Improved Continental Shelf Topography via Hydrodynamic Data Assimilation

Edward D. Zaron (Portland State University) & Marie-Aude Pradal (Johns Hopkins University)

Portland State UNIVERSITY

Summary

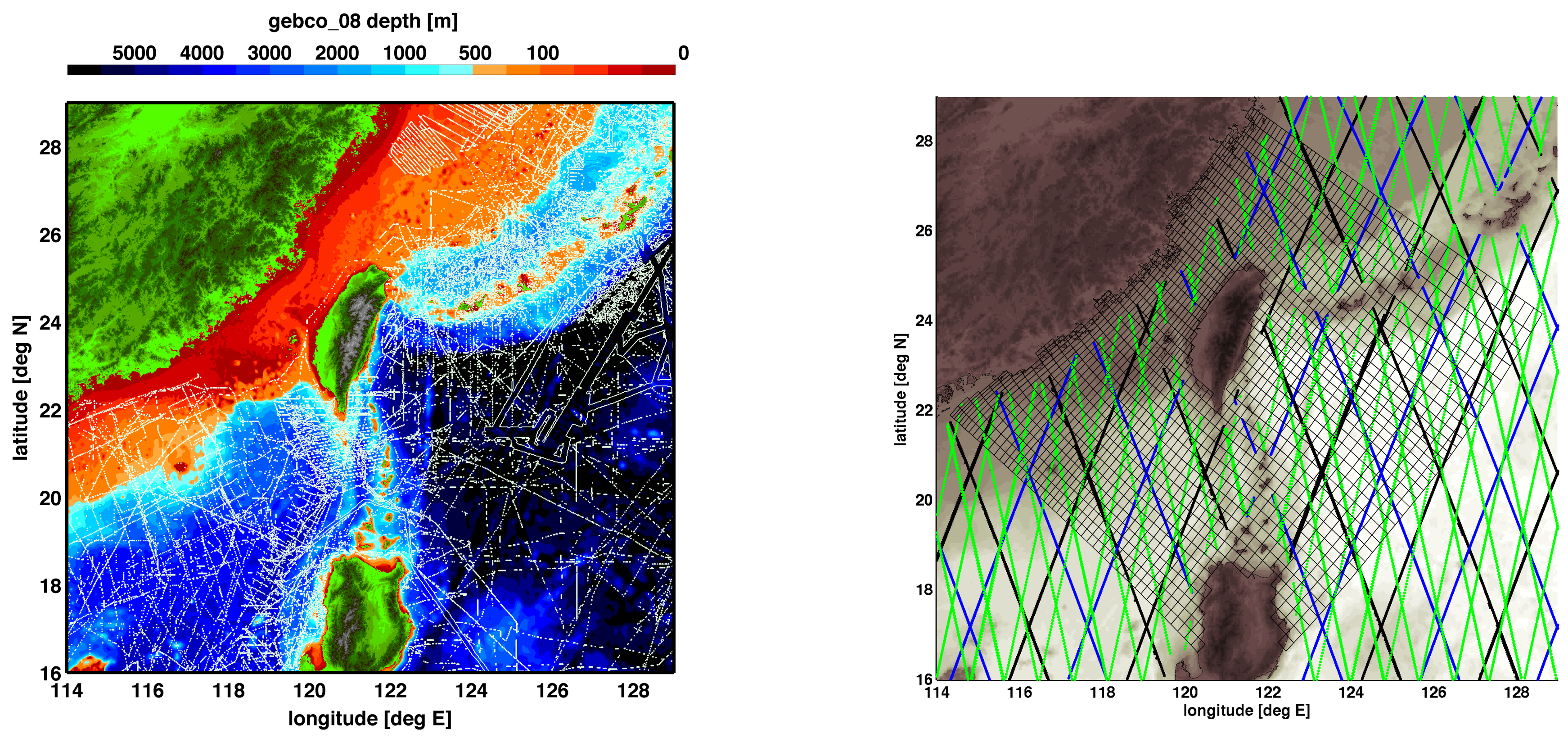
- Ocean bottom topography obtained by combining shipboard bathymetry with satellite gravimetry is sub-optimal on continental shelves due to the spatially-variable distribution and composition of shelf sediment, which makes the relationship between gravity and bathymetry uncertain.
- We have developed a methodology to improve continental shelf topography by combining ocean hydrodynamics and sea surface height data.
- This poster presents a demonstration of proof-of-concept with an "identical twin" experiment around Taiwan.

Methodology

Bottom topography, H, is regarded as a distributed parameter to be estimated by assimilating satellite sea surface height (SSH) into a barotropic shallow water model.

The proof-of-concept calculation incorporates the following information:

- "True" topography to be reconstructed: Smith & Sandwell v12.1.
- First guess topography: ETOPO2v2.
- Data: SSH along Jason-1 and Jason-2 ground tracks.
- Hydrodynamic model: barotropic shallow water equations.
- Nominal topographic error model: 10% of depth for $H < 200$m; 20m for $H \geq 200$m; 50km correlation scale.
- Solution technique: Picard iteration on nonlinearity + Krylov subspace method for linear subproblems + line search



(a) **Topography.** The color scale shows water depth (meters) around Taiwan. White dots indicate locations of shipboard bathymetry in GEBCO. Note the paucity of observations on the continental shelf between Taiwan and China. This region was chosen for this proof-of-concept calculation because tidal elevations are very sensitive to topography of Taiwan Strait; hence, measurements of SSH should provide a significant constraint on water depth.

(b) **Computational Domain and Satellite Ground Tracks.** Satellite SSH observations within the computational grid are assimilated to reconstruct S&S v12.1 bottom topography from ETOPO2v2 topography. Heavy lines show tracks of JASON-1, JASON-2, and Envisat altimeters. Thin black lines show curvilinear grid of hydrodynamic model.

Figure 1: Topography and Computational Domain

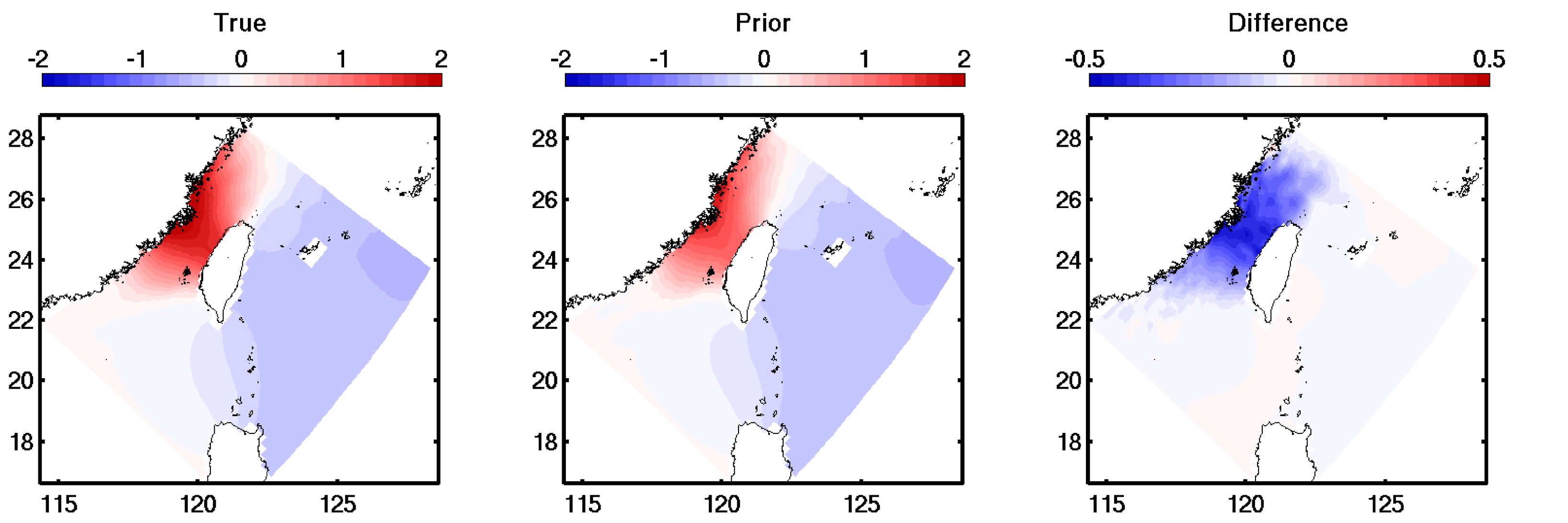


Figure 2: Modeled Sea Surface Height. Tidal SSH computed from S&S v12.1 (left) is visually similar to ETOPO2v2 (middle), except for the reduced tidal amplification in the Strait of Taiwan. The difference field (right) is used to reconstruct the bottom topography. Units of SSH are meters.

Results

Assimilation of SSH along satellite ground tracks in this "identical twin" experiment results in the following:

- In shallow water ($H < 500$m) the bias between S&S v12.1 and ETOPO2v2 is reduced from 4m to 0.3m.
- The root-mean-square error is reduced by almost 15%, with larger improvements occuring to the north and northeast of Taiwan where errors are largest.
- Improving bottom topography by assimilation of SSH appears feasible, at least over the continental shelf.
- Further work is needed to explore sensitivity of results to model resolution, spatial correlation structure of topography errors, SSH data error, and other factors.

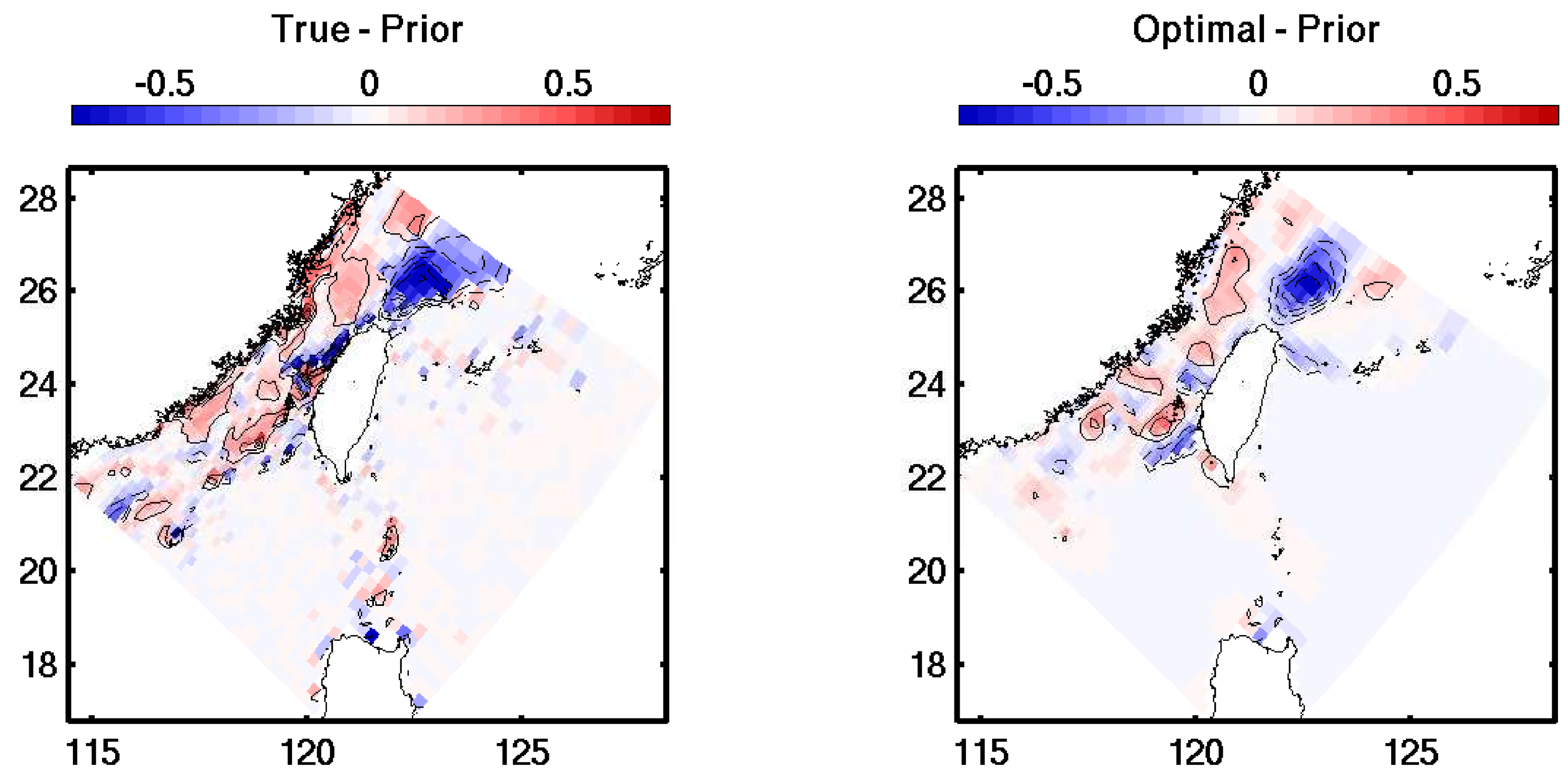


Figure 3: Results. Panels show the fractional topography error, i.e., the difference in topographies divided by the true topography. Left panel: S&S v12.1 minus ETOPO2v2. Right panel: optimal topography minus ETOPO2v2. The optimized topography has corrected the large error located northeast of Taiwan in the prior ETOPO2v2 topography.

For more information: See "Bottom Topography Mapping via Nonlinear Data Assimilation" by Zaron, Pradal, Miller, Blumberg, Georgas, Li, and Cornuelle (2011) *J. Atm. Ocean. Tech.*, to appear.

2011 GEBCO Bathymetric Science Day
La Jolla, CA
October 4, 2011

Edward D. Zaron
Department of Civil and Environmental Engineering
Portland State University
zaron@cee.pdx.edu