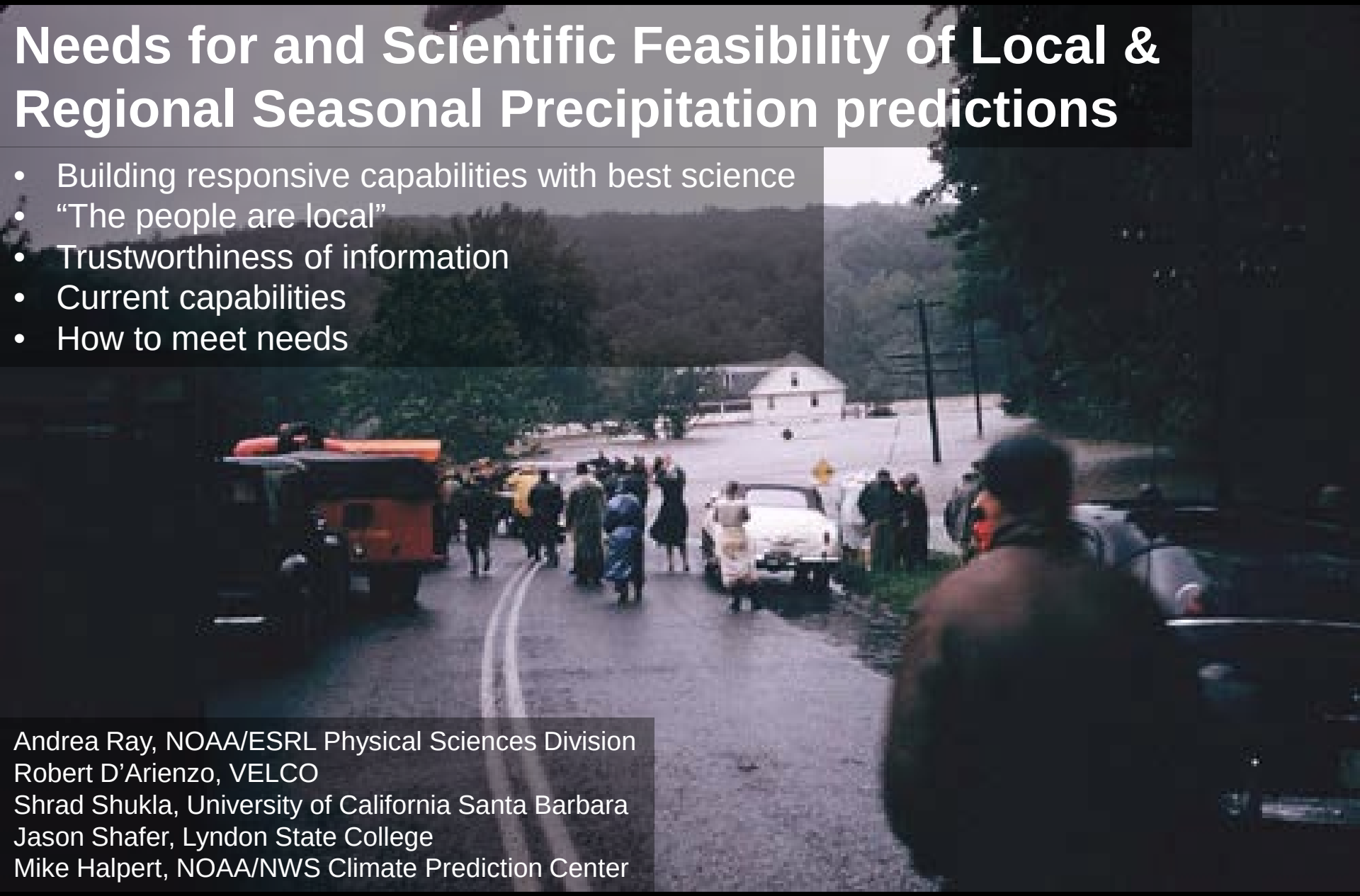
Needs for and Scientific Feasibility of Local & Regional Seasonal Precipitation predictions

- Building responsive capabilities with best science
- “The people are local”
- Trustworthiness of information
- Current capabilities
- How to meet needs

Andrea Ray, NOAA/ESRL Physical Sciences Division
Robert D’Arienzo, VELCO
Shrad Shukla, University of California Santa Barbara
Jason Shafer, Lyndon State College
Mike Halpert, NOAA/NWS Climate Prediction Center



Burlington Inn, destroyed in the floods of August, 1955

NOAA RESEARCH • ESRL • PHYSICAL SCIENCES DIVISION

Panel: Needs for and Scientific Feasibility of Local & Regional Seasonal Precipitation Predictions

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NOAA Climate Prediction Assessment Workshop
22 March 2016
Burlington, VT

Developing an understanding of user needs

- Ongoing engagement, iteration, with a variety user groups
- Some individual studies focussed on specific groups
- Multiple methods and perspectives
- Quantitative and qualitative & context-sensitive social science methods
- From these efforts, we have identified major classes of users, and the major needs ("EOFs")
- Need for ongoing social science work to *refine* needs, especially for less studied and under-served
- We know much more about user needs than official products are currently able to serve
- Examples of efforts:

RISAs, DOI CSCs, Dept of Ag Hubs

NOAA/SARP & related grants; River Forecast Center annual user meetings

WWA RISA work with reservoir/water supply managers and the CBRFC

NIDIS regional pilots; Nat'l Drought Mitig. Center

Seasonal Fire Assessments, led by CLIMAS

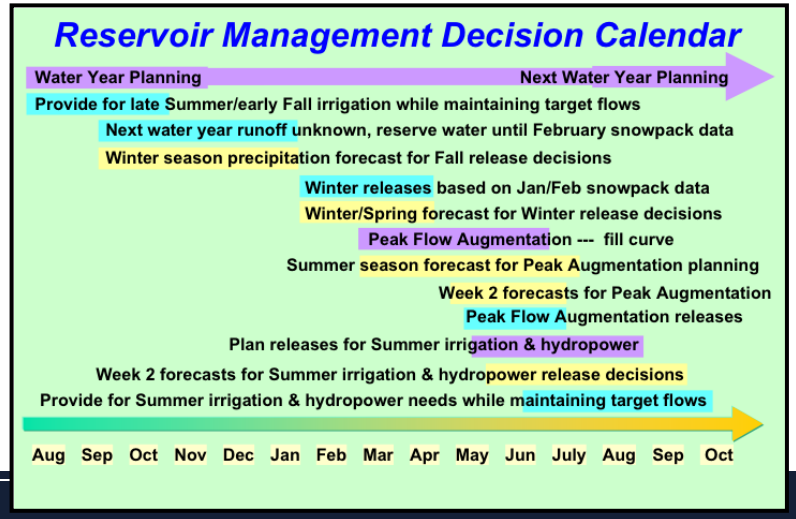
WHO uses for what:

Various user types, major distinction is who's using and what for

- For S2S & precipitation, *a major class of users* are *intermediaries* who do something with the information to manage the risks for the public
  - often with a preparedness or "ready-set-go" mindset, situational awareness, actions/decisions adjustable thru a season
  - skill needed varies, often changes as they better understand the products
  - for their jobs, have a *vested interest in learning about products*
- Within NWS: Warning Coord. Mets, River Forecast Centers, CSFPs, etc
- Reservoir and water supply managers, Wildfire managers, Public Land managers (grazing, controlling invasive grasses, etc); agriculture
- Many of these *already work with* a variety of uncertain and often probabilistic information

How climate/drought information might be used

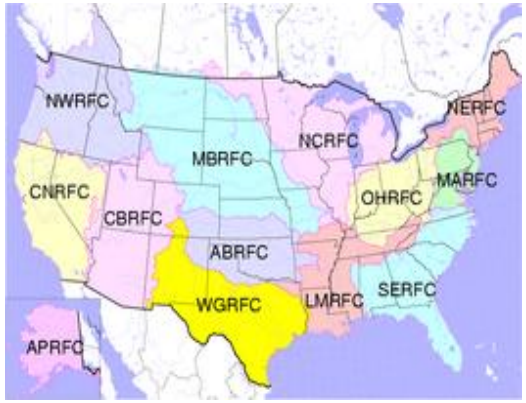
- As input to their operational/planning models – but not only
- Mental models of managers for their systems are important *as well as* hydrologic and management models
- Discussions within water management groups & with their management & stakeholders, & w/ scientists
  - "dialogue" about risks, e.g. water supply/drought/flood
- Relationship of climate information to their triggers & thresholds for action – in both ops/planning models *and* mental models
- Many actions/decisions adjustable thru a season/year, responding to updated risk
- As interested in the information behind the Drought Monitor as the DM itself, in order to make their own assessments about the data & products



Ray and Webb 2016, in "Climate in Context" RISA book out in April, AGU/Wiley

Water management user requirements I

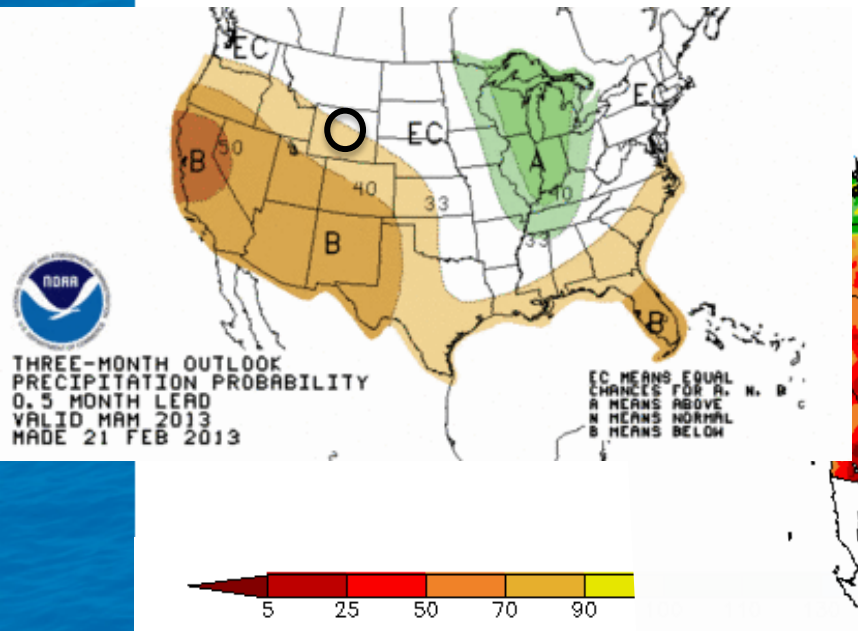
- Seasonal precipitation forecasts targeted at the water resources sector and related sub-seasonal to seasonal information.
  - One of their highest priorities (see WSWC 2014)
- Long range "mainstem" forecasts: precip, temp, wind, soil moisture
  - Different periods, e.g. snow season (Oct-March, Jan-Apr), vs standard 1 & 3 mo

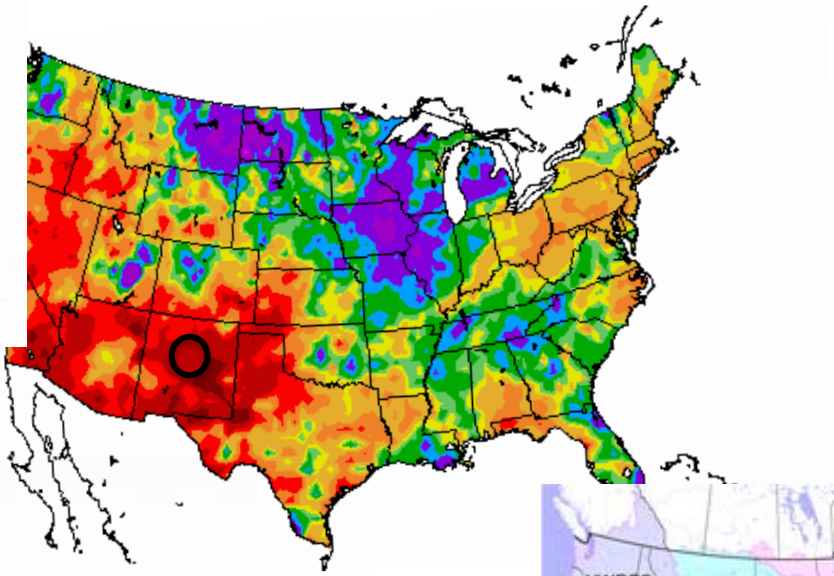


- Skill issue – remember: many users are professionals, already use probabilistic information
  - Need for and ability to use
- *Interpretive or translational information* along with numerical and map products, to inform & educate water management users:
  - Routine interpretation, narratives, product explanations, as well as webinars like those by RISAs or internally for NOAA staff, especially for ensemble streamflow prediction and seasonal outlooks -- Lets them put the information in the context of their triggers, models

Use of CPC Outlooks – from Bob Peters, Denver Water

% Normal Precip Mar-Apr-May 2013





Actual

Water management user requirements II

- Knowledge as well as "product" -- Need for synthesis of research knowledge into products & analysis that connect climate impacts to water management impacts
  - Beyond numerical predictions, what more can we say about risks, e.g. given the status of ENSO, certain conditions more/less likely
  - Impacts of temperature --> evaporation, rain/snow mix, urban demand, length of growing season
  - Timing of spring runoff --> water rights, reservoir reliability
  - Key climate features of interest to different regions: monsoon, Ice storms, heavy winter storms in the east coast; Pineapple Express/Atmospheric rivers
  - Seasonal precipitation outlooks will be of more interest if they reflect the risks of these regional concerns
- Simplifying to a two-category product, serves *some* users, but reduces the information available, doesn't meet the needs of many users to support decisions
  - **Keep both??** Let more sophisticated users can drill down
- "Services" includes a network of people who can connect products and knowledge to applications e.g. climate extension agents

Next steps

- We know more about user needs than are currently served
  - 20 years of RISAs; 20+ years of NOAA Climate Program Office "Climate and Society" funded work; other efforts outside these, e.g. NDMC, NIDIS
- Not adequately communicating those to CPC
  - Peer-reviewed papers not usually aimed at CPC communication
  - Presentations/networking at meetings like this aren't enough
- Need deliberate interation & engagement with CPC, "co-production" with those who study user needs
  - **Working group?** to work out issues of format, skill, interpretation/translation, integration of research knowledge
- RISA "lessons learned" book:, **Climate in Context: Science and Society Partnering for Adaptation,** eds Parris, Garfin, Dow, Meyer, Close; AGU/Wiley

Vermont Weather Analytics Center
Motivation

2016

Top 10 risks in terms of Likelihood	Top 10 risks in terms of Impact
1 Large-scale involuntary migration	1 Failure of climate-change mitigation and adaptation
2 Extreme weather events	2 Weapons of mass destruction
3 Failure of climate-change mitigation and adaptation	3 Water crises
4 Interstate conflict	4 Large-scale involuntary migration
5 Natural catastrophes	5 Energy price shock
6 Failure of national governance	6 Biodiversity loss and ecosystem collapse
7 Unemployment or underemployment	7 Fiscal crises
8 Data fraud or theft	8 Spread of infectious diseases
9 Water crises	9 Asset bubble
10 Illicit trade	10 Profound social instability

Sharp increase in environmental risks starting in 2011

Top 5 Global Risks in Terms of Likelihood

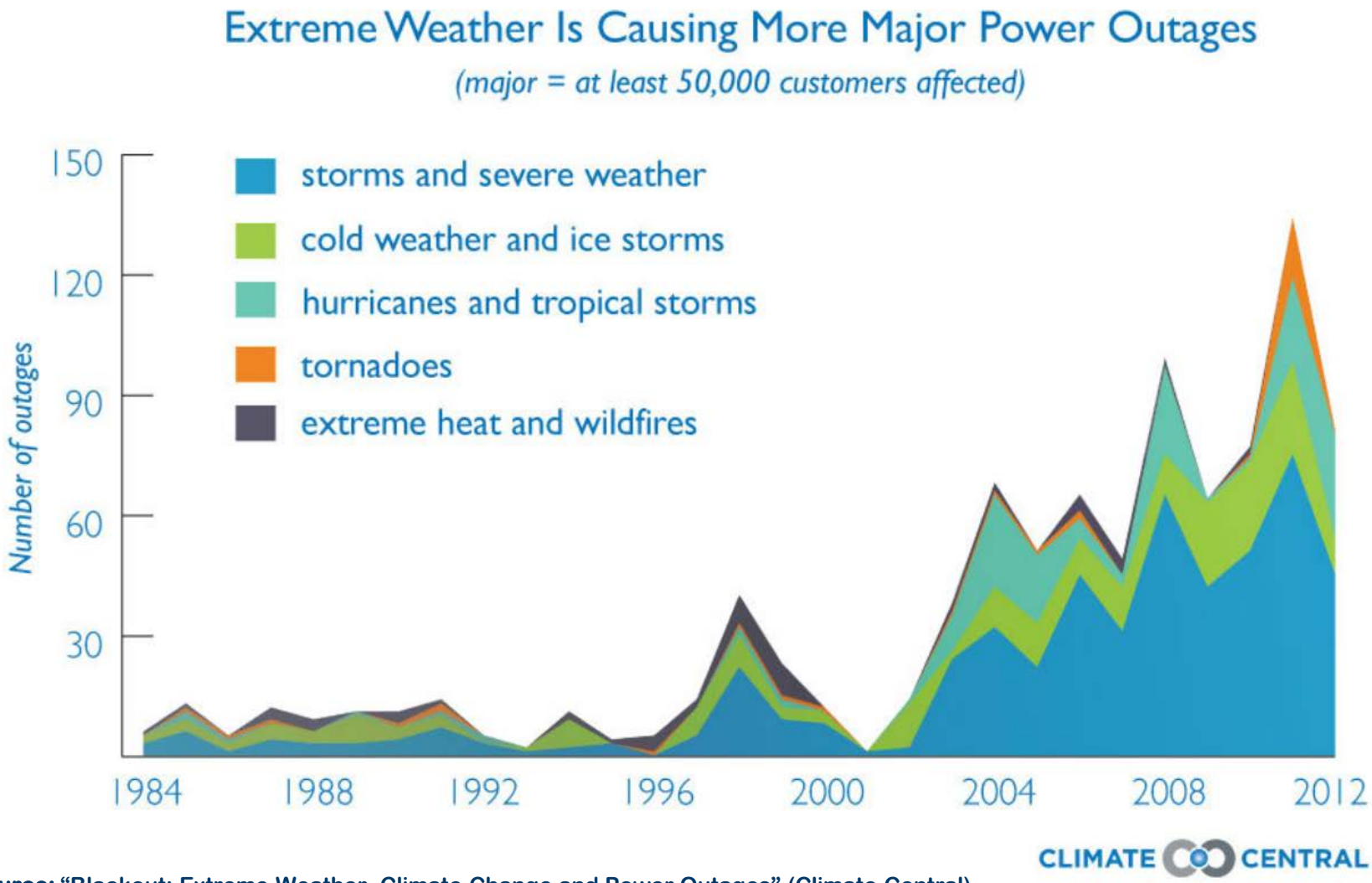
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1st	Breakdown of critical information infrastructure	Asset price collapse	Asset price collapse	Asset price collapse	Storms and cyclones	Severe income disparity	Severe income disparity	Income disparity	Interstate conflict with regional consequences	Large-scale involuntary migration
2nd	Chronic disease in developed countries	Middle East instability	Slowing Chinese economy (<6%)	Slowing Chinese economy (<6%)	Flooding	Chronic fiscal imbalances	Chronic fiscal imbalances	Extreme weather events	Extreme weather events	Extreme weather events
3rd	Oil price shock	Failed and failing states	Chronic disease	Chronic disease	Corruption	Rising greenhouse gas emissions	Rising greenhouse gas emissions	Unemployment and underemployment	Failure of national governance	Failure of climate-change mitigation and adaptation
4th	China economic hard landing	Oil and gas price spike	Global governance gaps	Fiscal crises	Biodiversity loss	Cyber attacks	Water supply crises	Climate change	State collapse or crisis	Interstate conflict with regional consequences
5th	Asset price collapse	Chronic disease, developed world	Retrenchment from globalization (emerging)	Global governance gaps	Climate change	Water supply crises	Mismanagement of population ageing	Cyber attacks	High structural unemployment or underemployment	Major natural catastrophes

Economic | Environmental | Geopolitical | Societal | Technological

Source: World Economic Forum

Vermont Weather Analytics Center

Motivation



Source: "Blackout: Extreme Weather, Climate Change and Power Outages" (Climate Central)

Vermont Weather Analytics Center

Project Overview

- Two-year, $16 million research undertaking to develop intellectual property using coupled data models and related software
- 2-year agreement/partnership with IBM
- 3 main goals:

Increase grid reliability

Lower weather event-related operational costs

Optimize utilization of renewable generation resources

Vermont Weather Analytics Center

Models

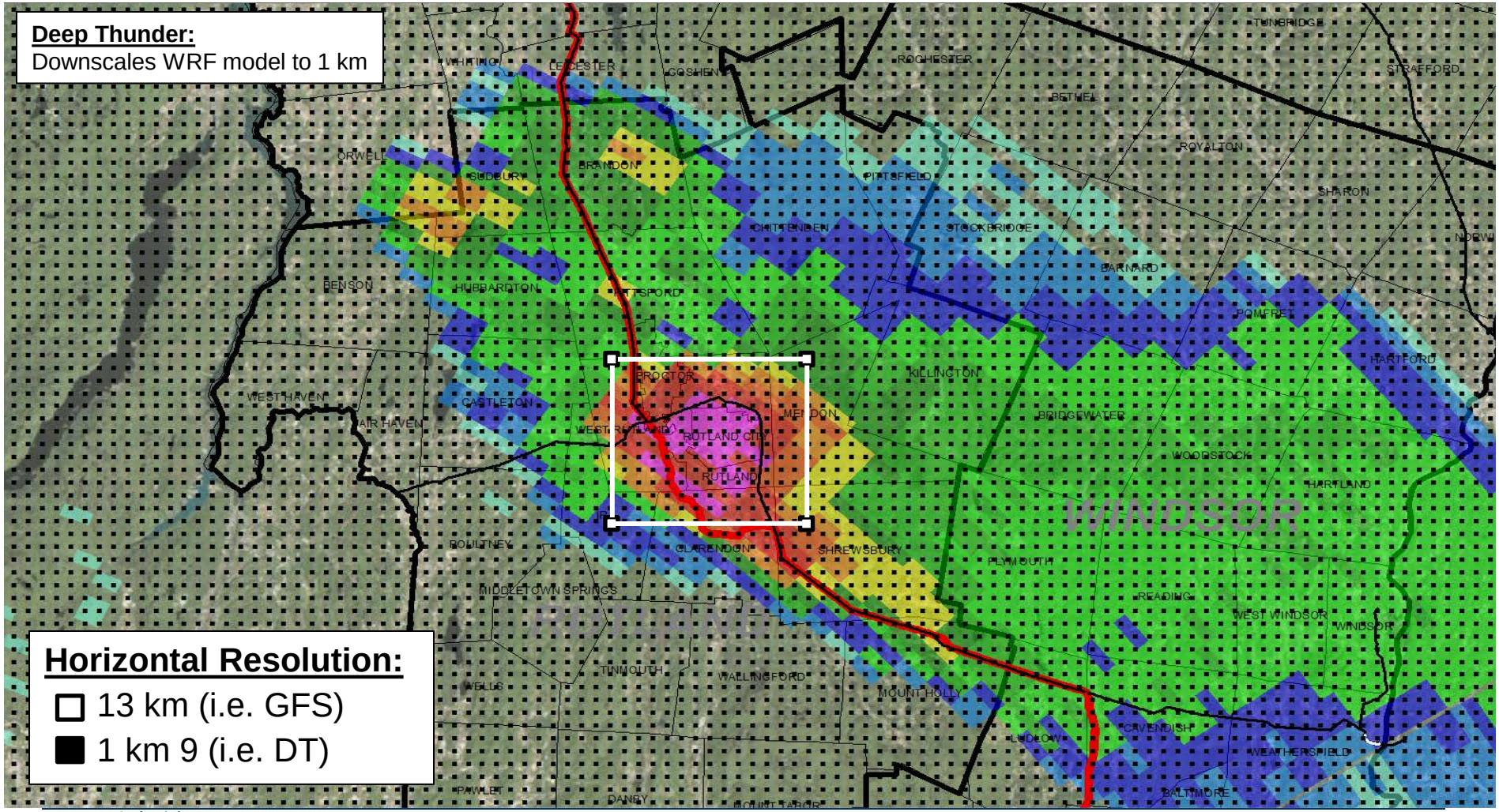
Deep Thunder → Demand → Renewable → Renewable Integrated Stochastic Engine (RISE)

Model	Function
Weather (Deep Thunder)	To produce accurate weather forecasts 72 hours in length down to 1 sq. km → Lower weather event costs
Demand	To increase accuracy of state load forecasts → Better plan for future needs
Renewable	To produce generation forecasts for solar and wind farms → Improve power supply/planning
Renewable Integration Stochastic Engine (RISE)*	To integrate the models' results to optimize the value of Vermont's generation, demand response, and transmission assets ***VELCO Only**

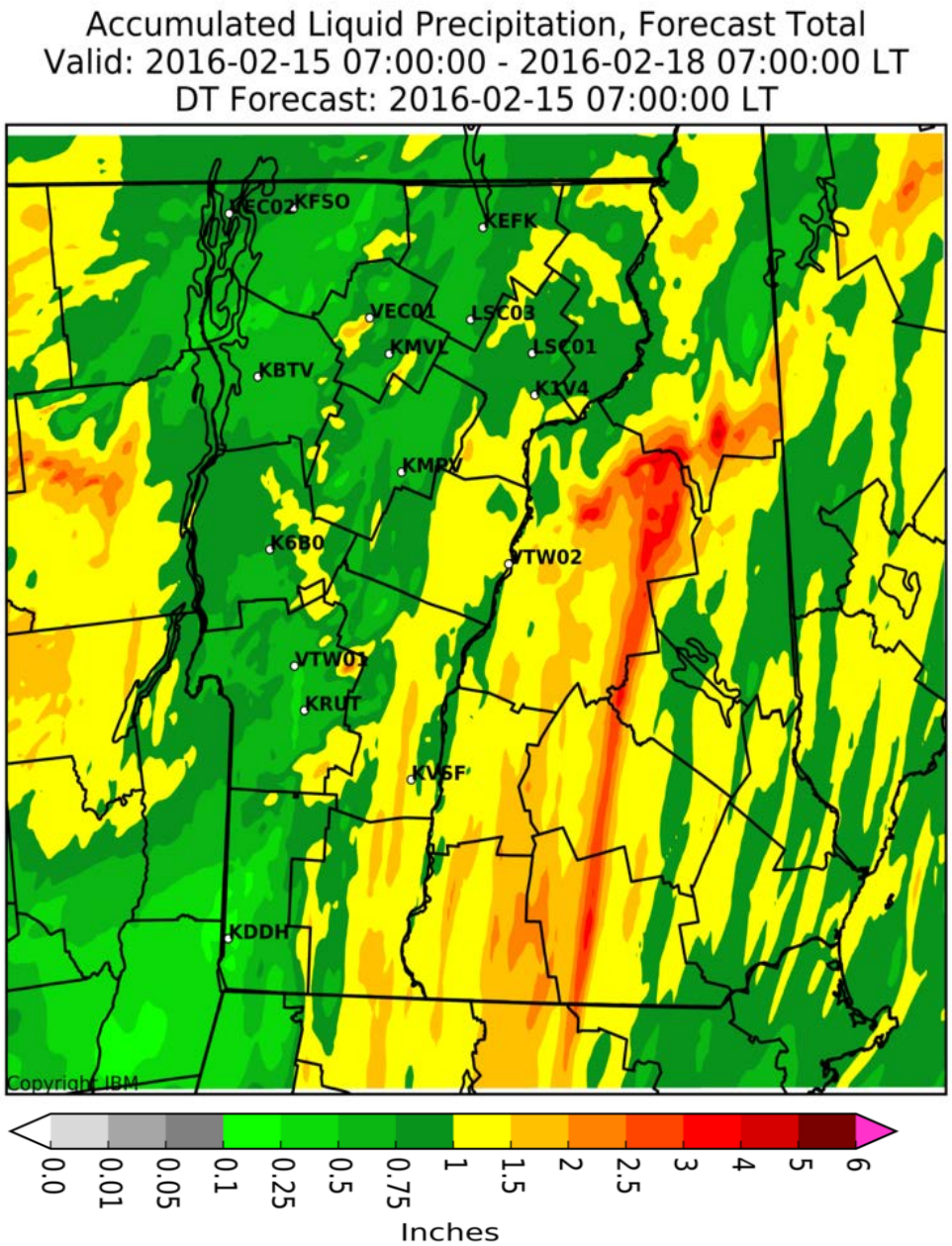
IBM Deep Thunder

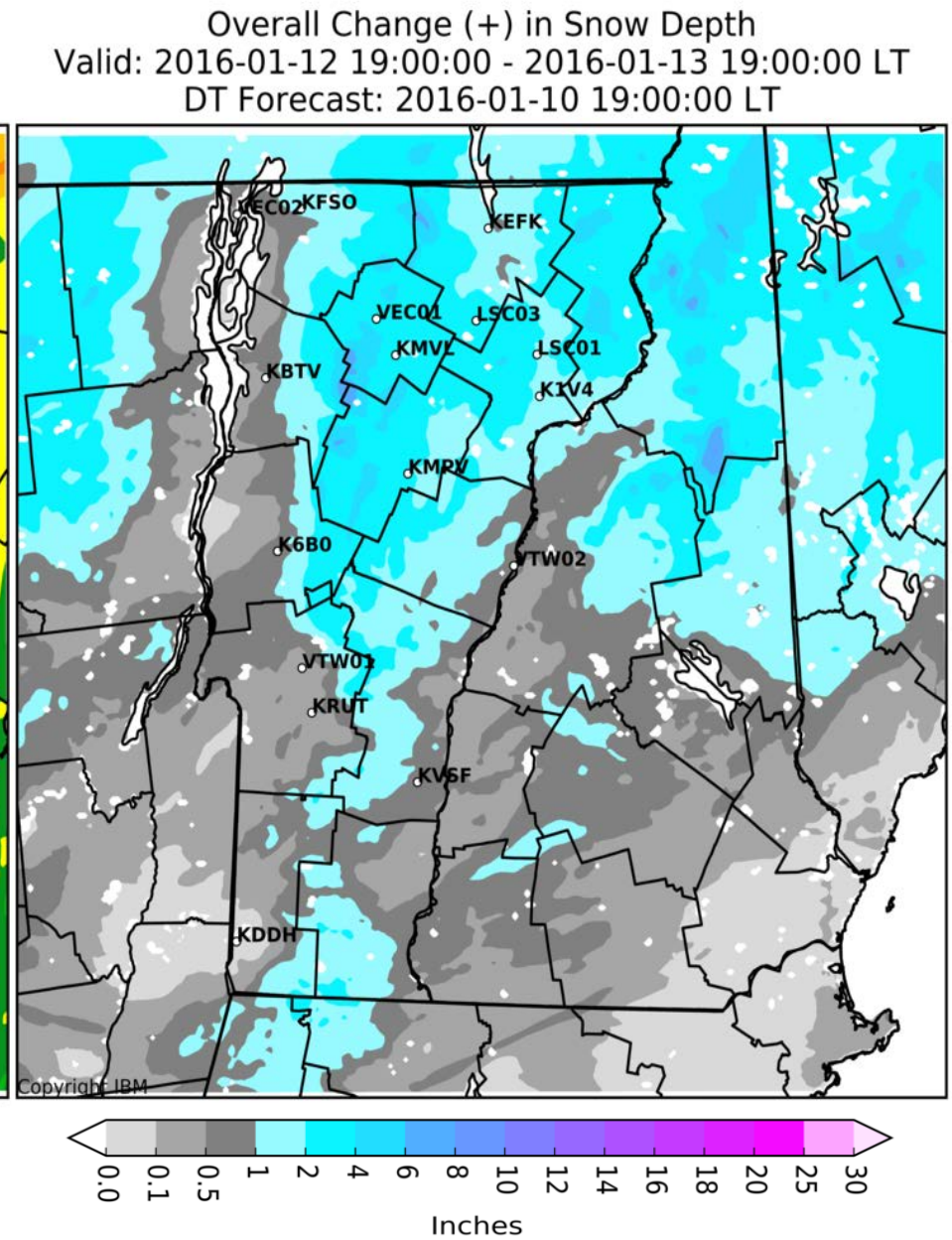
Model Specifications

Observed radar on 5/27/14 – Isolated supercell over Rutland that produced golf ball-sized hail, high wind gusts, and flash flooding



Precipitation Forecasts



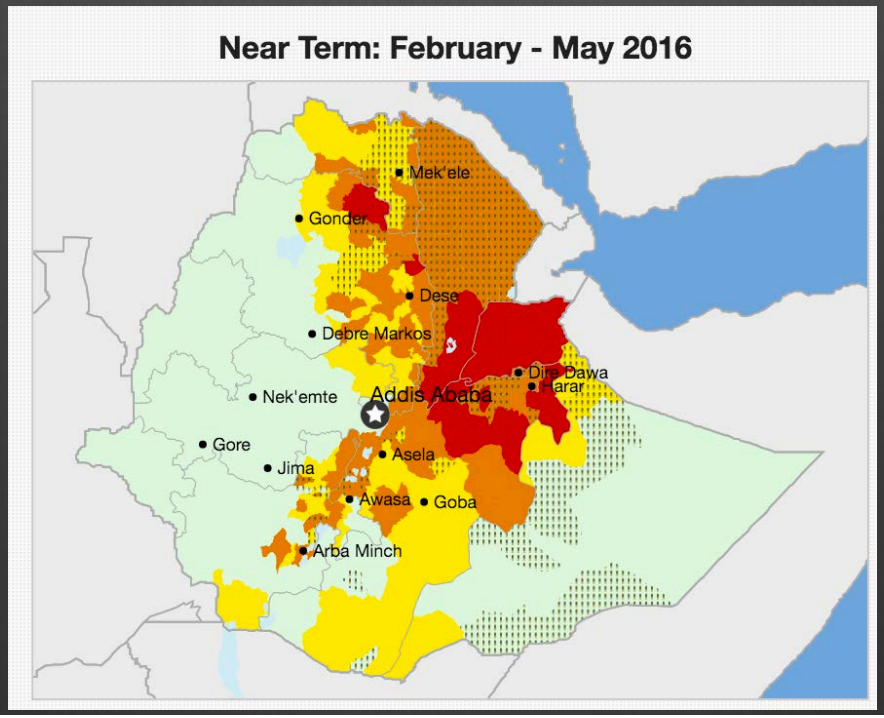


Seasonal precipitation forecast and downscaling

- Why?
- Issues
- Downscaling approaches and evaluation

Why?

To help* provide food security outlook



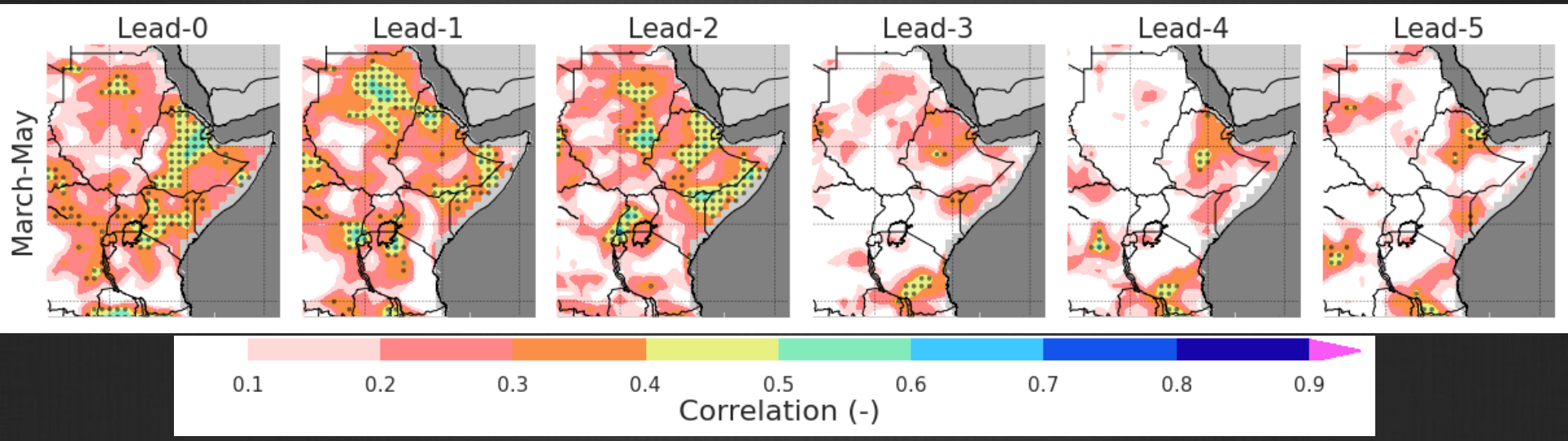
IPC 2.0 Acute Food Insecurity Phase

1: None or Minimal | 2: Stressed | 3: Crisis | 4: Emergency | 5: Catastrophe/Famine

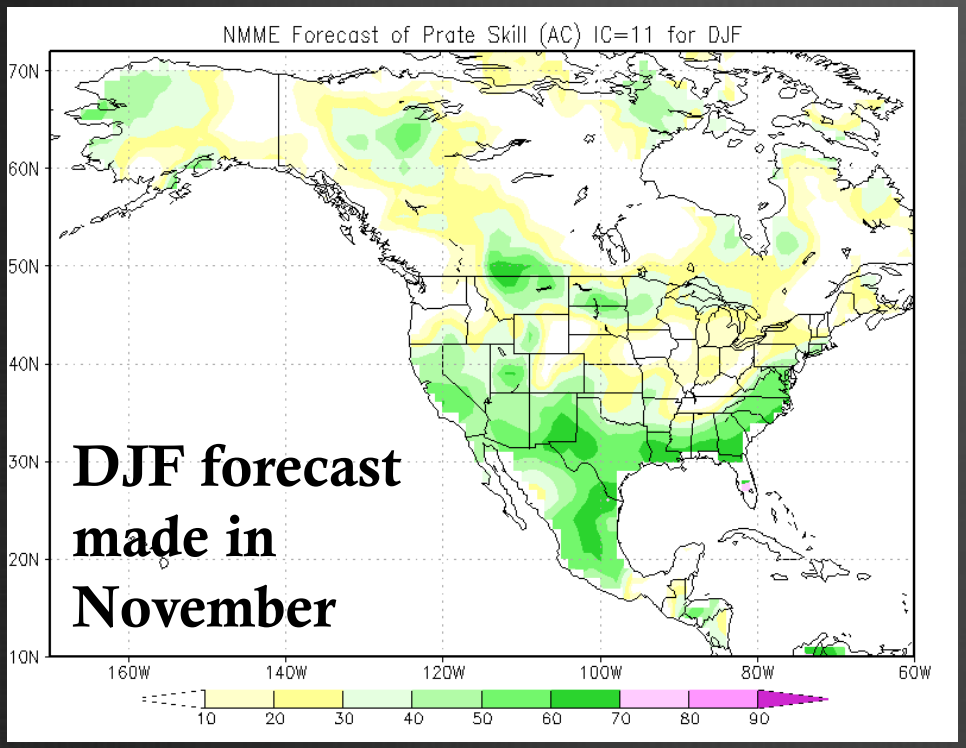
*Other crucial factors include Markets and Trade, Livelihoods and Nutrition information.

Issues

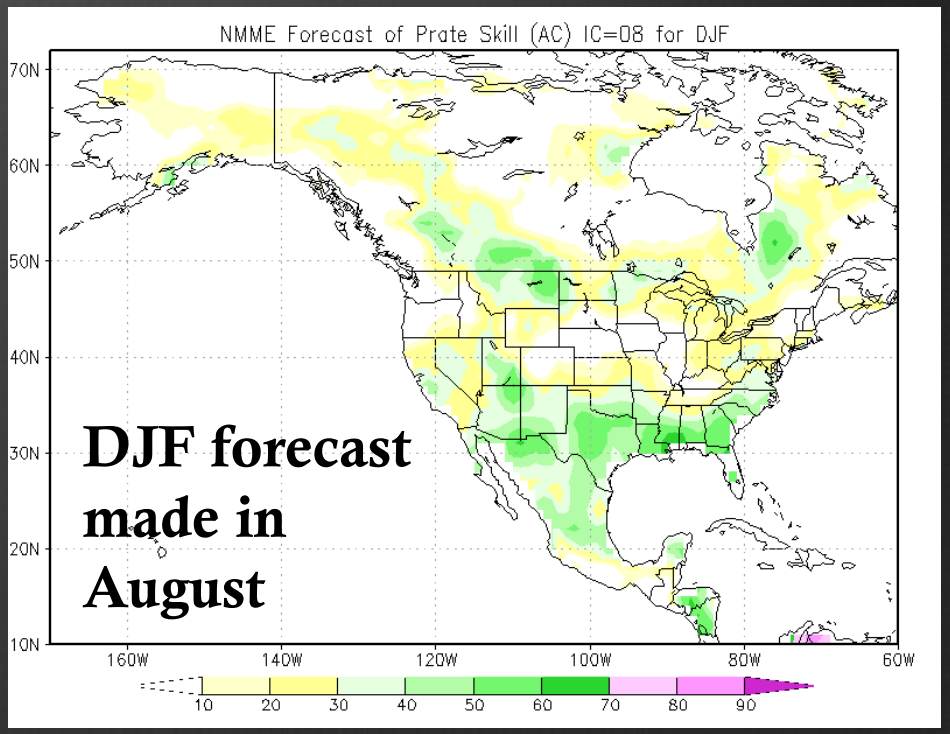
- Lack of seasonal precipitation forecast skill
- Uncertainty induced through downscaling methods
- Lack of long-term observations



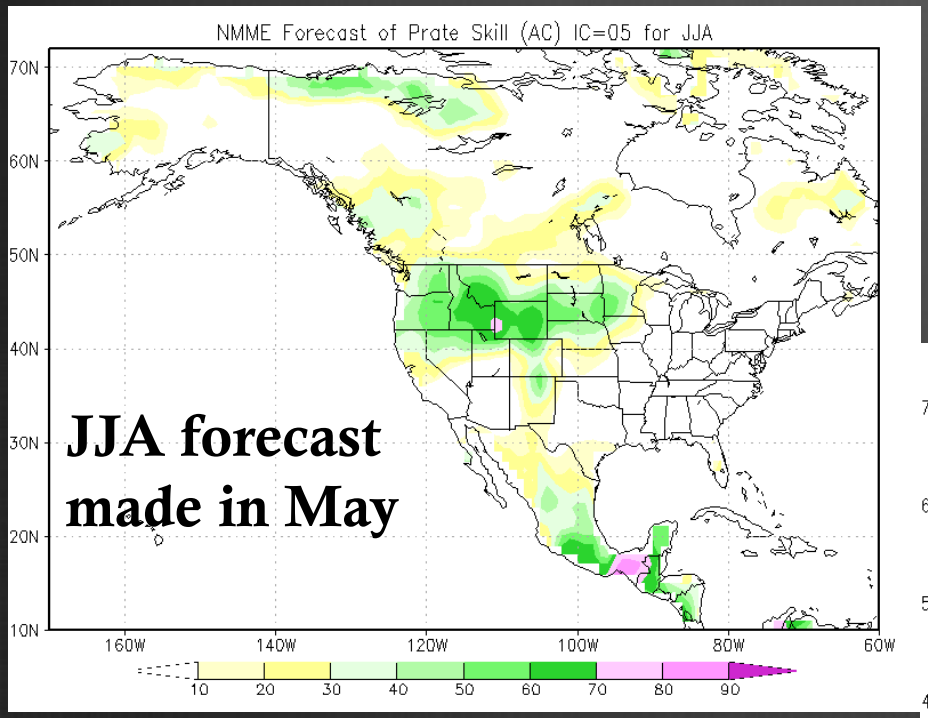
Skill of precipitation forecast

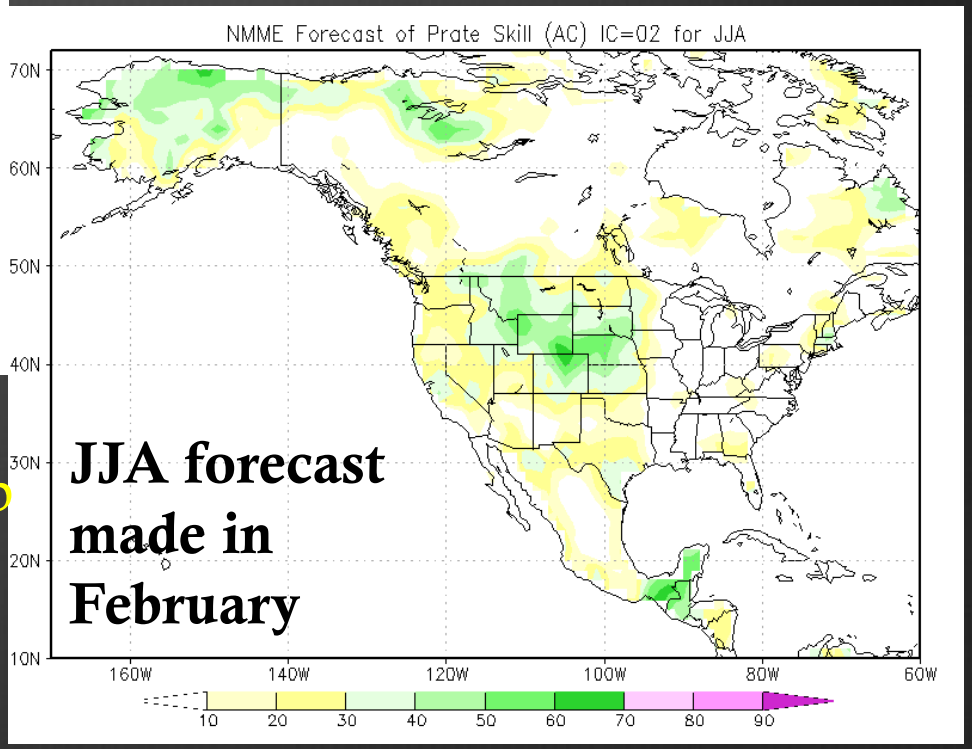


Source: CPC (http://www.cpc.ncep.noaa.gov/products/NMME/)



Skill of precipitation forecast





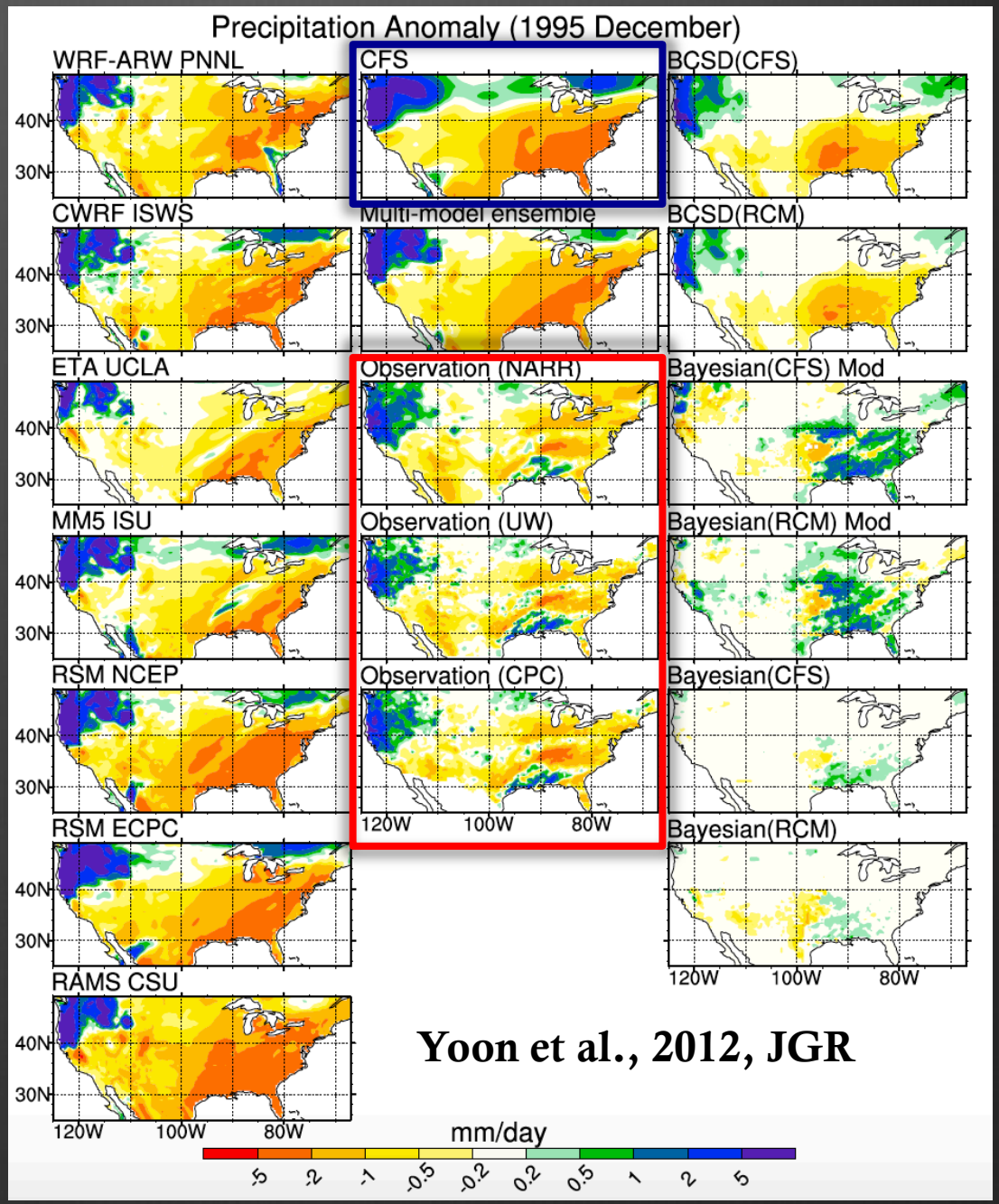
Source: CPC (http://www.cpc.ncep.noaa.gov/products/NMME/)

Statistical vs Dynamical Downscaling

- DD by the multiRCM produces finer-scale topographical features.
- However DD outputs suffer from inherent biases in both the global forecast model and the RCMs themselves.
- Statistical bias correction methods needs to be still applied to DD outputs.

Source of DD outputs: MultiRCM Ensemble Downscaling (MRED) Project

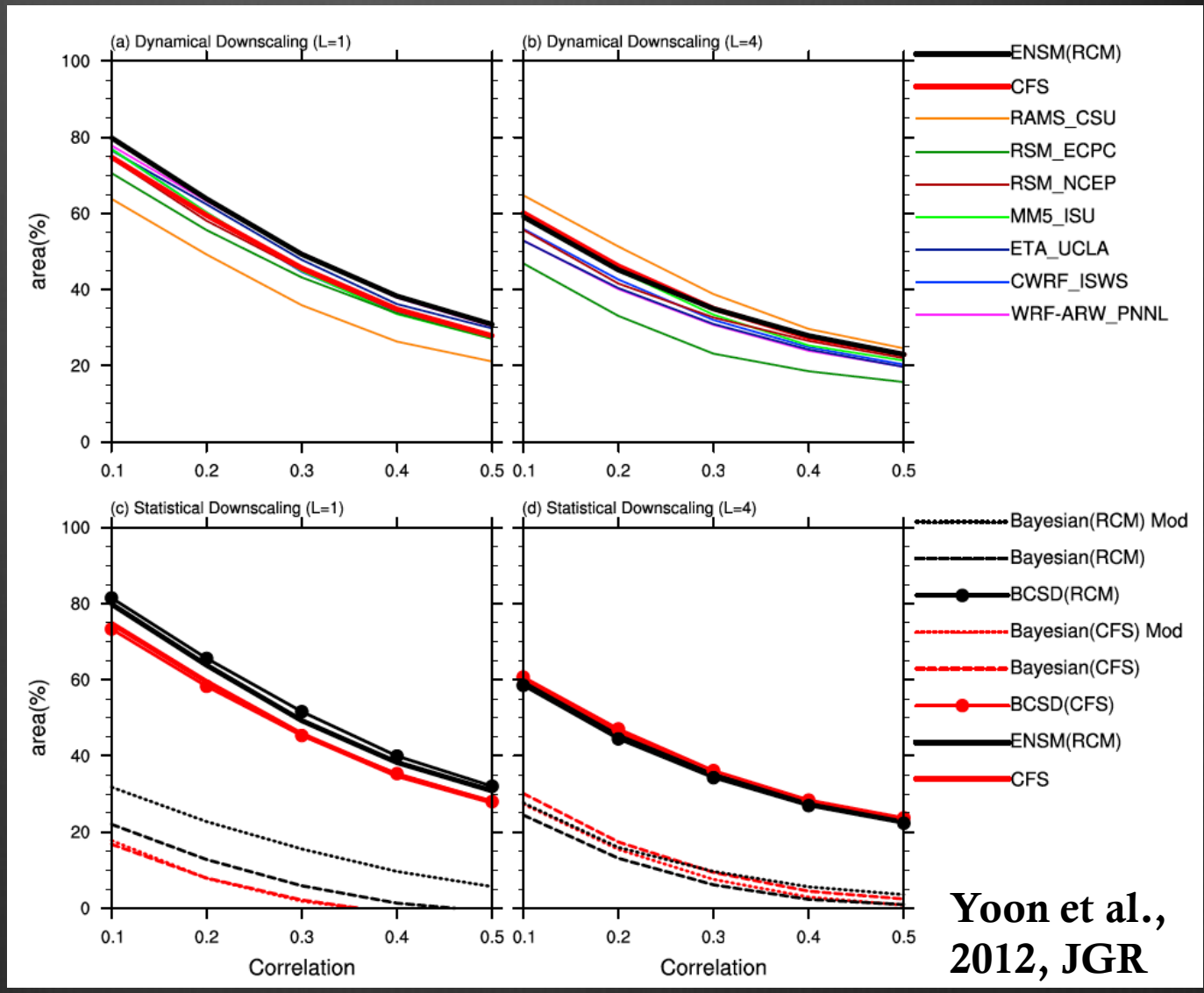
Dynamical Downscaling (DD)



Statistical Downscaling (SD)

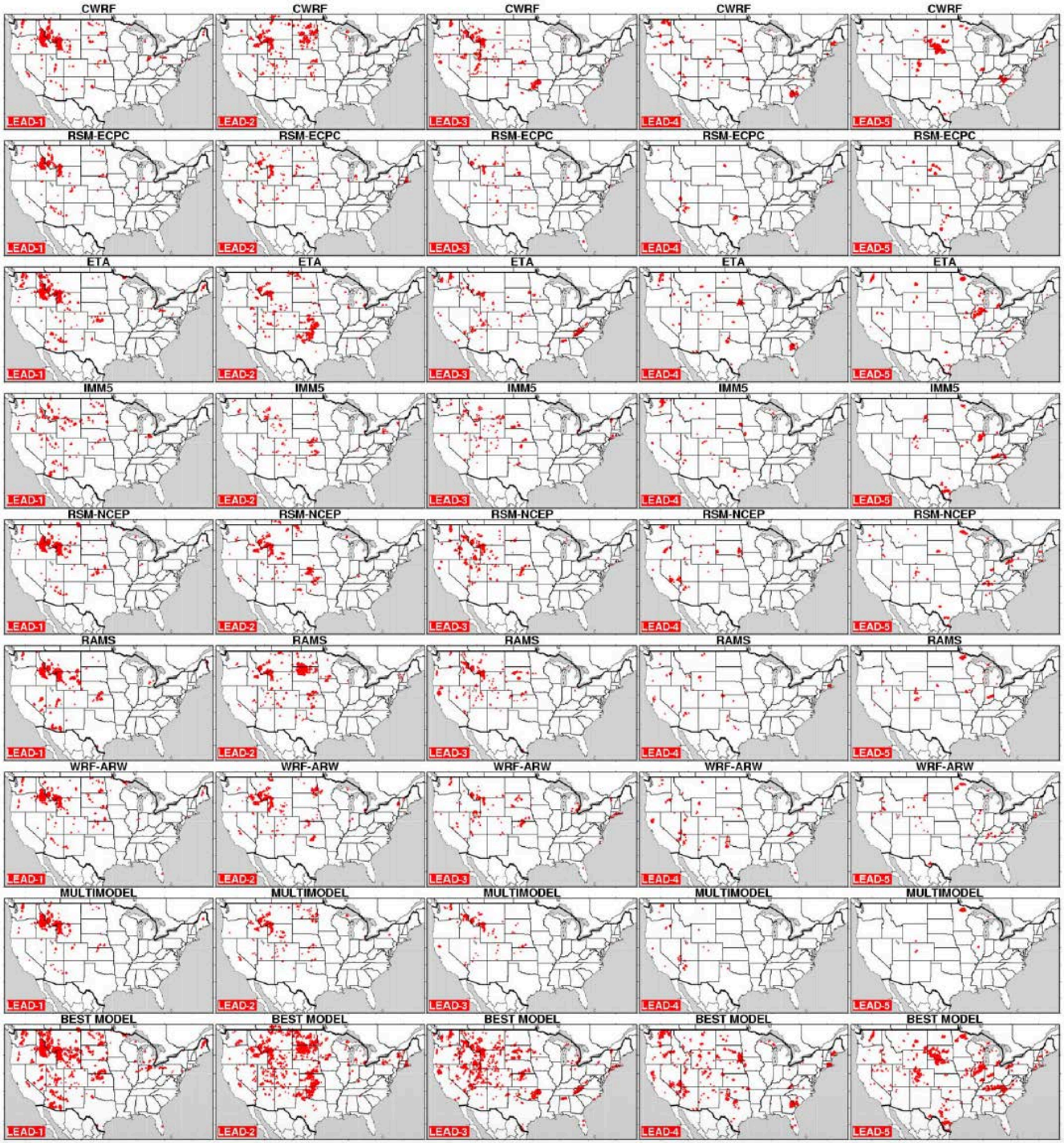
Evaluation of downscaling approches: Statistical vs Dynamical Downscaling

- Forecast skill of the downscaled P and T can vary for different metrics used in the cross validation.
- In terms of temporal AC, it is found that RCMs and statistical downscaling methods generally are somewhat higher than CFS.



Yoon et al., 2012, JGR

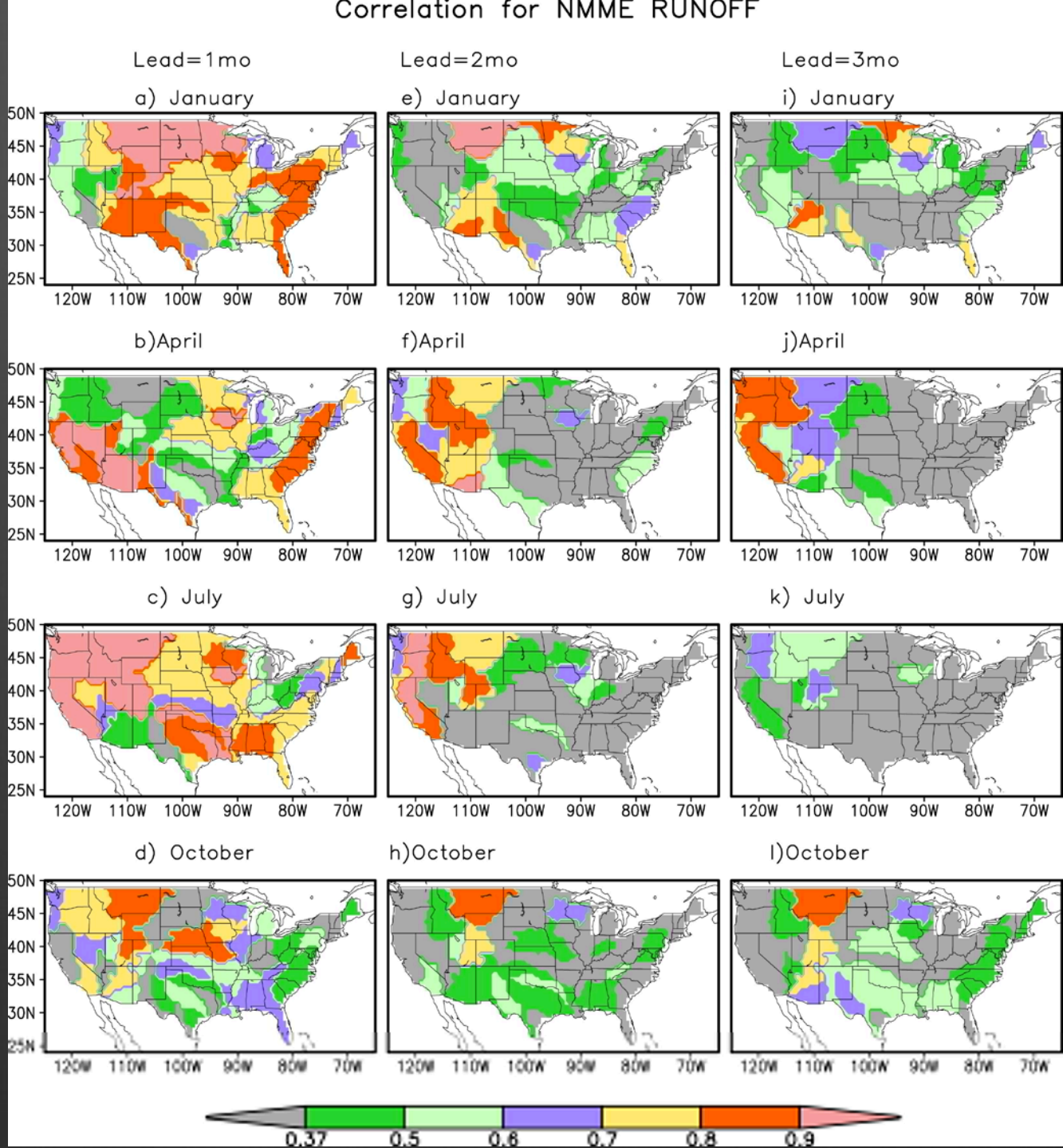
Alternative benchmark for precipitation forecast skill: Streamflow forecast-I



Red dot indicate improvement in runoff forecast by using DD relative to SD downscaling of CFS climate forecast.

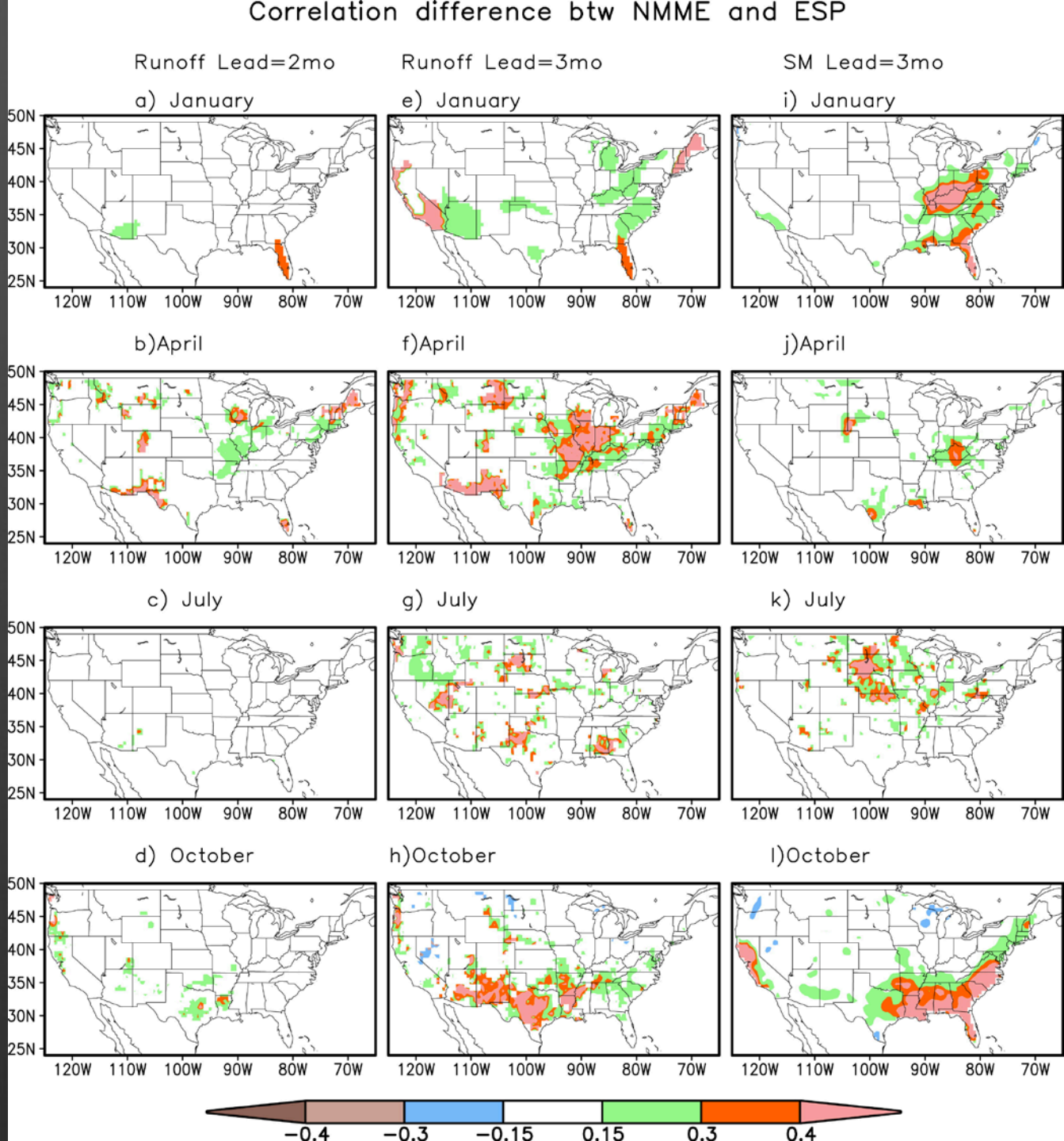
Shukla and Lettenmaier, 2013, JGR.

Alternative benchmark for precipitation forecast skill, Streamflow forecast-II



Mo and Lettenmaier 2012, JHM

- Streamflow forecasting can benefit most by improved precipitation forecast skill at longer lead time (> 1 month).

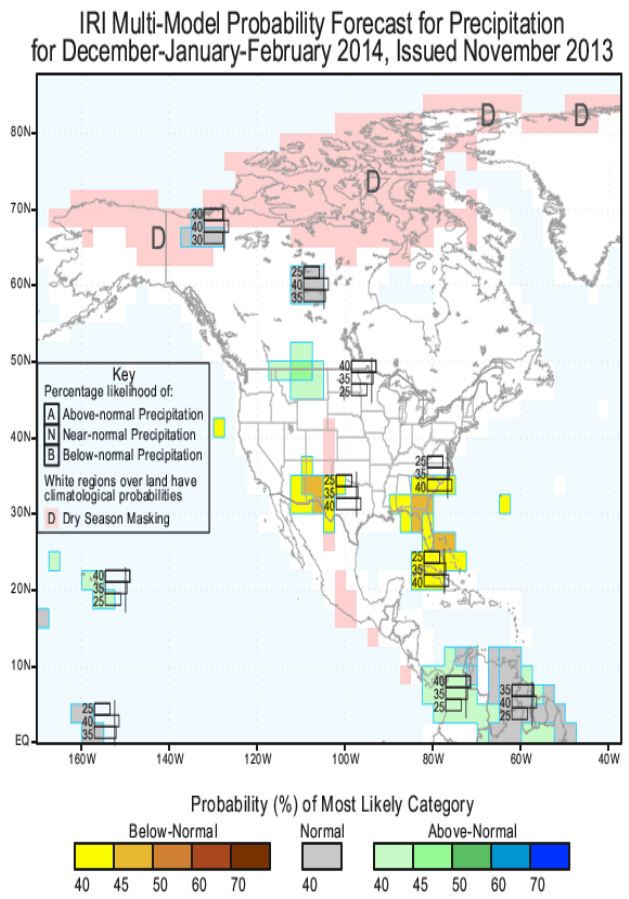


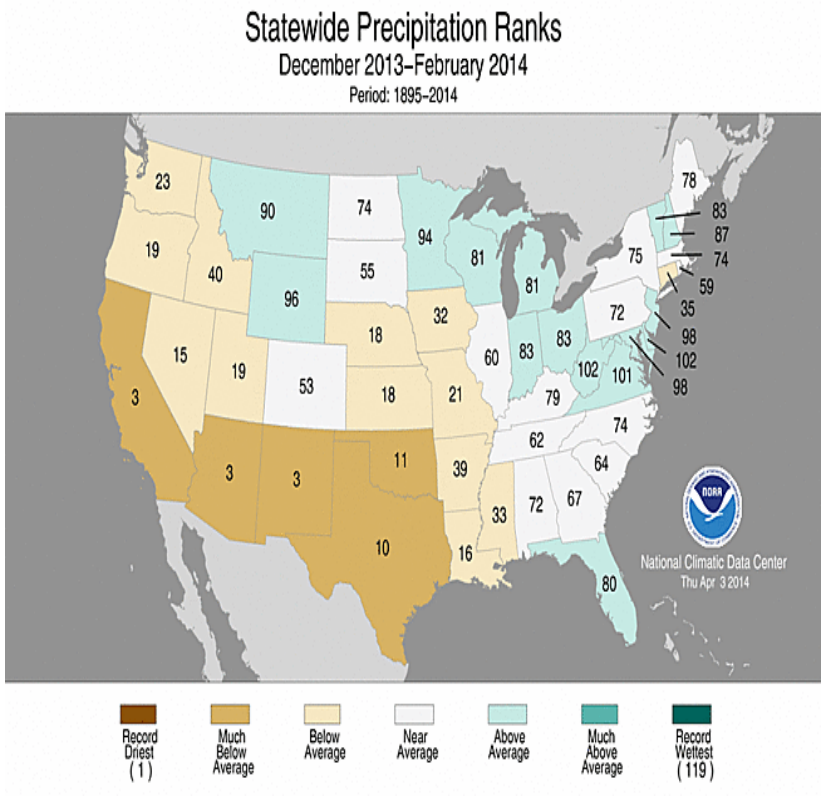
Mo and Lettenmaier 2012, JHM

Verification of US Winter Precipitation Forecasts

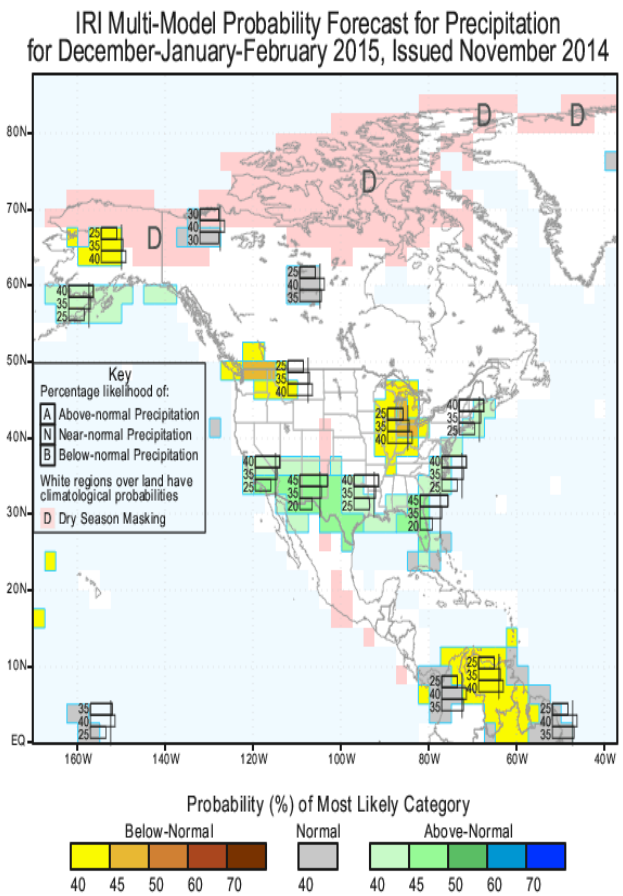
Jason Shafer
Lyndon State College

2013-14


IRI Multi-Model Probability Forecast for Precipitation
for December-January-February 2014, Issued November 2013
Key
Percentage likelihood of:
A Above-normal Precipitation
N Near-normal Precipitation
B Below-normal Precipitation
White regions over land have climatological probabilities
D Dry Season Masking
Probability (%) of Most Likely Category
Below-Normal
Normal
Above-Normal
40 45 50 60 70
40
40 45 50 60 70


Statewide Precipitation Ranks
December 2013–February 2014
Period: 1895–2014
National Climatic Data Center
Thu Apr 3 2014
Record Driest (1)
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Wettest (119)

2014-15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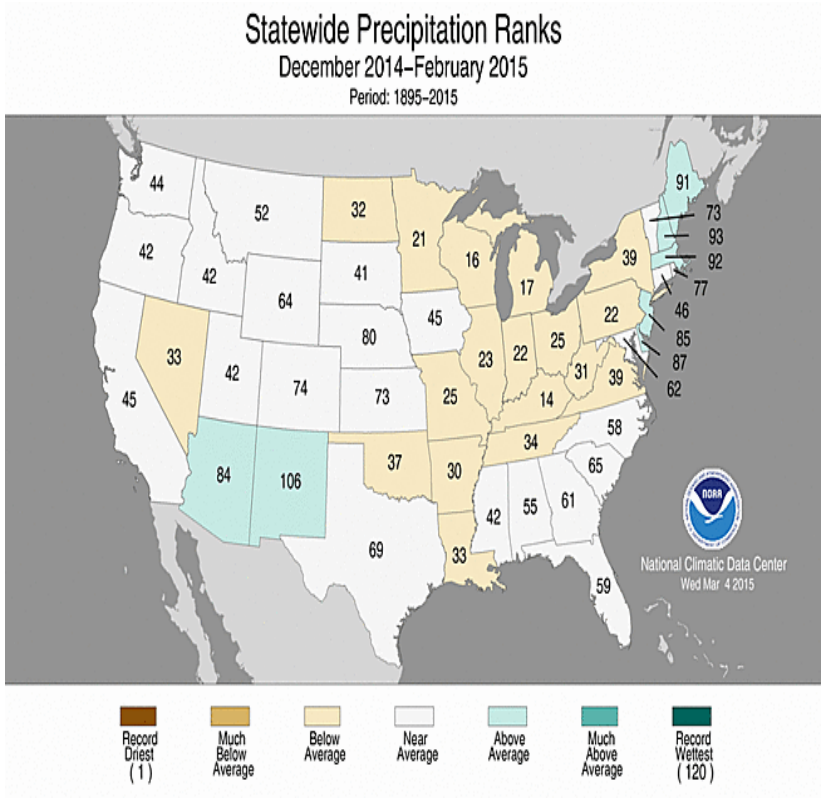
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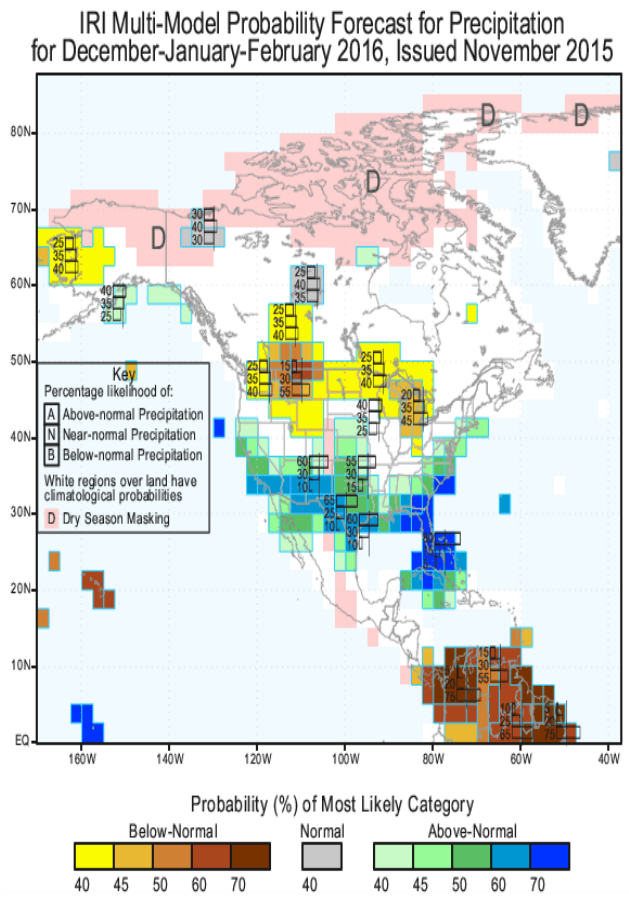
2015-16


IRI Multi-Model Probability Forecast for Precipitation
for December-January-February 2016, Issued November 2015
Key
Percentage likelihood of:
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N Near-normal Precipitation
B Below-normal Precipitation
White regions over land have climatological probabilities
D Dry Season Masking
Probability (%) of Most Likely Category
Below-Normal
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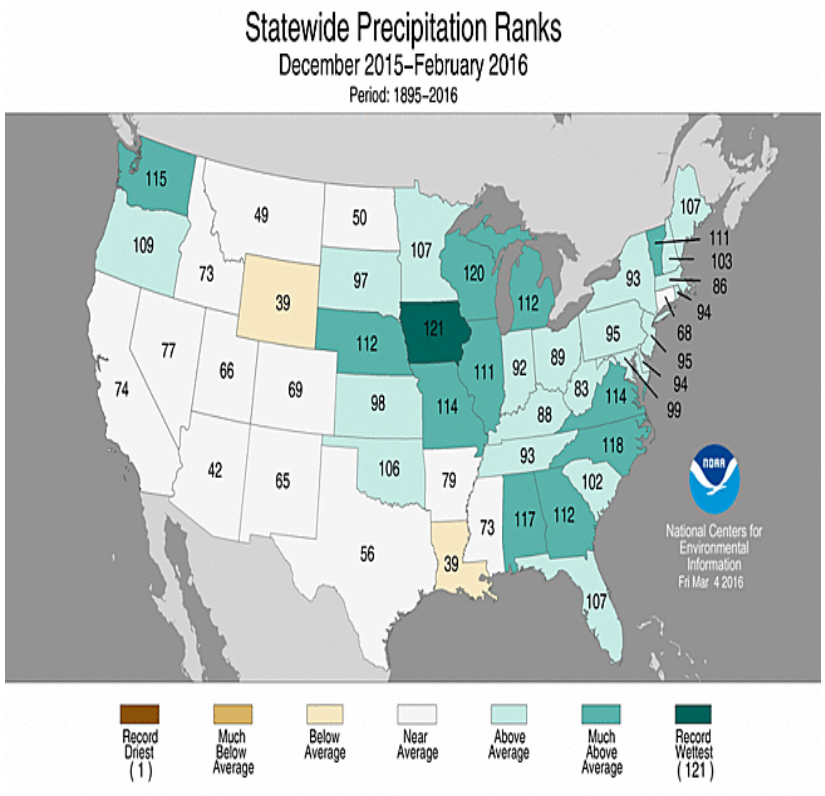
40
40 45 50 60 70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Above Average
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Record Wettest (121)