Precipitation intensity in downscaled seasonal forecasts

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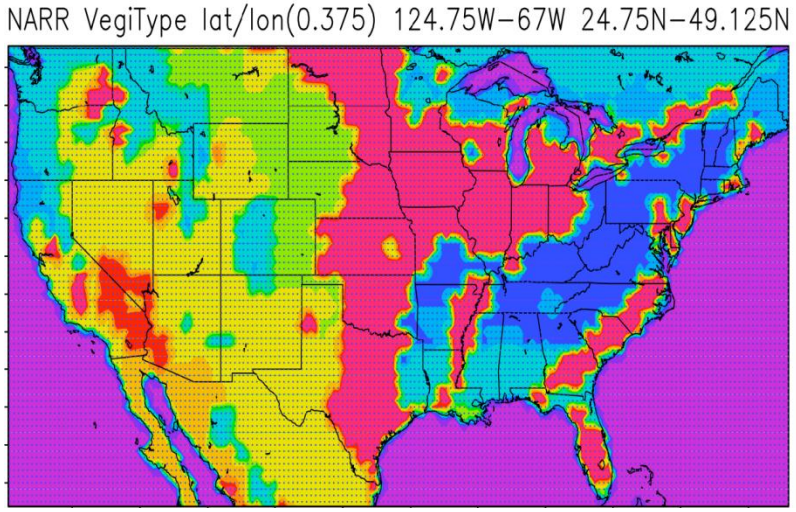
Overview

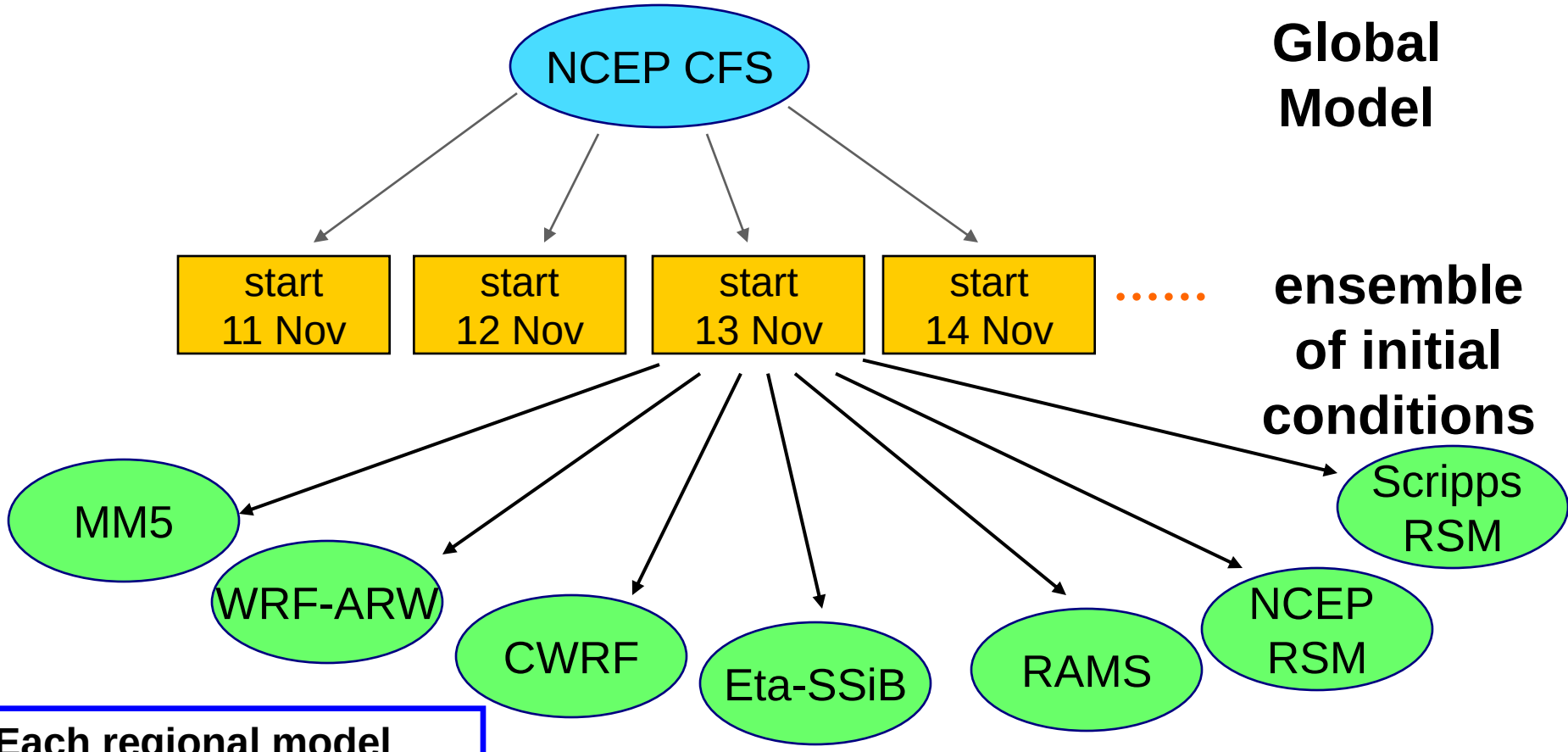
- Dynamical downscaling using regional climate models (RCMs) can add spatial detail to seasonal forecasts by AOGCMs.
- Evaluations of RCM precipitation have mostly focused on ability to reproduce means.
- Here we assess downscaled seasonal forecasts from RCMs participating in the MRED project in terms of the **distribution of daily precipitation intensity.**
  - important for both applications and processes

Multi-RCM Ensemble Downscaling of Global Seasonal Forecasts (MRED)

- Test downscaling of **winter seasonal forecasts** from global models by using an ensemble of regional models.
- Downscale 23 years of winter (December-April) reforecasts from NOAA CFS version 1 global seasonal forecast model (T62L64, ~1.9^{o} lat/lon).
- Domain is the coterminous U.S. at grid spacing 32 km.
- Downscale each member of a 10 member CFS ensemble for each winter 1982-2004.



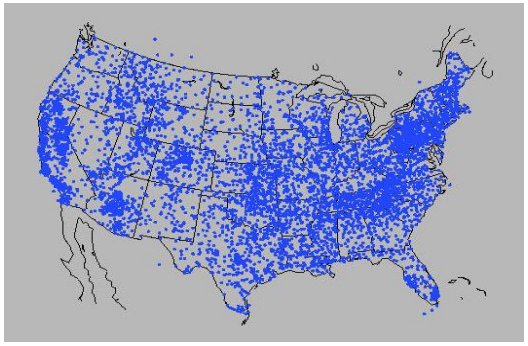
MRED Ensemble



Each regional model simulates all of the CFS ensemble members for each winter.

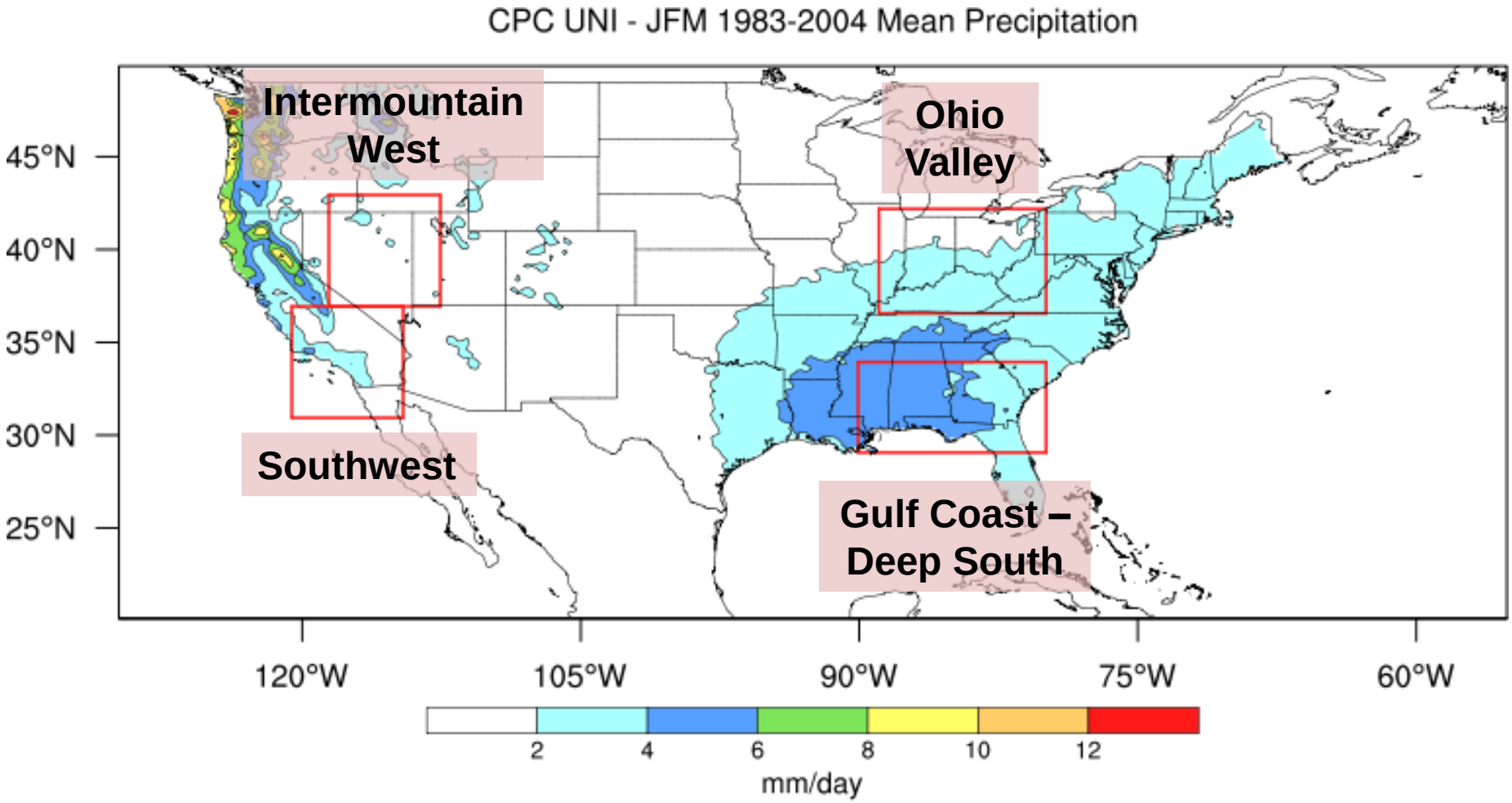
Observations

- CPC Unified Raingauge Dataset (UNI)
  - 0.25° x 0.25° grid
  - ~8000 stations with analysis valid at 1200 UTC



- North American Regional Reanalysis (NARR)
  - 32-km horizontal resolution
  - Assimilates observed precipitation using the Eta model (model-obs "hybrid").

Analysis regions



Seasonal distribution of precipitation intensity frequencies

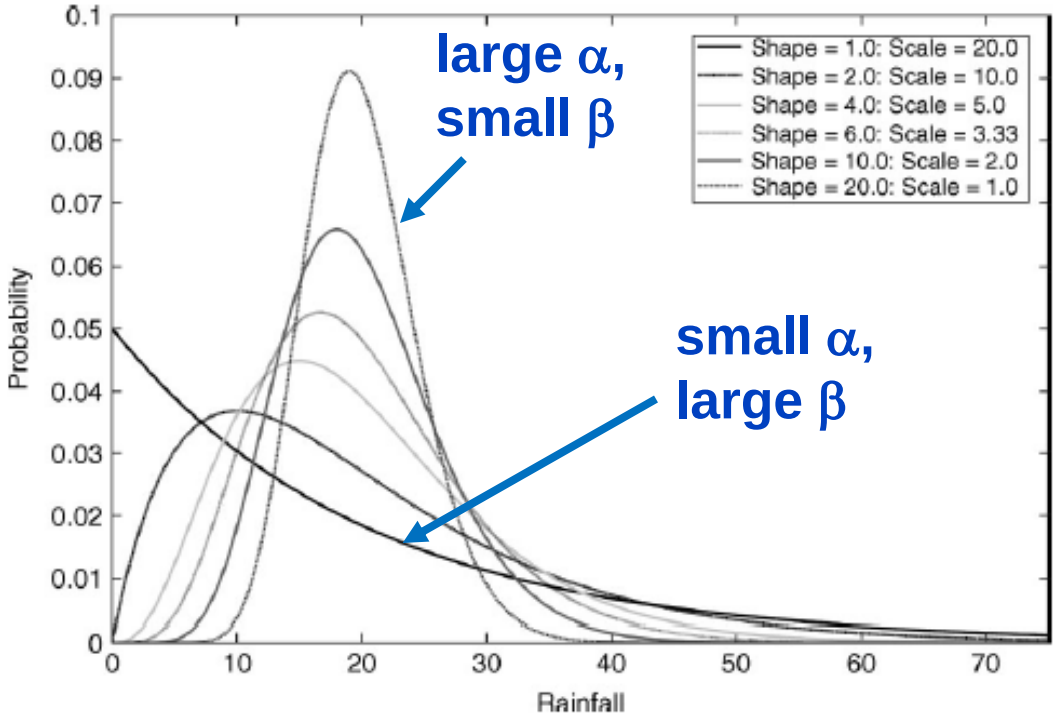
- Over each analysis region, accumulate precipitation into daily totals for January-February-March (JFM) and February-March-April (FMA) seasons.
- Fit daily precipitation intensity to gamma distribution:
  - Useful for summarizing non-negative, positively skewed distributions, though there is no physical basis for its application to precipitation.
  - Commonly used, e.g., Groisman et al. (1999), Gutowski et al. (2007), Husak et al. (2007), Becker et al. (2009).
  - We used both 1 mm bin width and unbinned (continuous) precipitation distribution.
  - Look separately at El Niño and La Niña winters.

The gamma distribution is defined by two parameters

- **Shape parameter, α:** Changes the overall nature (shape) of the curve: Exponential curve when α = 1, approaches a normal distribution when α is large.
- **Scale parameter, β:** Stretches (large β) or compresses (small β) the distribution along the x-axis.
- The mean of the distribution is $\mathbf{x} = \alpha\,\beta$
  - Parameters need to be evaluated together: for a given mean, α must increase as β decreases.
- Limitation: the gamma distribution applies only for precipitation greater than zero.
  - Threshold 0.254 mm day^{-1} (0.01 inch day^{-1})

The gamma distribution distinguishes observed data series with the same mean

- All of the distributions shown below have a mean of 20 ($\alpha\beta = 20$).



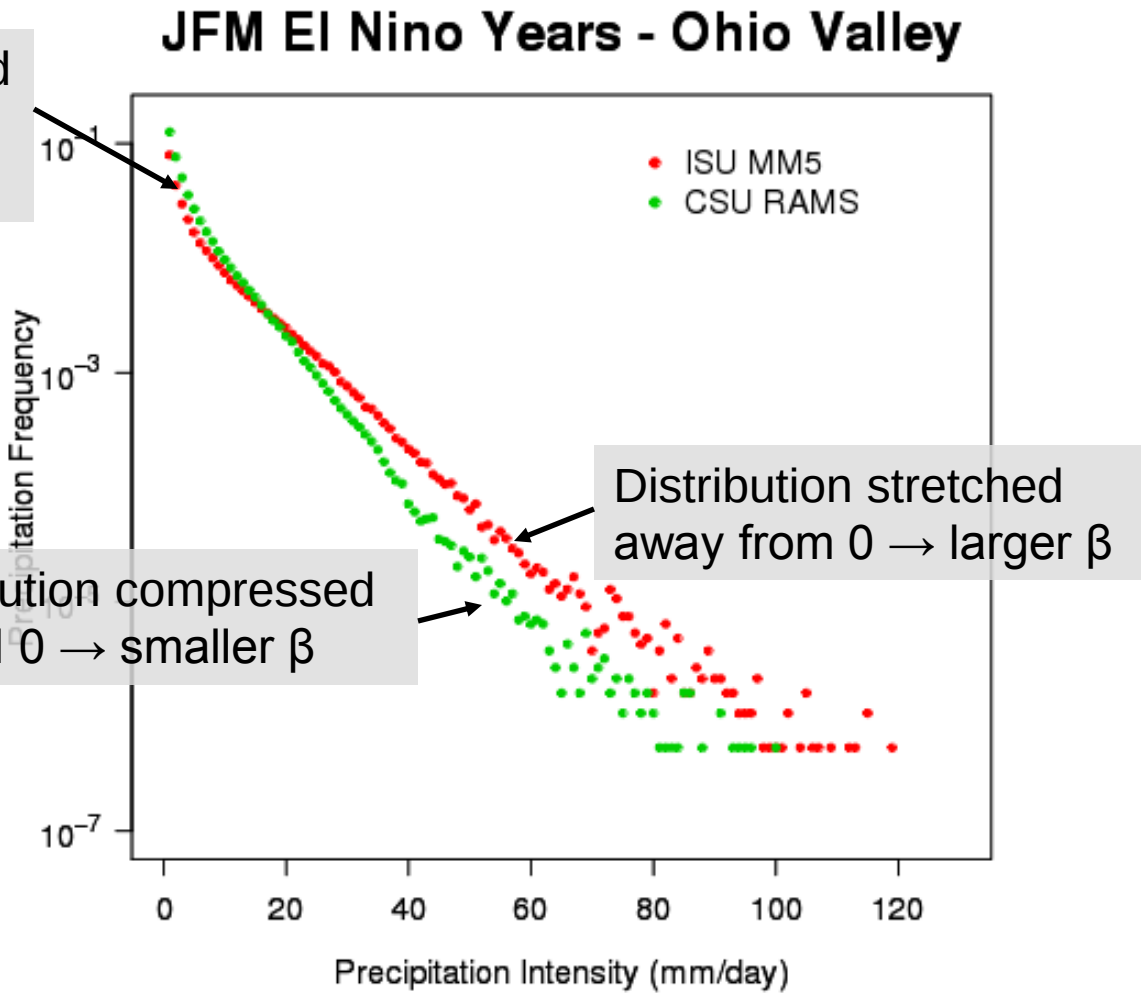
from Husak et al. (2007)

Using the gamma distribution parameters to summarize precipitation intensity statistics

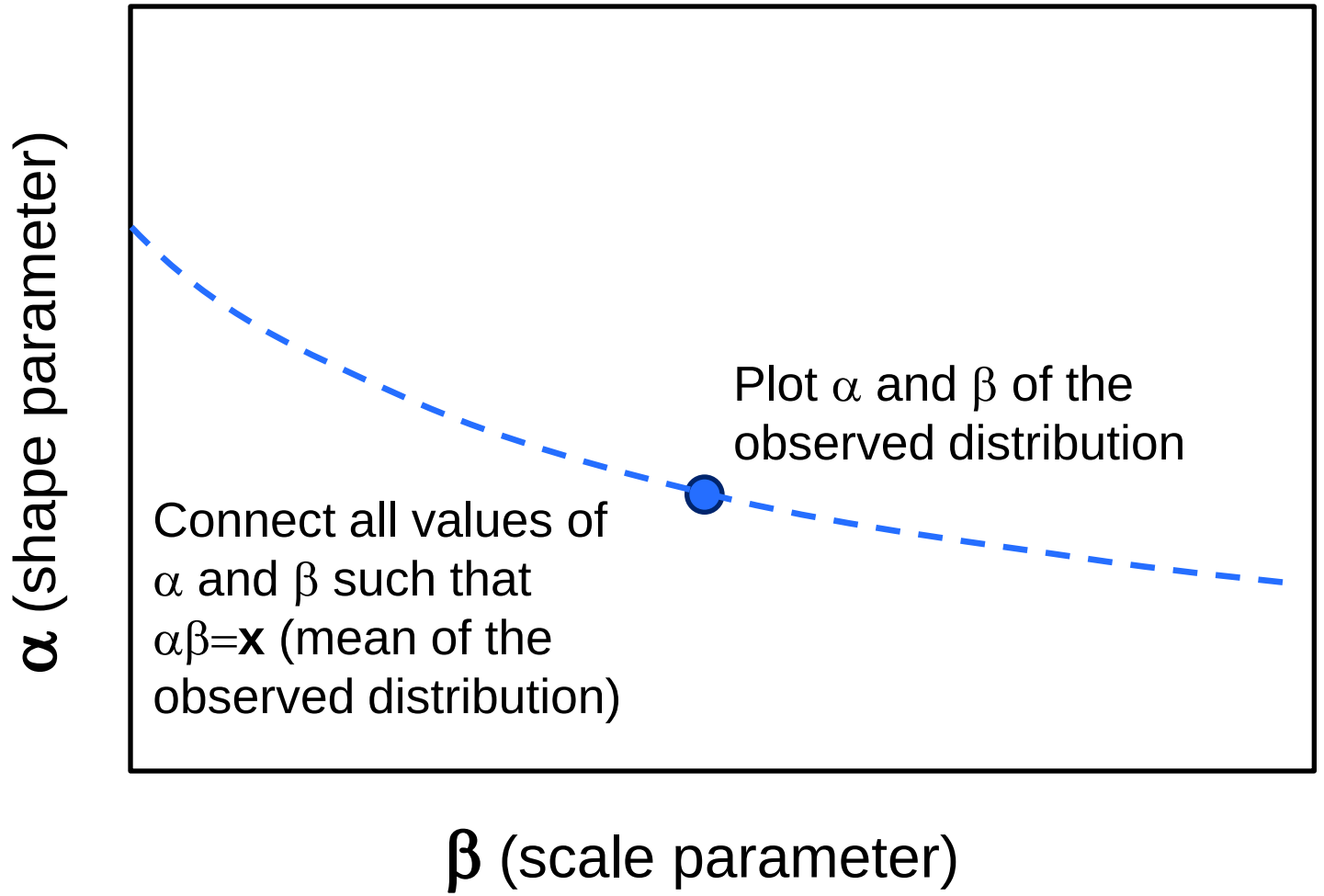
Smaller α in MM5 → more rapid decrease in frequency at small values than in RAMS

ISU MM5
Mean = 4.69 mm day^{-1}
α=0.48, β=9.76

CSU RAMS
Mean = 4.54 mm day^{-1}
α = 0.60, β = 7.50



We can use the properties of the gamma distribution to summarize both the mean and the intensity distribution



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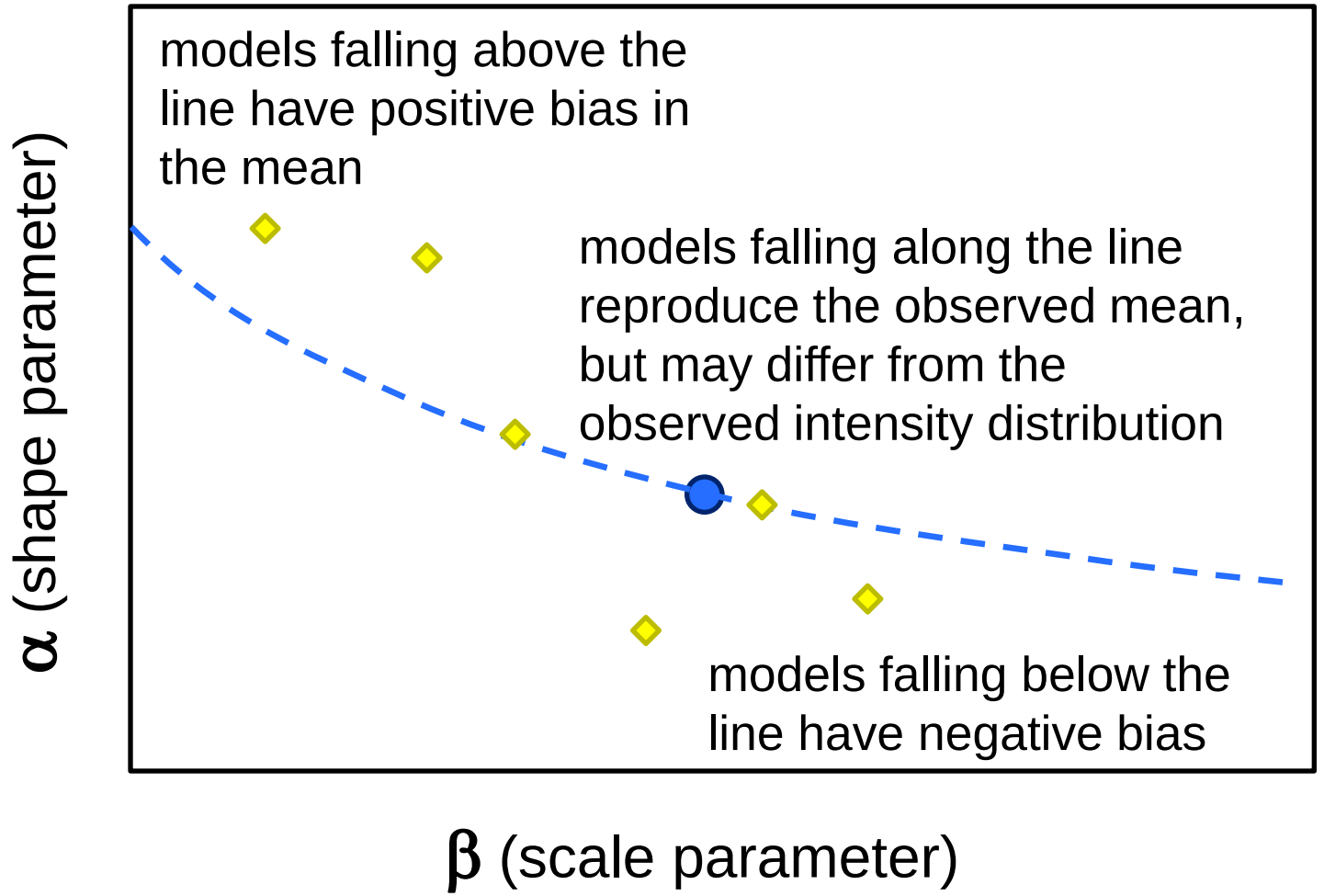
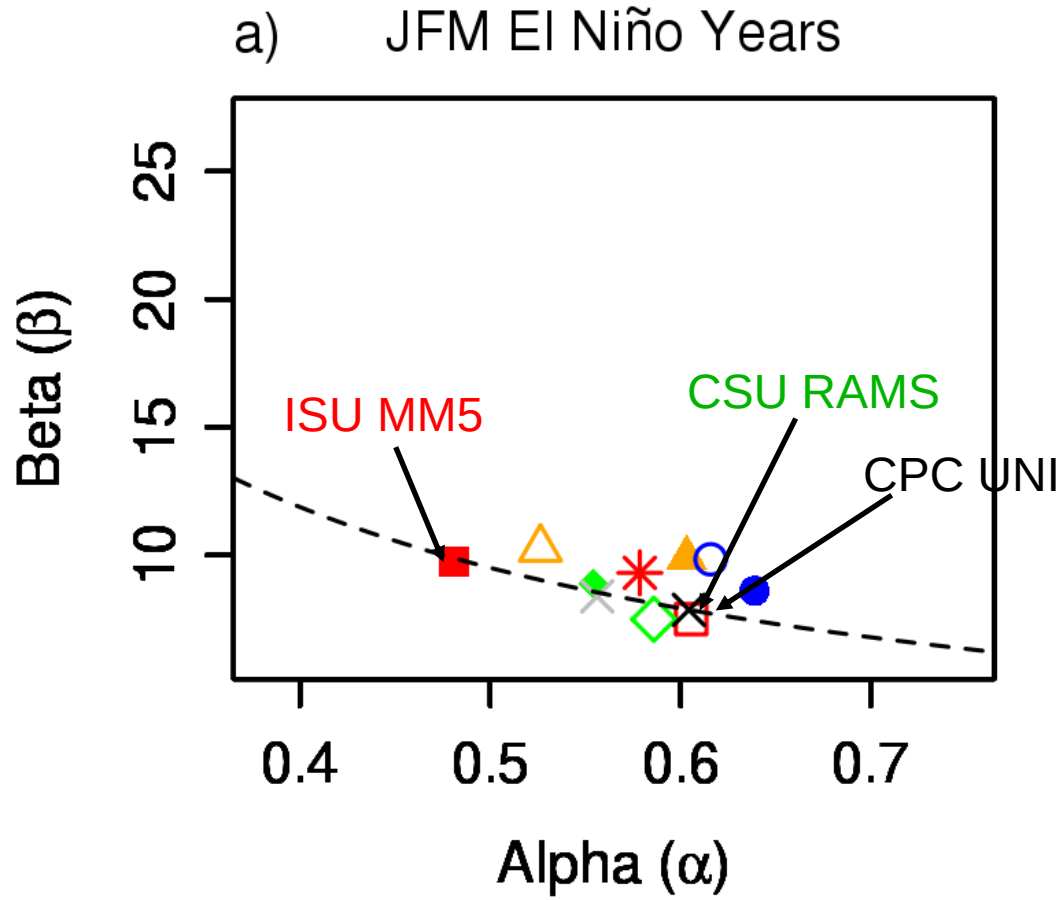


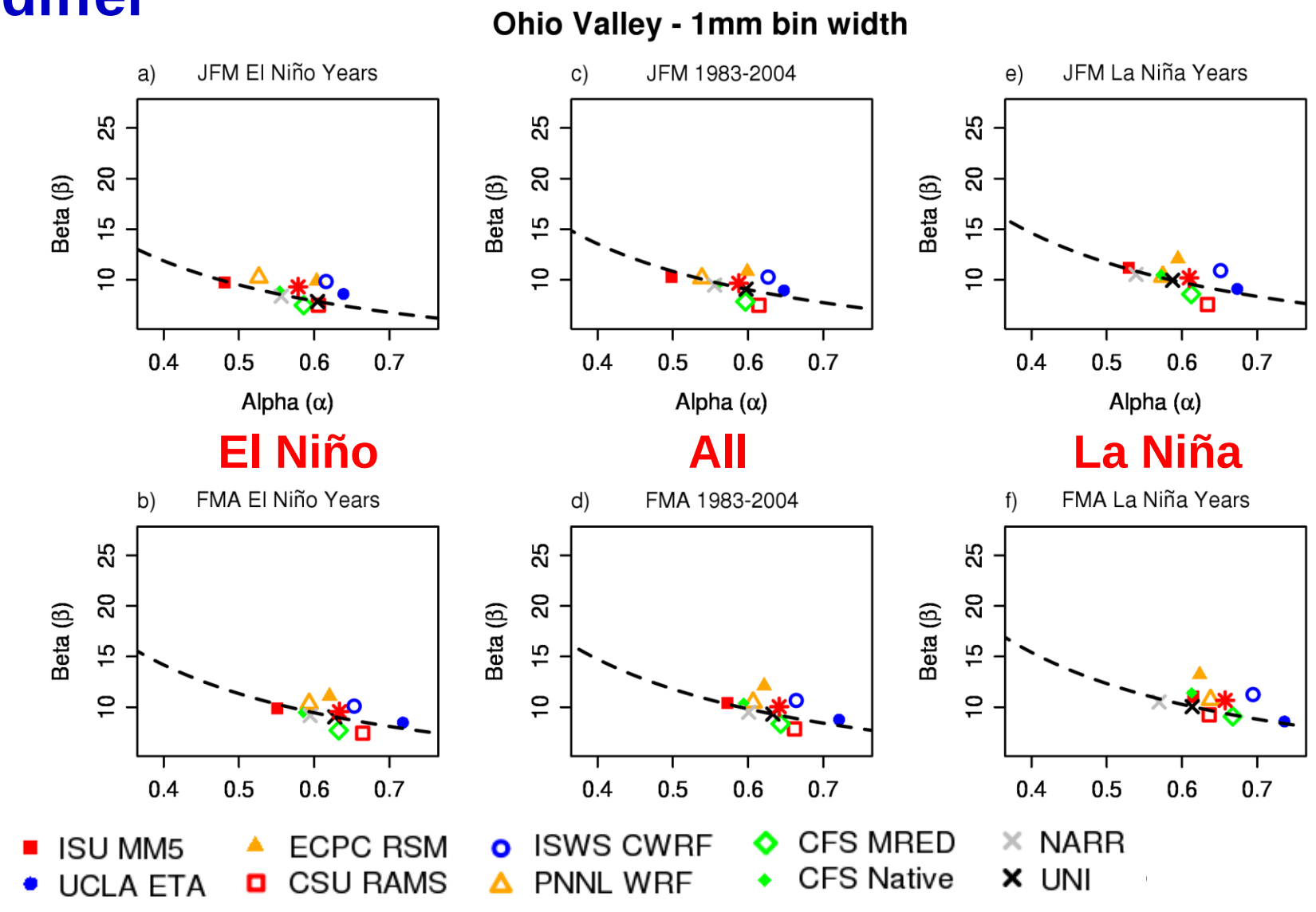
Use of gamma distribution parameters to distinguish distributions with similar means



Dashed line gives
$\alpha\ \beta$ =mean of UNI

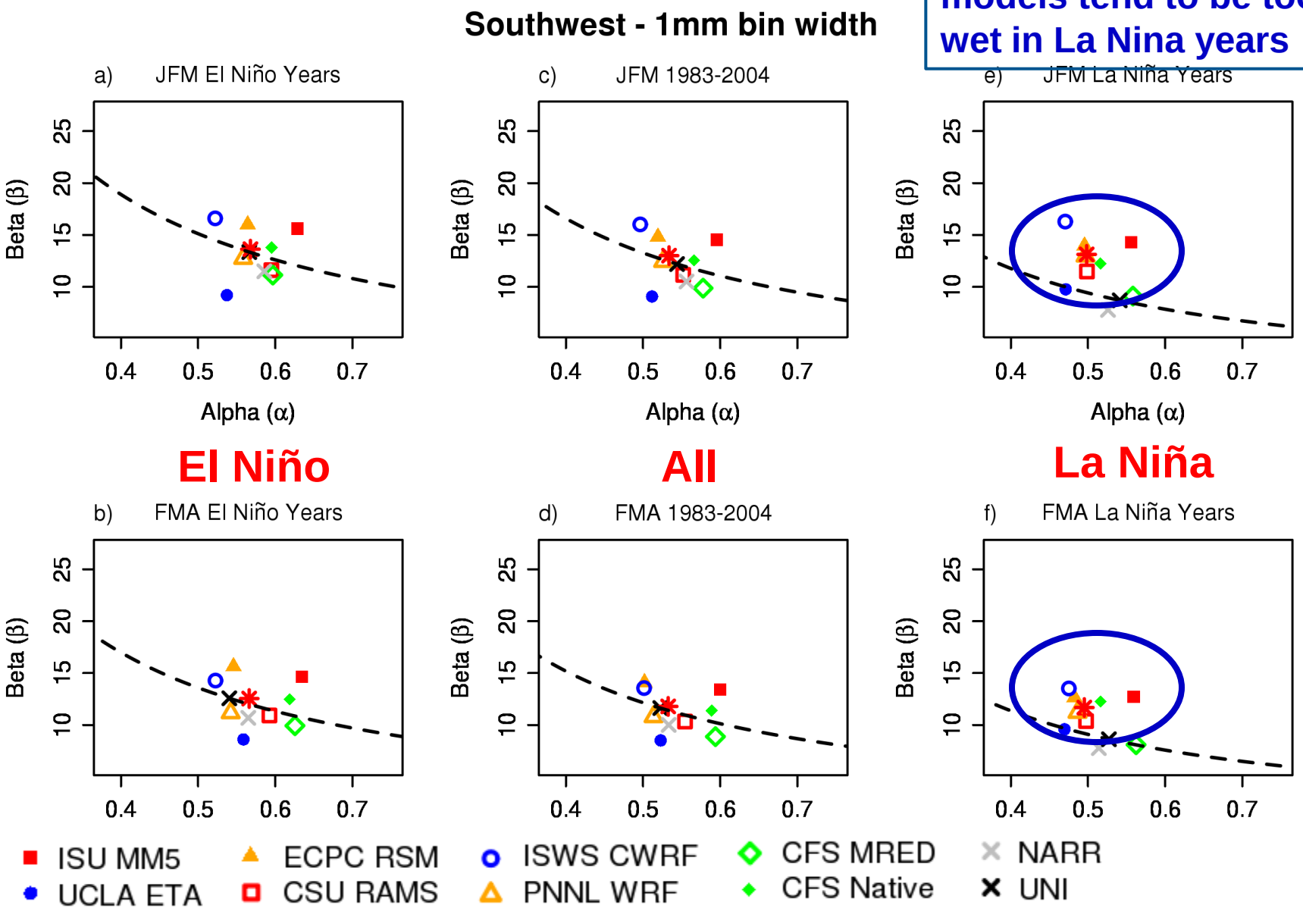
ISU MM5
UCLA ETA
ECPC RSM
CSU RAMS
ISWS CWRF
PNNL WRF
CFS MRED
CFS Native
NARR
UNI
Mean

For the Ohio Valley, all the models are close to the observed mean but intensity distributions differ

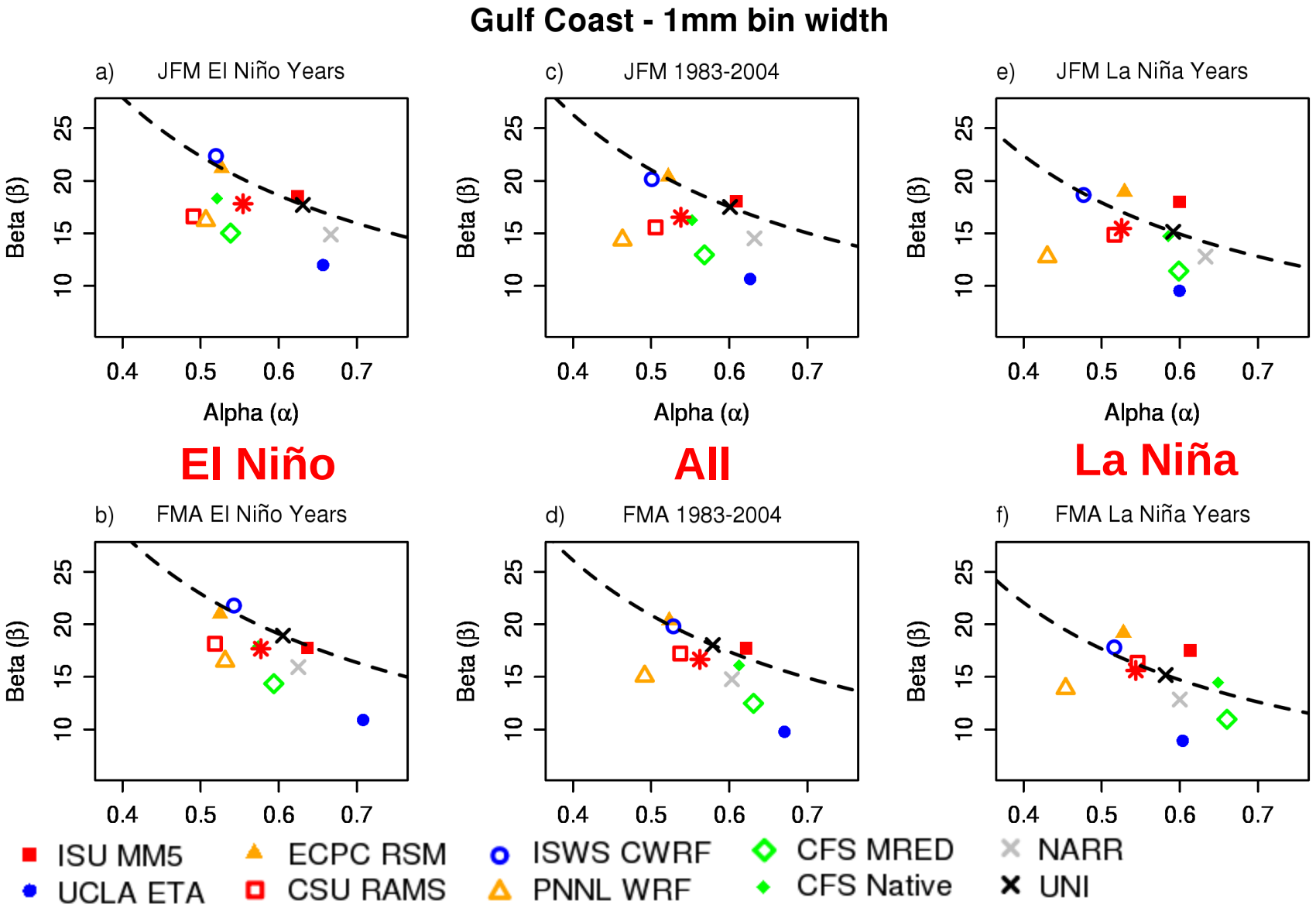


In the southwestern U.S. model performance is more variable

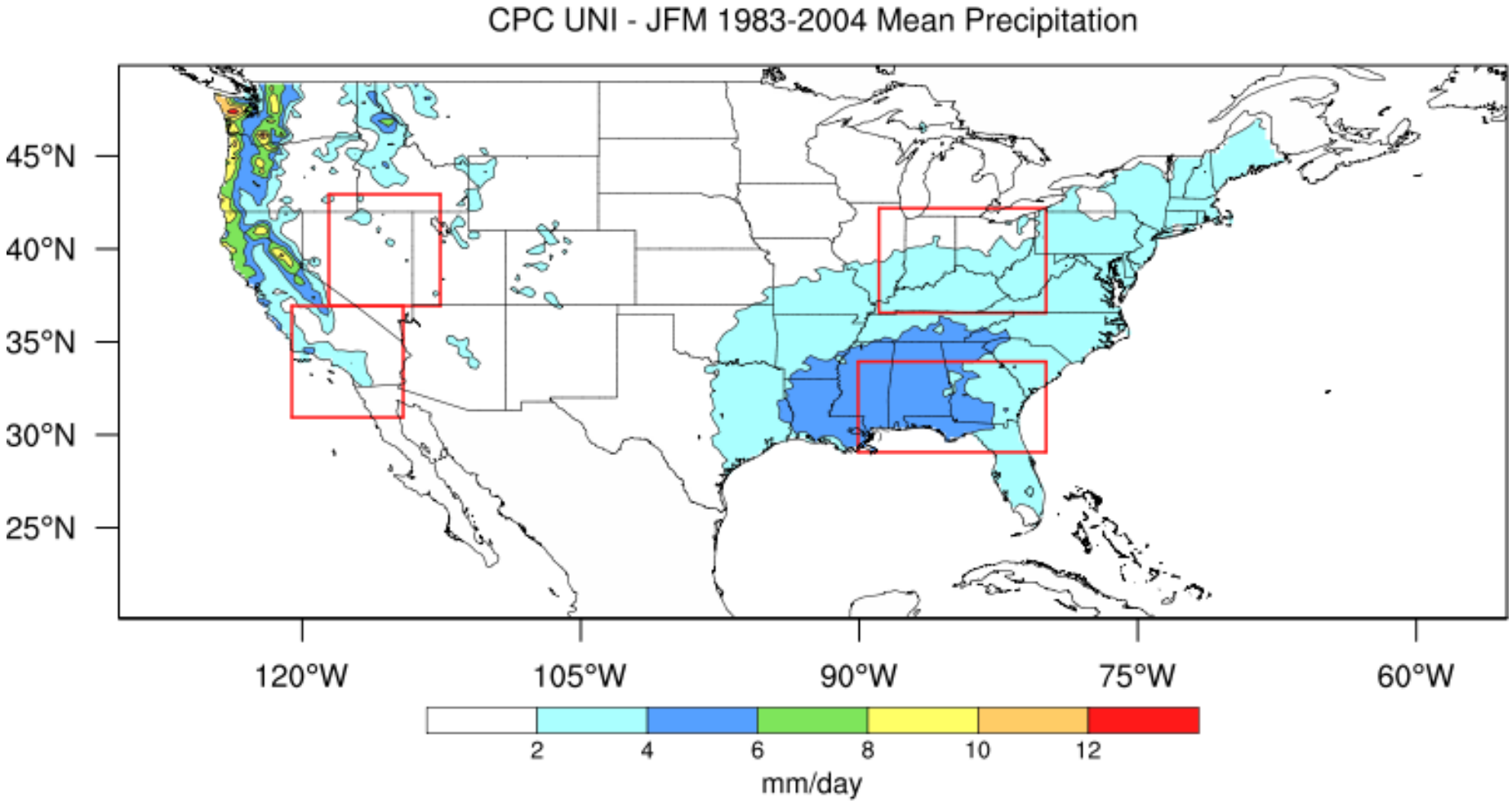
models tend to be too wet in La Nina years



In the Gulf Coast – Deep South region most models are too dry, especially in El Nino years



Gulf Coast – Deep South has heavier precipitation than the other regions



Summary and future work

- Downscaled seasonal forecasts tend to improve the distribution of daily precipitation intensity compared to the global seasonal forecast.
- Models that have similar skill in the mean can differ markedly in their distribution of daily precipitation intensity.
  - No single RCM consistently performs best for precipitation intensity.

Summary and future work

- Gamma distribution provides a concise way to compare the overall precipitation distributions but other methods should be used to characterize extremes.
- Strong dependence of downscaled results on the global model implies it would be useful to test multi-regional model downscaling of multi-global model forecasts.
  - Apply lessons learned from NARCCAP, ENSEMBLES and other multi-GCM x multi-RCM projects.
  - Collaborate with NMME (NAEFS) to develop GCM x RCM matrix?
  - **Hypothesis:** Downscaling from multiple AOGCMs will produce improved statistics compared with the same size RCM ensemble from a single GCM.

Daily precipitation intensity for the Ohio Valley