Changes in the timing of phytoplankton blooms: comparison between the northern and suthern Adriatic Sea

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INTRODUCTION

We study the changes in the phenology of phtoplankton blooms in the Adriatic Sea, using satellite images of chlorophyll a concentration. The northern Adriatic (NA) is a coastal, river-dominated ecosystem influenced by anthropogenic nutrient enrichment, while the southern Adriatic (SA) is characterized as a true pelagic ecosystem with minimal influence from coastal waters on nutrient levels. Here, the primary production is primarily controlled by meteorological conditions that dictate convective mixing and nutrient availability for autotrophic uptake. Most of NA experiences two phtoplankton blooms - a spring and an autumn bloom, while SA experiences one bloom only which starts in the autumn and usually peaks in the winter months. We investigate trends in the timing of the onset and peak of phytoplankton blooms, searching for environmental factors influencing these shifts. As anticipated, the onset of the autumn bloom is found to be delayed, with statistically significant trends observed only in some areas.

METHODS

Daily multi-satellite L4 chlorophyll a concetration data were obtained from CMEMS (DOI: 10.48670/moi-00300; OCEANCOLOUR_MED_BGC_L4_MY_009_144) for the 1998 to 2022 period. The Rate of change method (ROC) and Threshold method (TH) were used to identify the bloom initiation for each pixel in all of the years (Brody et al., 2013).

TH: Identify the highest Chl a value in a given period, go back in time until the value falls below a preset threshold for at least 13 consequtive days (Fig1).

ROC: Reconstruct a smooth time series by performing a Fourier and an inverse Fourer transform with a limited number of coefficients. The timing of the largest time derivative value in the series marks the onset of bloom. The maximum value of the curve marks the bloom peak (Fig 1).

The trend was obtained by a linear fit and p-value was used to determine statistical significance ($p < 0.05$).

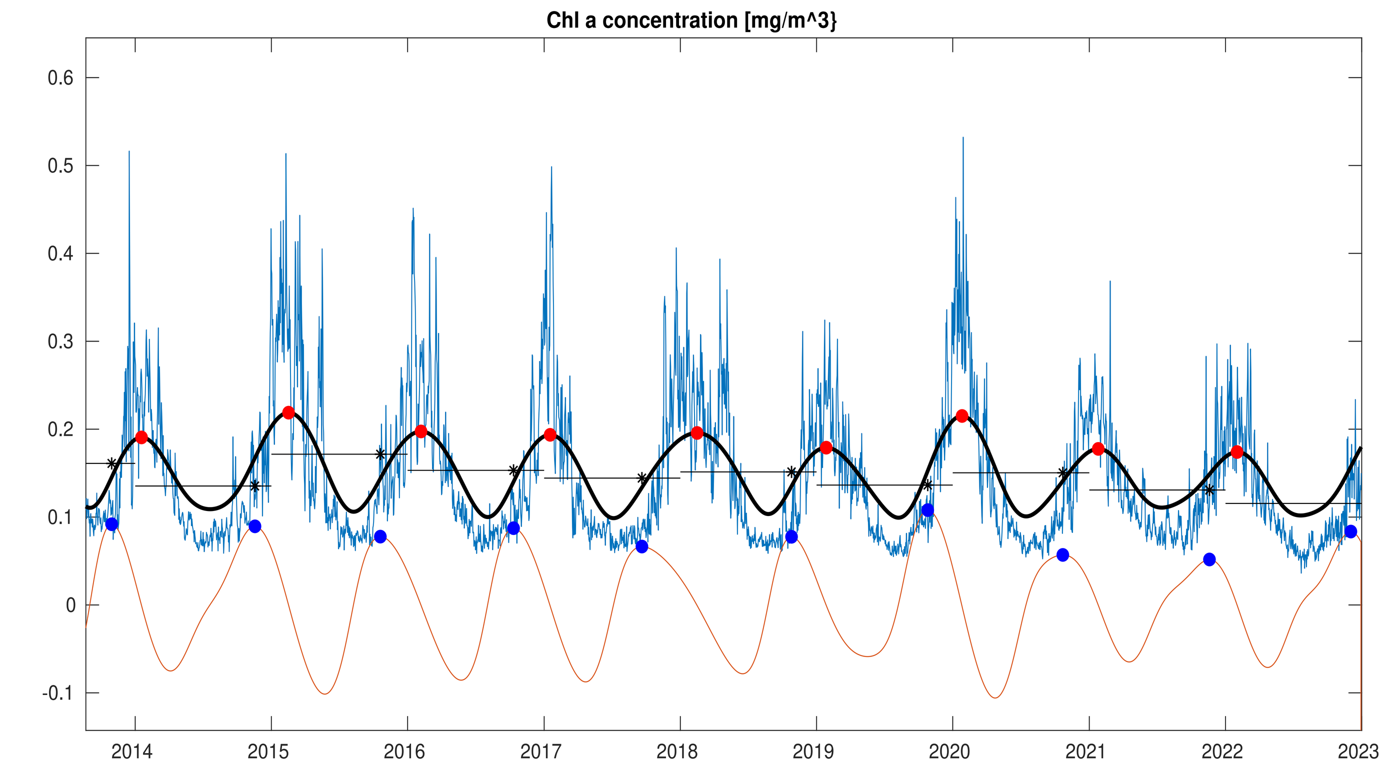

Fig 1: Satellite Chl a concentrations (blue line) for a shortened period (2014-2023) and presentation of both methods for a sample location in the Adriatic Sea. ***TH***: threshold value for each year (black horizontal ines), identified autumn bloom initiation (black star). ***ROC***: reconstructed time series (black curve), bloom peaks (red dots), time derivative of reconstructed time series (red curve), bloom initiation (blue dots).

RESULTS

The spring bloom is limited to the northern Adriatic and to the western part influenced by the Po river plume. The autumn bloom is present almost throughout the entire domain except for the area under heavy influence of northern Adriatic rivers (NE of the basin). The spring bloom shows almost no significant trend in the onset or peak timing. The autumn bloom shows a delay in the onset and peak timing, but lacks statistical significance in large parts of the domain. The timing of the bloom initiation somewhat differs for both methods, however, the areas subject to the spring bloom are surprisingly similar.

DISCUSSION

Both methods identify very similar regions that experience summer or autumn blooms or both. The autumn trend is statistically significant only in some locations. The lack of trend significance can partially be attributed to the relatively short period of satellite data availability (from 1998 onwards). The postive trend in autumn bloom initiation is expected. Higher sea surface temperatures delay the convective mixing which is the main trigger of the autumn bloom. The trends in the onset and depth of autumn-winter convective mixing will be the subject of our future work. The spring bloom is likely triggered by pronounced river runoff driven by snowmelt and shows no trend in timing.

ACKGNOWLEDGMENTS

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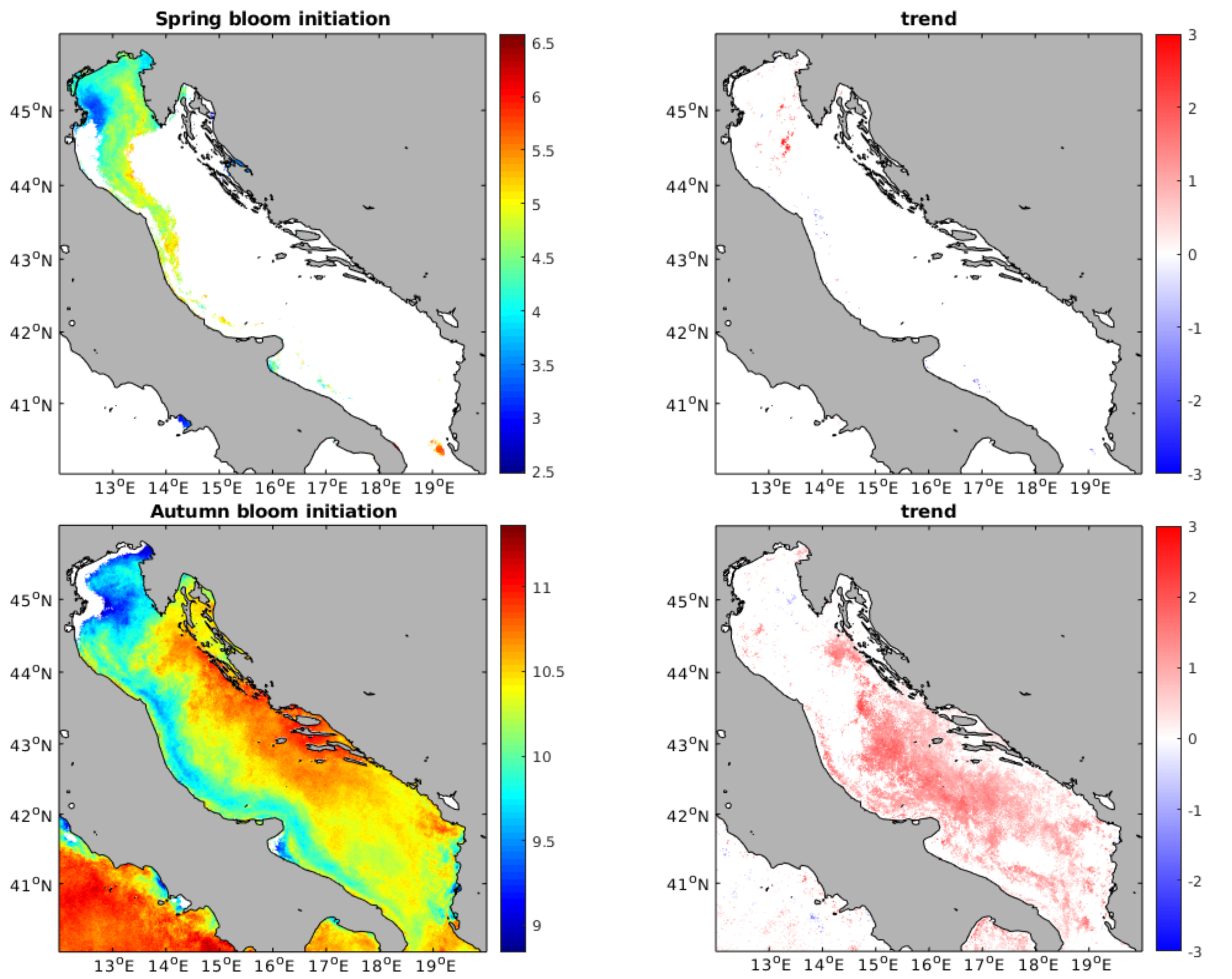

Fig 2: Spring (top) and autumn (bottom) bloom intiation using the Threshold method (***TH***). The timing of initiation is in months, the trend is in days per year.

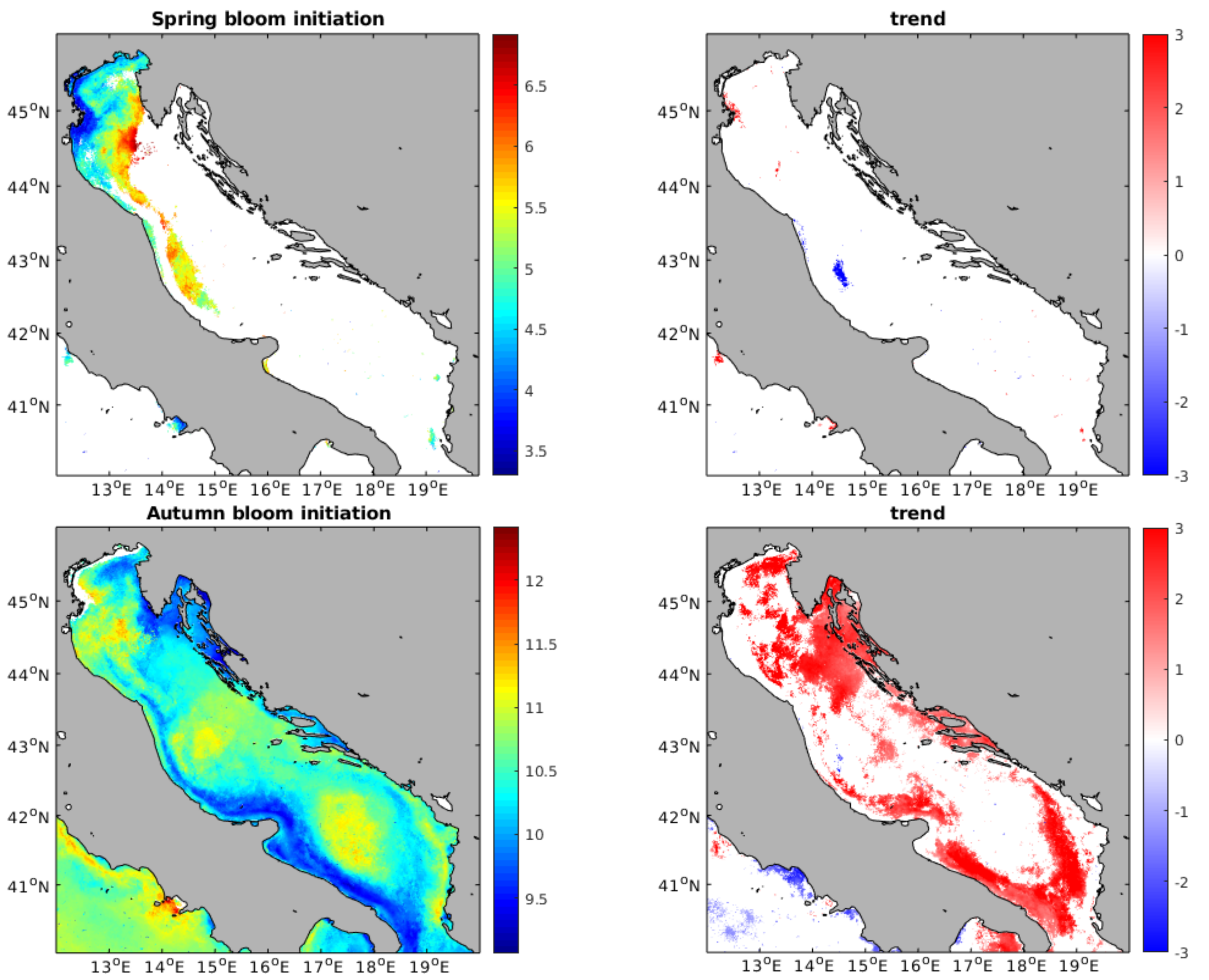

Fig 3: Spring (top) and autumn (bottom) bloom intiation using the Rate of change (***ROC***). The timing of initiation is in months, the trend is in days per year.

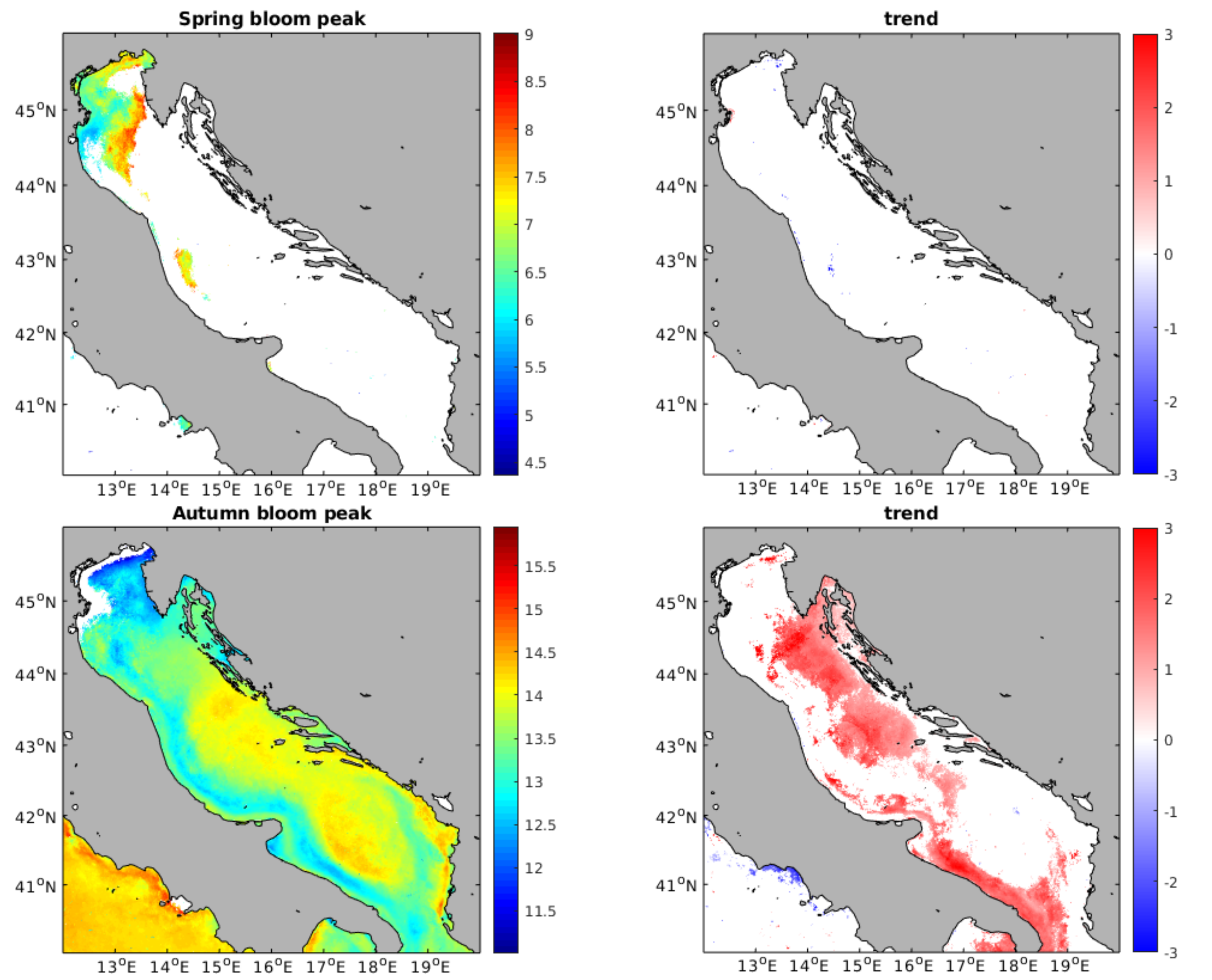

Fig 4: Spring (top) and autumn (bottom) bloom peak timing using the Rate of change (***ROC***). The timing of initiation is in months, the trend is in days per year.