11.4 EARLY RECOGNITION OF DROUGHT POTENTIAL RESULTING IN ENHANCED INTERAGENCY COLLABORATION DURING THE 2010/11 TEXAS WILDFIRE SEASON

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1. INTRODUCTION

The physical geography and areal size of Texas contribute to periodic severe drought episodes. Given that Texas encompasses such a large landmass, statewide episodes of severe to extreme drought are rare, but less severe drought on a sub-regional scale does occur with regularity. In the most extreme drought episodes, however, nearly all of the state's climate zones and sub regions will experience some degree of drought conditions.

In addition to physical geography, extreme drought conditions and antecedent wildfire dangers in Texas are closely linked to global scale climate variations. Some of the most extreme drought conditions in Texas have occurred in the past century. Of particular interest are the drought episodes from the 1950s through mid 2011. A short review of Texas climatology will be given. In addition several drought parameters will be discussed followed by an examination of the linkage to global climate signals that typically precede the onset of severe drought across the state.

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A comparison of the 2005/06 and 2010/11 drought signals will be discussed, leading to a discussion of the resultant wildfire danger. This comparison will set the background for the examination of the synoptic scale weather patterns prior to the onset of major fire outbreaks in Texas. These weather patterns facilitated the rapid growth and spread of several major fire complexes across the state.

Finally, the early recognition of an increased likelihood for enhanced drought and high fire danger led to unprecedented coordination between the National Weather Service (NWS), Texas Forest Service (TFS) and emergency responders. This coordinated effort led to strategic planning for the placement of a multi-agency Incident Command Posts (ICP) and the advance deployment of resources for instant response to numerous dangerous wildfires.

2. TEXAS CLIMATE DATA

The Climate Atlas of Texas (Larkin and Bomar, 1983) describes Texas as being within the "cool" and "warm" parts of the Temperate Zone of the Northern Hemisphere. Climate classifications put a majority of the state in a Modified Marine climate (Figure 1). With roughly the western quarter of the landmass classified as continental or mountain climates.

Climate records from the State of Texas and the US National Climatic Data Center (NCDC) show that annual precipitation varies widely. Average annual precipitation ranges from nearly 1219 mm (48 in) across southeast Texas which includes the upper Texas coast to less than 250 mm (10 in) across far west Texas.

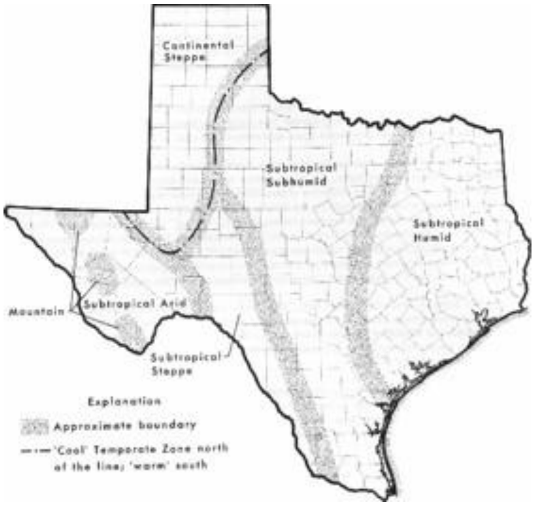

Fig. 1. Climate classification of Texas.

2.1 Maximum/Minimum Temperatures

July and August have the highest average daily maximum temperature, with values ranging from 32.8C (91F) to 35C (95F) statewide. The typical warm season extends from April to October. The average warm season is considerably shorter in the northern portions of the Panhandle and longer in Deep South Texas and Rio Grande Valley.

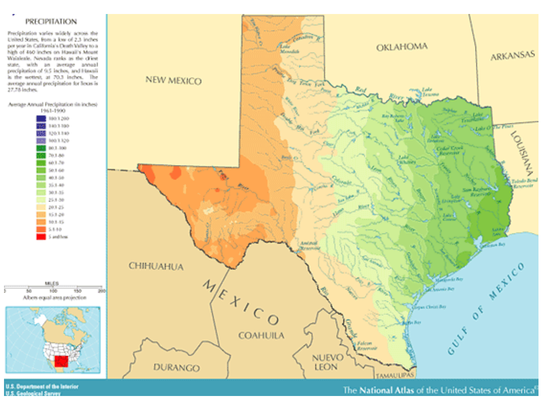

Fig. 2. Average annual precipitation in inches for Texas.

Average minimum temperature data shows a similar pattern with warm season temperatures peaking in July and August. These average minima range from 18.3C (65F) to 23.9C (75F). Again cooler values are found in the northern portions of the state and warmer values were noted in the south and along the lower Texas coast.

3. DROUGHT AND CLIMATE VARIABILITY

Since drought is nearly impossible to define uniformly across large regions, it is appropriate to use the term agricultural drought in this discussion. Agricultural drought occurs when there isn't enough soil moisture to meet the needs of a particular crop at a particular time. Agricultural drought occurs after meteorological drought (based on meteorological measurements) and prior to hydrological drought. (The Disaster Handbook 1998 National Edition, Institute of Food and Agricultural Science University of Florida)

The worst Texas drought occurred from 1950 - 1957 (Nielson-Gammon, 2004). The second most severe drought was recorded during the "Dust Bowl" years of 1932-1939. Additional severe drought conditions persisted from 1909-1918 and included the driest year on record (1917).

3.1 Climate Variability Signals

Drought episodes tend to be unique in duration and areal coverage. However certain global climate signals are common to drought episodes in Texas, and in particular to the Southern Plains. The Southern Plains and adjacent southwestern United States are regions that are particularly sensitive to variability, and strong La Niña events that occurred during 1946–1956 exposed that region's drought vulnerability (Hoerling, Quan, and Eischeid, 2009). Increased understanding and monitoring of the impacts of global climate systems has led to improved seasonal forecasting systems. In particular, the knowledge of the El Niño/La Niña Southern Oscillation (ENSO) and additional season oscillators coupled with observable weather trends across Texas has been useful in developing climatological scale forecasts.

The latest cycle of severe to extreme drought began in 2010 and has continued through mid 2011. A comparison of the Multivariate ENSO index (MEI) shows a significant relationship between the La Niña phase of the global ocean circulations and Texas drought (Figure 3).

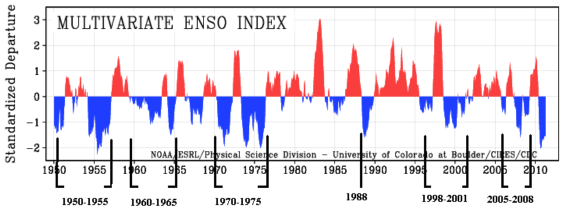

Fig. 3. Multivariate ENSO index (MEI) coincident with Texas drought years.

Season oscillators such as the Pacific North American (PNA) Oscillation are related to the global climate signals. Similar to La Niña, a moderate to strong negative phase in the PNA suggests split flow in the Pacific jet stream and weaker weather systems moving across the southern United Sates. Since the PNA is related to the ENSO signal, it follows that the negative phase of the PNA correlates well to enhanced drought episodes for Texas (Figure 4).

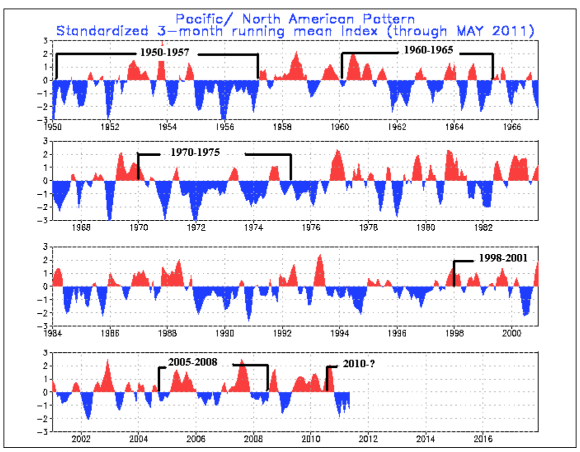

Fig. 4. PNA negative phase/Texas droughts.

Additional signals including the Arctic Oscillation (AO) and North Atlantic Oscillation (NAO) can contribute to drought conditions and drying of available vegetative or biofuels. During negative phases of the AO and NAO, cold season polar outbreaks are more intense and frequent over North America. The regular intrusion of arctic air masses into Texas and the Gulf of Mexico amplify the lack of cool season moisture (Gulf of Mexico return flow) available for drought relief.

3.2 Drought Comparison 2005/06 to 2010/11

Comparing the climate signals and seasonal oscillators from the 2005/06 drought to those occurring in 2010/11, a similar pattern of strong La Niña conditions coupled with moderate to strongly negative values in AO and NAO exists. The PNA changed from moderately positive to negative prior to the onset of each drought episode.

Climatological signals pointed to drought episodes beginning in both 2005 and 2010. The annual rainfall totals from each region are compared to normal precipitation values in (Figure 5). The departure from normal of precipitation for both events is significant in magnitude, but different with respect to the areal coverage. The drought of 2005/06 extended from Deep South Texas through western Texas and into the Panhandle region. In 2010/11 the drought conditions extended from southeast Texas through most of the state, with only northeast and north central Texas approaching normal rainfall amounts.

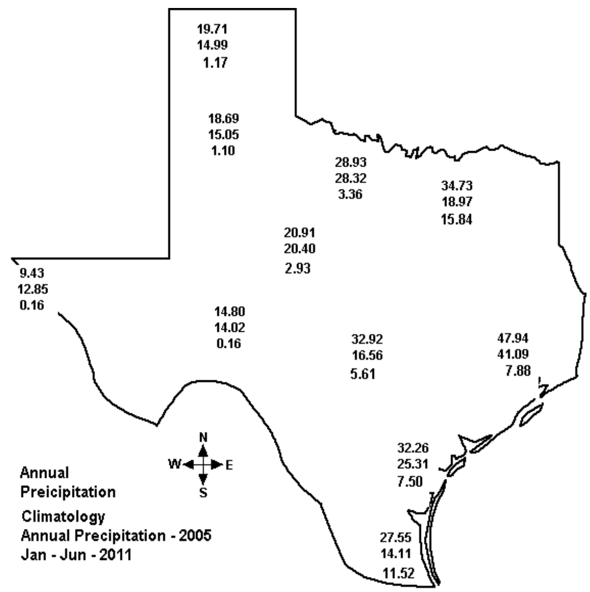

Fig. 5. Statewide rainfall amounts compared to normal.

The drought of 2010/11 was preceded by a nearly identical climate signal. However the departure from normal of precipitation values was more severe over a larger area. By July 1, 2011 the only locations that recorded 50 percent or more of normal precipitation were in north Texas and the immediate area surrounding Corpus Christi (Figure 6).

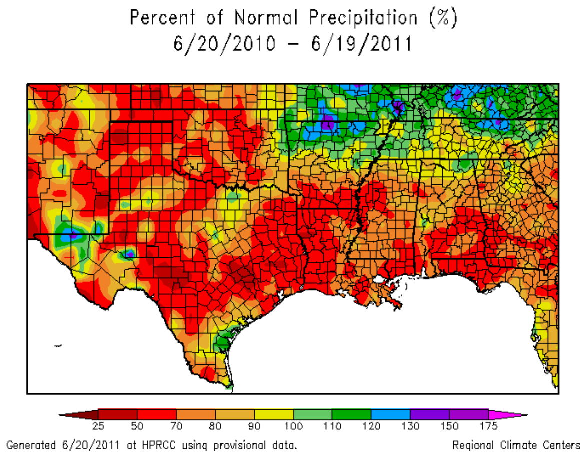

Fig 6. Rainfall percent of normal (Jun 2010 - Jun 2011).

The yearly rainfall totals for 2010 do not suggest that Texas was near a period of agricultural and subsequent hydrological drought (Figure 7). Most reporting stations across Texas recorded above normal precipitation from January - June. Houston and the Dallas/Fort Worth areas were the exception, with below average totals for the six month period.

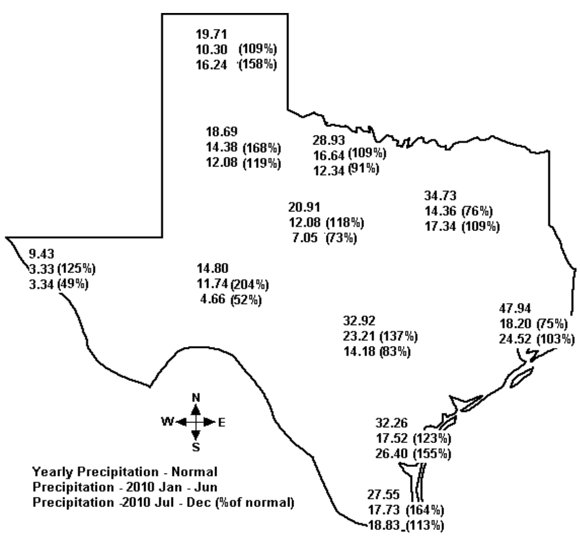

Fig 7. Texas rainfall amounts from Jan - Jun 2010 and Jul - Dec 2010 with percent of normal values.

During the July - December period about half the stations recorded near normal or above normal precipitation totals. Most of this above normal rainfall is associated with three tropical systems that moved across the state. Hurricane Alex, Tropical Depression #2 and Hurricane Hermine brought rain to much of coastal and deep south Texas, before moving across central and west Texas. The bulk of precipitation occurred prior to September and almost every station reported below normal rainfall from September - December.

The amount and timing of the rainfall during 2010 had a large impact on the 2011 wildfire season. Significant spring and summer rainfall, especially across west and central Texas, caused an increased loading of available fine fuels during the dry season (Oct - March). These fuels lay dormant and "cured" as the drought conditions accelerated during the end of 2010 and throughout 2011.

4. STRATEGIC ONSET FORECAST USING GLOBAL/SYNOPTIC SCALE SIGNALS

Even though the backdrop of the moderate winter La Niña of Dec 2010-Feb 2011 was climatologically suggestive of a dry and warm winter season there was an interruptive cold pattern that had to be taken into account. December 2011 was mostly characterized by a strongly negative phase (-1.78, west coast trough) of the Pacific/Northern American Pattern (PNA, Figure 8). Initially this led forecasters to anticipate a rapid and intense onset of the fire season across Texas in December.

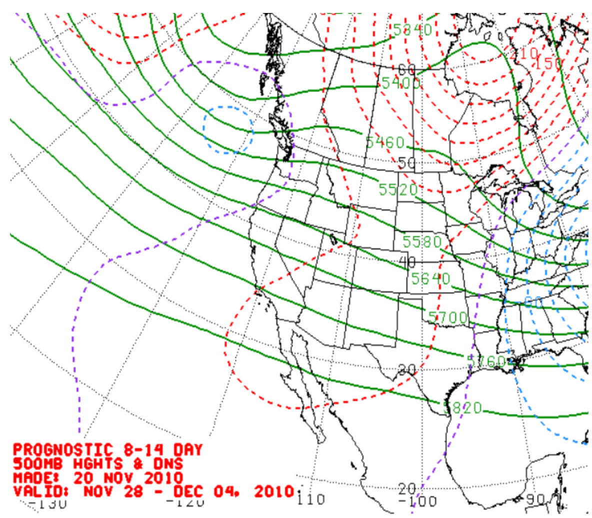

Fig. 8. Depiction of the 8-14 day forecast of the 500 hPa heights (solid green) and anomalys (dashed red) in the first week of December 2011.

This negative phase of the PNA was interrupted however, by an abrupt pattern change that began with the passage of a 500 hPa trough in the third week of December (Figure 9). The trough brought a widespread swath of cold rain to the state especially east of the 100th meridian.

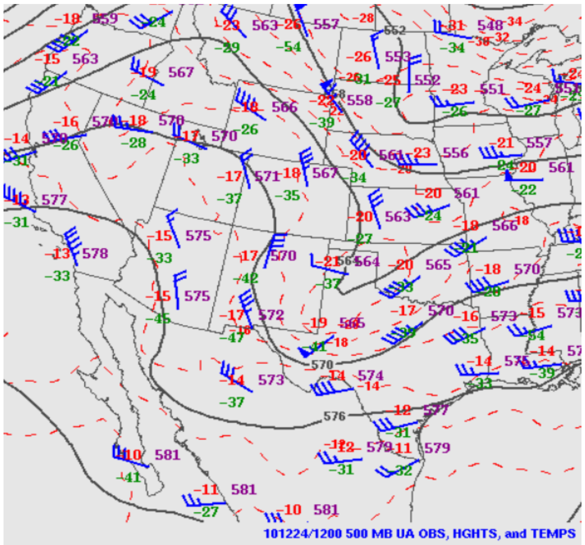

Fig. 9. 500 hPa heights and temperatures in black and red dashed contours showing a trough over Texas on Dec 24, 2011 12 UTC. 500 hPa wind barbs are in blue.

Thereafter a positive phase of the PNA ensued (Figure 10a) and amplified (Figure 10b) through the first week in February 2011.

The weather pattern was synergistic from the perspective that the west coast ridge favored frequent dry frontal passages and the intertwined negative AO favored polar and arctic intrusions through the plains states.

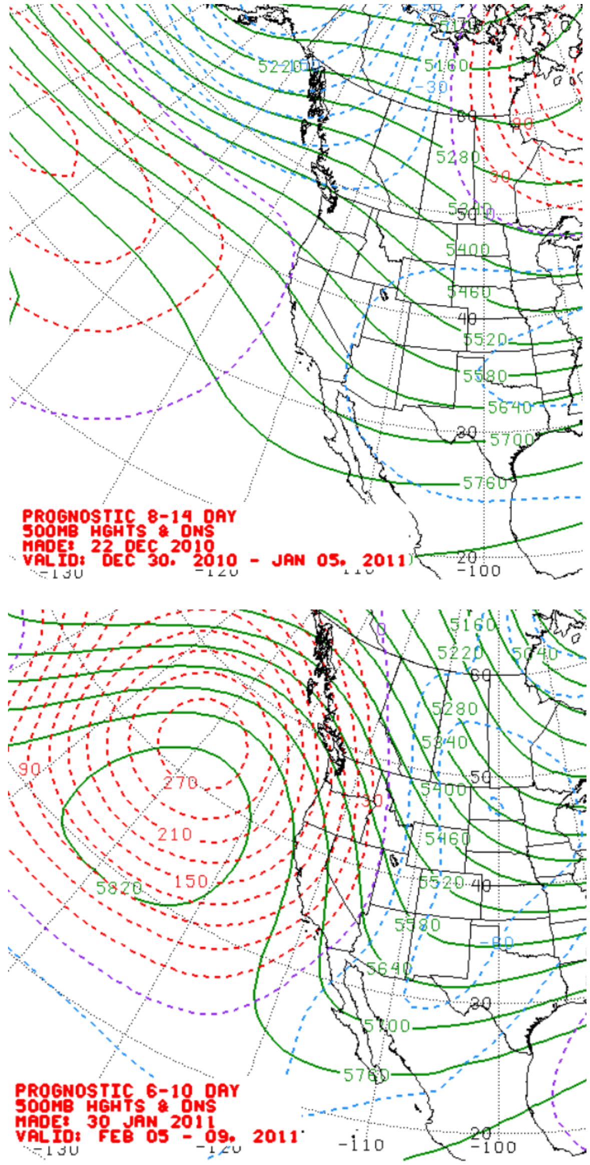

Fig. 10a and 10b. 6-10 and 8-14 day forecast 500 hPa charts depicting the ampflication of the positive PNA pattern (west coast ridge).

The degree of amplification was important as it was in alignment with a strongly negative AO (Figure 11). The net result was an intense period of a colder, drier and more progressive weather pattern.

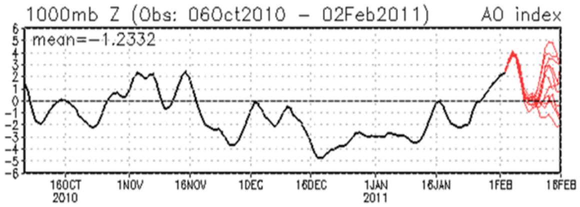

Fig. 11. Black line shows the observed negative AO from mid-December through mid-January. Red lines show ensemble AO forecast through mid-February.

Synoptic scale pattern changes were evident in the 8-14 day 500 hPa forecast issued by the Climate Prediction Center for the last half of February. Low amplitude quasi-zonal flow was forecast with an absence of the west coast ridge (negative PNA) and above normal heights across Texas (Figure 12).

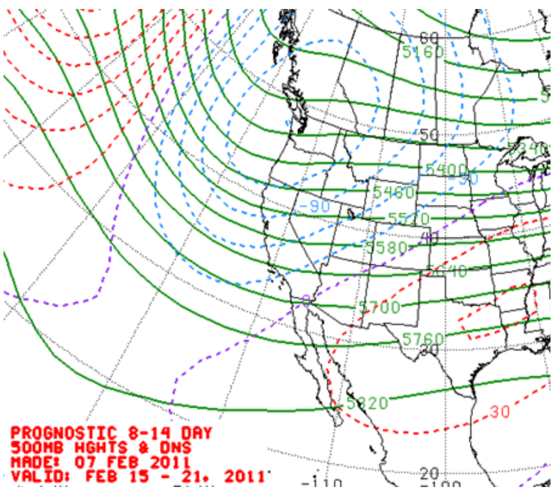

Fig. 12. 8-14 day forecast 500 hPa heights (solid green) and anomalies (dashed red) for the 3rd week in February 2011.

4.1 Resource Allocation and Build-up

As the La Niña pattern continued to strengthen and began to phase with the dry signal in the negative PNA, and the increasingly positive AO, Forecaster confidence increased that a warm progressive synoptic pattern would develop, increasing the potential for a prolonged dangerous fire weather season in Texas. (Figure 13).

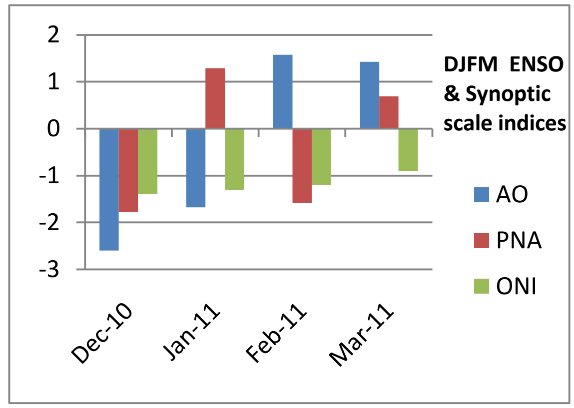

Fig. 13. Chart showing the synoptic scale pattern change with the global ONI as the backdrop. Note from Jan to Feb that the PNA turns negative and AO turns positive.

At this point, the Texas Forest Service (TFS) began hosting daily fire management briefings from the Emergency Operation Center (EOC) in College Station, Texas. Through these briefings along with probabilistic outlooks published to a secure online forum, predictions of pattern changes were communicated to the TFS by NWS forecasters in west Texas. In response, a rapid strategic build-up of resources commenced and was pre-positioned prior to the first Southern Plains wildfire outbreak of the 2011 season. This primary outbreak occurred on February 27, 2011 (Figures 14a, 14b, and 14c).

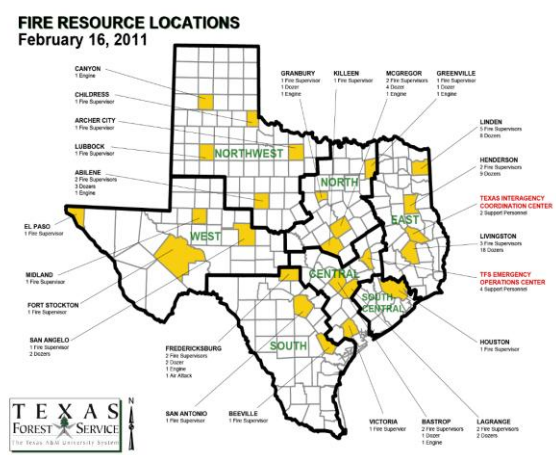

Fig. 14a. Fire resource location map from the TFS. Note the strategic build-up of resources that occurred from February 16, 2011.

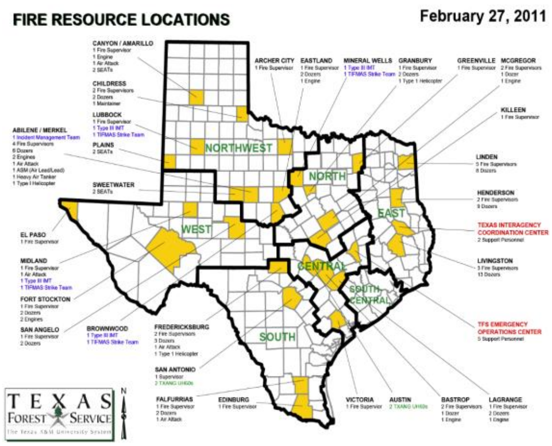

Fig. 14b. Fire resource location map from the TFS. Note the strategic build-up of resources that occurred from February 27, 2011.

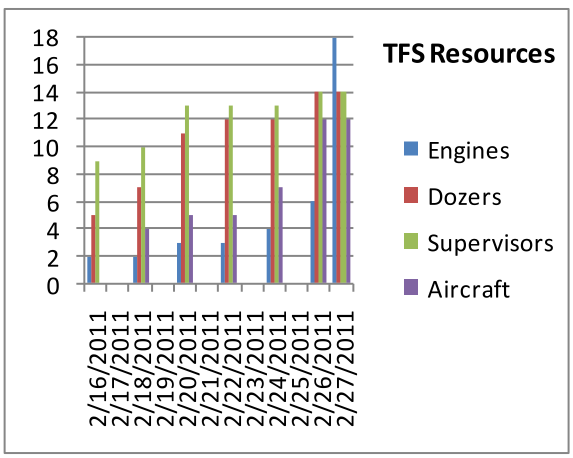

Fig. 14c. Specific TFS resource build-up in advance of the anticipated rapid onset of weather favorable for fires and control problems.

5. Verification

The 2011 fire season exceeded NWS and TFS expectations. From November 15, 2010 to August 2011 TFS reported 17,338 fires that burned more than 3.9 million acres (TFS Situation Report, 2011). In addition, the acreage burned in Texas accounted for 55 percent of the total acreage burned in the US for 2011. There were six fire complexes that burned more than 100,000 acres per complex during April 2011. The most complete archive of fire data for the state of Texas is available from the TFS covering the years of 2000 to present. On average the TFS responds to 544 fires during the winter to spring fire season during the months of December through March (Figure 15).

During a typical winter-spring fire season approximately 362 fires are 100 acres or greater resulting in a state average of 459,000 acres burned per year. Texas' winter to spring fire season is driven by the weather. In 2011, the drought amplified in the spring (Figures 16a and 16b) and the fuels reached record dry levels (Figures 17a and 17b).

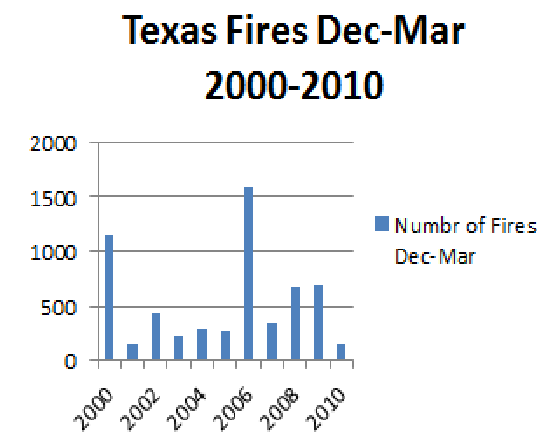

Fig. 15. Number of fires in Texas between the years 2000-2010 for the months of Dec-Mar.

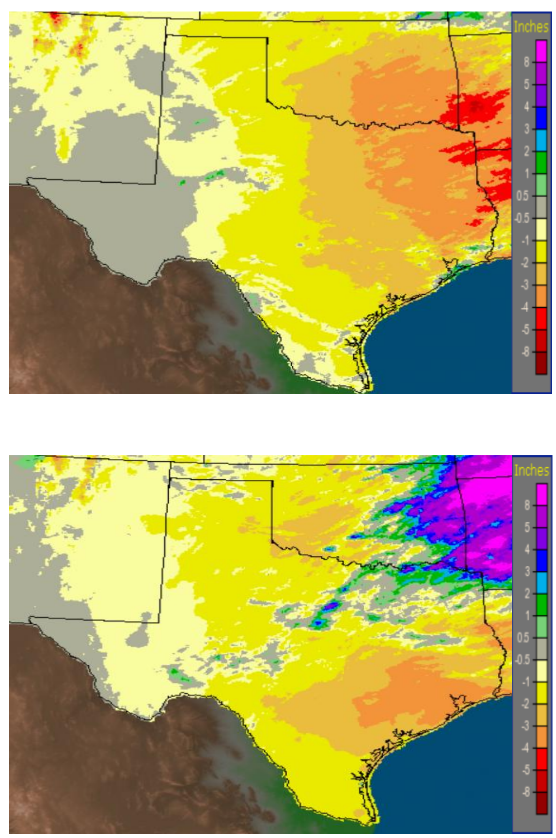

Fig. 16a and 16b. Departure from normal precipitation in inches for Mar and Apr 2011, respectively.

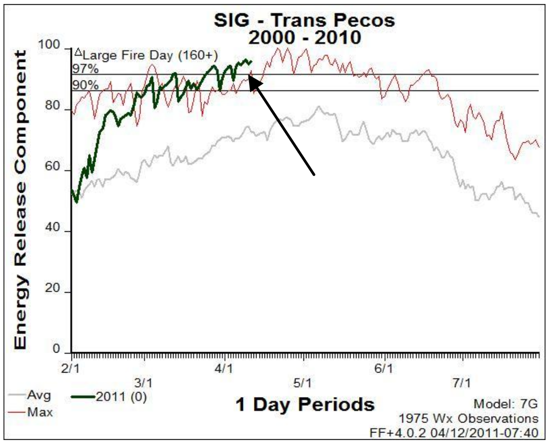

Fig. 17a. Energy Release Component plot. The black line is 2011 data compared to the maxima (red) and the average (gray). The plots represent the record dry fuels in late March across Texas from the Trans Pecos.

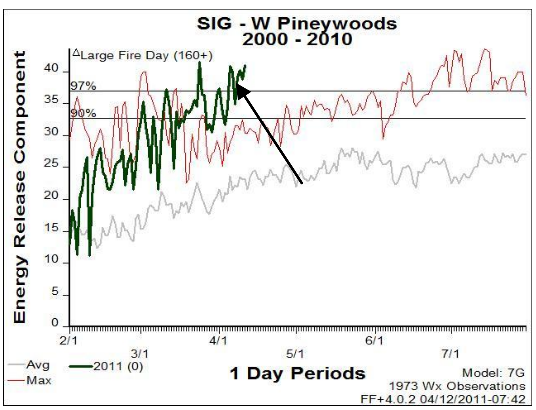

Fig. 17b. Energy Release Component plot. The heavy black line is 2011 data compared to the maxima (red) and the average (gray). The plots represent the record dry fuels in late March across Texas to the Pineywoods in the east (3b).

The four month period of 2011 from January to April was the third driest on recorded in Texas history (Figure 18). Widespread record dry fuels persisted through the month of April and fire occurrence increased rapidly with an increase in the frequency of dry, warm, and windy weather systems. Fire weather climatology shows that for west Texas, April, is the month with the highest frequency of critical fire weather conditions (Murdoch et al 2009, unpublished). A decadal record occurrence of eight Southern Plains Wildfire Outbreaks (Lindley et al 2007) occurred in 2011 with five such events in April 2011.

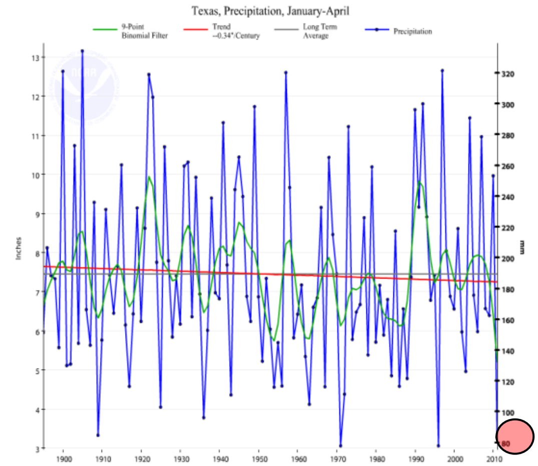

Fig. 18. Average Texas rainfall January-April for the years 1890 to 2011. 2011 was the 3rd driest on record (red circle).

Of significance was the establishment of a later climatological date for the occurrence of the Southern Plains Wildfire Outbreak cases. In the last decade, the previous latest occurrence of a Southern Plains Wildfire Outbreak was April 15, 2006. During the record breaking fire season of 2011 the date was extended to June 19-20. In summary, April 2011 was the apex of the weather driven fire season. The record dry fuels came into alignment with the peak climatological occurrence of critical fire weather conditions. The active pattern within a strongly negative phase of the PNA and the strong overall warm and dry signal from the cool episode of ENSO resulted in optimal conditions for an unusually active fire season.

6. MULTI AGENCY COORDINATION

In August 2010, planning began to hold an unprecedented Fire Threat Awareness Strategic Planning Symposium with the Texas Forest Service (TFS) and the National Weather Service (NWS). The purpose of this statewide meeting was to coordinate the TFS and NWS response to the expected active and potentially long-lived 2011 Fire Season. Based on the climatological signals in 2010, the predicted moderate La Niña signal suggested widespread precipitation deficits and possible drought conditions for 2011. By October 2010, continued tightening of both federal and state budgets through 2011 seemed assured. The prospect of having travel funds for a face-to-face meeting dimmed, especially if postponed past the beginning of 2011. If the wildland fire outlook was accurate – a coordination meeting any later than December

2010 would be too late to have a positive impact on coordination between the TFS and the NWS. Increased fuel loading from the 2010 wet season coupled with the forecasted La Niña event raised the level of concern about a severe wildland fire season beginning as early as December 2010.

The symposium was held Tuesday and Wednesday, 7-8 December 2010 at TFS Headquarters in College Station. Ten of the 13 NWS WFOs serving Texas were represented. NWS Southern Region, TFS, US Fish Wildlife Service, (USFS), National Park Service, Texas Office of State Climatologist, Region 8 Geographical Area Coordination Center (GACC) were also in attendance. A large coordination effort occurred between the lead organizers from NWS Austin-San Antonio, NWS Southern Region Headquarters and TFS Headquarters to ensure that symposium presentations contained the latest research and forecast methodologies from across the state.

TFS officials knew that the fuel loading had increased to critical levels. NWS meteorologists understood that a La Niña induced drought syncing with the typical dry and windy winter and spring seasons would aggravate fire weather variables (Van Speybroeck/Patrick 2008). Coordination included a seasonal climate outlook that emphasized the onset of a La Niña pattern, signaling chances of an abnormally dry winter (2010) and spring (2011). The outlook noted that the typical La Niña upper ridge pattern had already been established over the Pacific Ocean. NWS Southern Region Climate Services Branch & NOAA's Southern Climate Division provided long range climate planning information at the meeting. Routine updates continued through the 2011 fire season.

Other reference points that proved valuable to TFS decision makers were the analyses of Southern Plains Wildfire Outbreaks (Lindley, et al. 2007) and comparing meteorological proximity observations for significant wind-driven wildfire starts (Lindley, et al. 2011). These reviews raised TFS awareness and solidified the risk posed by the upcoming 2011 fire season. The NWS provided reviews of fire weather products and services, including a review of fire weather warning and watch criteria, spot forecast request protocols and procedures, the use of NWS internet graphicasts, gridded fire weather forecast elements, the Hazardous Weather Outlook and on-site decision support provided by Incident Meteorologists. TFS and the Geographical Area Coordination Center (GACC) reviewed fire danger and fuel forecasting products and internet-based tools.

Bringing TFS and the NWS together prior to the expected onset of severe fire weather conditions allowed for TFS to make definitive strategic planning decisions involving resource allocation, equipment staging and extended duty assignments. The meeting improved coordination between all the firefighting stakeholders, especially between the TFS and the NWS – in advance of an anticipated severe wildfire season.

In conjunction with meeting planning, a Memorandum of Agreement was negotiated between the TFS and NWS to provide on-site support at an Incident Command Post (ICP). The agreement allotted for $190,000 in funds to pay for specially trained NWS Incident Meteorologists to provide on-site support to the TFS, upon request, at any ICP that formed. Subsequently, the agreement was amended to increase the allotment to $260,000 due to greater demand for on-site support as the fire season extended into the summer of 2011.

7. SUMMARY

Texas is susceptible to drought and extreme fire weather conditions. Conceptual models are being refined to anticipate the climatological signals preceding widespread drought and the onset of extreme fire weather events. It has been shown that cool phase ENSO conditions (La Nina) prior to the Texas dry season is a strong signal pointing to weather driven wildland fires in the South Plains. Specifically, during the Texas 2011 fire season synoptic scale measures, like the Pacific North American (PNA) and Arctic Oscillation (AO), along with the global scale Oceanic Nino Index (ONI) and availability of fuels were used to accurately time the onset of the fire season. The availability of fuel from an unusually wet warm season in 2010, due in part to multiple land-falling tropical systems was a contributor to the potential magnitude of the 2011 fire season.

Prior to the rapid escalation of fires and favorable synoptic scale weather patterns, the NWS and TFS held a first of its kind pre-season

Fire Threat Awareness/Strategic Planning Symposium. This symposium allowed the NWS representatives to share the latest fire weather research, methodologies and techniques. In addition, the meeting allowed the agencies to see the each stake-holders perspective. NWS SRH administrative personnel, in coordination with the TFS were able to acquire the funds to hold the meeting. Every fire weather and management issue was addressed, from the identification of weather patterns, fuel loading, fire risk, and administrative roles. The result was a unified plan to respond to the wildland fire threat building across Texas.

The cool phase ENSO signal and the availability of fuels were known components. The challenge for operational forecasters was to determine the onset of weather patterns that promotes fires and fire growth. Forecasters were able to incorporate the PNA and AO with larger global scale ONI to build a stronger conceptual model for strategic fire weather forecasting. A positive phase of the PNA (ridge along the west) and strongly negative phase AO (cold air intrusion into the plains) dominated January through mid-February. Pattern changes as seen in the 8-14 day 500 hPa forecast issued by CPC were used time the onset of the fire season. This allowed the TFS to allocate resources in advance of the rapid onset of the Texas fire season.

The magnitude of the 2011 Texas drought and fire season was unprecedented. Comparing the areal extent of the state affected by drought and the degree of departure from earlier record drought years, 2011 was a statewide record drought. The nearly 4 million acres burned through the first 8 months of 2011 and is a contemporary state record. April was the peak of the fire season when approximately 1.1 million acres burned. This paper is intended to highlight the usefulness of global and synoptic scale seasonal indices within the realm of a strategic fire weather forecasting conceptual model.

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