Highlights 2010

A selection of content from *Environmental Research Letters* published in 2010.

Low solar activity is blamed for winter chill over Europe

A Perspective by Rasmus E Benestad

2010 *Environ. Res. Lett.* **5** 021001

Throughout recent centuries, there have been a large number of studies of the relationship between solar activity and various aspects of climate, and yet this question is still not entirely settled. In a recent study, Lockwood *et al* (2010) argue that the occurrence of persistent wintertime blocking events (periods with persistent high sea level pressure over a certain region) over the eastern Atlantic, and hence chilly winters over northern Europe, are linked to low solar activity. Is this then a breakthrough in our understanding of our climate?

The Wolf sunspot number, which dates back to Galileo's invention of the telescope in the 17th century, represents one of our longest geophysical data records. Galileo was also involved in building the first barometers and thermometers around that period. Hence, the 17th century represents the start of instrumental measurements of weather and climate, and there are indeed historical records of speculations or studies on the link between changes in the sun and conditions on Earth dating from that time (Helland-Hansen and Nansen 1920).

One notorious problem with many previous studies was that relationships established over the calibration interval subsequently broke down. There was a period in the mid-20th century when little work was done on solar activity and climate, but solar activity was considered a real forcing factor before 1920. With the advent of frontal theory, orbital forcing theory, and stronger awareness of the implications of enhanced greenhouse gas concentrations, the support for solar forcing seemed to have diminished in the climatology community by the mid-20th century (Monin 1972). But non-stationary relationships, the chaotic character of climate, weak effects, and lack of a physical understanding behind such a link, can also explain the low support for solar forcing at that time.

For a long time, it was not established whether more sunspots meant a brighter or dimmer sun (the answer is brighter), and then the direct effect from changes in the solar brightness (0.1%) was estimated to be too low to explain the temperature changes on Earth. The solar influence on changes in the global mean temperature has so far been found to be weak (Lean 2010, Benestad and Schmidt 2009). The important difference between recent and early studies is, however, that the latter lacked a theoretical framework based on physical mechanisms.

Now we understand that stratospheric conditions vary, and are affected by chemical reactions as well as the absorption of UV light. Furthermore, we know that such variations affect temperature profiles, wave propagations, and winds (Schindell *et al* 2001). Lean (2010) and Haigh (2003) provide nice reviews of recent progress on solar-terrestrial relationships, although questions regarding the quality of the oldest solar data records are still unanswered (Benestad 2005). All these studies still rely on empirical data analysis.

Much of the focus of the recent work has been on climate variation on global scales. The recent paper by Lockwood *et al* (2010) represents current progress, albeit that they emphasize that the relationship they identify has a regional rather than global character. Indeed, they stress that a change in the global mean temperature should not be confused with regional and seasonal means. The physical picture they provide is plausible, yet empirical relationships between solar activity and any of the indices describing the north Atlantic oscillation, the Arctic oscillation or the polar vortex are regarded as weak.

My impression is nevertheless that the explanation provided by the Lockwood *et al* (2010) study reflects real aspects of our climate, especially if the effect is asymmetric. They argue that solar-induced changes in the stratosphere in turn affect the occurrence of persistent wintertime blocking. But one comprehensive, definite, consistent, and convincing documentation of the entire chain causality is still not in place, due to the lack of long-term high-quality observations from remote sensing platforms. It is nevertheless well known that the temperature in northern Europe is strongly affected by atmospheric circulation. Crooks and Gray (2005) have identified a solar response in a number of atmospheric variables, and Labitske (1987), Labitske and Loon (1988) and Salby and Callagan (2000) provide convincing analyses suggesting that the zonal winds in the stratosphere are influenced by solar activity. Furthermore, Baldwin and Dunkerton (2001) provide a tentative link between the stratosphere and the troposphere. The results of Lockwood *et al* (2010) fit in with earlier work (Barriopedro *et al* 2008) and provide further evidence to support the current thinking on solar-terrestrial links. Thus, it is an example of incremental scientific progress rather than a breakthrough or a paradigm shift.

Are cold winters in Europe associated with low solar activity?

M Lockwood, R G Harrison, T Woollings and S K Solanki

2010 *Environ. Res. Lett.* **5** 024001

Featured on environmentalresearchweb.org

Abstract

Solar activity during the current sunspot minimum has fallen to levels unknown since the start of the 20th century. The Maunder minimum (about 1650–1700) was a prolonged episode of low solar activity which coincided with more severe winters in the United Kingdom and continental Europe. Motivated by recent relatively cold winters in the UK, we investigate the possible connection with solar activity. We identify regionally anomalous cold winters by detrending the Central England temperature (CET) record using reconstructions of the northern hemisphere mean temperature. We show that cold winter excursions from the hemispheric trend occur more commonly in the UK during low solar activity, consistent with the solar influence on the occurrence of persistent blocking events in the eastern Atlantic. We stress that this is a regional and seasonal effect relating to European winters and not a global effect. Average solar activity has declined rapidly since 1985 and cosmogenic isotopes suggest an 8% chance of a return to Maunder minimum conditions within the next 50 years (Lockwood 2010 *Proc. R. Soc.* A **466** 303–29): the results presented here indicate that, despite hemispheric warming, the UK and Europe could experience more cold winters than during recent decades.

Highlights 2010

Energy intensity ratios as net energy measures of United States energy production and expenditures

C W King

2010 *Environ. Res. Lett.* **5** 044006

Featured on environmentalresearchweb.org

Abstract

In this letter I compare two measures of energy quality, energy return on energy invested (EROI) and energy intensity ratio (EIR) for the fossil fuel consumption and production of the United States. All other characteristics being equal, a fuel or energy system with a higher EROI or EIR is of better quality because more energy is provided to society. I define and calculate the EIR for oil, natural gas, coal, and electricity as measures of the energy intensity (units of energy divided by money) of the energy resource relative to the energy intensity of the overall economy. EIR measures based upon various unit prices for energy (e.g. $/Btu of a barrel of oil) as well as total expenditures on energy supplies (e.g. total dollars spent on petroleum) indicate net energy at different points in the supply chain of the overall energy system. The results indicate that EIR is an easily calculated and effective proxy for EROI for US oil, gas, coal, and electricity. The EIR correlates well with previous EROI calculations, but adds additional information on energy resource quality within the supply chain. Furthermore, the EIR and EROI of oil and gas as well as coal were all in decline for two time periods within the last 40 years, and both time periods preceded economic recessions.

Radiative forcing and temperature response to changes in urban albedos and associated CO_2 offsets

Surabi Menon, Hashem Akbari, Sarith Mahanama, Igor Sednev and Ronnen Levinson

2010 *Environ. Res. Lett.* **5** 014005

Abstract

The two main forcings that can counteract to some extent the positive forcings from greenhouse gases from pre-industrial times to present day are the aerosol and related aerosol-cloud forcings, and the radiative response to changes in surface albedo. Here, we quantify the change in radiative forcing and land surface temperature that may be obtained by increasing the albedos of roofs and pavements in urban areas in temperate and tropical regions of the globe by 0.1. Using the catchment land surface model (the land model coupled to the GEOS-5 Atmospheric General Circulation Model), we quantify the change in the total outgoing (outgoing shortwave+longwave) radiation and land surface temperature to a 0.1 increase in urban albedos for all global land areas. The global average increase in the total outgoing radiation was 0.5 W m^{-2}, and temperature decreased by ~0.008 K for an average 0.003 increase in surface albedo. These averages represent all global land areas where data were available from the land surface model used and are for the boreal summer (June–July–August). For the continental US the total outgoing radiation increased by 2.3 W m^{-2}, and land surface temperature decreased by ~0.03 K for an average 0.01 increase in surface albedo. Based on these forcings, the expected emitted CO_2 offset for a plausible 0.25 and 0.15 increase in albedos of roofs and pavements, respectively, for all global urban areas, was found to be ~57 Gt CO_2. A more meaningful evaluation of the impacts of urban albedo increases on global climate and the expected CO_2 offsets would require simulations which better characterize urban surfaces and represent the full annual cycle.

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Robust negative impacts of climate change on African agriculture

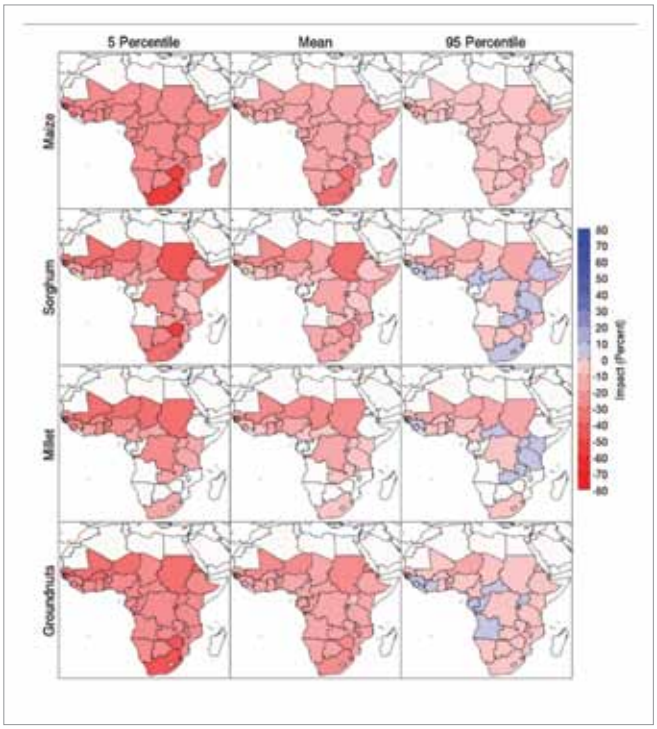
Wolfram Schlenker and David B Lobell

2010 *Environ. Res. Lett.* **5** 014010

Featured on environmentalresearchweb.org

Abstract

There is widespread interest in the impacts of climate change on agriculture in Sub-Saharan Africa (SSA), and on the most effective investments to assist adaptation to these changes, yet the scientific basis for estimating production risks and prioritizing investments has been quite limited. Here we show that by combining historical crop production and weather data into a panel analysis, a robust model of yield response to climate change emerges for several key African crops. By mid-century, the mean estimates of aggregate production changes in SSA under our preferred model specification are − 22, − 17, − 17, − 18, and − 8% for maize, sorghum, millet, groundnut, and cassava, respectively. In all cases except cassava, there is a 95% probability that damages exceed 7%, and a 5% probability that they exceed 27%. Moreover, countries with the highest average yields have the largest projected yield losses, suggesting that well-fertilized modern seed varieties are more susceptible to heat related losses.



Distribution of impacts from climate change by country (per cent yield change). Mean impacts (middle column) as well as the 5 and 95 percentile (left and right column, respectively) are shown. Each row represents one crop.

A second hydrocarbon boom threatens the Peruvian Amazon: trends, projections, and policy implications

Matt Finer and Martí Orta-Martínez

2010 *Environ. Res. Lett.* **5** 014012

Featured on environmentalresearchweb.org

Abstract

The Peruvian Amazon is home to extraordinary biological and cultural diversity, and vast swaths of this mega-diverse region remain largely intact. Recent analysis indicates, however, that the rapid proliferation of oil and gas exploration zones now threatens the region's biodiversity, indigenous peoples, and wilderness areas. To better elucidate this dynamic situation, we analyzed official Peruvian government hydrocarbon information and generated a quantitative analysis of the past, present, and future of oil and gas activities in the Peruvian Amazon. We document an extensive hydrocarbon history for the region—over 104 000 km of seismic lines and 679 exploratory and production wells—highlighted by a major exploration boom in the early 1970s. We show that an unprecedented 48.6% of the Peruvian Amazon has been recently covered by oil and gas concessions, up from just 7.1% in 2003. These oil and gas concessions overlap 17.1% of the Peruvian Amazon protected area system and over half of all titled indigenous lands. Moreover, we found that up to 72% of the Peruvian Amazon has been zoned for hydrocarbon activities (concessions plus technical evaluation agreements and proposed concessions) in the past two years, and over 84% at some point during the past 40 years. We project that the recent rapid proliferation of hydrocarbon zones will lead to a second exploration boom, characterized by over 20 000 km of new seismic testing and construction of over 180 new exploratory wells in remote, intact, and sensitive forest areas. As the Peruvian Amazon oil frontier rapidly expands, we conclude that a rigorous policy debate is urgently needed in order to avoid the major environmental impacts associated with the first exploration boom of the 1970s and to minimize the social conflict that recently led to deadly encounters between indigenous protesters and government forces.

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ERL articles have been downloaded more than 750 000 times since the journal launched in 2006.

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The role of pasture and soybean in deforestation of the Brazilian Amazon

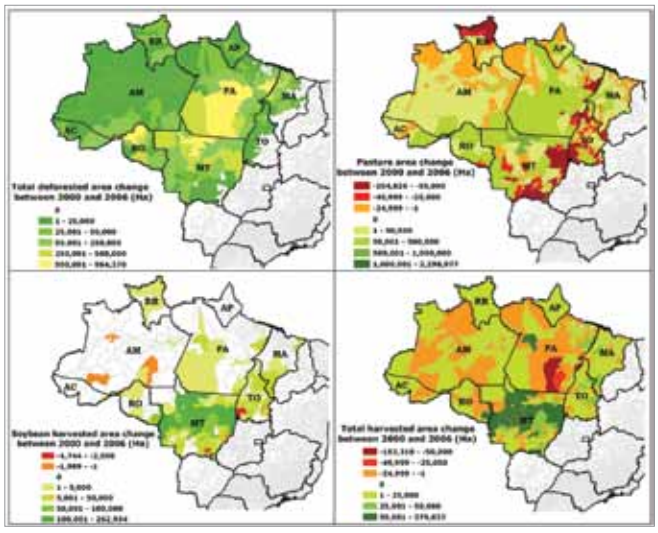
Elizabeth Barona, Navin Ramankutty, Glenn Hyman and Oliver T Coomes

2010 *Environ. Res. Lett.* **5** 024002

Featured on environmentalresearchweb.org

Abstract

The dynamics of deforestation in the Brazilian Amazon are complex. A growing debate considers the extent to which deforestation is a result of the expansion of the Brazilian soy industry. Most recent analyses suggest that deforestation is driven by the expansion of cattle ranching, rather than soy. Soy seems to be replacing previously deforested land and/or land previously under pasture. In this study, we use municipality-level statistics on agricultural and deforested areas across the Legal Amazon from 2000 to 2006 to examine the spatial patterns and statistical relationships between deforestation and changes in pasture and soybean areas. Our results support previous studies that showed that deforestation is predominantly a result of pasture expansion. However, we also find support for the hypothesis that an increase of soy in Mato Grosso has displaced pasture further north, leading to deforestation elsewhere. Although not conclusive, our findings suggest that the debate surrounding the drivers of Amazon deforestation is not over, and that indirect causal links between soy and deforestation may exist that need further exploration. Future research should examine more closely how interlinkages between land area, prices, and policies influence the relationship between soy and deforestation, in order to make a conclusive case for 'displacement deforestation'.



Changes in area of different land uses in the Legal Amazon from 2000 to 2006.

Self-charging of the Eyjafjallajökull volcanic ash plume

R G Harrison, K A Nicoll, Z Ulanowski and T A Mather

2010 *Environ. Res. Lett.* **5** 024004

Abstract

Volcanic plumes generate lightning from the electrification of plume particles. Volcanic plume charging at over 1200 km from its source was observed from *in situ* balloon sampling of the April 2010 Eyjafjallajökull plume over Scotland. Whilst upper and lower edge charging of a horizontal plume is expected from fair weather atmospheric electricity, the plume over Scotland showed sustained positive charge well beneath the upper plume edge. At these distances from the source, the charging cannot be a remnant of the eruption itself because of charge relaxation in the finite conductivity of atmospheric air.

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Oil carbon entered the coastal planktonic food web during the Deepwater Horizon oil spill

William M Graham, Robert H Condon, Ruth H Carmichael , Isabella D'Ambra, Heather K Patterson , Laura J Linn and Frank J Hernandez Jr

2010 *Environ. Res. Lett.* **5** 045301

Featured on environmentalresearchweb.org

Abstract

The Deepwater Horizon oil spill was unprecedented in total loading of petroleum hydrocarbons accidentally released to a marine ecosystem. Controversial application of chemical dispersants presumably accelerated microbial consumption of oil components, especially in warm Gulf of Mexico surface waters. We employed $\delta^{13}C$ as a tracer of oil-derived carbon to resolve two periods of isotopic carbon depletion in two plankton size classes. Carbon depletion was coincident with the arrival of surface oil slicks in the far northern Gulf, and demonstrated that subsurface oil carbon was incorporated into the plankton food web.

Atmospheric carbon dioxide removal: long-term consequences and commitment

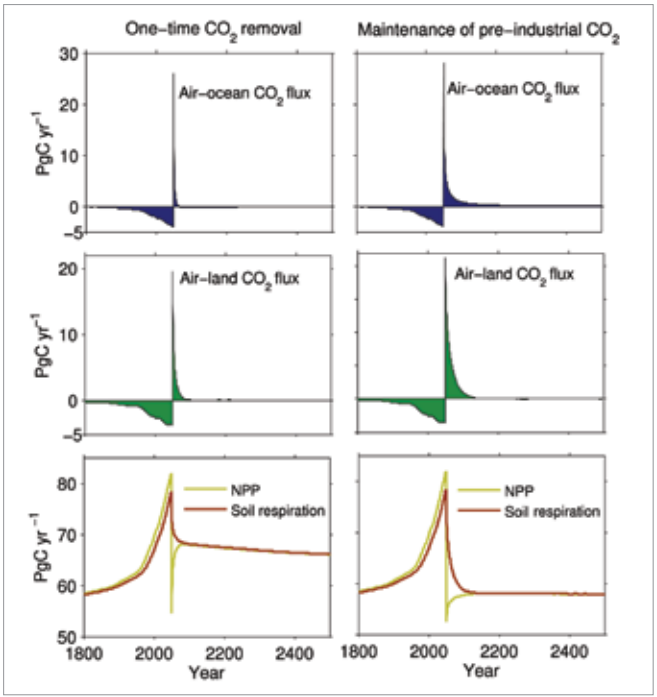
Long Cao and Ken Caldeira

2010 *Environ. Res. Lett.* **5** 024011

Featured on environmentalresearchweb.org

Abstract

Carbon capture from ambient air has been proposed as a mitigation strategy to counteract anthropogenic climate change. We use an Earth system model to investigate the response of the coupled climate–carbon system to an instantaneous removal of all anthropogenic CO_2 from the atmosphere. In our extreme and idealized simulations, anthropogenic CO_2 emissions are halted and all anthropogenic CO_2 is removed from the atmosphere at year 2050 under the IPCC A2 CO_2 emission scenario when the model-simulated atmospheric CO_2 reaches 511 ppm and surface temperature reaches 1.8 °C above the pre-industrial level. In our simulations a one-time removal of all anthropogenic CO_2 in the atmosphere reduces surface air temperature by 0.8 °C within a few years, but 1 °C surface warming above pre-industrial levels lasts for several centuries. In other words, a one-time removal of 100% excess CO_2 from the atmosphere offsets less than 50% of the warming experienced at the time of removal. To maintain atmospheric CO_2 and temperature at low levels, not only does anthropogenic CO_2 in the atmosphere need to be removed, but anthropogenic CO_2 stored in the ocean and land needs to be removed as well when it outgasses to the atmosphere. In our simulation to maintain atmospheric CO_2 concentrations at pre-industrial levels for centuries, an additional amount of CO_2 equal to the original CO_2 captured would need to be removed over the subsequent 80 years.



Model-simulated temporal evolution of atmosphere–ocean and atmosphere–land CO_2 fluxes, as well as terrestrial net primary production (NPP) and soil respiration. Flux is positive to the atmosphere and negative to the ocean and/or land. Left panels are for the simulation of one-time CO_2 removal starting at the beginning of year 2050, and right panels are for the simulation of the maintenance of atmospheric CO_2 at 278 ppm at year 2050 and thereafter.

Parking infrastructure: energy, emissions, and automobile life-cycle environmental accounting

Mikhail Chester, Arpad Horvath and Samer Madanat

2010 *Environ. Res. Lett.* **5** 034001

Abstract

The US parking infrastructure is vast and little is known about its scale and environmental impacts. The few parking space inventories that exist are typically regionalized and no known environmental assessment has been performed to determine the energy and emissions from providing this infrastructure. A better understanding of the scale of US parking is necessary to properly value the total costs of automobile travel. Energy and emissions from constructing and maintaining the parking infrastructure should be considered when assessing the total human health and environmental impacts of vehicle travel. We develop five parking space inventory scenarios and from these estimate the range of infrastructure provided in the US to be between 105 million and 2 billion spaces. Using these estimates, a life-cycle environmental inventory is performed to capture the energy consumption and emissions of greenhouse gases, CO, SO_2, NO_X, VOC (volatile organic compounds), and PM_{10} (PM: particulate matter) from raw material extraction, transport, asphalt and concrete production, and placement (including direct, indirect, and supply chain processes) of space construction and maintenance. The environmental

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assessment is then evaluated within the life-cycle performance of sedans, SUVs (sports utility vehicles), and pickups. Depending on the scenario and vehicle type, the inclusion of parking within the overall life-cycle inventory increases energy consumption from 3.1 to 4.8 MJ by 0.1–0.3 MJ and greenhouse gas emissions from 230 to 380 g CO_2e by 6–23 g CO_2e per passenger kilometer traveled. Life-cycle automobile SO_2 and PM_{10} emissions show some of the largest increases, by as much as 24% and 89% from the baseline inventory. The environmental consequences of providing the parking spaces are discussed as well as the uncertainty in allocating paved area between parking and roadways.

Accounting for soil carbon sequestration in national inventories: a soil scientist's perspective

Jonathan Sanderman and Jeffrey A Baldock

2010 *Environ. Res. Lett.* **5** 034003

Featured on environmentalresearchweb.org

Abstract

As nations debate whether and how best to include the agricultural sector in greenhouse gas pollution reduction schemes, the role of soil organic carbon as a potential large carbon sink has been thrust onto center stage. Results from most agricultural field trials indicate a relative increase in soil carbon stocks with the adoption of various improved management practices. However, the few available studies with time series data suggest that this relative gain is often due to a reduction or cessation of soil carbon losses rather than an actual increase in stocks. On the basis of this observation, we argue here that stock change data from agricultural field trials may have limited predictive power when the state of the soil carbon system is unknown and that current IPCC (Intergovernmental Panel on Climate Change) accounting methodologies developed from the trial results may not properly credit these management activities. In particular, the use of response ratios is inconsistent with the current scientific understanding of carbon cycling in soils and response ratios will overestimate the net–net sequestration of soil carbon if the baseline is not at steady state.

Is physical water scarcity a new phenomenon? Global assessment of water shortage over the last two millennia

Matti Kummu, Philip J Ward, Hans de Moel and Olli Varis

2010 *Environ. Res. Lett.* **5** 034006

Featured on environmentalresearchweb.org

Abstract

In this letter we analyse the temporal development of physical population-driven water scarcity, i.e. water shortage, over the period 0 AD to 2005 AD. This was done using population data derived from the HYDE dataset, and water resource availability based on the WaterGAP model results for the period 1961–90. Changes in historical water resources availability were simulated with the STREAM model, forced by climate output data of the ECBilt–CLIO–VECODE climate model. The water crowding index, i.e. Falkenmark water stress indicator, was used to identify water shortage in 284 sub-basins. Although our results show a few areas with moderate water shortage (1000–1700 m^3/capita/yr) around the year 1800, water shortage began in earnest at around 1900, when 2% of the world population was under chronic water shortage (<1000 m^3/capita/yr). By 1960, this percentage had risen to 9%. From then on, the number of people under water shortage increased rapidly to the year 2005, by which time 35% of the world population lived in areas with chronic water shortage. In this study, the effects of changes in population on water shortage are roughly four times more important than changes in water availability as a result of long-term climatic change. Global trends in adaptation measures to cope with reduced water resources per capita, such as irrigated area, reservoir storage, groundwater abstraction, and global trade of agricultural products, closely follow the recent increase in global water shortage.

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Climate control of terrestrial carbon exchange across biomes and continents

Chuixiang Yi et al

2010 *Environ. Res. Lett.* **5** 034007

Featured on environmentalresearchweb.org

Abstract

Understanding the relationships between climate and carbon exchange by terrestrial ecosystems is critical to predict future levels of atmospheric carbon dioxide because of the potential accelerating effects of positive climate–carbon cycle feedbacks. However, directly observed relationships between climate and terrestrial CO_2 exchange with the atmosphere across biomes and continents are lacking. Here we present data describing the relationships between net ecosystem exchange of carbon (NEE) and climate factors as measured using the eddy covariance method at 125 unique sites in various ecosystems over six continents with a total of 559 site-years. We find that NEE observed at eddy covariance sites is (1) a strong function of mean annual temperature at mid- and high-latitudes, (2) a strong function of dryness at mid- and low-latitudes, and (3) a function of both temperature and dryness around the mid-latitudinal belt (45°N). The sensitivity of NEE to mean annual temperature breaks down at ~16 °C (a threshold value of mean annual temperature), above which no further increase of CO_2 uptake with temperature was observed and dryness influence overrules temperature influence.

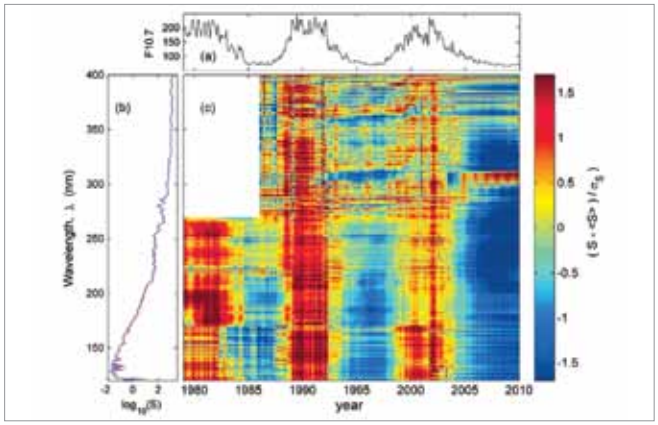
Top-down solar modulation of climate: evidence for centennial-scale change

M Lockwood, C Bell, T Woollings, R G Harrison, L J Gray and J D Haigh

2010 *Environ. Res. Lett.* **5** 034008

Abstract

During the descent into the recent 'exceptionally' low solar minimum, observations have revealed a larger change in solar UV emissions than seen at the same phase of previous solar cycles. This is particularly true at wavelengths responsible for stratospheric ozone production and heating. This implies that 'top-down' solar modulation could be a larger factor in long-term tropospheric change than previously believed, many climate models allowing only for the 'bottom-up' effect of the less-variable visible and infrared solar emissions. We present evidence for long-term drift in solar UV irradiance, which is not found in its commonly used proxies. In addition, we find that both stratospheric and tropospheric winds and temperatures show stronger regional variations with those solar indices that do show long-term trends. A top-down climate effect that shows long-term drift (and may also be out of phase with the bottom-up solar forcing) would change the spatial response patterns and would mean that climate-chemistry models that have sufficient resolution in the stratosphere would become very important for making accurate regional/seasonal climate predictions. Our results also provide a potential explanation of persistent palaeoclimate results showing solar influence on regional or local climate indicators.



(a) Temporal variation of 10.7 cm solar radio flux (b) Solar UV spectrum: the maximum and minimum of the monthly spectral irradiance S are shown (in red and blue, respectively) as a function of wavelength, λ. (c) Normalized variations inS, $(S - \langle S \rangle / \sigma_s$ where $\langle S \rangle$ and σ_s are the full data set means and standard deviations of S at that λ, as a function of time *t* and λ. SORCE data are used after 1 May 2004.

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On average in 2010, ERL received 27 000 downloads each month.

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Increased crop failure due to climate change: assessing adaptation options using models and socio-economic data for wheat in China

Andrew J Challinor, Elisabeth S Simelton, Evan D G Fraser, Debbie Hemming and Mathew Collins

2010 *Environ. Res. Lett.* **5** 034012

Featured on environmentalresearchweb.org

Abstract

Tools for projecting crop productivity under a range of conditions, and assessing adaptation options, are an important part of the endeavour to prioritize investment in adaptation. We present ensemble projections of crop productivity that account for biophysical processes, inherent uncertainty and adaptation, using spring wheat in Northeast China as a case study. A parallel 'vulnerability index' approach uses quantitative socio-economic data to account for autonomous farmer adaptation.

The simulations show crop failure rates increasing under climate change, due to increasing extremes of both heat and water stress. Crop failure rates increase with mean temperature, with increases in maximum failure rates being greater than those in median failure rates. The results suggest that significant adaptation is possible through either socio-economic measures such as greater investment, or biophysical measures such as drought or heat tolerance in crops. The results also show that adaptation becomes increasingly necessitated as mean temperature and the associated number of extremes rise. The results, and the limitations of this study, also suggest directions for research for linking climate and crop models, socio-economic analyses and crop variety trial data in order to prioritize options such as capacity building, plant breeding and biotechnology.

Analysis of the Copenhagen Accord pledges and its global climatic impacts—a snapshot of dissonant ambitions

Joeri Rogelj, Claudine Chen, Julia Nabel , Kirsten Macey, William Hare, Michiel Schaeffer, Kathleen Markmann, Niklas Höhne, Katrine Krogh Andersen and Malte Meinshausen

2010 *Environ. Res. Lett.* **5** 034013

Abstract

This analysis of the Copenhagen Accord evaluates emission reduction pledges by individual countries against the Accord's climate-related objectives. Probabilistic estimates of the climatic consequences for a set of resulting multi-gas scenarios over the 21st century are calculated with a reduced complexity climate model, yielding global temperature increase and atmospheric CO_2 and CO_2-equivalent concentrations. Provisions for banked surplus emission allowances and credits from land use, land-use change and forestry are assessed and are shown to have the potential to lead to significant deterioration of the ambition levels implied by the pledges in 2020. This analysis demonstrates that the Copenhagen Accord and the pledges made under it represent a set of dissonant ambitions. The ambition level of the current pledges for 2020 and the lack of commonly agreed goals for 2050 place in peril the Accord's own ambition: to limit global warming to below 2 °C, and even more so for 1.5 °C, which is referenced in the Accord in association with potentially strengthening the long-term temperature goal in 2015. Due to the limited level of ambition by 2020, the ability to limit emissions afterwards to pathways consistent with either the 2 or 1.5 °C goal is likely to become less feasible.

Agricultural net primary production in relation to that liberated by the extinction of Pleistocene mega-herbivores: an estimate of agricultural carrying capacity?

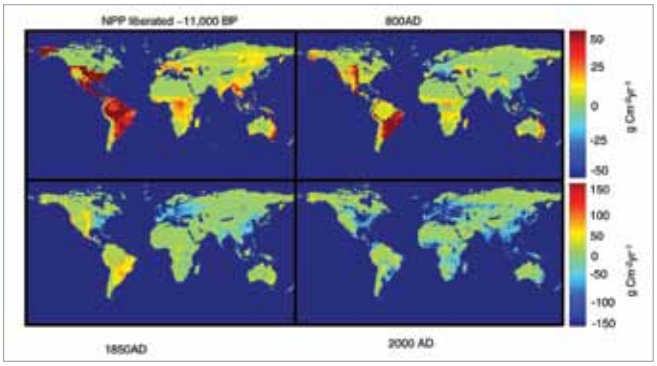
Christopher E Doughty and Christopher B Field

2010 *Environ. Res. Lett.* **5** 044001

Featured on environmentalresearchweb.org

Abstract

Mega-fauna (defined as animals > 44 kg) experienced a global extinction with 97 of 150 genera going extinct by ~10 000 years ago. We estimate the net primary production (NPP) that was liberated following the global extinction of these mega-herbivores. We then explore how humans, through agriculture, gradually appropriated this liberated NPP, with specific calculations for 800, 1850, and 2000 AD. By 1850, most of the liberated NPP had been appropriated by people, but NPP was still available in the Western US, South America and Australia. NPP liberated following the extinction of the mega-herbivores was ~2.5% (~1.4 (between 1.2 and 1.6) Pg yr^{-1} of 56 Pg C yr^{-1}; Pg: petagrams) of global terrestrial NPP. Liberated NPP peaked during the onset of agriculture and was sufficient for sustaining human agriculture until ~320 (250–500) years ago. Humans currently use ~6 times more NPP than was utilized by the extinct Pleistocene mega-herbivores.



Net primary production (NPP) liberated following the extinction of the mega-herbivores. Liberated NPP subtracted from agricultural and pastoral NPP in 800AD (top right), 1850AD (bottom left), 2000AD (bottom right). Rectangular borders appear because of differences in model resolution.