Institute of Coastal Research
Research Unit *Operational Systems*

RU 3
Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

High-resolution observations of submesoscale eddy dynamics

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False-color image, Baltic Sea, Landsat 8
August 2015 (NASA)

Submesosale Processes

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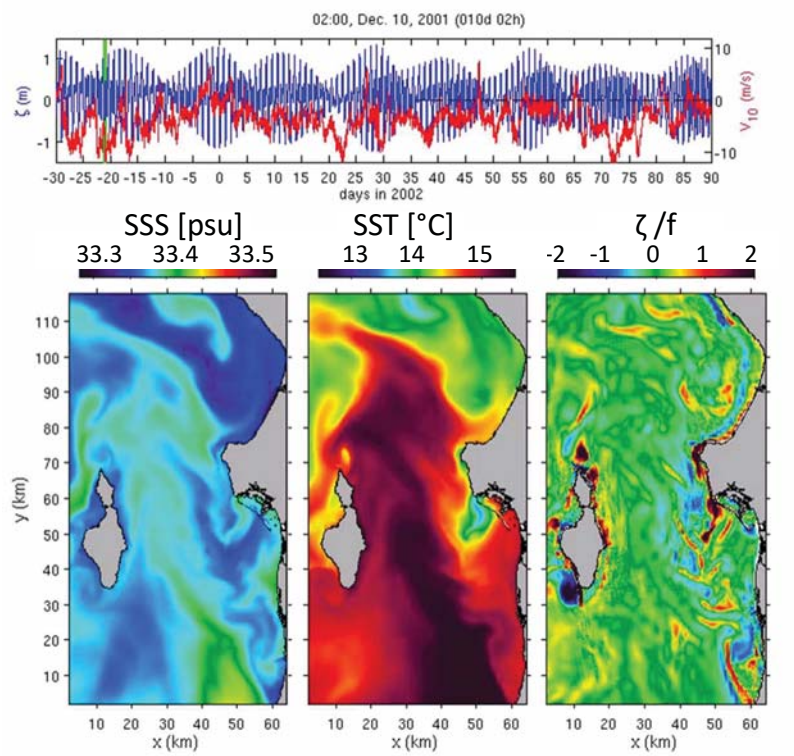
- Common in all oceans
- Length scales
  10 m to 10 km
- Ocean energy transport to dissipation
- May sustain up to 50% of global primary production
- High Rossby numbers
  Ro >1
- High vertical velocities
  ~100 m/day



Uchiyama, McWilliams & Shchepetkin (UCLA)

The Submesoscale Experiment

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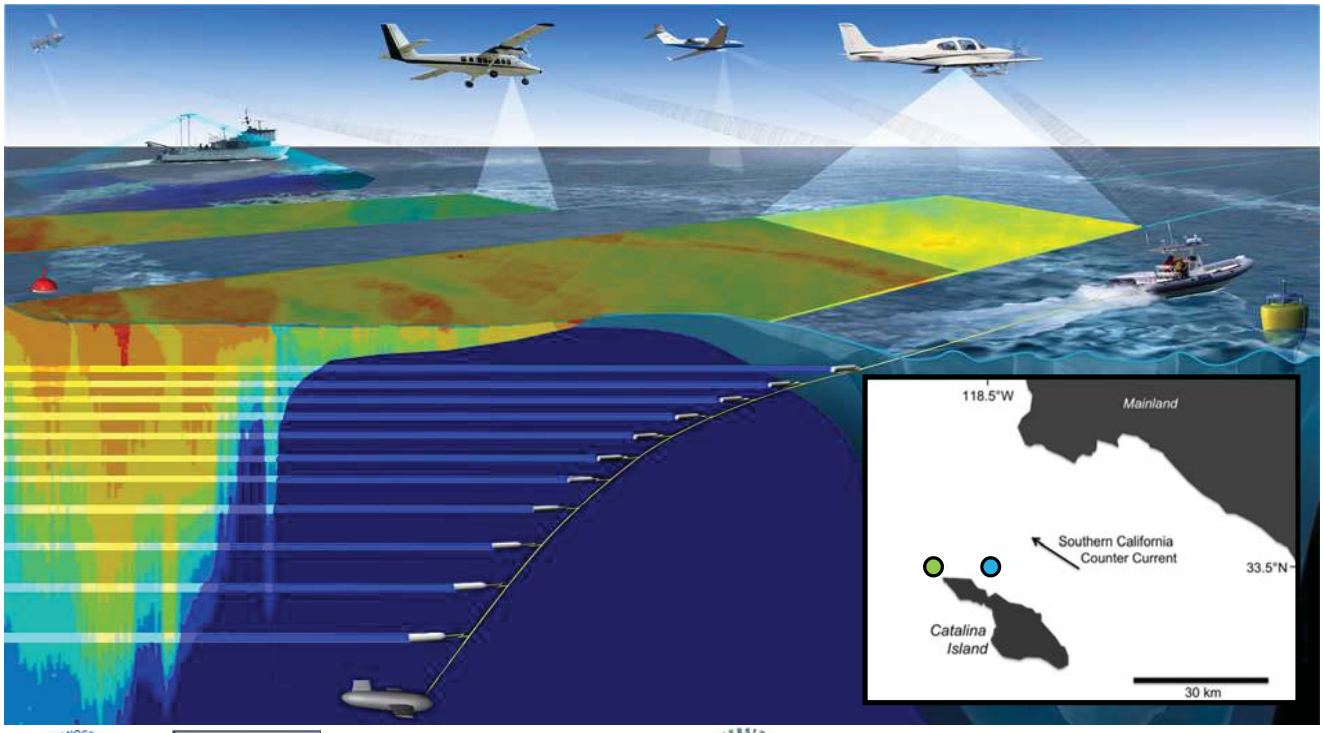

Multi-platform Approach

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Development of multi-platform measurements

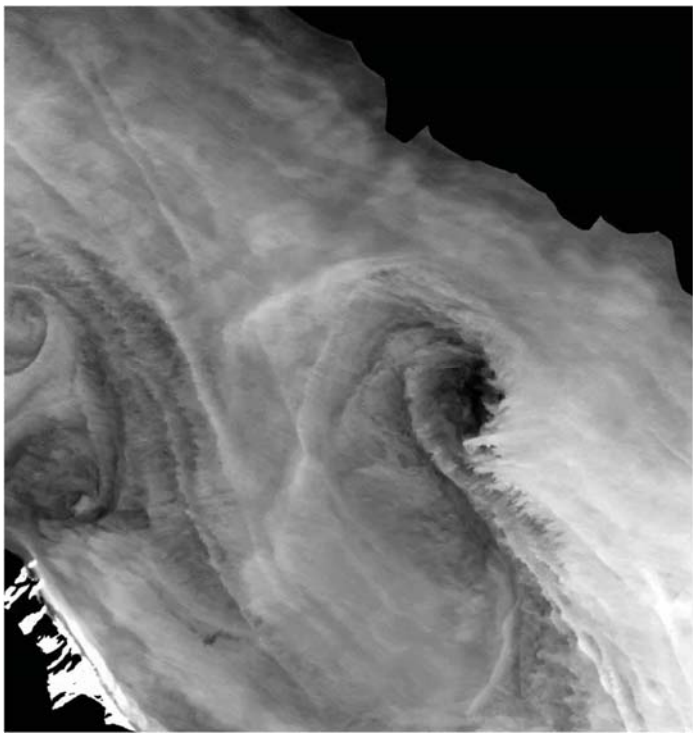
- Planes
- Speed boat, research vessels
- Towed CTD chain
- Radar
- Real-time data exchange

→ Very challenging flow conditions

→ Yielding most detailed observations

<u>Resolution</u>

horizontal/vertical	1-5 m
time	5 min
temperature	0.03°C



Submesoscale Eddies

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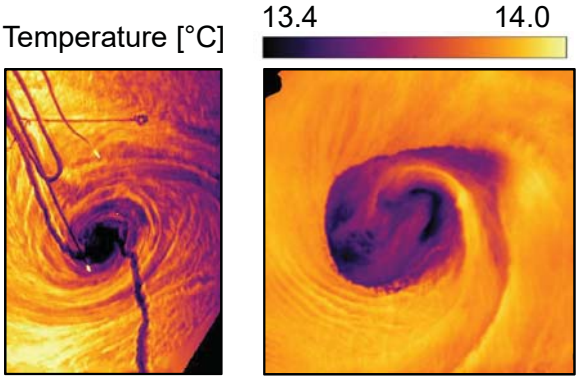
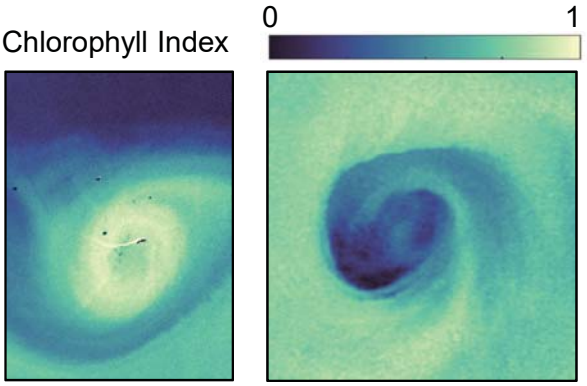
Example: eddies with similar characteristics

- Diameter ~ 1 km
- Cold core $\Delta T \approx 0.5°C$
- Very sharp boundary 1-5 m
- Rossby number 10 - 20



Different chlorophyll response

- High-chlorophyll core:
  Upwelling, confirming model results (growth or advection?)
- Low-chlorophyll core:
  Rapid export mechanism to sub-thermocline depths



Strong Physical-Biological Coupling

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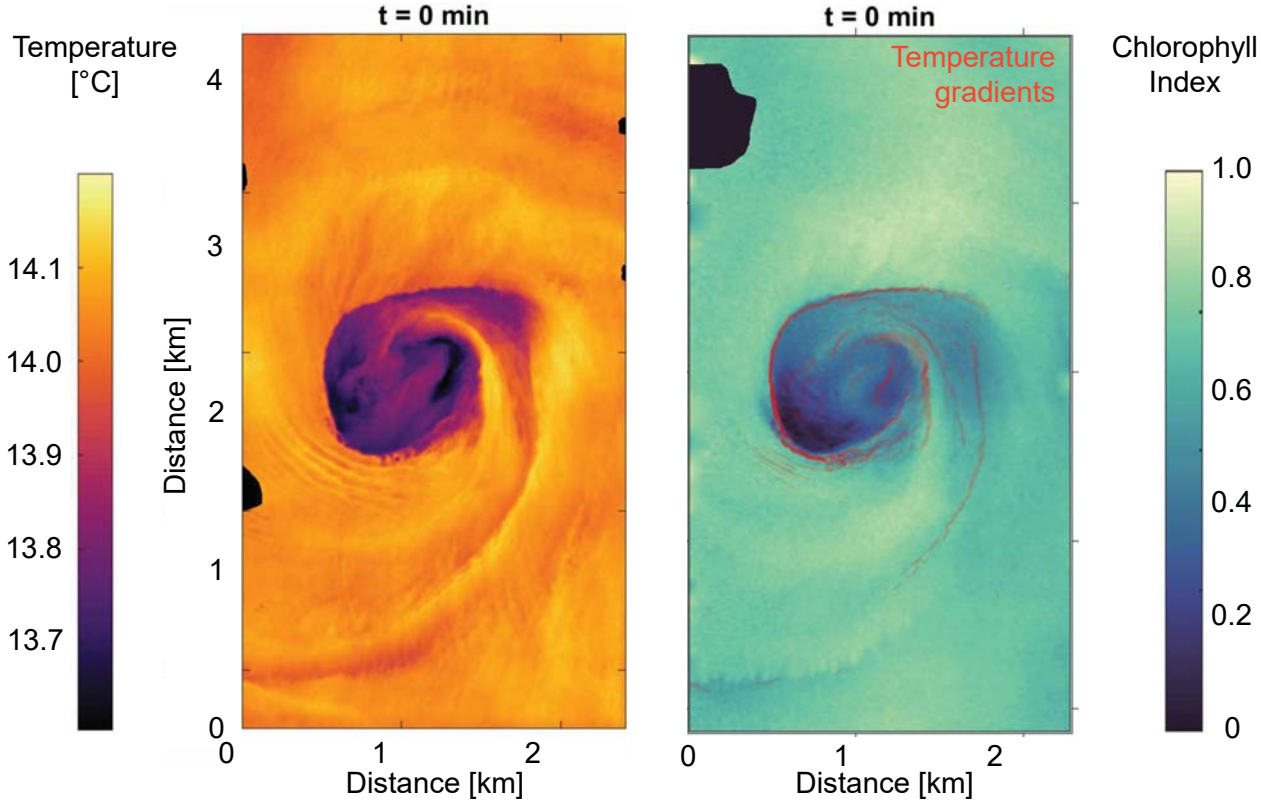

Intense Mixing

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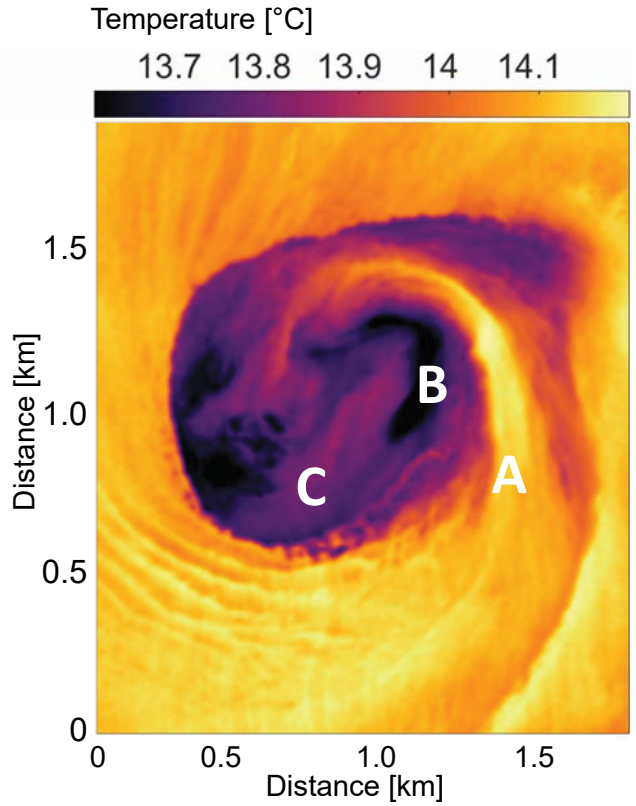

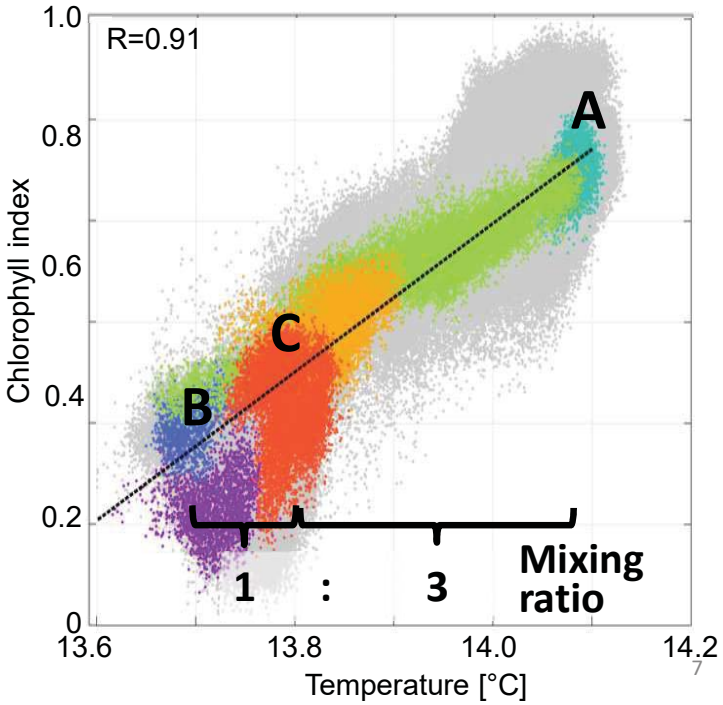

Rotational Flow

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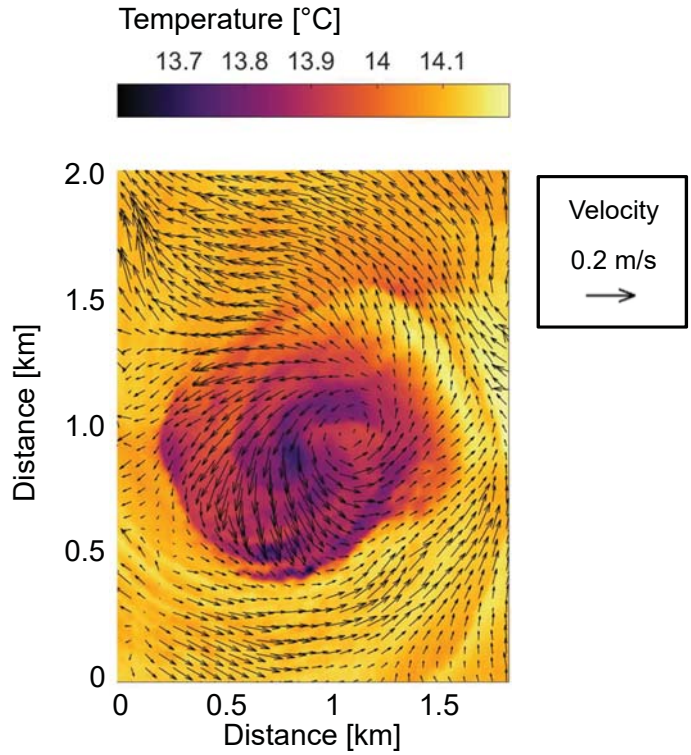

Rotational Flow

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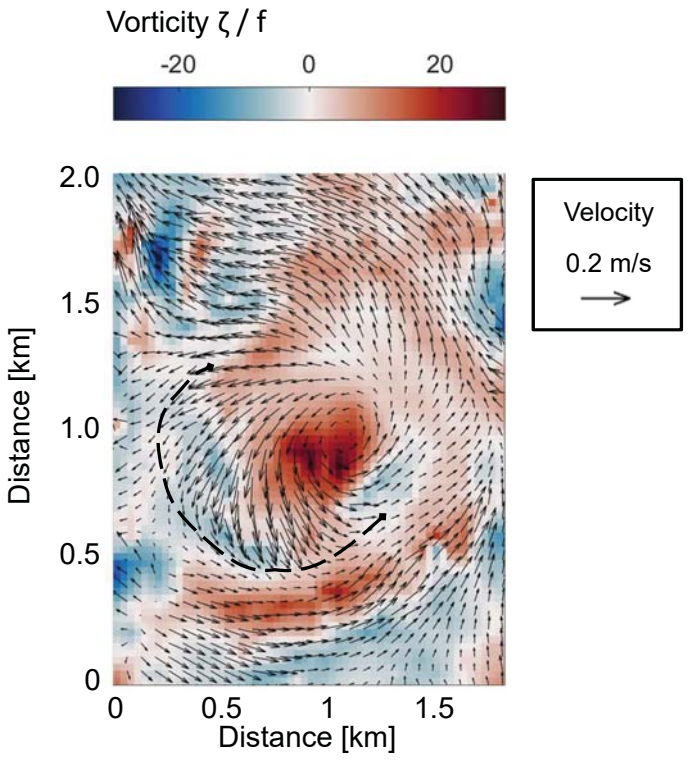

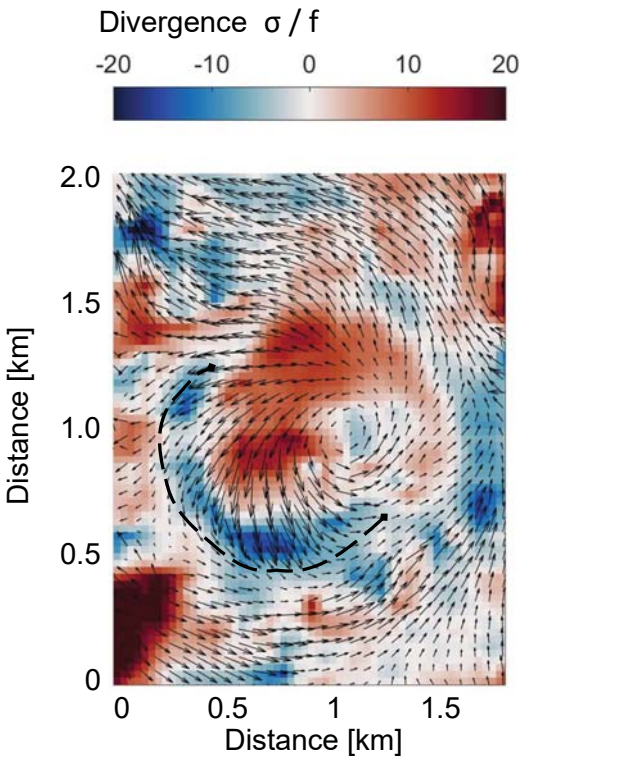

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Rapid Subduction and Export

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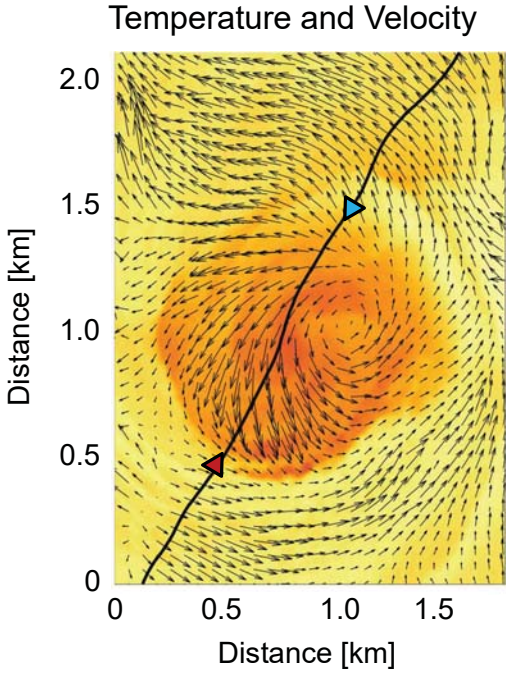
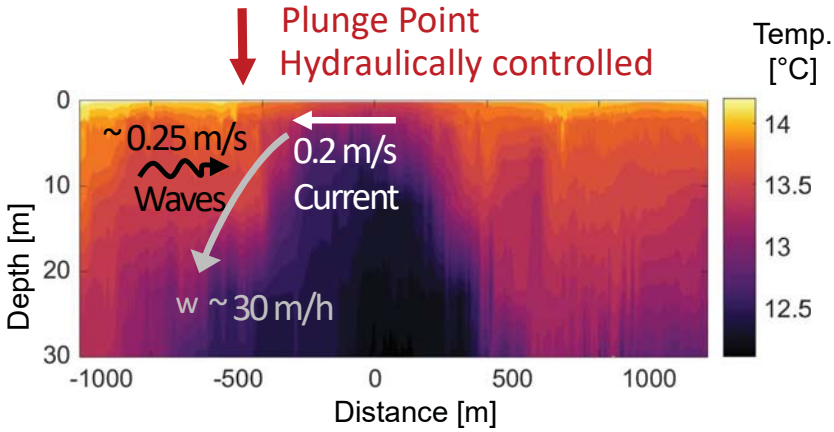
→ Export to sub-thermocline depth ~1 h
Eddy life time ~12 h

$$F_2^2 = \frac{\text{current speed}}{\text{wave speed}} \sim 0.8$$





→ First observations in deep water
Implications for flow adjustment

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Summary and Outlook

Most-detailed observations of submesoscale processes to date show

- Extremely dynamic flow (Ro ≈ 20) with intense and rapid mixing
- Strong bio-physical coupling
- Rapid export of phytoplankton to subsurface depth
- Hydraulically controlled flow in deep water observed

- Expedition Clockwork Ocean

- MOSES
  - Cape Verde
  - Deep convection in Golfe du Lion

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