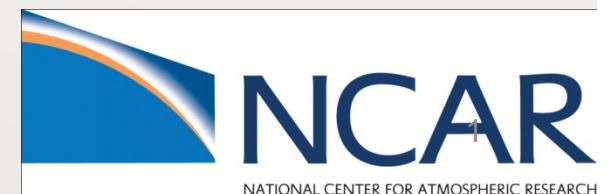
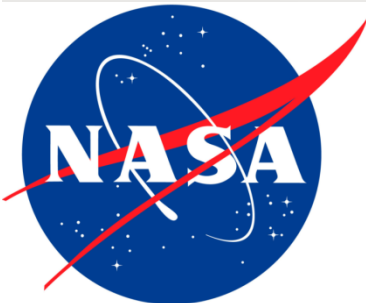


# The value of GRACE TWS data in estimating snow mass

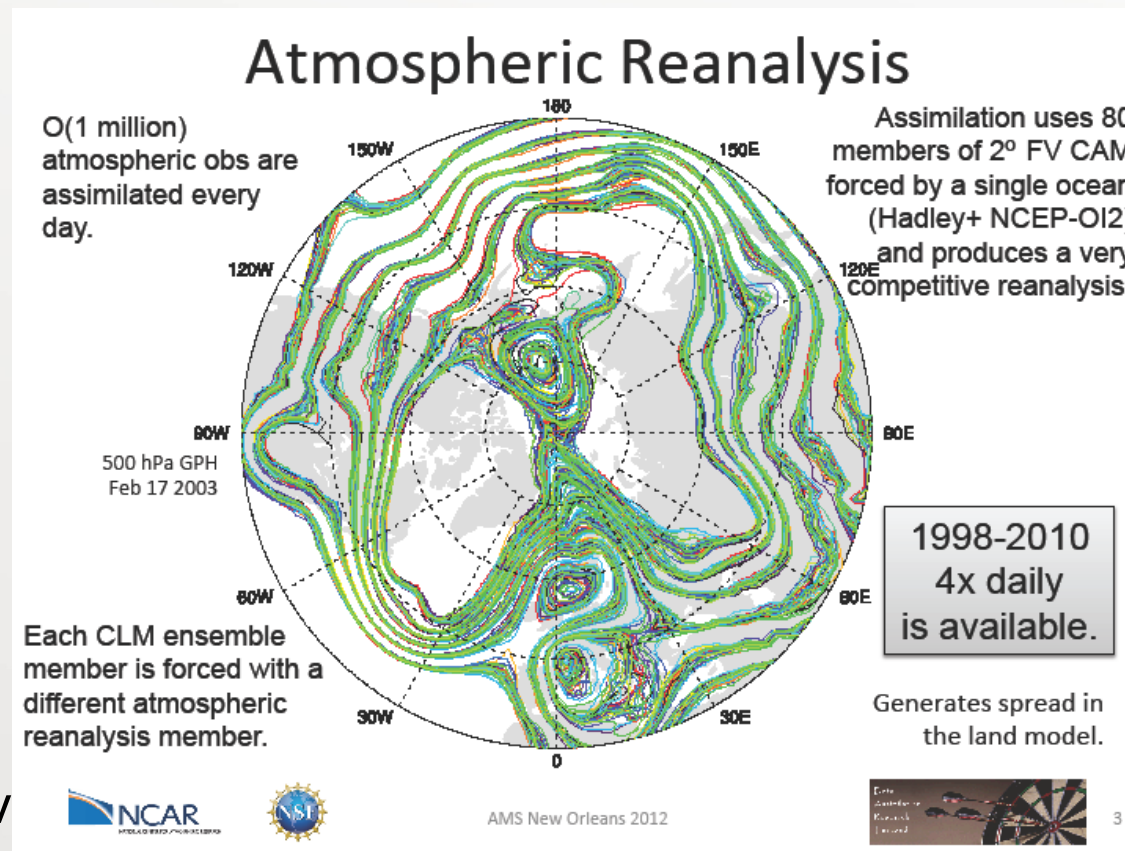
Yongfei Zhang<sup>1</sup>, Hua Su<sup>1</sup>, Zong-Liang Yang<sup>1</sup>, Tim  
Hoar<sup>2</sup>, Jeffrey Anderson<sup>2</sup>

<sup>1</sup>The University of Texas at Austin, Jackson School of  
Geosciences, Austin, Texas

<sup>2</sup>The National Center for Atmospheric Research,  
Boulder, Colorado



# CLM4/DART: data assimilation system



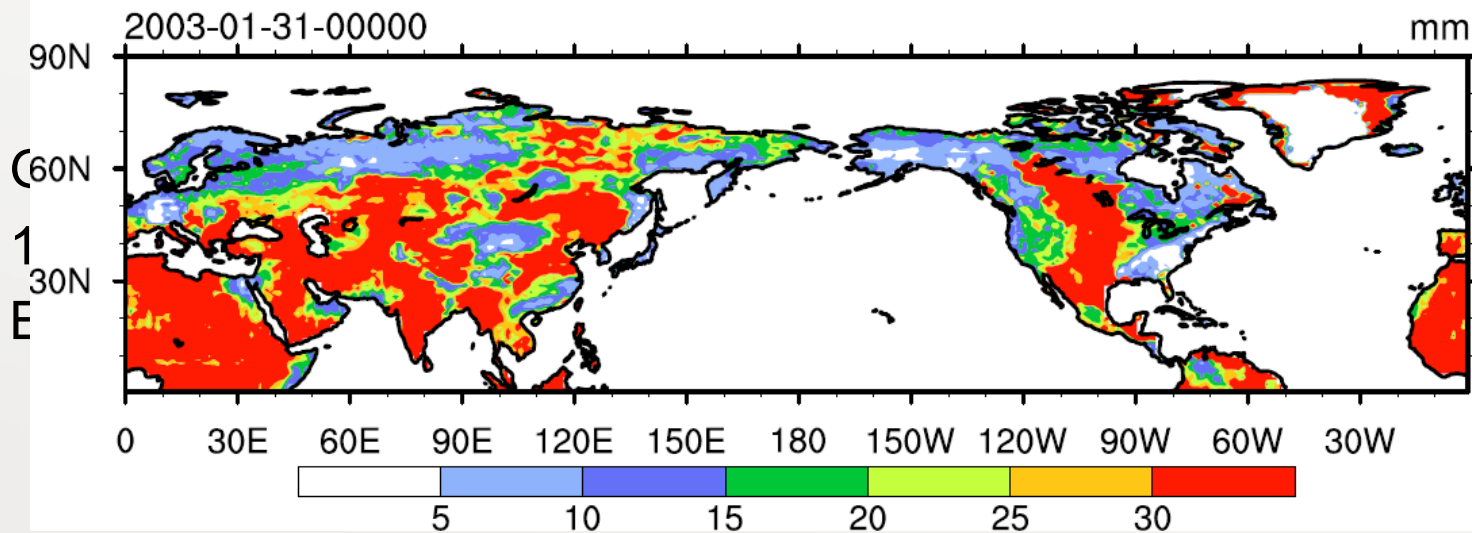
Satellite observ  
data.

CLM4: The Community Land Model version 4  
DART: The Data Assimilation Research Testbed  
MODIS: The Moderate Resolution Imaging Spectroradiometer

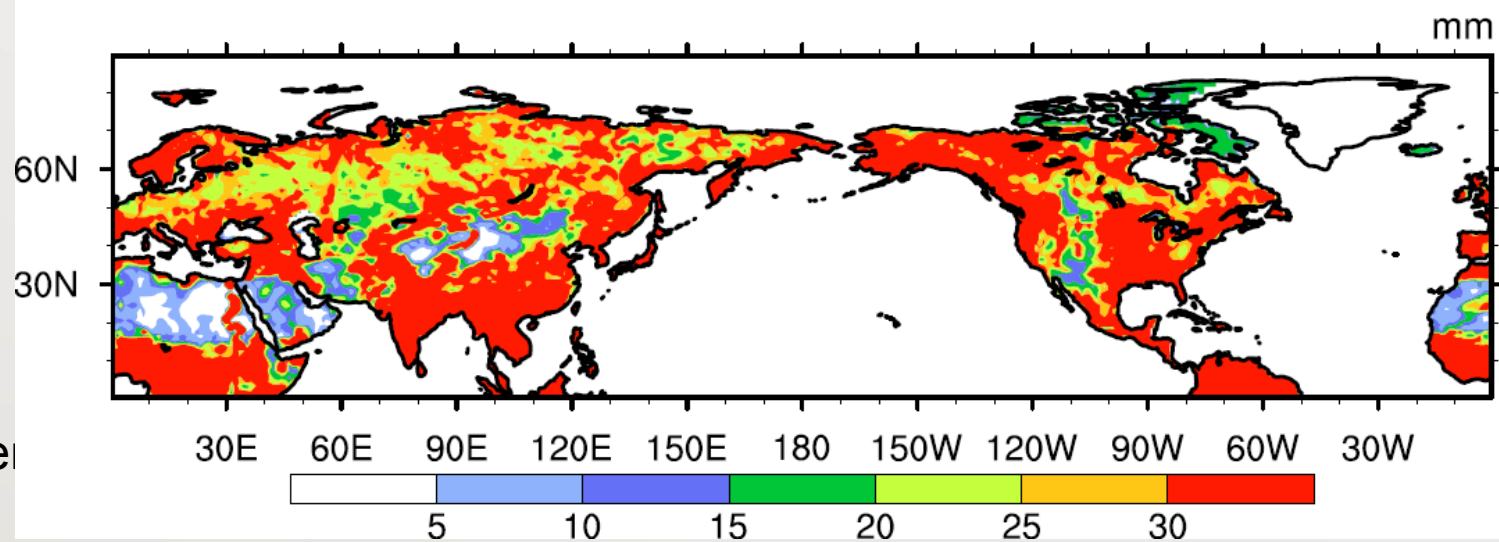
FACE TWS

*Hoar et al.,  
2012 AMS*

### Ensemble Spread of TWS

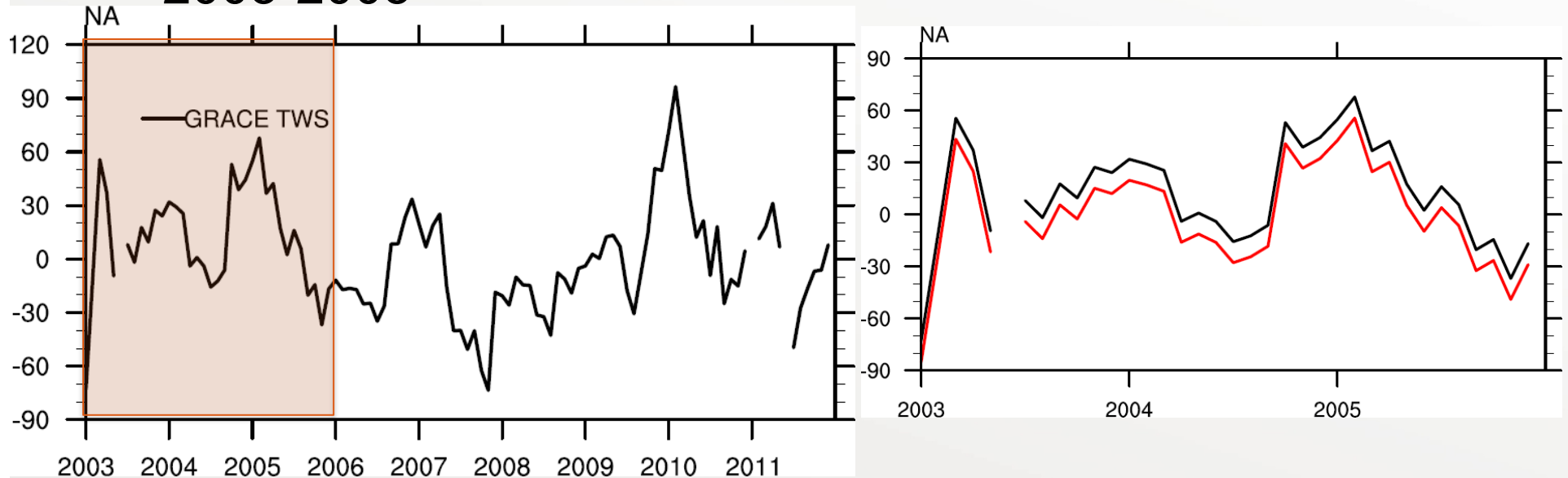


### Total Error of GRACE TWS Variations



TWS: Te

- Remove the mean over the model simulation period:  
2003-2005



- GRACE provides monthly variations, not the absolute value
- Add a mean to the GRACE variations
  - An open loop CLM4 ran for 3 years from 2003 and produced the mean

# MODIS snow cover observations

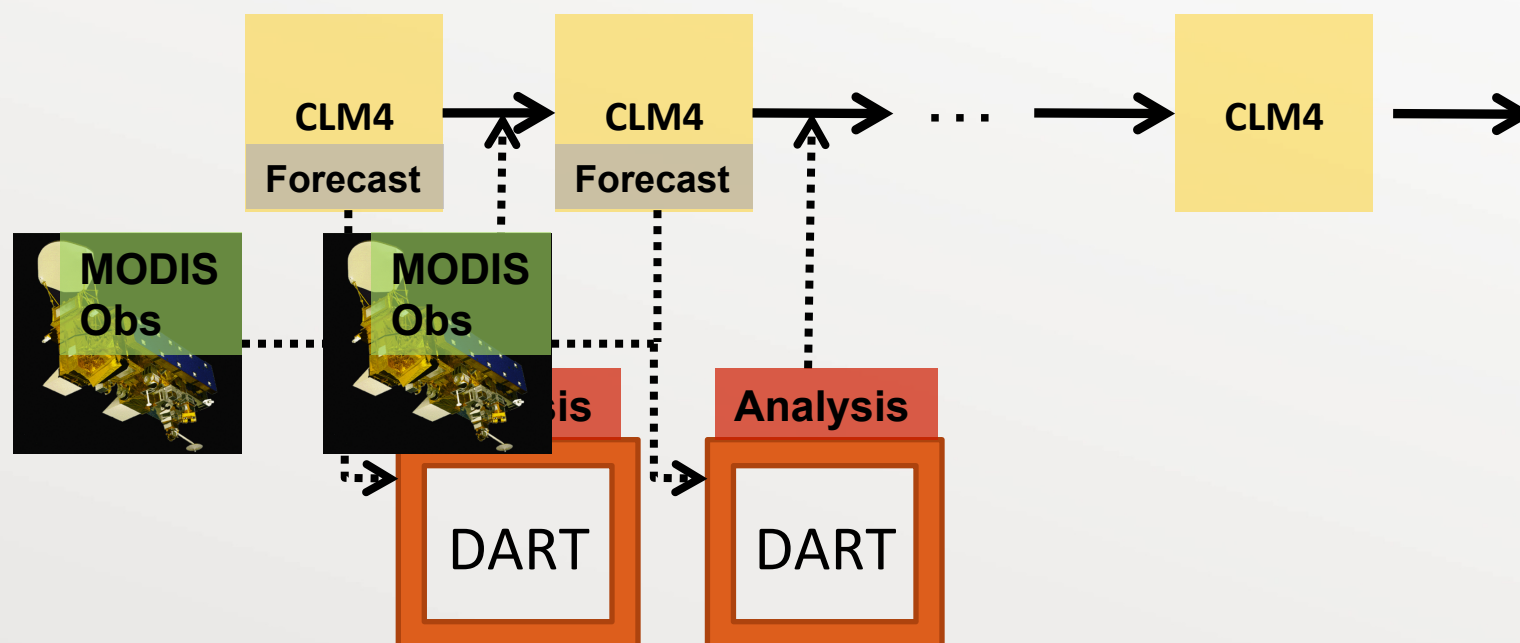
- MODIS/Terra daily snow cover (MOD10C2; 0.05° resolution; northern hemisphere)
  - Retrieved using the Normalized Difference Snow Index (NDSI)

$$\text{NDSI} = \frac{\text{band 4} - \text{band 6}}{\text{band 4} + \text{band 6}}$$

- Preprocessed to 0.9 ° x 1.25 ° “Level 4” data
  - Pixels with lower than 20% confidence index (percentage of clear sky over certain grid) will be discarded.

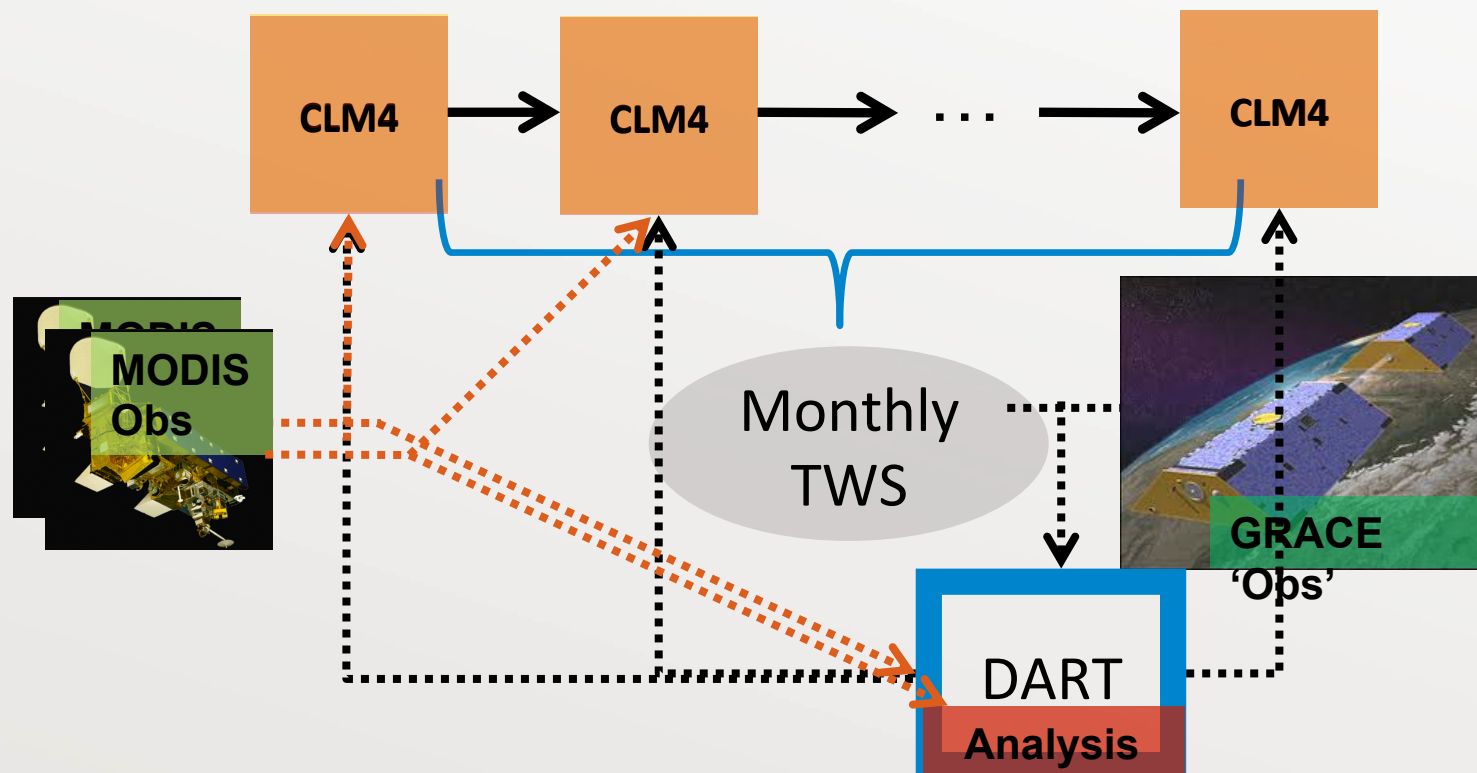
Collaboration with Ally Toure and Matt Rodell at NASA

# Flowchart of MODIS data assimilation



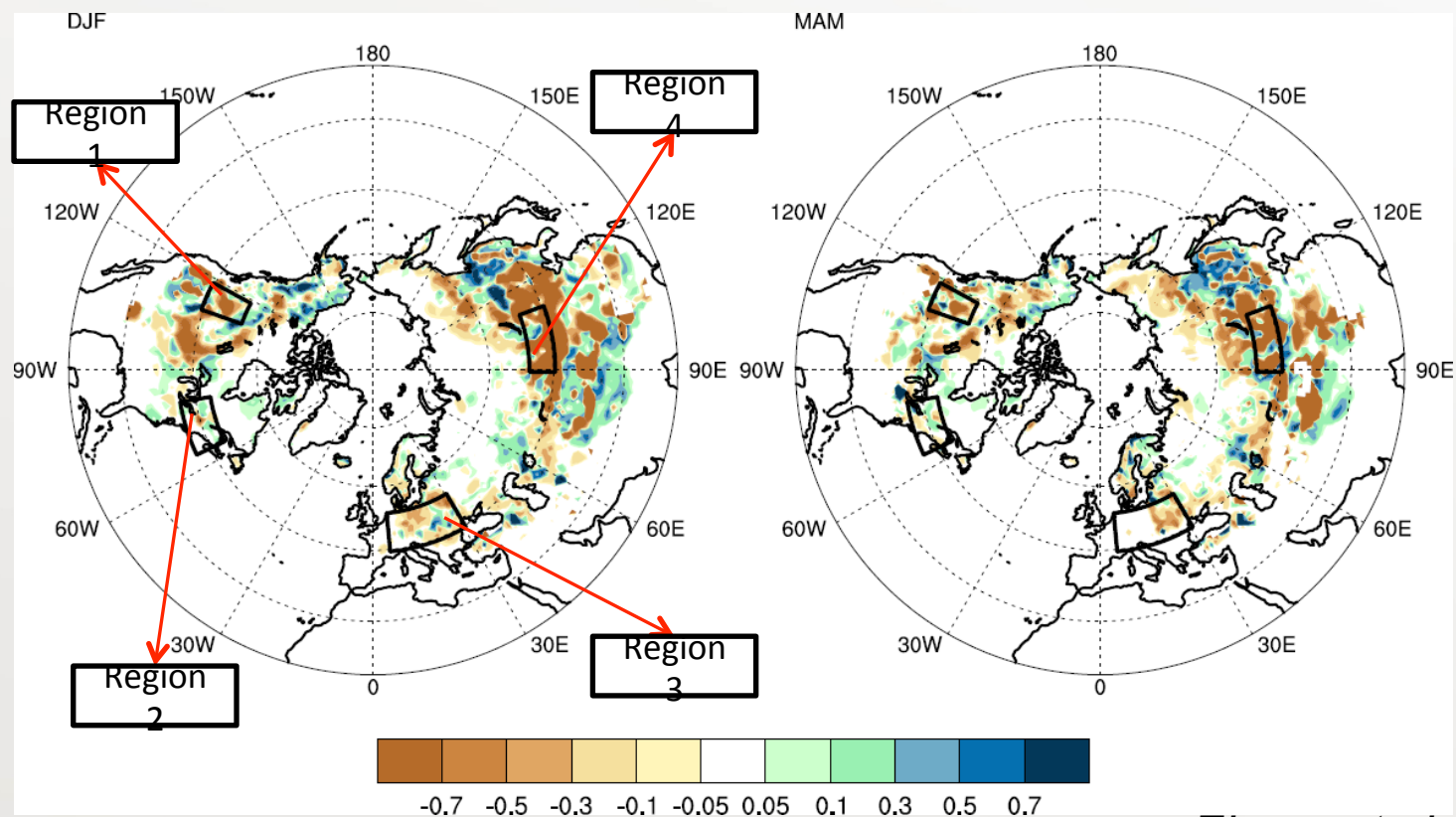


# Assimilation of MODIS + GRACE



# Assimilation of MODIS data

Relative difference between Model SWE and CMC SWE:  
Data assimilation minus Control

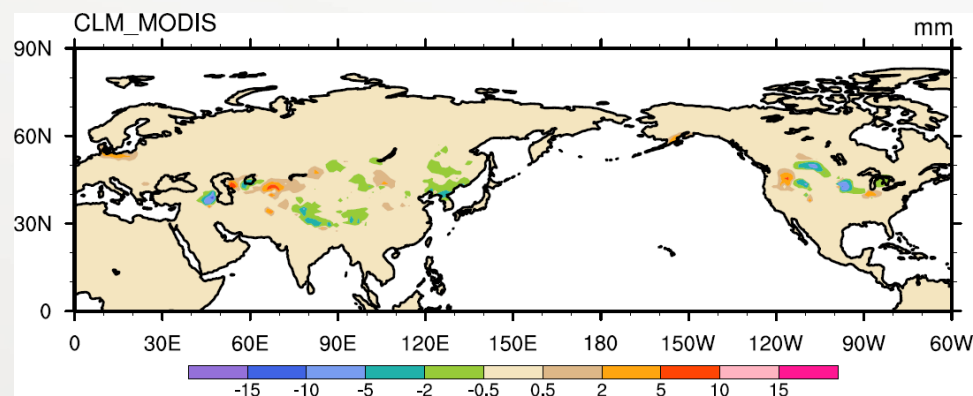


*Zhang et al, In  
Prep.*

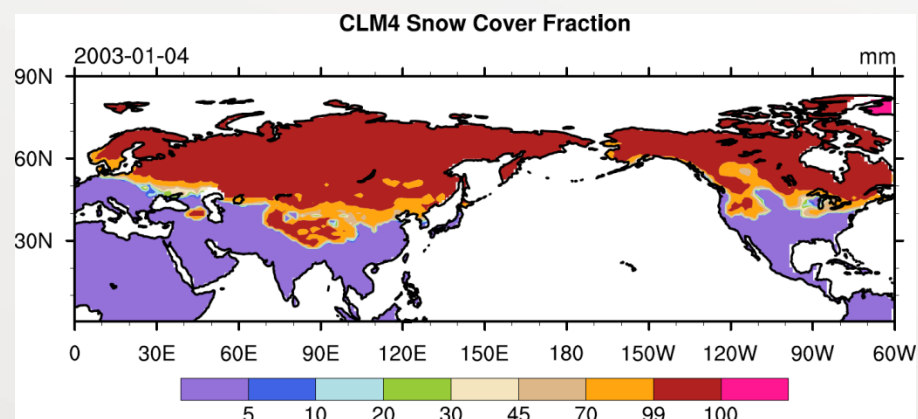
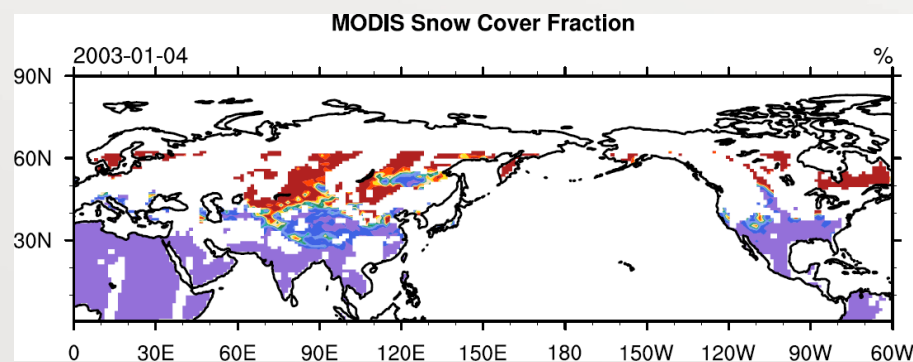
CMC: Canadian Meteorological Center  
SWE: Snow Water Equivalent



## Innovation: Analysis minus Forecast for SWE on 2003-01-04



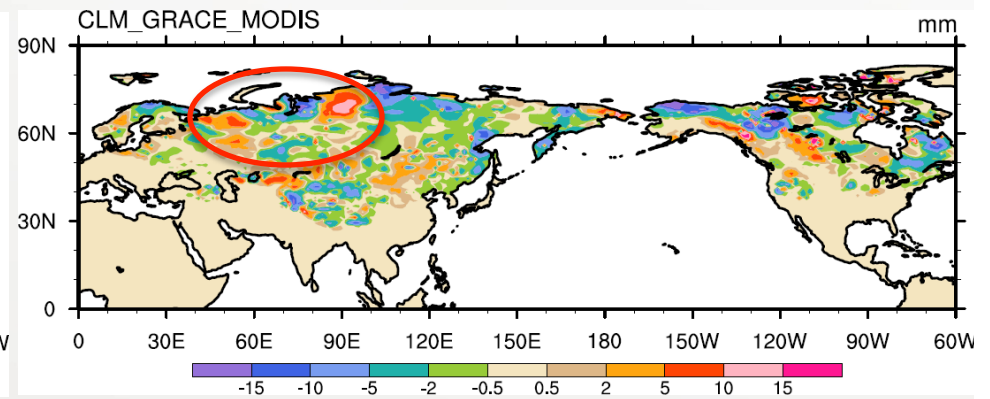
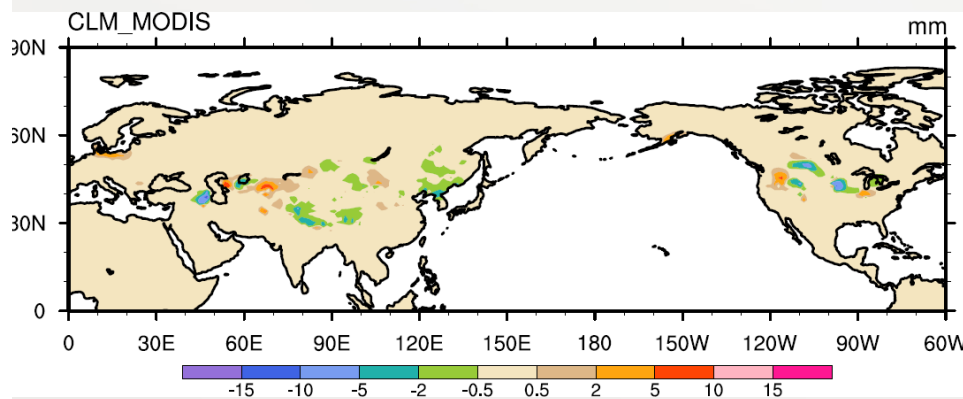
CLM\_MODIS: CLM4 assimilates MODIS data



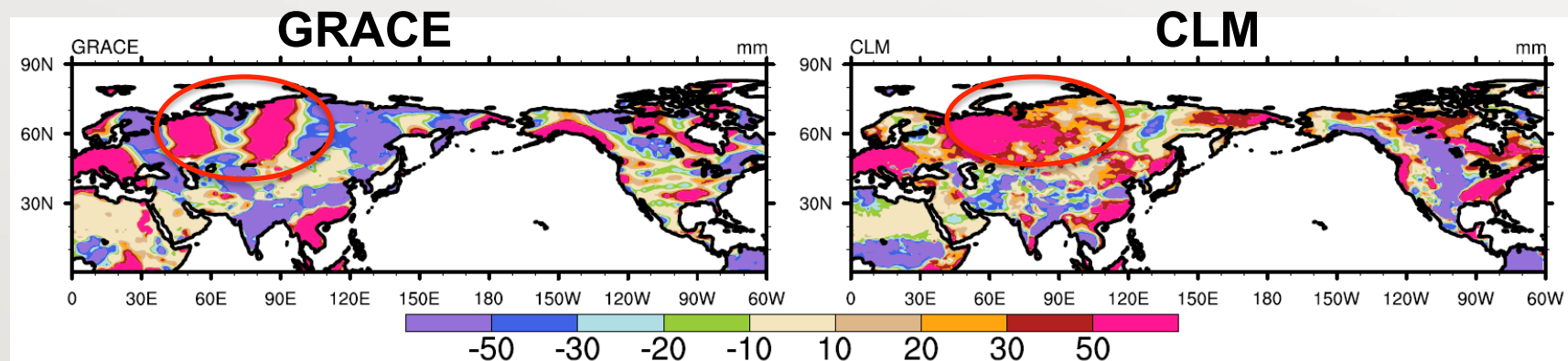
## Innovation: Analysis minus Forecast for SWE on 2003-01-04

CLM\_MODIS: CLM4 assimilates MODIS data

CLM\_MODIS\_GRACE: CLM4 assimilates both MODIS and GRACE data.

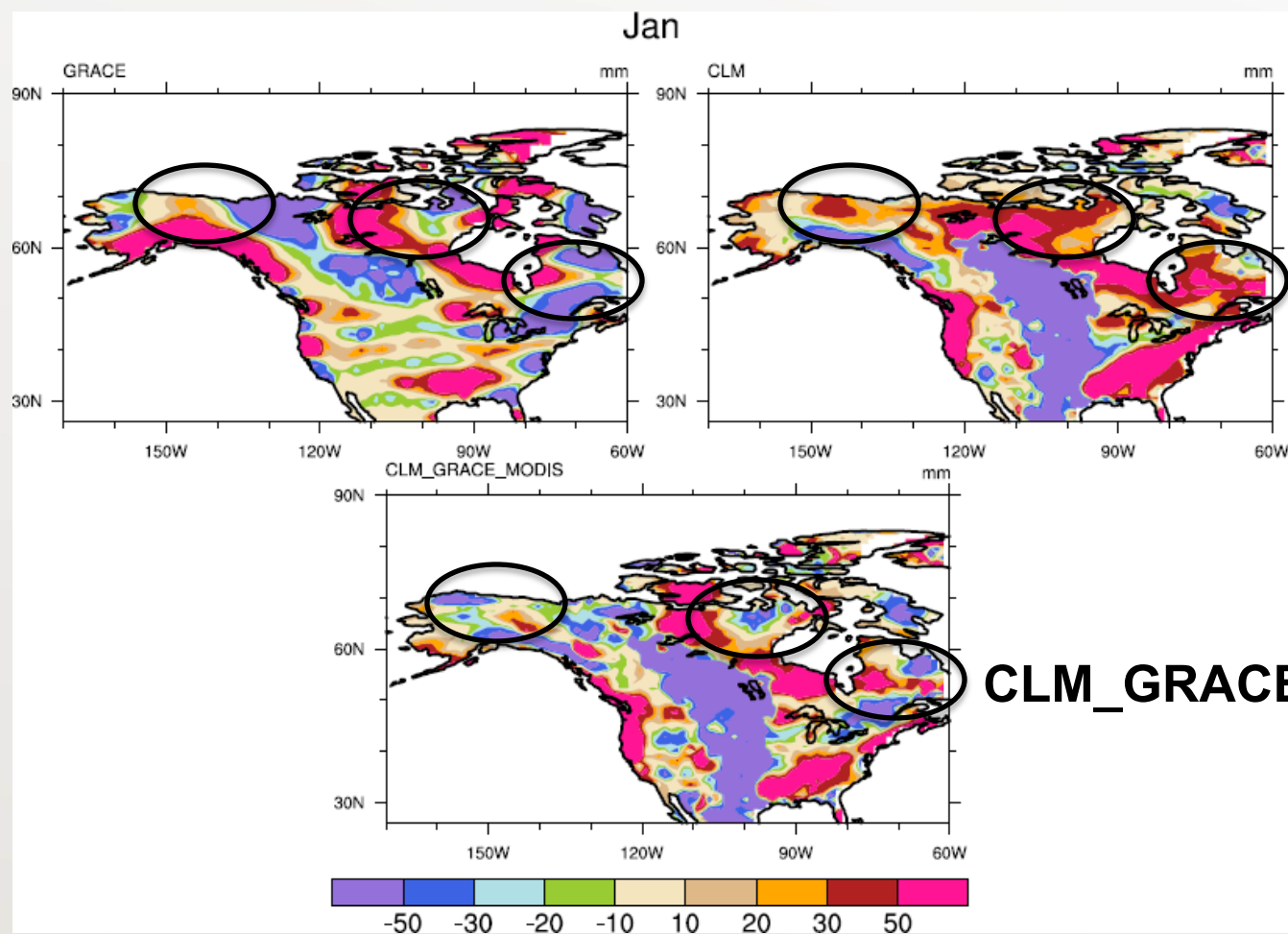


## TWS variations for Jan 2003



# TWS variations for Jan 2003 over NA

**GRACE**



**CLM**

**CLM\_GRACE\_MODIS**

# Summary

- The study assimilates GRACE and MODIS data jointly into CLM4, one step towards our ‘multi-sensor’ data assimilation goal.
- While MODIS data assimilation are mainly effective along snowline, GRACE provides valuable information on higher latitudes.
- More comprehensive evaluation of model results will be conducted and presented at the upcoming AGU.