An Energy-Focused Analysis of Extreme Humid Heat in the Southeast United States

Katherine G. Orletski

Meteorology Program, Embry-Riddle Aeronautical University, Daytona Beach, FL

Corresponding Author E-mail: orletskk@my.erau.edu

1. Motivation, Data, and Methods

Motivation

- **The Environmental Protection Agency (EPA) warns that rising temperatures lead to a higher demand for energy (i.e., cooling), increasing the chance of blackouts or other power disruptions**

Data

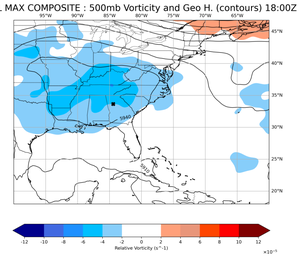
- **NOAA Integrated Surface Database (ISD), 1950 - 2023**
- **ERA5-Land Reanalysis, 1950–2023**
- **EIA hourly energy demand (MW), 2015-2023**

Methods

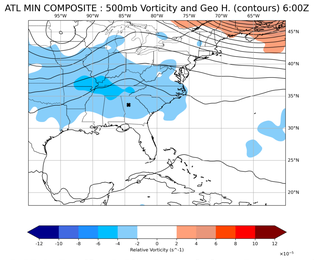
- **Liljegren WBGT; used custom python calculation package (pywbgt)**
- **Used SounderPy python package to create sounding composites**
- **99th percentile of daily max and daily min WBGT events at 13 locations**
- **Analyzed the synoptic characteristics: Geopotential height, temperature advection, vorticity, specific humidity, and sounding composites**
- **Composite averages for each synoptic variable were created**
- **Energy averages for each energy provider were calculated 2015-2024**
- **Energy averages for 99th percentile daily max and min WBGT events (2015-2023) were calculated**

2a. Synoptic Characteristics: Vorticity

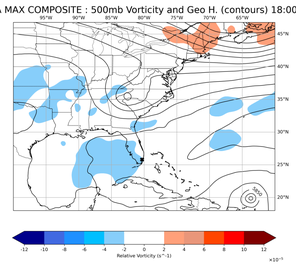
a). ATL Daily Max Vorticity Composite



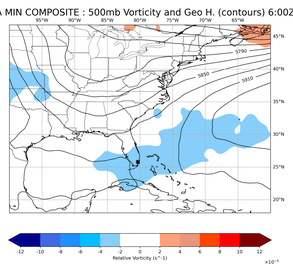
b). ATL Daily Min Vorticity Composite



c). MIA Daily Max Vorticity Composite

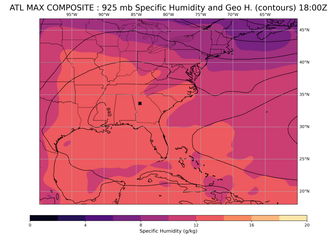


d). MIA Daily Min Vorticity Composite

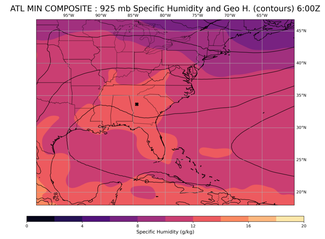


2b. Synoptic Characteristics: Specific Humidity

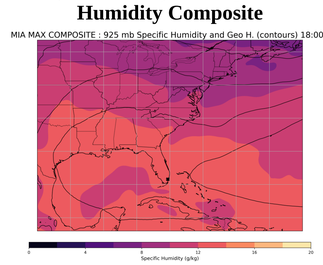
a). ATL Daily Max Specific Humidity Composite



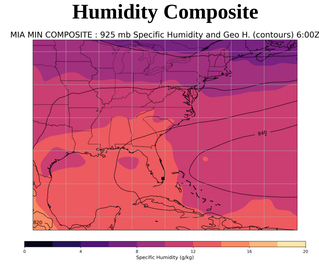
b). ATL Daily Min Specific Humidity Composite



c). MIA Daily Max Specific Humidity Composite

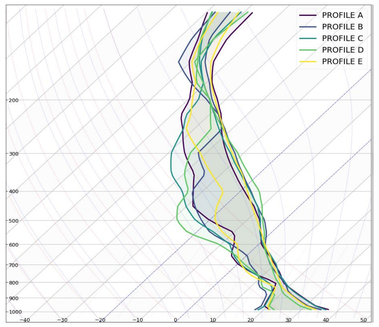


d). MIA Daily Min Specific Humidity Composite



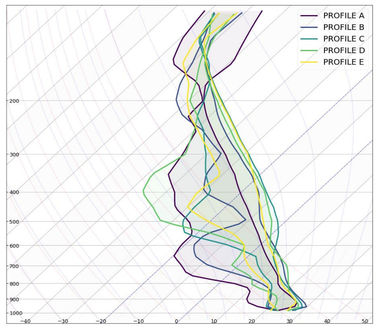
2c. Synoptic Characteristics: Sounding Composites

a). ATL Daily Max Sounding Composite



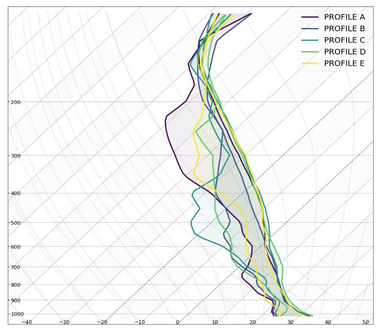
DATA TYPE	LOCATIONS	RUN/LAUNCH TIME	VALID TIME
A | F00 ERA5	A | [33.64, -84.42]	A | 18Z | 07-16-1980	A | 18Z | 07-16-1980
B | F00 ERA5	B | [33.64, -84.42]	B | 18Z | 08-23-2007	B | 18Z | 08-23-2007
C | F00 ERA5	C | [33.64, -84.42]	C | 18Z | 06-28-1952	C | 18Z | 06-28-1952
D | F00 ERA5	D | [33.64, -84.42]	D | 18Z | 08-05-1991	D | 18Z | 08-05-1991
E | F00 ERA5	E | [33.64, -84.42]	E | 18Z | 06-15-2010	E | 18Z | 06-15-2010

b). ATL Daily Min Sounding Composite



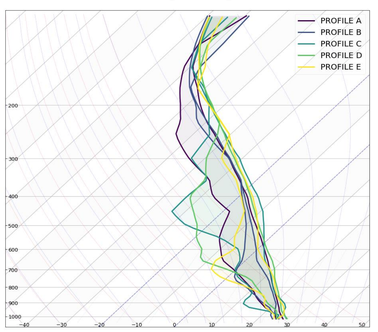
DATA TYPE	LOCATIONS	RUN/LAUNCH TIME	VALID TIME
A | F00 ERA5	A | [33.64, -84.42]	A | 06Z | 06-15-2021	A | 06Z | 06-15-2021
B | F00 ERA5	B | [33.64, -84.42]	B | 06Z | 07-12-1980	B | 06Z | 07-12-1980
C | F00 ERA5	C | [33.64, -84.42]	C | 06Z | 08-08-2007	C | 06Z | 08-08-2007
D | F00 ERA5	D | [33.64, -84.42]	D | 06Z | 08-23-2023	D | 06Z | 08-23-2023
E | F00 ERA5	E | [33.64, -84.42]	E | 06Z | 07-24-1995	E | 06Z | 07-24-1995

c). MIA Daily Max Sounding Composite



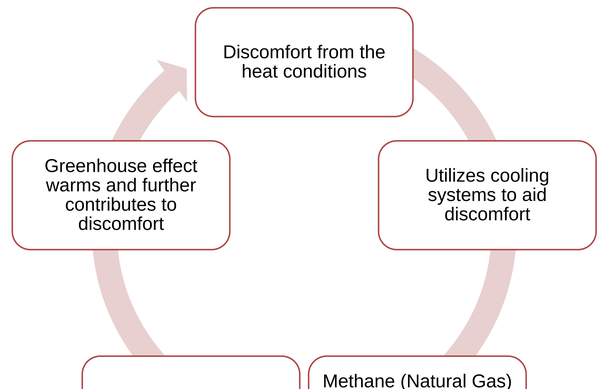
DATA TYPE	LOCATIONS	RUN/LAUNCH TIME	VALID TIME
A | F00 ERA5	A | [25.79, -80.31]	A | 18Z | 07-03-2021	A | 18Z | 07-03-2021
B | F00 ERA5	B | [25.79, -80.31]	B | 18Z | 08-21-1983	B | 18Z | 08-21-1983
C | F00 ERA5	C | [25.79, -80.31]	C | 18Z | 07-10-2020	C | 18Z | 07-10-2020
D | F00 ERA5	D | [25.79, -80.31]	D | 18Z | 08-10-2023	D | 18Z | 08-10-2023
E | F00 ERA5	E | [25.79, -80.31]	E | 18Z | 08-10-2016	E | 18Z | 08-10-2016

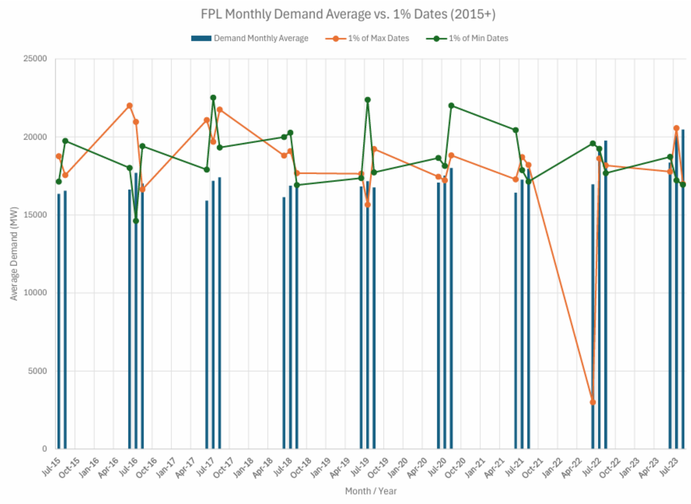
d). MIA Daily Min Sounding Composite



DATA TYPE	LOCATIONS	RUN/LAUNCH TIME	VALID TIME
A | F00 ERA5	A | [25.79, -80.31]	A | 06Z | 08-20-1971	A | 06Z | 08-20-1971
B | F00 ERA5	B | [25.79, -80.31]	B | 06Z | 08-09-1975	B | 06Z | 08-09-1975
C | F00 ERA5	C | [25.79, -80.31]	C | 06Z | 08-28-1981	C | 06Z | 08-28-1981
D | F00 ERA5	D | [25.79, -80.31]	D | 06Z | 08-07-1987	D | 06Z | 08-07-1987
E | F00 ERA5	E | [25.79, -80.31]	E | 06Z | 06-26-1995	E | 06Z | 06-26-1995

3. Energy Response





4. Conclusions and Future Work

Conclusions

- **Upper-level ridging (negative vorticity) play a significant role in creating subsidence inversions by promoting descent**
- **These ridges/inversions aid in stagnant atmospheric conditions and adiabatic warming, leading to extreme WBGT events**
- **The Southeast region does not show significant evidence that temperature advection greatly influences extreme WBGT events**
- **The continental region showed a larger influence by negative vorticity trends and upper-level ridging**
- **Florida exhibits a unique heat pattern which is largely influenced by subtropical ridging**
- **The combination of high levels of specific humidity, and high-pressure systems located southeast of each location drives low-level transport of tropical moisture to the Southeast. The additional presence of subsidence inversions help maintain these hot and humid conditions by suppressing convection**
- **There is a significant relative increase in number of recent (2015-present) 99th percentile daily minimum WBGT events compared to daily maximum WBGT events, suggesting that nighttime humid heat might be increasing faster than its daytime counterpart**

Future Work

- **Investigate the role topography plays in extreme humid heat events**
- **Investigate the influence marine heat waves have on the Gulf Coast region and the Southeast Atlantic Coastal region**

Selected Locations of Study

