A DOWNSCALING EXPERIMENT FOR THE LAGOON OF VENICE. TESTING POTENTIAL IMPACTS OF CHANGES IN PRECIPITATION TEMPORAL PATTERN ON BIOGEOCHEMICAL PROPRIETIES

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Abstract

A downscaling approach adopting a transport-biogeochemical model coupled with statistical and regional climate model data has been used to assess potential effects of nutrient loads variations, induced by climate changes, on the water quality of Venice lagoon. Results provide evidence of impact of possible regional effects of global climate change: the strengthening of seasonal dynamics - drier summer and rainier autumn - will produce a decrement of productivity of the ecosystem.

Keywords : Adriatic Sea, Lagoons, Global Change, Coastal Models, Geochemical Cycles.

Introduction - Nutrient loadings are among the most influential forcing in coastal and estuarine ecosystems. Climatic changes can induce variations of precipitation patterns and might substantially modify river runoff and nutrient loading both in terms of amount and timing thus affecting water quality of coastal ecosystems. This is one of the less studied effects of climatic changes because of difficulties in describing these cascading changes [1]. This study aims at assessing the potential impact of changes on seasonal precipitation pattern on biogeochemical proprieties in the lagoon of Venice, where spatial distributions and time variability of biogeochemical proprieties are clearly influenced by river runoff and lagoon-sea exchanges [2]. We implemented a downscaling experiment, represented in Fig. 1, which involves four components: a regional climate model providing inputs for two statistical models that gave boundary conditions for a coupled transport-biogeochemical model of the lagoon. The hierarchy of models was used to hindcast present climate and to explore two possible future scenarios.

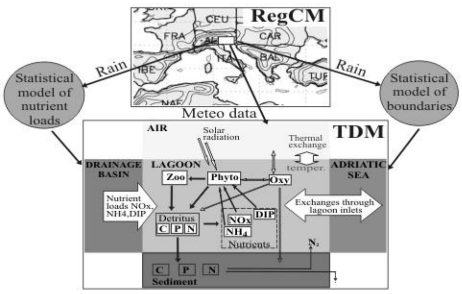

Fig. 1. Downscaling approach used in our study. domain of the RegCM (modified from [3], upper panel), statistical models (grey circles), TDM (lower panel). The superimposed box indicates the area of interest.

Models - We use the output of a Regional Climate model, RegCM [3], extracting high-resolved meteo data for the drainage basin of the Venice lagoon (Fig. 1). RegCM provided three multidecadal data sets, relative to a present-day climate (1961-1990, RF), and two future scenarios (2071-2100, A2 and B2) [4]. Output of RF run for the area of interest was validated against several climatologies. A statistical logarithmic regression model between annual nutrient loads and observed precipitation was calibrated using historical data and was used to provided annual loads from RegCM output. A climatological annual evolution of nutrients and phytoplankton concentrations at the lagoon-sea boundaries data was modulated according to seasonal precipitation of RegCM output and a regression model based on historical data. Finally a coupled transport-biogeochemical model (TDM) [5] was used to simulate trophodynamics in the lagoon. The model state variables are inorganic nutrients, phytoplankton and zooplankton concentrations and N, C and P contents in detritus and in sediment. Transport is described in term of pure turbulent diffusion, inhomogeneous and anisotropic diffusion tensors parametrize the tidal mixing. Model boundaries are taken from the two statistical models and directly from RegCM output for meteorological conditions. The TDM model, corroborated using experimental data of 2001-2003 period, showed a good performance when simulating very different conditions of both rainy and dry years.

Results - The projections of future climate simulated by the two RegCM scenarios, A2 and B2, show both a strengthening of the seasonal dynamics, resulting in more precipitation during the rainy season (autumn) and in less precipitation during the dry season (summer) with respect to the present-day situation (RF). The impact of these variations on biogeochemical proprieties was assessed comparing the present-day TDM run RF-forced, with TDM A2 and B2-forced scenarios. The comparison is summarized in Table 1. Changes of the rain regime implied a seasonal variation of nutrient loads characterized by a mean decrease in spring and summer (more intense in A2 than in B2), and an increase in winter and autumn. As a consequence, the mean level of DIN (sum of NH4 and NOx) during winter and autumn was higher in future scenarios than in the present-day run. Such a surplus of nutrients was not utilised in the system and resulted in an increase of nutrients export to Adriatic Sea in A2 and B2 scenarios. In spring and summer the decrease of nutrient loads implied a decrease of nutrient concentrations in the system. Under A2 scenario such reduction caused a widespread decrease in the productivity of system. The number of years characterized by very dry summer increased of about 20% with respect to the RF run.In B2 scenario, the decrement of nutrient content did affect neither mean seasonal phytoplankton biomass nor primary production, but had a strong impact on secondary production, that decreased by 10% during summer (Table 1).

Tab. 1. Seasonal means of RF run (first 4 rows). The other groups of rows report the comparisons (percentage variation) between A2, B2 and RF.

		Input N	DIN	Phytopl.	Prim. Prod.	Sec. Prod.	Export
		10^3kg/y	mg/l	mgC/l	10^3kg/y	10^3kg/y	10^3kg/y
RF	WIN	1304	0.558	0.290	1352	499	-988
	SPR	1629	0.359	0.702	4412	1295	-1119
	SUM	1290	0.172	0.924	4712	1135	-806
	AUT	1710	0.593	0.292	1507	509	-1325
A2	WIN	+12%	+12%	-2%	-2%	0%	+13%
	SPR	-4%	-2%	-1%	0%	+1%	+1%
	SUM	-9%	-16%	-3%	-6%	-13%	-11%
	AUT	+8%	+7%	+1%	+2%	+3%	+7%
B2	WIN	+15%	+12%	0%	0%	+2%	+14%
	SPR	-1%	+4%	0%	+3%	+5%	+7%
	SUM	-6%	-10%	0%	-3%	-10%	-5%
	AUT	+6%	+3%	0%	+1%	+2%	0%

Conclusions - Climate predictions showed a strengthening of seasonal dynamics and the decrease of summer precipitation would affect biogeochemical proprieties of the systems: and a productivity reduction of the system would be expected. Such an effect was amplified and more easily recognized in the higher trophic level of the ecosystem.

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