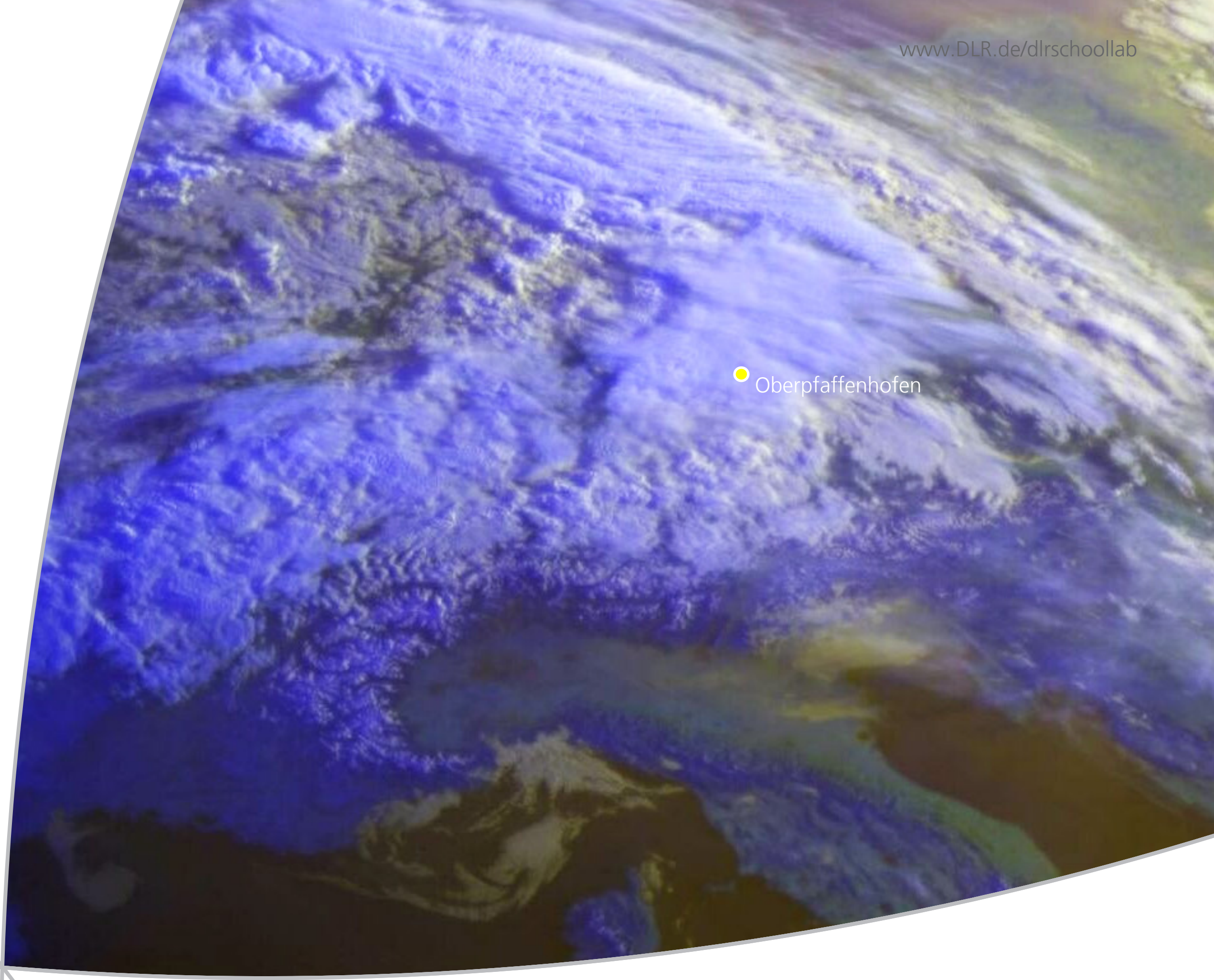
www.DLR.de/dlrschoollab

DLR



DLR_School_Lab
Oberpfaffenhofen

Weather and Climate

What ingredients are needed for a modern weather forecast?

In the daily news, weather forecasts can be obtained for up to six days in advance. How are these actually made? This becomes evident in the weather and climate experiment.

A diagnosis is the first step: we have to determine how the atmosphere is behaving and what the situation was a few hours ago, at midnight, yesterday, and the day before yesterday. Satellites help supply the answers, just as do climate stations worldwide and measurements with weather balloons.

To obtain a forecast one has to calculate forward into the future, faster than time passes. Complex equations are entered by way of approximation into a mathematical grid containing many layers. In gigantic computer centers trends in temperature, wind, humidity and rain are calculated for all the nodes in the grid at ten minute intervals up to a week in advance - for the entire globe in just a few hours!

Weather and Climate

Fig. 1: POLDIRAD on the IPA roof, with rain clouds approaching in the background

Is your curiosity aroused? On the day of your visit to DLR_School_Lab we will have a look at the actual weather situation and at forecasts around the globe using data and software from weather services.

Atmospheric Measurements

We briefly mention here a few important measurement methods:

Detecting areas with rainfall using radar
Since 1986 a polarimetric Doppler-radar (POLDIRAD) has been rotating on the roof of the Institute of Atmospheric Physics (IPA). This weather radar, which is unique in central Europe, can ascertain the extent and intensity of rain fields within a radius of 300 km. By making use of the Doppler effect it can also find out the direction in which the precipitation is moving as an indicator of the wind situation. By separately recording radar pulses emitted and received using two polarizations, it is also possible to distinguish the size of raindrops, sleet, snow and hail in thunderstorms.

Filming clouds with Meteosat
Cameramen need a fixed position relative to occurrences of interest. Only geostationary satellites have such an overview of the rotating earth. The Meteosat satellite, for example, transmits every 15 minutes an image of the hemisphere in its field of vision from a distance of ca. 36,000 km above the earth's surface. Europe is in sight of the Meteosat satellites which are controlled from a center in Darmstadt. We will have a look at current Meteosat images of the hemisphere and time-lapse film sequences showing the European situation over the course of several days. We wonder: can Meteosat see anything during nighttime?

Climate data from Envisat
Since 2002 this versatile European environmental satellite has been regularly providing data about the chemical composition of the atmosphere and sea surface temperatures, and it records, for example, ocean wave heights and directions, as well as the growth phases of plants. Although it flies only about 800 km above the surface of the earth and repeats its tracks only after a couple of days, it is much closer to the weather activity than we are on the ground.

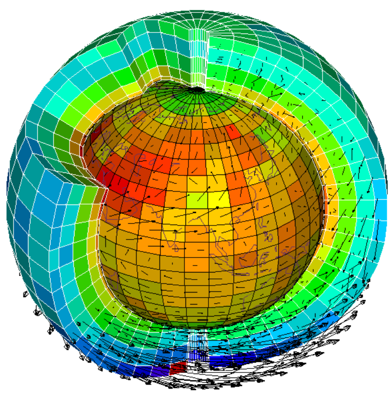


Fig. 2: Schematic grid used for global calculations; temperature (red: warm, blue: cold) and wind (arrows)

Monitoring Weather and Climate

We work with computers like professionals at the German Weather Service. After a brief introduction, each student or pair of students uploads various types of data for viewing on a monitor. These could be the weather situation a few hours ago for all of Europe, current satellite images, composite views from the radar network of precipitation monitoring stations, a constant-pressure map with data collected the previous night by weather balloons, or the temperature distribution of the entire northern hemisphere at 6 am.

DLR_School_Lab Oberpfaffenhofen

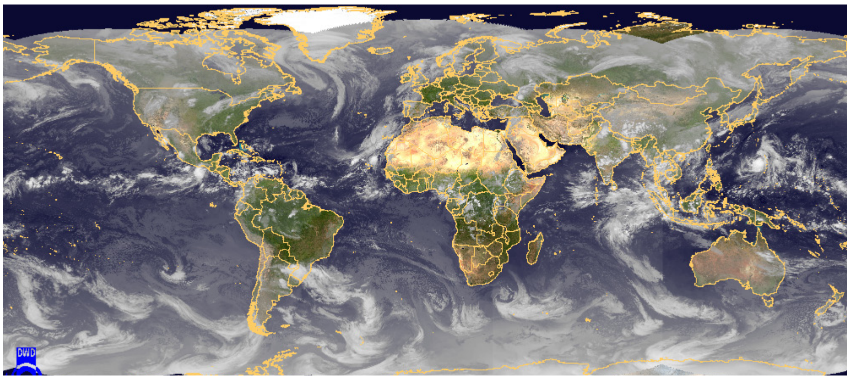


Fig. 3: The water vapor field around the globe as seen from several geostationary satellites

Based on what the visiting class already knows, we discuss the meteorological parameters pressure, wind, temperature, humidity, and precipitation, as well as concepts like the geostrophic wind, which theoretically balances the pressure gradient force with the Coriolis force. But does it really do that?

What will the weather be like tomorrow?

The atmosphere is a physical system. Its future state can be calculated for several days in advance if the initial state is known. The nonlinear terms in the equations are the reason why predictions based on calculations and what really happens later on progressively diverge. Because of this chaotic portion, the calculations have to be repeated daily, so that they can always incorporate the latest measurements. We will call up meteograms for the upcoming week from stations around the globe, either those resulting solely from a theoretical model, or ones that are combined with statistical values typical for central Europe.

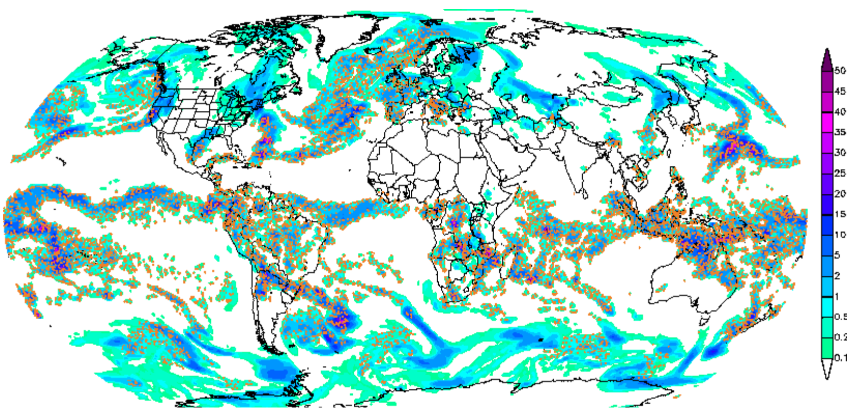


Fig. 4: Two-day forecast (actually a calculation) of a six-hour quantity of precipitation (in mm) for the entire globe; the magenta dots indicate regions with heavy thunderstorms

Glossary

Chaotic systems

Chaotic systems are complex processes in which small uncertainties in the starting conditions within a short time often make it impossible to calculate later conditions.

Meteorology

Meteorology is the study of the dynamics, physics, and increasingly also the chemistry, of the atmosphere. The weather is the momentary atmospheric situation. The climate is the collection of average values, extreme values, and in general the statistics for one location, region, or the entire globe.

Radar

Radar (radio wave detection and ranging) is a procedure for determining the position of some object by sending out electromagnetic microwaves as a pulse. When these waves encounter the object they are reflected back, and then collected. The location of the object (e.g., an airplane, or an area with rainfall) can be deduced from the time lapse between sending the pulse and the return of the echo. Making use of the Doppler effect it is also possible to determine the object's velocity relative to the radar equipment.

Satellite

Literally, a fellow traveler. Here it means a space probe circling the earth. The time for one revolution is highly dependent on the altitude (e.g., 100 min at 800 km, or 24 h at 36,000 km).

Concept and text: Dr. Hans Volkert, DLR-IPA

List of Figures

DLR at a Glance

DLR is Germany's national aeronautics and space research center. Its extensive research and development activities in the fields of aeronautics, space, transportation and energy are integrated in national and international cooperative ventures. In addition to this research, as Germany's space agency the federal government has given DLR the responsibility to plan and implement the German space program and to represent German interests internationally. DLR is also the umbrella organization for Germany's largest project management agencies.

Approximately 6,500 people are employed at DLR's 13 locations, which include Köln (headquarters), Berlin, Bonn, Braunschweig, Bremen, Göttingen, Hamburg, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stuttgart, Trauen and Weilheim. DLR also operates offices in Brussels, Paris and Washington D.C.

DLR Oberpfaffenhofen

Aerospace, environment and transportation are DLR's primary fields of interest in Oberpfaffenhofen. Some 1,500 people work there in nine different institutes and facilities, making DLR Oberpfaffenhofen the largest DLR location.

DLR
Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

DLR_School_Lab Oberpfaffenhofen
Münchner Straße 20
82234 Weßling

Contacts:
Head: Dr. Dieter Hausamann
Telephone +49 8153 28-2770
Telefax +49 8153 28-1070
E-Mail schoollab@dlr.de

School_Lab team assistant: Stefani Krznaric
Telephone +49 8153 28-1071
Telefax +49 8153 28-1070
E-Mail stefani.krznaric@dlr.de

www.DLR.de/dlrschoollab