Collaborative Effort to Predict Hourly Temperatures during the August 21, 2017 Total Solar Eclipse in the Mid-Atlantic and Southeast

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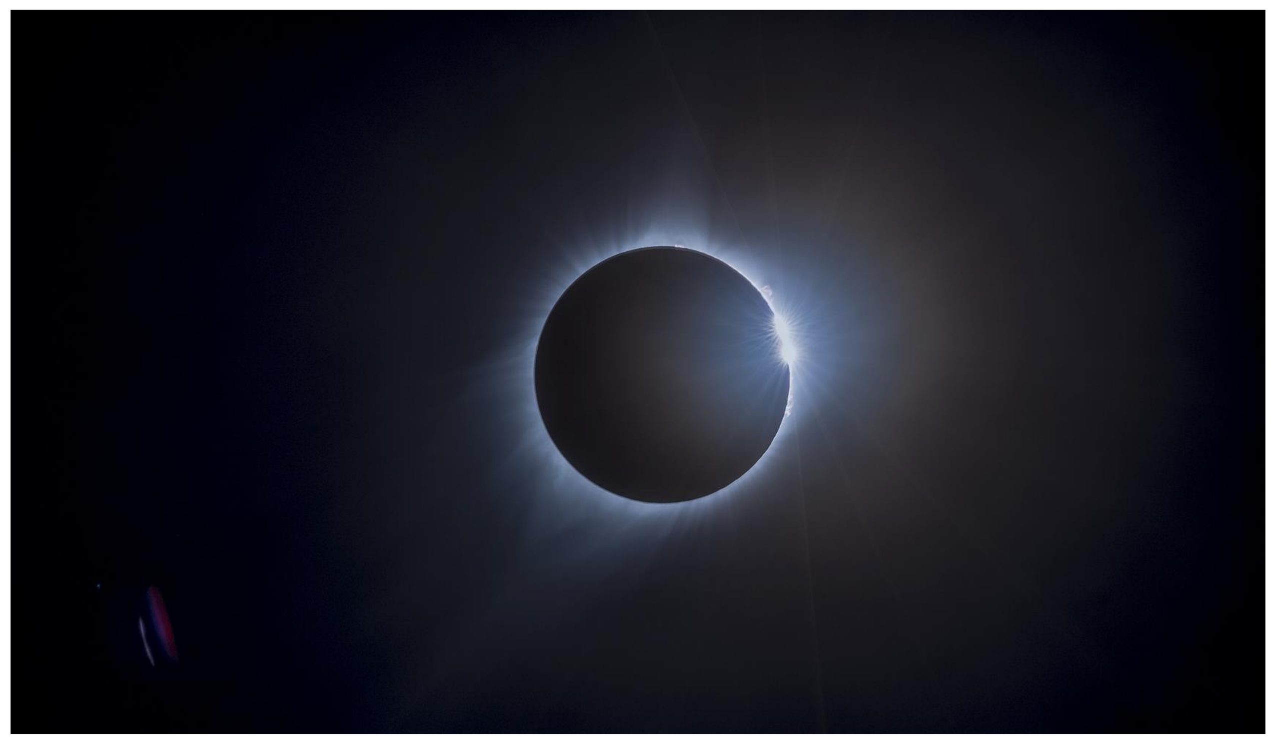
Background

- Meteorologists recognize that solar eclipses have a notable impact on the sensible weather in impacted regions including a decrease in surface temperature, changes in cloud cover, reduction and changes to surface winds, lowering of surface pressure, and more.
- Surprisingly, many operational numerical weather prediction systems do not account for the changes in incoming solar radiation from the sun during an eclipse and the resultant changes in the sensible weather.
- The eclipse was a high profile event, requiring an accurate and consistent forecast from National Weather Service (NWS) Weather Forecast Offices (WFOs). Since NWS forecasters provide forecasts of temperature, winds, and other fields at hourly time steps, the eclipse impacts needed to be captured.
- NWS meteorologist in the Southeast and Mid-Atlantic worked collaboratively to account for some of these impacts on official NWS forecasts prior to the eclipse.



NASA photo of the August 21, 2017 eclipse from Jefferson City, Missouri. A radiant "diamond" of sunlight is seen in the moments after totality. Photo credit: NASA/Rami Daud, Alcyon Technical Services.

Developing the Diurnal Temperature Drop Algorithm

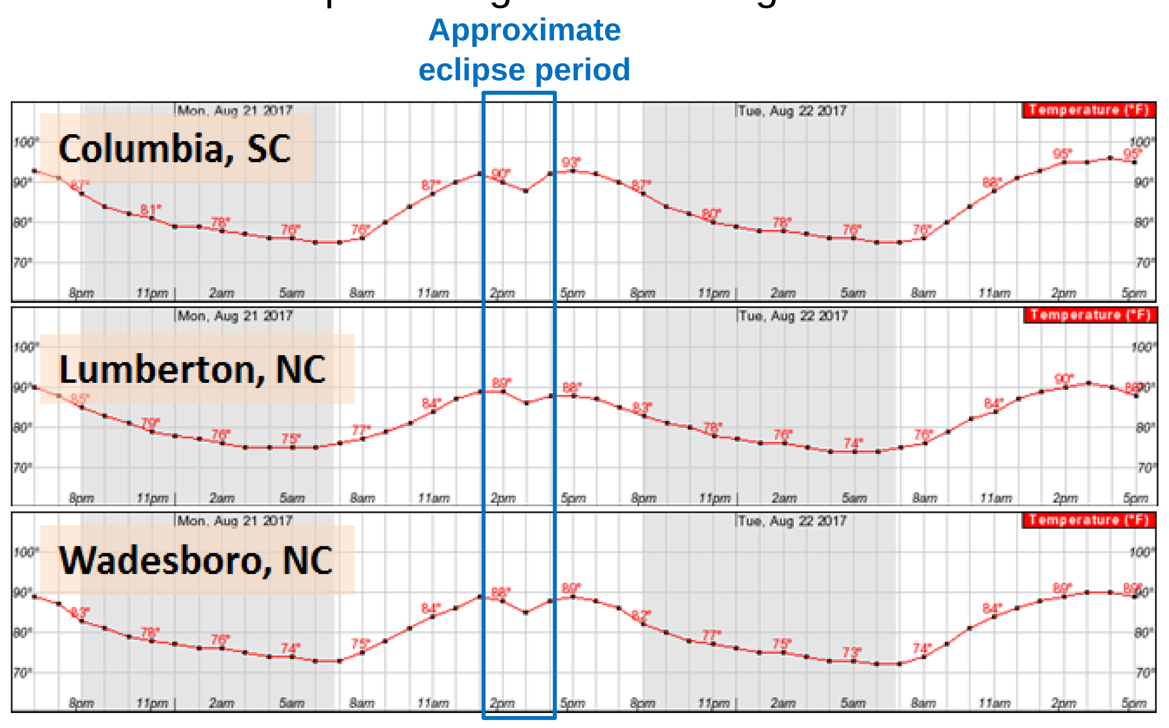
- Given the need for an accurate and consistent forecast, Josh Weiss from NWS WFO Wilmington, NC (ILM) developed an algorithm to adjust hourly temperatures based on climatological data and NASA research on diurnal temperatures during eclipses.
- The difference between the expected temperature at a specific time on a typical diurnal day and the realized temperature during the maximum impact of an eclipse can be referred to as the diurnal drop.
- A NASA study (https://eclipse2017.nasa.gov/faq) noted that the maximum temperature drop during a total solar eclipse can range from between 50% and 75% of the average diurnal range for the day. The 75% of the diurnal drop is more likely to be realized during eclipses with a longer period of totality (a total solar eclipse can last up to 7 minutes). The August 21 eclipse only lasted 2 to 3 minutes, so the 50% drop was more appropriate for this event.
- By using the diurnal range, inherent climatological factors such as the time of year and typical atmospheric moisture content would be somewhat represented. This is important as the typical diurnal range in the Southeast during humid summer months is different than in the cooler and drier months or in another region.

Developing a Forecast Tool

- An algorithm was developed to calculate the expected diurnal temperature drop by incorporating the forecast temperature, climatological diurnal range without an eclipse, the amount of solar obscuration by the moon, and cloud cover.
- These calculations were then incorporated into a Gridded Forecast Editor (GFE) procedure called "Eclipse Temperature" to provide a scientifically sound and consistent method to adjust the hourly temperature forecasts. The tool adjusts the hourly temperature forecast during the period of the eclipse (17Z-20Z).
- WFO ILM shared the GFE procedure with WFOs in the Southeast and Mid-Atlantic while other WFOs shared maps detailing eclipse obscuration percentages for AWIPS and related research.

Temperature Forecast for the Eclipse

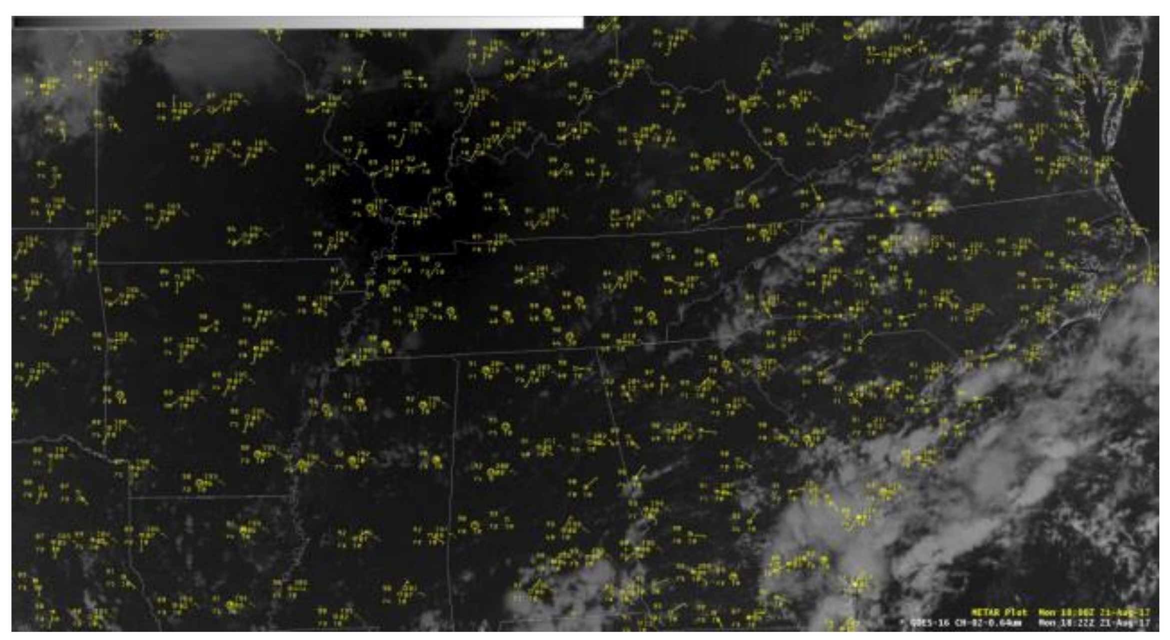
- Five WFOs used the GFE procedure to create forecasts prior to the eclipse. The hourly forecasts of temperature for three locations from three different WFOs (Columbia, SC; Wilmington, NC; and Raleigh, NC) are shown below. The differing temperature reductions during the eclipse period are influenced by various factors including solar obscuration percentage and differing amounts of cloud cover.



Official hourly forecasts of temperatures (degrees F) for three locations from Sunday, August 20, 2017 valid through Wednesday, August 23, 2017.

The August 21, 2017 Eclipse

- Areas of enhanced cloudiness along with scattered convection developed during the afternoon across coastal South Carolina in a region of instability and convergence near a surface boundary. More scattered cloudiness and isolated convection was noted across western South Carolina and North Carolina.



GOES-16 Channel 2 visible satellite imagery from 1822Z on August 21, 2017, just prior to totality in the Carolinas. Note the enhanced cumulus along the Appalachians, widespread cloud cover along the GA/SC/NC coasts, as well as the very dark area across TN/KY/MO which is beneath the totality shadow.

Results from the Eclipse

- One minute temperature data was collected from 16 ASOS locations across North Carolina, South Carolina, and Georgia. In addition, METAR observations were acquired to obtain the observed maximum and minimum temperature and cloud cover. Local radar data was used to identify locations of nearby convection.
- The algorithm was applied to the ASOS locations using the observed maximum and minimum temperature and cloud cover, as a proxy for the "expected" diurnal range to produce a "forecast" diurnal drop. This "forecast" diurnal drop is what the algorithm would have given had the forecast of temperature and sky cover been correct; a perfect hind cast.
- Of the 16 locations analyzed, 4 locations (KCHS, KCRE, KGSO, and KINT) observed precipitation or experienced cool outflow from nearby convection which corrupted the observed temperature drop.
- Of the remaining 12 locations, 5 locations observed the same temperature drop as predicted by the algorithm. In addition, 11 out of 12 had measured drops within 2 degrees of the algorithm forecast.

	Algorithm	Observed	Difference	Comments
KATL	6	6	0	
KFLO	6	6	0	
KLBT	7	7	0	
KMEB	7	7	0	
KOGB	7	7	0	
KRDU	8	6	2	
KCLT	5	4	1	
KFAY	7	6	1	
KBUY	5	6	-1	
KILM	4	6	-2	
KGSP	7	9	-2	
KCAE	7	4	3	
KINT	4	8	-4	Outflow from nearby convection
KCRE	3	8	-5	Outflow from nearby convection
KGSO	4	12	-8	Convection near METAR
KCHS	4	15	-11	Convection near METAR

A comparison of a perfect hind cast temperature drop to the observed temperature drop for the eclipse. Locations in green had observed temperature drops within 2 degrees of the algorithm. The orange location had difference of more than 2 degrees and red locations had corrupted observed temperatures because of precipitation or convective outflow.

Additional Thoughts

- The tool was a success with hourly temperature forecasts mimicking the observed temperature trend and capturing the temperature drop accurately.
- This effort built on the history and relationships already in place across the Southeast, and is a great example of many NWS meteorologists and WFOs working together to provide enhanced forecasts and service.
- The effort did not go unnoticed. Social media and news outlets began to note the forecast cooling created in both the NWS hourly weather graph as well as NDFD forecasts as early as August 17th. Numerous social media posts were made prior to the event about the NWS forecast temperatures for the eclipse.
- A more nationally consistent methodology could be derived from this effort to support temperature forecasters during the 2024 total solar eclipse.

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