OC 664 Modeling Project Assignment

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1 Introduction

A wide range of numerical models exist for predicting sediment transport, ranging from models that simulate individual sand grains and turbulence, to models that lump entire coastlines into a single bulk volume of sand. Currently, a class of models that are seeing a lot of attention are those that predict wave-driven hydrodynamics at horizontal resolution of order 10 m, sufficient to resolve processes like longshore currents, undertow, and rip currents, and their effects on morphological change. Contemporary examples of these models include XBeach, COAWST (ROMS), and Delft3D. These models cannot resolve the wave boundary layer, nor do they resolve individual waves, hence they require *parameterizations* in order to predict sediment transport. Such parameterizations aim to encapsulate the processes that we know are important, like bed shear stress, wave shape (skewness and asymmetry), and sediment suspension and deposition.

Many parameterizations exist and have been coded into models. In fact, models often include multiple parameterizations that can be turned on and off depending on user preference. Currently, there is no "winning" set of parameterizations that all modelers agree is best. However, a current state-of-the-art set of parameterizations were recently proposed by van der A et al. (2013), also know as the SANTOSS formulas. These are now being coded into models like COAWST.

2 Assignment

As a class, we will code the SANTOSS formulas from van der A et al. (2013) (hereafter VDA13) and use them to make predictions of sediment transport from field data. Note that the SANTOSS model is actually a synthesis of multiple sub-models, representing individual processes that have been previously studied and quantified by the research community. You will each be assigned one of the sub-models to study and implement in code. You'll then merge your codes together to solve for an overall sediment transport rate, equation (1) in VDA13. As a group it is your responsibility to coordinate your coding conventions and methods of sharing and debugging code, to solve the problem.

3 Important Simplifications

To make your task more tractable, we will add some simplifications to the VDA13 model. **IMPORTANT: Before you begin coding, read through the below list to avoid over-complicating your efforts and causing confusion!**

- Uni-directional waves. We will only consider waves propagating in the x-direction. You do not need to include wave angle in your codes.
- Fixed grainsize distribution. We will neglect the "Graded sand" formulations described in section 2.4. Assume static values for d_{50}, d_{90}, etc., will be provided as user inputs to your code.
- Neglect vertical fluid velocities. We will assume tunnel-like flow in which $w_{st} = w_{sc} = w_s$ (equations (29)–(30)).

4 Tasks and Deadlines

Start by reading the VDA13 paper. As a guide, attached you will find a partially-completed "formula tree" diagram showing the relevant VDA13 formulas. These formulas have been split into 8 categories, denoted by shaded boxes, and listed in the table below along with a reference paper (these papers will be posted on Canvas). Each of you will be assigned to one of the categories[1].

Category Label	Description	Article
A	Intra wave data extraction	[Elfrink et al., 2006]
B	Entrained sand load	[Ribberink, 1998]
C1	Wave-related friction factor	[Smyth and Hay, 2002]
C2	Current-related friction factor	[Grant and Madsen, 1979]
D	Ripple model	[O'Donoghue et al., 2006]
E	Phase lag effect	[Kranenburg et al., 2013]
F	Sheet flow layer thickness	[Dohmen-Janssen et al., 2001]
G	Main function, and github admin	[Ribberink et al., 2013]

The assignment itself is split into 3 tasks:

1. **Overview: Due April 24 (10% weight).**

    a. Become familiar with the physical process involved in your assigned category. Write a short paragraph describing what the process is and how it influences sediment transport, and send to me by **April 24**.

2. **Class Presentation: May 1 (30% weight).**

    a. Select a journal article related to your topic, either from the recommendation above, the VDA13 bibliography, or another of your choice. Prepare a 5-minute class presentation summarizing (i) the process in question, and (ii) the main related findings from the article. Send a final copy of your presentation slides to me by COB **April 30**, so I can have them loaded for your presentation.

    b. Present your 5-min summary in class on **May 1**.

3. **Coding Prep: Due May 13 (20% weight).** For your assigned category, do the following.

    a. Add connecting lines to the provided "formula tree" diagram to indicate the inputs and outputs of each formula within your category. For example, equation (A.3) requires knowing f_w, which comes from equation (A.4); so draw a line connecting those two equations. This should help you visualize how the formulas fit together, and hence how they need to be implemented in code.

    b. Some of your connecting lines from part (a) will extend into another class member's category, indicating your equations depend on theirs. Contact them to coordinate, and add input/output connecting lines to both of your diagrams.

    c. Identify any variables that do not come from formulas, such as physical constants, tuning parameters, and external inputs.

    d. Write code implementing the formulas in your category. Organize your code so that, given the required inputs, it will produce the required outputs — as you identified in part (b).

    e. Send your formula tree to me, and upload your code to github, by **May 13**. Your submission will be evaluated based on organization and documentation, less so on the correctness of your code. Remember to include appropriate code comments.

[1] You can swap topic assignments with someone else if you wish, but please let me know if you do.

4. **Model Validation: Due May 20 (40% weight).** Finally, combine your individual codes to solve for Equation (1) in VDA13. You will be working with near-bed velocity time series from the Sandyduck experiment (as in Homework #1). Your task is to produce a single code that predicts the net sediment transport rate based on the measured conditions. Work as a team to integrate your components together. Some notes:

   - Your group submission on **May 20** should take the form of a report that describes the test case and your validation results. The report should be 10 pages or less, and may include text/figures you made in earlier parts of the assignment. You will be graded mainly on your critical evaluation of the field validation results. Please upload the report to your github repo, and send me a link.
   - Please use github for your communications as much as possible. This will help keep everyone in the loop, and will help me understand the contributions of different group members.

References

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