GOES Imager IR Channel to Channel Co-Registration Correction Program in the GOES Ground System

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The Co-registration error between IR channel 2 and 4 can be as large as 1 pixels for GOES-13, which has significant impact on the reliability for the derived products that rely on the combinations of these IR channels.

The program consists of two components:
- An IR channel to channel Co-registration Characterization Algorithm to retrieve the co-registration errors among the IR channels and generate the Co-registration Table (CORT) to be used in the GOES Ground System
- An Image Resampling algorithm to re-project the image in one IR channel to make it align with the other IR channels.

The key to both components is the Fast Fourier Transformation Resampling Algorithm.

Fast Fourier Transformation Resampling Algorithm

Define a global Fourier expansion function for an input array:

\[ g(x) = \sum g(k) \sin(\frac{\pi}{N}kx) \]

The Fourier amplitudes \( g(k) \) are obtained from the input array, and \( N \) is the size of the array. The resampled array with the shift \( \delta \) can be expressed as

\[ G(x + \delta) = \frac{1}{N} \sum g(k) \sin(\frac{\pi}{N}(kx + \delta)) \]

The Fast Fourier Transformation is used in determining the Fourier Amplitudes and the image Resampling. The algorithm is generally reversible by performing the resampling on the resampled image with the shift \(-\delta\).

IR Channel to Channel Co-Registration Characterization Algorithm

Express the temperature correlation between difference IR channels as the function of the shift \( \delta \):

\[ R(\delta) = \sum (g(x) - \bar{g})(f(x) - \bar{f}) \]

The \( \delta \) value corresponding to the maximum correlation represents the Co-registration error. The correlation is calculated on line by line (East/West) or column by column (North/South) basis. The Co-registration error for an image is a weighted average:

\[ \bar{R}(\delta) = \frac{1}{N} \sum R'(\delta) \text{ for } R'(\delta) > 0.5 \]

\[ 0 \text{ for } R'(\delta) < 0.8 \]

Only the earth pixels are included in the calculation.

The Implementation in GOES Ground System

The resampling algorithm will be implemented in the Sensor Processing System (SPS).

The Image resampling in SPS uses the CORT to determine the resampling shift for a given time of a day.

The CORT in the SPS is updated periodically to account for seasonal changes.

The image resampling is performed along the East/West direction for each scan line, where the Co-registration errors are most significant.

The image resampling will be performed after the data in the IR channels are calibrated and before the data are packed into GVAR.

Only the channel 2 images for GOES-13 are resampled.

The GVAR Block 0 will include a resampling status word. The proposed update on GVAR block 0 is shown in the table below.

<table>
<thead>
<tr>
<th>Words</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-13</td>
<td></td>
<td>Resampling parameter, Related to the co-registration (LSB) of the word 262. The status bits are defined below:</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>The images in channel 4 are resampled.</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>The images in channel 2 are resampled.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The re-sampling in EW direction is disabled.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The re-sampling in EW direction is enabled.</td>
</tr>
</tbody>
</table>

Proposed GVAR Block 0 with the image resampling status word. Refer to Table 3-6 in GOES Operation Ground Equipment Interface Specification for complete information.