A Continental US testbed for Basin-scale S2S Climate Predictions supporting water management

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HEPEX Workshop: Forecasting across spatial scales and time horizons

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SMHI, Norrköping, Sweden

Gap, Motivation

Sub-seasonal to seasonal (S2S) climate prediction is fundamental to myriad, diverse applications across many sectors.

- the ability to predict climate beyond weather scales (2 weeks to 9 months) can inform water, energy, agriculture, terrestrial and aquatic ecosystems, infrastructure development, shipping and navigation, …

There is **no coherent source of guidance** on the '*latest and greatest*' S2S climate information for any particular application

- stakeholders with particular S2S climate needs
- S2S forecast developers (such as CGD) seeking a benchmark for their own modeling capabilities

Some raw model forecast skill assessments exist (in literature, on provider websites)

- default grids, default predictands
- not comprehensively intercomparable
- lacking breadth: e.g., only dynamical, only raw (no post-processing)

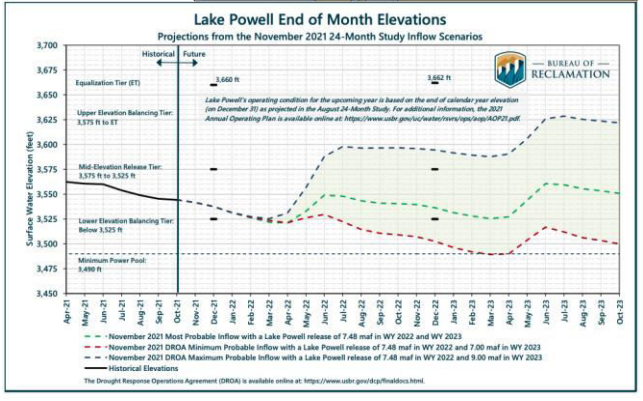
Example needs from current projects

Colorado River management needs

- Operated on predictions: short-range, S2S, 2 year (‘24-month study), and 5 year outlooks

- Almost no use of S2S climate predictions, despite intense interest
  - example of current approaches: 5-year average climatology for certain inflows; elsewhere unconditional ESP after 10 days

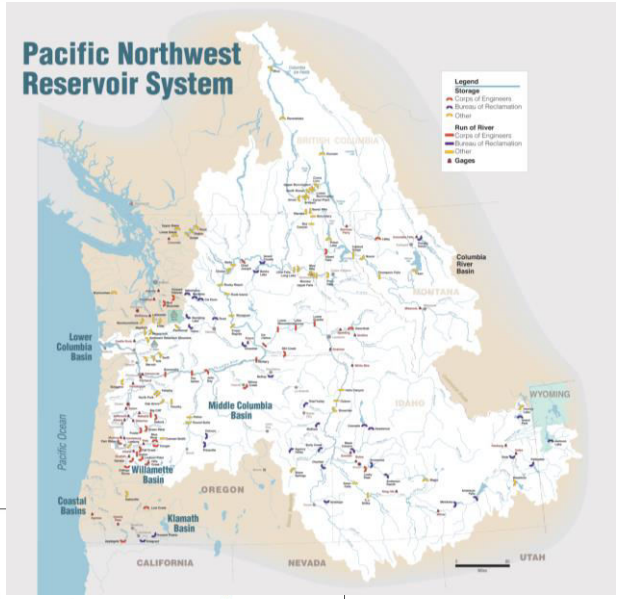
- Currently looking into North American monsoon season S2S predictions with the management agency, Reclamation

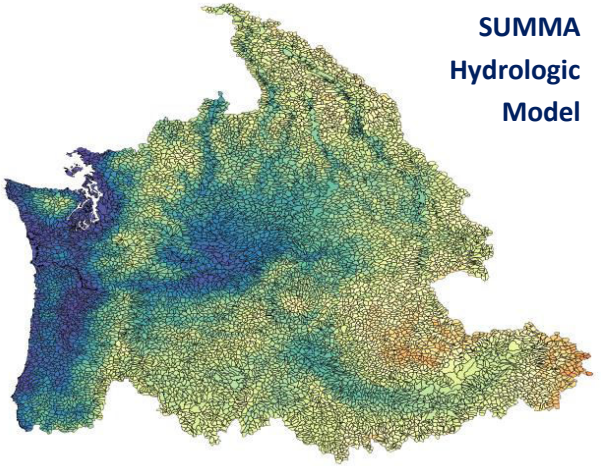


Example needs from current projects

Columbia River system management

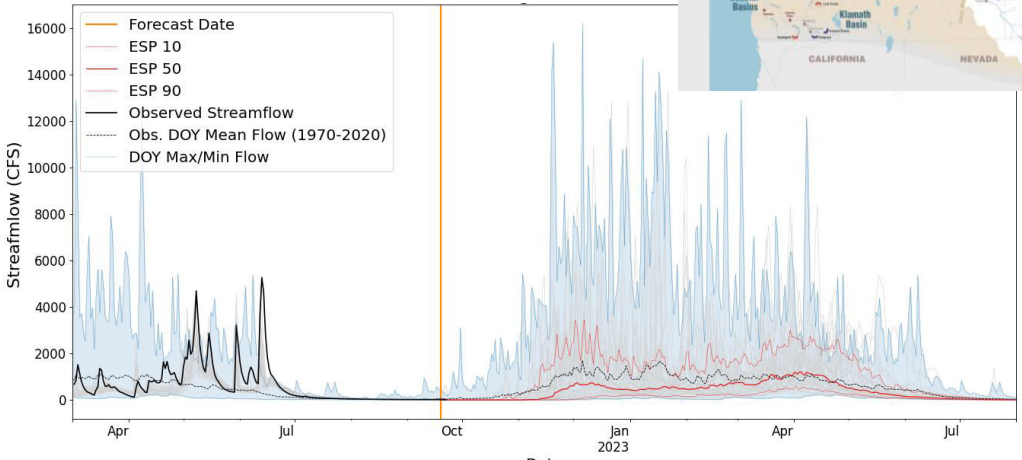
- USACE & Reclamation agencies
- Need S2S climate predictions to drive inflow forecasts
- Using GEFS for weather (1-7 day)
- GEFS for S2S (weeks 2-4)
- NMME for seasonal (Months 2-4)

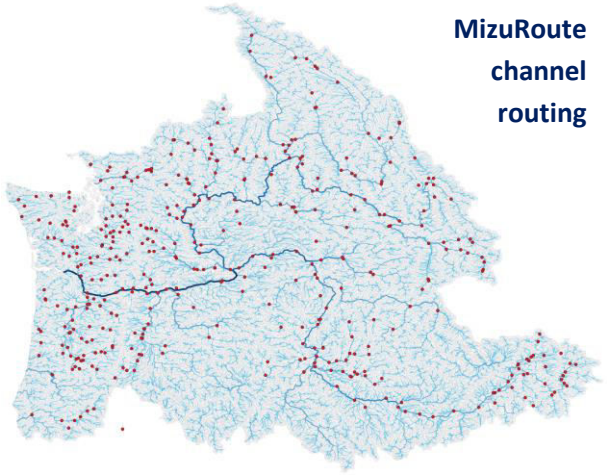




SUMMA Hydrologic Model

Ensemble S2S streamflow prediction



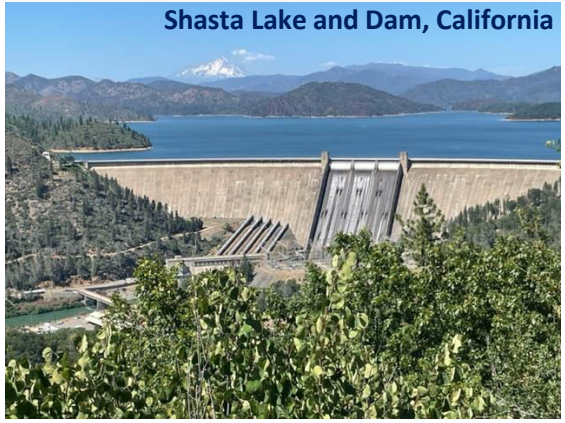


MizuRoute channel routing

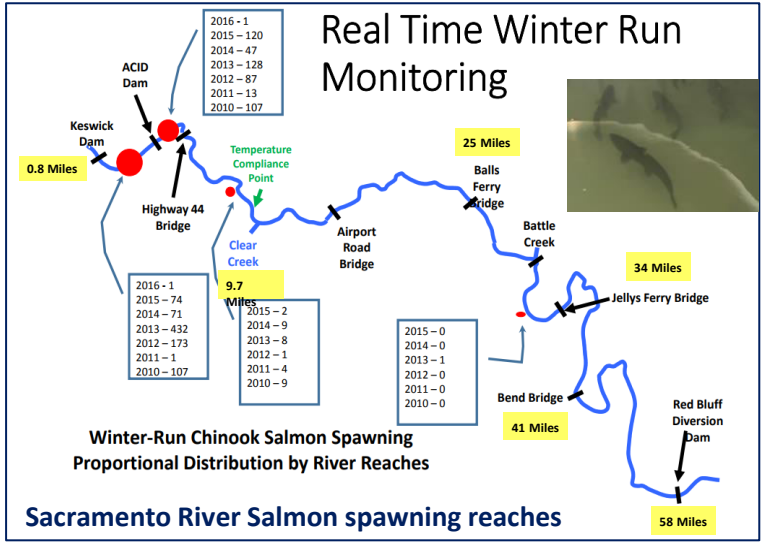
Example needs from current projects

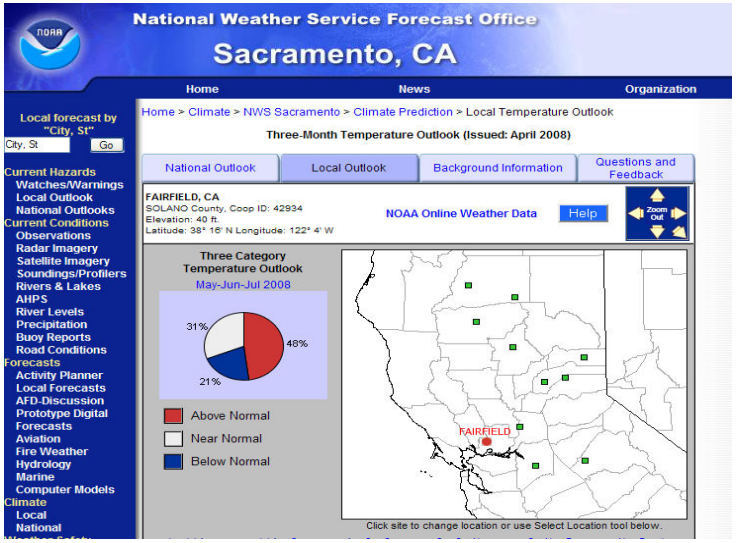
Sacramento River system management

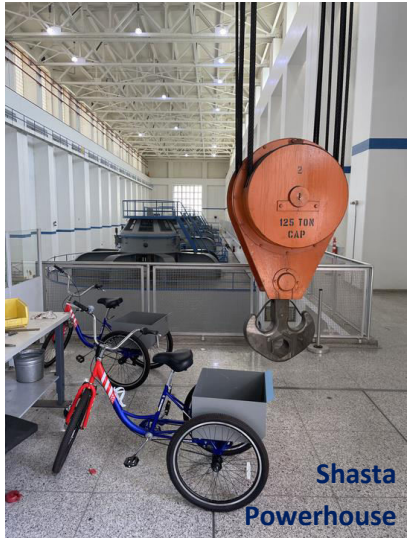
- Reclamation releases and use of cold water storage is determined by S2S stream temperature predictions from March to November
- Current approach: tercile forecasts of temperature + conditional resampling of met. inputs to a stream temperature model
- It has marginal skill in the first month only



Tercile climate forecasts from CPC







Testbed concept to serve multiple projects over time

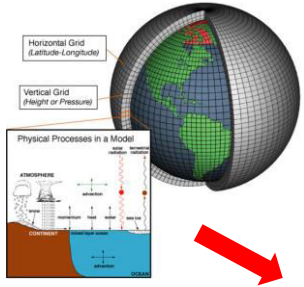
A testbed should merge cross-cutting expertise

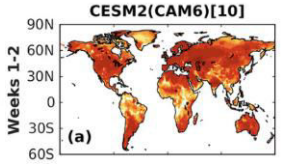
- climate forecast development
- data-driven post-processing
- stakeholder applications
- geospatial data analysis
- interactive visualization

It should include

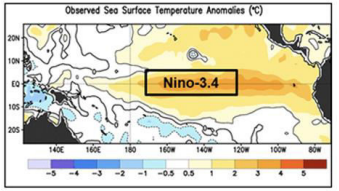
- stakeholder predictands & engagement
- broad intercomparison & benchmarking
- web focal point as community resource

dynamical forecasts

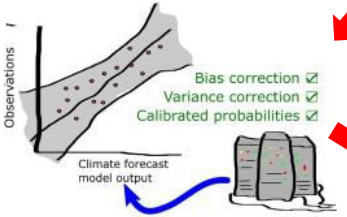




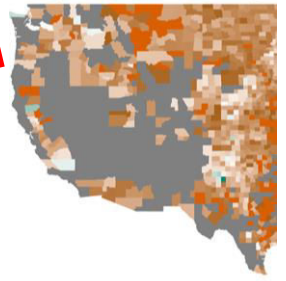
empirical forecasts



post-processing

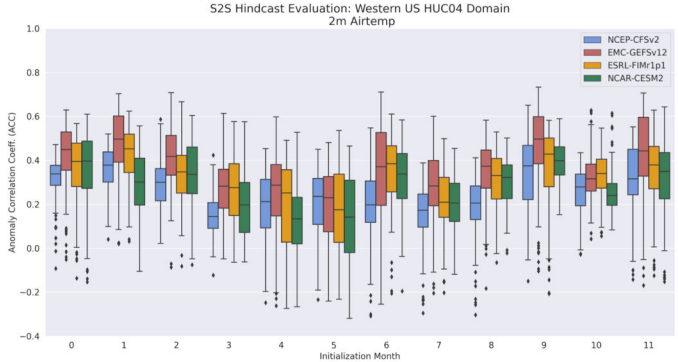


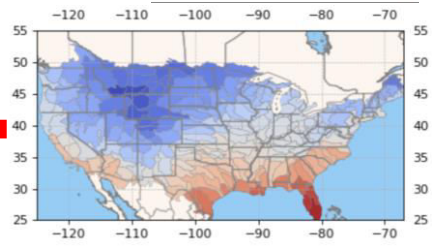
sector specific predictands



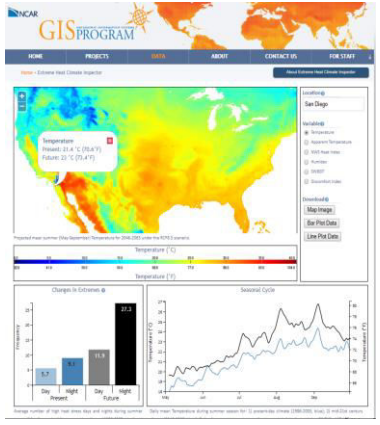
feedback to developers

verification and benchmarking





online interactive visualization



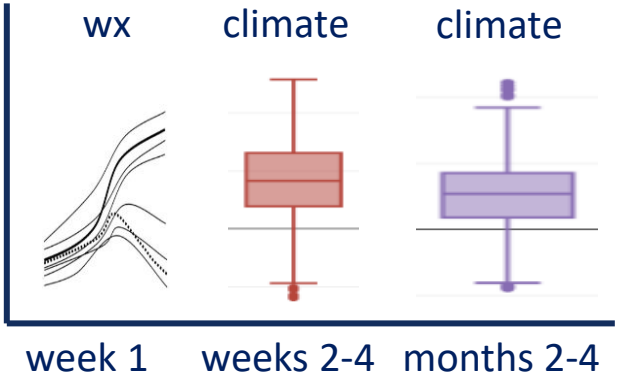
Strategy for S2S climate forecast use

Hydrologic prediction needs seamless forecast meteorology
- short (to medium) range weather forecasts
- sub-seasonal (eg weeks 2-4)
- seasonal (months 2+) climate signals

(1) Handle weather scale prediction relatively directly
- bias-corrected direct output from NWP

(2) Handle climate-scale prediction indirectly
- climate-forecast conditioned weather generation

Pros & cons for different sequencing
- optimal predictability varies, but expediency matters

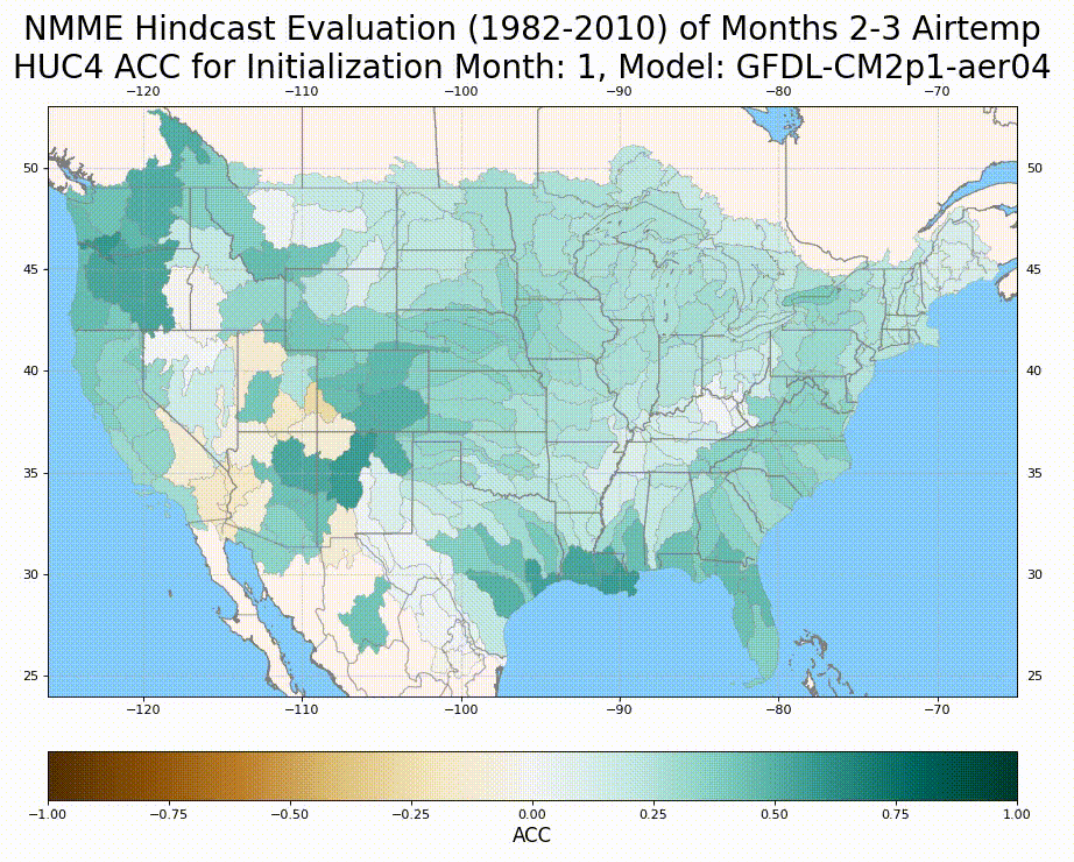


Examples of testbed S2S climate forecast investigation

Individual model skill evaluations

- Example: one dynamical model (GFDL) from NMME
- From various sources, we have not found a great solution for months 2/3 precipitation or air temperature (or month 2)

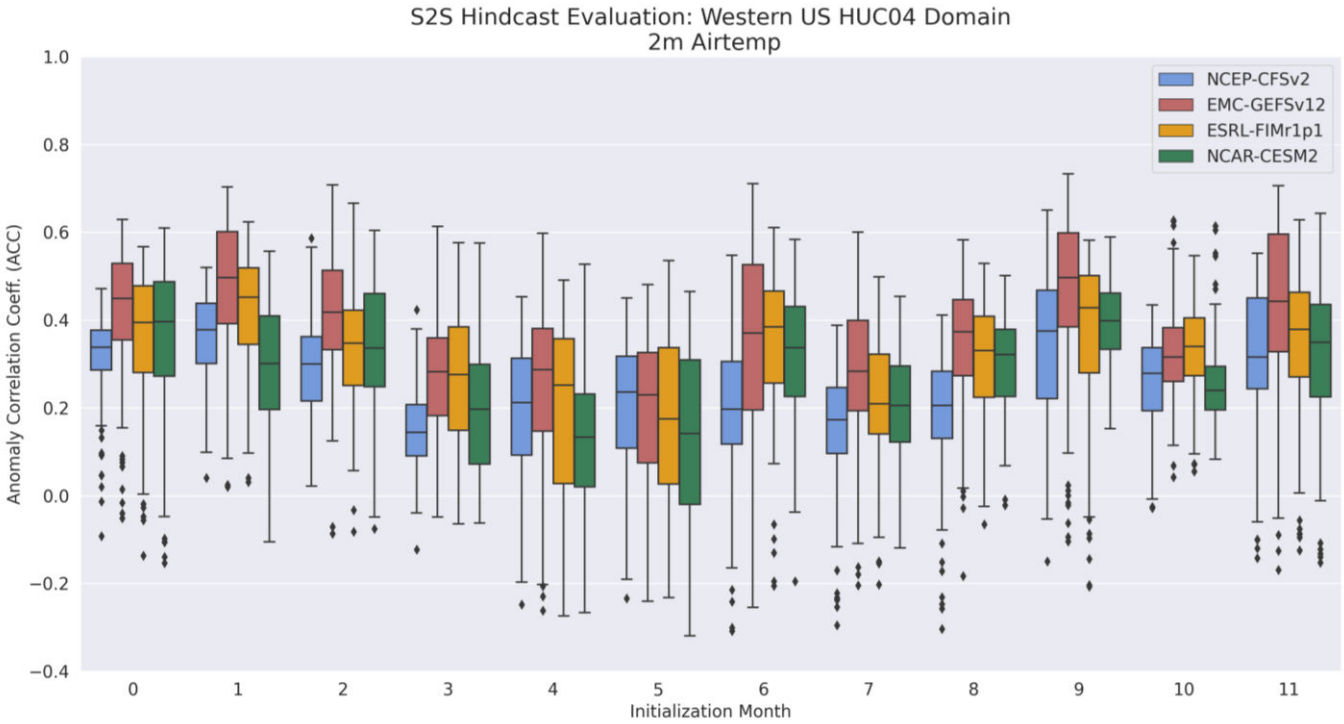
Note: have yet to add ECWMF's forecasts to testbed



Examples of testbed S2S climate forecast investigation

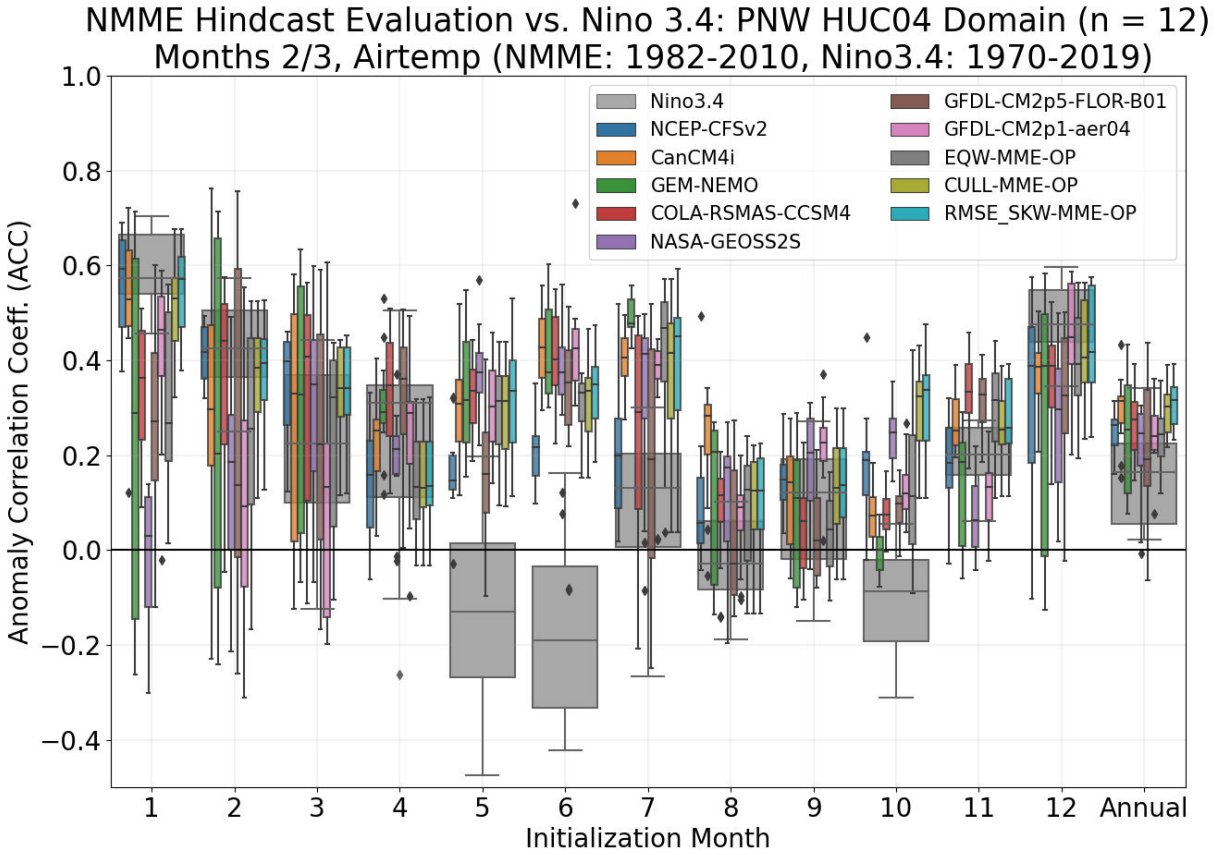
Comparative dynamical model skill evaluations

- Weeks 2-4 temperature and precipitation
- We looked mainly at the Sub-X models (dynamical sub-seasonal forecasting)
- To date, the NCEP Global Ensemble Forecast System (GEFS) provides the highest skill



Example: comparing empirical, dynamical predictions, some post-processing

- Simple empirical predictions (index-based) are still an important benchmark with dynamical and hybrid models (example, Nino3.4)
- Simple post-processing can help
- Months 2/3 skill is often too low in Western US; will focus on ‘season 2’ instead – eg, months 2-4, 3-5 ...
- There are more options to explore with the testbed methods (e.g., ML)

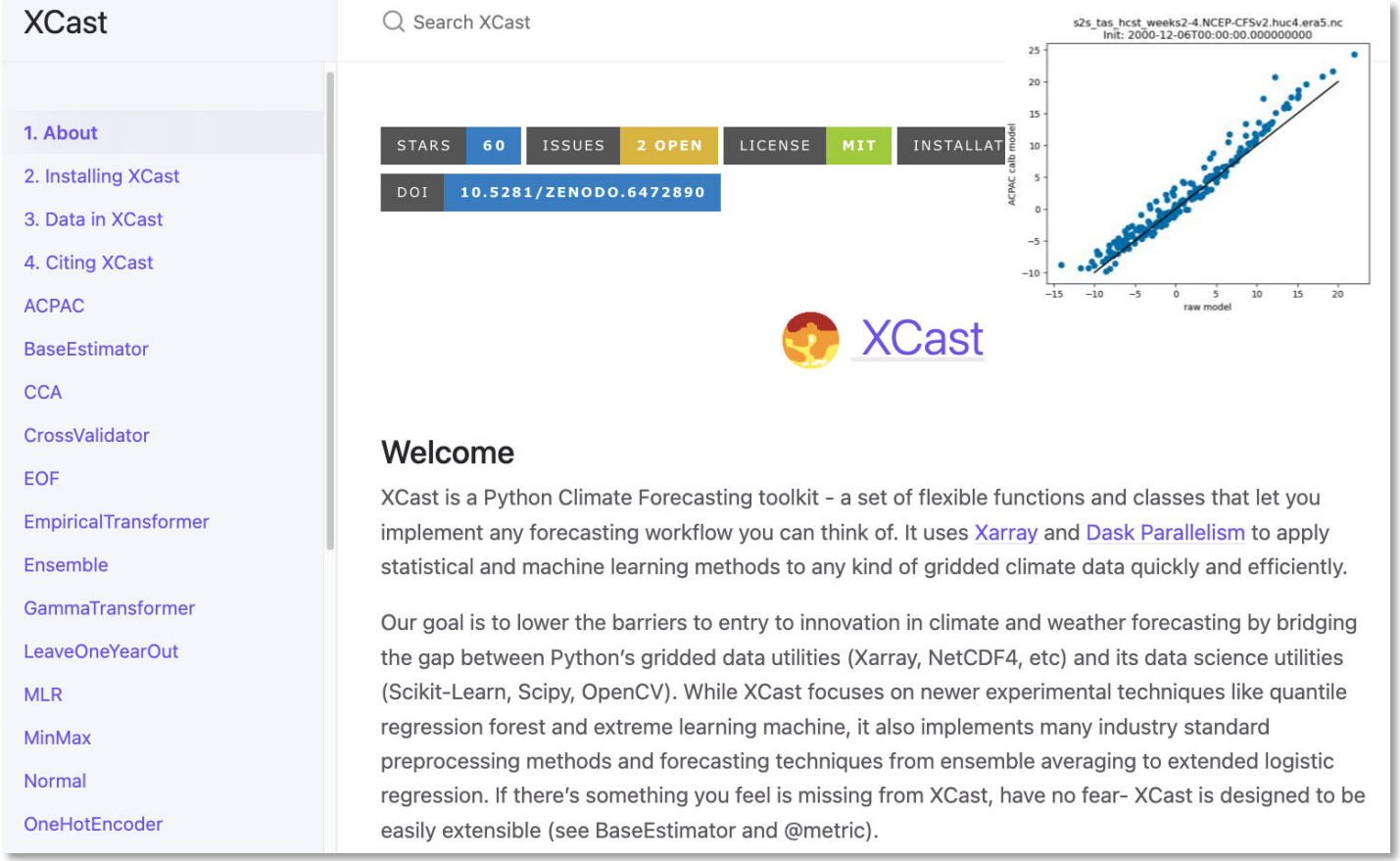


Assessing post-processing methods (ML)

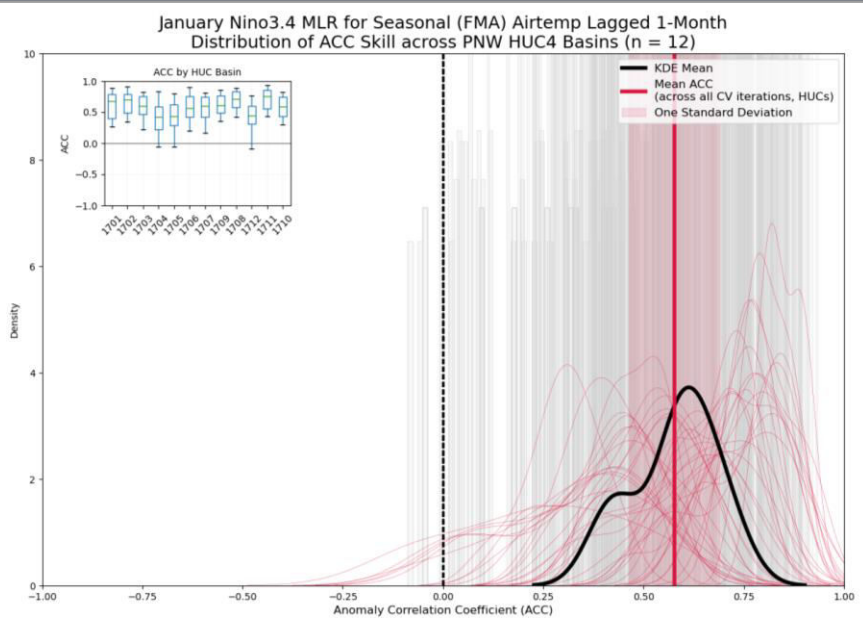
NCAR UCAR

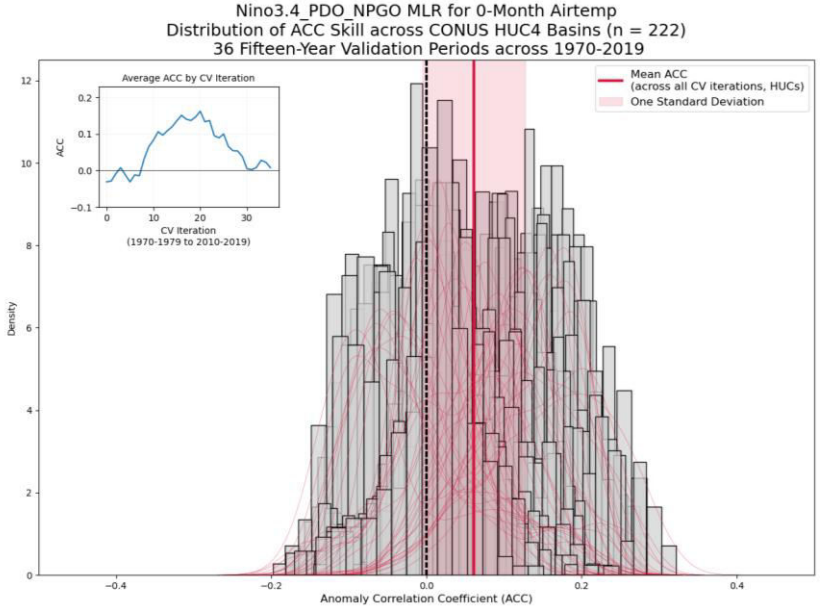
Exploring ML-based post-processing (hybrid forecasts)

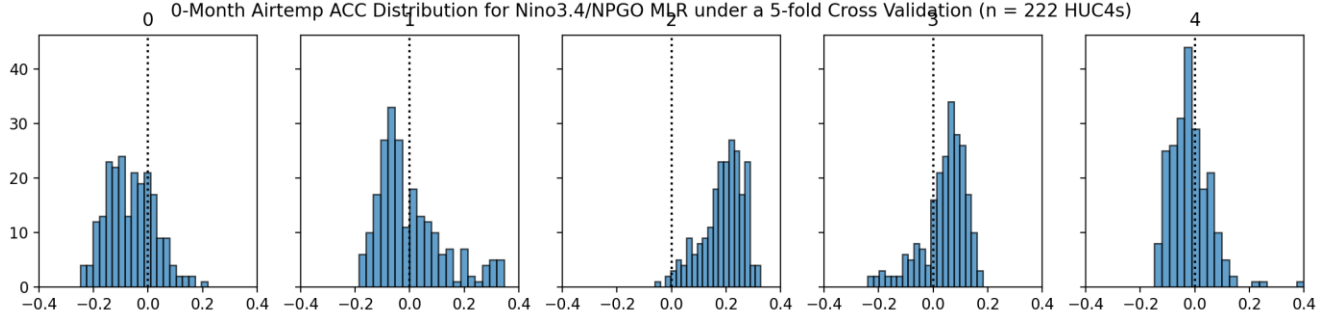
- e.g., XCast
- Used in IRI calibrated products
- Took 3rd place in AI/S2S Challenge
- We're collaborating with the XCast developer at NOAA/ESRL
- Other ML tools/packages are of interest



The challenge of small samples and skill metric uncertainty



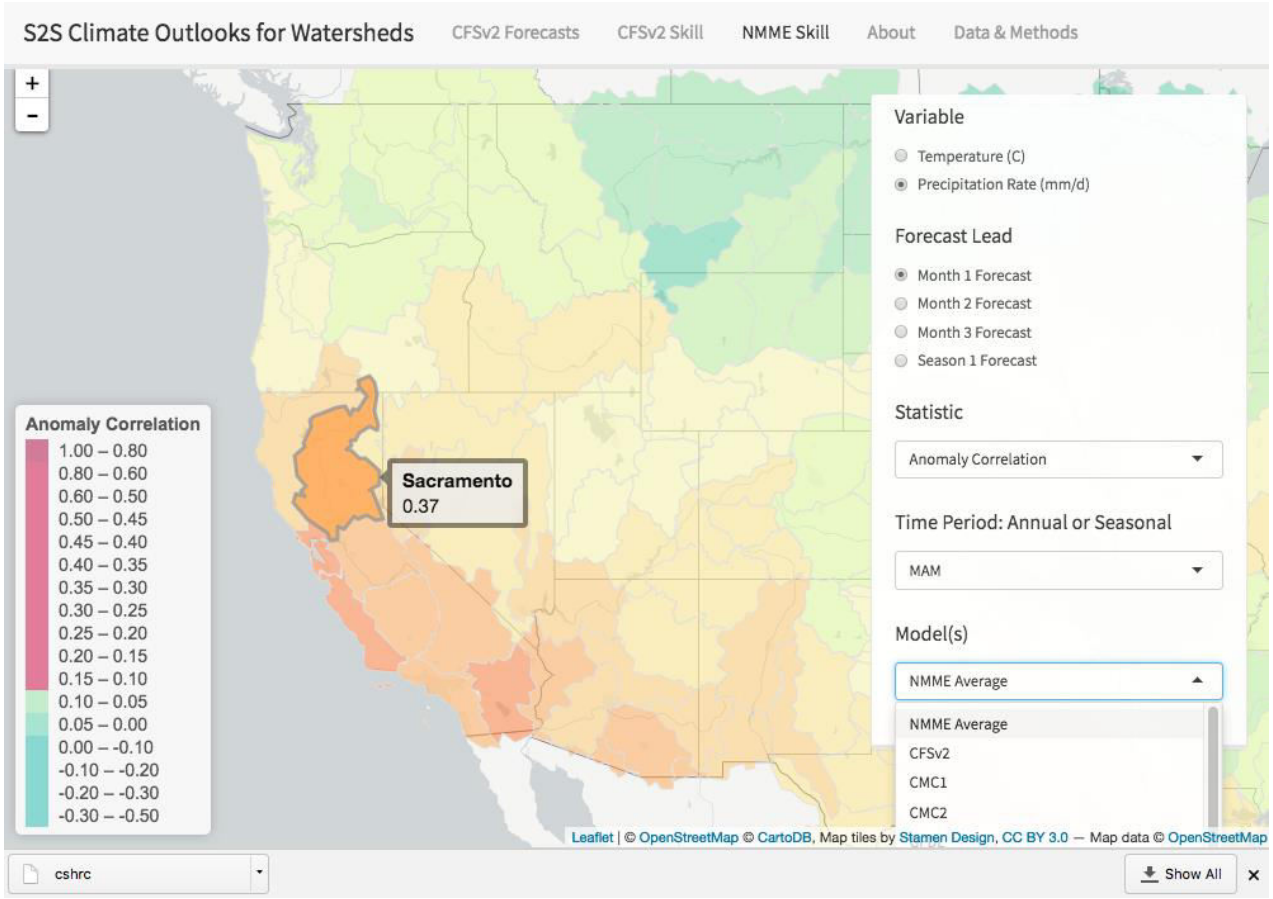




Interactive visualization

A previous project engaged water stakeholders via a watershed focused climate evaluation

A next step will be to revive this platform with the new data from the Testbed effort



Summary

- To support multiple forecast projects that need S2S climate predictions, we've created a testbed focusing on basin-level climate forecast skill
- The testbed shares a common infrastructure for evaluating dynamical, empirical, and hybrid predictions – including ML approaches
- We're assessing different convenient predictand periods
  - week 2, weeks 2-3, weeks 2-4, months 2, 3, …, months 2-3, season 1, 2, 3 …
- The testbed should help to benchmark new, individual efforts as they appear
- Funding and collaboration is currently somewhat ad hoc – support is from several different projects versus one dedicated coherent whole
- Estimating skill based on small samples and short records requires caution

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