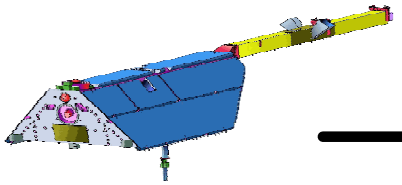

Detection and analysis of GPS radiooccultation signals under multipath conditions: Results from simulation studies

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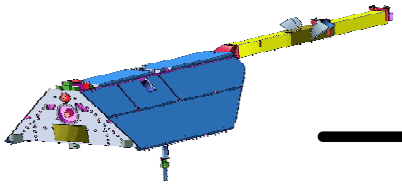
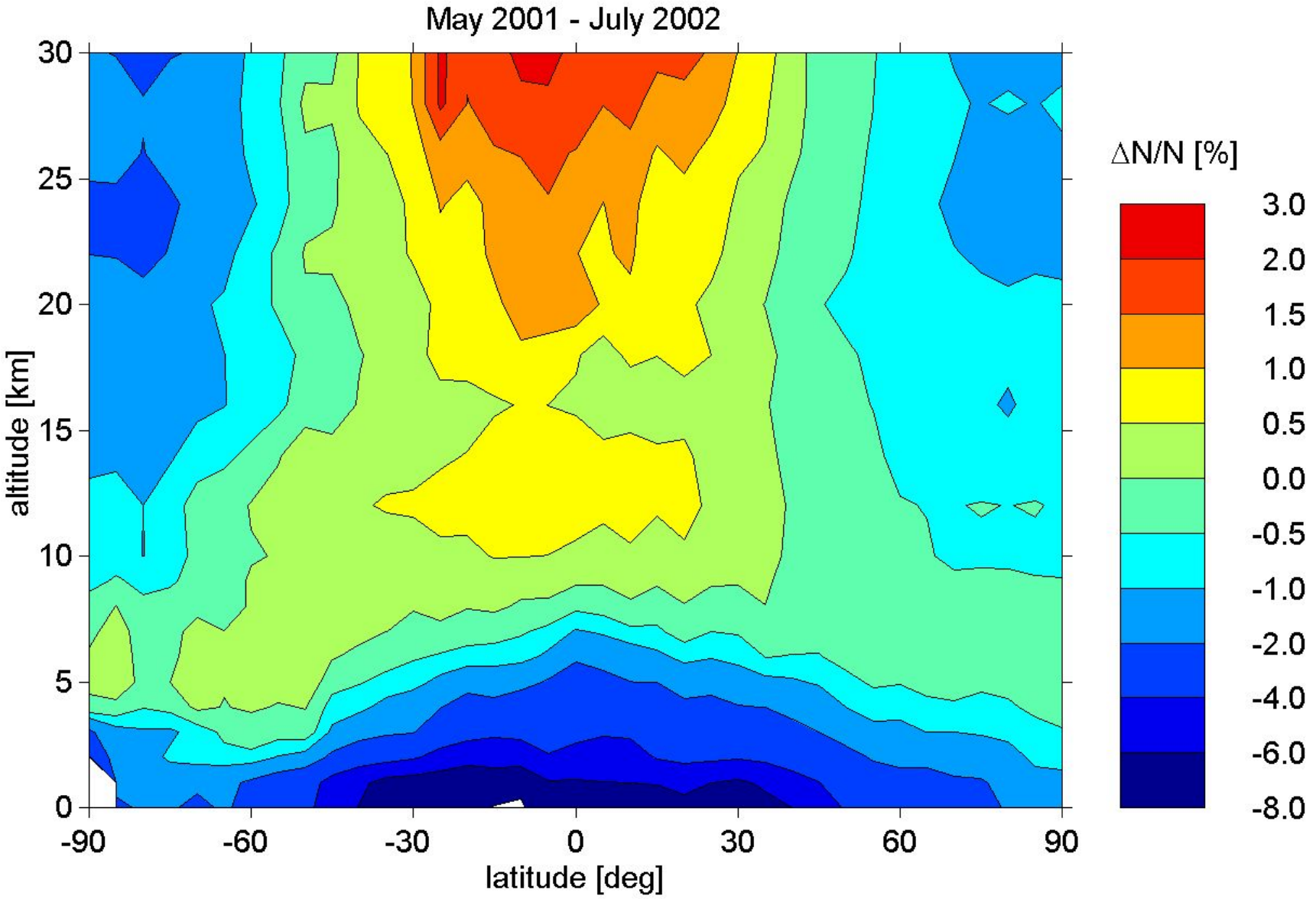
(1) GeoForschungsZentrum Potsdam, Telegrafenberg, Potsdam, Germany
(2) Institute for Atmospheric Physics, Moscow, Russia
(3) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, USA



Overview

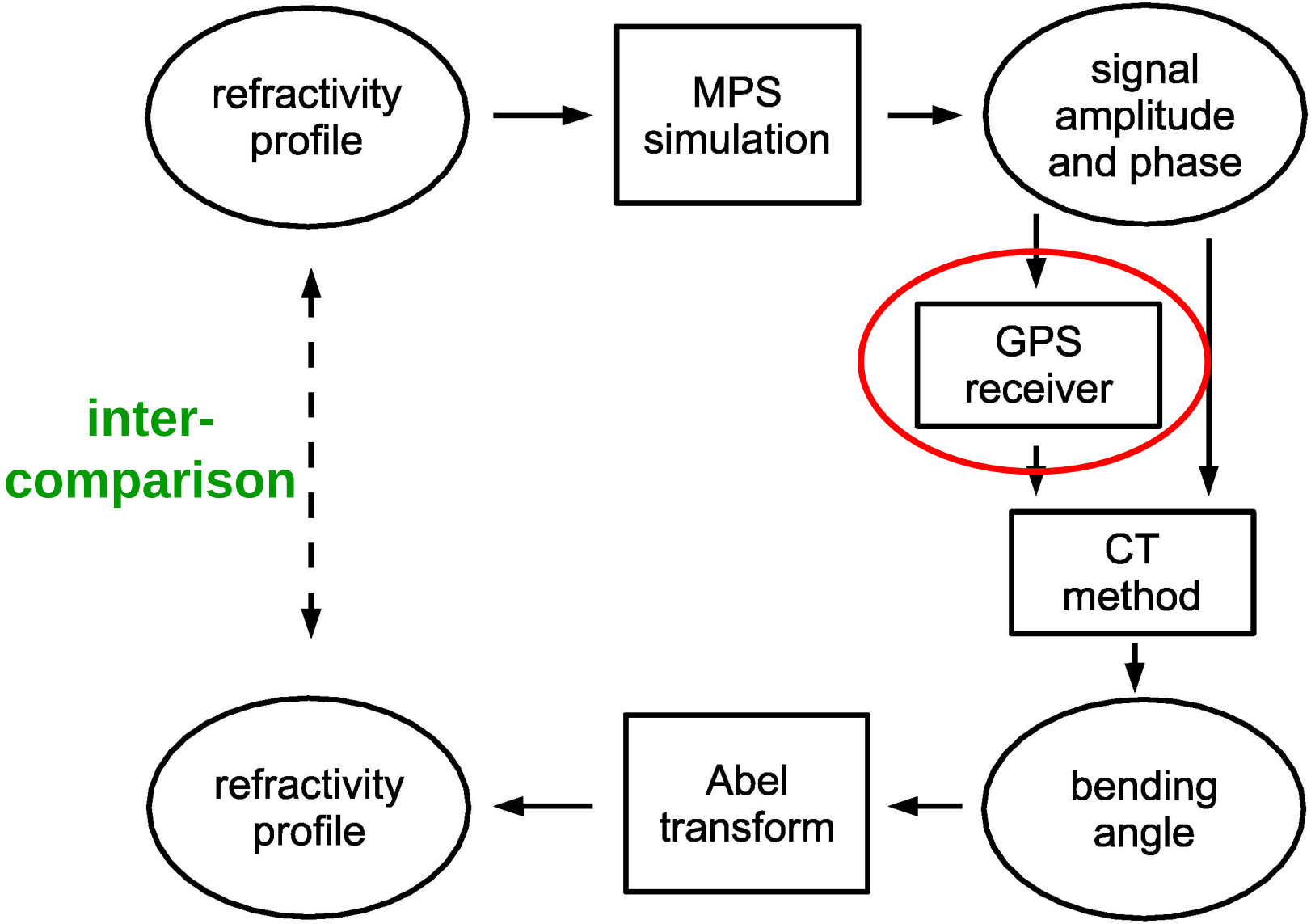
- **Introduction**
- **Simulation method**
- **Simulation results**
- **Conclusions**

Refractivity bias



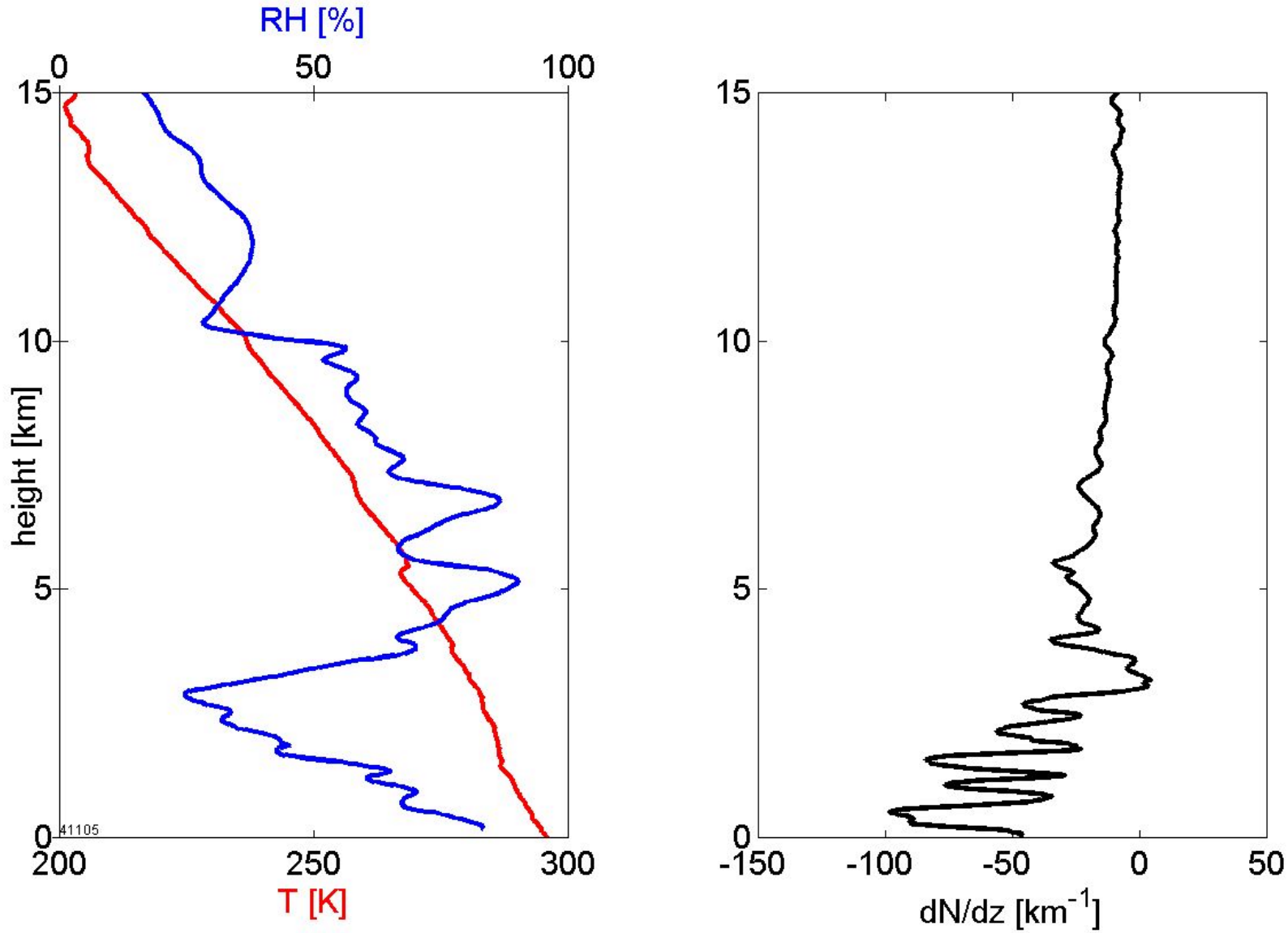
GFZ
POTSDAM

Simulation chain



GFZ POTSDAM

High-resolution radio sonde profile



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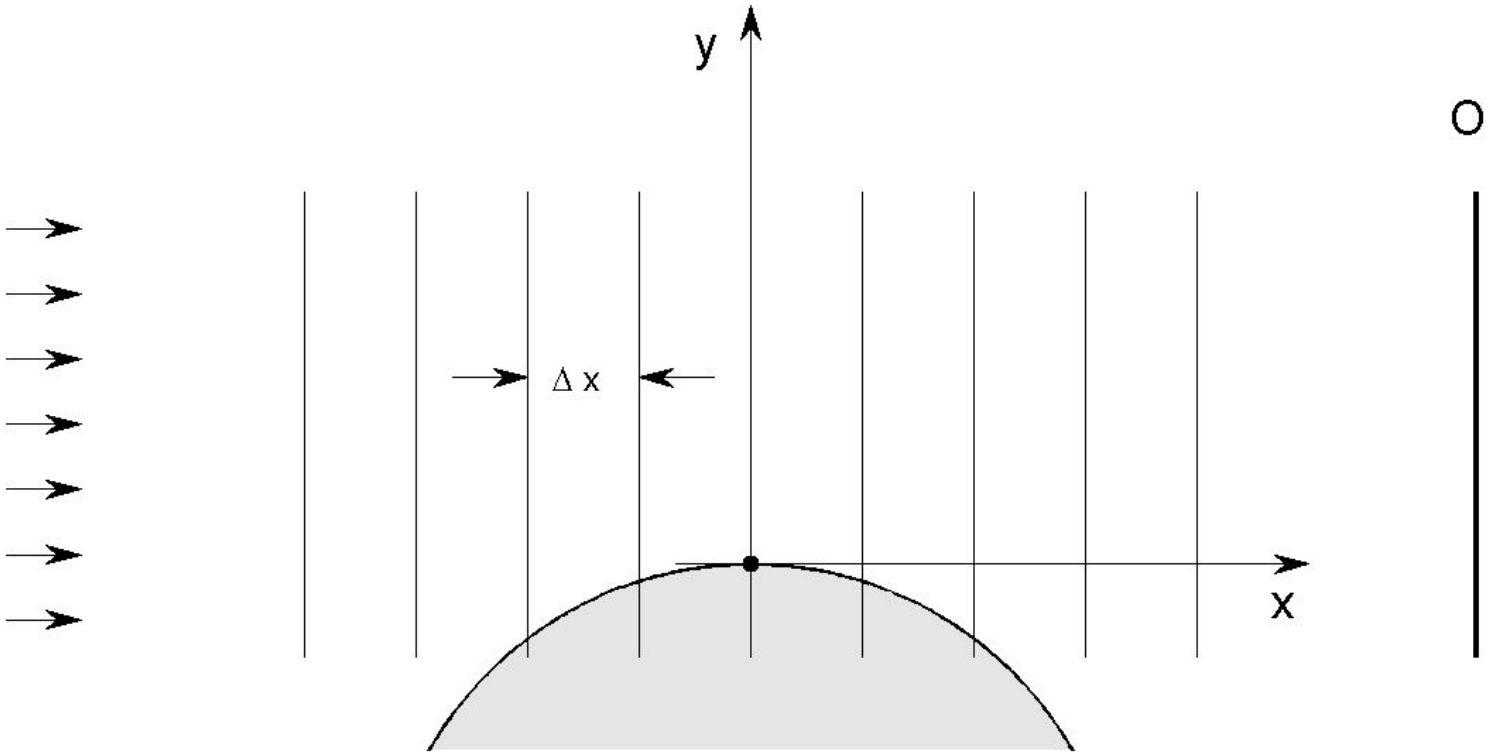
POTSDAM

Multiple phase screen method



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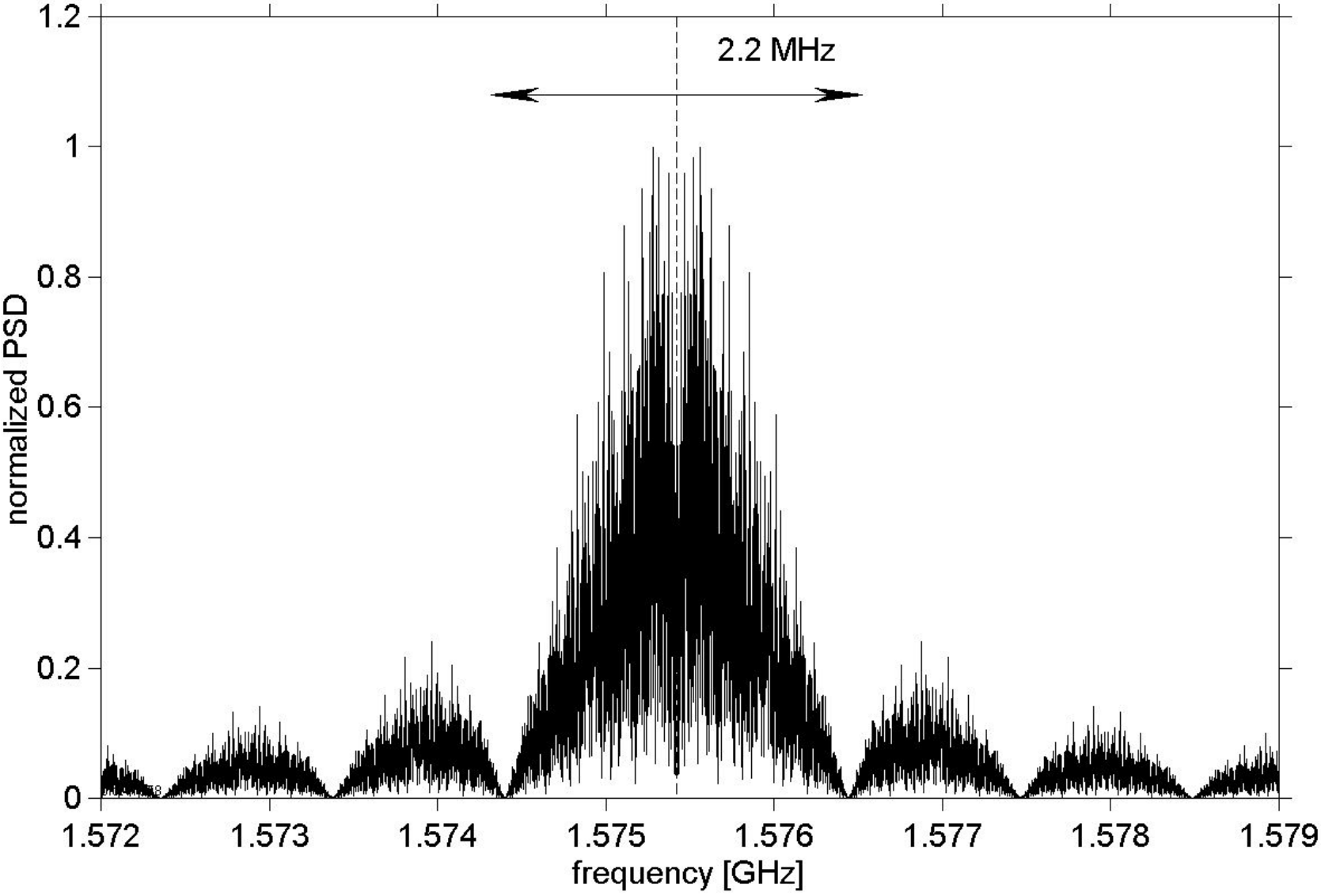
Spectrum of C/A code modulated signal



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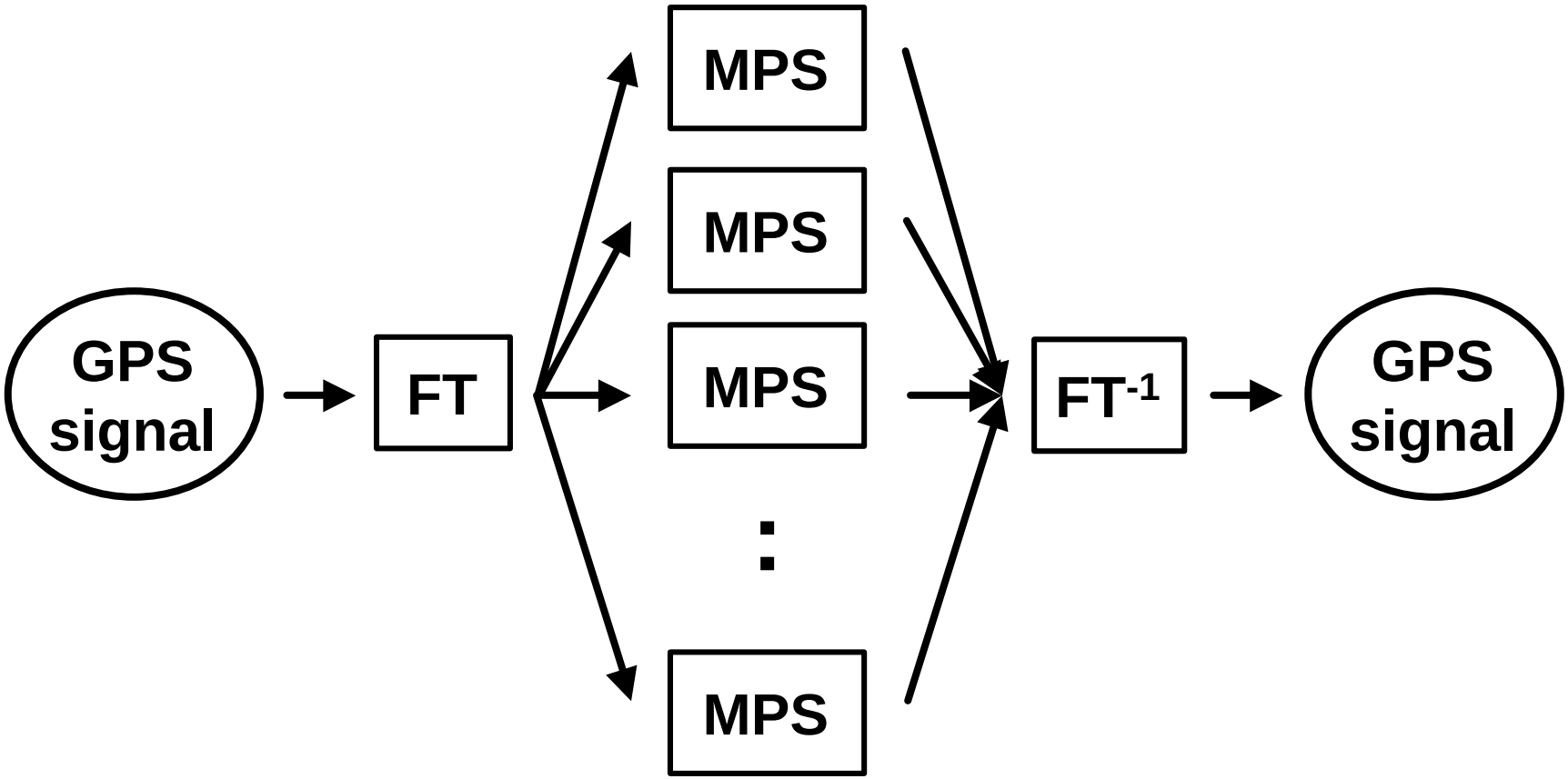
Propagation of a GPS signal



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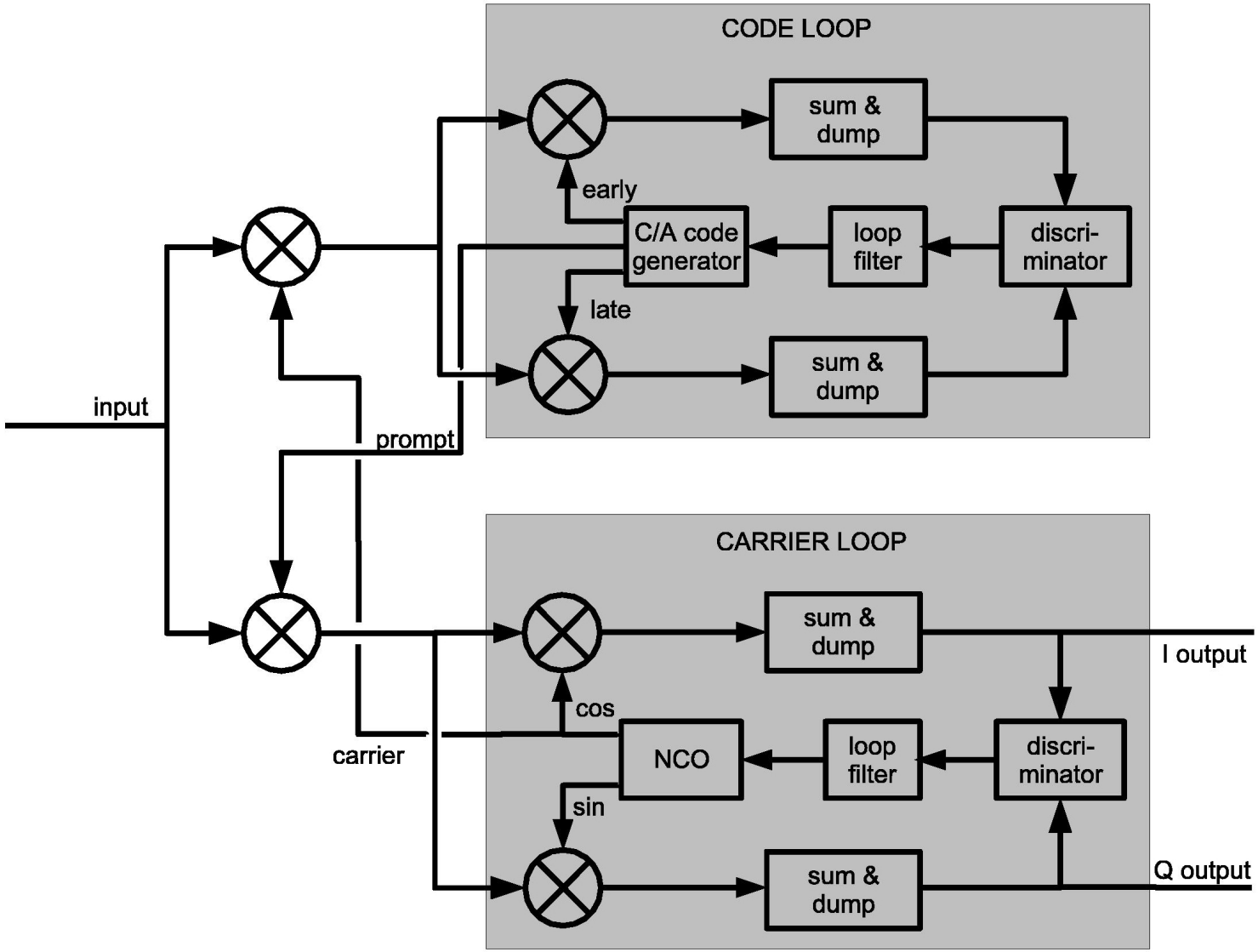
POTSDAM

Tracking loops schematic



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POTSDAM

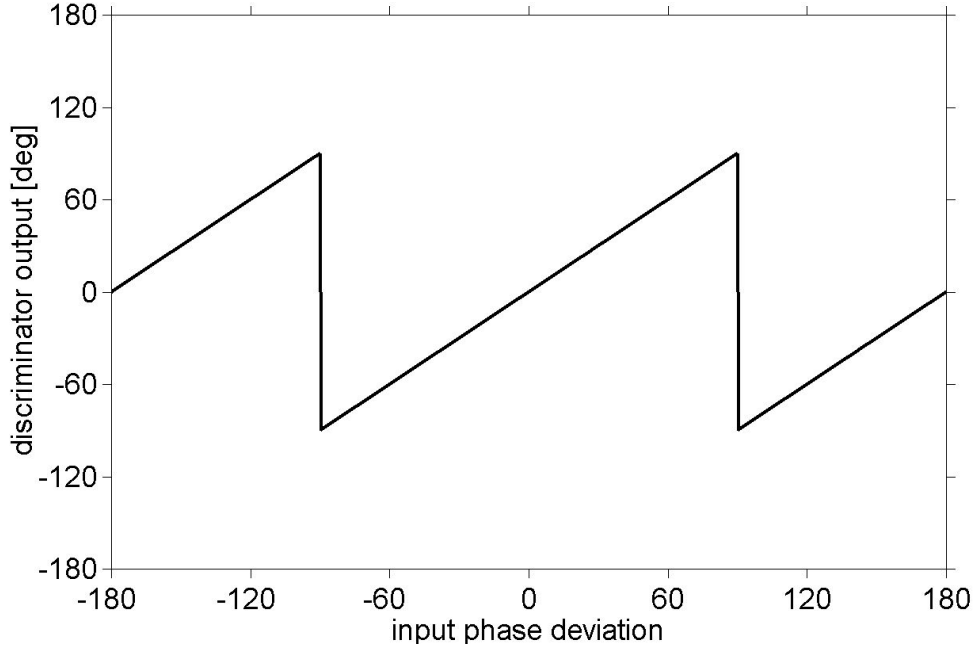
Tracking loop parameters

Parameter	carrier PLL	code PLL
bandwidth	20 Hz	1 Hz
gain	2π 200	50
damping ratio	0.7	0.7

(Ref: Tsui, Fundamentals of GPS receivers: A software approach, Wiley, 2000)

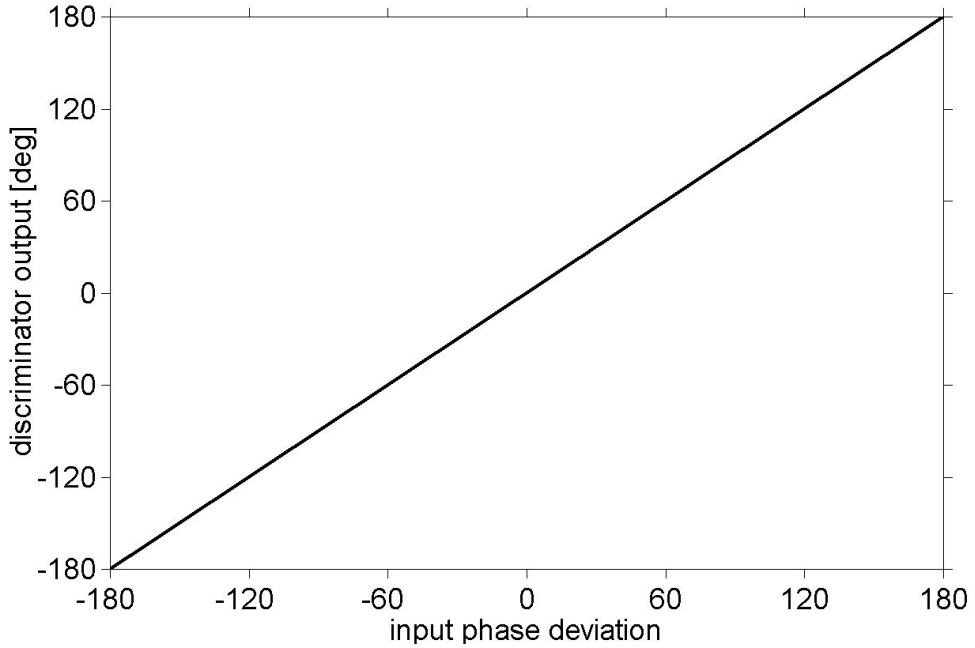
2-quadrant phase extractor

$\varepsilon = atan(Q / I)$



4-quadrant phase extractor

$\varepsilon = atan2(Q, I)$



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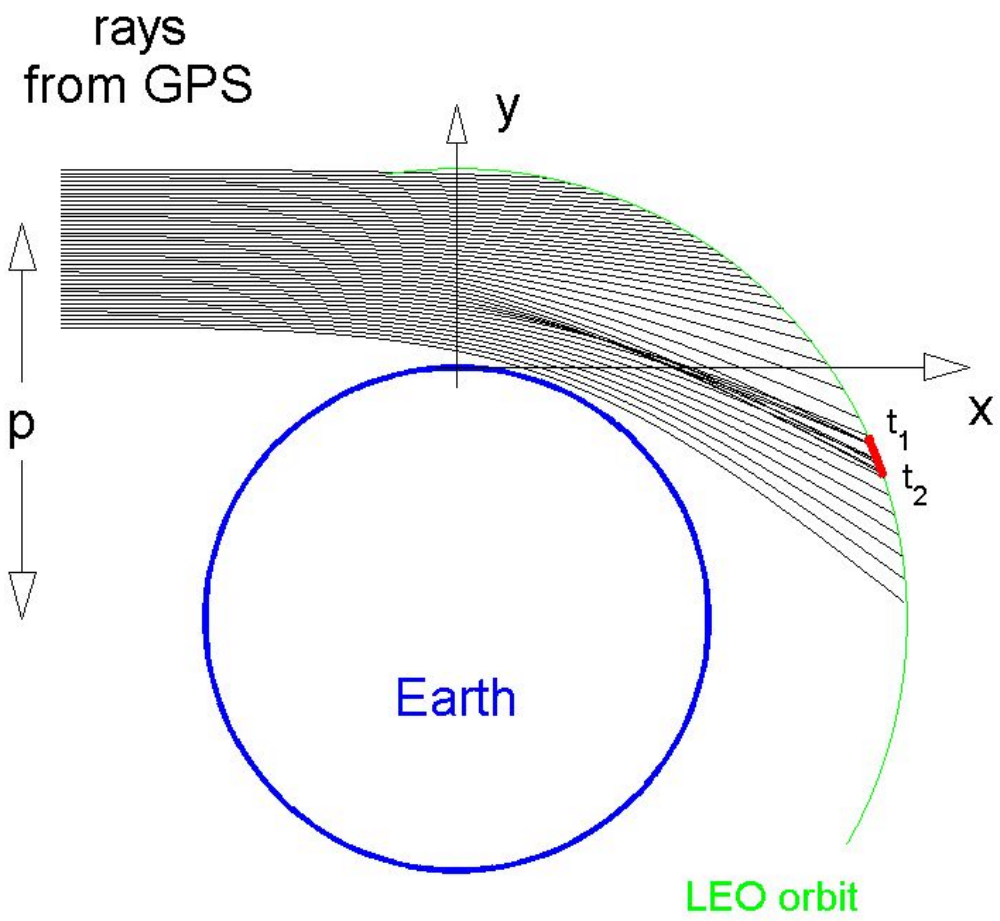
Multipath signal propagation



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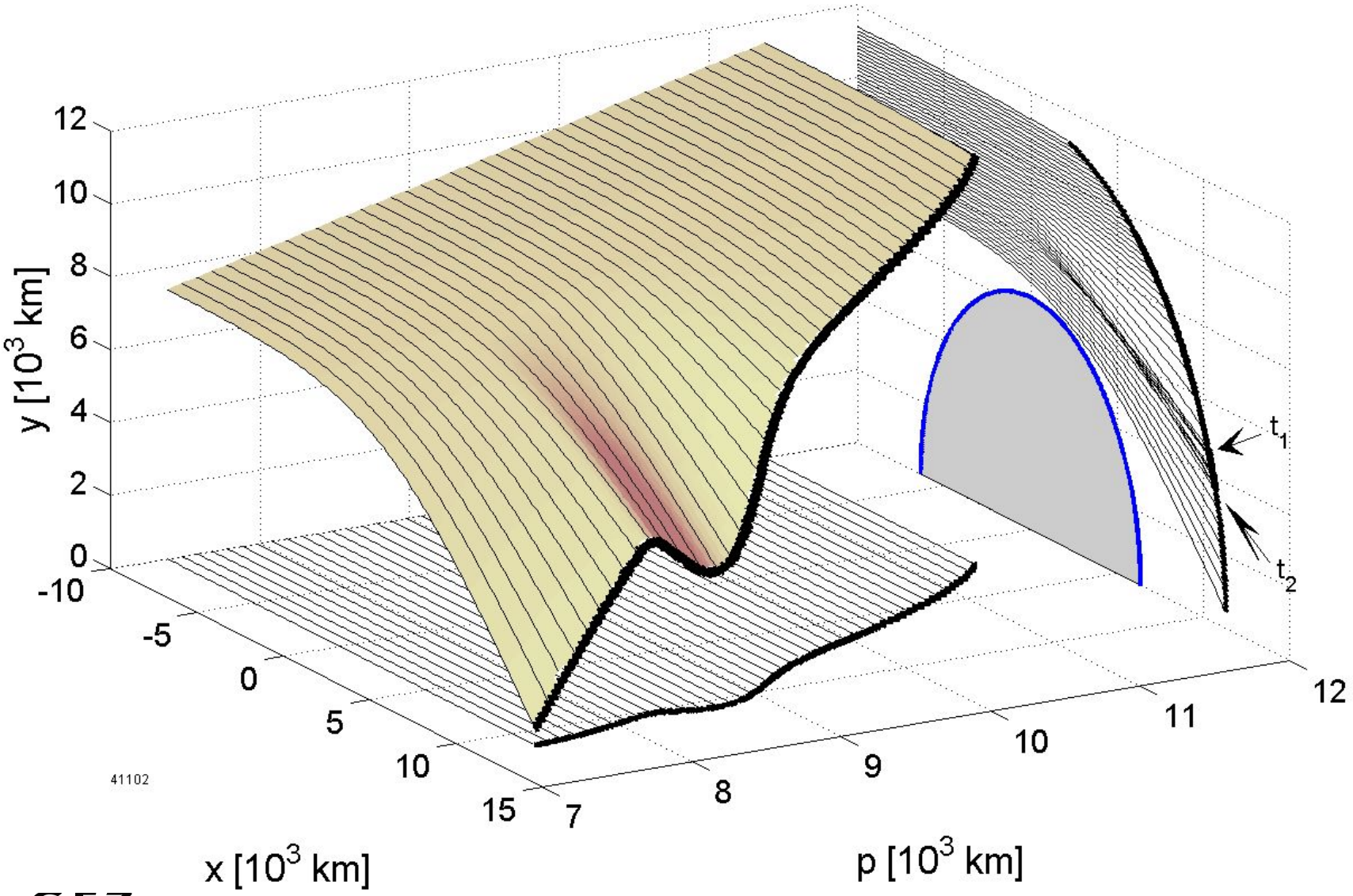
Ray manifold



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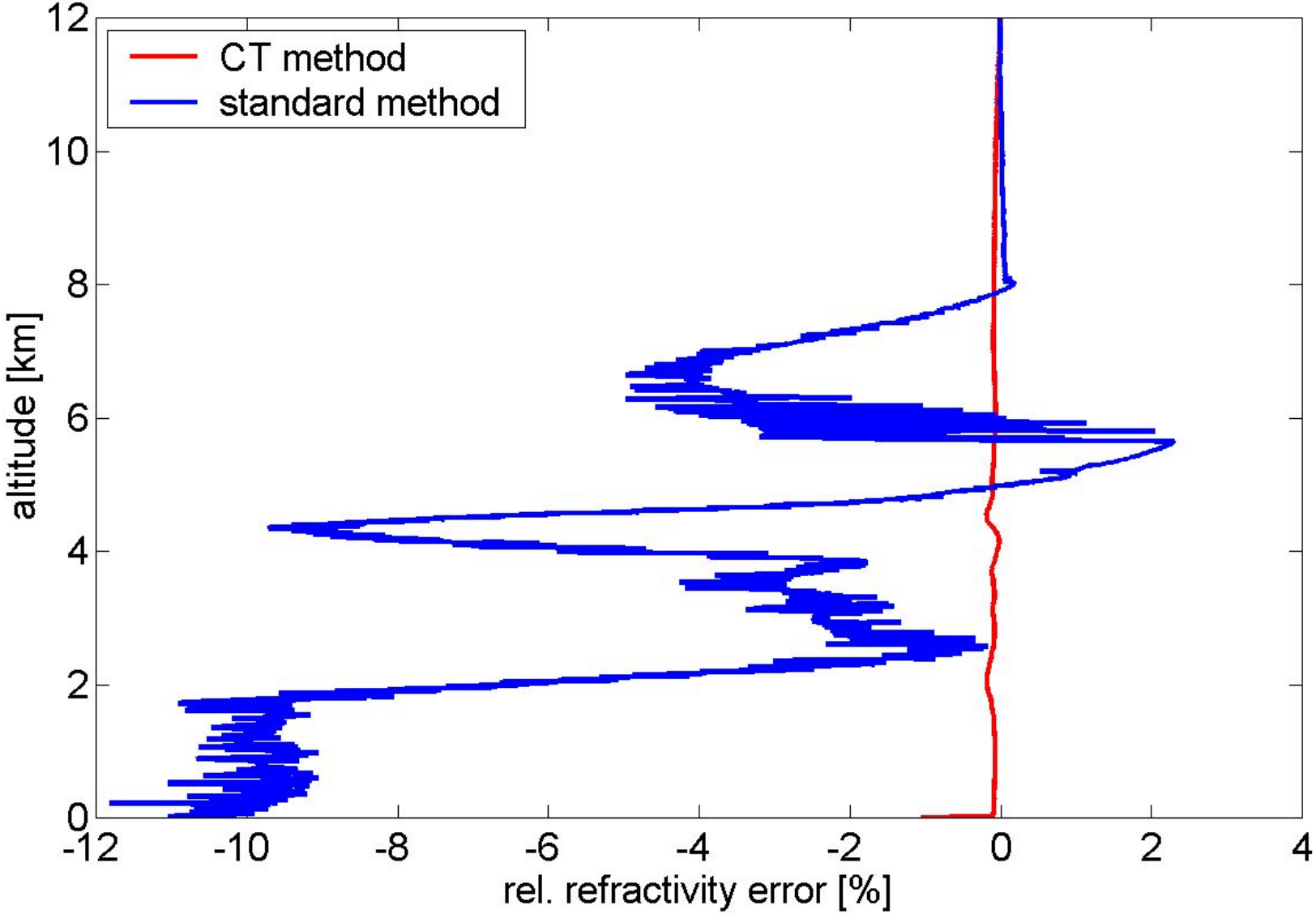
CT vs. standard method



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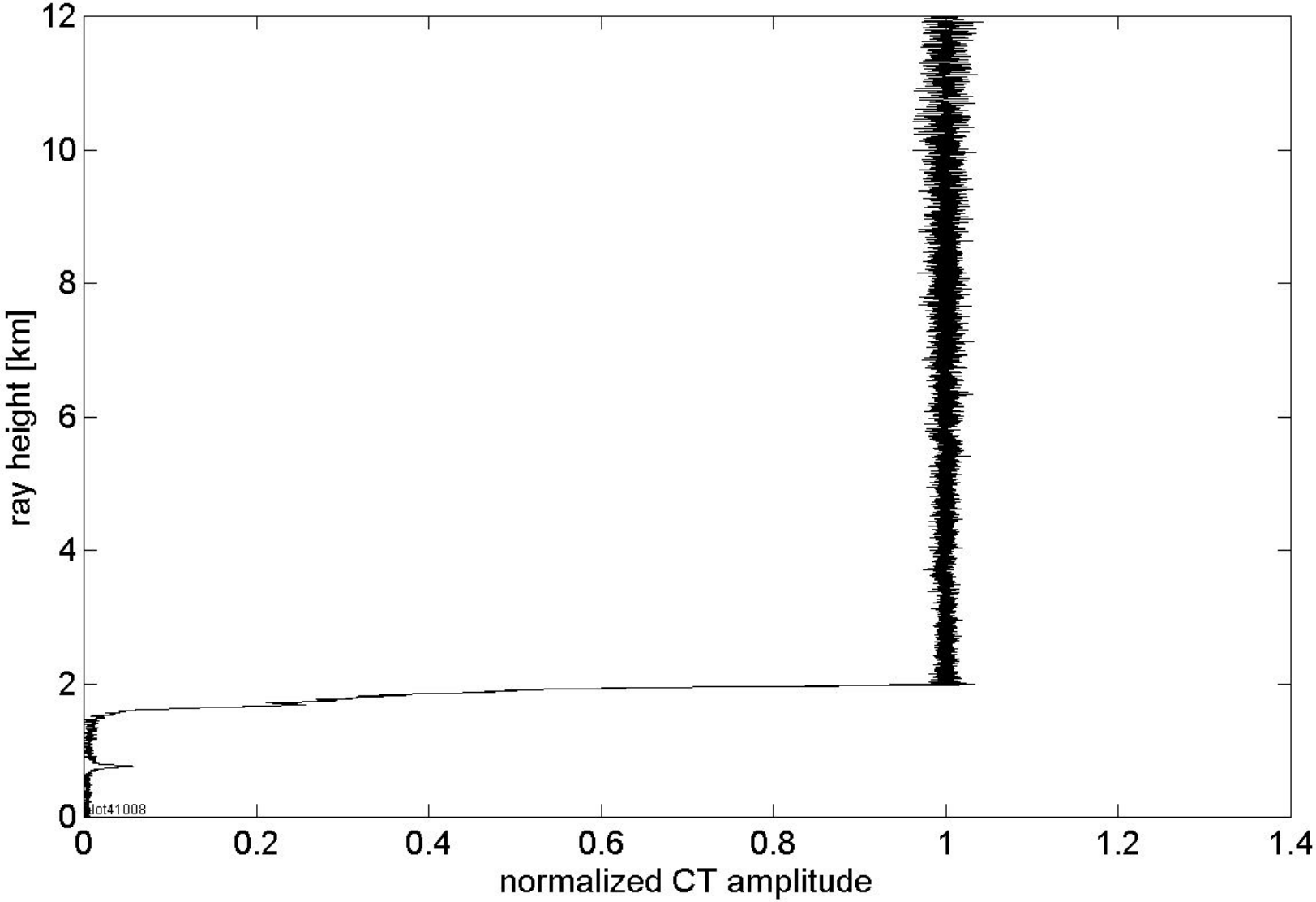
„CT amplitude“



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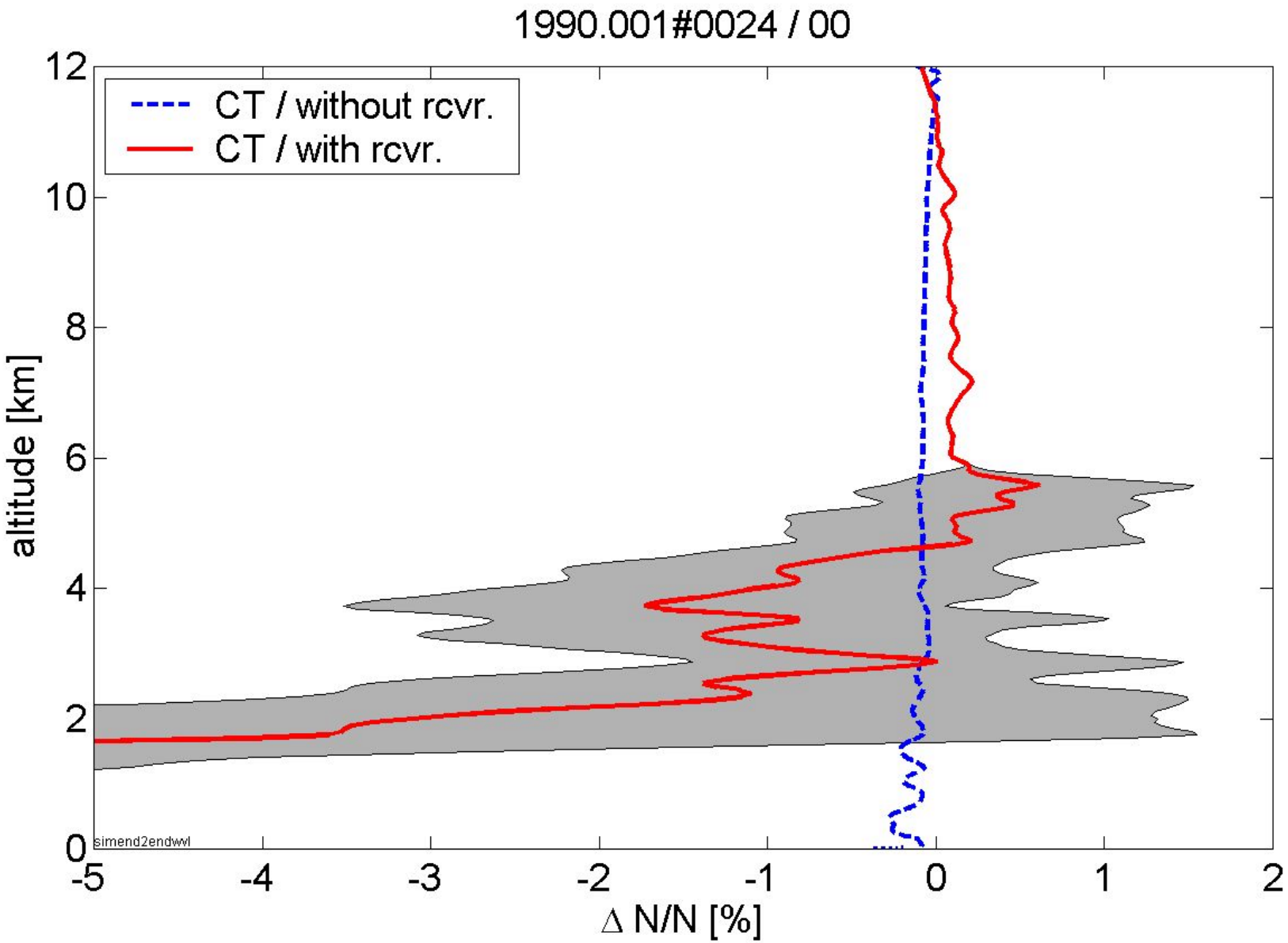
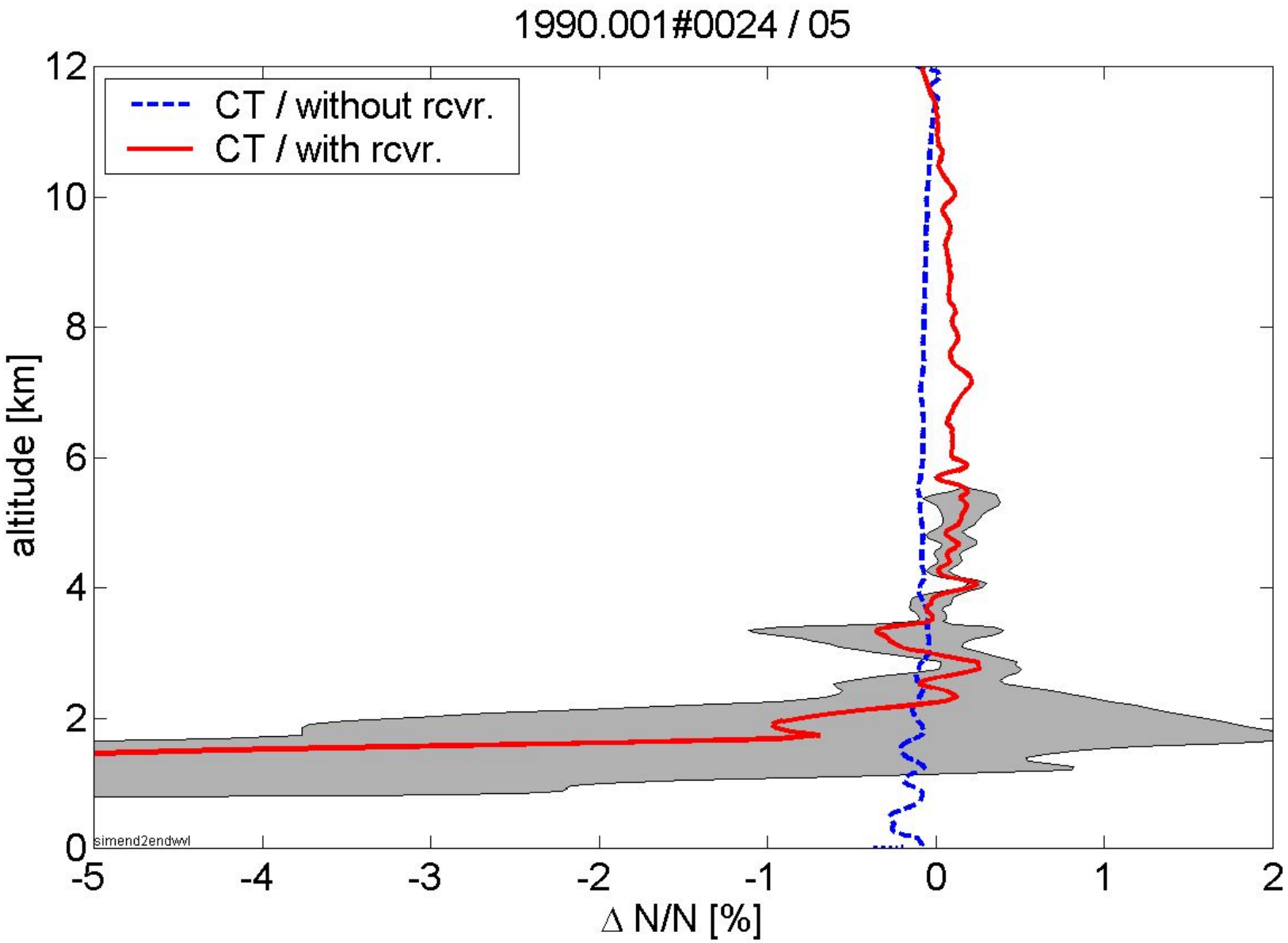
POTSDAM

2-quad. phase detect., 50 Hz sampl., 14 dB noise



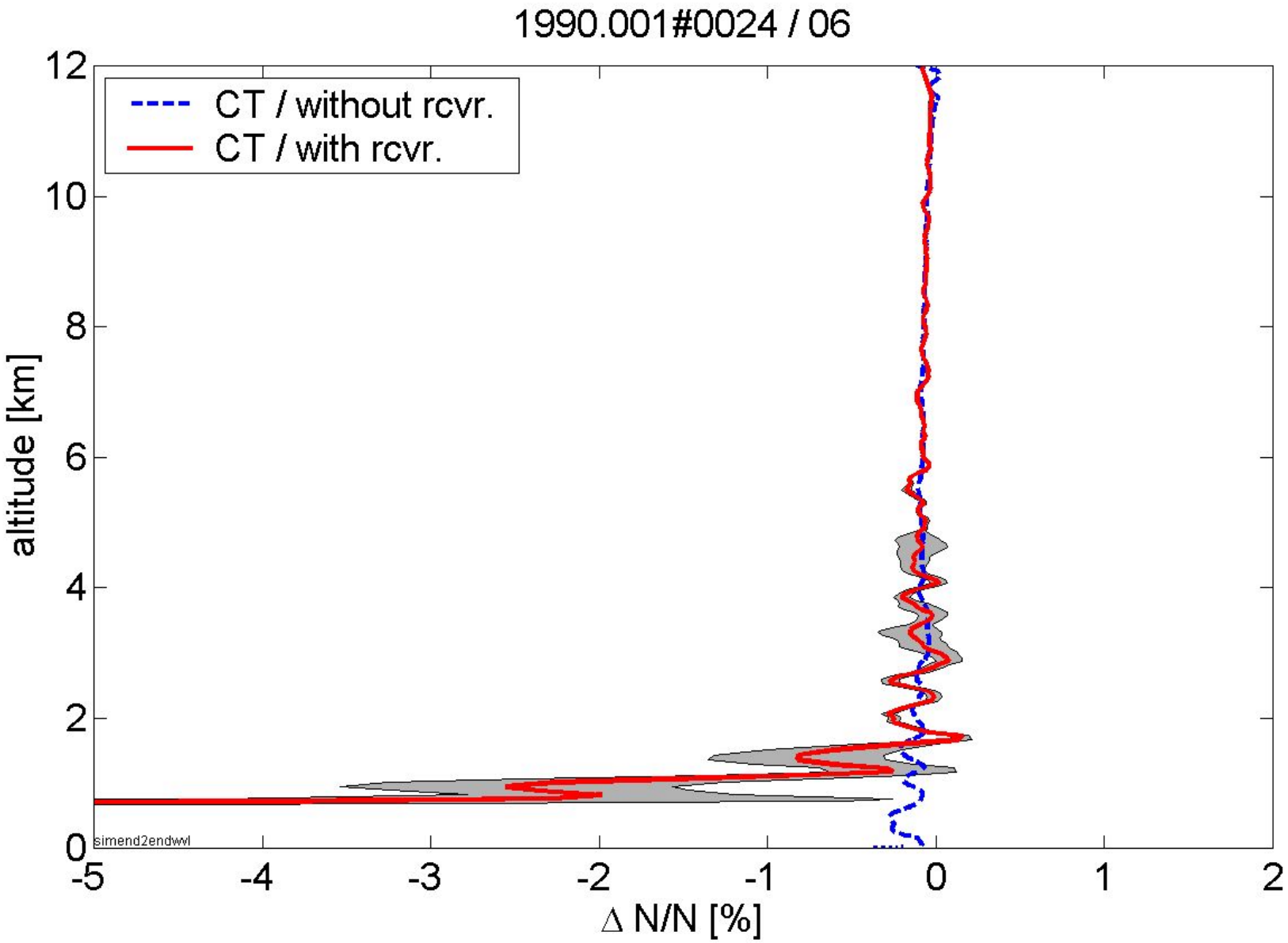
GFZ
POTSDAM

4-quad. phase detect., 50 Hz sampl., 14 dB noise



GFZ
POTSDAM

4-quad. phase detect., 200 Hz sampl., 14 dB noise



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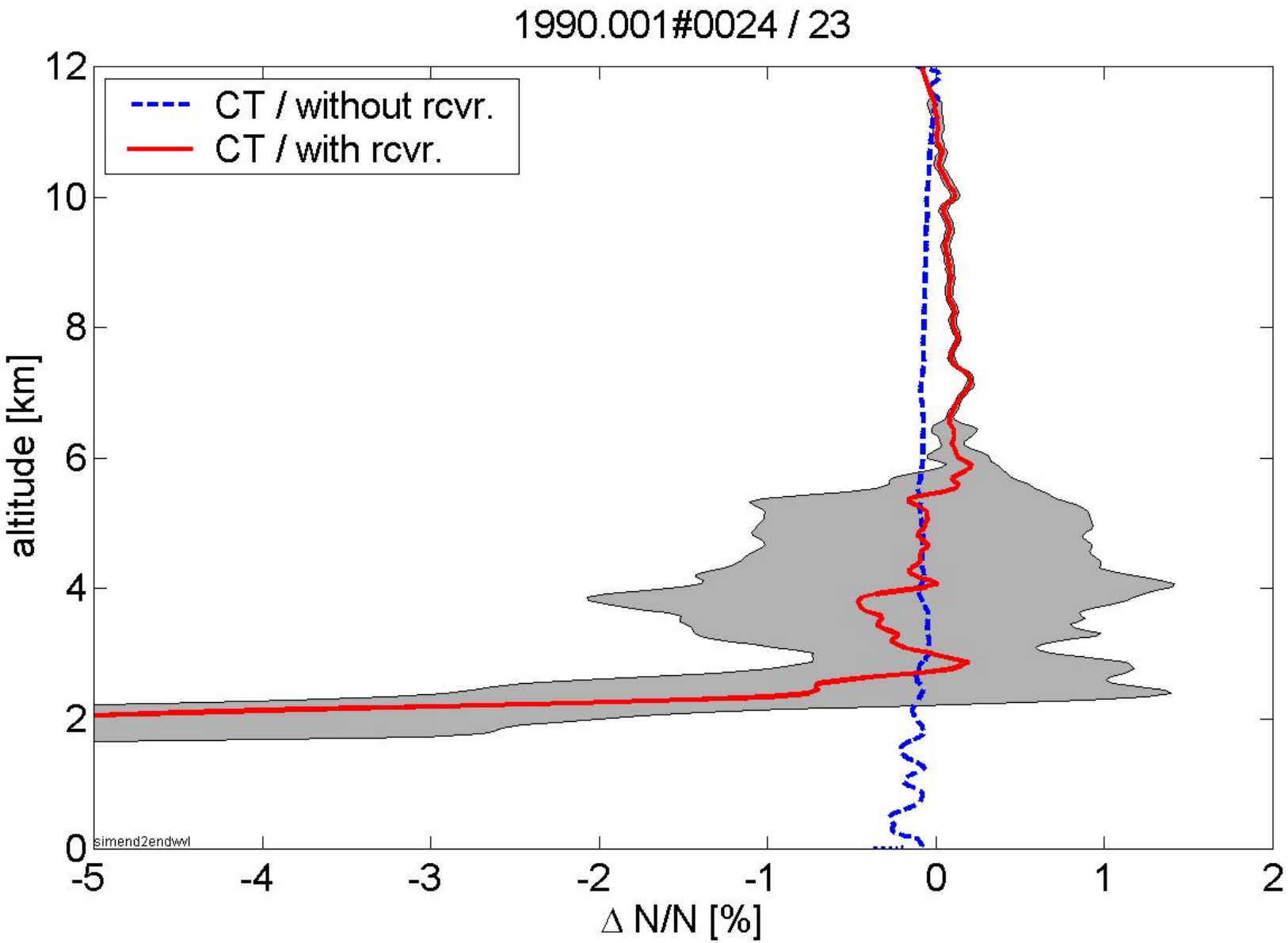
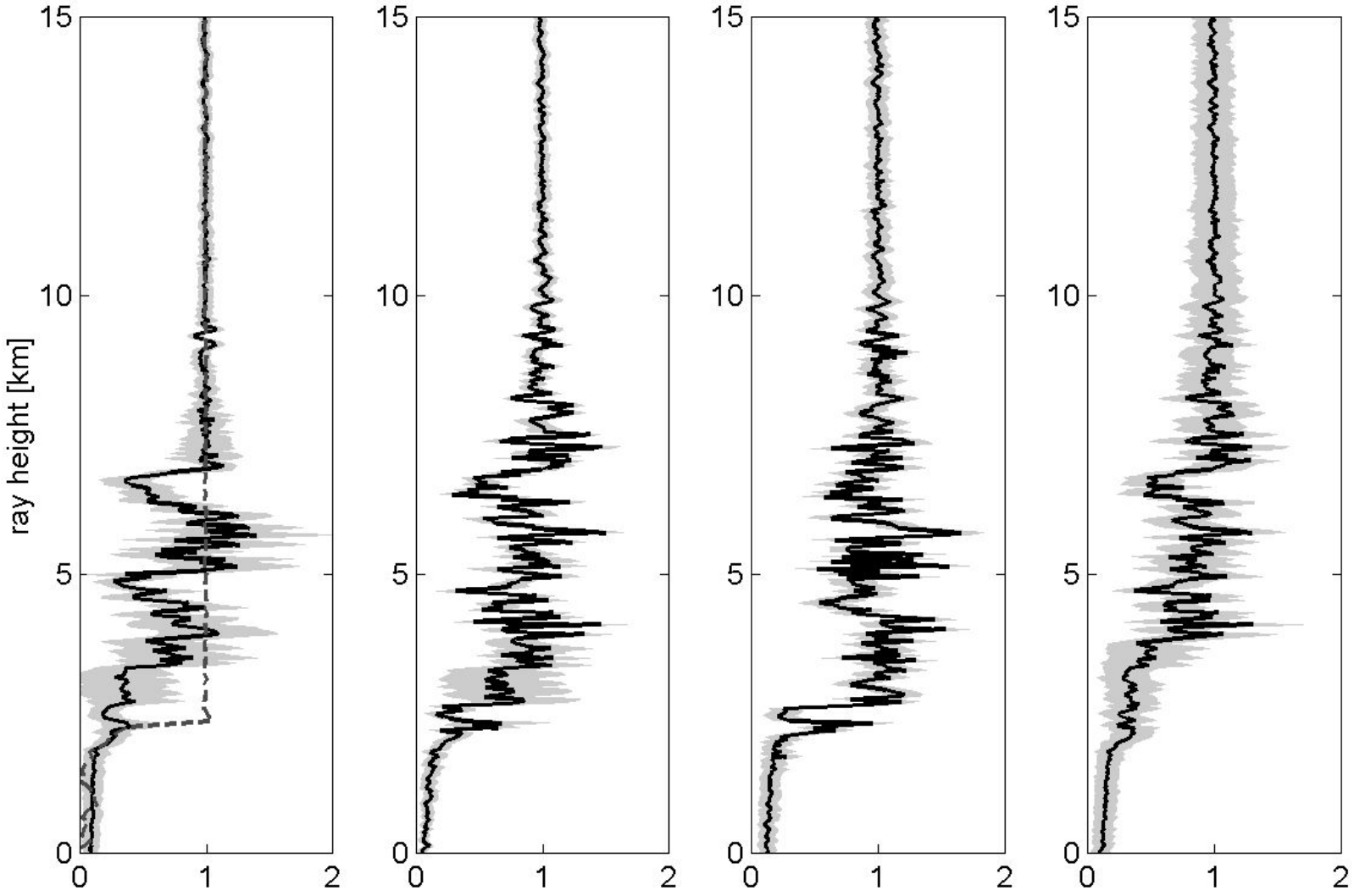
POTSDAM

4-quad. phase detect., 50 Hz sampl., 24 dB noise

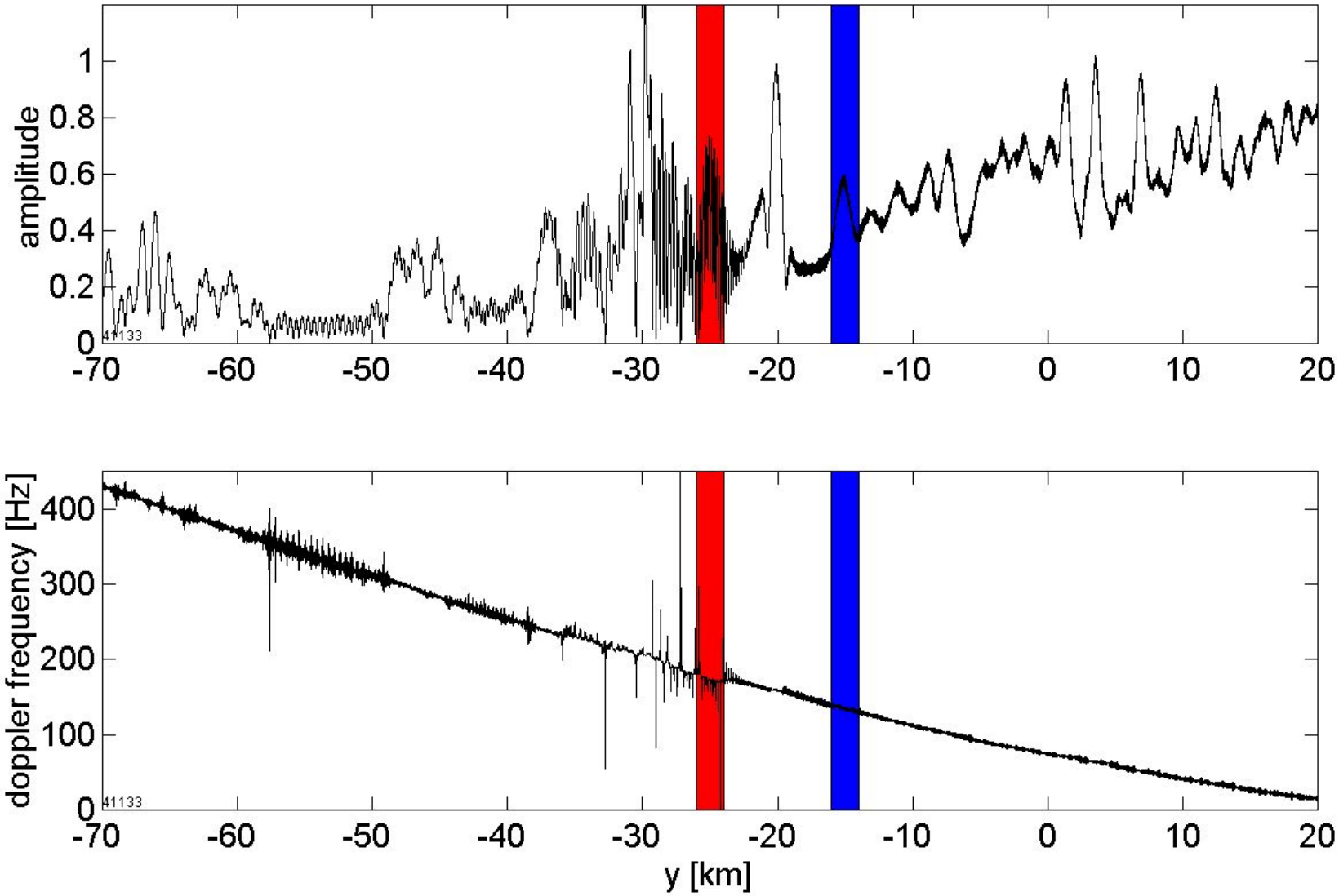


GFZ
POTSDAM


2q/50Hz/14dB
4q/50Hz/14dB
4q/200Hz/14dB
4q/50Hz/24dB
ray height [km]
15
10
5
0
0
1
2
CT amplitude

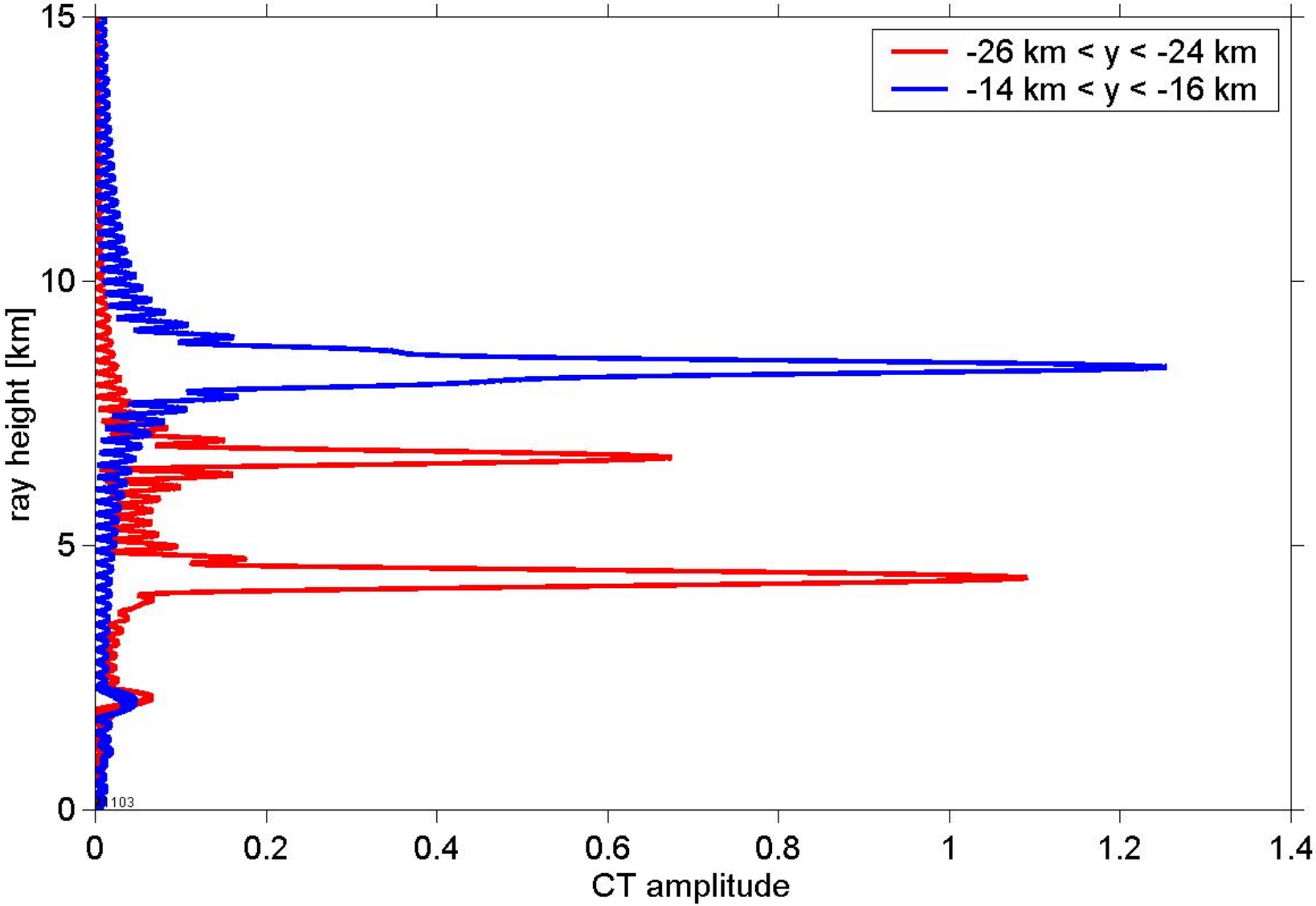
GFZ
POTSDAM

Signal amplitude and doppler



GFZ
POTSDAM

Multipath propagation



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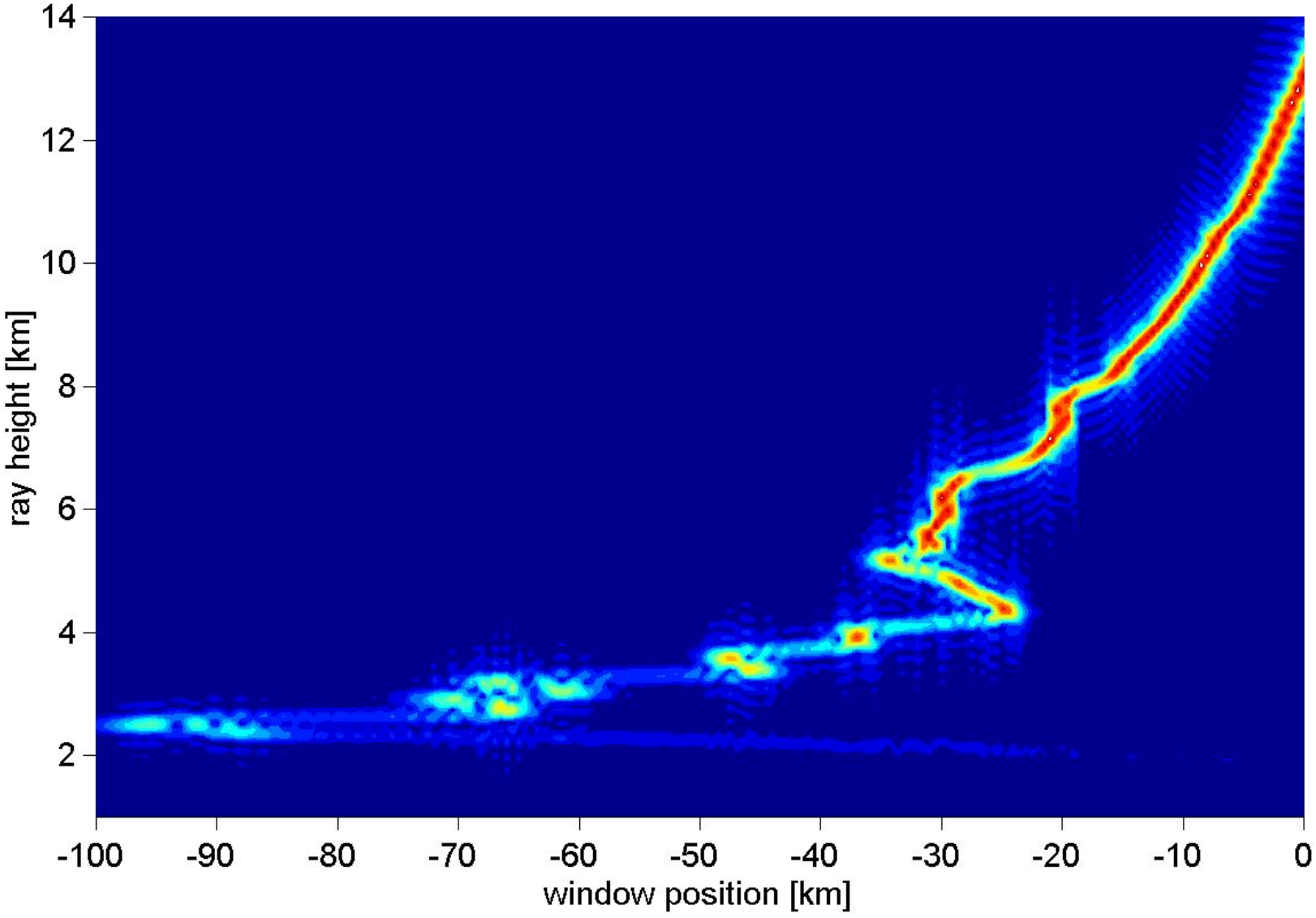
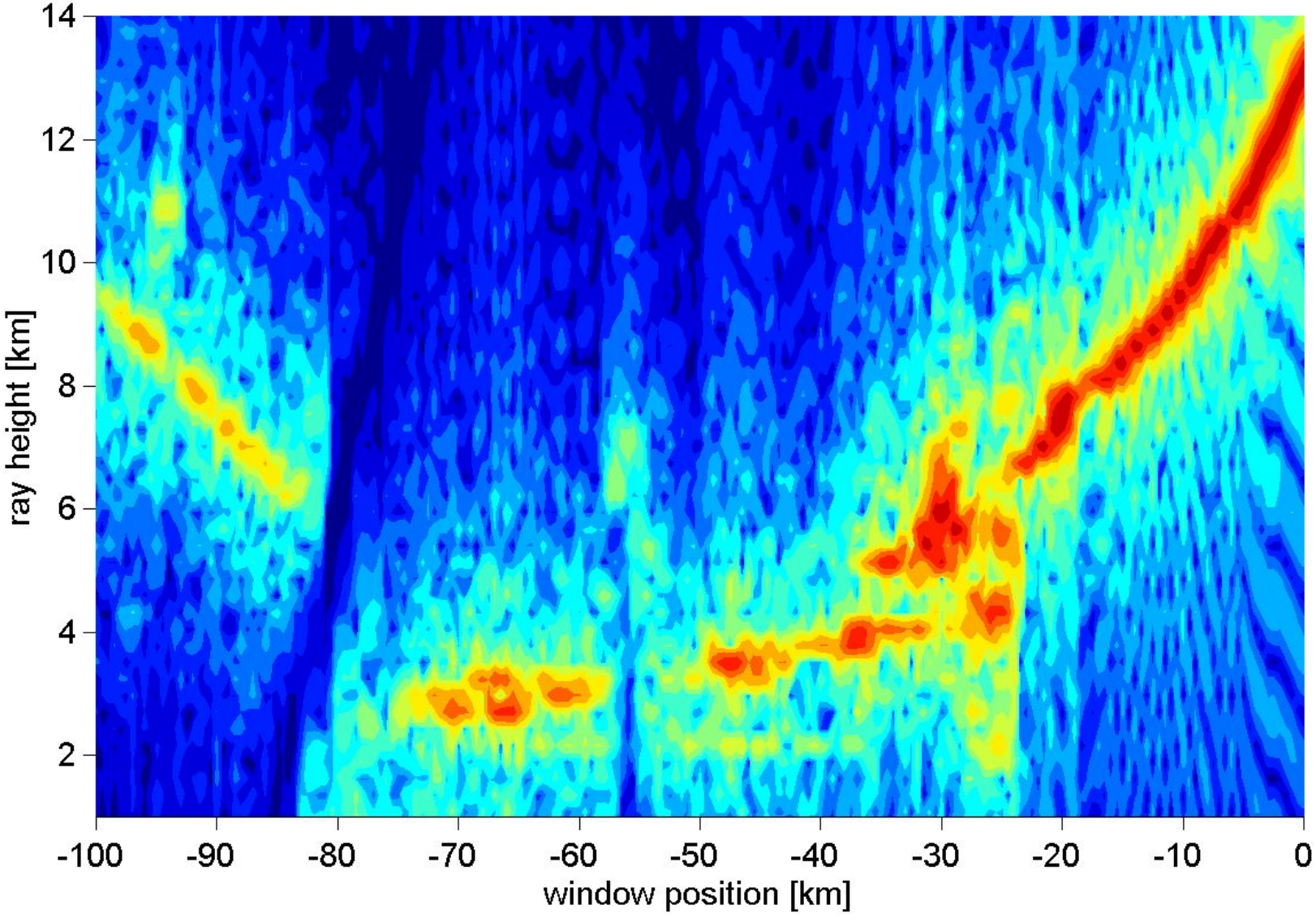
POTSDAM

CT amplitude (without receiver)



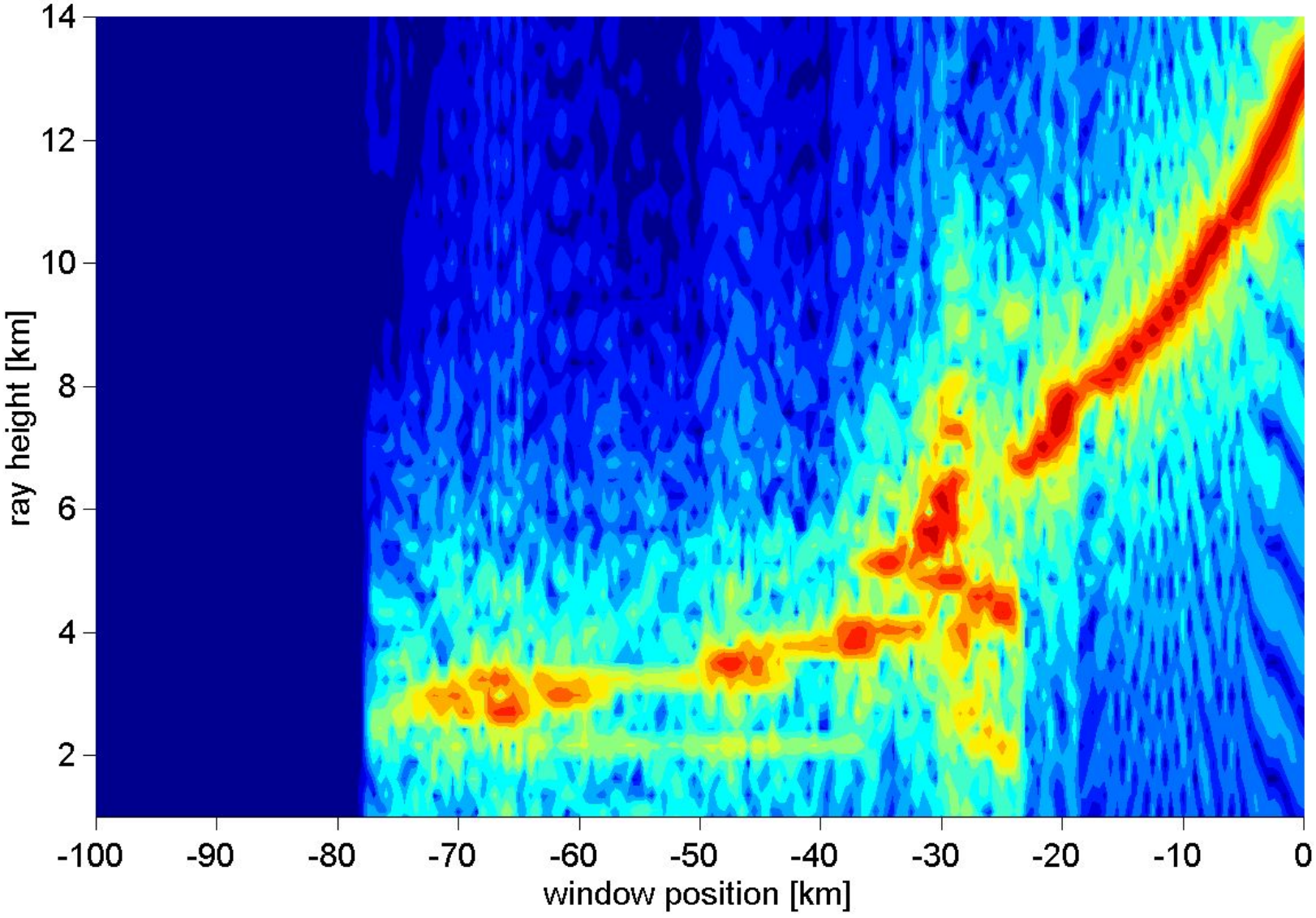
GFZ
POTSDAM

CT amplitude (rcvr: 2 quad. / 50 Hz / 14 dB)



GFZ
POTSDAM

CT amplitude (rcvr: 4 quad. / 200 Hz / 14 dB)



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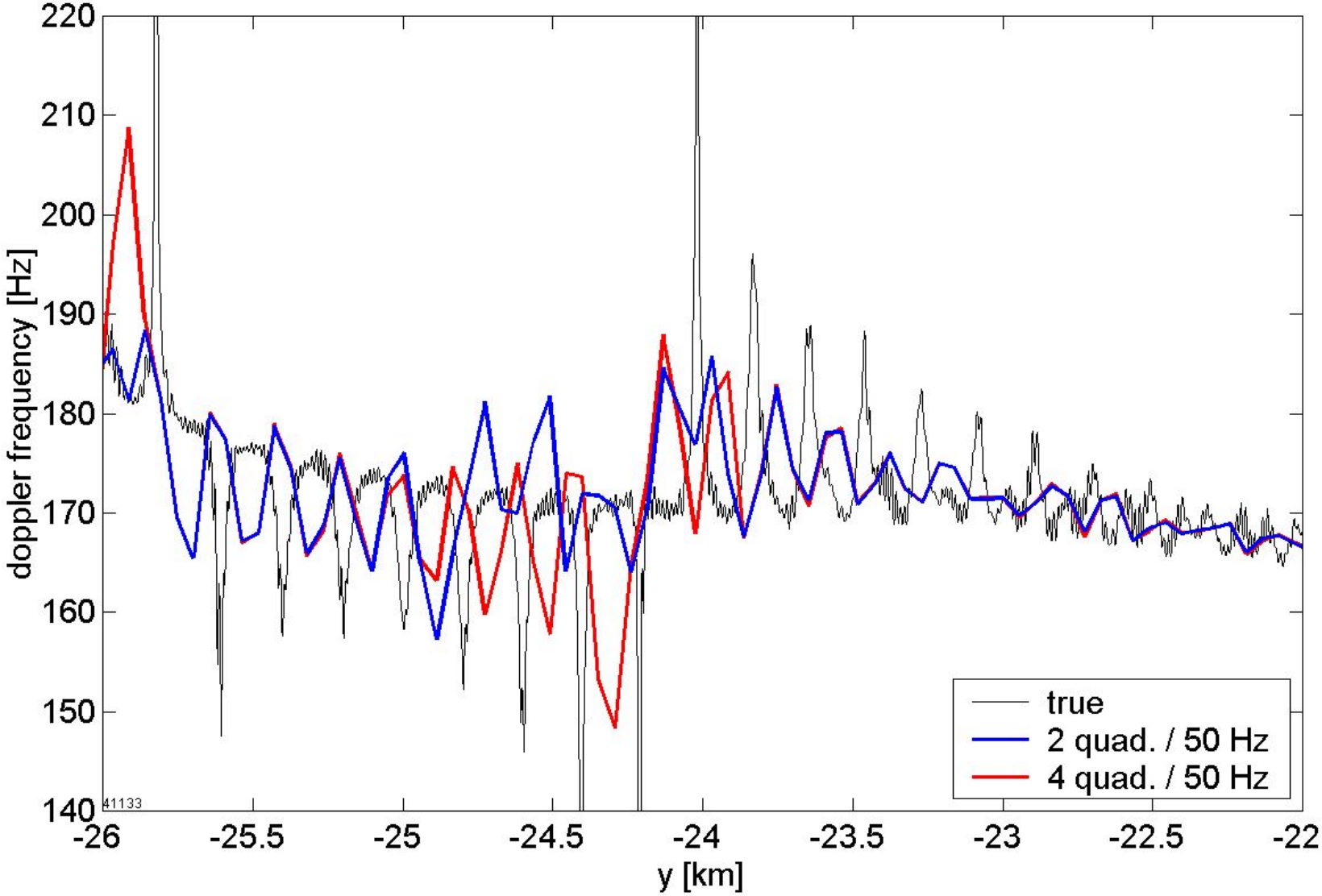
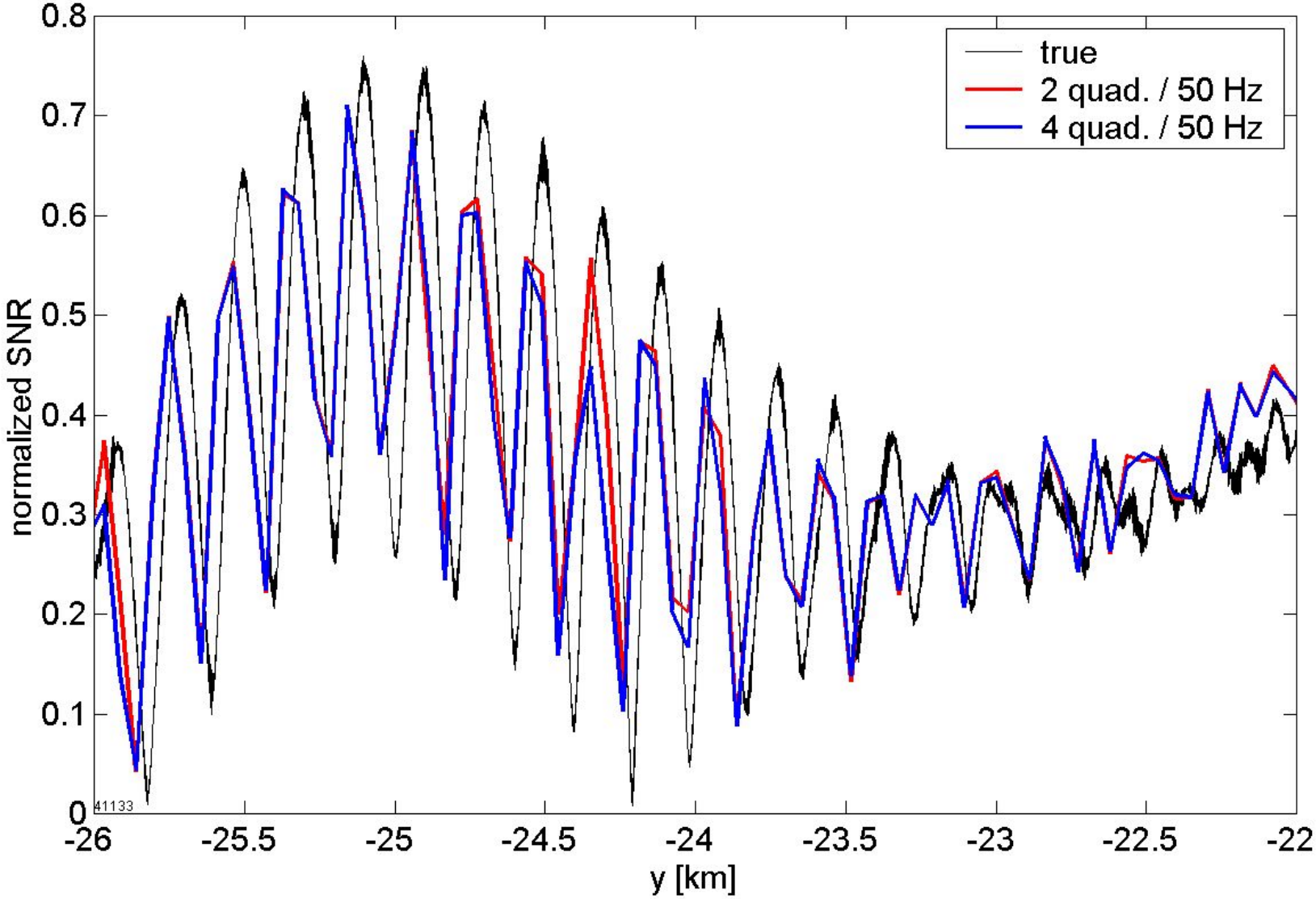
POTSDAM

Tracking errors (frequency)

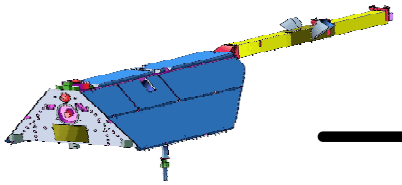


GFZ
POTSDAM

Tracking errors (SNR)



GFZ
POTSDAM



Conclusions

- Simulations - excluding a receiver model - reproduce true refractivity profile to better than 0.2% (<0.1% above 2 km).
- Tracking with receiver model (50 Hz sampling / Costas-type PLL) induces negative refractivity biases on the order of –1 to –2% between 2 and 6 km.
- Below 6 km altitude the retrieved refractivity profiles depend on receiver tracking algorithm.
- Refractivity bias can be reduced by a factor of 10 by increasing the sampling frequency from 50 to 200 Hz and replacing two-quadrant phase extractor with a four-quadrant discriminator.
- Canonical transform amplitude serves as diagnostic tool for data quality control.