**Climate-Related Hazards in the Town of Oro Valley, Arizona**

Storms, flooding, heat waves, and wildfire all pose potential threats to the Town of Oro Valley (TOV). Any of these hazards can—and have, in some cases—caused substantial damage, power-outages, injuries, and even deaths in Pima County. Monsoon storms, that come with high winds and lightning can knock down power lines. Storm-related flooding can cut off the north and south portions of TOV. Heat waves can place strain on electrical grids just at the time human health and well-being depends on electricity for air conditioning. And wildfires can directly threaten power lines and substations. All of these types of events emphasize the need for generator power at the EOC to ensure that residents receive the resources they need during an outage.

**Storms**

Storms are the most common loss-inducing hazard in Pima County. Between 2012 and 2017, the county experienced $1,306,827 in losses due to floods, $1,915,685 in losses due to high winds, and $1,826,960 in losses from severe storm damage.

These events can occur throughout the year, but damage is mostly from summer (monsoon) storms and fall storms (usually due to storm remnants from the eastern Pacific Ocean). In July 2012, monsoon storm damage caused $762,660 in losses. Hurricane Norbert, in September 2014 caused significant flooding across TOV including homes, streets, and damage to infrastructure. One death was reported due to the storm in Pima County. Flood events at times require safety personnel to conduct swift water rescues when ephemeral streams suddenly fill with rain.

Monsoon storms are highly localized events. They can hit one part of a community with incredible strength and leave a neighboring area dry. TOV has recorded storm events requiring some sort of EOC monitoring or response almost every year since 2012. Significant events include flooded homes, flooded streets, downed trees and powerlines, and damage to infrastructure and have occurred in 2014, 2015, 2016, and 2018.

The Cañada del Oro (CDO) Wash bisects TOV. It is an ephemeral stream, like many in the region, but experiences heavy flow during precipitation events. The annual average flowrate on the CDO is less than 1 cubic feet per second (cfs). However, during storm events, flow can be orders of magnitude higher, creating significant public safety hazards and putting infrastructure near the wash in jeopardy. The highest peakflow recorded at the gauge on the CDO was 9,870 cfs during Hurricane Norbert in 2014, an event that resulted in flooded homes and streets, and damaged infrastructure in TOV. During a major flood event, the CDO may become impassable due to flooding, bridge closures, or structural damages. In major rain events, first responders and other Town departments stage resources both north and south of the CDO. The Tangerine station would need to be fully functional, including generator power, to ensure proper resources are available during an extreme storm, especially if the CDO is impassable.

*High Winds and Lightning*

While flooding often causes the most economic damage, high winds can pose a significant threat during events and losses post-event. In July 2011, high winds knocked down trees and power

lines across Pima County and led to 20,000 residents losing power. In August of the same year, high winds knocked down 18 power poles along Ina Road in TOV, closing the road for several hours, effectively isolating people in area businesses and homes from the rest of the community. In July, 2014, one storm resulted in damages to park shade structures, and lightning struck the EOC during another storm the same month.

A monsoon storm in August of 2015 uprooted and knocked over a 40-foot tree that fell onto a home near Oracle Rd and 1st Ave in TOV, and several other trees were blown over (NOAA NCDC database). TOV also experienced power outages, impacts to information technology, and damage to infrastructure during this storm. The next month, in September of 2015, a wind event at Naranja Park resulted in almost $67,000 in damages. In August of 2016, a monsoon storm resulted in power outages and high wind damages, and in July 2018, lightning struck the main Police Department. Lightning strikes are a direct threat to power, and they are predicted to increase by about 50% by 2100 due to the temperature changes caused by climate change (Garfin et al., 2016). Indirectly, lightning strikes can also affect the power supply by igniting wildfires (see section on Wildfire below).

*Changes in Storm Patterns*

Damage from precipitation and winds during monsoon storms is a concern for TOV because climate research indicates that such storms may be increasing in intensity. Approximately half of Southern Arizona's precipitation (6 inches) falls during the summer during the North American Monsoon (NAM). There have been changes in the pattern of the NAM in recent decades that affect drought conditions, flood regimes, and storm-related hazards. Over the past 30 years, the Southwest U.S. has experienced more extreme precipitation associated with monsoon thunderstorms. Rising summer temperatures are intensifying rainfall because warmer air can hold more moisture and create conditions that favor heavy precipitation from convective storms (Luong et al. 2017) (see Fig. 1). In severe storms, maximum wind gusts have become higher (see Fig. 2). Higher winds during severe storms are also projected to continue in the future, especially for areas across Southwest Arizona (Luong et al. 2017; Castro 2017) (see Fig. 3). However, the frequency of such events has fallen, as has the average amount of monsoon precipitation (Castro 2017). The change in frequency is due to changes in the regional weather pattern at this time of year. The monsoon ridge – an area of high pressure over the Southwest – has strengthened and expanded over recent decades, making it more difficult for thunderstorms that form over high-elevation, mountainous areas to move into the low-elevation deserts (Lahmers et al. 2016) (see Fig. 4). These trends—less frequent storms, decreased average precipitation, but more intense storms—are likely to continue in the future.

**Heat**

High heat events are another significant concern throughout Pima County and in TOV. Since 2012, there have been 63 injuries and 8 deaths attributed to heat events in Pima County. June 2017 was the hottest June on record for Tucson, with an average monthly temperature of 89.7 °F. During the month there was a 3-day heat wave, with temperatures at Catalina State Park reaching 114-115 °F on all 3 days, all of which set the record high for the day.

High heat events can impact public safety in two ways. First, there are direct impacts on human health, particularly for vulnerable populations and those who work outdoors. Second, high heat

events can strain energy grids as residents increase their use of air conditioning to stay cool (Ebi et al. 2018). If residents lose power, there will be an increase in human health impacts, and more town residents are likely to be requesting help from emergency services.

Nighttime temperatures are especially important for human health. If nighttime temperatures stay high, then the body does not get the relief it needs from high daytime temperatures. If a monsoon storm knocks out power, as they often do, then residents are left without air conditioning and are not able to get relief from the heat.

*Temperature Trends*

Extreme temperatures and the frequency of heat waves are also expected to rise due to climate change. In Pima County the annual average temperature is projected to rise 4-5 °F by 2050 (see Fig. 5; analysis by J. Weiss – CLIMAS). Summertime daily high temperatures are also projected to rise approximately 4 °F by 2050. Nighttime temperatures are not dipping as low as in past decades, which means more air conditioning use at night, placing additional strain on the energy grid. Across the Southwest region, an additional 850 deaths/year are projected due to high heat events (Ebi et al. 2018).

**Wildfire**

TOV is one of the high-risk communities in the wildland-urban interface, according to the Pima County Community Wildfire Protection Plan. The wildfire threat to TOV comes from the heavily vegetated upland habitats along the foothills of the Catalina Mountains, the xeroriparian corridor of the CDO, and from the north near the towns of Catalina and Oracle. Wildfire can pose a direct threat to people and structures (including municipal buildings) as well as cause negative health impacts due to poor air quality.

Climate change has driven an increase in the area burned by wildfire in the western U.S. by increasing temperatures and drying forests, shrublands, and grasslands, making them more susceptible to burning. Climate models indicate that future fire frequency could increase 25% in the Southwest, and the frequency of very large fires (over 12,000 acres) could triple (Gonzalez et al., 2018). In 2011, the Wallow Fire—the largest in Arizona history—burned over 500,000 acres. The fire threatened electrical transmission lines that, if severed, could have led to power outages for hundreds of thousands of customers in the region during a time of year when temperatures regularly reach over 105 °F in southern Arizona. The high risk of large fires in the future from climate change leaves transmission lines vulnerable.

*Post-Fire Flooding*

Following severe wildland fires, high-intensity summer thunderstorms can trigger extensive erosion and debris flows. Intense precipitation, even years after a severe fire, can also generate debris flows and other geomorphic changes; this occurred in the Sabino Canyon Recreation Area in Tucson, during a high-intensity precipitation episode in 2006, three years after the 84,750-acre Aspen fire in the Santa Catalina Mountains (Magirl et al., 2007; Griffiths et al., 2009). The event damaged structures and roads and affected infrastructure within Tucson's urban boundary. With the risk of fire along the foothills of the Catalina Mountains, post-fire flooding and debris flows into TOV is a possibility in the future.

## Figures

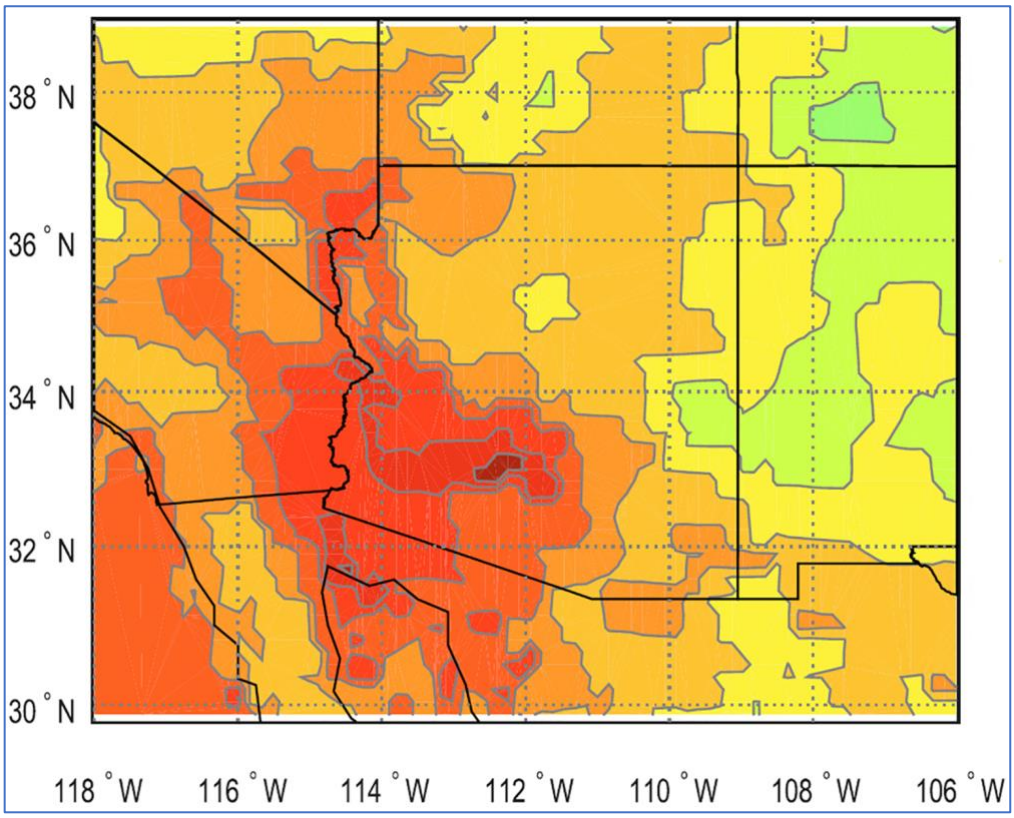


**Figure 1: The difference in the average amount of moisture in the atmosphere from present day (1980 – 2010) compared to the historical past (1950 – 1979). Figure adapted from Fig. 2b of Luong et al. (2017).**

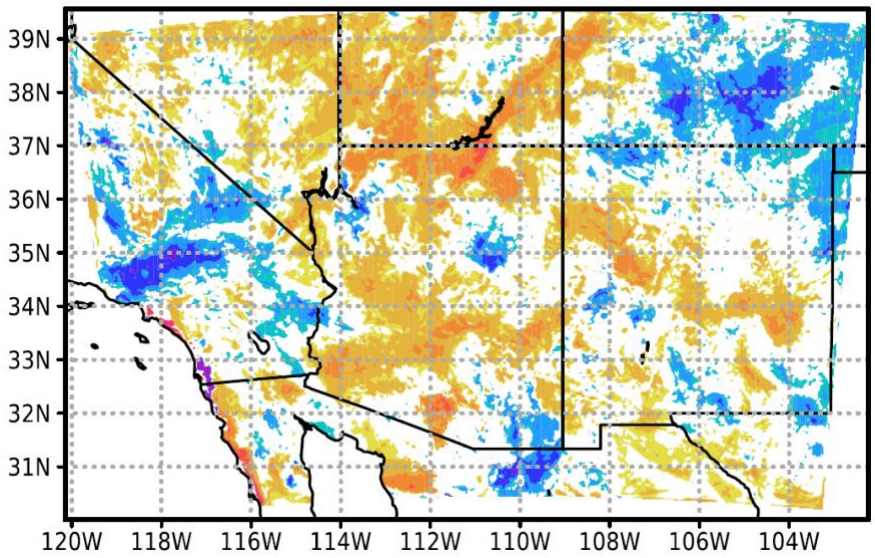


**Figure 2: Simulations of historical changes (1991-2010 compared to 1951-1970) in maximum wind speeds associated with severe storms. Orange and red colors indicate higher wind speeds, whereas blue and purple indicate lower wind speeds. Figure adapted from Fig. 15b of Luong et al. (2017).**

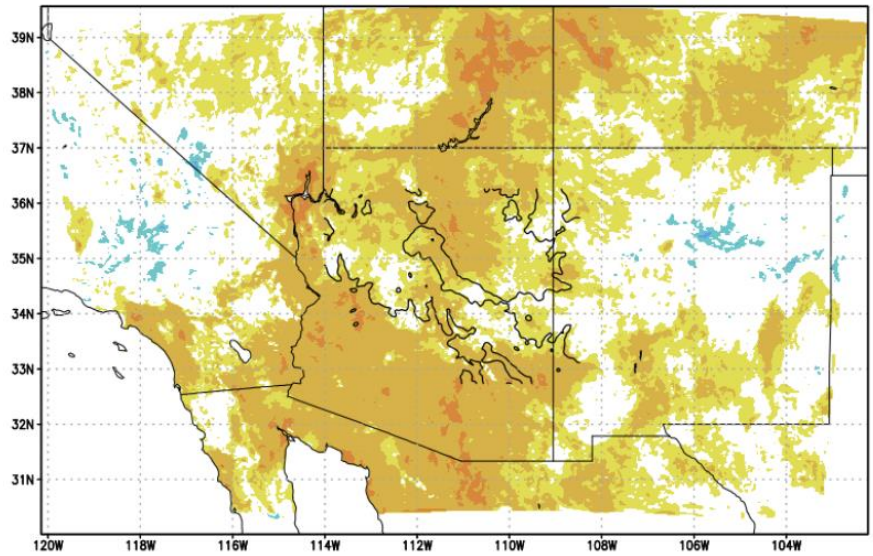


**Figure 3: Future projections (2021-2040 compared to 1991-2010) of extreme wind gusts of severe weather event days. Orange and red colors indicate higher wind speeds, whereas blue and purple indicate lower wind speeds. Figure adapted from Fig. 57 from Castro (2017).**

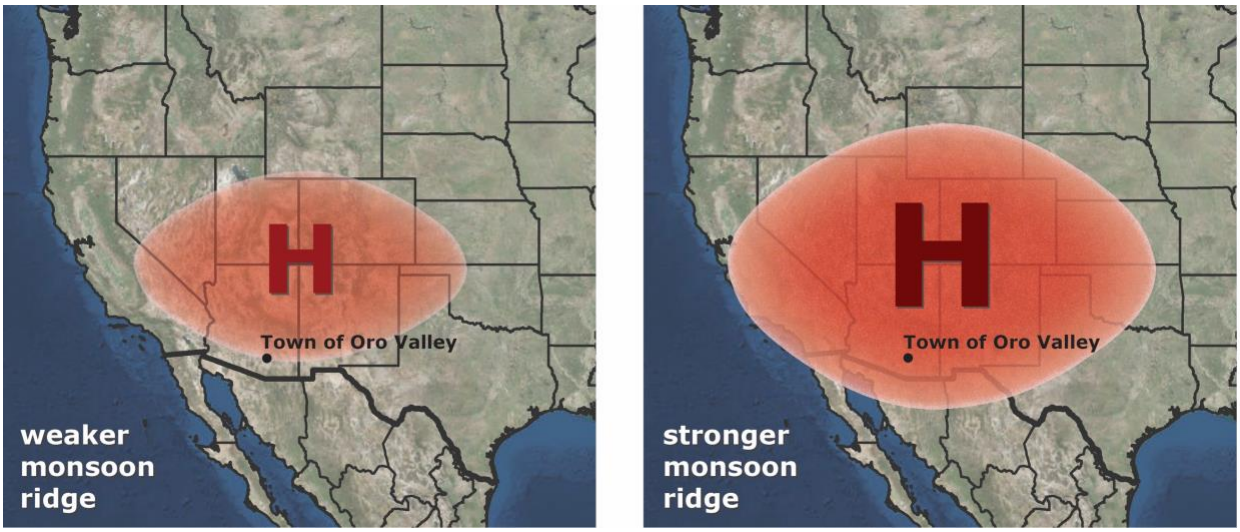


**Figure 4: The stronger monsoon ridge, which has been occurring in recent years, has reduced the frequency of storms in Pima County. However, when storms occur they are now more intense than in the past.**

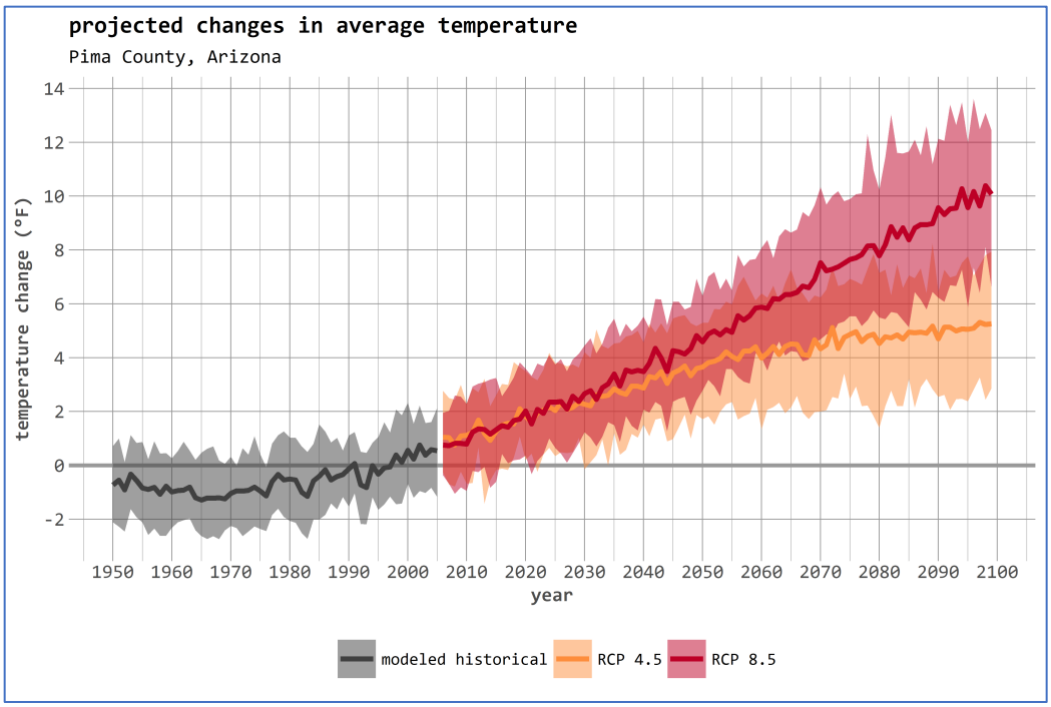


**Figure 5: Climate models project an increase in annual average temperatures for Pima County of approximately 4° F by 2050 for either the lower (Representative Concentration Pathway 4.5 (RCP 4.5)) or higher (RCP 8.5) scenario.**

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This report was prepared by:
Sarah R. LeRoy, Alison M. Meadow, and Jeremy Weiss with funding from the Climate Assessment for the Southwest at The University of Arizona
www.climas.arizona.edu

For more information, please contact:
Alison M. Meadow
University of Arizona – Institute of the Environment
meadow@email.arizona.edu