Altimetry

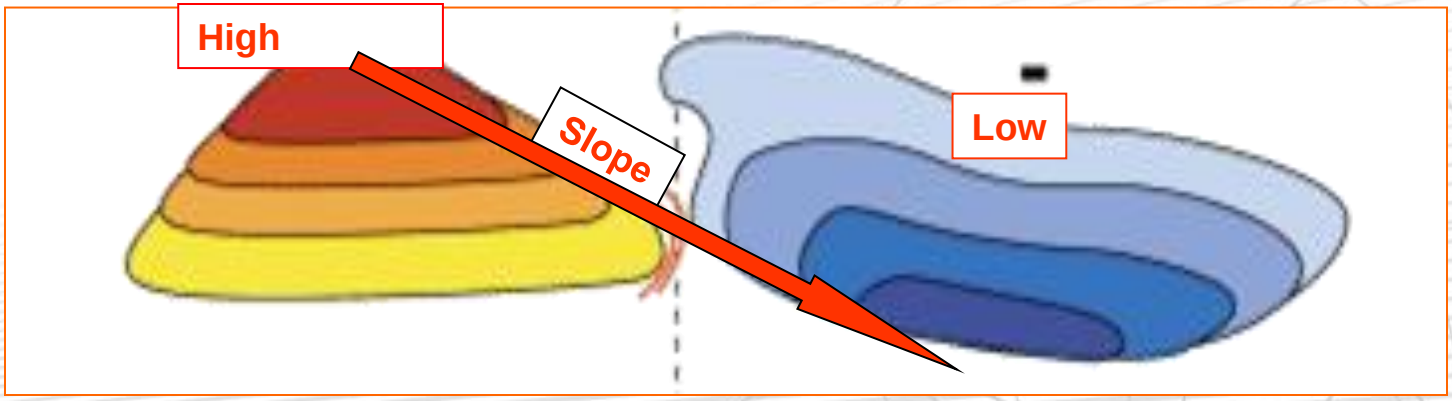
Workshop IPEE/CLS - 3-FEB-2010

Dynamic topography

- Global oceanic circulation:
  - sea level variations
  - sea surface currents
- => observed by altimetry

- Spatial altimetry shows:
  - that sea surface = highs and lows
  - Highs + lows appear and diseapper over time

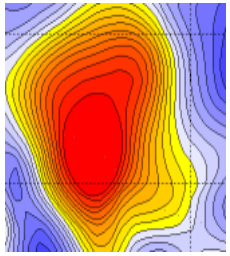
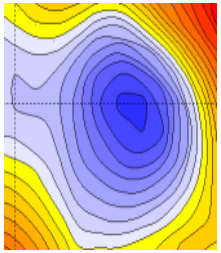
- After comparison with mean sea level, by removing tides and waves, sea level variations are sea level anomalies.



Eddies

Ocean:

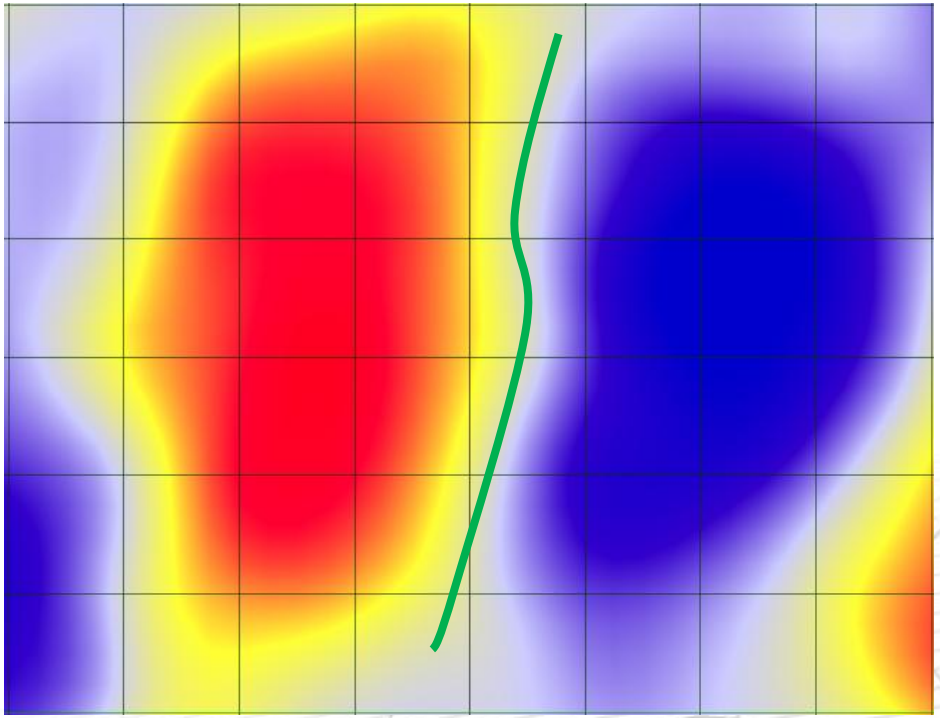
- Eddies and fronts
- Size from ~10 km to ~100 km

	Anticyclonic eddy (“bump”)	Cyclonic eddy (“low”)
		
Generally	**Warm water**	**Cold water**
North hemisphere		
South hemisphere		

Fronts

Fronts located between

- positive eddies (“high")
- negative eddies (“low")
- in area were currents are maximum



In frontal zones there are

- Convergence: warmest waters are diving from the surface in depth
- Divergence: upwelling of cold water from depth to the surface

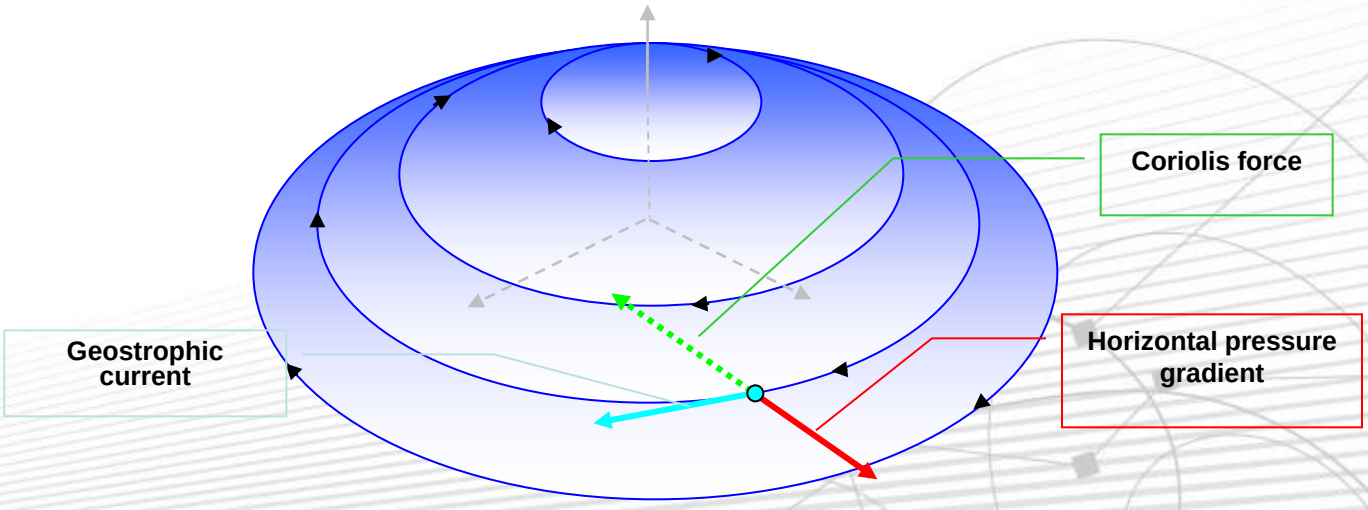
Surface currents

A difference in altitude generate a force that pushes water from highest levels to lowest level

➔ Pressure gradient

But, due to the Coriolis force, each horizontal force is linked to a current taht is orthogoanl to the axe of this difference:

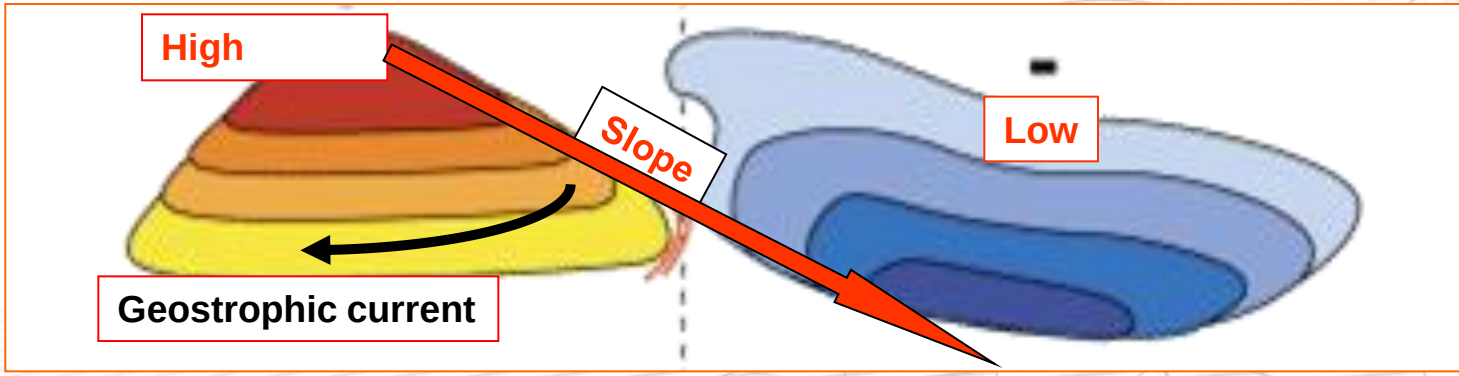
➔ Geostrophic current



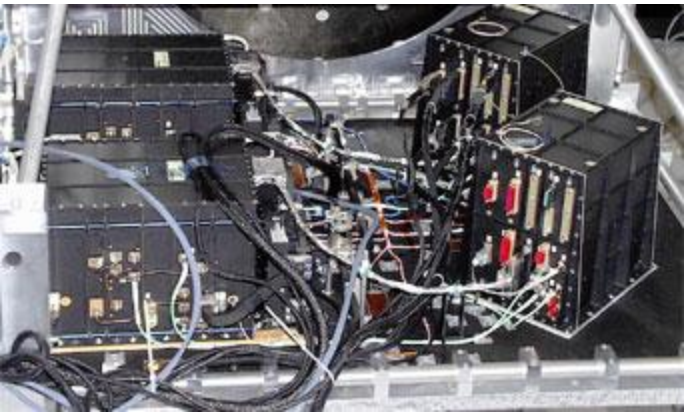
Surface currents

To summarize: sea level anomalies generate sea surface currents:

- In the northern hemisphere: currents are rotating anti-clockwise at the sea surface
- In the southern hemisphere: currents are rotating clockwise at the sea surface



What is an altimeter?



Altimeter

=

Radar instrument onboard a satellite

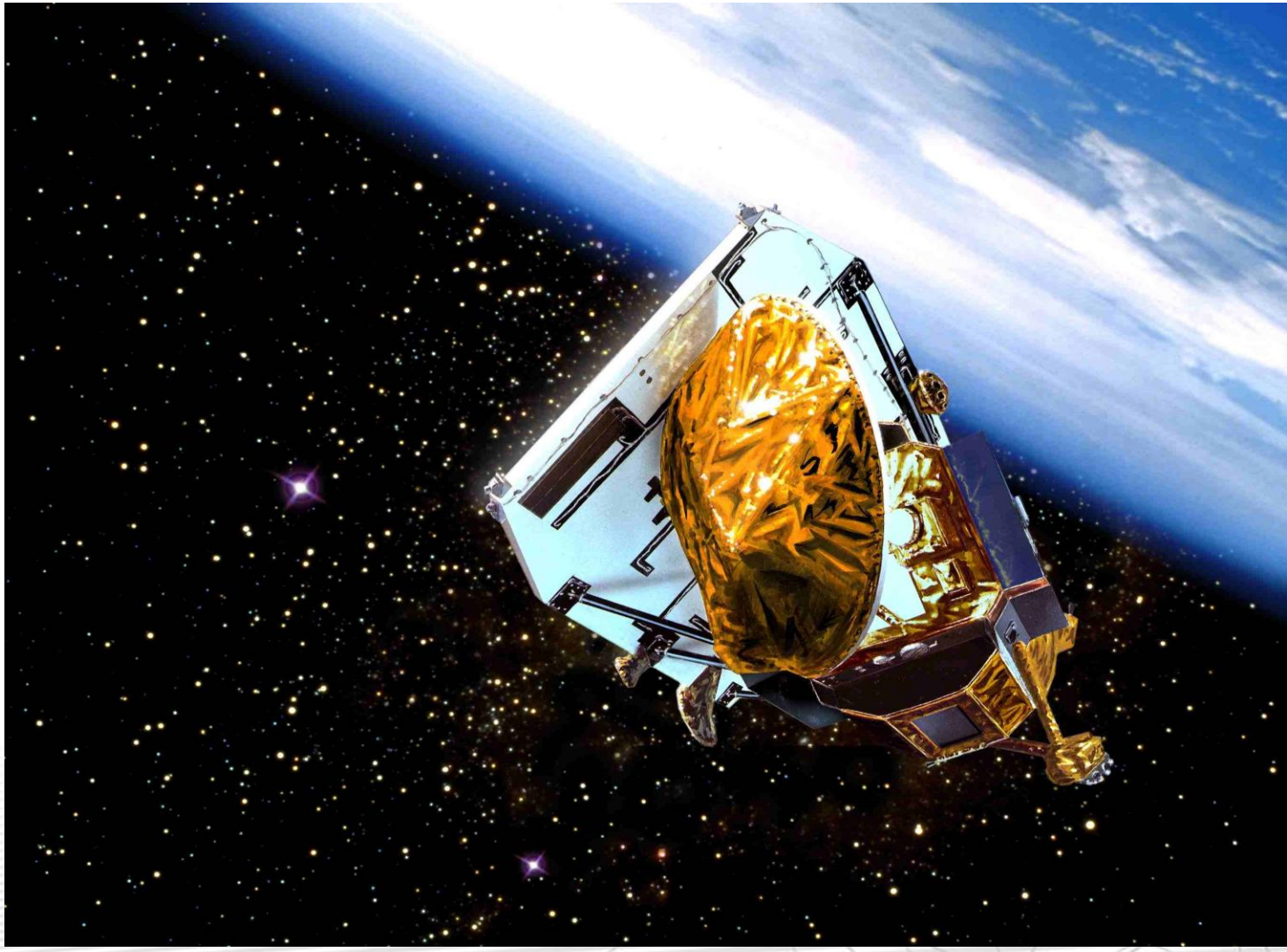
=

Measures the Range
i.e. its altitude respect to the surface of the Earth

Over sea measure ➔ Sea Level Anomalies (SLA)

TOPEX/Poséidon satellite

GFO satellite



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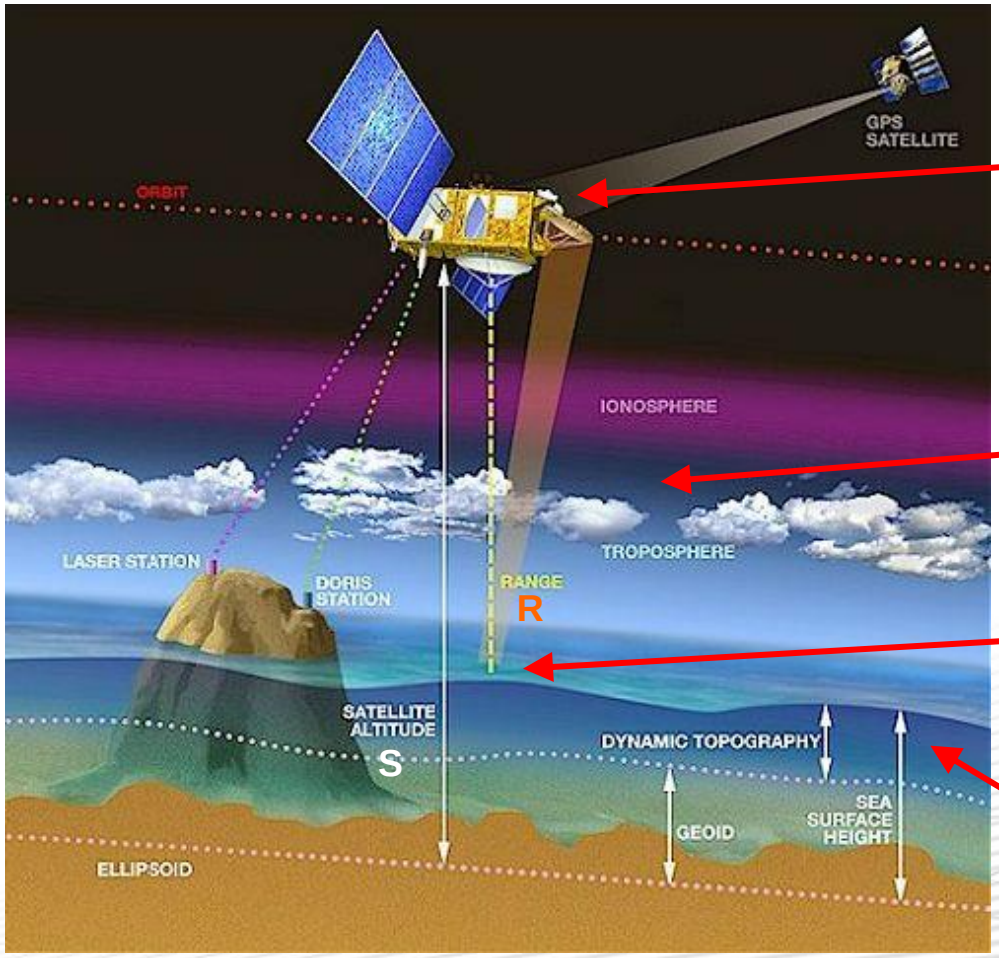
ENVISAT satellite

JASON satellites

Various corrections need to be applied to the signal

$$SLA = S - R - \Sigma Corr.$$



Instrumental corrections
The satellite is moving during the measure, the instruments are not perfect …

Environmental corrections
The atmosphere modifies the signal propagation

Sea surface state corrections
The sea surface is not flat …

Geophysical corrections
The measure contains some signals that we don't want to analyse

Key components of an altimetric mission

- Highly performing radar altimeters
- Precise orbit determination systems
- Additional systems (e.g. radiometer)

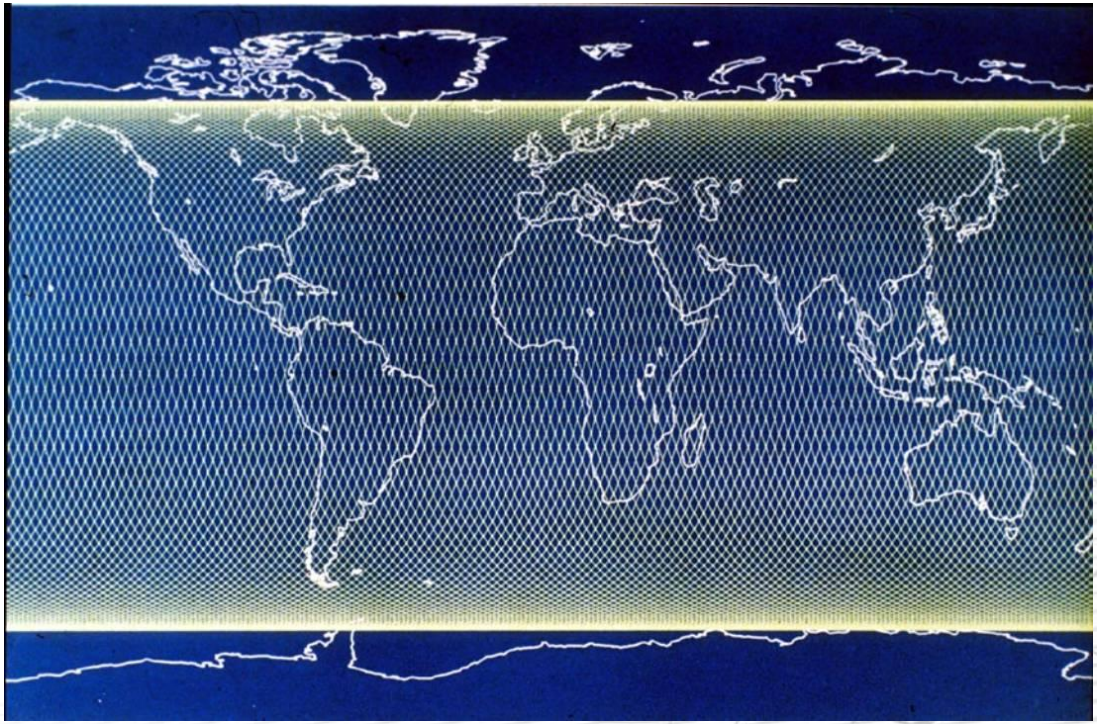
- projetorbites US.exe

Satellite altimetry coverage

Exact repeat orbits (to within 1 km)

- Spatial coverage :
  - global
  - homogeneous
  - Nadir (not swath)
- Temporal coverage :
  - repeat period

  10 days, T/P-Jason-1/2
  17 days, GFO
  35 days, ERS/ENVISAT

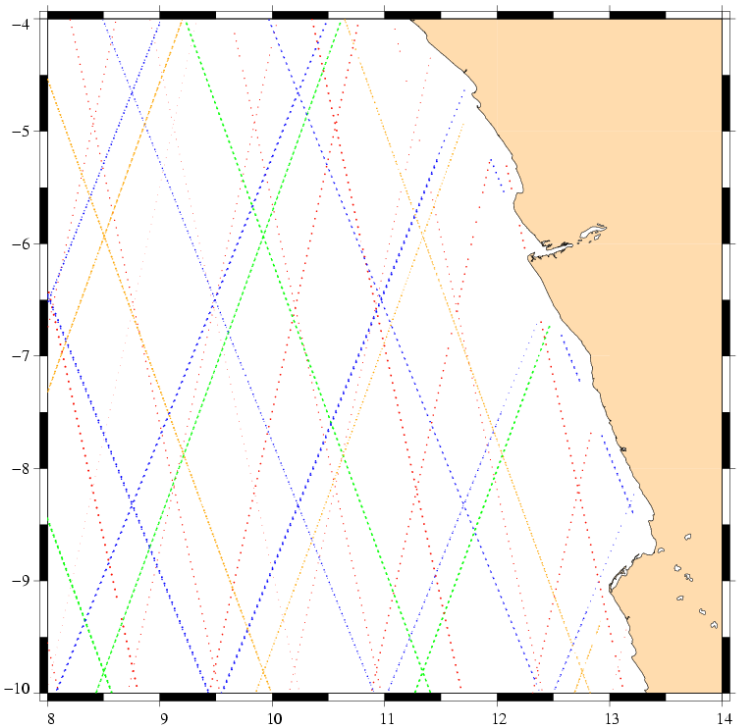


TOPEX/Poseidon or Jasons Sampling

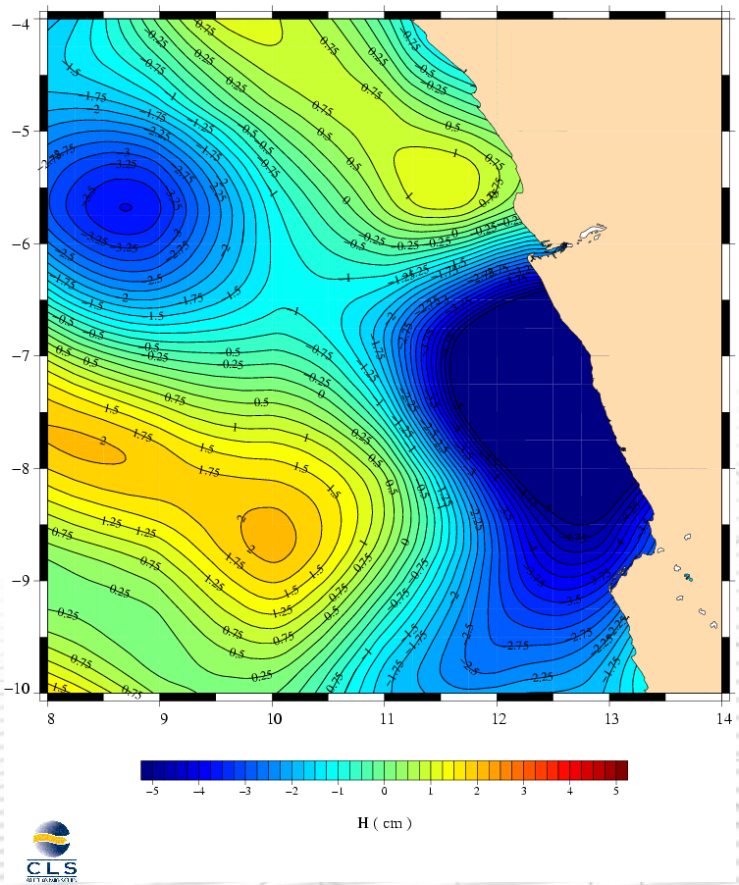
1 measure/1 s (every 7 km)
all weather (radar)

Maps of SLA

CLS data – Jason (Green) – ENVISAT (Red) – GFO (Blue) – TP (Orange)
Date : 19–May–2004



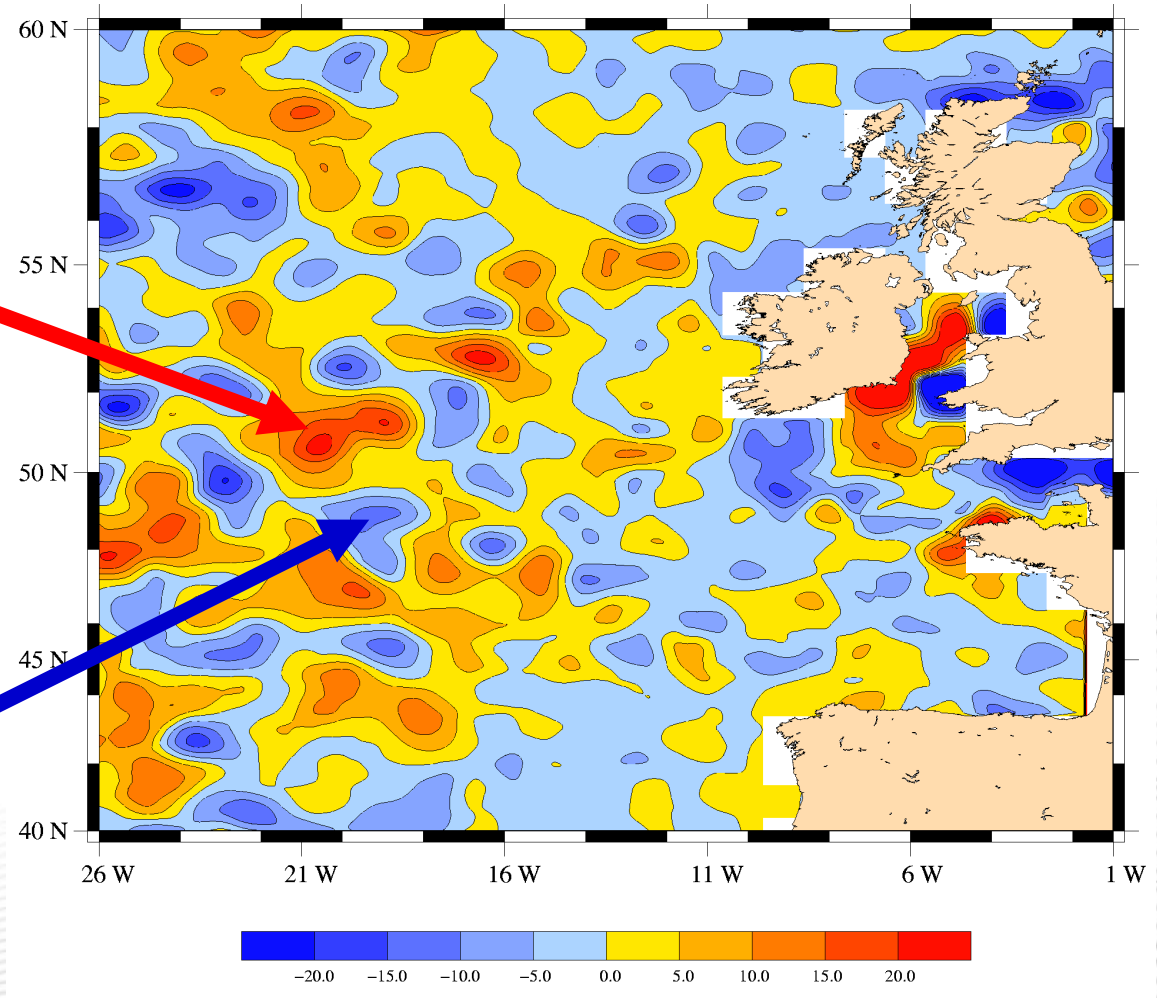
SSALTO/DUACS – NRT SLA – Merged product
19–May–2004 (CNES day 19862)



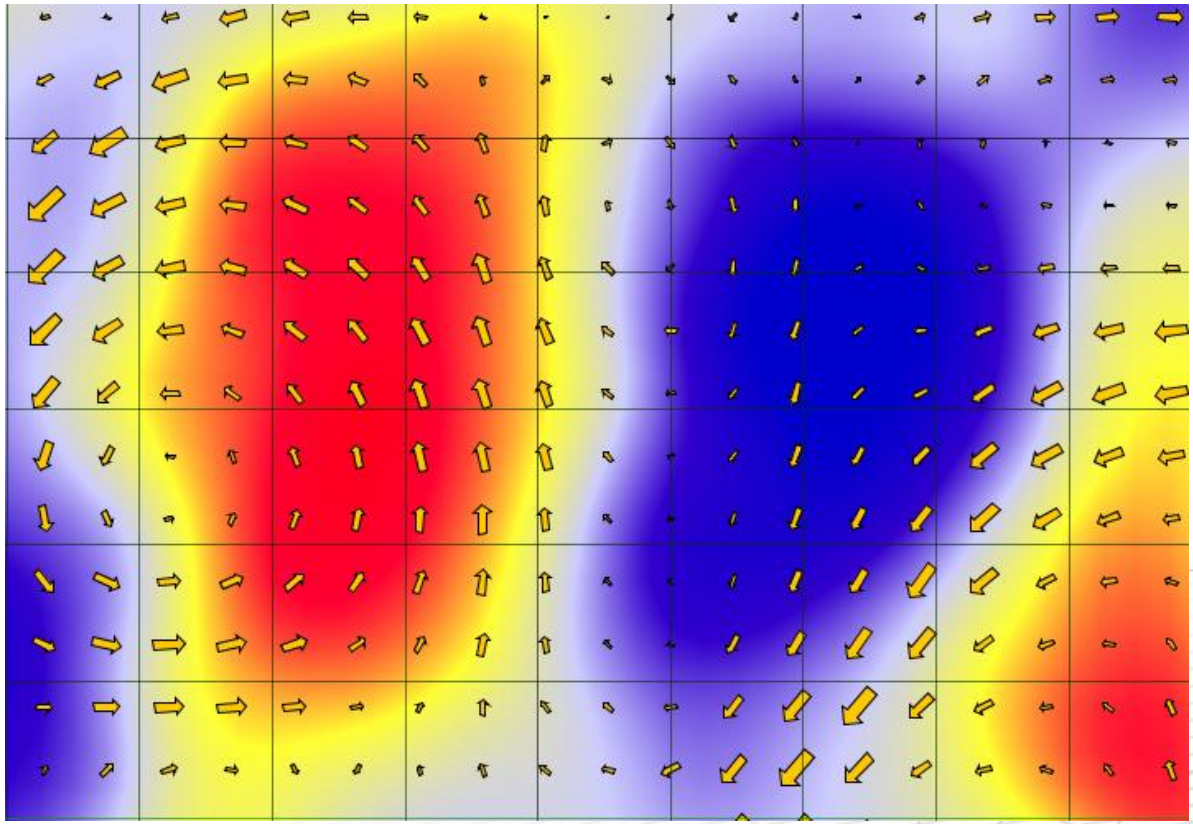
Maps of SLA

A high (bump) in the topography of the ocean (orange/red) is an anticyclonic structure linked to warm waters.

A low (hollow) is a cyclonic structure (blue) that is linked to cold waters where plankton is upwelling occurs (plankton going up)



Maps of geostrophic currents



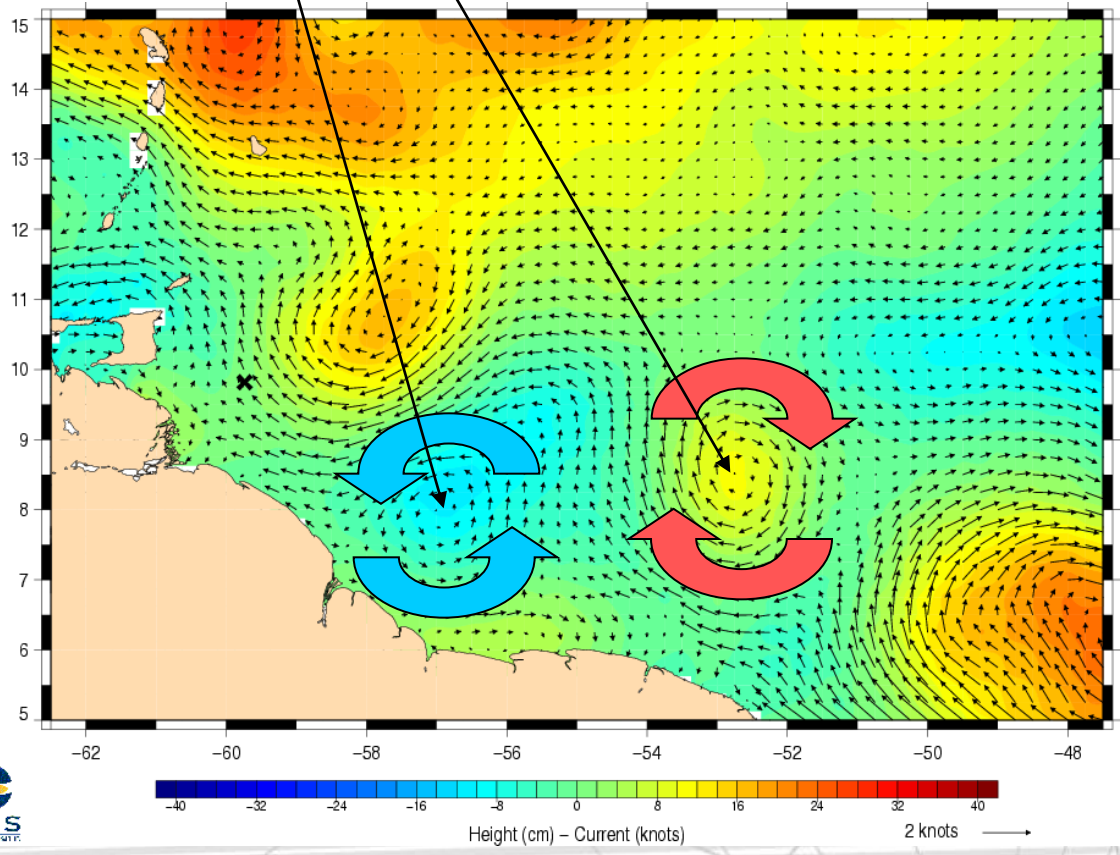
Maps of geostrophic currents are useful to localize

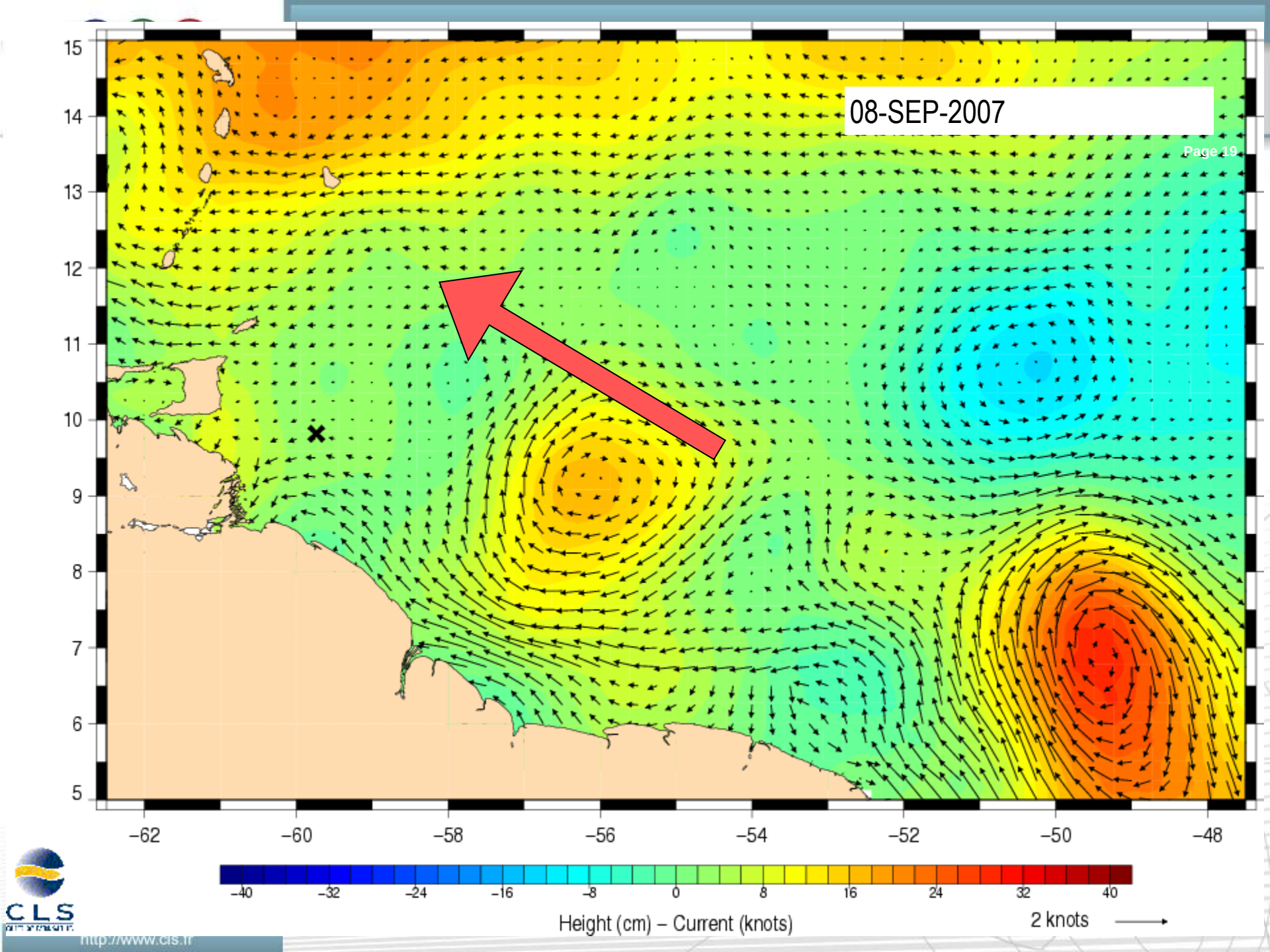
- Characteristics of the dynamic of the ocean (fronts and eddies)
- To be combine with maps of ocean color to confirm increase of decrease
- Areas rich of phytoplankton

Detecting oceanic eddies

With satellite observations of ocean topography and currents:

- Anticyclonic in red (bump)
- Cyclonic in blue (hollow)
- Currents are turning around eddies

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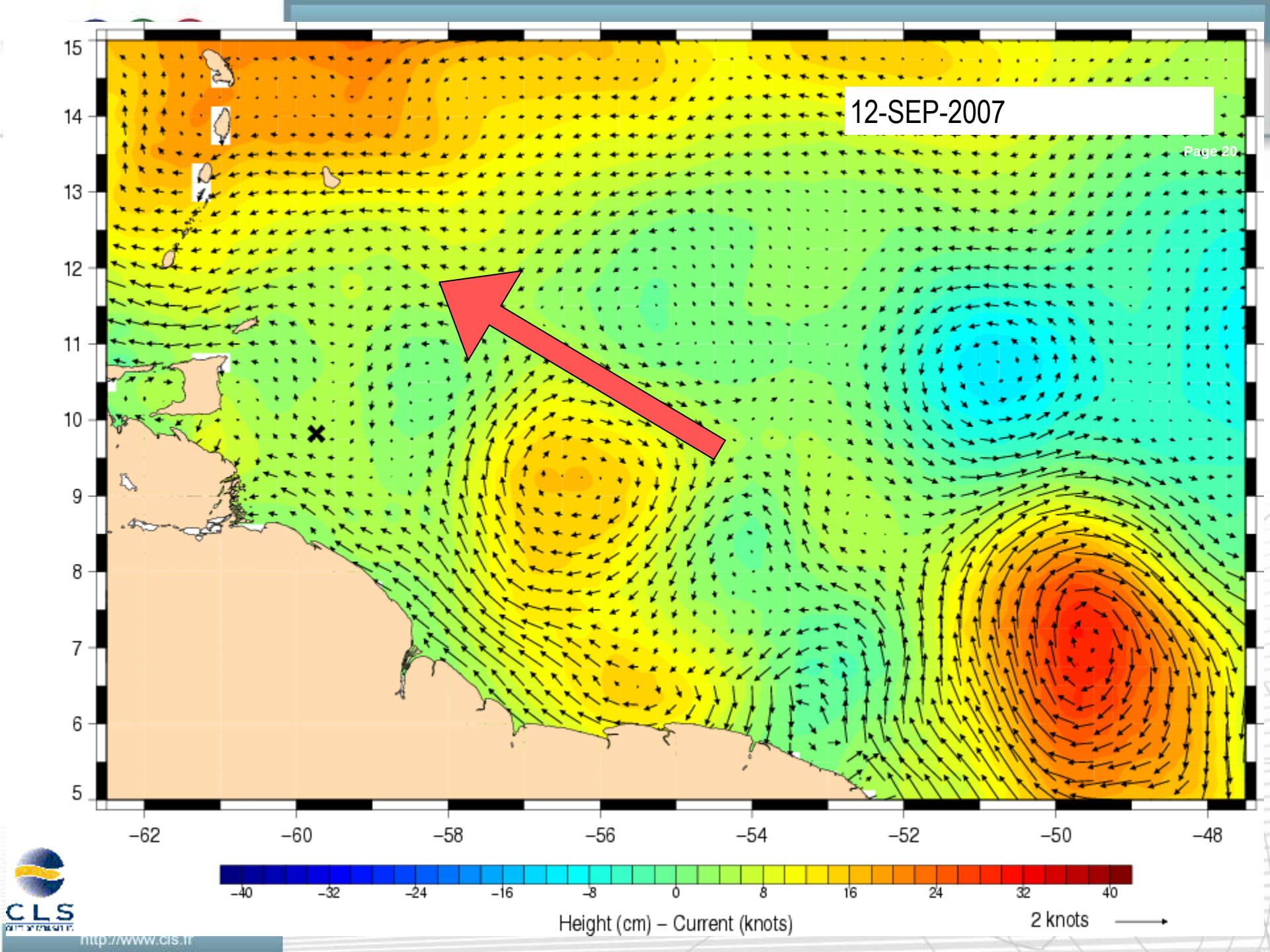
Height (cm) – Current (knots)
2 knots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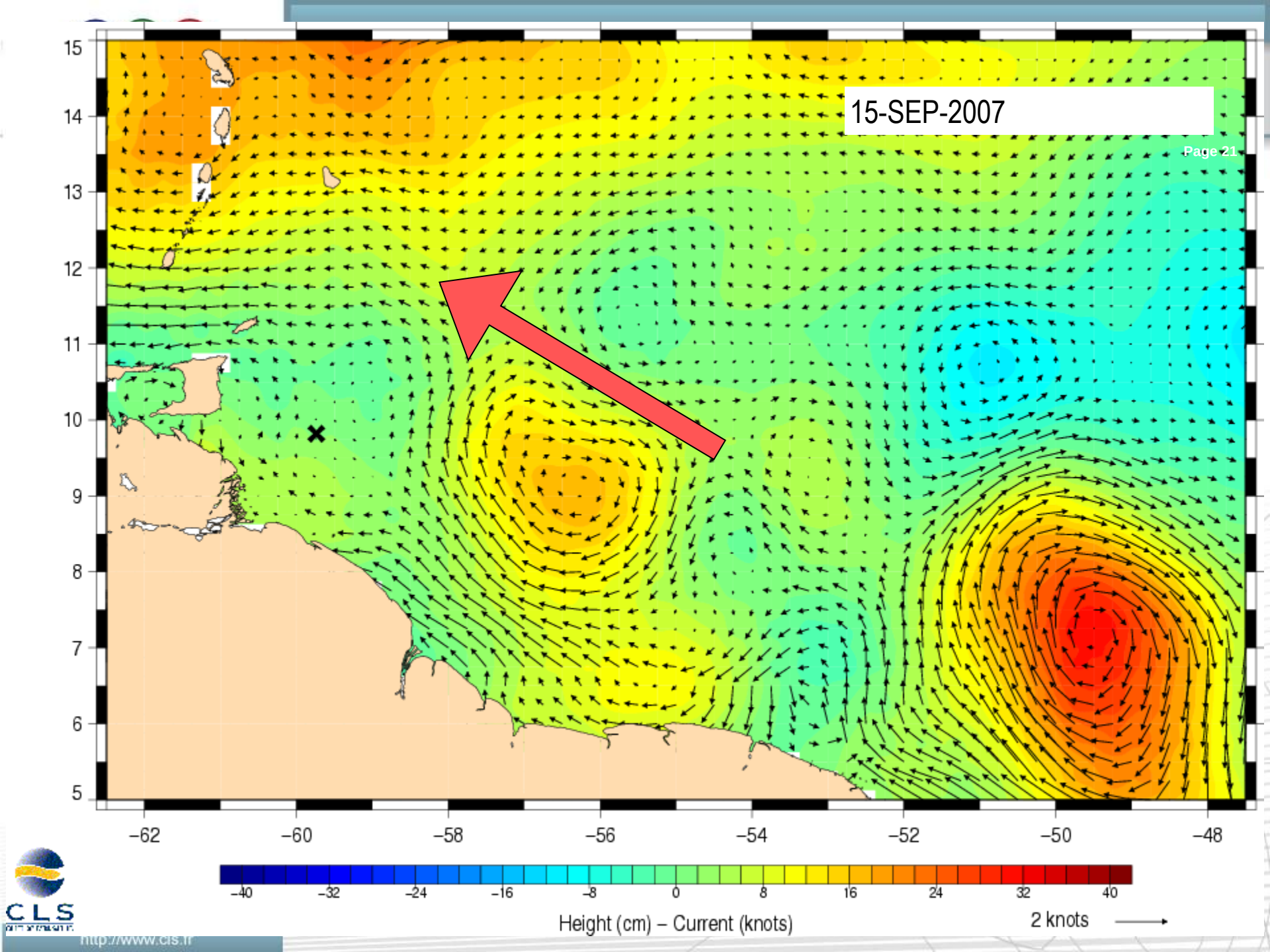
http://www.cls.fr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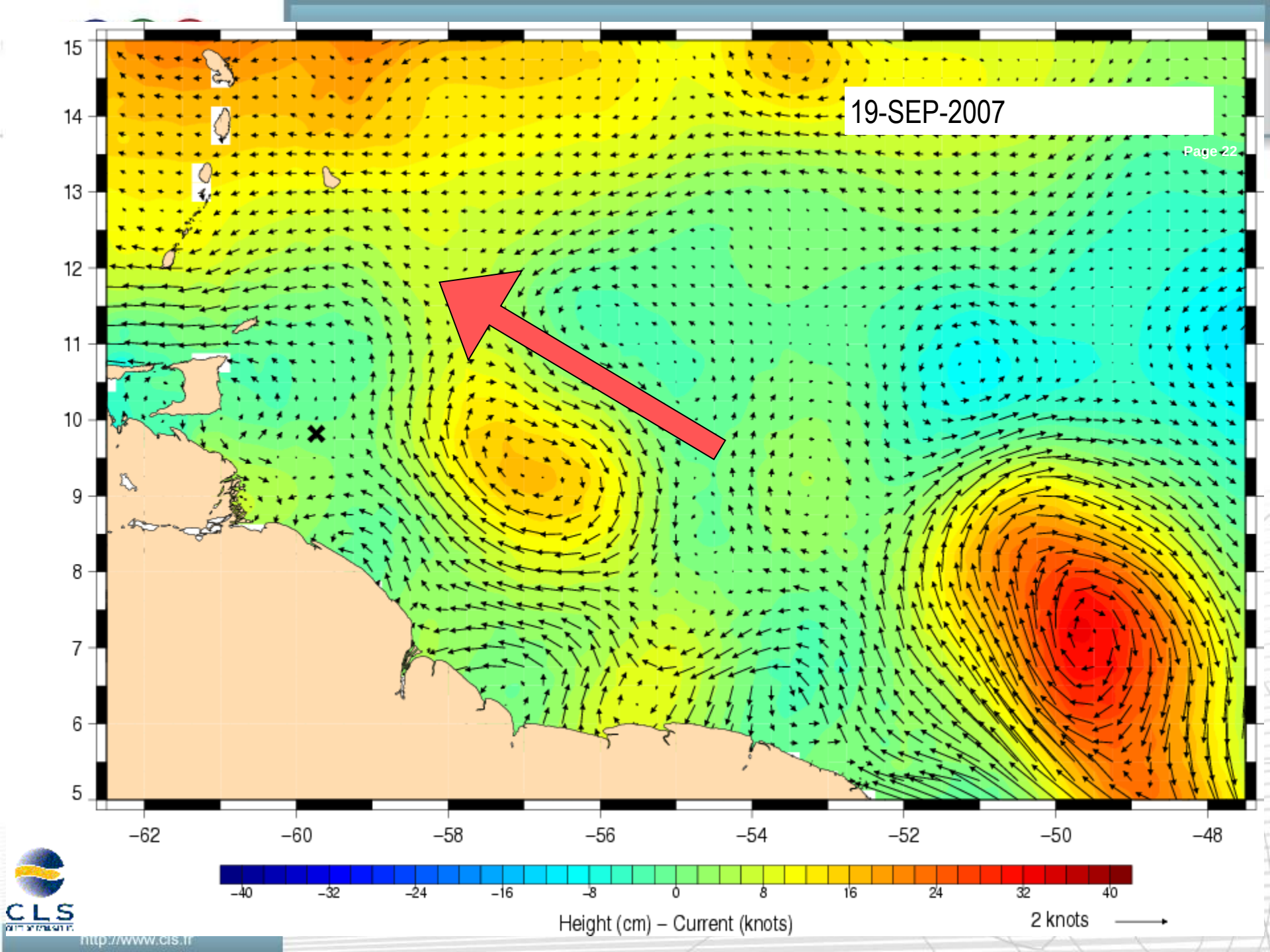
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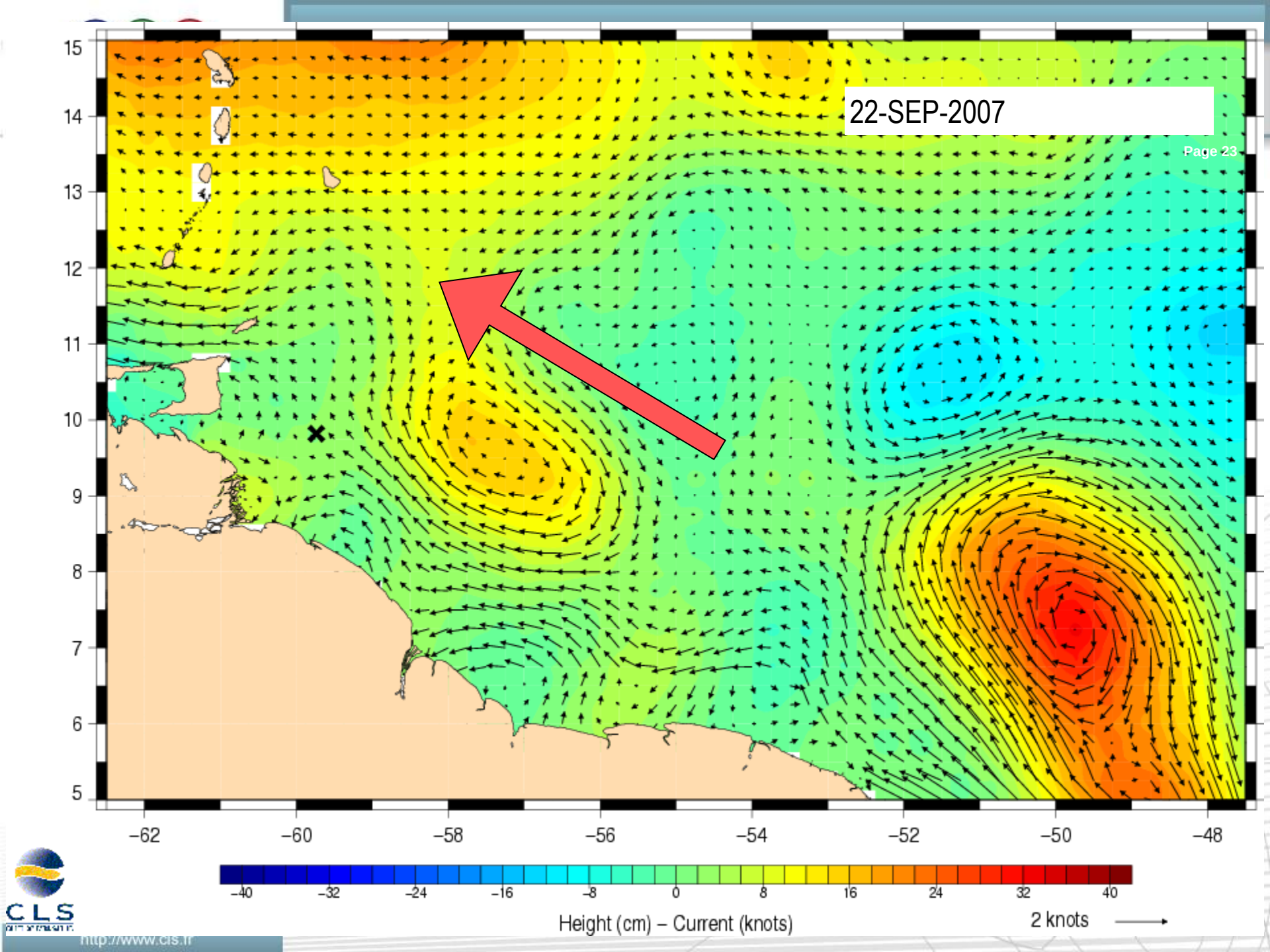
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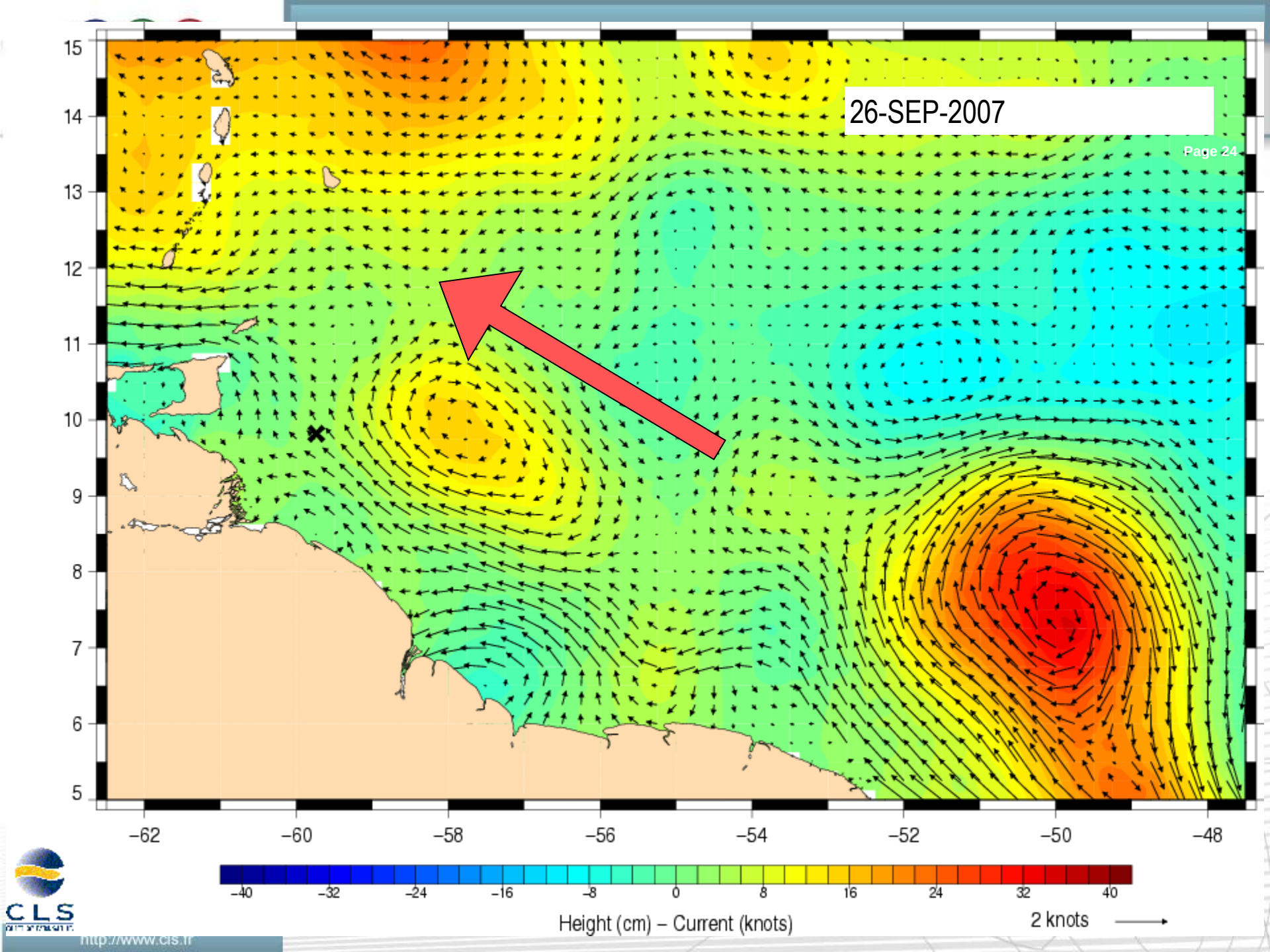
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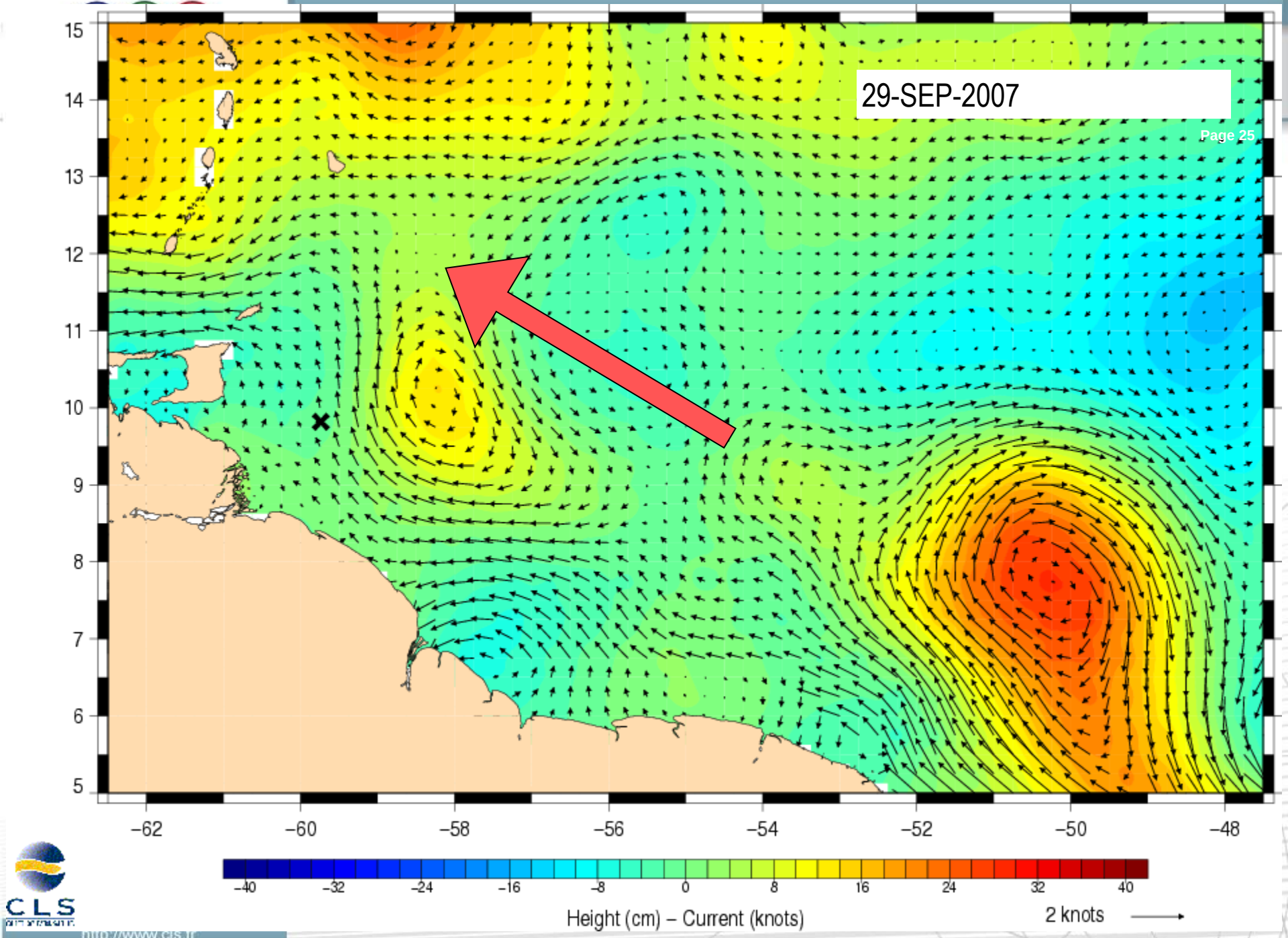
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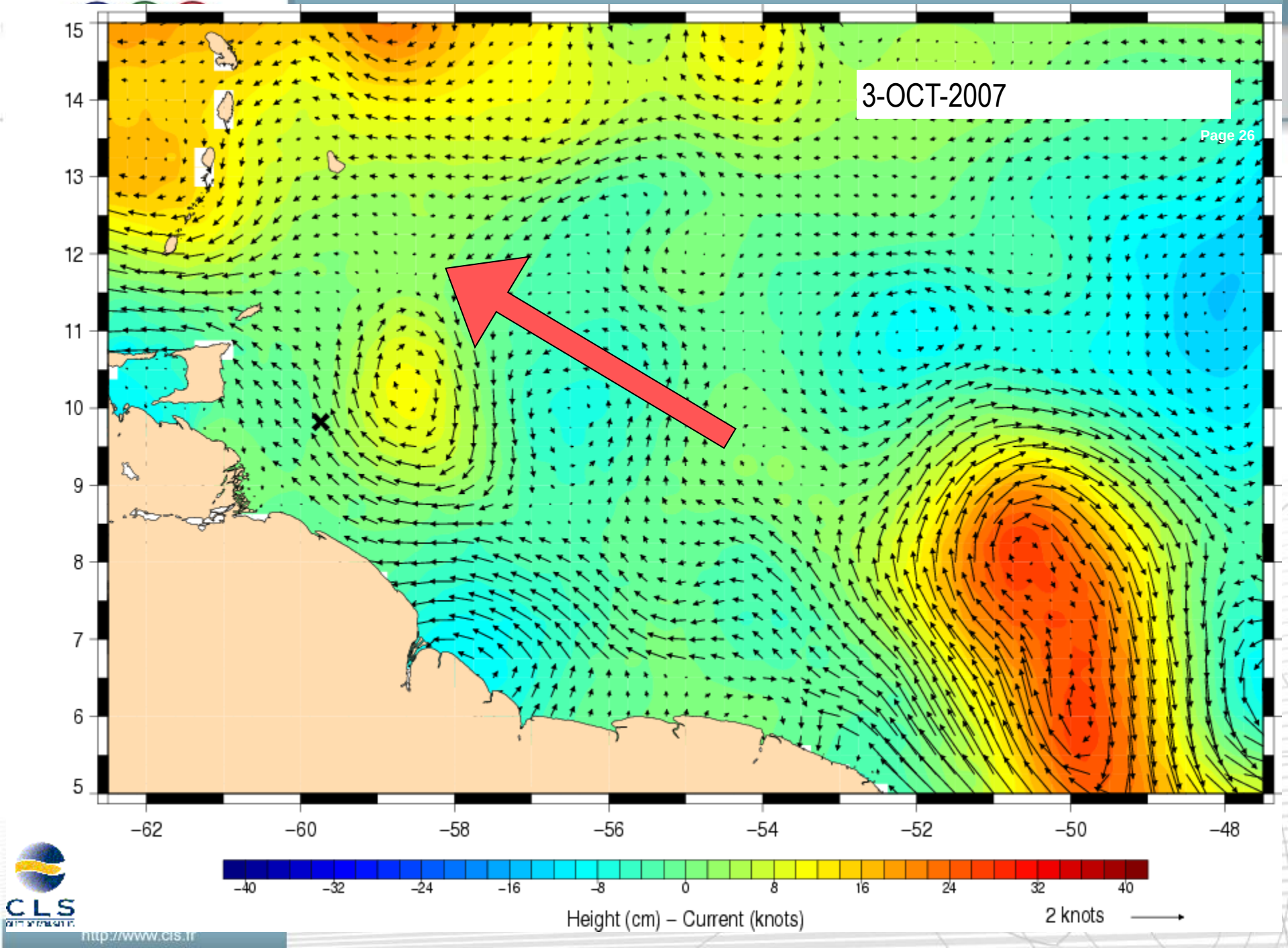
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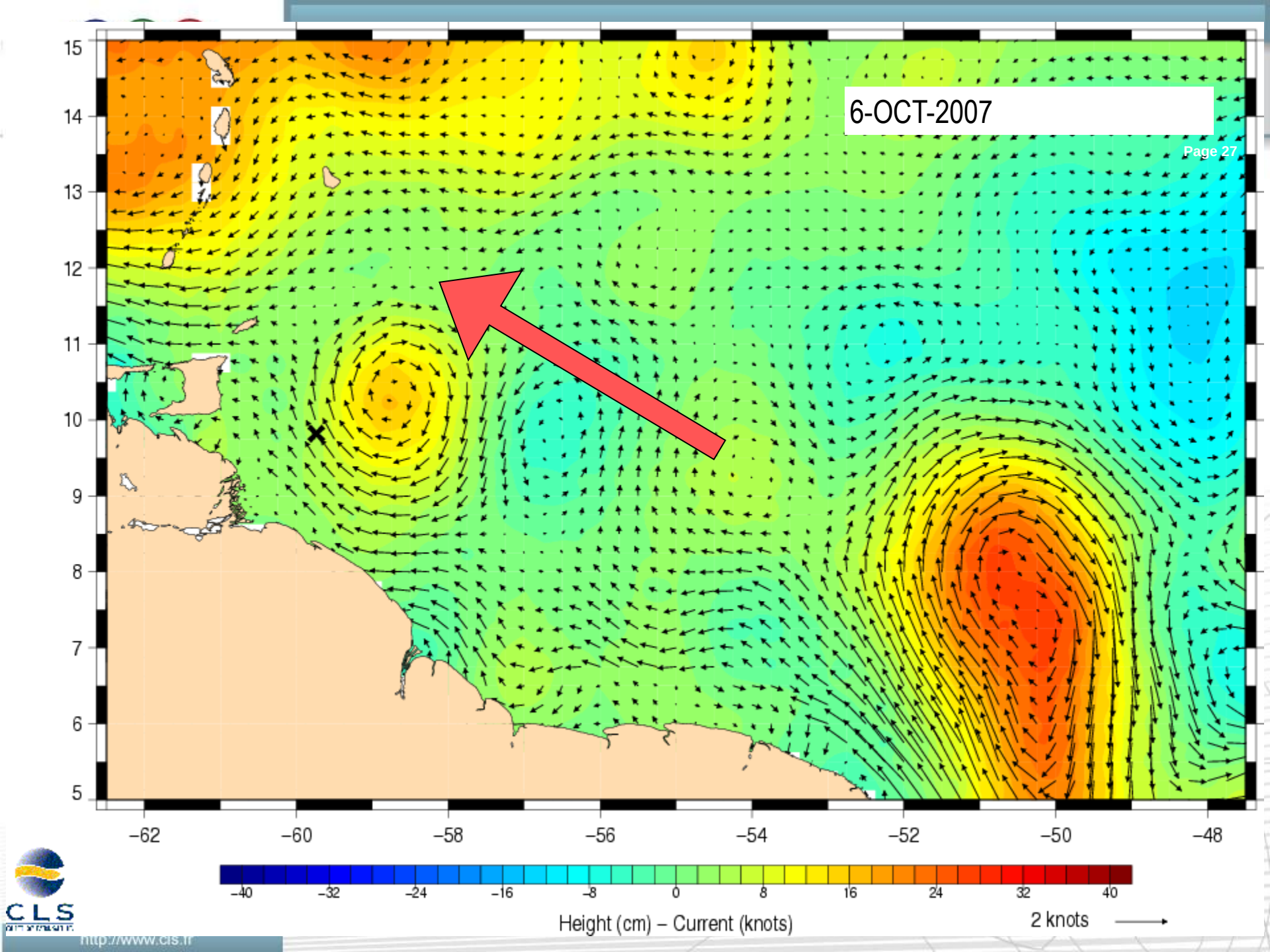
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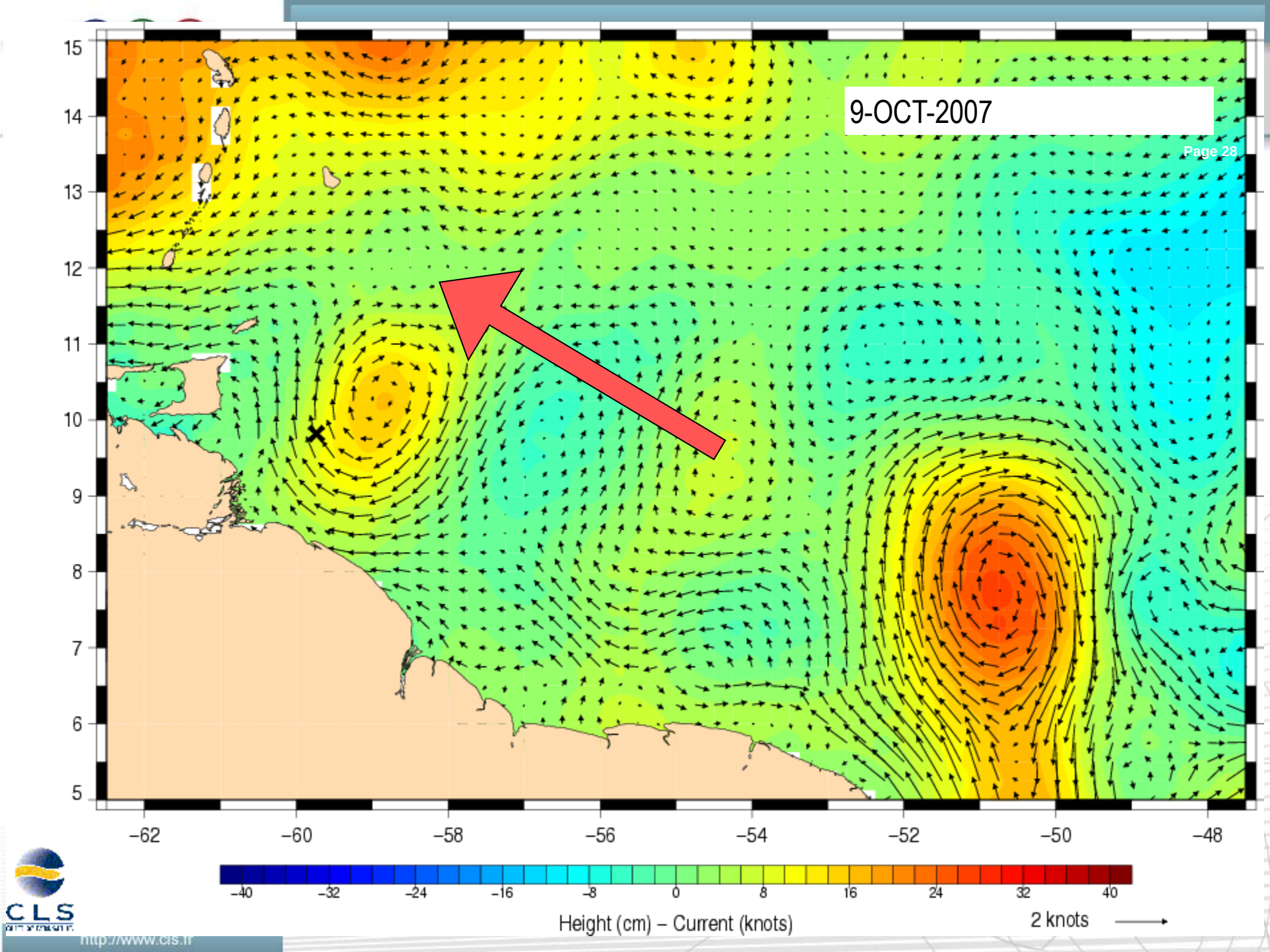
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Maps of SLA

Satellite observations of altimetry

Gulf of Bengal:

- To delineate fronts
- To localize warm eddies
- To localize cold eddies