Contrasting controls of network scale variability in isotope concentration during dry and very dry! conditions in the Western Cascades

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Introduction

- Understanding the spatiotemporal patterns of streamflow generation and their relationships with catchment characteristics remains one of the key challenges in the prediction of hydrologic behavior.
- Previous research has focused primarily on the prediction of storm events whereas much less attention has been given to baseflow conditions.
- Base flow is critical to the flow generation between events and during dry summers in Mediterranean climate. Furthermore, base flow samples collected during drought conditions can provide important information about the possible effects of climate change.
- Water stable isotopes during base flow provide important information on:
  - a) relative groundwater sources
  - b) hydrologic connectivity
  - c) lapse rates
  - d) the influence of geology and geomorphology on storage.

Study Area

We conducted this study in the H.J. Andrews Experimental Forest in the Western Cascades of Oregon. Annual precipitation varies from 2300 to 3550 mm. The coniferous forest landscape is underlain by rocks of volcanic origin [1]. Glacial, alluvial, and mass movement processes have created deeply dissected, locally steep drainage systems [2].

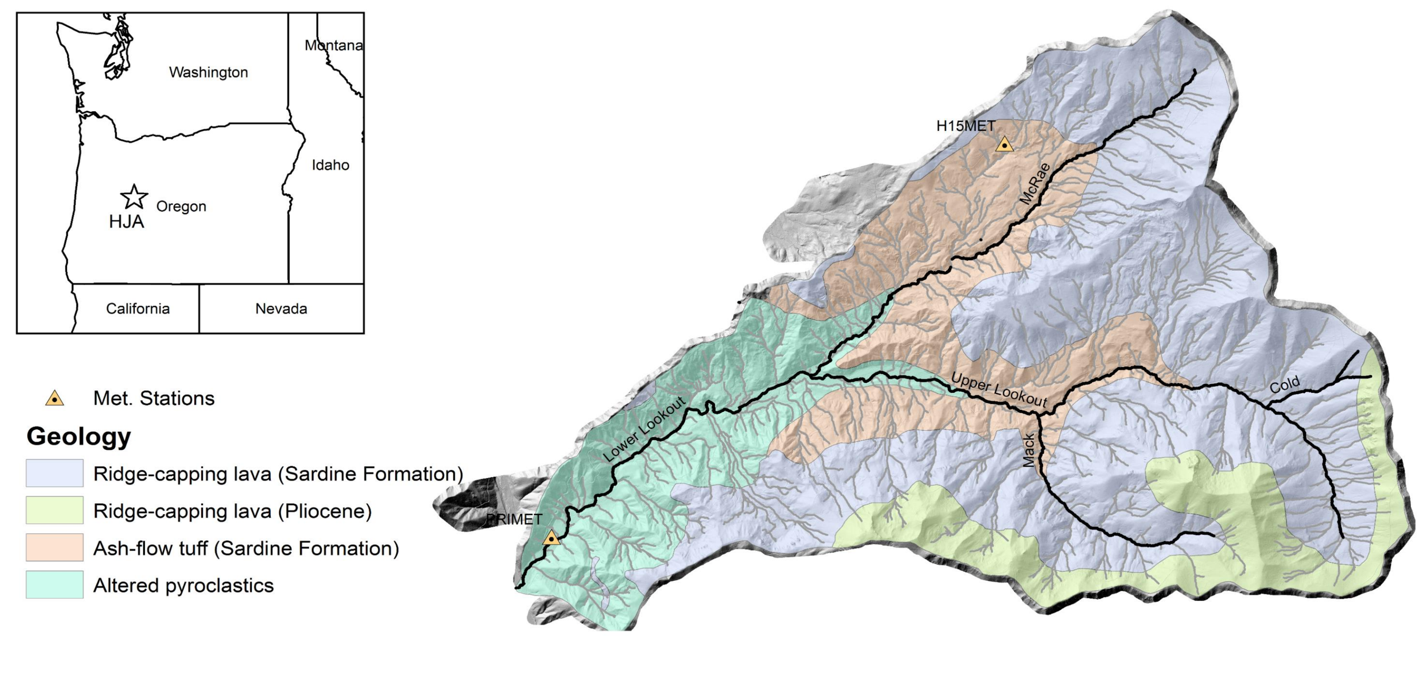

Fig. 1. Location and Geology of the H.J. Andrews Experimental Forest.

Methods

- We collected 607 grab samples over the network during 3 campaigns (Sep, 2015, June 2016, and Aug 2016).
- The 3 campaigns represent different moisture levels. Mean discharge in Lookout Creek, was 2.2 m^3/s (7th lowest) in 2015 and 3 m^3/s (19th lowest) in 2016 (considering a 59 yr record).
- Composite precipitation samples were collected ~twice a month between 2014 and 2016 at 2 locations (430 and 922 m.a.s.l.)
- The isotope concentrations were analyzed in terms of elevation lapse rates, spatial variability, and the relative contribution of main tributaries.
- We predicted isoscapes using Spatial Stream Network Models [3,4] considering landscape and local processes.

Results

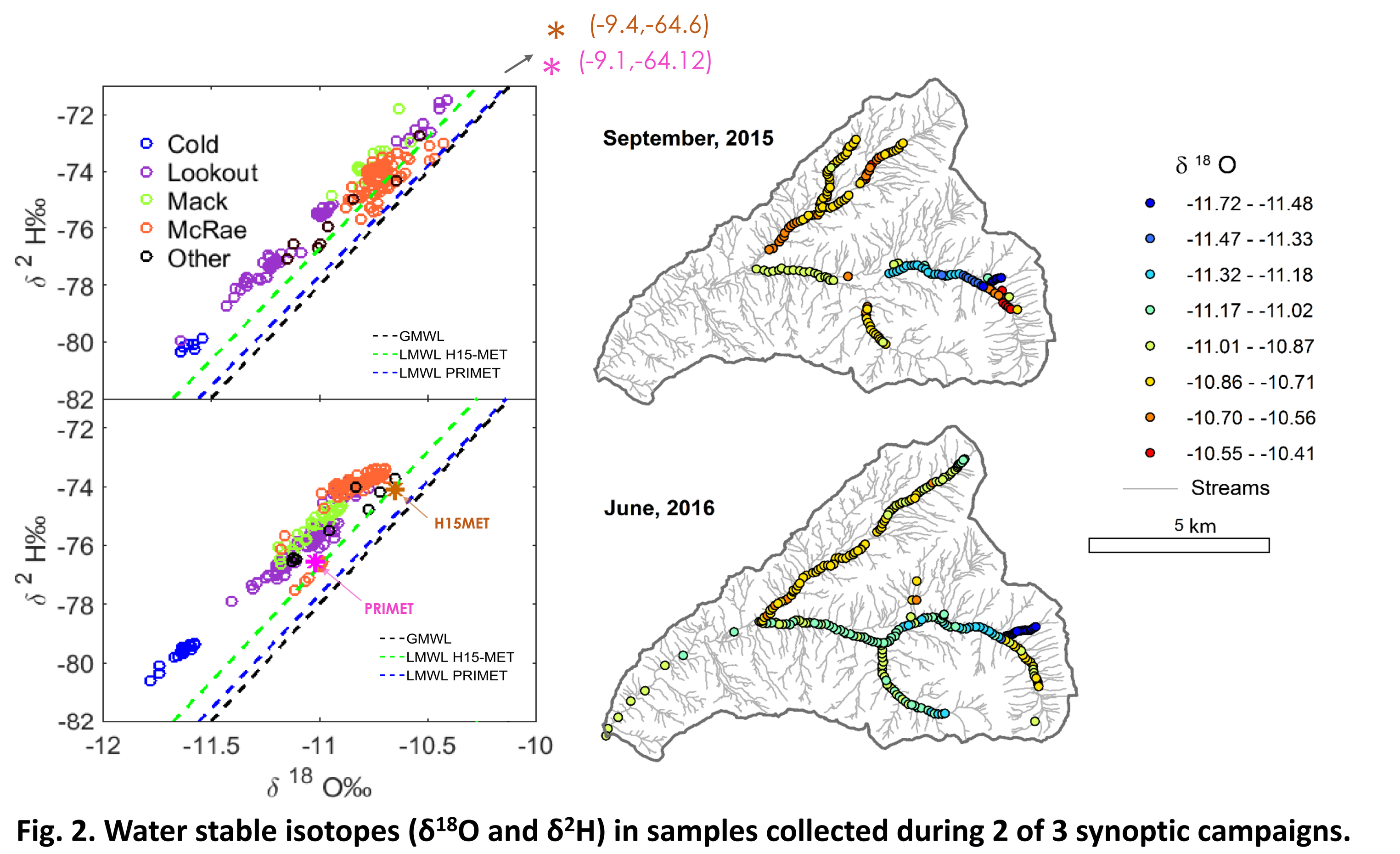

Fig. 2. Water stable isotopes ($\delta^{18}O$ and $\delta^{2}H$) in samples collected during 2 of 3 synoptic campaigns.

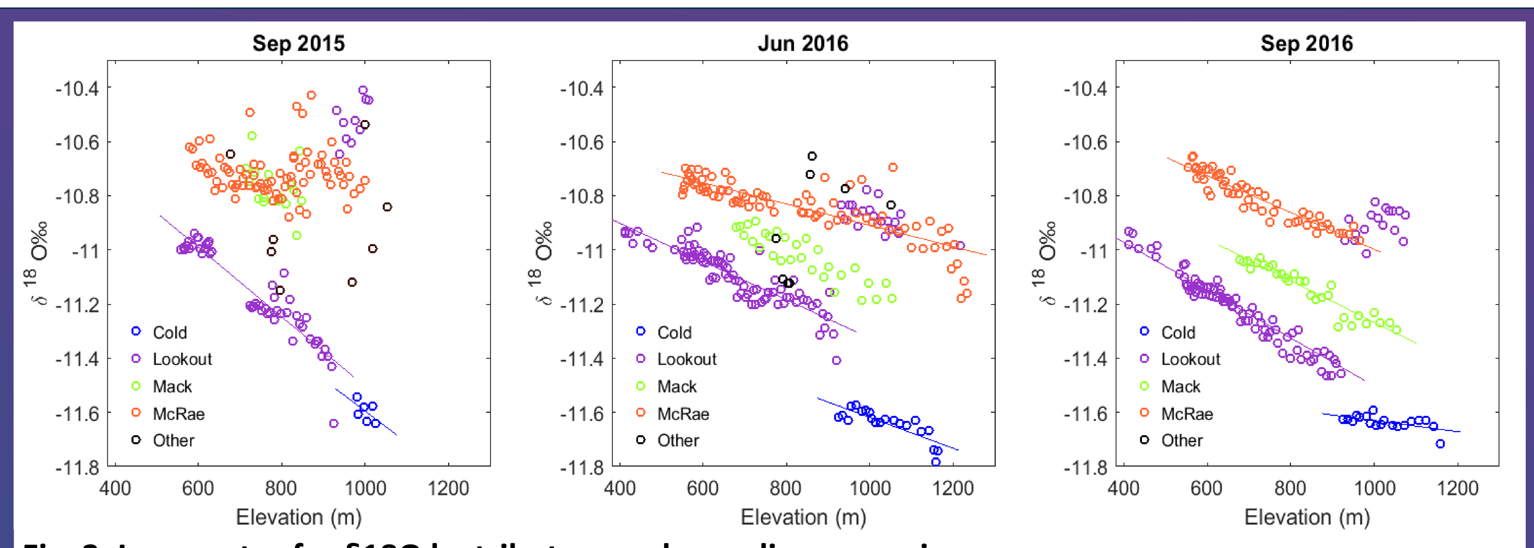

Fig. 3. Lapse rates for δ18O by tributary and sampling campaign.

- Weaker relations in 2015 (drought conditions) compared to 2016.
- The relations for Lookout below Cold Creek are consistently strong.

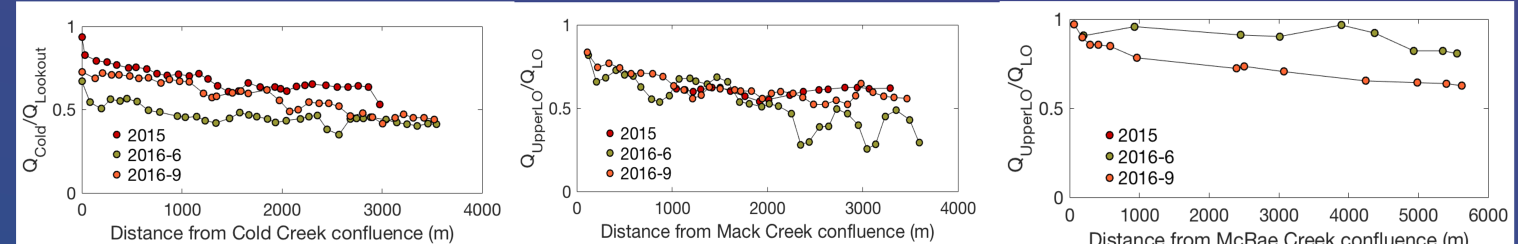

Fig. 4. Relative contribution of Cold Creek to Upper Lookout (a), and of upper lookout to Lookout before (b) and after (c) the confluence with McRae

A two-end member-mixing model indicated that the contribution of Cold Creek to the total discharge between its confluence and Mack Creek varies between 41-94%.
The contribution of Upper Lookout to Lookout between Mack and McRae varies between 54-62%, whereas below McRae Creek is above 95%.

Spatial Variability

McRae: Low variability in $\delta^{18}O$ & ^{2}H in 2015 and exponential increases in 2016.

Lookout: Evidence for the isotopic control of Cold Creek. The inflection at ~1700 indicates fine-scale patchiness imbedded within a broad-scale gradient.

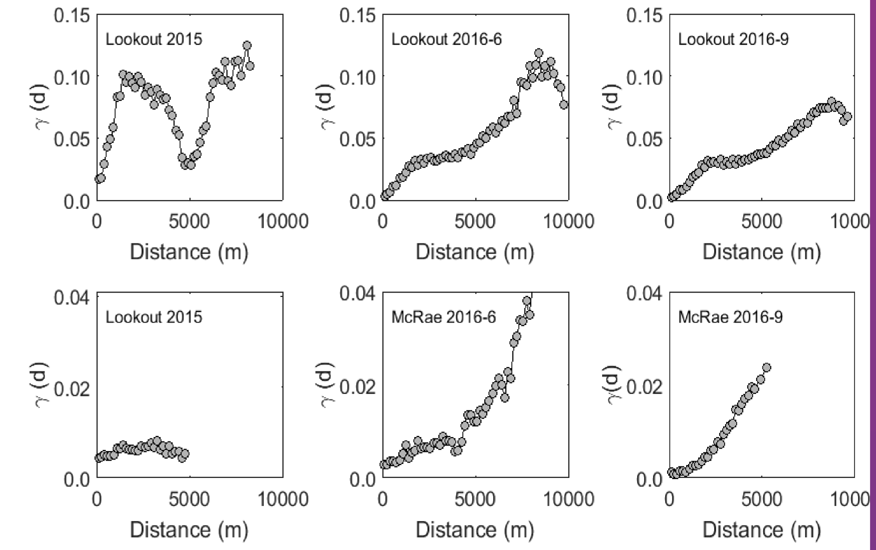

Fig. 5 Semivariograms (spatial Variability prior to modeling)

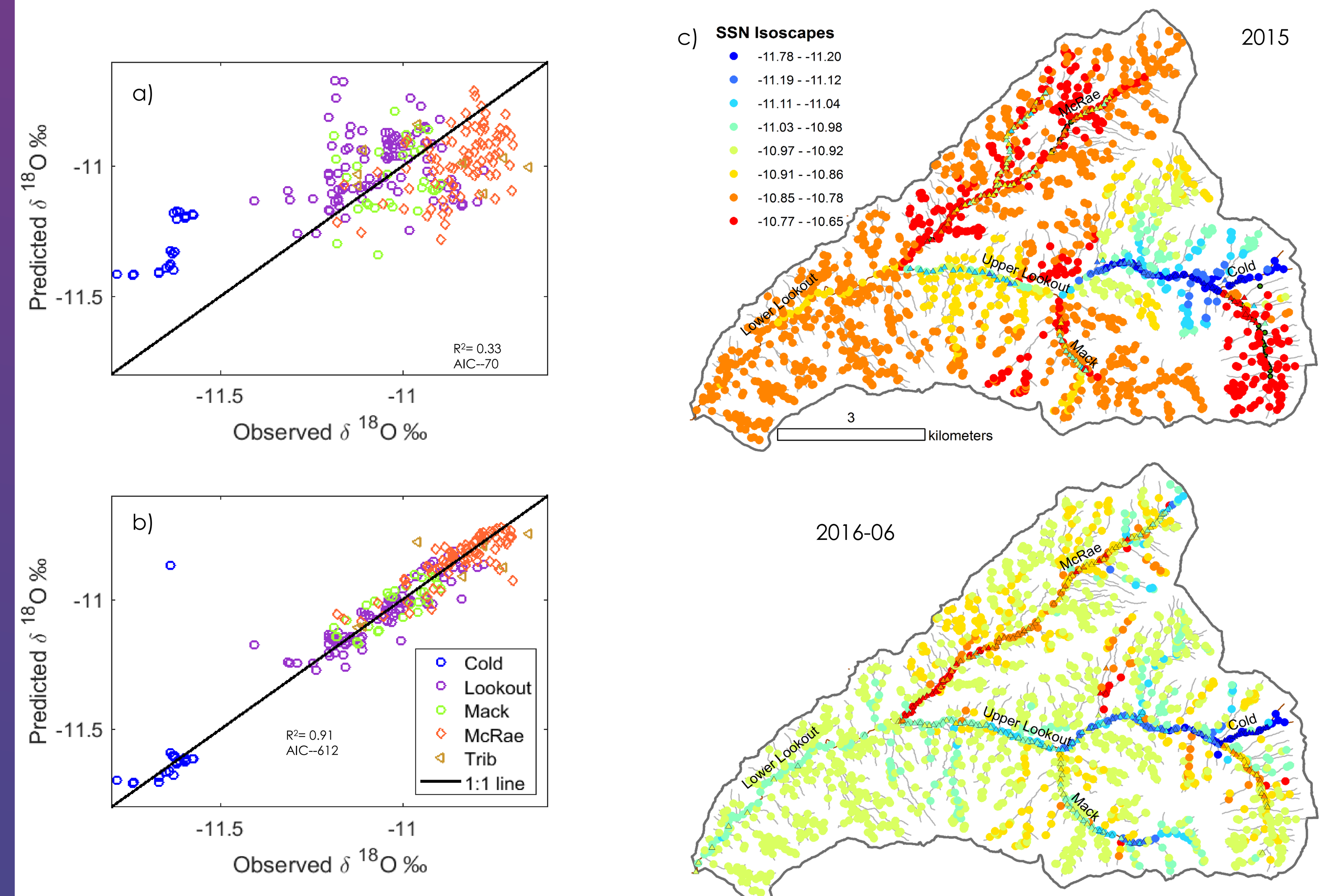

Fig. 6. Best linear model to predict $\delta^{18}O$ (2016-06) based on elevation, geology, roughness, and slope a) and best SSN model b). Panel c) presents Isoscapes for 2015 and 2016-06 (colored triangles are observations). Both SSN models (R^2>0.85) include roughness as a covariate.

Conclusions

- Strong differences in isotopic concentrations were detected between McRae and Lookout creeks.
- Isotopic lapse rates in 2015 were weak indicating stronger dependency on local storage than atmospheric inputs.
- Cold Creek, which occupies 4.5% of the basin, provides a remarkably high water contribution to downstream flow.
- Isoscapes were well predicted by the Spatial Stream Network Models based on local roughness revealing dramatic differences between 2015 and 2016.

Acknowledgments

Thanks to Sam Swanson and Stanley French for collecting many of the water samples, the HJA Long Term Ecological Research (LTER 7 –NSF Award # 1440409). The College of Forestry for providing funding for J. Tenny though the Mentored Employment Program; to Julia Jones and Fred Swanson for insightful discussions about the Andrews Forest, and to Erin Peterson, Jay Ver Hoef, and Daniel Isaak for discussions about the application of Spatial Stream Network models.

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