On the Dynamics of Oceanic Gravity Currents

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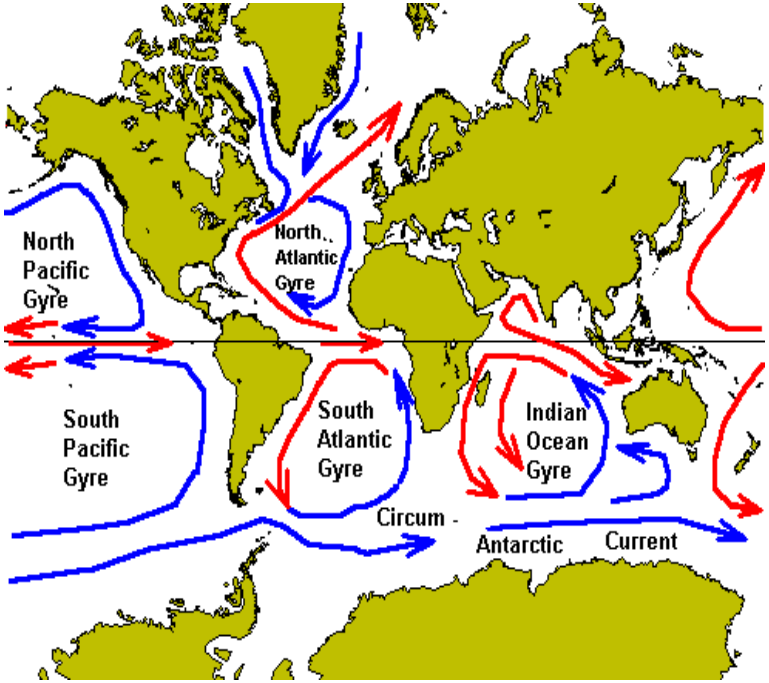
LEGI / CNRS

LEGOS, Dec 6, 2011

Ocean Circulation

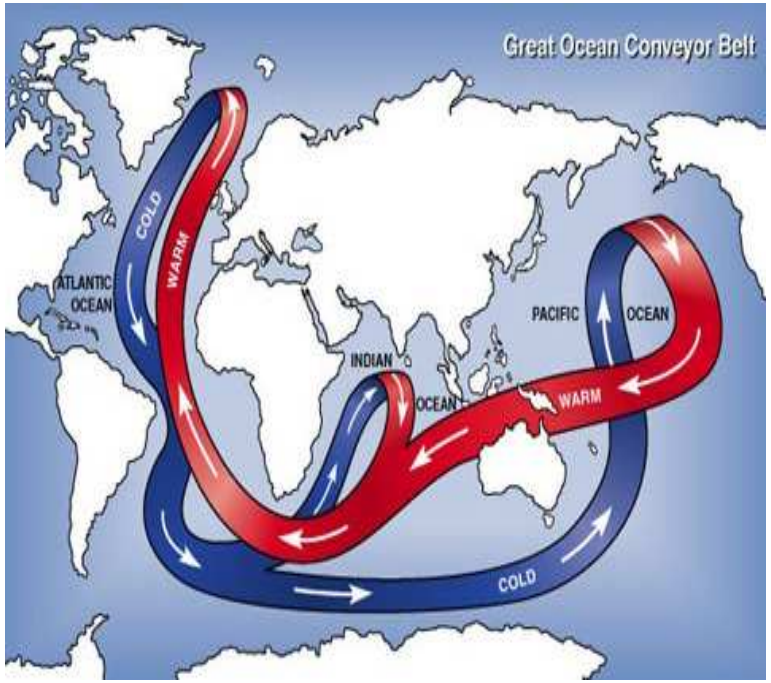
Gyre

"weather"

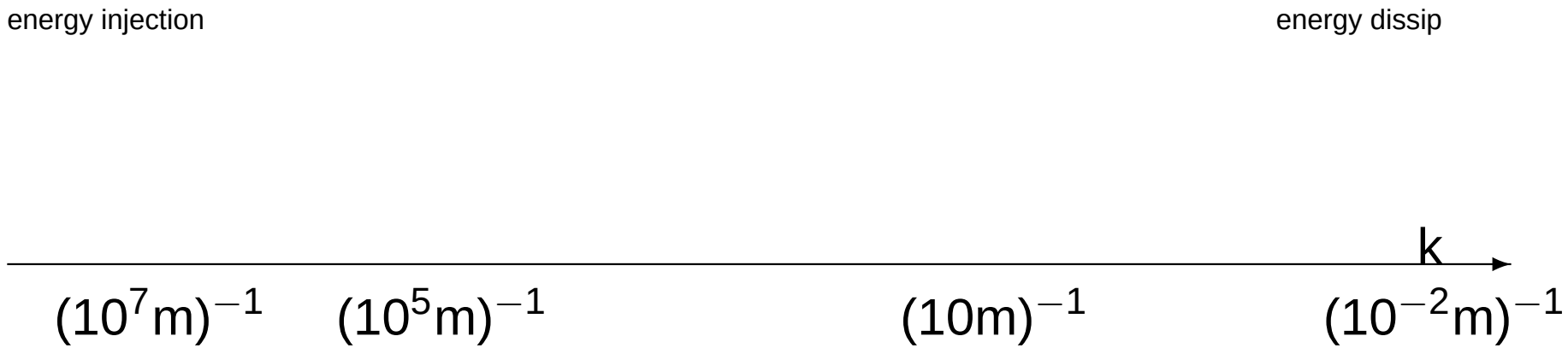


Overturning

"climat"



Ocean Dynamics by Scale



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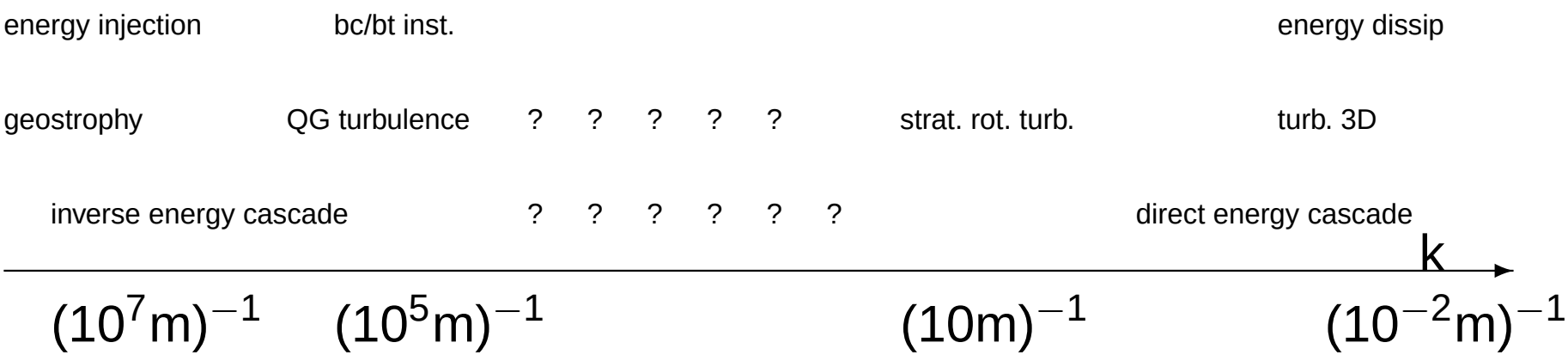
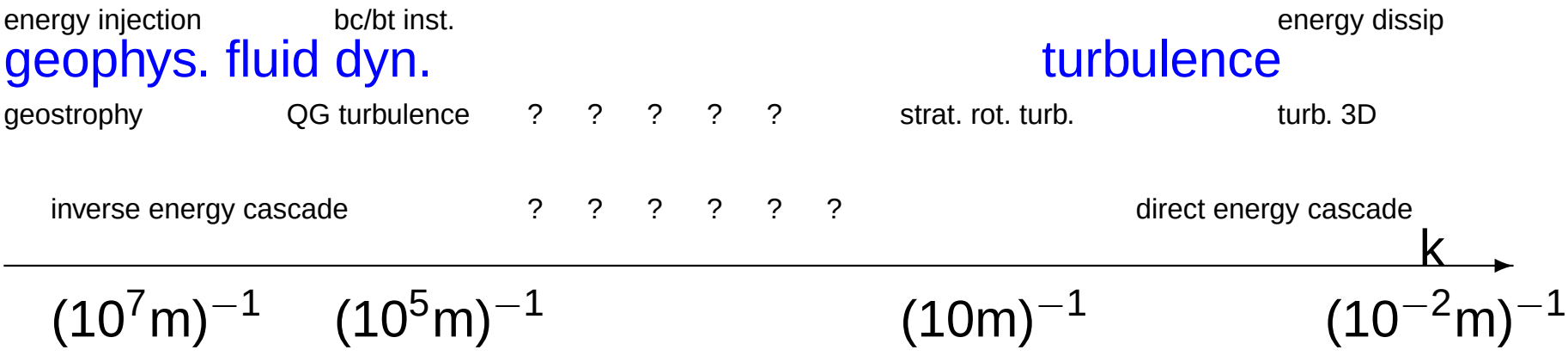
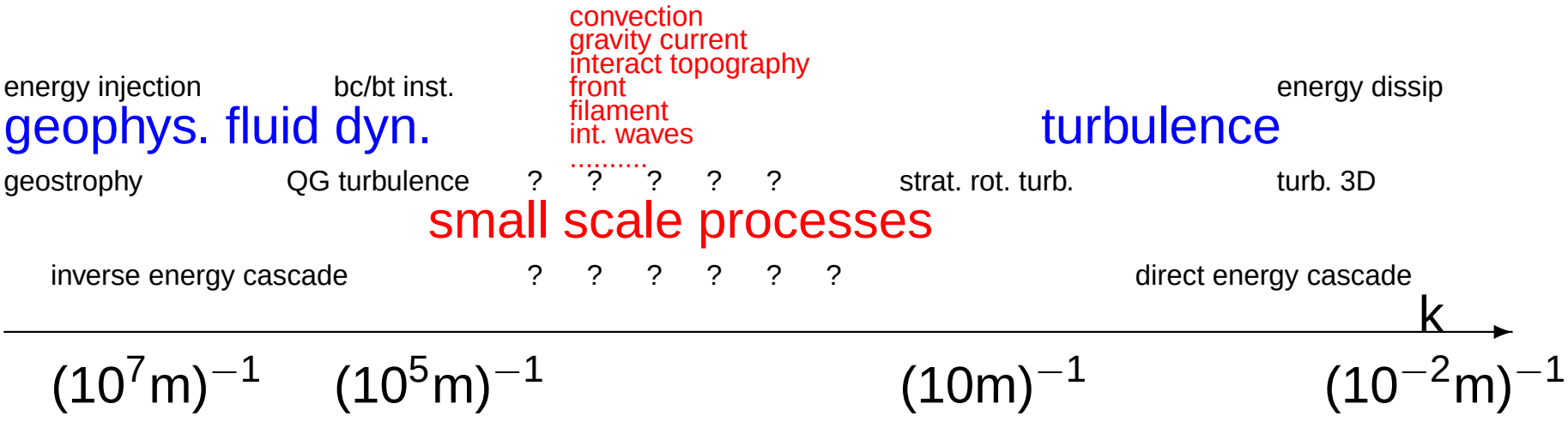


Ocean Dynamics by Scale



Ocean Dynamics by Scale



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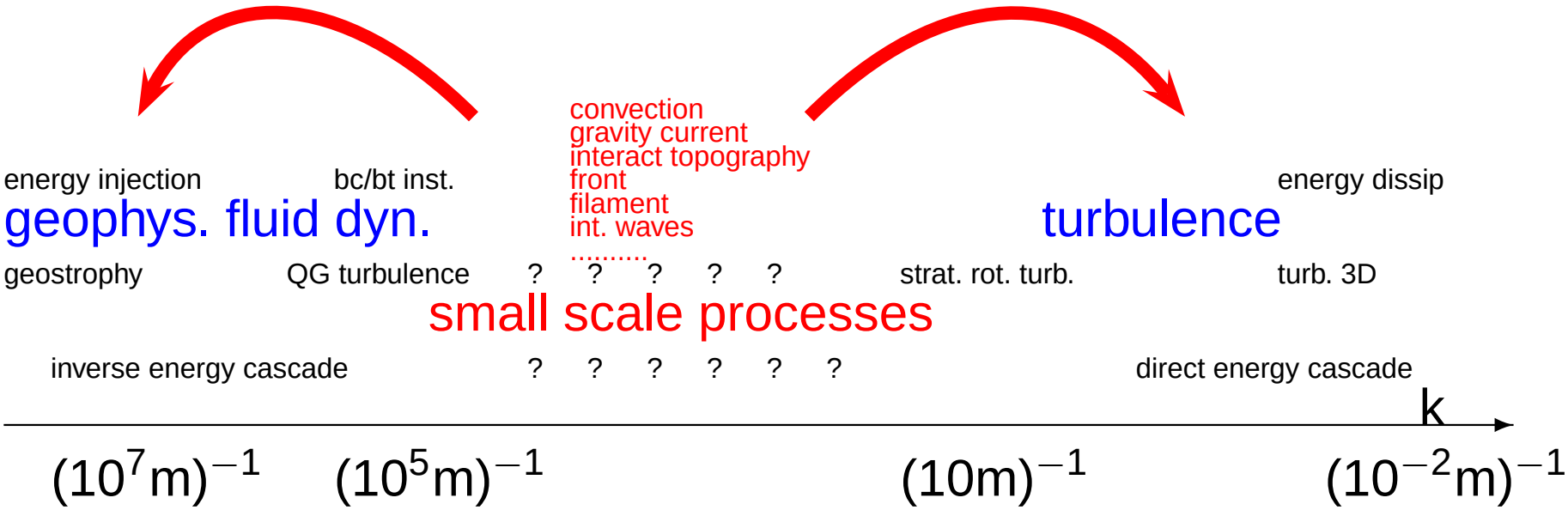
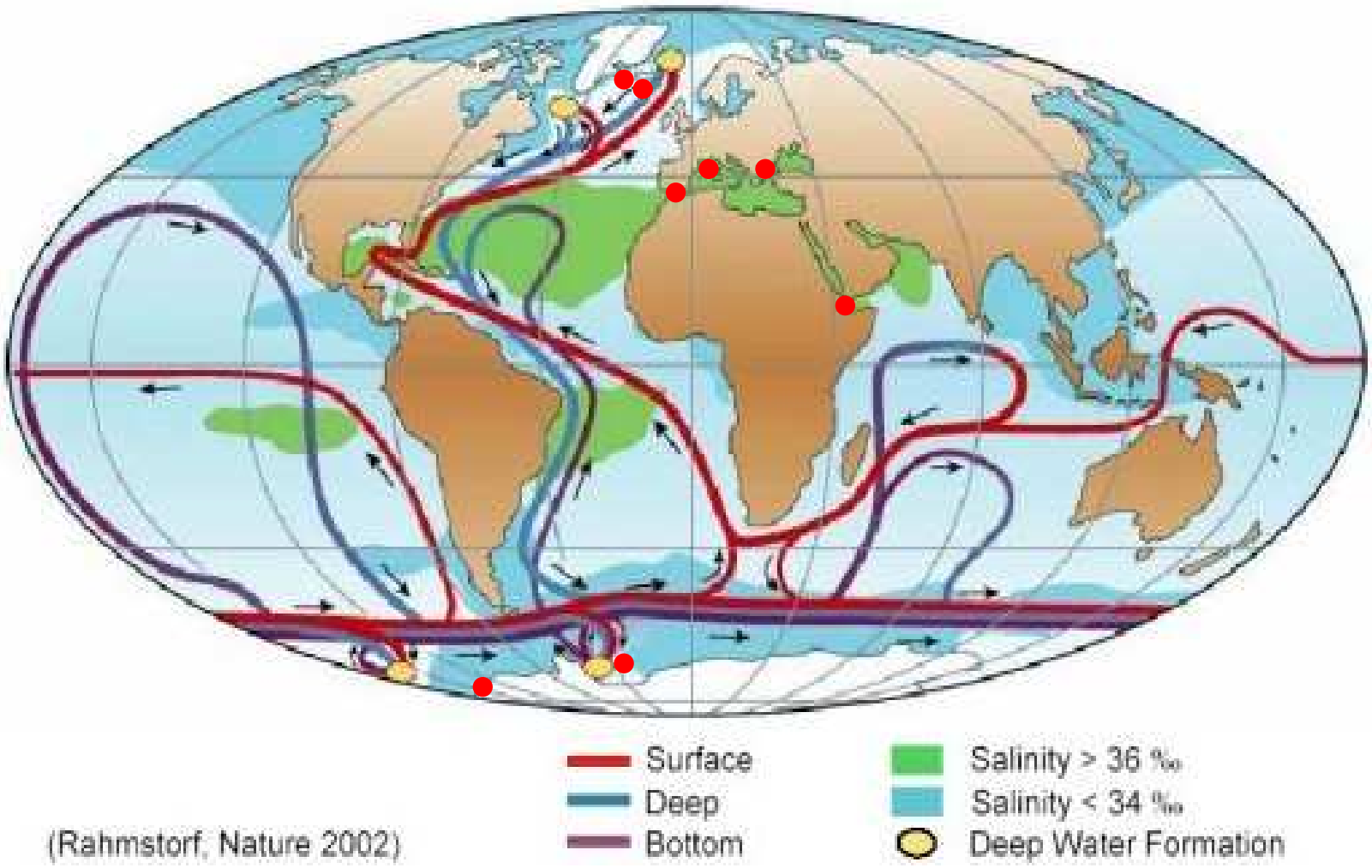
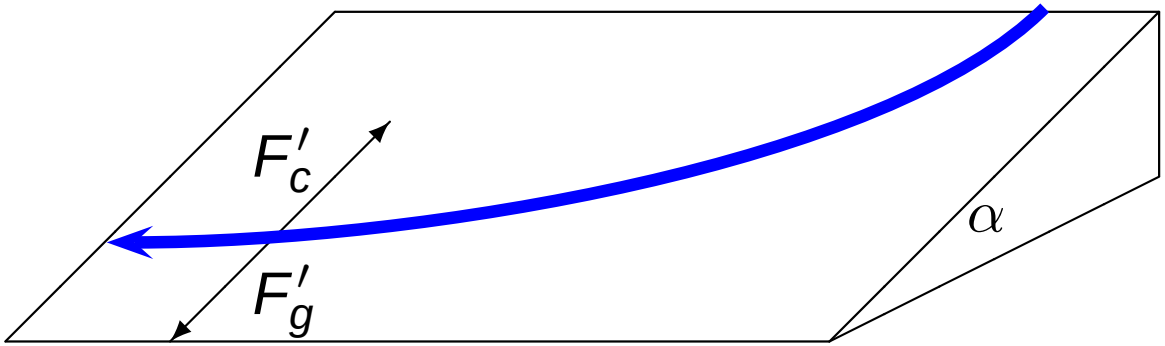


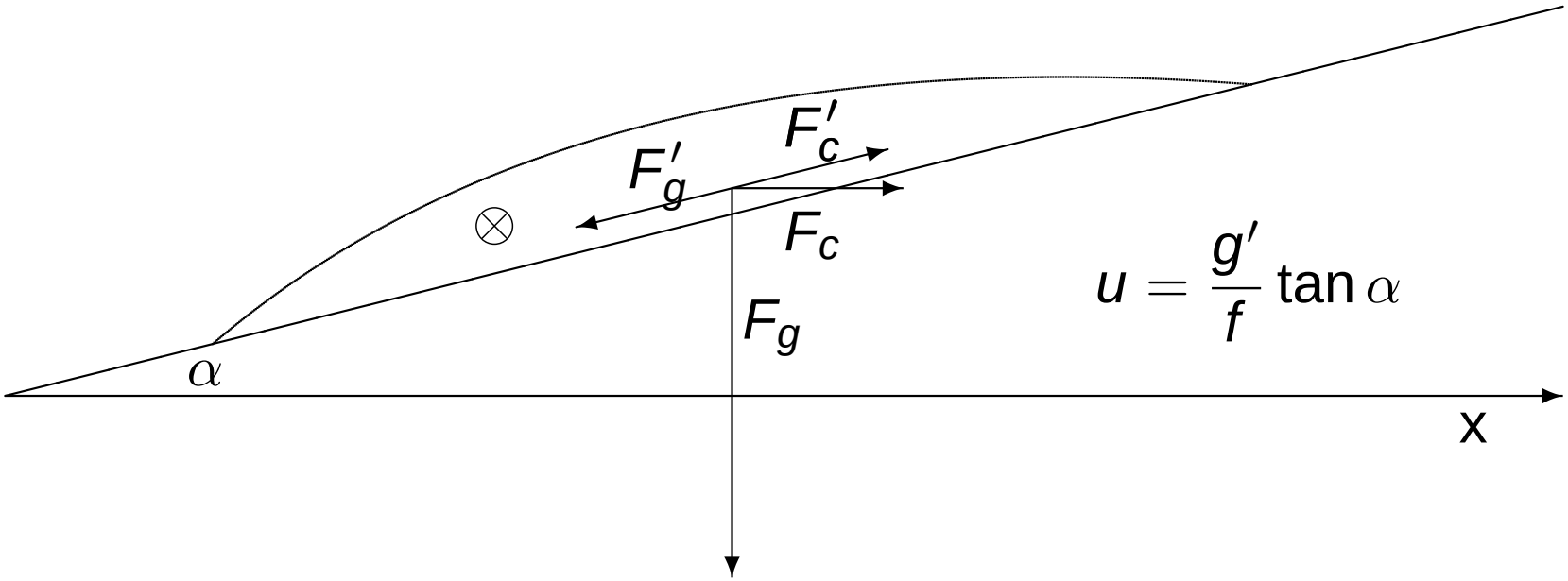
Gravity Current



(Rahmstorf, Nature 2002)

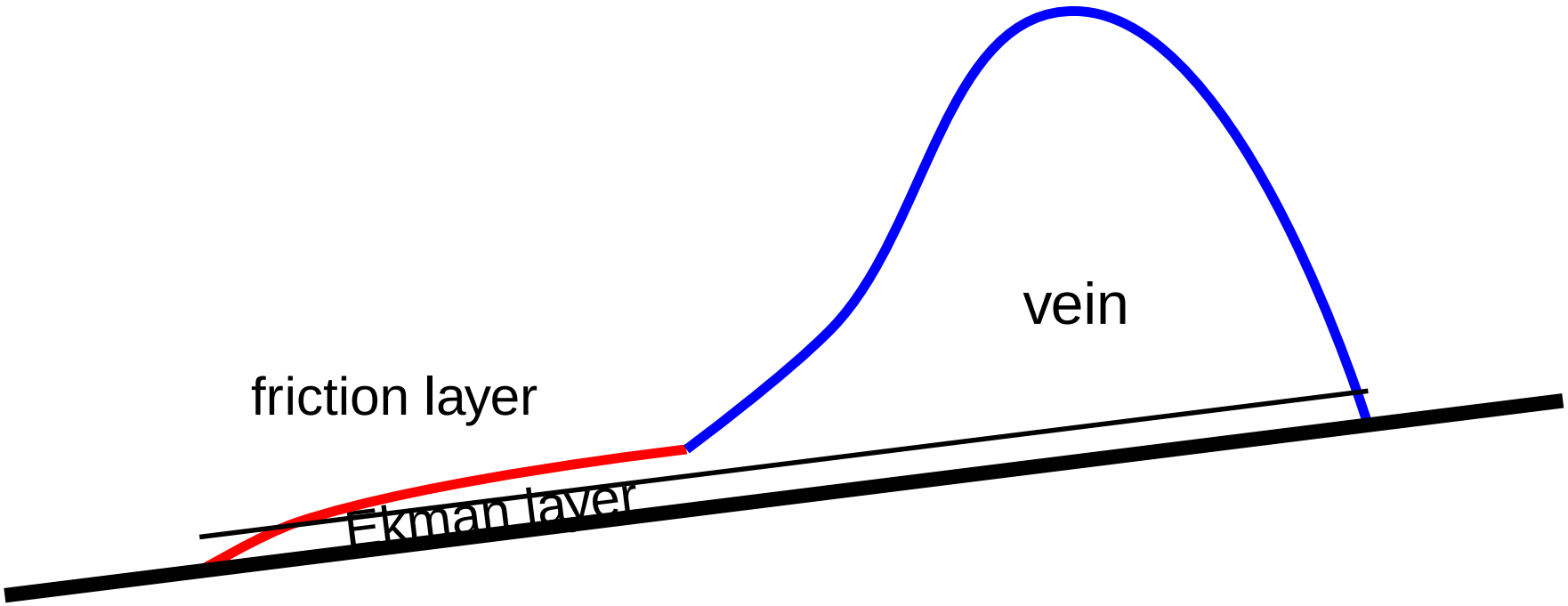
Geostrophy



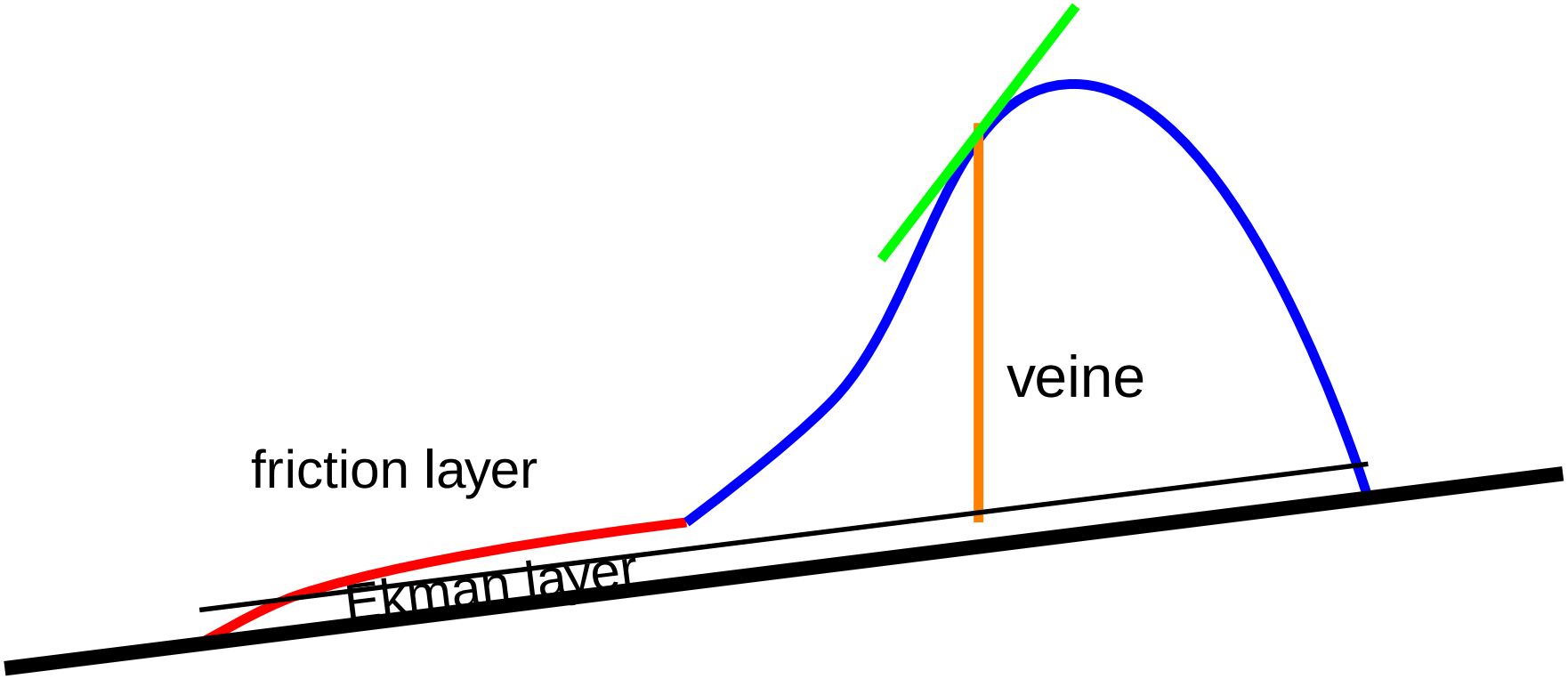


$$u = \frac{g'}{f} \tan \alpha$$

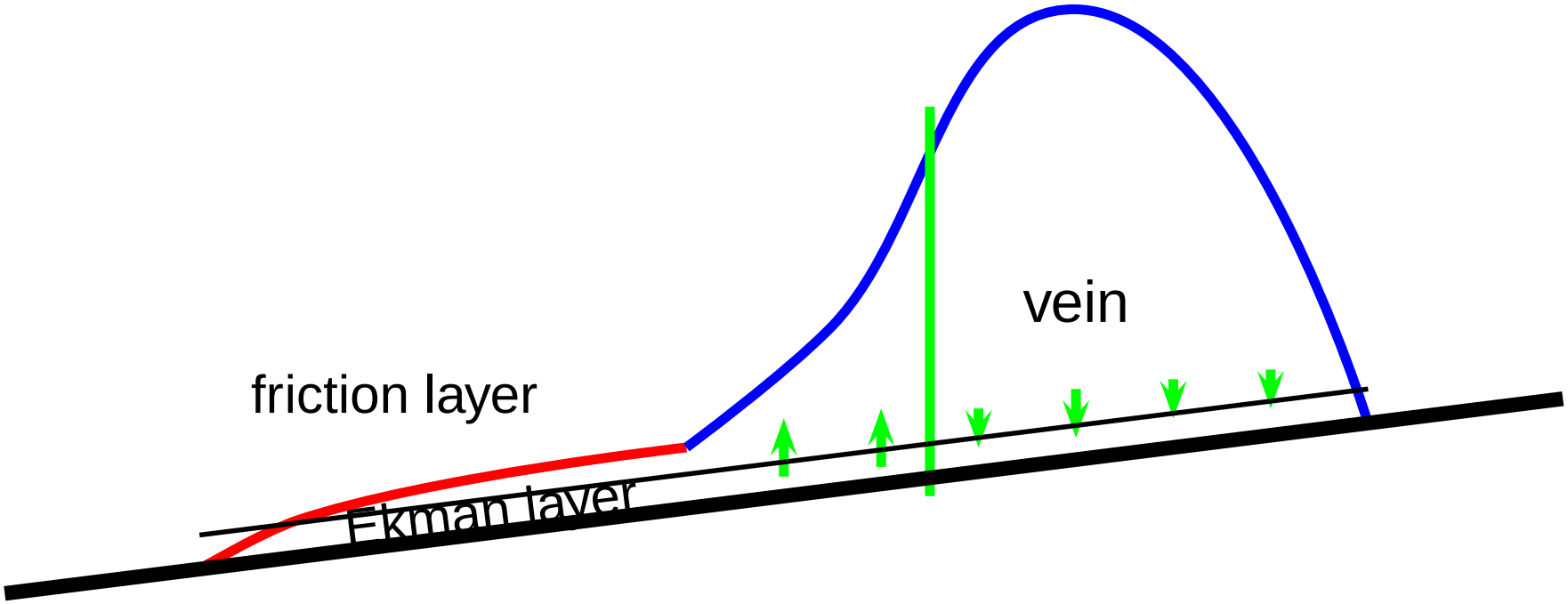
Forced Geostrophy



Forced Geostrophie



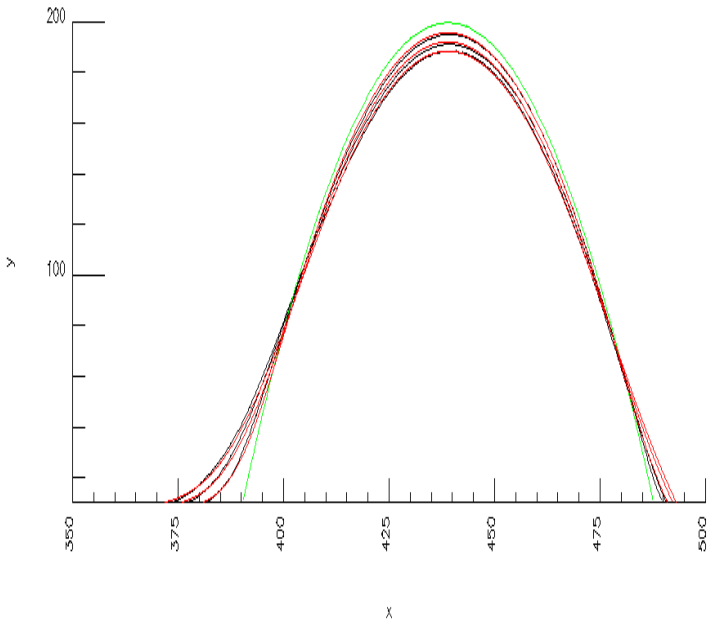
Forced Geostrophy



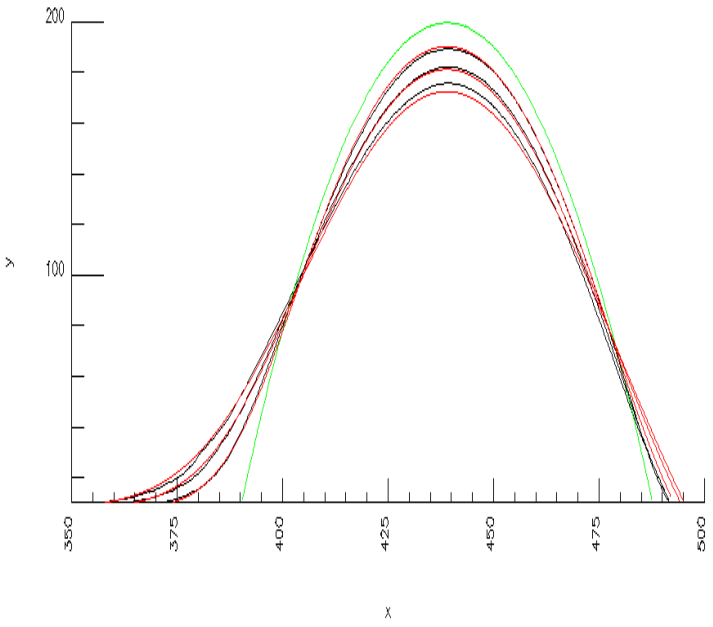
Heat Equation

$$\partial_t h = -\partial_x U_{Ek} = \frac{\delta}{2}\partial_x v_{\text{geo}} = \frac{\delta g'}{2f}\partial_{xx} h = \partial_x \left(\kappa_H \partial_x h\right)$$

24h



60h



Friction

... determines the dynamics of oceanic gravity currents.
The frictional processes can not be explicitely represented in today's (and tomorrow's) ocean models

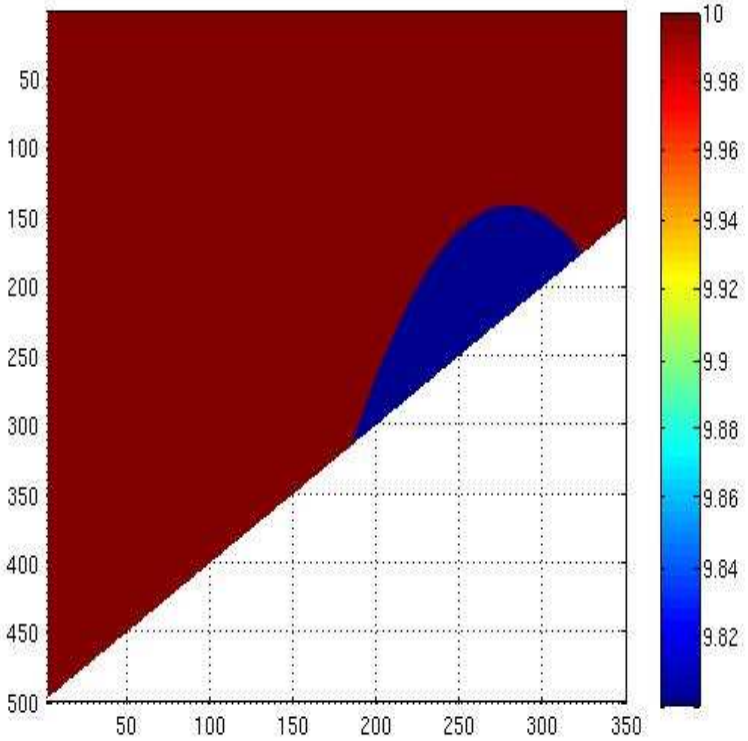
$$\tau + c_D|\mathbf{u}|$$

linear Rayleigh friction (τ)

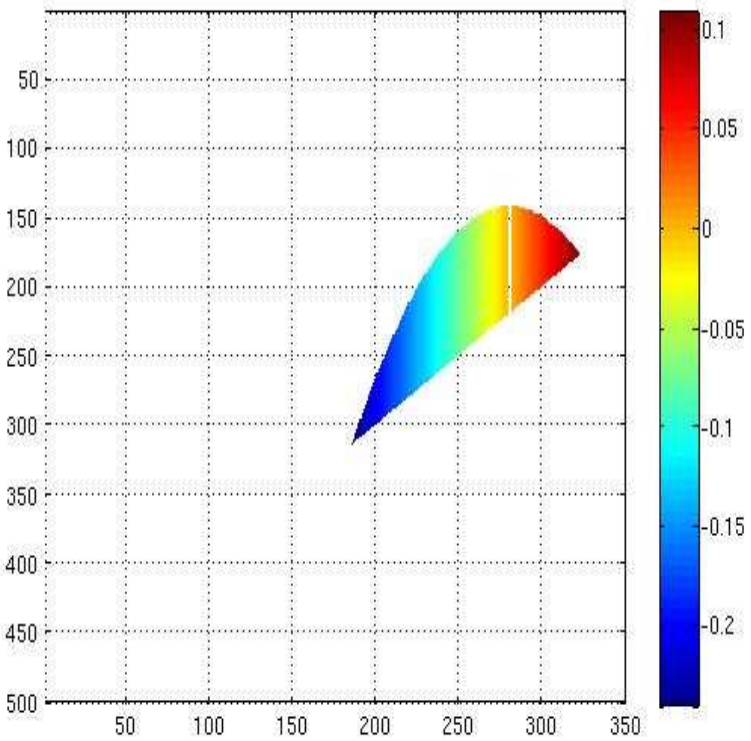
quadratic drag law (c_D)

Initial Conditions

Temp

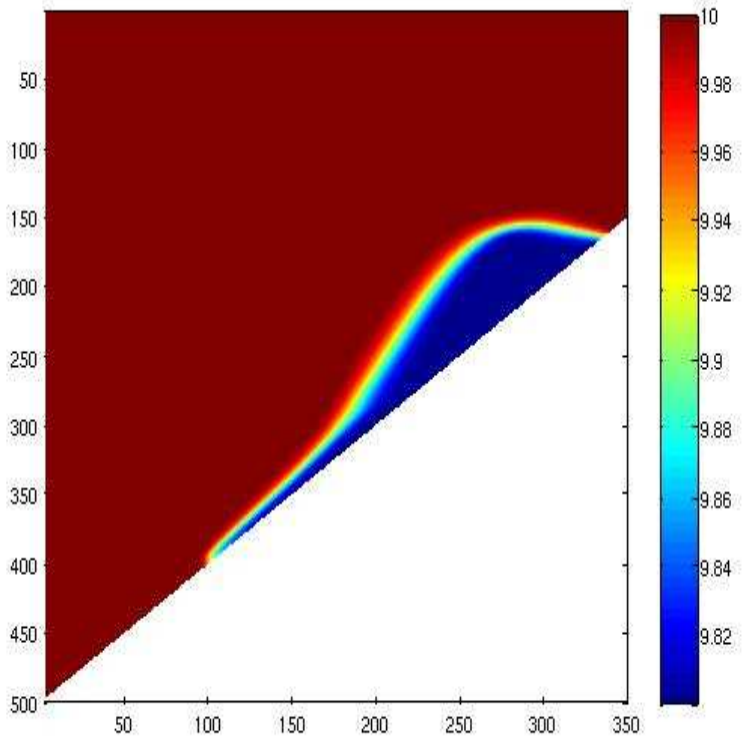


V_g

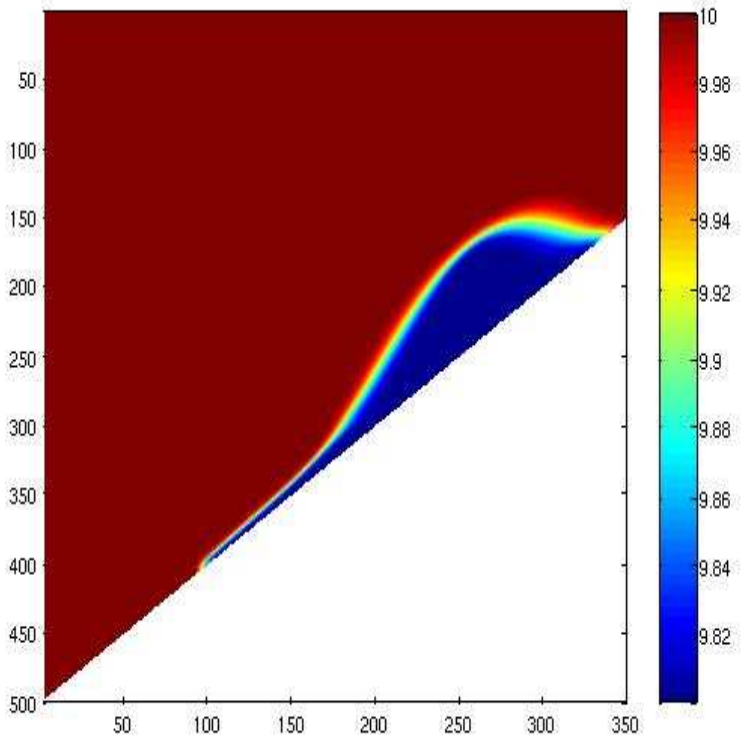


Reference Exp. (2D)

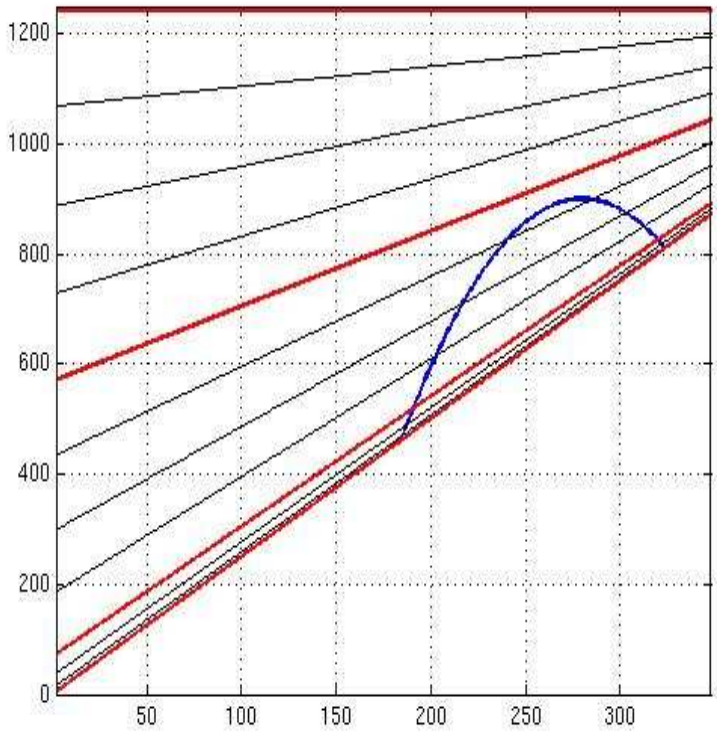
Z



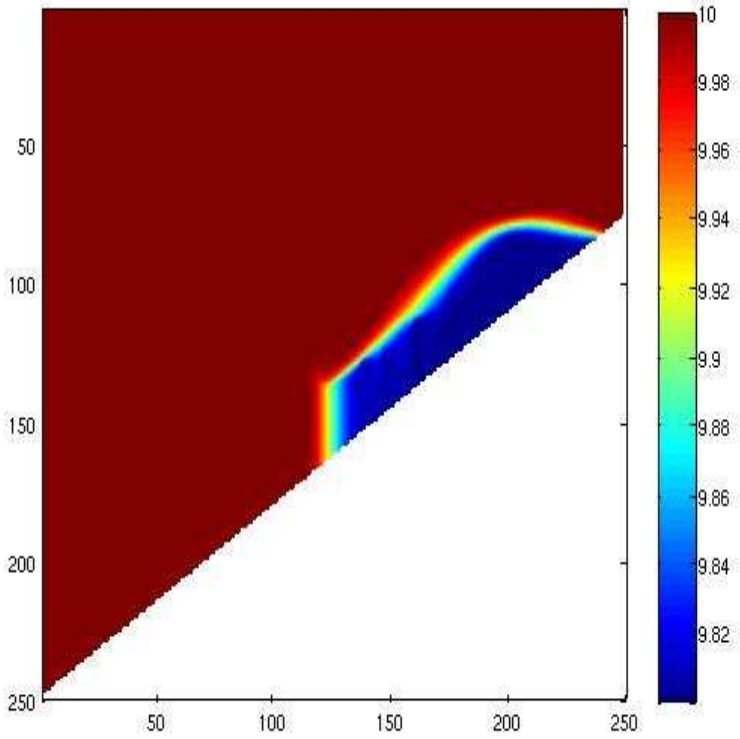
σ

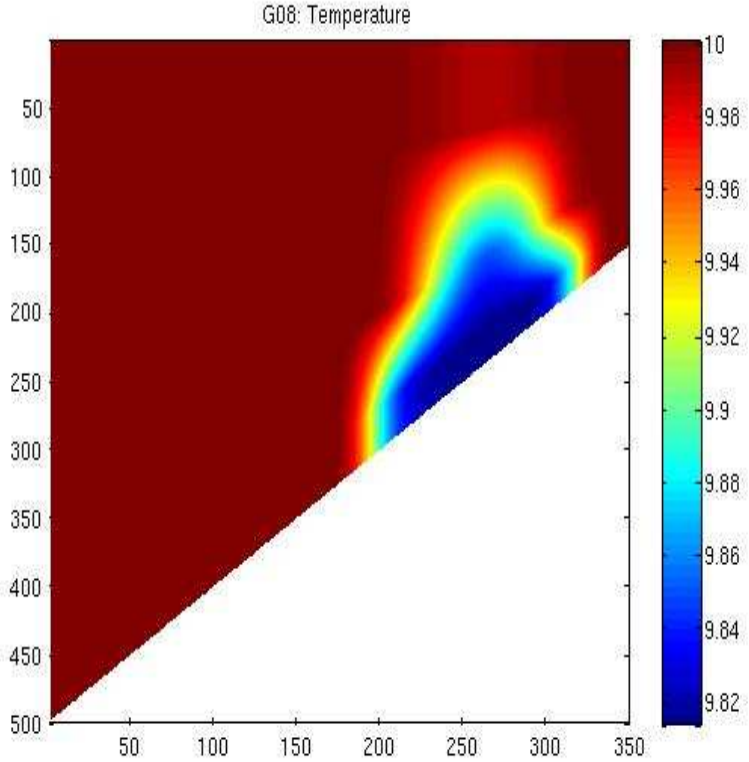


Grid σ

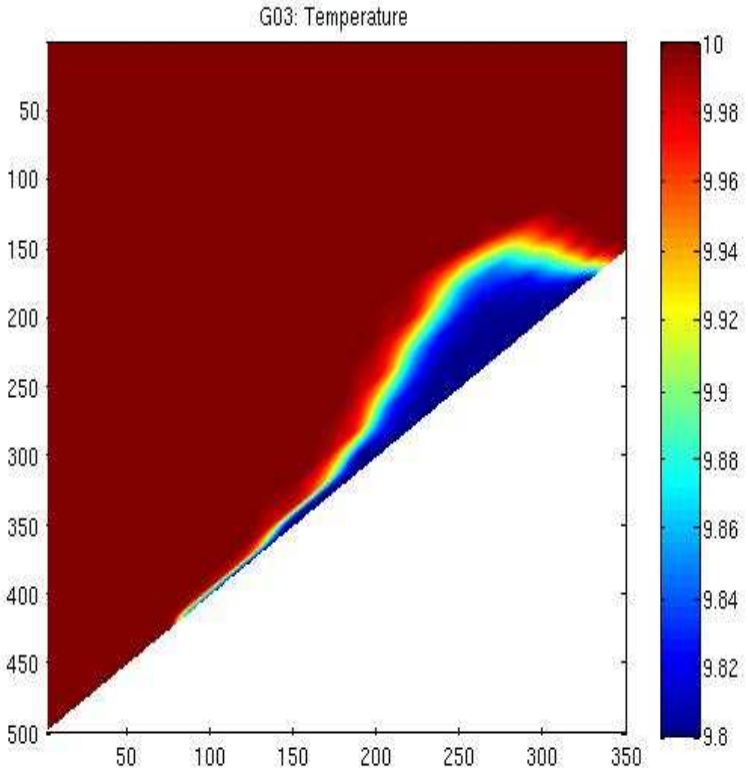


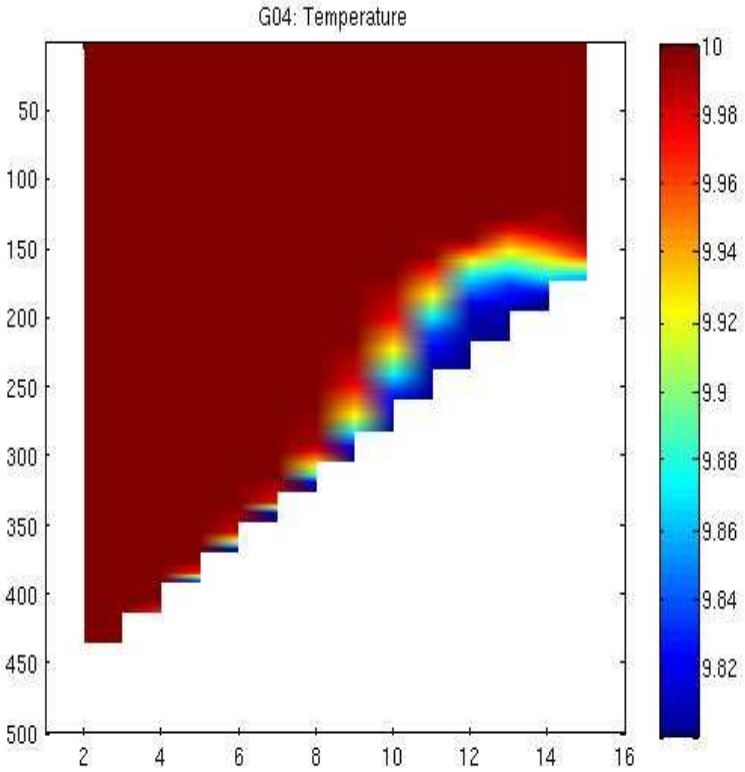
Convective Adjustment and Classic (2D)





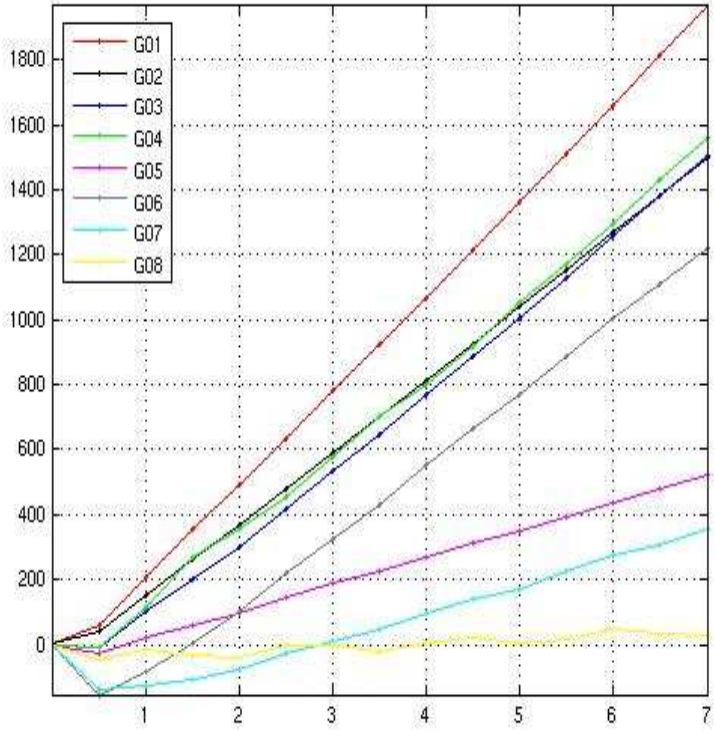
2+4+3 Levels (2D)



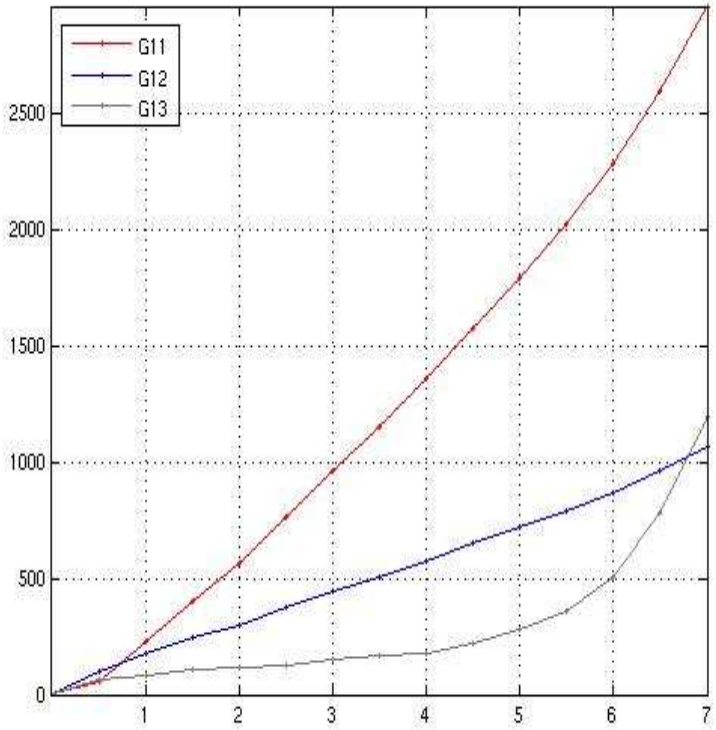


Down-slope transport

2.5D



3D



Conclusions A

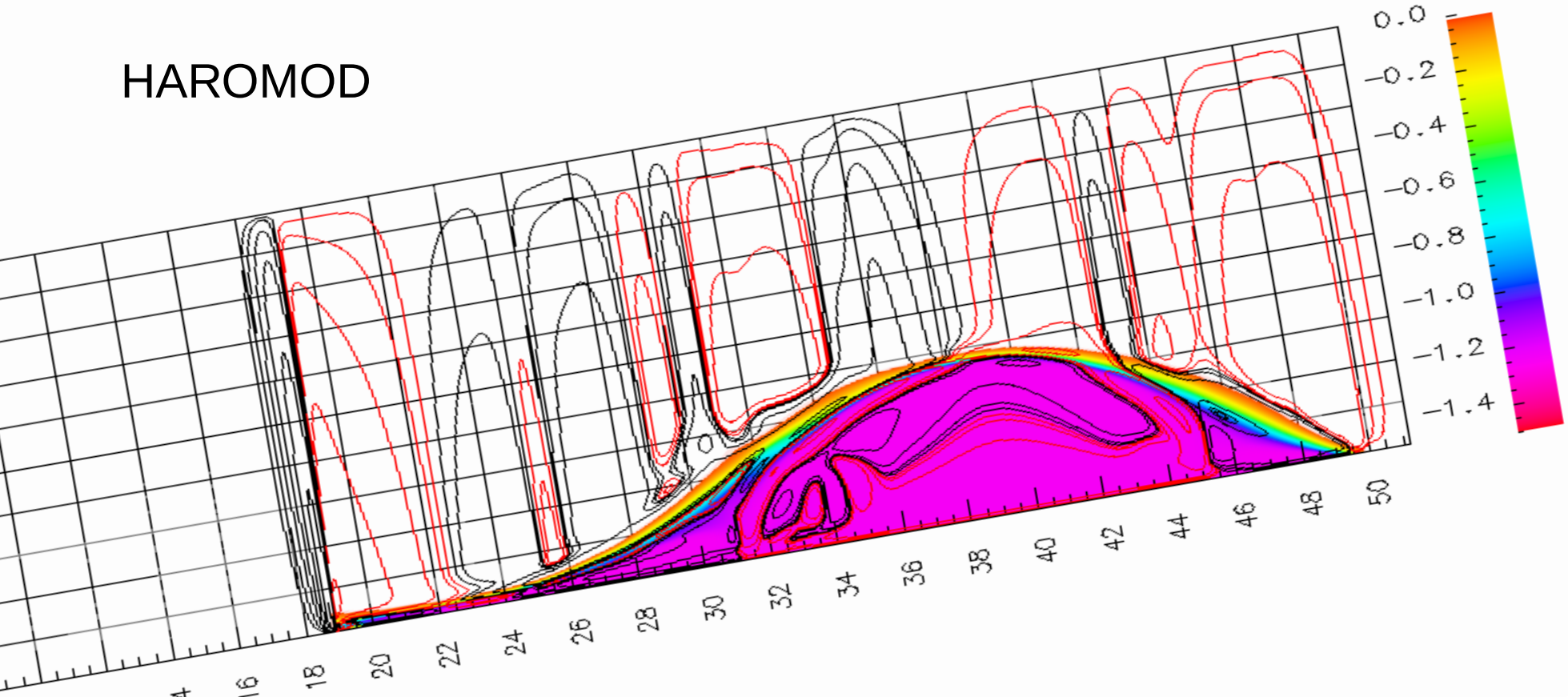
- The vertical resolution is key to correctly represent oceanic gravity currents.
- A few σ ($<$ 6) levels in the bottom layer are sufficient.
- The refinement of the vertical resoltuion at the bottom is more important than at the surface.
- These results are NOT restricted to gravity currents.

How do we find REAL bottom-friction

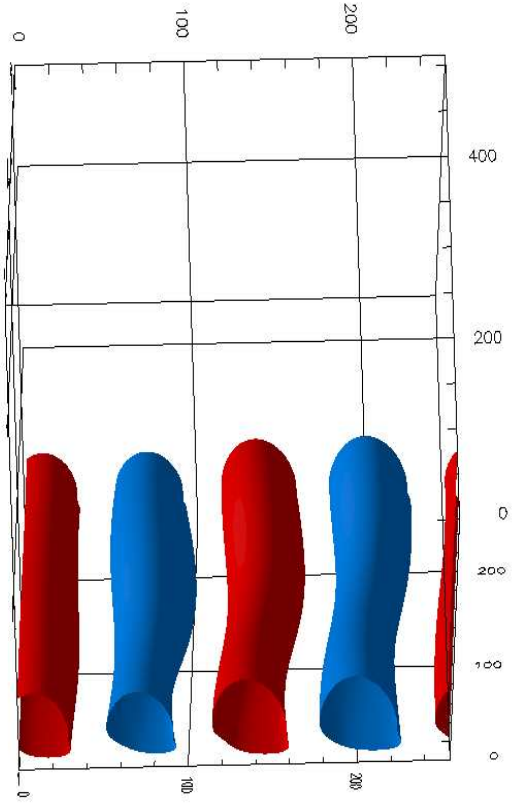
- Optimist : Study non-hydorstatic PBL-dynamics.
- Pessimist : Use data-assimilation to determine friction parameters from obs. (that we do not have).

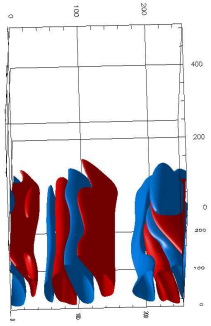
Non-hydrostatic simulation :

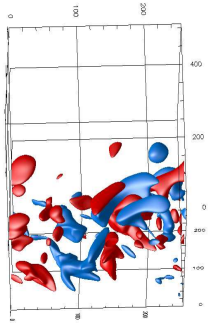
HAROMOD



Coherent Structures







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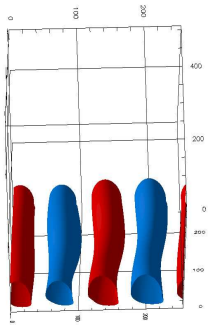
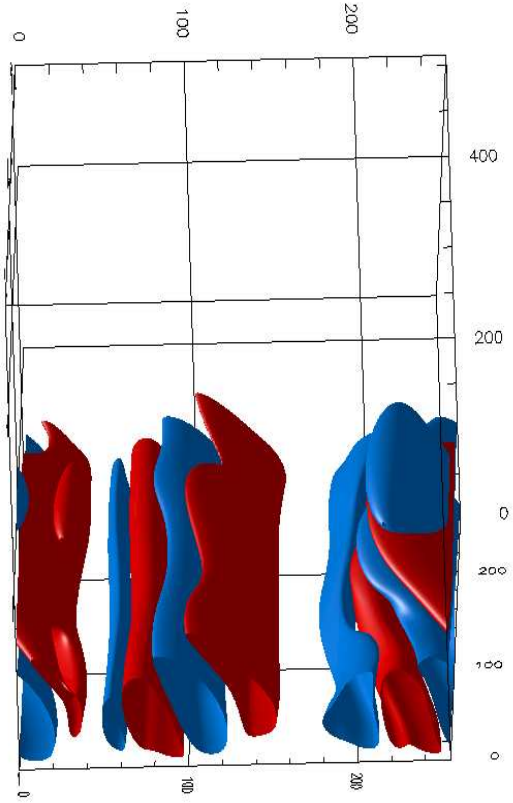
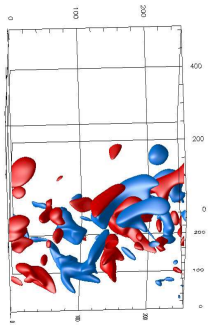
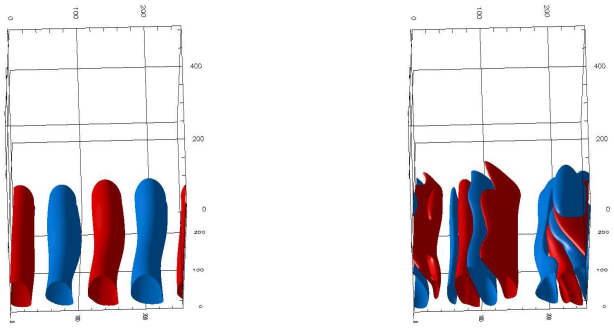
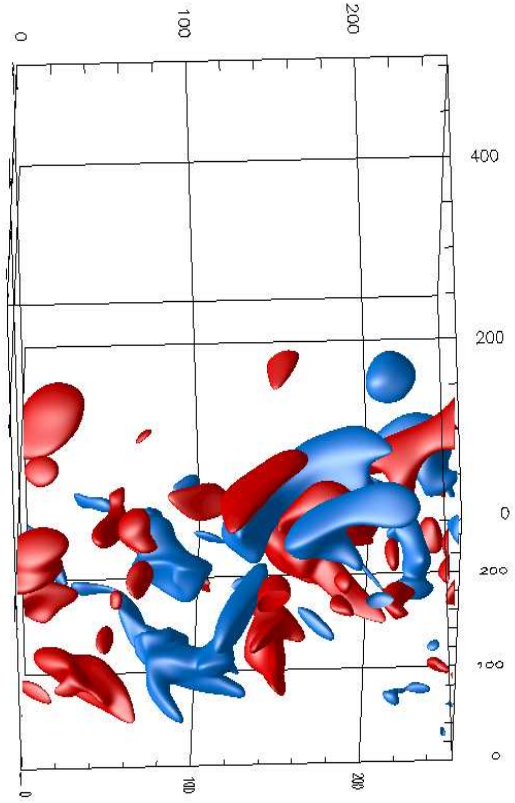






Coherent Structures





?

roughness of the ocean floor ?

variability of roughness ?

multiscale roughness (bio) ?

roughness type “k” vrs. “d” ?

orientation of roughness elements ?

suspension of sediments ?

tidal currents ?

waves ?

retroaction of currents on roughness ?

And : “The matter is far from beeing understood” Jiménez, Ann. Rev. Fluid Mech. (2004).

Friction

... determines the dynamics of oceanic gravity currents.
The frictional processes can not be explicitely represented in today's (and tomorrow's) ocean models

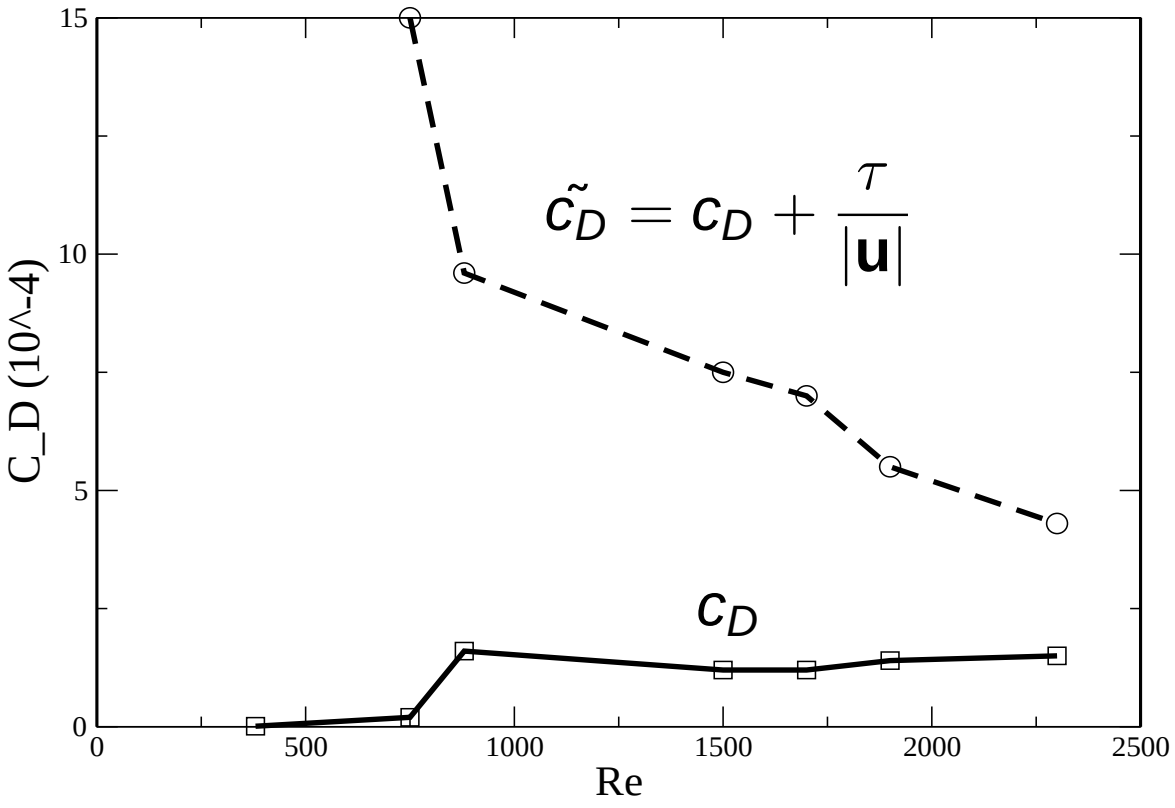
$$\tau + c_D|\mathbf{u}|$$

linear Rayleigh friction (τ)

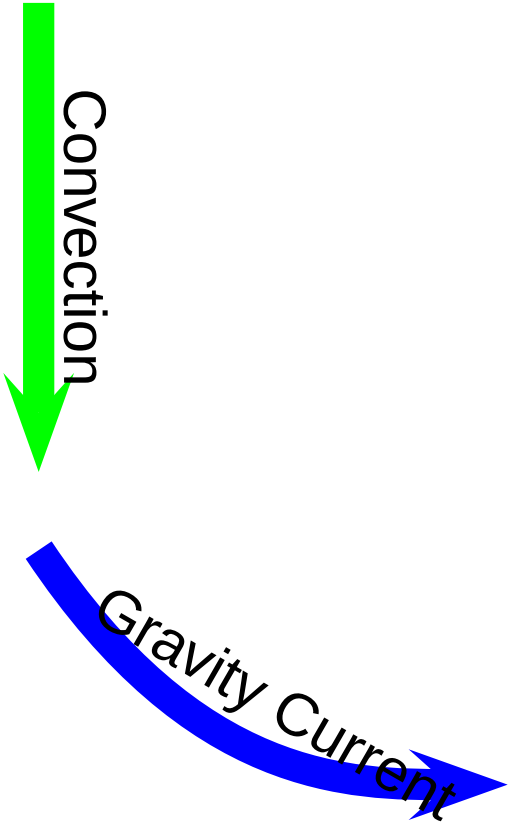
quadratic drag law (c_D)

Data Assimilation :

Estimation of parameters and friction laws :
detetction of transition from linear to quadratic law.



Conclusions



Conclusions & Perspectives