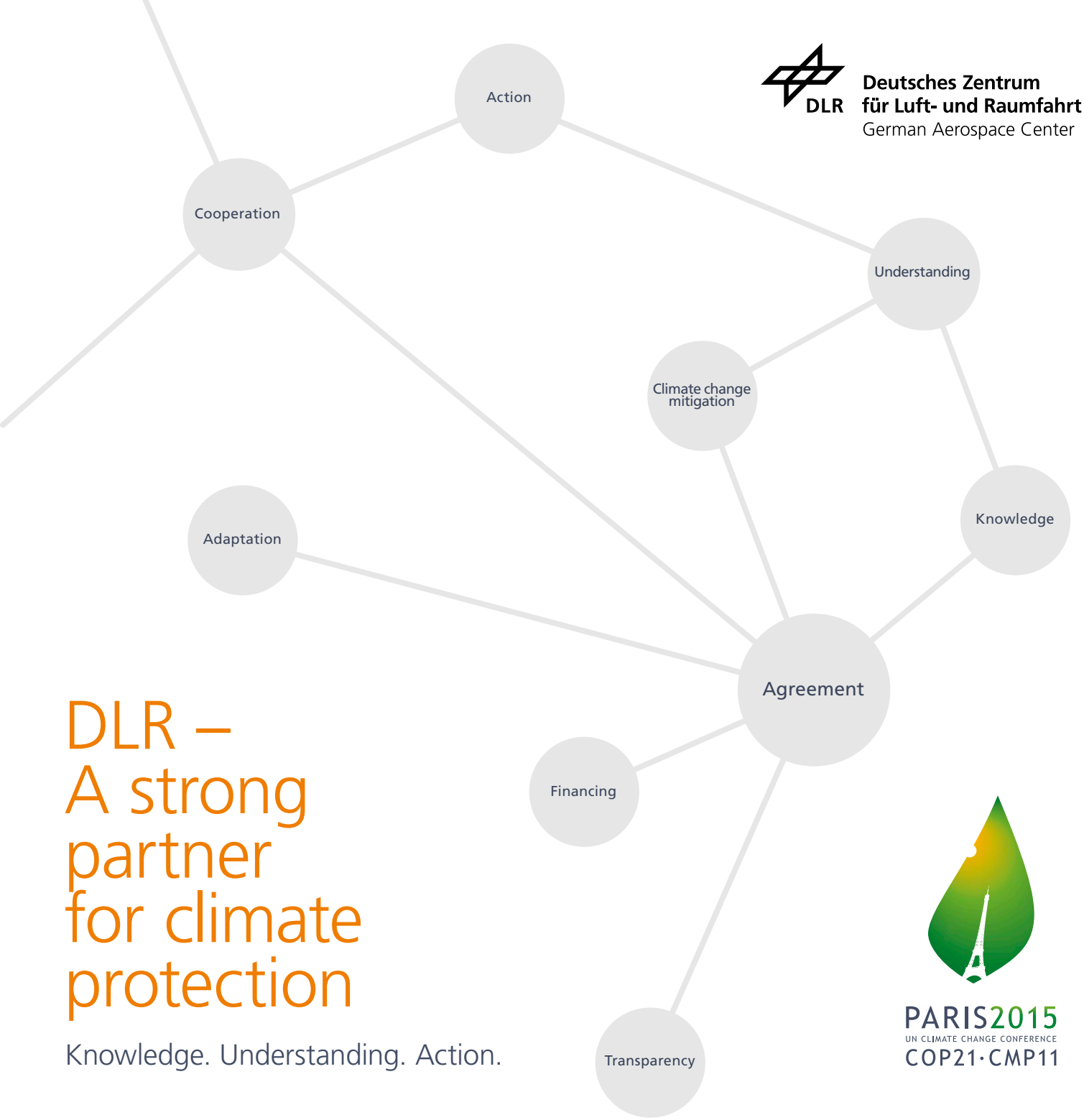
Deutsches Zentrum
für Luft- und Raumfahrt
German Aerospace Center



DLR – A strong partner for climate protection

Knowledge. Understanding. Action.

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

Foreword

How do our children and grandchildren perceive the climate on Earth, our planet? We know that the climate is changing, yet many questions have yet to be answered. The actions we take today will determine what life on our planet will be like in the future. What can we do to fulfil this responsibility?

Every five to seven years, the Intergovernmental Panel on Climate Change (IPCC) prepares reports that comprise the full scientific and technical assessment of climate change. These reports were the basis of decision-making at the recent Climate Change Conference that, after tough negotiations, came to a successful end on 11 December 2015. For the first time, the international community agreed to hold the increase in global average temperature to well below two degrees Celsius above pre-industrial levels – if possible, even to 1.5 degrees. What now? We will need more and better information and as much knowledge as possible: How exactly does the complex climate system work? What changes? What are the possibilities for action? Can we slow climate change? Is it possible for humans and nature to adapt to its effects – if so, how?

DLR's more than 8000 employees are reliable partners in the search for answers to these questions. Now more than ever, fundamental research, new technologies and the detailed analysis of climate data need our attention.

DLR can make important contributions. At its 16 sites, it conducts research from the basics through to application, working in an interdisciplinary and cooperative manner. At DLR, we are developing technologies to reduce emissions, monitor greenhouse gases, conduct climate system research and provide data for policy advice.

This is what is necessary today if we want to leave a liveable world for the next generation. For this purpose, we are mobilising the German Aerospace Center's research capacity, which has been entrusted to us and is unparalleled in Germany.

Pascale Ehrenfreund
Chair of DLR Executive Board

DLR as an expert policy adviser

As a research centre, project management organisation and aerospace agency, DLR possesses a unique range of know-how for policy advice. Its expertise ranges from climate- and research policy with regard to innovative climate protection technologies in aviation, transport and energy, through to the planning and implementation of the German space programme, which is carried out by the DLR Space Administration. This spectrum of expertise makes DLR a central point of contact for the German Federal Government, in particular where climate, research and innovation policy overlap. For many years, DLR has been conducting studies for energy policy and has made a significant contribution to the Energy Transition.

DLR also represents the Federal Government in statutory tasks and carries out important mediation work, for example in the European and international aerospace sectors, or at the interface between the United Nations Framework Convention on Climate Change (UNFCCC), the IPCC, the European and German energy and climate policy sector, and the relevant research landscape. DLR thus contributes to the implementation of the Federal Government's energy and climate policy programmes through its extensive knowledge, technological innovation and impartial advice.

DLR implements the national aeronautics research programme with other federal ministries on behalf of the German Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie; BMWi). DLR supports national regulatory authorities, such as the Federal Aviation Office (Luftfahrtbundesamt; LBA), with matters such as the development of standards and also brings this commitment to bear at the European level in its cooperation with the European Aviation Safety Agency (EASA), and globally by contributing to the work of the International Civil Aviation Organization (ICAO). In Clean Sky 2, the large-scale European aeronautics research programme initiated by the European Commission, DLR heads the Technology Evaluation, and in doing so provides numerous important research contributions.

"The agreement will create global momentum... – amongst scientists, creative minds, developers, especially investors and, of course, politicians all over the world."

German Federal Environment Minister Barbara Hendricks at the press conference after the agreement signing in Berlin on 14.12.2015

The 2015 Paris Agreement

Hurricanes, heavy rainfall, drought and forest fires – the connection between such extreme natural events and climate change has been globally acknowledged. Natural disasters threaten life and limb, leaving many injured and even dead. These disasters also cause significant material damage. The Paris Climate Change Conference recognises the threat posed by rapid, human-induced climate change, and requires all countries to take ambitious measures in order to limit global warming to well below two degrees Celsius above pre-industrial levels. It will pursue efforts to limit the temperature increase to 1.5 degrees Celsius.

It was also agreed to regularly check global progress and compliance with the national climate contributions announced in Paris, as well as to increase the number contributions with time.

To limit global warming, emissions should be reduced enough to "achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century." This means getting to 'net zero' emissions.

Image: NASA

Technologies for reducing emissions

A climate agreement was adopted by the parties to the United Nations Framework Convention on Climate Change (UNFCCC) at the end of 2015 in Paris. The agreement is legally binding, but implementation of the intended nationally determined contributions is up to the individual countries. Germany has set itself the goal of reducing its greenhouse gas emissions by at least 40 percent by 2020 compared to 1990 levels. In its 'Action Programme on Climate Protection 2020', the German Federal Government has defined additional measures to achieve this goal. By 2050, greenhouse gas emissions should be reduced by 80 to 95 percent. To achieve this, a 'Climate Action Plan 2050' should be adopted by the end of 2016 on the basis of a broad-based dialogue process. To meet the German and international climate targets, new technologies – in, for example energy, transport and aviation – are required. This is precisely what DLR is working on. It stands for excellence – under one roof. It can produce fundamental research results, as well as the technologies and product developments demanded by society. New technologies are born at DLR. And DLR contributes its expertise to national and international advisory bodies.

The following examples show the potential of research and development at the German Aerospace Center to implement the decisions made at the Paris Climate Change Conference in December 2015.

Eco-efficient flying on optimised routes

DLR's aeronautics research is helping to minimise the impact of aviation on the climate. Scientists are investigating what economical, lightweight and safe aircraft of the future will look like. These, together with a proficient air traffic management system, could help reduce climatic effects to achieve sustainable mobility.

DLR is, for example, studying the influence of fuel composition on combustion emissions and their effects on contrails, cirrus clouds and the climate as a whole. Alternative fuels are an option for the reduction of carbon dioxide emissions from aviation as well as the adverse climatic effects of particle emissions and contrails. To study this, in-situ measurements are combined with laboratory experiments and modelling. The change in cloudiness due to contrail-cirrus is presently believed to be the most significant climate effect from aviation.

In addition, weather information can be better used to reduce the climate-relevant effects of air transport that are not attributable to aircraft carbon dioxide emissions. Contrails, cirrus clouds and ozone have a strong spatial variability that is governed by meteorology. This connection will be determined and taken advantage of in flight route optimisation to create eco-efficient air travel. The resulting cost-benefit analysis will be compared with alternative concepts from the field of design and flight guidance to find reduction potentials for the climate impact of aviation.

Another research focus with a significant impact on future generations of aircraft and their effects on the climate is digitalisation. DLR develops simulation and modelling methods to study virtual aircraft in a virtual atmosphere and thus comprehensively predict and evaluate at an early stage their economic and environmental impact throughout their entire life cycle.

- Increasing the eco-efficiency of aircraft with aerodynamic performance, new technologies and materials for lighter, fuel-efficient flying and more new efficient aviation concepts
- Research to understand the effects of weather and emissions on contrails, ice clouds and climate, including clarification of the potential of alternative fuels
- Flight route optimisation according to meteorological conditions in terms of eco-efficient flying
- Unification of European airspace for efficient and low-emission air traffic
- Virtualisation of design, development, testing, manufacturing and operational processes in the aviation industry to identify the potential of new technologies for a more environment-friendly and more economical aviation and to accelerate their introduction
- Life cycle management and technology assessment for new aircraft concepts

Environment-friendly energy generation, storage and supply

The primary source of global greenhouse gas emissions in 2010 was the energy sector, at 35 percent of the total. Here also lies the greatest savings potential. According to the 2014 IPCC report, in order to meet the two degree Celsius global warming limit, the carbon dioxide emissions from the energy sector must, by the middle of this century, be reduced by 90 percent with respect to 2010 levels, and then continue to decrease.

DLR's research follows a strategy to provide controllable sustainable power. This is done along two paths. The first involves economically developed renewable energy sources combined with energy storage. The other is one in which controlled energy converters, such as gas turbines and fuel cells, are optimised and powered by climate-neutral fuels such as hydrogen and biofuels.

An example of controllable power supply is research conducted in solar thermal power plants. These focus sunlight on the mirror to generate high temperatures, which are then used to produce electricity via a classic steam power process. Solar power plants are an interesting option for generating electricity, especially if they are located in Earth's Sun Belt. Thanks to new technologies, the high temperature heat recovered can now also be stored economically so that electricity is available regardless of clouds or time of day.

DLR's research on the use of solar energy concerns both the technical components of solar thermal power plants, such as mirrors, radiation receivers and heat transfer media, and the operational optimisation of the power plants under desert conditions. DLR energy researchers are also working on economical heat storage systems.

- Solar thermal power plants
- Wind power plants
- High-temperature heat storage systems for power plants and efficient industrial processes
- Power storage
- Alternative fuels
- Flexible gas turbines
- Decentralised power generation systems
- Fuel cell systems
- New approaches for the intelligent coupling of electricity, heat and fuel supply
- Systems analysis for policy advice

Transport 2020: Intelligent control, climate-friendly driving

Sustainable mobility is the central theme of DLR transport research. For this, the scientists are working on alternative drive systems, the use of regenerative energies, lighter structures, improved aerodynamics, smarter driver assistance and new mobility concepts designed to meet the needs of users. On this basis, DLR is also addressing the transition from fossil to post-fossil mobility. It is thus carrying out research on innovative free-piston linear generators – an internal combustion engine without a crankshaft that produces electricity to extend the range of electrically powered vehicles, and the use of which saves fuel.

Exploring technical possibilities in pursuit of future electromobility goes hand in hand with the analysis of user needs. An important component is the appropriate charging infrastructure that meets the demand for e-mobility and conforms to the technical features of the electric vehicles. When determining the need for new infrastructure, researchers take the technical parameters into account, such as the range of electric vehicles, as well as user behaviour.

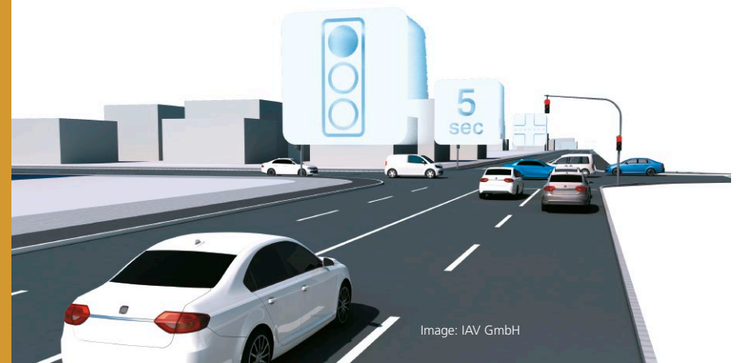


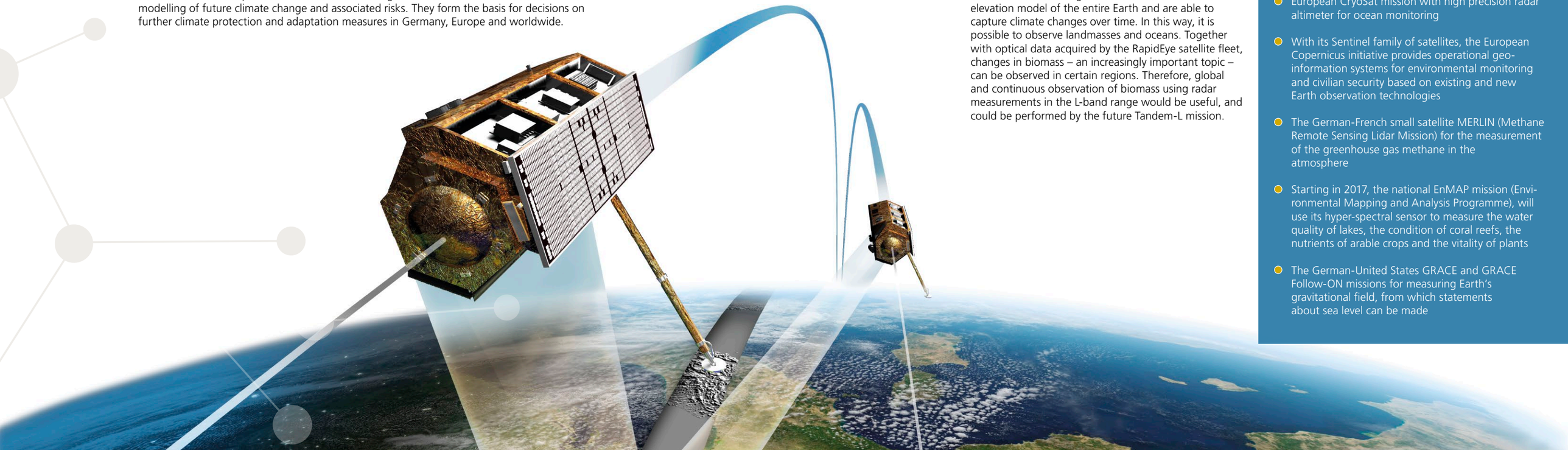
Image: IAV GmbH

- Alternative drives
- Vehicle concepts and lightweight construction, for example based on composite fibre materials
- Driver assistance and automation systems
- On-board power generation from waste heat
- Smart traffic management and intelligent traffic light control
- Analysis of user requirements and behaviours, including electro-mobility
- Modal and multi-modal mobility and traffic concepts
- Interaction of transport and energy systems
- Systems analysis for policy advice

Another way to reduce transport emissions is intelligent traffic management, especially in the city. Hence, together with regional and national partners, DLR has set up the Application Platform for Intelligent Mobility (AIM), with which the intelligent mobility services of the future are tested in the real environment of the city of Braunschweig and surrounding regions. On specially selected routes, DLR monitored and analysed traffic using high-performance instruments. On this foundation, traffic researchers simulate traffic flows and test measures to influence them. Consequently, DLR has, amongst other things, developed new intelligent control methods for traffic lights that reduce the waiting time at intersections by up to 40 percent compared to the current situation, thus directly reducing fuel consumption and emissions.

Understanding the climate better

DLR has long supported numerous national and international projects as well as remote sensing missions that help to collect data about climate change, better understand its causes and assess the effect of anthropogenic greenhouse gases on the climate. To this end, comprehensive climate data have been collected over a long period. To achieve this, DLR uses its successful fleet of research aircraft, as well as national and international satellites. Long-term observations are also required to verify independently whether the emission targets are being achieved and climate protection measures are having an effect. The data are included in the modelling of future climate change and associated risks. They form the basis for decisions on further climate protection and adaptation measures in Germany, Europe and worldwide.



Satellites and sensors for Earth observation and remote sensing

How is Earth changing? What processes are at play? Satellite-borne sensors make it possible to collect comprehensive information about the processes involved. DLR develops and provides technologies for Earth observation systems. The German radar satellite duo TerraSAR-X and TanDEM-X is an exceptional source of data. The satellites generate a three-dimensional elevation model of the entire Earth and are able to capture climate changes over time. In this way, it is possible to observe landmasses and oceans. Together with optical data acquired by the RapidEye satellite fleet, changes in biomass – an increasingly important topic – can be observed in certain regions. Therefore, global and continuous observation of biomass using radar measurements in the L-band range would be useful, and could be performed by the future Tandem-L mission.

National, European and international satellite systems

- DLR TerraSAR-X and TanDEM-X radar satellite duo
- European CryoSat mission with high precision radar altimeter for ocean monitoring
- With its Sentinel family of satellites, the European Copernicus initiative provides operational geo-information systems for environmental monitoring and civilian security based on existing and new Earth observation technologies
- The German-French small satellite MERLIN (Methane Remote Sensing Lidar Mission) for the measurement of the greenhouse gas methane in the atmosphere
- Starting in 2017, the national EnMAP mission (Environmental Mapping and Analysis Programme), will use its hyper-spectral sensor to measure the water quality of lakes, the condition of coral reefs, the nutrients of arable crops and the vitality of plants
- The German-United States GRACE and GRACE Follow-ON missions for measuring Earth's gravitational field, from which statements about sea level can be made

Data for climate research

At the European level, the ESA Earth Observation framework programme, in particular the Earth Explorer science satellites, the European Copernicus programme, as well as the operational EUMETSAT programme, contribute to the understanding of the Earth system and climate monitoring. The constellations of Sentinel satellites and instruments of the Copernicus programme will systematically document changes on Earth – natural and man-made – for several decades. DLR is involved in all of these programmes.

Climate protection and climate forecasts are only successful when data acquired over long periods of time are recorded, archived and evaluated. Only time series draw a reliable picture of how the Earth system is changing climatically. They provide insights for reliable climate modelling based on accurate data. This does not only require pure measurement data, but also their synthesis over long periods of time. DLR's German Remote Sensing Data Center and ESA's Long-term Data Preservation programme (LTDP) and 'Climate Change Initiative' (CCI), in which important climate variables are calculated systematically, are making significant contributions to this.

DLR's research aircraft fleet also provides climate scientists with powerful platforms. With their flagship HALO (High Altitude and Long Range) research aircraft, DLR scientists are continuously succeeding, together with other research institutions, in identifying the complex processes of climate change and their effects, for example in the polar atmosphere. Hence, what happens between the layers of the atmosphere is gradually becoming understood.

Image: Gero Francke/FH Aachen

Research, analyse and act

Natural disasters cannot be completely prevented; they are part of our lives. But they are occurring more and more due to climate change. The Paris Agreement therefore has the global objective to make our civilisation less vulnerable to the effects of climate change. Science can help here. In order to reduce the risks associated with natural disasters, these phenomena must be better understood. Analyses based on DLR satellite data provide important information for developing strategies and measures for the adaptation of civilisation to global changes as well as to check their effectiveness. Agricultural adaptation measures such as dams and irrigation systems are part of this, as are the protection of sensitive coastal zones and the reforestation of protected forests in mountain regions. DLR Earth observation technologies provide spatially resolved information for evaluating risks and assessing the vulnerability of the region concerned. In the event of a crisis, emergency services are provided quickly and reliably with this information (for example, the number of people affected, the damage to critical infrastructure and buildings, as well as people's ability to respond to natural hazards and restore their livelihoods).

Independent and globally consistent measurements of emissions promote the mutual trust of the parties and thus strengthen the implementation of the agreement. From the air or with the help of satellites, it is possible, for example, to globally measure the emissions of the two most important greenhouse gases, carbon dioxide and methane. Local greenhouse gas sources, including carbon dioxide emissions in congested urban areas and methane sources from intensive livestock farming, can be uniformly identified in all regions of the world. DLR's airborne lidar CHARM-F on board the German HALO (High Altitude and Long Range) research aircraft is ideal for collecting the corresponding data. These complement the results from ground stations, which are currently still limited. The French-German MERLIN satellite mission – supported by CHARM-F – will lead to a breakthrough in the understanding of regional and global methane emissions. It is scheduled for launch in 2020 and will be developed and built in Germany under the leadership of DLR. The lidar sensor will collect data on methane emissions from an altitude of 500 kilometres. It will also be possible to monitor methane emissions from gas hydrates, which are released by permafrost and ocean sediments due to the effect of the climate.

Humanity has an obligation

The Paris Agreement includes obligations for all countries. Help should be given to poorer and more vulnerable countries in particular. This includes not only financial support from industrialised countries, but especially agreements that promote capacity building activities and technology transfer, as well as the protection of carbon-rich ecosystems, especially forests.

DLR satellite data and the derived location-based information may contribute to improved assessments of humanitarian emergencies or planning of relief operations, thereby alleviating the consequences of crisis situations. Extreme weather and climate events through to disasters have severe consequences and may trigger migration. Better protection against natural disasters, as well as early warning and risk assessment of crises play an increasingly important role. The DLR Center for Satellite Based Crisis Information (ZKI) provides valuable information for rapid response in the event of a crisis.

Location images in support of relief operations, the analysis and mapping of refugee camps, as well as the assessment of the impact of refugees on the surrounding environment are more and more important. DLR can provide medium and long-term analyses of the possible triggers and causes of conflicts and crisis situations, such as climate change, resource depletion and population growth. These are important for assessing the extent and intensity of crises. Emerging and developing countries with low resources can, in the event of a disaster, request information to support emergency services through the International Charter ‘Space and Major Disasters’.

The Charter is a worldwide collaboration among space agencies – which includes DLR, represented by the DLR Space Administration. In the event of climate-related natural disasters, the Charter provides civil protection authorities and relief services with satellite-based data and products that are derived quickly and without bureaucratic formalities.

DLR participates in United Nations programmes, for example, in the UN-SPIDER programme, to improve access to space data, to prevent disasters and manage them better during emergencies. Despite the numerous programmes and organisations involved in different phases of disaster preparedness and disaster management, there has yet to be a universally recognised interface between space agencies and users that enables fast orientation and provides access to space-based information for affected countries and national and international relief organisations. DLR can assist with the development and expansion of the necessary capacities – particularly in developing and newly industrialised countries – through education and expert training. In this way, the needs of relief organisations can be further defined and their cooperation with space agencies improved in the event of a disaster.

Research provides answers

Whether in the field of Earth observation or new technologies for energy, aviation, transport and space, DLR has the skills to provide answers to both the current and long-term problems. The scientists, engineers and other employees in DLR's 35 institutes and facilities are aware of their social responsibility. They work in an interdisciplinary manner and cooperate with partners in Germany, Europe and the world. They have access to modern infrastructure, with cutting-edge large-scale facilities, satellites and a unique research aircraft fleet. DLR and its employees can, want and will help to meet the objectives of the Paris Agreement.

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