CPC Contributions to a Climate Ready Nation

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Climate Prediction Center Director

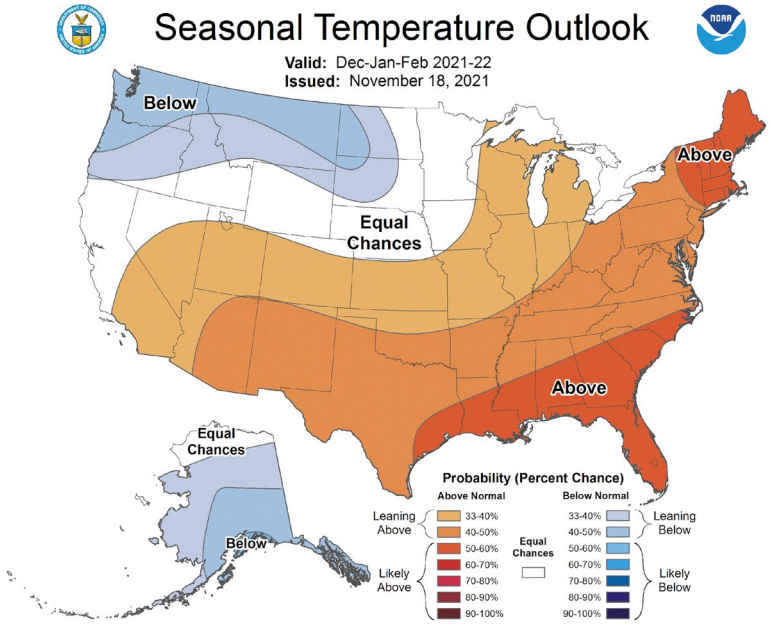
Outline

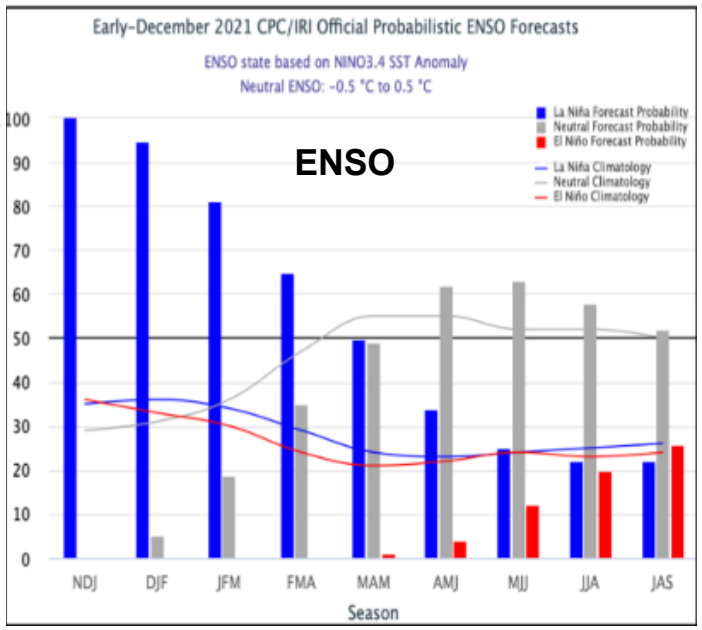
- CPC Mission
- Sub-Seasonal to Seasonal (S2S) Threat Vector: Finding the overlap between forecast skill and user risk tolerance
- S2S Climate Services:
  - NWS Decision Support Services (DSS) paradigm
  - CPC DSS Core Partners (partial list)
  - CPC Domestic DSS for Core Partners
  - Possible Future Directions
- S2S Climate Prediction:
  - Science Challenges
  - Possible Future Directions
- Final Thoughts

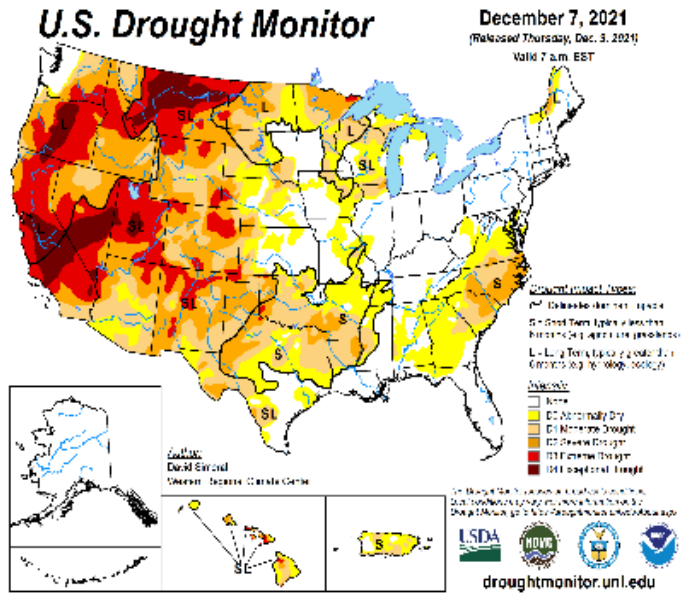
CPC Mission

"Deliver real-time products and information that predict and describe climate variations on timescales from weeks to year(s) thereby promoting effective management of climate risk and a climate-resilient society."

Strong alignment with the sub-seasonal to seasonal prediction mandate contained in the "Weather Research and Forecasting Innovation Act of 2017, Section 201", and the NOAA and DOC Strategic Plans focusing on enabling a Climate Ready Nation.



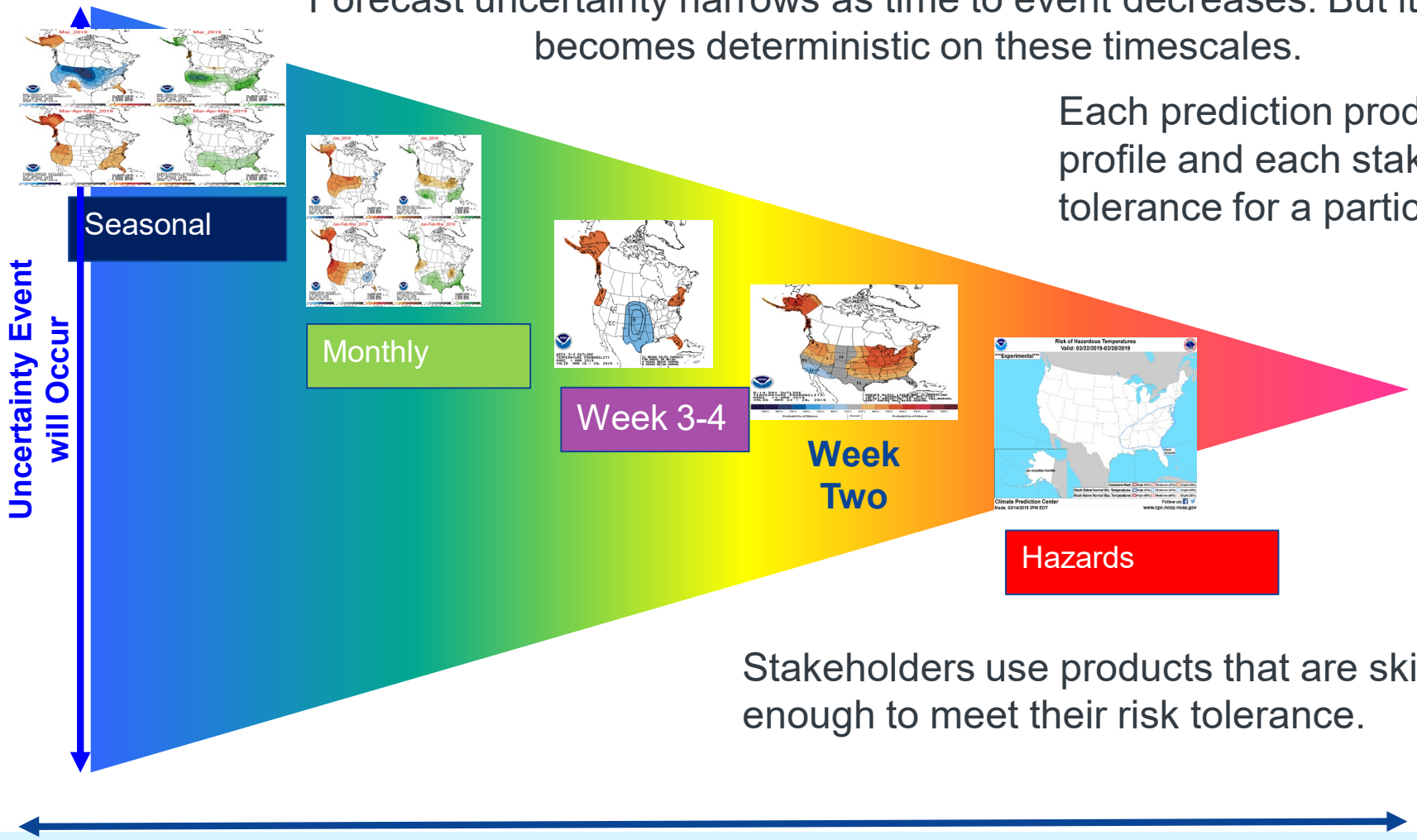




Sub-Seasonal to Seasonal Skill (Uncertainty) Profile

Forecast uncertainty narrows as time to event decreases. But it never becomes deterministic on these timescales.

Each prediction product has a skill profile and each stakeholder has a risk tolerance for a particular decision.

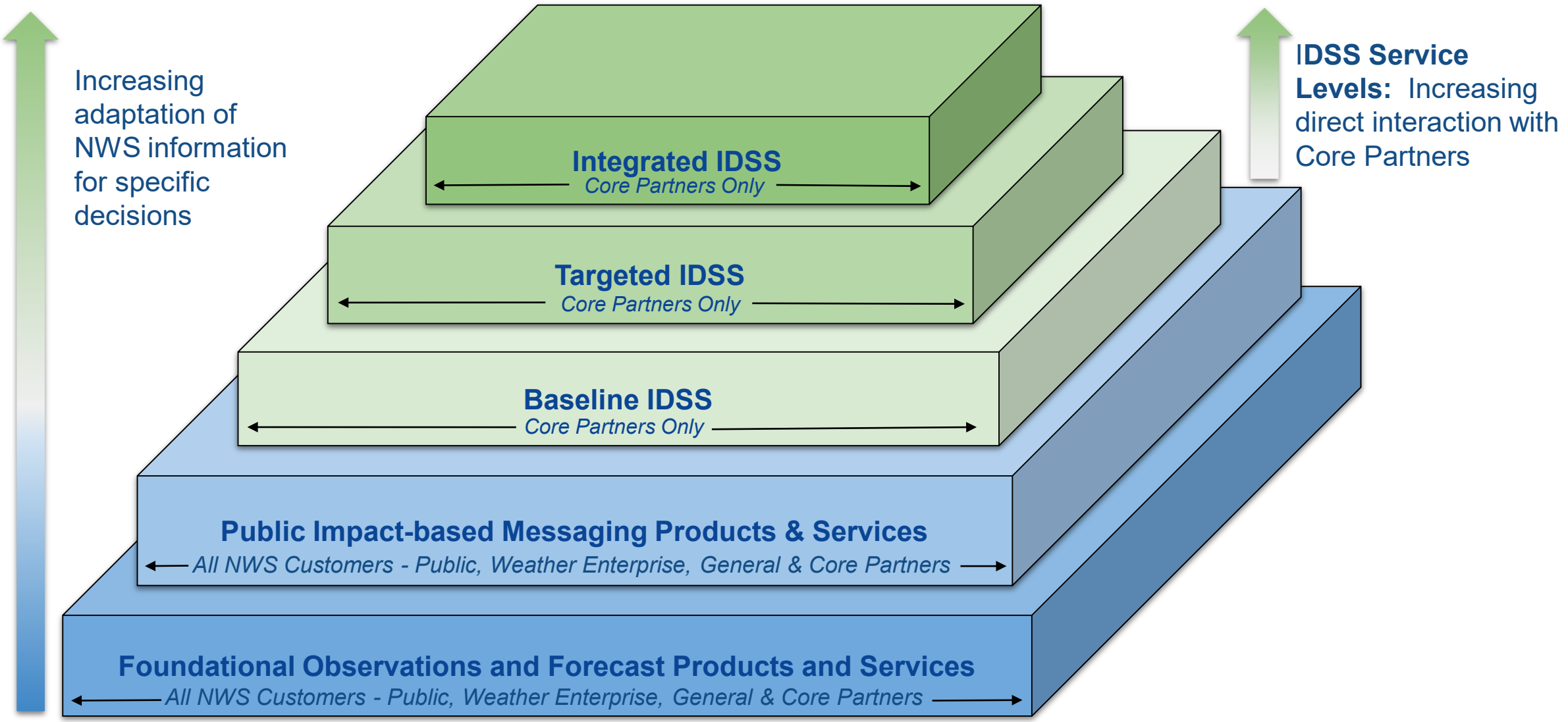


Stakeholders use products that are skillful enough to meet their risk tolerance.

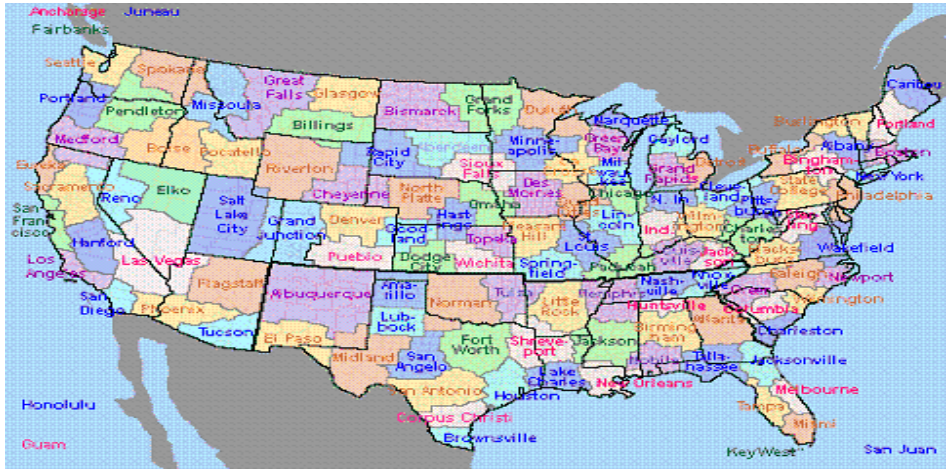
Sub-Seasonal to Seasonal Climate Services Through a National Weather Service Impact-Based Decision Support Services Lens

- The National Weather Service (NWS) implemented a new user-focused service paradigm known as impact-based decision support service (IDSS) across its service areas.
- The IDSS paradigm employs a tiered approach to services, with service level depending on the stakeholder community.
- CPC collaborates extensively within NOAA, other federal agencies, the academic sector, and international partners to develop the foundational science capabilities for and to deliver S2S climate IDSS.
- CPC's role in the IDSS service delivery value chain is situationally dependent, i.e. sometimes we lead and sometimes we support. Whole of government approach.
- <u>The administration's climate services strategy is to focus climate services on the challenges that pose the greatest risks and opportunities to society.</u>

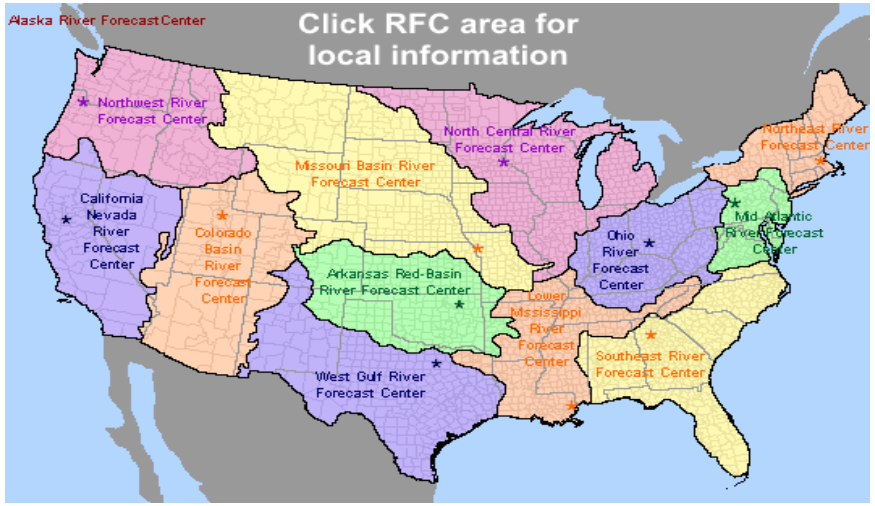
Continuum of IDSS



Examples of CPC Core Partners (Partial List)

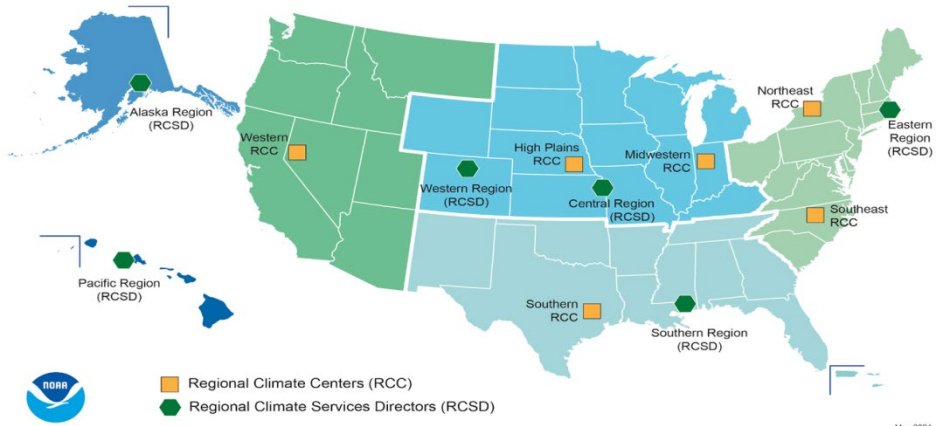


NWS Weather Forecast Offices/Regions



NWS River Forecast Centers

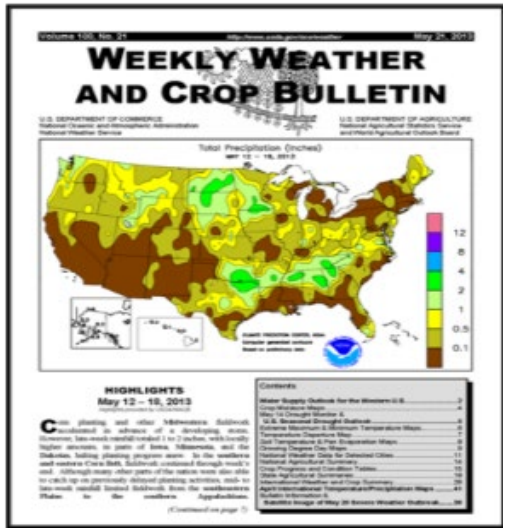
USDA Climate Hubs

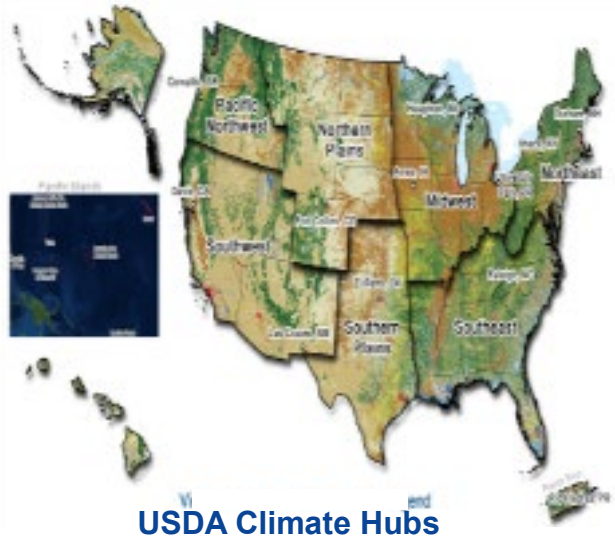


NOAA Regional Climate Centers and Regional Climate Services Directors

Decision Support Services (DSS) for Core Partner: USDA

- **Joint Agricultural Weather Facility (JAWF) and World Agricultural Outlook Board (WAOB):**
  - Weekly Weather and Crop Bulletin:
    - Used by USDA to assess likely impacts on domestic and international crop production and commodity prices due to short-term climate variability.
  - Customized tools and products.
- **Climate Hubs:**
  - Use CPC prediction and monitoring products to deliver science-based, region-specific information in agricultural contexts.

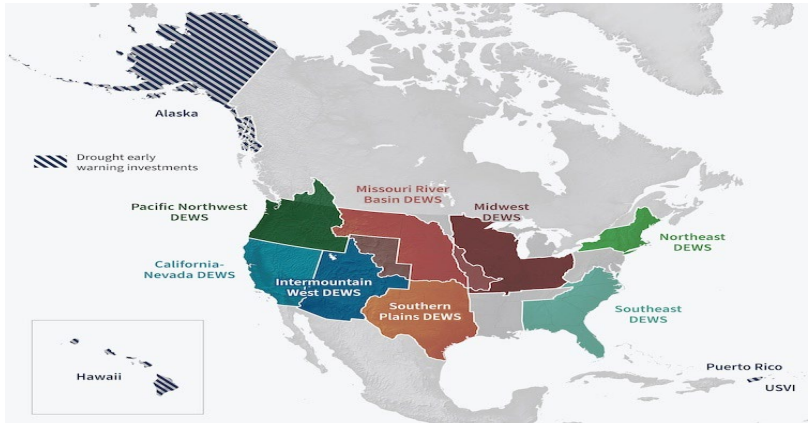




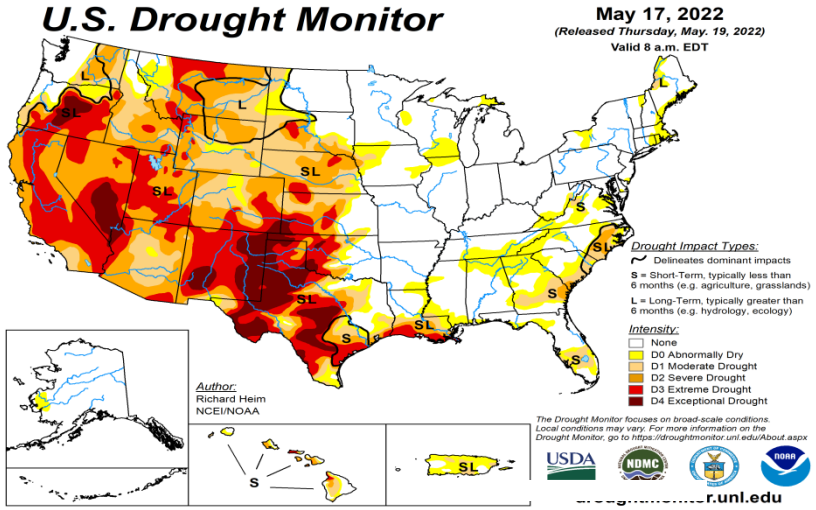
USDA Climate Hubs

Decision Support Services (DSS) for Core Partners: NIDIS and USDM

- **National Integrated Drought Information System (NIDIS):**
  - CPC provides custom S2S prediction and science briefings to the NIDIS program and the NIDIS Regional Drought Early Warning Systems.
  - CPC is collaborating with NIDIS to develop improved, objective drought prediction products.



- **United States Drought Monitor (USDM):**
  - CPC partners with the National Centers for Environmental Information (NCEI), United States Department of Agriculture (USDA), and the National Drought Mitigation Center (NDMC) to co-produce the USDM with and for a large number of stakeholders from across the country.



CPC Targeted DSS for NWS Field: Week-2 Key Messages

Bitterly Cold Temperatures for Much of the Lower 48 Heading into the Holidays, with the Potential for a Winter Storm in the East

Issued December 12, 2022
Updated December 15, 2022

Effective December 23 - 29, 2022

KEY MESSAGES

Very cold Arctic air masses will envelop much of the nation during the week 2 period **(a)**, including the busy holiday travel season.

Temperatures in the negative teens are possible in the Northern Plains and Upper Midwest, with sub-zero temperatures reaching as far south as the Central Plains **(b)**.

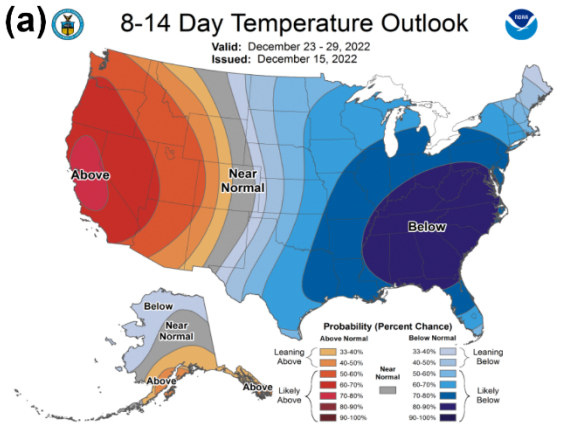
The Great Lakes, Ohio Valley, Mid-Atlantic, and Northeast are favored to have temperatures reach the single digits and teens. Widespread below freezing temperatures are also expected throughout the Southeast and Southern Plains, including southern Texas and much of the Gulf Coast.

A potentially impactful winter storm may occur for parts of the eastern Great Lakes, Mid-Atlantic, and Northeast leading up to and including Christmas Eve, near the leading edge of these Arctic air masses **(c)**.

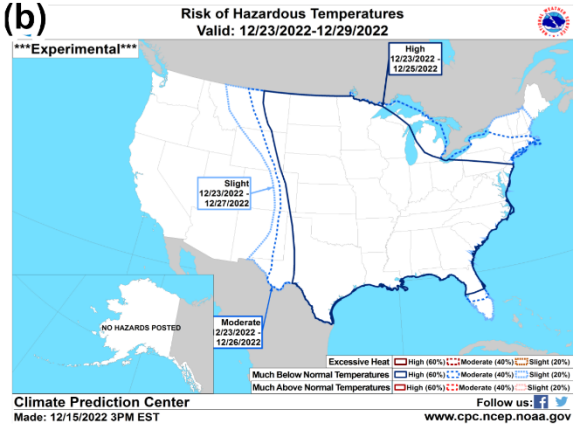
Timing: Cold air outbreaks are expected to lead up to* and continue through December 23 - 29, 2022. The cold is expected to move southward then eastward as the week 2 period progresses, with the winter storm potentially occurring late next week.

** For short-term forecasts (prior to December 23), visit www.wpc.ncep.noaa.gov and weather.gov.*

(a)



(b)



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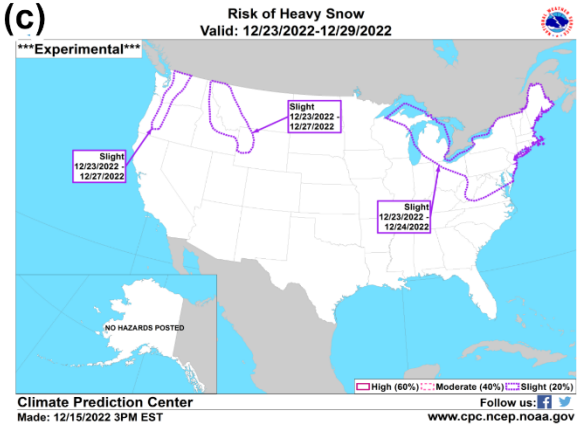

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Climate Prediction Center
www.cpc.ncep.noaa.gov

****Key messages are subject to change due to changes in forecast information and tools.*

Longer Term Baseline DSS Example: CPC Products are Part of End to End DSS

Central Region Regional Operations Center
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crhroc@noaa.gov
weather.gov/crh

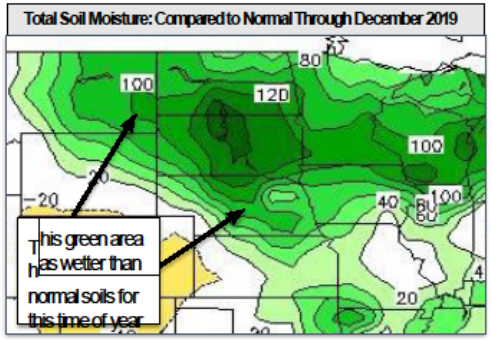
Extremely Wet Conditions Across the Missouri Basin Sets the Stage for a Significant Spring Flood Season

Setting the Stage:
Precipitation and Soil Moisture

Well above normal rain and snowfall throughout 2019 has led to record flooding and abnormally wet ground for the winter season across much of the Missouri River Basin.

Through the end of December 2019, the Missouri River Basin has had its 3rd wettest year in 124 years of modern record keeping.

Across the Missouri River Basin ND, SD, NE and KS recorded their top 5 wettest years (January 2019 – December 2019).



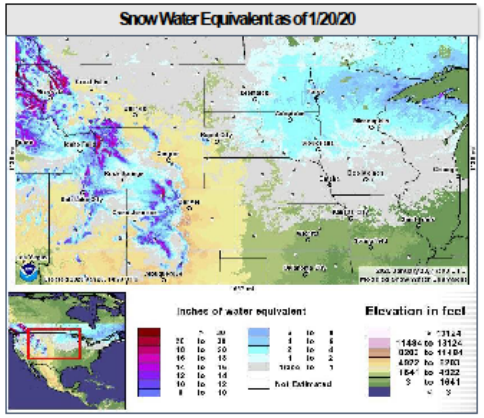
ABOVE: Wet soils across most of the Missouri River Basin can accept very little or no more water. *Source: NOAA/NCEP/CPC*

Setting the Stage:
Snow Pack

The seasonal snowpack continues to build across the headwaters of the Missouri. The plains snowpack across the eastern Dakotas is already at 8-20 inches of snow depth, which is holding 2-3+ inches of water. Elsewhere across the plains, the snowpack varies. However, with the potential for below normal temperatures and above normal precipitation anticipated for the month of February, there is a chance to increase snowpack in areas that have little to none currently.

Overall, the mountain snowpack is running about average at this time. We still have a few months left to accumulate additional snow as we are only a little over halfway through the season.

NOAA's Spring Flood Outlook
Release: March 23, 2020



ABOVE: Snow Water Equivalent Map as of January 20, 2020.
Source OWP/NOHRSC

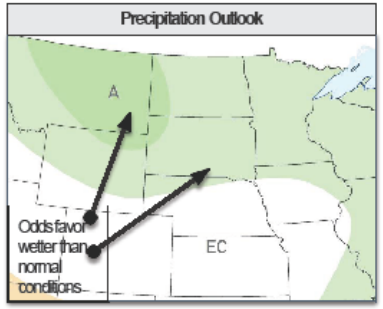
Central Region Regional Operations Center
816-200-1140
crhroc@noaa.gov
weather.gov/crh

Precipitation Outlook and Potential Impacts this Spring

Late Winter/Spring 2020:
Outlook

We are heading into the spring with wetter than normal soils, a healthy snowpack and latest guidance shows that several rivers and streams are running higher than normal.

The latest 2020 Winter Outlook suggests that odds favor a normal to **wetter than normal February through April** across much of the Upper Missouri River basin, with higher odds farther north. We are also expecting **cooler than normal temperatures** as you head further north, which could hold onto the snowpack longer into the spring. This increases the chances for a sudden and high-impact thaw in the spring.



ABOVE: The outlook indicates odds favor wetter than normal precipitation from February through April across areas that already have wet soil and high river levels.
(Get the latest outlook: www.cpc.ncep.noaa.gov)

What are the ingredients of a significant spring flood season?

A repeat of 2019 is not a guarantee. There is still a lot of time and factors that would need to come together before we will know just how bad, or how uneventful it will be.

Factors that would improve our situation:

- A period of dry, warm weather allowing soil to drain and evaporate existing moisture
- Little to no additional snowfall with no extreme cold snaps
- Gradual transition out of winter into spring with mild daytime temperatures and night time low temperatures below freezing - this will allow snow to ripen and melt off a little bit at a time

Factors that would lead to significant spring flooding:

- Above normal snowpack across the basin
- A long-lived, widespread cold snap on bare ground that freezes the soil deep below the surface and builds a thick layer of river ice
- Sudden transition from winter to spring that melts the snowpack rapidly and increases the chance for ice jams on the rivers
- A significant rain event on top of snow pack that releases the water in the snow rapidly

Potential Impacts

Unusually high streamflow, water levels, and abnormally wet soil suggest the following potential impacts for the upcoming spring flood season:

- Widespread ice jams, including on some rivers that are not usually affected by ice jams
- Widespread major flooding again this spring
- Delay or prevention of crop planting
- Long-term soil damage
- Travel impacts due to road, dam, levee, and bridge damage

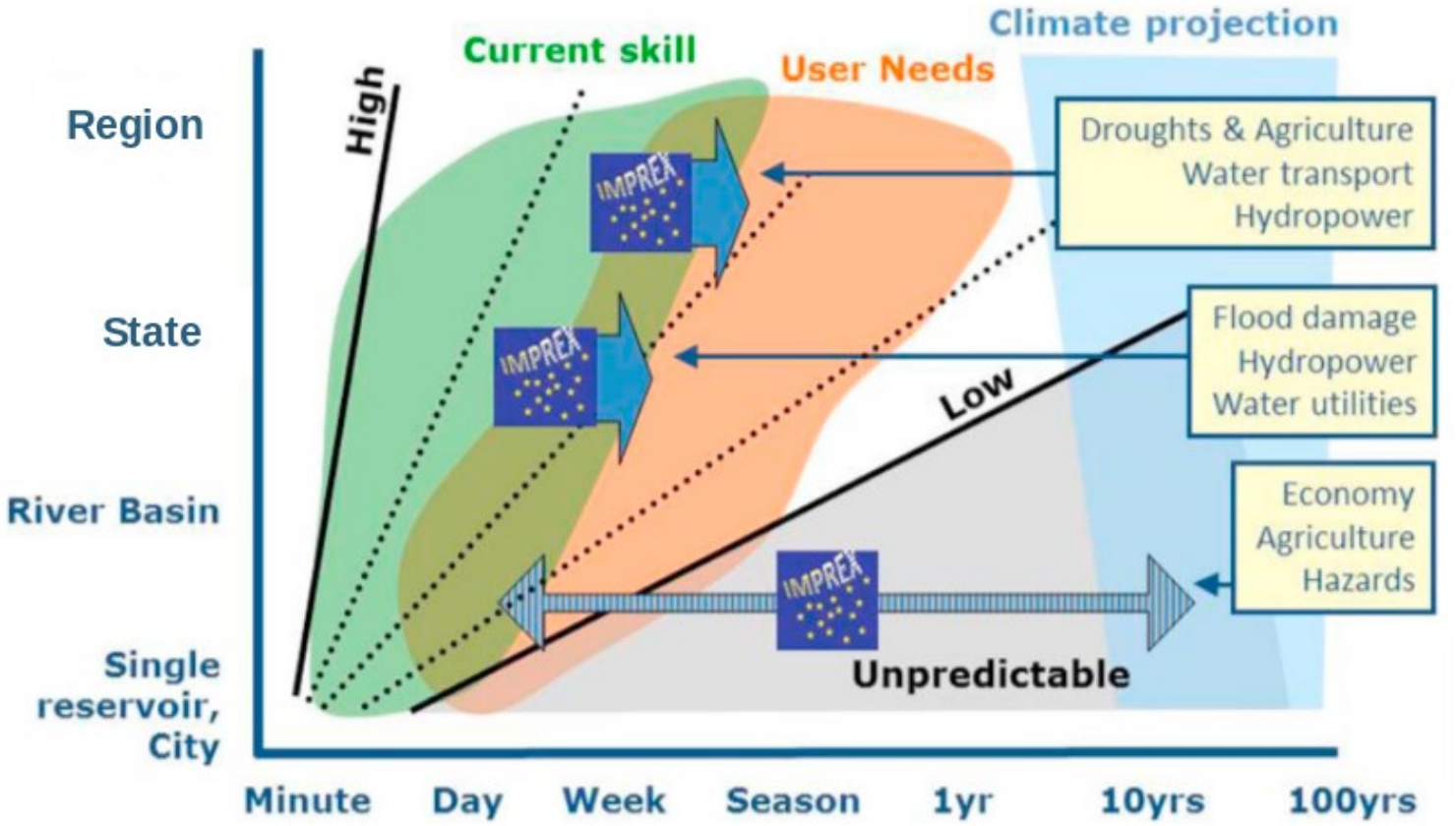
For more information visit:

Local Forecast– weather.gov
Long-Range Outlooks– cpc.ncep.noaa.gov
River Forecasts– water.weather.gov/ahps/forecasts.php
Weather & Climate Data– ncei.noaa.gov

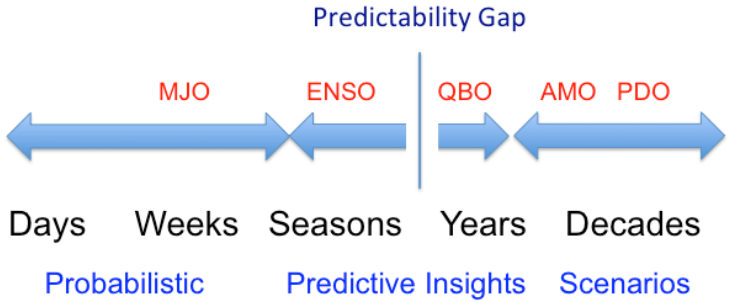
Climate Services: Future Actions

- Work with core partners to understand their S2S product needs including decision thresholds/triggers and preferred formats for products.
  - Co-develop products with partners to meet those needs.
    - Provide rigorous estimates of forecast skill/uncertainty that are based on extensive reforecasts, and which are meaningful to partners.
    - Provide interactive tools that allow users to tailor prediction information to their own risk tolerance.
- Get clarity on NWS constraints on developing S2S products for the private sector, i.e. the Fair Weather Report.
- Perform quantitative evaluation of the impact of CPC products and services (pending resources).

Understanding/Estimating S2S Predictability Limits



Predictability, prediction and scenarios



Statistics of Extreme Events

black swans, surprises, discontinuities, abrupt change

From J. Curry (2018).

Climate Prediction: Future Actions

- Establish rigorous paradigms for prediction tool evaluation based on extended, cross-validated reforecasts:
  - Revisit previous events that weren't well predicted.
- Perform multi-faceted, multi-timescale predictability diagnostics including event specific diagnostics, i.e. Hoell et al. study on predictability of the 2017 Northern Plains Drought.
- Focus research on understanding and predicting sub-seasonal modes of climate variability, whose impacts can be (much) larger than seasonal modes, i.e. ENSO:
  - Madden-Julian Oscillation (MJO)
  - Stratospheric sudden warming
- Focus research on reducing systematic errors that limit predictive skill.
- Focus research on understanding and predicting large-scale regime transitions, especially those impacting precipitation.

Final Thoughts

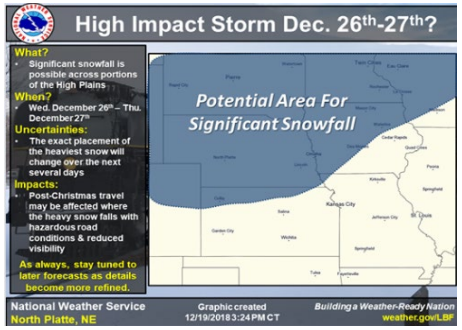
- CPC collaborates across the weather, water, and climate enterprise to co-produce sub-seasonal to seasonal prediction and decision support services products.
- CPC partners with numerous organizations to deliver impactful sub-seasonal to seasonal climate decision support services in response to stakeholder needs.
- CPC's role in the decision support services value chain is situationally dependent and follows the NWS tiered paradigm from general services through custom products for core partners.
- CPC continually evaluates our decision support services portfolio both in terms of existing products/activities as well as possible expansion of this portfolio.
- Please feel free to reach out to me to discuss any of the topics covered in this presentation.

Extra Slides

Continuum of Impact-based Messaging Services

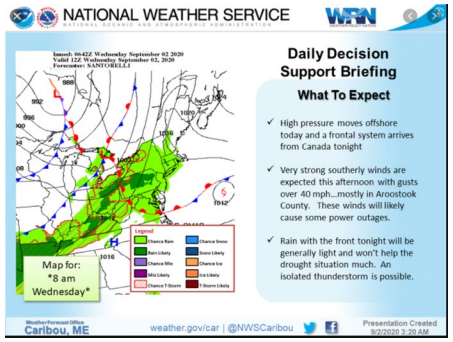
Messaging Foundation → Increasing direct interaction with Core Partners

Public Services



NDFD drives general forecast information, while forecaster generated Weather Graphics and Social Media posts convey ***general impacts.***

Baseline IDSS

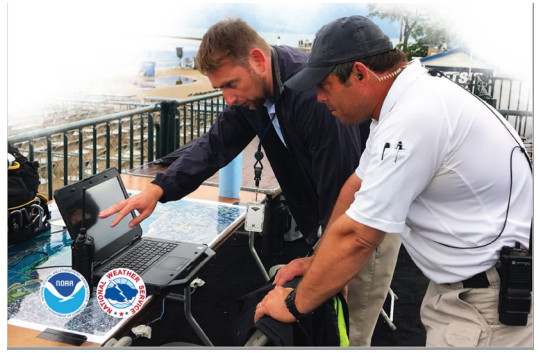


Forecasters directly send IDSS Graphic Packages, and conduct Webinars to all Core Partners, focusing on ***general impacts.*** *They respond to Core Partner questions in NWSChat.*

Targeted IDSS

Targeted Webinars, Emails, Graphics Packages, etc. to subsets of Core Partners to convey ***impacts based on their customized thresholds in a way tailored to their needs***

Integrated IDSS



Integrated One on One Virtual or Onsite Support to an Individual Core Partner that requires ***on-demand customized impact information***

Increasing adaptation of NWS information for specific decisions

Real-Time Attribution/Diagnostics/Predictability Assessment

Product frequency:

- Produced once per month, archive going back to 2016 available.

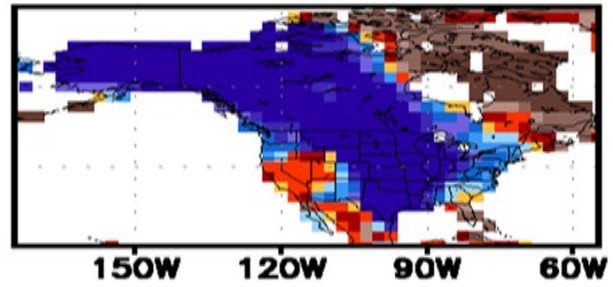
Assessment Provides

- Review of observations and predictions for most recent season
- Assessment of predictability

Example predictability result for February 2021

- Much-below normal temperature in February 2021 wasn't predictable beyond one month lead.

OBS



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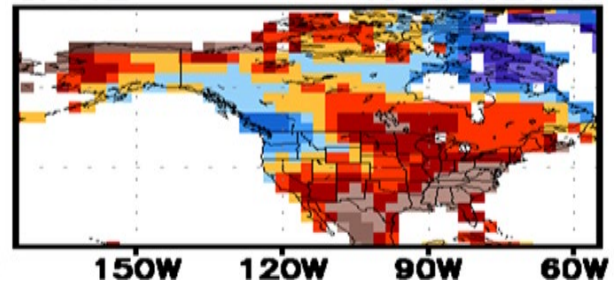
IC=Dec2020



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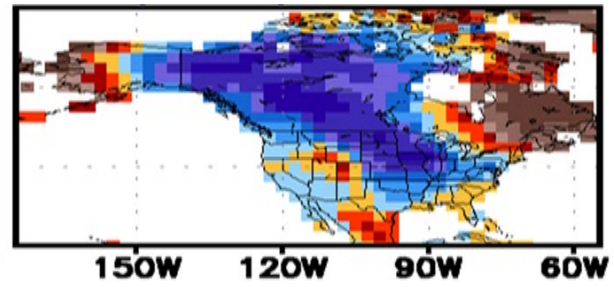
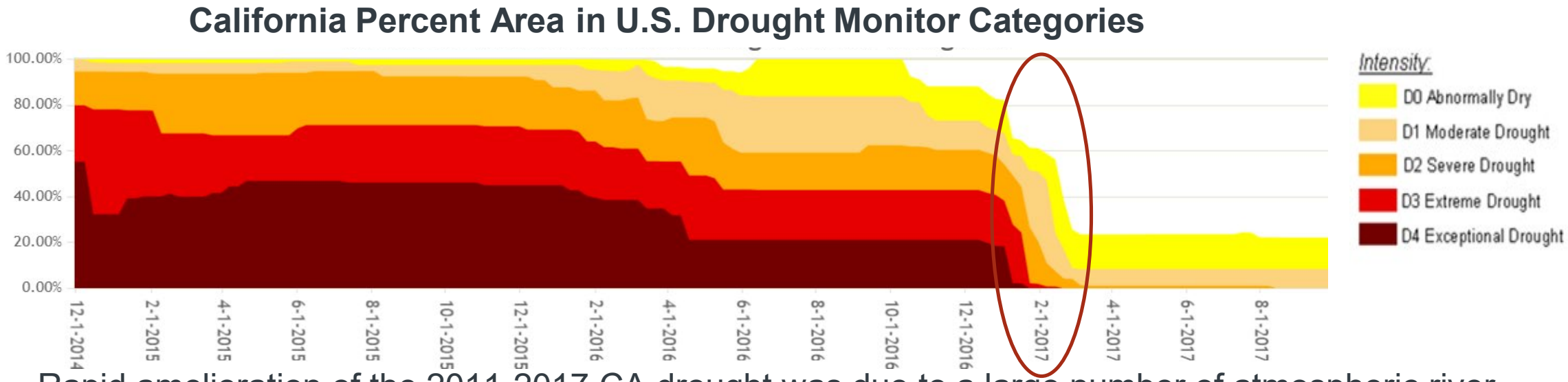


Precipitation Prediction Grand Challenge Example

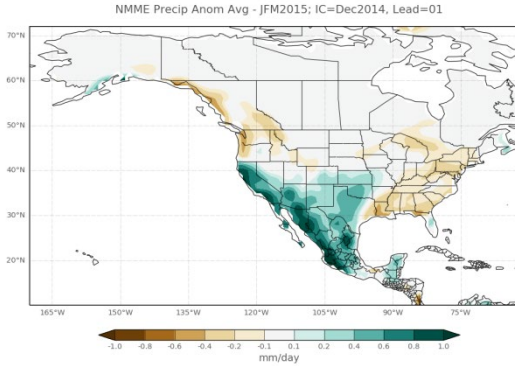
Failure to Predict Drought Amelioration



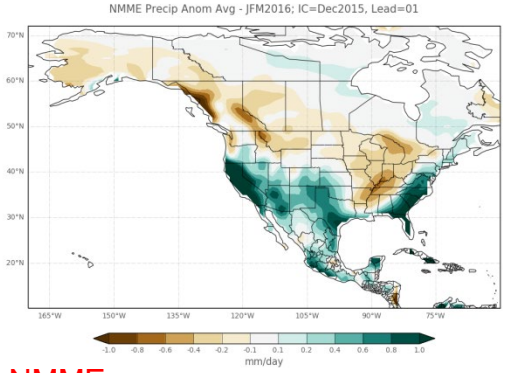
- Rapid amelioration of the 2011-2017 CA drought was due to a large number of atmospheric river events. They formed and penetrated to CA after persistent large-scaling ridging over the eastern Pacific broke down.
- This occurred despite an ongoing La Niña, which tends to support ridging and below-normal precipitation in this region.

All models failed to predict this regime transition of the large scale atmospheric state and subsequent heavy rains beyond about two weeks lead.

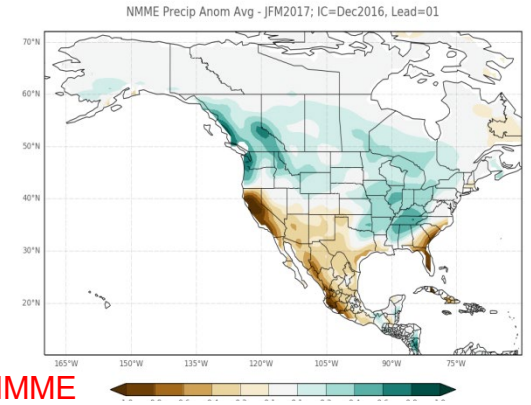
Key Science Challenges to Improving S2S Precipitation Prediction Skill



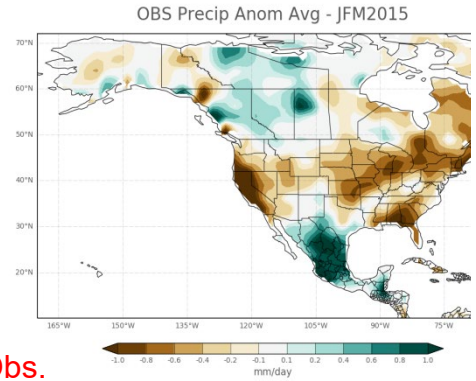
NMME 2015



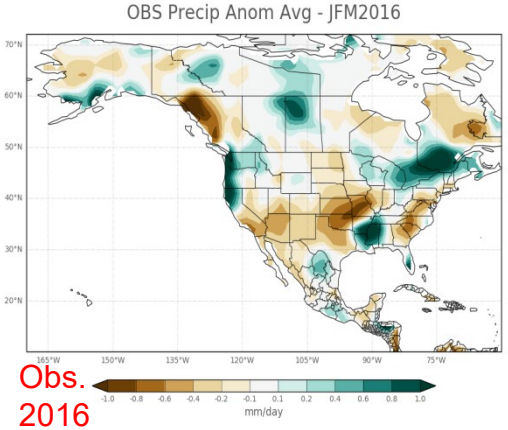
NMME 2016



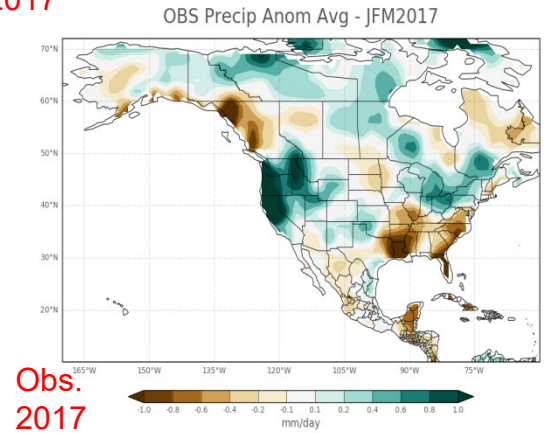
NMME 2017



Obs. 2015



Obs. 2016



Obs. 2017

State of the art NMME first season precipitation forecasts for winters of 2014-2017 were consistently of wrong sign over California and most of the west. Is this due to a limit in predictability, or missing or misrepresented physical processes?