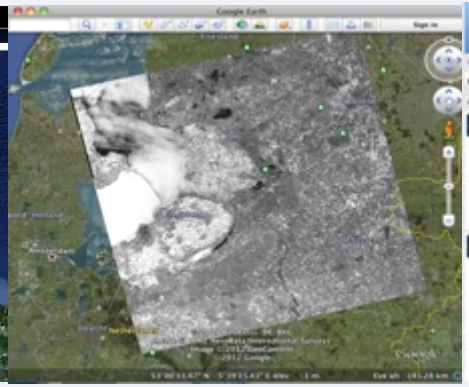
S-1 instrument and product performance status


Fringe Workshop, ESRIN, 2015

N. Miranda, ESA, EOP-G

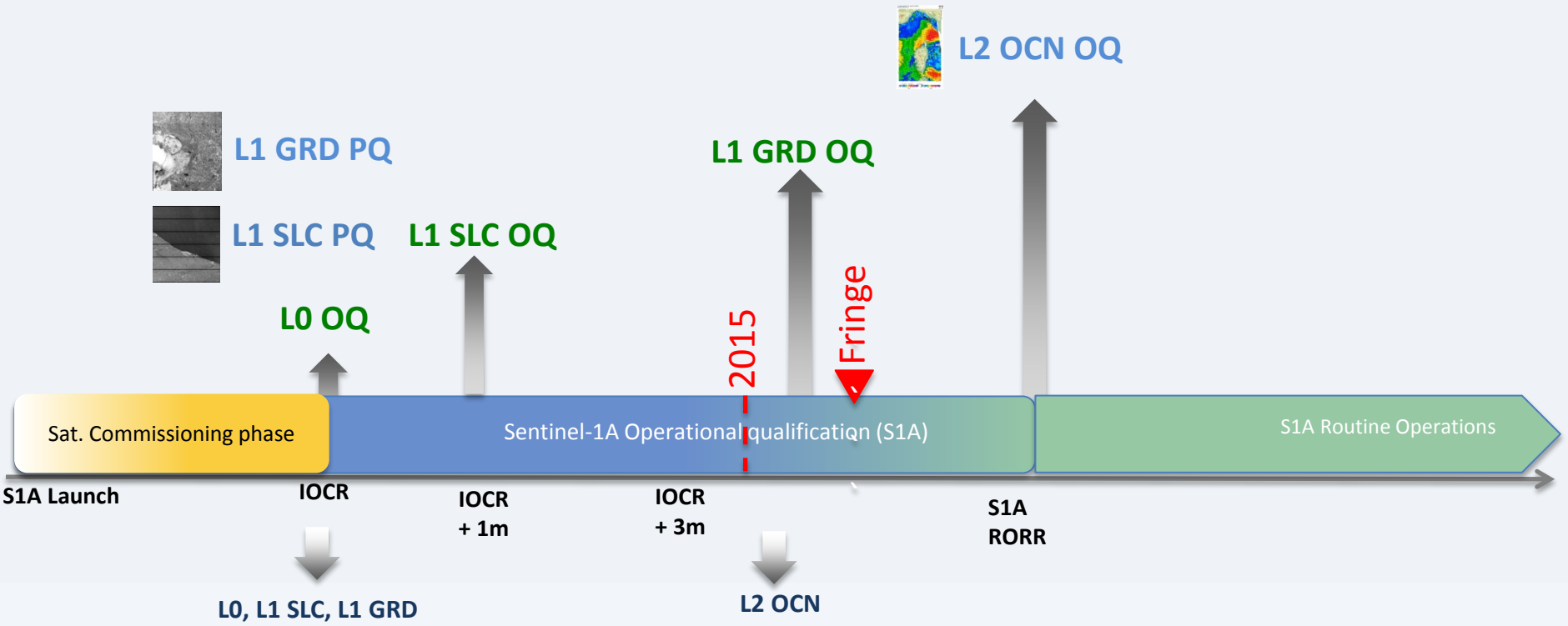
G. Palumbo, Serco SPA

S-1 Mission Performance Center:

- G. Hajduch, R. Husson, P. Vincent, CLS (FR)
- P. Meadows, A. Pilgrim, BAE Systems (UK)
- D. Giudici, R. Piantanida, Aresys (IT)
- D. Small, A. Schubert, UZH (CH)
- A. Mouche, Ifremer (FR)
- H. Johnsen, Norut (N)
- F. Collard, ODL (FR)

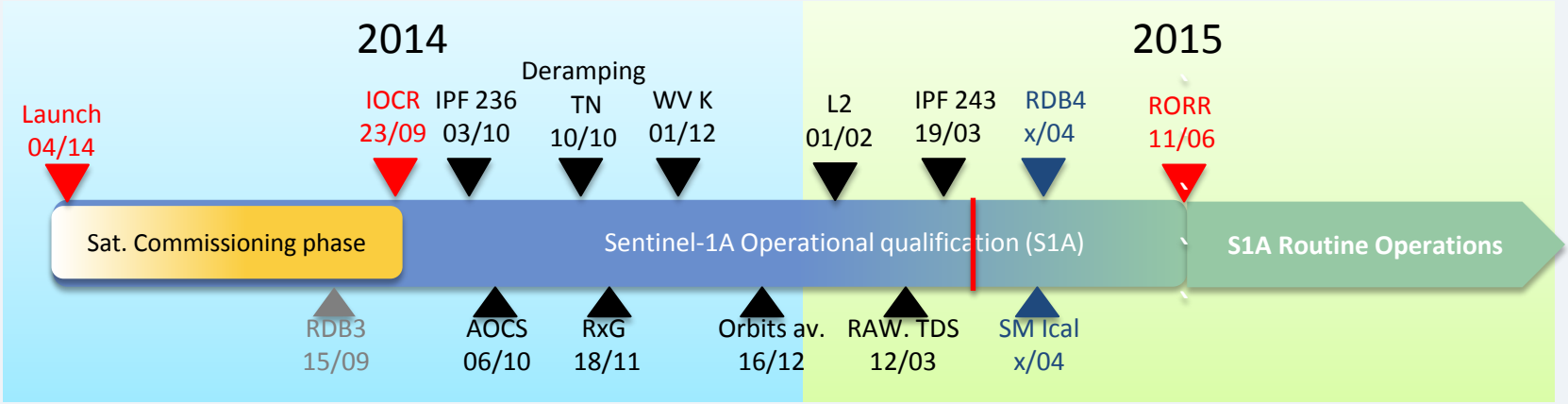
Operational user products qualification

- The Sentinel-1 product qualification is a major objective of the ramp-up phase.
  - The qualification activities have started at launch following a step-wise approach (L0→L1→L2)
  - L1 Product qualification will be completed in two steps during the ramp-up phase
  - Early release to users before full quality is achieved



PQ: Preliminary Qualification
OQ: Operational Qualification

S-1A : Events since IOCR



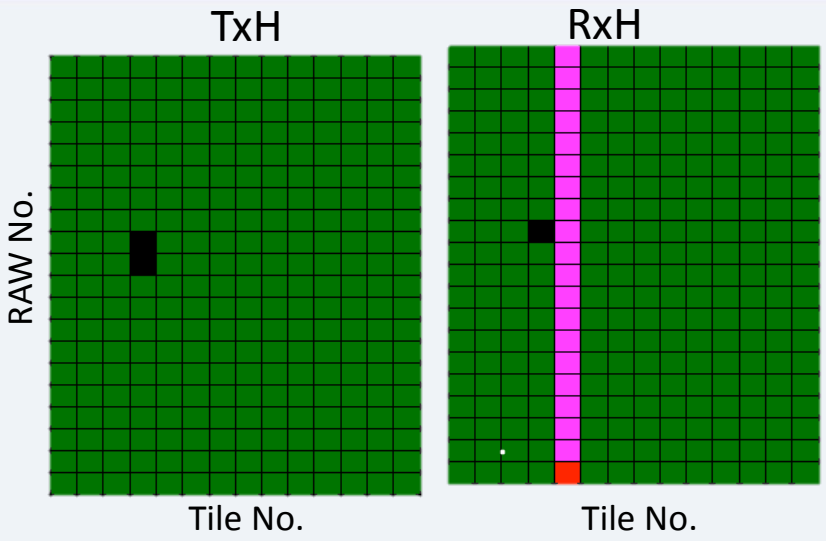
- IPF 236 : Data released to the users, preliminary calibration
- AOCS : Update of the AOCS to correct for roll and pitch offset
- Deramping TN: Release of the TOPS deramping Tech. Note, **Sentinel online library** [**Fringe recom.**]
- RxG: Activation of the Rx Gain correction (Range varying gain)
- WV K: WV product calibrated
- Orbit Av : Availability of restituted and precise orbit files **https://qc.sentinel1.eo.esa.int/**
- L2 : generation of L2 Ocean product for validation
- RAW TDS: Delivery of the RAW decoded TN and associated TDS, **Sentinel online library** [**Fringe recom.**]
- IPF 243: IPF processor update improving calibration, fixing GRD slicing issues, 1st L1 format change

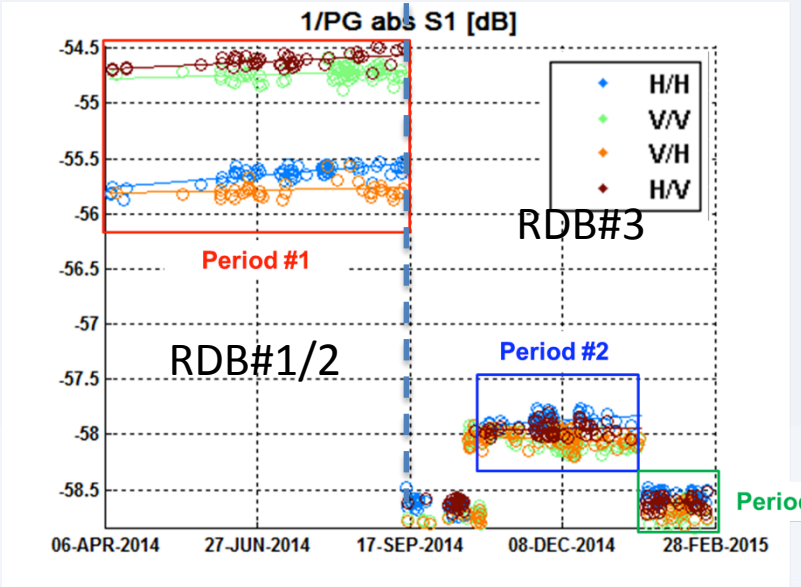
Next To come:

- RDB4 : Update of the RDB to introduce new quaternion reference frame
- SM Ical : Removal of the calibration pulses in SM to correct for scalloping effect

S-1A antenna status

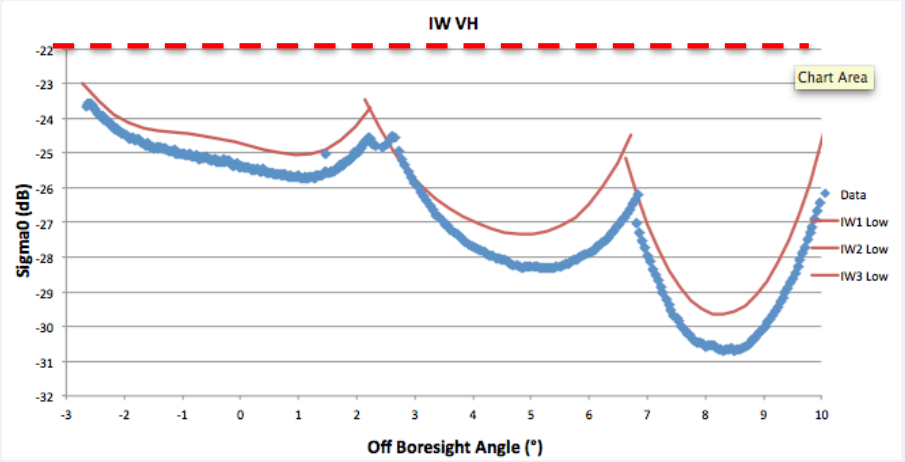
- The antenna is monitored using the internal calibration:
  - RFC: allowing to characterize the drift/failures of each TRMS:
    - 2 TRMs are failed since the CP
    - Intermittent anomaly on “tile 5” not working in RxH and V from:
      - 2014-10-18 → 2015-01-27 with no impact on the data (https://qc.sentinel1.eo.esa.int/disclaimer/)
      - Restarted for few days last week
  - Interleaved cal: allowing to monitor the instrument gain drift
    - Drift of 0.484dB/y measured during the CP under assessment
    - Doesn’t impact the data quality as the internal calibration is used in the processing



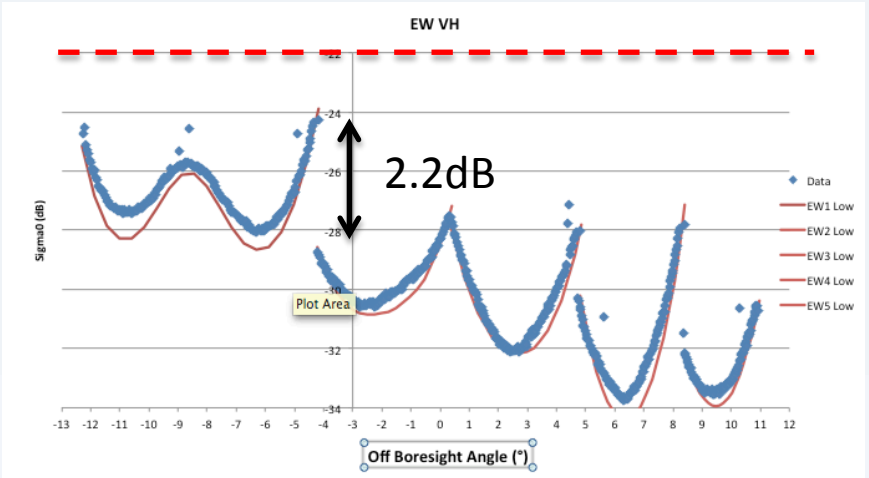


Instrument sensitivity: Noise Equivalent Sigma Zero

- NESZ is measured over area of low backscatter (e.g. ocean under low wind speed) and compared with theoretical profiles (---)
- Mission requirement is -22dB (- - -)
- NESZ is as expected



-- NESZ theo.
-- Measurement

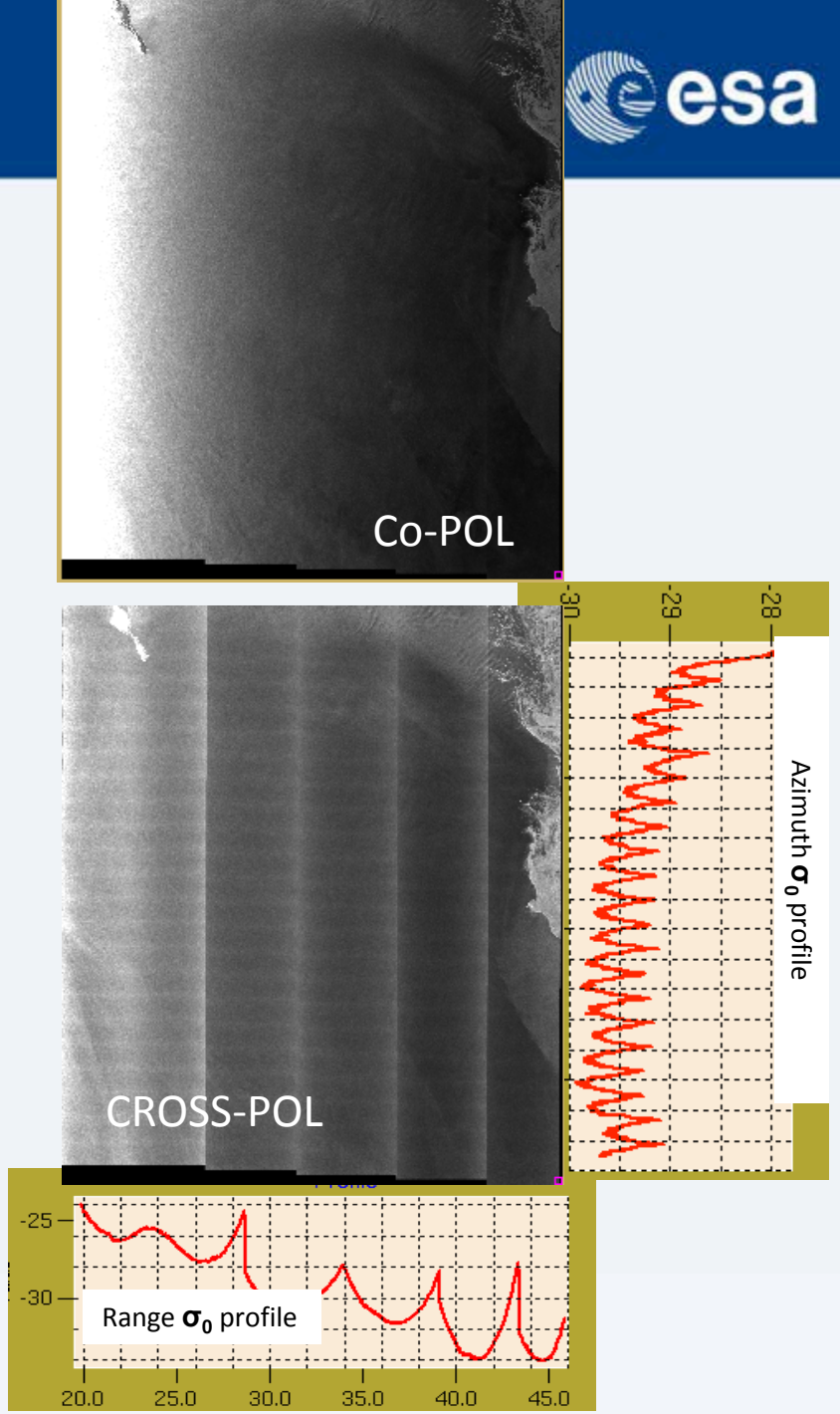


NESZ

- TOPS products are radiometricaly corrected for:
  - Elevation Antenna Pattern
  - Azimuth Antenna Element Pattern (TOPS descalloping)

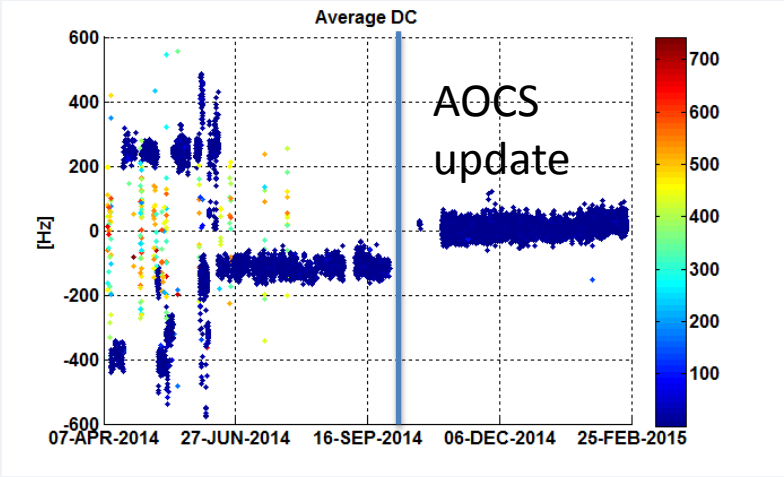
- In presence of noise (no signal returned to the radar), these corrections are shaping the <u>noise</u>
  - Data acquired over ocean at low wind speed
  - Cross-polarisation

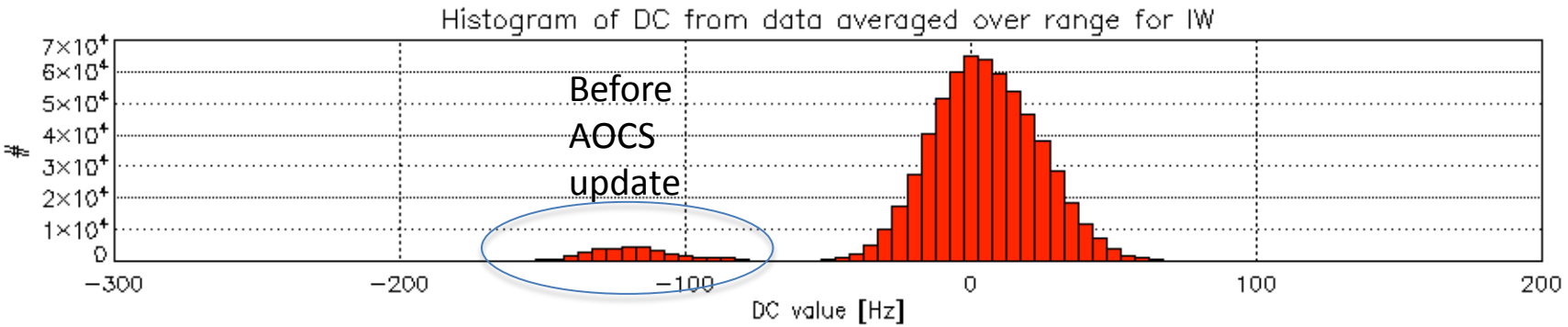
- It is visually not “nice” but it is an **<u>expected feature</u>** of the processing



Total Zero Doppler Steering

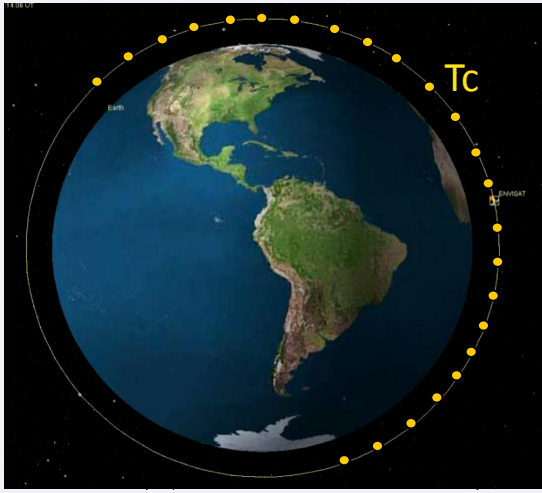
- S-1 is Total Zero Doppler Steered
- The Doppler centroid is monitored since launch as an indicator of steering performance
- Doppler measured from IW products is stable: 6.2±19.494Hz with no noticeable trends





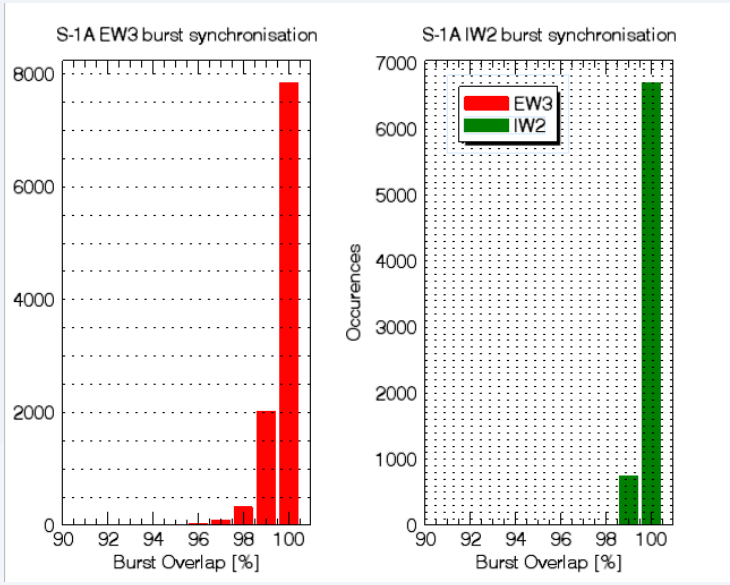
Burst Synchronization (TOPS)

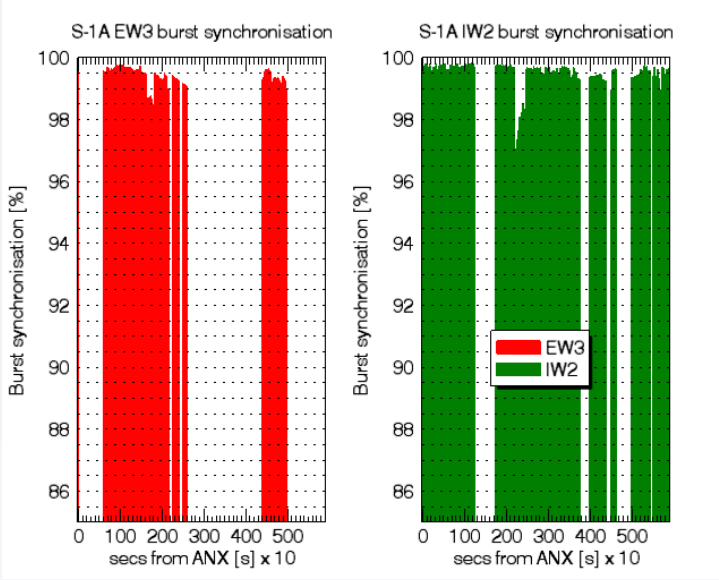
- S-1 is the first mission using TOPS as main operational mode →**Burst Synchronisation (BS) is a pre-requisite for TOPS interferometry**



- BS is ensured by snapping the acquisition start on pre-defined grid where each points are separated by the burst cycle (Tc).

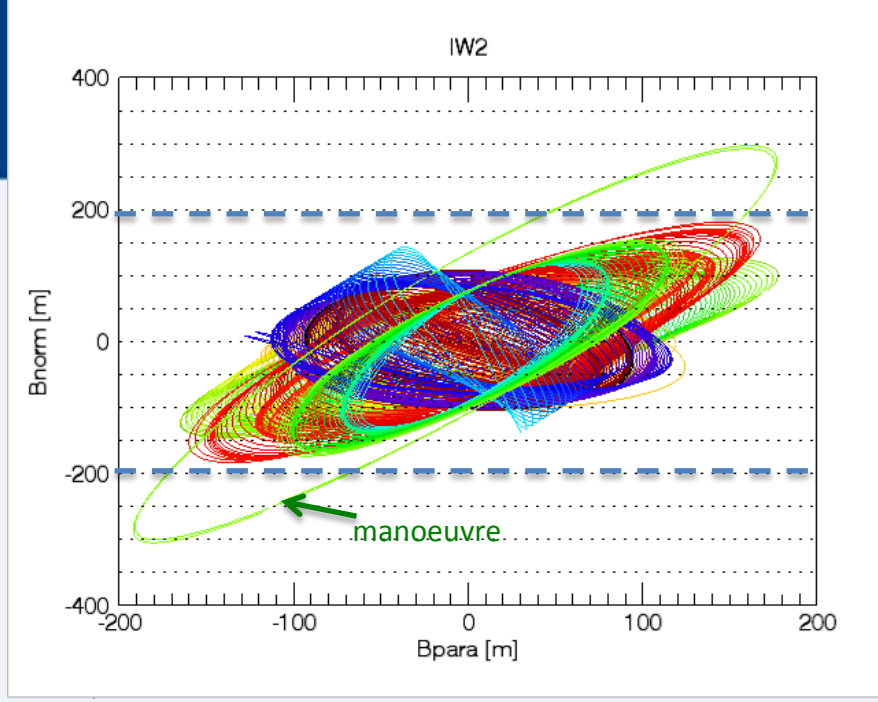
- Bust overlap > 96% with no trend around the orbit



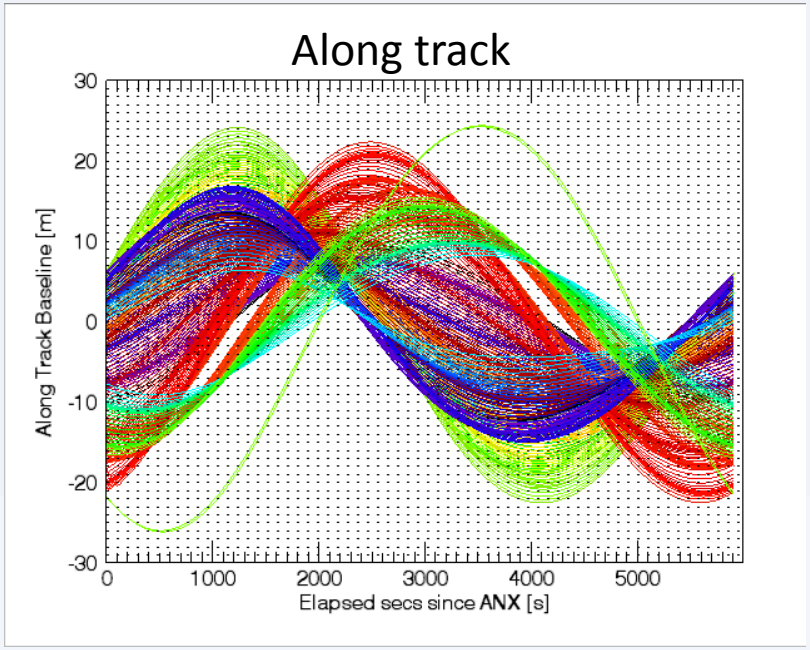


Orbit baseline stability

- The orbit dead-band mission requirement was ±60m
- IOCR recommendation was to increase dead-band to ±120m to reduce the number of manoeuvers/weeks, relaxed to 200m under high solar activity
- Normal baseline is of 3.17±75m
- Along track baseline is within ±20m ensuring good burst synchronization

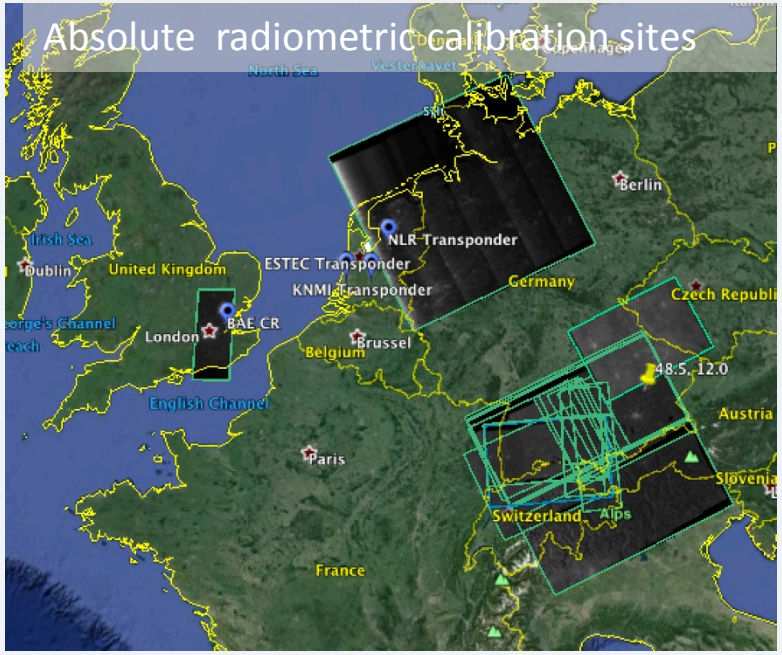


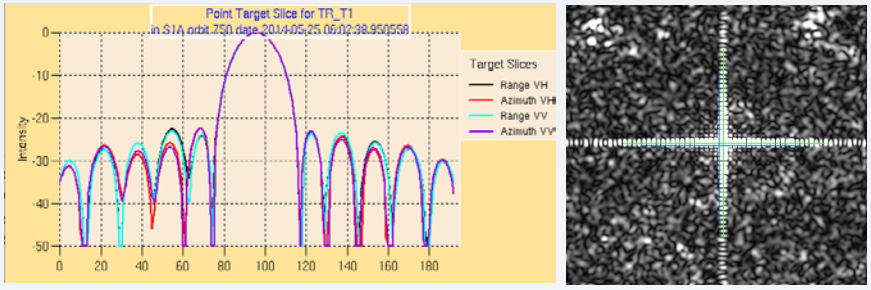
S-1A baseline for January 2015

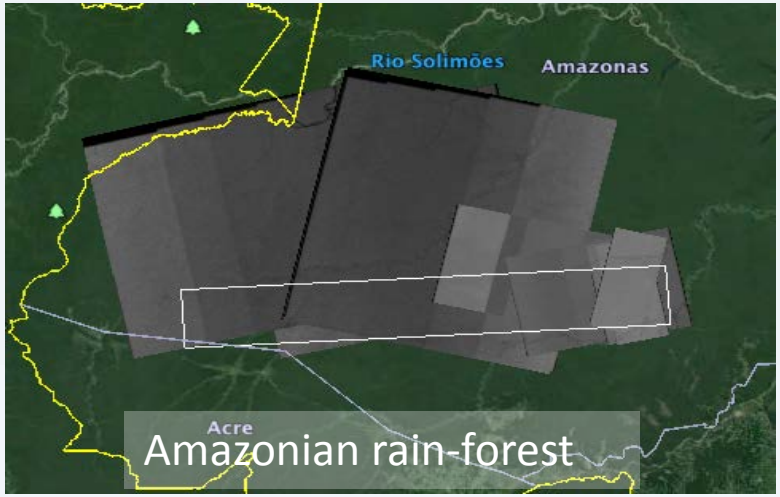


L1 Product Verification results

- The L1 product verification was mainly performed over dedicated calibration sites:
  - Man made devices deployed for the sake of instrument commissioning and product verification : ESA and DLR transponders, UZH, BAE and DLR corner reflectors
  - Natural sites like the Amazonian rain-forest
- Product Basic Quality Indicators
- Product radiometric/polarimetric calibration
- Product geolocation accuracy







Product performance verification

Acq. Mode	Product Type	Resol. Class	Resol. [m]		ENL		PSLR [dB]		ISLR [dB]	
			Req.	Meas.	Req.	Meas.	Req.	Meas.	Req. (1D)	Meas. (2D)
SM	SLC		[1.7 x 4.3] to [3.6 x 4.9]	[1.7 x 4.3] to [3.6 x 4.9]	1	0.94	< -21.2	-20.18±0.87	<-16.7	-12.56±0.81(1)
	GRD	FR	9 x 9	8.7x8.6	[3.5-3.7	3.40		-20.61±0.68		-12.81±1.14(1)
IW	SLC		[2.7 x 22] to [3.5 x 22]	[2.5 x 21.6] to [3.5 x 21.6]	1	0.94	< -21.2	-19.10±4.56	< -16.7	-12.46±3.03(1)
	GRD	HR	20 x 22	19.85x21.43	4.4	4.80		-19.72±3.34		-12.17±3.07(1)
EW	SLC		[7.9 x 42] to [14.4 x 44]	[7.9 x 42.9] to [14.6 x 43.8]	1	0.90	< -21.2	-20.54±3.12	< -16.7	-12.46±3.03(1)
	GRD	HR	50 x 50	50.56x50.46	2.7	2.60		-20.22±1.41		-11.73±4.57(1)

(1) Worse than the requirement due to the measurement approach being more stringent (2D-ISLR) than the requirement (1D-ISLR). Using an adapted approach ISLR is back within specification

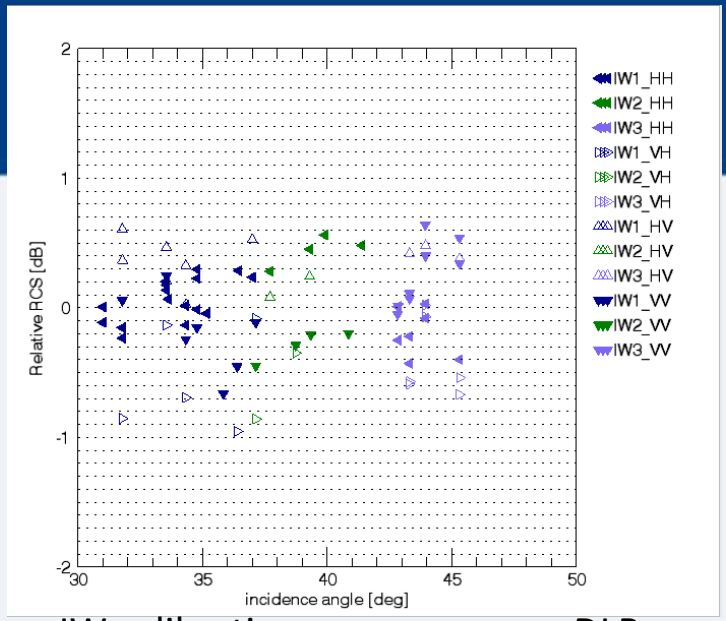
S-1 Absolute Radiometric Calibration

- Radiometric accuracy of products processed with the IPF V236, considering all beams and polarisation together
  - For SM : -0.03±0.24dB
  - For EW: -0.16±0.35dB
  - For IW: 0.016±0.3 dB

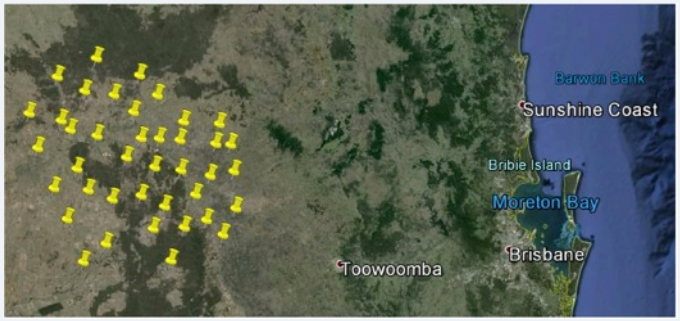
- Most of the measurement were made while all the radiometric correction were not yet applied
  - Roll correction → EAP
  - Gain variation over Rx time

- The radiometric accuracy is for the time being limited by two main issues:
  - Unexpected polarimetric gain imbalance
  - Residual of range radiometric corrections (under assessment)

- Radiometric calibration activity is on-going:
  - Geoscience Australia site
  - DLR site will restart soon



IW calibration measures over DLR target



Geoscience Australia site

Mean relative RCS IW1 = 0.01±0.23dB

Mean relative RCS IW2 =0.04±0.32dB

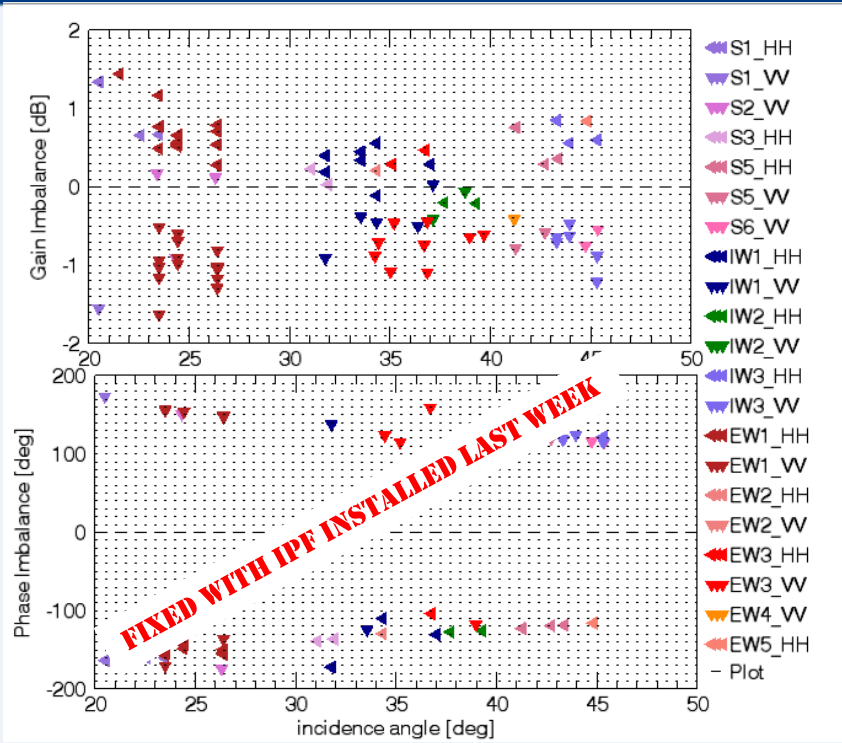
Polarimetric calibration

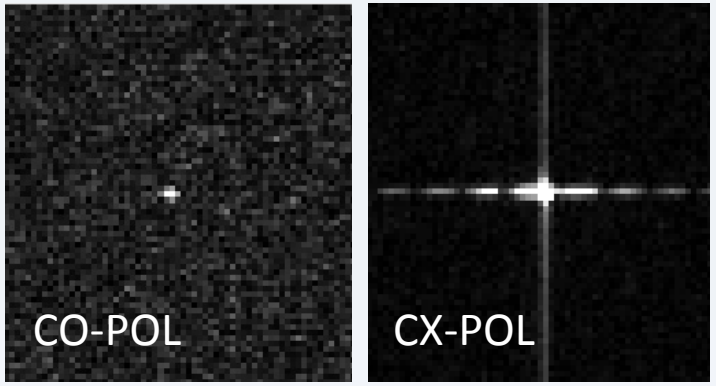
- Using the DLR transponders it has been possible to assess the polarimetric calibration:
  - ✖ Gain imbalance: RxV > RxH
  - ☑ Phase imbalance:

    →fully corrected with the latest IPF 243 installed in 19/03/2015

- DLR CR were used to measure the X-talk (antenna isolation) during the CP. X-talk ~-38dB was measured (requirement is >-30dB)

- Similar measurements are on-going with the CSA RSAT2 transponders
  - Variation between [-29, -38]dB is observed





CSA Ottawa transponder
20150312

Geolocation accuracy

- Precise geolocation has been assessed over dedicated site deployed by UZH over Torny-le-Grand and Dubendorf

- Assessment of the geolocation accuracy was performed using:
  - Different state vector sources
  - atmospheric path delay correction (3m)
  - plate tectonics (~cm)
  - Solid earth tides (~cm)

SM SLC	Slant range offset [m]	Azimuth offset [m]	SM GRDF	Slant range offset [m]	Azimuth offset [m]
~~Internal (SSP)~~	~~5.45±24.33~~	~~2.19±58.2~~	~~Internal (SSP)~~	~~5.37±2.59~~	~~0.49±59~~
~~Restituted~~	~~1.30±0.06~~	~~2.03±0.58~~	~~Restituted~~	~~1.30±0.19~~	~~1.95±0.51~~
Precise	1.27±0.06	1.96±0.41	Precise	1.27±0.19	1.89±0.40

Fix under implementation

User product

Precise geolocation accuracy

S2

4 asc., 8 desc.

Mean ± standard deviation:

Δrg 1.27±0.07 m

Δaz 1.57±0.18 m

S4

7 asc., 3 desc.

Mean ± standard deviation:

Δrg 1.27±0.06 m

Δaz 2.07±0.13 m

IW

7 asc., 3 desc.

Mean ± standard deviation:

Δrg 1.47±0.23 m

Δaz 2.45± 0.49m

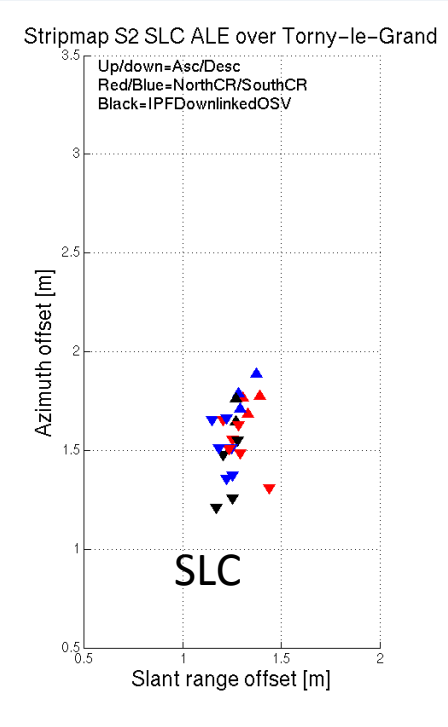
IW

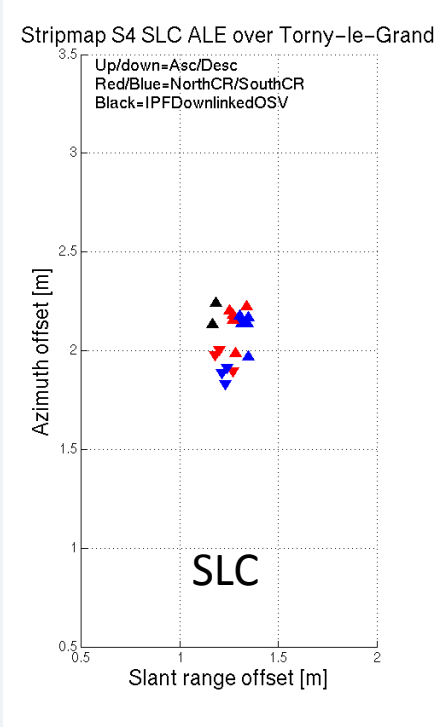
7 asc., 3 desc.

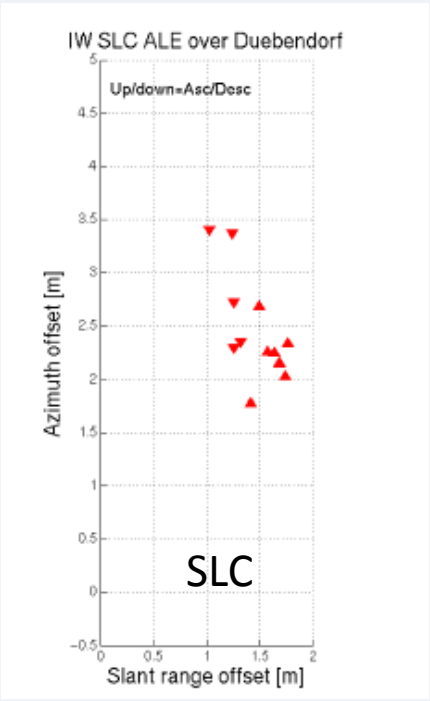
Mean ± standard deviation:

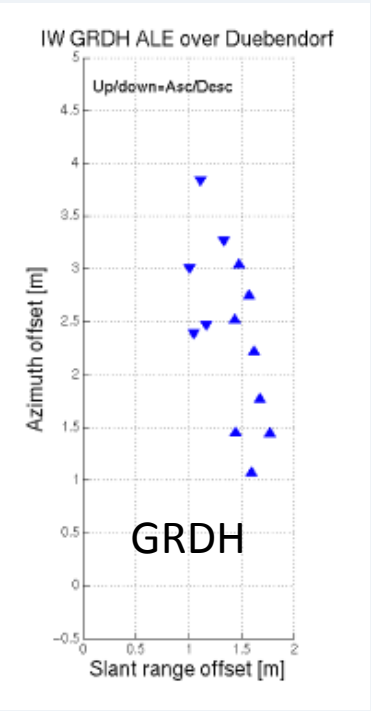
Δrg 1.47±0.25m

Δaz 2.40± 0.8m



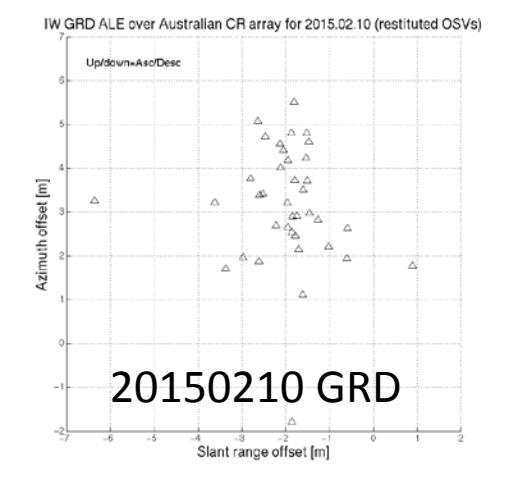






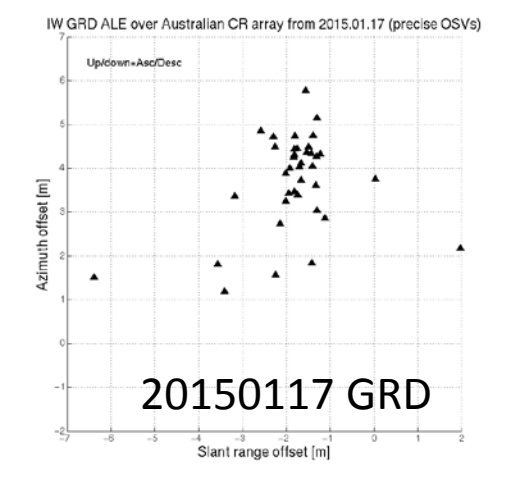
Product geometric accuracy

- What is the product geometric location accuracy if those correction are not performed?
- Absolute Location Error (ALE) has over Geoscience Australia site has been assessed
  - Range location error increases due to the non atmospheric path delay compensation (~3m) and due to inaccuracies (we believe) in the survey
  - Azimuth location error increased (survey issue)
- ALE is within the pixel!



IW GRD ALE using restituted OSVs
Mean ± standard deviation:
Δrg: -2.00±1.07 m
Δaz: 3.15±1.36 m

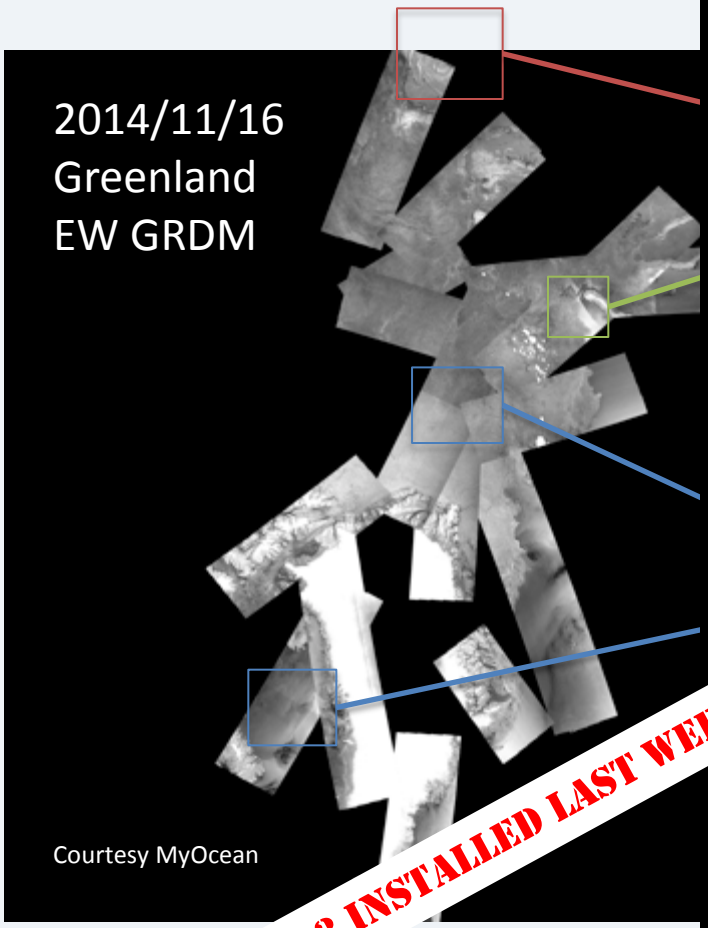
Spacing 10x10m



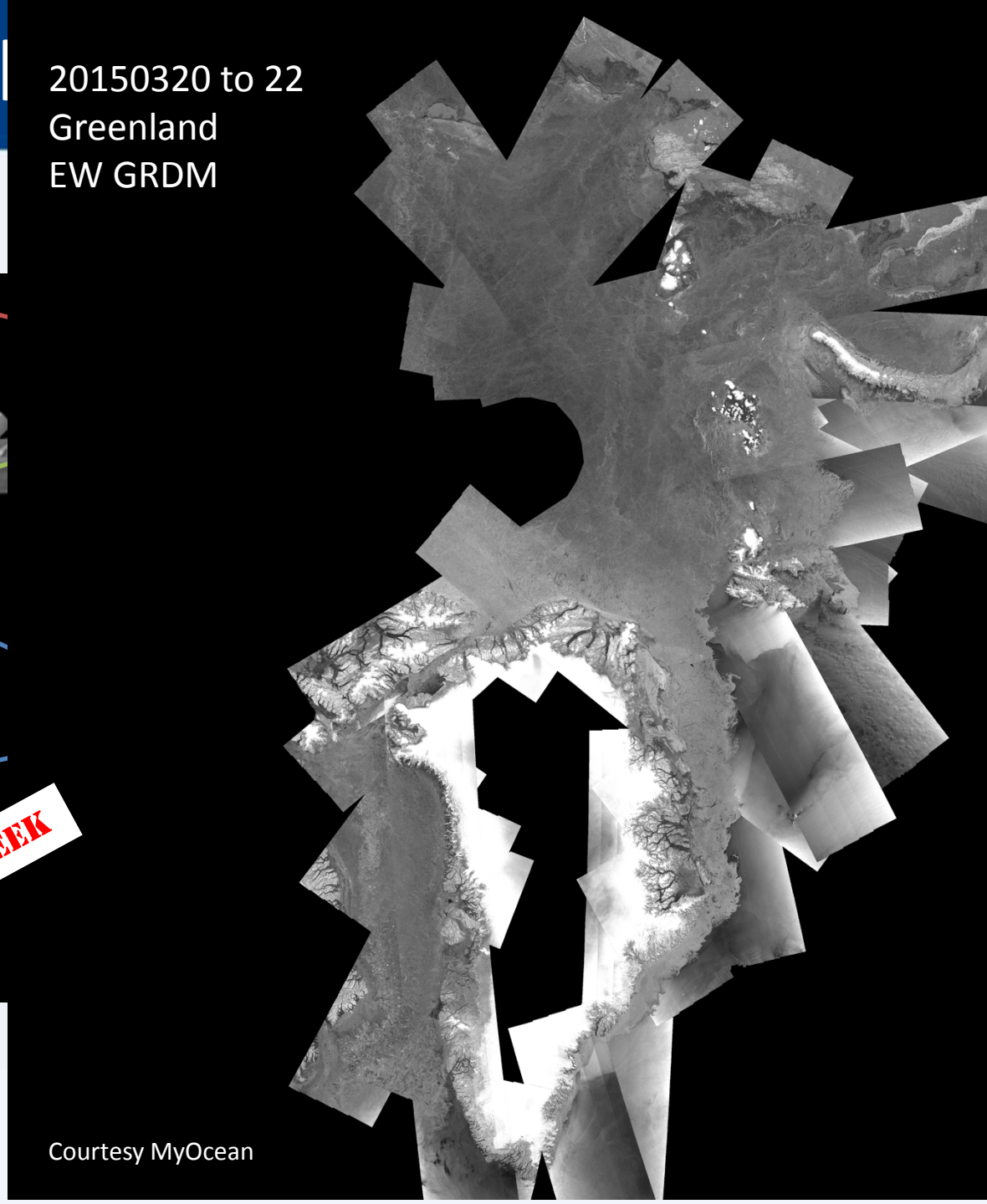
IW GRD ALE using precise OSVs
Mean ± standard deviation:
Δrg: -1.83±1.17 m
Δaz: 3.70±1.09 m

Spacing 10x10m

Anthology of sl



FIXED WITH IPF 243 INSTALLED LAST WEEK



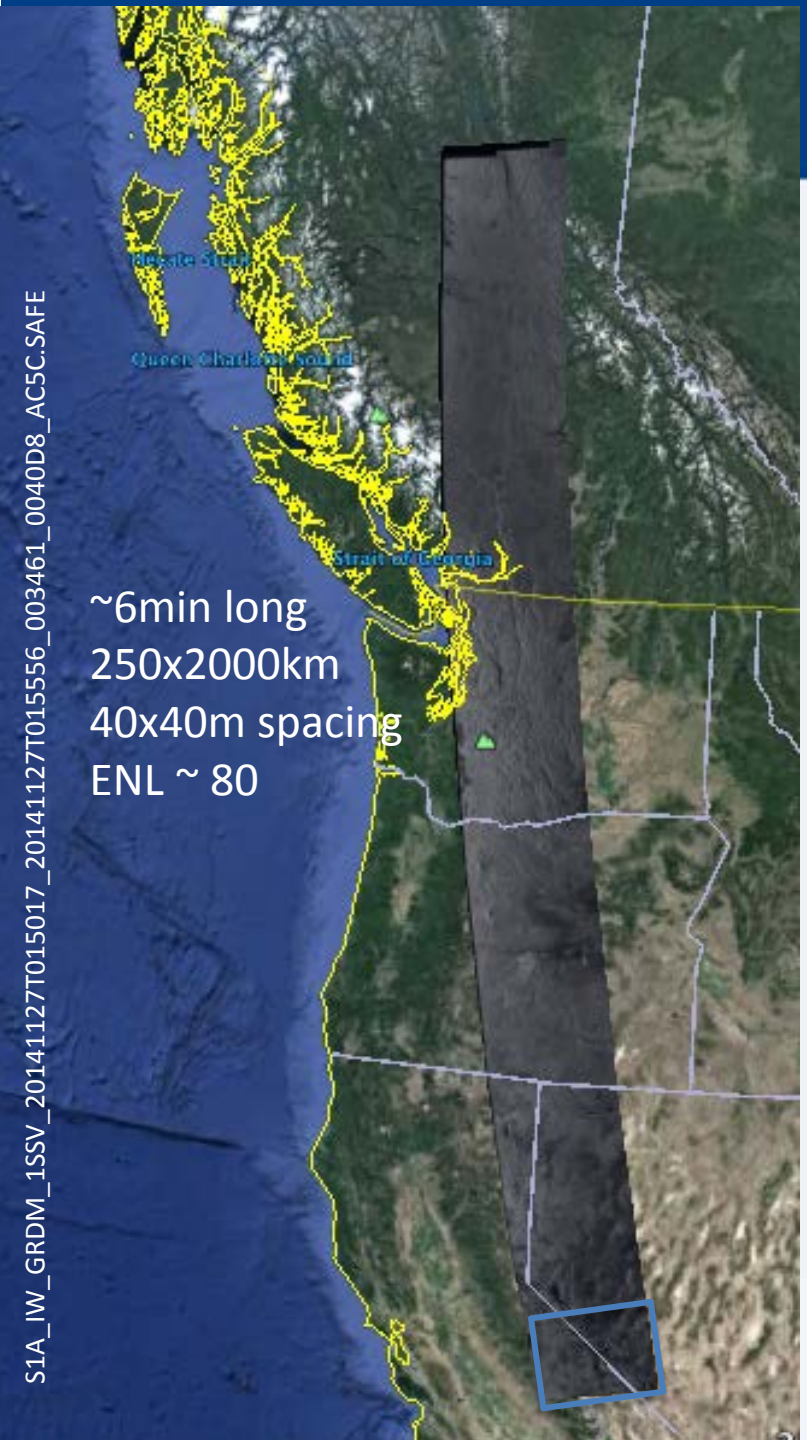
Other known issues

- L1 products are qualified but are not yet perfect!
- There are non-blocking known issues :
  - Jitter in the TOPS SLC burst timing → doesn't prevent interferometric application
  - Jitter in the product orbit annotation creating phase jumps if used → mitigated by the usage of external orbits
  - Geolocation error if no orbit files are used for processing→ mitigated by the usage of RESORB orbits during processing
  - Denoise vector not verified yet→ doesn't prevent any application
- Soon corrected
  - Scalloping in SM → will be fixed by removing the internal calibration pulse sequence from the timeline
  - Geometric Doppler not reliable → will be fixed by changing the frame of the quaternions on-board

Conclusion

- Instrument is performing as expected with no major degradation impacting the product quality since IOCR
- S-1A Level-1 product qualification is completed. S-1A products are suitable for supporting all applications including INSAR
- Instrument and product performance are routinely monitored by a dedicated team of experts (S-1 Mission Performance Center)
- Product improvement loop is on-going:
  - Know issues are being addressed
  - Further improvement in the radiometric calibration will come in short term
- We need your feedback to improve

EOSUPPORT@COPERNICUS.ESA.INT


Strait of Georgia
~6min long
250x2000km
40x40m spacing
ENL ~ 80
S1A_IW_GRDM_1SSV_20141127T015017_20141127T015556_003461_0040D8_AC5C.SAFE