A Zeppelin-based Study on GNSS Reflectometry for Altimetric Application

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Geodätische Woche
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Image: Zeppelin NT in action (ZOIS, 2010)

Outline

Motivation

- Ocean Altimetry
- GNSS-R Experiments

Zeppelin Experiment

- Airborne Setup
- Differential Data
- Model Requirements

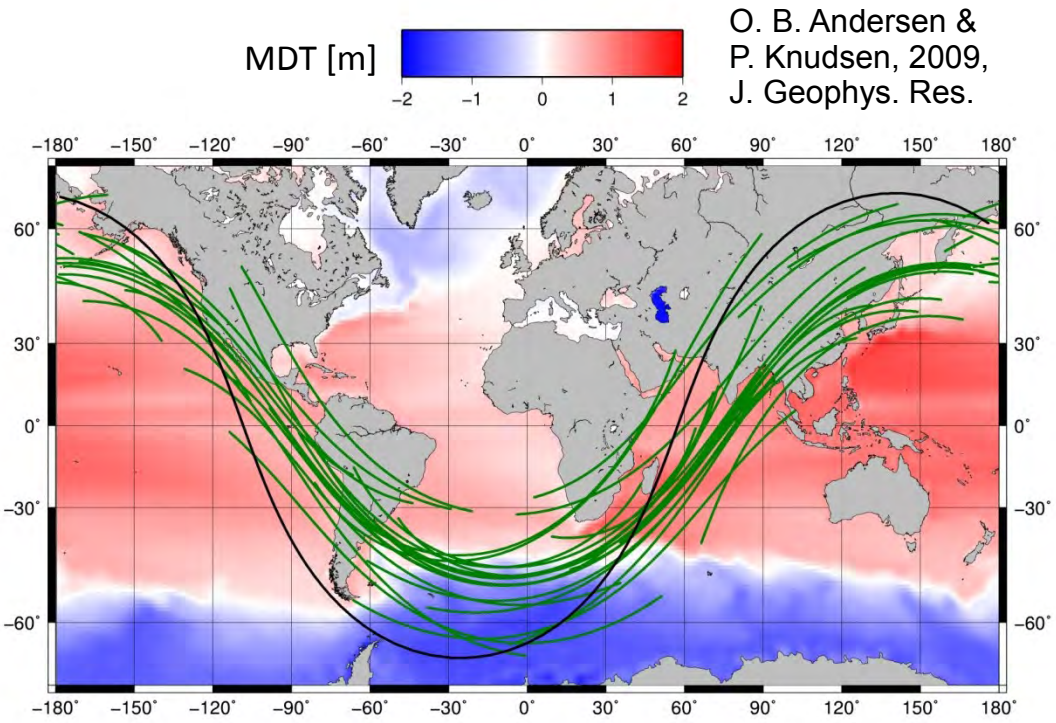
Lake Altimetry

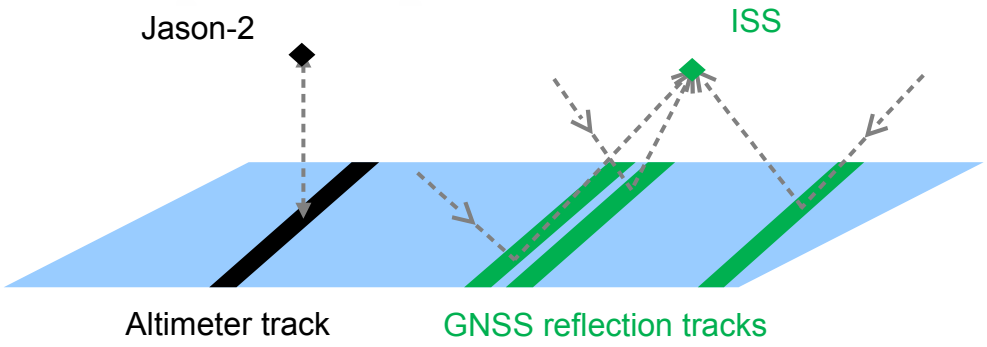
- Reflection Event
- Height Retrieval
- Crossover Calibration

Summary & Outlook

Motivation

Ocean Altimetry





Sea Surface Topography

- characterises ocean circulation
- indicator for change of Earth energy budget
- improved observation coverage required

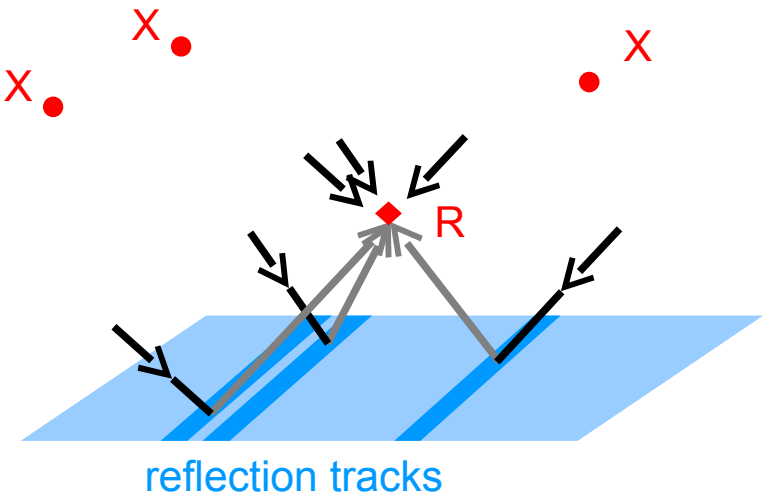
Coverage

- single track Jason-2 Altimetry (Ocean Surface Topography Mission) 2014/04/19 6h57 – 9h00 UTC
- tracks potential ISS Reflectometry (proposed GEROS Mission) 2014/04/19 6h05 – 7h42 UTC

GNSS-R Experiments

GNSS-R Concept

- synchronized system of transmitters X
- passive receiver R on various platforms
- precise carrier phase data
- campaigns over Lake Constance and Mediterranean Sea

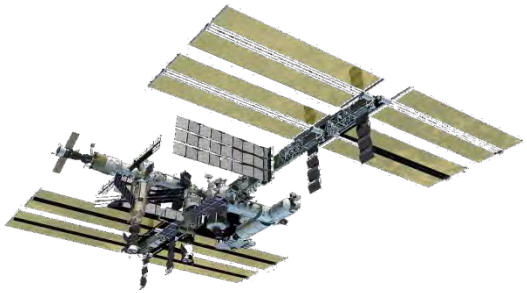


Zeppelin

M. Semmling et al., 2013, Radio Science.

HALO

M. Semmling et al., 2014, Geophys. Res. Lett.



ISS

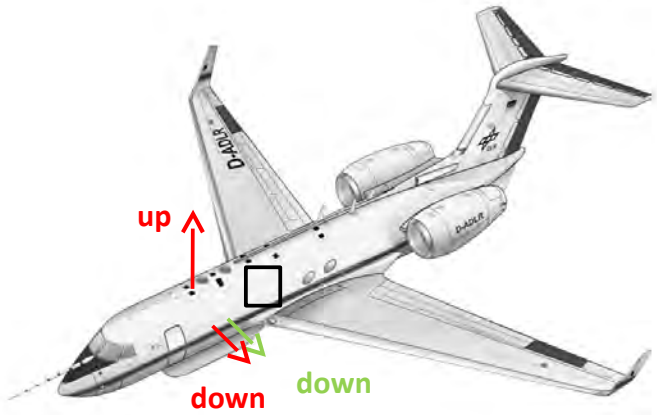
Wickert et al., 2014, Geophys. Res. Abstracts

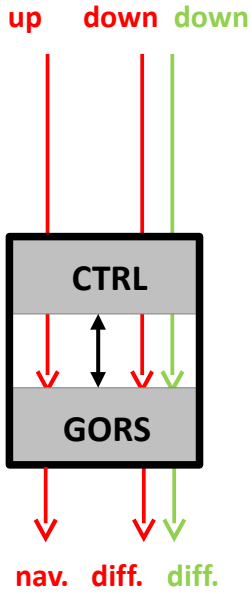
GNSS-R Platforms

- Zeppelin over Lake Constance
- HALO over Mediterranean Sea
- Internat. Space Station (proposed)

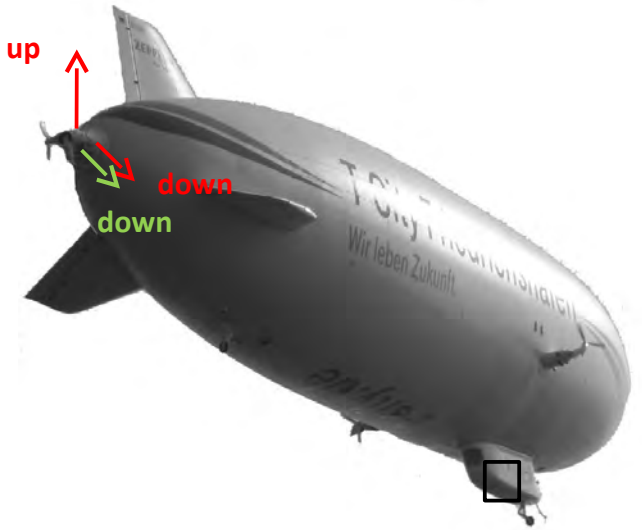
Zeppelin Experiment

Airborne Setup





M. Semmling et al., 2013, Radio Science.



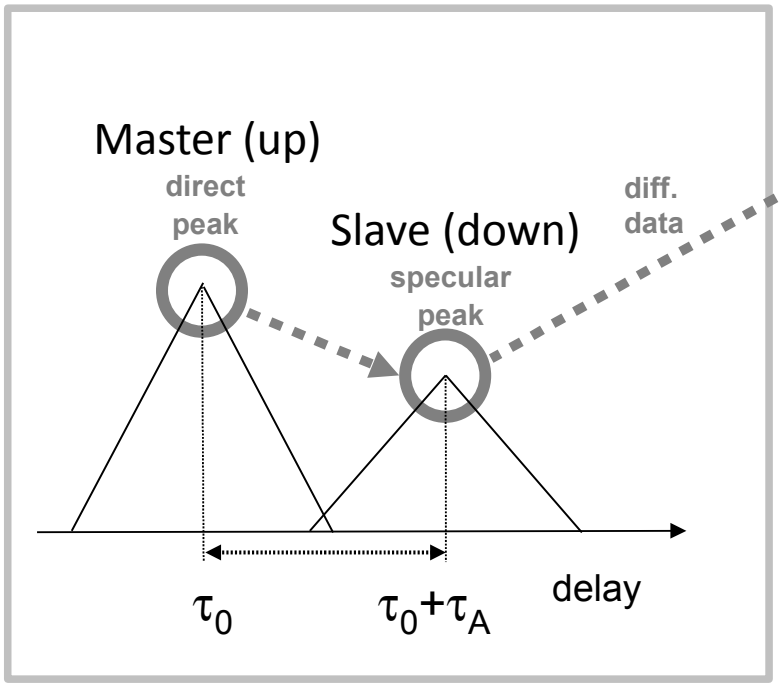
Antennas

- direct signal acquisition
  - co-pol. (RHCP) antenna up
- reflected signal acquisition
- co-pol. (RHCP) antenna down
  - cross-pol. (LHCP) antenna down

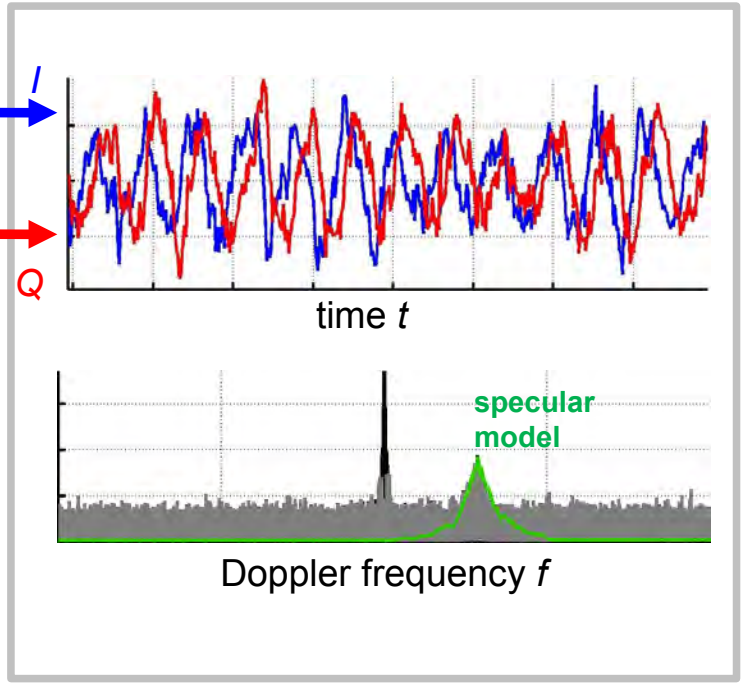
Receiver

- GORS unit for real-time navigation data (up signal)
- GORS unit for differential data (down - up signal)
- control pc for data recording and reflection tracking

Differential Data



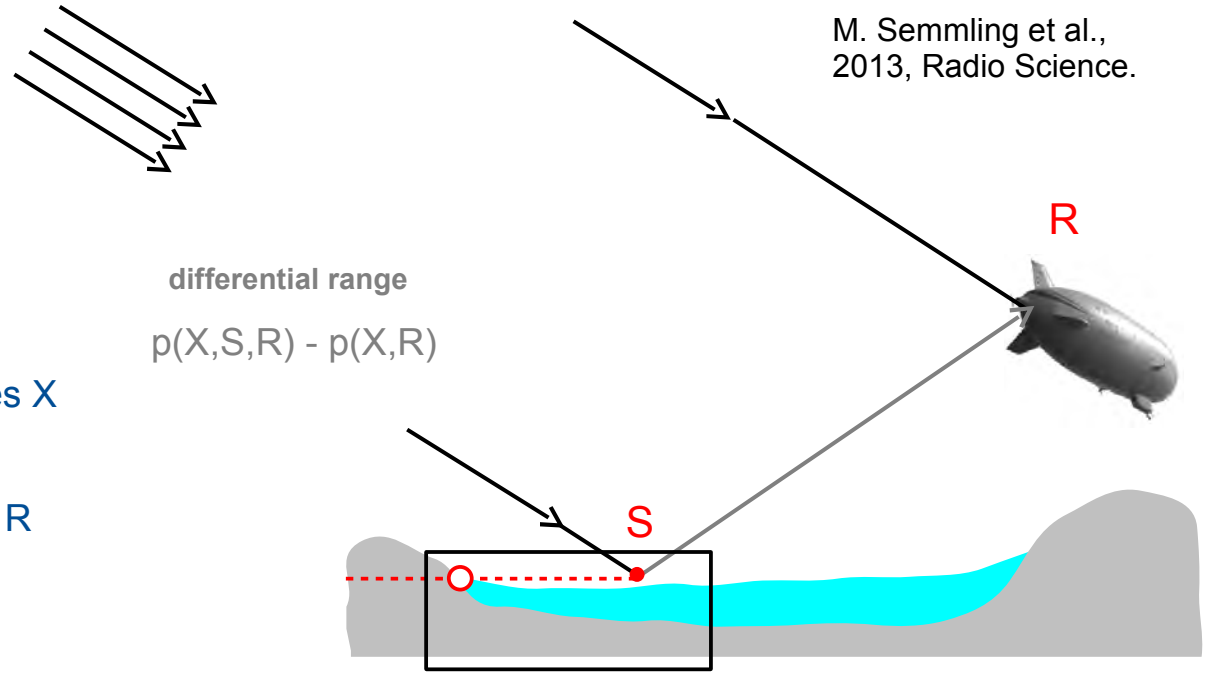
Master and Slave sampling



diff. data

Model Requirements

M. Semmling et al., 2013, Radio Science.



differential range

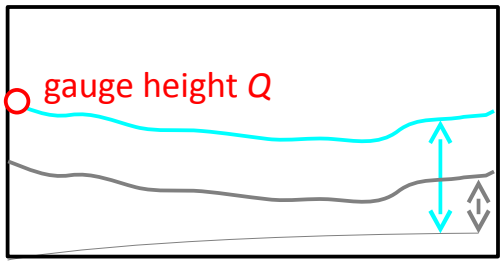
$p(X,S,R) - p(X,R)$

Specular Model

- broadcast ephemerides X
- trajectory, attitude and antenna baselines R
- troposphere refraction
- apriori surface height (e.g. gauge stations)

geoid undulation

$G = H - Q$



lake surface height *H*

geoid *G*

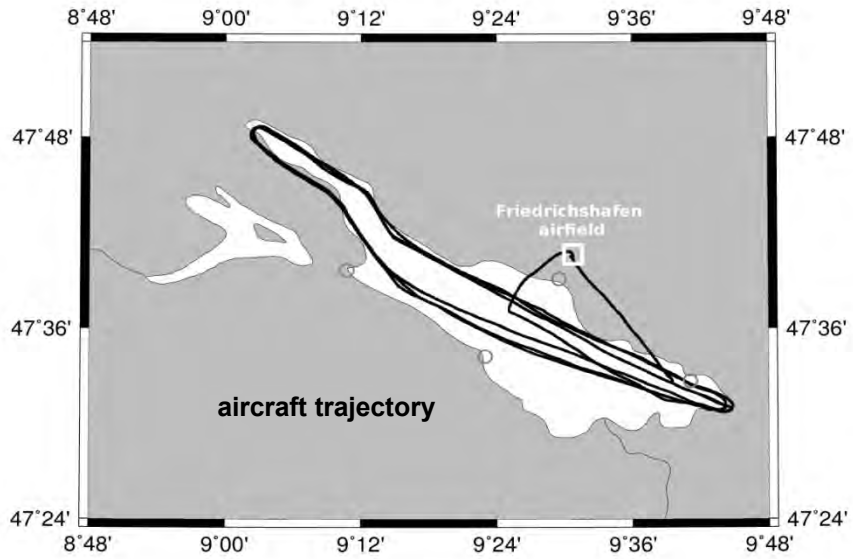
ellipsoid

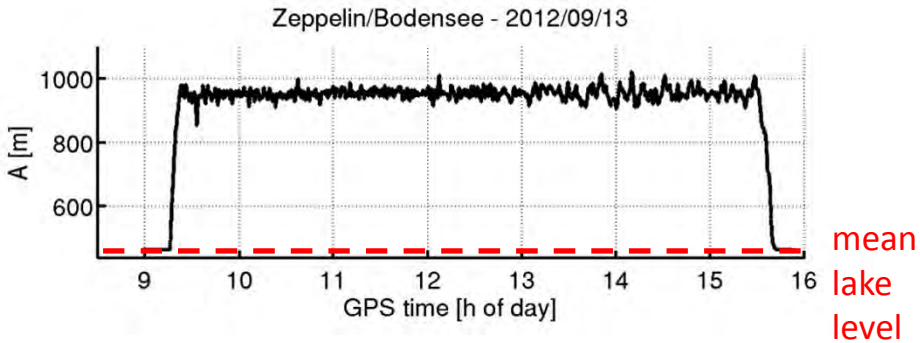
Height Definition

- ellipsoidal heights *H*
- normal height *Q*

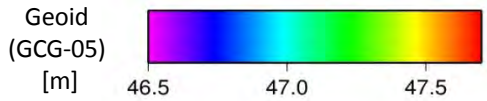
Lake Altimetry

Reflection Event

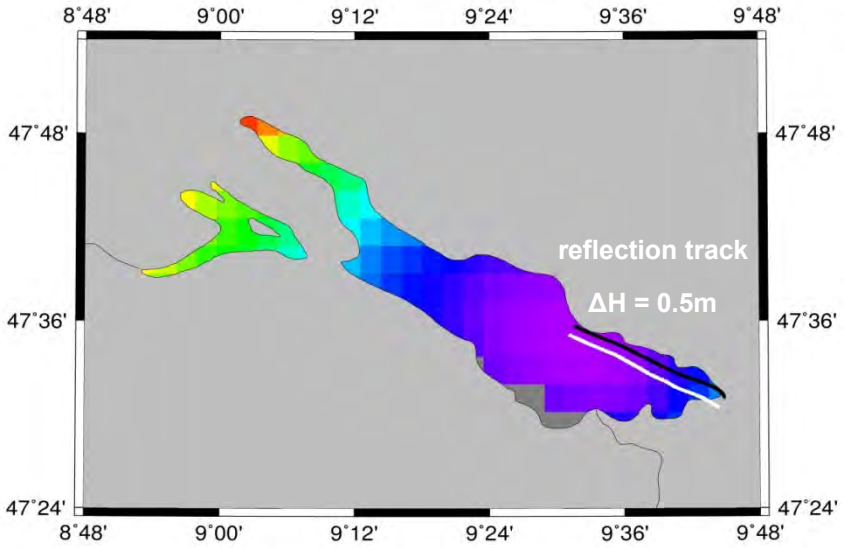




mean lake level



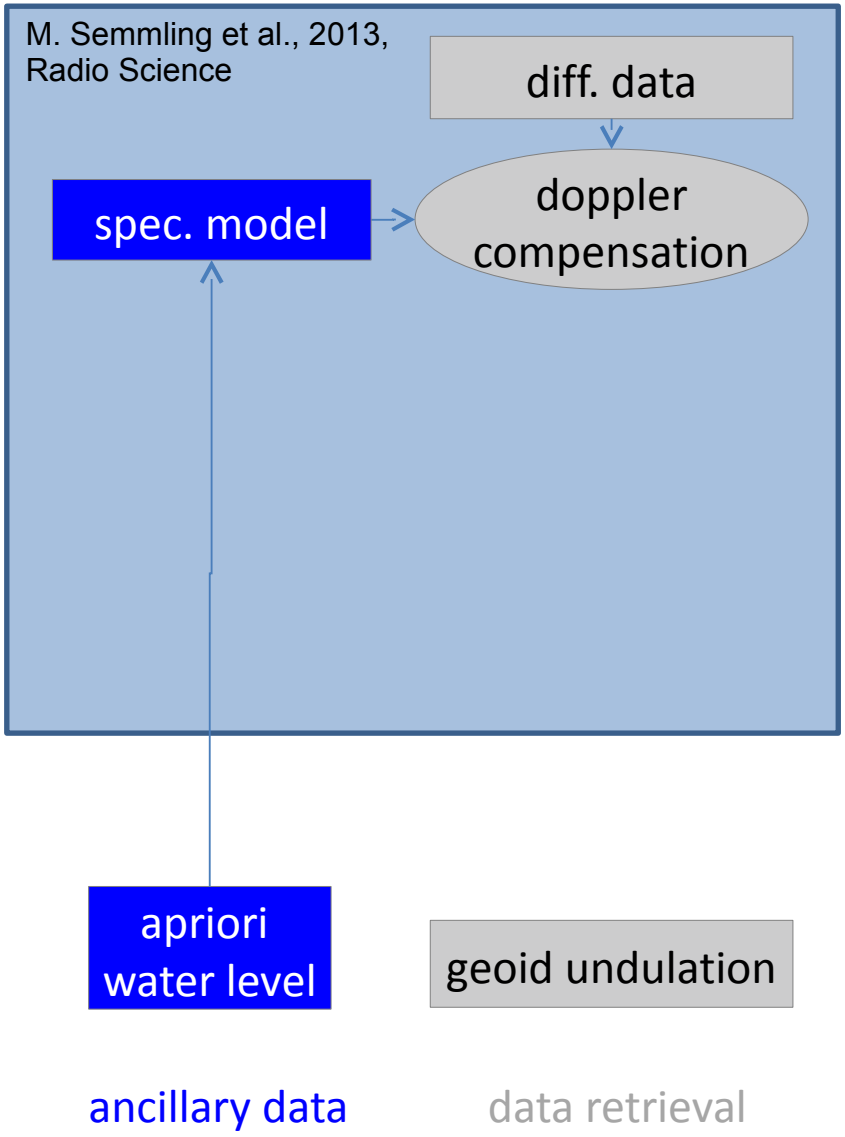
G. Liebsch et al., 2006, DVW.

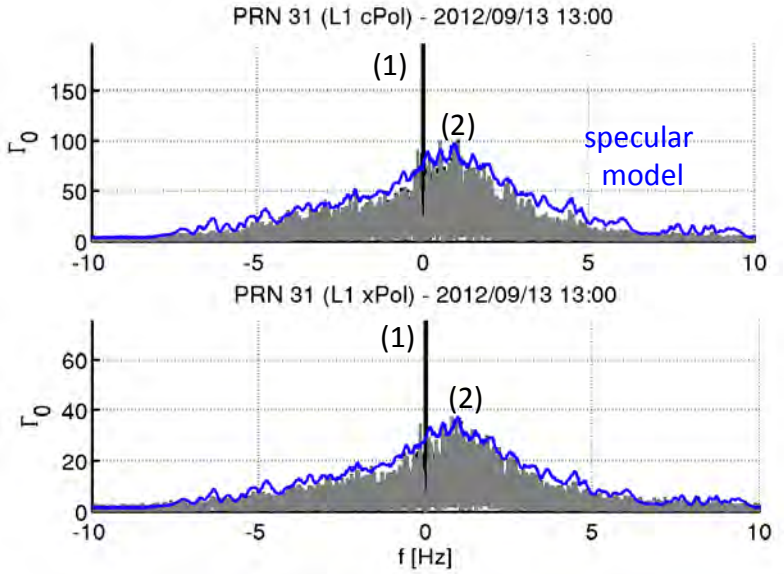


Event PRN 31 13h00

- observed starboard
- sat. at elevation 24-17deg
- length 15 km and duration 16 min

Height Retrieval

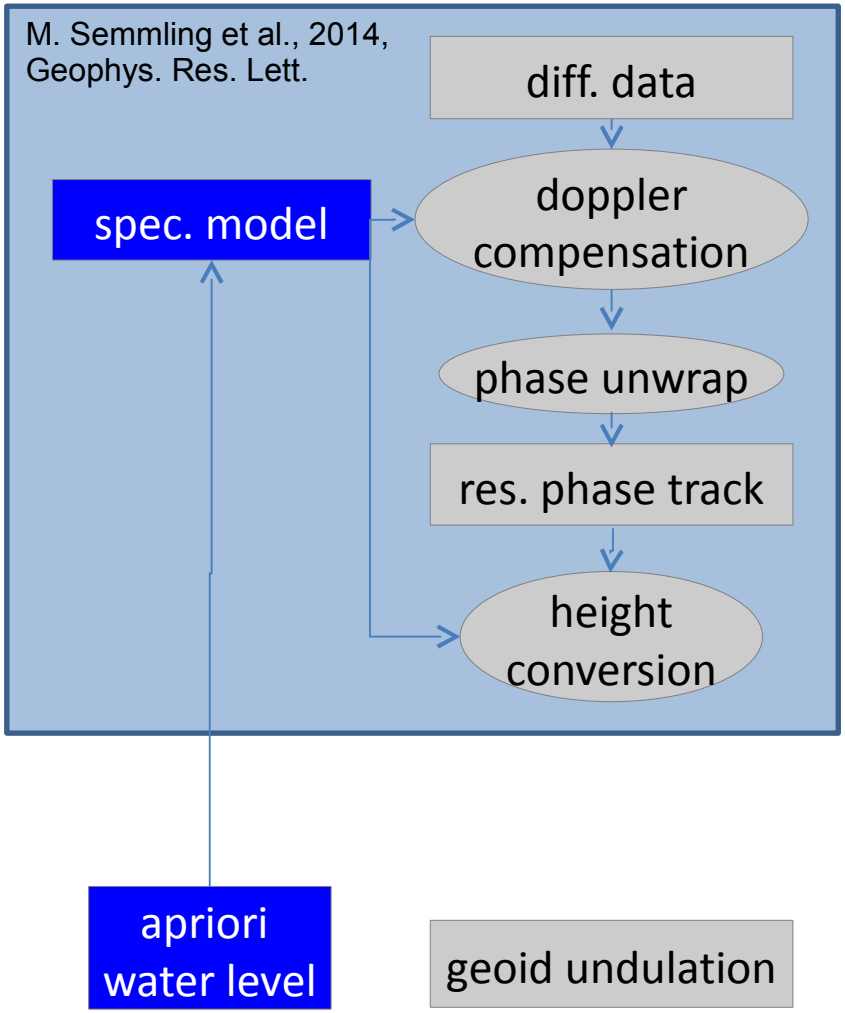


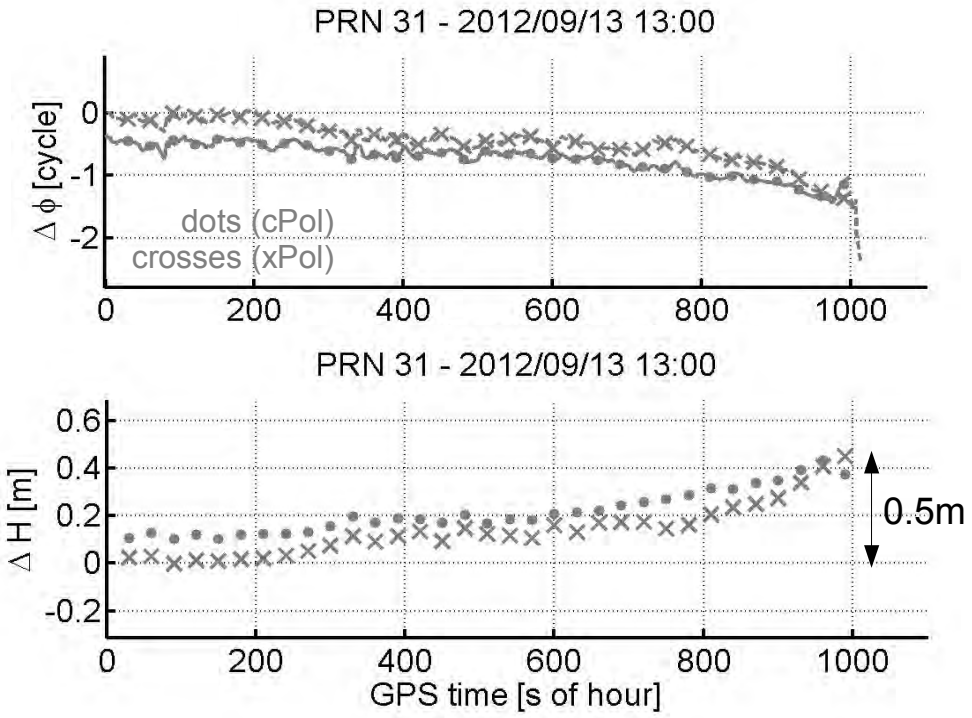


Diff. Data Spectrum

- co- and cross polarization (cPol, xPol)
- narrow peak (1) refer to direct signal
- broader peak (2) refer to reflected signal
- identified by specular model

Height Retrieval

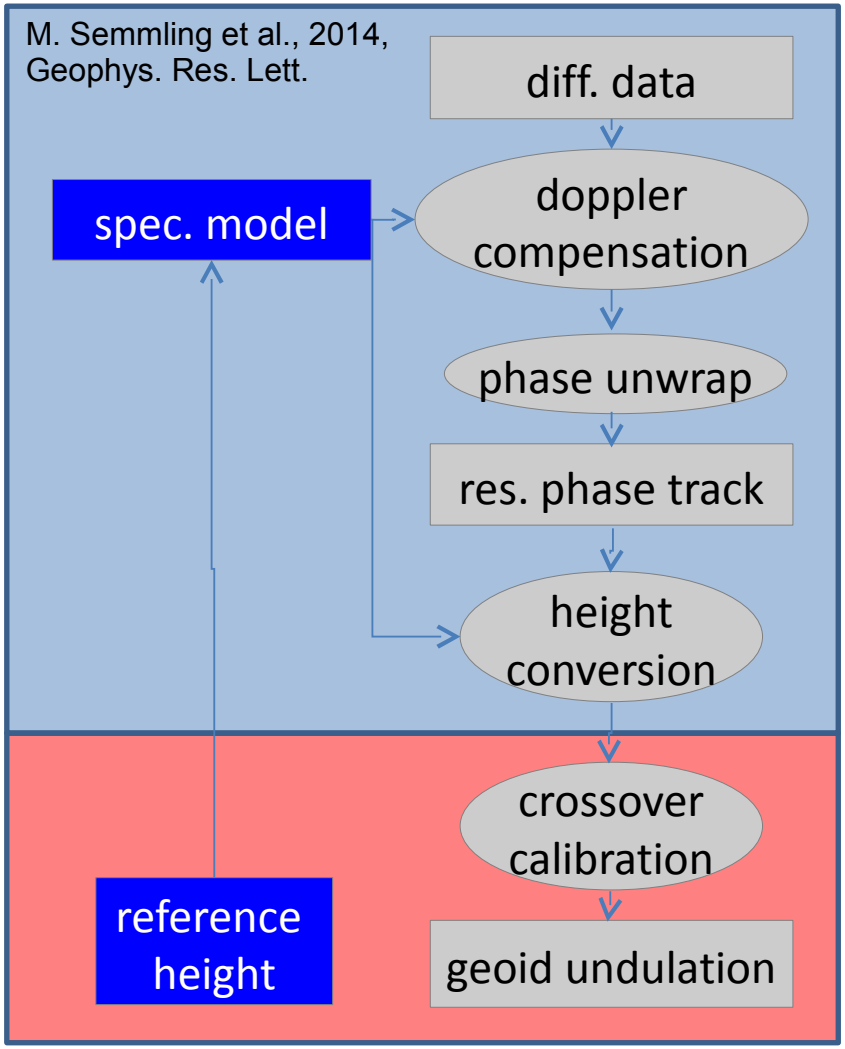


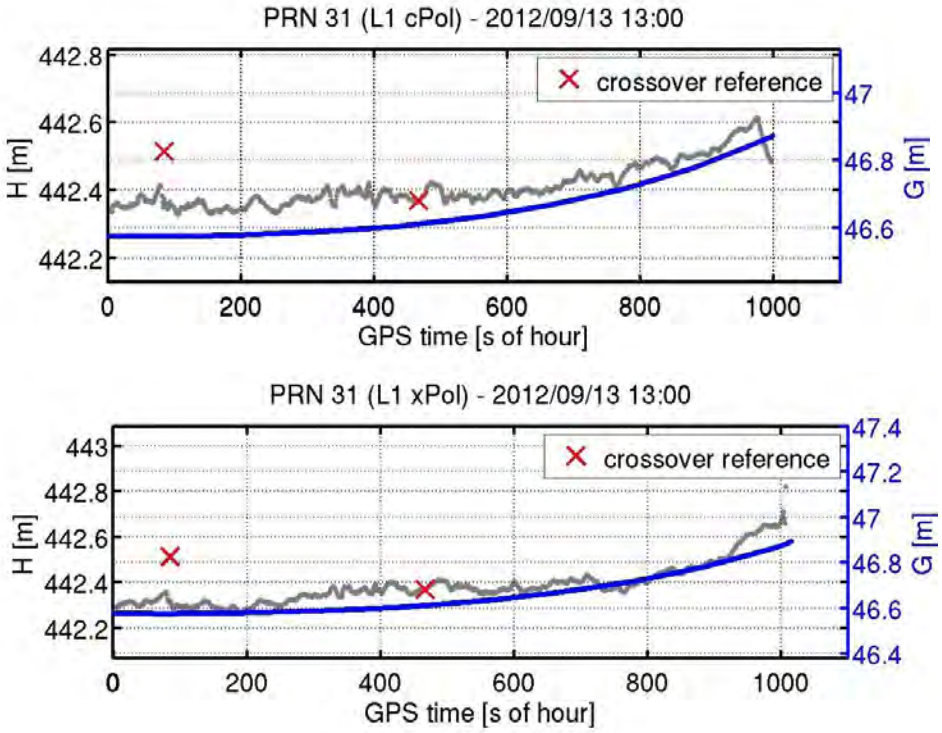


Residual Phase & Height Variation

- continuous phase tracks (ambiguity)
- converted to height tracks (offset bias)
- height variation in geoid range (0.5m amplitude)

Crossover Calibration

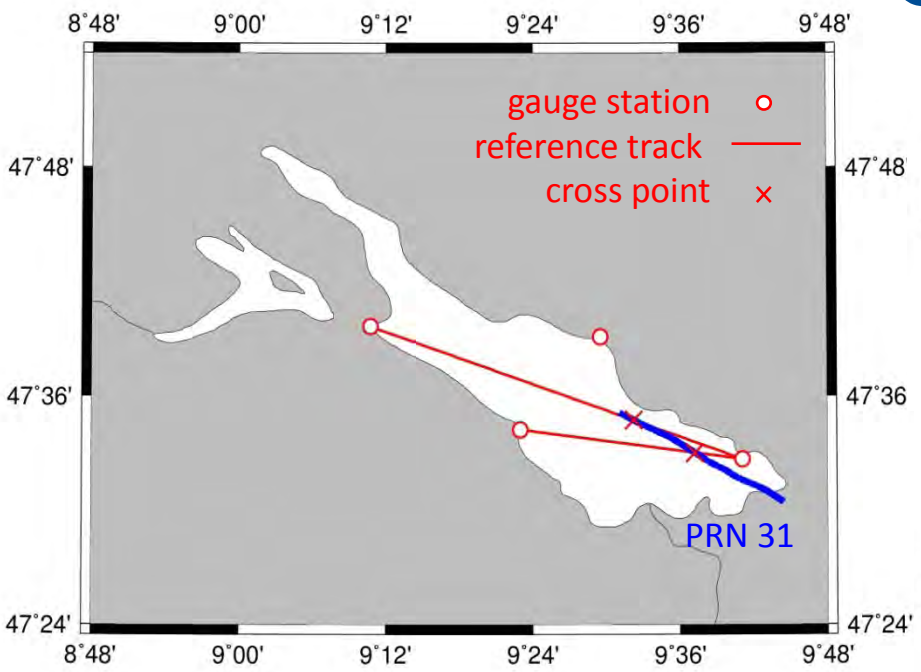


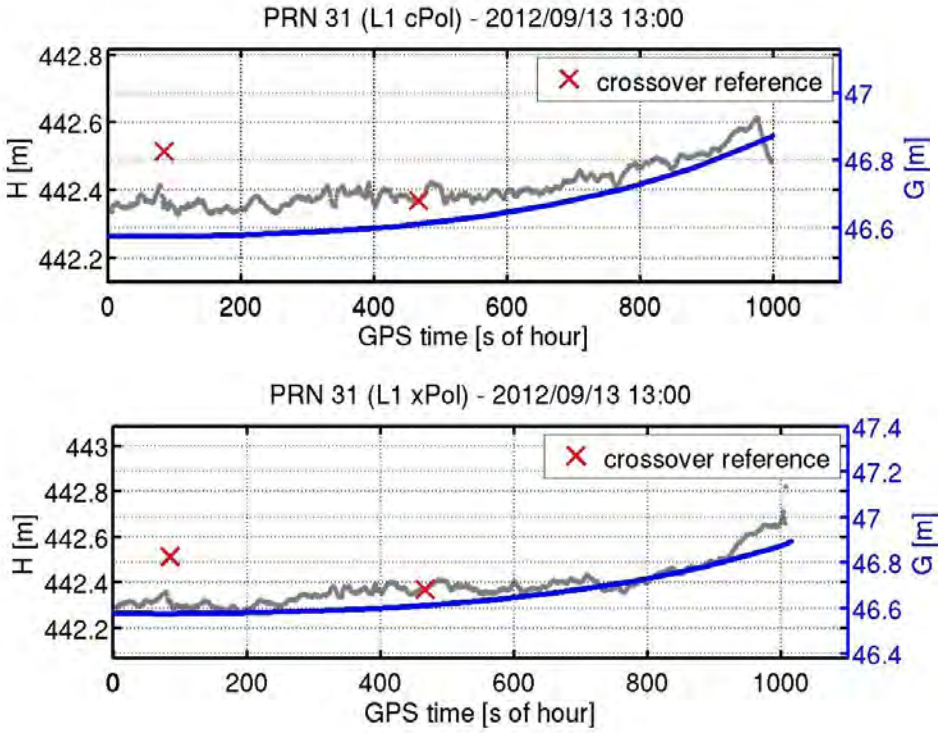


Reference Height

- given at crossover point
- calibrated height scale
- validate with geoid model

Crossover Calibration





Calibration & Validation

- cal. tracks between gauge stations
- obs. track fixed @ crossover point
- val. track deduced from Geoid model

	bias	precision
Δ G (cPol)	7 cm	3 cm
Δ G (xPol)	5 cm	4 cm

Summary

Zeppelin Experiment

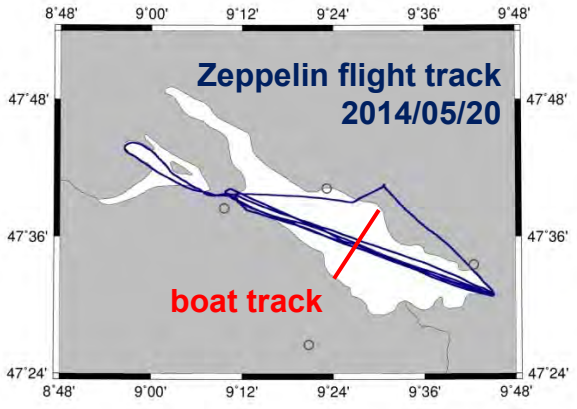
- airborne setups: Zeppelin airship, three antennas, GORS receiver
- differential data: Master samples direct signal & Slave samples reflected signal
- model requirement: specular reflection, ancillary data (receiver trajectory etc.)

Lake Altimetry

- specular reflection event observed during Zeppelin flight (500m above lake surface)
- geoid undulation resolved (centimetre-precision) using carrier phase data
- bias mitigated by crossover calibration using gauge data

Outlook

- crossover calibration with boat and Zeppelin measurements
- study specular reflection conditions for airborne application
- study space-based options (GEROS mission)



Support from our partners is gratefully acknowledged.

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Thank you, for your attention!

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