# GNSS-geoid study 2015

## *Using shipborne GNSS data to evaluate geoid models at sea*
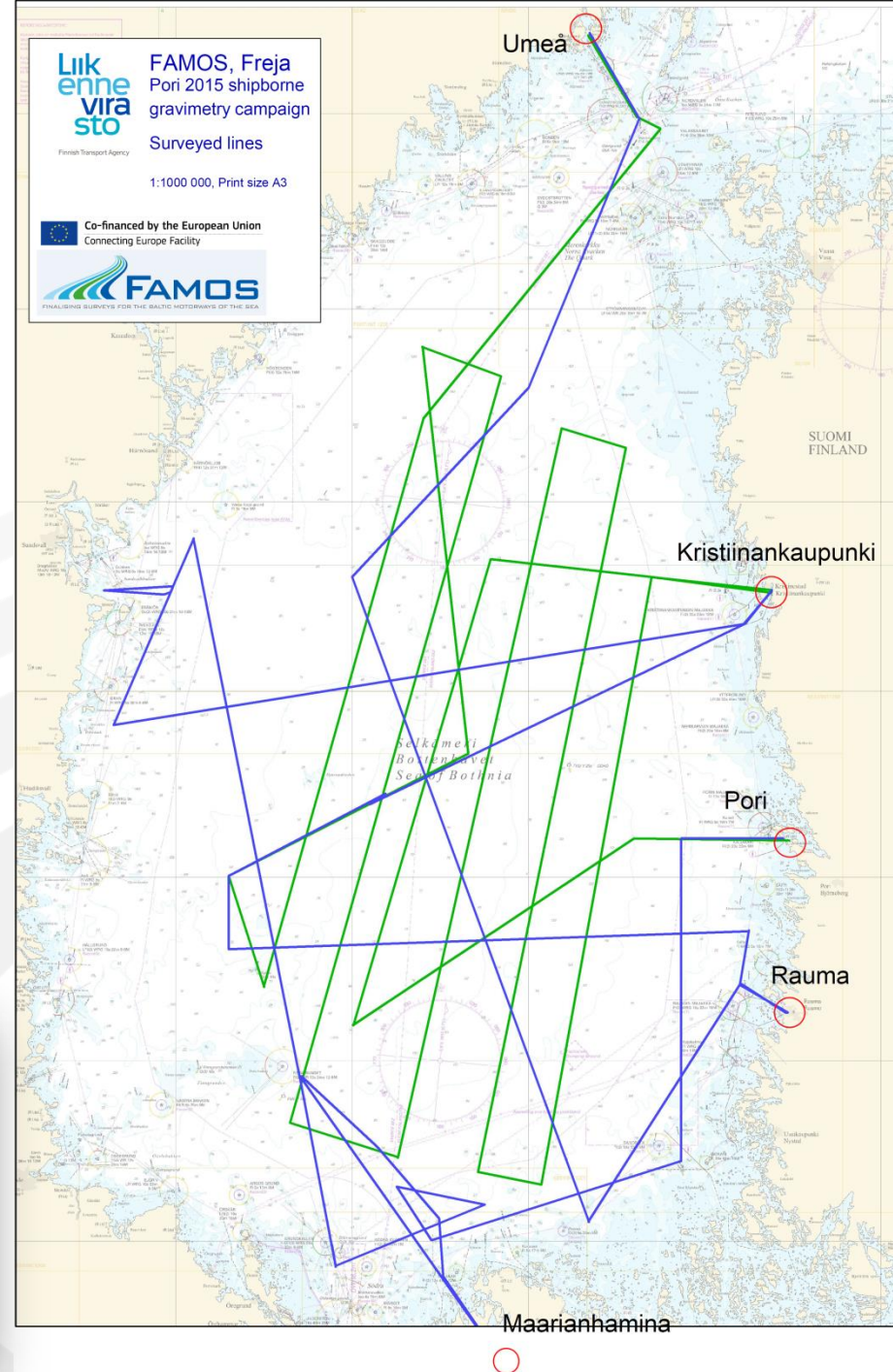
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Hannu Koivula, Jaakko Kuokkanen, Maaria Nordman,

Ulla Kallio, Pasi Häkli, Sonja Lahtinen

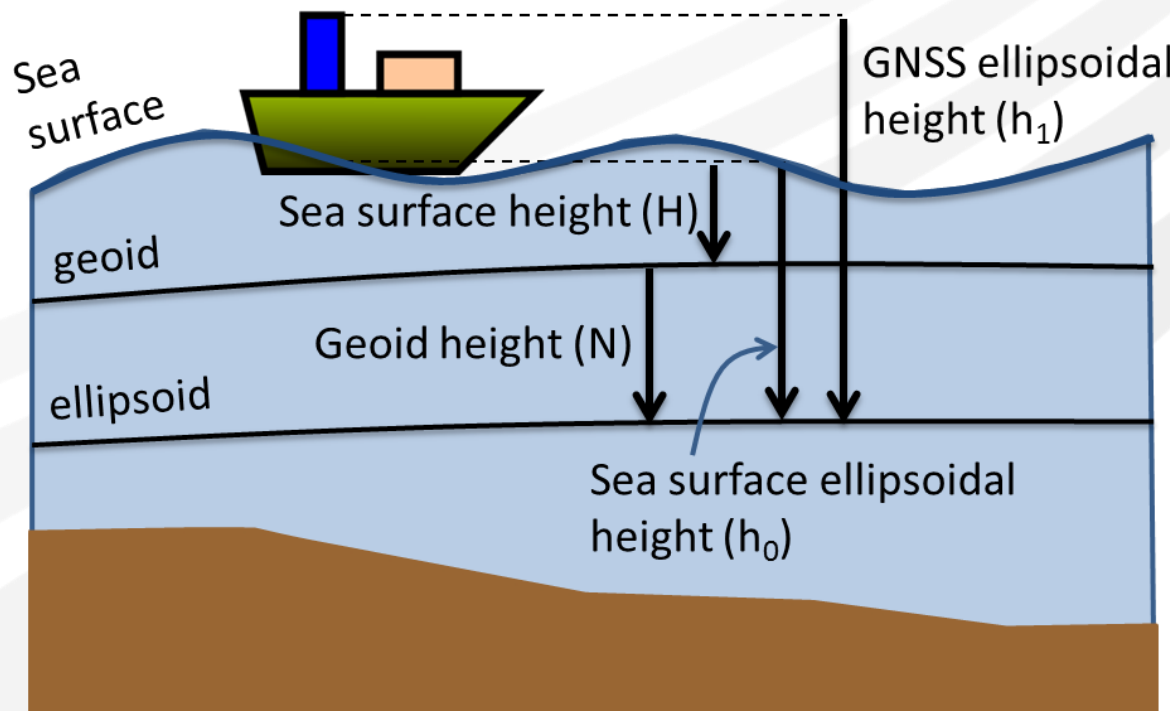Co-financed by the European Union
Connecting Europe Facility

# Airisto Campaign 2015

- Dedicated gravity survey on board the survey vessel Airisto (Meritaito Oy)

- 26.9. – 7.10. (Umeå) – 12.10.

- Total length: 2060 nm

- Vessel GNSS data stored

- Well determined
    - internal coordinate system
    - Squat table
    - Static draft readings





FAMOS, Freja
Pori 2015 shipborne gravimetry campaign

Surveyed lines

1:1000 000, Print size A3

Co-financed by the European Union
Connecting Europe Facility

FAMOS
FINALISING SURVEYS FOR THE BALTIC MOTORWAYS OF THE SEA

Umeå

SUOMI
FINLAND

Kristiinankaupunki

Pori

Rauma

Maarianhamina

Purpose: Derive geoid heights from GNSS observations at sea

# FAMOS 2015 Airisto campaign - GNSS data analysis

**Coordinate System**

**GNSS Base station processing**
- Data download and post-processing
- Result: Consistent reference coordinates to the processing system

IGb08 2015.754770

↓

**Kinematic Processing of vessel GNSS/IMU data**
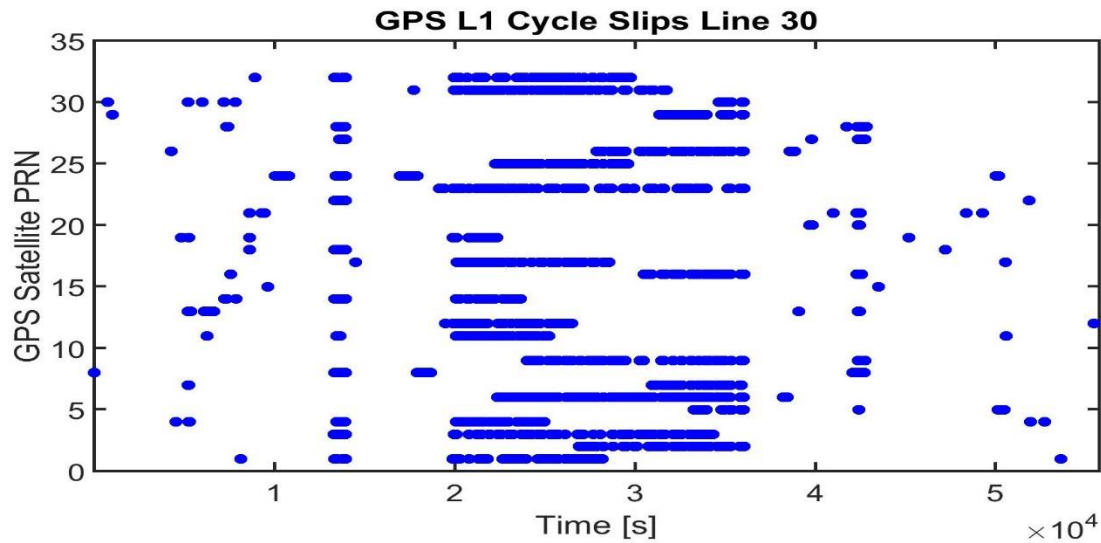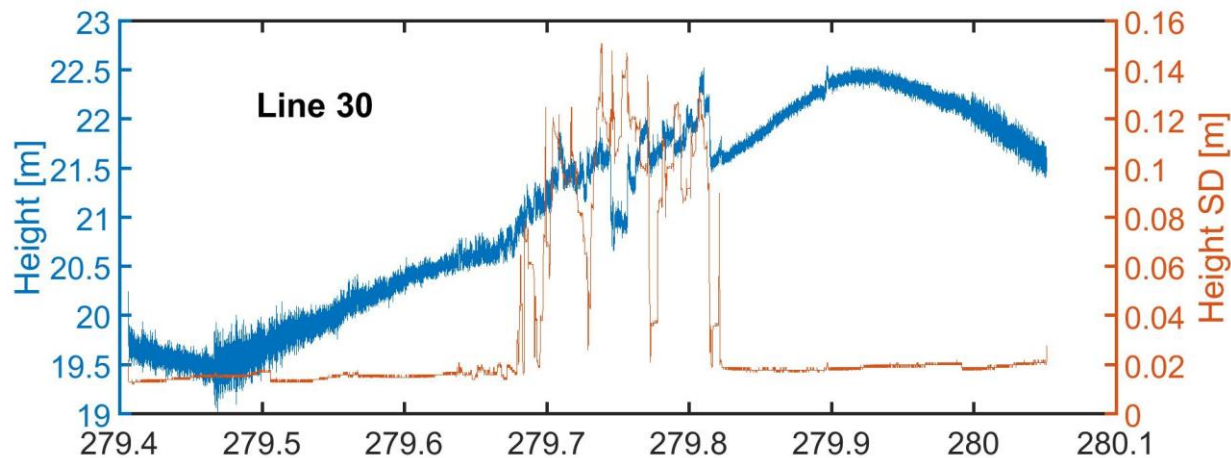- Result: Ellipsoidal height of the vessel origin in the processing coordinate system

Applanix POSPac MMS 7.1
Smooth Best Estimate Trajectory

↓

**Coordinate Tranformation**
- Result: Ellipsoidal height of the vessel origin in the systems related to the geoid models in use

ETRF96 1997.000
ETRF2000 2000.000

# FAMOS 2015 Airisto campaign - GNSS data analysis

Height transformation  from vessel origin to sea surface

- Reductions

  - Pitch and Roll (small effect)

  - Heave: short term vertical movements of the vessel

  - Static draft: Impact of ships load changes to draft

  - Dynamic draft: Squat (velocity effect to draft)

- Result: ellipsoid height at the sea surface

**Roll**
**0 – 5 cm**

**Pitch**
**0 – 4 cm**

**Static draft**
**10 cm**

**Squat**
**0 – 20 cm**
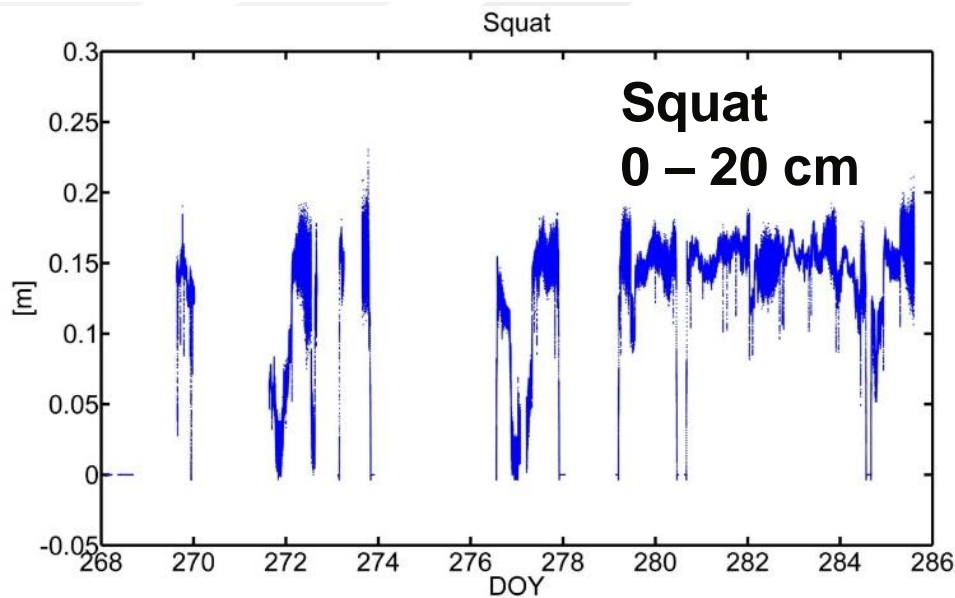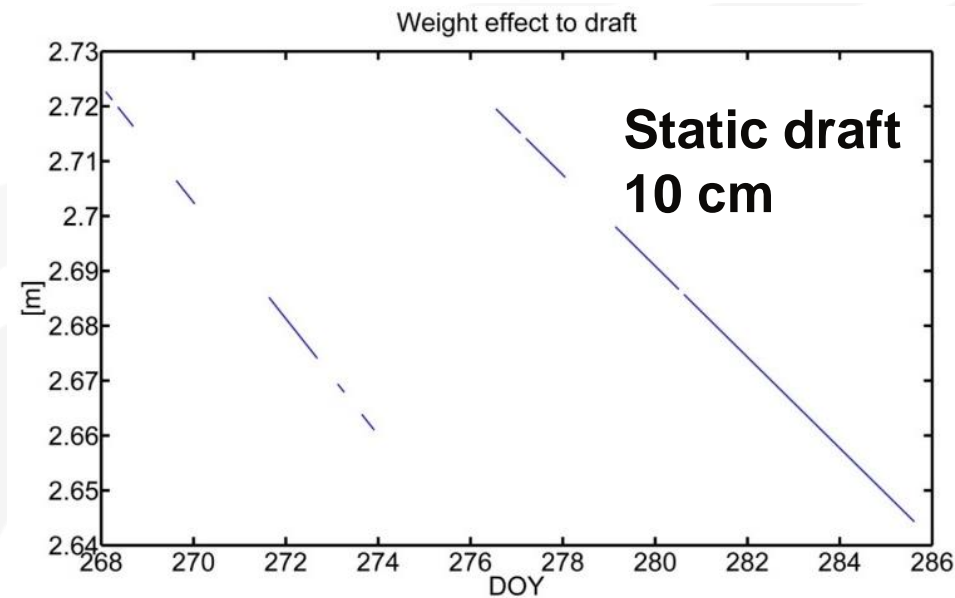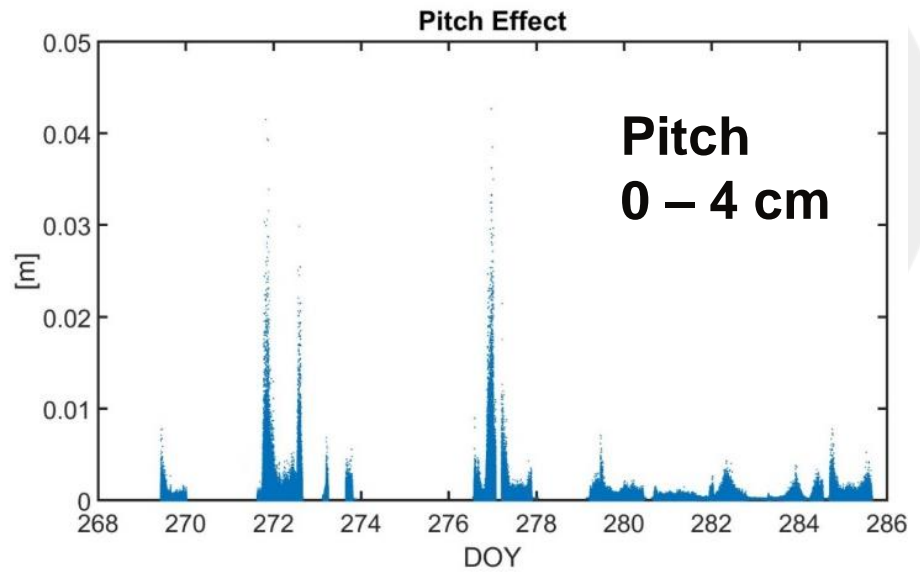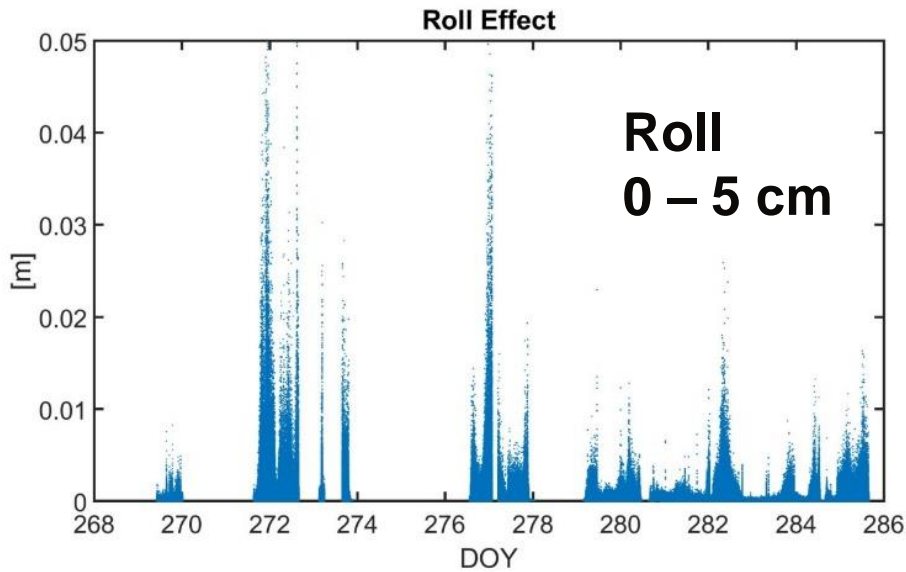
# FAMOS 2015 Airisto campaign
## - GNSS data analysis

Height transformation from sea surface to geoid level (zero height)

Sea surface modelling:

- Tide gauge method
  - 6 Swedish tide gauges
  - 10 Finnish tide gauges

- Physical model method
  - Baltic Sea physics analysis and forecast (Copernicus Marine Environment Monitoring Service ,CMEMS)
  - Fitted to tide gauges



Tide gauge surface 2015-09-26 12:00:00
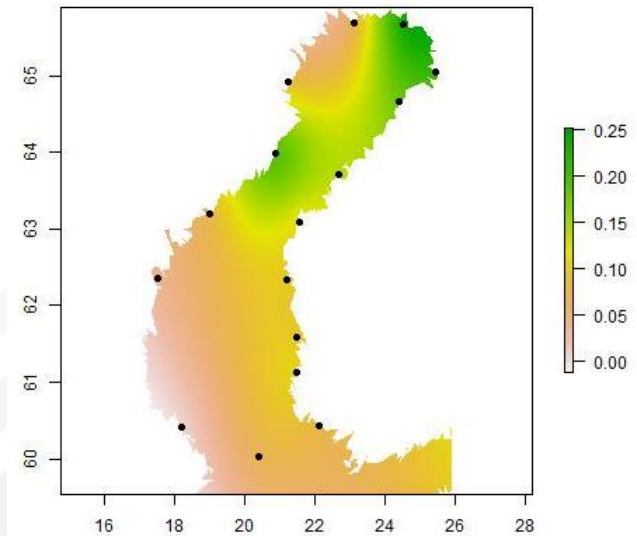


Corrected physical model surface 2015-09-26 12:00:00

Co-financed by the European Union
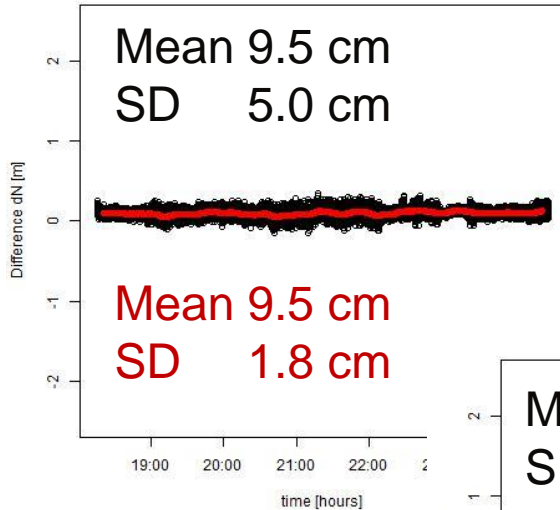Connecting Europe Facility
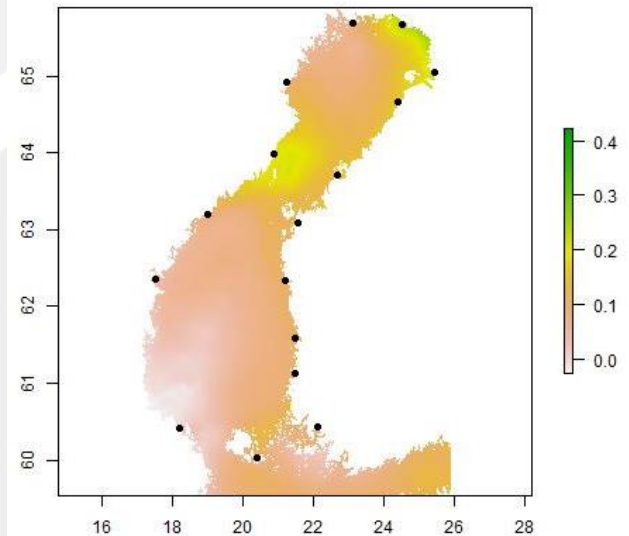
# FAMOS 2015 Airisto campaign - GNSS data analysis
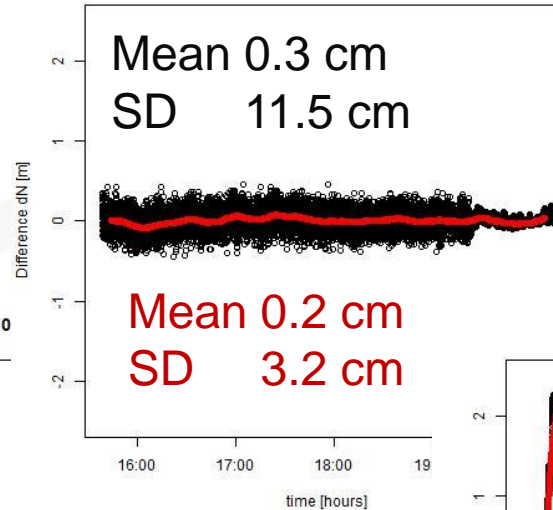
Comparison with geoid models

$$dN = h_{\text{GNSS}} - H_{\text{sea surface}} - N_{\text{geoid model}}$$



Line 7 FIN   date: 2015-09-26

Mean 9.5 cm
SD     5.0 cm

Mean 9.5 cm
SD     1.8 cm

Line 19 FIN   date: 2015-09-30

Mean 0.3 cm
SD     11.5 cm

Mean 0.2 cm
SD     3.2 cm

Line 30 FIN   date: 2015-10

Mean 15.5 cm
SD     20.9 cm

Mean 15.6 cm
SD     19.1 cm
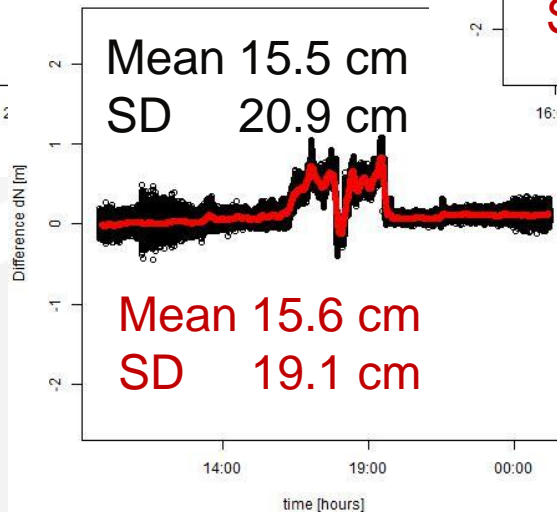
Line 36 FIN   date: 2015-10-07

Mean -3.5 cm
SD     60.4 cm

Mean -3.6 cm
SD     58.8 cm
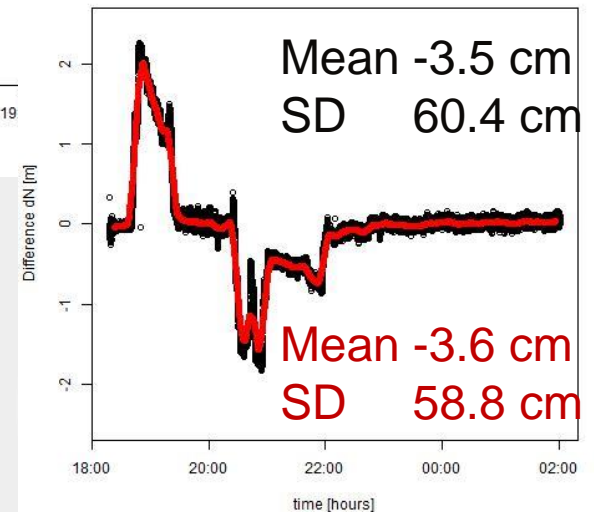
# FAMOS 2015 Airisto campaign - GNSS data analysis

Comparison with geoid models

- 7 lines rejected

- Means of means and standard deviations

| Non-filtered FIN2005N00 model | | | | Non-filtered NKG2015 model | | | |
|---|---|---|---|---|---|---|---|
| Tide gauge surface | | Physical model | | Tide gauge surface | | Physical model | |
| mean (cm) | sd (cm) | mean (cm) | sd (cm) | mean (cm) | sd (cm) | mean (cm) | sd (cm) |
| 4.7 | 10.9 | 3.7 | 11.2 | 3.2 | 10.9 | 2.1 | 11.1 |

| Filtered FIN2005N00 model | | | | Filtered NKG2015 model | | | |
|---|---|---|---|---|---|---|---|
| Tide gauge surface | | Physical model | | Tide gauge surface | | Physical model | |
| mean (cm) | sd (cm) | mean (cm) | sd (cm) | mean (cm) | sd (cm) | mean (cm) | sd (cm) |
| 4.7 | 4.3 | 3.7 | 4.3 | 3.1 | 4.3 | 2.1 | 4.2 |

**It is possible to recover geoid heights from GNSS observations at sea and validate existing geoid models**

- Important:

  - Common processing of base stations

  - Coordinate transformation to systems related to geoid model

  - Pitch and roll

  - Static draft and squat