Advancing Ocean Prediction Science for Societal Benefits
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Solving tidal challenges in regional and coastal ocean modeling: key guidance demonstrated via a case study of the seas surrounding Korea

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1. Introduction

- **Provides Guidance for Three Fundamental Technical Challenges**
  - Associated with modeling tides at regional or coastal scales
  - Challenges often encountered by those new to tide modeling

2. Method & Results

1) How to generate tidal forcings from coarser tidal constant databases

Problem (Existing individual interpolation)

- Abrupt phase lag change abruptly from 350° to 10° require precise control to prevent systematic errors in tidal forcing on open boundaries (Fig. 1B)

Solution (Cartesian coordinate based interpolation)

- Converting Polar Coordinates (r_i, φ_i) to Cartesian Coordinates (x_i, y_i), using $(x_i, y_i) = (r_i \cos\varphi_i, r_i \sin\varphi_i)$
- Separately interpolating $(r_i \cos\varphi_i)$ and $(r_i \sin\varphi_i)$, resulting in x'_i and y'_i
- Converting Cartesian Coordinates (x'_i, y'_i) to Polar Coordinates (r'_i, φ'_i), using $r'_i = \sqrt{(x'_i)^2 + (y'_i)^2}$ and $\varphi'_i = atan2(y'_i, x'_i)$ for amplitudes and phase lags (Fig. 1C,D)

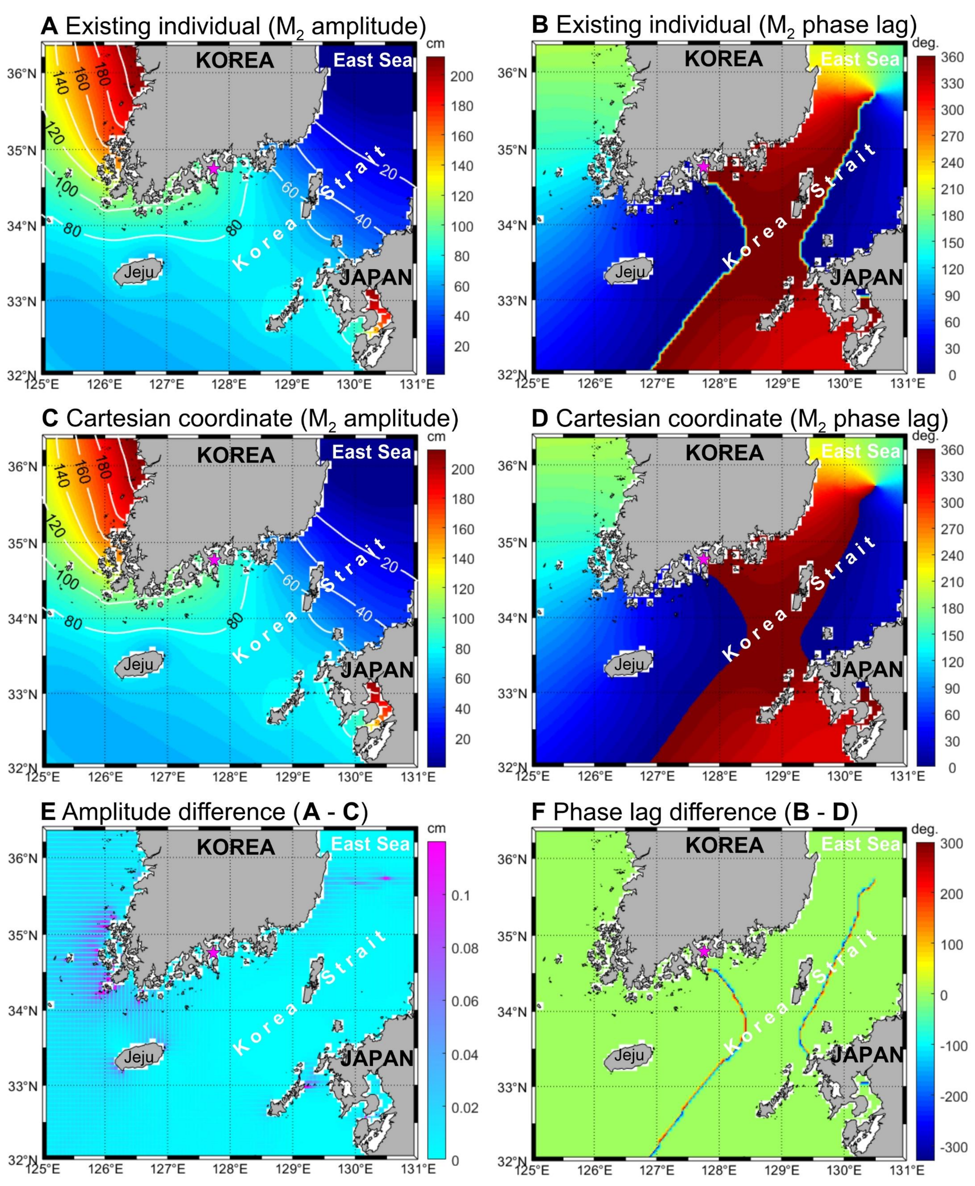

Figure 1. M_2 co-amplitude and cotidal charts (A–D) around Korea Strait produced using the existing individual linear interpolation method (A, B) and the Cartesian coordinate based linear interpolation method (C, D) with FES2014 tidal constant data (horizontal resolution of 1/16°). Plots (E, F) of the differences between the two interpolated charts (i.e., (A–C), and (B–D) are shown to highlight the errors introduced using the existing linear interpolation method (E, F). Phase lags are referenced to Greenwich.

2) How to generate perpetual interannual tidal predictions inside a hydrodynamic model

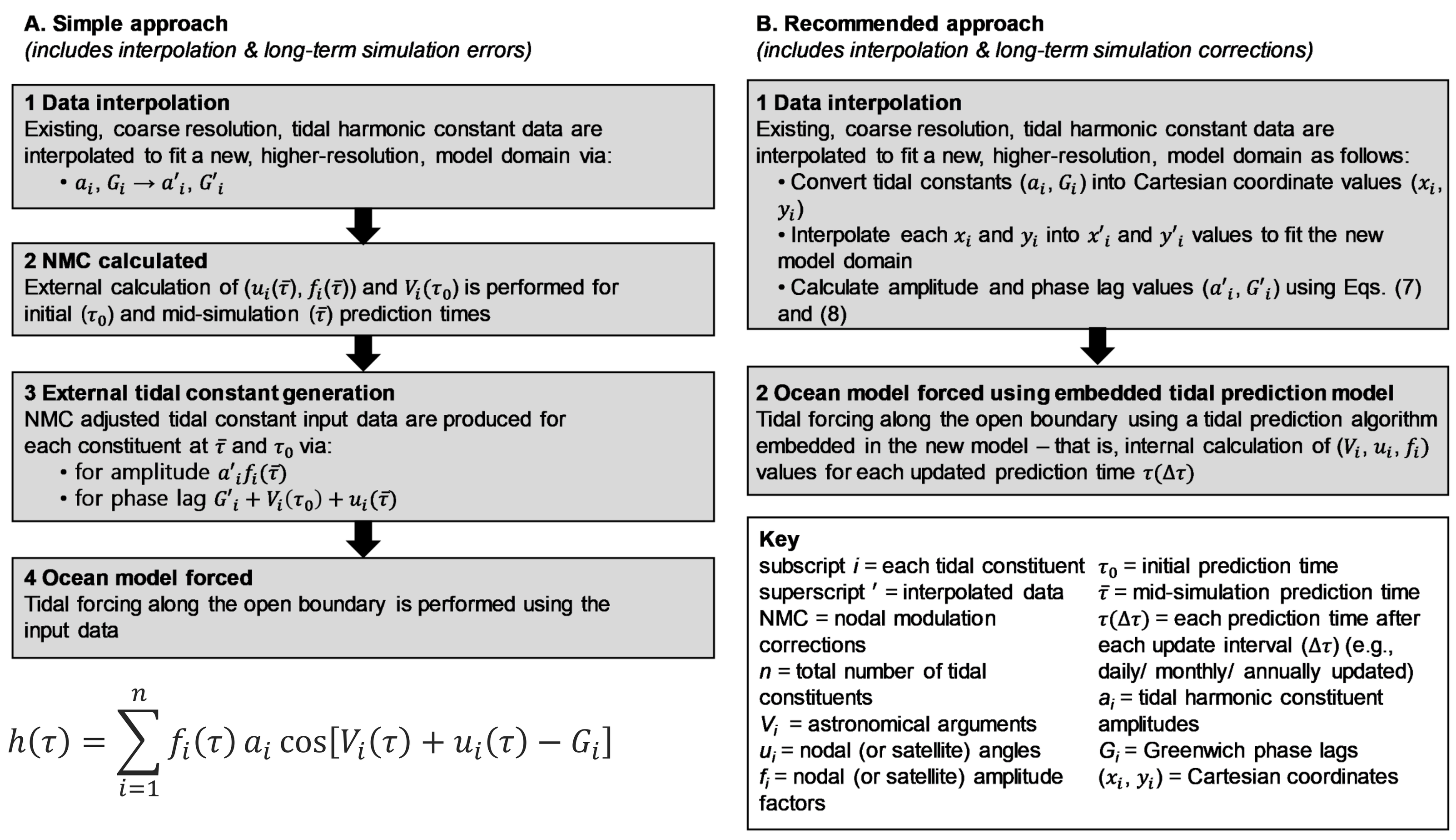

Figure 2. Comparison of (A) simple (error prone) and (B) improved alternative (standard harmonic prediction based) methodological procedures for generating the tidal forcings file needed to predict tides in regional and coastal ocean models.

3) How to derive tidal harmonic constants

Key points to produce a reliable harmonic constant Database

- **Nodal Modulation Correction (NMC) Effects**: Verify inclusion or exclusion of NMC in simulations
- **Data Length**: Determine necessary length of simulated tidal height data for harmonic analysis (Table 1)
- **Phase Lag Time Zone**: Confirm the phase lag time zone employed

Table 1. Synodic periods of main pairs of neighboring semidiurnal and diurnal constituents associated with the length of model output of sea levels required for separating out each constituent in a conventional harmonic analysis

Tide species	Constituent pairs (ω_i, ω_j)	Synodic period (days)	Angular speed $(\omega_i$, ° hr$^{-1})$
Semidiurnal constituents	(M_2, S_2)	14.765	ω_{M_2} = 28.9841042 ω_{N_2} = 28.4397295 ω_{S_2} = 30.0000000 ω_{K_2} = 30.0821373 ω_{Q_1} = 13.3986609 ω_{O_1} = 13.9430356 ω_{P_1} = 14.9589314 ω_{K_1} = 15.0410686
	(M_2, N_2)	27.555	
	(S_2, K_2)	182.621	
Diurnal constituents	(K_1, O_1)	13.661	
	(O_1, Q_1)	27.555	
	(K_1, P_1)	182.621	

3. Conclusions

Generating Accurate High Resolution Tidal Forcing Inputs:
- Uses Cartesian coordinate based interpolation

Providing Practical Solution for Tidal Prediction in ROMS:
- Provides a modified 'set_tides.F' code* which resolves issues with continuous long-term tidal predictions

*Available online at: https://www.frontiersin.org/articles/10.3389/fmars.2023.1150305/full#supplementary-material

Successful Procedure for Producing Tidal Harmonic Constants:
- Checks key points such as NMC effect, input data length for harmonic analysis, and phase lag time zone

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