FAMOS
FINALISING SURVEYS FOR THE BALTIC MOTORWAYS OF THE SEA

GNSS-geoid study

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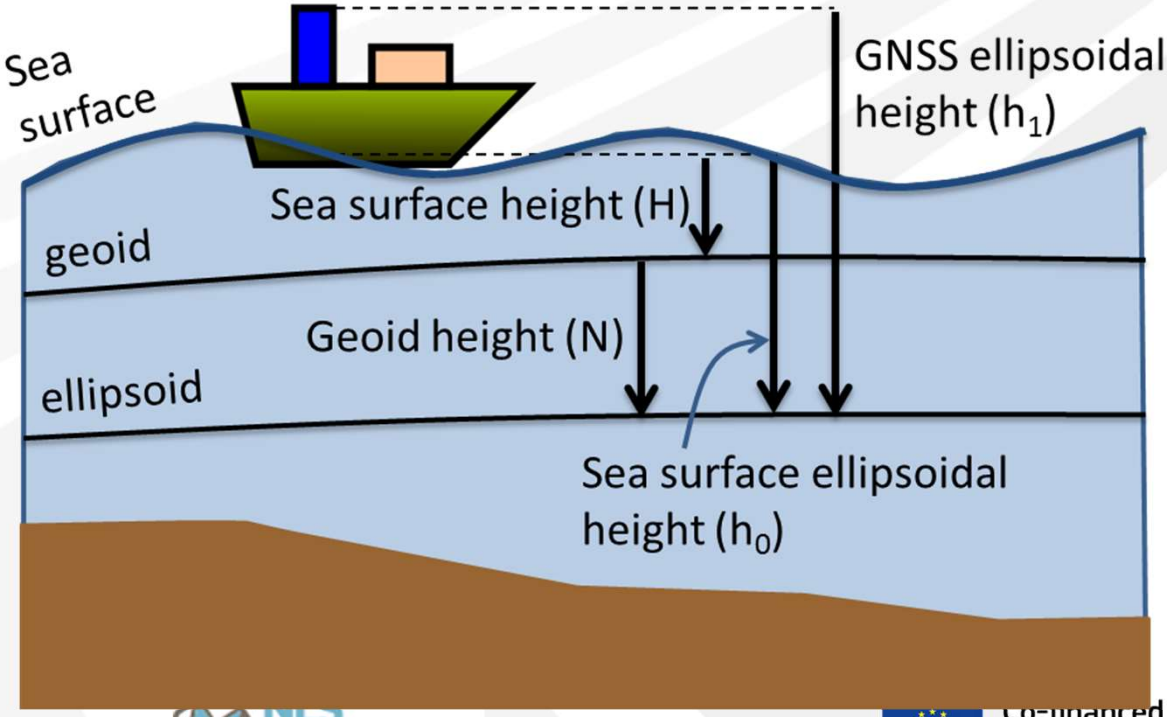
FAMOS 2015 Airisto campaign - GNSS data analysis

Purpose: Derive geoid heights from GNSS observations at sea and validate how good is the agreement with FIN2005N00 and NKG2015 geoid models (separation model).

Motivation: Finland is changing vertical datum from MSL to Baltic Sea Chart Datum 2000 which is geodetic height system and relates depths and heights to geoid.



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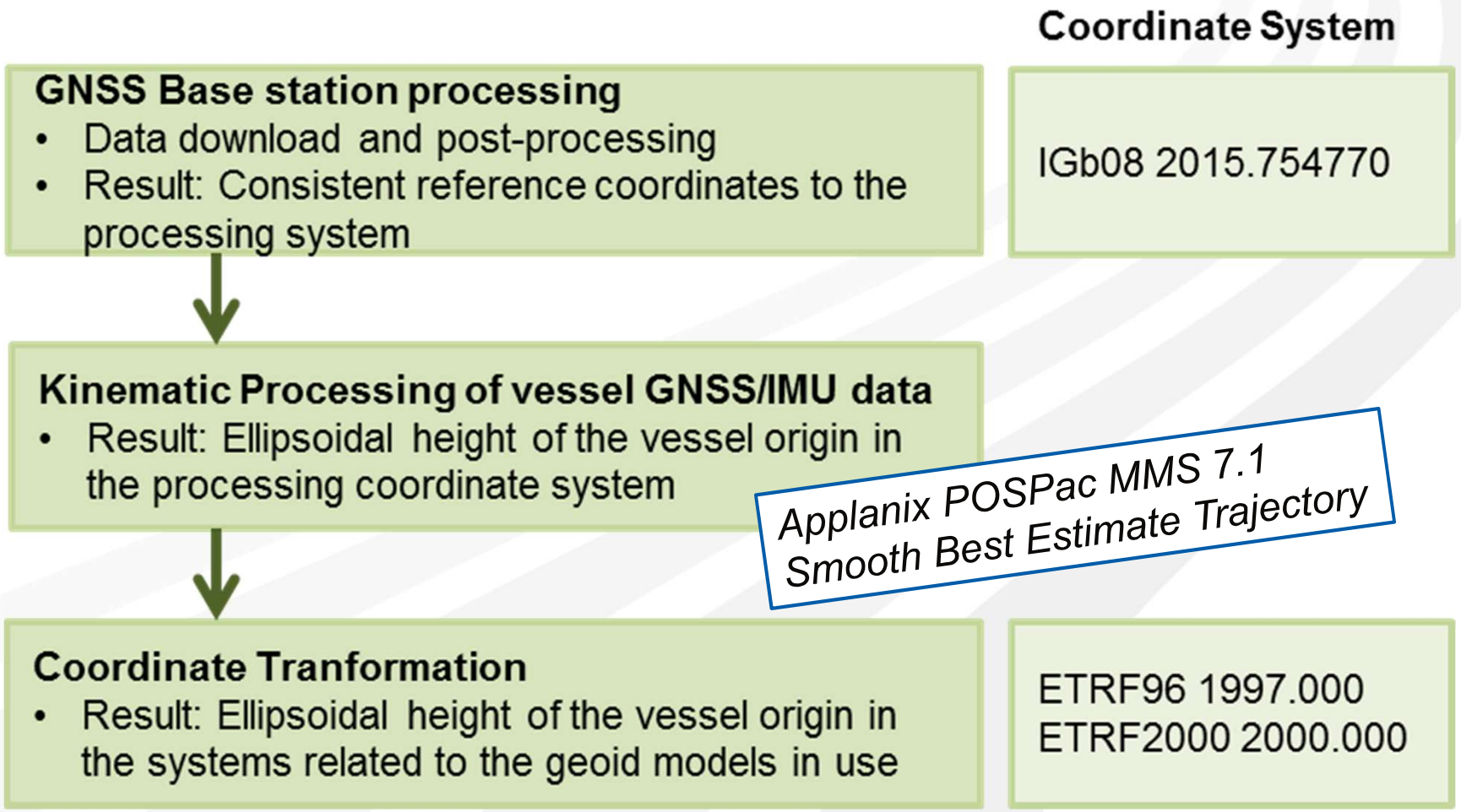

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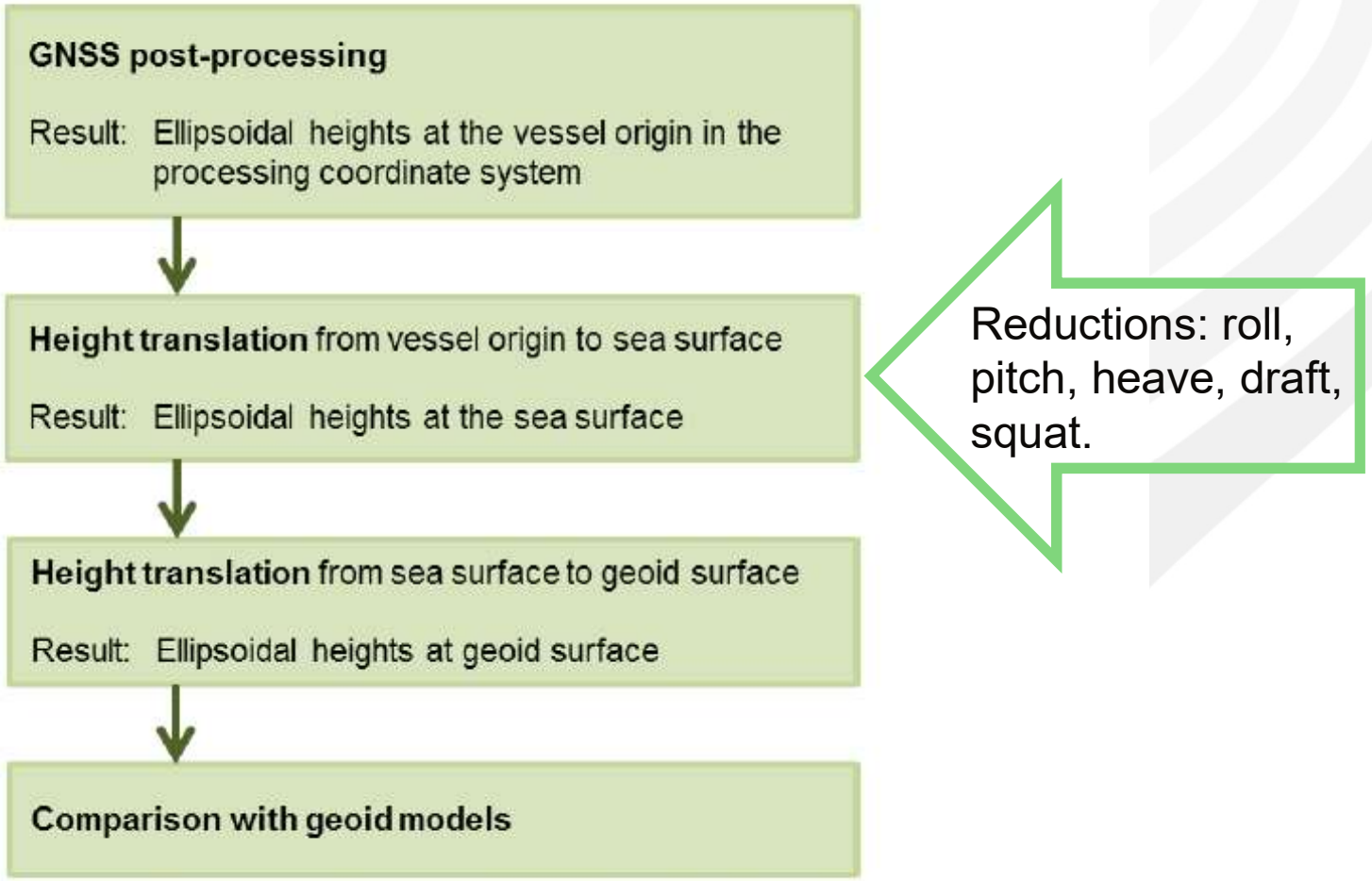
From vessel origin to ellipsoidal heights at geoid surface



Reference surfaces and heights related to the campaign

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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

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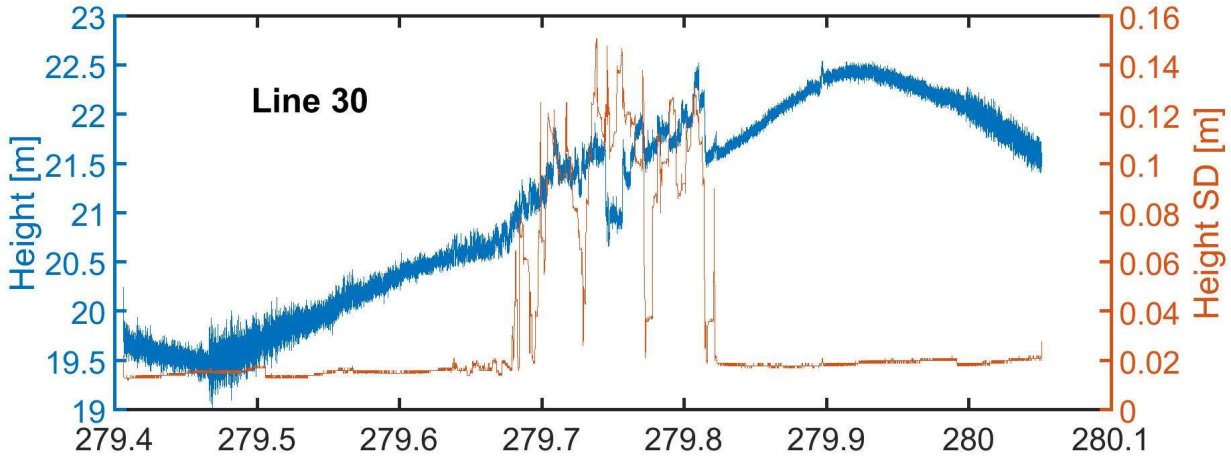

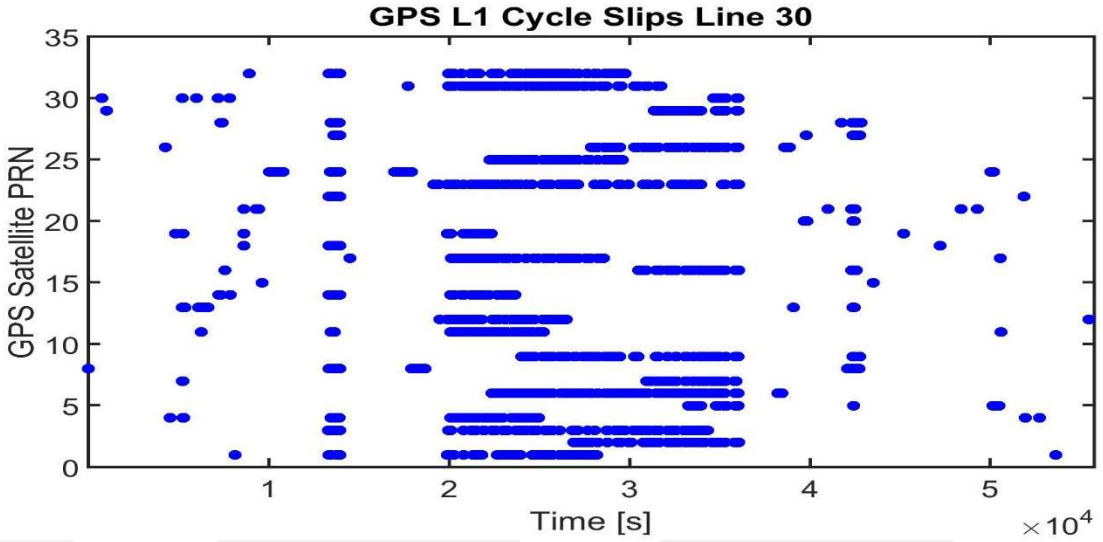

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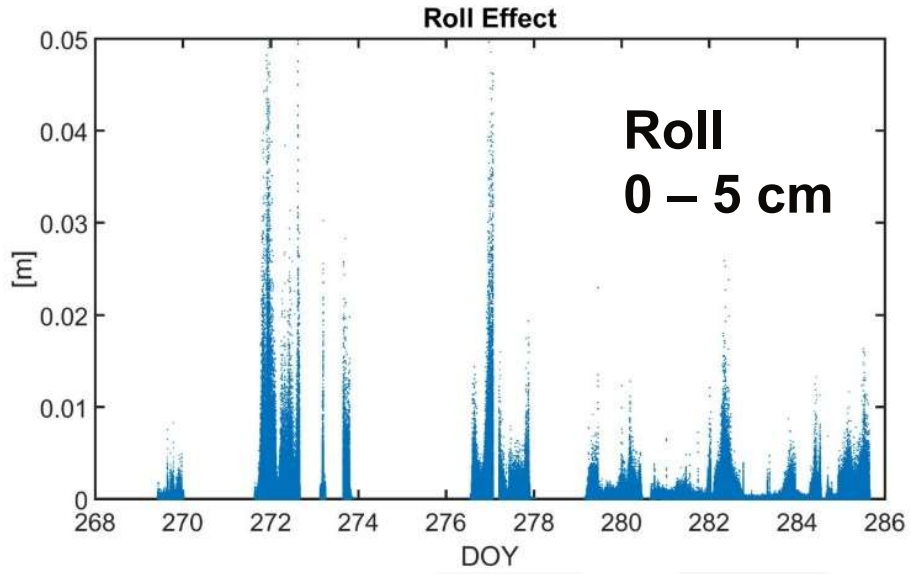
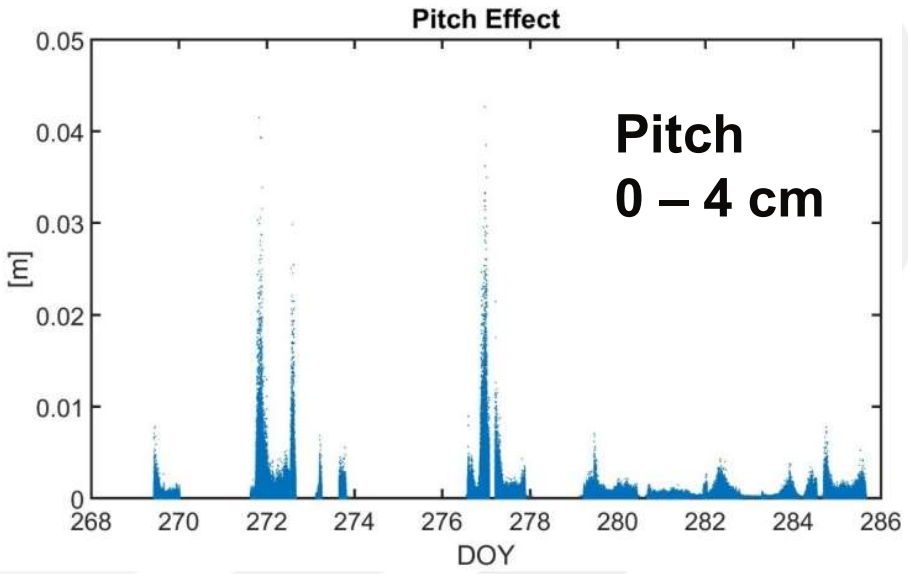
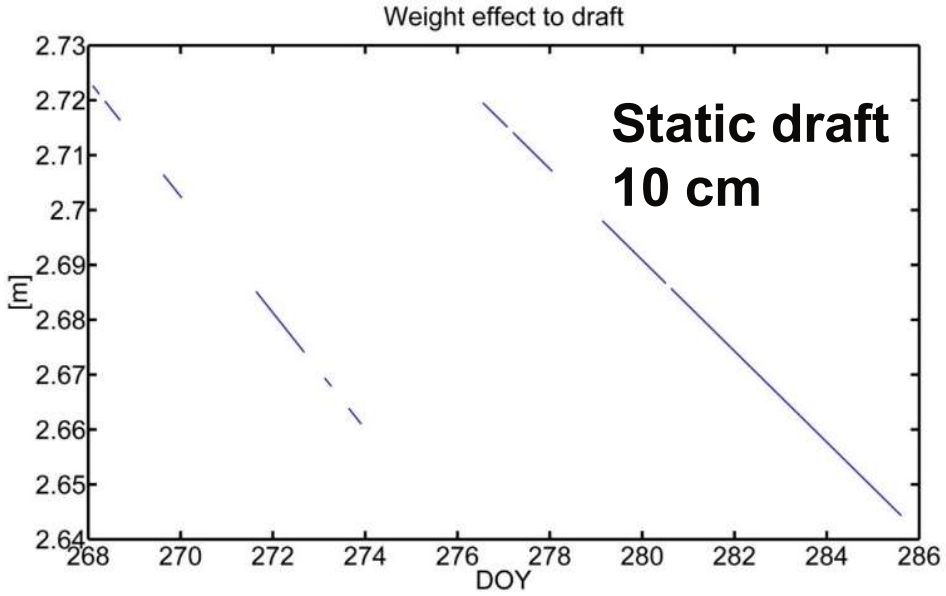
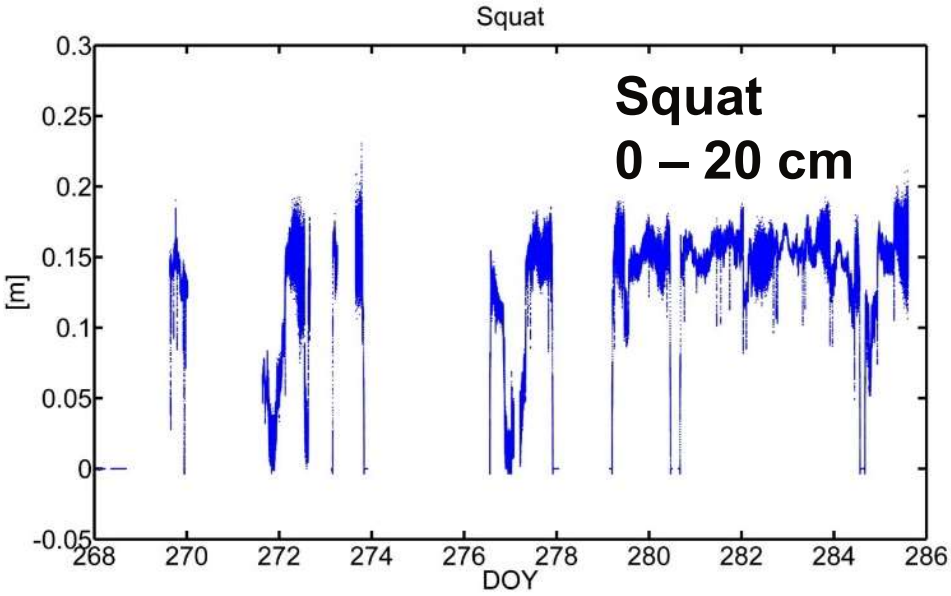
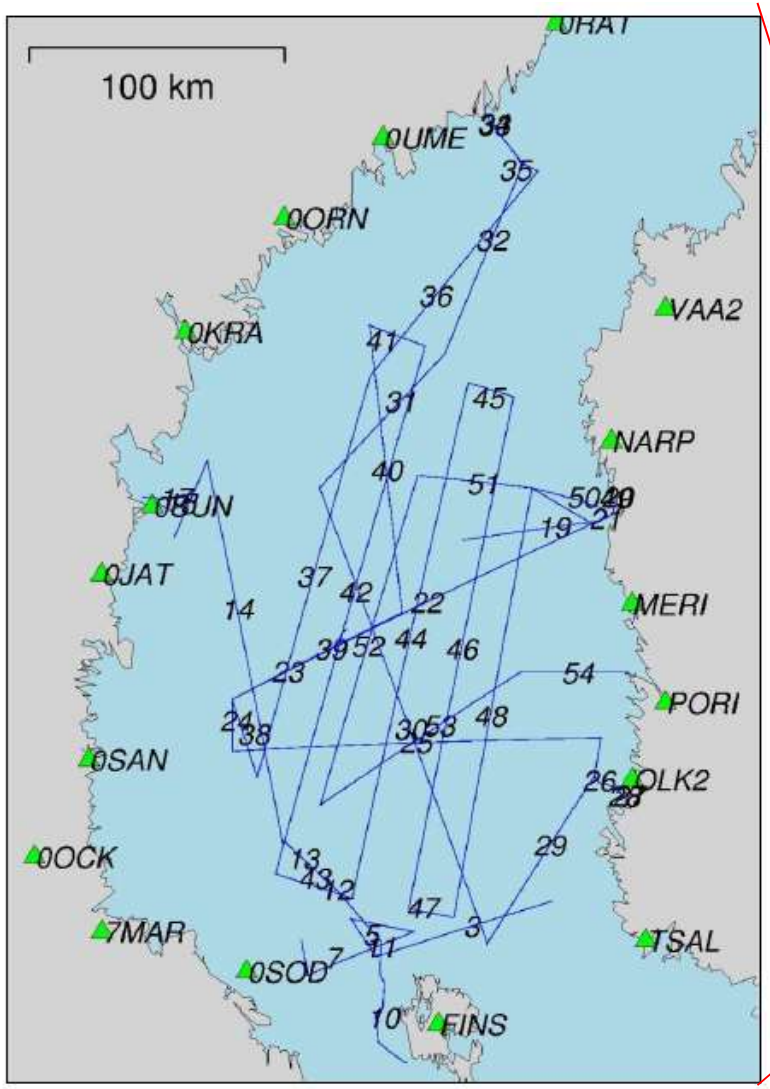








FAMOS 2015 Airisto campaign – vessel tracks



Amendment by Jyrki Mononen, 3.4.2019 / TWCWG4-presentation.

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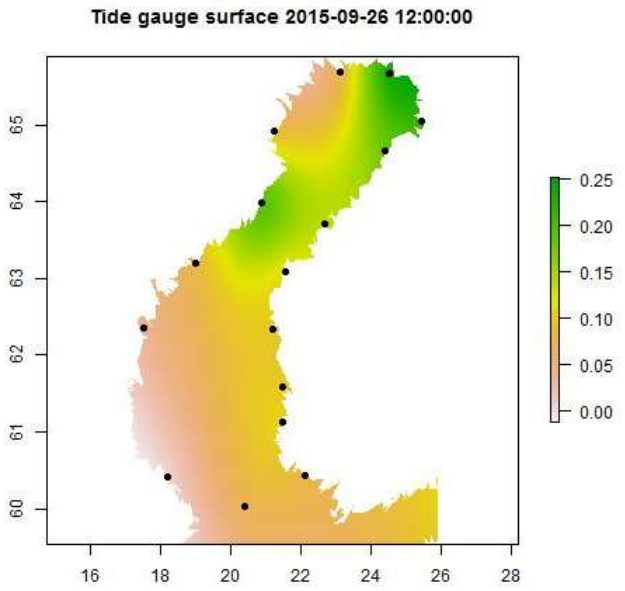
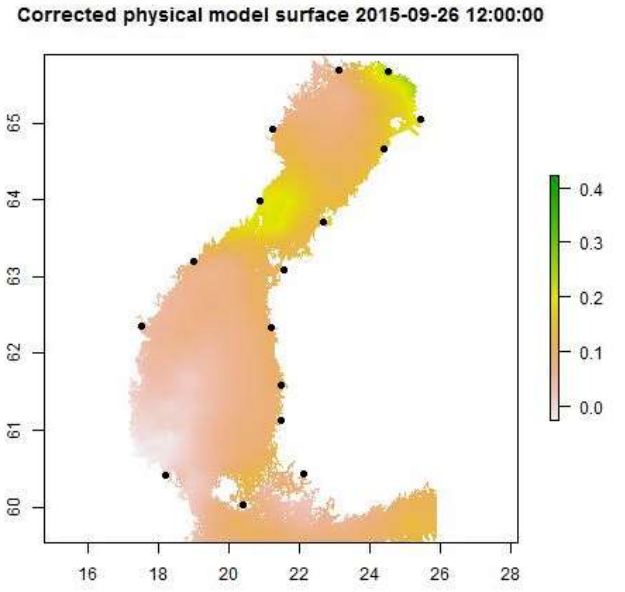
Height transformation from sea surface to geoid level (zero height)

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





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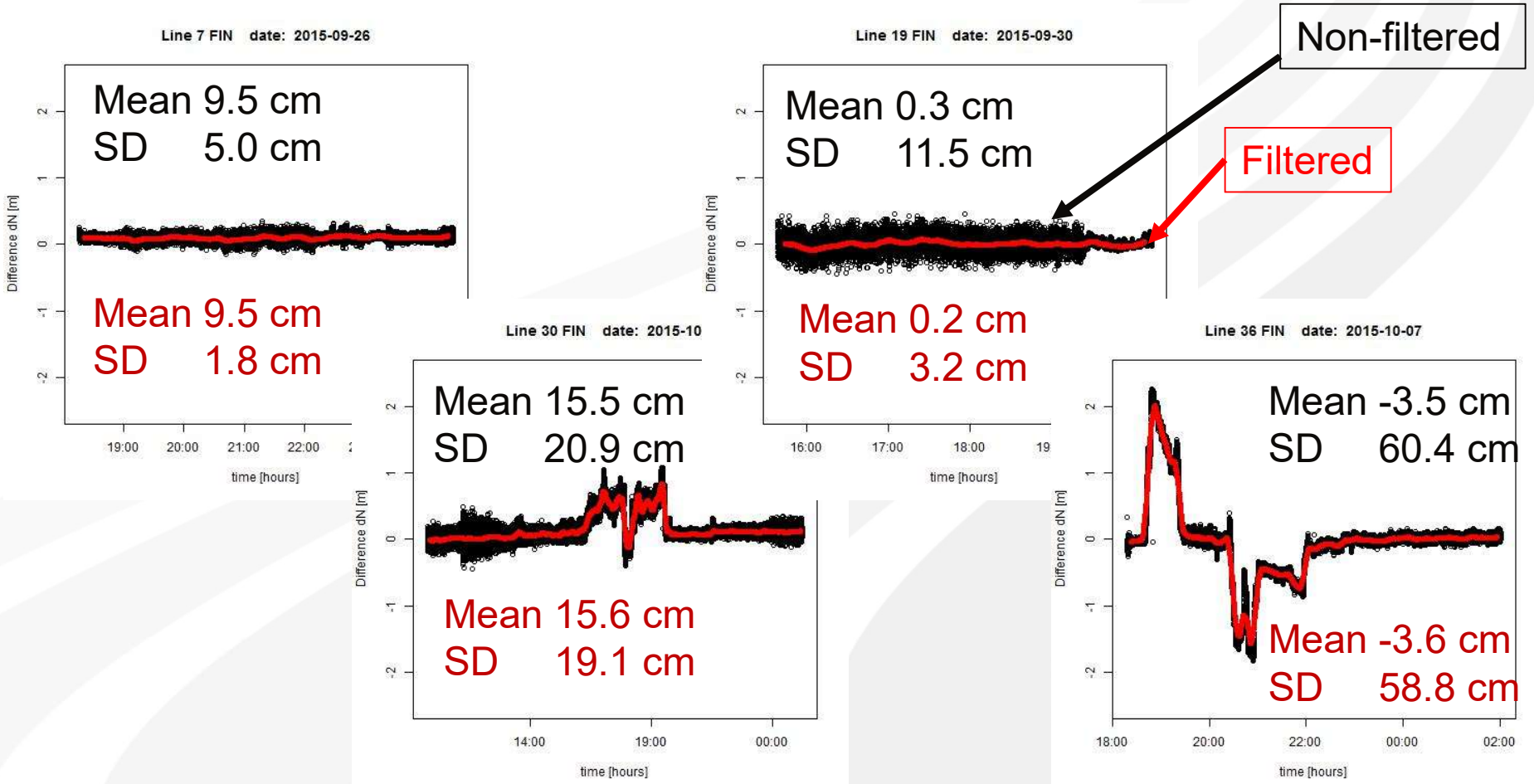
Comparison with geoid models $dN = h_{\text{GNSS}} - H_{\text{sea surface}} - N_{\text{geoid model}}$



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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

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Conclusions

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

⇔

[Amendment by Jyrki Mononen 3.4.2019 / TWCWG4]:

Conversely: using GNSS heights with right geoid model (separation model) it is possible to measure depths relative to chart datum within few centimeters uncertainty at the area of this study

- Important:
  - Common processing of base stations
  - Coordinate transformation to systems related to geoid model
  - Pitch and roll
  - Static draft and squat
  - Internal coordinate system of the vessel has to be known
  - Sea surface topography

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Discussion

[Amendment by Jyrki Mononen 3.4.2019 / TWCWG4]

- In practical implementation for navigation there still are many questions e.g:
  - How well vessel movements could be known for individual ships => effects to the accuracy
  - How well vessl coordinate system could be defined for individual ships => effects accuracy
  - How good the GNSS-height determination could be at individual ships
  - How well the sea surface topography is really known away from water level/tide gauges gauges

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