A Brief Overview of the Operational Implementation of the National Water Model (WRF-Hydro)

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Large integrated NWC and NCAR team

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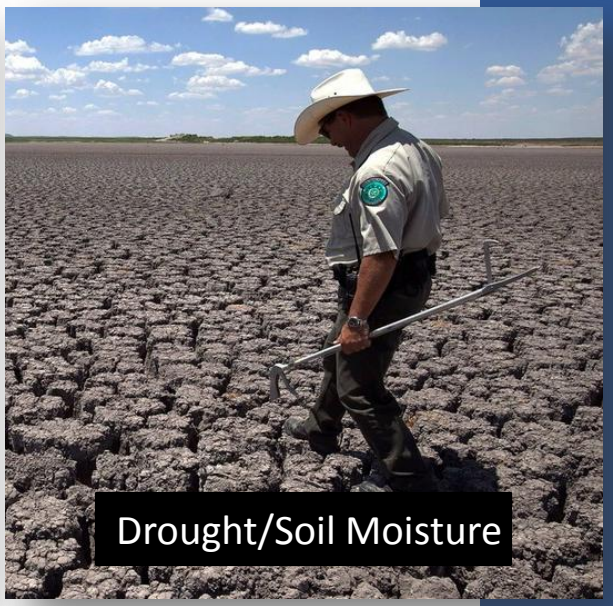
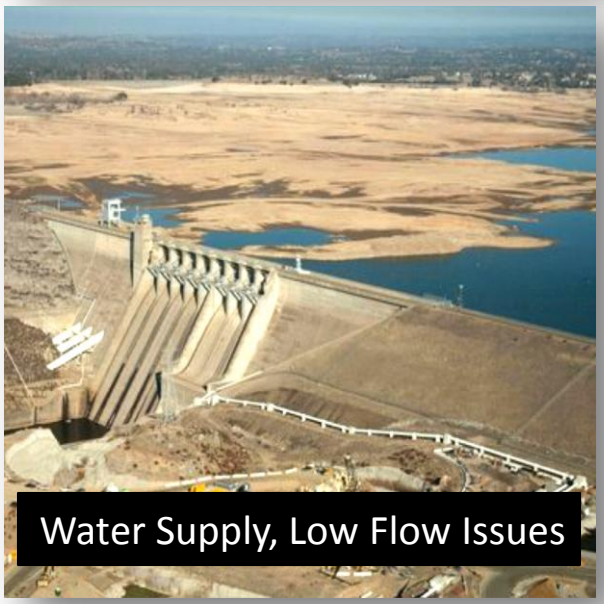
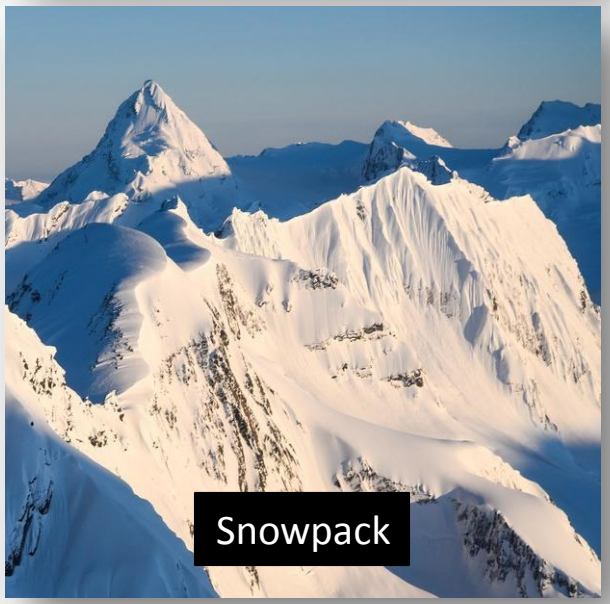
Outline

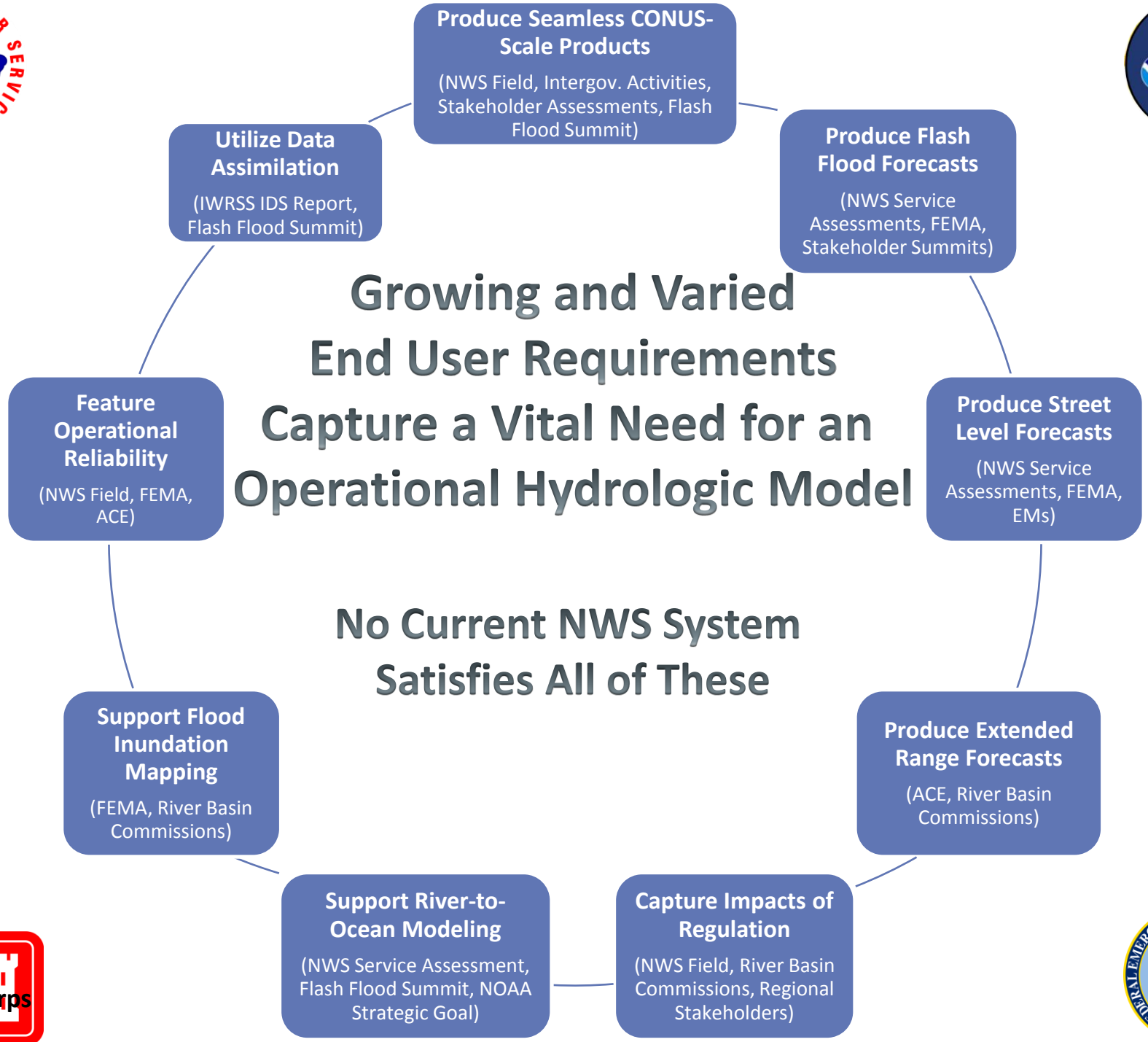
1. Growing need for actionable hydrologic information
2. WRF-Hydro overview
3. Model configuration
4. Products and dissemination
5. End users
6. Initial validation examples
7. Summary and future directions

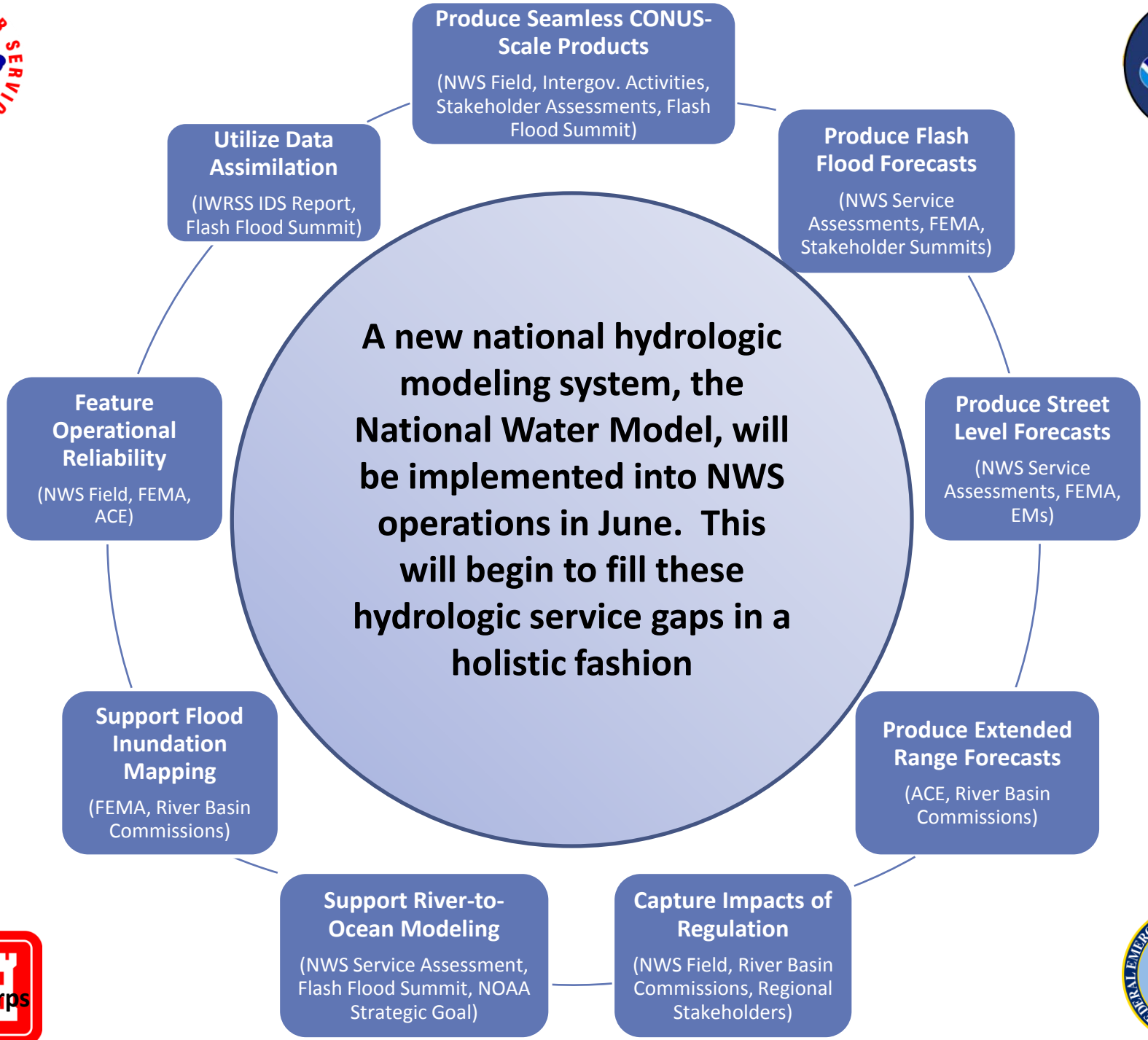
Hydro Analysis/Forecast Needs Extremely Broad








Produce Seamless CONUS-Scale Products
(NWS Field, Intergov. Activities, Stakeholder Assessments, Flash Flood Summit)
Produce Flash Flood Forecasts
(NWS Service Assessments, FEMA, Stakeholder Summits)
Produce Street Level Forecasts
(NWS Service Assessments, FEMA, EMs)
Produce Extended Range Forecasts
(ACE, River Basin Commissions)
Capture Impacts of Regulation
(NWS Field, River Basin Commissions, Regional Stakeholders)
Support River-to-Ocean Modeling
(NWS Service Assessment, Flash Flood Summit, NOAA Strategic Goal)
Support Flood Inundation Mapping
(FEMA, River Basin Commissions)
Feature Operational Reliability
(NWS Field, FEMA, ACE)
Utilize Data Assimilation
(IWRSS IDS Report, Flash Flood Summit)
Growing and Varied End User Requirements Capture a Vital Need for an Operational Hydrologic Model
No Current NWS System Satisfies All of These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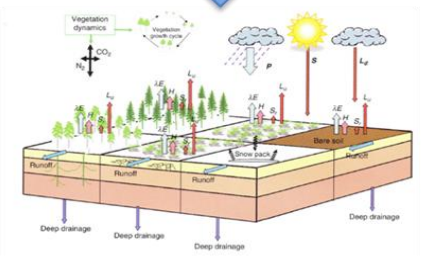
A new national hydrologic modeling system, the National Water Model, will be implemented into NWS operations in June. This will begin to fill these hydrologic service gaps in a holistic fashion

National Water Model (NWM) Core: WRF-Hydro

- WRF-Hydro forms the foundation of the National Water Model
- A community-based hydrologic modeling *framework* supported by NCAR being put into operations by an NWC, NCAR and NCEP partnership
- *Not dependent* on a particular forcing data source or choice of LSM
- Able to operate over multiple scales and with multiple physics options

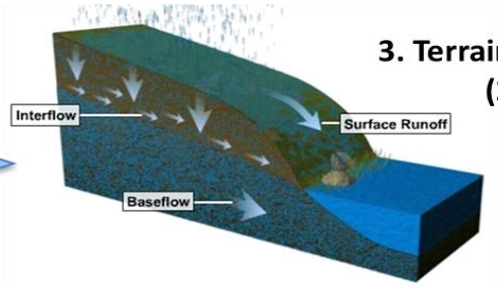
IOC System Flow (Uncoupled)

1. WRF-Hydro Forcing Engine (1 km grid)



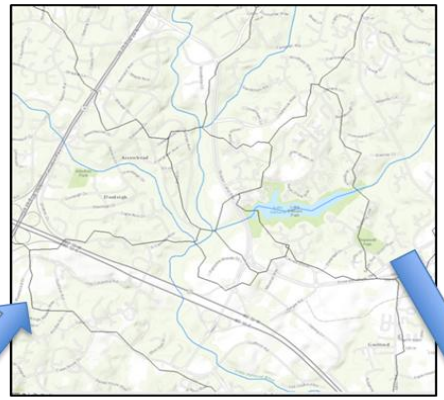
2. NoahMP LSM (1 km grid)

2-way coupling



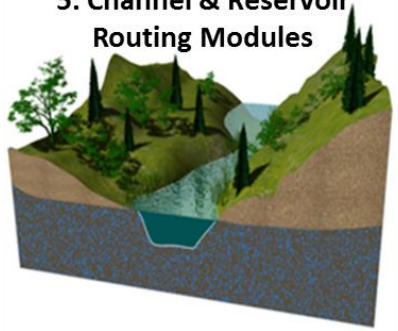
3. Terrain Routing Module (250 m grid)

4. NHDPlus Catchment Aggregation



(avg. size ~3km^2)

5. Channel & Reservoir Routing Modules



Forecasts

National Water Model: Initial Operating Capability (IOC)

- Initial efforts are focusing on implementing a capable and solid foundation that will support year-over-year growth in operational hydrologic forecasting capability
- Goals for this NWM Initial Operating Capability (three year project accelerated into one year)
  - Provide forecast streamflow guidance for underserved locations
  - Produce spatially continuous national estimates of hydrologic states (soil moisture, snow pack, etc.)
  - Seamlessly interface real-time hydrologic products into an advanced geospatial intelligence framework
  - Implement a modeling architecture that permits rapid infusion of new data, science and technology

NWM Operational Configuration

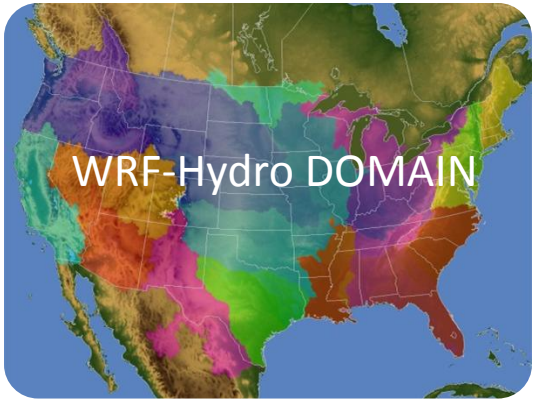
Analysis & Assimilation	Short-Range	Medium-Range	Long-Range
Cycling Frequency			
Hourly	Hourly	Daily	Daily (16 mem)
Forecast Duration			
- 3 hrs	0-18 hours	0-10 days	0-30 days
Meteorological Forcing			
MRMS blend/ HRRR/RAP bkgnd.	Downscaled HRRR/RAP blend	Downscaled GFS	Downscaled & bias-corrected CFS
Spatial Discretization & Routing			
1km/250m/NHDPlus Reach	1km/250m/NHDPlus Reach	1km/250m/NHDPlus Reach	1 km/NHDPlus Reach

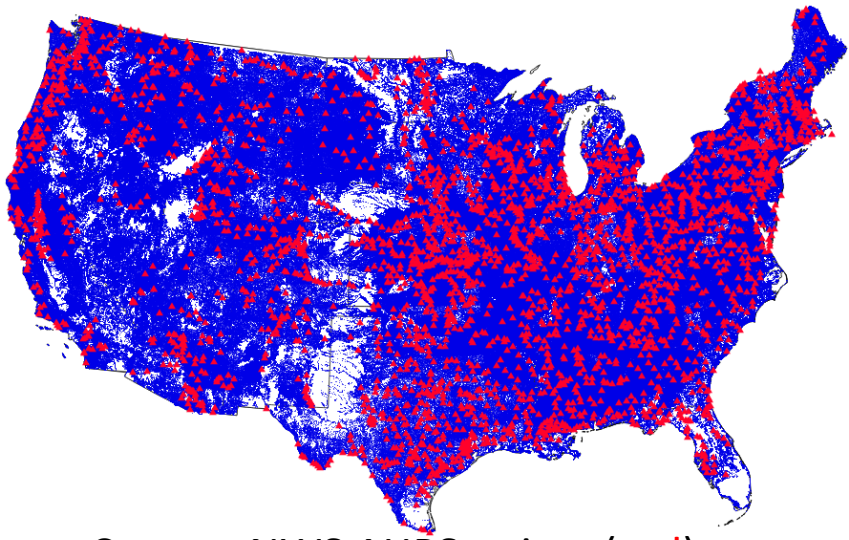
Assimilation of USGS Obs

Reservoirs (1615 water bodies parameterized with level pool scheme)

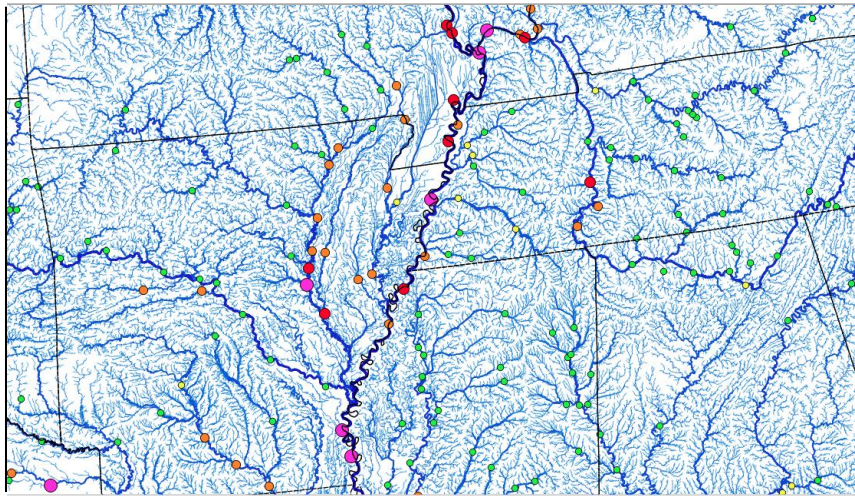
NWM IOC EXPERIMENTAL OUTPUT

- Hydrologic Output
  - River channel discharge and velocity at 2.6 million river reaches
  - Surface water depth and subsurface flow (250 m CONUS+ grid)
- Land Surface Output
  - 1km CONUS+ grid
  - Soil and snow pack states
  - Energy and water fluxes
- Direct-output and value-added geointelligence products





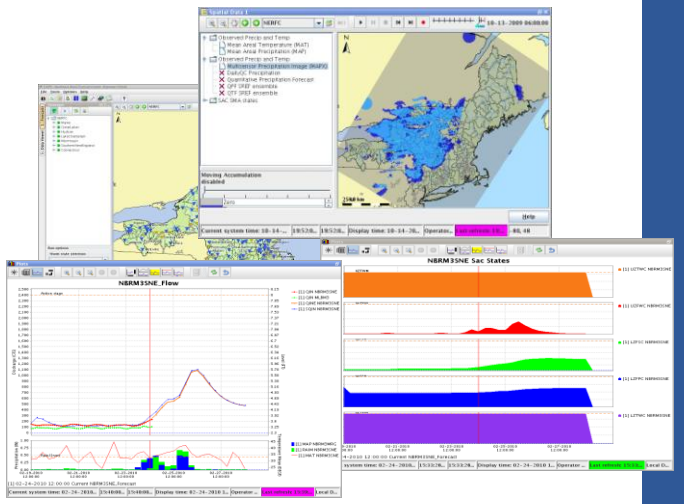
Current NWS AHPS points (red)
NWM output points (blue)



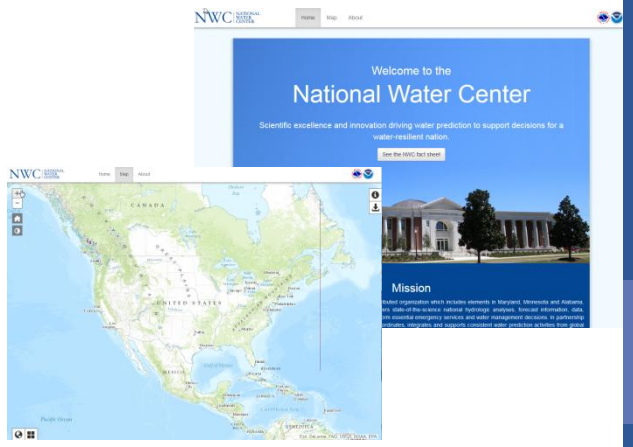
Current NWS River Forecast Points (circles)
Overlaid with NWM Stream Reaches

NWM IOC EXPERIMENTAL OUTPUT DISSEMINATION

- Visualization and data dissemination key to success, area of active development
- Three-pronged experimental output dissemination strategy
  - NWC website-based viewer
    - Public-facing visualization option
    - GIS-enabled dynamic visualization
    - Streamflow and soil moisture initially
  - Community Hydrologic Prediction System
    - Used operationally by RFCs
    - WFO access via remote-login
    - Geographically subsetted NWM data
    - Streamflow, velocity at river reaches
    - Gridded soil moisture output
    - Direct dissemination to RFCs
  - File dissemination via NOAA NOMADS server (*full* set of output variables)



CHPS



NWC Website

NWM END USERS

- National Weather Service
  - River Forecast Centers—River flow analyses and forecasts
  - National Water Center—Operational forecast and research support
  - Weather Forecast Offices—Flash flood forecasts
  - Environmental Modeling Center—Fluxes, land states for NLDAS, research
  - Weather Prediction Center—Input to excessive rainfall forecasts
  - Climate Prediction Center—Long range guidance for anomaly forecasts
- External Users
  - Federal Emergency Management Agency—Flood/drought forecasts
  - Army Corps of Engineers—Reservoir inflow forecasts
  - Local emergency managers, first responders—Hyper-local forecasts
  - National Ocean Service—Total Water Prediction (coupled ocean/estuary)
  - National Integrated Drought Information System—Drought forecasts
  - Academia—Research and Development
  - Private Sector—Development of value added products

Universities

Private Sector

NIDIS

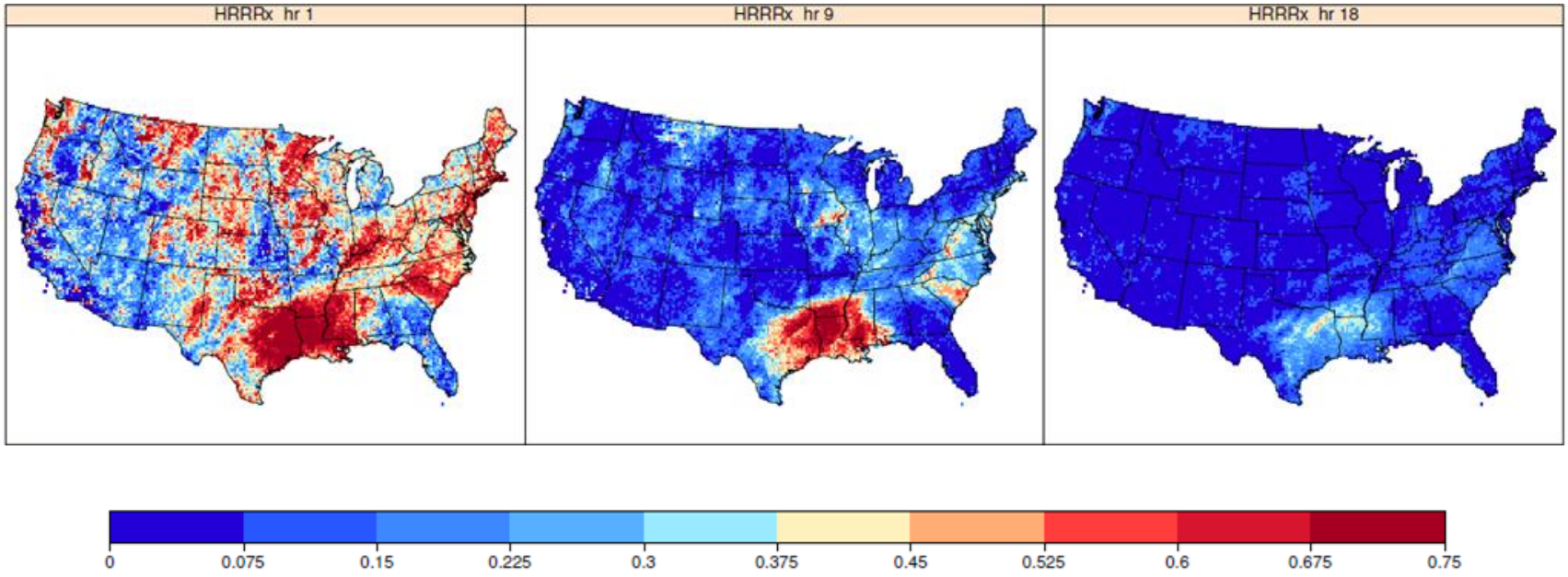
National Ocean Service

Emergency Managers

Initial NWM Evaluation

- Concerted push to build overall hydro evaluation into fabric of NWC
  - Pre-implementation NWM evaluation underway
    - Multi-faceted assessment of HRRR-, RAP-, GFS- and CFS-based forcing data
    - Retrospective and real-time WRF-Hydro test simulations
  - *Example* types of forecast verification approaches follow

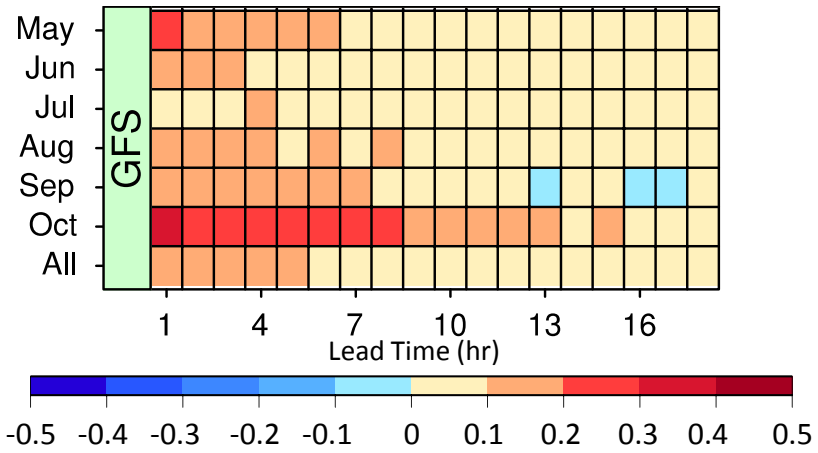
Critical Success Index (CSI) for 1, 9, and 18 hour HRRRx Forecast Lead Times
Threshold Applied=0.01 inch/hour Average for October 2015



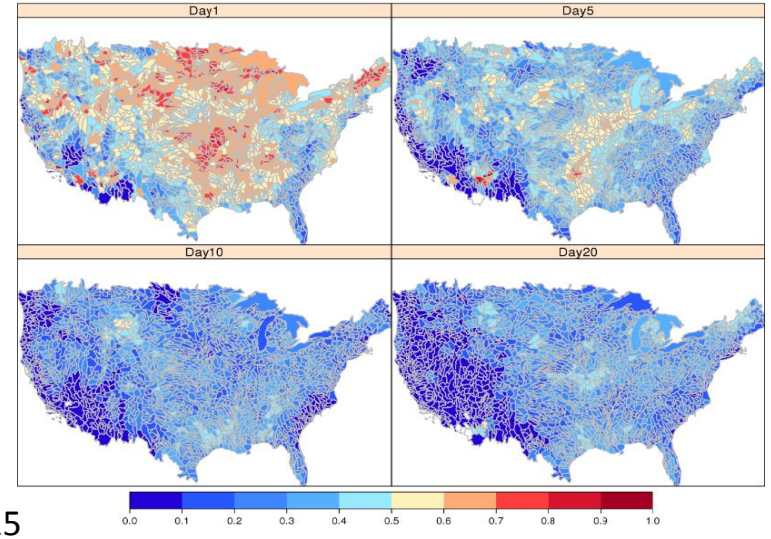
(CSI ranges from 0 to 1, with a value of 1 indicating a perfect forecast. It takes into account false alarms and missed events.)

Example NWM Precipitation Forcing Evaluations

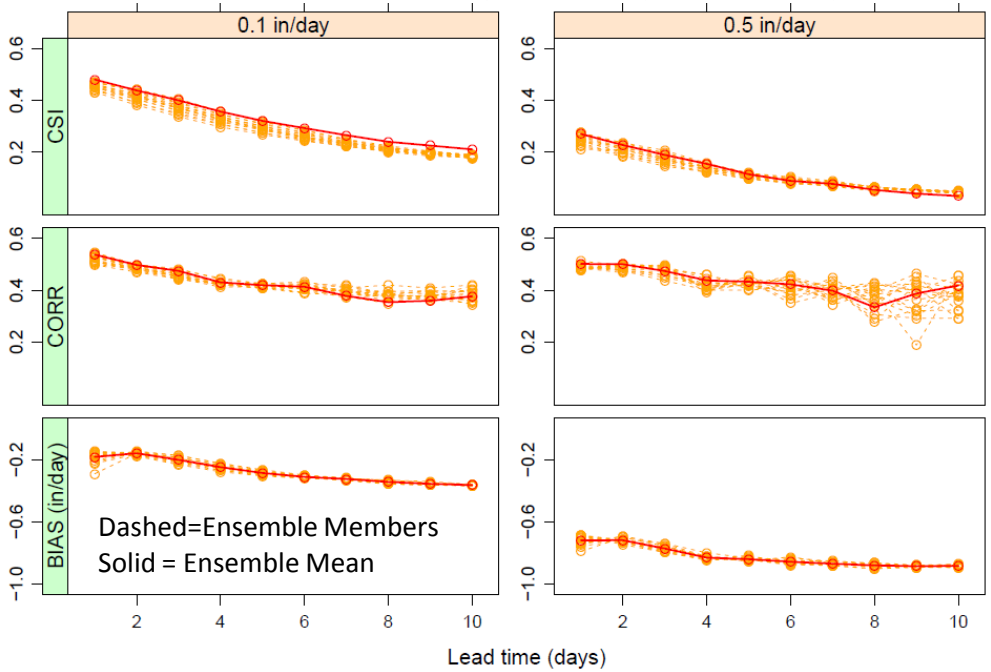
Correlation for Hourly GFS Precipitation
May-Oct 2015, CONUS Avg, 0.1 inch/hr threshold



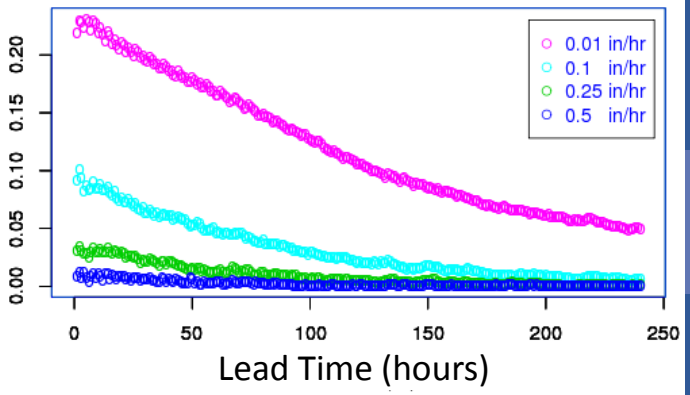
CSI for Single Member Daily CFS Precipitation
May-Oct 2015, HUC 8 Regions, 0.1 in/dy threshold



Assessment of Daily CONUS Avg CFS Precipitation, May-Oct 2015



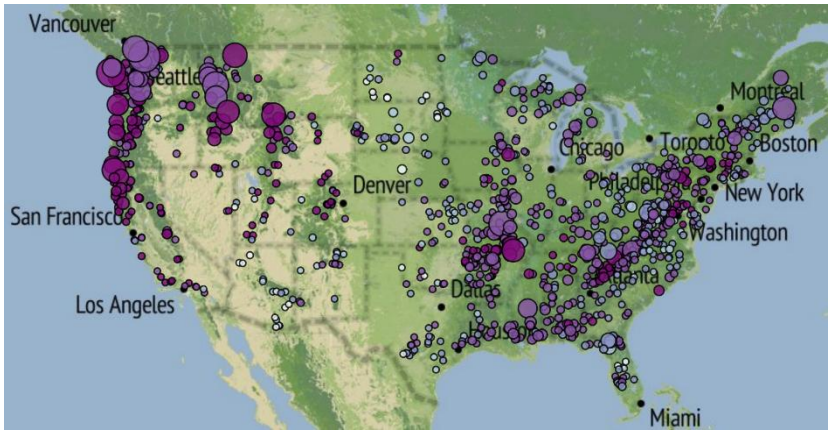
CSI for Hourly GFS Precipitation
Averaged Over May-Oct 2015

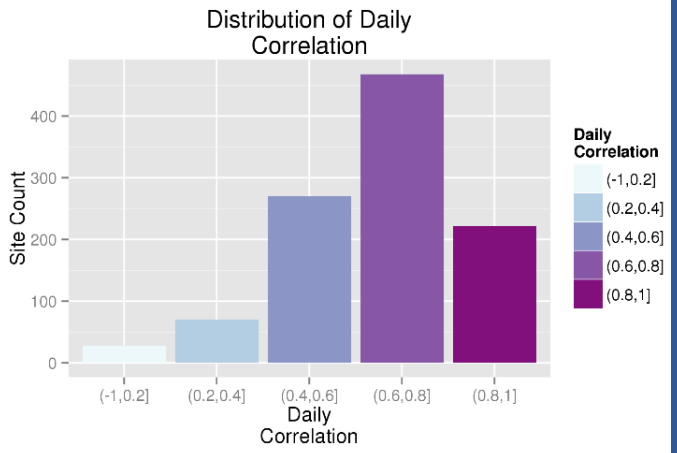


Initial NWM Developmental Output Evaluation: Streamflow

Average Daily Streamflow Correlation Over Gages II Unregulated Basins 2011-2013
Simulation With NLDAS2 Forcing, Initial Parameters, No Data Assimilation or Reservoirs

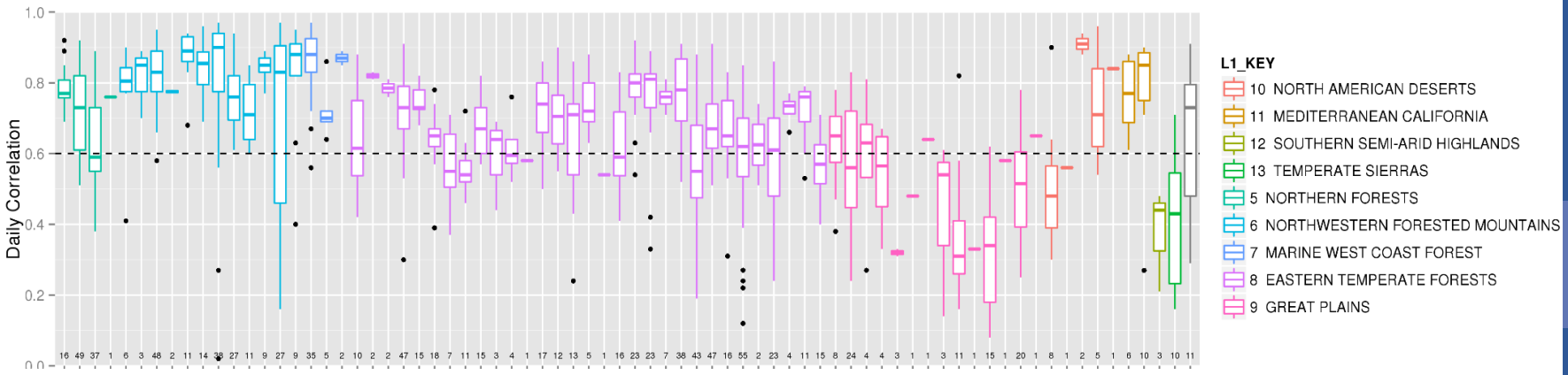
Distributed CONUS Analysis





71% of basins had correlation > 0.6

Regional Box-and Whisker Type Analysis

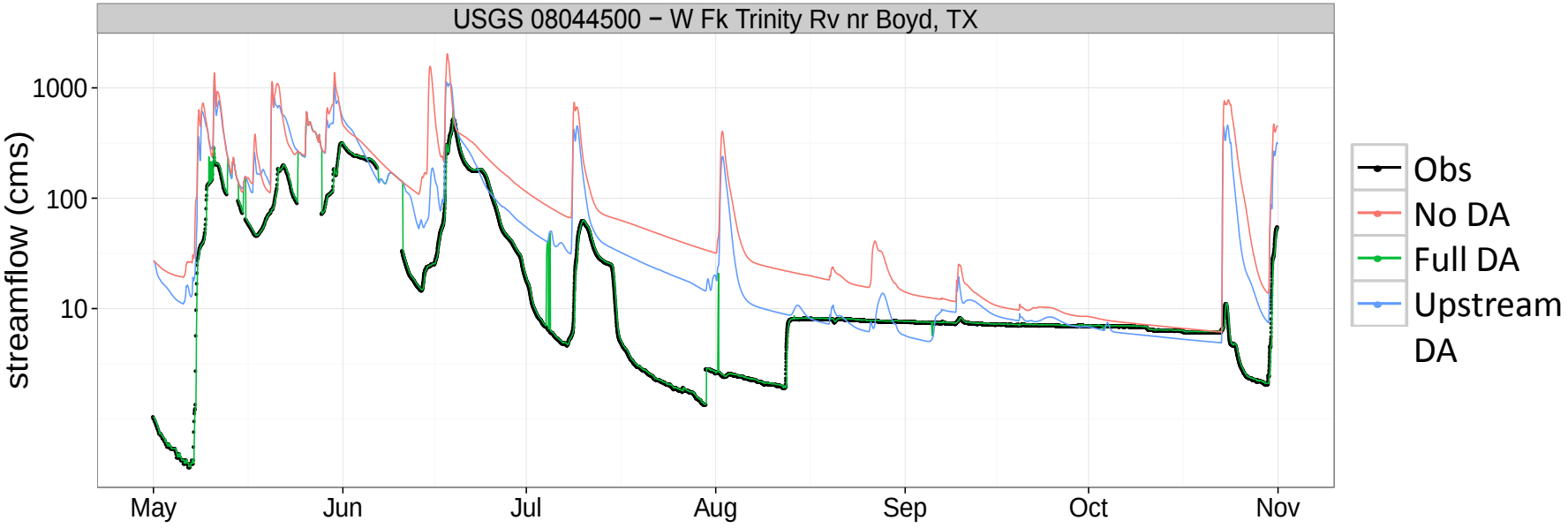


Analysis courtesy Aubrey Dugger (NCAR)…talk given in AMS Benchmarking Session

Initial NWM Output Evaluations: Streamflow

- Nudging-based streamflow data assimilation
- ~7000 USGS real-time stations across U.S.
- Provides improved national streamflow analyses and forecasts

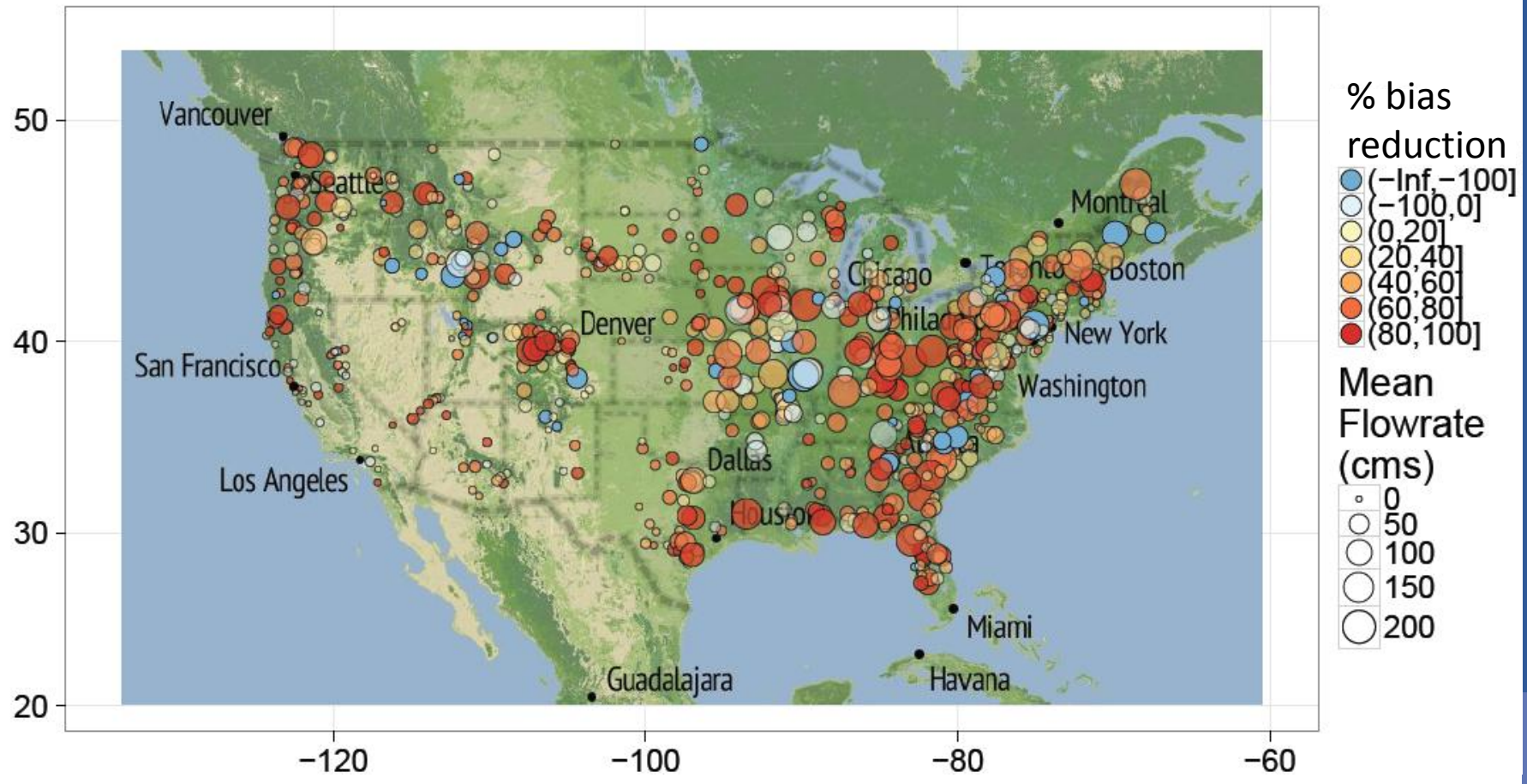
Assessment of NWM Hourly Streamflow Analysis, With and Without DA Simulation With NLDAS2 Forcing, Initial Parameters, May–Nov 2015



Analysis courtesy James McCreight (NCAR)…talk given in Data Assimilation Session

Initial NWM Output Evaluations: Streamflow

Percent Reduction in Hourly Streamflow Bias Achieved Through Assimilation of USGS Gauge Observations May–Oct 2015



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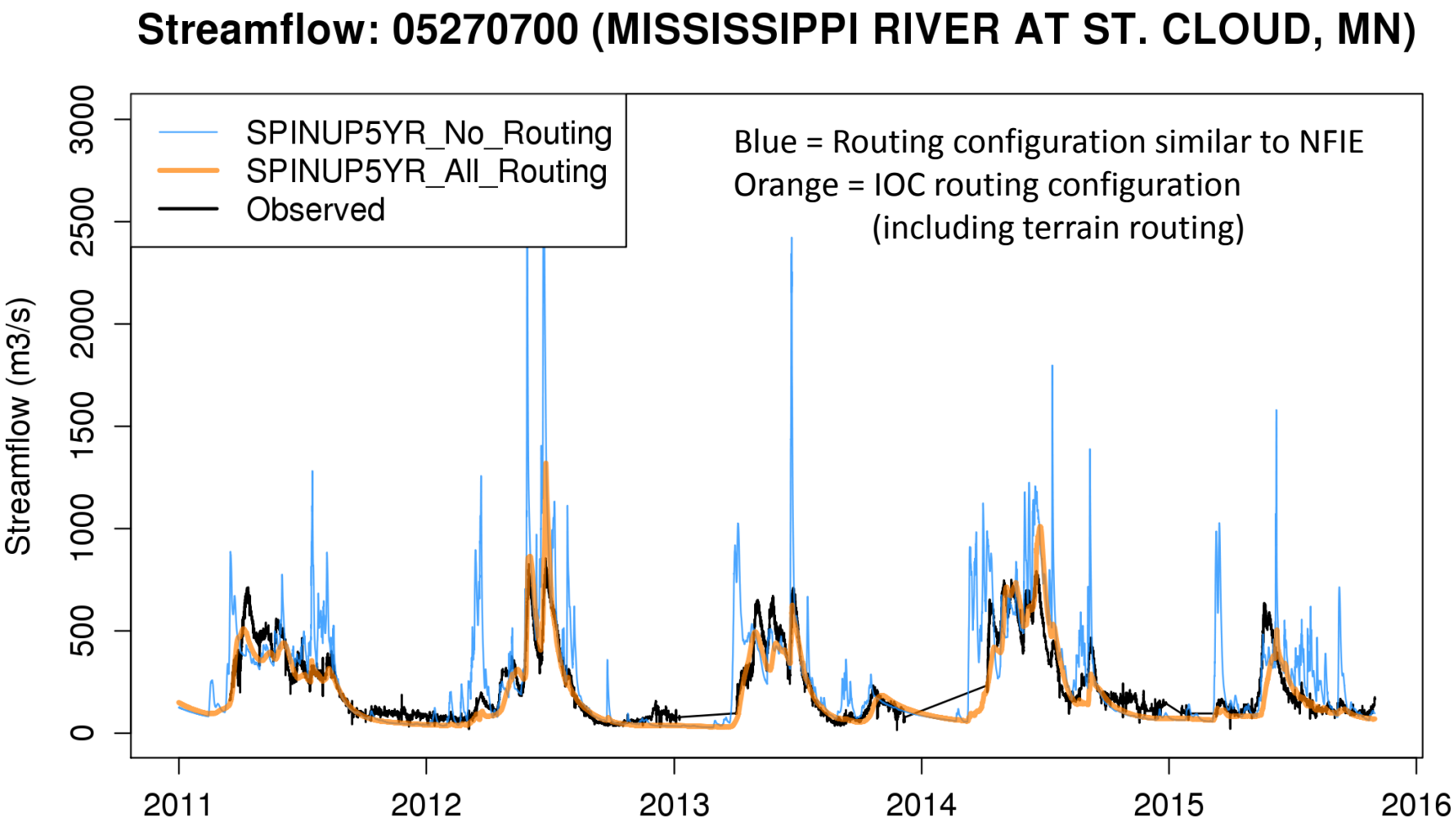
Initial NWM Developmental Output Evaluation: Streamflow



*Note: Development version with no data assimilation, no reservoirs, initial parameters

Summary and Future Activities

- National Water Model set for a June/July implementation
  - Effective NWC/NCAR/NCEP collaboration
  - Automated real-time tests this week on NOAA supercomputer
- An important operational hydrologic modeling capability—but just version 1.0
  - Improved data assimilation, hyper-resolution nested modeling windows
  - Domain enlargements and linkages to ocean/estuary models
  - Increased use of ensemble forcing and ensemble simulations
- Integration into ongoing R2O efforts like NGGPS and NLDAS key
- Strong partnerships with government agencies, academia and the private sector important to the system's long term success

Thanks!

Any Questions: **Brian.Cosgrove@noaa.gov**
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