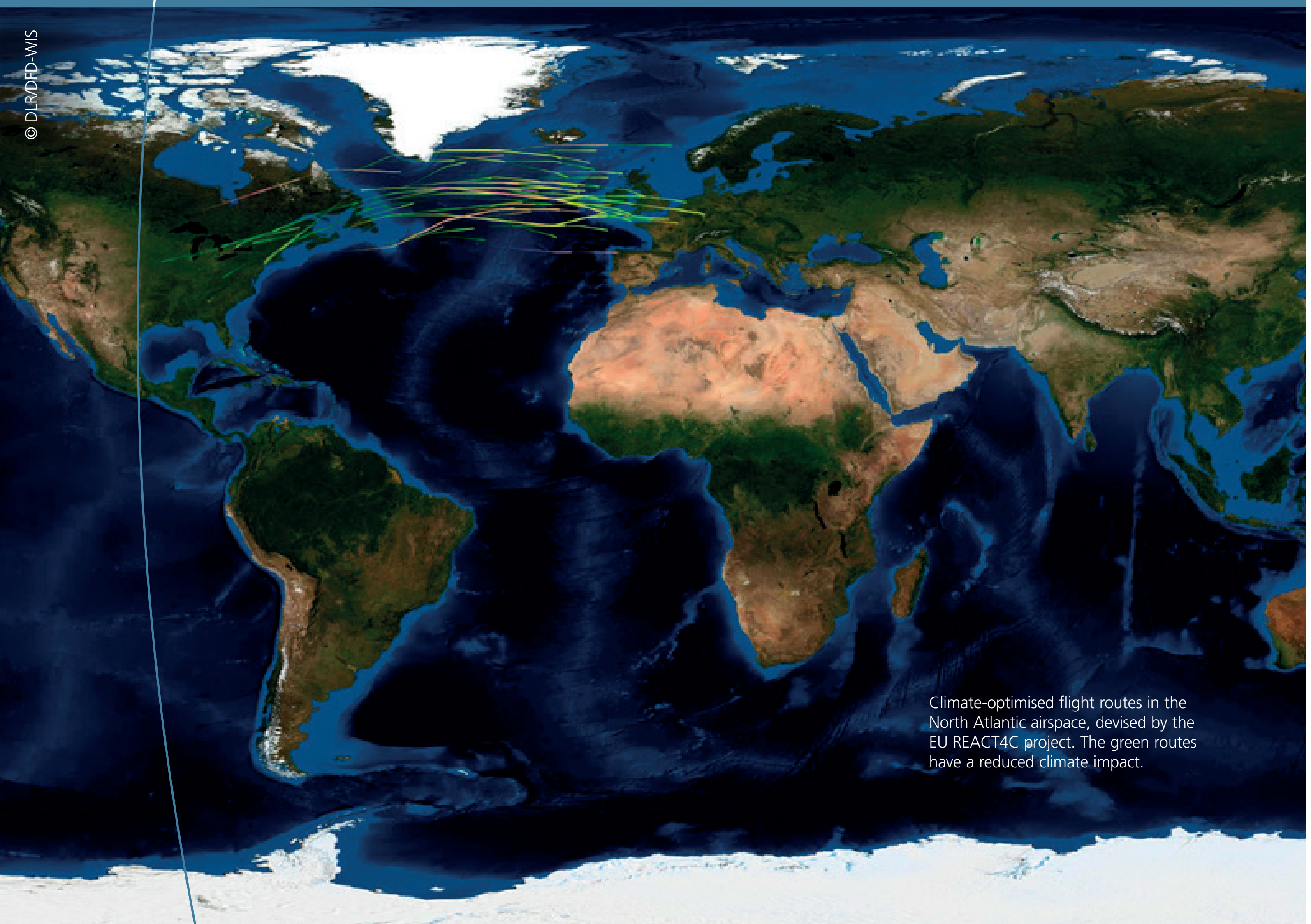
FOLLOWING THE YELLOW BRICK ROAD

In this interview, a DLR atmospheric researcher explains possible routes towards more climate-friendly air transport.

By Bernadette Jung



Climate-optimised flight routes in the North Atlantic airspace, devised by the EU REACT4C project. The green routes have a reduced climate impact.

Global change is transforming aviation. Atmosphere physicist Sigrun Matthes talks to DLR editor Bernadette Jung about how atmospheric research can contribute to making air transport more environmentally friendly over the next 30 years and what challenges still need to be overcome.

Sigrun Matthes

works at the DLR Institute of Atmospheric Physics in Oberpfaffenhofen. Her particular research interest is numerical modelling of the climate impact of air transport using the global Earth system model EMAC. Matthes is especially interested in the quantification of the climate effects of anthropogenic emissions. She is currently leading interdisciplinary research work as part of the Horizon 2020 ACACIA and ClimOP projects, which focus on the climate impact of air transport. Matthes is also Chair of the Environmentally Compatible Air Transport System (ECATS) research association and network of excellence, which is developing pathways towards sustainable air transport. As part of ECATS, she chairs the 'Aviation Climate Impact and Mitigation Options' working group.

As air traffic increases, so do emissions. How are you addressing this in your research?

: Air transport still relies on fossil fuels and its emissions are contributing to climate change. The processes in the atmosphere that cause this climate impact are highly complex and sometimes very difficult to measure. In order to enable aircraft to fly in the most climate-optimised way possible, research has to provide information about the impact of specific emissions and their interaction with the atmosphere. Those working in this field rely on a highly interdisciplinary approach. I am currently working on various national and European research projects. DLR has been awarded the contract for the Horizon 2020 research project ACACIA (Advancing the Science for Aviation and Climate), which is investigating the impact of air traffic emissions on the climate. We are paying particular attention to what are referred to as non-carbon-dioxide effects. These are not yet sufficiently understood, so they have not yet been taken into account for emissions trading schemes. The climate impact of non-carbon-dioxide effects is more complex and possibly also stronger than that of carbon dioxide itself. As atmospheric researchers, we want to investigate this area and reduce the uncertainties in our estimates.

What is known about these non-carbon-dioxide effects?

: Aircraft emit different trace substances, each of which has an impact on the atmosphere and thus on the radiation balance and climate. For example, the nitrogen oxides that are emitted interfere with atmospheric chemistry. This produces ozone, which causes warming of the atmosphere. However, the processes triggered by the nitrogen oxides also lead to a reduction in atmospheric methane and this has a cooling effect. Other impacts include long-lasting condensation trails and contrail cirrus clouds – the only non-carbon-dioxide effects of air transport that are visible in the sky. These can spread in the atmosphere over several hours and, depending on the situation, can have a cooling or a warming radiative effect. In total – over day and night and across the globe – they have a warming effect.

One effect that may have been underestimated until now is the 'indirect aerosol effect', which has been the subject of little research. This effect is caused by the emission of aerosols during the combustion of kerosene. Aerosols are tiny particles floating in the air – soot and sulphate droplets, in particular. These continue to influence natural cloud formation long after they have been emitted and far from the flightpaths. They can change the extent of cloud cover and the properties of the clouds. It is thought possible that such aircraft aerosols have a climate impact that is at least equal to that of carbon dioxide. At present, however, the impact of these non-carbon-dioxide effects

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has not been proven by measurements and observations, and existing estimates of the indirect aerosol effect are still very uncertain. We want to change this.

So, you are tracking them down. What comes next?

: As part of ACACIA, we are developing a measurement strategy to identify the mechanisms and processes of the indirect aerosol effect and estimate the severity of its impact. In order to do this, we have to determine whether and in what way existing measurement data can be used for this purpose. This includes data from long-term measurements on scheduled aircraft, from observations made during airborne measurement campaigns, including those conducted by our DLR research aircraft, and data acquired by satellite missions. The ACACIA team will also investigate where data are still missing or where they are imprecise. We would like to close these gaps and further refine the forecasts produced by climate models.

How can these findings contribute towards more climate-friendly air transport?

: We need to obtain a more accurate understanding of how the atmosphere reacts to the different emissions produced by air traffic. Only then will we be able to develop sustainable strategies for air transport and optimal measures for protecting the climate. As part of the ACACIA project, we will be looking at the interactions between the various effects. This will allow us to ensure that a measure aimed at mitigating the climate impact of one type of emission will not inadvertently exacerbate that of another. The DLR Institute of Atmospheric Physics is also involved in the European ClimOP research project, which began at the start of this year. In this case, we are looking for technological and operational measures that are suitable for reducing

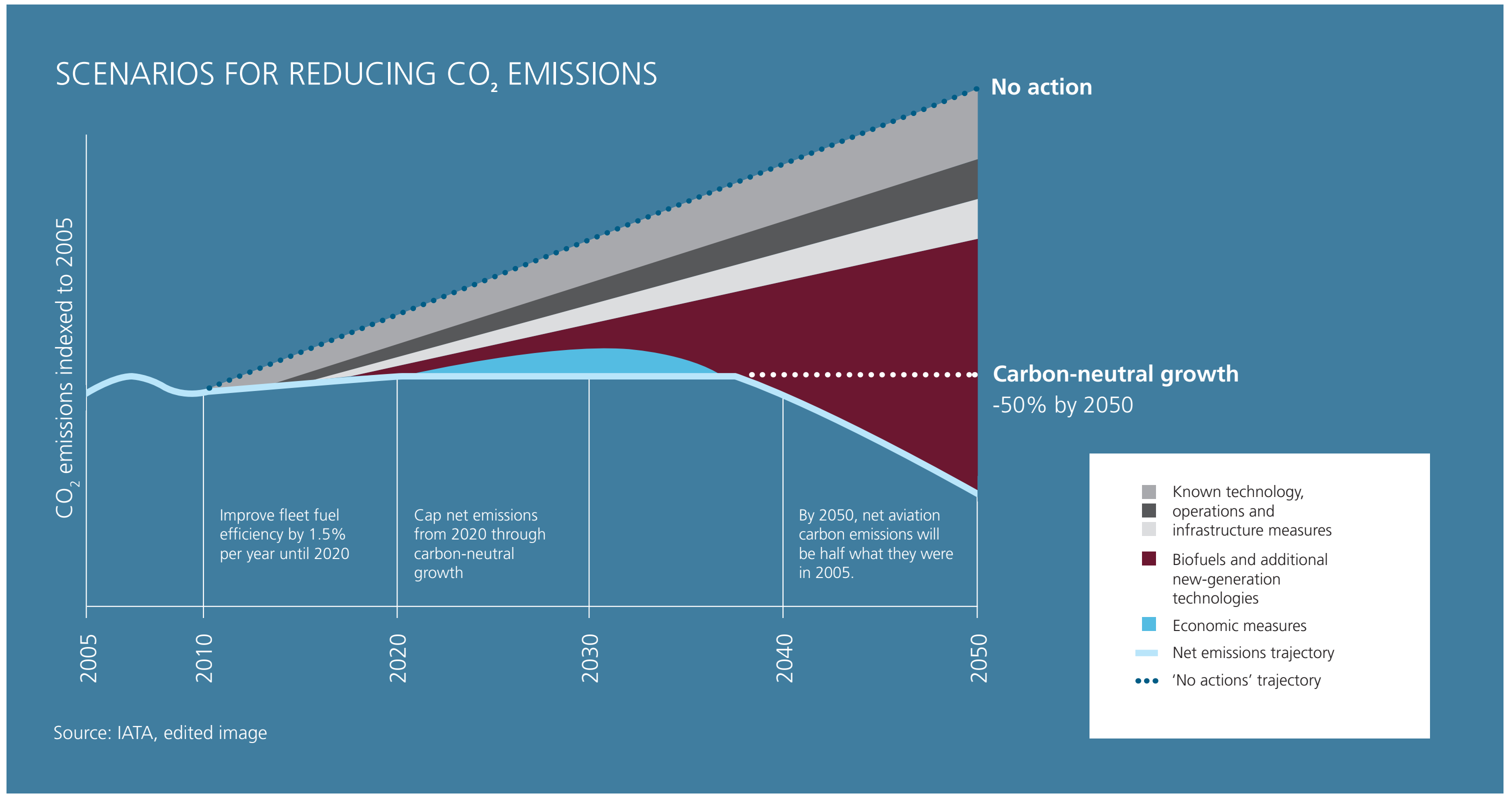
How condensation trails form and develop and how nitrogen oxide emissions affect atmospheric chemistry is being investigated with, among others, DLR's High Altitude and Long Range (HALO) research aircraft.

the climate impact of air transport. To this end, we are systematically examining previously proposed measures and new ideas for their climate benefits and feasibility, as well as determining the steps necessary to introduce those that appear promising.

What needs to be considered when developing such measures?
: Let us say, for example, that we want to avoid the formation of condensation trails because, on average, these lead to warming of the atmosphere. A high level of humidity promotes cloud formation and thus the creation of contrails. However, it would not make sense to route planes only through drier and warmer regions, because this would result in long detours and additional fuel consumption. Care must also be taken with measures to reduce fuel consumption. Increasing combustion temperatures in the engine, for example, increase the efficiency of the engine, so that it uses less fuel. So far so good. At the same time, however, more nitrogen oxides are produced, correspondingly larger quantities of which are therefore emitted into the atmosphere. This would not result in the desired effect. In order to devise the best possible measures, we have to 'play through' scenarios in the atmosphere in their entirety. As such, our knowledge of atmospheric processes needs to be as detailed as possible.

Your research topic transgresses national borders – how important is cooperation?
: The Environmentally Compatible Air Transport System (ECATS) was formed around DLR 10 years ago, with the aim of developing pathways towards sustainable air transport. One of its working groups is investigating the effect of air transport on the climate and what mitigation strategies are available. Thanks to the complementary research activities being undertaken at the Institute and as part of collaborative efforts, we are generating greater synergy effects at DLR. While in the ACACIA project we are expanding our understanding of complex atmospheric processes, we can also use findings from projects such as ClimOP to develop recommendations for action. In the interests of climate protection and sustainable air transport, we will thus continue to pursue the evidence in and questions about the atmosphere through joint efforts.

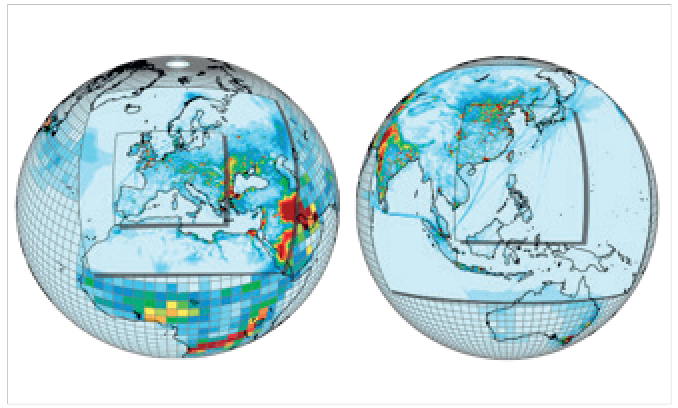
Bernadette Jung is an editor at the DLR site in Oberpfaffenhofen.



IN BRIEF

MODELLING THE EFFECTS OF AIR TRAFFIC

The interactions in the Earth system are extremely complex. Therefore, it is difficult to calculate the impact of air transport on the atmosphere or to establish how aviation can be made more climate friendly. Simulation models can help to describe and understand these processes. With the help of the EMAC climate chemistry model, scientists at the DLR Institute of Atmospheric Physics are studying the effects of aircraft emissions and investigating the way in which the climate reacts to anthropogenic influences. EMAC is also proving helpful in optimising flight routes interactively, under both current and future climate conditions. This is now possible on a regional and global scale. At present, the DLR team is working on researching and modelling the effects of air-traffic induced aerosol emissions on clouds. The EMAC model system, which employs a modular design, has been made available as part of an international research consortium and is supported by leading supercomputing centres in Germany.



The EMAC climate model allows the representation of processes in the atmosphere, their interactions with oceans and land surfaces, and anthropogenic influences.

GREEN PATHWAYS

The Greener Air Traffic Operations (GreAT) project, which is being coordinated by the DLR Institute of Flight Guidance and was launched in January 2020, is aimed at establishing new strategies for environmentally friendly flight routes. An international team of scientists is working on new methods for more sustainable air traffic control. To this end, the team of researchers is testing out new algorithms and concepts that are intended to improve flight guidance in terms of cross-country flight, arrival at and departure from airports, and ground movements. This would allow busy airspace and airports to continue to be used efficiently. The researchers can also use fast-time and real-time simulations to determine the limits of the new concepts when it comes to saving on fuel and cutting emissions. European and Chinese partners are working together on GreAT, among them air traffic control organisations, aviation research institutes, universities and airspace users. The project will run for 3.5 years.

A COMMON EUROPEAN AIRSPACE

Europe's air transport system now carries more than 1.6 billion passengers on over 10 million flights every year, and these numbers are still rising. The aim of the SESAR2020 programme is to develop new systems for standardising European airspace and bring them to market readiness, in order to meet the needs of growing air traffic. DLR is involved in several SESAR projects. Among other things, it has developed an air traffic management solution that can be used to inform pilots of predicted contrails. The researchers are currently developing a concept that allows flight routes to be analysed in terms of their climate impact and optimised accordingly. For this, DLR is working with industry partners to provide a meteorological service that quantifies the effect of air transport emissions on the climate.

As part of SESAR, scientists at the remote tower facility at DLR in Braunschweig are conducting research into remote airport monitoring by controllers.