Parameterizing Role of Eddies in Climate Models

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17 participants

Major points:

1. Low resolution models, like 1 degree, will be continued to be used for certain purposes for the foreseeable future, so high quality eddy parameterizations are important.
2. Current implementations in global ocean models have been improving since 1990s, and are highly tuned to quantitative metrics in global simulations (MOC, MHT, Drake passage throughflow, etc)
3. New parameterizations are important, but must ultimately be tested in realistic domains and compared against the state of the art implementations in global models.

Action Items:

1. We need to have a standardized framework to compare all these different parameterizations, including:
    a. model settings,
    b. code for parameterizations
    c. list of diagnostics
    d. data for comparison
2. Energy closures are important. We should focus more on what might be missing from parameterisations – focus on parameterizing eddy energy.
3. We have lots of high-resolution simulation parked here and there. Cataloging existing runs would be very useful, whilst accepting making data available is expensive.

Other topics discussed:

1. Current parameterizations may not work for many situations.
    a. different spatial regimes
    b. 2D turbulence on coasts versus open ocean (Alastair Adcroft)
    c. topography

    d. GM not working for Arctic eddies (Qiang Wang)
2. Is there one theory that could cover all this, or are many needed? There were concerns about having too many parameterizations in one model.
3. AI and machine learning holds great promise, but potentially at the price of less understanding of the underlying physics. (Laur Zanna and Alexander Gavrikov)
4. Concern over non-physical conflation of skew and eddy tensors (Bolus versus Redi) (Alastair Adcroft)
5. Air-sea exchange and bulk formula in coupled models are tuned to observations. Are parameterizations needed for coupling and validation? (Hyodae Seo)

Los Alamos, NM. One hour ago.

Model/Obs diagnostics of energy transfer across scales

Why do we care about meso-scale energetics and cross-scale energy exchanges?

- Refine our understanding of W & F budgets—regional specificity, temporal variability
- Improving models that do not represent the meso-scale
  - Improving eddy-closures: GM coefficients, GEOMETRIC
  - Constraints on diapycnal mixing
  - Representing impacts of air-sea coupling at fine scales
- Improving models that (partially) resolve meso-scales
  - Process-driven validation of models (beyond model-data misfits)
  - Closing energetics of eddying models
  - May improve forecast skill in operational models

What are the target quantities we want?

- Exchanges of both mechanical and thermal energy appear to be important
- Do we have all the terms for constraining meso-scale/sub-grid energy equations? Sources, sinks, fluxes. Possibly formulating an inverse problem
- Do we have all the terms for constraining meso-scale/sub-grid tracer variance equations? Important for air-sea interactions and stochastic closures
- Do we target theory-driven budgets or specific informative metrics (velocity structure functions)?
- Do we need a 3D or depth integrated description: Partitioning of energy in the vertical.
- Little is known about deep ocean energetics—interaction of eddies with bottom. Evidence suggests they are important.

Data sources and gaps

- Most existing observations could be leveraged
  - Examples: High-res surface velocity, Argo, Current meters, global drifters, etc.
- How to use upcoming datasets:
  - SWOT, deep Argo, Satellite surface currents
- How to design field campaigns for sampling log-normal distributions?
- Can we use models to help design an observational experiment
- Gap in land/ocean interface makes budget computations difficult

Global Energy Budget Breakout

Consistent Energetics Framework

- Problems with definition of *Available Potential Energy*
  - What is appropriate reference state?
  - Does definition matter for source/sink terms?
  - Is it still a useful concept?
    - Even if it does not naturally follow from PE budget?
  - Should ocean models routinely output energy balance diagnostics?
    - Kinetic energy budget is hard to diagnose, but it is possible
    - Potential energy is very complicated and expensive to diagnose correctly

What don’t we know about energetics

- What is maximum model for which we understand energetics?
  - QG, stacked shallow-water?
  - Linear EOS? Nonlinear EOS?

What we don’t know about sources

- Wind
- Is buoyancy source important (as in those that favor APE)?

What we don’t know about sinks

- What is bottom drag?
  - Bottom form stress does not dissipate energy
- Is there an important interior sink?
  - How do mesoscale eddies lose balance?
- Energy loss to atmosphere through relative winds

What we don’t know about transfers

- Is paradigm of mesoscale energizing submesoscale well established?
  - Some think submesoscale energized by turbulence
- Is modal decomposition appropriate way to frame transfer of energy through scales?
  - How do you define those modes (e.g., in presence of bathymetry?)
- It is important to resolve ambiguity of transfer diagnostics
  - Is Galilean Invariance a property of our energy transfer diagnostics?