Theme 5: Prediction, Analysis, and Uncertainty Quantification of Water Cycle Mean and Extremes

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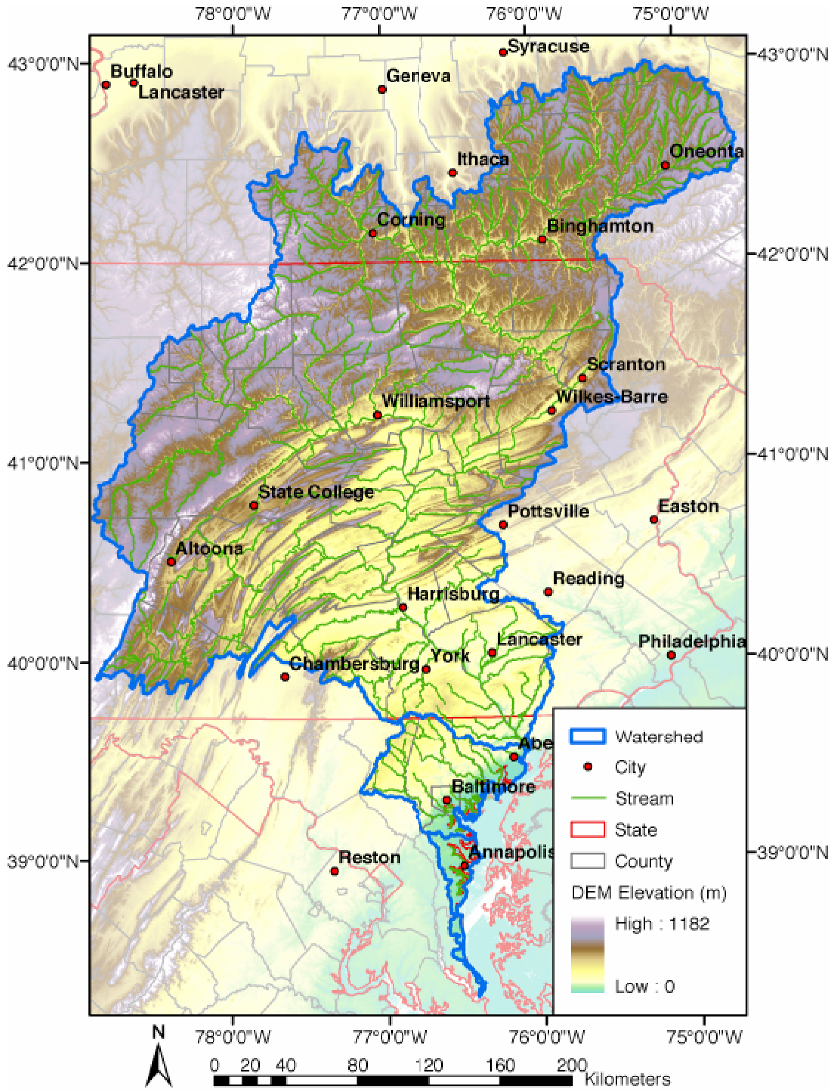
White paper draws on the following reference:
Reed et al., "Bridging River Basin Scales and Processes to Assess Human-Climate Impacts and Terrestrial Hydrologic System" Water Resources Research, 42, W07418, doi:10.1029/2005WR004153, 2006.

Organizing Question

What does the goal of predicting mean and extreme hydrologic states as well as their associated uncertainties presume in terms of our theoretical, observational, and institutional understanding of the water cycle?

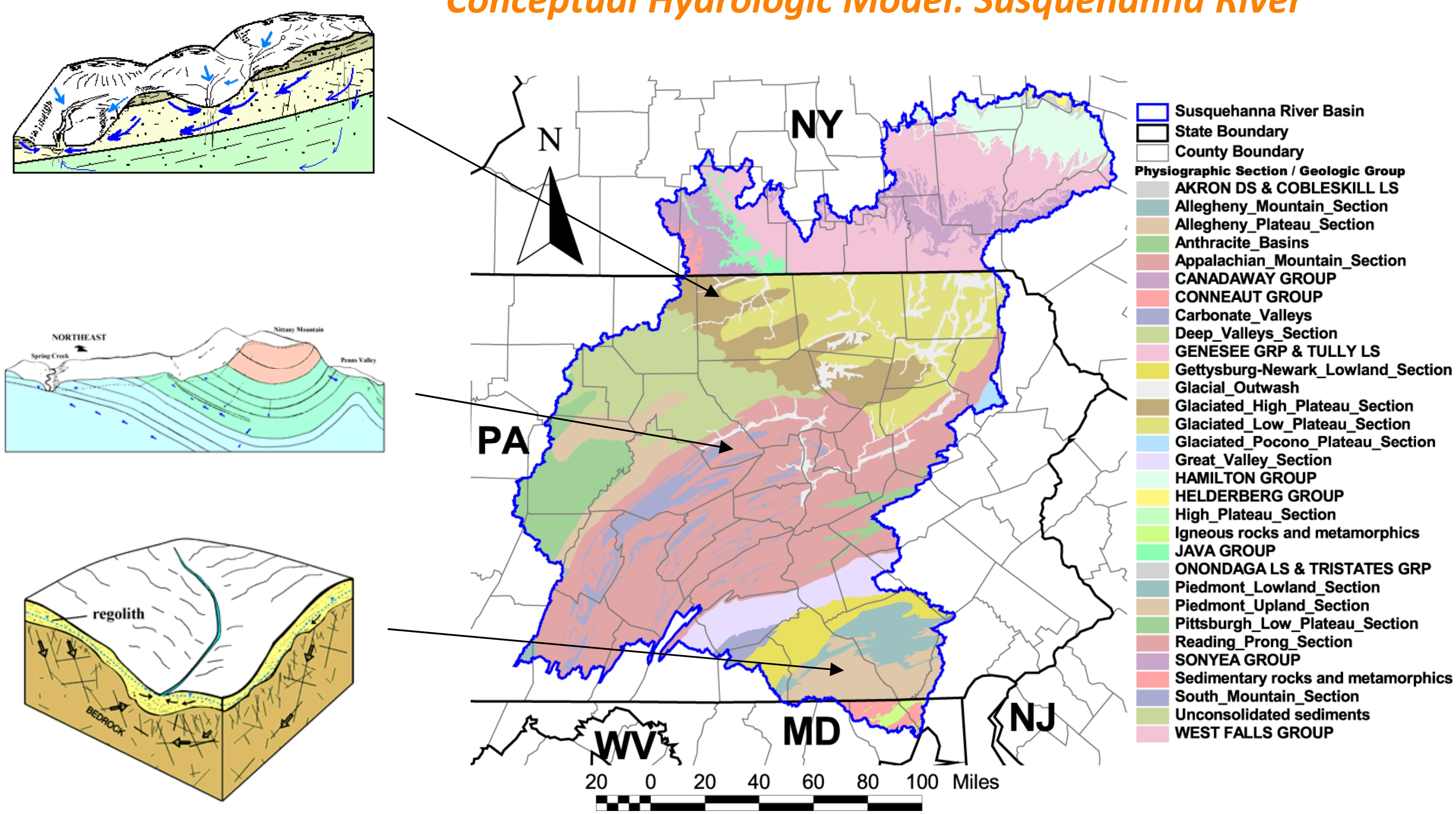
- Organizing spatial scale—*River Basin*
- Context is everything
  - –Geometrical, material, and forcing frameworks
  - –Built system (transfers, PS/NPS pollution, LU/LC, reservoirs, energy markets, water supply…)
  - –Agents (humans/ecosystems change behavior)

Illustrative Example: The Susquehanna Context



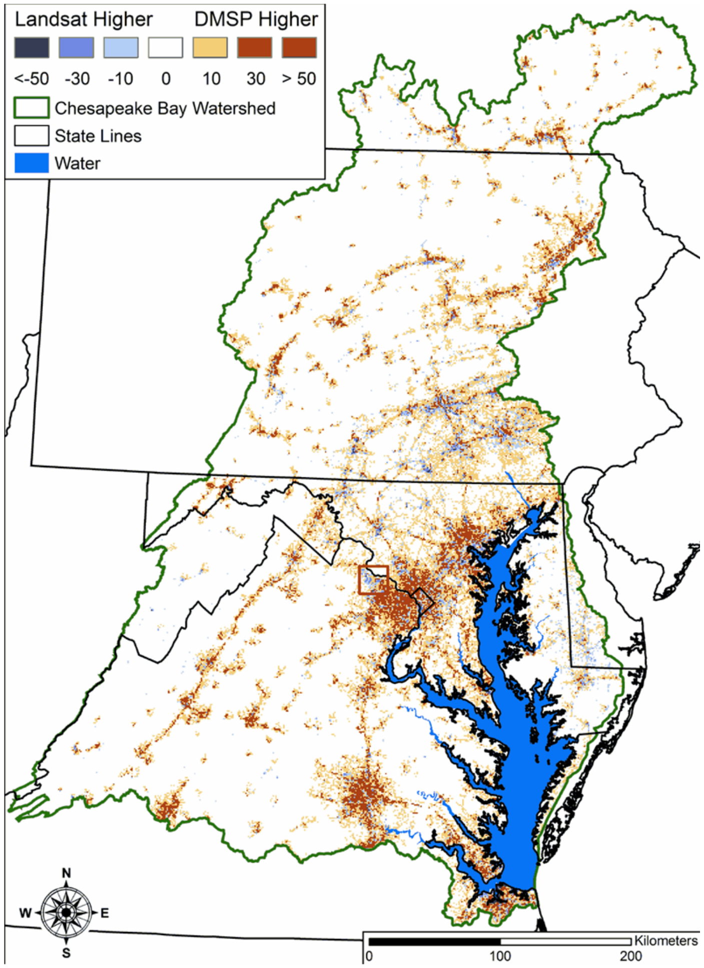
Building a Conceptual Basin Model

Conceptual Hydrologic Model: Susquehanna River

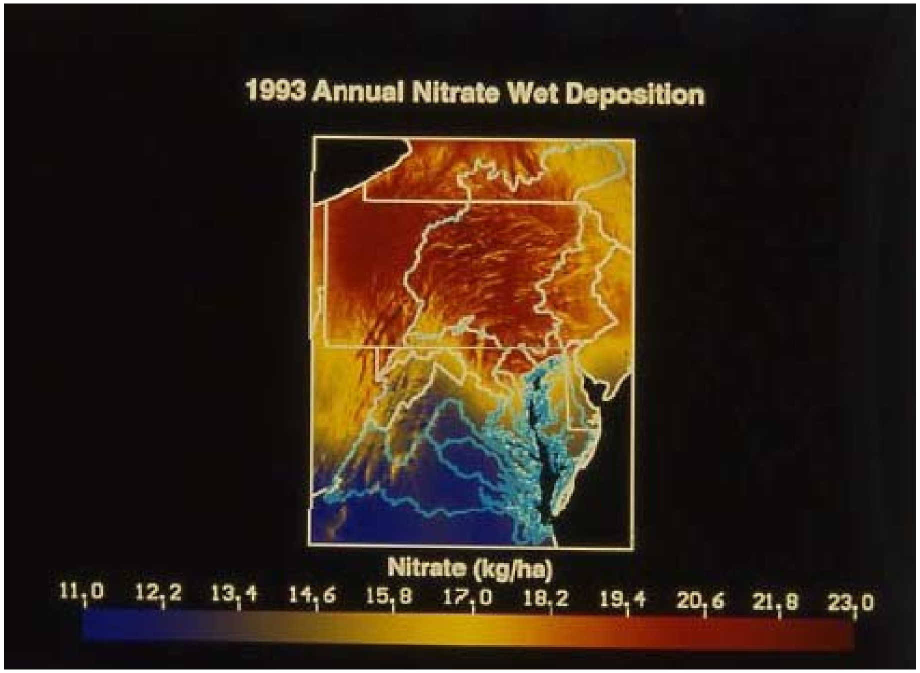


Courtesy of Chris Duffy, Penn State

Human System Impacts

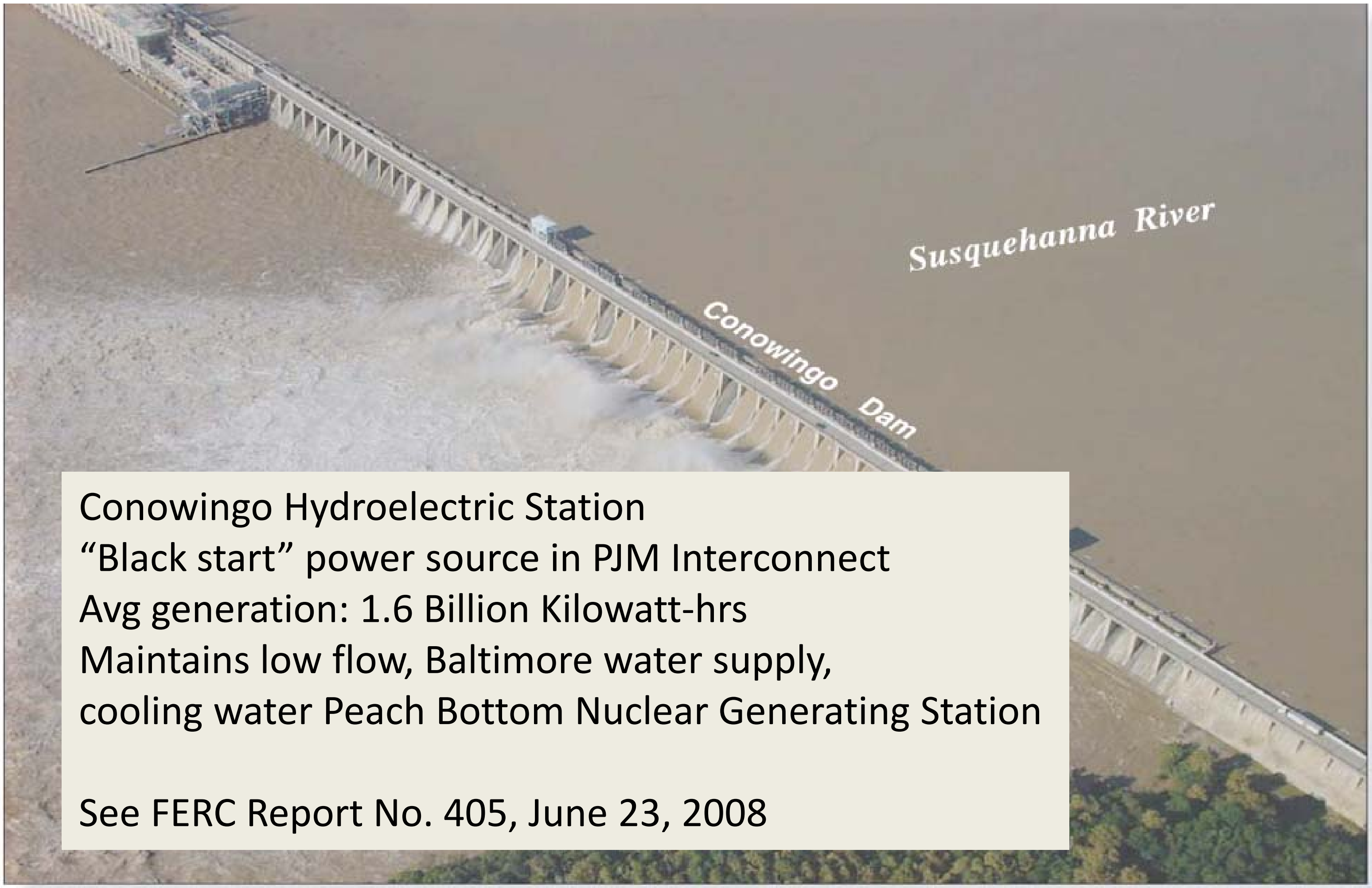


Adapted from Goetz & Jantz, EOS, 87(15), 2006



Courtesy of Sheeder et al., 2002

Coupled Human-Climate System Response to Floods

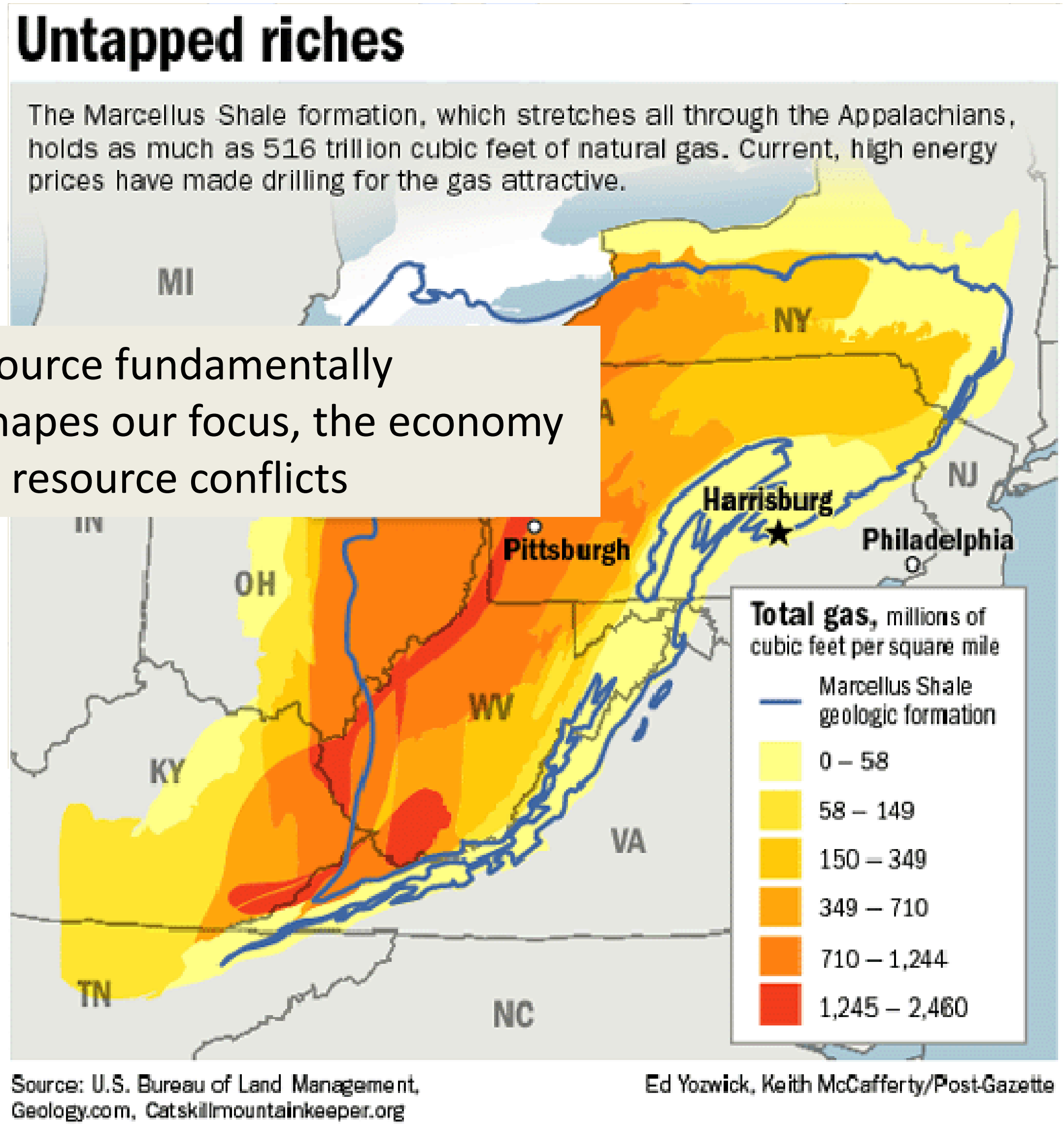


Conowingo Hydroelectric Station
"Black start" power source in PJM Interconnect
Avg generation: 1.6 Billion Kilowatt-hrs
Maintains low flow, Baltimore water supply,
cooling water Peach Bottom Nuclear Generating Station

See FERC Report No. 405, June 23, 2008

Figure 2. Release of water from the Conowingo dam on the Susquehanna River in Maryland on 21 September 2004 after Hurricane Ivan on 17–18 September 2004. The discharge is 384,000 cubic feet per second. This figure and the supporting data were adapted from *Gellis et al.* [2005]. The photo is courtesy of W. McPherson, USGS.

Regional, National, International Energy Concerns



Resource fundamentally reshapes our focus, the economy and resource conflicts

Some final key points from our white paper

- Beware of your favorite cartoons
  - River basins as multidimensional resource/economic systems
  - Hydrologic extremes expose dependencies/competition
    - Industry, Energy, Agriculture, Water Supply, Recreation, Ecosystem Services, Institutions, Regulations, Markets, etc
    - Timescales (*minutes—controls and management, decades—planning*)
- New methods/tools/cyberinfrastructure
  - Foundation for evaluation of models' strengths/failures
  - Web-services for enhanced natural systems/socio-economic monitoring
  - Enhance collaborative access to stochastic baselines
  - Need to understand emerging gaps in our observations/knowledge
  - Need for ESM UQ methods for analyzing "acceptable risk"
- At a minimum, given design characteristics for a given sector:
  - Uncertainty analysis must provide likelihood that services support given domain tolerances ("*acceptable risk*")
  - Models must have sufficient fidelity to inform "*real decisions*"
  - Results must be robust to changing contexts *("deep uncertainties")*

After a dose of reality, some questions for modeling centers

- What are the skills of current models in predicting characteristics of the regional water cycle including its extremes?
- What are the critical missing capabilities or components in current modeling systems for predicting regional water cycle variability, change, and extremes?
- What improvements can be gained by quantitative assessment of uncertainty in the predictions? What methods are more suited to the particular challenges of the water cycle problem?
- What tools can facilitate integrative research in prediction, analysis, and uncertainty quantification?

List of Break-out talks

- Dave Easterling – observations & evaluation
- Mike Wehner – hi-res models & extremes
- Steve Klein – UQ analysis & model errors
- Ana Barros – impacts & applications