The effect of the 18.6-year lunar nodal cycle on steric sea level changes

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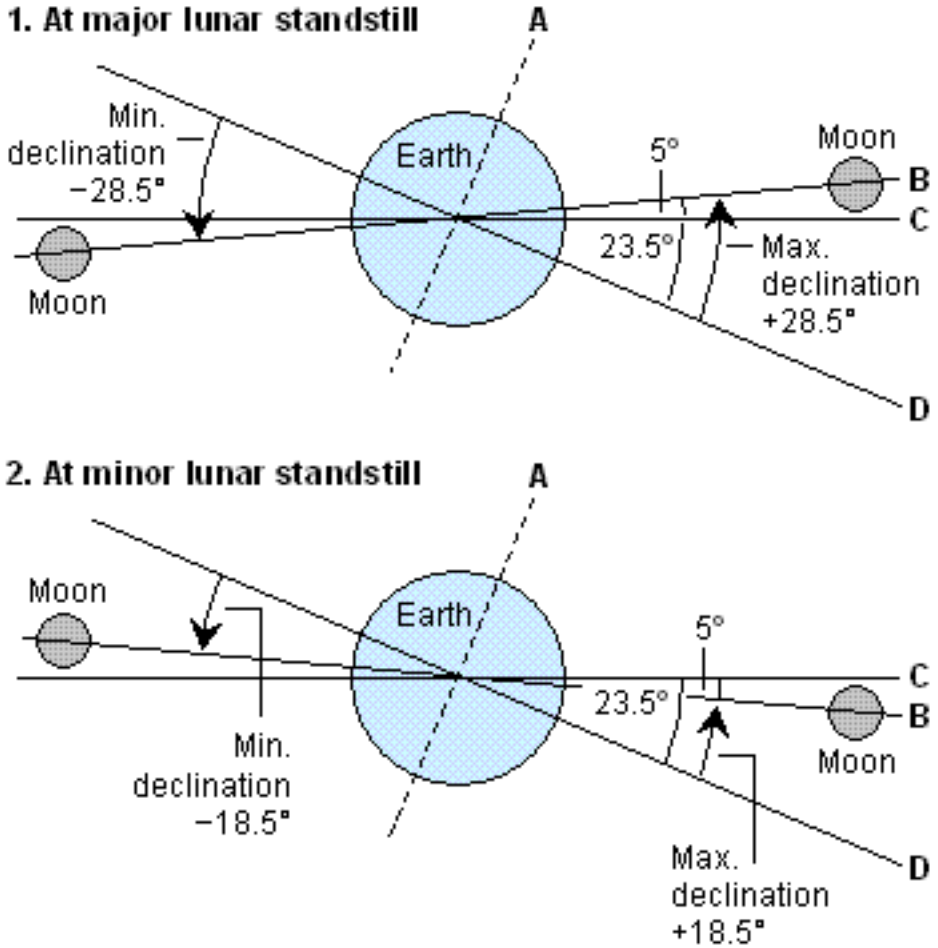
Protect
CRYOSPHERE & SEA LEVEL

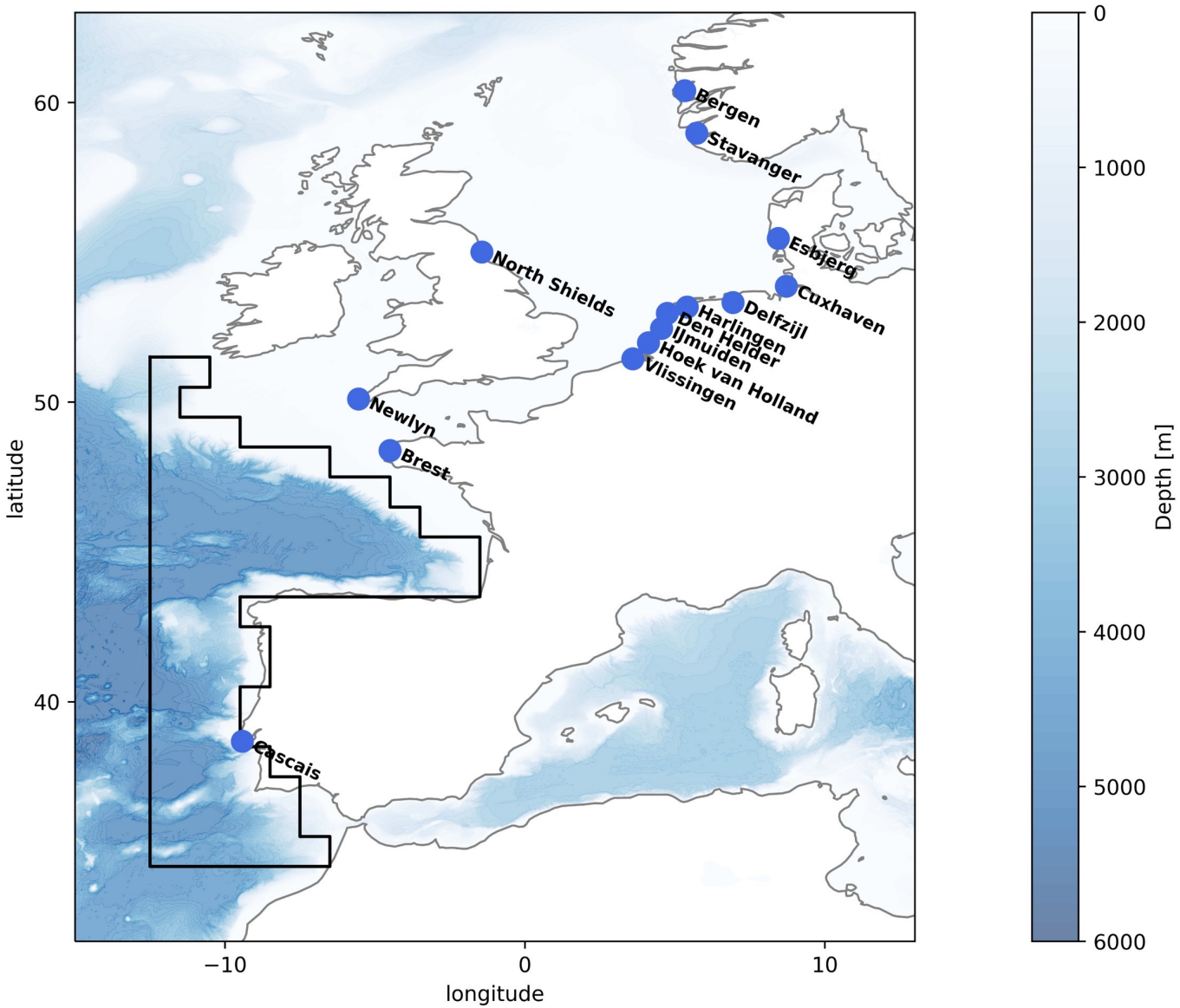
Nodal cycle



A – Earth's rotational axis
B – Plane of Moon's orbit around Earth (edge on)
Moon shown at two diametrically opposite positions
C – Plane of Earth's orbit around Sun (edge on)
D – Plane of Earth's equator (edge on)

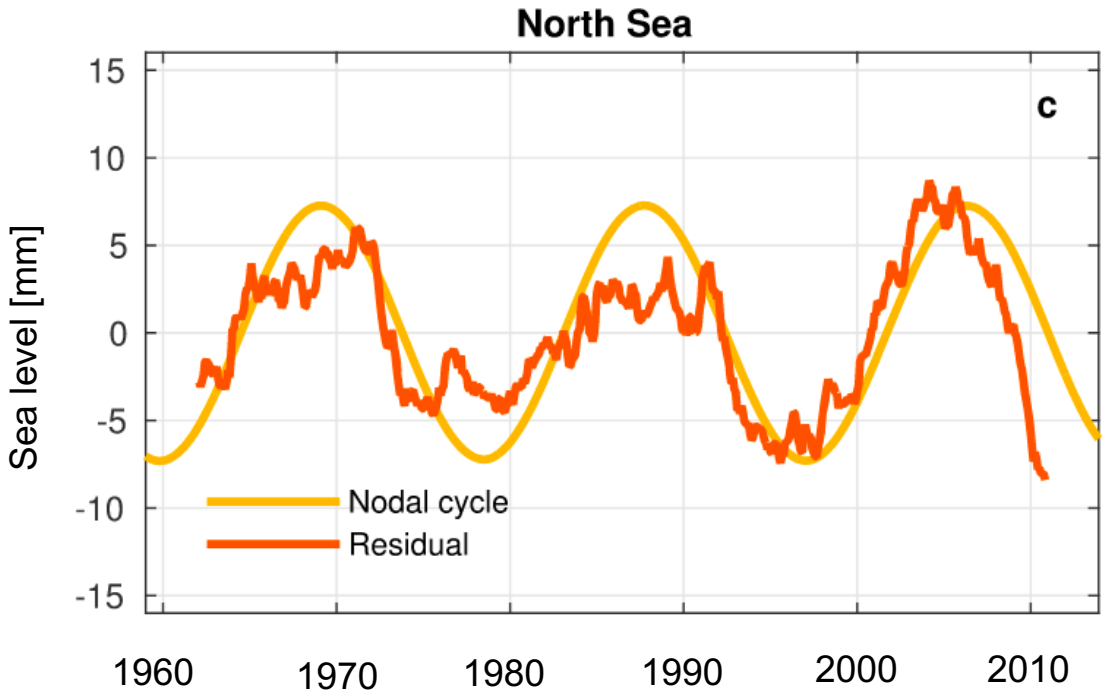
- Precession of the moon's orbit
- Period of 18.6 years
- Influence on mean sea level and on high frequency tides

Region and data



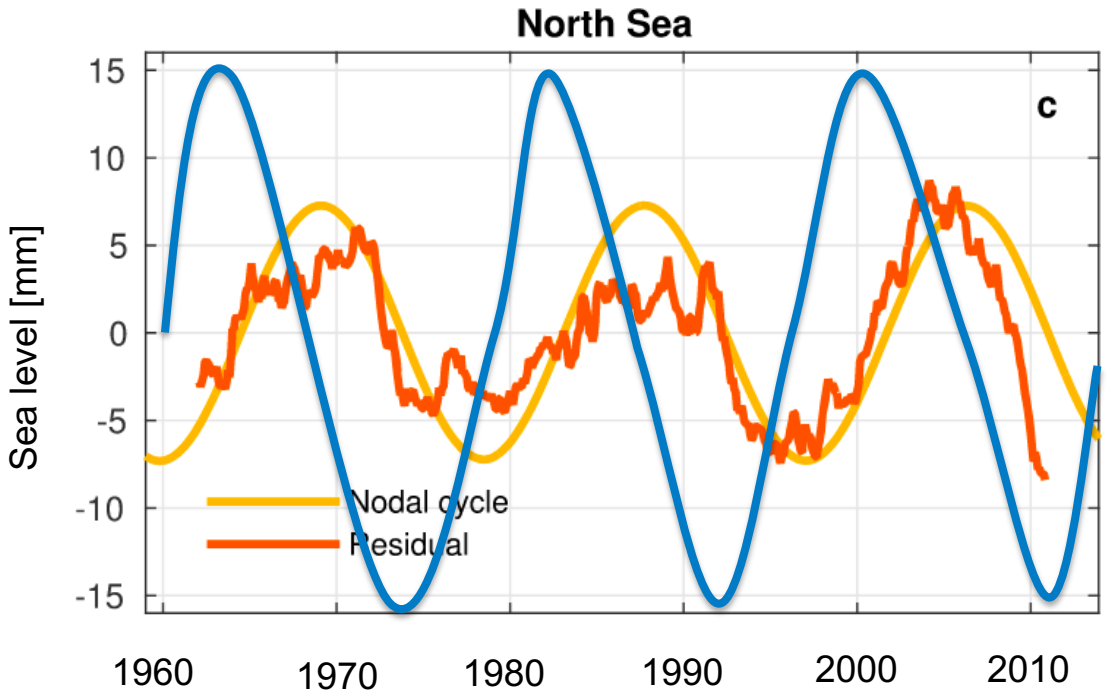
- We use 14 tide gauges covering at least 5 nodal cycle periods (~90 years)
- Steric sea level change in the extended Bay of Biscay

The discrepancy



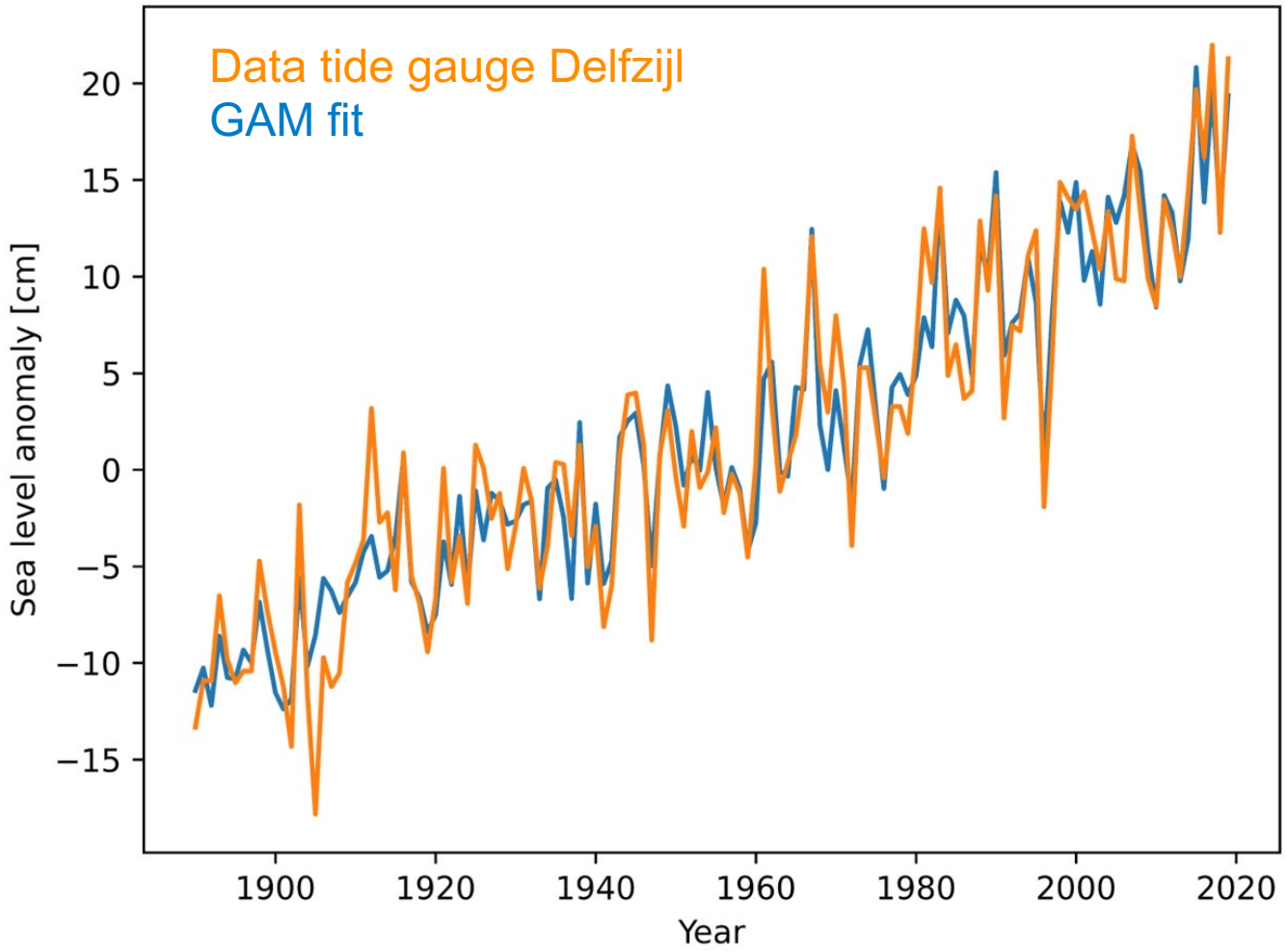
- *Frederikse et al. 2016* could close the sea level budget assuming the nodal cycle follows the equilibrium

The discrepancy



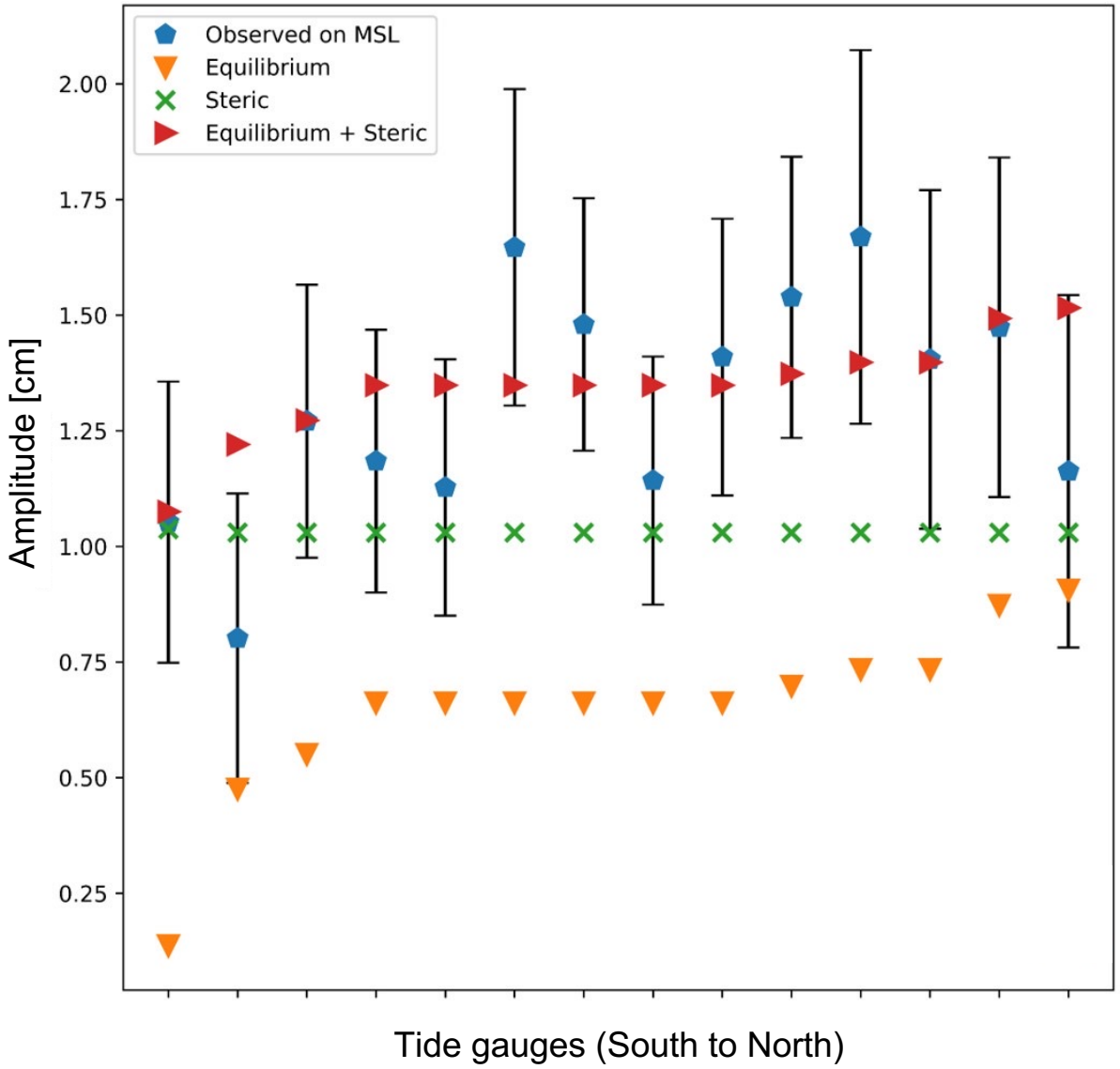
- *Frederikse et al. 2016* could close the sea level budget assuming the nodal cycle follows the equilibrium
- *Keizer et al. 2023* found larger amplitude and different phase

Method

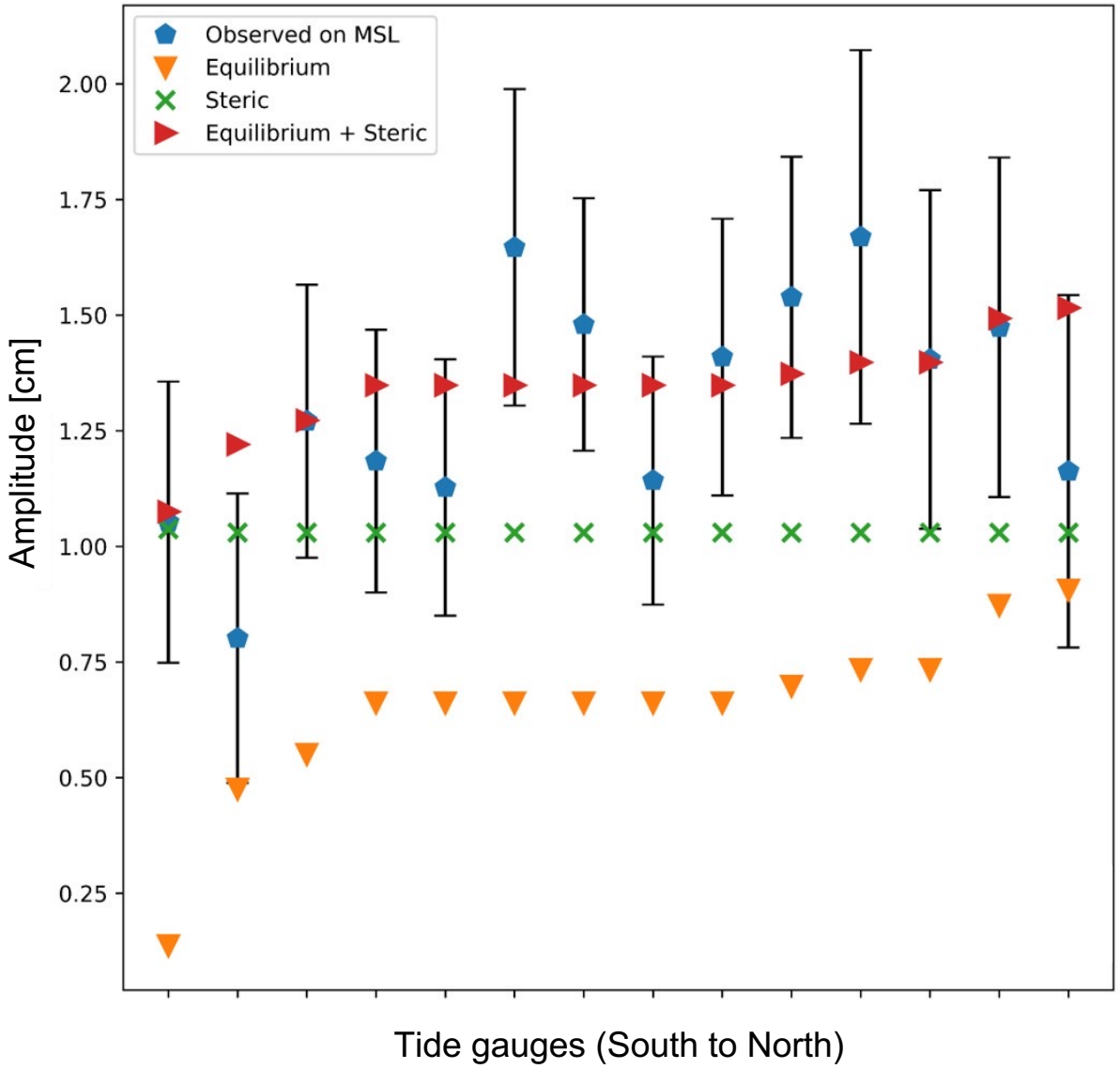


- We fit a Generalized Additive Model (GAM) to each tide gauge time series
- Explaining variables:
  - Zonal and meridional wind
  - Sinusoidal function of period 18.6 (nodal cycle)
  - Non-linear trend (sea level rise)

Results


Observed on MSL
Equilibrium
Steric
Equilibrium + Steric
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
Amplitude [cm]
Tide gauges (South to North)

Results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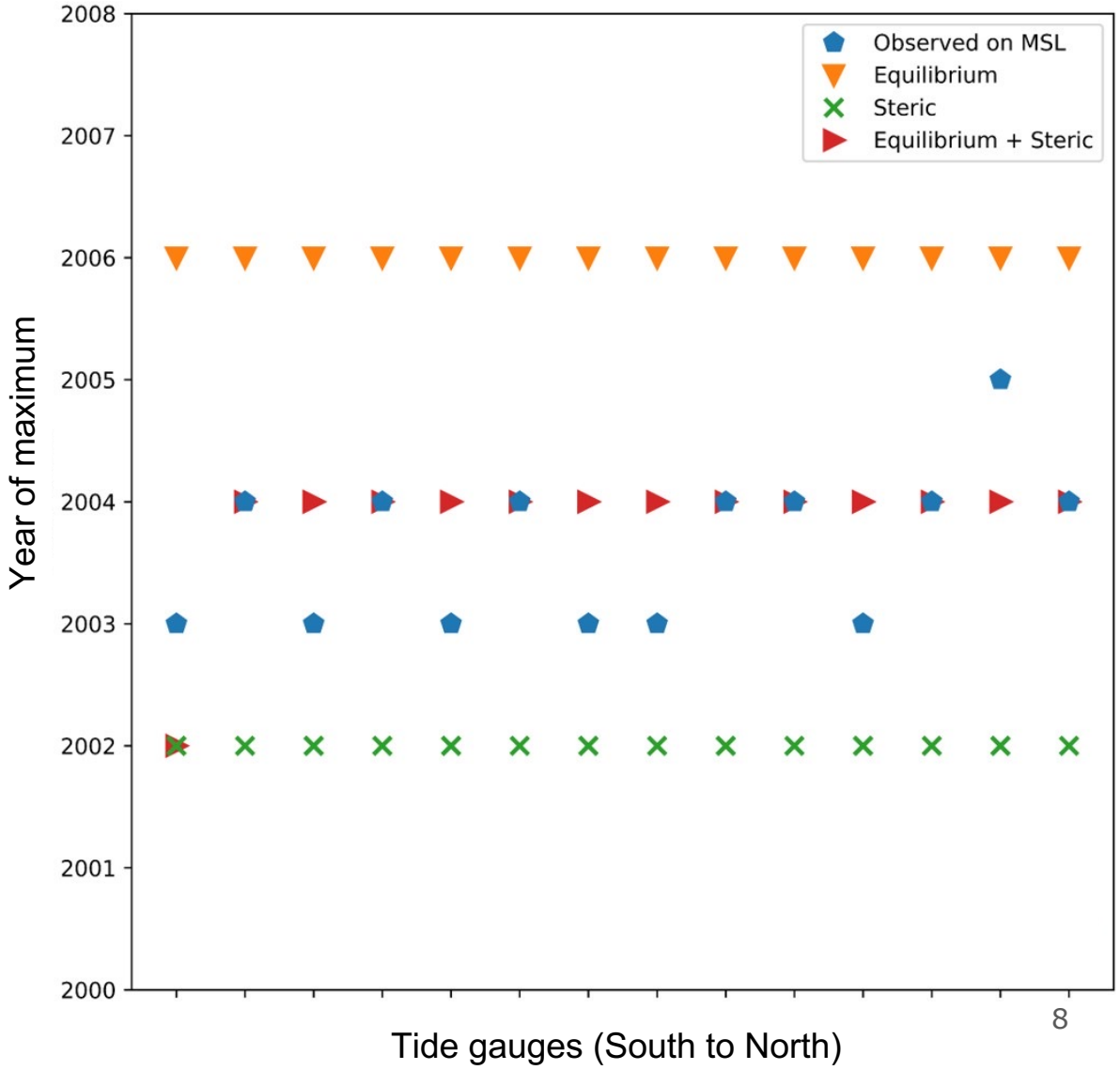
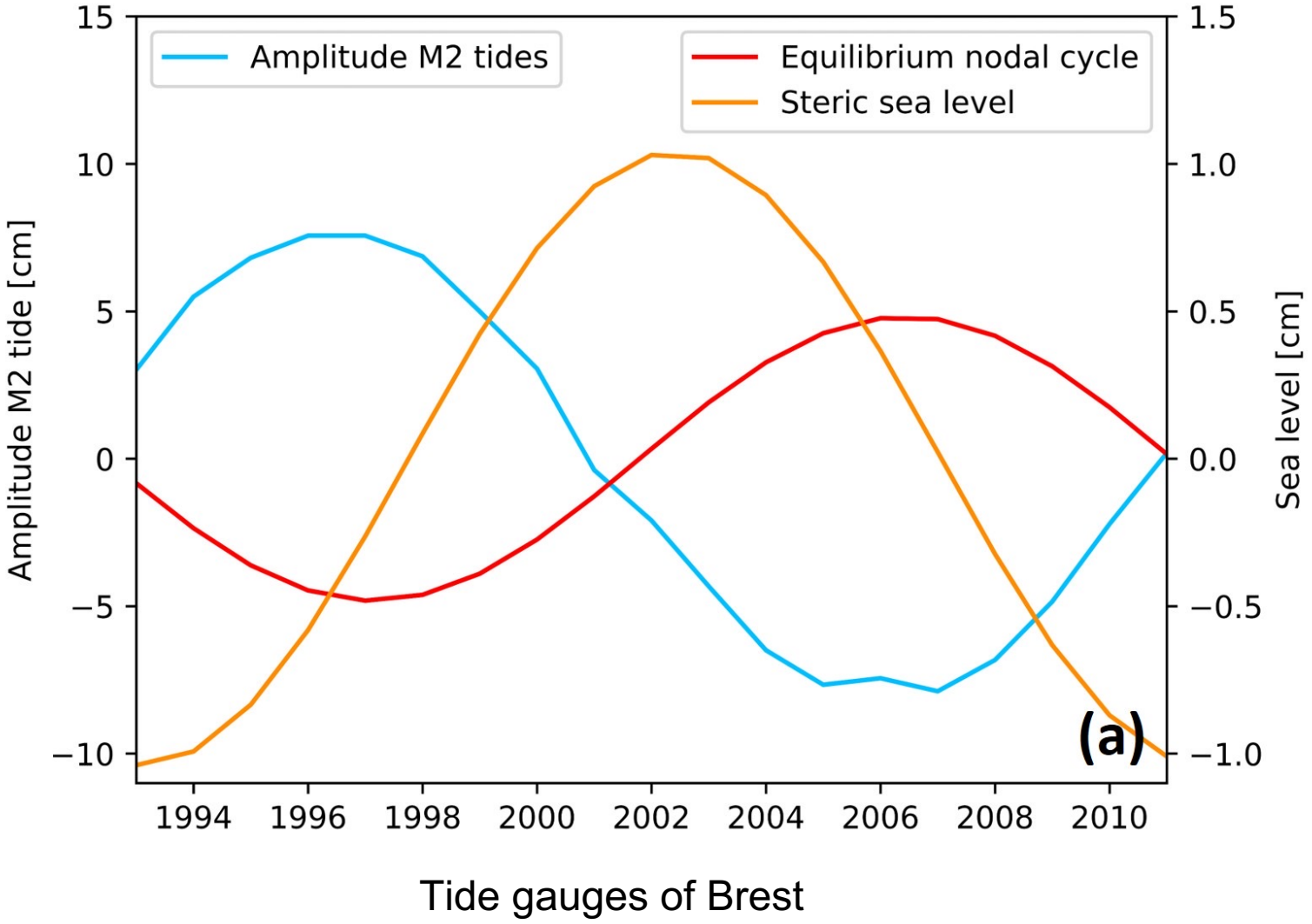
Tide gauges (South to North)


Observed on MSL
Equilibrium
Steric
Equilibrium + Steric
Year of maximum
2008
2007
2006
2005
2004
2003
2002
2001
2000
Tide gauges (South to North)

Mechanism



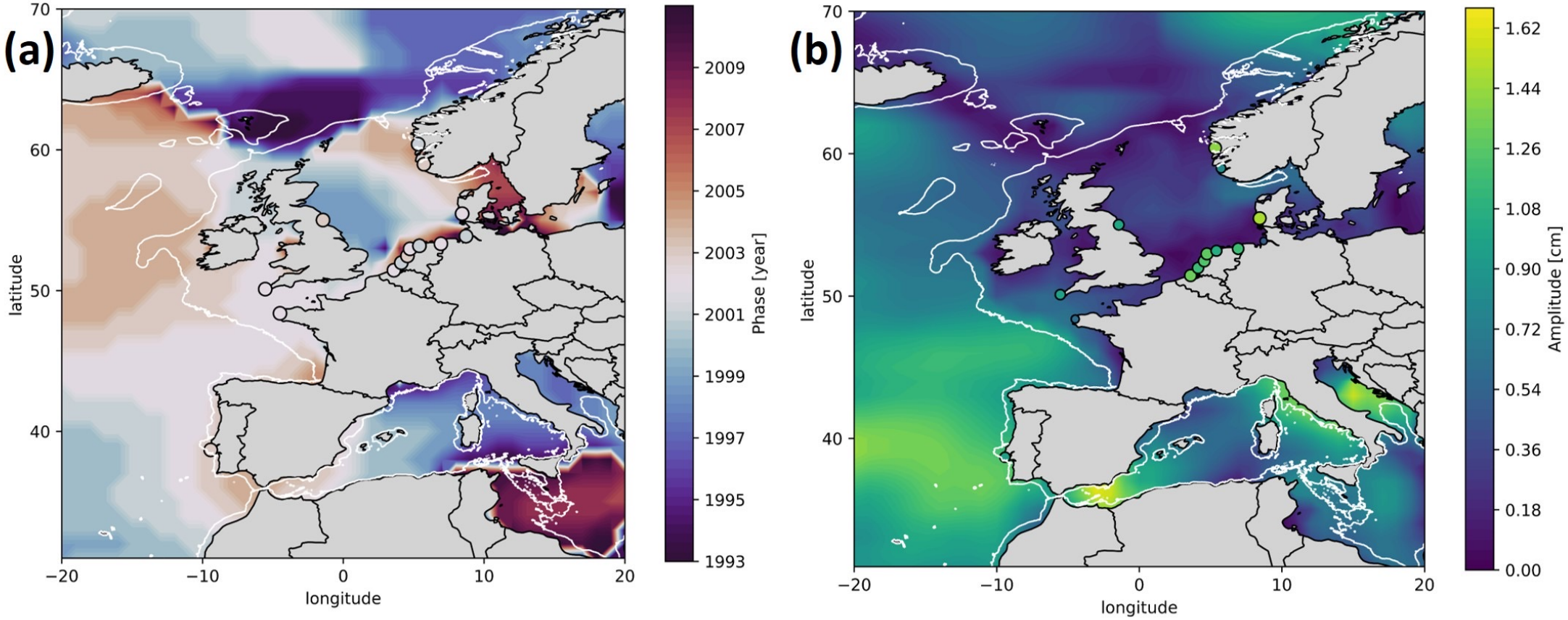
- We hypothesize that larger M2 tides are responsible for steric sea level rise in the Bay of Biscay

Conclusions

- We resolved the discrepancy between the observed nodal cycle and the budget closure
- The difference between the observed nodal cycle and the equilibrium computations seems to come from changes in steric sea level
- Which physical mechanism provides a link between M2 tides and steric sea level in the Bay of Biscay?

Additional slides

Maps



Phase and b) amplitude of the nodal modulation in the steric sea level changes integrated over the top 400m of the ocean for the EN4 dataset post-1960. The white lines represent the 400m isobath. The phase is defined as the year when the sinusoidal signal reaches a maximum between 1993 and 2011. The dots indicate the phase (a) and amplitude (b) of the observed sea level minus the equilibrium tide at the tide gauges.

Mechanisms?

- Increased vertical mixing due to tidal current on the continental shelf
- Internal waves breaking on the continental slope