FERGUSSON : FAIR Environmental Research data Gathering in Upper tropoSphere and lower Stratosphere through innovative ObservatioNs

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(1) GSMA, UMR CNRS 7331, Université de Reims, FRANCE
(2) Centre National d'Etudes Spatiales Toulouse, FRANCE
(3) Karlsruhe Institute of Technology, IMK-ASF, Karlsruhe, GERMANY
(4) Forschungszentrum Juelich GmbH, Juelich, GERMANY
(5) CNR-ISAC, Roma, ITALY
(6) CNR-INO, Sesto Fiorentino, ITALY
(7) LATMOS, CNRS, Sorbonne Université, Université de Versailles-Saint-Quentin-en-Yvelines, Paris, France
(8) CNRS SAFIRE, Aéroport de Toulouse Francazal, Cugnaux-France, FRANCE
(9) LPC2E/CNRS, UMR 7328, Orléans, FRANCE
(10) Laboratoire de PhysicoChimie de l'Atmosphère, Université du Littoral Côte d'Opale, Dunkerque, FRANCE
(11) DT-INSU, CNRS, Meudon, FRANCE

Institutes / laboratories

Research infrastructures

Agencies

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Companies

Context

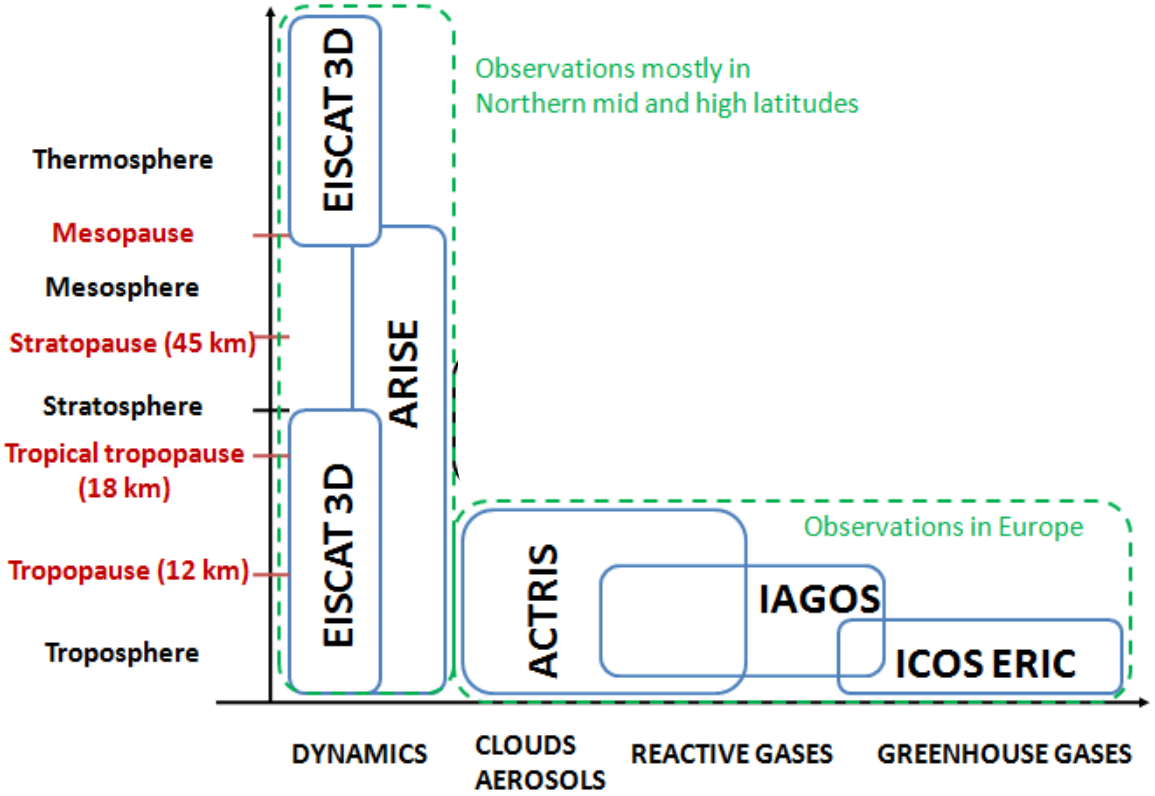
In-situ observations of the stratosphere are rare.
Comprehensive datasets are currently taken in dedicated aircraft and balloon campaigns
=>limited to target regions and limited in frequency

Stratospheric data come from satellite
In situ data come from radiosondes (not reliable for humidity) or ground-based observations at insufficient resolution

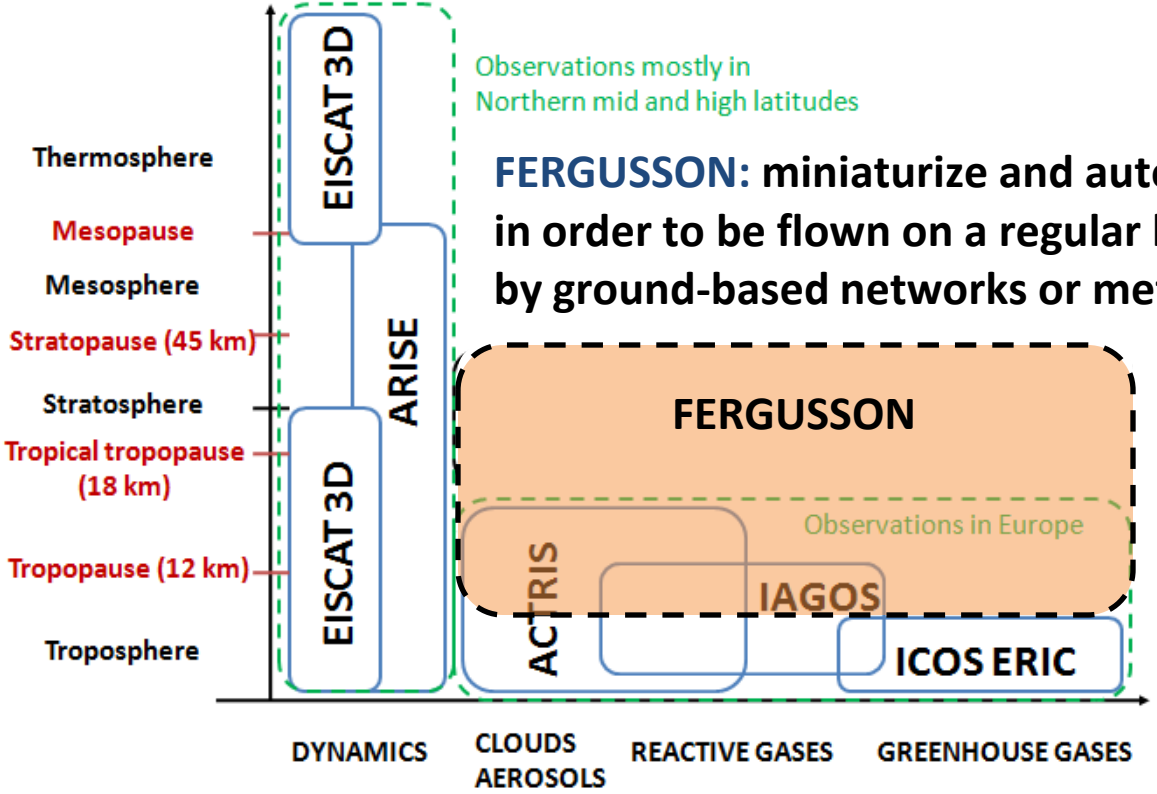
However, in situ data are essential to:
- Feed climate reanalyses
- Calibrate and validate satellite meas.
- Evaluate and improve climate models

Stratosphere is hard to reach, only accessible high altitude aircrafts in high latitudes or with balloons

FERGUSSON within the UE landscape



FERGUSSON within the UE landscape



FERGUSSON: miniaturize and automatize sophisticated instruments in order to be flown on a regular basis to probe regions not covered by ground-based networks or meteorological soundings

FERGUSSON in main points

The main characteristics of FERGUSSON are :

1. Technological innovation for better and lower cost observations in UTLS and stratosphere

2. Development of sustainable systems for long-term regular observations in UTLS and stratosphere

3. FAIR in-situ datasets in support of climate reanalyses, modelling and science

4. Support of Cal/Val activities for Copernicus Expansion missions, the ESA FORUM mission, Sentinels, EarthCARE and Altius missions, EumetSat (IASI-NG) and other relevant satellite missions (e.g. CNES MicroCarb, ESA MERLIN...)

Structure of FERGUSSON

AQUAVIT-4 Int. campaign (funded by ATMO-ACCESS)

Balloon-borne campaign Sept 2022 synergy with GRUAN (funded by CNES)

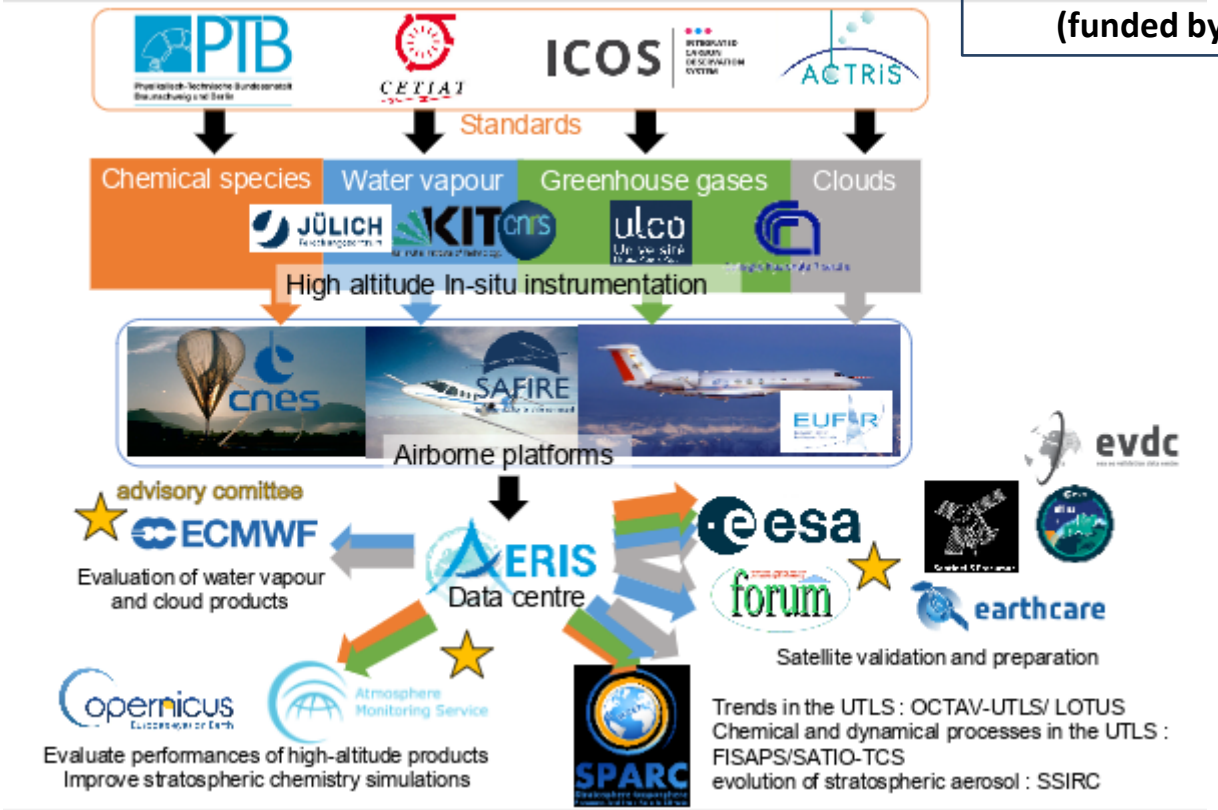
ECV Standards

Instruments & scientific teams

Airborne operators

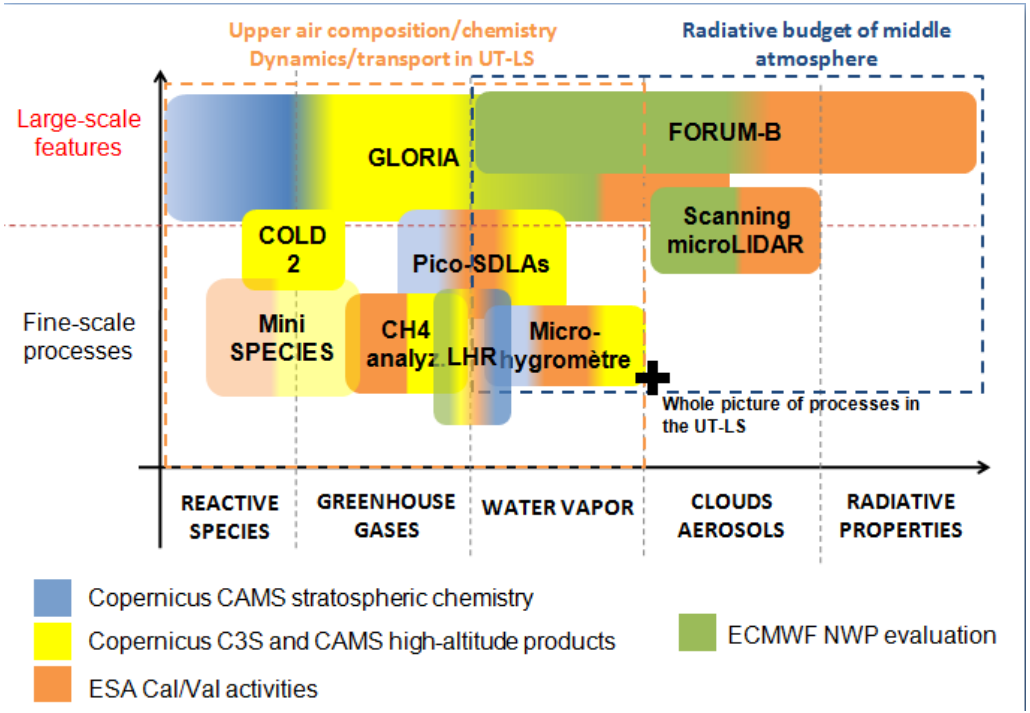
Data center

Climate modeling Satellite missions & science



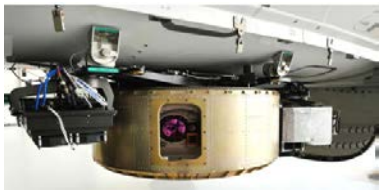
The consortium & observational capabilities

Complementarity of observations for a comprehensive picture of the UT-LS



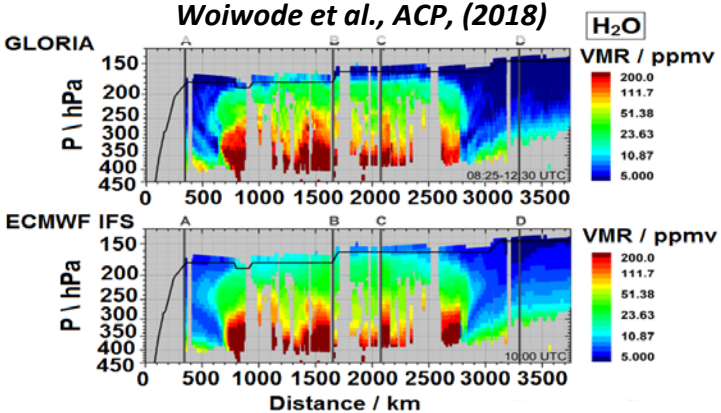
GLORIA & FORUM –B: 2-D picture of broad range of parameters

GLORIA-LITE – PIs: F. Friedl-Vallon (KIT) P.Preusse (FZJ)

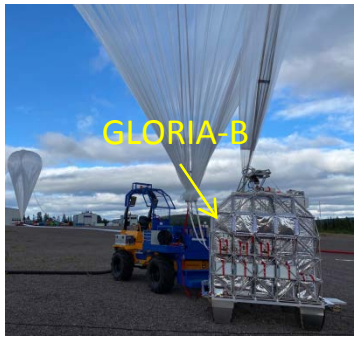


Hyperspectral limb viewing FTIR
2-D picture of multiple reactive and non-reactive species
Ultra compact version of GLORIA-AB/B

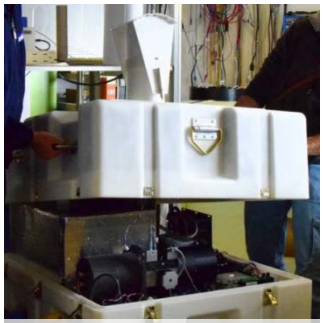
Woiwode et al., ACP, (2018)



Tropopause fold from flight of GLORIA onboard HALO aircraft in January 2019 over Italy

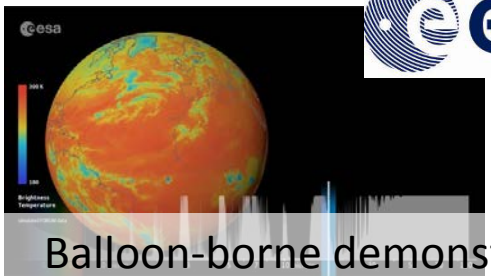


FORUM-B (CNR) – PI: L. Palchetti



FIR spectrometer
First-time measurements of FIR portion of OLR

FIRMOS-B instrument



Balloon-borne demonstrator for the FORUM mission

Talk of F. Friedl-Vallon, July 5 – 10AM

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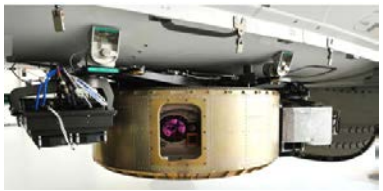

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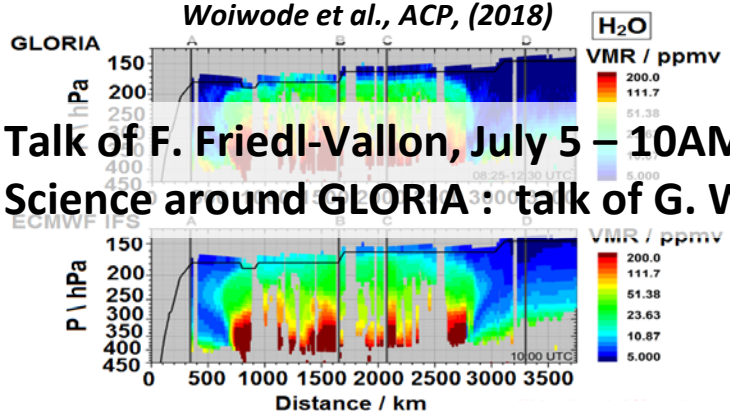

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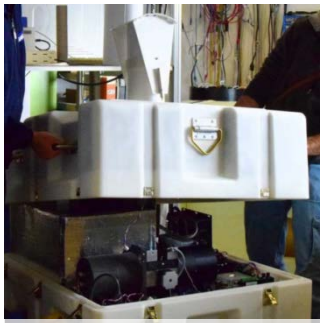
Talk of F. Friedl-Vallon, July 5 – 10AM

Science around GLORIA : talk of G. Wetzel @ 12:20 PM

FORUM-B (CNR) – PI: L. Palchetti



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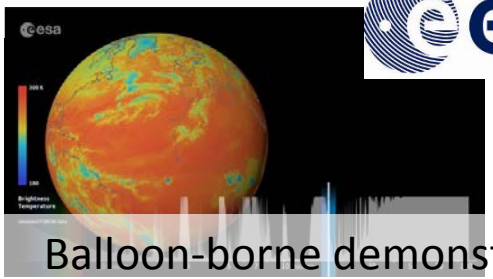

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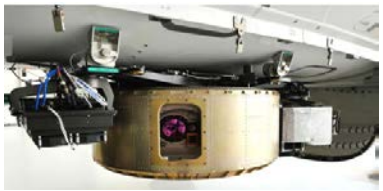

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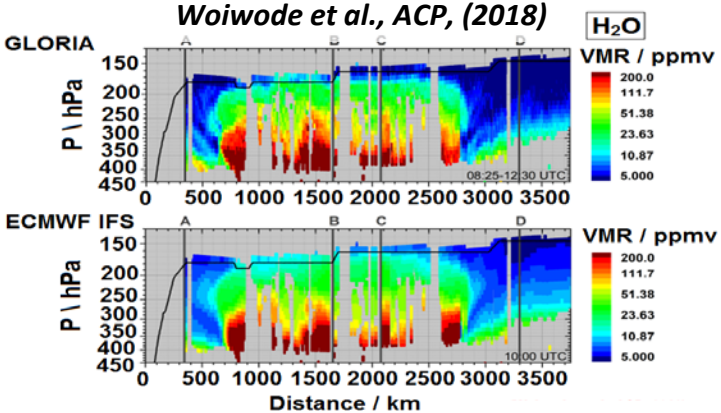

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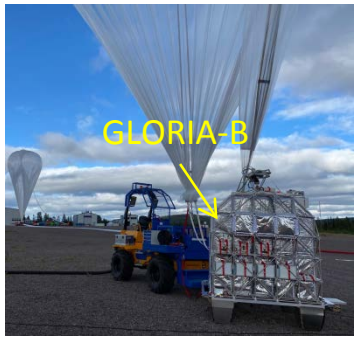

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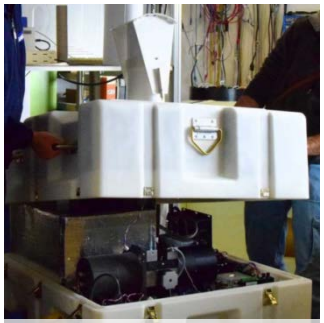

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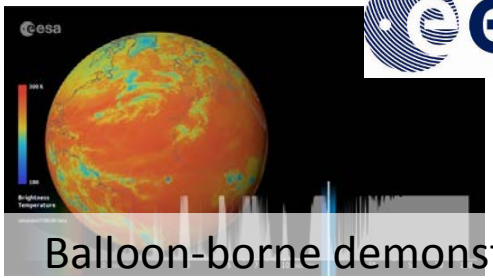

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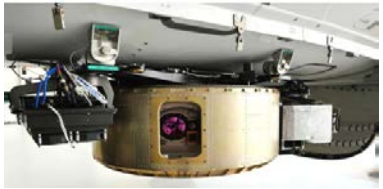

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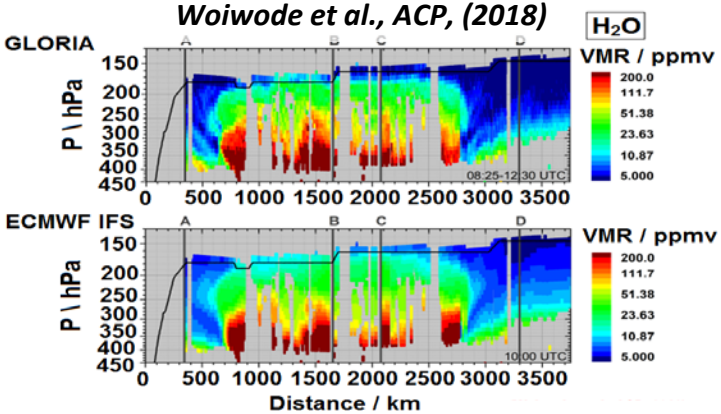

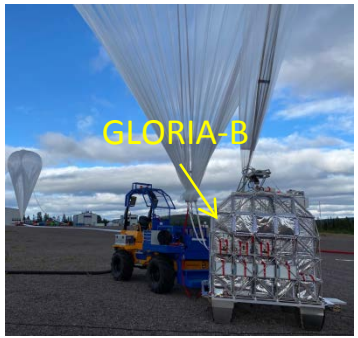

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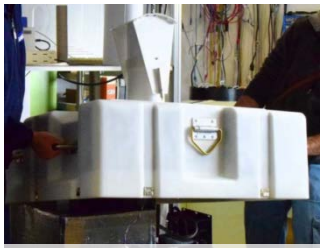

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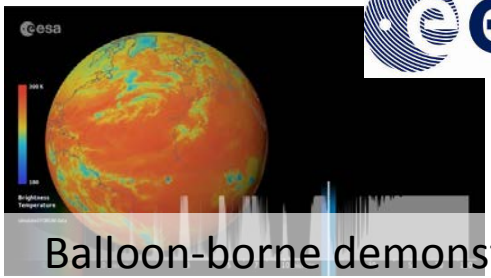
Talk of L. Palchetti session S9, July 6 @ 09:00 AM

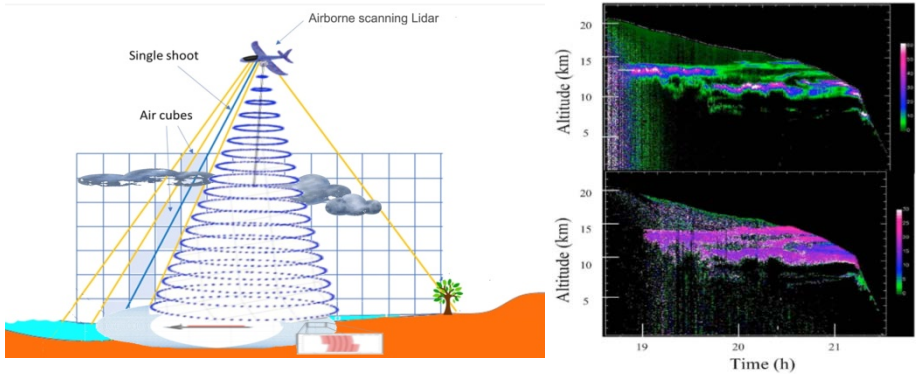
FIRMOS-B instrument



Balloon-borne demonstrator for the FORUM mission

Complementing nadir looking sounder data

MULID2-Scan (CNR)
PIs: F. Cairo/G. Di DonFrancesco



Di Donfrancesco et al., Appl. Opt., (2006)

Cloud profile during long-duration of MULID in the framework of the HIBISCUS European project

Scanning elastic LIDAR with 2 wavelenghts and polarization diversity.
Cloud top/bottom, Ice Water Content, optical thickness, vertical mass distribution of particulates

Together with FORUM-B : Impact of ice cirrus clouds properties on the ERB

Tunable diode laser instruments

High precision, high spatial/temporal resolution for selected set of parameters

Pico-SDLAs (GSMA/DT-INSU), PIs: G. Durry/M. Ghysels

Autonomous & quick launches

Long-duration observations & highly-resolved vertical profiles

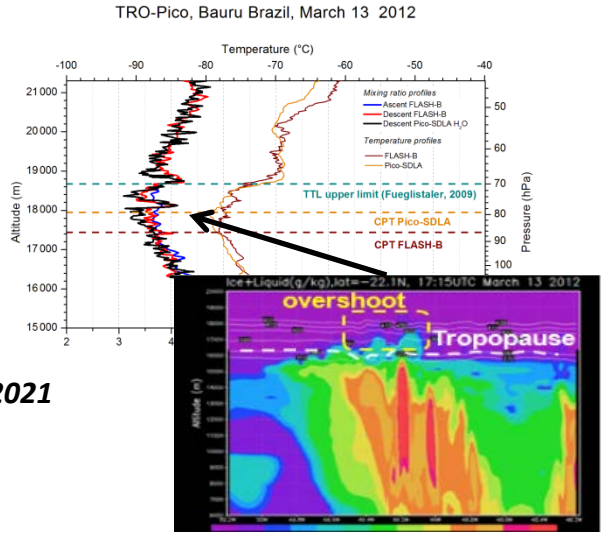
Pico-Light H_2O

Pico-STRAT H_2O/CO_2

Ghysels et al., AMT, (2016)

Riviere et al., EGU 2021

Ghysels et al., ESA WV CCI User workshop, June 14-16, 2021

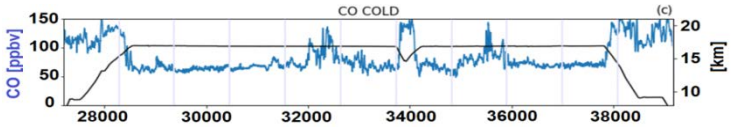


COLD2 & methane analyzer (CNR), PIs: F. D'Amato/S. Viciani

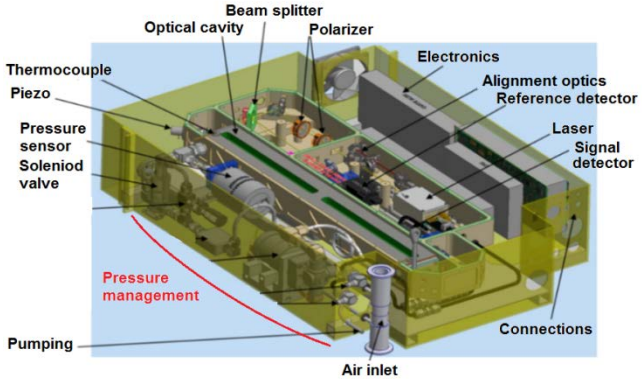
Profiles of CO, N_2O, CH_4, CO_2

Viciani et al., sensors, (2018)

Bucci et al., ACP, (2020)



Tunable diode laser instruments



Mini SPECIES (LPC2E), PI: V. Catoire

In-situ OF-CEAS: N_2O, CO_2, $^{13}CO_2$, CH_4, CH_2O, NO

Expected precision of about 0.2 ppbv

Precision better than 0.5%
referenced to WMO-NOAA scale

Talk of V. Catoire – earlier: July 5 @ 10:15 AM

Large range of atmospheric composition datasets at high spatial and temporal resolution

Development of new sounding techniques

Micro hygrometer (LPC2E)
PI: M. Chartier, G. Krysztofiak

Non-cryogenic frost-point hygrometer
Frost-point techniques evolution for long-duration flights

Ground-based LHR (ULCO)
PI: W. Chen

Mobile Ground-based Laser Heterodyne Radiometer
Trace columns & vertical profiles : CO_2, CH_4, water vapor and isotopes
In complement of EM27 & FTIR => observation networks

New airborne platforms for climate research and more…

Broad applicative developments on sounding systems

Long-duration balloons:

Persistent, navigable long-duration balloon (CNES/CNIM Air Space)
First prototype by 2024 - Business model to be defined
Flights of several months - navigable - stationnary position possible

Long-duration sounding balloons (CNES)
Increase of sounding balloon flight duration : from 2 hours to several days

Communication systems :
Upgrade of the EMPIRE & ETAG systems (Swedish Space Corporation)
Control of flight, science data transmission, could accommodate TransAtlantic flights, transmission of basic meteorological parameters (e.g. P, T and wind)

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Talk of F. Vacher– Session S9, July 5 @ 12:15 AM

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Airborne campaigns and satellite validation activities

4 airborne campaigns from 2024 - 2026

Kiruna 2024

TransAtlantic flight
duration: 4 to 6 days
Kiruna => Northern Canada
GLORIA LITE: test flight
Mini SPECIES

Brazil 2024

Radiosounding flights
Qualification campaign
Pico-Light and micro hygrometer

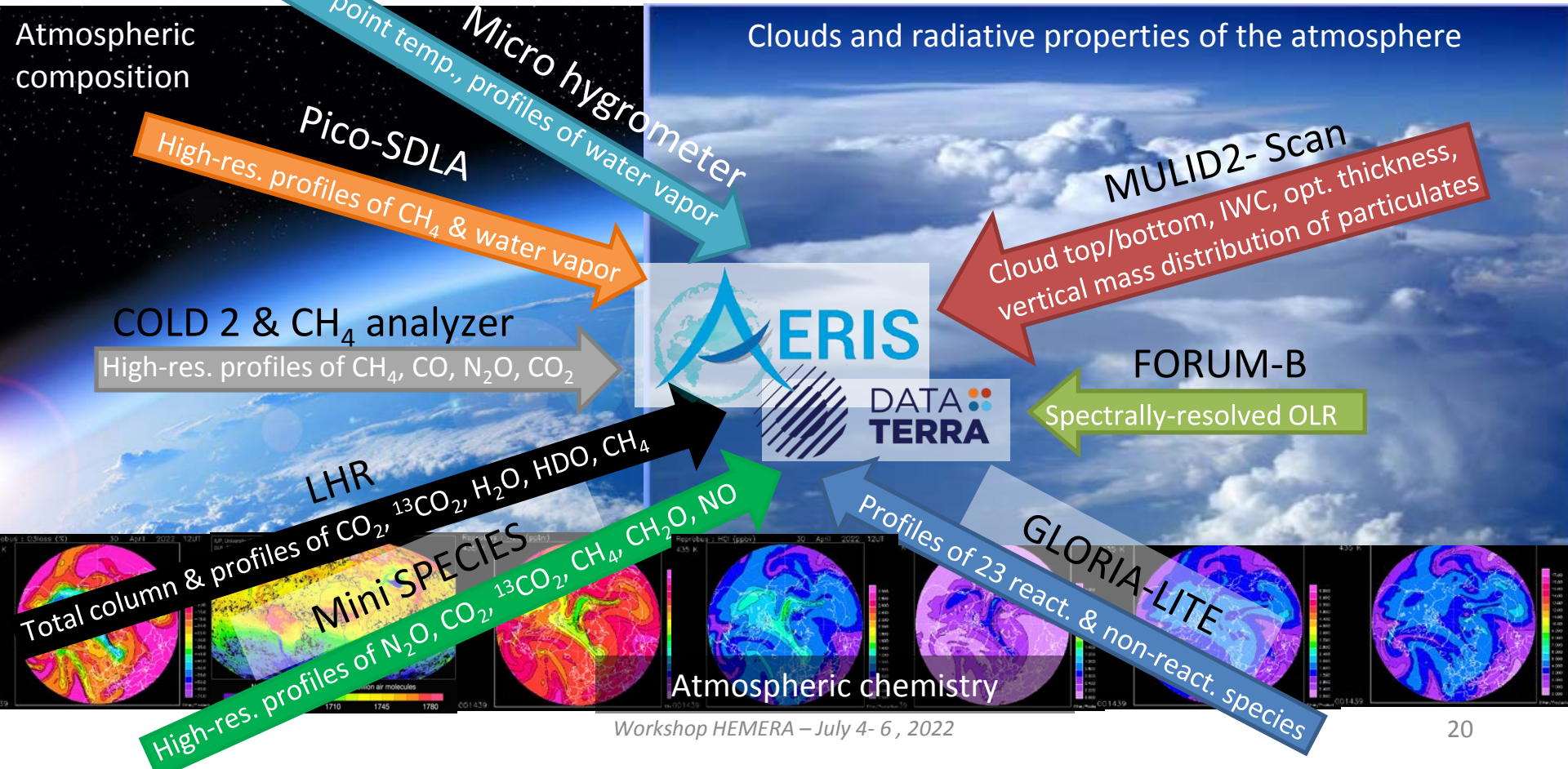
Toulouse 2025

10-hours of flights : ATR 42
Interoperability of payloads
Pico-Light, Mini SPECIES

Brazil 2026

Demonstration campaign
All instruments
ZPB, SPB, RS flights
Impact assessment
Satellite validation activities

From in-situ datasets to scientific community



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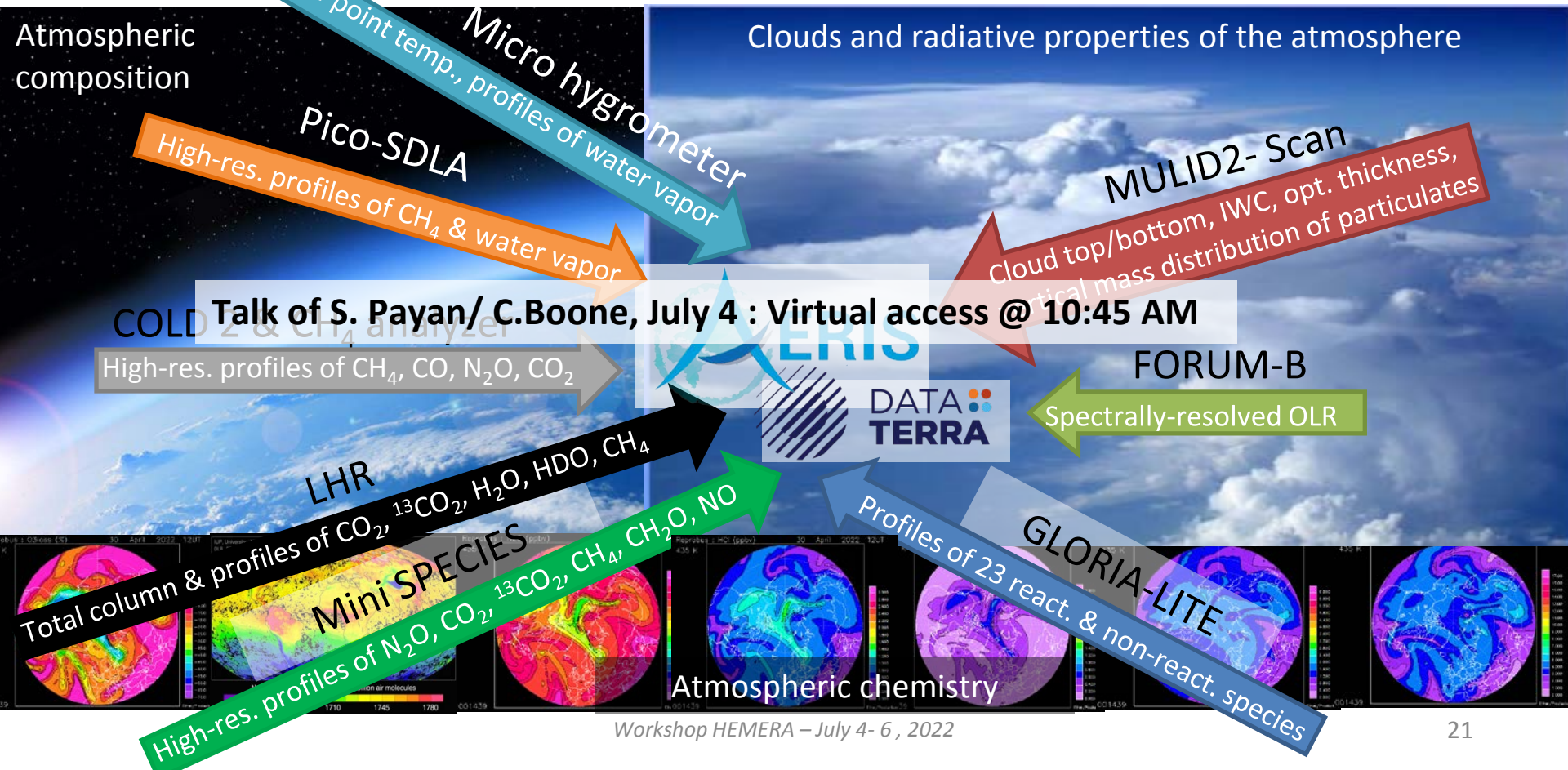


Talk of S. Payan/ C.Boone, July 4 : Virtual access @ 10:45 AM

Validation activities

Steering comittee

Evaluation of water vapor and cloud products

Climate modeling

Evaluate performances of high altitude products
Improve stratospheric chemistry simulations

Trends in the UT-LS: OCTAV-UTLS, LOTUS
Chemical and dynamical processes in the UT-LS: FISAPS/SATIO-LS
Evolution of stratospheric aerosols: SSIRC

Satellite validation

Mission	Year of launch	Measured variables related to FERGUSSON
FORUM (ESA)	2027	Spectral OLR flux, Water vapor, cirrus clouds properties (IWP, Effective Diam., CTH), FIR surface emissivity
CO2M (Copernicus Expansion)	2025	XCO_2, XCH_4, NO_2 tropospheric column, aerosols and clouds information
MicroCarb (CNES)	2024	XCO_2
IASI-NG	2024	Temperature and water vapour profiles, cloud properties All trace gases, reactive gases, biogenic burning tracers, aerosol components
MERLIN (ESA)	2024	XCH_4
EarthCare (ESA/JAXA)	2023	Cloud informations
Sentinels 4, 5 and 5P (Copernicus, ESA)	2017	O_3, SO_2, CH_4, CO, cloud information
Aura MLS (NASA)	2004	water vapour, temperature, CH_4, CO, N_2O, HNO_3, O_3

Conclusion

Proposes evolution on scientific-grade airborne instrumentation: interoperability, open access
=> increased temporal and spatial coverage of the hard-to-reach stratosphere

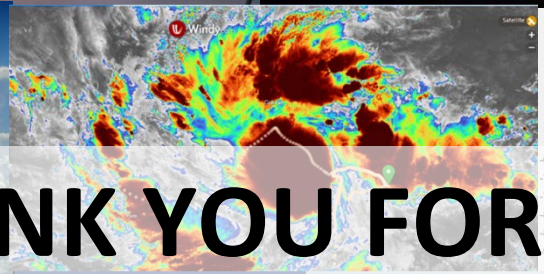
Proposes developments of new airborne platforms allowing long-duration, innovative capabilities for climate sounding

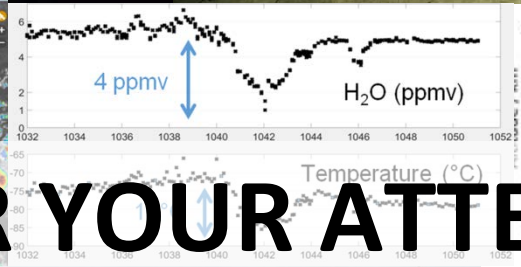
Unfortunately not funded this time, but we do not give up!

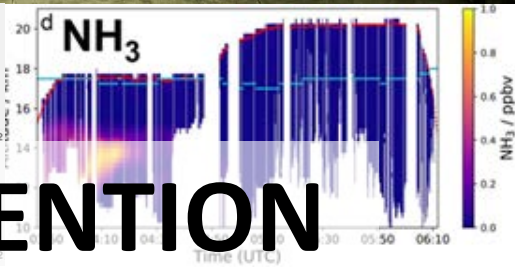
In preparation for a FERGUSSON 2











THANK YOU FOR YOUR ATTENTION