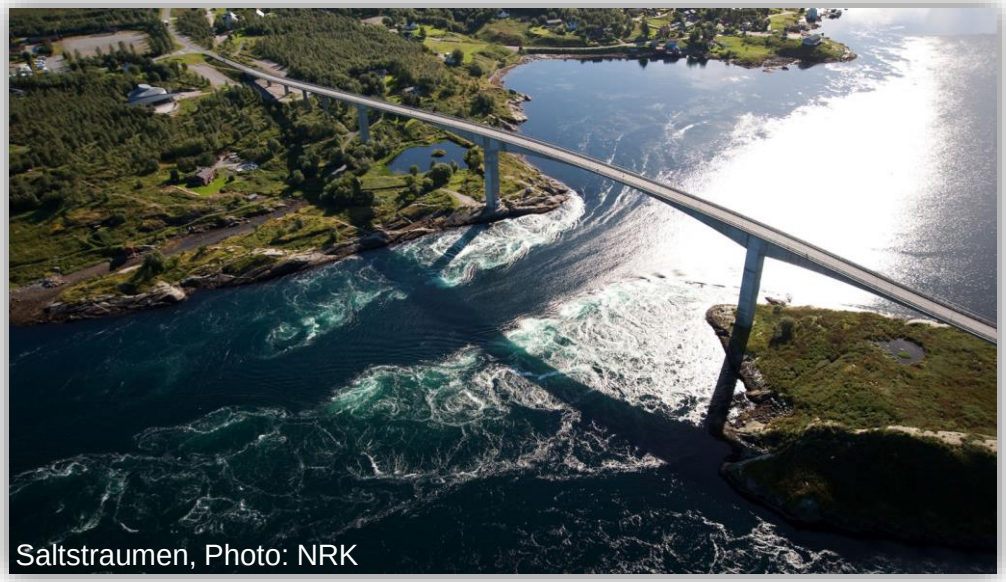
JONSMOD 2016

# Adjusting global tidal forcing for use in high-resolution fjord models



Saltstraumen, Photo: NRK

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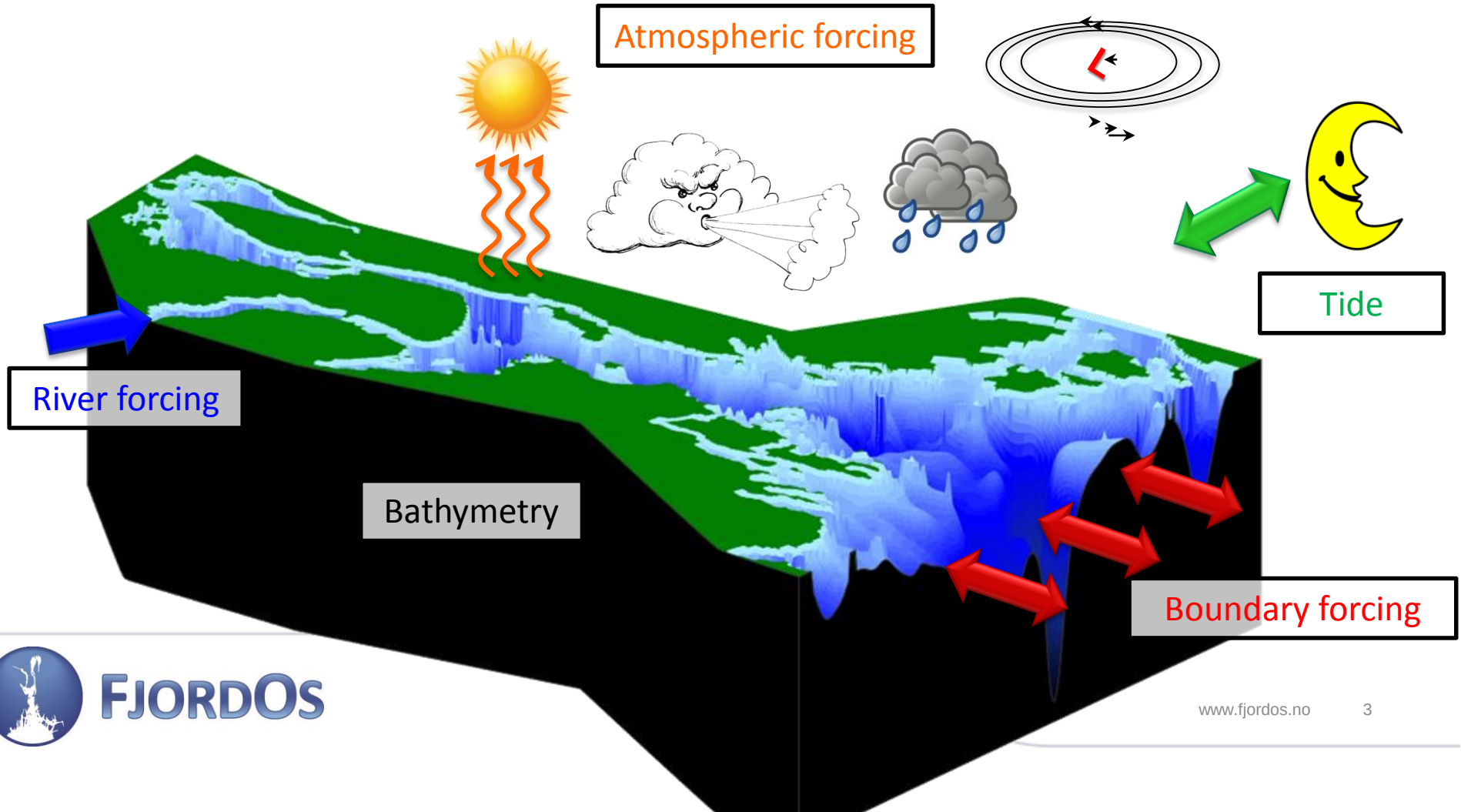
# Outline

- Motivation
- Method
- Two test areas
- Illustrate method
- Some results from the simulations
- Summary

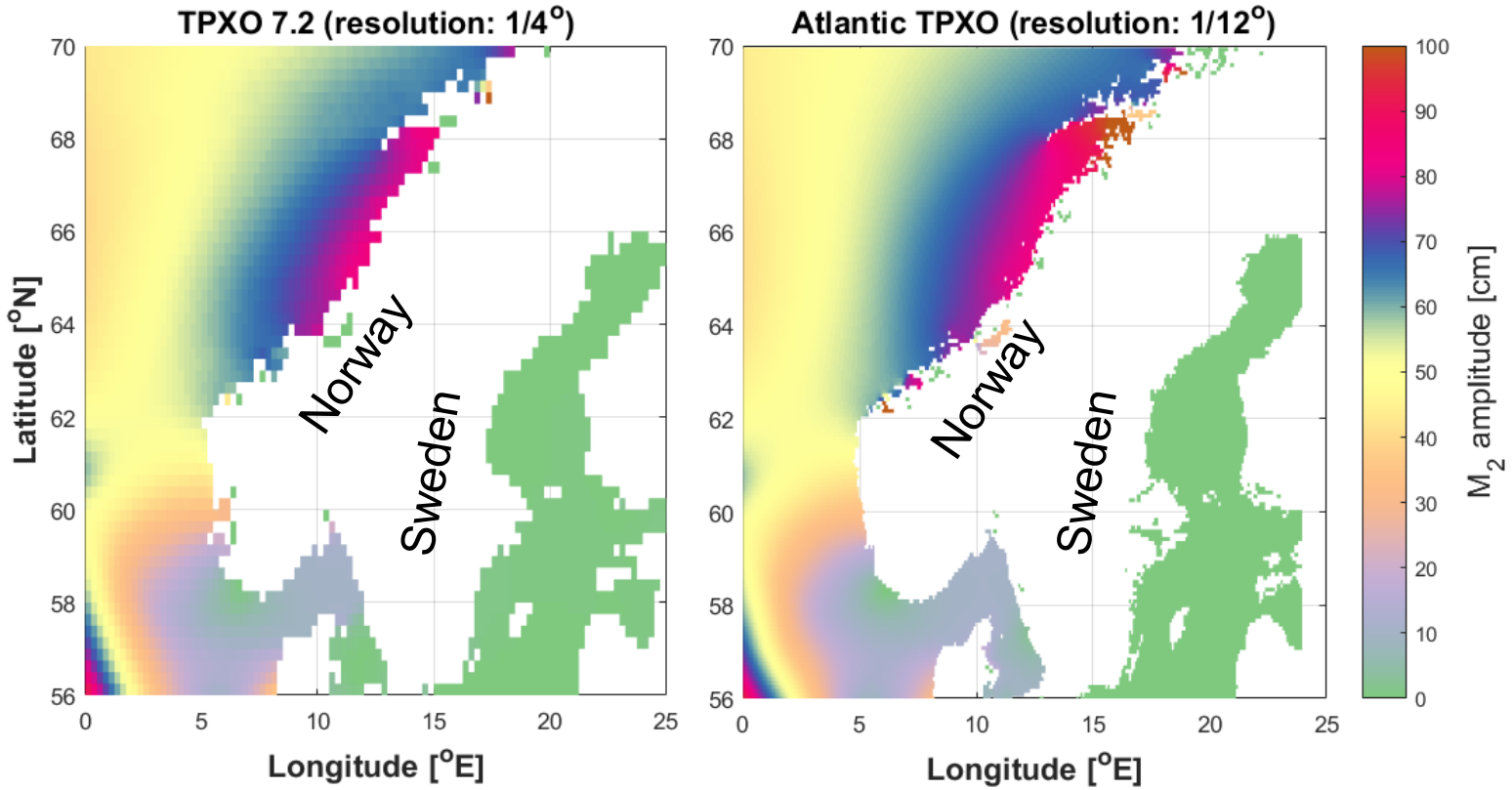
# Motivation

Accurate tidal forcing crucial for fjord models



# Motivation

Global tidal forcing to coarse for fjord modelling



# Method

1. Run model with global tidal forcing
2. Compare simulated and observed water level for each tidal component close to boundary

$$c^n = \frac{a^n_{obs}}{a^n_{sim}}, \qquad \Delta\phi^n = \phi^n_{obs} - \phi^n_{sim}$$

3. Adjust tidal forcing for both water level and currents

$$a^n_{tf,new} = c^n \times a^n_{tf,old}, \quad \phi^n_{tf,new} = \phi^n_{tf,old} + \Delta\phi^n$$

4. Rerun the model with adjusted tidal forcing
5. Check results

# Two test areas

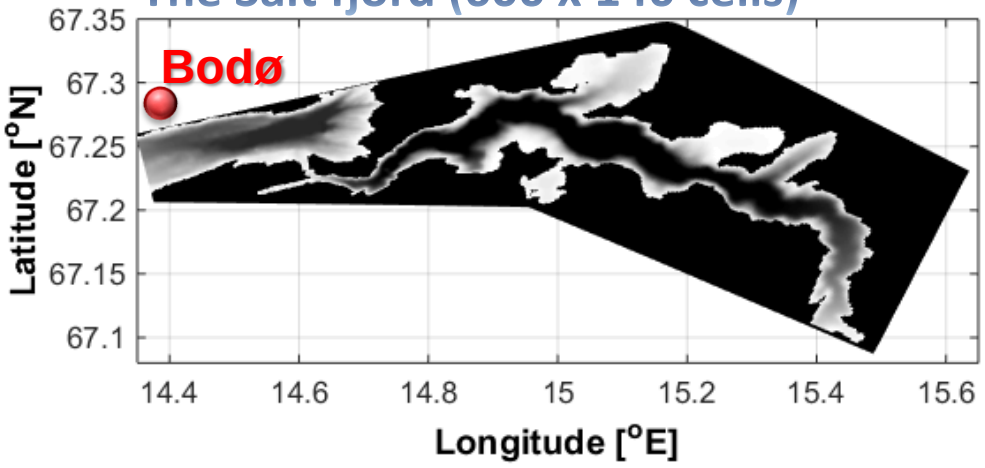


Norwegian Sea
Sverige
Sweden
Norge
Suomi
Finland
Eesti
Estonia
Latvija
Latvia
Baltic Sea
North Sea
Danmark
Denmark
United
Kingdom
Ireland
Éire
Nederland
Netherlands
België
Belgique
Belgium
Polska
Poland
Česká rep
Czech Rep
Slovensko
Slovakia
Österreich
Austria
France
România
Google

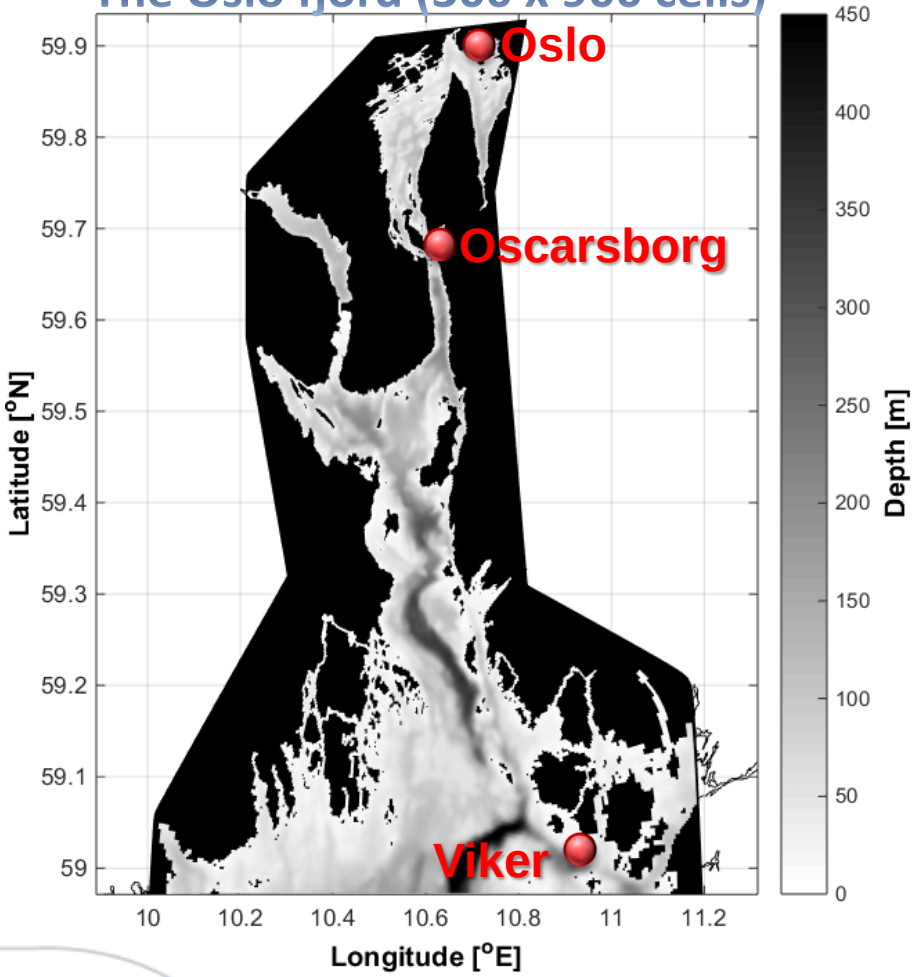
# Initial model setup

- ROMS (42 layers)
- Curvilinear grids
- Coarse tidal forcing

The Salt fjord (600 x 140 cells)



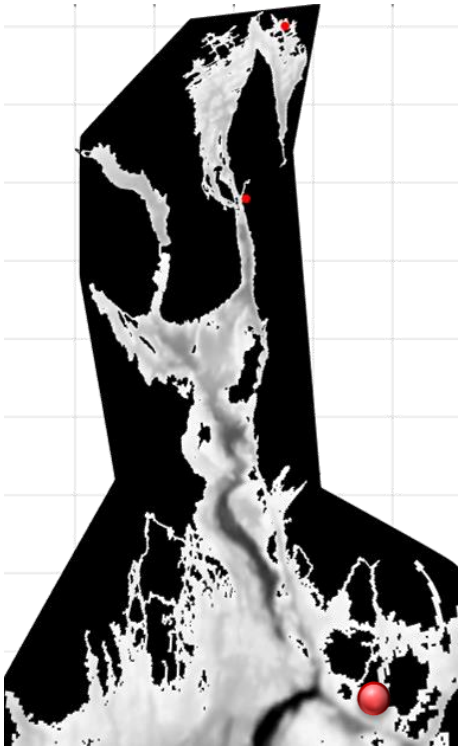

The Oslo fjord (300 x 900 cells)

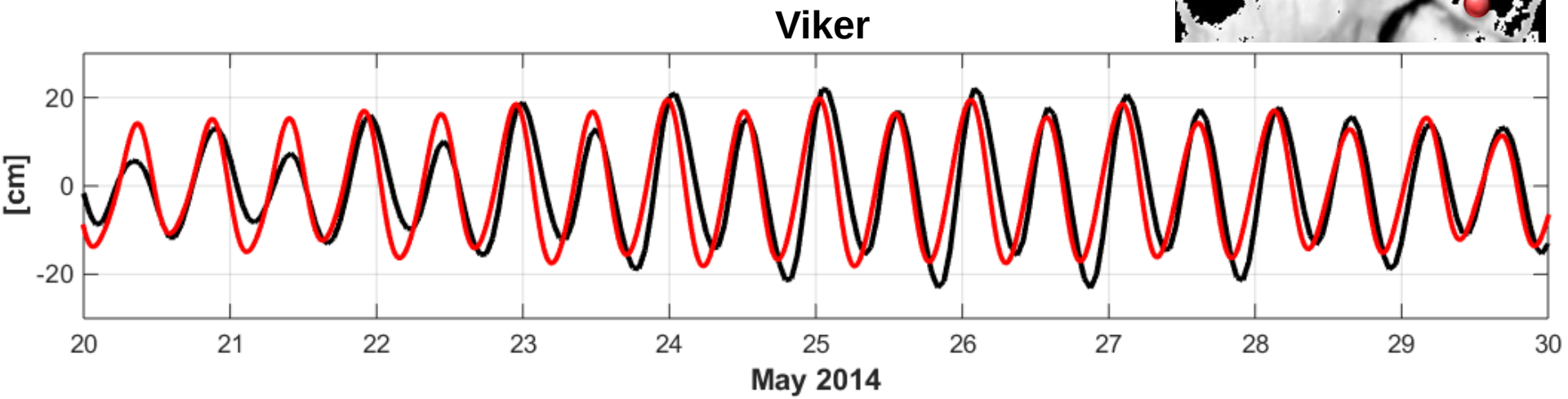



FJORDOS

# Analyse water level

- Tides analysed using t_tide
  (Pawlowicz, R., Beardsley, B., & Lentz, S., 2002)
- Observed and simulated tidal water level close to open boundary:






Observed
Simulated

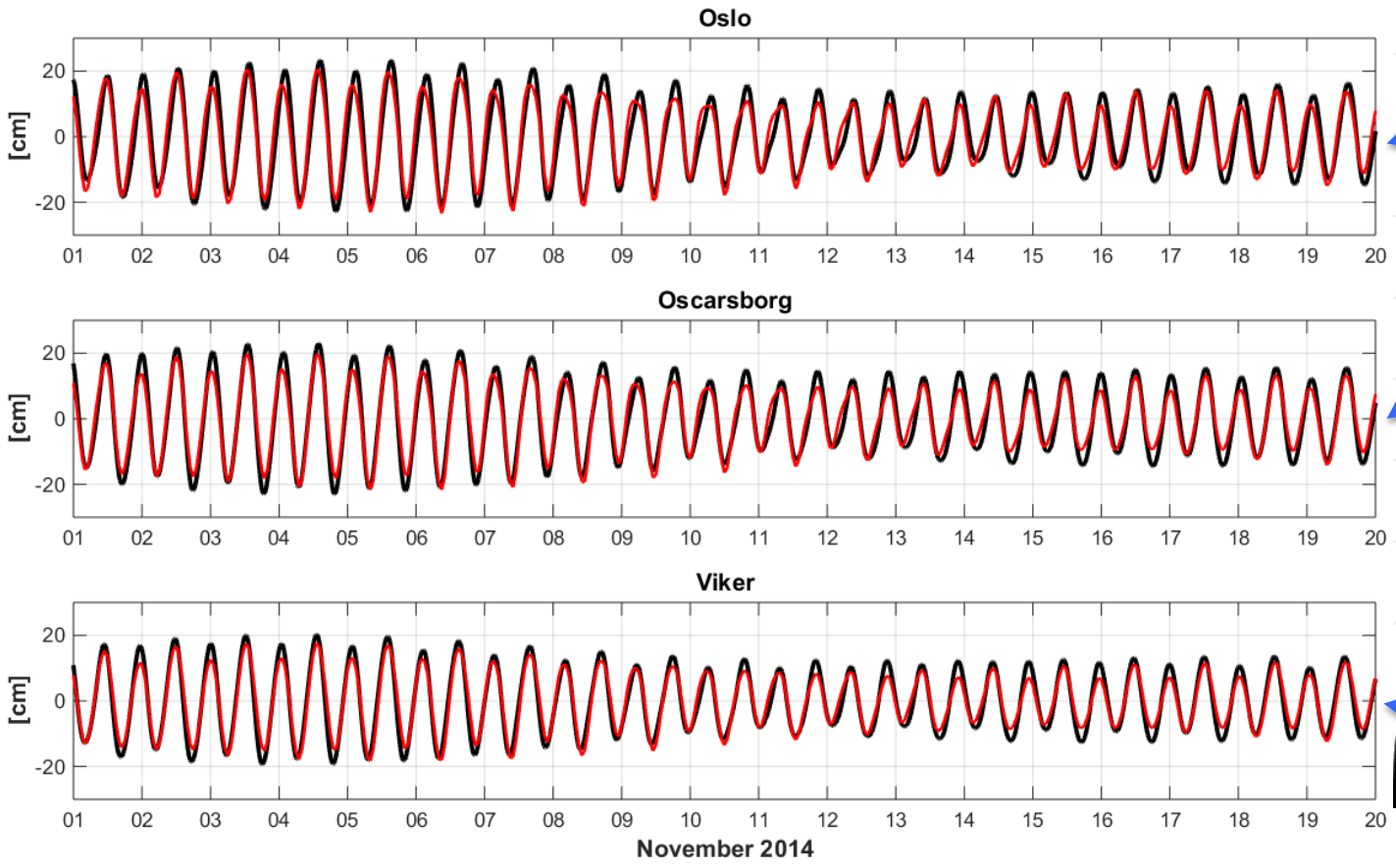
# Compare tidal phase and amplitudes at Viker

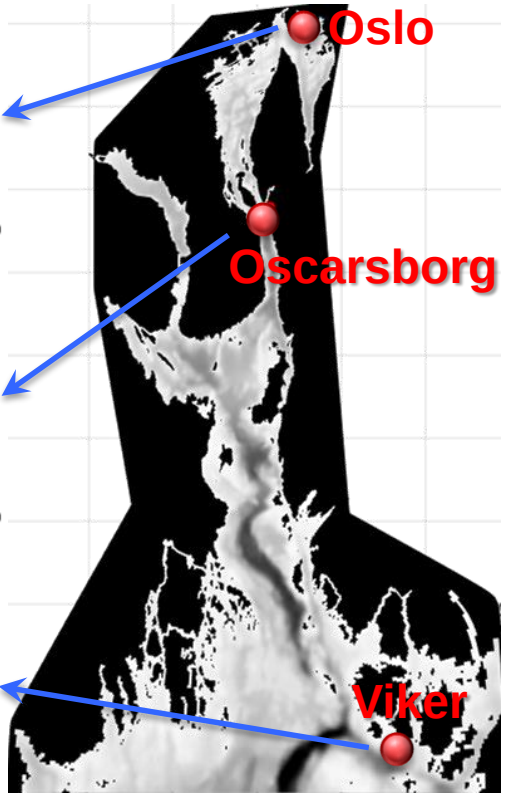
| Component | | Observation | | Simulation | | Tidal forcing | | Adjustment | |
|---|---|---|---|---|---|---|---|---|---|
| Name | Period [h] | $a_{obs}$ [cm] | $\phi_{obs}$ [deg] | $a_{sim}$ [cm] | $\phi_{sim}$ [deg] | $a_{tf}$ [cm] | $\phi_{tf}$ [deg] | Ratio c | Phase diff. $\Delta\phi$ |
| $S_2$ | 12.0000 | 3 | 43.9 | 5.1 | 81.2 | 2.7 | 0.6 | 0.588 | -37.37 |
| $M_2$ | 12.4206 | 11.8 | 110.1 | 9.7 | 122.1 | 10.3 | 3 | 1.225 | -11.98 |
| $N_2$ | 12.6584 | 3.4 | 61.8 | 5.7 | 81.3 | 2.8 | 1.6 | 0.595 | -19.45 |
| $K_1$ | 23.9345 | 0.7 | 138.2 | 1.2 | 211.7 | 0.9 | 2.2 | 0.552 | -73.48 |
| $P_1$ | 24.0659 | 0.5 | 68.6 | 1.2 | 211.7 | 0.6 | 1.6 | 0.421 | -143.12 |
| $O_1$ | 25.8193 | 2.2 | 281.5 | 3.7 | 19.3 | 0.9 | 1.8 | 0.591 | 262.13 |
| $MN_4$ | 6.2692 | 0.4 | 272.4 | 1 | 140.8 | 0.2 | 3.6 | 0.37 | 131.65 |
| $M_4$ | 6.2103 | 1.2 | 284.2 | 0.7 | 25.4 | 1 | 3 | 1.737 | 258.77 |
| $MS_4$ | 6.1033 | 0.3 | 357.7 | 1.1 | 110.8 | 0.7 | 2.3 | 0.272 | 246.95 |

$$c = \frac{a_{obs}}{a_{sim}}$$

$$\Delta\phi = \phi_{obs} - \phi_{sim}$$

# Rerun with adjusted tidal forcing

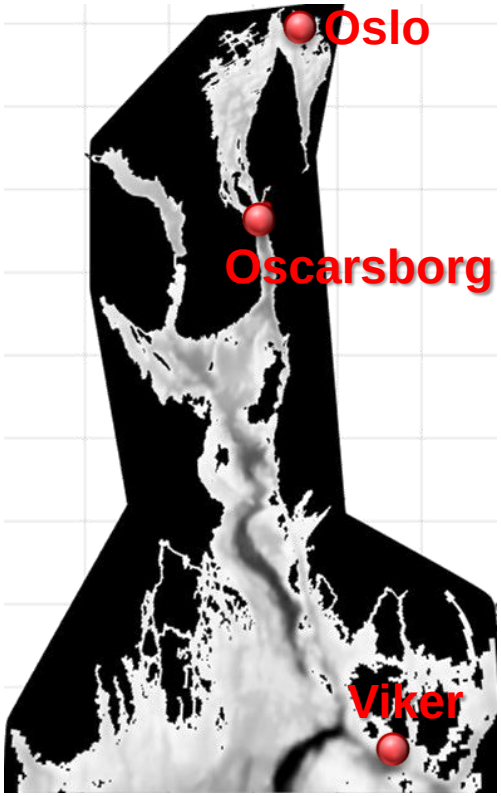


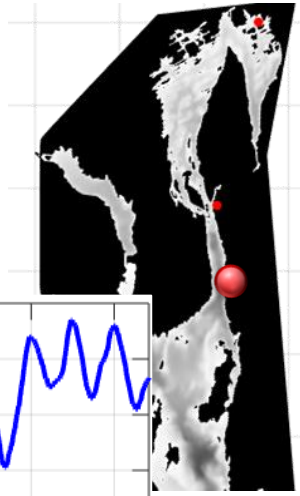

Observed
Simulated

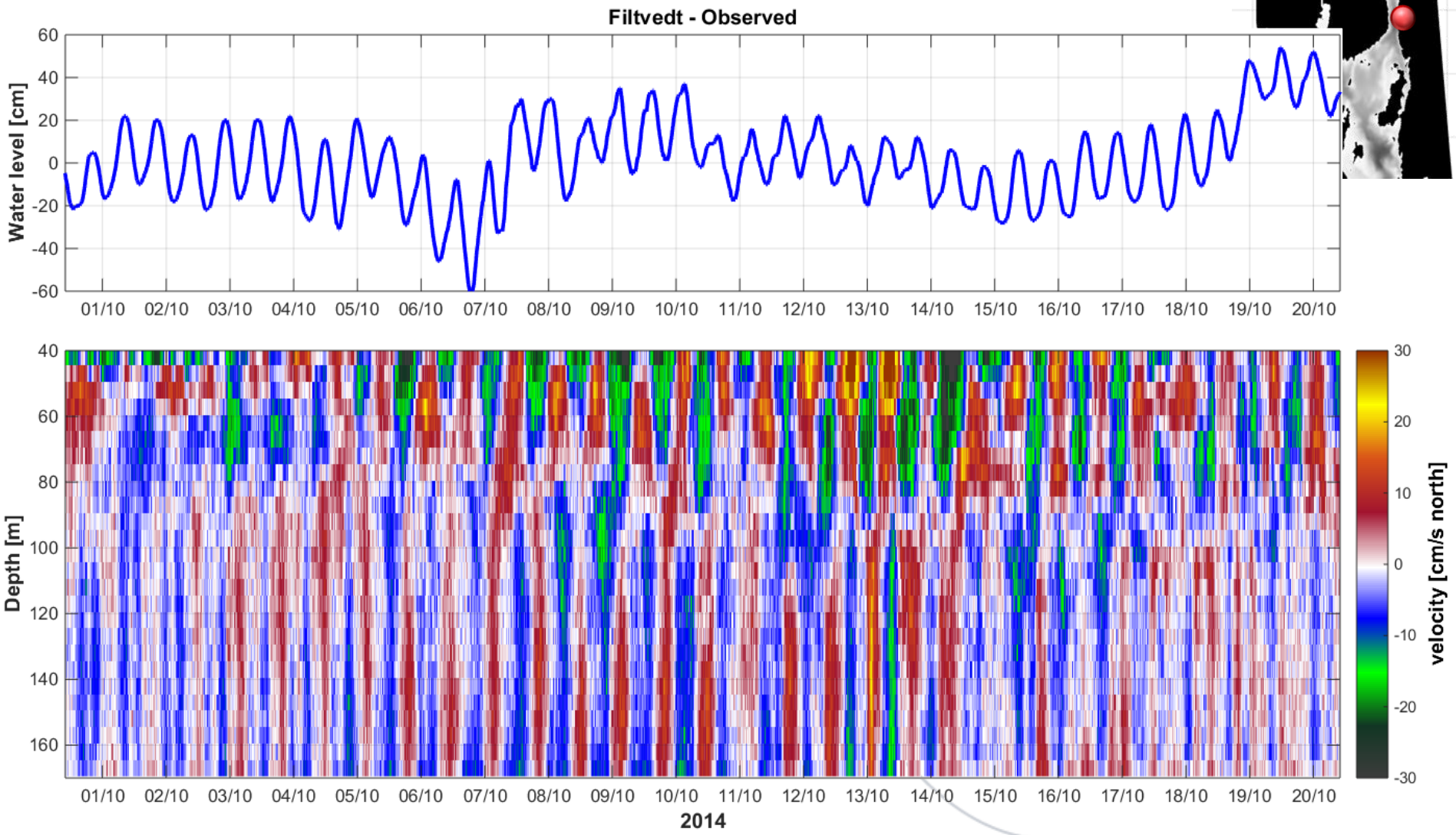
# Rerun with adjusted tidal forcing

| | | Oslo | | Oscarsborg | | Viker | |
|---|---|---|---|---|---|---|---|
| | | Amp [cm] | Fase [deg] | Amp [cm] | Fase [deg] | Amp [cm] | Fase [deg] |
| K2 | Observed | 1.4 | 57 | 1.7 | 59 | 1.4 | 40 |
| | Simulated | 2.3 | 12 | 2.1 | 10 | 1.7 | 7 |
| S2 | Observed | 3.7 | 65 | 3.6 | 59 | 3 | 39 |
| | Simulated | 4.1 | 68 | 3.8 | 67 | 3.2 | 62 |
| M2 | Observed | 14.2 | 123 | 13.7 | 121 | 11.8 | 105 |
| | Simulated | 13.5 | 110 | 12.7 | 109 | 11.1 | 102 |
| N2 | Observed | 3.6 | 79 | 3.9 | 74 | 3.4 | 57 |
| | Simulated | 3.4 | 73 | 3.2 | 71 | 2.7 | 65 |
| K1 | Observed | 0.9 | 124 | 0.9 | 138 | 0.7 | 136 |
| | Simulated | 0.1 | 146 | 0.1 | 163 | 0.1 | 192 |
| P1 | Observed | 0.6 | 86 | 0.7 | 74 | 0.5 | 66 |
| | Simulated | 0.6 | 342 | 0.6 | 337 | 0.5 | 321 |
| O1 | Observed | 2.6 | 281 | 2.4 | 281 | 2.2 | 279 |
| | Simulated | 3.4 | 339 | 3.4 | 339 | 3.1 | 338 |
| MN4 | Observed | 0.7 | 304 | 0.6 | 307 | 0.4 | 263 |
| | Simulated | 0.5 | 33 | 0.4 | 30 | 0.2 | 4 |
| M4 | Observed | 2.3 | 331 | 1.7 | 319 | 1.2 | 275 |
| | Simulated | 2.2 | 19 | 1.6 | 14 | 0.9 | 351 |
| MS4 | Observed | 0.6 | 55 | 0.4 | 32 | 0.3 | 347 |
| | Simulated | 1.4 | 107 | 1.1 | 103 | 0.5 | 76 |

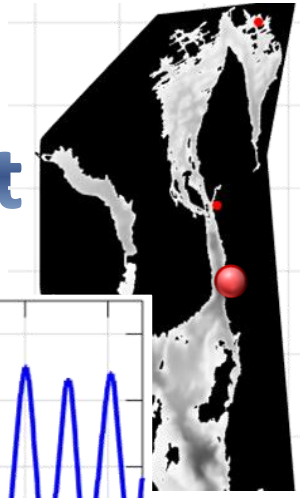


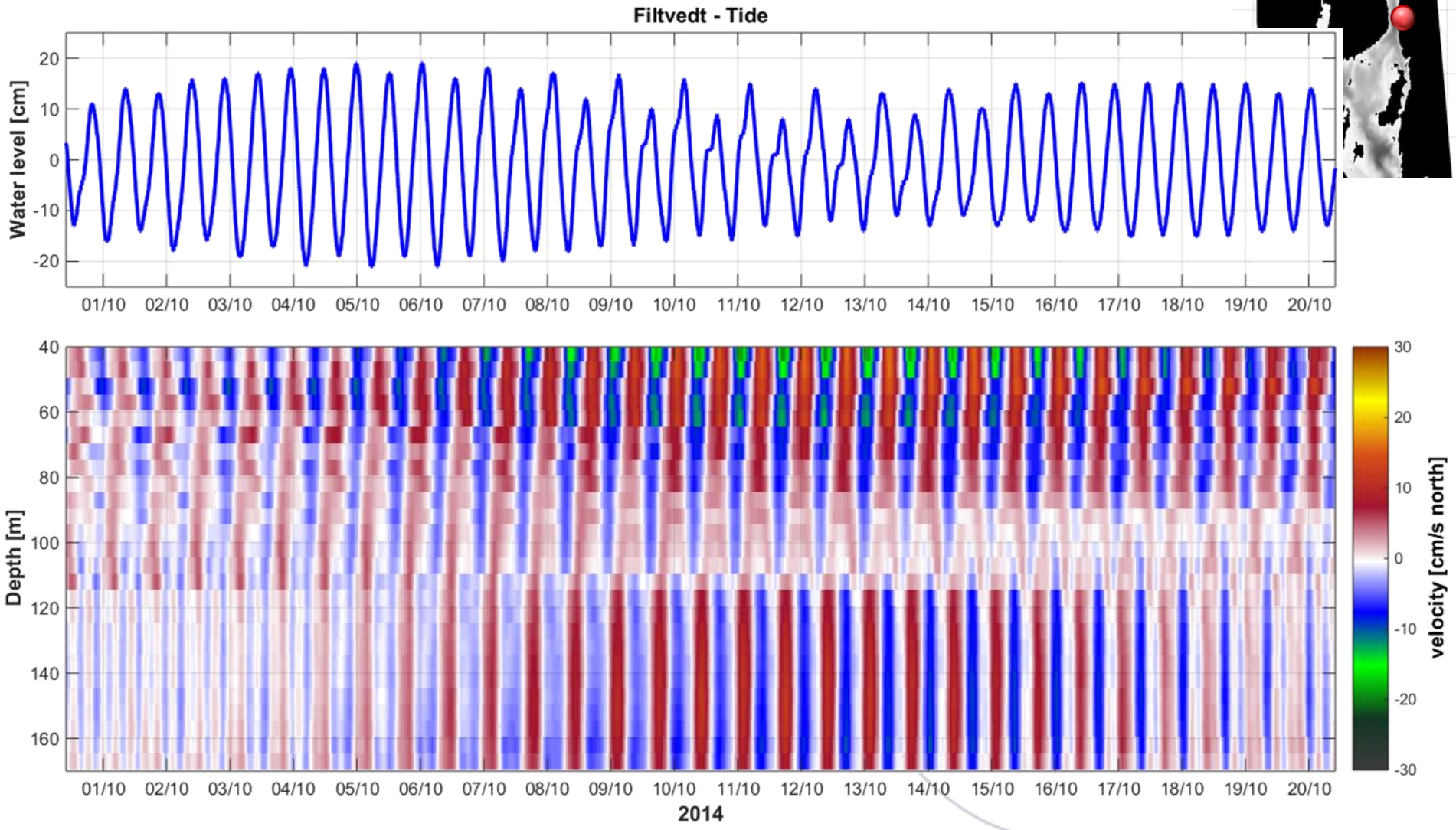
# Observed water level and current



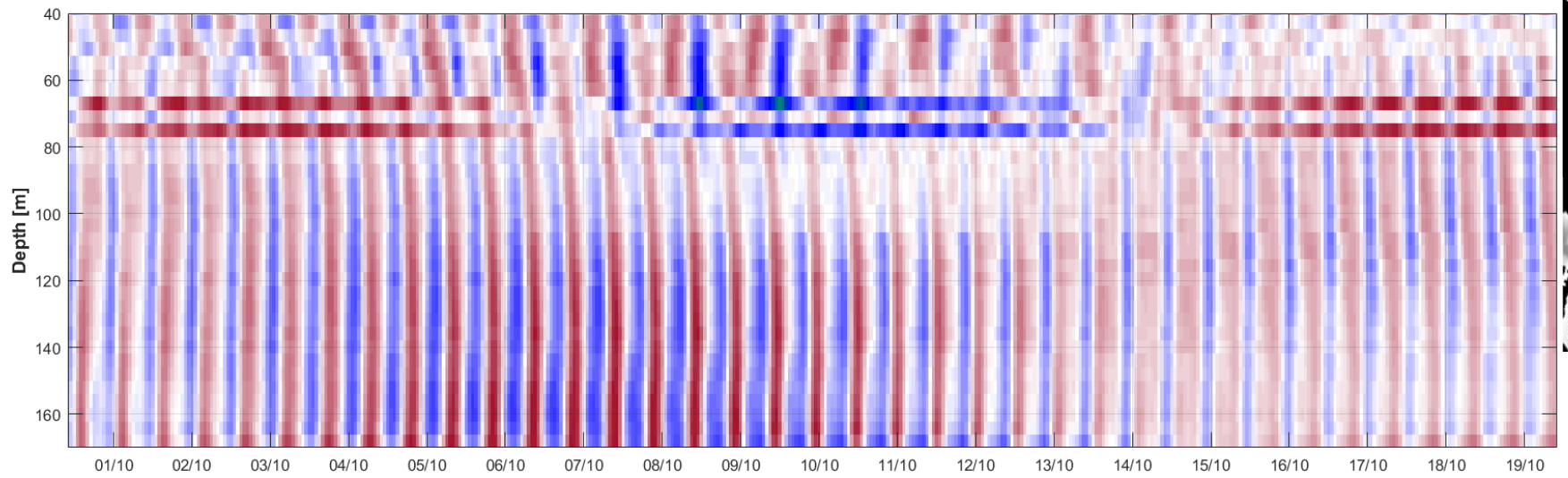


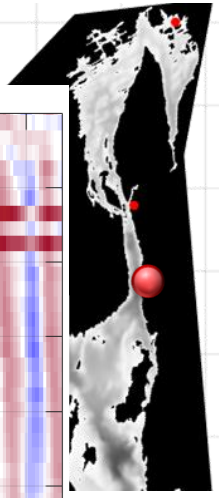
# Observed tidal water level and current



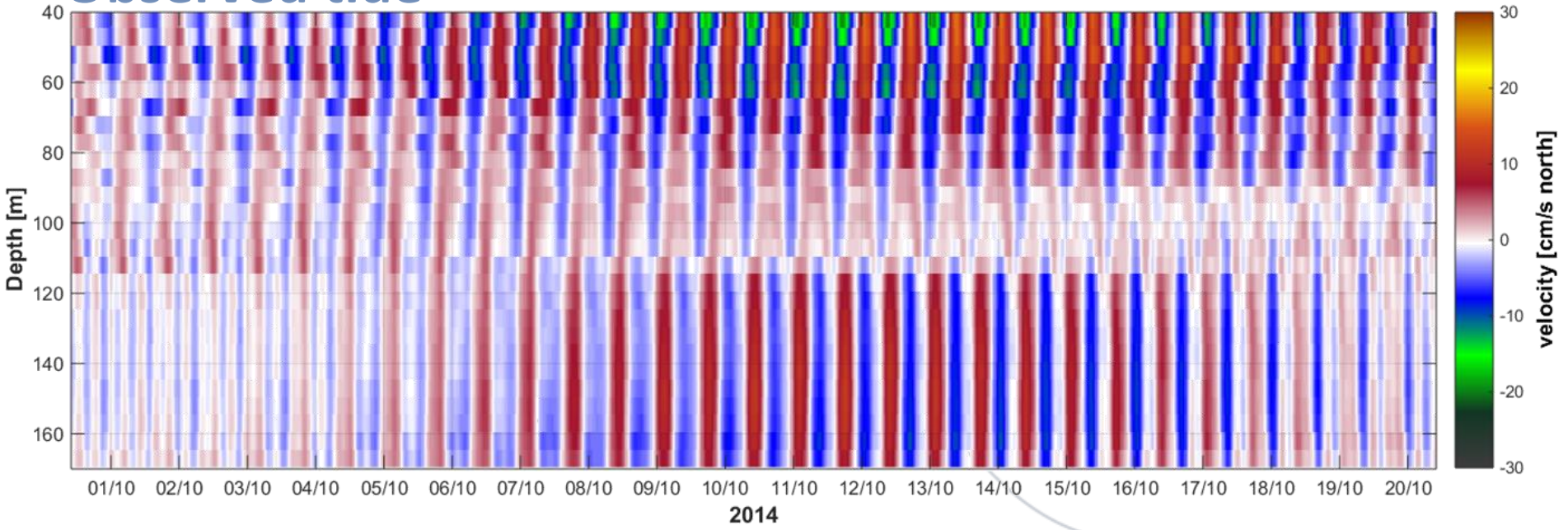


# Simulated tide

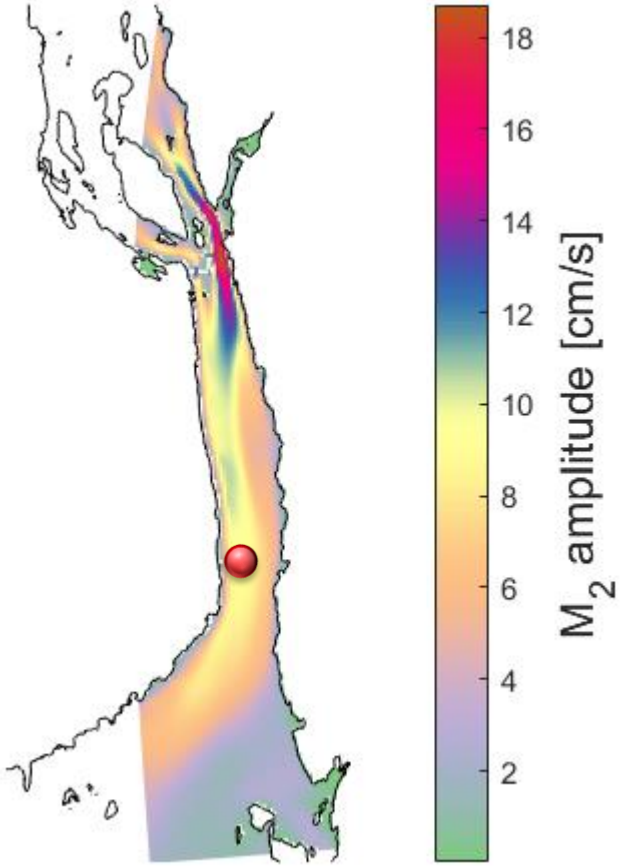


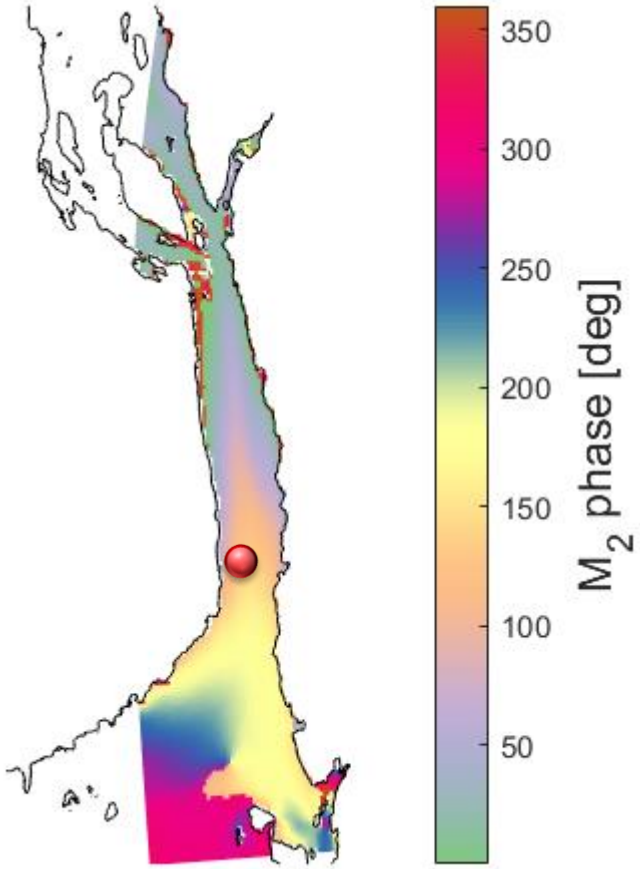



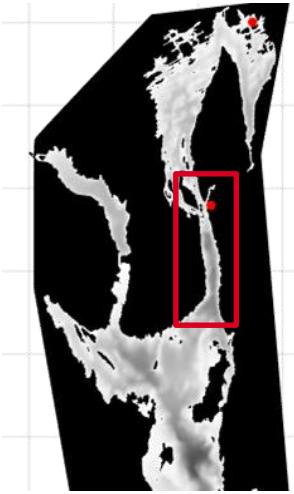
# Observed tide



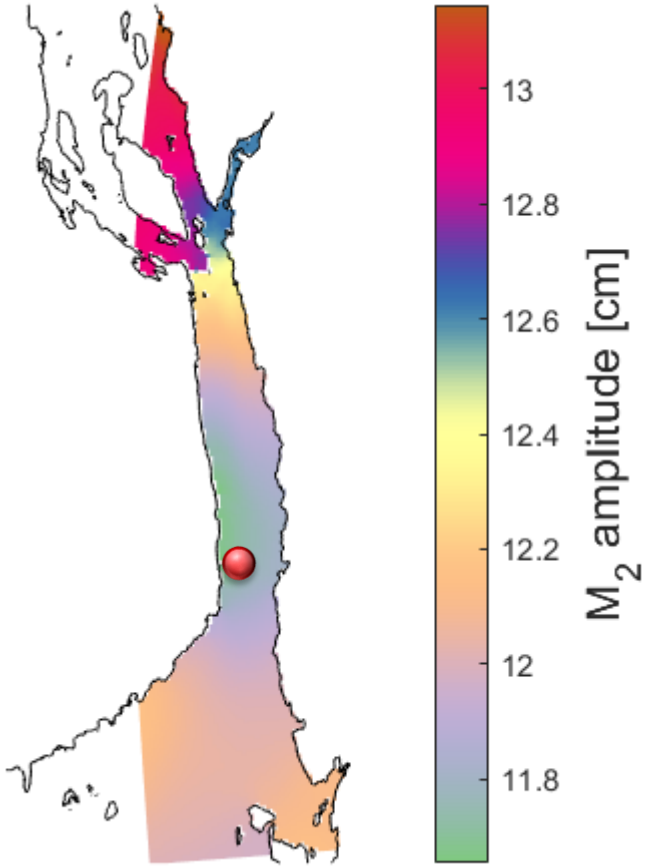
# Spatial variation (surface current)

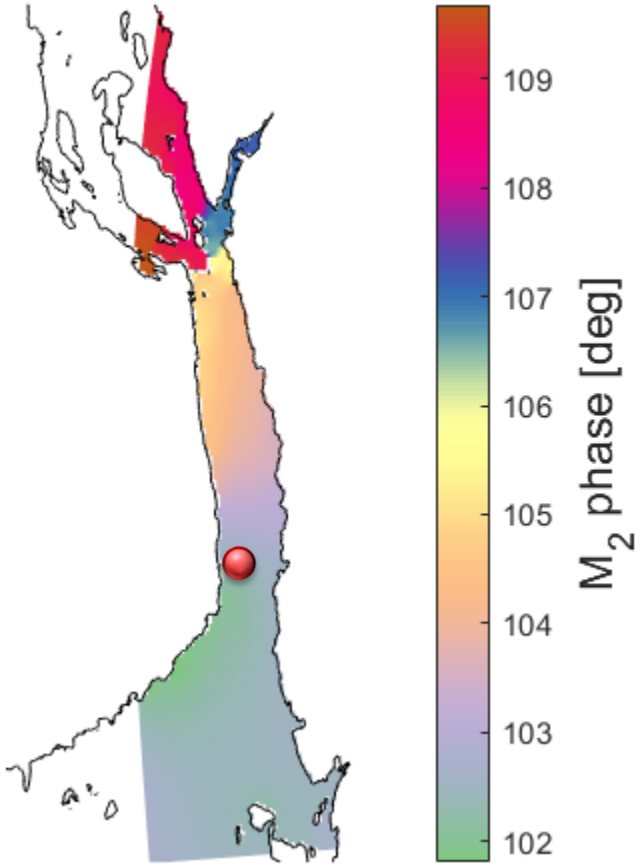


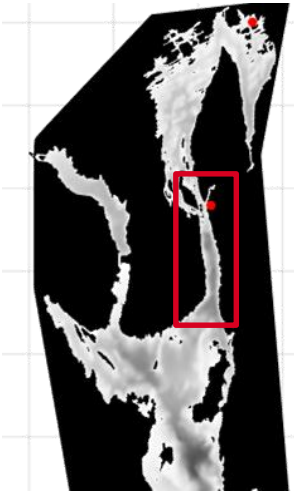



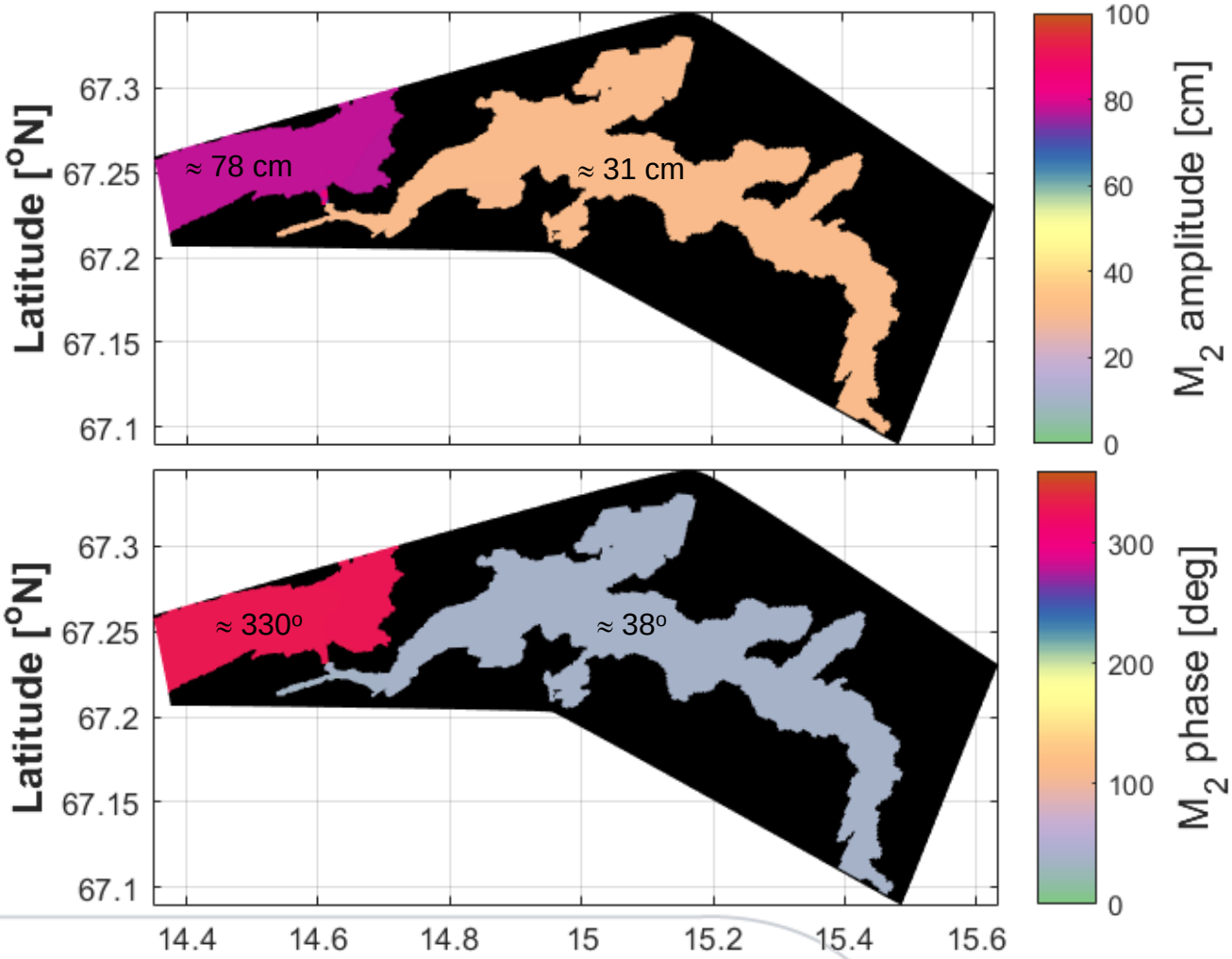
# Spatial variation (water level)



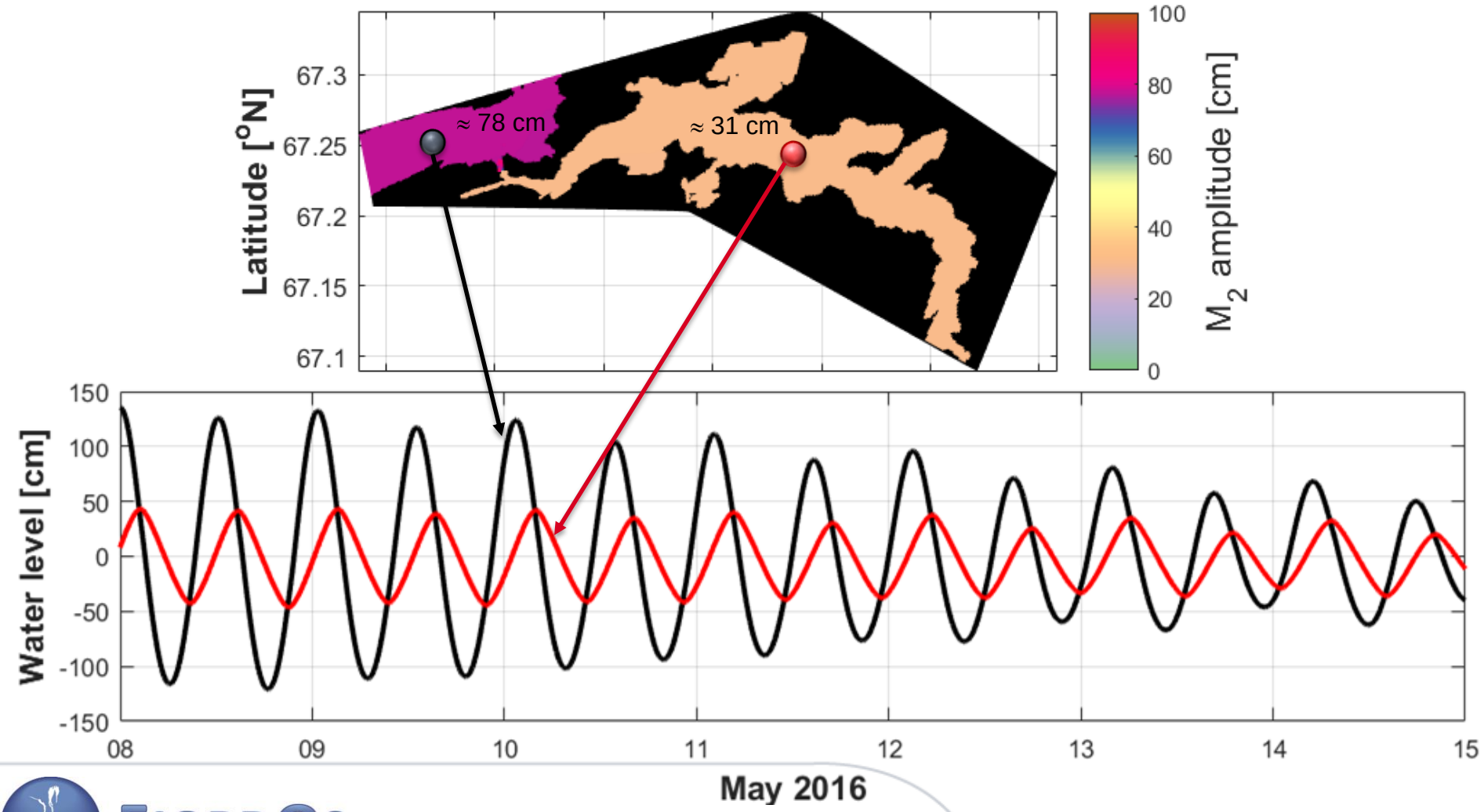



# Spatial variation in the Salt fjord



# Spatial variation



# Summary

- Accurate tidal forcing is important in fjord models
- We have proposed a new and simple method to adjust tidal forcing
- The method is tested on two different areas
- The results are promising