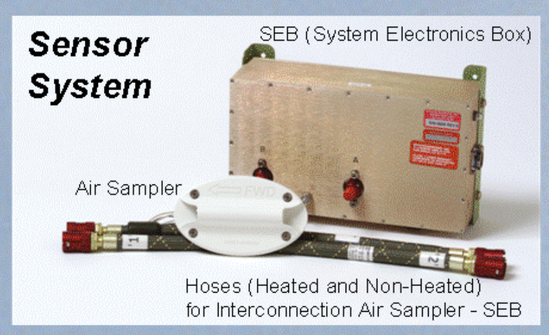
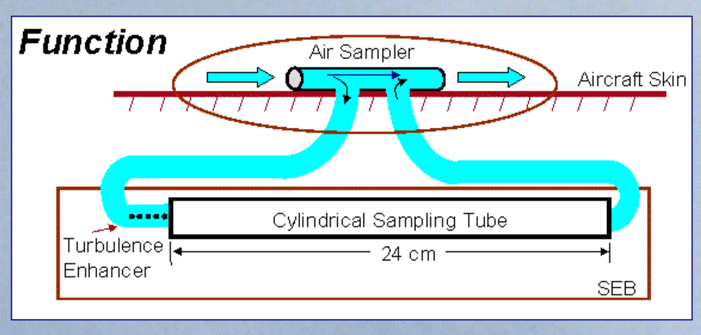
Deutscher Wetterdienst

Aircraft Humidity Sensor Enters the E-AMDAR Fleet

Up to now the worldwide network of AMDAR (Aircraft Meteorological Data Relay) yields vertical profiles and upper troposphere series of temperature, pressure, and wind measured by commercial in-service aircraft. Meanwhile the humidity measurement starts to be added to E-AMDAR (EUMETNET AMDAR), the European cooperation of weather services for AMDAR.

As a first step under the authority of the DWD (Deutscher Wetterdienst), three aircraft (Airbus A320 family) of the Lufthansa fleet are equipped with humidity sensors.



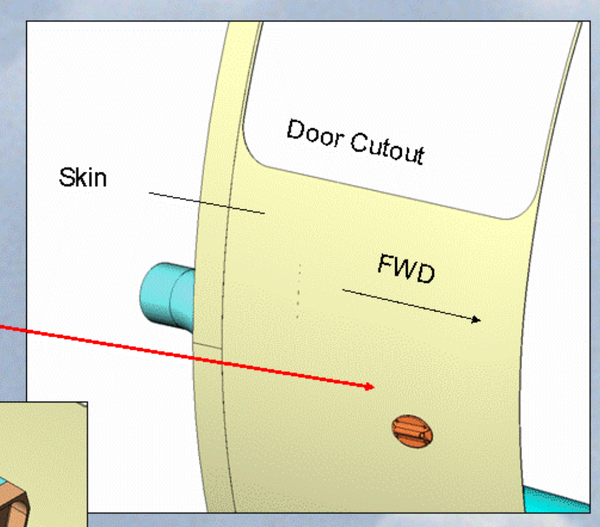


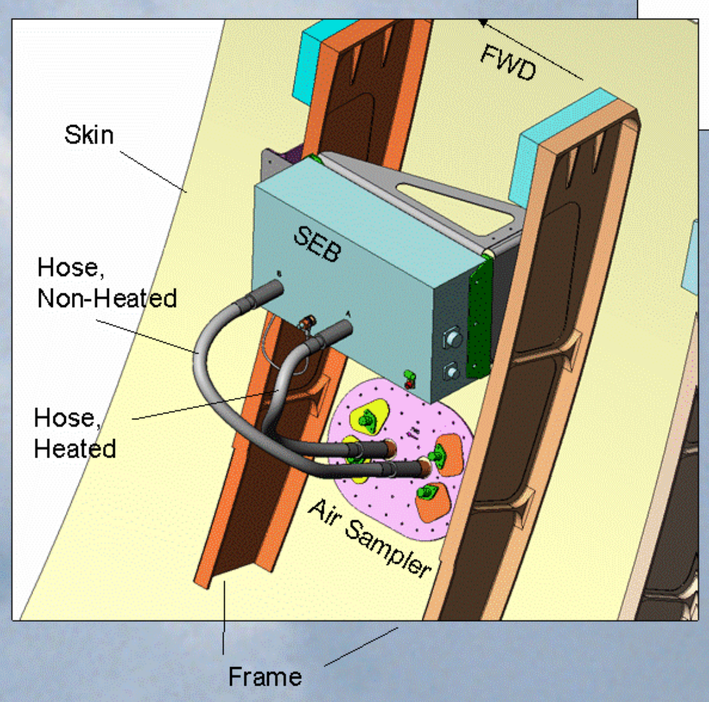
The sensor system is a near-infrared absorption spectrometer based on a Tunable Diode Laser (SpectraSensors, WVSS-II). The system draws air obtained from the outside-mounted air sampler into the System Electronics Box (SEB), which houses the electronics and the spectrometer. The absorption result as a measure for the water vapor content together with temperature and pressure, locally observed within the sampling tube, are used for the computation of the output parameter: water vapor mass mixing ratio.

The inlet hose is heated in sense of preventing any condensation or ice aggregation in the upstream section.

Integration on the Aircraft

Air Sampler





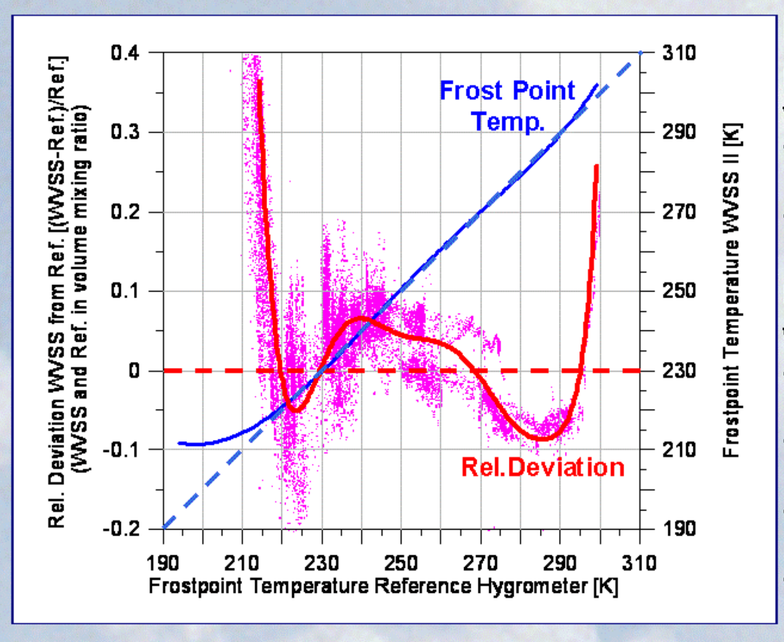
The sensor system is installed at the nose section on the right hand side of the aircraft below passenger door #1.

The air sampler is located 4.8 m aft from aircraft nose on the external fuselage skin in approx. 4 o'clock position. For the air inlet, an adjustment angle of 2° versus waterline is applied in regard of the airflow. Due to fuselage skin penetration, a reinforcement doubler is installed to restore the skin loads capability.

The ARINC 429 output of the SEB is fed into the avionics units being involved in the data flow of AMDAR.

Laboratory Tests

- In the Climate Chambers of FZJ (Research Centre Jülich) and DWD (Deutscher Wetterdienst)
- Atmospheric Conditions:
  - Pressure between Ground Level and 200 hPa
  - Frostpoint / Dewpoint between -60 °C and +25 °C



FZJ (Research Centre Jülich)

Frost Point of WVSS-II vs. References as

- Lyman-α Flourescence Hygrometer (1 - 1000 ppmv)
- Dewpoint Hygrometer (1000 - 40000 ppmv)

Relative Accuracy < | ±5% |

WVSS-II at Frostpoints

- above ~300 K: No Reliable Signal,
- 225 K - 290 K: Accuracy, ±(5 to 10 %),
- 215 K - 225 K: Limited Accuracy, ±(10 to 15 %),
- below ~215 K: below Detection Limit.

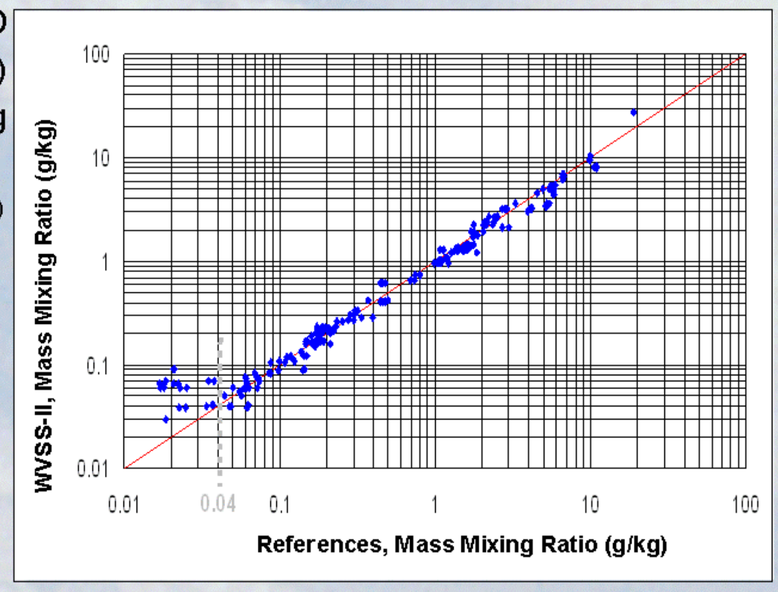
DWD (Deutscher Wetterdienst) Met. Observatory Lindenberg

Mass Mixing Ratio of WVSS-II (4 Units) vs. References as

- Dewpoint Mirror TOROS
- Dewpoint Mirror MBW 373
- Capacitive Sensor, FN Method

WVSS-II at Mass Mixing Ratios

- 0.04 - 10 g/kg: Reasonable, ±10 % Rel. Dev.
- below 0.04 g/kg: below Detection Limit



WVSS-II will give valuable results for mixing ratios above 0.04 g/kg. For typical mid-latitude humidity profiles the useful vertical measuring range is about

- up to 200 hPa in summer,
- up to 400 hPa in winter.

Ideas for Further Sensor Development

(1) The air inlet should be outside of the fuselage's boundary layer flow.
Herewith, the necessity of deicing power has to be accepted but:

- Memory effects and contaminations from the upstream line are avoided.

(2) The sample air flow should be kept near the total pressure instead of the local ambient pressure.
This would result in two advantageous effects:

- Temperature rise,
  ⇒ no precautions for condensation and ice aggregation (no hose heating required),
  ⇒ easier stabilization of a homogeneously heated air in the sampling tube.
  This effect can be kept on the ideal side, if heat conduction away from the inner walls of the sample air flow is kept small.
- Pressure rise,
  ⇒ increased water vapor density at the same mixing ratio leads to better accuracy of the absorption measurement.

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