Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Aviation weather forecasting for the “flying telescope”

The Meteorological Watch Office of the German Weather Service (Deutscher Wetterdienst) at Frankfurt Airport is currently supporting SOFIA, a joint project of NASA and the German Aerospace Center (DLR), by providing weather forecasts and briefings.

SOFIA (Stratospheric Observatory for Infrared Astronomy) is a jumbo jet equipped with a 17-ton telescope. In February and March, the Boeing 747SP (Special Performance) will take off from Cologne/Bonn airport for approximately 20 missions. During these flights, which last more than 8 hours, a door - located behind the wing and big enough to fit a car - is opened in the fuselage at altitudes of 36,000-43,000 feet – something not usually recommended in any normal aircraft. The Boeing thus becomes a flying telescope (see Figure 1). With outside temperatures of -40 to -65°C in the stratosphere and very low air pressure, the infrared telescope studies exoplanets, the birth of stars, the Milky Way as well as planets, moons, asteroids and comets in our solar system. As a result, this research project was able to prove the existence of water molecules on the moon, amongst other things, to develop a more precise method for determining the age of stellar nurseries and to survey the inside of the Milky Way galaxy.

Such measurements would hardly be possible with a ground-based infrared telescope, as the water vapour in the lowest layer of the atmosphere (troposphere) partly absorbs the infrared radiation emitted from space. Beyond the atmosphere, the “thermal background noise” would of course be even lower, but the flexible use of instruments of this size would be very difficult. This is what makes SOFIA such a unique and successful research project.

Instead of starting from its home base in Palmdale (California, USA), the mission currently takes off from Cologne/Bonn airport. In order to conduct safe and successful missions, detailed and precise resource planning is important. For this, the crew is supported by the Meteorological Watch Office at Frankfurt Airport. The special construction of the aircraft, the exceptionally high cruising altitudes and the extended duration of the missions require specific meteorological conditions.

In wintery conditions, the large telescope door does not allow for de-icing, making take-offs in snow or freezing rain impossible. In addition, wind conditions with a strong cross- or tailwind, thunderstorms as well as dense fog often prevent flight operations. The required, good conditions must not only prevail at Cologne/Bonn, but also at selected alternates and waypoints that may be approached in emergencies. Hence, individual forecasts are prepared for a number of European airports.

Severe icing occurs mostly in dense clouds between temperatures of approximately -5 to -20°C and is a hazard particularly during climb-out and descent. Turbulence in frontal areas, around so-called low-level jets or marked jet streams at great altitudes, for example, can occur during all phases of a flight and require a detailed analysis and forecast of the wind situation for the entire route. On flight routes heading south and for the Atlantic, very high-reaching cumulonimbus clouds with thunderstorms may develop even in winter. Around these severe weather zones, which may in part be embedded in the surrounding clouds, lightning, hail, icing and extreme turbulence must be expected. It is therefore imperative for the crew to avoid these zones or, as far as possible, fly over them at great altitudes. While the telescope is in operation, the airspace above the Boeing should be free of cirrus clouds (ice clouds in the upper levels of the troposphere) as far as possible. They rarely occur

above the tropopause in the stratosphere. For flight planning, it is thus very important to forecast at what altitude the tropopause (upper edge of the troposphere) is located and whether it may be reached with the maximum cruising altitude.

In order to predict all of these meteorological parameters, as aviation forecasters, we use various model forecasts, which we compare and analyse in order to produce up-to-date briefing documents for the crew. Prior to take-off, the crew is then briefed online, and the current weather situation and specific conditions are explained in more detail (see Figure 2). In the area of aviation weather forecasting, we have also previously supported other unusual and important projects. Providing meteorological expertise for these missions, however, is a particularly demanding, but also exciting and unique challenge.

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Figure 1: The Boeing 747SP as Stratospheric Observatory for Infrared Astronomy (SOFIA). Credit: NASA/DLR

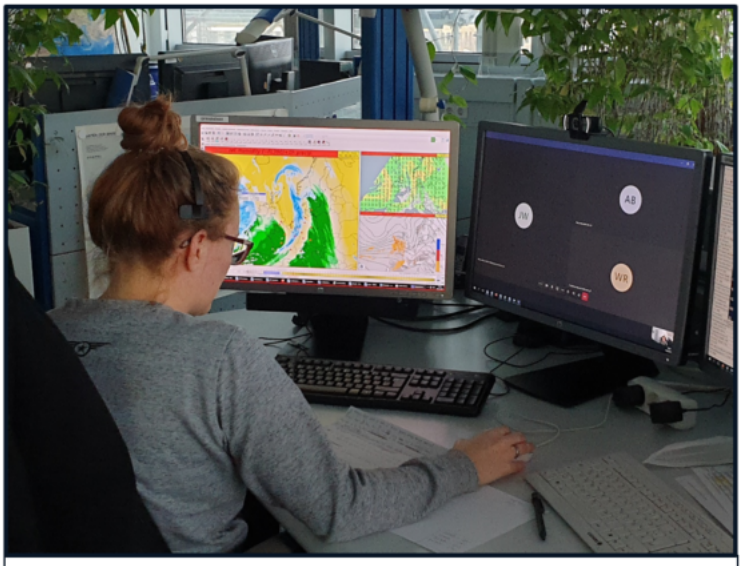

Figure 2: Aviation weather forecast by the DWD meteorologist Anika Seier during the online briefing of the SOFIA Crew. Credit: DWD, Berthold Lescher