A decade of observations and achievements of the MOOSE observatory in the Northwestern Mediterranean Sea

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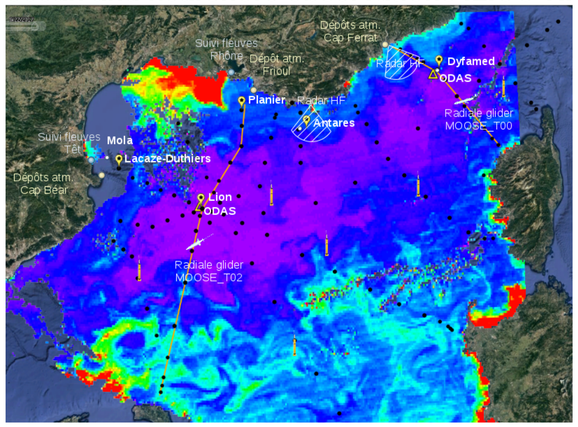
Initiated in 2010, the **Mediterranean Ocean Observing System for the Environment (MOOSE)** integrates a range of platforms to detect and identify **long-term environmental anomalies** in the NW Mediterranean Sea :

- **Fixed observatories :**
  Deep moorings from EMSO-France : LION, DYFAMED, ALBATROSS
  Meteorological buoys : LION, AZUR
  Canyons moorings : PLANIER, LACAZE
  HF Radars : 2 sites off Toulon and Nice
  Atm. deposition : Cap Béar, Frioul, cap Ferrat
  River monitoring : Rhône and Têt
- **Repeated oceanographic cruises :**
  yearly basin-scale : MOOSE-GE
  monthly profiles : DYF., ANTARES, MOLA
- **Autonomous platforms :**
  Gliders (two endurance lines)
  Argo profiling floats from EURO-ARGO

The MOOSE network, part of the French Research Infrastructure (RI) for coastal ocean and nearshore observations ILICO-RI

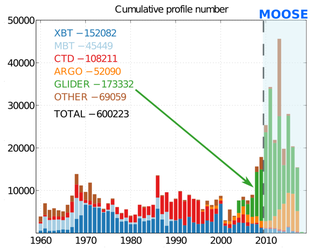


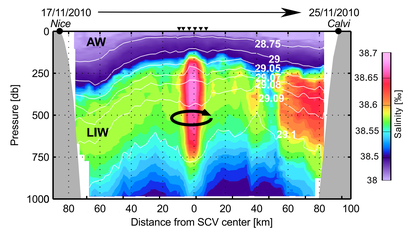
Learn more about ILICO-RI

Cocquempot, et al (2019). *Coastal ocean and nearshore observation: A French case study.* Frontiers in Marine Science.

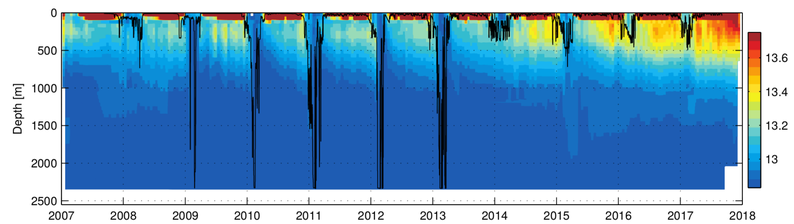
WP1 : Water mass properties and regional circulation

MOOSE gliders = major source of TS profiles in the region





Major breakthroughs about **coherent eddies** *(Bosse et al 2015, 2016, 2017; Damien et al 2017)*, **deep convection and cascading** *(Durrieu de Madron et al 2013, 2017; Houpert et al 2016; Margirier et al 2017, 2021; Testor et al 2018)* and **submesoscale** *(Bosse et al, 2021)*.



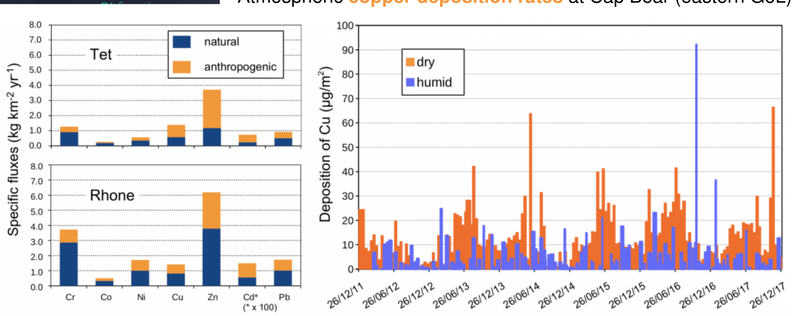
Temperature measurement at the LION mooring site. (Margirier, et al (2021), Scientific Reports)

- **Long-term monitoring of deep convection** in the NW Mediterranean : **Abrupt warming** of intermediate waters linked to a **shift winter convection**.
- Characterization of the **general circulation** (mean transport and variability of the Northern Current) : comparison with satellite *(Carret et al, 2019)*.

WP2 : Climate and anthropogenic impacts from river inputs and atmospheric depositions

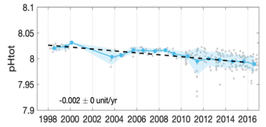
← Satellite image of the **Rhone river plume** during a flooding event.

Atmospheric **copper deposition rates** at Cap Béar (eastern GoL) ↓



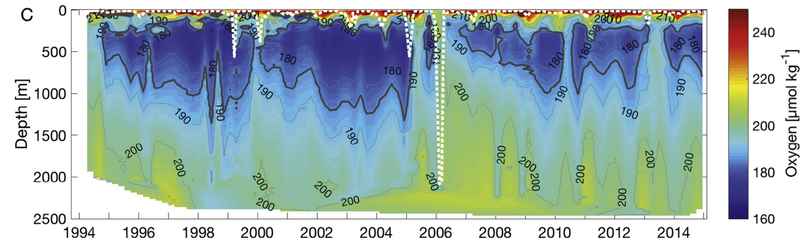
- First quantification of the **long-term evolution of nutrient inputs** from Têt and Rhône river water discharges of natural and anthropogenic origin. *(Dumas et al 2015)*

WP3 : Marine biogeochemical cycles and acidification



Evolution of pH in the Ligurian Sea. (Coppola et al, 2020)

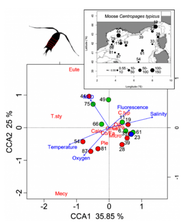
- Quantification of the **acidification trend** of the NW Mediterranean, the increase of the associated carbon sink and set up a **carbon audit** of the NW Mediterranean *(WP7, EuroSea H2020 project)*.



Monthly CTD stations @ DYFAMED **monitoring dissolved oxygen since 1994**. *(Coppola et al 2018)*

- Observation of **long-term oxygen minimum variability** at intermediate depth sensitive to vertical mixing and biological activity
- Development of a method to infer biogeochemical variables based on temperature, salinity, and oxygen using **new deep learning techniques** *(e.g. CANYON-MED; Fourrier et al., 2020)*.

WP4 : Biological communities and biodiversity



- **Long-term monitoring of zoo and phytoplankton communities** (nets and DNA metabarcoding).
- Deep convection region is an area of both enhanced energy transfer to higher trophic levels and organic matter export in the NW Mediterranean Sea. *(Donoso et al, 2017)*
- **Marine mammals monitoring** during MOOSE-GE cruises and by autonomous platforms. *(Cauchy et al, 2020)*

Data Management

Once the data are qualified, they are **distributed to the public** through Coriolis (http://www.coriolis.eu.org) in near real time when possible, and in delayed mode on the Sea Scientific Open Data Edition (SEANOE) repository (https://www.moose-network.fr/fr/doi-moose-2/). Data from MOOSE are available via the ODATIS ocean and coastal data cluster of the French DATA TERRA RI *(Schmidt et al., 2020)*.

Perspectives

MOOSE is now a **model of integrated regional observing system** within the Global Ocean Observing System (GOOS https://www.goosocean.org/) and contributes to its components (Go-Ship, OceanGliders, OceanSites, Argo). MOOSE aims also contributes to **coordination of observational activities at the European level** (Euro-GOOS, MONGOOS, MSFD) and is supported by National/European Research Infrastructures and projects (Flotte Océanographique Française, IR-ILICO, IR-OHIS, EMSO ERIC, EuroArgo ERIC, H2020 EuroSea, H2020 GROOMII, H2020 JERICO-RI).