Monitoring the Snowpack in Remote, Sparsely Gauged, Snow-Dominated Mountains

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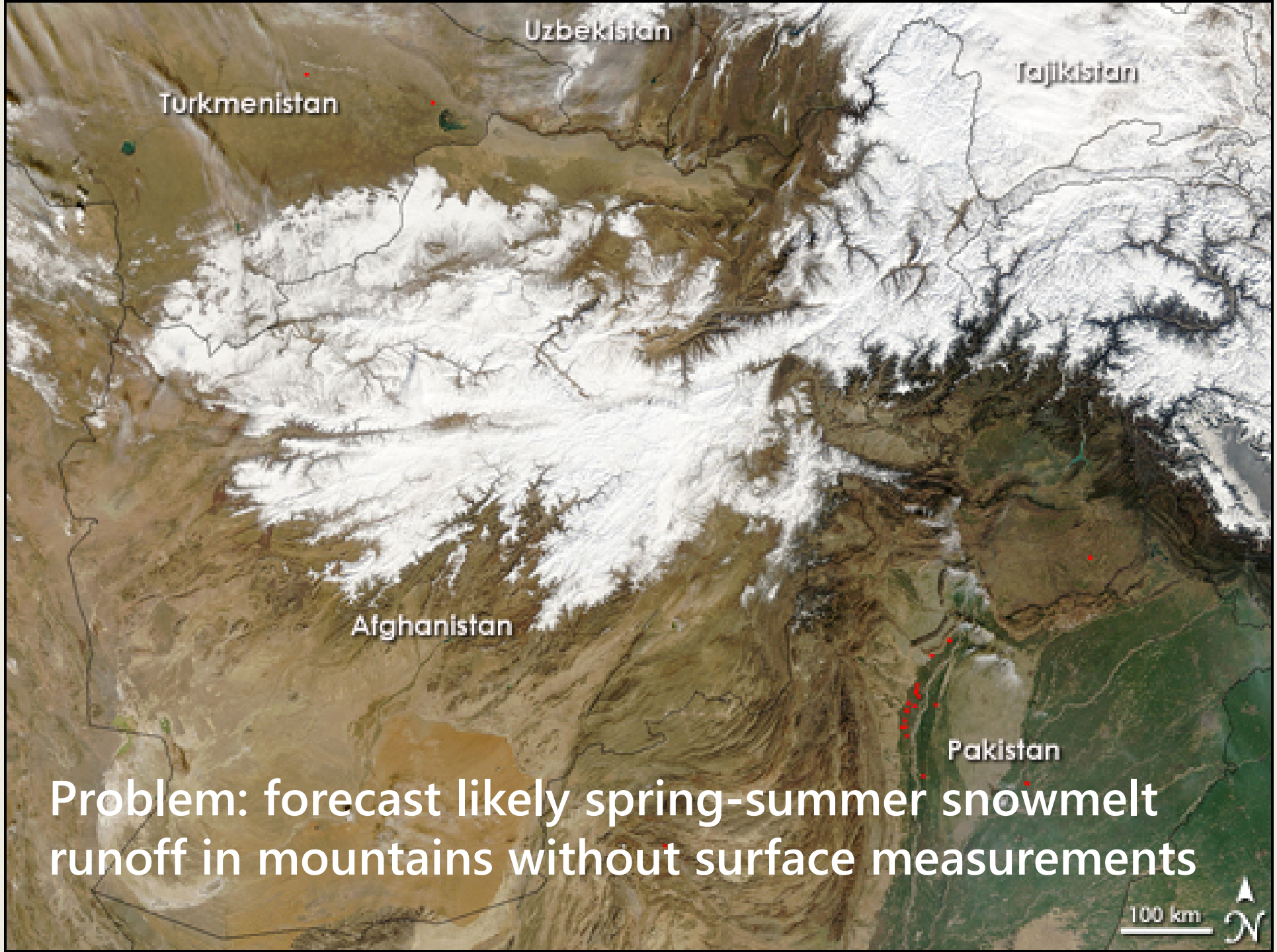
2015 March 03



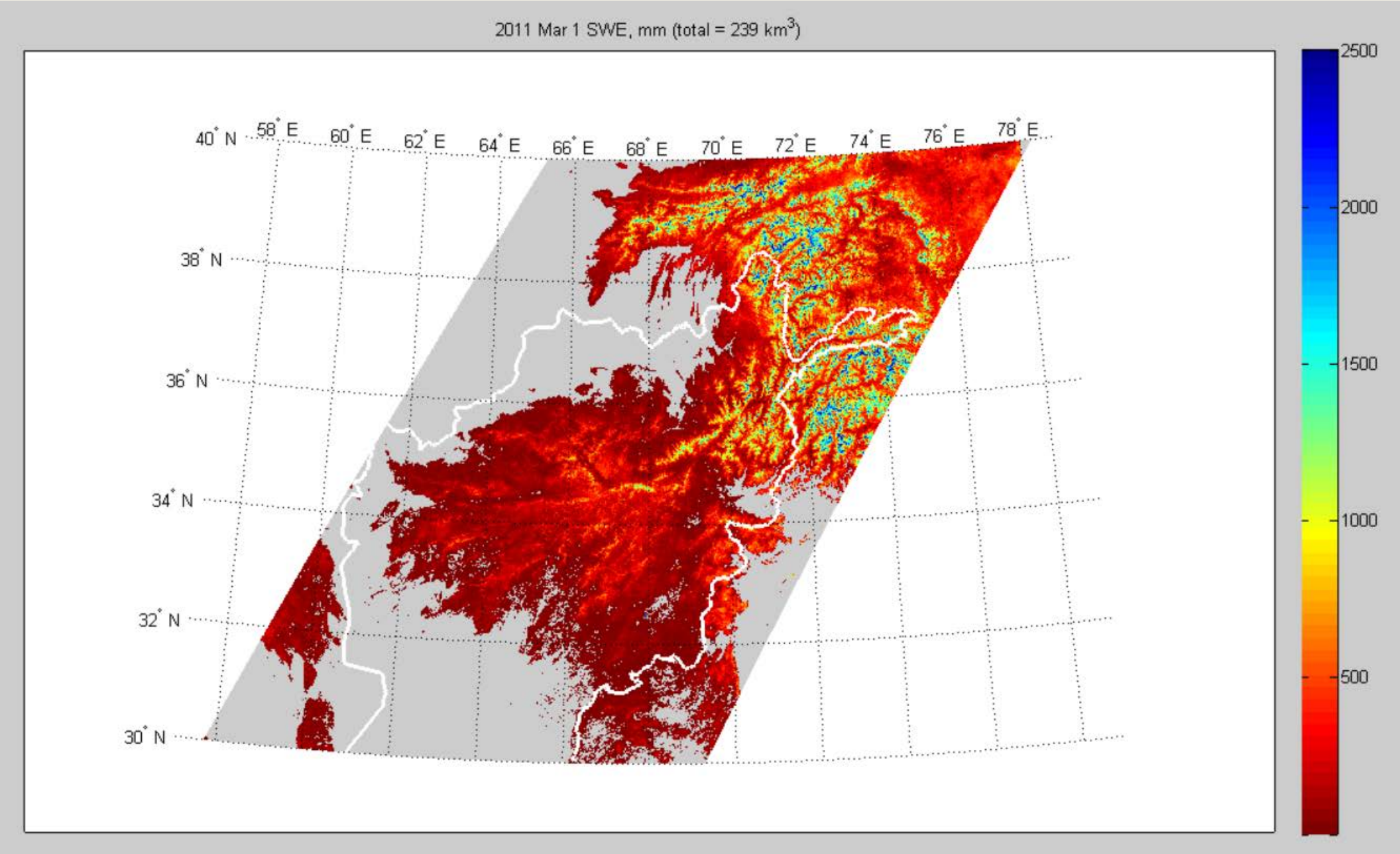
Problem: forecast likely spring-summer snowmelt runoff in mountains without surface measurements

- Partners: UCSB, US Army CRREL, Isciences
- Stakeholders: US AFWA, US Army COE, NGA, Calif DWR
- End Users: US Embassies, Marine Corps Intell, US Central Command, NATO, USGS, USDA FAS, USAID

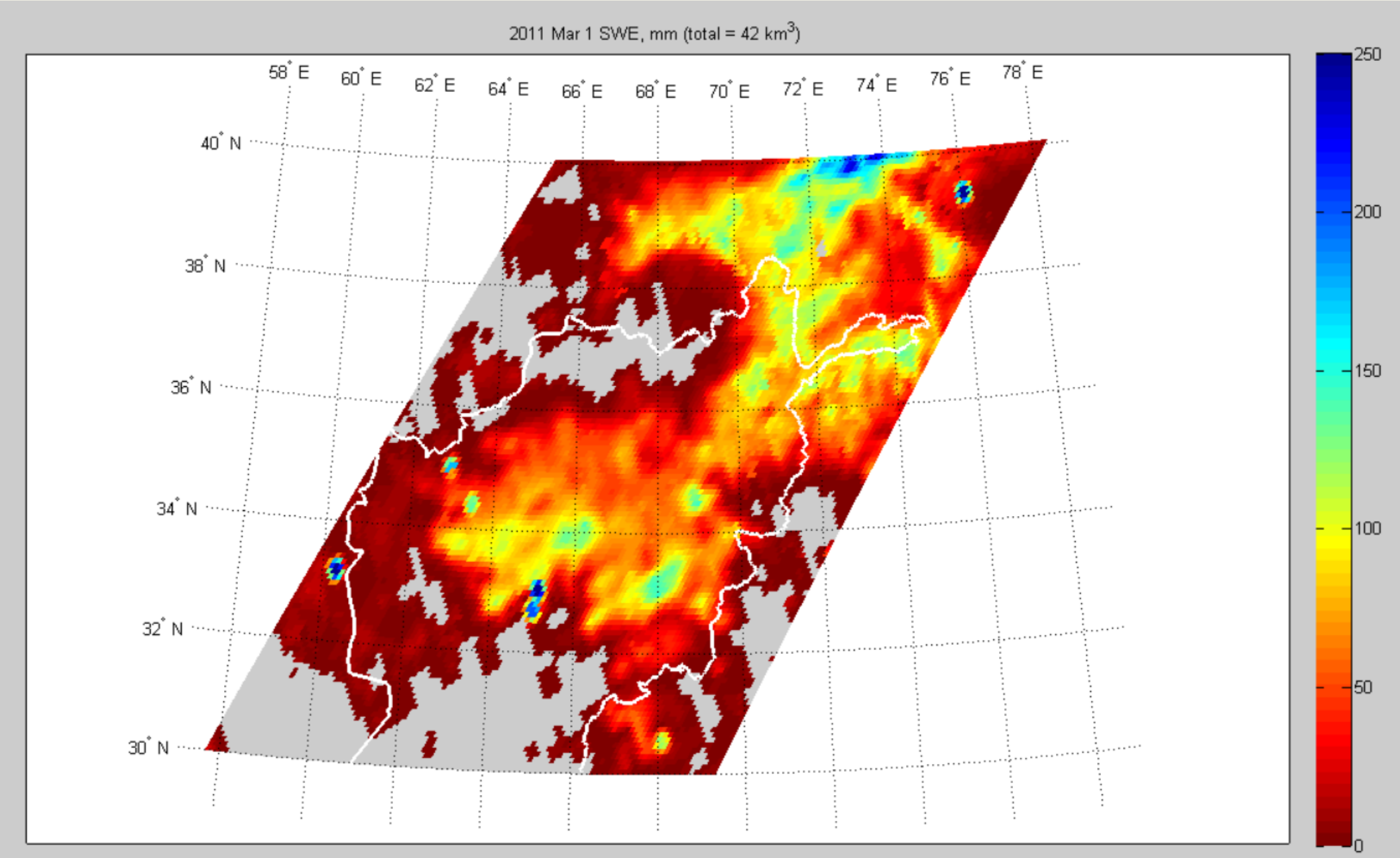
Datasets

- Reconstructed snow water equivalent (SWE) from fractional snow-covered area (**MODIS** or **VIIRS**) and snowmelt model driven by **GLDAS**
- Historical estimates of SWE from **AMSR-E**
- Real-time estimates
  - Snow depth from **AMSR2** produced by JAXA (or can used algorithm adapted from AMSR-E)
  - Fractional snow-covered area (**MODIS** / **VIIRS**) produced by JPL
  - SWE from **Central Asian Snow Model**
  - Precipitation from **GPM**

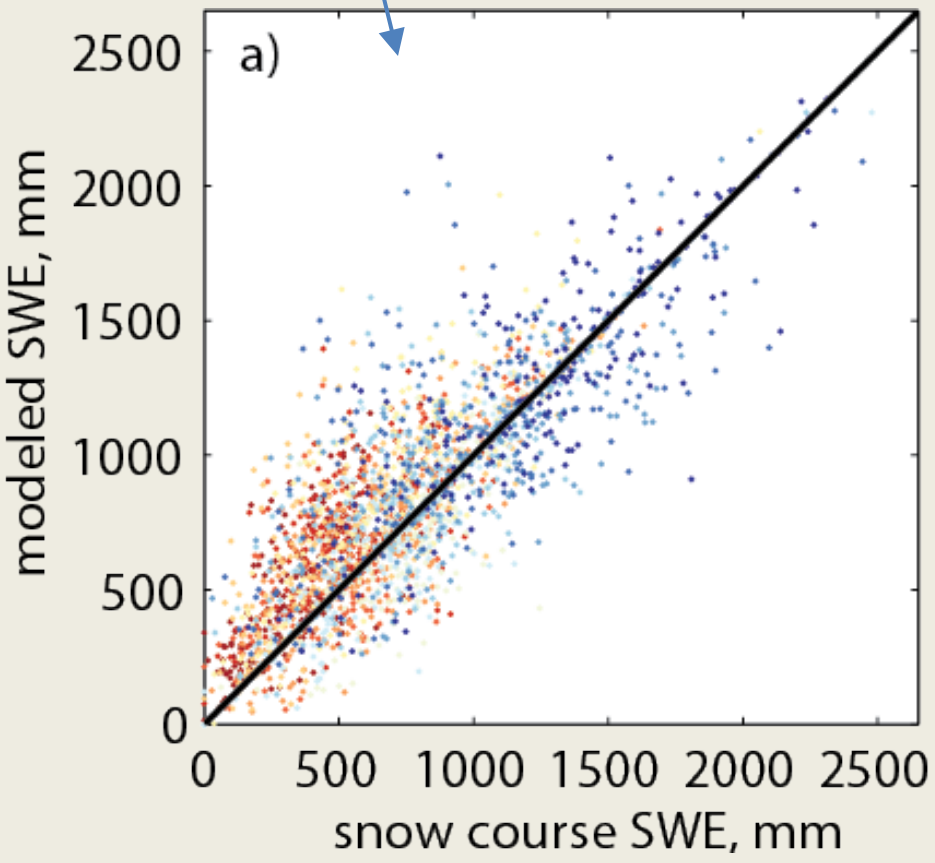
Reconstructed SWE Mar 2011

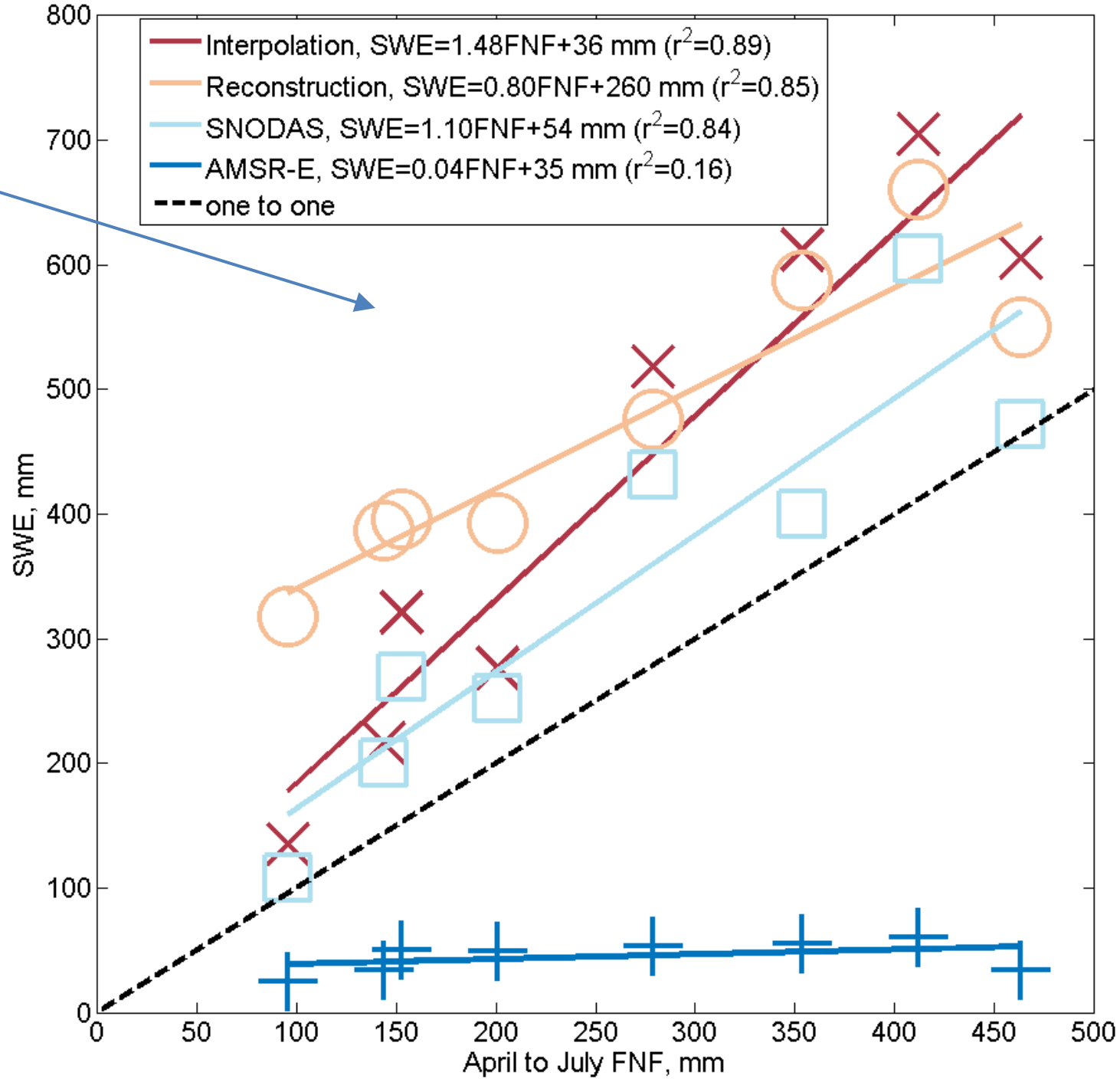


AMSR-E SWE Mar 2011



Validation of reconstruction in Sierra Nevada: estimated SWE vs full natural flow snow courses

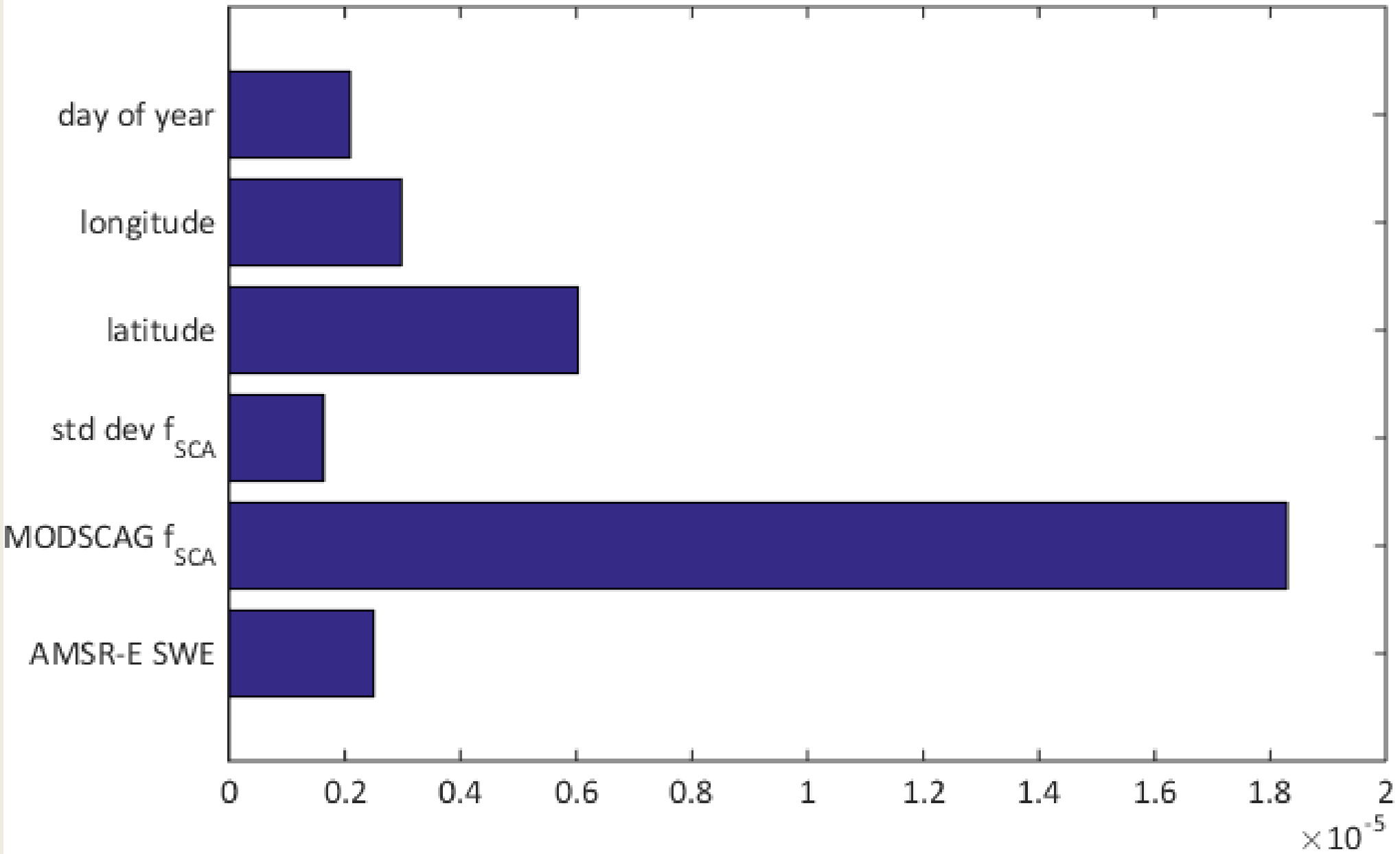




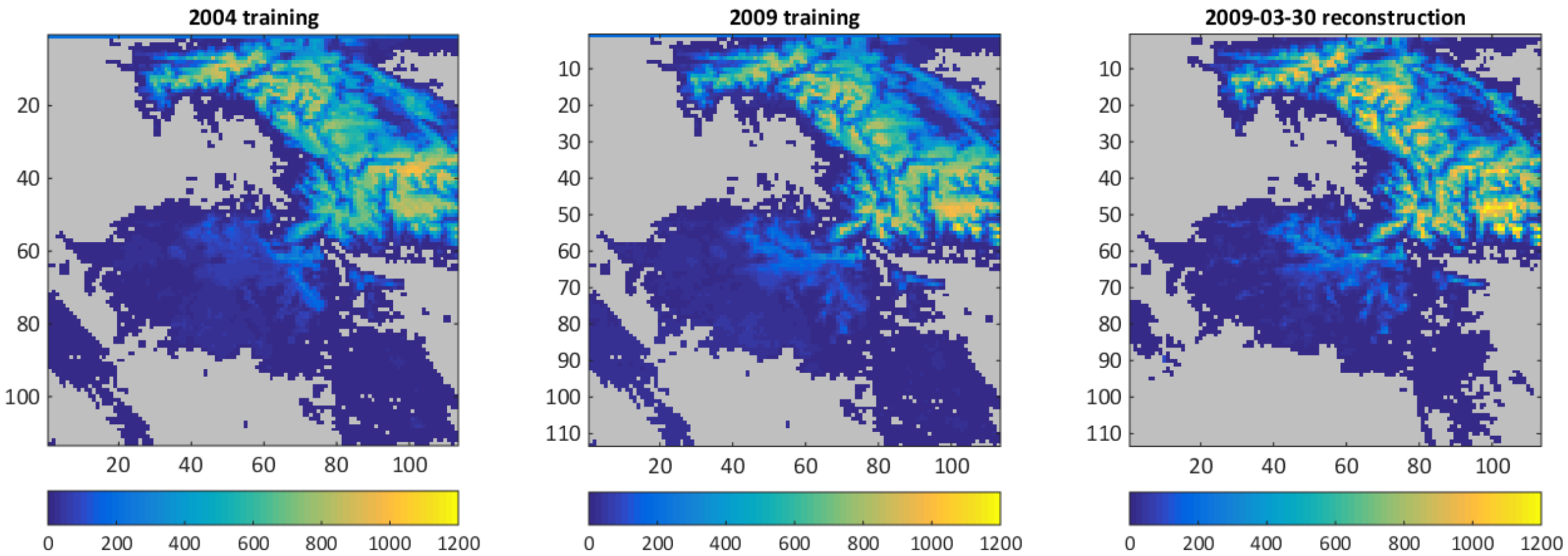
The problem

- Discover a pattern that uses real-time data—passive microwave SWE and snow-covered area from optical sensor—to match reconstructed SWE, which is available only after the snow is gone

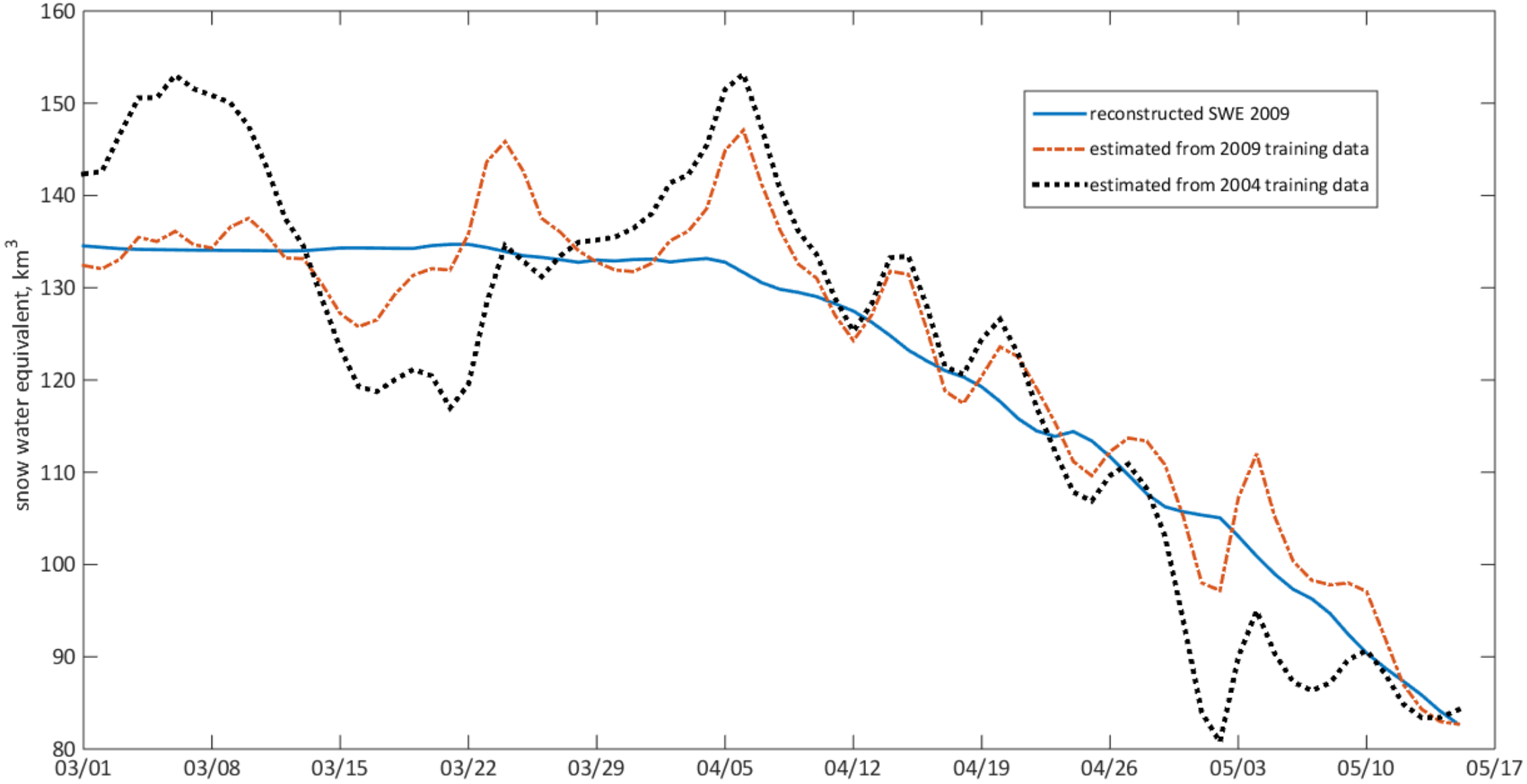
Initial approach: regression boosted decision tree



Example, 2009 Mar 30 SWE, trained on 2009 and 2004 data



Same example, integrated total SWE (km^3)



USE CASE: USDA FAS – Accumulation trends

- "We had competing precipitation models, which often provided divergent assessments for temporal and cumulative rainfall, and thus we were often at odds to determine reliably what the moisture availability was on croplands or in the snowpack. Your snow model was evaluated alongside our precipitation data to determine which data source was generally more reliable and consistent."

Mike Shean

USE CASE: USDA FAS – Case for accurate snow volumes and depletion trends

- "Is available water supply for irrigated crops satisfactory during the time it is needed most?"
- "So having intelligence on the ebb and flow of water supplies in all the major catchments and the downstream distribution would be fantastic."
- "Any development work you do which would overcome the absolute lack of real-time hydrological readings in irrigated croplands would be especially beneficial to USDA crop forecasters."

Mike Shean

This year's tasks

- Accumulation phase: compare Central Asian Snow Model (Karsten/Verdin/Fall) with passive microwave and snow-covered area
- Depletion phase: compare passive microwave and the Central Asian Snow Model with our melt and reconstruction models
- Accumulation and depletion: compare peak dates, normalized
- Consider how snow-covered area vs depth affects the passive microwave signal

Transition (next year)

- Bake the science this year
- Implement processing chain at US Army CRREL or on cloud-based service (Microsoft Azure or Amazon Web Service)
- Develop user interface and web-based portal