NIOZ Royal Netherlands Institute for Sea Research

Tidal motions above Great Meteor Seamount and evidence of sediment resuspension

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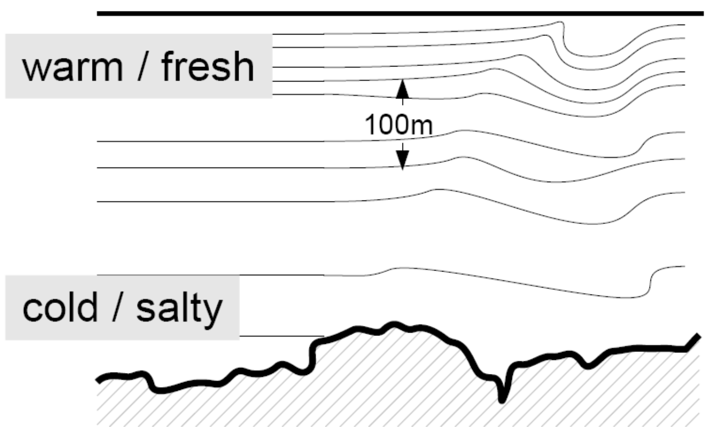
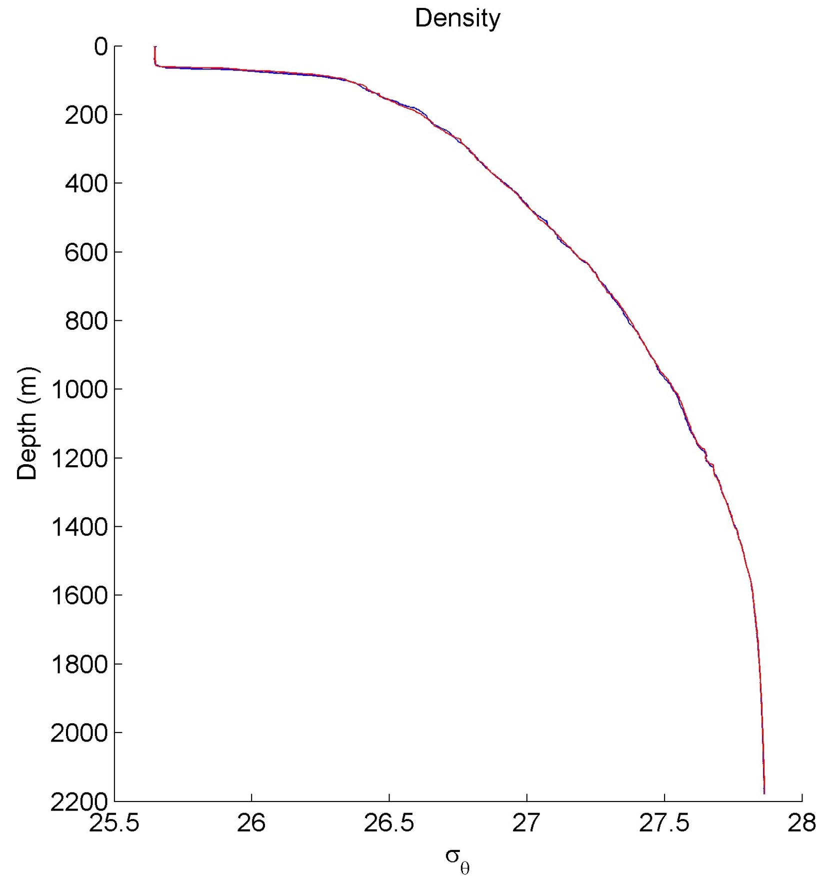
NIOZ is part of the Netherlands Organisation for Scientific Research (NWO)

What are internal waves?

Vertical stratification in density supports **internal gravity waves**



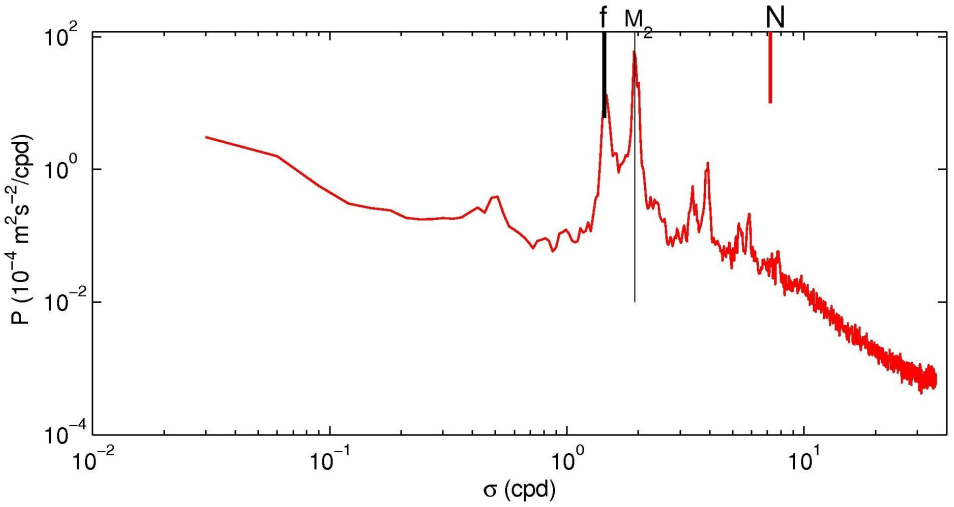
wave frequency < N



- N = buoyancy frequency, function of **stratification** (=0 without stratification)

How are they generated ?

- Atmospheric forcing at the surface (wind stress, passage of depressions)
  - -> broad forcing, narrow response (f)
- Tidal forcing above topography
  - -> particular frequencies (M2) + nonlinearities
- Typical periods :
  - 10 minutes to 1 day !



What do they affect ?

- sediment transport (“nepheloid layers”)
- biology

  plankton moving in/out the photic zone

  supply of nutrients in photic zone
- large-scale meridional overturning circulation

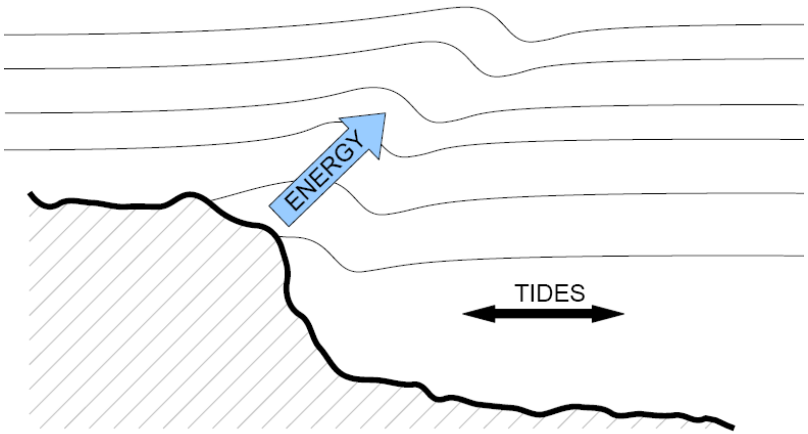
  the ocean is very different from the (convective) atmosphere.

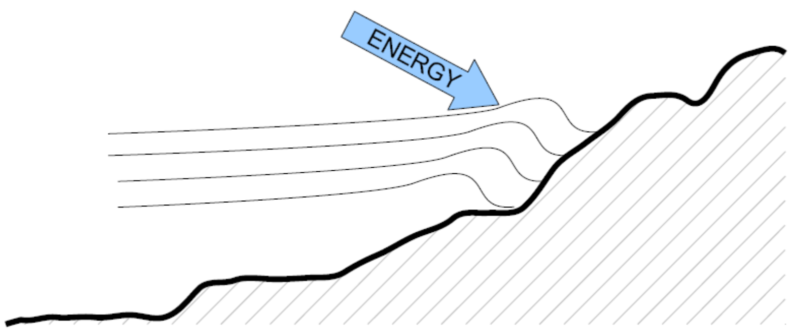
turbulent mixing is induced by breaking internal waves,

mostly at sloping bottoms

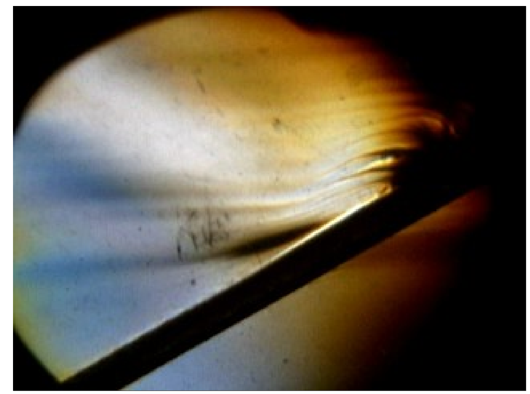
Importance of topography for internal waves

- Both generation and breaking occur on topography

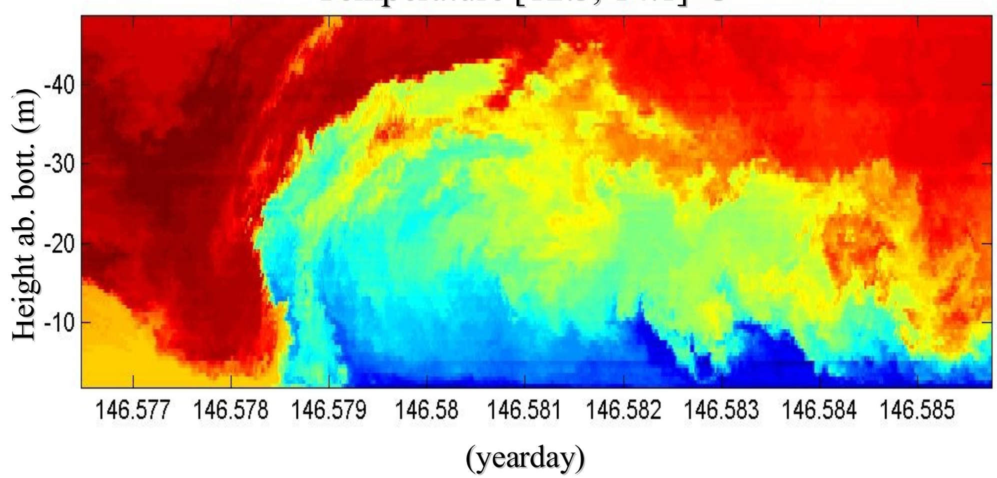




breaking = non-linear effects



Temperature [12.3, 14.1]°C

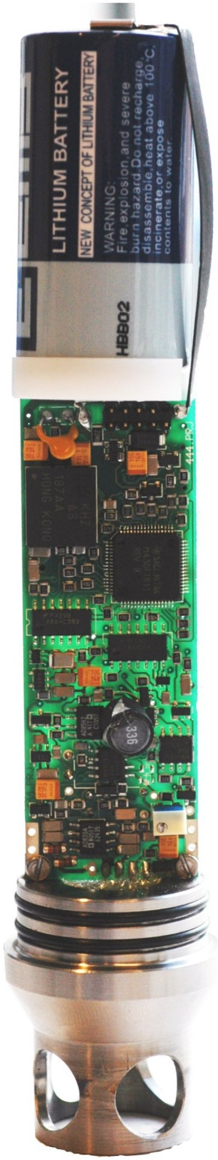


14 minutes detail

How to observe internal waves?

- Physical parameters:
  - Temperature and salinity (density)
  - Pressure
  - Velocity
- Shipborne observations: CTD –snapshots in time and space
- Traditional moored observations:
  - Salinity and pressure are difficult
  - Temperature and velocity lack resolution in moorings
    - \- vertical : O(10-100) m over 500-5000 m
    - \- time : 10 min over 1 year

NIOZ3 specifications

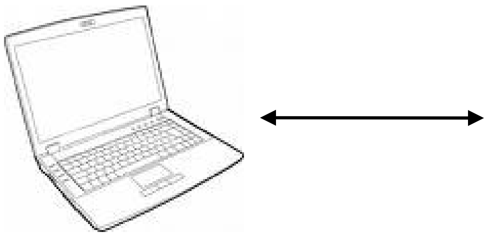


- Accuracy <0.001 °C
- Response time 0.25 s
- Autonomy 1.5 years at 1 Hz sampling

- Sensors are **independent** :
  - -> any number (100 or more)
  - -> at any position on moorings
  - -> no connecting cables
- Every clock is **synchronized** inductively
  - -> sensors stay synchronized at < 1 s
- Broadcast **programming** with LED-code indicators
  - -> no need to open the sensors

Deployment procedure : a child's play

- Programming and synchronization of the sensors



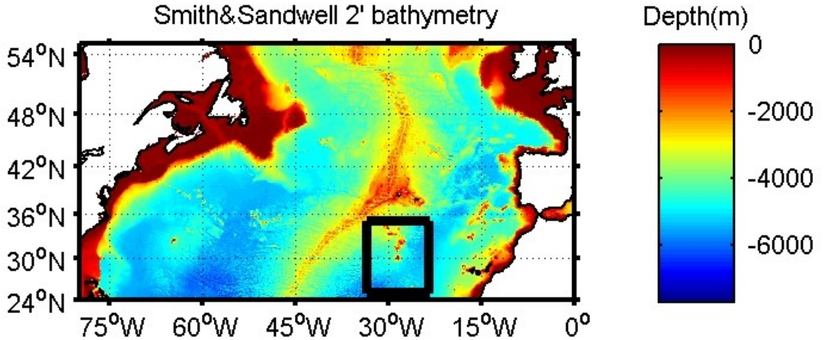
- Fixation on mooring line (Ytape)

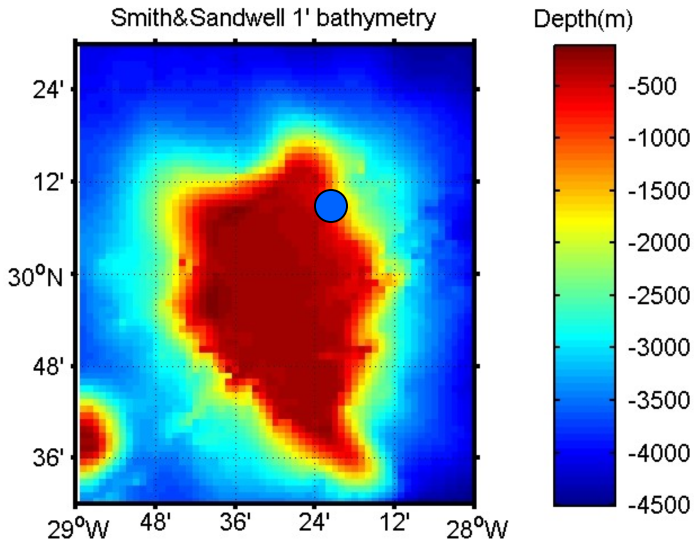
- Deployment

Fotos: B. Aggenbach

Exercise 1 : 19 days mooring

Great Meteor Seamount : a 4000m high guyot in the middle of the Canary Basin

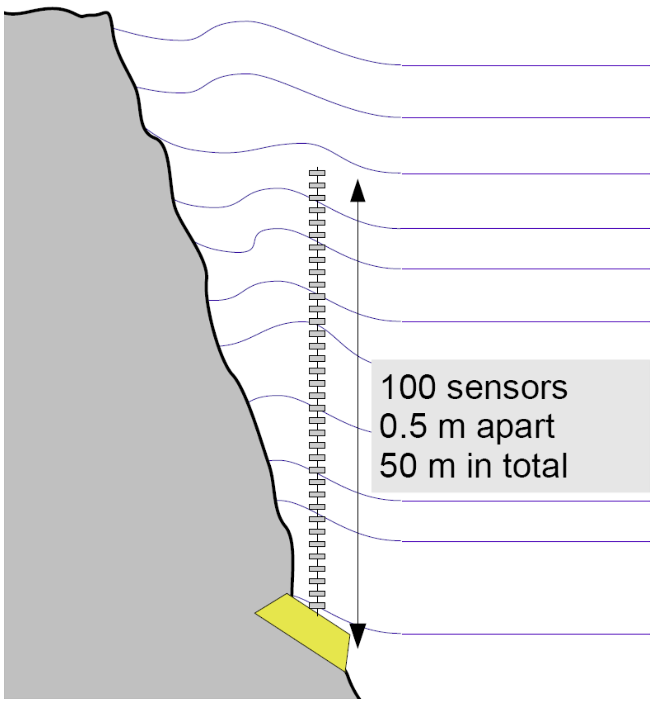




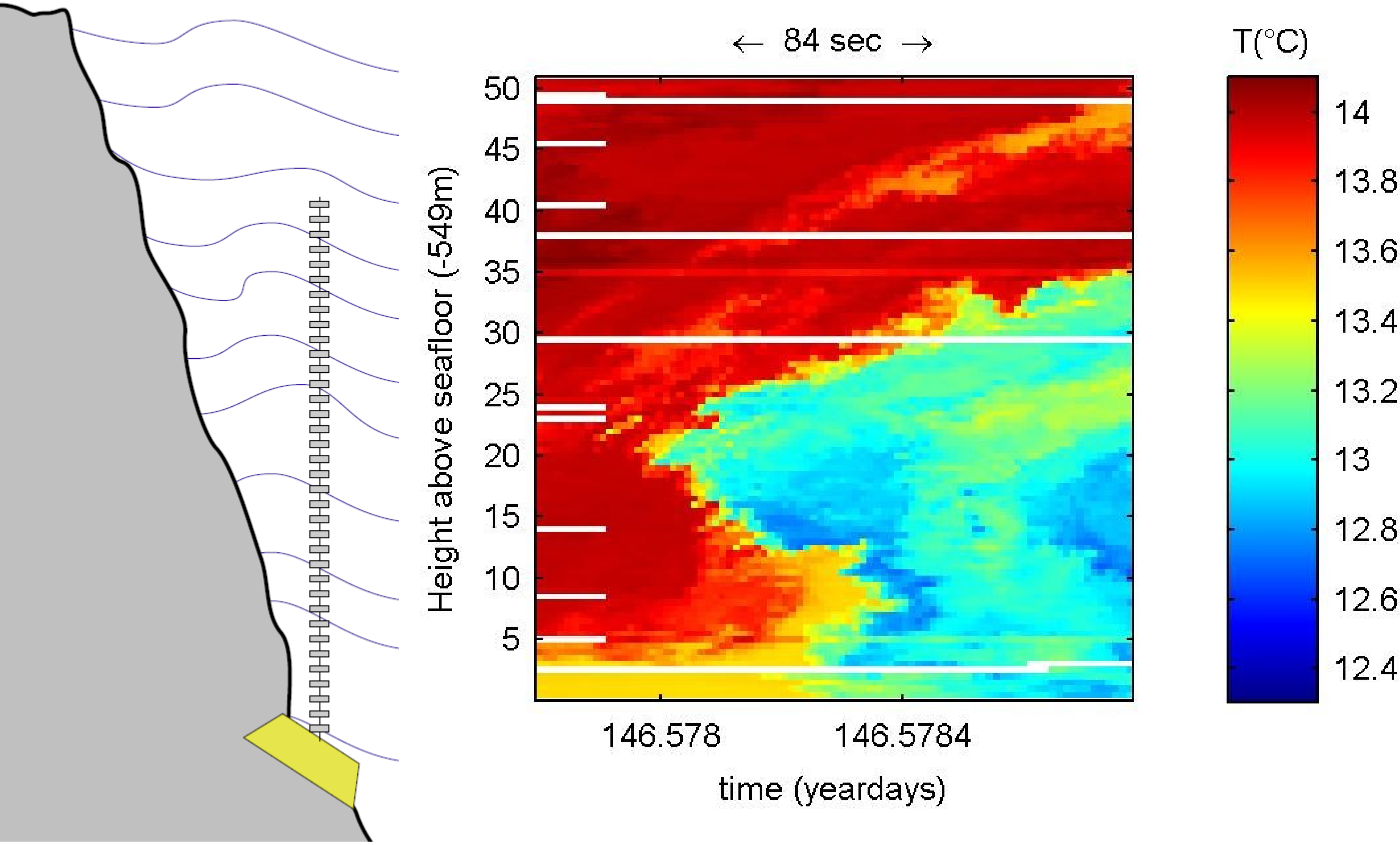
Cruise 64PE248

May 2006

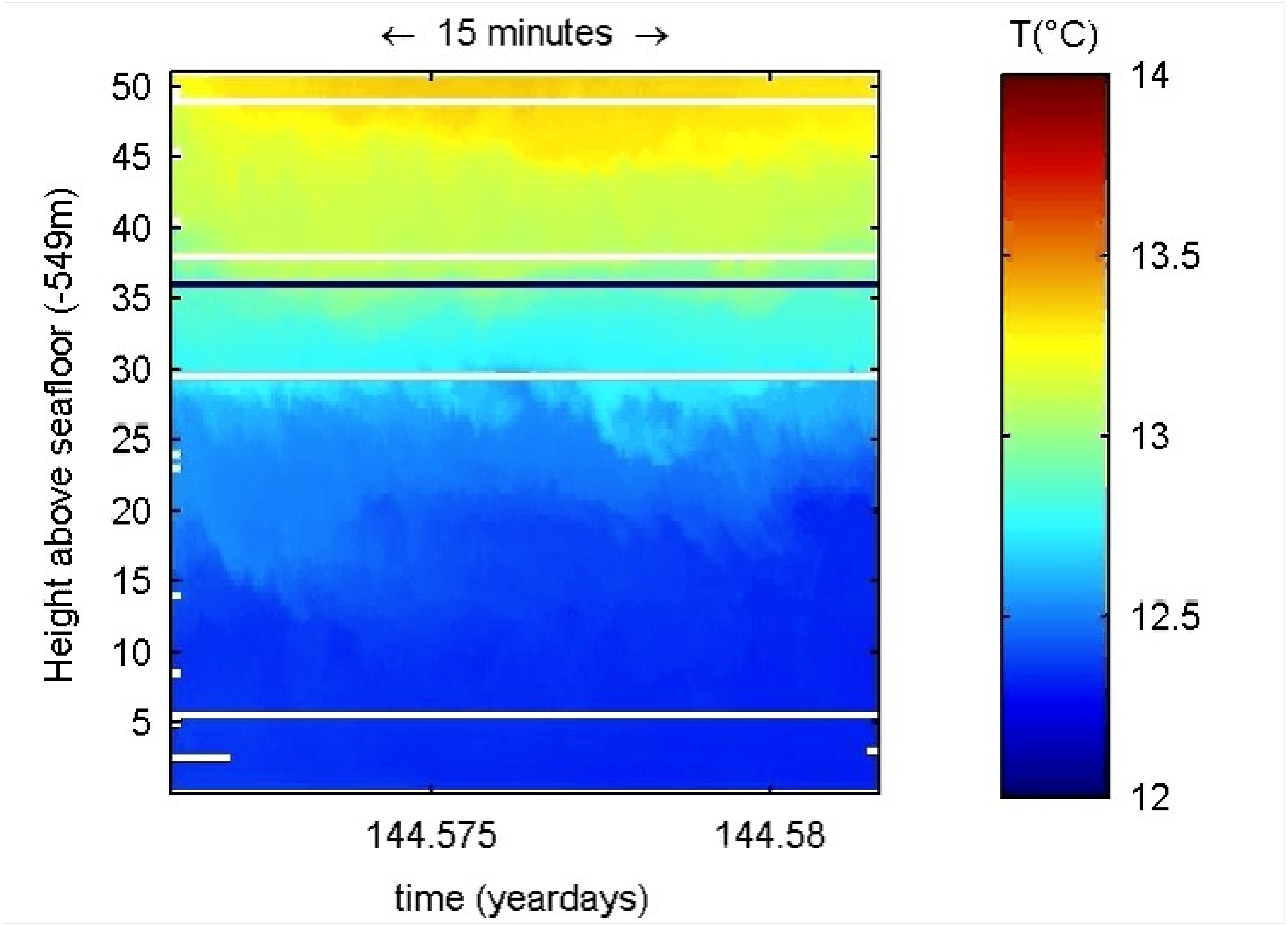
Mooring depth 550m



Non-linear tidal motions

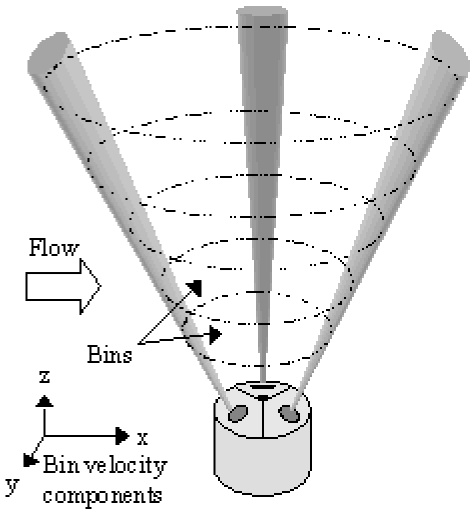


Movie 1 : internal waves above Great Meteor Seamount (2 days out of 19)



ADCP measurements

- RDI Sentinel 300kHz ADCP
- Attached to the bottom lander, upward-looking



(B) Vertically-oriented profiler

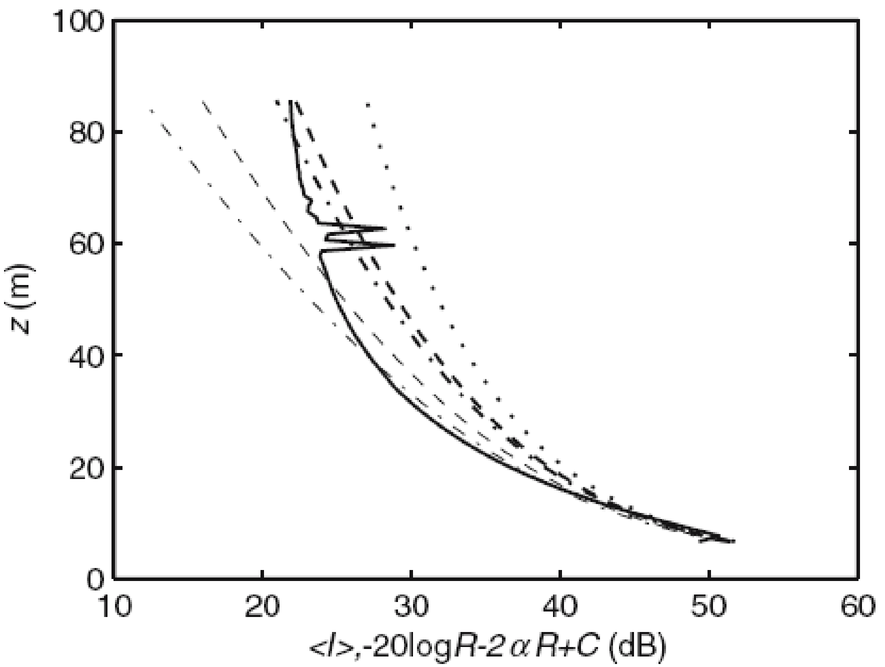
4 beams making an angle of 20° with horizontal
-> velocity along the four beams
-> 3D velocity

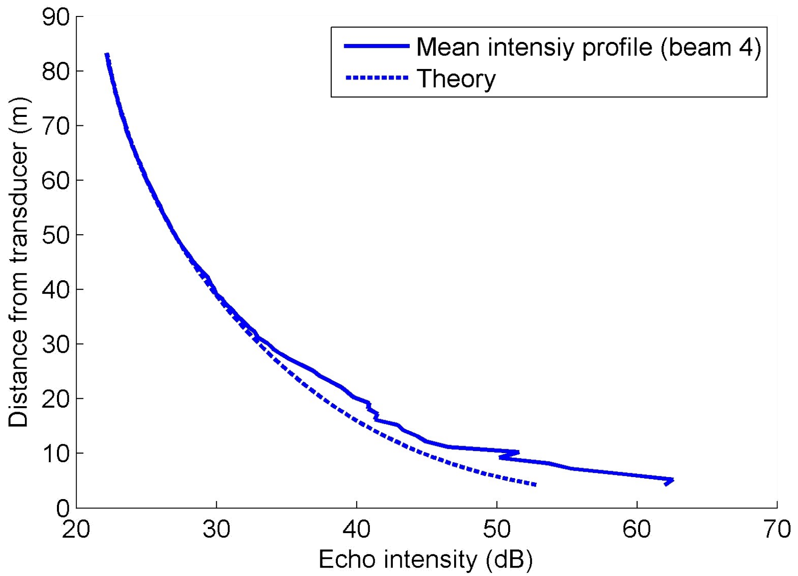
Echo intensity data processing

- van Haren, H. Echo intensity data as a directional antenna for observing processes above sloping ocean bottoms Ocean Dyn., 2007, 57, 135-149

$$I = S + B - 20\log(R) - 2\alpha R + C, \ \ in\, dB$$

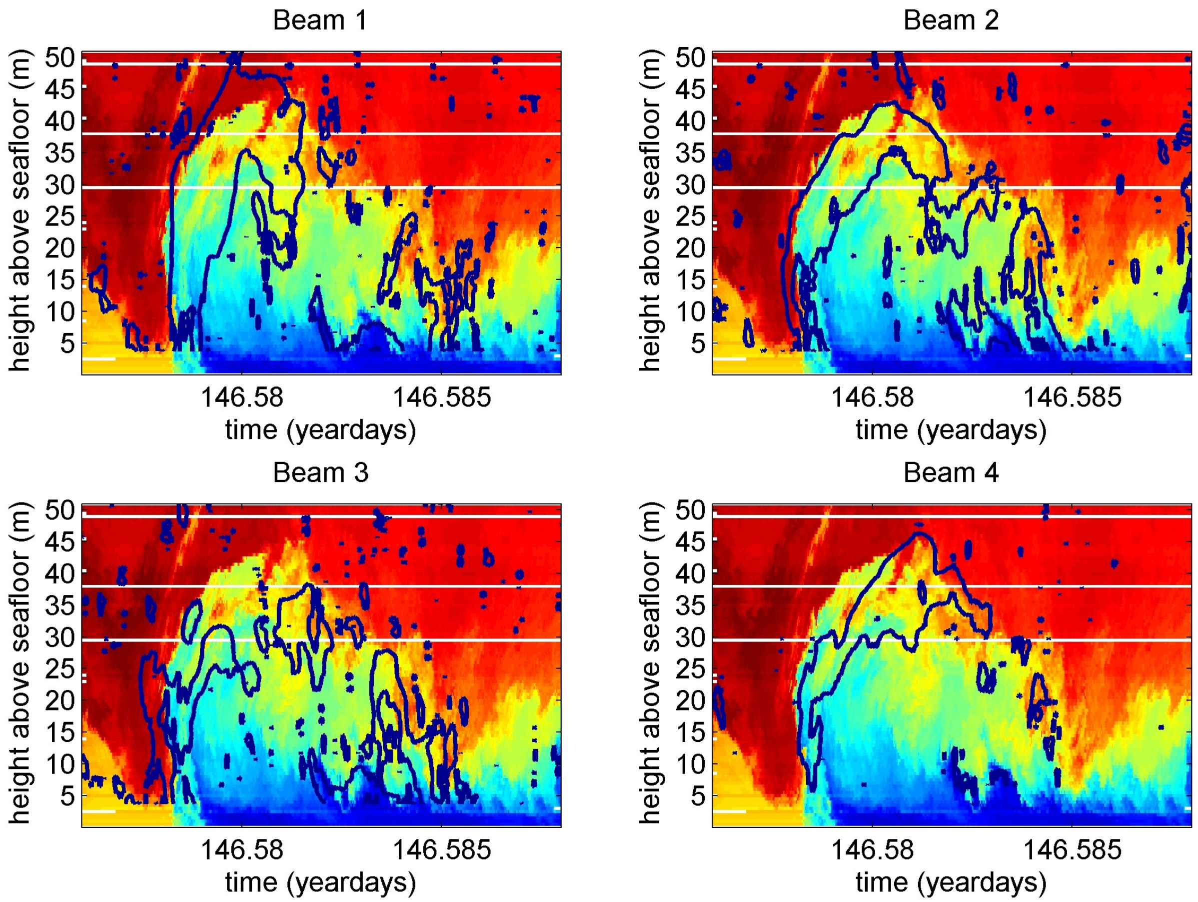
- How about ambient noise ?



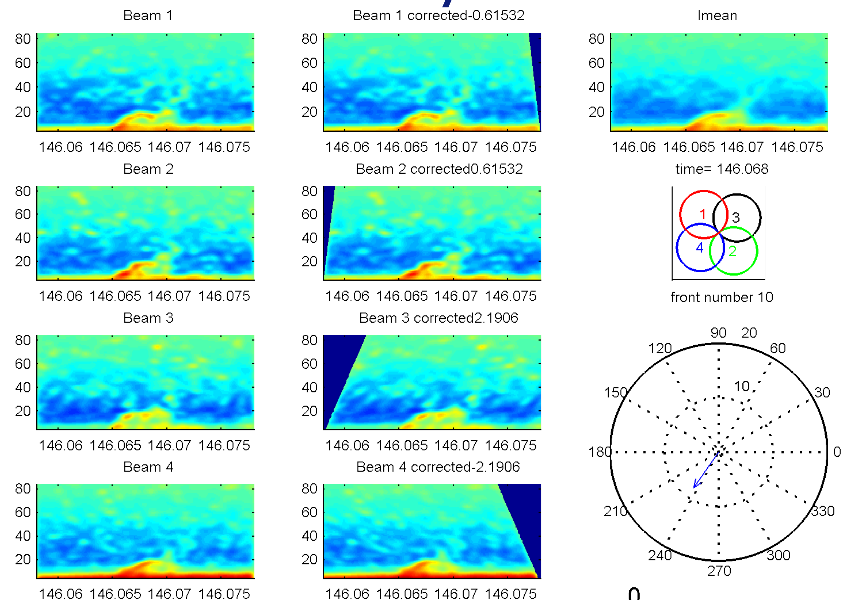


ADCP Echo Intensity associated with fronts

- 300kHz upwardlooking ADCP

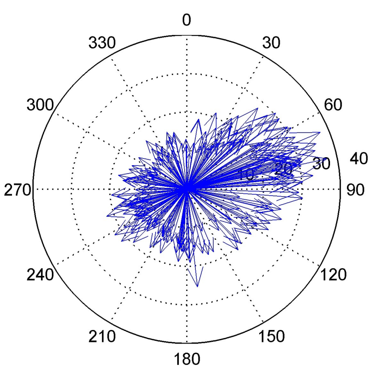


Fronts direction from Echo Intensity correlations

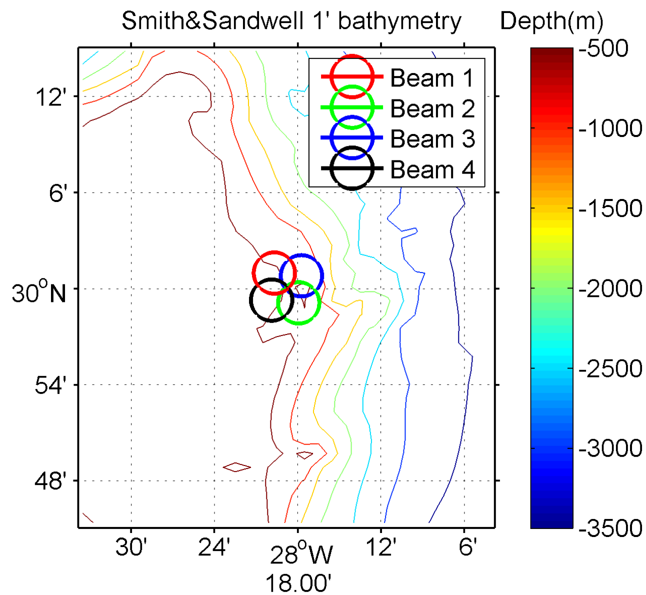


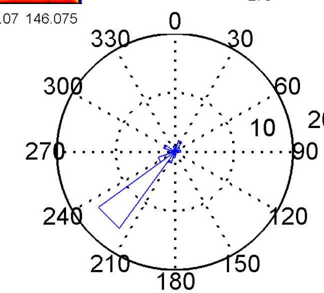
- Opposite beams intensity signals are symetrycally sheared due to beam inclination :
  this can be measured

- This shear gives information on front speed amplitude and direction

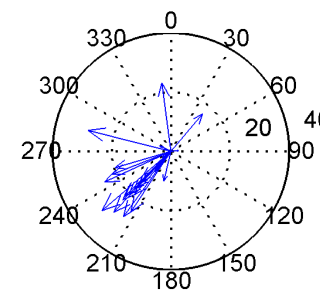


ADCP velocity





Statistical distribution of front direction



Hodograph of front velocities (cm/s)

Improved moored instrumentation: NIOZ thermistor strings

- History started in 1994…

NIOZ1:

32 sensors **connected**

15 days autonomy at 0.03Hz

4.10^{-5} °C noise level

NIOZ2:

128 sensors **connected**

15 days autonomy at 1Hz

1.10^{-3} °C noise level

- Last generation : NIOZ 3, **independent** but synchronized