Snowpack in the Pacific Northwest: *What are the Controls?*

Guillaume Mauger and Nate Mantua
UW Climate Impacts Group

BACKGROUND:

Snowpack -- both its extent and duration -- is of central importance to resource managers. Prior studies have investigated trends and sensitivities of spring snowpack, of particular interest to water managers (*e.g., Hamlet et al., 2005; Elsner et al., 2009; Casola et al., 2009; Stoelinga et al., 2010*).

Water availability in cool and high-mountain ecosystems is often strongly sensitive to the ability of snowpack to persist into late spring and even summer. An improved understanding of the controls on late-season snowpack would allow resource managers to make more informed decisions regarding the vulnerabilities of forested lands.

GOALS:

1. **Identify primary controls on late-season snowpack**, both on regional scales and through case studies. Develop simple snow-sensitivity metrics for snow extent and duration.

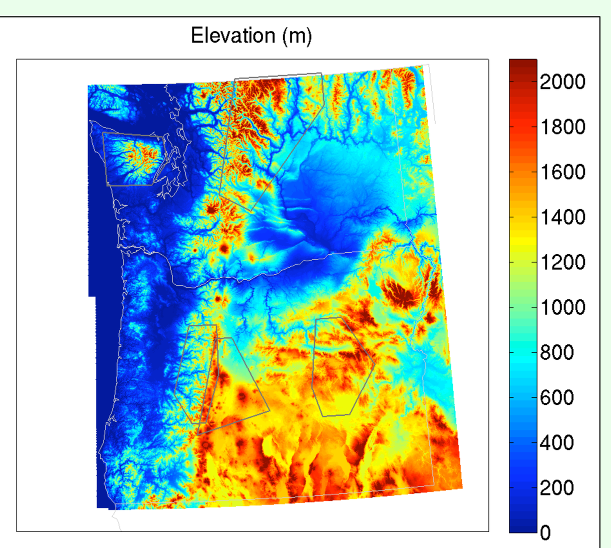
2. **Develop a high-resolution snow** dataset for use with NetMaps* mapping software.

*NetMaps is a community-based watershed science mapping utility that can be used for analysis and decision-support in resource management (http://www.netmaptools.org)

FOCUS REGIONS:

USFS lands in Oregon and Washington

Specific attention paid to:
Olympics, Wenatchee-Okanogan. Willamette. Deschutes, and Malheur National Forests



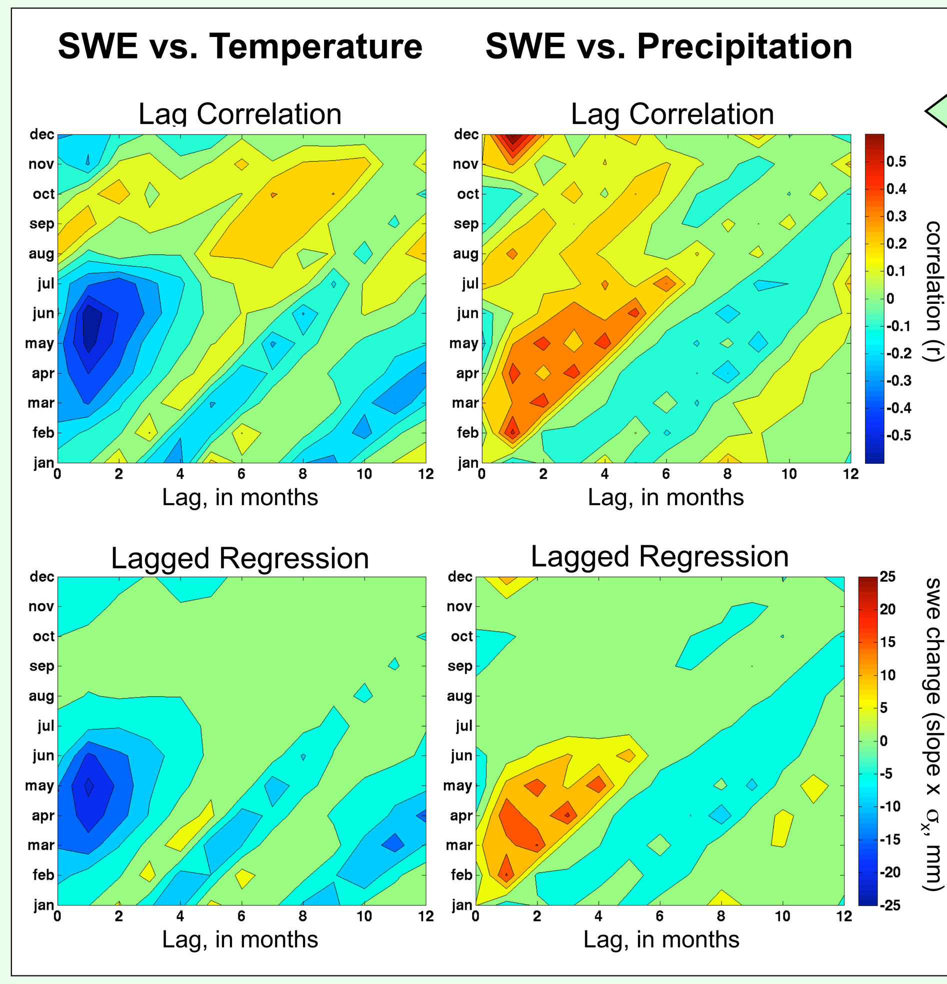
DATA:

1. **VIC:** Variable Infiltration Capacity Hydrologic model, run over the Columbia River basin and coastal drainages of the Pacific Northwest. Simulations were performed using historical data for 1916-2006 and future climate scenarios for the 2040s and 2080s. *Resolution:* 1/16th degree (~6 km), and 30 arc-seconds* (~800 m)
** 30 arc-second version modified to use slope/aspect in radiative calculations*

2. **SNODAS:** SNOw Data Assimilation System, developed by NWS National Operational Hydrologic Remote Sensing Center (NOHRSC). Daily data available from Oct 1, 2003 to present. *Resolution:* 30 arc seconds (~800 m)

3. **SNOTEL:** SNOpack TELemetry network. System for automated snowpack measurements with stations across the Western U.S. Daily data. Longest records in OR/WA extend back ~25 yrs.

REGIONAL-SCALE SENSITIVITIES:

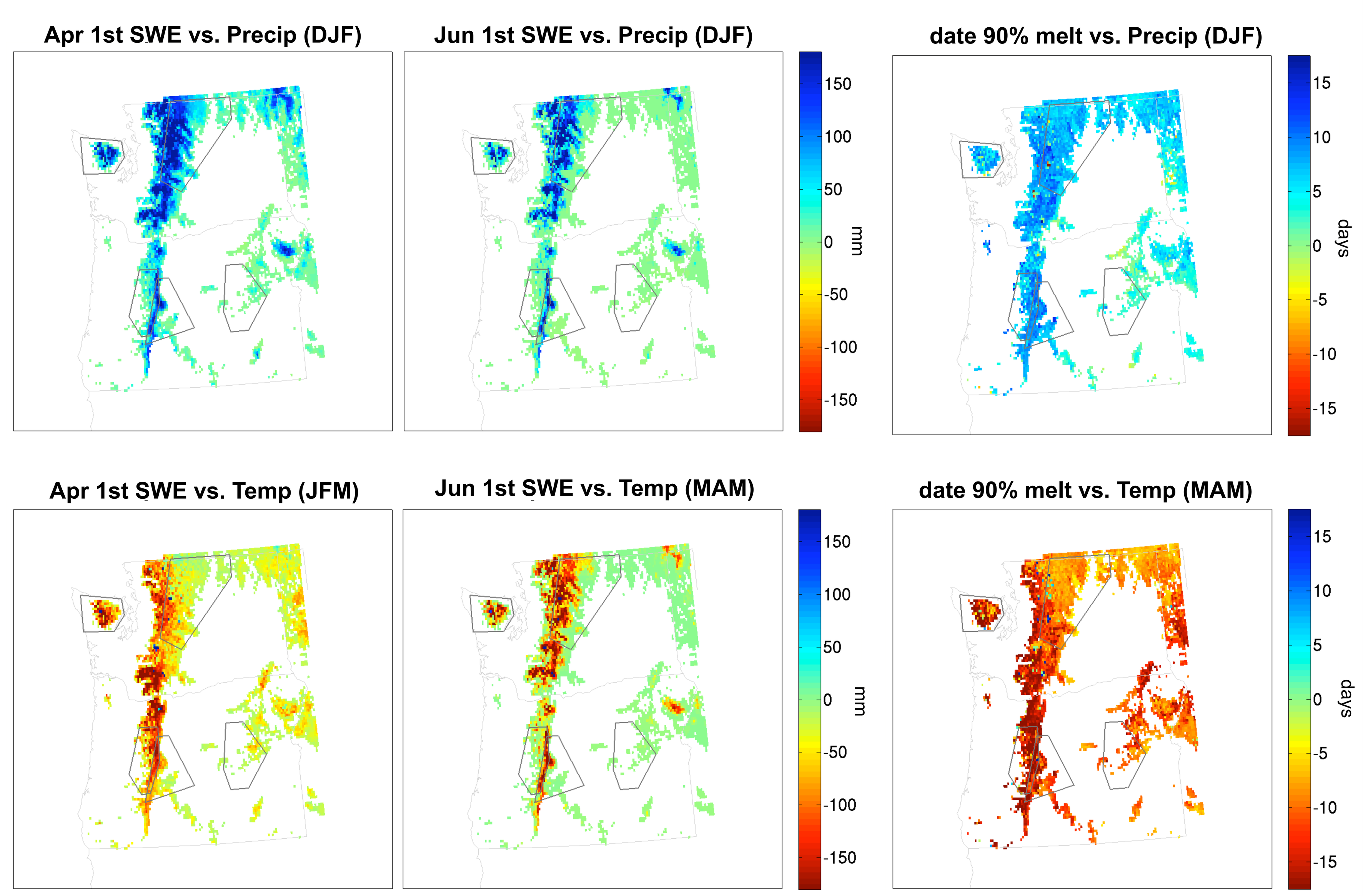


Lagged sensitivities of SWE to regional changes in temperature and precipitation from VIC. Both correlations and regressions are presented in order to highlight both the sensitivity and the absolute magnitude of the associated changes.

Grid-point resolved regressions of SWE and the date of 90% snow melt against regional changes in Mar-Apr-May (MAM) average Temperature (°C) and Dec-Jan-Feb (DJF) total Precipitation (mm).

The slope of the regression is multiplied by the standard deviation in either T or P in order to reflect resultant changes in SWE and melt dates. Note that as a result, regions with greater SWE and more variable melt dates are generally highlighted by the regressions. The same sensitivities are reflected in the correlations, which show generally uniform correlations for all elevated regions.

Pixel-by-pixel Regressions



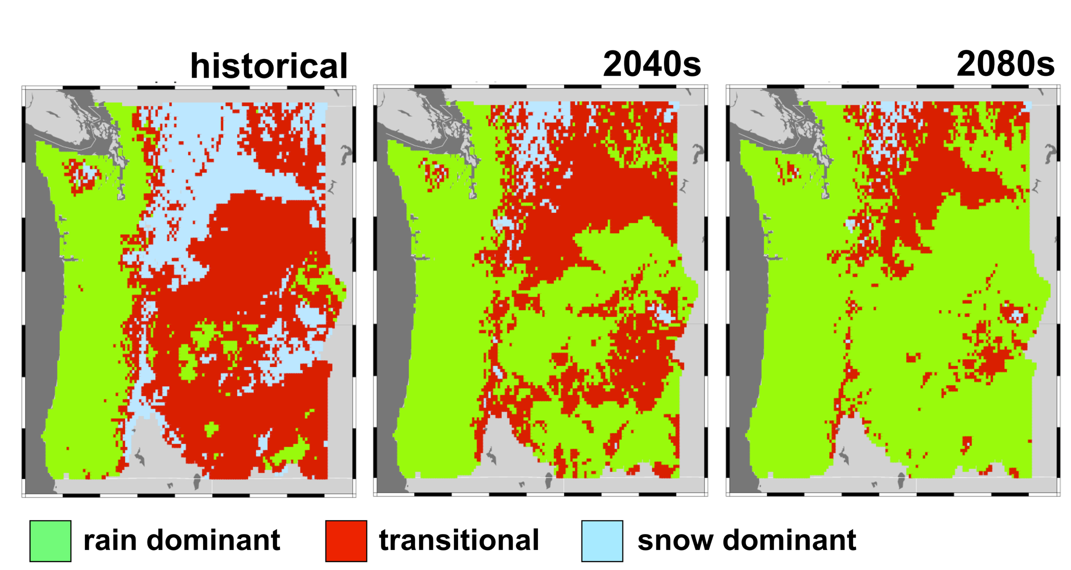
note: regressions only plotted for grid points with Apr 1st SWE > 10 mm

Rain v. Snow dominance:

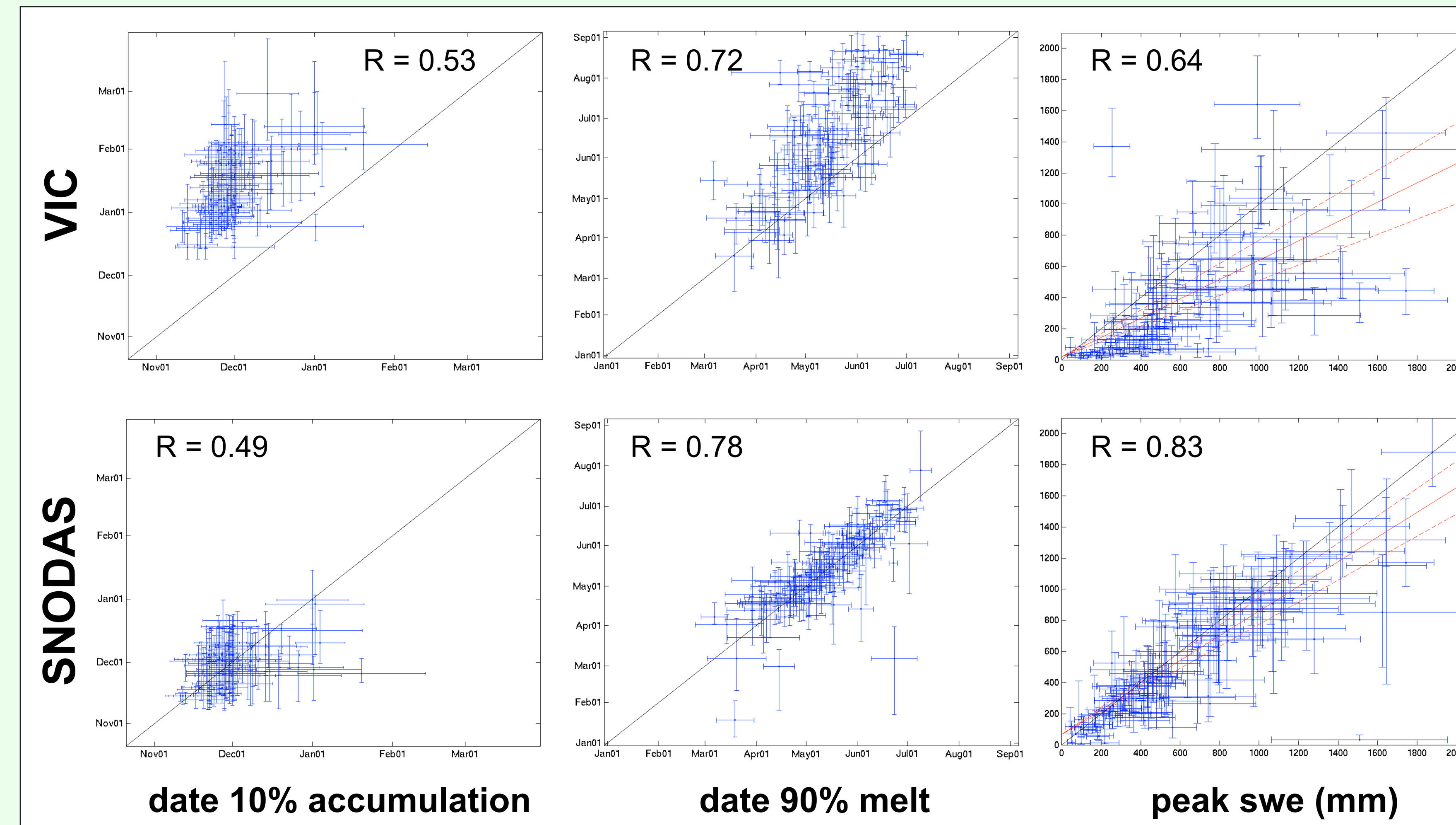
Ratio of April 1st snow water equivalent (SWE) to Oct-Mar total precipitation.

Computed for historical and future projections (A1B scenario, composite deltas for T/P).

April 1st snowpack is strongly linked to summer water availability.



COMPARISON with SNOTEL:



Comparing climatological snowpack from VIC, SNOTEL, and SNODAS. Each point shows the mean and 25th-75th percentile spread.

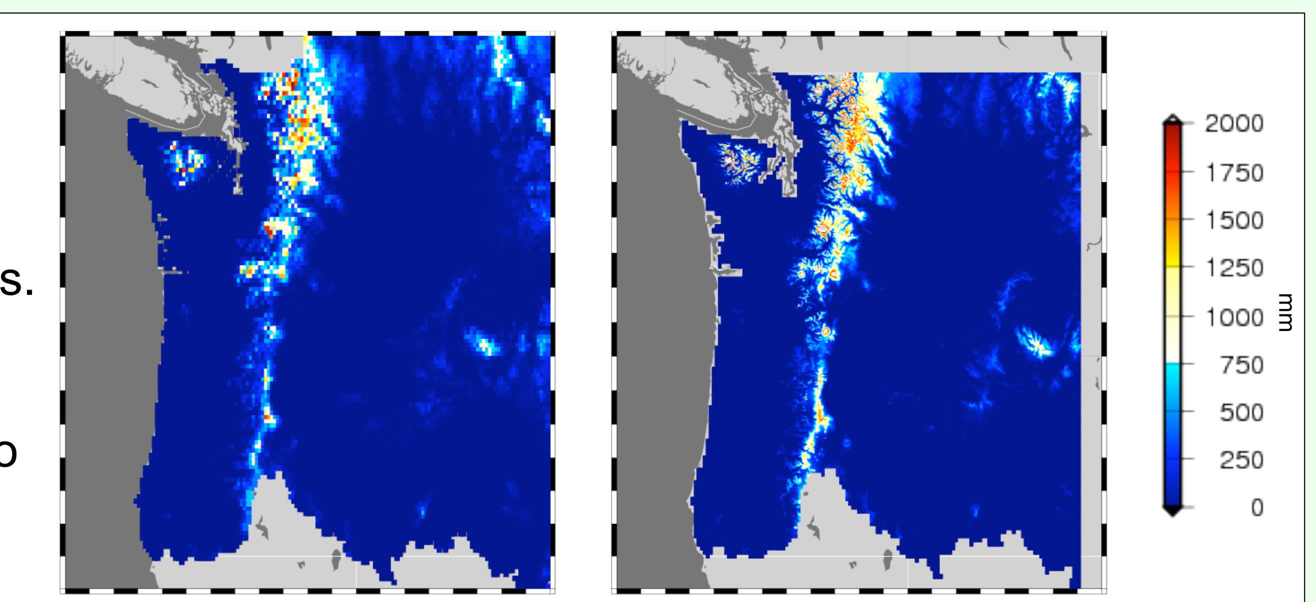
Note the substantial amount of agreement between the three datasets, despite significant differences in data source, measurement type, and resolution.

FINE-SCALE SIMULATIONS:

April 1st SWE

Preliminary results.

Comparing:
1/16th degree to 30 arc-second simulations



CONCLUSIONS:

The broad-scale sensitivities of late-season snowpack do not appear to be very different from those for April 1st. Furthermore, as confirmed by prior studies, VIC appears to faithfully capture the dynamics of snow cover at these scales, and is therefore suitable for assessing sensitivities at regional to smaller scales.

It is likely that snowpack is **also sensitive to more localized processes** related to landscape features and vegetation. However, attempts to associate snowpack persistence with landscape features (e.g., slope, aspect) have not yet not yielded any clear associations in either the VIC or the SNODAS data. (note: this appears to be true for both the 1/16th degree and 30 arc-second VIC simulations, the latter of which do account for the influence of slope and aspect). Possible explanations include the limited horizontal resolution, an incomplete radiative scheme, or confounding influences due to soil and/or vegetation type.

Contact Info: gmauger@uw.edu, (206) 685-0317