An assessment of the characteristics of SSMIS from F-16 to F-18

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During 2010 the data from the latest Special Sensor Microwave Imager/Sounder (SSMIS) instrument onboard the U.S. Defense Military Satellite Program (DMSP) F-18 satellite were made available to Numerical Weather Prediction (NWP) Centres. Assimilating the new data into the Met Office’s global NWP model is expected to improve the current data coverage, as well as enhance the NWP system’s future robustness. However, the F-18 instrument has been found to suffer from a distinct ascending and descending systematic bias.

The bias characteristics of the SSMIS data streams from the F-16, F-17 and F-18 satellites have been investigated with respect to the Met Office’s global forecast NWP model. The influence of the new ascending/descending (asc/desc) bias predictor (being introduced in order to mitigate the strong bias present in the F-18 data), is presented.

Characteristics of the various ‘flavours’ of SSMIS data

At the Met Office we assimilate SSMIS data from the F-16 instrument that is pre-processed using our original in-house SSMIS ‘PP’ pre-processing software. In preparation for switching to use SSMIS data pre-processed using the Unified Pre-Processor (UPP) at the Naval Research Laboratory, the characteristics of our operational ‘PP’ data are compared with that of the ‘UPP’. The nature of the F-17 and F-18 data are also shown below.

F-16 ‘PP’

As part of the SSMIS ‘PP’ pre-processing, observations contaminated by solar intrusion are flagged and later rejected, as here.

The characteristics of our operational ‘PP’ data were found to be very similar to that of the ‘UPP’ data, as can be seen when comparing histograms of observations – background (O-B) departures.

F-16 ‘UPP’

SSMIS data pre-processing using the UPP in which additional corrections are applied, enables observations in the solar intrusion regions to be utilized, thus providing better data coverage.

F-17 ‘UPP’

The channels exhibit similar behaviour in each instrument, although in F-18 there is a distinct separation between the ascending and descending passes. The O-B bias structures are effectively mitigated (except in F-18) when the Harris and Kelly’s bias correction scheme is applied, with the corrected observation – background (O-B) departures, now resembling Gaussian distributions.

In F-18, the separation of the ascending and descending nodes is quite distinct, and is ~0.7K. This does not result from a cross-scan bias dependence, but from an asc/desc bias. This can be clearly seen in the global map of the C-B departures, as well as the histograms, with the descending pass being distinctly cooler than the model background.

F-18 ‘UPP’

Although not particularly apparent, the F-16 instrument is also known to suffer from a similar issue, although to a much lesser degree, with the bias being ~0.2K in magnitude.

Introducing a new predictor

In order to compensate for the ascending/descending bias, a new bias predictor was developed whereby application of a co-sinusoidal predictor was found to most effectively reduce the departures. When implemented, the predictor is scaled according to the assimilation system.

A seasonal dependence

Monitoring of the F-18 UPP data over a six month period revealed that the magnitude of the bias varied throughout the season, such that it was most significant around the summer solstice. The position of maximum bias was also observed to deviate from the equator.

An amendment to the predictor

Simply adding an additional phase term, \( \psi \) into the predictor enabled the position of the maxima to be varied, so that seasonal variation could be corrected for upon a bias update. Thus:

\[
\text{Predictor} = \text{pass.cos}(L - \psi)
\]

This is implemented as a two-part predictor in order to conform to the Harris and Kelly scheme. Thus:

\[
\text{Predictor}_{\text{asc}} = \text{pass.cos}(L)
\]

\[
\text{Predictor}_{\text{desc}} = \text{sin}(L)
\]

Assembling the data

Preliminary NWP trials have been run to assess the impact of assimilating the new data into the Met Office model. Given the need to use the asc/desc bias predictor in order to assimilate the F-18 data, and that F-16 was also found to benefit from the correction, the ‘asc/desc’ predictor was used to correct all the SSMIS data assimilated in the trials undertaken. Interestingly, both instruments are found to provide slight positive impact when used independently, yet neutral benefit is realised when they are simultaneously included in the assimilation.

Satellite data used in trial

<table>
<thead>
<tr>
<th>Satellite data used in trial</th>
<th>NWP Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>All obs corrected using ‘asc/desc’ predictor</td>
<td>( v_{\text{Obs}} )</td>
</tr>
<tr>
<td>F-16 UPP</td>
<td>+0.21</td>
</tr>
<tr>
<td>F-18 UPP</td>
<td>+0.21</td>
</tr>
<tr>
<td>F-16 and F-18 UPP</td>
<td>+0.03</td>
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Notes:

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