Data-Unconstrained Modeling and Detection of 9 Individual Partial Ocean Tides of Third-Degree by Terrestrial Gravimetry

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Introduction

Topic

- Degree-3 ocean tides arising from the asymmetry of lunar TGP

Motivation

- Global tidal ocean mass variations for GRACE de-aliasing
- Validation of solid Earth model for third-degree tides

Challenge

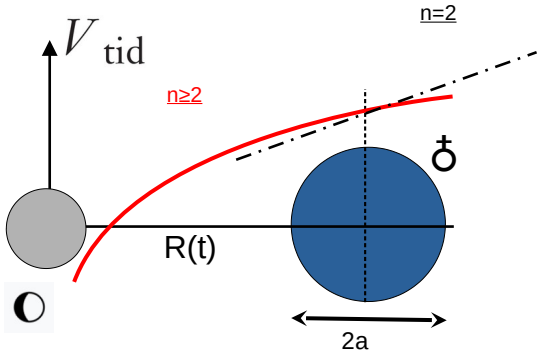
- Tiny signals: ~5mm sea level change, ~0.1 nm/s² induced gravity

Approach

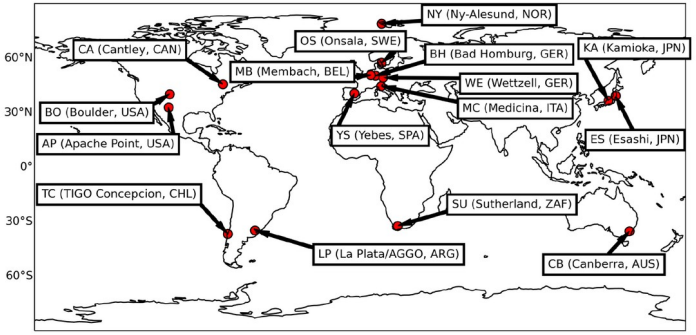
- Data-unconstrained modeling of third-degree ocean tides
- Model validation with superconducting gravimeter (SG) data

Results

→ ?



Global ensemble of 16 SG stations



Ocean Tide Modelling

TiME2021 (→ Sulzbach et. al. 2021)

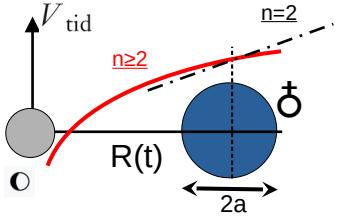
- Barotropic (2D), data-unconstrained
- 1/12° rotated-pole grid
- M_2-agreement ~85% with data-const. FES14 (Lyard 2021)

Degree-3 Tide-Generating Potential (TGP)

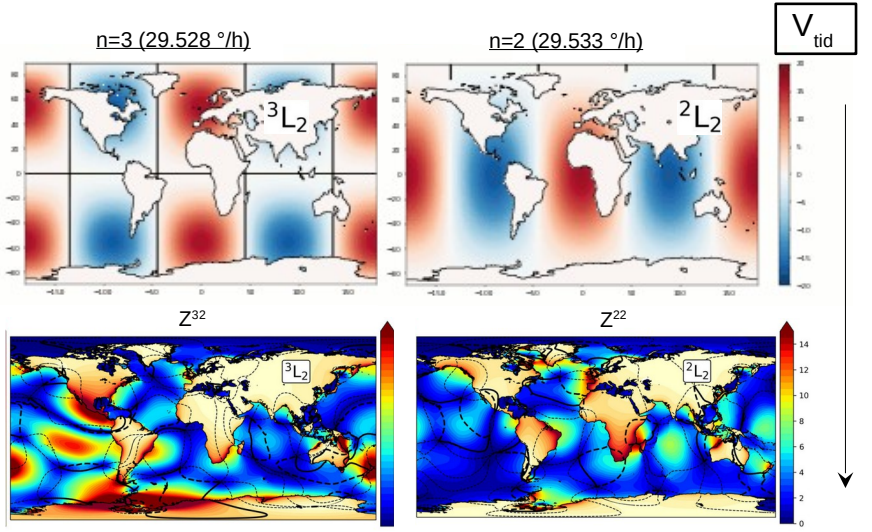
- Asymmetry of lunar TGP (to suborbital Lunar point)
  → Description by Legendre Polynomials with n>2

$$V_{\mathrm{tid}}(t) = \frac{GM_{\mathrm{ext}}}{R(t)} \sum_{n=2}^{\infty} \left(\frac{a}{R(t)} \right)^n P_n[\cos \alpha(t)]$$

- Small correction as **R/a ~ 60**



global simulation of n=3 tides



admittance (=normalized ocean surface response to V_{tid})

TiME2021

Unrelated admittance-patterns
→ **No estimation of degree-3 tides with linear admittance from n=2**

Global Ocean Tide Solutions

TICON-td ▽ (Hart-Davis et al. 2022)

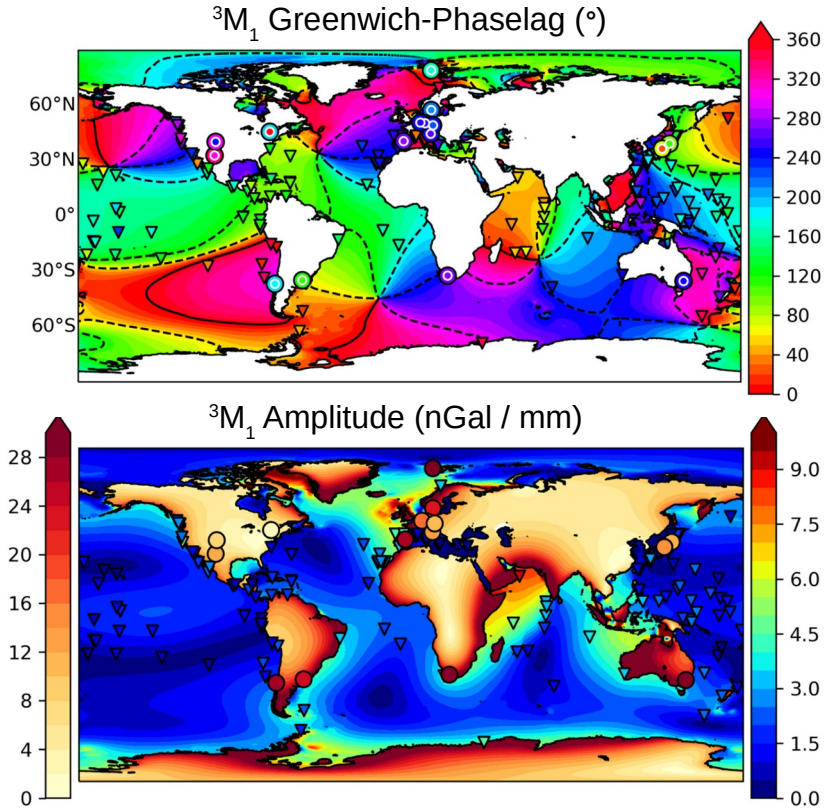
- 143 TGs from GESLA (Woodworth et al. 2017)
  → Agreement: 33% ($^3M_1$) to 64% ($^3L_2$)

Superconducting Gravimeter Data ○

- 16 SGs (IGETS, station operators)
- Analysis with → ETERNA-x[1]

Induced Gravity from TiME2021

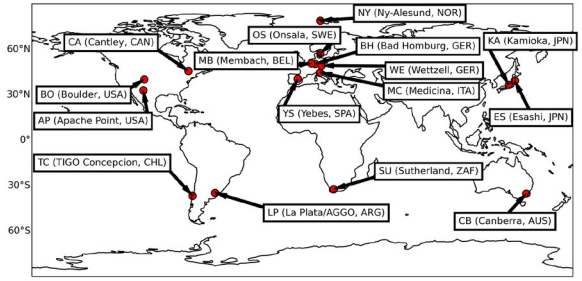
- Global amplitude prediction (Merriam, 1980)
- Prediction at SG-station with NLOADF (Agnew, 1997)



[1]Version v81 available at (Schüller 2015) http://ggp.bkg.bund.de/eterna.

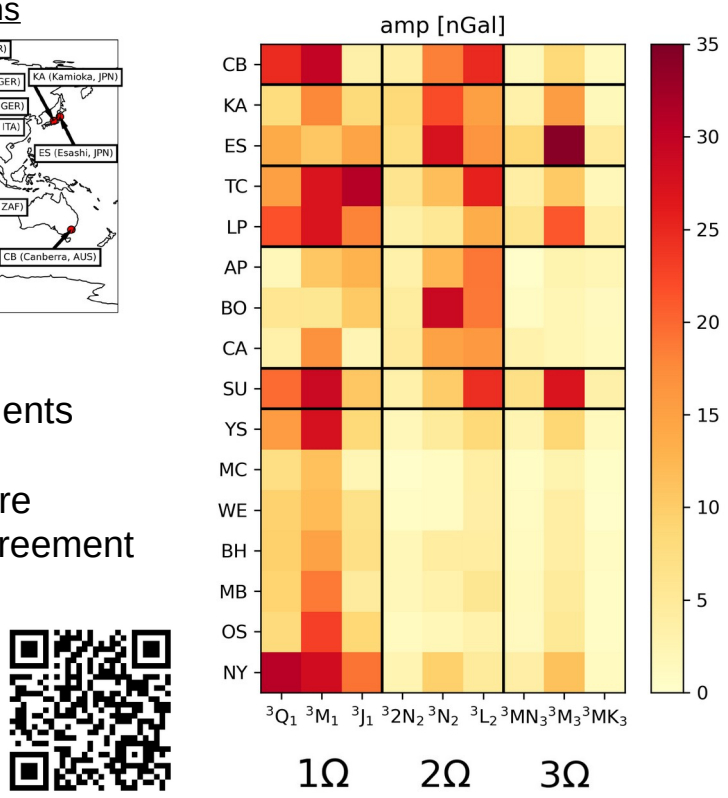
Gravimetric Constituents

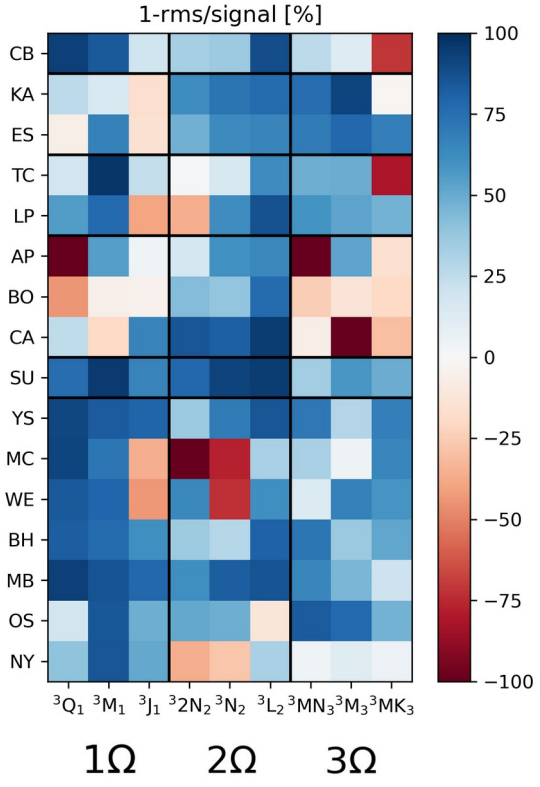
Ensemble of SG-stations



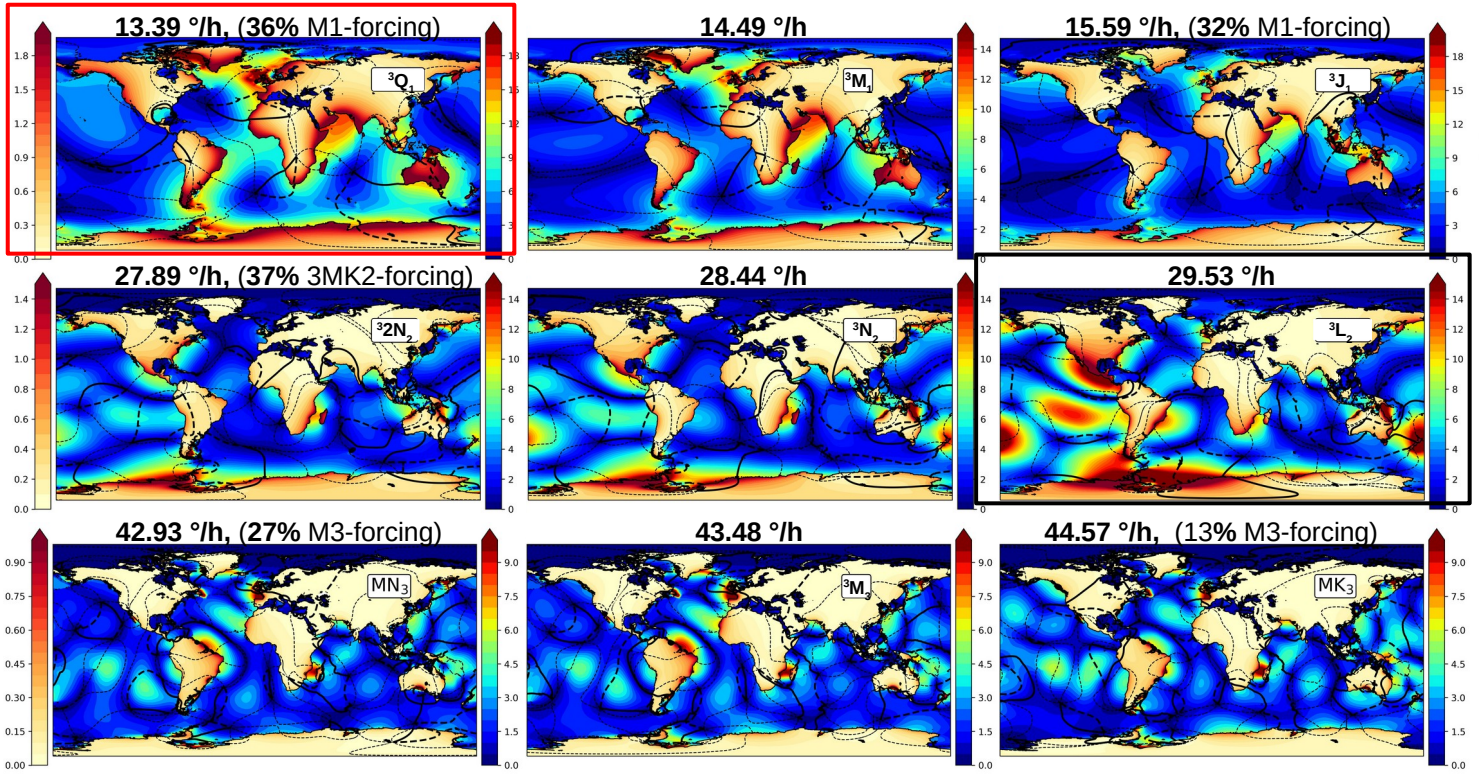
- Tidal analysis depicts constituents with amplitudes <45 nGal
- Even constituents <10 nGal are predicted at a high level of agreement
- $^3M_1$, $^3M_3$, $^3L_2$ and $^3N_2$ show mean agreement of **63-80 %**

Sulzbach et. al. (2022)
Journal of Geodesy





Degree-3 Admittance-Function

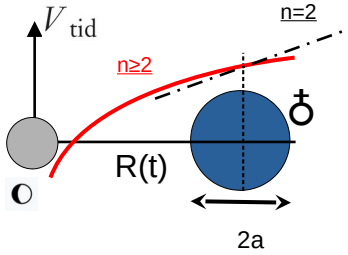


Global **diurnal** and **semi-diurnal** resonances are excited

Summary

Topic

- Degree-3 tides arising from the asymmetry of lunar TGP



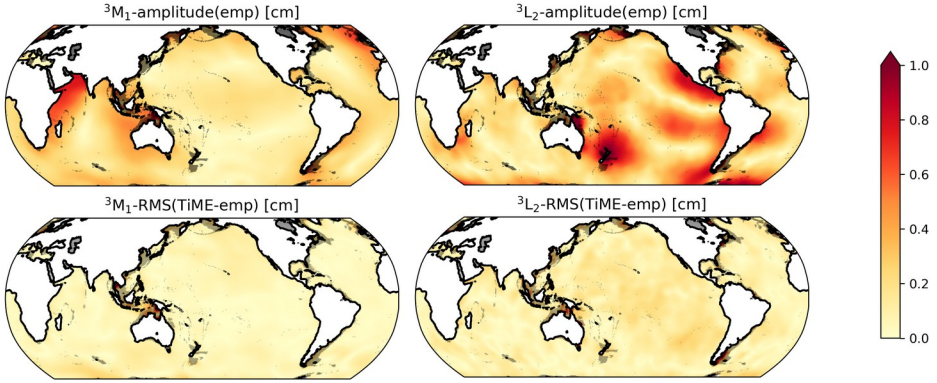
Approach

- Data-unconstrained modeling of third-degree ocean tides (9 partial tides)
  → Stokes coefficients at doi: *10.5880/GFZ.1.3.2021.001*
- Compilation of global tide gauge data set TICON-td for third-degree tides
  → Tidal constituents at doi: *10.1594/PANGAEA.943444*
- Tidal analysis of SG data from 16 stations with ETERNA-x

Results

- Good agreement for TG validation
- Agreement of >50 % with SG-constituents
- Close correspondence with empirical, satellite-data derived solutions of Ray (2020)
- Global diurnal and semi-diurnal resonances

Thank you very much for your attention!



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