Work on Improvements in Ocean Mixing

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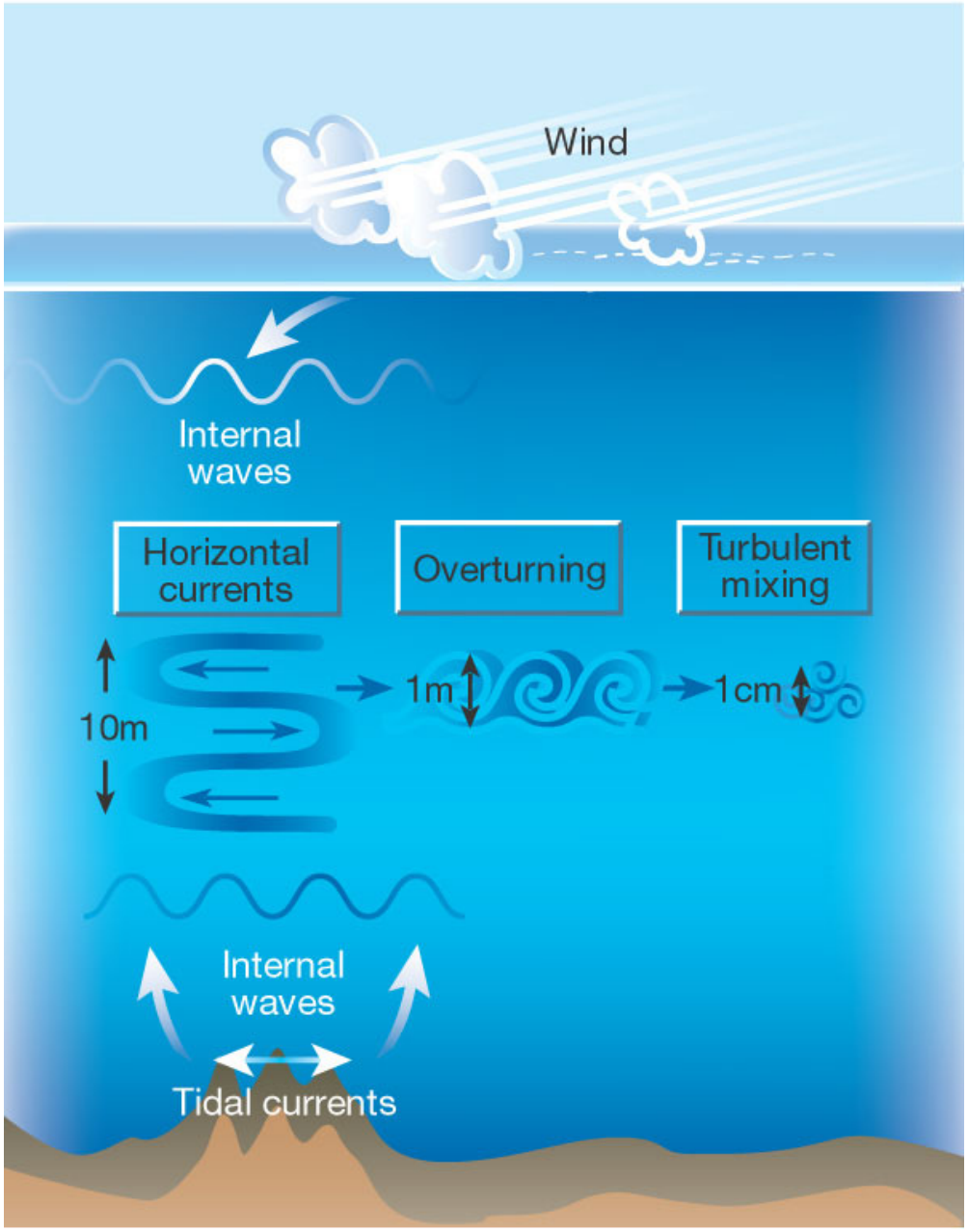
I. Improvements in Ocean Mixing Tested in a Stand Alone Ocean now to be implemented in the Coupled Model:

- Latitude dependence of interior background vertical mixing
- Double Diffusion: Salt Fingers and Diffusive Convection in same framework
- Geographically varying enhanced deep vertical mixing due to Internal Tides [2.0 TW] - Bottom Boundary Layer
- Geographically variable enhanced lateral bottom viscosity and vertical mixing due to Tidal Drag [1.5 TW]

II. Improvements to be Tested in a Stand Alone Ocean Model before being implemented in the Coupled Model:

- Vertical mixing up to infinite Richardson number including double diffusivity effects
- Parameterization of Mesoscale Eddy vertical and horizontal heat and salt fluxes in the Mixed Layer and Interior diabatic fluxes

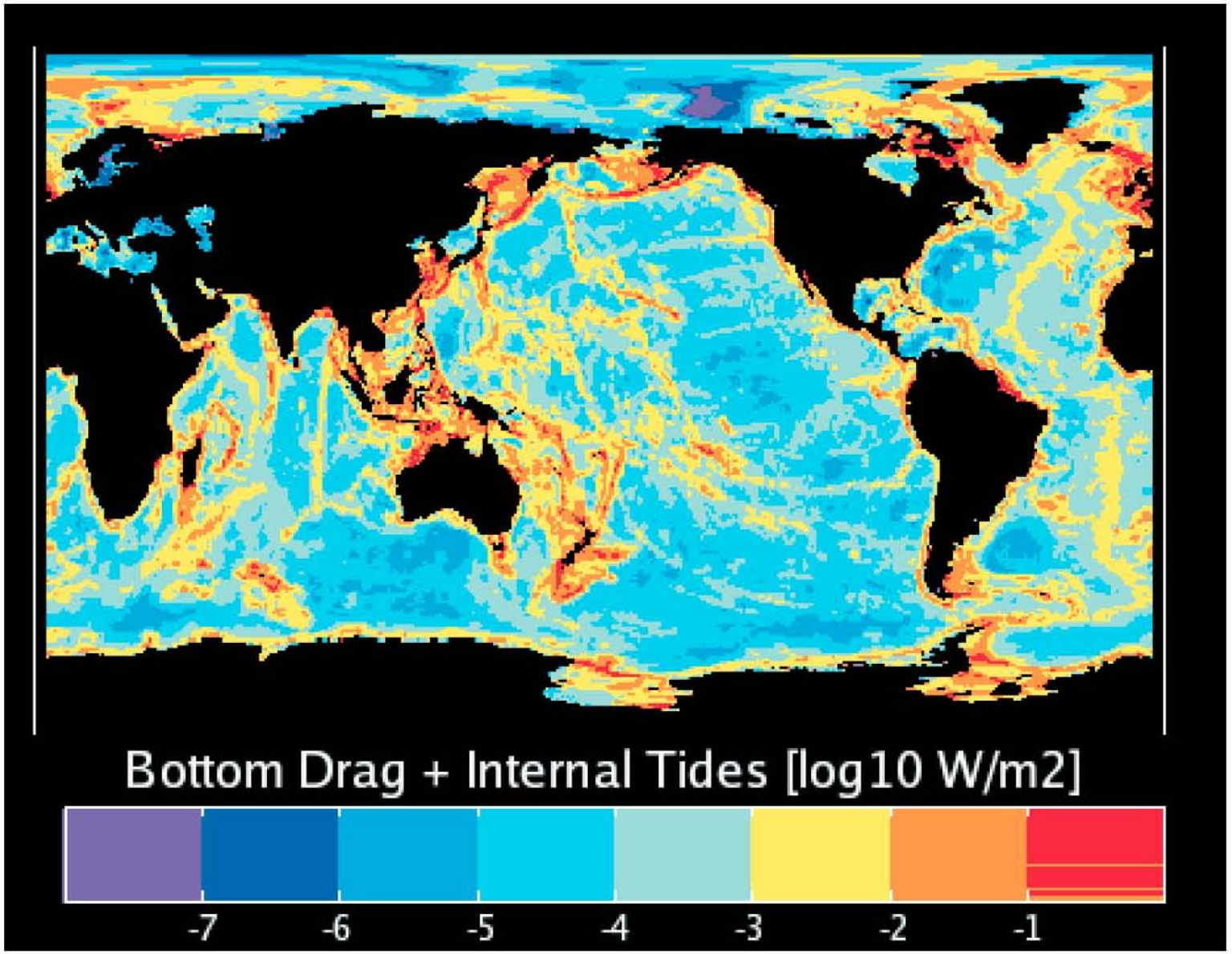


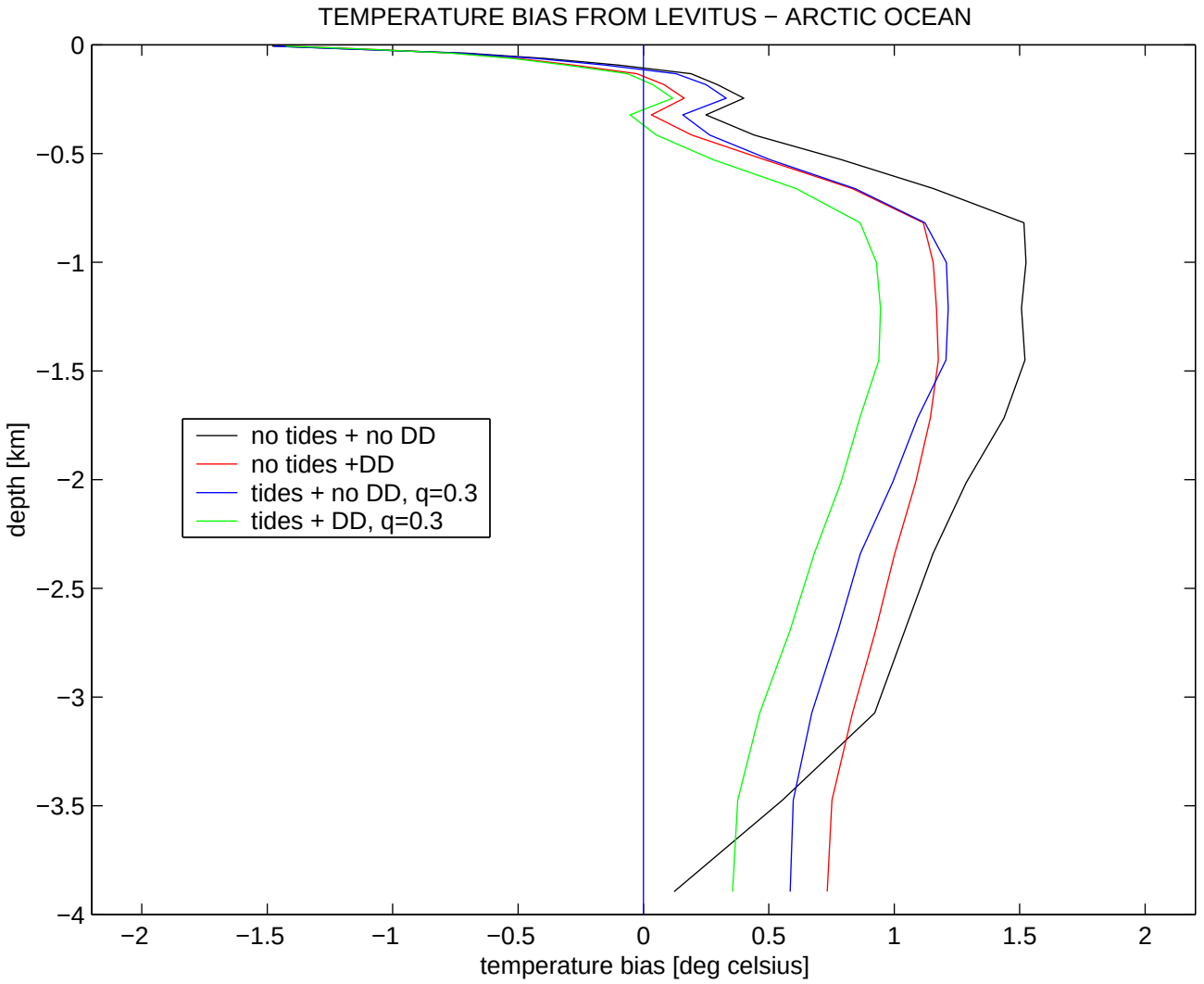
Tidal flow hits topography

=> internal waves
=> dissipation of the energy carried by those waves
=> mixing

[Garrett, Nature 2003]

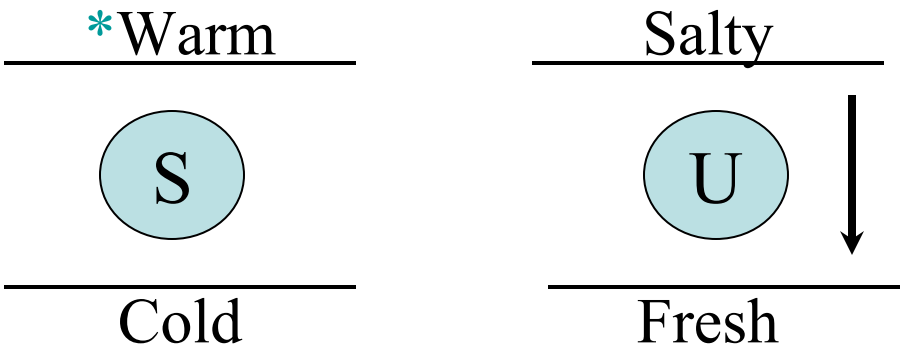
3.5 TW Tidal Dissipation



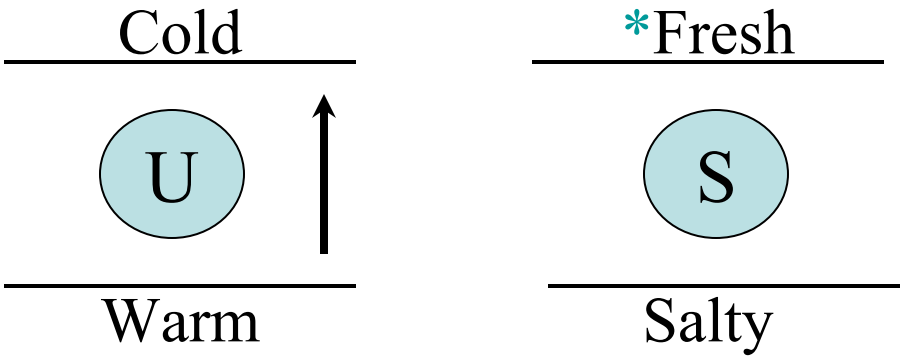

TEMPERATURE BIAS FROM LEVITUS − ARCTIC OCEAN
depth [km]
temperature bias [deg celsius]
no tides + no DD
no tides +DD
tides + no DD, q=0.3
tides + DD, q=0.3
0
−0.5
−1
−1.5
−2
−2.5
−3
−3.5
−4
−2
−1.5
−1
−0.5
0
0.5
1
1.5
2

* dominates

Double Diffusion



SF (Med.)

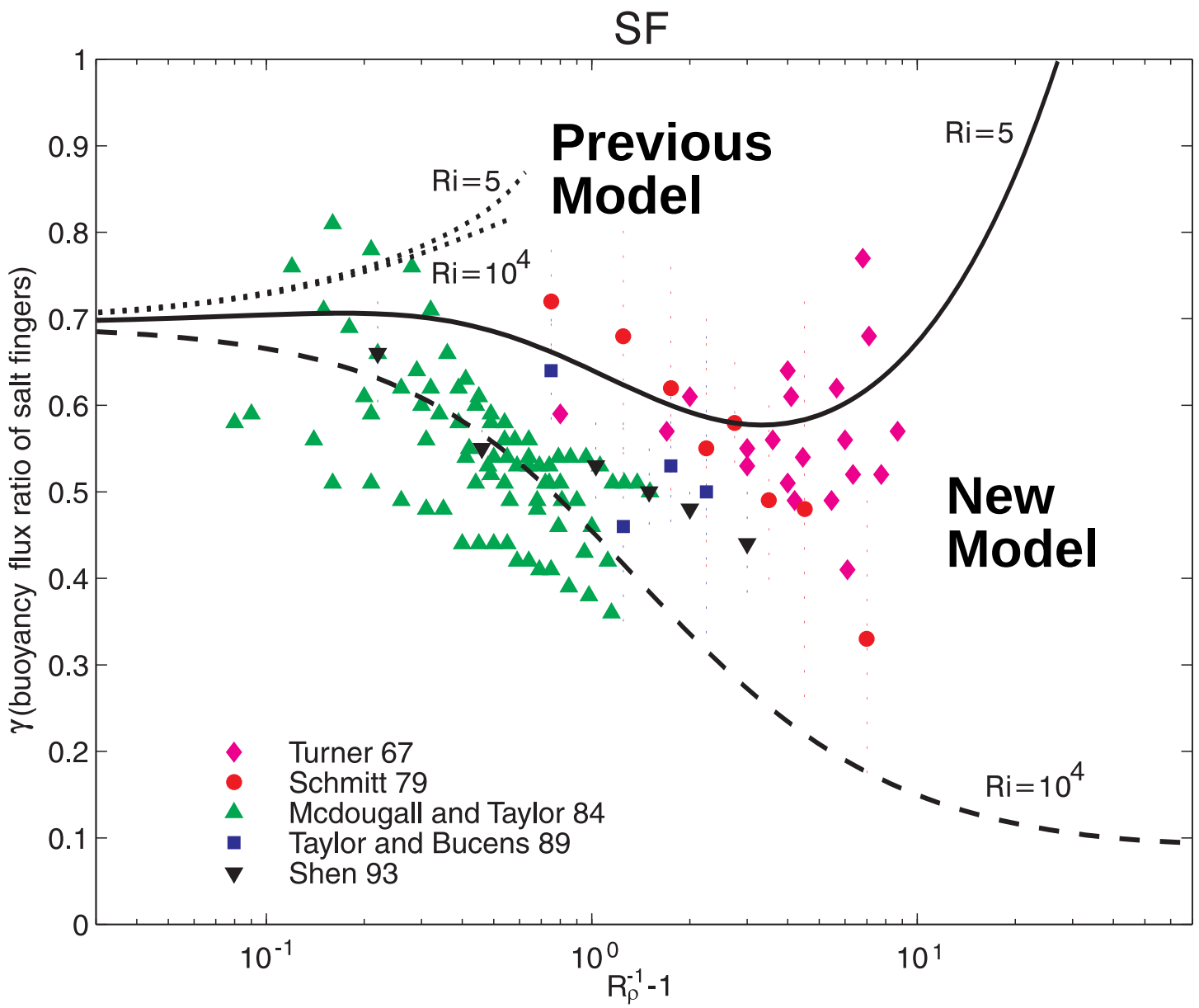


DC (water/ice)

SF: $R_\rho < 1; \quad \gamma < 1$

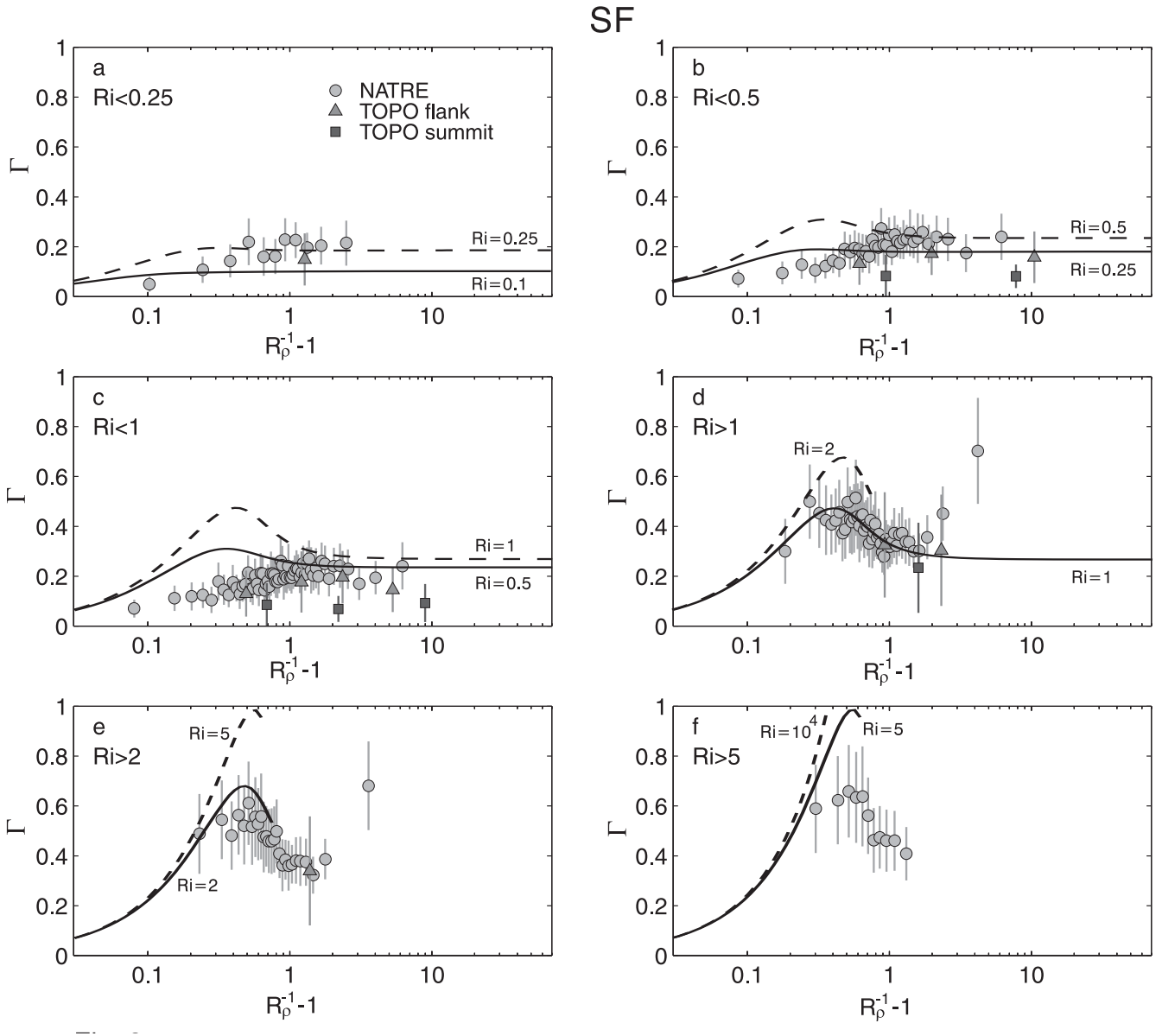
DC: $R_\rho > 1; \quad \gamma > 1$

$$R_\rho = \frac{\alpha_S \partial S/\partial z}{\alpha_T \partial T/\partial z}, \quad \gamma = \frac{\alpha_T \overline{w\theta}}{\alpha_s \overline{ws}}, \quad \Gamma_{H,S} = \frac{K_{H,S} N^2}{\varepsilon}$$


SF
Previous Model
Ri=5
Ri=10^4
Ri=5
New Model
Ri=10^4
γ(buoyancy flux ratio of salt fingers)
R_ρ^-1 -1
Turner 67
Schmitt 79
Mcdougall and Taylor 84
Taylor and Bucens 89
Shen 93

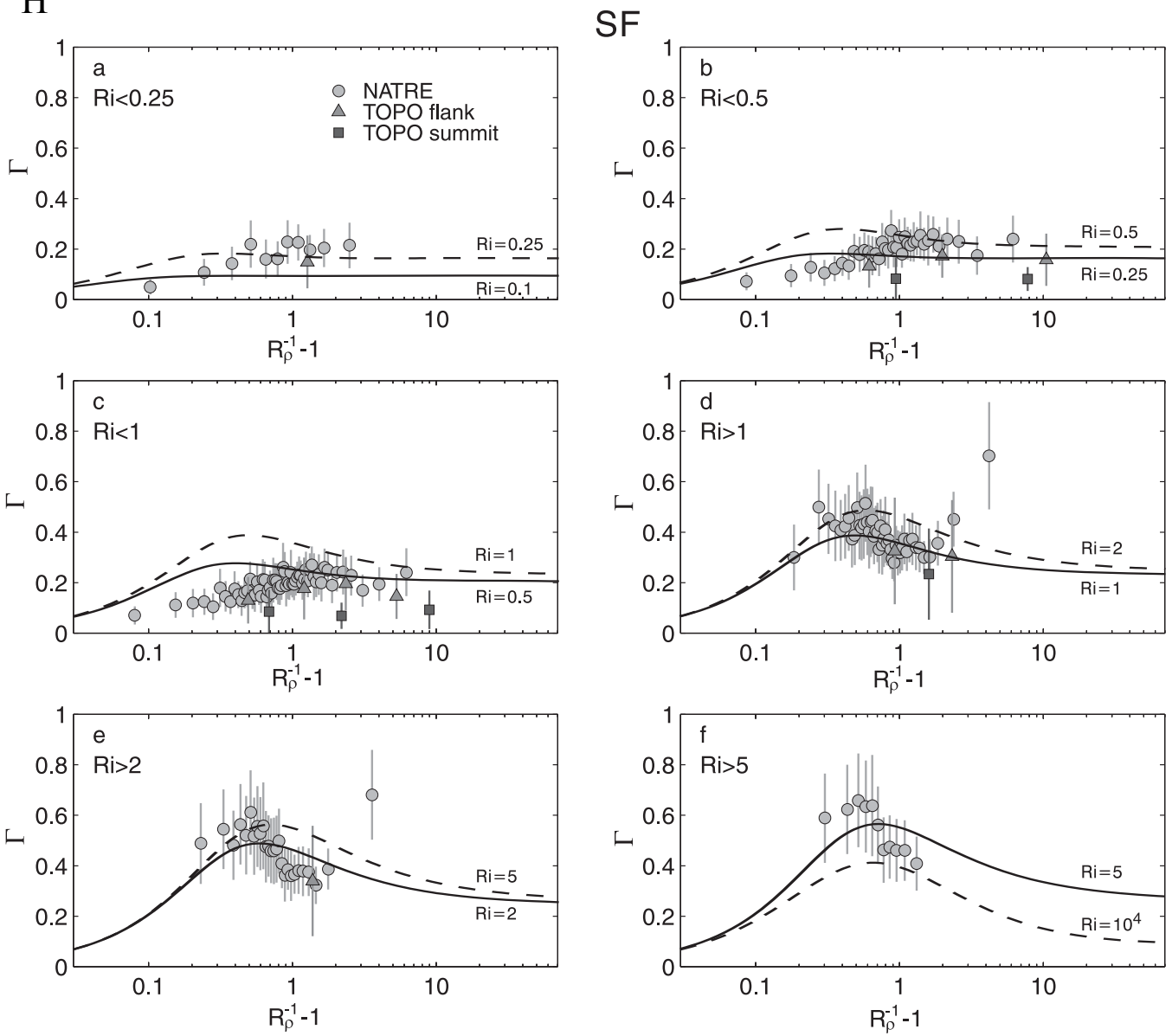
GISS Model 2002:

Γ_H

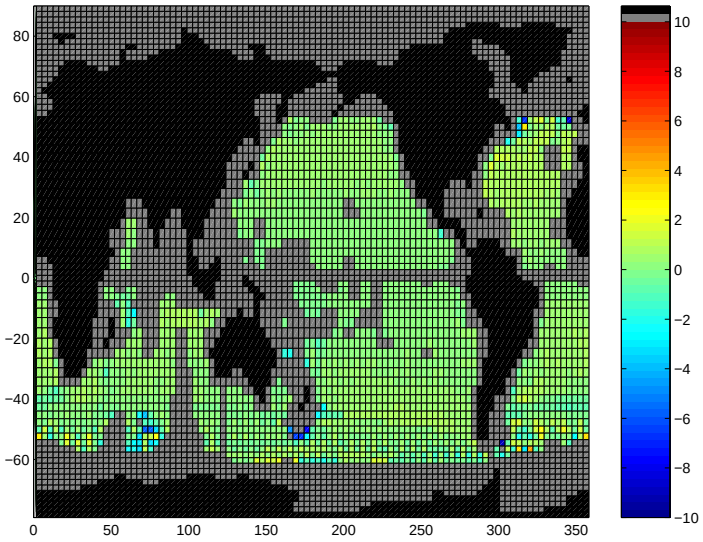


GISS Model 2008:

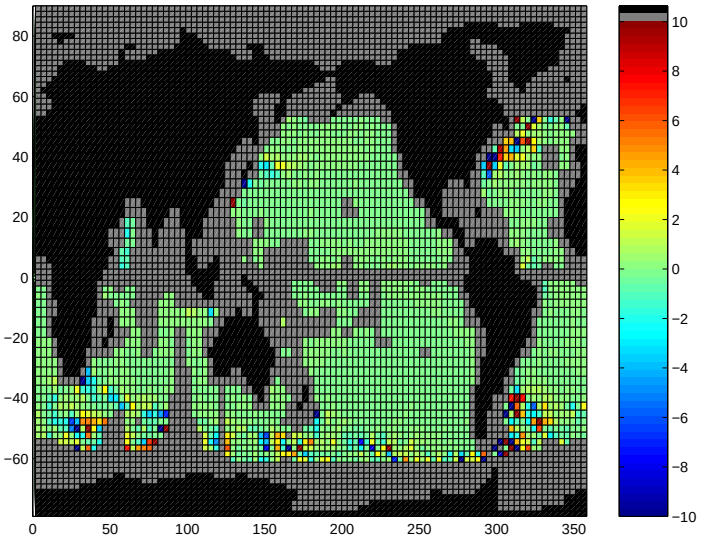
Γ_H



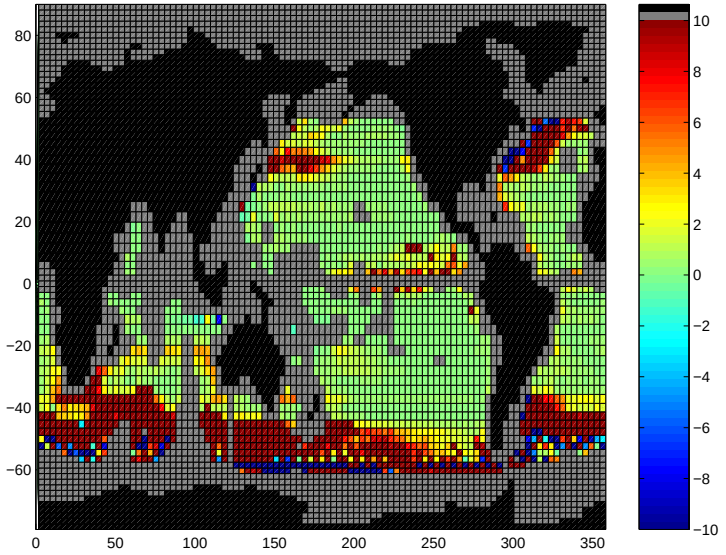
Small scale turbulence



Mesoscale non-adiabatic



Mesoscale residual flux



Upwelling due to mixing

across 27.96 kg/m^3 neutral density surface

m/yr