New methods for comparing in situ snow measurements to gridded products

Nicholas Dawson, Patrick Broxton, and Xubin Zeng

University of Arizona

Introduction

- Why is snow initialization important?
    - Errors can propagate through the forecast

- Why do we upscale in situ measurements?
    - Comparing a gridded product to point measurements is not ideal

We have developed two methods
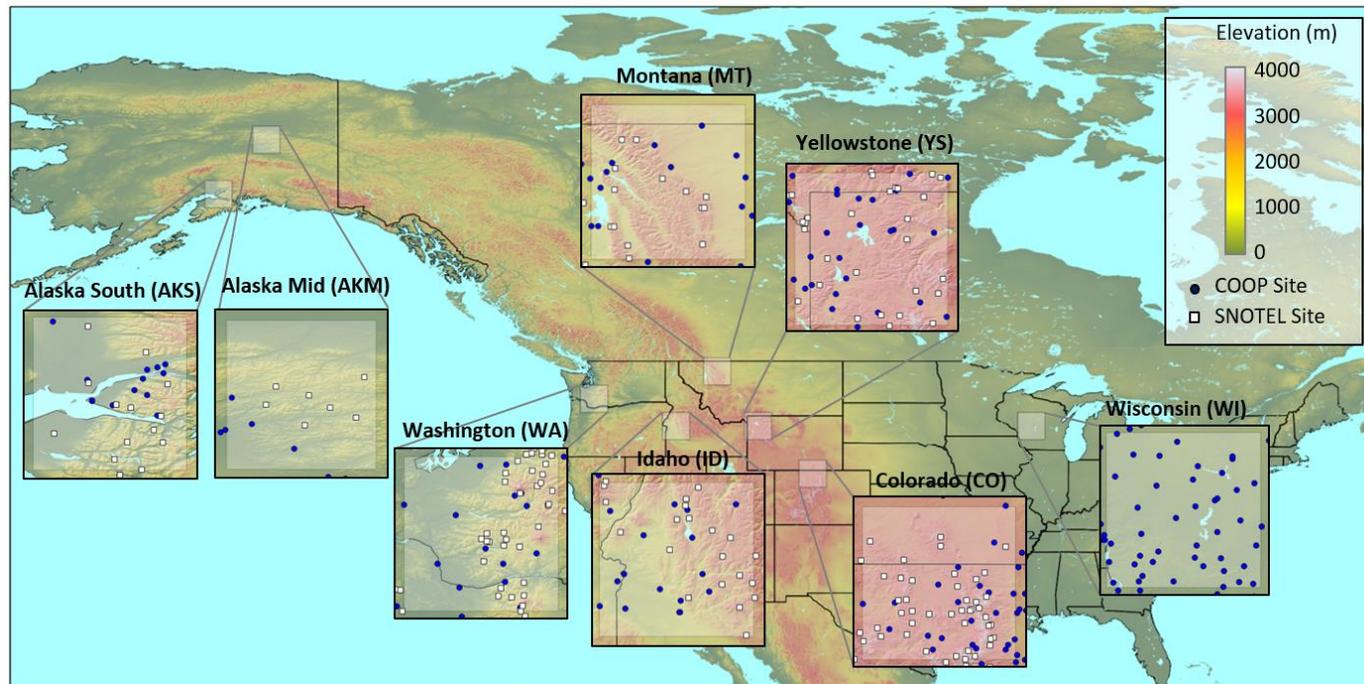
1. Piecewise Bins
   - Bin data
   - Determine critical bin
   - Apply piecewise regressions
   - Extrapolate to highest/lowest elevation
   - Interpolate residuals
   - Add interpolation to first guess for final analysis
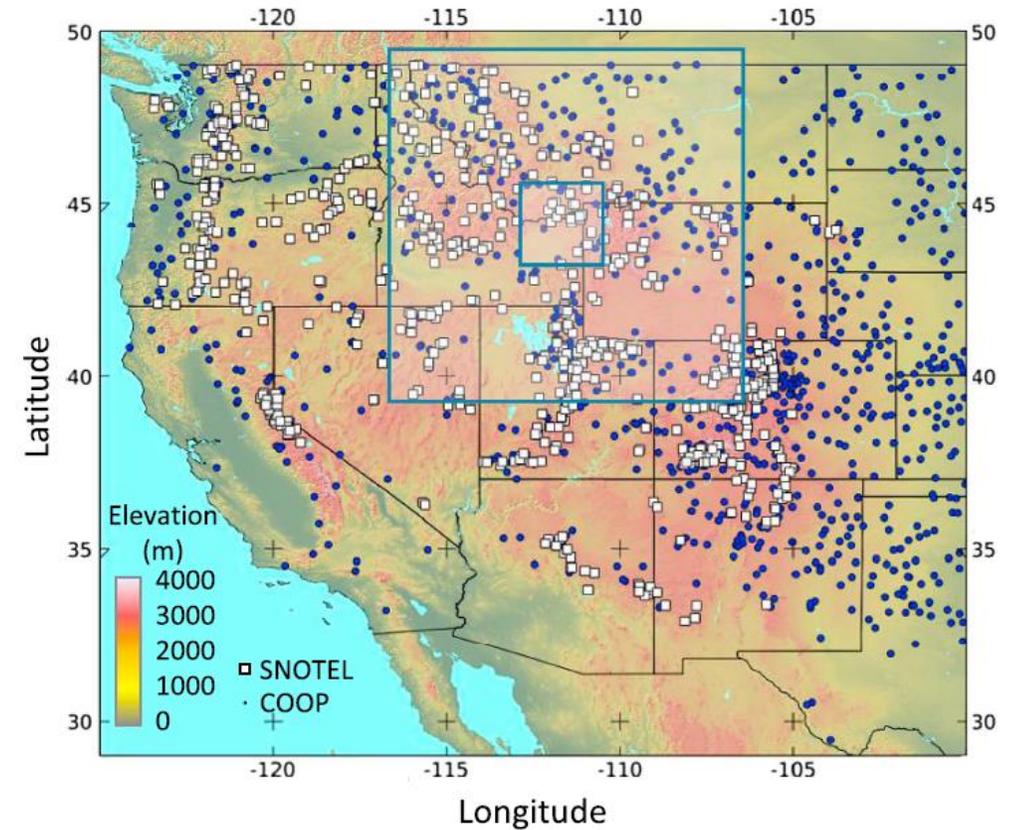
2. Normalization
   - Determine accumulated snowfall
   - Normalize data by snowfall
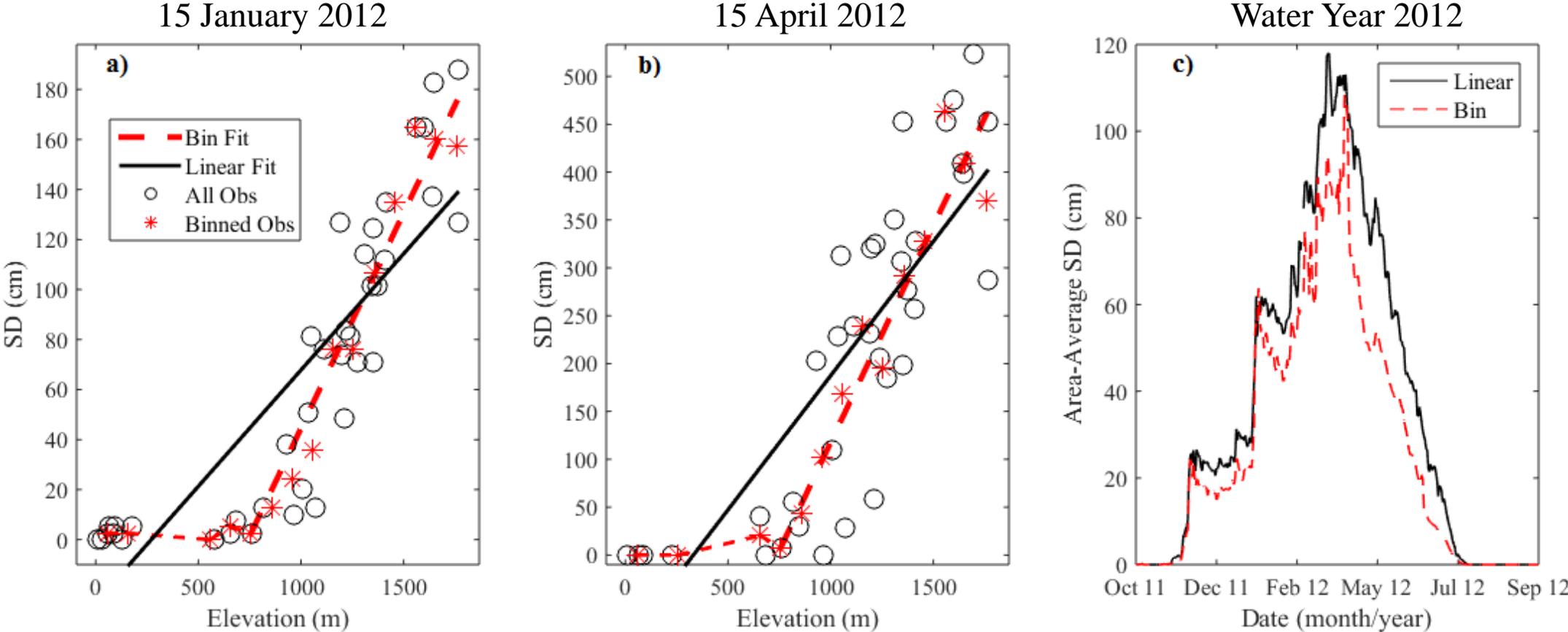   - Interpolate
   - Multiply by snowfall

In situ data

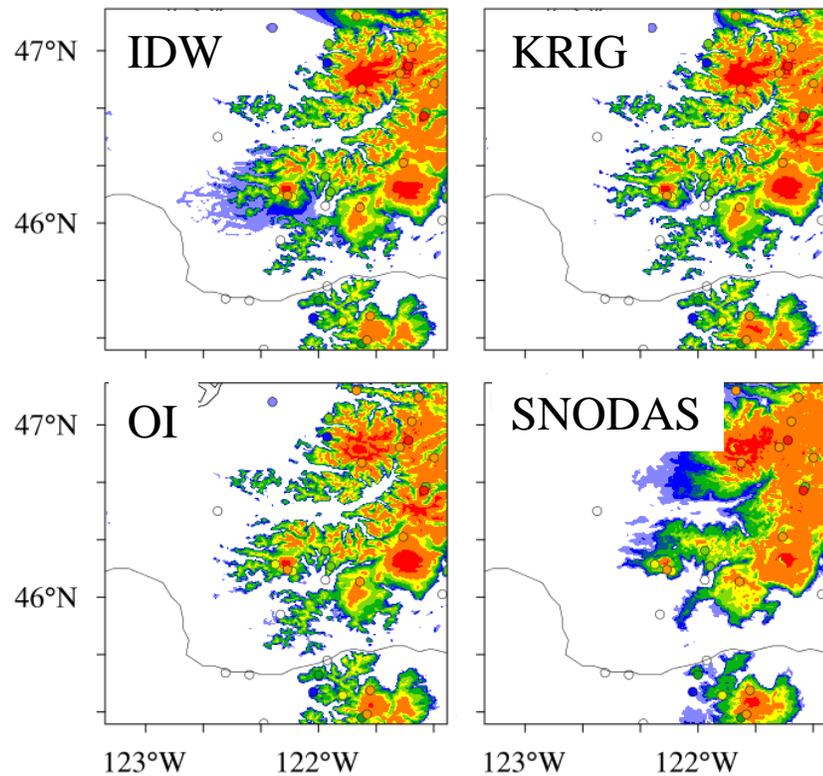Piecewise Bins Method

Normalization Method

Piecewise Bins method for the Washington Box

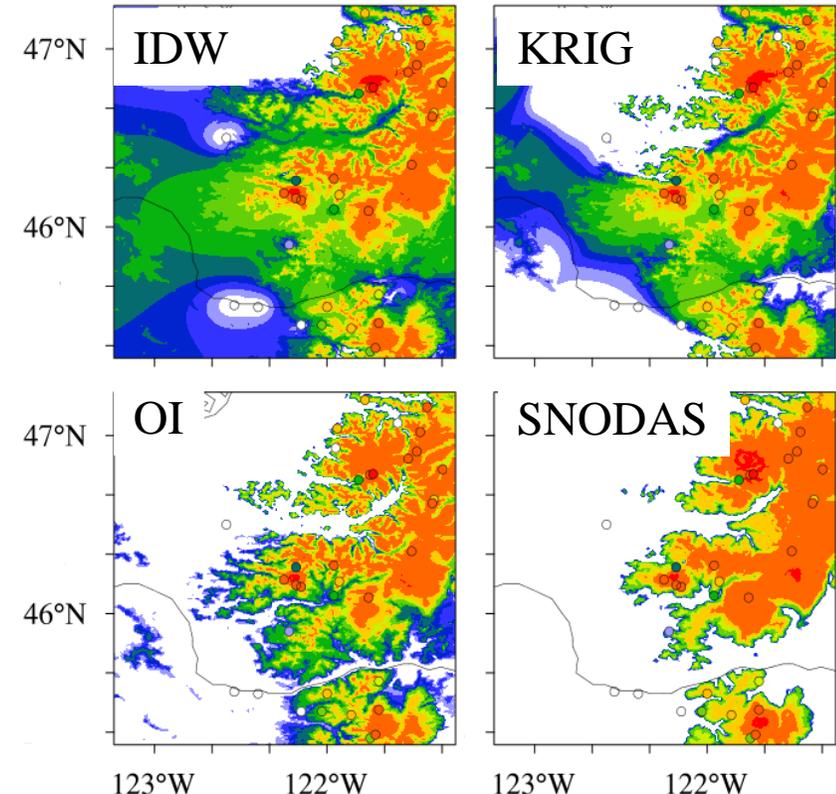

15 January 2012   15 April 2012   Water Year 2012

Piecewise Bins decreases first guess snow depth (panel c) by 10% – 30% compared to linear regression

Piecewise Bins - Evaluation of interpolation methods
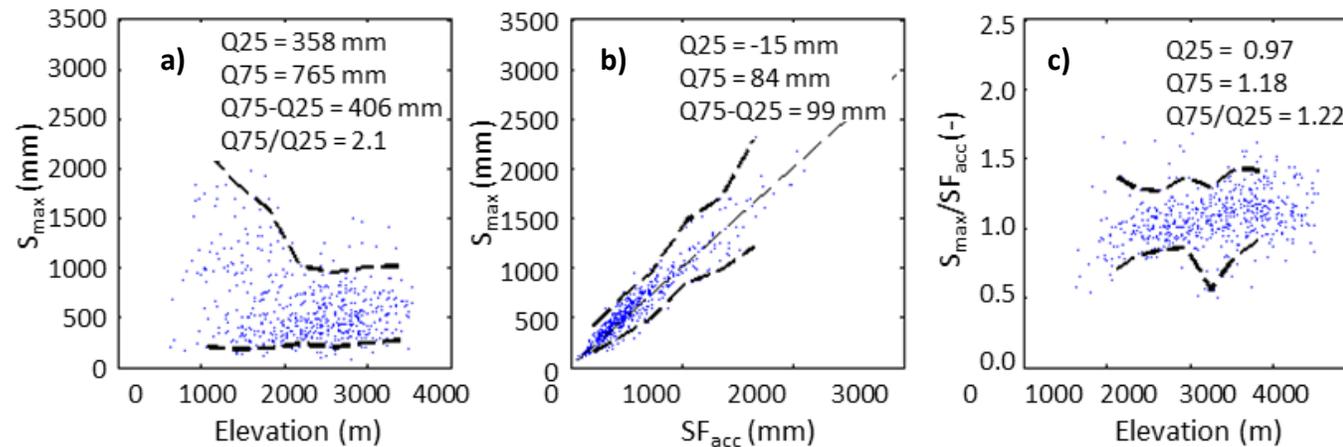
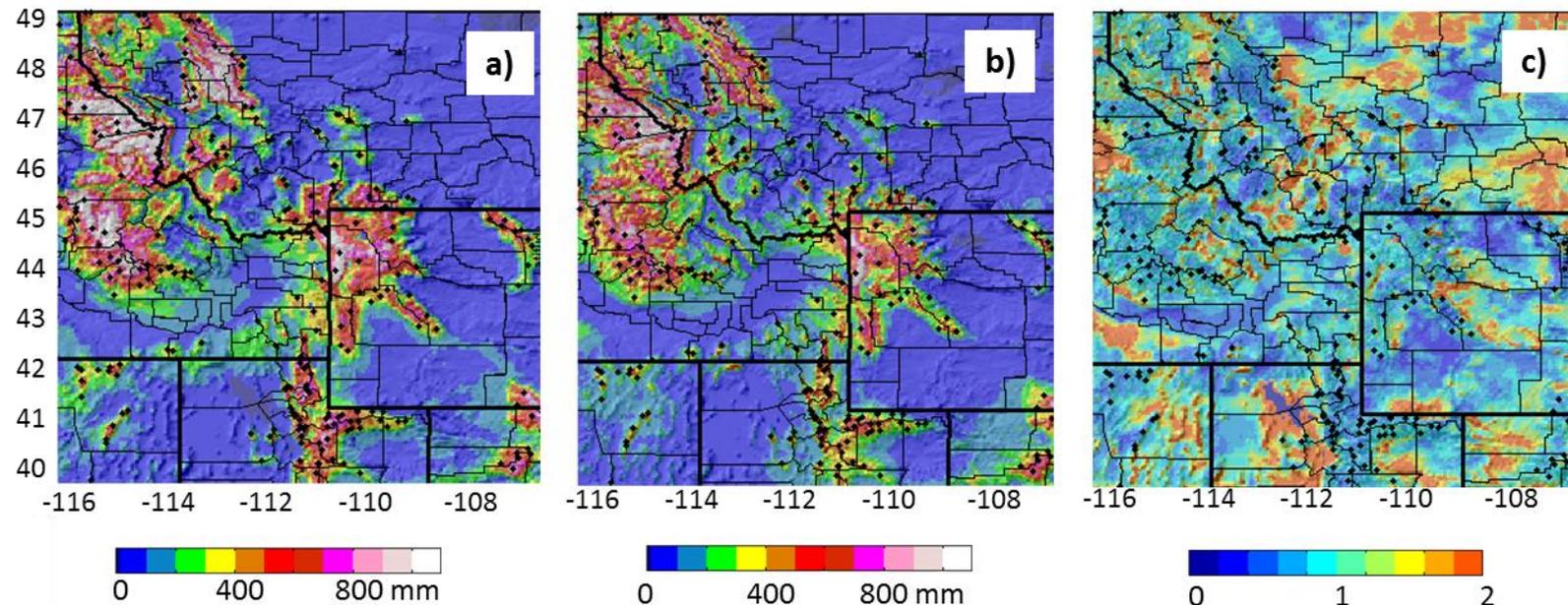15 January 2012 (WA box)

15 April 2012 (WA box)

Normalization method - uncertainty reduction

Water Year 2008, SNOTEL data from 10x10 degree box in Northern Rockies
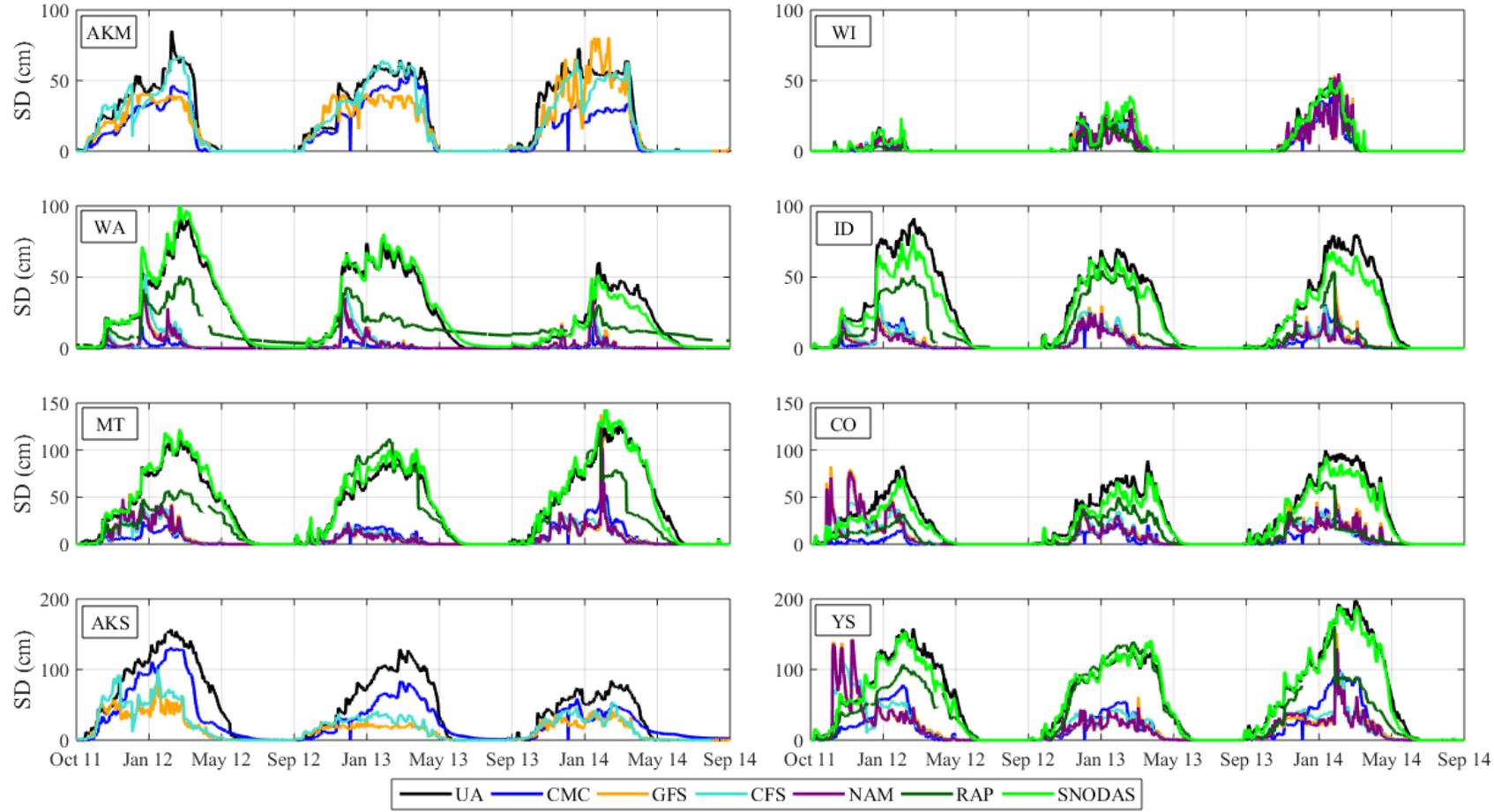

- Large scatter of data for relationship between max SWE and elevation (panel a)
- A strong relationship exists between accumulated snowfall and max SWE (panel b)
- Less scatter is present when comparing normalized max SWE with elevation (panel c)

Normalization method - spatial comparison with SNODAS

- Maximum SWE for each grid box in WY 2008 from SNODAS (a) and the Normalization method (b)

- The ratio (b/a) indicates that the Normalization method generally has slightly lower max SWE compared to SNODAS near areas of observations (black dots), and tends to have higher max SWE mainly where observations are sparse
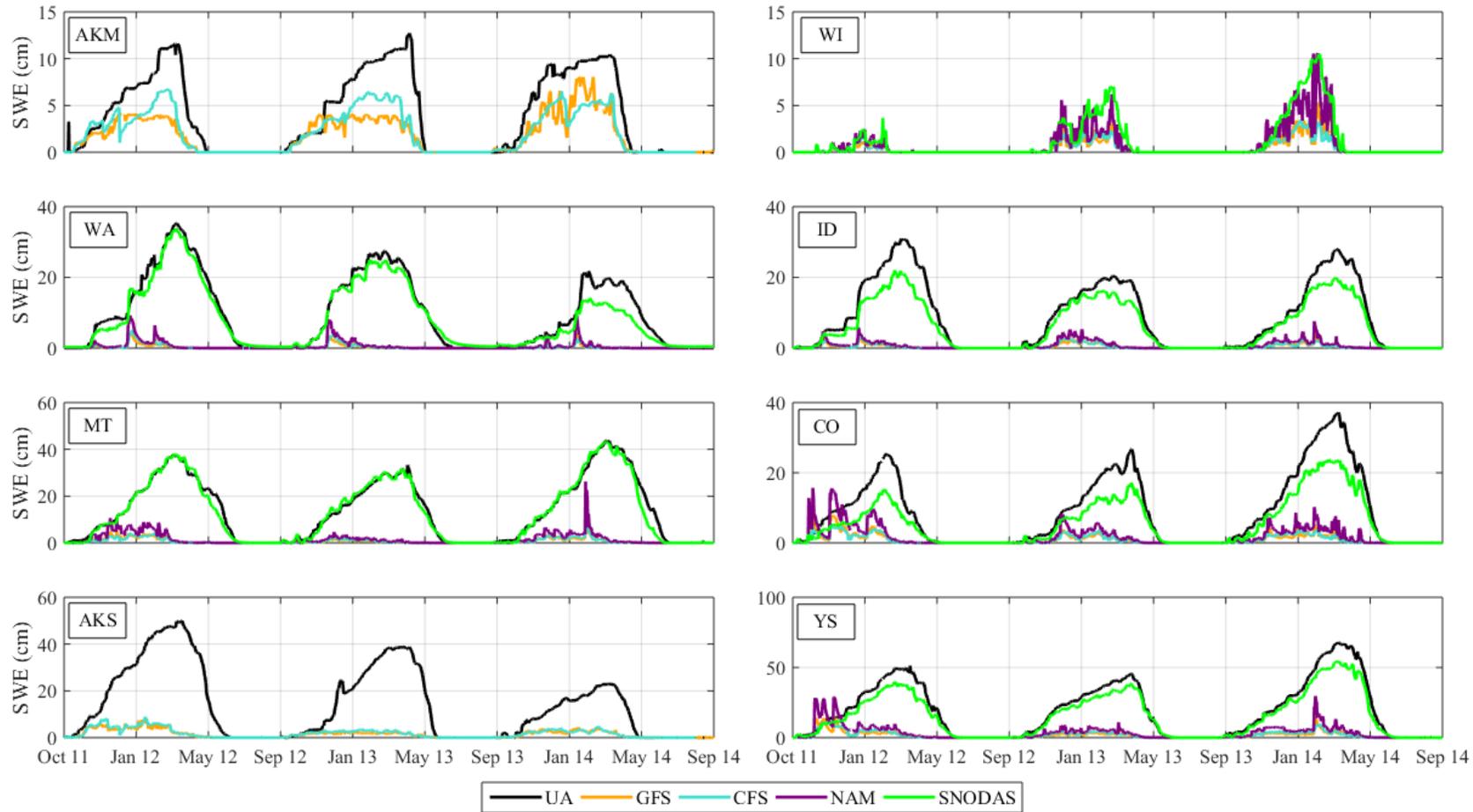
NCEP SD initialization evaluation with Piecewise Bins

Among GFS, CFS, NAM, and RAP:

- NCEP initializations produce SD which is too shallow

- RAP model performs the best

- Grid size does not impact results

NCEP SWE initialization evaluation with Piecewise Bins

- NCEP assumes constant density (100 or 200 kg m^{-3}) to calculate SWE from SD

- This produces very low SWE values

Ratio Comparison

	GFS		CFS		NAM	
	SD	*SWE*	*SD*	*SWE*	*SD*	*SWE*
December	0.58	0.19	0.58	0.19	0.58	0.39
April	0.26	0.02	0.20	0.02	0.44	0.04

- Calculated as mean of December (April) NCEP quantity divided by Piecewise Bin quantity
  - Mean of all boxes except Alaska for all three water years

- SWE ratios decline more than SD ratios as winter progresses
  - Due to constant snow density assumption (100 or 200 kg m^{-3})

Ongoing work

- Given importance of snow on land-atmosphere interactions, this problem likely affects other quantities.

- We are currently documenting this linkage, evaluating other products (NLDAS, GLDAS and reanalysis), and developing a new snow density model for SWE initialization

- Questions?

- Dawson, N., P. Broxton, X. Zeng, M. Leuthold, M. Barlage, P. Holbrook (2016), An evaluation of snow initializations in NCEP global and regional forecasting models, *Journal of Hydrometeorology*, in press.

- Broxton, P., N. Dawson, and X. Zeng (2016), Linking snowfall and snow accumulation to generate spatial maps of SWE and snow depth, *Earth and Space Science*, **3**, doi:10.1002/2016EA000174.