Application of the National Water Model (NWM) for Drought Monitoring: An Overview of CPC Activities

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Li Xu *et al*. Poster, Wednesday 4:30-6:00pm

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- simulates and forecasts how water moves throughout US rivers and streams,
- produces hydrologic guidance at a very fine spatial and temporal scale, complementing the NWS RFC hydrologic guidance.
  - Hourly, 250m-1km, 2.7 million river reaches in the CONUS

Current River Forecast Points (~3,600)

+

NWM Streamflow Output Points (~2.7 mil)

https://water.noaa.gov/about/nwm

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- ➢ produced real-time analysis (06/2019-present) and a 26-year (1993-2018) retrospective simulation for v2.0, which allows for ***drought monitoring***
  - Streamflow, surface runoff, soil moisture, evaporation, snow, and other parameters.

An NWM Project

- Project
  - Application of the National Water Model for Drought Monitoring (09/2017-08/2020)
- Team
  - NOAA/OWP: **Mark Glaudemans**, Dale Unruh, Fernando Salas, Fred Ogden
  - NOAA/PSL: **Robert Webb**, Mimi Hughes, Darren Jackson, Mike Hobbins, Rob Cifelli, Bob Zamora
  - NOAA/CPC: **David DeWitt**, Kingtse Mo, Hailan Wang, Li Xu, Muthuvel Chelliah
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- Key results
  - Evaluated the NWM v1.2 and 2.0 retrospective simulations using ***in-situ observations***
    - ***Soil moisture***:
      - Positively biased at most CONUS locations
      - Variability and <=10th percentile events: comparable to the NLDAS-2 model suite
    - ***Streamflow***:
      - Wet biased across much of the CONUS
      - Low-flow streamflow (<=10th percentile): acceptable performance in Pacific Northwest and southeast US

Hughes et al. 2020 (in prep)

An NWM Project: Application of the NWM for Drought Monitoring
Outstanding issues in the NWM v2.0

1) Its retrospective period (1993-2018) is relatively short
   - will be remedied in v2.1, which starts from 1979 for the retrospective simulation
2) It uses different precipitation forcings for the retrospective and real-time periods
   - Retrospective: NLDAS-2
   - Real-time: HRRR/RAP/MRMS/MPE

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An NWM Project: Application of the NWM for Drought Monitoring
CPC Contribution (01/2020-08/2020)

1. Evaluated the NWM v2.0 retrospective simulation using the USDM
2. Studied an outstanding issue of the NWM v2.0 for drought monitoring
   - Precipitation mismatch between the retrospective and real-time analysis

An NWM Project: Application of the NWM for Drought Monitoring

CPC Contribution (01/2020-08/2020)

1. Evaluated the NWM v2.0 retrospective simulation using the USDM
   - Processed the NWM v2.0 data (1993-2018) by interpolating the native model data (3-hourly, 1km) to daily means at NLDAS-2's lat-lon grid

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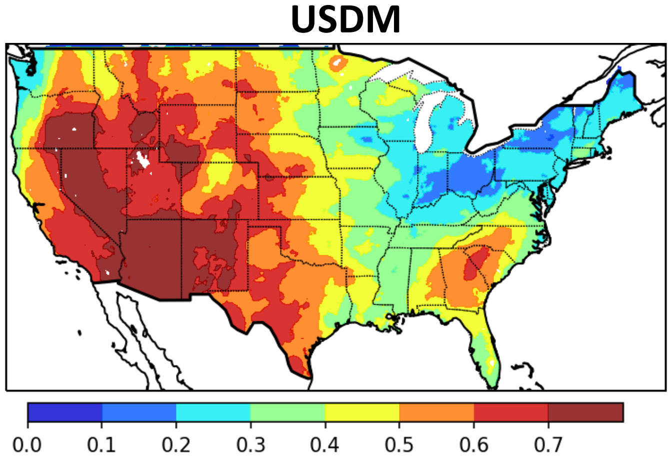
   - Evaluated the NWM ***soil moisture*** using contingency table based metrics
     - NWM soil moisture percentiles are converted to D0-D4 in order to compare with the USDM
     - Focus on their common period: 2000-2018

1.1 An Evaluation of the NWM using the USDM: *Evaluation*

Frequency of drought occurrence (D0-D4)



USDM: considerably more frequent drought occurrence in the western (W) US and southeastern (SE) US

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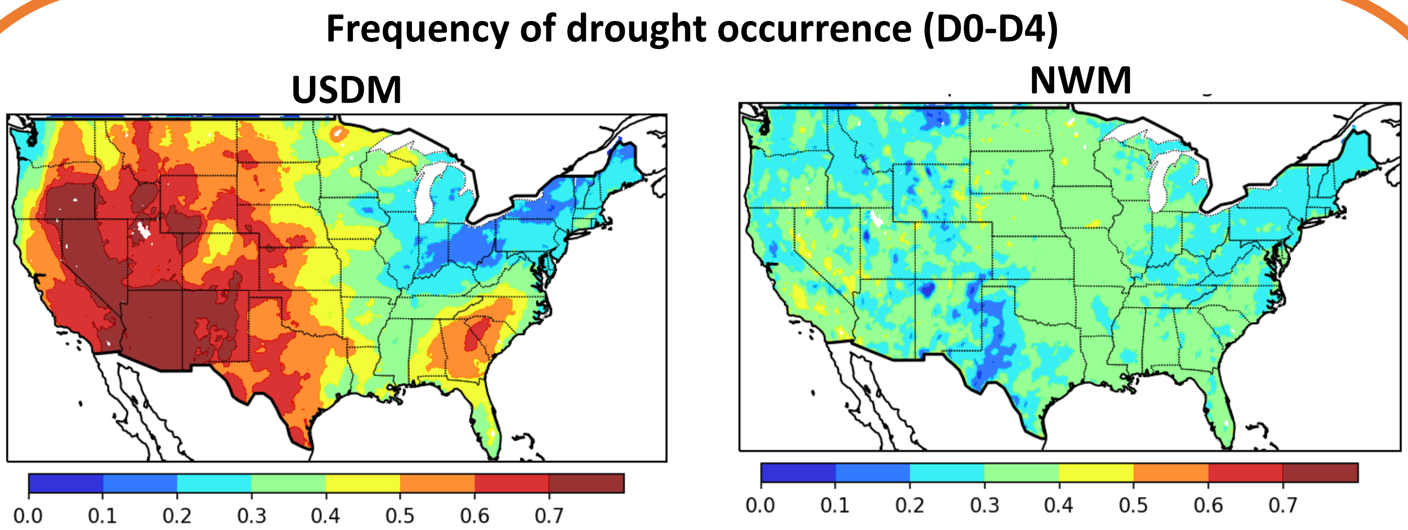

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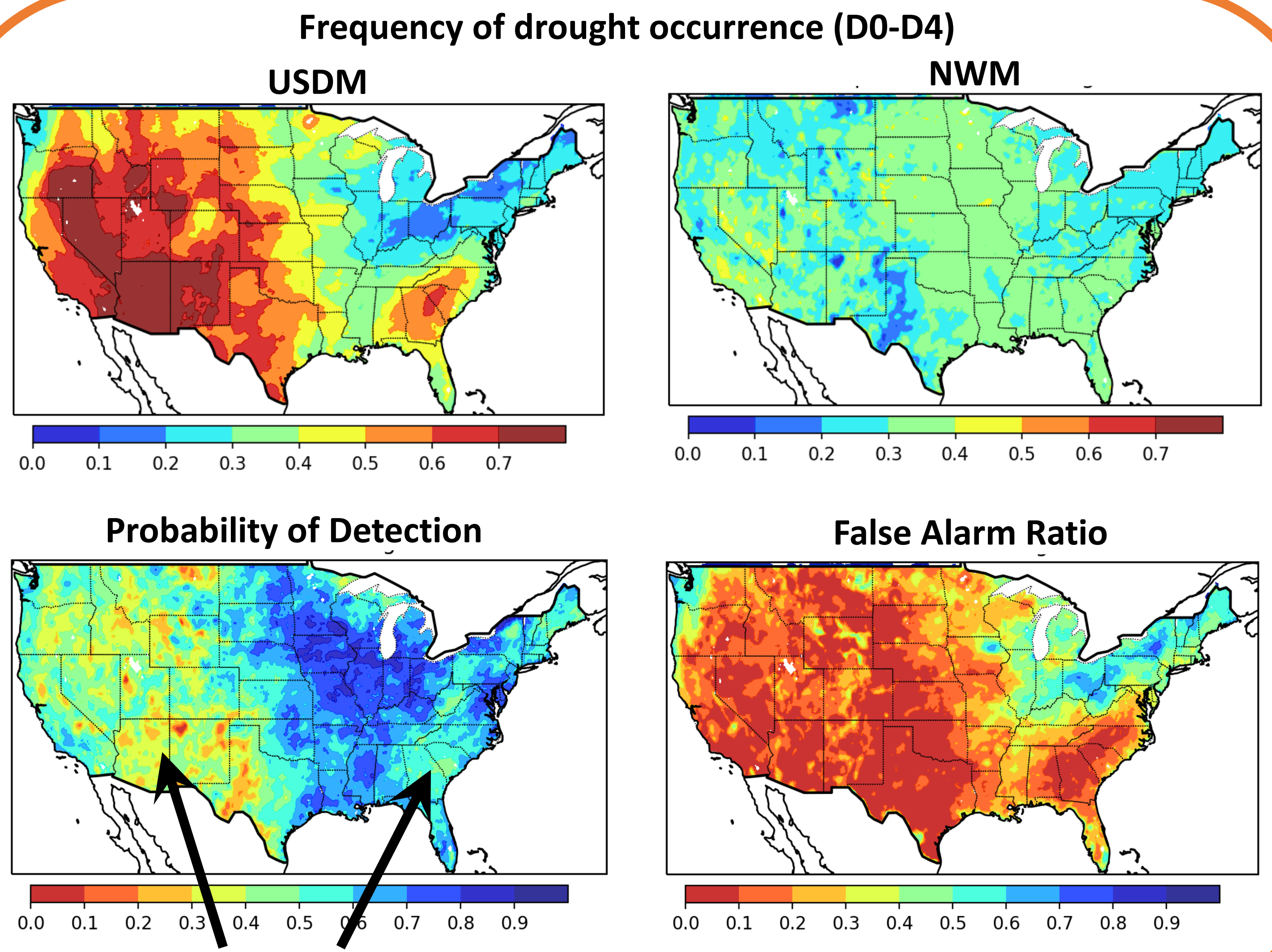

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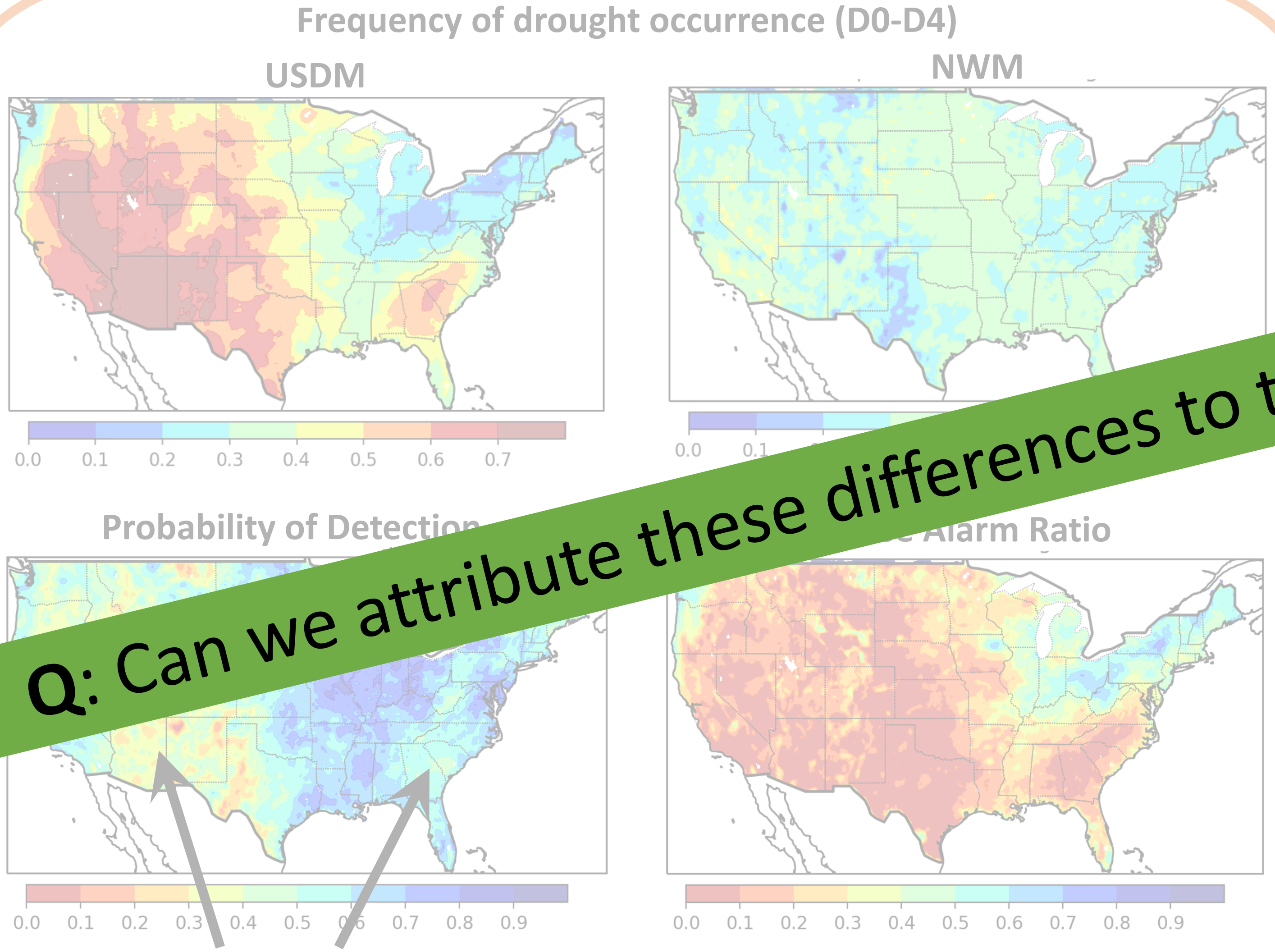

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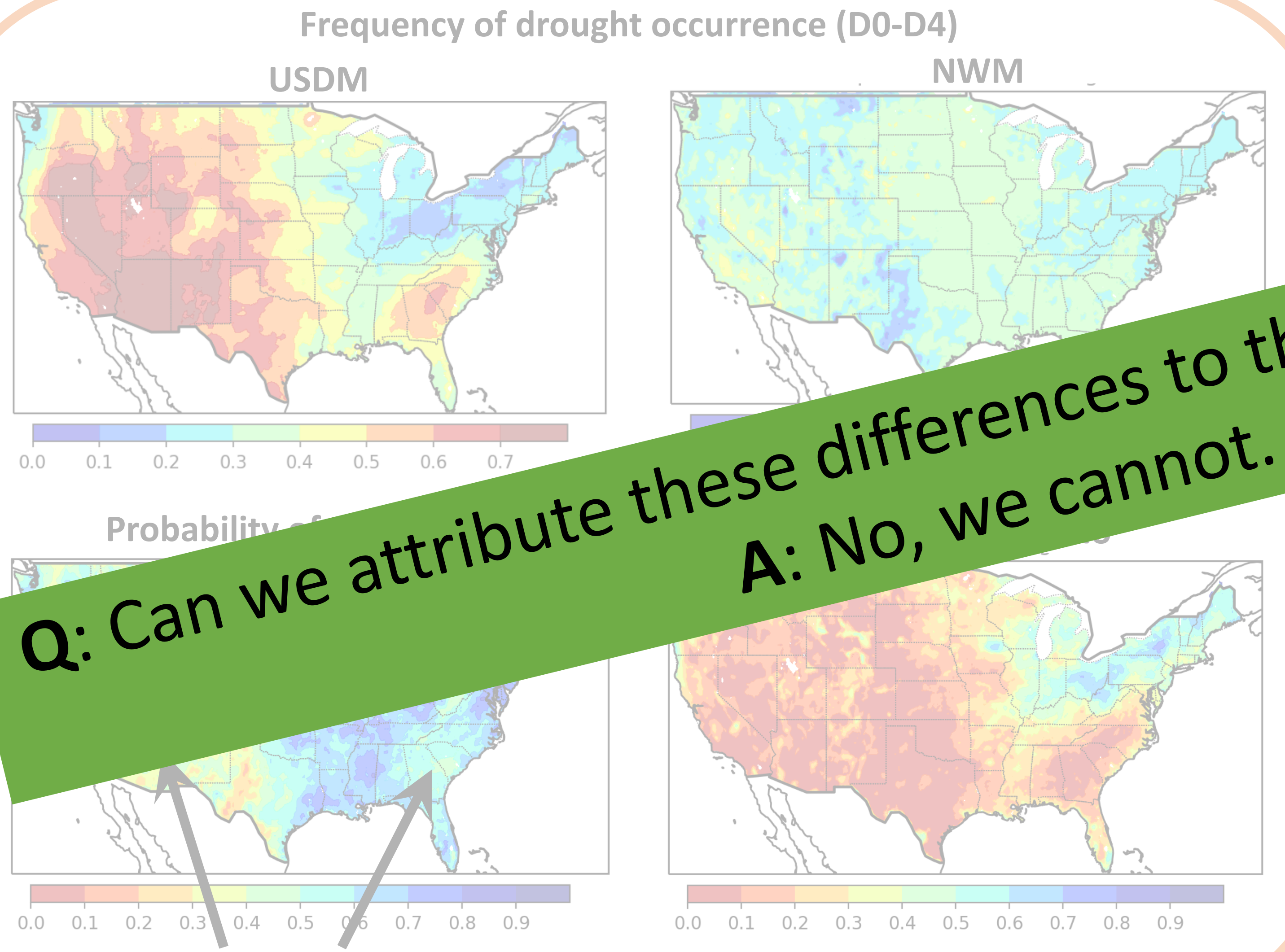

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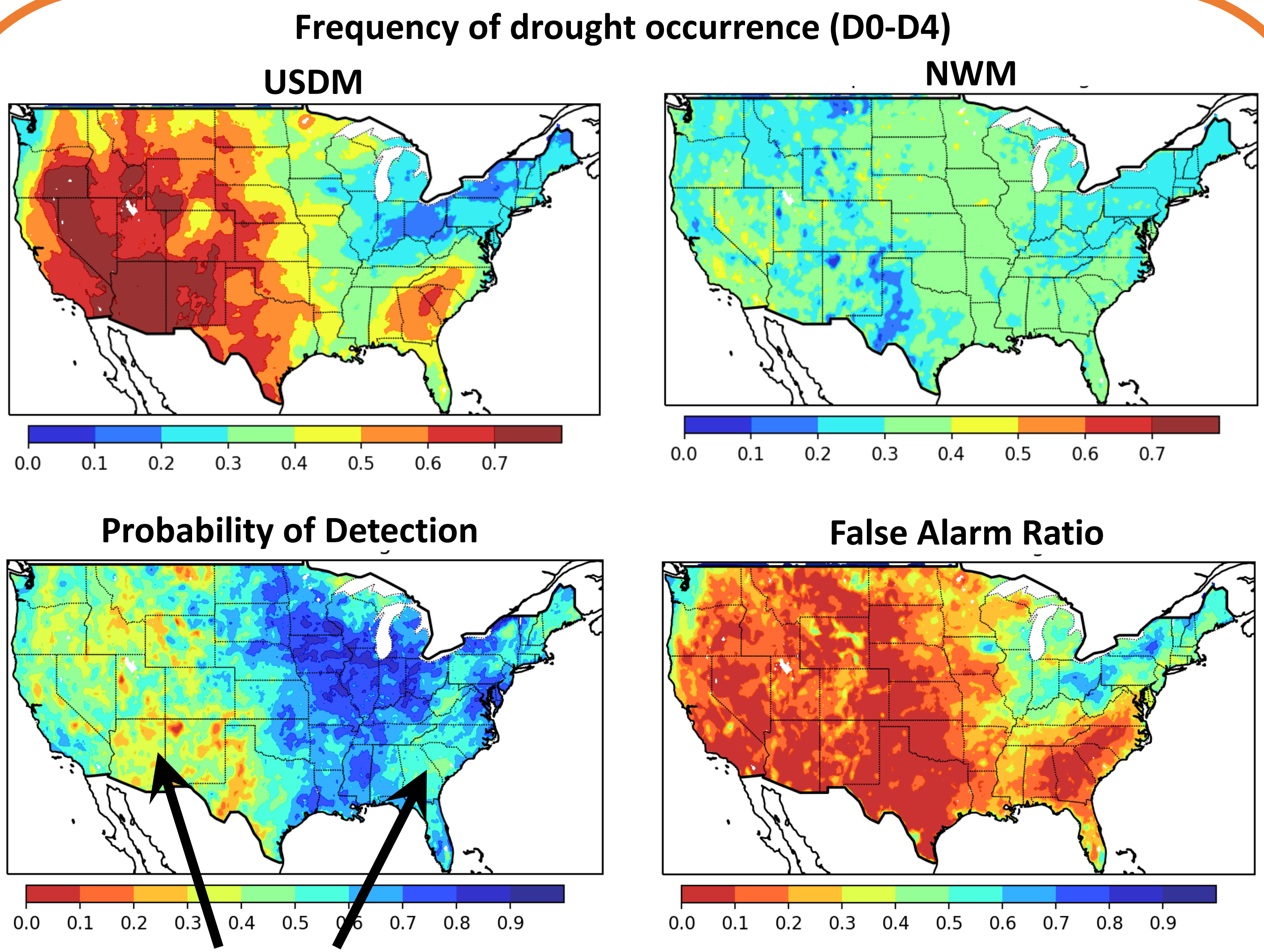

<50% detection rate in the western US and southeastern US

We need to use caution when using the USDM to evaluate land surface models (LSMs), because it is not a fair apple-to-apple comparison:

1. They use different base periods to quantify drought anomalies.
   - ➢ The USDM uses century-long data and captures both short-term and long-term droughts, whereas LSMs are subject to the length of their available simulations

2. The USDM integrates a multitude of drought indices, whereas LSMs usually use a single variable (e.g. soil moisture) to indicate drought conditions.

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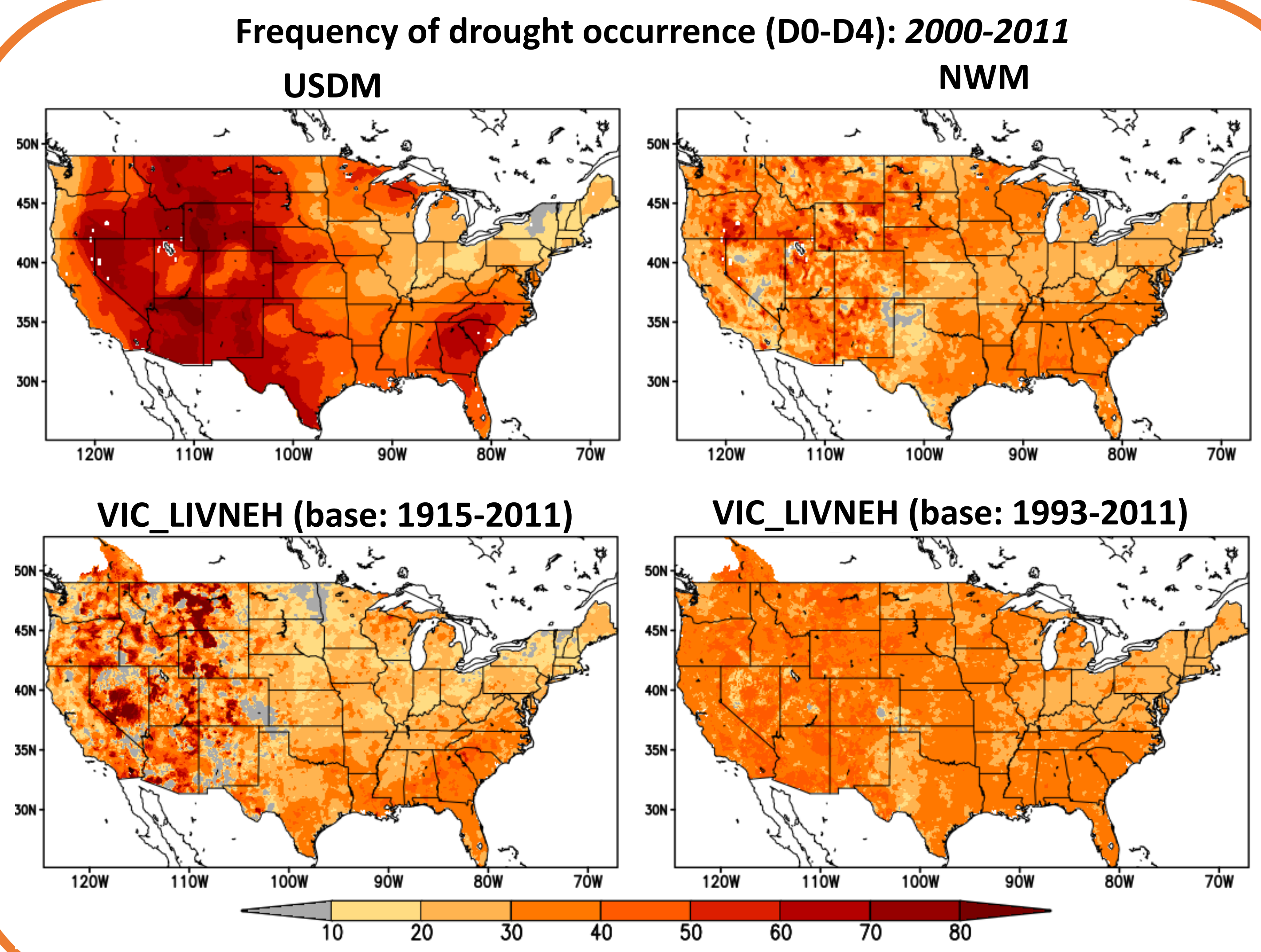

The VIC_LIVNEH simulation (1915-2011, Livneh *et al*. 2013) is used to help interpret the NWM vs. USDM differences, while keeping in mind that it uses a different LSM from the NWM:

1. When a century-long base period is used, the VIC_LIVNEH captures long-term droughts in the W US and SE US.
2. With a century-long base period, the VIC_LIVNEH still considerably differs from the USDM, in part due to the differences in the drought indicators they use.

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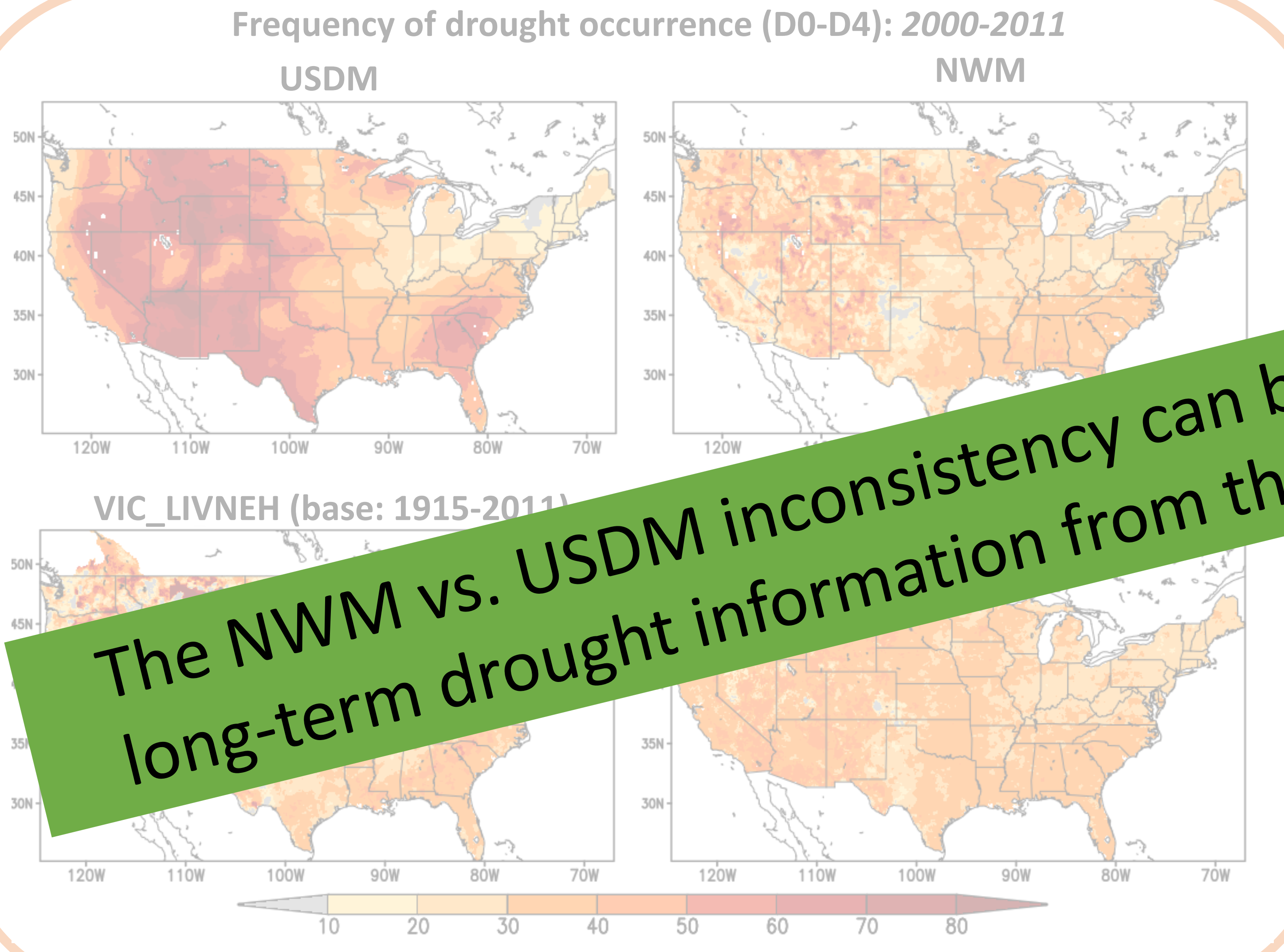

The NWM vs. USDM inconsistency can be remedied by merging long-term drought information from the USDM with the NWM.

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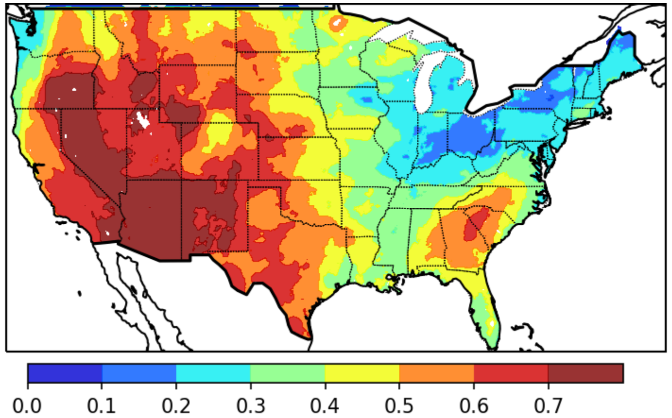
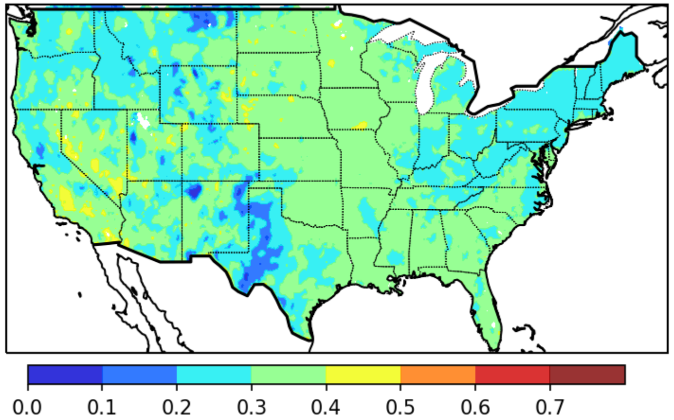
An approach to remedy the USDM vs. NWM inconsistency

Frequency of drought occurrence (D0-D4)

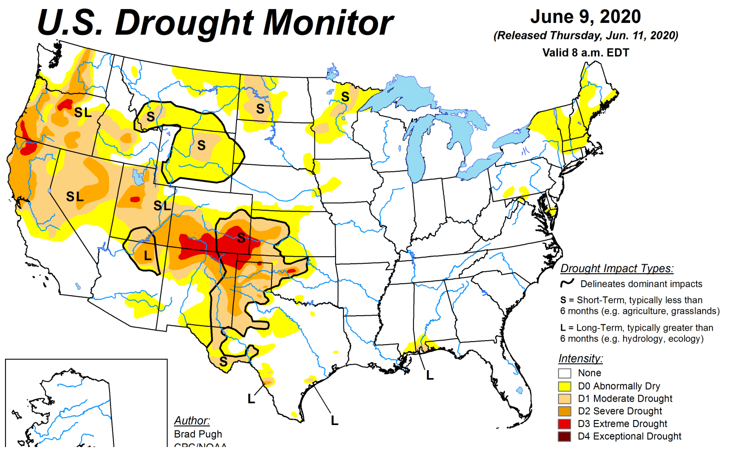
USDM

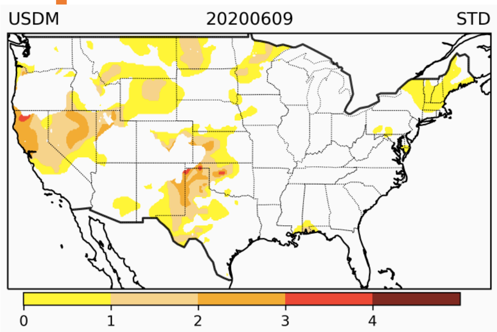


NWM

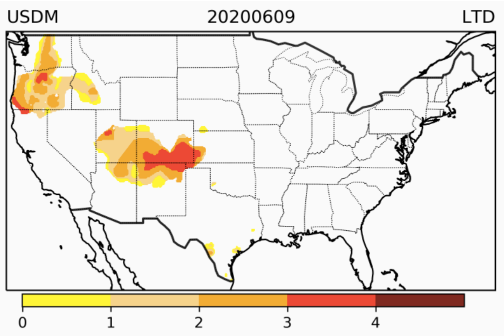


USDM decomposition into short-term and long-term drought components





short-term drought (<6 mons)



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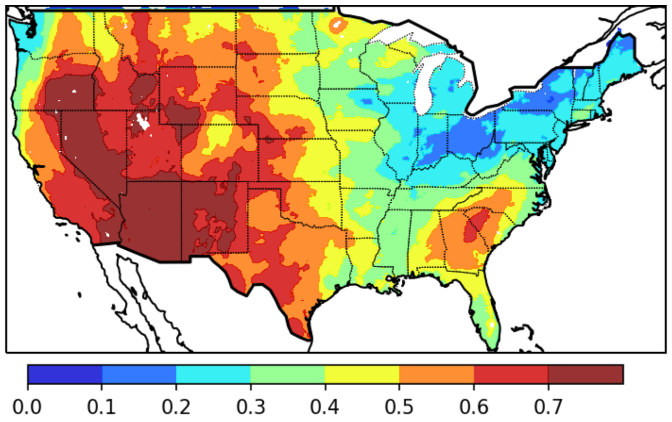
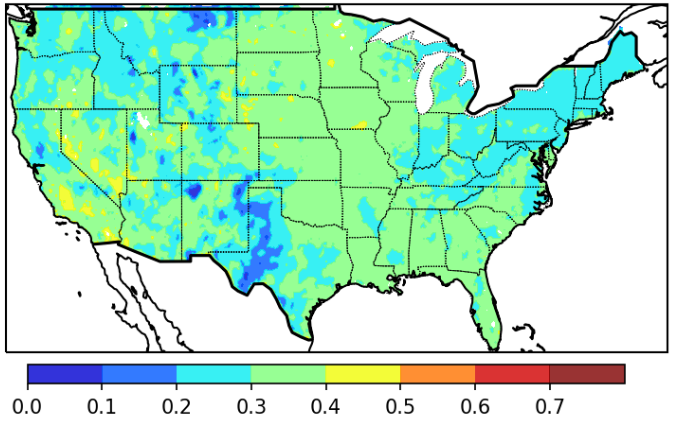


NWM



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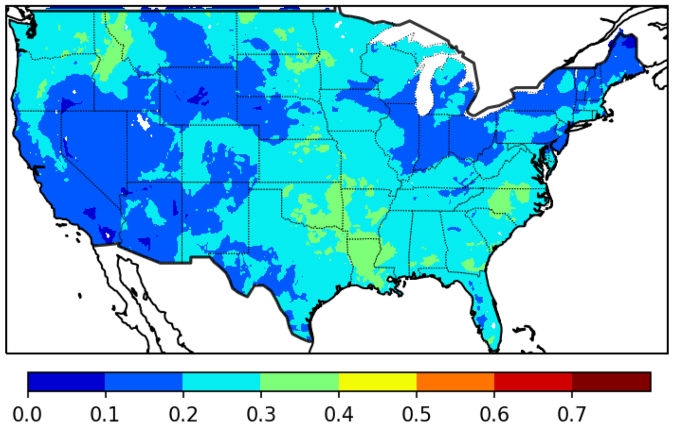

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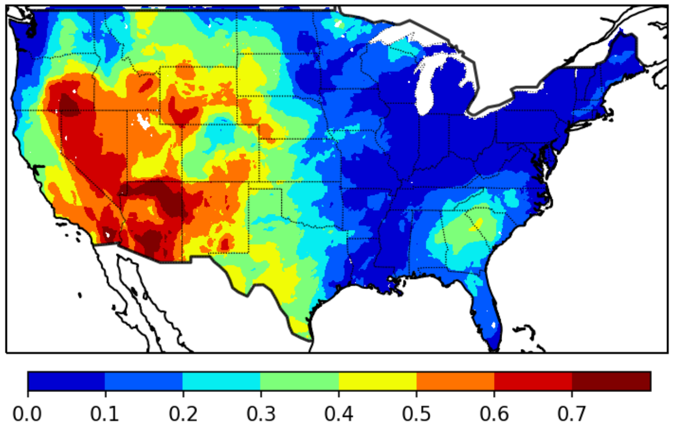

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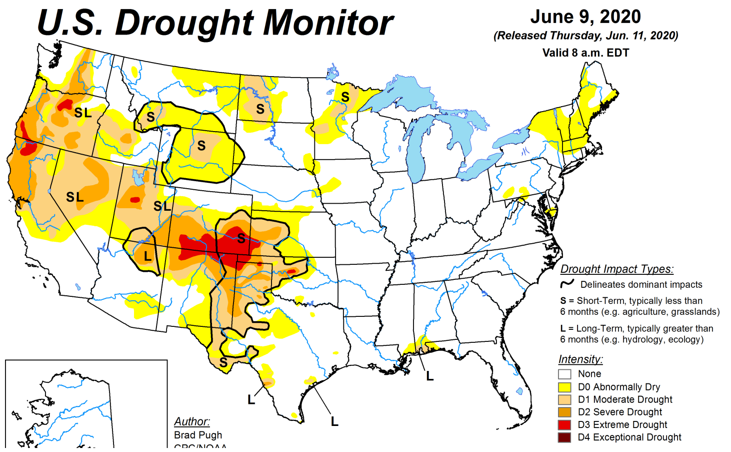

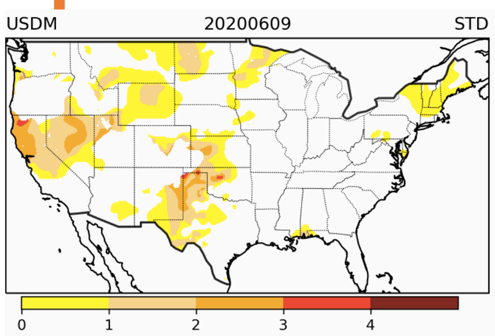

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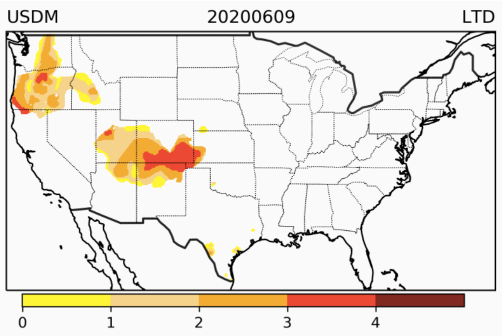

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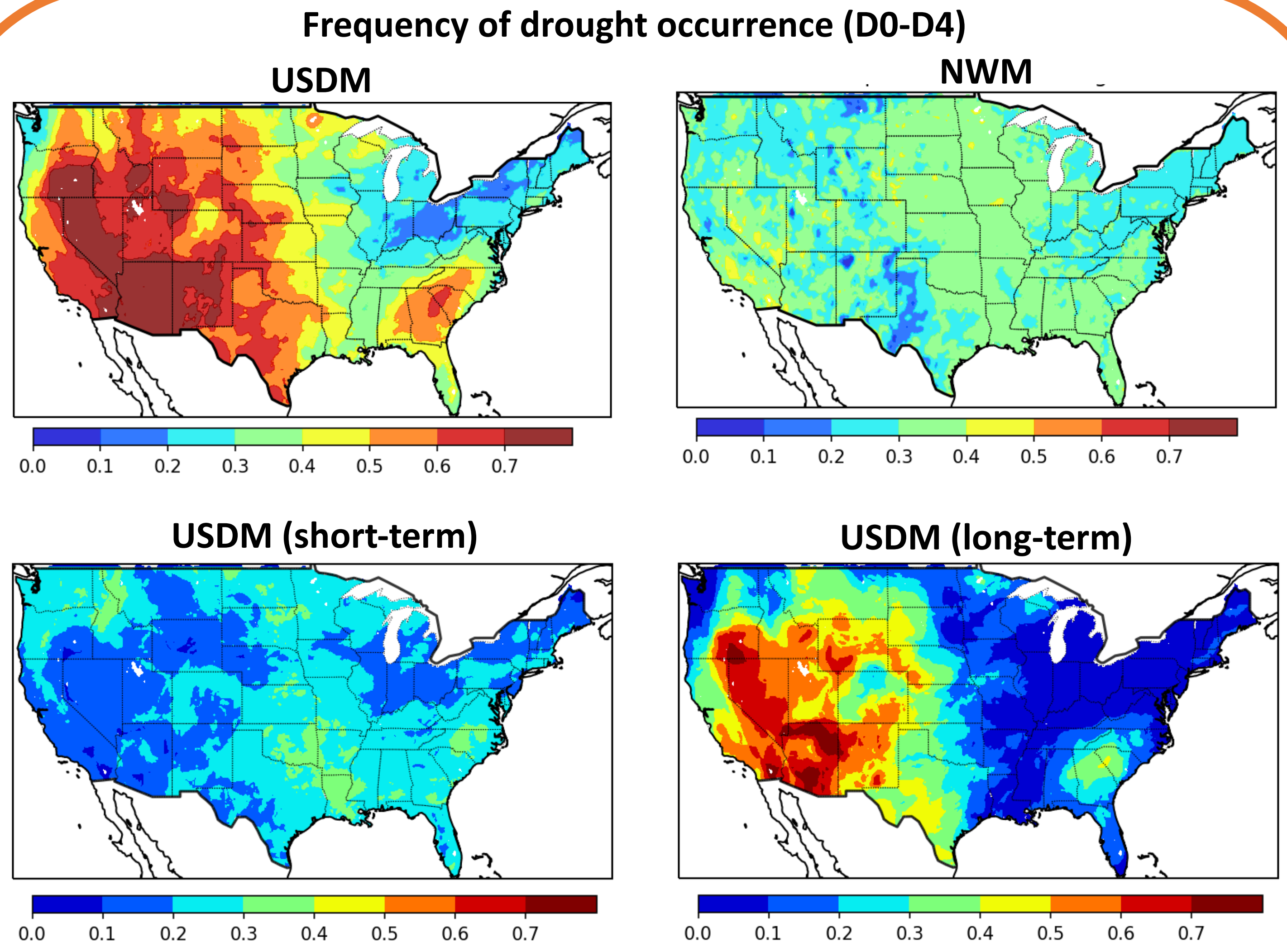

A key reason for the USDM vs. NWM inconsistency:

- long-term droughts are insufficiently captured in the NWM because of its relatively short duration

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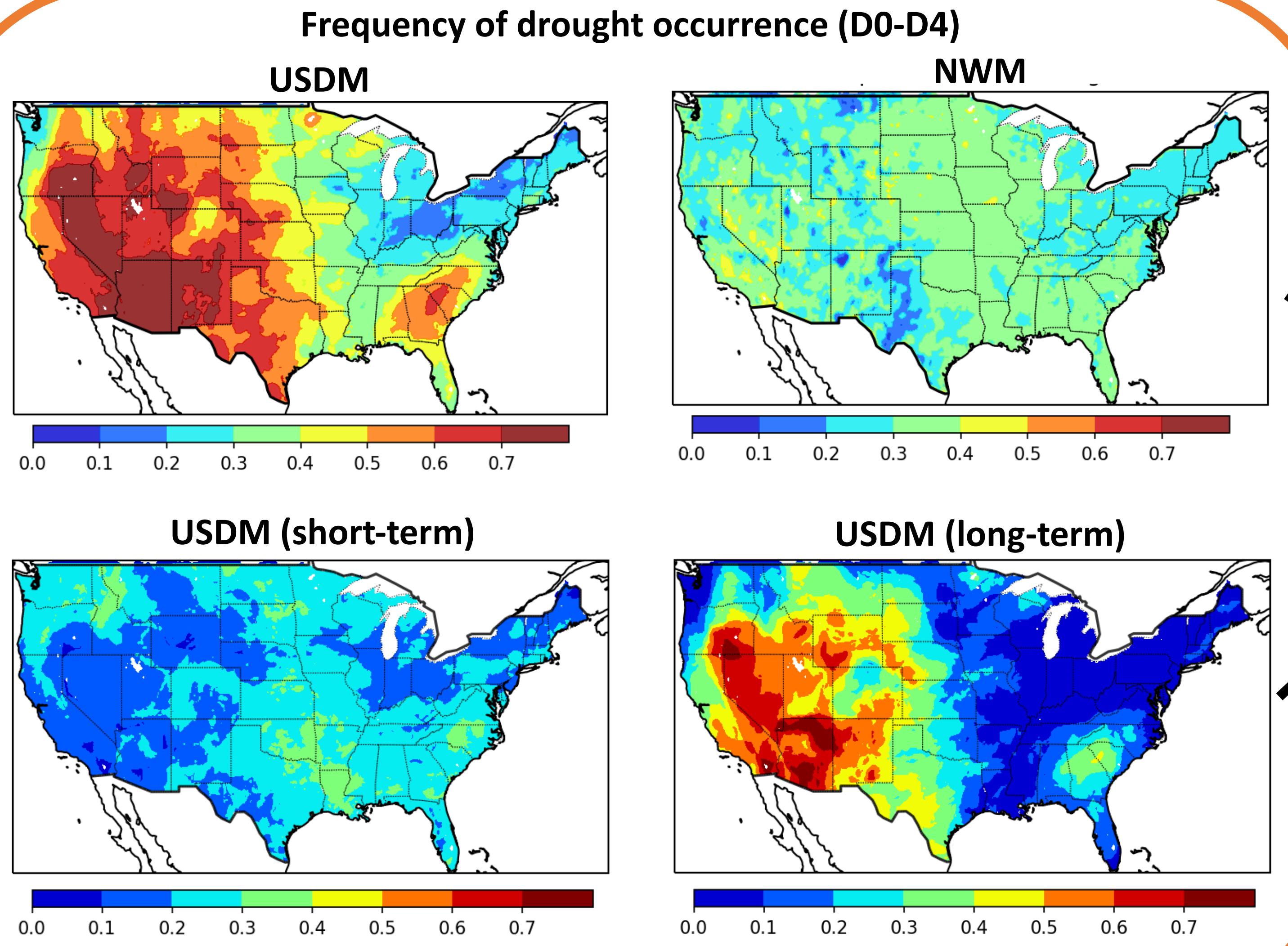

Integrate the NWM with the USDM long-term drought component using their joint probability (Hao and AghaKouchak 2014) to produce ***a preliminary merged NWM product***

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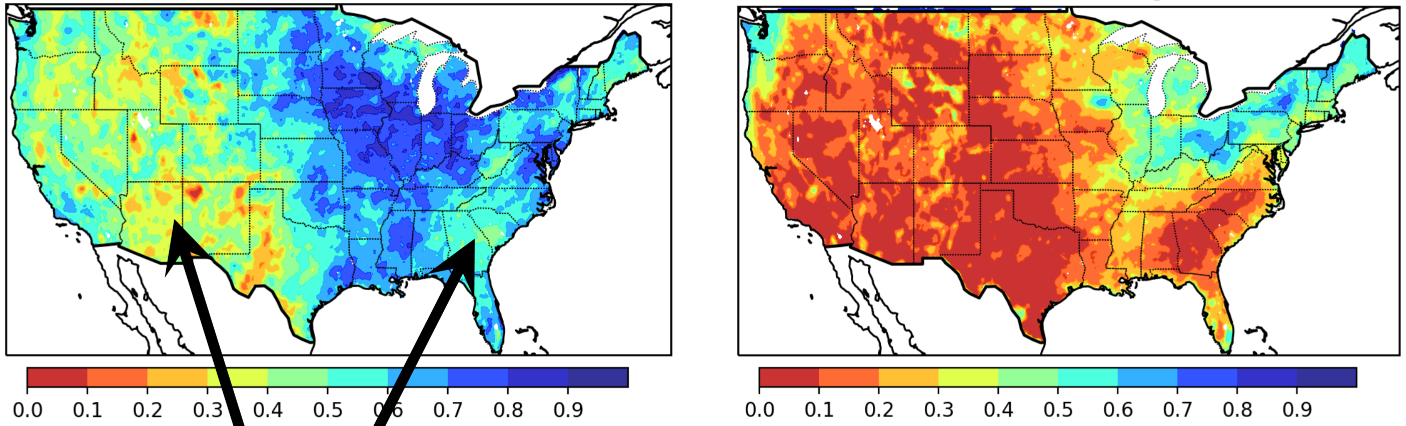
Probability of Detection | **False Alarm Ratio**

NWM vs. USDM



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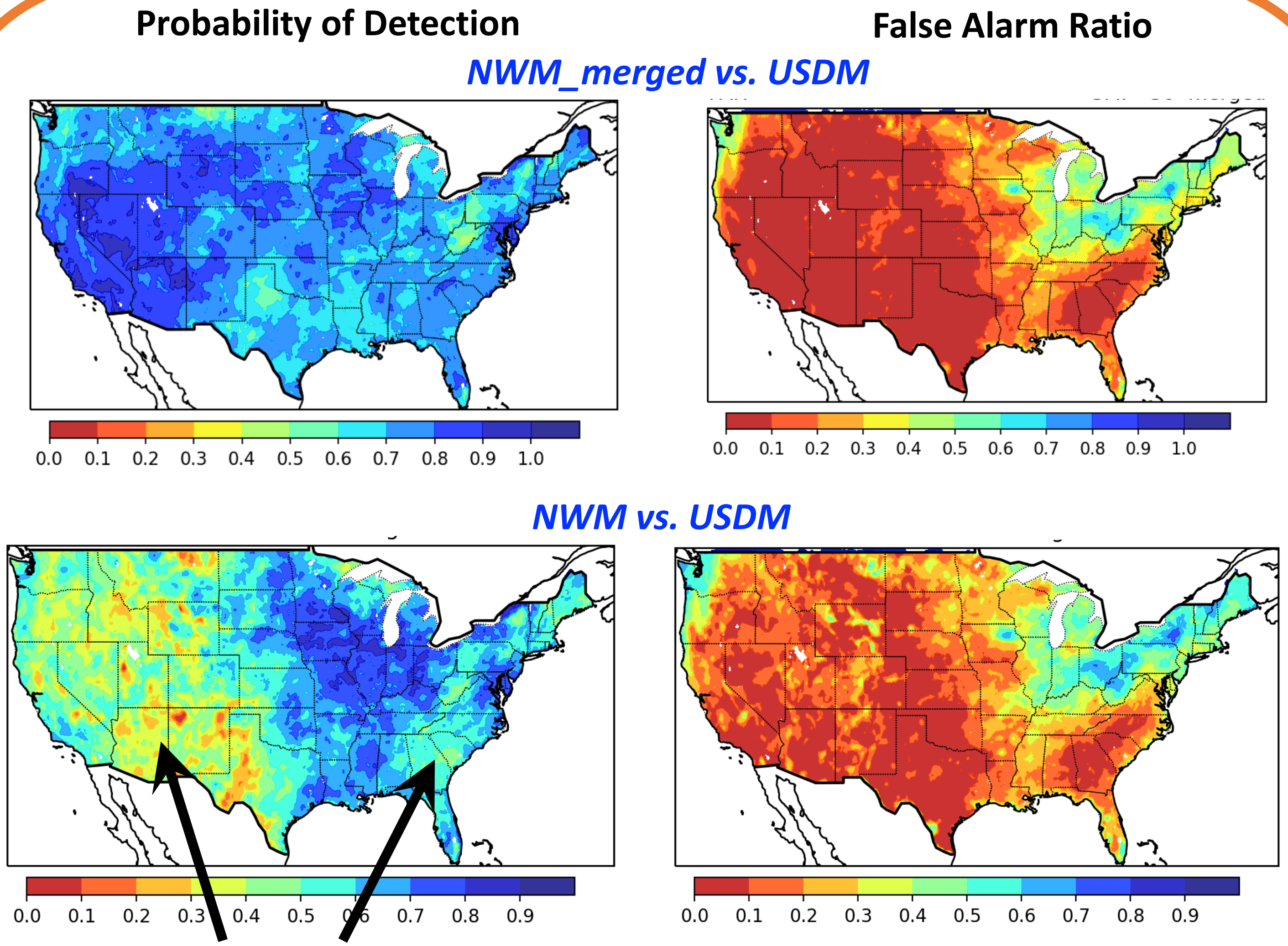

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Merging the USDM long-term drought component with the NWM:

- ➢ substantially improves drought detection rate
- ➢ reduces false alarm ratio.

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Outstanding issues in the NWM v2.0

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   - Retrospective: NLDAS-2
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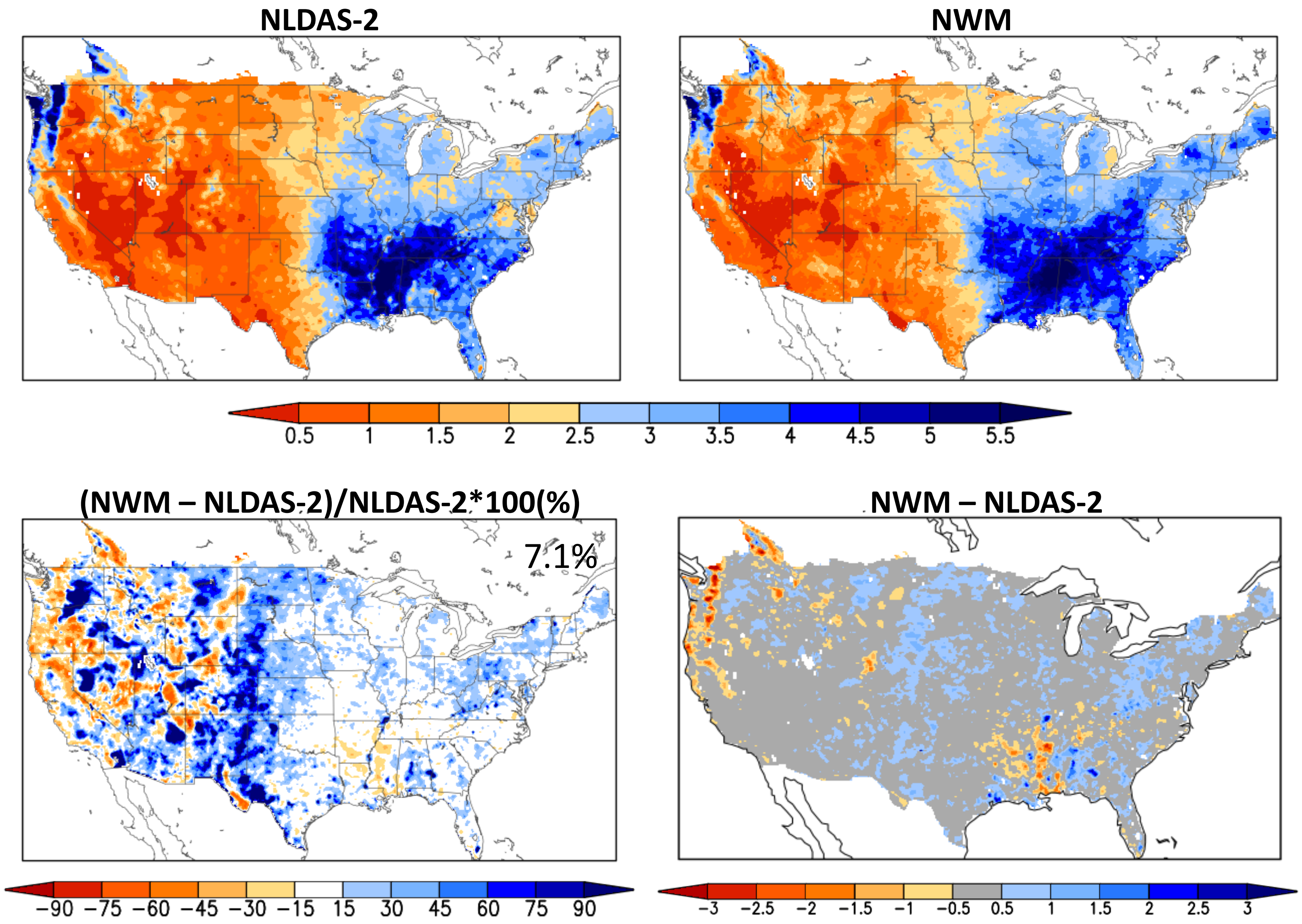
Hughes et al. 2020 (in prep)

2. An Outstanding Issue of the NWM v2.0
Retrospective vs. real-time P forcing inconsistency



NWM analysis vs. NLDAS-2 precipitation comparison (06/20/2019-06/19/2020):

- NWM is noticeably wetter than NLDAS-2 across much of the CONUS (7.1%).

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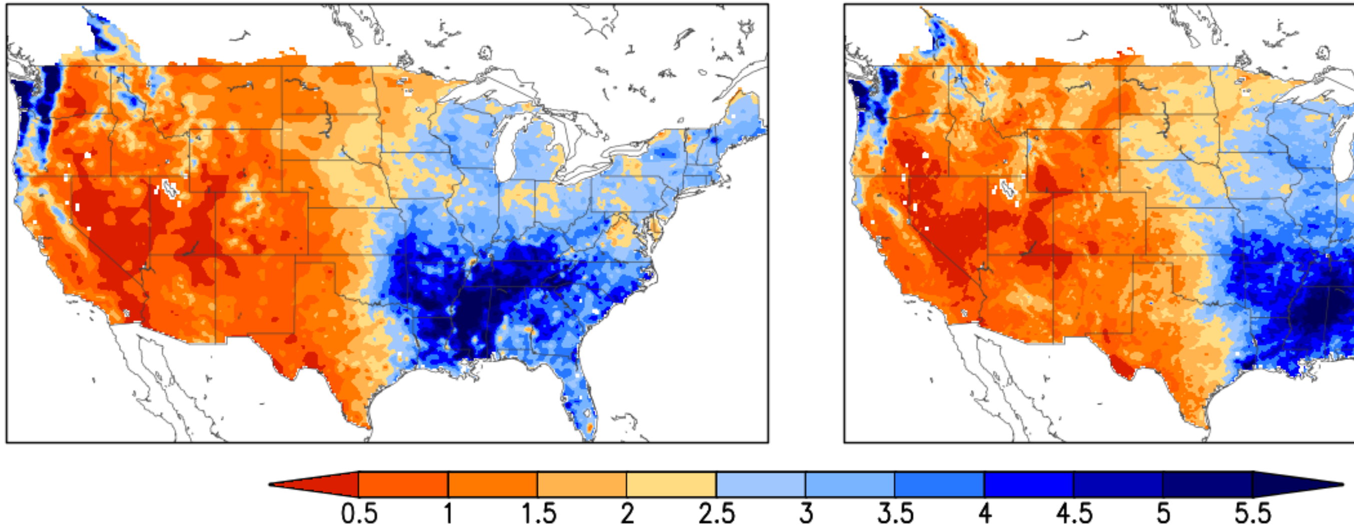
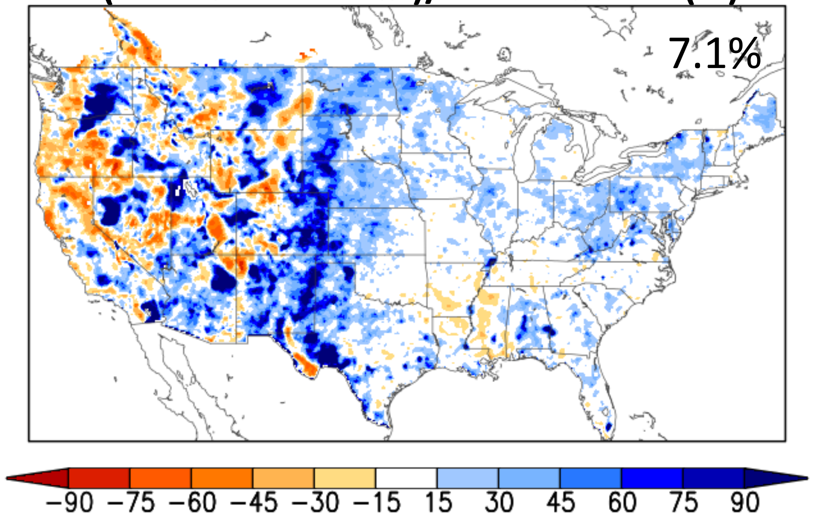
Retrospective vs. real-time P forcing inconsistency

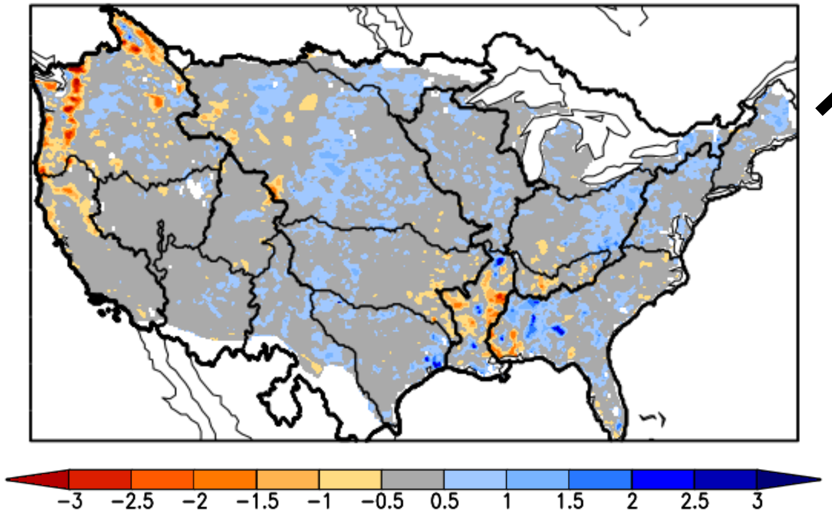
NLDAS-2 | NWM

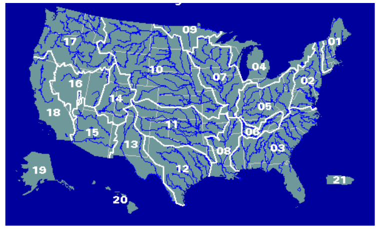


(NWM – NLDAS-2)/NLDAS-2*100(%)



NWM – NLDAS-2





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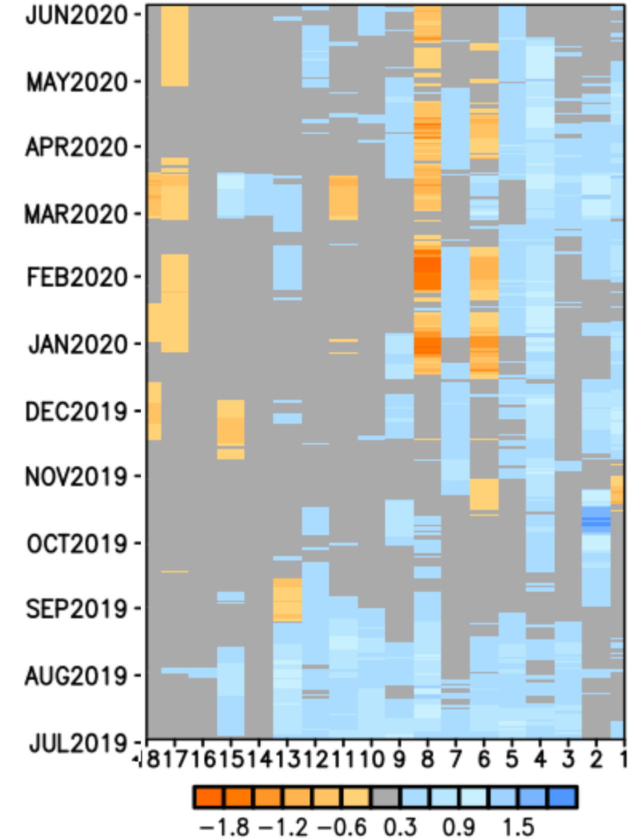

HUC2 mask (Darren Jackson, NOAA/PSL)

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   - ➢ Such NWM underestimation is due to a typical caveat of using the USDM to evaluate land surface models (LSMs), and thus cannot be attributed to the NWM deficiencies alone.
     - The USDM uses a century-long base period to estimate drought anomalies and thus captures both short-term and long-term droughts, whereas LSMs are subject to the length of their simulations.
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    - ➢ The USDM vs. NWM inconsistency can be remedied by merging the NWM with the USDM long-term drought component.

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2. An outstanding issue of the NWM v2.0

- The NWM v2.0 uses different precipitation (P) forcings for its retrospective simulation and real-time analysis, which impacts its quantification of real-time drought anomalies.
  - The P differences vary with region, season and weather event, with the NWM analysis being ~7.1% wetter than NLDAS-2 for the annual mean in the CONUS.

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Looking Forward

Future NWM versions are expected to have continued improvements in drought monitoring capability

- Longer retrospective simulation (e.g. v2.1 starts from 1979)
- Upgrades in forcings and model physics
- Domain expansion