The METOP-SG Satellites & the SCA Radar

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The METOP-SG SATELLITES I

- Two or Three Flight Models of Two Different Satellites (SAT-A and SAT-B) are foreseen.
- SAT-A1, SAT-B1, SAT-A2, SAT-B2, (SAT-A3) & (SAT-B3).
- The nominal lifetime of each satellite is 7.5 years.

- SAT-A carries the following payload:
- METIMAGE (Visible & Infra-Red Imager)
- IASI-NG (Infra-Red Sounder)
- MWS (Cross-Track Scanning Microwave Sounder)
- SENTINEL-5 (Ozone and Atmospheric Chemistry Instrument)
- 3MI (Multi-polarisation, Multi-viewing angle, Multi-frequency Imager)
- RO (Radio Occultation Instrument)

The METOP-SG SATELLITES II

- SAT-B carries the following payload:
- SCA (C-band Wind Scatterometer Radar)
- MWI (Conical Scanning Microwave Imager)
- ICI (Conical Scanning Ice Cloud Imager)
- RO (Radio Occultation Instrument)
- A-DCS (ARGOS Data Collection System)

- Both satellites also carry:
- Navigation Receiver
- Attitude Control System employing Star Trackers

SCA RADAR

- Spatial / Temporal Coverage
- Orbits = Metop Orbit Type (Polar, Sun-Synchronous, Descending Node at 09:30 LST)
- Ground Track Repeat Cycle = 29 day / 412 orbits. (Approximate 5 day sub-cycle.)
- Two SCA Swathes, each of circa ~ 650 km
- VV Polarisation: Fore, Mid & Aft / VH Polarisation: Mid only

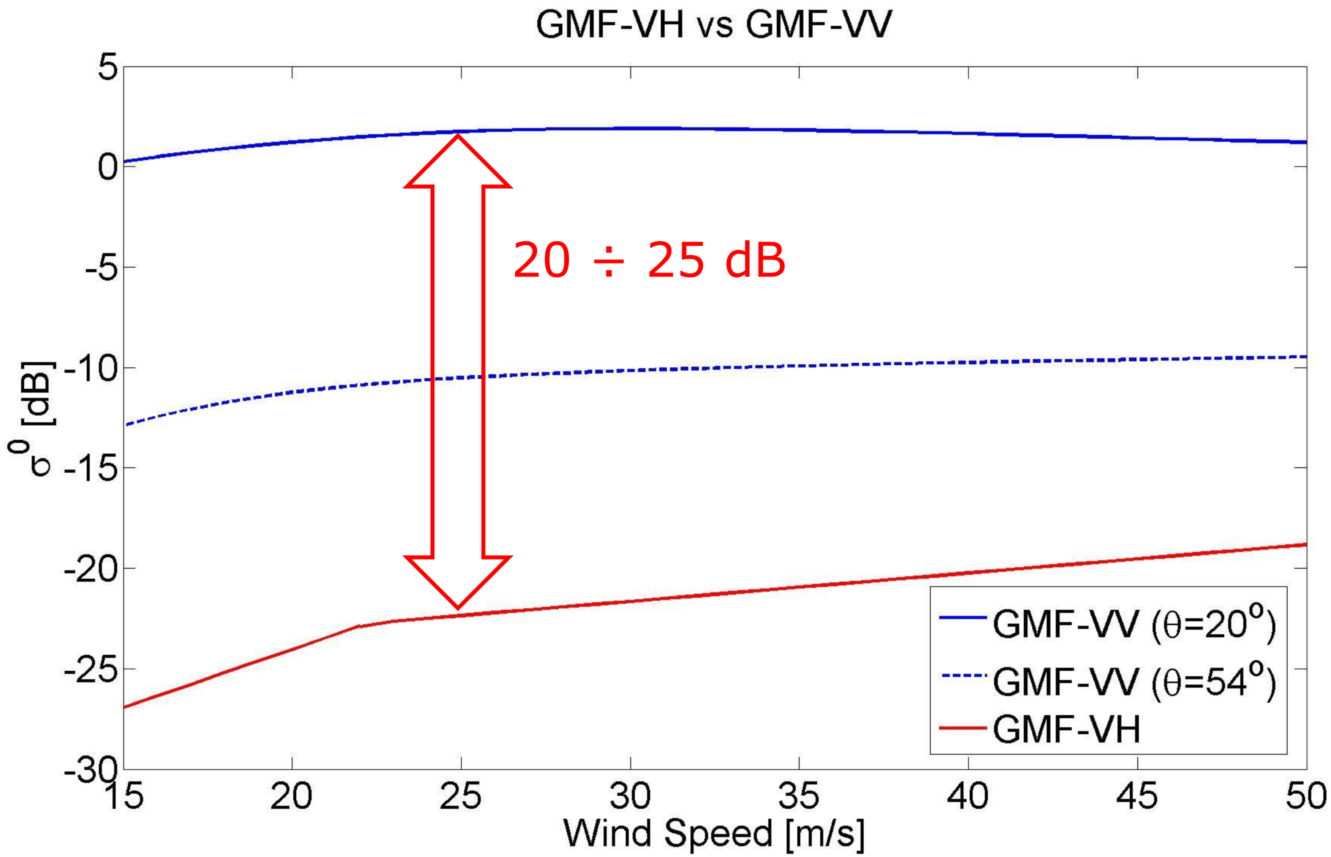
- Carrier Frequency
- Frequency = 5.3 GHz (TBC)
- Bandwidth ~ 2 MHz

SCA PERFORMANCE

- Radiometric Resolution
- **VV Performance**
- 25 km x 25 km Horizontal Resolution Product (Nominal Product)
- Kp (VV) at 4 m/s Cross-Wind ≤ 3 % for $i \leq 25°$
- ≤ (0.175 i - 1.375) % for $i > 25°$
- Kp (VV) at 25 m/s Up-Wind ≤ 3 %
- **VH Performance**
- 25 km x 25 km Horizontal Resolution Product
- Kp (VH) at 20 m/s ≤ 4.5 %
- And Better Performance at Higher Wind Speeds.
- Radiometric Stability
- Radiometric Stability ≤ 0.1 dB (one sigma)
- Radiometric Accuracy
- Radiometric Accuracy ≤ 0.35 dB (peak-to-peak)

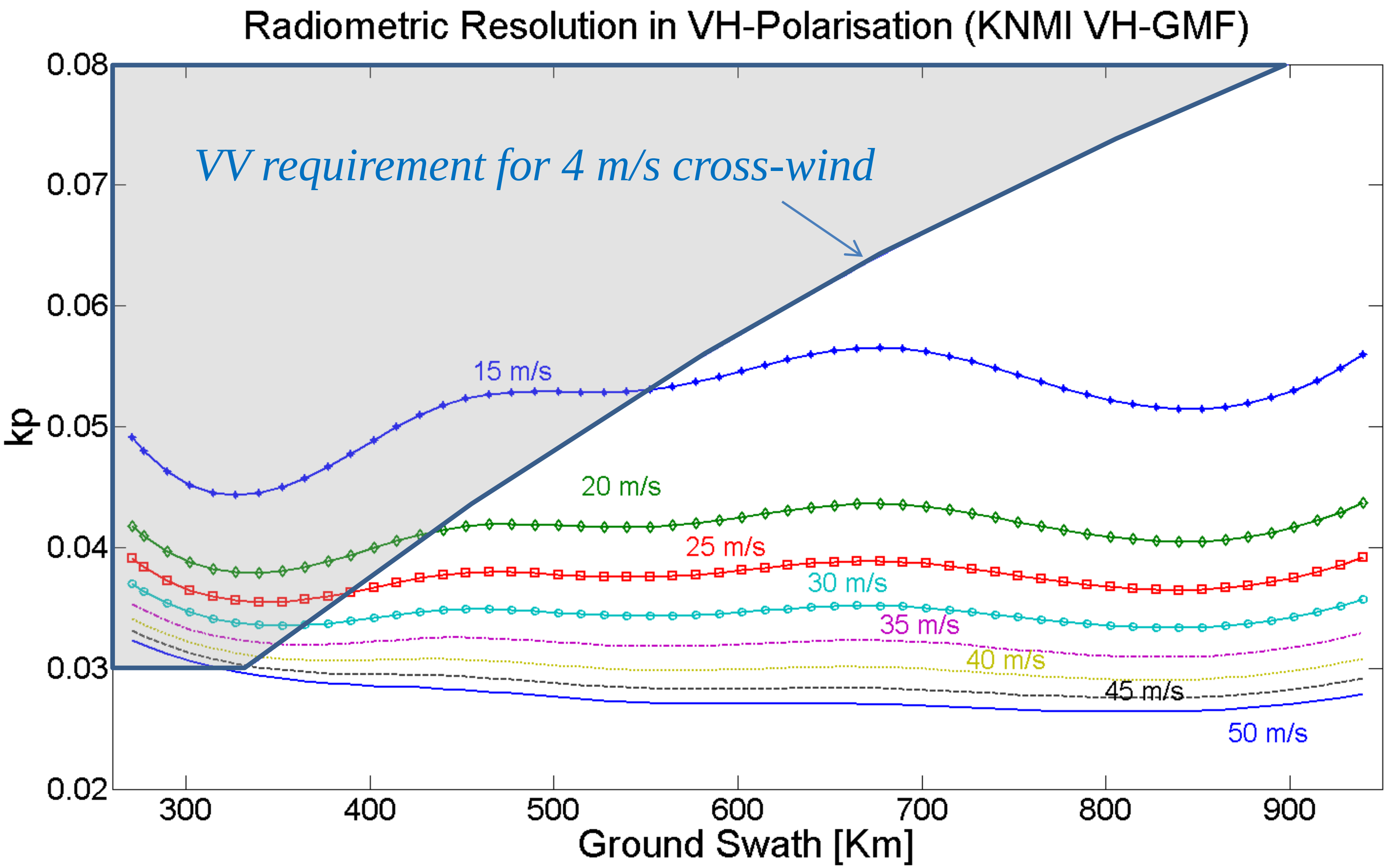
GMF-VH vs. GMF-VV

Difference in the order of 20 ÷ 25 dB is expected between GMF–VV & GMF-VH under the worst conditions (up-wind)



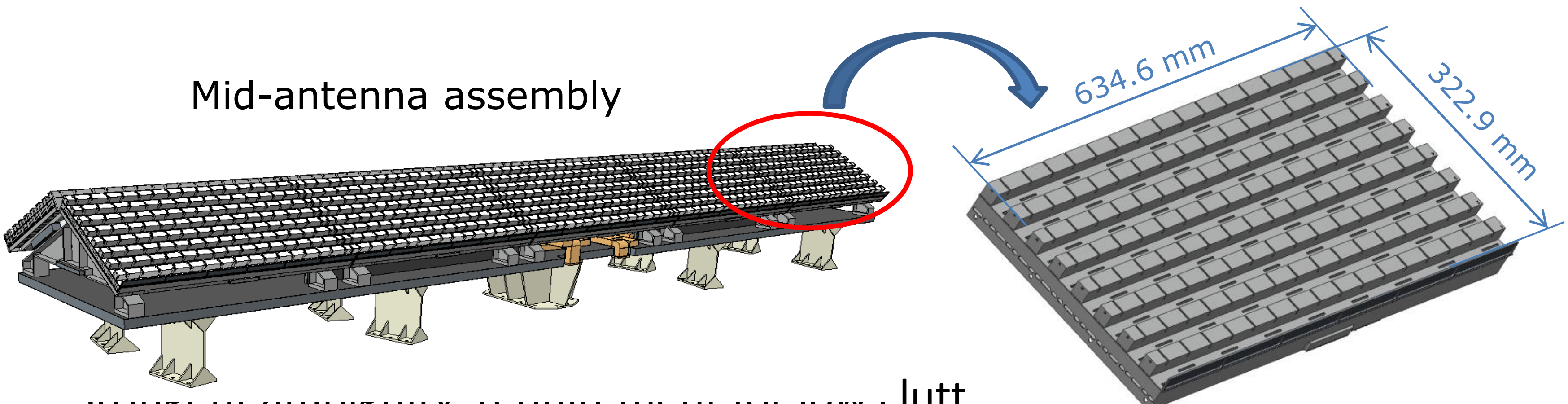
Predicted Radiometric Resolution for VH-Pol

VH-pol. shall not drive the instrument power!!!



Key Design Requirements associated with a Dual-pol. system

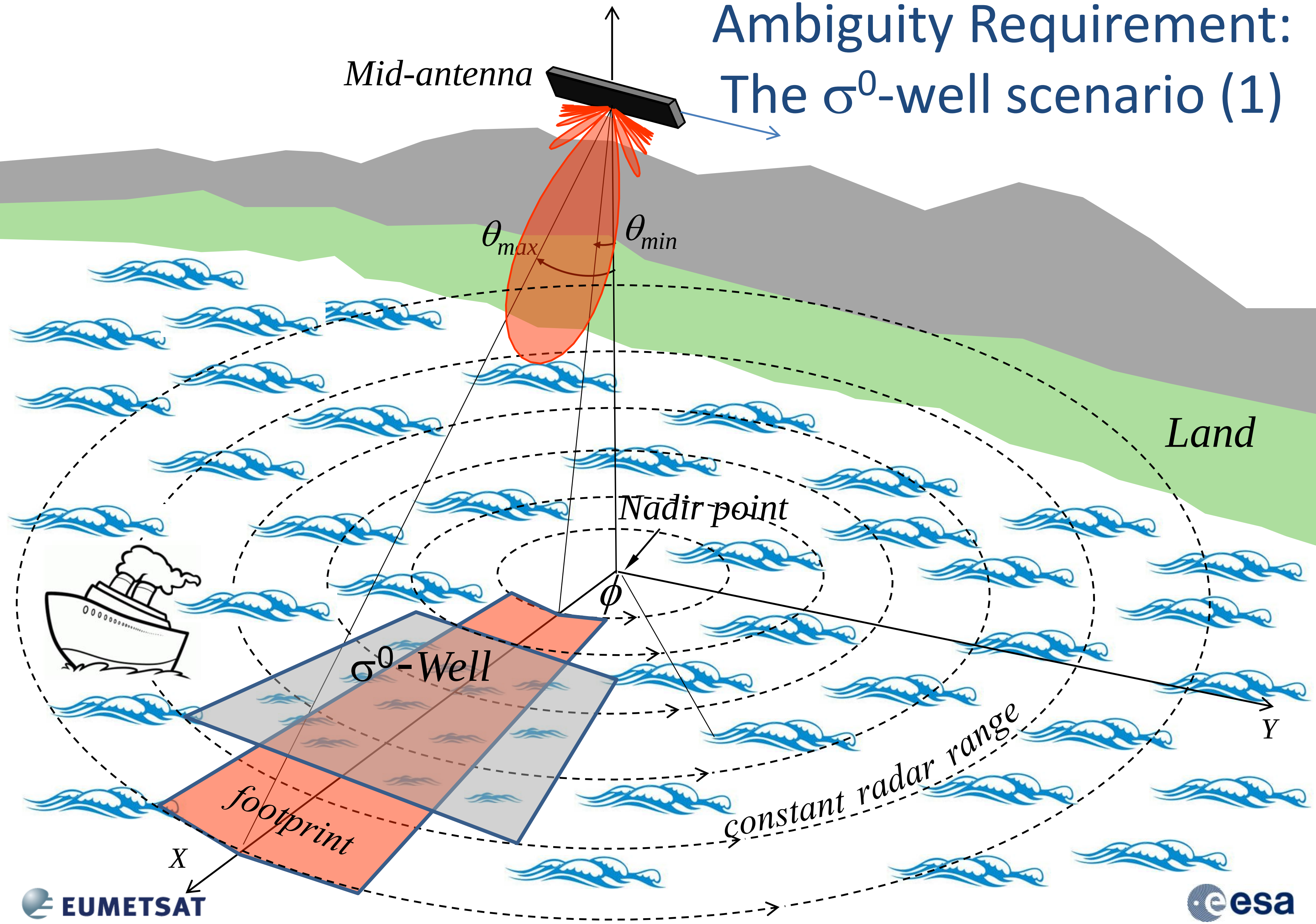
- Dual-pol. antenna, with very low cross-polarised radiation , transmitting V-pol signals and receiving V-pol & H-pol signals (either simultaneously or not simultaneously).



scenario – next slide).

- Dual-pol. transponder, receiving V-pol signals and transmitting both V-pol. and H-pol. signals, for E2E system calibration/characterization – must have better cross-pol. performance than SCA!

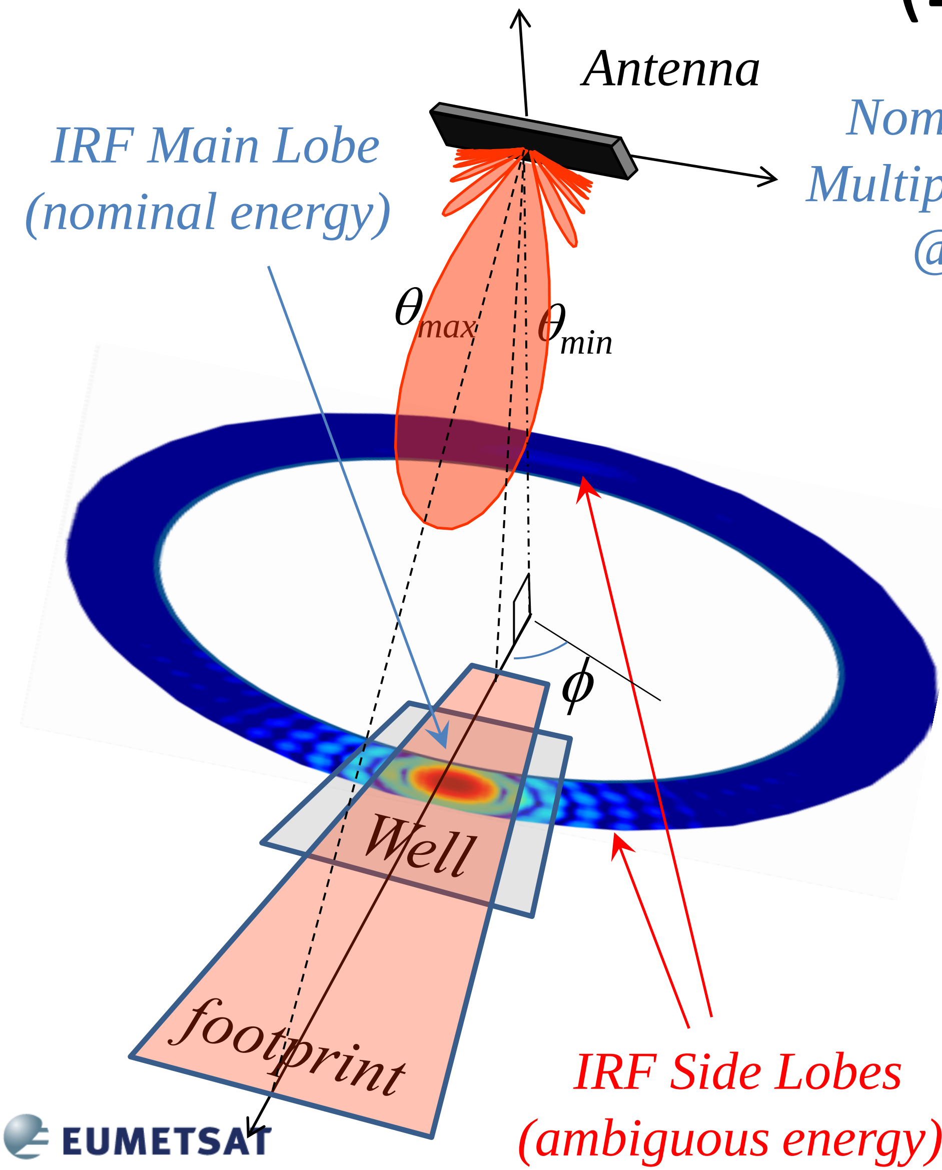
Ambiguity Requirement: The σ^0-well scenario (1)

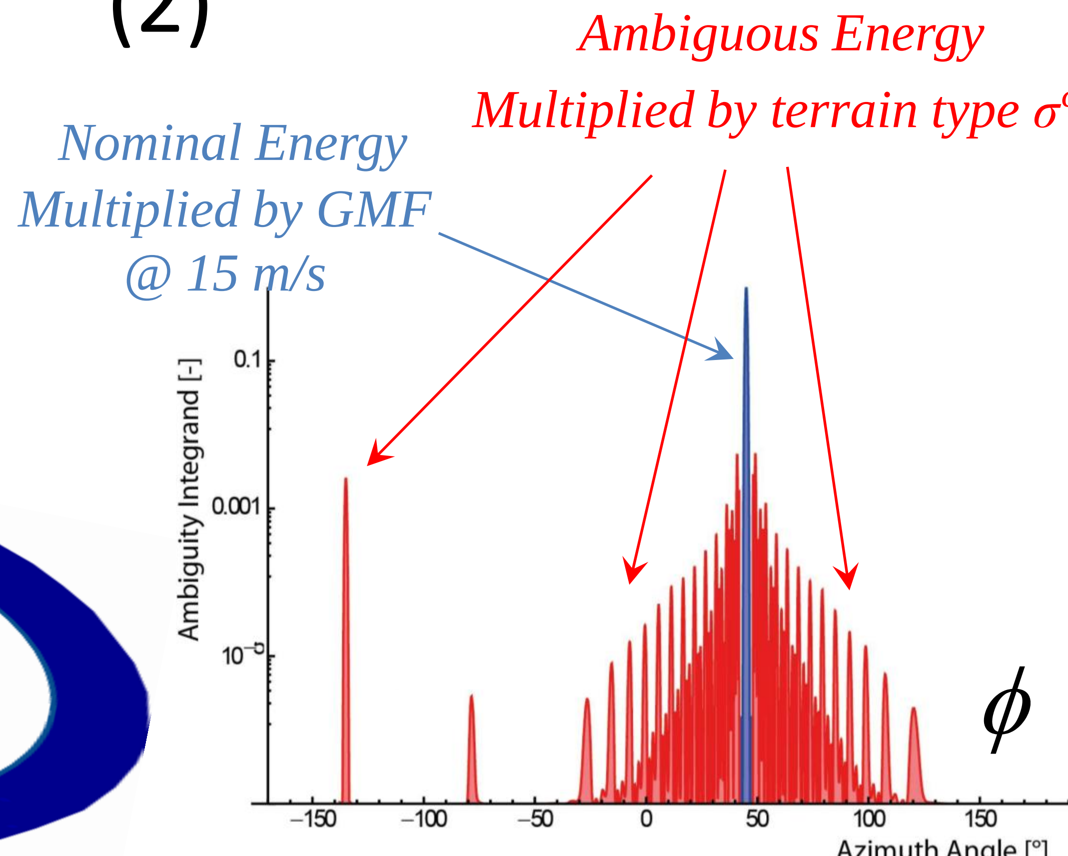


EUMETSAT

esa

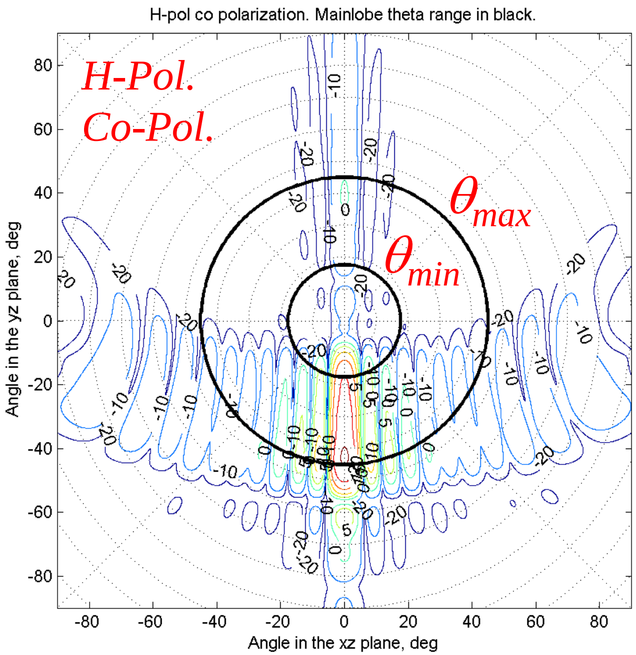
Ambiguity Requirement: The Well Scenario (2)

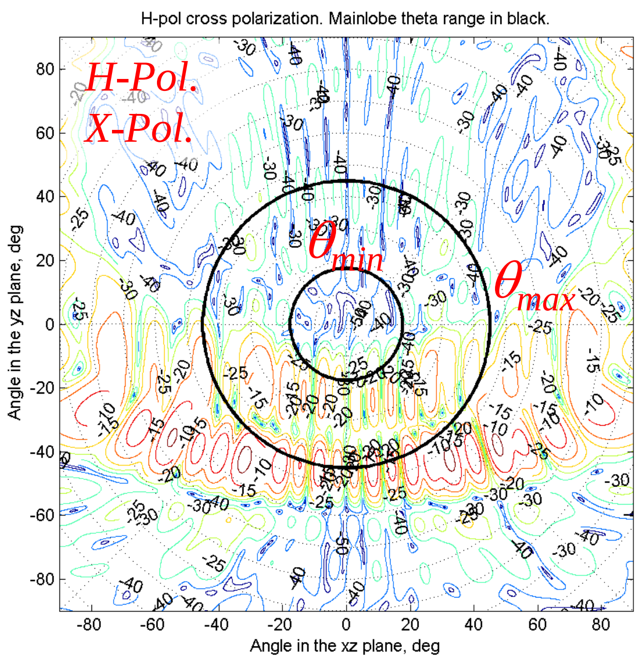




$$M_{vh} = Gtx_{vv} \cdot S_{vh} \cdot Grx_{hh} + Gtx_{vh} \cdot S_{hh} \cdot Grx_{hh} + Gtx_{vv} \cdot S_{vv} \cdot Grx_{vh} + Gtx_{vh} \cdot S_{hv} \cdot Grx_{vh}$$

X-talk Requirement





The integrated cross-talk shall be less than -25 dB across the swath.

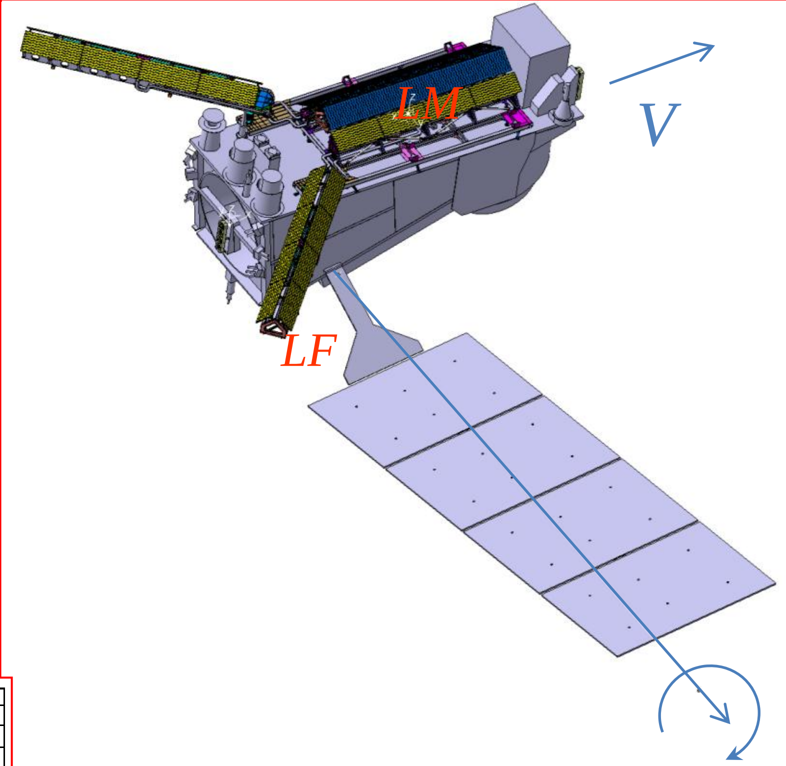
$$X_{ant}(\theta) = \frac{\int_{-\pi}^{\pi} G_x(\theta,\phi)d\phi}{\int_{-\Delta}^{\Delta} G_{co}(\theta,\phi)d\phi}$$

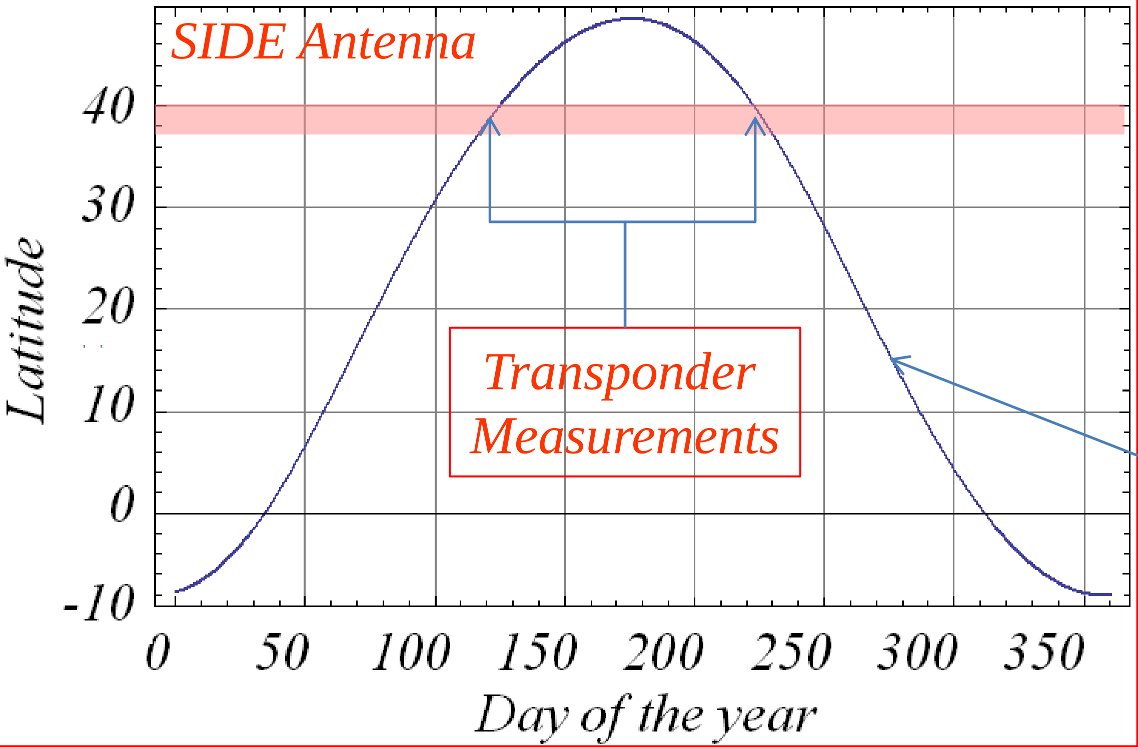
G_x is the cross-polar gain,
G_{co} is the co-polar gain,
Δ is the -3dB azimuth beam-width.

Recent antenna bread-boarding activities have shown that such a requirement is very challenging (particularly at the edge of the swath).

Solar Array Multipath Effects (1)

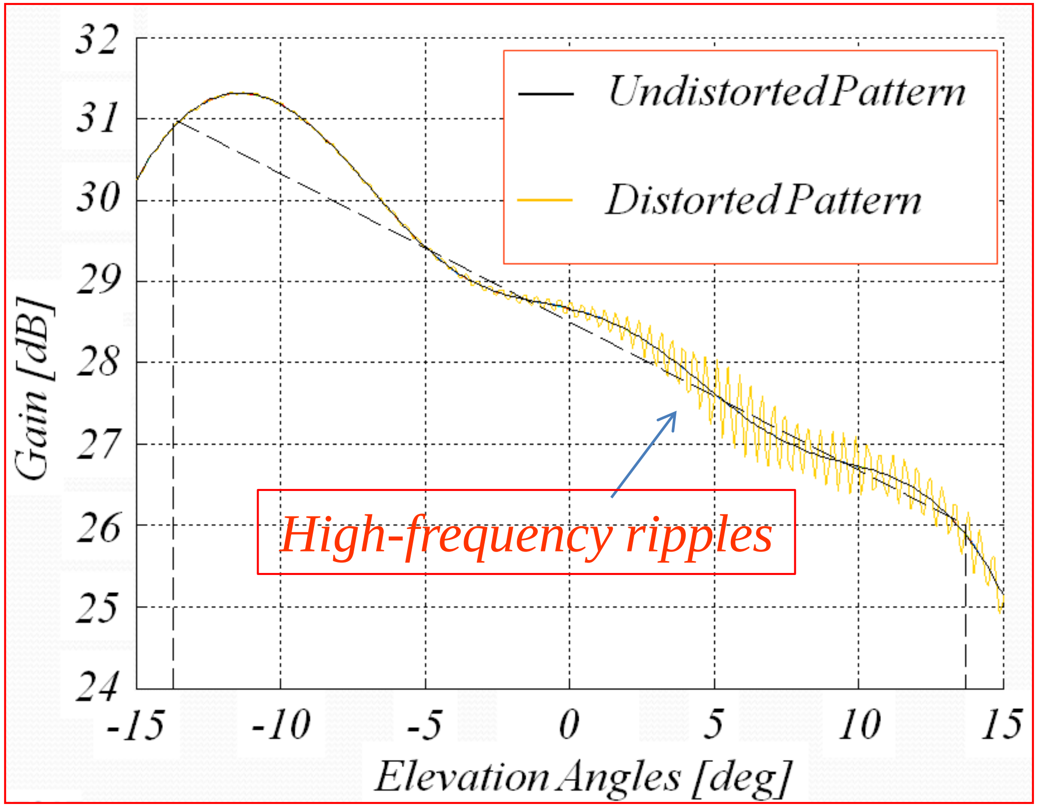
- *Major impact on radiometric stability and cross-polar performance.*
- *The worst-case angles are 0º, for the LM antenna, and 15º for the LF antenna.*





Latitudes where solar array has rotation angle 15 deg (worst case for LF antenna)

Solar Array Multipath Effects (2)



__Preliminary conclusion:__

- *Thanks to the Ground Weighting Function (acting as a filter), the effect of high-frequency ripples on Level-1b products is expected to be negligible.*
- *Transponder locations shall be selected such as to avoid/minimise occurrence of multipath effects.*
- *If not possible, transponder measurements made with the solar array at 0º (LM) or 15º (LF) rotation angles shall be discarded.*

SCA CALIBRATION

- Continuous SCA transponder calibration without interruption to SCA operations.
- Addition of VH-channel introduces a number of challenges for the transponder design (characterisation of VV and VH separately; transponder polarisation performance).
- Transponder locations to be optimised for minimising multipath effects.
- Baseline (TBC): Three new SCA transponders at existing Turkish sites / 58-day sliding calibration window.
- Calibration quality will be the same as that of ASCAT.
- Possible interruptions / degradation to service due to failed transponders in spite of spares.
- Is this sufficient, or further transponders at alternative sites (for Climatology) ?

- More robust and cost-efficient solution could be sought through end-to-end system trade-offs (e.g. avoidance of multipath effects; maintenance; etc.) …

SCA PRODUCTS

- (1) 25 km x 25 km Horizontal Resolution Product. (Nominal Product)
- Sigma Zero Quadruplets (Fore VV, Mid VV, Aft VV, Mid VH)

- (2) Full Horizontal Resolution Product at Radar Resolution.
- Sigma Zero Quadruplet (Fore VV, Mid VV, Aft VV, Mid VH)
- ***Residual Doppler Shift***
- ***VV/VH Echo Return Phase Difference (if allowed by radar)***
- Noise Powers (Fore V, Mid V, Aft V, Mid H)

SCA CALIBRATION

- Continuous SCA Transponder Calibration without interruption to SCA Measurements.
- Baseline: Three New SCA Transponders at Existing Turkish Sites / 58-day sliding Calibration Window.
- Calibration Quality will be the same as ASCAT.
- Possible interruptions / degradation to service due to Failed Transponders in spite of spares.
- Is this sufficient (for Climatology) ?

- More robust solution could be foreseen using six SCA transponders at six sites (3 existing and 3 new) plus spares.