Project Hyperion:

Developing Use-Inspired Climate Science for Water Management

Effective planning in the face of climate uncertainty requires reliable and actionable climate information and expert guidance. Meaningful collaboration between scientists and practitioners is critical to ensure that climate science evolves to meet these challenges.

About Project Hyperion

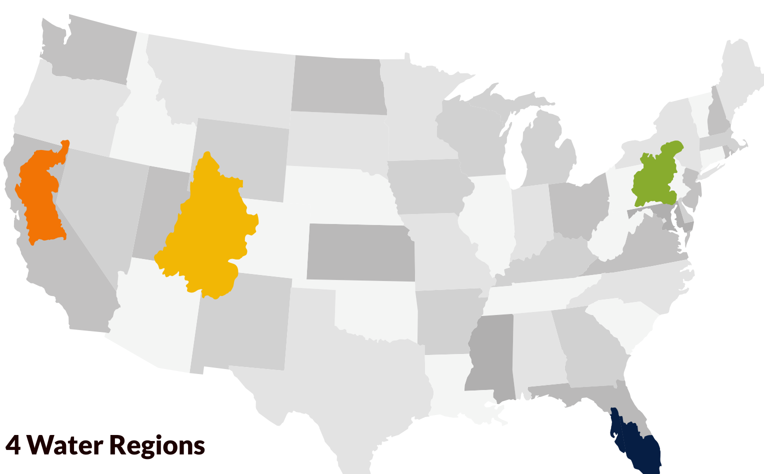
Scientists from 9 research institutions collaborated with managers from 12 water agencies to co-develop a framework that evaluates the suitability of hydro-climate data for water management.

This research provides insights to regional practitioners on the usability of current climate science. It also enables scientists to improve climate models for management relevant outcomes. Hyperion and its successor project "HyperFACETS," are developing broadly applicable methods for co-producing actionable knowledge.

Key Outputs and Outcomes

- Developed a framework to improve the usability of basic climate research and modeling.
- Fostered effective working relationships between water managers and scientists.
- Co-produced region-specific and decision-relevant climatic metrics for water management.
- Developed 60+ peer-reviewed publications that improve understanding of the performance of regional hydro-climatic data for decision-making.

Co-Produced Climate Science in 4 Key Water Regions



4 Water Regions

- Sacramento/San Joaquin
- Susquehanna
- Colorado Headwaters
- South Florida

Diverse Collaborators

Hydrologists
Climate Modelers
Social Scientists
Atmospheric Scientists
Water Managers

Actionable Science

Model Skill
Regional Data
Collaboration Strategies

Susquehanna River Basin

- Spans 444 miles through 3 states
- Provides half the freshwater flow to the Chesapeake Bay
- Produces 100s of millions of gallons of water per day

What Challenges Do Water Managers Face?

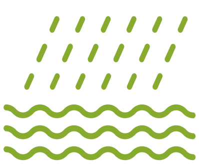
- Floods about 1x every 15 years
- 5 severe droughts over past 3 decades
- Water quality in Chesapeake Bay

"These results are helpful in briefing our leadership, advisory committees, and partner agencies on the project and initiating discussions regarding updates to regulations, policies, and plans to improve water resources management in our basin."

– A Susquehanna water manager involved in the project

Research Solutions at a Glance

Extreme Precipitation: IDF estimates specifying the intensity of precipitation events of different durations and frequencies are useful for flood and stormwater management, but these often vary by climate model–and little guidance exists on applying them to management decisions. The Hyperion team assessed how well different climate models predict historical and future IDFs for a 24-hour duration storm at 50 weather stations across the region. A method of "pooling" data from specific models based on performance was developed to address disparate estimates among models. This reduces estimation uncertainty, and is found to be a better option than relying on one specific model.



Water Supply: Predicting water supply relies on accurate streamflow estimates. But while high-resolution, region-specific streamflow estimates exist, little is understood about their accuracy, or about which model components are responsible for inaccuracies. The Hyperion team used a region-specific hydrologic model to compare two streamflow simulations: one using high-resolution, climate-model derived precipitation data, and another using observed stream-gauge precipitation data. In both simulations, the model was able to estimate overall streamflow reasonably well; however both underestimated peak flows. This suggests that the hydrologic model is likely sufficient for use in overall water availability assessments, but may not fully capture extreme precipitation events.

Coastal Storms: Coastal storm preparedness efforts could potentially benefit from high-resolution climate models capable of accurately simulating tropical and extratropical cyclones (TCs and ETCs). Since increasing model resolution can be costly, the Hyperion team worked to determine the minimum resolution needed to accurately capture these events, and to understand their ability to simulate wintertime precipitation associated with ETCs in the northeastern U.S. The study found that the current class of global earth system models (with resolution ~1 degree) are generally capable of representing ETCs at regional scale. However, uncertainties exist as to precipitation associated with these events. Higher-resolution models can be beneficial for capturing more nuanced basin-scale or finer precipitation impacts.

Sacramento/San Joaquin

- Two river basins serving 39 million + people
- Supports $50 billion in agriculture
- Diverse aquatic and terrestrial habitats

What Challenges Do Water Managers Face?

- Severe drought
- Diminishing snowpack
- Extreme heat
- Sea level rise

"In California, the state develops many climate change scenarios for water planners to use. The Hyperion results can help both state and federal climate scientists refine which models they use and how they use them when developing recommended planning scenarios."

– A California water manager involved in the project

Research Solutions at a Glance

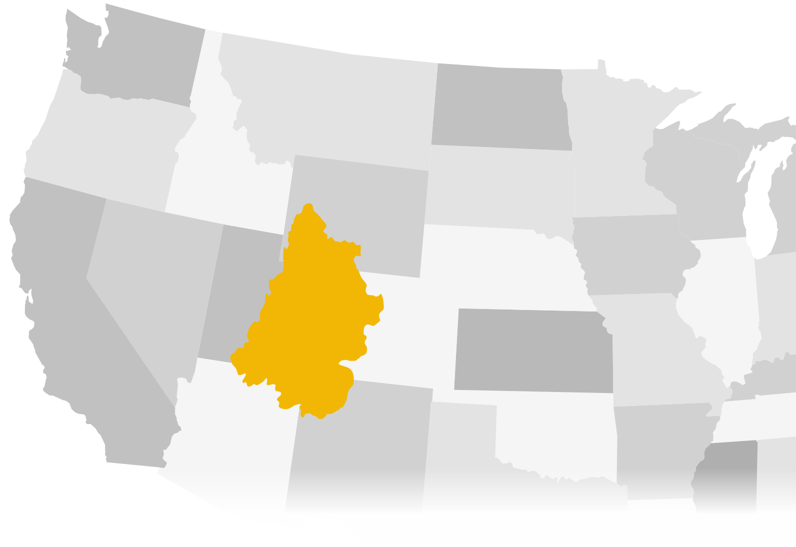
Atmospheric Rivers: ARs form 20-50% of California's annual water supply. Understanding how well models capture AR events is essential to water supply and flood management. The Hyperion team evaluated how well a community earth system model estimated extreme ARs and how future AR-associated precipitation might change. A spatial resolution of less than 10km was needed to accurately capture extreme ARs. By late-century extreme ARs can lead to 20-50% more precipitation per event, which will be made up of a higher fraction of rain rather than snow. These ARs will have higher hourly rainfall rates, which could substantially increase the risk of flash flooding.

Snowpack: Many techniques exist to estimate mountain snowpack–an integral aspect of Western U.S. water supply, but their efficacy for use in water management is not well known. The Hyperion team examined historical and future model simulations for six decision-relevant snowpack metrics, including snowpack accumulation; snowpack melt rate; and length of melt season. In general, models represent snow accumulation better than snowmelt, with simulated snowmelt rates being too fast as compared to observations. Overall, peak snowpack volume is expected to dramatically decline--57-81% by end of century based on the downscaling technique used.

Droughts: The California drought of 2012–2016 caused extensive social, political, and economic repercussions. The Hyperion team examined how an analogous drought, exacerbated by climate change, would look by midcentury. In the future drought, drier regions and time periods would become drier, and wetter regions and periods become wetter. But increased precipitation in wet periods does not translate to increased snowpack due to warmer temperatures, leading to a loss of 16-30% in peak snow volume by midcentury. Temperatures would be 0.8-1.4°C higher in the Central Valley and 1.2-2.0°C higher in mountains and the interior.

Colorado Headwaters

- 80% precipitation as snowpack in Western Colorado
- Large transbasin diversions of water from east to west
- 2/3 water used for other states



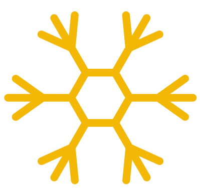
What Challenges Do Water Managers Face?

- Drought
- Reduced snowpack
- Variable water supply
- Increased temperature and extremes

“In talks regarding the management of the Colorado River system, Project Hyperion results will provide valuable insights that may increase confidence in policy making. Referencing the regional narrative for the Colorado River will add confidence to decisions made through negotiation.”

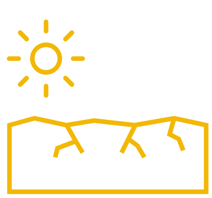
– A Colorado water manager involved in the project

Research Solutions at a Glance

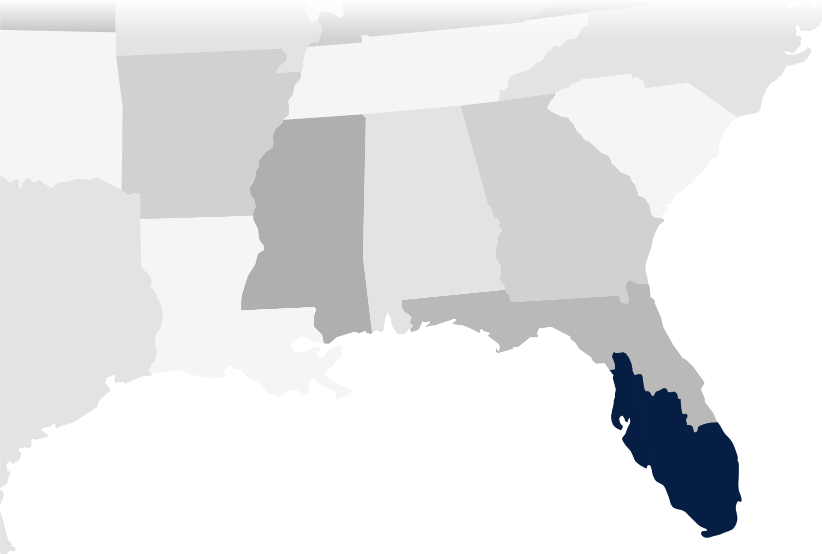


Snowpack: Many techniques exist for estimating mountain snowpack–an integral aspect of Western U.S. water supply, but their efficacy for use in water management is not well known. The Hyperion team evaluated how well models represent six decision-relevant snowpack metrics, including snowpack accumulation; snowpack melt rate; and length of melt season, and how these metrics could change in the future. In general, models represent snow accumulation better than snowmelt, with snowmelt rates being too fast as compared to observations. Snowpack is expected to dramatically decline by the end of the century, while the melt season lengthens.

Monsoons: The North American Monsoon Season (NAMS) contributes more than 30% of precipitation, and marks the end of fire season in the Southwest. The Hyperion team evaluated how well different observational datasets and models were able to capture the timing of NAMS onset. The various observational datasets differed by about a week for NAMS onset dates. There were also large disparities between simulations of different models. Overall, modeled onset occurs earlier than observed in the southern part of the region, and later in the northern part, and onset estimates did not improve with higher-resolution models.



Water Supply: Projections of multi-year drought for the next 5-10 years can help forecast water supply - but regional estimates are unavailable. The Hyperion team explored whether a credible technique could be developed for decadal forecast of Colorado River water supply. The study also tests an earth system model’s capacity to predict total soil water, and determine whether it tracks Colorado water supply. Using the Great Salt Lakes as a proxy region for the Colorado river, this study developed a technique able to simulate regional surface and subsurface features and predict Colorado water supply up to 10 years. The variable resolution earth systems model reasonably represented the total soil water of the river basin, which in turn was able to track Colorado water supply.



South Florida

- 8 million people
- 5 metro areas
- Home to the Florida Everglades

What Challenges Do Water Managers Face?

- Sea-level rise
- Flood protection
- Saltwater intrusion
- Protecting natural resources
- Extreme heat
- Drought

"The potential changes to the intensity-duration-frequency of extreme rainfall will help design future stormwater systems which may experience climate change."

– A Florida water manager involved in the project

Research Solutions at a Glance

Extreme Precipitation: IDF estimates specifying the intensity of precipitation events of different durations and frequencies are useful for flood and stormwater management, but these often vary by climate model– and little guidance exists on applying them to management decisions. The Hyperion team assessed how well different climate models predict historical and future IDFs for a 24-hour duration storm at 70 weather stations across South Florida. A method of "pooling" data from specific models based on performance was developed to address disparate estimates among models. This reduces estimation uncertainty, and is found to be a better option than relying on one specific model.

Sea Breeze: In Florida 50% or more of precipitation has been shown to come from local atmospheric circulations like sea breeze, rather than larger-scale storm systems. The Hyperion team evaluated how well climate models represent sea breeze by comparing precipitation on days with and without sea breeze. The study found that across Florida's agricultural regions more than 35% of rainfall occurs on days when sea breeze was detected along both coastlines, showing that sea breeze contributes significantly to summertime precipitation. However, model estimates of sea breeze occurrences were five times less frequent and weaker than observations, suggesting that some climate models may fail to accurately detect sea breezes.

Tropical Cyclones: In Florida tropical cyclones can lead to heavy precipitation and substantial disaster-related loss. However, conventional climate models struggle to adequately simulate these events and associated rainfall at regional scales. The team studied how well variable resolution models track frequency and distribution of landfalling tropical cyclones, and how these storms contribute to mean and extreme precipitation. Variable resolution models produce significantly improved simulations of tropical cyclone frequency in the North Atlantic, but still underestimate the percentage of extreme precipitation from these events. These storms were shown to make up just about 1-2% of average annual precipitation, but as much as 30% of extreme precipitation in some regions.