



# **National Report Germany**

## **CEOS – WGCV Plenary # 31**

**Albrecht von Barga, DLR Space Agency**

**Bolger Center, Potomac (USA), March 2<sup>nd</sup> – 4<sup>th</sup>, 2010**

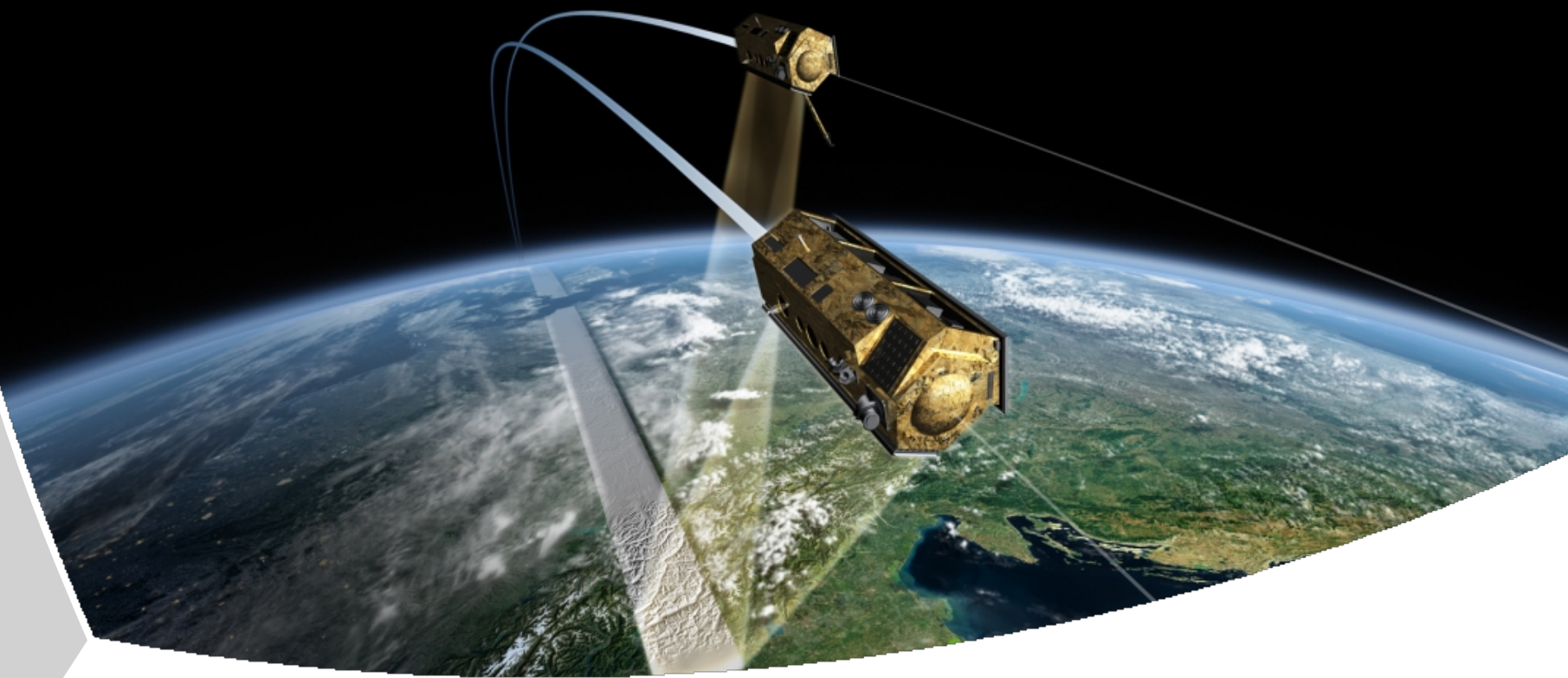


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# Outline

- Current Missions (with German contributions)
  - TerraSar-X Re-Calibration Campaign in 2009
  - SCIAMACHY
- Missions in the pipeline
  - Tandem-X Status
  - EnMAP Status and Cal/Val conceptional outline
  - French / German climate mission
- Contribution to QA4EO campaign

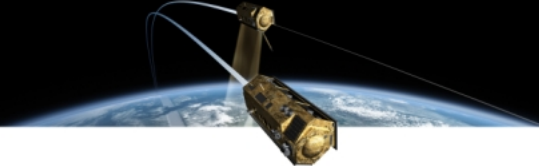


## TSX Re-Calibration and DRA Campaigns performed in 2009

**Marco Schwerdt**, Markus Bachmann, Dirk Schrank,  
Clemens Schulz, Björn Döring, Jaime Hueso Gonzales



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# Calibration Tasks Performed

## **Re-Calibration**

- Geometric Calibration
- Antenna Pointing Determination
- Antenna Model Verification
- Radiometric Calibration
- Internal Calibration

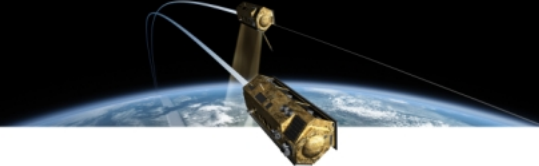
} similar to Commissioning Phase  
but reduced effort

## **DRA Campaigns**

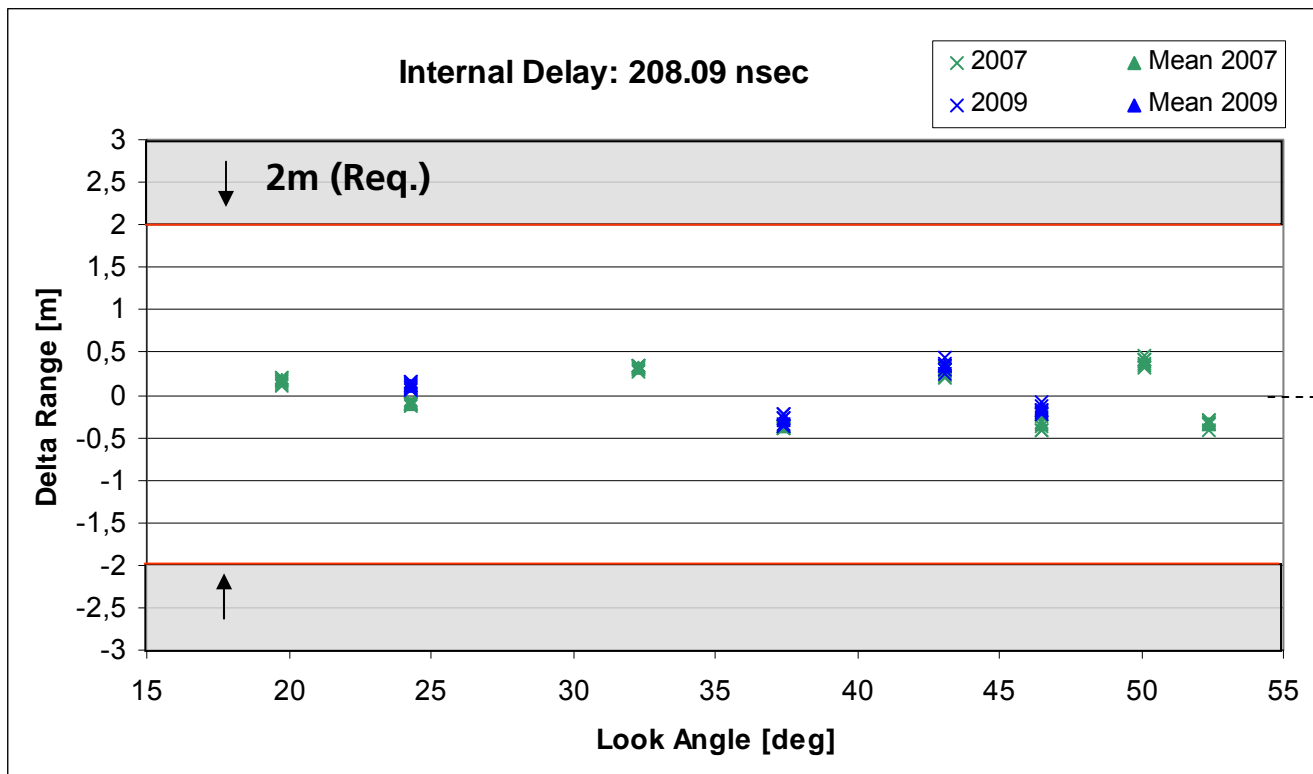
- Geometric Calibration
- Antenna Model Verification
- Channel Imbalance, Phase
- Channel Imbalance, Amplitude => Radiometric Calibration
- Cross Talk

## **Activities performed in total**

- **213 Acquisition** within 6 Repeat Cycles 16.04.2009 – 23.07.2009 (3 DRA, 3 Re-cal)
- **171 Measurements** across the **Rainforest** (131 Re, 40 DRA)
- **42 Calibration Campaigns** against Reference Targets (5 Pre, 17 DRA, 20 Re-Cal)
- successfully performed by a Cal Team of **27 HR Colleagues**
- Analysis, Evaluation and Documentation of all Measurements and SAR Data are finished



# Geometric Calibration



## Updates

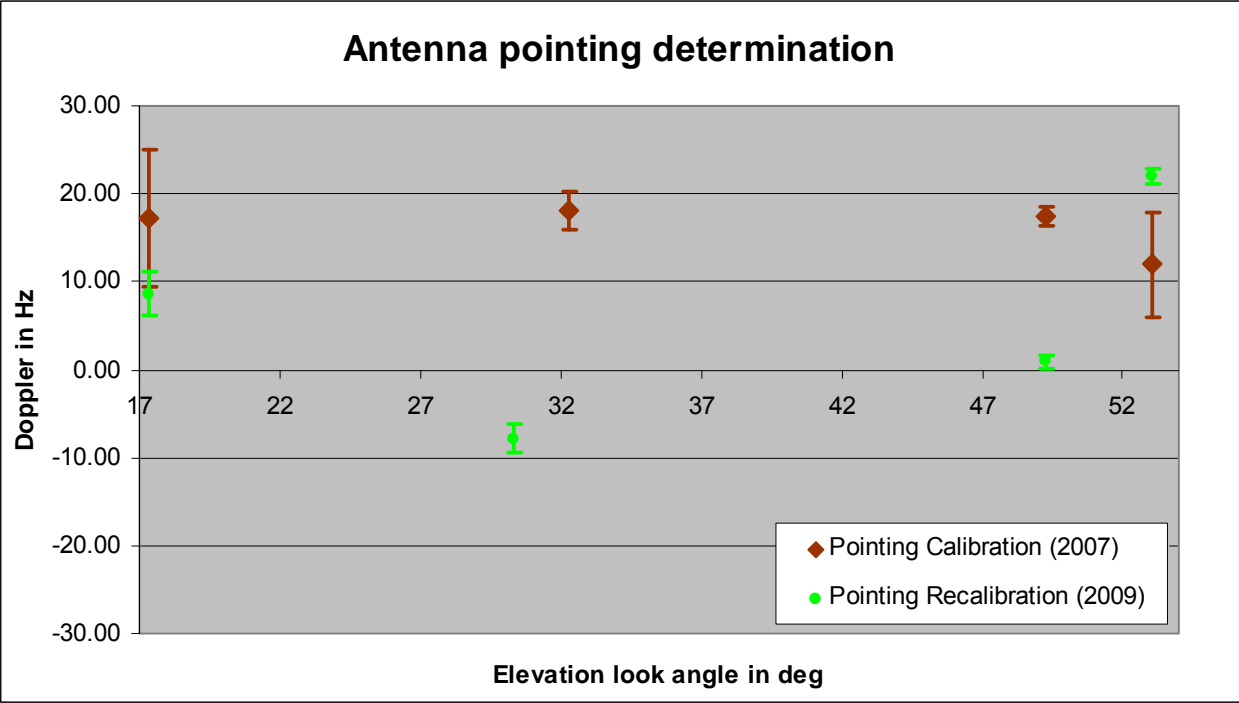
- Improved Cal Target Position
- Internal Delay (Patch-Distance OGC)
- no Bandwidth Dependency

- Pixel Localization Accuracy (Range)  $\sigma = 30 \text{ cm}$  ( $1\sigma$ ) (2 nsec) → **no trend since 2 years**
- Residual Offset (In-Flight  $\leftrightarrow$  OGC) **3.75 cm** (0.25 nsec)





# Pointing Determination in Azimuth

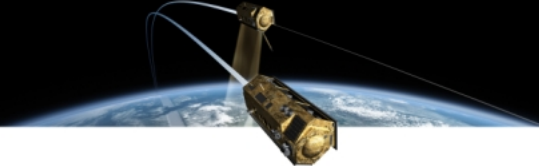


## Updates

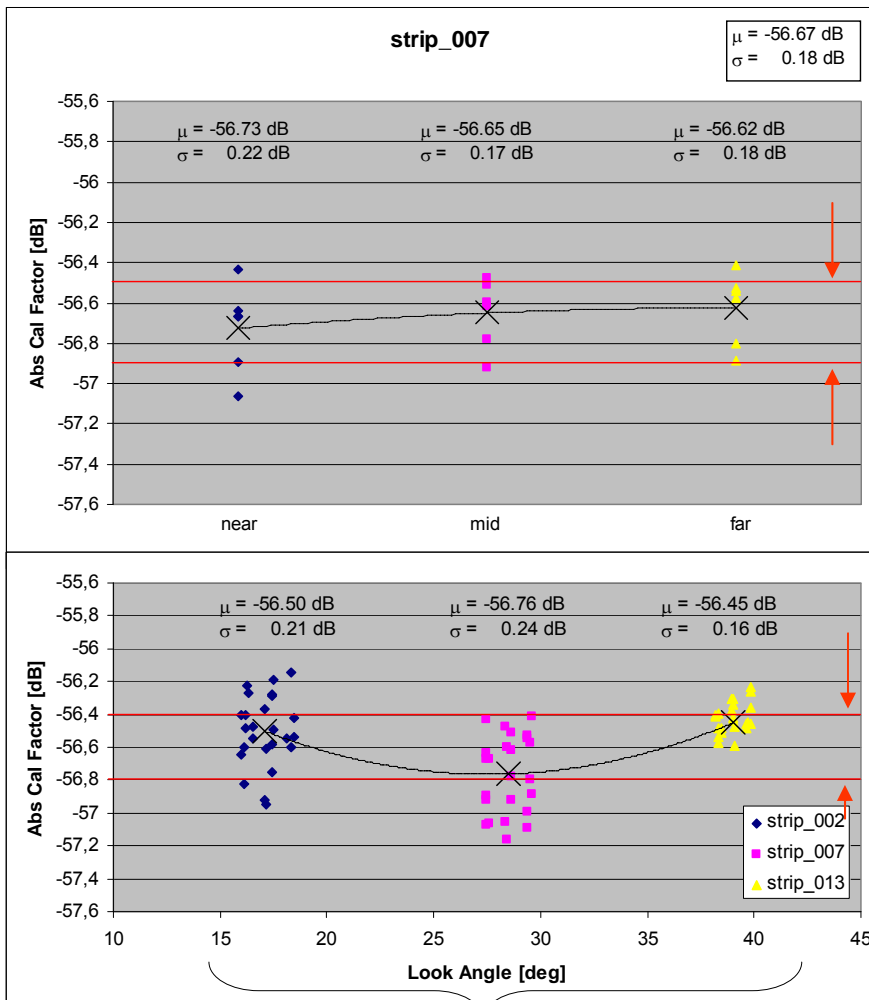
- Improved Ground Receiver Position
- Re-Adjustment between Star Trackers



Improvements	2007	2009
✓ Measurement Accuracy per Pass	≤ 7.9 Hz < 1.0 mdeg	≤ 2.6 Hz (1σ) < 0.33 mdeg
✓ Mean Doppler	16 Hz 2 mdeg	5.9 Hz 0.74 mdeg



# Radiometric Calibration I



CR: corner reflector

$$\mu_{2009} = -56.53\text{dB} + 0.10\text{dB (CR)} = -56.43\text{dB}$$

$\mu \leq \pm 0.2\text{dB}$   
within Scene

$\mu \leq \pm 0.2\text{dB}$   
within full  
performance  
range

- **6 Corner Reflectors** across the **swath**
- **3 Beams** (low, mid, high, Inc)

• **Antenna Model**  
 $\leq \pm 0.2\text{dB}$

• **Radiometric Stability**

	<i>Abs. Cal Factor</i>
2007	- 56.58 dB
2009	- 56.43 dB

**0.15dB**

over 2 years

**TerraSAR-X**  
is **extremely stable**

Requirement 0.5 dB ( $1\sigma$ )  
over 6 months !



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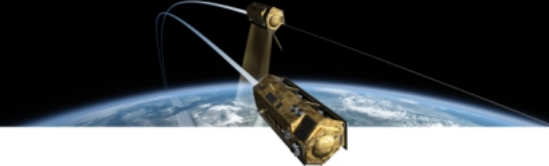
TSX Calibration Campaigns 2009



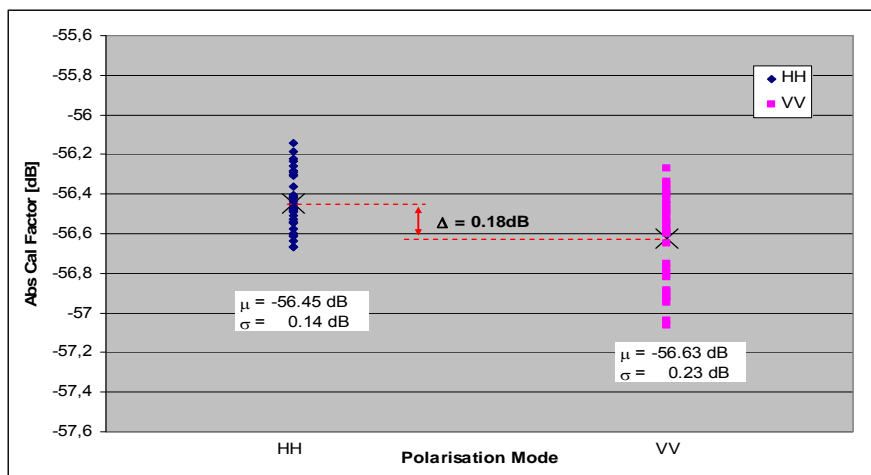
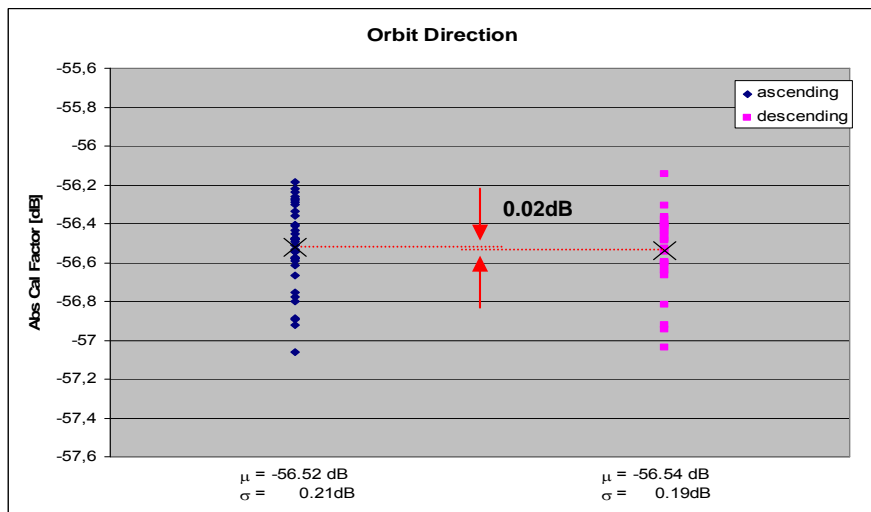
CEOS WGCV 31 National Report Germany

Folie 7





# Radiometric Calibration II



## Absolute Calibration Factor

- $\mu \leq \pm 0.2\text{dB}$  within Scene
- $\mu \leq \pm 0.2\text{dB}$  within Full Performance Range
- Radiometric Stability 0.15dB
- Independent of Orbit Direction

HH/VV Offset  
**0.18dB**

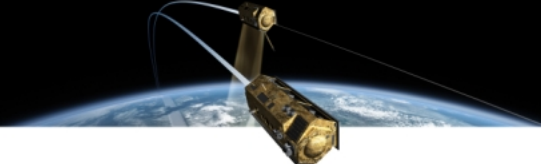


- Antenna Model ?
- RX-Gain Setting ?
- Instrument Commanding
- ...

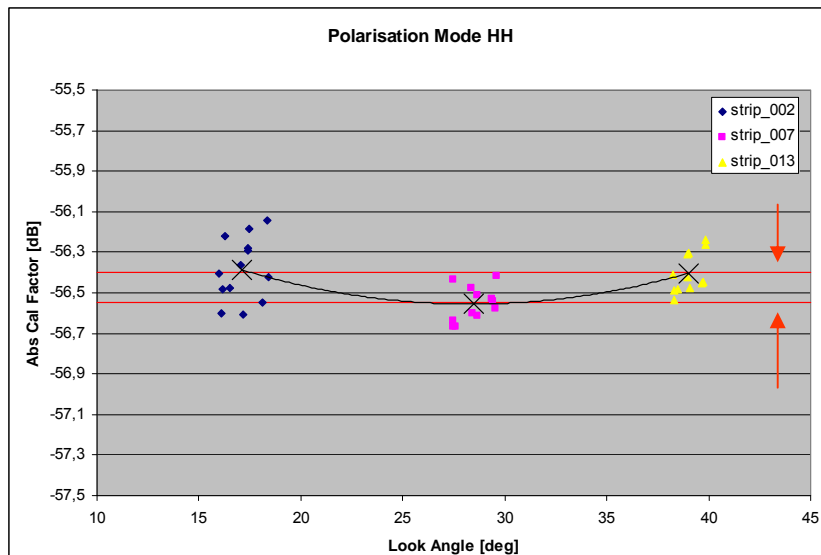
no Systematics  
observed







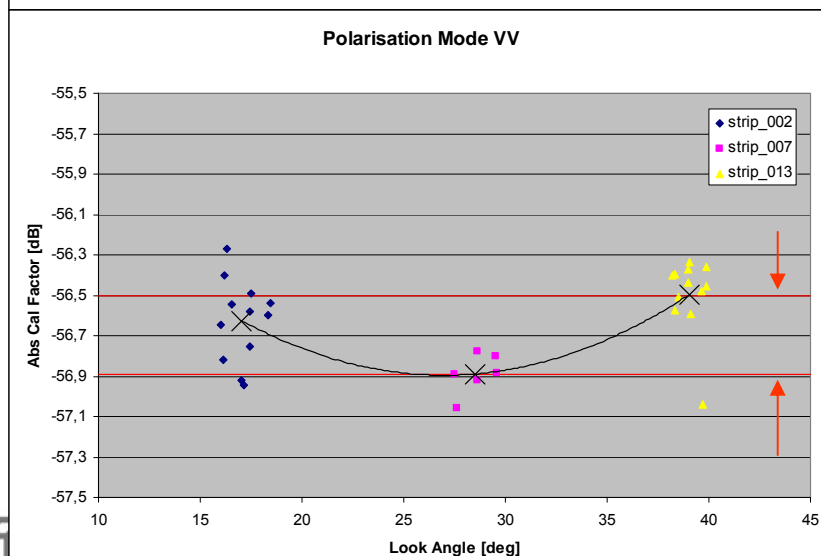
# Radiometric Calibration III



$\mu < \pm 0.09\text{dB}$   
within Scene

## Antenna Model ( $\leq \pm 0.2\text{dB}$ )

- Linear System
- Accuracy of Input Data slightly different for H and V (embedded H/V-pattern, excitation laws...)



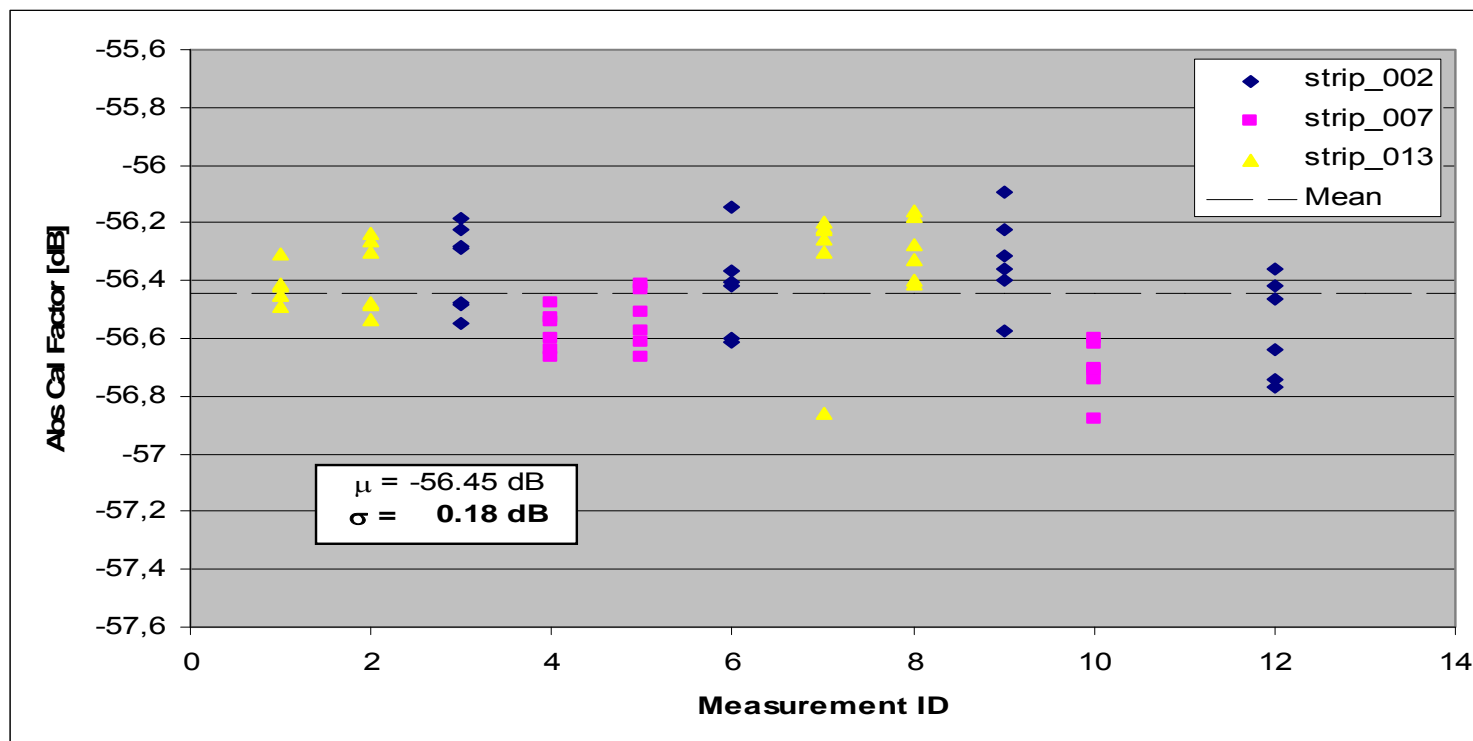
$\mu < \pm 0.19\text{dB}$   
within Scene

↓

**-0.18dB Offset Compensation**  
by Gain Correction **of V-Pattern**  
derived from the **Antenna Model**



# Absolute Radiometric Accuracy



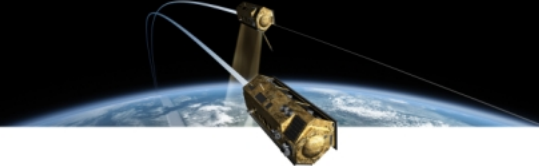
Absolute Calibration Factor independent of

- Position within the Swath
- Beam being operated

## Absolute Radiometric Accuracy

**0.18 dB ( $1\sigma$ )**

during Re-Cal in StripMap Operation



# Final Re-Calibration Results of TerraSAR-X

## Internal Calibration

- |   |                       |   |
|---|-----------------------|---|
| ➤ Amplitude / Phase Drift (80sec DT length) | < 0.9 deg / < 0.05 dB | ✓ |
| ➤ TRM Amplitude and Phase Setting           | stable compared to CP | ✓ |

## Comm Phase

## Geometric Calibration

- |   |                 |   |
|---|-----------------|---|
| ➤ Pixel Localisation Accuracy (Azimuth / Range) | 0.54 m / 0.31 m | ✓ |
|---|-----------------|---|

## Pointing

- |                                  |                             |            |
|----------------------------------|-----------------------------|------------|
| ➤ Azimuth / Elevation            | < 1 mdeg (5.9 Hz) / < 4mdeg | } Improved |
| ➤ Accuracy (Azimuth / Elevation) | < 1 mdeg / < 2 mdeg         |            |

## Antenna Model

- |                                       |                                       |   |
|---------------------------------------|---------------------------------------|---|
| ➤ Antenna Model (Shape / Gain-Offset) | $\leq \pm 0.2$ dB / $\leq \pm 0.2$ dB | ✓ |
|---------------------------------------|---------------------------------------|---|

## Radiometric Accuracy

- |  |                         |            |
|--|-------------------------|------------|
| - Relative Radiometric Accuracy                    | 0.18 dB*                | } Improved |
| - Radiometric Stability (Req. 0.5dB over 6 months) | 0.15 dB over 2 years    |            |
| - Absolute Radiometric Accuracy                    | 0.39 dB* (3 years left) |            |

→ All Results are documented by the **TSX Cal Report 2009**

TX-IOCS-RP-4352, Issue 2.0, 03.11.2009

\* StripMap Mode





# Essential Modifications

## *Geometric Calibration*

- Instrument Delay: **208.09 nsec**
- **No Bandwidth Dependency** (but on acs/des orbit caused by propagation effects)

## *Antenna Model*

- Provides Phase Pattern for Compensation during SAR Data Processing

## *Radiometric Calibration*

- Antenna **Gain Shift** for **V-Pol** on receive: **-0.18 dB**
- Absolute Calibration Factor: **-56.35 dB**



# Résumé TerraSAR-X

**TerraSAR-X** has been  
not only a **precise**  
but also **stable** SAR System since Launch  
and  
not only for **basic SAR Products**  
but also for **experimental** Modes  
like the **DRA Mode**

**IEEE Transactions on Geoscience and Remote Sensing**  
**Volume 48, No. 2, February 2010**

**Special Issue on TerraSar-X: Mission, Calibration, and First Results**

# New SCIAMACHY operational processor version switched in February 2010 – validation will start soon

Contact ESA (Responsible for ESA products): [Thorsten.Fehr@esa.int](mailto:Thorsten.Fehr@esa.int)

Contact DLR (Responsible for operational prototype):

[Guenter.Lichtenberg@dlr.de](mailto:Guenter.Lichtenberg@dlr.de)

Contact IUP (Coordinator SCIAMACHY Quality Working Group):

[Heinrich.Bovensmann@iup.phxsik.uni-bremen.de](mailto:Heinrich.Bovensmann@iup.phxsik.uni-bremen.de)



# New SCIAMACHY processing baseline activated

- ESA has successfully activated the new SCIAMACHY processing baseline, Level 1b Version 7.03 and Level 2 Version 5.01.
- 9 new, important geophysical Level 2 parameters, among them:
  - Sulphur Dioxide (SO<sub>2</sub>) vertical columns for anthropogenic emissions and volcanic eruptions
  - Bromine Oxide (BrO) vertical columns and stratospheric profiles
  - Water Vapour vertical columns
  - Chlorine dioxide (OCIO) slant columns
  - Carbon Monoxide (CO) vertical columns
  - Limb Cloud Flags for Polar Stratospheric Clouds (PSC) and tropospheric clouds
- In addition several important improvements in existing algorithms were implemented.
  - Improved stratospheric Ozone and Nitrogen Dioxide profiles
  - Improved total column Ozone





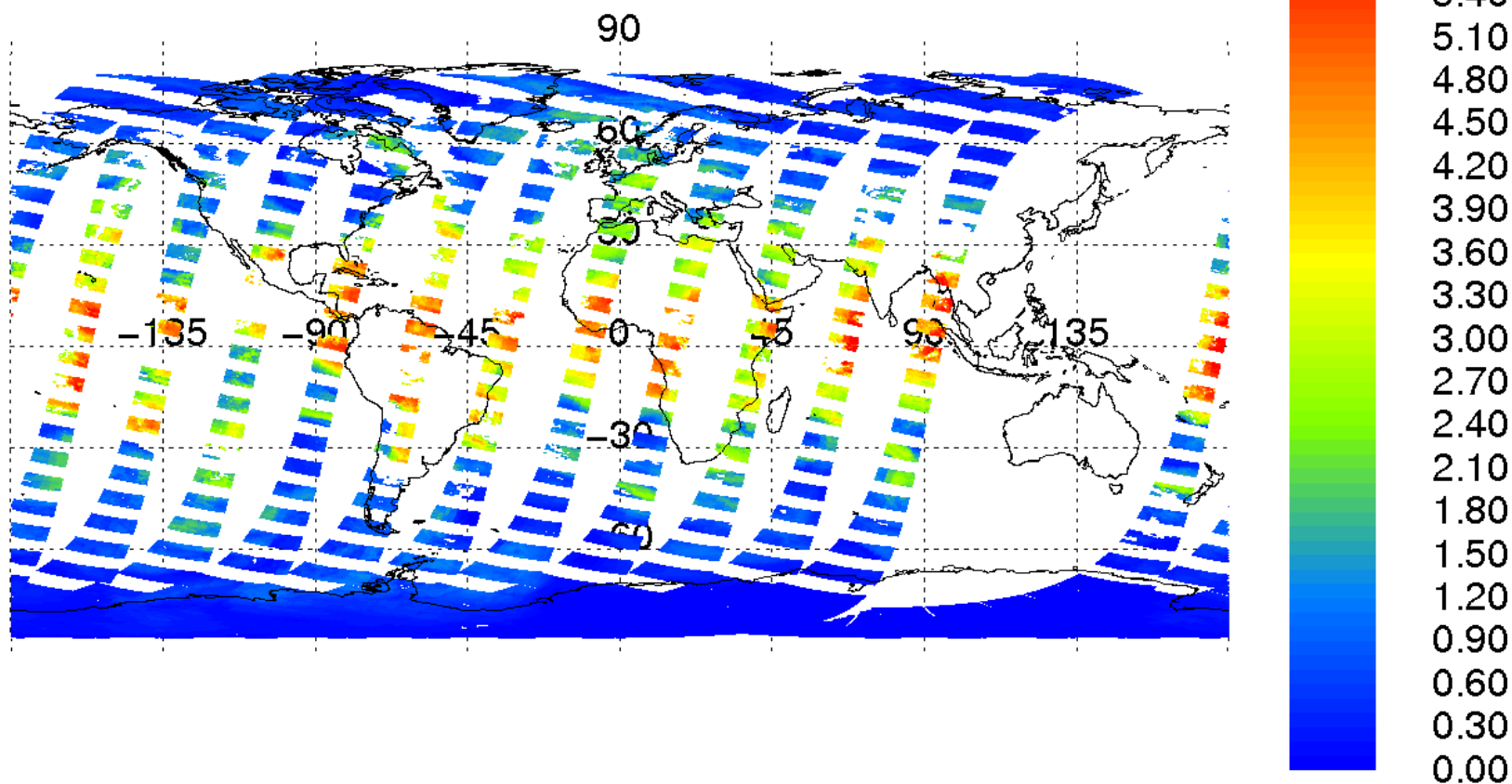
# New SCIAMACHY Level 2 Fast Delivery Service

- With this new service ESA will provide SCIAMACHY Level 2 datasets processed and provided at D-PAC within 24 hours of sensing.
- The Level 2 processor is equivalent to consolidated data processing, i.e., includes all species and has the same product format.
- The data is retrieved from the Level 1b near real-time data and predicted instead of consolidated auxiliary files are used.
- Please note that the SCIAMACHY Level 2 Fast-Delivery data processing is still in a test phase.



# New Product: H<sub>2</sub>O Nadir

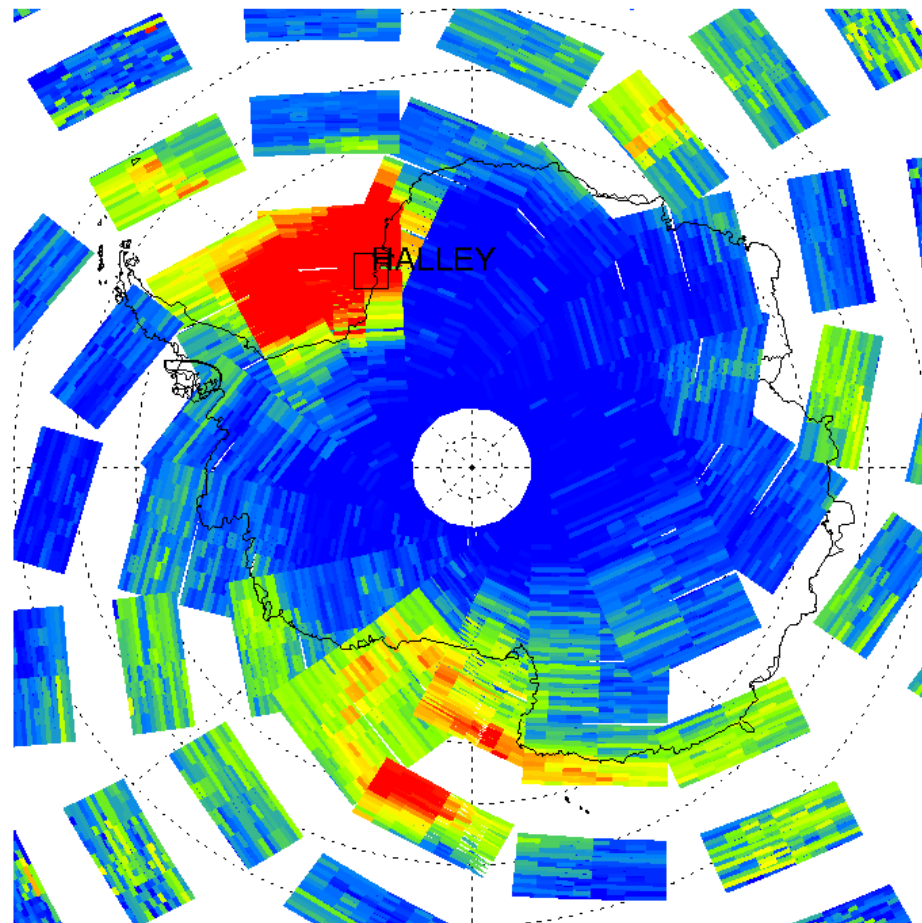
SCIAMACHY WATER VAPOR TOTAL COLUMN (G/CM<sup>2</sup>) 20061013



# New Product BrO Nadir

## Halley Station "Bromine Explosion" Event

DLR BrO VERTICAL COLUMN 20071009



1.0e+14

9.4e+13

8.7e+13

8.0e+13

7.3e+13

6.6e+13

5.9e+13

5.2e+13

4.5e+13

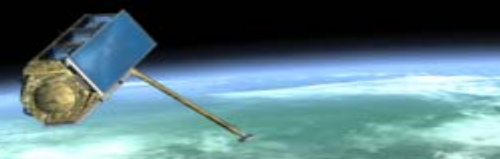


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# Coming Missions in the Pipeline

- Tandem-X: Status
- EnMAP: Status + Information about Cal/Val  
Detailed Outline about Cal/Val @ WGCV-32
- French / German climate mission



## TanDEM-X

- December 2009 Launch Slot has been resigned after shipment of spacecraft to Baikonur in late October 2009 has been canceled.
- 3 months of trouble shooting were necessary to isolate failure in RF unit.
- Unit has been refurbished and re-acceptance has been performed, successfully.
- Environmental test campaign has been resumed in late February.
- Launch is anticipated for 2nd half of May 2010.
- Ground Segment development and tests are completed.
- Ground Segment is ready for launch.
- Release for bi-static commissioning phase at launch +3 months
- At launch + 6 months TanDEM-X Mission will be operational.



# EnMAP

- Project is currently in Phase C/D
- In today's presentation we provide the integrated view of Cal / Val in one slide, but
- At WGCV-32 the Cal/Val concept will be presented in more detail containing the outline of the
  - On-ground characterization & calibration plan
  - In-flight calibration and instrument Monitoring concept including the quality control sub-system
  - Validation plan

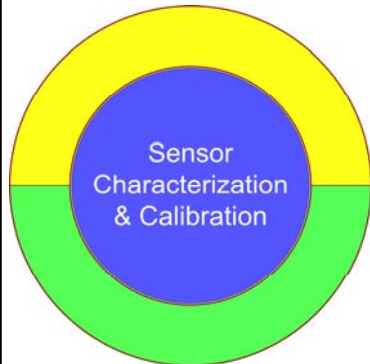
Note: All information can only reflect the current status.



# EnMAP

## Space Segment on-ground

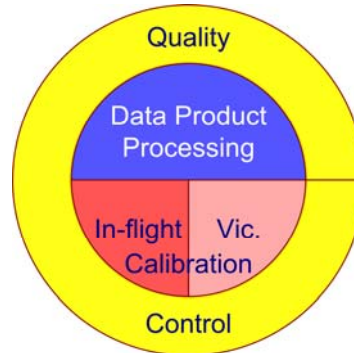
On-ground Sensor  
Characterization  
& Calibration



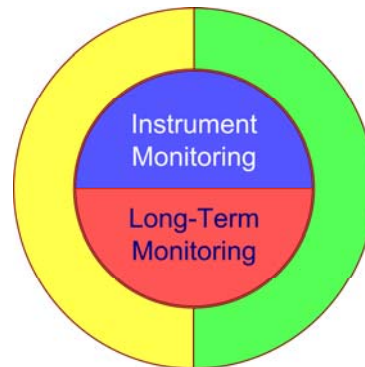
LEOP & Commissioning  
(Calibration, HK,  
Telemetry, etc.)

In-flight

## Ground Segment



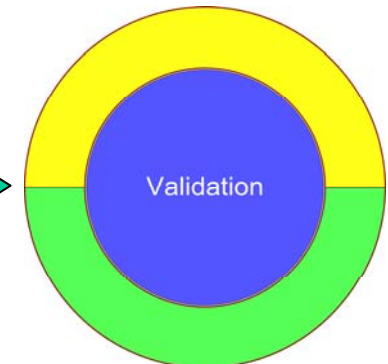
Trend Analysis  
(Calibration,  
HK, Telemetry)



Instrument  
Performance  
Analysis


## Validation

Product  
Quality  
Evaluation  
(Ground-based, Airborne)



Instrument  
Performance  
Analysis  
(Scene-based evaluation)





# French / German Climate Mission: Overall Context

## CH<sub>4</sub> Atmospheric Remote Monitor

- DLR is sensor provider: CH<sub>4</sub> Lidar instrument,
- CNES provides the platform (and its control centre)
- Planned launch date: 2013/2014
- Joint management by both agencies and two (joint) national science teams
- Boundary conditions
  - Innovative mission: no redundancy with other European initiatives
  - High scientific value
  - Demonstrator of a potential series of future operational missions (e.g. monitoring of international agreements of GHGs)
  - Launch date objective: planned 2013/2014



# Research Objectives and Challenges

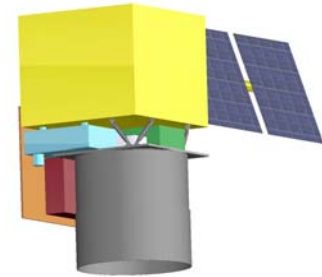
## Global carbon cycle and climate change

The mission will measure the **spatial and temporal gradients** of atmospheric CH<sub>4</sub> with high precision and **unprecedented accuracy** to constrain emissions from anthropogenic and natural sources **significantly better** than with the **current observational network**

## Kyoto protocol and emission inventories

The mission will contribute to an **independent verification** of the national emission inventory with respect to methane as formulated in the **Kyoto Protocol**

# Technical heritage



- Large number of **mission elements** are **space qualified**
- French / German Climate mission will benefit from development of
  - Complete **Airborne Lidar CHARM-F**, kick-off Oct'09
  - **EQM of Laser-Transmitter** (most critical item), kick-off Nov'09
- MYRIADE platform space proven, e.g. Demeter, Parasol
- Joint heritage by common studies on Wind Lidar projects (ADM-Aeolus, Airborne WIND)
  
- Due to the technical heritage and the joint preparatory work the French / German Climate mission can be realised in a **short timeframe** and with **low budget**

# Participation in QA4EO CalVal Campaign Tuz Gölü, Turkey

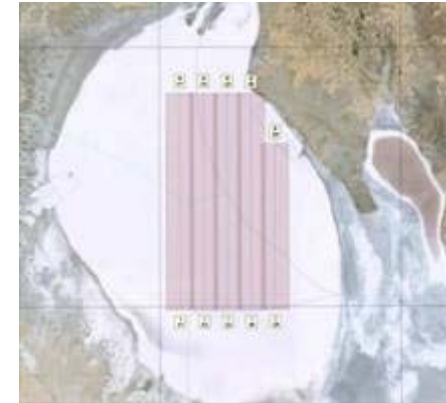
CEOS WGCV pilot

*“Comparison of techniques/instruments used for vicarious calibration of land surface imaging through a ground reference standard test site”*

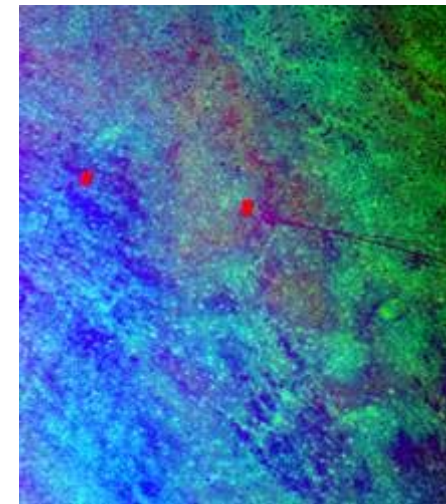
- Participation in field measurements
  - Spectroscopic field measurements as part of CEOS campaign
  - Additional provision of sun photometers
- Assessment of measurement uncertainty
  - Uncertainty budget for spectroscopic field measurements
  - Contribution to QA4EO-WGCV-IVO-CLC-002
- Airborne hyperspectral data acquisition
  - HyMap sensor on board of DLR aircraft
  - 5 flightlines over test area Tuz Gölü
  - Data pre-processing incl. ortho-rectification and atmospheric correction
  - Additional in-flight calibration
  - Report on data quality



HyMap flightline 5  
(true colors, Gaussian stretch)



Setup of the HyMap flightlines



Zoom on study area  
(HyMap data, MNF-transformed)

