

CENRAIS – CWG Extended Navigation and Registration Assessment and Improvement System for GOES-R ABI Sensor

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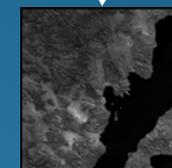
(CWG Extended Navigation & Registration Analysis and Improvement System)

CENRAIS goals:

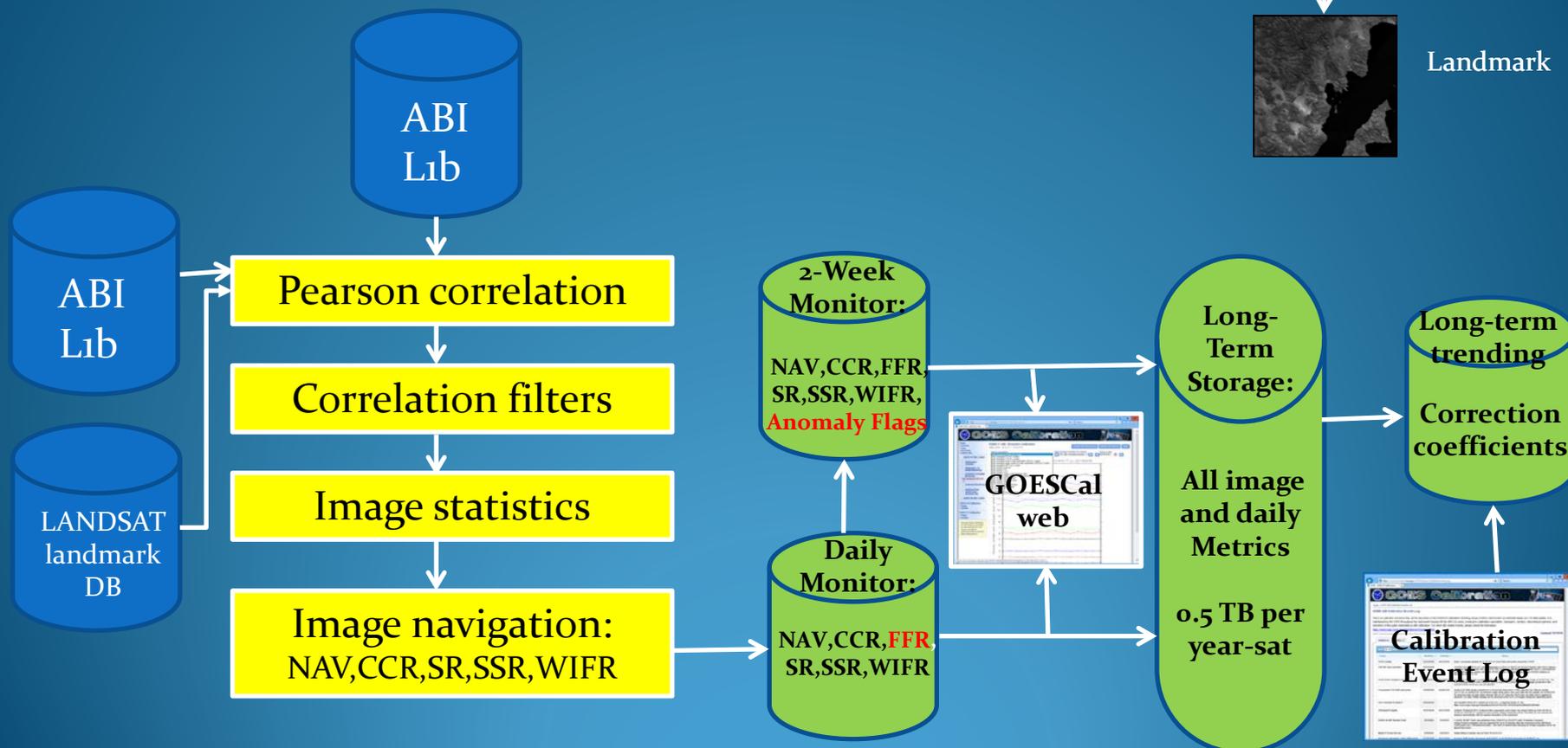
- Assess quality of geometric calibration of ABI L1b images*
- Detect navigation anomalies and provide detailed diagnostic information*
- Trend navigation of ABI L1b images and provide de-trending estimates*



ABI Image

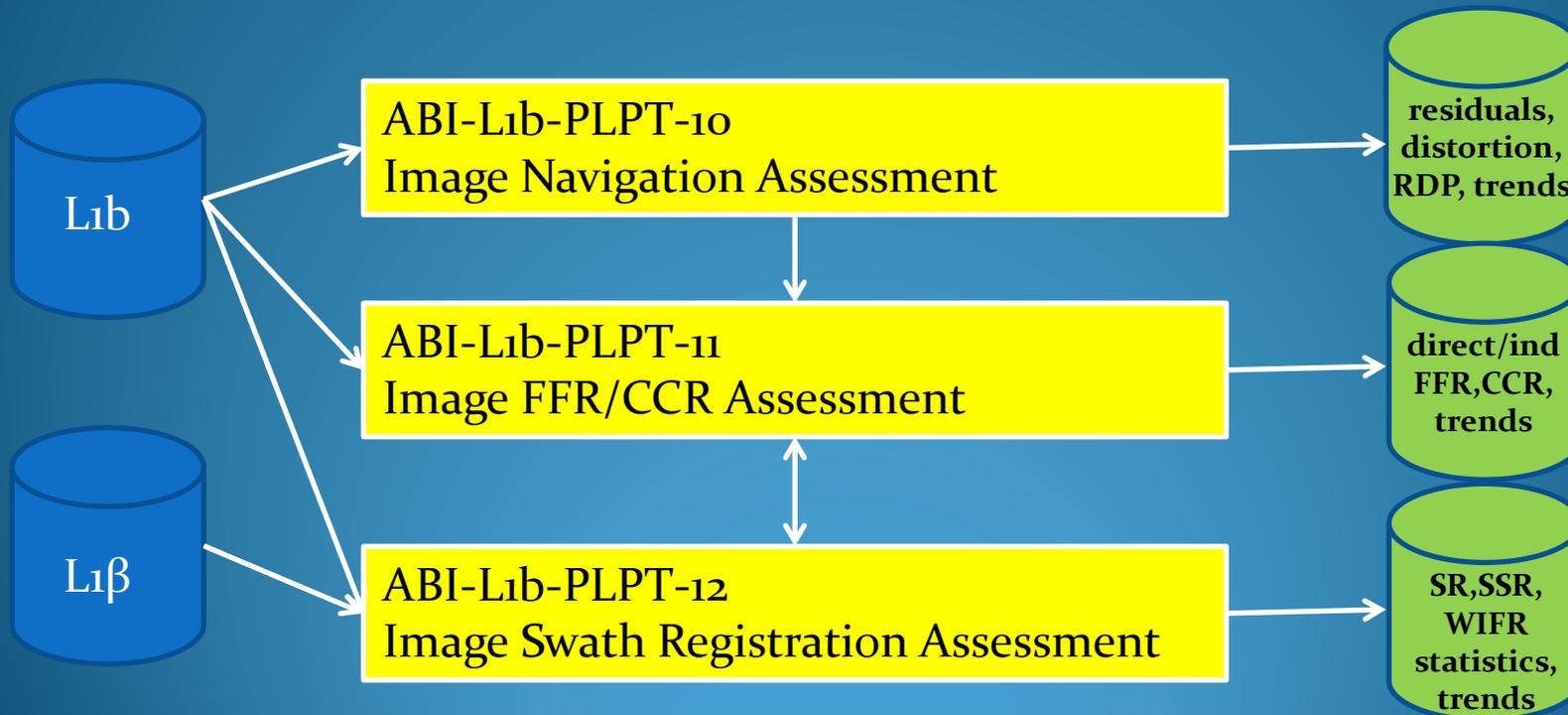


Landmark

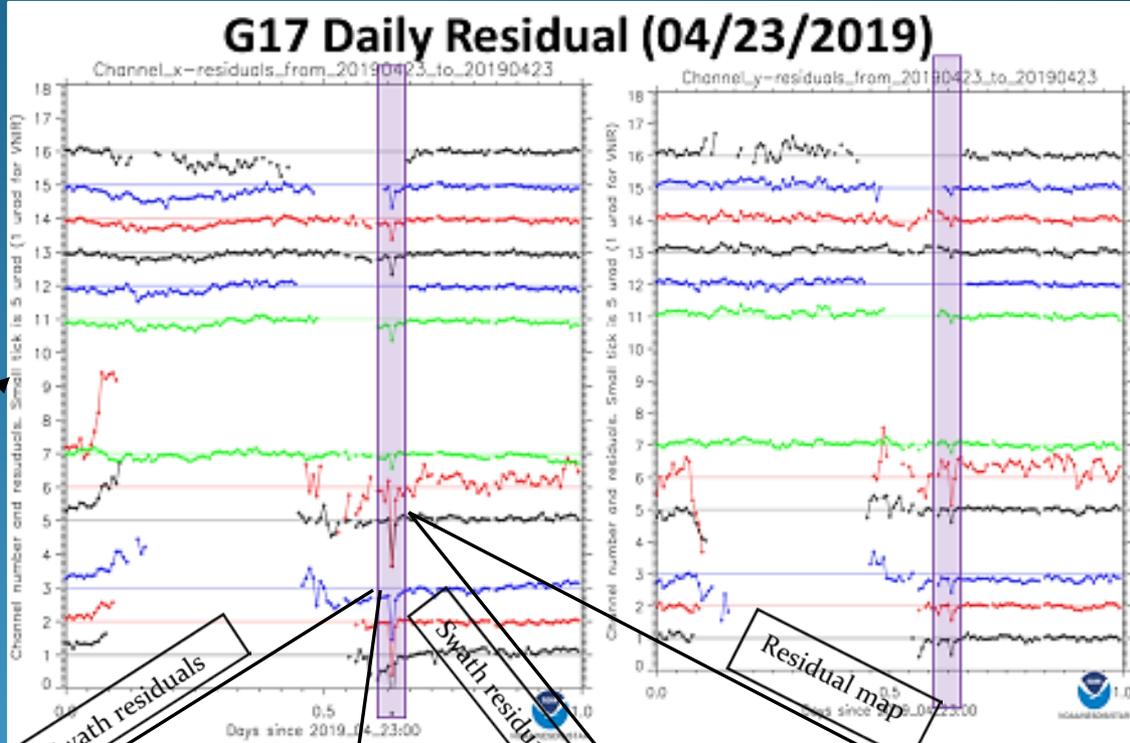
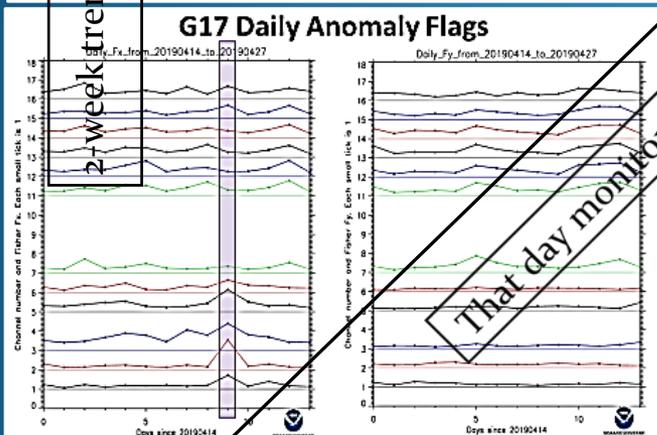
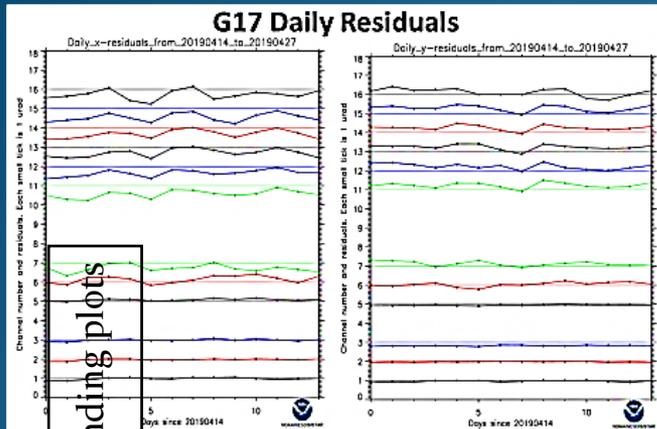


- ❖ <https://www.star.nesdis.noaa.gov/GOESCal/>
- ❖ Pull-Down Menu (PDM) leads to the ABI geometric calibration monitoring web page for each satellite.
- ❖ First PDM on the page lists the monitored parameters.
- ❖ Second PDM lists the plots for selected parameter, including anomaly flags for 2-week trending.
- ❖ Third PDM shows the calendar.

- ❑ Post-Launch Product Testing (PLPT) is the major focus of CWG post-launch activities organized in three stages:
 - ❑ Beta maturity
 - ❑ Provisional maturity
 - ❑ Fully-validated maturity
- ❑ After each stage, a PS-PVR meeting is held featuring CWG report, which includes the navigation assessment.
- ❑ Navigation assessment is organized in 3 PLPT:



Navigation Anomaly Monitoring



2-week trending plots

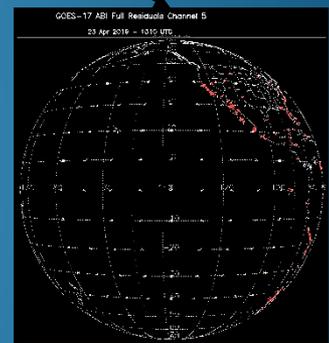
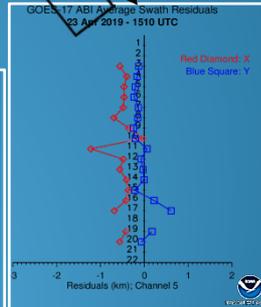
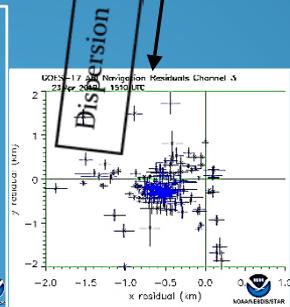
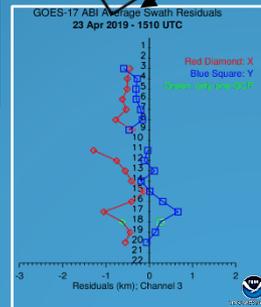
That day monitor

Swath residuals

Swath residuals

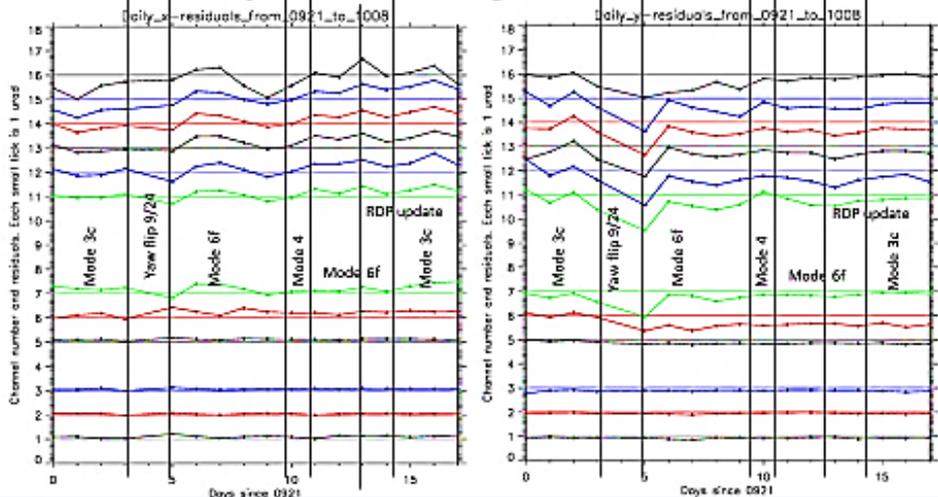
Residual map

Anomaly detected

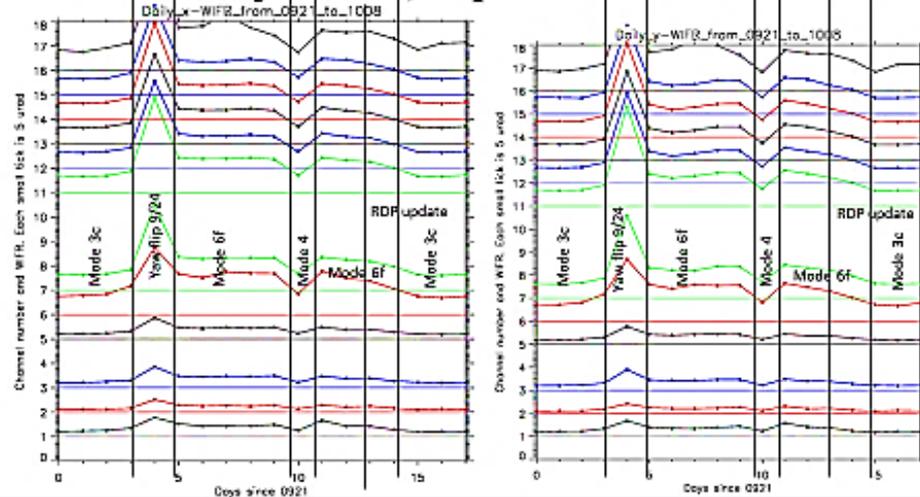


Navigation Update Monitoring

ABI/G17 Daily Residuals, September 21 – October 8

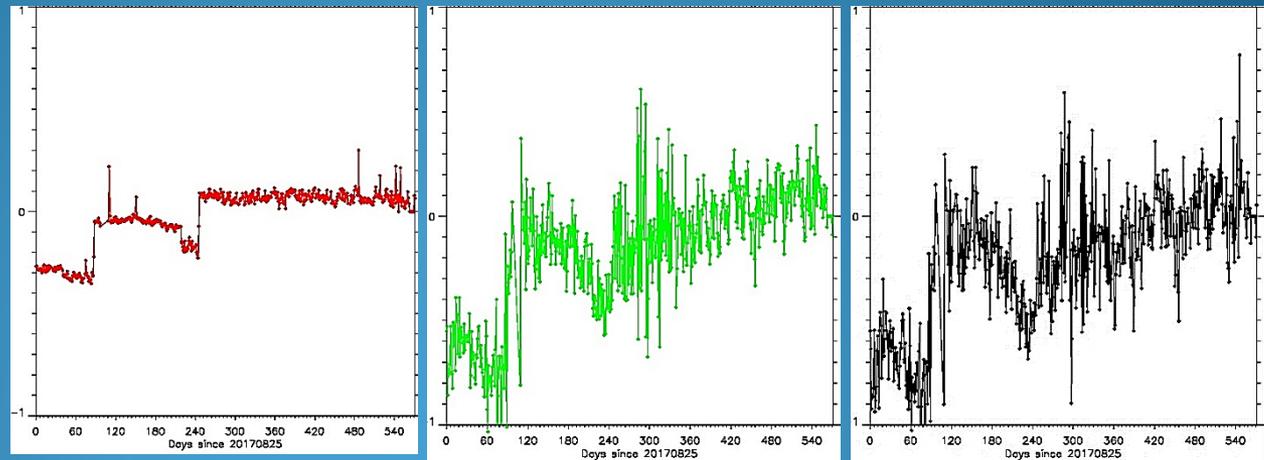
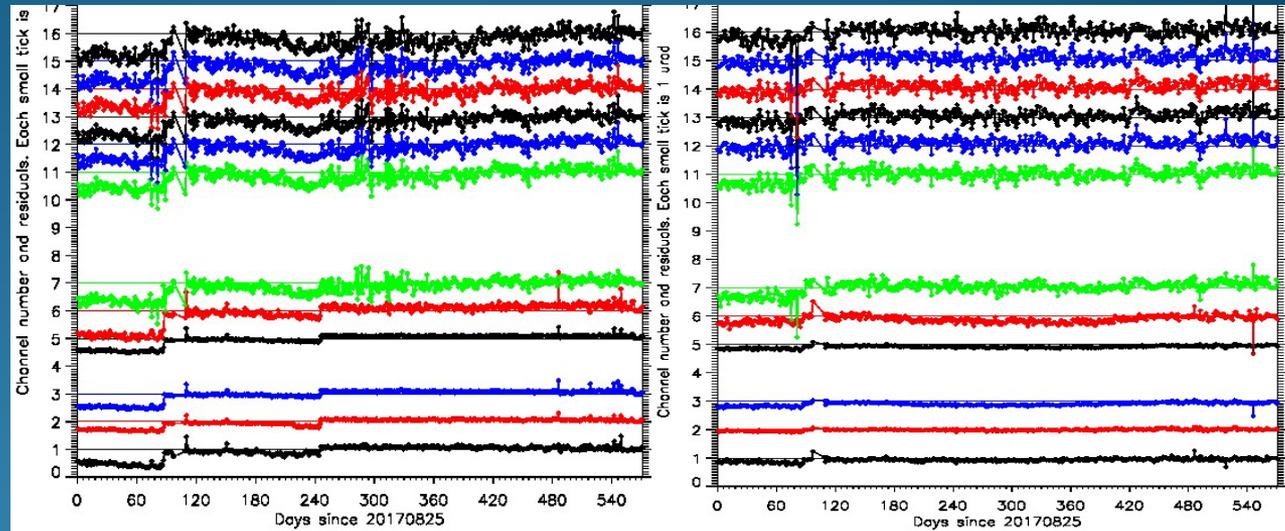


ABI/G17 Daily WIFR, September 21 – October 8



CENRAIS allows for a simultaneous tracking of several INR parameters, which can give some additional information. Plots above cover a busy period in ABI/GOES-17 PLT and PLPT. Different scanning modes are tried, with often overlapping RDP update. Daily residuals and daily WIFR tell complementary stories about changes in the navigation and in the image quality.

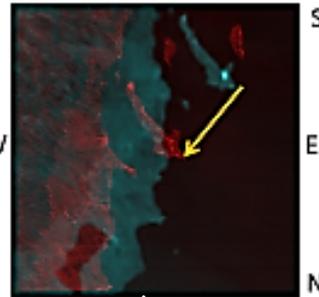
- Daily-averaged navigation residuals in x- and y- directions over 570 days of monitoring for ABI on GOES-16 will be analyzed with account for CWG Calibration Event Log (CEL).
- Channel 2, 7, and 13 EW (x) navigation residuals (left to right) are affected by the calibration events and noise. The records will be divided by the CEL dates and denoised on each time interval separately, producing the long-term trending and corrections to residuals and co-registration



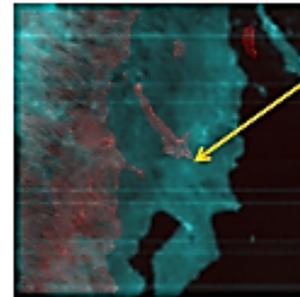
- CENRAIS has a diagnostic mode, when it outputs the ABI images overlapped with the landmarks.
- This mode proved to be useful in assessment of the first visible images of ABI on GOES-17 with the large LOS offsets (left image).
- Removal of the large offsets by shifting the ABI image allows to apply CENRAIS navigation algorithm to refine the value of the large shift and assess its variation over the image. This approach may provide the estimates for a static ABI LOS correction and for the focal planes misalignment.

Channel 1 Navigation Example

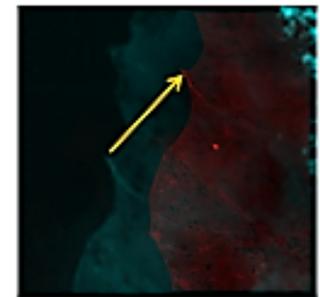
First Light
 $\Delta x = -17.5$ km
 $\Delta y = +22.0$ km
 Time: 2018-04-13 17:15 UTC



Flip back
 $\Delta x = -26.25$ km
 $\Delta y = +37.5$ km
 Time: 2018-06-20 18:42 UTC



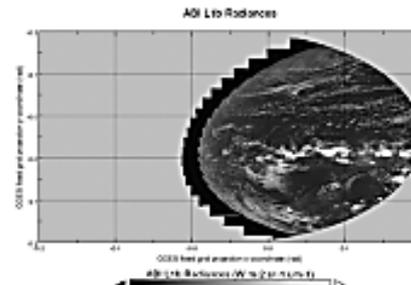
Flip Now
 $\Delta x = +21.25$ km
 $\Delta y = -23.5$ km
 Time: 2018-09-25 00:00 UTC



Interpolated ABI image is blue. Averaged landmark image is red.

First flip did not produce a navigable image:

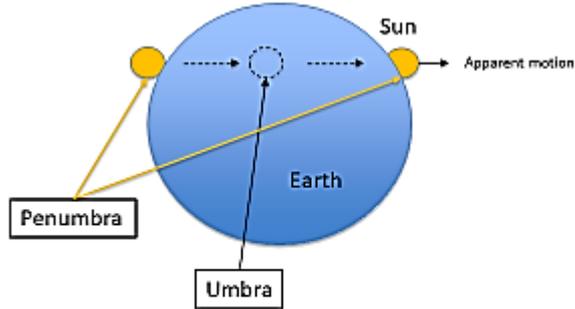
5/2/2019



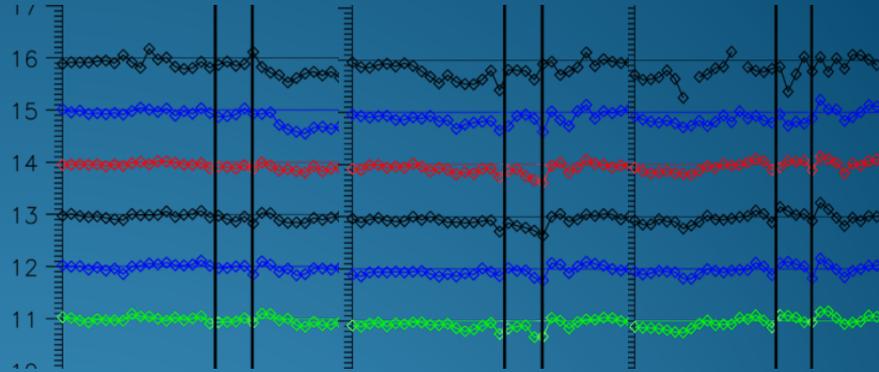
4

- In addition, this approach allowed to evaluate ABI LOS change under the yaw flip. As after the first three flips ABI restarted without a static LOS correction, it became possible to compare the LOS deviation from nadir for subsequent yaw flips. Conclusion was made that the yaw flip maneuver is performed gently enough for not changing the static LOS offsets.

Application Example: Eclipse

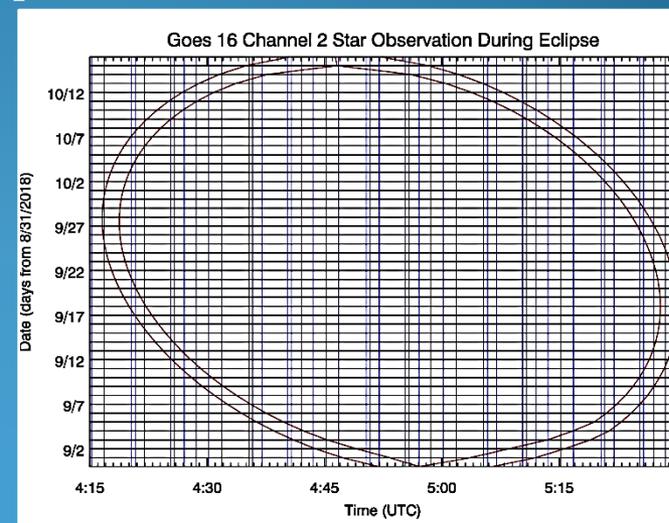
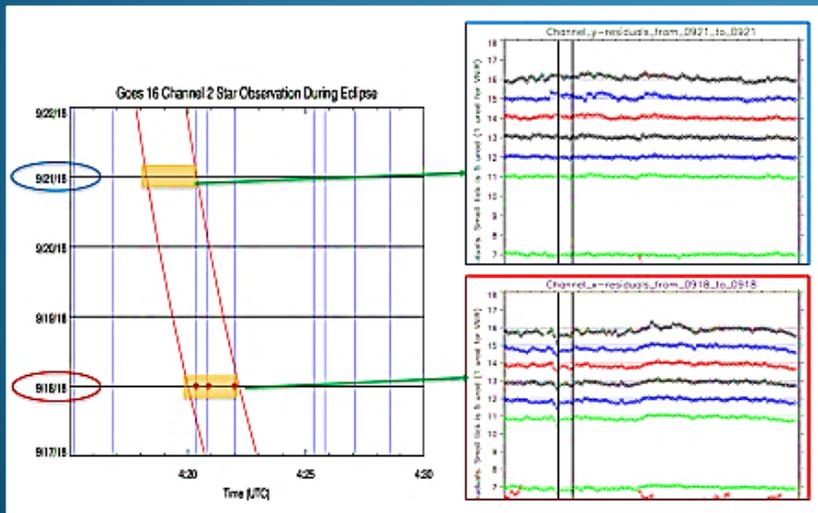


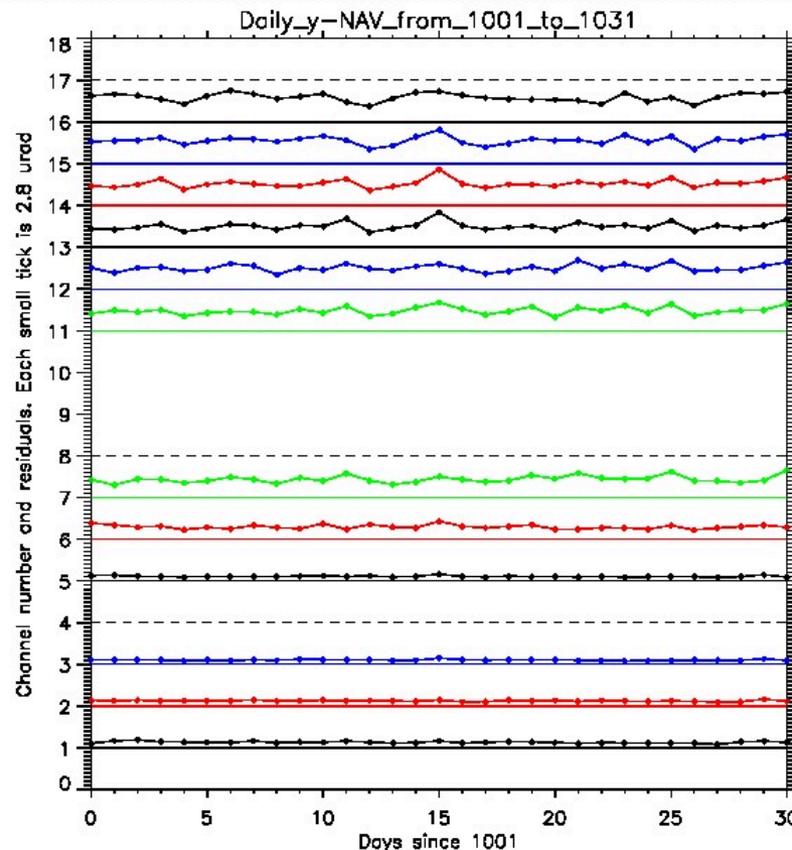
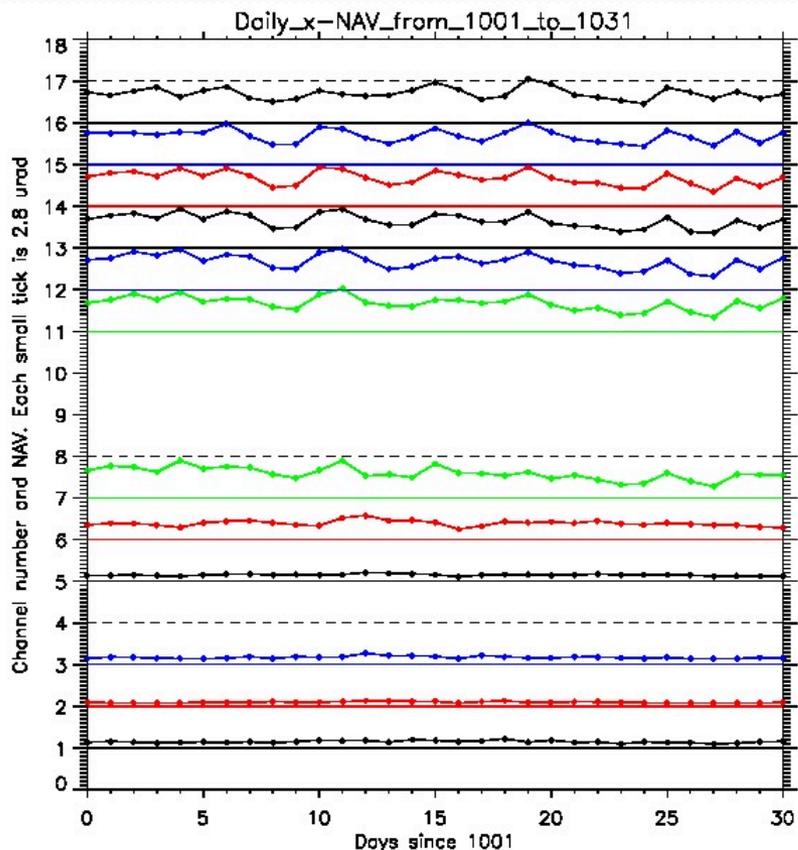
In its apparent motion, Sun is approaching Earth from the left. When it touches Earth, the period of **penumbra** starts (Sun is partially shadowed). Fully-shadowed period is called **umbra**. It is followed by another period of **penumbra**.



Navigation error dependence on time is **highly-variable day-to-day**, but the peaks of the navigation errors are always **locked on the penumbral phase** of the eclipse.

What brings the day-to-day variability near penumbra?

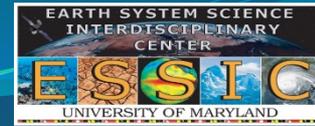




Legend: Total navigation error ($|\text{bias}| + 3\text{std}$) is plotted on the level equal to the channel number. Left plot is for the EW (x), right is for the NS (y) directions. Color is varying to distinguish the neighboring plots. The spacing between the horizontal lines is 28 urad (MRD requirement).
Observations: Requirements are satisfied on all days of October 2019 for all channels.



Summary



- ❖ One of CWG responses to the challenge of the validation and verification of the ABI calibration was creation of CENRAIS system.
- ❖ CENRAIS is able to navigate the ABI image of any format – Full Disk, CONUS, and MESO.
- ❖ Navigation accuracy is verified by comparison with the operational image navigation systems.
- ❖ The main use of CENRAIS is the navigation control of the L1b images and anomaly detection.
- ❖ CENRAIS has shown a high sensitivity to the navigation anomalies with absence of the false positive alarms.
- ❖ CENRAIS has many applications in the navigation problem diagnostics.