A comparison of different ocean tides models

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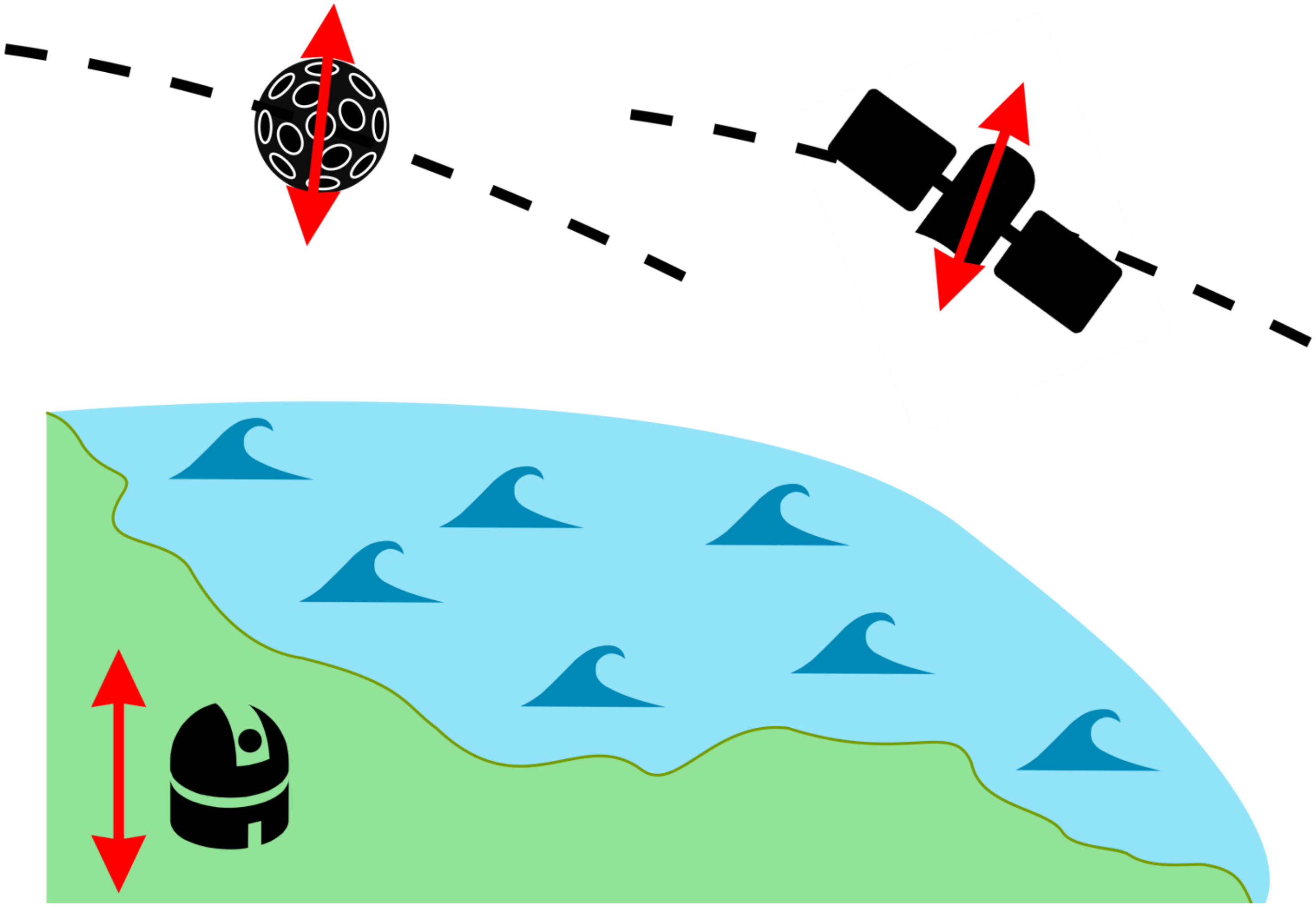
Motivation (1)

- Accurate knowledge of ocean tides is required for many geophysical applications such as precise orbit determination (POD), solid-earth geophysics and coastal flooding (Stammer et al., 2014)
- Important as "corrections" of various measurements, e.g. use of barotropic tide models to remove tidal variability from space-geodetic observations
- Essential for successful satellite altimetry and satellite gravimetry to reduce aliased tidal "noise"
- Continuous improvement over the last decades by empirically enhancing previous models or adding new types of data

Motivation (2)

- In case of the space-geodetic technique satellite laser ranging (SLR), ocean tides affect both the position of ground-based observing stations and the satellite in orbit
- Tidal (and non-tidal) loading affect the station positions
- Mainly gravitational variations affect the satellite orbit



Source: some graphics from ggos.org

Models in this comparison

- **Empirical Ocean Tide (EOT) 11a** (Savcenko R. and Bosch W., 2012)
  - Main tides (18): Ω_1, Ω_2, S_a, S_{sa}, M_m, M_f, M_{tm}, M_{sqm}, Q_1, O_1, P_1, K_1, $2N_2$, N_2, M_2, S_2, K_2, M_4
  - DGFI-TUM-specific: + atmospheric tides S_1, S_2 (Biancale R. and Bode A., 2006)

- **Finite Element Solution (FES) 2014c** (Lyard F.H. et al., 2021)
  - Main tides (34): Ω_1, Ω_2, S_a, S_{sa}, M_m, M_{sf}, M_f, M_{tm}, M_{sqm}, Q_1, O_1, P_1, S_1, K_1, J_1, ϵ_2, $2N_2$, μ_2, N_2, ν_2, M_2, MKS_2, λ_2, L_2, T_2, S_2, R_2, K_2, M_3, N_4, MN_4, M_4, MS_4, S_4, M_6, M_8
  - DGFI-TUM-specific + Atmospheric tides S_1, S_2

- **EOT20** (Hart-Davis M.G. et al., 2021)
  - Main tides (19): Ω_1, Ω_2, S_a, S_{sa}, M_m, M_f, Q_1, O_1, P_1, S_1, K_1, J_1, $2N_2$, N_2, M_2, T_2, S_2, K_2, M_4
  - DGFI-TUM-specific + Atmospheric tides S_1, S_2

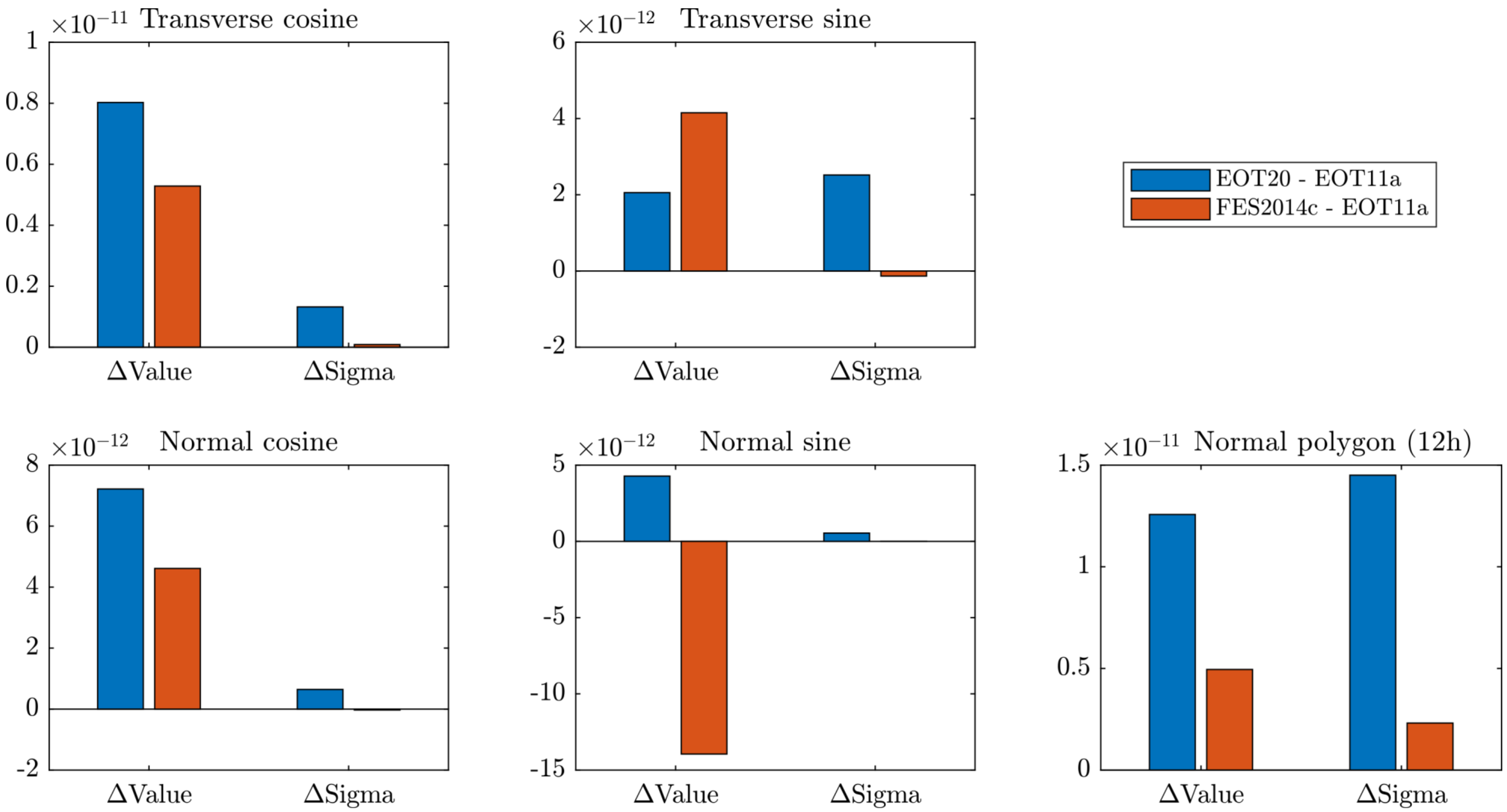
Model comparison

Settings:

- POD of TOPEX/Poseidon (non-spherical), LARES, and LAGEOS-1 (both spherical)
  - TOPEX/Poseidon: data used between 1992 – 2005, **1337 km** altitude
  - LARES: data used between 2018 – 2022, **1450 km** altitude
  - LAGEOS-1: data used between 2018 – 2022, **5860 km** altitude
- A priori sigma of various parameters set to 0.01 to prevent absorption of ocean tides effects
- Stations coordinates are estimated
- Comparison of POD parameters such as empirical accelerations or scaling factors of atmospheric drag and Earth albedo

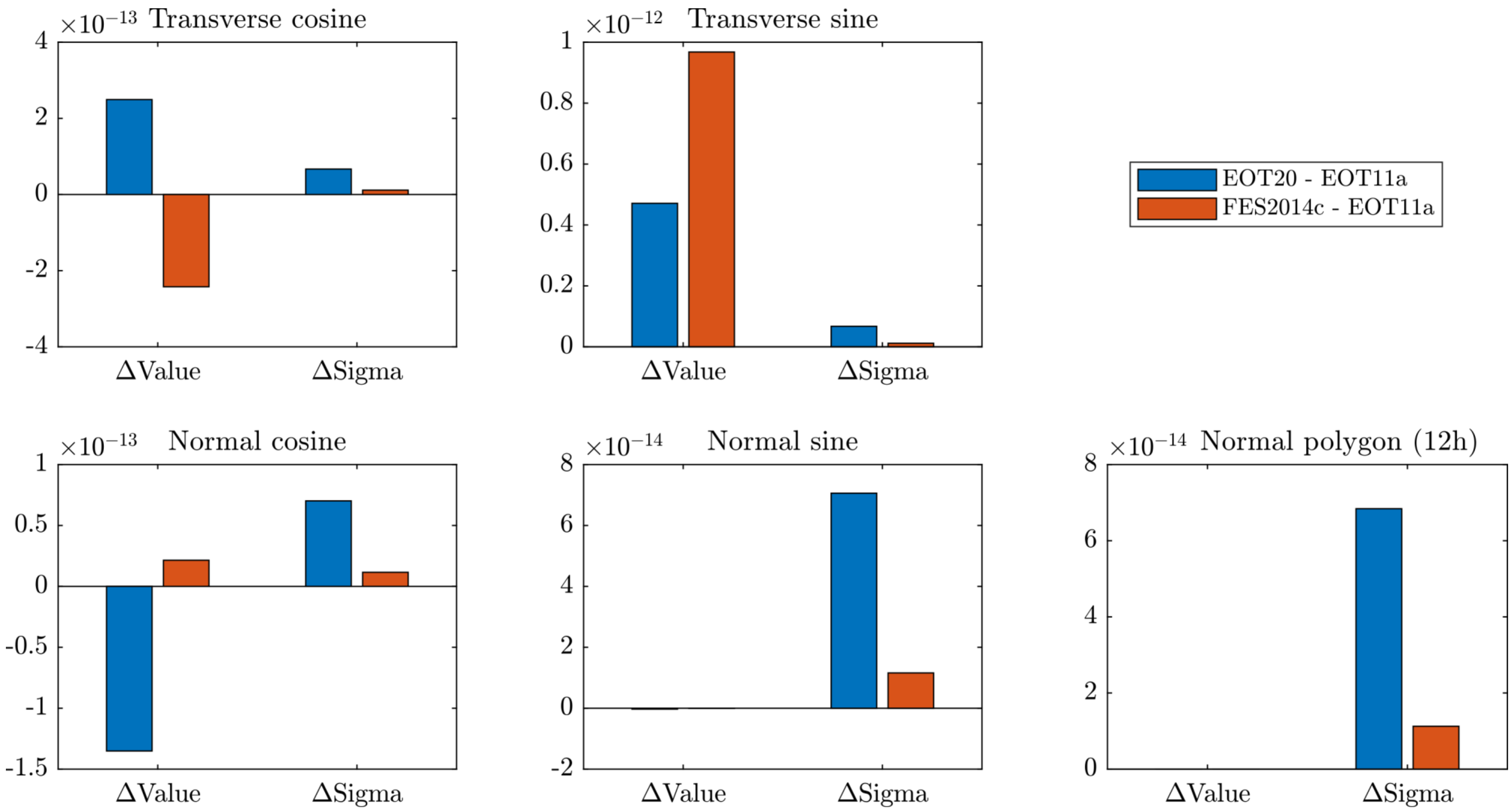
Model comparison

TOPEX/Poseidon: empirical accelerations [m/s²]



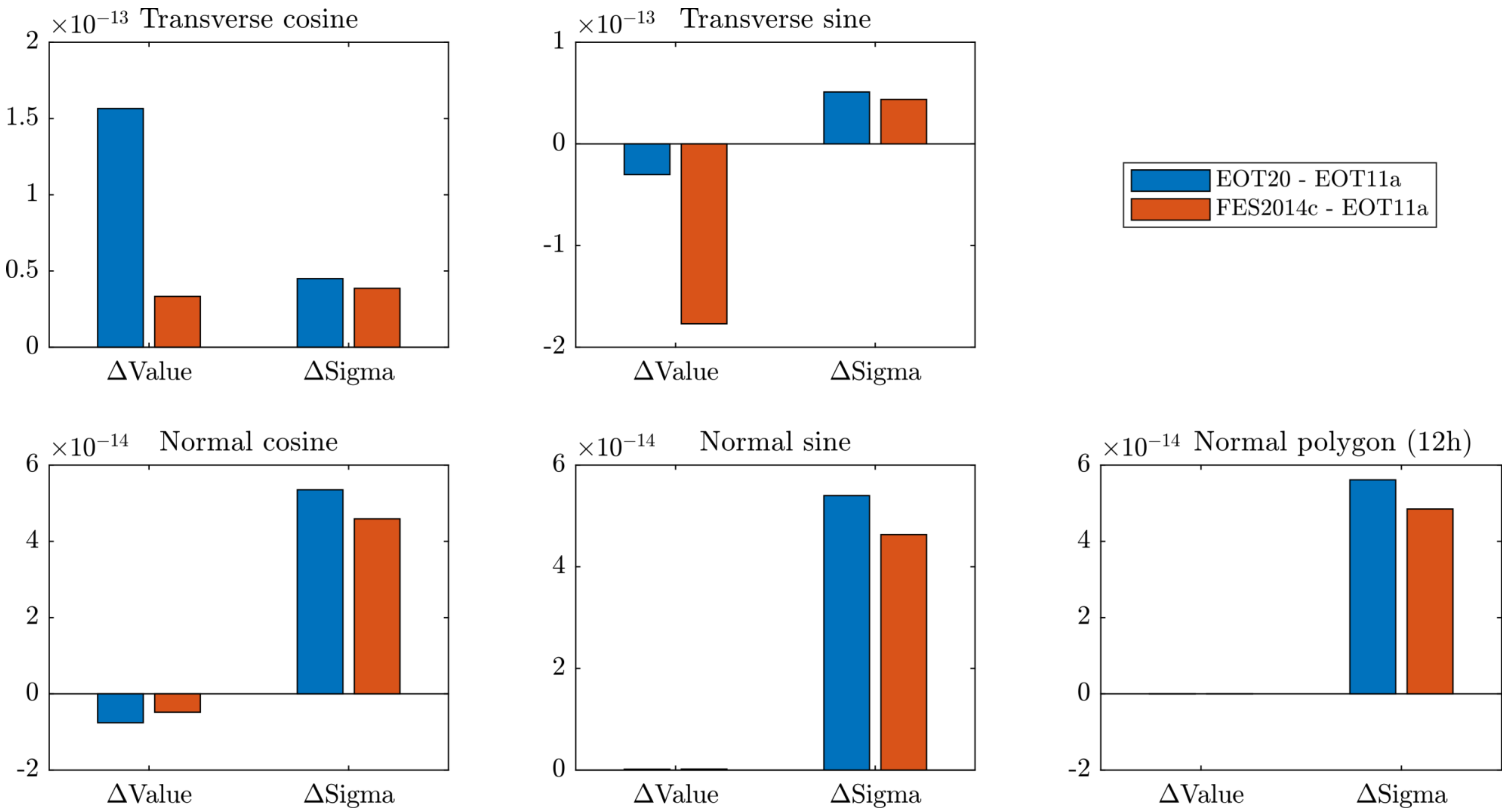
Model comparison

LARES: empirical accelerations [m/s²]

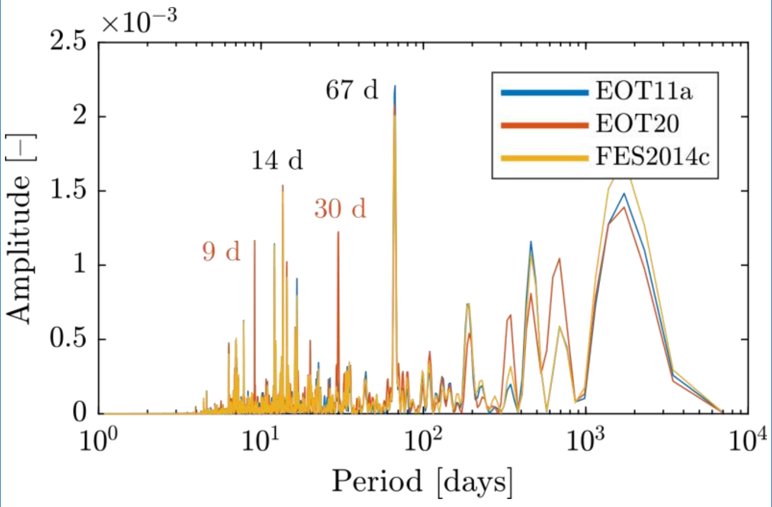


Model comparison

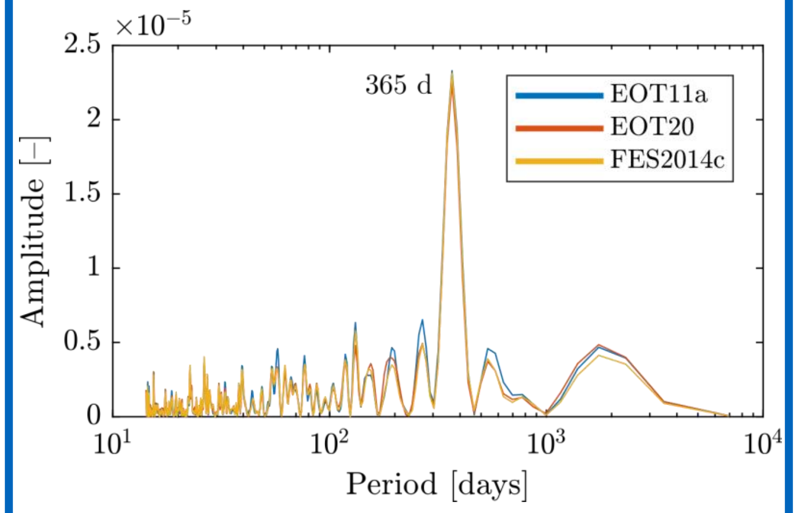
LAGEOS-1: empirical accelerations [m/s²]



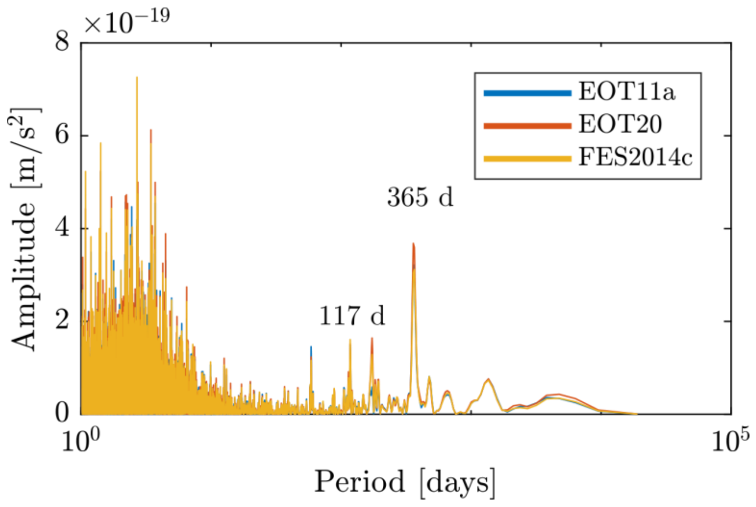
Model comparison – frequency analysis



- LARES
- Atmospheric drag scale factor
- EOT20 periods at 9 and 30 days

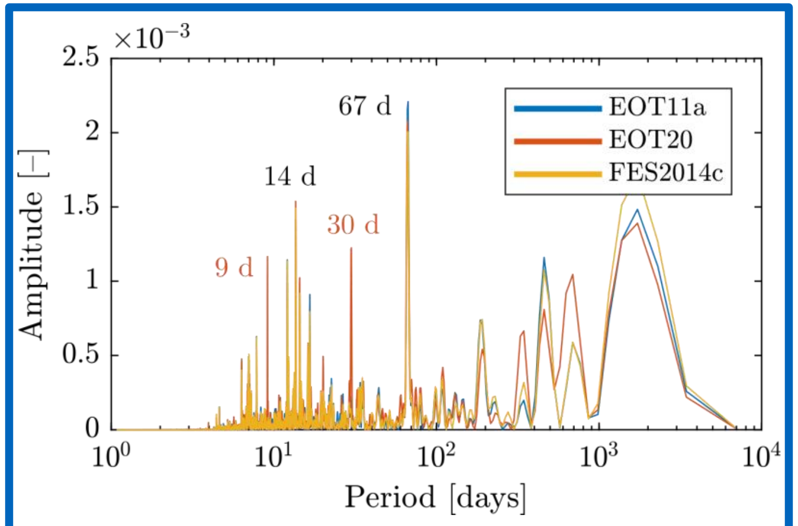


- LAGEOS-1
- Albedo scale factor
- EOT11a sometimes largest amplitude



- TOPEX/Poseidon
- Emp. acc. normal polygon (12 h)
- Draconitic period visible

Model comparison – frequency analysis



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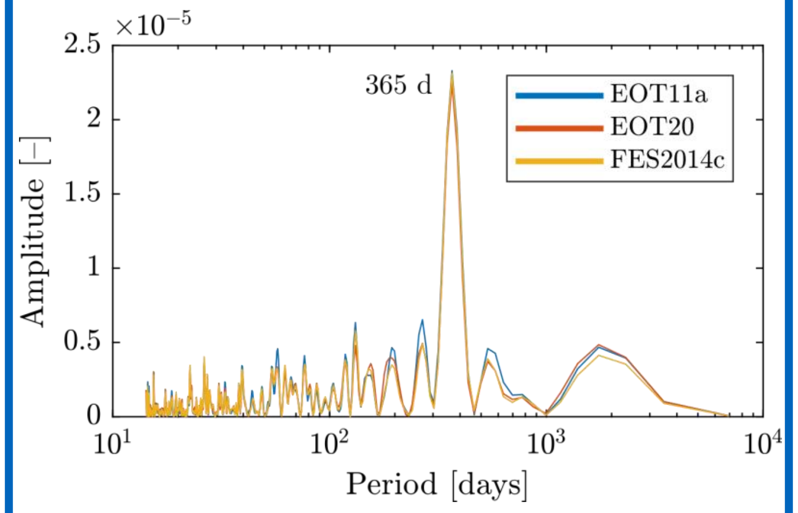

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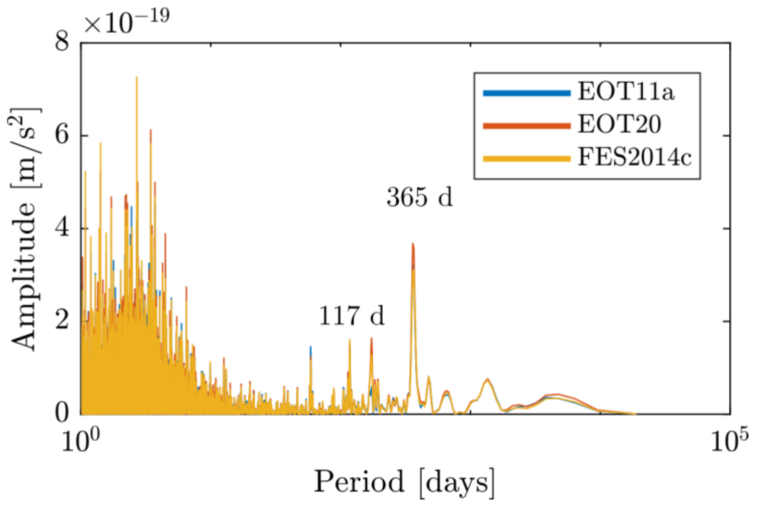

- TOPEX/Poseidon
- Emp. acc. normal polygon (12 h)
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No clear improvement in any parameter when using a specific ocean tides model!

Conclusion and Outlook

- Effects of ocean tides within the analysis of SLR observations are essential to consider
- Both ground-based stations and satellites affected either by gravitational or loading effects
- Comparisons of the models EOT11a, EOT20, and FES2014c show only a small impact on the POD of spherical and non-spherical satellites → high consistency of global ocean tides models (on the open ocean, differences mainly in coastal areas)
- The use of different models of different institutions is beneficial for model validation and detection of possible systematics hidden in any model → the ILRS ACs are free to choose any adequate model
- Inclusion of the GOT4.10c model to extend the comparison of ocean tides models

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Thank you very much for your attention!