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# Developing a High-Resolution Extreme Weather Event Climatology for the Kennedy Space Center Using a Combination of High-Density Observations and Detailed Infrastructure Mapping

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## Introduction and Motivation

- CCAFS/KSC is main facility for launching payloads into low-Earth orbit
- CCAFS/KSC accounted for 66 % of all U.S. space launches during 2003 – 2012 (Lanicci and Thropp 2014).
- CCAFS/KSC responsible for commercial launch revenues of nearly $1.9 billion during same period (Lanicci and Thropp 2014).
- KSC installation covers a total area of 160,000 acres
  - Only 14,000 acres are facilities; more federally protected species than any federal property in continental U.S. (Hall et al. 2011)
- Concerns about vulnerability of KSC natural / physical environments to extreme weather events and climatic anomalies under global climate change.

## Data Collection and Analysis

- Analysis of buildings and structures in KSC Basic Information Guide (KSC 2013)
  - Square footage, ownership, year built, and physical location of over 1100 semi-permanent and permanent buildings, bridges, towers, antennas, and other structures over KSC and CCAFS.
- Mapped facilities onto NASA's Geographic Information System / Facility Information Center (GIS/FIC) grid map
- Categorized 673 severe thunderstorm and tornado reports over Brevard County by Dry/Wet season and transition period, using NCEI Storm Events database, covering period 1953–2016.
- Leveraged Schnapp's (2014) extreme value statistical analysis (EVSA) of heavy rainfall events over KSC/CCAFS using rainfall data from NASA's Tropical Rainfall Measuring Mission (TRMM) archive for 1998–2012.

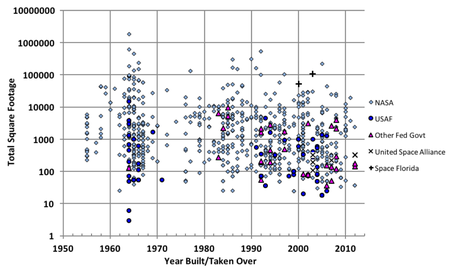
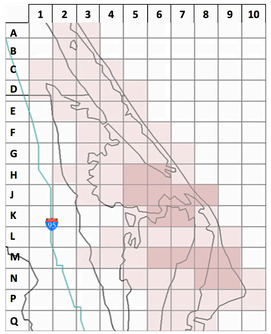



Fig. 1. Distribution of facility/structure size as a function of age, sorted by owner.

Nearly 1/3 of structures built before 1980; eight are > 100,000 sq. ft:
- Indian and Banana River Bridges (1964)
- Vehicle Assembly and Operations and Checkout Buildings (1964)
- KSC Headquarters Building and Central Instrumentation Facility (1965)
- Launch Control Center (1966)
- Orbiter Processing Facility (1977)



Key Infrastructure (darker red boxes in Fig. 2)
- Shuttle Landing Facility: H5, H6, J5, J6, K6
- Space Launch Complexes 39B and 39A: J7, J8, K7
- Vehicle Assembly Building and Contractors Road: K6, K7
- KSC Industrial Area and Visitors Center complex: M6, M7
- CCAFS Industrial Area: M8, N8
- CCAFS launch complexes: M9, N9

Fig. 2. GIS/FIC map adapted from KSC Basic Information Guide used as common mapping system for analyses presented in this study.

## Results – Severe Storms

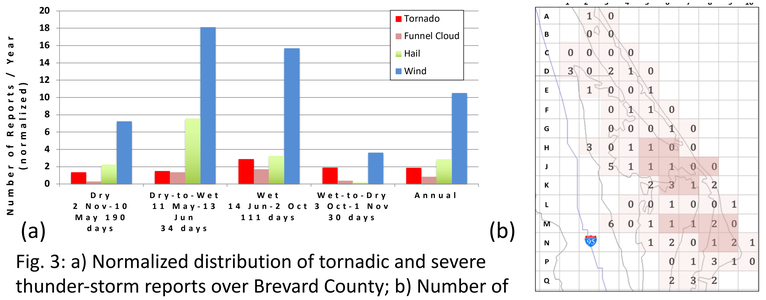
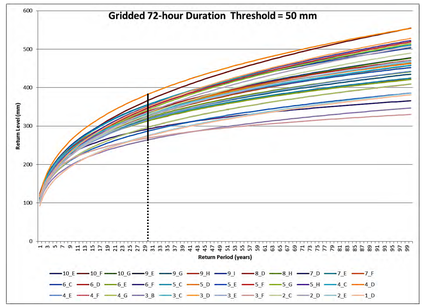


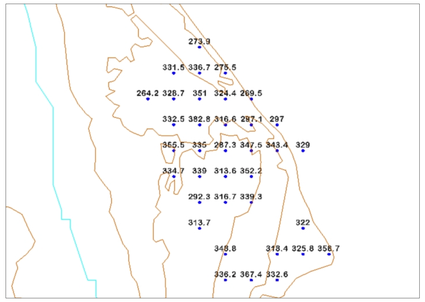

Fig. 3: a) Normalized distribution of tornadic and severe thunder-storm reports over Brevard County; b) Number of severe and tornadic thunderstorm reports per grid square over the GIS/FIC map area.

- Highest normalized annual frequencies of tornadoes and funnel clouds occur during Wet Season (2.9 $yr^{-1}$ and 1.7 $yr^{-1}$, respectively).
- Highest normalized annual frequencies of wind and hail occur during Dry-to-Wet Season transition (18.1 $yr^{-1}$ and 7.6 $yr^{-1}$ , respectively).
- Lowest normalized annual frequencies of all severe-storm types occur during Wet-to-Dry Season transition; exception is tornadoes.
- 65 individual reports in 38 of the 65 GIS/FIC grid squares; 14 located within critical infrastructure grid squares H5–6, J5–8, K6–7, M6–9, and N8–9. 65 reports during 64-year period of record ≈ 1 report $yr^{-1}$.

## Results – Heavy Rainfall




(a)




(b)

- EVSA over TRMM grid (Fig. 4a) shows large spatial variability in estimated rainfall, which increases with return period.
- Geographic rainfall distribution for 30-yr return period (Fig. 4b) ranges from 264.2 to 382.8 mm (10.4–15.1"), with highest value in approximate location of GIS/FIC grid squares J5–6 (Shuttle Landing Facility).
- Secondary maximum of 356.7 mm (14.0") over the CCAFS launch complexes.

## Conclusions

- Nearly 1/3 of catalogued structures built before 1980; eight of these have a surface area > 100,000 $ft^2$ and with one exception were built in the 1960s.
- Largest footprint of structural area (> 1 million $ft^2$) is in GIS/FIC grid squares that contain the VAB and KSC Industrial areas.
  - 14 of 65 severe-storm reports occurred within critical infrastructure grid squares.
- There is about a 58% chance that a location within the GIS/FIC grid will experience at least one severe-storm report in any given year.
- EVSA has high spatial variability over TRMM grid, which is much greater than that of conventional EVSAs [e.g., NOAA Atlas 14, Volume 9 (Perica et al. 2013)], despite the small geographic area (~600 $km^2$).

### References

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