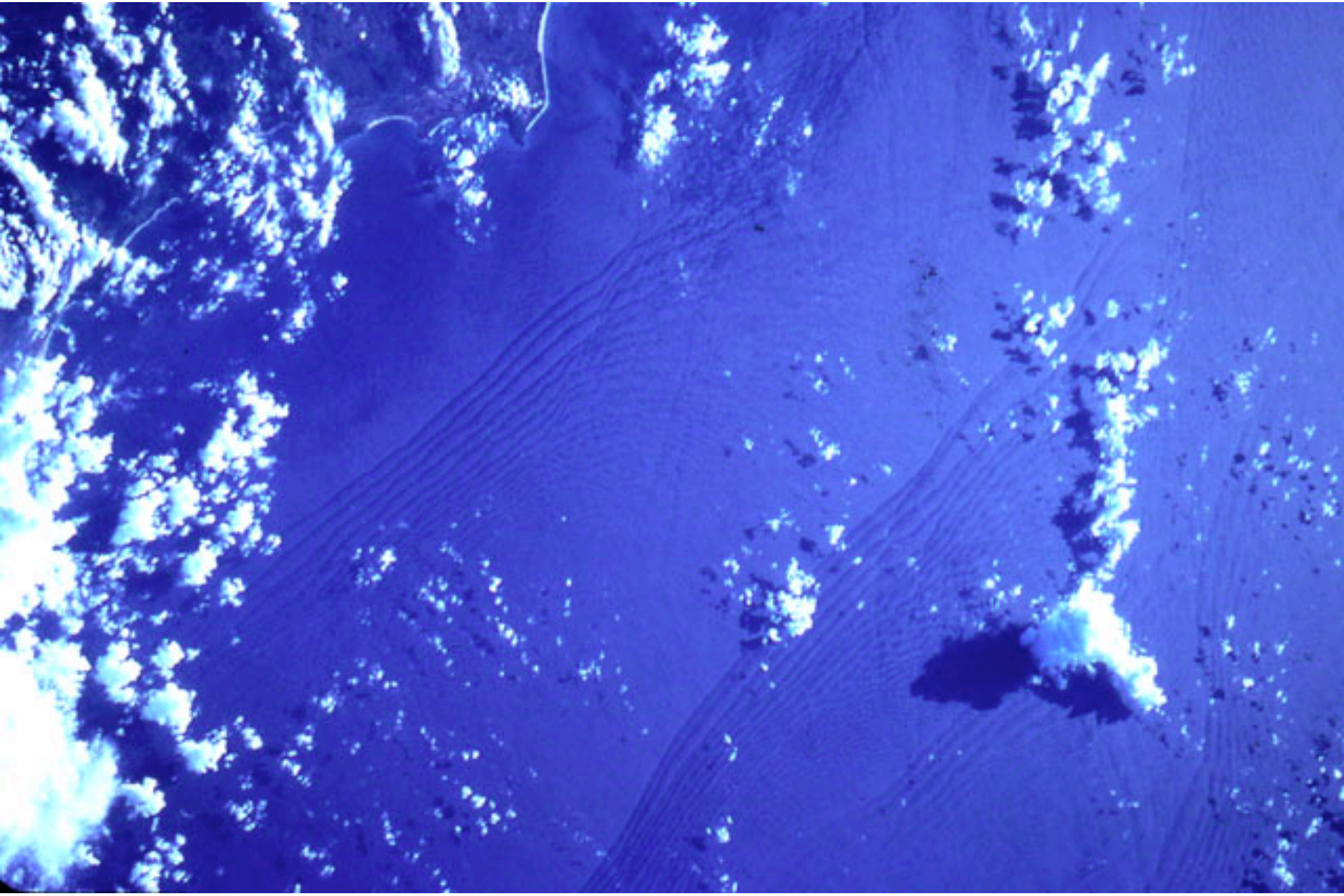
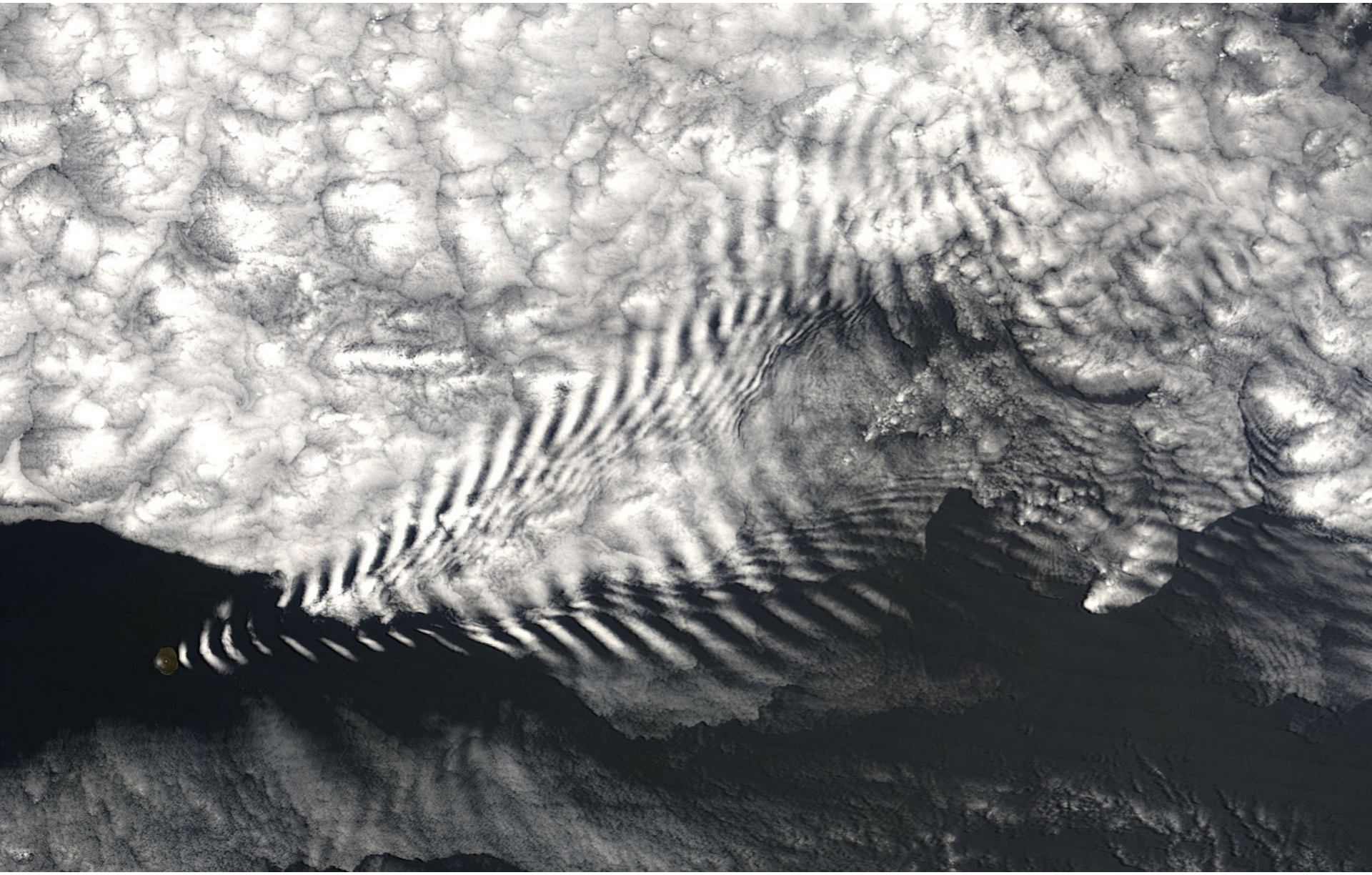
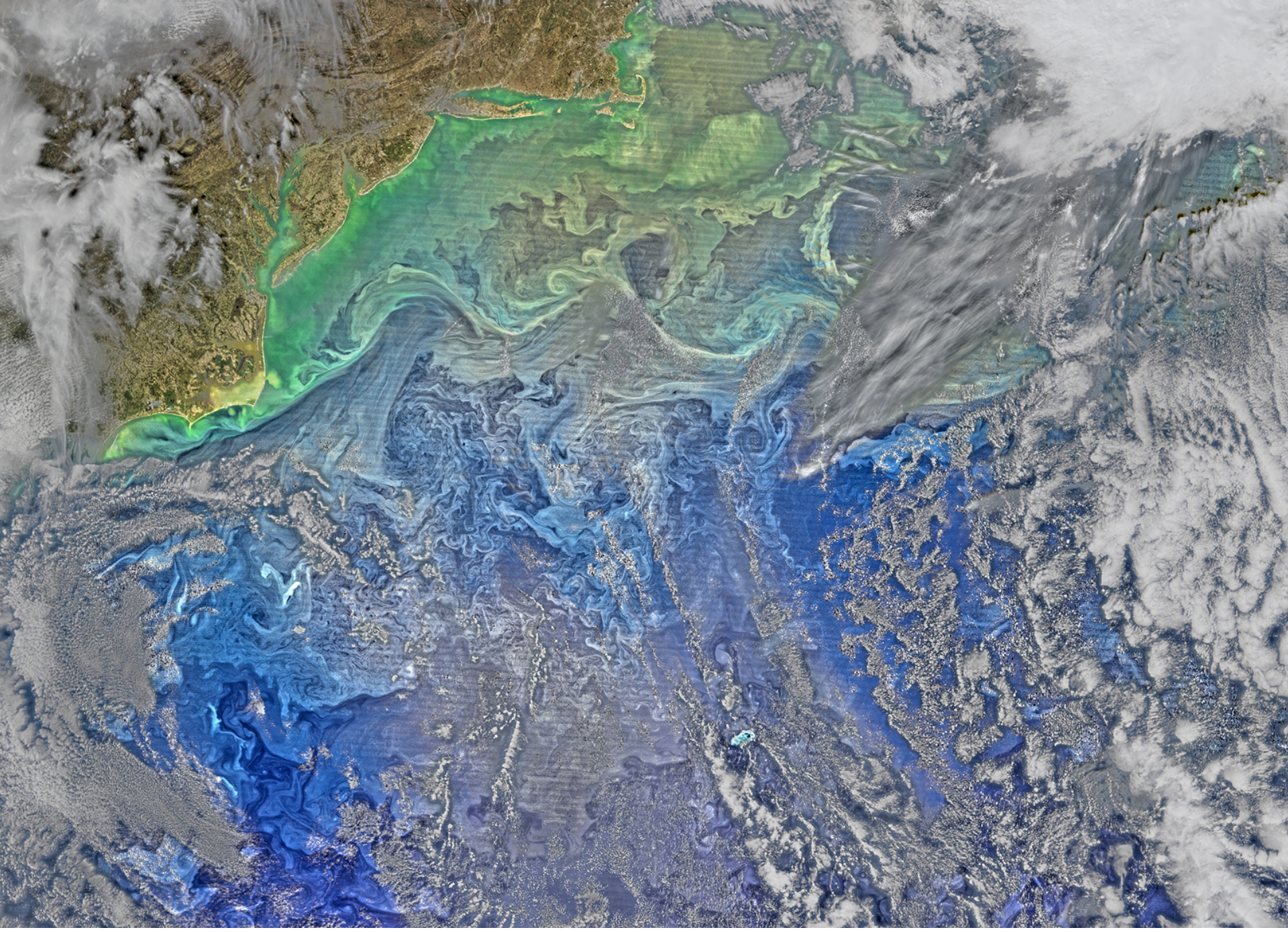
FLUIDS 2

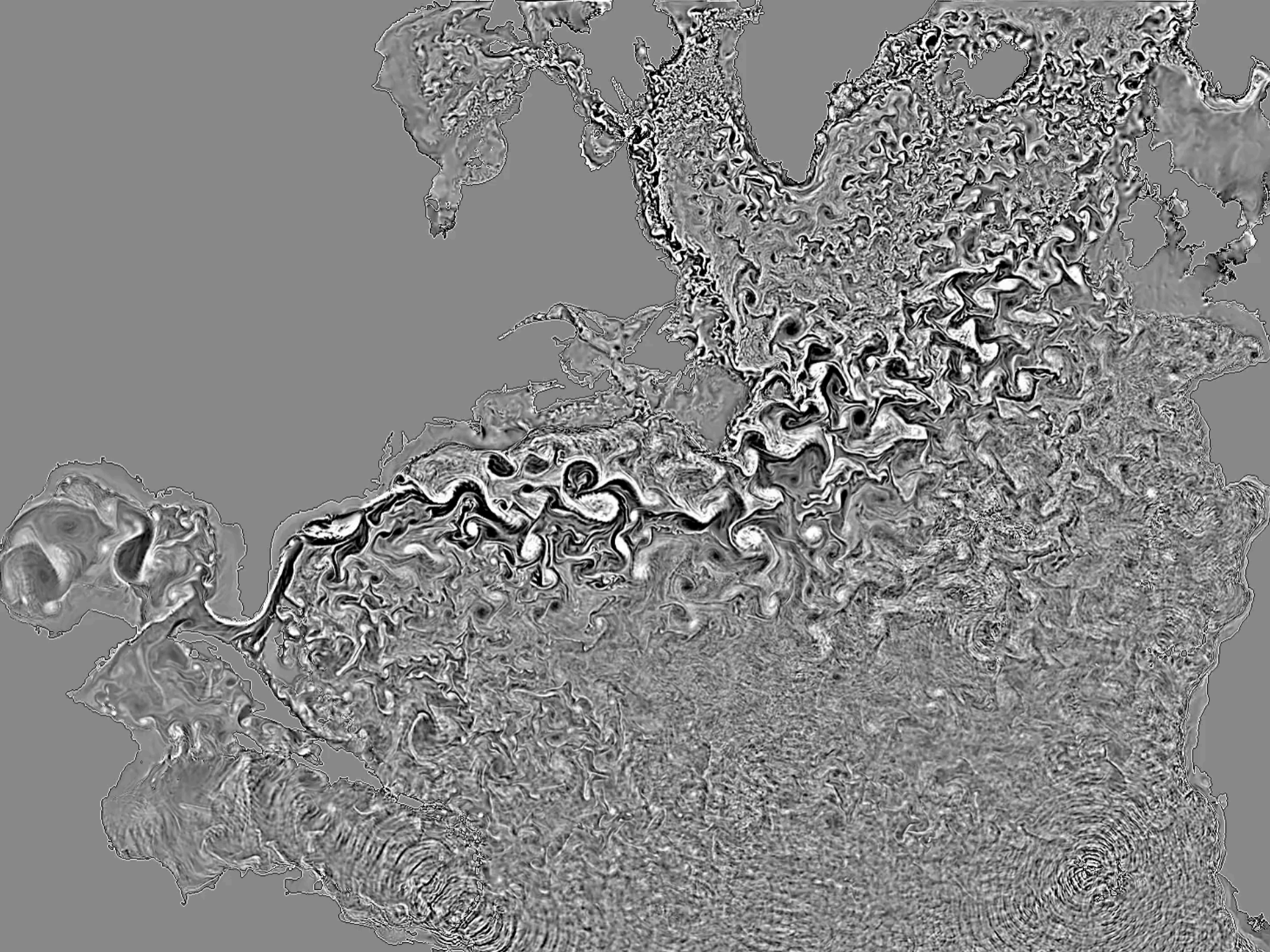
Jonathan GULA
gula@univ-brest.fr




ENEOS
龍 泉 洞
Ryusendo Cave
51Km
三 王 岩
Sannoiwa Rocks
20Km
浄 土 ヶ 浜
Jodogahama Beach
4Km
シートピアなあど
Seatopia Naado
1Km

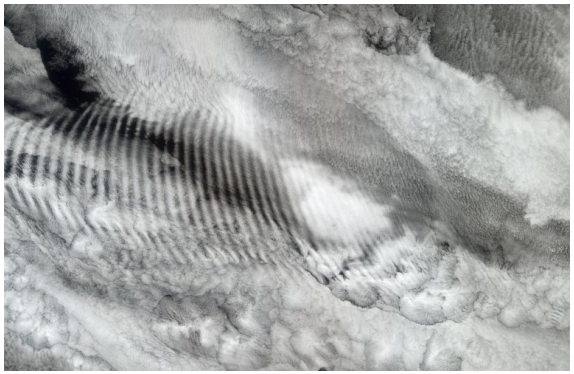




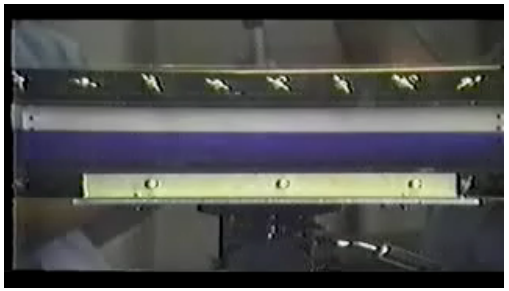


FLUIDS 2

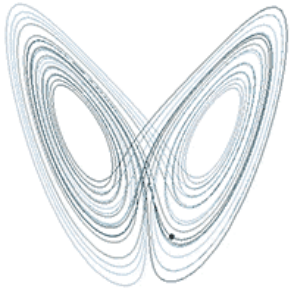
1. Waves



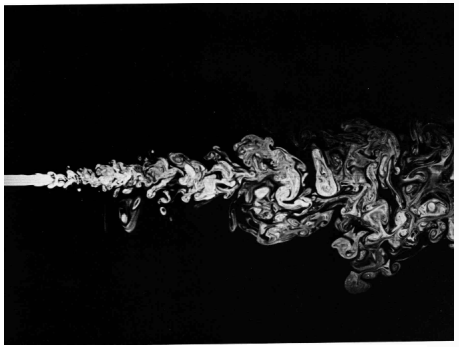
2. Instabilities

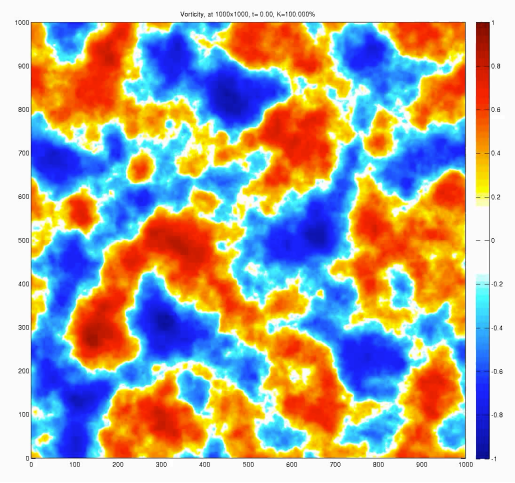


3. Chaos



4. Turbulence





I. WAVES

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gula@univ-brest.fr

I. WAVES

I.1. Introduction

I.2. General properties of Waves

I.3. Different type of ocean waves

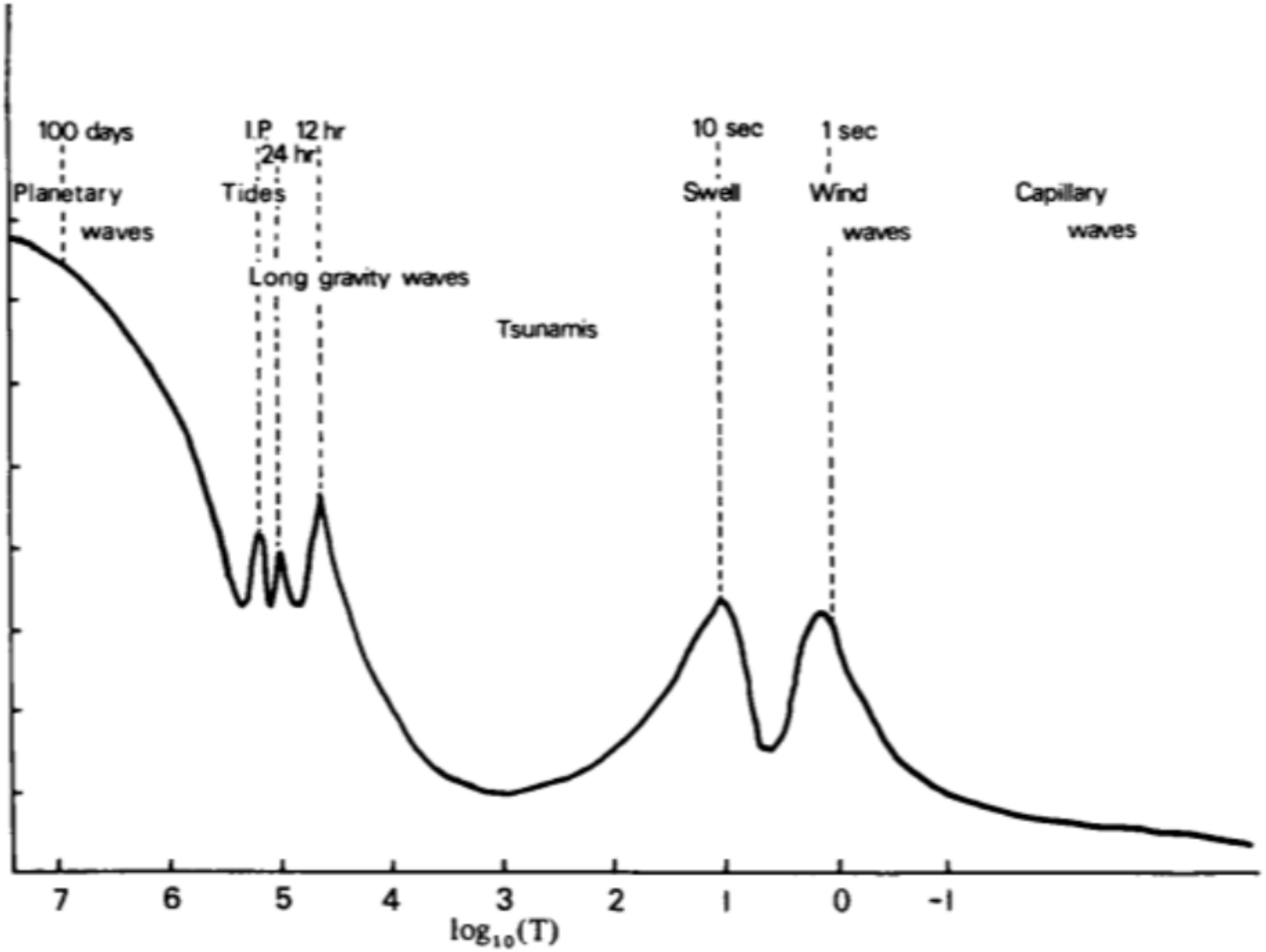
- I.3.1 Surface Gravity Waves
- I.3.2 Internal Waves
- I.3.3 Acoustic Waves

I.4. Ray Theory

Bibliography

- Whitham (1974) : *Linear and nonlinear waves*
- Leblond-Mysak (1977) : *Waves in the ocean*

Ocean Waves



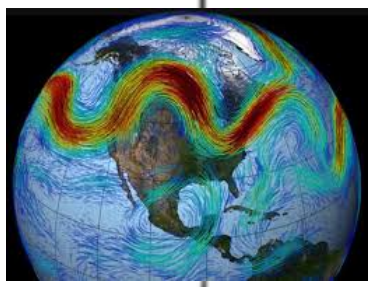
Schematic energy spectrum of ocean variability [Leblond & Mysak]

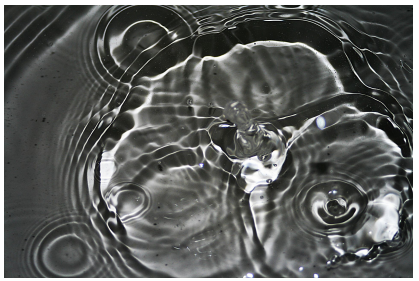
Ocean Waves

Different type of waves are classified on the basis of:

- Disturbing force
- Restoring force
- Wavelength
- Free wave Vs forced wave

Ocean Waves





100 days
Planetary waves
I.P. 12 hr
24 hr
Tides
Long gravity waves
Tsunamis
10 sec
Swell
1 sec
Wind waves
Capillary waves

7 6 5 4 3 2 1 0 -1
$\log_{10}(T)$

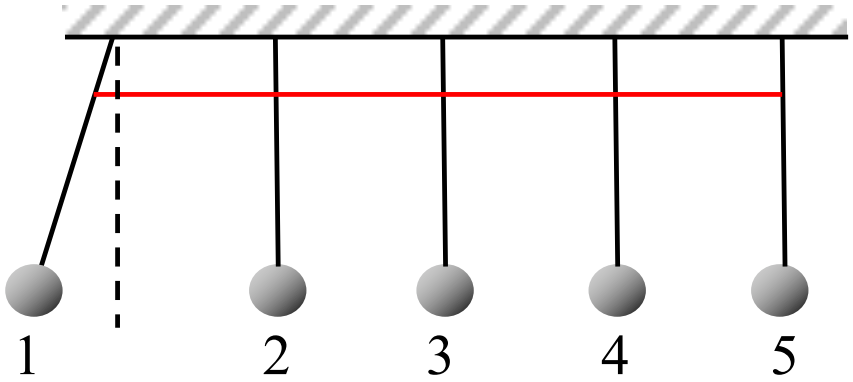
Schematic energy spectrum of ocean variability [Leblond & Mysak]

Definition of a wave:

- *A wave is a recognizable signal that is transferred from one part of the medium to another with a recognizable velocity of propagation. The signal may be any feature of the disturbance, such as a maximum or an abrupt change in some quantity, provided that it can be clearly recognized and its location at any time can be determined*. [Whitham: « Linear and nonlinear waves »]
-

Definition of a wave:

- *Restoring force and a continuous medium to transport oscillation*



Definition of a wave:

- *Restoring force and a continuous medium to transport oscillation*

http://hal.elte.hu/fij/wave/pmwiki.php?n=Main.Model

I.2.1 Simple Wave example

- Mathematically two main classes of waves:

Hyperbolic waves and **dispersive waves**

Hyperbolic waves

1. Hyperbolic waves are formulated in terms of hyperbolic partial differential equations, for example:

$$\eta_t + c\nabla\eta = 0 \qquad \eta_{tt} - c^2\nabla^2\eta = 0$$

Hyperbolic waves

1. Hyperbolic waves are formulated in terms of hyperbolic partial differential equations, for example:

$$\eta_t + c\nabla\eta = 0 \qquad \eta_{tt} - c^2\nabla^2\eta = 0$$

- Activity: Write the general solution of $\eta_{tt} - c^2\nabla^2\eta = 0$

With Initial Conditions:

$$\eta(x,0) = f(x) \qquad \eta_t(x,0) = 0$$

Hyperbolic waves

1. Hyperbolic waves are formulated in terms of hyperbolic partial differential equations, for example:

$$\eta_t + c\nabla\eta = 0 \qquad \eta_{tt} - c^2\nabla^2\eta = 0$$

- With general solutions in the form:

$$\eta = f(x - ct) \qquad \eta = f(x - ct) + g(x + ct)$$

- Very frequent in acoustics, elasticity, electromagnetism, etc.

Hyperbolic waves

1. Examples of **Hyperbolic waves**

- Flood wave, tidal bores

- Shock wave

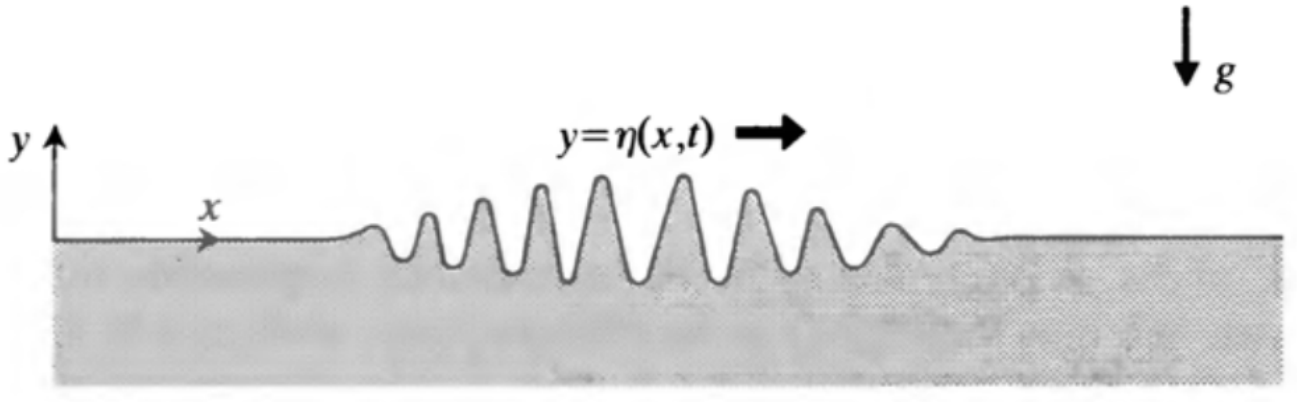
Dispersive waves

2. Dispersive waves come from a variety of partial differential equations, they are characterized principally by their dispersion relation:

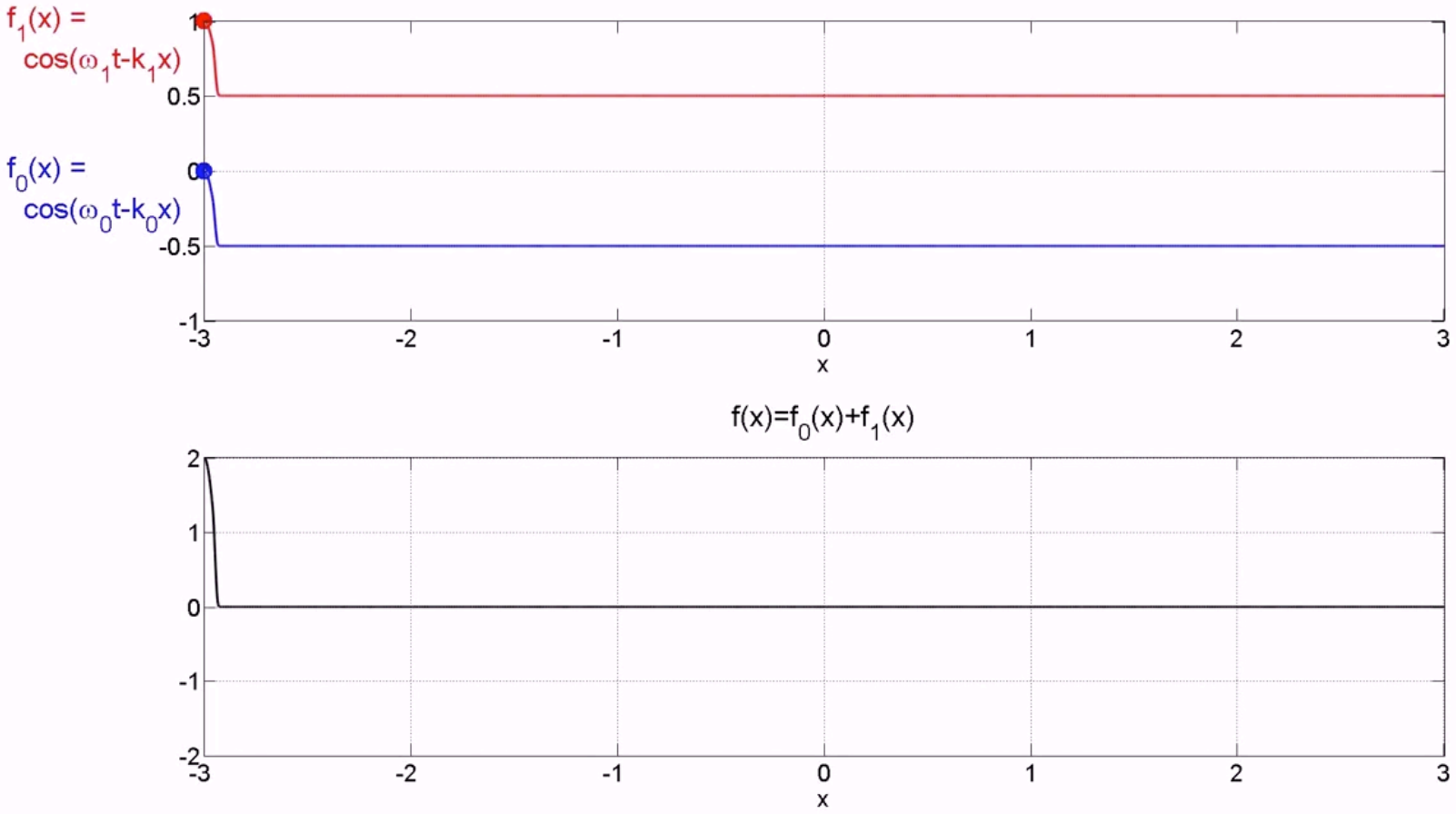
$$\omega = f(k)$$

Connecting the frequency and the wave number.

They are visualized as a group of waves where the different Fourier components propagate at different speeds



Dispersive waves



Source: https://www.youtube.com/watch?v=uii9clp_DSg

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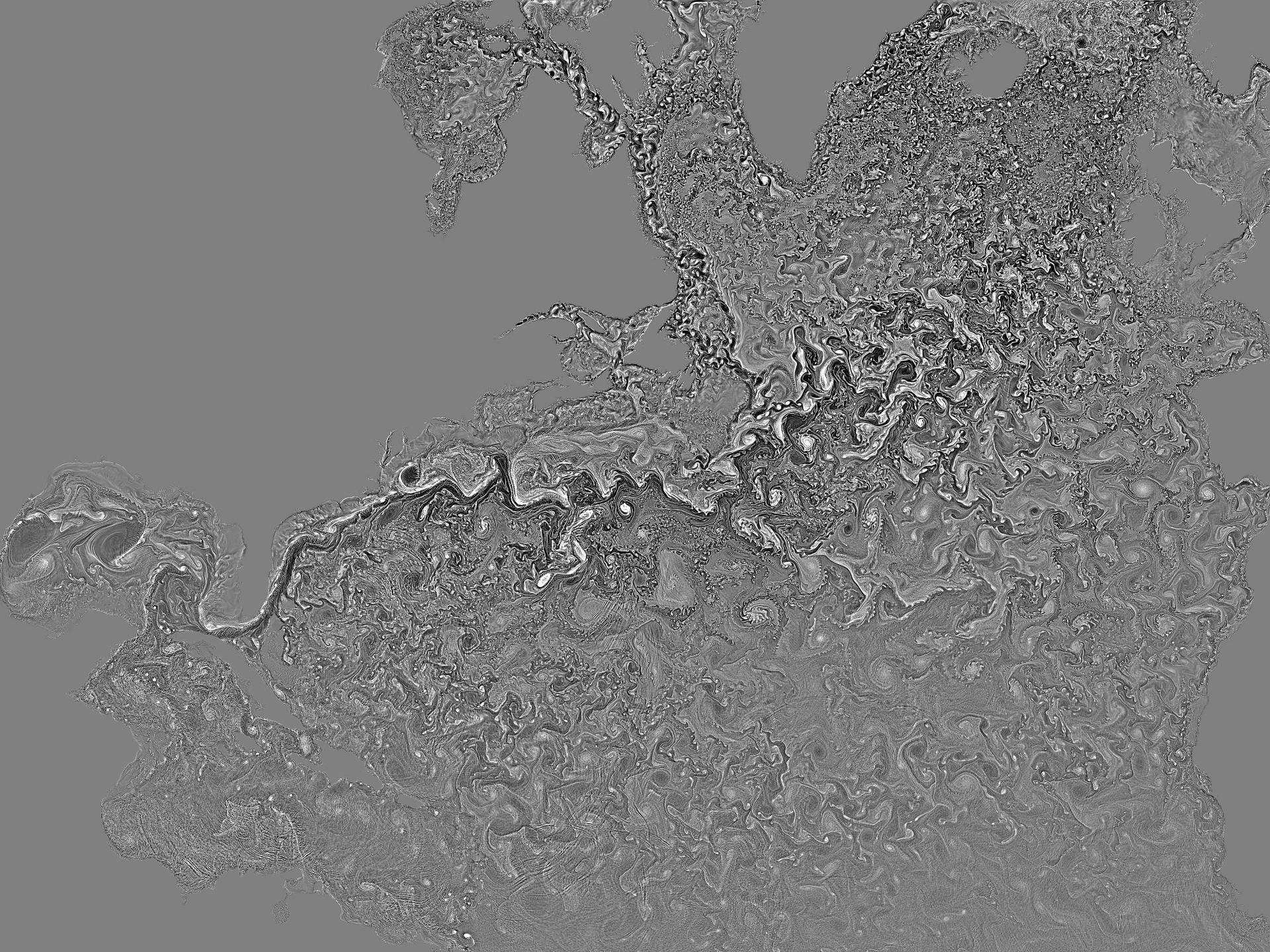
I.4. Ray Theory

I.2.2 Planar Wave example

I.2. General properties



I.3. Different type of ocean waves

I.3.1 Surface gravity waves

I.3.1.1 Long waves

I.3.1.2 Short waves

I.3.1.3 The general case

I.3. Different type of ocean waves

I.3. Different type of ocean waves

I.3.1 Surface gravity waves

I.3.1.1 Long waves

I.3.1.2 Short waves

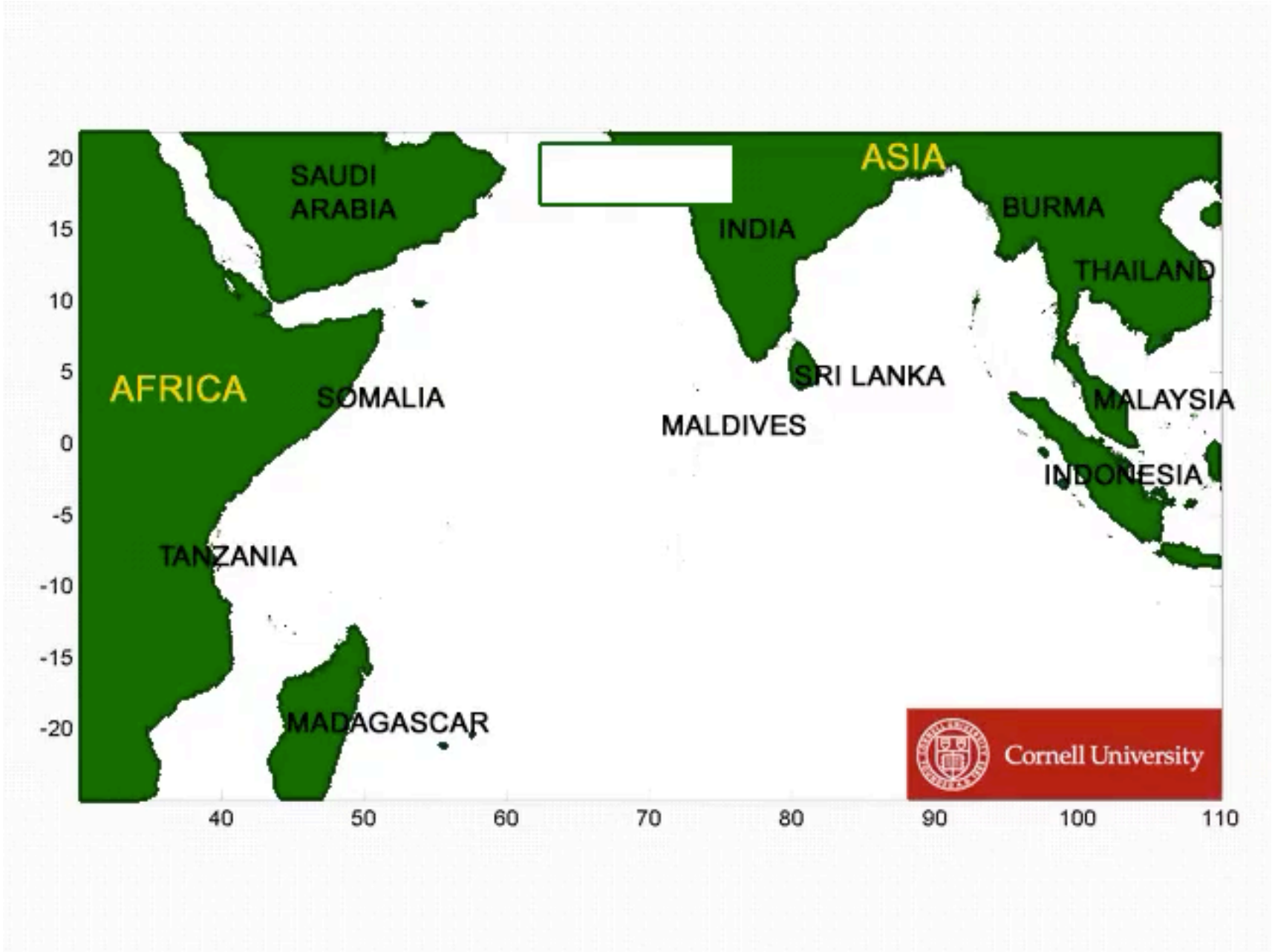
I.3.1.3 The general case

I.3.1.1 Long waves

Example of long waves:

- **Tsunamis**
- **Tidal bores**

I.3.1.1 Long waves



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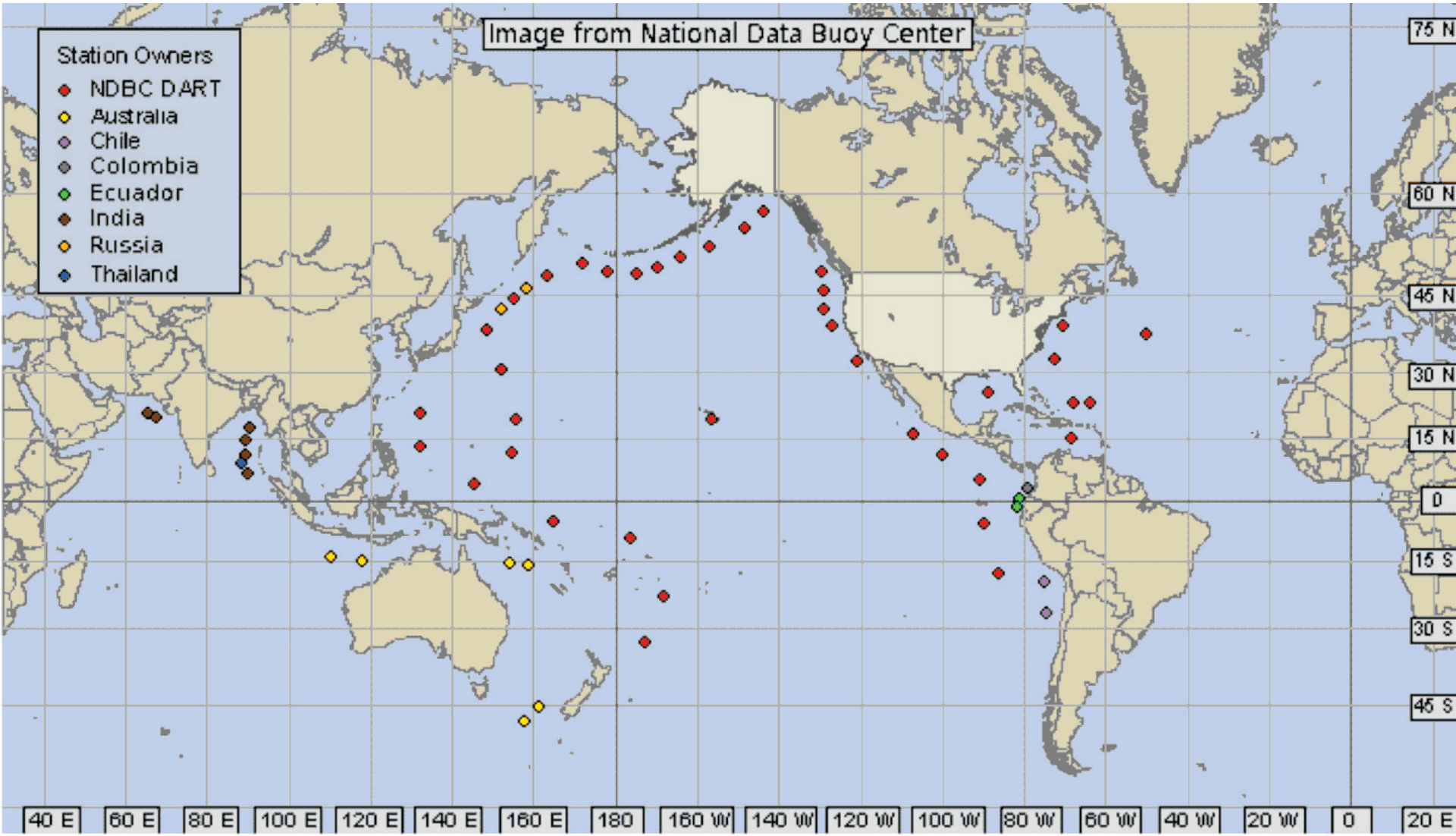
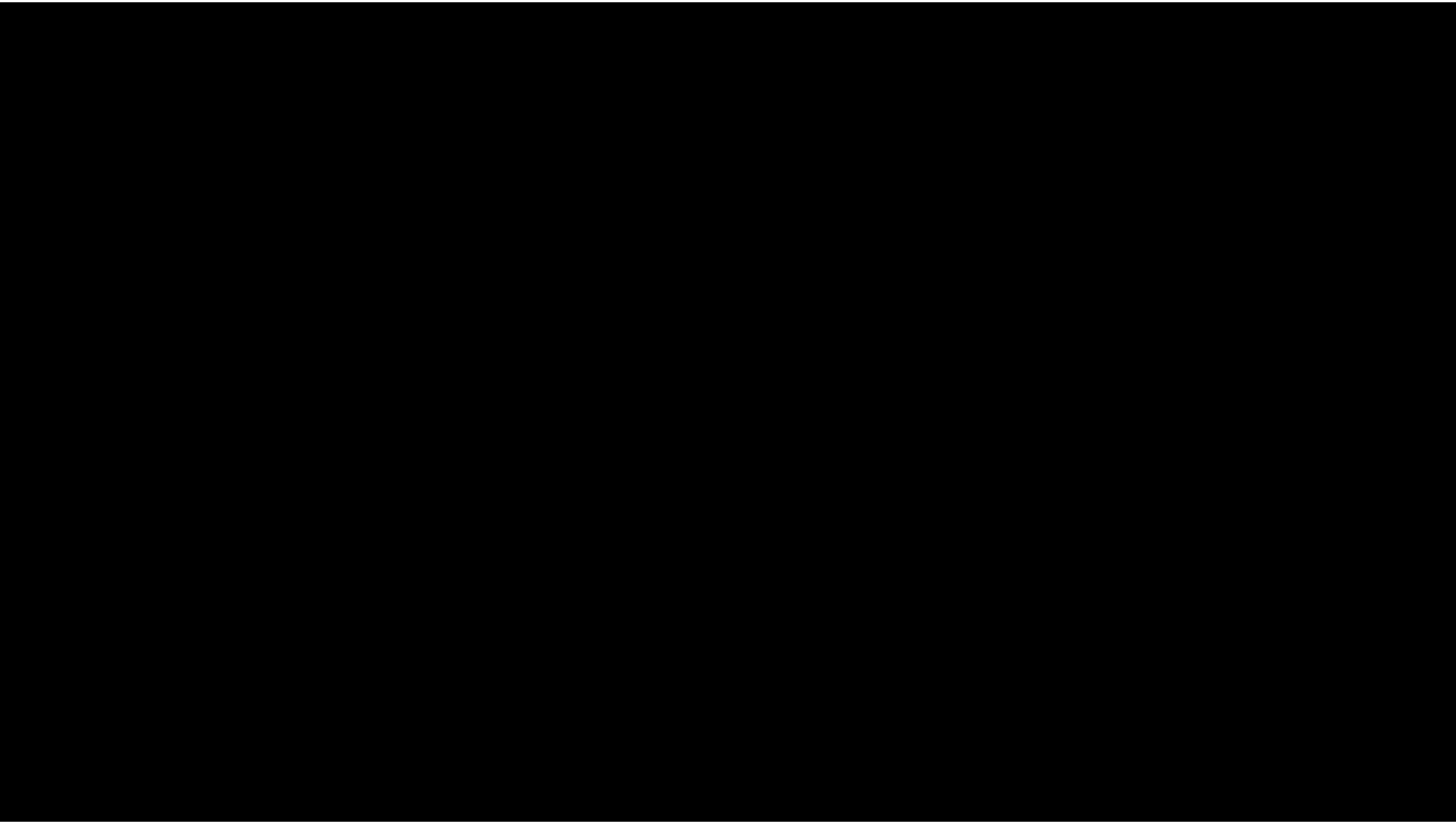


Tsunami detection buoys have been placed around many tectonically active locations. M
Map is from NOAA Tsunami Detection website http://www.ndbc.noaa.gov/dart.shtml

I.3.1.1 Long waves

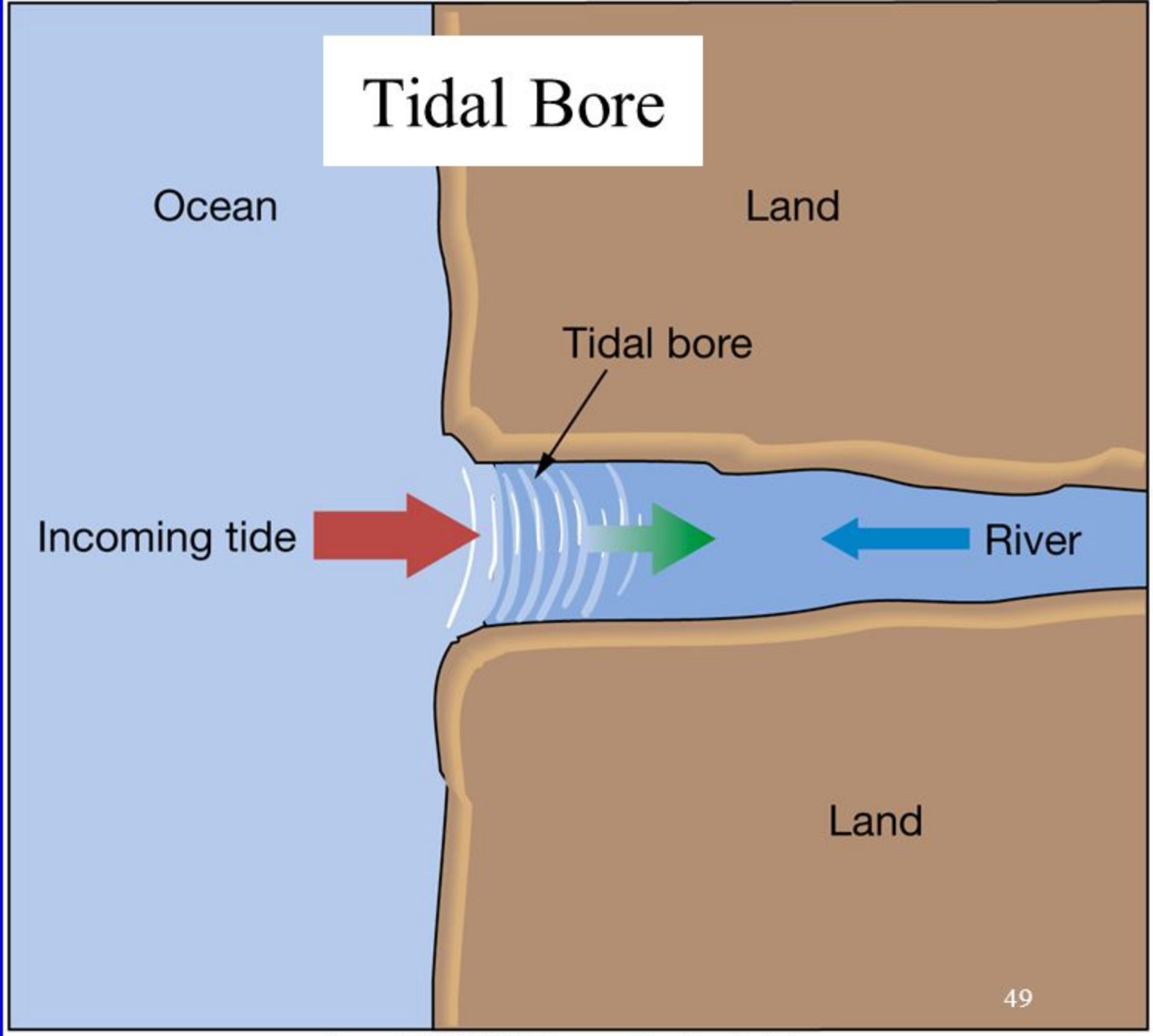


I.3.1.1 Long waves

Example of long waves:

- **Tsunamis**
- **Tidal bores**

A tidal bore is a wall of water that surges upriver with the advancing high tide.



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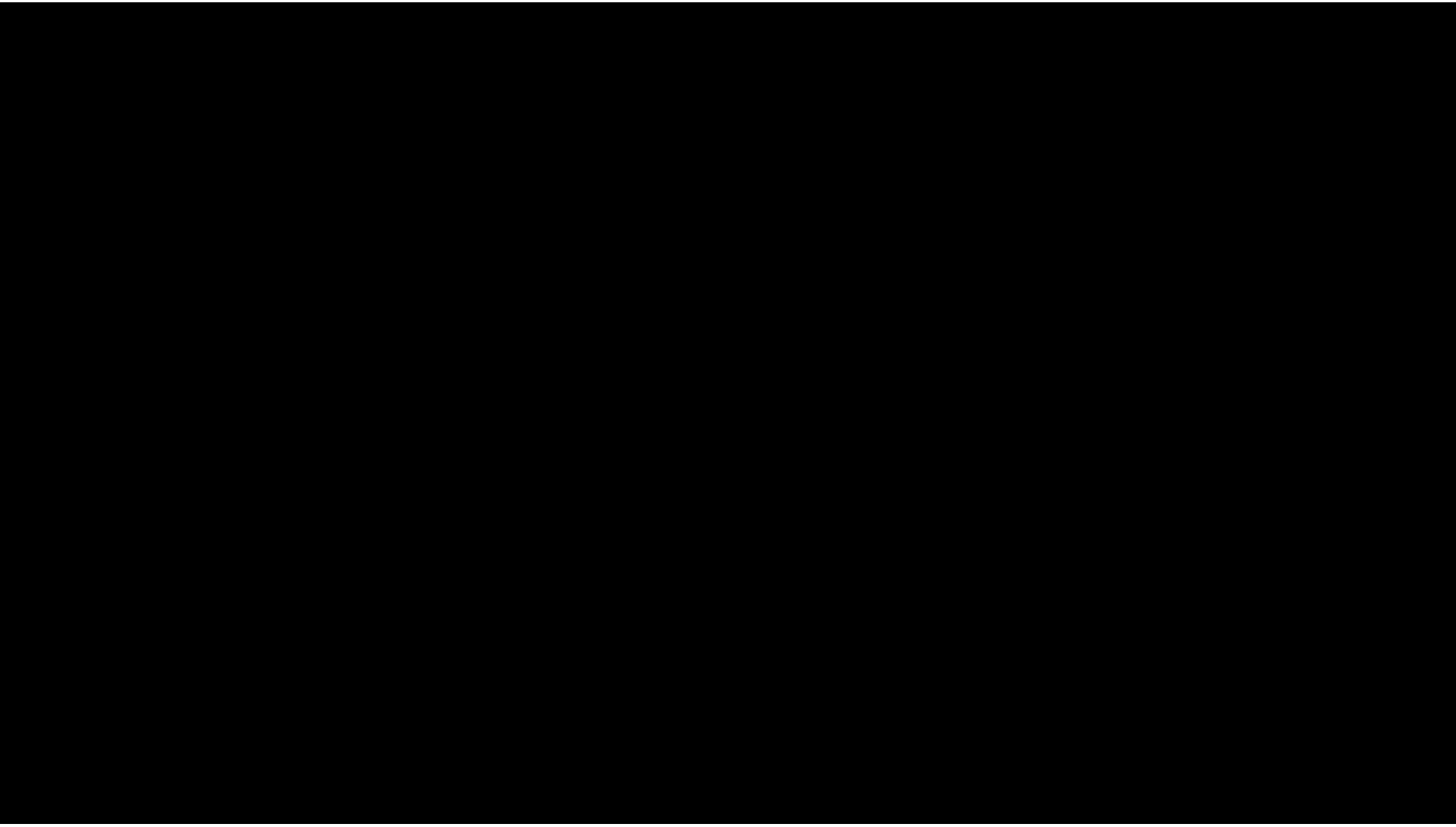

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I.3.1.2 Short waves

I.3.1.3 The general case

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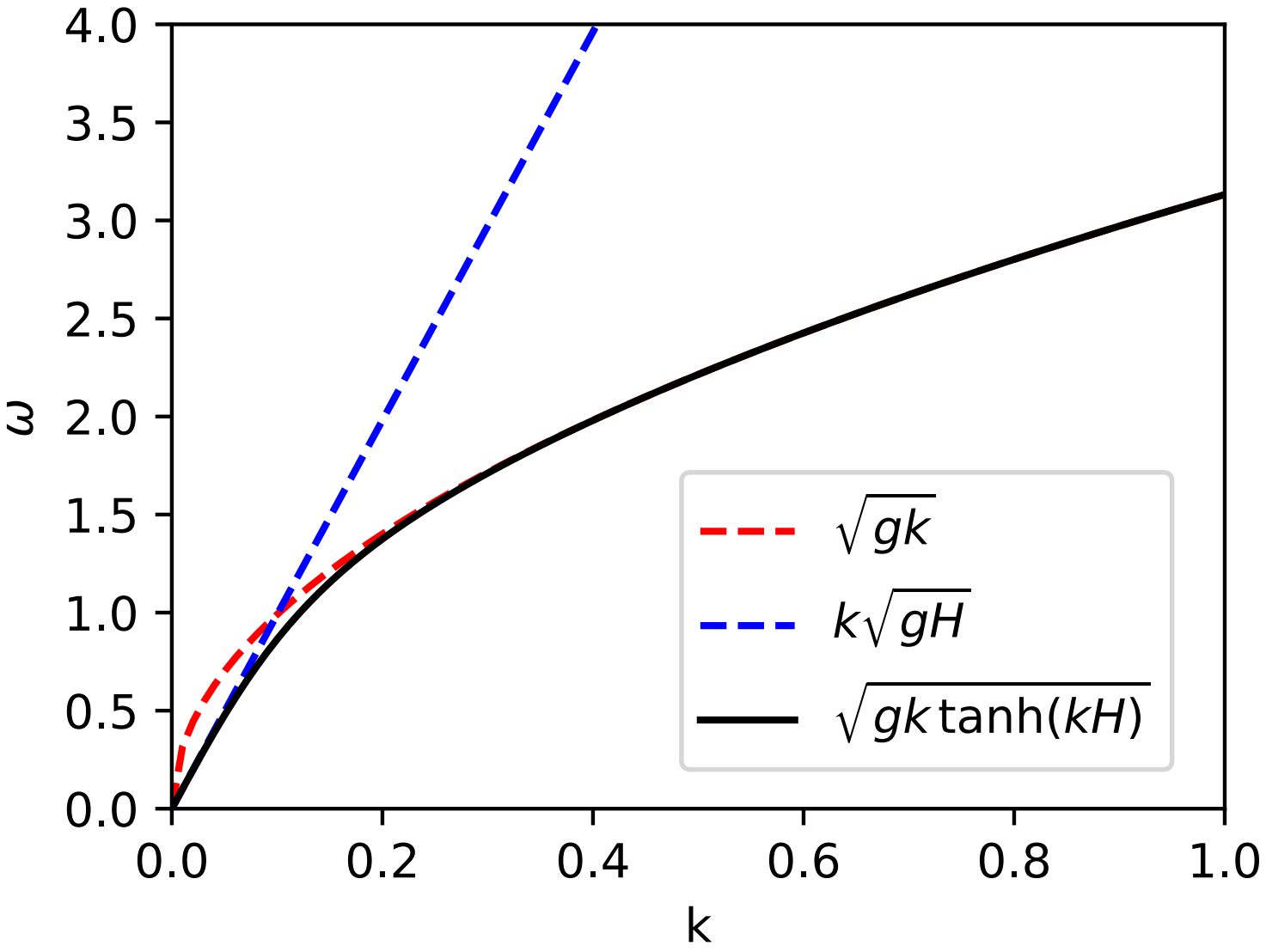
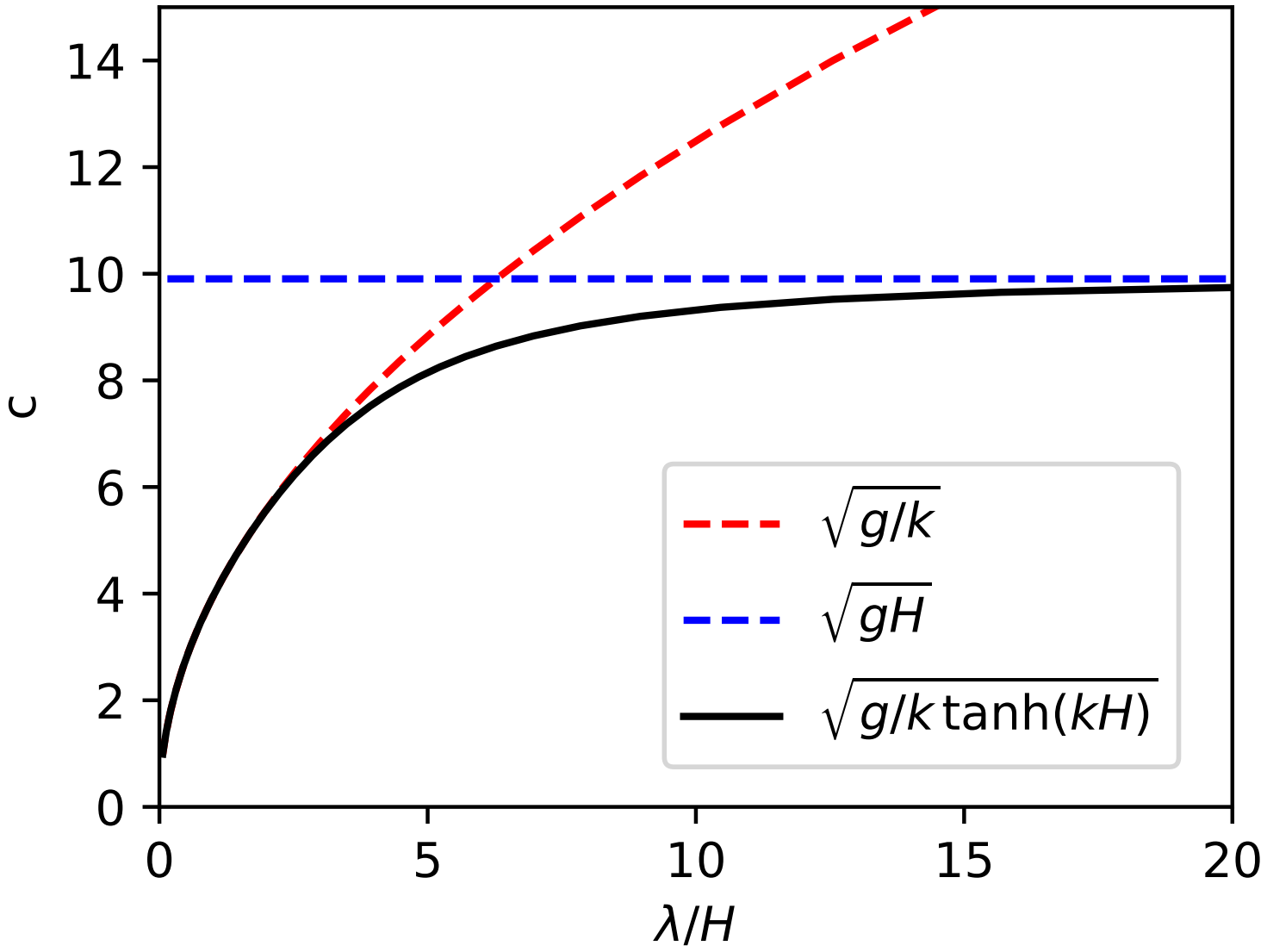
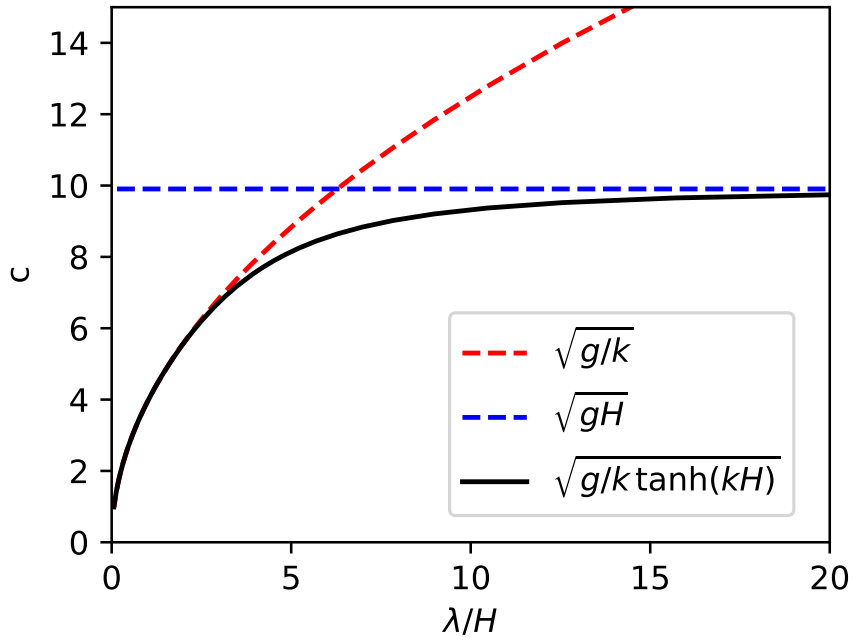
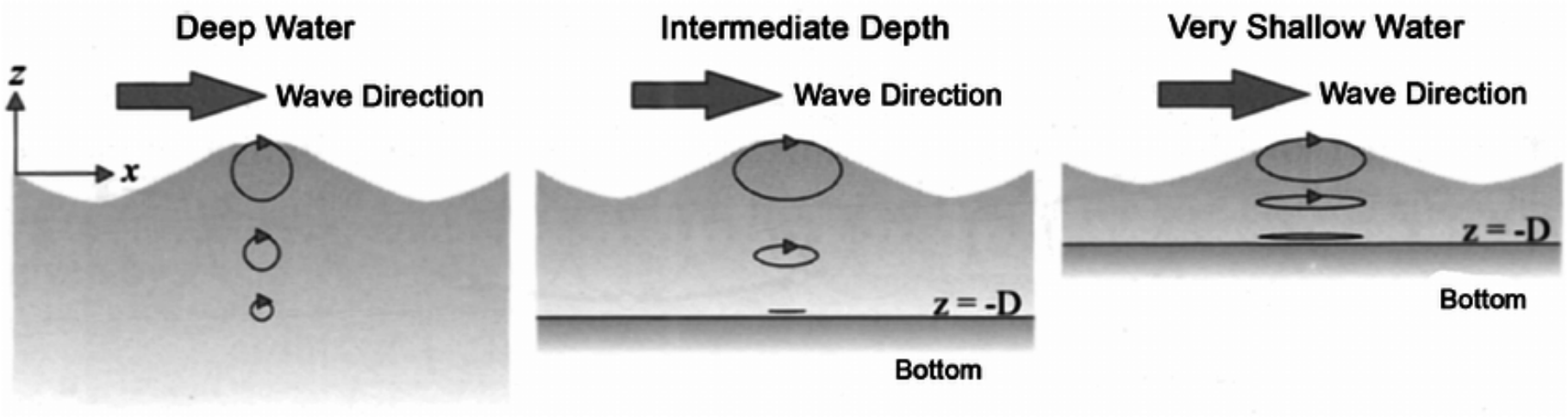


I.3.1.3 The general case



I.3.1.3 The general case





I.3.1.3 The general case