Importance of improving ocean process parameterizations

- Ocean climate is strongly affected by processes on scales finer than model grid
- New approach to sub-grid-scale processes: Physically-based, energetically-consistent parameterizations that vary temporally and spatially
- Climate models which allow sub-grid-scale mixing to evolve with time are more credible for climate change projection
As a participant in USCLIVAR Eddy-Mixed Layer Interaction Climate Process Team, GFDL improved representation of eddies in the mixed layer

- Surface boundary matching for Gent-McWilliams implemented in CM2M (Ferrari et al, 2008)
- Upper ocean submesoscale eddies parameterized in CM2M and CM2G (Fox-Kemper et al, 2008)

**Impact of submesoscale eddy parameterization in GOLD-SIS**
Improved Overflow Representation

GFDL collaborated in USCLIVAR Gravity Current Entrainment Climate Process Team, leveraging observational and theoretical community expertise

- New representation of flow through narrow straits
- New parameterization of shear driven mixing, in overflows and elsewhere, in CM2G (Jackson et al, 2008)
- New parameterization of frictional bottom boundary layer mixing (Legg et al, 2006)

Diffusivities diagnosed from simulation and predicted by different parameterizations

Mediterranean outflow salinity: comparison between CM2G and observed climatology (Legg et al, 2009)
Parameterizing Tidal Mixing

- Tides flow over bottom topography and generate internal waves and mixing.

- A new energetically-consistent parameterization represents localization of tidal mixing at rough topography used in CM2G, CM2M (based on Simmons et al, 2004)

- Ongoing process studies and collaborations aim to extend this parameterization to include:
  - effects of steep slopes
  - nonlinear wave-wave interactions,
  - wave scattering at topography,
  - parametric subharmonic instability.

- Tidal flow over steep ridges leads to internal hydraulic jumps which cause localized mixing (Legg and Klymak, 2008)
Summary: Processes and parameterization

• Improved representation of small-scale processes: 
an important component of GFDL’s efforts to develop the world’s best ocean 
climate models

• Physically-based parameterizations: 
necessary for credible future climate projections

• Improvements have recently been made in representation of eddy-mixed layer interaction, overflows, tidal mixing

• Outside collaborations, e.g. Climate Process Teams, are vital to this effort: 
provide understanding of physical processes through observations/process 
studies