Effects of *lunar precessions* and *solar activity* on sea-level variations in the Gulf of Mexico and eastern US

**Water level variations in Eastern US and Gulf of Mexico**

One-year low-pass filtered *Eastern US*

Homöllner diagrams of detrended, one-year low-pass filtered sea level. Horizontal lines (constant in distance) indicate data coverage for each station. Red contour lines indicate periods and locations of anomalously high sea levels (in the late 1940s, early 1970s and after 2012).

**Water level variations in Eastern US and Gulf of Mexico**

One-year low-pass filtered *Gulf of Mexico*

**Mode 1 of Empirical Orthogonal Functions for Gulf of Mexico and Eastern US**

Spatial structure (eigenvectors) of EOF Mode 1 for the Gulf of Mexico. This mode explains 77% of the detrended, one-year low-pass filtered variability of the water level in the gulf.

**Mode 1 Coefficients GOMSO**

Coefficients of EOF Mode 1 for the Gulf of Mexico (blue line). Red line describes a 4 yr smoothed version of the blue line. This is proposed as the Gulf of Mexico sea-level oscillation (GOMSO) index.

**Mode 1 Coefficients Entire eastern seaboard**

Coefficients of EOF Mode 1 for the Gulf of Mexico (blue line), the southeastern US (red line), and the entire east coast of the US (magenta line). Each line is shifted vertically by 0.2 for visualization and has its corresponding 4-yr smoothed version. The 3 lines show essentially the same long-term (>4 yr) variations.

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**Month** | **Name** | **Reference** | **Length (days)**
---|---|---|---
Sy | Synodic | New moon to new moon | 29.530589
An | Anomalistic | Perigee to perigee | 27.554551
Sl | Sidereal | Moon revolution around Earth relative to fixed star (fixed star to fixed star) | 27.321661
Tr | Tropical | Moon revolution around Earth relative to vernal point (equinox to equinox) | 27.321582
Dr | Draconic | ascending node to ascending node | 27.212221

**INTERACTIONS** (modulation or interference) between different periods, in years. An interaction is obtained from the difference in frequency between two lunar frequencies, i.e., 1/1.5 = 1/An. NP, PP and AP denote Nodal Precession, Perigee Precession (or Apsis Precession), and Argument of the Perigee, respectively.

**OTHER INTERACTIONS**

**Solar Activity (SU):** between 10 and 11 years

Interaction between Nodal Precession (NP) and Solar Activity (SU); 21.6109 and 26.8947 years

Interaction between Nodal and Perigee Precessions; 16.87 years

**GOMSO (blue) and sea-level oscillations (red) reproduced with lunar precessions and solar activity**

Lunar Precessions NP (18.61 y); NP/2 (9.305 y); PP (8.85 y); PP/2 (4.425 y); AP (6 y)

12% of variability

As ‘a’ plus SU (10 & 11 y); NP - SU (21.6 & 27.9 y); NP - PP (16.9 y)

47% of variability

As above plus Nodal-Perigee Mean (13.73 y)

73% of variability

Projection for the rest of the 21st century with lunar precessions and solar activity interactions

Blue line is GOMSO. Red and black lines are projections with the fits that explain 73% and 47% of the variability, respectively (see above panels). Green numbers indicate years of expected increases in sea level.