ALOS-2, the Ionosphere & BIOMASS calibration

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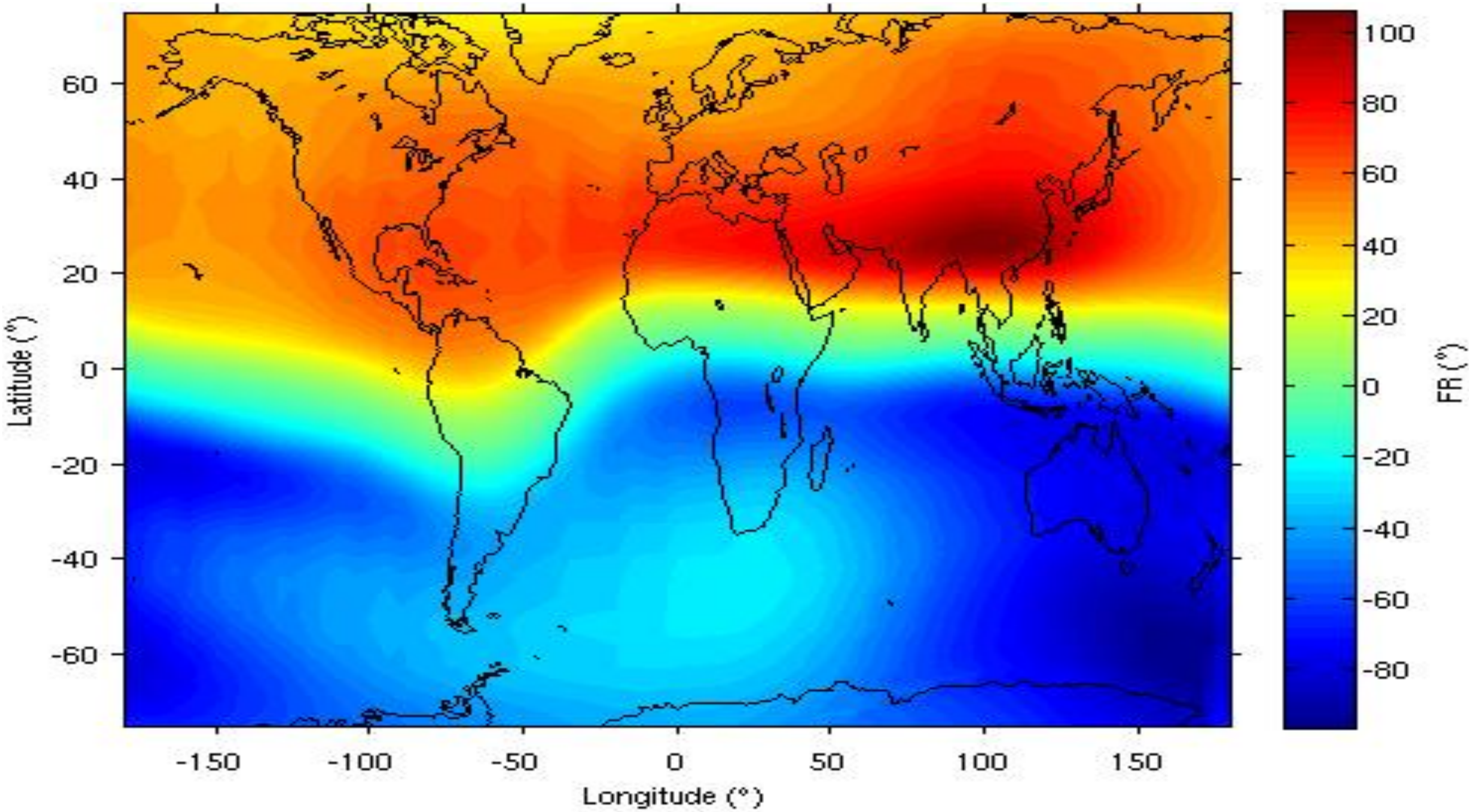
The problem

1. Faraday rotation will affect every image produced by BIOMASS and will be corrected using the Bickel & Bates (1965) estimator to accuracies of a fraction of degree. This is more than adequate for polarimetry, PolInSAR and tomography.
2. FR is a problem because it interferes with polarimetric calibration. We need either
    a. A scheme that can simultaneously solve for FR and the calibration parameters, OR
    b. To estimate the calibration parameters where the FR=0 (near the magnetic equator.
3. So we have been using PALSAR-2 polarimetric images to look at the equatorial ionosphere.

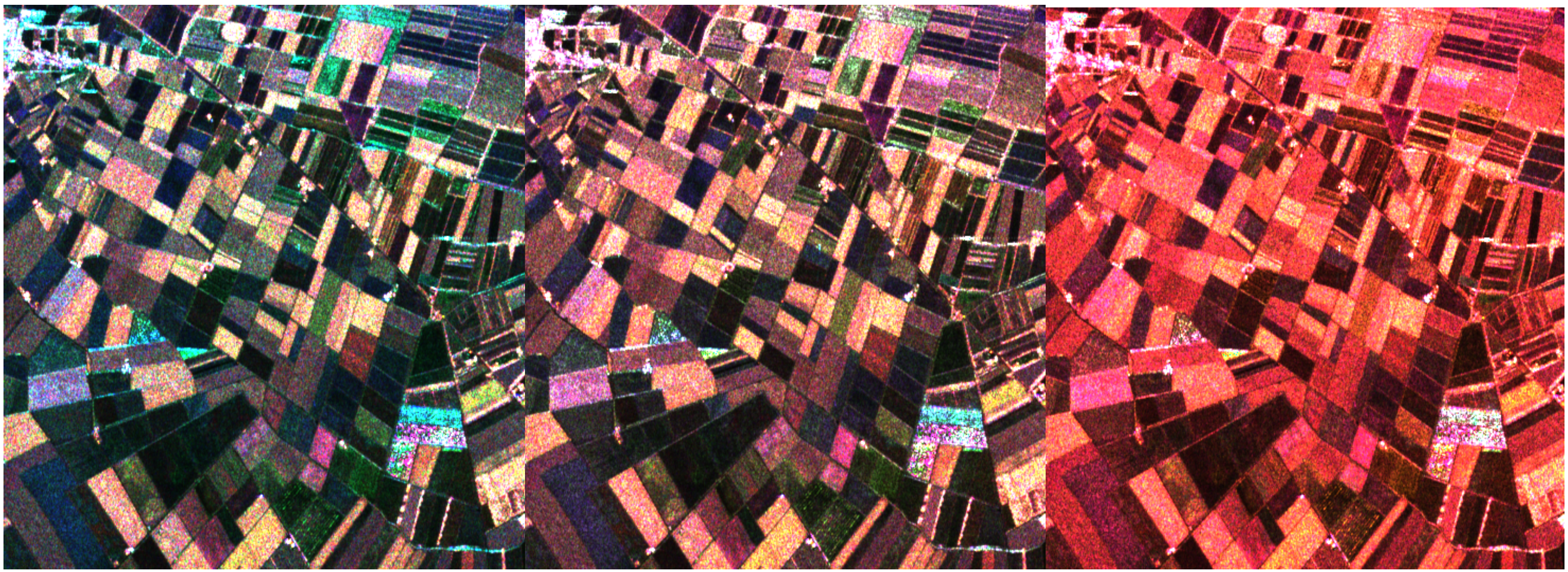
Simulated Faraday Rotation for BIOMASS (dusk side, median conditions)



Faraday rotation is a factor 9 less in PALSAR images.
Near the magnetic equator FR = 0.

Faraday rotation effects (airborne simulation)

FR clearly must be corrected (but this is readily done using the Bickel & Bates algorithm)



FR = 0° **FR = 10°** **FR = 20°**

Polarisation: B = HH, G = VV, R = HV

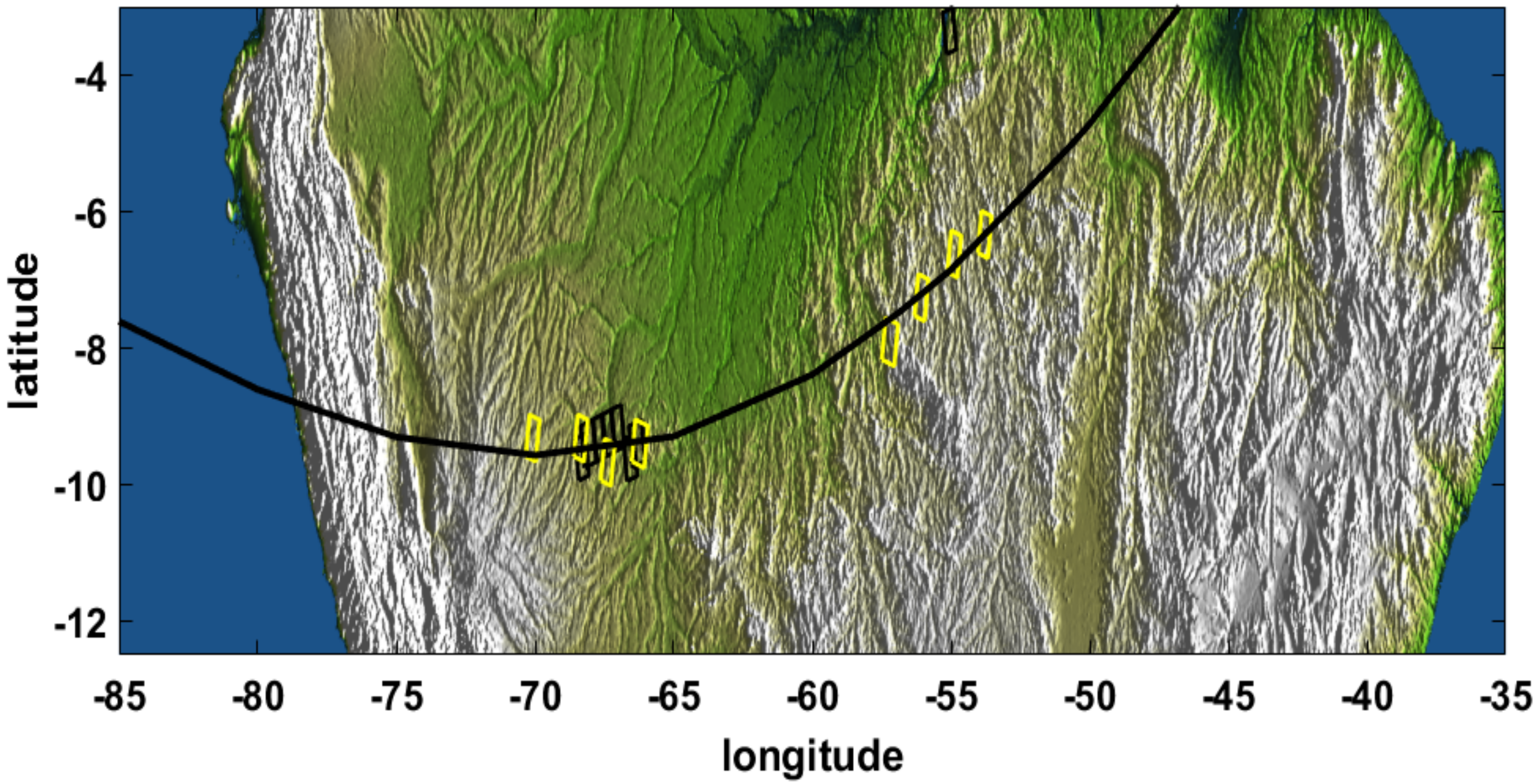
Estimating cross-talk

Question addressed: can distributed targets with reflection symmetry near the magnetic equator be used to estimate cross-talk with sufficient accuracy?

Major advantages of this approach:
• no deployment of man-made devices;
• cross-talk can be measured on every scene that meets the conditions for the algorithm to be applicable.

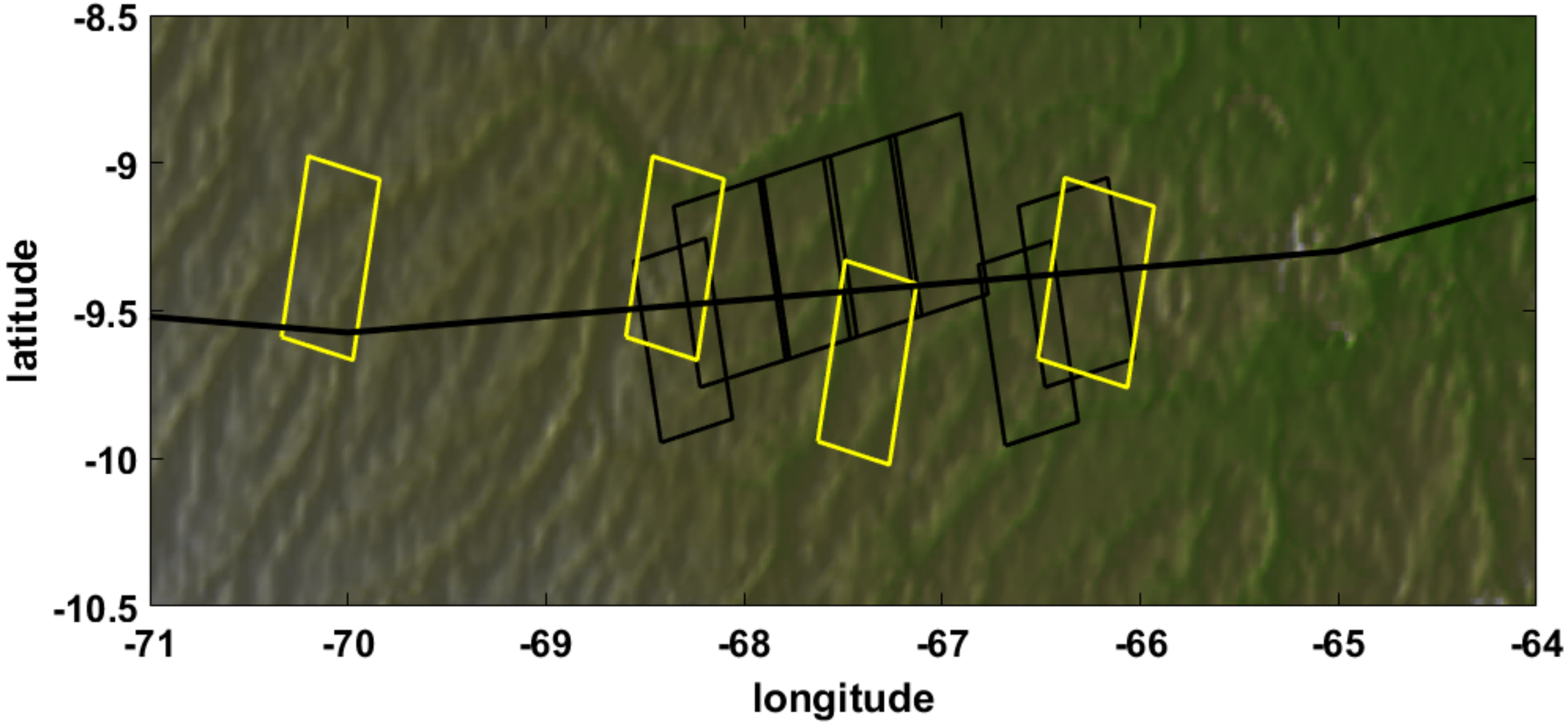
Best place to look: dense forest in Amazonia (almost elsewhere the magnetic equator is over ocean or heavily modified land surface)

Selected ALOS-2 quad-pol scenes



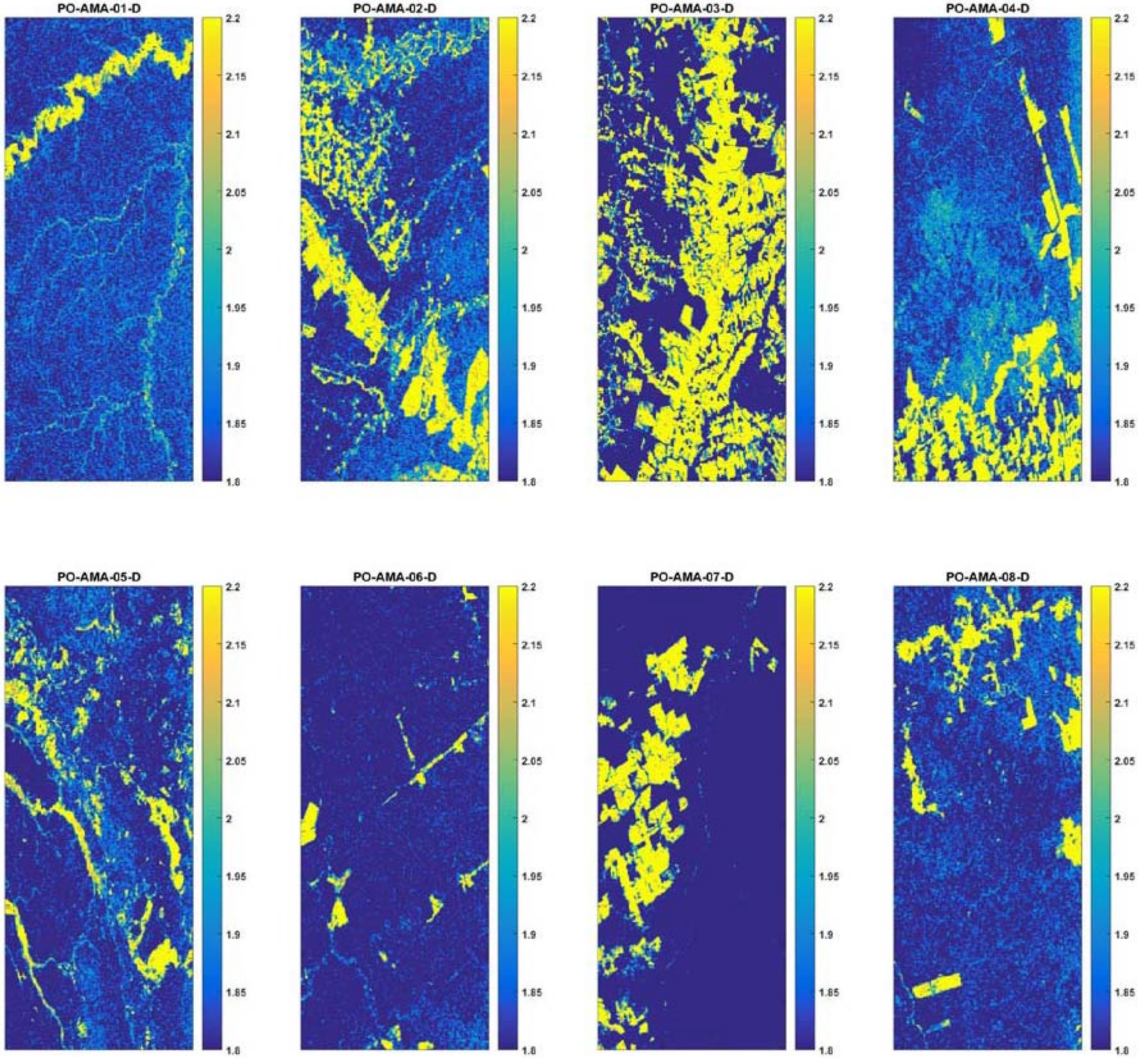
Ascending in black, descending in yellow.
Black line: FR = 0 on ascending pass (midnight)

Western group of ALOS-2 quad-pol scenes

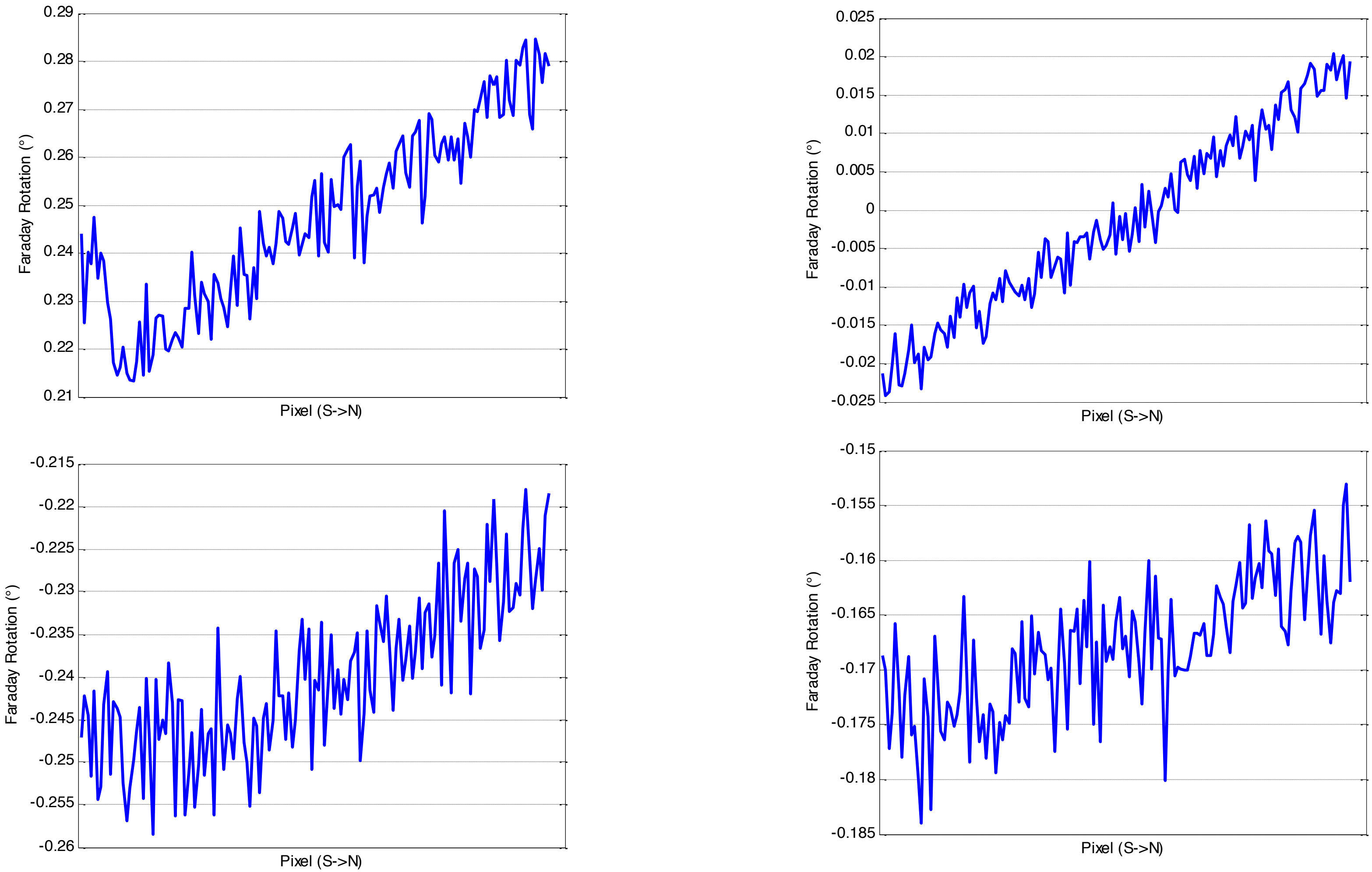


Descending in yellow, ascending in black.
Black line: FR = 0 on ascending pass (midnight)

ALOS-2 HH/HV descending (forest discrimination)

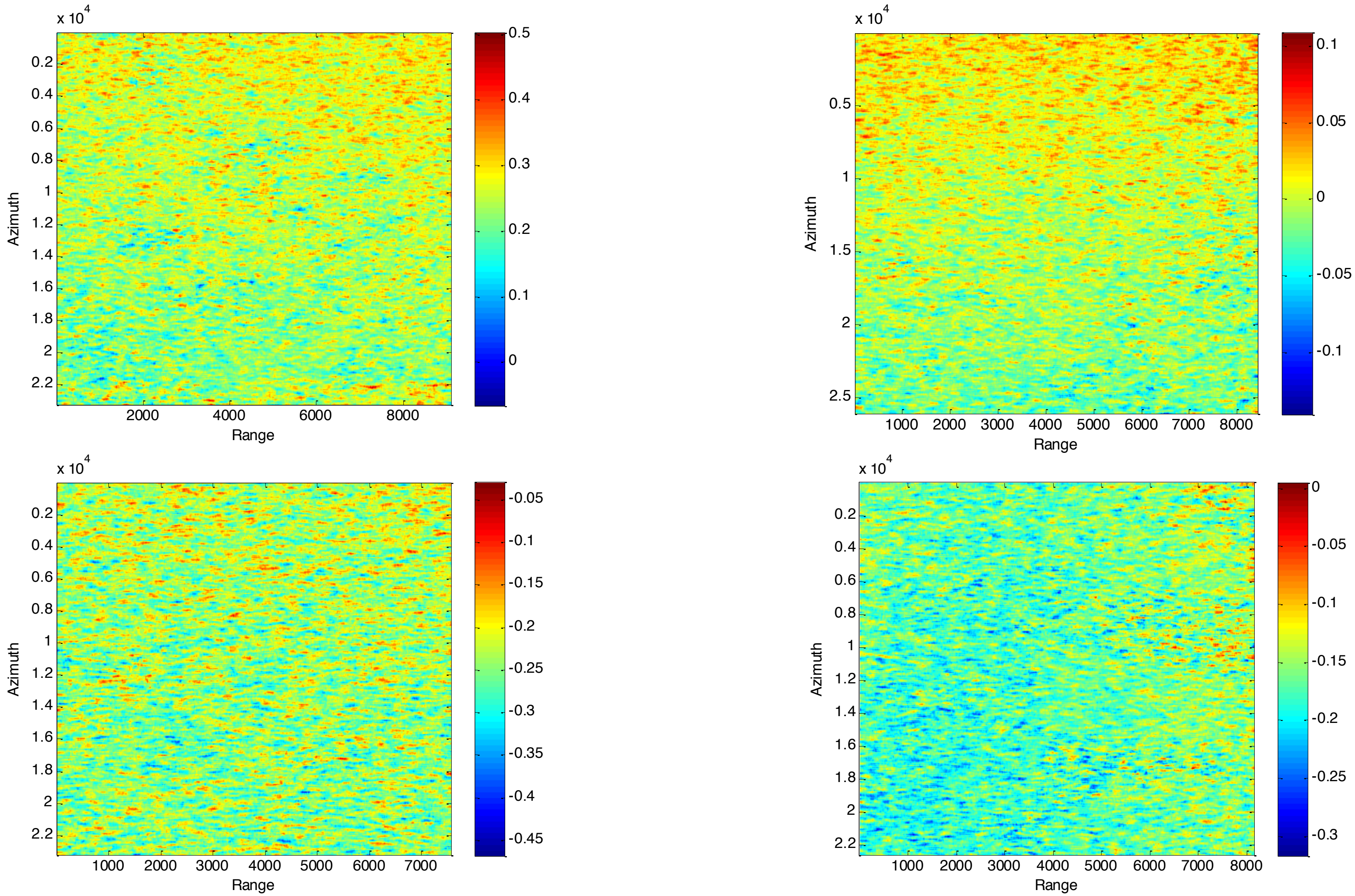


Ionospheric structure along azimuth (south to north) near the zero-FR line, ascending passes



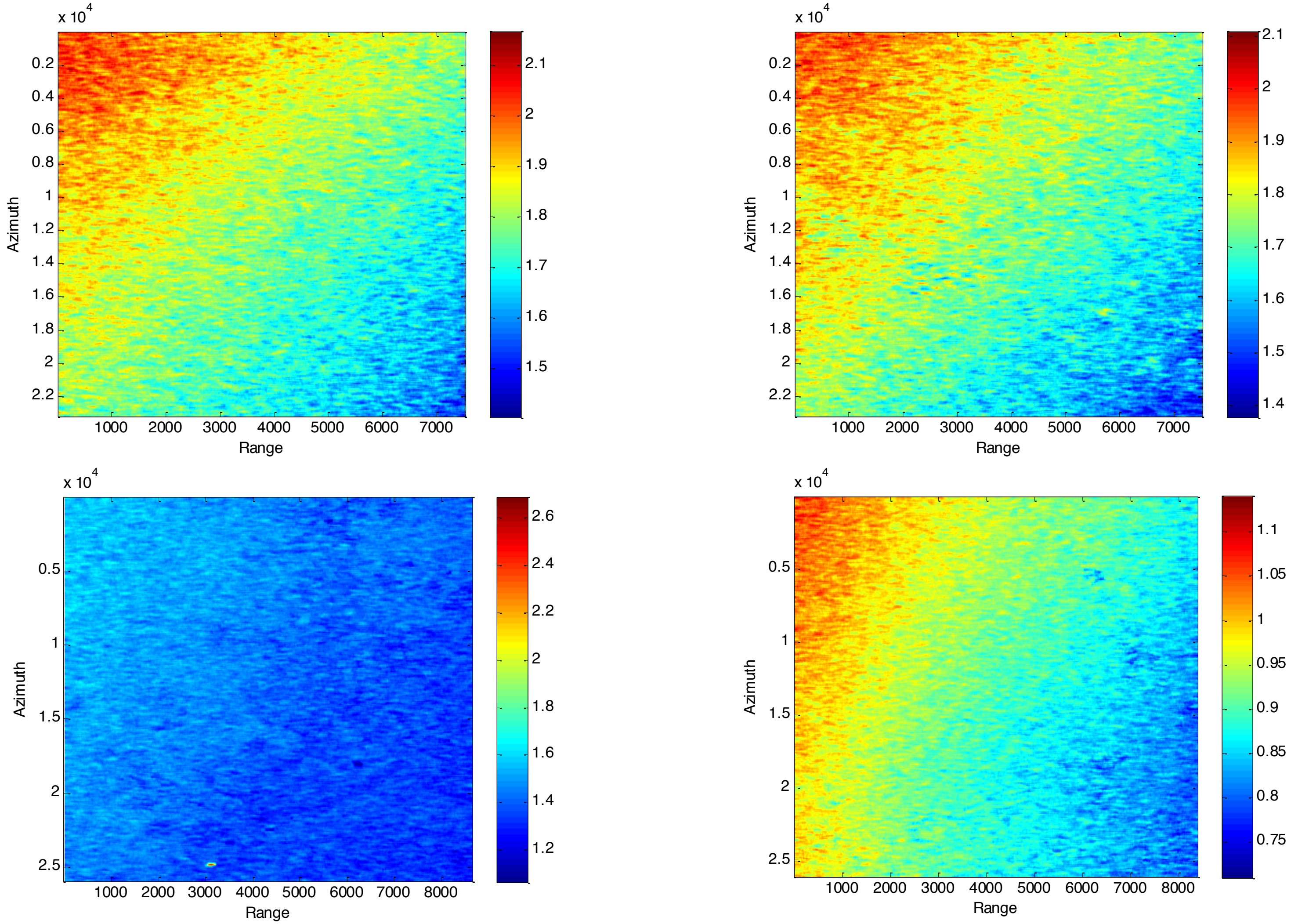
FR estimated along azimuth from South to North

500 m block averaging FR - ascending



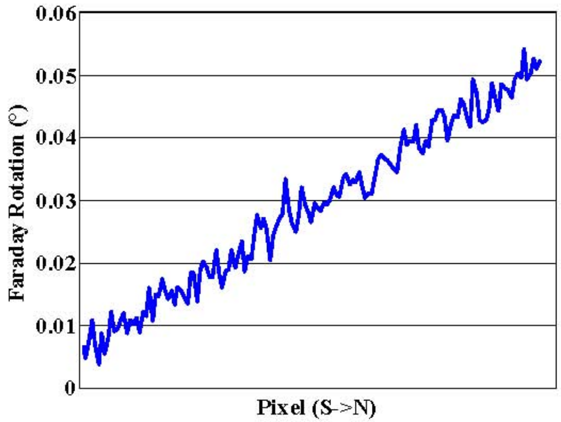
2-D estimates for the same data; gradients seen in FR (hence in the ionospheric Total Electron Content [TEC])

500 m block averaging FR - descending

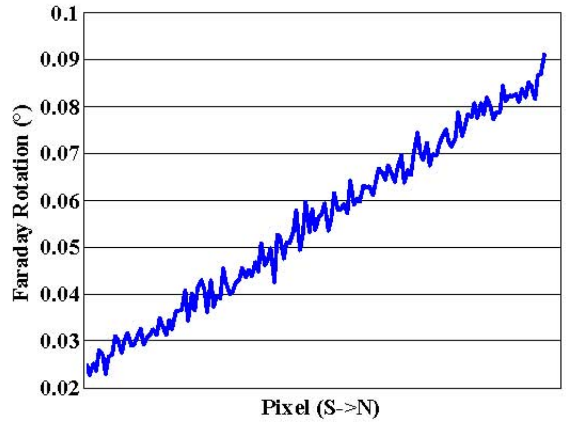


2-D estimates,descending; stronger gradients seen in FR (so TEC). Direction affected by the different orientation of the magnetic field relative to the orbit.

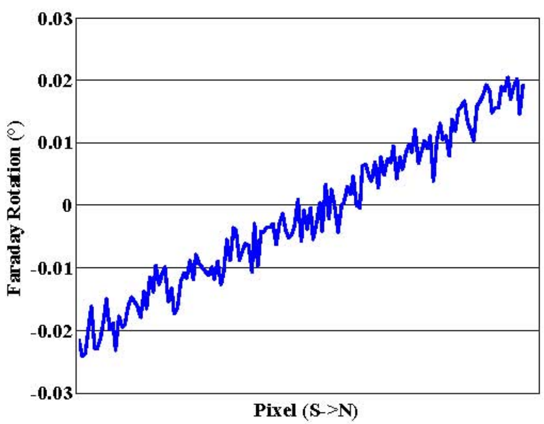
Repeat scenes: the zero-FR line is NOT STABLE in time



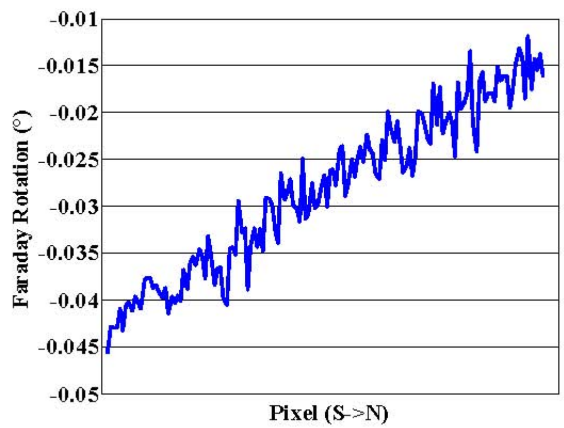
(a) 08-08-2014



(b) 26-12-2014



(a) 07-08-2015



(b) 13-05-2016

In repeat scenes the zero-FR line is not in the same place.
Why does it move with time?

- Ionospheric currents modify the direction of the mag. field?
- Changes in ionospheric height?
- Changes in ionospheric structure?
- Something else?

Summary

1. PALSAR-2 data have shown that the behaviour of Faraday rotation near the magnetic equator cannot be accurately predicted using just orbit geometry and standard magnetic field models.

2. This complicates the BIOMASS polarimetric calibration strategy: we are still working out the consequences.

3. The PALSAR data contain a lot of information about ionospheric behaviour (travelling ionospheric disturbances, ionospheric currents, magnetic field fluctuations) which we intend to investigate further.