



WORLD
METEOROLOGICAL
ORGANIZATION

ICAO Symposium on Non-CO₂ Aviation Emissions

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WMO and its Members: key stakeholders in worldwide environmental monitoring to support the aviation industry

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We need continuously measurements for operational use!

Measurements is the first gear of the knowledge chain for worldwide stakeholders



We need better NWP on WVM at upper levels, especially for contrail avoidance!

What are WMO members doing on measuring non-CO2 emissions?



1 – Coordinating research projects through Global Atmospheric Watch (GAW)

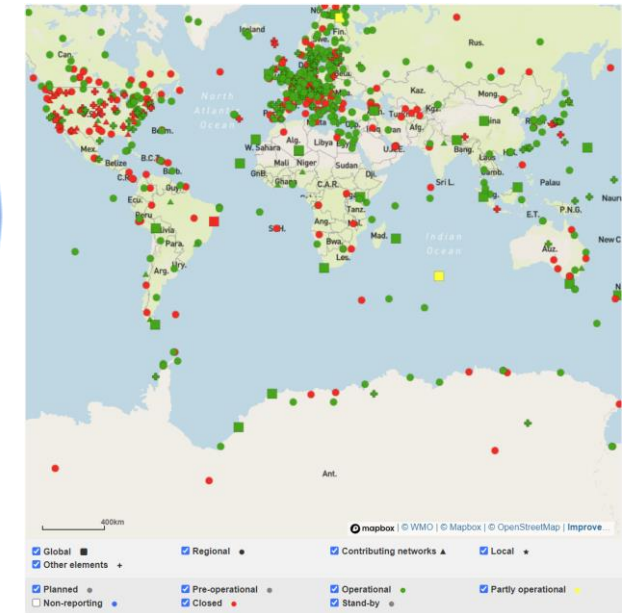
This network consists of GAW Global and Regional measurement stations with additional measurements from Contributing stations. Both Global and Regional stations are operated by their host countries, either by their National Meteorological Services or by other national scientific organizations

GAW Focal areas

- **Greenhouse Gases:** carbon dioxide CO₂, methane CH₄, nitrous oxide N₂O, halogenated compounds and SF₆.
- Ozone
- Aerosol
- Selected Reactive Gases: surface and tropospheric ozone - carbon monoxide (CO) - Volatile Organic Compounds (VOCs), - nitrogen oxides (NO_x, NO and NO₂) - sulphur dioxide (SO₂) - molecular hydrogen (H₂)
- Total Atmospheric Deposition
- Ultraviolet (UV) Radiation

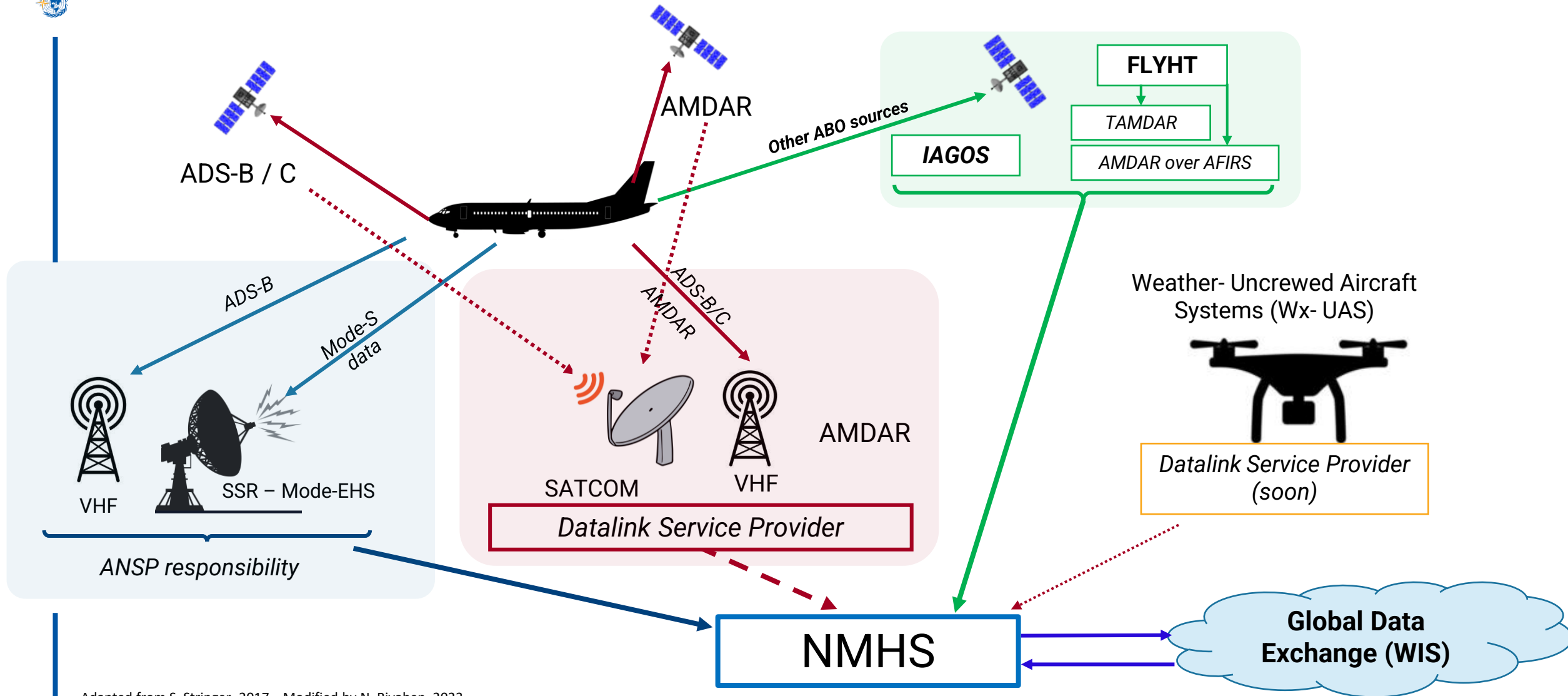


G3W: Global Greenhouse Gas Watch



What are WMO members doing on measuring non-CO2 emissions?

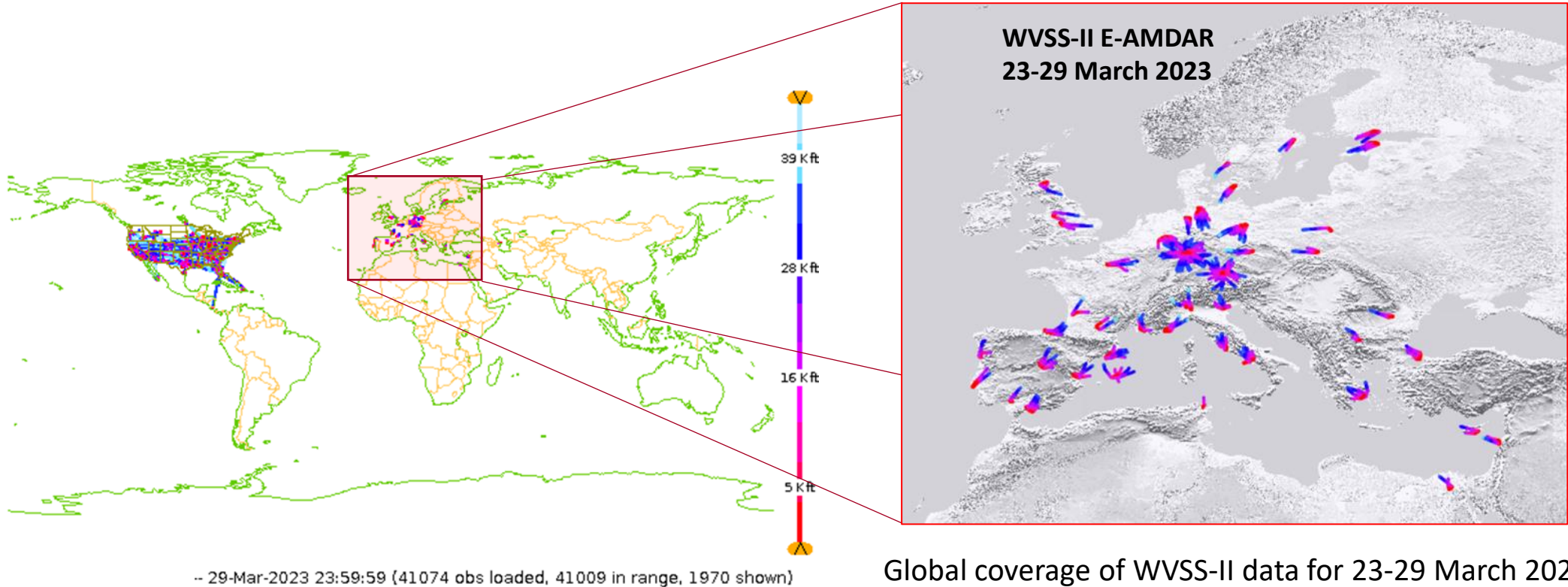
2 – Coordinating Aircraft-based Observations with National Meteorological and Hydrological Services (NMHS)



What are WMO members doing on measuring non-CO2 emissions?



2 – Coordinating Aircraft-based Observations with National Meteorological and Hydrological Services (NMHS)



Global coverage of WVSS-II data for 23-29 March 2023

140 WVSS-II equipped aircraft are operational, of which **131** fly mostly over the **contiguous United States**. **Nine** are operated mainly over **Europe**. UK Met Office will install 13 WVSS-II sensors.

Main issue: lack of sensor accuracy for contrail avoidance purposes.



What are WMO members doing for contrail avoidance?



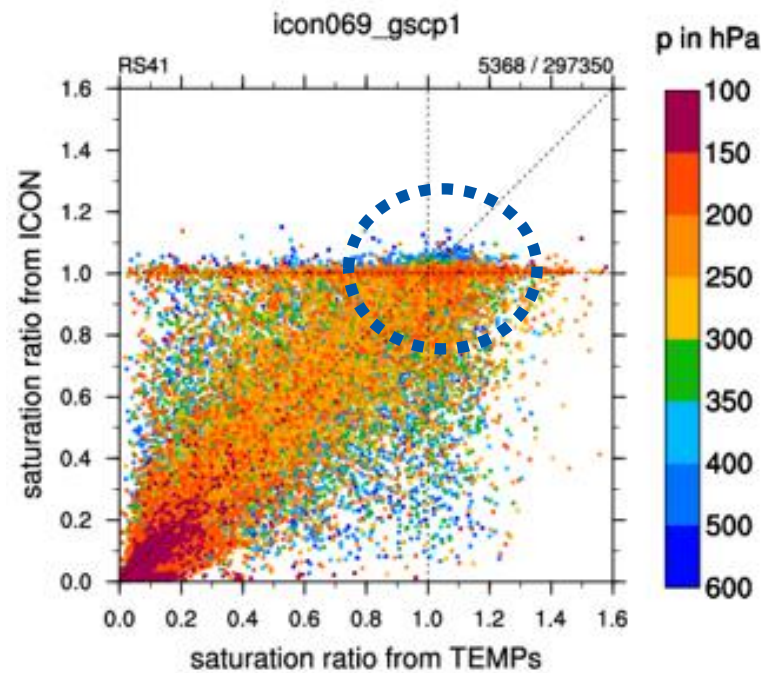
1 – Humidity forecast – Improvement of Numerical Weather Prediction Model (NWP)

Representation of humidity supersaturation: **Ice Super Saturated Regions (ISSR)** are critical for contrails avoidance

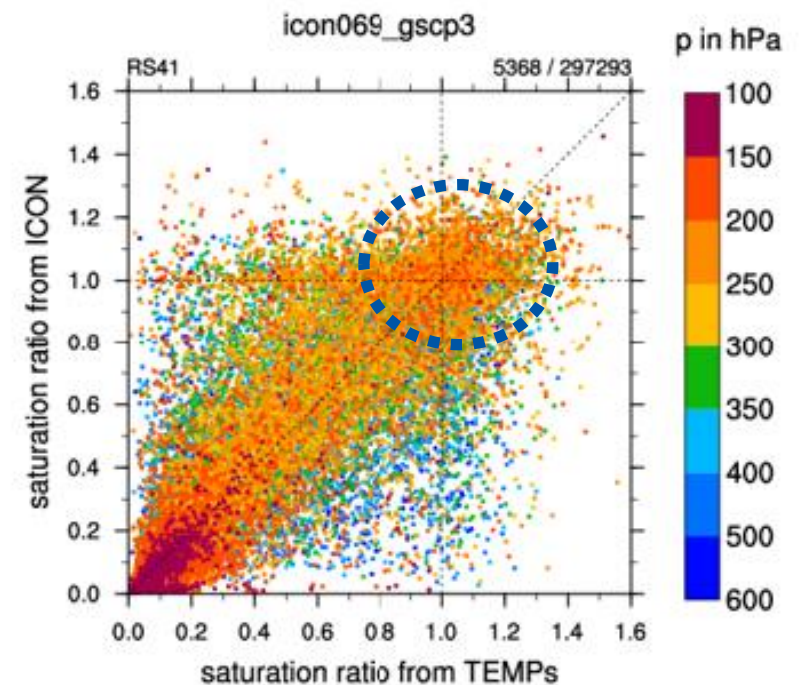
Source: A. Seifert/DWD

Changes on NWP model parametrisation:

- DWD operational and global model: Improved cloud ice microphysics



Model version with no humidity supersaturation



Model version with improve cloud-ice microphysics

Comparison DWD model humidity forecast output with radiosonde observations

ISSR calculation with realistic threshold for $RH_{ice} \geq 100\%$ possible



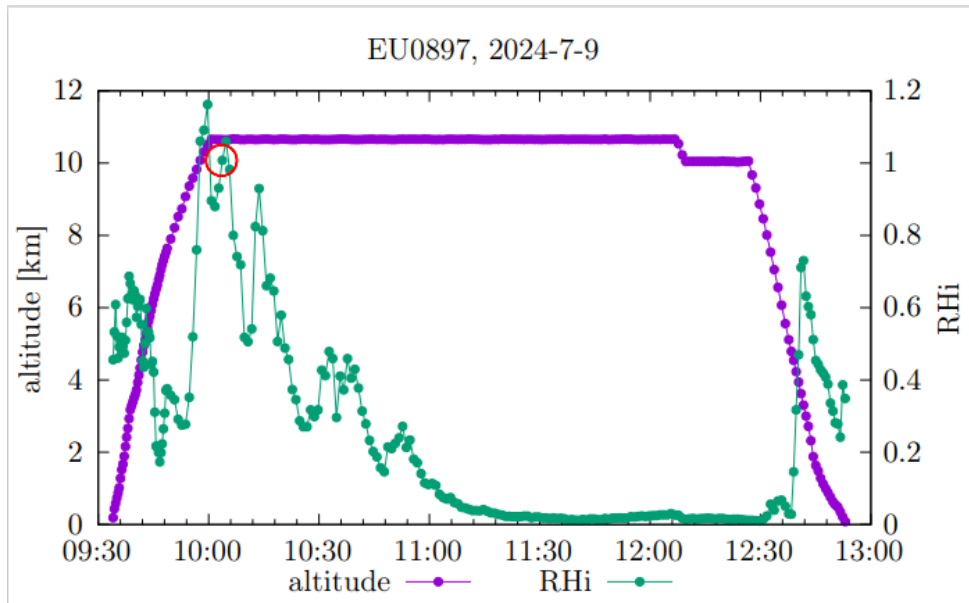
What are WMO members doing for contrail avoidance?



2 – Changes on AMDAR humidity observation over Europe – ISSR detection

Project LuFo MEFKON (Germany) will:

- Use enroute humidity measurements to improve humidity forecast for contrail avoidance.
- Analyse sensor quality.
- Estimate the amount of data required (number of aircraft with sensors) for significant improvement of humidity and ISSR forecasts using the larger amount of data over the USA.



Source: M. Neumann/DWD



Example :

- 2024-07-09, 10:03 UTC, Hochfelln Alps.
- RH_{ice} by AMDAR = 100,8%

Source: Crowd source images from DWD warning weather APP



ICAO Regulations in the context of aircraft-based observations; to be updated?

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- **Annex 6 Operation of Aircraft Part I, Chapter 6 Aeroplane instruments, equipment and flight document:**
 - Water vapor sensors are not yet listed here.
 - For more cost efficiency and effectiveness in rerouting as well as climate effectiveness in contrail avoidance, humidity sensors are proposed as a recommendation.
- **Annex 3 Meteorological Service for International Air Navigation / ICAO DOC 8896 Manual of Aeronautical Meteorological Practice. Two issues should be highlighted:**
 - Sampling frequency of 15 minutes in cruise level too small
 - Humidity range only from 0 to 100%; supersaturation must be taken into account





Thank you

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