Global simulation models with varied sources of emission and behaviour of air pollutants

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Greenhouse gases and aerosols have an undisputed impact on climate. Long-lived greenhouse gases such as carbon dioxide (CO2) and methane have a well-understood warming effect. Aerosols, tiny particles of human or natural origin ranging from 0.01 to 10 millionth-of-a-meter, also have a cooling effect. Although they live no longer than a week in the atmosphere, they have an impact on air quality and thus our health, while their action on climate is not fully understood. The challenge is to predict concentrations of these pollutants in the atmosphere in order to improve climate and air quality models.

Enter two French scientists Frédéric Chevallier (FC), leader of the inversion-data assimilation-remote sensing team at the Climate and Environmental Sciences Laboratory in Gif-sur-Yvette, France, and Olivier Boucher (OB), research director at the Meteorological Dynamics Laboratory in Paris. Both scientists have been involved in the EU-funded MACC-IIproject, as leaders of the greenhouse gases and aerosol sub-projects, respectively. This three years project began in 2011 with the objective of delivering data and forecasts related to the atmosphere. They both talk to youris.com about the scope of their global simulation models' predictions and their relevance to models used by other scientists, such as, among others, those working at the Intergovernmental Panel of Climate Change (IPCC).

What do your models consist of?

FC: We have built a model that simulates the evolution of CO2 concentration in time, on a world scale. To fine-tune our model, we fit it to greenhouse gases data, mainly collected on the ground by US National Oceanic and Atmospheric Administration stations, and by the European network ICOS, currently being built. Satellite data is also useful, but metrology of greenhouse gases from space still has to gain accuracy.

OB: As for aerosols, our model mimics the emission of natural sources, such as marine salts wiped away by the wind, desert dust, forest fires, and human emissions from industry or agriculture such as sulfates, soot, and nitrates... We also simulate the transportation of aerosols by the wind. And we perform simulations of what are referred to as wells—reservoirs absorbing these aerosols through dry deposits on the ground or washing away by rainfalls. We then fit our simulations to ground data, and satellite data of forest fires monitoring and measurements of aerosol content in the atmosphere. To run our models, we both rely on computing capabilities implemented for meteorological purposes at the European Centre for Medium-Range Weather Forecasts based in Reading, UK.

What kind of forecast can your models deliver?

FC: Greenhouse gases concentrations can be predicted up to four days ahead, with a resolution of 15 by 15 kilometres. Furthermore, for the purpose of climate studies, we use our model in reverse to estimate global CO2 emissions from concentrations measured on the ground. As an example, we have been able to calculate CO2 emissions from 1979 to 2012, with a resolution of some 200 by 200 kilometres

OB: We deliver a daily global distribution of aerosols, with a focus on Europe, but data at a smaller scale are downloadable. From this distribution, we forecast concentrations up to 5 days ahead, with a resolution of about 50 by 50 kilometres.

Who are the users?

FC: Mostly scientists, so far. Those who wish to launch airborne CO2 measurement campaigns use our predictions to know when and where to explore. The implementation of space-borne remote sensing of greenhouse gases from space can also benefit from our data. Similarly, ground stations managers may compare their CO2 measurements to our forecasts. Lastly, we have contributed to the summary balance sheet of greenhouse gas wells for the IPCC.

OB: Air quality managers at a regional scale use our predictions to constrain their own models, which are at a smaller scale, and give them so-called boundary conditions. The World Meteorological Organization has a forecast system of atmospheric dust called SDS-WAS, to which MACC-II contributes. As for research, our data and model help assess the effects of aerosols on climate, as used by IPCC scientists.

Is the private sector interested?

FC: Some initiatives are emerging. As an example, the European space services company, Astrium, considers delivering greenhouse gases forecast services at the scale of a city. A demonstration was made in London during the Olympic Games in 2012, using the project data. However, as long as there is no regulation on CO2 emissions, there will be no market!

OB: The solar energy industry is concerned. Assessing the solar potential of a region is indeed crucial to estimate the production of a future solar plant. Aerosols, by scattering sunlight, lower the solar potential. Therefore, our model can help choose the most suitable locations to install solar plants.