5-20-2014

Buoyant and gravity-driven transport on the Waipaoa shelf

J. M. Moriarty
Virginia Institute of Marine Science

C. K. Harris
Virginia Institute of Marine Science

C. T. Friedrichs
Virginia Institute of Marine Science

M. G. Hadfield

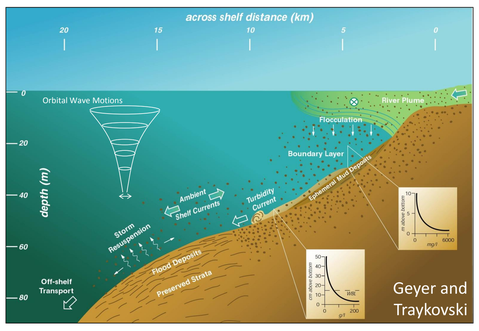
Buoyant and gravity-driven transport on the Waipaoa Shelf

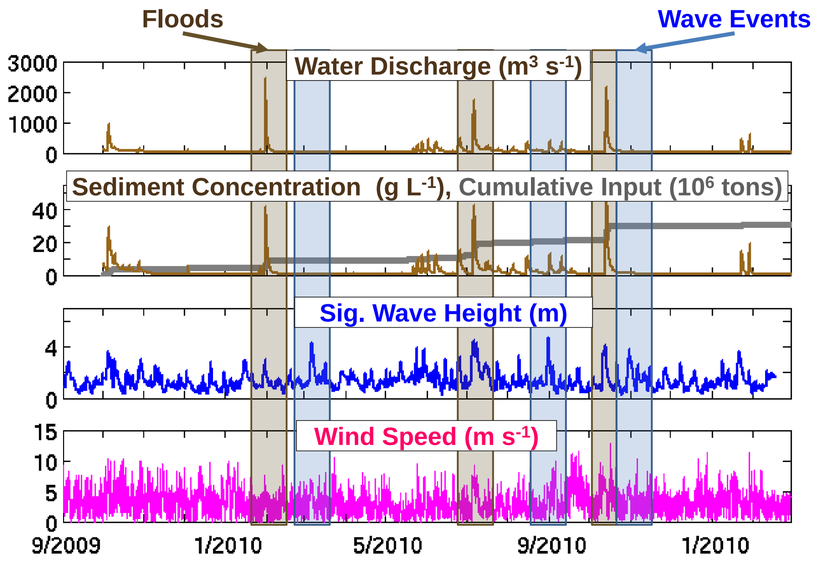
J.M. Moriarty[1], C.K. Harris[1], C.T. Friedrichs[1], M.G. Hadfield[2]

[1]Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, VA, USA [2]National Institute of Water and Atmospheric Research, Wellington, New Zealand

I. Motivation & Methods

Riverine deposits on continental shelves reflect terrestrial signatures, but are typically modified by the marine environment. Partitioning between various transport mechanisms (dilute suspension vs. gravity-driven) may influence the location and characteristics of these deposits.



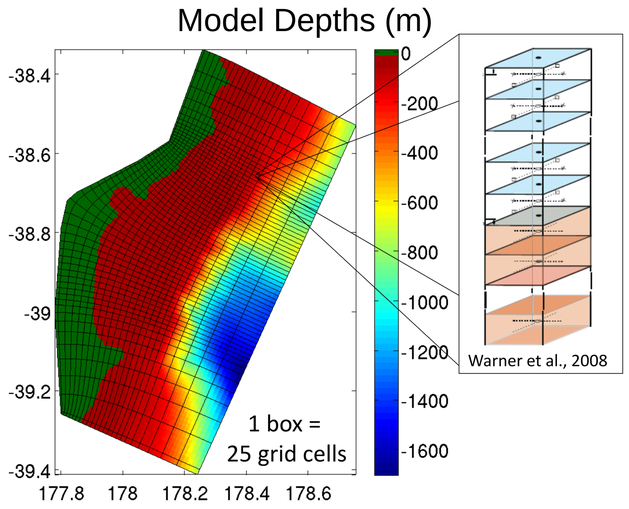


We used two numerical models to analyze sediment fluxes and fate on the continental shelf from January 2010 – February 2011.

Discharge and sediment rating curve: Greg Hall and D. Peacock (Gisborne District Council); Waves: New Zealand Wave model (NZWAVE: Tolman et al., 2001); Winds: New Zealand Limited Area Model (NZLAM: Davies et al., 2005)

Water-column Model: ROMS-CSTMS

Model Depths (m)



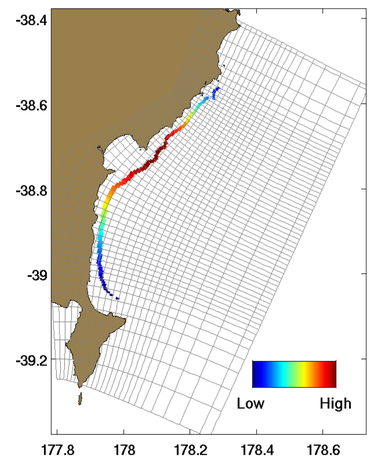
Buoyant fluxes were estimated with a 3D hydrodynamic-sediment transport model described in detail in Moriarty *et al.* (2014).

PROs: Includes water column processes, including river plume behavior, and wave resuspension

CONs: Insufficient vertical resolution for the wave-current boundary layer

Gravity-Flow Model

Initial Sediment Distribution



Wave- and current- driven gravity fluxes were estimated with a 2D Chezy equation model that balances friction and gravity following Ma *et al.* (2010).

PROs: Accounts for near-bed turbid layer; computationally efficient

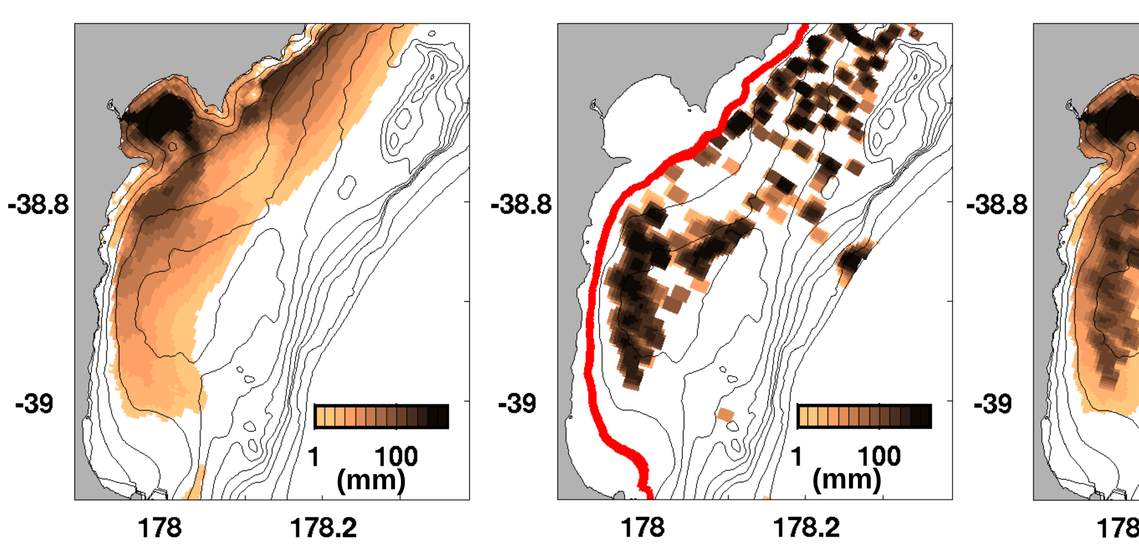
CONs: Cannot account for water column processes

ROMS (Regional Ocean Modeling System): Haidvogel et al., 2000, 2008; Shchepetkin and McWilliams, 2005, 2009; Moriarty et al., 2014. *CSTMS (Community Sediment Transport Modeling System):* Warner et al., 2008. Gravity Flow Model: Scully et al., 2003; Ma et al., 2010

II. Deposition from Buoyant and Gravity-Driven Processes

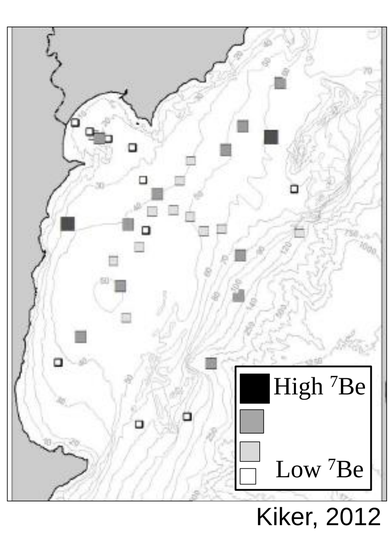
Estimated Deposition: Jan 2010 – Feb 2011

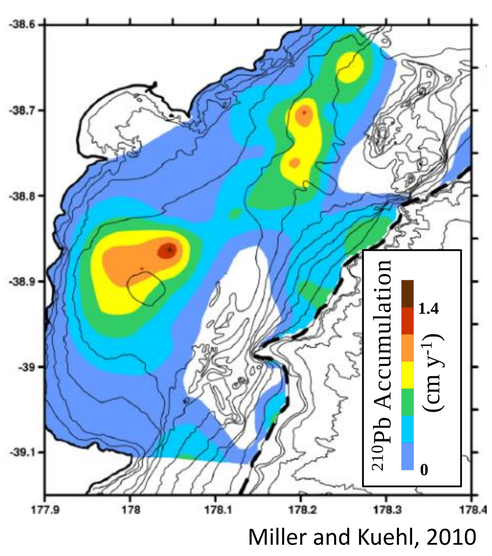
Water Column Model | Gravity Flow Model | Buoyant Transport + Gravity Flows



Observed Radioisotope Signatures:

Recent Deposition: ^{7}Be Inventories, 9/2010 | Long-term Accumulation: ^{210}Pb Accumulation Rates

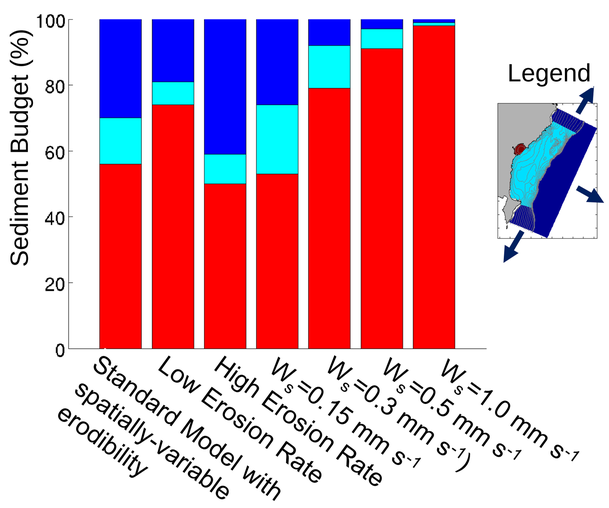




- Transport within the river plume during energetic wave events distributed sediment along-shore, to either side of Poverty Bay.
- Gravity flows transported material to long-term shelf depocenters (50-70 m water depth) and the continental slope during energetic wave events.

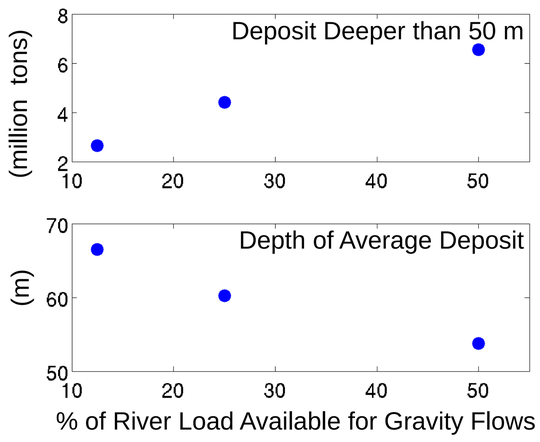
III. Model Sensitivity

Water Column Fluxes



- Slow settling material was dispersed farther from the river mouth and to deeper depths.
- High erosion rate parameters affected the distribution of sediment within Poverty Bay and the shelf.

Gravity Flows



- More sediment input created thicker deposits, but shifted deposition closer to shore, implying that gravity flows on the Waipaoa shelf are transport-limited.
- Spatial distribution of modeled deposits also depended on the along-shore distribution of riverine sediment.

Conclusions

Buoyant fluxes within ROMS-CSTMS

- distributed sediment along-shore, to either side of Poverty Bay.
- did not extend to water deeper than 50 m.
- were especially sensitive to settling velocity.

Wave- and current- gravity flows

- exported sediment to long-term shelf depocenters (50 – 70 m water depth) and to the continental slope.
- were sensitive to parameterizations of sediment input.

Implications

- Both buoyant fluxes and gravity flows can be important for modeling shelf deposition.

Acknowledgements

Funding was provided by NSF MARGINS program, VIMS, and NIWA. Data, feedback, and technical assistance were provided by J.P. Walsh, R. Corbett, A. Ogston, A. Orpin, T. Kniskern, A. Bever, R. Hale, J. Kiker, S. Kuehl, A. Kettner, S. Stephens, M. Uddstrom and the Meterorological and Wave Science Staff at NIWA, G. Hall, D. Peacock, J. McNinch, NOAA, A. Miller, and D. Weiss.

References **Haidvogel**, D. B., Arango, H. G., Hedstrom, K., Beckmann, A., Malanotte-Rizzoli, P., Shchepetkin, A. F., 2000. Dynamics of Atmospheres and Oceans, 32 (3-4). **Haidvogel**, D. B., Arango, H., Budgell, W. P., Cornuelle, B. D., Curchitser, E., Di Lorenzo, E., et al., 2008. Journal of Computational Physics, 227 (7). **Kiker**, J.M., 2012. M.S. Thesis, East Carolina University, Greenville, NC. **Ma**, Y., Friedrichs, C. T., Harris, C. K., Wright, L. D., 2010. Marine Geology, 275 (1-4). **Miller**, A. J., Kuehl, S. A., 2010. Marine Geology, 270 (1-4). **Moriarty**, J.M., Harris, C.K., Hadfield, M.G., 2014. Journal of Marine Science and Engineering, 2 (2). **Scully**, M.E., Friedrichs, C.T., Wright, L.D., 2003. Journal of Geophysical Research, 108: C4. **Shchepetkin**, A. F., McWilliams, J. C. (2005). Ocean Modelling, 9(4). **Shchepetkin**, A. F., McWilliams, J. C. (2009). Journal of Computational Physics, 228 (24). **Warner**, J. C., Sherwood, C. R., Signell, R. P., Harris, C. K., Arango, H. G., 2008. Computers & Geosciences, 34 (10).