Modeling Seasonal Variability of Arctic Barotropic and Baroclinic Diurnal Tides: Implications for the Tide's Role in Evolving Arctic Ocean State

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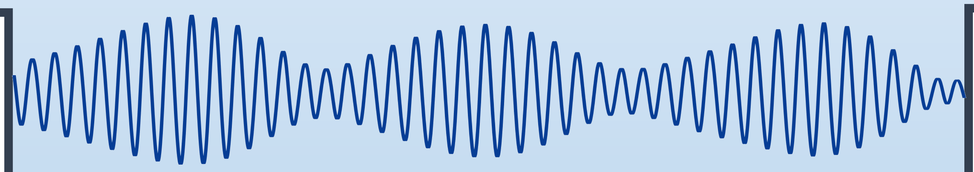
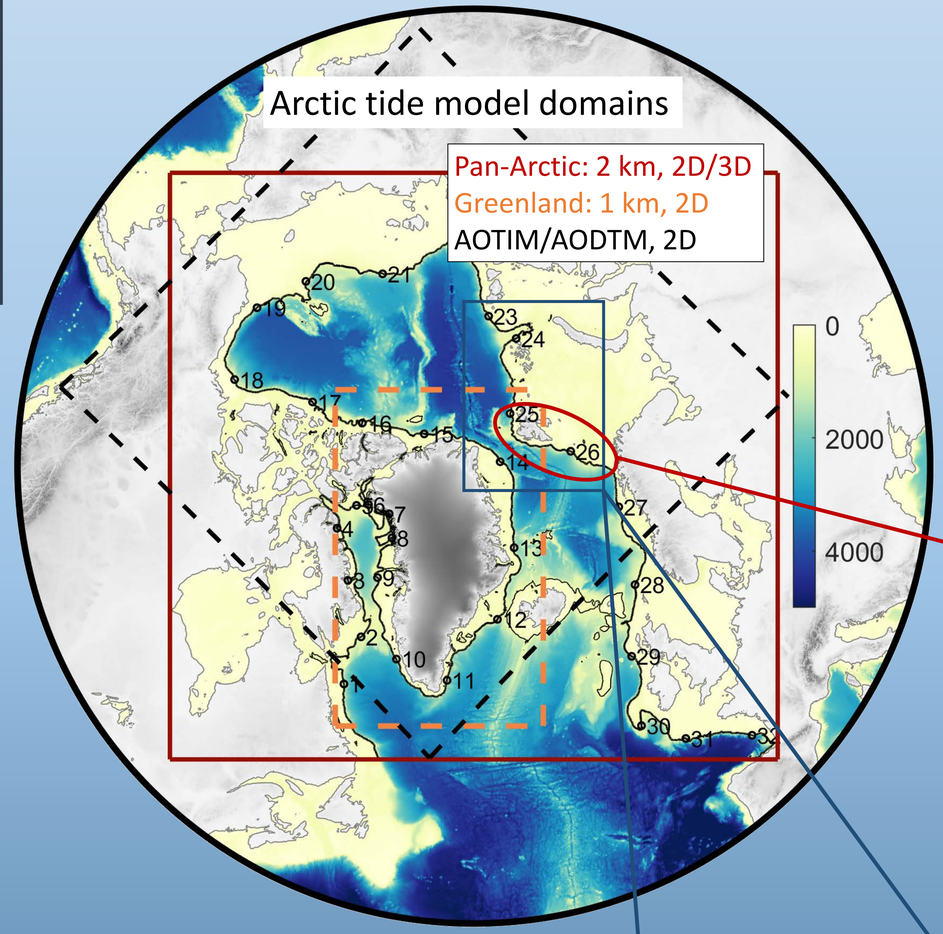
Motivation

Diurnal tidal currents dominate diapycnal mixing at many sites along pathways for warm Atlantic Water circulating in the Arctic Ocean along the continental slope. We use high resolution 3D tide models to investigate sensitivity of Arctic diurnal tides to background ocean state, towards understanding tidal contributions to Arctic change.

Model Description

- ROMS3.7 with potential tide code
- 2 km grid x (1, 5, 25) levels
- Forcing: TPXO9.1 at boundaries, + potential tides
- K1 and O1 constituents run separately
- 3 cases: No stratification; and March and September strat + mean flow
- For stratified cases: Initial conditions from monthly averaged output from MITgcm (*T*, *S*, *u*, *v* and sea surface height)

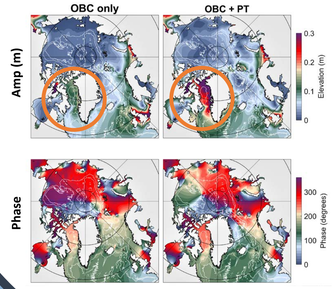


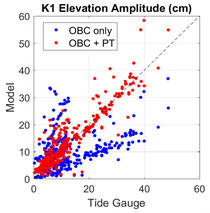


Conclusions

- Forcing with both open boundaries and potential tides is needed for accurate models of Arctic diurnal tides
- Adding stratification leads to large changes in diurnal currents, but seasonal variability is generally small
- Second harmonics from diurnal forcing add to the semidiurnal upper ocean current field
- Upper-ocean currents affecting sea ice are sensitive to stratification
- New validation data set must filter out poor records to provide a more accurate assessment of models
- Tidal mixing and ice/ocean interactions will change as Arctic Ocean state evolves: tides should be explicitly modeled

Potential tide forcing is essential for accurate modeling of Arctic diurnal tides

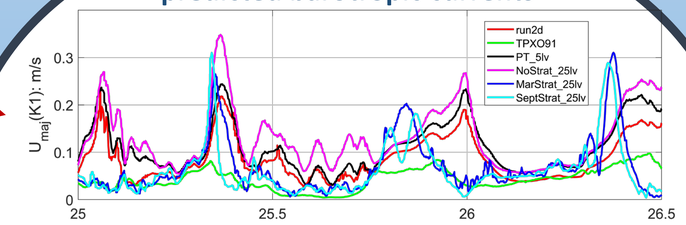




Validation of K1 forcing models (OBC only and OBC + potential tides) using a new Arctic tide gauge database, in development. O1 results are similar.

Forcing	Mean Error (cm)	
	K1	O1
OBC only	9.12	5.32
OBC+ PT	4.60	3.24

Stratification changes the predicted barotropic currents



K1 major axis current (m/s) along 500 m isobath across Barents Sea Opening (between '25' and '26.5' on central map). Note changes between: barotropic runs without and with potential tides (red vs black); homogeneous and stratified (magenta vs blue/cyan); and March and September at some points (blue vs cyan).

New Arctic and Greenland barotropic forward models

Two new high resolution barotropic forward models are being finalized and will be published later this year, to replace AOTIM5.

Models	Mean Error (cm)	
	K1	O1
Forward		
Pan Arctic	4.54	2.63
AODTM5	5.80	2.73
Inverse		
AOTIM5	3.75	2.39
AOTIM2018	3.66	2.10
TPXO9.1	4.55	2.15

Comparison of Pan Arctic model with other tide models. Data-assimilation ("inverse") models produce more accurate results in height but may lead to tidal current errors.

Pan-Arctic: 2 km

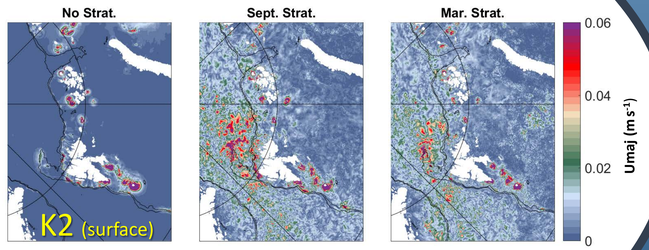
Forced at open boundaries with TPXO9.1 and with potential tides

Greenland: 1 km

Semi-diurnals: 2D model forced at open boundaries with TPXO9.1

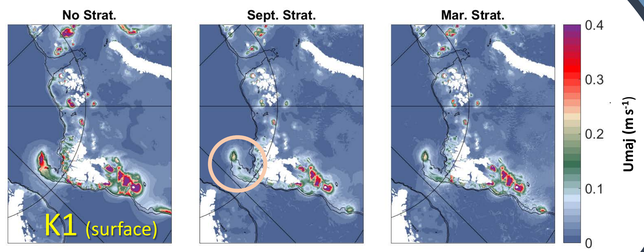
Diurnals: Forced at open boundaries with Pan-Arctic model and with potential tides

Stratification excites the second harmonics of the diurnal tides



The second-harmonic (K2) major axis for the surface layer from three runs forced with K1 only. K2 has a ~ 12 hr period. The region influenced by tides is much broader with stratification.

Stratification alters upper ocean currents relative to barotropic models



The major axis for the surface K1 tide over the Yermak Plateau (circled in middle panel) decreases substantially when stratification is included.

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