Climate-Aquatics Blog #17: It's the same but different. Why context matters for stream responses to climate change

Hi Everyone,
So this week we're down in the stream to start looking at trends in stream flow runoff relative to climate change. And here, in contrast to stream temperatures or virtually any other type of stream dataset, we are blessed to have long-term monitoring data from an extensive network of flow gages that USGS and other entities established many decades ago. Being able to simply look for, and describe, long-term trends in real data significantly reduces many of the uncertainties & complexities that are otherwise involved with using models to reconstruct temporal or spatial trends.

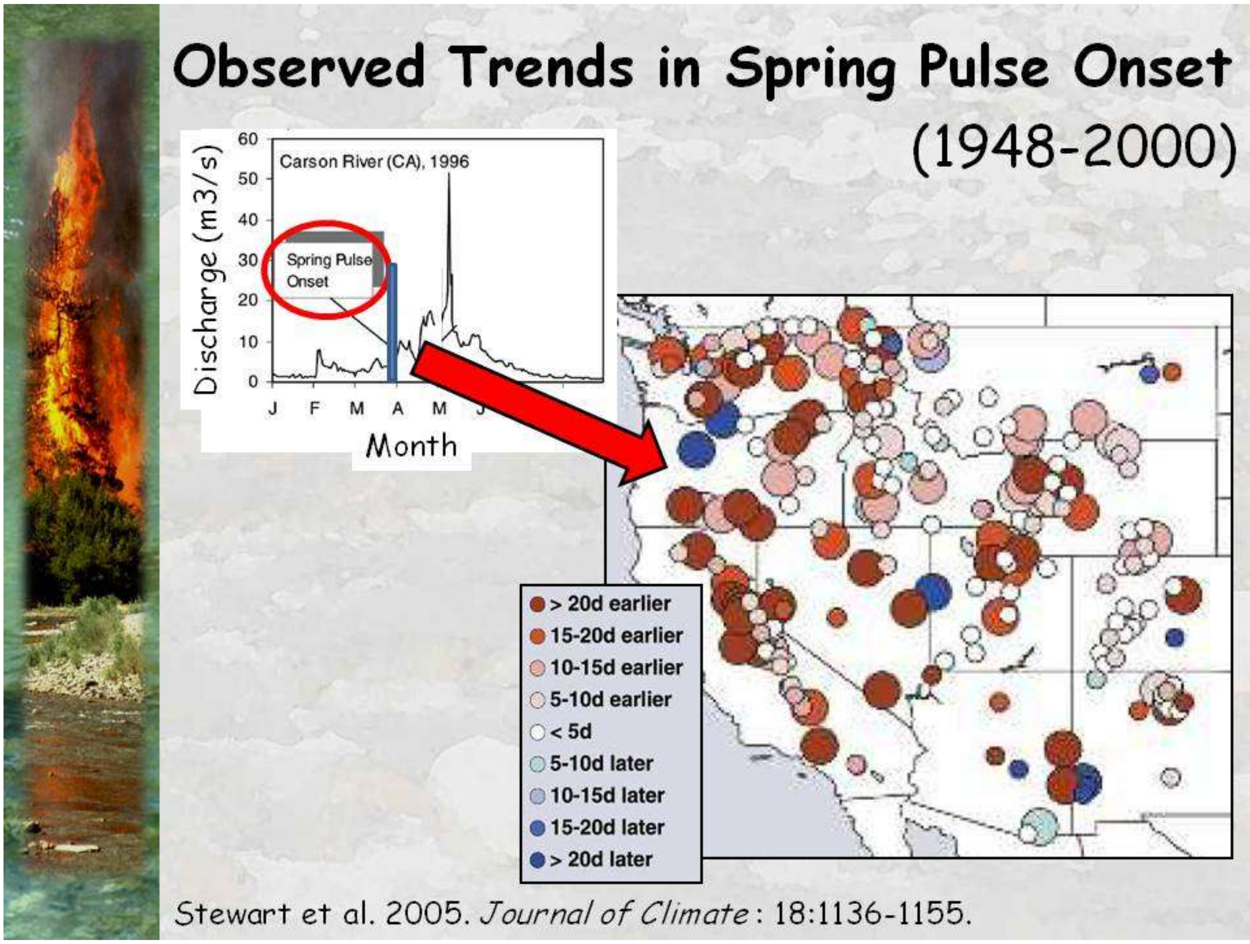
The first study we'll look at is by Iris Stewart and colleagues who examined trends at more than 300 minimally altered flow gage sites across the western US over a 55 year period. They looked at several flow parameters, but we'll focus on two they highlighted, the timing of the spring pulse onset (i.e., the date when flows start to increase each year from snowmelt) and the timing of the center of flow mass (i.e., the date when half the year's flow volume has occurred). In both cases, their data suggest broadly coherent, regional trends toward earlier runoff dates in snow-fed streams as one might expect with warming temperatures (graphics 1 and 2). The pattern is not universal, with spring onsets actually occurring later in some streams (we'll explore factors contributing to these local anomalies in a subsequent post) or not showing much of a response. The non-responders are often clustered in some of the highest elevation areas (e.g., Colorado, the High Sierras, parts of WY/ID/MT), which makes sense, given that air temperatures are well below freezing there, and as we saw last week with the Mote paper, snowpacks in the coldest places aren't yet showing decreasing trends. Even with all this noise, however, the average snowmelt driven stream in the western US now appears to be running off 2 – 3 weeks earlier than it was a half century ago.

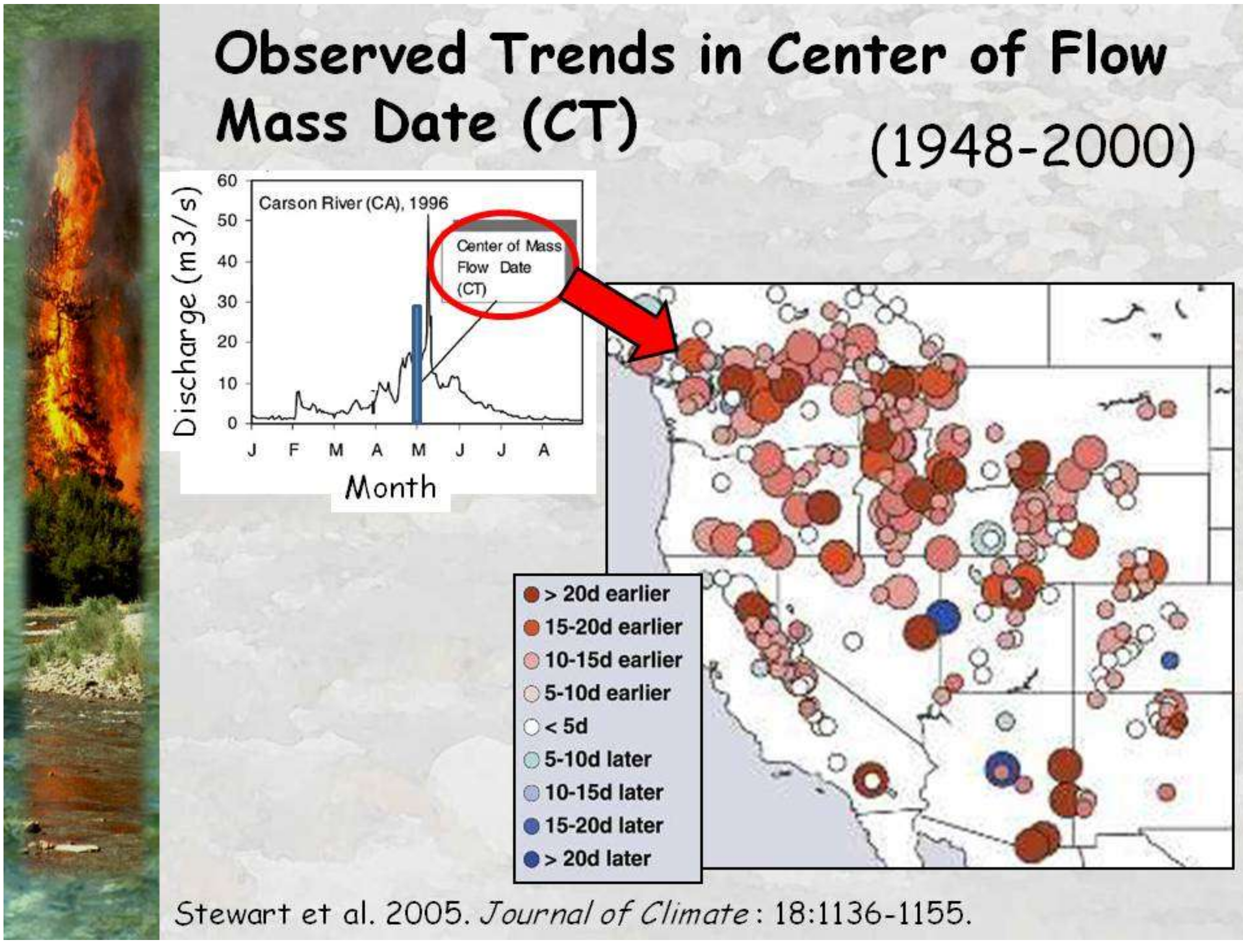
With a broadly consistent pattern like that, I would have expected a similarly consistent response in peak flows and flood risks (but I'm a fish biologist, so what do I know?). Our second study by Alan Hamlet and Dennis Lettenmaier, however, shows such consistency is not the case, at least at first glance. Rather than all or most streams moving in a similar fashion, they break into response classes that depend largely on their basin elevations relative to the mid-winter freezing threshold. In the highest elevation basins, the frequency of 20-year floods actually decreased slightly during the 20th century (graphic 3); whereas low elevation, warm basins show little change because precipitation was already occurring as rainfall rather than snow. The most interesting systems are those basins at intermediate elevations and temperatures where the winter precipitation regime has historically been a mix of snow and rain. As things warm up & these areas shift gradually towards greater rainfall fractions, flood frequencies have actually increased during the last century.

So I'm glossing over many of the details here regarding the various mechanisms that are involved, and I'd encourage you to read the papers if interested in better understanding those details and important uncertainties. There is, however, a broader point that these two papers illustrate nicely and which I'll conclude with. It takes us back to the title of this post, which alludes to the fact that as we impose a strong, relatively consistent and prolonged warming signal on landscapes and biotas globally, we won't necessarily always see a consistent, easily predictable response (though in many cases we will). Those responses will ultimately depend on the local context, complex biophysical interactions, and the proximity of resources we care about to important thresholds. This complexity could be a source of consternation, or we could instead use it as an opportunity to learn more about aquatic ecosystems that wasn't possible in a world characterized by a dynamic equilibrium. All systems are being perturbed to a greater or lesser extent in the global experiment we're running and that should lend itself to making specific, testable predictions about system responses to climate forcing. Through the deployment & maintenance of detailed, long-term monitoring networks and development of accurate models from these data, we'll be able to continually assess and revise those predictions over the spans of our careers to refine our knowledge of aquatic ecosystems.

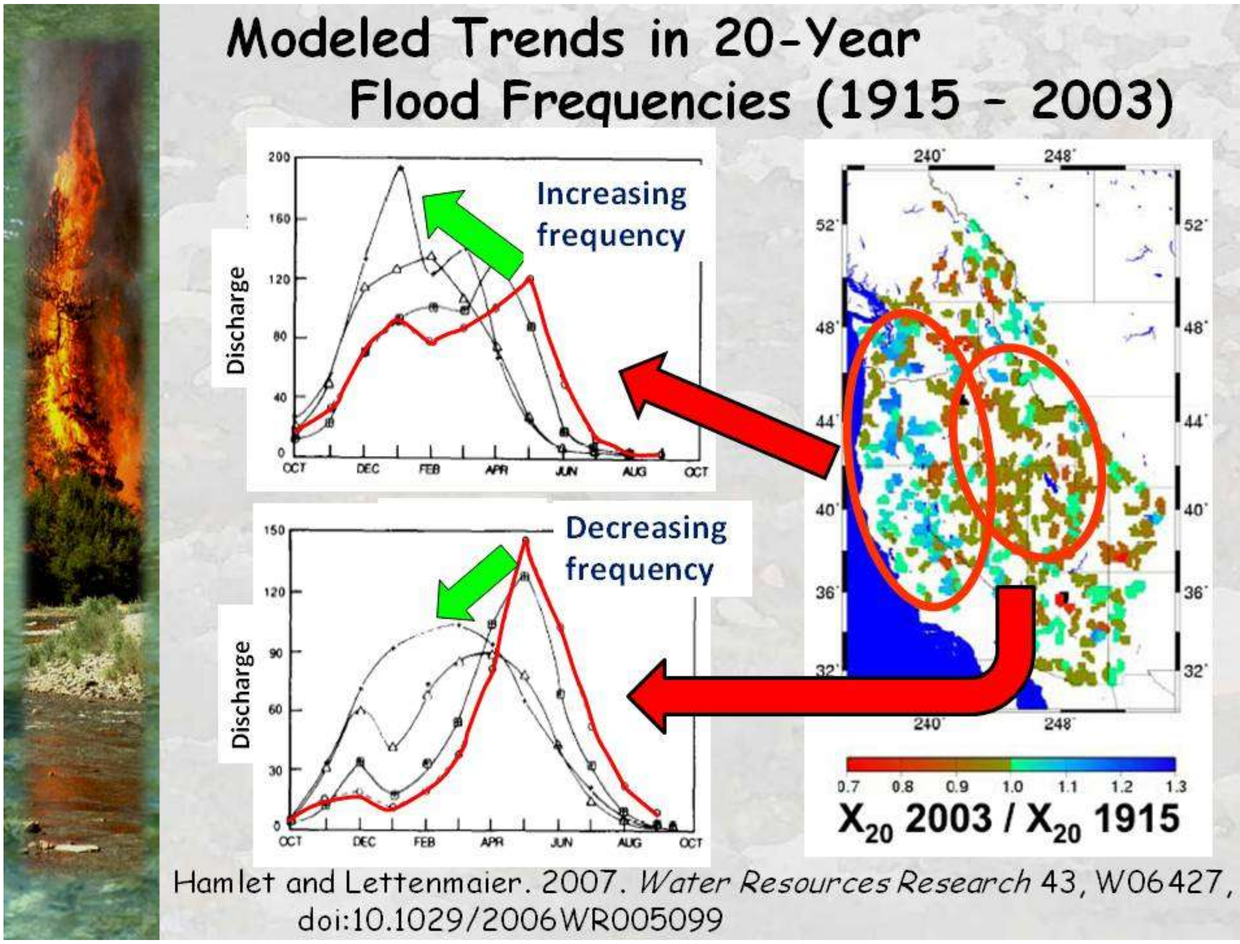
Until next time, best regards,

Dan





Observed Trends in Center of Flow Mass Date (CT)
(1948-2000)
Carson River (CA), 1996
Center of Mass Flow Date (CT)
Discharge (m3/s)
60
50
40
30
20
10
0
J F M A M J J A
Month
> 20d earlier
15-20d earlier
10-15d earlier
5-10d earlier
< 5d
5-10d later
10-15d later
15-20d later
> 20d later
Stewart et al. 2005. Journal of Climate : 18:1136-1155.



Welcome to the Climate-Aquatics Blog. For those new to the blog, previous posts can be seen by clicking on the hyperlinks below or by navigate to the blog webpage at this hyperlink (Climate-Aquatics Blog). 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 2,300 (& 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

Future topics…

Climate-Aquatics Biology Module
Climate-Aquatics Management Module