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The Faucet: Informal Attribution of the May 2015 Record-Setting Texas Rains

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1. Introduction

Texas received its all-time wettest month of rainfall in May 2015, with an average of 9.05 inches (230 mm) across the state according to National Centers for Environmental Information (NCEI) climate division data.

The purpose of this talk is to put the extreme rainfall events in Texas in 2015 in a historical perspective and to consider the possible role of contributing factors, including anthropogenic climate change, in the May 2015 rainfall.

2. Monthly rainfall totals

The wettest months of the year in Texas are climatologically May, June, September, and October. Historically, 80% of the largest monthly rainfall totals have occurred during one of those four months. Figure 1 shows the historical distribution of rainfall in Texas for those four months, with the four months of 2015 highlighted in red. May 2015 was an extreme outlier. The gap between May 2015 and the second largest total (6.66", or 170 mm) is as large as the gap between the second largest total and the 88th largest total. The May 2015 total was easily sufficient to break the record for wettest 31 consecutive days as well. Longer-duration records were also broken, such as the wettest first six months of the year.

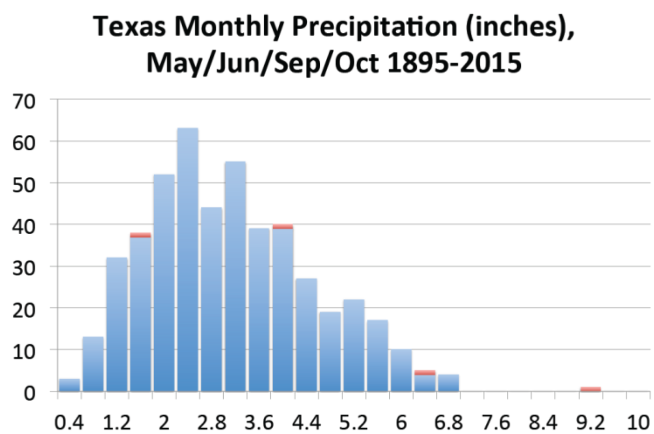

Fig. 1 Monthly precipitation totals during the wettest months of the year in Texas, with 2015 totals in red.

October 2015 was also relatively wet, with 6.17" (157 mm) tying for the second wettest October on record. Despite this, the month started off dry, with 80% of the precipitation falling in the final ten days and setting a record for the wettest ten consecutive days in Texas. For daily precipitation totals, I aggregate the spatial precipitation analyses produced by the Northeast Regional Climate Center; these analyses cover the period 1950-present.

Within that ten-day period, Texas also experienced its wettest storm system on record, based on two-day (2.34", 60 mm), three-day (3.02", 77 mm), four-day (3.61", 92 mm), and five-day (3.88", 99 mm) totals.

When the mud settled, Texas had experienced its wettest year on record, breaking the previous record by nearly an inch.

Both May and October effectively ended droughts in Texas. According to NCEI Palmer Drought Severity Index calculations, the 2010-2015 Texas drought ended in November 2014, but much of the state was still suffering from unusually low reservoir levels. In May, numerous reservoirs went from less than 20%

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of conservation storage capacity to over 100%, ending the water supply drought across the entire state. The October rainfall ended a flash drought whose impacts were almost entirely agricultural, as streamflow and reservoir levels remained high.

3. Attribution and the faucet

The precipitation received over a given area in a given period of time is the result of a combination of dynamical and thermodynamical factors that ultimately result in precipitation production through ascent of moist air and subsequent receipt of that precipitation on the ground. Extreme events in particular tend to require a combination of factors all interacting favorably. Strictly speaking, the individual factors cannot be cleanly separated, because each factor influences the others. However, in the case of precipitation it is useful to separately consider the thermodynamic effects of climate change separately from the dynamic effects of climate change.

The direct thermodynamic effect of climate change is to increase the water vapor carrying capacity of the atmosphere. All else being equal, a saturated atmosphere that is warmer will produce more precipitation. Of course, all else is never equal, and the other thermodynamic and dynamic effects of climate change help to control the frequency of precipitation events, the vigor of ascent, and the intensity of storms, such that the total precipitation received during a given month or year is a product of the changing dynamics and thermodynamics of the atmosphere.

A good analogy is a water faucet. The direct thermodynamic effect is comparable to the size of the pipe, which controls how much water can be delivered to the faucet. The remaining dynamic and thermodynamic

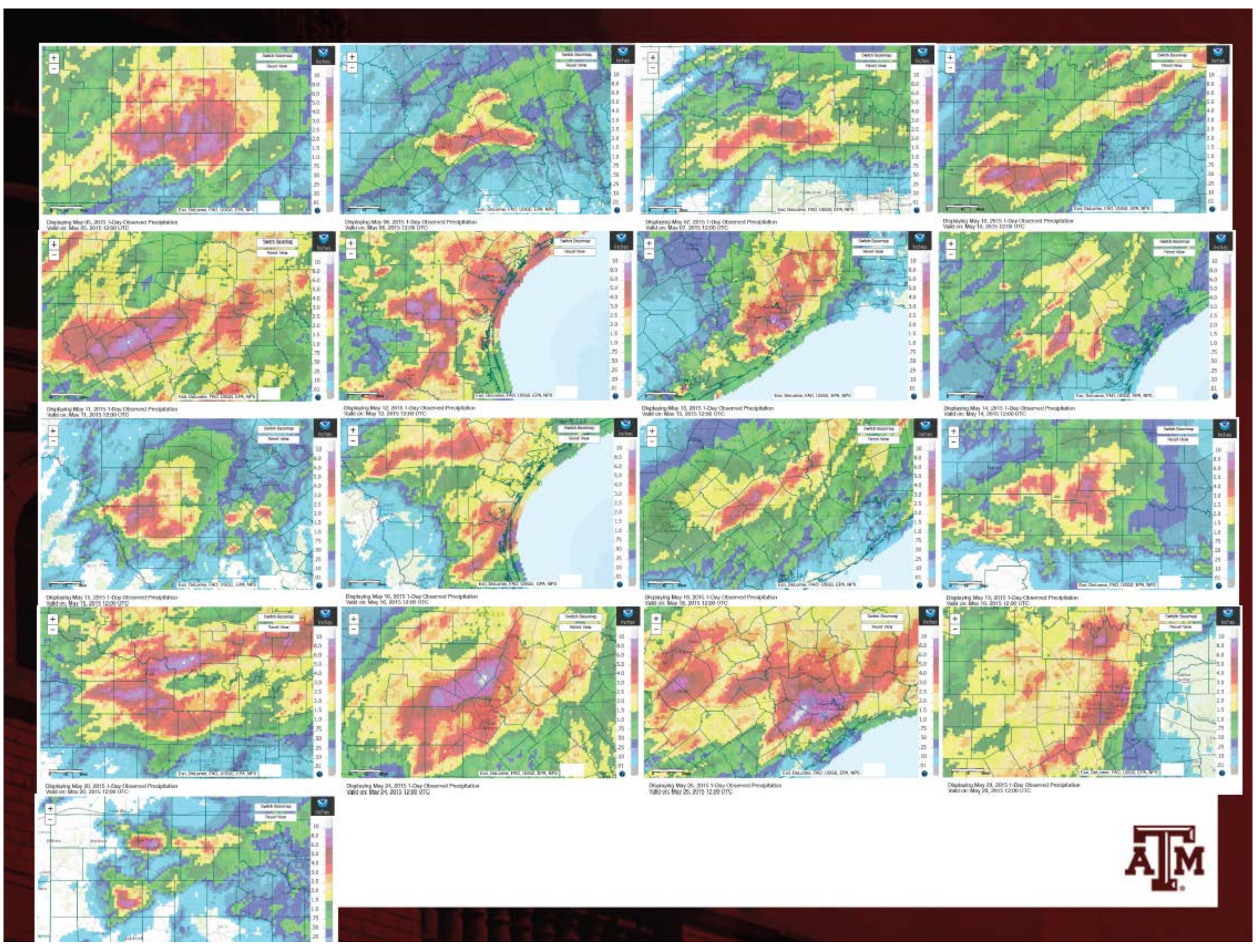

Fig. 2 Individual extreme rainfall events (defined as at least 6” (152 mm) of rainfall in one day) during May 2015 in Texas, from daily Advanced Hydrologic Predictions System (AHPS) rainfall analyses.

effects are comparable to the handle of the faucet, which may be closed, slightly open, or fully open. The net resulting precipitation depends on both the size of the pipe and the position of the handle. However, when the handle is wide open, the precipitation intensity is controlled only by the size of the pipe.

Over the past 121 years, there is essentially no trend in springtime precipitation in Texas. If anthropogenic climate change has had an effect, it has been offset by natural variability. It is thus difficult to argue that climate change played a direct role in the record-setting May rainfall.

An upward trend does exist in intense one-day and two-day rainfall events in the south-central United States (e.g., Janssen et al. 2014). This means either that the precipitation handle is wide open more frequently, or that on days in which the precipitation handle is wide open, the atmosphere is delivering more precipitation. Since overall precipitation has not increased, we presume that the pipe has become wider rather than the handle position becoming more favorable. In other words, climate change is increasing the amount of precipitation on those days in which ideal intense precipitation conditions are present.

As for a possible interaction effect between natural variability and climate change, Wang et al. (2015) have found that global warming may have enhanced the atmospheric response to El Niño in Texas, which even without climate change favors enhanced springtime precipitation under developing El Niño conditions.

4. The pipe: Heavy rainfall events during May 2015

During May 2015, near-ideal intense precipitation conditions were present in various locations across Texas. On sixteen different days, some locations in Texas received at least six inches (152 mm) of rainfall (Fig. 2). These events occurred within every climate division of the state, and included major flooding events north of Fort Worth, along the Blanco River in Wimberly and San Marcos, and in parts of Houston. Individual events such of these appear to have been made more likely due to climate change.

5. Summary

With the lack of a positive trend in monthly springtime precipitation, there is no direct observational evidence that the record-setting May 2015 statewide rainfall total in Texas had an anthropogenic component. One study has found a possible enhancement of the springtime Texas rainfall response to El Niño. Much more apparent is the likely contribution of anthropogenic climate change to individual intense rainfall events within the month of May. This contribution is analogous to the effect of a wider pipe on water delivered by a faucet.

References

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