



# Seasonal Forecasting and Extension Applications with Weather Generators

Adrienne Wootten  
Southeast Climate Consortium  
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# Introduction

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## What is a weather generator?

- Wilks and Wilby (1999)
- Models of daily weather sequences
- Can fill in missing data or produce weather series which simulate properties of observed weather records or forecasts
  - Agriculture, ecosystem simulations



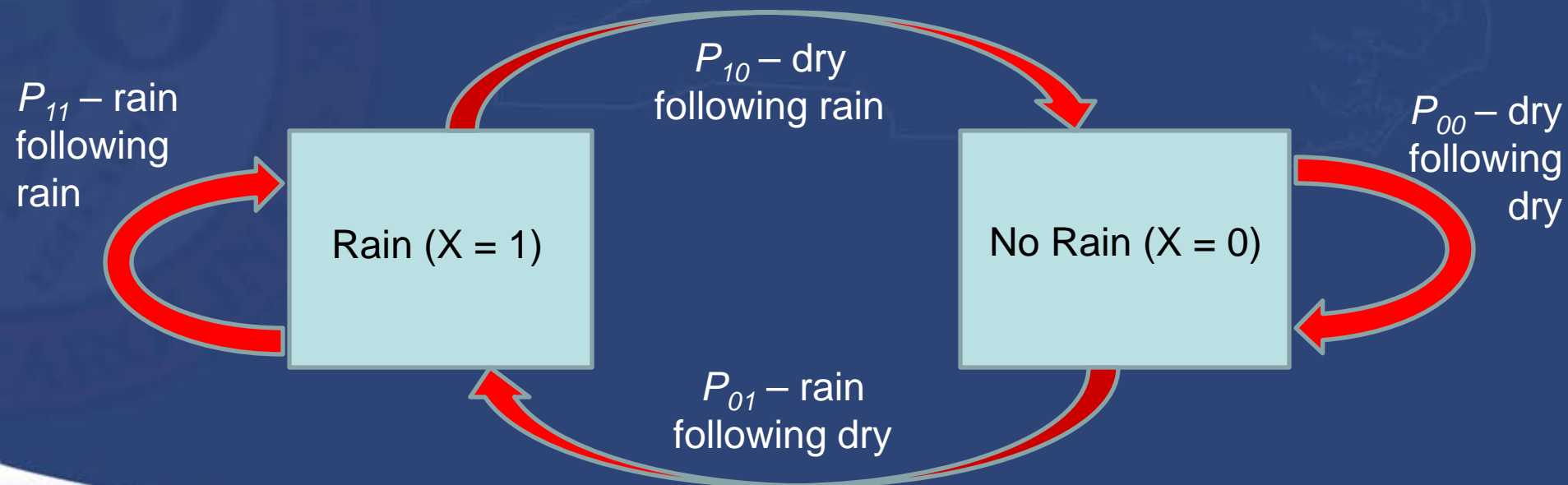
# Generator Structure

- Precipitation events
- Precipitation amounts
- Maximum / Minimum temperatures
- Solar Radiation
  - Generated using precipitation as a surrogate for cloud cover.
  - Commonly use Auto regression



# Event Generation

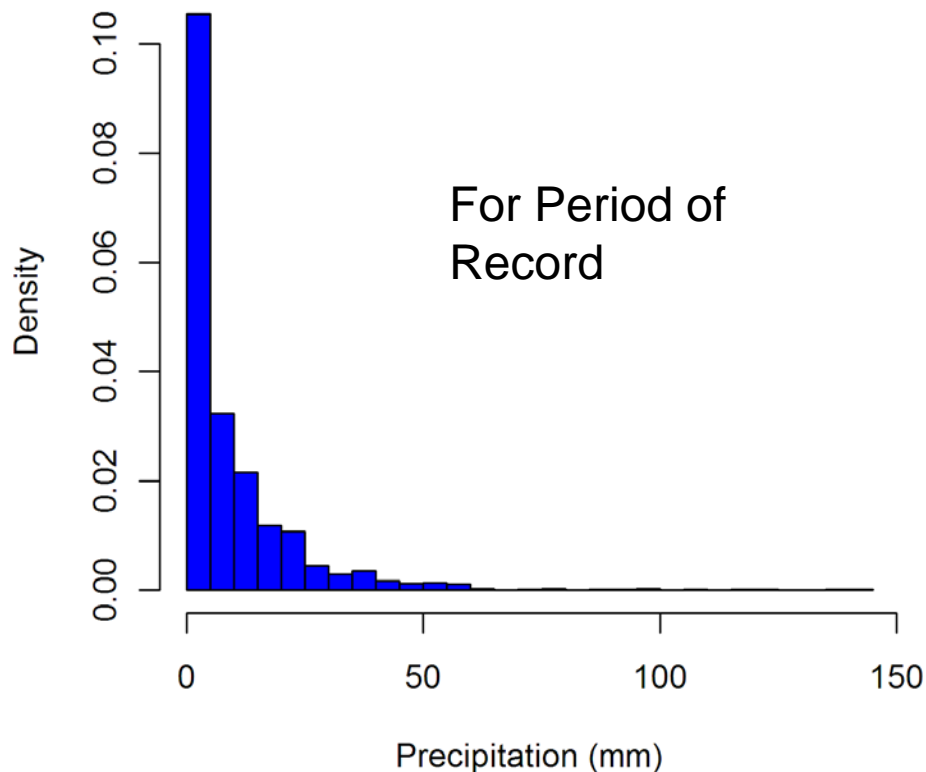
- Markov chains for events



# Amount Generation

- Precipitation amounts are drawn from statistical distributions
  - Gamma
  - Exponential
  - Mixed-Exponential

Histogram of Historical Daily Nonzero Precipitation at Raleigh-Durham Airport (KRDU)



# Weather Generator History

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- WGEN (Richardson and Wright, 1984)
- LARS-WG (Racsko et al, 1991, Semenov and Barrow, 1997)
- Geo-Spatial Temporal Weather Generator (GiST, Baigorria and Jones, 2010)
  - based on WGEN



# Advantages

- Can produce a virtually limitless number of scenarios of any length in areas with sparse observed data
- Can be easily perturbed such that scenarios reflect changes in both the mean and the variability.



# Disadvantages

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- Lack of consideration of spatial structure
- Do not capture the variability associated with extreme events.
- Recent studies have looked at both



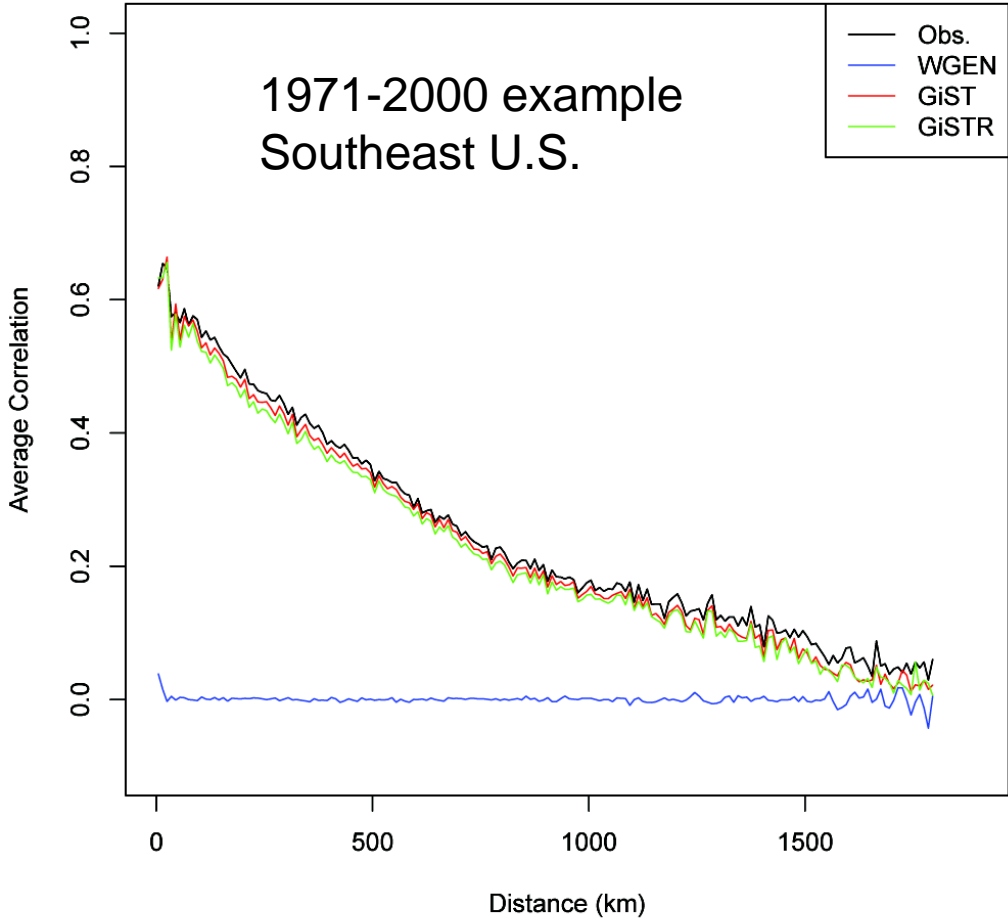
# Spatial Structure

- Most Weather generators are like WGEN, they don't incorporate spatial structure
- GiST / GiSTR incorporate spatial structure



# Spatial Structure

Average Decay Function Correlogram For Month : 1  
Precipitation Events



Most Weather Generators have the problem that WGEN has, they can't replicate the observed spatial structure, such as shown by these average decay function correlograms.

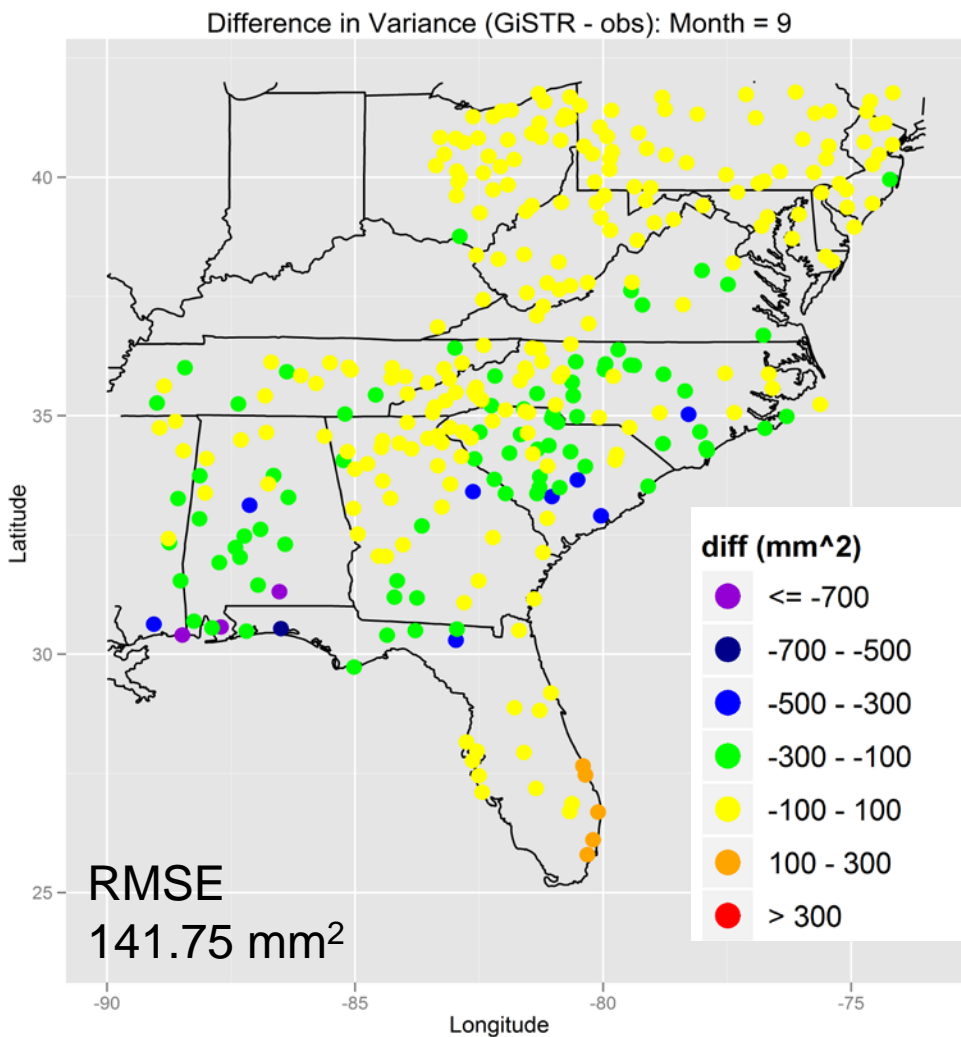
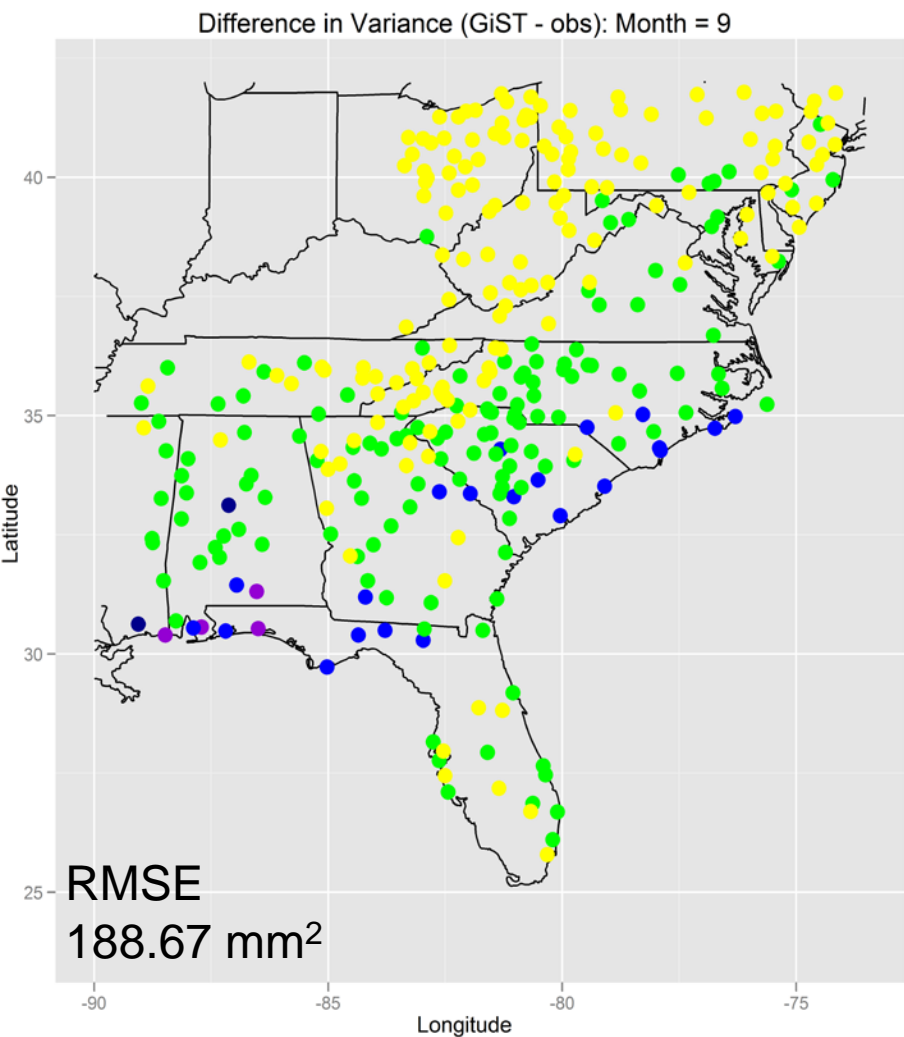
GiST and GiSTR are the exception

# Precipitation Extremes

- Most generators have a tendency to underestimate two things
  - The variance of daily nonzero precipitation
  - The inter-annual variability
- Addressed by several investigators in the past five years.



# Precipitation Extremes



# Applications

- Historically
  - Producing synthetic weather data as inputs for crop models
    - Precipitation
    - Max / Min Temperature
    - Solar Radiation
- Recently – Seasonal Forecasting / Climate Change Studies



# Recent Applications

- Seasonal Forecast Downscaling
- Climate Change Downscaling

Downscaling with weather generators works by perturbing the inputs to reflect the change portrayed by the GCM used



# More Applications

The advantages of weather generators lend them to providing:

- Multiple Daily Realizations
  - Multiple scenarios fed to crop and hydrology models
- Point Probabilistic Guidance
  - Point Downscales from generators
  - Direct Information for the end user



# Application Example

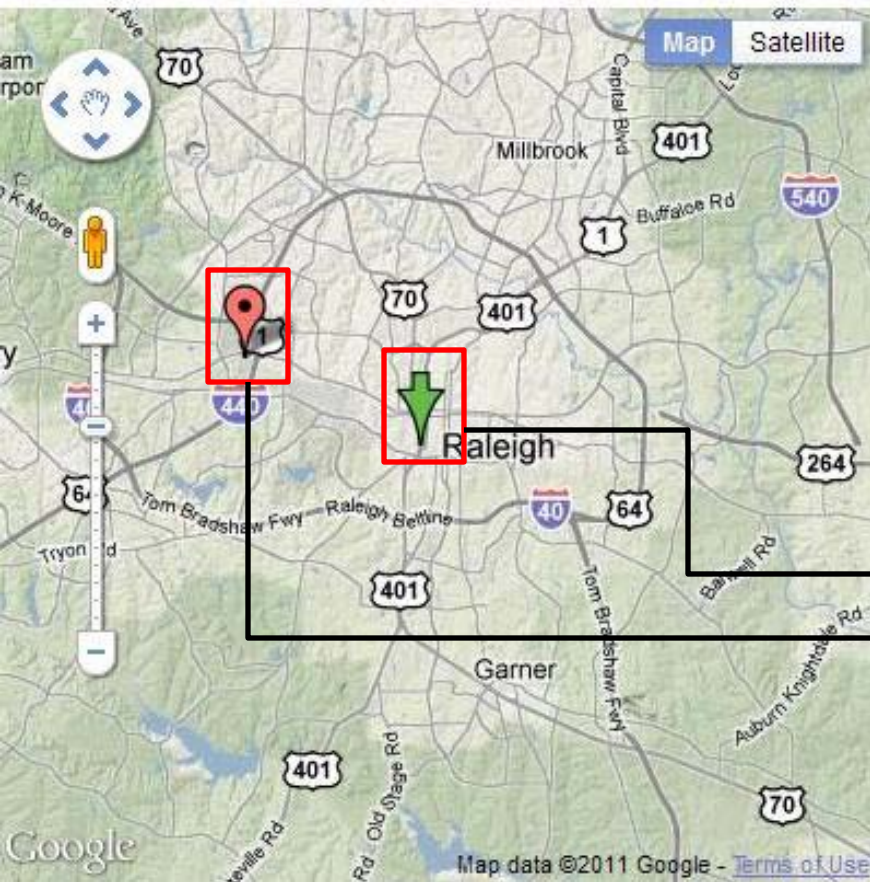
- Suppose a user is interested in the following
  - Number of rainy days
  - In Raleigh, NC
  - During summer

The output a user might see, may include things like this...



# CFS / GiST Local Seasonal Forecast

## June, July, August 2011



### Forecast Summary

Number of Days with Rain	40 days $\pm$ 5 days
Maximum	50 days
Minimum	30 days
Normal Number of Days with Rain	35 days $\pm$ 5 days

Requested Location: Raleigh, NC

Nearest Forecast Location:

Station: 317079

Name: Raleigh State Univ.

City, State: Raleigh, NC

Distance: 3.718 miles

[Modify Query](#)

*This fictional example indicates the combined CFS and GiST forecast for the number of days with rain, with several measures of confidence and a comparison to what is normal during that season in that location. But what about a query of how likely it is to receive a certain amount of rain...*

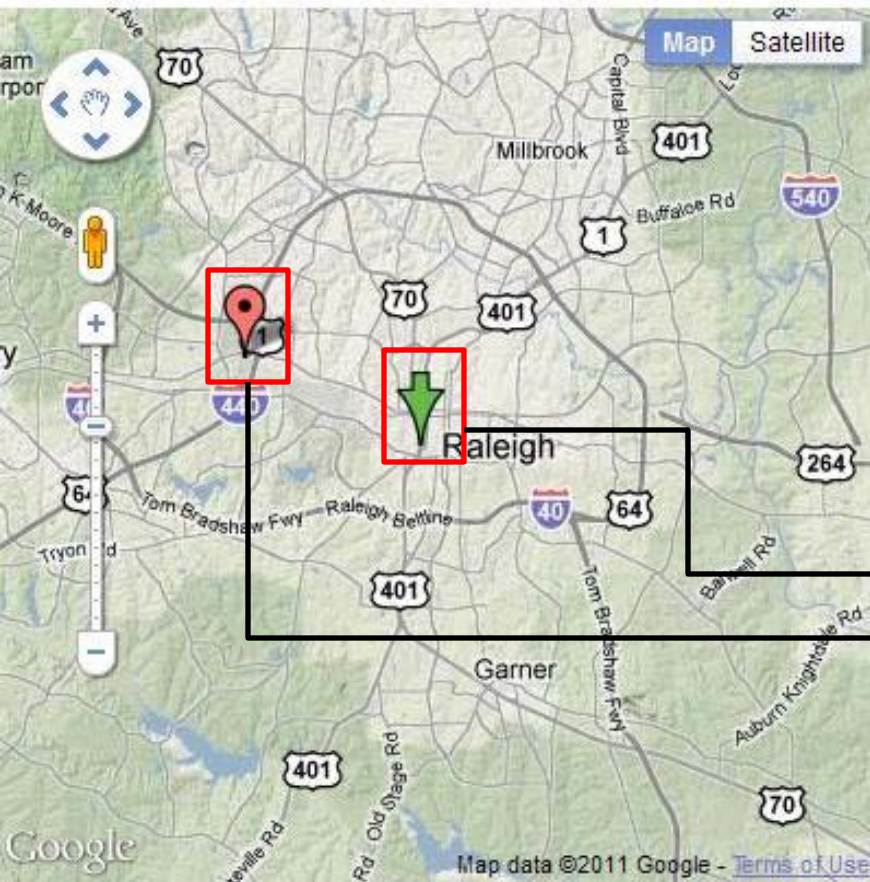
# Modify Query

- Likelihood of Less than 10 inches of total rainfall
- Raleigh, NC
- Summer 2011



# CFS / GiST Local Seasonal Forecast

## June, July, August 2011



### Forecast Summary

*Probability of Less than 10 total inches of precipitation*

30%

How often has the total precipitation been less than 10 inches?

23%

Requested Location: Raleigh, NC

Nearest Forecast Location:

Station: 317079

Name: Raleigh State Univ.

City, State: Raleigh, NC

Distance: 3.718 miles

Modify Query

*This fictional example indicates the combined CFS and GiST forecast for how likely that the total precipitation will be less than 10 inches. In this case, "normal" might be more indicated by how often the event of interest has occurred in history.*

# Other notes

- Parameters of interest to the user derived from the ensemble produced by the downscaling process
- All ensemble members available as inputs to other models.
- Other visualizations include mapping or gridding the results



# Closing Remarks

- The advantages lend weather generators to do more than produce synthetic weather data
- What's lacking?
- What are the details of how a generator works?
  - Come by my poster to learn more!





# Questions and Discussion