Jason-1 microwave radiometer on orbit validation

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On orbit validation of the Jason-1 Microwave Radiometer (JMR) will be conducted. Techniques that were developed for the TOPEX Microwave Radiometer (TMR) will be used wherever appropriate. In addition, new validation procedures will be developed to deal with significant differences in the JMR instrument design, relative to TMR.
The objectives include validation of the wet path delay (PD) estimated from raw measurements of the brightness temperature (TB), as well as validation of the absolute accuracy of the individual TBs themselves.

There are three major components to the planned validation effort:

• Assembly of a ground truth data base

The database will include three independent measurements of PD and two independent references for TB. The PD measurements are:
a) coincident TMR data;
b) a ground based water vapor radiometer deployed on the Jason-1 ground track;
and c) routine national weather service radiosonde profiles at selected island launch sites lying on or near the ground track.
The two reference TBs will be derived from depolarized regions of the tropical rain forest, for high TBs, and calm, clear, dry sub-polar regions of the open ocean, for low TBs.

• Validation of JMR Flight Algorithms

JMR Flight Algorithms for instrument calibration have been developed and implemented.
The ground truth data bases assembled here will be used during the early, commissioning, phase of the mission to validate the flight software.

• Long term assessment of the instrument and path delay retrieval stability

The ground truth databases will be updated and archived throughout the mission lifetime. JMR stability will be monitored against these data. Of particular interest in the case of instrument stability is the behavior of the on-board reference noise diodes, against which JMR calibration is absolutely referenced. This approach to radiometer calibration has never been tried before by a flight mission.

Background

The Jason Microwave Radiometer (JMR) on the Jason-1 satellite will measure radiometric brightness temperature (TB) at 18.7, 23.8, and 34.0 GHz in the nadir direction, from which is estimated the excess path delay (PD) through the atmosphere experienced by the radar altimeter signal due to water vapor and suspended cloud liquid water. The Jason-1 project-level error budget allocates 1.0 cm of uncertainty to the PD correction provided by JMR. This is a 20% reduction, relative to the TOPEX Microwave Radiometer (TMR), and suggests that an on orbit validation program is warranted on the order of that conducted for TMR.

In addition, there is one significant change in the instrument design, from TMR to JMR, which the on-orbit validation should take into account. In the case of TMR, absolute calibration was referenced to a warm black body load and a cold sky view of space. These calibration reference points bracket the range of Earth TBs measured over the life of the TOPEX/POSEIDON (T/P) mission.
In the case of JMR, the cold sky horn has been replaced by a trio of internal noise diodes, which provide a hot reference point above that of JMR's warm black body load.
This change presents two particular concerns that will be considered during validation. The calibration points will no longer bracket the Earth TBs. Absolute calibration will involve an extrapolation from, rather than an interpolation between, reference points. One obvious cause for concern is the increased sensitivity, in the case of an extrapolation, to non-linearities in the instrument behavior. This issue will be considered during the on-orbit validation discussed here.
The second concern with the noise diodes involves possible long term aging effects in the space environment. Three noise diodes were used for generic reliability reasons and also in order to correct for independent short term variations in their noise power. Correlated long term drifts due, for example, to radiation exposure, cannot be internally detected and corrected.
An external absolute reference, such as is planned here, is necessary.
It should be noted that flight results to date with the reference noise diodes used by the NSCAT radar on ADEOS-1 suggest that there should not be a gross drift problem [E. Njoku, 1997, pers. comm.].
However, the absolute accuracy of the NSCAT results is not sufficient to guarantee JMR's 1.0 cm uncertainty requirement over the life of the Jason-1 mission.

Validation of Flight Algorithms

Antenna Temperature (receiver calibration)

The Antenna Temperature calibration algorithm for JMR will include a basic two point calibration of receiver gain and offset, using a warm black body load and a trio of hot noise diodes. Non-linearities in the receiver response will be characterized during pre-flight thermal/vacuum (T/V) testing. The dependence of the calibration on instrument temperature will also be assessed during T/V.

On orbit validation will begin with an immediate assessment of algorithm performance using the entire suite of available ground truth data that will be assembled. Longer term validation will likely concentrate on the stability of the reference noise diodes, particularly with regard to correlated aging due to the space radiation environment. Again, independent ground truth comparisons will form the basis for detecting drifts in the gain or offset of the antenna temperature calibration.

Brightness Temperature (antenna pattern correction)

The Brightness Temperature calibration algorithm for JMR has been developed. The algorithm corrects for the gain and offset shifts in calibration due to the antenna sidelobes. It will be validated using the vicarious cold reference method developed by Ruf [2000].

Path delay retrieval

The wet tropospheric path delay retrieval algorithm estimates the integrated refractivity of the atmosphere due to water vapor and suspended cloud liquid water from the TBs. The JMR Flight Algorithm has been developed using a two-step, stratified, statistical algorithm that is similar in form to the TMR PD algorithm [Keihm et al., 1995]. Differences include the change in frequencies from TMR to JMR and utilization of recent improvements in the atmospheric water vapor absorption model [Cruz Pol et al., 1997] and the sea water dielectric property model [Guillou et al., 1997]. On orbit validation of the algorithm will be based on intercomparisons between JMR and ground based WVR [Keihm and Ruf, 1995] and RaOb [Ruf et al., 1994] measurements of the PD, in a manner similar to TMR.

References

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