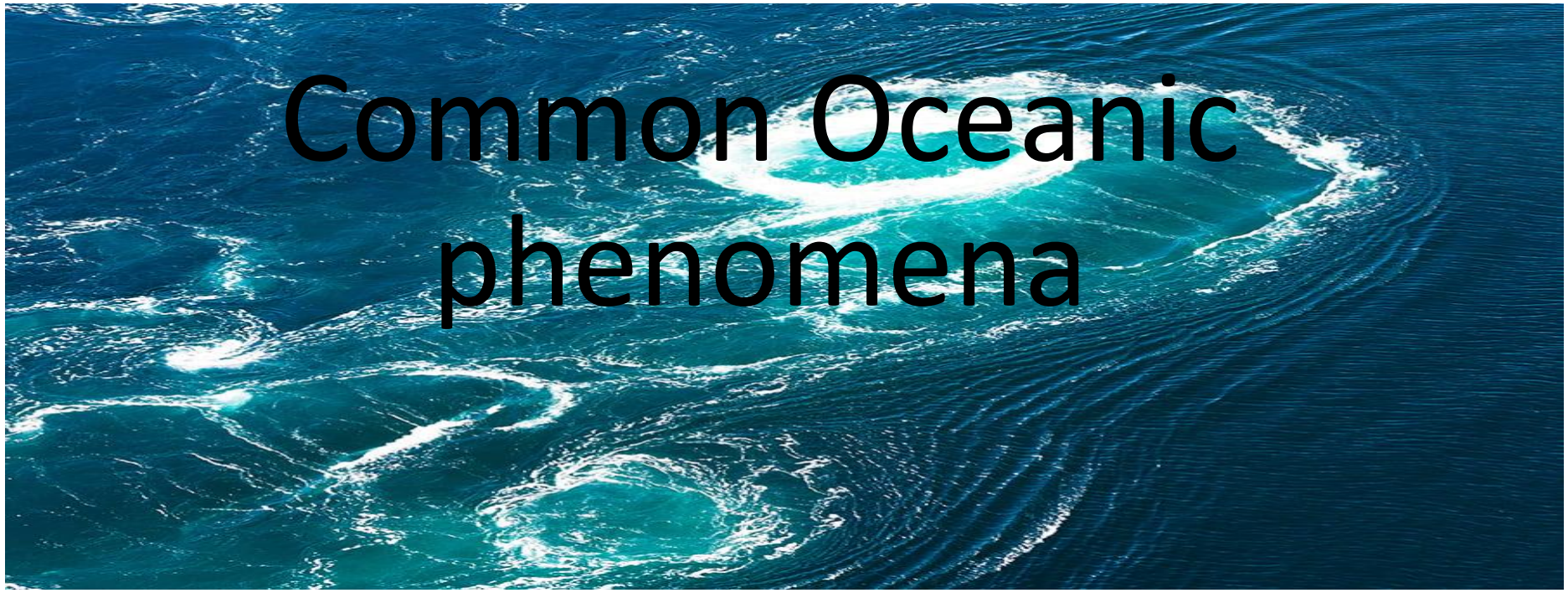


Common Oceanic phenomena

Jamal Alhinai

basics : waves and currents

What is a wave? What is current ?

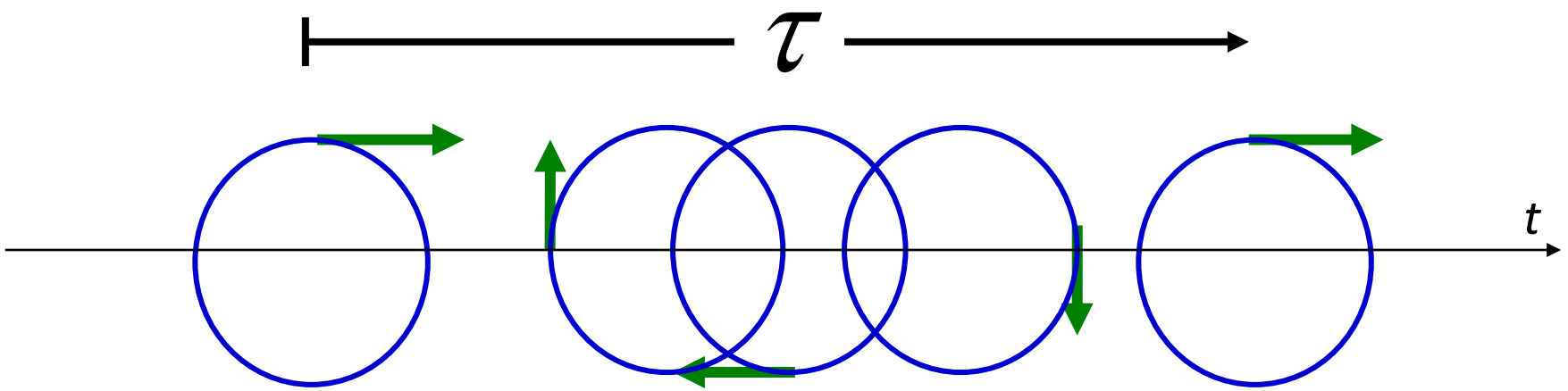
A wave is a periodic process.

Current is a non periodic process.

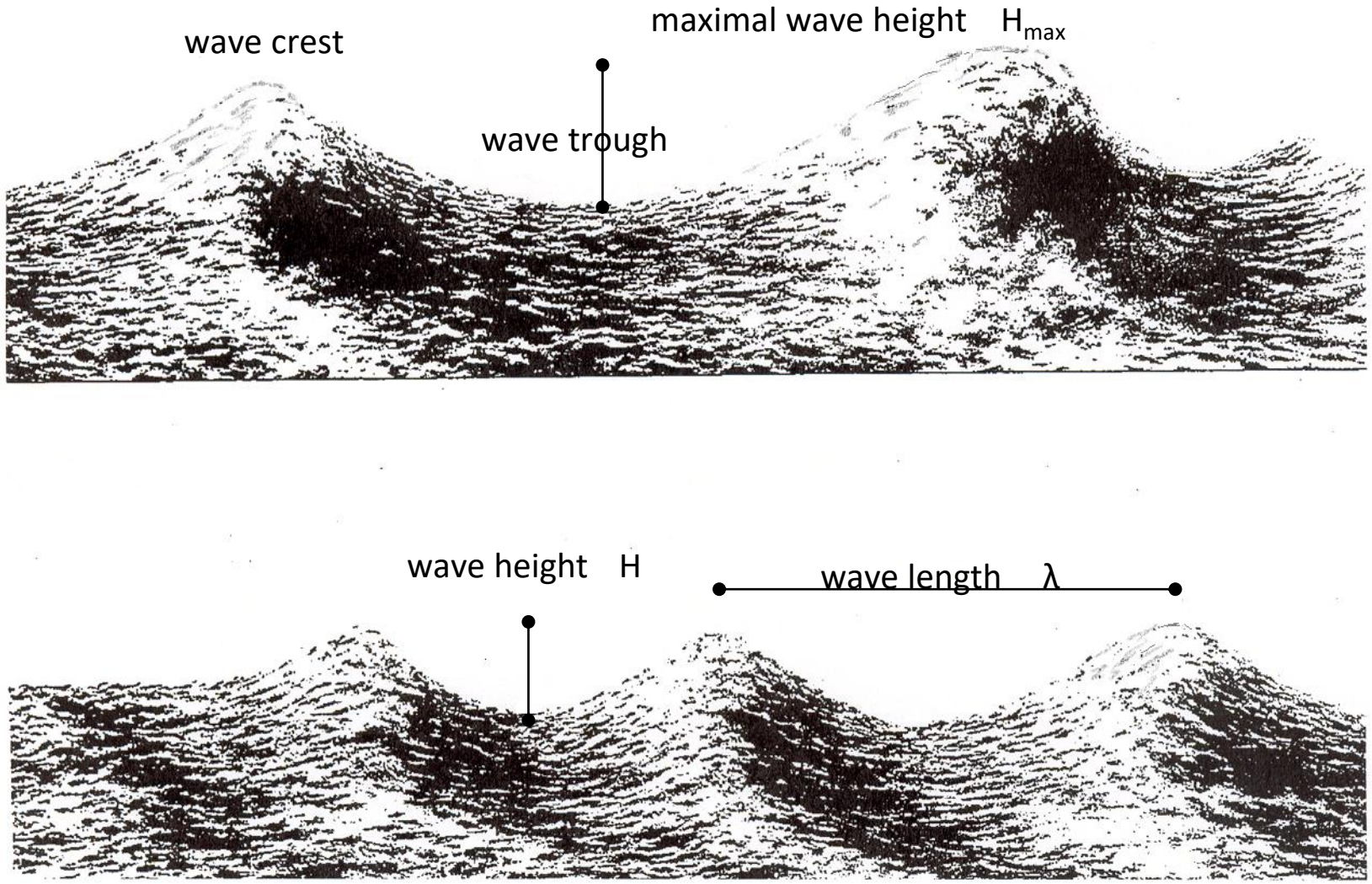
A wave is an oscillation of water particles around a position of equilibrium.

→ The individual particle remains roughly at its original position.

→ The wave propagation follows a law of dispersion.



during a wave period τ


wave crest
maximal wave height H_{max}
wave trough
wave height H
wave length λ

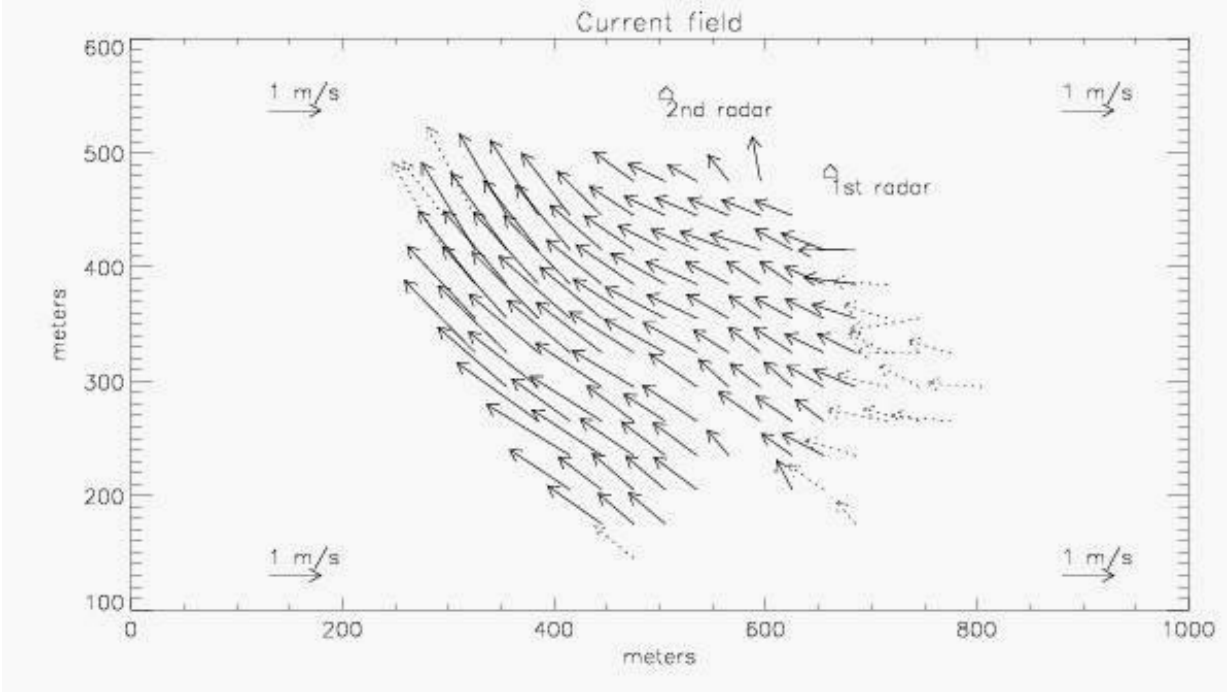
Current is the transport of water particles along stream lines.

→ The individual particle never again reaches its original position.

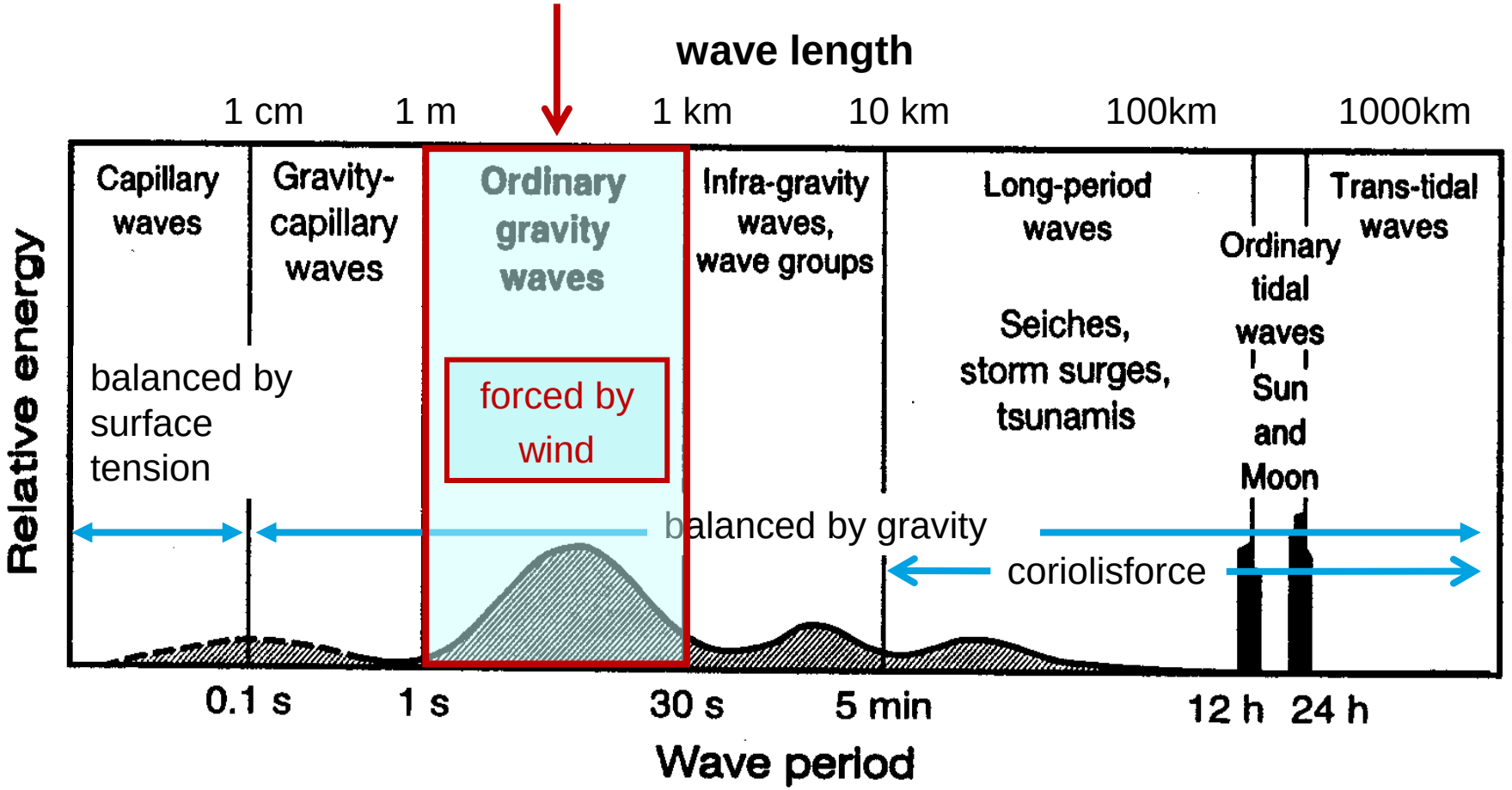
→ For current no law of dispersion may be defined.

Current transports water particles

The current speed depends from the water depth: $c = \sqrt{gh}$



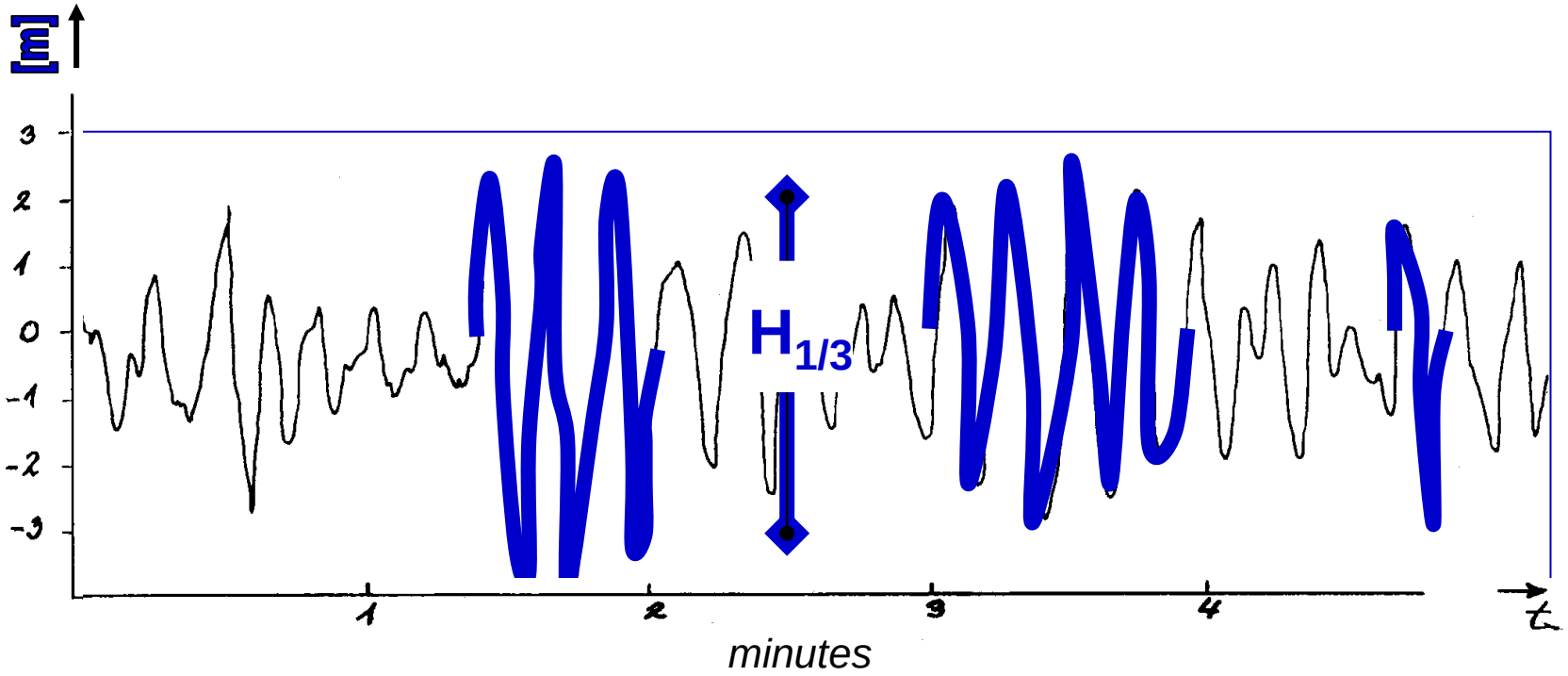
wave generating and balancing forces



some definitions for waves

Wave period	time between the trespassing of two succeeding wave crests	τ	[s]
Wave length:	distance between two succeeding wave crests	λ	[m]
Wave frequency	Inverse of period	ω=2π/ τ	[2π/s]
Propagation direction	angle of wave number	θ	[°]
Phase speed	speed of a single wave component	c	[m/s]
Steepness:	ratio height to length	δ	no dim.
Wave height	vertical distance between a trough and a the next succeeding crest	H	[m]

Definition of Significant wave height ($H_{1/3}$)



Example:

- **You see 24 single wave trains.**
- **The blue marked waves are the 8 highest waves.**
- **These 8 waves correspond to 1/3 of the 24 waves observed in total.**
- **$H_{1/3}$ is defined as the average on that third of the highest waves.**

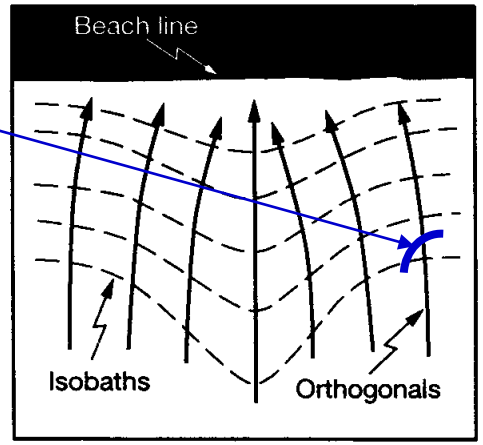
Refraction is described by “Snell’s” law:

$$\frac{\sin\theta_1}{c_1} = \frac{\sin\theta_2}{c_2} = const.$$

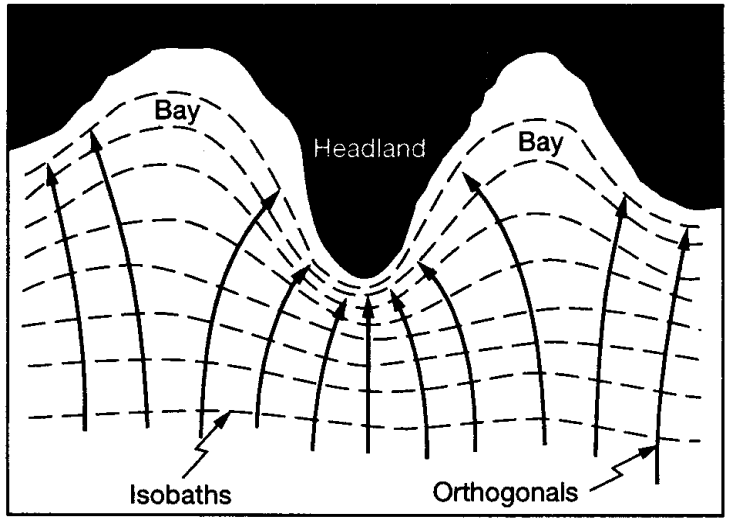
θ is the local angle between the isobaths and the phase propagation angle.

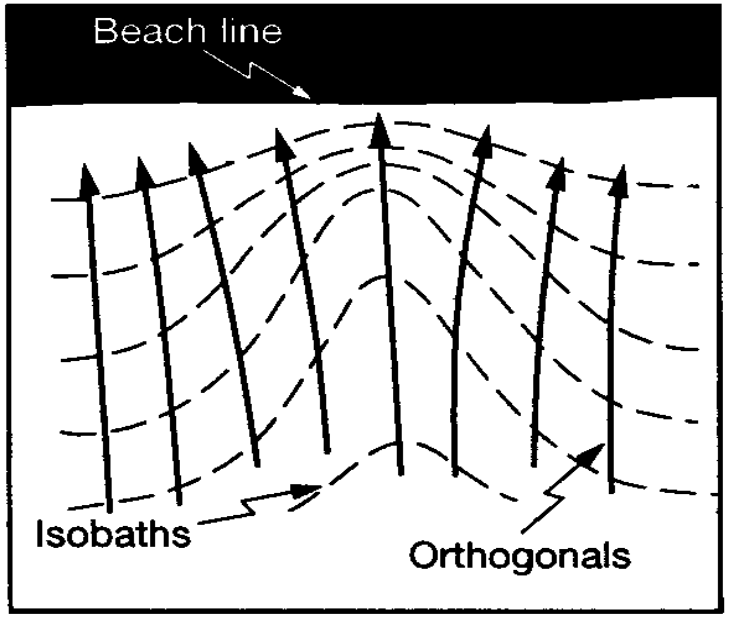
A local change in phase speed is balanced by a change in θ. Thus the phase speed c controls the local angle of the wave number vector:

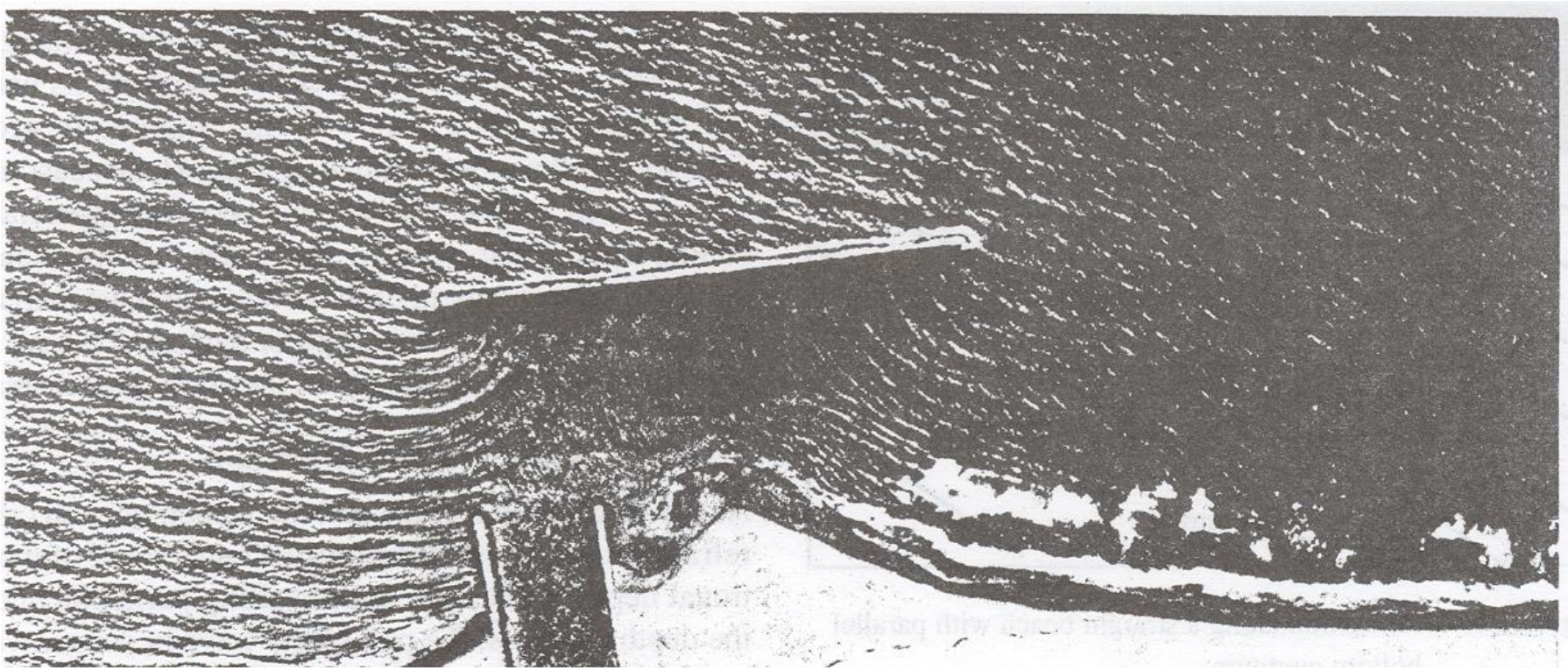
$$c = \sqrt{\frac{g}{k}\tanh(kh)} \;\; with \;\; \vec{c} \| \vec{k}$$



refraction at different bathymmetries







Diffraction may let wave energy enter shadowed zones.

Behind fix constructions and other obstacles diffraction does not affect the wave dispersion.

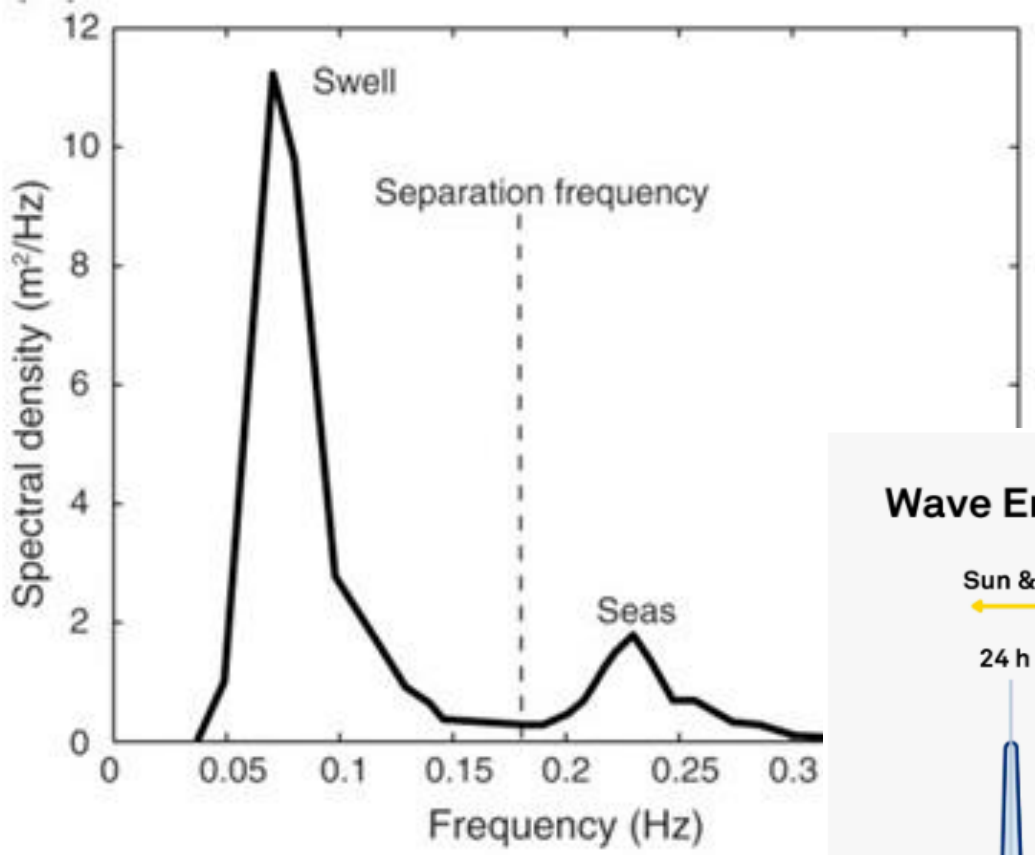
If current affects diffraction the dispersion is changed locally

shoaling and breaking

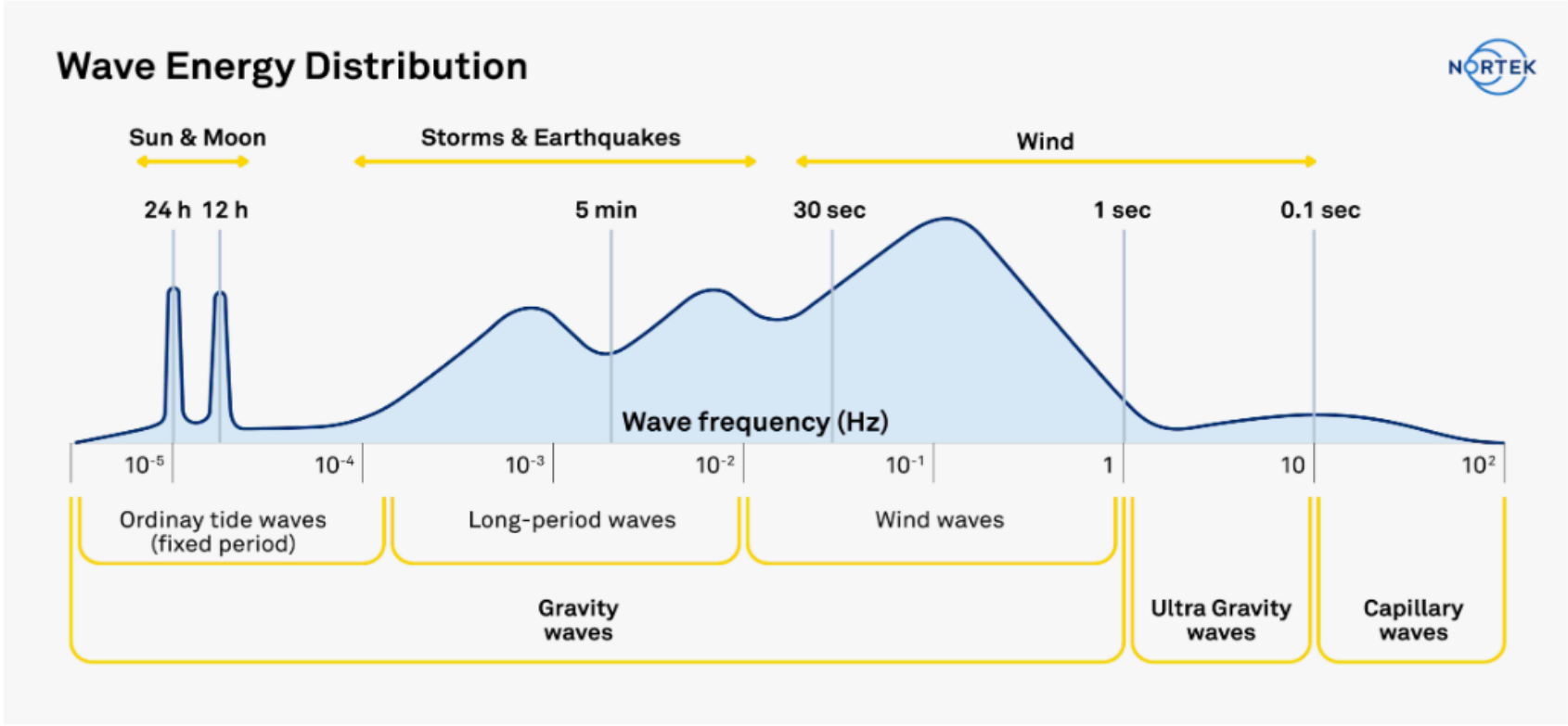
if a wave propagates from deep water into shallow coastal water

➔ wave speed and wave length decrease
➔ therefore the wave height has to increase in order to maintain a constant energy flux (wave period remains constant)
➔ the wave breakes if the wave height ~ local water depth

Example for a two peak spectrum

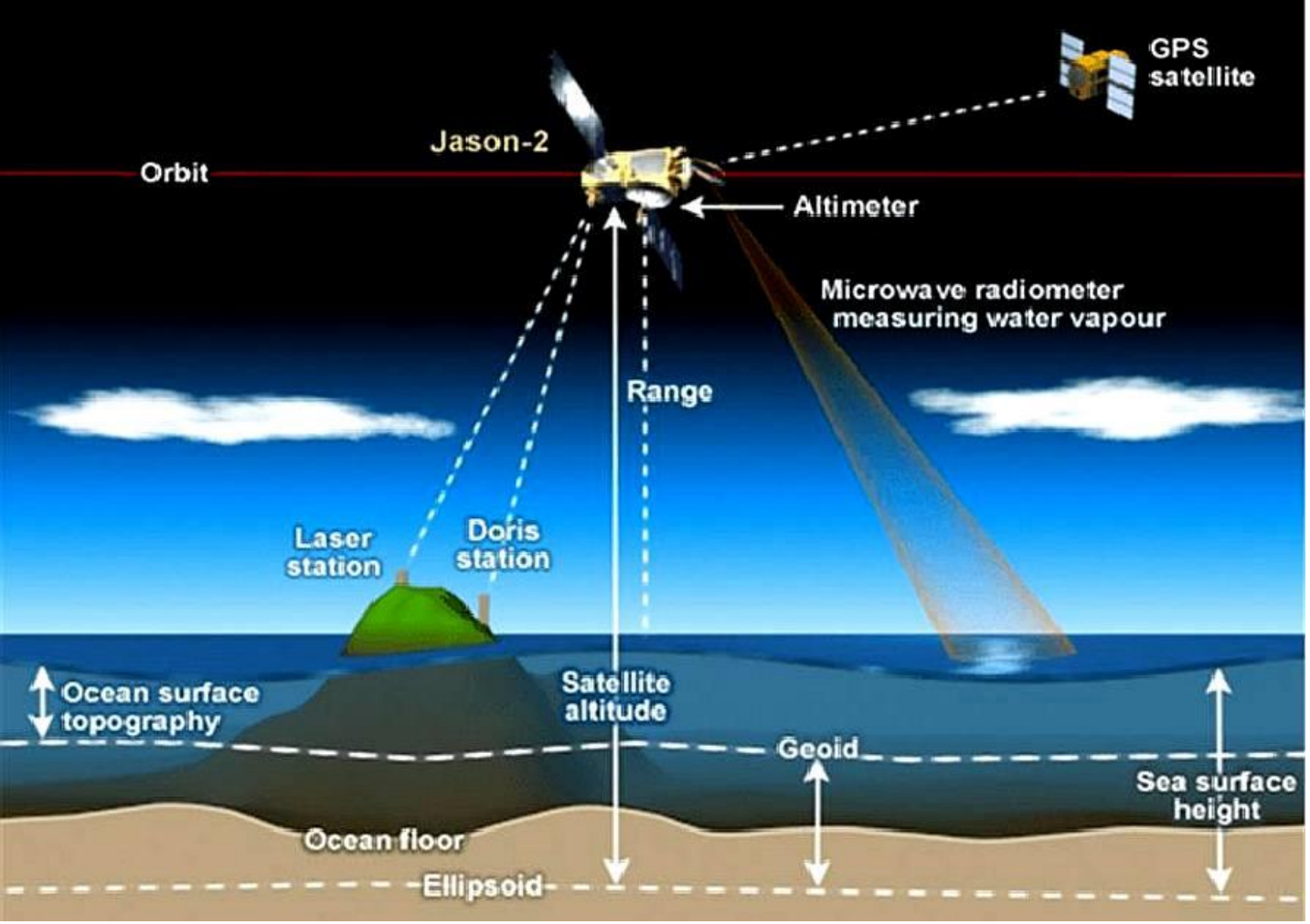


A total wave spectrum can be separated in a windsea- (or sea-) and swell- spectrum.
The sea spectrum is the part of the total spectrum, which is under the influence of the local wind speed.
The remaining part of the total spectrum is called swell.



Types of surface waves, showing relationship between the forces that cause them (e.g. wind) and their frequency, in Hz, or period, in seconds (period is the inverse of frequency, so 10 Hz = 1/10 = 0.1 second). The blue shaded area shows the relative energy of each wave frequency. The higher the shaded area, the more energy that frequency has.

How to know sea state?



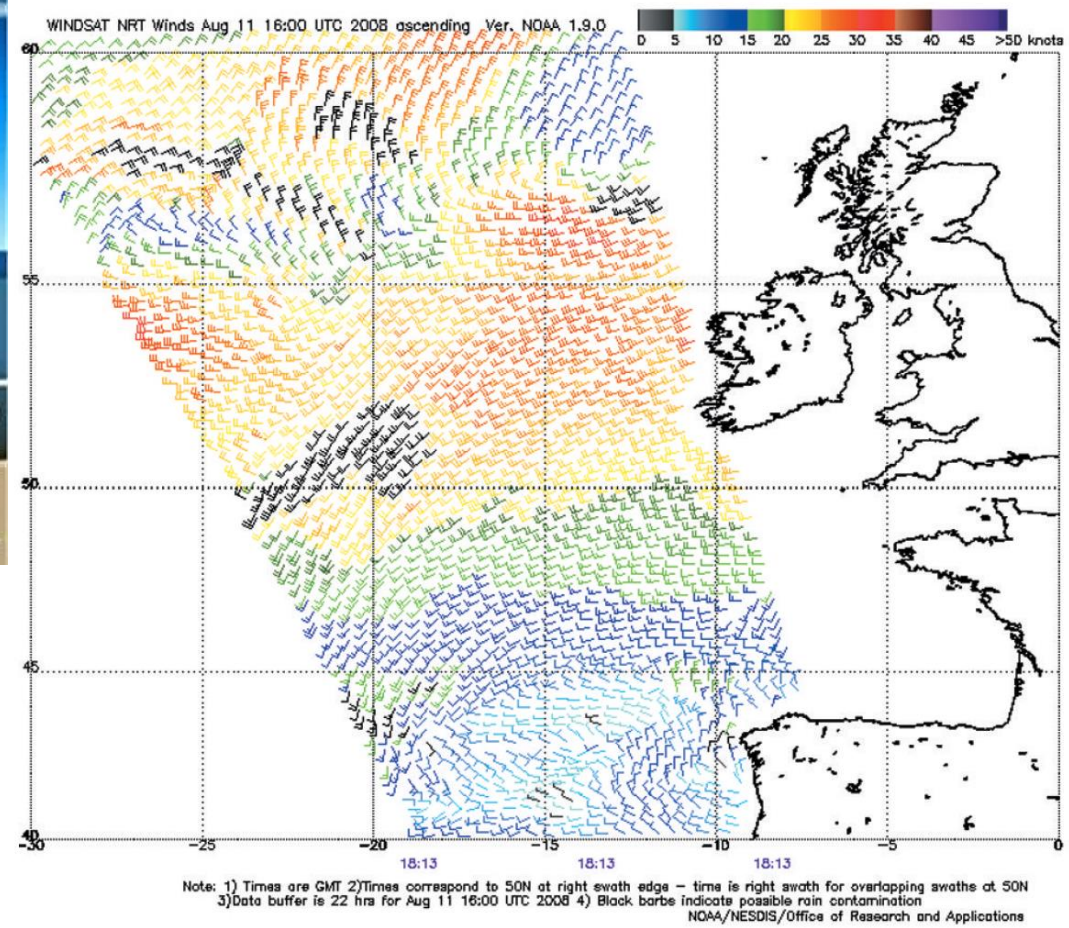
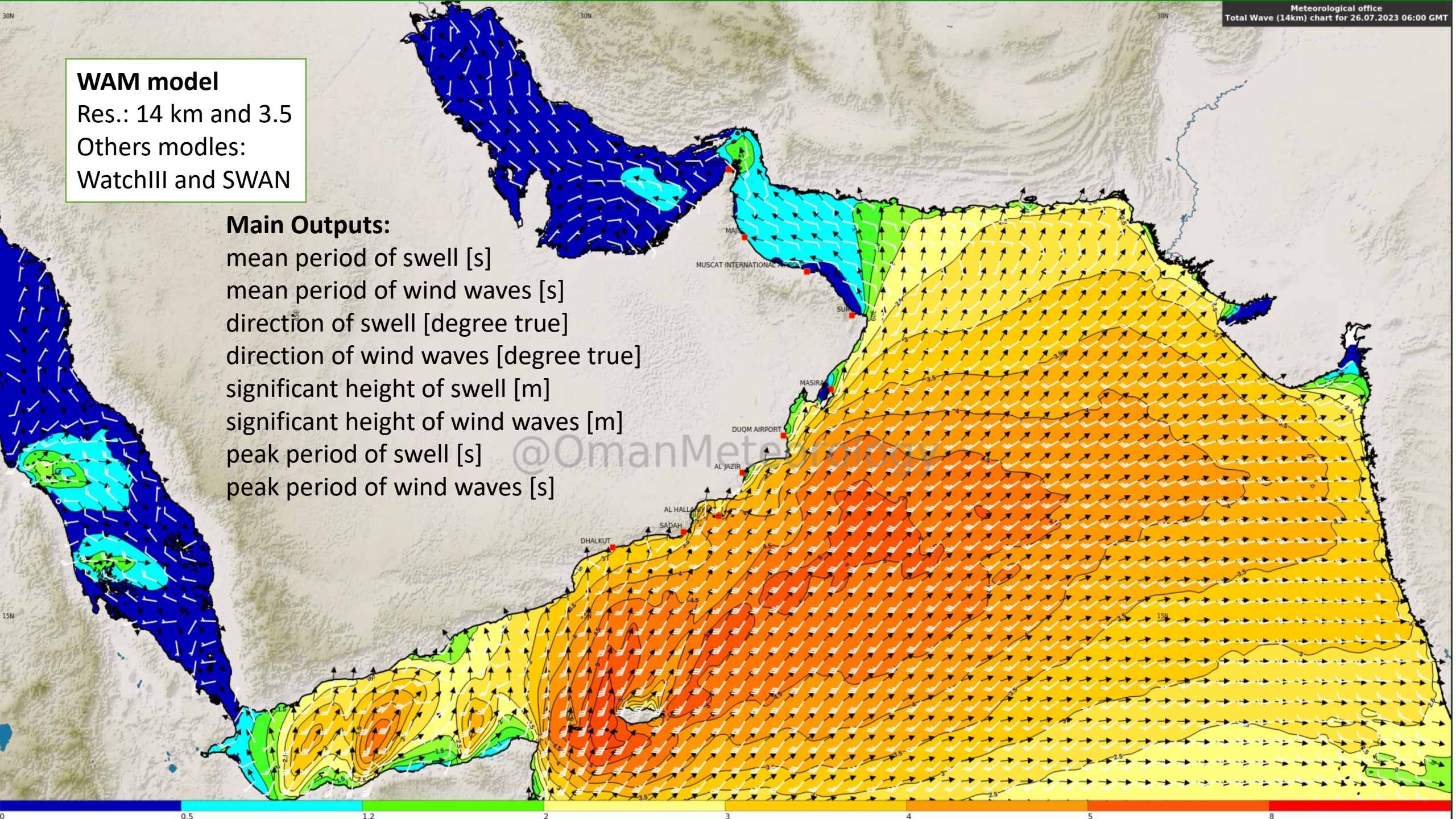
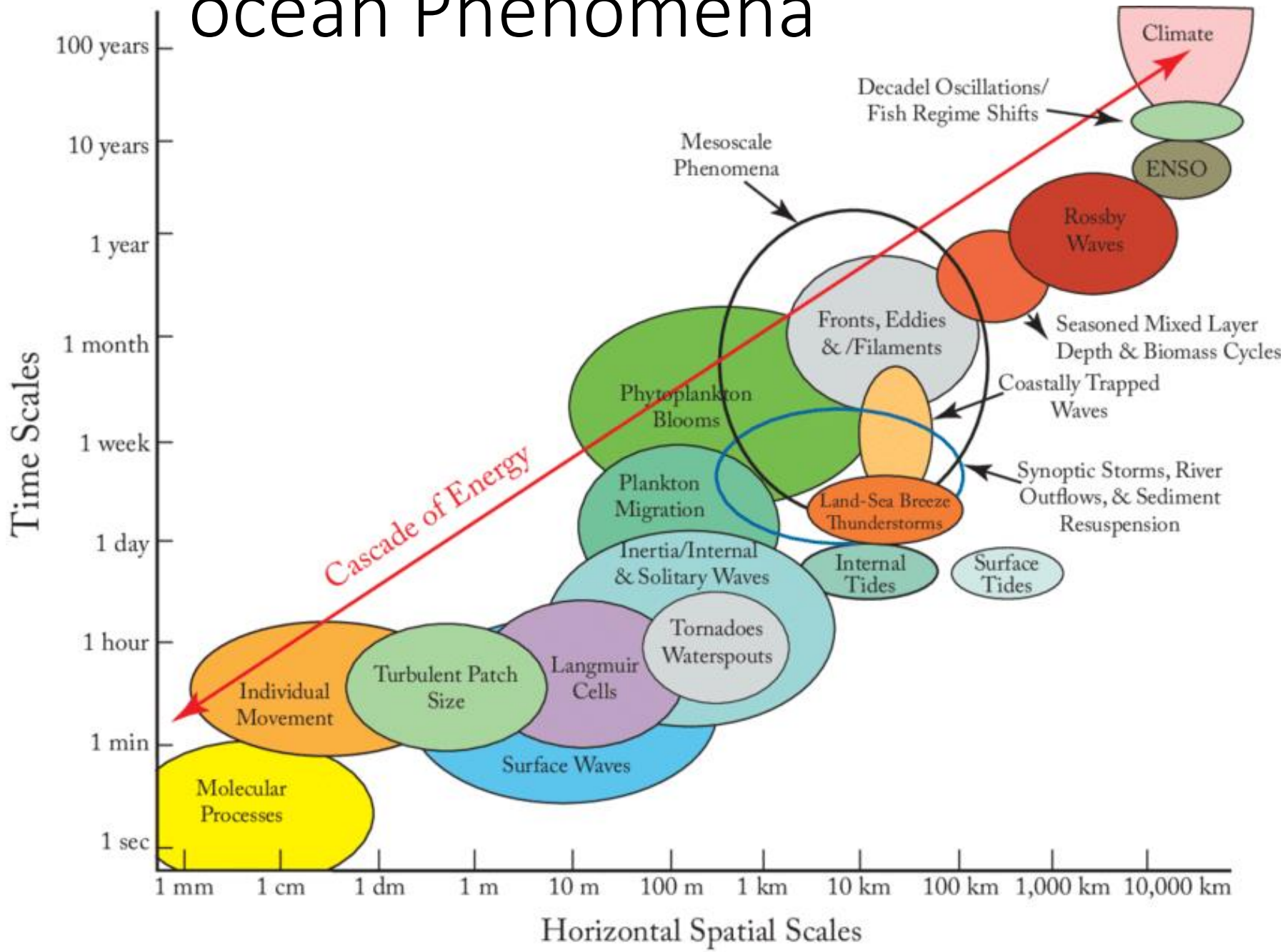
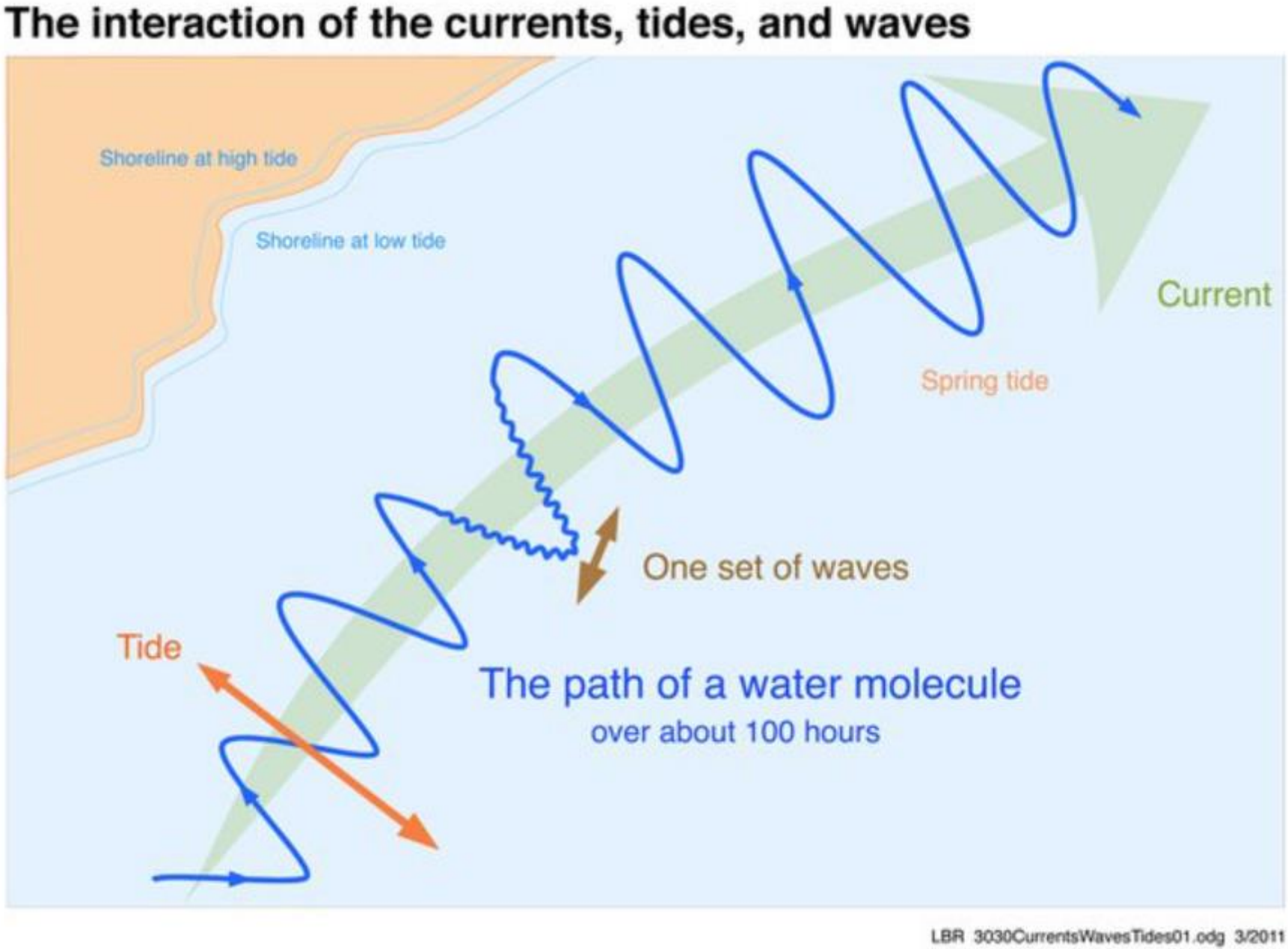


Figure 9.5. Example of wind vector output from Windsat produced in near-real time by NOAA.


Meteorological office
Total Wave (14km) chart for 26.07.2023 06:00 GMT
WAM model
Res.: 14 km and 3.5
Others modles:
WatchIII and SWAN
Main Outputs:
mean period of swell [s]
mean period of wind waves [s]
direction of swell [degree true]
direction of wind waves [degree true]
significant height of swell [m]
significant height of wind waves [m]
peak period of swell [s]
peak period of wind waves [s]
@OmanMeteorology
MUSCAT INTERNATIONAL AIRPORT
MASIRAH
DUQM AIRPORT
AL JAZIR
AL HALLANIYAT
SADAH
DHALKUT
30N
15N
0
0.5
1.2
2
3
4
5
8

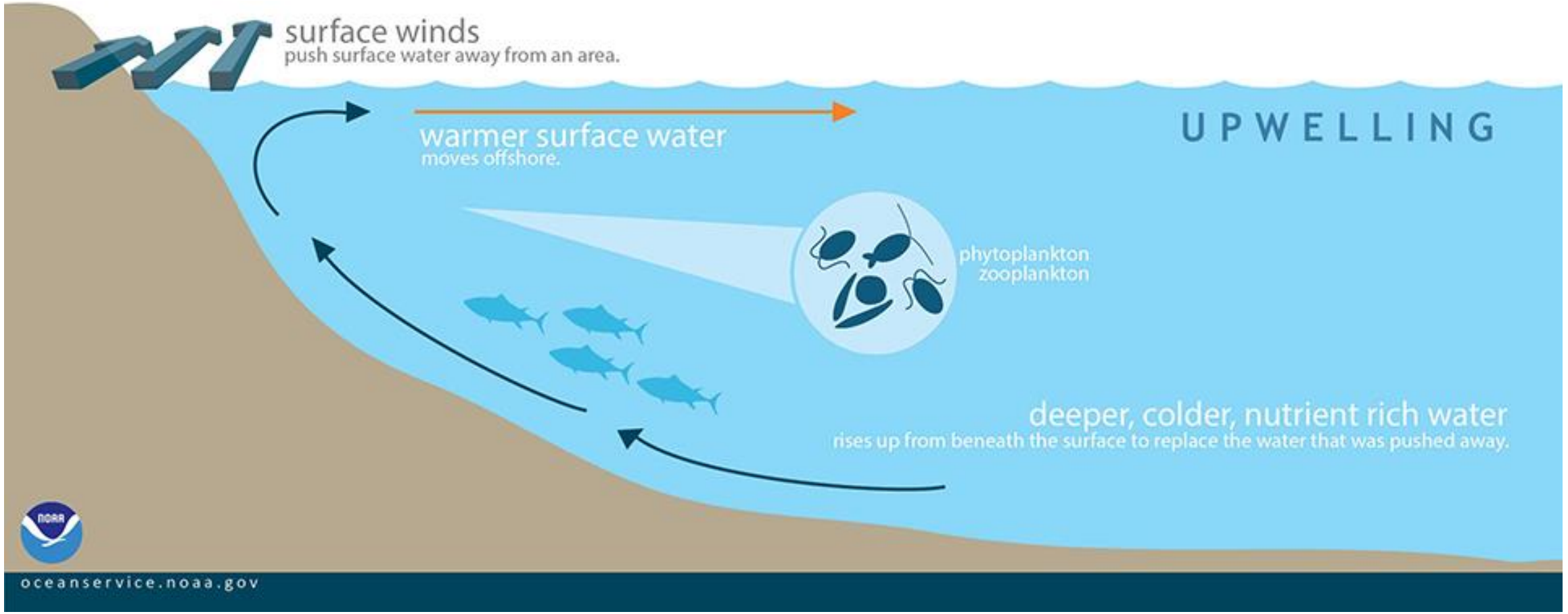
ocean Phenomena





(Image source : Sci Water: Oceans (Ocean Floor, Tides, Waves, Currents) - Lessons - Tes Teach)

Upwelling is a process in which **deep, cold water rises** toward the surface.



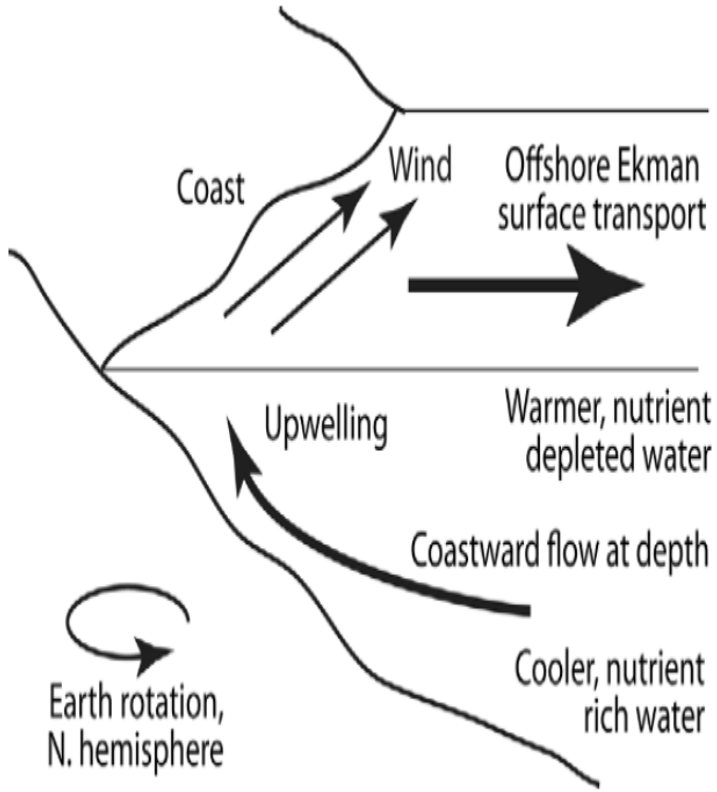
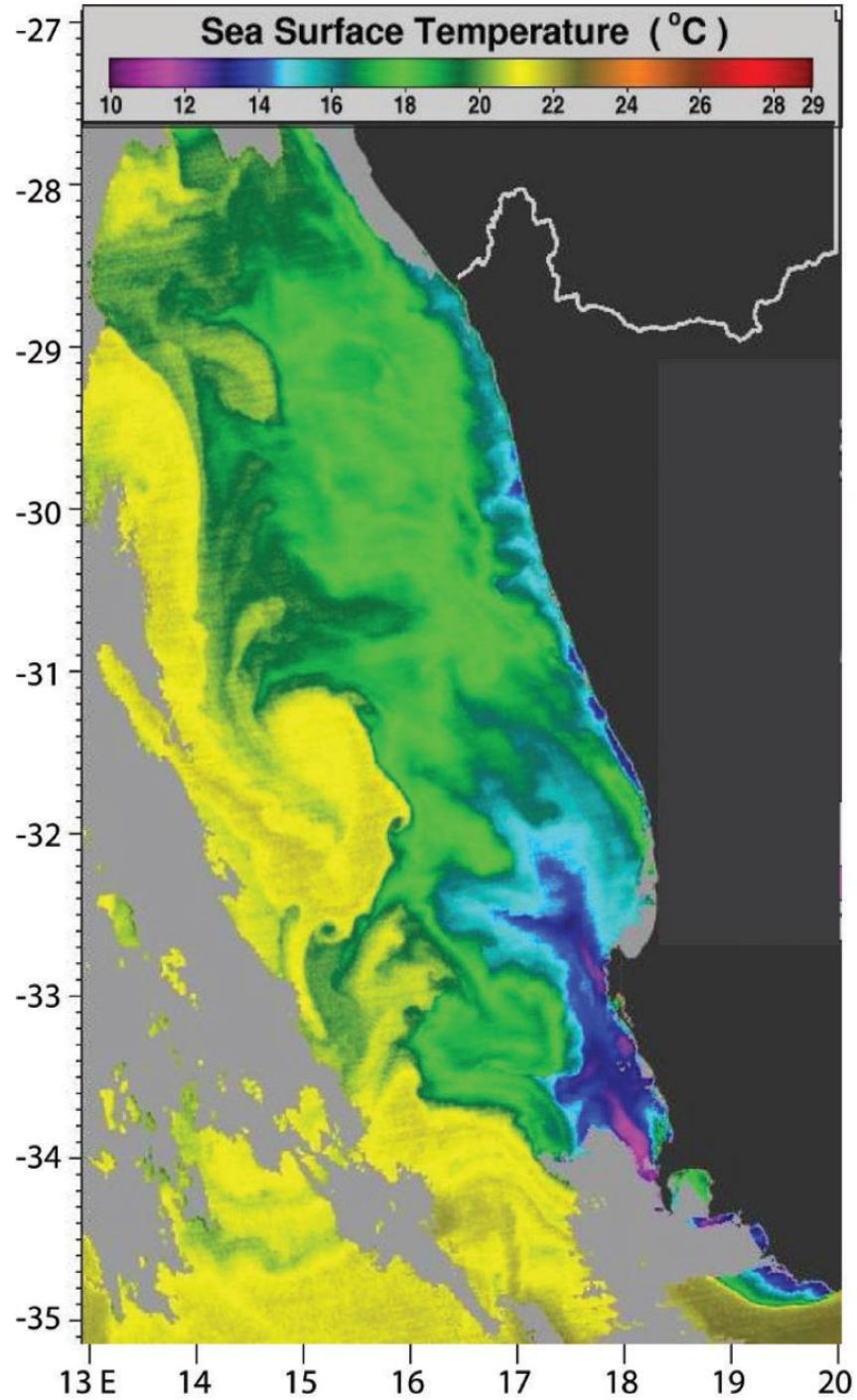


Figure 5.1. Coastal upwelling.



Sea eddies are large, circular currents that form in the ocean. They are typically 10 to 100 kilometers in diameter, and they can last for weeks or months.

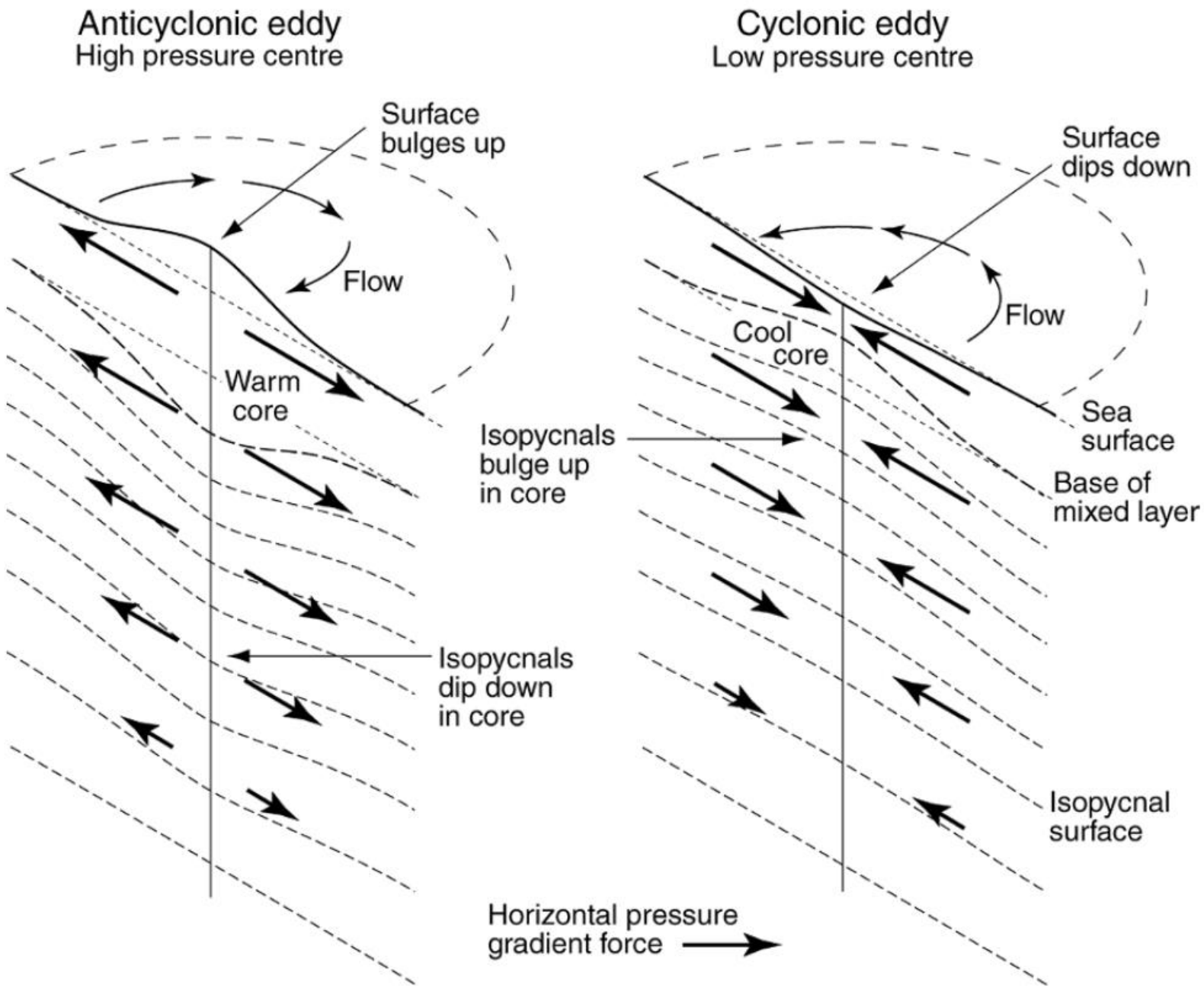
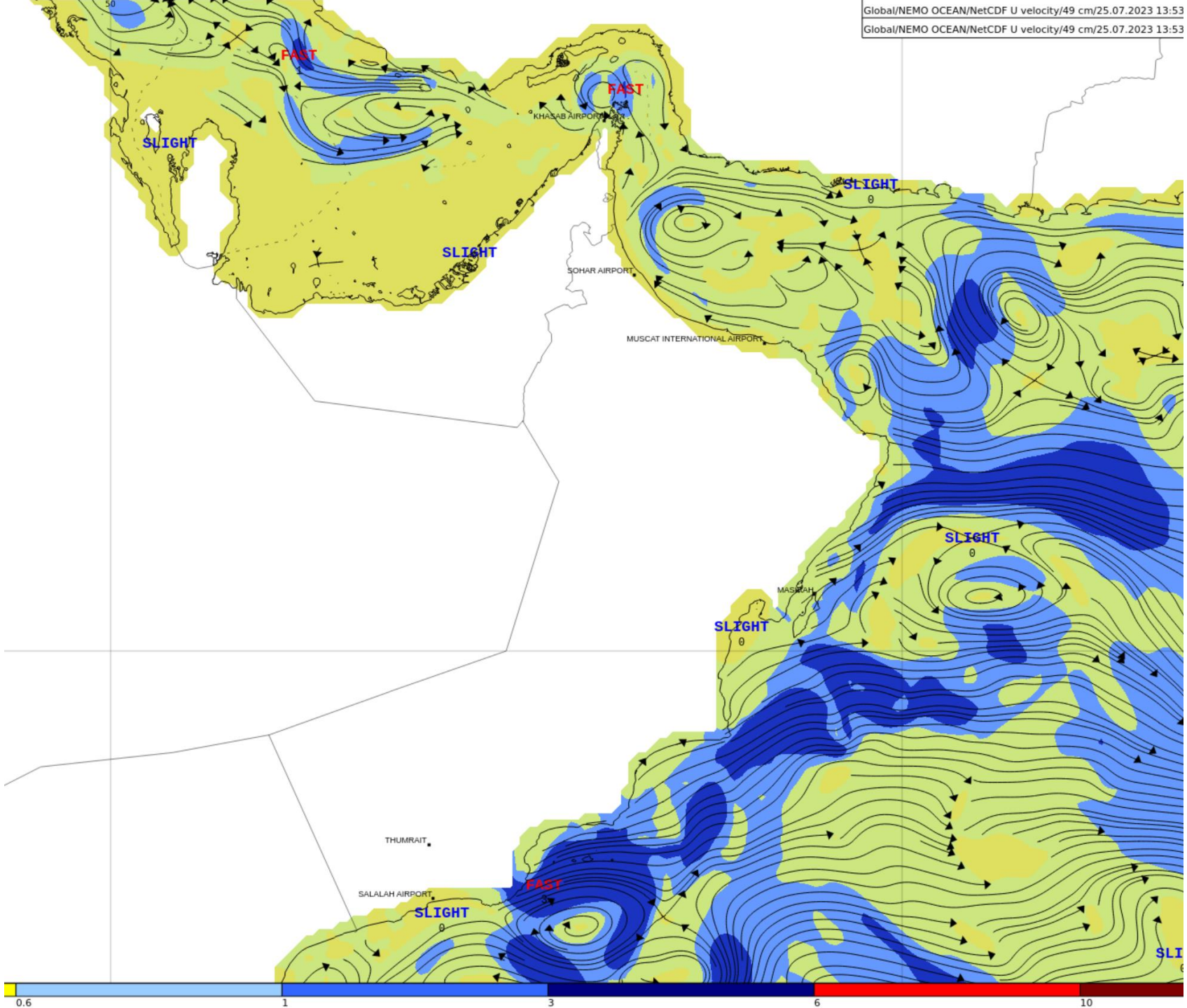


Figure 3.7. Schematic of the basic structure of a simple eddy in the northern hemisphere. On the left is an anticyclonic eddy (warm core) and on the right is a cyclonic eddy (cold core).


Global/NEMO OCEAN/NetCDF U velocity/49 cm/25.07.2023 13:53
Global/NEMO OCEAN/NetCDF U velocity/49 cm/25.07.2023 13:53
FAST
FAST
SLIGHT
SLIGHT
SLIGHT
SLIGHT
SLIGHT
SLIGHT
FAST
SLIGHT
KHASAB AIRPORT
SOHAR AIRPORT
MUSCAT INTERNATIONAL AIRPORT
MASIRAH
THUMRAIT
SALALAH AIRPORT
0.6
1
3
6
10

Thanks