SOIL MOISTURE PERFORMANCE PREDICTION
FOR THE NPOESS MICROWAVE IMAGER/SOUNDER (MIS)

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Abstract

The National Polar-orbiting Operational Environmental Satellite System's (NPOESS) Microwave Imager/Sounder (MIS) instrument is in development at the Naval Research Laboratory, with soil moisture sensing depth as one of the two Key Performance Parameters (KPPs). Based on the current design, the MIS sensor shares many channel configurations similar to the WindSat instrument, which provides an opportunity to predict MIS soil moisture performance using WindSat data and algorithm. To predict MIS soil moisture performance, two simulation systems are built – the proxy data study and simulation test bed.

In the proxy data study, a land algorithm was adapted from WindSat to run on WindSat proxy data, which simulate MIS SDRs by adding Gaussian noise to WindSat SDRs according to their differences in effective NEDTs. MIS effective NEDTs are derived from 45 km CFOV (Composite Field of View) sizes that meet soil moisture HCS requirements. This proxy data approach cannot accommodate the EIA (Earth-Incidence-Angle) increase from WindSat to MIS; but a simplified analytical estimation indicates that the impact of such an EIA increase on soil moisture performance varies from low, for bare soil, to moderate, for dense vegetation. The simulation results suggest that the soil moisture performance meets the MIS algorithm specification with 40% margin given that the RFI impacts can be effectively mitigated. There is virtually no difference between MIS and WindSat performance in soil moisture retrieval based on the current MIS design. In general, we found that the land EDR performance meets the algorithm specification with 40% margin given that the RFI (Radio-Frequency interference) and EIA impacts can be effectively mitigated. The predicted MIS performance is 0.0605 g/cm^3, i.e. 6.0%, which is well within requirement. In addition, the predicted MIS soil moisture EDR performance, although realistic and based on real data, is likely to be conservative due to large spatial error between the validation source (mostly point measurements) and the WindSat CFOV. Besides, the MIS pathfinder algorithm is based on existing WindSat 10-37 GHz algorithm; we can expect better performance with the addition of future MIS RFI mitigated 6 GHz channels. We also carried out the RFI sensitivity analysis and mitigation requirements based on WindSat proxy data. Our RFI sensitivity analysis results show that RFI impacts are significant even at low level. Assuming 100% probability of detection requirement, the allowable RFI is approximately 1.1 K for 10V, 2.2 K for 10H, 0.7 K for 18V and 0.3K for 18H, respectively (TBR). However, the final decision should consider both the land algorithm RFI sensitivity and the RFI Scenario simulation study. The ~2.6^o EIA increase from WindSat to MIS poses some performance risk for land EDR performance. The EIA error will reduce the performance margin (40%) for the soil moisture EDR requirement, but will unlikely push the performance out of the algorithm specification.

The MIS Land EDR Simulator is carried out using the Observing System Synthetic Experiment (OSSE) concept that is flexible in studying sensor design and retrieval performance and impacts. The Simulator has five modules: environmental data, radiative transfer up-scaling, sensor error, retrieval, and EDR error statistics. The environmental data module ingests spatial distribution and

temporal evolution of the surface and vegetation state characteristics (soil moisture, vegetation water content, land surface temperature, topography, freeze/thaw, open water, and snow cover etc) based on collections of in-situ observation, WindSat land retrievals, Land Information System (LIS) model runs, and MODIS global land-cover database. The simulated MIS TB maps are obtained for a variety of climatic conditions and radiative transfer model at EASE-Grid resolution. The sensor error module generates TB noise according to sensor specification and injects the simulated SDR instrument measurement error into the MIS TB maps. The retrieval module converts multi-channel simulated MIS observations into the EDR retrievals of soil moisture, vegetation water content and land surface temperature data. The EDR error statistics module compares the retrievals with the environmental data to generate MIS sensor performance predictions. The simulator has the flexibility of using WindSat and LIS data as a truth data and incorporating all the sensor error, model error, in-situ data mismatch, and possibly heterogeneity of land-cover if cost/schedule allows, for the predicts of the error propagation through the simulator.

Defining a detailed error budget is essential for identifying the EDR performance driver for the land algorithm. This task can be implemented by linking the sensor specification and the EDR specification through the retrieval simulator. We will present detailed error budget for the potential performance driver for land algorithm, which include sensor NEDT, RFI, NRF (Noise Reduction Factor), EIA, and inter-channel accuracy.

References

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