Relative trends of AIRS and IASI radiometric calibrations

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- Climate studies impose much more stringent requirements on radiometric accuracy than operational weather prediction does
- AIRS and IASI were both funded for their use in weather prediction—yet both are performing so well that it is tempting to use them for climate also
- Ideally, climate instruments require high absolute accuracy, stability, low noise, and bias that is independent of scene temperature, instrument scan angle, scene geographic location, surface emissivity, and the presence or absence of clouds

Introduction

- In this study we examine the stability of AIRS and IASI radiometric calibrations by checking for relative trends in observed brightness temperatures of window channels
- If found, such trends would complicate using AIRS and IASI in studies where very small changes of the earth's climate with time are under investigation

Tropical Oceans obs - calc

Night

Each plotted point represents the mean of about 6,000 measurements

Day

- The cold biases are due to cloud leaks—the spatial coherence filter is not perfect and lets some clouds through, reducing “obs” but not “calc” (because “calc” assumes perfectly clear)
- The differential bias, AIRS versus IASI, of 100 mK is due to the fact that the IASI spatial coherence test, in addition to the 2x2 array, also uses the IASI imager. Thus the IASI cloud filter is stronger (less leakage) than the AIRS cloud filter
- The seasonal dependence comes from the fact that cloud types differ seasonally, and some types show more leakage than others
- We believe the deeper AIRS minima are a diurnal effect—some cloud type appears preferentially at AIRS crossing time

- Fit a low-order harmonic series to the (obs – calc) data (black lines)
- Subtract the fit from the data to form the “anomaly”
- Calculate and plot the double difference, (AIRS anomaly) - (IASI anomaly)
- The dark black curve is a smoothed version of the anomaly difference (32-day running mean)
- The calculated trend for the night data is -4 ± 2 mK/yr (one sigma)
- The calculated trend for daytime is -2 ± 2 mK/yr (one sigma)
- Neither trend is statistically significant
- Note that the uncertainty is well below 10 mK/yr

Surgut and Dome C

- 400 AIRS and 180 IASI points per day
- The mean is -0.23 K
- The peak-to-peak variation of the annual cycle is 3 K
- The trend is $+29 \pm 73$ mK/yr—insignificant

- We cannot conclude that no trend big enough to affect climate studies exists
- At least two factors have contributed to the uncertainty being too big to eliminate the possibility of trends large enough to complicate climate studies
 - AIRS versus IASI orbital differences lead to significant diurnal effects at Surgut
 - Lack of reliable ground truth
- The (obs – calc) method is not applicable over land
 - The scenes are not spatially or spectrally uniform
 - The emissivity of the surface is variable and poorly known

- 240 AIRS and 90 IASI spectra per day (no cloud filtering used)
- IASI count is noticeably less than 4/9 of the AIRS count
- AIRS – IASI is clearly cyclical
 - Peak near 3 K in southern summer
 - Value near 0 in winter
- The behavior of the AIRS – IASI difference is dominated by the previously-reported data incompleteness problem for IASI at Dome C (see reference)
- Spectrally uniform scenes with brightness temperatures in the approximate range of 240 to 260 K are often missing from IASI Level 1C products
 - The instrument's own emission partially cancels the scene signal internally within the interferometer
 - On-board quality control zeroes out spectra that exceed a noise threshold
- Dome C scene temperatures in the sensitive range are fairly common in the summer but not in the winter
- The net result is that (at Dome C) AIRS has an artificial warm bias with respect to IASI in the southern summer

- The above chart is from our talk presented here two years ago
- Note the sharp drop off of IASI spectra counts starting at 240 K
- Above 250 K no IASI spectra appear at all, although AIRS does see some scenes as warm as 255 K

- Note that the AIRS versus IASI difference is small at very low temperatures and also at the higher temperatures seen at Surgut
- Note also that for Surgut the difference is near zero all the way down to 230 K (the lowest temperatures seen at Surgut)
- But for temperatures above 215 K at Dome C the difference is as high as 5 K
 - Apparently, some IASI Dome C spectra are influenced by the interference problem even when they pass the on-board quality check. The observed brightness temperatures are affected.

- Here, before calculating daily means, we have eliminated all spectra with a brightness temperature in the range 240–260 K
- Of course the noise is increased in and around that range
- Note that the AIRS - IASI difference for Dome C in the range 230 to 240 has noticeably decreased and the distribution has tightened—further evidence that IASI spectra at Dome C are affected by the interference problem even when they pass quality control, at scene temperatures as low as 215 K

Conclusions

- AIRS and IASI radiometric calibrations agree very well at 1231 cm^{-1} and 961 cm^{-1} , but there is some bias between them
 - At least some of the bias seen in (obs – calc) for tropical oceans is due to differences in cloud sensitivity
 - At Dome C most of the bias is due to IASI data incompleteness
- This problem is not restricted just to Dome C. It is likely to affect large regions of the ocean that are covered with low stratus clouds, complicating comparisons of global trends using data that include both clear and cloudy areas
- The (obs – calc) technique permits us to state with confidence that there is no relative trend between AIRS and IASI that would invalidate climate studies involving tropical oceans

- No significant trends were seen at lower temperatures using Dome C and Surgut data, but the uncertainty in the trends does not rule out the possibility of trends large enough to affect climate studies
- In areas with cold spectrally uniform scenes, such as Dome C and oceans covered with low stratus, IASI data are incomplete. Also, some spectra that survive the on-board quality control have artificially low observed scene temperatures. Ignoring these facts could lead to selection effects that could result in invalid inferences from the data