ASSESSMENT OF TRENDS IN SOUTH FLORIDA SUB-DAILY RAINFALL

Jayantha Obeysekera[1], Michelle Irizarry-Ortiz[2], Carolina Maran[3], Anupama John[1], Oscar Guzman[1], Brett D. Johnston[2] ,Jenifer Barnes[3], Samuel Robles[1]

[1]Florida International University, Miami
[2]UnIted States Geological Survey, Orlando
[3]South Florida Water Management District

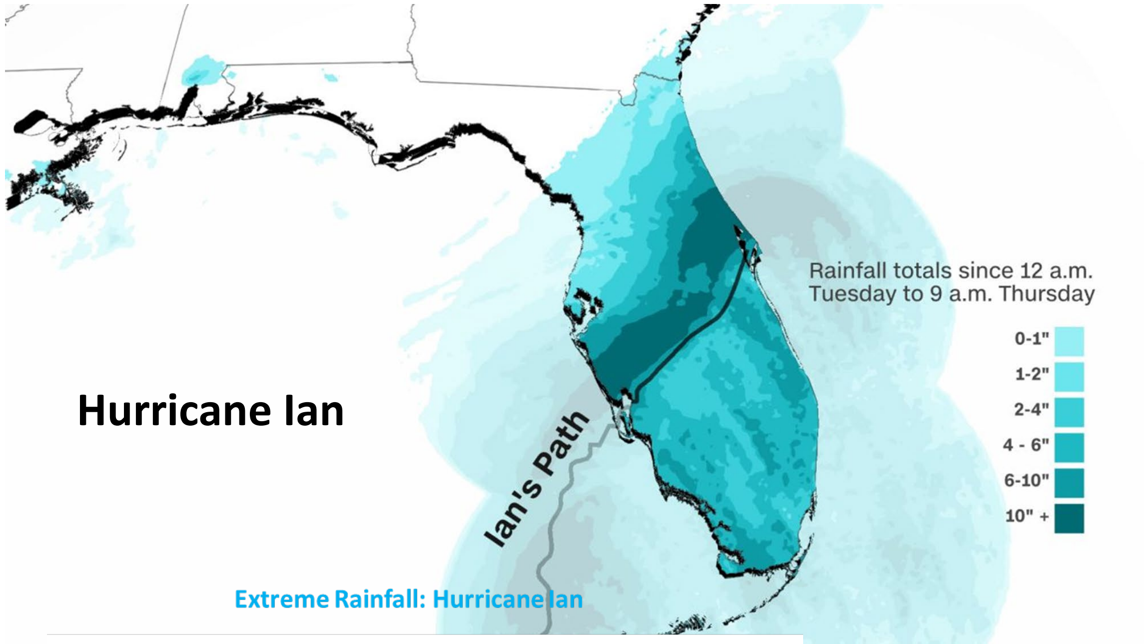
Web: https://environment.fiu.edu | http://slsc.fiu.edu
Facebook: @FIUWater | **Twitter**: @FIUWater

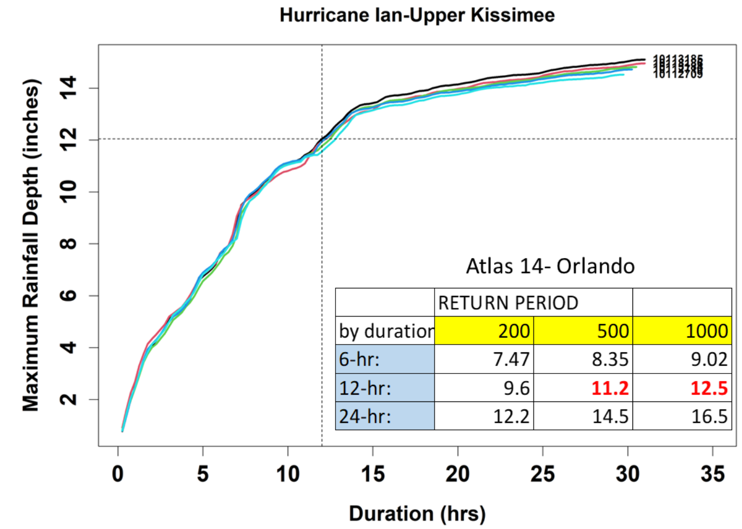
FIU Institute of Environment
FLORIDA INTERNATIONAL UNIVERSITY

FIU Sea Level Solutions Center
FLORIDA INTERNATIONAL UNIVERSITY

USGS science for a changing world

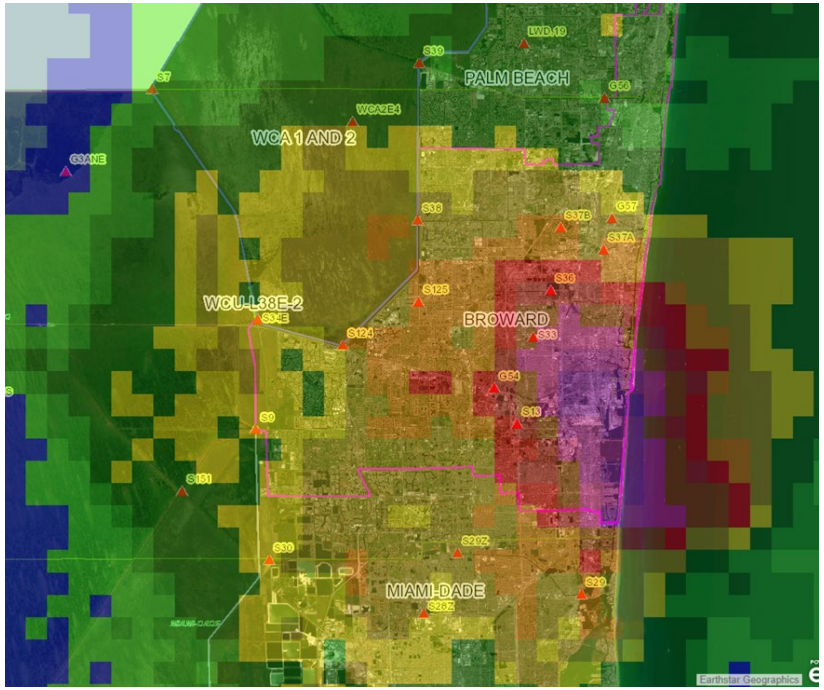
Is extreme rainfall increasing?

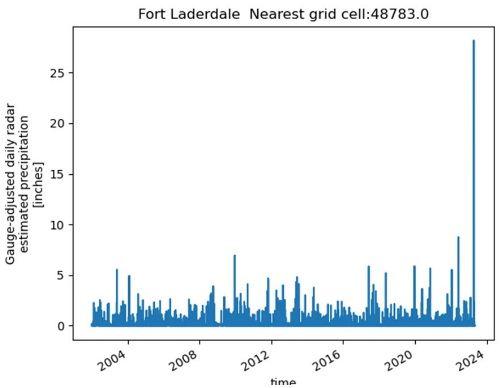


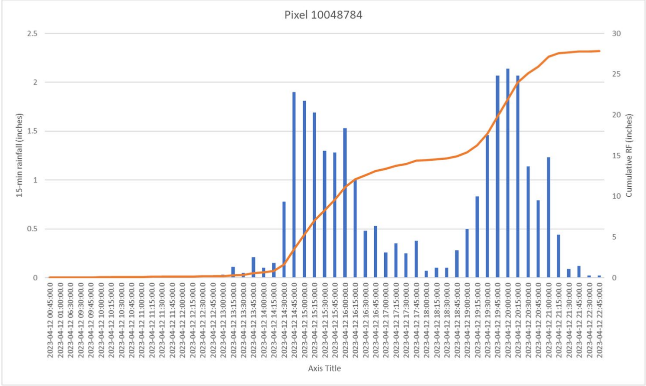


	RETURN PERIOD		
by duration	200	500	1000
6-hr:	7.47	8.35	9.02
12-hr:	9.6	11.2	12.5
24-hr:	12.2	14.5	16.5

Fort Lauderdale, April 12, 2023







Key Takeaways

- Sub-daily precipitation records in Florida are notably lacking and insufficient to conduct a thorough trend analysis.
- There is an urgent requirement for creating a comprehensive database containing all available sub-daily rainfall data.
- Statistical analyses reveal upward trends in multiple Florida locations.
- The relationship between extreme rainfall and temperature suggests potential instances of super Clausius-Clapeyron scaling in several locations.

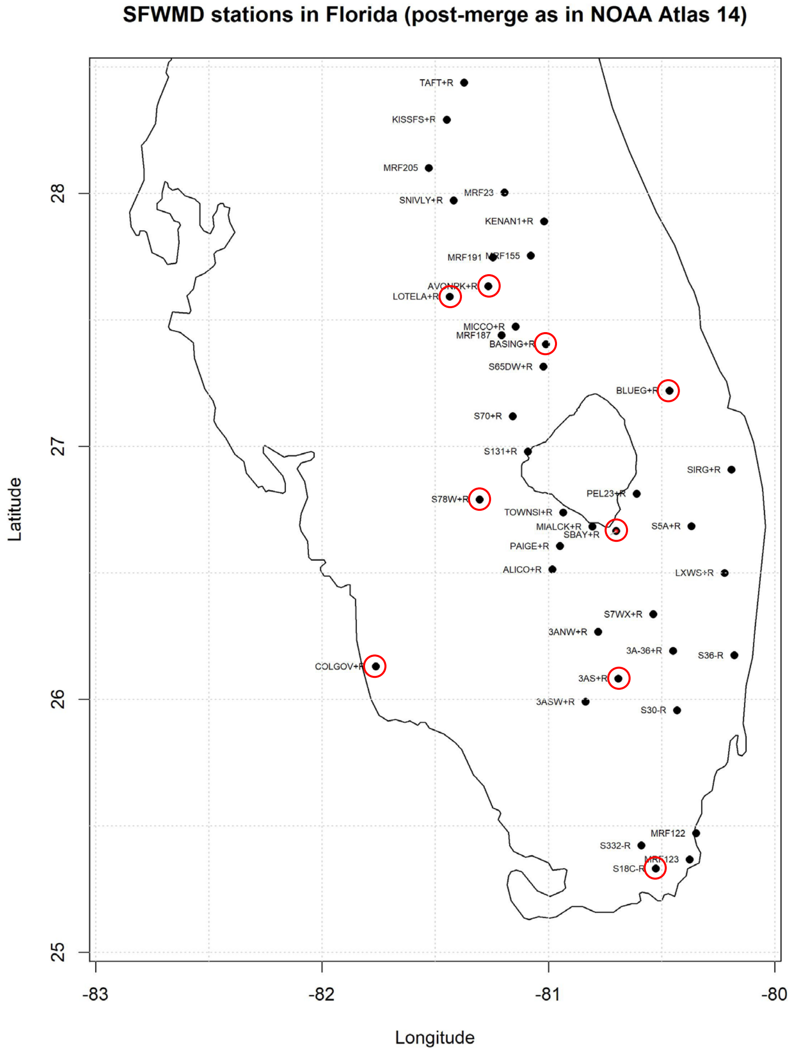
Outline

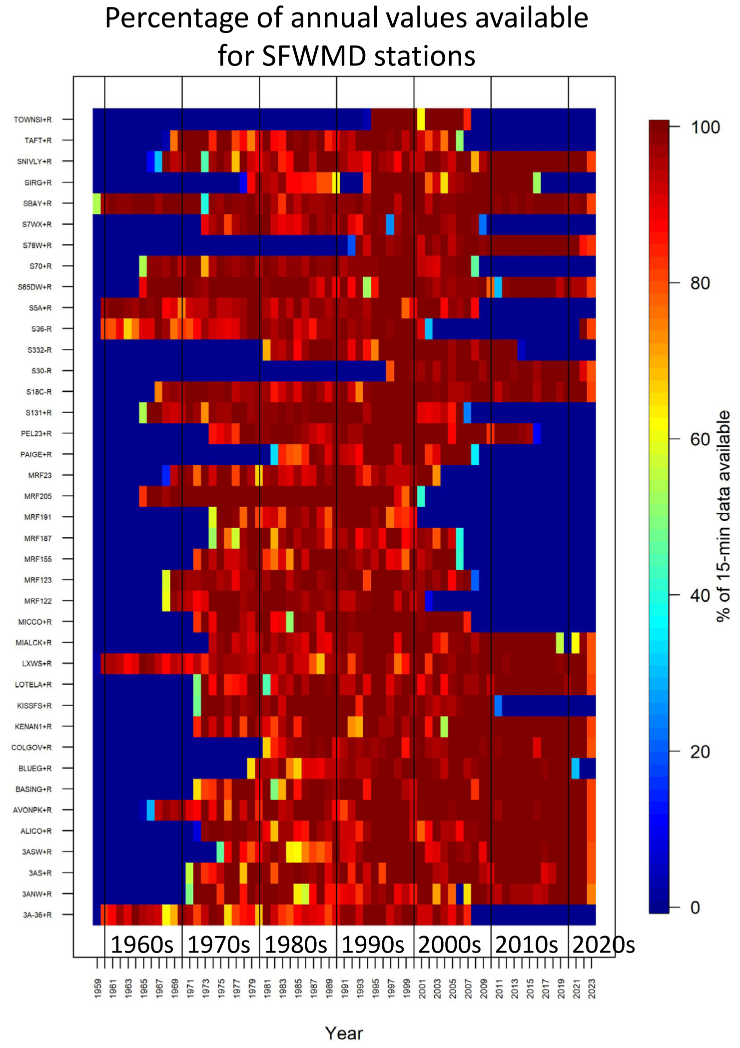
DATA AVAILABILITY:
DAILY, 5-15 MIN, SATELLITE

TREND ASSESSMENT:
STATISTICAL METHODS

TEMPERATURE SCALING:
CLAUSIUS-CLAPEYRON

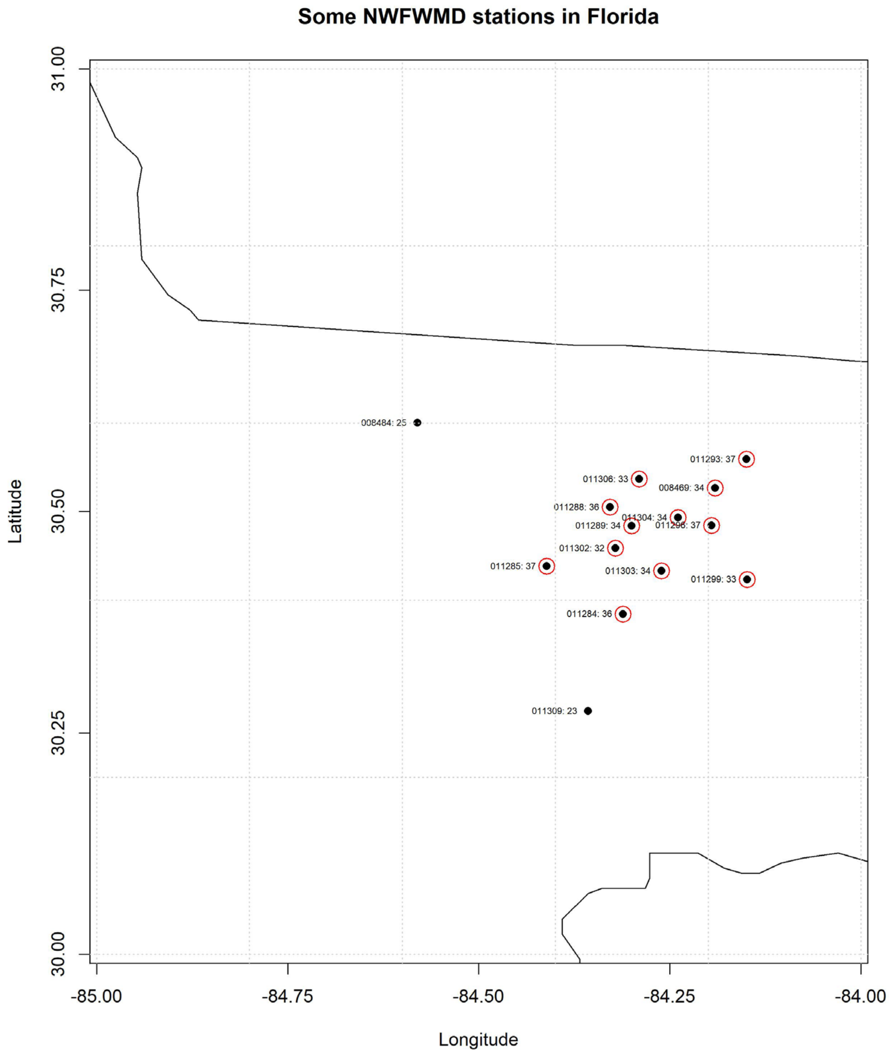
SFWMD 15-min Data

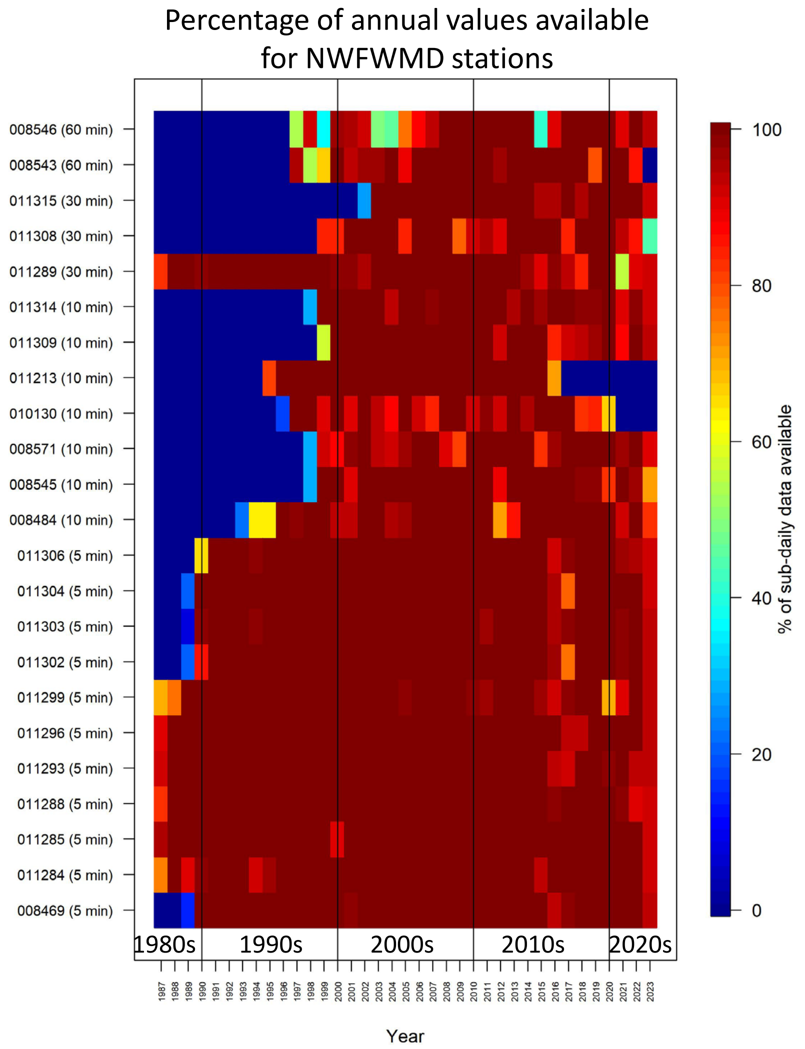




9 SFWMD stations (circled in red) have > 90% of 15-min rainfall data available per year for at least the last 30 years.

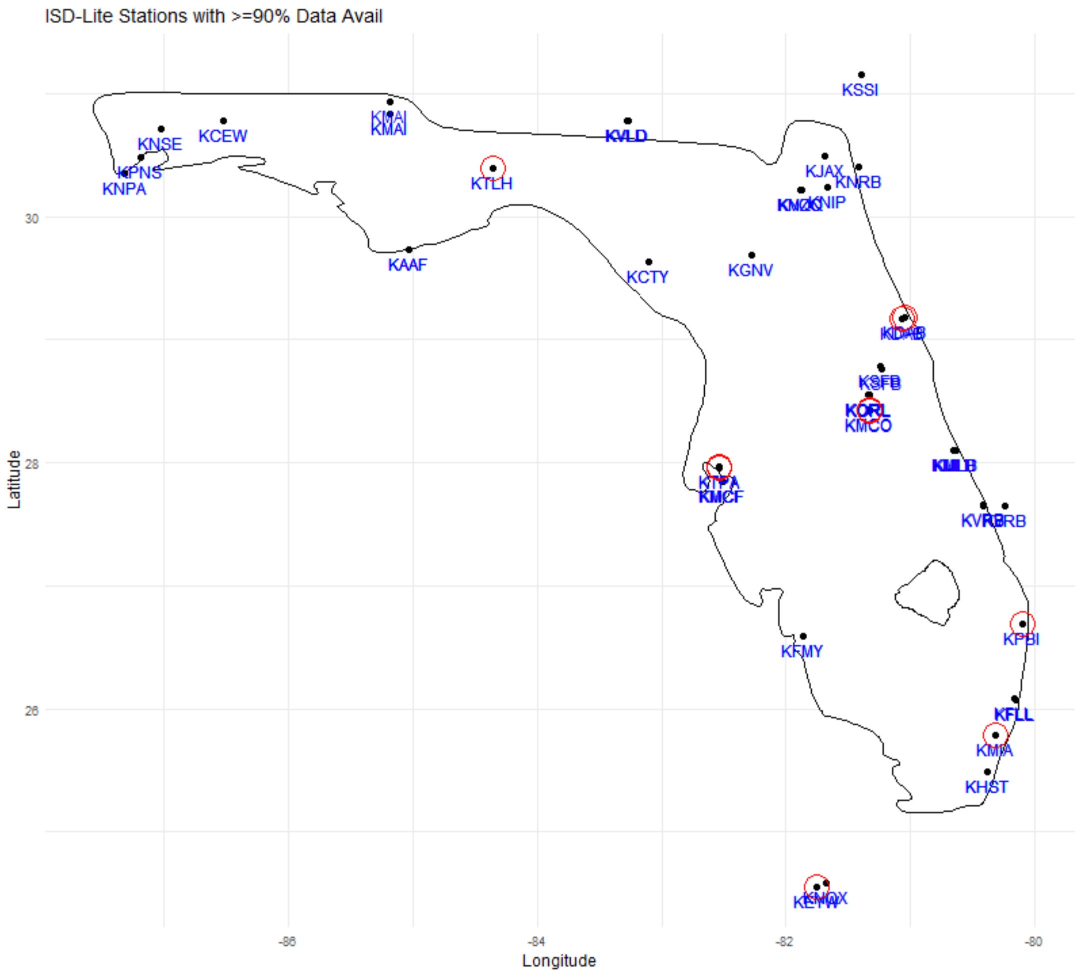
NWFWMD 5-min Data

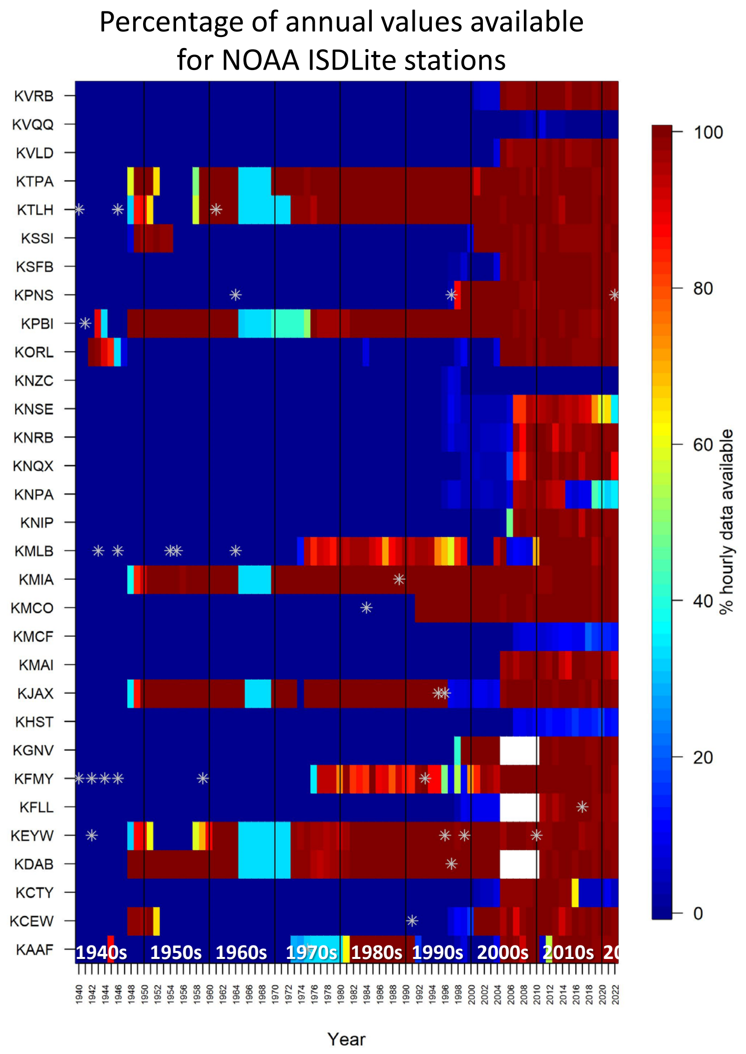




12 NWFWMD stations (circled in red) have > 90% of 5-min rainfall data available per year for at least the last 30 years (all located within Tallahassee).

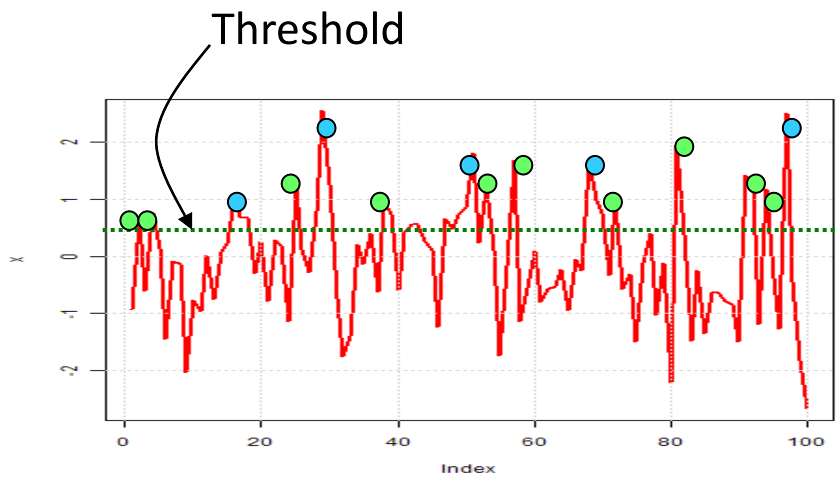
NOAA Integrated Surface Data (ISD)-Lite Data





7 NOAA ISD-Lite (circled in red) have > 90% of 60-min rainfall data available per year for at least the last 30 years (all located at airports).

Poisson Process Model – Trends in frequency



- **Nonhomgeneous Poisson Process (NHPP)**

$$\log(\lambda(t;\beta)) = X^T(t)\,\beta$$

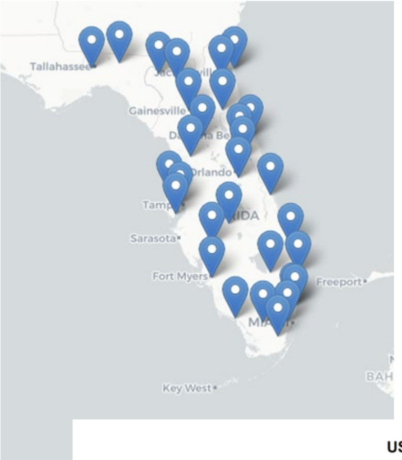
R package: NHPoisson (Cebrian et al. 2015)

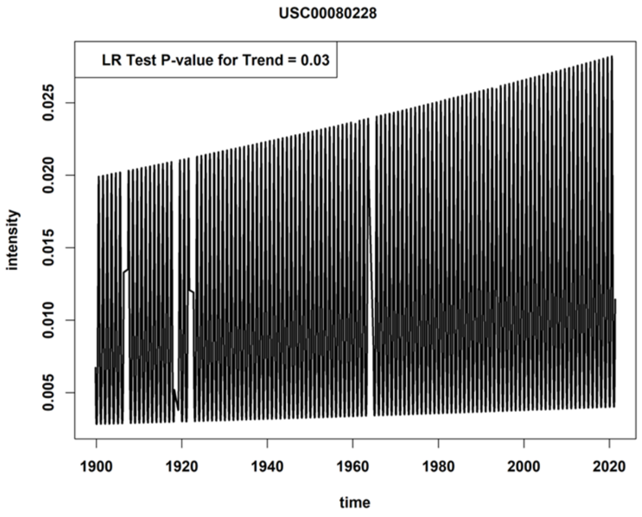
$$LL\left(\beta;(t_i)_{i=1}^{n}\right) = -\sum_{t=1}^{T}\lambda(t;\beta) + \sum_{i=1}^{n}\log\lambda(t_i;\beta),$$

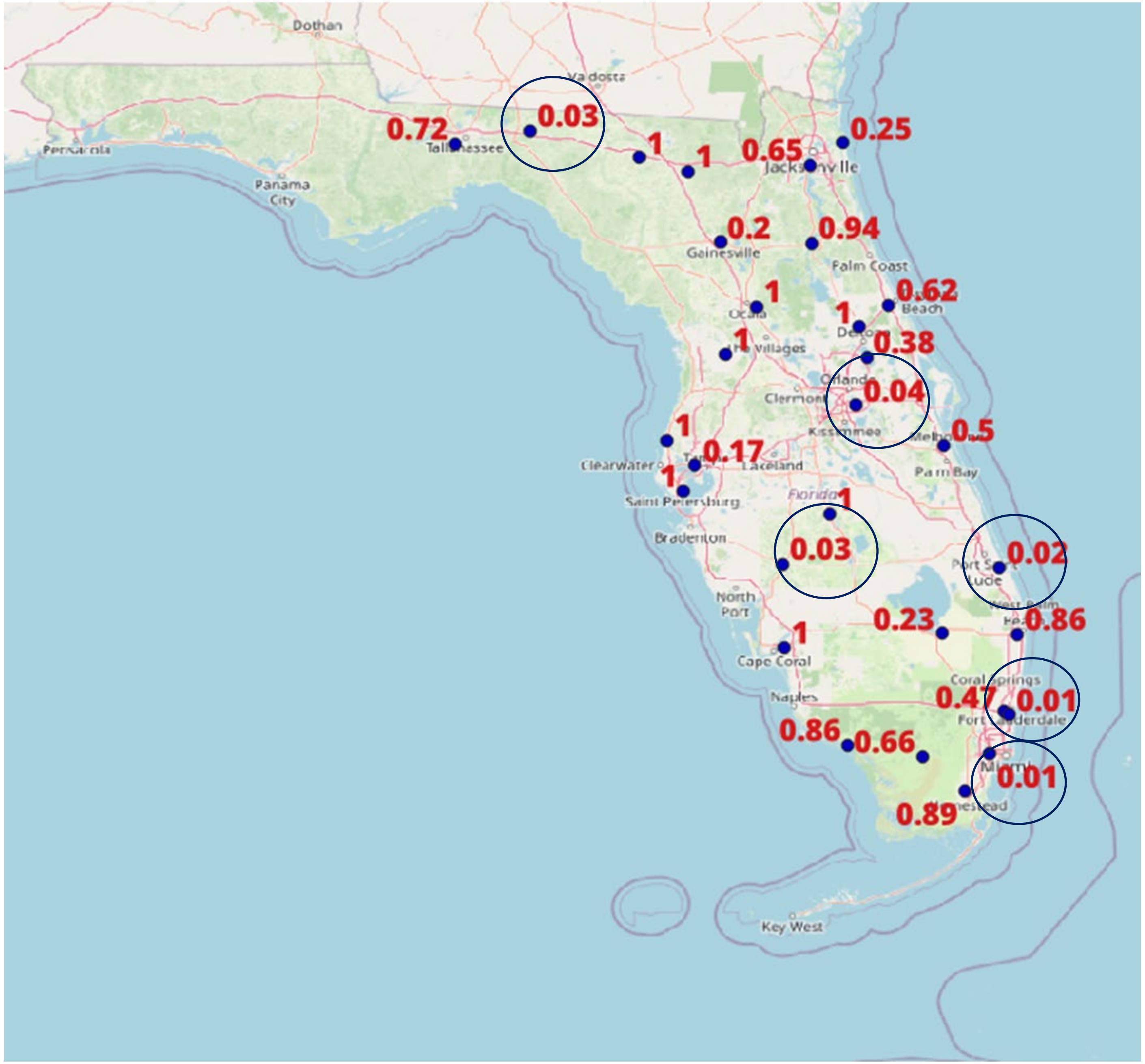
- Fixed λ (over time)
- λ as a function of a single harmonic
  - covB <- f(cos(2 * pi * yday / 365),sin(2 * pi * yday / 365))
- λ as a function of a single harmonic and time (t)
  - covB <- f(cos(2 * pi * yday / 365),sin(2 * pi * yday / 365),tyear-byear)
- Likelihood Ratio Test to determine the significance of the models:
  - p0 = p-value, Fixed vs. Single Harmonic
  - p1 = p values, Single Harmonic vs. Single Harmonic+Trend

Daily Trends

30 rain gauge locations





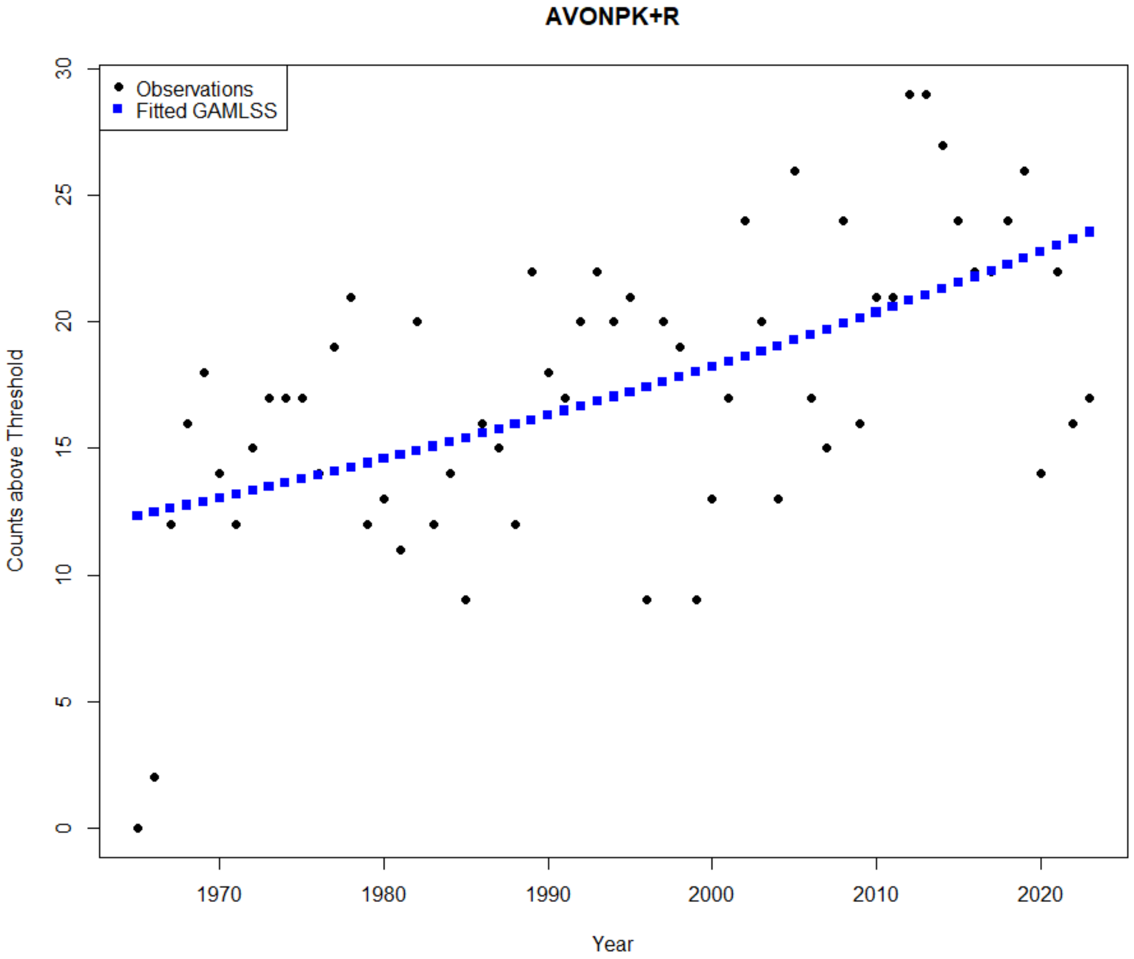


GAMLSS Modeling of 15-min data

- **G**eneralized **A**dditive **M**odel for **L**ocation, **S**cale and **S**hape Parameters (GAMLSS)
- Observations, $\boldsymbol{y_i}$, pdf **f**$(\boldsymbol{y_i}|\boldsymbol{\theta^i})$, $\boldsymbol{\theta^i} = (\boldsymbol{\mu_i}, \boldsymbol{\sigma_i}, \boldsymbol{\nu_i}, \boldsymbol{\tau_i}), \boldsymbol{i} = \boldsymbol{1}, \boldsymbol{2}, \ldots \boldsymbol{n}$
- Most general form

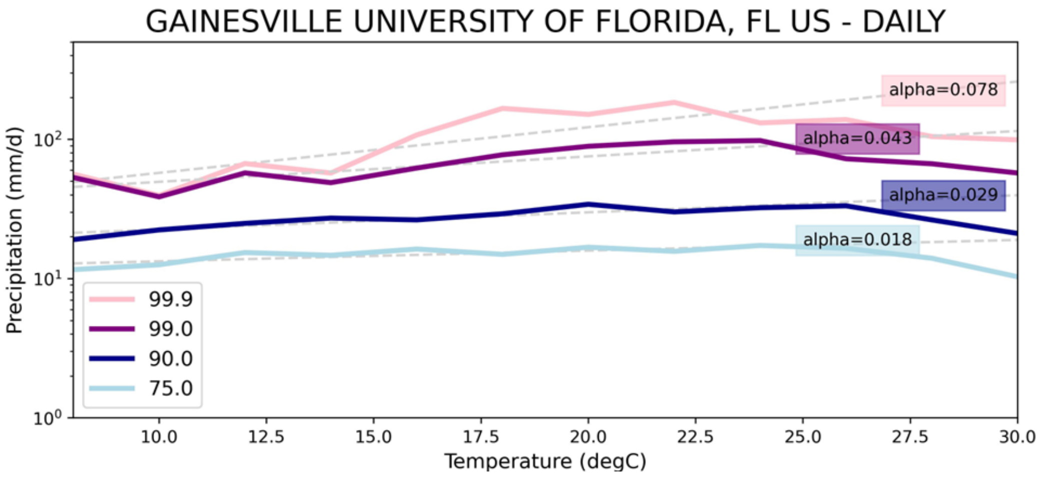
$$\boldsymbol{g_k(\theta_k) = \eta_k = X_k \beta_k}$$

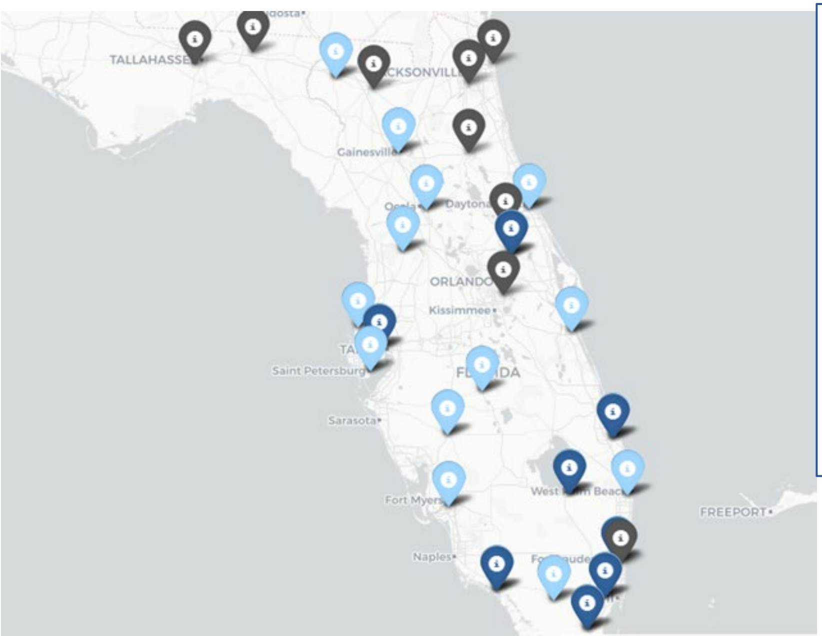
- **Variable: Number of Counts above a pre-specified threshold** in the daily maxima series
  - Counts [dmax > threshold]
- **Modeled Counts as Poison Distribution** with location parameter = f(time) - nonstationarity



Temperature Scaling

- Deriving the exponential relationship between precipitation and temperature to find the rate of chang (slope) Jones, et. et al. (2010):
  - $P_{t+\Delta t} = P_t(1 + \alpha)^{\Delta t}$
- Results in the increase of the water-holding capacity of the atmosphere by ~ 7% for every 1°C (1.8°F) rise in temperature (empirically): **Clausius-Clapeyron (CC)**
  - > 7% = Super relationship (SCC)
  - > 14% = Double relationship (2CC)





Dark blue – Super CC (Alpha > 12%)

Light blue – CC (Alpha > 7%)

Gray - Others

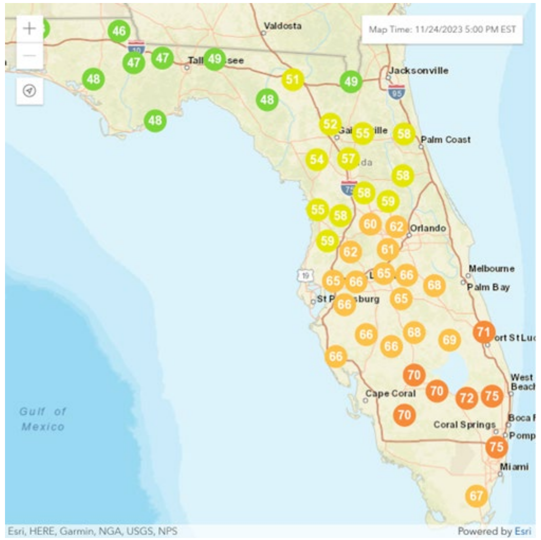
Temperature Scaling (with Dew Point): 15 min. FAWN Data

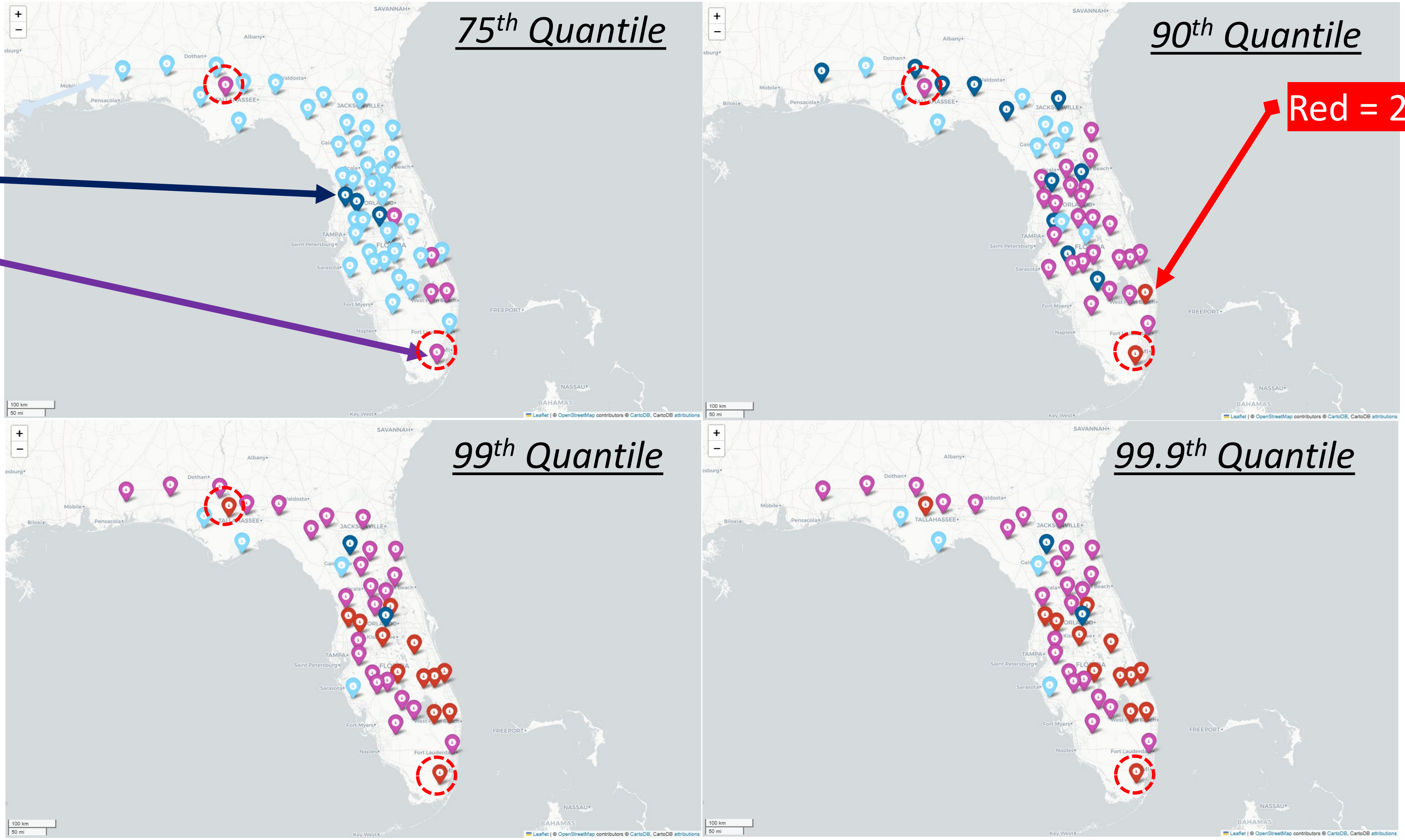
Light-blue = sub-CC

Dark-blue = CC

Purple = SCC

Red = 2CC





RESULTS – Alpha Value Totals

Station Percentages by Quantile (52 stations)

Quantile	Alpha < 0.07	0.07 <= Alpha < 0.14	Alpha >= 0.14	All Alpha > 0.07
75.0%	84.62%	15.38%	0.00%	15.38%
90.0%	23.08%	75.00%	3.85%	75.00%
99.0%	7.69%	55.77%	26.92%	82.69%
99.9%	7.69%	55.77%	26.92%	82.69%

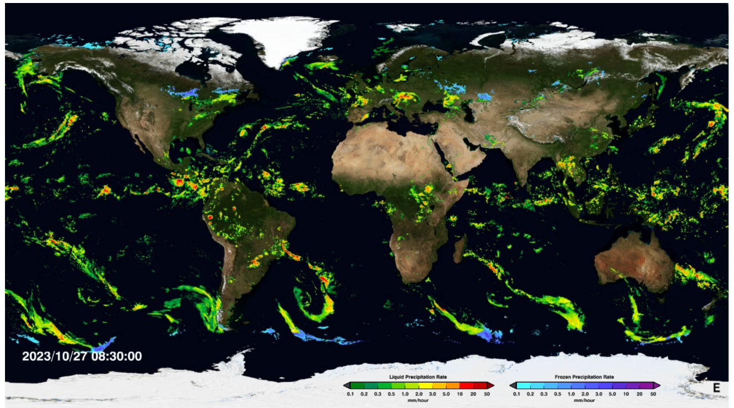
sub-CC

Standard-CC

Double-CC

Super-CC

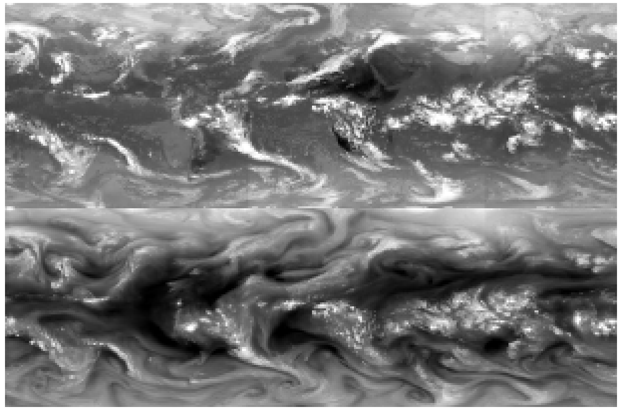
SATELLITE & MODEL DATA



IMERG - GPM

Integrated Integrated Multi-satellite Retrievals for GPM

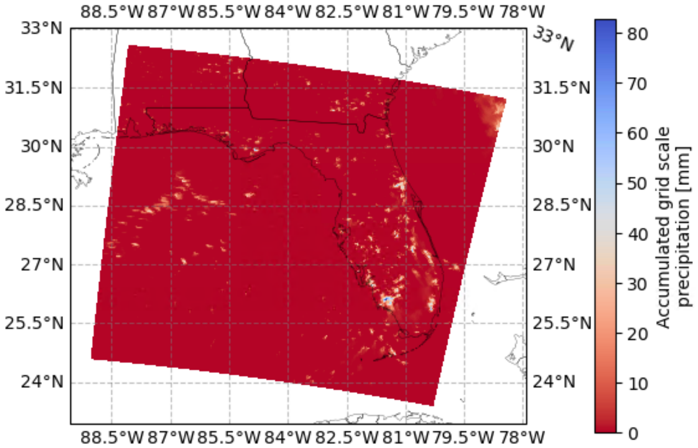
Precipitation satellite retrievals,
on **<u>1/10th degree grid every 30 minutes</u>**
(We only used every 3 hours to match with GRIDSAT-B1)
From June 2000 until December 2021



GRIDSAT Dataset

Geostationary IR Channel Brightness Temperature - GridSat B1

Top of the cloud temperatures, (near 11 microns)
on **<u>0.07 degree grid every 3-hours</u>**
From January 1981 to December 2020.



CONUS 404

WRF-Based hydro-climate database Temperature, dewpoint at 2 meters, and accumulated grid scale precipitation

Temperature, dewpoint, and precipitation
on **<u>4 km grid every hour</u>**
From January 1980 to December 2021.

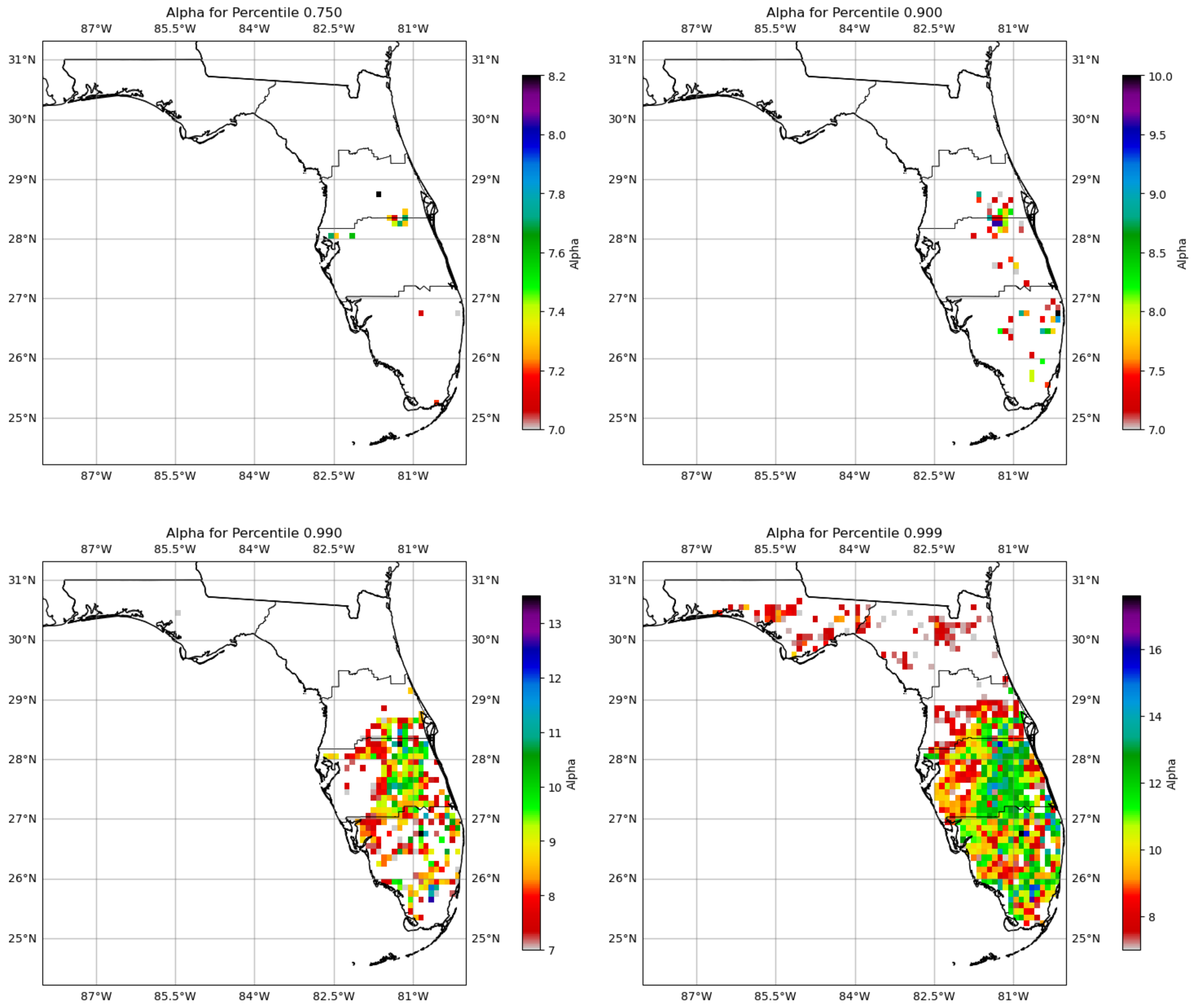
RESULTS Clausius–Clapeyron Scaling at the surface

CONUS404 Temperatures (2m)

With

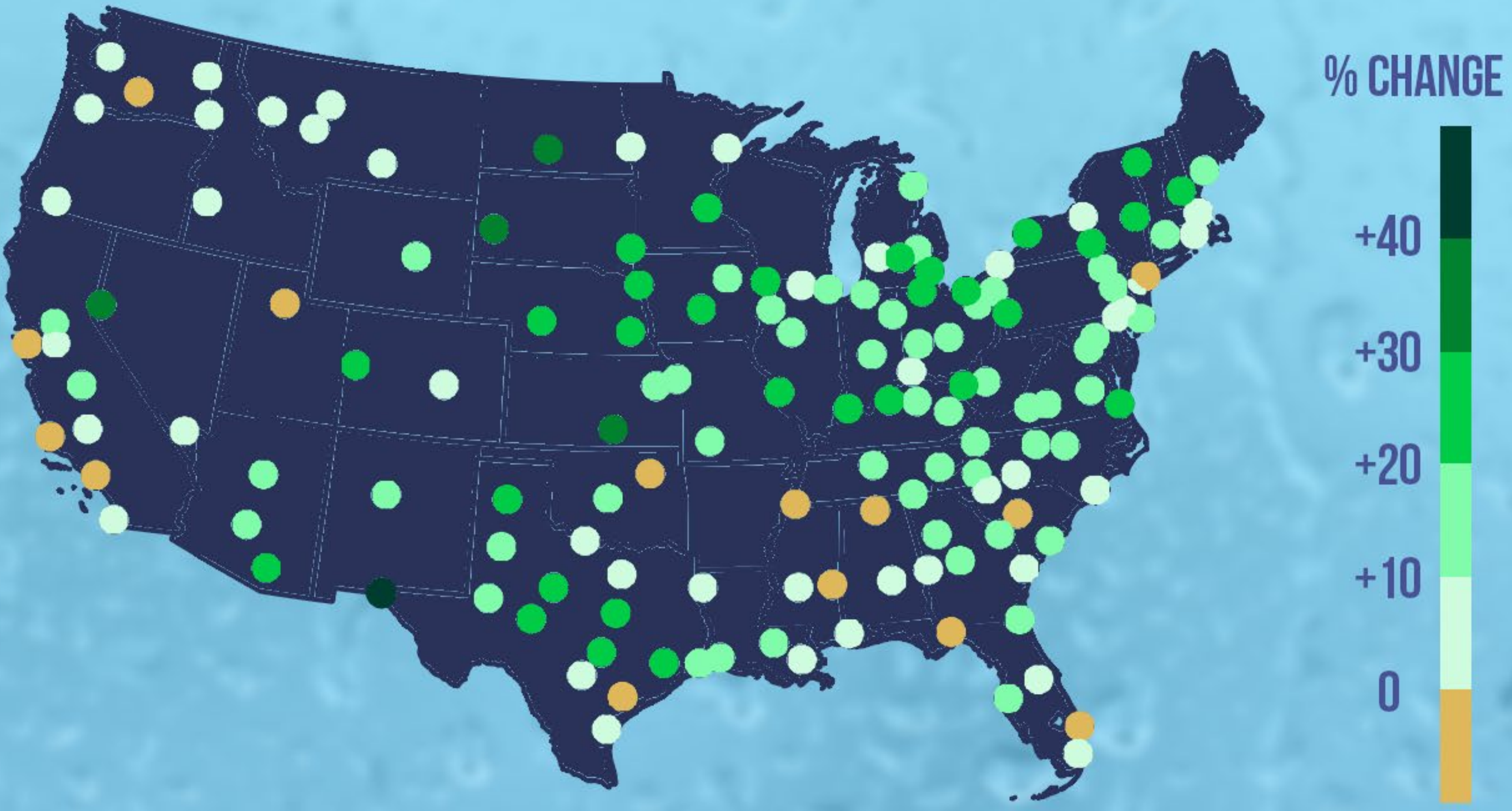
IMERG Precipitation

CC-scale plots
White areas = below 7%



RAINFALL INTENSITY

Change in annual average hourly rainfall since 1970



Average hourly rainfall is the total annual rainfall divided by the number of hours with rainfall.
Source: RCC-ACIS.org; NCEI Climate at a Glance

CLIMATE CENTRAL