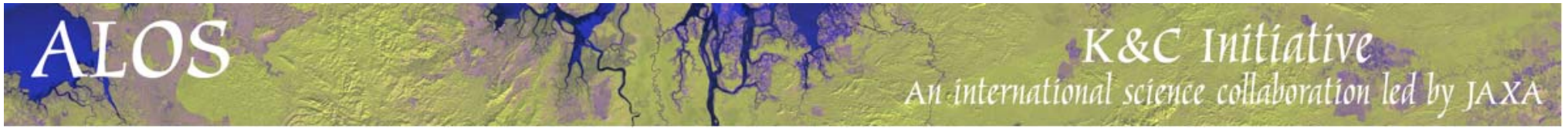


Ortho-rectification and calibration of multi-temporal ALOS PALSAR SCANSAR data for mapping wetland dynamics

Bruce Chapman[1], Laura Hess[2], and Kyle McDonald[1]

1 Jet Propulsion Laboratory, California Institute of Technology

2 University of California, Santa Barbara

ALOS PALSAR Kyoto and Carbon Initiative and NASA Measures

- ALOS, which launched in 2006, carries an L-band SAR.
  - Operates with different modes: SCANSAR modes, fine beam modes (plus experimental Polarimetric mode)
- The ALOS Kyoto and Carbon Initiative (ALOS KC) is a science program lead by JAXA to develop global products related to carbon cycle science
  - Wetland Theme
  - Forest theme
  - Desert/Water theme
  - Mosaic theme
  - Global acquisition strategy
- The NASA MEASURES program has funded a task lead by Kyle McDonald to develop inundated wetlands products from ALOS PALSAR and other instruments

ALOS SCANSAR and FBD data for mapping inundated wetlands

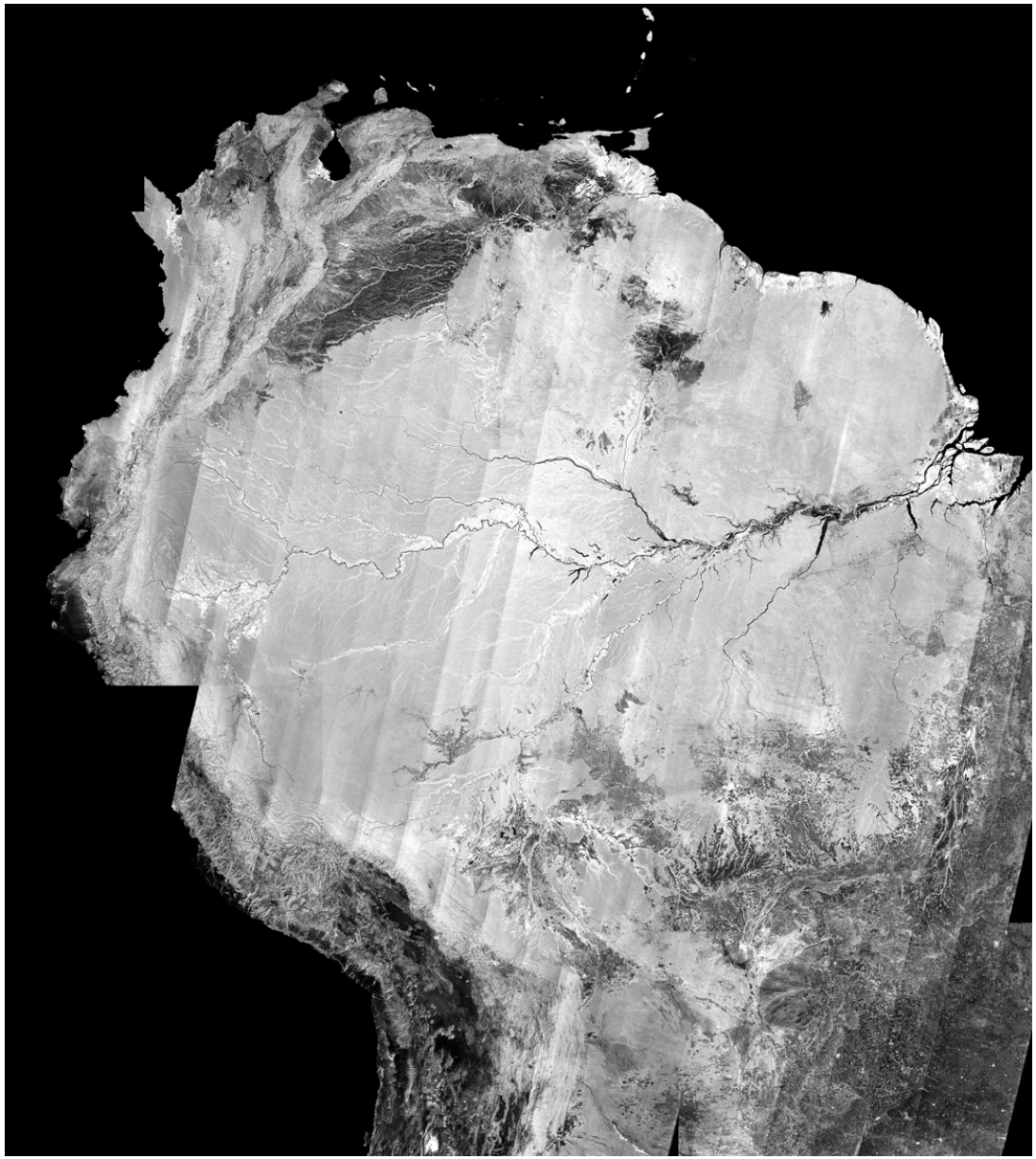
- The dual polarization FBD mode will be used to determine forest structure
  - One coverage
  - Non-vegetated, Herbaceous, Shrub, Woodland, Forest
- The SCANSAR mode data will be used to monitor inundation state
  - Inundated, not inundated
  - Coverage every 46 days
  - Focused on large wetland regions (Amazon basin, etc)
- Currently developing products for N/S America

From acquisition to products

- ALOS acquires data
- JAXA EORC produces special slant range image strips
  - Thousands of km long, rather than image frames typically created
  - Reduced resolution FBD data (~50m)
- Next, orthorectify the data using the SRTM DEM, and apply radiometric corrections, if necessary
  - Including radiometric terrain correction
- Using these mosaic products plus other ancillary information, produce the inundation products
- Comparison and synthesis with products developed from different sensors.
- Distribute products

SCANSAR mosaic 2007

3 arcsecond postings
(same as SRTM)



Typically each pixel here is an average of 10 SCANSAR image pixels

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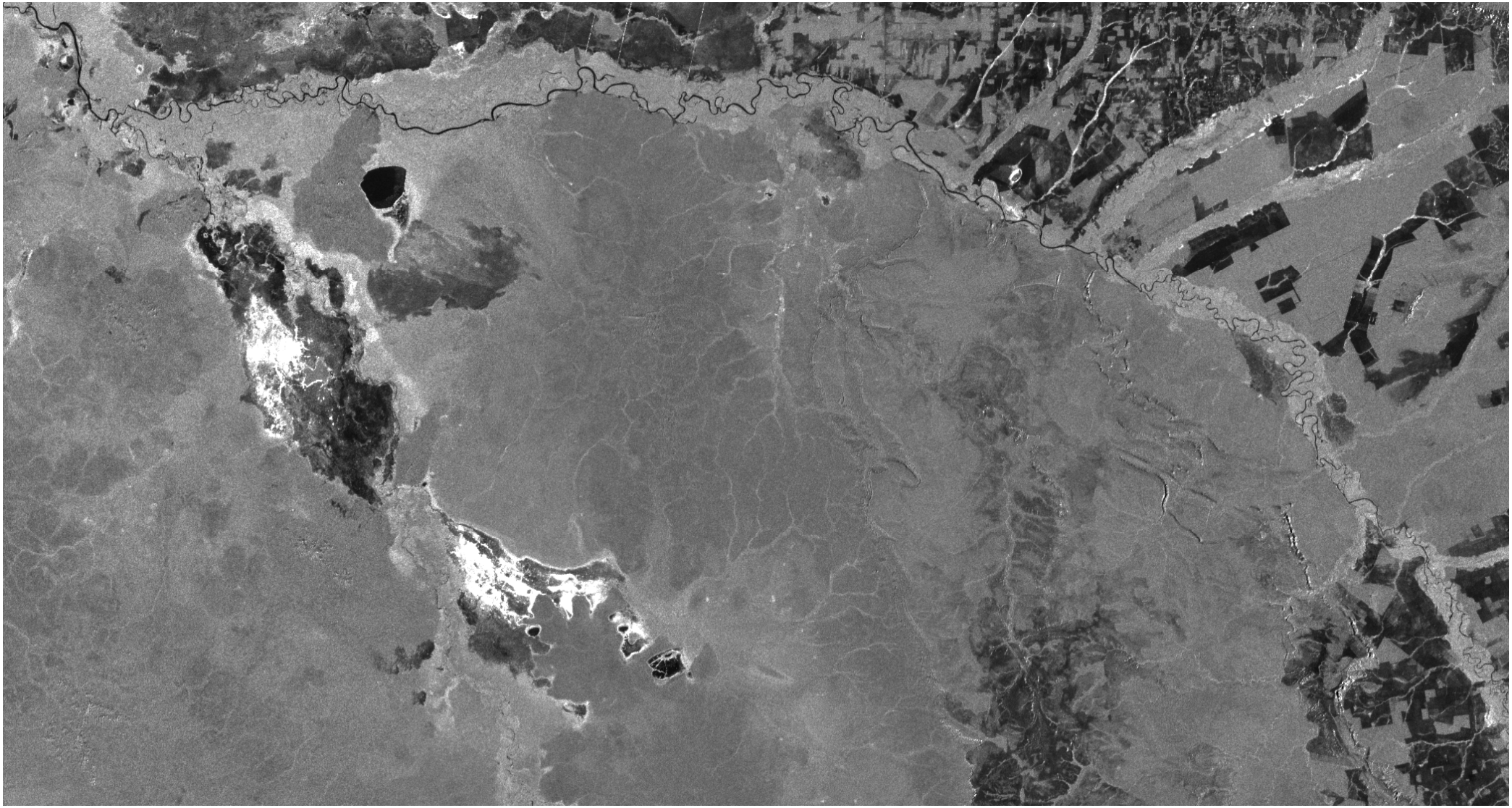
Noel Kempff National Park



ALOS

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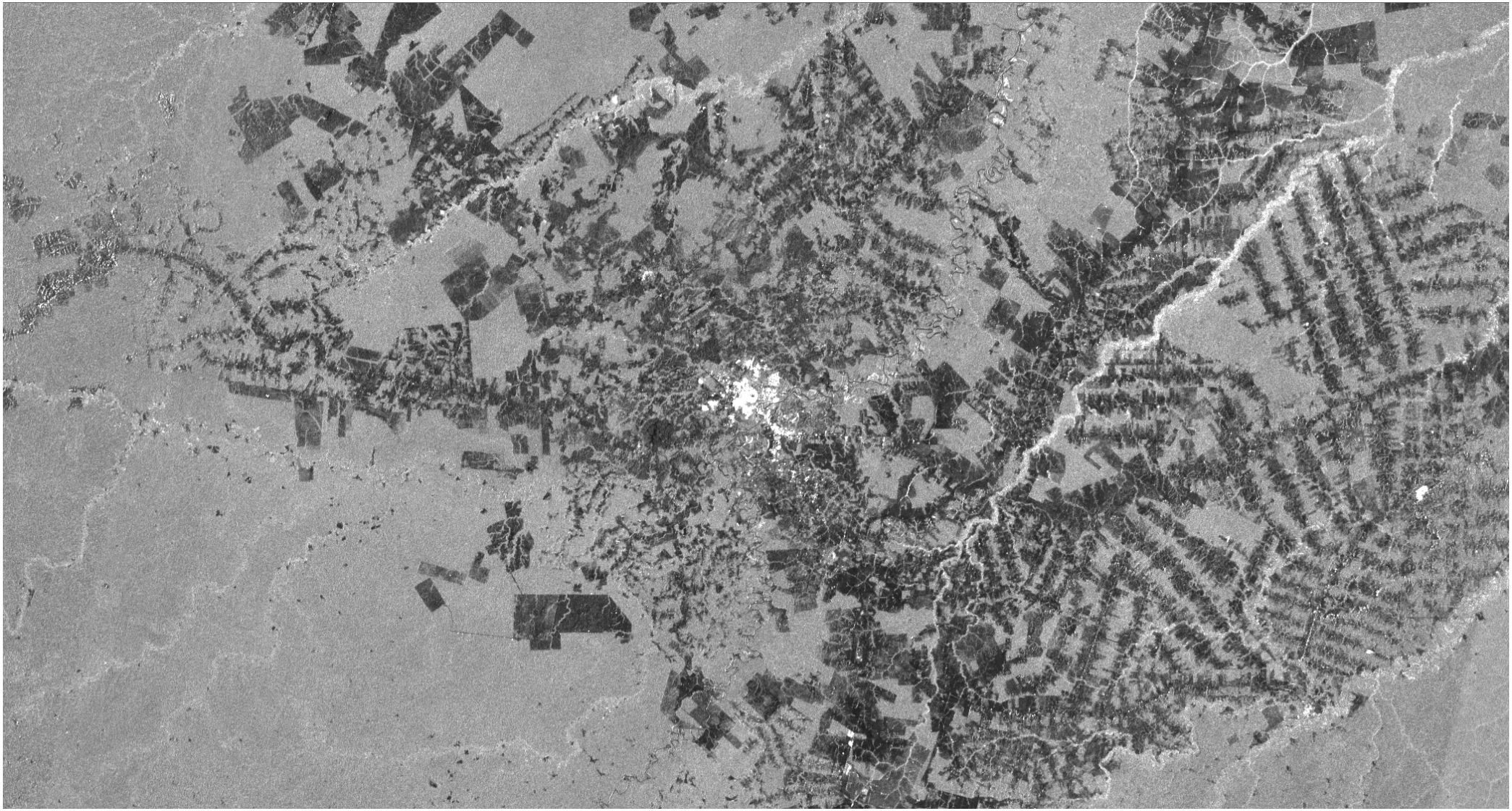
Rio Branco



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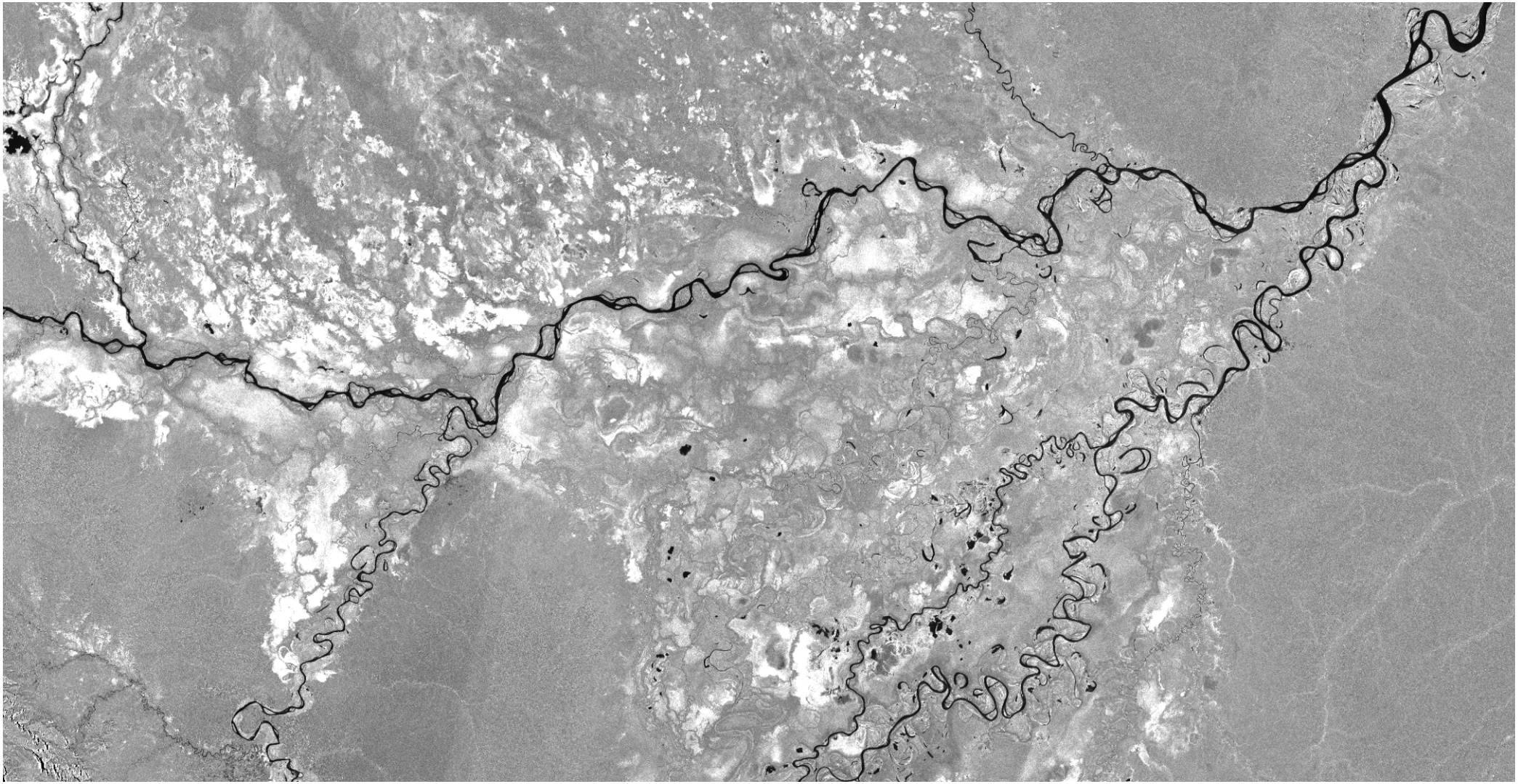
Palm Swamps



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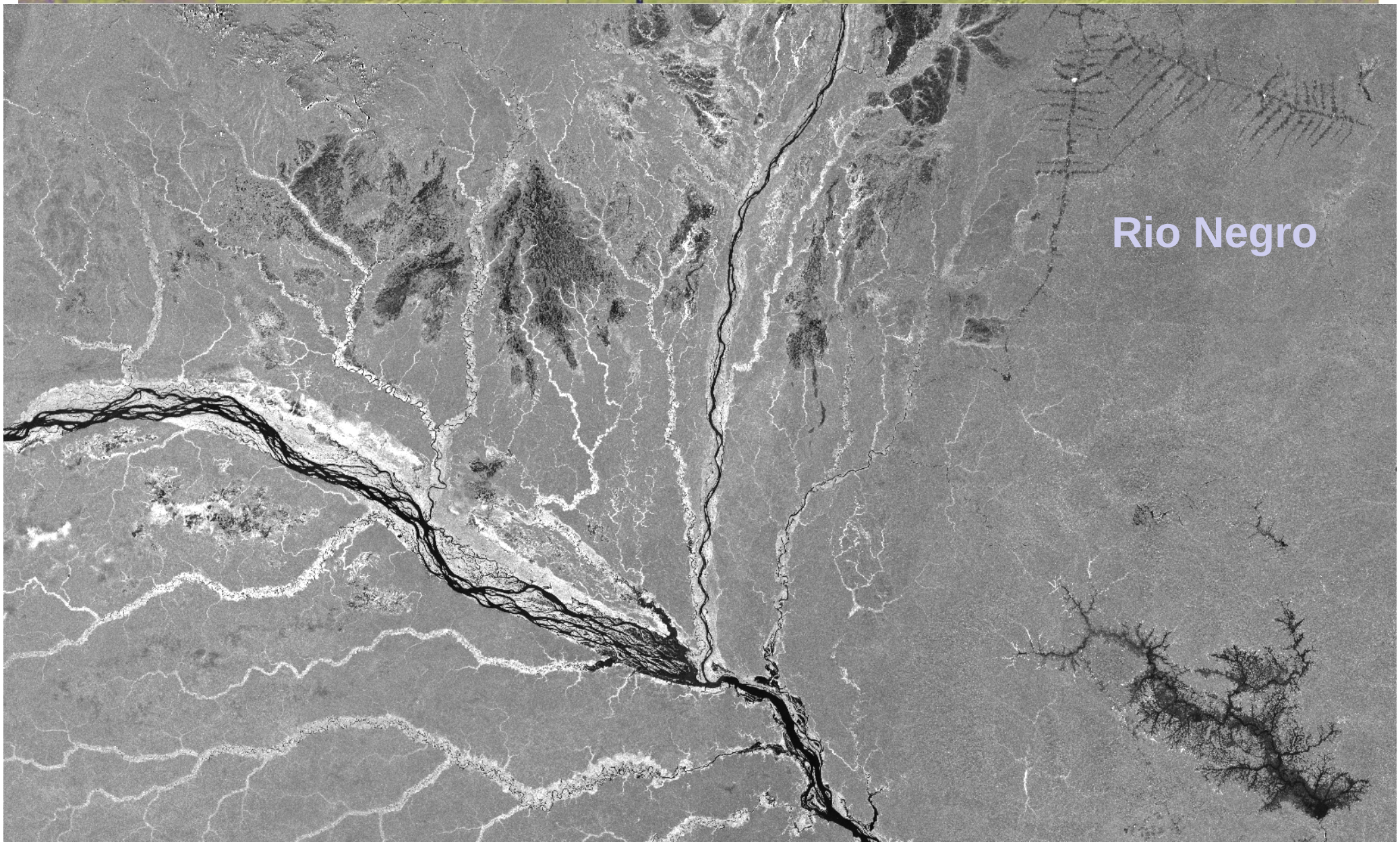

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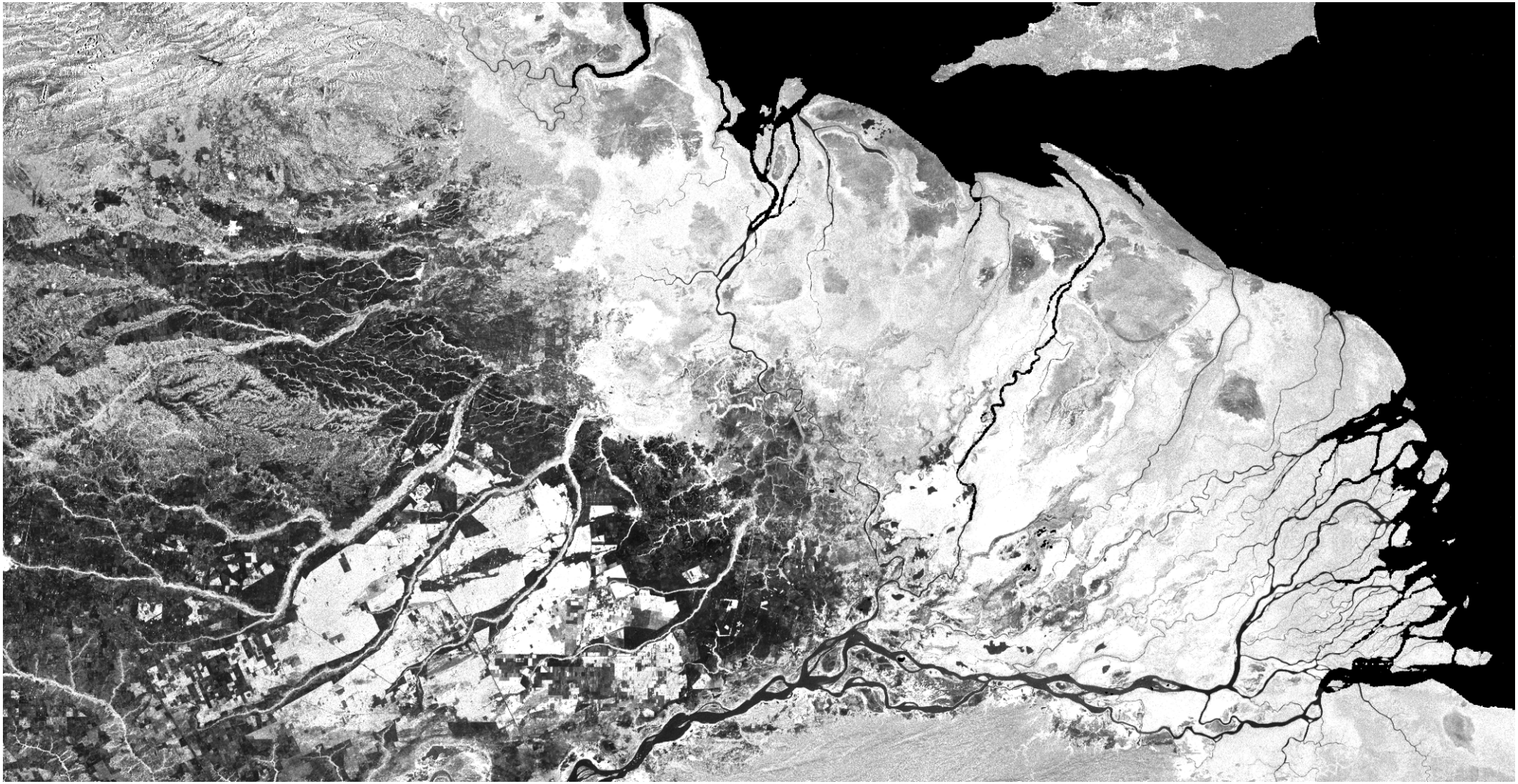
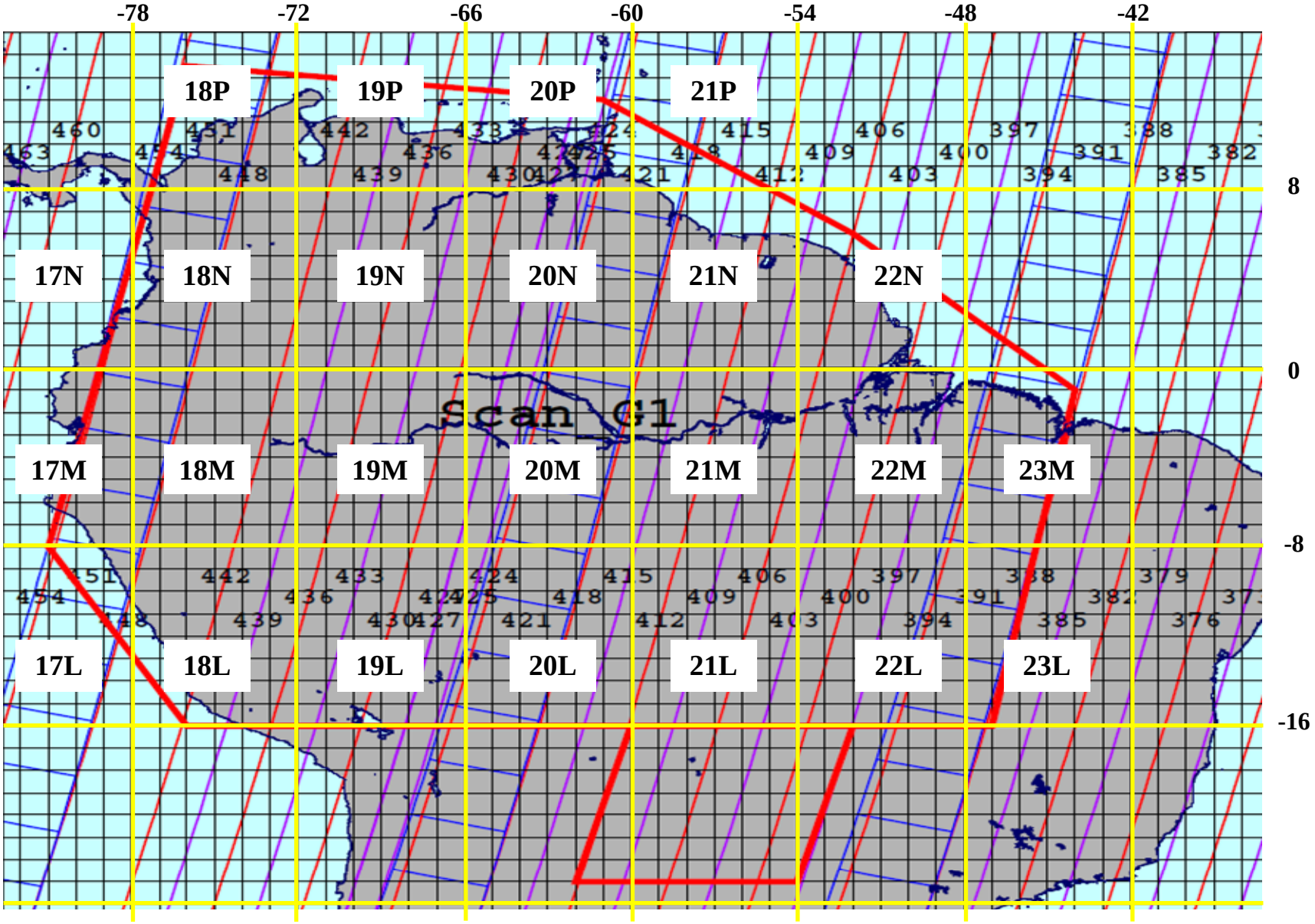
Orinoco



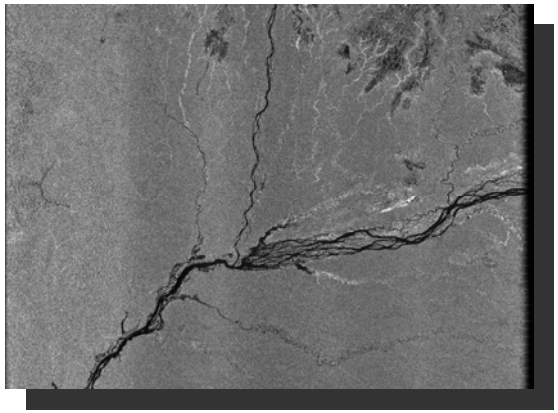
Geometric corrections:

The ScanSAR data, processed by the EORC through the ALOS K&C initiative, and orthorectified by the software package from Gamma Remote Sensing, are not accurately orthorectified using orbit data alone:

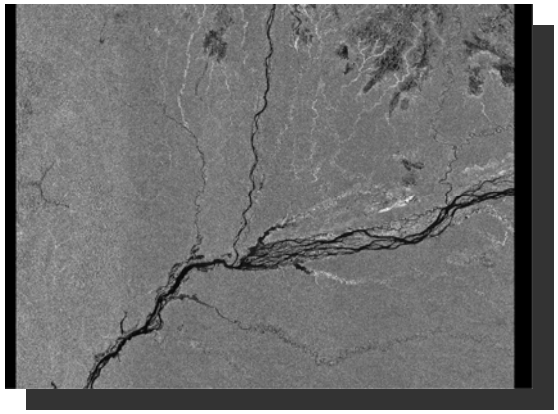
- A matching and fitting algorithm included with the Gamma software can be used to correct the orbit-based geocoding parameters
- The dynamics of the wetlands can make this challenging
  - ➧ Landscape features such as rivers and wetlands are changing with water level
- Pixel-level geolocation accuracy is critical for monitoring wetland dynamics


-78
-72
-66
-60
-54
-48
-42
8
0
-8
-16
18P
19P
20P
21P
17N
18N
19N
20N
21N
22N
Scan G1
17M
18M
19M
20M
21M
22M
23M
17L
18L
19L
20L
21L
22L
23L

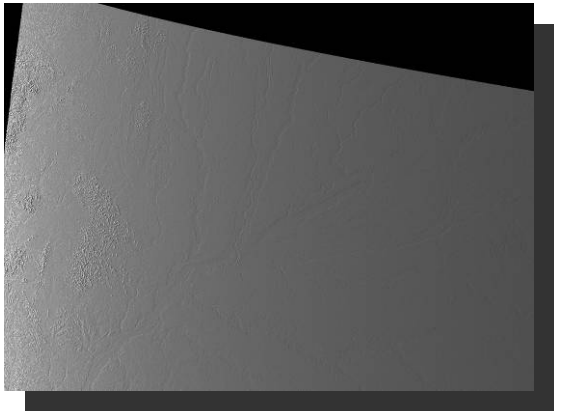
Calibration and matching



Original slant range image



Trimmed and calibrated



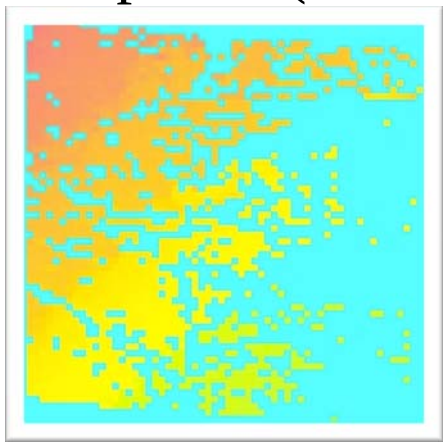
Simulated SAR image based on SRTM

Varying Range and Azimuth Offsets

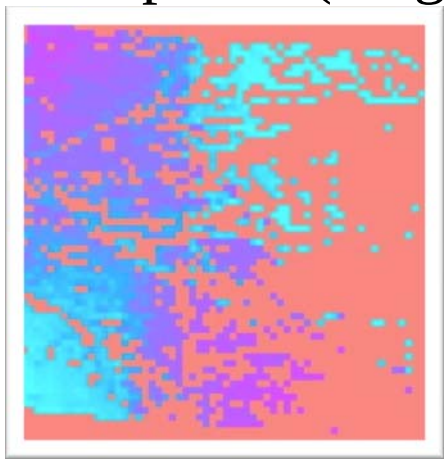
One Example

Before geocoding refinement

0 to 23 pixels (azimuth)



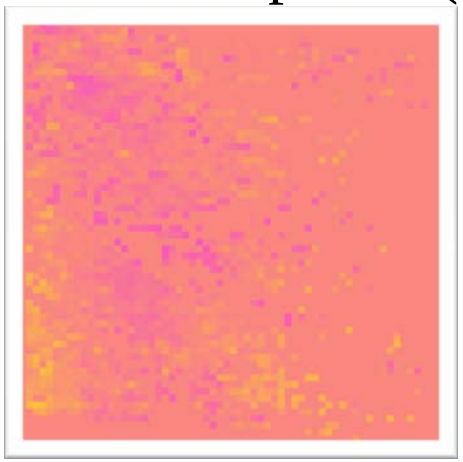
-2 to +2 pixels (range)



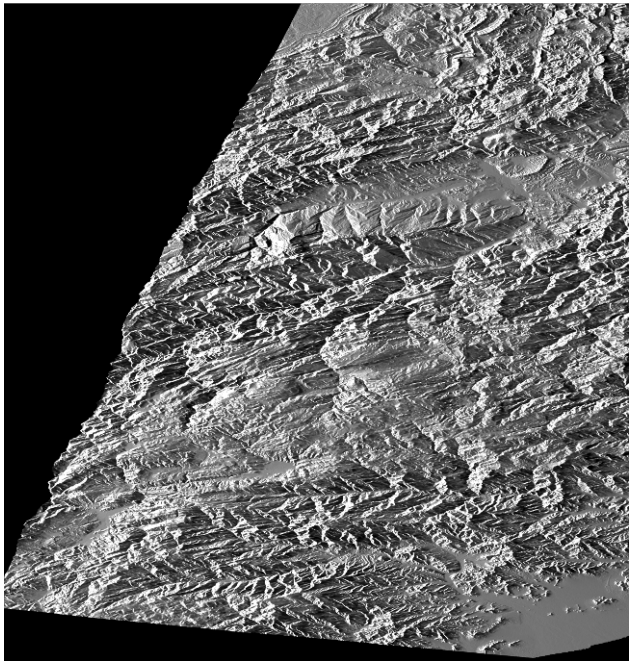
After geocoding refinement

-1 to +1 pixels (azimuth)

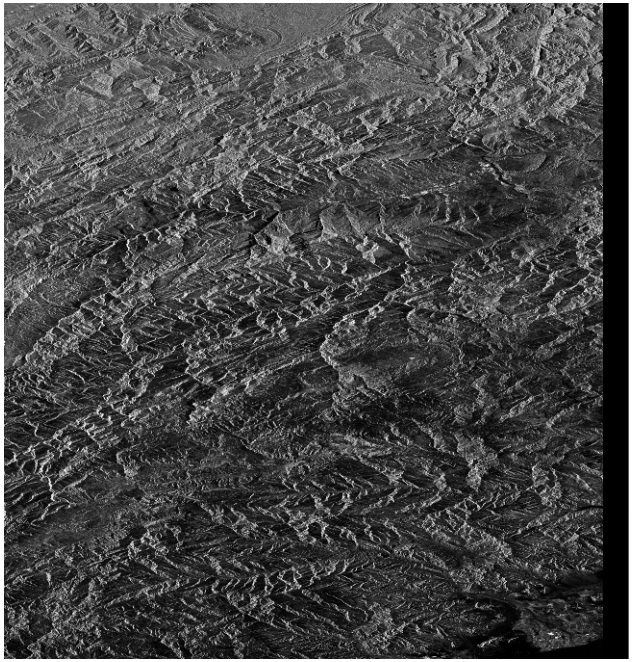
-1 to +1 pixels (range)



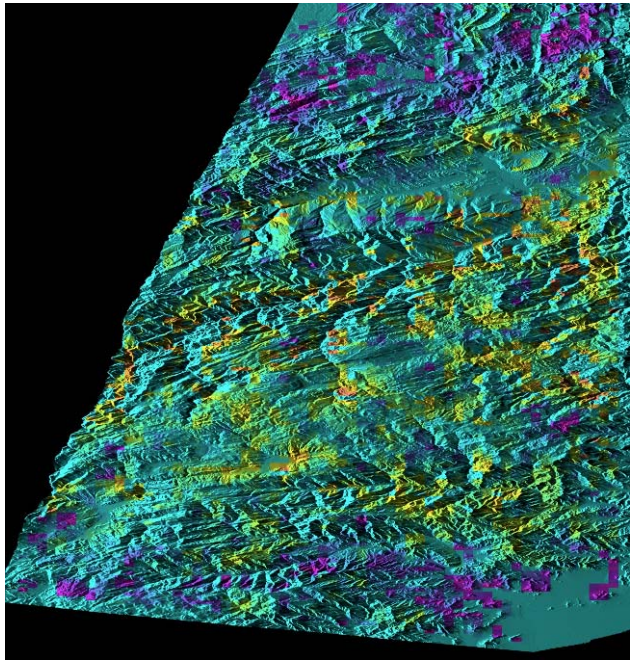
Range and Azimuth Offsets



Simulated SAR image from DEM

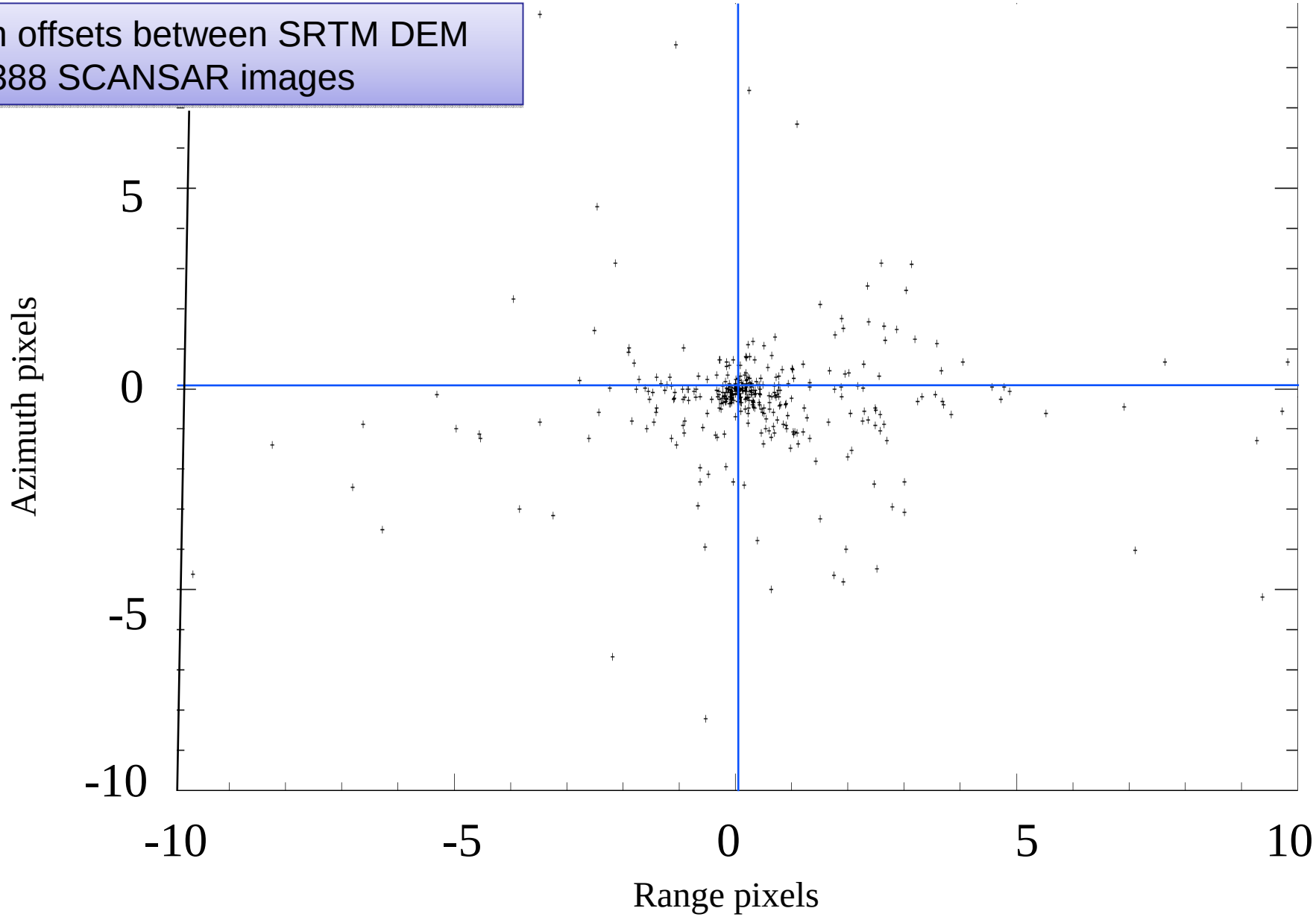


ALOS SCANSAR image

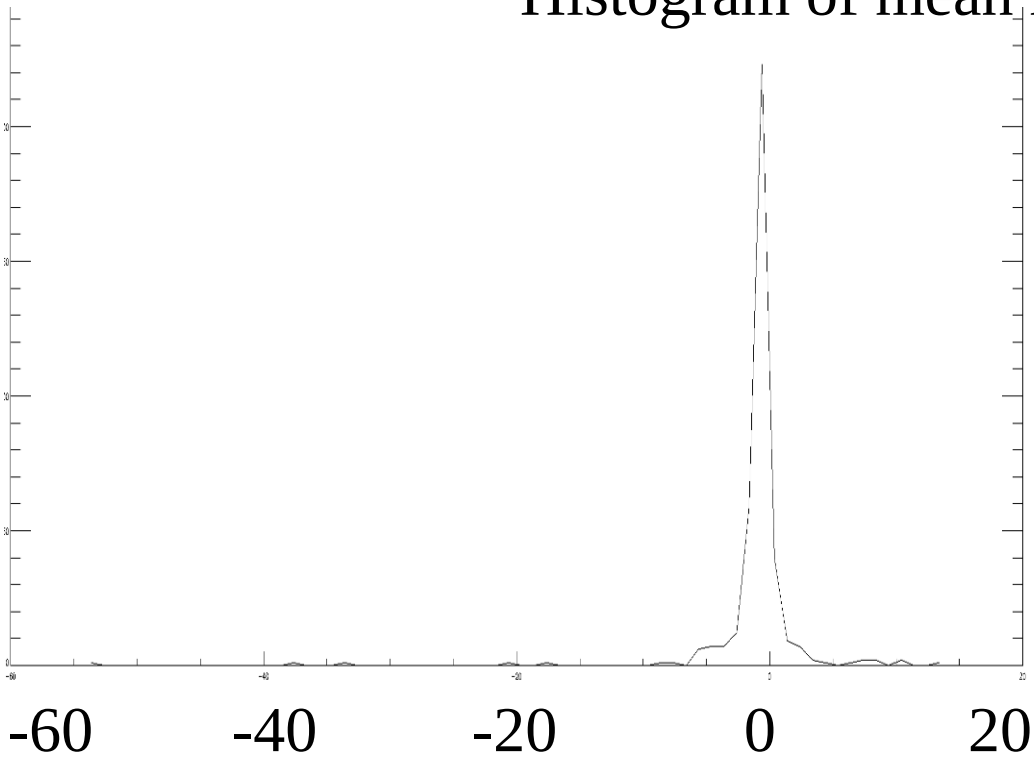


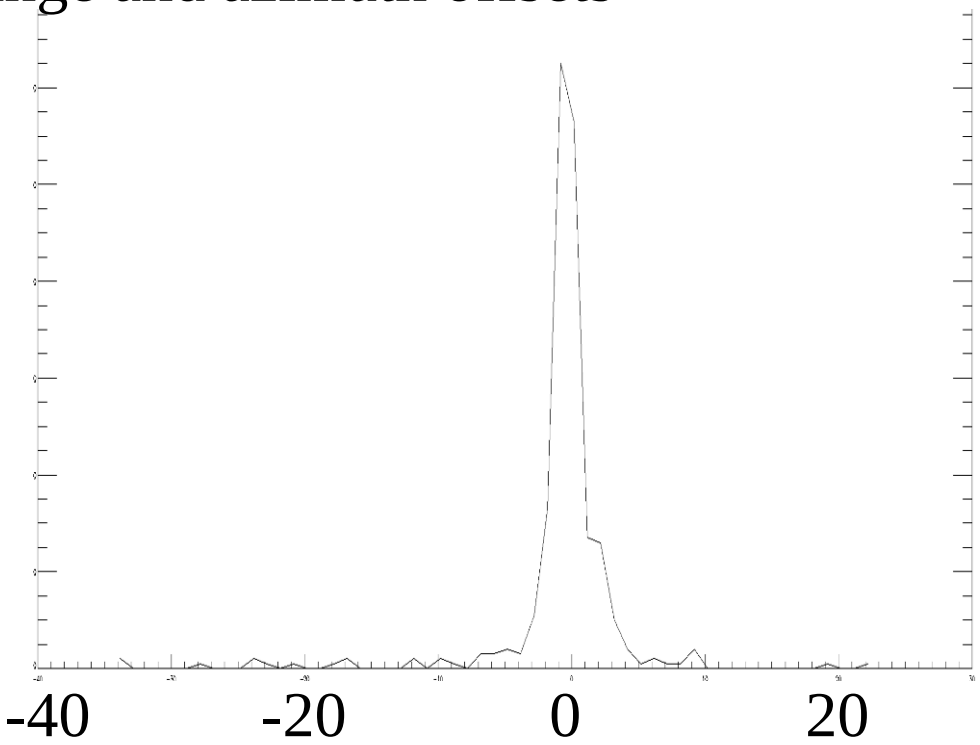
Range offsets over simulated SAR image (0-1 pixel)

Mean offsets between SRTM DEM and 388 SCANSAR images



Histogram of mean range and azimuth offsets





Mean offsets (actual offsets vary across image):

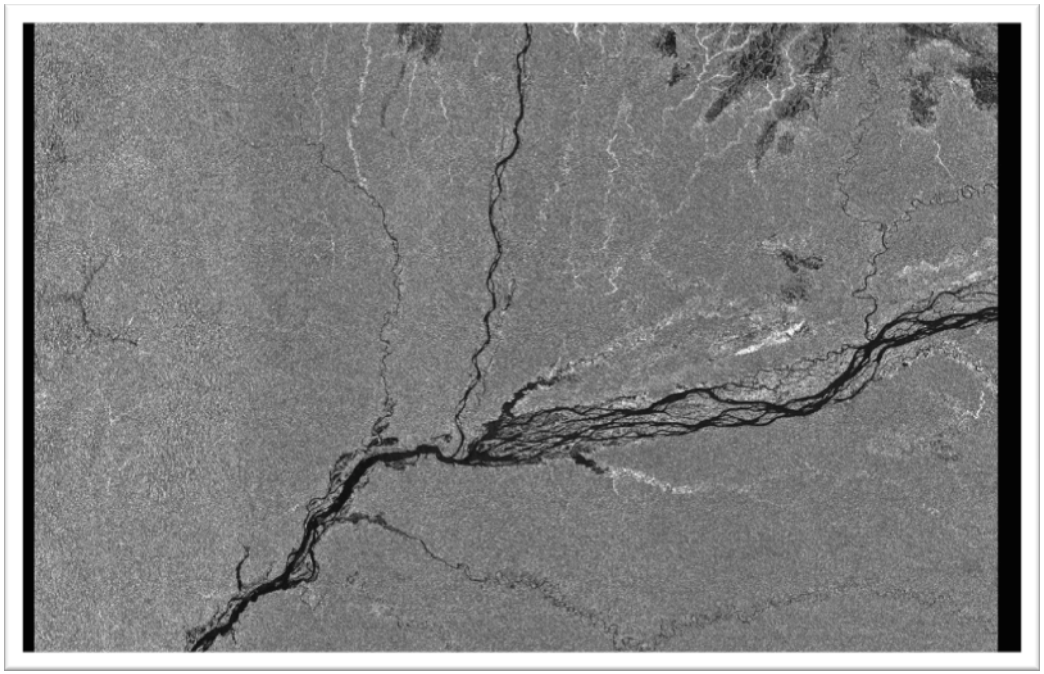
Range: average offset = -0.22 pixels ± 4.8 pixels
Azimuth: average offset = -0.54 pixels ± 4.4 pixels

Most outliers (>10 pixels) are from one path (RSP424)
(0.34 ± 2.2, and -0.22 ± 1.7 when within ±10

Range spacing is 37.5 meters
Azimuth spacing is 70 meters

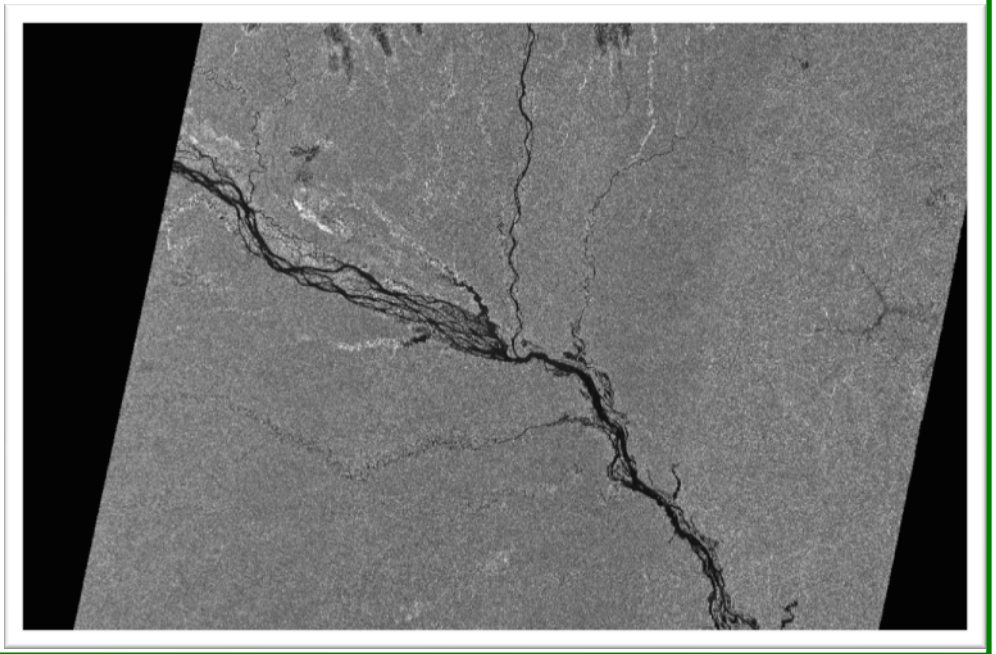
Range = -8.3 m ± 180 m (12.8 m ± 82.5 m)
Azimuth = -37.8 m ± 308 m (-15.4 m ± 119 m)

Slant range data - versus – orthorectified to SRTM



Slant range image

Geocoded image



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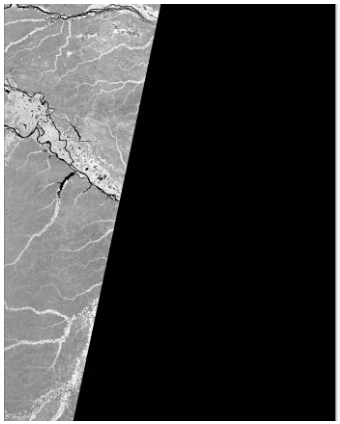
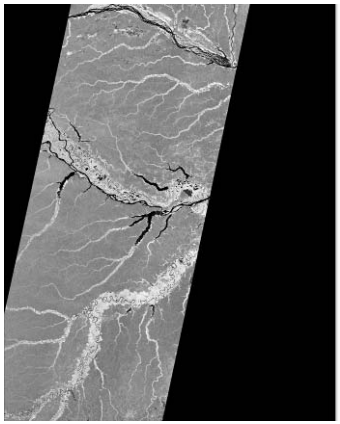
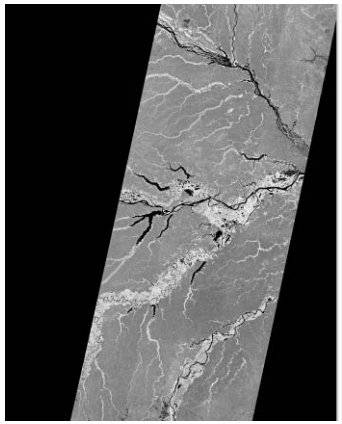
RSP 415



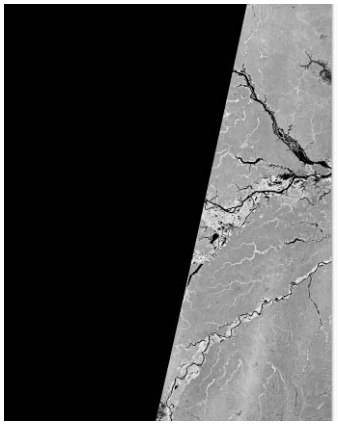
RSP 418



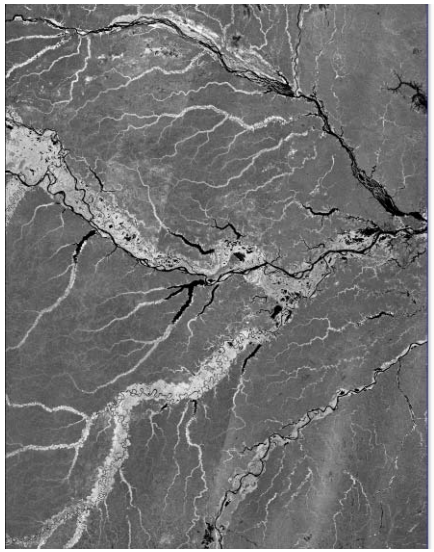
RSP 421



RSP 424



RSP 427



Mosaicking eliminates overlapping coverage

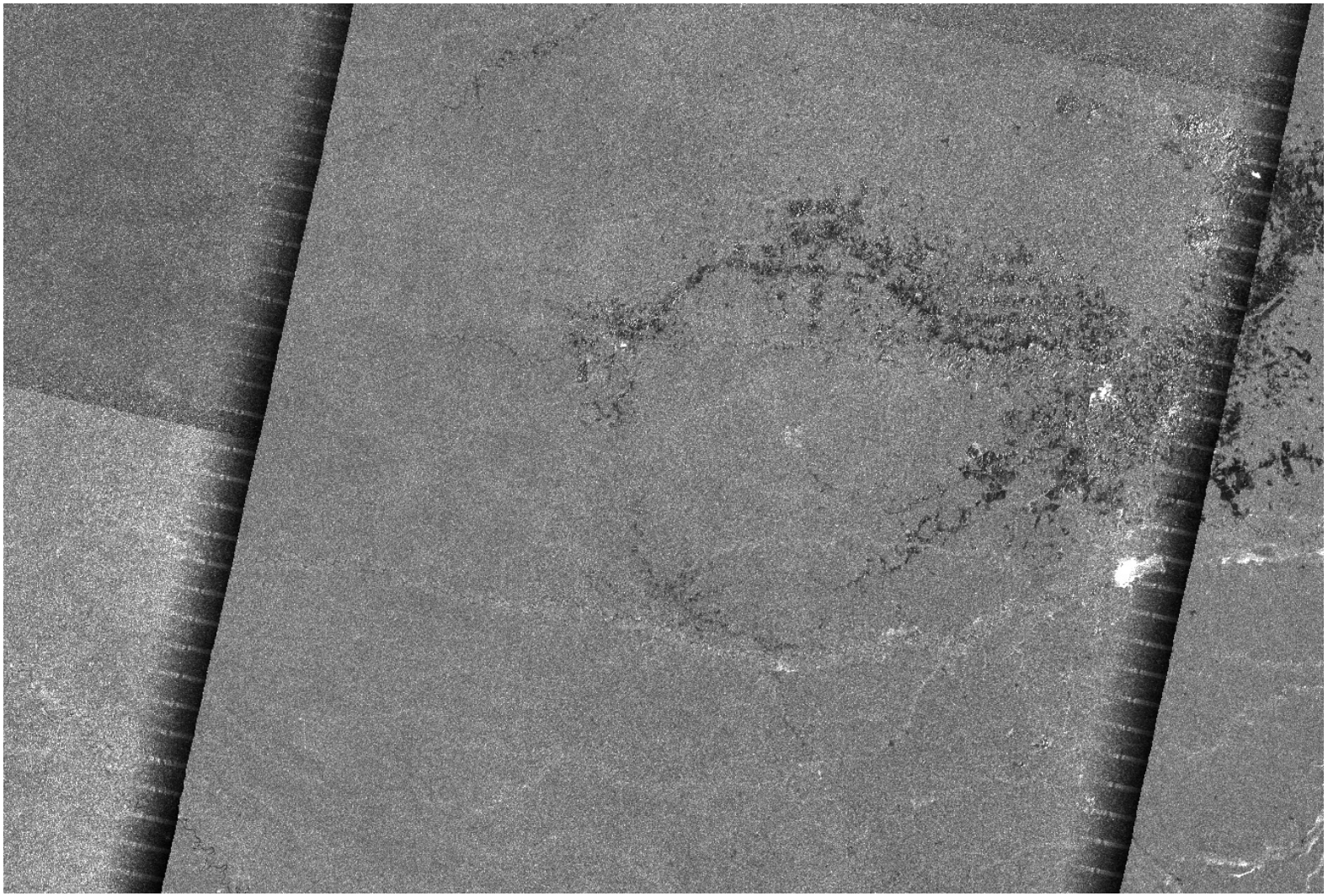
UTM tile 20M

Radiometric corrections:

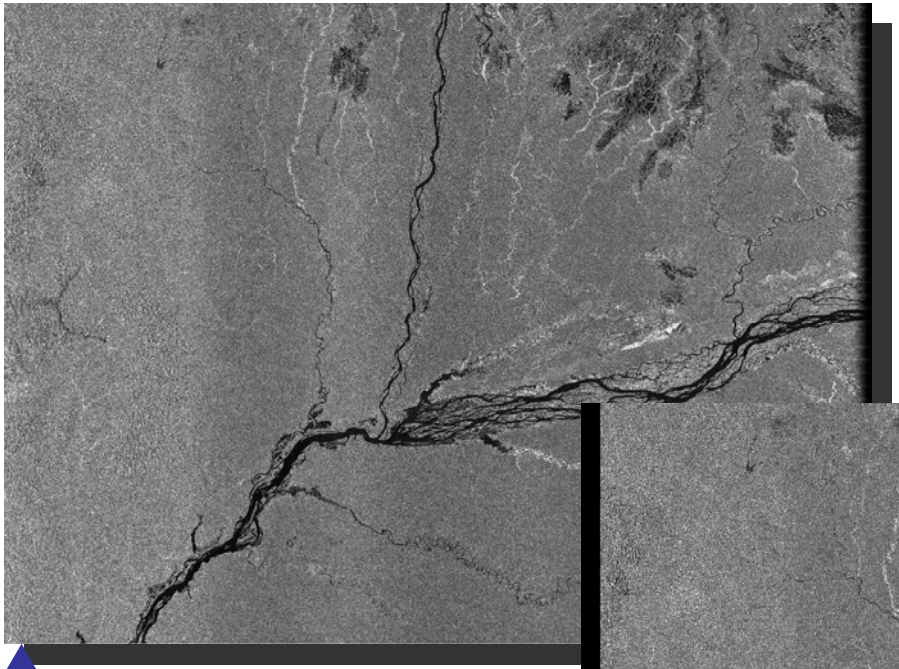
The ScanSAR data has three common radiometric problems:

- Artifacts in the near and far range
  - ➧trim
- along track banding
  - ➧Empirical correction required
- strip to strip brightness variations
  - ➧Calibration error or real change?

Far range artifacts in SCANSAR data

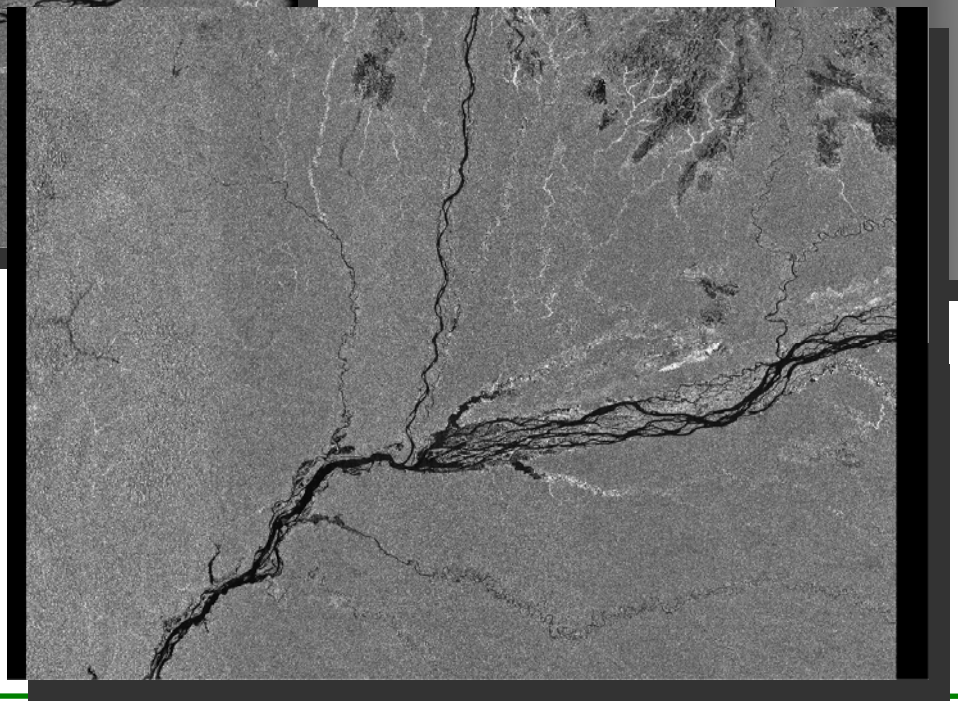


Not calibrated and trimmed versus calibrated and trimmed



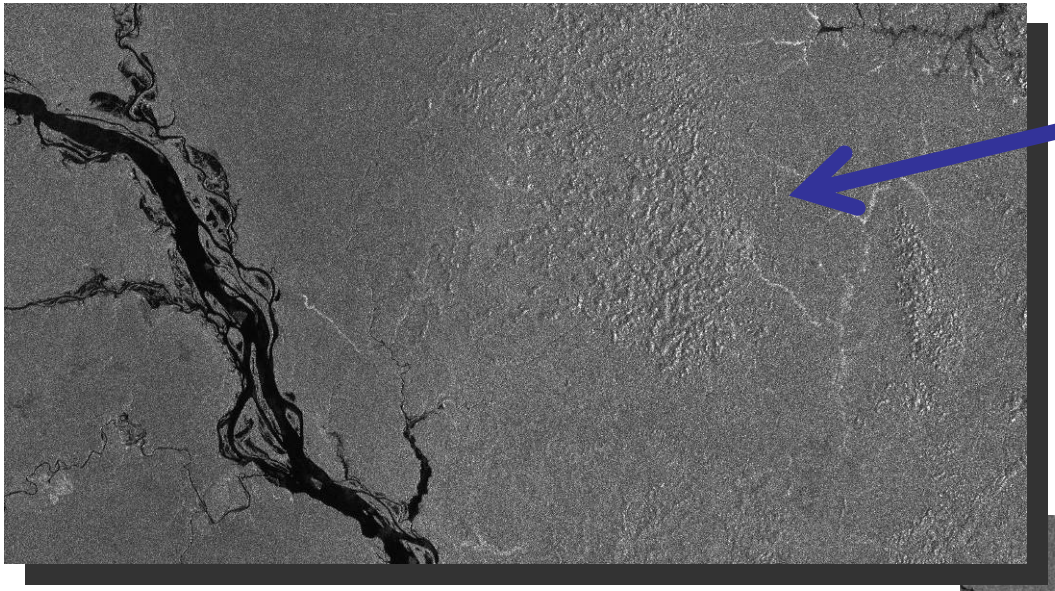
Original slant range image

Calibrated and trimmed



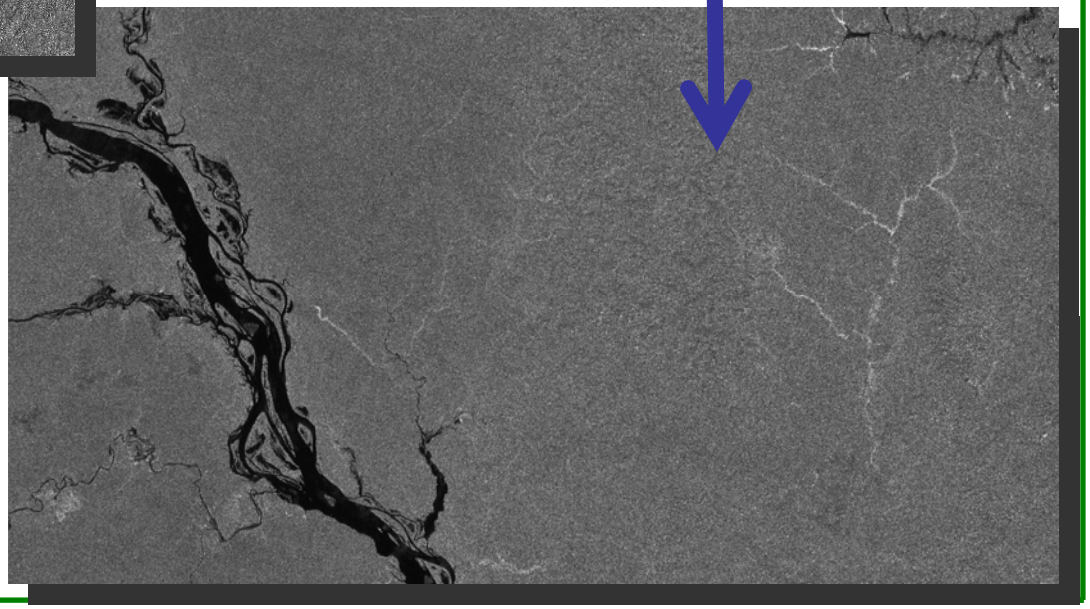
Radiometric correction applied to slant range image

Terrain correction to radiometry versus no Terrain correction



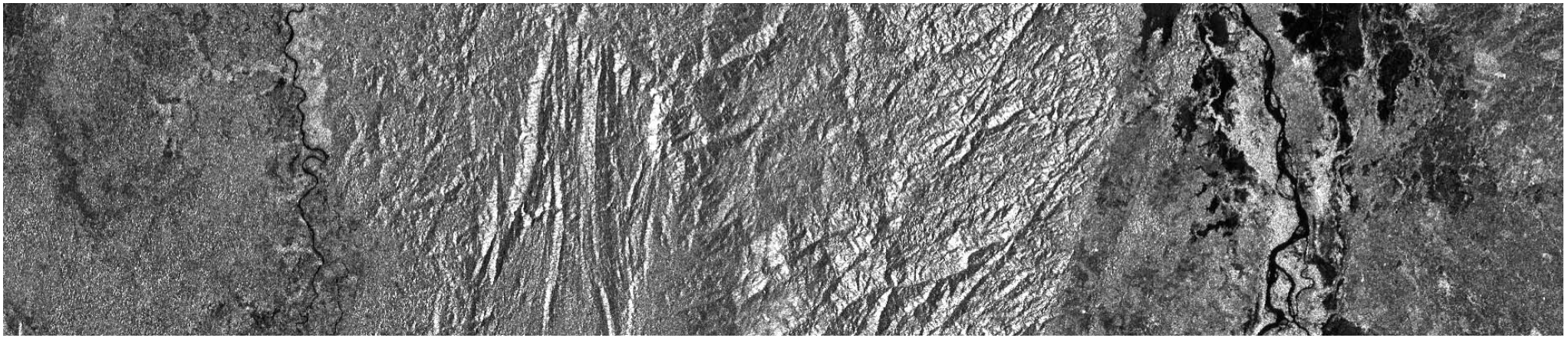
Terrain effects due to slope

Terrain effects reduced

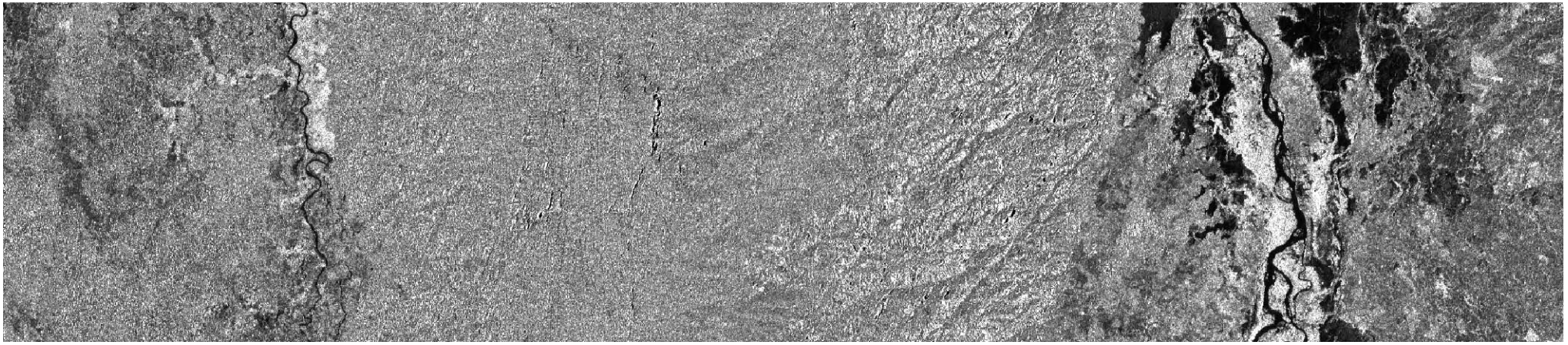


- ✓ Terrain effects can cause confusion during classification
- ✓ Correction requires accurate geolocation

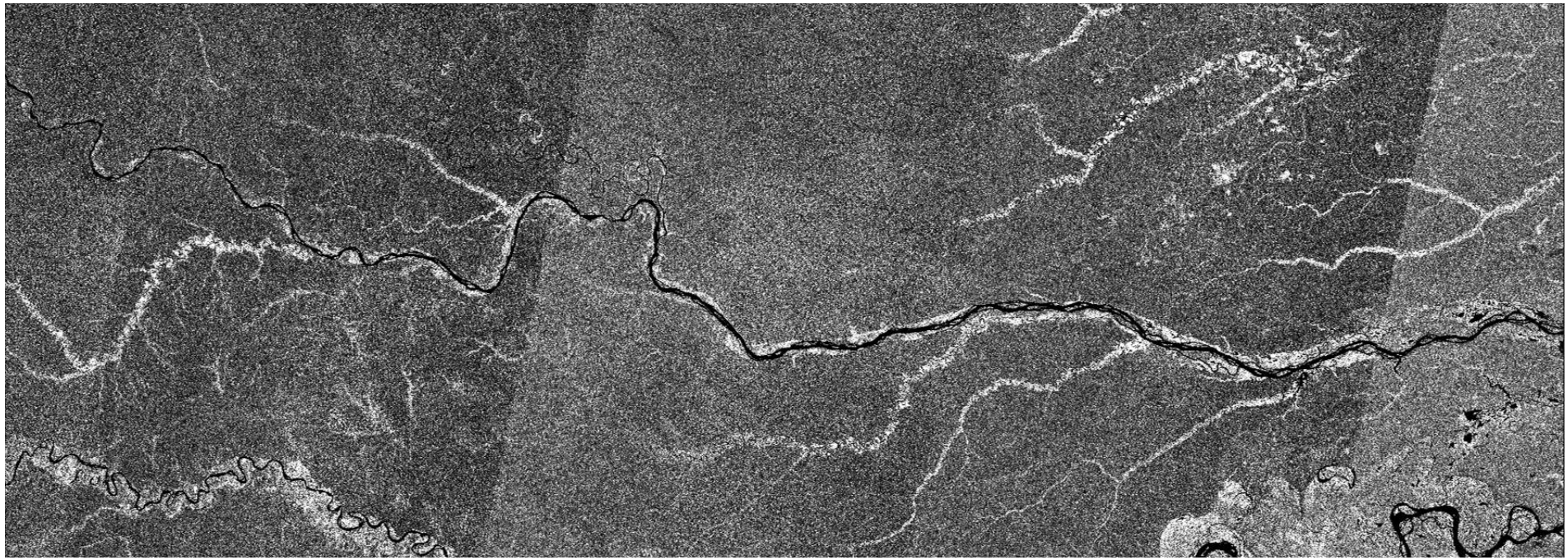
Before terrain correction



After terrain correction



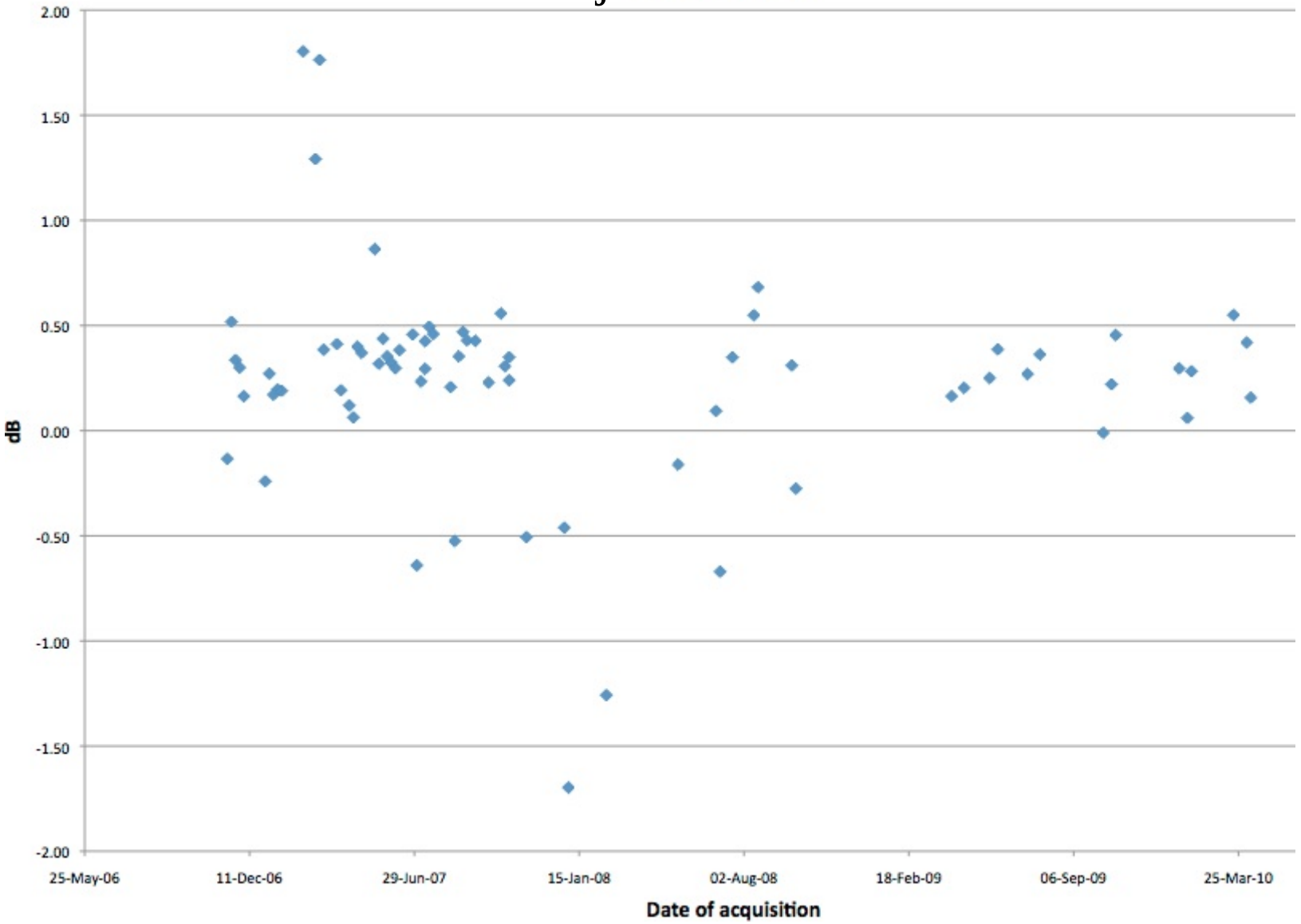
Absolute Calibration Errors (or banding caused by environmental changes to signal)

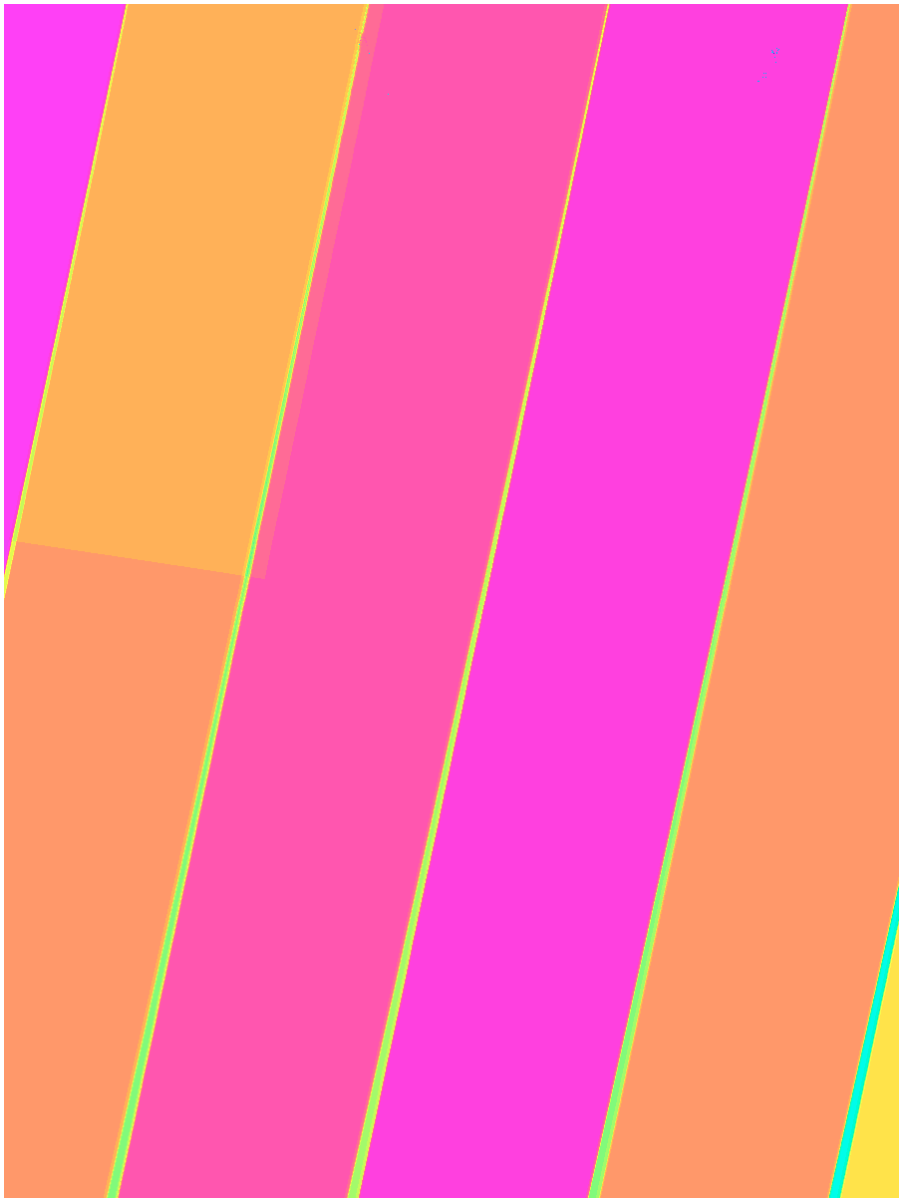


Estimation of absolute calibration "adjustment"

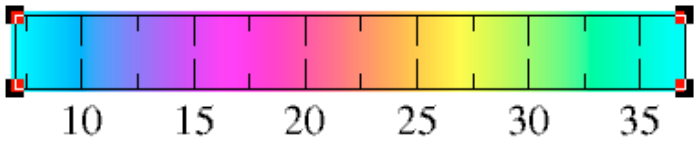
- Calculate average of all images in UTM tile (typically more than 70 image swaths)
  - Assumes on average the calibration of the ALOS data is accurate.
  - Image strips clearly in error can be excluded from average
- Calculate the standard deviation of terrain corrected backscatter for each pixel
- Calculate the ratio of the standard deviation to the average for each pixel
- If the ratio of the standard deviation to the average is less than 0.3 (not open water or sometimes inundated vegetation), calculate the mean difference between each image and the average image.
  - Usually millions of pixels satisfy this criteria
- This is the adjustment value to be used to 'calibrate' each image
- Some of these adjustments may be due to changing physical signature of terrain due to moisture changes or other effects.

Adjustment Value



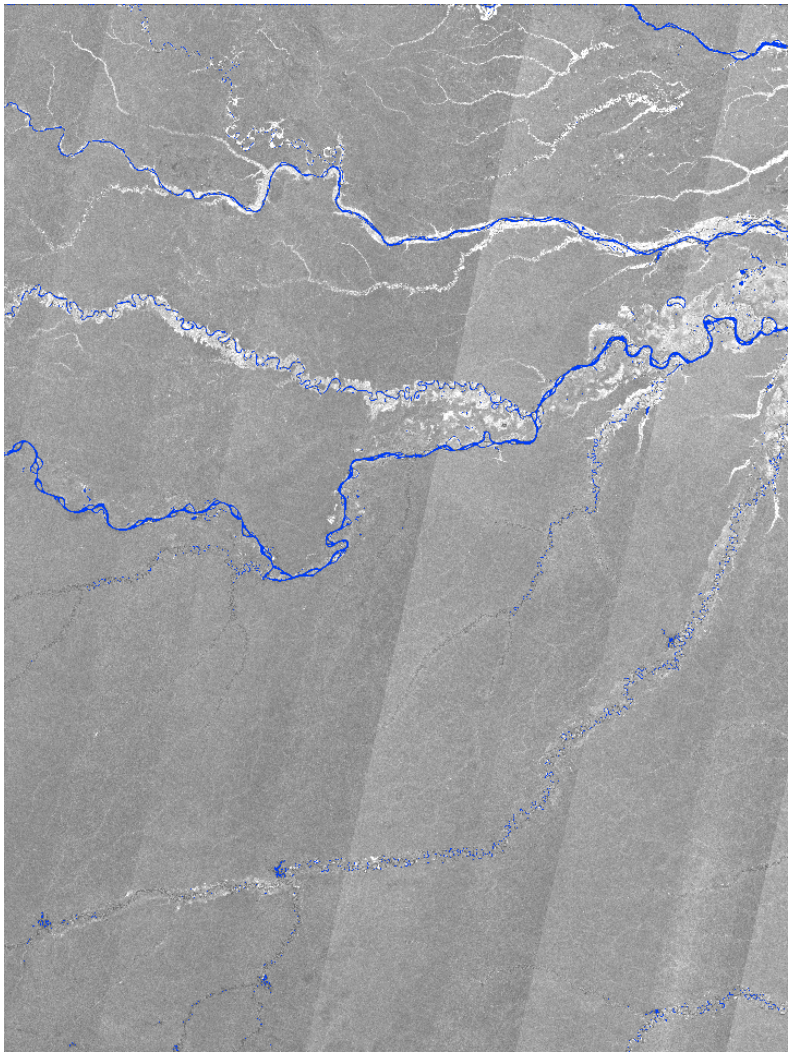


Each pixel is imaged variable number of times depending on image geometry and timing of each satellite pass

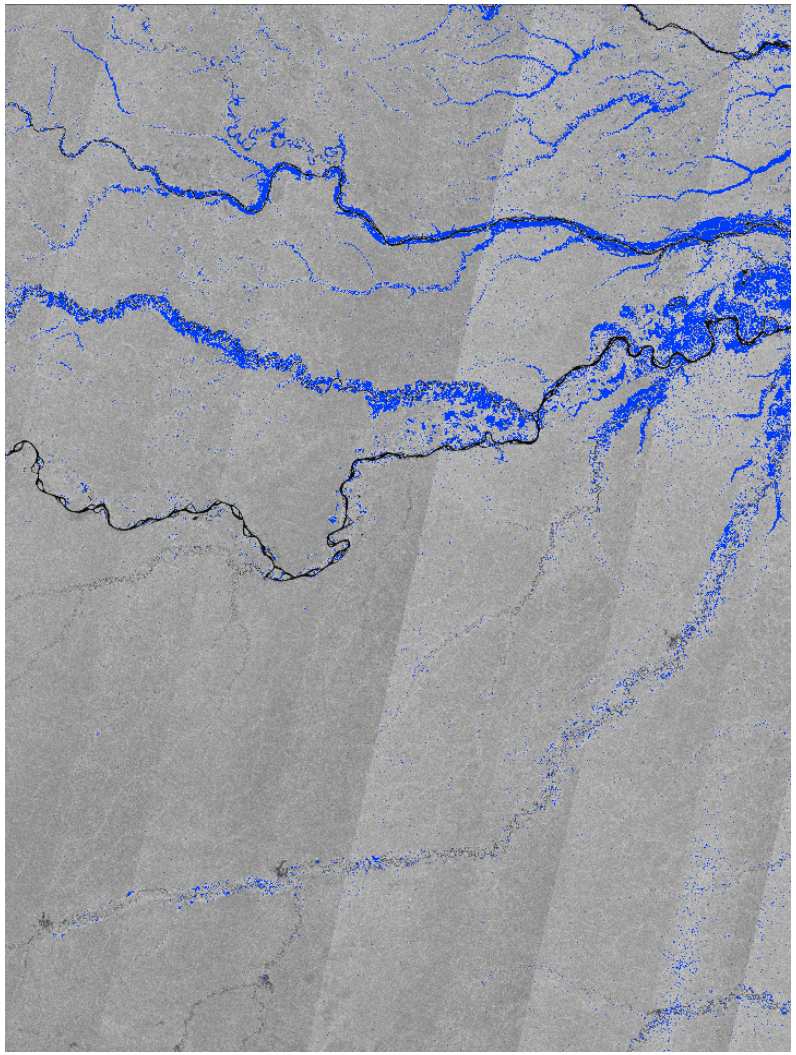


Number of times each pixel was imaged

Simple thresholds for identifying open water and inundated vegetation



Open water → less than -10dB



Inundated Vegetation → greater than -6 dB

19M

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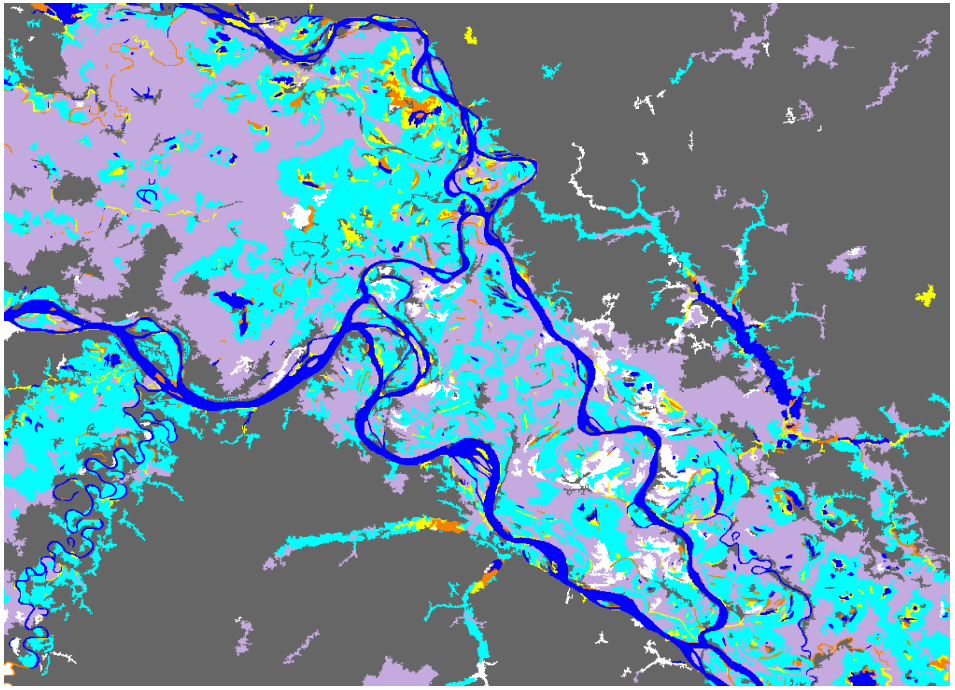
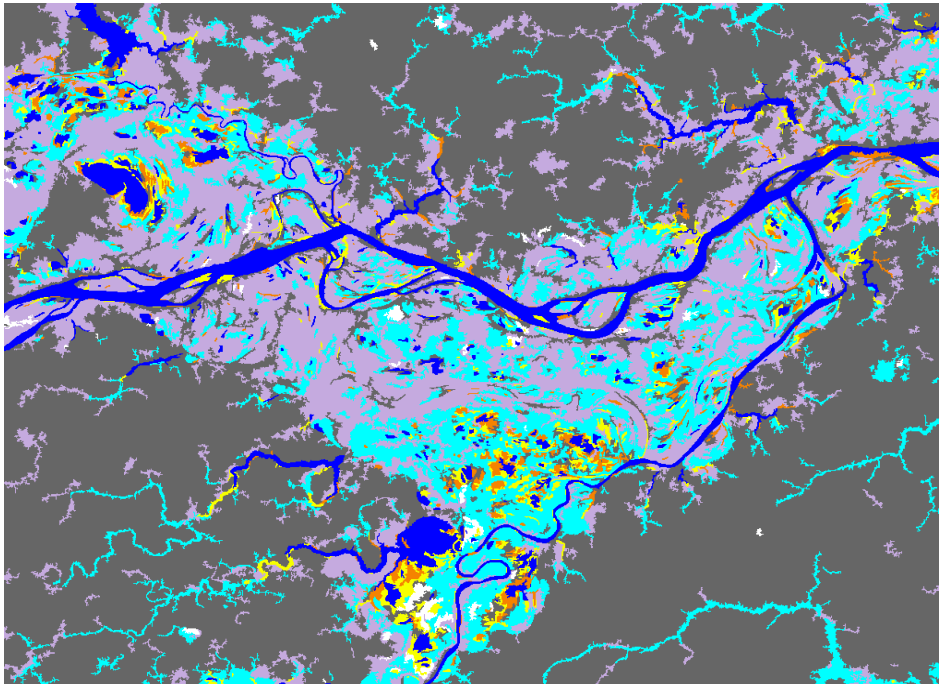
Wetland Habitat Mapping for Várzea Sustainable Development Reserves

Mamirauá



Piagaçu-Purus



- Open water
- Aquatic macrophyte
- Shrub
- Non-wetland
- Forest, flooded 1-2 m/a
- Forest, flooded 3-6 m/a
- Forest, flooded > 6 m/a

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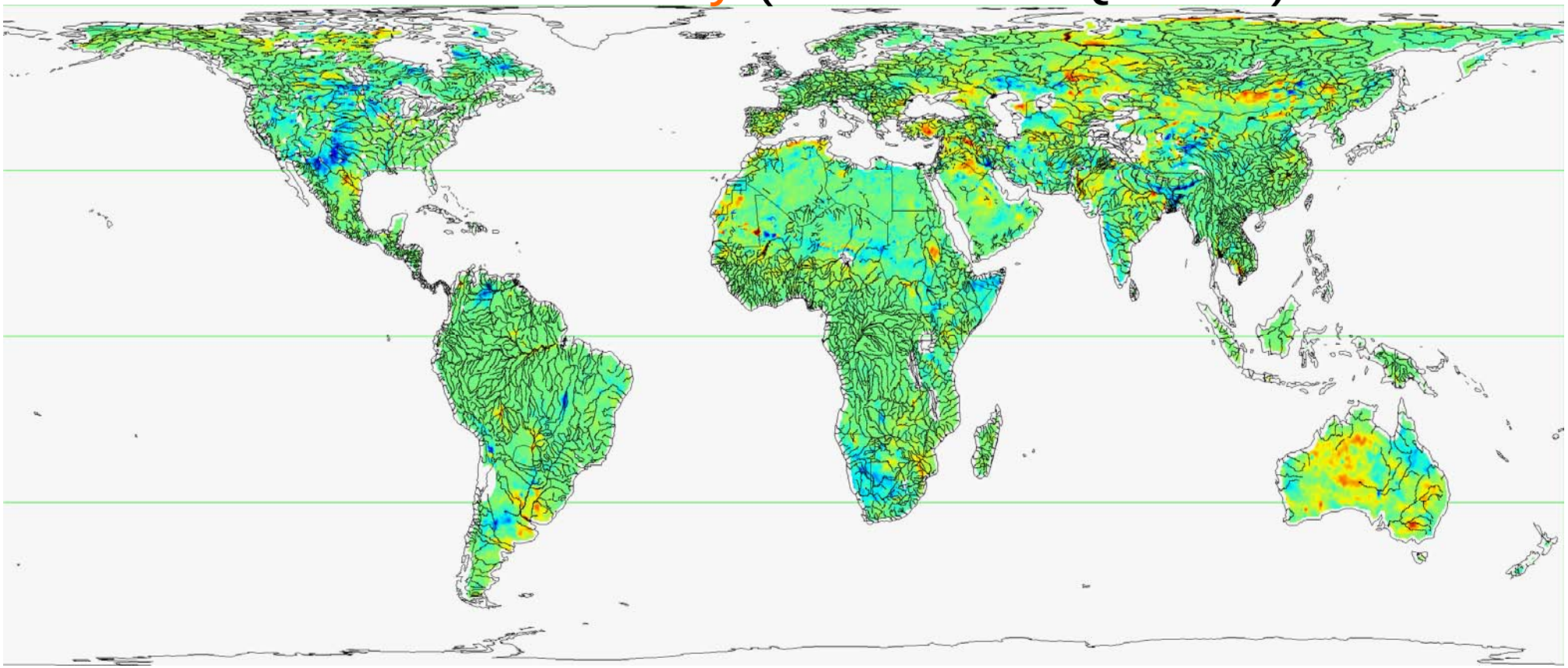
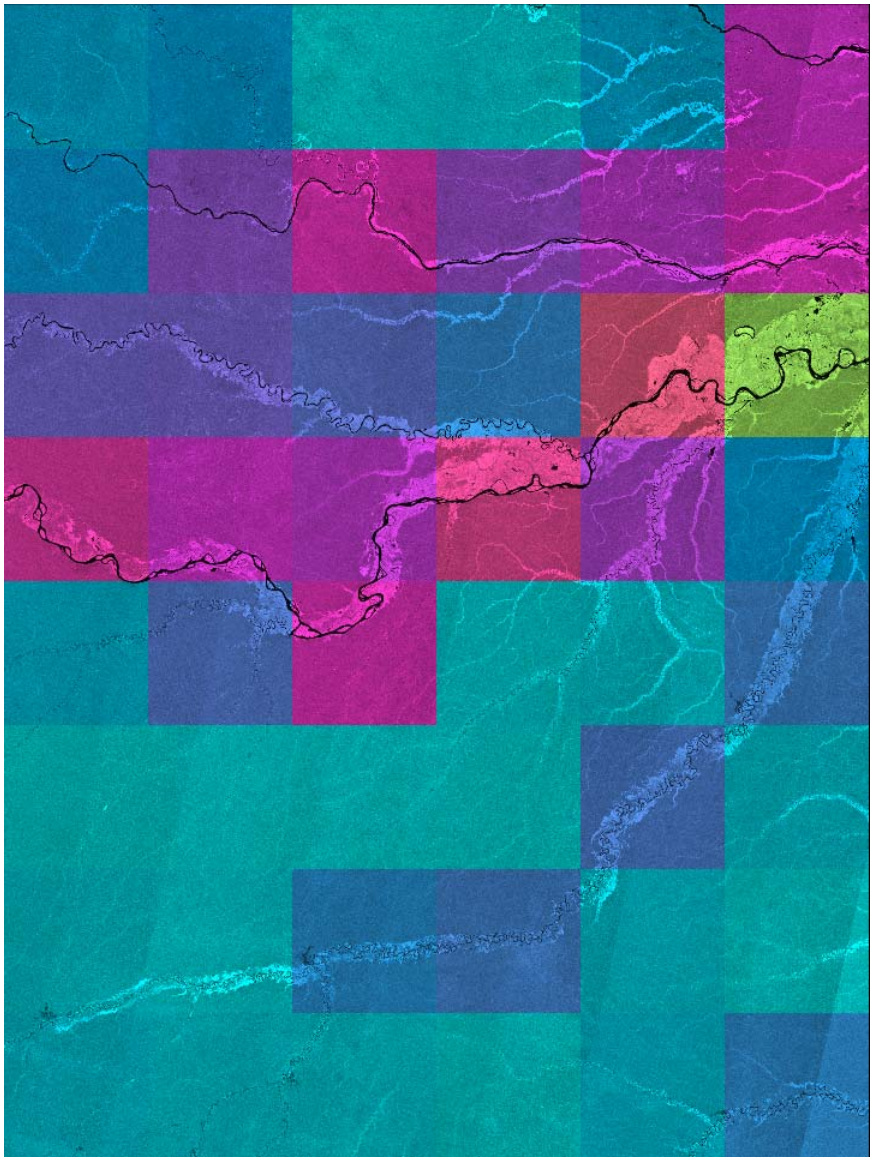
Inundation Anomaly (AMSR-E & QSCAT) 2004

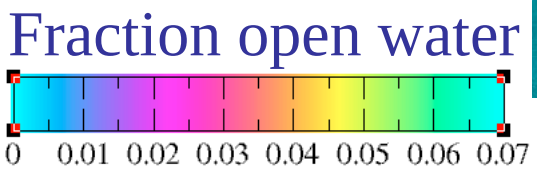


Percent inundated area by pixel

-5 -2.5 0 2.5 5

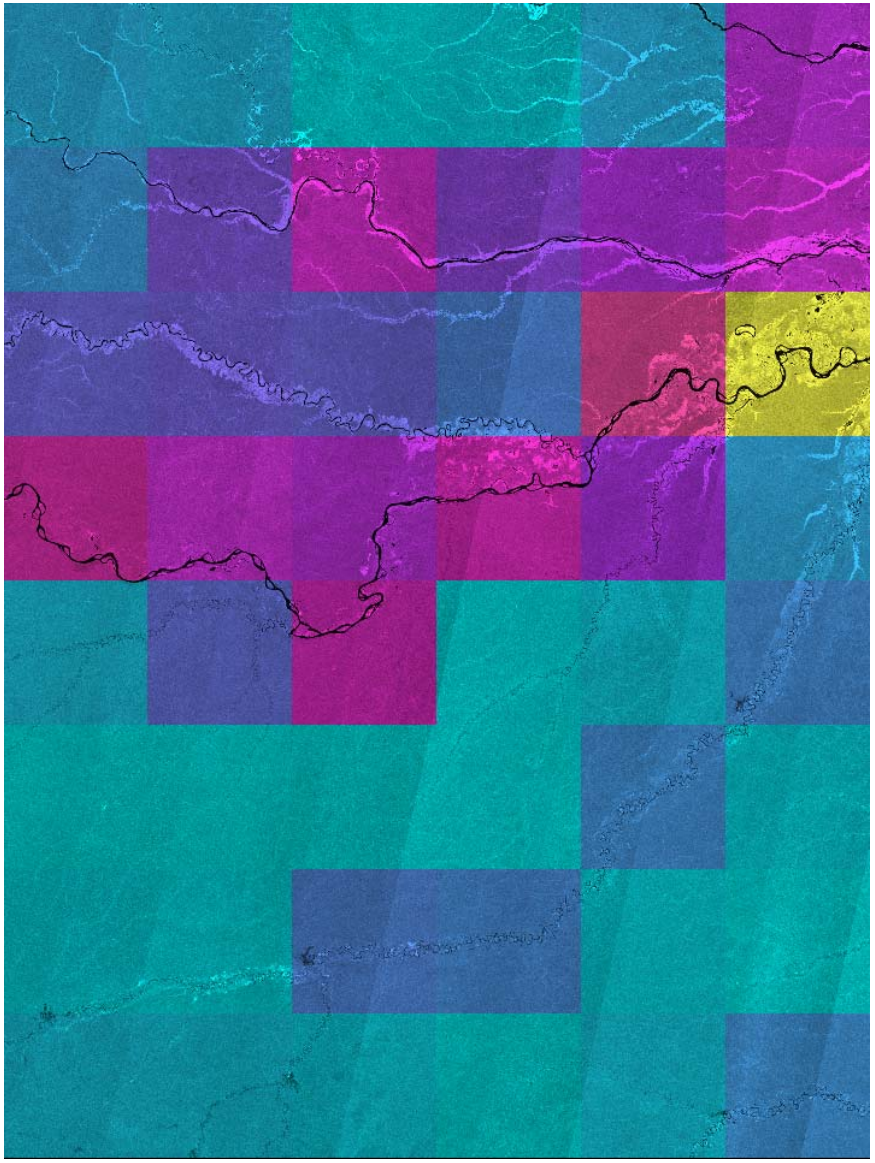
Fraction for each 1deg cell that is open water

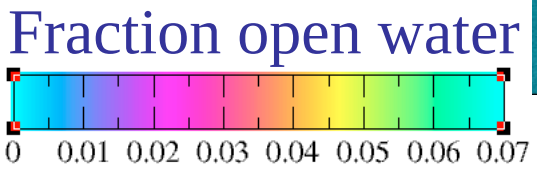




May-June 2007 19M

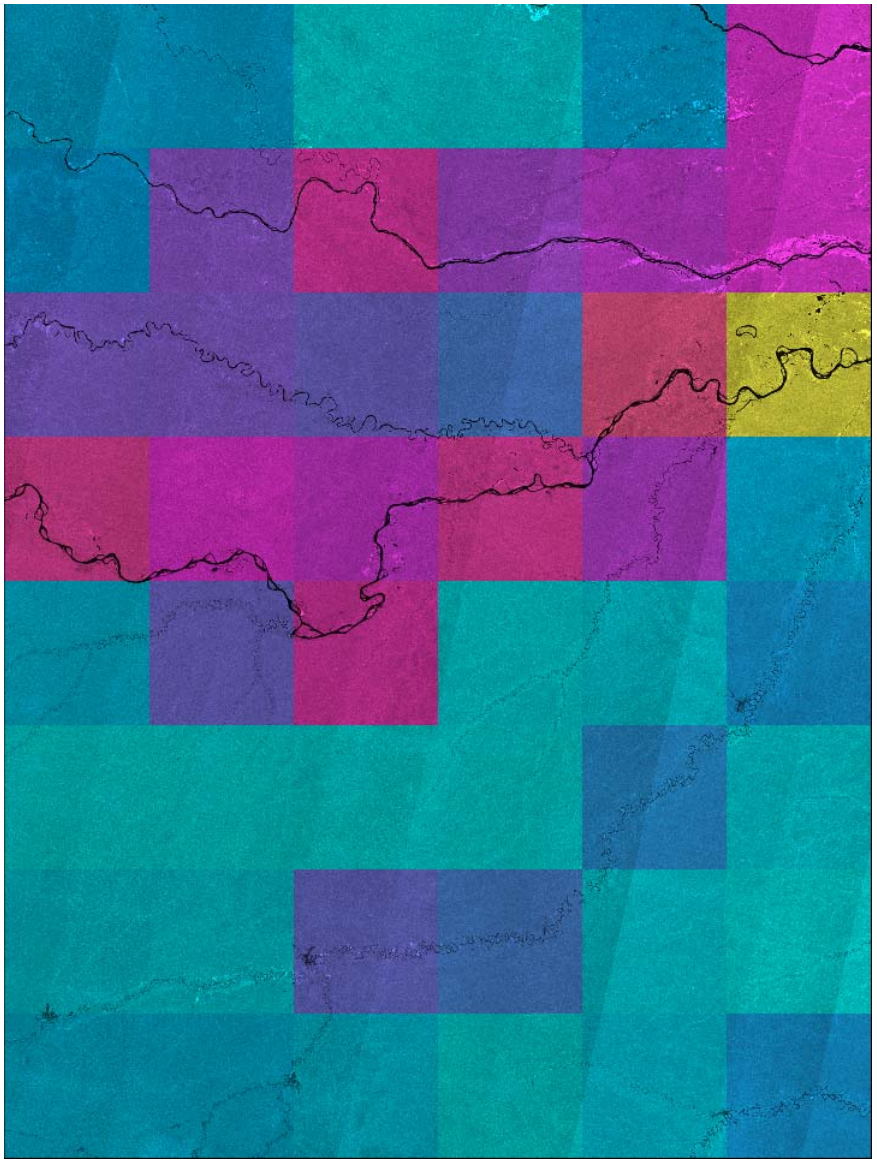
Fraction for each 1deg cell that is open water

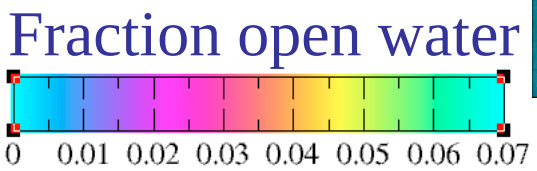




July 2007

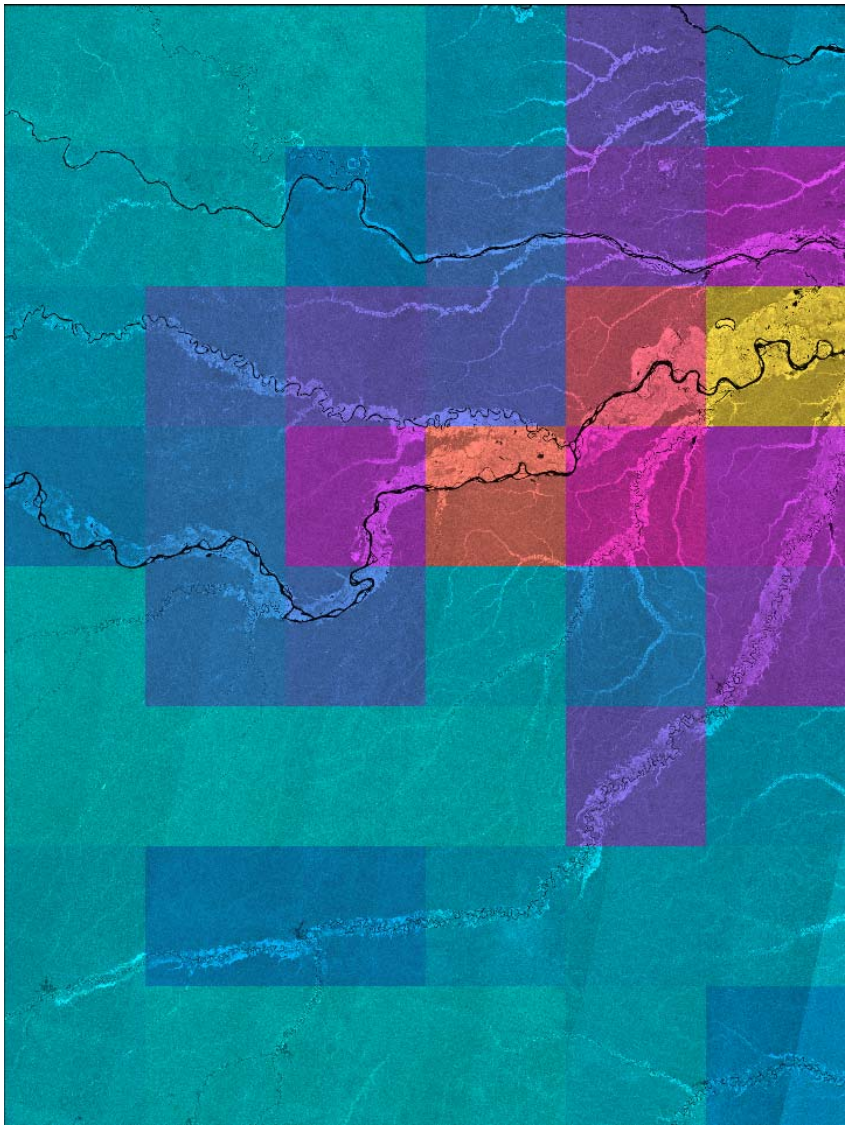
Fraction for each 1deg cell that is open water

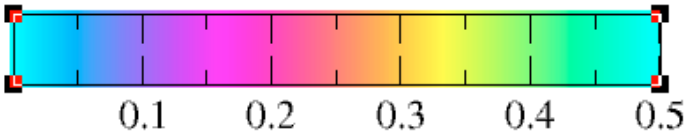




Aug-Sept 2007 19M

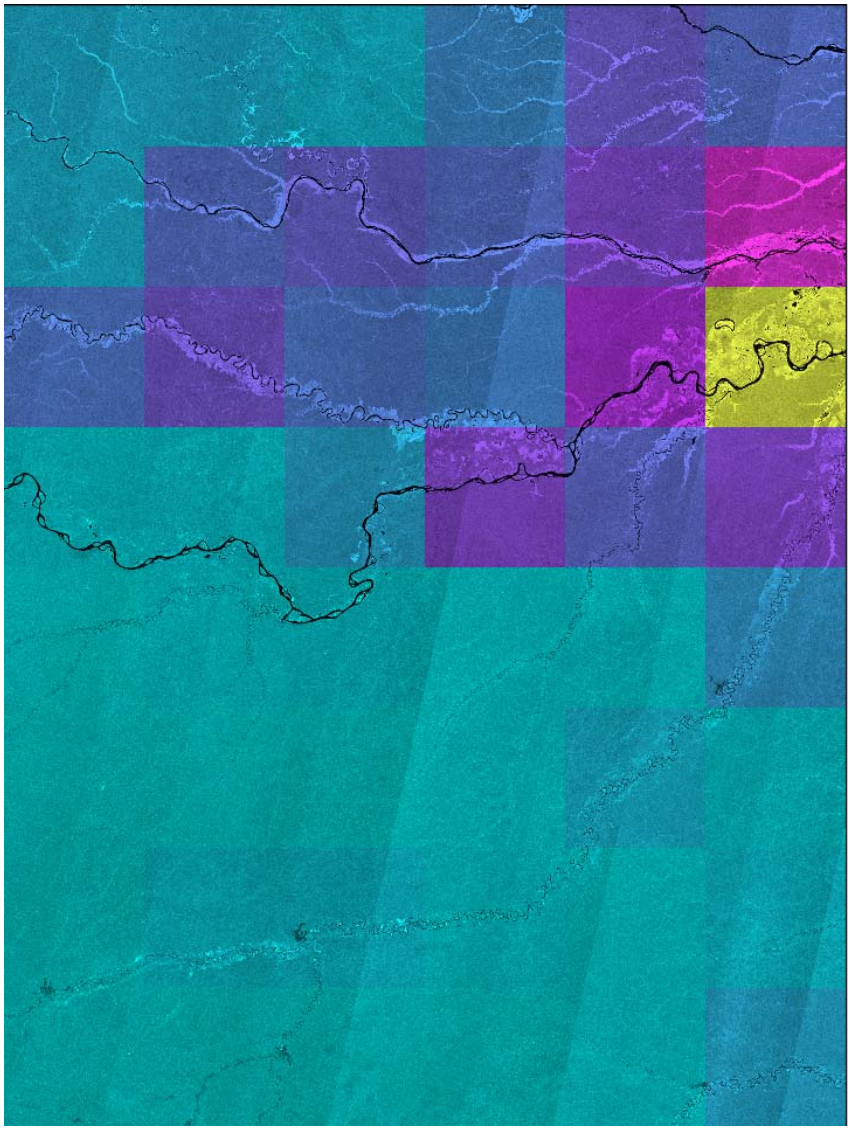
Fraction for each 1deg cell that is inundated vegetation

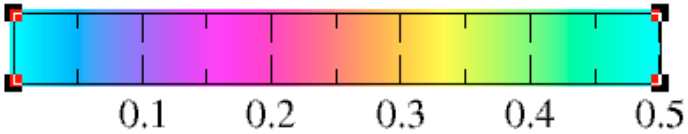




May-June 2007 19M

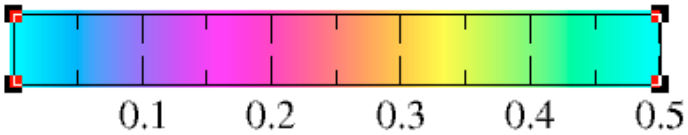
Fraction for each 1deg cell that is inundated vegetation





July 2007

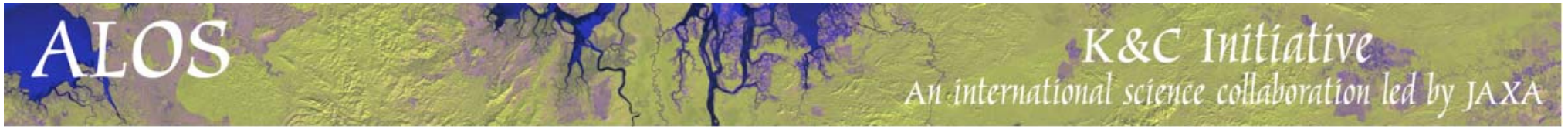
Fraction for each 1deg cell that is inundated vegetation



Aug-Sept 2007 19M

Conclusions

- The uncorrected SCANSAR strip image data has, on average, a geolocation accuracy better than 1 pixel, but errors larger than this are common, and must be corrected.
- Relative and absolute calibration corrections are difficult due to varying terrain types, the dynamic nature of the landscape, and environmental effects such as changing moisture content, but can be done well enough to enable characterization of wetland dynamics.
- The backscatter signature from open water and inundated vegetation is distinct from other land cover types and conditions. Quantitative wetland products are now being developed.



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