

Workshop Outputs

- Meeting reports – US-CLIVAR/CLIVAR
- Contentious questions
 - OMDP and SOC, distributed for comment to workshop participants
- JAMES paper
 - State of science
 - Future directions
 - Open questions
 - Leads: SOC+
 - Opportunity to contribute, distributed for comment to workshop participants
 - Use feedback from breakouts to structure
 - Contentious questions, known knowns, known unknowns

Breakouts

1. Parameterizing the role of eddies in climate
2. What we don't know about the global energy budget
3. Model/Obs diagnosis of energy transfer across scales.

Parameterizing the role of eddies in climate

- Higher level energy closure
- different spatial regimes, coasts, topography
- Stochastic and AI ...
- GM not working for Arctic eddies
- Non-physical conflation of skew and eddy tensors
- Air-sea exchange and bulk formula
- RECOMMENDATIONS
 - Energy closure and what might be missing from parameterisations – focus on parameterizing eddy energy.
 - Have lots of high-res simulation parked here and there. Cataloging existing runs would be very useful, whilst accepting making data available is expensive.

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?

Thanks

- Sponsors
- Scientific Organising Committee
- Program Organising Committee – Mike, Jeff, Jennie
- Eric Chassignet and local hosts FSU
- OMDP and Liping Yin (CLIVAR)