Analysing the tidal state of a pre-plate tectonic Earth during the Archean Eon (3.9 Ga)

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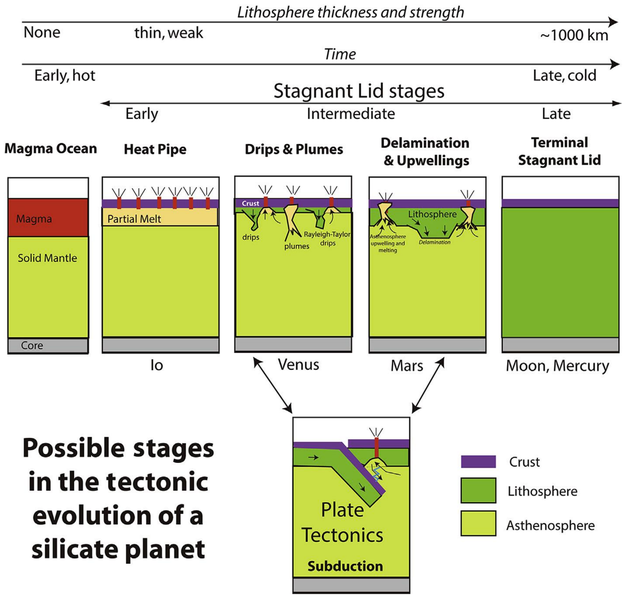
Archean 3.9 Ga

Previous work/Motivation

- Combined tidal and tectonic modelling for:
  - Cryogenian – (715 – 613 Ma)
  - Devonian – (420 – 380 Ma)
  - Phanerozoic – (330 – 0 Ma)
  - Future – (0 - +250 Ma)

ALL have periods of **tectonically** induced **tidal resonance**!

The **effect** of plate tectonics (the **supercontinent and Wilson cycle**) on **tides** over **geological timescales** is **established**, but what about for a period of Earth where **plate tectonics** (or at least the supercontinent cycle) is **not the dominant geodynamic regime**?



An artists rendering of the Archean Earth

Methods

What **the Archean Earth looked like** and the **forces at play** (both **tidal** and **tectonic**) are still **debated** therefore we use an **ensemble approximation** of the **Archean**.

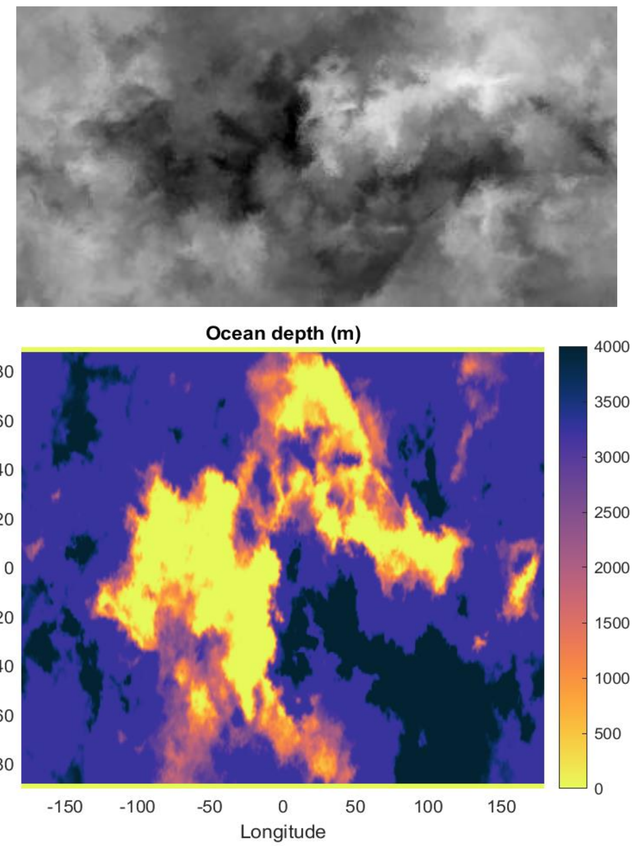
Tectonics

- Adapted maps from (Blackledge et al., 2020)
- Ensemble maps (120) “Flooded” to 5-15% land area

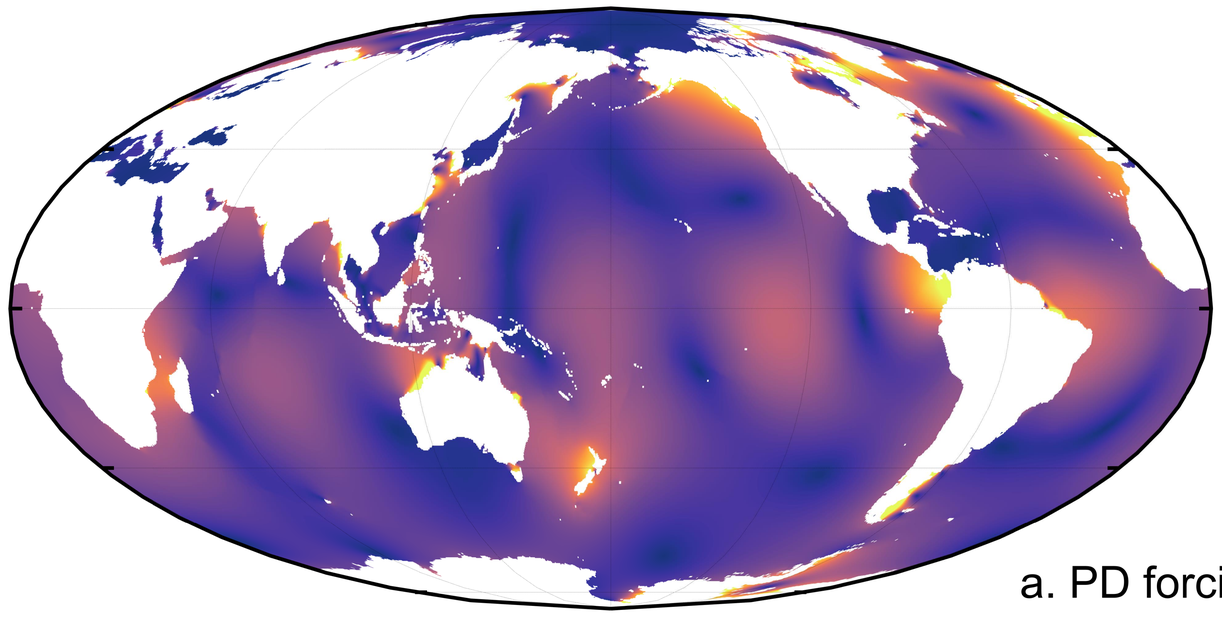
Tides – M_2 S_2 K_1 & O_1

- 13.1 h day – 6.78 h Semi diurnal tide
- Lunar Semi-Major axis of 263 000 Km
- 3.4x PD equilibrium tide

Raw “bathymetry” from Blackledge et al., (2020) (top) converted into an Archean approximation (bottom)

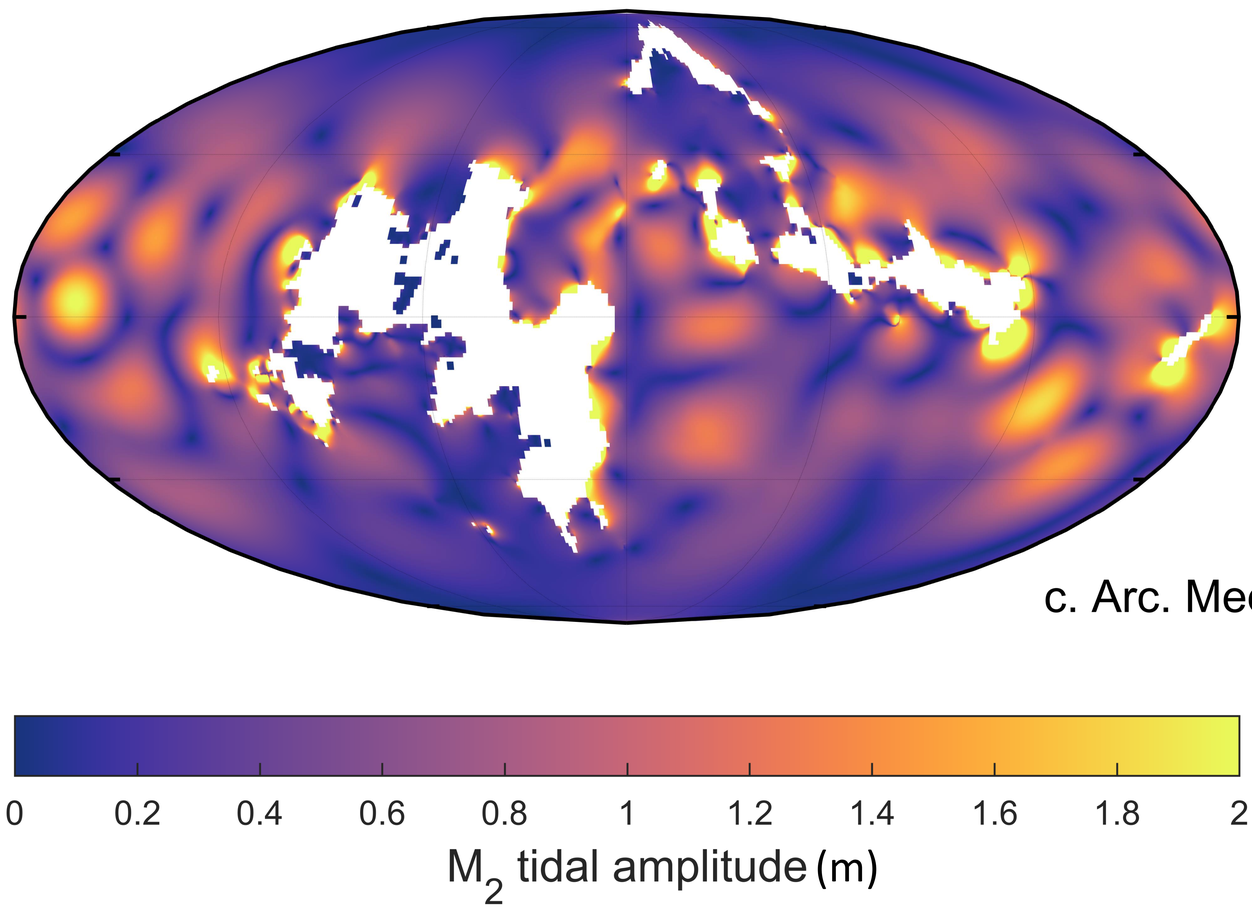


Output – Present day control



a. PD forcing

Output – A representative map selected from the Archean ensemble because it has median tidal amplitudes



c. Arc. Median

Archean tides

Key results – Avg. Archean tidal dissipation

- M_2 132% stronger than PD
- S_2 66% weaker than PD
- K_1 143% stronger than PD
- O_1 141% stronger than PD

Key results – Avg. Archean tidal amplitudes

- M_2 162% higher than PD
- S_2 55% lower than PD
- K_1 125% higher than PD
- O_1 114% higher than PD

Key results – Standard deviation

- M_2 – 0.86
- S_2 – 0.07
- K_1 – 0.22
- O_1 – 0.15

Conclusions

- Archean tides are **more energetic** but **not as energetic** as we **predicted**.
- SD illustrates we have a **good approximation** of the **Archean tide** (assuming the Archean looked like our ensemble bathymetries).
- **Super-tidal signal is present** but not as clearly as previous studies – energetic tides and small landmasses.

Total global dissipation for all four constituents plotted against a non-dimensional R value (Blackledge et al., 2020) The triangle marks present day dissipation and R value, and circle is present day with Archean tidal forcing.