Creation of an Eddy Parameterization Challenge Suite

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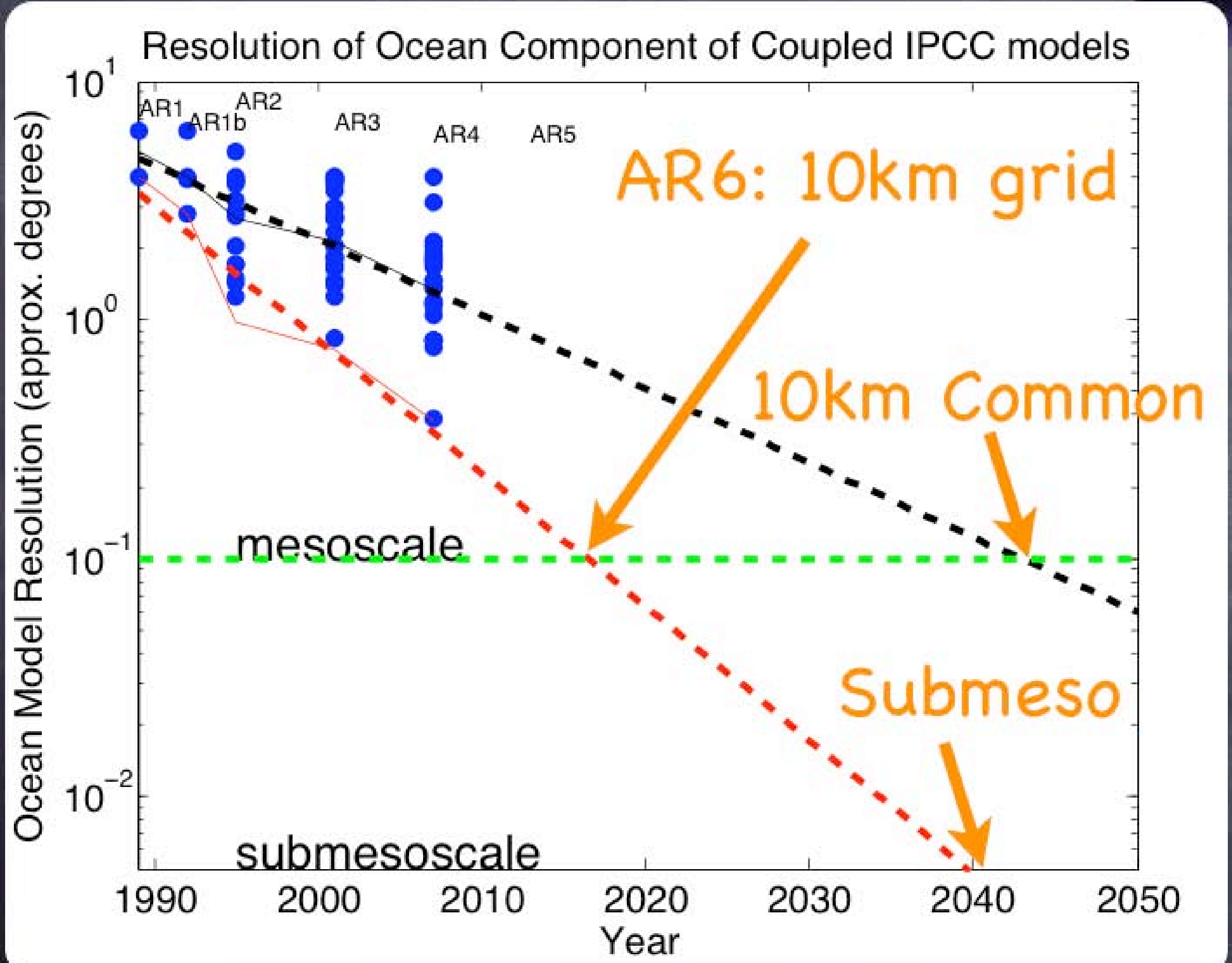
Outline

- What is the motivation behind the challenge suite?
- What will it be used for and what is the justification for creating it?
- What the challenge suite *REALLY* is
- Idealized examples
- Future Work

The Future of Resolution



Tracer Flux-Gradient Relationship

$$\overline{\mathbf{u}'\tau'} = -\mathbf{M}\nabla\overline{\tau}$$

- Virtually all subgridscale eddy closures may be written as: GM, Redi, FFH Submesoscale
- Relates the eddy flux to the coarse-grain gradients
- May have a flow/property dependent $\mathbf{M}$

$$\overline{\mathbf{u}'\tau'} = -\mathbf{M}\nabla\overline{\tau}$$

Fox-Kemper, Ferrari, & Hallberg (2008) form (a mixed layer (submeso) eddy param.):

$$\begin{bmatrix} \overline{u'\tau'} \\ \overline{v'\tau'} \\ \overline{w'\tau'} \end{bmatrix} = - \begin{bmatrix} 0 & 0 & -\mathbf{\Psi_y} \\ 0 & 0 & \mathbf{\Psi_x} \\ \mathbf{\Psi_y} & -\mathbf{\Psi_x} & 0 \end{bmatrix} \begin{bmatrix} \overline{\tau}_x \\ \overline{\tau}_y \\ \overline{\tau}_z \end{bmatrix}$$

Antisymmetric Elements in Fox-Kemper, Ferrari, & Hallberg (2008) are scaled to overturn fronts, make vertical fluxes extract PE, and restratify the fluid, At a rate validated against eddying simulations!

The Character of the Submesoscale

(Capet et al., 2008)

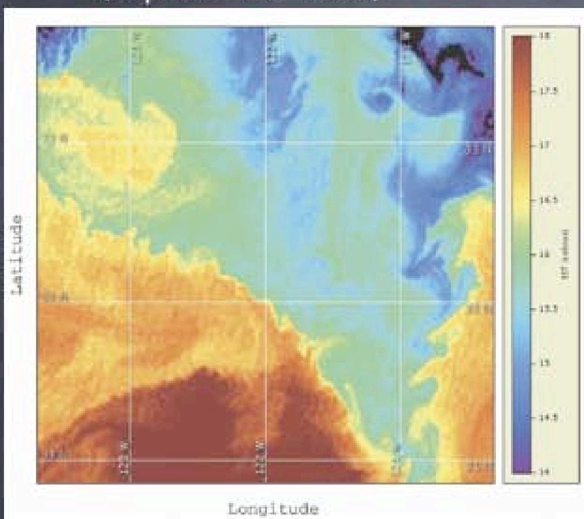
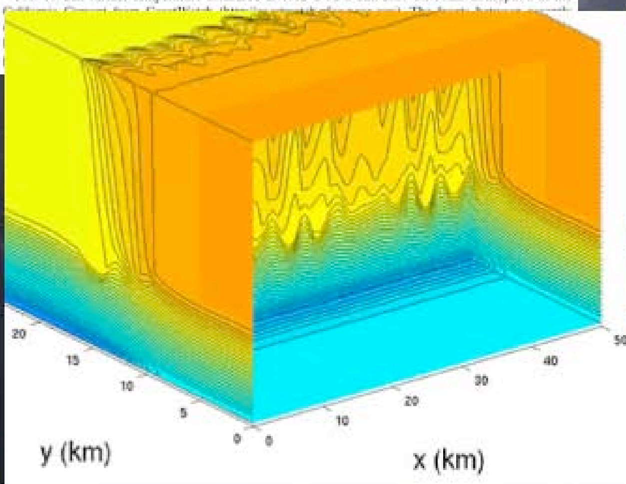


FIG. 16. Sea surface temperature measured at 1832 UTC 3 Jun 2006 off Point Conception in the

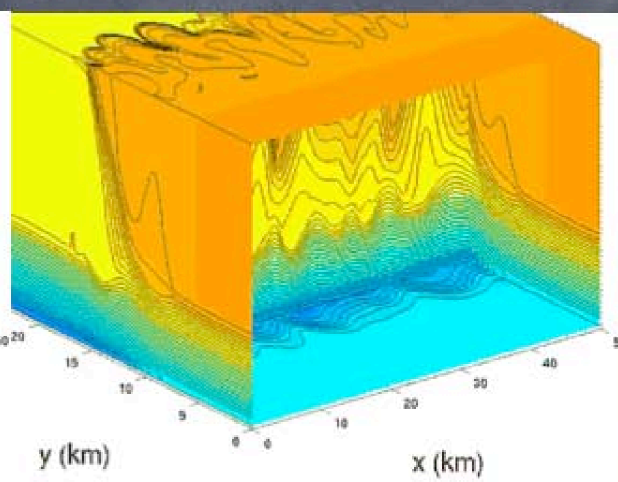
- Fronts
- Eddies
- Ro=O(1)
- Ri=O(1)
- near-surface

(NASA GSFC Gallery)

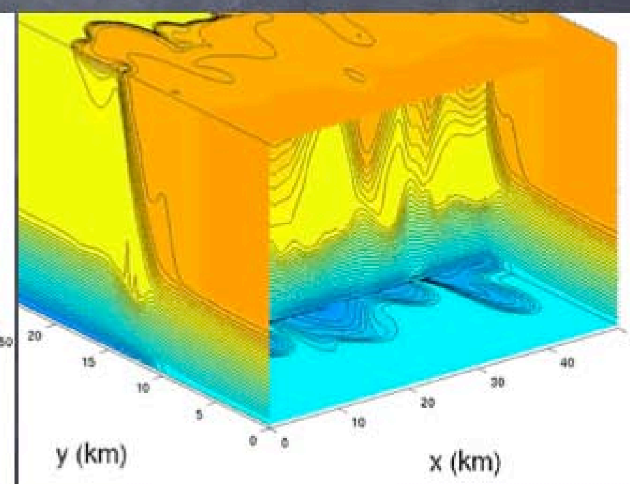
100 km



Simple Spindown



Simple Spindown



Simple Spindown

The Problem is:

The mesoscale equivalent isn't rEady

- FFH param. doesn't do interior stratification/ PV gradients
- PV jumps are OK, e.g, surface & mixed layer base
- But, Mesoscale==Full Depth, so PV Varies
- Smith (07) shows interior PV gradients dominate mesoscale energy extraction

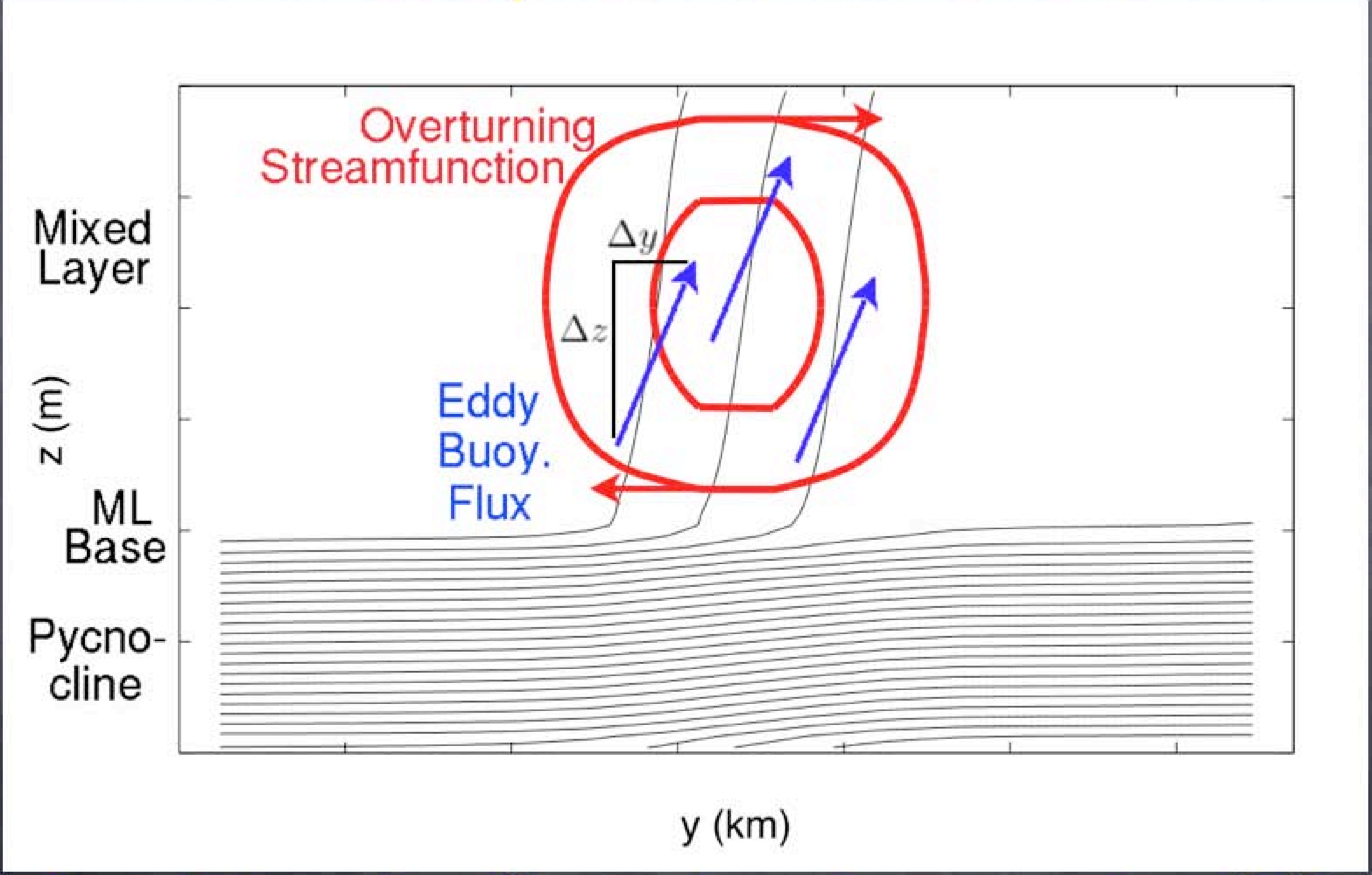
What to do?
The Parameterization Challenge Suite

- Uses a model (MITgcm) that includes shear, strain, stratification, etc.
- Will simulate individually: O(2000) simulations
- Simultaneous runs exploring parameter space
- A suite of several different challenges, using both idealized and reality-based problems
- Will extract “typical” eddy configurations in the global model by EOF or SOM

Examples?

Overturning Schematic:

An Eady-like Problem

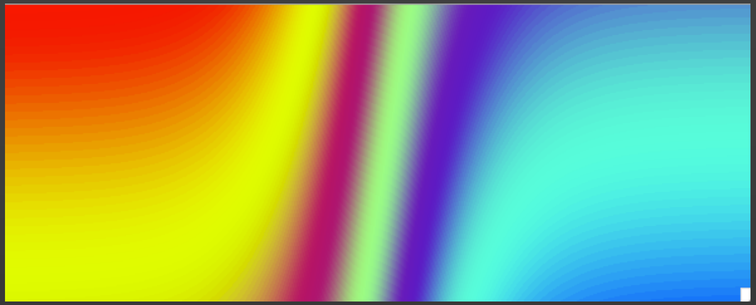


Horizontal scale of overturning = scale of front

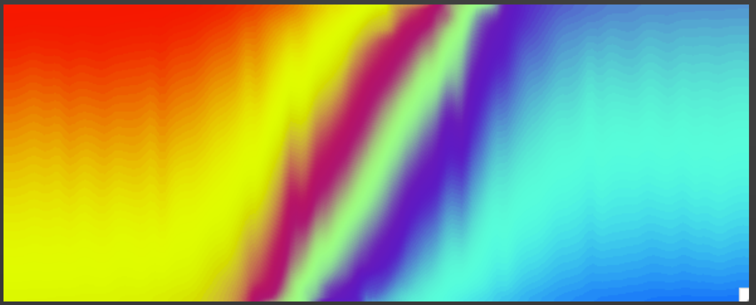
Vertical structure of overturning = ?

Eady Snapshots

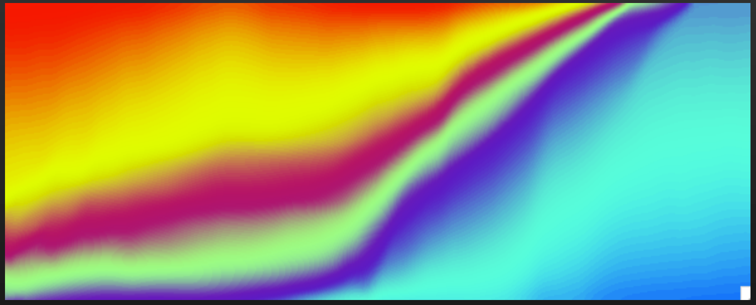
Density surfaces



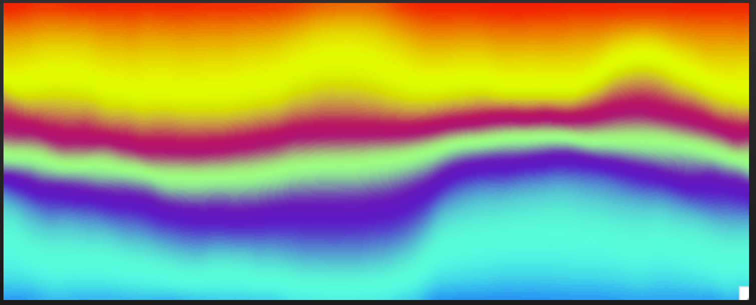
Initial configuration



10 days



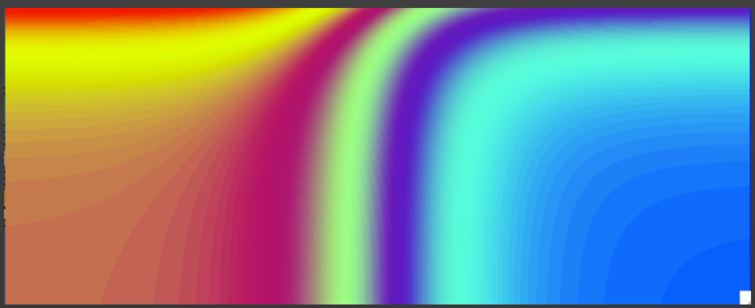
20 days



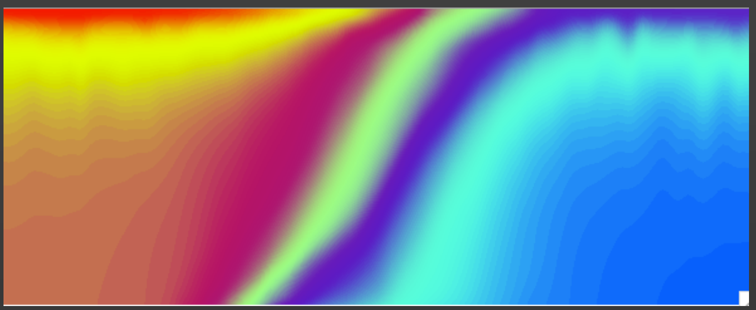
30 days

Charney Snapshots

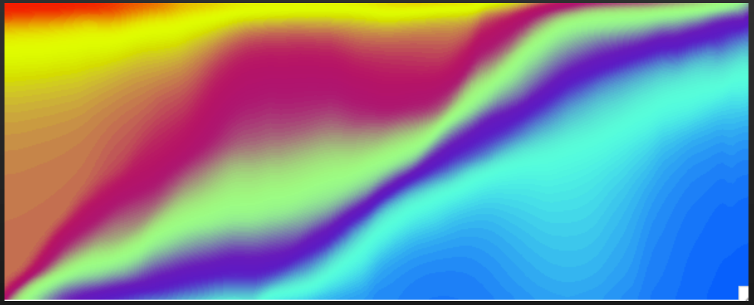
Density surfaces



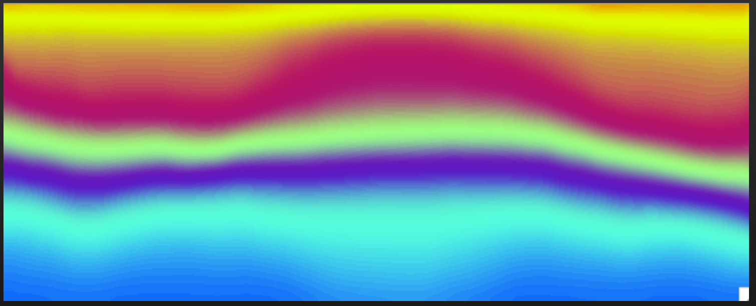
Initial configuration



10 days



20 days



30 days

Evaluating the Results

- How fast is the slumping?

- Multiple tracer approach to diagnose M (Bratseth, 1998)

The Future!

- Investigate smoothing operator in FVG

$$\left(c^2\frac{\mathrm{d}^2}{\mathrm{d}z^2}-N^2\right)\widetilde{\boldsymbol{\Psi}}=-\kappa\nabla\bar{b}$$

$$\widetilde{\boldsymbol{\Psi}}=0,\quad z=0,-H$$

- Selection of more challenges
  - PV jumps
  - Sinusoids
- Suggestions from the audience?

The Character of the Mesoscale

(Capet et al., 2008)

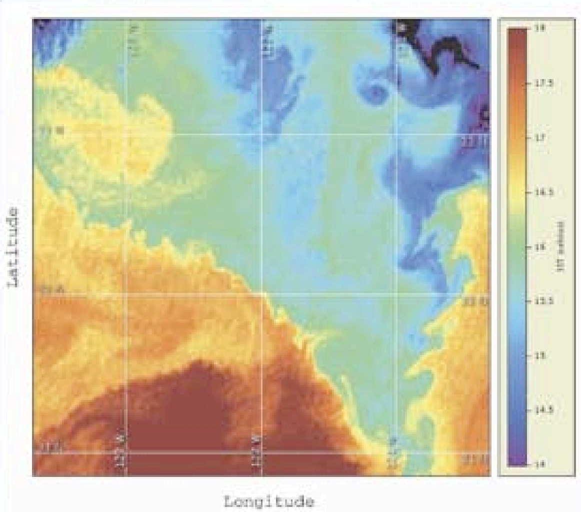


FIG. 16. Sea surface temperature measured at 1832 UTC 3 Jun 2006 off Point Conception in the California Current from CoastWatch (http://coastwatch.pfeg.noaa.gov). The fronts between recently upwelled water (i.e., 15°–16°C) and offshore water (≥17°C) show submesoscale instabilities with wavelengths around 30 km (right front) or 15 km (left front). Images for 1 day earlier and 4 days later show persistence of the instability events.

- Boundary Currents
- Eddies
- Ro=O(0.1)
- Ri=O(1000)
- Full Depth

(NASA GSFC Gallery)

100 km

But, dominant eddy process still baroclinic instability.

Why can't we just use submesoscale scaling of FFH? for a flow-dependent GM-like param?

MORAL OF THIS SLIDE:

Scaling Laws for streamfunction can be deduced empirically from the models

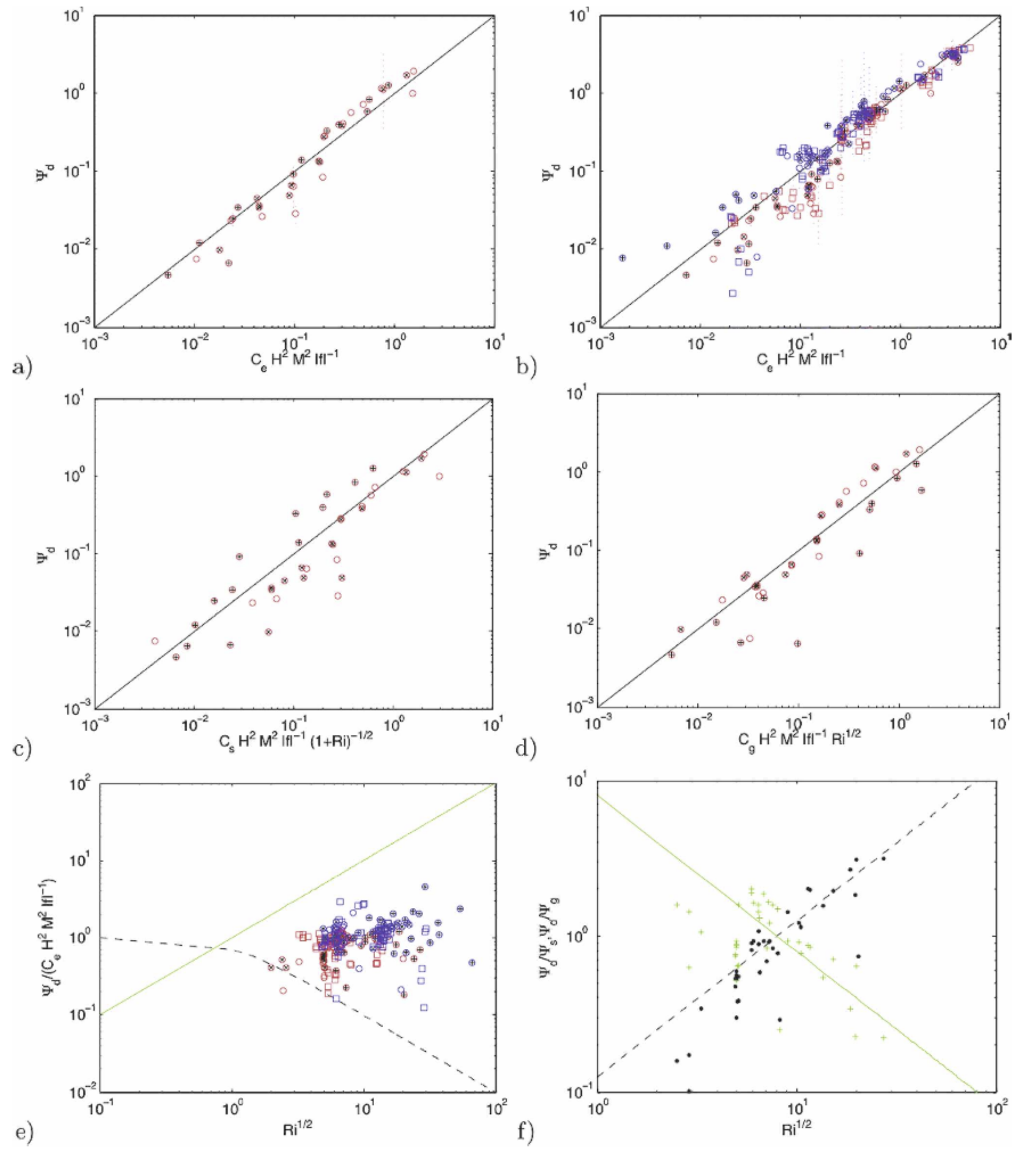


FIG. 14. Magnitude of Ψ_d vs theories for magnitude of Ψ for simulations with diurnal cycle (blue) and without (red) starting from balanced (circles) or unbalanced (squares) initial conditions. Plus signs and crosses indicate balanced simulations where $Ri_0 > 1$ or $Ri_0 < 1$ initially: (a) Ψ_d in the balanced, no diurnal cycle simulations vs $\overline{C_e \overline{b_y}^{xz} H^2 |f|^{-1}}^{yt}$, $C_e = 0.06$, and (b) unbalanced and diurnal cycle simulations, $C_e = 0.08$; (c) Stone's theory, (36), $C_s = 0.53$; (d) Green's theory, (37), $C_g = 0.0085$; (e) $\Psi_d / \overline{C_e \overline{b_y}^{xz} H^2 |f|^{-1}}^{yt}$ vs $Ri^{1/2}$. Also shown are lines parallel to $Ri^{1/2}$ and $(1 + Ri)^{-1/2}$: (f) Ψ_d/Ψ_s (black dots) and Ψ_d/Ψ_g (green crosses) vs $Ri^{1/2}$. Also shown are lines parallel to $Ri^{\pm 1/2}$; Ψ_d, Ψ_s, and Ψ_g are defined in (35), (36), and (37).