Verification study of passive microwave snowfall products using ground-based radar network observations

Mario Montopoli\textsuperscript{1}, Kamil Mroz\textsuperscript{2}, Giulia Panegrossi\textsuperscript{1}, Daniele Casella\textsuperscript{1}, Luca Baldini\textsuperscript{1}, Paolo Sanò\textsuperscript{1}, Andrea Camplani\textsuperscript{1}, Sante Laviola\textsuperscript{1}, Pierre Kirstetter\textsuperscript{3}, Mark Kulie\textsuperscript{4}, and Alessandro Battaglia\textsuperscript{2}

\textsuperscript{1}CNR, ISAC, Dept. Of Geography, Rome, Italy (mario.montopoli@gmail.com)
\textsuperscript{2}Univ. of Leicester, Leicester UK
\textsuperscript{3}University of Oklahoma, 120 David L Boren Blvd #5900, Norman, OK 73072, US
\textsuperscript{4}NOAA/NESDIS/STAR/ASPB at SSEC 1225 W. Dayton St., Madison WI 53706 USA

Snowfall remote sensing is becoming an increasingly popular topic within both the scientific community and operational services. Studies focused on snow retrievals are important because snow represents a reservoir of fresh water and its quantification is a crucial task to thoroughly understanding the hydrological cycle. In addition, snow-cover plays a key role in the climate system, modifying the global energy budget because of its high albedo. In addition, snowfalls often represent a hazard to several public services (e.g. transportations, energy providers) as well as properties (e.g. roof loading) but also an opportunity (e.g. for hydropower).

Passive microwave observations provided by currently operating spaceborne radiometers (e.g. Advanced Technology Microwave Sounder (ATMS), the Global Precipitation Measurement (GPM) Microwave Imager (GMI)) are a unique source of global information on the occurrence and the quantity of snowfall. However, because of the weaker and more complex signatures of snow at microwave frequencies \cite{1} compared to those from rainfall, the retrieval schemes used by such instruments are still not fully optimised for snowfall detection and estimation, and subject to large errors. The ESA-funded RAINCAST project aims, among other tasks, at the verification of passive microwave snowfall products with the goal of fostering and defining new retrieval algorithms and mission concepts specifically optimised for snowfall quantification.

In this study we show a comparative analysis between passive microwave snowfall rate estimates and high quality ground-based radar snowfall measurements to quantify the actual strengths and limitations in state-of-the-art passive microwave snowfall products. In particular, the performance of the Goddard profiling algorithm version 5A (GPROF V5A) and of a recently developed snowfall retrieval algorithm for GMI named SLALOM \cite{2, 3} are investigated. The differences between GPROF and SLALOM are explored in relation to the environmental conditions (including the presence of supercooled droplets aloft that tend to mask the typical snowfall signature) where the snowfall retrievals are likely less accurate. In addition, ATMS snowfall products are analysed as well for selected case studies to evidence the potential and limitations of the different snowfall products in relation to the algorithm's design (e.g., GPROF vs. SLALOM) and sensor characteristics (GMI and
ATMS). Then quantitative assessments for all products are discussed by exploiting one year of ground reference radar network data over Northern U.S. and Canada provided by the Multi-Radar/Multi-sensor System (MRMS) product, available at 1x1 km horizontal regular resolution and 2 min time sampling, and providing gauge adjusted surface precipitation rate together with the indication of its phase.

Our analysis confirms results from recent work on the same topic [e.g., 4], although a long term large scale analysis that quantify passive microwave retrieval is not found in the past literature.

This work is particularly relevant not only for the quantification of the limitations of the current snowfall retrieval algorithms, but also to give recommendations for algorithm development for upcoming satellite missions (e.g. EPS-SG MWS, MWI/ICI), and for future satellite mission concepts.

**REFERENCES**


