Modeled snow intercomparison over Fairbanks, Alaska domain:

spatial and interannual variability from Land Information System simulations

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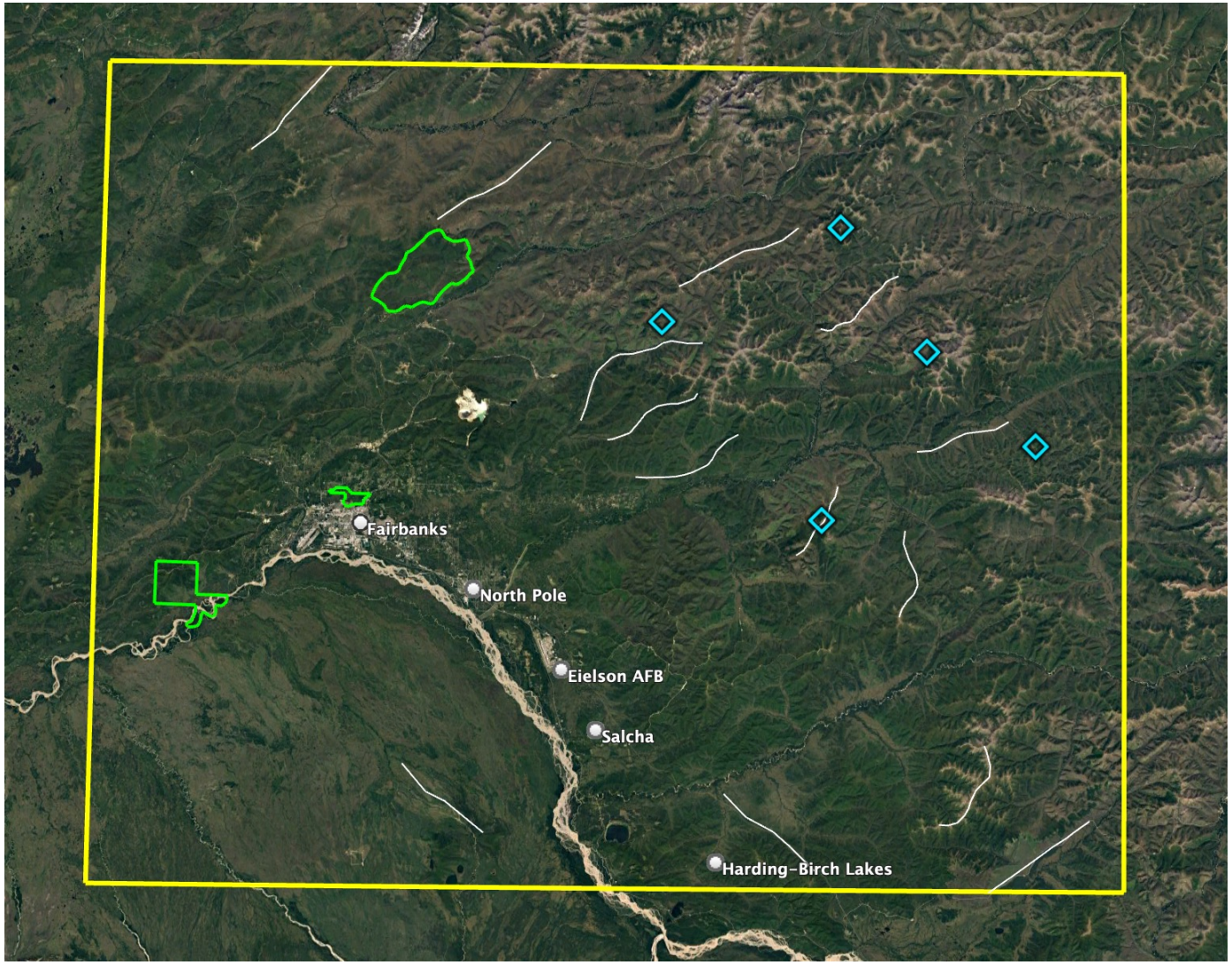
In support of the upcoming SnowEx field campaigns in Alaska, a model intercomparison effort that aims to:

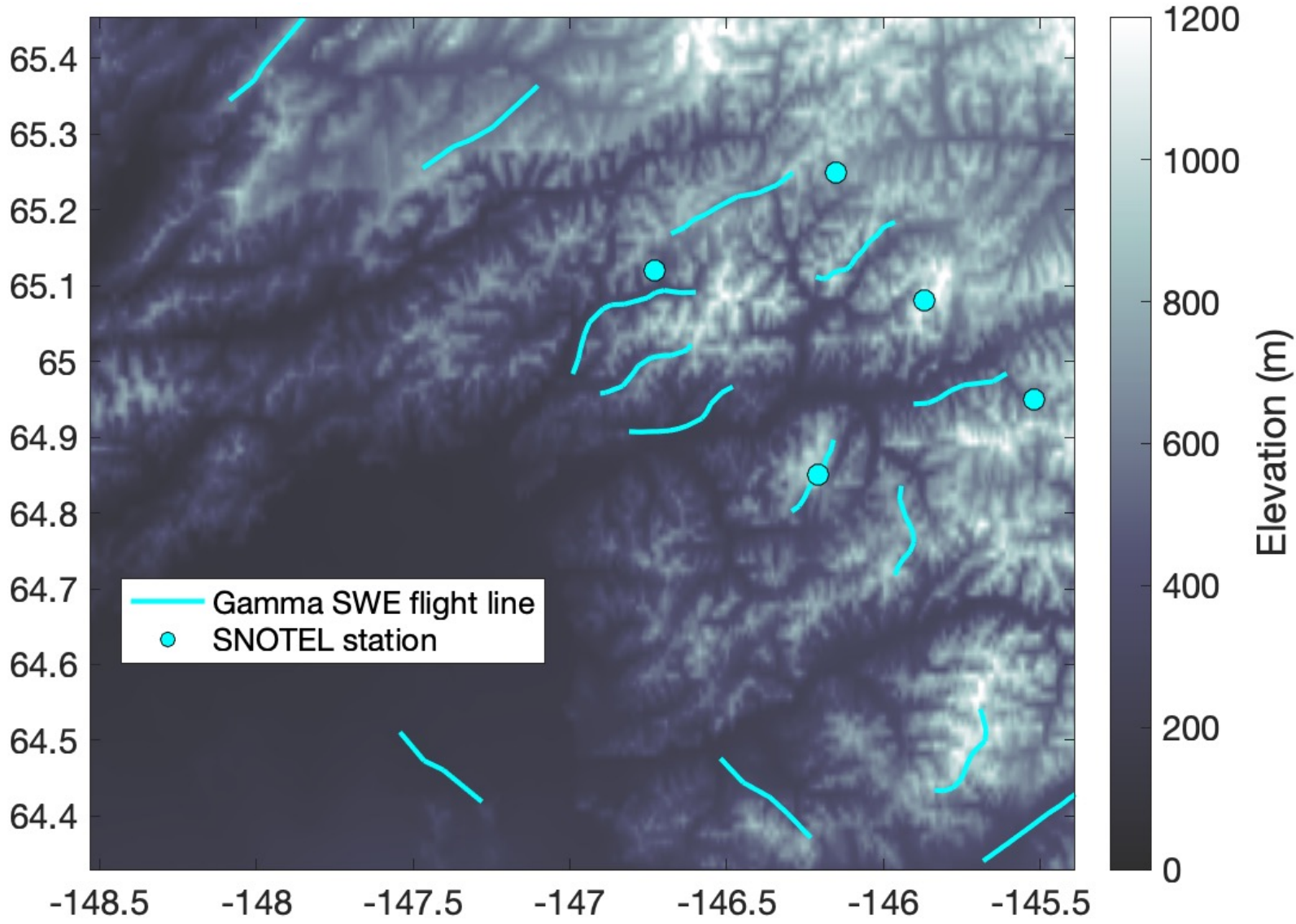
- understand where models agree/disagree,
- determine where we need more observations for constraining model simulations
- test assimilation of observations collected during the campaign



Yellow box is approximate model domain.
Green outlines indicate SnowEx field site locations
Blue squares are SNOTEL sites and white lines are Gamma SWE flight surveys.

Objective: multi-year simulations over Fairbanks domain to better understand spatial and temporal variability of snow

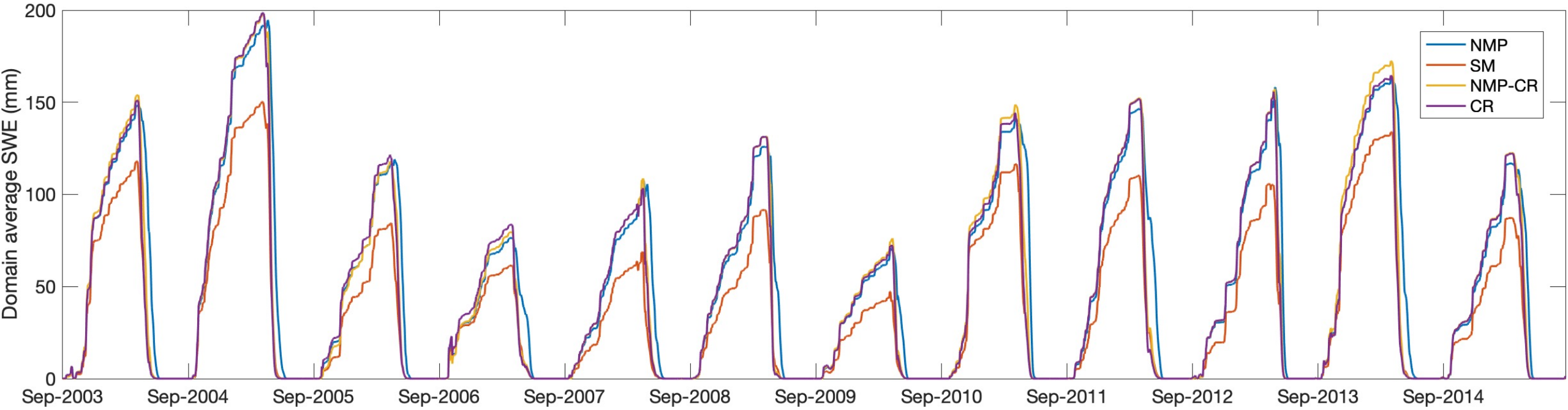
- Models: NoahMP, Crocus, and SnowModel
  - Run at 100 m resolution
  - Coupled versions:
    - NoahMP-Crocus
    - NoahMP-SnowModel (still in development)
- Forcing data: 4 km Alaska WRF simulation from NCAR
- September 2003 – September 2015
- All simulations run with the NASA Land Information System (LIS)

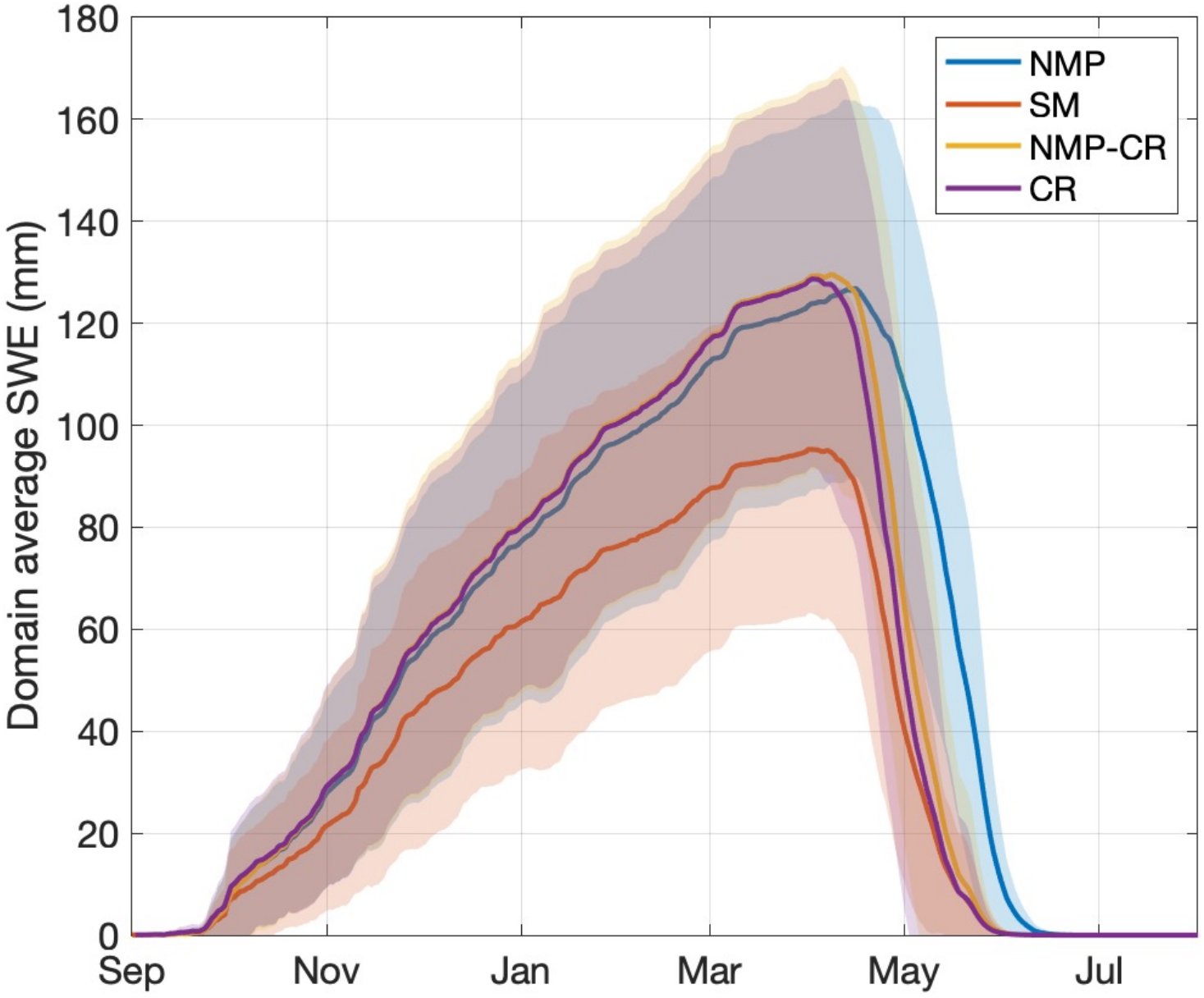


Model domain with SNOTEL and Gamma evaluation locations

Comparison of domain averaged SWE from the four models show that:

- **NoahMP**, **NoahMP-Crocus**, and **Crocus** have similar estimates throughout accumulation, peak SWE, and melt
- **SnowModel** with lower SWE values
- **NoahMP** tends to melt the latest





Water Year 2004-2015 average SWE

Solid line indicates the 12-year average from each model and the shading is +/- one standard deviation

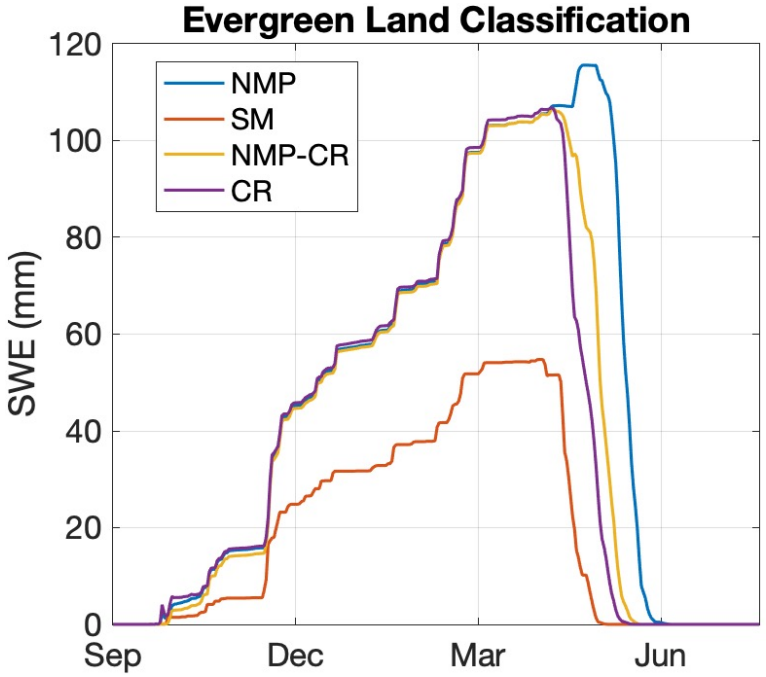
- **NoahMP-Crocus** and **Crocus** are nearly identical through early April.
- **NoahMP** melts the latest
- **SnowModel** has the lowest estimate

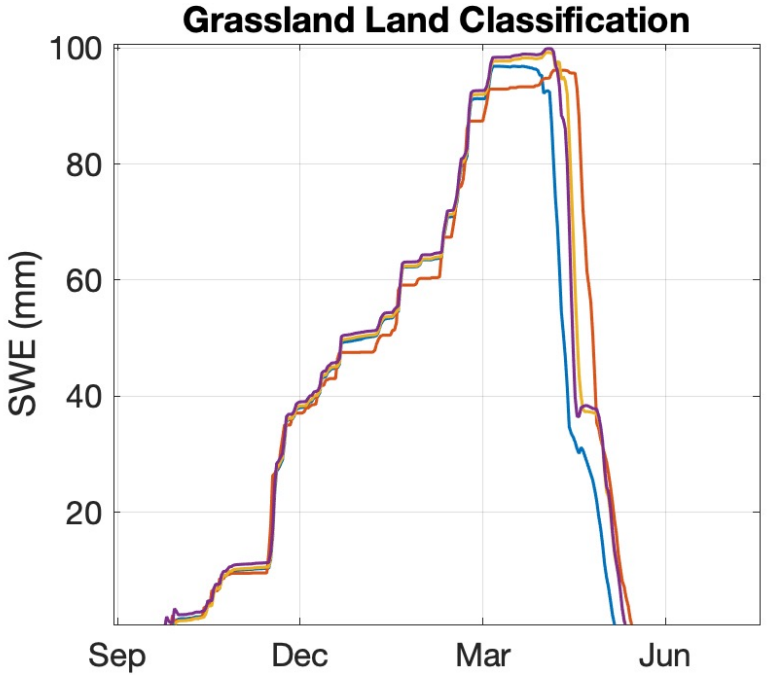
Lower SWE values in SnowModel might be related to canopy interception parameterizations

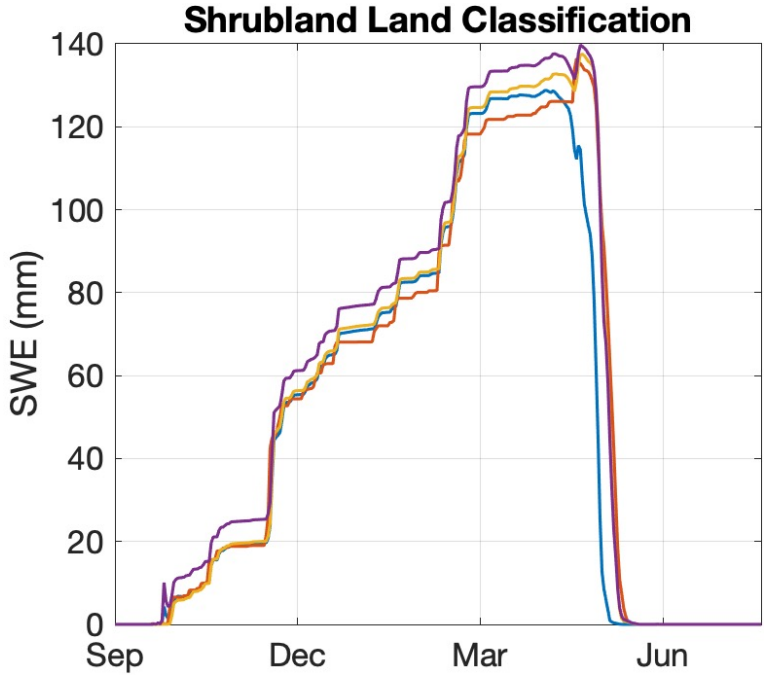
SnowModel has a different land classifications than the other models (NALCMS vs. IGBP-modified). We compare SWE for grid cells with similar land cover types in both classifications.

→ For grass and shrub regions, all four models have high agreement.

→ In evergreen forests, though, **SnowModel** has much lower SWE values

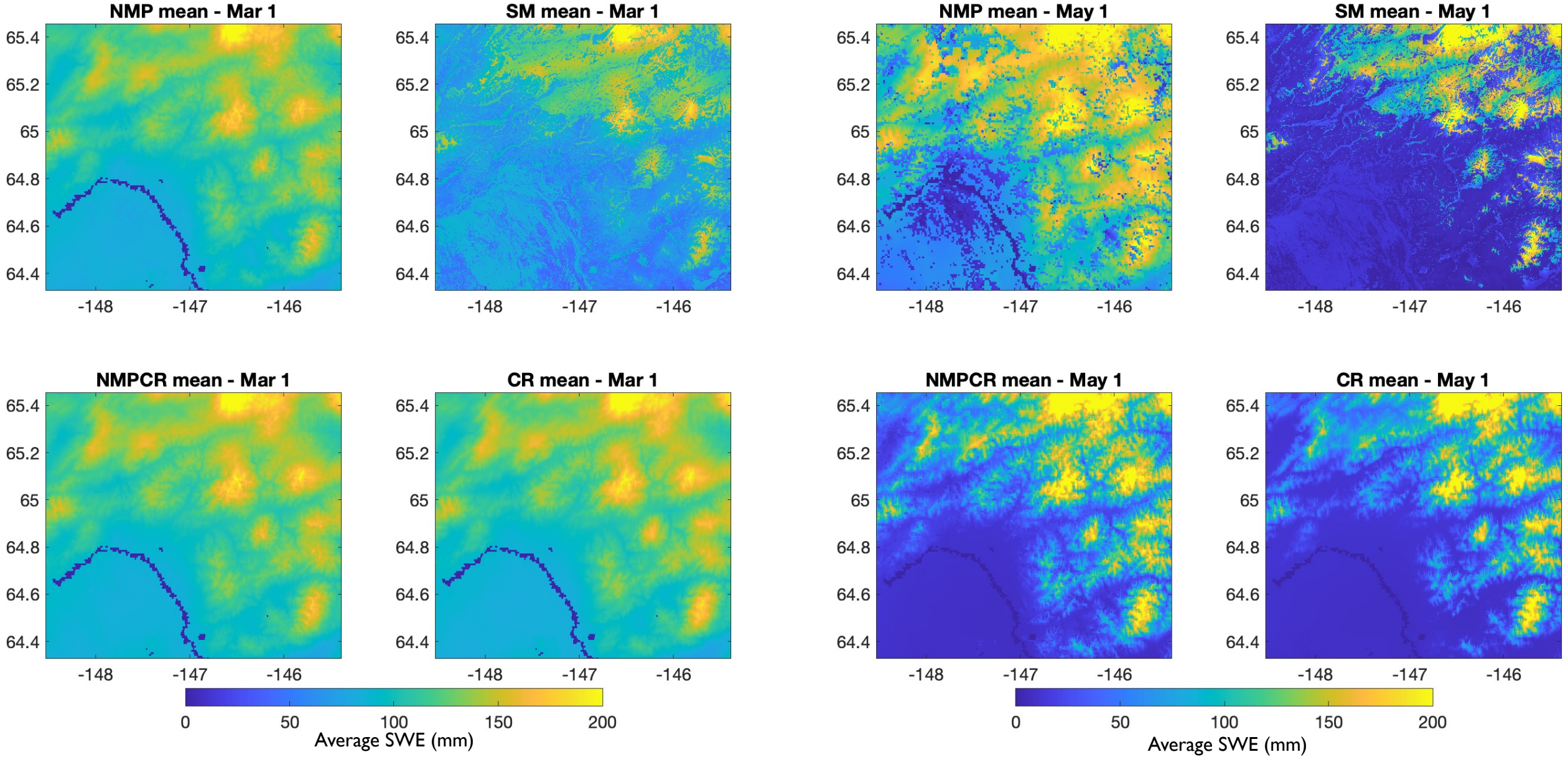


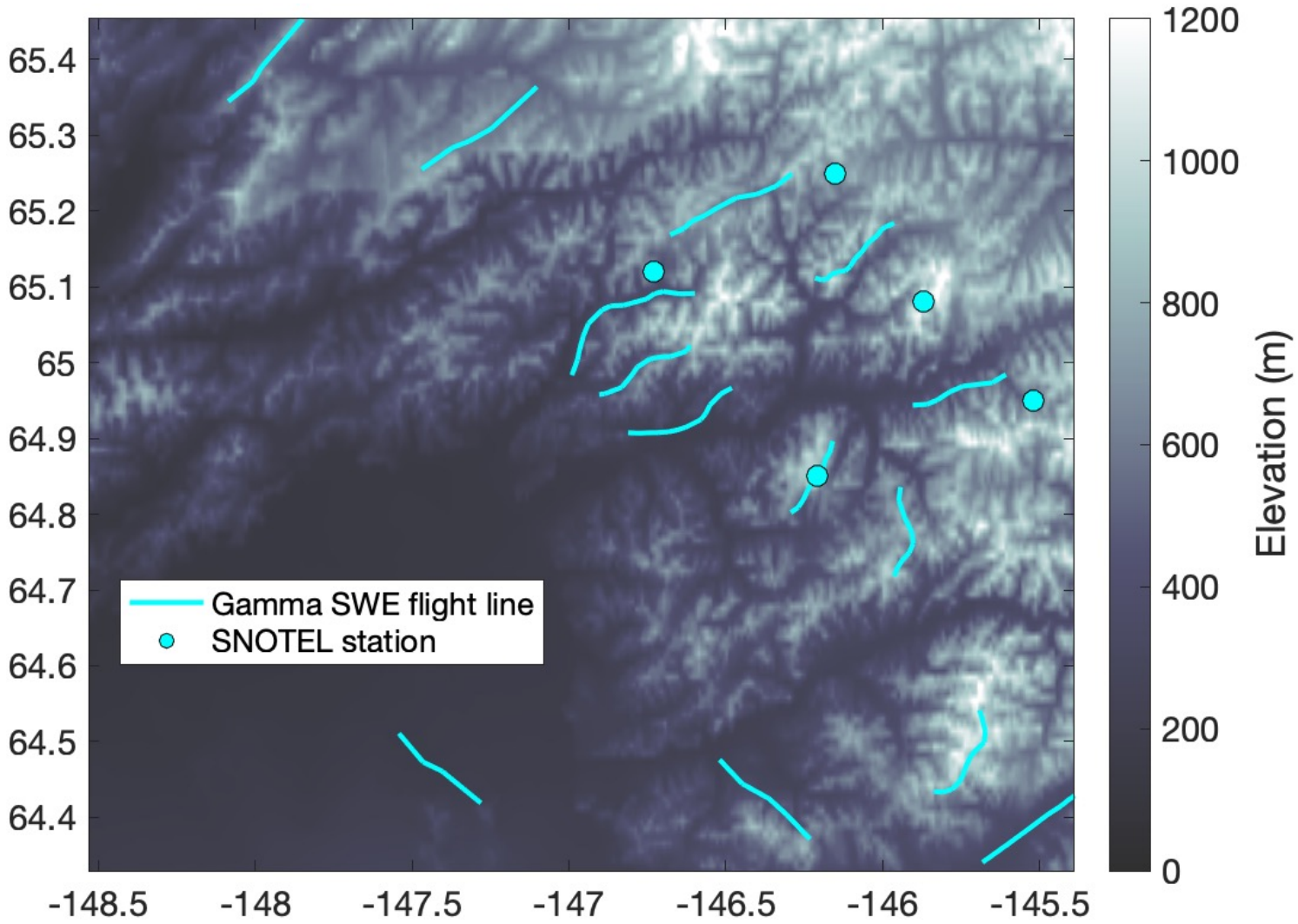




Spatial maps of average SWE conditions on March 1 (left) and May 1 (right)

Before melt begins, SnowModel underestimates the other models. After melt begins, NoahMP overestimates the other models.





Model evaluation to assess SWE magnitude and melt timing

Four model estimates compared to:

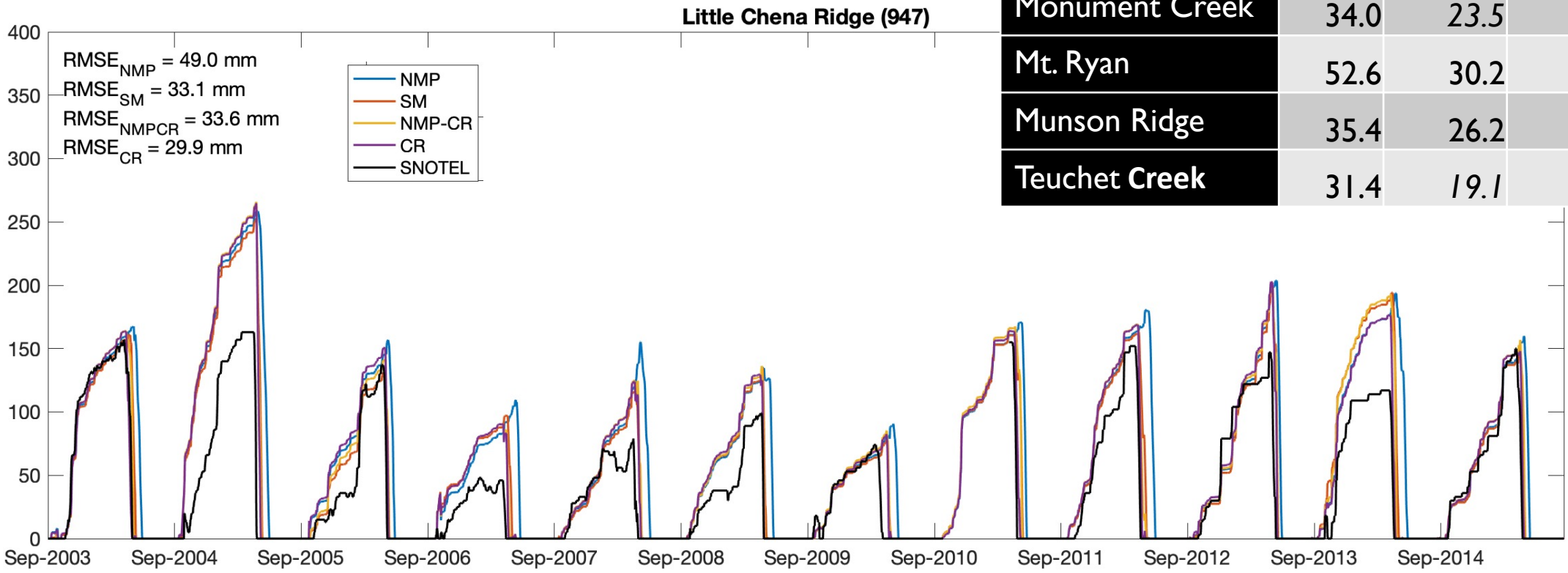
- SNOTEL (5 stations)
- Gamma SWE surveys (14 flight lines)
- MODIS – for snow covered area

Model estimates vs. SNOTEL

The snow process models – **SnowModel** and **Crocus** – generally have better performance vs. SNOTEL record than **NoahMP** or **NoahMP-Crocus**

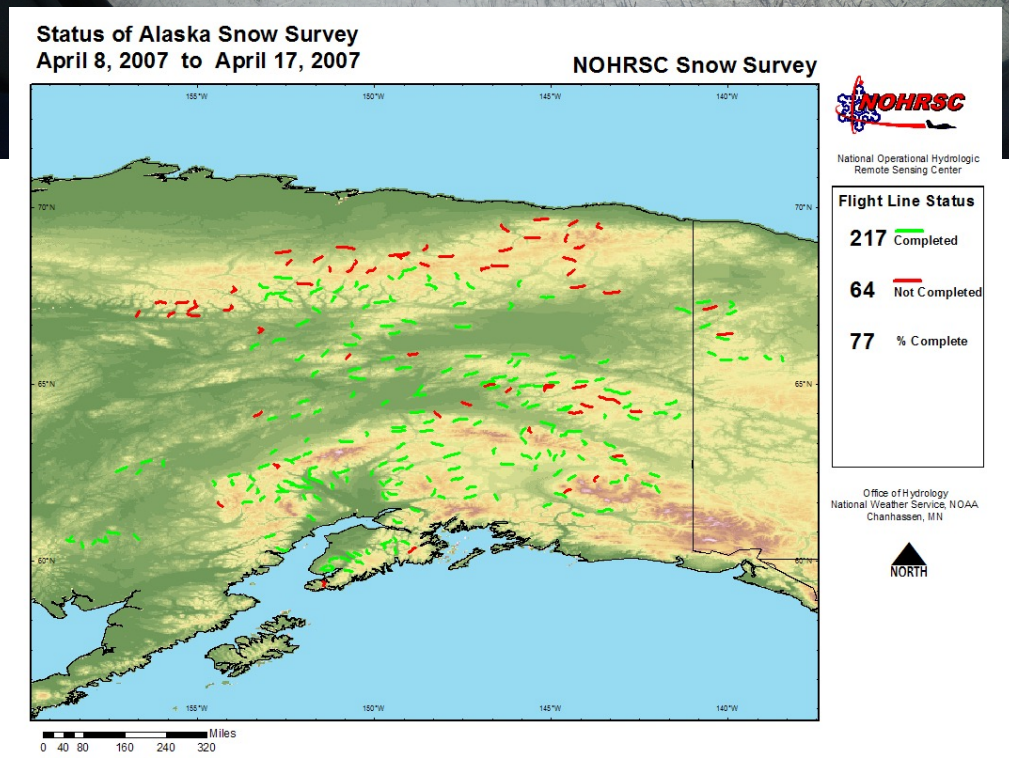
SWE comparison over 5 SNOTEL stations for water years 2004-2015

Mean RMSE (mm) *Italics indicate best performance*				
Stations	NMP	SM	NMP-CR	Crocus
Little Chena Ridge	49.0	33.1	33.6	*29.9*
Monument Creek	34.0	*23.5*	40.3	47.7
Mt. Ryan	52.6	30.2	33.1	*27.7*
Munson Ridge	35.4	26.2	*25.8*	28.2
Teuchet Creek	31.4	*19.1*	30.7	29.9

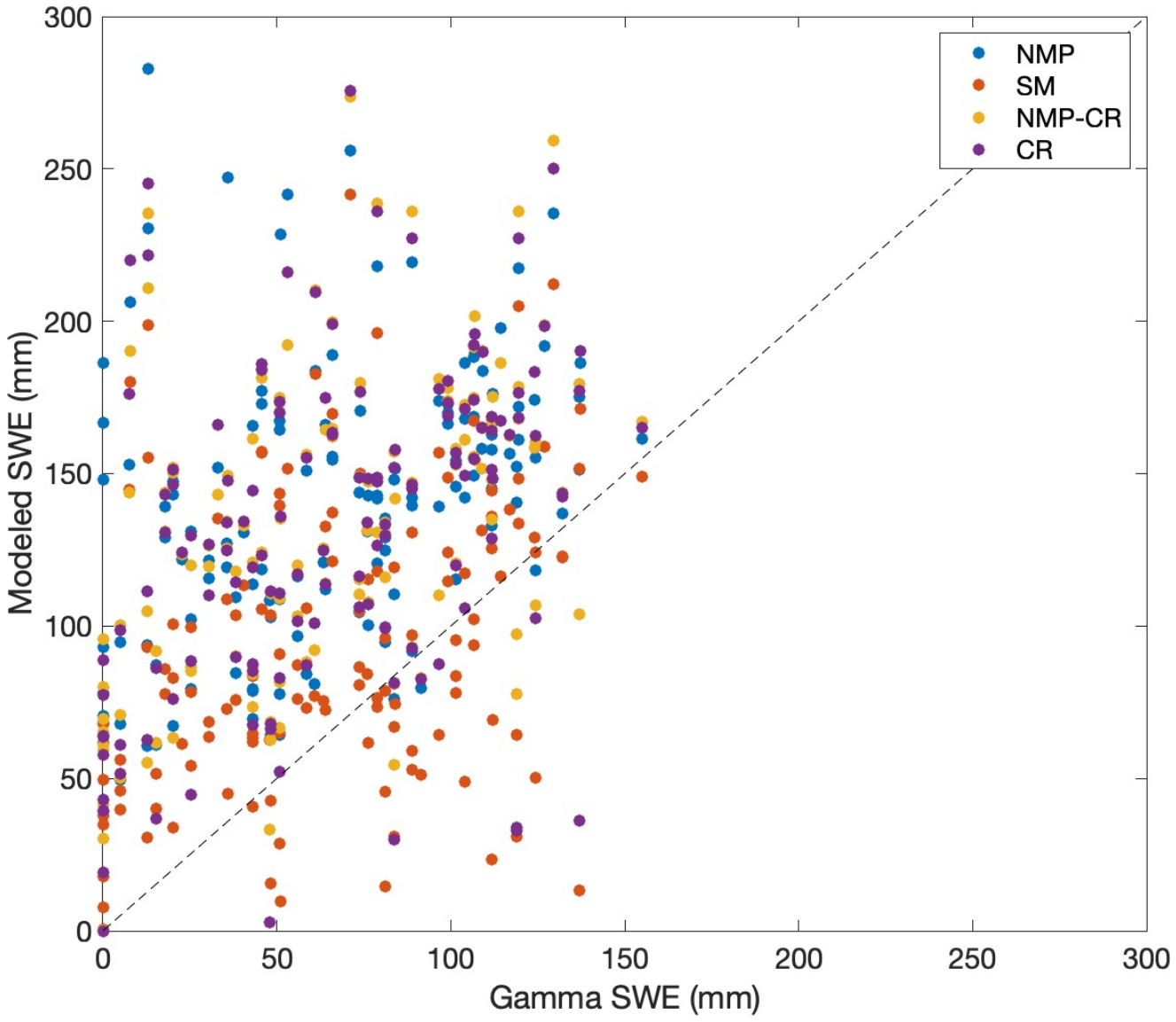


Gamma SWE comparison

- Annual airborne surveys operated by the NWS NOHRSC
- Flight lines are typically 16 km long and 300 m wide, which produce one estimate of SWE per flight line
- SWE uncertainty generally assumed to be 2 cm or less
- Model grid cells are matched to the flight lines and SWE values are averaged together



Model estimates vs. Gamma SWE



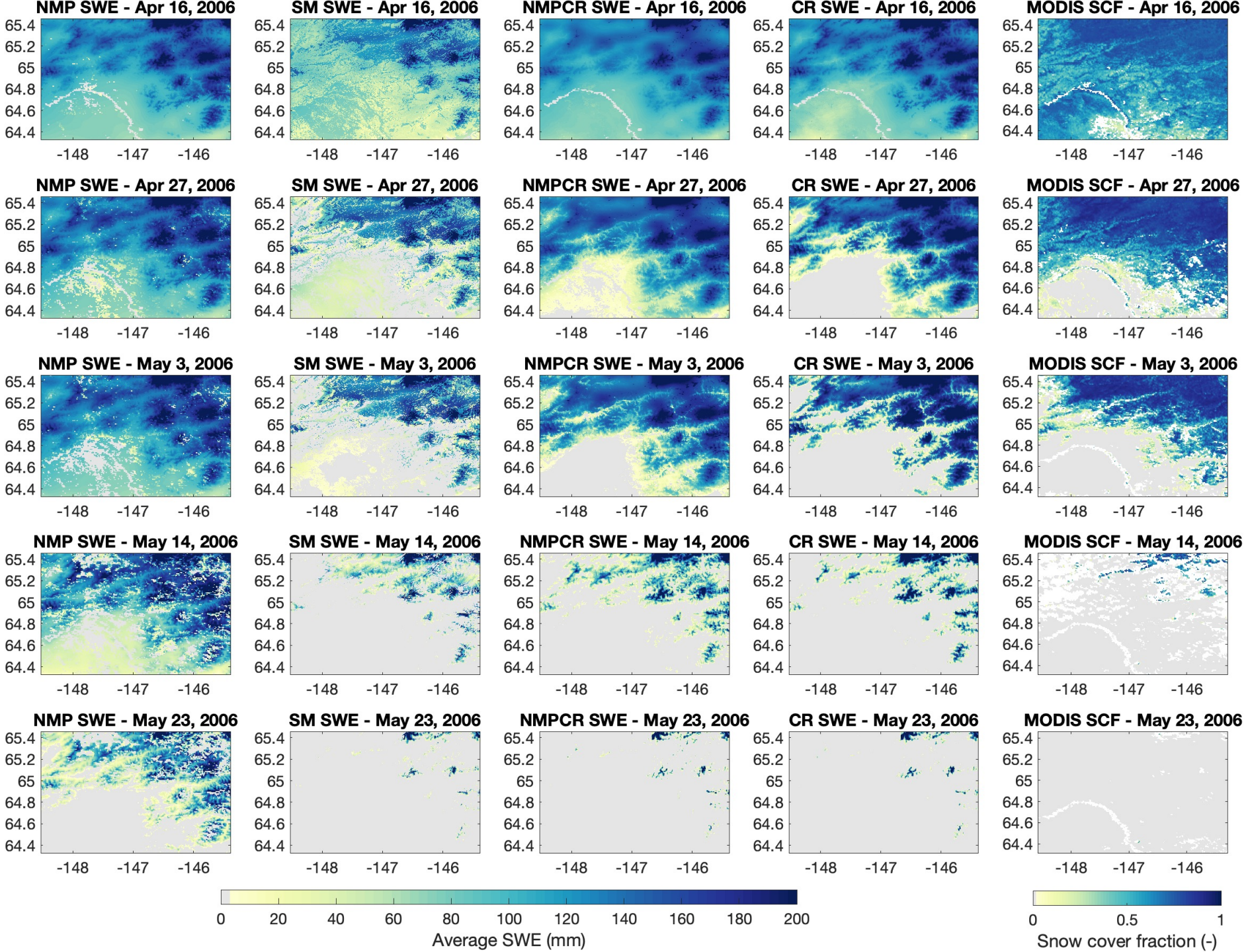
- Each point represents a Gamma SWE survey flight from a single year and the associated model averaged value
- 14 flight lines in model domain
- At least 8 flights available each year, normally 10+ airborne surveys
- For the same flight line, **NoahMP**/**NoahMP-Crocus**/**Crocus** generally have higher SWE than **SnowModel**

Model	Mean SWE Bias (mm)	Mean SWE RMSE (mm)	Mean SWE MAE (mm)
NoahMP	72.49	87.38	72.88
SnowModel	28.44	53.10	44.35
NoahMP-**Crocus**	67.55	81.99	70.08
Crocus	64.67	83.87	70.84

Spatial distribution of snow during the melt season for water year 2006, a medium snow year

Right column is MODIS SCF for comparing patterns of snow disappearance with modeled SWE

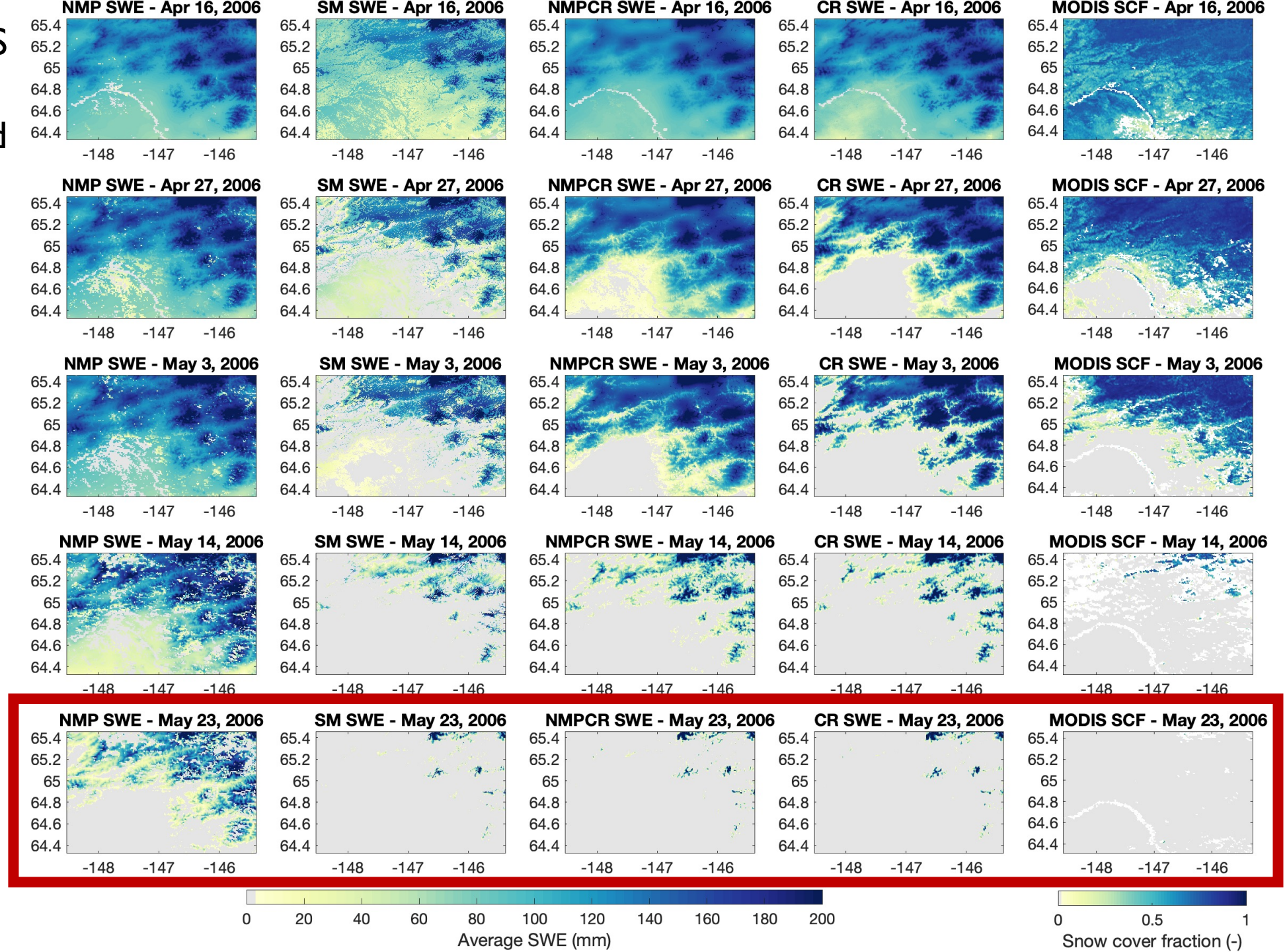
Gray indicates zero snow (whether SWE or SCF). White on MODIS plots is no observation (cloud, water, etc)



By May 23, 2006, MODIS suggests most of the domain is snow free, and SnowModel, NoahMP-Crocus, and Crocus all agree most of the snow has melted.

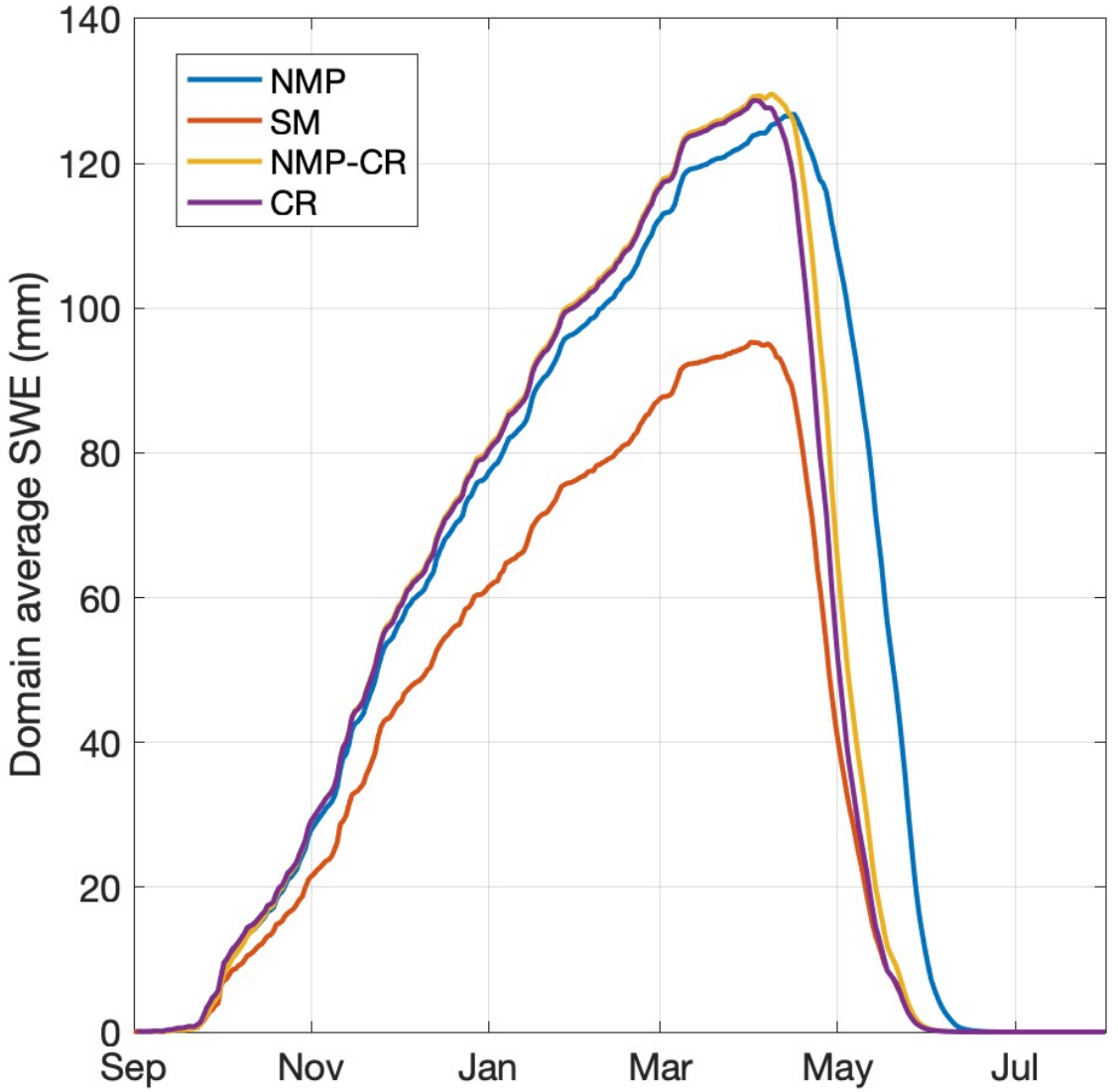
NoahMP still has snow on May 23, with SWE values >100 mm for many grid cells, across the domain.

MODIS comparison for 2006 and other years supports snow in NoahMP persists too long in the melt season



Summary:

- **SnowModel** performs the best compared to SNOTEL and Gamma SWE surveys
- **NoahMP**, **NoahMP-Crocus**, and **Crocus** are in agreement for peak SWE magnitude; all 4 in general agreement with peak SWE timing
- **NoahMP** melts the latest – comparisons with MODIS suggest that snow in **NoahMP** persists too long
- Coupling **Crocus with NoahMP** addresses the late snowmelt
- Ongoing work to assess whether **SnowModel**'s lower SWE is due to canopy interception parameterizations



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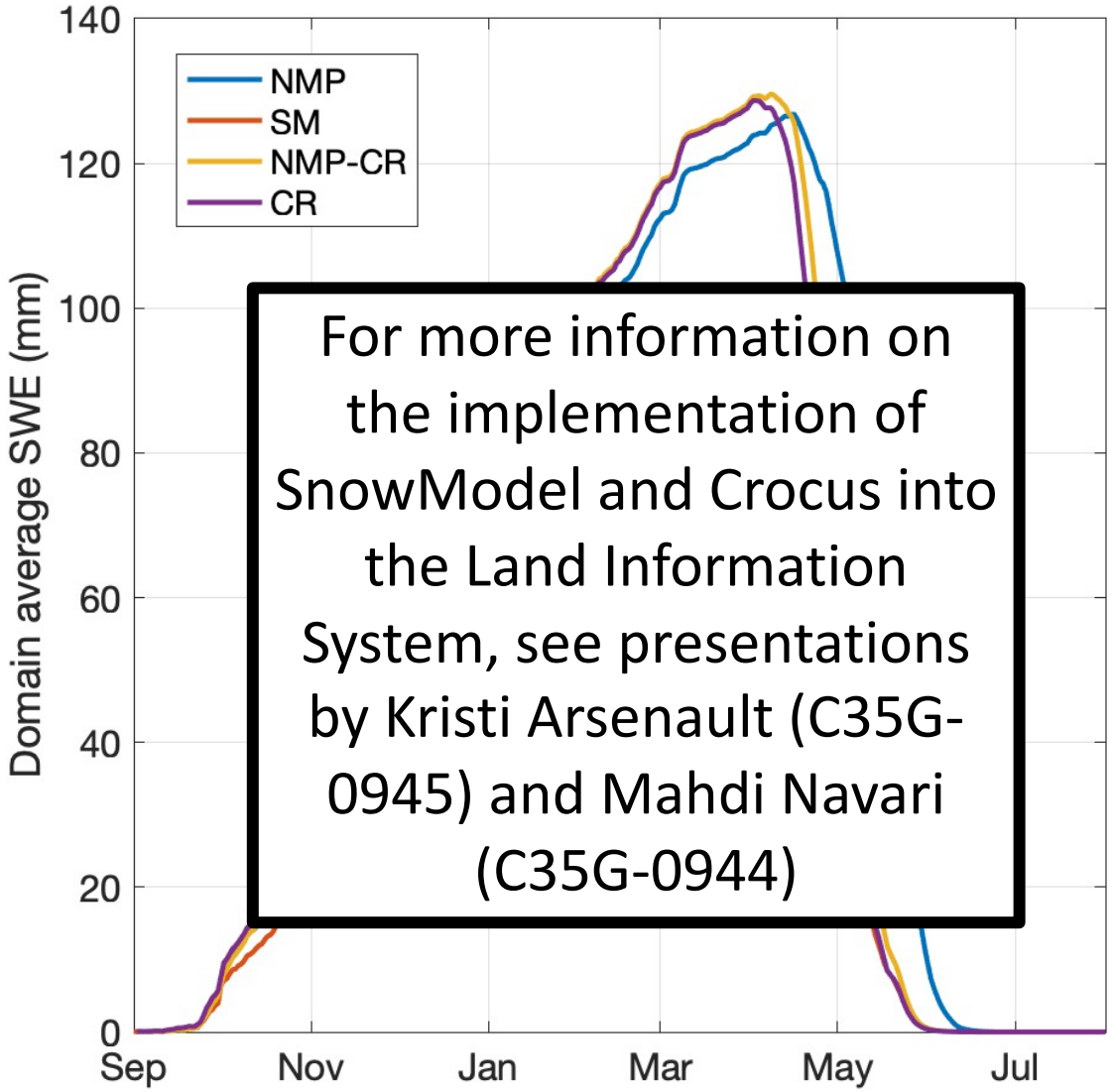

For more information on the implementation of SnowModel and Crocus into the Land Information System, see presentations by Kristi Arsenault (C35G-0945) and Mahdi Navari (C35G-0944)