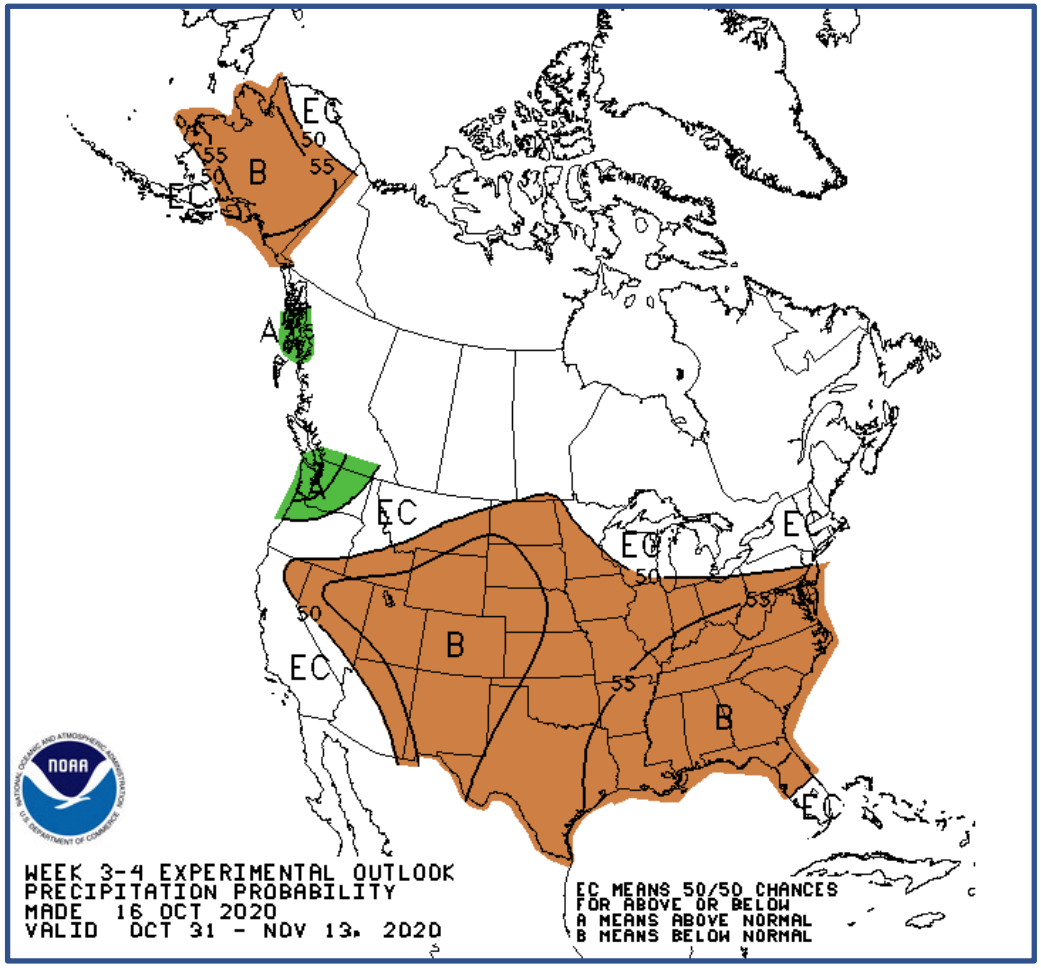
On the Challenge of Defining Normal Precipitation with Medians



Cory Baggett &
Emerson LaJoie

Innovim, LLC / Climate Prediction Center

2020 Climate Diagnostics and Prediction Workshop

October 22, 2020

Virtual, Earth

Week 3-4 Experimental Precipitation Outlook

There are two outlook categories – above or below normal with respect to precipitation's median climatology for the valid period.

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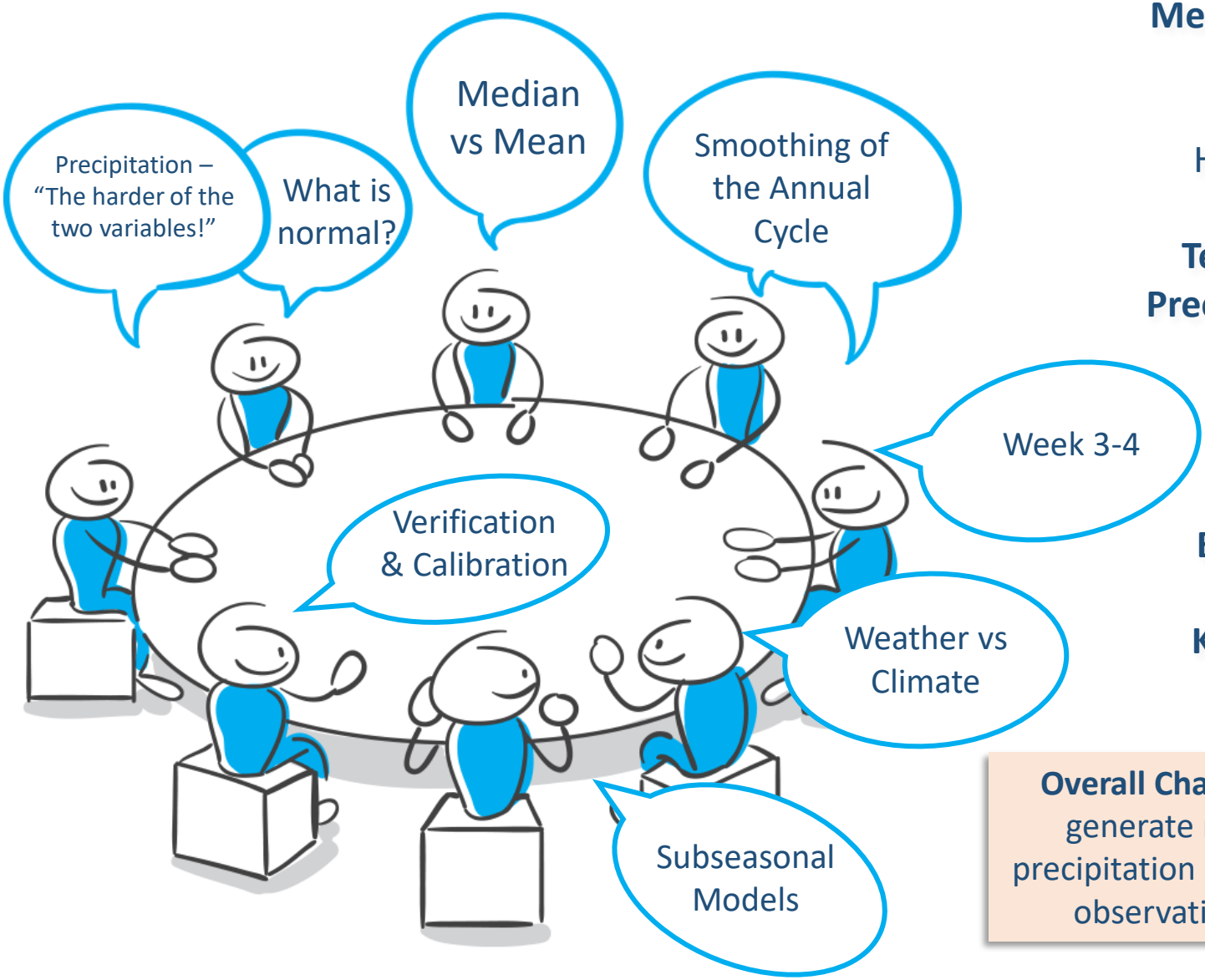


Image: South Kitsap School District

Median versus Mean Roundtable

Hosted by CPC's

Temperature and Precipitation Outlook Workgroup

Led by

Emerson LaJoie
and
Kyle MacRitchie

Overall Challenge: We wish to generate robust, Week 3-4 precipitation climatologies in both observations and models.

On the Challenge of Defining Normal Precipitation with Medians

Overall Challenge: We wish to generate robust, Week 3-4 precipitation climatologies in both observations and models.

Challenge #1: Precipitation is inherently noisy across time and space.

Challenge #2: Precipitation has non-Gaussian distributions, with medians less than the means.

Challenge #3: Annual cycles of precipitation medians can be quite irregular.

Challenge #4: Smoothing raw cycles risks being arbitrary.

Challenge #5: The climatological period of interest matters.

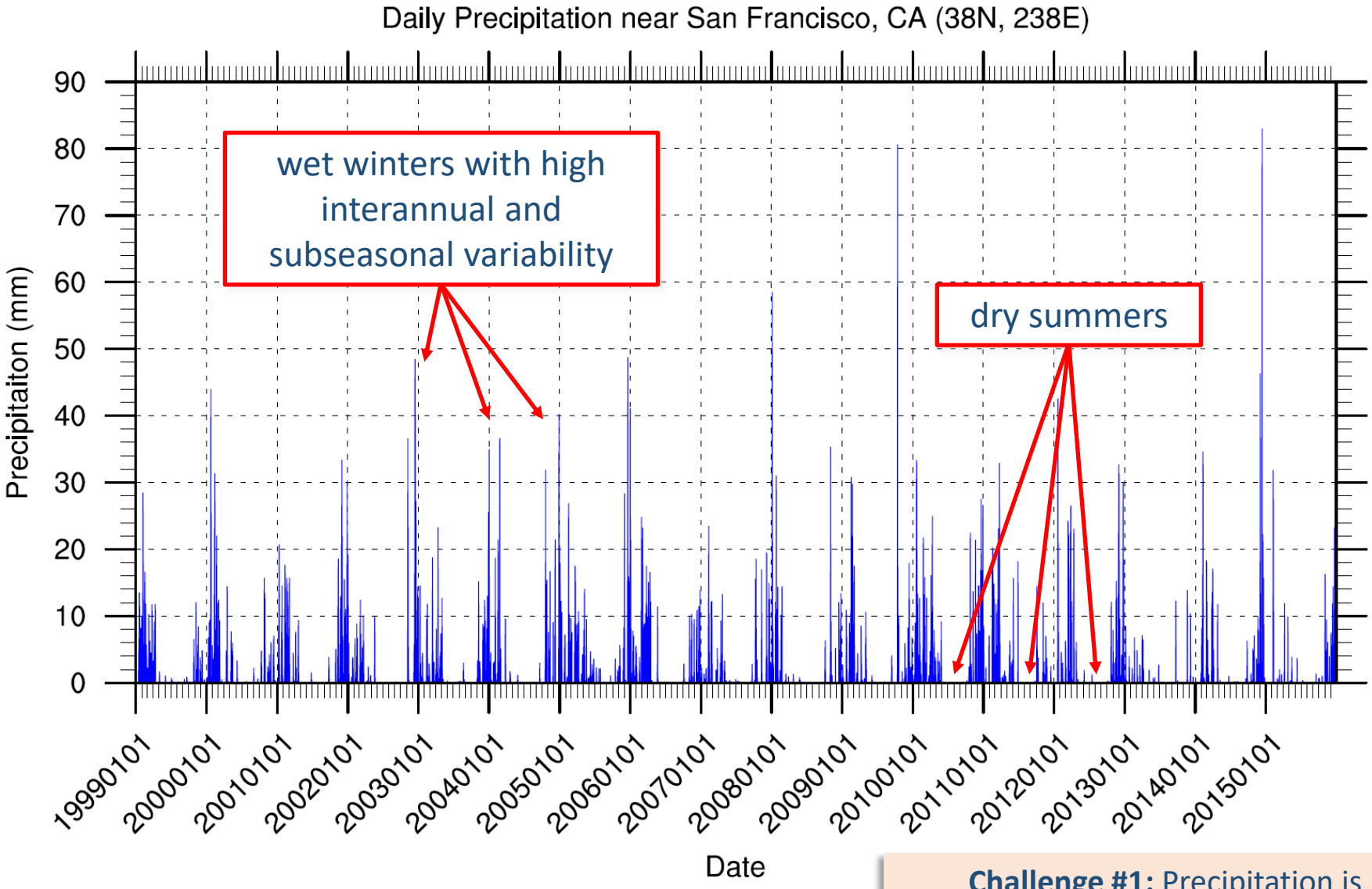
Challenge #6: Calculating medians in subseasonal models is not a trivial task.

Challenge #7: The subseasonal models have climatologies that are highly dependent on lead-time.

Challenge #8: The subseasonal models have climatologies that differ from observations across all lead times.

And more…

On the Challenge of Defining Normal Precipitation with Medians



Challenge #1: Precipitation is inherently noisy across time and space.

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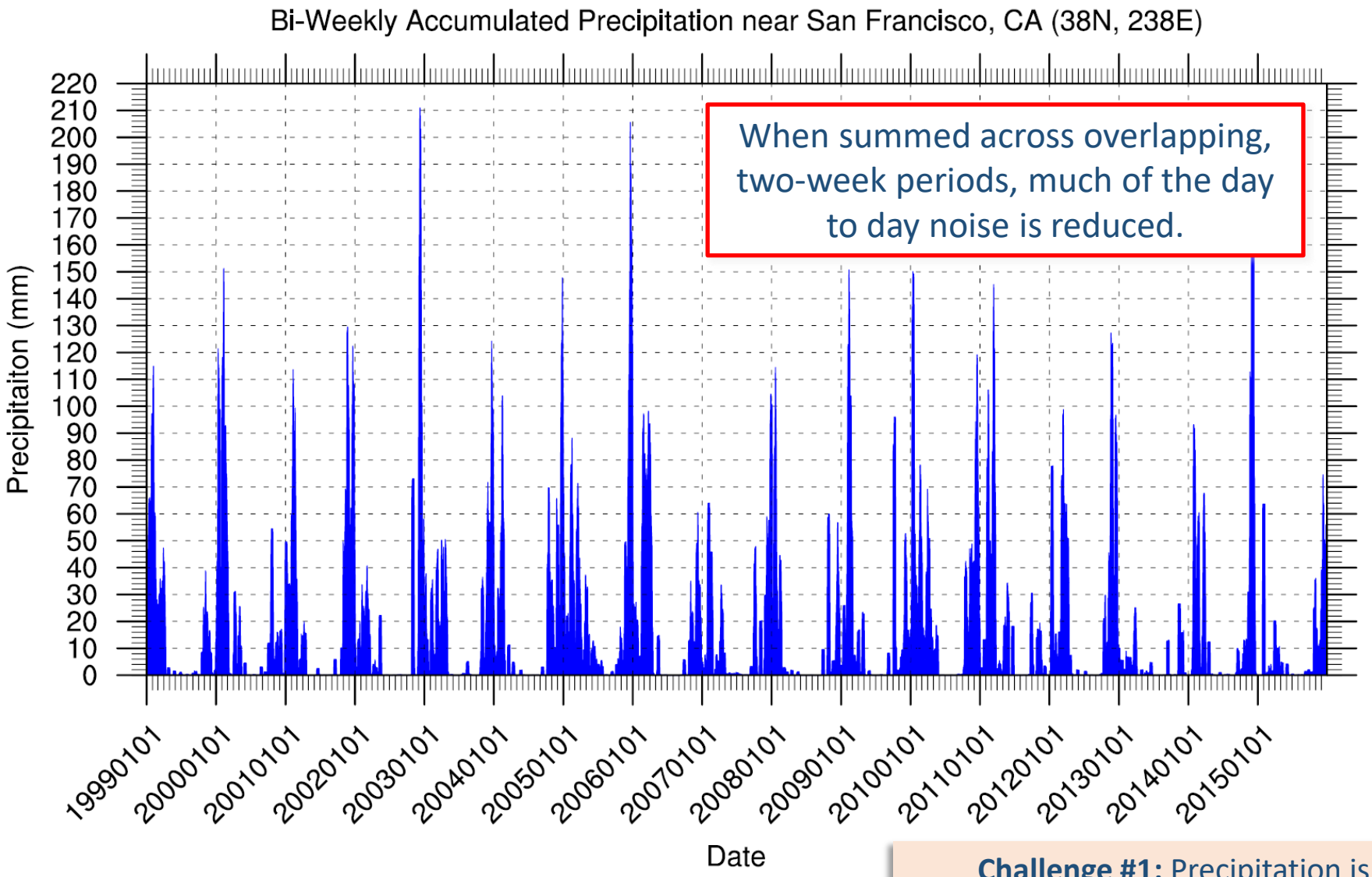
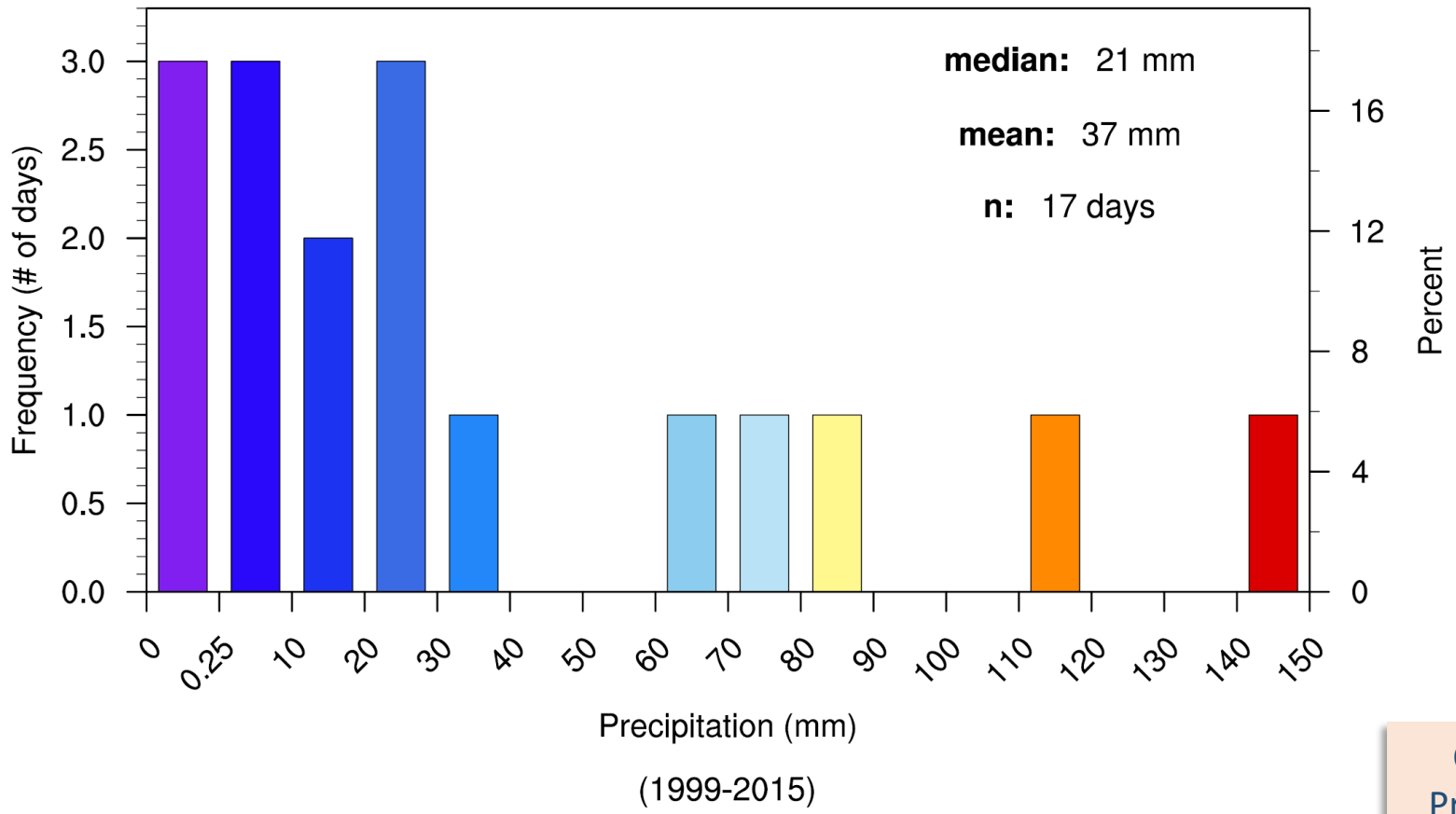


Challenge #1: Precipitation is inherently noisy across time and space.

On the Challenge of Defining Normal Precipitation with Medians

January 16th Histogram of Two-Week Precipitation near San Francisco, CA (38N, 238E)

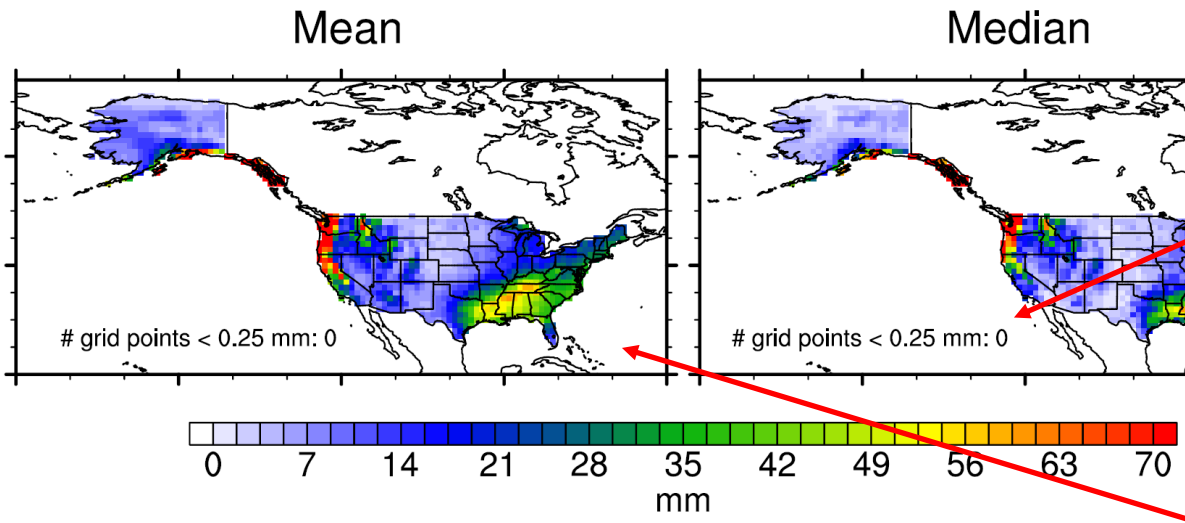


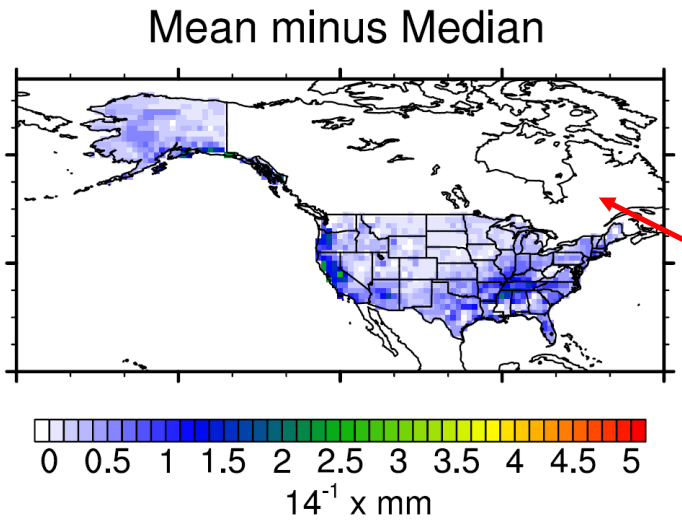
With two-week aggregation, medians are non-zero. One can forecast below normal. The histogram is rather disjointed though.

Challenge #2: Precipitation has non-Gaussian distributions, with medians less than the means.

On the Challenge of Defining Normal Precipitation with Medians

January 16th Two-Week Precipitation Climatology (1999-2015)





There are no grid points with near-zero medians.

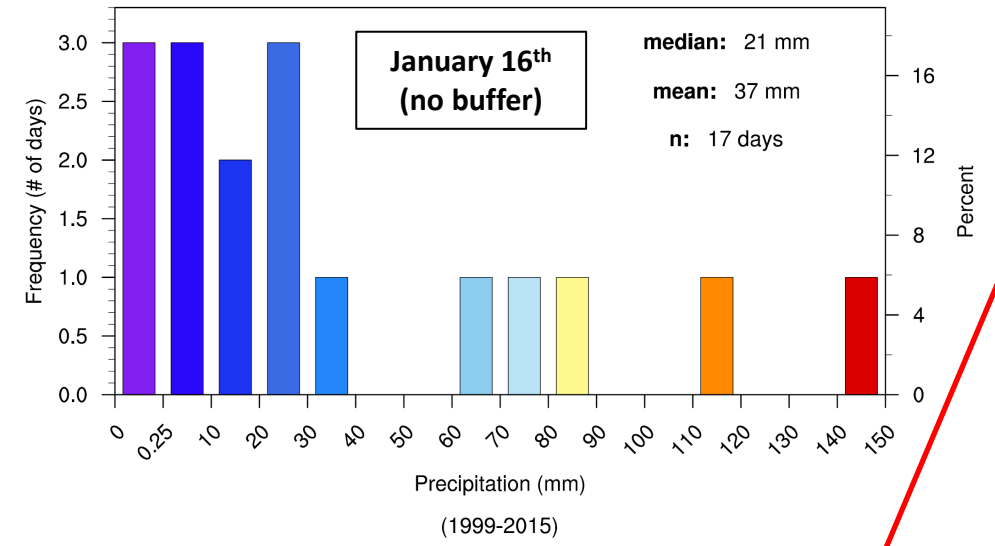
Two-week periods beginning on January 16th have means and medians that are spatially similar.

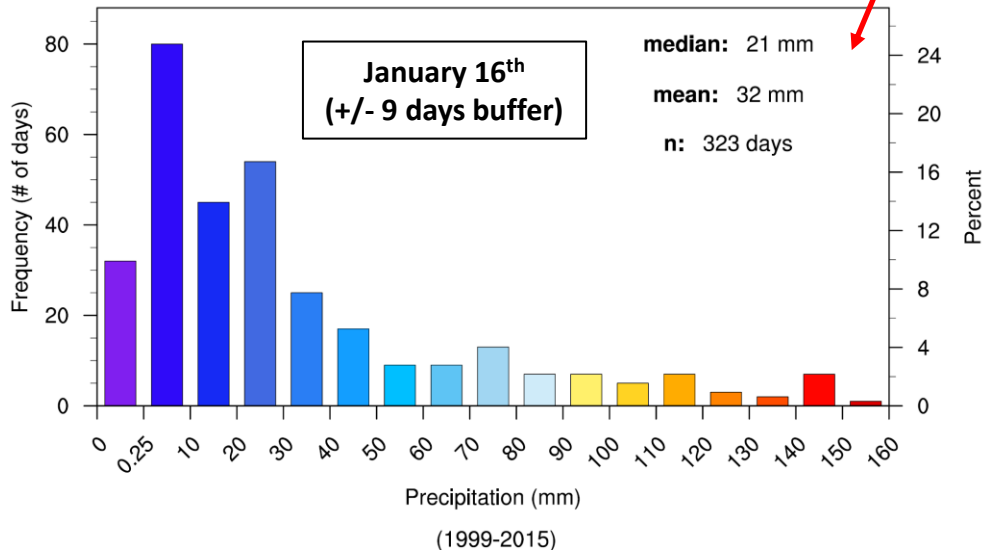
The means are everywhere greater than the medians.

Challenge #2: Precipitation has non-Gaussian distributions, with medians less than the means.

On the Challenge of Defining Normal Precipitation with Medians

Histograms of Two-Week Precipitation near San Francisco, CA (38N, 238E)





With the addition of a +/- 9 days buffer, the January 16th histogram becomes more fully distributed.

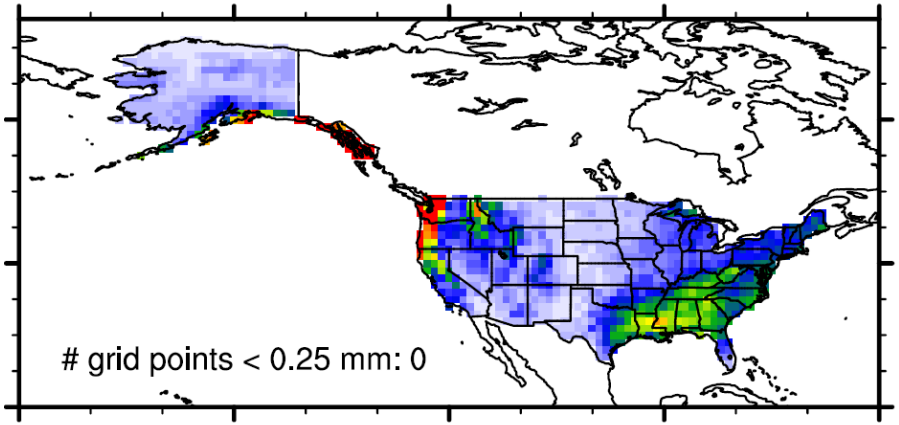
However, the medians are still less than the means. This implies that if one were to use the mean as climatology, then verifications will likely be biased toward below normal. Thus a forecaster could game the system and forecast below normal to increase skill. We do not want to do this; thus we use medians to define normal precipitation.

Challenge #2: Precipitation has non-Gaussian distributions, with medians less than the means.

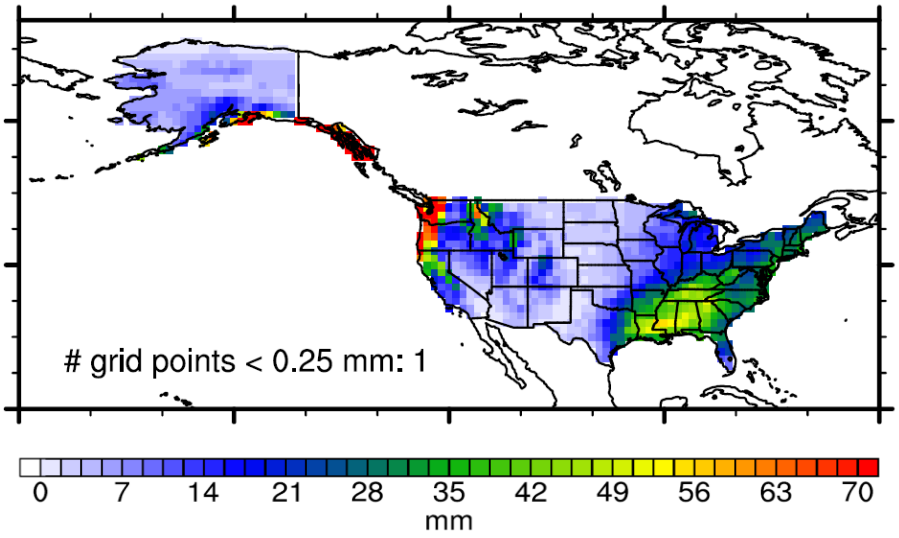
On the Challenge of Defining Normal Precipitation with Medians

January 16th Two-Week Precipitation Climatology (1999-2015)

Median (no buffer)



Median (+/- 9 days buffer)



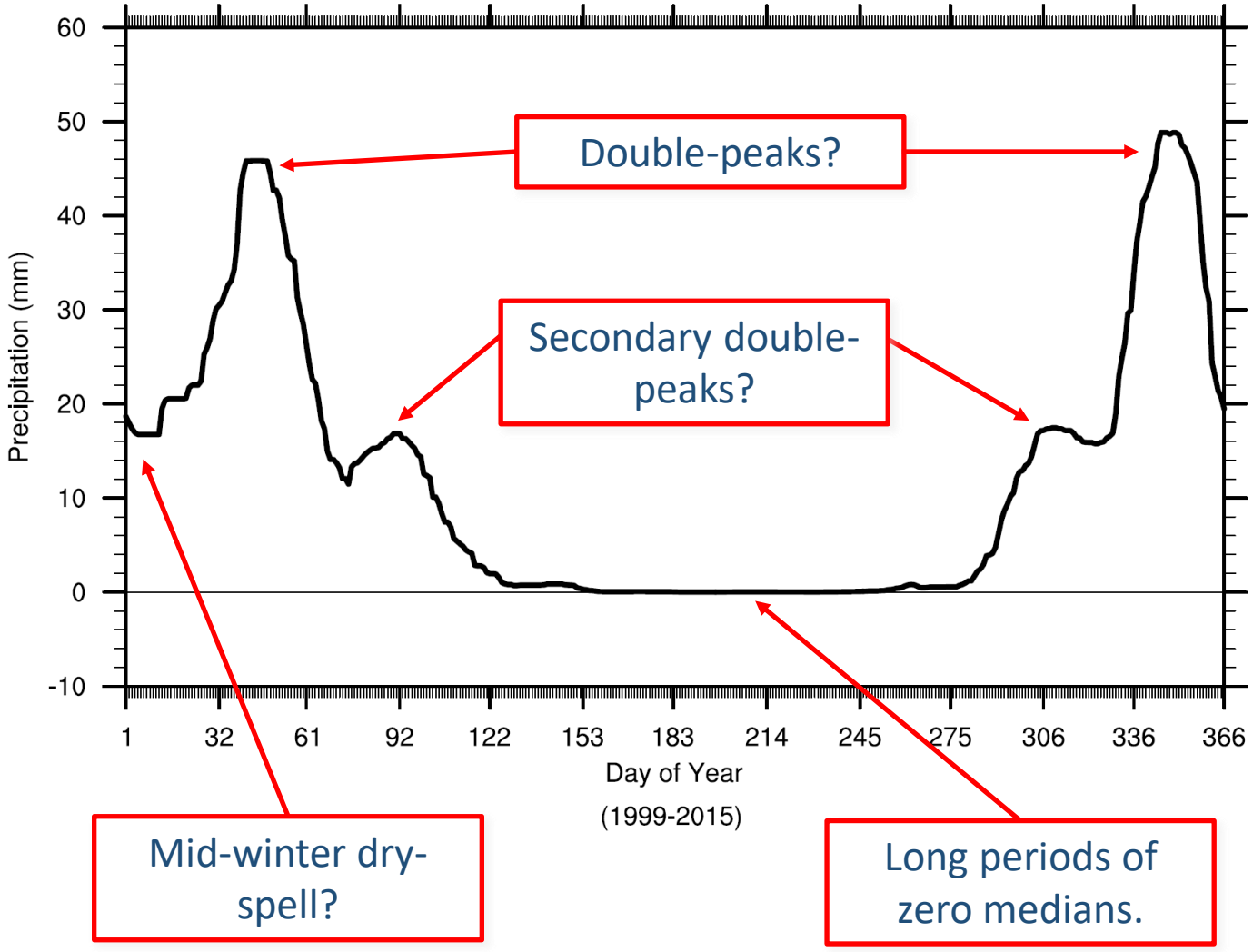
Application of the +/- 9 days buffer does not change the values of the medians by much, but, interestingly, the temporal aggregation does lead to a reduction in spatial noise.

Challenge #2: Precipitation has non-Gaussian distributions, with medians less than the means.

Partial Resolution: Sum precipitation over the period of interest, such as two-week periods useful for Week 3-4 forecasting AND apply a +/- 9 days buffer.

On the Challenge of Defining Normal Precipitation with Medians

Raw Annual Cycle of Two-Week Precipitation near San Francisco, CA (38N, 238E)



Do we smooth this? How? How much?

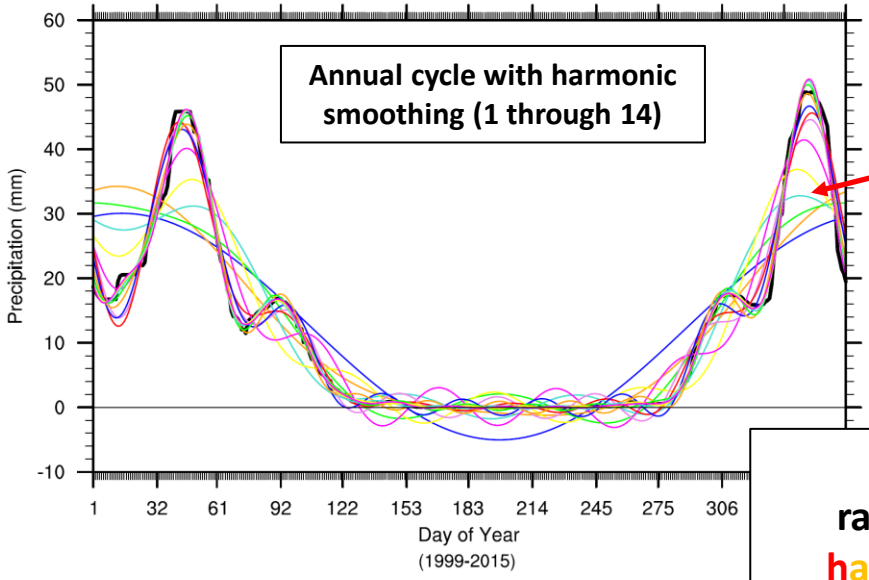
Is the 1999-2015 climate period too short? Dominated by weather?

What type of physically-forced precipitation variability would one expect to see in an annual cycle? Seasonal? Monsoon? Jet? ~~MJO~~? ~~Synoptic~~?

Challenge #3: Raw annual cycles of precipitation medians can be quite irregular.

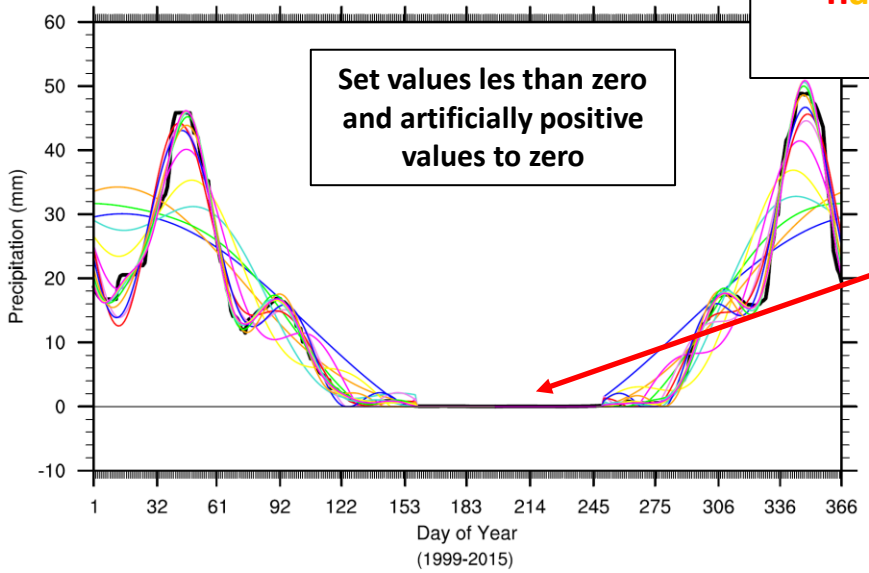
On the Challenge of Defining Normal Precipitation with Medians

Annual Cycle of Two-Week Precipitation near San Francisco, CA (38N, 238E)



The double-peaks in winter only start showing up after four harmonics have been retained.

raw cycle
harmonics



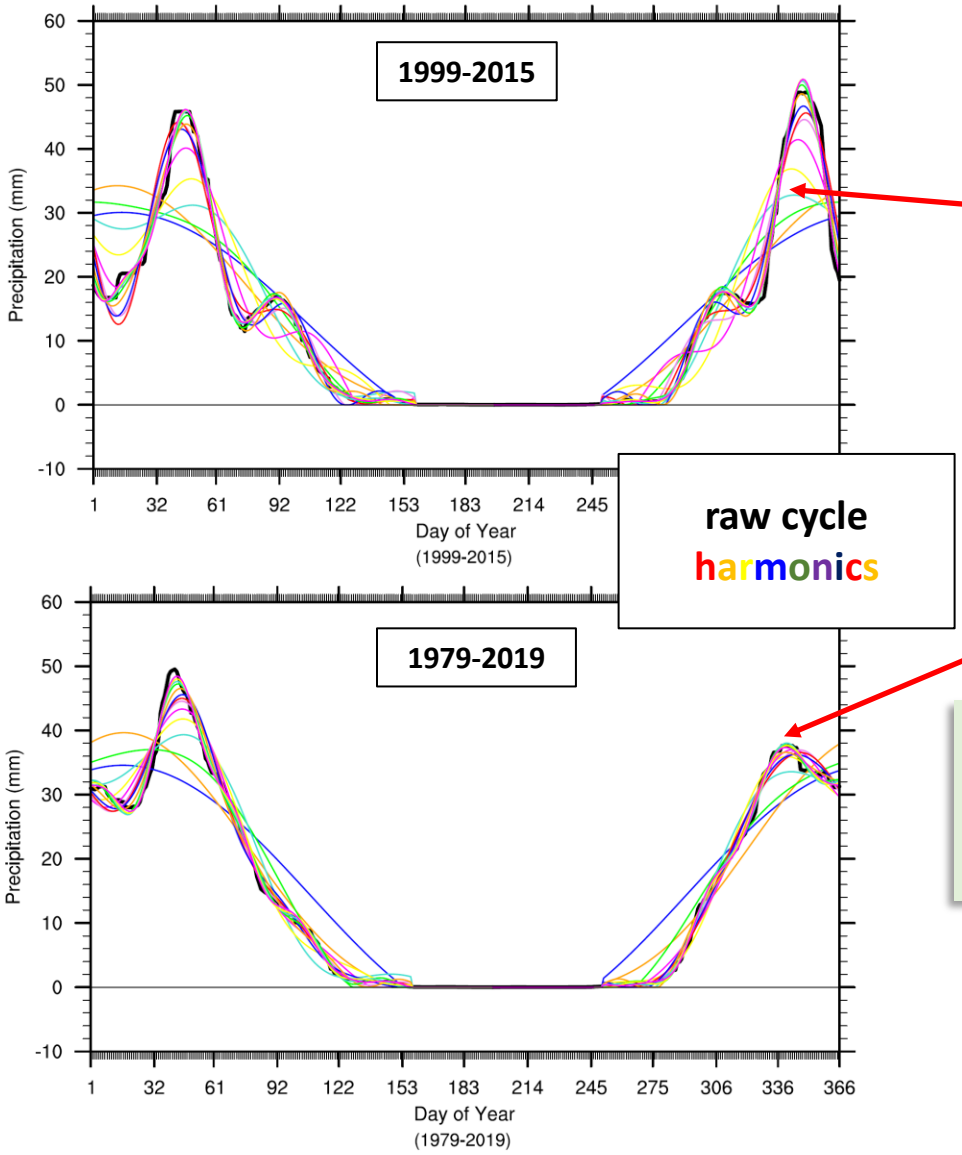
Clean-up

Challenge #4: Smoothing raw cycles risks being arbitrary.

Partial Resolution: We can smooth at will and obtain nearly a perfect fit with 14 harmonics. But should we? Some housekeeping still needs to be done by removing sub-zero values and artificially small positive values.

On the Challenge of Defining Normal Precipitation with Medians

Annual Cycle of Two-Week Precipitation near San Francisco, CA (38N, 238E)



Smoothed cycles with 5 or fewer harmonics derived from the 1999-2015 period appear to have a better fit with the 1979-2019 period.

The double-peaks are not as prominent in the 1979-2019 climatology, and the secondary peaks have completely disappeared.

Why? Over longer climate periods, MJO- and synoptic-related variability will tend to cancel out for a given calendar day when this may not be the case for shorter climate periods.

Challenge #5: The climatological period of interest matters.

On the Challenge of Defining Normal Precipitation with Medians

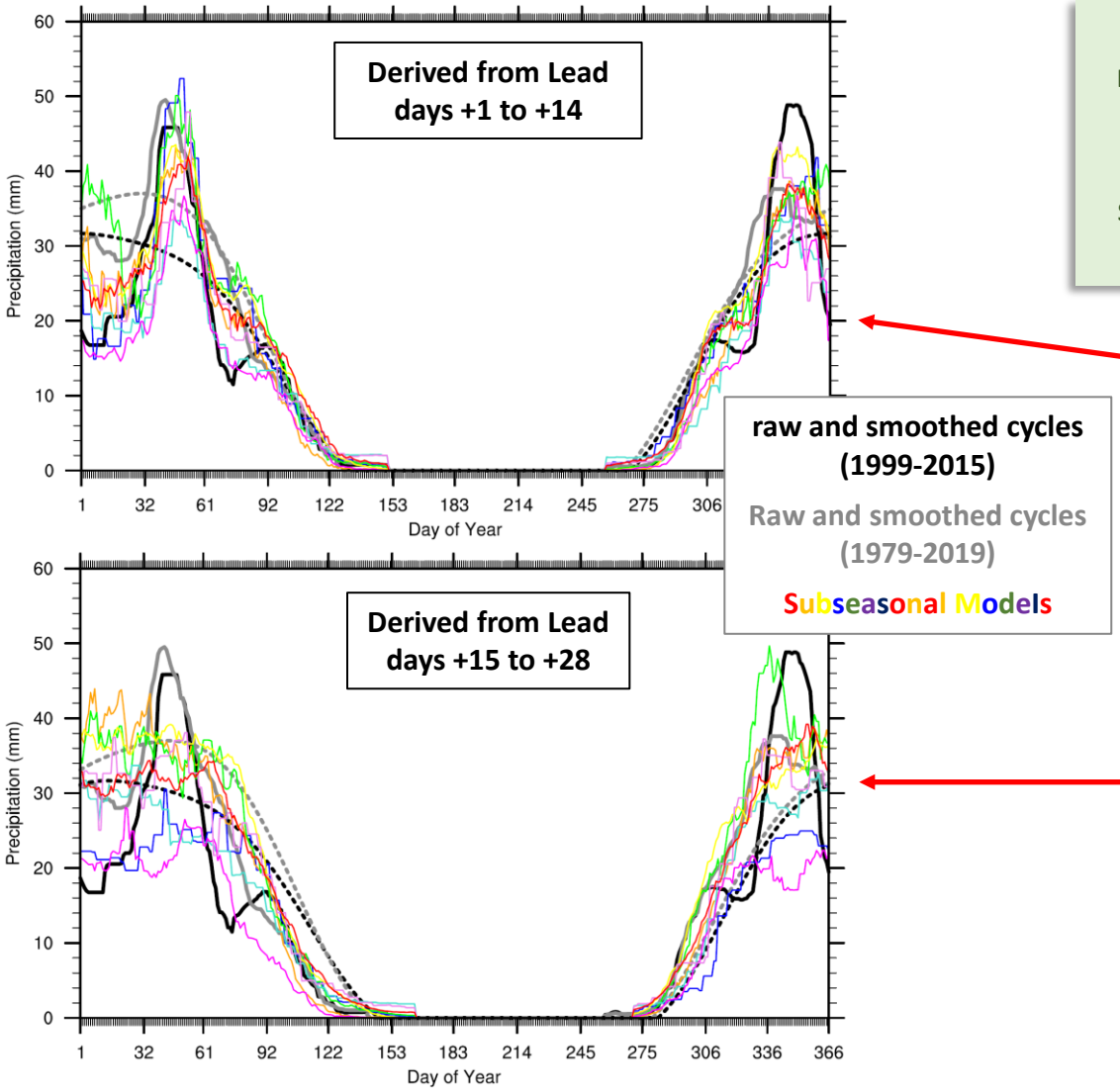
Calculating Medians in Subseasonal Models

- CPC uses the following subseasonal models in operations for Week 3-4:
  - Operational: ECMWF, JMA, CFSv2, GEFSv12 (soon)
  - Experimental (following the SubX protocol): ECCC_GEM, ESRL_FIMv2, NASA_GEOS, NRL_NESM, and RSMAS_CCSM4.
- SubX protocol hindcast period: 1999-2015
- For each individual model, Two-week medians are calculated as a function of calendar day, grid point, and lead time.
- To find these medians, distributions are created by gathering all two-week periods across 1) all model initializations within +/- 9 days of the calendar date of interest 2) all years in the hindcast period, and 3) all ensemble members.
- For example, CFSv2 has 4 members/day x 19 days/year x 17 years = 1292 members.
- Why +/- 9 days? Arbitrary, but it is short enough to avoid negative impacts from the seasonal cycle yet long enough to grab several model initializations from those models that do not initialize daily.

Challenge #6: Calculating medians in subseasonal models is not a trivial task.

On the Challenge of Defining Normal Precipitation with Medians

Subseasonal Model Two-Week Climatologies (1999-2015) near San Francisco, CA (38N, 238E)



Do the longer lead times of the subseasonal models provide a "truer" climatology than their shorter lead times? In other words, does the Week 3-4 climatology from the models give us some information about a climatological period longer than their respective hindcast period?

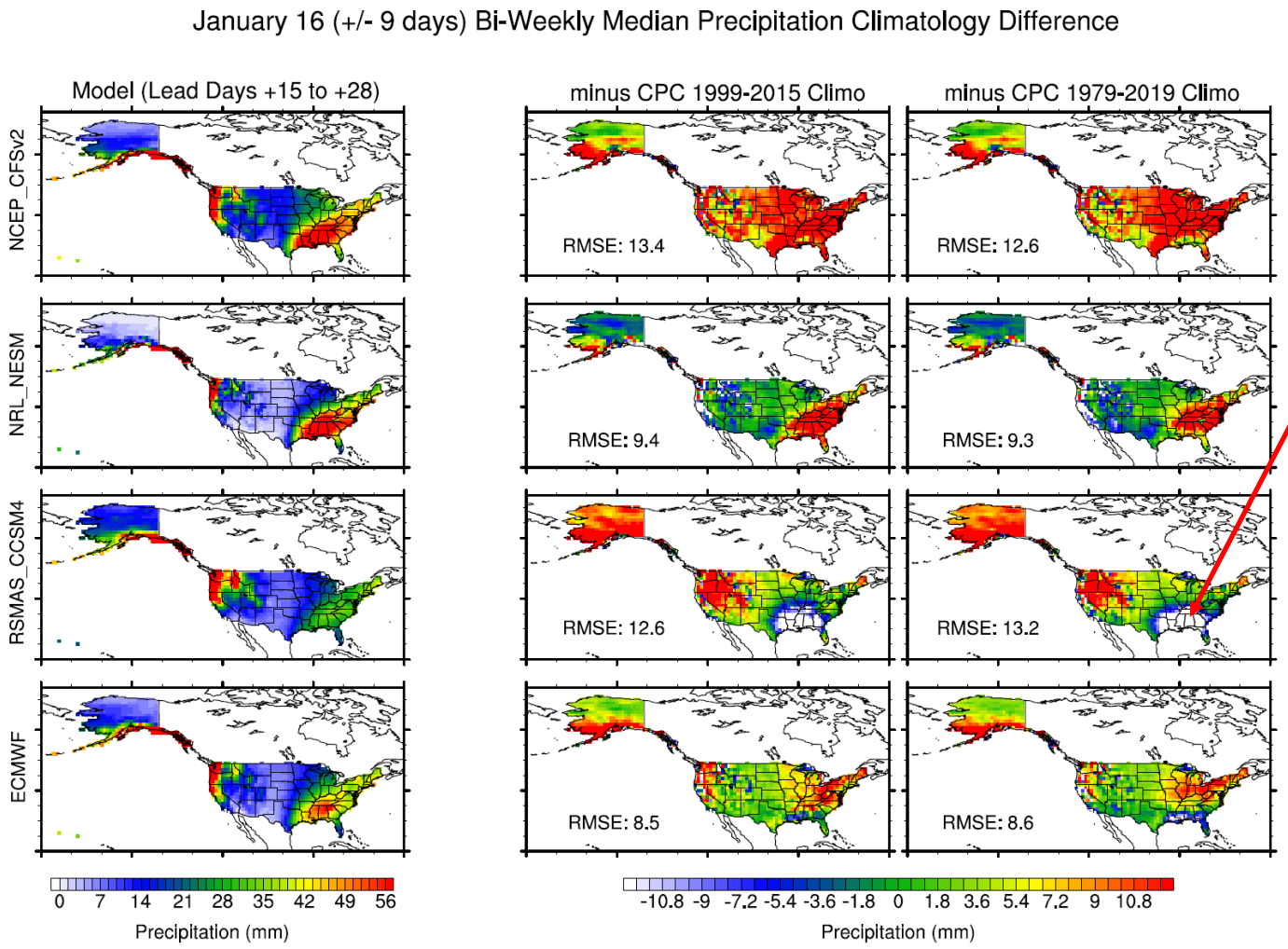
The subseasonal models simulate the observed raw annual cycle reasonably well when the first two weeks of their simulation are used. They are skillful at predicting the weather at short leads.

The subseasonal models have a much different climatology during their Week 3-4 lead times. They look more like the longer 1979-2019 climatology.

Challenge #7: The subseasonal models have climatologies that are highly dependent on lead-time.

On the Challenge of Defining Normal Precipitation with Medians

Difference between Two-Week Climatologies derived from Week 3-4 in the Subseasonal Models and the 1999-2015 and 1979-2019 periods.



For January 16th, the RMSEs are generally the same or less for the 1979-2019 period.

Individual models have regional biases.

Challenge #8: The subseasonal models have climatologies that differ from observations.

Partial Resolution: Calibration and using model climatologies to define above or below normal in model space is recommended.

On the Challenge of Defining Normal Precipitation with Medians

RMSE between Two-Week Climatologies derived from Week 3-4 in the Subseasonal Models and the 1999-2015 and 1979-2019 periods.

Model	Versus 1999-2015 Climo	Versus 1979-2019 Climo
ECCC_GEM	14.1	13.7
EMC_GEFS	14.9	14.7
ESRL_FIMv2	13.0	12.5
NASA_GEOS	12.1	12.3
NCEP_CFSv2	13.6	13.1
NRL_NESM	11.8	11.8
RSMAS_CCSM4	12.9	12.9
ECMWF	10.0	9.8

*Calendar-day RMSEs calculated across all USA grid points, then averaged across all calendar days

** units are in mm

In the aggregate, Week 3-4 of the subseasonal models have less error with respect to the 1979-2019 period than the 1999-2015 period despite the hindcast period being 1999-2015.

Why? Are the models reverting to a "true" climatology at longer leads?

Challenge #8: The subseasonal models have climatologies that differ from observations.

On the Challenge of Defining Normal Precipitation with Medians

Moral of the story: Tread cautiously with precipitation!

A one-size fits all approach may not be appropriate. While most of the above is not new, it highlights the continuing discussion that CPC has in-house to define the best climatology given 1) changing climate normal periods, 2) new products, such as Week 3-4 experimental precipitation, and 3) new model versions as they are released, such as GEFSv12.

Thank you! Any questions?

EXTRA SLIDES

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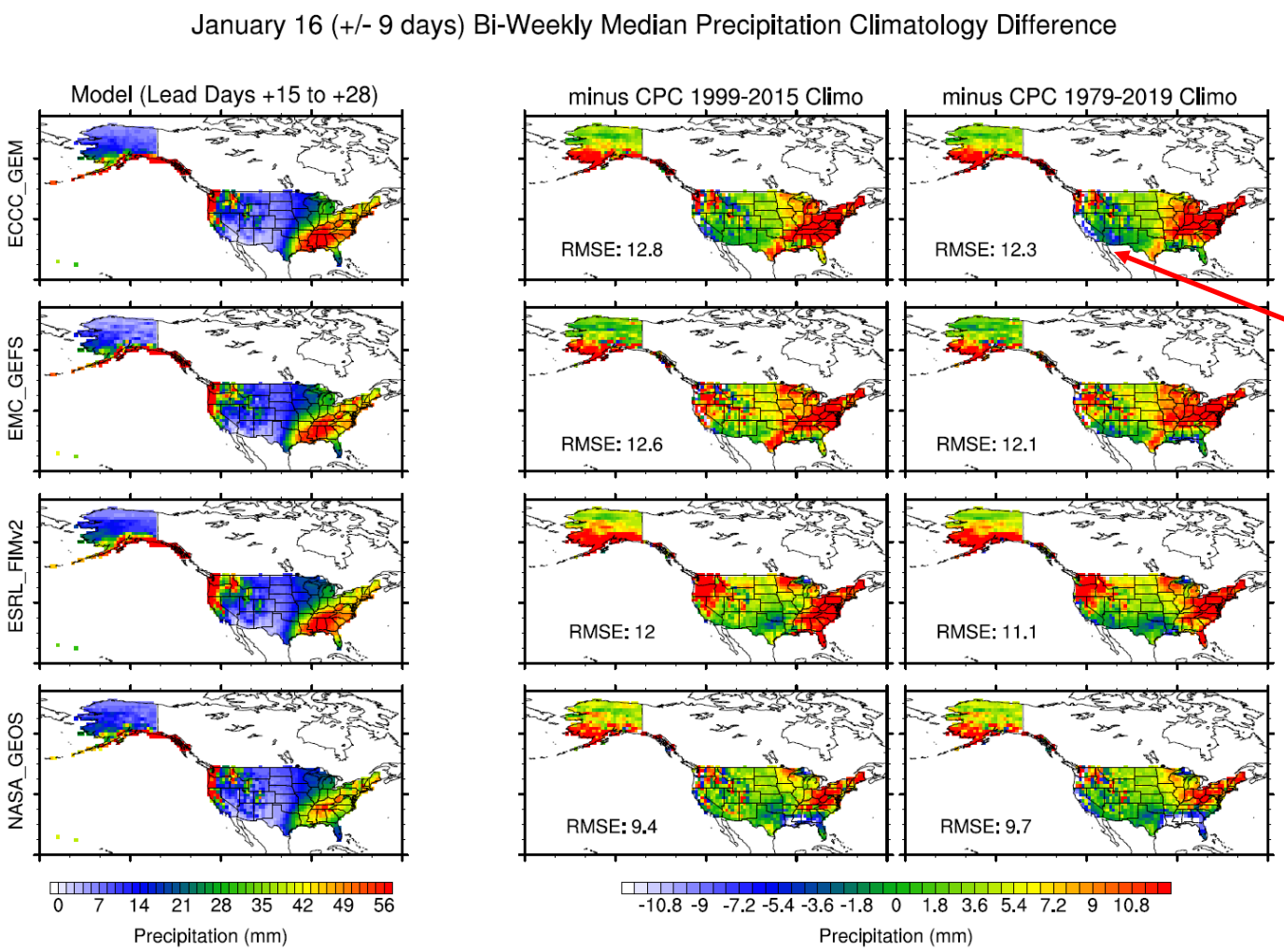

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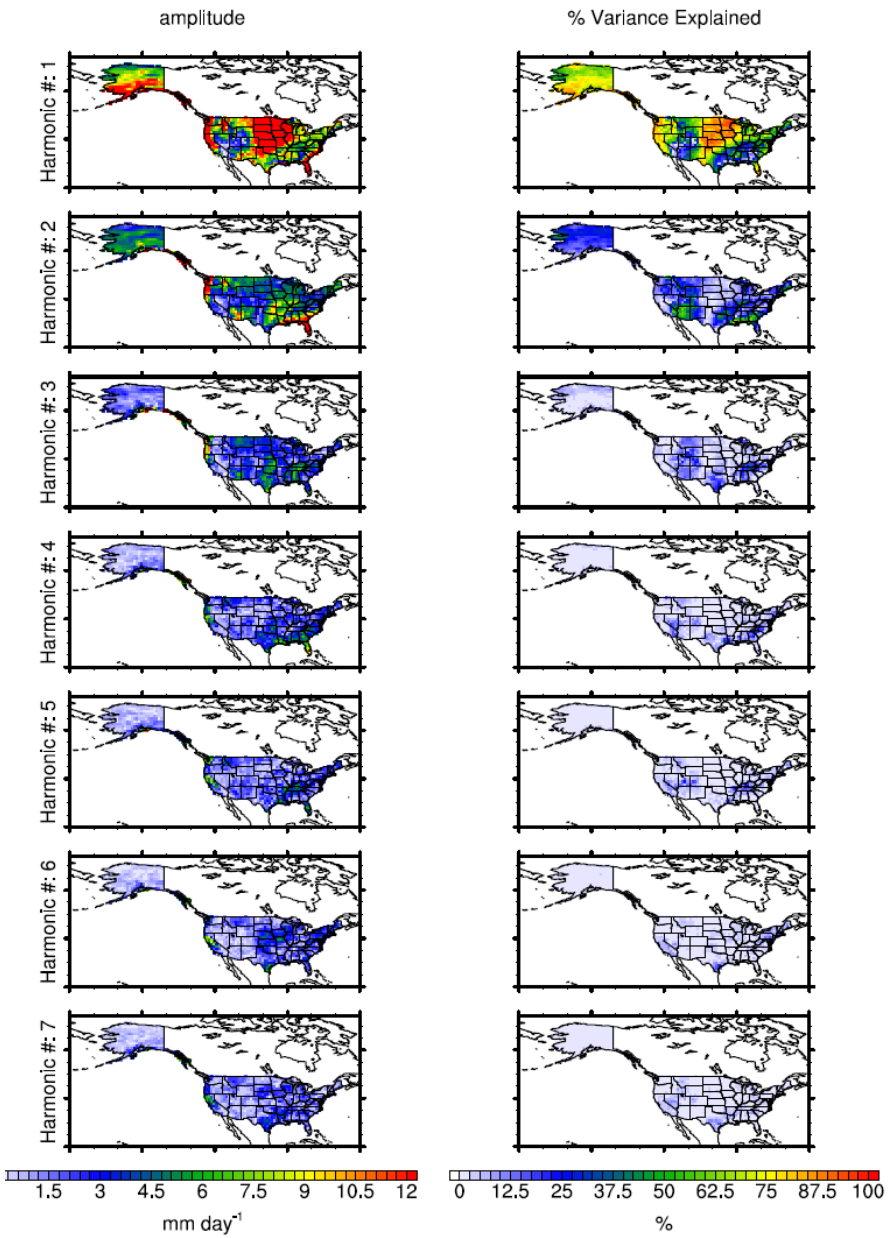

Amplitude and % Variance Explained per Harmonic during 1999-2015

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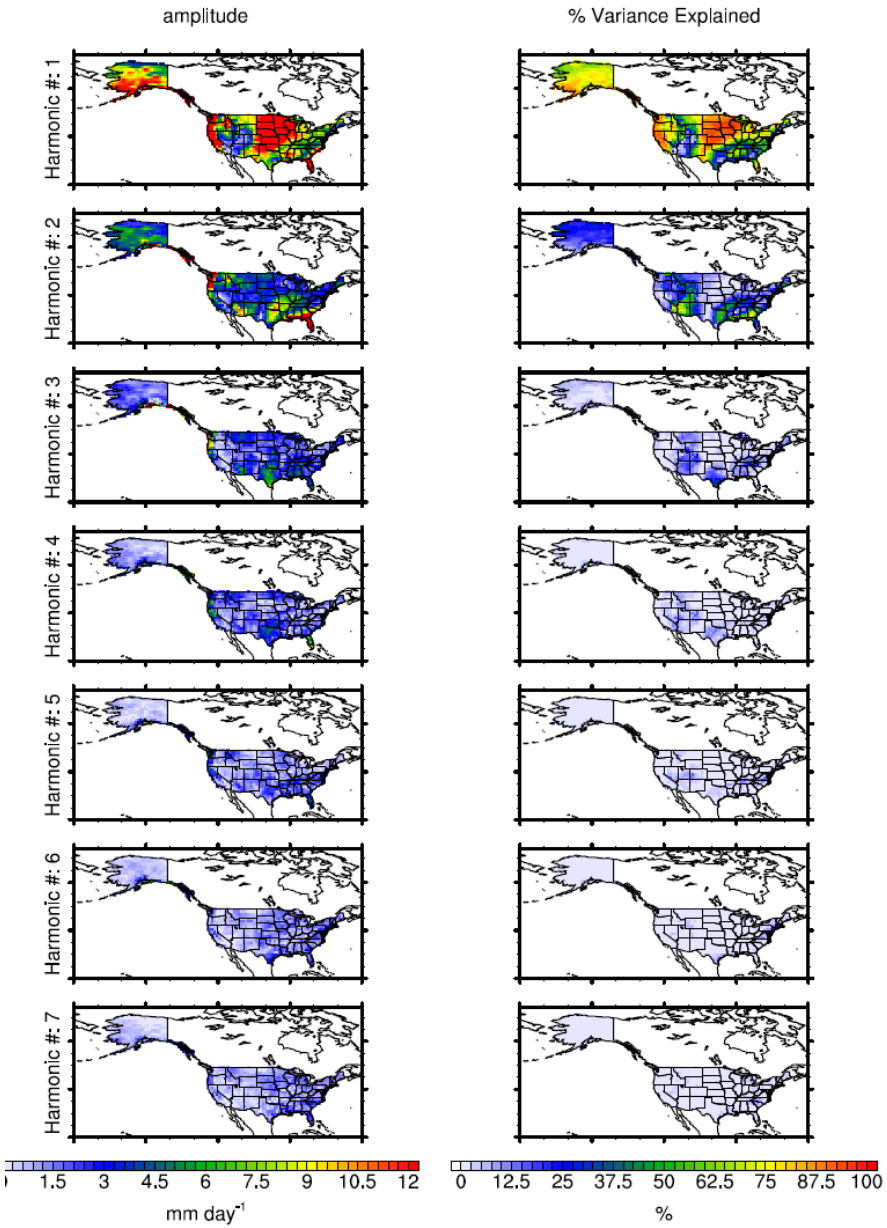
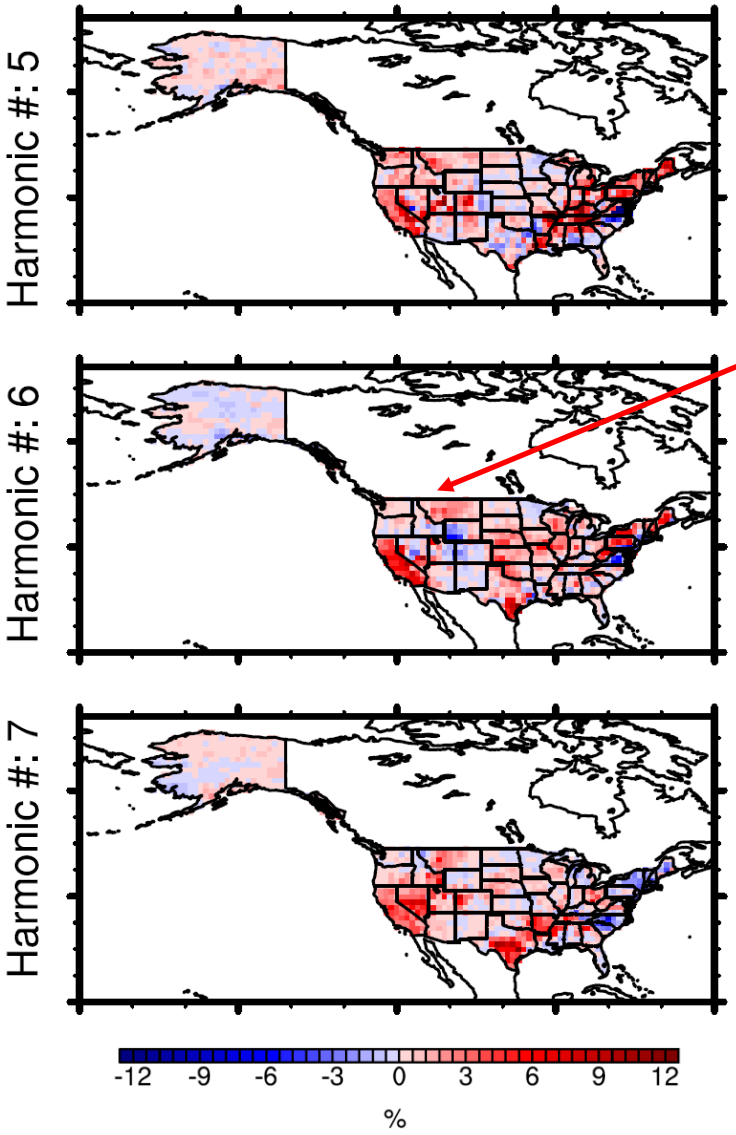


Amplitude and % Variance Explained per Harmonic during 1979-2019

1979-1999

On the Challenge of Defining Normal Precipitation with Medians

Difference in % Variance Explained per Harmonic (1999-2015 minus 1979-2019)

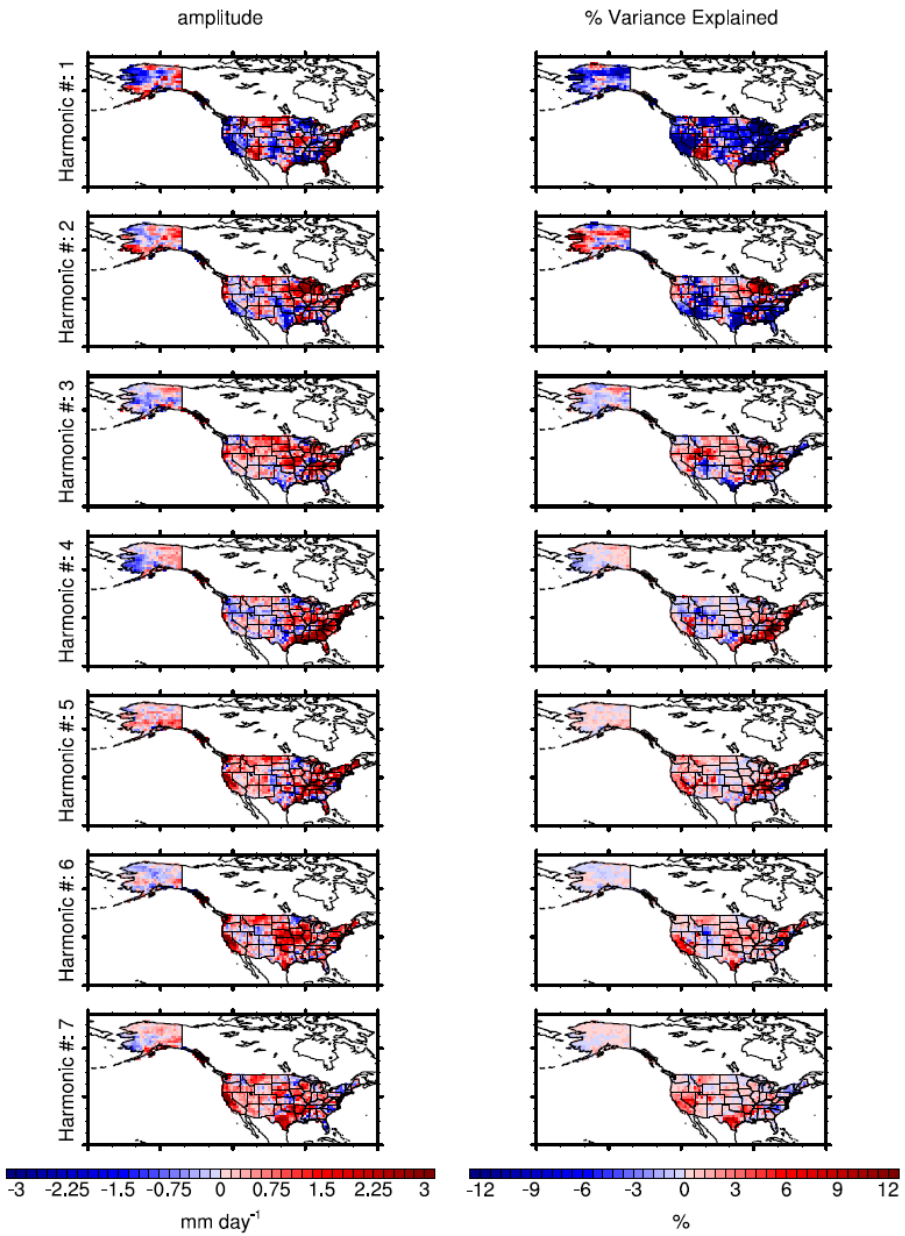


Higher number harmonics explain more variance, in regions like California, during the 1999-2015 period.

Challenge #5: The climatological period of interest matters.

Partial Resolution: Weather likely dominates shorter climate periods. Thus, a longer climate period is advisable and/or smoothing with a limited number of harmonics to obtain a "true" climatology.

On the Challenge of Defining Normal Precipitation with Medians



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