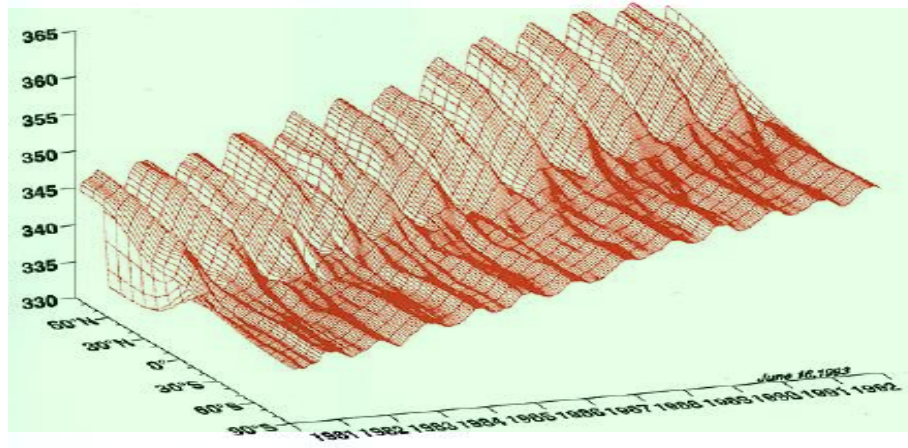


Cooperation history between LSCE and PKU

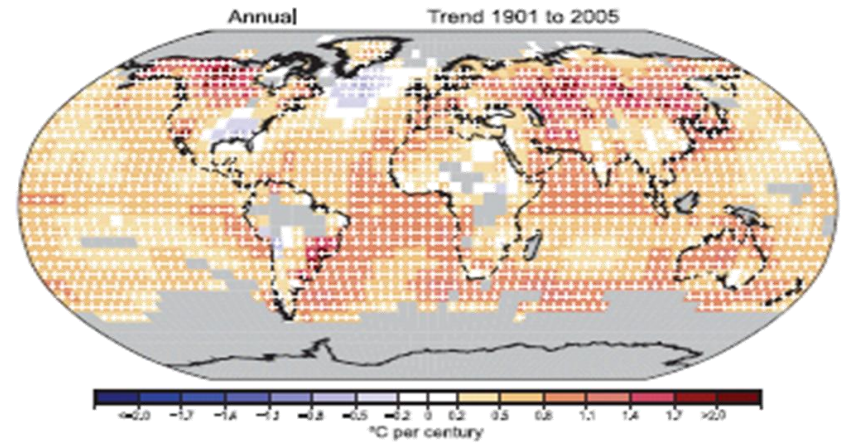
Shilong Piao & Phillipe Ciais



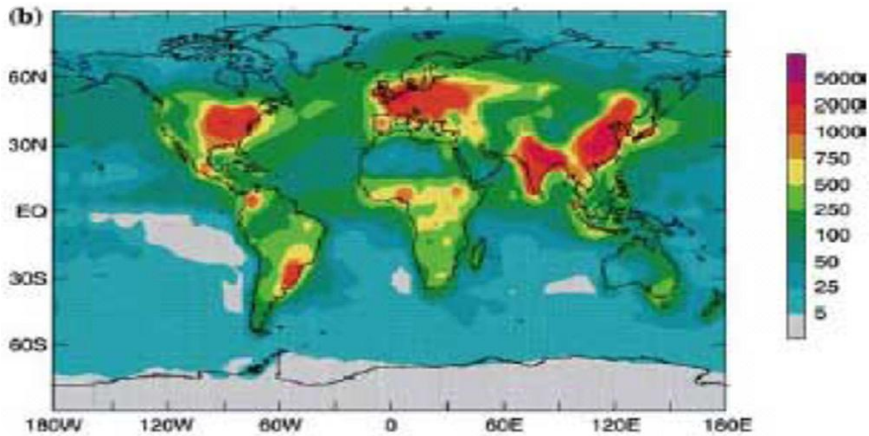
Changes in climate and atmospheric components



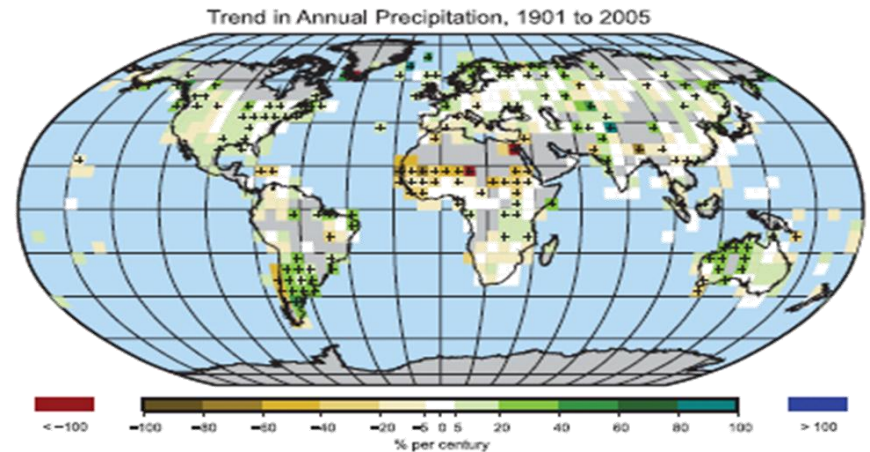
CO2 increase



Temperature change

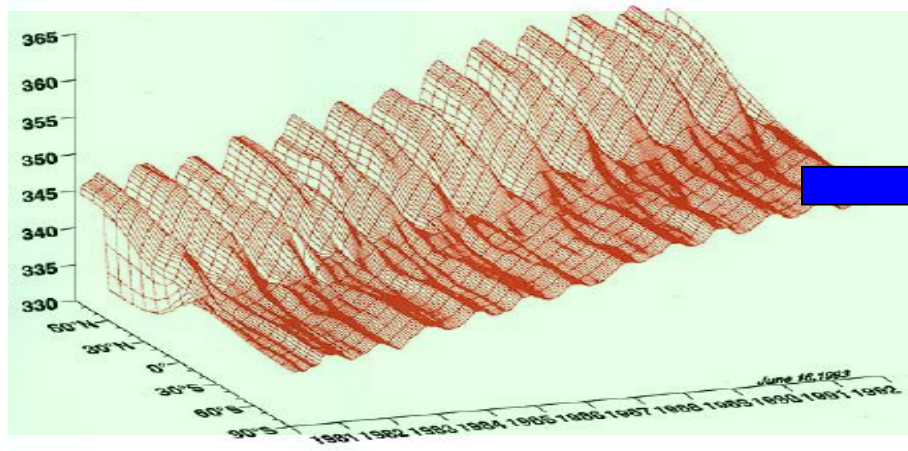


Nitrogen deposition

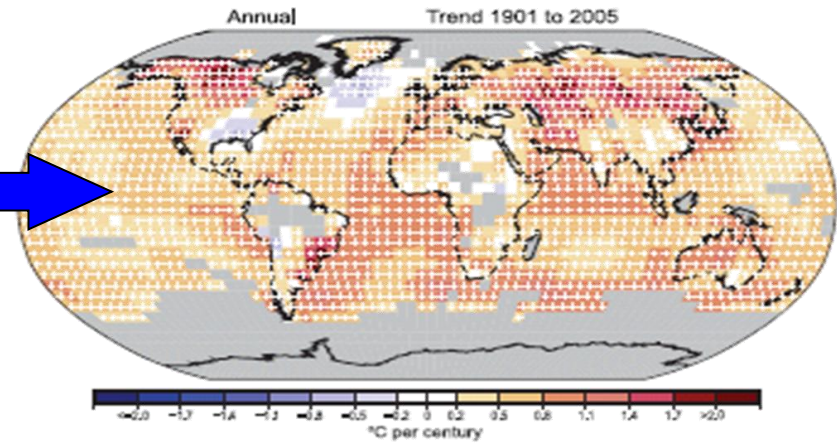


Precipitation change

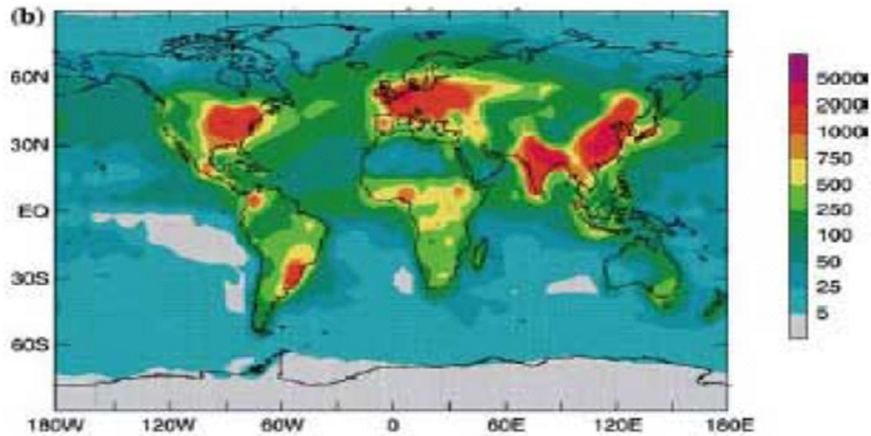
Atmospheric Scientists have established:



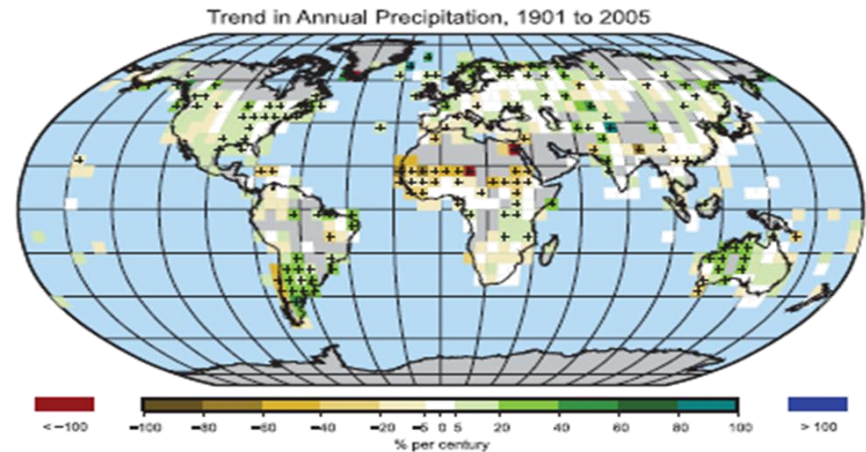
CO2 increase



Temperature change

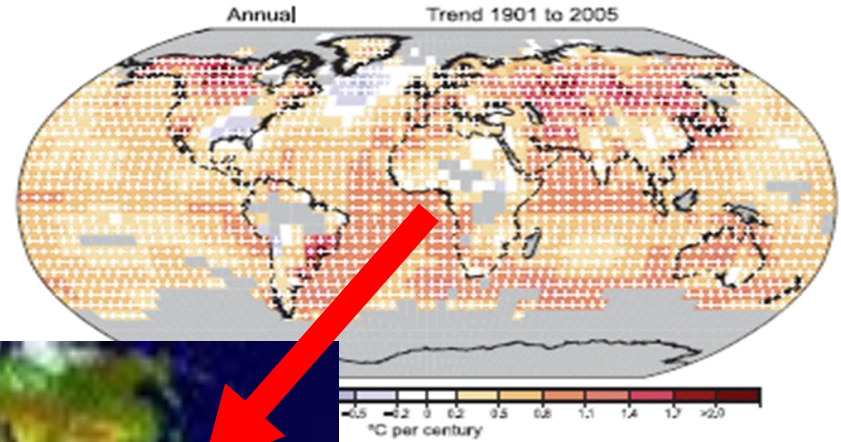
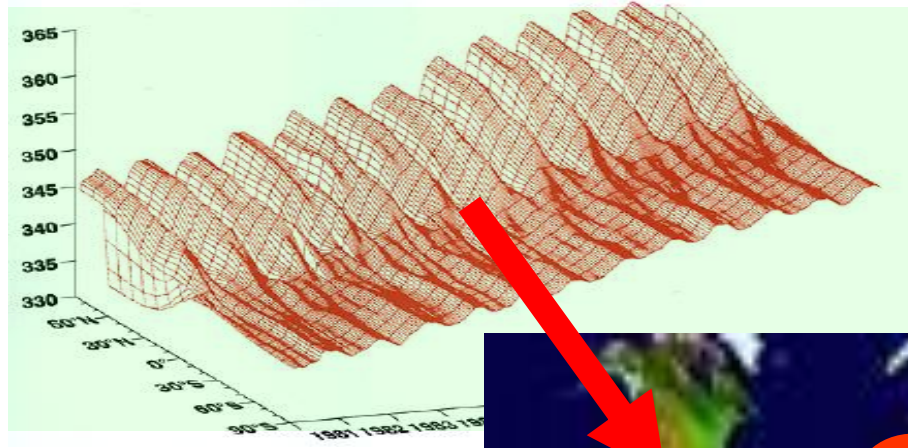


Nitrogen deposition



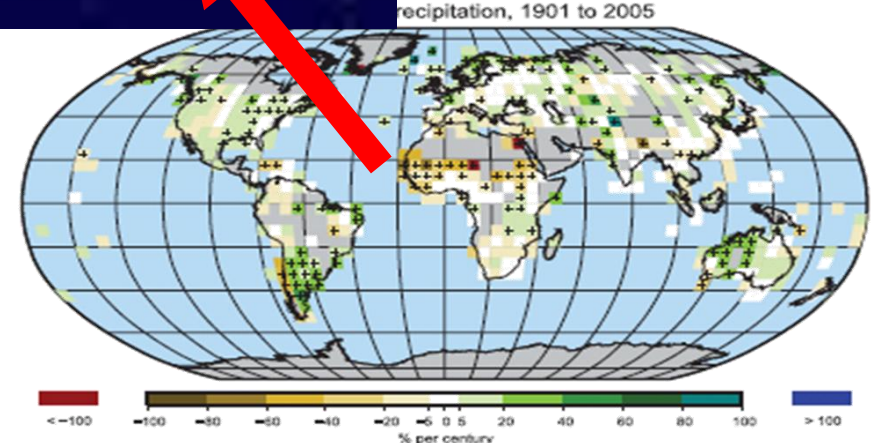
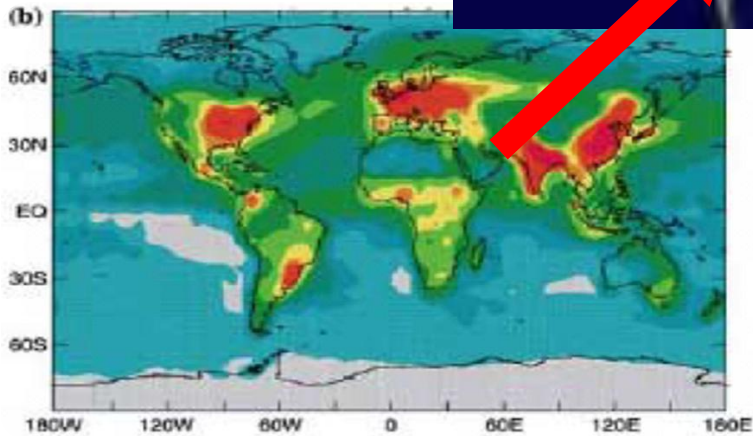
Precipitation change

What are the responses of terrestrial ecosystem to these changes?



CO2 increase

Temperature change



Nitrogen deposition

Precipitation change

Present & Past Subjects (2004-)

- **The impacts of climate changes on vegetation productivity;**
- **Change in phenology and its effects on terrestrial carbon cycle;**
- **Global/regional carbon budget;**
- **The impacts of climate change on water resource.**

(1) The impact of climate change on vegetation productivity

Investigate the spatial patterns of change in vegetation growth and its mechanisms in the Northern Hemisphere

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 108, NO. D14, 4401, doi:10.1029/2002JD002848, 2003

Interannual variations of monthly and seasonal normalized difference vegetation index

Journal of Vegetation Science 15: 219-226, 2004
© IAVS: Opulus Press Uppsala

Shilong Piao,¹ Jingyun Fan
Yan Li,¹ and Shu Tao¹

Received 15 August 2002; revised 2

[1] In this paper, we analyze the interannual variations of monthly and seasonal normalized difference vegetation index (NDVI) and their relationship with precipitation and human activities. NDVI increased significantly over 85.9% of the area (0.0018 yr⁻¹) over 85.9% of the area (5.2% with a trend of 0.00 show a marked heterogeneous trend. There is about a 0.2°C increase in temperature (February) and

Piao Shilong¹;

¹Department of Ecology
Ministry of Education, Peking
University, Beijing, China
²Department of Resource
Ecology, Beijing Normal
University, Beijing, China
³Department of Ecology,
College of Urban and Environmental
Science, Peking University, Beijing,
China

Var

Changes in vegetation index

1982 to 1999 in the Northern Hemisphere

Shilong Piao,^{1,2} Jingyun Fan,
Yan Li,¹ and Shu Tao⁴
Received 31 March 2004; revised 15 October 2004; accepted 18 September 2005
[1] Terrestrial net primary production (NPP) is a key indicator of ecosystem health and function. The northern middle and high latitudes have experienced seasonal and interannual variations in NPP over the past two decades.

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 19, GB2027, doi:10.1029/2004GB002274, 2005

GEOPHYSICAL RESEARCH LETTERS, VOL. 32, L06402, doi:10.1029/2004GL021764, 2005

GEOPHYSICAL RESEARCH LETTERS, VOL. 33, LXXXXX, doi:10.1029/2006GL028205, 2006

NDVI indices over the past two decades

Shilong Piao, Jiyun Fan,
Yan Li, and Shu Tao
Department of Ecology,
Peking University, Beijing,
China
Received 15 October 2004; revised 18 September 2005; accepted 18 September 2005
[1] In this study, we analyze the interannual variations of monthly and seasonal normalized difference vegetation index (NDVI) and their relationship with precipitation and human activities. NDVI increased significantly over 85.9% of the area (0.0018 yr⁻¹) over 85.9% of the area (5.2% with a trend of 0.00 show a marked heterogeneous trend. There is about a 0.2°C increase in temperature (February) and



Effect of climate and CO₂ changes on the greening of the Northern Hemisphere over the past two decades

Shilong Piao,¹ Pierre Friedlingstein,¹ Philippe Ciais,¹ Liming Zhou,² and Anping Chen³

Received 18 September 2005

[1] Study of the effect of climate and CO₂ changes on the greening of the Northern Hemisphere over the past two decades is a critical requirement for projecting future ecosystem dynamics. Parts of North America (NA) have experienced a spring cooling trend over the last three decades, but little is known about the mechanisms responsible for this trend.

Spring temperature change and its implication in the change of vegetation growth in North America from 1982 to 2006

Xuhui Wang^a, Shilong Piao^{a,b}, Philippe Ciais^a, Junsheng Li^c, Pierre Friedlingstein^{b,d}, Charlie Koven^e, and Anping Chen^f

^aDepartment of Ecology, College of Urban and Environmental Science, Peking University, Beijing 100871, China; ^bLaboratoire des Sciences du Climat et de l'Environnement, Unité Mixte de Recherche Commissariat à l'Energie Atomique-Centre National de la Recherche Scientifique-Université de Versailles Saint-Quentin-en-Yvelines, Batiment 709, CE L'Orme des Merisiers, Gif-sur-Yvette, F-91191, France; ^cChinese Research Academy of Environmental Sciences, Beijing 100012, China; ^dQuantifying and Understanding the Earth System (QUEST), Department of Earth Sciences, University of Bristol, Wills Memorial Building, Queen's Road, Bristol BS8 1RJ, United Kingdom; ^eEarth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720; and ^fDepartment of Ecology and Evolutionary Biology, Princeton University, Princeton, NJ 08544

Edited by Robert E. Dickinson, University of Texas at Austin, Austin, TX, and approved December 6, 2010 (received for review September 27, 2010)

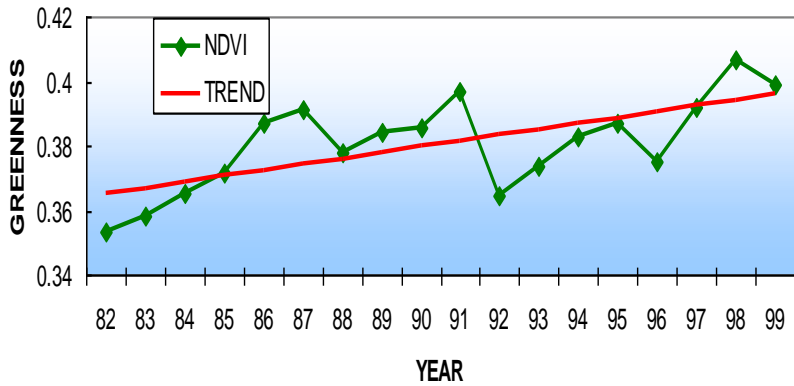
Understanding how vegetation growth responds to climate change is a critical requirement for projecting future ecosystem dynamics. Parts of North America (NA) have experienced a spring cooling trend over the last three decades, but little is known about the mechanisms responsible for this trend.

temperature has risen by 1.1°C since the 1980s (16). Warmer spring temperature will generally enhance vegetation productivity by extending the growing season. Rather than responding to changes in continental mean temperature, vegetation growth is

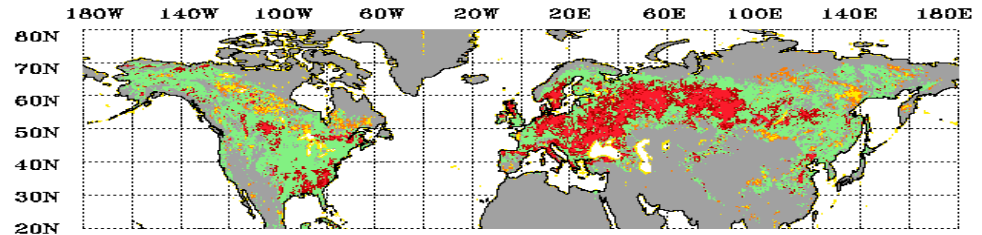
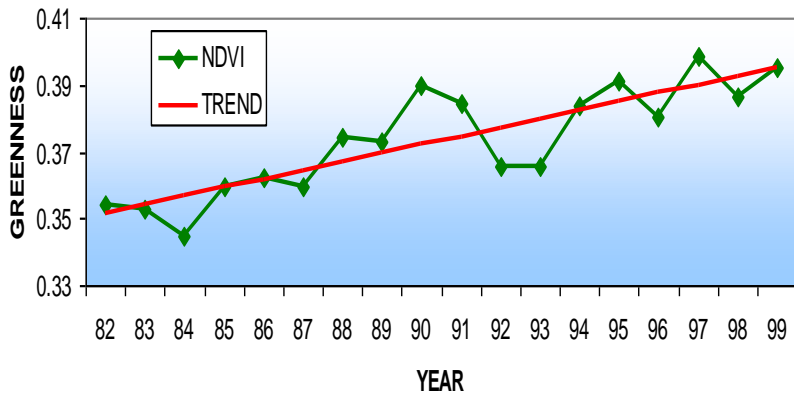
(1) The impact of climate change on vegetation productivity

Enhanced vegetation growth

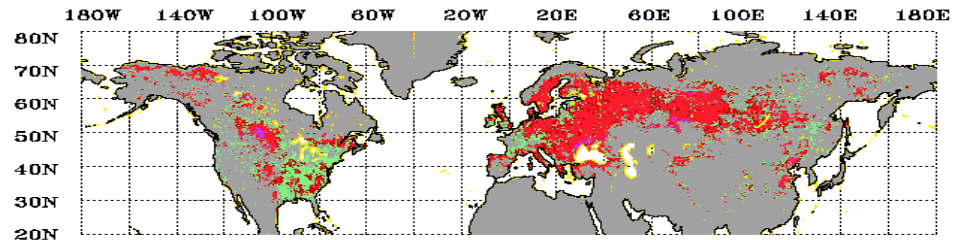
NORTH AMERICA (40N~70N)



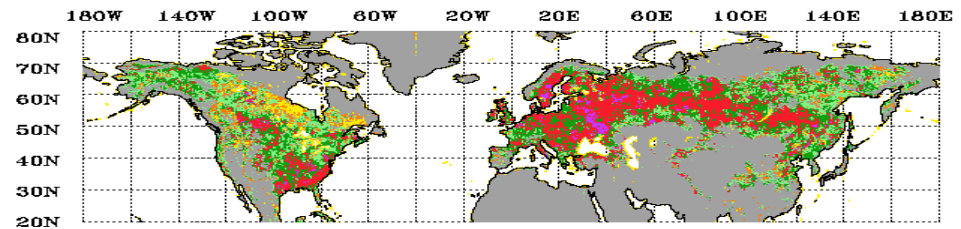
EURASIA (40N~70N)



NDVI DIFFERENCE BETWEEN 1995-99 AND 1982-86



NDVI TREND WITH 5% SIGNIFICANCE LEVEL



PERSISTENCE INDEX OF NDVI INCREASE

(1) The impact of climate change on vegetation productivity

Zhou et al. (2001)

detrending the original time series. To estimate the relation between NDVI and temperature, we estimate the regression model

$$Y = \beta_0 + \beta_1 X + \beta_2 \text{time} + \varepsilon, \quad (11)$$

where Y is the dependent variable, time is the deterministic variable, X is the independent variable, β_0 , β_1 and β_2 are regression coefficients, and ε is a stochastic error term. This



Greening of NH was chiefly driven by rising **temperature**

Ahlbeck et al. (2002)

[2] To confirm Ahlbeck's results, we estimate the following equation:

$$\text{NDVI} = \beta_0 + \beta_1 \text{temp} + \beta_2 \text{CO}_2 + \varepsilon, \quad (1)$$

with data from North America and Eurasia. Here temp denotes temperature. To determine whether CO_2 or temperature has a statistically measurable effect on NDVI, we use a t statistic to test the null hypothesis that the



Greening of NH was chiefly driven by rising **atmospheric CO2**

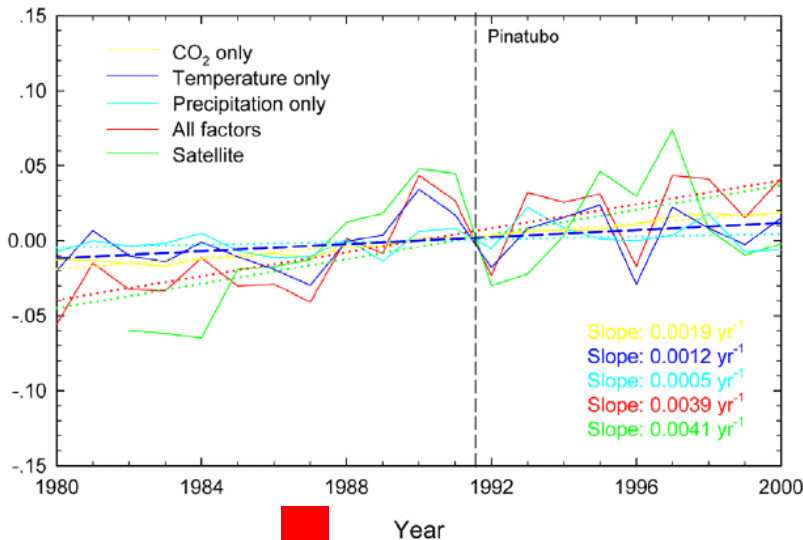
Mechanisms controlling current enhanced vegetation growth in the Northern Hemisphere are under debate!

(1) The impact of climate change on vegetation productivity

Effect of climate and CO₂ changes on the greening of the Northern Hemisphere over the past two decades

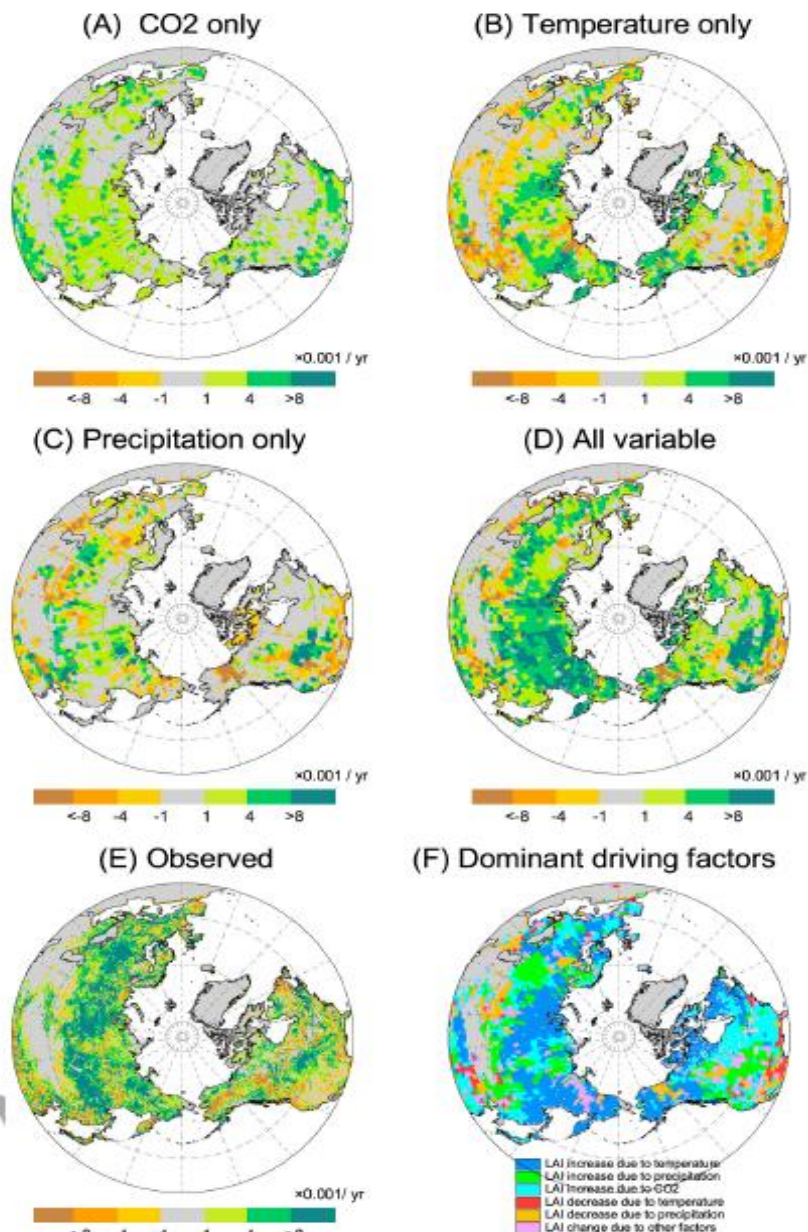
Shilong Piao,¹ Pierre Friedlingstein,¹ Philippe Ciais,¹ Liming Zhou,² and Anpin;

Received 18 September 2006; revised 24 October 2006; accepted 27 October 2006; published XX Month 200



At the continental scale, Interannual variation was chiefly driven by temperature;

For the trend: rising atmospheric CO₂ contributed by 49%; while temperature contributed by 31%.



Spring temperature change and its implication

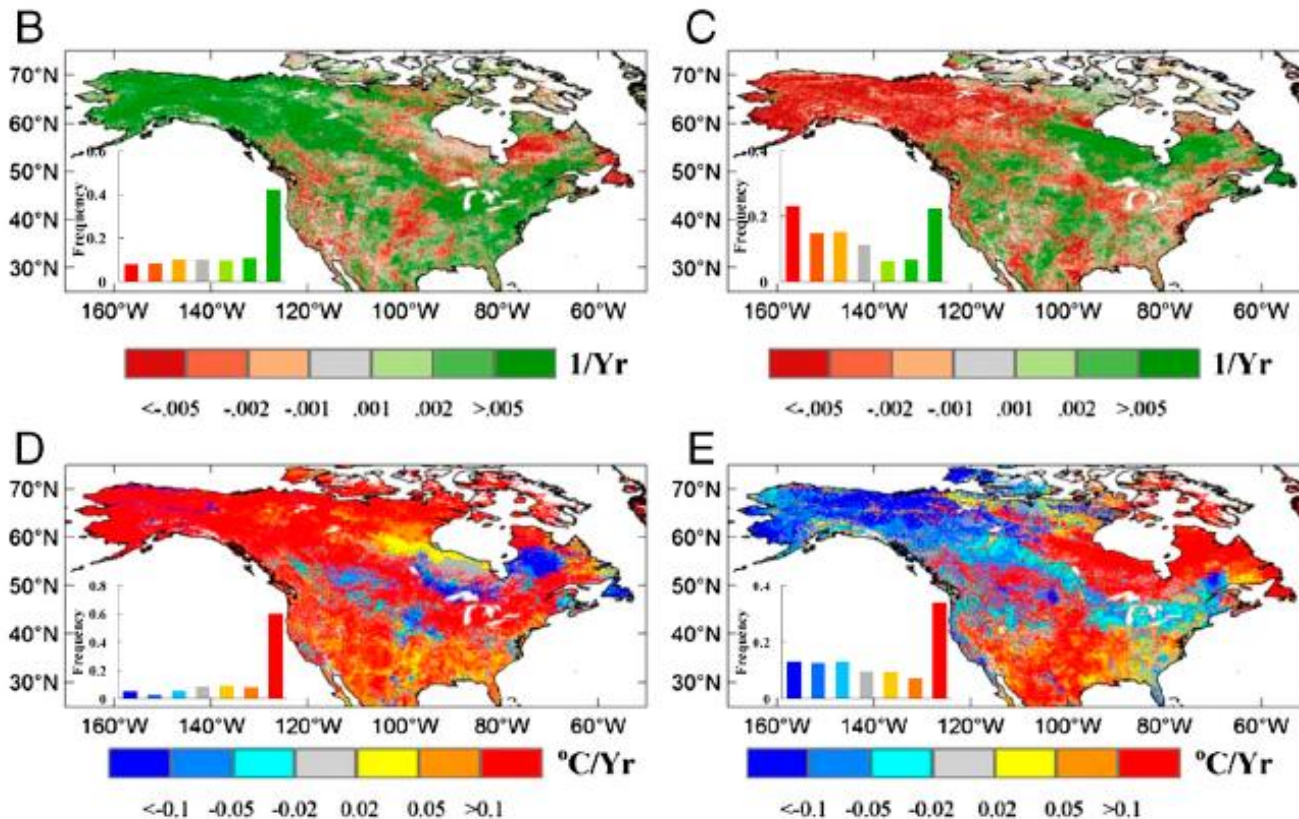
(1) The impact of climate change on vegetation productivity

Xuhui Wang^a, Shilong Piao^{a,1}, Philippe Ciais^b, Junsheng Li^{c,1}, Pierre Friedlingstein^{b,d}, Charlie Koven^e, and Anping Chen^f

^aDepartment of Ecology, College of Urban and Environmental Science, Peking University, Beijing 100871, China; ^bLaboratoire des Sciences du Climat et de l'Environnement, Unité Mixte de Recherche Commissariat à l'Énergie Atomique–Centre National de la Recherche Scientifique–Université de Versailles Saint-Quentin-en-Yvelines, Batiment 709, CE L'Orme des Merisiers, Gif-sur-Yvette, F-91191, France; ^cChinese Research Academy of Environmental Sciences, Beijing 100012, China; ^dQuantifying and Understanding the Earth System (QUEST), Department of Earth Sciences, University of Bristol, Wills Memorial Building, Queen's Road, Bristol BS8 1RJ, United Kingdom; ^eEarth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720; and ^fDepartment of Ecology and Evolutionary Biology, Princeton University, Princeton, NJ 08544

Edited by Robert E. Dickinson, University of Texas at Austin, Austin, TX, and approved December 6, 2010 (received for review September 27, 2010)

Understanding how vegetation growth responds to climate change temperature has risen by 1.1 °C since the 1980s (16). Warmer



(2) Phenology change and its effects on terrestrial carbon cycle

Investigate the links between the trends of phenological events and terrestrial carbon fluxes over NH

Global Change Biology (2006) 12, 672–6

Variations in satellite-estimated growing season length and phenology of temperate vegetation

SHILONG PIAO*, JINGYUN F.

*Department of Ecology, College of Environmental and Plant Biology, Peking University, Beijing 100871, China; †Department of Ecology, Georgia Institute of Technology, Atlanta, GA 30332, USA ‡LSC, CNRS, Montpellier, France

Abstract

The relationship between climate change and phenology is a key research area because climate changes. In this study, we use satellite-estimated growing season length (GSL) and phenology of temperate vegetation (NDVI) to investigate the relationship between climate change and phenology. We find that the growing season has advanced very high resolution (1 km) and concurrent mean temperature (NDVI) biweekly time series. Trends in the GSL are significant trend toward longer growing seasons (0.28 days yr⁻¹, R² = 0.48) and delayed vegetation senescence (0.16 days yr⁻¹, R² = 0.48) in the study period, the growing season length in the northern region of China. The green-up date is advanced in the dormancy delayed in the northern region. The green-up events are most significant in the northern region. A warming in the northern region leads to an increase in NPP of 2.8 g C m⁻² yr⁻¹ and decomposition accompan-



Growing season length and phenology of the Northern Hemisphere

Shilong Piao,¹ Pierre Friedlingstein¹ and Jérôme Demarty¹

Received 9 November 2006; accepted 12 December 2006

[1] A number of studies have shown that the growing season length (GSL) has increased significantly in the Northern Hemisphere (>25°N) during 1980–2000, with an increase of 0.30 days yr⁻¹ in the onset in spring (0.16 days yr⁻¹ in the end in autumn). Trends in the GSL are significant trend toward longer growing seasons (0.28 days yr⁻¹, R² = 0.48) and delayed vegetation senescence (0.16 days yr⁻¹, R² = 0.48) in the study period. Our results also show that the green-up date is advanced in the northern region. The green-up events are most significant in the northern region. A warming in the northern region leads to an increase in NPP of 2.8 g C m⁻² yr⁻¹ and decomposition accompan-

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 21, GB3018, doi:10.1029/2006GB002888, 2007

Vol 45 | 3 January 2008 | doi:10.1038/nature06444

nature

LETTERS

PHILOSOPHICAL
TRANSACTIONS
OF
THE ROYAL
SOCIETY

Influence of spring transitions on forest carbon balance

Andrew D. Richardson¹

Nicolas Delbart⁴, M

David Y. Hollinger⁷, We

Sebastian Luys

Leonardo Montagnani^{12,1}

Shilong Piao¹⁵, Corinn

Nobuko Saigusa¹⁸, En

and 1

¹Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA, USA

³Faculty of Land and Food Systems, British Columbia University, Vancouver, BC, Canada

⁴Laboratoire des Sciences du Climat et de l'Environnement, Gif-sur-Yvette, France

⁵Department of Geography and Environmental Science, University of Cambridge, Cambridge, UK

Net carbon dioxide losses of northern ecosystems in response to autumn warming

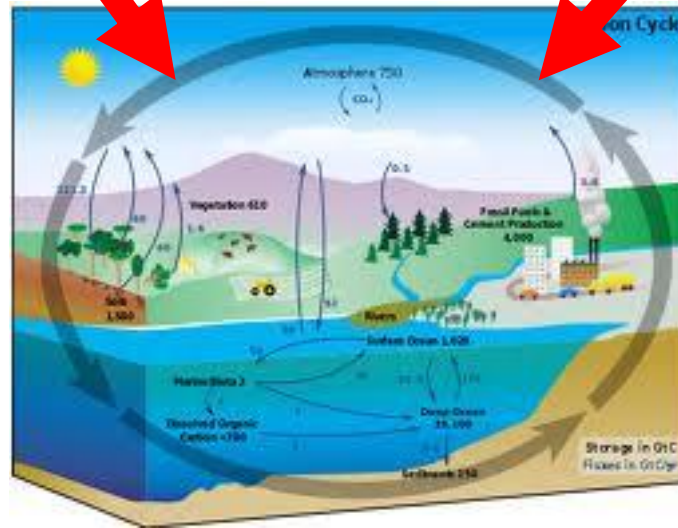
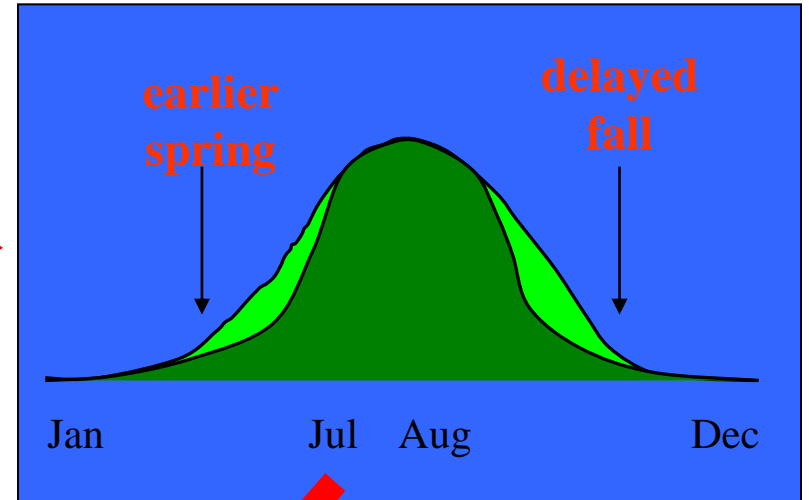
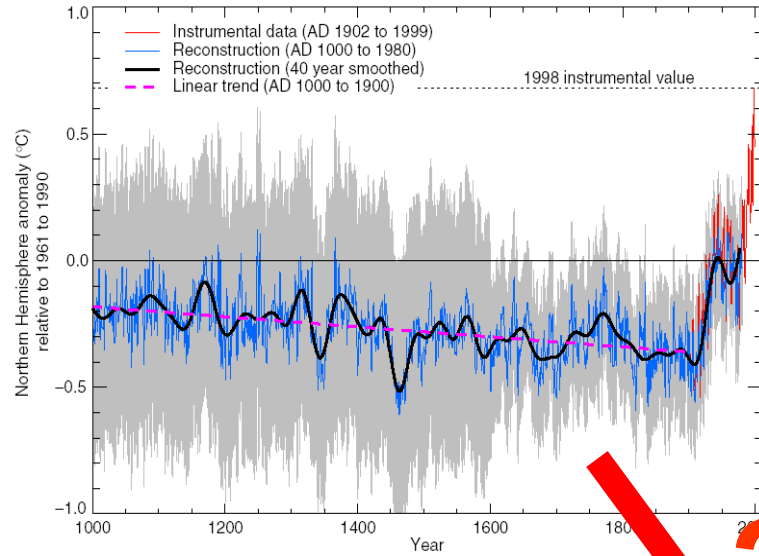
Shilong Piao¹, Philippe Ciais¹, Pierre Friedlingstein¹, Philippe Peylin², Markus Reichstein³, Sebastiaan Luysaert⁴, Hank Margolis⁵, Jingyun Fang⁶, Alan Barr⁷, Anping Chen⁸, Achim Grelle⁹, David Y. Hollinger¹⁰, Tuomas Laurila¹¹, Anders Lindroth¹², Andrew D. Richardson¹³ & Timo Vesala¹⁴

The carbon balance of terrestrial ecosystems is particularly sensitive to climatic changes in autumn and spring^{1–4}, with spring and autumn temperatures over northern latitudes having risen by about 1.1 °C and 0.8 °C, respectively, over the past two decades⁵. A simultaneous greening trend has also been observed, characterized by a longer growing season and greater photosynthetic activity^{6,7}. These observations have led to speculation that spring and autumn warming could enhance carbon sequestration and extend the period of net carbon uptake in the future⁸. Here we analyse interannual variations in atmospheric carbon dioxide concentration data and ecosystem carbon dioxide fluxes. We find that atmospheric records from the past 20 years show a trend towards an earlier autumn-to-winter carbon dioxide build-up, suggesting a shorter net carbon uptake period. This trend cannot be explained by changes in atmospheric transport alone and, together with the ecosystem flux data, suggest increasing carbon losses in autumn. We use a process-based terrestrial biosphere model and satellite

process-oriented terrestrial biosphere model (ORCHIDEE)¹⁶ is combined with an atmospheric transport model (LMDZt)¹⁷ to quantify the processes through which autumn warming controls the carbon balance of ecosystems (see Methods).

The seasonal cycle of atmospheric CO₂ concentrations provides an integrated measure of the net land-atmosphere carbon exchange (net ecosystem productivity; NEP) and its temporal characteristics^{18,19}. We analysed the ten atmospheric CO₂ measurement records from the NOAA-ESRL air-sampling network²⁰, which cover at least 15 years of data in the Northern Hemisphere (Fig. 1 and Supplementary Table 1). The upward zero-crossing date of CO₂ was determined as the day when the de-trended atmospheric CO₂ seasonal cycle crosses the zero line from negative to positive values (see Methods). This date occurs in autumn at northern high-latitude stations and in early winter at northern tropical stations (Supplementary Table 1). We found that variations in the CO₂ zero-crossing date are negatively correlated with anomalies in autumn air tempera-

(2) Phenology change and its effects on terrestrial carbon cycle

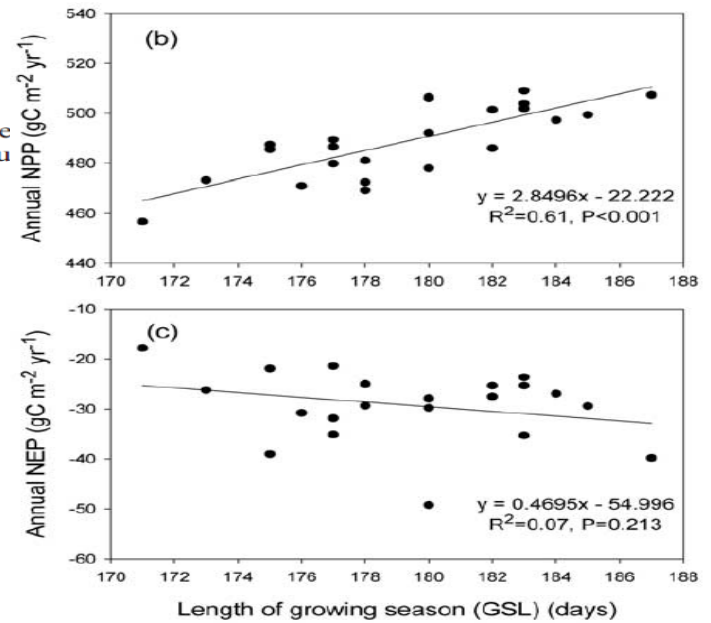
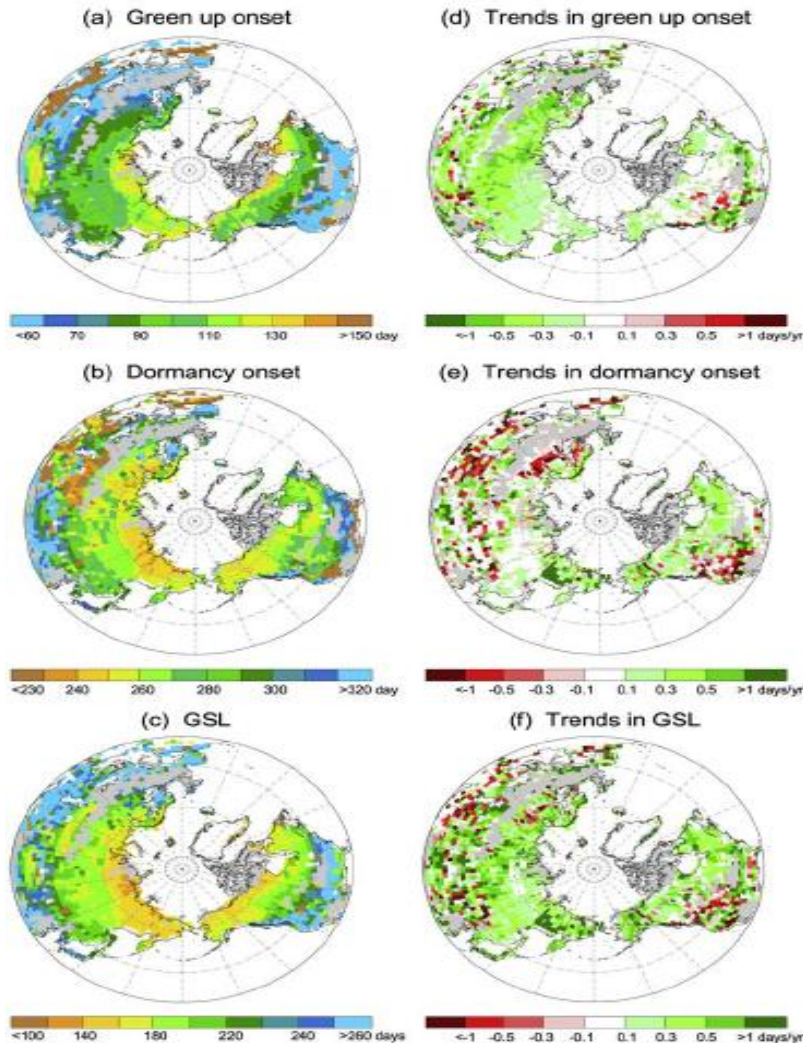


Gr th (2) Phenology change and its effects on terrestrial carbon cycle

Shilong Piao,¹ Pierre Friedlingstein,¹ Philippe Ciais,¹ Nicolas Viovy,¹ and Jérôme Demarty¹

Received 9 November 2006; revised 29 May 2007; accepted 9 July 2007; published 25 September 2007.

[1] A number of studies have suggested that the growing season duration has significantly lengthened during the past decades, but the connections between phenology and the terrestrial carbon (C) cycle are far from clear. In this study, we



RESEARCH HIGHLIGHTS

more dusty in summer, with important implications for central Asian climate.

Alicia Newton



Biodiversity and Ecology Carbon balance

Global Biogeochem. Cy. 21, GB3018 (2007)

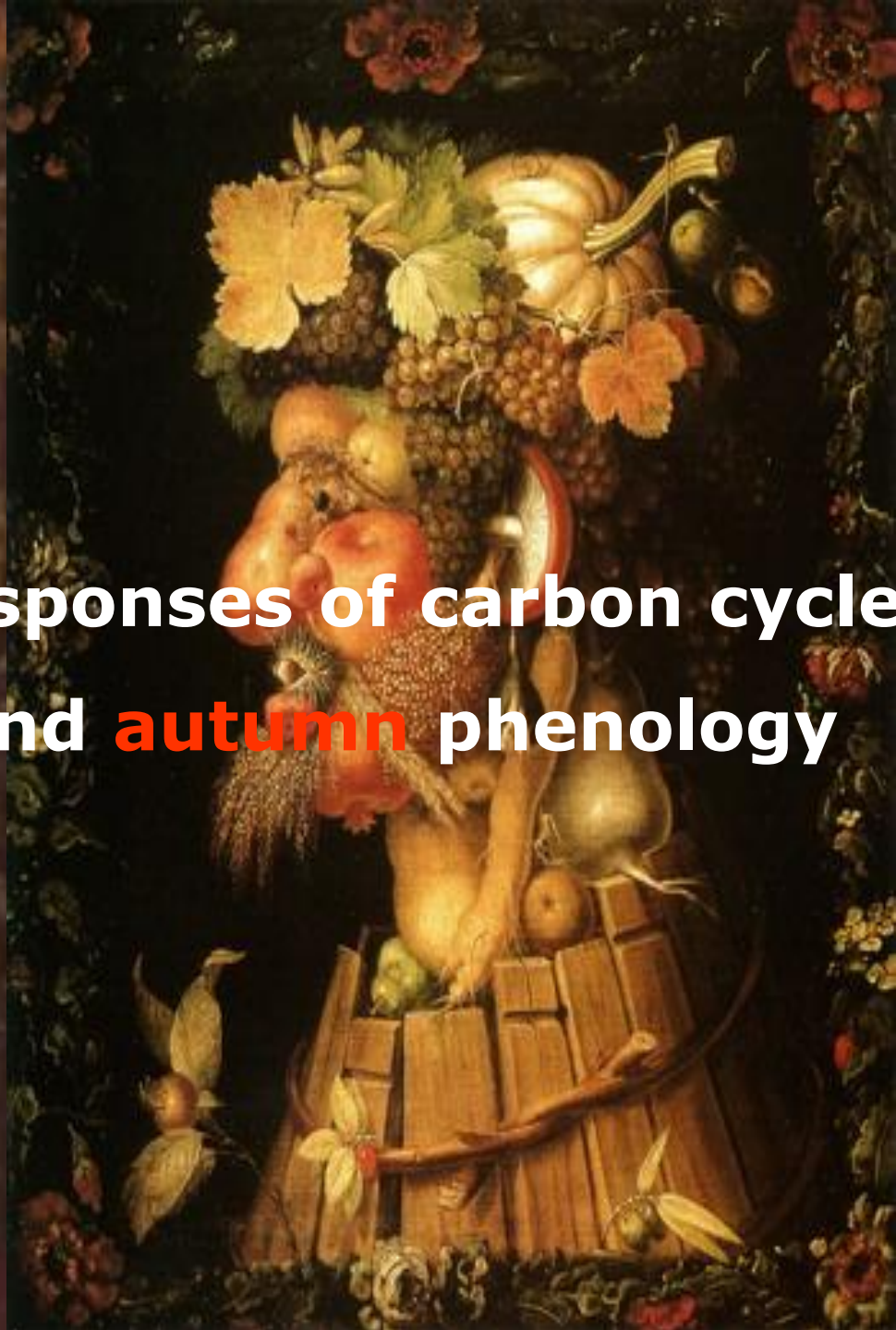
The growing season in the Northern Hemisphere has lengthened over the past few decades, but the atmospheric carbon dioxide mopped up by plant growth has been offset by a parallel rise in soil carbon decomposition, finds a new study.

Shilong Piao and colleagues from the Laboratoire des Sciences du Climat et de l'Environnement in Gif sur Yvette, France

Insight
Authority
Accessibility

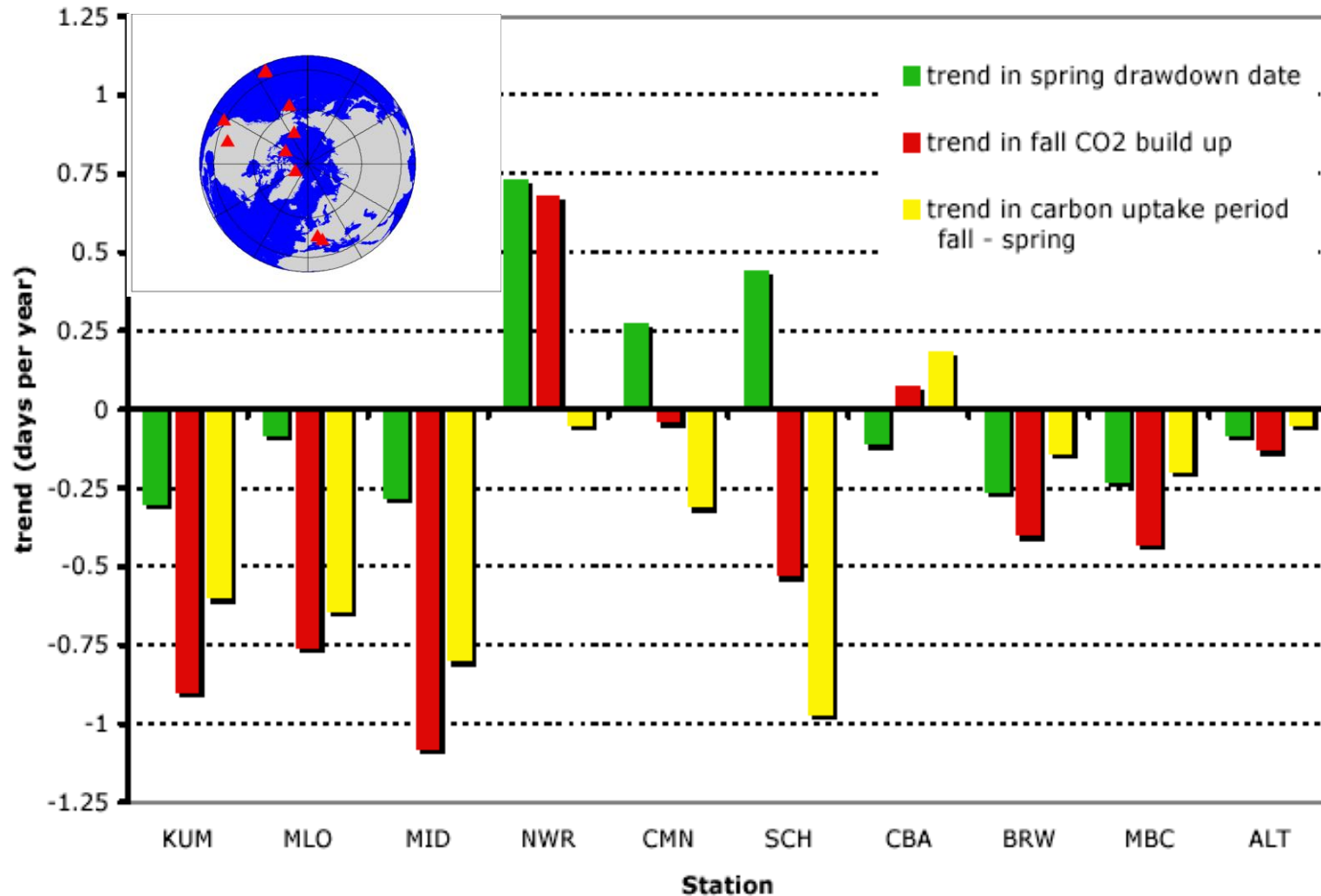
naturenews

Science news from

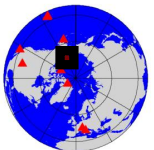
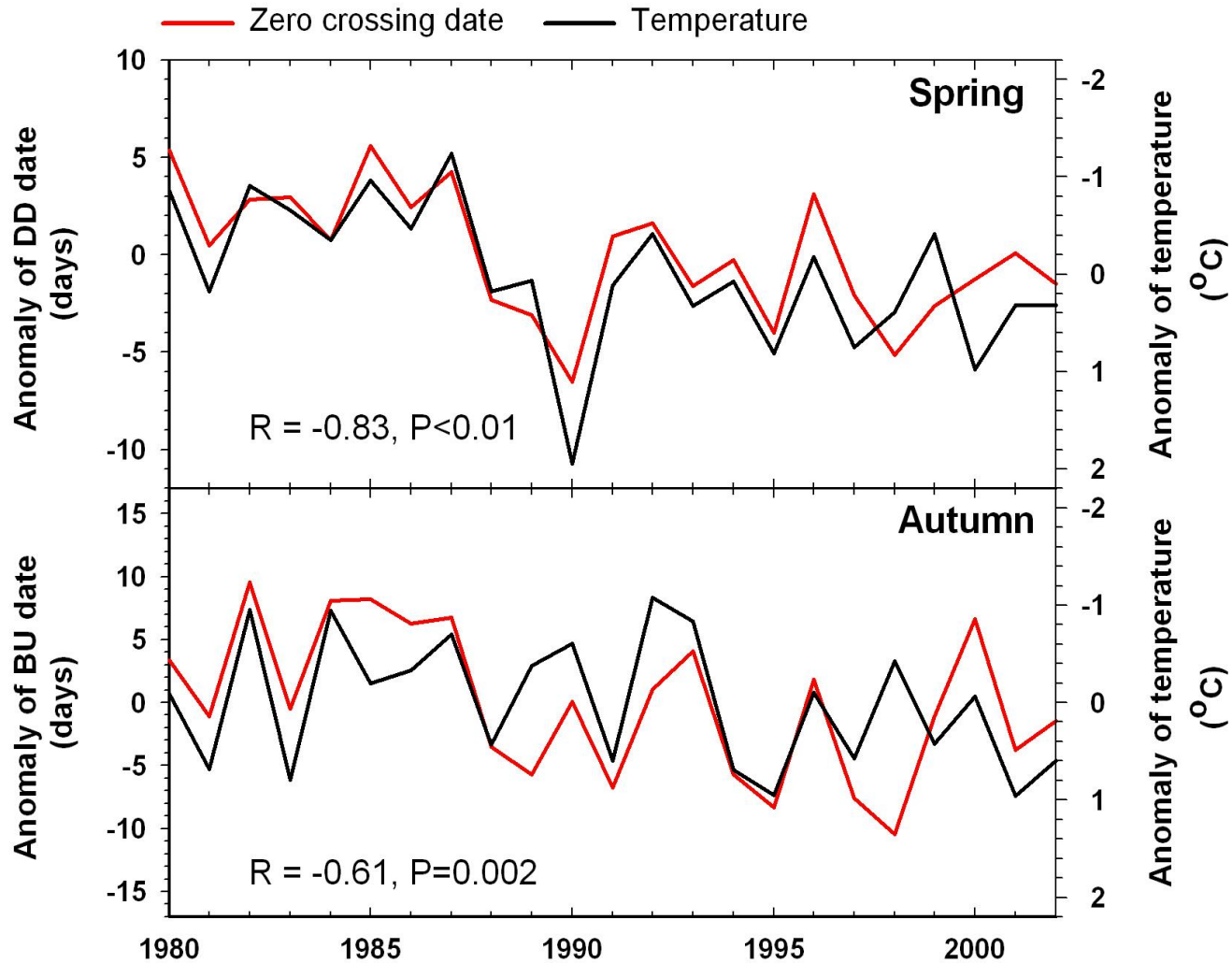


There are different responses of carbon cycle to the **spring** and **autumn** phenology

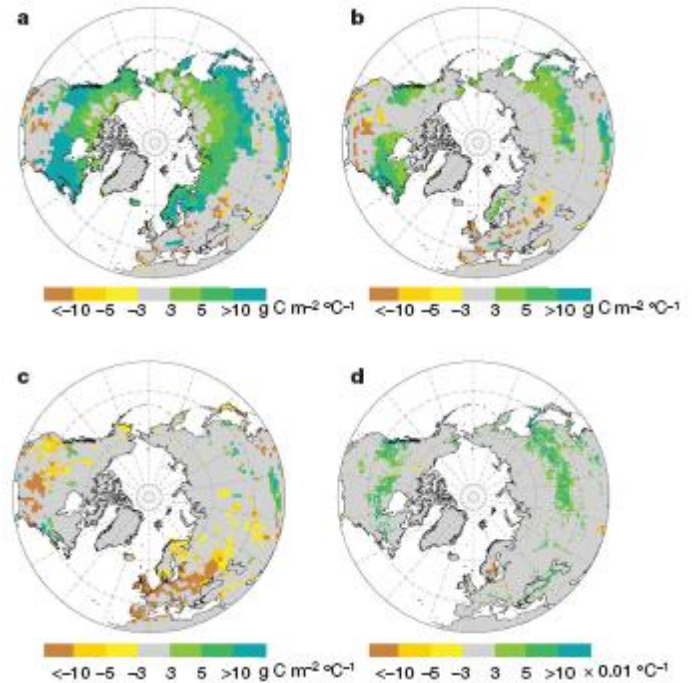
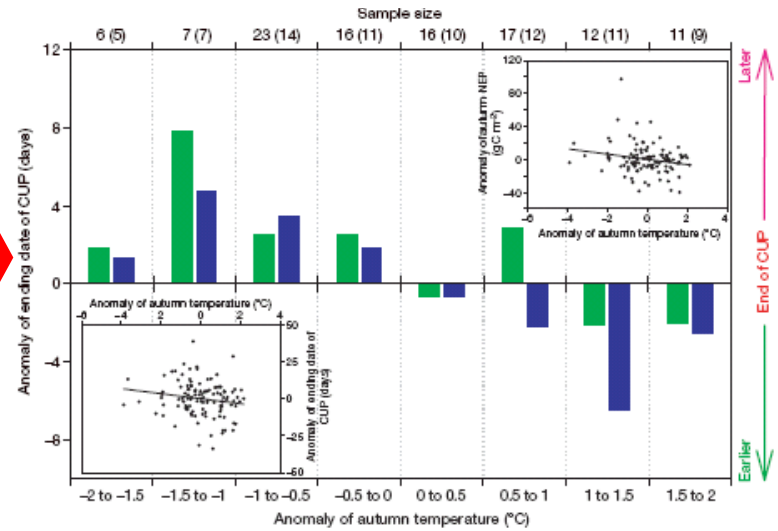
(2) Phenology change and its effects on terrestrial carbon cycle



(2) Phenology change and its effects on terrestrial carbon cycle



(2) Phenology change and its effects on terrestrial carbon cycle



(2) Phenology change and its effects on terrestrial carbon cycle

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Warming forests sop up less greenhouse gases than thought

Tom Snare, CarWest Home Services Ottawa Citizen

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04 January 2008

Drunken flies get hypersexual
Chronic boozing sends male flies chasing after any and every potential mate.

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- Net carbon dioxide losses of northern ecosystems in response to autumn warming
- Geology: The next land rush
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NATURE | Vol 451 | 3 January 2008

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Warming Autumns May H Climate-Cooling Role

ScienceDaily

Global Warming May Reduce Carbon Sink Capacity In

ScienceDaily (Jan. 3, 2008) — An international study investigating the carbon sink capacity of northern terrestrial ecosystems discovered that the duration of the net carbon uptake period (CUP) has on average decreased due to warmer autumn temperatures.

Net carbon uptake of northern ecosystems is decreasing in response to autumnal warming according to findings recently published January 3rd, on the journal Nature. The carbon balance of terrestrial ecosystems is particularly sensitive to climatic changes in autumn and spring. Over the past two decades autumn temperatures in northern latitudes have risen by about 1.1 °C with spring temperatures up by 0.8 °C.

Many northern terrestrial ecosystems currently lose carbon dioxide (CO₂) in response to autumn warming, offsetting 50% of the carbon dioxide uptake during spring. Using computer modeling to integrate forest canopy measurements and remote satellite data, researchers found that while warm spring temperatures accelerate growth more than soil decomposition and enhance carbon uptake, autumn warming greatly increases soil decomposition and significantly reduces carbon uptake.

Lead author of the study, Dr. Shilong Piao from the LSCE, CNRS/CEA/IRD in France says "Warming in autumn occurs at a faster rate than in spring, the ability of northern ecosystems to sequester carbon will diminish in the future".

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RESEARCH HIGHLIGHTS

Jan 9, 2008

Warmer autumns may reduce carbon storage

Warmer autumns could reduce the ability of ecosystems the northern hemisphere to sequester carbon dioxide shortening the carbon-uptake period during the year new result contradicts previous speculation that warm autumnal temperatures would enhance carbon storage plantlife, thanks to extra photosynthesis, as they stay green for longer.

Autumn and spring temperatures in the northern hemisphere have risen by about 1.1 °C and 0.8 °C respectively over 20 years. The carbon balance of terrestrial ecosystems is highly sensitive to these climatic changes. The tempera increases have also been accompanied by a "greening" t characterized by a longer growing season for plants and increased photosynthesis.

All this led many scientists to believe that spring and autumn warming would increase carbon sequestration via photosynthesis and that the period of net carbon uptake rise in the future. Researchers at the Laboratoire des Climat de l'Environnement in Paris, France, and colleagues in Europe, China, Canada and the US are now saying that may not be true. They have found that the length of the carbon uptake period has actually decreased at nearly all northern hemisphere terrestrial carbon dioxide storator during the last two decades because of rising autumnal temperatures.

"This finding stands in apparent contradiction with auto greening and longer-lasting vegetation activity detected mid-to-high northern latitudes by remote sensing and phenological data." leading author Shilong Piao told

CARBON CYCLE Sources, sinks and seasons

John B. Miller

Changes in the phasing of seasonal cycles of carbon dioxide in the atmosphere mark the time when a region becomes a source or a sink of CO₂. One study of such changes prompts thought-provoking conclusions.

We are currently getting a 50% discount on the climatic impact of our fossil-fuel emissions. Since 1957, and the beginning of the Mauna Loa record of atmospheric carbon dioxide, only about half of the CO₂ emissions from fossil-fuel combustion have remained in the atmosphere, with the other half being taken up by the land and ocean. In the face of increasing fossil-fuel emissions, this remarkably stable 'airborne fraction' has meant that the rate of carbon absorption by the land and ocean has accelerated over time¹. Unfortunately, we have no guarantee that the 50% discount will continue, and if it disappears we will feel the full climatic brunt of our unrelenting emission of CO₂ from fossil fuels. Indeed, climate models that include descriptions of the carbon cycle predict that terrestrial uptake of carbon will decrease in the next century as climate warms². As they describe elsewhere in this issue (page 49), Piao *et al.*³ have used observational data to show that rising temperatures may already be decreasing the efficiency of terrestrial carbon uptake in the Northern Hemisphere.

Piao *et al.* looked at changes in the phasing of seasonal cycles of atmospheric CO₂ concentrations at ten sites north of about 20° N. Seasonal cycles of atmospheric CO₂ are caused prima-

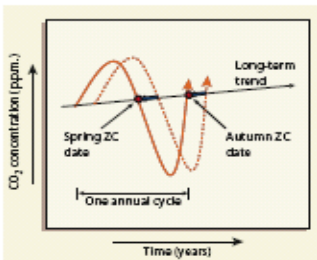


Figure 1 | Zero-crossing (ZC) dates. These dates, shown by red dots, are defined as the time when the annual cycle of atmospheric CO₂ crosses the calculated long-term trend in CO₂ concentration. In spring, this occurs as net CO₂ uptake is increasing and atmospheric CO₂ concentration is falling, and in autumn as net CO₂ release is increasing and atmospheric CO₂ concentration is rising. The phasing of this cycle is determined by net carbon uptake or release throughout the year, which, in turn, is the balance between respiration and photosynthesis. Because net flux is the relatively small difference between the much larger photosynthetic and respiratory fluxes, small fractional changes in either photosynthesis or respiration can have large impacts on the timing

of carbon in autumn seems to largely cancel the uptake gains made by earlier, greener springs, just as the atmospheric data did.

Piao and colleagues' results link temperature and carbon uptake, but using them to predict the future trajectory of carbon uptake is tricky. Even if we know that temperatures will increase, we still need to know temperature trends for spring and autumn. If spring temperatures rise more quickly than those in autumn, sinks could get larger, whereas more rapid increases in autumn temperatures would cause sinks to diminish. Furthermore, the authors point out that, so far, spring temperatures have been rising faster in Eurasia than in North America, whereas autumn temperatures have been rising faster in North America, adding a level of geographical complexity to future projections.

Even for now, however, the picture remains incomplete. Just as measures of greenness from space can't determine total carbon balance because they miss the respiratory side of the equation, so the study by Piao *et al.* doesn't address carbon balance in the winter and summer. And the annual net carbon balance is what is needed in order to understand whether carbon sinks are disappearing, remaining steady or getting stronger.

In light of Piao and colleagues' results, and of two recent studies showing diminishing ocean sinks in the critical carbon-uptake areas of the North Atlantic⁷ and Southern Ocean⁸, it may seem odd to consider that carbon sinks might be getting stronger. But this is exactly what the steady airborne fraction of global CO₂ is telling us. The global CO₂ signal is most significant for two reasons: first, it is the most robust determination of carbon uptake, because the errors in atmospheric observations and fossil-fuel emissions are very small; and second, the global CO₂

(3) Carbon budget at regional or global scale

Estimate regional and global carbon budget

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 110, G01006, doi:10.1029/2005JG000014, 2005

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 21, GB2002, doi:10.1029/2005GB002634, 2007

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Forest biomass carbon density and changes in forest biomass carbon density in 1982 and 1990s

Shilong Piao, Jingyun Fang, and Markus Reichert
Department of Ecology, College of Life Sciences, Peking University, Beijing, China

Received 17 January 2005; revised 10 February 2005; accepted 10 February 2005.
[1] Forests are major carbon sinks and crucial components for environmental protection. We analyzed the changes in distribution of C sinks/sinks density of 45.31 Mg C/ha in the 1990s (average for annual sequestration rate of 1.6 Pg C/yr) in the lower C density. Both environmental changes and human activities have influenced the carbon sink.

Changes in forest biomass carbon density in 1982 and 1990s

Shilong Piao,¹ Jingyun Fang,¹ and Markus Reichert,²
Received 7 October 2004; revised 10 February 2005; accepted 10 February 2005.

[1] Terrestrial ecosystems are major carbon sinks and crucial components for environmental protection. We analyzed the changes in distribution of C sinks/sinks density of 45.31 Mg C/ha in the 1990s (average for annual sequestration rate of 1.6 Pg C/yr) in the lower C density. Both environmental changes and human activities have influenced the carbon sink.

Carbon Footprint of The European Forests

European forests carbon harvest statistics
Received 7 October 2004; revised 10 February 2005; accepted 10 February 2005.

[1] In this study, we use a conceptual model to estimate the carbon footprint of European forests. The carbon footprint is defined as the amount of CO₂ emitted by the forest to produce the harvested wood. We find that the carbon footprint of European forests is 1.6 Pg C/yr, which is comparable to the carbon sink of European forests.

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GEOPHYSICAL RESEARCH LETTERS, VOL. 36, L07404, doi:10.1029/2009GL037381, 2009

PROGRESS ARTICLE

Global Change Biology

Global Change Biology (2009), doi: 10.1111/j.1365-2486.2009.02056.x

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 23, GB4026, doi:10.1029/2008GB003339, 2009

The European Forest Carbon Budget

S. LUYSSAERT¹, M. J. SCHELHAUT¹, C. BEER¹, J. GRUNDEL¹, G. J. NABUURS¹, I. A. JANSSENS¹, and M. J. COLEMAN²
¹Department of Biology and ²Department of Chemistry, Ghent University, Coupure links 653, 9000 Ghent, Belgium

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Spatiotemporal patterns of terrestrial carbon cycle during the 20th century

Shilong Piao,^{1,2} Patricia Cadule,³ and Markus Reichert,⁴
Received 21 August 2008; revised 10 February 2009; accepted 10 February 2009.

[1] We evaluate use change influence on the carbon cycle process-based ecosystem models. We find that the carbon sink of European forests is 1.6 Pg C/yr, which is comparable to the carbon sink of European forests.

Vol. 458 | 23 April 2009 | doi:10.1038/nature07944

nature

LETTERS

The carbon balance of terrestrial ecosystems in China

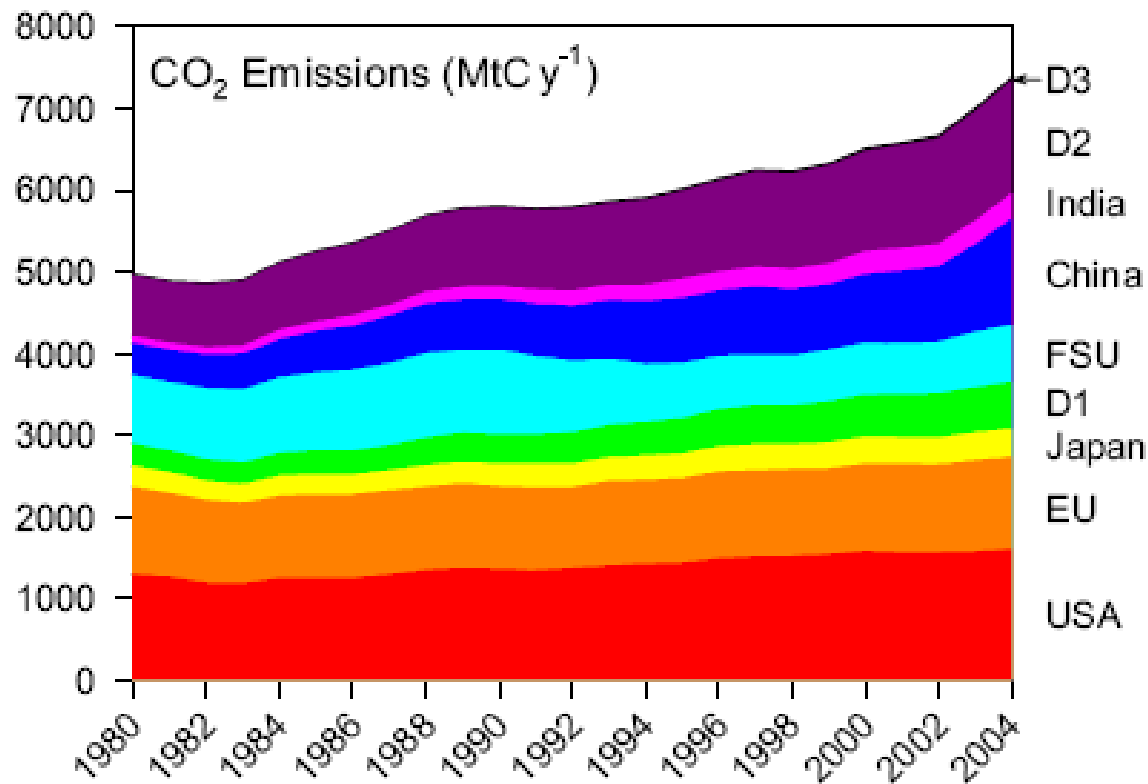
Shilong Piao¹, Jingyun Fang¹, Philippe Ciais², Philippe Peylin³, Yao Huang⁴, Stephen Sitch⁵ & Tao Wang¹

Global terrestrial ecosystems absorbed carbon at a rate of 1–4 Pg yr⁻¹ during the 1980s and 1990s, offsetting 10–60 per cent of the fossil-fuel emissions^{1,2}. The regional patterns and causes of terrestrial carbon sources and sinks, however, remain uncertain^{3,4}. With increasing scientific and political interest in regional aspects of the global carbon cycle, there is a strong impetus to better understand the carbon balance of China^{5,6}. This is not only because China is the world's most populous country and the largest emitter of fossil-fuel CO₂ into the atmosphere⁷, but also because it has experienced regionally distinct land-use histories and climate trends⁸, which together control the carbon budget of its ecosystems. Here we analyse the current terrestrial carbon balance of China and its driving mechanisms during the 1980s and 1990s using three different methods: biomass and soil carbon inventories extrapolated by satellite greenness measurements, ecosystem models and atmospheric inversions. The three methods produce similar estimates of a net carbon sink in the range of 0.19–0.26 Pg carbon (PgC) per year, which is smaller than that in the conterminous United States⁹ but comparable to that in geographic Europe¹⁰. We find that northeast China is a net source of CO₂ to the

In parallel with the recent economic boom in China, there has been a steep rise in energy demand, sustained by the use of fossil fuels. Fossil-fuel CO₂ emissions have thus climbed from 0.4 PgC yr⁻¹ in 1980 to 1.5 PgC yr⁻¹ in 2006, making China the largest emitter in the world⁷. Quantifying the carbon balance of Chinese ecosystems is necessary not only to assess the magnitude of the Northern Hemispheric and global sinks, but also to define new objectives for the management of terrestrial ecosystems in the context of the global impetus to slow the rate of CO₂ growth. In this study, we use three different methods: sample-based biomass and soil carbon inventories combined with remotely sensed vegetation greenness index, ecosystem models and atmospheric inversions of CO₂ concentration data (Methods), to assess the carbon balance of China during the 1980s and 1990s.

Forests cover ~14% of China. Analysis of the national forest inventory data (Methods) suggests that forest biomass carbon stock increased significantly during the 1980s and 1990s. This translates into a carbon sink of 0.058 ± 0.026 PgC yr⁻¹ during the 1980s and one of 0.092 ± 0.044 PgC yr⁻¹ during the 1990s (Table 1). A total amount of 1.65 ± 0.76 PgC has been sequestered into forest biomass since 1982. On an area basis, this accumulation of carbon in standing tree

It is of critical importance to quantify China's carbon budget

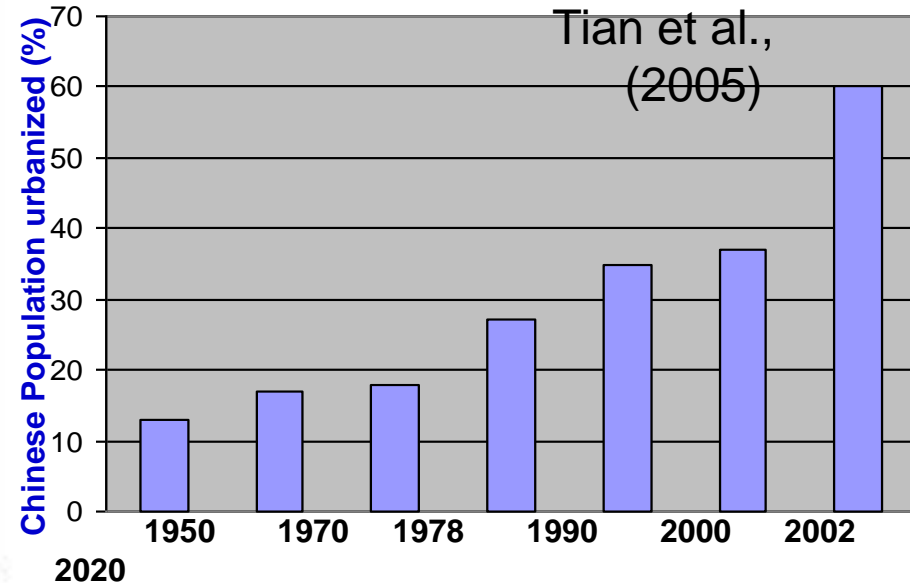
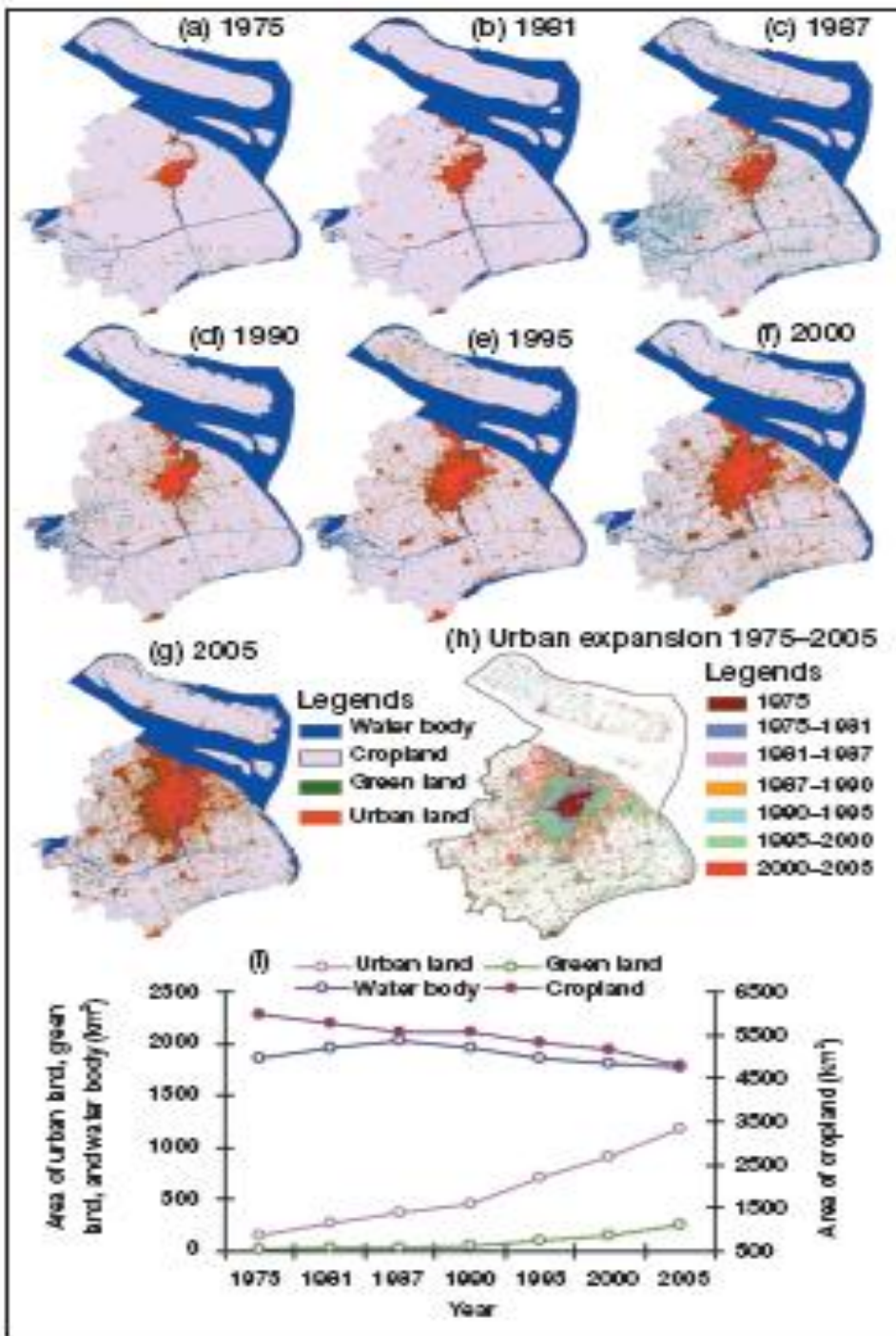


In parallel with the recent economic boom in China, fossil fuel CO₂ emissions have climbed from **0.4 PgC yr⁻¹** in 1980 to **1.5 PgC yr⁻¹** in 2006, placing China as **the largest emitter in the world**.

Rapid Urbanization

Carbon loss from new urban settlements

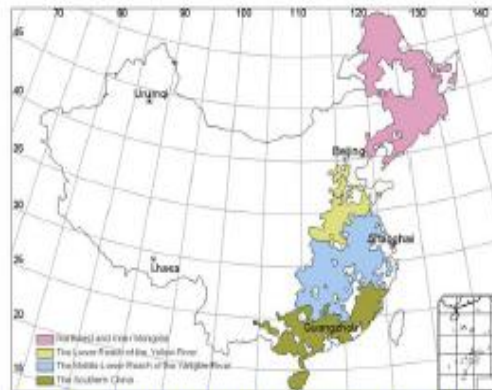
Carbon gain since movement of rural population to cities have diminished the collection of fuel wood, accelerating the recovery of vegetation



Afforestation/reforestation projects



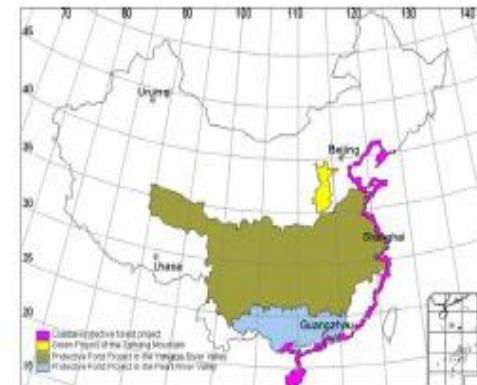
Three-North protective forest and sand-control plantation surrounding Beijing



Fast-growing high yield timber forest bases project of key regions



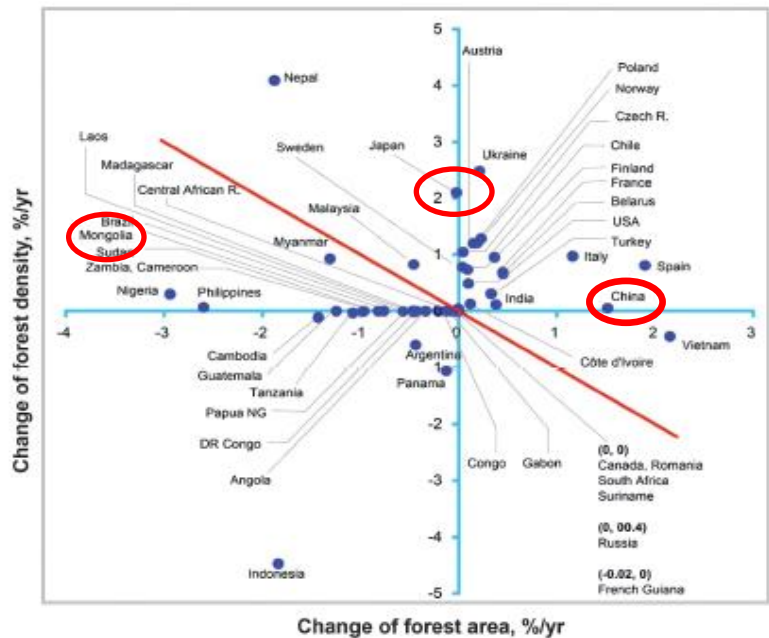
Protective Project of Natural Forests



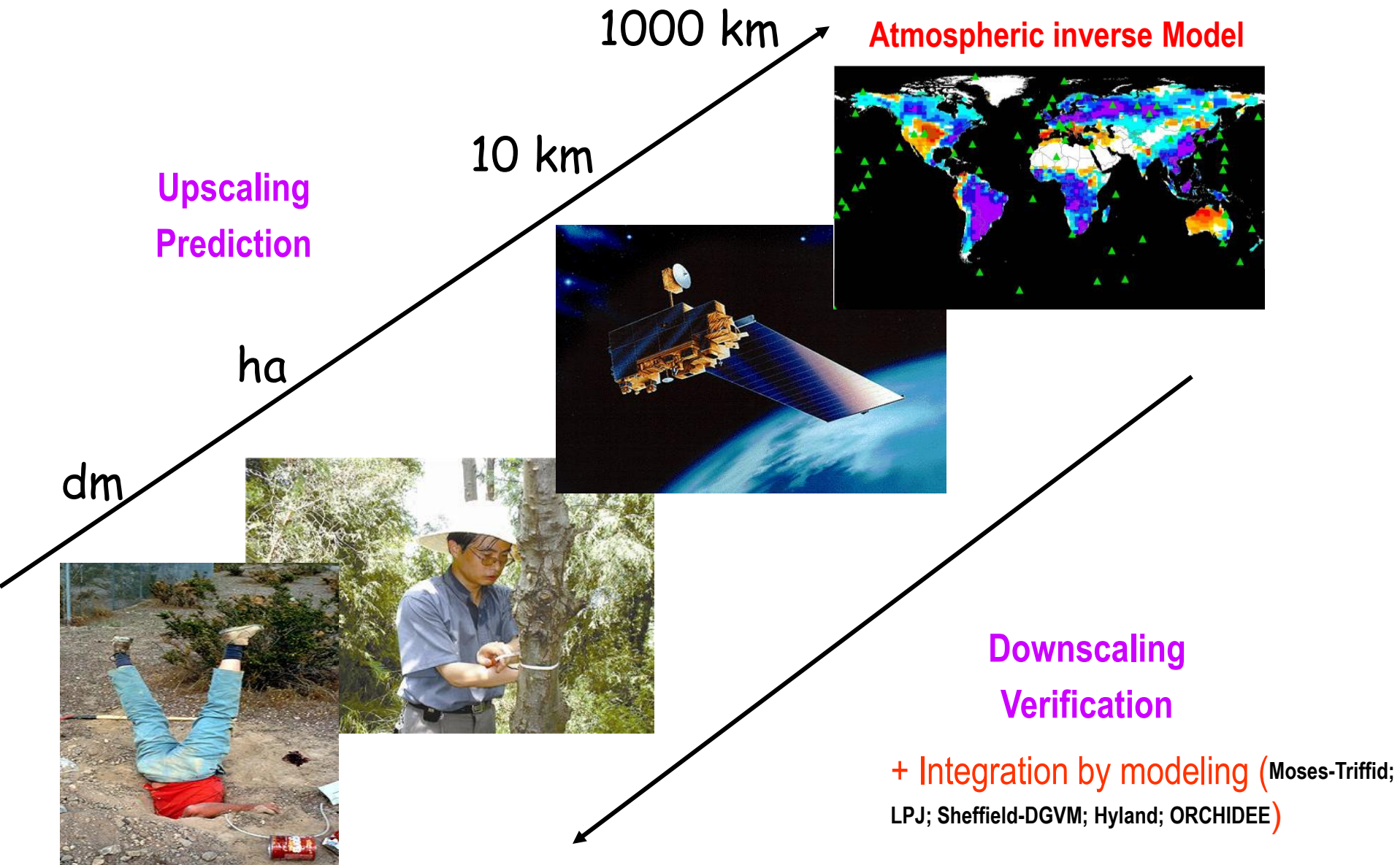
River valley and coastal protective project

-China contributed about **one quarter** of the global plantation area.

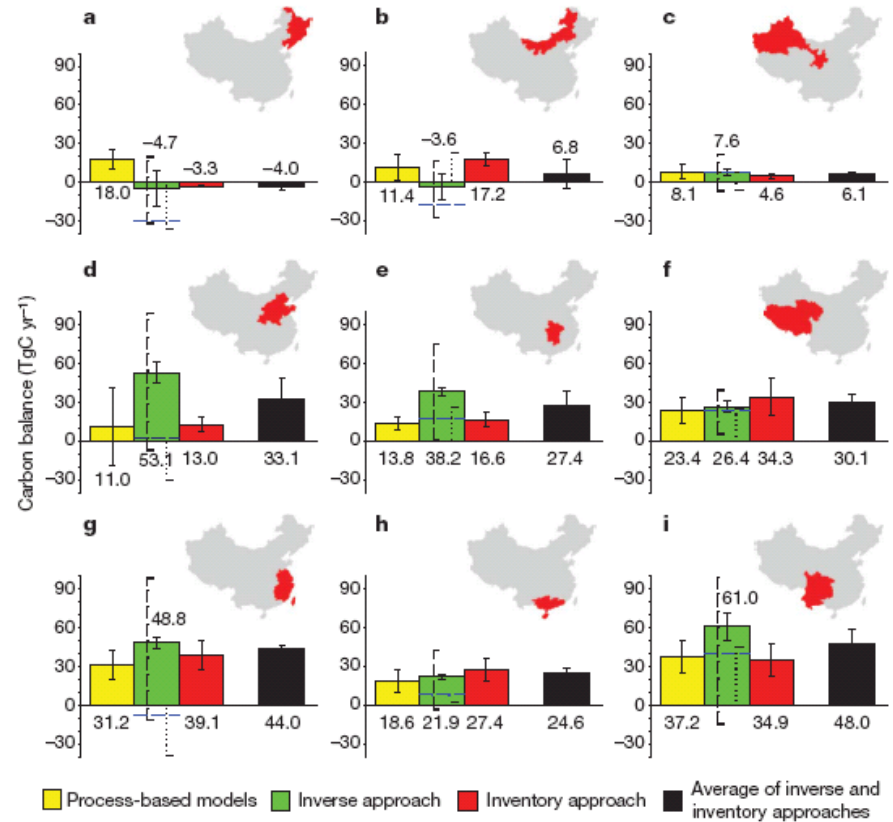
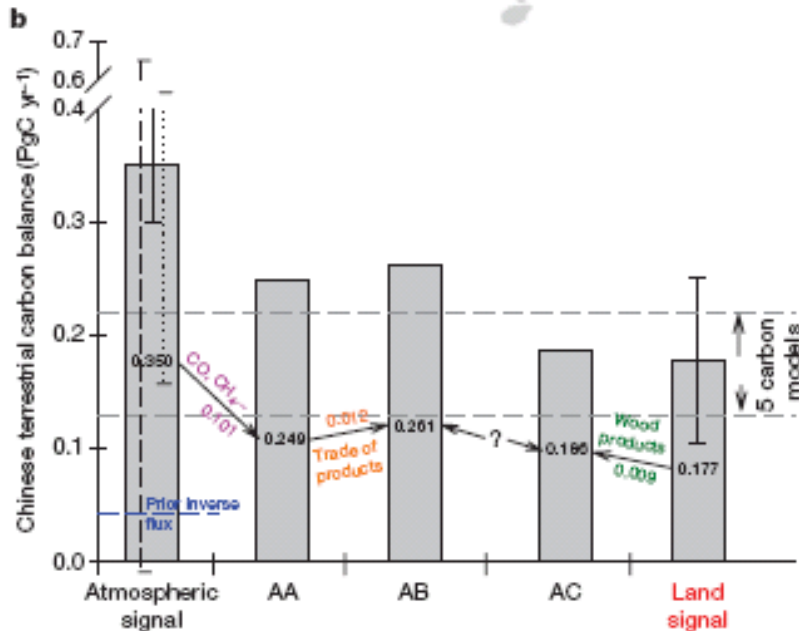
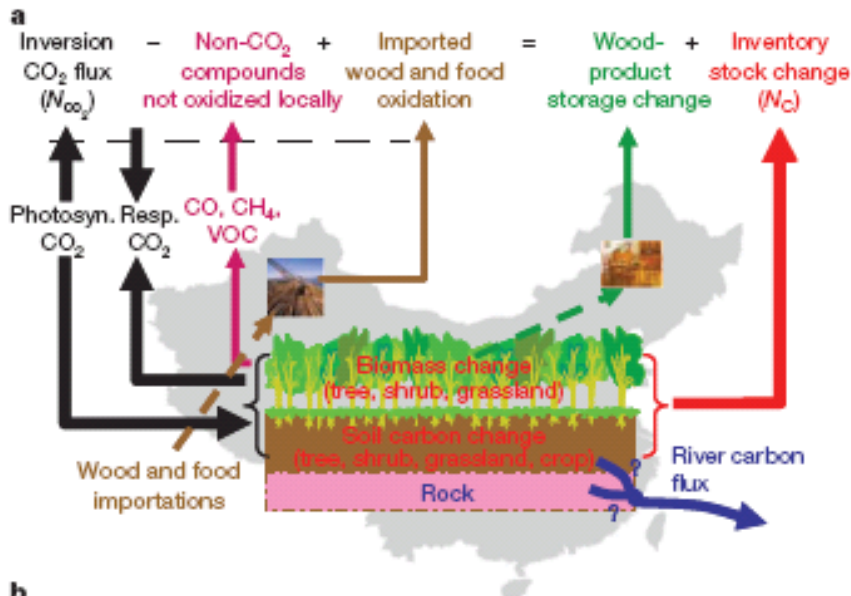
-Forest plantation benefit net carbon uptake



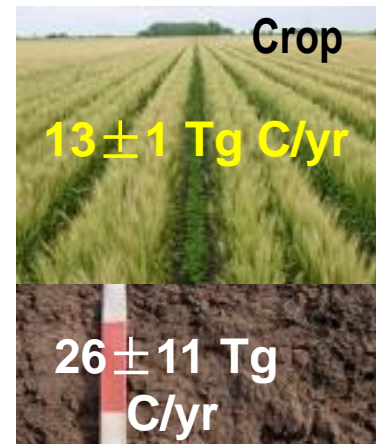
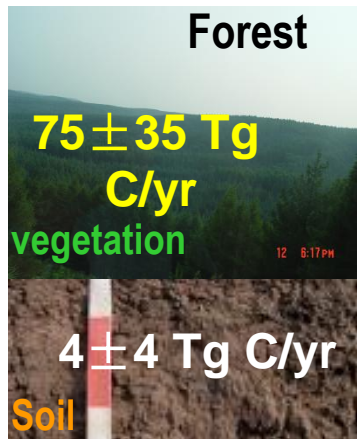
(3) Carbon budget at regional or global scale



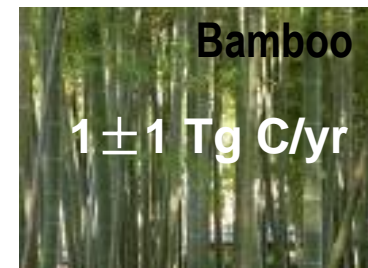
(3) Carbon budget at regional or global scale



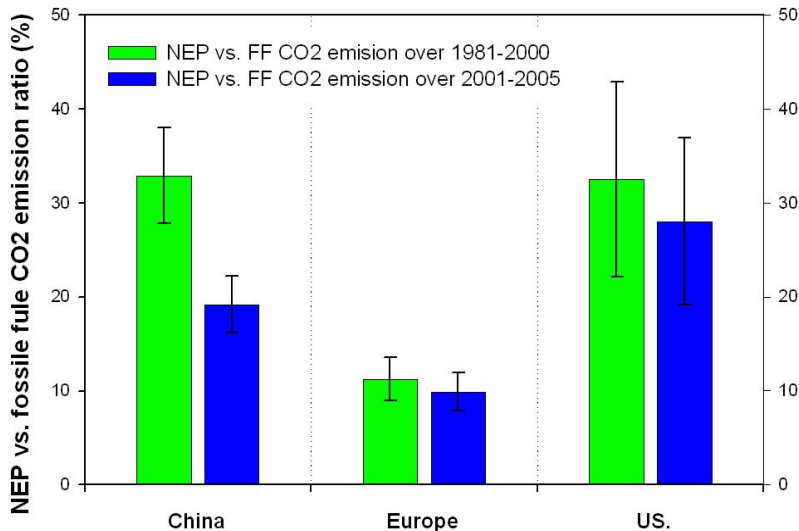
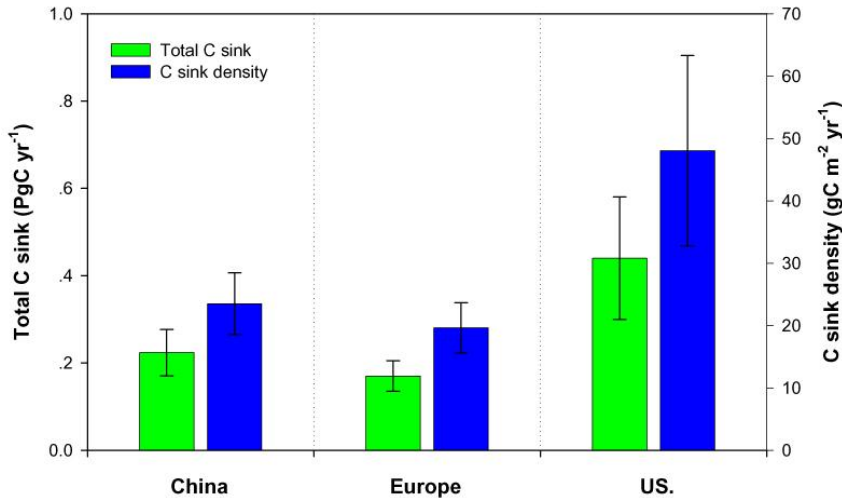
(3) Carbon budget at regional or global scale



$177 \pm 73 \text{ Tg C/yr} =$



(3) Carbon budget at regional or global scale



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NEWS & VIEWS NATURE | Vol 458 | 23 April 2009

GLOBAL CHANGE

China at the carbon crossroads

Kevin Robert Gurney

In China, as in other nations that produce carbon dioxide from fossil fuels on a large scale, the terrestrial biosphere mops up a proportion of the emissions. Estimates of the amounts involved are now available.

According to recent estimates^{1,2}, in late 2006 China overtook the United States as the world's number one emitter of carbon dioxide, the primary greenhouse gas. This dubious honour highlighted the swift growth of CO₂ emissions in China, much of that growth being due to rapid industrialization fuelled by coal-powered energy and cement manufacturing (during which especially

large amounts of CO₂ are produced). As reported on page 1009 by Piao and colleagues³, and as in other large CO₂ emitters of the Northern Hemisphere, China's trees, shrubs and soils are acting to partly offset the CO₂ emissions resulting from fossil-fuel combustion. Piao *et al.* estimate this biospheric offset by examining changes in soils and vegetation across China and comparing these

(4) The impact of climate change on water resource

Estimate the impact of change in climate and land use on water resource

IOP Publishing
Environ. Res. Lett. 4 (2009) 040412 (6pp)

ENVIRONMENTAL RESEARCH LETTERS
doi:10.1088/1748-9326/4/4/040412

Summer soil moisture regulated by precipitation frequency in China

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Abstract
Drought is one of the most important but least understood issues in global environmental changes. Decrease in soil moisture is an indicator of drought. Here, we analyze summer (June–August) soil moisture measurement data across 50 sites in China in order to investigate the linkage between climate change and drought. At the country scale, a significant decrease in summer soil moisture in the top 50 cm was observed during 1981–2002, resulting mainly from the decline in soil moisture in North China. Statistical analyses suggest that changes in precipitation frequency have significant consequences for soil moisture dynamics, but the ability to use precipitation frequency changes to explain the variation of soil moisture depends on the discriminating criteria of precipitation events. Among five criteria (0.5, 10, 15, 20 mm day⁻¹), the maximum coefficient of correlation between summer soil moisture in the top 50 cm and precipitation frequency occurs when considering the number of days on which daily precipitation amount is larger than 10 mm (PF10). Spatially, the correlation between soil moisture in the top 50 cm and PF10 is weak for very dry and very wet soils and is much stronger for intermediate values.

Changes in climate and land use have a larger direct impact than rising CO₂ on global river runoff trends

Shilong Piao*, Pierre Friedlingstein*, Philippe Ciais*, Nathalie de Noblet-Ducoudré*, David Labat*, and Sönke Zaehle*

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Vol 467 | 2 September 2010 | doi:10.1038/nature09364

nature

REVIEWS

The impacts of climate change on water resources and agriculture in China

Shilong Piao¹, Philippe Ciais², Yao Huang³, Zehao Shen¹, Shushi Peng¹, Junsheng Li⁴, Liping Zhou¹, Hongyan Liu¹, Yuecun Ma¹, Yihui Ding⁵, Pierre Friedlingstein^{2,6}, Chunzhen Liu⁷, Kun Tan¹, Yongqiang Yu³, Tianyi Zhang³ & Jingyun Fang¹

China is the world's most populous country and a major emitter of greenhouse gases. Consequently, much research has focused on China's influence on climate change but somewhat less has been written about the impact of climate change on China. China experienced explosive economic growth in recent decades, but with only 7% of the world's arable land available to feed 22% of the world's population, China's economy may be vulnerable to climate change itself. We find, however, that notwithstanding the clear warming that has occurred in China in recent decades, current understanding does not allow a clear assessment of the impact of anthropogenic climate change on China's water resources and agriculture and therefore China's ability to feed its people. To reach a more definitive conclusion, future work must improve regional climate simulations—especially of precipitation—and develop a better understanding of the managed and unmanaged responses of crops to changes in climate, diseases, pests and atmospheric constituents.

Climate change and its impacts on water resources and crop production is a major force with which China and the rest of the world will have to cope in the twenty-first century^{1,2}. In China, despite the growing importance of industry, agriculture has a central role in ensuring the food security and welfare of

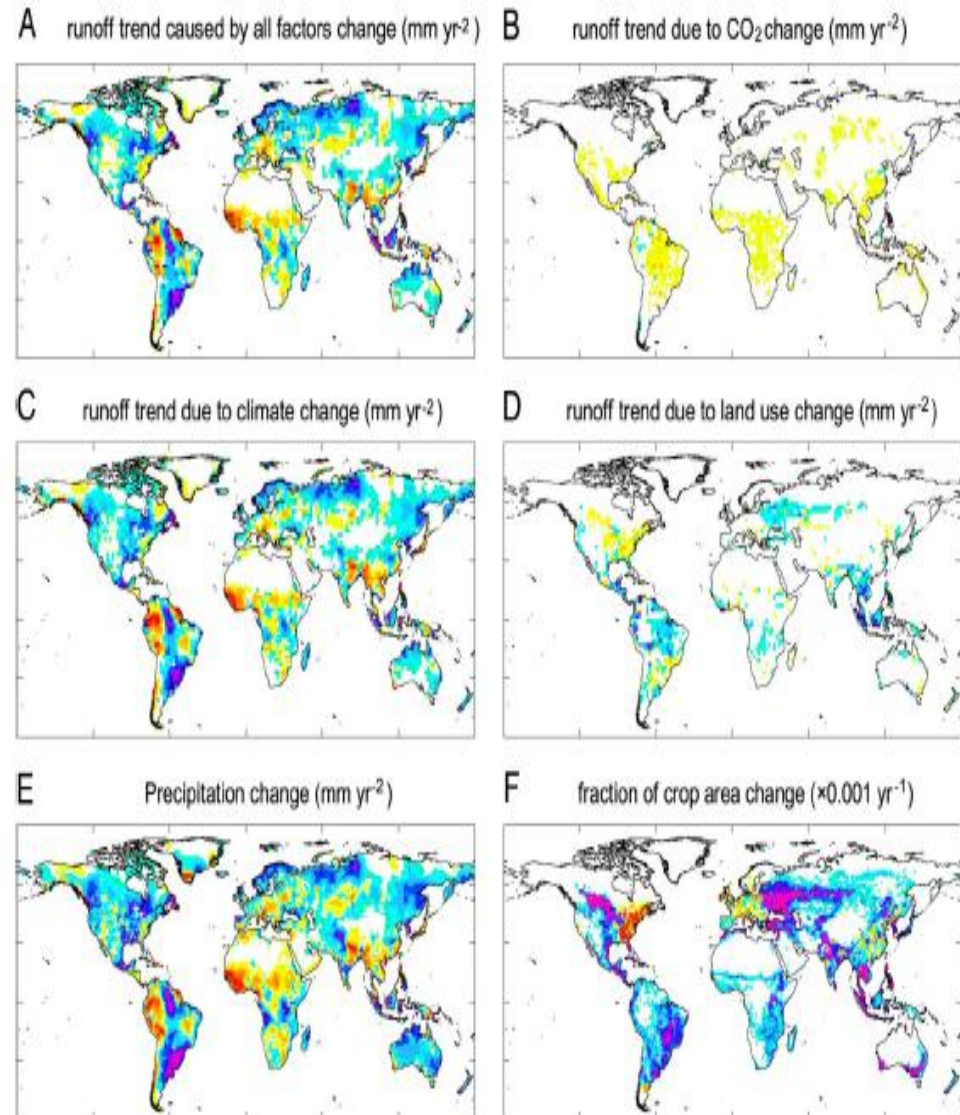
agricultural production, and the role of agricultural adaptation potentials, within a more conceptual and speculative framework.

Through this analysis, we show that China's climate has clearly warmed since 1960, with an increased frequency of heatwaves, and that glaciers are in retreat. But the geographic and interannual variability of

Changes in climate and land use have a larger direct impact than rising CO₂ on global river runoff trends

Shilong Piao¹, Pierre Friedlingstein^{1*}, Philippe Ciais², Nathalie de Noblet-Ducoudré¹, David Labat³, and Sönke Zaehle¹

(4) The impact of climate change on water resource



----- Message original -----
 Sujet: PNAS
 Date: Mon, 4 Feb 2008 13:33:39 -0500
 De: Weiss, Nathan <NWeiss@nas.edu>
 Pour: <pierre.friedlingstein@lscce.ipsl.fr>

February 4, 2008

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The Editorial Board of the /Proceedings of the National Academy of Sciences / (PNAS) would like to thank you for publishing in PNAS. We are pleased to report that your PNAS paper, "Changes in climate and land use have a larger direct impact than rising CO₂ on global river runoff trends" is one of our 20 most-read papers online during the month of December 2007 (www.pnas.org/reports/mfr1.dtl <http://www.pnas.org/reports/mfr1.dtl>). /We expect this online interest will result in increased citations of your paper. / /

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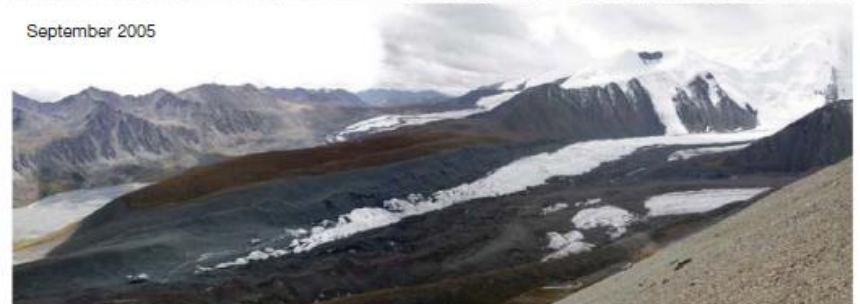
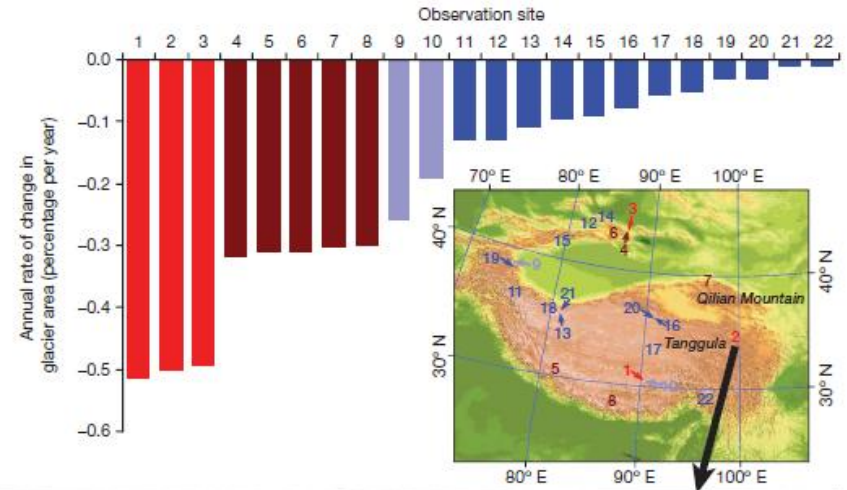
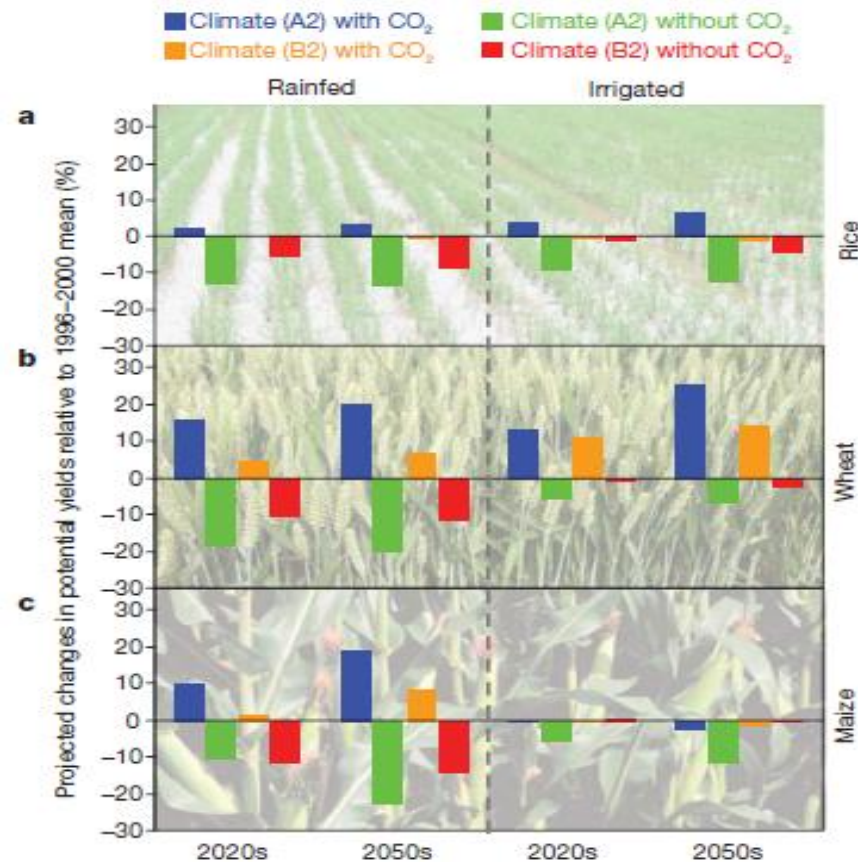
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(4) The impact of climate change on water resource

REVIEWS

The impacts of climate change on water resources and agriculture in China

Shilong Piao¹, Philippe Ciais², Yao Huang³, Zehao Shen¹, Shushi Peng¹, Junsheng Li⁴, Liping Zhou¹, Hongyan Liu¹, Yuecun Ma¹, Yihui Ding⁵, Pierre Friedlingstein^{2,6}, Chunzhen Liu⁷, Kun Tan¹, Yongqiang Yu⁸, Tianyi Zhang² & Jingyun Fang¹



Publication (2007-)

Journal	Number	发表年份
<i>Nature</i>	3	2008-2010
<i>PNAS</i>	2	2007,2011
<i>Nature Geosciences</i>	2	2008, 2010
<i>Ecology</i>	1	2010
<i>Global Change Biology</i>	7	2007-
<i>Global Biogeochem Cycles</i>	4	2007-2010
<i>Biogeosciences</i>	3	2009,2010
<i>J. Geophysical Research</i>	1	2011
<i>Geophysical Res. Letters</i>	2	2007, 2009
<i>Soil Biology and Biochemistry</i>	2	2009, 2010
<i>Global and Planetary Change</i>	1	2011
<i>Environmental Research Letters</i>	1	2009
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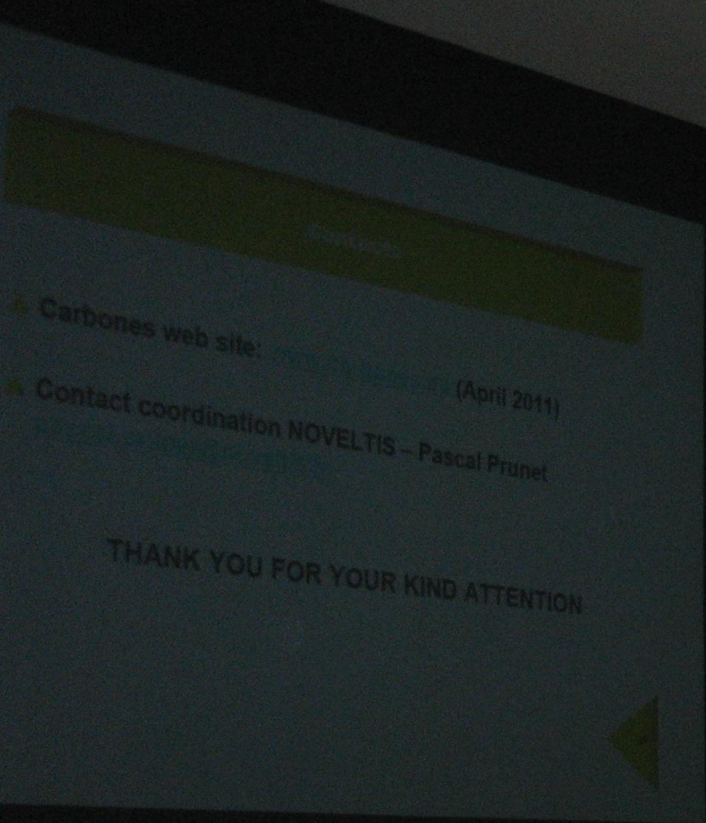


30-year re-analysis of CARBON fluxES and pools



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Visits of students, post-docs and senior staff

Name	Status	Time	Duration
Shilong Piao	Post Dr	2004-2007	3 years
Kun Tan	Post Dr	2010.3-	3 years
Tao Wang	PhD	2008.10-	3 years
Chao Yue	PhD	2010.11-	3 years
Jingfeng Chang	PhD	2011.2-	3 years
Jingyun Fang	Visit as Prof.	2008.4	2 days
Shushi Peng	Visit as PhD student	2008.11-12	1 month
Xuhui Wang	Visit as Ms student	2010.9-11	2 months
Kun Tan	Visit as PhD student	2008.3-10	7 months



Thanks !