Climate-Aquatics Blog #21: Lots more to know regarding the flow

Hi Everyone,
So wrapping up the hydrology module with a few miscellaneous thoughts this time out….

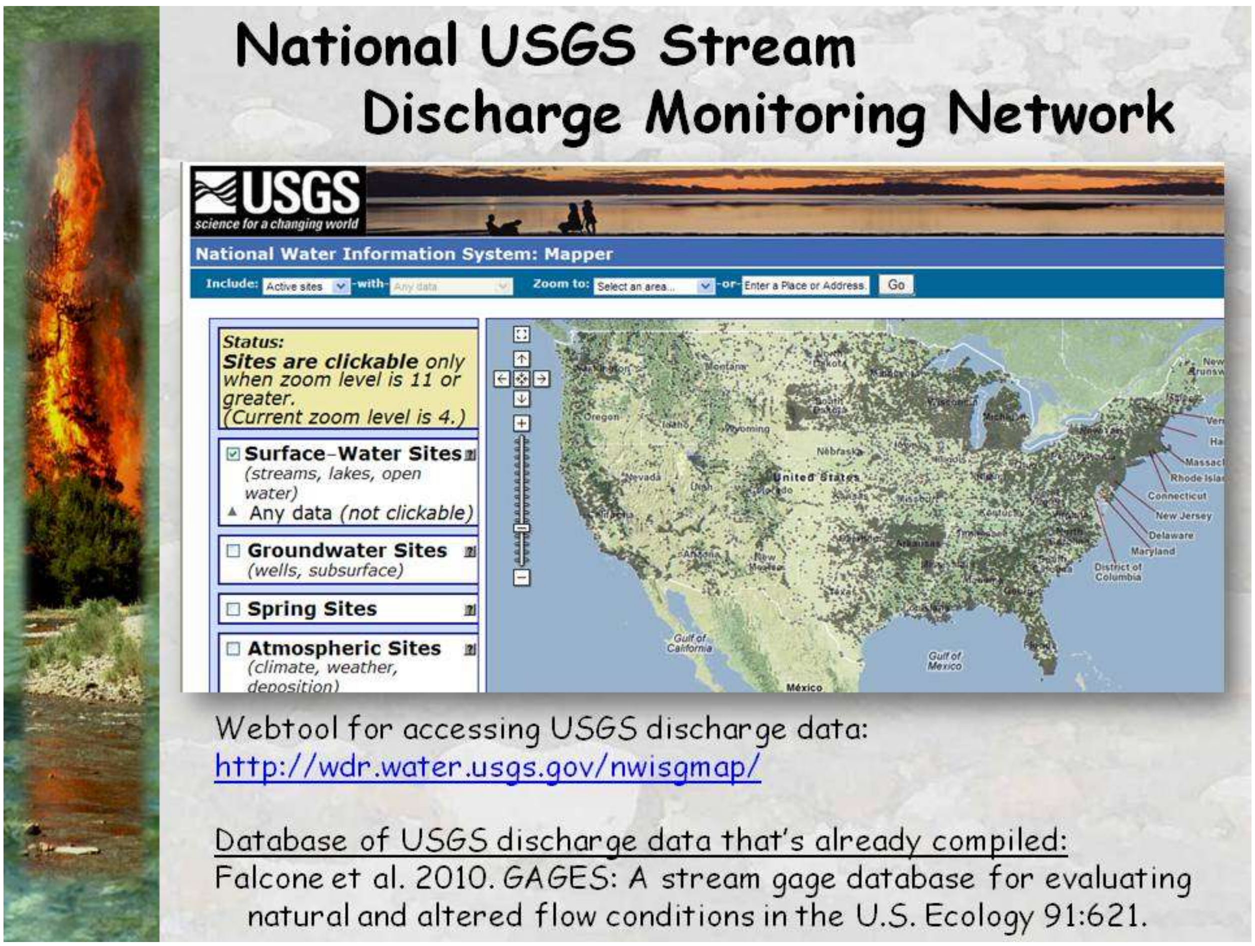
As you might recall from previous blog posts in this module since last September, we actually know quite a bit regarding how stream discharges are evolving across the western US in response to climate change. Warmer temperatures are causing snowpacks to shrink in many places (blog #16), streams are running off sooner, flood risks are changing (blog #17), summer flows are trending lower for a variety of reasons, of which climate is likely one (blog #18), groundwater inputs may or may not buffer some streams against these changes (blog #19), and GIS tools exist for mapping historical trends and future discharge scenarios in streams across the region (blog #20). Fundamental to most of what we can infer regarding long-term trends are the empirical measurements of stream discharge that are routinely taken at thousands of stream gages (~10,000) long maintained by the USGS and a few other agencies across the country (graphic 1).

Thousands of monitoring sites sounds like a lot but these sites are not uniformly distributed in space, nor were they originally set up in association with any sort of probabilistic statistical design that would be representative of the river and stream networks across the U.S. so there are important limits regarding the information this network can ultimately yield. Moreover, there are literally 100,000's, perhaps more than a million, stream kilometers across the U.S. that the existing gage network has to provide information about. Just as a small sub-regional example of the disparity between the magnitude of stream networks and number of monitoring sites, graphic 2 summarizes what the full stream network across Montana and northern Idaho looks like when the composite stream segments are plotted by their contributing areas and elevations. That universe consists of more than 300,000 stream kilometers, yet it's presently monitored by only about 400 active gages, which translates to 1 gage for every 750 kilometers of stream.

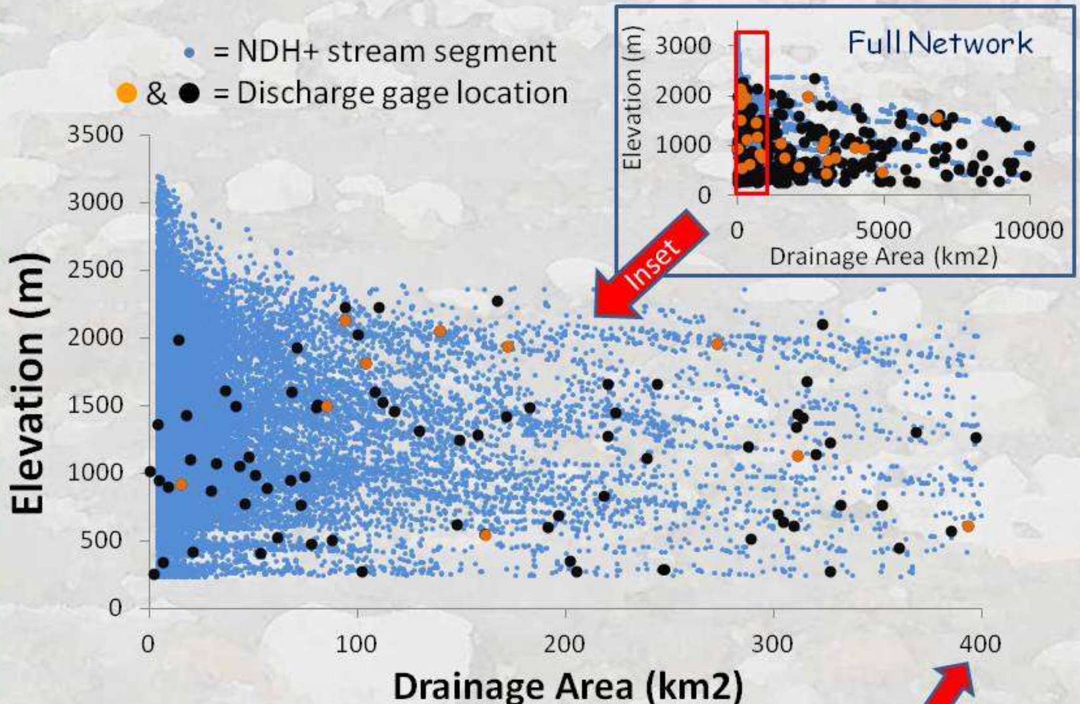
No doubt, monitoring even at low densities, especially when maintained for as many years as discharge gages often are, provides invaluable information. But a low sampling density also means that the existing network is best at describing only the most general things about regional patterns and the places being monitored. Discharge measured at the outlet of a basin integrates across many places doing different things at different times, and one of the primary challenges hydrologists face is how to determine what is going on in the places that are not measured. Models can help us estimate different flow patterns in different parts of the basin (blog #20) but validation at finer resolution is also necessary to test and refine the models. As was the case with stream temperature monitoring (blog #'s 3, 4, 8, 9), new sensor technologies now make it possible to collect accurate discharge data more cost-effectively than was historically the case (graphic 3). These sensors might be used to densify the existing discharge monitoring network in key ways that enable important questions to be addressed with relatively small investments of time and money if done with proper forethought.

So that's it for the hydrology module, but did want to give a random shout-out to a great paper by Olden & Poff (2003), which is a meta-analysis that examined and synthesized all the different ways that stream discharge has been quantified to describe hydraulic regimes. They threw 171 different discharge metrics into a multivariate analyses to describe their common variability and most were proven to be highly redundant (graphic 4). This suggests it's possible to describe the core attributes associated with a regime through a much smaller set of relevant descriptors. Things aren't quite there yet with regards to stream temperatures because we have so little full year data that "regime" thinking isn't quite as far along (see Poole et al. 2003 for an important exception), but we've got a good start on a confusing & redundant mix of summer temperature metrics that all carry pretty much the same information. Hopefully before lots of full year stream temperature data start coming online from the massive regional monitoring networks now in place (blog #4), someone will put good thought into developing a concise but fully descriptive set of temperature metrics that describe thermal regimes so we don't get to 171. Having a common lexicon with which we all speak "temperature" would be a very useful thing since we'll be doing a lot of it this century.

Until next time, best regards.
Dan

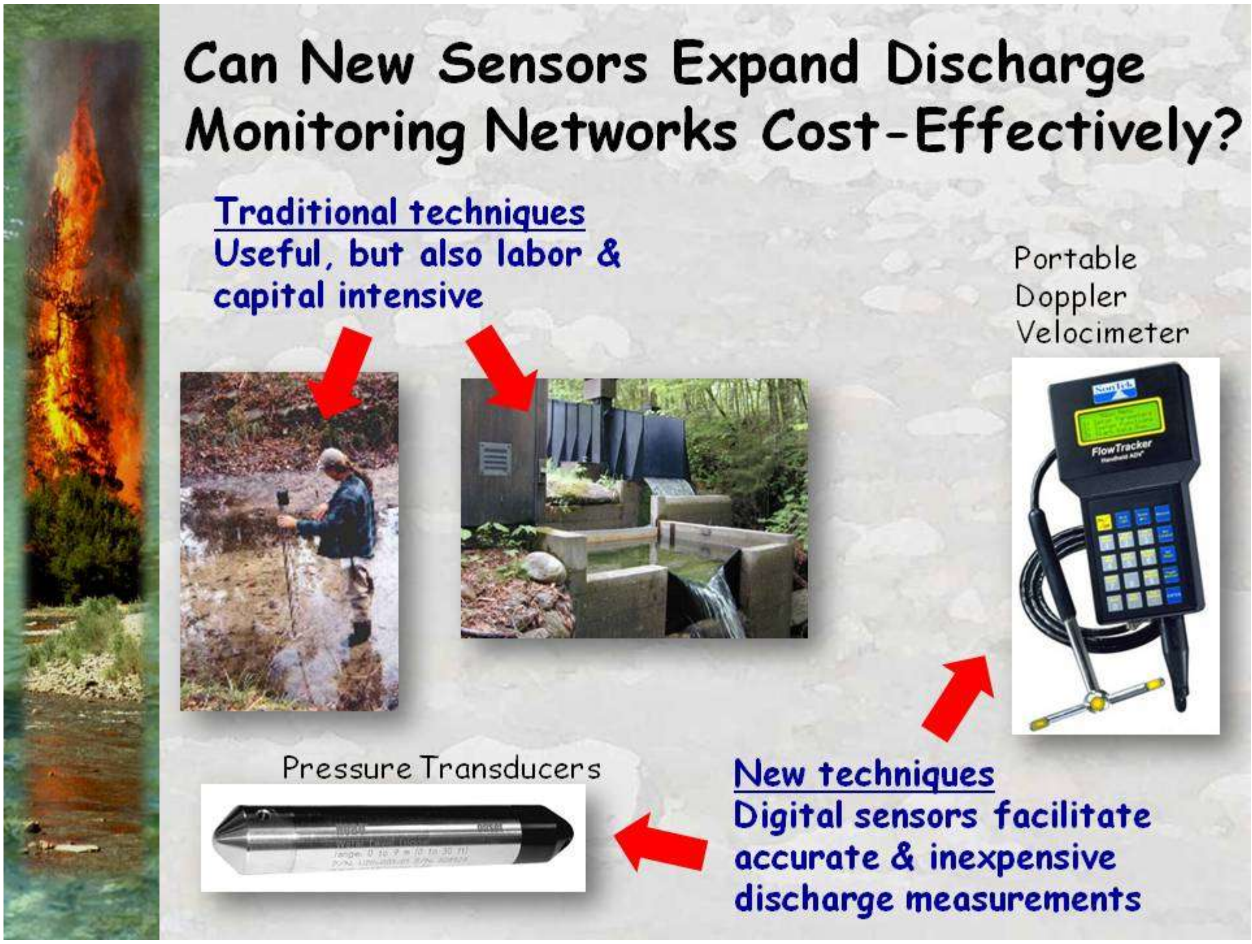


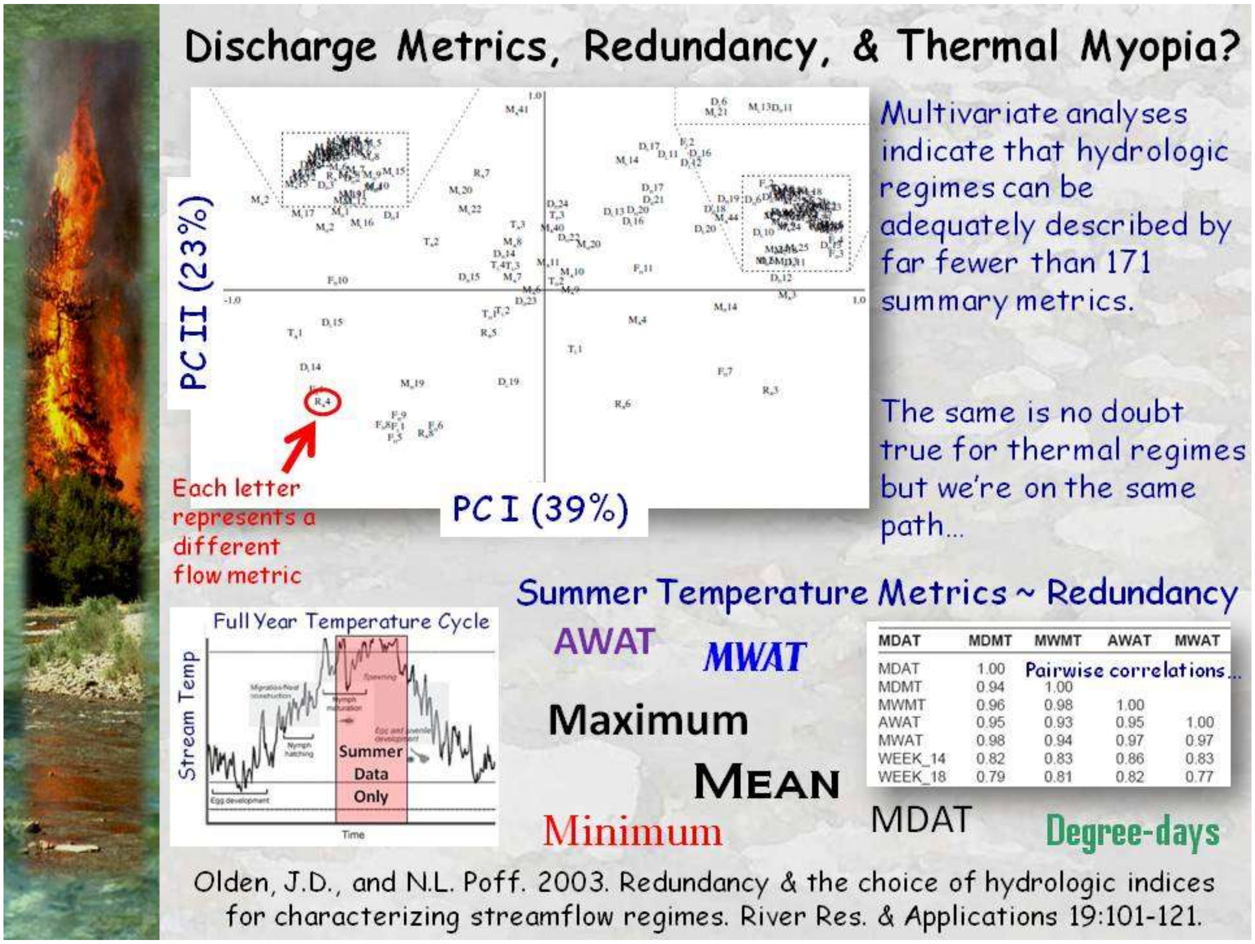
Stream Discharge Monitoring vs. the Stream Network Universe



300,000+ stream kilometers comprise the drainage network across Montana and northern Idaho, yet only 400 gages actively monitor discharge in network.

X-axis truncated to enhance visibility of stream segments


Can New Sensors Expand Discharge Monitoring Networks Cost-Effectively?
Traditional techniques
Useful, but also labor & capital intensive
Portable Doppler Velocimeter
FlowTracker
Pressure Transducers
New techniques
Digital sensors facilitate accurate & inexpensive discharge measurements



Welcome to the Climate-Aquatics Blog. For those new to the blog, previous posts with embedded graphics can be seen by clicking on the hyperlinks at the bottom or by navigating to the blog archive webpage on our Forest Service site at: (http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temp/stream_temperature_climate_aquatics_blog.html). To discuss these topics with other interested parties, a Google discussion group has also been established and instructions for joining the group are also on the webpage. The intent of the Climate-Aquatics Blog and associated discussion group is to provide a means for the 3,285 (& growing) field biologists, hydrologists, anglers, students, managers, and researchers currently on this mailing list across North America, Europe, and Asia to more broadly and rapidly discuss topical issues associated with aquatic ecosystems and climate change.

Messages periodically posted to the blog will highlight new peer-reviewed research and science tools that may be useful in addressing this global phenomenon. Admittedly, many of the ideas for postings have their roots in studies I and my colleagues have been a part of in the Rocky Mountain region, but attempts will be made to present topics & tools in ways that highlight their broader, global relevance. Moreover, I acknowledge that the studies, tools, and techniques highlighted in future missives are by no means the only, or perhaps even the best, science products in existence on particular topics, so the hope is that this discussion group engages others doing, or interested in, similar work and that healthy debates & information exchanges will occur to facilitate the rapid dissemination of knowledge among those most concerned about climate change and its effects on aquatic ecosystems.

If you know of others interested in climate change and aquatic ecosystems, please forward this message and their names can be added to the mailing list for notification regarding additional science products on this topic. If you do not want to be contacted regarding future such notifications, please reply to that effect and you will be removed from this mailing list.

Previous Posts

Climate-Aquatics Overviews

Blog #1: Climate-aquatics workshop science presentations available online
Blog #2: A new climate-aquatics synthesis report

Climate-Aquatics Thermal Module

Blog #3: Underwater epoxy technique for full-year stream temperature monitoring
Blog #4: A GoogleMap tool for interagency coordination of regional stream temperature monitoring
Blog #5: Massive air & stream sensor networks for ecologically relevant climate downscaling
Blog #6: Thoughts on monitoring air temperatures in complex, forested terrain
Blog #7: Accurate downscaling of climate change effects on river network temperatures through use of inter-agency temperature databases and application of new spatial statistical stream models
Blog #8: Thoughts on monitoring designs for temperature sensor networks across river and stream basins
Blog #9: Assessing climate sensitivity of aquatic habitats by direct measurement of stream & air temperatures
Blog #10: Long-term monitoring shows climate change effects on river & stream temperatures
Blog #11: Long-term monitoring shows climate change effects on lake temperatures
Blog #12: Climate trends & climate cycles & weather weirdness
Blog #13: Tools for visualizing local historical climate trends
Blog #14: Leveraging short-term stream temperature records to describe long-term trends
Blog #15: Wildfire & riparian vegetation change as the wildcards in climate warming of streams

Climate-Aquatics Hydrology Module

Blog #16: Shrinking snowpacks across the western US associated with climate change
Blog #17: Advances in stream flow runoff and changing flood risks across the western US
Blog #18: Climate change & observed trends toward lower summer flows in the northwest US
Blog #19: Groundwater mediation of stream flow responses to climate change
Blog #20: GIS tools for mapping flow responses of western U.S. streams to climate change

Future topics…

Climate-Aquatics Biology Module
Climate-Aquatics Management Module