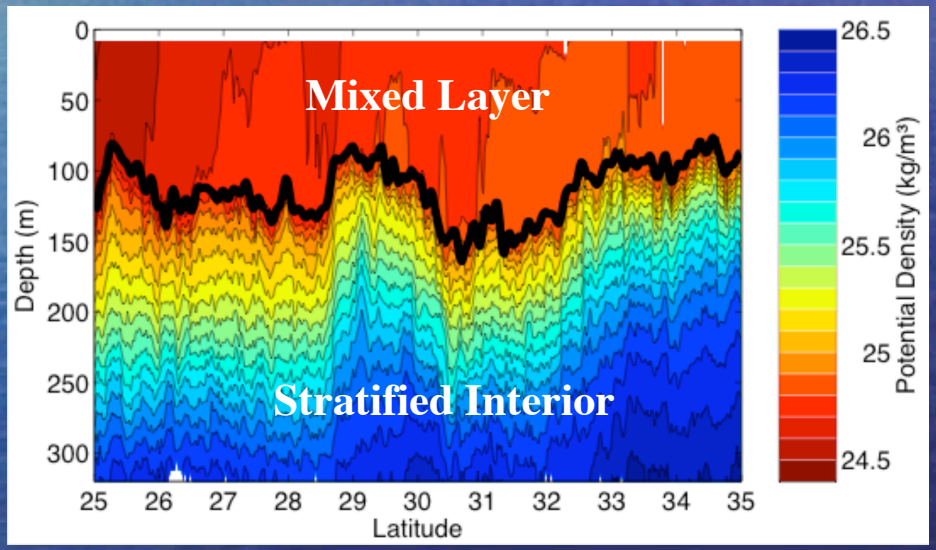
Breckenridge
July 27, 2006

Climate Process Team on Eddy-Mixed Layer Interactions



PI: Raffaele Ferrari

Co-PIs: Flierl, Khatiwala, Marshall, McWilliams, Rudnick, Speer, Tandon, Thomas, Vallis, Weller

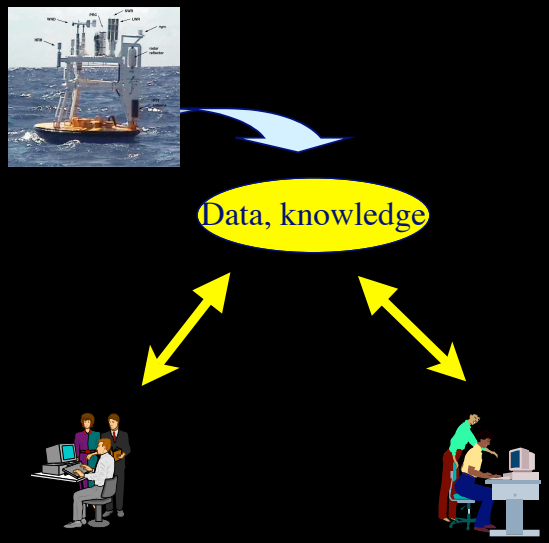
Modeling centers: GFDL and NCAR

Climate Process Teams Framework

- Imperfect or missing *parameterizations of unresolved processes* are a major source of model error and impact predictability skill of climate models

- *Incorporation of parameterizations in climate models lags by ten years* the improved knowledge about unresolved processes

Traditional Framework



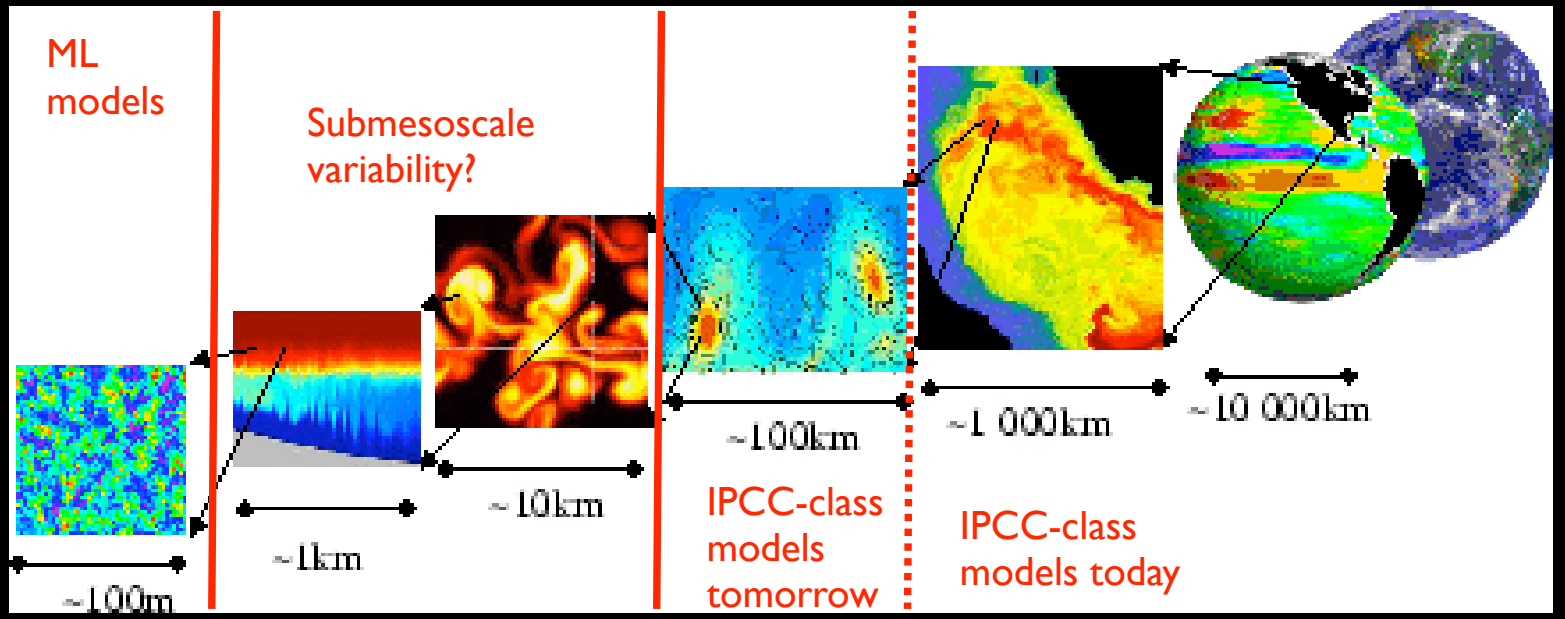
CPT Framework

Deliverables

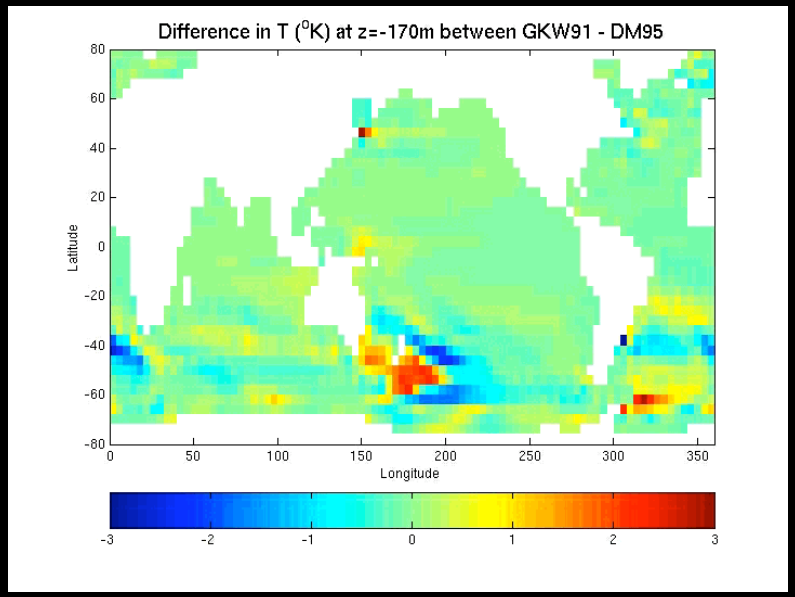
Documented observations
Improved parameterizations
Impact evaluation
Plans for additional process studies
Observing requirements

Subgrid ocean processes in IPCC-class climate models

- Large-scale ocean circulation (100 - 10,1000 km)
- Mesoscale variability (10 - 100 km)
- Submesoscale variability (100 m - 10 km)
- Turbulent mixing (10 cm - 100 m)



CPT on Eddy Mixed Layer Interaction

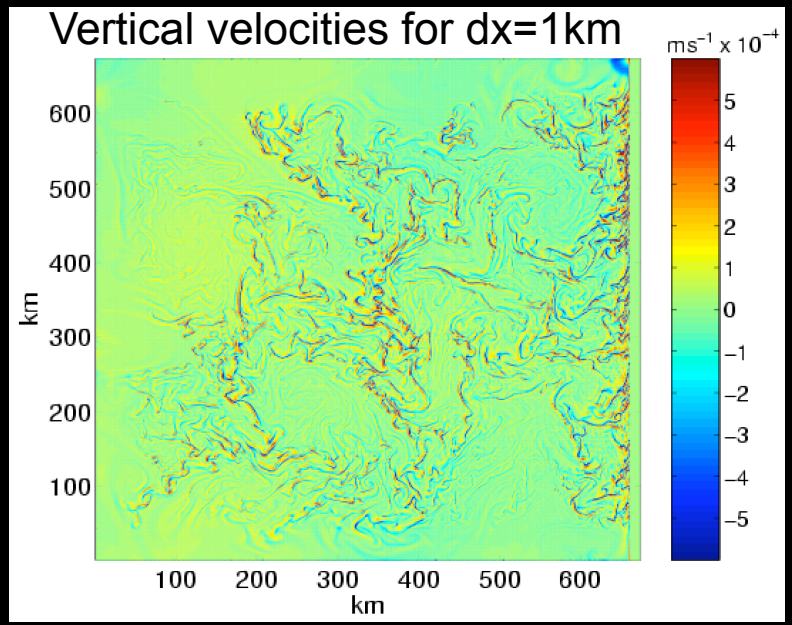


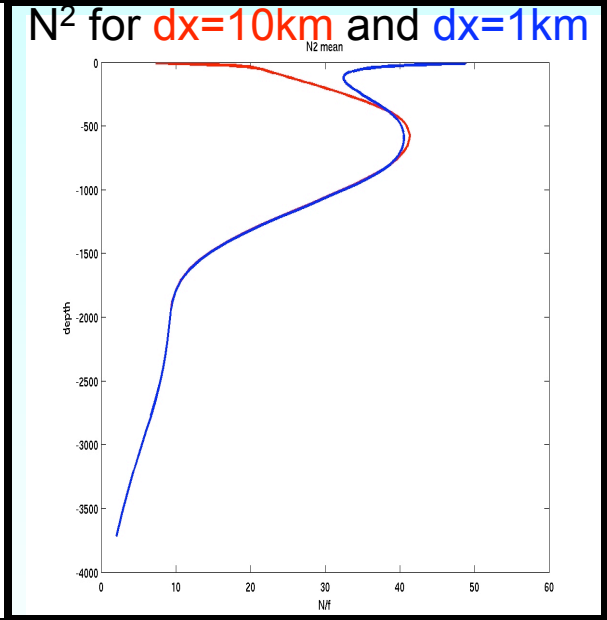
Identify model deficiency

- Existing parameterization of eddy fluxes are valid only in the ocean interior
- Ocean models are sensitive to ad-hoc choices in tapering of eddy fluxes parameterizations in upper ocean

Understand process

Mesoscale and submesoscale dynamics in upper ocean drive loss of balance and affect ocean stratification and ventilation



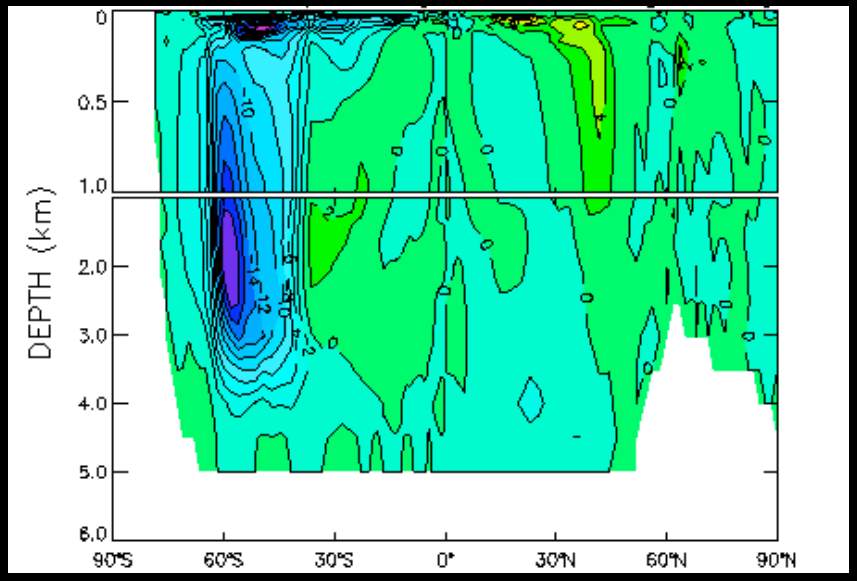


CPT on Eddy Mixed Layer Interaction

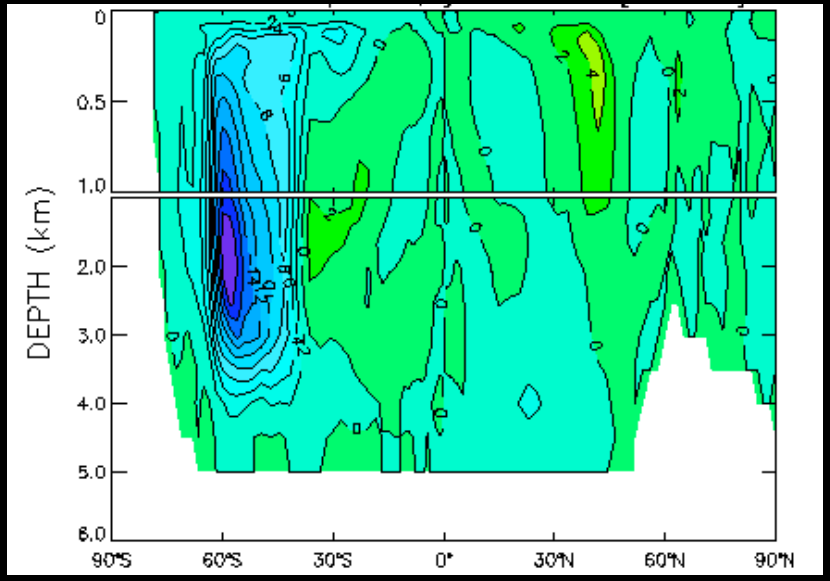
- **Funded for three years in September 2003**
  - four postdocs
- **Research focus**
  - process modeling of upper ocean dynamics (MIT, Princeton, UCLA)
  - comparison with observations (FSU, MIT, WHOI, Scripps)
  - implementation of parameterizations (MIT, GFDL, NCAR)
- **Meetings**
  - Boulder 2004, Providence 2005, Honolulu 2006
- **Reviewed in March 2006 and funded for additional two years**
- **Research focus for the nest two years**
  - test impact of new parameterizations versus global data sets
  - test climate sensitivity of new parameterizations in coupled models

Parameterizing eddy fluxes in ocean models

- In the ocean interior turbulent mixing is weak and eddy fluxes are along density surfaces
- At the boundaries turbulent mixing is strong and eddies cross isopycnal surfaces
- A new parameterization of eddy fluxes in the upper ocean was developed by the CPT (Plumb and Ferrari, 2005; Ferrari and McWilliams, 2006)

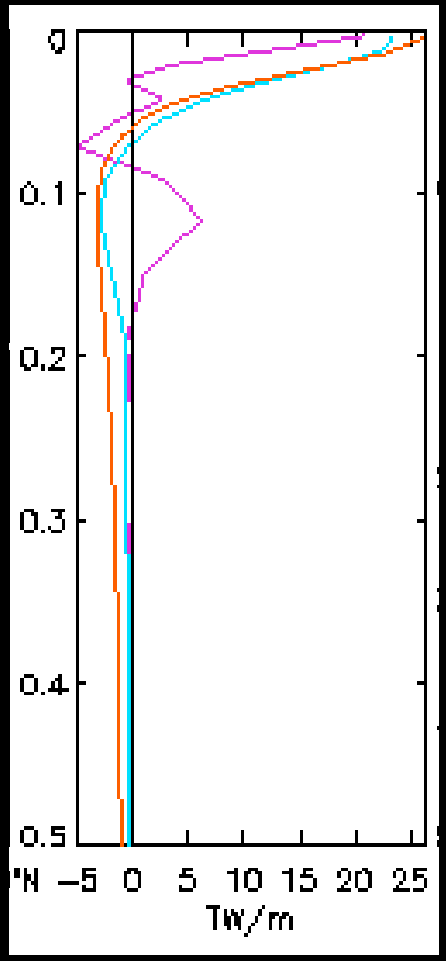


CCSM3 eddy-induced overturning streamfunction with Gent-McWilliams parameterization



CCSM3 eddy-induced overturning streamfunction with CPT parameterization

New parameterization and ocean heat transport



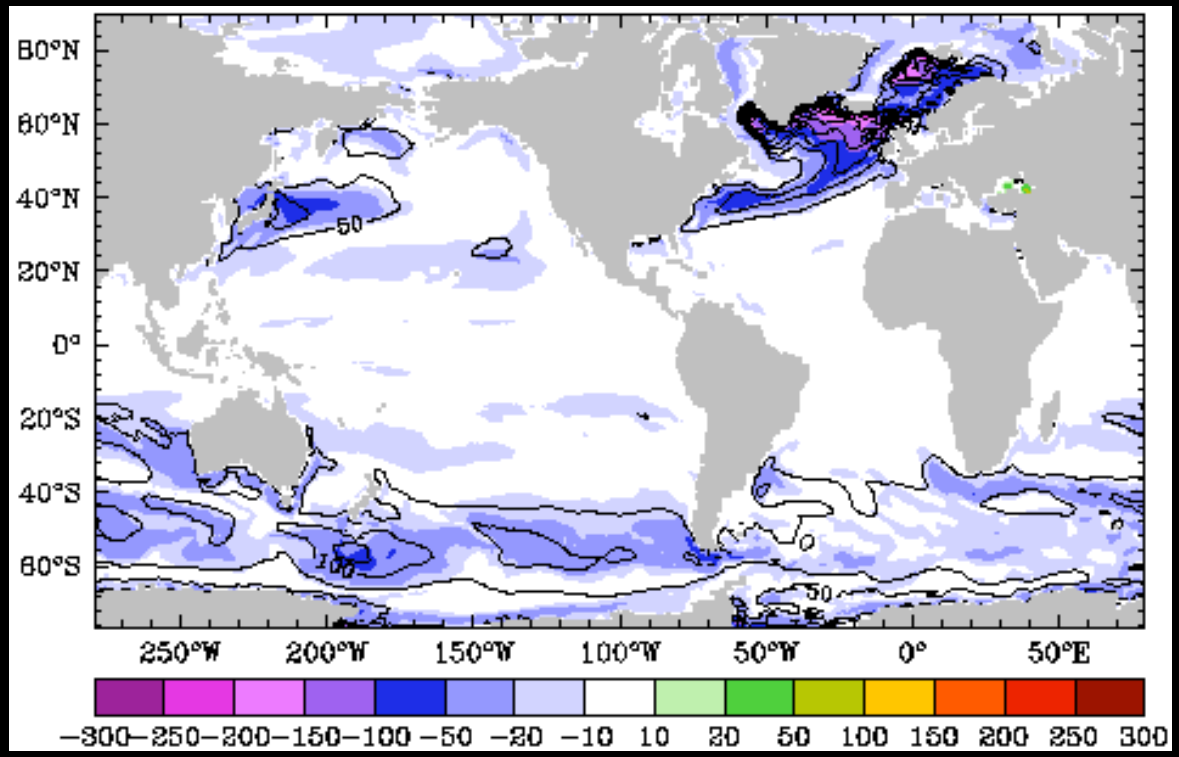
Zonally averaged heat transport across 47degS in the Southern Ocean from three different simulations:

- CCSM3 at 1 degree resolution with Gent-McWilliams parameterization (purple line)
- CCSM3 at 3 degree resolution with new parameterization (cyan line)
- MITgcm at 1/10 degree resolution. This simulation explicitly resolve eddy transport and is run as a benchmark for testing parameterizations (red line)

Danabasolglu, Ferrari, McWilliams, J. Climate, 2006

New parameterization and mixed-layer depth

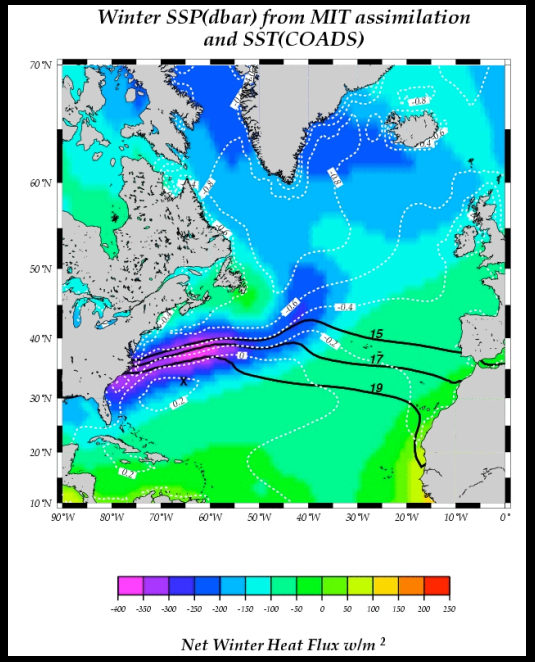
- The new parameterization includes generation/destruction of PV by submesoscale fronts



Fox-Kemper, Ferrari, Hallberg, J. Climate, 2006

CPT EMILIE and FIELD PROGRAMS

- CLIMODE
  - process study funded by NSF
  - goal is to quantify the role of eddies in the formation of Eighteen Degree Mode Water
  - CPT links: Ferrari and Masrhall



- AESOP (McWilliams)
  - process study funded by ONR
  - goal is to quantify the role of submesoscale eddies in Monterey Bay
  - CPT links: McWilliams and Rudnick

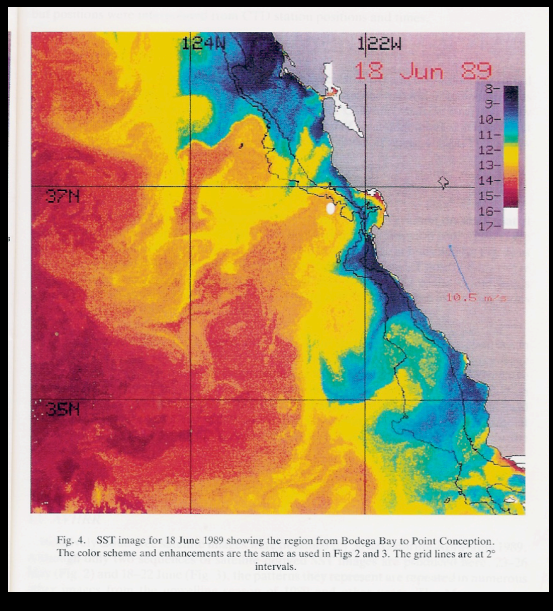


Fig. 4. SST image for 18 June 1989 showing the region from Bodega Bay to Point Conception. The color scheme and enhancements are the same as used in Figs 2 and 3. The grid lines are at 2° intervals.

Strategic Plan for the Climate Change Science Program

In February 2002 the US President announced the formation of the Climate Change Science Program (CCSP) to coordinate and direct the US research efforts in the areas of climate and global change

- Goal 1 - Improve knowledge of the Earth's past and present climate and its natural variability
- Goal 2 - Improve quantification of the forces bringing about those changes
- Goal 3 - Reduce uncertainty in projections of how the Earth's climate may change in the future

➡ Accelerate incorporation of improved knowledge of climate processes and feedbacks into climate models to reduce uncertainty about climate sensitivity