Snowfall Rate Retrieval using Passive Microwave Satellite Measurements

Huan Meng[1], Banghua Yan[1], Ralph Ferraro[1], Cezar Kongoli[2], Nai-Yu Wang[2], Limin Zhao[1]
[1]NOAA/NESDIS
[2]ESSIC/Cooperative Institute for Climate and Satellites

Hydrology

JPSS RR/PG

Introduction

- Due to the challenging nature of winter precipitation retrieval, there are few satellite based snowfall rate algorithms in existence, even though rain rate algorithms have been running operationally for more than a decade
- There is a real need for satellite snowfall rate product for weather forecast and for the development of blended precipitation products, especially in data sparse areas due to the limitations in radar and gauge coverage
- An AMSU/MHS snowfall rate (SFR) product has been developed and is running operationally at NESDIS
- ATMS snowfall detection and snowfall rate algorithms are under development

Methodology

1. Methodology of AMSU/MHS SFR

- Detect snowfall (Kongoli *et al*., 2003; Ferraro *et al*., 2005; Zhao and Weng, 2002; Foster *et al*., 2012)
- Retrieve cloud properties with an inversion method (Yan *et al.*, 2008)
- Compute snow particle terminal velocity and derive snowfall rate (Heymsfield and Westbrook, 2010; Meng *et al*., 2012)

2. Methodology of ATMS SFR

- New snowfall detection algorithm using PCA and probabilistic statistical model
- Snowfall rate will follow the approach of the AMSU/MHS SFR

Expected Outcomes

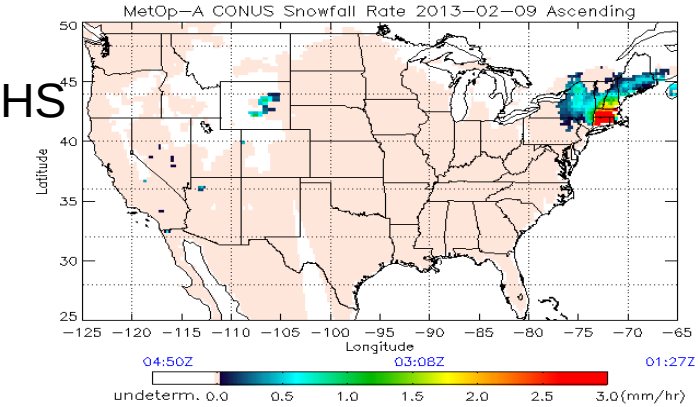
- An ATMS snowfall detection algorithm*
- A prototype ATMS snowfall rate (water equivalent) algorithm*
- Potential algorithms extension to colder regions

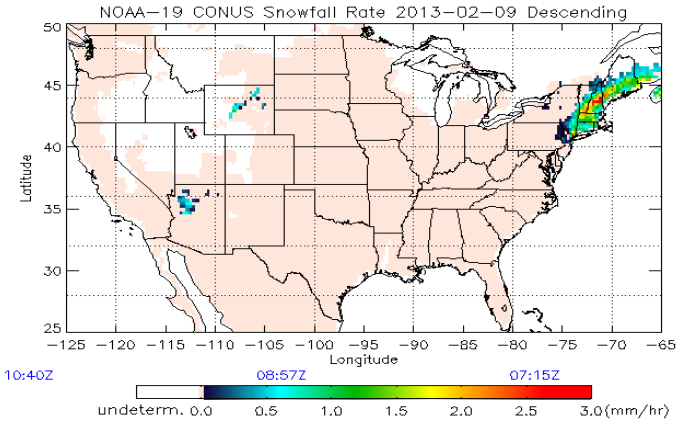
* Both algorithms are over global land

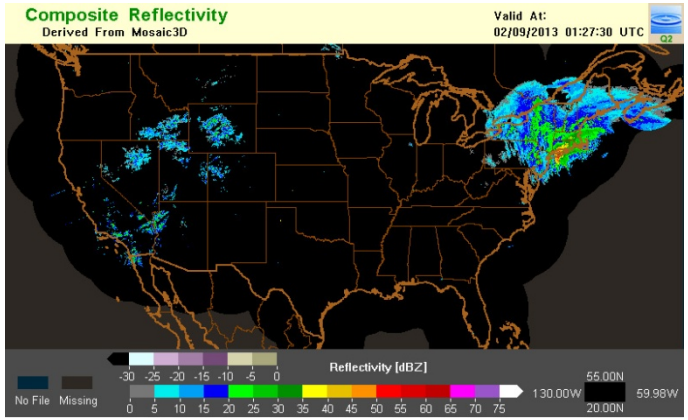
AMSU/MHS SFR Results (1/3)

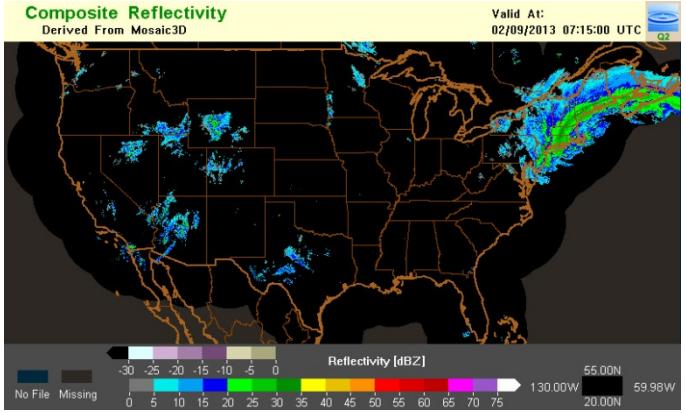
- Validation with NMQ (radar), StageIV (radar and gauge), and station data
- Case 1: Northeast snowstorm, Feb 7-9, 2013

AMSU/MHS SFR







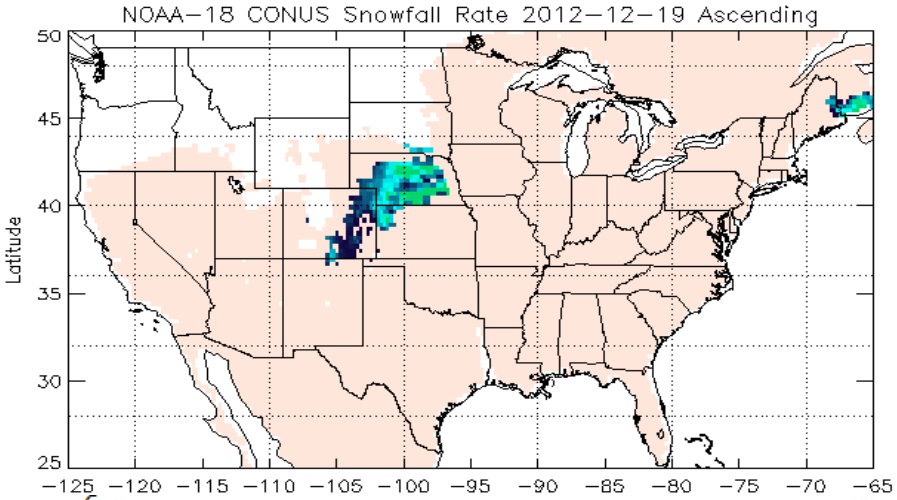


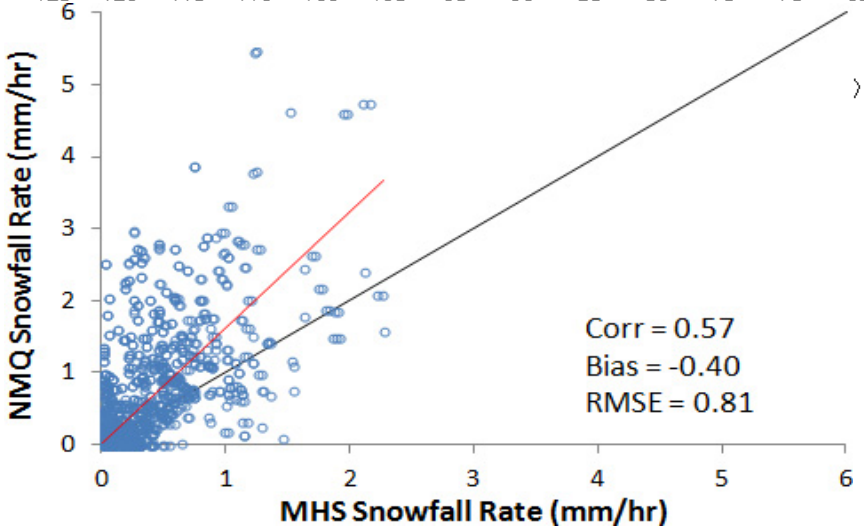
NMQ Reflectivity

AMSU/MHS SFR Results (2/3)

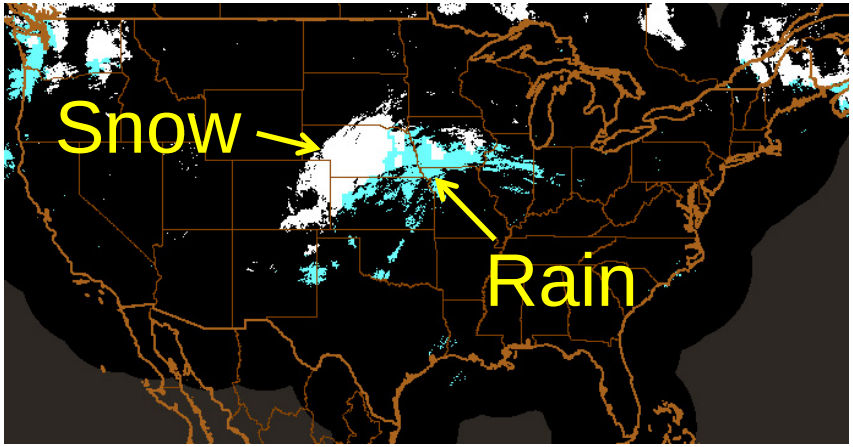
- Case 2: Snow event on Dec 18-21, 2012

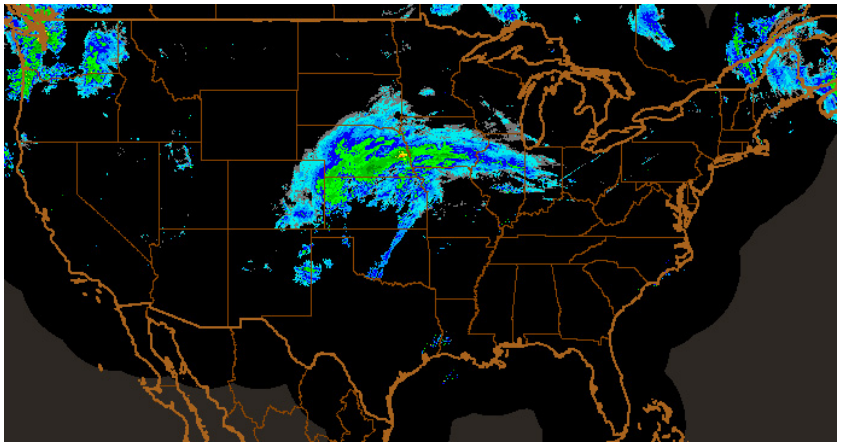
AMSU/MHS SFR





NMQ phase and reflectivity

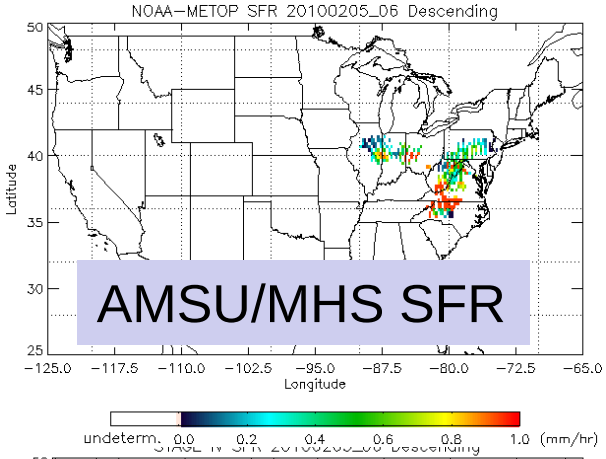


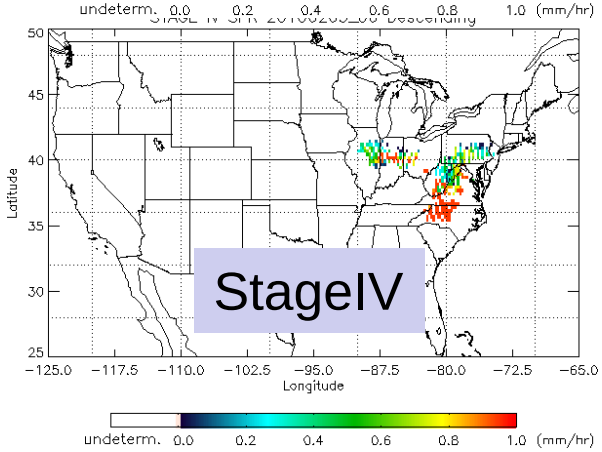


AMSU/MHS SFR Results (3/3)

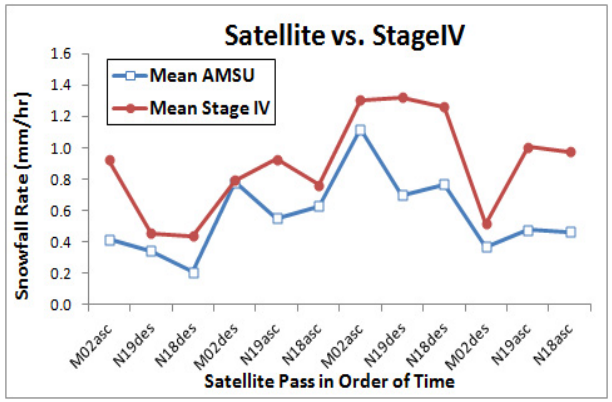
- Case 3: Major nor'easter on Feb 5-6, 2010

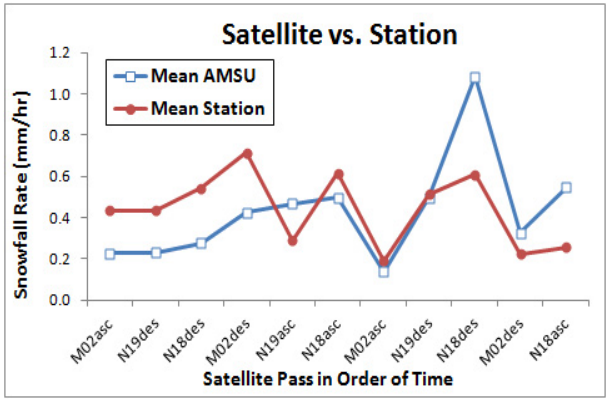
Images of Matching Data

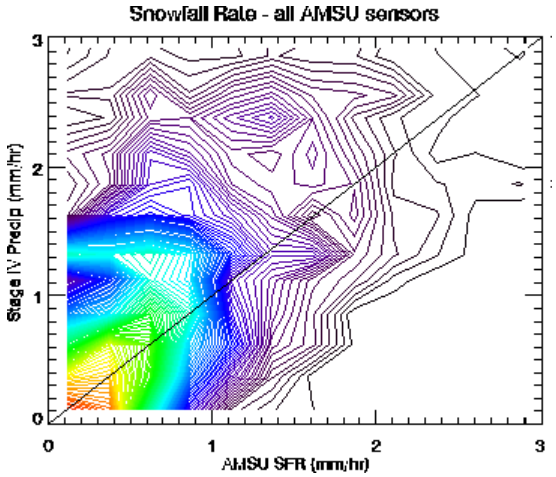




Time Series of Areal Mean







val

source	bias	RMSE	Corr
StageIV	-0.31	0.65	0.50
Station	0.03	0.63	0.23

Possible Path to Operations

- We could work with SPoRT to integrate the ATMS snowfall rate product into AWIPS and provide to WFOs and SAB for evaluation
- The ATMS products would also need comprehensive validation
- Once validation is complete and feedback from users are collected with positive result, we would seek operational approval from SPSRB

Future Plans

Possible future extensions include

1. Validation of the ATMS snowfall algorithms (snowfall detection and snowfall rate)
2. The prototype ATMS snowfall rate algorithm will benefit from future enhancements to its utility and accuracy
   - Develop a time lag index to determine the time required for the retrieved SFR (in the atmosphere) to reach the surface
   - Certain constants in the SFR algorithm should be modified to be functions of environmental conditions, e.g. spherical snow particle, constant ice water content adjusting factor, etc.
   - Add liquid water to the RTM to better handle cloud properties in the presence of liquid water in cloud
   - Extension to colder climate

References

- Ferraro, R.R., F. Weng, N. Grody, L. Zhao, H. Meng, C. Kongoli, P. Pellegrino, S. Qiu and C. Dean, 2005: NOAA operational hydrological products derived from the AMSU. *IEEE Trans. Geo. Rem. Sens.,* **43,** 1036 – 1049.
- Foster, J.L., G. Skofronick-Jackson, H. Meng, J. R. Wang, G. Riggs, P. J. Kocin, B. T. Johnson, J. Cohen, D. K. Hall, S. V. Nghiem, 2012: Remote Sensing of the Historic February 2010 Snow Storms in the Baltimore/Washington D.C. Region. *Hydrological Processes*, 26, 3459-3471, doi: 10.1002/hyp.8418
- Heymsfield, A.J. and C.D. Westbrook, 2010, Advances in the Estimation of Ice Particle Fall Speeds Using Laboratory and Field Measurements. *J. Atmos. Sci.*, **67**, 2469-2482, doi: 10.1175/2010JAS3379.1
- Kongoli, C., P. Pellegrino, R. Ferraro, N. Grody and H. Meng, 2003: A new snowfall detection algorithm over land using measurements from the Advanced Microwave Sounding Unit (AMSU). *Geophys. Res. Let.*, **30,** 1756-1759.
- Meng, H., B. Yan, R. Ferraro, C. Kongoli, 2012: Snowfall Rate Retrieval Using Passive Microwave Measurements. 12th Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment, Frascati, Italy, 5-9 March, 2012
- Yan, B, F. Weng, and H. Meng, 2008: Retrieval of Snow Surface Microwave Emissivity under All Weather Conditions from AMSU Window Channel Brightness Temperatures. *J. Geophys. Res.,* **113**, D19206. doi:10.1029/2007JD009559.
- Zhao, L. and F. Weng, 2002: Retrieval of ice cloud parameters using the AMSU. *J. Appl. Meteor*., 41, 384-295.