Joint ICTP-TWAS Workshop on Climate Change in Mediterranean and Caribbean Seas:
Research Experiences and New Scientific Challenges
8 - 11 May 2012
CIIFEN Headquarters, Guayaquil, Ecuador

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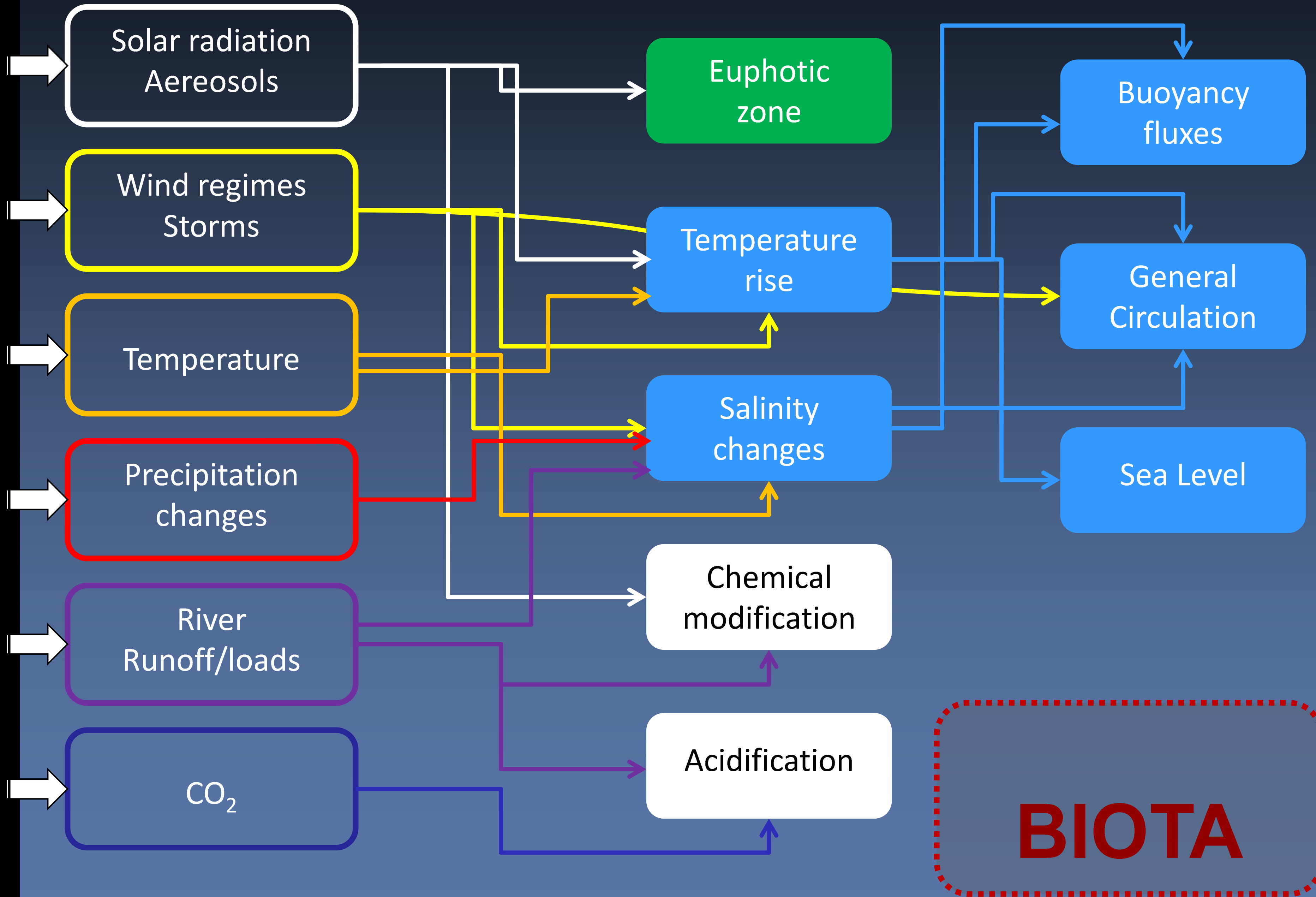
Impact of climatic drivers on Mediterranean biogeochemistry

CIIFEN ICTP twas

OUTLINE

- Climatic Domino Effect
- Temperature effects
- Rivers loads and PP
- Po River system

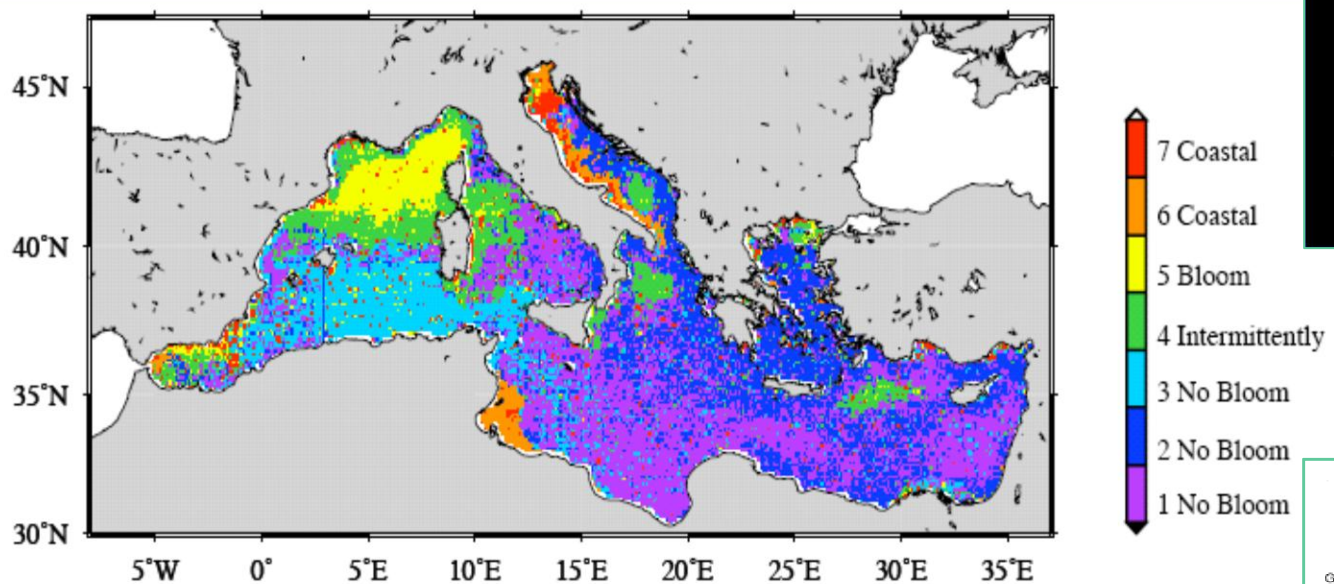
The Domino Effect in Climate Change: the Ocean Case



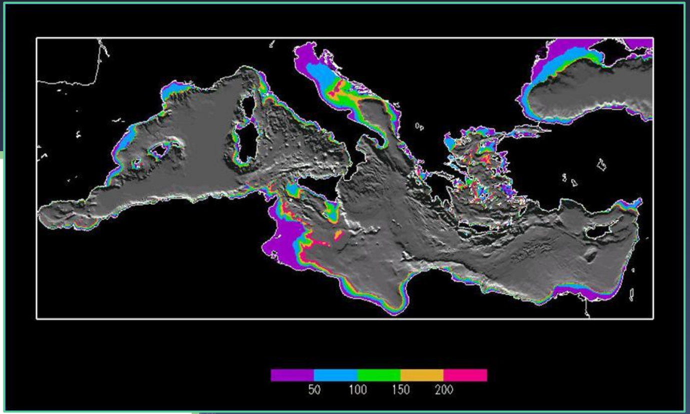
HOW SENSITIVE IS THE MEDITERRANEAN ECOSYSTEM TO CLIMATE CHANGE?

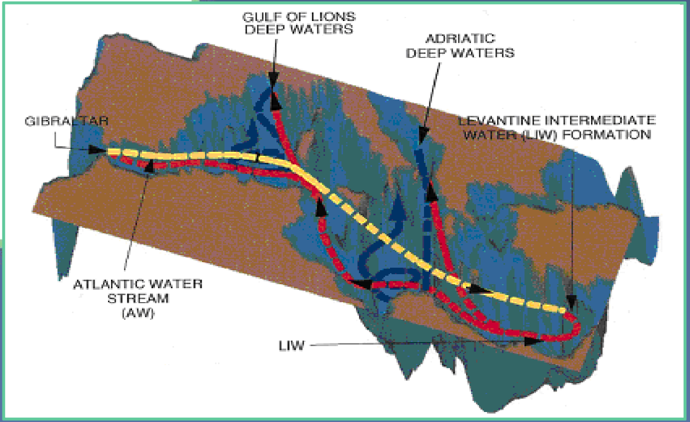
The Mediterranean bioprovinces

Objective classification of chl-a satellite images



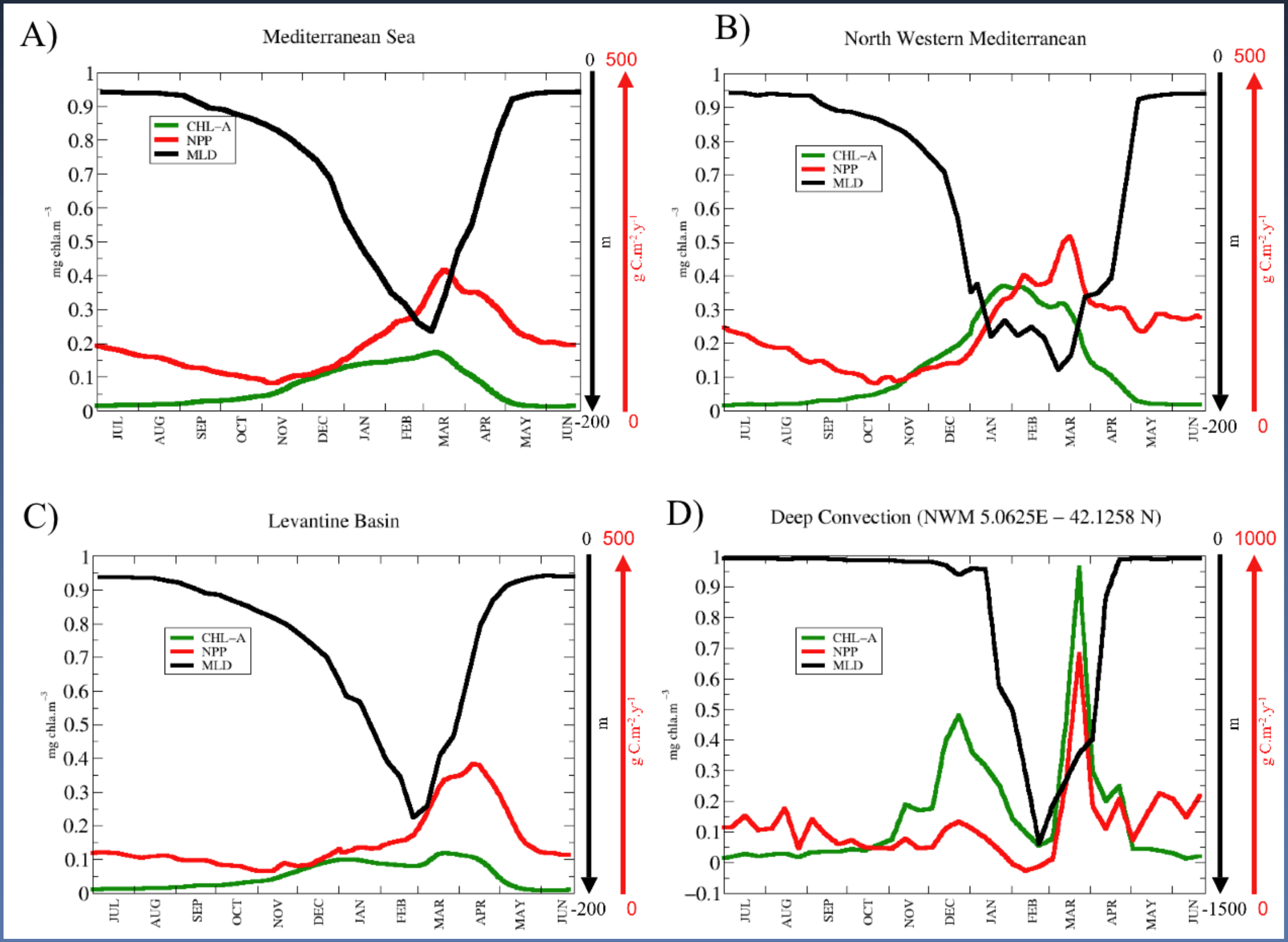
(D'Ortenzio et al., 2008)



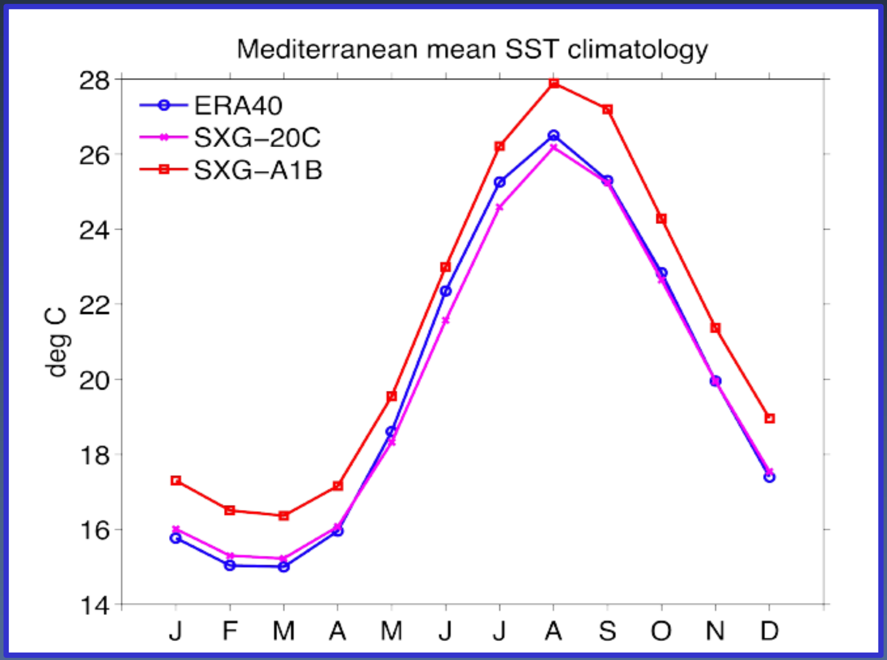


- Mediterranean bioprovinces are obtained by a classification of the Chl-a seasonal cycle
- Classification strongly influenced by basin physiography and dynamical processes
- Strongly interconnected by general circulation processes
- Spatial scales small if compared with the global ocean bioprovinces (Longhurst, 2006)
- High biodiversity compared to the area and volume (Bianchi and Morri, 2000)

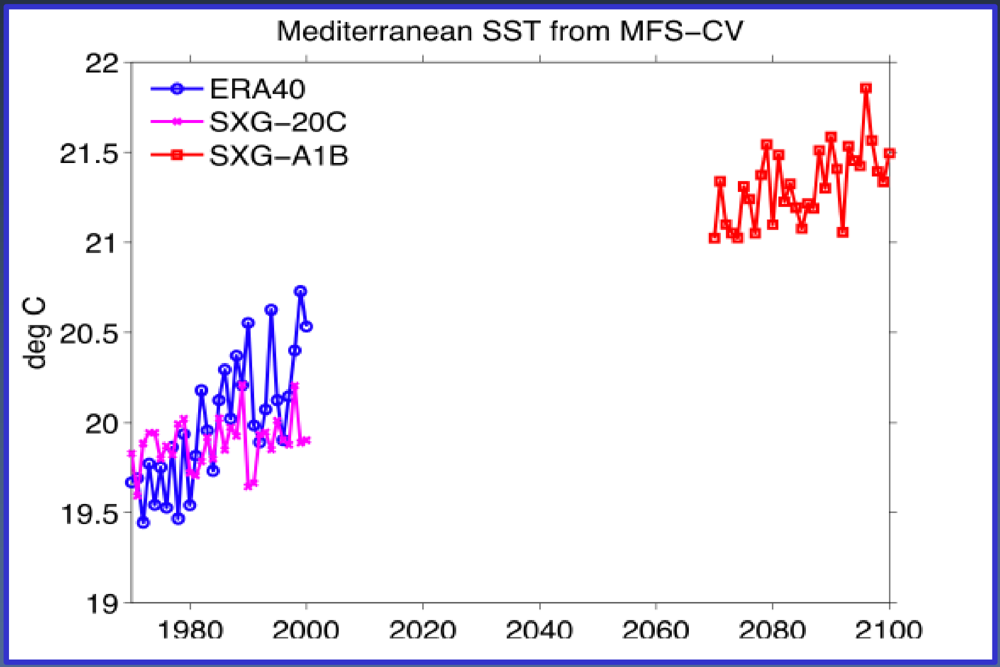
Mediterranean biogeochemical seasonal cycle: Longhurst diagrams (Longhurst, 1995)



SEA SURFACE TRENDS FOR XX and XXI CENTURY



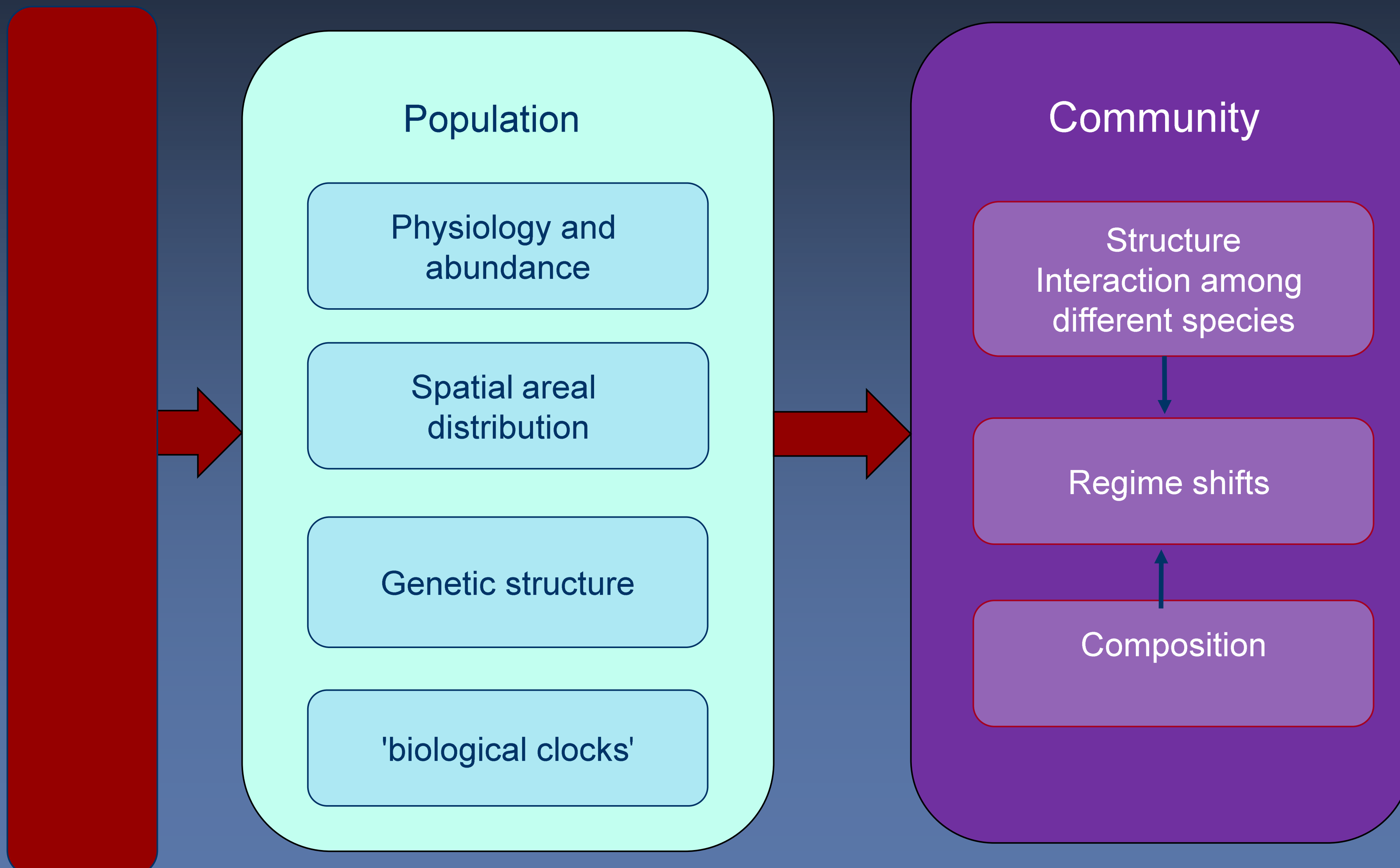
Mediterranean Sea.
Seasonal cycle of SST from the 20th and 21st century simulations



Mediterranean Sea.
Time series of SST from the 20th and 21st century simulations

(After Zavatarelli et al., 2010)

Adaptations strategies of the biota to the sea temperature rise

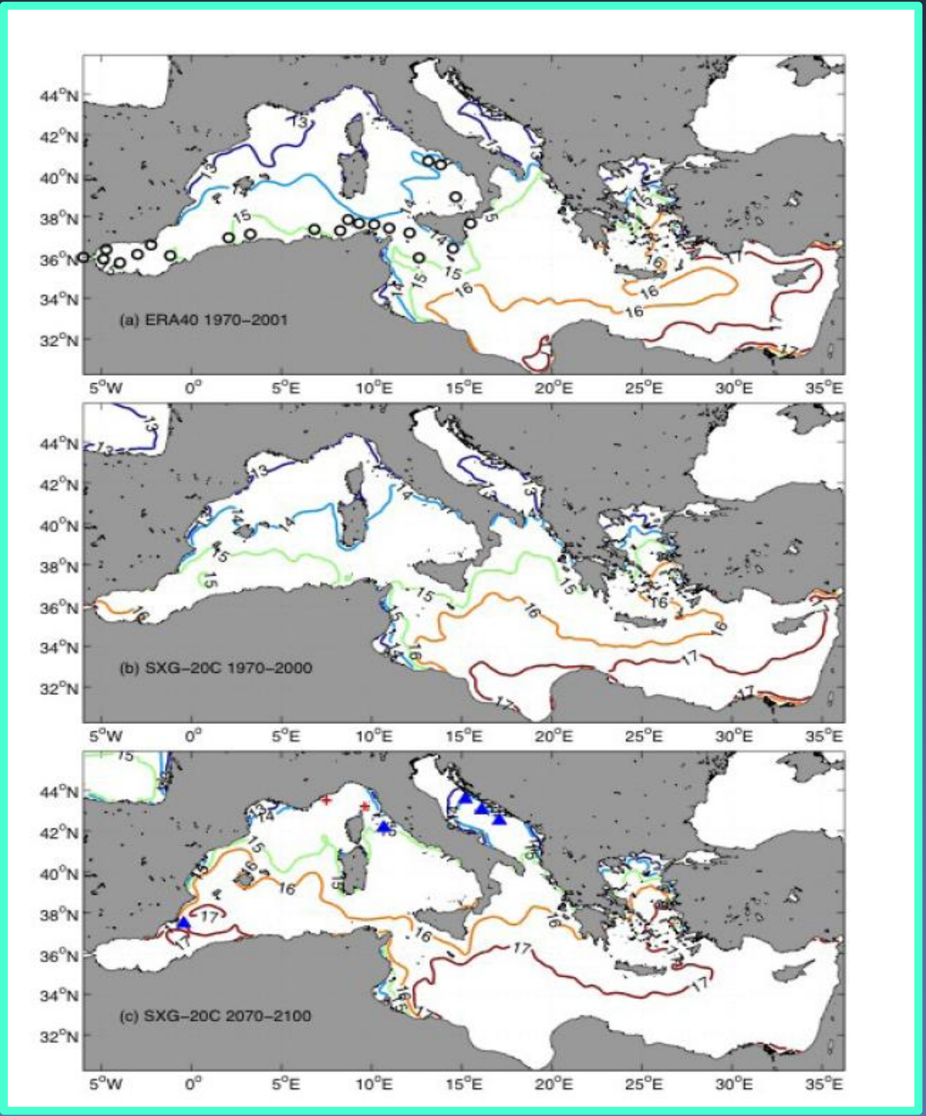


Temperature rise: meridionaliation

The positive trends in the temperature ranges facilitate the northward shift of the areal distribution of species typical of South Mediterranean

The ornate wrasse *(Thalassoma pavo*) (above) and the Mediterranean parrot fish (below), known as termophiclic species, can be found up to the Ligurian basin (Vacchi et al., 1999) and, for the first one, in the North Adriatic Sea (Dulcic, 2003)

A meridionalization example: the case of *Astroides calycularis*



(Zavatarelli et al.,SESAME WP6 Final Report)

Climatological surface temperature distribution in February from the ERA40 model simulation(1970-2001) and distributional ranges of *A. calycularis* (open circles, from Bianchi, 2007).

February SST distribution in the present climate SXG20C simulation.

Projected SST distribution at the end of the 21st century (2070-2100) from the SXGA1B simulation (blue triangles = recent records, *Grubelic et al., 2004)* red cross = fossil records, *Zibrowius, 1995).*

Tropicalization: aliens species invasion

More than 700 alien species (Galil, 2007),mostly from mid-latitude or tropical origin, have been established in the Mediterranean Sea in the last century

***Origin*:**

- Red Sea through the Suez Canal
- Atlantic Ocean through the Gibraltar Strait
- Ballast waters through commercial ships

Tropicalization: impact on community structure

***Siganus rivulatus* and *S. luridus* , entered the Mediterranean from the Red Sea through the Suez Canal**, and were first recorded off the coast of Israel in 1924 (Steinitz, 1927) .

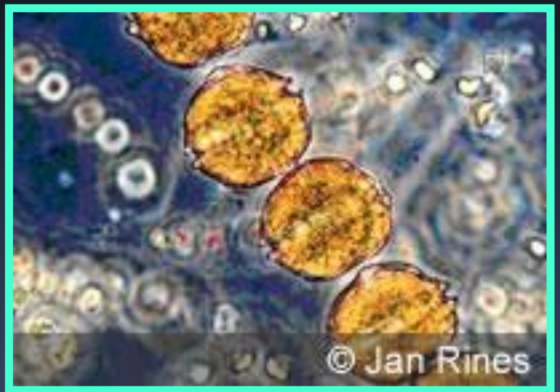
Areal distribution:
as west as the southern Adriatic Sea, Sicily and Tunisia (Ktari-Chakroun and Bahloul, 1971);

Present abundance:
up to 80% of the abundance of the herbivorous fish in shallow coastal sites in Lebanon (Bariche et al., 2004) one third of the fish biomass in rocky habitats along the Israeli coast (Goren and Galil, 2001).

Ecosystem changes induced:
The pristine community was poor in herbivores: these fish apparently accelerated the transfer of energy from the producer to the consumer levels Impacting on macroalgae crops

The siganids have altered the community structure and the native food web along the Levantine rocky infralittoral

Alien species invasion: *A. catenella*, a cool water Dynoflagellate



Alexandrium catenella

A. catenella was probably introduced with ballast water discharges. Its resting cells were found in sediment samples from ballast tanks. .

Areal distribution:

Mainly on the South-West French Coasts and Catalan Shelf; signaled in many other spots.

Growth is stimulated by the supply of ammonium and inorganic nitrogen. Optimal growth at cool temperature (17-23 ℃), and low salinity (26-32).

Present abundance:

This species is rapidly expanding and its abundance increasing.

Impacts

Responsible for creating "red tides", it is a known paralytic shellfish poisoning (PSP) toxins-producing species.

The toxins can affect humans, other mammals, fish and birds. Recently, it has been shown that PSP toxins can also be found in crabs and lobsters

The anthropogenic factor is recognized as one of the most relevant climate change pressure

RIVERS INPACT ON BIOGEOCHEMICAL CYCLES THE MEDITERRANEAN SEA IN XXI CENTURY

The climatological annual cycle of the Mediterranean Sea circulation and thermohaline/biogeochemical properties have been obtained from simulations carried out with the 20th century ECMWF ERA40 (WP4) data, the 20th century SXG output and the end of the 21st century SXG output

SGX — Global Climate Model (CMCC)

↓

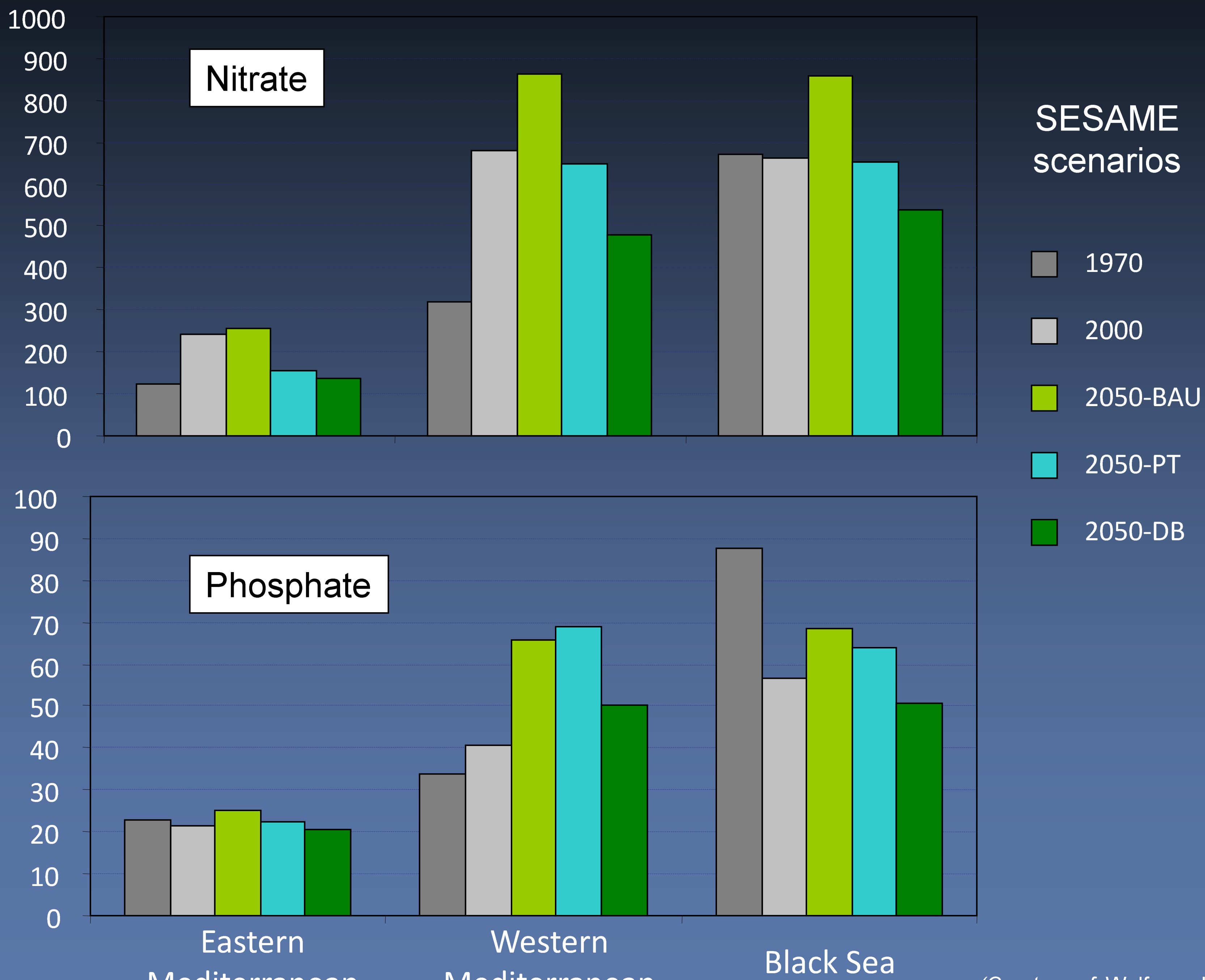
MEDSYS — Mediterranean Hydrodynamic Model (INGV, UniBO)

↓

BFM — Biogeochemical Flux Model (OGS)

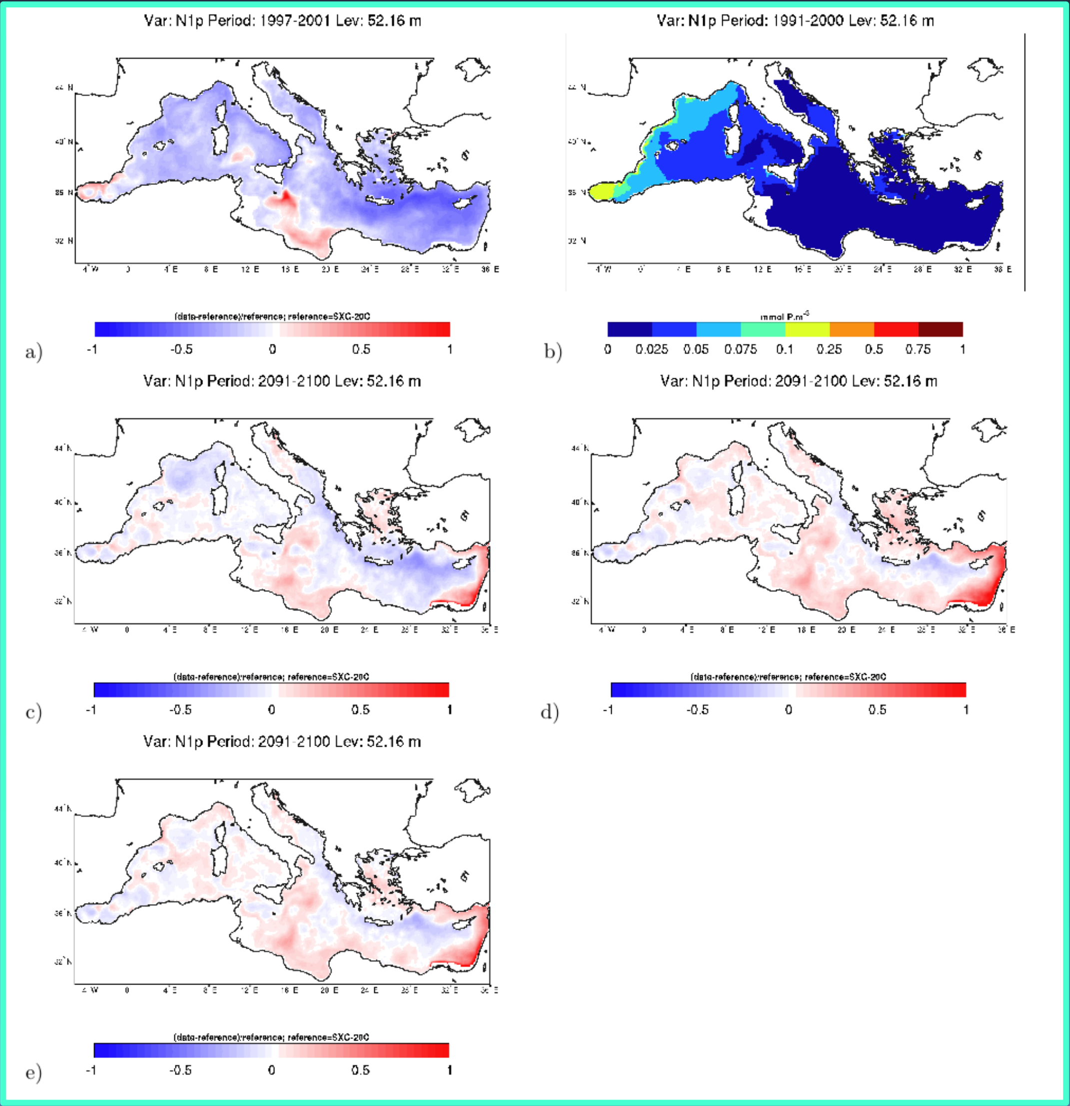
A1B scenario belongs to A1 “World Market” IPCC family of scenarios, characterized by increasing of globalization and rapid economic growth.
A1B is defined by a balanced use of all energy sources.

The role of the river input in the nutrient budget



(Courtesy of Wolfgang Ludwig)

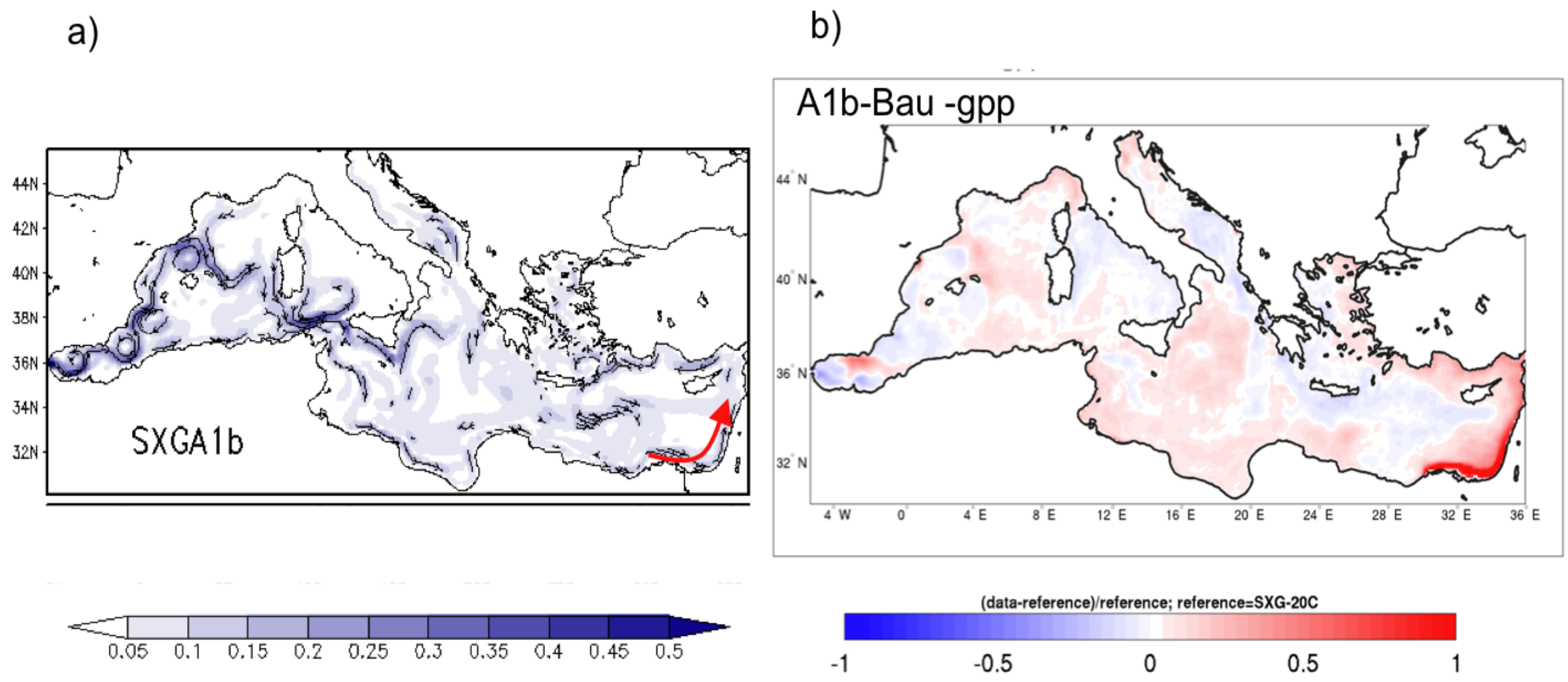
Primary production hindcast and future projections



- West East Gradient
- Higher anomaly in the Levantine
- 'Meandering' anomalies: second order magnitude

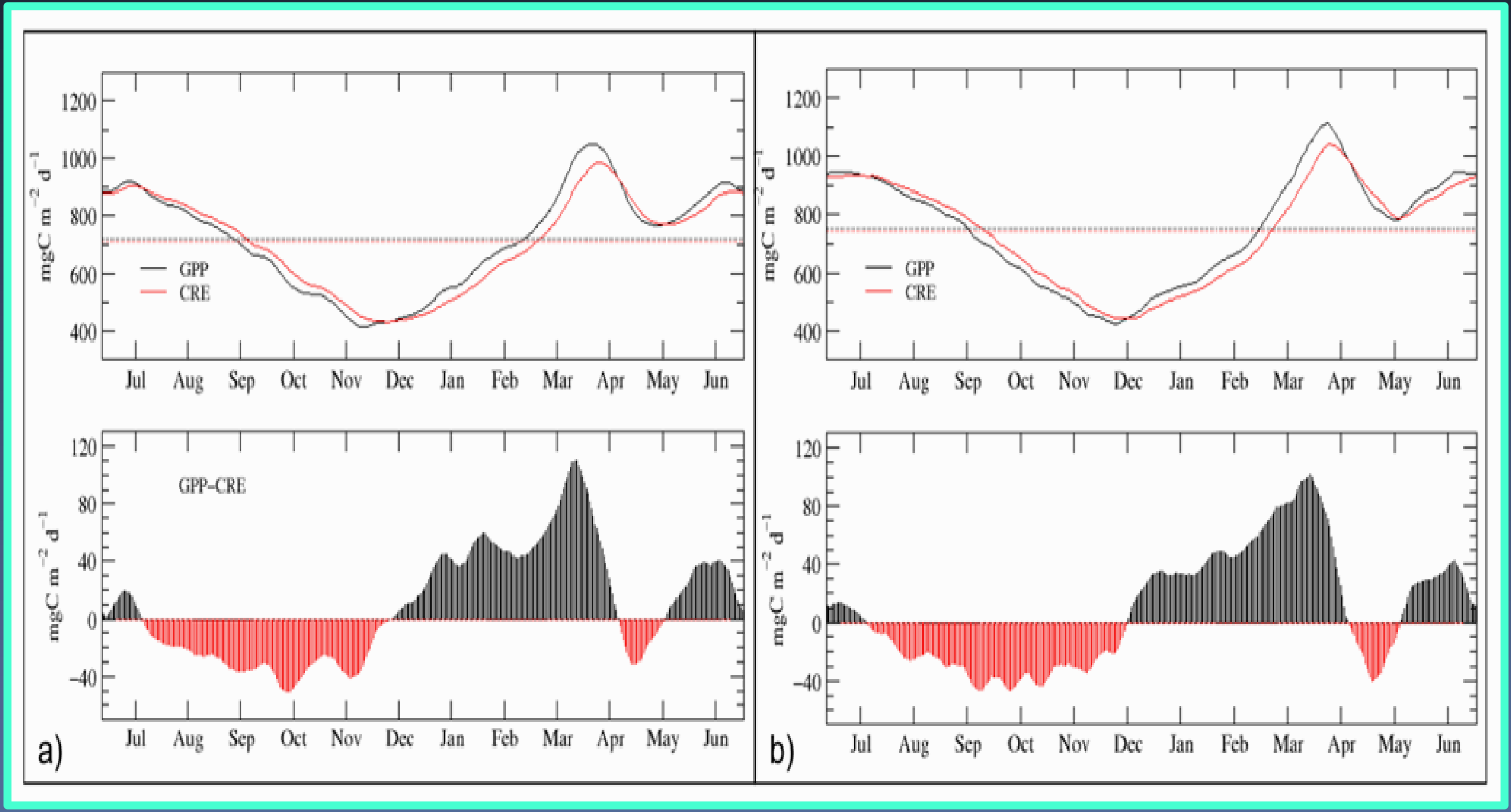
Scenario	PO4 (kTon/y)	NO3 (kTon/y)	Redfield ratio
IMOO-2000	60	887	32.7
BAU-2095	107	1325	27.4
PT-2095	106	719	15.0
DB-2095	72	324	10.0

A1B driven PP Predictions: advective processes responsible for higher Levantine productivity?



Average velocity field for the 10 years simulations for th A1B forcing fields SXG A1B (panel a), and the anomaly between reference simulation (SXG-20C) of gross primary production in che case of and A1B-BAU scenario (panel b)

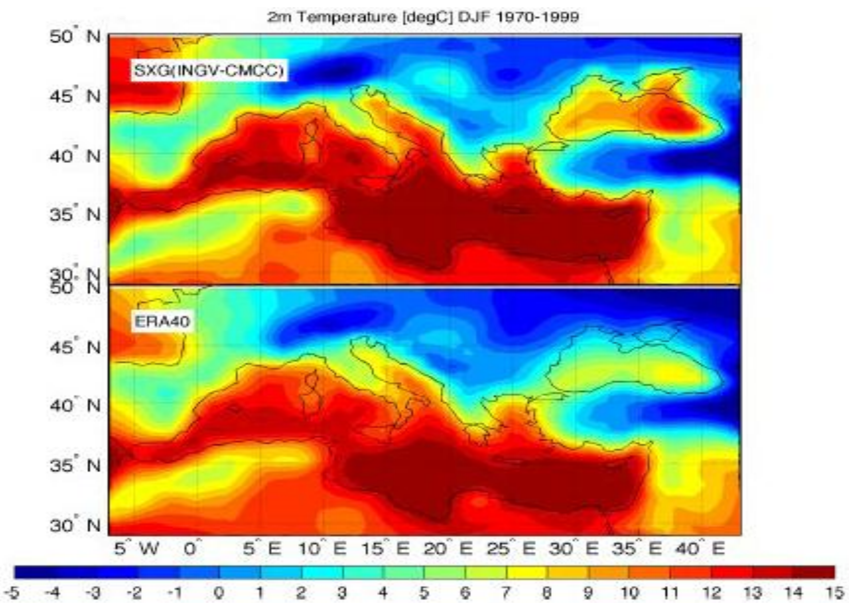
Primary Production projections



Gross primary production and community respiration seasonal cycle averaged over the ten years simulation (1991-2000 and 2091-2100), for SXG-20C-IM00 (a) and SXG-A1B-BAU (b)

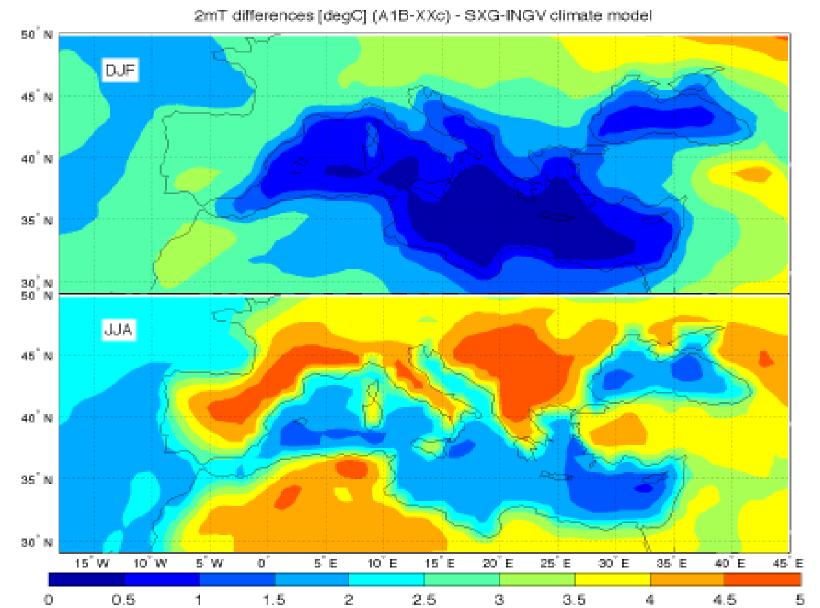
Air temperature in Winter A1B Scenario

Control vs Reference (XX cent.)



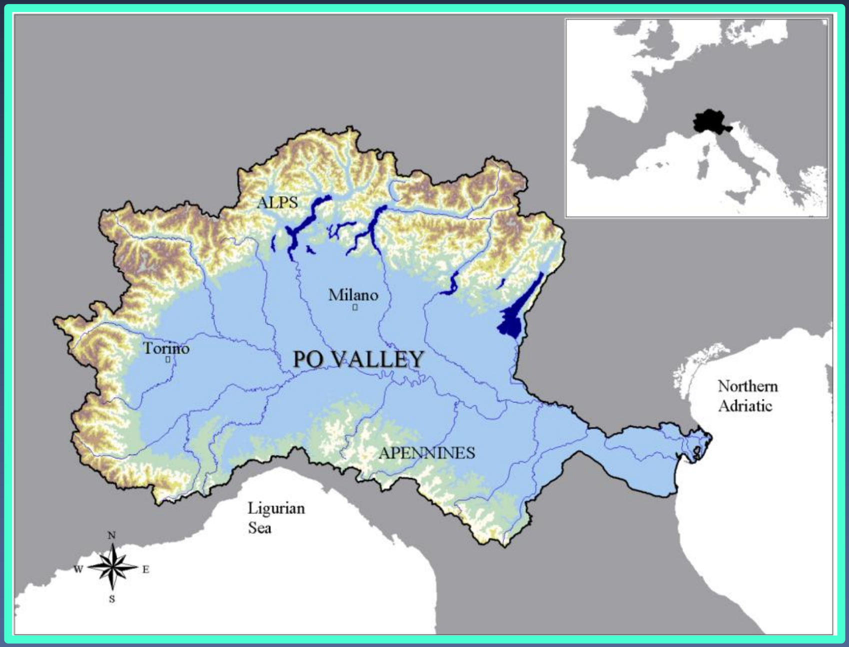
Winter air temperature over the SES region from the SXG climatic model outputs (upper panel) and the ECMWF ERA4 reanalysis (lower panel).

A1B prediction vs Control



Winter (upper panel) and summer (lower panel) temperature difference at 2 m height between 21st and 20th century SXG data (climatological means over the period 1970-1999 and 2070-2099, respectively).

Po river loads in XXI century: sensitivity to the different scenarios



Regional Climate Model

Interactive River Scheme

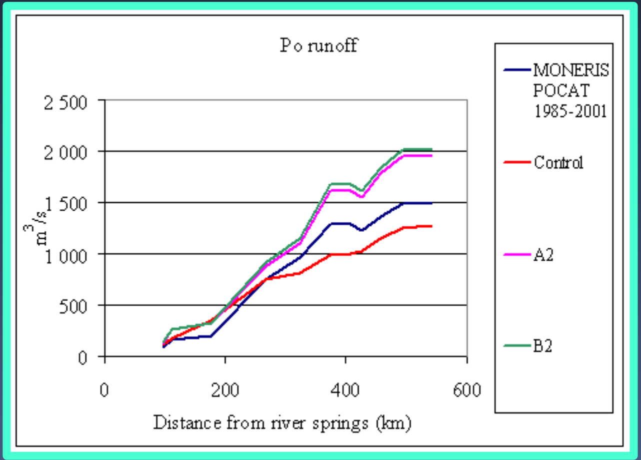
Modelling Nutrient Emissions into River Systems

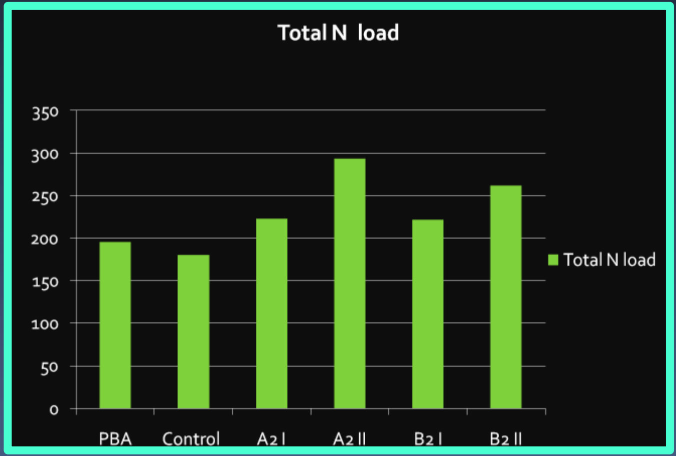
An estimate of Nitrogen (N) and Phosphorus (P) river loads is obtained via a hierarchy of models both under present climate condition and future scenarios *(Carniato et al., in prep.)*

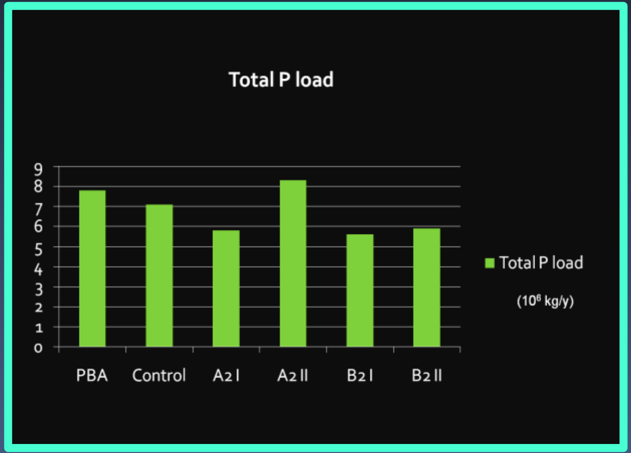
Protocol for the river runoff projections

	IM00-2000	BAU-2095	PT-2095	DB-2095
Rivers Kton $P.y^{-1}$	60	107	106	72
Rivers Kton $N.y^{-1}$	887	1325	719	324
Atm Kton $P.y^{-1}$	16(W)/20(E)	16(W)/20(E)	16(W)/20(E)	16(W)/20(E)
Atm Kton $N.y^{-1}$	580(W)/558(E)	580(W)/558(E)	580(W)/558(E)	580(W)/558(E)

Po river loads climatic model
RESULTS



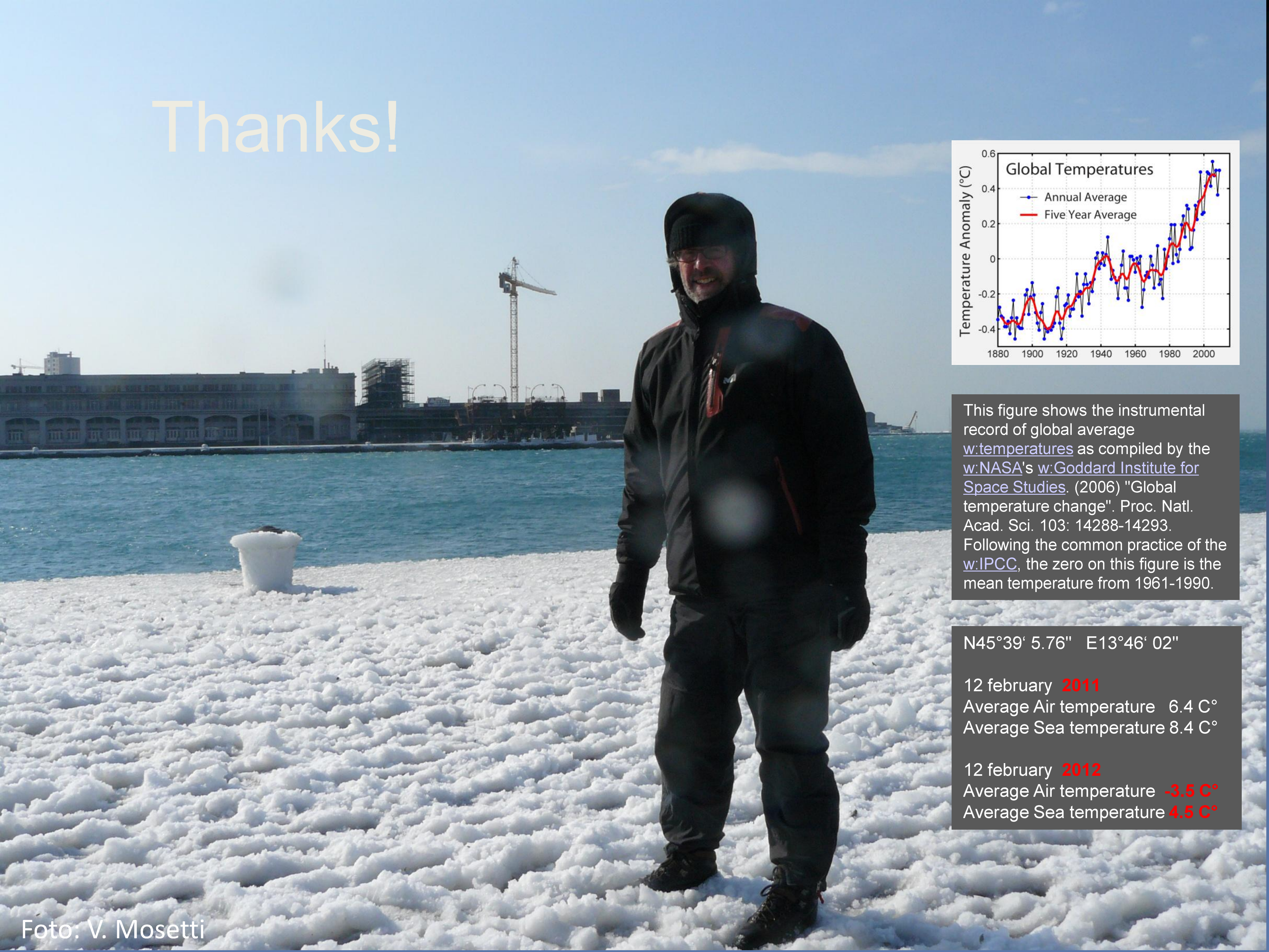




Ranges of expected variations at 2100 with respect to Palmeri et al. (2005) for Total Nitrogen and Total Phosphorus

TN	+13%	⟷	+50%
TP	-28%	⟷	+ 6%

Thanks!



This figure shows the instrumental record of global average w:temperatures as compiled by the w:NASA's w:Goddard Institute for Space Studies. (2006) "Global temperature change". Proc. Natl. Acad. Sci. 103: 14288-14293. Following the common practice of the w:IPCC, the zero on this figure is the mean temperature from 1961-1990.

N45°39‘ 5.76"   E13°46‘ 02"

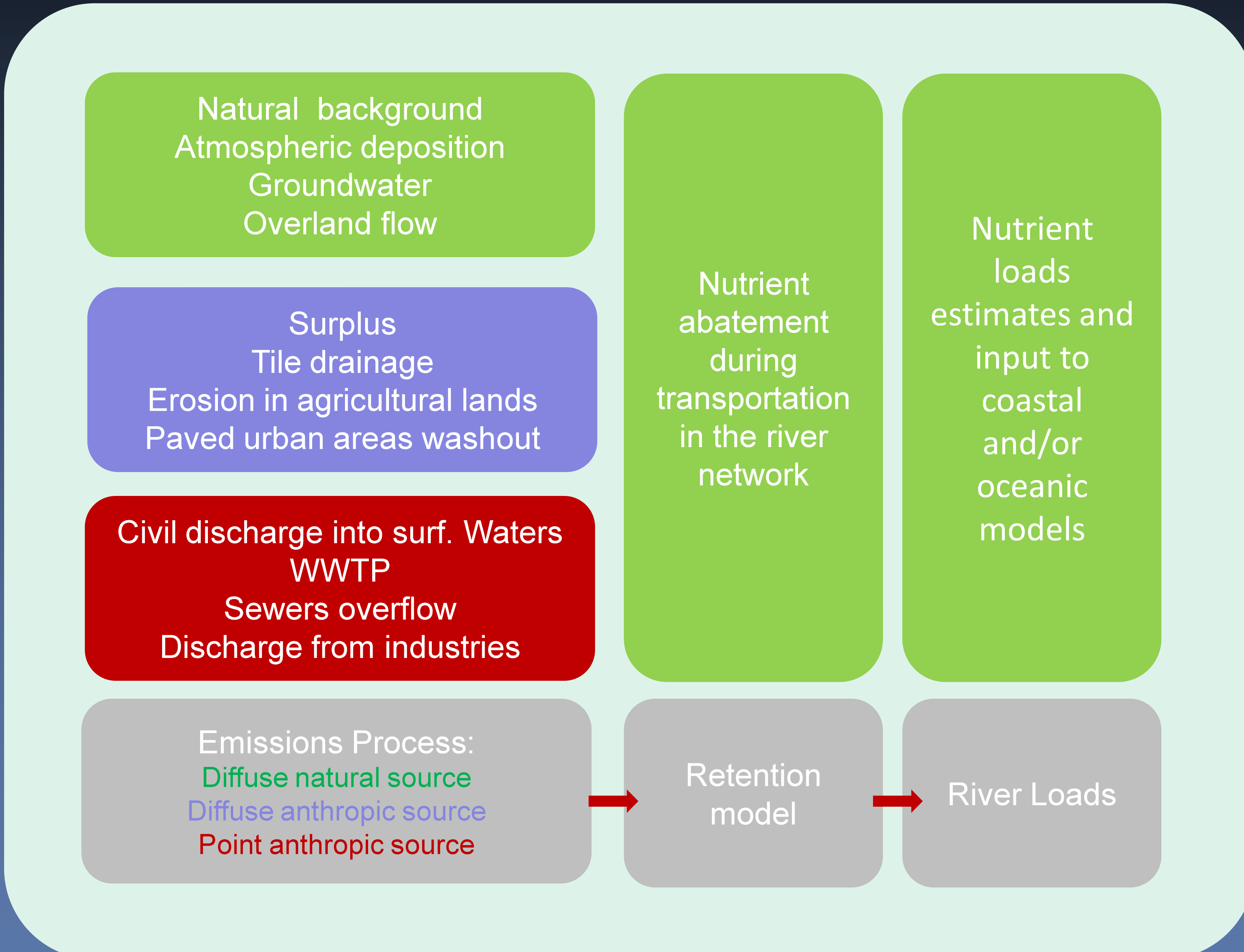
12 february **2011**
Average Air temperature 6.4 C°
Average Sea temperature 8.4 C°

12 february **2012**
Average Air temperature **-3.5 C°**
Average Sea temperature **4.5 C°**

Foto: V. Mosetti

Po river loads climatic model

Nutrient emission pathways and processes in MONERIS



Po river loads climatic model
The experiments

Reference hind-cast run (MONERIS only)

Observed input data from gov. sources

Palmeri, Bendoricchio and Artioli, 2005
Calibration period: 1990-1995
Validation period: 1996-2000

Control experiment (RegCM+IRIS+MONERIS)

Simulation period: 1960-1990
Driving GCM: HadAM3H

Modelled runoff from PRUDENCE

Scenario experiment (RegCM+IRIS+MONERIS)

Simulation period: 2071-2100
Driving GCM: HadAM3H (A2 / B2)

Runoff from PRUDENCE, land use variations from IPCC, Population growth extrapolated from ISTAT estimates, variations in fertilizer consumption following either the ELBA model (fixed surpluses) or Tilman 2001 (dependent both on population growth and on the adopted policies in fertilizer consumptions)

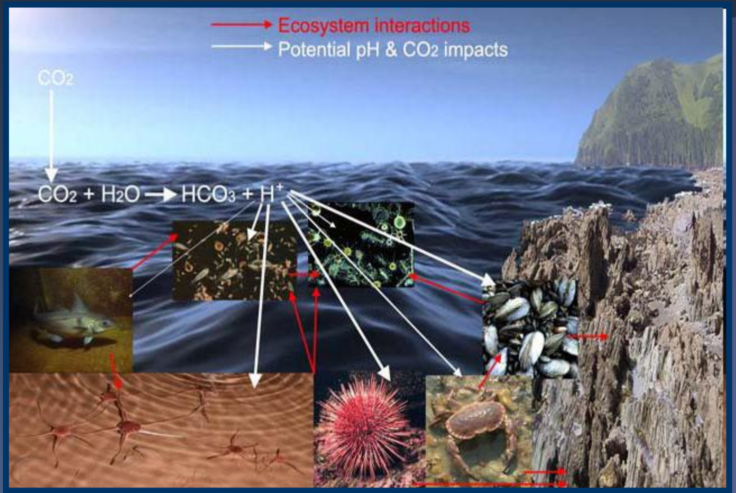
Acidification in Mediterranean Sea

Increase of the CO2 concentration atmosphere

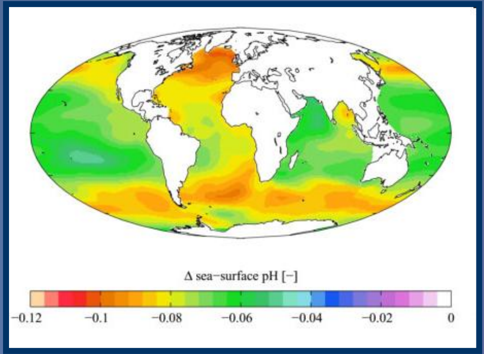
ocean acidification

impacto on primary production

Remineralization and carbon export



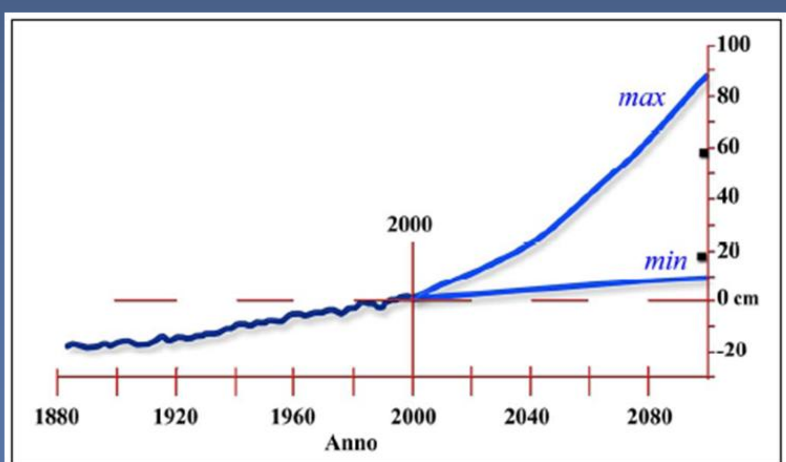
EcoMED project on-going



Mediterranean EPOCA companion

Sea level rise

The Earth 22000 years ago (maximum peak of the last glacial period) was covered by huge ice sheets, even over 4000 meters thick. In our regions, ice coverage included a large portion of northern Europe and the main mountain ranges, such as the Alps.



Geomorphological Italian (Climex maps, Vai & Cantelli., 2004) during the last Glacial (22 ka cal BP).