CGMS XXXII NOAA-WP-26
Prepared by NOAA
Agenda Item: I/3

Coriolis WindSat Evaluation: Calibration and Validation

To provide an overview of the Coriolis WindSat mission, evaluation of the calibration/validation modes and discuss the potential distribution of data sets for outside evaluation.

Coriolis WindSat Evaluation: Calibration and Validation

1. Introduction

WindSat, an experimental sensor on the Coriolis mission, is intended to measure the partially polarized emission from the ocean surface, and thereby indirectly measure the ocean surface wind vector. The sensor was designed and built at the Naval Research Laboratory (NRL) in Washington, DC, under the sponsorship of the U.S. Navy and the NPOESS Integrated Program Office (IPO). The WindSat radiometer operates in discrete bands at 6.8, 10.7, 18.7, 23.8, and 37.0 GHz. The 10.7, 18.7, and 37.0 GHz channels are fully polarimetric, while the 6.8 and 23.8 GHz channels are dual polarized only (vertical and horizontal). It uses a conically scanning 1.8 m offset reflector antenna and will be launched into an 830-km sun-synchronous orbit. Mission success is defined as a conclusive determination of the viability of using passive polarimetry to measure wind vector. The WindSat performance specifications have been guided by a sensitivity analysis developed using the data collected over a 3-year period by airborne polarimetric radiometers. The calibration/validation effort serves three discreet purposes: (1) to verify and calibrate the system performance; (2) to diagnose system errors and develop methods to address these errors and; (3) to validate the retrieved wind vector.

Dr. Peter Gaiser (NRL) is the WindSat Program Principle Investigator (PI). The core calibration/validation team comprises Dr. Karen St.Germain (NRL), Mr. Gene Poe (NRL), Dr. Paul Chang (NOAA/NESDIS), and Dr. Linwood Jones (Microwave Remote Sensing Consultants). This core team is supported by engineers and scientists at each institution. In addition to this core group, an extended calibration/validation team and science team contributes to the calibration/validation effort. This group comprises individuals and institutions funded by NRL, NPOESS-IPO, ONR, NOAA and other agencies. Together, the WindSat calibration/validation and science teams include more than 30 scientists and engineers. These investigators will contribute to executing specific portions of the calibration/validation plan. For example, one investigator may analyze SDR data against *in situ* measurements; another group may underfly WindSat with an airborne polarimetric radiometer; and a third group may provide *in situ* data from buoys.

2. Calibration

Immediately after launch and power-up, WindSat operated in a special mode (as opposed to the nominal operating mode) to monitor the sensor warm-up. This mode collects radiometer data over the entire 360° scan, thereby allowing an examination of data in the scene transition zones as well as potential FOV intrusions by the spacecraft. Once the radiometers reached thermal stability, the receiver gains and offsets were adjusted to optimize the use of the analog-to-digital converter dynamic range. Radiometer sensitivity, NEDT, was established and compared with pre-launch test data. A qualitative assessment of the relative beam pointing accuracies was also made.

The calibration of the WindSat radiometer incorporates many analyses and comparisons with independent data sets. Among the calibration/validation activities are the following:

- Comparison of WindSat brightness temperatures and antenna temperatures with SSM/I data.
- Evaluation and correction of WindSat geolocation through rigorous examination of coastal crossings and antenna analyses. WindSat geolocation errors are < 5 km.
- Pitch maneuver to evaluate performance of WindSat cold sky reflector and calibration stability. These data sets are also useful for evaluating cross-channel biases.
- Match-up analysis with environmental data from NWP (NCEP GDAS products), SSM/I, TMI and QuikSCAT. These environmental data products are used as is and as input to radiative transfer models to produce modeled scene brightness temperatures.
- Analysis of pitch data and match-up sets to evaluate and correct scan uniformity performance.
- Evaluation of antenna pattern correction (APC) performance using match-up sets and numerical analyses.
- Vicarious calibration using natural scenes with well-understood radiometric properties such as Amazon rain forest and low-TB ocean scenes. This is useful for establishing stability, absolute calibration, cross-channel biases, and scan uniformity.
- Underflights of the WindSat system with airborne polarimetric radiometers and scatterometers.

3. Wind Vector Retrieval and Evaluation

In parallel with the brightness temperature calibration, wind direction retrieval algorithms and forward models are being developed. Some of the models are physically based and tuned using the match-up data sets. Other models are empirically-based and are derived from the match-up sets. There are three primary retrieval algorithms: 1) maximum likelihood estimator (MLE); 2) optimal estimation (OE); and 3) empirical regressions. The aforementioned match-up sets are divided into training and testing subsets. The retrieval algorithms and models are developed with the training data and evaluated with the test data. Performance and analysis of the retrievals and models provide valuable feedback to the system calibration.

Once the detailed system calibration has been completed, the models and algorithms can be finalized. At this time, validation of EDR products begins. The primary sources of truth data for the wind vector validation will be QuikSCAT, SSM/I, NWP fields, and buoys. Attempts are also underway to coordinate flights of airborne scatterometers, radiometers and wind LIDAR systems. While ocean surface wind vector is the primary objective of the WindSat mission, other EDRs produced include integrated water vapor and cloud liquid water, and sea surface temperature. The WindSat project aims to retrieve these to the level of accuracy required to support the ocean surface wind vector retrieval. The validation of the EDRs involves not only absolute assessment of the uncertainty of the products, but also a characterization of the performance in a variety of conditions.

4. Future Plans

Once the WindSat calibration/validation team is confident in the validation and characterization of the wind vector product, the WindSat data will be made available to the science and user community for further evaluation. Feedback from these groups is essential, as they ultimately determine the utility of the WindSat data products. In the final phase, the WindSat will undertake algorithm and calibration improvements to address issues and concerns identified by the science and user communities. These efforts may range from algorithm tuning to development of alternate algorithms, as warranted.