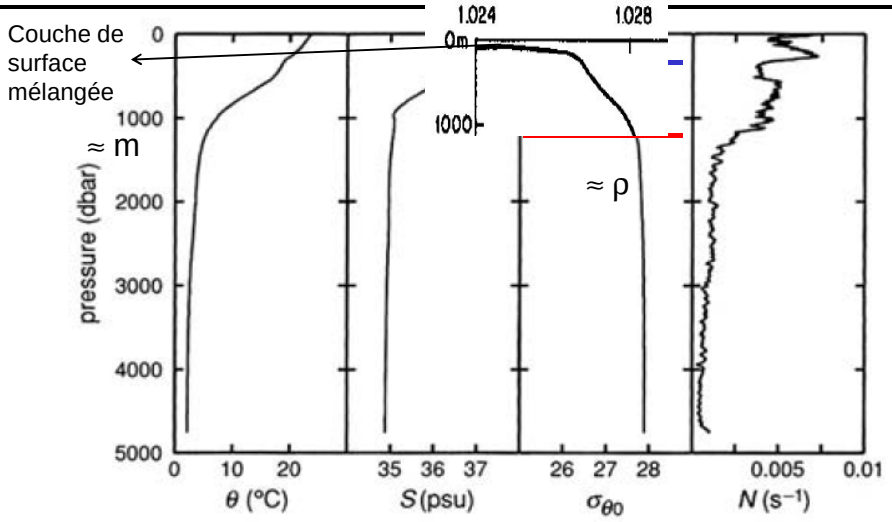
Structure verticale des océans

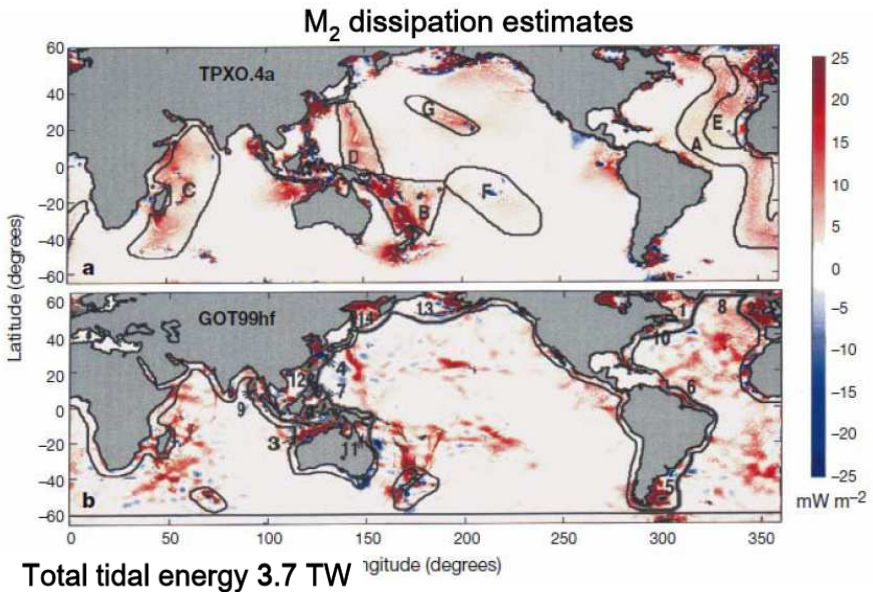


Atlantique Nord 26°N en avril 2004

Thermocline (pycnocline) saisonnière

Thermocline (pycnocline) principale

Energie des marées et dissipation

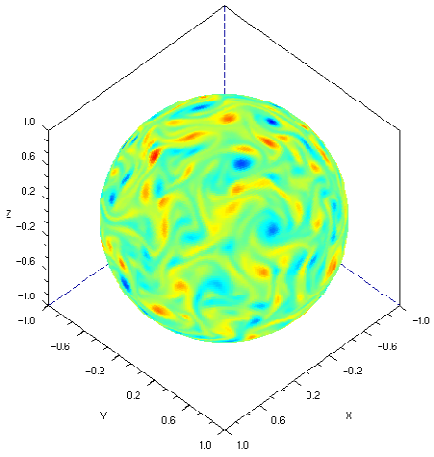


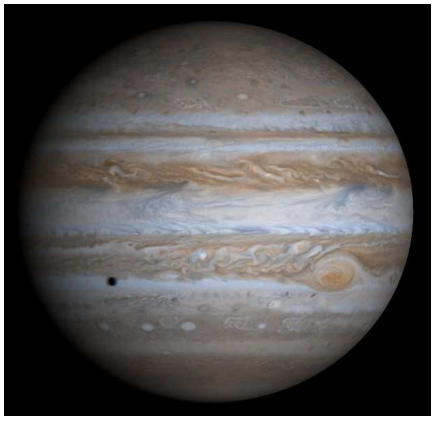
- Total tidal energy 3.7 TW

Turbulence environnementale ? turbulence planétaire…

Echelle planétaire pour l'atmosphère (terrestre ? Jovienne ?)

Page personnelle de O. Pannekoucke
http://www.cnrm.meteo.fr/recyf/spip.php?rubrique74&lang=en

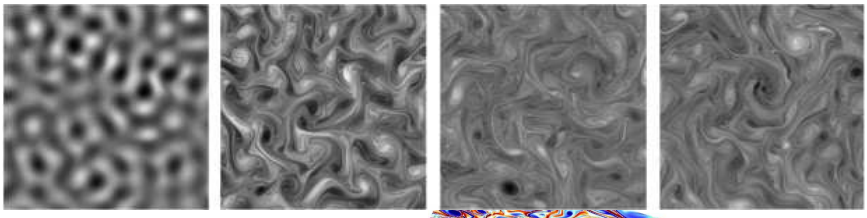




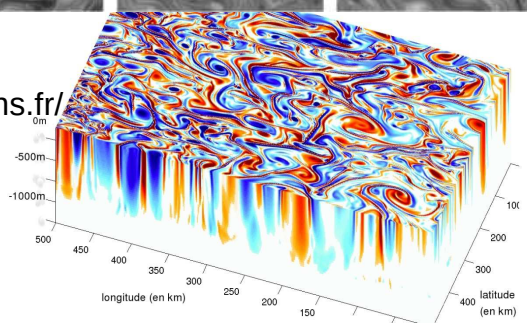
Jets zonaux

Turbulence environnementale ? turbulence avec rotation

Echelles synoptiques pour l'atmosphère et l'océan
Turbulence quasi-géostrophique



http://www.lmd.ens.fr/glapeyre/



Turbulence environnementale ? déferlement d'ondes internes

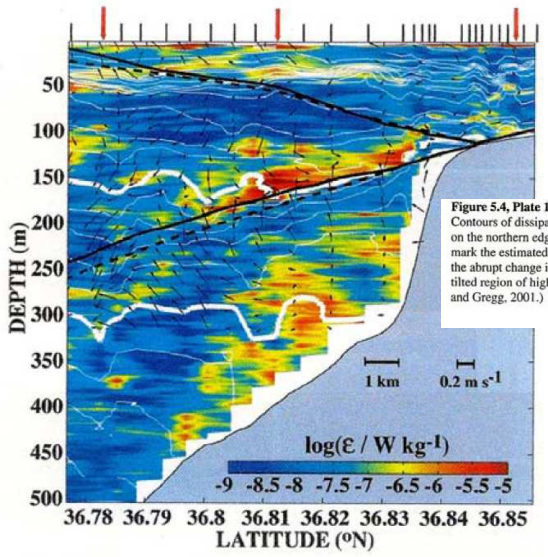
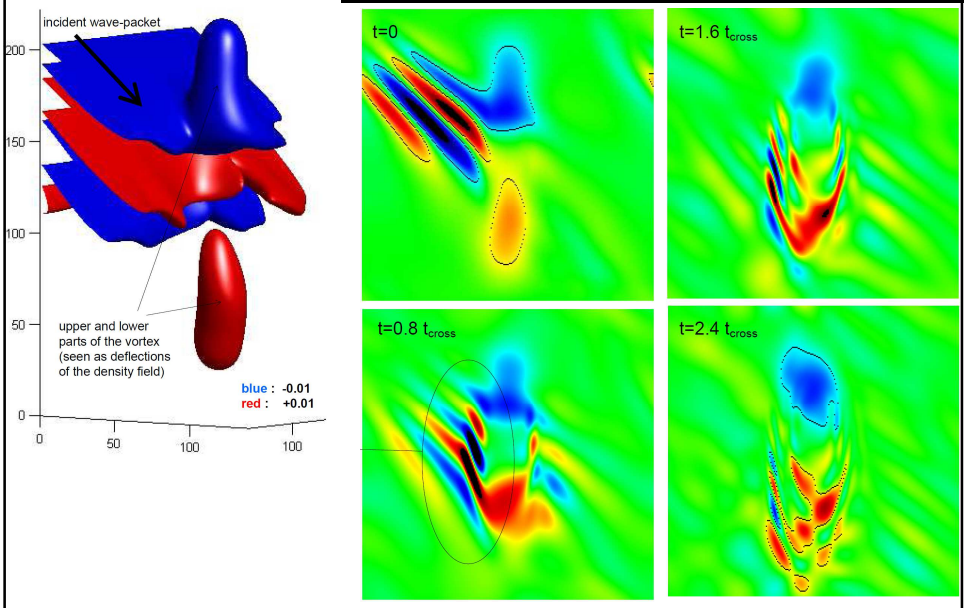


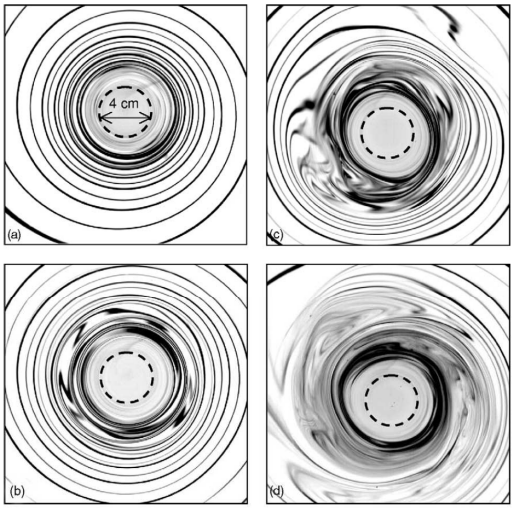
Figure 5.4, Plate 11. Mixing by an internal tide propagating near its source as a ray. Contours of dissipation, ε, are shown measured in a section across a ridge (lower right) on the northern edge of the continental slope flanking Monteray Bay. The solid lines mark the estimated paths of internal wave rays of M_2 tidal frequency from its source at the abrupt change in slope at the edge of the ridge. The lower ray closely matches the tilted region of high dissipation. Sampling stations are marked at the top. (From Lien and Gregg, 2001.)

Thorpe 2007

Turbulence environnementale ? déferlement d'ondes internes



Turbulence environnementale ? déferlement d'ondes internes



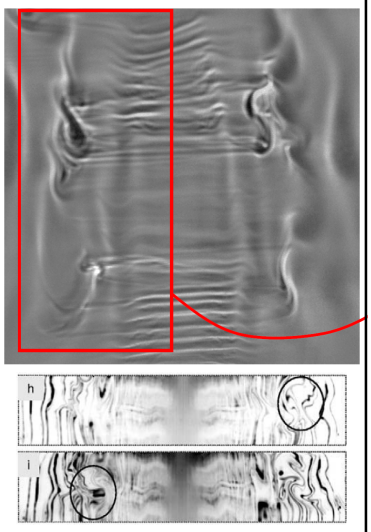
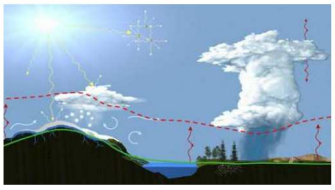


Fig. 5. Top-view dye-visualisation of the trapping and breaking of the wave in the vortex for $t = (a)$ 15 s, (b) 65 s, (c) 103 s and (d) 124 s after removal of the tube. Experimental parameters: $f = 0.5\,s^{-1}$, $N = 1.3\,s^{-1}$, $V = 3.0\,L$, $D = 5.0$ cm, $A_{cyl} = 3.0$ cm, $\omega_{abs} = 0.85\,s^{-1}$. Waves are generated at $t = 34$ s near the bottom of the tank and propagate from right to left.

Turbulence environnementale ? Couche limite atmosphérique



http://www.esrl.noaa.gov/research/themes/pbl

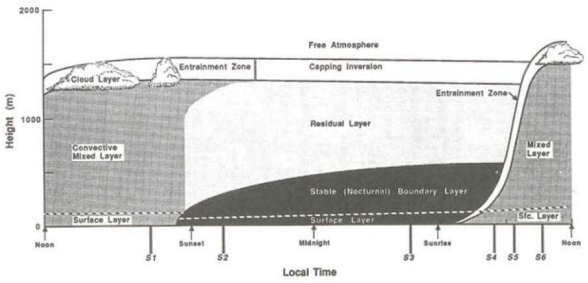
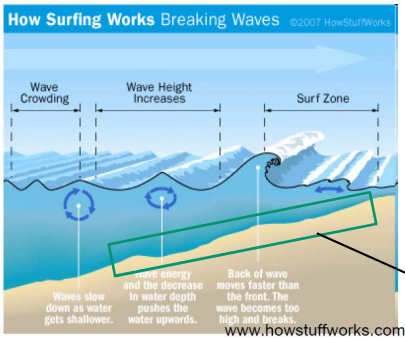


Fig. 1.7 The boundary layer in high pressure regions over land consists of three major parts: a very turbulent mixed layer; a less-turbulent residual layer containing former mixed-layer air; and a nocturnal stable boundary layer of sporadic turbulence. The mixed layer can be subdivided into a cloud layer and a subcloud layer. Time markers indicated by S1-S6 will be used in Fig. 1.12.

Stull 1988

Turbulence environnementale ? Surf zone

- Source of turbulence: overturning/breaking waves on sloping beaches
- random but coherent structures
- Waves produce mean motion: Stokes drift
- Air is entrained
- turbulence also produced by induced flows
- turbulence affects dispersion of pollutants (oil,..)



NASA

couche limite benthique périodique ici

Turbulence environnementale ? Hydrobiologie

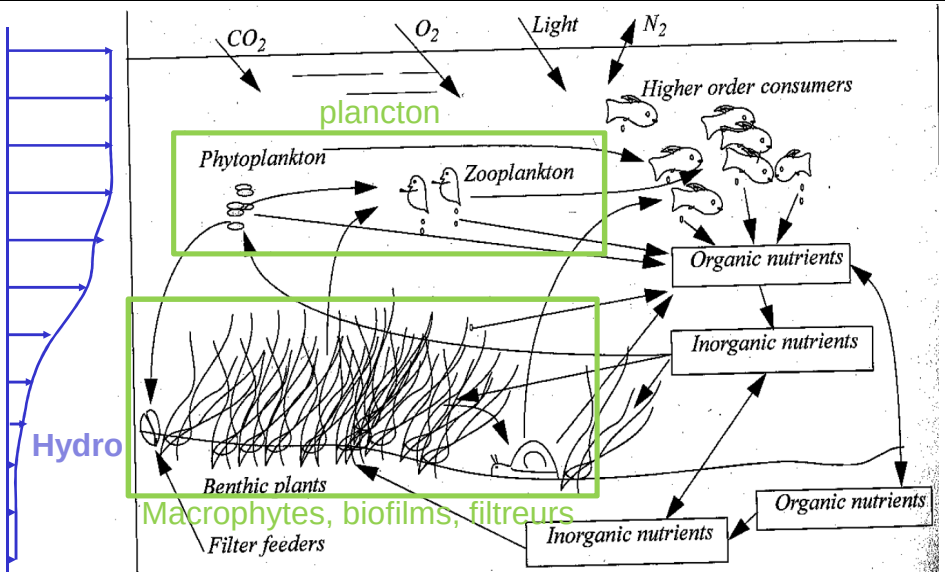
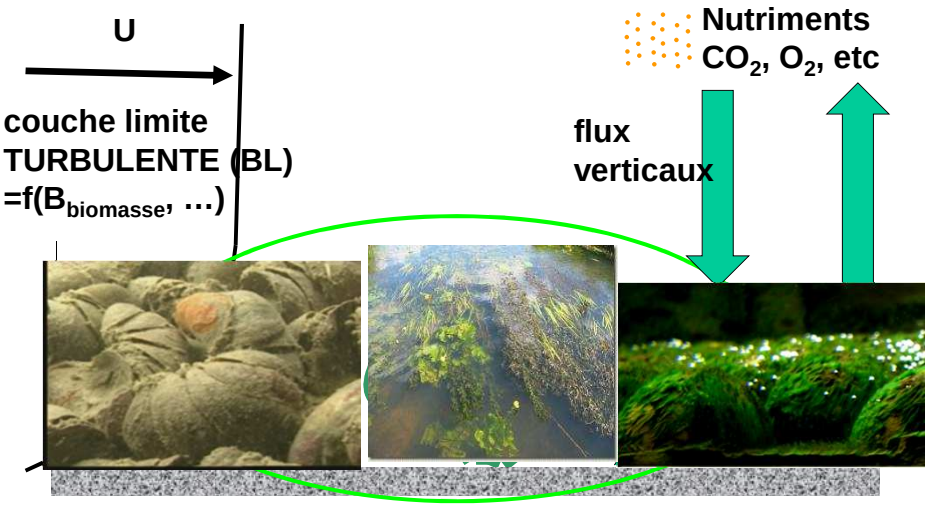


Figure 13.1 de “Hydrobiological Modelling” de Brian Williams

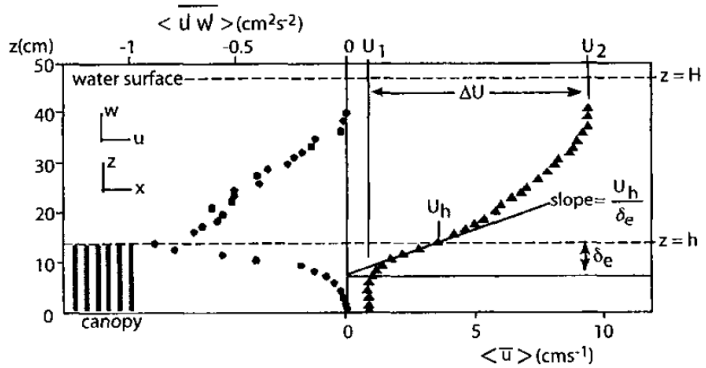
Turbulence environnementale ? Hydrobiologie



$dB_{biomasse}/dt=f(nutriments,CO_2,écoulement\ LOCAL)$

Turbulence environnementale ? Hydrobiologie

Exemple des canopées végétales (Nepf et al. 2007) :



exchange zone

$\Phi_v=(k_e/\delta_e)\ C_{ex}$ avec $k_e=0.19u^*(C_dah)^{0.13}$ et $\delta_e=0.23h/(C_dah)$

soit $\Phi_v=\underbrace{0.8u^*(C_dah)^{1.13}}_{U_E}C_{ex} \approx 0.8u^*(k_s)^{1.13}C_{ex}$