

Abstract

In 2005 the North Olympic Peninsula Resource Conservation and Development Council applied for a grant from NASA through its Earth-Sun System Division Applied Science Program. The grant was awarded in 2006 to create a Solutions Network of local, regional, and federal agencies to develop a water budget model of the Dungeness Watershed, and implement it in decision making. Water budget modeling is needed by water managers to improve the scientific basis of decision making in meeting the demands of increasing allocations and decreasing supplies. Climate change is credited for decreasing winter snowpack and earlier run-off, leading to longer and more severe late summer droughts.

Introduction

The Dungeness River and its main tributary the Gray Wolf River drain an area of 172,000 acres. The Dungeness River is the second steepest river in the U.S., falling about



The Sequim-Dungeness Valley

3,300 ft. in 28 miles for an average gradient of 0.022. The Dungeness River has a mean annual flow of 380 cubic feet per second (cfs) with high flows up to 7,610 cfs and low flows down to 142 cfs (Bureau of Reclamation, 2006).

Water flows in the Dungeness River vary by season with high flows in the winter due to rain, and early summer due to snowmelt (Simonds, 2002). Below its confluence with the Gray Wolf River at RM 15.8, the gradient is consistently less steep, with the lower eleven miles having an average gradient of 48 feet per mile (Simonds, 2002). It is in this lower eleven

miles that the river carves through a broad alluvial fan known as the Sequim-Dungeness valley. About 23,000 of Clallam County's approximately 65,000 residents live in the valley, home to the city of Sequim with a population of 4,928 (2004 census). Water uses are divided amongst, sometimes competing, uses for municipalities, agriculture, and fisheries.

The majority of the Dungeness Watershed is located within a rainshadow and does not receive as much precipitation as other coastal areas in Washington (Clark, 1995). Precipitation in the Dungeness Watershed varies throughout the year, with 38% occurring from December through February (Thomas et al, 1999). The upper 155 square miles of the watershed receives an estimated annual precipitation of 63 inches (Clark, 1995). The lower 116 square miles of the watershed receives an average annual rainfall of 29 inches due to the watershed effect (Clark, 1995). Due to the limited rainfall in the Sequim-Dungeness Prairie, agriculture relies heavily on groundwater and irrigation.

Historically, eleven fish populations lived in the Dungeness River (Puget Sound Recovery Plan, 2007). Currently, the river is home to threatened stocks of early-run

chinook, summer chum, and bull trout. The river also supports “early” and “late” pink, fall chum, coho, steelhead, cutthroat runs and resident rainbow trout.

During the late summer drought of 2005, irrigation for agriculture was suspended in the Dungeness to ensure that river flows were high enough for endangered salmon to make it upstream to spawn. This issue, and others, encouraged Dungeness river managers to seek assistance from NASA in developing a better water modeling tool for decision making.

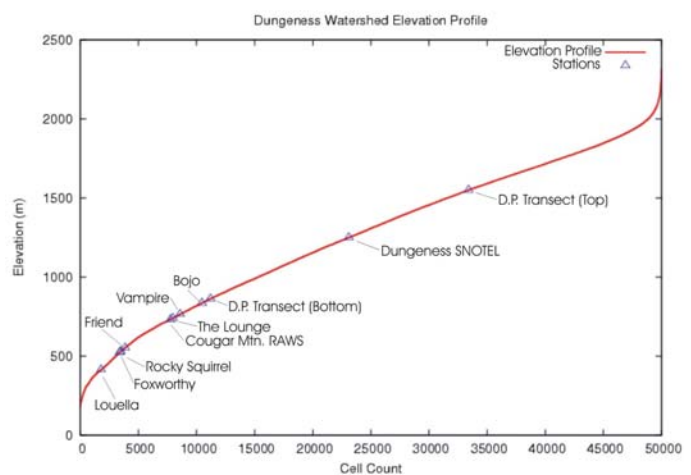
A water budget model tracks and quantifies all of the water in a drainage basin including precipitation, snowpack, groundwater, and stream flows. The model is then used to forecast stream flows in the future. The water budget model Dungeness river managers have been using is limited in its accuracy and ability to predict low flow events. The model uses observations and historic flows to make predictions no smaller than one month blocks, and with significant inaccuracies. The new NASA hybrid model uses current satellite data combined with data transmitting stations on the ground to produce a forecast that has higher resolution and greater dependability.

With this study, Chris DeSisto and Shea McDonald, working under Dwight Barry, are seeking to address the following research questions:

- 1) How can we develop a better flow forecast using NASA technology?
- 2) How does the ground-truthing data correlate with the model outputs?

Methods

To aid in development of the Hybrid Model, Shea and Chris, along with Dr. Dwight Barry conduct research in the field to collect snow and weather data. Snow Telemetry (SNOTEL) sites are located throughout the watershed in higher elevations where frequent access is not possible. These high elevations areas are pretty stable and easier to model than mid elevation areas. Their field work is conducted in the mid elevation range that sees lots of change in the **snow line** over the course of the winter. To help researchers figure out what in these areas that are difficult for the satellites to see, they have established **snow courses** and installed **meteorology stations** throughout the watershed:



1. They have set up ten snow courses in the Dungeness watershed. The courses are sampled every few weeks to determine the amount of water stored as snow. This is done by pushing a tube vertically through the snow and removing a core. Using a scale, the weight of the core is translated into **snow water equivalent** (SWE). This information is valuable because snow depth is not even throughout the mid elevations; it is used to check how well the satellites measure how much water is in the watershed.



Chris collecting a snow sample

2. At seven of the ten snow courses, they have set up meteorology stations which record rainfall and temperature 24 hours a day, seven days a week. When visiting the snow courses, they download the weather data and return it to the lab. The amount of snow on the ground depends on the weather in the area, warmer weather and rain will melt the snow, knowing the conditions at each site help understand why snow is deeper in some places.
3. As the SWE and weather data is collected, it is sent to researchers at Batelle National Laboratories in Richland, WA. The data is compared to what the satellites see and helps improve the Hyrbid model.



Meteorology Station

The research crew's snow sampling efforts will continue into the spring until the snow melts and weather data downloading will be conducted year round.

Discussion

This research project was begun in 2007. The water model is only one part the solutions network of researchers, operators, and users. The creation of the Solutions Network and development of the water budget model was scheduled for a three-year plan. A web-page

operated at Peninsula College serves to provide water managers with forecasts from the model.

The Solutions Network and water budget model is also being adapted for the Elwha watershed, to the west of the Dungeness. The lessons learned from applying the solutions network to the Dungeness and Elwha will be used to evaluate the potential for improving water, agricultural, and ecological decision-making in other areas across the nation.

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