Supplement of “Formulation of a new explicit tidal scheme in revised LICOM2.0” #2

Jiangbo Jin[1,2], Run Guo[1,3], Minghua Zhang[4], Guangqing Zhou[1], Qingcun Zeng[1,*]

[1]International Center for Climate and Environment Sciences, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China

[2]State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou 310012, China

[3]College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing 100049, China

[4]School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York, USA

Correspondence: Qingcun Zeng (zqc@mail.iap.ac.cn)

Supplemental materials

1 Figures and table for major comments #3

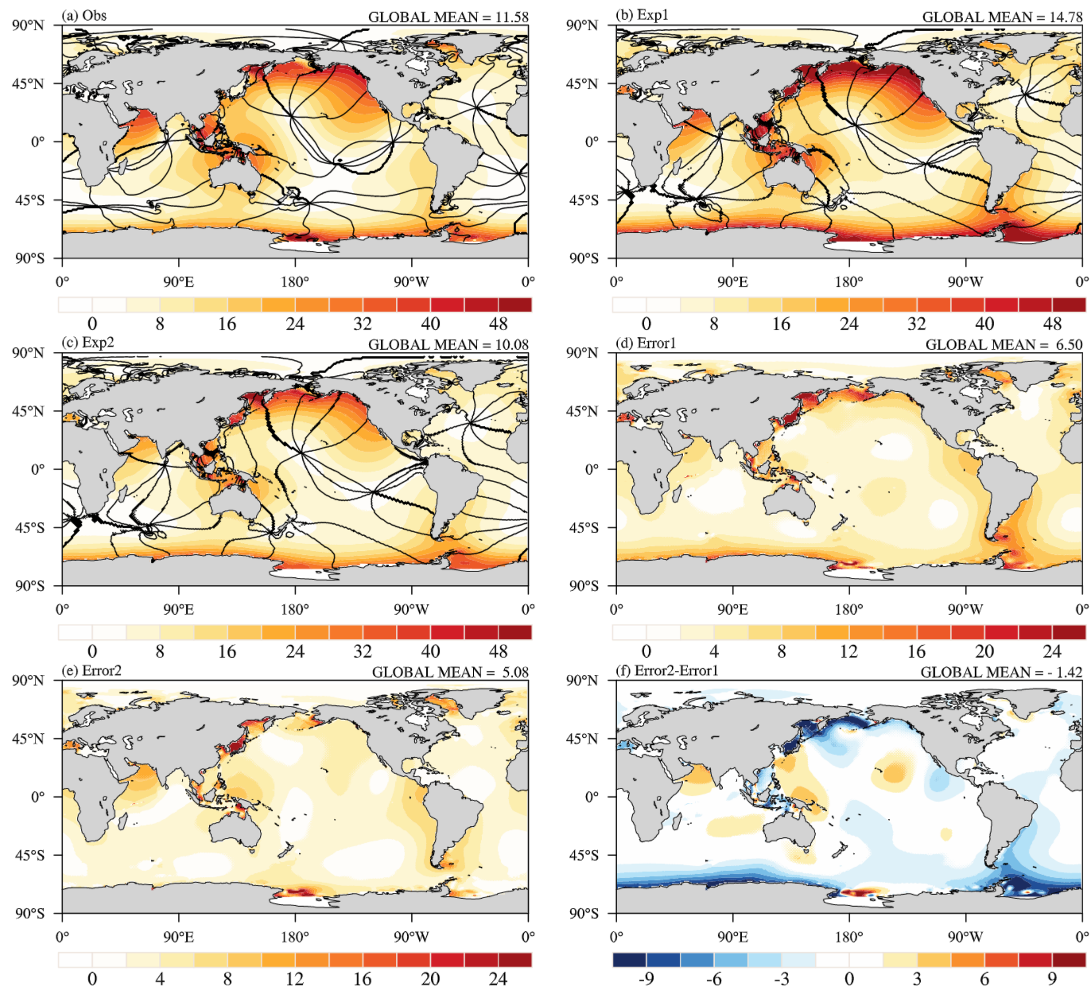

Figure R1. Spatial patterns of the amplitude and phase of K1 for (a) the observation (Obs), (b) Exp1, (c) Exp2, (d) the total error for Exp1, (e) the total error for Exp2, and (f) the difference in error between Exp2 and Exp1. The observation is from TPXO9v2 (Egbert and Erofeeva, 2002). The units are cm, and the lines of the constant phase are plotted every 45° in black.

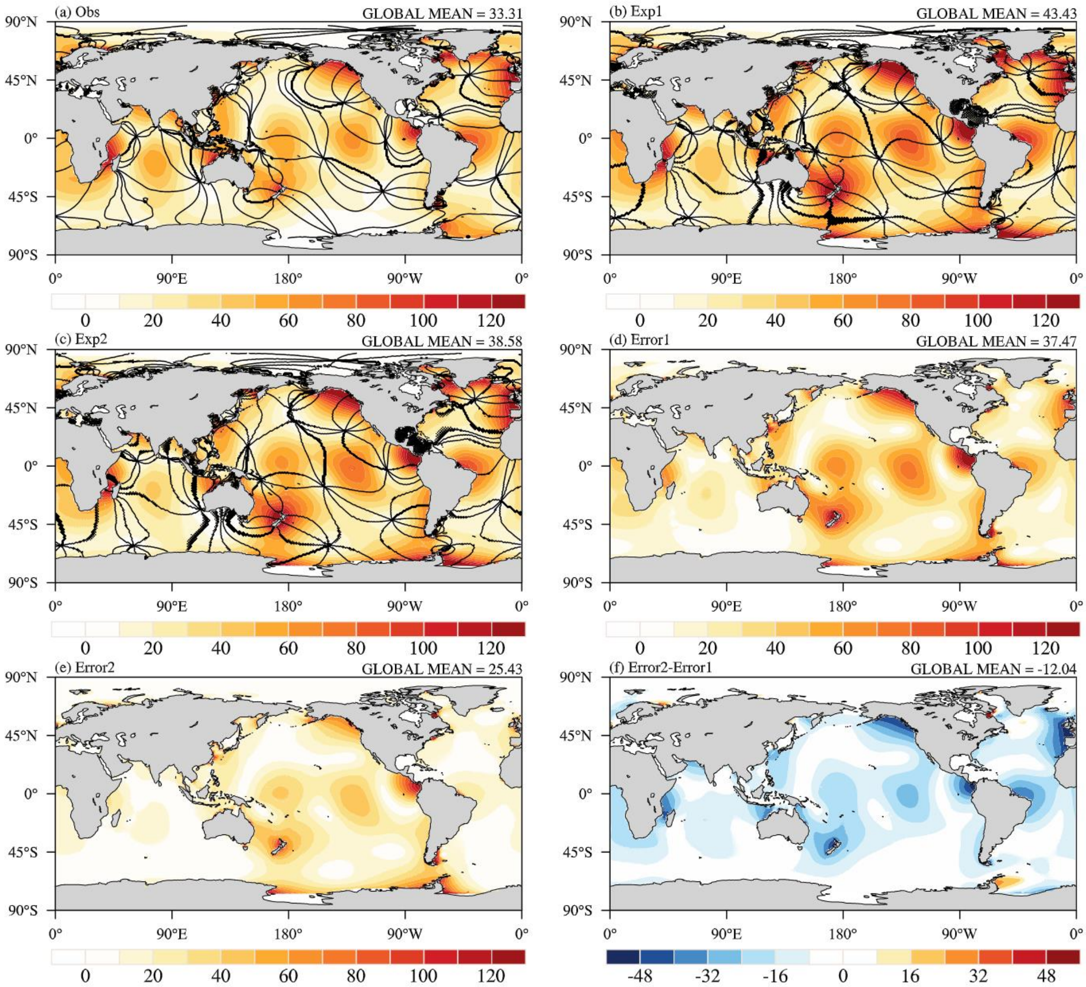

Figure R2. Spatial patterns of the amplitude and phase of M2 for (a) the observation (Obs), (b) Exp1, (c) Exp2, (d) the total error for Exp1, (e) the total error for Exp2, and (f) the difference in error between Exp2 and Exp1. The observation is from TPXO9v2 (Egbert and Erofeeva, 2002). The units are cm, and the lines of the constant phase are plotted every 45° in black.

Table R1. Global mean values of the amplitudes of the eight tidal constituents during observation, Exp1 and Exp2, and the amplitude, phase, and total errors of the eight tidal constituents in Exp1 and Exp2. The units are cm. The better amplitude and lower errors in Exp2 relative to Exp1 are marked by bold font.

	Global mean			Amplitude Error		Phase Error		Total Error	
	Obs	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2	Exp1	Exp2
M2	33.31	43.43	**38.58**	15.18	**13.11**	34.26	**21.78**	37.47	**25.43**
S2	13.35	13.70	11.46	5.30	5.44	7.71	**5.79**	9.35	**7.94**
N2	7.08	11.29	**6.91**	4.34	**1.99**	8.35	**3.03**	9.41	**3.62**
K2	3.75	7.5	**7.01**	3.92	**3.54**	7.60	**6.26**	8.56	**7.19**
K1	11.58	14.78	**10.08**	5.05	**3.78**	4.09	**3.40**	6.50	**5.08**
O1	8.34	11.65	**9.92**	3.94	**3.18**	9.22	**4.04**	10.02	**5.14**
P1	3.62	11.65	**8.25**	7.53	**4.50**	4.98	**4.12**	9.03	**6.10**
Q1	1.76	2.91	**1.80**	1.14	**0.50**	2.20	**0.51**	2.48	**0.71**

2 Figures and table for minor comments #8

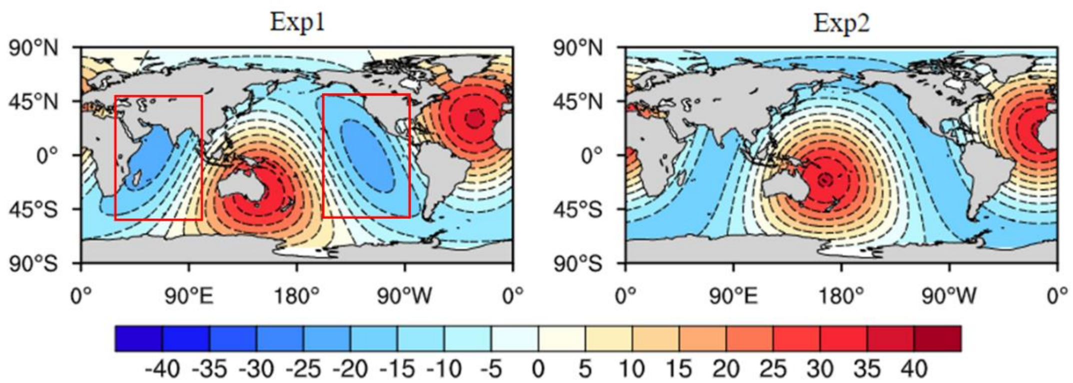

Figure R3. Spatial patterns of the spring tides for Exp1 (left) and Exp2 (right). The red boxes in Exp1 mean the closed minimums. The units are cm.

3 Detailed steps for the derivation of equation (4)

Assuming that the Earth is a rigid body, the horizontal tide-generating force is (Cartwright, 1999; Boon, 2004):

$$F_{tide,m} = \frac{GM_m}{L^2}\sin(\theta_m + r) - \frac{GM_m}{{D_m}^2}\sin\theta_m \quad (1)$$

According to analytic geometry and the law of cosines, we can obtain:

$$\sin(\theta_m + r) = \frac{D_m \sin\theta_m}{L} \tag{2}$$

$$L^2 = {D_m}^2 + a^2 - 2aD_m \cos\theta_m \tag{3}$$

Formulas (1) and (2) are combined to obtain:

$$F_{tide,m} = \frac{GM_m}{L^2}\frac{D_m \sin\theta_m}{L} - \frac{GM_m}{{D_m}^2}\sin\theta_m$$

$$F_{tide,m} = GM_m \sin\theta_m \left(\frac{D_m}{L^3} - \frac{1}{{D_m}^2}\right) \tag{4}$$

At the same time, from Formula (3), it can be obtained that:

$$L^{-1} = {D_m}^{-1}\left(1 + \frac{a^2}{{D_m}^2} - 2\frac{a}{D_m}\cos\theta_m\right)^{-\frac{1}{2}}$$

$$\frac{D_m}{L^3} = {D_m}^{-2}\left(1 + \frac{a^2}{{D_m}^2} - 2\frac{a}{D_m}\cos\theta_m\right)^{-\frac{3}{2}} \tag{5}$$

$G = g\frac{a^2}{E}$ and formulas (1) and (2) are combined to obtain:

$$F_{tide,m} = \frac{M_m}{E}\frac{a^2}{{D_m}^2} g \sin\theta_m \left[\left(1 + \frac{a^2}{{D_m}^2} - 2\frac{a}{D_m}\cos\theta_m\right)^{-\frac{3}{2}} - 1\right] \tag{6}$$

since $\frac{a}{D_m}$ equals approximately 0.017 and $\left|\frac{a^2}{{D_m}^2} - 2\frac{a}{D_m}\cos\theta_m\right| < 1$, binomial series can be used:

$$\left(1 + \frac{a^2}{{D_m}^2} - 2\frac{a}{D_m}\cos\theta_m\right)^{-\frac{3}{2}}$$

$$= 1 + 3\frac{a}{D_m}\cos\theta_m - \frac{3}{2}\frac{a^2}{{D_m}^2} + \frac{15}{8}\left(\frac{a^2}{{D_m}^2} - 2\frac{a}{D_m}\cos\theta_m\right)^2 + \cdots$$

Omit the minor term and equation (6) can be recorded as:

$$F_{tide,m} \approx \frac{M_m}{E}\frac{a^2}{{D_m}^2} g \sin\theta_m \left[1 + 3\frac{a}{D_m}\cos\theta_m - 1\right]$$

$$= \frac{3}{2}\frac{M_m}{E}\left(\frac{a}{D_m}\right)^3 g \sin 2\theta_m$$