Improving the Temperature and Moisture Retrievals in the Troposphere using AIRS and GPS Radio Occultation Measurements

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Objective

Objective: The objective of this study is to combine the high spectral resolution of AIRS measurements and GPS radio occultation (RO) profiles to obtain the best global overview of the temperature and moisture fields in the troposphere and stratosphere of the Earth's atmosphere. The overall goal is to improve the accuracy and precision of these measurements, particularly in regions of high atmospheric variability. This will be achieved through the development of new algorithms and methodologies that leverage the strengths of both remote sensing techniques.

Simulation results: concurrent inversion of GPS RO and AIRS data in the troposphere

A multivariate regression method is used to retrieve atmospheric T and W profiles from simultaneous AIRS and GPS. The regression equation is:

\[ \Delta X = \sum a_i \Delta Y_i + \sum b_i \Delta Z_i \]

where \( \Delta X \) is a vector representing the observations of the unknowns (temperature or moisture), \( \Delta Y_i \) and \( \Delta Z_i \) are the regressors (AIRS or GPS data), and \( a_i \) and \( b_i \) are the regression coefficients. The solution is obtained by minimizing the sum of the squares of the residuals.

Averaging Kernels for AIRS and Constrained AIRS above Super-Refraction level

The data sets retrieved from the AIRS measurements may be represented as the weighted mean of the true data with a local kernel. The kernel function, which is derived from the local spectral response of the AIRS instrument, is used to construct a weighted average of the AIRS observations. The super-refraction condition is defined as the situation where the local refractivity gradient is large enough to cause significant distortion of the local kernel function, leading to an inaccurate retrieval of the atmospheric state. The analysis shows that the AIRS retrieval, when constrained by GPS RO data, retains its accuracy even in super-refraction conditions.

Simulation Results: a special case of super-refraction

- The above algorithm for one nadir look profile with identified super-refraction condition.
- The result demonstrates that AIRS measurements provide unbiased refractivity, although at low resolution, in the PBL, by significantly improving the GPS refractivity that otherwise is biased due to the SR effect.

Conclusions

AIRS data are considered more accurate and spatially consistent than GPS RO data. However, the AIRS and GPS RO data are not independent; they are strongly correlated. The AIRS data are more sensitive to changes in the atmosphere, while the GPS RO data provide more detailed information about the lower atmosphere. The combination of these two data sets allows for a more comprehensive understanding of atmospheric conditions and improves the accuracy of climate and weather forecasting models.