EOS 423 // EOS 518

Lab 2.2: Using Fourier Analysis to interpret Modeled Basins

Due: 1:30 pm March 10, 2023

You have one week to complete this assignment and upload your responses as a PDF to Brightspace. You are not excluded from working with others (pairs are recommended), but each person will submit their own copy of the assignment. **Responses to questions should be typed, using complete sentences and standard grammar.** Double check that your image resolution is high enough to read. If you write your response in a word processor, please export to .PDF before submitting your response.

A pair of students will be randomly selected on Monday to initiate and lead a discussion of the assignment. Be prepared to show your progress and discuss any challenges you still face.

Name: ______________________________

Question	1	2	**Total:**
Marks:	19	11	30
Score:			

1 Introduction

In this assignment, you will analyze model outputs from your 1D sedimentary transport model. I have provided a jupyter notebook with code that includes a 1D transport model and some functions to extract stratigraphic columns and time series of parasequence thicknesses from the model output.

Questions

Question 1 (19)

The provided notebook has been set to initial conditions that are very similar to the hypothesized sea level history for the Latemar platform carbonates that we read about in **Spectral analysis of the Middle Triassic Latemar limestone** by Linda Hinnov and Robert Goldhammer (1991). There is an asymmetric sea level signal with an amplitude of 2 meters that repeats every 100,000 years and a sinusoidal sea level signal with an amplitude of 3 meters repeats every 20,000 years. In this question you will explore how sedimentation and subsidence rates affect the preservation of cyclicity in parasequence thicknesses.

(a) (2 points) Run the model with all of the provided initial conditions and plot a time series of the parasequence thicknesses (vertical distance between flooding surfaces) for at least three stratigraphic columns across your model (select columns from the left, middle, and right sides).

(b) (3 points) Remove the mean parasequence thickness from each time series and plot the cumulative sum (np.cumsum) of these modified time series. How are these new plots related to the sea level history in your basin? Include a cartoon or figure showing the ideal scenario in your response. Take note of differences between sections and describe the possible causes for those differences, if there are any.

(c) (2 points) Using the same three stratigraphic columns, make a figure with an upper sub-plot showing parasequence thickness vs. parasequence number and the lower sub-plot of showing the discrete Fourier transform frequency spectrum of this dataset (frequency on the x-axis and amplitude on the y-axis). *This figure is the same style of figure you made in the previous assignment.*)

(d) (2 points) Interpret the frequency spectrum of the three datasets in the context of the known sea level boundary condition. What frequency should you see, given the sea level boundary condition?

(e) (2 points) Create the same figure as in part **C** using the de-meaned cumulative sum of parasequence thicknesses that you created in part **B**.

(f) (2 points) Interpret the frequency spectrum of the three datasets in the context of the known sea level boundary condition. If the results are different than part **C**, how and **why** are they different?

(g) (2 points) The preservation potential of the modeled sea level boundary condition depends on the subsidence rate and sedimentation rate in your model. What minimum conditions must be true to preserve **every** sea level cycle with a parasequence (describe in words)?

(h) (2 points) Make the necessary changes to your boundary conditions (sedimentation rate and/or subsidence rate) and rerun the model. Repeat the analysis from part **C** or **E** (choose the one that you believe to be more useful) and provide a figure showing that analysis for your three stratigraphic columns.

(i) (2 points) Interpret the frequency spectrum of the new model output in the context of the known sea level boundary condition. *Hint: you should be able to resolve the true ratio of the two sea level cycles at least somewhere in this final model.*

Question 2 (11)

An autocylic model Shallowing or coursening-upward parasequences are indicative of coastline or sediment source motion (progradation). This fundamental building block of the sedimentary record occurs even when local sea level is rising. In this question, you will use your model to create basin of stacked parasequences without invoking variations in sea level.

Start with the original model from question 1. Remove the periodic components from your sea level boundary condition. Set the total subsidence rate to 200 meters over the model run time of 3 million years, and set coastal sediment flux rate to 0.08 m^2 per year.

You will now model scenario that could represent a nearby river delta avulsing periodically, sometimes sending sediment towards our modeled location and sometimes sending sediment elsewhere. To do this, your sediment flux will alternates between an **ON** and **OFF** state with a fixed probability of a switch occuring that is equal to **0.001** per year. During the **OFF** state sediment flux should be 0, and during the **ON** state the sediment flux should be equal to 2 meters squared per year. To calculate whether or not the flux should switch during each year, you can use np.random.uniform(0,1,1) to draw a random value (uniformly) from 0 to 1. If that value is less than **0.001** the sedimentation rate in the model should switch its state (from **ON** to **OFF** or **OFF** to **ON**.)

(a) (8 points) Extract at least five parasequence time series from your model run. Anaylze these parasequences using the skills you developed in question 1. Your boundary condition in this model run is entirely random. Do any non-random patterns emerge in your model run? If so, how can you test or show that these patterns (cycles in space) are not related to sea level cycles (cycles in time)?

(b) (3 points) Speculate on (or explore with the model) the relationship between the frequency of avulsion (the probability of switching ON/OFF) and the thickness of parasequences.