Investigating Surface Temperature Inversions at a Gulf of Mexico Coast South Alabama Mesonet Station over a 3-year period.

Logan E. Smith and Dr. Sytske K. Kimball

Background

What is an Inversion?

An inversion is a reversal of the normal behavior of temperature in the troposphere in which a layer of cool air at the surface is overlain by a layer of warmer air. For an inversion to be possible a few thing must happen. There must be clear skies, low humidly, and light to calm winds. A series of large temperature inversions can be seen in Figure 1 during calm clear nights. The night of 24-25 October did not have an inversion because of the stronger winds that occurred that night.

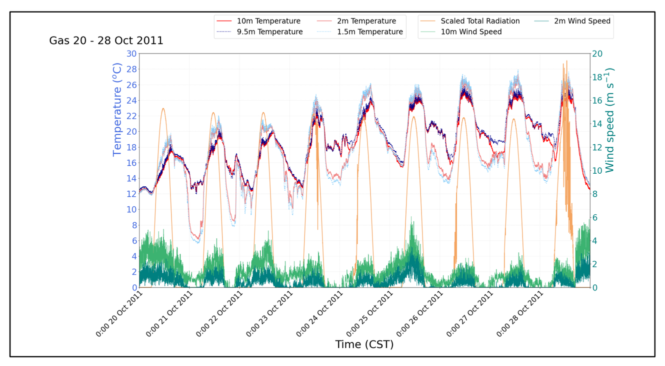


Figure 1: Time series of Temperature at 4 levels (colors see legend), solar radiation (orange), and wind speed at 2 levels (green) at Gasque from 20 – 28 October 2011.

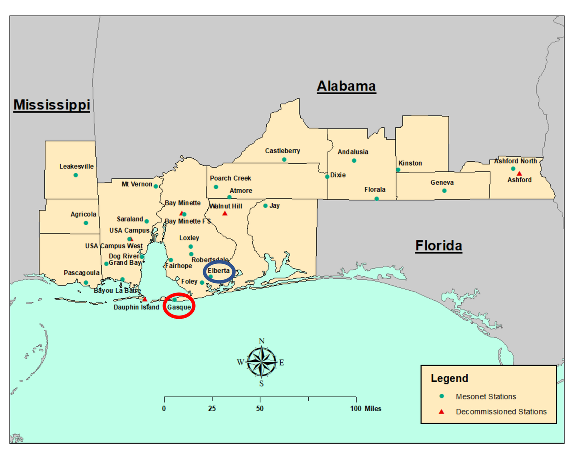
Why are Inversions Important?

Temperature inversions this close to the surface have large impacts on agriculture. If a low-level inversion like this is present when a farmer sprays their crops with pesticide the pesticide could easily spread to fields that it was not intended for or into residential areas. These inversions also have impacts in the winter with freezing of crops. Therefore, issuing warnings of inversions would be beneficial. However, doing so is challenging because near-surface temperature inversions are very localized and depend on local land use and terrain characteristics.

South Alabama Mesonet

The South Alabama Mesonet is a network of 27 automated weather stations located in the north-central Gulf Coast area and was founded in 2004 by University of South Alabama Meteorology professor Dr. Sytske Kimball. The weather stations collect 16 meteorological- and soil- quantities including temperature, rainfall, wind speed and direction, soil temperature and humidity. All stations measure temperatures at 2 and 10 m as well as at 1.5 m and 9.5 m, which ideally suited to measuring temperature inversions. Measurements are made automatically every minute of the day, every day of the year. Image 1 shows all South Alabama Mesonet Stations. The station used in this study (Gasque) is circled. The station that Gasque will be compared to is Elberta.

Figure 2: A map of all station in the South Alabama Mesonet. The Gasque station is circled in red. The Elberta station is circled in blue.



About The Stations

The station used in this study is 1.17 km from the Gulf of Mexico. The ground around the station is covered in sand. This is the only South Alabama Mesonet station built on sand. The station is somewhat sheltered from the north by a building and by trees from other directions.

Figure 3: A picture of the Gasque station from the North

Figure 4: A Google Earth photo of the Gasque station. (Station marked with red dot)

Figure 5: A picture of the Elberta station from the North

Figure 6: A Google Earth photo of the Elberta station. (Station marked with red dot)

Specific Heat

Specific Heat is the quantity of heat required to raise the temperature of one kilogram of a substance by one degree Kelvin (or Celsius).

Substance	Specific Heat (J/kg K)
Sand	830
Clay	878

Goal of this Research

- Does the sand around the station help cause strong surface inversions?
- Establish a typical inversion duration.
- Which month has the strongest inversions, longest inversions and the strongest.

Methods

- Temperature data from 1.5 and 9.5 m was used
- Temperature data from 2 and 10 m was used for quality control
- Temperature data from 2011-2013 was manually quality controlled.
- Bad temperature was removed.
- Inversions are defined as follows: $T_{1.5m} - T_{9.5m} < -1.2$ºC
- 1.2ºC was chosen because it is three times the sensor error. We chose three times due to instrument drift.
- Inversion statistics were calculated.
  - Number of Inversions per year
  - Number of Inversions per month
  - Duration of Inversions
  - Magnitude of Inversions

Findings

Gasque

- The average inversion lasted 70 mins.
- The average inversion strength was 1.69 °C.
- The strongest inversion was 8.52 °C (47.3 °F)

Elberta

- The average inversion lasted 52 mins.
- The average inversion strength was 1.1°C
- The strongest inversion was 6.92°C

Findings con.

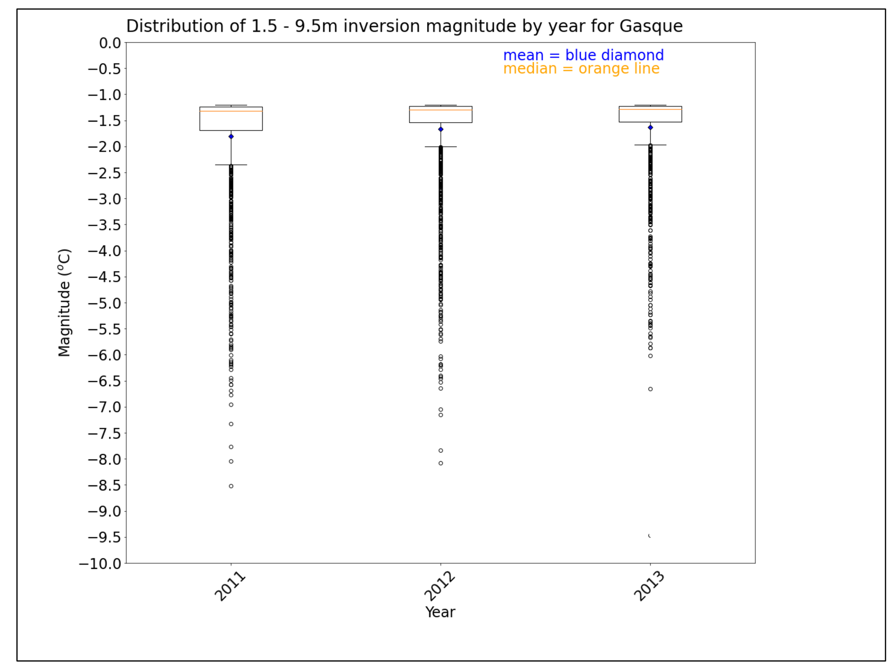
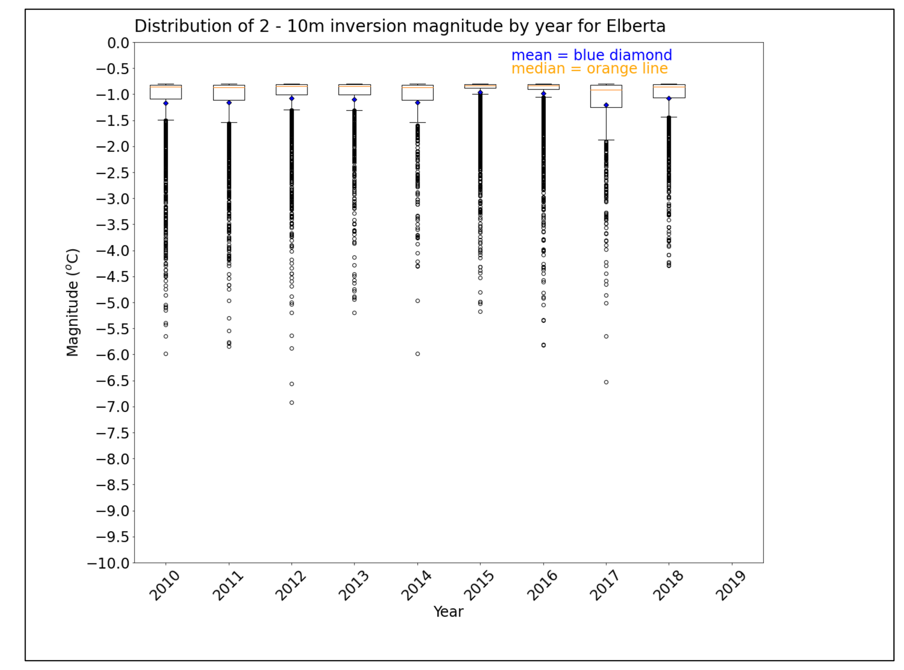


Figure 7



- Figure 8
  - Only years 2011-2013 were used

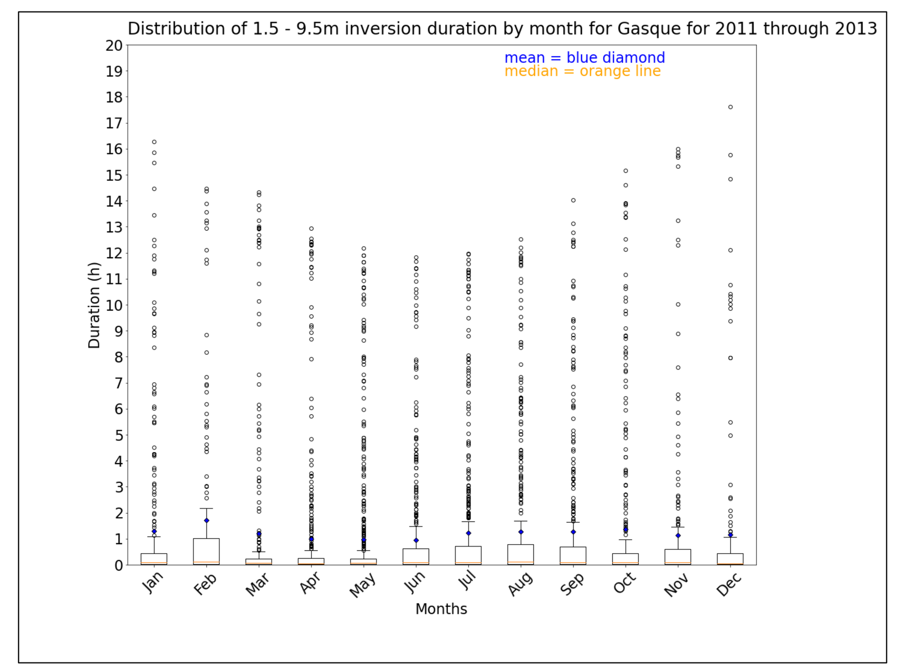
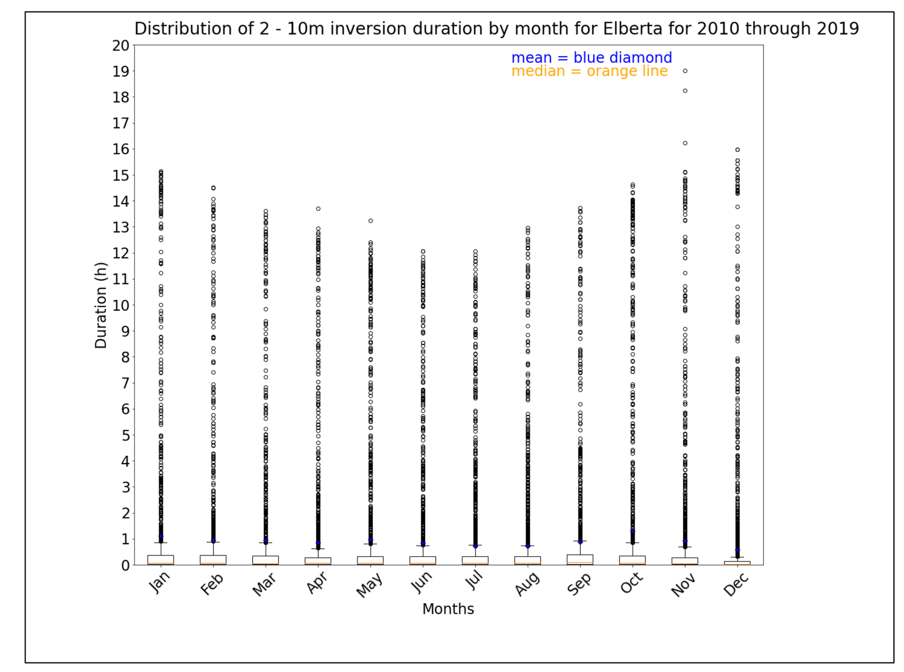


Figure 9



- Figure 10
  - Only years 2011-2013 were used

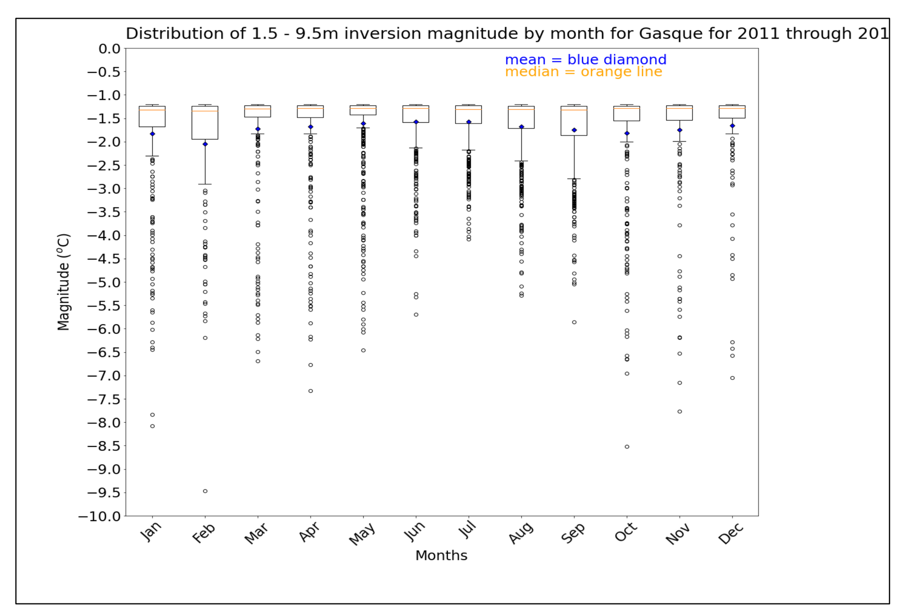


Figure 11

- The boxplots in figures 7 and 8 show that in Gasque the mean and maximum inversion magnitude is larger than in Elberta for all years shown.
- The boxplots in figure 9 and 10 show that in the hottest months of the year, inversions do not last as long.
- The boxplots in Figure 11 shows the hotter months has the weakest inversion while it also shows Oct-Jan has the strongest inversions.

Conclusions

- The Gasque station showed stronger and longer inversions because its strong sheltering favors low wind speeds, and the low heat capacity of sand causes rapid cooling of the surface at night. More research is required to find out which of these has a larger impact on inversion.
- An inversion of 1.2°C on average will last just over an hour
- The months of November, December, and January have the strongest and longest lasting inversions. This could be caused by the longer nights that time of year.
- The month of July had the weakest and shortest inversions. This could be due to the shorter nights in July.

Cited works

Bish, Mandy, and ET AL. *Inversion Climatology in High-Production Agricultural Regions of Missouri and Implications for Pesticide Applications*.

Enz, John, and ET AL. *Air Temperature Inversions*.

South Alabama Mesonet