Scan-to-Scan Variability in HIRDLS Radiances: A Path Toward Improving Retrievals

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ABSTRACT

Radiance observed by HIRDLS exhibit large variations at a given tangent height vs. time; i.e., from one scan to the next. This so-called scan-to-scan (STS) variation can lead to inaccuracies in the radiances, resulting in degraded and noisy retrievals. This is shown by isolating the STS variation in a HIRDLS channel and imposing it on “truth” radiances simulated by the forward model. Retrievals on these perturbed truth radiances can be degraded as much as retrievals on the observed radiances, depending on the channel. This is in contrast to retrievals on the unperturbed truth radiances that are very accurate. It is then shown that when the amplitude of the imposed STS variation is substantially reduced, the resulting retrievals improve markedly, having accuracies close to those of the retrievals on the unperturbed truth radiances. These results suggest that HIRDLS retrievals should improve significantly once the cause of the STS variability is identified and the feature is reduced or eliminated.

Introduction

Scan-to-scan (STS) variability in HIRDLS radiances is illustrated in the radiance time series of Fig. 1 in two columns, each having four plots. The left column is for channel 17 (CH₄) and the right column for channel 21 (NO₂). Each column shows the variation of radiances with time (scan no.) for a full orbit at four tangent heights: 50 km (top plots), 40 km, 30 km, and 20 km. In each plot the red curve is the observed HIRDLS radiance (v5, corrected for the kapton signal), the blue curve is a 9-point smoothed version of the red curve, and the green line shows the radiances simulated by the forward model based on a “truth” climatology that is sampled at the same HIRDLS locations as those for the red curve.

The prominent feature of the HIRDLS radiances (red) is their large variations from one scan to the next at a given tangent height. Considering that a complete scan (up or down) takes about 12 s, these large variations are likely not geophysical in nature. This is also evident by noting that the truth radiances (green) show a much smoother variation with time; i.e., if the STS variations are mainly geophysical, the truth radiances should contain them as well.

Possible reasons for the STS variation are: (1) the variability of the kapton signal (see the poster by Gene Francis), and/or (2) some artifacts of these correction algorithms.

The effects of the STS variation on the retrievals are discussed below and shown in the panels to the right.

Retrievals on Truth+STS

The curtain plots below show the effect on the retrievals of adding the STS variations to the truth radiances. Each plot shows data as a function of tangent height and latitude along a full orbit of HIRDLS observations on 18 May, 2006. The panels for each species show the following:

a) Retrieval on truth radiances
b) Truth climatology sampled along the same HIRDLS orbit (MOZART3 for CH₄, NO₂; Aura MLS v2.2 for H₂O, N₂O)
c) Retrieval on Truth+STS radiances
d) Retrievals on HIRDLS observed radiances (v5, most recent version)

The plots for each species show that the accurate retrievals on truth radiances (a) are degraded to a level (c) closely resembling the retrievals on observed radiances (d).

How Does STS Variability Affect the Retrievals?

Truth radiances provide an effective means of studying the impact of STS variations on retrievals:

- They do not contain these variations
- Retrievals based on truth radiances are very accurate (see curtain plots at right)

This leads to the question: What happens to these accurate retrievals if STS variation is imposed on truth radiances (Truth+STS)?

Fig. 2 shows examples of imposing STS variations of Fig. 1 on the truth radiances. The green lines are the truth radiances, the blue curves are the isolated STS variations, and the red curves are Truth+STS. When this is done at all tangent heights of every scan throughout the orbit the resulting retrievals look very similar to those based on observed radiances (curtain plots at right).

Effect of Reducing STS Amplitude

As the plots below show, when the amplitude of STS variations is reduced by a factor of 10 before adding them to the truth radiances (truth+0.1STS), the resulting retrievals improve nearly to the same level as the retrievals on truth radiances.

Conclusions

The STS variability degrades the very accurate retrievals on truth radiances to nearly the same level as v5 data. However, these degraded retrievals improve dramatically when the amplitude of the STS variation is reduced by 10x. These results imply that HIRDLS retrievals should improve significantly if the STS variation is diagnosed and eliminated.

Causes of STS variability may either be due to some artifact(s) of the kapton correction algorithms and/or variability from one scan to the next in the kapton signal in atmospheric view that is not captured in detail by these algorithms.

Fig. 1 Radiance time series

Fig. 2 Time series of isolated STS variation (blue) and Truth+STS (red)