AIRS Near Real Time (NRT) data products

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1 Introduction

This memo examines differences between the routine processing and Near Real Time (NRT) processing of the AIRS Level 1b and Level 2 standard data products. Speed takes precedence over accuracy for the NRT data. Therefore the NRT data processing differs from the routine processing in a four ways to meet the three hour latency requirements of the Land Atmosphere NRT Capability Earth Observing System (LANCE):

1. The NRT granules are produced without previous or subsequent granules if those granules are not available within 5 minutes (previous and subsequent granules are used for calibration and are generally present in 5 minutes);

2. Predictive ephemeris/attitude data are used (in contrast, a more accurate definitive ephemeris/attitude data are used for processing the routine products);

3. Nominally, a forecast surface pressure is used; if this is unavailable, a surface climatology is then used;

4. No ice cloud properties retrievals are performed (ice cloud properties are a new retrieval in the Version 6 support product AIRX2SUP).

Typically, the NRT Level 1b and Level 2 NRT data products are available in less than 3 hours while the routine products are available after $\sim$ 24 hours. Figure 1 shows a histogram of the latencies for a year of NRT Level 1b and Level 2 granules.

An understanding of the differences between NRT and routine processing is important for users who may want to give up some accuracy in the retrieval in exchange for a rapid solution. Section 2 describes the differences between the NRT and routine processing of AIRS Level 1b data. Section 3 describes the differences between the NRT and routine processing of AIRS Level 2data. Section 4 summarizes our conclusions.

2 Level 1b

The forecast surface pressure is not used in Level 1b processing. Therefore the only differences are due to the less accurate ephemeris/attitude and whether or not the previous or subsequent

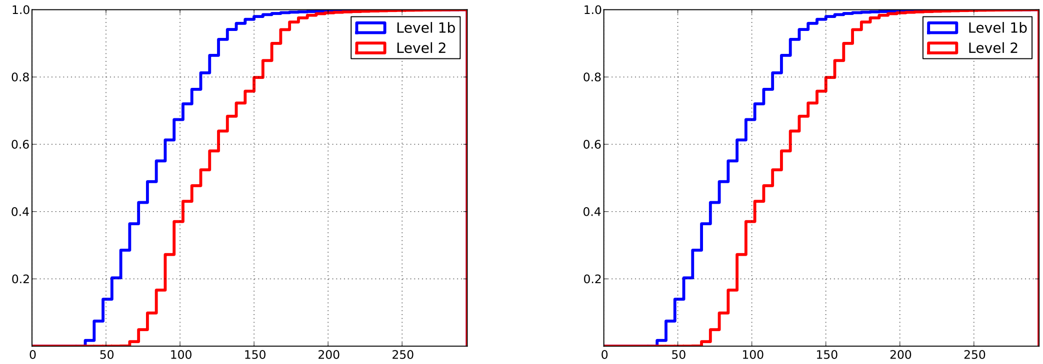


Figure 1: The figure shows the latencies and cumulative latencies for a year of Level 1b and Level 2 granules. Although the histograms have been truncated at 300 minutes, delays only last for more than 300 minutes when either the processing system is down or there are network problems.

granules are present. The less accurate ephemeris/attitude data result in geolocation errors that are typically less than 100 meters. This is negligible compared to the AIRS footprint which has a $\sim$ 15 km diameter. The geolocation errors can lead to small errors in the assumed land-fraction (along coastlines) and surface pressure, however they have no effect on the observed radiances. Figure 2 shows the differences between the NRT and routine processing position and landFrac parameter for 3 granules.

The radiances from the NRT processing are identical to those of the routine processing for most granules. However, since the AIRS calibration algorithms use space views from previous and subsequent granules there can be some differences when data from the previous or subsequent granules are not present. This usually only happens once per orbit when AIRS loses contact with the down-link station. Figure 3 shows that when the subsequent granule is not present the difference in brightness temperature over all channels can be $\sim$ .1 Kelvin. Although this can lead to a bias between the NRT and routine Level 2 products (e.g., **TSurfAir**) for any given few scans, over many orbits the bias will cancel out (see Figure 3). The differences are the largest for the last (first) few scans if the subsequent (previous) granule is missing because the offset calculation uses a running average of spaceviews from the subsequent (previous) few scans. Radiances from all scans in a granule can also be affected (to a smaller extent) because a mean gain calculation is used for each granule.

3 Level 2

3.1 Processing without the Previous or Subsequent Granule

Figures 3 & 4 show that small differences in radiances observed when the NRT data are processed without a subsequent granule can affect the retrieved parameters. This can produce small biases relative to the routine processing in the last few scans of at least one granule

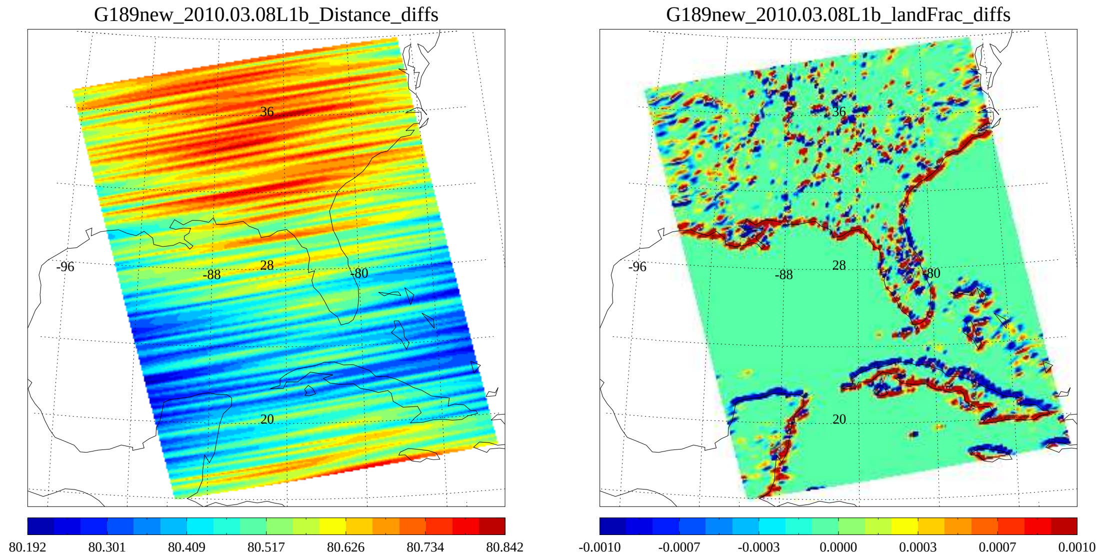


Figure 2: The figure shows difference between the NRT and routine processing of the Level 1b geolocation (in meters) and the **landFrac** parameter.

every orbit. Although the bias can be observed for the affected few scanlines, it appears to be random (i.e., For one set of scans the bias may be positive while it is negative in the subsequent set of scans). The difference can be seen in the **TSurfAir**, **totH2OStd** and to a smaller extent **TAirStd** at 500 mbar. Since some granules may be processed without previous or subsequent granules in the AIRS routine processing, those data will also be affected when previous or subsequent scans are not available.

3.2 Processing without definitive ephemeris

By definition, the definitive ephemeris/attitude is more accurate than the predicted ephemeris/attitude in geolocation determination of satellite data. However, the definitive ephemeris is often not available for data that require timely delivery such as weather, direct broadcast, and near real time (NRT) processing. As a result, a predicted ephemeris is used to generate the geolocation information required for these kinds of data processing. The satellite orbital parameters of predicted ephemeris/attitude are computed from NORAD Two Line Element Set (TLE), whose mean elements are not the same as true values. The accuracy of parameters for a given orbit in predicted ephemeris/attitude is therefore dependent on the predicted methods used in computation. The accurate method should be compatible with the way in which these TLE elements were generated. Such method was presented by Hoots and Roehrich[1], which gave equations for five models completely compatible with NORAD predictions. These models are rather complicated and the Direct Readout Lab of the NASA/GSFC employed instead a simple but less accurate extrapolation algorithm to compute parameters of predicted ephemeris/attitude based on a small number of elements of the TLE only. The algorithm, called **aqua_main**, was used to create predicted ephemeris data for our NRT processing.

[1] F. R. Hoots, R. L. Roehrich, "Models for Propagation of NORAD Element Sets", Spacetrack Report No. 3. 1980.

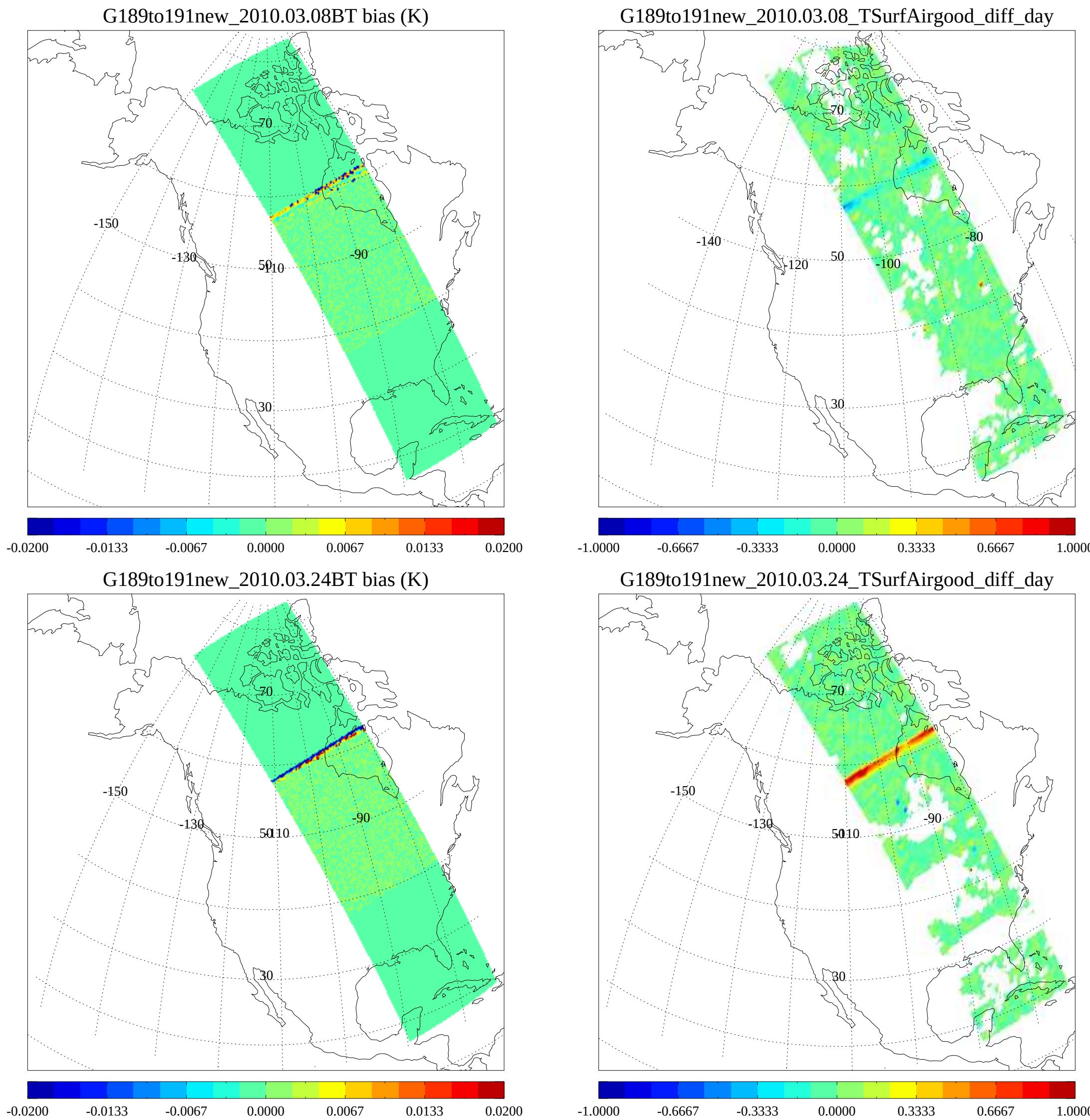


Figure 3: The figure shows data from granules 189, 190, and 191 on March 8, 2010 (top) and March 24, 2010 (bottom) as Aqua passed over north America from the Gulf of Mexico to Canada. The left panels show the mean brightness temperature difference between the NRT and routine processing averaged over all channels. The right panels show the differences in the **TSurfAir** parameter. The northern most granule arrived 1 hour after the other granules. Since it was not present when the center granule was processed, there are some differences between the NRT and routing processing.

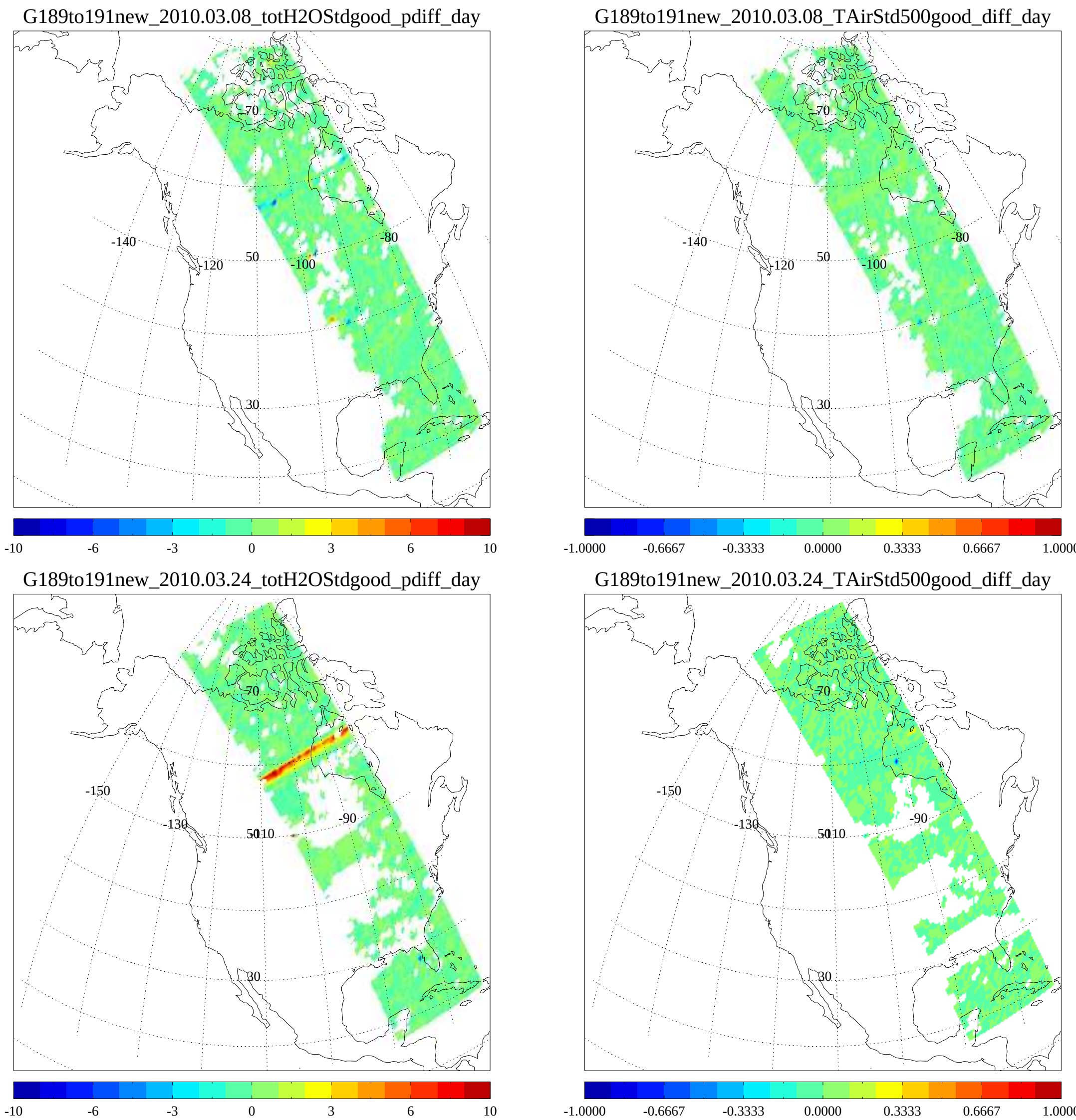


Figure 4: The figure shows data from granules 189, 190, and 191 on March 8, 2010 (top) and March 24, 2010 (bottom) as Aqua passed over north America from the Gulf of Mexico to Canada. The left panels show the percent difference between total water vapor. The right panels show the differences in the **TAirStd** parameter at 500 mbar. The northern most granule arrived 1 hour after the other granules. Since it was not present when the center granule was processed, there are some differences between the NRT and routing processing.

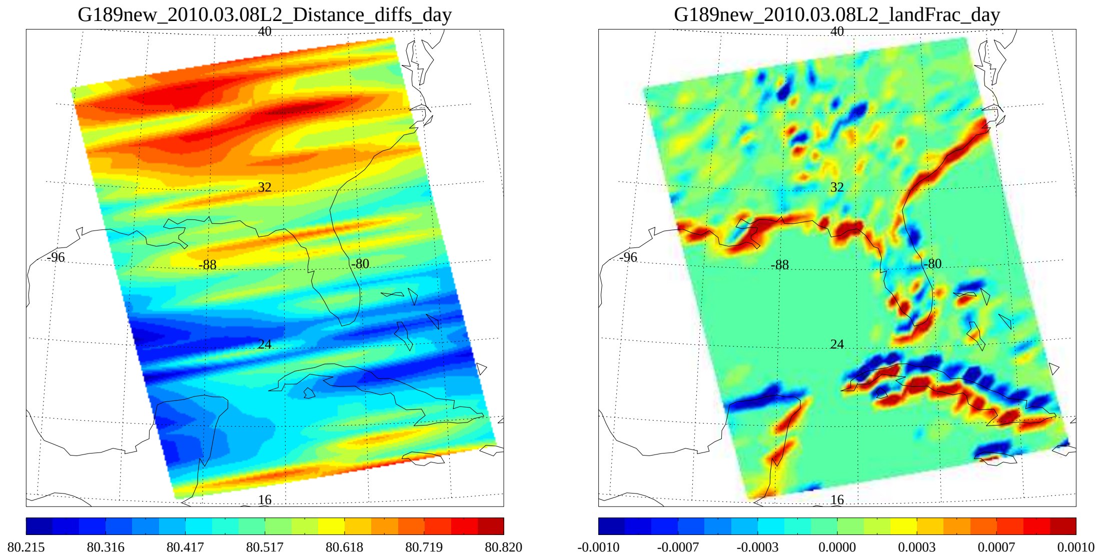


Figure 5: The figure shows difference between the NRT and routine processing of the Level 2 geolocation (in meters) and the **landFrac** parameter.

The definitive ephemeris data used for geolocation in the routine processing is only available once every 24 hours, therefore the NRT processing uses a predicted ephemeris and attitude. Figure 5 shows the differences between the NRT and routine processing position and landFrac parameter for 3 granules. Although the errors are small (a few tens of meters) they can lead to some differences in the assumed surface pressure. There can also be errors in the land fraction "landFrac." Since different quality control thresholds are used for land and ocean scenes there can be some differences in yield along coastlines.

3.3 Level 2 dependence on surface pressure

The AIRS retrieval algorithm uses the surface air pressure from the Global Forecast System (GFS) model provided by the National Oceanic and Atmospheric Administration (NOAA). The assumed surface pressure can affect the AIRS Level 2 parameters. Each AIRS infrared channel measures a signal sensitive to temperature, cloudiness, water vapor, and trace gas concentration in a specific range of levels in the atmosphere. Some "window channels" also sense Earth's surface. Because of the emissive process in the atmosphere, these signals are correlated to a particular pressure altitude (measured in millibars or hectopascals) rather than to a particular elevation in meters above sea level. The precise surface pressure in millibars for a given location varies with passing high- and low-pressure systems which cannot be sensed by AIRS. For those frequencies sensitive to the surface and the lowest part of the atmosphere, the amount of signal coming from the atmosphere versus the surface will shift with changing weather patterns. The different interpretations of the near-surface environment also affect retrieved temperature, water vapor, and trace gas profiles throughout the atmosphere. Therefore, for best results AIRS processing uses a surface pressure derived from a forecast, specifically NOAA's GFS (formerly called "Aviation Forecast" or "AVN"). The small differences between the NRTand routine processing geolocation propagate to small differences in the predicted surfaces pressure. Figure 6 shows the difference between the NRT and routine processing for the assumed surface pressure (**PSurfStd**), surface air temperature (**TSurfAir**), total water vapor (**totH2OStd**), and the air temperature (**TAirStd**) at 500 mbar. The differences in the surface pressure over the Appalachians have no discernible effect on the retrieved parameters. However, when the forecast surface pressure is not available, a climatological average surface pressure is assumed which can affect the level 2 parameters (see, Sec. 3.4).

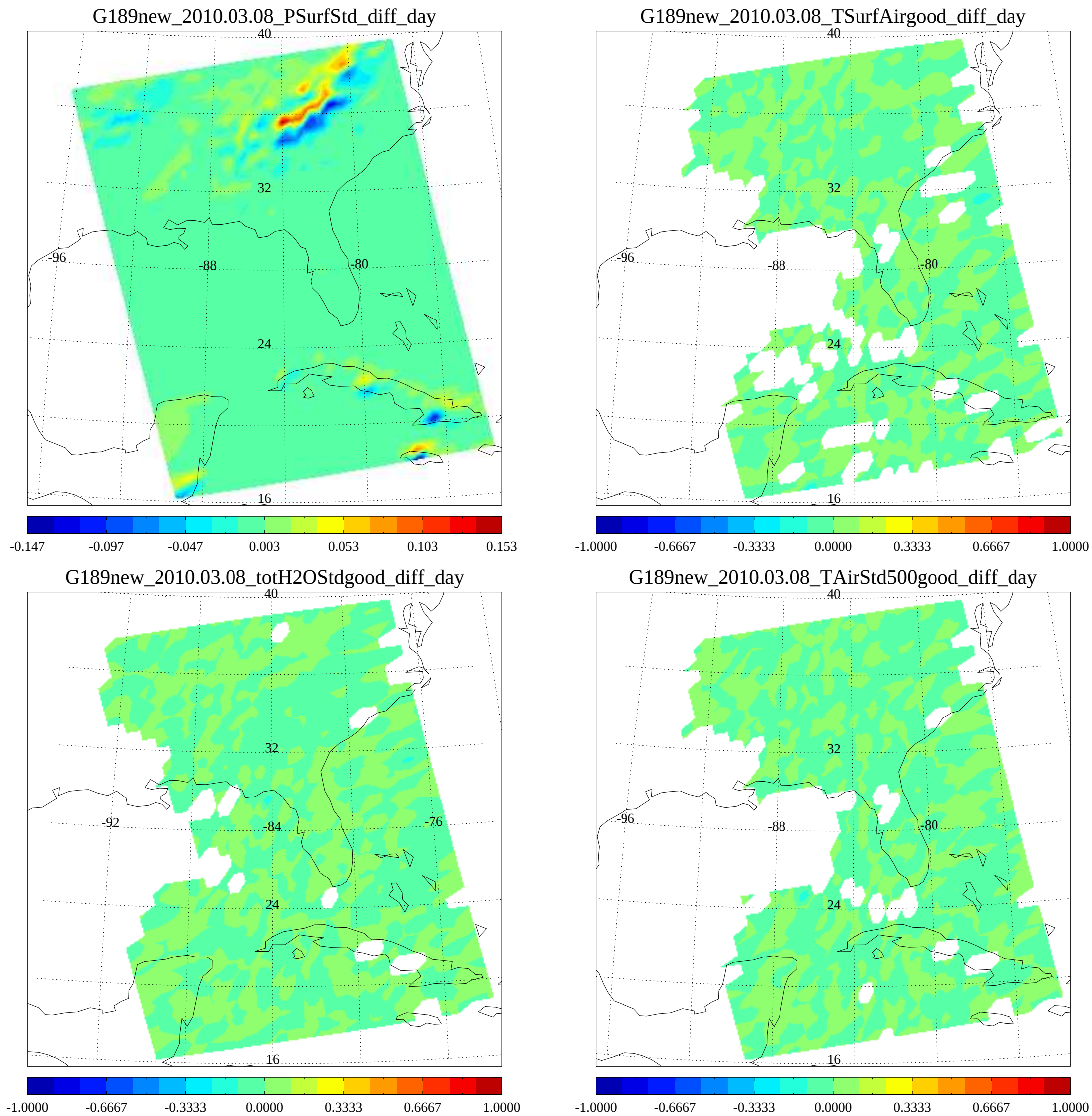
3.4 Processing without NOAA/GFS

When the forecast surface pressure is not available, a climatological average surface pressure is assumed which is based on a Digital Elevation Map (DEM). Since the DEM does not account for synoptic weather events there can be larger deviations from the actual surface pressure during these types of events. For example Figure. 7 shows the differences between the NRT and routine processing for a granule in which there was a high pressure system over the Gulf Coast This slight negative pressure bias in the assumed surface pressure lead to a slight warm bias in the **TSurfAir** (the surface air temperature). We note that it is very rare that the forecast is not present for NRT processing. An analysis of GFS latencies compared to L1B NRT latencies for all of 2009 showed that the forecasts would have been available in time for all granules had the system been configured to use them and had the GFS been delivered regularly. While testing the lastest NRT processing code on 2 weeks of data in 2010 there was one orbit ($\sim$ 16 granules) for which the GFS was delivered 3 hours later than usual as was thus not available for processing the Level 2 NRT.

Users who want to verify that the forecast was present for the NRT processing can examine the Level 2 parameters called **Qual_Guess_Psurf**. It is set to 0 when the forecast surface pressure is used, it is set to 1 if the DEM based surface pressure is used, and it is set to 2 if the data should not be used.

4 Conclusions

The AIRS NRT data products are generally available 24 hours before the routine products and are very similar to those produced by routine processing. Usually there are only small differences in geolocation, radiances, and retrieved atmospheric parameters. The largest differences between the NRT and routine products tend to occur along coastlines. The last few scans of a granule may be slightly noisier when there is not subsequent granule present. Users are also cautioned that the data quality can suffer a slight degradation when processed without the forecast surface pressure. However, the **Qual_Guess_Psurf** quality flag can be querried to find whether the forecast surace pressure was used.


G189new_2010.03.08_PSurfStd_diff_day
40
32
-96
-88
-80
24
16
-0.147
-0.097
-0.047
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0.053
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0.153
G189new_2010.03.08_TSurfAirgood_diff_day
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G189new_2010.03.08_totH2OStdgood_diff_day
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G189new_2010.03.08_TAirStd500good_diff_day
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Figure 6:

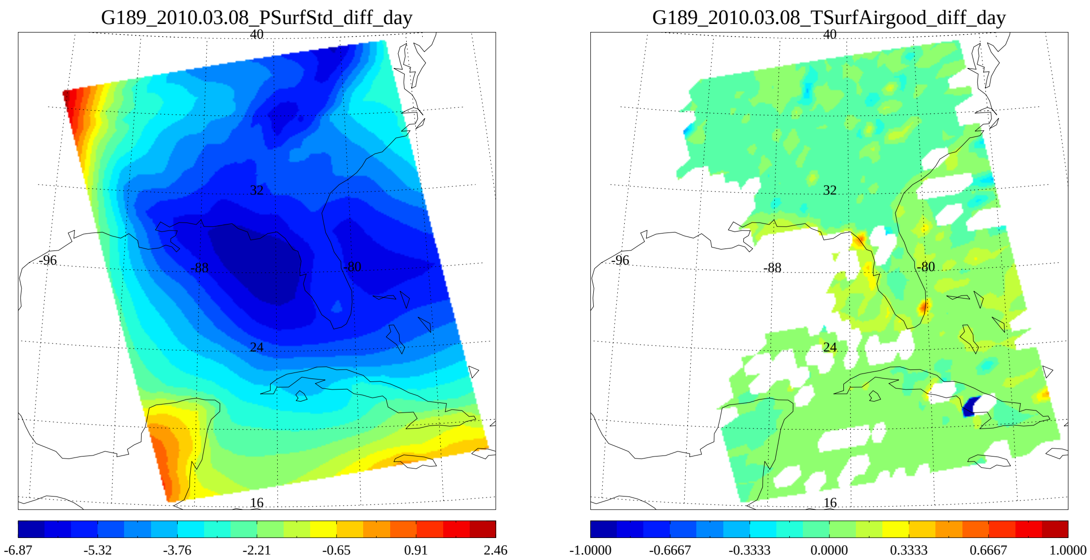

Figure 7: Difference in Pressure when the forecast is not available.