



MERMeX: « Marine Ecosystems Response in the Mediterranean Experiment »

Initiative for an experimental project on the response of Mediterranean Ecosystems to climate change and anthropogenic pressure

This project belongs to the CNRS/INSU 'Mediterranean project'

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(<https://mermex.com.univ-mrs.fr/>)

MerMex group in 2009

MERMEX currently includes more than 15 french laboratories and more than 500 scientists

MERMEX will be the main french oceanographic programme for 2012-2020

It will be supported by France (CNRS, INSU, IFREMER, IRD, Universities)

One MERMEX duty is to seek for collaborations in UE and country from southern Med. Sea

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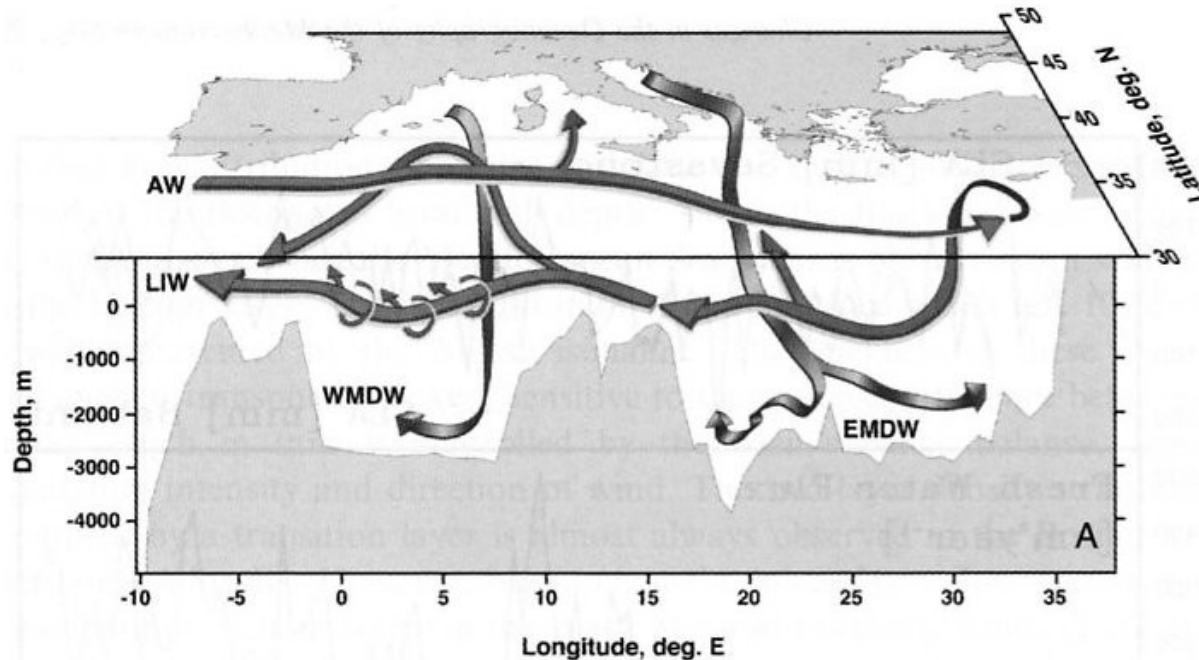
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MEDITERRANEAN SPECIFICITIES

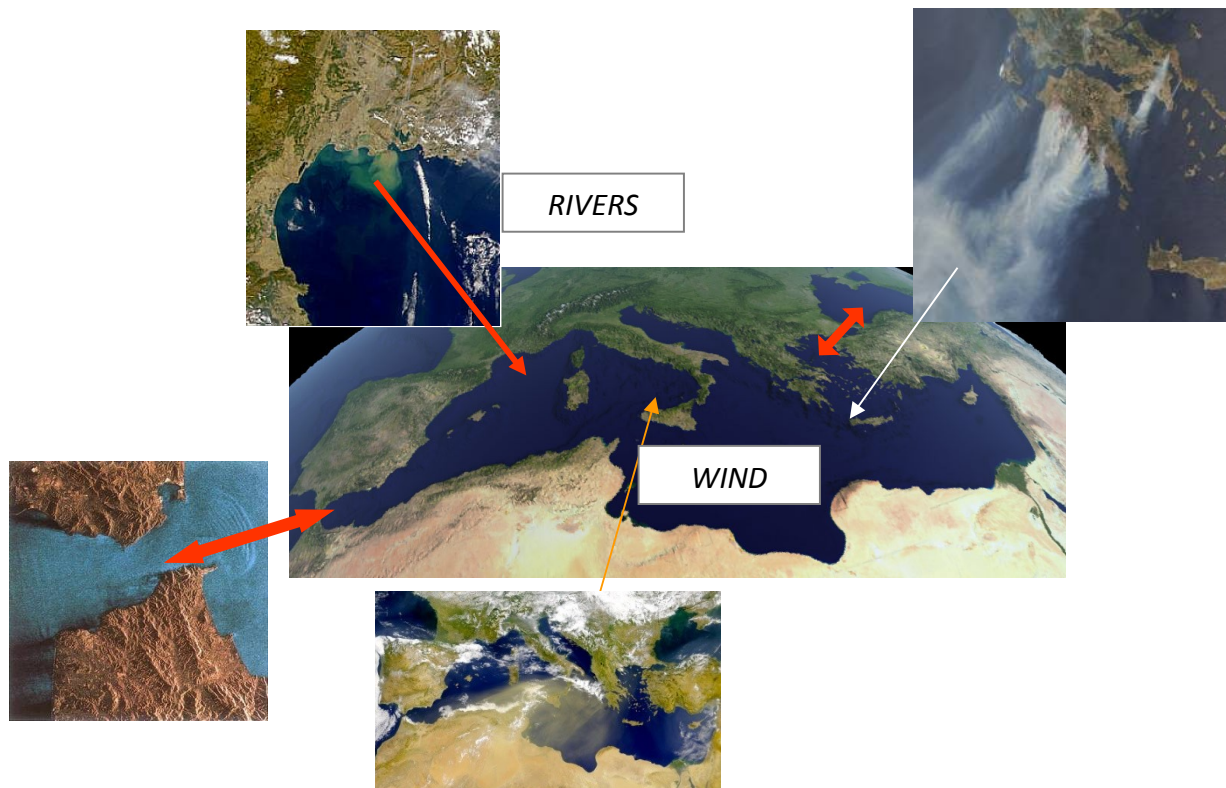
Important physical features:

- *short residence time (<100ans); cascading; dense water formation etc. and peculiarity such as existence of EMT (an abrupt change in deep circulation in Eastern Med in the 80's...etc.*
- *evaporation basin: 0.5 – 1 m/an*
- *thermo-haline circulation : "Conveyor Belt" analogous to global ocean*
- *chemical characteristics very different between Atlantic and Med.*



MEDITERRANEAN SPECIFICITIES

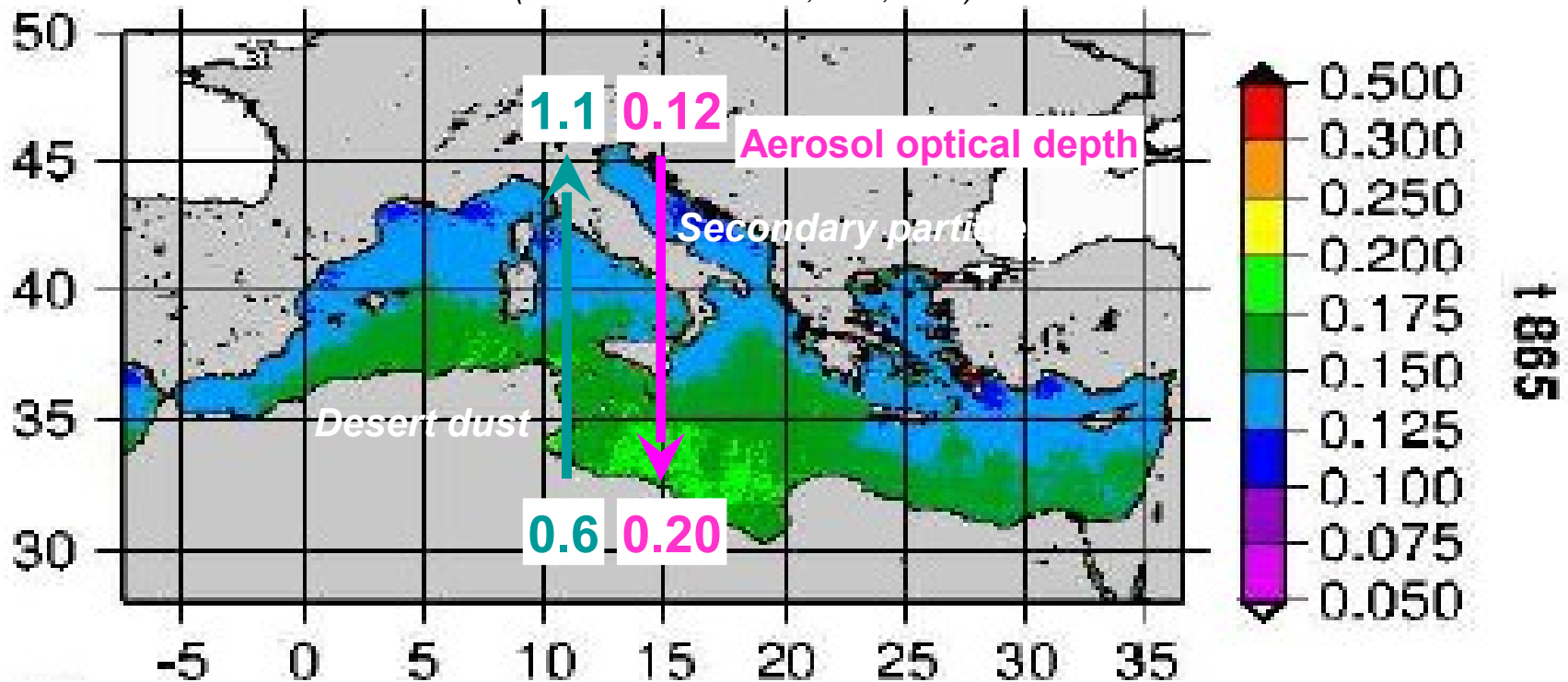
*Strong links between 3 main domains: OCEAN/ ATMOSPHERE/CONTINENT
→ Proximity and importance of inputs and exchanges*



The Mediterranean atmosphere (info from Charmex prog.)

- ⇒ Intense solar radiation
- ⇒ Aerosol climatologies at the basin scale from Meteorological satellites
(Moulin et al., JGR, 1998)

1998-2003 average of SeaWiFS-derived aerosol optical depth at 865 nm
(Antoine and Nobileau, JGR, 2006)



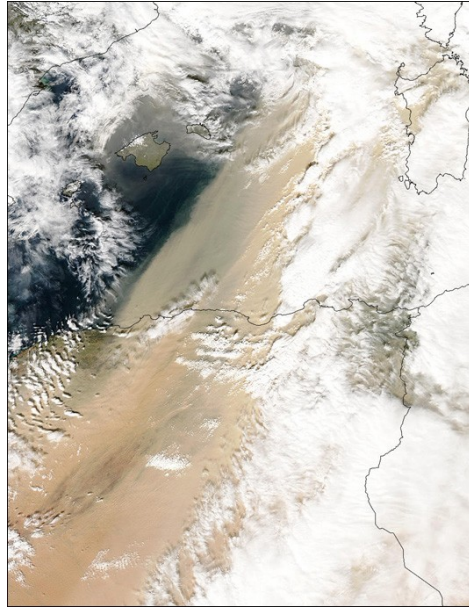
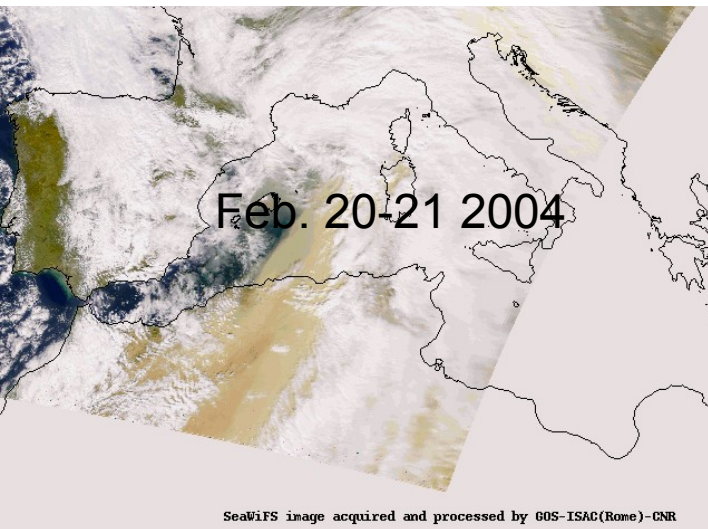
- ⇒ African dust is dominant

Occurrence of extremes atmospheric events in the Med Sea

2 examples

Saharan Dust event

ex. event in western Med.: dust input to the surface



Biomass burning

ex. in Greece in August 2007:
several weeks of emissions and
inputs to the surface waters



According to 2007 IPCC report, these events are expected to increase: what will be the **impact in the biogeochemistry of the Med Sea?**

Recently, the occurrence of Saharan events with extremely strong fluxes ($>20 \text{ t.km}^{-2} \cdot \text{event}^{-1}$) was significantly higher than in the 90's: **how those high inputs of new phosphorus will impact New Production, in particular from diazotrophs?**

Aerosols may impact the solar radiation budget

Aerosol may significantly decrease the solar radiation at the Med. Sea surface

Aerosol pollution

$\Delta F_{BOA} \sim -34 \text{ W m}^{-2}$

(Mallet et al., Atmos. Env., 2006)

~~Aerosol pollution~~

Aerosol pollution

$\Delta F_{BOA} \sim -15 \text{ W m}^{-2}$

(Tafuro et al., JGR, 2007)

Aged biomass burning

$\Delta F_{BOA} \sim -64 \text{ W m}^{-2}$

(Formenti et al., JGR, 2002)

$\Delta F_{BOA} \sim -28 \text{ W m}^{-2}$

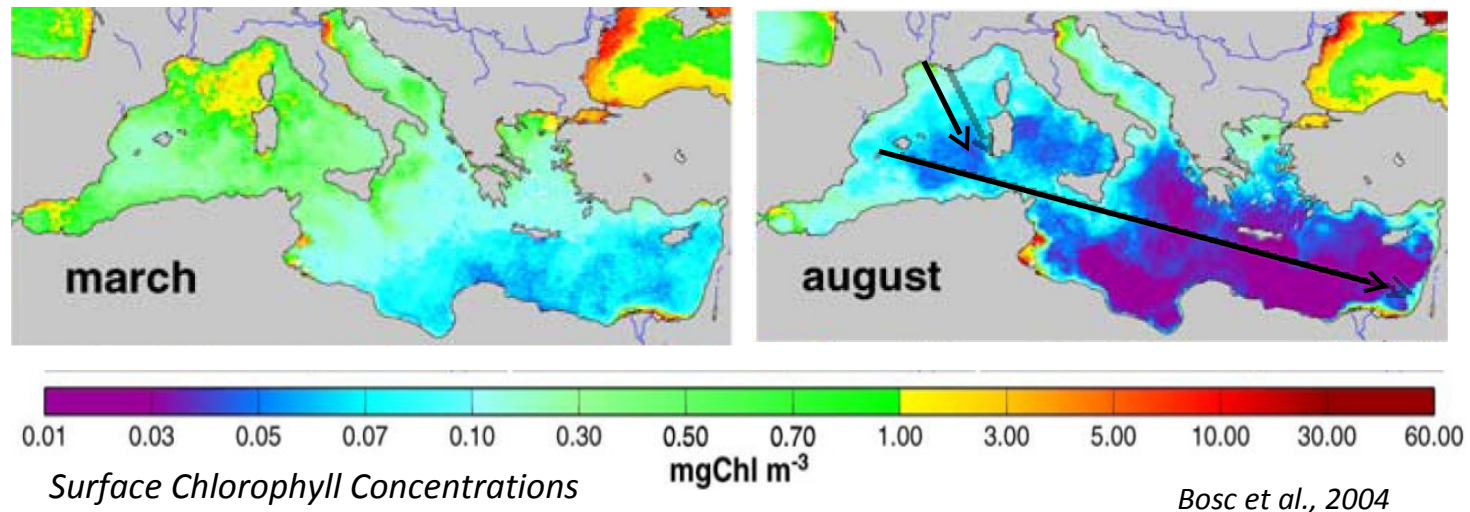
(Horvath et al., JGR, 2002)

$-15 < \text{diurnal } \Delta F_{BOA} < -64 \text{ W m}^{-2}$

MEDITERRANEAN SPECIFICITIES

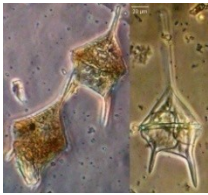
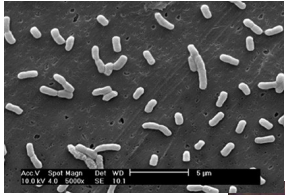
An Oligotrophic Sea

- *Highly stratified, strong intra-annual variability*
- *Strong trophic gradient (coastal zone → open-sea; West → East (very oligotrophic in Eastern basin))*
- *Phytoplankton and bacteria are mainly limited by phosphorus.*
- *N and P budget extremely badly constrained.*
- *Role of diazotrophs organisms in N and P budget still unknown.*



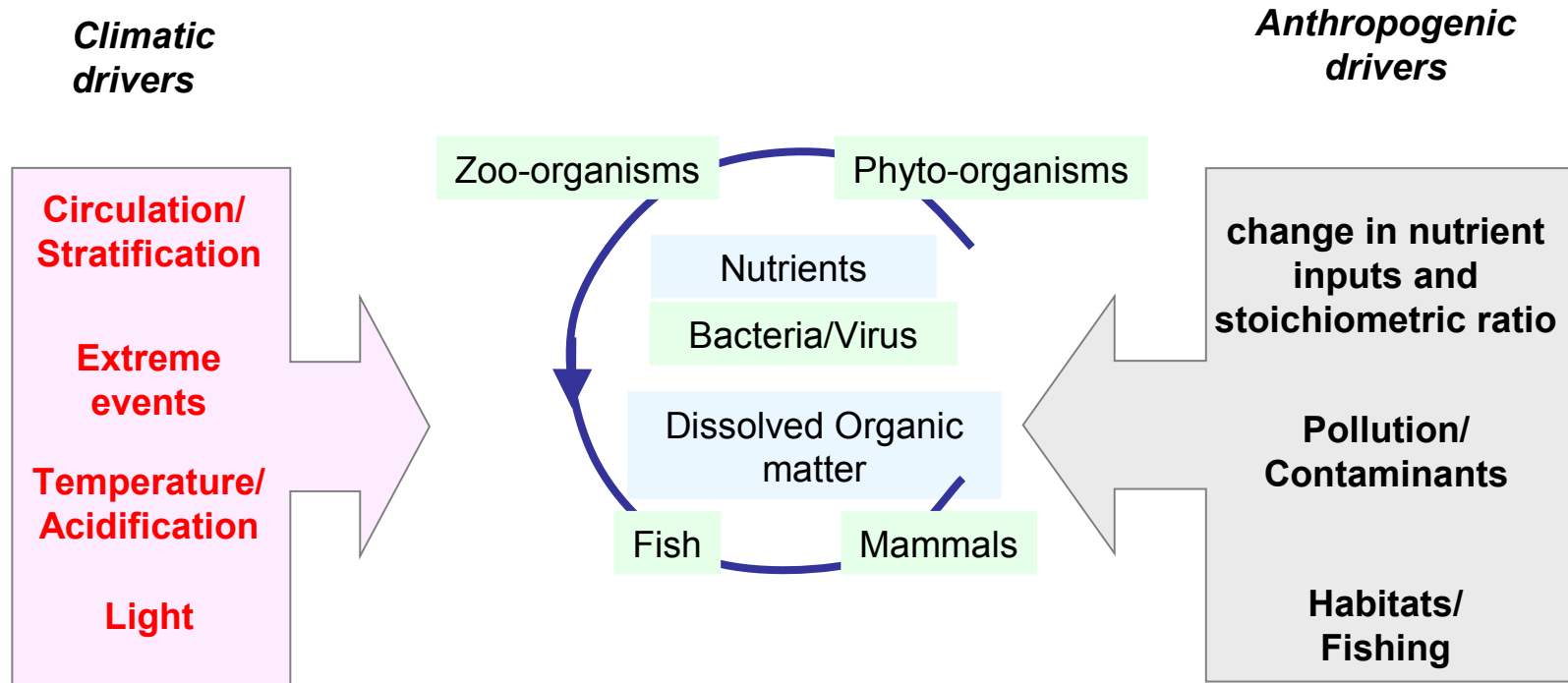
Med Sea = 0.7% of global Ocean. However includes more than 15% of biodiversity in coastal and open sea. Lack of knowledge.

Major area for reproduction, migration of species



Recent introduction of thermophilic species that induce ecological changes.





Main scientific questions concern impacts of physical, chemical and economical impact on biodiversity and on ecosystems functioning for the 21st century (according to different scenarios)

- Impact of oceanic stratification and convection on carbon export and on meso-and bathypelagic mineralization), on transfer of contaminants, mixing, O₂ availability? (Hymex/Mermex)
- Acidification impacts on food web including production and mineralization, biodiversity, fishing ?
- Impact of temperature increase on food web, biodiversity, fishing ?
- Extreme events vs more continuous fluxes? anthropogenic contaminants [(organic/inorganic) and pathogens] and impacts on the food web including small organisms and fishing? (Hymex/Mermex)
- Occurrence and impact of River flood in coastal ecosystems biogeochemistry?
- Importance of dust event (including natural and anthropogenic) on productivity ? on mineralization ? Diming and light availability for marine photothythesis, photochemistry (Charmex/Mermex)
- Current straits exchanges and future modifications on nutrients and ood web?

- To study marine waters from the coast to open Ocean and by considering the Med Sea-atmosphere interface
- To have an 'end to end' approach
- To combine: experiments, observations, oceanographic cruises and modeling.
- First study area : North western Mediterranean Sea.
- To establish Mediterranean partnership for a global study of the Med Sea

Long Observation Periods (LOP) : Monitoring of the marine system at some key stations through the MOOSE programme:

Selected Rivers: At least Rhône River

Straits Gibraltar? Sicilian Strait, Bosphorus?

Coastal Sea : Gulf of Lion, Spanish, Italian, Greek, Turkish Coasts

Areas of deep water formation

Typical remote and anthropogenic areas

Collaborations between Mermex, Charmex

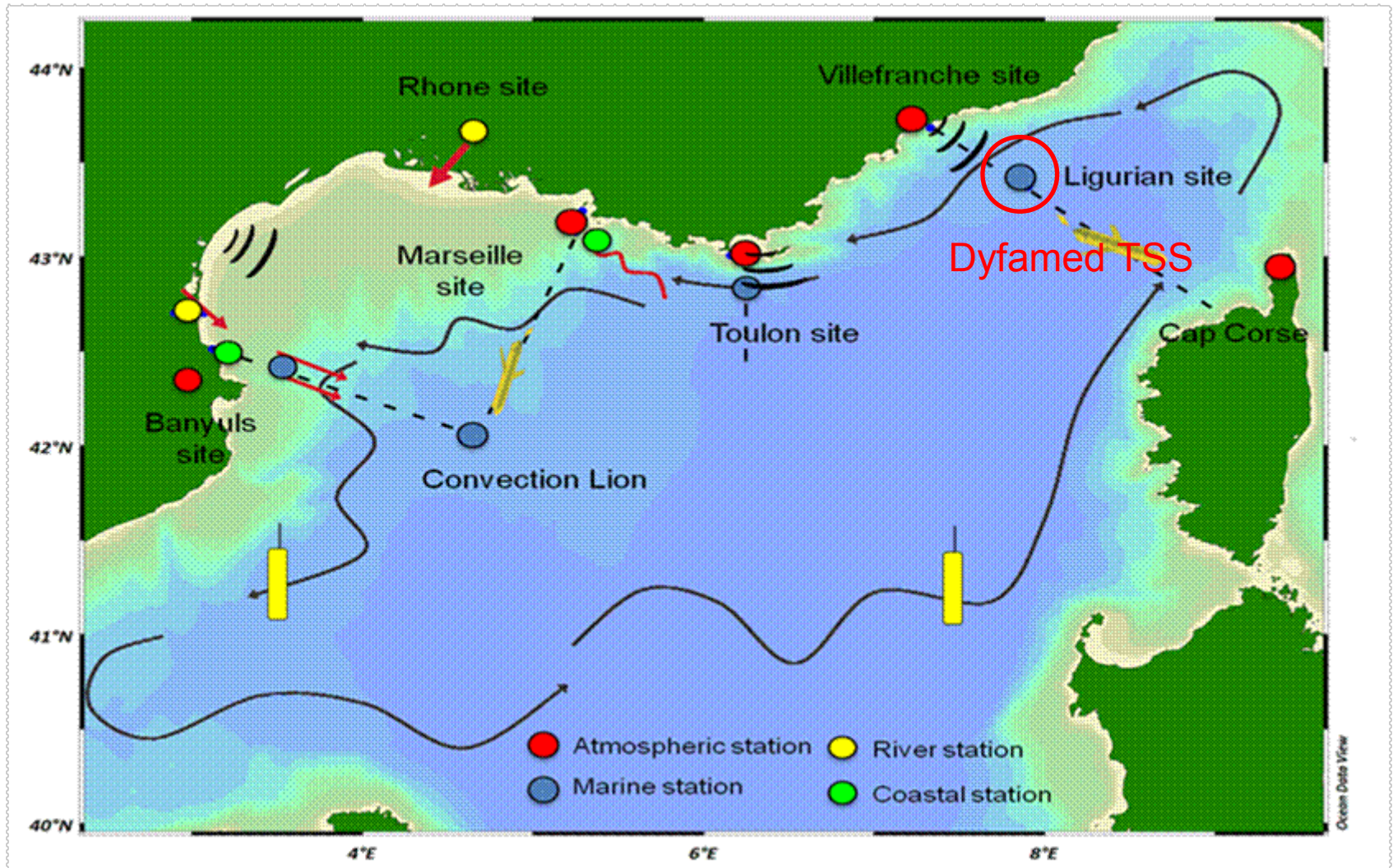
Short Observation Periods (SOP): Impact of winter convection on biogeochemistry (nutrient, carbon transfer, remineralization, oxygen distribution. Common cruises in 2012-2013 (Hymex, Mermex, Charmex) in the Gulf of Lions

Enhanced Observation Periods (EOP): Impact of flood on biogeochemistry in coastal areas.....: RV, Mooring, Gliders, AUVs

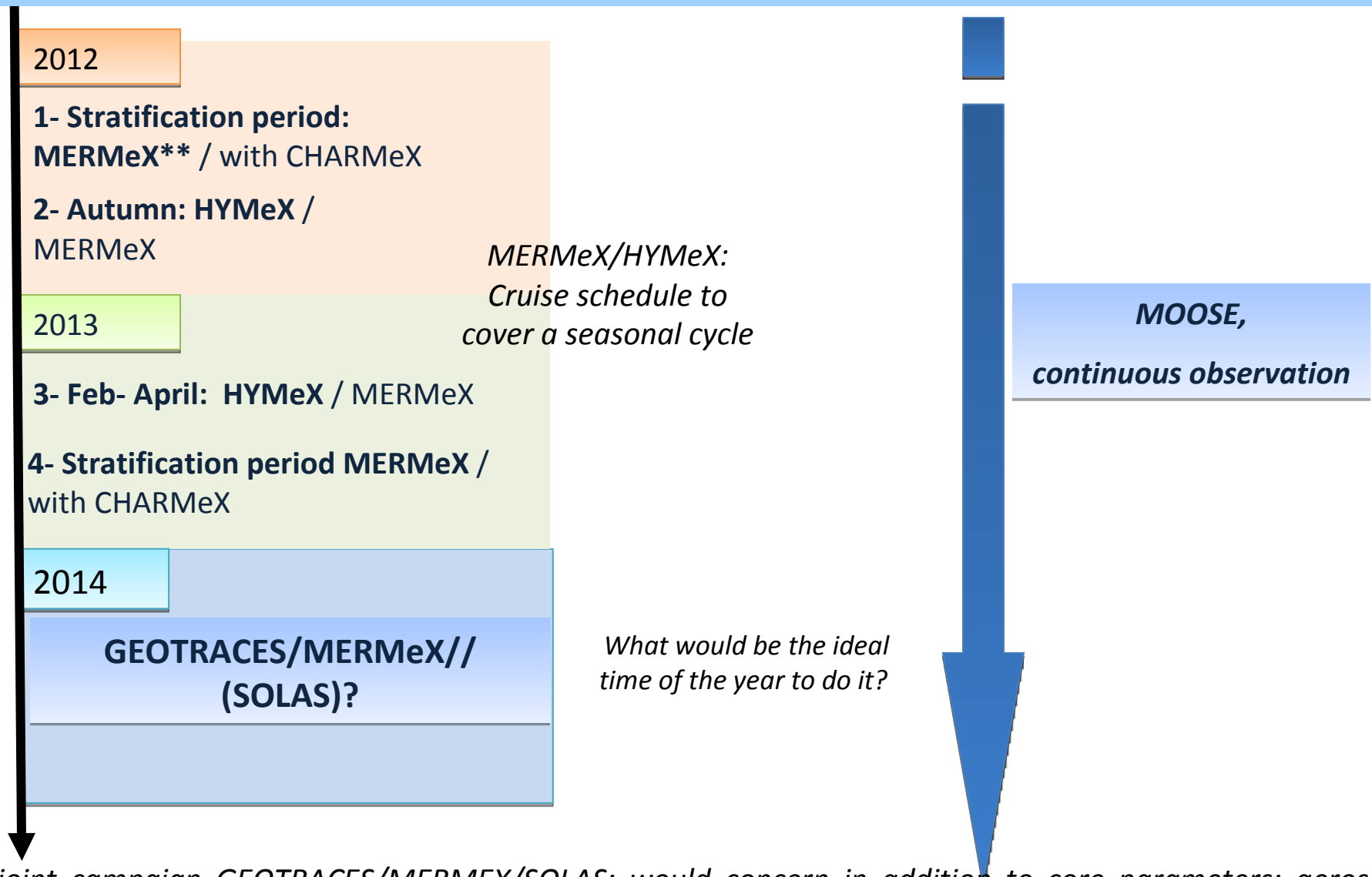
Modeling, to predict Med Sea ecosystem response according to different IPCC scenarios

+ Laboratory Experimentations

MOOSE : a network of fixed and mobile platforms in the NW Med Sea and strong links with EU countries: W Med Sea process study?



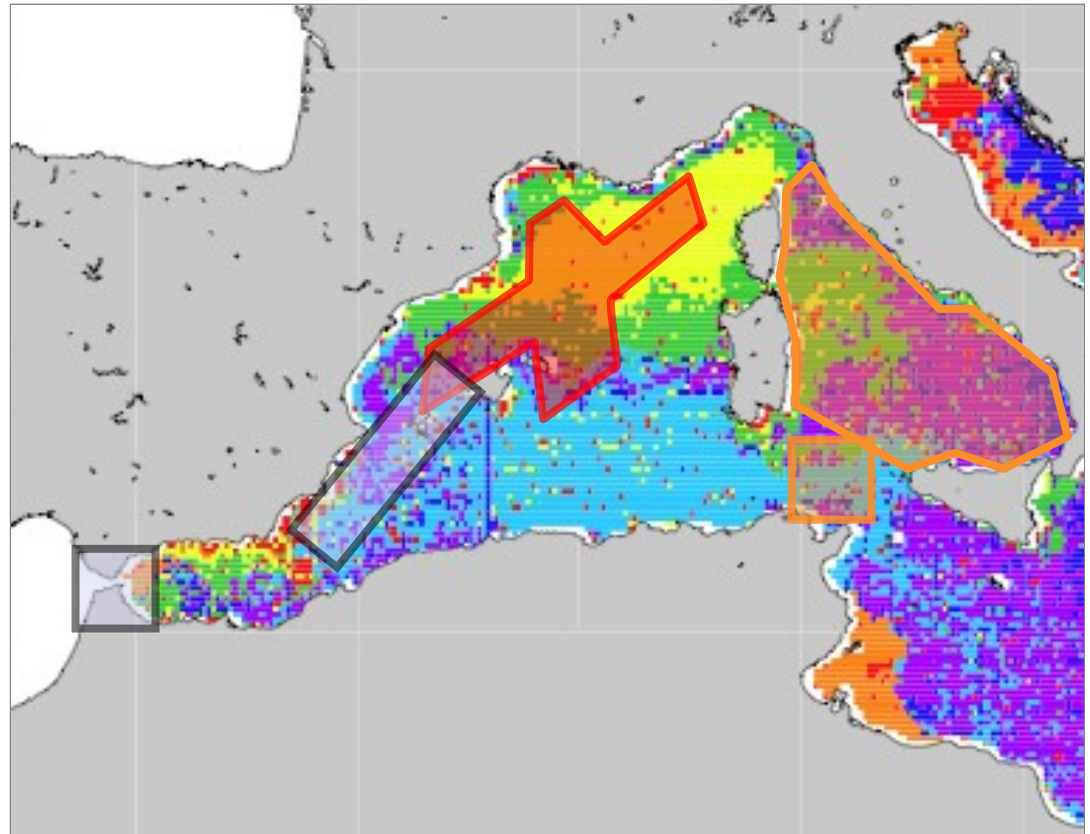
MERMeX: SOP strategy and possible schedule for a joint cruise



A joint campaign GEOTRACES/MERMEX/SOLAS: would concern in addition to core parameters: aerosols, biogases, processes studies: there is thus a need for a minimum bio parameters - nutrients, Pigments, Cytometry, Biodiversity (molecular biology), $O_2/pCO_2/C_T/A_T$ DOM/POM,

NW Med Sea

We seek collaborations with others Med Programmes (Observation, cruises, models)



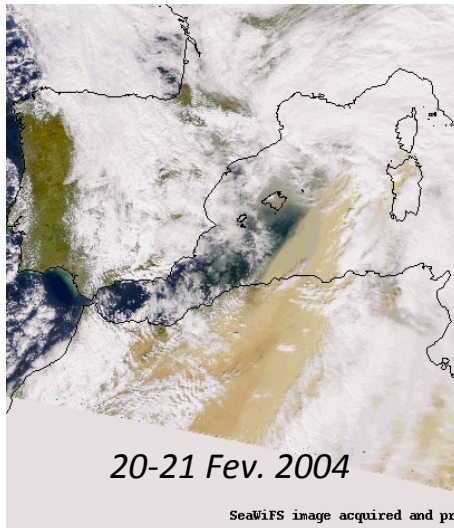
MEDITERRANEAN SPECIFICITIES

Importance of Extremes events

Their role in Mediterranean budget (chemical elements, particulate material etc.)?

Saharan Event

Ex. 50 tons of dust/km²/2days



Recently the frequency of extremes saharan event has increased (flux > 20 t.km²/event)

Heat wave → Biomass burning (ex. fires in Greece in august 2007)



Pyrogenic inputs are predicted to increase (related to increase in heat wave frequency)

Flood, some large rivers (Rhône, Po etc.) and many smaller rivers (all around the basin), dry most of the time with violent events

ex. Paillon, (french riviera)



sept. 2000

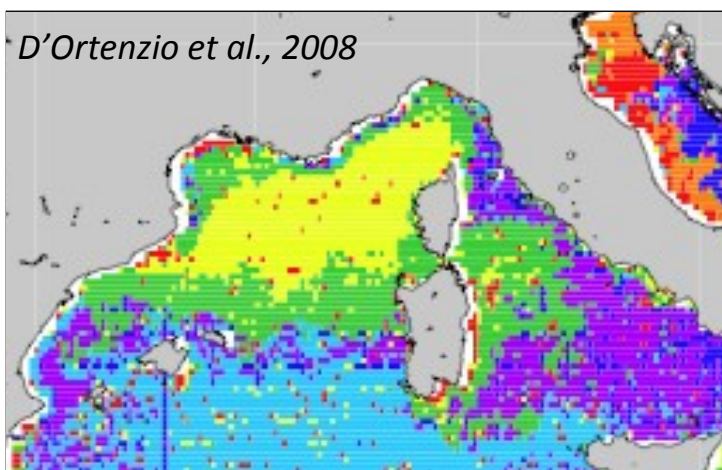


Few days later

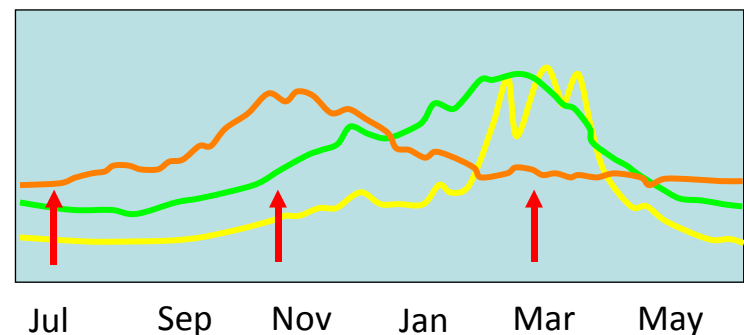


La Méditerranée Nord-Occidentale → avantages

- Comporte tous les types de forçage que nous avons identifiés comme clefs dans la question centrale du projet.
- Zone la mieux documentée en particulier par les travaux de la communauté française que ce soit à travers des projets ponctuels ou des sites d'observation implantés depuis plusieurs années.
- Plusieurs écorégions typiques de toutes la Méditerranée y sont représentées.
- Les actions connexes HYMEX et CHARMEX ont également décidé de focaliser sur cette zone d'étude leurs activités au démarrage du Chantier et la mise en place de cette synergie est une chance pour l'ensemble du Chantier.



régionalisation obtenue à partir de l'étude de 10 années de données de Chl de surface de SeaWiFS:



→ fait apparaître des régions caractérisées par des régimes et des tendances saisonnières identiques

→ nécessité d'étudier les écosystèmes à des moments clefs de l'année

Une stratégie de campagnes pour couvrir un cycle annuel



MERMeX

Les interfaces avec les autres programmes spécifiques du chantier

Chantier Méditerranée

ACTIONS

OBSERVATION

MERMEX
Marine Ecosystems
Response

CHARMEX
Chemistry-Aerosol

HYMEX
Hydrological Cycle

certaines stations
d'observation communes
ont été identifiées afin de
servir les objectifs
communs aux différentes
actions.

Observation 'pérenne' (sites
d'observation communs) +
données existantes

MOOSE

Impact des apports atmosphériques (poussières désertiques, anthropiques ou issues des feux de biomasse) sur la biogéochimie de surface marine via leur dépôt à la surface ou via leur potentiel d'atténuation du rayonnement UV/Visible.

Impact de la formation des eaux denses durant la période hivernale sur la disponibilité des éléments nutritifs, la composition, la qualité et le recyclage de la matière organique en zone mésopélagique et bathypélagique.



Zones d'étude et timing: phase 1 Méditerranée Nord-Occidentale

Long observation periods (LOP) sur 10 years (2010-2020). Stations fixes, mouillages, sorties en bateaux de station et navires côtiers de l'INSU → variabilités saisonnières et interannuelles d'un grand nombre de paramètres biogéochimiques. *France = MOOSE + Internationalisation*

Enhanced observation periods (EOP) de quelques années afin de renforcer en certains sites la LOP avec des périodes d'échantillonnage intensif et de l'instrumentation temporaire. Exemple EOP à l'embouchure du Rhône. *La programmation des EOP n'est pas encore établie et doit être mise en place dans les 6 prochains mois.*

Special observation periods (SOP): = campagnes océanographiques dédiées aux études de processus contrôlant le fonctionnement des écosystèmes. Trois périodes clefs identifiées: (1) période de transition entre la convection hivernale et le bloom printanier (Mars-Avril), (2) période estivale stratifiée et oligotrophe (Juillet-Aout); (3) période automnale de déstratification (septembre-Octobre).

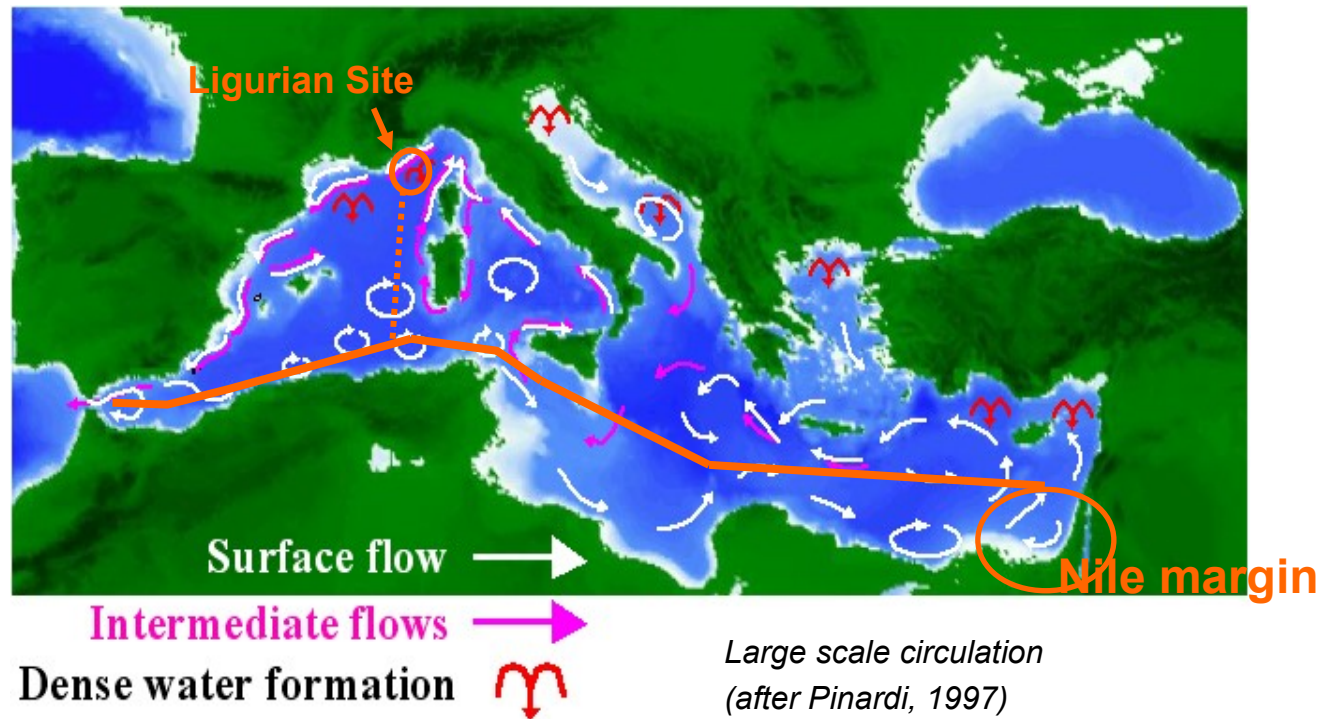
Modélisation. MERMeX propose la mise en place d'un groupe de modèles capables de simuler les évolutions des écosystèmes méditerranéen selon différents scénarii. Ces modèles seront capables (1) de représenter des situations complexes où tous les forçages coexistent et interfèrent et (2) de répondre à un large spectre de questions allant des aspects fonctionnels (par ex. capacité des écosystèmes à séquestrer le carbone) à l'influence des contaminants le long de la chaîne trophique. Ils permettront également une estimation actuelle et future des ressources nutritives de la Mer Méditerranée.

Approaches

Strategy should conciliate **monitoring** along a transect W to E
and **process study** aspects

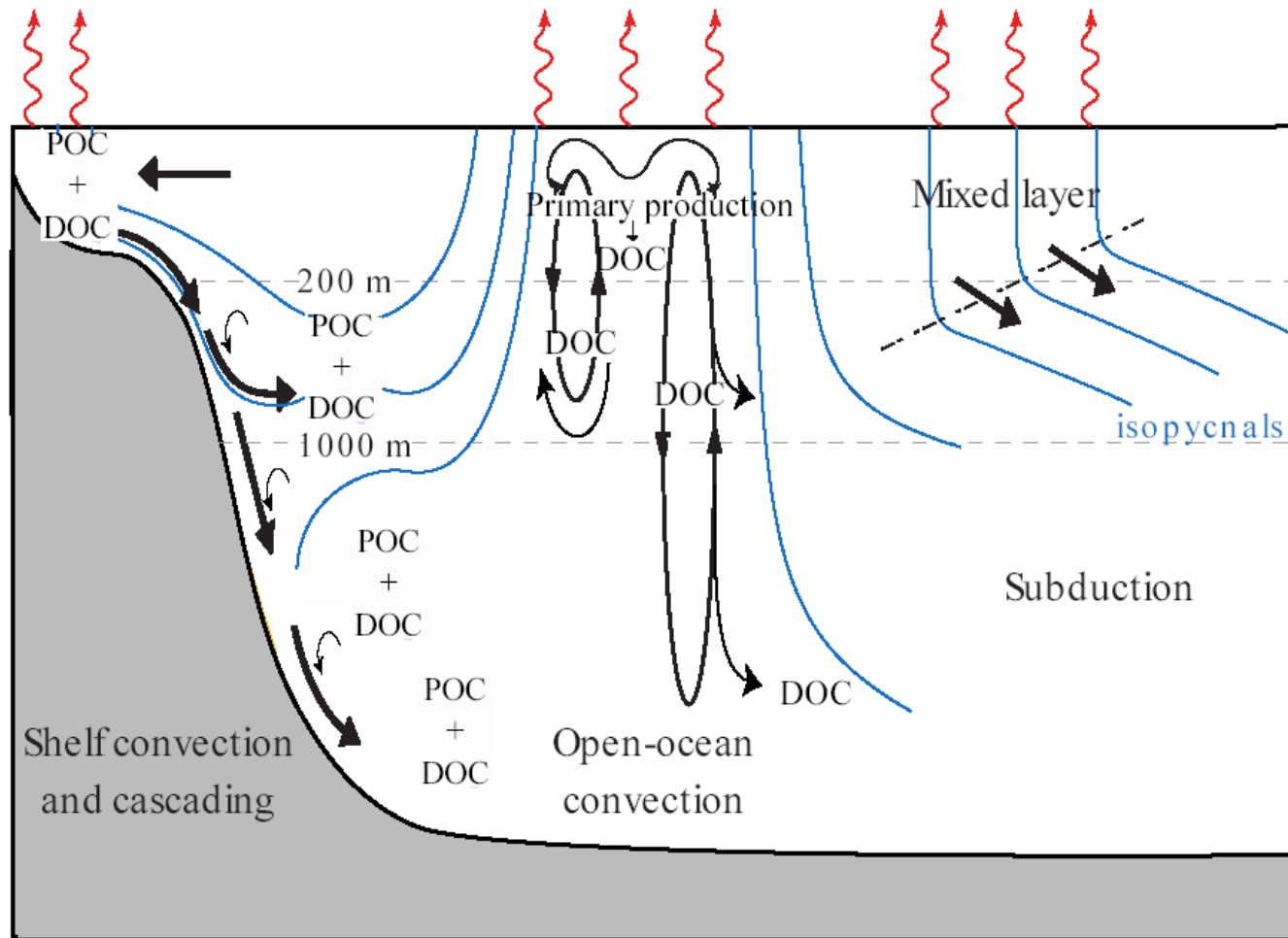
The processes studies could take place at the DYFAMED site: in addition the data acquired at that site as part of the time-series will be necessary to interpret the TEIs measurements acquired along a transect on a short time scale

A transect West to East (to be precisely defined with physicists) will allow to study the different water masses and influence from straits. Process study along the Nile margin required



Impact of winter convection and cascading on organic carbon (DOC+POC) export

Surface buoyancy loss



In this case organic carbon is mineralized in intermediate and deep waters. Then 80% of carbon is transform to CO₂ through bacterial respiration in deep water instead that in surface waters. According to IPCCs scenarios convection may stop in Med Sea.