ECOSTRESS

ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

L1 Calibration and Geolocation Review

Science Team Meeting
17AUG2021

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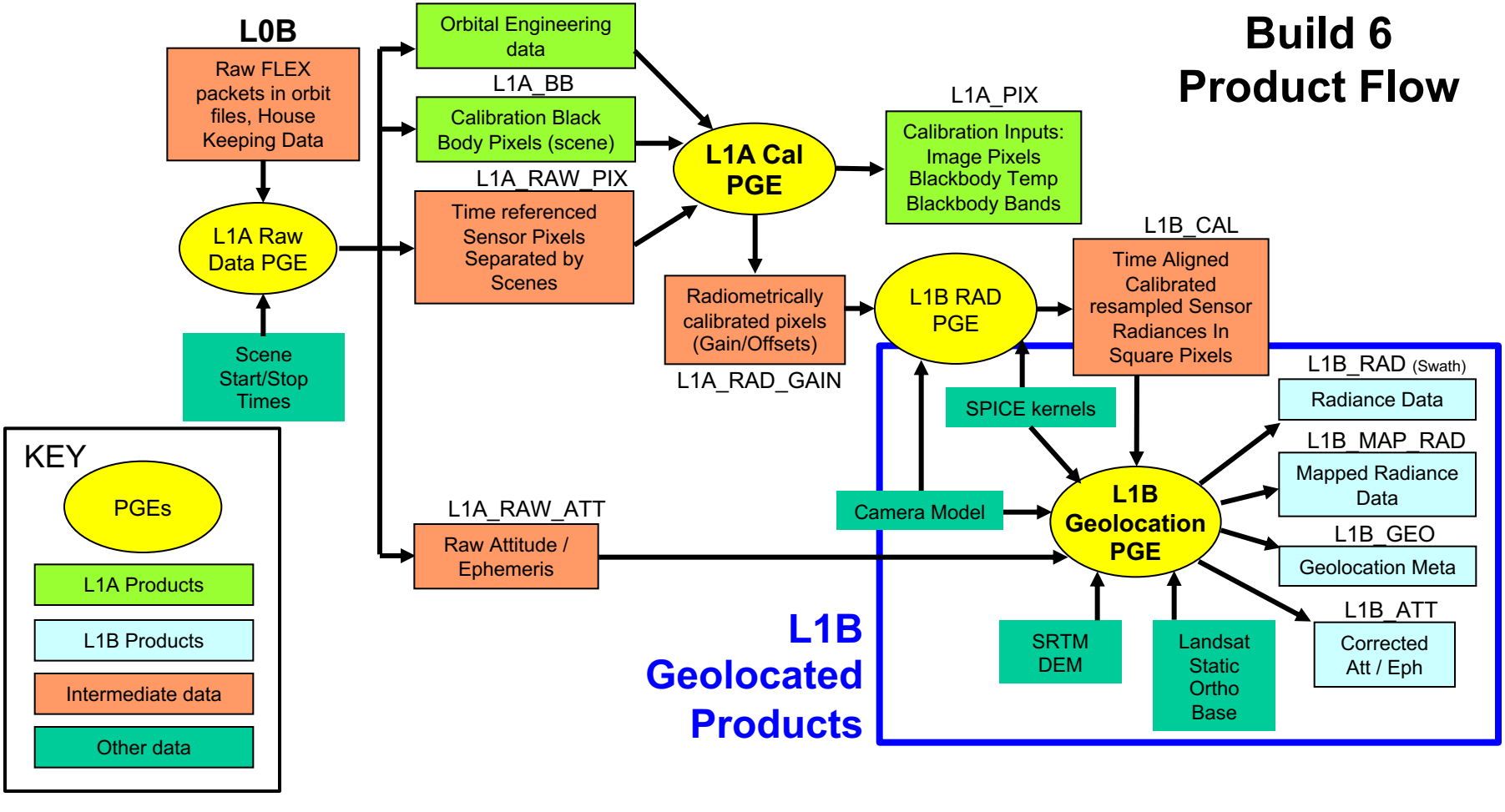
L1 Data Flow Diagram



L1A Updates for Build 7

- A new “FieldOfViewObstruction” Flag will be provided in the Standard Metadata.
  - “Yes/No” codes will identify View Obstruction due to ISS Solar Panels.

- Two underperforming focal plane (FPA) pixels have been identified in the 10.5micron band.
  - They correspond to product scan Lines 1 and 110, repeating in 128 line intervals:
    - Lines 1, 129, 257, 385, 513, 641, etc.
    - Lines 110, 238, 366, 494, 622, 750, etc.
  - These scan lines will be marked as “Bad Data” code -9999.
    - Bad Data lines are not interpolated.
  - Users of Build 6 data should be aware of quality issues with these lines in L2 Products.

L1B Updates for Build 7

- A variety of miscellaneous L1B Upgrades.
  - Radiance gain/offset adjustment parameters will implemented.
  - Add HDF5 product compression.
  - L1B_Map_RAD product moved to L2 product line.

- Geolocation Improvements:
  - Expanded Metadata.
  - Co-Registration improvements.

- Scan-to-Scan Alignment Improvements for Build 7+

L1B Geolocation

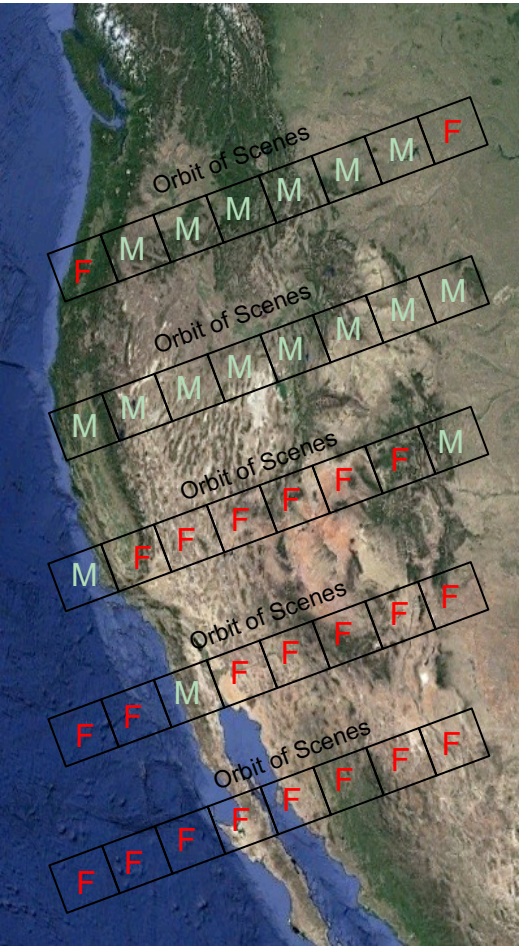
- Geolocation calculates the Latitude and Longitude of each image pixel.
- Latitude and Longitude are calculated from Spacecraft Attitude or Attitude corrected by an Orthobase (i.e., Earth Map Image).
  - ECOSTRESS does **not** have a Star Tracker for attitude/orientation correction.
  - ECOSTRESS extrapolates ephemeris/pointing/timing (BAD*) information from the ISS to the camera system on the JEM module and 1553 HK/Telemetry Data.
    - Errors include ISS altitude, pitch, yaw, roll, time, drift, and camera jitter.
    - Composited errors at the ECOSTRESS module are estimated as:
      - 2.5km error at 1-sigma**
      - 7.5km error at 3-sigma
  - Attitude correction is performed by co-registration/matching an ECOSTRESS image with a similar wavelength ortho-rectified Landsat map mosaic.
    - The ortho-mosaic map is based on Landsat7 imagery circa 2000.
    - The estimated positional accuracy of the map mosaic is 0.5-0.6 pixel (Pan).
- Pixel Latitude and Longitude coordinates are passed to L2 processing.

* BAD: ISS Broadcast Ancillary Data
**Documented in: "Level-1B Resampling and Geolocation Algorithm Theoretical Basis Document (ATBD)," JPL D-94641

Geolocation From Co-Registration

- Geolocation correction is only possible for scenes where image matching with the Orthobase can be performed.
- Automated Image Matching is performed by a grid of FFTs between the ECOSTRESS Scene and the Landsat Orthobase.
- Automated Image Matching may fail for a variety of reasons:
  - Image is over water/ocean.
  - Image is cloudy.
  - Image lacks ground features that can be matched
    - Fog; Poor Lighting; Non-Descript Terrain
- Images without Geolocation Matching use the available ISS positioning information which can be 2.5km to 7.5km from true geographic location.

Current Orbital Geolocation from Scene Matching



Orbital Attitude Geolocation extrapolated from Matched Scenes

Every Scene Matched and contributes to orbital Attitude

Geolocation for Failed Scenes interpolated from Between Matched Scenes

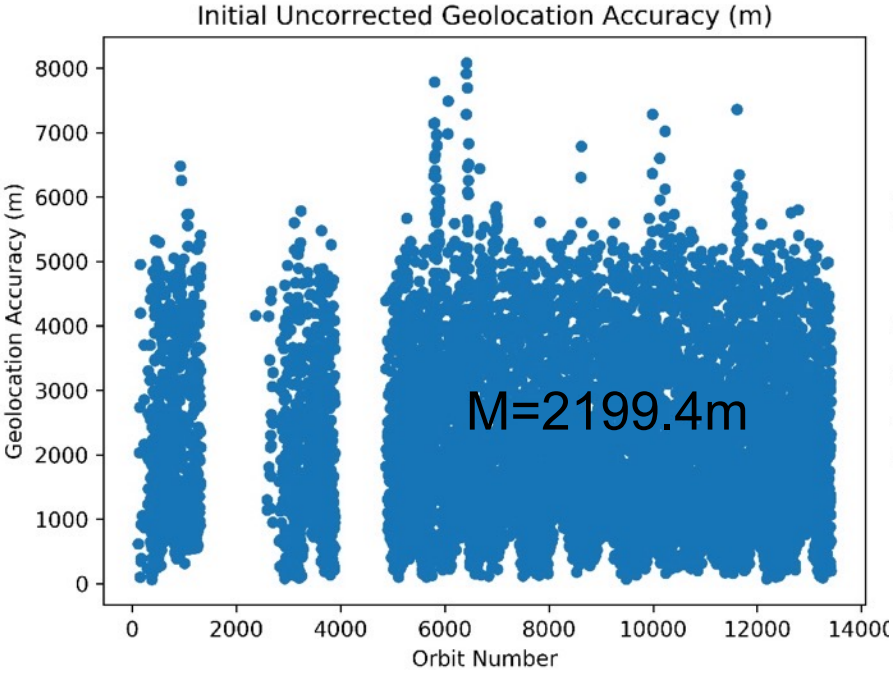
Orbital Attitude extrapolated from Single Matched Scene

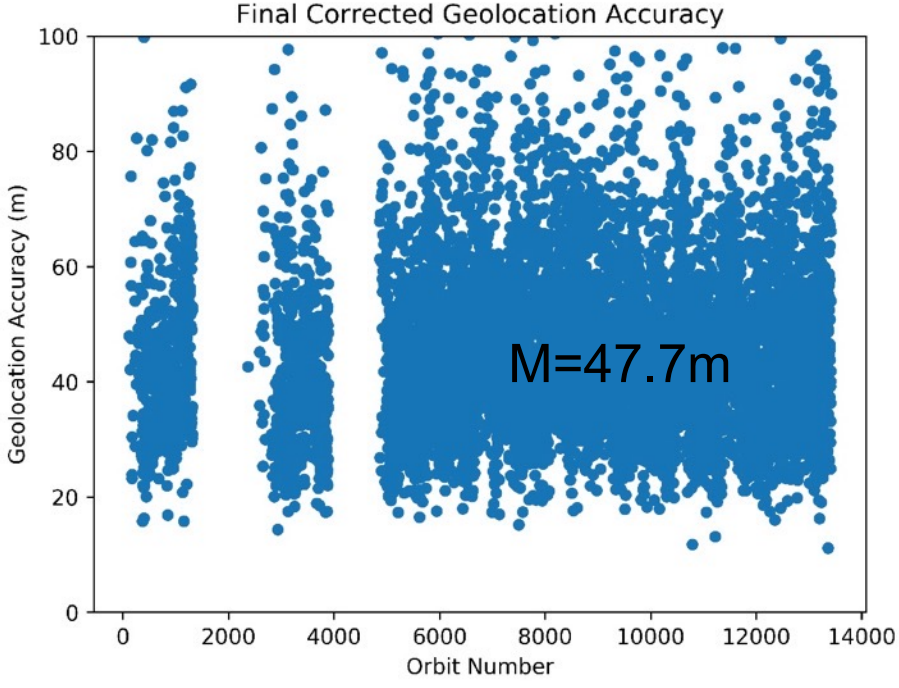
Geolocation Failed; Using ISS Attitude information

Matched Scene to orthobase
Failed Scene Matching due to Water, Clouds, Other

Typical Orbital Error Correction

- Plots of Individual Scene Errors Before and After Geolocation Correction
  - Average 2.2 kilometer Error Reduces to 48 meters



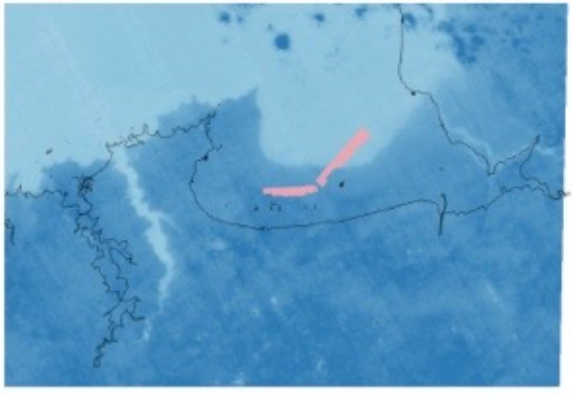


Data Statistics Compiled
17NOV2020

Geolocation Issues

User Test Case

- "Night" (mostly early morning) scenes are difficult to co-register to the Landsat orthobase because of the low sun angle and diurnal temperature effects. A few false matches can produce mis-registration errors.

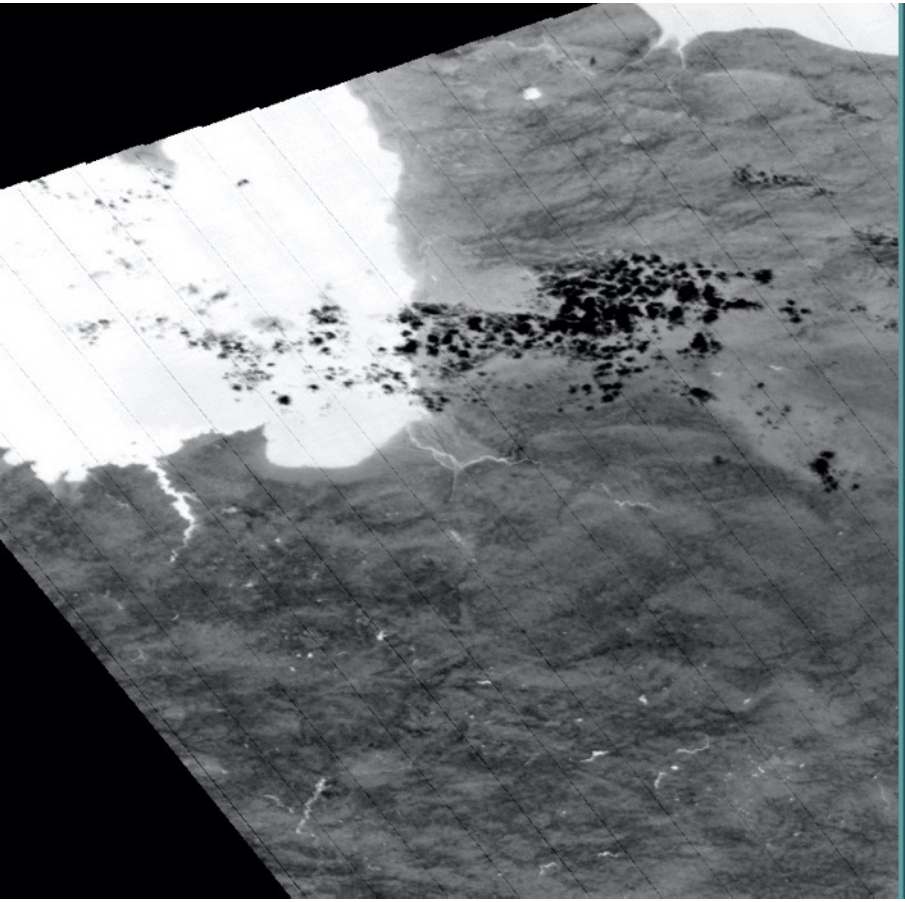


3798_001 No clouds **8.8 km error**
Build ID 0503
Orbit Correction TRUE

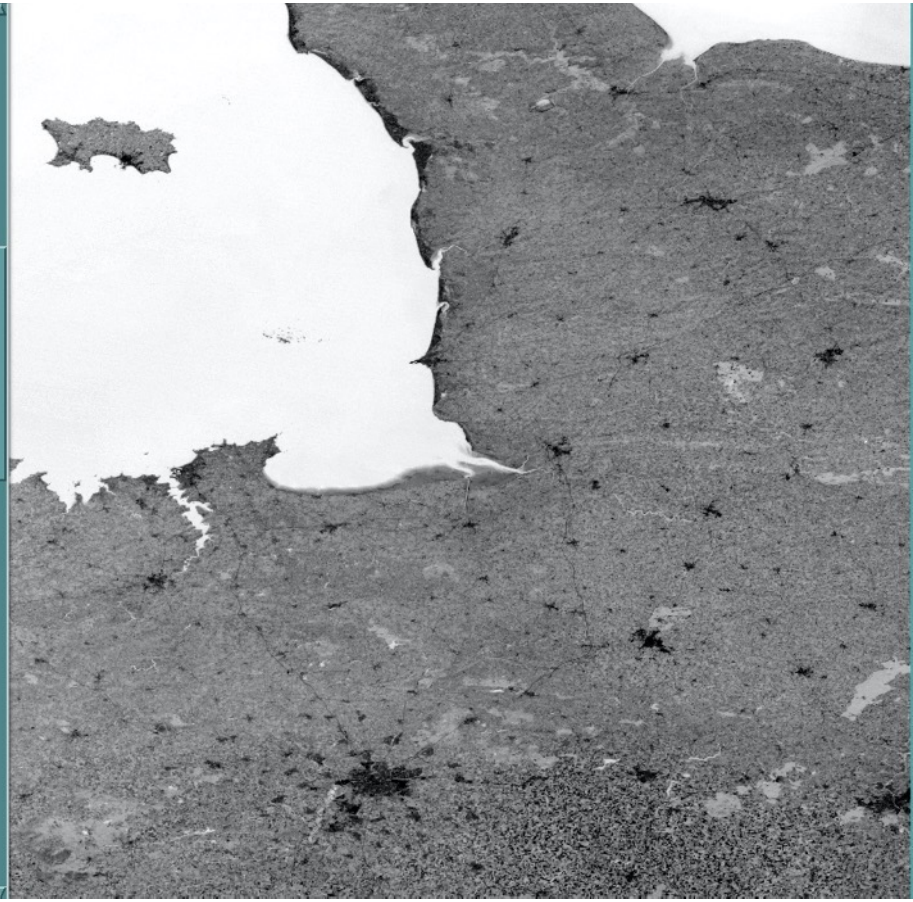
User-Supplied Pix

Geolocation Issues

“Night” Scenes May Not Look Like the Orthobase



ECOSTRESS 03798_001 B4 Scene Detail



Landsat7 TIR Orthobase Detail (inverted)

Planned Geolocation Improvements

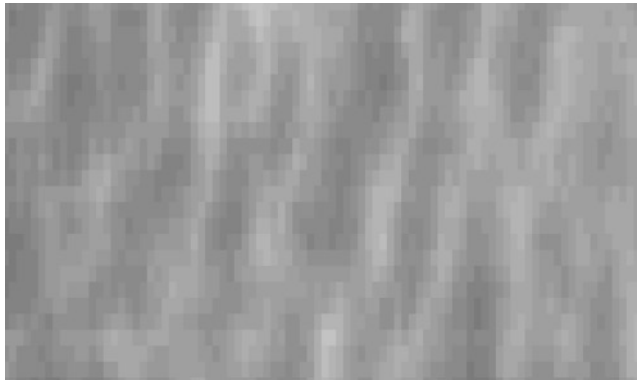
- Improve Geolocation QA Metadata:
  - Current Geolocation QA is binary: Match / No Match in Orbit
    - /L1GEOMetadata/OrbitCorrectionPerformed="TRUE"
    - A single metadata value represents the entire orbit.
    - Value indicates if matching occurred somewhere in the orbit, or failed everywhere.
    - Does not provide information as to the quality of the match.
  - Provide a more descriptive QA flag:
    - Best – Image matching was performed for this scene, expect good geolocation accuracy.
    - Good – Image matching was performed on a nearby scene, and correction has been interpolated/extrapolated. Expect good geolocation accuracy.
    - Suspect – Matched somewhere in the orbit. Expect better geolocation than orbits w/o image matching, but may still have large errors.
    - No Match – No matches in the orbit. Expect largest geolocation errors.

Planned Geolocation Improvements (cont.)

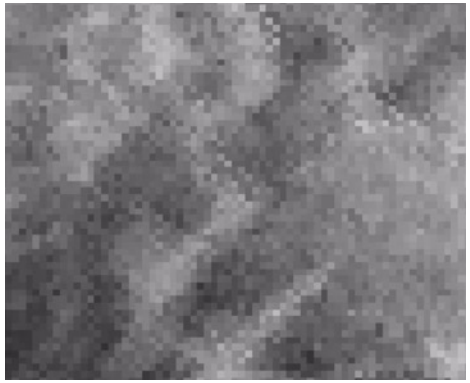
- Improve Geolocation Code/Parameters:
  - Plan is to adjust Image Scene Matching parameters:
    - Increase the number of FFTs per image scene.
      - Obtain more Tiepoints.
    - Adjust the geographic coverage size of the FFTs.
      - Increase matching feature detail.
    - On fail, adjust specific parameters and try again.
      - Change the initial matching location.
      - Up to 4 tries with modified parameters.

Scan-to-Scan Alignment Calibration Issue

- A mis-alignment between adjacent scan lines has been observed.
  - The Offset may vary from 1 to 4 pixels, with larger offsets at higher view angles.
  - The offset may be compounded in scan overlap areas when using the Lat/Lon files for pixel georeferencing, manifesting as a “checkerboard” pattern or blurring.



Scan Line Offsets in L1B Data?



“Checkerboard” Pattern in User’s L2/L3 Data?

Scan Line Offset Issue

Scan-to-Scan Alignment Correction Options

For Build 7+

- Successive image scans are created from both/opposite sides of the scan mirror.
- Scan-to-Scan calibration is necessary to align the mirror scans.
  - The initial offset/fit was calculated during IOC (July 2018) and assumed to be constant.
  - It is not clear why the mirror scan offset should change over time.
  - We will trend this offset over a period of several months and compare with historical data.
    - Is a “one time” correction sufficient?
    - Do we need multiple time-based corrections?
    - Is there an automatic image matching correction option?
- Solutions:
  - Some form of time-based correction adjustment is expected.
  - An automated 15x15 pixel image matching approach would be ideal, but it could easily unexpectedly fail with changes in ISS altitude and pointing.

Backup

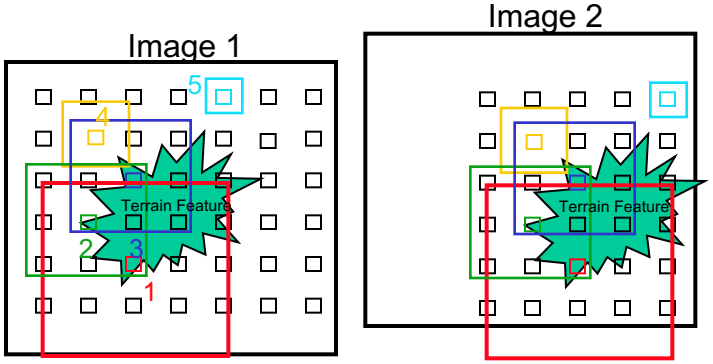
AFIDS FFT Image Registration Process

FFT Co-Registration Approach

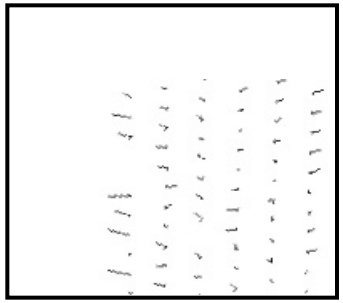
- AFIDS FFT Approach
  - Uses a grid of 2-D Fast Fourier Transforms (FFTs*) to produce tie points between images.
  - The FFT's Size initially starts out big (to cover large geographic areas) in order to catch the offset between two images, then reduces in size as the ability to predict the next tie point location improves.
  - A list of tie point matches with correlation and offset values is produced and processed to remove outliers.
  - The remaining best correlation points are used to create a polynomial fit between the two images and generate an ultra fine resolution correction grid.
  - A triangular interpolation between points in the correction grid is used to war/register the two images together.

*C.D. Kuglin and D.C. Hines, "The Phase Correlation Image Alignment Method," Proc. Int. Conference on Cybernetics & Society, pp. 163-165., 1975.

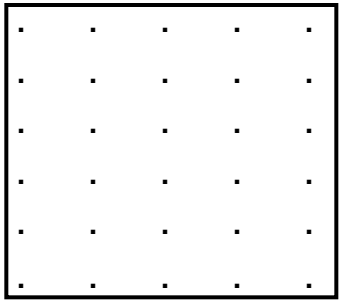
AFIDS FFT Tiepoint Interpolation Approach



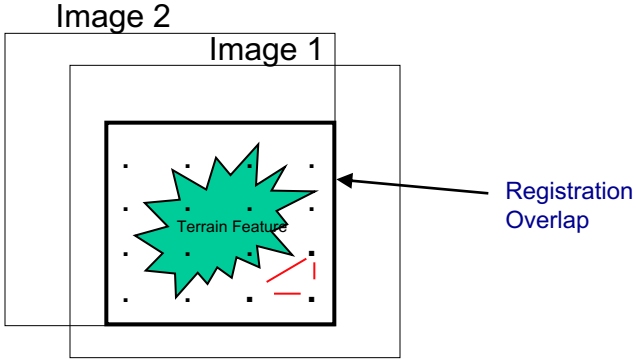
A grid of FFT tiepoints is used to match two images. FFT size starts large then decreases as matching becomes reliable. Tie point matching location order is randomly controlled by a "seed" value.



A subset of tiepoints are selected based on correlation score and offsets. Outliers are discarded. The maximum number of FFTs is 4096.



A polynomial fit is applied to the tiepoints to create an Ultra Fine grid of registration correction points. Fit options include Quad, Cubic, Linear, Keystone, and Thiessen.



A triangular interpolation is performed between points in the correction grid to produced the final registered image.