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comment**

Interactive comment on "Numerical modelling of the tides in the Caspian Sea" *by* Igor Medvedev et al.

Anonymous Referee #1

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GENERAL COMMENTS

The manuscript deals with an interesting, regionally relevant topic. The presented results and conclusions will certainly serve as a basis for future oceanographic, hydrological and geophysical investigations in the Caspian Sea environment. Given the particular sensitivity of the Caspian Sea and its mean water level to the changing climate, and in view of the current focus of the international research community on quantifying the variability of ocean tides over climatic time scales, especially the presented numerical experiments that reveal the dependence of both the tidal pattern and local seiches frequencies on the mean sea level is timely and highly relevant. Methods, results and conclusions are well presented. The paper is well structured; the amount and choice of figures, tables and equations is appropriate; the wording is generally adequate and

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clear (some suggestions for rewording are given below). There are relatively few bibliographic references, but this might indicate in fact a shortage of previous work on this topic.

SPECIFIC COMMENTS

The scientific approach and the applied methods are valid and do, in my opinion, not require any correction.

Having myself a primarily observational background, I would have welcomed more information about the confrontation of the presented model with available sea-level data (tide gauges, altimetry). This is certainly a subjective preference, and I realize that this has been dealt in previous work (Medvedev et al. 2017, 2019: tide gauges) or may be the subject of upcoming publications (altimetry). Nevertheless, the reader could be provided with some additional interesting information, perhaps even in a qualitative way, adding a few sentences to the Introduction or Discussion. For example, what is the proportion of the relatively small astronomic tides in the total observable sea-level variation (i.e., how efficient is the presented model to predict real sea-level changes)?

The last paragraph of the Conclusions (p19,l6-11) is interesting and deserves more space. If the presented model indeed qualifies as an appropriate complement of global ocean tide models, this would be a mayor outcome of the paper and increase significantly its value. This question should be discussed in more detail. Purely empiric ocean tide models based on satellite altimetry should not be "distorted" by any assumption on the Caspian MSL. Here, again, rises the question about how well agree the presented model and altimetry, which could be offered as an outlook to future work or posed as an open research question. An invalid assumption on the Caspian MSL could indeed affect dynamical and assimilation models, but then it should be demonstrated which particular global ocean tide model assumes a wrong Caspian sea level and to which extent the tidal signal is distorted.

TECHNICAL CORRECTIONS

C2

p1,l14: I understand that the splitting into two amphidromies occurs only in the diurnal case. If so, make this explicit: "For the diurnal constituents, the Absheron Peninsula splits this system into two separate amphidromies..." or so.

p1,l20-22: rephrase, e.g.: Numerical experiments with tidal simulation were made using different mean sea levels of the Caspian Sea (within a range of 5 m). The results indicate that the spatial features of the tides are strongly sensitive to changes of the mean sea level.

p1,l25: I prefer "one of the major drivers of ocean water motion" to "one of the major types".

p2,l1: "unique object for THE analysis"

p2,l5: "7.7 cm based on AN analysis of 30-day"

p2,l6: "performed A spectral analysis"

p2,l9: I prefer "Analyzing annual series..." to "Having analyzed annual series..."

p2,l14: "for different parts of the Caspian Sea" instead of "for different sea parts"

p2,l14: "... tide gauges. A maximum tidal range..."

p2,l16: "performed A high-resolution spectral analysis"

p2,l17: I prefer: "Southern (or Northern) Caspian" to "South (or North) Caspian" - throughout the text. Also "Central Caspian" to "Middle Caspian".

p2,l18: "of THE diurnal radiational constituent S1"

p2,l19: "than those of THE gravitational constituents"

p2,l22: "examination OF specific tidal features"

p2,l23: "in THE deep-water areas"

p2,l25: check reference format: "Caspian Sea (Medvedev et al. 2019)." or "Caspian

Sea in Medvedev et al. (2019)."

p3,l2: "we used A 2D version"

p3,l3: "in THE two-dimensional shallow water equations"

p3l12: check if this complies with the journal's reference format, or if there is another reference to this model to cite.

p3,l18: "THE energy dissipation of THE generated flows is caused by THE vertical turbulent viscosity. THE friction..."

p3,l22: "is THE flow velocity above..."

p4,l2: I prefer "to avoid a vanishing bottom drag in very deep waters"

p4,l4: "THE numerical simulations"

p4l6: "In section 3.1, a mean sea level (MSL) of the Caspian of -28 m with respect to the Baltic Height System (BHS, relative to the zero of the Kronstadt gauge) was adopted in the numerical modelling."

p4,l8: "from -25 m to -30 m with respect to the BHS. THE boundary conditions..." Consider replacing "** m of the BHS" by "** m with respect to the BHS" throughout the text.

p4,l11: reference format (see p2,l25); same in the following sentence

p5,Fig1: Kizlyar Bay is not indicated; also the tide gauges stations listed in Table 2 would be helpful to display. If necessary, the isobath annotation could be thinned out, or even omitted, if a color scale would be provided. In the caption, include a reference to the bathymetry model: "Figure 1: The bathymetry of the Caspian Sea according to ..."

p5,l8: "A numerical model with A MSL of -28 m with respect to the BHS..."

p6,l1: perhaps better "examine" instead of "consider"

C4

p6,l2: "taking THE major constituents..."

p6,l3: "THE diurnal pattern includes..."

p6,l5: "have [or: feature] A counterclockwise rotation."

p6,l9: reference format (see p2,l25); I suggest rephrasing, e.g.: "Medvedev et al. (2019) showed that the results of numerical modelling are not really reliable in the Northern Caspian due to the very shallow depths in this area with about 20% of this part of the Caspian being less than 1 m deep (Baydin and Kosarev, 1986)."

p6,l12: "... have a spatial distribution similar to that of K1."

p6,l19: "The areas ... are: 1) the western part of the Southern Caspian..." or, better: "Maximum M2 amplitudes are found in 1) the western part of the Southern Caspian..."

p6,l24: "of THE major tidal constituents at selected cities [or: towns] around the Caspian Sea"

p7,Fig2: Add panel identifier "a)" and constituent identifier "K1" to the left panel.

p8,Tab2: After a quick glance at Fig. 2 it seems somewhat surprising that Fort Shevchenko features the largest tidal range. Perhaps this deserves a short comment.

p8,l7: "form factor AS determined by the AMPLITUDE ratio of the MAJOR diurnal and semidiurnal constituents"

p8,l11: "In general, A mixed mainly semidiurnal..."

p8,l12: "Only in THE western and eastern parts..."

p9,l3: "Based on the results of THE numerical modeling..."

p9,l6: I prefer "features a pattern similar to the M2 amplitude distribution"

p9,l9: I prefer here "are included" to "are presented"

p10,l3: "THE spatial structure..." I am used to the expression "semi-major axis" instead

of "major semi-axis" - revise throughout the text, same for semi-minor axis. "The largest M2 current velocities are observed [or: found] in:", or: "The areas of the largest M2 current velocities are:"

p10,l8: "up to 12.5 cm/s and 11.7 cm/s"

p10,l9: I prefer "depending on local topographic features."

p10,l11: "and THE tidal currents are nearly rectilinear."

p10,l12: "The spatial pattern of THE S2 tidal currents"

p10,l13: Perhaps "only the S2 semi-major axis is half of that of M2."

p10,l16: "repeats THE pattern of M2, too."

p10,l17: I prefer "by a factor of 1.8." to "by 1.8 times."

p11Fig4 caption: Semi-major axis velocity magnitudes (cm/s) for M2 tidal currents. Blue ellipses indicate clockwise circulation, red ellipses counterclockwise circulation.

p11,l4: I prefer: "3.4 Numerical experiments with VARYING MSL"

p11,l5: "THE interannual MSL variability..."

p11,l8: "and 20% of this area has a depth less than 1 m" - this has already been stated above, consider dropping this statement here.

p11,l9: I prefer "As a result, changes of the Caspian MSL by 2-3 m (as observed, e.g., between 1974 and 1994) lead to significant changes in the hydrodynamics of the Northern Caspian as well as in coastal waters of the Central and Southern Caspian."

p11,l11: "THE spatial characteristics of natural resonant oscillations in the basin (seiches)"

p11,l13: "experiments with tidal simulationS using..."

p11,l14: "This corresponds to the natural range of MSL changes..."

p11,l16: "THE results of these experiments allow to estimate [or: identify] the changes..."

p11,l18: "THE numerical results reveal that..."

p12,Fig5 caption: I prefer "Orange areas fall dry as a result of the assumed MSL changes."

p12,l6: "THE spatial structure of THE semidiurnal and diurnal TIDES is modified..."

p12,l8: "..from -25 m to -29 m, it leads to A general ..." "amplitudes of 1.5-2 cm and also to the east" is not clear - is there something missing?

p12,l10: I prefer "along almost the entire eastern shore" "In the Southern Caspian, THE tidal amphidromy also shifts to the east and THE amplitudeS increase along the western coast."

p13,l3: "...drops to -28 m, THE amplitude in this bay..."

p13,l5: "with a MSL of -30 m." (add the negative sign)

p13,l16: "A more pronounced modification occurs", or: "An even more pronounced modification", or: "More pronounced modifications occur"

p13,l19: "The amplitude of THE diurnal tide"

p13,l22: "THIS is caused ... AT low MSL."

p13,l23: rephrase, e.g.: "Strong modifications of the diurnal tidal pattern due to MSL changes occur along the transition between Northern and Central Caspian. At a MSL of -25 m the largest amplitudes are located..."

p13,l26: "With decreasing MSL, large amplitudes extent farther west."

p13,l27: "At a MSL of...", revise throughout the text.

p13,l28: I prefer "These changes are probably caused by a strong modification... and

,as a result, of the frequency [or: resonant] properties of this part of the sea [or: sub-basin]."

p13,l31: "THE change in the spatial structure"

p13,l32: I prefer "The maximum tidal range of 22 cm is found in the Mangyshlak Bay for a MSL of -25 m. At this MSL the tidal range in the Turkmen Bay amounts to 13 cm and in the Türkmenbaşy Gulf to 15.5 cm."

p16,l1: "The changes in tidal characteristics..."

p16,l2: "tidal vector diagrams... for different MSL of the Caspian Sea."

p16,l4: "However, the M2 phase lag ... 100° and the M2 amplitude doubles: from 2.5 cm at a MSL of ..."

p17,l1: "THE results of THE numerical tidal modelling... of A harmonic analysis..."

p17,l4: "... spectra FROM the western coast" (or: at)

p17,l6: "simulation of THE K1 amplitude"

p17,l8: "eastern part of THE Southern Caspian"

p17,l11: I prefer "..., the area and length of the island increase significantly, and the islands becomes an effective boundary to the west, reflecting THE tidal waves..."

p17,l13: reference format: Badyukova

p17,l17: I prefer "... , with a maximum elevation of the island of 2 m at a MSL of -28 m. Thus, in the experiments assuming a MSL of -25 m, the island was completely submerged."

p17,l22: "A comparison of the island's..."

p17,l23: I prefer "has gradually moved eastward and has changed its geometrical configuration due to the redistribution of deposits and erosion."

p17,l25: I prefer "The greatest contribution to this process originates from eolian redistribution." reference format: Nikiforov

p17,l28: "THE magnitude and direction of THE generated wind fields"

p17,l29: "A spectral analysis..."

p17,l31: rephrase, e.g.: When the MSL of the Caspian Sea decreases, the Q-factor of seiches with a period of about 12 hours significantly decreases in the Türkmenbaşy Gulf and at a MSL of -29 m it does not exceed any more the spectral noise level.

p18,l1: "In the Turkmen Bay a decrease in MSL from -26 m to -29 m causes the spectral peak of the main seiches mode to migrate towards lower frequencies..."

p18,l3: Consider dropping "Apparently,". "This is due to the progressive elongation of Ogurja Ada Island which represents the western boundary of the bay."

p18,l12: "In this study THE tidal dynamics of the Caspian Sea HAVE been numerically investigated."

p18,l17: "THE results of THE numerical simulation"

p18,l20: I prefer "hydrodynamics" to "water dynamic"; "... might have been underestimated so far."

p19,l1: "OUR numerical experiments indicate... sensitive to changes in the MSL. A modification..."

p19,l3: "including the Northern Caspian, which results in significant changes in the frequency response of the basin. This is also confirmed by..."

p19,l6: "in THE improvement of"

p19,l7: "Stammer et al. (2014) present a detailed comparison of the main modern global barotropic tide models."

p19,l12: I prefer "We believe that our findings on the tidal dynamics can help to better

C9

understand the diurnal and semidiurnal variability in the sea level and currents in the Caspian Sea."

p19,l18 (Author contribution): It think that "IP" should be replaced by "IM" throughout section 7.

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