

Analysis of Heavy Multi-day Precipitation Events In CMIP6 Model Simulations in Support of the Fifth National Climate Assessment

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Research Question

- Can global climate models simulate the climatology of the largest precipitation events?
- Will such events increase as the globe warms in response to increasing greenhouse gas concentrations?

Research Approach

- Analysis of historical precipitation data to identify the largest multi-day precipitation events in the U.S. historical record
- Analysis of select global climate model simulations from the new CMIP6 archive

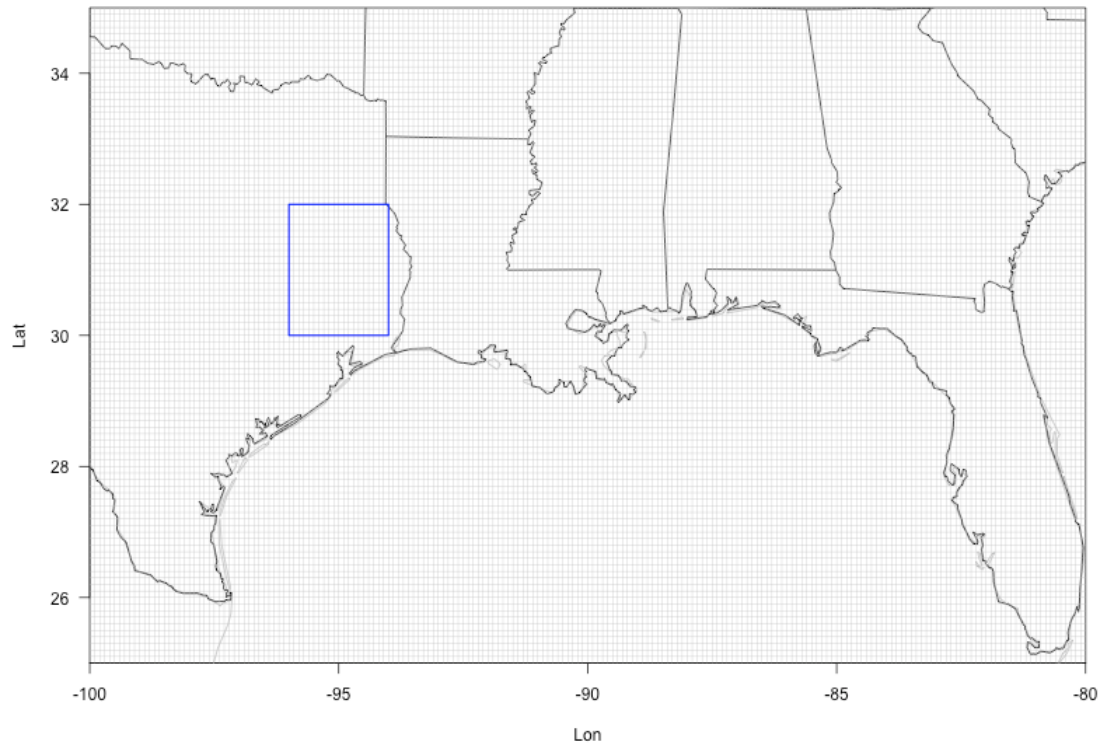
Historical Precipitation Analysis

- Examination of area-averaged rainfall in approximately square boxes
- 1949-2018
- Conterminous U.S.
- For temporal consistency, only used with less than 10% missing daily precipitation data from the Global Historical Climatology Network

Historical Precipitation Analysis

- Defined an overlapping grid of cells separated by $1/5$ degree in latitude and $1/5$ degree in longitude covering conterminous U.S.
- Within the grid, considered all possible 2-degree by 2-degree (nominal) cells (all cells like the bold box in the following figure) (an approximate area of 20,000 mi²)
- Computed daily precipitation for 1949-2018 as a simple average of all stations in each cell. All cells that are partly over water were not included in this analysis.

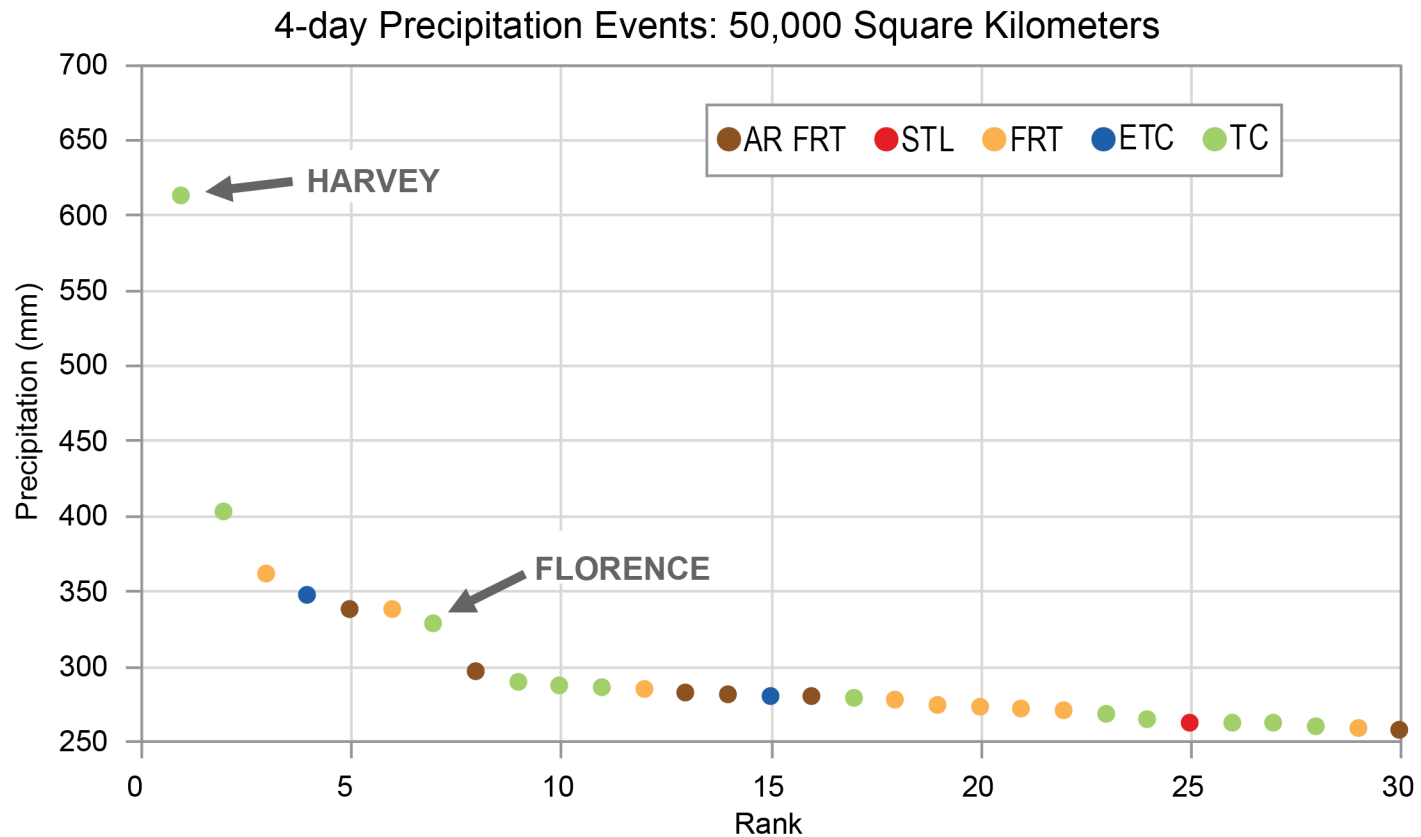
Grid Box Analysis



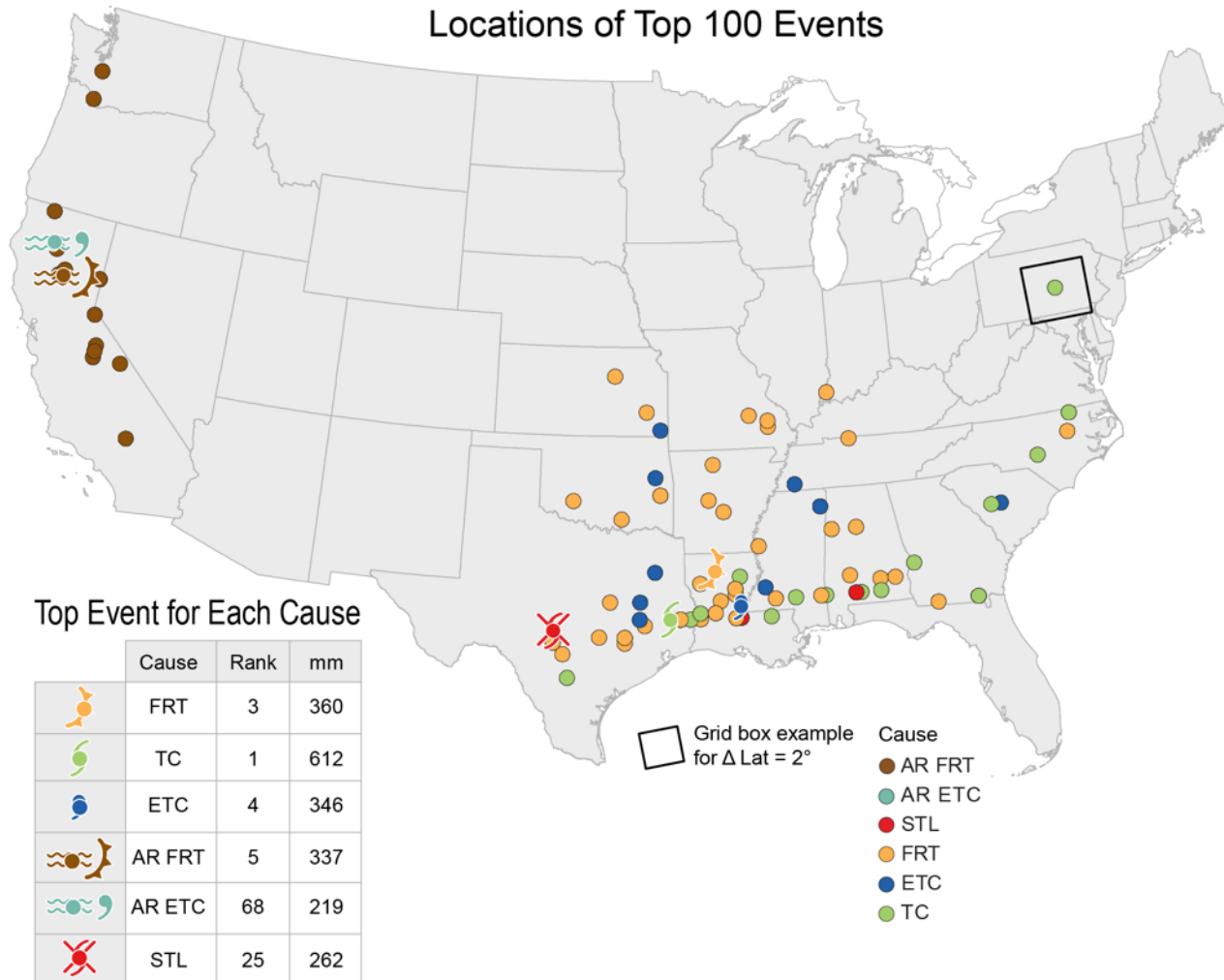
Historical Precipitation Analysis

- For each cell, identified the top (non-overlapping) **4-day precipitation** totals.
- Pooled everything (top events for all cells) together and identified the **top 100 events for 1949–2018** across the entire conterminous U.S., **eliminating** those that **overlap in time or space** with a larger event.
- Repeated analysis on several grid sizes from **1.0° to 3.0°**

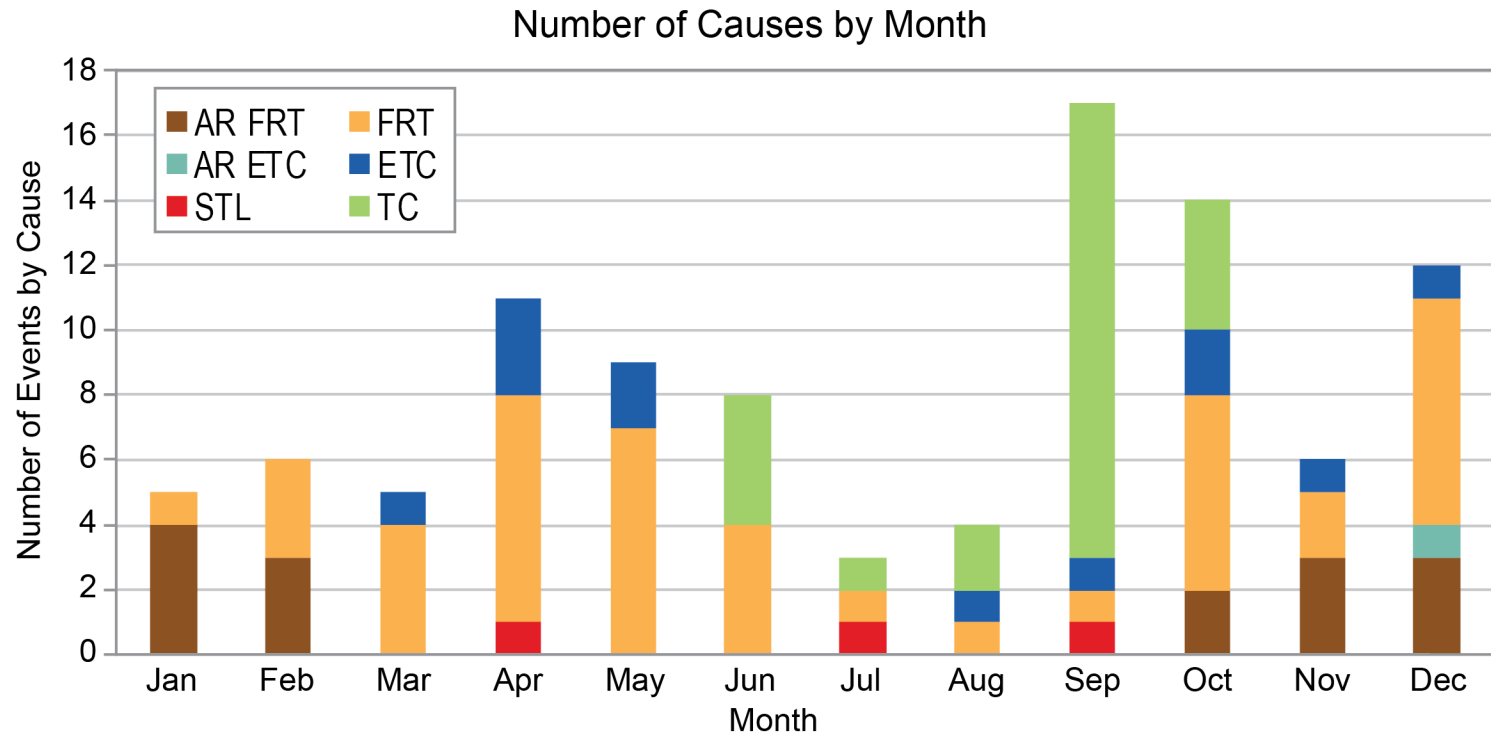
Top 30 Events-Ranked



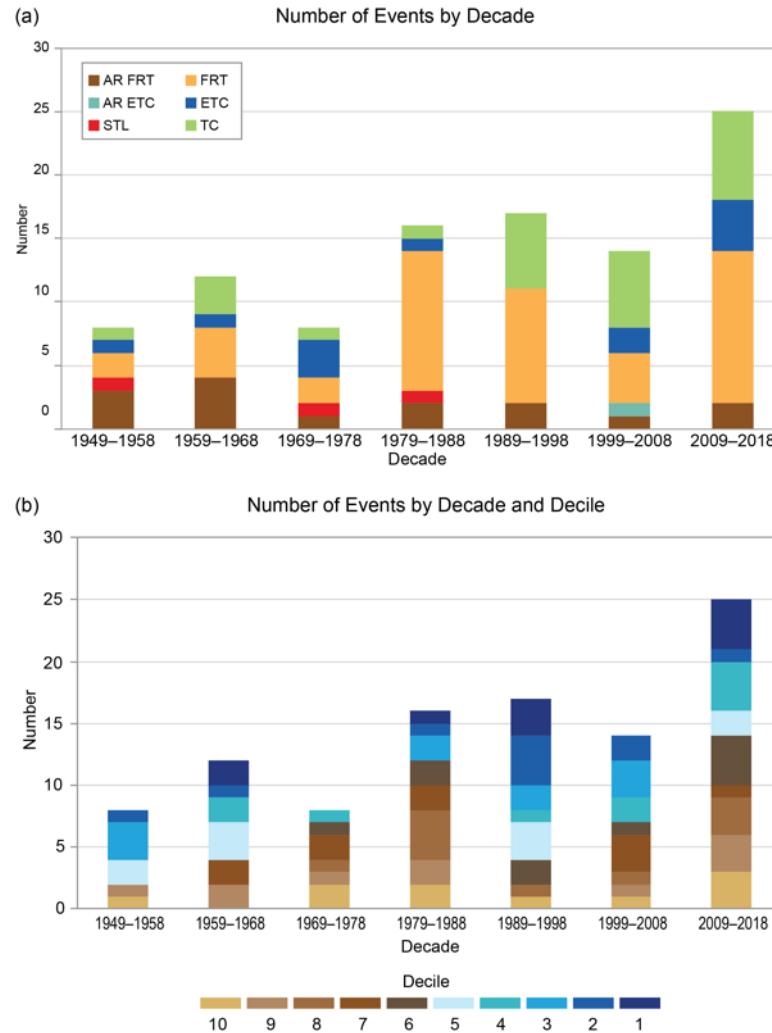
Locations and Causes



Monthly Distribution



Temporal Distribution



Historical Analysis – Key Findings

- Events concentrated along the Gulf and West Coasts
- 59% of events caused by fronts and 25% by tropical cyclones
- Two peaks in monthly distribution – spring and early fall
- Upward trend in the number of events

Historical Analysis – Key Findings

- Kunkel, K.E. and S.M. Champion, 2019: An assessment of rainfall from Hurricanes Harvey and Florence relative to other extremely wet storms in the United States. *Geophys. Res. Lett.*, 46, 13,500–13,506.
<https://doi.org/10.1029/2019GL085034>.

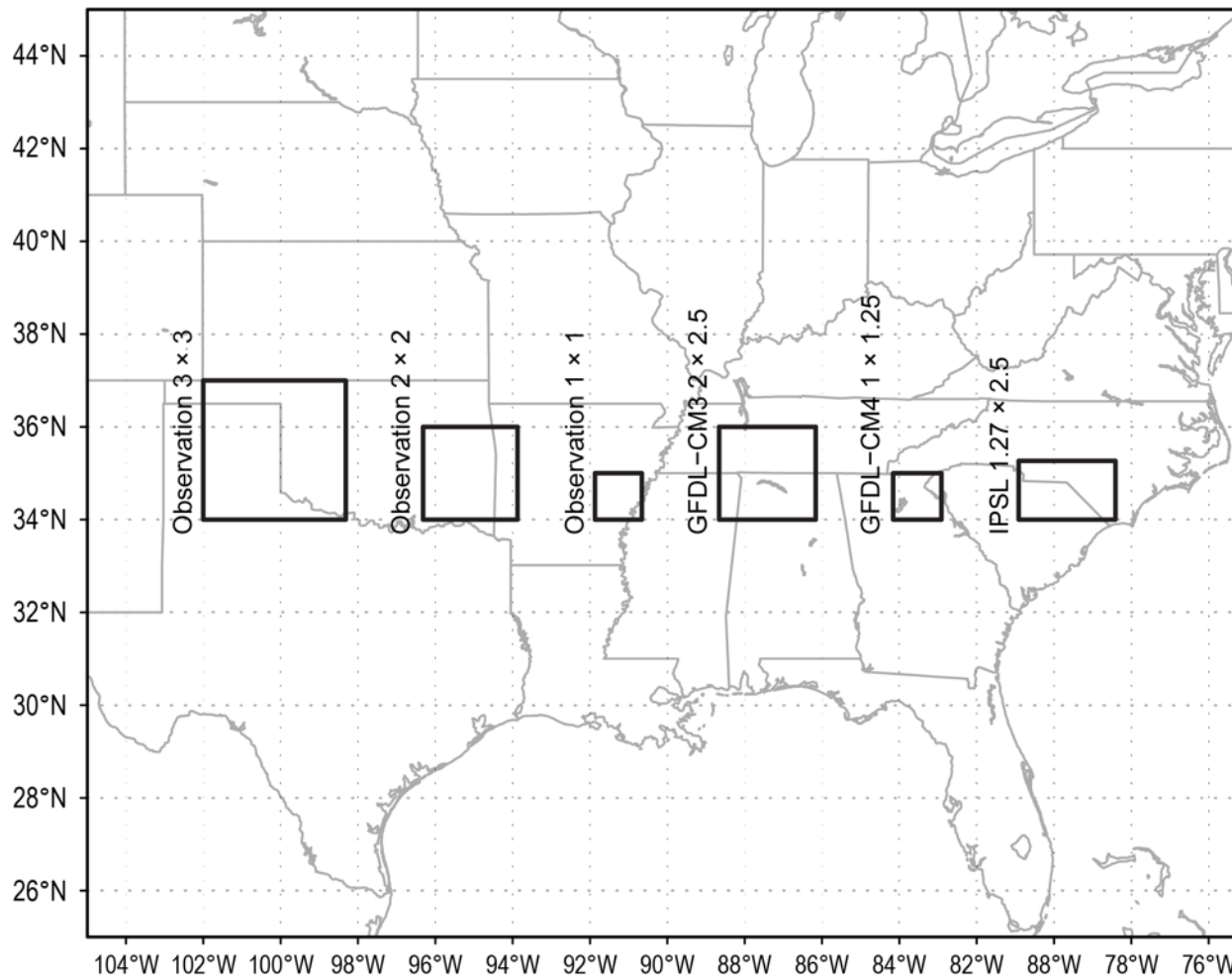
CMIP Precipitation Analysis

- Pilot analysis
- 1 model from CMIP5 and 2 from CMIP6
- NOAA GFDL
 - CM3: CMIP5, Pre-industrial control
 - CM4: CMIP6, Pre-industrial control
- IPSL
 - CMIP6, Pre-industrial control, Doubled CO₂

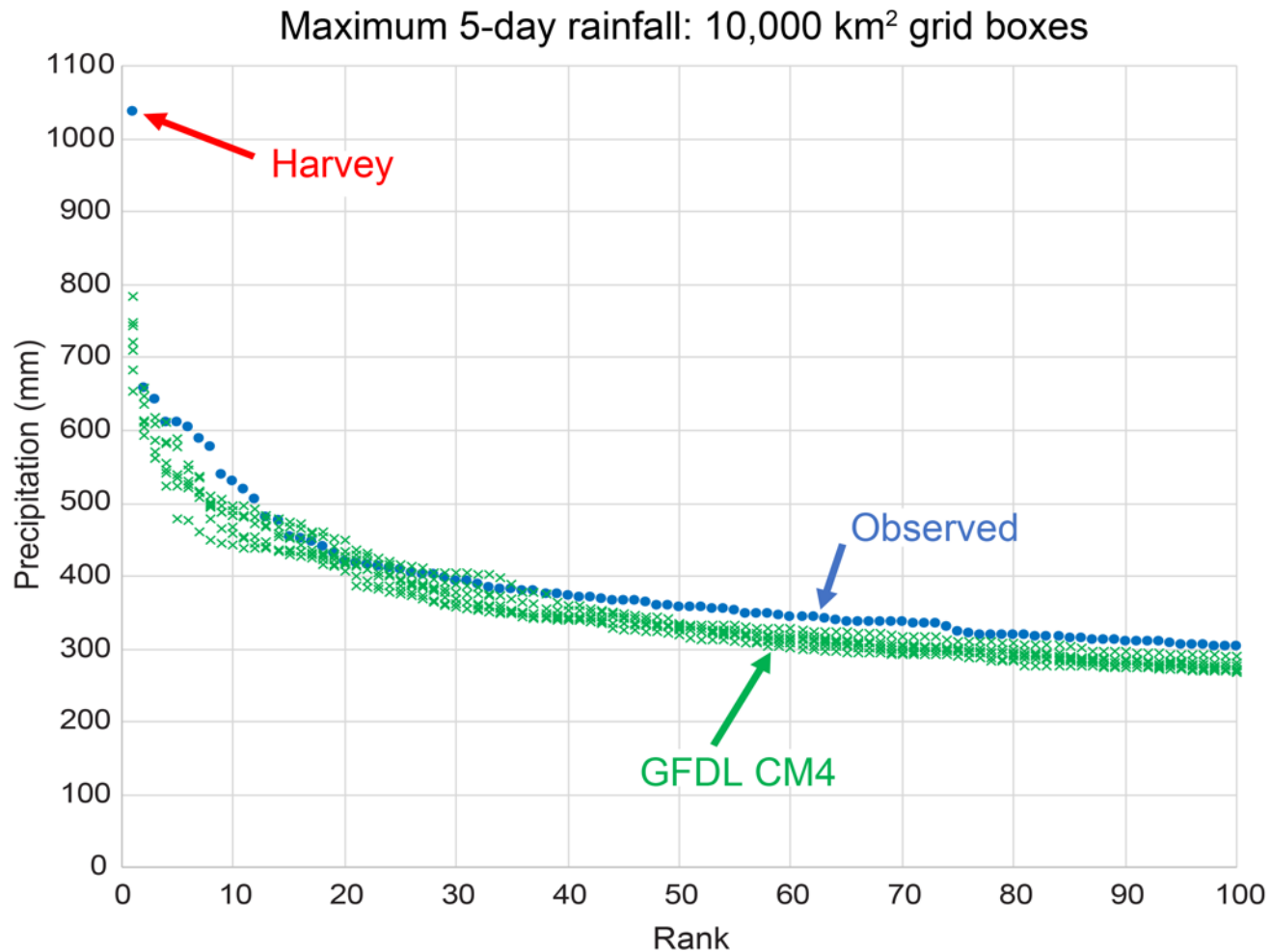
CMIP Precipitation Analysis

- Match historical analysis resolution with climate model native resolution
- Broke climate model simulations into 70-yr segments to match historical period length

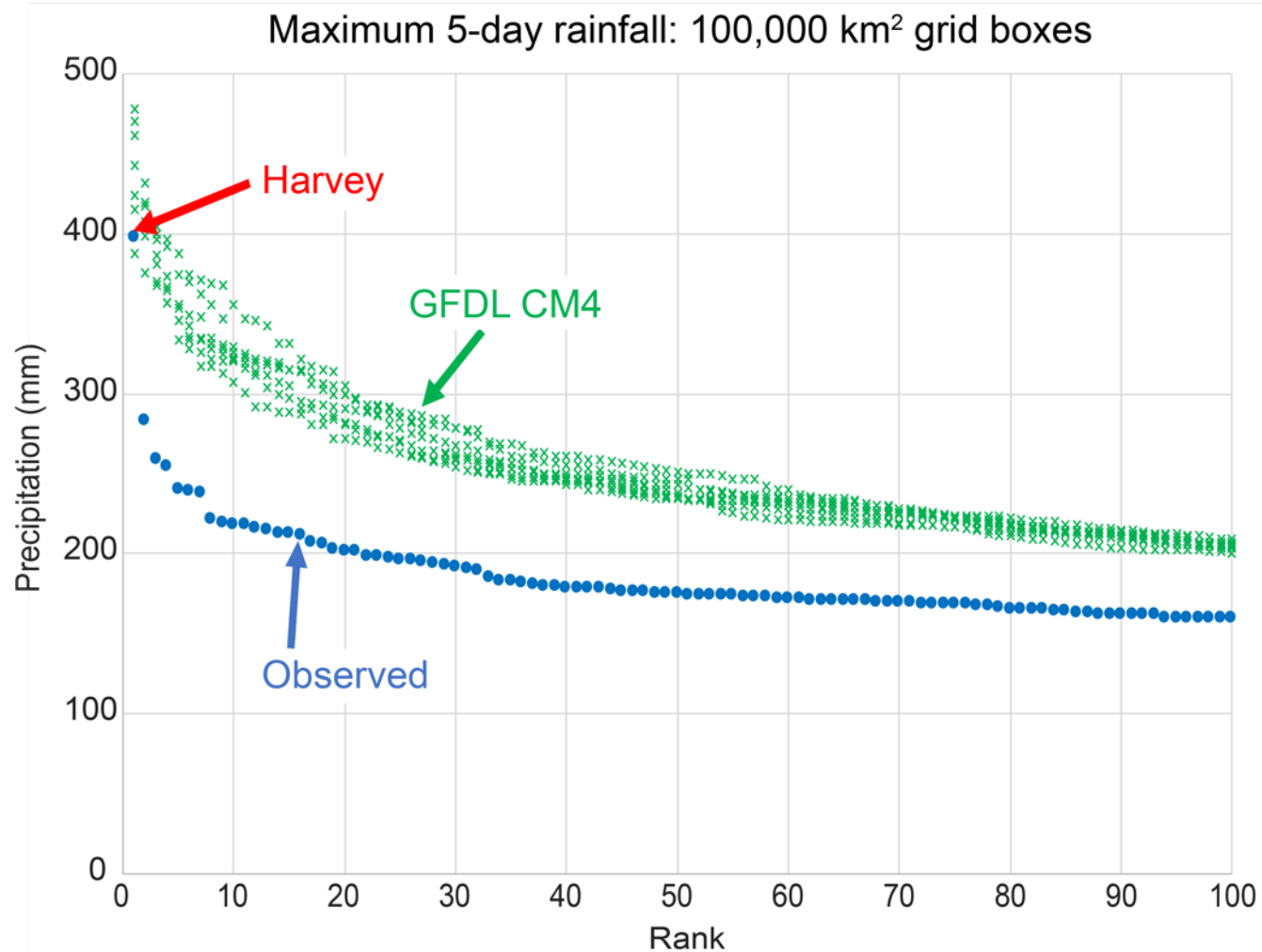
Grid Box Sizes



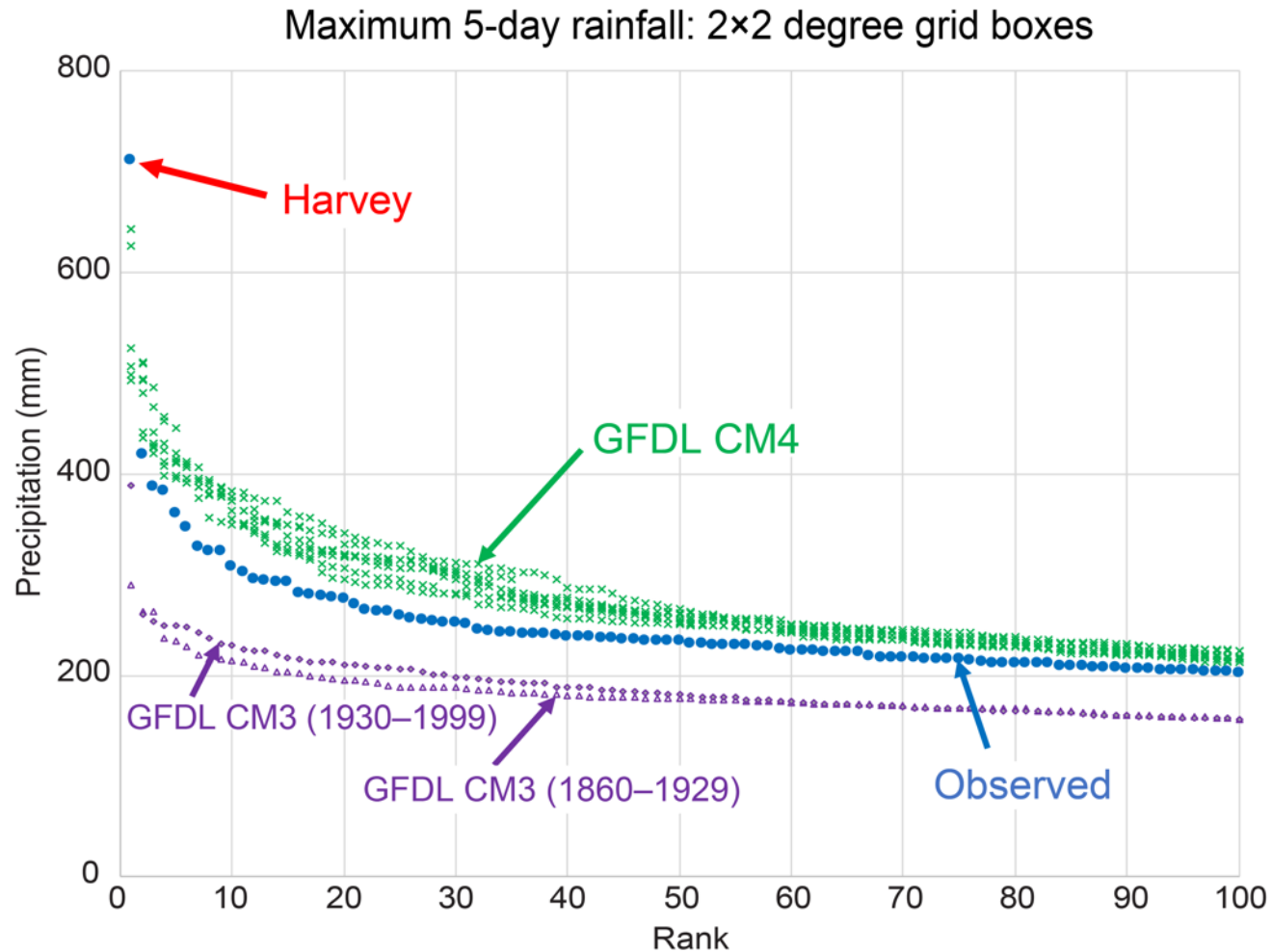
GFDL CM4 – native resolution



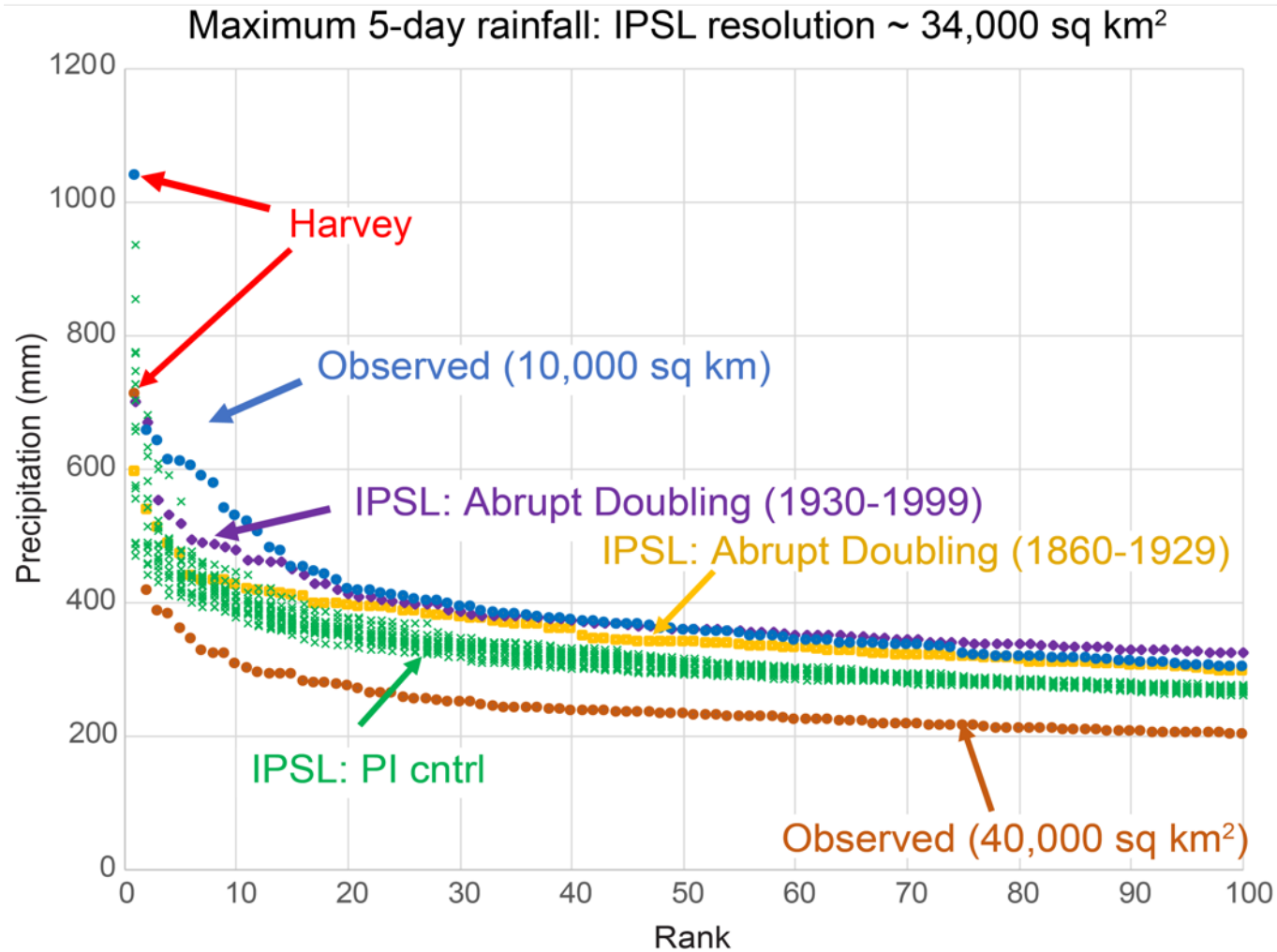
GFDL CM4 – 100,000 sq. km.



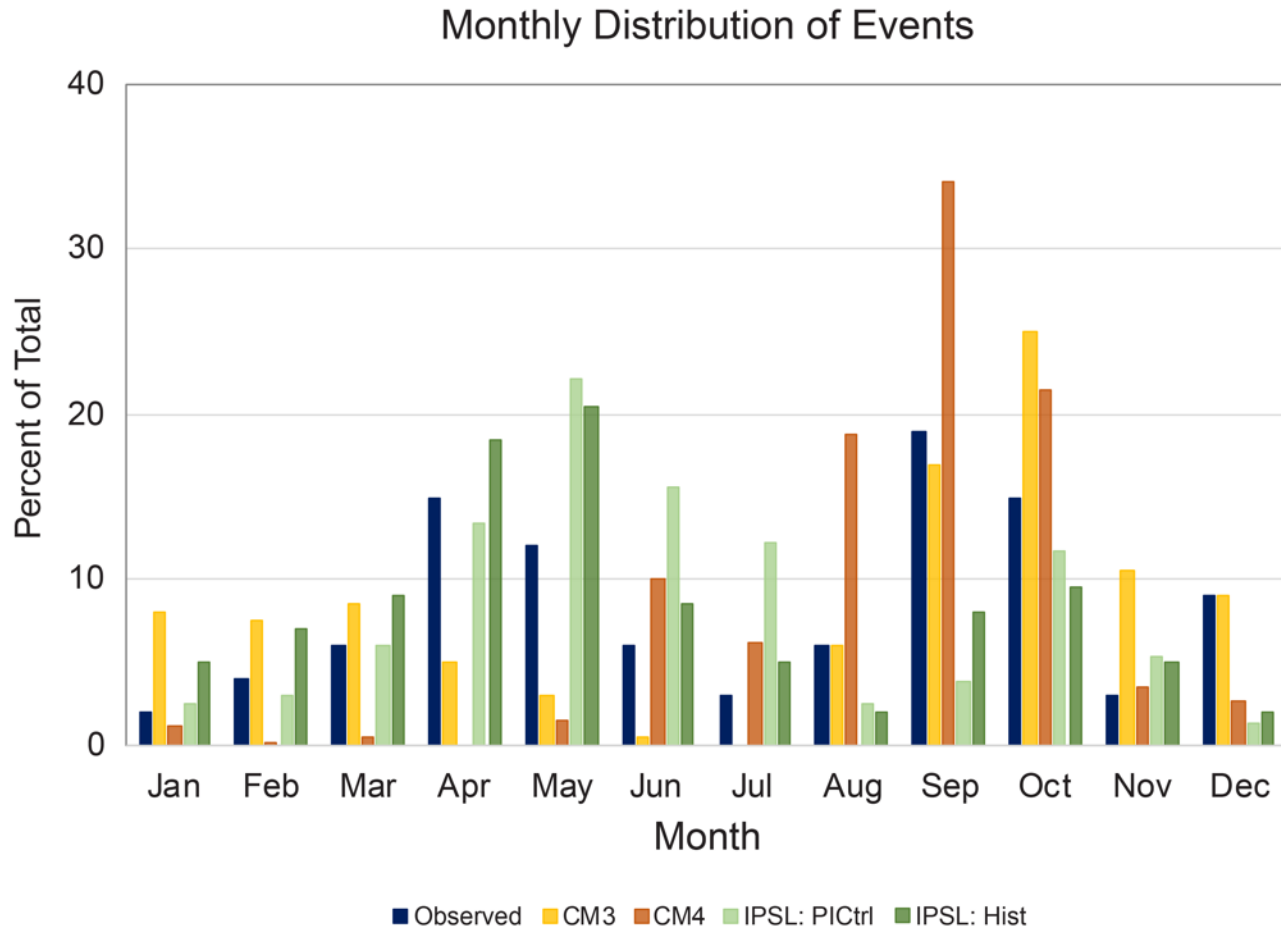
GFDL CM3 and CM4



IPSL



Monthly Distribution



CMIP Precipitation Analysis

- The GFDL CM4 models results are superior to GFDL CM3 model results in event magnitude, although the seasonal distribution is biased and events are too large at the 100,000 km² scale
- The IPSL model events are a little higher than observed when comparing similar box sizes
- At their native resolutions, none of the model simulations produce an event of the size of Harvey