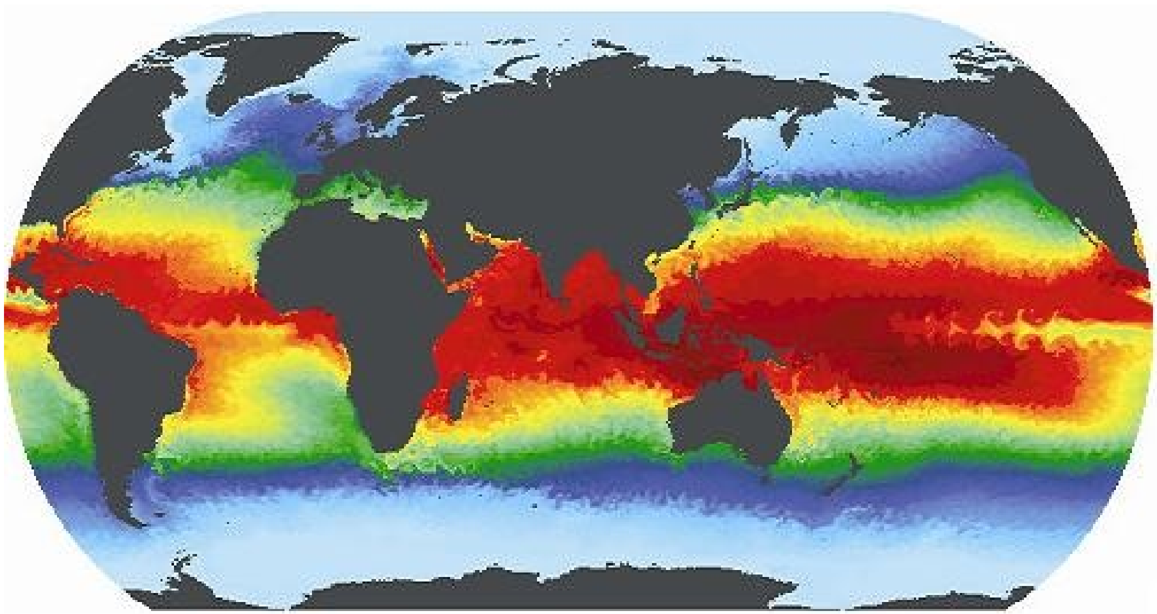
Metrics for the CCSM Ocean Model

Steven Jayne
Julie McClean



CCSM Ocean Working Group meeting

Introduction

- How well is an ocean model doing at simulating the true ocean dynamics?
- What is the most important thing to get right? SST?
- There are a lot of ocean observations, but much of them have not been synthesized into usable forms for model validation.
- What about paleo and climate change scenarios?

Verification, Validation and Confirmation of Numerical Models in the Earth Sciences

Naomi Oreskes, Kristin Shrader-Frechette, and Kenneth Belitz

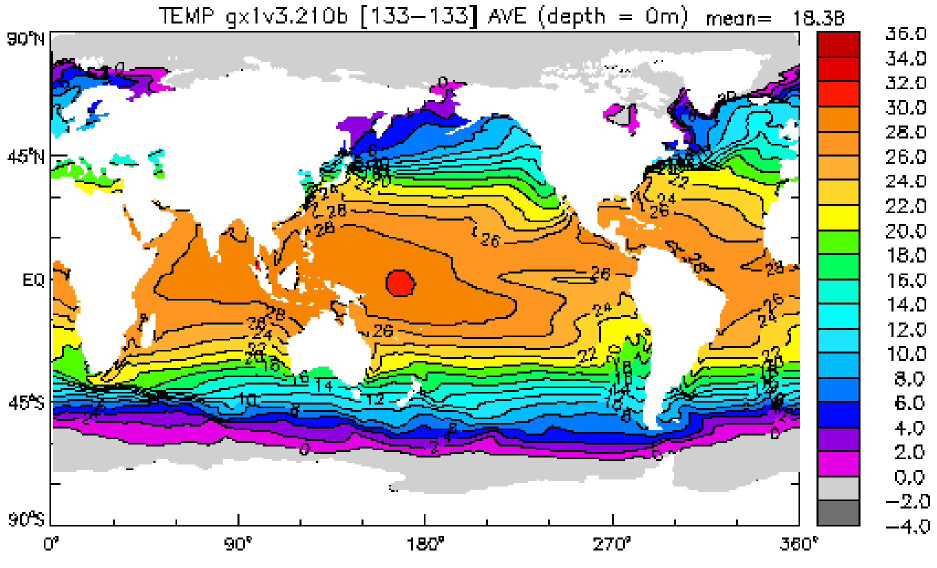
Verification and validation of numerical models of natural systems is impossible. This is because natural systems are never closed and because models results are always non-unique. Models can be confirmed by the demonstration of agreement between observation and prediction, but confirmation is inherently partial. Complete confirmation is logically precluded by the fallacy of affirming the consequent and by incomplete access to natural phenomena. Models can only be evaluated in relative terms, and their predictive value is always open to question. The primary value of models is heuristic.

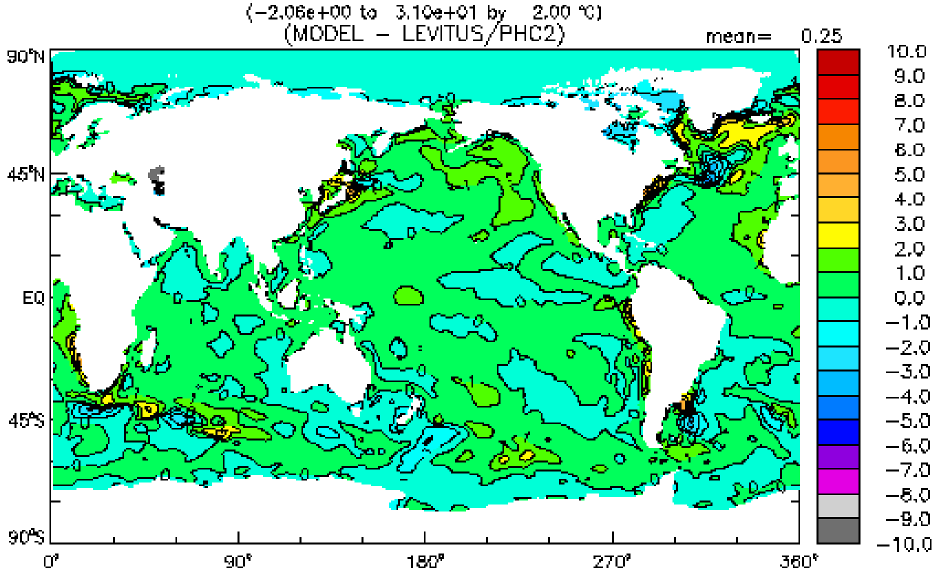
Science, volume 263, page 641-646, 4 February 1994

Current practice

- Compare against gridded hydrography
- Transports: Drake Passage, ITF, MOC
- Tracers: CFC-11, CFC-12
- Sea surface height from altimetry
- El Niño indices
- Sea surface temperature and salinity
- WOCE sections, XBT lines
- Surface drifter velocities

Example from current practice





CCSM Ocean Working Group meeting

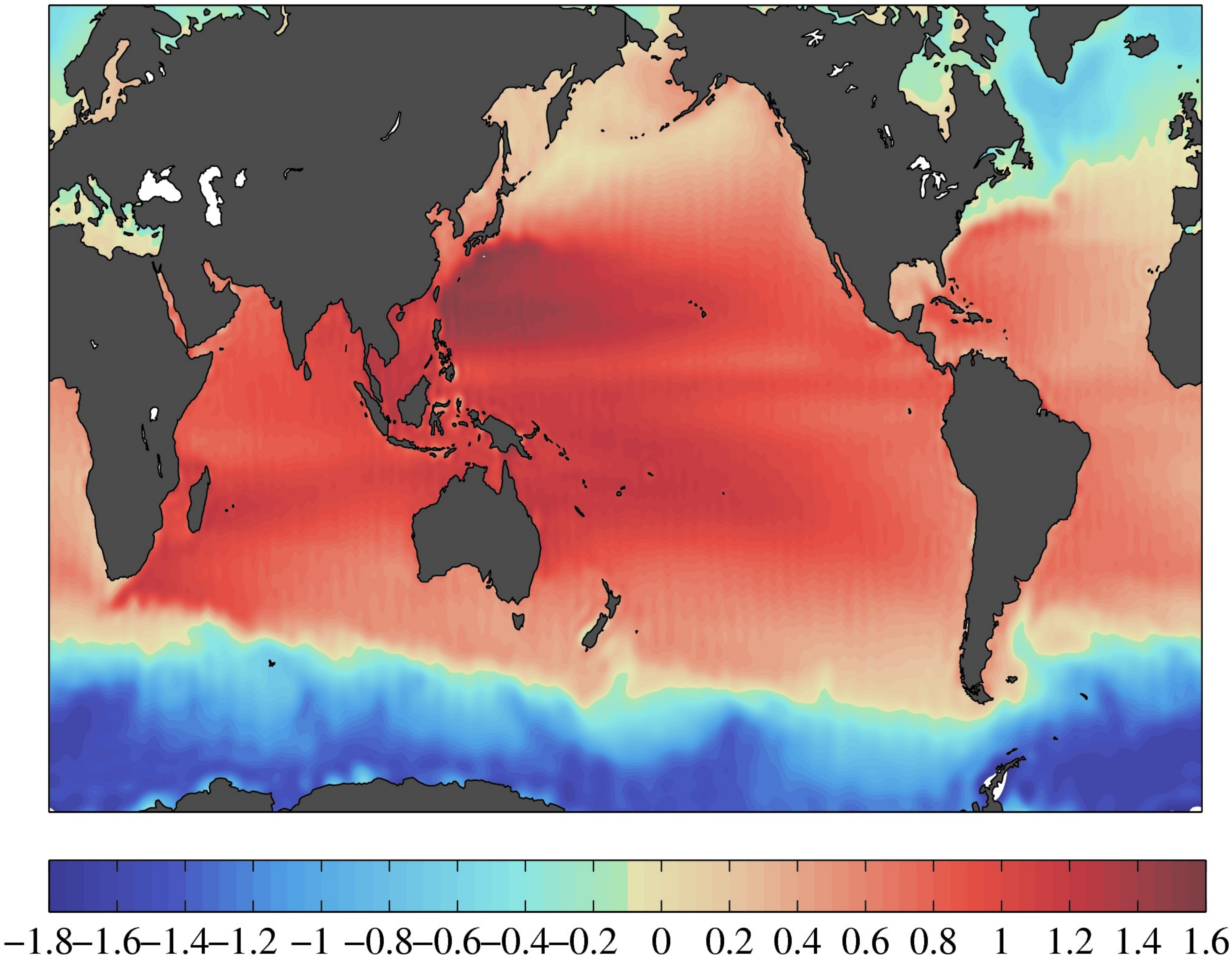
WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

Deterministic fields used as metrics

- Temporal-mean hydrography, tracers, CFCs
- Annual cycle, semi-annual cycle
- Transports: Drake Passage, Florida Straits, MOC
- Temporal-mean sea surface height, mean current paths, from altimetry and drifters
- EOFs of sea surface height from altimetry, basin modes from GRACE
- El Niño indices in forced runs
- Poleward heat transport

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

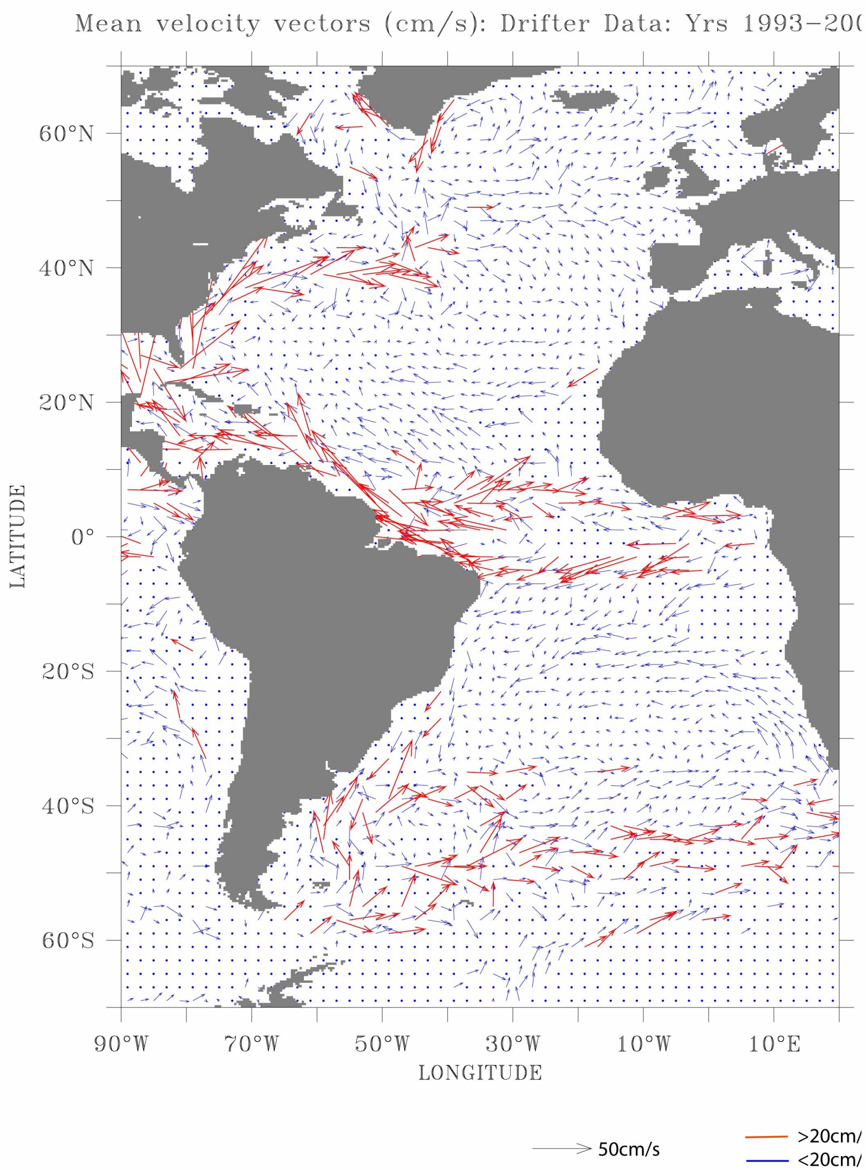
Mean sea surface height

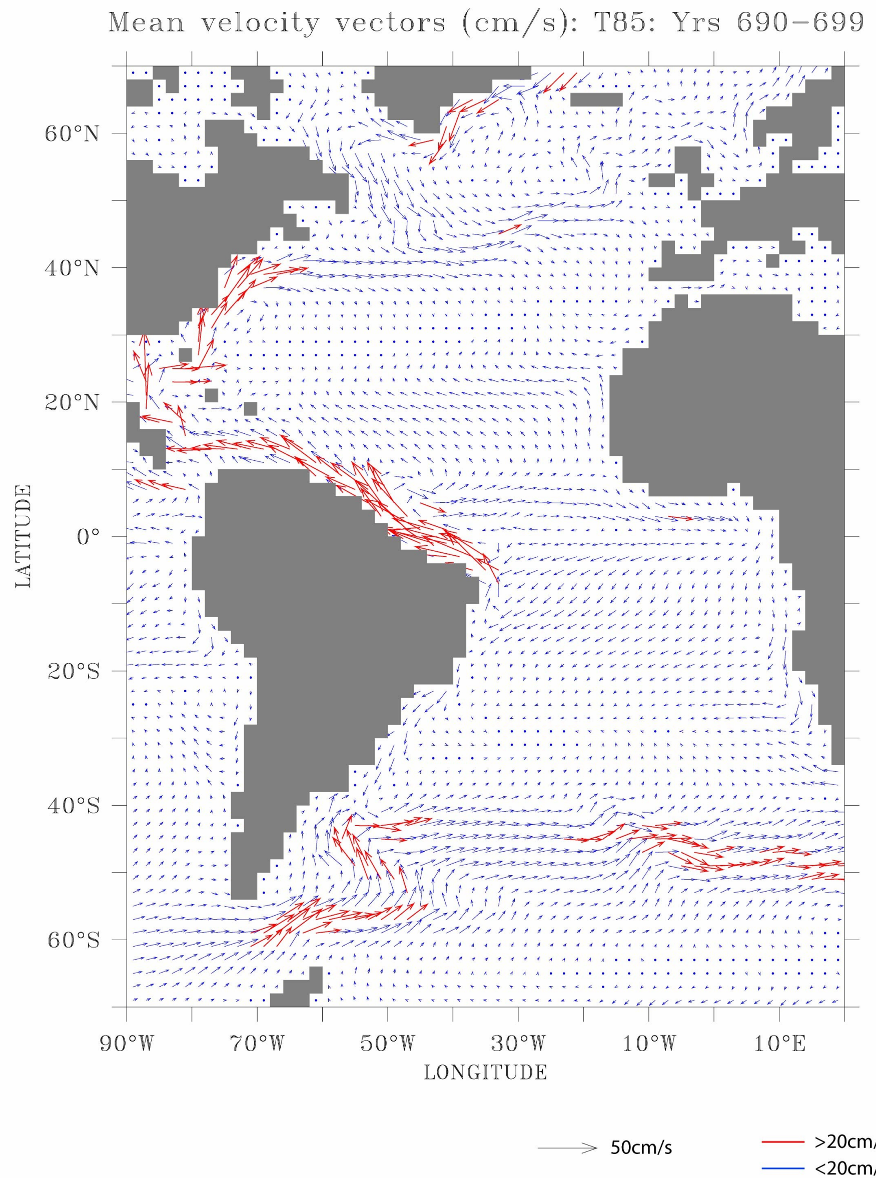


CCSM Ocean Working Group meeting

WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

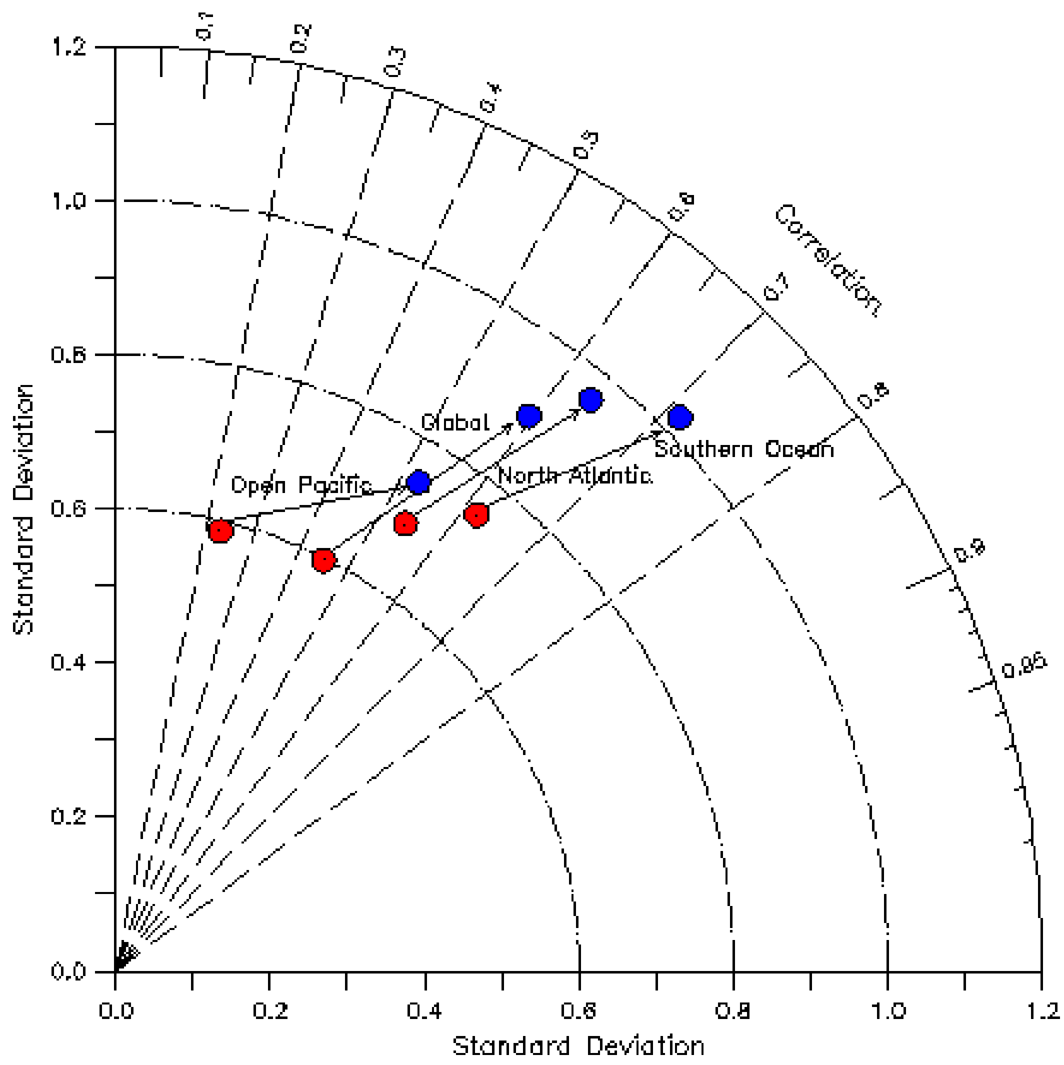
Drifter Comparison to CCSM3/T85





1930

Taylor Diagram for SSH anomaly

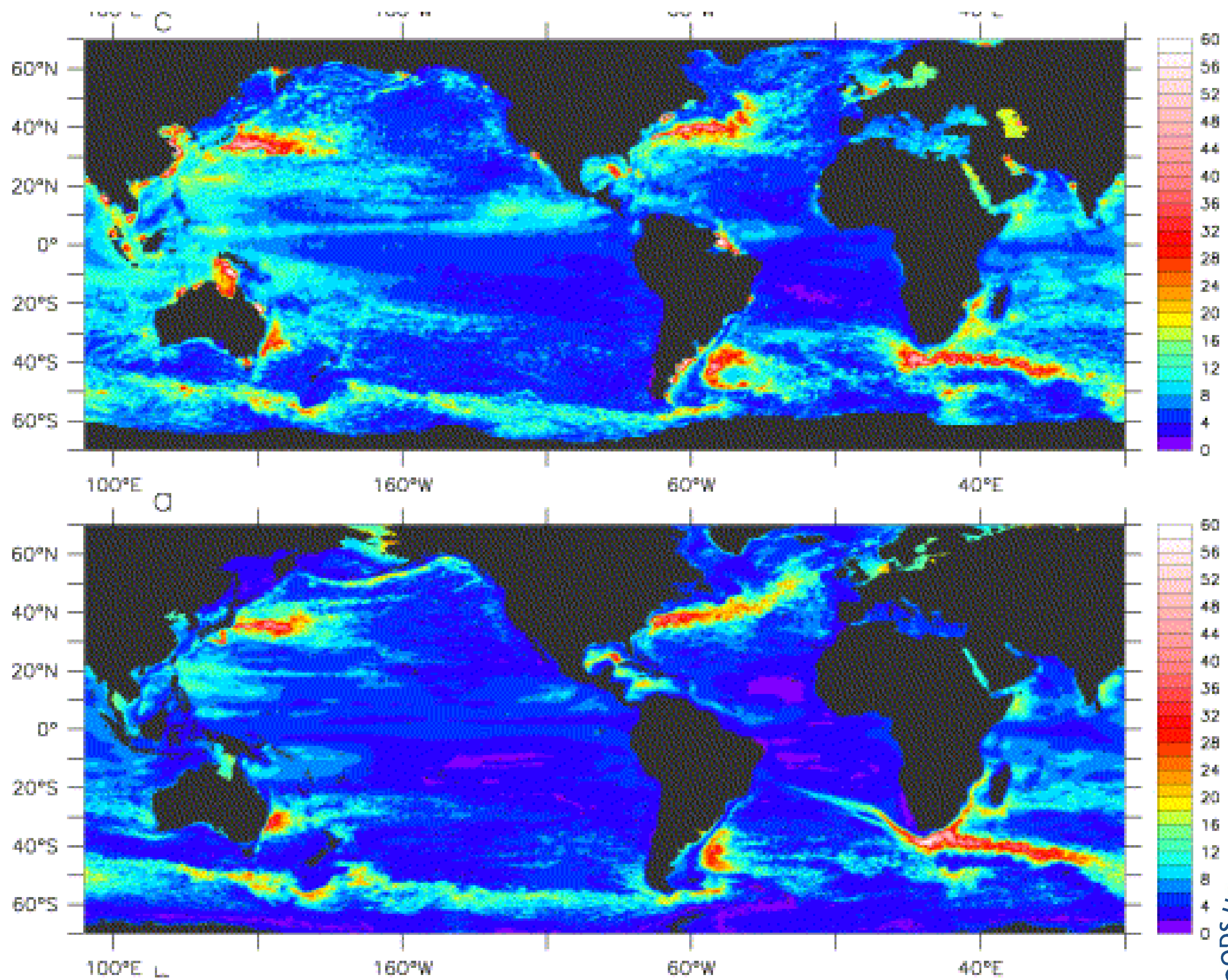


CCSM Ocean Working Group meeting

Stochastic fields used as metrics

- Eddy kinetic energy or SSH variance for mesoscale eddies and tropical instability waves
- Agulhas Rings – number and path
- Kuroshio path mode?
- El Niño indices in coupled runs

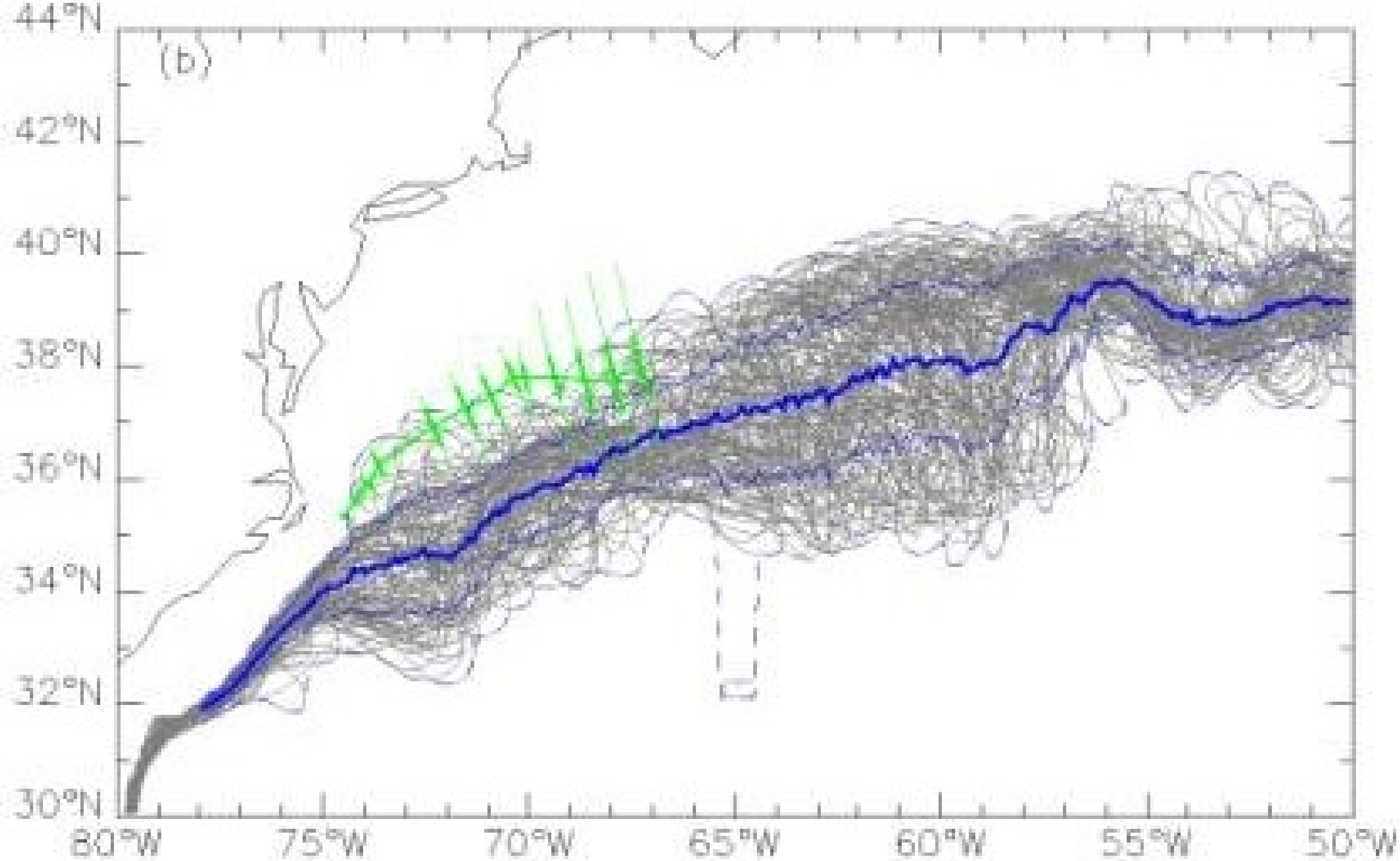
Sea surface height varibilty



CCSM Ocean Working Group meeting

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

Gulf Stream path



Ocean dynamics as metrics

- Maybe the simulated ocean state is wrong because of incorrect forcing, but the model is doing the right physics, how do we assess that?
- Correlations between SSH and heat content
- Reynolds stresses

Western Boundary Current Dynamics as a Model Metric

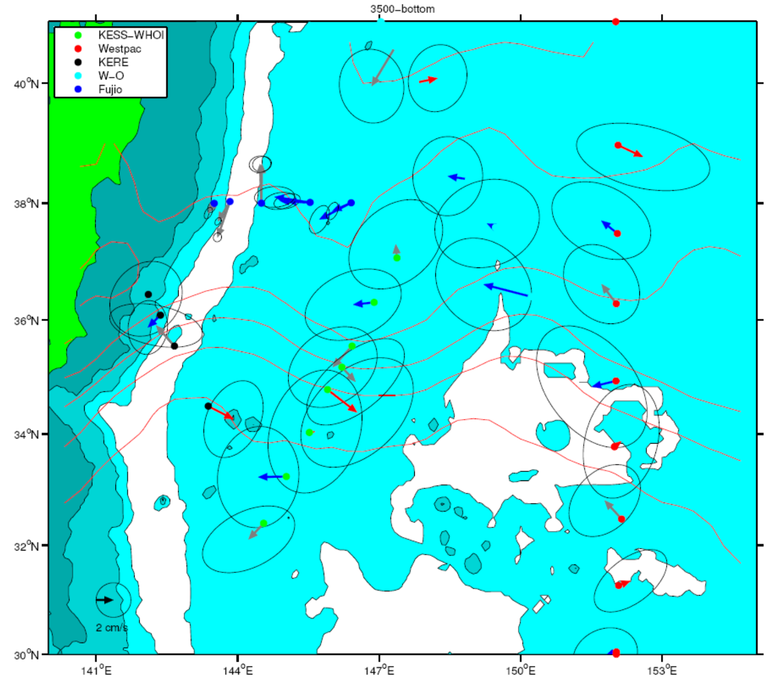
Steven Jayne and Stephanie Waterman

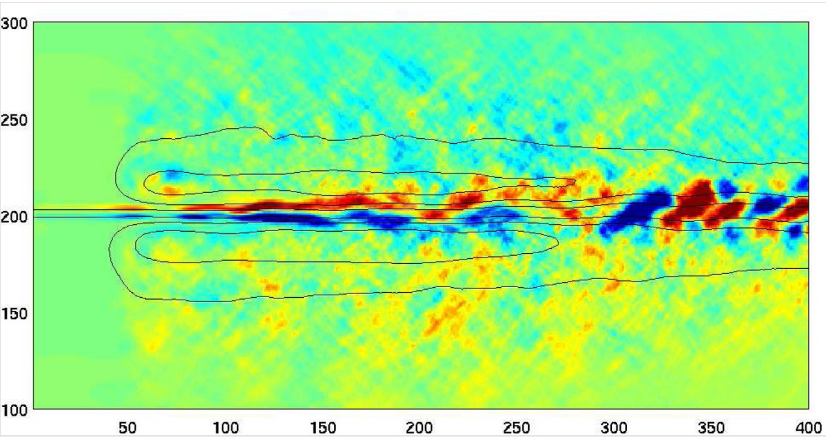
Quote from a paper I recently reviewed: “Finally, we emphasize that observational data need to be accumulated and diagnosed to evaluate the validity of model diagnoses.”

The Reynolds stresses can be used as a possible diagnostic model metric since they are observable in the ocean

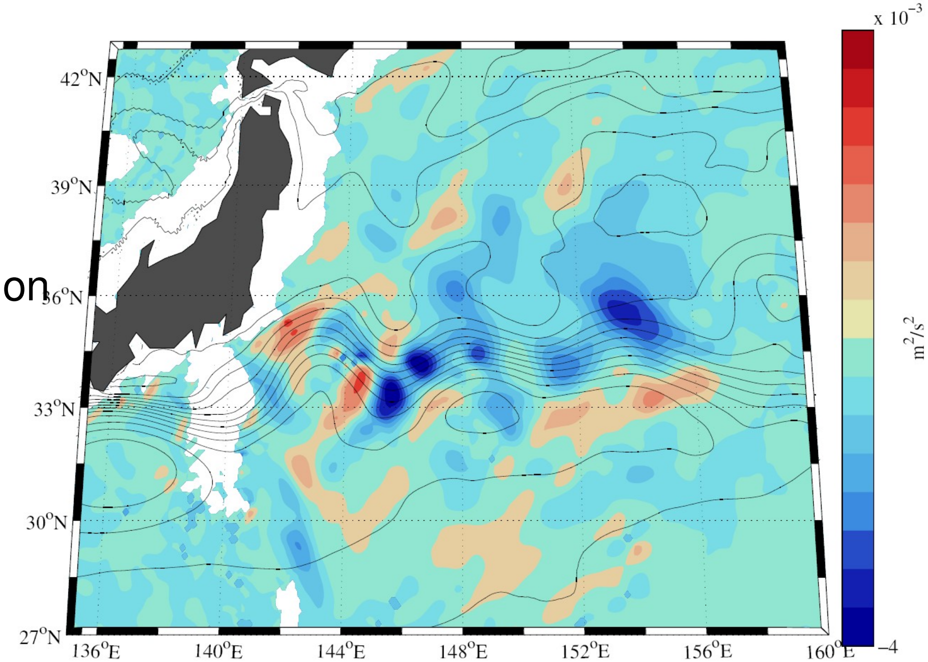
Other “eddy” quantities can derived, but they would require 2-dimensional coherent arrays in order to take derivatives

What can Reynolds stresses tell us about the jet's dynamics?





←Using QG models we can try to under- stand high-resolution PE models →



CCSM Ocean Working Group meeting

Long-timescale integration issues

- If we want to do integrations of hundreds of years in duration, how do we judge the fidelity of the model over long timescales?
- What do we force such a simulation with? It is not clear that present day forcing (e.g. normal year or reanalysis) is in equilibrium with the present day ocean (or even that it should be).
- Forcing fields before 1950s are not available, forcing fields before 1970s are questionable

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

Ocean state estimates

- "Routine" analyses and re-analyses are still in their infancy for the ocean, but they have to developed enough that we should be utilizing them.
- ECCO and SODA-POP represent the best available estimates. ECCO is a full data-assimilation model (adjoint method), SODA-POP is an optimal interpolation method
- CCSM OWG should consider enhanced cooperation with the ECCO and SODA-POP efforts

What do we want?