General notes:

- Pg. 6, last paragraph → zoom into this conceptually, put into context of this proposal, and dive deeper
- Examine Section 3.3 in Strobach paper (re-read whole paper)
- An idea to add in: currently using data from CM2.6, compare with data from other GCMs with high resolution (e.g. model from Strobach paper)

1. Title of the Proposal

Example: "Diagnostics of Air-Sea Fluxes and Their Impact on Submesoscale Dynamics"

2. Introduction

- **Context**: Begin by providing background on the importance of air-sea interactions, particularly in relation to submesoscale dynamics, which refer to phenomena at smaller scales (10 km to 100 km) in ocean currents.
- **Relevance**: Mention the significance of understanding air-sea fluxes, as outlined in the White-paper, and how these fluxes influence weather patterns, ocean circulation, and climate.
- **Purpose**: State the purpose of the project: to diagnose and quantify the effects of air-sea fluxes on submesoscale phenomena, which remain poorly understood but have considerable impacts on oceanic and atmospheric processes.

3. Theoretical Framework & Background

- Provide a brief summary of the key concepts from the White-paper, such as:
  - **Submesoscale Dynamics**: Small-scale oceanic currents, eddies, and turbulence that are highly influenced by surface forcing (wind, heat, etc.).
  - **Air-Sea Fluxes**: Exchange of momentum, heat, and moisture between the atmosphere and ocean surface.
  - **Impact on Climate and Weather**: Discuss the link between these small-scale processes and larger climate systems (e.g., El Niño, ocean heat content, etc.).

4. Research Objectives

- **Primary Objective**: To provide comprehensive diagnostics that assess the influence of SGS air-sea fluxes (e.g., heat, momentum, and freshwater fluxes) on various processes
- **Sub-objectives**:
  - Identify key processes and mechanisms that control air-sea interactions at submesoscale.
  - Quantify the impact of these fluxes on local ocean currents and atmospheric conditions.

    - Explore the role of submesoscale processes in larger-scale climate and weather systems.

5. Methodology

- **Step 1:**
    - Compute high-res, low-res, SGS fluxes for each data type (satellite observations, in-situ measurements, coupled & uncoupled GCMs)
    - Very few actual in-situ measurements, but maybe use ERA5 instead? ERA5 is made up of both model and observation data, so it is a good halfway point
    - Use AeroBulk to do so
- **Step 2:**
    - Examine the differences in high-res, low-res, SGS flux between data types
    - Explore datasets to understand where these differences come from (e.g. machinery used for observations, GCM biases, etc)
- **Step 3:**
    - Examine how SGS air-sea interactions affect various BL-related processes
        - Marine heat waves
        - Coastal upwelling
        - Ocean-ice-atmosphere interaction
        - Energetics in the BL
        - Western boundary currents
- **Step 4:**
    - Turn on/off certain components in GCMs and determine how this affects SGS air-sea flux calculations
    - Does this shed light on how the different components of bulk formulae equations contribute to flux calculations?

6. Expected Outcomes

- Quantification of how SGS air-sea fluxes influence boundary-layer dynamics.
- Improved understanding of how these fluxes contribute to energy transfer in the ocean-atmosphere system.
- Insight into the role of submesoscale interactions in larger climate systems (i.e., how small-scale processes impact broader weather and climate patterns).
- A diagnostic framework that can be applied in future studies of submesoscale processes.

7. Impact

- **Scientific Contribution**: The project would contribute to the understanding of air-sea interaction processes between the submesoscale and larger scales, which is a key gap in current climate modeling and prediction efforts.

- **Practical Application**: The findings could be used to refine climate models, improve weather predictions, and assist in better forecasting of oceanic phenomena.
- **Broader Implications**: The study could help understand regional climate variability, including effects on coastal ecosystems, fisheries, and extreme weather events.

Rewrite 11/20/24:

Research Plan: Quantifying Uncertainties in Air-Sea Fluxes

Objective:
Investigate how varying spatial model resolutions (from climate models to LES) affect bulk exchange coefficients for air-sea fluxes

1. Recompute Exchange Coefficients

- Calculate exchange coefficients within the 10 min - 1 hr temporal range.
- Analyze how these recalculations impact flux estimates

2. Quantify Uncertainties

- Assess how flux uncertainties propagate across model scales.
- *No idea how to do this?*

3. Model Comparison

- Steps 1&2 for ocean-only and coupled atmosphere-ocean models
    - Account for all types of coupling we've read about (e.g. one stationary component, averagign feedbacks, etc)
- Examine differences in flux representation.

4. Recommendations

- Suggest improvements to bulk parameterizations for more accurate air-sea flux predictions at smaller scales.
- *Maybe this is a launching point for the next research project?*