Updated Theoretical Resource Assessment for US Riverine Hydrokinetic Energy

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Introduction: Motivation

Stakeholder resource information and data needs

- River hydrokinetic industry- energy planners, developers, and researchers
- Theoretical & Technical Resources, Geographical distribution, Seasonal variations, etc.

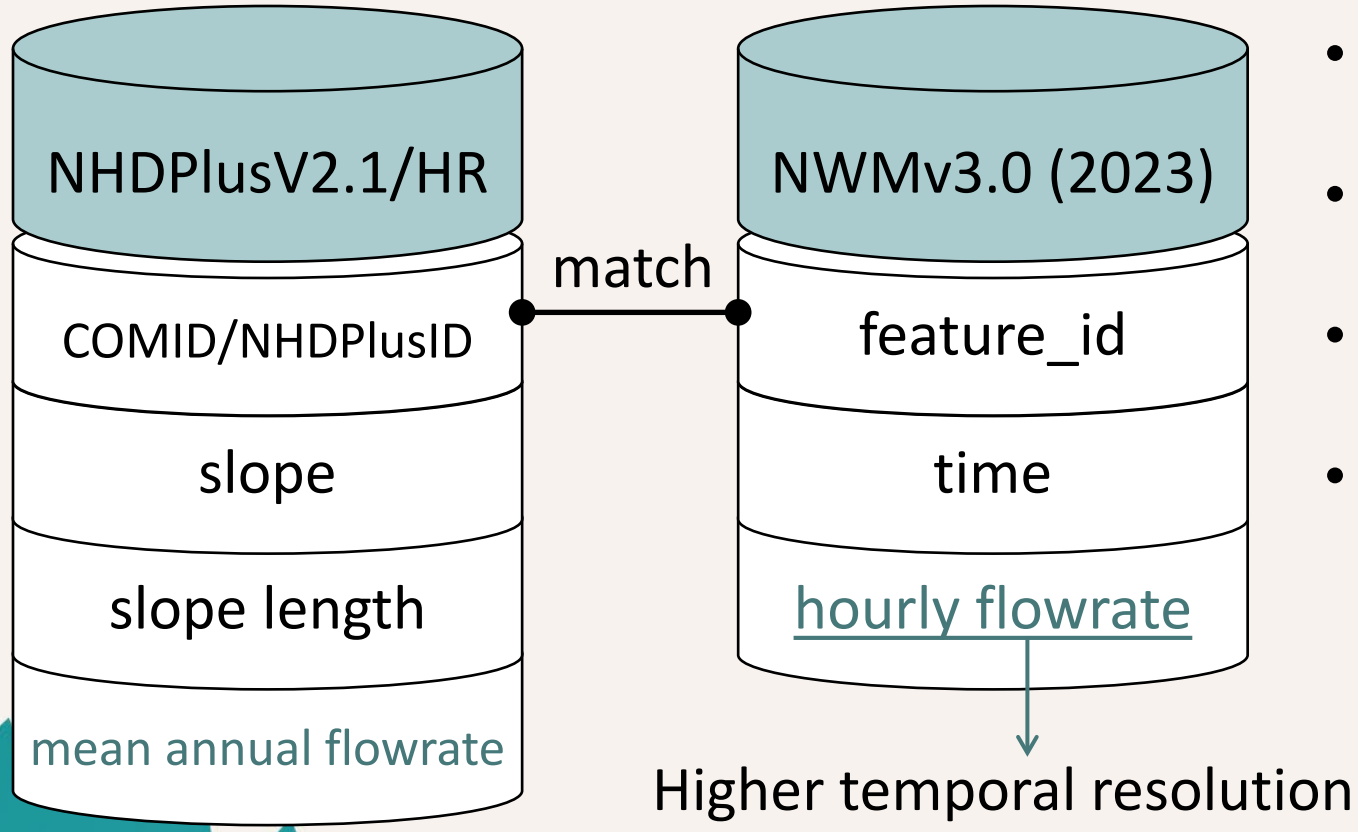
Higher Temporal Resolution

Higher Spatial Resolution

Improved and Updated Hydrologic Model and Dataset

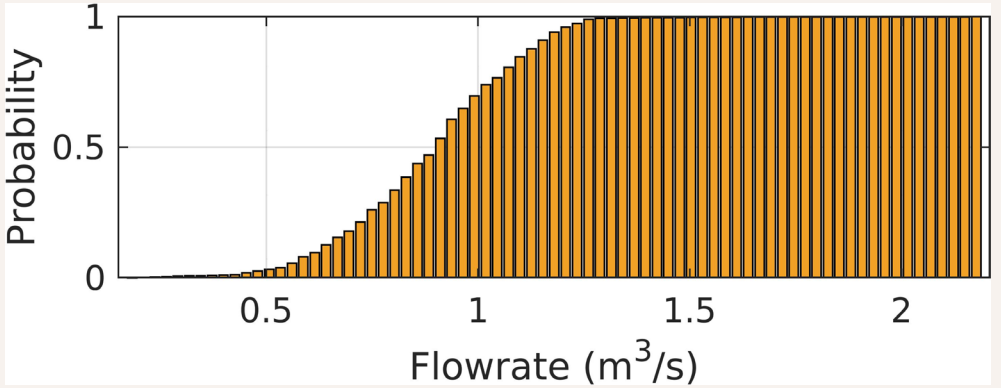
- EPRI (2012)
  - Using the mean annual flowrate & bulk velocity in NHDPlusV1 (30m NED)
  - Flowrate restriction: Over 1000 cfs
- National Water Model v3.0 (NWMv3.0)
- National Hydrography Dataset Plus V2.1 (NHDPlusV2.1): CONUS, HI, PR
- National Hydrography Dataset Higher Resolution (NHDPlusHR): AK

Data



- CONUS: Feb 1979-Jan 2023 (1 hr)
  - # of feature_id: 2776734
- Hawaii: Jan 1994-Jan 2014 (15 min)
  - # of feature_id: 13637
- Puerto Rico: Jan 2008-Jun2023 (1 hr)
  - # of feature_id: 14017
- Alaska: Jan 1981-Dec 2019 (1 hr)
  - # of feature_id: 391528
  - NHDPlusHR dataset

Methodology



1 Flowrate Analysis

- Monthly, annual, and FPR (full periods of record) weighted average flowrate with 75-bin CDF histogram of hourly flowrate (IEC 301).

2 Theoretical Power Assessment

- Compute the theoretical power and annual energy production (AEP) using weighted average flowrate.

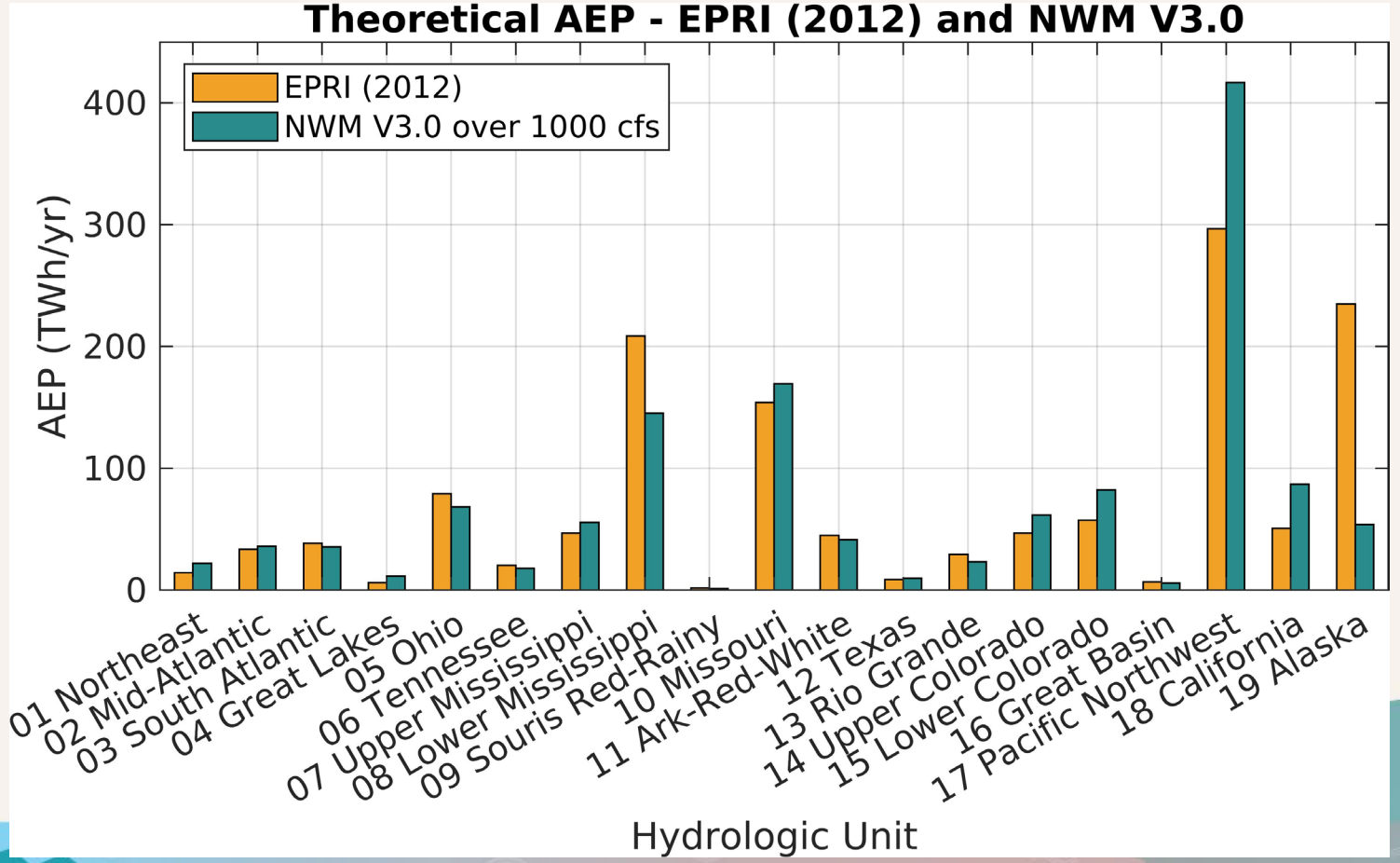
$$P_{th} = \gamma \cdot Q \cdot \Delta H \qquad AEP = P_{th} \cdot 8760\ hrs/yr$$

3 Temporal Variability Assessment

- Interannual and seasonal variability for each hydrologic unit (HU).

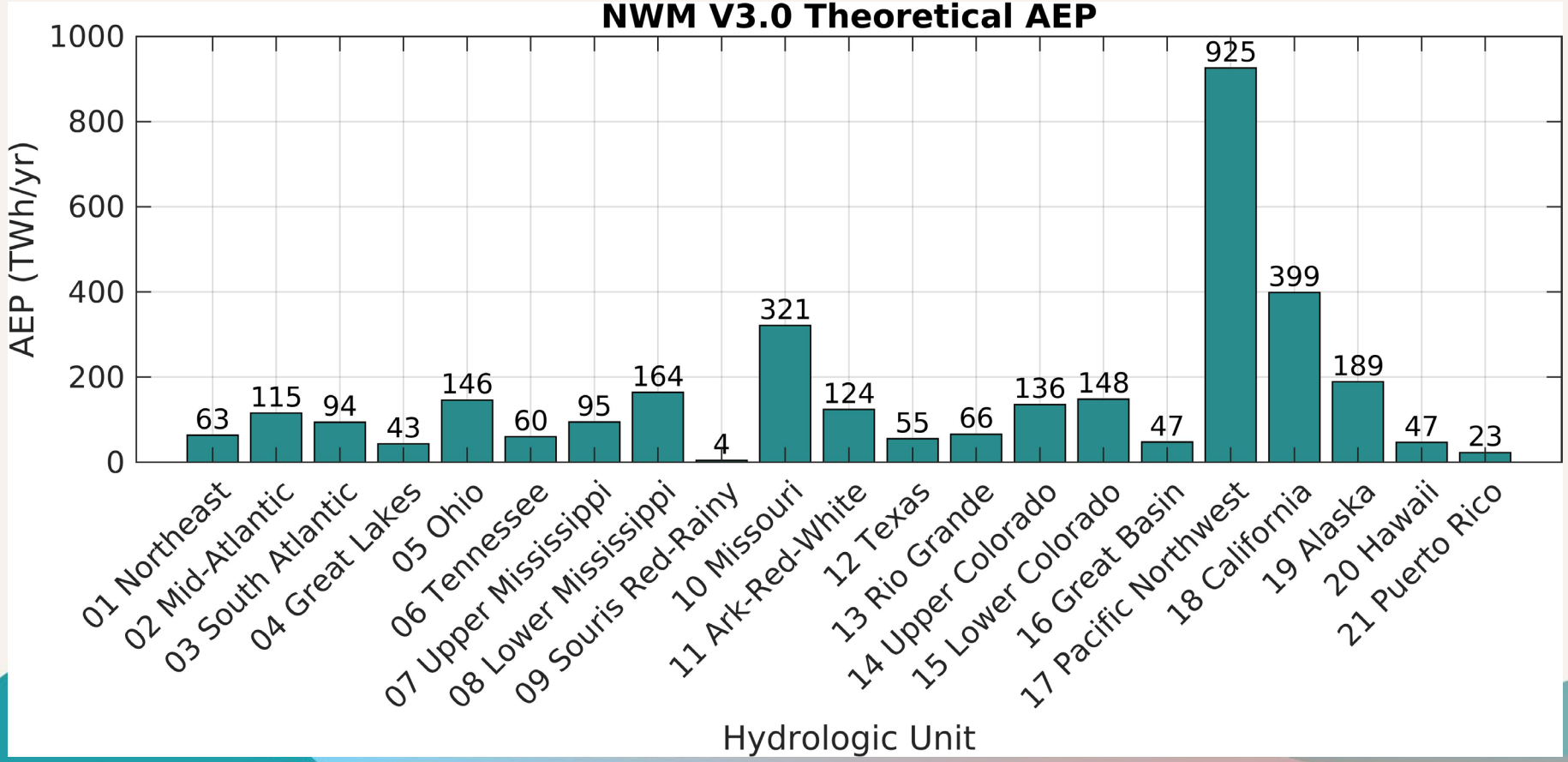
FPR Average AEP With 1000 cfs Restriction

- FPR: full periods of record (CONUS: 1980-2022, Alaska: 1981-2019)
- 1000 cfs restriction: 2.9 million → 70 thousands
- EPRI (2012)
  - CONUS: 1146.4 TWh/yr [1]
  - + Alaska: 1381 TWh/yr [1]
- NWM v3.0
  - CONUS: 1291.45 TWh/yr
    - (13% larger)
  - + Alaska: 1345.23 Twh/yr
    - (3% smaller)



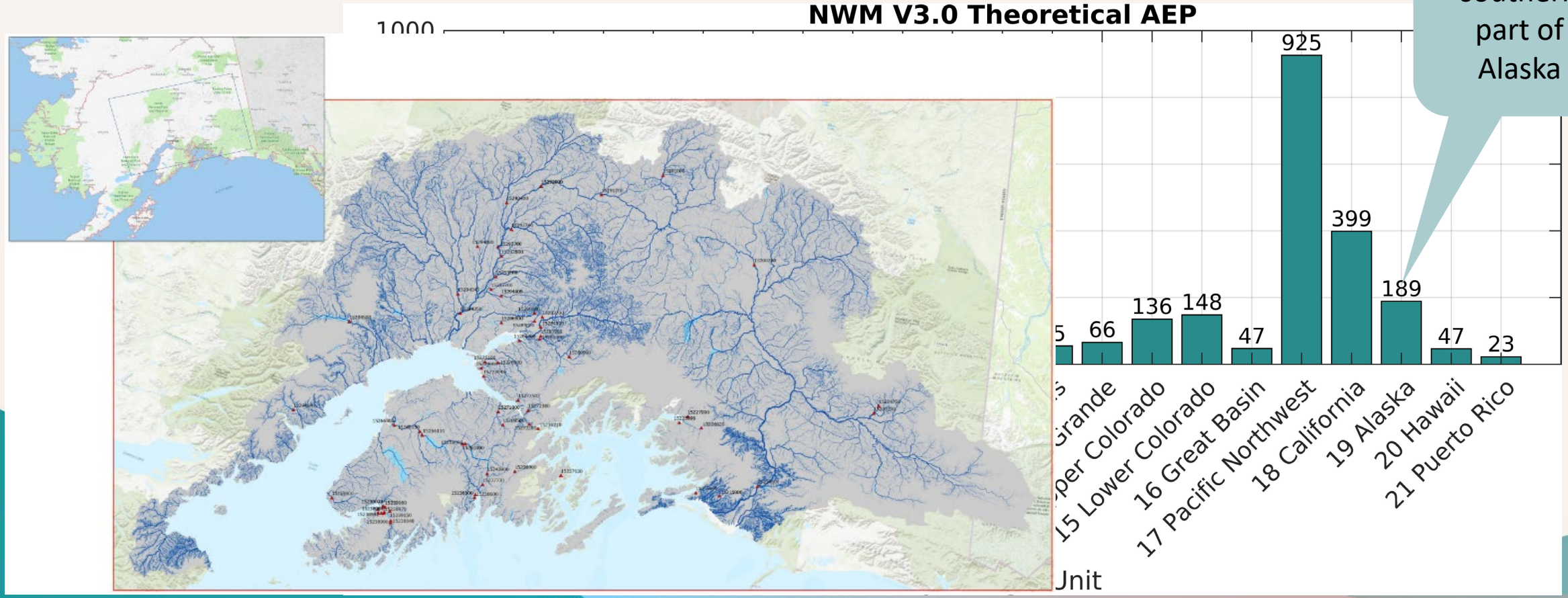
FPR Average AEP Without 1000 cfs Restriction (1)

- 3264.69 TWh/yr for the entire US
- 2.36 times greater than EPRI



FPR Average AEP Without 1000 cfs Restriction (2)

- 3264.69 TWh/yr for the entire US
- 2.36 times greater than EPRI

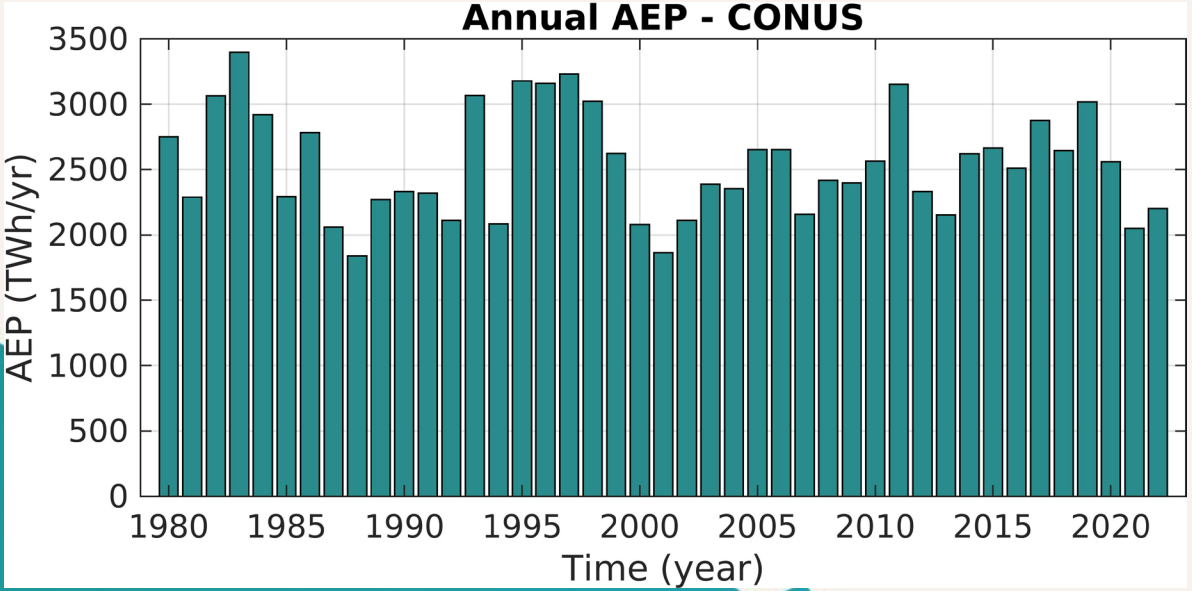


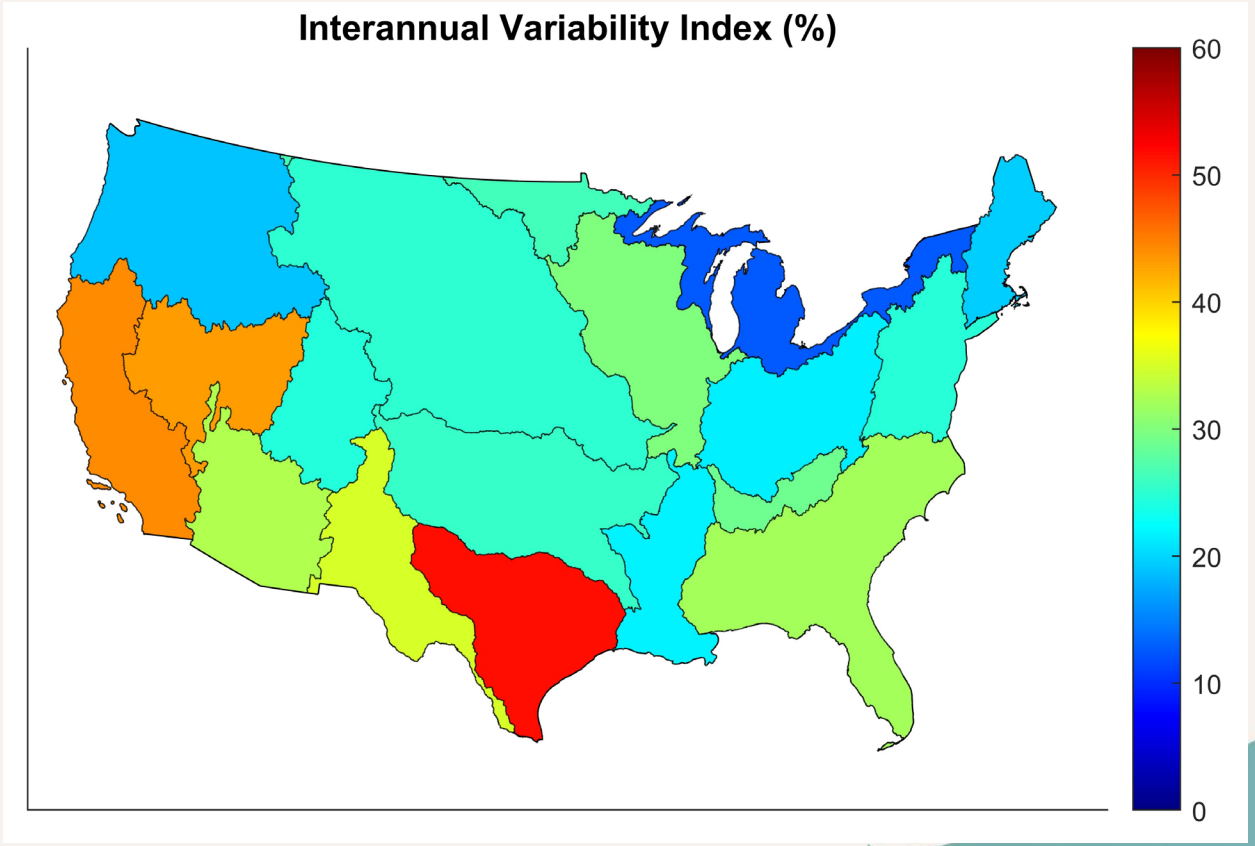
NWM covers the southern part of Alaska

(Cosgrove et al., 2024)

AEP Variation

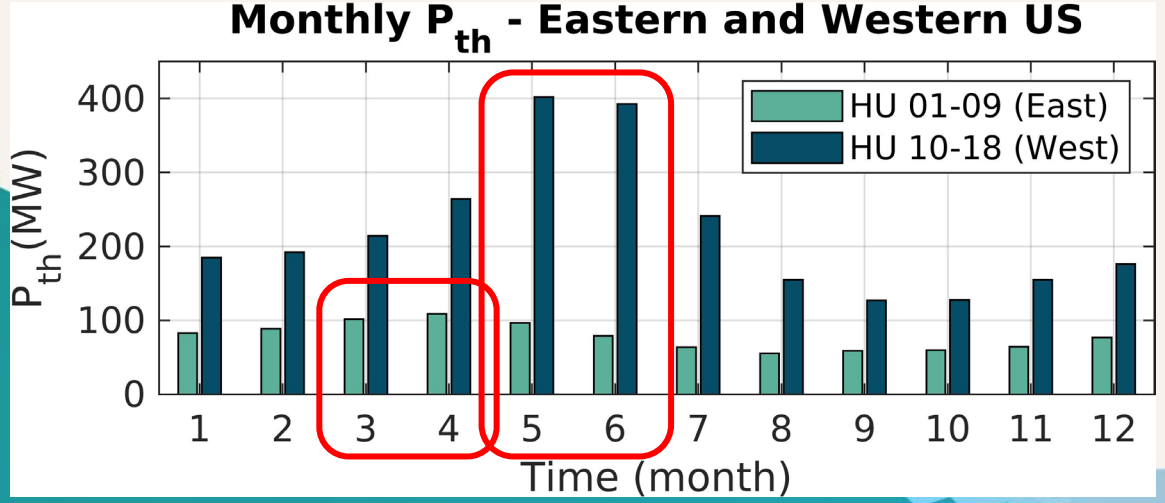
- Interannual variability: Fluctuations in resources due to climate change
- $t_i = \frac{\sigma[AEP(Y) - (S_1 Y + S_2)]}{E(AEP)} \times 100\%$ (IEC 301)
  - CONUS: 5.25%
  - HU12 Texas: 51.68%
  - HU04 Great Lakes: 12.59%

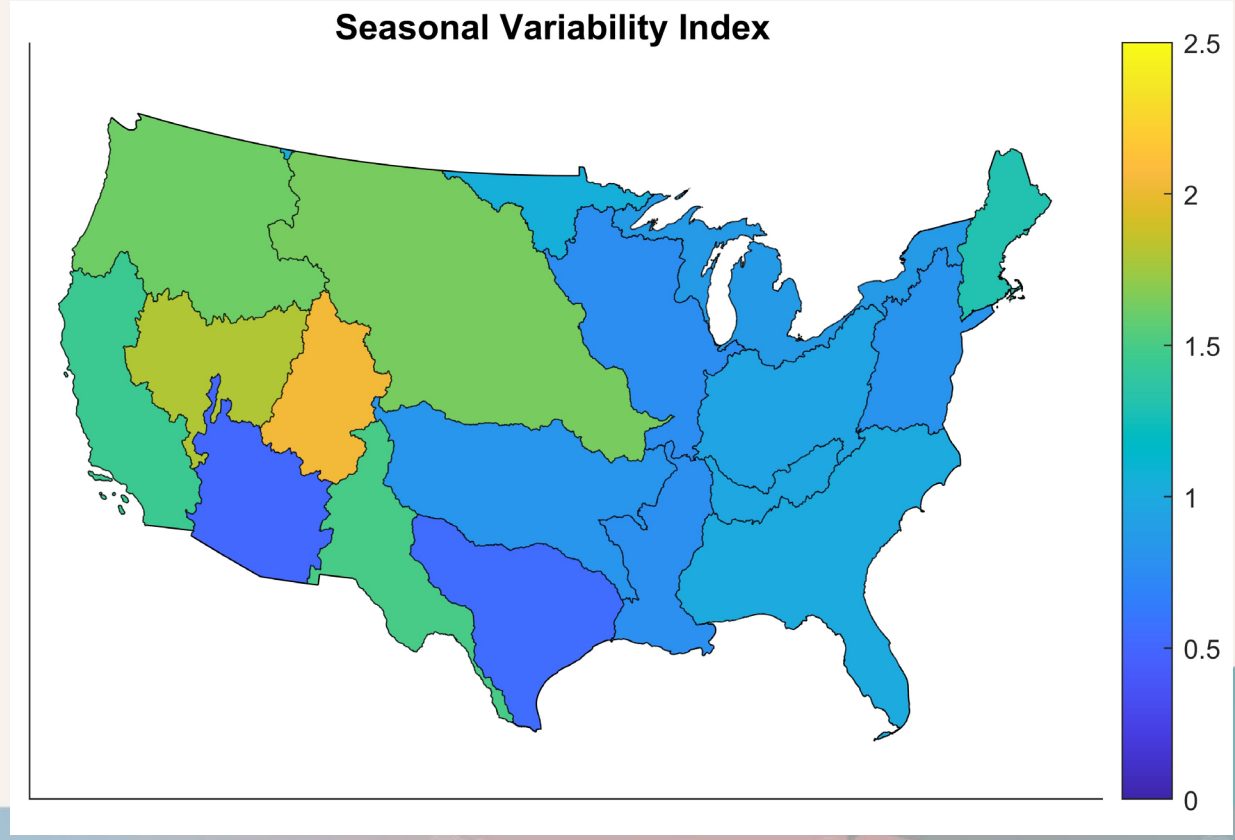




Monthly Theoretical Power Variation

- Seasonal variability: Normalized difference between the months of the maximum and minimum theoretical power
- $t_m = \frac{\left[P_{th}(M) \cdot \frac{T_{43year}}{T_{month}}\right]_{max} - \left[P_{th}(M) \cdot \frac{T_{43year}}{T_{month}}\right]_{min}}{sum\ (P_{th}(M))}$, (IEC 101, Ahn et al., 2020)
  - CONUS: 1.03
  - HU14 Upper Colorado: 2.03
  - HU15 Lower Colorado: 0.54





Conclusions

- Opportunity to use improved data source enabled: 1) more accurate assessment of theoretical power in the US with a wider, longer, and higher-resolution dataset without a flowrate restriction; 2) assessment of seasonal variability.
- Total 3264.69 TWh/yr of AEP is estimated for the US, including Alaska, Hawaii, and Puerto Rico, which is 2.36 times greater than the result by EPRI (2012).
- Spatial distribution is consistent with the previous study (EPRI, 2012), and Alaska shows a large AEP of 189 TWh/yr despite computing only the AEP of the southern regions.
- Interannual variability of the CONUS is much lower (5 %) than those of the HUs (13-52 %).
- Seasonal variability is shown to have peak energy in the eastern US in spring and the wetern US in summer.

- Future works: Classification System, Uncertainty anlysis

References

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Questions?