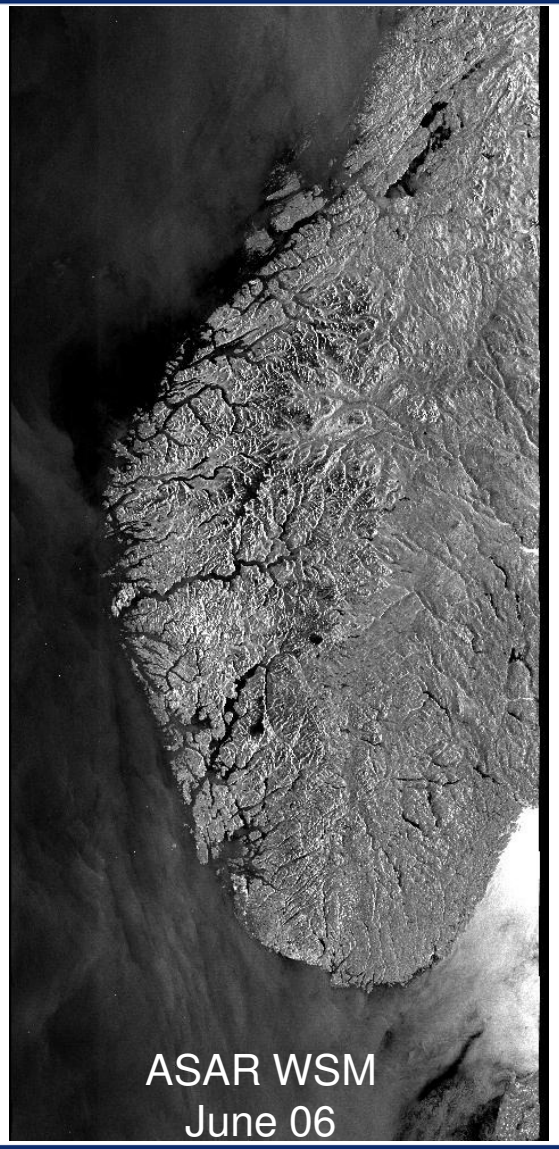
STATUS OF ENVISAT ASAR INSTRUMENTS AND PRODUCTS

N. Miranda*, P.J. Meadows**, D. D'Aria***, D. Giudici***
*ESA, **BAE Systems, ***Aresys

Summary of ASAR Status

- Envisat is now in its 8th year of operation (launched in March 2002 for a nominal mission of 5 years)
- All modes operational with nominal performance
- Alternating Polarisation Mode constraints removed thanks to the upload of the on-board s/w pacth#09 in May 2009 → reduction of AP swath wrt Image Mode
- Instrument status:
  - Redundant Data Sub System (since 03)
  - Antenna TRM failures with minimal impact on performance



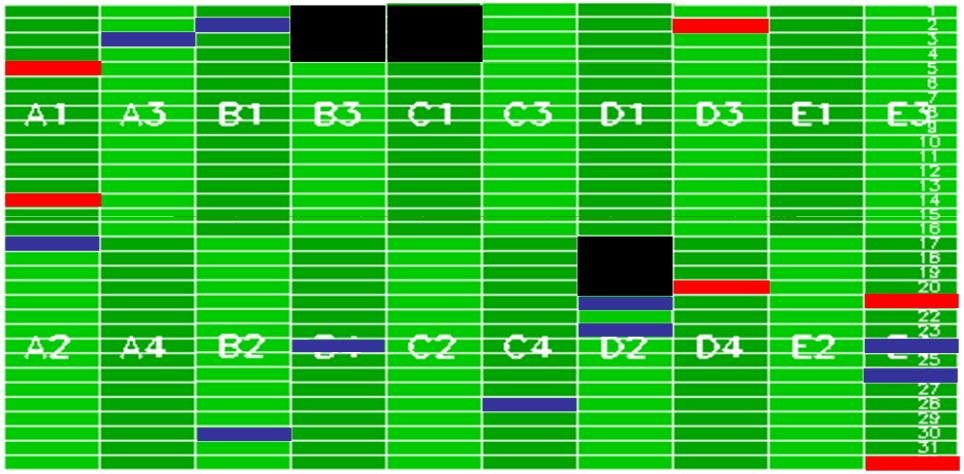
ASAR WSM
June 06

ASAR: an active antenna

Antenna failures since launch:

- partial PSU failures (8 TRMs) in Tx (HH & VV): May02, Feb07
- 1 complete PSU failure (4 TRM in Tx & Rx, HH & VV): Feb03
- individual TRMs failures in Tx (10 in HH and 6 in VV): Apr04,May04, Nov04 Jan05,Nov05,Jan07 May07,Jul08,Oct08 Jan09, Jul09, Sep09, Oct09, Dec09, Jun10

Tx-H
TX-V
Both Tx

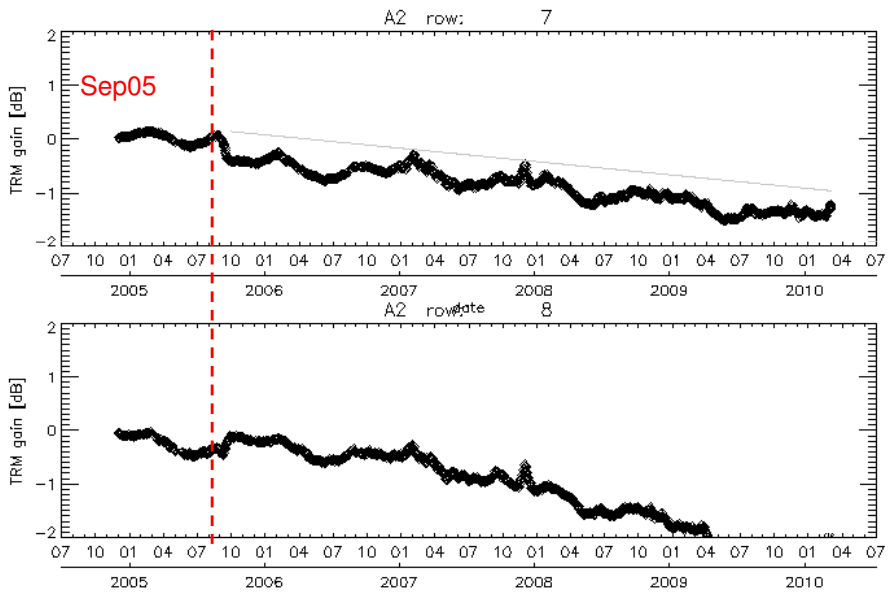


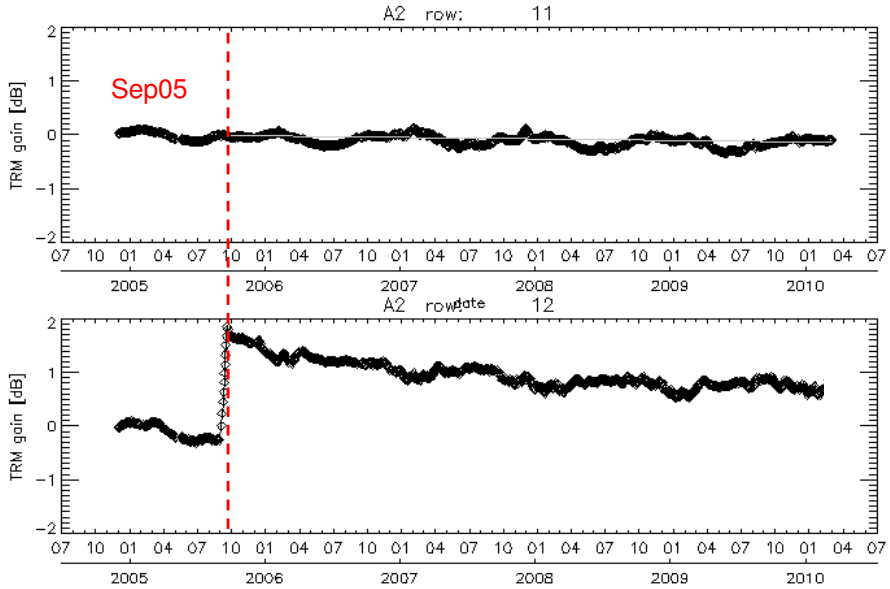
Total of: 22 TRMs failures in Tx-H and 18 in Tx-V
4 TRMs failures in Rx in each polarisation

→ No significant degradation on the performance and data quality

ASAR antenna: TRM drifts

- TRM gain and phase drifts are monitored in time with the dedicated Module Stepping (MSM) calibration mode
  - One MSM product acquired every day → daily antenna monitoring

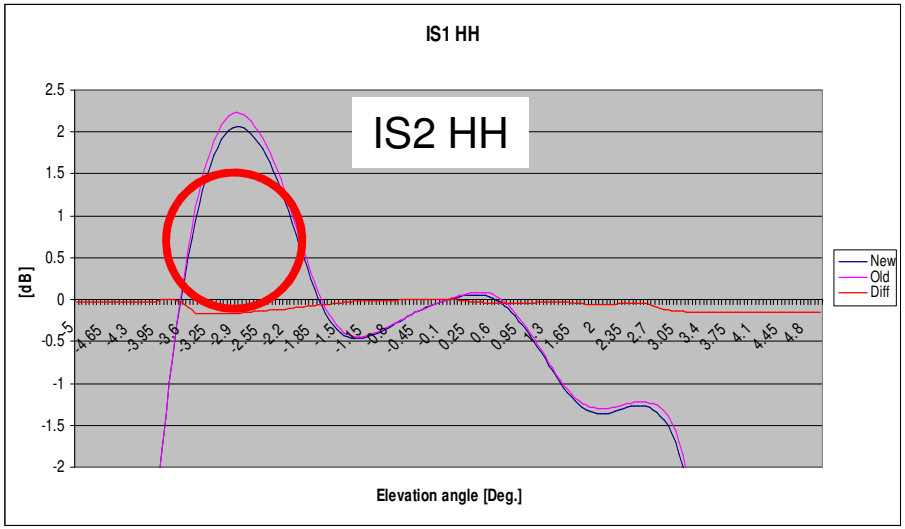


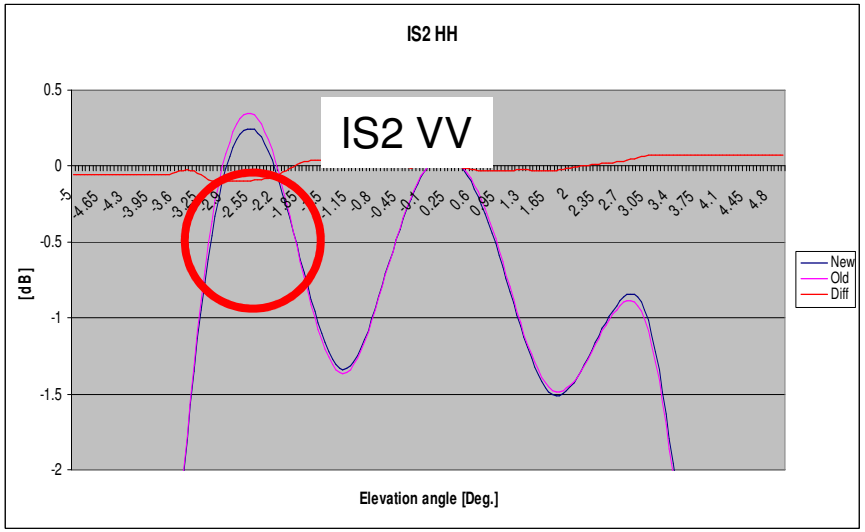


  - TRM gain & phase drifts can be corrected:
    - A first correction performed on 14&16 September 2005
    - A second correction performed on 11 and 17 March 2010 (2 steps)

ASAR: Recalibration

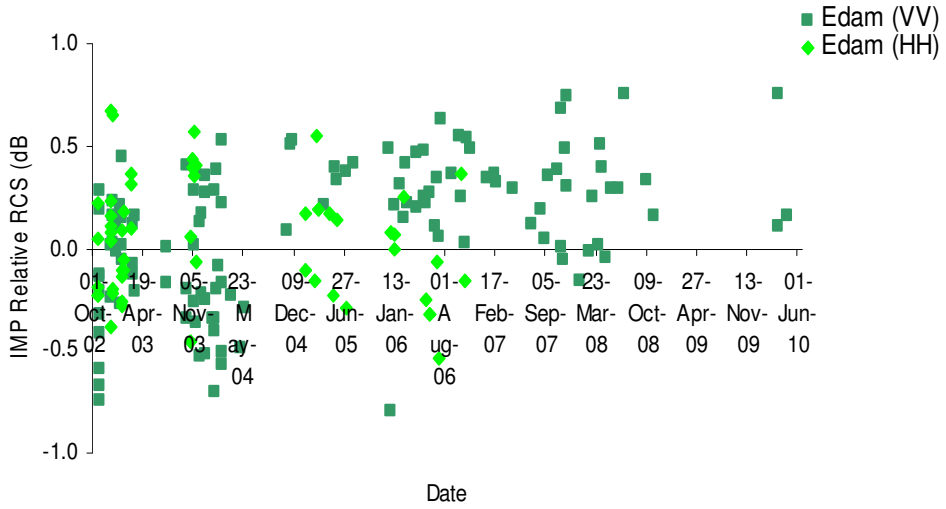
- An antenna maintenance activity took place in March 2010 (next talk)
- This implies slight changes in the radiating beam patterns and internal calibration pulses levels
- Re-calibration campaign undertaken and completed in 09/06/2010 with dissemination of new EAP and reference gains:
    - Changes in EAP HH:IS1 to IS7, SS2 to SS5
    - Changes in EAP VV:IS3 to IS7, SS1 to SS5





ASAR Radiometric calibration (1/2)

- Instrument absolute radiometric calibration
  - Derivation of the absolute calibration factor
  - Determination of the radiometric accuracy and stability from transponders



Tran. Site	Product Type	Operation Dates	Relative RCS (dB)	Num
NL	IMP	25/09/02 – 21/04/10	0.07±0.33	181
	APP	12/11/02 – 08/11/06	0.04±0.30	98
KP	IMP	07/07/06 – 08/10/08	-0.55±0.67	121
	APP	04/07/06 – 22/03/07	-0.75±0.38	20
OT	IMP	04/12/06 – 23/05/10	-0.29±0.60	189
	APP	30/10/06 – 04/05/10	-0.39±0.43	10
RE	IMP	22/08/06 – 01/10/07	-0.40±0.63	51
	APP	24/08/06 – 23/11/06	-0.01±0.19	13

ASAR Radiometric calibration (2/2)

ASAR radiometric accuracy and stability:

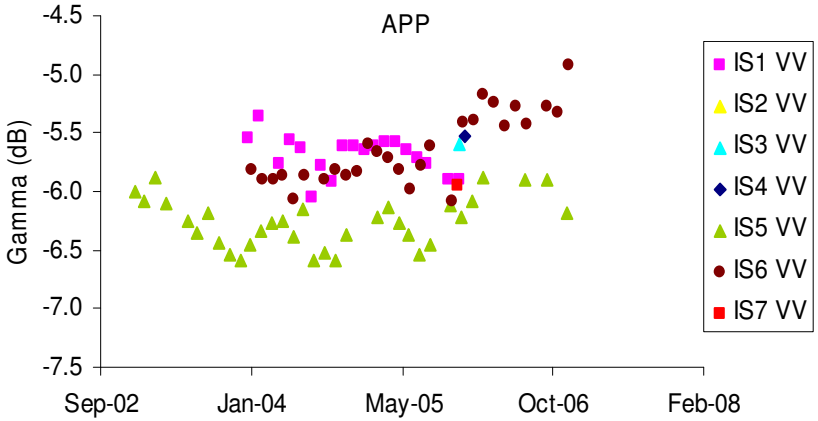
- NL transponders and all swaths (previous slide):
  - IMP : relative RCS = 0.07 ± 0.33dB
  - APP: relative RCS = 0.04 ± 0.30dB
- All transponders and all swaths:
  - IMP : relative RCS = -0.24 ± 0.60dB
  - APP : relative RCS = -0.11 ± 0.41dB

http://earth.esa.int/pcs/envisat/asar/public_reports/

Product	All Swaths	IS1	IS2	IS3	IS4	IS5	IS6	IS7	Num
IMP	-0.24±0.60	-0.17	-0.20	-0.57	-0.44	-0.04	-0.03	-0.28	542
IMG	-0.19±0.63	-0.35	-0.22	-0.47	-0.45	0.17	0.09	-0.09	540
IMS	-0.19±0.60	-0.33	-0.08	-0.57	-0.43	-0.04	0.08	-0.15	540
APP	-0.11±0.42	-0.42	-0.22	-0.07	-0.10	-0.03	0.07	-0.07	141
APG	-0.10±0.50	-0.37	-0.21	0.00	-0.17	-0.14	0.20	-0.09	140
APS	-0.12±0.52	-0.28	-0.26	0.02	-0.35	-0.15	0.10	0.03	139

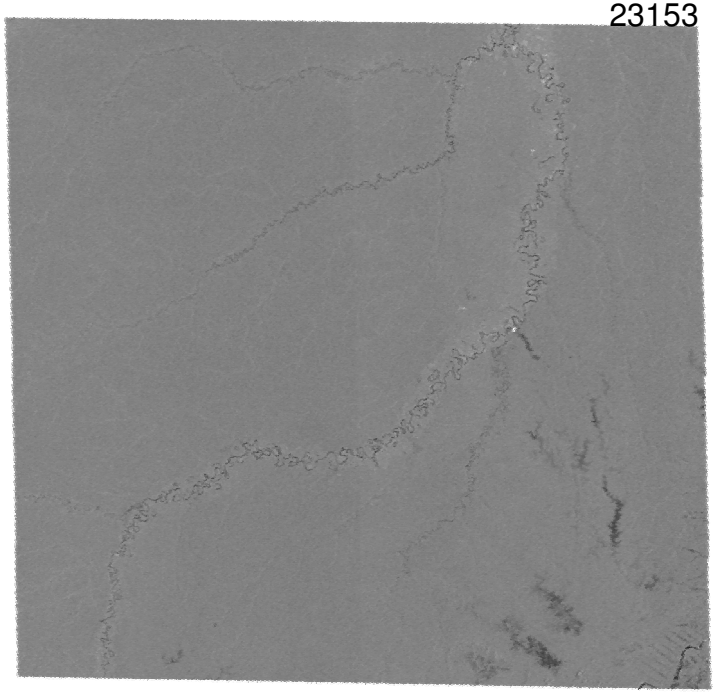
ASAR Radiometric calibration (3/3)

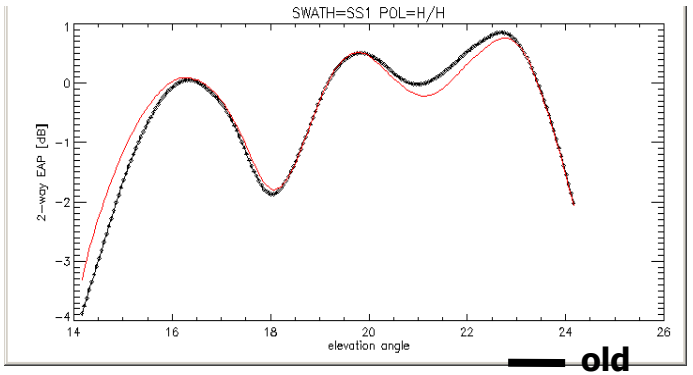
- Routine Monitoring of the Elevation Antenna Pattern:
  - Over the Amazonian Rain Forest



Amazonian Rain Forest mean gamma temporal evolution

Amazonian Rain Forest, ASAR WSM, orbit 23153

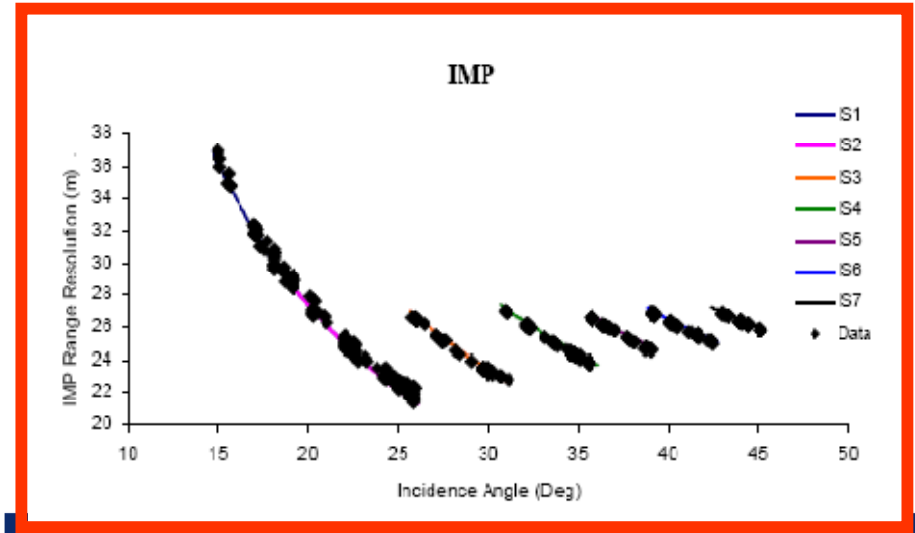


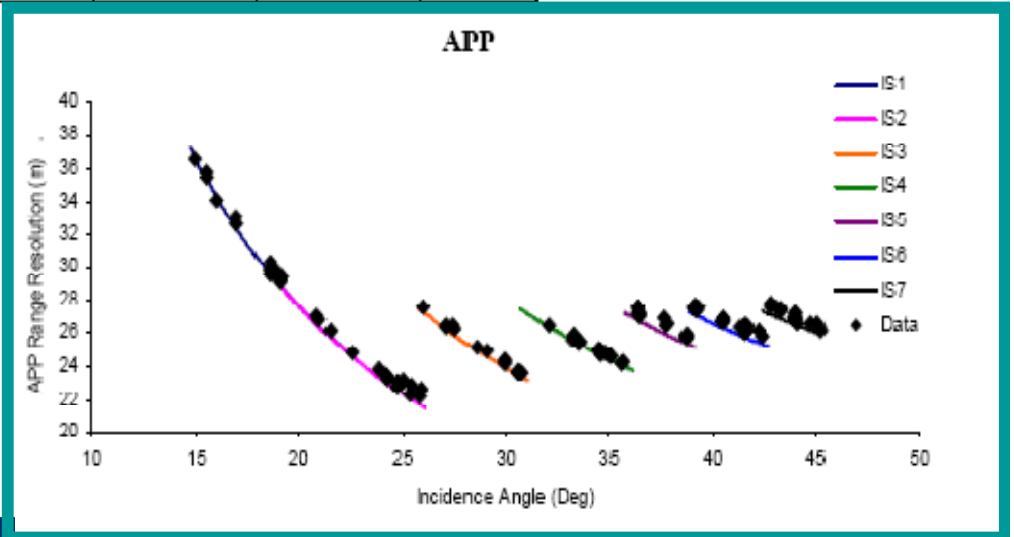


ASAR instrument performance (1/2)

- IRF parameters measured using the transponders:
  - Nominal IRF Quality parameters

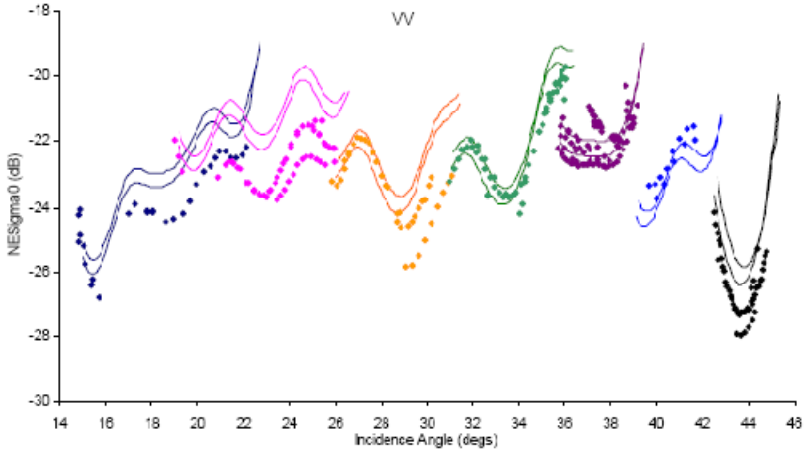
Product Type	Azimuth Res (m)	Range Res (m)	ISLR (dB)	PSLR (dB)	SSLR (dB)	No of Results
IMP	22.14±0.49	Fig 1(a)	-13.48±0.55	-16.72±0.99	-22.76±1.76	459
IMG	22.39±0.47	21.6 – 35.8	-13.54±0.53	-16.90±1.01	-23.51±1.68	458
IMS	4.77±0.04 5.56±0.07	9.43±0.05	-14.45±0.29	-19.07±0.46	-28.38±0.63	450
APP	27.61±0.79	Fig 1(b)	-12.87±0.47	-19.13±0.99	-27.04±1.61	133
APG	27.70±0.76	22.6 – 36.4	-12.94±0.49	-19.23±0.97	-27.70±1.30	132
APS	4.42±1.83	8.40±0.07	3.95±2.49	-1.98±1.38	-16.90±4.33	131



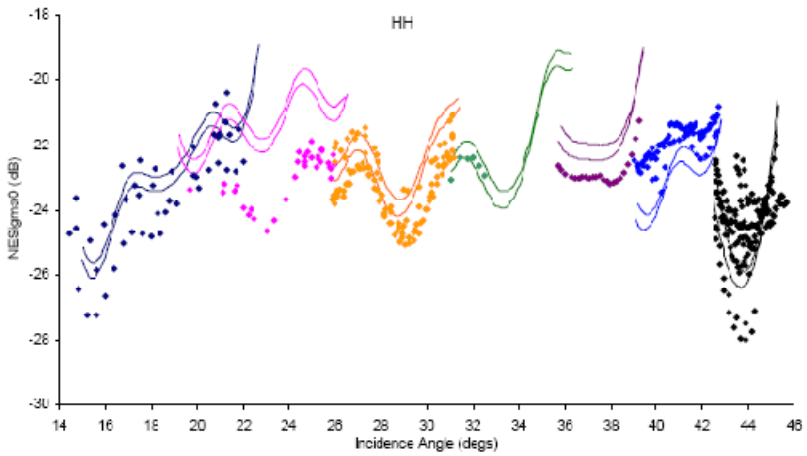


ASAR instrument performance (2/2)

- NES0 monitoring based on data measurement over areas of very low backscatter (ocean, lakes)
  - No significant drift or pattern indicating an instrument performance degradation



IMP



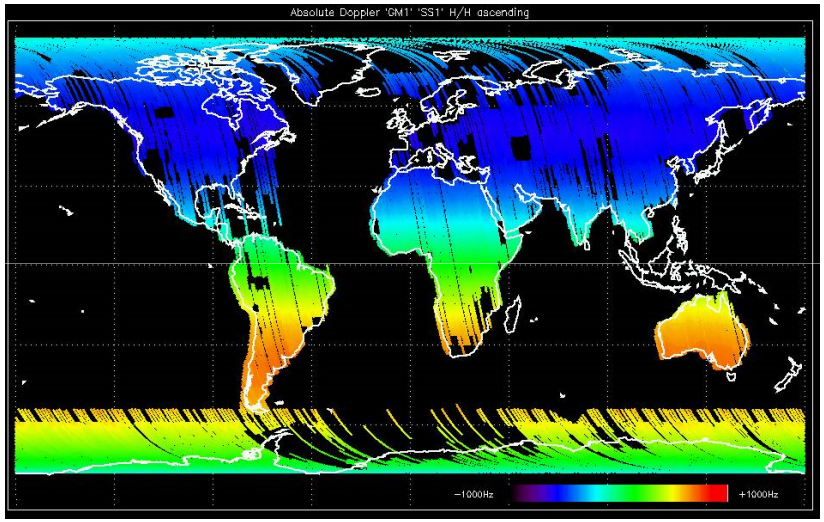
IMP

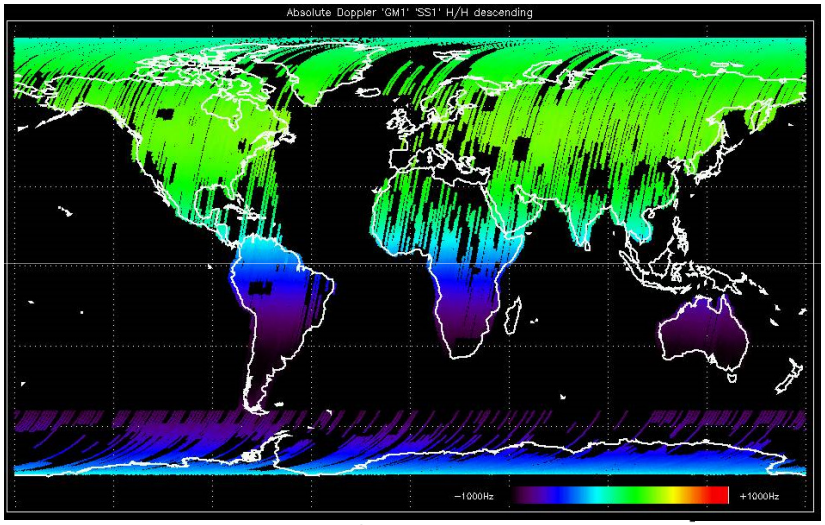
http://earth.esa.int/pcs/envisat/asar/public_reports/

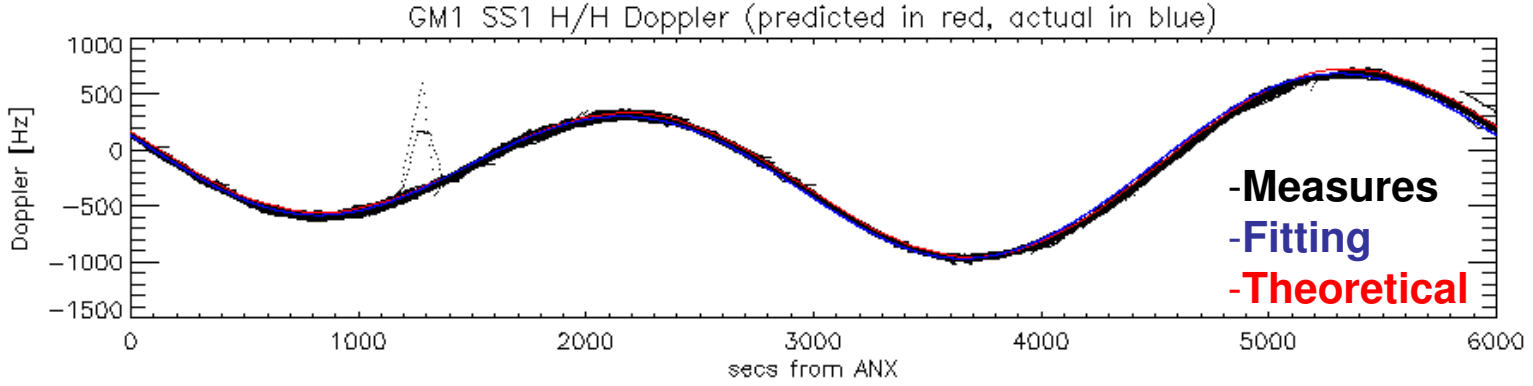
Pointing / Doppler performance

- Antenna pointing monitored through the Doppler annotation in L1 products
  - → Very good antenna pointing performance

October-November 2009







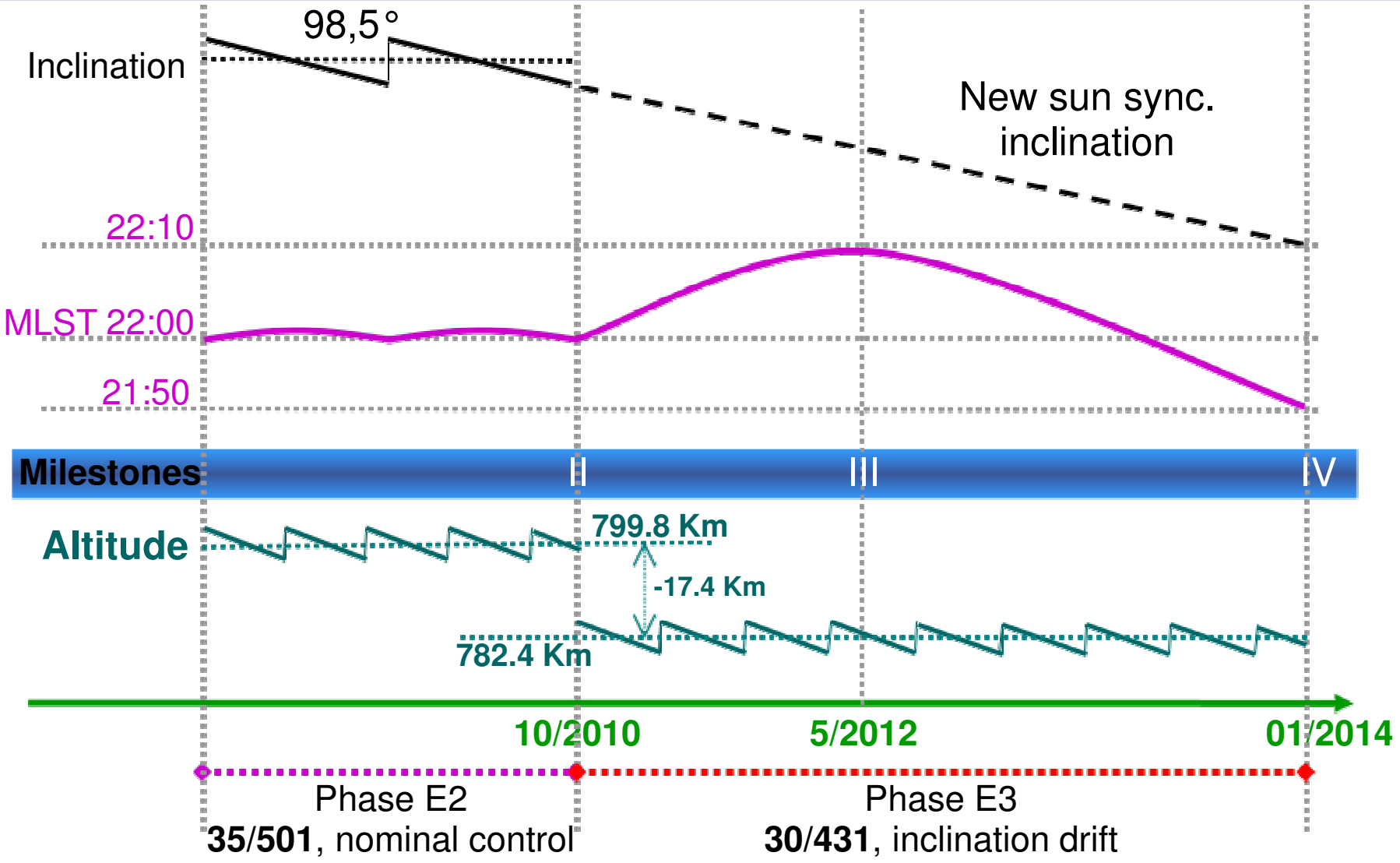
ASAR Mission extension

Envisat Mission extension

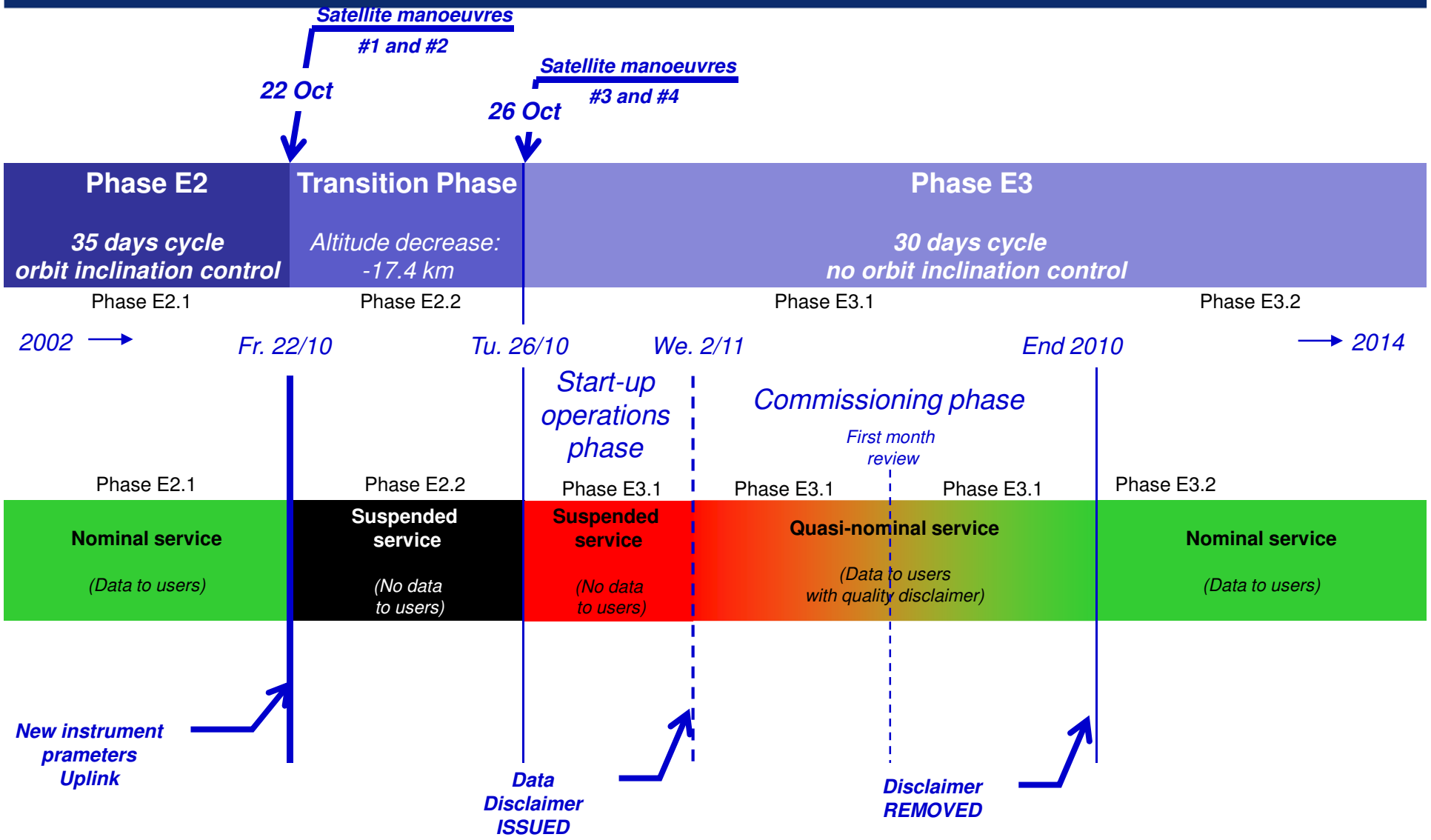
Rationale:

- Envisat has limited amount of hydrazine on-board
- The current orbit control strategy is demanding in terms of hydrazine consumption
- Maintaining the current orbit control means a mission end of life in ~2012
- A new orbit control strategy has been proposed allowing to extend ALL Envisat missions with the smallest impact possible on applications
- New orbit scenario will be applicable since 26/10/2010:
  - New orbit lowered by ~17km (799km → 782km)
  - New repeat cycle (30/431)
  - New orbit control strategy (no inclination control)
  - Mission extended till 2014 (40 cycles)

Mission Extension Scenario



Mission extension phases



Mission extension phases

- Phase E2.1: current phase till 22/10/2010
- Phase E2.2: transition phase 22 to 26/10/2010
  - New instrument parameters uplink
  - Instrument operated in WV mode for thermal (safety) reasons
  - No data delivered to the users

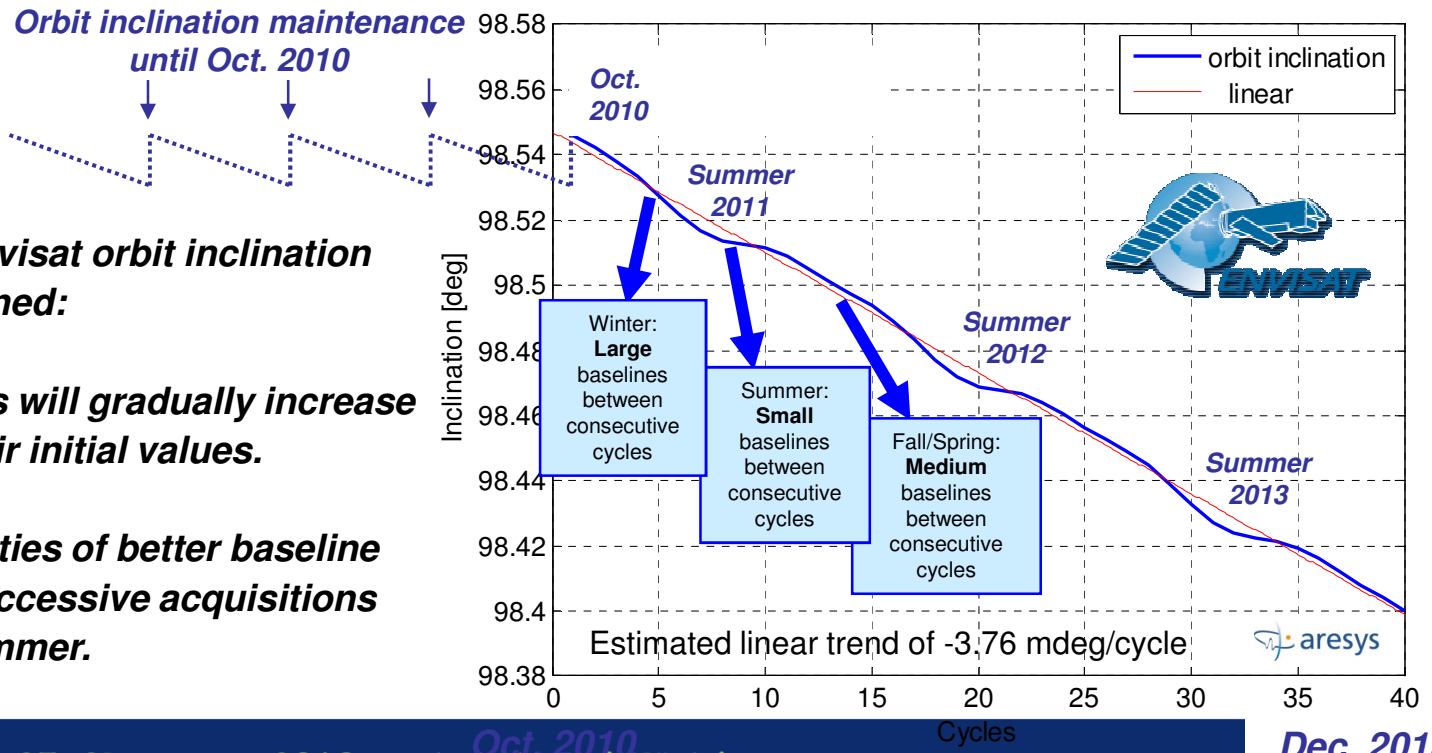
- Phase E3.1 – startup operation phase (26/10 to 02/11/2010)
  - Instrument and product vital verifications
  - → Quality disclaimer issued to notify on the initial data quality
  - → Data open to the users on the 02/11

- Phase E3.1 – Commissioning phase (02/11/2010 to end 2010)
  - Instrument and product re-calibration
  - Performance monitoring
  - Specific Wave IS4/HH campaign of 2 weeks planned
  - → Dissemnination of new auxiliary data files
  - → Removal of disclaimer

- Phase E3.2: 2011 to end of life: Nominal services

Impacts of new orbit on ASAR data quality and applications

- The ASAR instrument will have to be reconfigured with new optimal settings for every swath. The reduced orbit altitude may improve the instrument sensitivity.
- As the coverage in Wide Swath mode is ensured with the new orbit, the monitoring applications will be maintained (e.g. oil slick monitoring, sea ice monitoring, ship detection).
- ASAR Interferometry will be largely affected due to the slow orbit inclination drift. Indeed interferometric baselines will be too large outside a geographical band around 38 deg latitude.



After Oct. 2010, Envisat orbit inclination will not be maintained:

➔ ***InSAR baselines will gradually increase with respect to their initial values.***

➔ ***some opportunities of better baseline values between successive acquisitions during (boreal) summer.***

Dec. 2013

ASAR Instrument reconfiguration

- The orbit lowering implies that the ASAR instrument needs to be reconfigured with optimal parameters for each swath

- Instrument reconfiguration drivers:
  - Keep the beams as per current definition → conserving the same antenna excitation coefficients and thus the same radiating beam pattern
    - ➔no recalibration of the beams necessary
  - Maintain the instrument performance as today (e.g. no nadir return in Rx window, DTAR, sensitivity,…)
    - ➔PRF, SWST, SWL and Tx pulse length have to be re-optimised
    - ➔New swath definition

Swath characteristics

- Small impact on swath characteristics:
  - Total access (IS1 → IS7) reduced by ~11-12km on ground.
  - Swaths closer to nadir and shifted from 4.1km (at near swath) to 15.7km (at far swath).
  - Swath extent lowered by 1.6-5.3 km for all the swaths

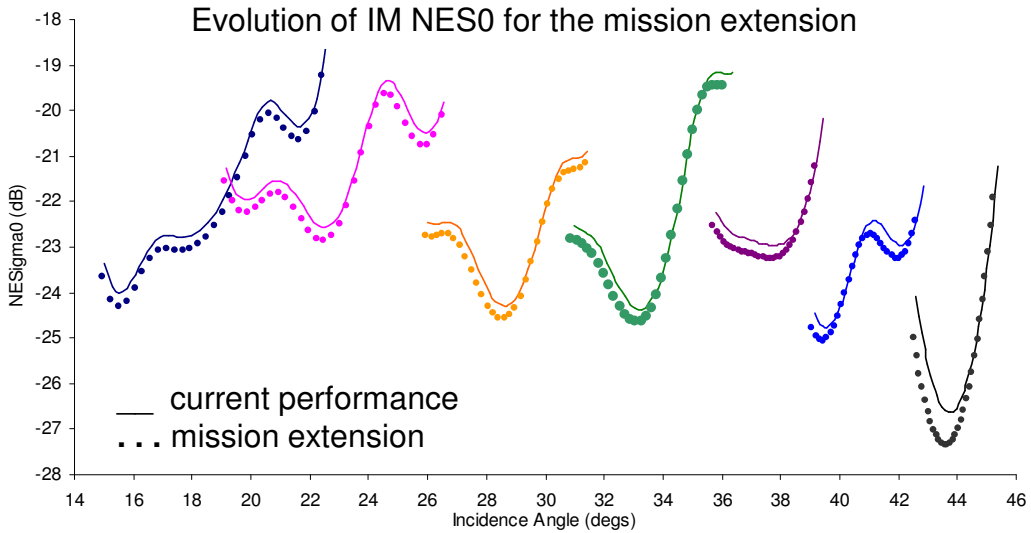
- As the coverage in Wide Swath mode is ensured with the new orbit, the monitoring applications will be maintained (e.g. oil slick monitoring, sea ice monitoring, ship detection).

swath	New swath characteristics					
	look angles		incidence angle		swath	
	Look angle near range [deg]	Look angle far range [deg]	Incidence angle near range [deg]	Incidence angle far range [deg]	ground range coverage [km]	swath overlap [km]
IS1	13.2	20.1	14.9	22.8	105.1	n/a
IS2	16.8	23.5	19.0	26.6	104.9	48.7
IS3	22.9	27.6	25.9	31.4	83.2	11.8
IS4	27.2	31.7	30.9	36.2	85.9	8.9
IS5	31.3	34.2	35.7	39.2	61.9	14.3
IS6	34.1	37.1	39.0	42.7	68.4	3.7
IS7	37.0	39.3	42.5	45.3	56.5	5.3
WS1	15.1	23.6	17.1	26.8	133.4	n/a
WS2	22.9	27.7	25.9	31.5	83.2	14.6
WS3	27.2	31.9	31.0	36.4	89.5	9.0
WS4	31.3	34.3	35.7	39.2	62.6	20.3
WS5	37.2	34.1	42.8	39.0	72.1	5.4

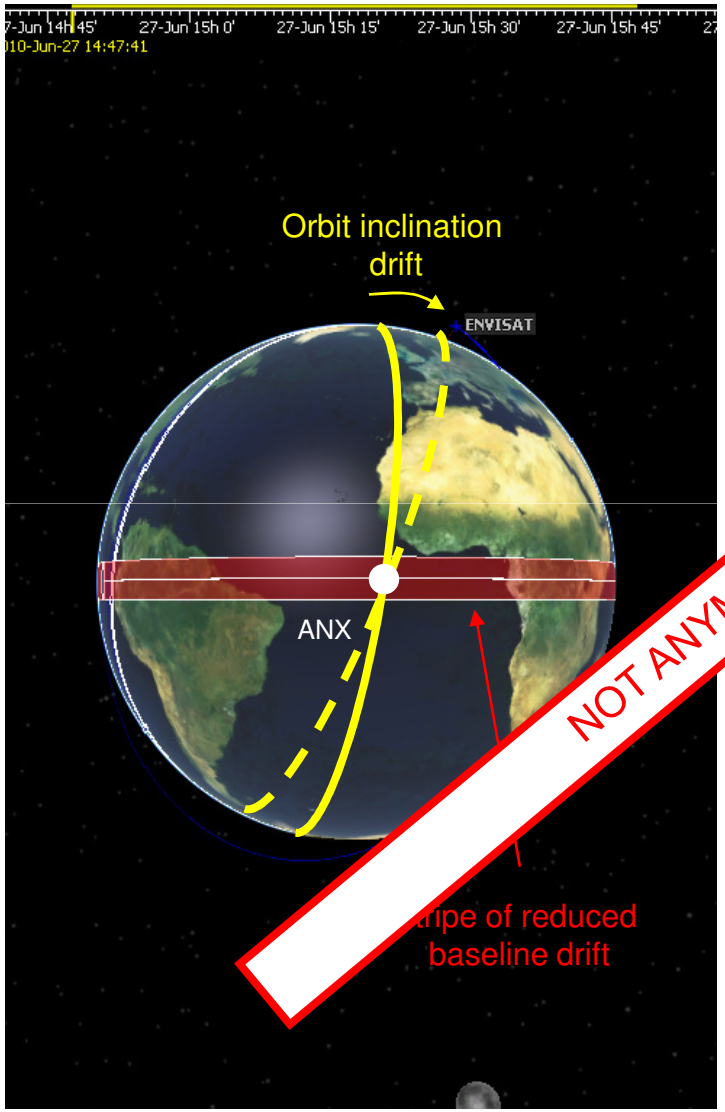
Values are under refinement and might slightly change

Instrument performance

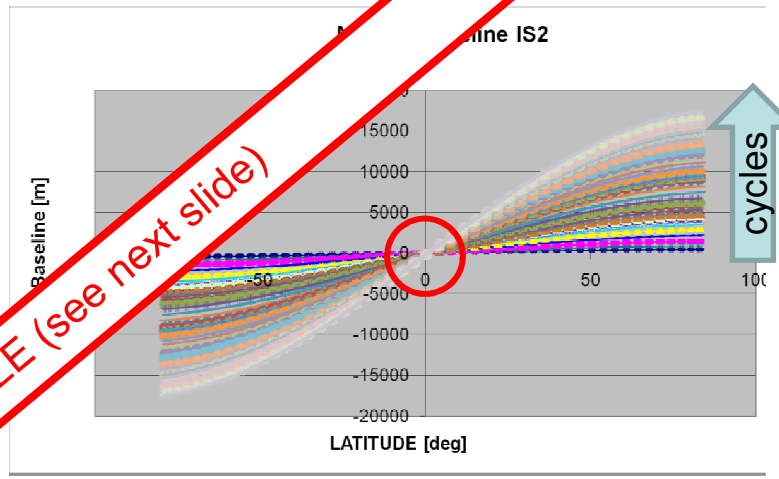
- After instrument reconfiguration the performance will remain similar as today:
  - (almost) no impact on IRF parameters
  - No impact on radiating beam patterns
  - Slight improvement of the instrument sensitivity



ASAR extension: interferometry (Dec 2009)



Baseline analysis

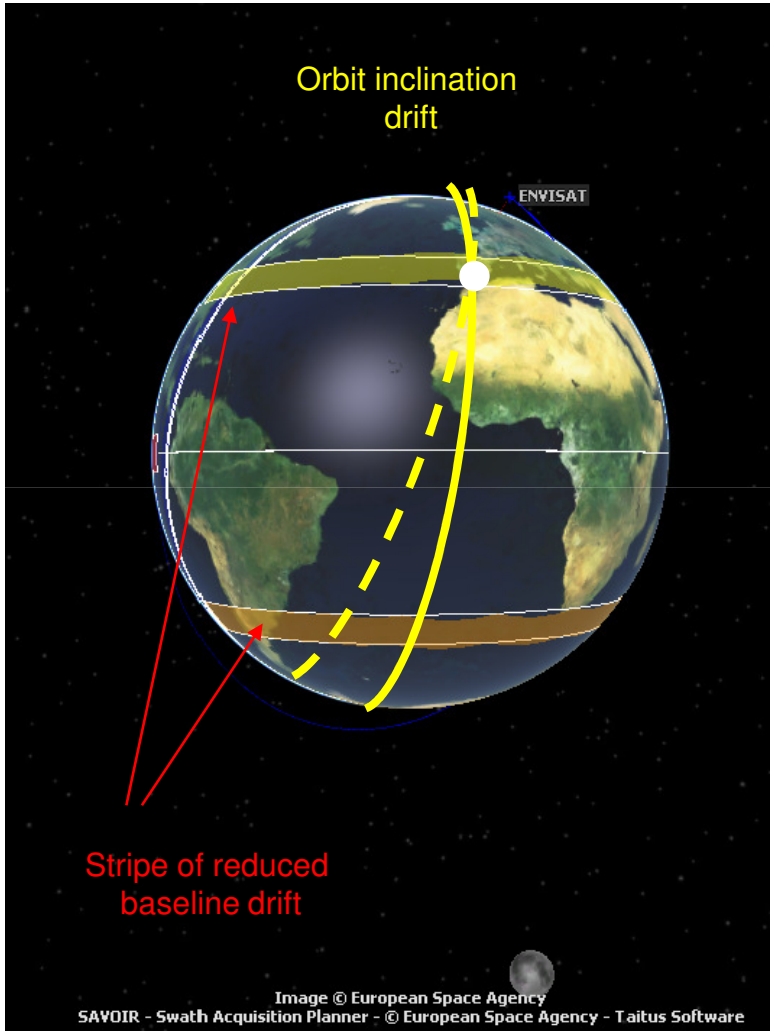


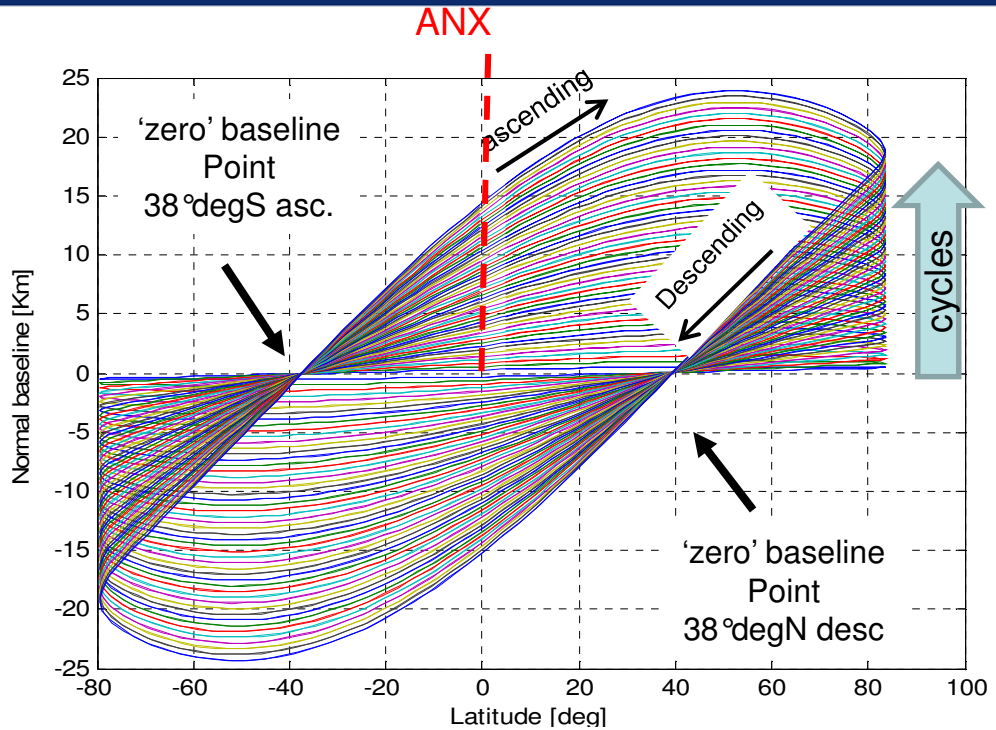
NOT ANYMORE APPLICABLE (see next slide)

Inclination drift induces an increase of the baseline that is latitude dependent:

- Equator: small baseline increase
- Increase with the latitude
- It is possible to identify an area centered around the equator where baseline remains small → maximising the chances of finding interferometric pairs

ASAR extension: interferometry



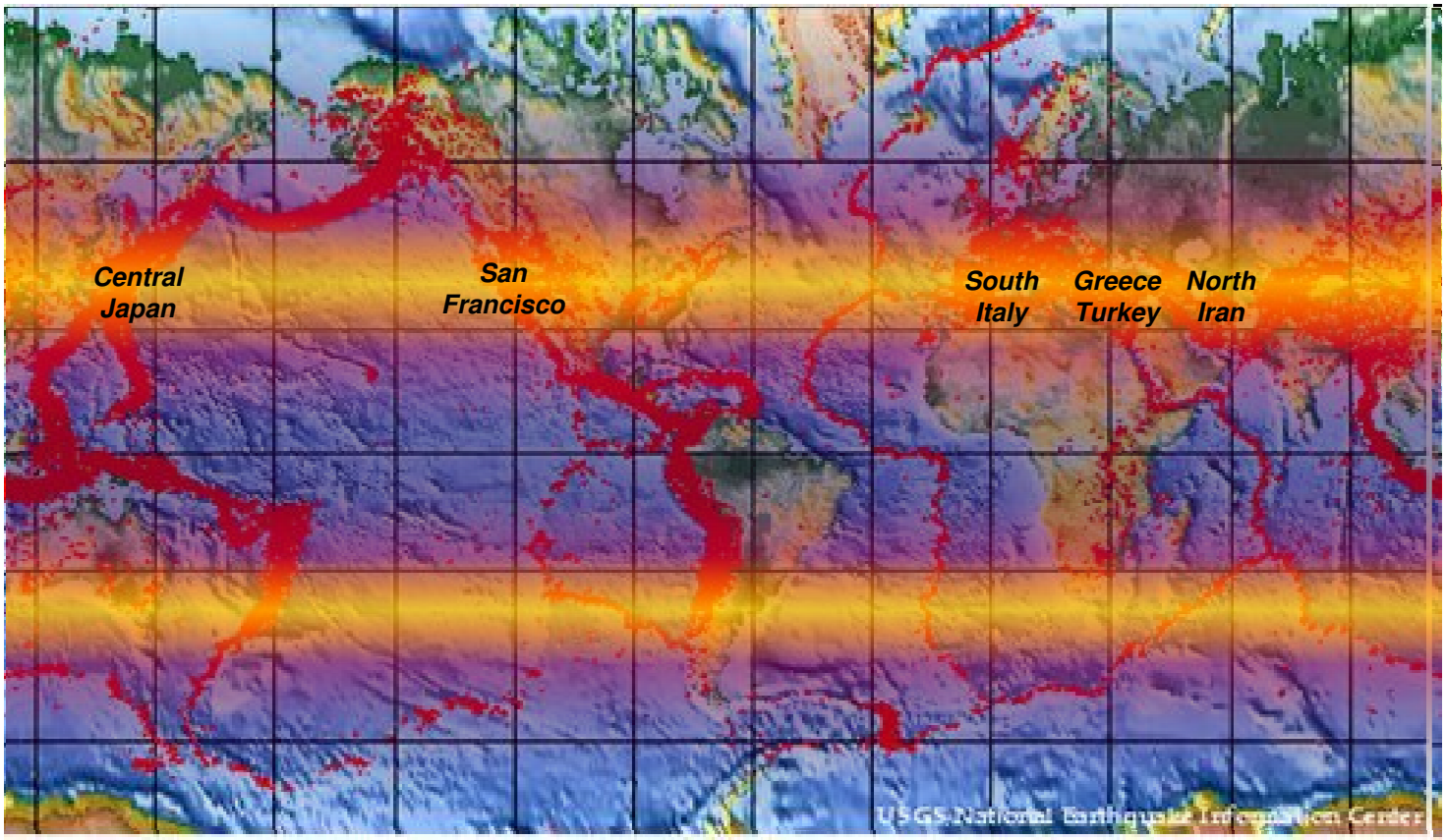


- Rotation of the orbital node such that the reduced baseline area matches with interesting tectonics area:
  - 38deg North descending allowing to cover: South Italy, California, Turkey, Iran, Japan,…
  - 38degN ascending (symmetrical to the previous

ASAR Interferometry after October 2010

For differential interferometry, smallest multi-pass baseline values will be within a band centred at 38 deg. latitude North (for descending pass) and at 38 deg. latitude South (for ascending pass).

38 deg N
Descending pass



38 deg S
Ascending pass

Conclusion

- ASAR is performing well since the beginning of the mission
  - Performance are routinely monitored and the results are available on a cyclic basis

    http://earth.esa.int/pcs/envisat/asar/public_reports

  - Quality parameters are well within the requirement
- ASAR mission extension allows data provision till 2014
  - Swath reduction but no performance degradation
  - All applications are maintained untouched except INSAR
  - New orbit definition has been defined to maintain a certain INSAR capacity in interesting tectonic areas

Thank you

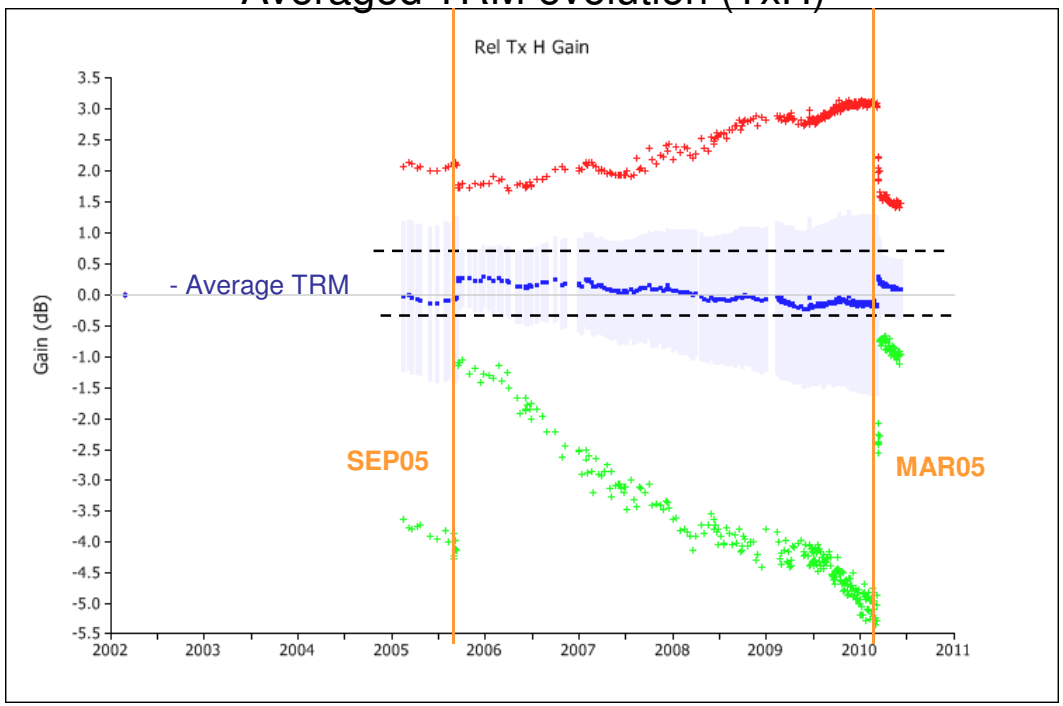
STATUS OF ENVISAT ASAR INSTRUMENT AND PRODUCTS

N. Miranda
Earth Observation Application Programmes
Ground Segment Department

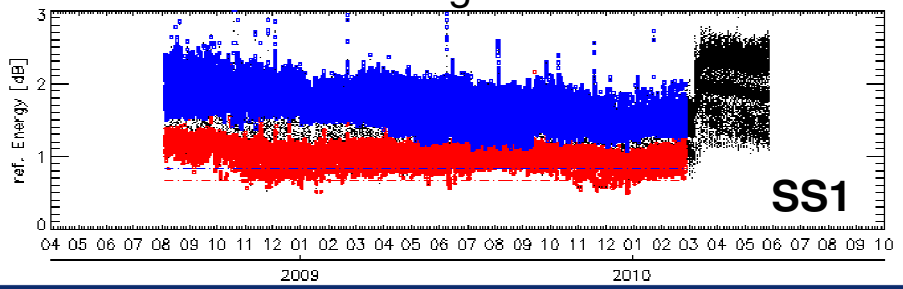
aresys
BAE SYSTEMS

ASAR: antenna maintenance

Averaged TRM evolution (TxH)



Instrument gain variation



- Majority of TRM gain and phases values are:
  - closer to the pre-launch values
  - similar to just after the previous maintenance in September 2005
- Instrument gain increased as expected
- Unless significant changes happen, it is not planned to perform this antenna maintenance again before the end of the mission

ASAR: antenna maintenance

- Majority of TRM gain and phases values are:
  - closer to the pre-launch values
  - similar to the ones just after the previous maintenance in September 2005

- Instrument gain has increased as expected

- Unless significant changes happen, it is not planned to perform this maintenance again before the end of the mission

ASAR: antenna maintenance

A significant **antenna maintenance activity** was undertaken on 11-17 March 2010, to correct as much as possible, the existing TRMs gain & phase drifts.

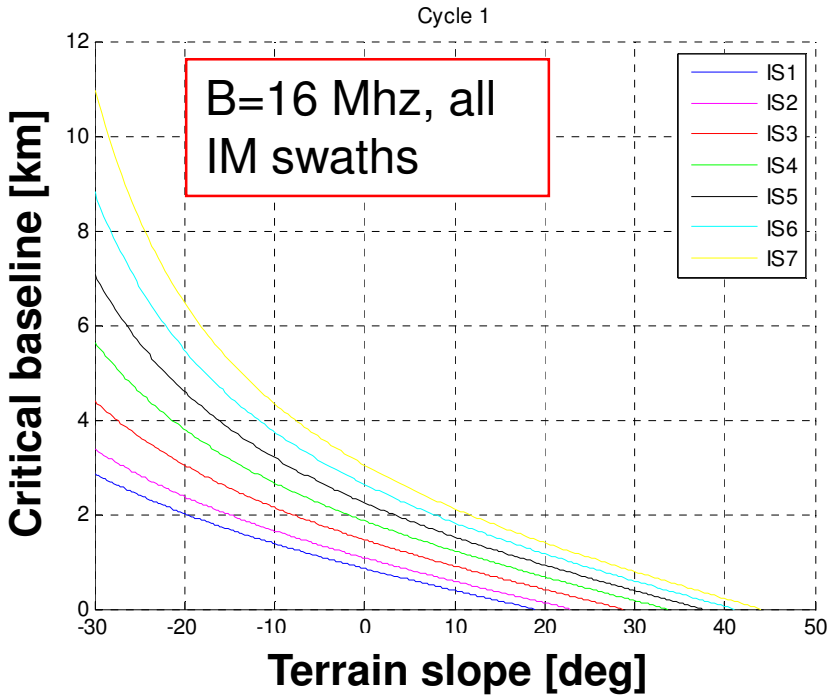
ASAR extension: interferometry

What is the interferometric area extent ?

- It depends on the swath (critical baseline, Bcrit)
- Far beams (e.g. IS6) are less sensitive to the baseline than near beams (e.g. IS2)

- Considering the entire mission extension (40 cycles) and a threshold of Bcrit/2
  - Area extent IS2: ±1.3deg
  - Area extent IS6: ± 4deg

- ASAR interferometric BRM will move to IS6



$$B_{crit} = \frac{\lambda . B . R_s . \tan(\vartheta - \alpha)}{c}$$