

RESEARCH AT JRC in support of EU CLIMATE CHANGE policy making

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RESEARCH AT JRC in support of EU CLIMATE CHANGE policy making

edited by *Frank Raes*
Eimear Kelleher

Foreword

The Joint Research Centre of the European Commission focuses its resources to respond to the Scientific and Technical (S/T) challenges arising from European Union policy making. The JRC is also key in fostering synergies with other sources of S/T support available in the Commission and in the EU Member States and it cooperates with EU Agencies and International Organisations.

Developing climate change policies is definitely an area where a joint and integrated approach to the provision of S/T support is required.

Since the first edition of this booklet in 2005, EU climate change policy has accelerated and, so far, it culminated with a call, in March 2007, for ambitious integrated Energy and Climate policies by the European Council.

The present edition shows how research activities at the JRC have contributed to this process, in particular by giving support to the Directorate-General Environment, which is guiding the development of EU climate change policies.

It shows, i.a., the contributions to the *Communication on "Limiting Global Climate Change to 2 degrees Celsius. The way ahead for 2020 and beyond"*, to the *Green Paper "Adaptation to climate change in Europe – options for EU action"* and to the *EU Greenhouse Gas Monitoring System*. The booklet further presents activities that will contribute to a sound science base for future policy actions.

We consider the collaboration between our Directorate-Generals of great importance for "Winning the Battle against Global Climate Change", in a way which is science based, environmentally and economically effective and acceptable for citizens in Europe and the World.

Roland Schenkel
Director General
Directorate-General JOINT RESEARCH CENTRE

Mogens Peter Carl
Director General
Directorate-General ENVIRONMENT

JRCs Research Strategy

in support of EU climate change policy making

The JRC Climate Change Research Strategy aims at determining costs and benefits of mitigation and adaptation policies in monetary and non-monetary terms.

Benefits are assessed not only in terms of reducing climate change risks, but also in terms of enhancing energy security, reducing air pollution, protection against climate variability and other co-benefits.

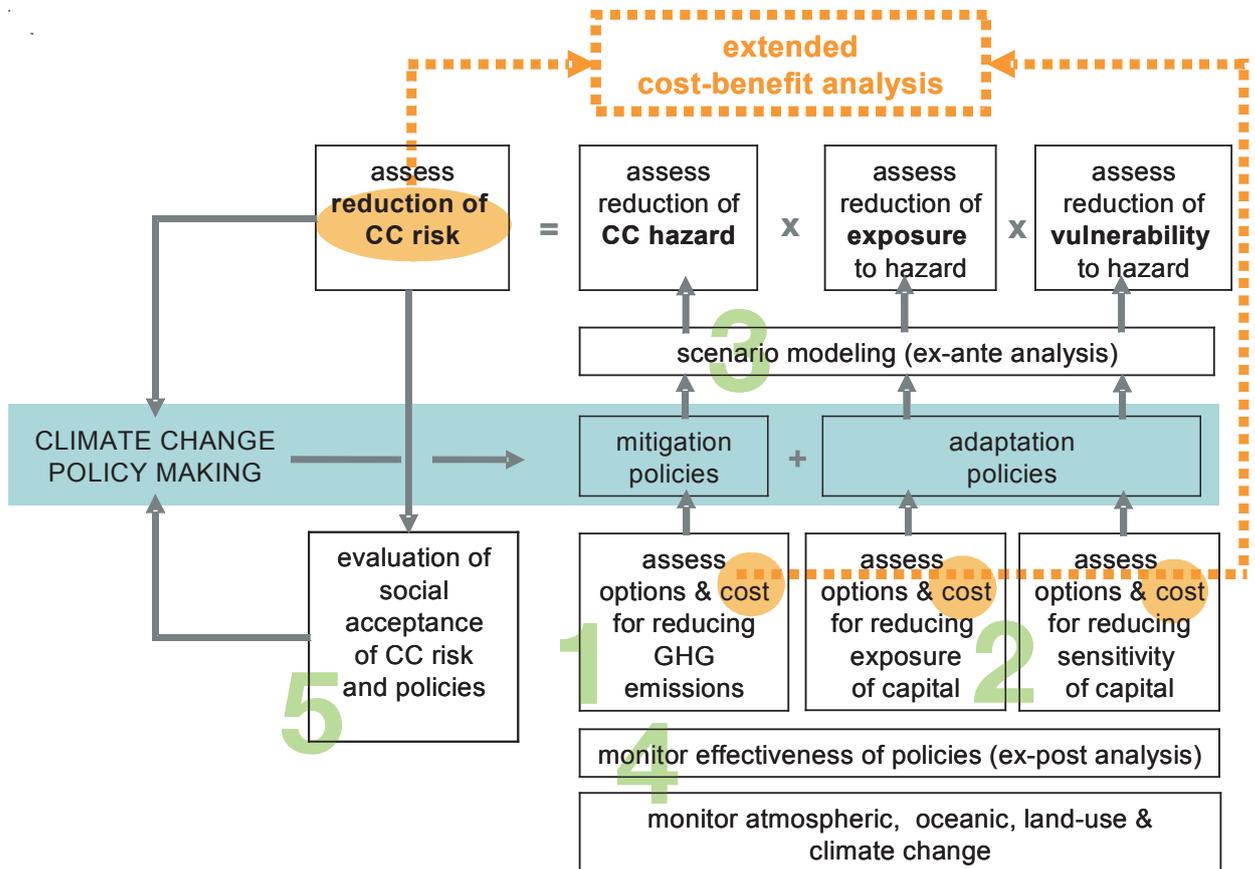
Within this context, the JRC performs studies in the following 5 areas:

- 1 Mitigation:** Quantitative assessment of the benefits, co-benefits and cost of various options to reduce climate change hazards by reduction of greenhouse gas emissions and enhancement of their sinks.
- 2 Adaptation:** Quantitative assessment of the exposure and vulnerability of various forms of “capital” (e.g. infrastructure, human life, biodiversity,...) to climate change hazards, and assessment of the benefits, co-benefits and cost of reducing exposure and vulnerability.
- 3 Scenario Modelling:** Ex-ante evaluation of the environmental and economic effectiveness of mitigation and adaptation strategies.
- 4 Monitoring and Verification:** Development and promotion of EU and world-wide methodologies for monitoring climate change, its drivers and its effects, as well as monitoring the effectiveness of policies and verification of reported data and claims.
- 5 Civil Society Perspectives:** Awareness building and assessment of the social acceptance of climate change risks and climate change policies through involvement of civil society.

The JRC Climate Change Research Strategy explores climate change questions from a **European and global perspective**, in support of European Commission services, EU Member States and International Organisations.

The report organises the various JRC activities according to the 5 areas mentioned above.

CLIMATE CHANGE POLICY = MITIGATION + ADAPTATION



To address the climate change problem both mitigation (by reducing greenhouse gas emissions) and adaptation (by reducing exposure and vulnerability to climate change impacts) are needed. The JRC assesses options and costs of such policies, as well as their benefits and co-benefits.

See text for further explanation.

Modelling Energy Futures

greenhouse gas emission pathways for meeting the EU 2°C target

The JRC uses dedicated energy and transport models as well as multi-sectoral general equilibrium models to conduct impact assessments of EU policies in the areas of transport, energy and environment. These models include TRANSTOOLS for transportation, and POLES and GEM-E3 for climate and energy issues.

The JRC has played a central role in the European Commission World Energy Technology Outlook-2050 (WETO-H2) study, which provides a coherent framework to analyse the energy, technology and environmental scenarios over the period from now to 2050. Projections until 2050 have been made with the world energy sector simulation model – the POLES model – that describes the development of the national and regional energy systems, and their interactions through international energy markets, under constraints on resources and climate policies.

The POLES and the general equilibrium model GEM-E3 have further been used to assess the technological and economic options for reducing global greenhouse gas emissions to meet the EU 2°C target. Those analyses have been included in the Impact Assessment accompanying the January 2007 *Communication of the European Commission on 'Limiting Global Climate Change to 2 degrees Celsius - The way ahead for 2020 and beyond'*. This Communication has been the basis for the call by the European Council for an ambitious integrated energy and climate policy package, on 8/9 March 2007.

Key Publication:

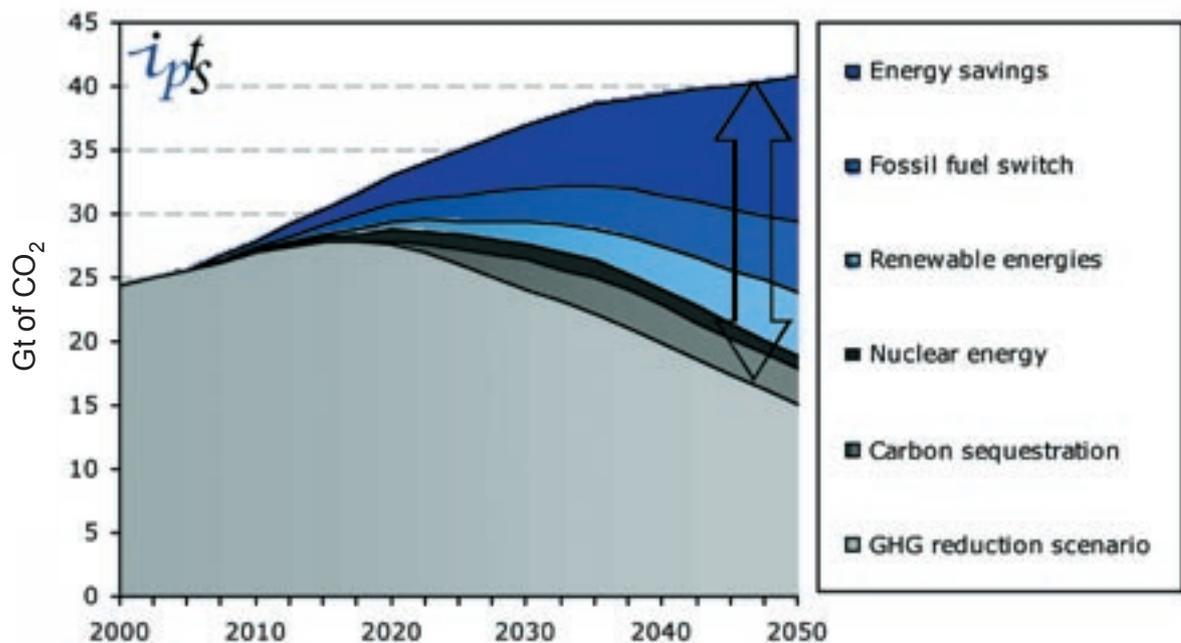
P. Russ, T. Wiesenthal, D. van Regemorter, J.C. Ciscar, L. Szabó. Analysis of Global Climate Policy Scenarios for 2030 and beyond - Greenhouse Gas Emission Reduction Pathway Scenarios with the POLES and GEM-E3 models. EUR Report (available at the conference).

For more info:

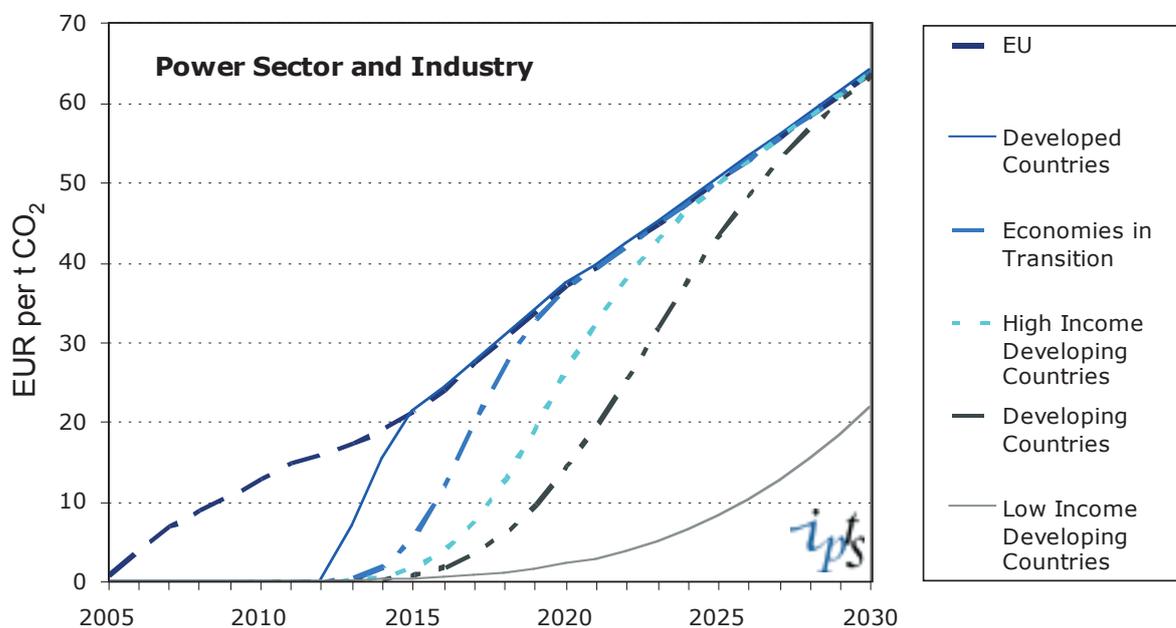
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Competitiveness and Sustainability Unit

Institute for Prospective Technological Studies



Contribution of various actions to reduce global CO₂ emissions. Under a baseline development, emissions are projected to increase substantially, following the upper line. Introducing dedicated climate change policies so as to bring emissions down to a level that will allow meeting the EU's long term 2 degree target (grey bottom area) triggers substantial changes in the energy system. Energy savings in all sectors are a key element, followed by a switch to lower carbon or non-carbon fuels.



Development of the price of CO₂ emission allowances over time in the power sector and industry sector in a scenario that will allow meeting the 2 degree target. In this scenario, emissions from power sector and industry can be traded among world regions. Even though no emission cap is assumed for developing countries before 2030, their industry sectors would experience a cost for CO₂ emission allowances as a consequence of instruments such as the Clean Development Mechanism.

Modelling Energy Futures

CO₂ emissions from the electricity system in Europe

Driven by the continuous increase of electricity demand and the forthcoming retirement of a significant number of old power plants, new electricity generation capacity will need to be constructed in Europe in the short to medium term.

Despite initiatives to expand the share of renewable energy technologies, energy forecasts highlight that most of the new capacity will be fossil fuel (coal and gas fired) power plants. This will potentially have a great impact on the European efforts to reduce CO₂ emission levels, as well as on other European challenges such as security of energy supply and competitiveness. The technology and fossil fuel mix for the future electricity sector will have to be formulated in a way that is compatible with the goals of the EU energy and environment policies.

The JRC has assessed the development of fossil fuel (coal and natural gas) electricity generation technology up to 2030, based on a number of alternative scenarios for the evolution of the world coal and gas prices, the cost of CO₂ emission allowances, the penetration of renewable and nuclear power generating technologies, and the technological maturity of carbon capture and storage technologies.

Key for CO₂ emissions in the sector, is the price of CO₂ emission allowances but also the price of coal and natural gas themselves. Clearly, coal plants will always have a fuel cost advantage. However, if the absolute price of natural gas is low, the generally lower fixed cost of gas powered installations will shift the balance towards such installations even if CO₂ emission allowances are expensive.

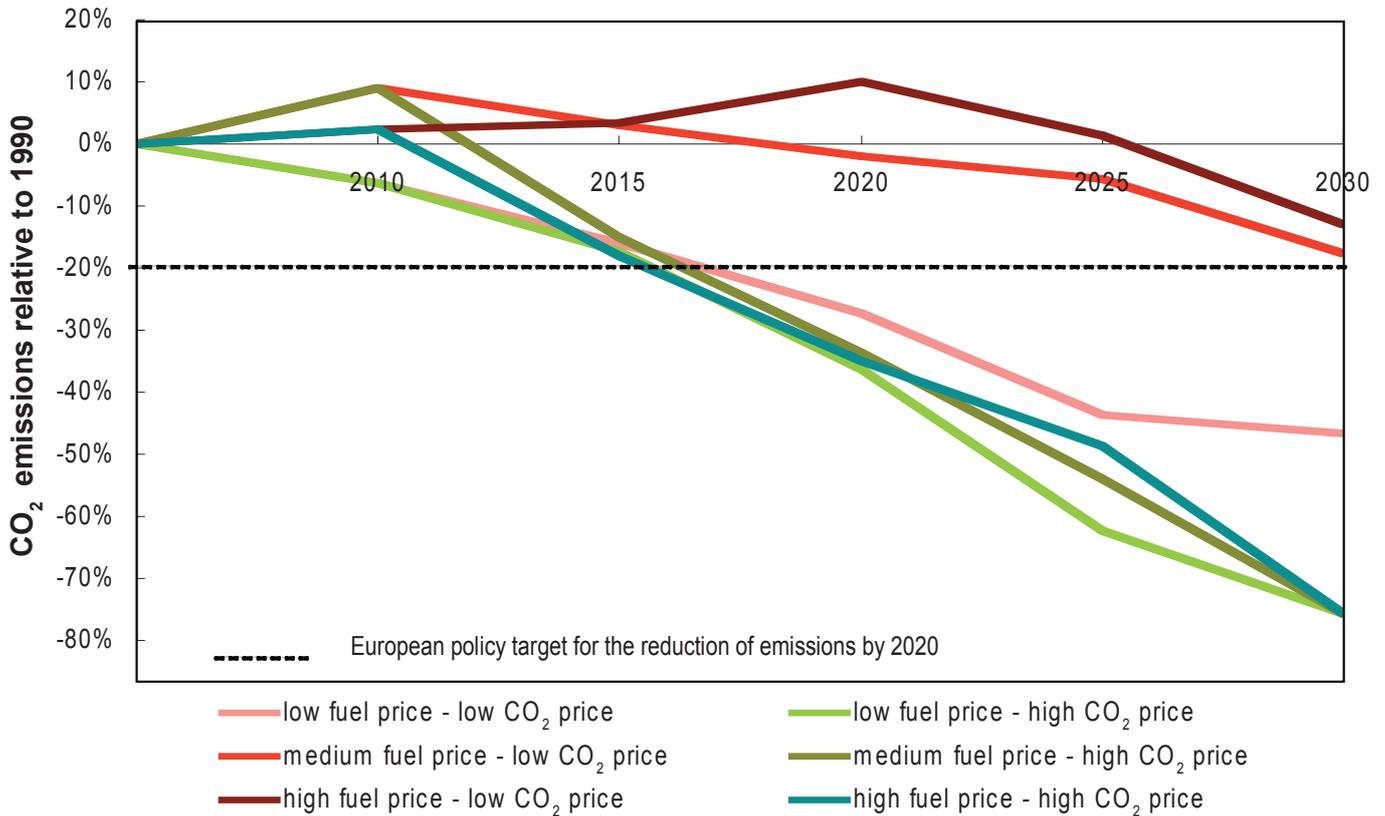
Key Publication:

Tzimas E., Georgakaki A., Garcia Cortes C., Peteves S.D. The Evolution of the European Fossil Fuel Power Generation Sector and its Impact on the Sustainability of the Energy System. POWER-GEN Europe 2007, Madrid, 16-18 June 2007.

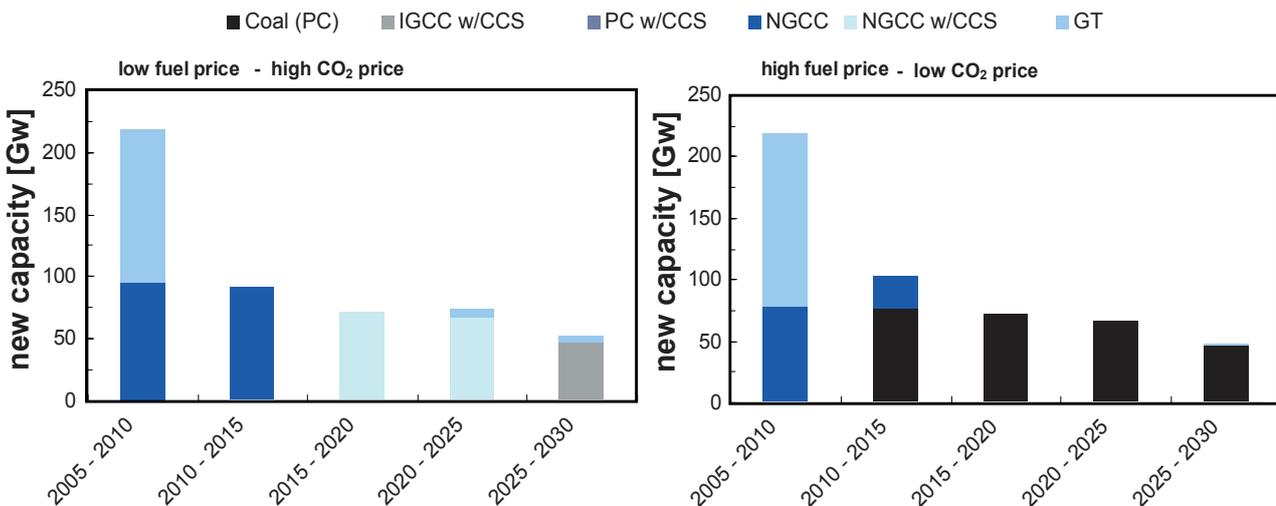
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Energy System Evaluation Unit

Institute for Energy



Annual CO₂ emissions from the electricity generation sector in Europe for different fuel (coal and natural gas) prices and different prices for CO₂ emission allowances. It is assumed that carbon capture technology is mature and can be deployed commercially during the period 2015-2020. High prices of CO₂ emission allowances are generally effective to drive the CO₂ emissions in the electricity sector down. However, if the price for gas is low, the lower fixed cost of gas powered installations will anyway shift the balance towards such installations and to lower CO₂ emissions.



Construction of new fossil fuel electricity generation capacity for a most optimistic (left) and most pessimistic (right) combination of fuel and CO₂ emission allowance prices (assuming again that carbon capture technology is mature and can be deployed commercially during the period 2015-2020).

PC (Pulverised Coal), IGCC (Integrated Gasification Combined Cycle), NGCC (Natural Gas Combined Cycle respectively), GT (Gas Turbine) and CCS (Carbon Capture and Storage)

Linkages with Air Pollution

air pollution in a future climate

Climate change and conventional air pollution are linked primarily because both result from burning fossil fuels. A changing climate, however, can have a further influence on air pollution, through changes in meteorological conditions such as convection, frequency of frontal passages, subsidence, atmospheric stability, hydrological cycle, etc.

The JRC organised an international comparison of global atmospheric models to calculate the effects of air pollution control strategies and climate change on surface ozone by 2030 (see Figures). The evaluation included future emission scenario's under unchanged climate conditions (Figs. b,c), as well as a scenario assuming the IS92a climate change scenario associated with a global mean surface warming of roughly 0.7 °C between 2000 and 2030 (Fig. d).

The Figures show the ensemble average of about 25 global models in calculating current and 2030 ozone concentrations at ground level.

A changing climate leads to a reduction of ozone over large parts of the oceans, whereas over the continents it might lead to increases, hence working against air pollution control policies. In any case, during the 2000 – 2030 period, ground based ozone levels seem to be more sensitive to changing emissions than to a changing climate.

This study was in support of the fourth assessment report of the IPCC, and involved scientists of DG-RTDs ACCENT Network of Excellence.

Key Publication:

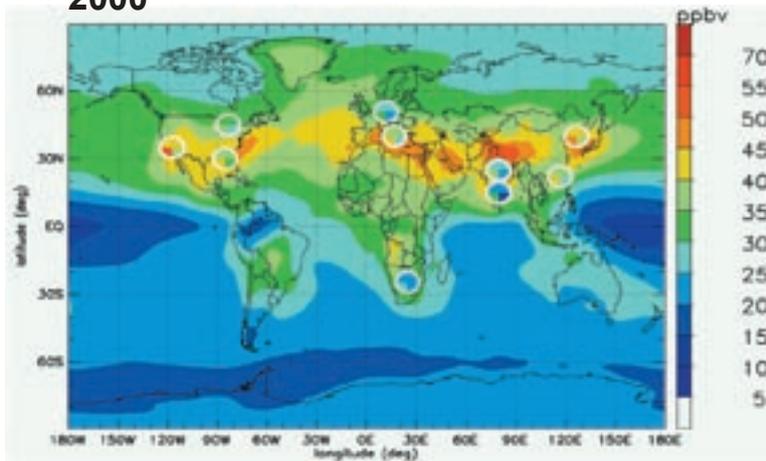
*Dentener, F., D. Stevenson, K. Ellingsen, T. Van Noije, M. Schultz, M. Amann, C. Atherton, N. Bell, D. Bergmann, I. Bey, L. Bouwman, T. Butler, J. Cofala, W. Collins, R. Doherty, J. Drevet, B. Eickhout, E. H., A. Fiore, M. Gauss, D. Hauglustaine, L. Horowitz, I. Isaksen, B. Josse, M. Krol, J.F. Lamarque, M. Lawrence, V. Montanaro, J.F. Müller, V.H. Peuch, G. Pitari, J. Pyle, S. Rast, J. Rodriguez, M. Sanderson, N. Savage, D. Shindell, S. Strahan, S. Szopa, K. Sudo, R. Van Dingenen, O. Wild, and G. Zeng, Global Atmospheric Environment for the next generation, **Environmental Science and Technology**, 40, 3586-3594, 2006*

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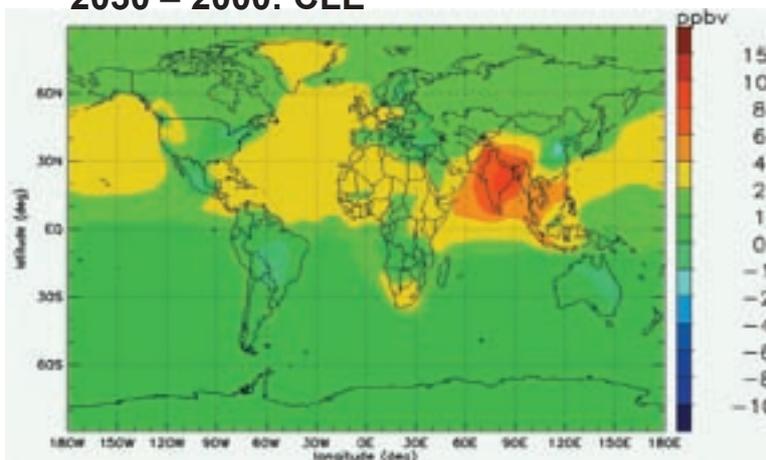
Institute for Environment and Sustainability

2000



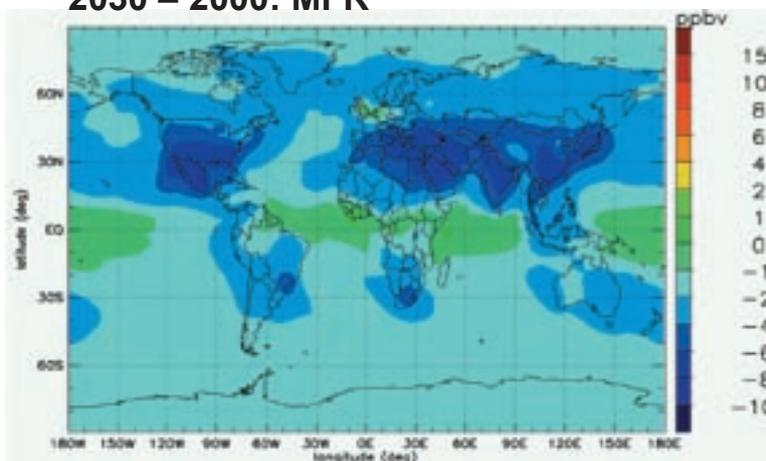
a) Global surface ozone concentration [ppbv] in the year 2000 calculated with an ensemble of global air pollution models.

2030 – 2000: CLE



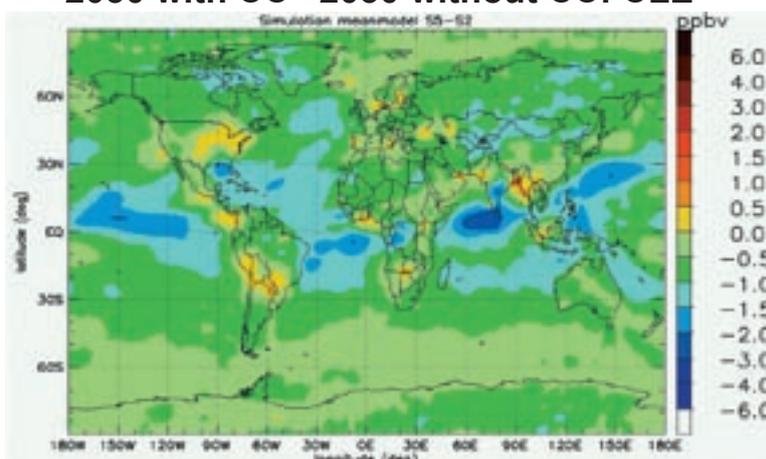
b) Change of surface ozone between 2000 and 2030 as a result of development and currently decided world-wide emission reductions policies (CLE), but assuming climate to remain stable.

2030 – 2000: MFR



c) Change in surface ozone reductions between 2000 and 2030 achieved when all currently available emission reduction technologies would be implemented (MFR), assuming climate to be stable.

2030 with CC– 2030 without CC: CLE



d) Effect of allowing climate to change between 2000 and 2030 on surface ozone in the year 2030. Climate change alone is expected to reduce ozone over the oceans. Over land only small increases (< 1 ppb) are expected in some areas.

Renewable Energies

potential and growth in Europe

The European Council, in its conclusions of 8/9 March 2007, endorsed a binding target of a 20% share of renewable energies in overall EU energy consumption by 2020.

More in general, the implementation of renewable energy systems and improved electricity end-use efficiency are key means of satisfying the twin objectives of sustainability and security of energy supply.

The JRC established a Scientific Technical Reference System for Renewable Energy and Energy End-Use Efficiency (REFREE) as a “one-stop shop” for quality-checked, robust and validated data for European Institutions, Member States and stakeholders. It provides feedback on the effectiveness of renewable energy policy measures, particularly with respect to CO₂ emission reductions.

REFREE monitors the progress of the implementation of wind energy, bio-energy and photovoltaics in EU Member States, and compares it with targets set in a range of EU directives (see Figure). An important part of this activity is dedicated to reaching agreement with industry to reduce electricity demand by accelerating new technologies such as efficient lighting and reduction of stand-by loads.

The JRC also intervenes in specific technological areas where research and harmonisation is required such as in solar photovoltaic electricity. In this context, the JRC predicts the electricity generation costs from photovoltaic systems on a regional level (<http://re.jrc.cec.eu.int/pvgis/pv/>), based on long term historical solar radiation data interpolated to cover every 1x1 km² spot in Europe, including topographical shadowing conditions (see Figure).

Key publications:

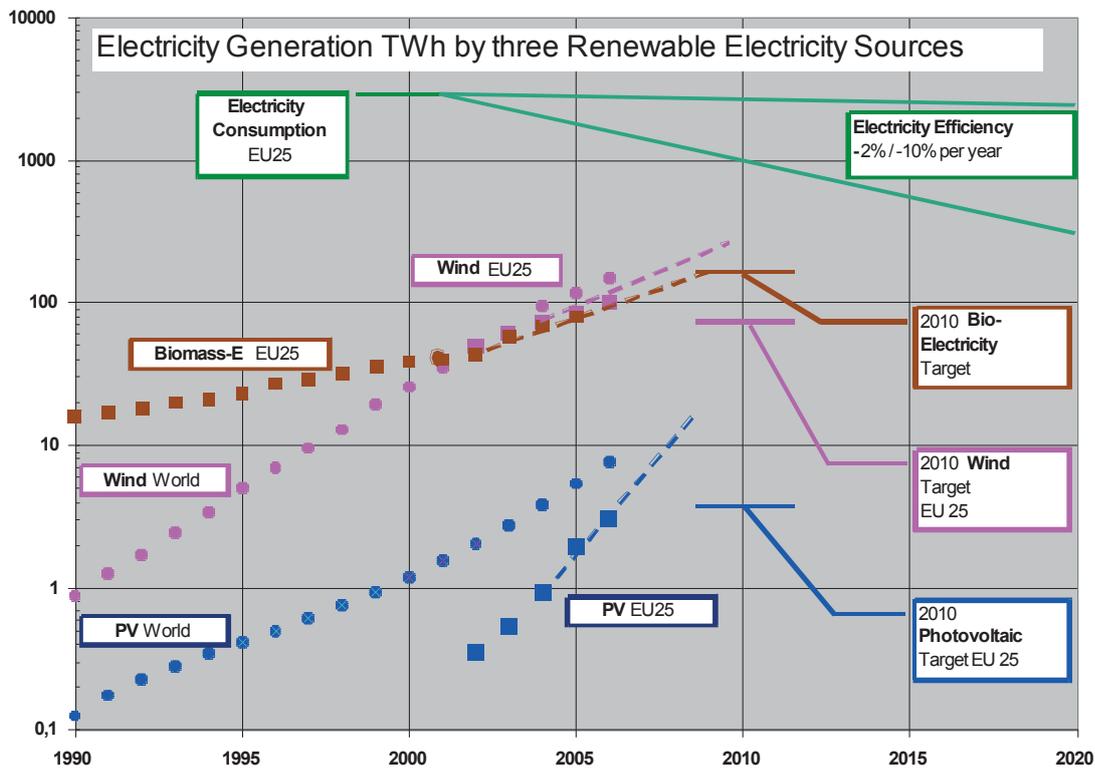
Jaeger-Waldau et al., Progress of Electricity from Biomass, Wind and Photovoltaics in the European Union. Renewable & Sustainable Energy Reviews, Vol 8, No 2, 157 -182, 2004

Electricity Consumption and Efficiency Trends in the Enlarged European Union - Status Report 2006- EUR 22753 EN, ISBN 978-92-79-0558-4, B. Atanasiu and P. Bertoldi

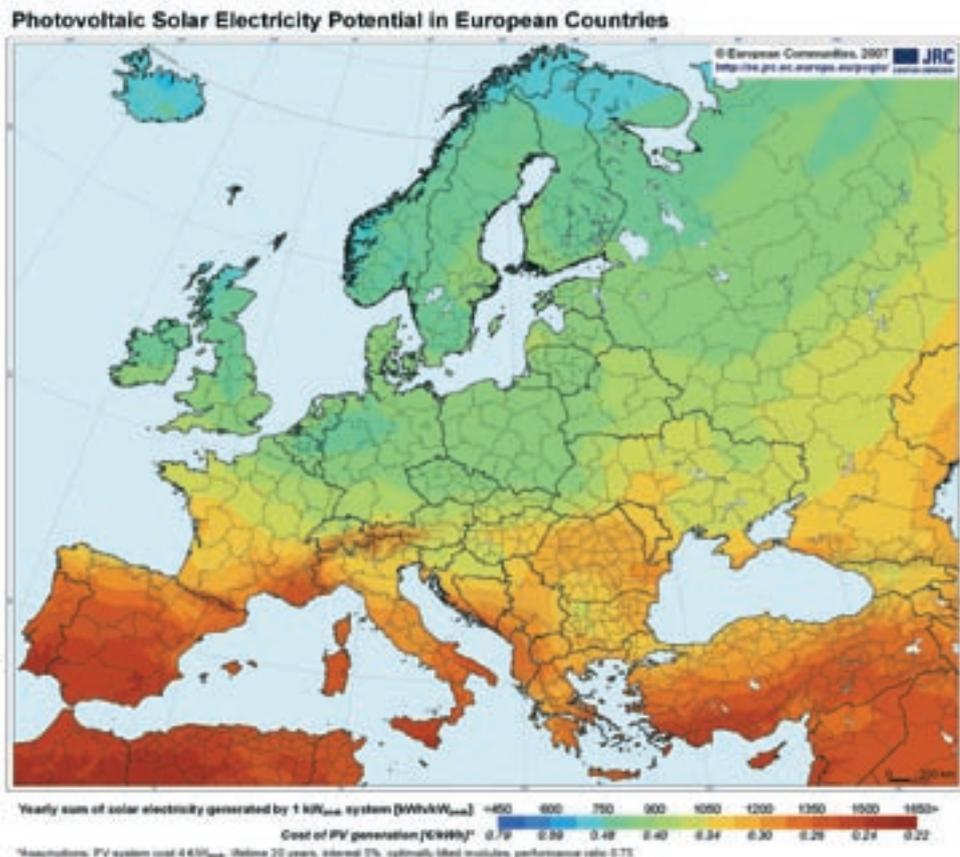
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Progress in major renewable electricity technologies, as compared to EU targets for 2010. The graph includes EU electricity consumption and effect of end-use efficiency measures. (Units: TWh/yr).



Cost of PV electricity in Europe assuming a PV system with optimally-tilted modules, performance ratio 0.75, system price €4000/kWp, payback time 20 years, interest rate 5% p.a., and annual maintenance cost equal to 1% of the system cost. © European Communities, 2007.

Managing CO₂ from Fossil Fuels

innovative power generation technologies

Energy outlooks confirm that fossil fuels will continue to be the backbone of the European power generation system for the foreseeable future. Hence, the development and deployment of innovative fossil fuel energy conversion technologies with a minimal carbon footprint are essential elements of a strategy to combat global climate change. The commercialisation of these technologies will depend however on their ability to operate economically in a power system with increasing shares of intermittent renewable energy sources, such as wind and solar.

The co-production of electricity and hydrogen from coal via gasification with the simultaneous pre-combustion capture of carbon dioxide is one such technological option as it offers a simple route of capturing carbon dioxide for geological storage.

The JRC has demonstrated that such a power plant can be cost-competitive, even when renewables have a significant share in electricity generation, by being able to vary its output of hydrogen and electricity within short times in response to the demand of these two energy carriers. To this end, the JRC has evaluated different gasification, syngas treatment and carbon capture technologies using advanced process flow modelling techniques and it has identified the most promising technologies that can maximise the process efficiency, carbon capture rate, output flexibility and reliability of the plant whilst minimising costs. An example of a design concept developed by the JRC is shown in the Figure.

The JRC has also identified areas which require further research and development, such as hydrogen fuelled gas turbines, hydrogen and CO₂ purity issues, plant integration etc.

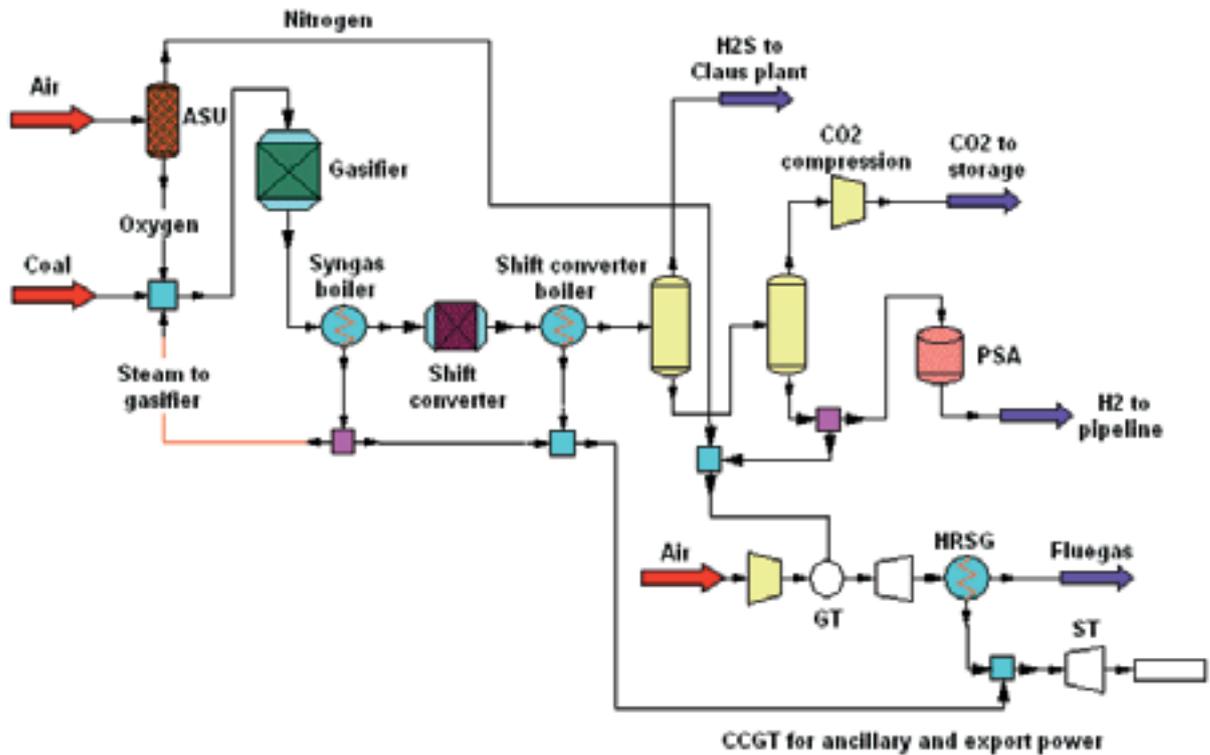
Key Publication:

F. Starr, E. Tzimas and S. Peteves, Critical factors in the design, operation and economics of coal gasification plants: The case of the flexible co-production of hydrogen and electricity, International Journal of Hydrogen Energy, 32 (10-11), (2007), p. 1477-1485

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Generalised flow scheme, developed by the JRC, of a gasification plant that converts coal into hydrogen and electricity with the simultaneous capture of carbon dioxide (CO₂). Coal and oxygen produced in an air separation unit (ASU) enter a gasifier and react in high temperature to produce a mixture of hydrogen, carbon monoxide (CO) and other gases. This gas mixture is sent to a shift converter where CO reacts with steam to produce CO₂ and more hydrogen. The CO₂ is then selectively removed, compressed and sent to storage. The resulting hydrogen-rich and CO₂-free gas is combusted in a gas turbine generating electricity but no CO₂ emissions, while a stream of very high purity hydrogen is obtained by further purification via pressure swing absorption (PSA) and exported via pipelines to hydrogen consumers.

Managing CO₂ from Fossil Fuels

CO₂ storage through Enhanced Oil Recovery

Enhanced oil recovery using carbon dioxide (CO₂-EOR) is a technological option that can simultaneously store carbon dioxide (CO₂) in oil reservoirs and increase oil production beyond what is achievable by conventional recovery methods. Hence, this approach can both reduce CO₂ emissions and improve the security of energy supply. So far, the lack of CO₂ supply to oil recovery projects at a competitive cost and the high operating and capital expenses, especially for offshore projects have hindered the implementation of such projects in Europe. However, the urgent need to curb CO₂ emissions, the implementation of the European emissions trading scheme (ETS), and high oil prices may now justify investment in CO₂-EOR. The emergence of this political landscape coincides with the end of operation of many oilfields in the North Sea, hence, soon, a decision needs to be taken to either decommission these oilfields or to keep them operating through investment in enhanced oil recovery methods.

The JRC has estimated the potential for CO₂ storage and additional oil production in oil recovery projects of the North Sea (see Figure), as well as the associated costs. The analysis has shown that while CO₂-EOR could increase considerably European oil production, the maximum potential for CO₂ storage in the oilfields of the North Sea may not prove significant when standard practices are applied. If, however, the price of CO₂ emission allowances becomes high, CO₂-EOR operations could be designed to maximise the retention of CO₂ underground.

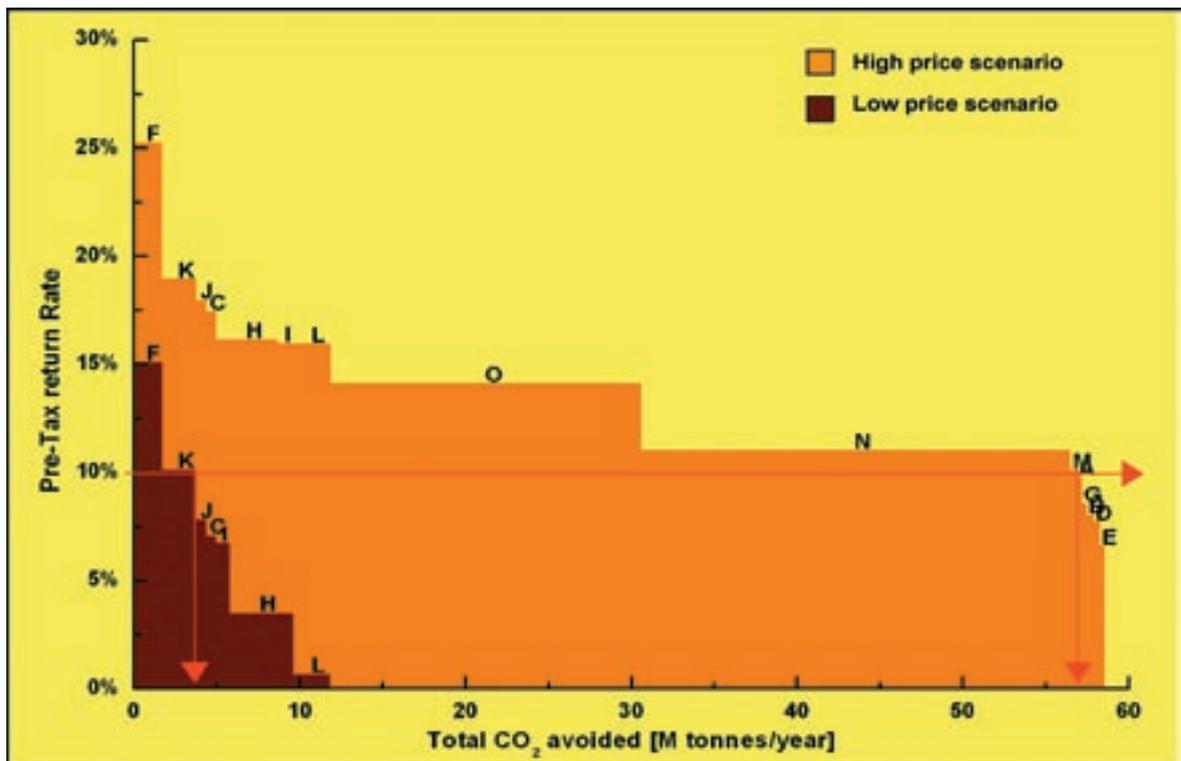
Key Publication:

E. Tzimas, A. Georgakaki, C. Garcia Cortes and S.D. Peteves. Enhanced Oil Recovery using Carbon Dioxide in the European Energy System. Institute for Energy, Joint Research Centre, Petten, The Netherlands. EUR 21895 EN, ISBN 92-7901044-1, December 2005.

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Potential cumulative CO₂ emissions avoided by Enhanced Oil Recovery projects in the North Sea.

Letters identify individual oil recovery projects: the height of the corresponding box indicates the profitability of the project in terms of its return rate before taxes, the width of the box indicates the annual amount of CO₂ stored (i.e. emissions avoided) by the project.

The high price scenario refers to \$35/bbl for oil and €25/t for CO₂ emission allowances. The low price scenario refers to \$25/bbl and €15/t respectively.

The analysis shows that at a 10% return rate the amount of CO₂ avoided ranges between 4 and 57 Mtonne per annum depending on the price scenario. As a reference: The CO₂ emissions from the UK power generation sector in 2003 were about 155 Mtonne.

Biofuels in Transport

the JRC-EUCAR-CONCAWE well-to-wheels analysis

The European Council, in its conclusions of 8/9 March 2007, endorsed a binding minimum target of a 10% share of biofuels in overall EU transport petrol and diesel consumption by 2020. The JRC, together with EUCAR and CONCAWE, carried out a Well-To-Wheels (WTW) analysis to estimate greenhouse gas emissions, energy efficiency and industrial costs of all significant automotive fuels and power-trains for the European Union after 2010.

The study specifies all input data and assumptions. This allows stakeholders (e.g. automotive and biofuels industries) to suggest improvements, which are incorporated in periodic updates. It is already being used as a reference by the Directorate-General Transport and Energy of the EC and in tasks of the International Energy Agency.

As an example, the WTW analysis shows that EU production of biodiesel and bio-ethanol from arable crops offers well-to-wheels greenhouse gas savings, but at much higher cost (> 100 €/tonne CO₂) than many other forms of greenhouse gas mitigation (see Figure).

Blending with conventional fuels gives the lowest costs. Making fuels from straw and forest residuals seems more attractive, but the processes are not yet demonstrated. Dimethyl ether (DME) should avoid slightly more greenhouse gas per euro than other wood-derived fuels, such as synthetic diesel/gasoline, methanol, ethanol, or hydrogen, and would be even better in fleet applications where new distribution infrastructure is less costly.

The study concluded that if the maximum feasible level of bio-resources in the EU was concentrated into making transport fuel, by 2010 one could replace 8 to 12% of EU gasoline and diesel, depending on the mix of fuels chosen. This would reduce greenhouse gas emissions from transport by 5-11%.

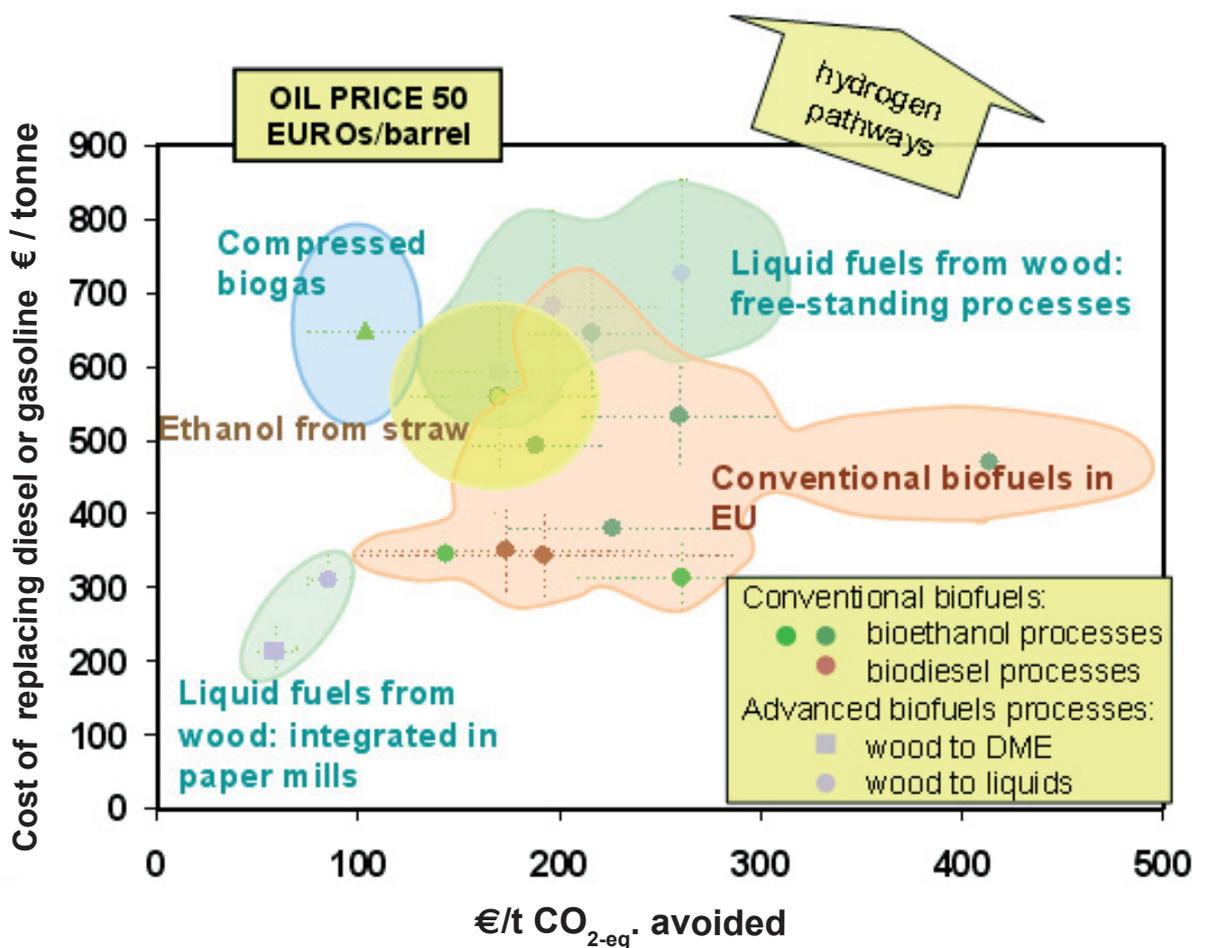
Key Publication:

The complete well-to-wheels report can be downloaded from <http://ies.jrc.cec.eu.int/wtw>

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The graph shows two important indicators for biofuels policy: how much it costs to replace fossil fuel in transport (vertical axis) and the cost of avoiding greenhouse gas emissions (horizontal axis) The costs here refer to the cost-to-Europe of the entire well-to-wheels chain, excluding taxes, subsidies and indirect effects on GDP etc.

We see that the cost of saving greenhouse gas for most biofuels pathways is in excess of 100 Euros/tonne CO_{2-eq}. By comparison, the price of CO₂ emission allowances in Europe's Carbon Trading system has rarely risen above 20 €/tonne CO_{2-eq}. This shows that biofuels are generally an expensive way to save greenhouse gas, compared to interventions in other sectors.

Except for the limited supply which could be produced in paper mills, the minimum cost of replacing fossil road fuel with biofuels is about 300 €/tonne. The expected EU road fuel demand in 2017-2020 is around 300 Mtoe/yr, so our best estimate of the minimum cost of replacing 10% of this (in line with the review of the biofuels directive) would be about 9 billion euros per year.

Note: this data is not the same as in JEC-WTW V2c (March 2007) because JRC has updated the commodity prices using the latest 2007 projection from FAPRI (used by US Government and DG-AGRI), for the year 2017. Costs for wastes are based on JRC cost-supply curves For definitive data, download V3 of the JEC WTW study, due early 2008.

Biofuels, how green are they?

N₂O emissions from biocrop production

In connection with the JRC-EUCAR-CONCAWE Well-To-Wheels study (see page 17), JRC pays attention to the following issues:

- availability of biomass from EU and world sources
- energy balance,
- environmental impact,
- potential in emerging countries,
- Greenhouse gas balance

With respect to the last issue, there is great attention to the production of nitrous oxide (N₂O) during biocrop production.

N₂O emissions caused by application of nitrogen fertilizers are crucial in determining how 'climate-friendly' biofuels are and whether they have a positive climate effect at all. N₂O emissions are depending on many factors – environmental and farm management – and therefore, it is very difficult to make a reliable emission estimate. In fact, these emissions dominate the uncertainty of greenhouse gas inventories in most countries.

The JRC, in collaboration with the University of Bonn, Germany, has set-up a modeling framework combining the economic model for agriculture CAPRI (Common Agricultural Policy Regional Impact assessment) and the mechanistic model DNDC (Denitrification Decomposition). It allows simulating nitrogen turnover in arable soils at a high spatial resolution and within a realistic socio-economic framework and leads thus to a significant reduction of the uncertainty in nitrogen gas fluxes from arable soils.

The calculations show, for example, that on average, direct plus estimated indirect N₂O emissions, alone do not offset the reductions in CO₂ equivalent emissions through the use of biofuels. If however the CO₂ emitted during fertiliser production and the use of fossil fuel during field operations are accounted for too, the climate benefit of biofuels based on rapeseed oil becomes negligible.

Key Publication:

*Leip, A., Koeble, R., Marchi, G., Kempen, M., Heckelej, T. , and Britz, W.: Linking an economic model for European agriculture with a mechanistic model to estimate nitrogen losses from cropland soil in Europe, **Biogeosciences Discussion**, 4, 2215–2278, 2007.*

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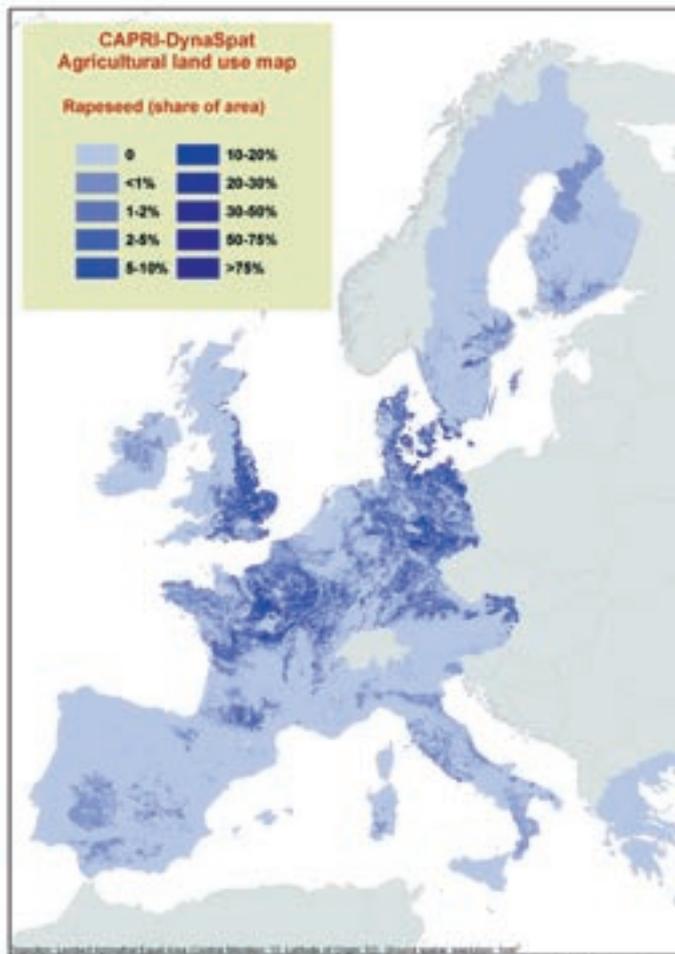
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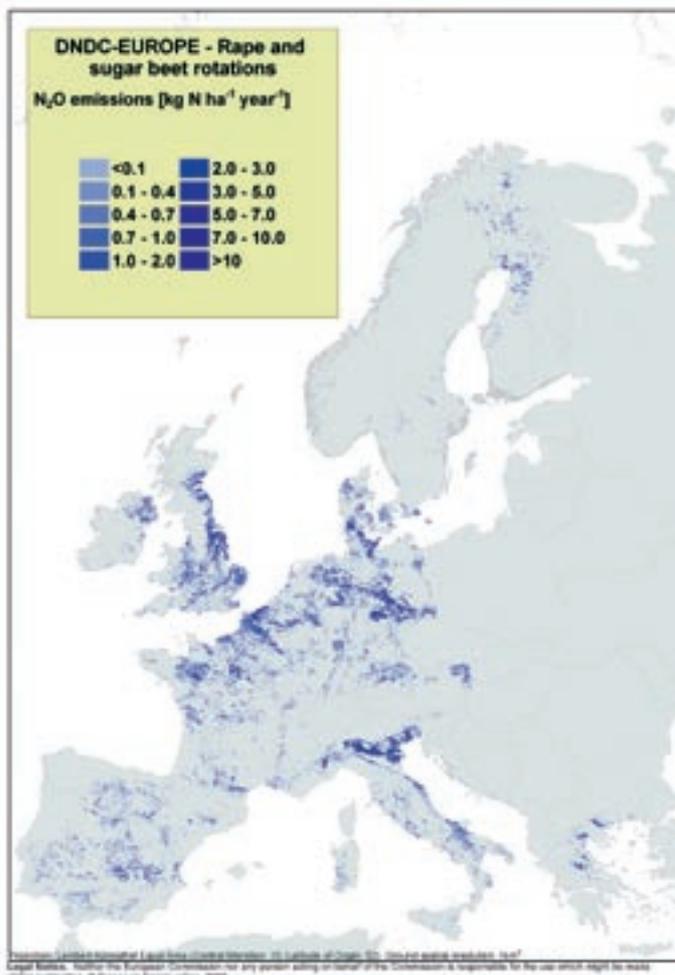
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Renewable Energies Unit

Institute for Environment and Sustainability



A prerequisite for reducing the high uncertainty of estimates of N₂O emissions from agricultural soils in Europe is to match agricultural activities and environmental conditions. The JRC in collaboration with partners of the DG-RTD project CAPRI-Dyna-Spat developed agricultural land use maps for 29 crops at high resolution. The map on the left shows rapeseed cultivation for the year 2000.



Rapeseed and sugar beet are important crops for the production of biofuels (bio-diesel and bio- ethanol, respectively) in Europe. The map on the left shows a 10-year average of N₂O fluxes simulated at ca. 8000 representative fields with rapeseed and sugar beet rotations.

Sustainable Consumption and Production

life cycle thinking and assessment

The full life cycle of goods and services must be taken into account when considering their environmental impacts, including their carbon footprints. Those impacts must not be shifted from one life cycle stage to another, nor from one impact category to others or across political boundaries. Life cycle thinking is now key in the upcoming European Sustainable Consumption and Production Action Plan.

One of the key impact categories of a LCA is climate change. Significant opportunities for greenhouse gas emission reductions can be identified using life cycle assessment. For example, GHG emissions from municipal wastes are up to 1.4 tonnes of CO_{2-eq} per tonne of waste in some regions, which can be up to 7% of their overall GHG emissions. Contributions are highest for the uncontrolled landfilling of large quantities of biodegradable waste. Through optimised management strategies, most of the organic waste that contributes to GHG emissions can be diverted from landfills reducing these emissions to almost zero. If this organic waste is used to produce compost (replacing artificial fertilizers) or to produce energy (replacing fossil fuels), and if recycling of waste in general is considered (avoiding the extraction and processing of raw materials), the reduction of GHG emissions by such waste management strategies can be up to 20% of the overall GHG emissions in some regions.

The European Commission therefore initiated the "European Platform on Life Cycle Assessment". The Platform is implemented by the JRC in collaboration with Directorate-General Environment. Working closely with key stakeholders, such as European business associations, the Platform provides the European Life Cycle Reference Data System (ELCD) for the life cycle emissions, resource consumption, and associated recommended impact indicators for core materials, energy carriers, and services.

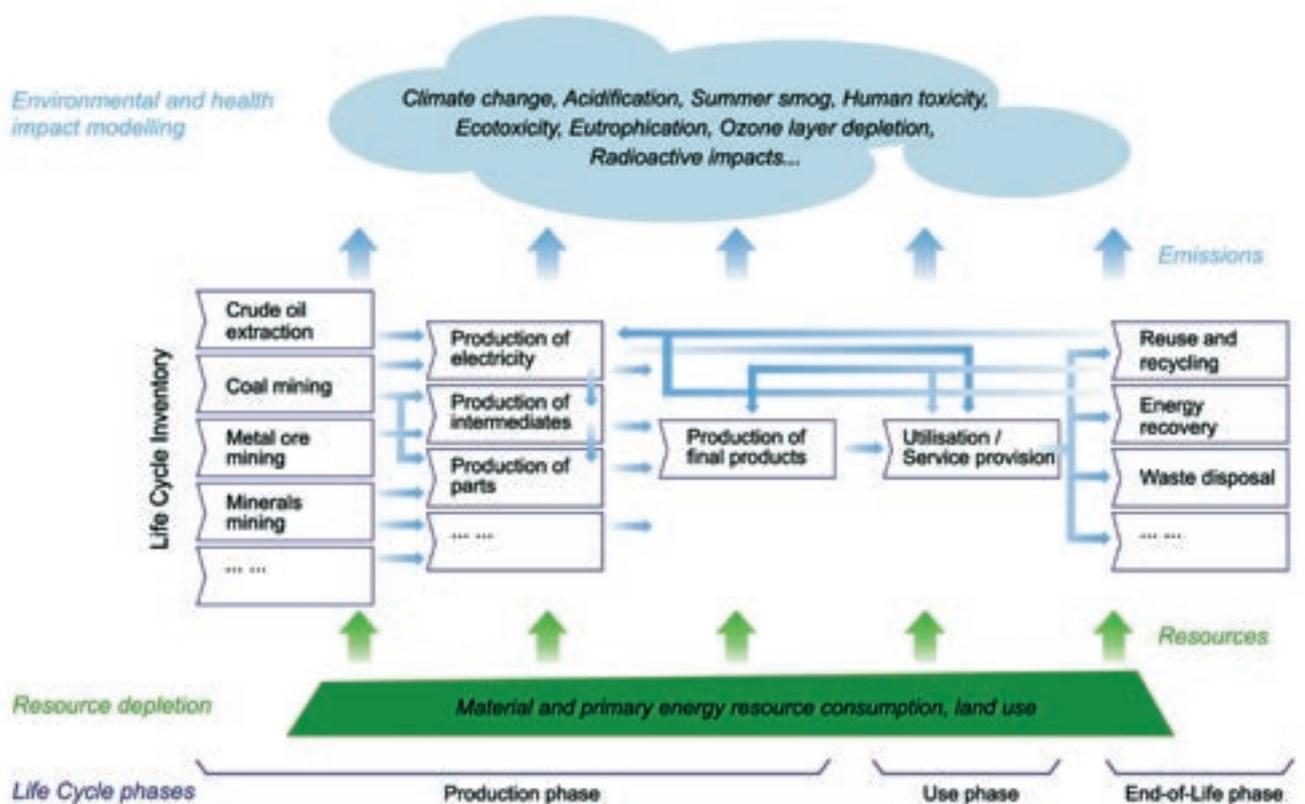
Key publication:

K. Konecny, R. Bersani, M.A. Wolf, D.W. Pennington. Recommendations for Life Cycle based Indicators for Sustainable Consumption and Production in the European Union, EUR 22879, 2007

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Life cycle assessment (LCA) is an internationally standardized method (ISO 14040, ISO 14044) for the environmental assessment of goods and services along their life cycle.

Left-to-right: product life cycle along the production phase, use phase, and end-of-life. Bottom-to-top: inventory of resource consumption and emission flows at each stage. Top: cross-comparable assessment indicators for resource consumption as well as environmental and social impact categories.

Avoiding Deforestation

exploration of an accounting mechanism

At COP-11 (Montreal, 2005) a process was launched to investigate technical issues surrounding a scheme to reduce greenhouse gas emissions from deforestation in developing countries. There is potential in such a scheme, especially in tropical forests, where both rates of deforestation and of carbon stock changes can be high. If such a scheme is to be considered under a post-2012 system, then adequate mechanisms will be required to ensure that any credits given for reducing emissions from deforestation really do reflect a positive carbon balance over the reference deforestation scenario. Such mechanisms require methodologies for the measurement of forest conversion, for determining carbon stock values of forests and for designing reference scenarios for carbon crediting.

The JRC explored a potential mechanism in the context of reducing emissions from deforestation in the tropics, including technical options for determining baselines of forest conversions (see Key Publication). This study builds on achievements in estimating tropical deforestation rates and distinguishing between 'intact' and 'non intact' forests using satellite-based measurements (see Figures).

At the same time, research is being carried out for obtaining minimum estimates of reduced emissions from deforestation even when poor data, e.g. on forest carbon stocks, is available.

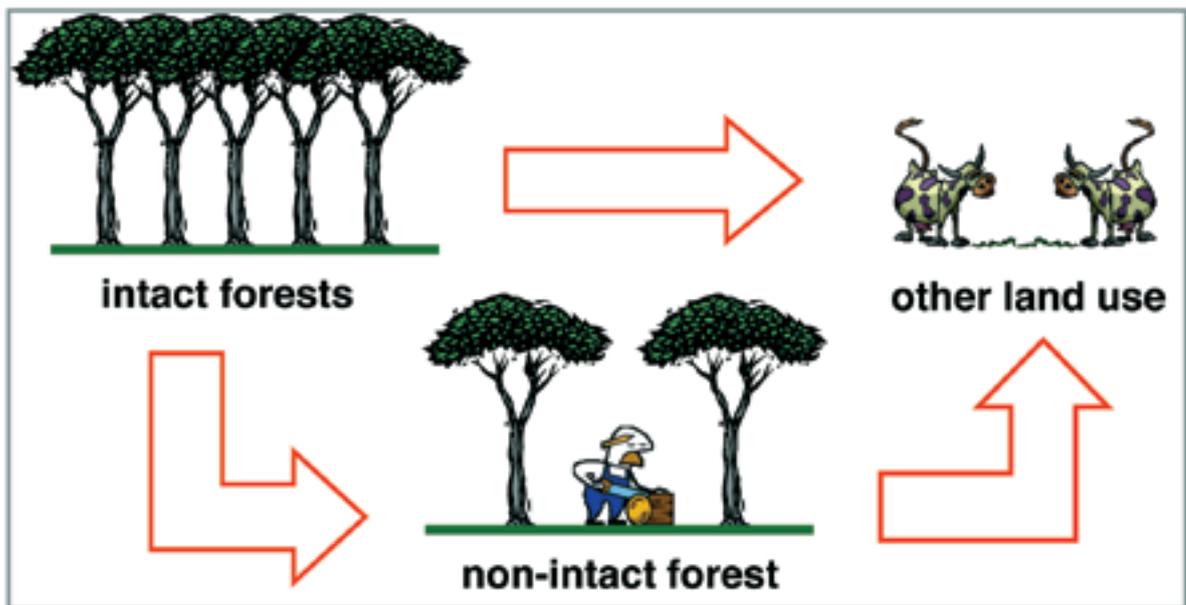
Key Publication:

Mollicone D., F. Achard, S. Federici, H.D. Eva, G. Grassi, A. Belward, F. Raes, G. Seufert, H.-J. Stibig, G. Matteucci and E.-D. Schulze, *Avoiding deforestation: An incentive accounting mechanism for avoided conversion of intact and non-intact forests*. **Climatic Change**, 83:477–493, 2007

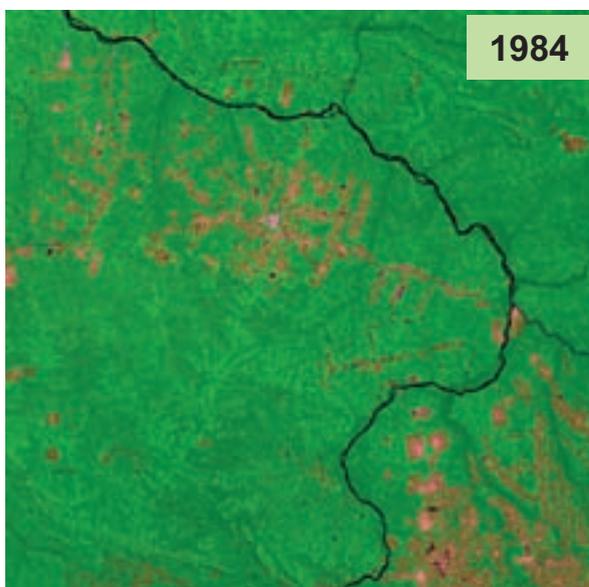
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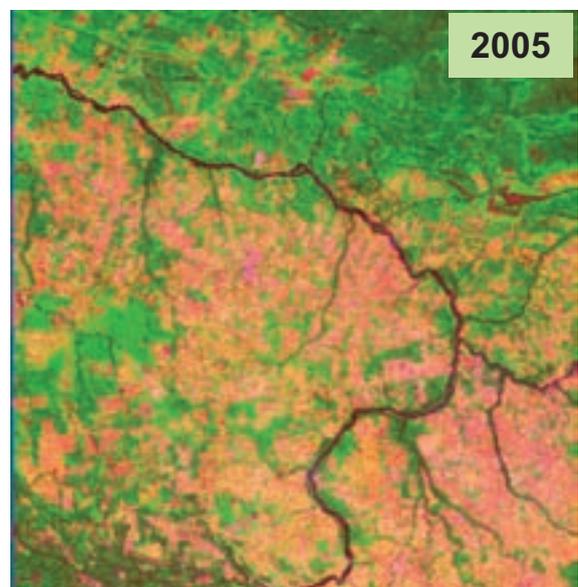
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Under the Kyoto Protocol, a “forest” may have a minimum 10-30% of crown cover. This means that, if degradation is not considered, the emissions caused by a 70-90% loss in crown cover would be ignored. For this reason, in the mechanism explored by the JRC both “intact” or fully-stocked forests (e.g. 100% of the original forest biomass) and “non-intact” or degraded forests (down to 10% tree canopy) are taken into account.



a) Landsat TM imagery
Source: NASA / USGS



b) ENVISAT MERIS mosaic
Source: ESA / MEDIAS-France

Satellite data can be used to monitor forest area changes (in this case 150 km across). Here we see the outlined region change from natural forest (green) in 1984 to forest and clear cut areas (red) in 2005 in the region of Alta Floresta, Brazil. In the same way that satellites can monitor deforestation, they can follow the loss of intact forests.

Floods and Droughts in Europe

the changing hydrological cycle

The JRC has developed a methodology to assess global warming induced changes in the hydrological cycle and the consequent socio-economic impacts. The physical impact assessment integrates high-resolution regional climate information, pan-European hydro-morphological data sets, hydrological modelling, and statistical analysis to predict changes in hydrological variables. Resulting economic impacts were estimated in several transnational river basins for the PESETA study on the cost of climate change (see page 26).

Results indicate (see Figures - page 24) that discharge will generally increase in northern parts of Europe, although summer discharge may decrease. Southern and south-eastern regions of Europe, which already suffer from water stress, will be particularly exposed to reductions in water resources and see an increase in the frequency and intensity of droughts. On the other hand, an increase in extreme high river flows, those which return only every 100 years, is projected for large parts of Europe, even in regions where it will get drier on average.

The consequent changes in water availability and the occurrence of extreme events across Europe will strongly affect ecosystems and socio-economic sectors such as water management, agriculture, energy production, navigation, and tourism.

Key Publication:

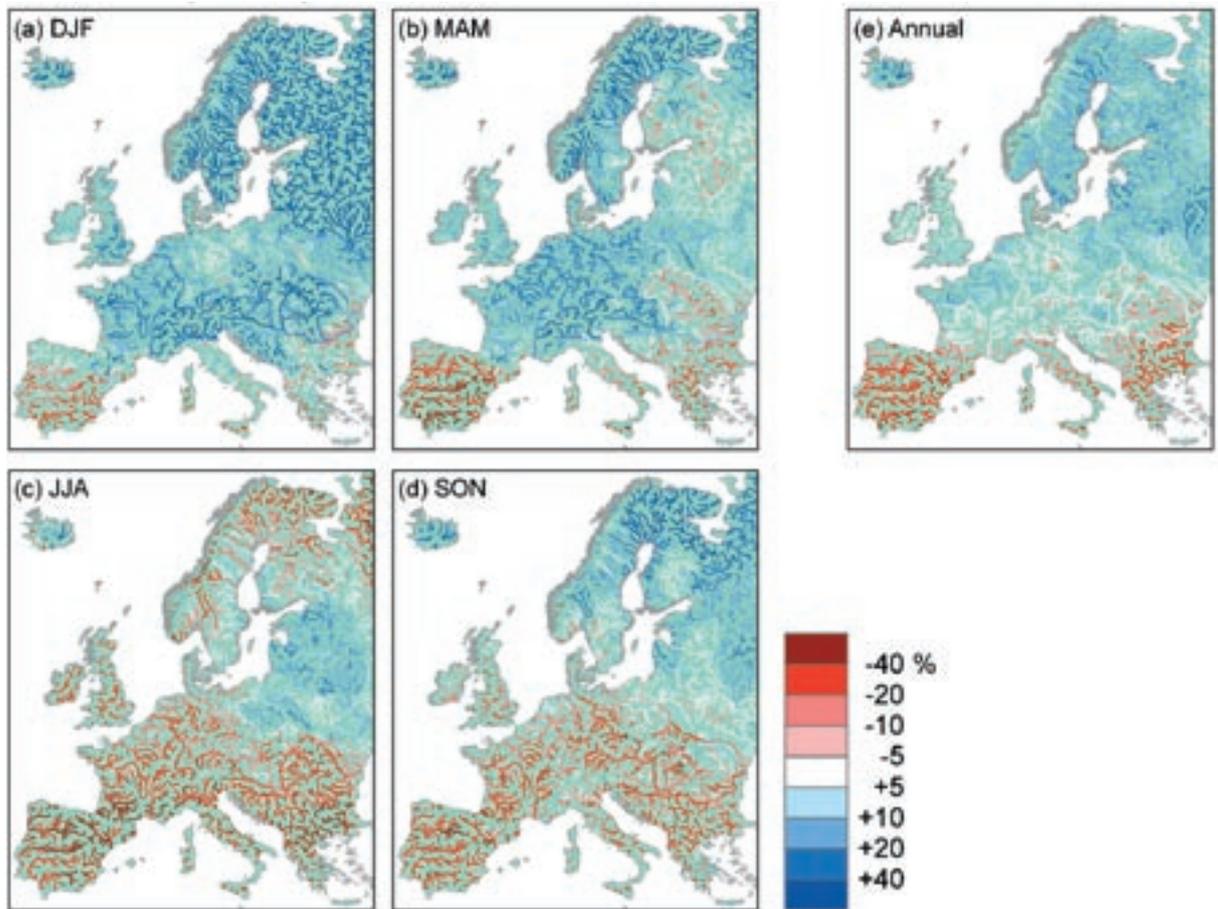
Dankers, R., O. B. Christensen, L. Feyen, M. Kalas, A. de Roo, 2007. Evaluation of very high-resolution climate model data for simulating flood hazards in the Upper Danube Basin, Journal of Hydrology, doi:10.1016/j.jhydrol.2007.09.055.

For more info:

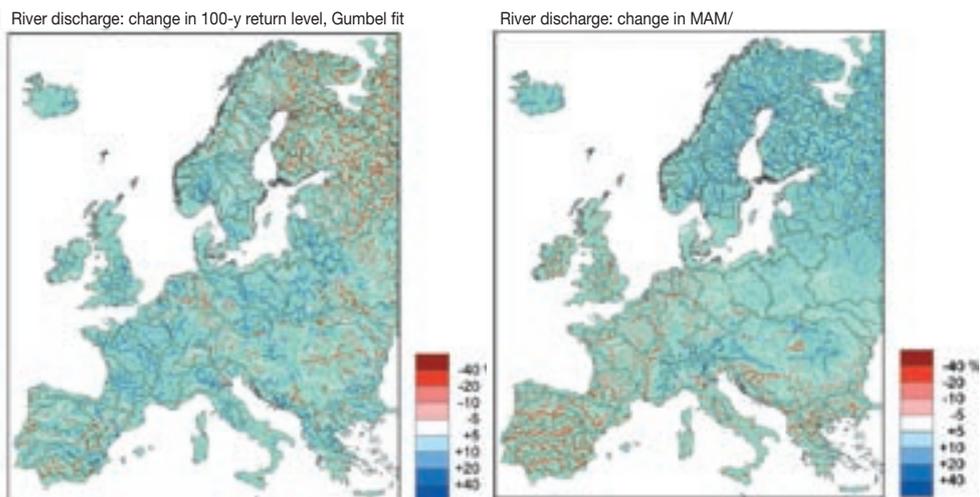
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Changes in mean annual and seasonal river discharge between the period 2071-2100 and 1961-1990. Shown here are only rivers with an upstream catchment area of 1000 km² or more. (Simulations with LISFLOOD driven by HIRHAM – HadAM3H/HadCM3 and IPCC SRES scenario A2).



Left plate (**floods**): relative change in 100-year return level of river discharge between 2071-2100 and 1961-1990. Right plate (**droughts**): relative change in mean annual minimum 7-day river discharge between 2071-2100 and 1961-1990. Shown here are only rivers with an upstream area of 1000 km² or more. (Simulations with LISFLOOD driven by HIRHAM – HadAM3H/HadCM3 and IPCC SRES scenario A2).

The PESETA Study

sectoral impacts of climate change in Europe

In June 2007, the European Commission published its Green Paper on Adaptation, which sets out options for EU action. The Green Paper and its annex include early results of the JRC PESETA study on the possible impacts of climate change in Europe over the 21st century.

PESETA focuses on the impacts of climate change, for the 2011-2040 and 2071-2100 time horizons, in the following sectors: Coastal Systems, Energy Demand, Human Health, Agriculture, Tourism, and Floods.

PESETA is coordinated by JRC, and involves several research institutes (JRC itself, ICIS-Maastricht University, AEA Technology, Metroeconomica, FEDEA, University of Southampton, FEEM, and Polytechnic University of Madrid and the Rossby Centre).

Two general methodological approaches are adopted for the physical impact assessments.

- Process modelling for Agriculture, Coastal Systems, and River Basin Floods. The impacts in these sectors are assessed through detailed, structural modelling systems: the DSSAT model for Agriculture, the DIVA model for Coastal Systems and the LISFLOOD model for River Basin Floods (see Figure).

- Reduced-form approaches for Human Health, Tourism and Energy Demand. They follow a more simplified framework in which direct relationships between climate variables and impacts are considered. For the case of Human Health, the exposure-response functions are derived from the available scientific literature. For Tourism and Energy Demand they come from statistical and econometric analysis.

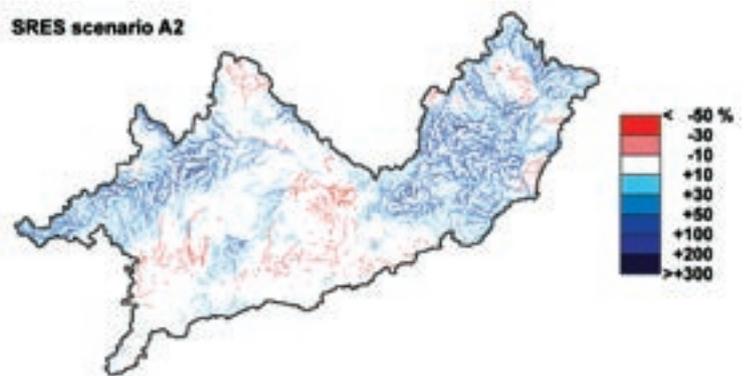
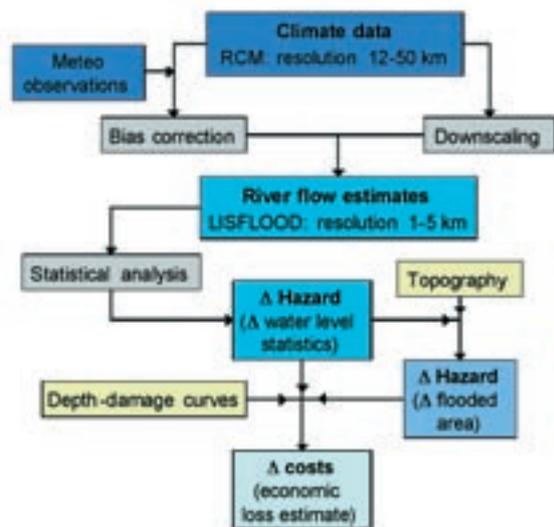
Despite many limitations, the PESETA project provides a valuable indication of the economic costs of climate change in Europe based on physical impact assessment and state-of-art high-resolution climate scenarios.

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Relative increase in extreme high river water levels (with 100 years return frequency) in the Upper Danube catchment between the end of the previous century and the end of the current century.

A2 control run					
Land use type	Depth >0 to 1	Depth 1 to 2	Depth 2 to 3	Depth 3 to 4	Depth > 4
Continuous urban fabric	251.5	298.9	335.3	118.7	0
Discontinuous urban fabric	18,462.0	15,149.3	6,329.4	3,198.9	1,993.7
Industrial or commercial units	54.3	104.4	64.0	47.5	81.1
Road and rail networks	2.7	7.2	5.8	2.0	0
Construction sites	0.6	0.9	0	0	0
Green urban areas	11.2	21.4	22.5	18.9	15.6
Sport and leisure facilities	301.1	298.9	175.0	19.3	73.9
Non-irrigated arable land	36.1	34.5	11.3	4.7	2.9
Total per water depth class	19,119.5	15,915.4	6,943.1	3,410.0	2,167.1
Total damage	47,555				

A2 scenario run					
Land use type	Depth >0 to 1	Depth 1 to 2	Depth 2 to 3	Depth 3 to 4	Depth > 4
Continuous urban fabric	240.1	313.2	402.3	387.1	249.1
Discontinuous urban fabric	17,205.0	16,320.3	11,113.6	7,054.3	10,864.4
Industrial or commercial units	50.4	114.4	106.3	83.3	212.7
Road and rail networks	2.6	6.1	8.0	5.0	5.5
Construction sites	0.8	0.5	0.9	0	0
Green urban areas	10.9	17.5	23.2	21.4	47.0
Sport and leisure facilities	266.5	312.3	241.7	126.7	202.7
Non-irrigated arable land	32.3	36.6	21.8	10.9	14.5
Total per water depth class	17,808.6	17,121.0	11,917.9	7,688.7	11,595.8
Total damage	66,132				

Flood damages (in million €) per land use type and water depth (m) class at the end of the previous century and at the end of the present century in the Upper Danube (IPCC A2 scenario).

Influence on European Agriculture

changing conditions for production

Agricultural production is very sensitive to climate variability and will be affected by climate change.

The JRC is analysing the changes in basic conditions for agricultural production, such as the growing season length (see Figure) and water availability, in support of EU agricultural policies and funding schemes.

For what concerns water availability, water deficit has so far been compensated by irrigation, which has largely been used to also increase production. However climate change, in particular in southern Europe, is expected to reduce water availability for irrigation [see page 25] while increasing the total water demand for agricultural purposes.

The increase of CO₂ concentration in the air is also expected to affect agricultural production, through its fertilization effect (particularly on C3 crops) and through the increase in water use efficiency. In addition an increase of temperature due to climate change is expected to enhance organic matter mineralization, to affect denitrification and in general the nitrogen and carbon cycle as a whole.

The JRC is developing and applying tools to assess those impacts of climate change on crop nutrient and water requirements. Preliminary results indicate that in the coming few decades crop production will in general increase in northern countries because of a longer growing season, CO₂ fertilization and a more efficient use of endogenous nitrogen coming from soil mineralization. The results also show that irrigation requirements will increase and that irrigated areas will spread throughout Europe.

Key Publications:

Genovese et al., Climate changes for Europe reflected in the phenology of wheat simulated with the CGMS Model". VIII Congress of European Society for Agronomy, Copenhagen, 11-15 July 2004, pp. 263-264.

Bouraoui F., Grizzetti B., Granlund K, Rekolainen S, Bidoglio G., 2004. Impact of Climate Change on the Water Cycle and Nutrient Losses in a Finnish Catchment. Climatic Change 66: 109-126.

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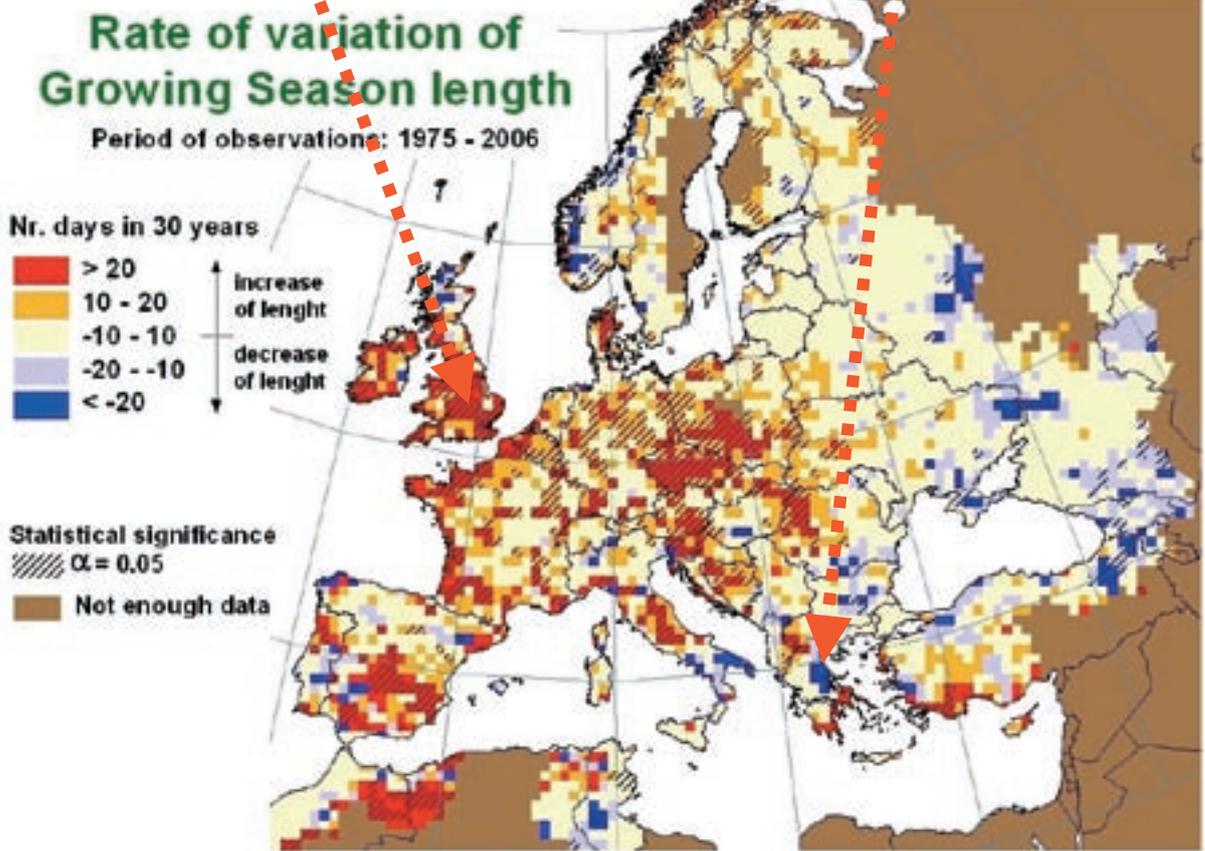
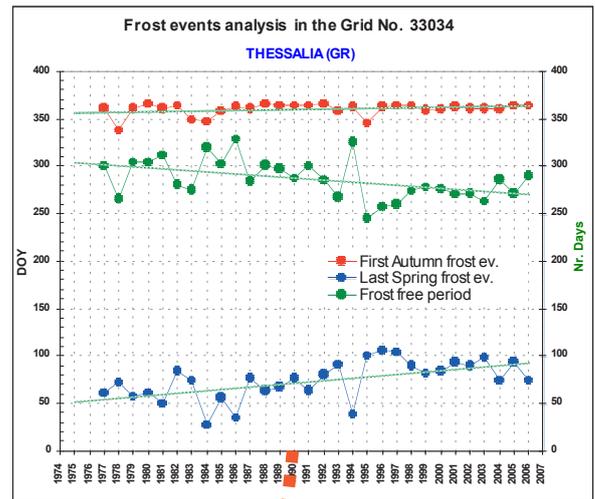
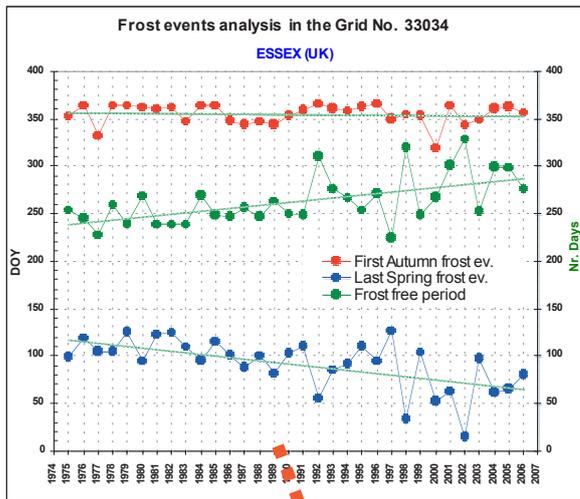
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The growing season length is defined as the number of days between the last spring and the first autumn frost event. During the past 30 years the growing season has lengthened over most of the EU territory. (Change is statistically significant in hatched areas). The northern latitudes benefit from a longer growing season coupled with higher temperatures. On the opposite, particular areas in southern and central Europe experience a decrease of the growing season length due to delayed spring frost events, which themselves are a result of a larger climate variability in those areas.

Climate Change and Development

the ACP observatory for sustainable development

The European Commissions Green Paper on Adaptation, mentions as one of the four pillars for EU action collaboration with third countries, in particular the least developed ones.

Climate Change is indeed a development problem since its adverse effects will disproportionately affect poor countries where economies are predominantly based on natural resources and rain-fed agriculture.

The JRC has developed, over the last 20 years, capacities for systematically assessing land and vegetation conditions in Africa by measuring several bio-physical parameters: albedo, solar radiation, fires, surface water bodies, photosynthetic activity...

These activities are now conducted in the frame of the African-Caribbean-Pacific (ACP) Observatory for Sustainable Development developed by JRC, which provides diagnostics and scenarios in the following domains: sustainable management of natural resources; land degradation and desertification, crop production and food security; crisis response and humanitarian aid.

For example, extreme events and their consequences are monitored by Earth Observation images, and the information is delivered to local and EU decision-makers (see Figures). Another example is the availability of solar energy. Most regions in ACP countries are rich in solar energy sources, with an average daily global irradiation of more than 5.5 kWh/m². Very little of this free energy is being exploited, despite the fact that in rural and peri-urban Africa the overall level of electrification is less than 15%. For the majority of African countries, levels of 1-2% are more common.

Key Publication:

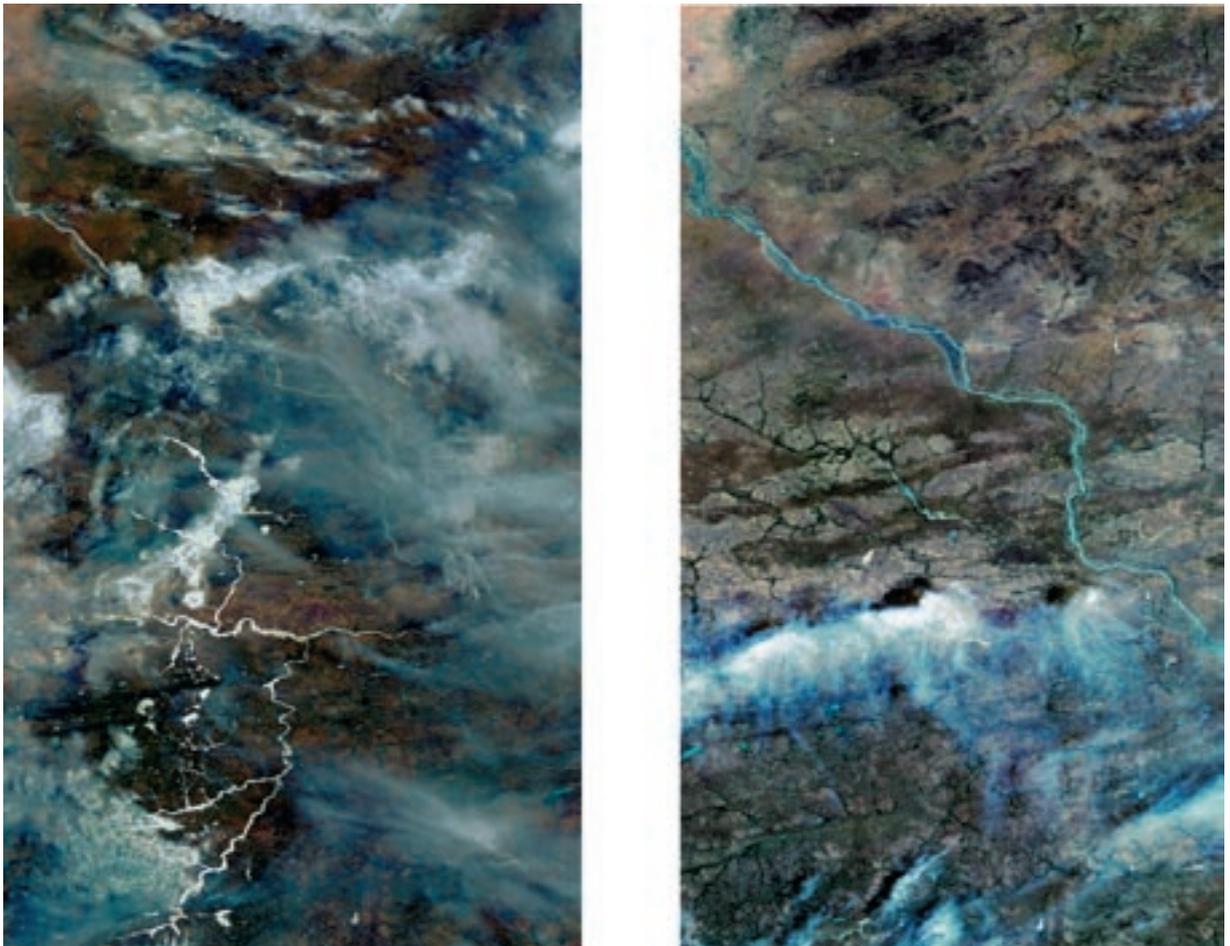
Carrara, P., Bordogna, G., Boschetti, M., Brivio, P.A., Nelson, A. and Stroppiana, D., 2007. A Flexible Multi-Source Spatial Data Fusion System for Environmental Status Assessment at Continental Scale, Int. J. of Geographical Information Science (in press)

Bartholomé E. et al., 2006, VGT4Africa user manual - First Edition, EUR 22344 FR

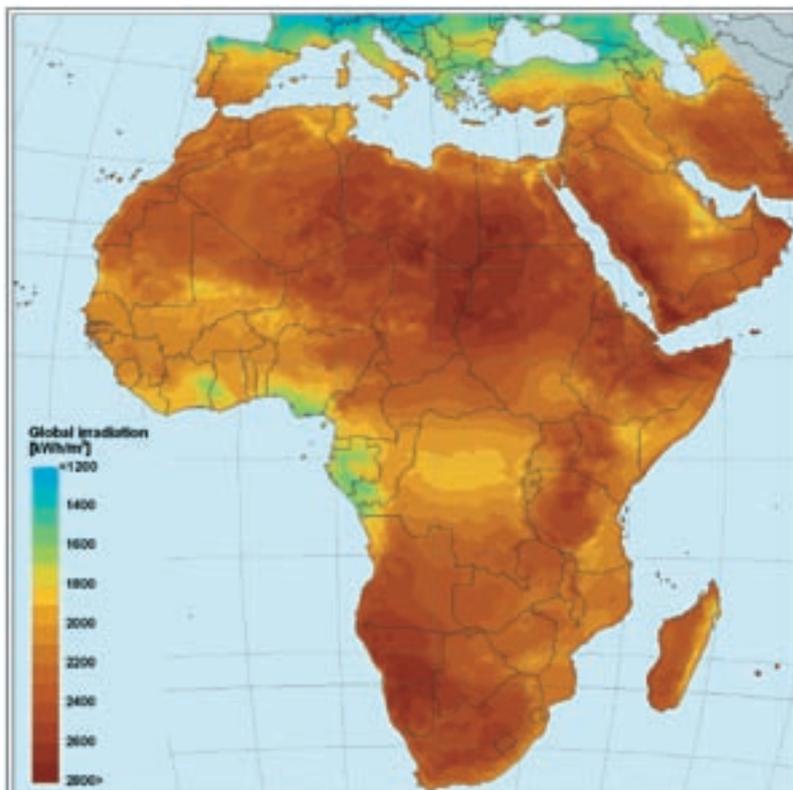
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The MERIS imagery of 03 (left) and 19 (right) September 2007 illustrates the extent of the floods in Northern Burkina Faso, at the borders of Mali and Niger. The flash floods (in white) are much larger than the normal temporary water bodies, but disappear very quickly.



"Annual solar radiation incident on optimally-tilted photovoltaic modules (kWh/m₂). The map has been prepared in collaboration with Ecole des Mines de Paris."

The EC GHG inventory system

focus on the largest uncertainties: agriculture and forestry

As a Party to both the UNFCCC and its Kyoto Protocol, the European Community has to submit its annual greenhouse gases (GHG) inventory. The compilation of this inventory is a joint activity of the Member States and the European Commission (Directorate-General Environment), supported by the European Environmental Agency, Eurostat and the JRC. This inventory includes estimates of anthropogenic GHG emissions and removals from land-related activities. The importance of these activities is well recognized: in the EU removals from Land Use Change and Forestry (LULUCF) are about 8 % of the overall EU GHG emissions. These current removals by LULUCF, should not be confounded with the removals which will be accounted under the Kyoto Protocol according to Art. 3.3 and 3.4 which in the EU-15 will equal to about 39 Mt CO₂ per year of the commitment period, equivalent to 11% of the EU-15 reduction commitment under the Kyoto Protocol.

Within the EC GHG inventory system, the JRC is responsible for the QA/QC emissions and sinks in Agriculture, Forests and Other Land Uses (AFOLU), which includes the check of Member States' inventories, the contribution to the EC Inventory Report and support to the UNFCCC review process.

The JRC complements these activities complemented by continuous efforts for harmonizing and improving the measuring and reporting of GHG emissions and sinks in the AFOLU sector. To this aim, the JRC-based web site "AFOLU DATA" offers EU-wide data sets, models and other tools to promote transparent, complete, consistent and comparable estimates. Target users are both greenhouse gas inventory practitioners and scientists.

Key Publications:

AFOLU DATA: Agriculture, Forestry and Other Land Uses

<http://afoludata.jrc.it/index.cfm>

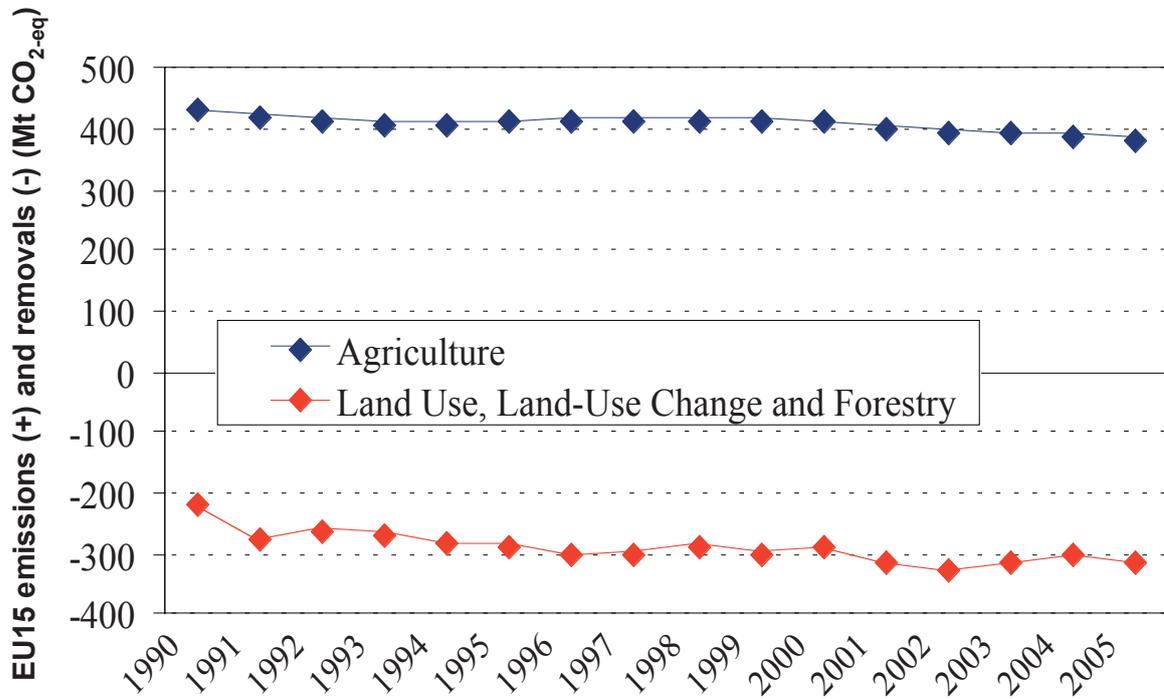
Ph. Ciais, ..., G. Seufert, ... Europe-wide reduction in primary productivity caused by the heat and drought in 2003 **Nature** 437, 529 – 533, 2005

For more info:

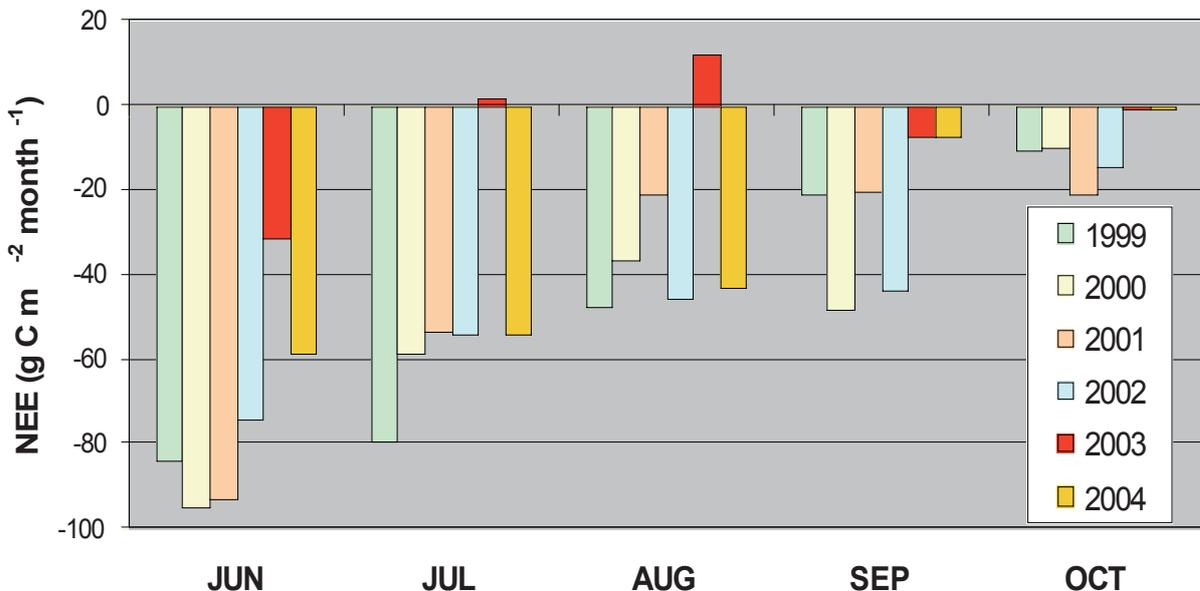
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According to the latest EC GHG inventory submitted to UNFCCC (2007), the GHG removals by LULUCF – largely dominated by forests - are totally offset by the GHG emissions from agriculture. When such official data are compared with estimates from experimental and modeling research, large source of uncertainties still emerge, especially regarding emissions from soil [see page 39]. It should be considered that the methodology applied by GHG inventories to estimate forest removals is essentially based on extrapolations between periodical forest inventories and hence does not allow to detect specific events such as the significant decrease in CO₂ uptake in the biosphere observed in summer 2003 (see Figure below).



Monthly Net Ecosystem Exchange for the summer periods in 1999-2004, at the JRC long-term test site at San Rossore (Italy). Negative values mean a net uptake (= sink) of CO₂ by the forest. The data show that during the heat wave of 2003 in Europe, the carbon sink turned into a source, indicating the unstability of the biospheric carbon sink in a future warmer climate. (in collaboration with DG-RTD project CarboEurope).

The EDGAR Emission Inventory

consistent emissions of greenhouse and air pollutants

A consistent emission inventory of greenhouse gases and conventional air pollutants is an important tool to study linkages between climate change and air pollution and to develop integrated climate change and air pollution policies.

The JRC in collaboration with the Dutch Environment Assessment Agency is developing the Global Emission Database for Atmospheric Research. EDGAR provides past and present (1970-2004) anthropogenic emissions of greenhouse gases and air pollutants (gases and aerosols). Emissions have been calculated using an emission factor approach where technology based activity data per country are coupled with country specific emissions factors taking into account technology and abatement measures. Emissions by country and sector are distributed on 1 x 1 and on 0.1 x 0.1 degree grid, allowing global and regional, models to use these data for atmospheric/climate studies.

EDGAR is used as reference dataset for studies on hemispheric transport or air pollutants under the UN Convention on Long Range Transboundary Air Pollution (EDGAR-HTAP). In 2008, improvements in EDGAR are sought through collaboration with experts from different countries to provide up-to-date information on local conditions.

Illustrations of EDGARs contents are shown in the Figures.

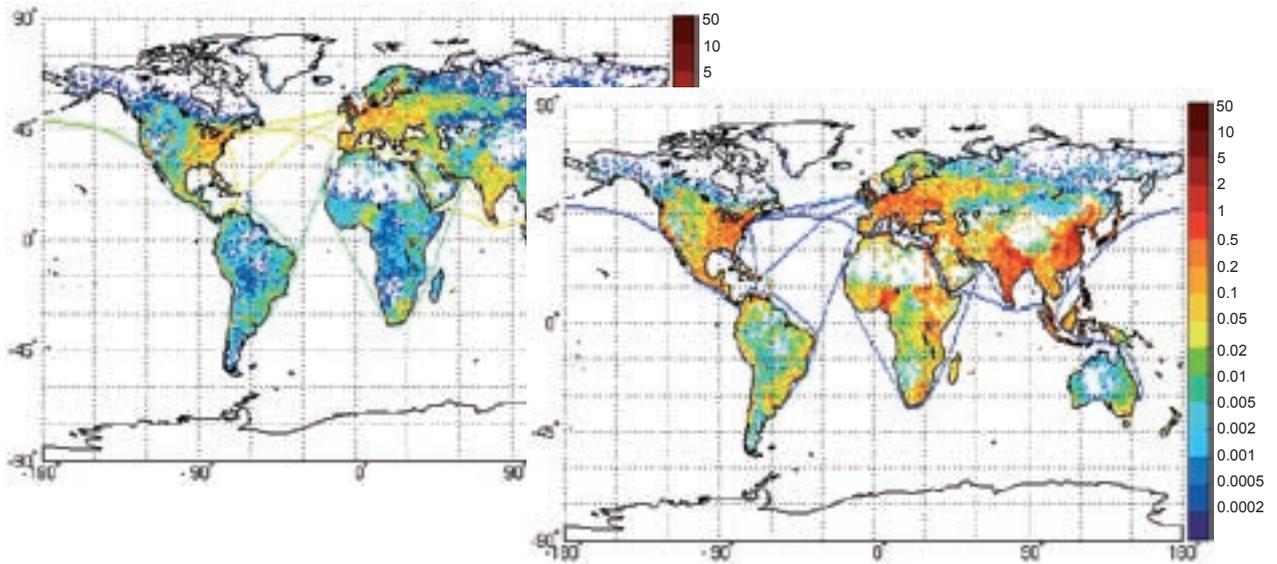
Key Publication:

In the 4th Quarter of 2007 global anthropogenic emissions of the Kyoto Protocol Gases and of the air pollutants CO, NMVOC, NOx, SO2, NH3 and aerosols (Black Carbon, Organic Carbon) will be made available on the website: <http://edgar.jrc.it>

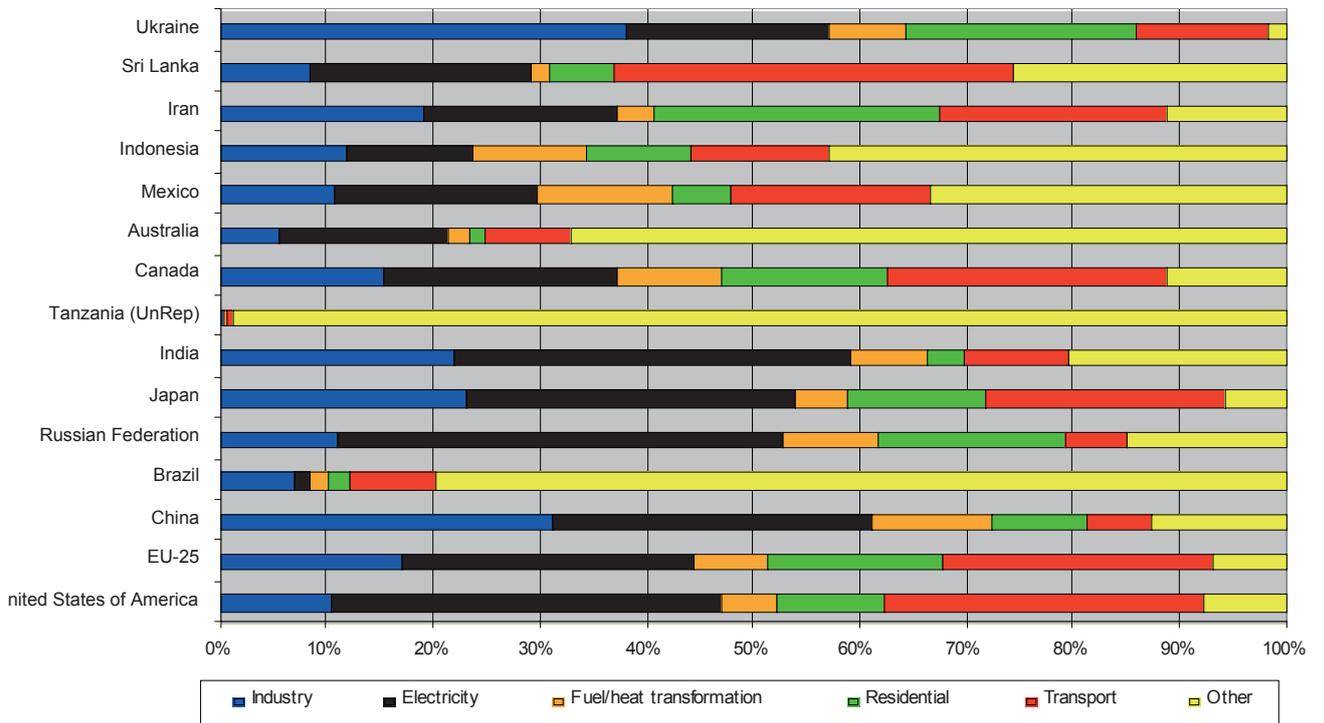
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Global emissions of anthropogenic carbon monoxide CO (left) and nitrogen oxide NOx (right) (units $10^9 \text{ kg m}^{-2} \text{ s}^{-1}$) on a 1x1 degree grid, in the year 2000.



Contribution of different emission sources to the national total of the 15 largest CO₂ emitters in the year 2000.

Verification of GHG Inventories

using atmospheric monitoring and inverse modelling

Atmospheric monitoring of greenhouse gases (GHGs), combined with inverse modelling, can trace back observed atmospheric concentrations of GHGs to their origin, i.e. to the regions where they have been emitted into the atmosphere, and provide top-down estimates of the GHG emissions (see Figure).

This technique can be used to verify emission estimates based on bottom-up inventories, such as the national GHG emissions reported to the UNFCCC.

It appears to be most useful for F-gases (which are almost entirely due to anthropogenic activities), and for CH₄ and N₂O (which for most European countries are dominated by anthropogenic emissions). In contrast, for CO₂ inverse modelling is especially useful to better estimate natural sources and sinks (biosphere, ocean), while anthropogenic fossil CO₂ emissions are assumed to be known with relatively high accuracy.

The JRC has assessed the current European atmospheric monitoring programs and the state of the art of inverse modelling techniques at a recent workshop (see Key Publication 1). Essential is the maintenance and further extension of existing atmospheric monitoring stations, and, on the European scale, the setup of an integrated, operational network in order to ensure the availability of long-term, high-quality atmospheric measurements e.g. greenhouse gases.

Key Publications:

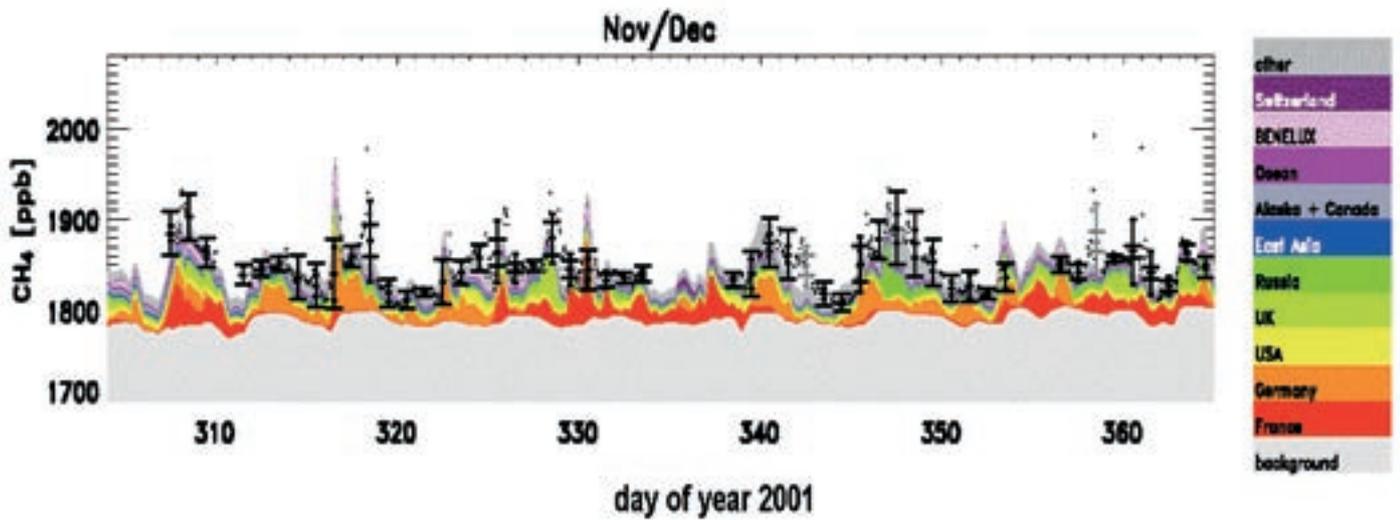
Bergamaschi, P. (Ed.), Atmospheric Monitoring and Inverse Modelling for Verification of National and EU Bottom-up GHG Inventories - report of the workshop "Atmospheric Monitoring and Inverse Modelling for Verification of National and EU Bottom-up GHG Inventories" under the mandate of Climate Change Committee Working Group I, Casa Don Guanella, Ispra, Italy (08-09 March 2007), 153 pp., European Commission Joint Research Centre, Institute for Environment and Sustainability, EUR 22893 EN, Scientific and Technical Research series, ISBN 978-92-79-06621-4, 2007.

Bergamaschi, P., M. Krol, F. Dentener, A. Vermeulen, F. Meinhardt, R. Graul, M. Ramonet, W. Peters, and E. J. Dlugokencky, Inverse modelling of national and European CH₄ emissions using the atmospheric zoom model TM5, Atmos. Chem. Phys., 5, 2431-2460, 2005.

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In-situ measured and simulated CH₄ concentration at a selected monitoring site (Schauinsland, Germany, Observations: Umweltbundesamt). By adjusting the emissions and fitting model results with measurements the inverse modelling technique allows attributing the observed variability to the contribution of recent emissions from different European countries and global regions (colour bars). Light grey shows the contribution from the global CH₄ background.

Monitoring Carbon in Soil

a practical sampling protocol

Soil contains between 70 and 90% of the total carbon in terrestrial ecosystems. This makes soil a key player in climate change mitigation activities addressing the removal of greenhouse gases from the atmosphere. In addition, carbon sequestration in soil enhances ecosystems resilience, increases the sustainability of rural livelihoods which in turn minimizes negative socio-economic and environment consequences of global warming.

The soil is among the mandatory carbon pools to be reported for the agricultural, land use and forestry activities under the Kyoto Protocol, and it is certainly one with the highest potential, both in terms of enhancement of C sink and reduction of C emissions. However, the major challenge is to find a methodology for monitoring changes of soil carbon over time which is cost-effective and easily applicable at a range of spatial scales.

The JRC developed a new Area-Frame Randomized Soil Sampling (AFRSS) Protocol, aiming at a reliable, transparent, verifiable and low-cost methodology for the determination of changes of organic carbon stock in mineral soils within the EU. The AFRSS Protocol considers the ISO recommendations on “Sampling to support legal or regulatory action”.

Field tests of the AFRSS Protocol have shown that monitoring costs vary from 3 € to 8 € per 1 tC (tonne of carbon), for a field size of 4 ha and depending on the commercial prices for the analysis in the EU. These costs will reduce for larger fields.

The methodology mainly addresses the need of a cost-effective estimation of soil organic carbon changes arising from specific projects or regional/national policies aimed at increasing soil carbon. Potentially it may be used also to support country-level reporting under the Kyoto Protocol, by improving specific components of IPCC’s default methodologies.

Key Publication:

Stolbovoy, V., Montanarella, L., Filippi, N., Jones, A., Gallego, J., & Grassi, G., 2007. Soil sampling protocol to certify the changes of organic carbon stock in mineral soil of the European Union. Version 2. EUR 21576 EN/2. 56 pp. Office for Official Publications of the European Communities, Luxembourg. ISBN: 978-92-79-05379-5

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The sampling plot (yellow line) is photographed from aircraft and the picture is overlaid with a computer generated frame. Red dots are randomly selected cells where composite soil samples are taken. Three composite samples allow the computation of the average organic carbon stock and its standard error for the plot. The cell position is recorded by GPS to allow comparison with observations in the future.

The AFRSS test in the Marche region (Italy) (right photo).

Observing Essential Climate Variables

contribution to the Global Climate Observing System

The JRC co-authored the implementation plan of the Global Climate Observing System (GCOS), which was approved at COP-10 (Buenos Aires, 2004). This plan identifies Essential Climate Variables (ECVs) which represent high priority geophysical variables that are critical to drive or constrain current and future models of the climate and the environment.

Renewed efforts are called for to generate comprehensive databases of these variables, both with a retrospective perspective (to provide historical background or establish trends) and operationally (to support current assessments and forecasting activities).

In parallel, the EU and the European Space Agency (ESA) Councils have repeatedly emphasised the strategic importance for Europe of independent and permanent access to global information for environmental management and monitoring. The Global Monitoring for Environment and Security (GMES), a joint EC and ESA programme, is Europe's response and it is the EUs contribution to GEOSS.

The JRC has a long standing history and continued commitment to R&D on remote sensing science; including algorithm development and benchmarking, specifying future observing instruments, etc..

The JRC generates and distributes information on some of the GCOS' ECVs such as the plant photosynthetic activity and biomass (see Figures), as well as environment descriptors such as the brightness of the planet, the productivity of the vegetation, deforestation, changes in land cover, biomass burning, etc.

The JRC also hosts WMO's World Data Centre for Aerosols, which contains data on global aerosol pollution. Amongst others the Aerosol Optical Depth which is another GCOS ECV.

Key Publications:

Knorr W., Gobron N., Scholze M., Kaminski T., Schnur R., and Pinty B. (2007) 'Impact of terrestrial biosphere carbon exchanges on the anomalous CO₂ increase in 2002-2003', **Geophysical Research Letters**, 34, L09703, doi:10.1029/2006GL029019.

Mélin, F., Steinich, C., Gobron, N., Pinty, B., Verstraete, M.M.: Optimal merging of LAC and GAC data from SeaWiFS. **Int. J. Remote Sens.**, 23, 801-807, 2002.

For more info:

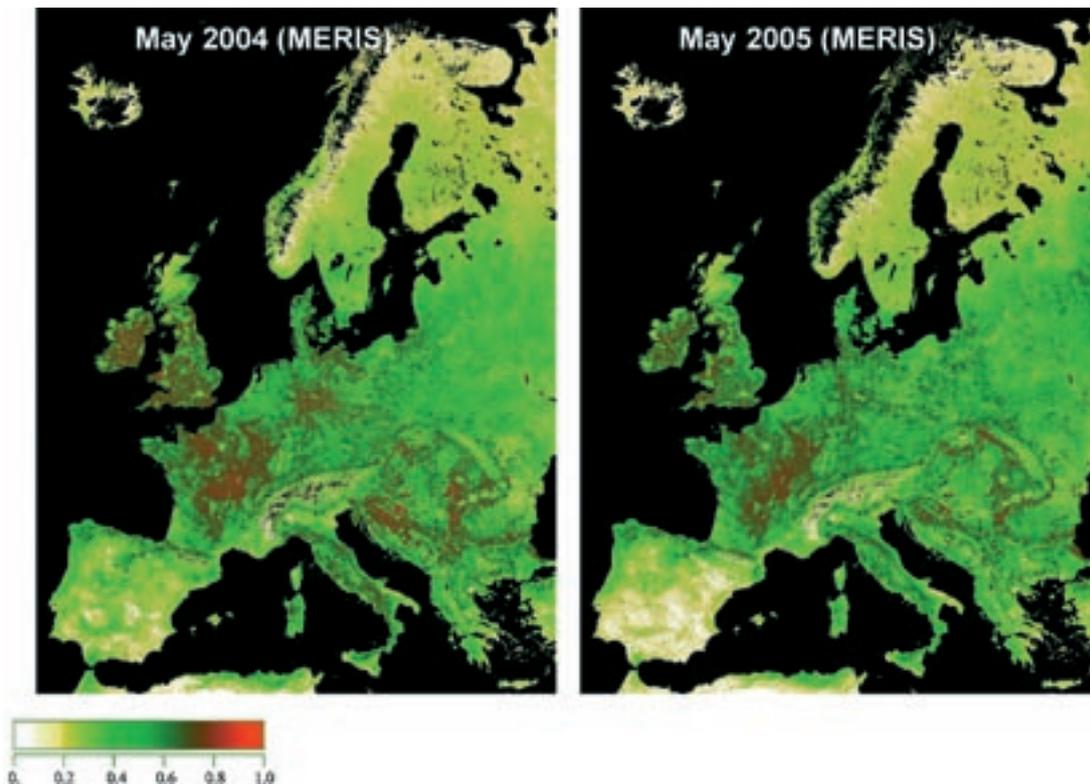
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These figures exhibit the inter-annual variation in plant photosynthetic activity (FAPAR) over Europe between May 2004 and May 2005. The effect of the 2005 drought in Spain is particularly noticeable. The color scale is selected so that unproductive areas appear in white, while highly productive regions are shown in red and intermediary values appear in shades of green.

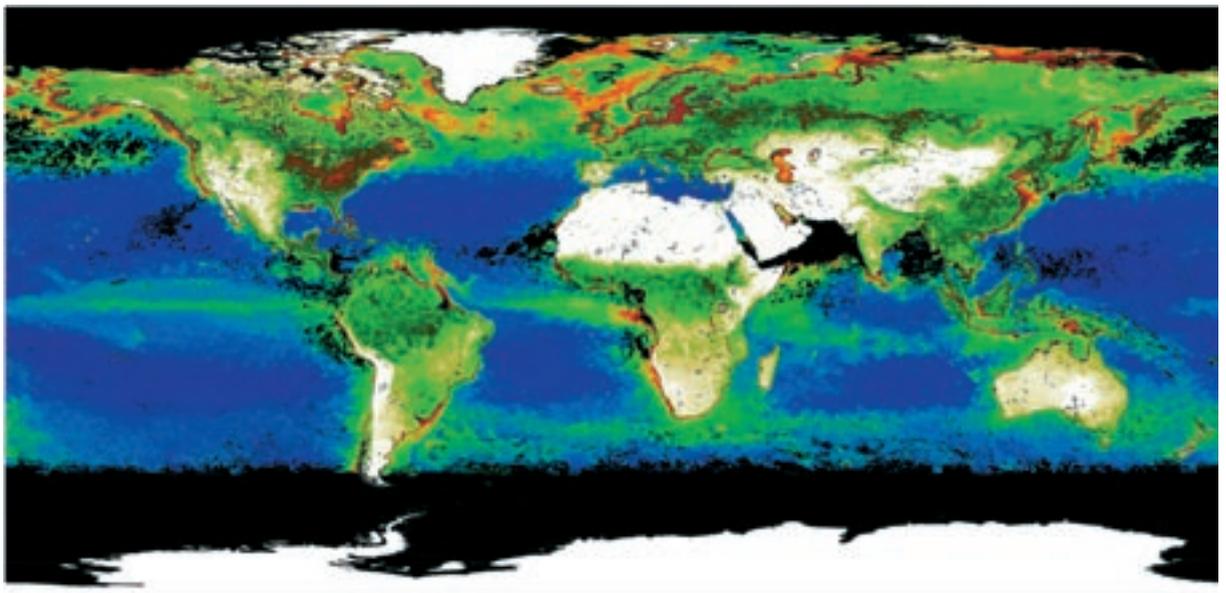


Image showing global distribution of biosphere Essential Climate Variables for July 2006. Chlorophyll concentration (mg/m^3) from the SeaWiFS sensor (NASA) mapped over the ocean and FAPAR (relative units) from the MERIS sensor (ESA) mapped over land (data processed at JRC).

Monitoring Global Forest Resources

Deforestation, mainly in the tropics, accounts for about 20% of man-made emissions of CO₂ into the atmosphere. Implementation of policies to control these emissions (see page 23), and to manage forest resources in general, requires effective forest monitoring systems that are reproducible, provide consistent results and meet standards for mapping accuracy.

Remotely-sensed data supported by ground observations are crucial to effective monitoring. They can give a continental perspective, which is required to ensure consistency among national monitoring systems. They can also identify hot spots of change and prioritising areas for monitoring at higher resolution.

The JRC has carried out extensive research over the last 15 years into monitoring forest extent and into measuring forest area change from global to local scales using satellite observations: the JRC has used satellite data to map the extent of forest domains at continental levels, to monitor individual protected areas, to calculate changes in tropical forest areas at global scales and to monitor logging activities.

The JRC launched originally the TREES project with the European Space Agency in 1991 to monitor changes in forest cover in the tropics. TREES entered its third phase in 2007, the purpose of which is to reduce uncertainties in global estimates of forest area change with a focus on the Tropics.

The JRC is working closely with the FAO's Forest Resource Assessment program to finalise the methods for producing continental forest conversion rates.

Key Publications:

*Achard F, Eva H, Mayaux P, Stibig HJ, Belward A, Improved estimates of net carbon emissions from land cover change in the tropics for the 1990's. **Global Biogeochemical Cycles** 18:GB2008, 2004.*

*Mollicone D., Eva H., Achard F, Ecology Human role in Russian wild fires. **Nature** 440, 436 - 437 .*

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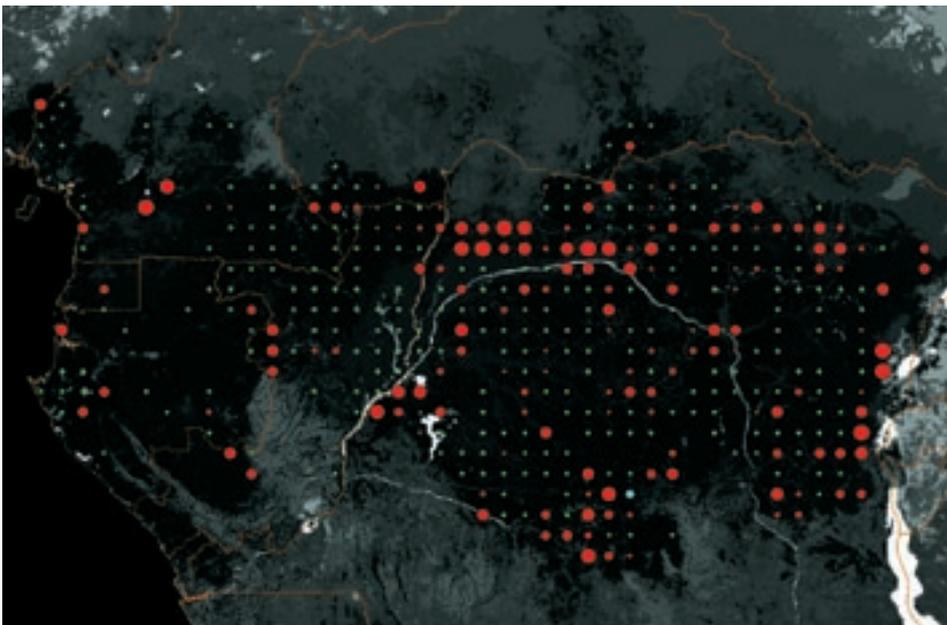
Institute for Environment and Sustainability



AQUA/TERRA MODIS
mosaic from year 2006

Data source: NASA;
Processing: JRC

Coarse resolution (250 m) satellite data can be used to map remaining forest areas. Here we see the forest cover status of Borneo for the year 2006 with remaining undisturbed forests in dark green, degraded forests, agriculture and burnt areas in respectively light green, yellow and purple.



Example given for the Congo Basin where forest area changes were estimated between 1990 and 2000 using a sample of circa 600 sites (10 × 10 km² size). It shows the spatial distribution of gross deforestation. Each circle corresponds to a sample and its size is proportional to the surface affected by gross deforestation.

You Control Climate Change!

The importance of individual action to fight climate change was already well recognised by the European Commission campaign "You Control Climate Change!" launched in June 2006 by President José Manuel Barroso and Environment Commissioner Stavros Dimas.
[<http://ec.europa.eu/environment/climat/campaign/>]

The JRC has developed several "games" that are part of the campaign, and that, more in general, support learning environments and public debate about climate change.

VGAS© soon to be released in 21 languages and tailored for 25 EU countries, is a virtual reality game that makes the link between lifestyles and emissions of 3 greenhouse gases (CO₂, CH₄, and N₂O). The models behind calculations are based on the IPCC guidelines and individual emissions are compared with Kyoto targets, world and national per capita emissions, so that the user gets an understanding about his "place" with regards to this global 'problematique'.

During the campaign more than 2000 schools and companies, as well as local authorities have requested and received copies of this game.

mobGAS  will be the first mobile application about climate change with wide distribution in Europe and the world.

mobGAS© aims to make the connection between daily activities and the emissions of greenhouse gases and, when possible, suggests changes to improve individual performances. It is a kind of diary of users' behaviour through the emissions of greenhouse gases (GHG).

Key Publication:

Guimarães Pereira, Â. and Pedrosa T., V GAS Energy , lifestyles and climate".

European Commission-Joint Research Centre: **EUR 21385 EN**

[<http://kam.jrc.it/vgas>]

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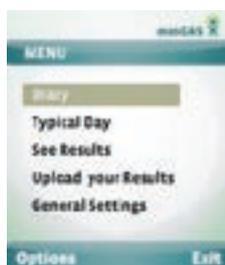
Econometrics and Applied Statistics Unit

Institute for the Protection and Security of the Citizen



mobGAS© will challenge individuals to make small changes to their daily routine in order to achieve significant reductions of greenhouse gas emissions.

It will be developed for the 27 EU countries, and available in 21 languages, and easily adaptable to others.



mobGAS© includes several icons representing activities or appliances that are used every day (more than 60). These activities or appliances may be set along the day reflecting users' daily choices. This will finally be converted in individual emissions of GHG that may be compared with the weekly average or with a country or world average. Further more the application includes an animation comparing the users contribution to the Kyoto target. Tips are given on how the users' behaviour may improve.

European Commission

EUR 21855EN/2 – Joint Research Centre

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The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

