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Center for Earth Observation and Digital Earth
Chinese Academy of Sciences

Global Vegetation Phenology Response to Climate Changes from 1982 to 2006

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Contents

1. Introduction

- Highly sensitive to **global change** : “Phenology…is perhaps the simplest process in which to track changes in the ecology of species in response to climate change ” (IPCC AR4: Climate Change 2007-Impacts, Adaptation and Vulnerability, page 99)
- **Feedbacks** to the **climate**.**system** (Albedo, surface energy balance, CO_2 exchange)
- Factor in **ecological interactions**（productivity, competition, pollination, seed dispersal ）
- Relevance for land **management** (agriculture, forestry, invasive plants and pests) and human health (transport of allergens and disease vectors)

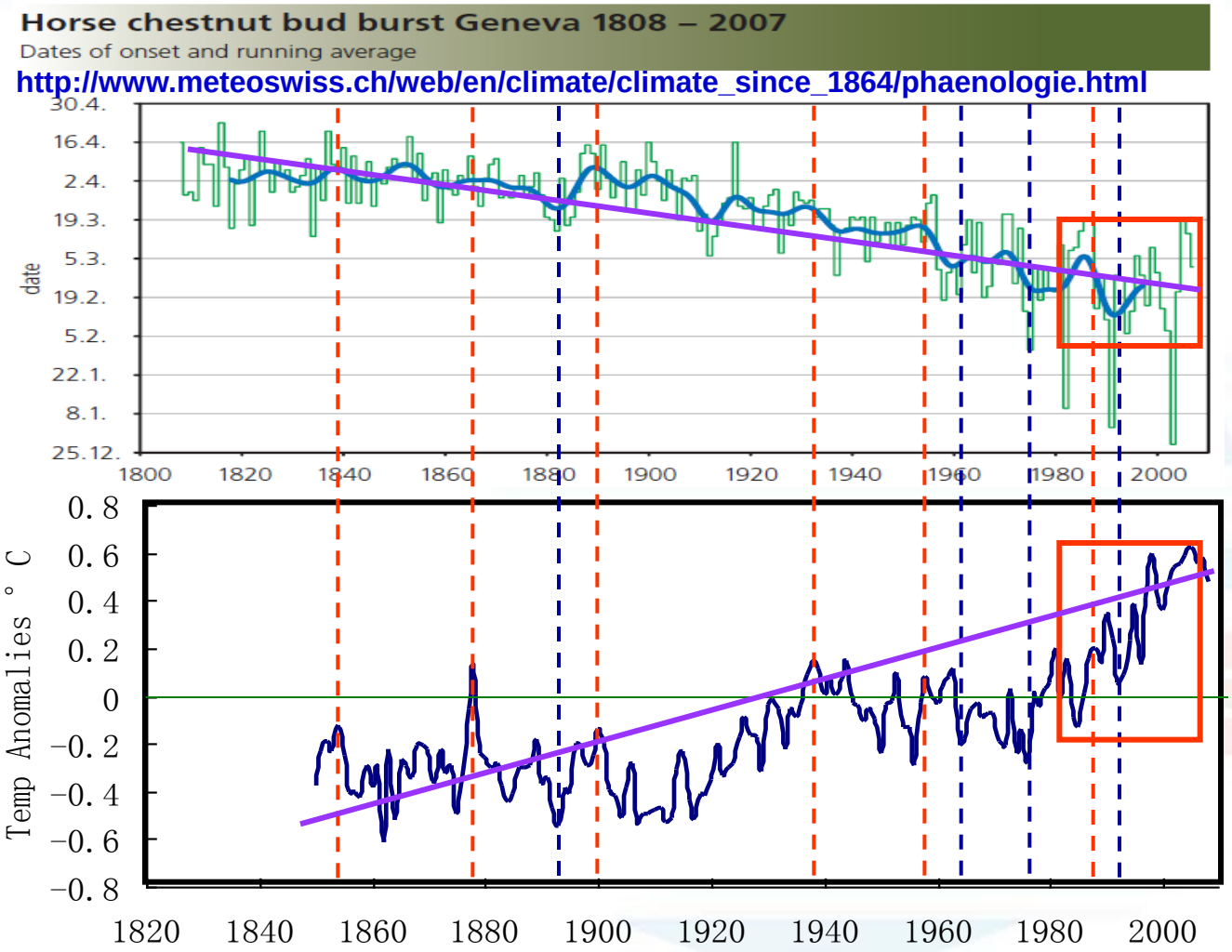
1. Introduction

Many uncertainties about vegetation phenology response to climate changes.

Hughes (2000) mentioned that the nature of scientific publishing is such that papers showing advancing spring due to global warming are more likely to be submitted and published in scientific journals than others. The paper by Kozlov and Berlina (2002) represents a counter example. Here, the authors report a decline in the length of the snow-free and ice-free periods due to both delayed spring and advanced autumn/winter on the Kola Peninsula, Russia, as well as a strong advance of birch first leaf fall by 22 days compared to the 1930s. In general, geographical differences in climate change and corresponding plant responses are quite common. For the Balkan region a delayed onset of spring phases is observed (Menzel and Fabian, 1999) which is also reflected by a later bird arrival in the Slovak Republic (Sparks et al., 1999). Regional studies of plant and animal phenology are extremely important, and due to the advantage of relatively low costs, once the data have been reported by volunteers, phenological studies can shed light on regional peculiarities.

PHENOLOGY: ITS IMPORTANCE TO THE GLOBAL CHANGE COMMUNITY
An Editorial Comment. Climatic Change **54:** 379–385, 2002.

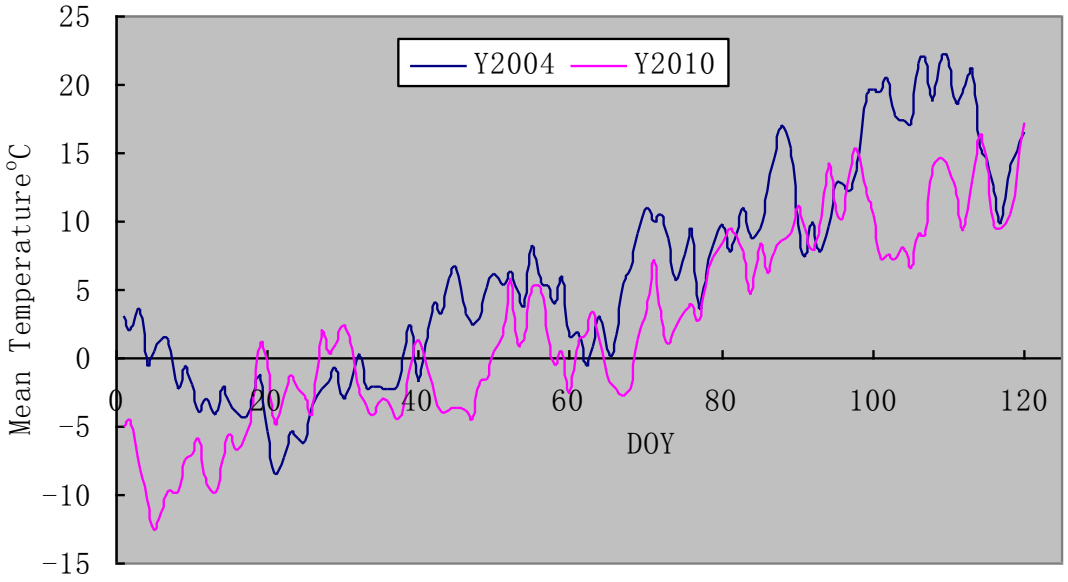
1. Introduction



Jones et al. 2009 http://cdiac.ornl.gov/ftp/trends/temp/jonescru/nh.dat

This is attributable not only to global climate change, but also to changes in the local city climate (Defila and Clot, 2001). Given the strong temperature dependence of plant development, phenological time series are good indicators of the impacts of climate change.

1. Introduction



GDD@2004.4.12=493

Mean T@2004.4=16.3

GDD@2010.4.30=487

Mean T@2010.4=11.3

Hawthorn Tree

2. Materials and Methods

Remote Sensing Data:

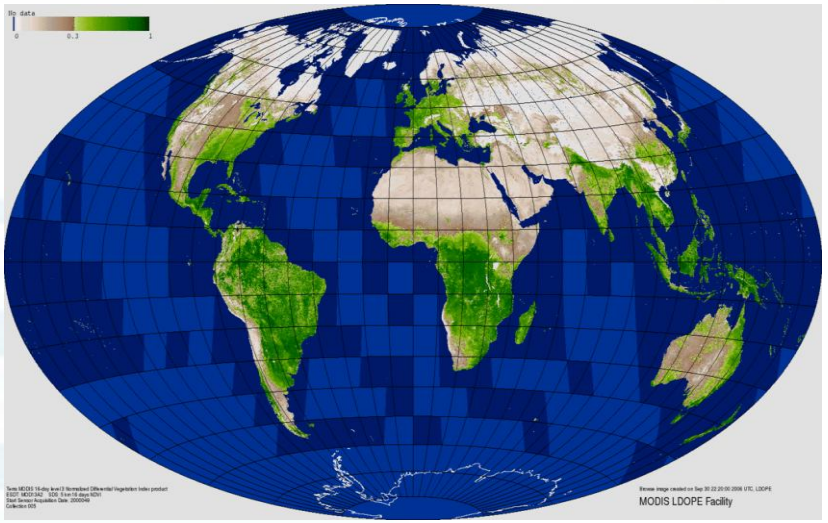
GIMMS AVHRR NDVI datasets, offering continuous and consistent **NDVI** time-series at a **15-day** interval over **8Km** spatial resolution

Meteorological Data:

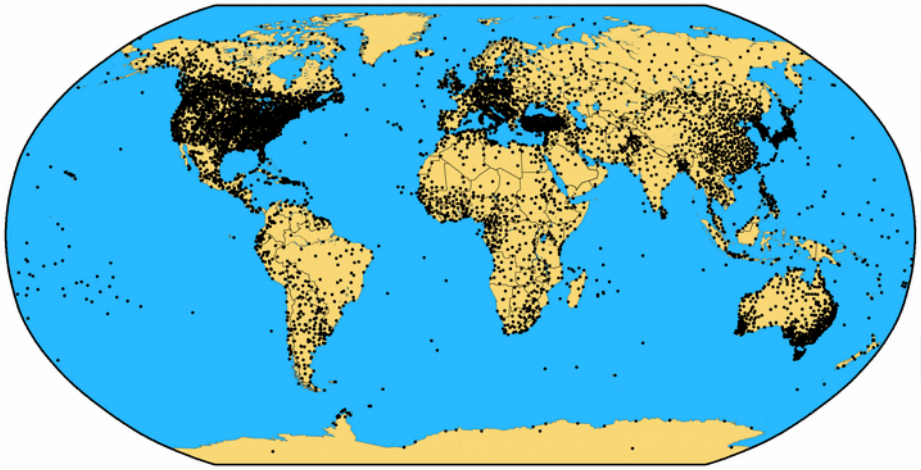
The Global Historical Climatology Network (**GHCN-Monthly**) data base ,more than 6000 stations

Land Use/Land Cover Data:

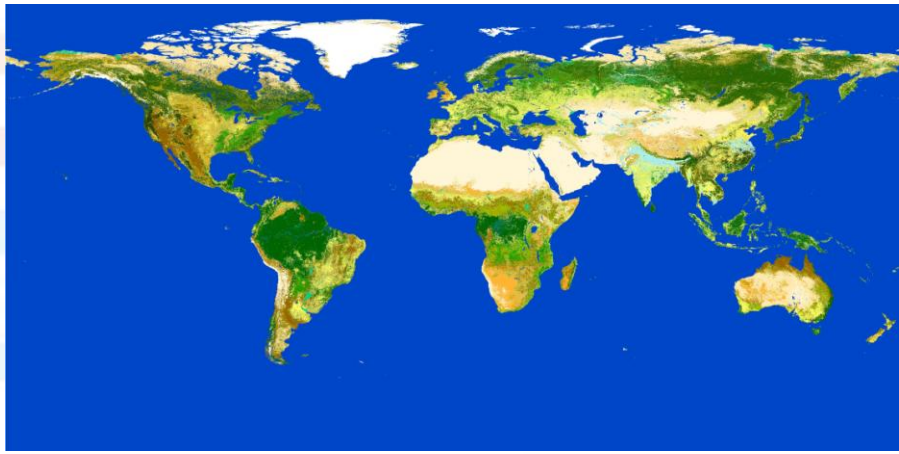
GlobCover data products is made by ESA, derived from the **300m** MERIS sensor on board the ENVISAT satellite mission.



GIMMS AVHRR NDVI



GHCN-Monthly Coverage Map for Mean T



global land cover map

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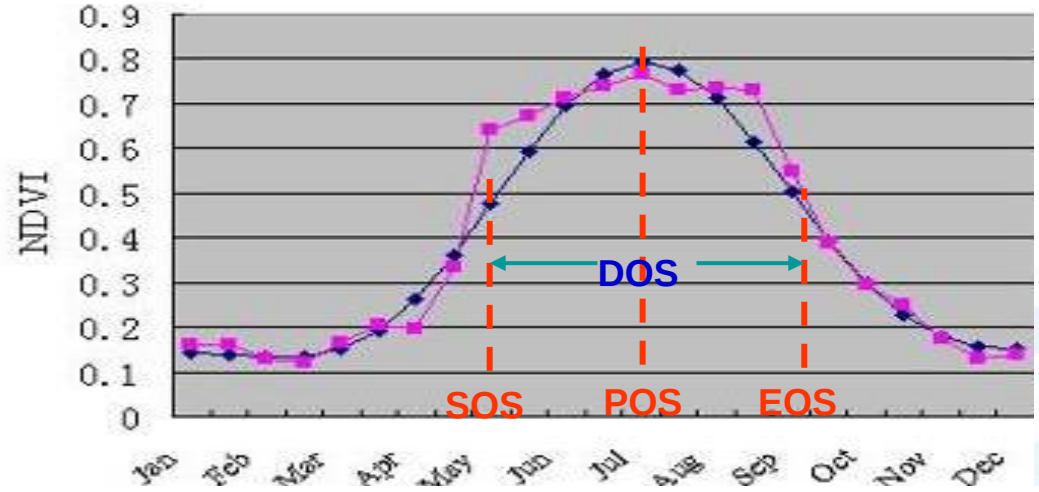
2. Materials and Methods



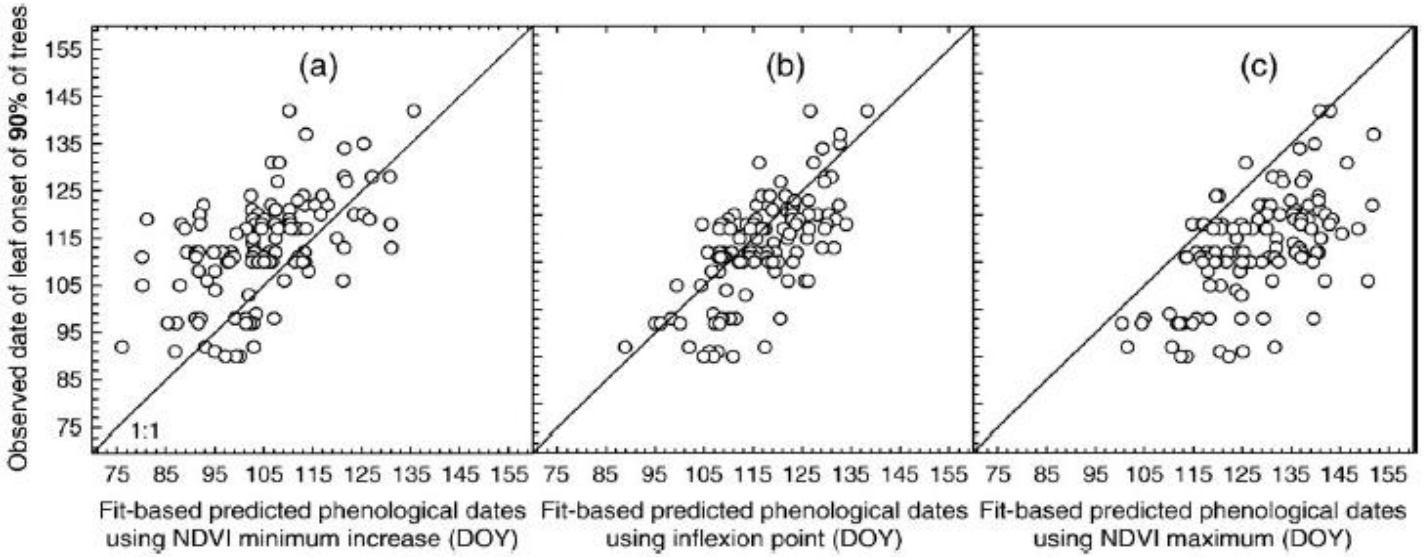
SOS: start of season

EOS: end of season

DOS: duration of season

POS: peak of season

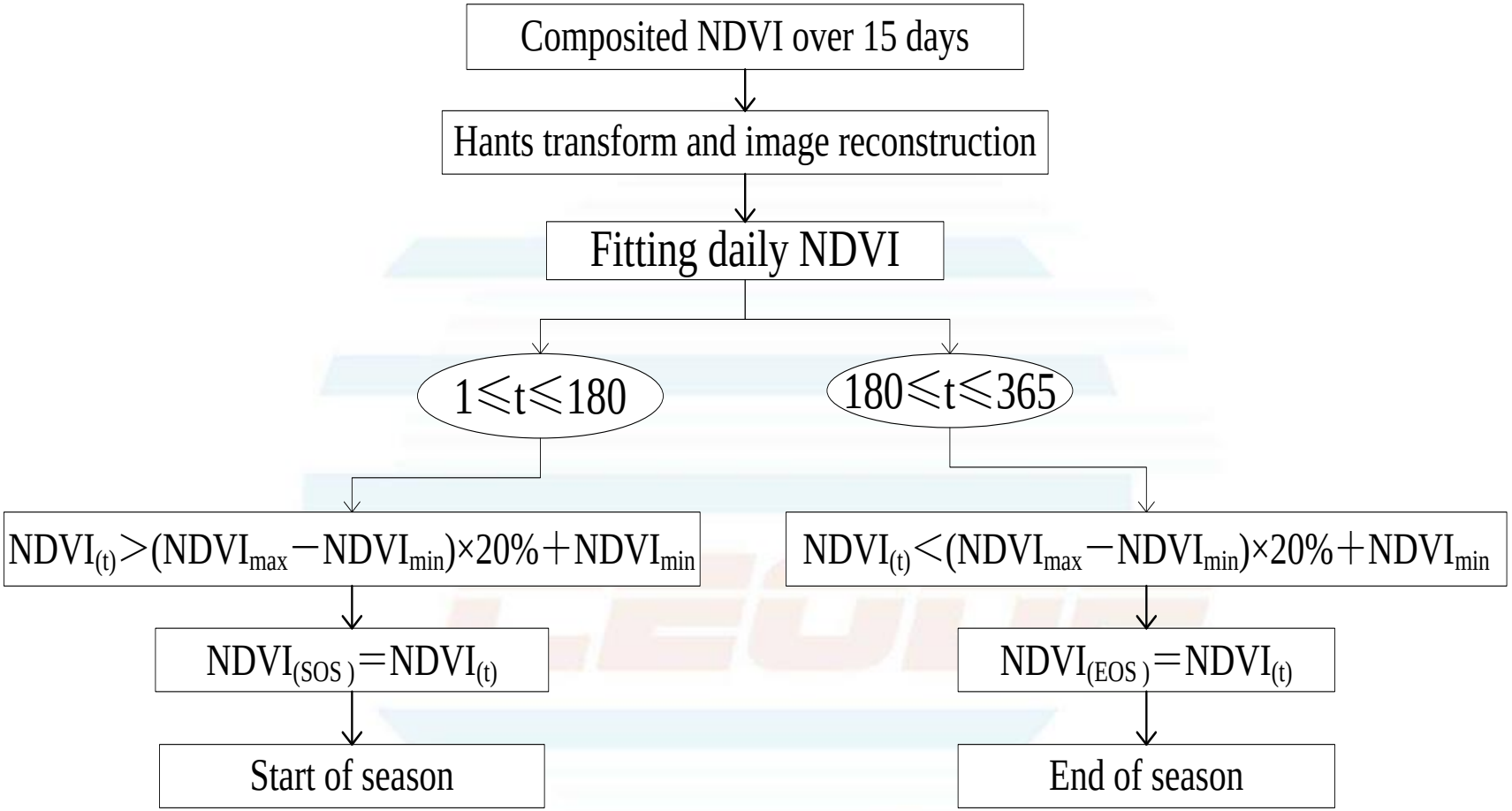
Typical results of Harmonic Analysis of Time Series on NDVI



Soudani et al. Remote Sensing of Environment 112 (2008) 2643–2655

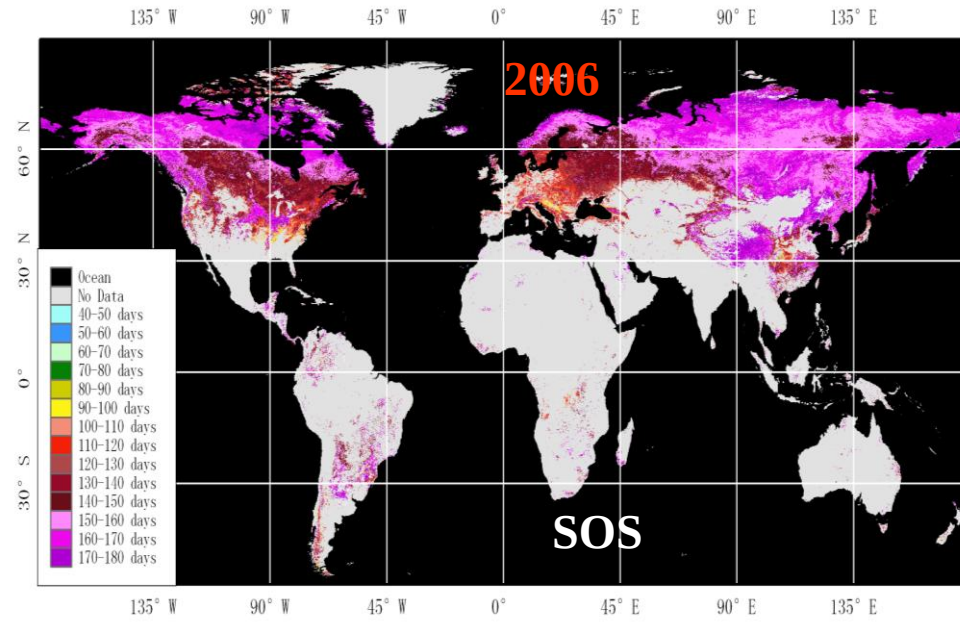
Fig. 4. Comparative analysis between predictions from fitted NDVI time-series and field observations of the date of onset of green-up at 90% (*OG90%*).

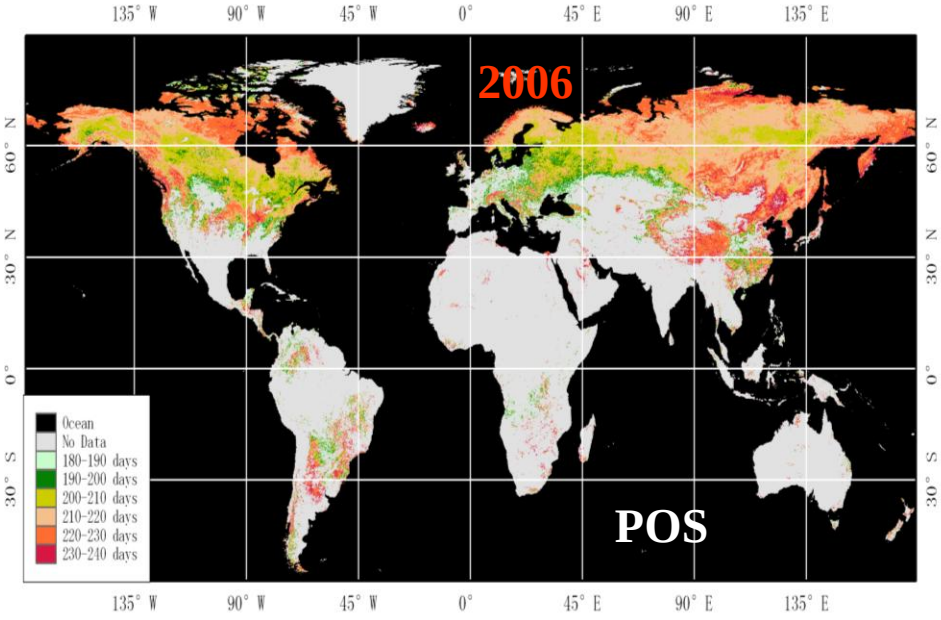
2. Materials and Methods

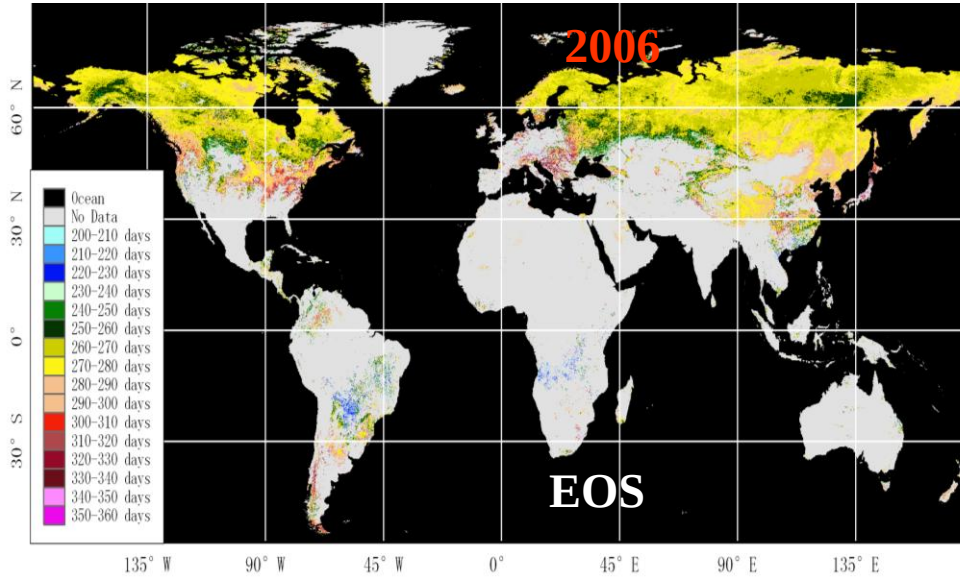


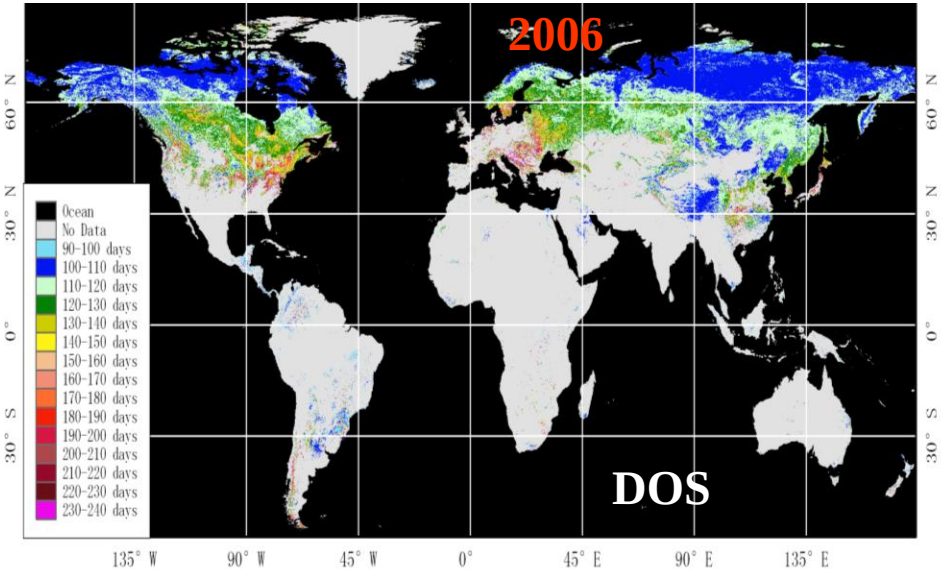
Flow chart of dynamic threshold method for phenological dates from time-series NDVI

3. Global Vegetation Phenology









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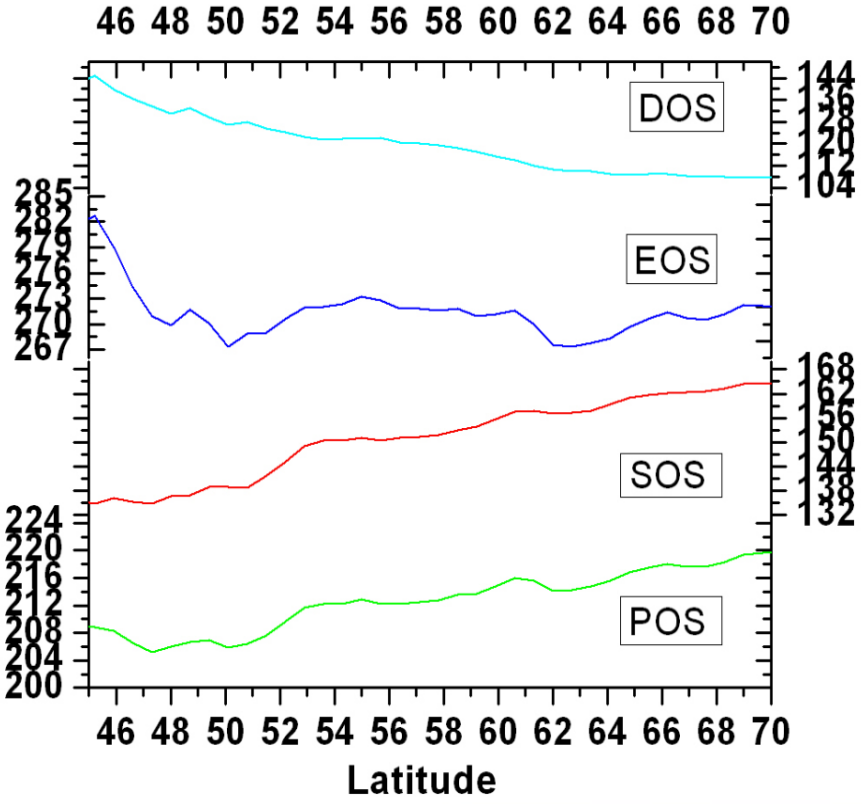
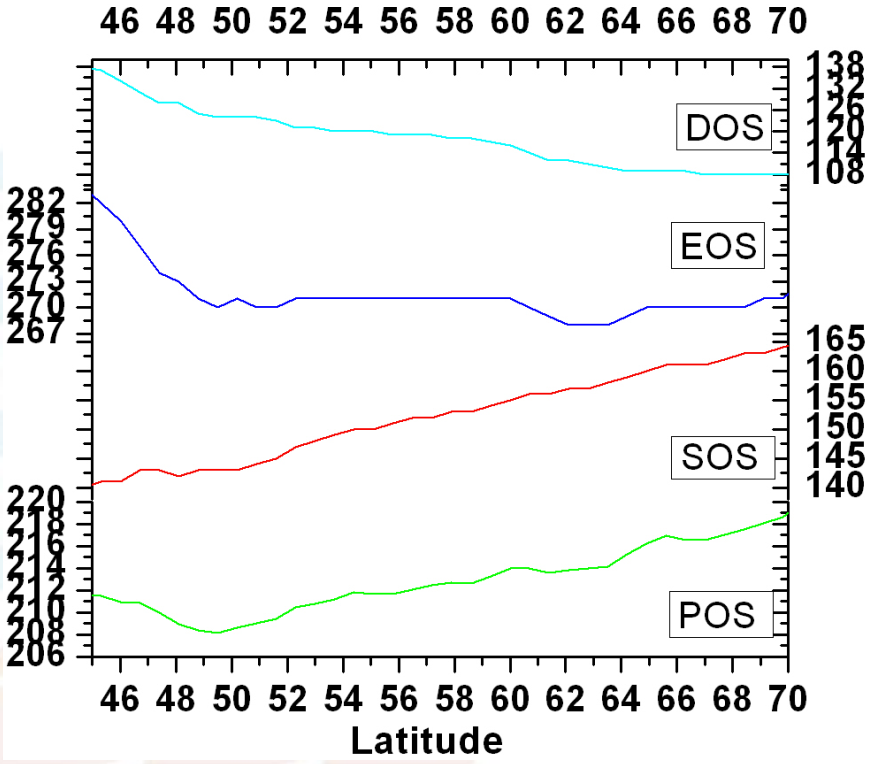
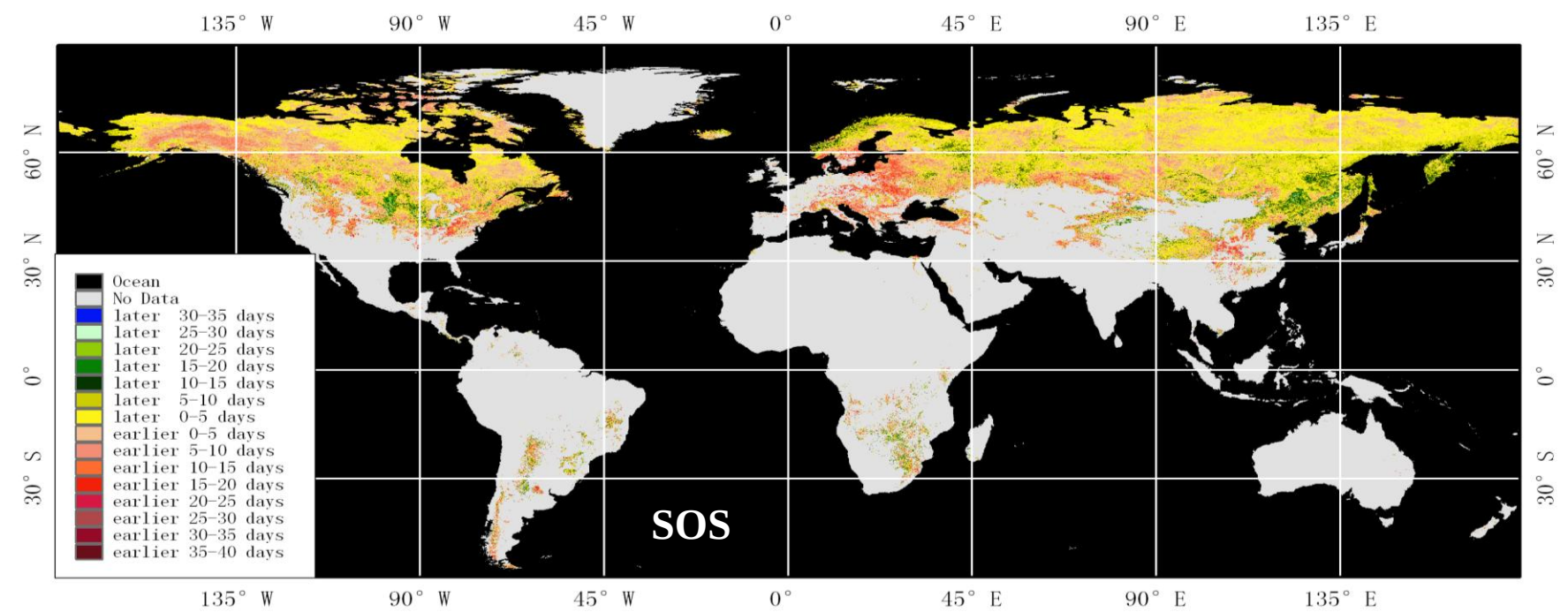
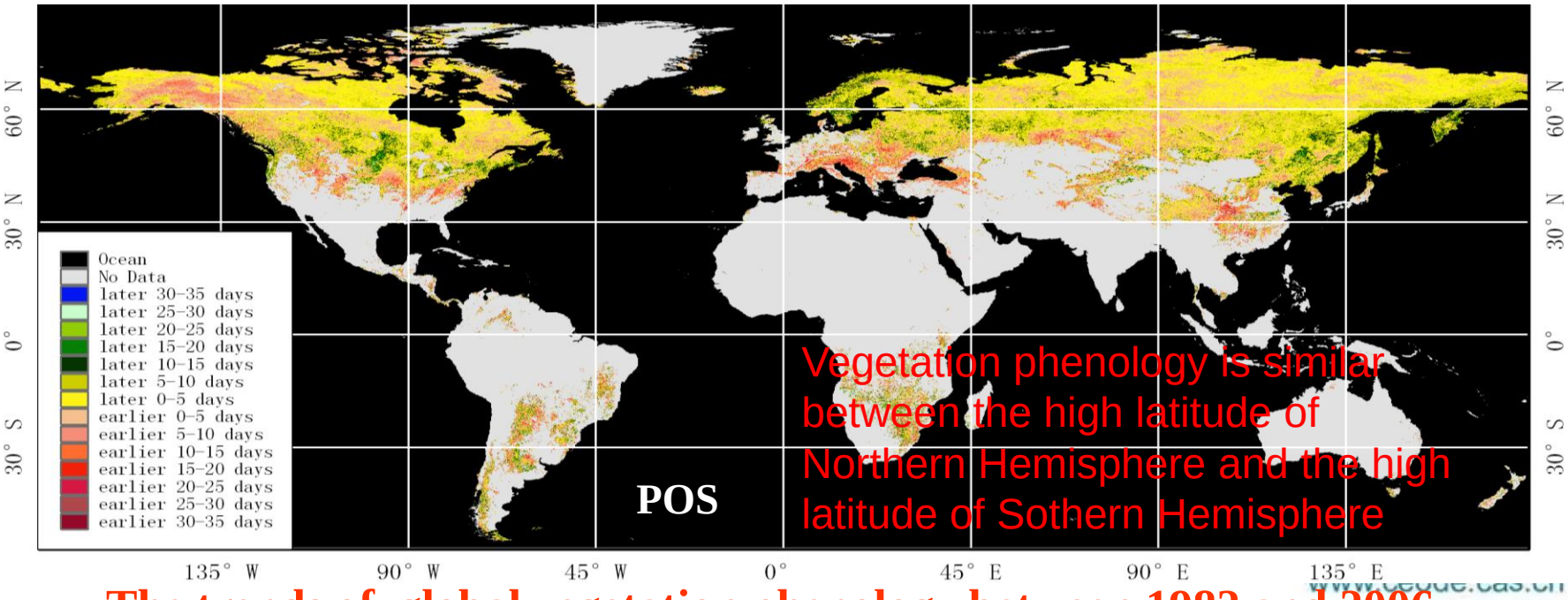


The trends of phenology metrics increasing with latitude in North America （America and Canada） in 2006

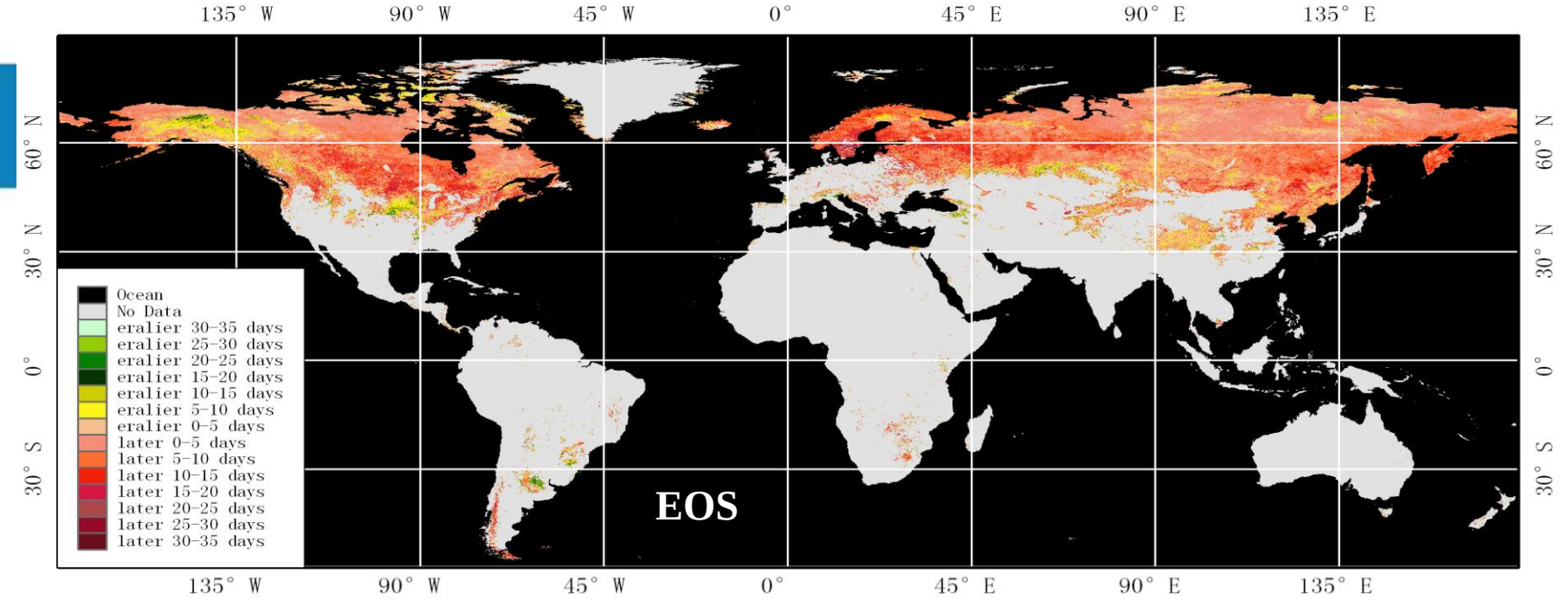


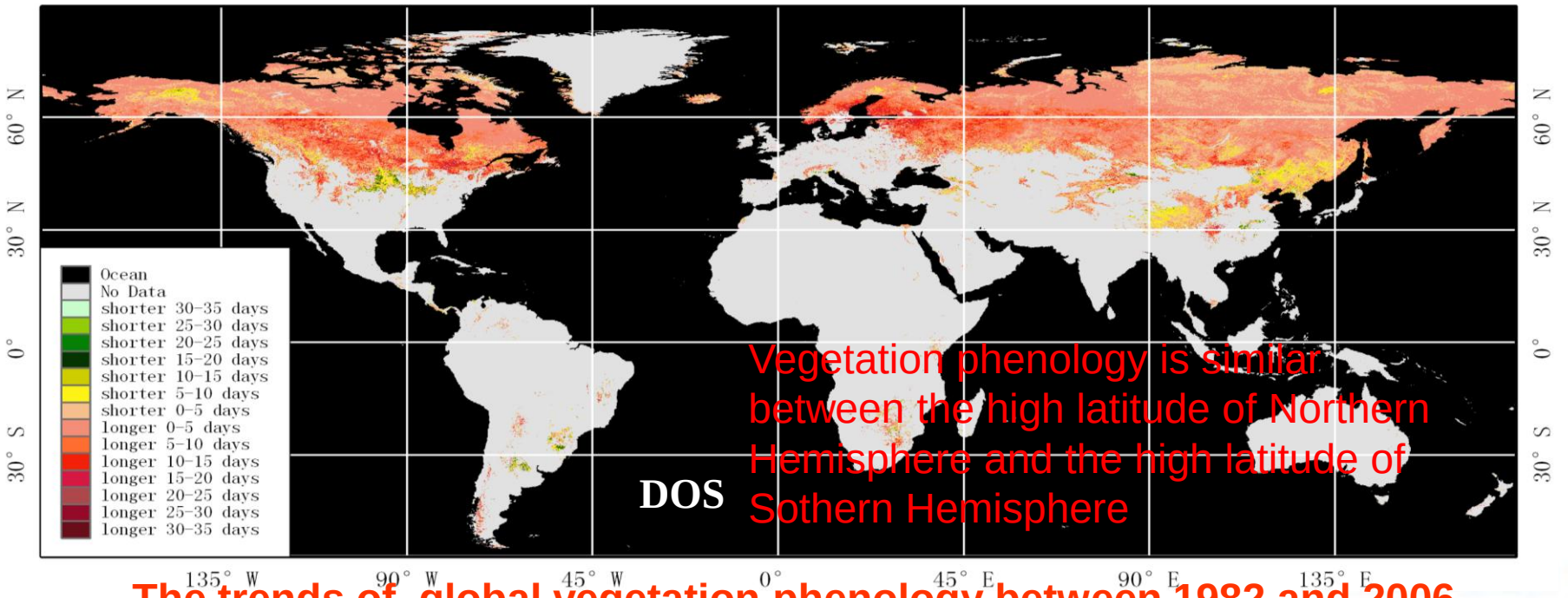
The trends of phenology metrics increasing with latitude in Northeast Asia in 2006





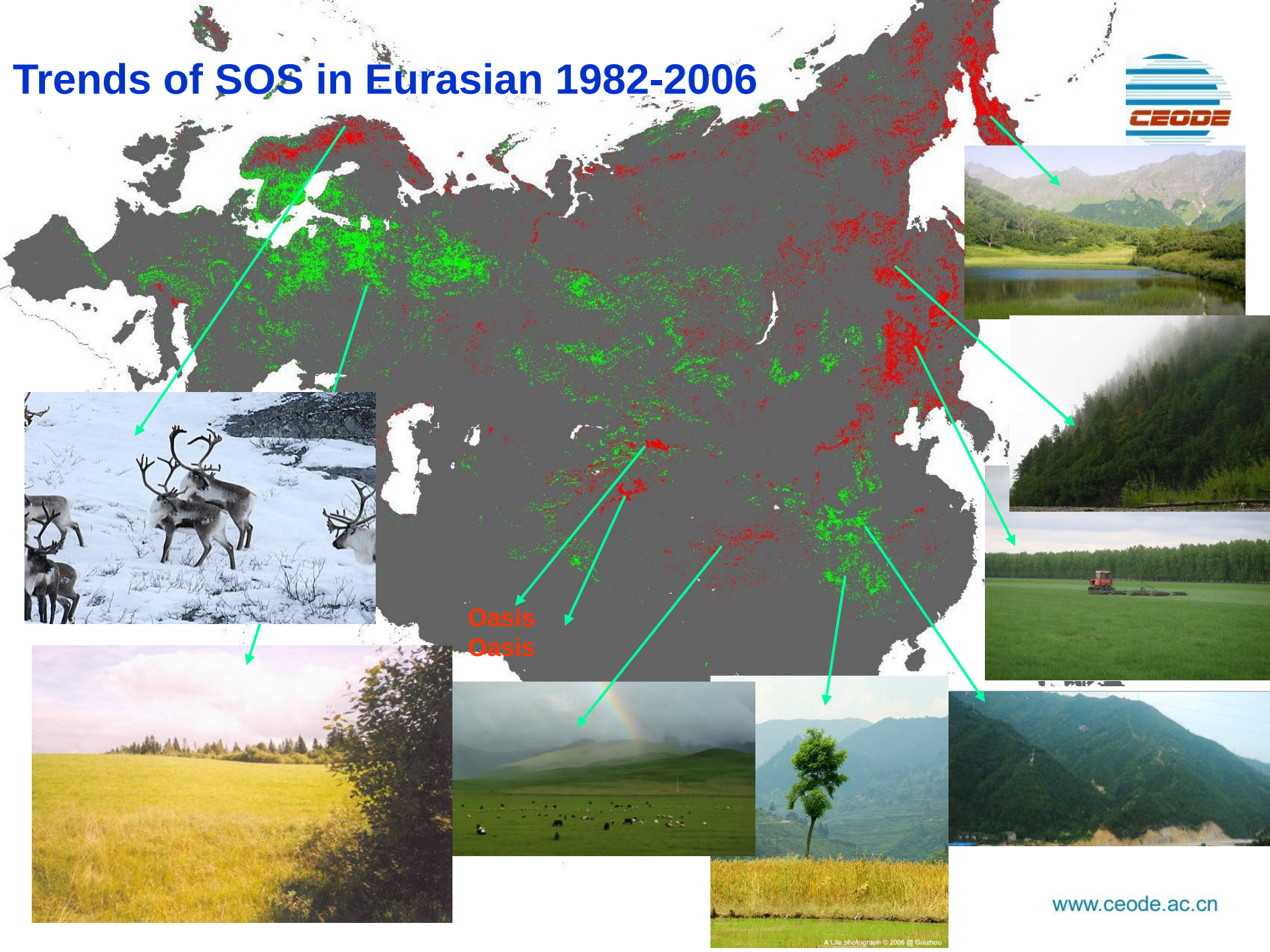
The trends of global vegetation phenology between 1982 and 2006





The trends of global vegetation phenology between 1982 and 2006

Trends of SOS in Eurasian 1982-2006



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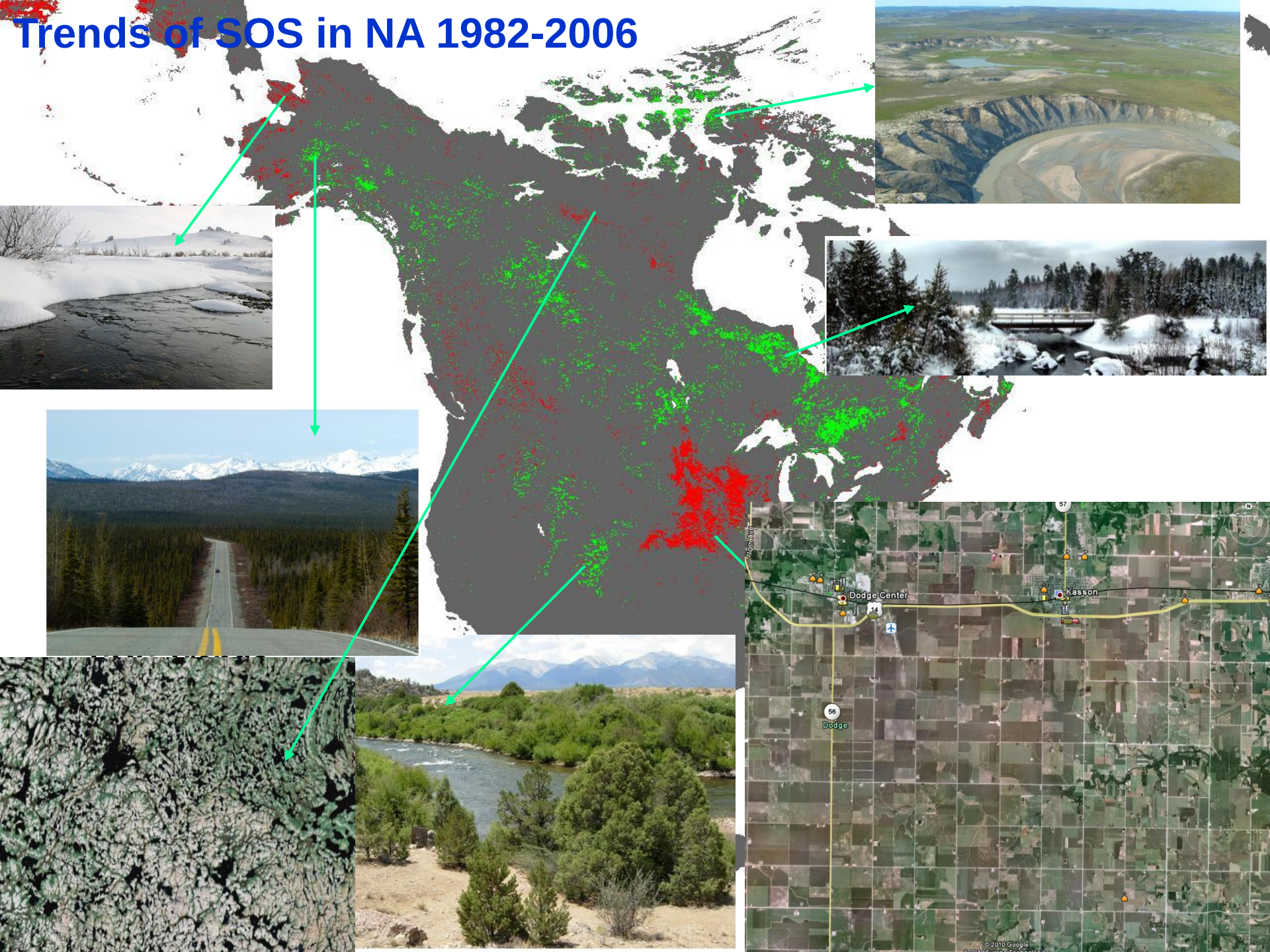
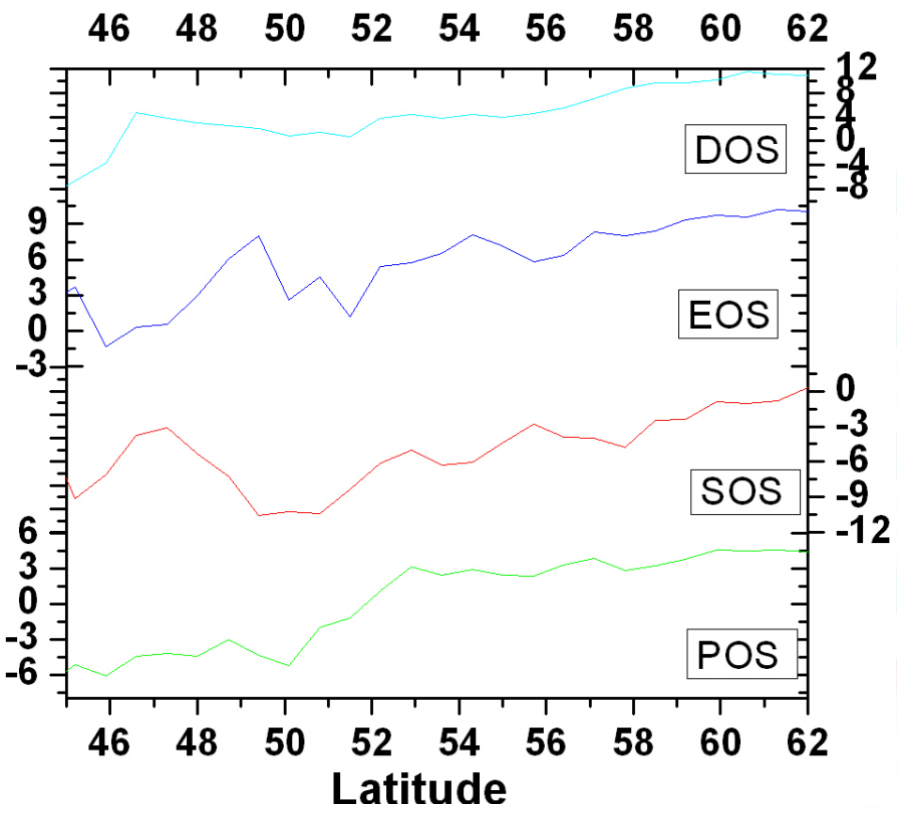
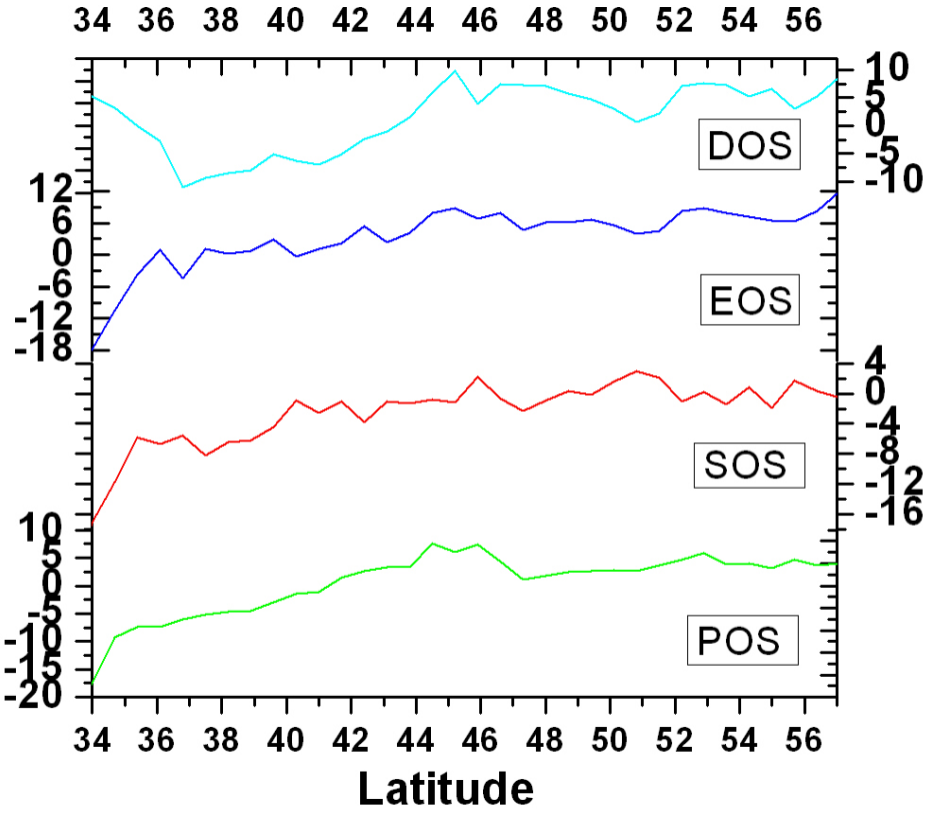
Trends of SOS in NA 1982-2006



The trends of vegetation phenology



The trends of phenology metrics of closed (>40%) broadleaved deciduous forest (>5m) increasing with latitude from 1982 to 2006 in Europe

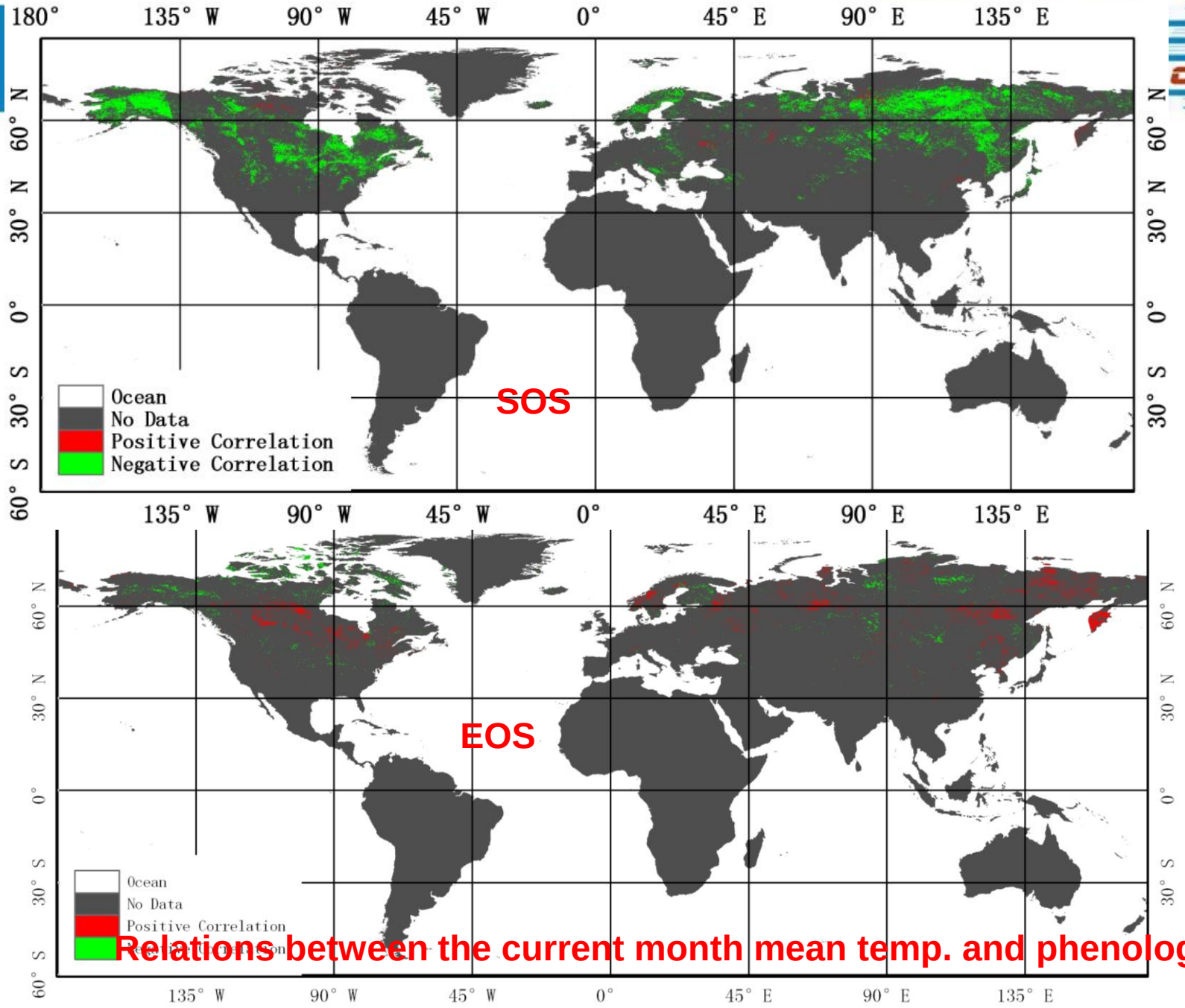


The trends of phenology metrics of closed (>40%) broadleaved deciduous forest (>5m) increasing with latitude from 1982 to 2006 in North America

The changed EOS days/24 years for LULCs

Days	Std	Label
8.0	4.1	Mosaic cropland/vegetation
7.6	3.8	Mosaic vegetation / cropland
6.6	2.6	Closed (>40%) broadleaved deciduous forest (>5m)
8.7	5.7	Closed (>40%) needleleaved evergreen forest (>5m)
8.3	2.5	Open (15-40%) needleleaved deciduous forest
7.3	3.5	Closed to open (>15%) mixed forest (>5m)
6.8	2.0	Mosaic forest or shrubland / grassland
6.6	2.3	Mosaic grassland / forest
8.6	5.2	Closed to open (>15%) shrubland (<5m)
7.2	3.3	Closed to open (>15%) herbaceous vegetation
8.3	2.4	Sparse (<15%) vegetation
7.5	3.8	Closed to open (>15%) wetland grassland or woody
13.7	7.5	Urban areas >50%)
7.2	3.3	Bare areas

Phenology's response to global warming



Relations between the current month mean temp. and phenologies

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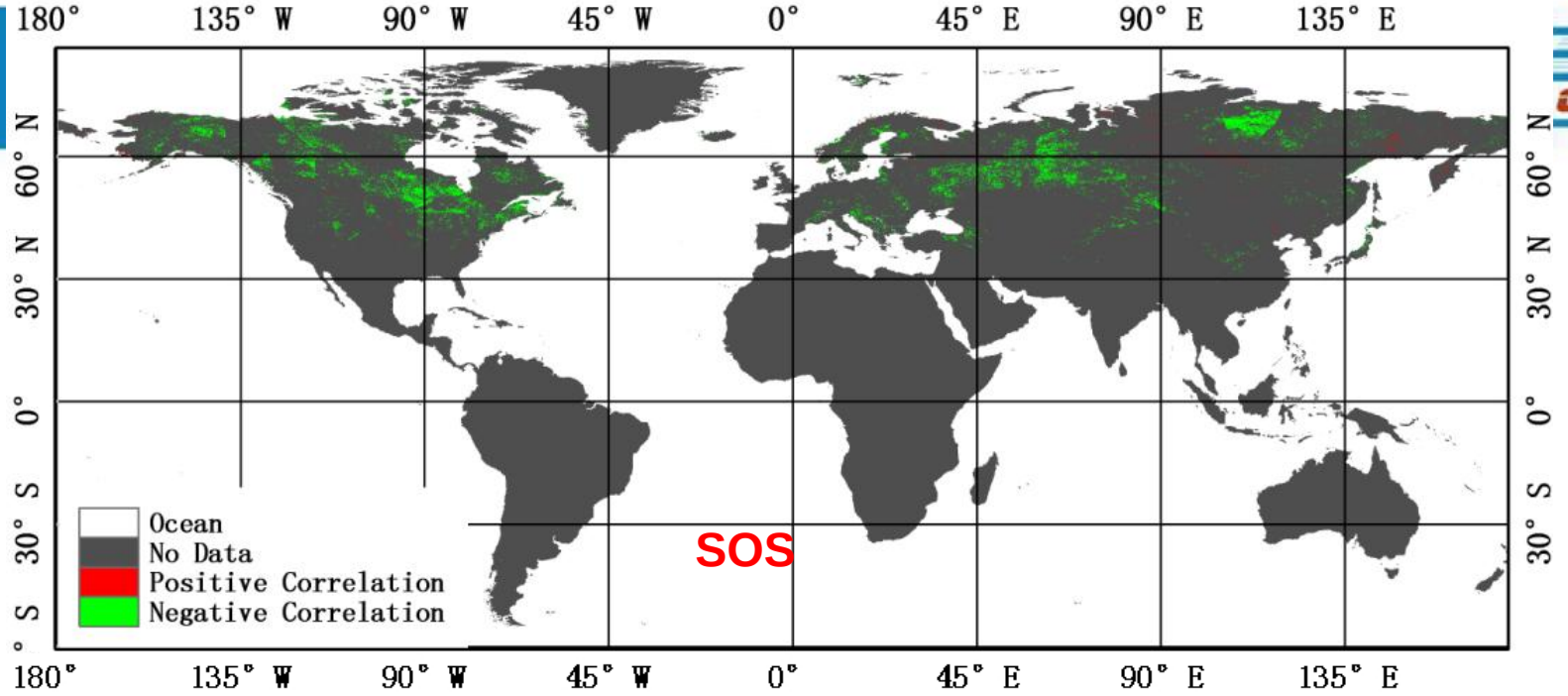
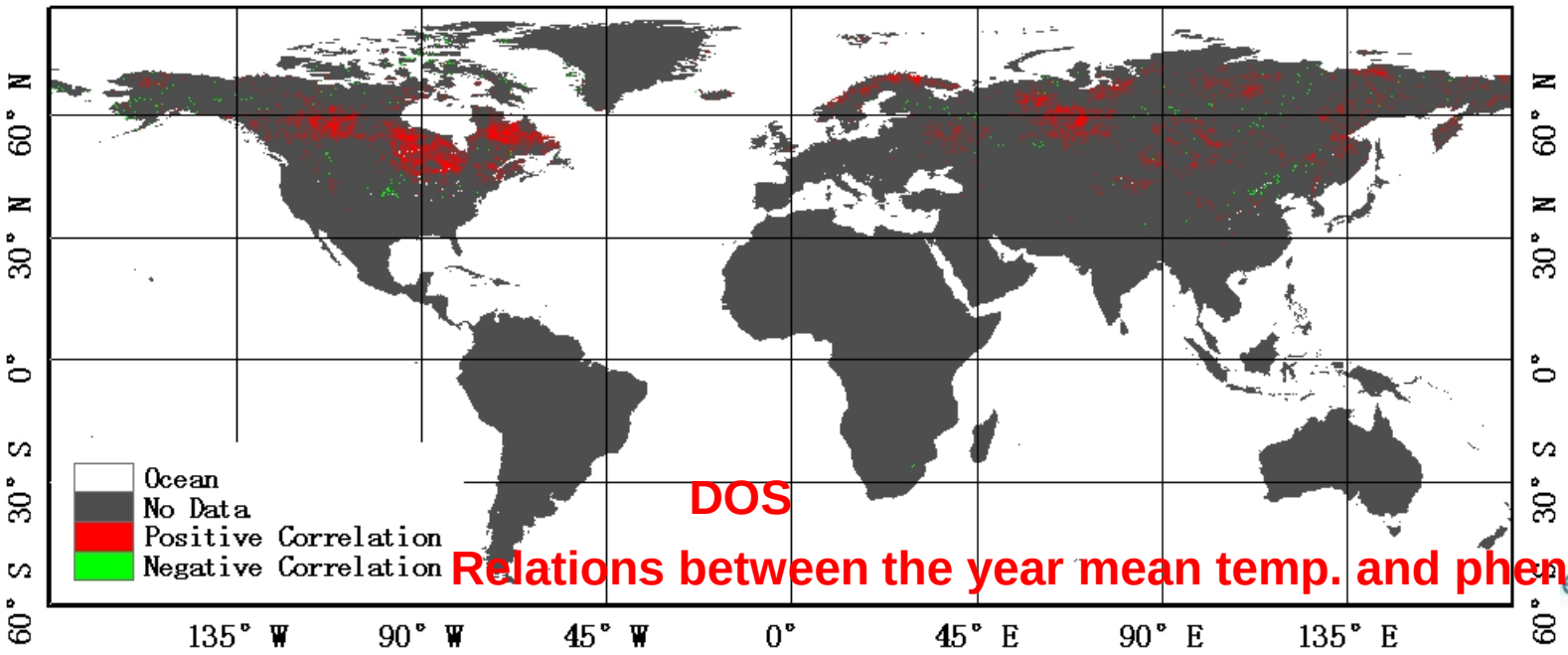
Phenology's response to global warming





Relations between the year mean temp. and phenologies

Phenology's response to global warming

The response of SOS to the current month's mean temp. days/ °C

Samples	Days	STD	label
3217	-4.2	2.2	Rainfed croplands
2649	-3.1	2.0	Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest)
5607	-3.4	1.5	Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland
21	-7.4	3.5	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest
9940	-3.7	1.9	Closed (>40%) broadleaved deciduous forest (>5m)
164	-2.4	1.0	Open (15-40%) broadleaved deciduous forest/woodland (>5m)
3611	-3.9	2.1	Closed (>40%) needleleaved evergreen forest (>5m)
89371	-1.9	1.1	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)
6602	-2.5	1.3	Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)
11433	-2.4	1.5	Mosaic forest or shrubland (50-70%) / grassland (20-50%)
7440	-1.5	0.9	Mosaic grassland (50-70%) / forest or shrubland (20-50%)
1831	-4.3	2.4	Closed to open (>15%) shrubland (<5m)
9961	-3.0	1.6	Closed to open (>15%) herbaceous vegetation
17764	-2.2	1.5	Sparse (<15%) vegetation
4	-3.0	1.3	Closed (>40%) broadleaved forest or shrubland permanently flooded
1406	-1.5	0.9	Closed to open (>15%) grassland or woody vegetation regularly flooded
148	-3.8	1.8	Artificial surfaces and associated areas (Urban areas >50%)
4042	-2.5	1.4	Bare areas
14990	-3.2	2.1	Water bodies
2348	-3.7	1.8	Permanent snow and ice

Phenology's response to global warming

The response of EOS to the current month's mean temp. days/ °C

Samples	Days	STD	label
797	5.0	2.3	Rainfed croplands
1064	4.3	1.7	Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest)
867	4.0	2.0	Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland
2	6.8	1.2	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest
3543	4.3	1.7	Closed (>40%) broadleaved deciduous forest (>5m)
32	3.5	1.8	Open (15-40%) broadleaved deciduous forest/woodland (>5m)
828	4.0	1.8	Closed (>40%) needleleaved evergreen forest (>5m)
17936	2.3	1.5	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)
2136	3.5	1.6	Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)
1511	3.7	2.0	Mosaic forest or shrubland (50-70%) / grassland (20-50%)
1220	2.0	1.6	Mosaic grassland (50-70%) / forest or shrubland (20-50%)
139	5.5	3.7	Closed to open (>15%) shrubland (<5m)
1721	3.7	1.7	Closed to open (>15%) herbaceous vegetation
5264	2.4	1.9	Sparse (<15%) vegetation
824	2.7	1.1	Closed (>40%) broadleaved forest or shrubland permanently flooded
39	4.6	2.5	Artificial surfaces and associated areas (Urban areas >50%)
1621	2.8	2.3	Bare areas
5954	4.6	2.5	Water bodies
100	3.1	2.4	Permanent snow and ice

Phenology's response to global warming

The response of DOS to the year's mean temp. days/ °C

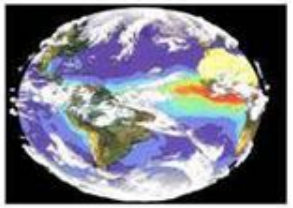
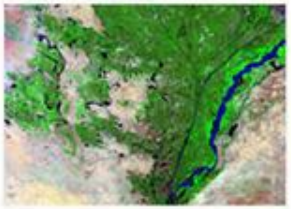
Samples	Days	STD	label
2129	7.5	6.9	Rainfed croplands
3994	6.8	5.1	Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest)
3186	6.6	6.2	Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland
16	13.0	10.0	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest
8251	9.0	6.2	Closed (>40%) broadleaved deciduous forest (>5m)
92	7.8	6.5	Open (15-40%) broadleaved deciduous forest/woodland (>5m)
3071	7.9	6.1	Closed (>40%) needleleaved evergreen forest (>5m)
35919	3.3	3.7	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)
6518	7.0	5.6	Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)
3892	4.1	5.1	Mosaic forest or shrubland (50-70%) / grassland (20-50%)
2062	1.8	2.2	Mosaic grassland (50-70%) / forest or shrubland (20-50%)
215	11.0	14.1	Closed to open (>15%) shrubland (<5m)
4175	5.9	5.6	Closed to open (>15%) herbaceous vegetation
10240	2.7	3.8	Sparse (<15%) vegetation
3	15.5	4.5	Closed (>40%) broadleaved forest or shrubland permanently flooded
1188	4.3	3.2	Closed to open (>15%) grassland or woody vegetation regularly flooded
86	10.5	8.2	Artificial surfaces and associated areas (Urban areas >50%)
3113	4.3	4.4	Bare areas
11815	6.8	7.5	Water bodies
335	4.7	4.6	Permanent snow and ice

Changes and Prospects

- **Validation** :ground-observed phenology , the effective accumulated temperature, GPP， NPP
- **Methodology**: comparison and analysis of different methods, NDVI threshold, Smoothed moving average, Seasonal midpoint NDVI methodology, Singular value decomposition, Empirical orthogonal function resolution, Double Gaussian Model
- **Comparison:** compare the phenology metrics derived from MODIS, Landsat with them extracted from GIMMS AVHRR NDVI

Thanks !



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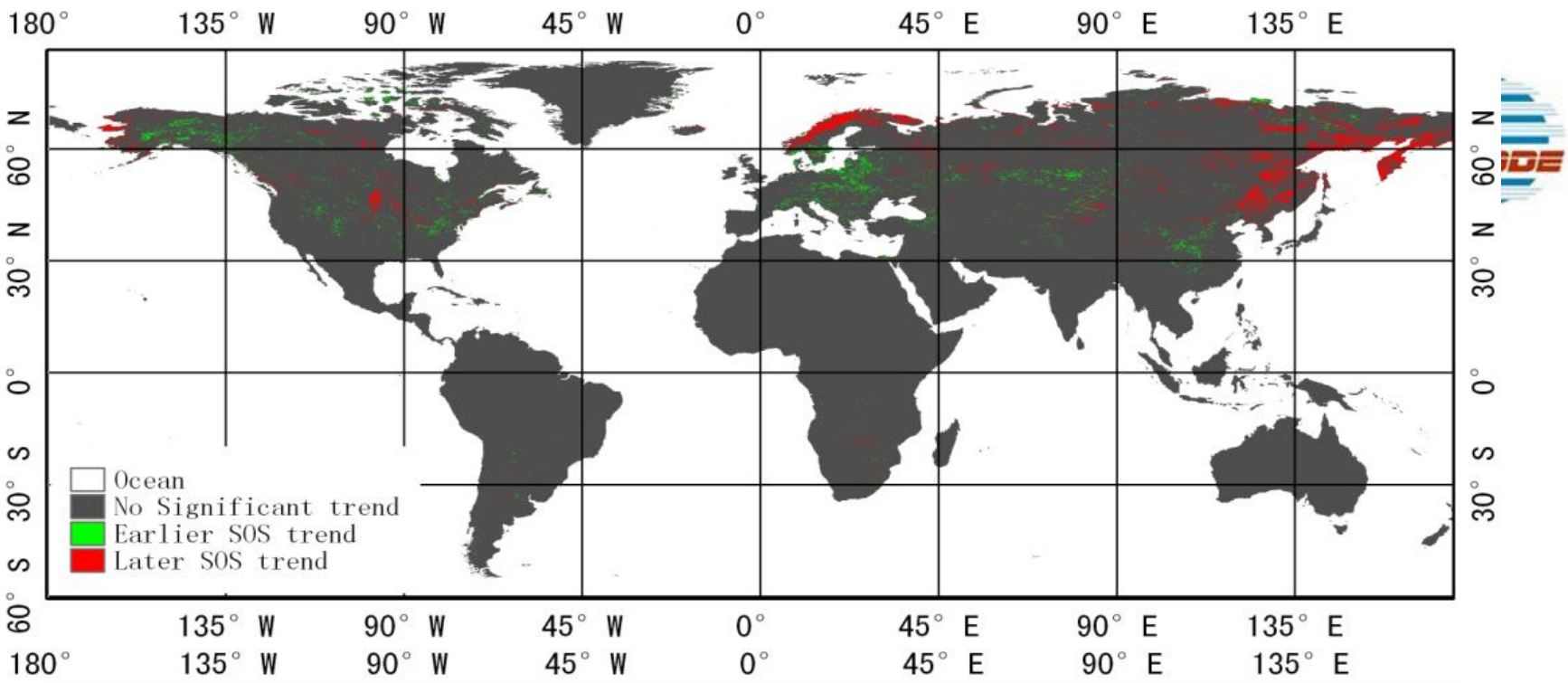
Web:www.ceode.cas.cn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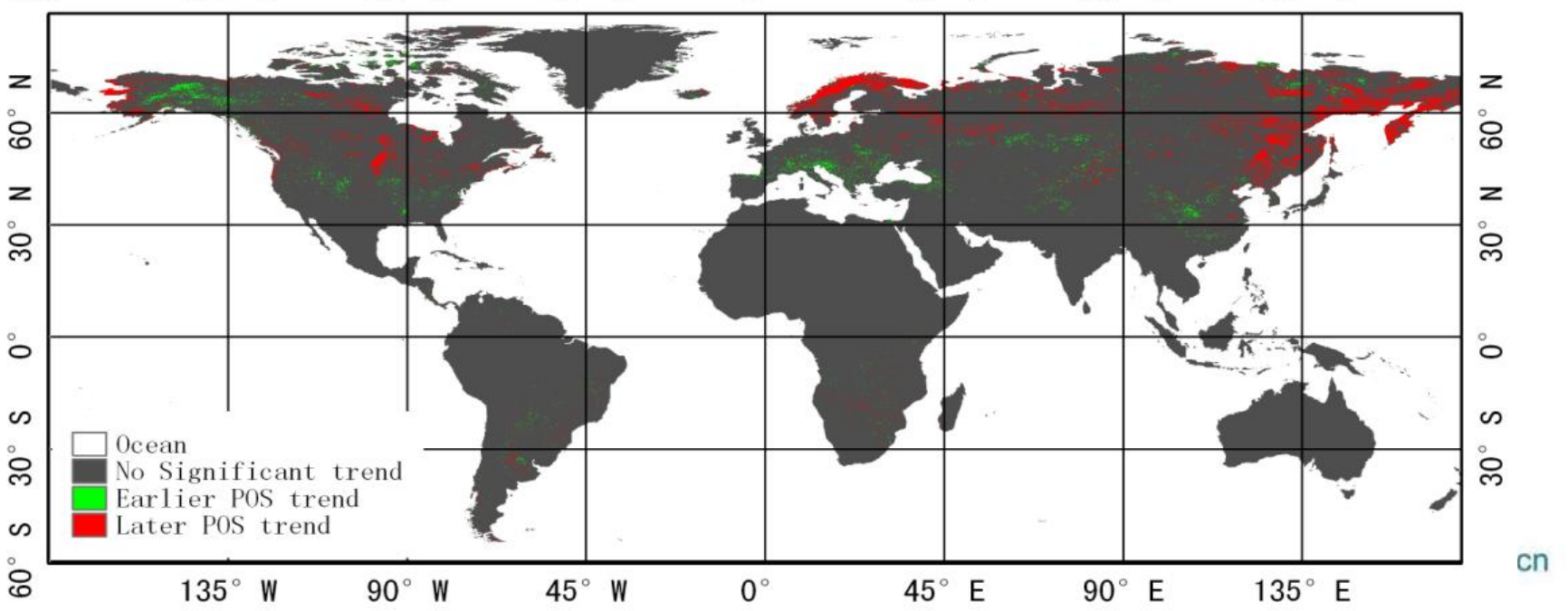
60° S
Ocean
No Significant trend
Earlier SOS trend
Later SOS trend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Ocean
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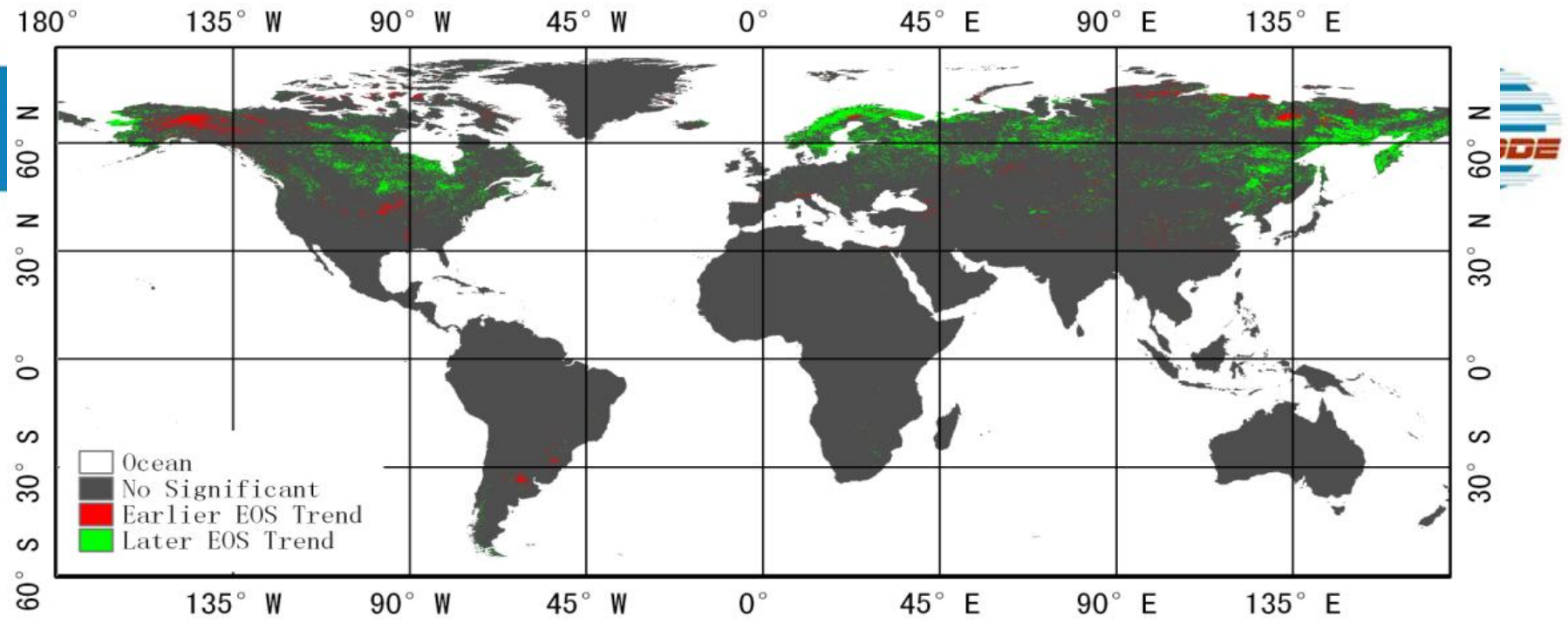
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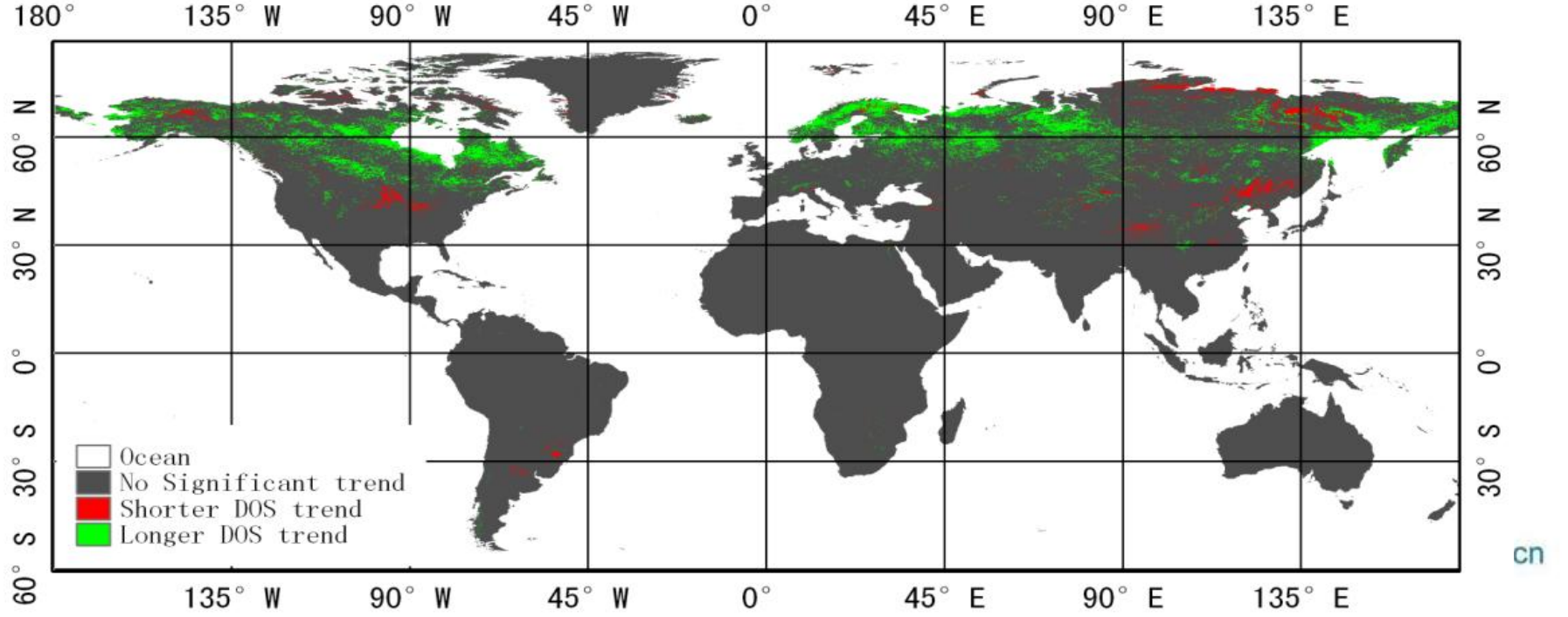
135° E
60° N
30° N
0°
30° S
60° S
Ocean
No Significant
Earlier EOS Trend
Later EOS Trend


180°
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90° W
45° W
0°
45° E
90° E
135° E
60° N
30° N
0°
30° S
60° S
Ocean
No Significant trend
Shorter DOS trend
Longer DOS trend