





# Assimilation of AMSR-E Soil Moisture and Snow Products

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# Introduction

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Conclusion

- AMSR-E soil moisture assimilation
  - ◆ Catchment LSM,  $1/2^\circ \times 2/3^\circ$
  - ◆ USA
  - ◆ SCAN & AMSR-E CalVal-region validation
  
- AMSR-E snow assimilation
  - ◆ Noah LSM, 1 km
  - ◆ Colorado, North Park
  - ◆ SNOTEL & COOP validation



# Experiment setup

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How to improve soil moisture estimates?

Effect of retrieval assimilation; effect of precipitation corrections?

- assimilate AMSR-E surface soil moisture (2002-09) into NASA Catchment model
- AMSR-E data obtained from NSIDC
- 4 different precip forcings:
  - ◆ MERRA: reanalysis product
  - ◆ CMAP, GPCP: pentad, global – satellite + gauges
  - ◆ CPC: daily, continental US – gauges
- different climatology Catchment model vs. AMSR-E obs: anomaly assimilation (EnKF)



# Experiment setup

Validate with in situ data from USDA SCAN stations (only 50 of ~100 suitable), and from AMSR-E (SMAP) CalVal sites

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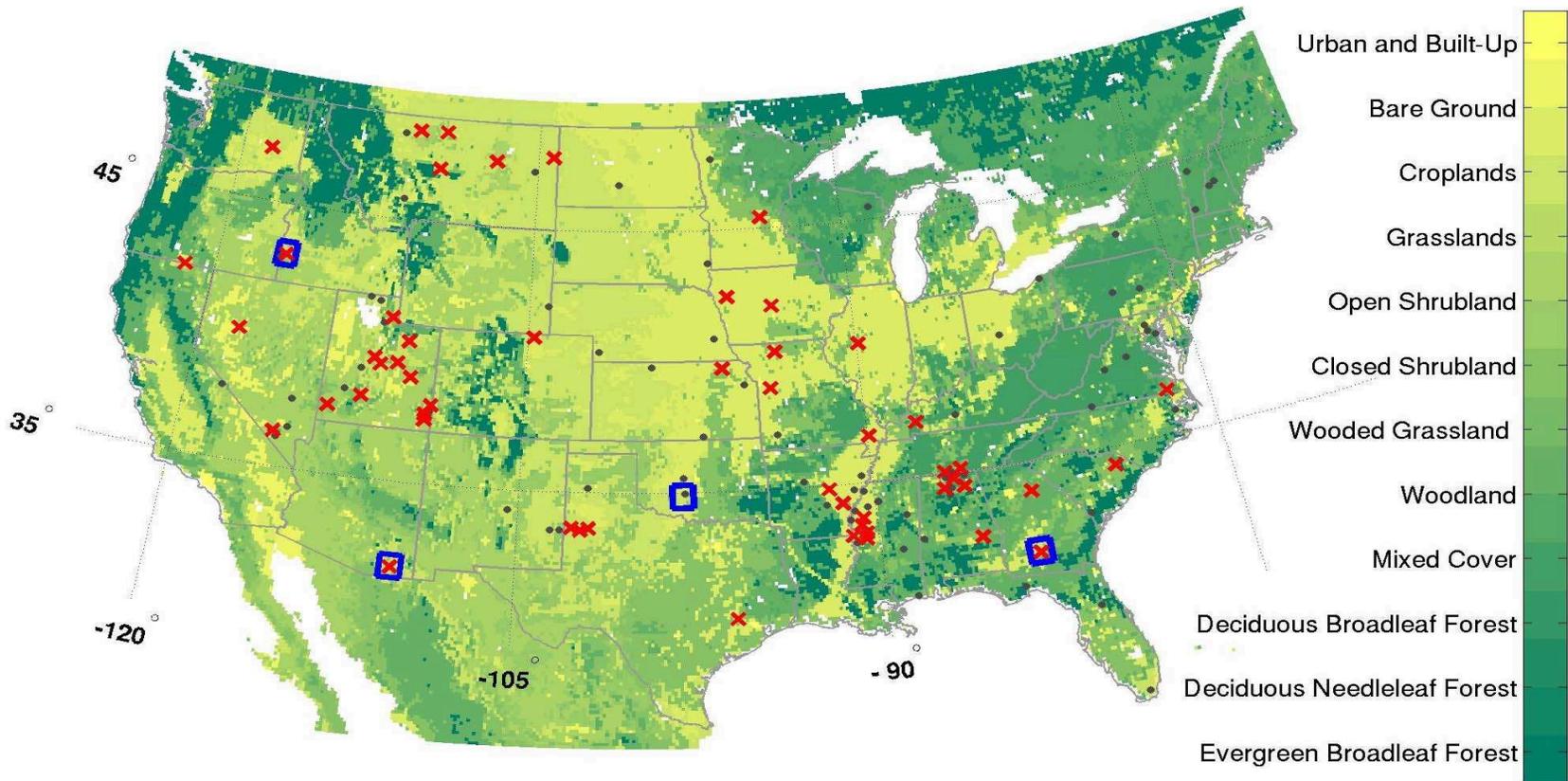
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Q. Liu et al. (2010) updated from Reichle et al. (2007) J Geophys Res, doi:10.1029/2006JD008033.



# Results

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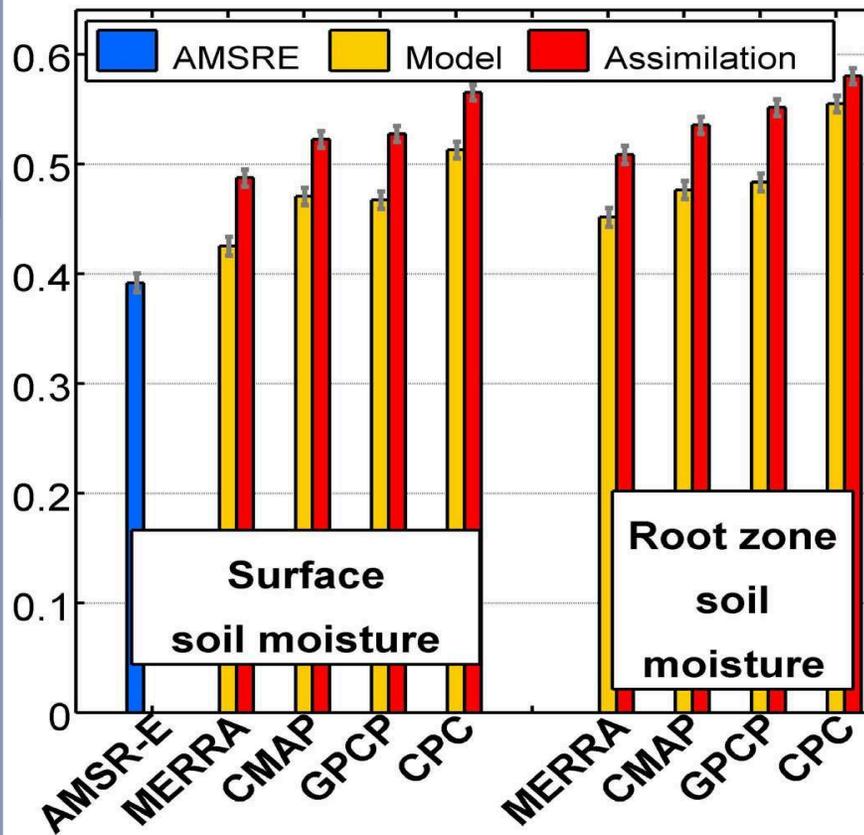
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### Skill (R) v. SCAN in situ observations

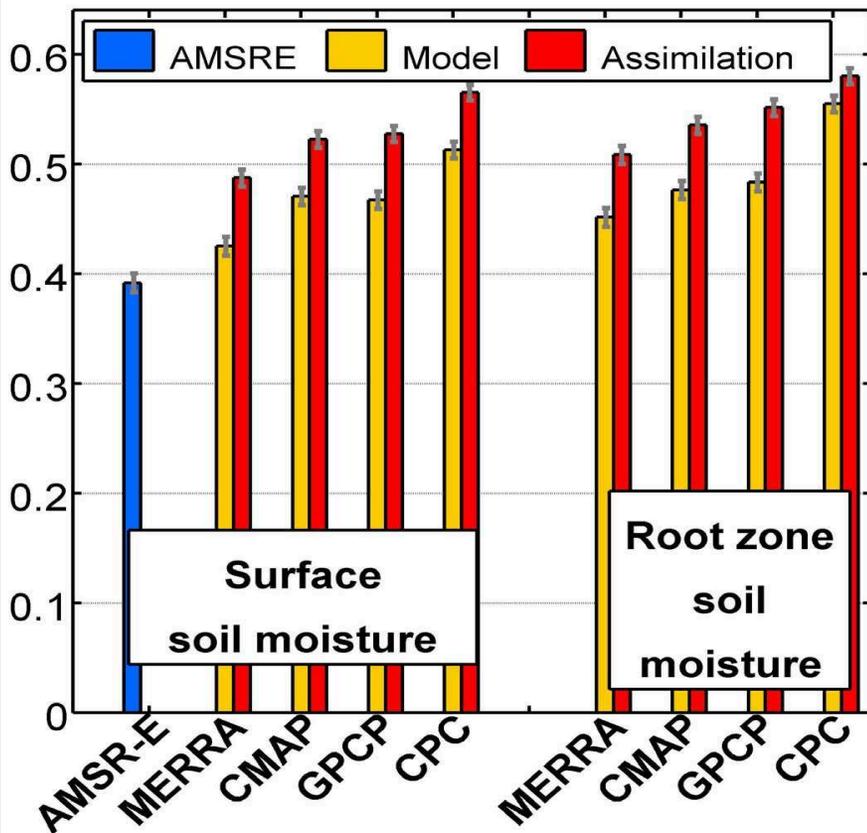




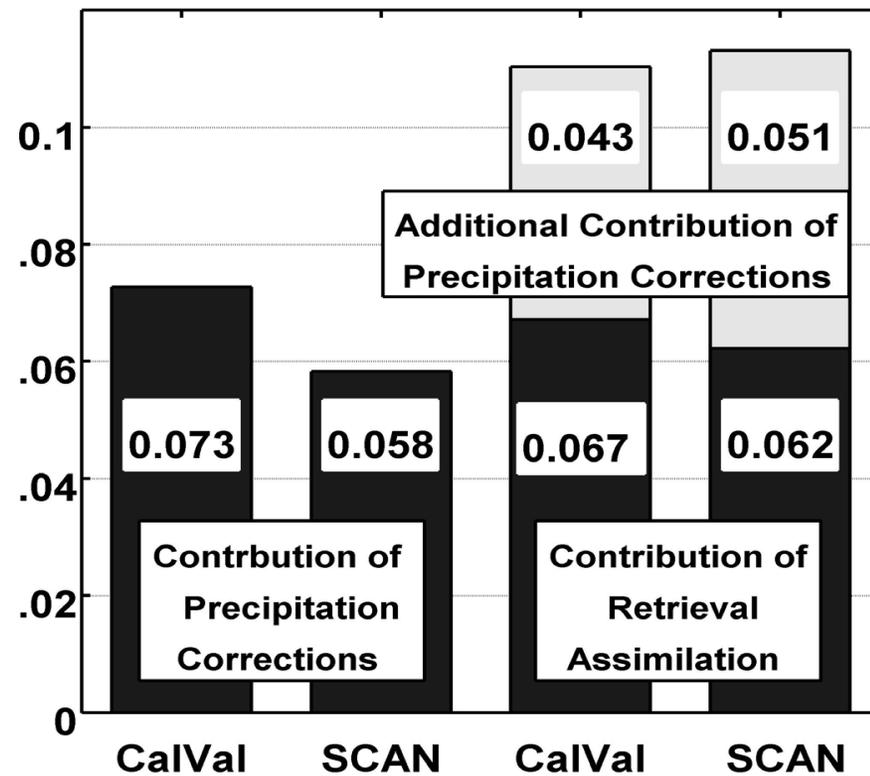
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Skill (R) v. SCAN in situ observations



Skill improvement ( $\Delta R$ )





# Results

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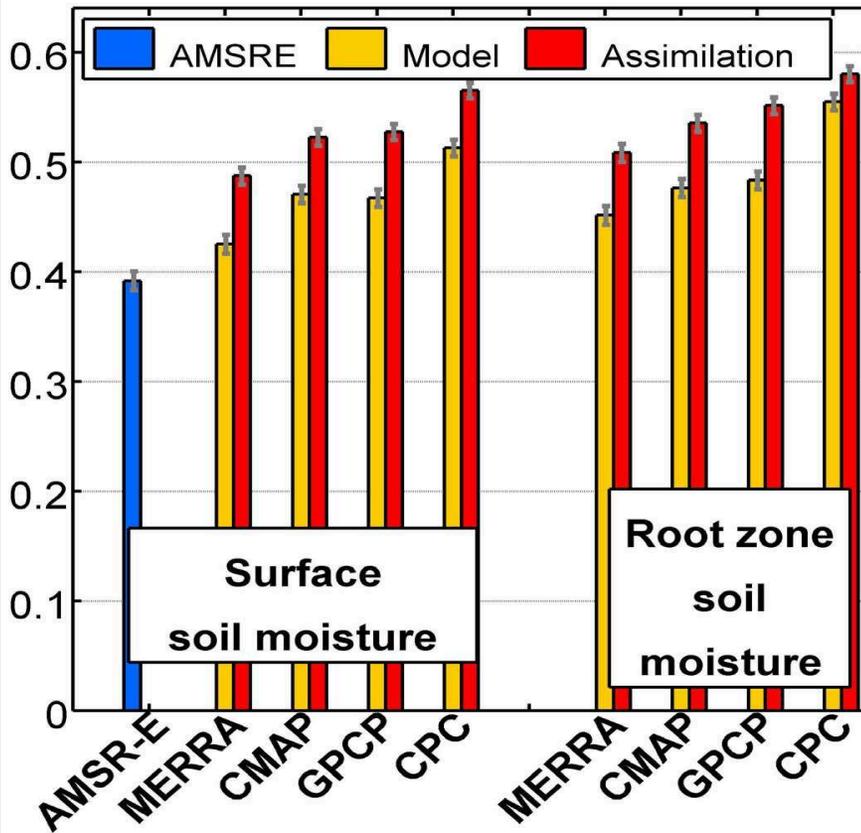
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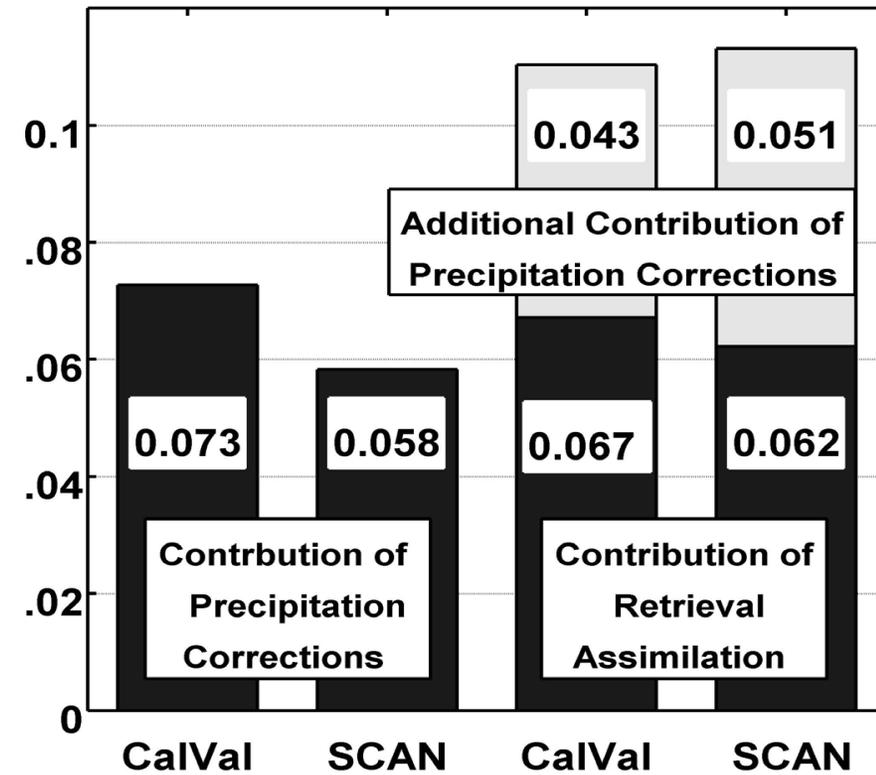
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Skill (R) v. SCAN in situ observations



Skill improvement ( $\Delta R$ )



Results by Q. Liu et al. (2010) updated from Reichle et al. (2007) J Geophys Res, doi:10.1029/2006JD008033.

- skill increases with better precipitation forcing and satellite data assimilation; improvements may be critical for applications.
- root-zone not observed by satellite



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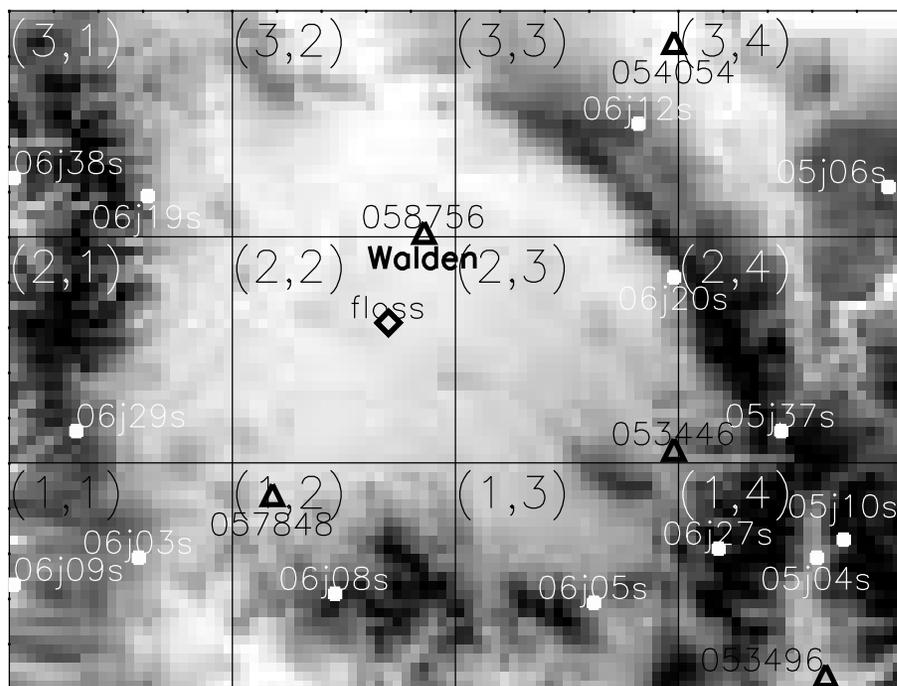
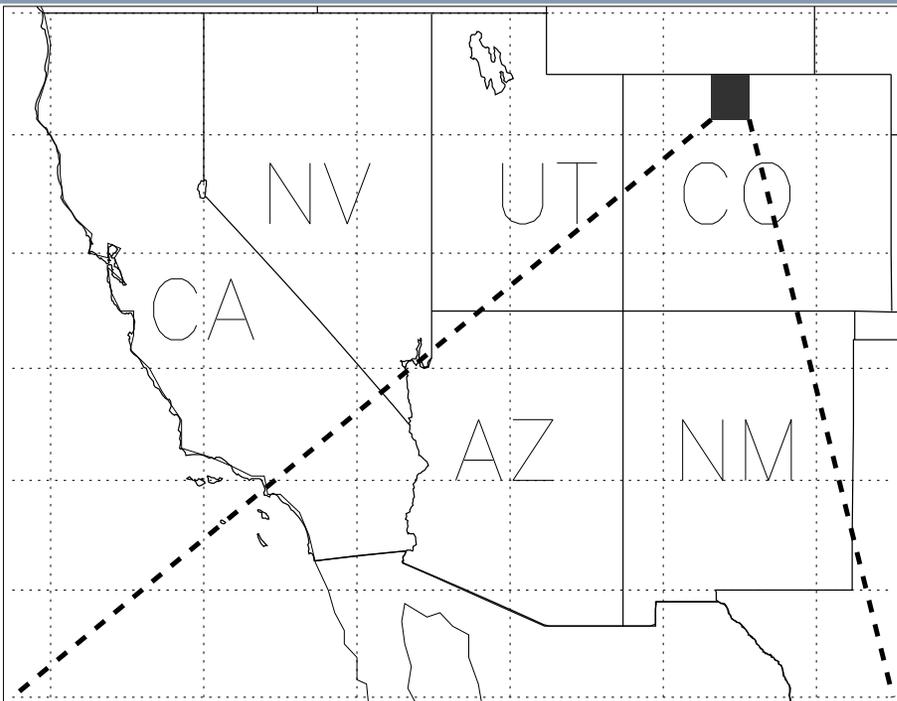
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How to optimally use satellite snow products?

- North Park, CO
- $75 \times 100 \text{ km}^2$
- period 2002-2007
- 12 AMSR-E pixels  
DA daily 1:00 am LT
- 7500 MODIS pixels  
DA daily 10:00 am LT
- validation:  
SNOTEL SWE,  
COOP SND



# AMSR-E SWE, MODIS SCF

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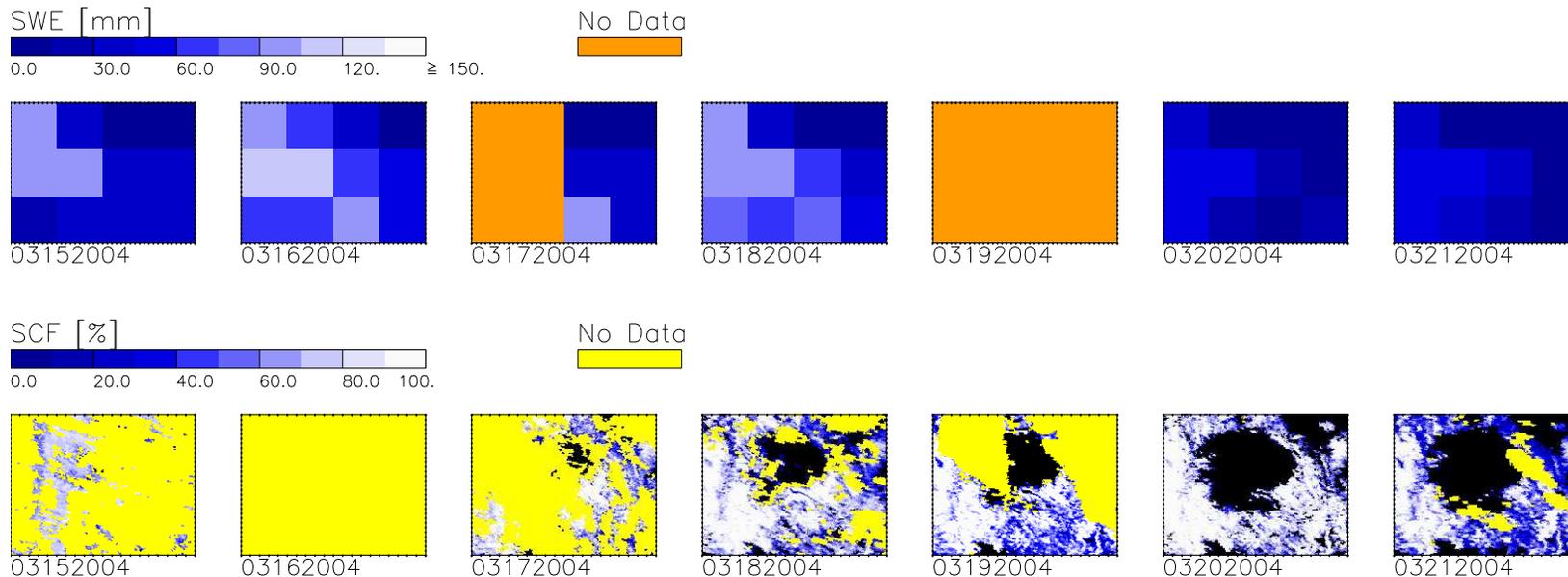
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■ mapped from EASE/sinusoidal to latlon



# AMSR-E SWE, MODIS SCF

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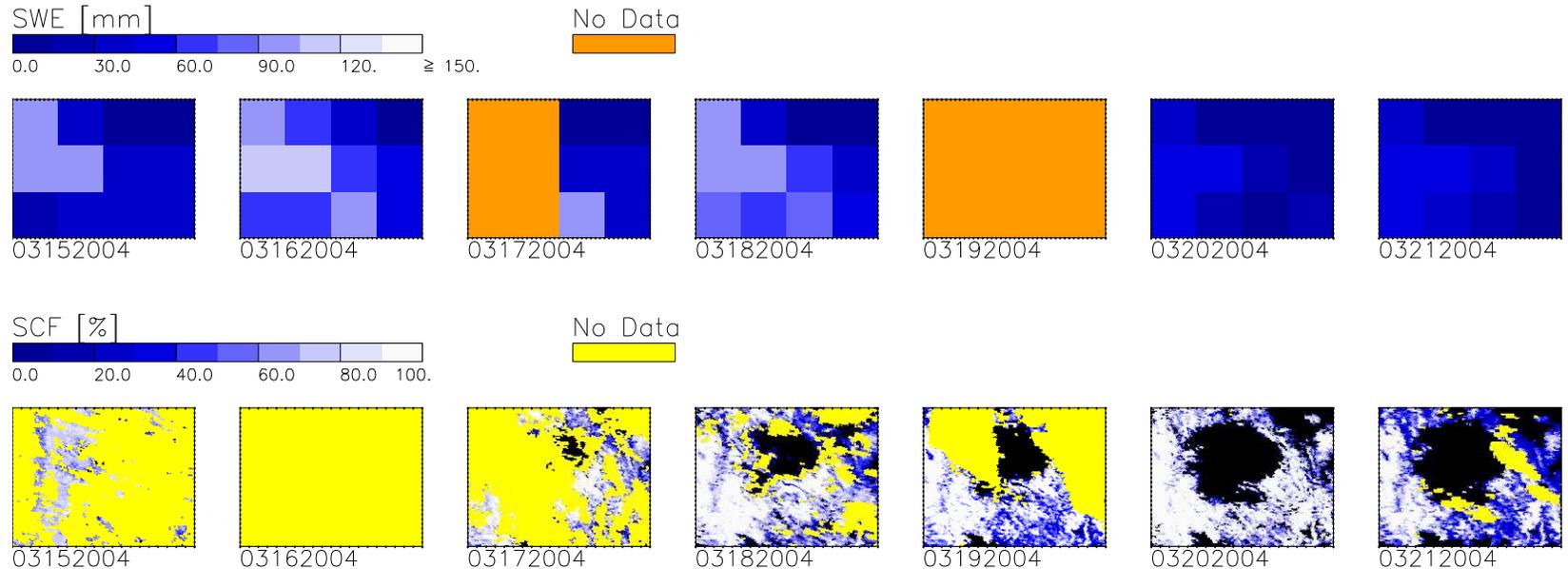
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- mapped from EASE/sinusoidal to latlon
- observation error assumptions:  
 $\sigma_{AMSR} = 5 + 0.2 \cdot SWE$  [mm],  
 $\sigma_{MODIS} = 0\%(0\%) \rightarrow 25\%(50\%) \rightarrow 0\%(100\%)$
- SWE DA: downscaling of 25 km AMSR-E pixels, 3D EnKF
- SCF DA: averaging of 500 m MODIS to 1 km, 1D EnKF



# Land Surface Model

Spatial average at 14 SNOTEL / 5 COOP sites  $\pm$  stdv

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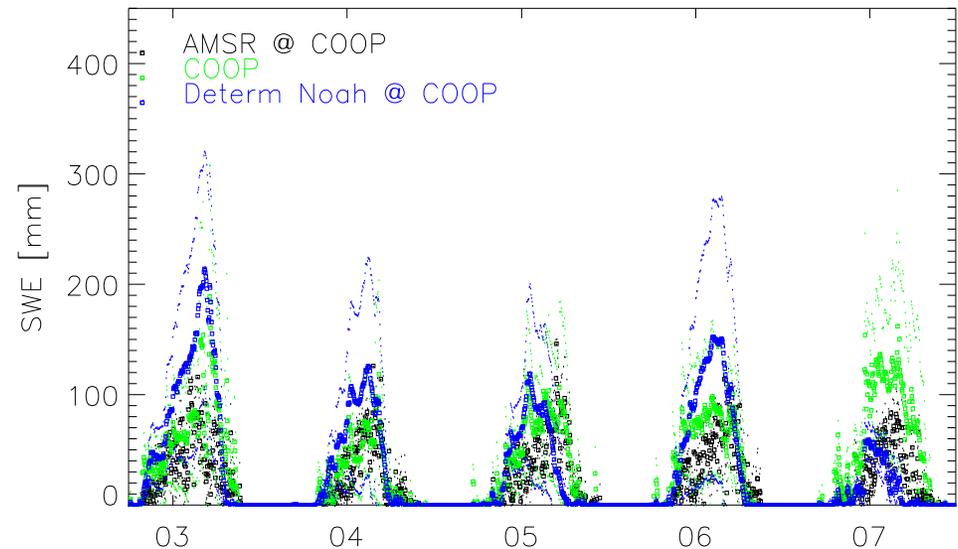
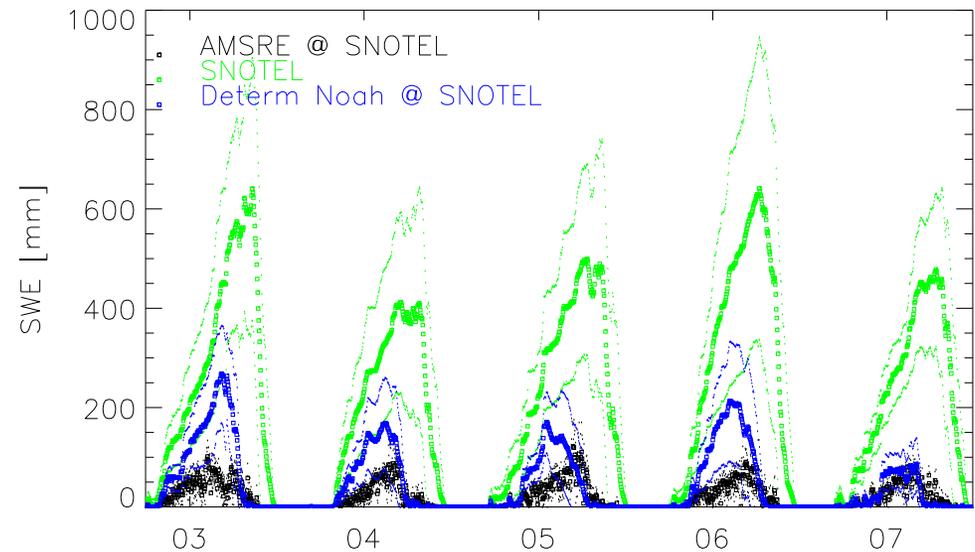
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- SNOTEL sites are at high elevations
- Noah early melt
- Bias (+scale!)

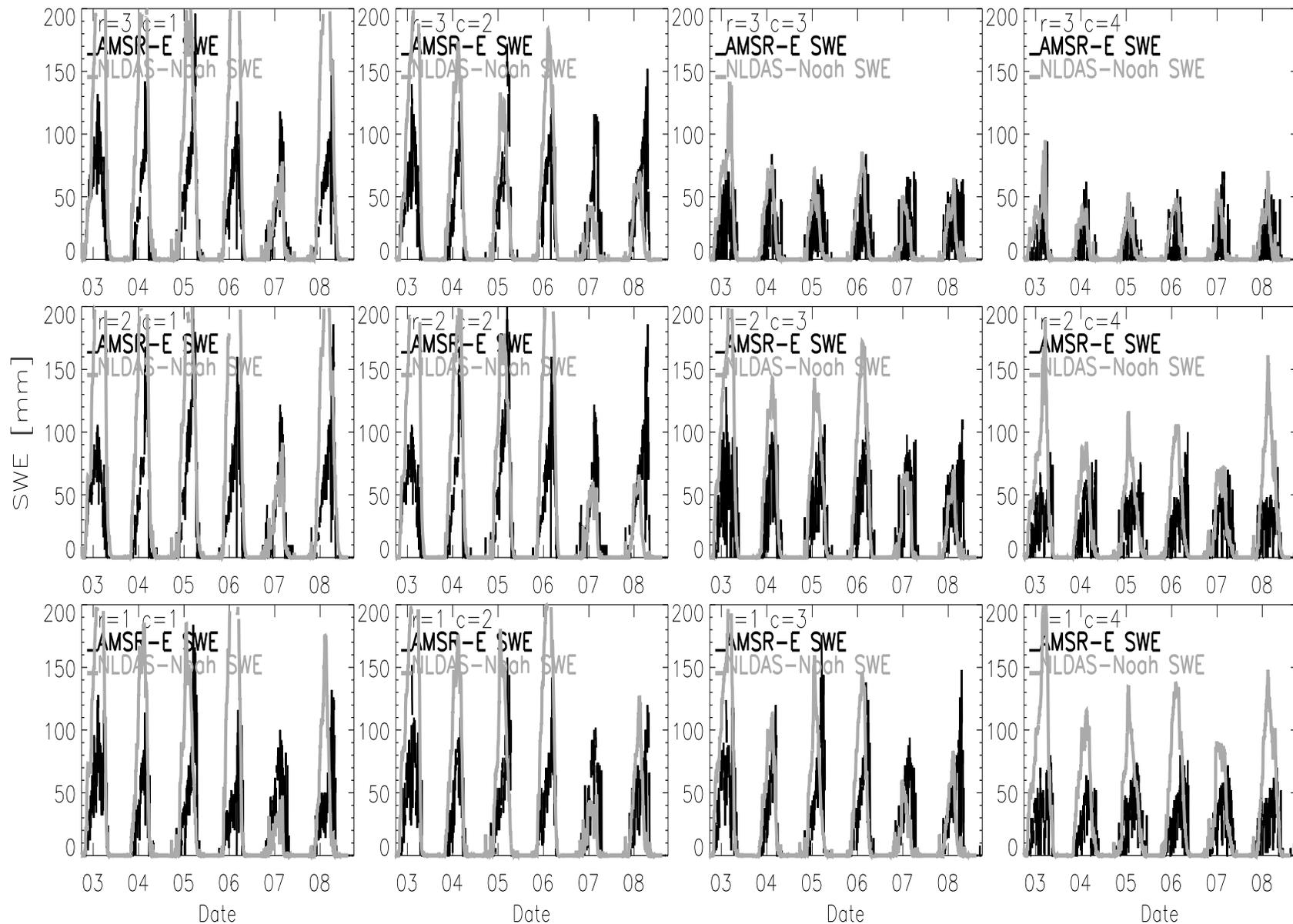




# Land Surface Model

At 25 km scale:

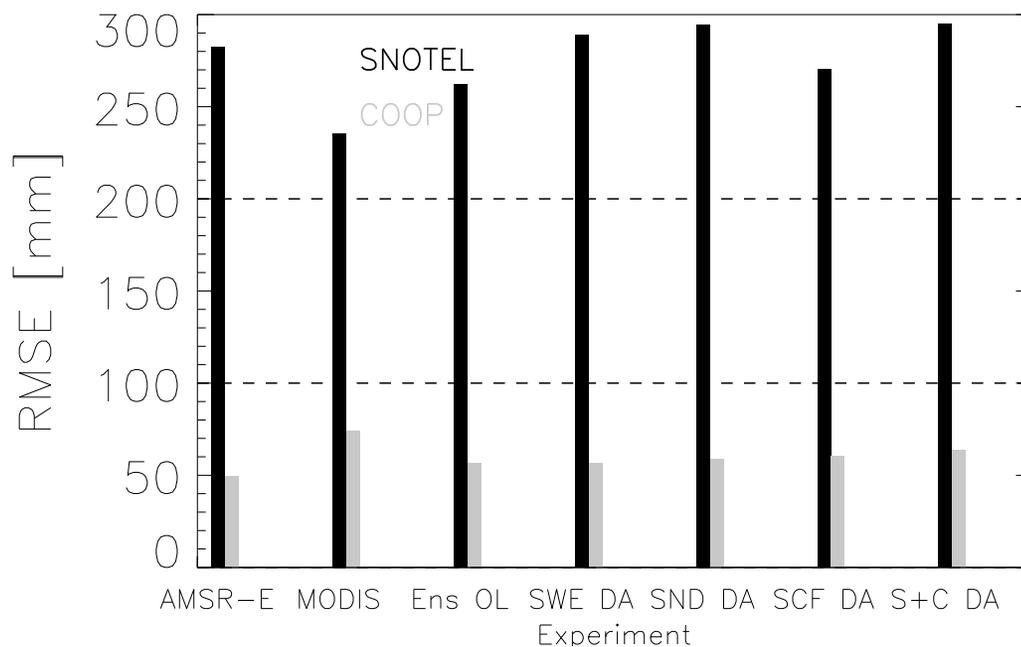
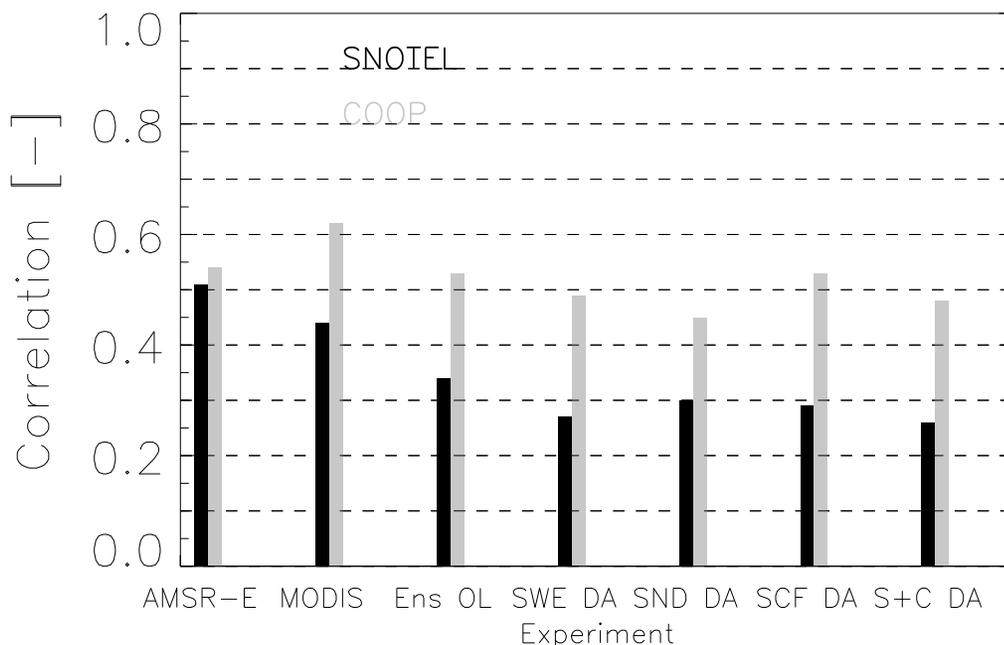
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# Time Series Results

Assimilation of raw data



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# Time Series Results

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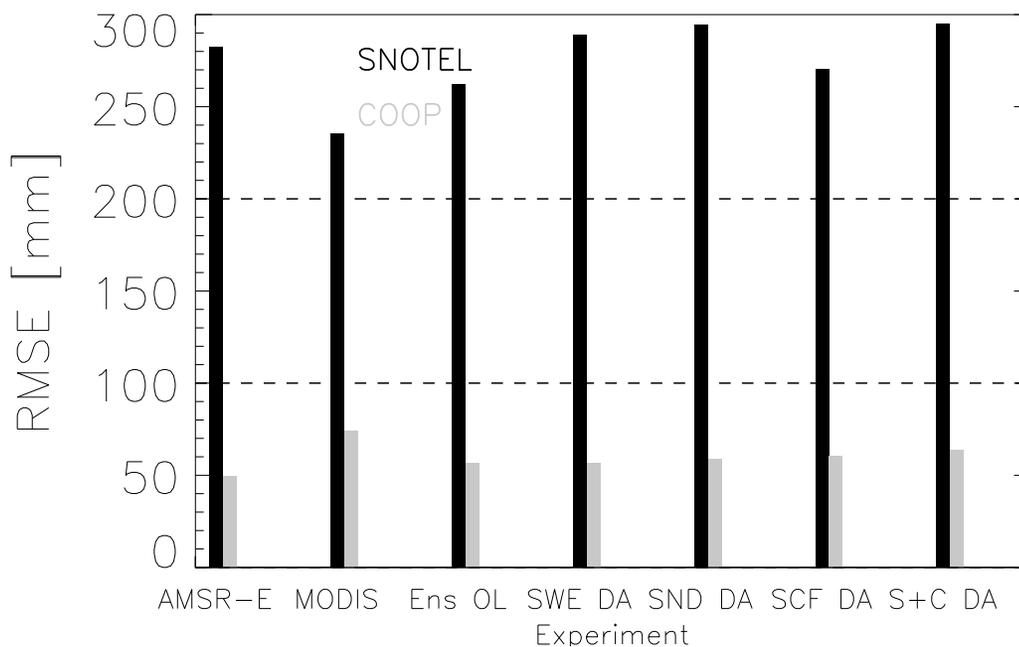
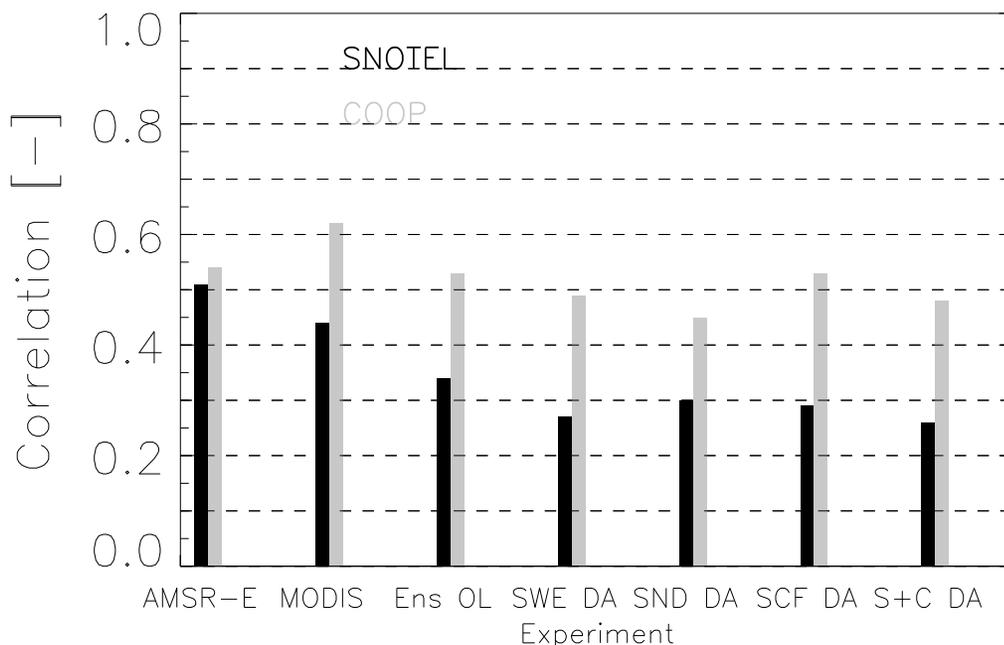
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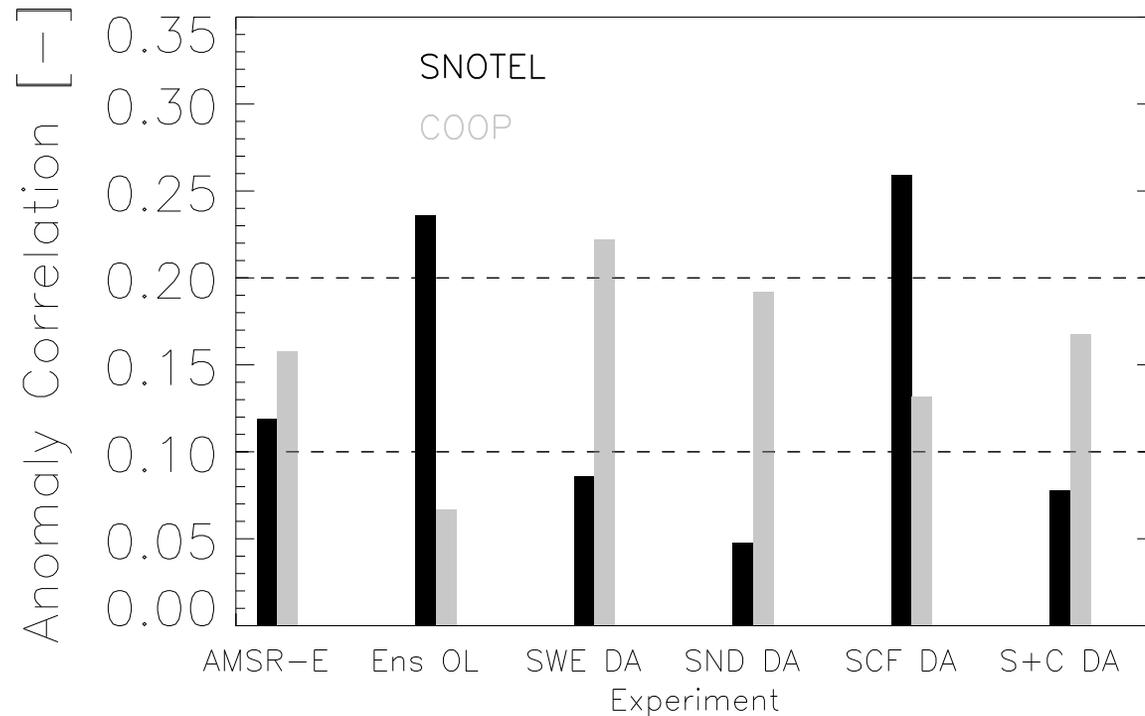
## Assimilation of raw data

- problem: large RMSE, different climatologies
- better agreement at COOP sites
- \*absolute\* R: AMSR-E/MODIS data better than EnsOL
- DA degrades performance
- note: SCF and SND converted to SWE for validation metrics



# Time Series Results

## Anomaly assimilation (5 winters)



- \*anomaly\* R: AMSR-E data worse than EnsOL (SNOTEL)
- DA: worse at SNOTEL, better at COOP
- problem: AMSR-E SWE lacks interannual variability
- note: SCF and SND converted to SWE for validation metrics



# Spatial Pattern Results

## Anomaly assimilation (CLPX I winter 2002-2003)

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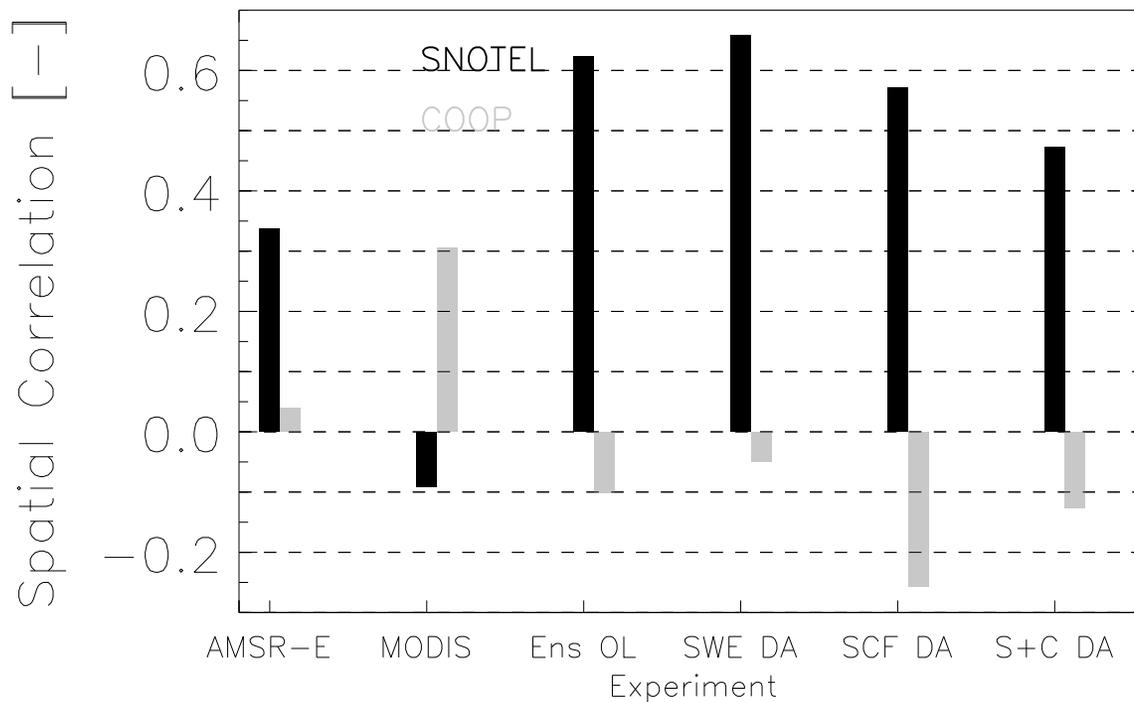
Experiment

AMSR/MODIS

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- model generates spatial pattern
- SWE DA does not destroy the pattern (3D filter)
- SCF DA slightly worsens the pattern (SCF → SWE)
- COOP not representative in space (4 stations)



# Results

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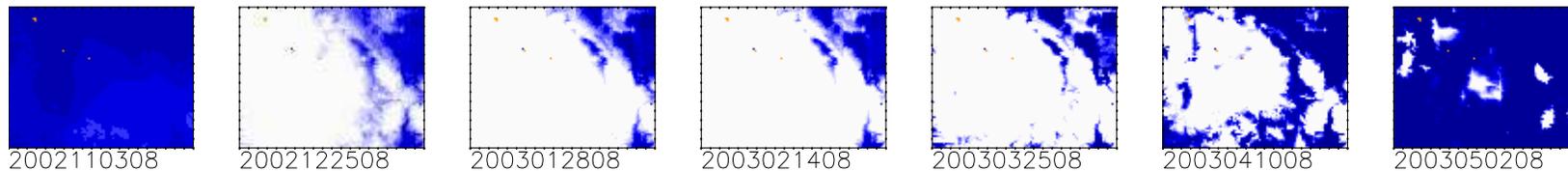
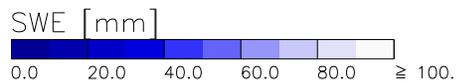
Experiment

AMSR/MODIS

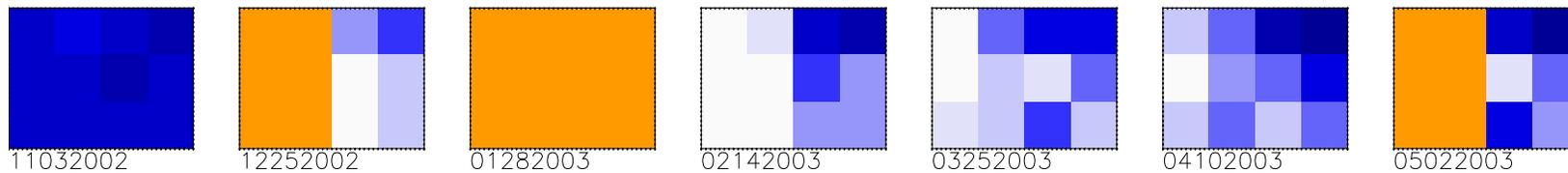
LSM

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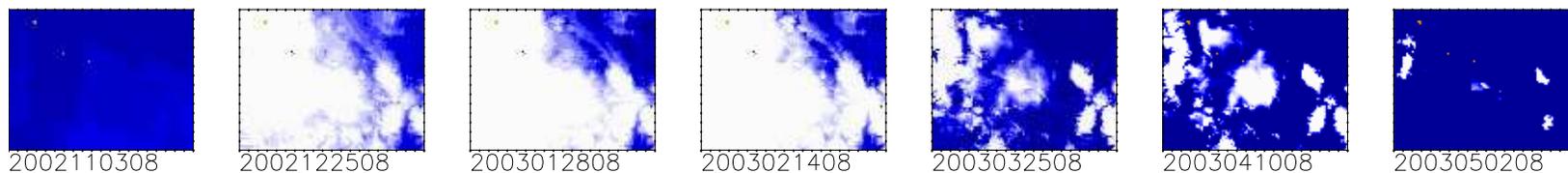
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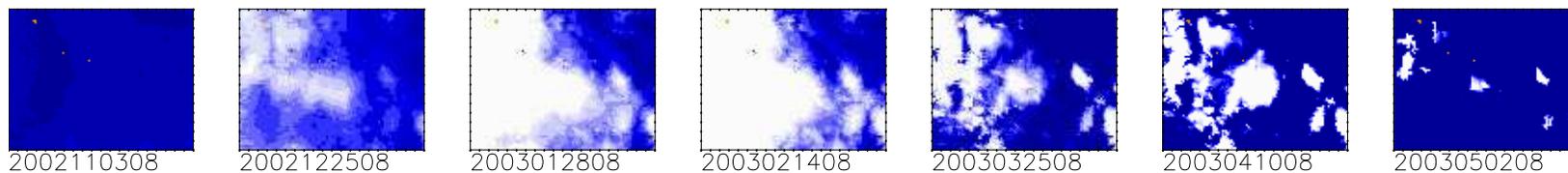
## Ens OL



## Rescaled AMSR-E SWE



## SWE DA



## SND DA



# Results

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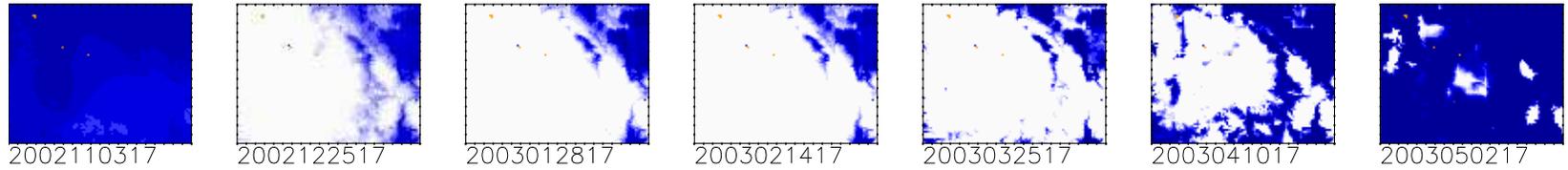
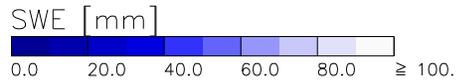
Experiment

AMSR/MODIS

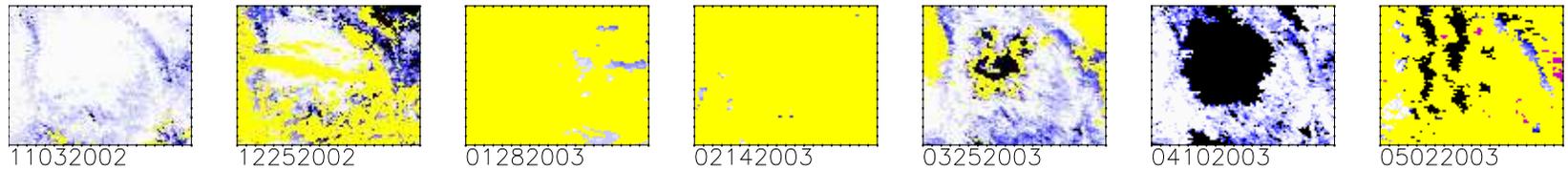
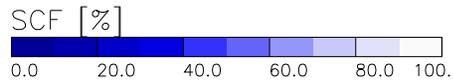
LSM

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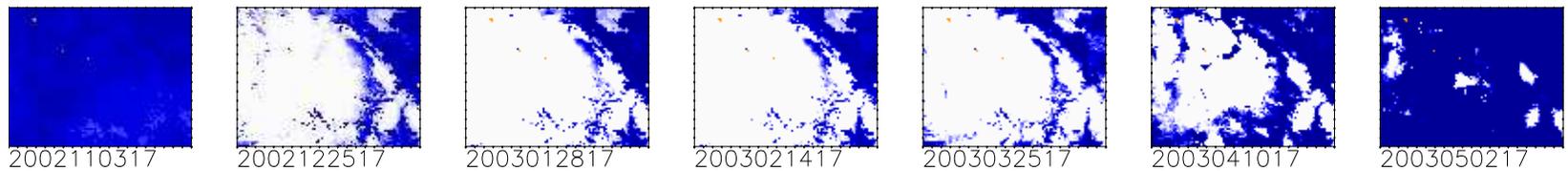
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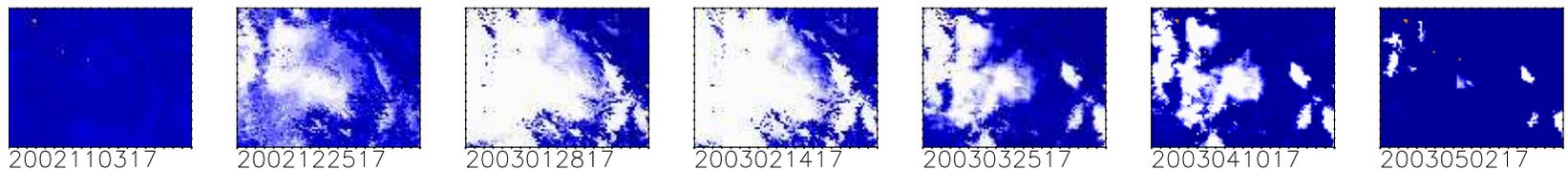
## Ens OL



## MODIS SCF



## SCF DA



## SND+SCF DA



# Conclusion

- AMSR-E soil moisture assimilation
  - ◆ better precipitation → better skill
  - ◆ AMSR-E SM assimilation → better skill
  - ◆ anomaly R: AMSR-E SM < open loop model integration
  - ◆ **yet, AMSR-E SM assimilation increases the analysis skill**

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# Conclusion

## ■ AMSR-E soil moisture assimilation

- ◆ better precipitation → better skill
- ◆ AMSR-E SM assimilation → better skill
- ◆ anomaly R: AMSR-E SM < open loop model integration
- ◆ **yet, AMSR-E SM assimilation increases the analysis skill**

## ■ AMSR-E snow assimilation

- ◆ absolute R: AMSR-E SWE > open loop model
- ◆ anomaly R: AMSR-E SWE < open loop model
- ◆ SCF assimilation does not harm the time series skill
- ◆ **SWE assimilation decreases the time series skill**
- ◆ **SWE downscaling does not harm the spatial pattern**
- ◆ work on conversions SND, SWE, SCF for validation

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