Long-term monitoring of land surface phenological changes

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Abstract

Land surface phenology (LSP) is associated with climate over space and time, and the monitoring of LSP help understandings of the terrestrial environmental changes. The LSP is often inferred by satellite observation, and long-term and regularly composite satellite imagery is now freely available. In this study, we demonstrate how LSP changes over space and time at the global scale over the last three decades by using GIMMS3g datasets. We focus on the magnitude and the timing of the peak of yearly phenological activity, estimated from a harmonic analysis. The first harmonic curve is regarded as a proxy of the overall productivity of vegetation and the second one is interpreted as a sensitive bimodal system changes. Results show the long-term trend of LSP changes; for example the peak of phenogical activity tend to be earlier in high-latitude regions. Land surface phenology (LSP) is associated with climate over space and time, and the monitoring of LSP help understandings of the terrestrial environmental changes. The LSP is often inferred by satellite observation, and long-term and regularly composite satellite imagery is now freely available. In this study, we demonstrate how LSP changes over space and time at the global scale over the last three decades by using GIMMS3g datasets. We focus on the magnitude and the timing of the peak of yearly phenological activity, estimated from a harmonic analysis. The first harmonic curve is regarded as a proxy of the overall productivity of vegetation and the second one is interpreted as a sensitive bimodal system changes. Results show the long-term trend of LSP changes; for example the peak of phenogical activity tend to be earlier in high-latitude regions.

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Introduction

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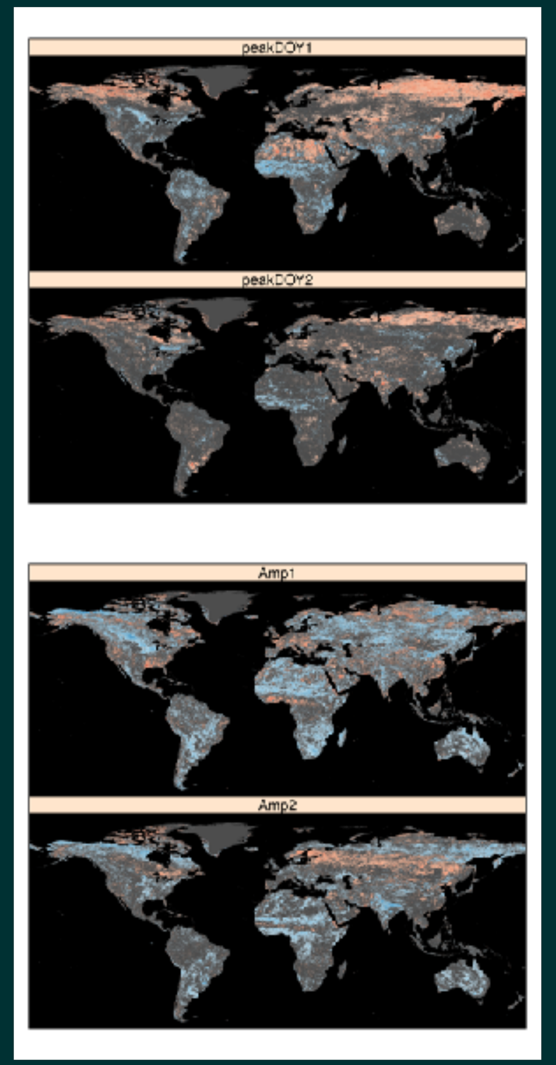
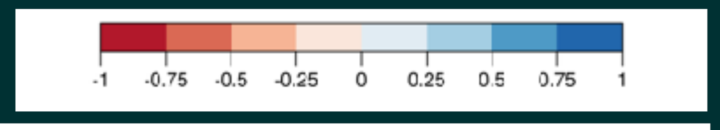
Results

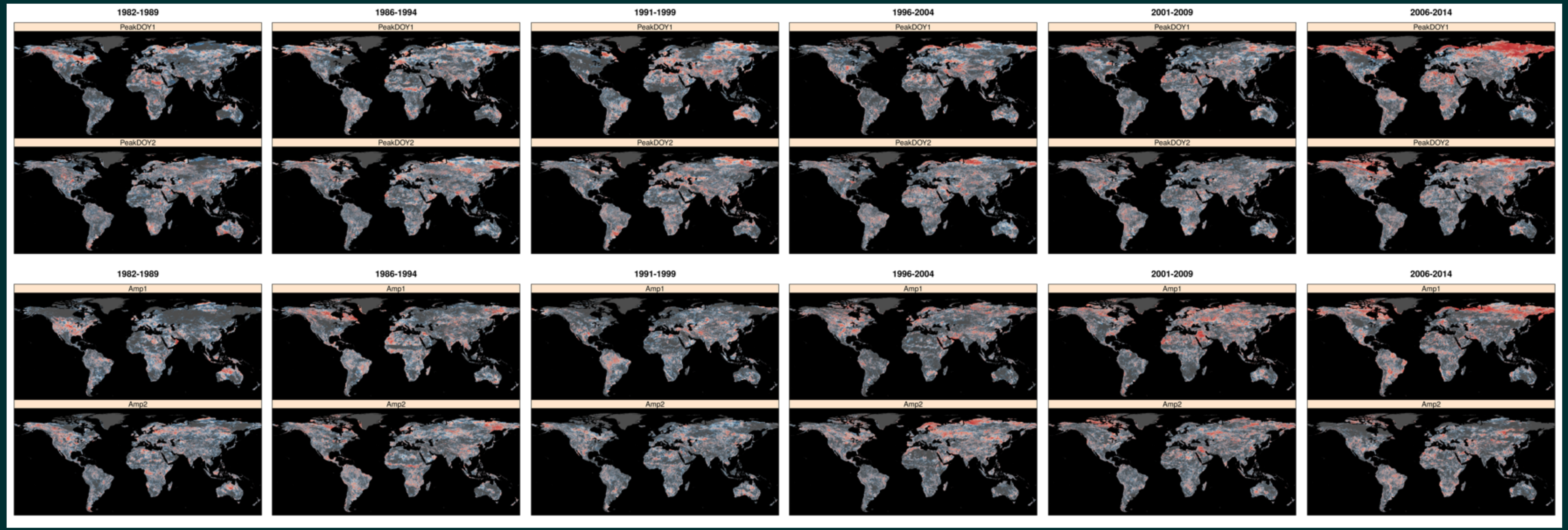
MannKendall trend test with mask (p<=0.05)

1982-2015

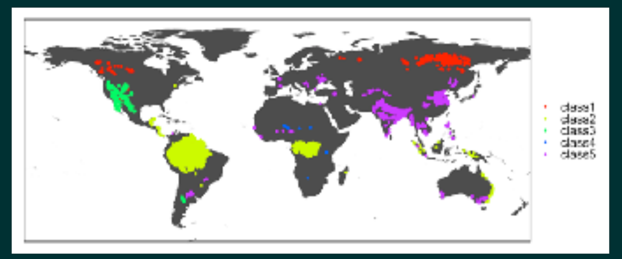


10 years moving window at 5 years interval





Distribution of homogenous land cover points



Land cover class

class1: Evergreen/Deciduous Needleleaf Trees (n=900)
class2: Evergreen/Deciduous Broadleaf Trees (n=900)
class3: Shrubs (n=900)
class4: Herbaceous Vegetation (n=24)
class5: Cultivated and Managed Vegetation (n=900)

Homogenous and temporally consistent land cover pixel locations are picked up. GLCC(1992-1993, version 2), GLC2000 (2000, version 1.1), and GlobCover (2005, version 2.2 and 2009, version 2.3) are spatially aggregated into the same size as GIMMS3g pixel. Land cover definitions are also aggregated into general classes above. Water-related body and mix-land cover classes are excluded. Finally stratified sampling (n=900) is implemented so that sampling numbers of all classes can be the same, although number of class4 is insufficient (n=24).

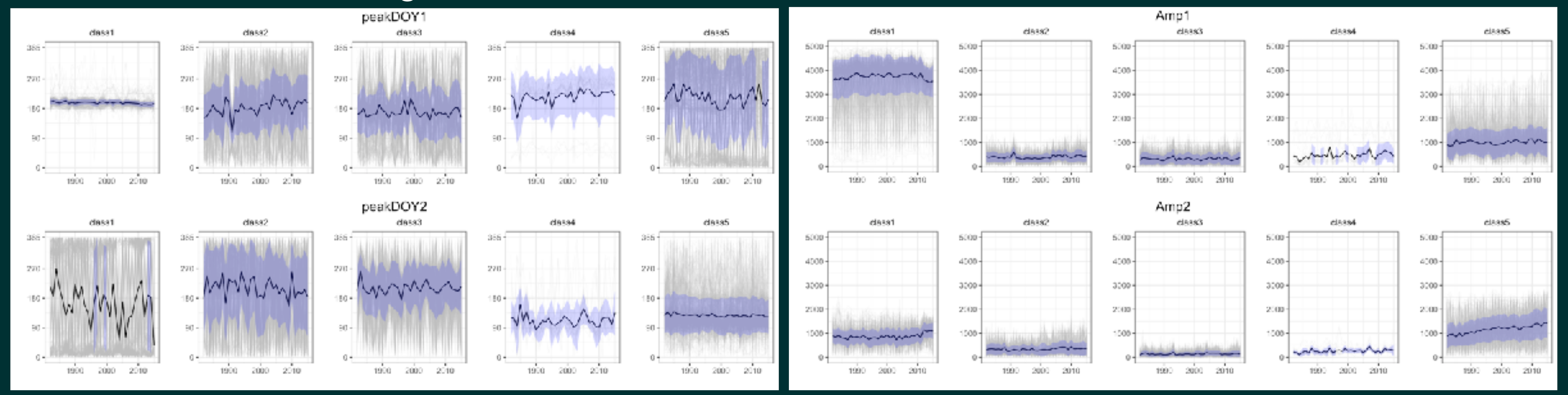
Materials & METHODOLOGY

GIMMS3g datasets which summarize the longest historical NDVI is used for the year 1982-2015. Harmonic analysis is annually applied so that the magnitude and the timing of the peak of yearly phenological activity are estimated every year.

$$f(x) = \sum_{k=1}^{n}\left(c_k cos\left(\frac{2\pi kx}{L} + \emptyset_k\right)\right) + c_0 + \varepsilon,$$

The first harmonic curve which indicates a simple cosine curve in a year is regarded as a proxy of the overall productivity of vegetation, and the second one is interpreted as a sensitive bimodal system changes. The magnitude in the first wave is considered as c1 in the formula and the peakDOY is estimated from phase ϕ1 so that the DOY of the top of the curve is assigned. They are also estimated by the same procedure for the second wave (c2 and ϕ2) .
Finally non-parametric Man-Kendall trend test is applied for the magnitude and peakDOY of the first and second waves in the 34 years. Time series data split by 5 years step (1985, 1990,.., 2010) including following/previous 5 years are also applied to investigate temporally specific trends.
In order to see differences of trends according to terrestrial land cover, time series of peakDOY and Amplitude of the first and second harmonic waves are picked up in homogenous land cover.

Time series change in Land cover



A black line and a blue band shows the average and the standard deviation of time series in each class, respectively.

Average Mann-Kendall tau in 1982-2015
in each land cover class. standard deviation in bracket.

	peakDOY1	peakDOY2	amp1	amp2
class1	-0.277 (0.209)	0.026 (0.166)	0.043 (0.285)	0.16 (0.218)
class2	0.141 (0.159)	-0.052 (0.147)	0.057 (0.19)	0.07 (0.153)
class3	-0.053 (0.183)	-0.001 (0.132)	-0.001 (0.207)	0.05 (0.155)
class4	0.246 (0.138)	0.009 (0.075)	0.222 (0.126)	0.2 (0.196)
class5	-0.063 (0.233)	-0.091 (0.293)	0.087 (0.292)	0.38 (0.281)

Although focusing on homogeneous land cover pixels, there are much internal variation of peakDOY in class. However, *Evergreen/Deciduous Needleleaf Trees* shows explicit trends of peakDOY1 (gradually earlier) and Amp2 (larger since 2011). Cultivated and Managed Vegetation also showed gradually increasing trend in Amp2

CONCLUSIONS

Based on GIMMS3g (version 1) data processing, spatio-temporal trends of peak and the amplitude of the first two annual curves are explored. Overall, peaks tend to be shifted earlier in high latitude regions, and amplitudes tend to be stronger in many regions. The changes in 2006-2014 are explicitly outstanding such as earlier shifts of the peak and decreasing amplitude of the first wave.
Analyses of the relation between such changes and Land cover are still difficult due to the internal variation of change in land cover class even when omitting mixed pixels, however earlier shifts to the peak of the unimodal annual wave in boreal needleleaf forest. Further analyses will be focused on the cause of this change to investigate relations to climate.

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