Processing of GPS radio occultation data from TerraSAR-X and TanDEM-X: Current status & future plans

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TerraSAR-X & TanDEM-X

...is a twin satellite configuration; separation ~ 200 – 500 m.
We present results from TerraSAR-X & TanDEM-X profile-to-profile comparison (collocated setting occultations).

We study the sensitivity of retrievals w.r.t. signal tracking parameters. E.g. simulations studies indicate that if the OL Doppler model is biased the retrieved refractivity is potentially biased as well.

First rising occultations on TerraSAR-X & TanDEM-X: Status & future plans.

Summary.
Processing overview

GFZs processing software package POCS-X (Beyerle et al., 2011, ACP) is used to derive atmospheric products.

Level 1:
- The on-board OL Doppler model is used in postprocessing of OL data.
- Occultations are discarded if Navigation Bits are not available. Navigation Bits are collected by GFZ's ground station network.

Level 2:
- The Full Spectrum Inversion (FSI) is used to obtain Bending Angles (BAs).
- FSI retrieved BAs are replaced by standard retrieved BAs above 12 km.
TerraSAR-X center2center comparison (POCS-X - UCAR)

Fractional N-deviation versus altitude. The thick/thin line indicates the mean/one-sigma deviation.


* Differences at altitudes > 25 km can be explained by differences in the Statistical Optimization.

* Differences at altitudes < 8 km depend on tunable parameters, e.g. the length of the RO signal (Sokolovskiy et al. 2010, JGR).

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(1) TanDEM-X - TerraSAR-X (a typical occultation pair)

Left: TDX & TSX dry temperature versus altitude. Right: Fractional N-deviation versus altitude. (7.9°S, 64.4°W, 11:25 UTC, DOY 330, Y2011)

* The agreement is excellent; both indicate the same height of the tropopause and both indicate the same height of the moist ABL.
TanDEM-X - TerraSAR-X

Fractional N-deviation versus altitude. The thick/thin line indicates the mean/one-sigma deviation.

Period: Y2011, DOY 330-336, 761 occultation pairs with horizontal Tangent Point differences < 1 km.

* In the altitude range 10 - 20 km the standard deviation is < 0.2%.

What happens if we change the TanDEM-X OL Doppler model by ± 10 Hz?
(2) TanDEM-X – TerraSAR-X (OL Doppler model - 10 Hz)

Fractional N-deviation versus altitude. The thick/thin line indicates the mean/one-sigma deviation.

Period: Y2011, DOY 354-355, 213 occultation pairs with horizontal Tangent Point differences < 1 km.
TanDEM-X – TerraSAR-X (OL Doppler model + 10 Hz)

Fractional N-deviation versus altitude. The thick/thin line indicates the mean/one-sigma deviation.

Period: Y2012, DOY 49-55, 712 occultation pairs with horizontal Tangent Point differences < 1 km.

* A bias in OL Doppler model of ±10 Hz introduces a bias of up to ± 0.5 % in the retrieved refractivity. Why?
TanDEM-X – TerraSAR-X (occultation pair #1)

Left: TerraSAR-X SNR versus SLTA. Middle: L1 Doppler difference versus SLTA. Right: Fractional N-deviation versus altitude.
TanDEM-X – TerraSAR-X (occultation pair #2)

Left: TerraSAR-X SNR versus SLTA. Middle: L1 Doppler difference versus SLTA. Right: Fractional N-deviation versus altitude.

In SLTA regions where SNR is low the Doppler differences tend to be systematic (positive) since the OL Doppler model differences are systematic (positive).
Fractional N-deviation versus altitude. The thick/thin line indicates the mean/one-sigma deviation.

Period: Y2012, DOY 49-55, 425 occultation pairs with horizontal Tangent Point differences <1km.

An ad hoc QC procedure:
Compare the excess phase profiles and discard the occultation if the profiles deviate from each other.

* The bias is reduced, but (!) 40 % of all occultations are discarded.
(3) TerraSAR-X NRT data


Currently TerraSAR-X NRT data from setting occultations are available.

We plan to provide Tandem-X NRT data from rising occultations. This will eventually double input for NWP from the twin satellites.

Some issues must be solved first ...
First results from rising occultations: TerraSAR-X – ECMWF

Fractional N-deviation versus altitude. The thick/thin line indicates the mean/one-sigma deviation.

Period: Y2010, DOY 89-93, 243 profiles.

* A large number of profiles do not pass QC. Those who pass QC show a negative bias in the UTLS (same for TanDEM-X).

We plan a center2center comparison (UCAR will help us) to figure out if it is a matter of our processing.
First results from rising occultations: TanDEM-X – ECMWF

Fractional N-deviation versus altitude. The thick/thin line indicates the mean/one-sigma deviation.

(4) Summary

- The agreement between collocated TerraSAR-X & TanDEM-X profiles is very good.

- An off-set in the OL Doppler model of ± 10 Hz introduces a bias in the retrieved refractivity of ± 0.5 % in the LT (globally). Our explanation: in regions of low SNR, the residual Doppler is randomly distributed around the Doppler model. If Doppler model is biased, the retrieved Doppler, bending angle & refractivity is biased. Plans: Continue simulation studies by Beyerle et al. 2006, JGR.

- Retrievals from setting events observed by TerraSAR-X are available in NRT (output of GFZ's operational software POCS). Retrievals from rising events observed by TanDEM-X will follow in near future. Some problems (data throughput & quality) must be solved first.
Appendix
LT: TanDEM-X (Doppler model + 10 Hz 'Repeatability')

Fractional N-deviation versus altitude for different pairs; mean deviation (left) & standard deviation (right).

LT: TanDEM-X (Doppler model + 10 Hz 'Repeatability')

Fractional N-deviation versus altitude for different pairs; mean deviation (left) & standard deviation (right).


We only consider profiles where the minimum SLTA difference is < 1 km.

Which OL Doppler model is better? Most likely the one on TerraSAR-X (there must be a negative bias due to critical refraction).