

# TanDEM-X Interferometric System Calibration Review and DEM Quality Status

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German Aerospace Center

Knowledge for Tomorrow

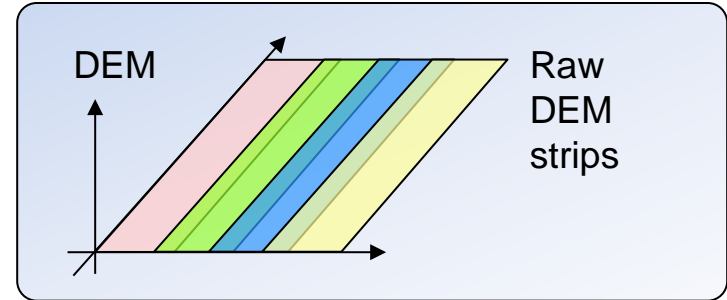
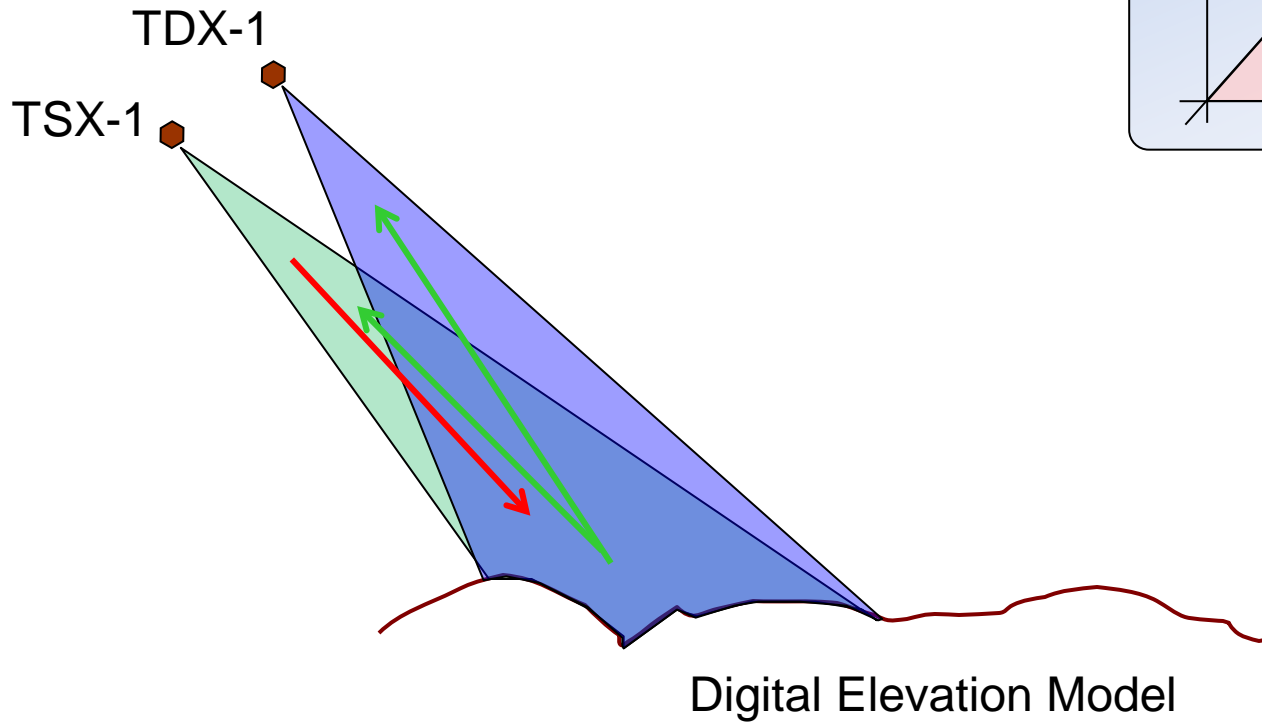


# Outline

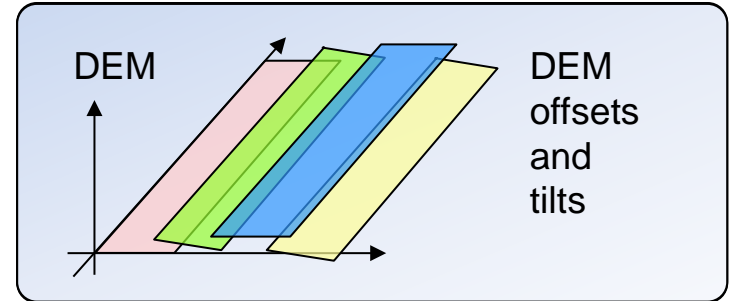
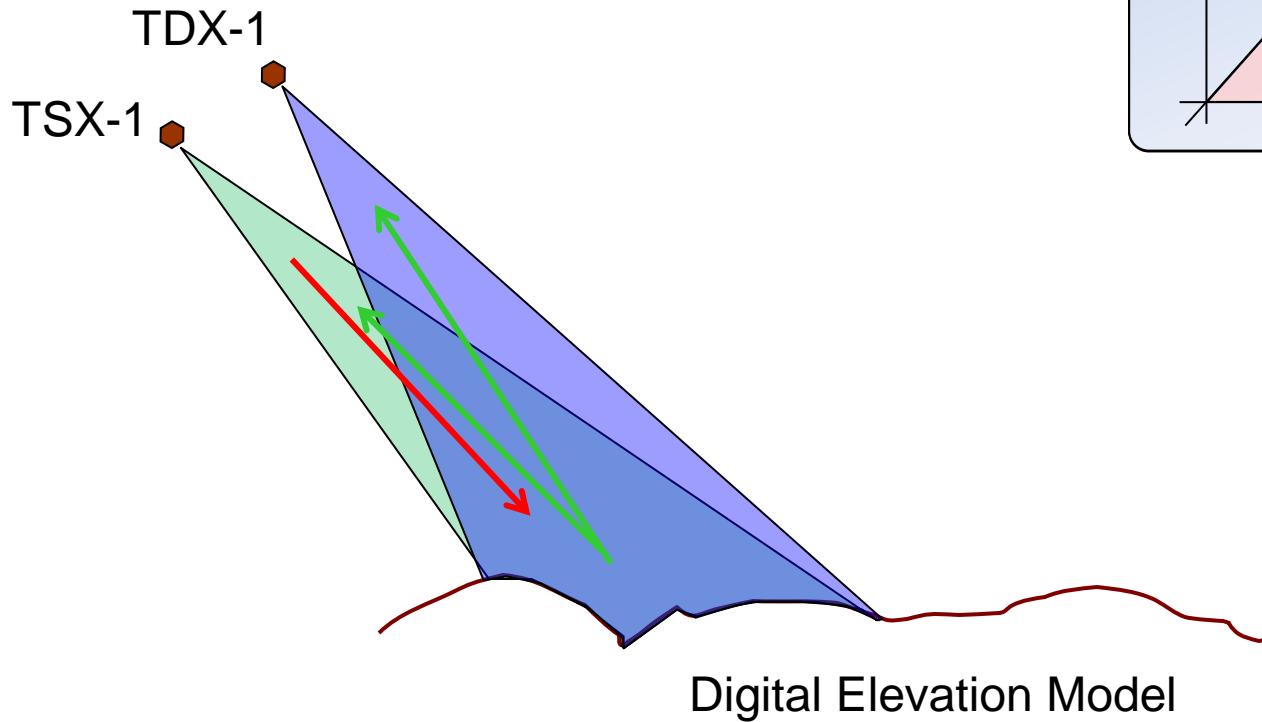
- Calibration of the interferometric system
  - Baseline calibration
  - Differential delays
  - Phase offsets
  - => Calibrated raw DEMs
  
- Quality of the final TanDEM-X DEM
  - Coverages
  - Relative height accuracy
  - Absolute height accuracy



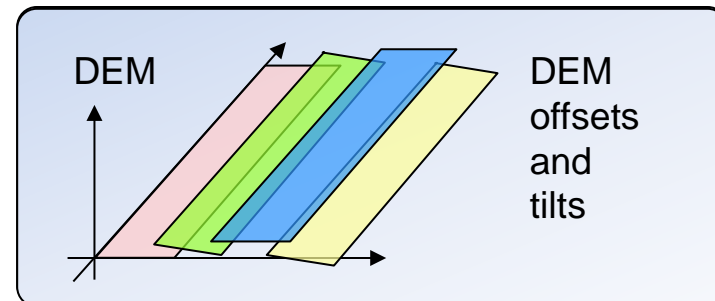
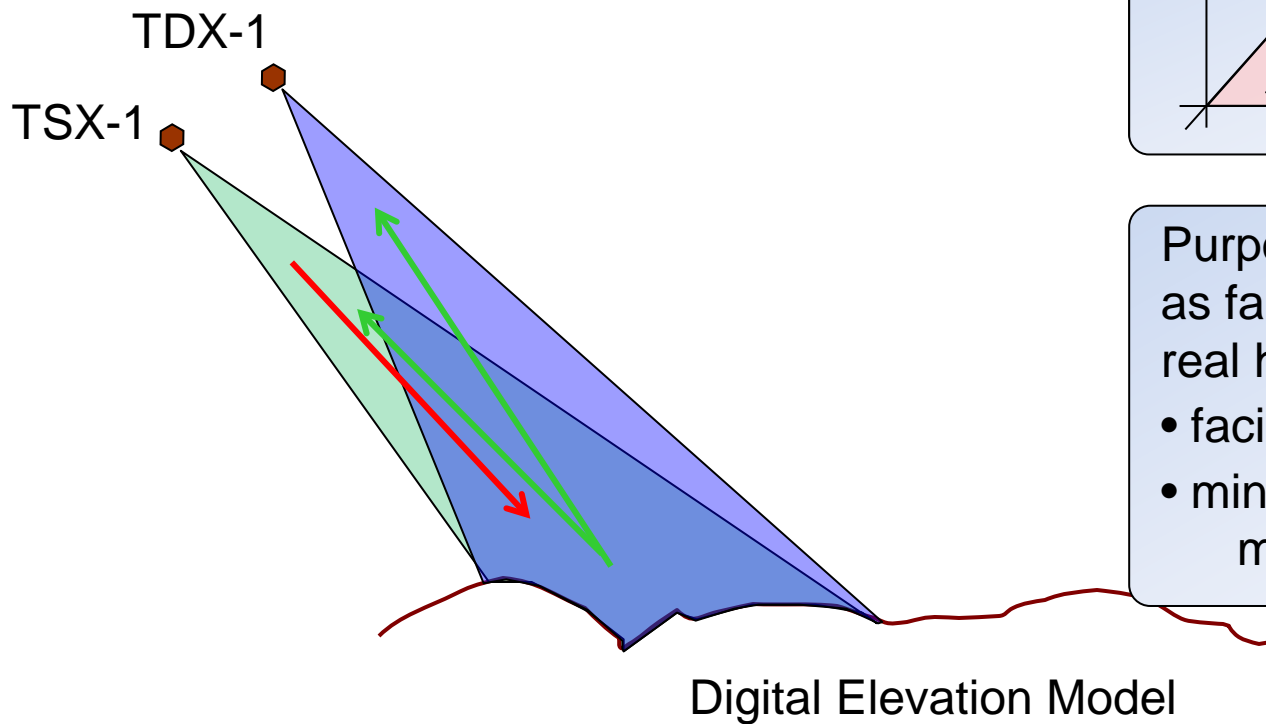
# TanDEM-X Mission Introduction



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# Interferometric Calibration Purpose

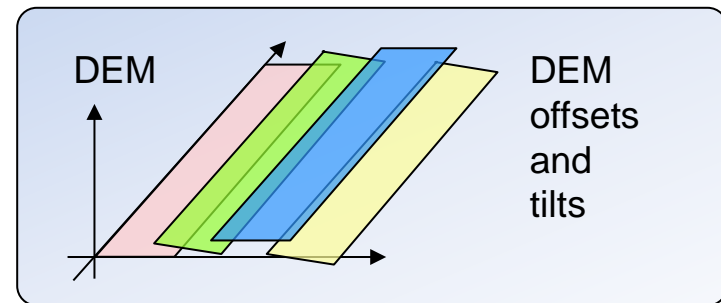
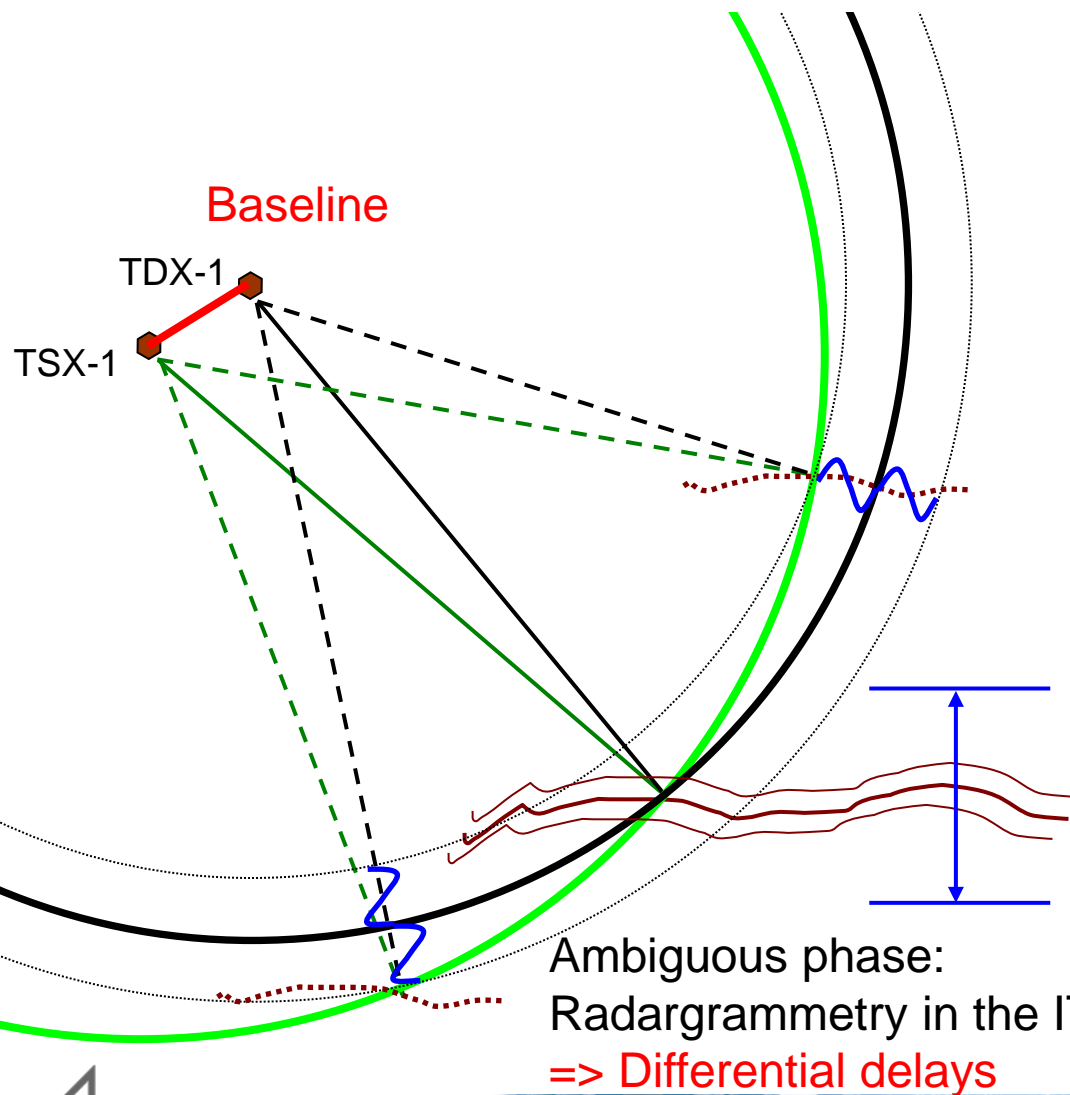


Purpose: Bring the RawDEMs as far as possible down to their real height location in order to

- facilitate accurate geocoding
- minimize effort during DEM mosaicking



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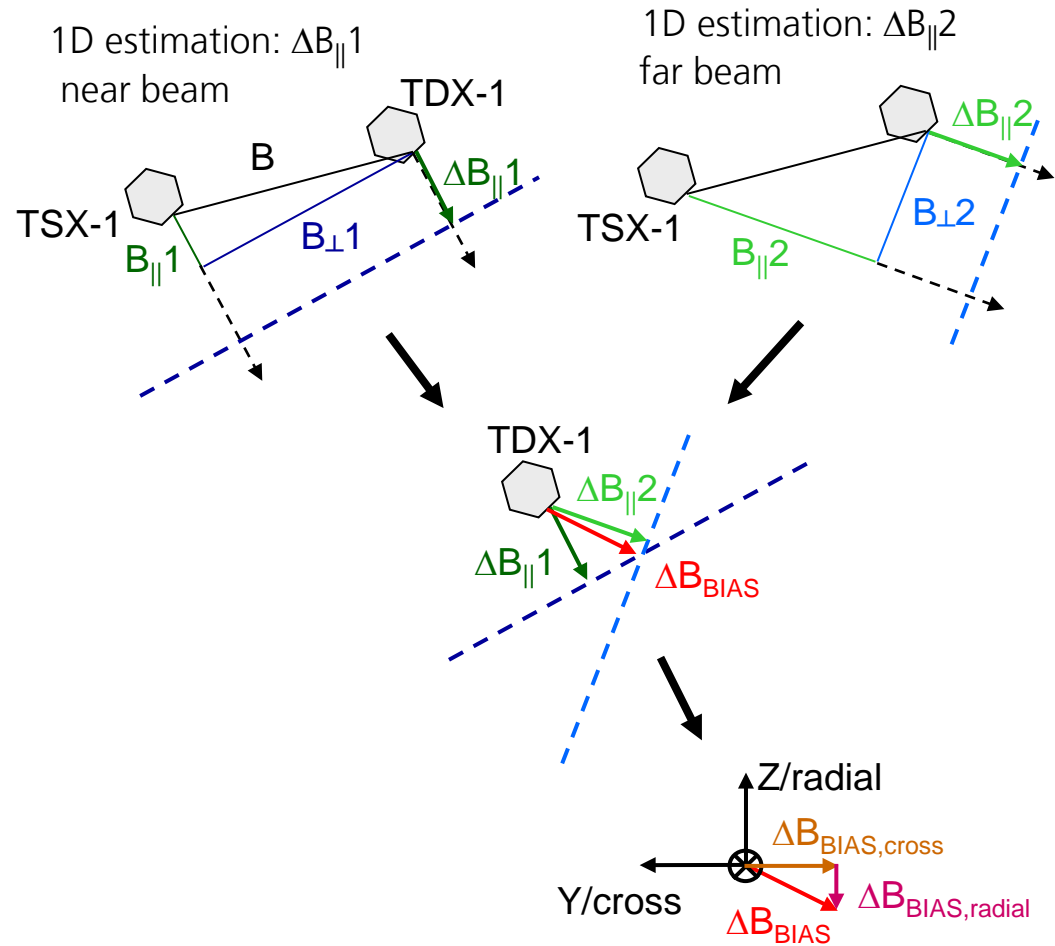
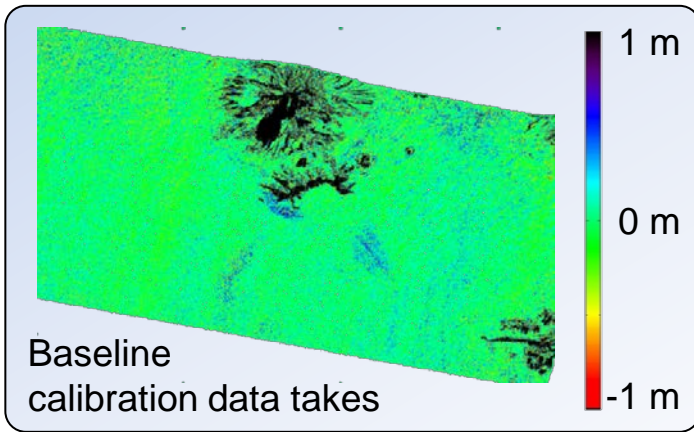
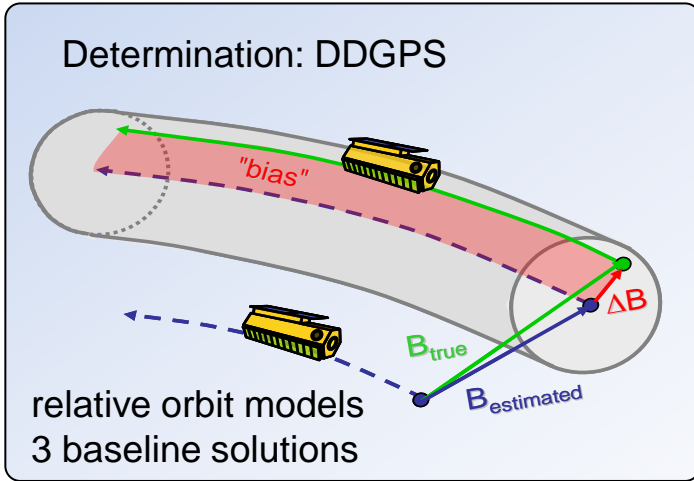
Absolute height error  
=> **Differential phase**

Ambiguous phase:  
Radargrammetry in the ITP  
=> **Differential delays**

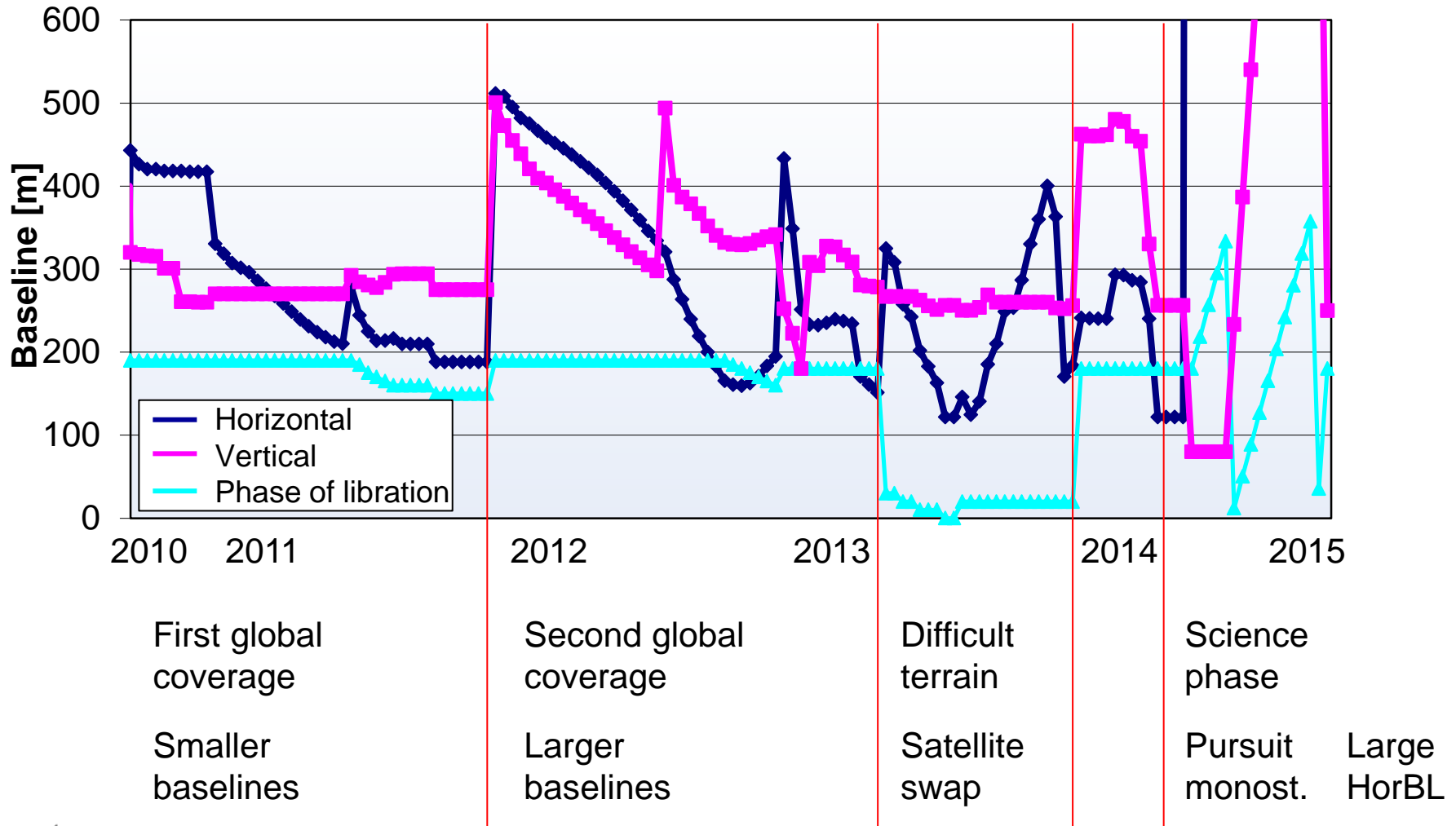




# Baseline Calibration Approach

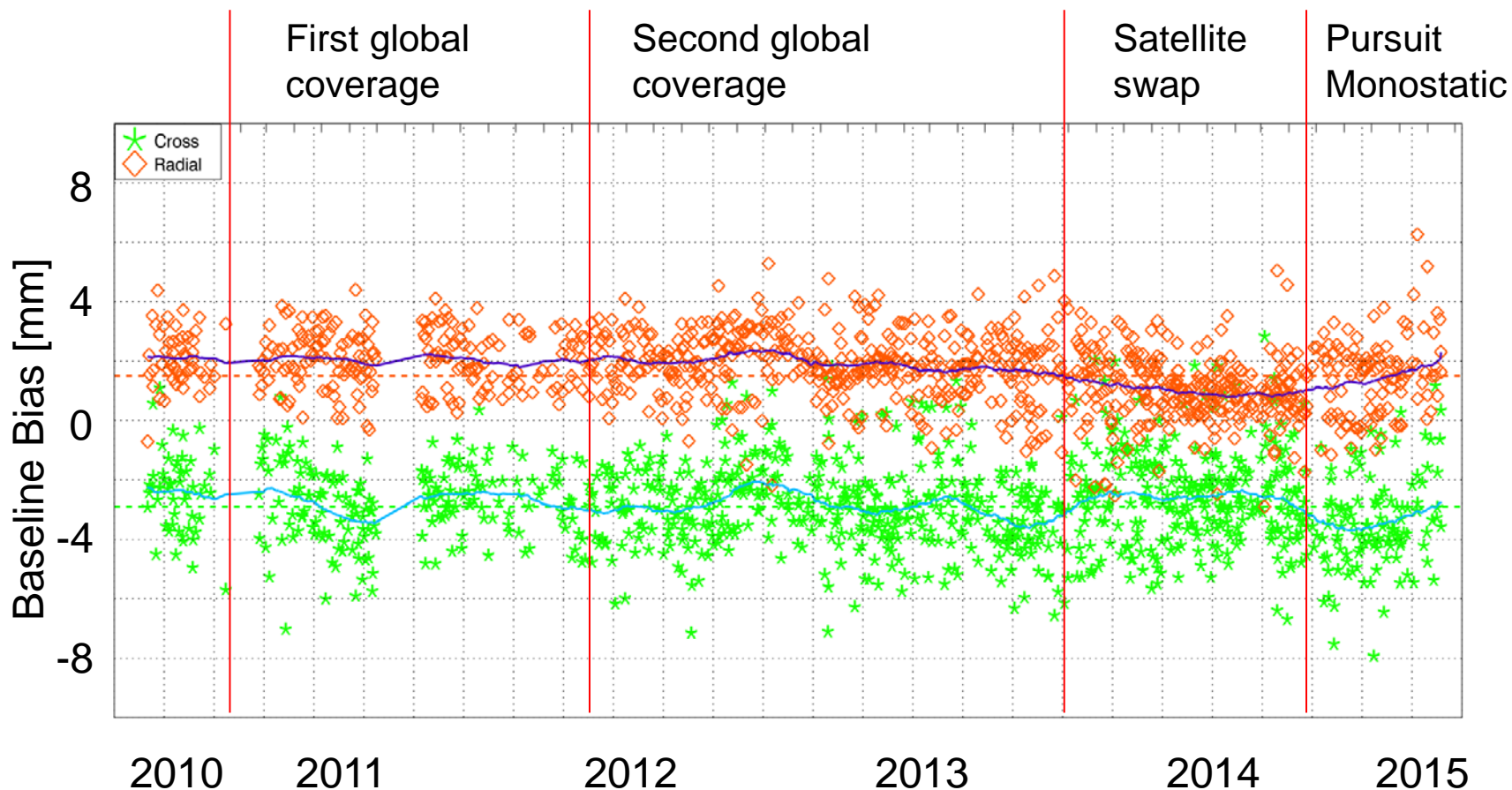


# TanDEM-X Formations





# Baseline Calibration Results



Baseline Error: < 1.2 mm (2010 – 2013)



# Baseline Calibration Results

## Large Horizontal Baseline Phase Limitations:

### Very low height of ambiguity:

- strong effect on inaccurate reference heights
- Accurate baseline offset determination not possible

### Precise baseline determination:

- Outages/reboots in the TDX1 baseline determination system
- Switch of the receiver chain
- Different offsets

### First results from the actual small baseline phase:

- Baseline offsets look good again and in coincidence to before



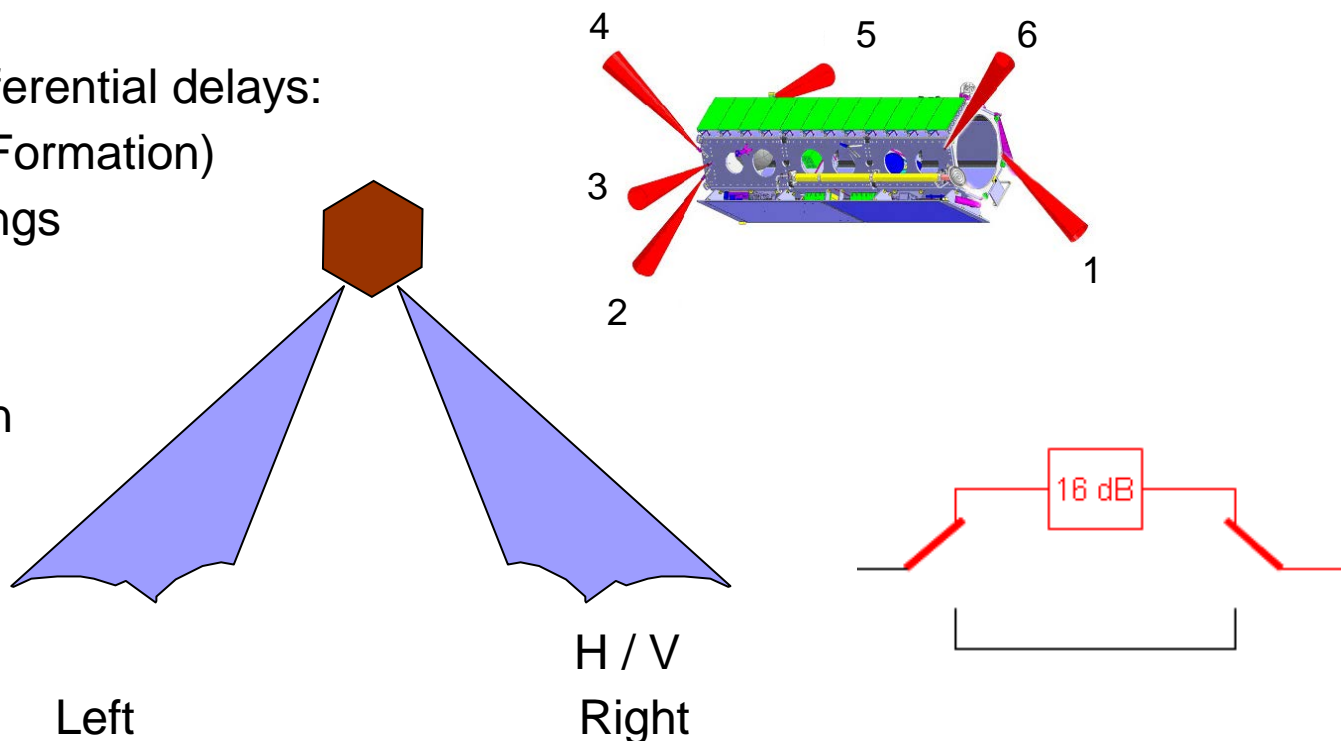
# Differential Delay Calibration required for Radargrammetry

## Radargrammetry:

- Implemented by the ITP to determine correct phase band
- Use of signal travel times for coarse height determination
- Comparison to simulated SRTM shifts

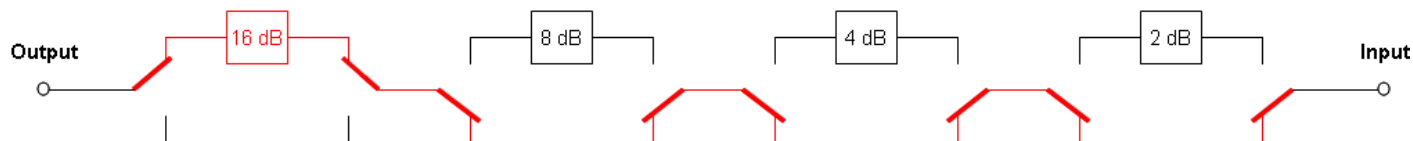
## Sensitive to differential delays:

- Sync horns (Formation)
- RXGain settings
- Bandwidth
- Polarization
- Look direction

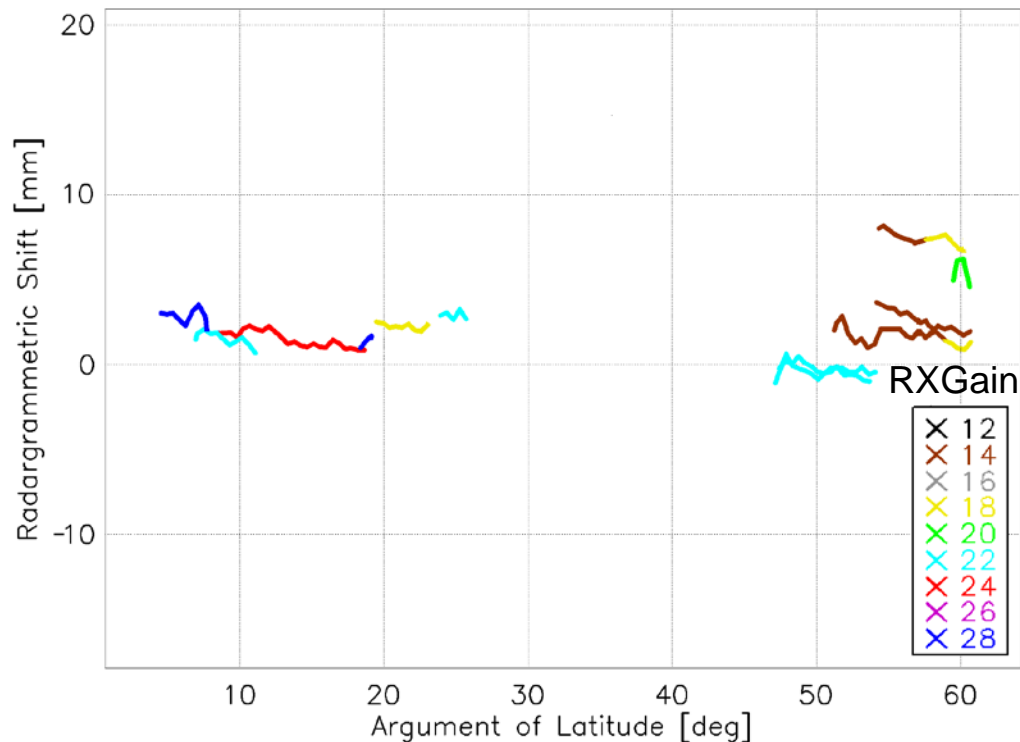


# Receiver Gain Setting – Differential Delay Calibration

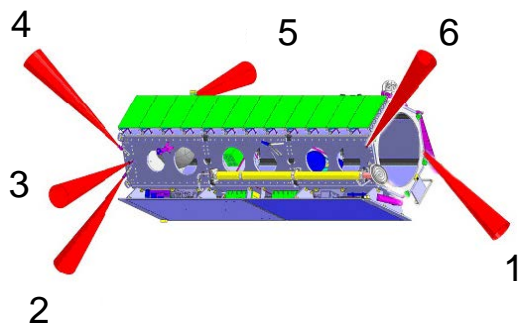
16 dB:



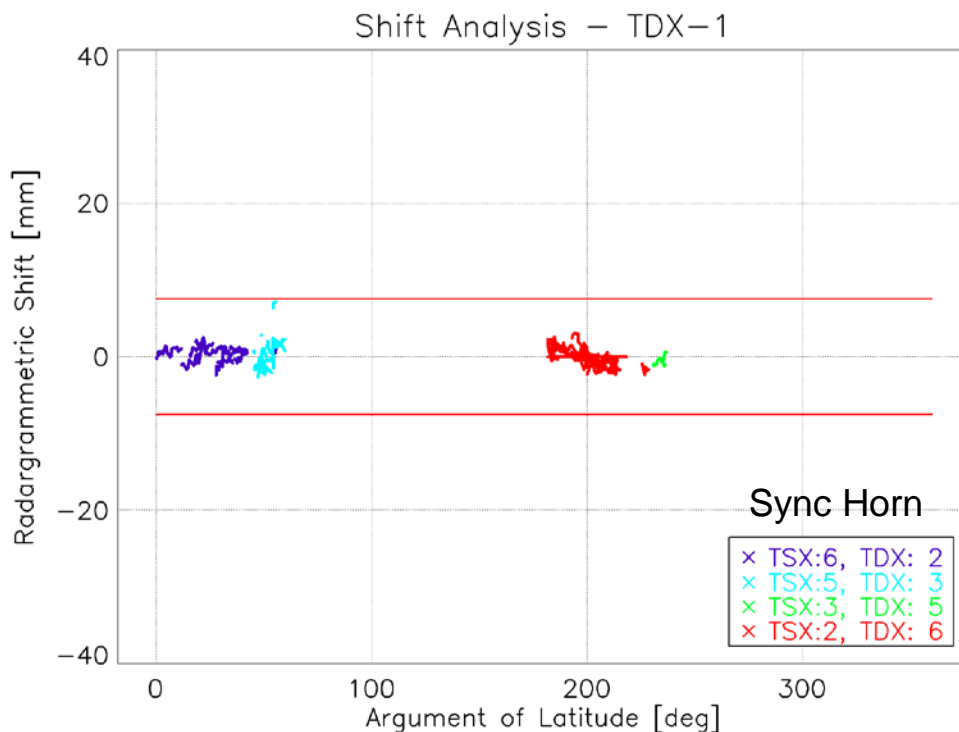
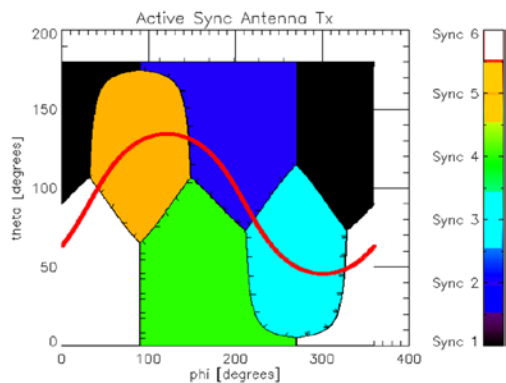
- Corrections between 0-13mm depending on RxGain configuration
- Determination from
  - radargrammetric shifts
  - from dedicated measurements
- **Effect due to phase trimming**



# Sync Horns - Differential Delay Calibration

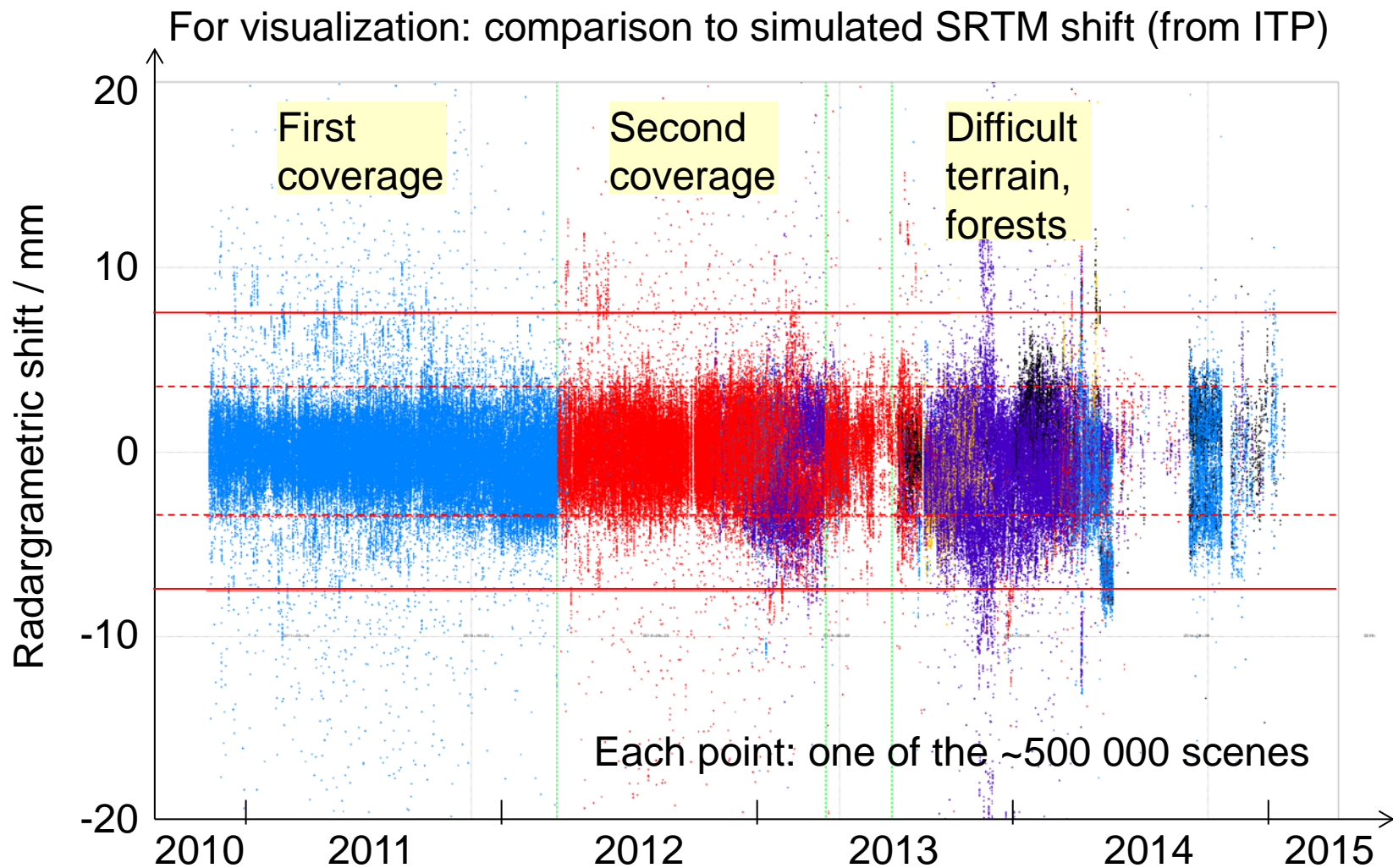


- Uncompensated electronic delay depending on the active sync horn pair
- Different sync horns after satellite swap





# Differential Delay Calibration - Results and History





# Absolute Phase Offset Calibration

- Phase offset calibration for accurate height location
- Initial calibration 2011: Deviations to SRTM/ICESat (one global constant)



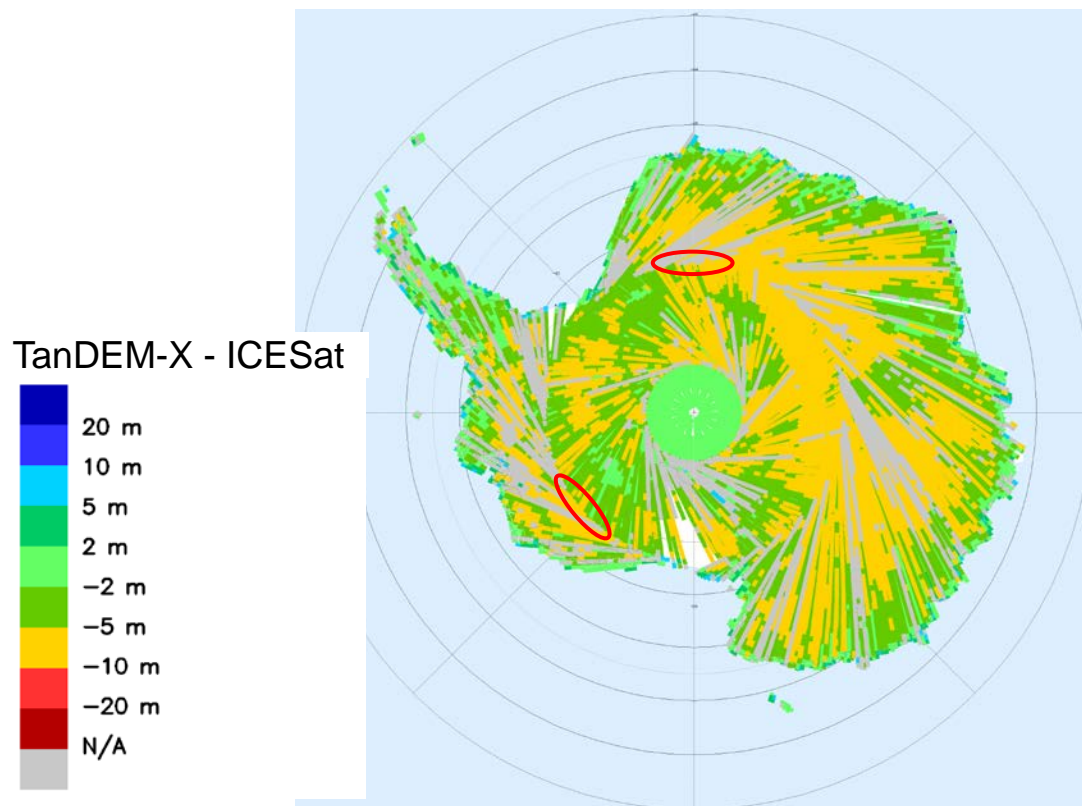
# Absolute Phase Offset Calibration for Left Looking (2015)

- Phase offset calibration for accurate height location
- Initial calibration 2011: Deviations to SRTM/ICESat (one global constant)



# Absolute Phase Offset Calibration for Left Looking (2015)

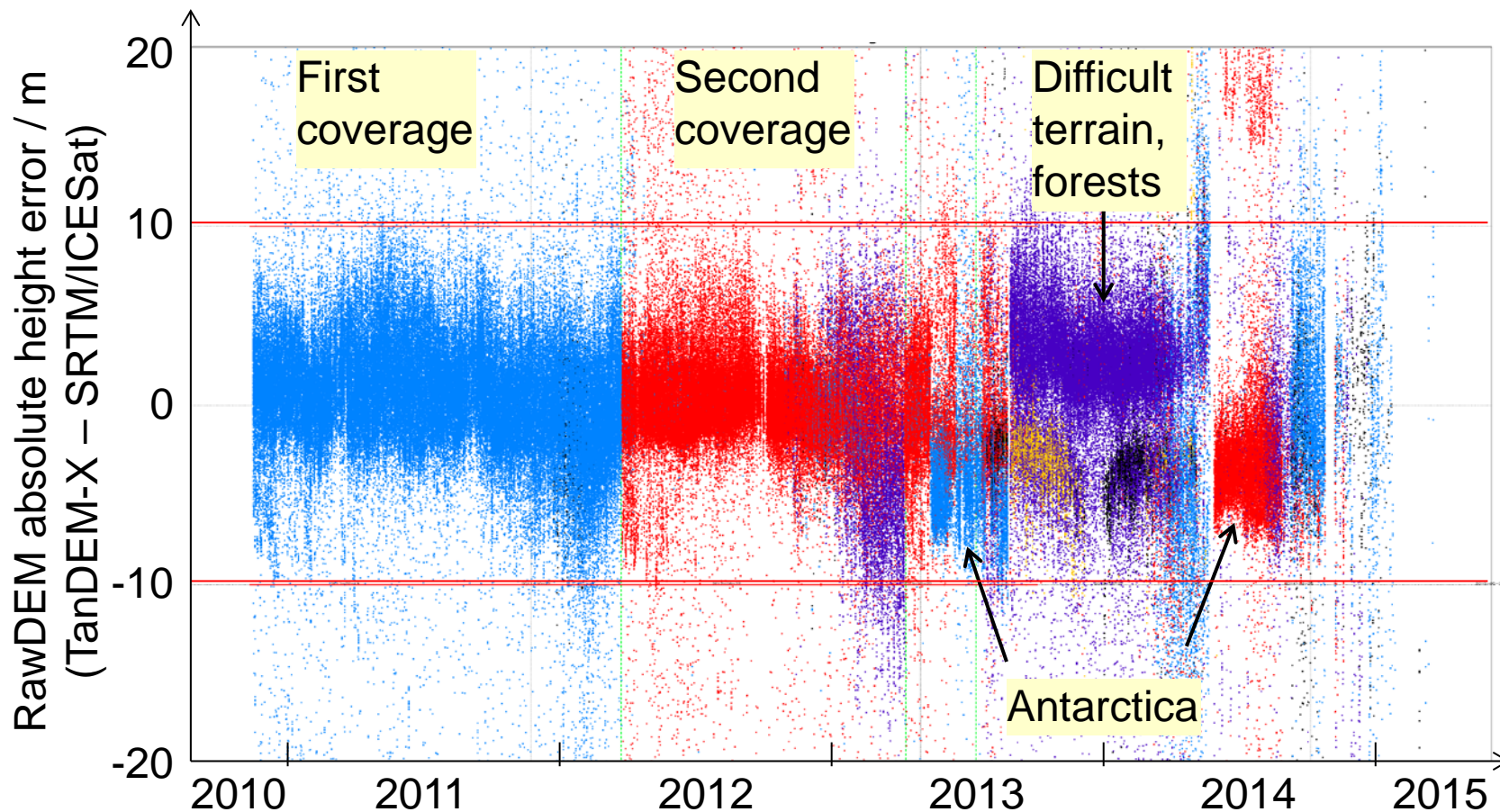
- Phase offset calibration for accurate height location
- Initial calibration 2011: Deviations to SRTM/ICESat (one global constant)



➤ Left Looking calibration using overlapping areas to right looking acquisitions



# RawDEM Absolute Height Offsets

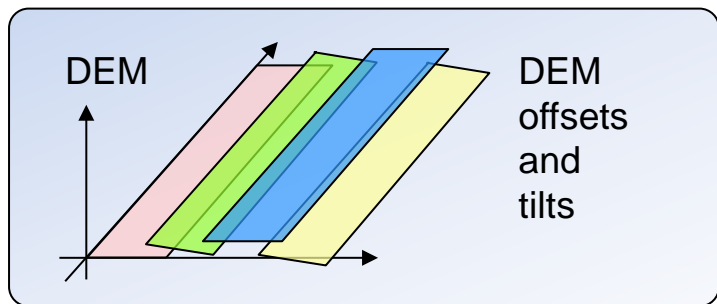


Different penetration mechanisms TanDEM-X vs. laser (ice) and SRTM (forests)  
RawDEM absolute height offset < 4 m (stddev)

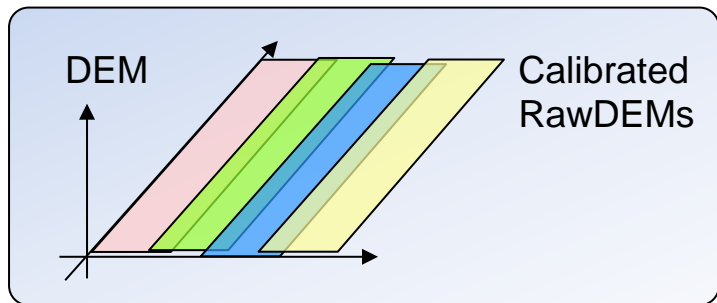




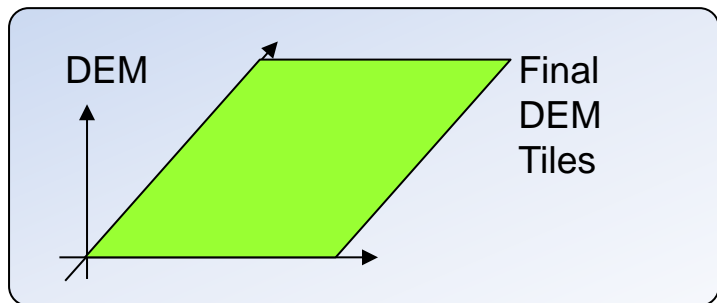
# DEM Quality Status



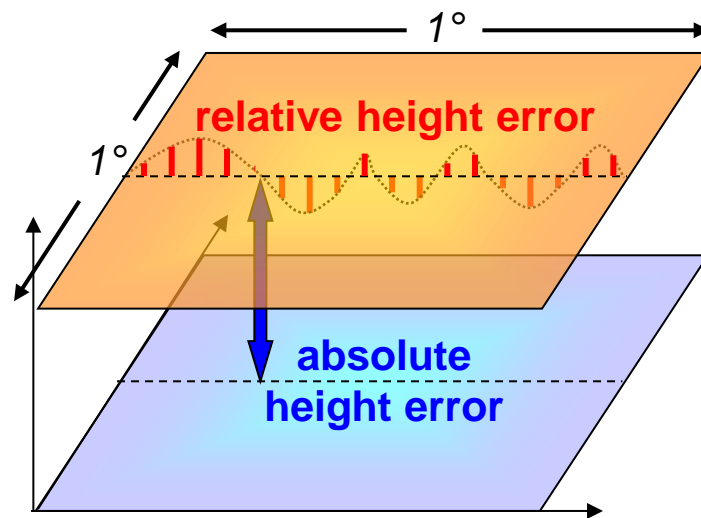
RawDEM Calibration



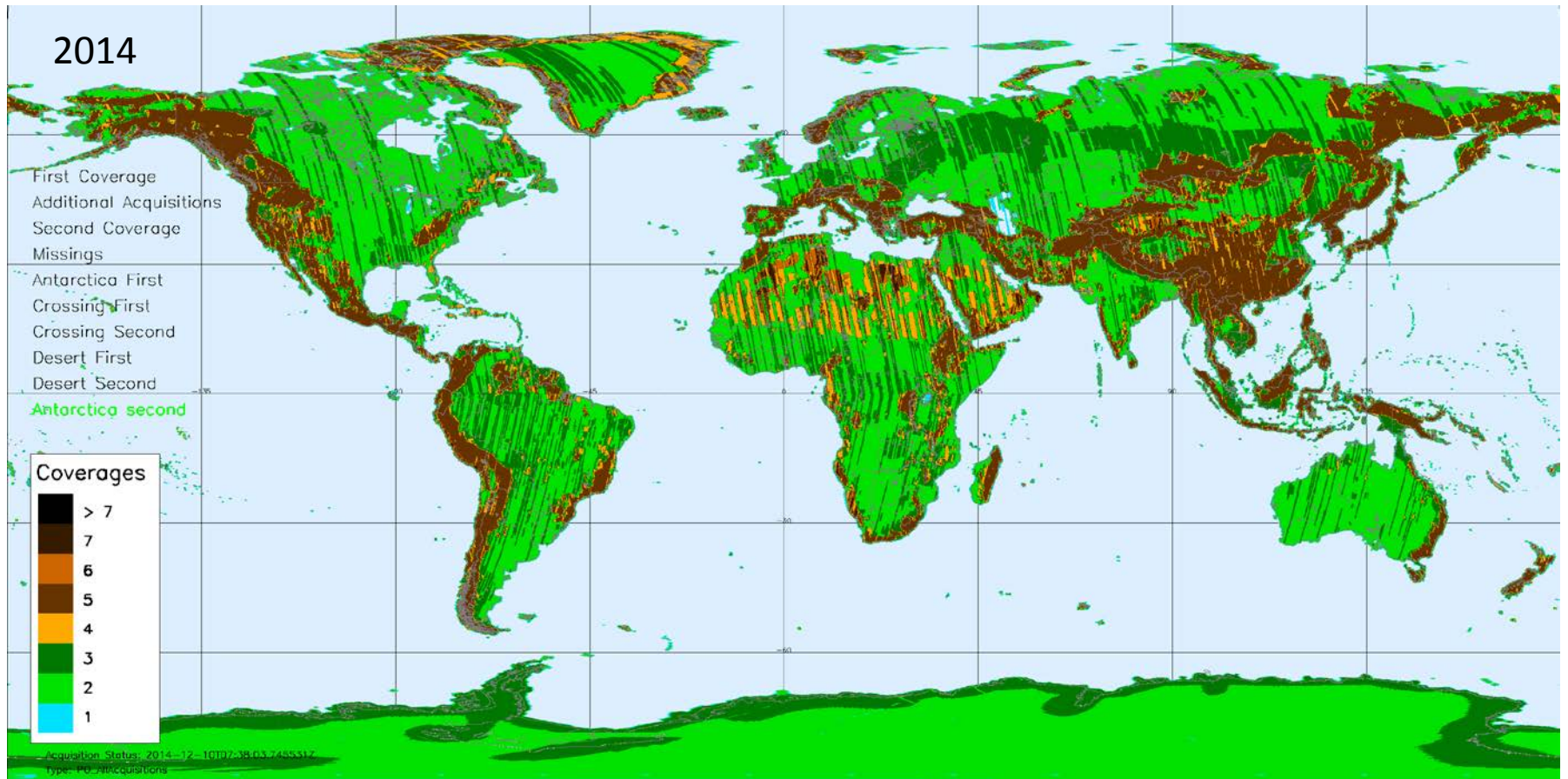
DEM Mosaicking



	Specifications
Relative Height Accuracy	$\leq 2$ m (slope $\leq 20\%$ ) $\leq 4$ m (slope $> 20\%$ ) (90% confidence level)
Absolute Height Accuracy	$\leq 10$ m (90% linear error)
Land Coverage	$\geq 97\%$

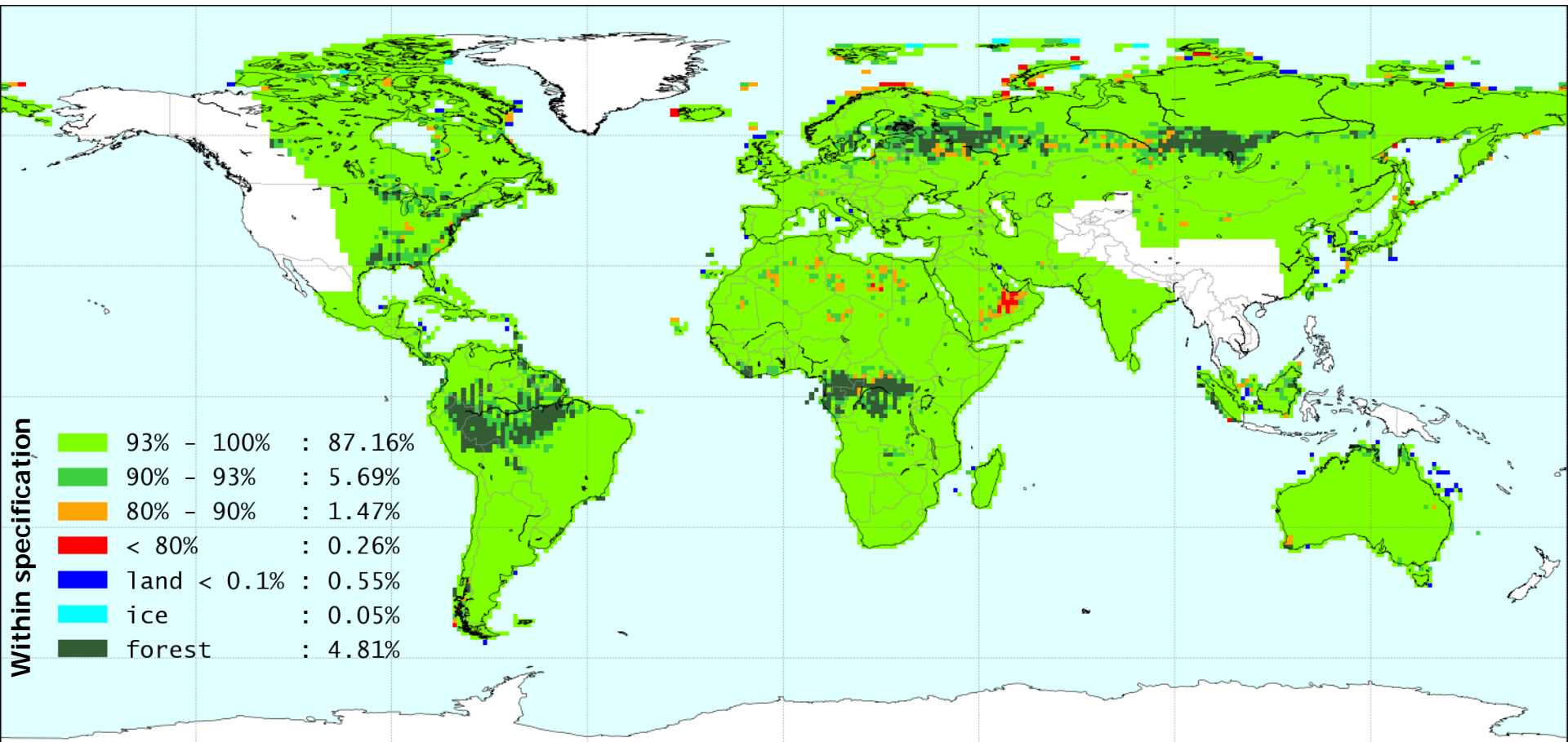


# DEM Acquisition – Coverages





# Final DEM Quality – Relative Height Error

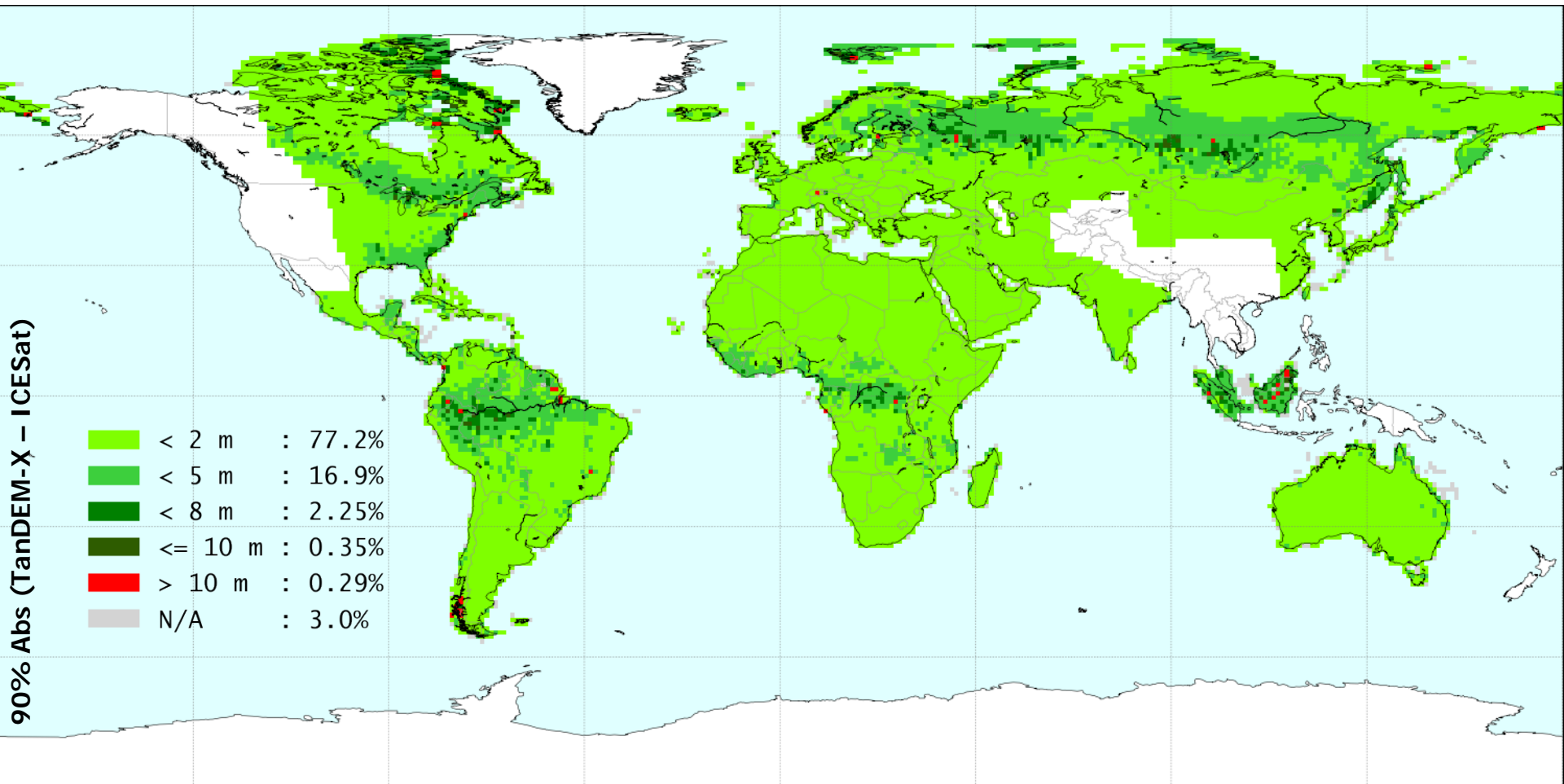


75% of the land masses mosaicked

98.2% of final DEMs achieve relative height accuracy specification (2m/4m)



# Final DEM Quality – Absolute Height Error



99.7% of final DEMs within 10 m accuracy (90% linear accuracy)

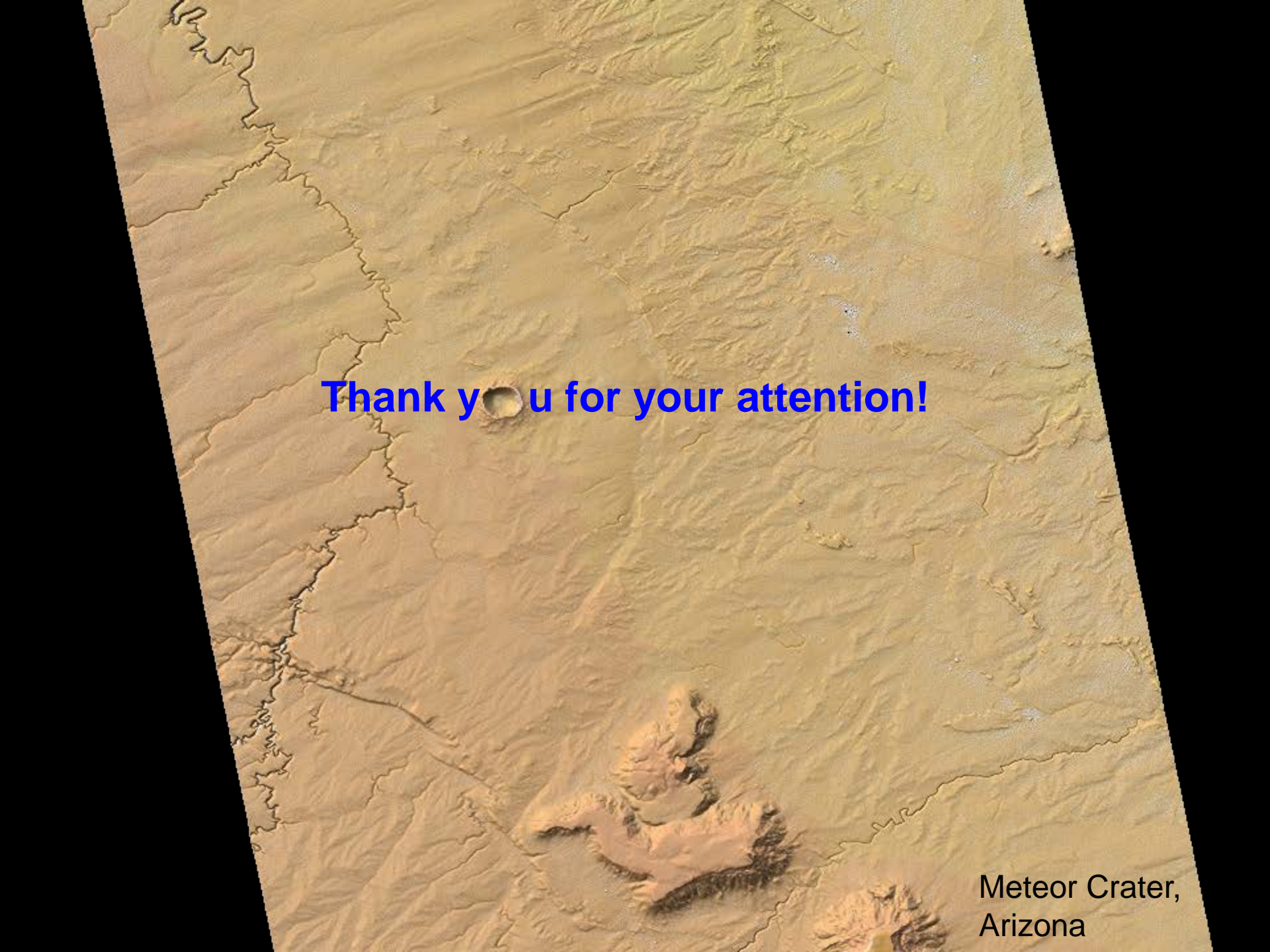


# Conclusion

- Calibration of the interferometric system: still very stable
  - Baseline: 1.2 mm (stddev)
  - Phase offsets: RawDEM absolute height offsets < 4 m (stddev)
  
- Final DEM quality
  - Relative height accuracy: 98.2% of DEMs within 2 m / 4 m
  - Absolute height accuracy: 99.7% of DEMs within 10 m
  
- TanDEM-X future
  - TanDEM-X mission will continue after 2015 with
    - High Resolution DEMs
    - Science





A topographic map of Meteor Crater, Arizona, showing the crater's rim and surrounding terrain. The map is oriented vertically and tilted slightly to the right. The terrain is depicted with brown and tan colors, indicating elevation. A prominent feature is the circular rim of the crater, which is clearly visible in the lower half of the image. The text "Thank you for your attention!" is overlaid in the center of the map.

**Thank you for your attention!**

Meteor Crater,  
Arizona