Water availability representation in production cost model
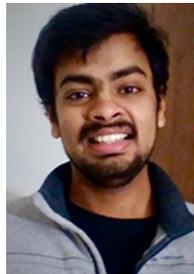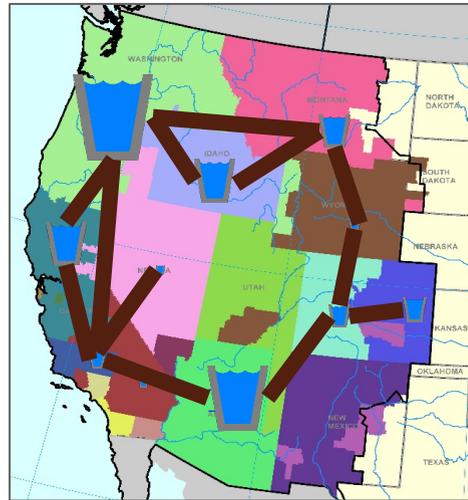
Nathalie Voisin
Mort Webster
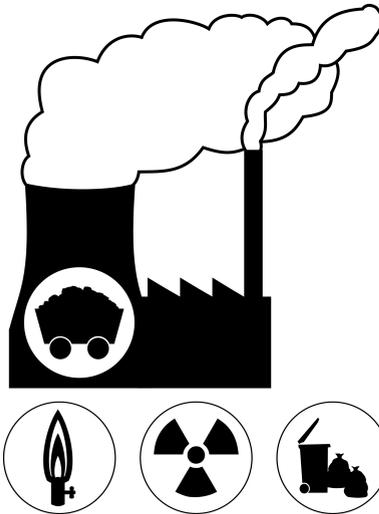Vijay Kumar*
Sean Turner*

July 15, 2019
Snowmass, CO

PNNL is operated by Battelle for the U.S. Department of Energy
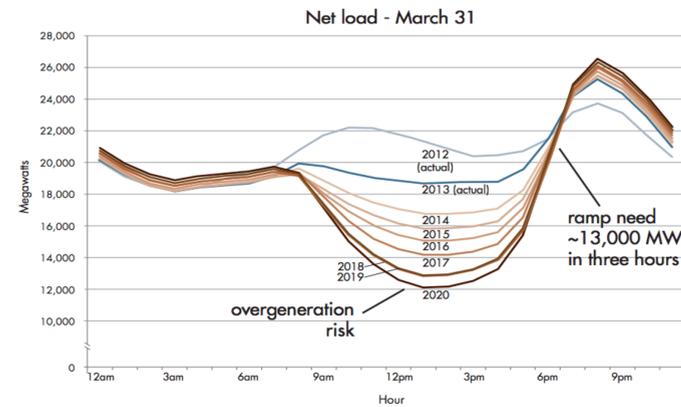
Is a monthly representation of water availability good enough to understand water-electricity dependencies during extreme events?

MONTHLY hydropower potential at each hydropower dam

MONTHLY maximum capacity at thermoelectric plant

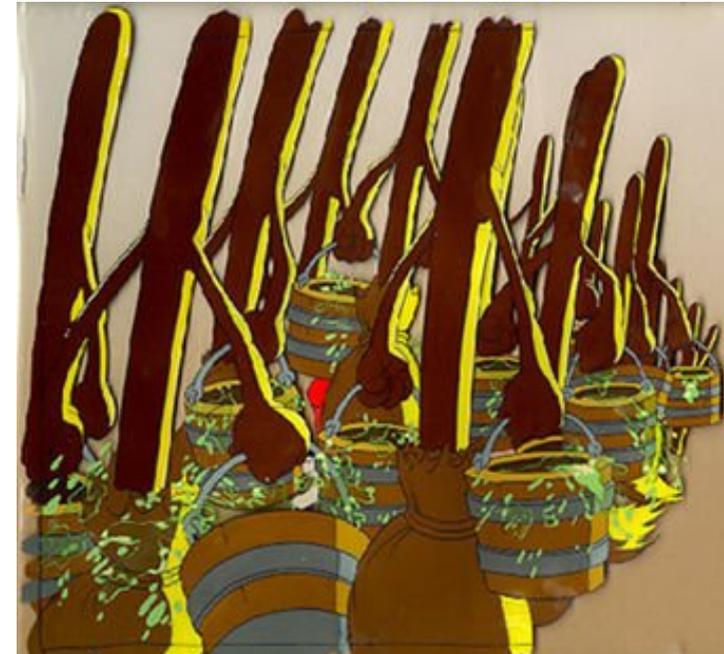
HOURLY electricity demand

Production cost models optimize resources based on availability, short term flexibility and cost.

Daily reservoir operations are driven by price rather than water availability

Production Cost Model optimizes hourly and daily operations


Underlying assumption that river dynamics can achieve this scheduling of operations

What is the sensitivity of sub-monthly hydropower dispatch to simple mass balance constraints on the storage and release of water in a cascade reservoir system?

Model capability development

We developed a river routing – reservoir operations scheme WITHIN the production cost model to represent mass balance constraints over a river stretch of the Columbia River Basin.
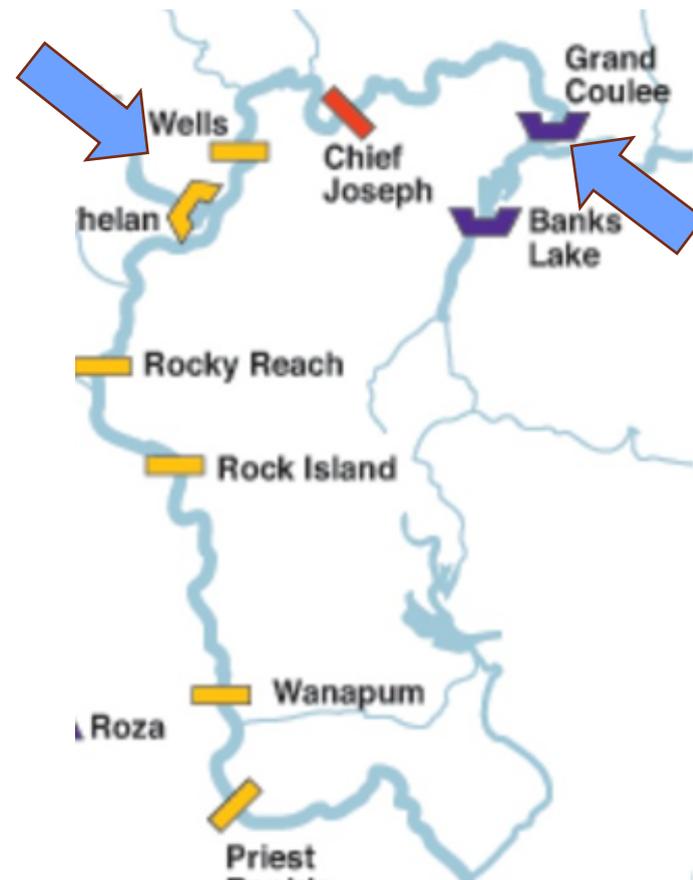
Time series forcing & constraints:
- observed inflow into Grand Coulee,
- observed inflow from Chelan,
- observed tributaries inflow
- Reservoir operational storage variations
- Spill/Generation requirements

Numerical Experiment

Observed monthly hydropower potential at each dam

Benchmark UC_Obs	UC_EC	UC_WC
• Exogeneous observed dispatch of hydropower: **prescribed observed hourly water availability** and **reservoir storage**	• PCM default dispatch driven by cost and constrained by generator constraints (max/min generation and ramp rates)	• UC_EC set up further constrained by mass balance and other river routing and environmental release dynamics

• Benchmark hourly generation
• Observed release & storage

• Hourly generation
• Inferred reservoir releases & storage: **water violations**

• Hourly generation
• Simulated hourly releases & storage

• Apply river routing constraints and infer **energy violations**

Analytics – hourly operations in January 2012

Storage variation is irrealistic

No spill violation in this case

Larger differences from observed generation than between simulated dispatch (classification in progress)

Flood control

Storage [m3]

Spill [m3/s]

Generation [MWh]

Hours of the month
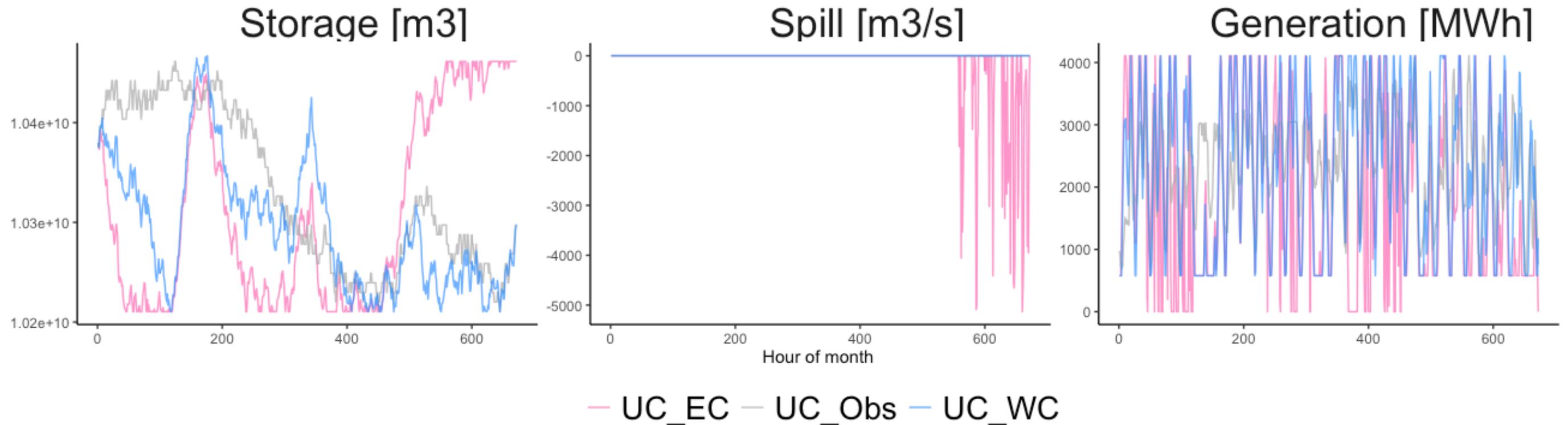
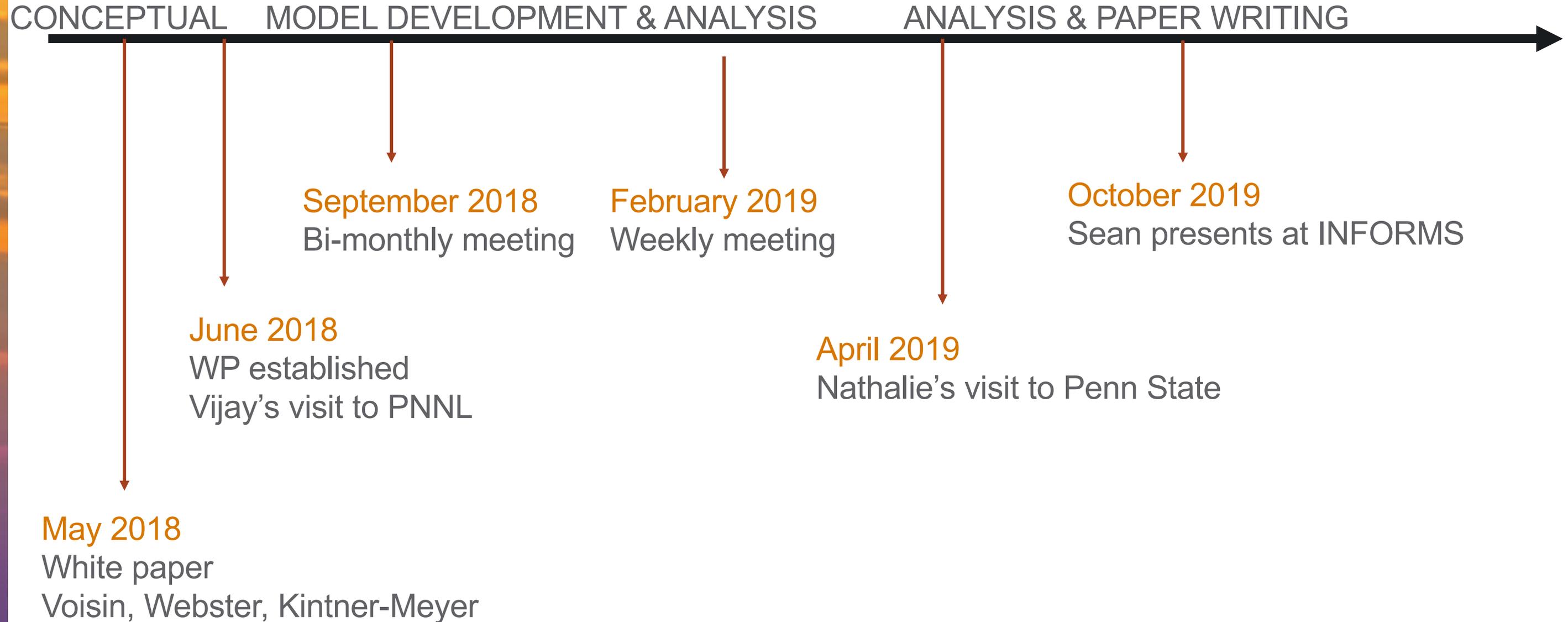— UC_EC — UC_Obs — UC_WC
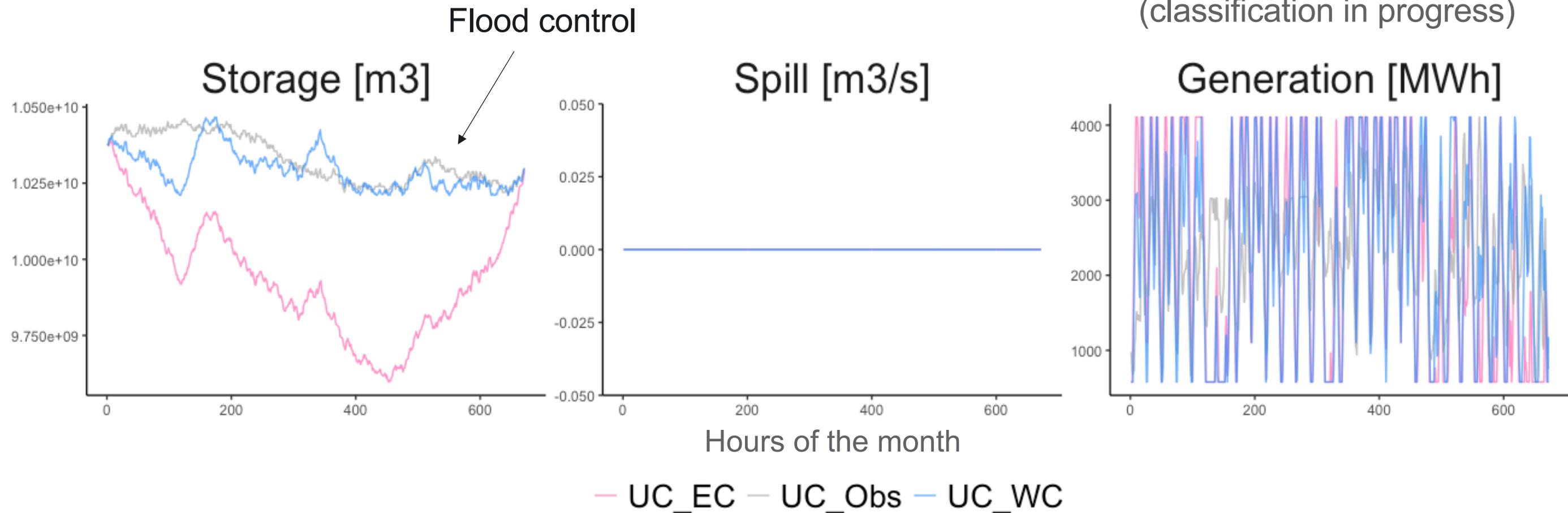
Analytics – hourly operations in January 2012

End of period storage should impact the following month results

Spill violations

Generation violations

Collaboration in brief

CONCEPTUAL　　　MODEL DEVELOPMENT & ANALYSIS　　　ANALYSIS & PAPER WRITING

September 2018
Bi-monthly meeting

February 2019
Weekly meeting

October 2019
Sean presents at INFORMS

June 2018
WP established
Vijay's visit to PNNL

April 2019
Nathalie's visit to Penn State

May 2018
White paper
Voisin, Webster, Kintner-Meyer

Thank you

<for reference – what is asked to present>

- - a brief overview of the project (objectives, status of the research, etc…)

- - how far along is the collaboration (conceptual phase, analysis and model development, manuscript writing, articles already published, etc…)
  - how this collaboration get to be (how was the team put together? Did you secure dedicated funding? Etc…)
  - what were the success/challenges in terms of communication, data sharing, data analysis, writing of manuscript, etc…

- - if you were to start a new collaboration with researchers from another MSD research group, what would you do differently
  - what support do you wish you had received (from DOE or other) to facilitate the collaboration

- - any other insight to inform future collaborative work between MSD groups

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