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Marine Ecosystem Evolution in a Changing Environment

SIMULATING THE INTERANNUAL VARIABILITY OF THE ADRIATIC SEA ECOSYSTEM
(Work in progress)

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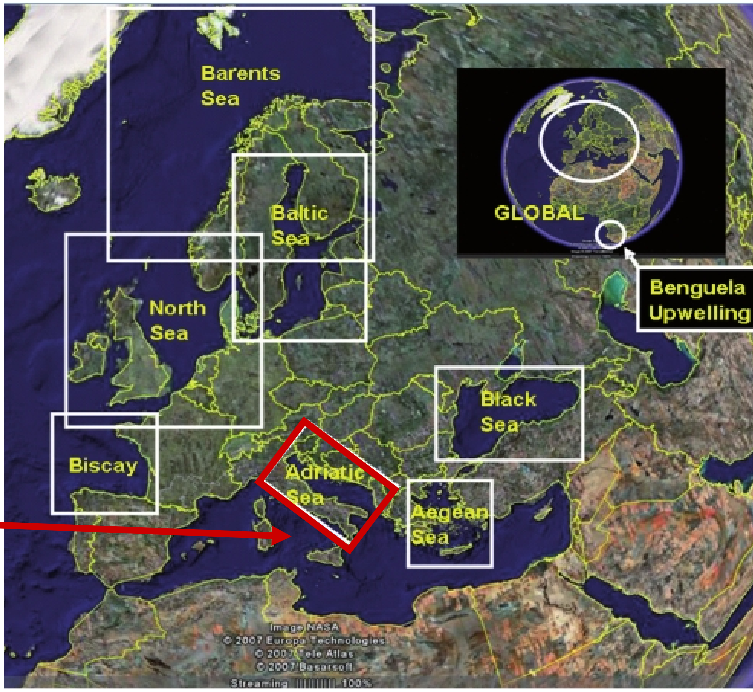
INTRODUCTION & OBJECTIVES

MEECE Marine Ecosystem Evolution in a Changing Environment (EU-FP7) project uses predictive models to explore the impacts of both climate (global warming, ocean acidification) and human induced drivers (fishing, pollution, invasive species and eutrophication) in 7 European seas (plus Benguela).



Adriatic Sea Activities

Focus on climate drivers:

- Hindcast the 20th Century ecosystem dynamics
- Predict 21st Century ecosystem dynamics

under unified consensus (IPCC) scenarios of climate change.

Focus on Human induced drivers:

- Expand modelling system to representation of higher trophic levels (with fishery pressure) and organic pollutants

MEECE NUMERICAL SIMULATIONS CARRIED OUT

- 2001-2005 to validate the model & compare with satellite data
- 20th century: 1980-1990 to be extended to 2000
- 21st century: 2080-2088 to be extended to 2100

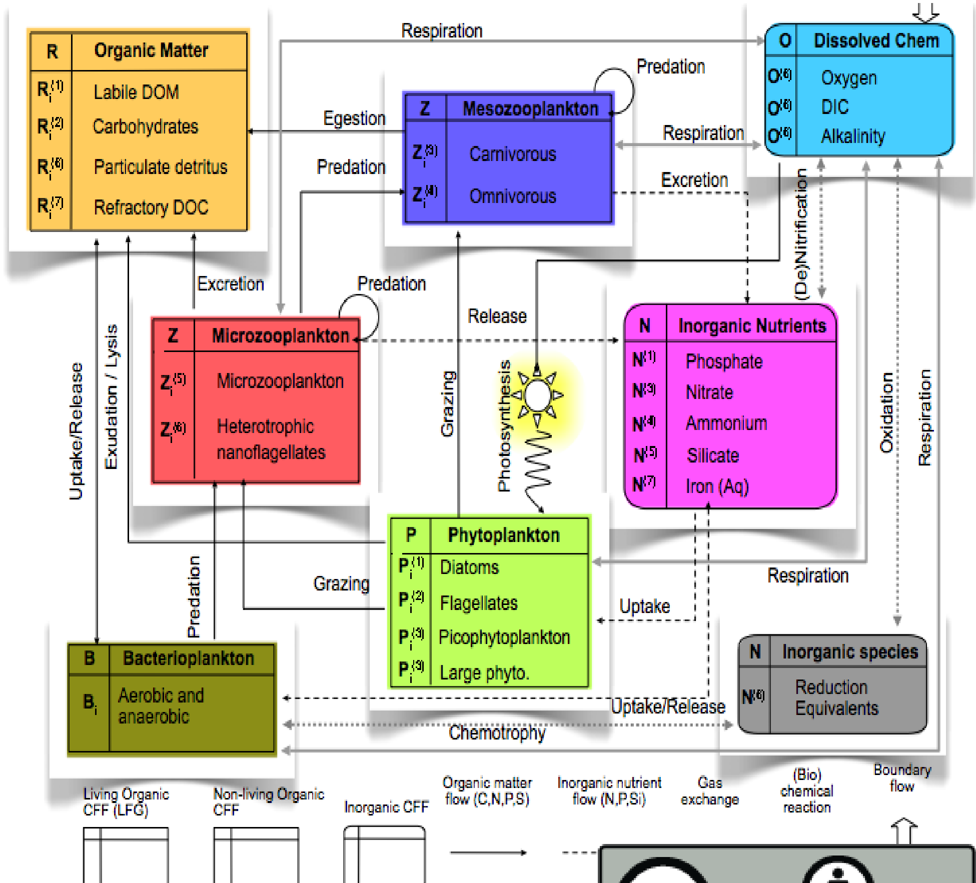
COUPLED PHYSICAL – BIOGEOCHEMICAL MODEL

Physical Model = POM (Princeton Ocean Model)

3D oceanographic model, sigma coordinates, free surface, time step splitting: external 2D mode (time step 5s.); internal 3D mode (time step 500s.)

Biogeochemical Model = BFM (Biogeochemical Flux Model)

- physiological and population processe of lower trophic levels
- 3 main trophic groups: primary producers, predators, decomposers (standard organism)
- functional group biomass defined by internal constituents (chemical currencies): Carbon, Nitrogen, Phosphorus and Silicon (only for diatoms)



Vichi et al. 2007

At each model time step, hydrodynamics provides BFM with information about the physical environment (T, S, V..)

CASE STUDY: ADRIATIC SEA

Adriatic Sea implementation

GRID and BATHIMETRY

• Horizontal resolution: 2 kms, 27 sigma vert. levels
• Model bathymetry from US Navy DBDB1 (1 min) with modifications in shallow areas

INITIAL CONDITIONS

Biogeochemistry

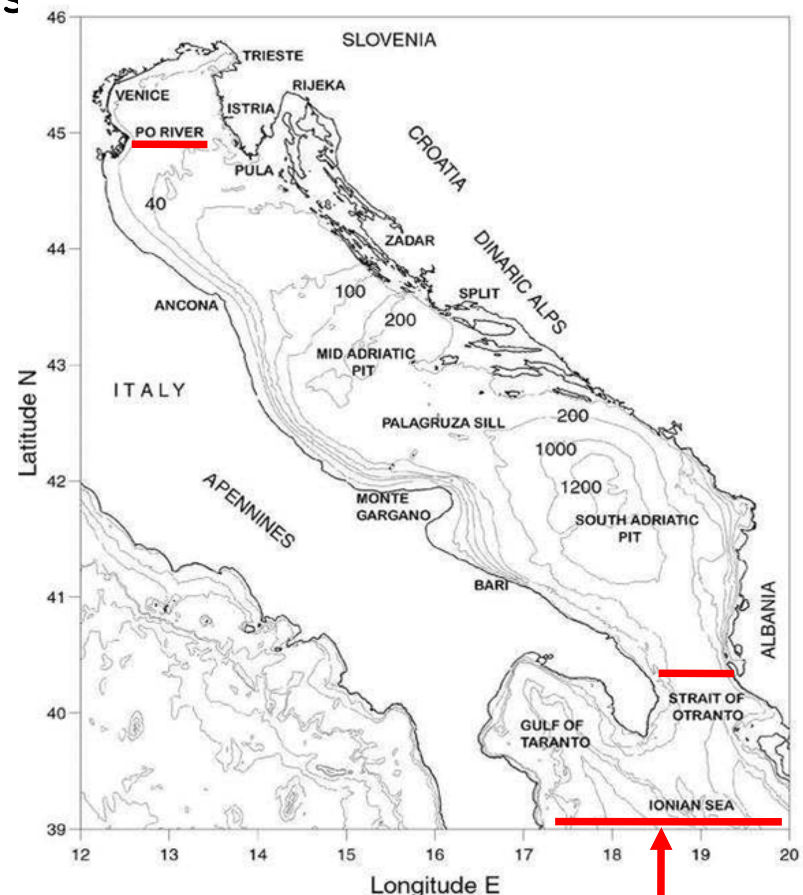
• **Nutrients, Phytoplankton and Oxygen:** estimated from ABCD dataset [Zavatarelli et al., 1998] winter averages: vertically variable, horizontally homogeneous
• **Others state Variables:** const. values provided by literature

Physics

Restart from physics only simulations.

OPEN BOUNDARY CONDITIONS

Physical conditions,
South to Otranto channel,
Nesting with the High resolution (1/16°) NEMO based Mediterranean Sea Model (Oddo et al. 2009)



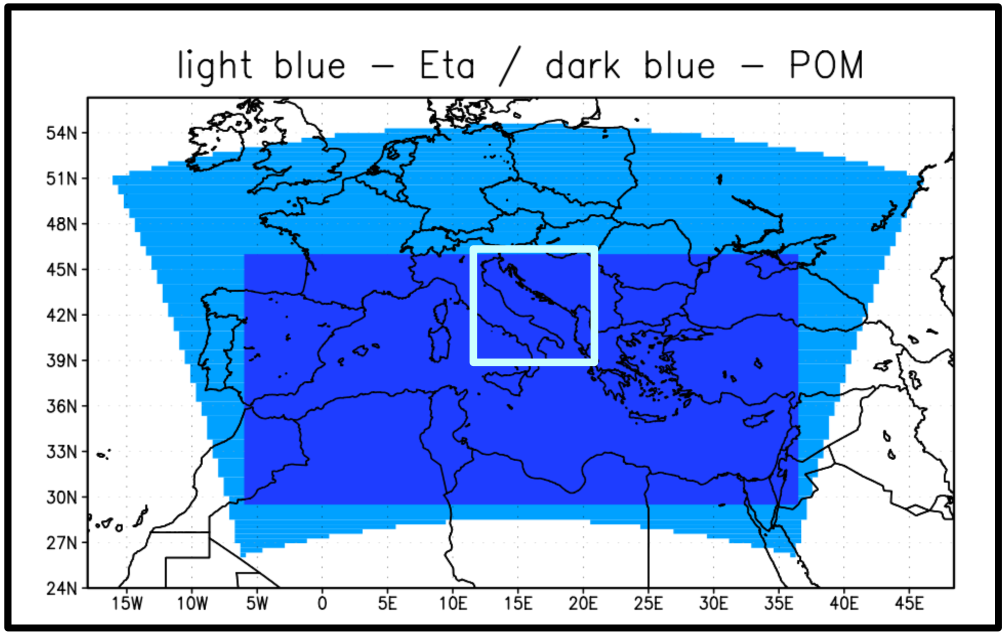
OPEN BOUNDARY

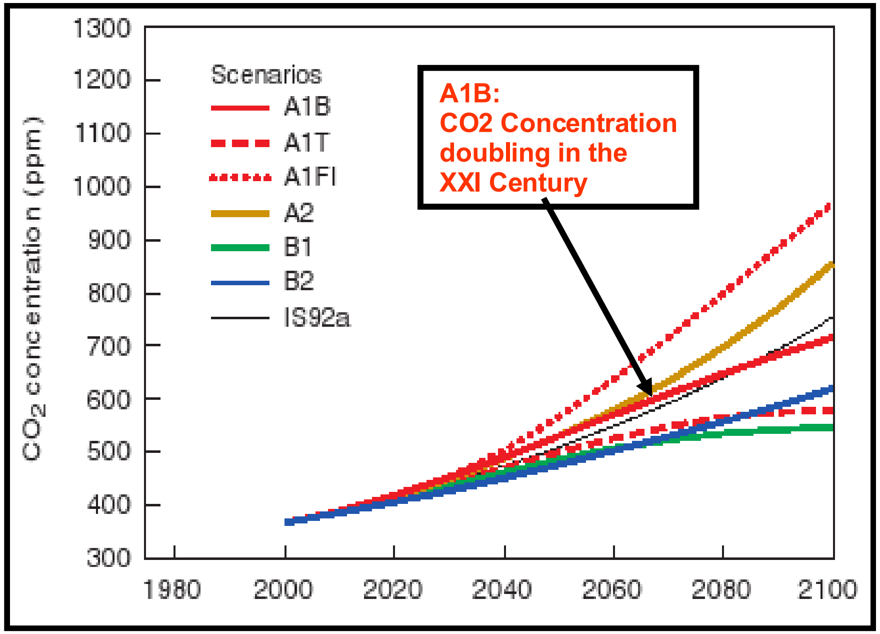
SURFACE ATMOSPHERIC FORCING

High frequency surface forcing (6 hours) data are derived from the atmospheric component of a two way interactively coupled EBU-POM Model, computed with dynamic downscaling of global scale climate model.

Atmospheric component: Eta Model (EBU=Eta Belgrade Univ.) has 0.25 horizontal resolution (~30km)

• Hindcast climate integration: 1961-2000 (under observed CO2 concentration)
• Future climate integration: 2001-2030 + 2071-2100 (under A1B IPPC CO2 emission scenario).





RIVER RUNOFF & NUTRIENT LOAD

The model has been forced with river runoff and nutrient load deduced from:

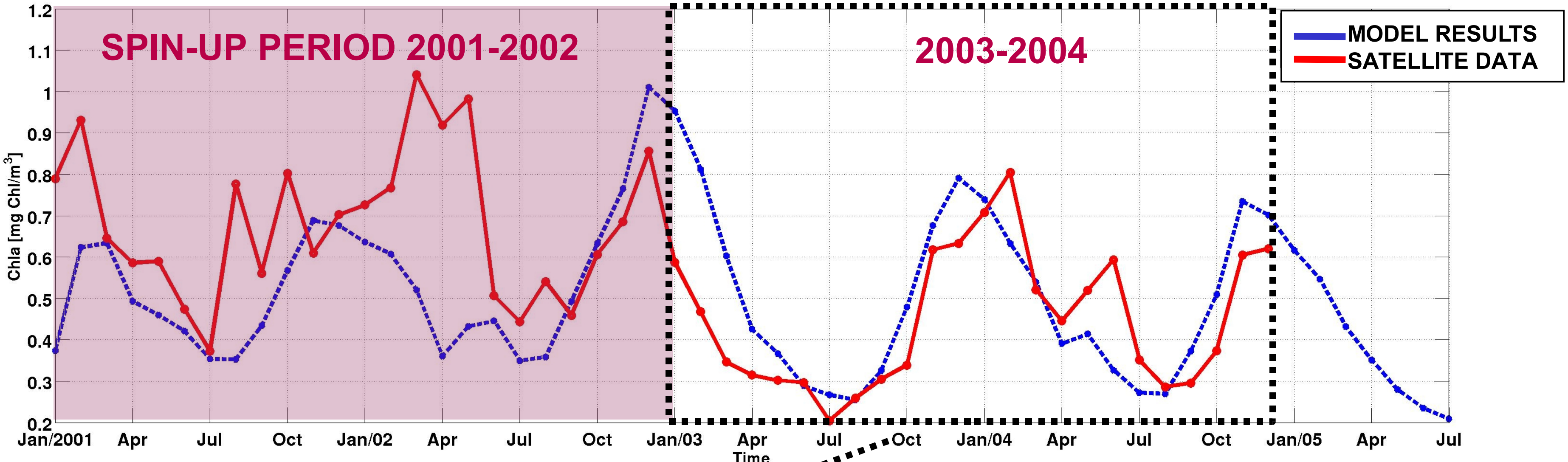
- Daily observations (where available)
- Monthly climatologies (perpetual year)
- Interannually varying monthly averages, from an hydrological model of the Mediterranean watershed forced with 20th century re-analysis (Ludwig et al. 2009) or 21st century A1b scenario (Ludwig et al. 2010)

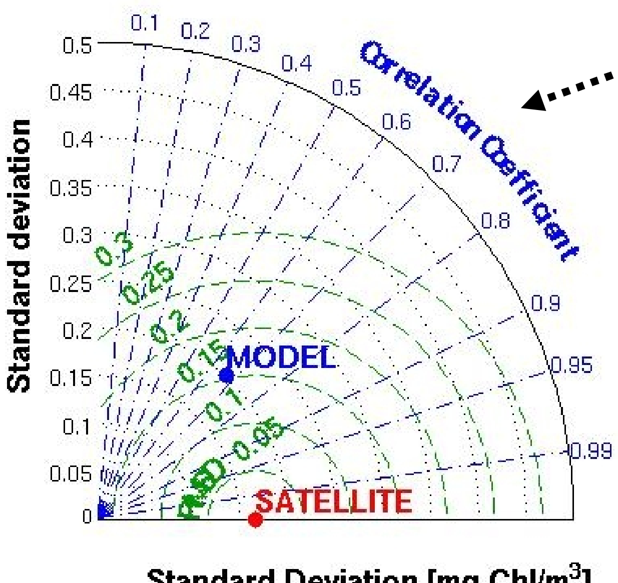
SESAME
Southern European Seas: Assessing and Modelling Ecosystem changes

	SIMULATIONS 20th century	SIMULATIONS 21st century
PO RIVER RUNOFF	Observed daily averages	Monthly averages (interannually varying) from an hydrological model under A1b scenario
OTHER RIVERS RUNOFF	Monthly climatologies (perpetual year) or Monthly averages (interannually varying) from an hydrological model	
ALL RIVER NUTRIENT LOAD	Annual estimates or Monthly averages (interannually varying) from an hydrological model	Monthly averages (interannually varying) from an hydrological model under A1b scenario & the **"Business as Usual" (BaU) assumption**

RUN 2001-2004: MODEL VALIDATION

Chlorophyll-a monthly mean averages over the light e-folding depth MODEL RESULS vs. SATELLITE DATA



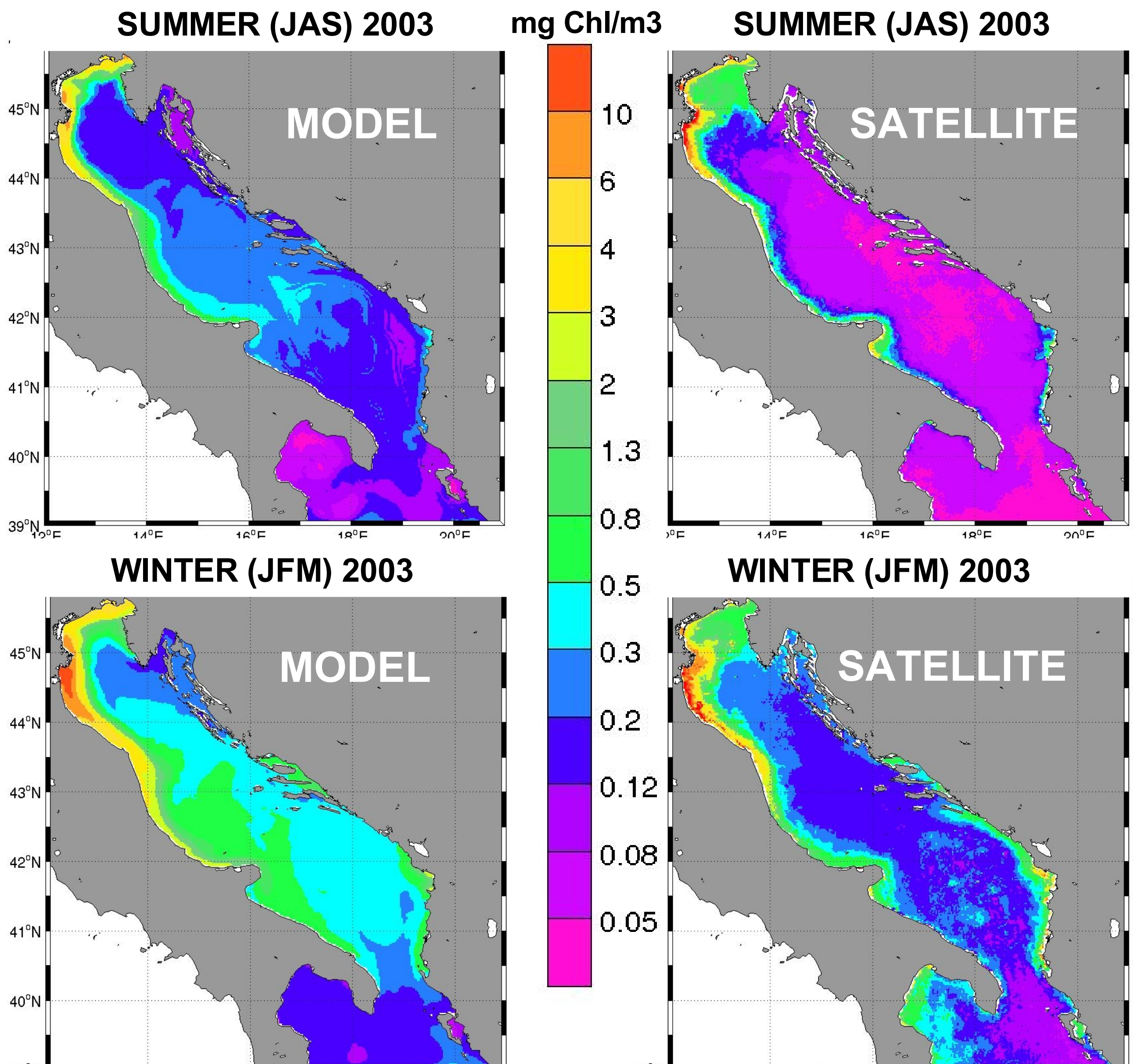


MODEL

- overestimates chlorophyll concentrations
- correlation coefficient = 0.7
- variability in phase with data
- approximatively the same STD

RUN 2001-2004: MODEL VALIDATION

Chlorophyll-a concentrations averaged over the light e-folding depth



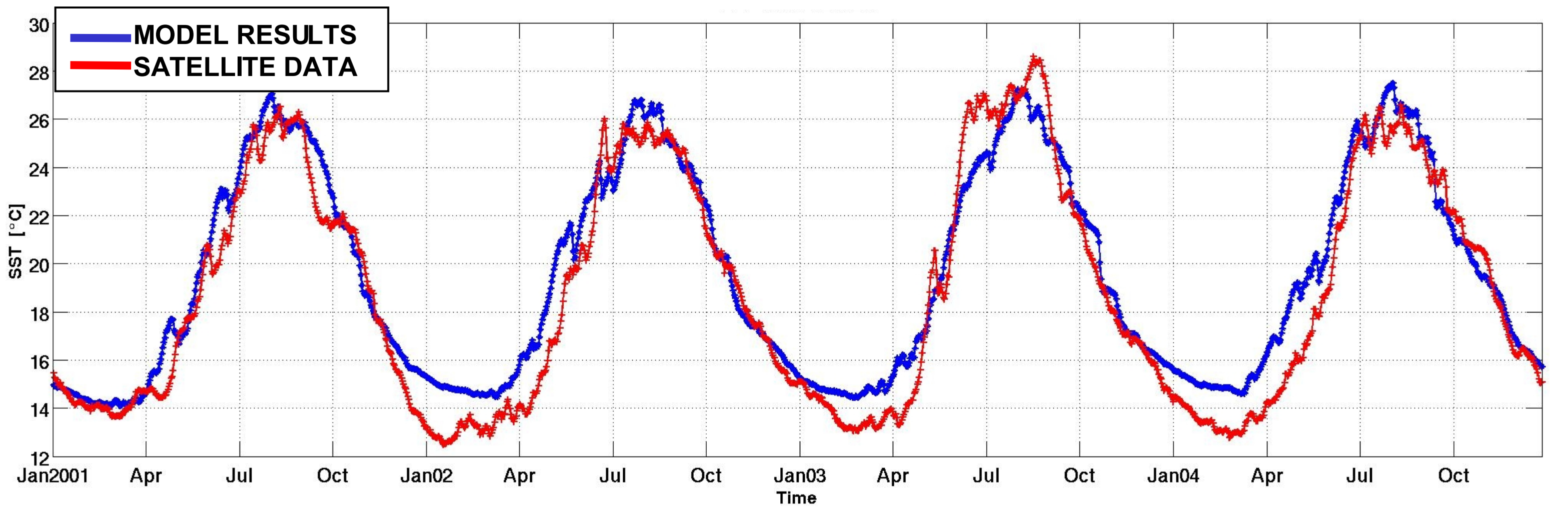
- Qualitative agreement between model results and satellite measurements

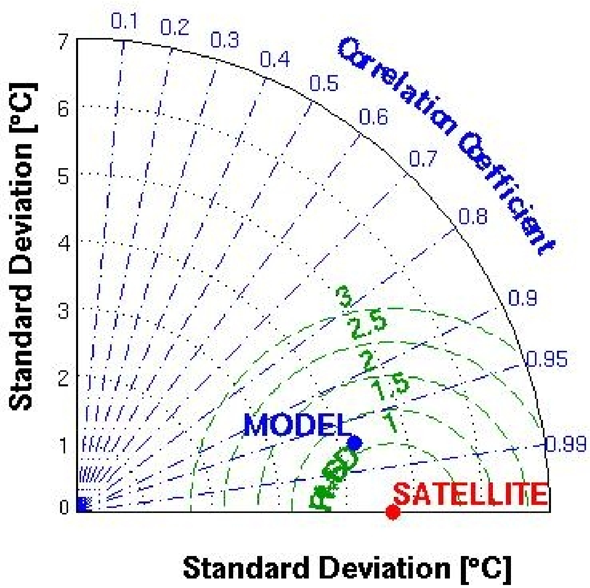
- Model represents spatial variability (higher concentrations in North-West region that decease in deeper areas)

- Overall overestimation of satellite data in particular during winter bloom

RUN 2001-2004: MODEL VALIDATION

Sea Surface Temperature daily averages
MODEL RESULS vs. SATELLITE DATA

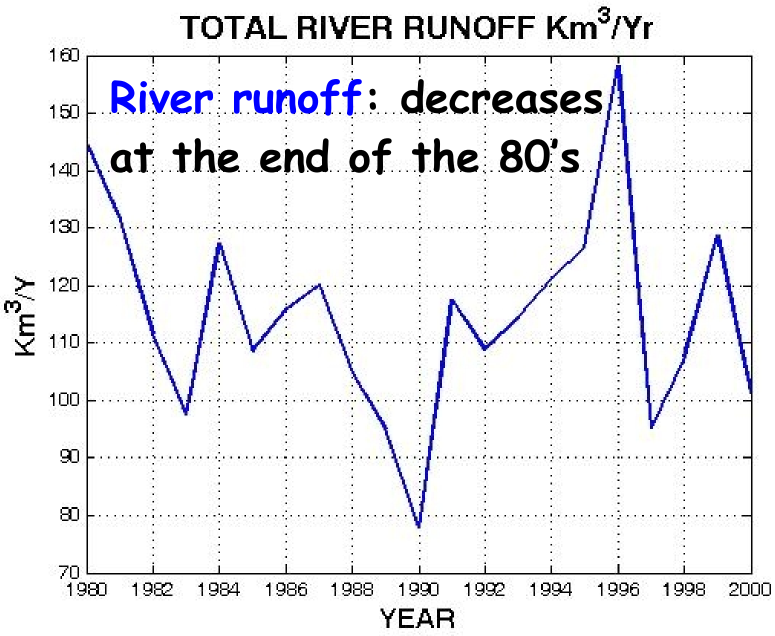


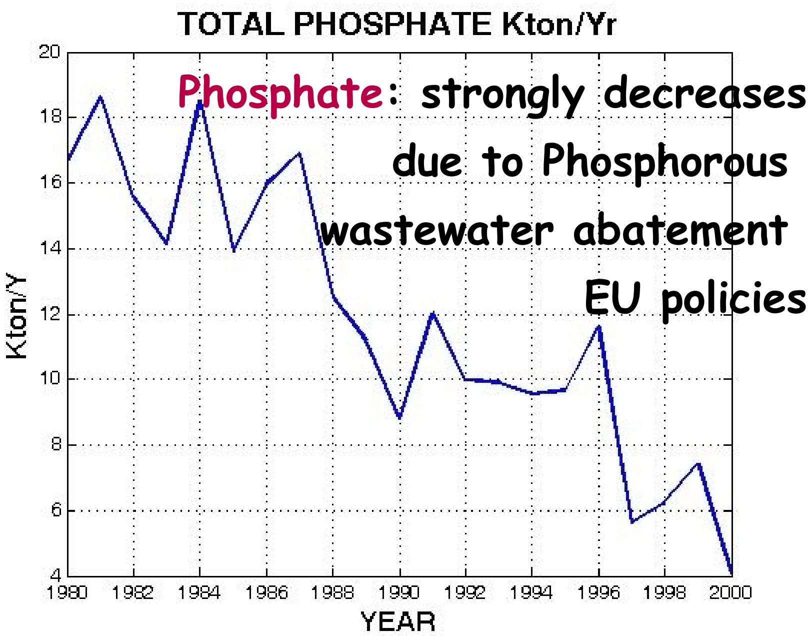


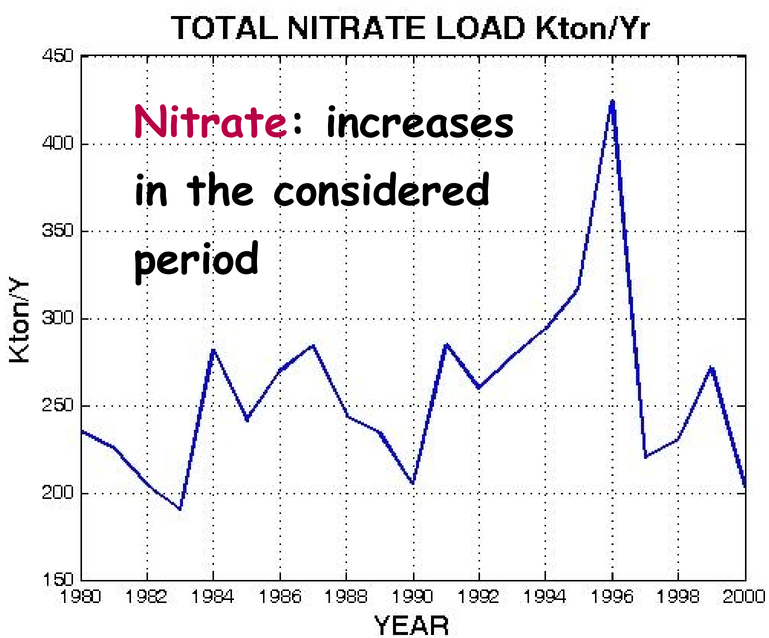
MODEL

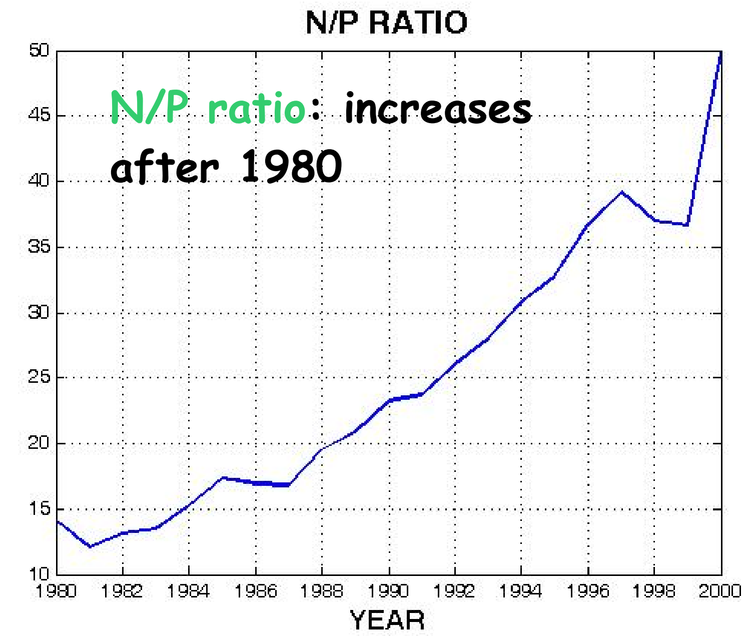
- overestimates satellite data (+0,6°C)
- correlation coefficient = 0.97
- variability in phase with data

RIVER RUNOFF & NUTRIENT LOAD 1980-2000

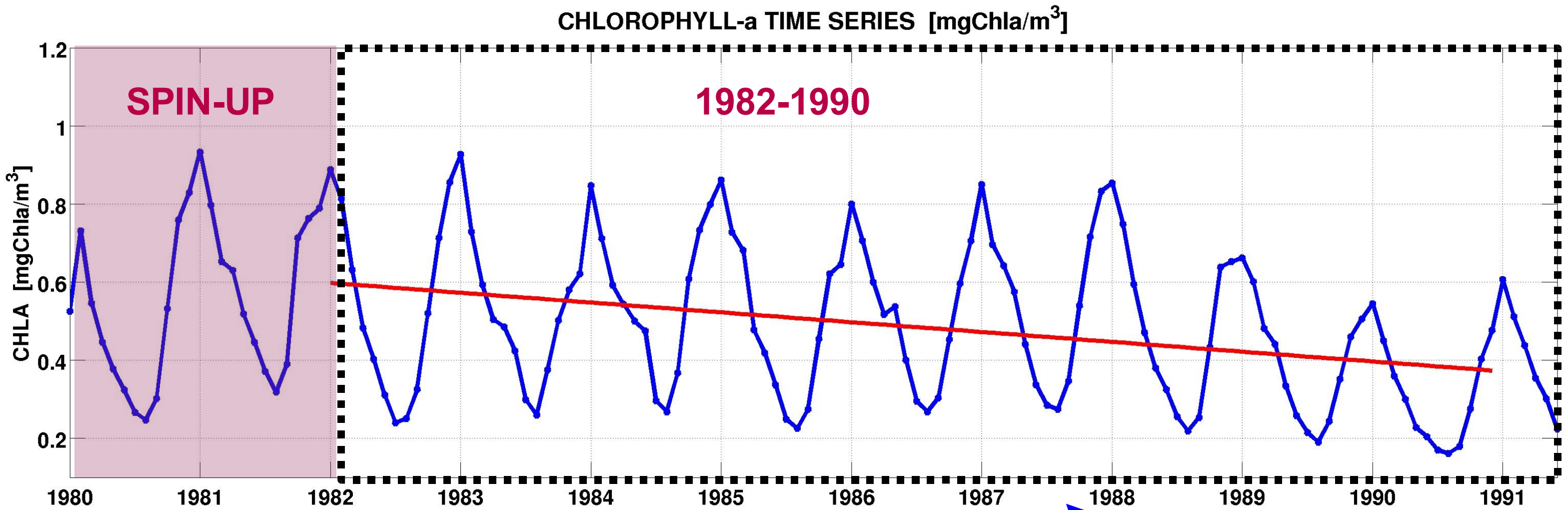


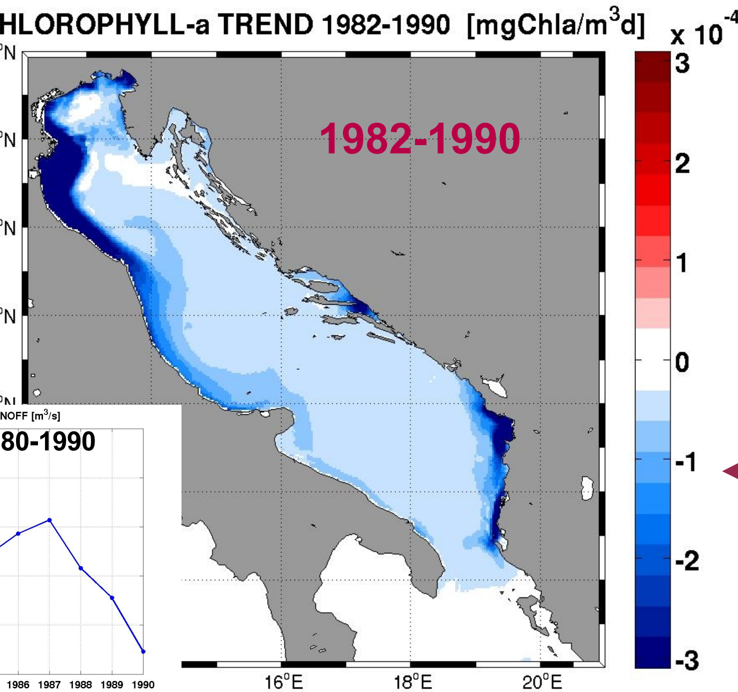


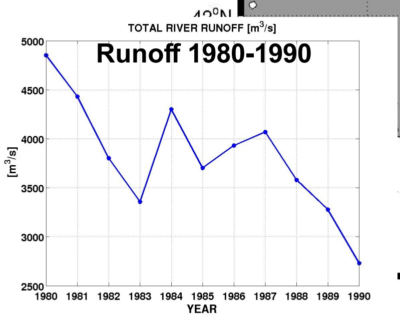




RESULTS 20th CENTURY: CHLOROPHYLL



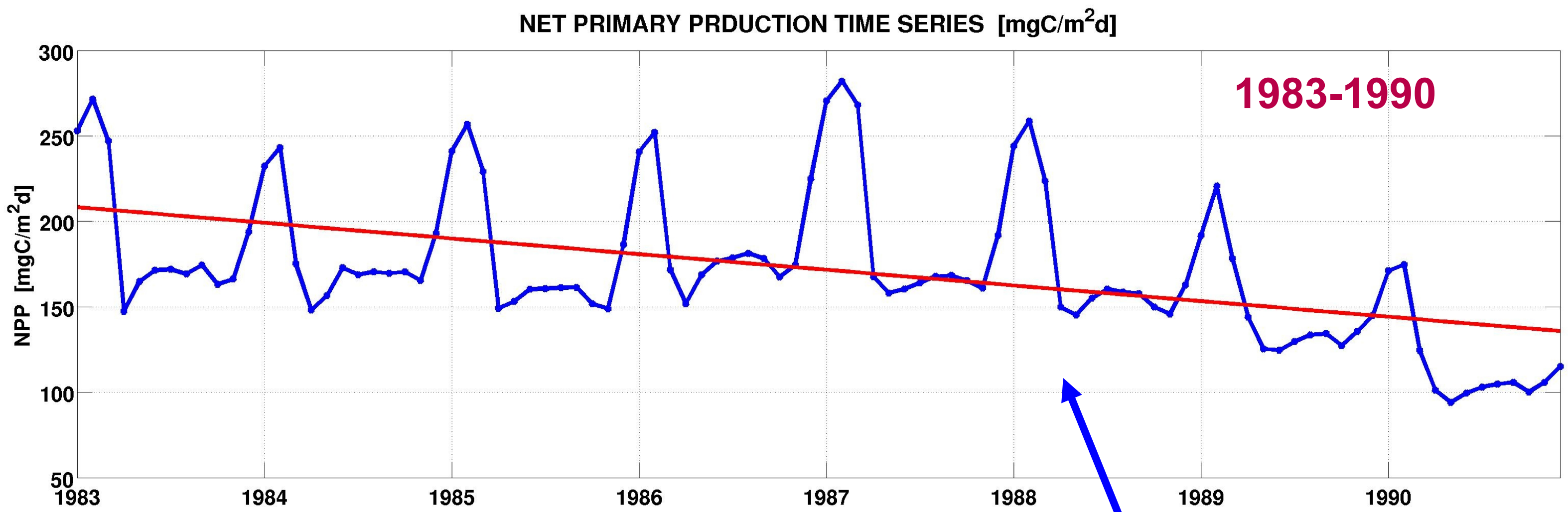


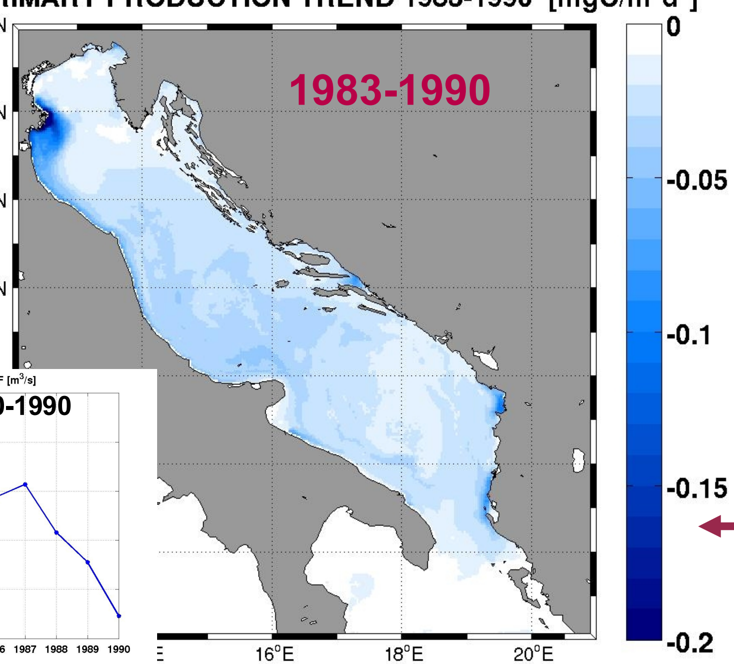


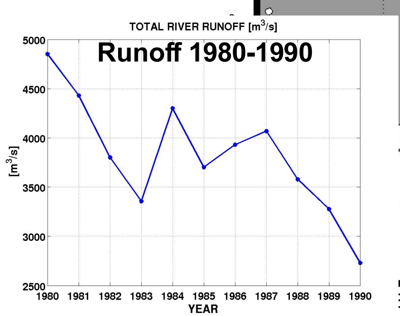
Chlorophyll-a time series: monthly averages decrease in the simulated period, in particular at the end of the 80's

Map of Chlorophyll trend: negative values in the entire basin

RESULTS 20th CENTURY: PRIMARY PRODUCTIO



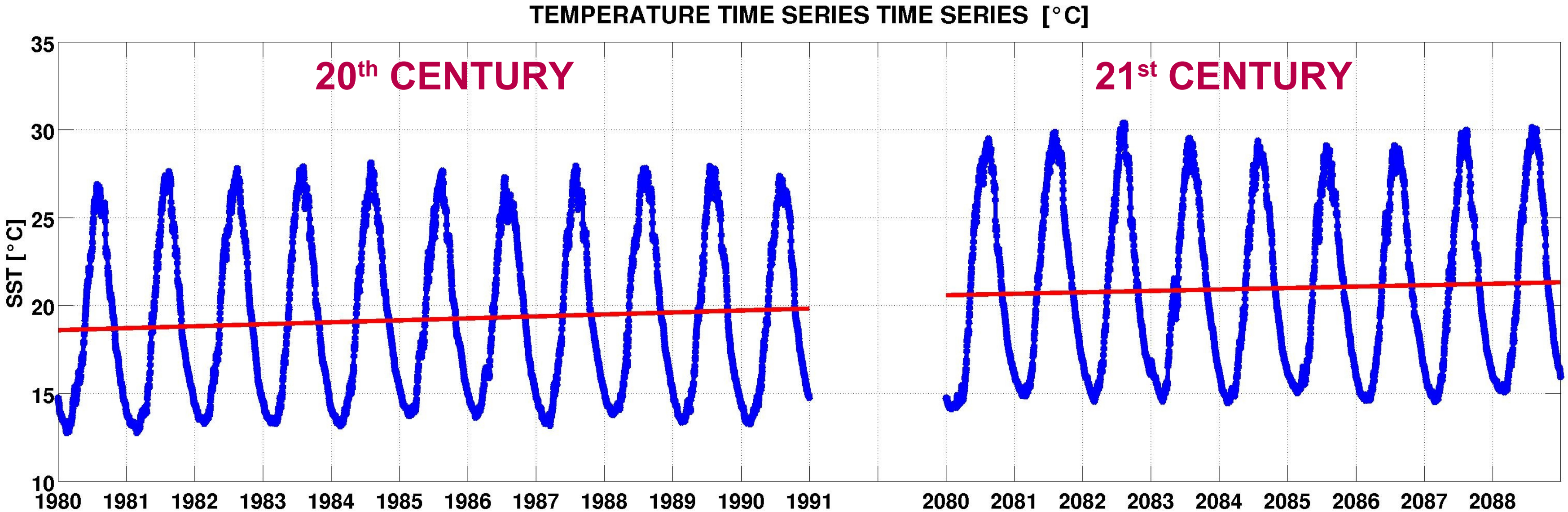


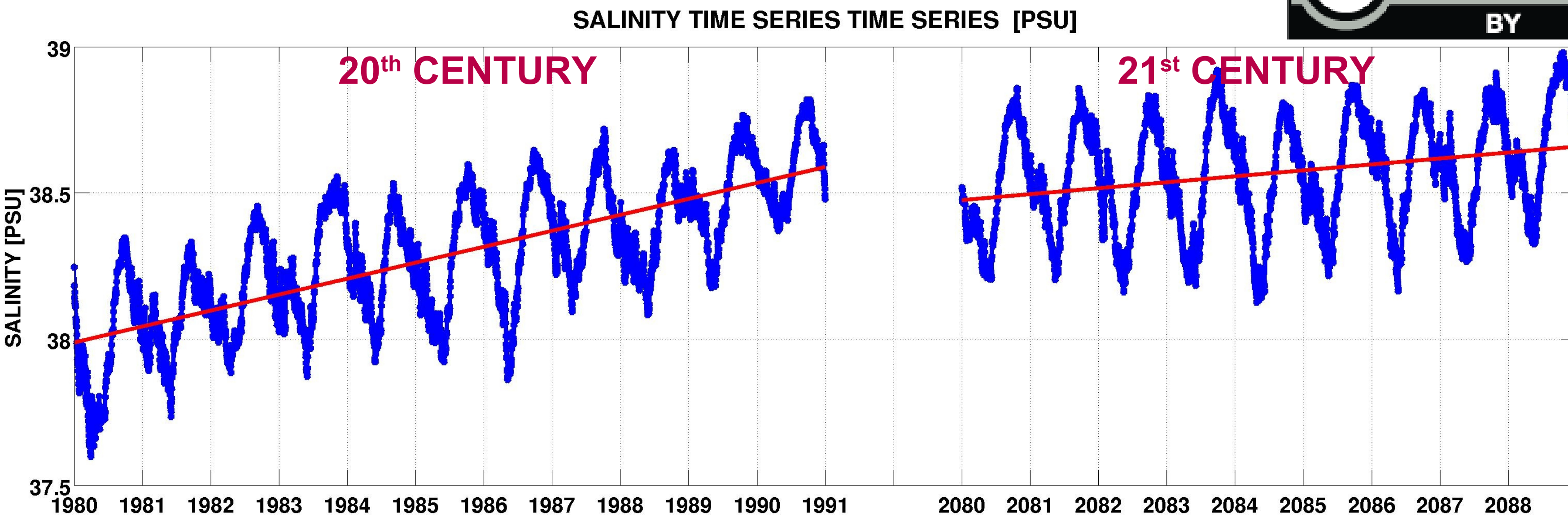


Primary Production time series: monthly averages decrease in the simulated period, in particular at the end of the 80's following the riverine nutrient load trend

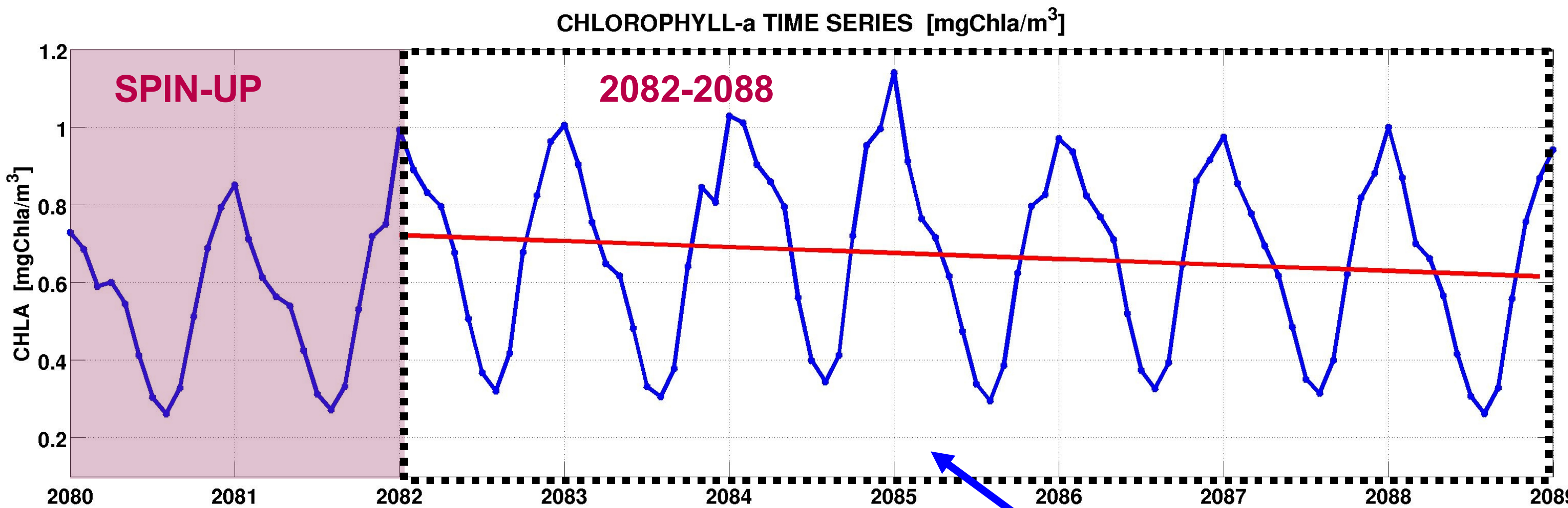
Map of Primary Production trend: negative values in the entire basin

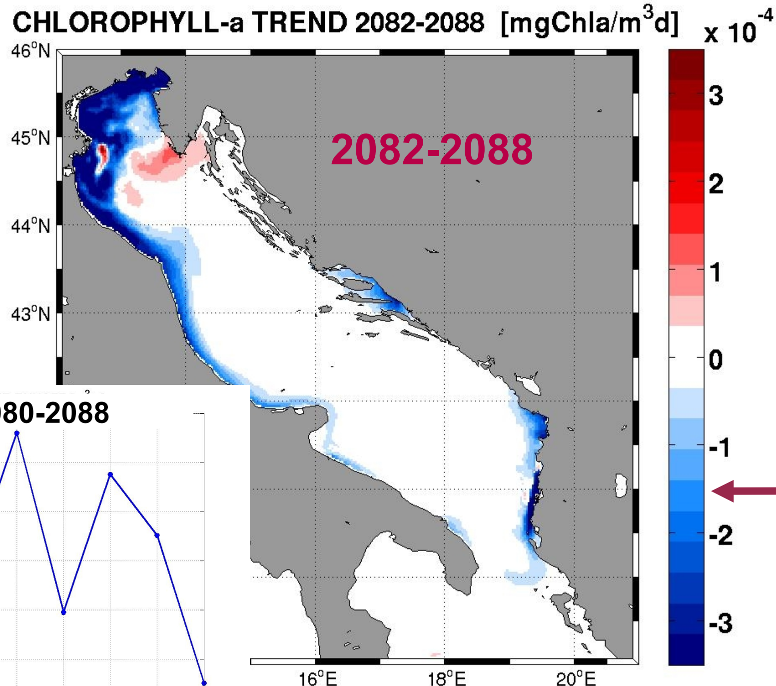
RESULTS 20th + 21st CENTURIES: SEA SURFACE TEMPERATURE & SALINITY

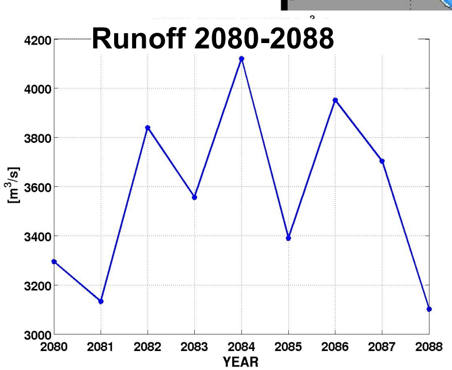




RESULTS 21st CENTURY: CHLOROPHYLL



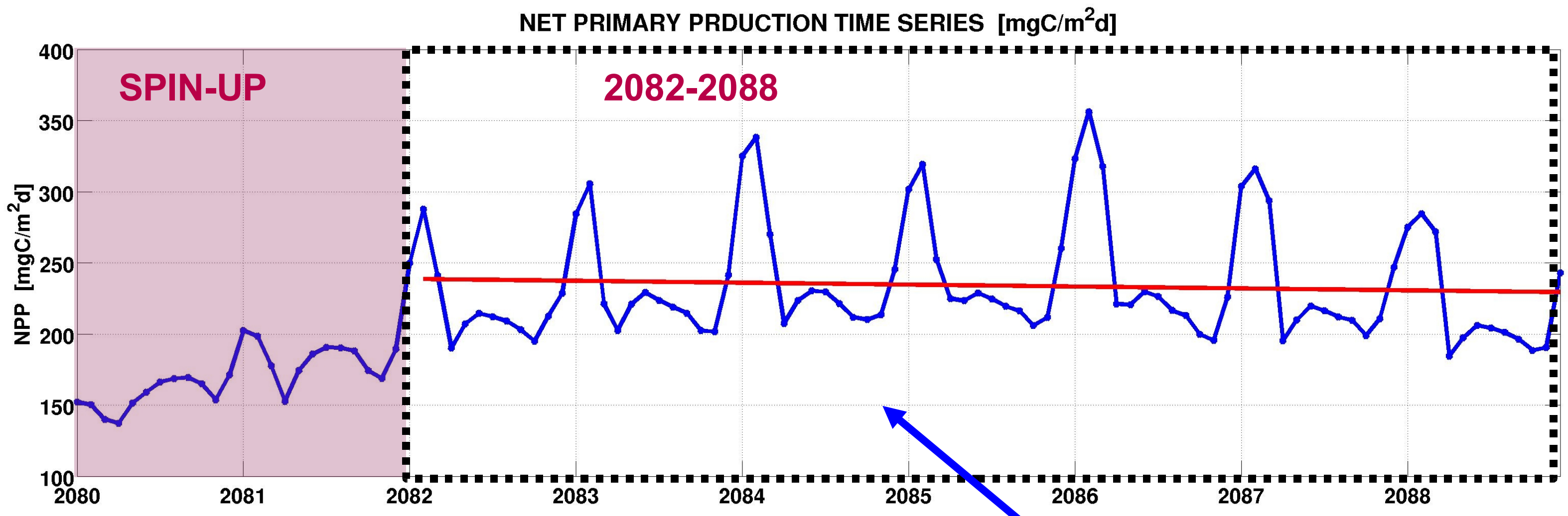


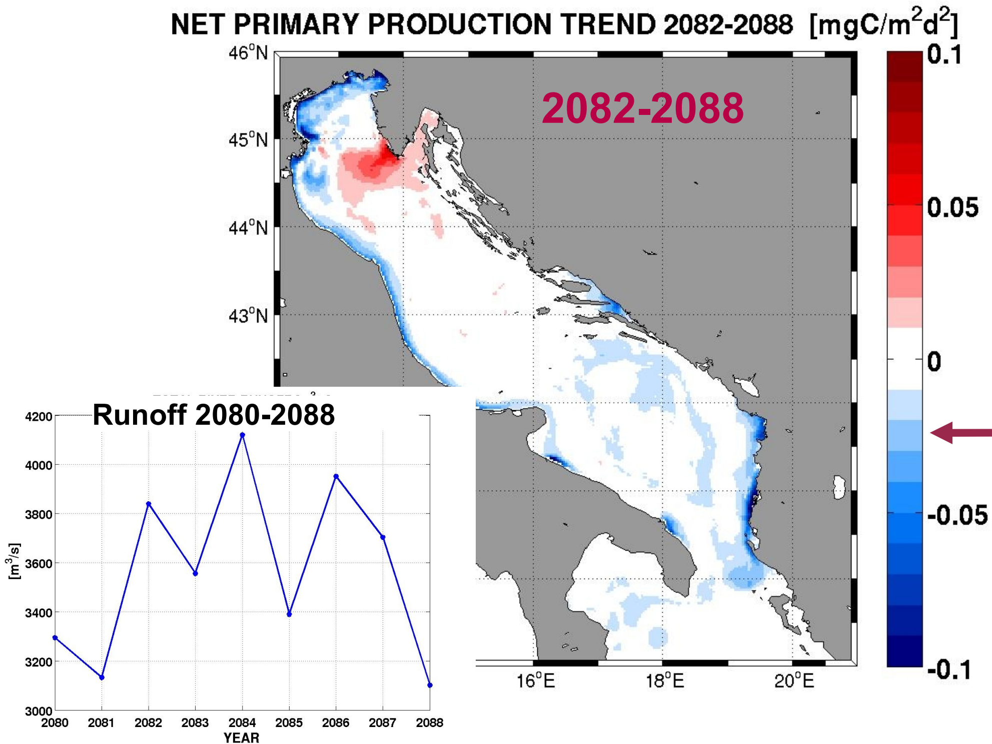


Chlorophyll-a time series: monthly averages slightly decrease at the end of the simulated period

Map of Chlorophyll trend: negative values in particular in the North-West area

RESULTS 21st CENTURY: PRIMARY PRODUCTIO

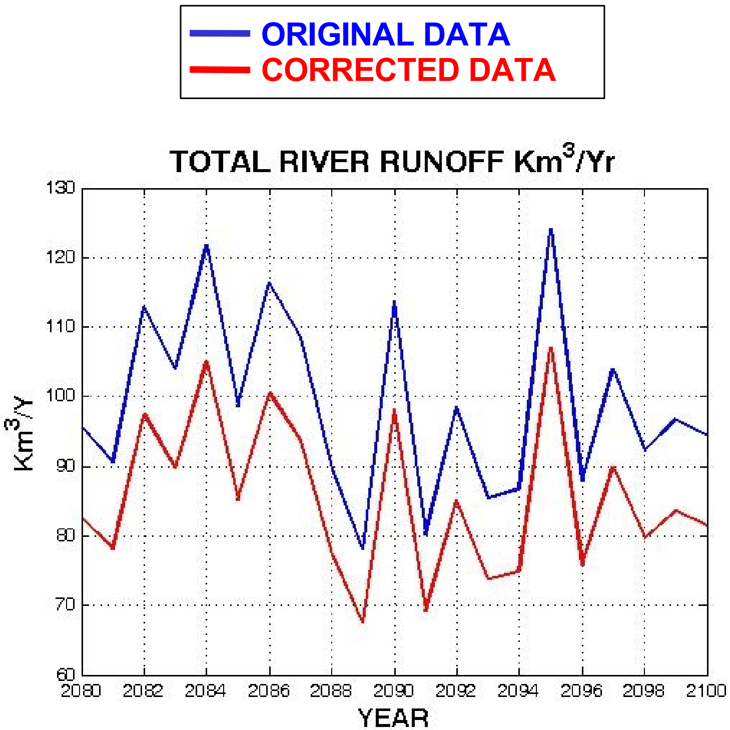




Primary Production time series: no significant trend is detected in the period 2082-2088

Map of Primary Production trend

RIVER RUNOFF & NUTRIENT LOAD 2080-2100

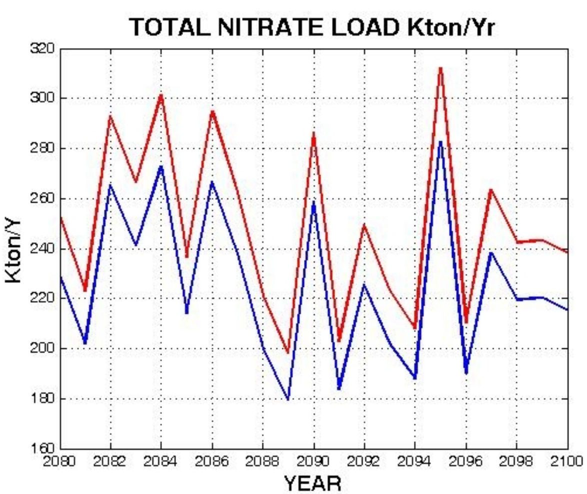


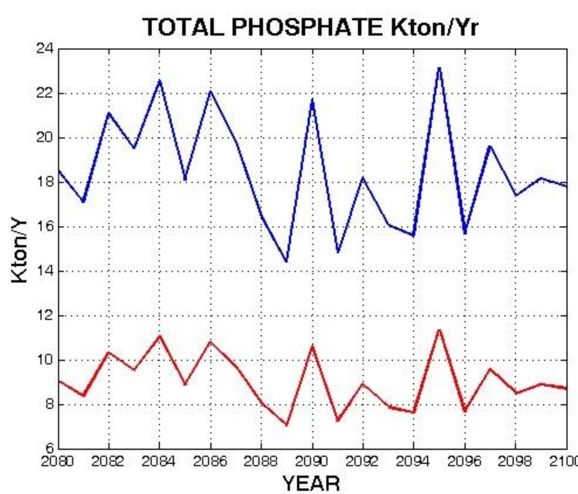
Original data: very **high** values used for simulation 2080-2088 (Previous 2 slides)

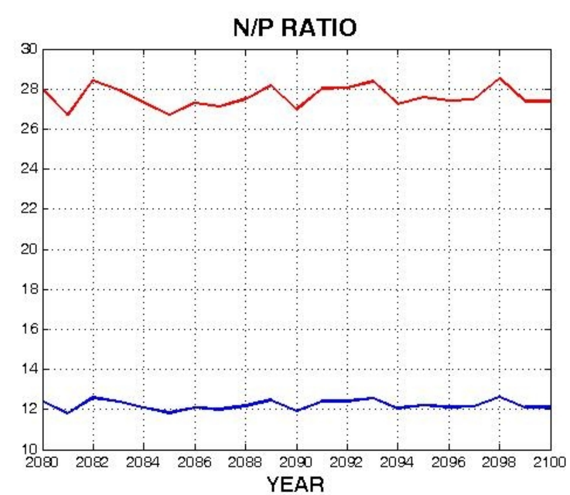
UNCERTAINTY VERY HIGH

Corrected data on the basis of the differences between 20th century observations (Po river) and corresponding hydrological model simulations.

To be used as forcing function in the 21st century simulation.







CONCLUSIONS

- The model generally overestimates primary producers and temperature but seasonal cycle in good qualitative agreement

- Primary production patterns are crucially linked to the load based nutrient inputs

- The reduction of Phosphate sensibly affects the lower trophic levels

- Uncertainty in the 21st century river runoff and nutrient load must be taken into account