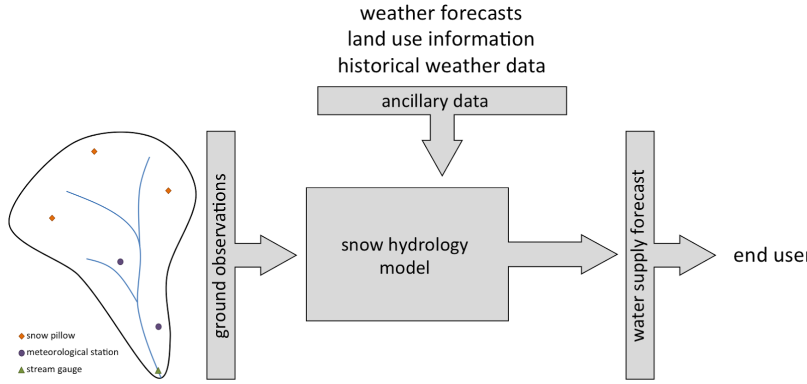
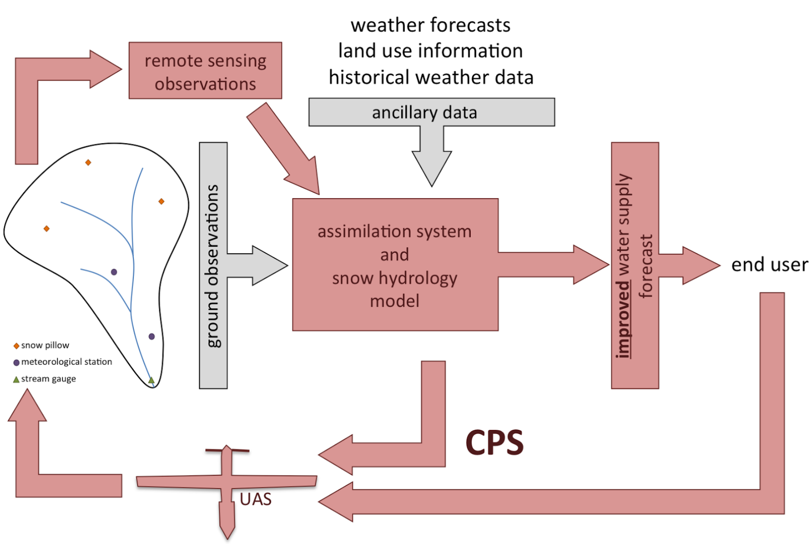
TOWERS: Transforming Operations in Water-resources with Efficient Remote-Sensing

Mountains are the water towers of the world, providing over 50% of the water supply for the world and over 75% in the Pacific Northwest. Currently, these regions are too poorly sampled to quantify the amount of water stored. This problem can now be solved through a coordinated effort to combine new capabilities in aerial remote sensing, in unmanned aerial systems, and in the processing, manipulation, and transfer of large datasets, to improve hydrologic prediction and water management.

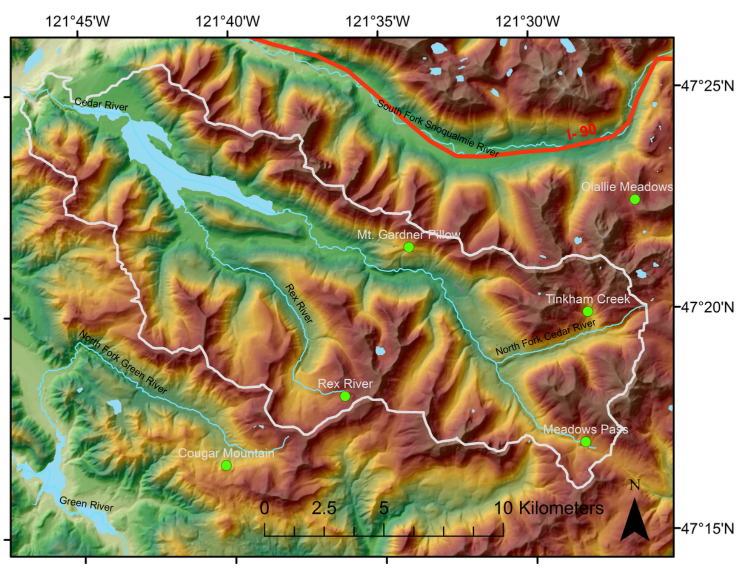


Historically, water supply forecasts have been made based on a snow hydrology model (either statistical, conceptual or physically-based) that combines sparse in-situ observations with ancillary information such as land use, historical weather data and weather forecasts. These forecasts or outlooks can be used by end users such as public utilities, irrigation or flood control districts, hydropower generators and other water management entities. A major hurdle in providing improved water supply forecasts is the paucity of in-situ observations that can be used to initialize, update, and constrain the snow hydrology models. Most of the snow is stored in areas that are inaccessible during much of the winter and where in-situ observations are expensive and difficult to maintain. Because of terrain effects on precipitation, radiation, wind and vegetation, mountain snow packs also exhibit large spatial variability, which makes it difficult to synthesize areal water storage estimates from isolated point measurements.



New capabilities in aerial remote sensing and unmanned aerial systems (UAS) enable targeted field observation campaigns during the snow accumulation and ablation seasons. New software and hardware capabilities offer the potential to implement the necessary feedback mechanisms that will allow targeting decisions (when, where and what) to be made by a skilled operator or autonomously by smart software systems that aim to reduce uncertainties in the snow hydrology model. Improved assimilation techniques will integrate these new measurements with existing sources of information to produce an improved water supply forecast.

Our vision is for an integrated cyber-physical system (CPS) that can autonomously dispatch independent observing platforms in remote terrain and under adverse weather conditions to gather targeted information that will minimize model uncertainty and hence maximize forecast value. Such an integrated CPS has the potential to revolutionize field observation campaigns for a wide range of applications. Here we focus on the initial steps towards building such an integrated system to support snow remote sensing and improve water supply forecasts. We have identified specific science questions for the cyber component, i.e. the system that implements the feedback loops and data transfers; the physical component, i.e. the mobile observing platform; and the application component, i.e. the assimilation, modeling and forecast delivery system. Together, these questions explore a next-generation CPS application using a multi-disciplinary technical approach to address the societal challenge of water resources management. As such, the proposed Synergy Project is directly responsive to the Program Solicitation, in particular research target area II.A.2 Technology for Cyber-Physical Systems.



The proposed work includes a Transition-to-Practice (TTP) option, which will test the integrated CPS in a real-world environment. We propose to take remote sensing snow measurements in the Cedar River basin, which supplies drinking water to the City of Seattle and surrounding communities. Remote sensing measurements will be made using an Aerovel Flexrotor as the observing platform and these measurements will be assimilated into a snow model of the Cedar River basin to produce water supply forecasts for Seattle Public Utilities.