Local Resilience to Natural Disasters: Meteorology & Hydrology Science

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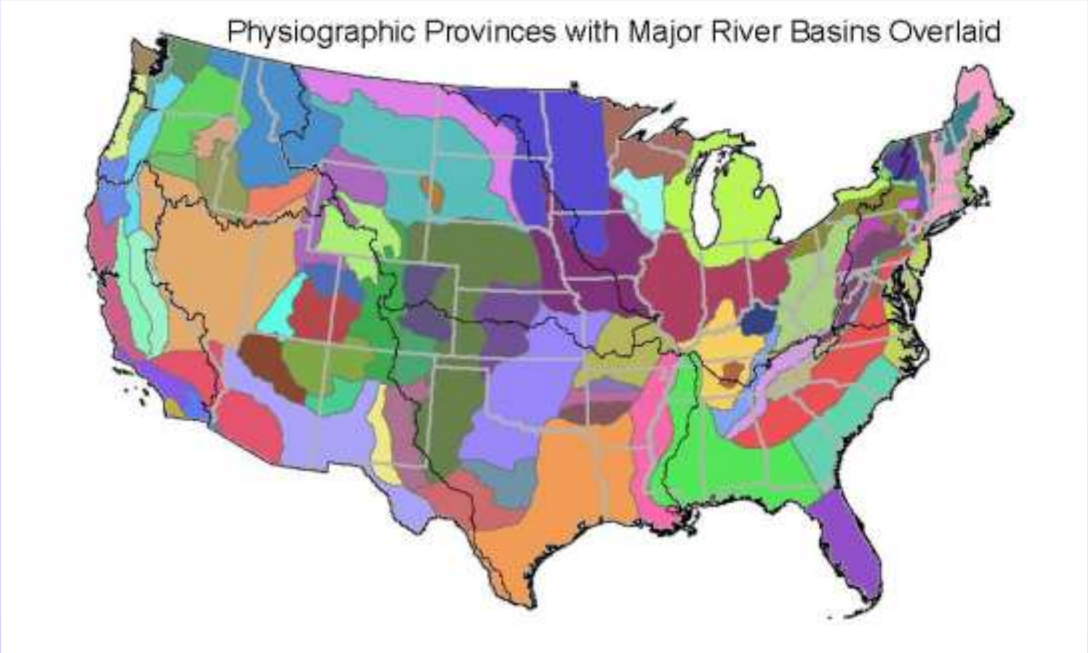
Outline

- Foundational observations of the atmosphere and lithosphere: establishing, maintaining, and adapting monitoring infrastructure (both *in situ* and remote sensing) to capture not only individual events, but also environmental conditions leading to them; and preserving those observations in an *accessible* historical record is also critical.
- Understanding physical processes: combining scientific theory and foundational observations to develop a robust understanding of key physical processes driving extreme weather and water events at continental, regional and local scales.
- Understanding anthropogenic processes: what humans are doing on the landscape that influences aspects of the hydrologic cycle.
- Models and forecasting: encoding those understandings to leverage new data, with the data already acquired, in models that accurately (in space and time) reproduce and forecast events.

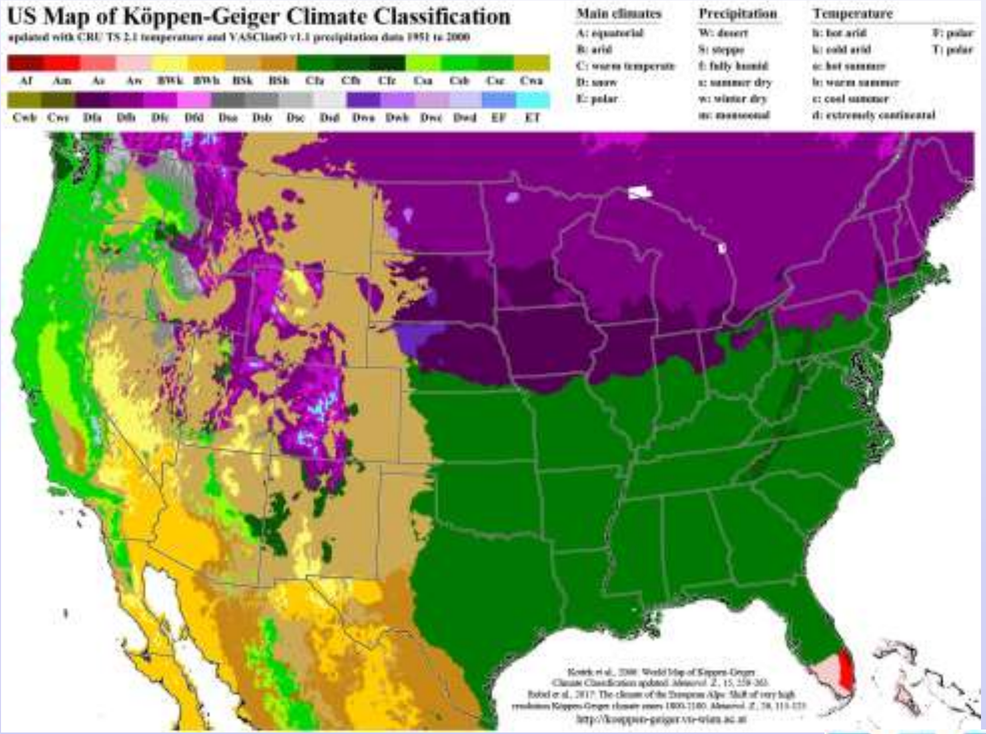
Weather-Ready Nation

Abundant Heterogeneity

Physical Character



Climate Character



Foundational observations of extreme weather and hydrologic events

- In situ and remote sensing
  - Observational networks – many exist, but some do not
    - *Adequate resolution to observe what you want to predict*
      - Doppler radar revolutionized tornado prediction, is there a hydrologic corollary?
      - Soil observations
        - » In situ observations few and far between; scientific instruments on every tractor?
        - » Can we measure what we need to know for modeling?
        - » Can satellites measure at fine enough resolution the information we need to know?
      - Cold season observations
        - » Snow, Ice, Soil
      - Streamflow spatial scale
      - Coastal Zone
- Environmental Conditions Leading Up To Events
  - Mid-continent complexity

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Selected Observation Gaps Detail

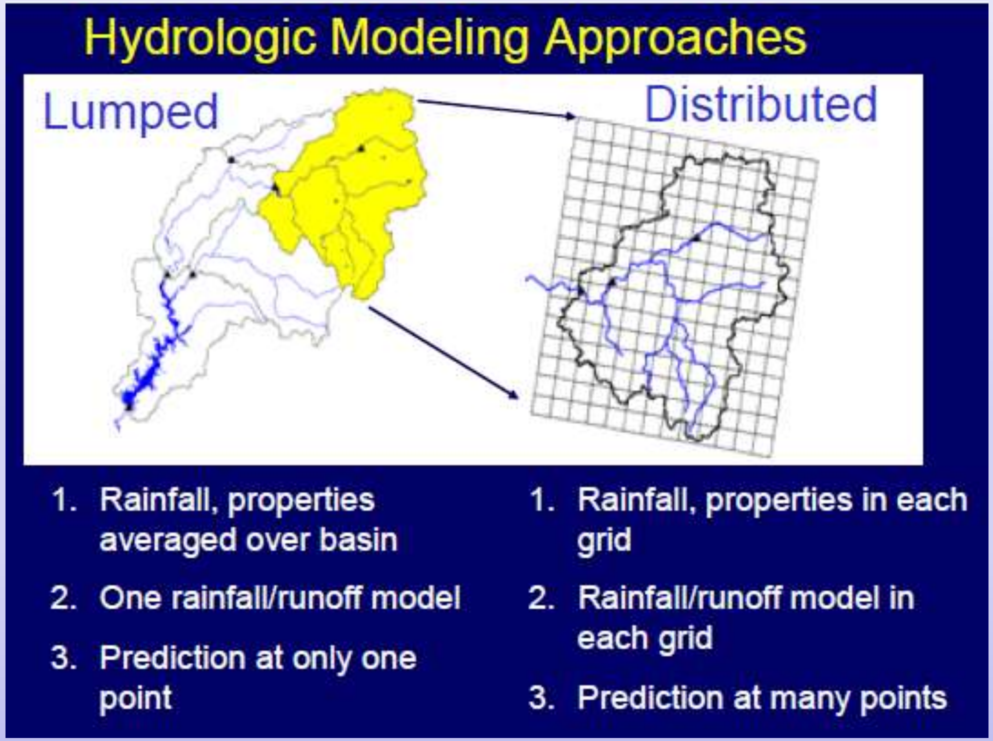
- Increased real-time data on river reaches as well as routine near real-time post event high water mark data collection and data sharing (funding for high water mark collection similar to how currently it is funded by FEMA mission assignments to USGS for hurricanes and high impact events)
- Understanding hydrologic impacts of changing agricultural practices (tiling, removal or addition of terraces, retention ponds, etc); with lumped watershed modeling, these things are implicitly accounted for; Discovery Farms
- Ground based (precipitation, soil, snow, etc) observation network(s) is/are too sparse, strategic enhancing needed to make up for remote sensing gaps.
- Unmanned Arial Vehicles are underutilized as a observational platform.
- This is not an exhaustive list, only selected examples.

Understanding anthropogenic processes

- Drainage – extent and impact on hydrologic cycle uncertain
  - Moving target as agriculture battles precipitation extremes
- Urbanization
  - Groundwater, stormwater and wastewater management
- Levees
  - Observed increase in extreme event runoff stresses ability to “stay ahead of it”
- Dams
  - Sharing non-proprietary data; Most nearing end of design life
- Agricultural Practices
  - Agricultural land makes up 60% of the land use of the watershed
  - Thousands of individuals work the soil
  - Do working soils behave in the same manner as non-working soils?

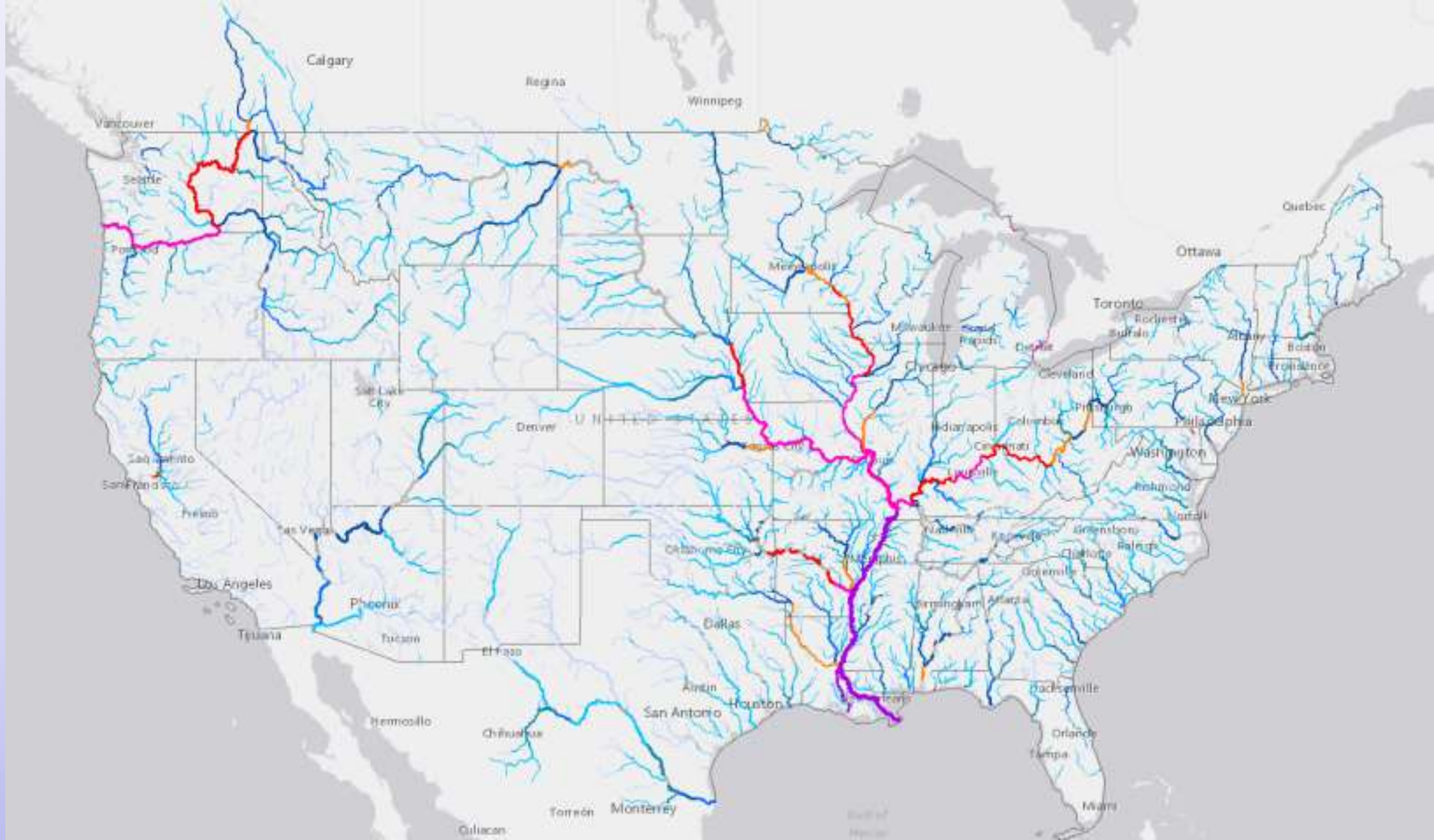
Models and forecasting

- Hydrologic and Hydraulic models
  - Partitioning of rain/snow melt into runoff or infiltration
    - *Lumped vs Distributed (grid or irregular)*
  - Routing water in channel
    - *Hi-res Digital Elevation Models are great, what about hi-res river bathymetry for routing models?*
      - Perhaps channel mapping instrument on commercial boats (planes take atmospheric observations)



Models and forecasting

- Hydrologic and Hydraulic Models
- National Water Model (NOAA etal)
  - Good platform to answer watershed scale questions

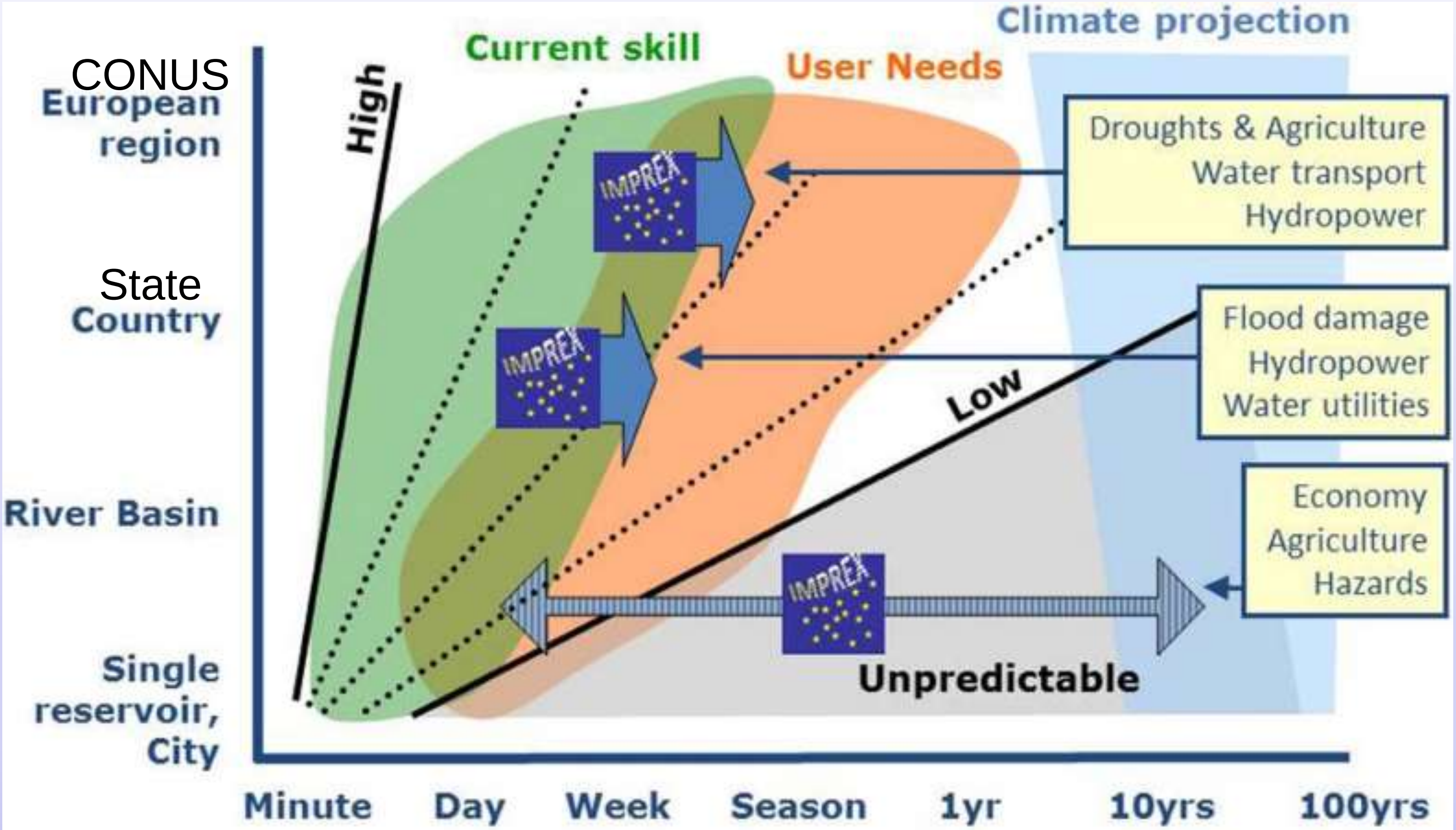


Hydrologic Modeling Next Steps

- Development and optimization of localized operational modeling based on multi-model solutions (local high res hydro models, lumped models for efficiency of scale, and national modeling, etc)
  - Cold region hydrologic modeling and prediction.
  - Need resource support to address operational use of models that can incorporate soil moisture and soil temperature data at multiple depths to integrate data network temperature soil probes to help determine freezing depths and calculate the impacts on runoff processes given the soil moisture and soil temperatures.
- Next Generation Hydrologic ensembles that better predicts extreme events. Current generation of capabilities is weak. Both meteorology and hydrology advances needed.
- Develop artificial intelligence/machine learning techniques to weave archived water history into current predictions.
- This is not an exhaustive list, only selected examples.

Models and forecasting

- Hydrologic and Hydraulic models
- National Water Model (NOAA etal)
- Precipitation Forecasting



From Bart et al. (2016)

NOAA’s Precipitation Prediction Grand Challenge

What is the Precipitation Prediction Grand Challenge?

Provide more accurate, reliable, and timely precipitation forecasts across timescales, from mesoscale weather, through week 3-4, S2S, to S2D through the development and application of a seamless, fully coupled Earth System prediction model.

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General Gaps

- Exchange/interoperability of data/model/tactical information amongst the water community.
- Big Data. Artificial Intelligence. Need to change our paradigm of tucking away archives and making them nearly inaccessible to accessible and usable.
- Social science bridging the gap between scientists who make the predictions and the consumers.
  - Social science to inform the integration of ensemble hydrologic modeling into National Weather Service warning services tools and Impact-based Decision Support Services messaging.

Capture the Inspiration of Decades Past

We choose to go to the Moon... We choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard; because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one we intend to win, and the others, too. John F. Kennedy September 12, 1962