# ASSESSING THE ANGULAR DENSITY OF PASSIVE MICROWAVE L-BAND DATA

*Sandy Peischl[1], Nan Ye[1], Jeffrey P. Walker[1], Dongryeol Ryu[2] and Yann Kerr[3]*

[1]Department of Civil Engineering, Faculty of Engineering, Monash University, Clayton, Australia
[2]Department of Infrastructure Engineering, School of Engineering, The University of Melbourne, Melbourne, Australia
[3]Biospheric Processes, CESBIO, Toulouse, France

## 1. INTRODUCTION

With the launch of the European Space Agency's (ESA) Soil Moisture and Ocean Salinity (SMOS) mission on 2nd November 2009, there is a new opportunity for global near-surface soil moisture mapping from space [1-2]. Along with its innovative sensor design, a 2-dimensional array of L-band passive microwave radiometers distributed on a Y-shaped synthetic aperture antenna, a new generation of retrieval models were developed [3]. One aspect of the novel technology is the capability of multi-incidence angle brightness temperature measurements by SMOS. This is understood to facilitate the retrieval process by i) enabling the simultaneous retrieval of ancillary parameters and thus reducing the dependency on external sources, and ii) enhancing the retrieval accuracy [4]. This paper investigates the impact of the total number of available multi-incidence angle L-band data, following described as angular density, on the performance of the soil moisture retrieval model.

## 2. EXPERIMENTAL DATA AND METHODOLOGY

The data analysis was based on in-situ measurements from the National Airborne Field Experiment (NAFE) in New South Wales, Australia in 2005 [5]. The ground data included near-surface soil moisture, soil surface temperature, soil profile temperature, soil texture, surface roughness and vegetation water content over an agricultural test site. This study focused on data from two separate days, representing dry to moderate moisture conditions (~0.14 $m^3m^{-3}$) and wet conditions (~0.42 $m^3m^{-3}$).

For the purpose of comparing different densities of angular brightness temperature (TB) data and the resulting impact on the model robustness (in terms of the retrieval error), the number of simulated TB samples within a particular angular range was varied between 1 and 10. Figure 1 depicts the general data processing chain. According to this schematic, the ground data described above were

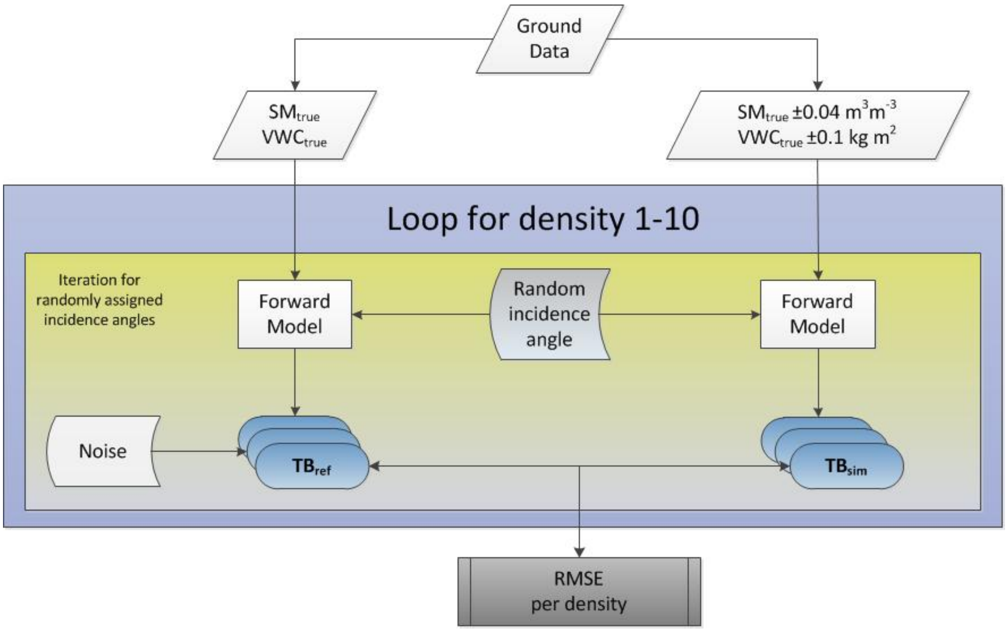


**Figure 1:** Schematic of data preparation and forward modeling in order to test the model performance (RMSE – root mean square error) for varying angular TB data density.

processed through the L-MEB radio brightness forward model (L-band Microwave Emission of the Biosphere, [6]) to generate a TB response. The incidence angle and the corresponding simulated TB data were randomly assigned and further processed at different density steps of 1-10. Additionally, the total angular range of 0° to 50° was divided into five classes of 10° steps each. For example, a density factor of 1 means that a single TB value was simulated within each of the five groups at a random incidence angle, and thus resulting in a total of five TB values across the whole angular range. For each density factor the random sampling of incidence angles and the subsequent forward modeling were performed in iterations. The simulated TB data were averaged until the change between the averaged TB and the last iteration was either less than 0.001 K or a total of 500 iterations were reached.

The comparison between $TB_{ref}$, which was simulated from the ground information with added noise, and $TB_{sim}$, which considered two variable parameters (SM: soil moisture, and VWC: vegetation water content) but the same randomly assigned angular information, was based on the root mean square error (RMSE) derived for each individual density factor.

## 3. RESULTS

The angular density was found to have a significant impact on the retrieval model performance, as shown in Figure 2. The results illustrated an explicit rise in the model robustness when the number of

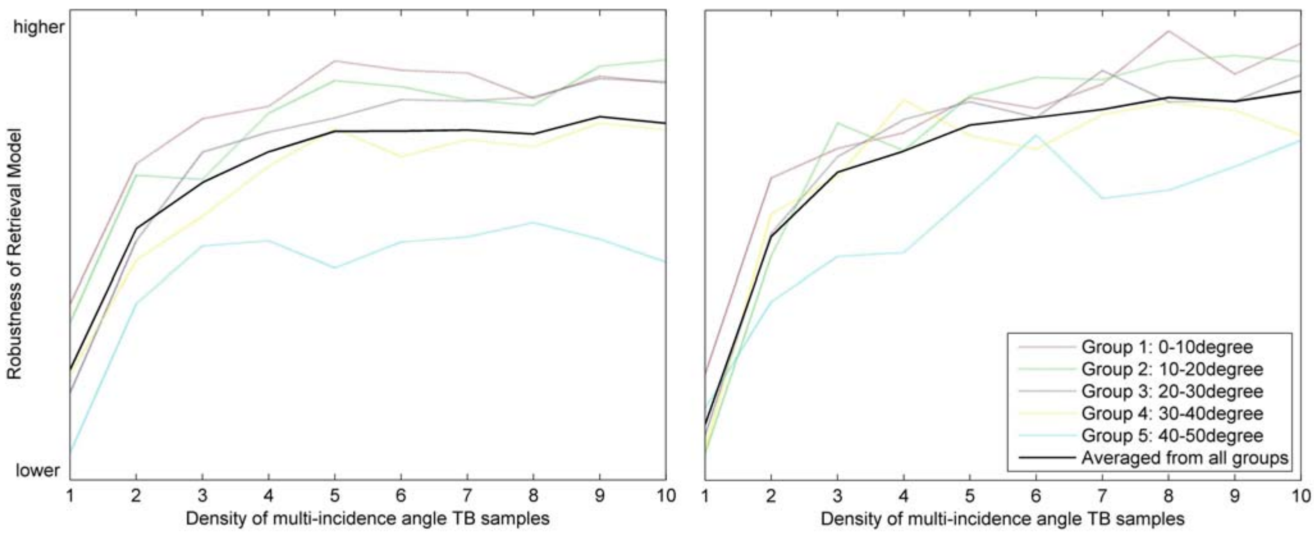


**Figure 2:** Robustness of the retrieval model for varying densities of multi-incidence angle data within each 10° step of angular groups. For instance, a density factor of 3 suggests that a total of 15 TB samples were available across the whole angular range of 0-50°. The left panel shows the case of dry soil moisture conditions and the right panel shows the case of wet soil moisture conditions.

TB was increased from a total of 5 to 15 samples across the angular range. A density factor of 3 to 4 was found to be a zone of transition, whereby additional TB samples resulted in only minor changes in the model performance. This behavior was similar for both moisture conditions tested.

With respect to particular angular groups, two main aspects were apparent: i) within each of the five groups a similar trend was noted across the densities tested; ii) results from TB samples made at incidence angles between 40-50° were consistently outside the range demonstrated by the remaining groups at smaller incidence angles.

## 4. CONCLUSION

This study found that having between 15 and 20 TB samples across the angular range of 0° to 50° resulted in the maximum robustness of the tested multi-angle retrieval model. Further increases in the number of TB samples achieved only minor or none enhancement of the model performance.

## 5. ACKNOWLEDGEMENTS

The authors would like to acknowledge the team of the National Airborne Field Experiment 2005 for collecting and providing the data set used in this study. The NAFE campaign has been made possible by funding from the Australian Research Council through infrastructure (LE0453434 and

LE0560930) and research (DP0557543and DP0556941) grants. This study was financially supported by an ARC DP0879212 grant within the framework of the MoistureMap project.

## 5. REFERENCES

[1] Y. H. Kerr, J. Font, P. Waldteufel, and M. Berger, "The Soil Moisture and Ocean Salinity Mission-SMOS," *ESA Earth Observation Quarterly,* no. 66, pp. 18-26, 2000.

[2] Y. H. Kerr, P. Waldteufel, J.-P. Wigneron, S. Delwart, F. Cabot, J. Boutin, M. J. Escorihuela, J. Font, N. Reul, and C. Gruhier, "The SMOS Mission: New Tool for Monitoring Key Elements of the Global Water Cycle," *Proceedings of the IEEE,* vol. 98, no. 5, pp. 666-687, doi: 10.1109/JPROC.2010.2043032, 2010.

[3] Y. H. Kerr, P. Waldteufel, P. Richaume, J.-P. Wigneron, P. Ferrazzoli, and R. J. Gurney, "SMOS level 2 processor for soil moisture - Algorithm Theoretical Based Document (ATBD)," CESBIO, Toulouse, France, Report ESA No.: SO-TN-ESL-SM-GS-0001, CBSA, SO-TN-ESL-SM-GS-0001, Issue 3.e, 121 pp., 24.01.2011 2011, Available: http://www.cesbio.ups-tlse.fr/fr/indexsmos.html.

[4] J.-P. Wigneron, P. Waldteufel, A. Chanzy, J.-C. Calvet, and Y. H. Kerr, "Two-dimensional microwave interferometer retrieval capabilities over land surfaces (SMOS Mission)," *Remote Sensing of Environment,* vol. 73, no. 3, pp. 270-282, doi: 10.1016/S0034-4257(00)00103-6, Sep. 2000.

[5] R. Panciera, J. P. Walker, J. D. Kalma, E. J. Kim, J. Hacker, O. Merlin, M. Berger, and N. Skou, "The NAFE'05/CoSMOS Data Set: Toward SMOS Soil Moisture Retrieval, Downscaling, and Assimilation," *IEEE Transactions on Geoscience and Remote Sensing,* vol. 46, no. 3, pp. 736-745, doi: 10.1109/Tgrs.2007.915403, Mar. 2008.

[6] J.-P. Wigneron, Y. H. Kerr, P. Waldteufel, K. Saleh, M. J. Escorihuela, P. Richaume, P. Ferrazzoli, P. de Rosnay, R. J. Gurney, J.-C. Calvet, J. P. Grant, M. Guglielmetti, B. Hornbuckle, C. Mätzler, T. Pellarin, and M. Schwank, "L-band Microwave Emission of the Biosphere (L-MEB) Model: Description and calibration against experimental data sets over crop fields," *Remote Sensing of Environment,* vol. 107, no. 4, pp. 639-655, doi: 10.1016/j.rse.2006.10.014, Apr. 2007.