Background:
Prince William Sound (PWS), located in southcentral Alaska, takes in large, seasonal additions of freshwater from rivers and melting glaciers that result in rich marine habitat for plankton, fish, and marine animals (Figure 1). The nearshore freshwater budget also serves as a crucial boundary condition in the Regional Ocean Modeling System (ROMS) for PWS, which provides forecasts of the dynamic ocean currents important to transoceanic ships, oil tankers, state ferries, fishing boats, cruise ships, sailboats and kayaks that travel the Sound.

We propose to develop and validate a new hydrological model of PWS to estimate freshwater discharge into the Sound. Quantification of hydrological processes in PWS are difficult due to chronic undersampling, where the vast majority of the terrain is not represented by the sparse measurements. Previous efforts to model freshwater discharge (FWD) into PWS have been heavily empirical, in that many physical processes were absorbed into calibration coefficients that, in many cases, were calibrated to streams and rivers not hydrologically similar to those found in the Sound. Our effort will adapt state-of-the-art, highly distributed, physically based weather, snowmelt, and hydrological runoff models to the PWS watershed in order to improve projections of discharge into the Sound.

Study Objectives:
1. Apply and modify a suite of recently developed and proven highly distributed models for the prediction of weather, snowmelt processes, and streamflow to the PWS watershed.
2. Utilize existing PWS weather stations to validate distributed weather fields and stream gaging stations to validate runoff calculations.
3. Integrate our modeling work and data collection efforts with other related modeling and observational efforts in PWS.

Weather data:
Long-term, continuous measurements of temperature (Tair), precipitation (PPT) and snow depth data needed to calibrate hydrological models are sparse in the PWS region and most are located at elevations <20 m asl (Figure 2). Therefore we utilize the North American Regional Reanalysis (NARR) dataset as the atmospheric forcing data to drive the weather model. This dataset provides 3-hourly PPT, Tair, RH, and WS/WD on a 32 km grid across the model domain from 1979-2011.

Runoff modeling:

Weather model:
MicroMet (Liston and Elder, 2006b) is used to distribute high-resolution meteorological data that utilizes station or gridded reanalysis observed PPT, Tair, RH, and WS/WD data and surrounding topography (DEM) as input. At each timestep PPT, Tair, RH, WS/WD, SW and LW radiation, and surface pressure are calculated and distributed to be used in SnowModel. In preliminary tests, NARR reanalysis estimates were used as atmospheric forcing data on a 3-hour timestep and 1000 m grid size.

Snowmelt model:
SnowModel (Liston and Elder, 2006a) is a spatially distributed snow-evolution modeling system which uses MicroMet output to simulate snow accumulation; blowing-snow redistributition and sublimation; forest canopy interception, unloading, and sublimation; density evolution, and snowpack melt. We will validate a recent modification of SnowModel which simulates glacier/ice melt on the Columbia and Valdez glaciers which collect glacier runoff measurements.

Runoff model:
HydroFlow (Liston and Mernild, 2012) is a runoff-routing model that transports water across glaciers and land to the outlet basin. Grid-cell runoff output from SnowModel will be routed through the river drainage networks to calculate basin runoff hydrographs and the land-ocean interface in PWS.

Preliminary test:
MicroMet and SnowModel were adapted to the northern Gulf of Alaska watershed to simulate spatially distributed weather and snow water equivalent (SWE) evolution from 01 Sept 2001 to 27 Feb 2010. The model used DEM and vegetation maps with 1000 m grid cells and a domain 2069 km E-W and 880 km N-S. A daily time series of gridded SWE depths was output (Figure 4) and the values were extracted and summed for the PWS watershed (Figure 5) showing interannual variation in SWE volume.

Runoff data:
The majority of the runoff in PWS comes from glacier runoff and loss and small, distributed sources difficult to gage, only 3 stream gages are currently operating, 2 from glacier runoff (Figure 3). Streamflow records indicate three contrasting dominant discharge regimes in PWS: (1) glacier controlled, (2) snowfed, and (3) rainfed. Validation of runoff model will need to address each watershed type.

Snowmodel Evaluation:
Daily simulated SWE was evaluated for WY 2006 by comparing with observed SWE from 14 active SnoTel sites (Figures 6 and 7). Model underpredicts SWE in PWS region, next step is to calibrate with measured weather data and possibly modify important parameters (albedo, T/P lapse rates).

Expected products:
1. High resolution (in space and time) estimates of freshwater runoff into PWS, which will benefit hydrologists interested in terrestrial processes and aid in predicting impact of oil spills on nearshore communities.
2. Coastal freshwater flux estimates will be built into ROMS project or NOAA’s GNOME project.
3. A new suite of modeling tools centered on the freshwater resources of Prince William Sound and will acquire new and valuable datasets on weather and streamflow.