temps computed from extreme values of monthly AO indices.



Mean DJF temperature and rainfall anomalies by climatic division for the four most extreme combinations of DJF AO and NDJ NINO 3.4 since 1950.



Daily AO and PNA indices for the 1988-89, 1984-85, 1991-92, and 1965-66 winter seasons representing the four extreme combinations of AO and ENSO plotted with mean daily and record high/low daily AO (1950-2011).



Temperature anomalies by climatic division corresponding to the periods represented by the blue ovals above.

Mean monthly anomalies of NH 1000mb GPH, 500mb GPH, and 250 mb zonal wind corresponding to the periods represented by the blue ovals above.

