Climatology of Sounding-derived Parameters Associated with Tropical Cyclone Tornado Outbreaks

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Introduction

Tropical cyclone tornadoes (TCTOR) may be produced at all stages of a tropical cyclone (TC) including the extratropical remnant stage.

These tornadoes often result in loss of life and increased tropical cyclone damage.

Previous studies have documented links between individual tornadoes and synoptic meteorological conditions.

This study uses operational, synoptic data to develop a baseline climatology of parameters found to be important in tropical cyclone tornado occurrence in general.

Data Sources and Methods

TCTORs are any tornado verified to have been produced within the cyclonic envelope of the parent TC.

Data obtained from the SPC ONETOR database.

Clusters were defined as six or more TCTORs in a six-hour period centered on 00, 06, 12, 18, 18 UTC.

POR: 1955-2011; 25 TCs produced 55 clusters.

Radiosonde data from Plymouth State University archive. Sounding from station closest to TC location in space and time.

Choice of parameters driven by a literature review of TCTOR case studies and supercell events.

Sounding-based: Total Totals, Precipitable Water, Lifted Index, K Index, SWEAT Index.

Air Parcel – based: CAPE and Convective Inhibition.

Wind – based: Bulk Shear, Storm Relative Helicity, Energy Helicity Index, Bulk Richardson Number, 700 hPa wind speed.

Data Analysis performed using SPSS software:
Central Tendency, and Variability.
In addition, a Hierarchical cluster analysis of outbreaks and a PCA of the parameters was performed.

NWS Radiosonde Stations
Used in Baseline Climatology
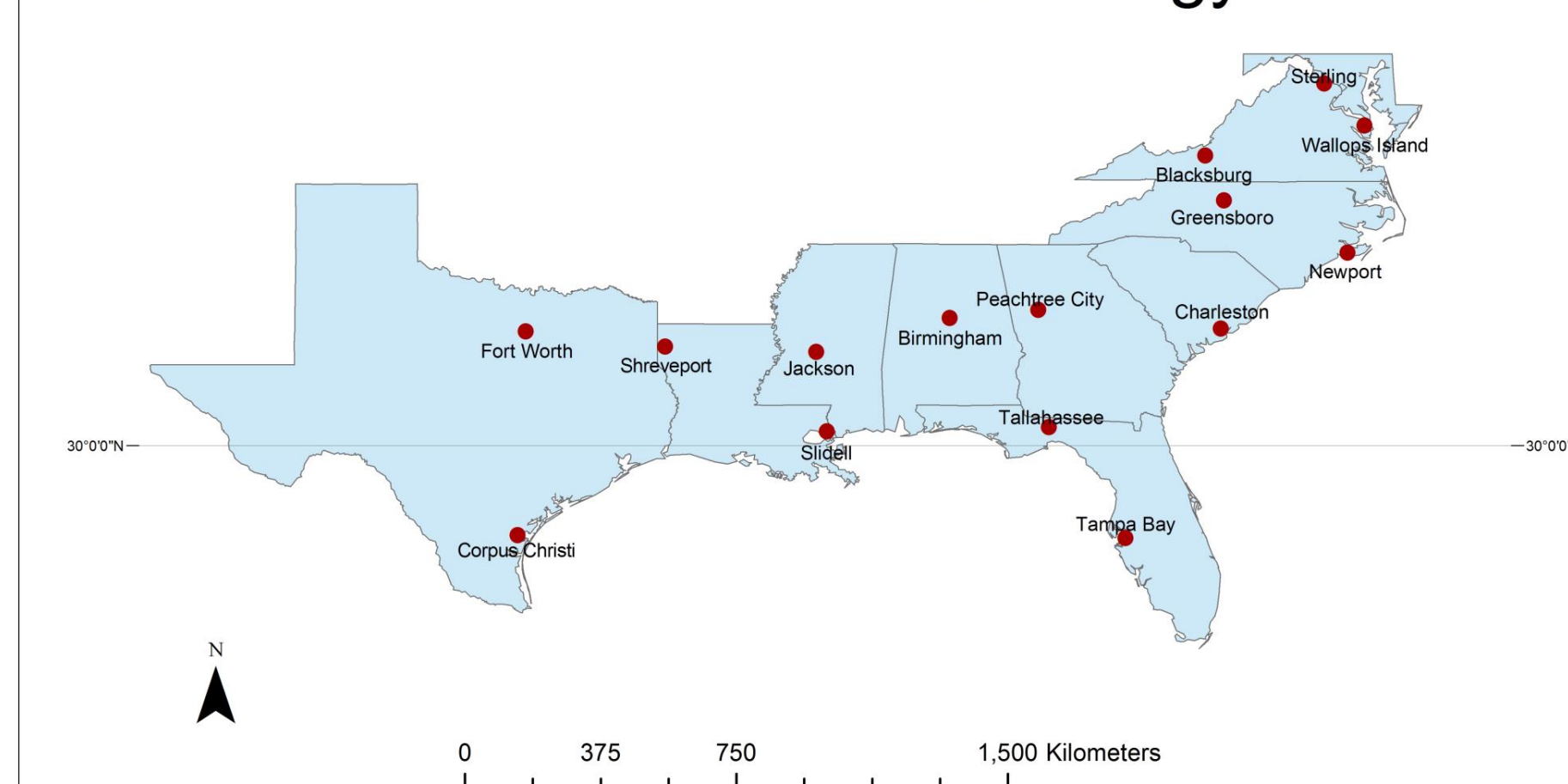
Measures of Central Tendency and Variability

- Mean, Median, 10% and 90%

- Range, Standard Deviation, Median Absolute Deviation, Semi-quartile Range, and Coefficient of Variation

Normal Distribution

Tested with K_S one sample test.

Only Convective Inhibition and Bulk Richardson Number found to be non-normal P<0.001.

Cluster Solution for Outbreaks

Ward's Method with Squared Euclidian Distance, Variables Standardized.

4 Cluster Solution: 21, 19, 8, 6 outbreaks.

Precipitable Water, K Index, CAPE, and Energy Helicity Index give best discrimination among clusters.

PCA Solution

4 Principle Components retained, 80.2% of variance.

Loadings

- PC1: 700 hPa Wind Speed, Storm Relative Helicity, SWEAT Index
- PC2: CAPE, (Lifted Index), Energy Helicity Index, Bulk Richardson Number.
- PC3: K Index, Total totals, Precipitable Water.
- PC4: Bulk Shear, Convective Inhibition.

Description

- PC1: tendency for rotation to develop.
- PC2: vertical acceleration and spin of rising air
- PC3: atmospheric moisture
- PC4: unresolved
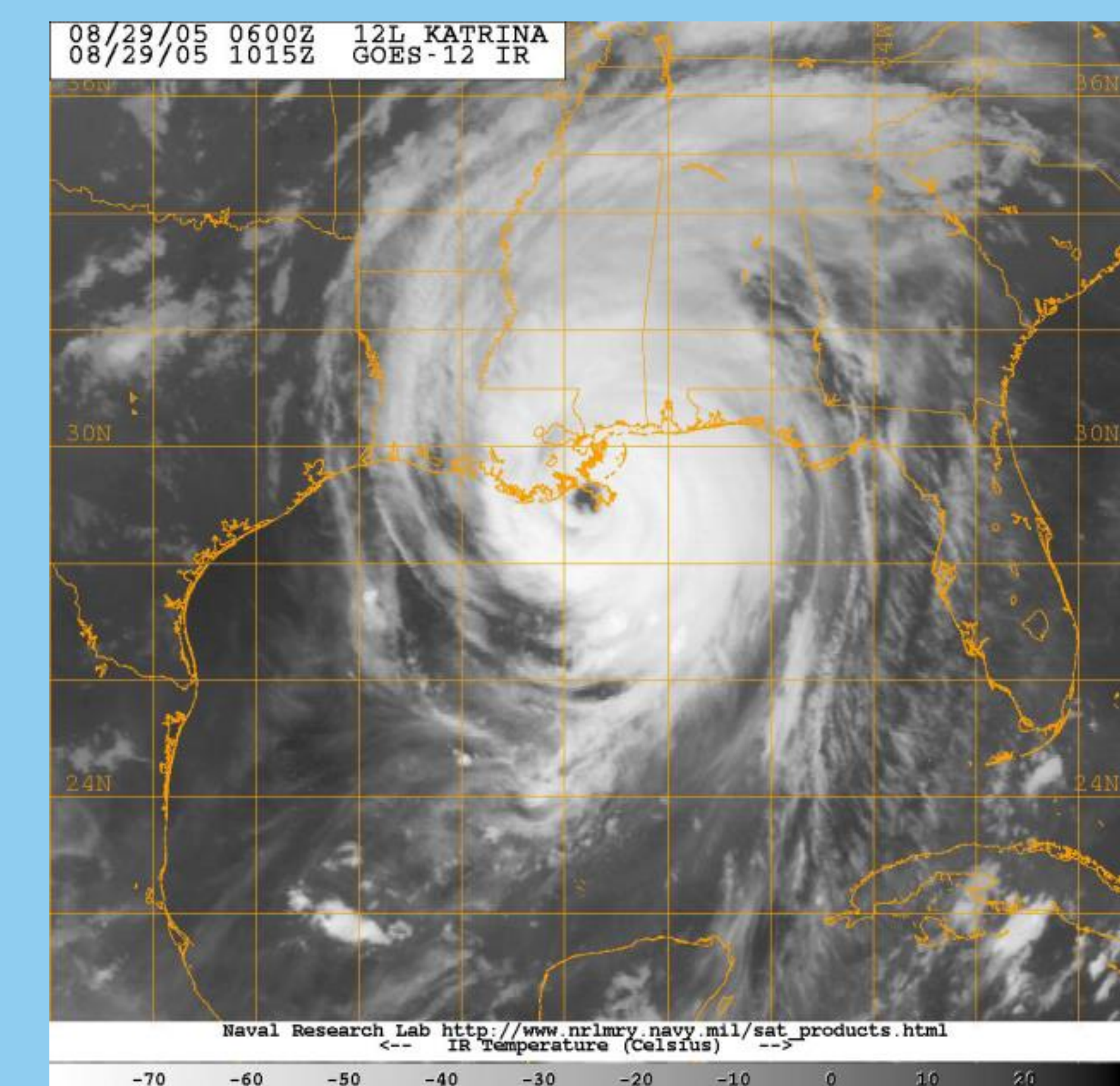
Conclusions

Developed a baseline climatology of upper-air parameters associated with TCTOR clusters to describe the atmospheric environment, an air parcel within that environment, and wind characteristics aloft.

Can a set of indices be developed which predict TCTOR occurrence and severity from operational data?