AN OVERVIEW OF THE CURRENT NASA OPERATIONAL AMSR-E/AMSR2 SNOW SCIENCE TEAM ACTIVITIES

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INTRODUCTION

- Despite many algorithms were developed since the 1980s in order to retrieve SWE from spaceborne observations, there is still room for improvement and increase the accuracy.

- Automated operational estimates of snow depth and SWE were produced using data collected by the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) during its operational period (2002 - 2011).

- The recently launched Advanced Microwave Scanning Radiometer 2 (AMSR2) has offered the opportunity to continue the SWE product generation.

AMSR-E/2
Snow Science Team Activities

1. Preliminary cross-calibration between AMSR-E and AMSR2
2. Development and assessment of a new research prototype algorithm. Comparison between current operational algorithm and research prototype algorithm.
3. Assessment of the potential of an enhanced spatial resolution product.
4. Introduction of a dynamic snow density mask.
5. Update the Snow Possible/Snow Impossible mask using revised historical datasets.

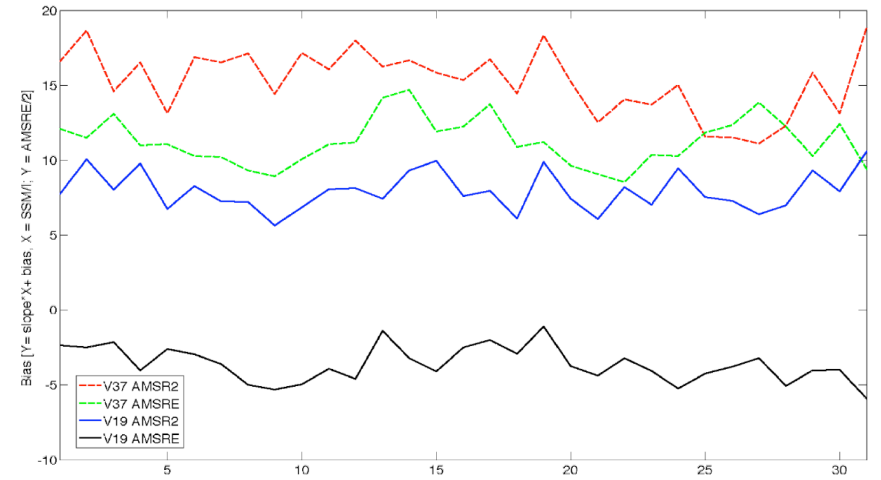
PRELIMINARY CROSS-CALIBRATION BETWEEN AMSR-E AND AMSR2

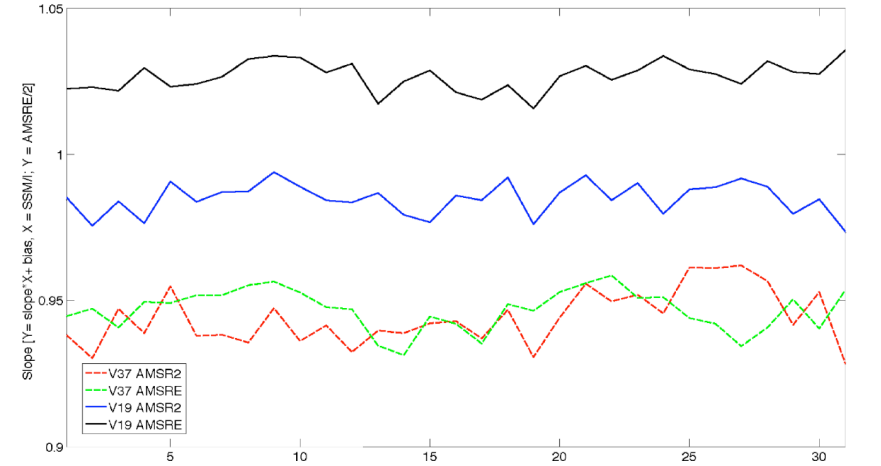
(NORTHERN HEMISPHERE)

- Different sources of Brightness Temperatures (Tbs) between AMSR-E and AMSR2 algorithms:
  - AMSR-E: Tbs inputs consisted of AMSR-E/Aqua L2A Global Swath Spatially-Resampled Brightness Temperatures.
  - AMSR2: Tbs inputs consist of Level 1R Tb values produced by the Japan Aerospace Exploration Agency (JAXA).
- Due to lack of overlapping between the two sources a cross-calibration was performed using data collected by the Special Sensor Microwave Imager/Sounder (SSMIS) on the F17 platform.
- Upgrade of the original AMSR-E SWE algorithm to use AMSR2-L1R data (rather than AMSRE L2A data). Data available at NASA Earthdata (https://ghrc.nsstc.nasa.gov/hydro/details.pl?ds=A2_DySno_NRT)

PRELIMINARY CROSS-CALIBRATION BETWEEN AMSR-E AND AMSR2

(NORTHERN HEMISPHERE -DECEMBER)





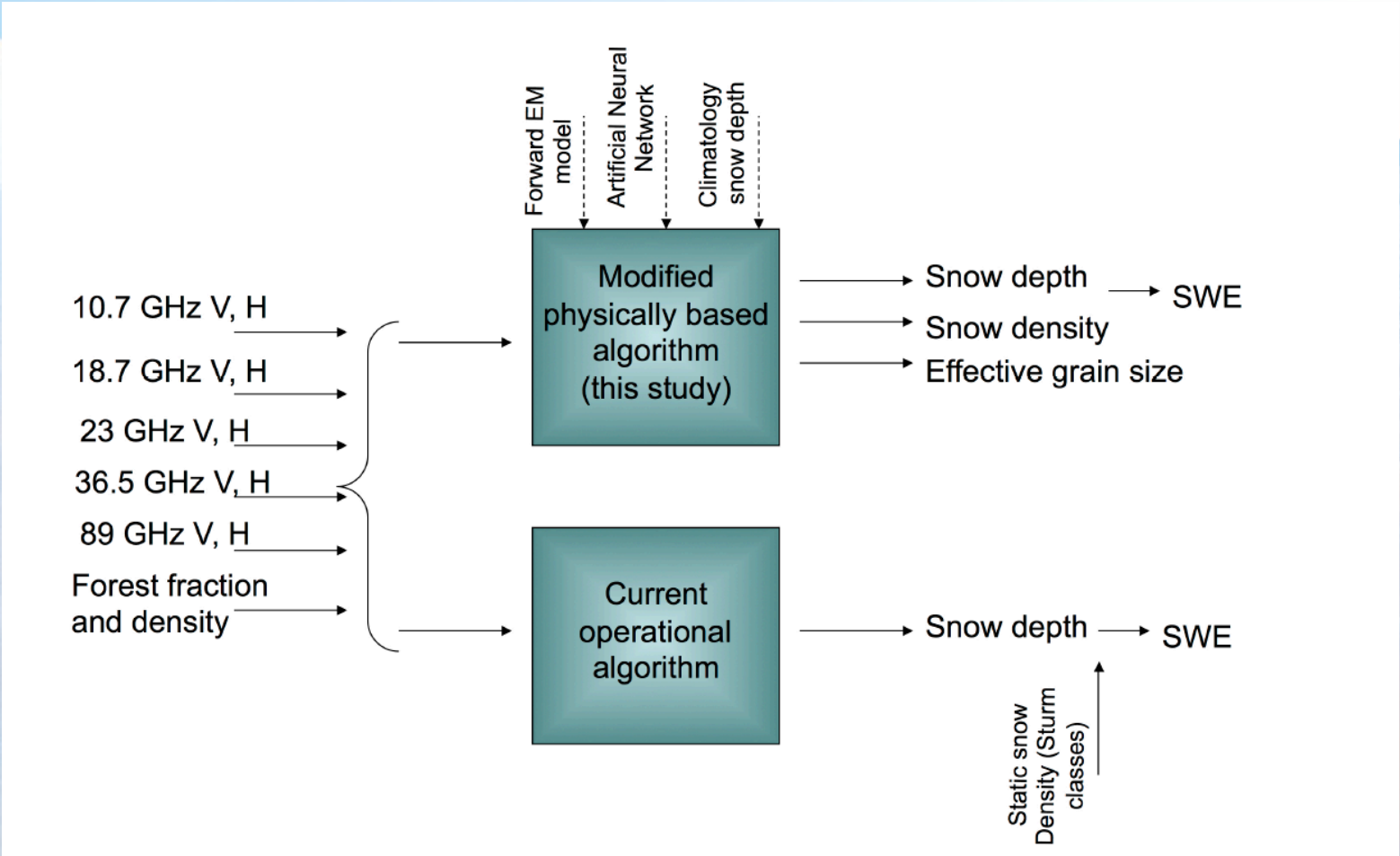
Daily values of the bias and slope of the AMSR-E and AMSR2 Tbs values with respect to the SSM/I F17 values acquired over the northern hemisphere during the month of December (2010 for AMSR-E, 2012 for AMSR2).

- Results show that Tbs from AMSR2 tend to slightly overestimate the Tbs from AMSR-E
- The slope shows a significant agreement between the two sensors (especially at 37 GHz)

ASSESSMENT OF A RESEARCH PROTOTYPE ALGORITHM

- A research prototype version of the NASA operational AMSRE-E SWE algorithm has been proposed by Tedesco(2012).
- This new product is based on climatological data, electromagnetic modeling and artificial neural networks (ANN).
- New spatio-temporal dynamic snow density mask, among other modifications.

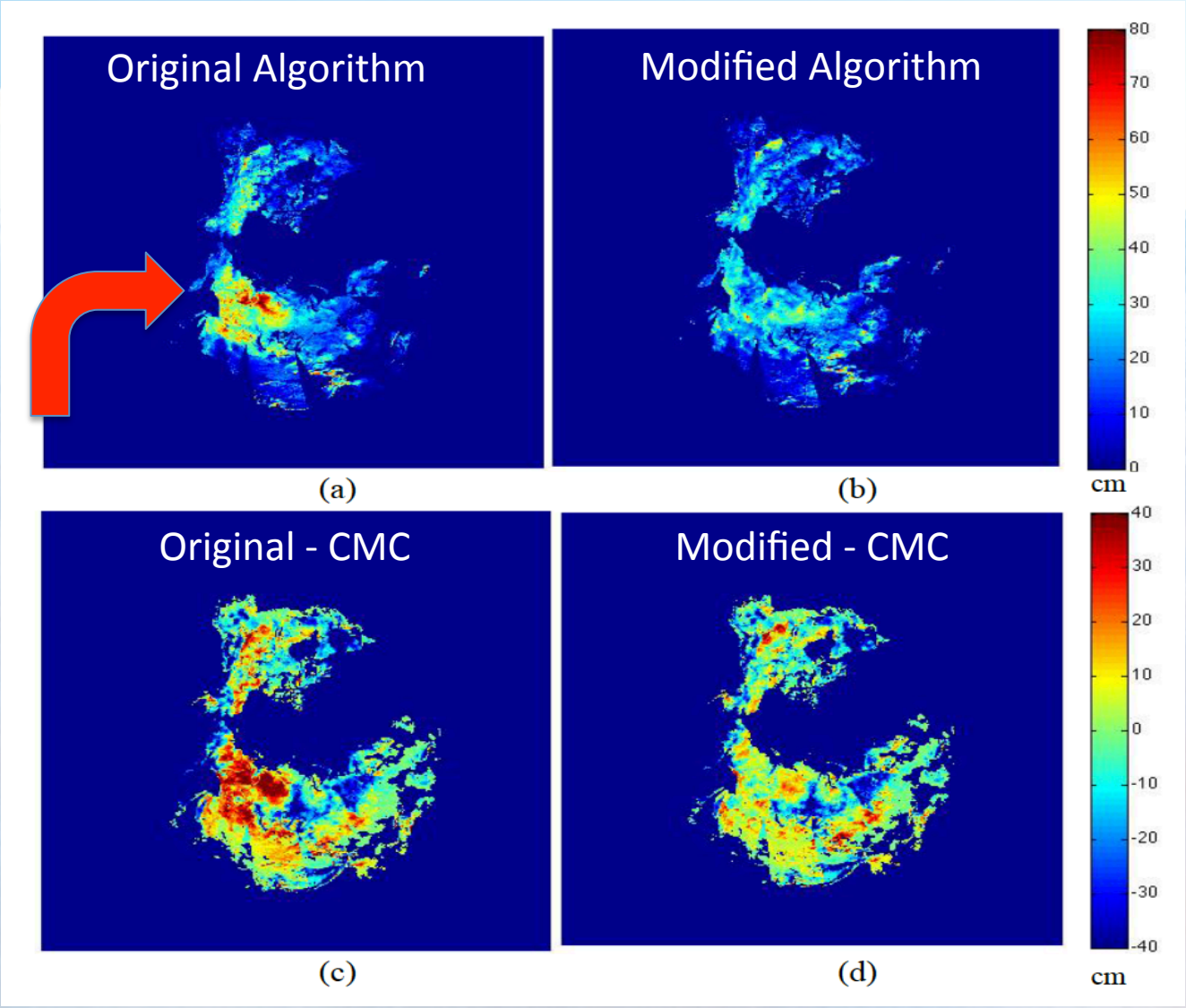
ASSESSMENT OF THE RESEARCH PROTOTYPE ALGORITHM



ASSESSMENT OF THE RESEARCH PROTOTYPE ALGORITHM

- Assessment of the modified algorithm by comparing SWE outputs with those from the current NASA operational AMSR-E SWE algorithm.
- Comparison was performed using Canadian Meteorological Centre (CMC) data set (Brown et al., 2010).

ASSESSMENT WITH CMC



Snow depth values obtained for January 1st, 2004, with:

a) original algorithm,
b) the modified algorithm,
c) Difference between the original algorithm and CMC
d) Difference between the modified algorithm and CMC

ASSESSMENT WITH CMC & WMO

	Original			Modified		
	Correlation	RMSE	Bias	Correlation	RMSE	Bias
January	0.2197	21.3003	21.3983	**0.351**	**17.0357**	**15.9389**
February	0.1923	23.4831	26.5166	**0.2874**	**19.778**	**21.3222**
March	0.0644	25.6249	33.5941	**0.1482**	**23.2104**	**27.3179**
April	-0.0631	27.6975	38.3672	**0.2082**	**21.2398**	**25.9138**
October	0.037	12.3247	11.9423	**0.1536**	**10.3858**	**9.1645**
November	0.1238	14.3137	14.5536	**0.1895**	**12.7779**	**11.4269**
December	0.2005	17.9307	16.9576	**0.3091**	**14.9568**	**12.4535**

Table 1: Monthly averaged correlation values, RMSE, slope and bias between the AMSR-E derived snow depth values and those estimated in the CMC data set.

	Original		Modified	
	RMSE	Bias	RMSE	Bias
January	20.661	29.187	17.931	20.571
February	22.775	37.884	19.173	27.537
March	27.336	45.62	24.703	37.289
April	32.123	44.678	27.897	30.303
October	11.4344	11.234	10.3453	10.235
November	13.6451	13.8224	13.156	11.0168
December	17.1517	18.207	16.1324	13.5751

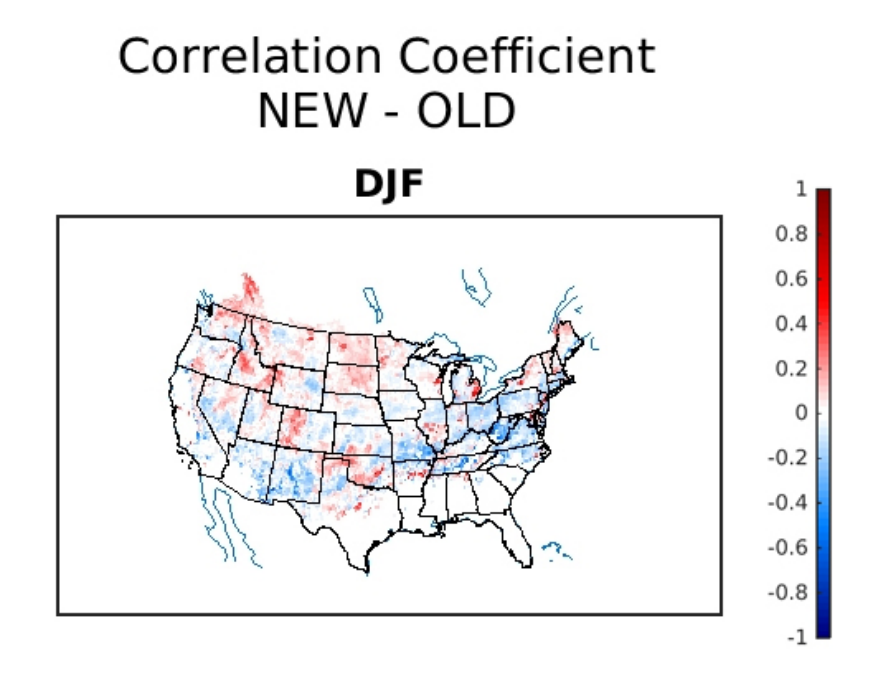
Table 2: RMSE, Slope and bias of the AMSR-E estimated and WMO measured snow depth values using the original and the modified algorithms.

ASSESSMENT WITH SNODAS

- Performance assessment of the SWE retrieval algorithms over continental U.S. using SNOw Data Assimilation System "SNODAS" by the NOAA National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC).
- Performance comparison with the current operational AMSR-E SWE algorithm.

- **SNODAS PRODUCT, FEATURES**:
  - ✓ Gridded data set for the continental United States at 1 km spatial resolution and 24 hour temporal resolution
  - ✓ The data set was reprojected from EASEGrid to EASEGrid 2.0 format before comparison with other data sets.

ASSESSMENT USING SNODAS



Comparison between NEW and OLD algorithm correlation coefficients for 5-day moving averages over DJF. Red denote stronger correlation for the NEW algorithm and blue denotes stronger correlation for OLD algorithm.

- It could be seen that for the NEW algorithm, SWE values especially over the rocky mountains and along the canadian border near North Dakota, correlate better with SNODAS than the old algorithm.

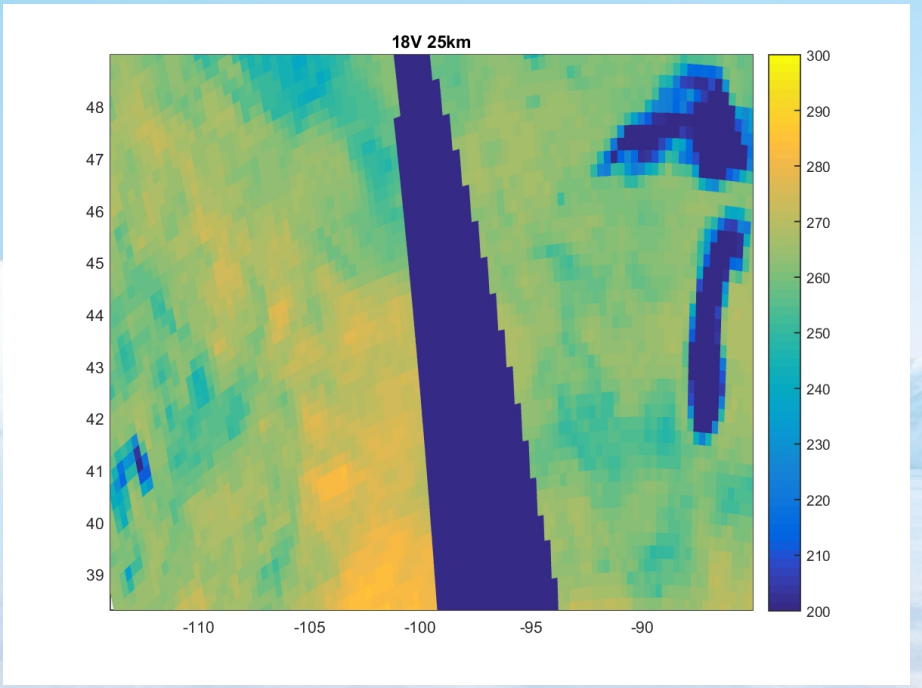
AMSR-E ENHANCED RESOLUTION PRODUCT

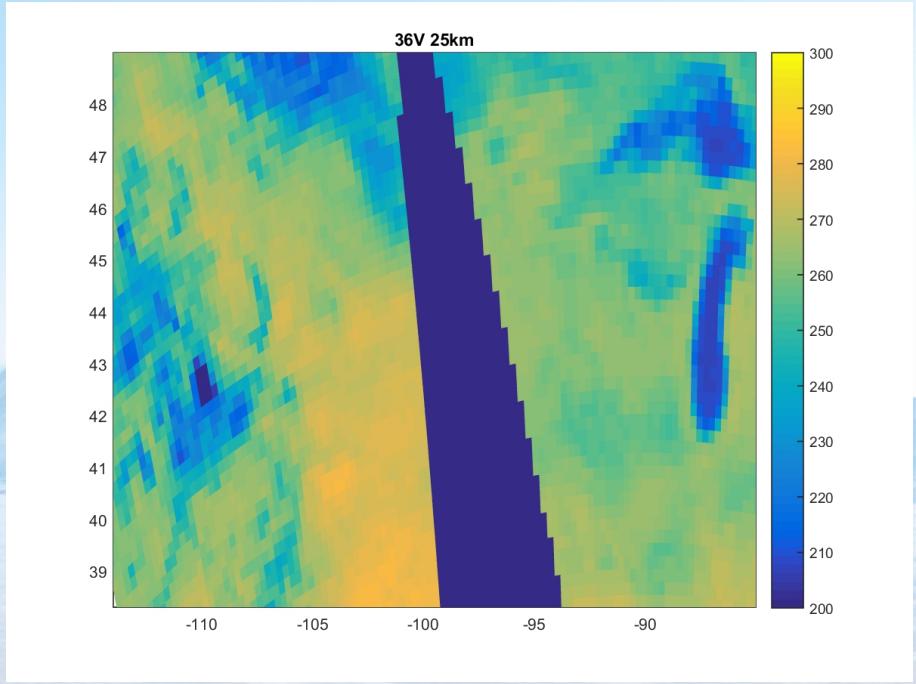
- The AMSR-E sensor has 12 passive channels consisting of six dual polarization frequency channels: 6.925, 10.65, 18.7, 23.8, 36.5, and 89.0 GHz. The spatial resolution of the data varies with frequency, with 6 GHz being the coarsest and 89 GHz having the finest resolution.

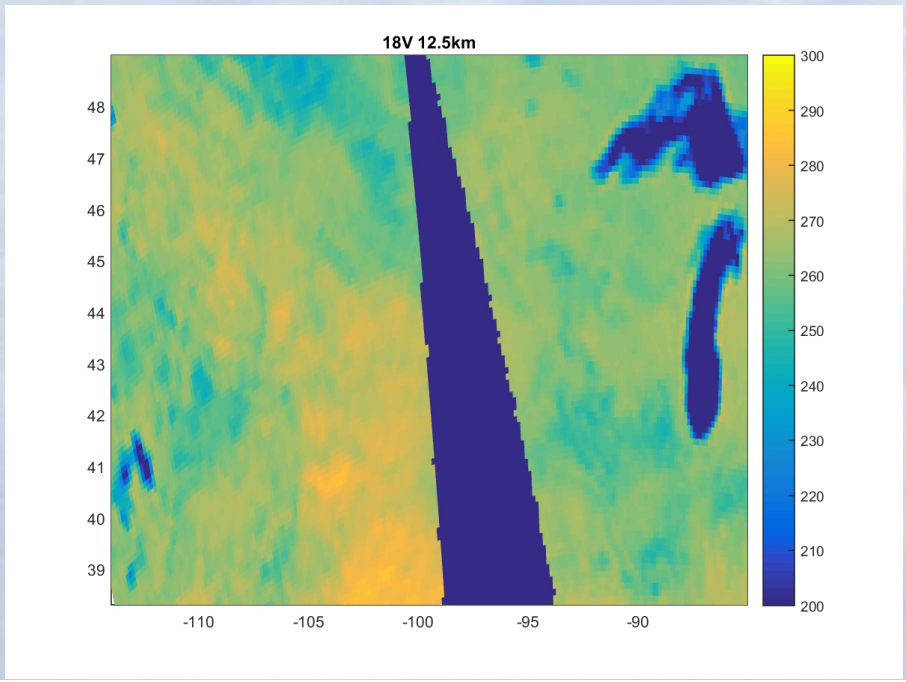
- Enhanced resolution TB images are generated for each frequency and polarization using multiple orbits via the radiometer version of the Scattermeter Image Reconstruction (SIR) algoritm(Long and Daum, 1998).

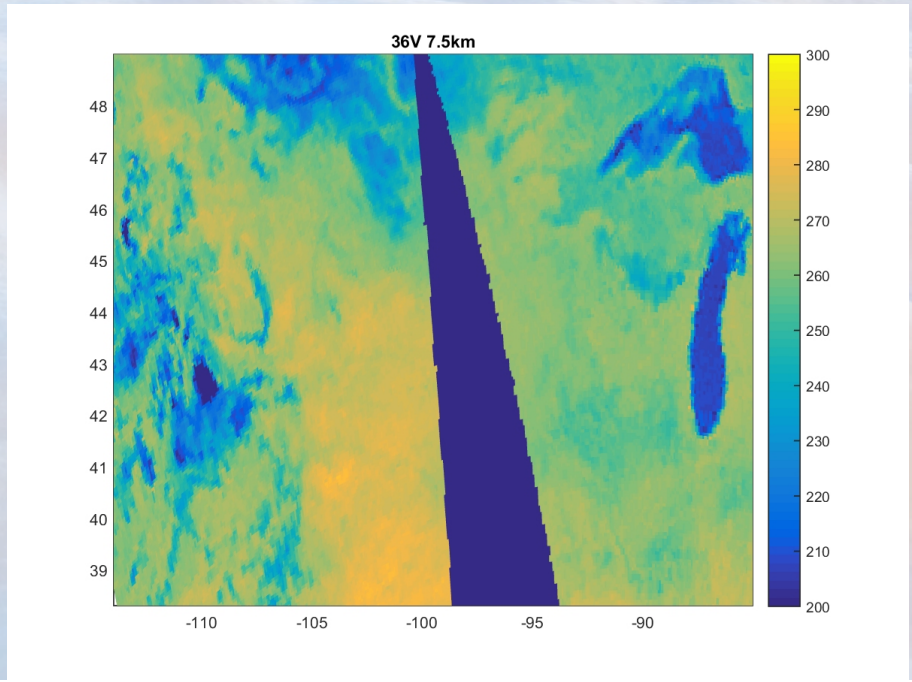
Center Freq (GHz)	6.9	10.7	18.7	23.8	36.5	89.0
Band Width (MHz)	350	100	200	400	1000	3000
Sensitivity (K)	0.3	0.6	0.6	0.6	0.6	1.1
IFOV (km x km)	76 x 44	49 x 28	28 x 16	31 x 18	14 x 8	6 x 4
Sampling Rate (km x km)	10 x 10	10 x 10	10 x 10	10 x 10	10 x 10	5 x 5
Integration Time (msec)	2.6	2.6	2.6	2.6	2.6	1.3
Main Beam Efficiency (%)	95.3	95.0	96.4	96.4	95.3	96.0
Beam Width (deg)	2.2	1.4	0.8	0.9	0.4	0.18

Upper-Midwest Enhanced AMSR-E Resolution Images

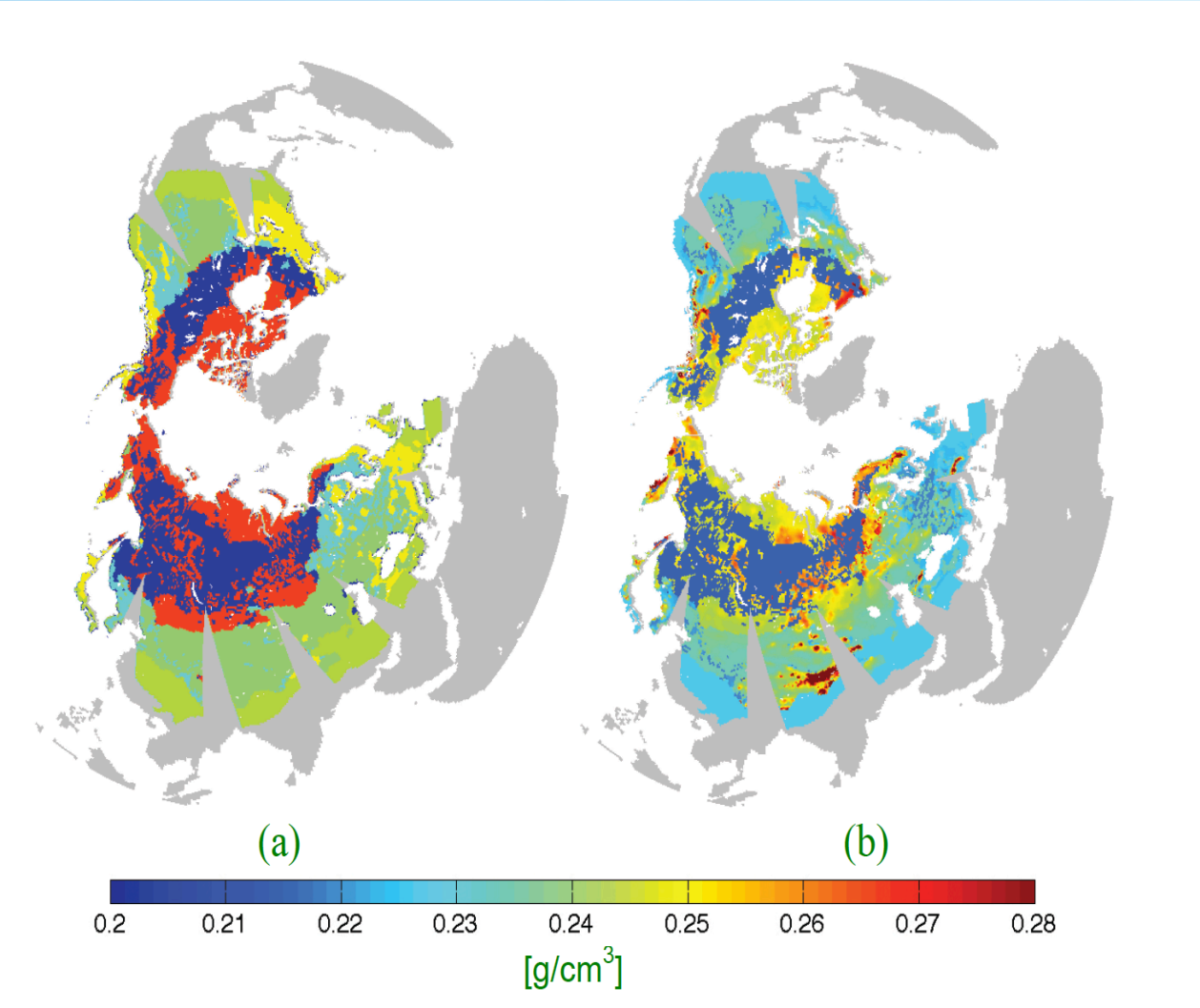








DYNAMIC SNOW DENSITY MASK

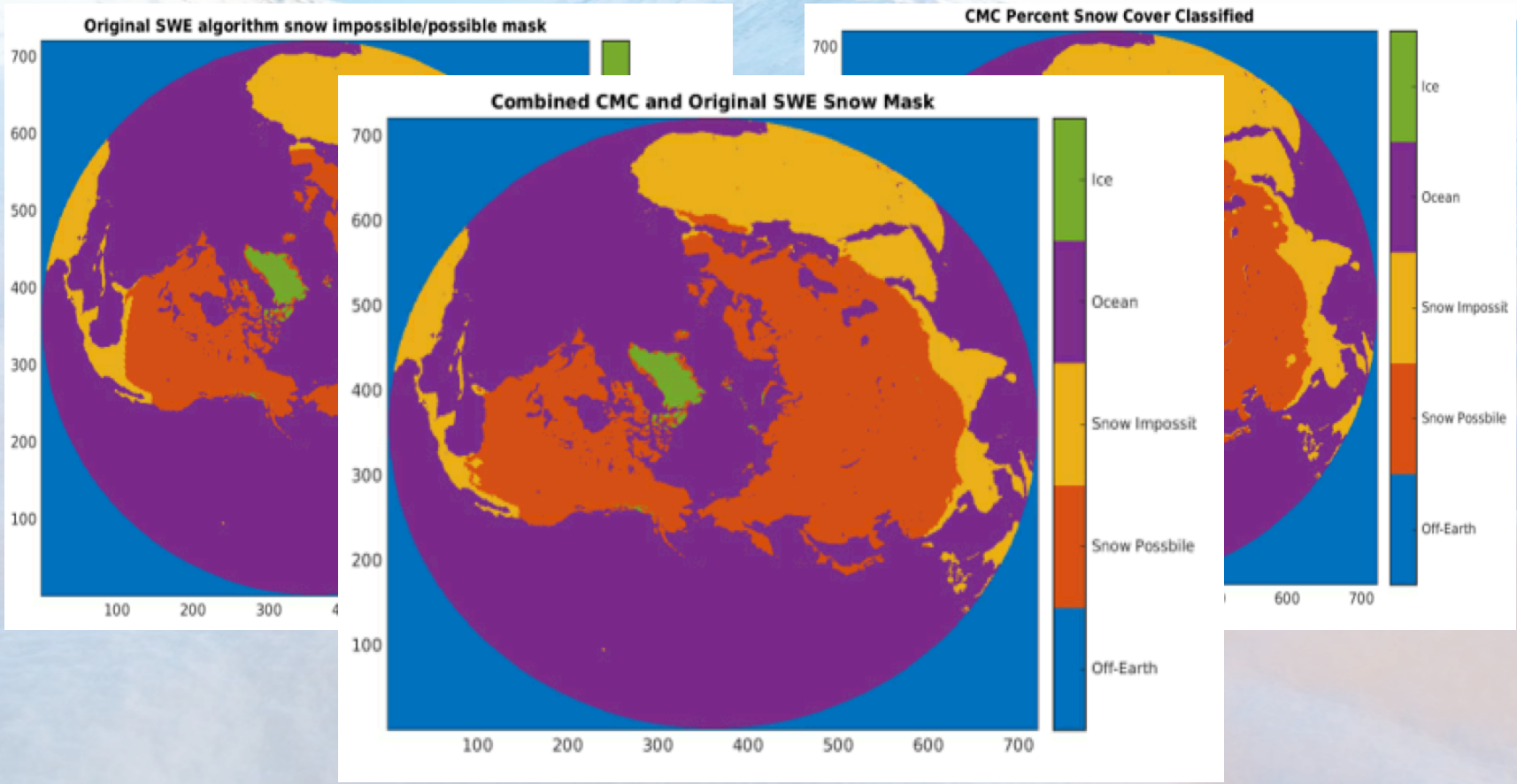


Spatio-temporal dynamic snow density mask is obtained following Sturm et al. (2010) approach, based on the relationship between DOY, SD, climate class and the BULK DENSITY

Density map for day January 30th , 2003 used
a) Current AMSR-E SWE algorithm (temporally static)
b) Obtained using the proposed method in the new algorithm.

UPDATE OF THE SNOW POSSIBLE/ SNOW IMPOSSIBLE MASK

- Updated the original mask using CMC dataset



CONCLUSIONS

- The modified algorithm shows a better performance with respect to the current NASA operational algorithm over the Northern Hemisphere (CMC) and over continental U.S. (SNODAS).
- Future research shall be dedicated to further improvement of the SWE retrieval algorithm:

1. *Enhancing spatial resolution*
2. *Application of a water bodies mask*
3. *Implementation of an atmosphere correction*

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