Tidal Modeling of Glacier Bay, Alaska - Methodology, Results, and Applications

D.F. Hill[1]
Department of Civil & Environmental Engineering
The Pennsylvania State University
University Park, PA 16802

June 2007

[1]Contact: 814.863.7305, dfh@engr.psu.edu

Contents

List of Figures

List of Tables

Preface

The work described in this report is the result of a 10 day kayak trip in Glacier Bay during the summer of 2004 and a healthy dose of serendipity. On the way to an up-bay drop off point, the author overhead two other kayakers discussing acoustic doppler current profilers. This is decidedly *not* in the lexicon of your average kayaker and it certainly caught the ear of the author. The ensuing conversation with Dr. Lisa Etherington (then of the U.S.G.S.) and a well-timed sabbatical leave granted by the Pennsylvania State University to the author during the 2005-2006 academic year are responsible for the following pages.

The author is indebted to Dr. Etherington for her interest in and enthusiasm for a hydrodynamic study of the tides in Glacier Bay and for her provision of many useful data and reports regarding the Bay. Additional thanks are due to Jennifer Mondragon, Erika Madison, and Jennifer Fisher, all of whom provided valuable physical data to the author. This work was financially supported, in part, through a grant from the National Park Service. The author would like to also acknowledge the significant assistance he received from Lewis Sharman of the NPS. Finally, financial assistance from the U.S.G.S. allowed the author to attend and participate in the 2004 Glacier Bay Science Symposium.

This report serves two very different purposes and two very different audiences. On the one hand, it is a 'user's guide' of sorts, laying out, in rather extensive detail, the steps involved in running simulations of the tidal flows in Glacier Bay. These steps involve extensive pre-processing, parallel computations on a Linux cluster, and extensive post-processing and data visualization. The path taken by the author relied heavily on freely-available software and data and this report should assist other researchers similarly interested in conducting open-source numerical studies of tidal circulation.

On the other hand, the report serves the non-specialist who is interested in the 'big picture' of tides in the Bay. Biologists and ecologists stand to benefit from an appreciation of circulations in the bay. Model runs have produced extensive data sets which are easily queried in order to produce information on tidal elevations, water velocities, and particle trajectories.

Summary

A tidal circulation model (ADCRIC) has been adapted to Glacier Bay National Park. The model domain includes Glacier Bay proper and the outlying waters of Icy Strait and Cross Sound. A very high spatial resolution was used in constructing the model domain, allowing for the resolution of many of the small islands and tidal channels in the bay.

The model is forced with tides at the open boundaries in the Gulf of Alaska and Lynn Canal, meteorological conditions, and freshwater inputs. Presently, model runs are two-dimensional (depth integrated), allowing for accurate simulation of the water surface elevation and barotropic tidal velocities.

Model output includes time series of elevation and velocity at specified locations, global elevation and velocity output, and harmonic analysis of these fields. The simulations have been validated against tidal data and known tidal constituents and have shown very good agreement.

Specific results of interest include predictions of tidal datums, such as mean high water, tidal range, etc., at all points in the model domain. Additionally, calculations of root-mean-square tidal speed have been made and are indicative of regions of strong tidal mixing. Lagrangian particle tracking has been performed and demonstrates the dramatic variability in tidal excursions in the bay.

The ADCIRC model is open source and the pre- and post-processing tools developed by the author are also freely available. The net effect of this is a modeling package that is available to any interested scientist.

Future work on this project is centered upon extending the model to three dimensions. Given the strong freshwater inputs to Glacier Bay and the documented strong vertical stratification, this step is essential to a full understanding of the baroclinic currents in the bay.