GRUAN / ICM-13
M10 GDP corrections and results overview, and launching of the M20 GDP

JC. Dupont (IPSL), E. Assy (MODEM), A. Farah (MODEM)

Outline

Status of M10 GDP (JC. Dupont, IPSL)

- Actual state of the M10 GDP
- Data production and data flux

M10 GDP Corrections (E. Assy, Modem)

- Corrections and uncertainties

Validation of M10 results (E. Assy, Modem)

M20 Gruan Data Product (E. Assy, Modem)

Perspectives (JC. Dupont, IPSL)

Organization

Who? : Organization for the GRUAN GDP M10

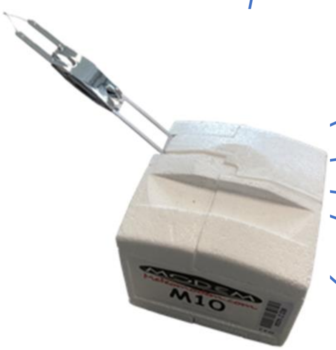
1. **IPSL** (JC. Dupont, M. Haeffelin, MA. Drouin): Leader of the project, scientific relationship with GRUAN, algorithm development for M10 L1 and GDP + SIRTA site instruments
2. **Météo-France** (F. Marin, P. Jann) : Operationnal aspect for radiosondes at TRP and REU sites
3. **AERIS/ESPRI** (S. Cloché, C. Laplace) : Data flow at AERIS Data Center
4. **MODEM** (E. Assy, A. Farah) : Corrections and uncertainties for M10
5. **LACy, OSU** (S. Evan): M10 GDP validation and Maïdo site instruments

Status of M10 GDP

Status of the GRUAN certification for M10 RS

Technical Document (last TD-8), version 3 submitted on November 2021 (260 pages)

Scientific documents Dupont et al., 2020 and Madonna et al. 2020



Two operational sites (twice a day for TRP & REU)

Next French operational site in South Pacific Ocean, FAA

Dataflow and datacenter: (https://www.gruan.org/data/measurements/sondelaunches) and AERIS datacenter

An established dataset for each site/sonde

Review of certification document by GRUAN in progress

Begining of M20 GDP

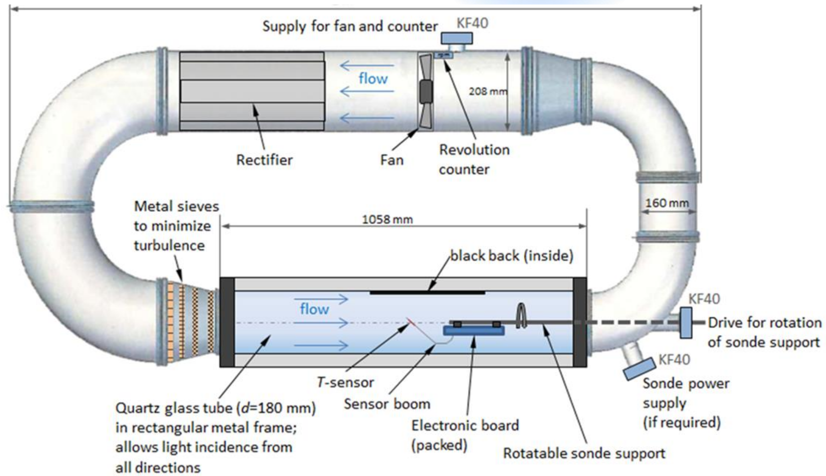
M10 GDP corrections (1/3)

Solar Radiation correction

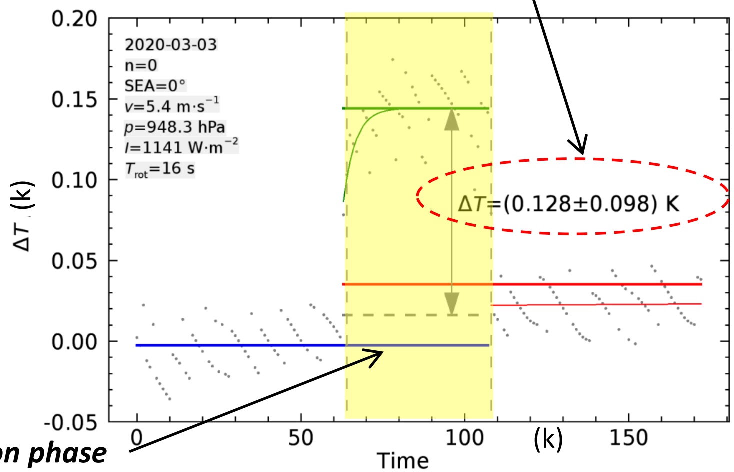
New set up developed by Christophe Von Rohden and his team

- **Using pvlib.clearsky.simplified_solis:**
  - Estimation of the solar angle
  - Determination of solar irradiance

    Clear sky conditions (fixed integrated water wapor of 15mm), with Fixed aerosol optical depth of 0.08, altitude of M10 and solar zenith angle
- **Solar irradiance correction factors**
  - Determined @ Lindenberg 2020 «wind Channel» for direct and diffuse irradiance



The estimated contribution of a direct irradiation



Irradiation phase

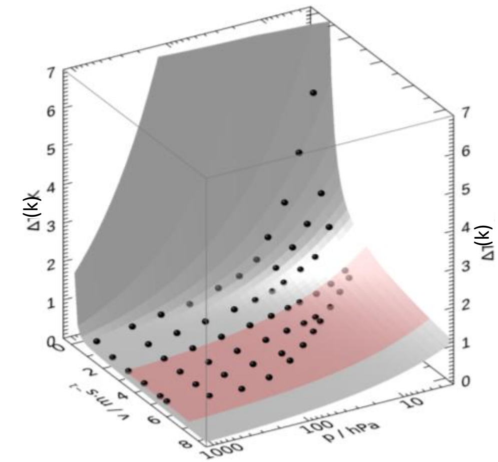
Difference between M10 and reference in the wind channel, before (blue line), during (green line) and after (red line)

f(P,v) = deltaT @ swdir and sza constant

$$\Delta T\,(p,v) = c_{00} + c_{10}\,1/p^{1/2} + c_{01}\,1/v^{1/2} + c_{11}\,1/p^{1/2}\cdot 1/v^{1/2} + c_{02}\,1/v + c_{12}\,1/p^{1/2}\cdot 1/v + c_{03}\cdot 1/v^{3/2} + c_{13}\,1/p^{1/2}\cdot 1/v^{3/2}$$

I=(1024±24) W·m^{-2}
SEA=(59±2)°

c_{00} = -2.975E-002
c_{10} = -1.232E+000
c_{01} = 3.367E-001
c_{11} = 1.018E+001
c_{02} = -4.103E-001
c_{12} = -1.155E+001
c_{03} = 1.237E-001
c_{13} = 8.016E+000

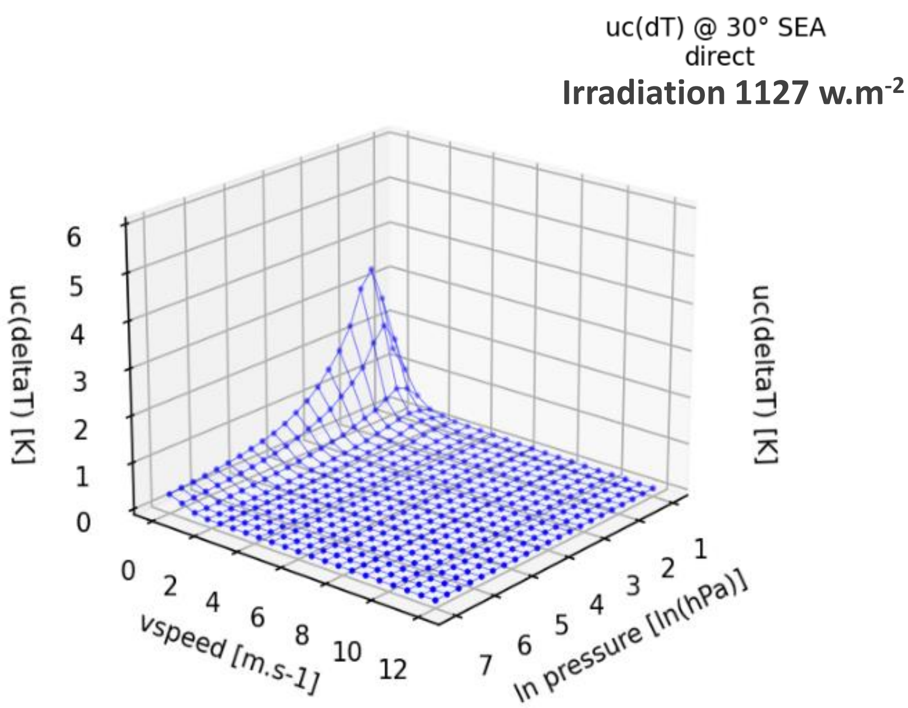


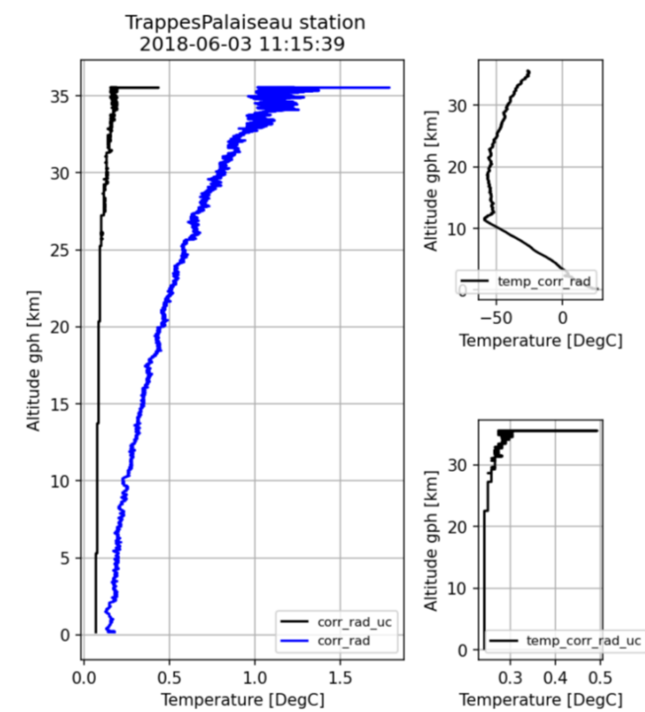
Temperaturte bias proportional to irradiation ➔ Every polynomial solution normalized by the experimental irradiation and calculated for a given irradiation in flight

M10 GDP corrections (2/3)

Radiative correction uncertainties

- ✓ Uncertainty on solar elevation angle (SEA) and solar irradiation assumed to be negligible
- ✓ Uncertainty on radiative correction factor given in the form of table with fixed experimental SEA
    - Based on the uncertainty in the determination of dT at each point, the experimental radiation power, the indication of pressure and the ventilation speed
    - Interpolation between dT uc value and the angle i at each altitude
    - Compilation of diffuse and direct flux uncertainty





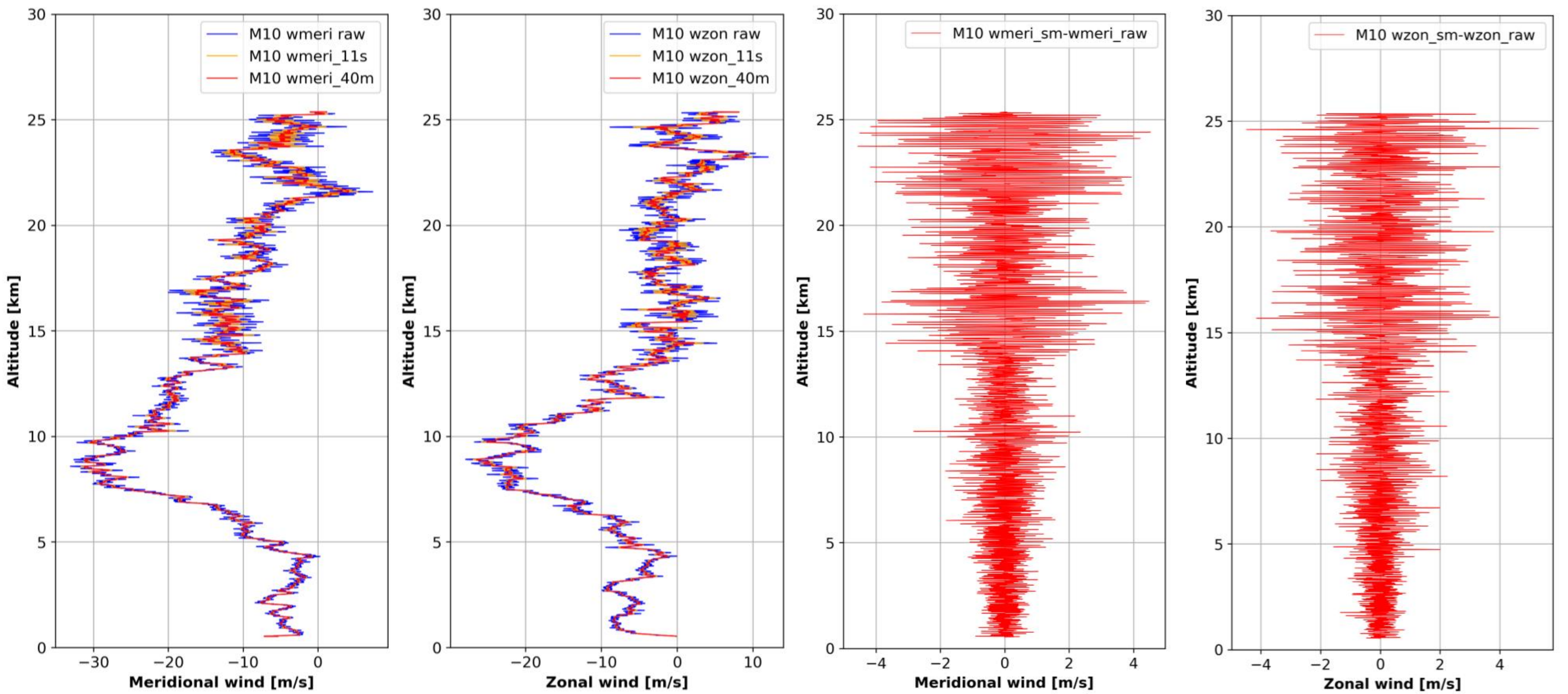
Uncertainty of radiation correction increases with altitude

M10 GDP corrections (3/3)

Zonal and meridional wind corrections and uncertainties

Two smoothing procedures:

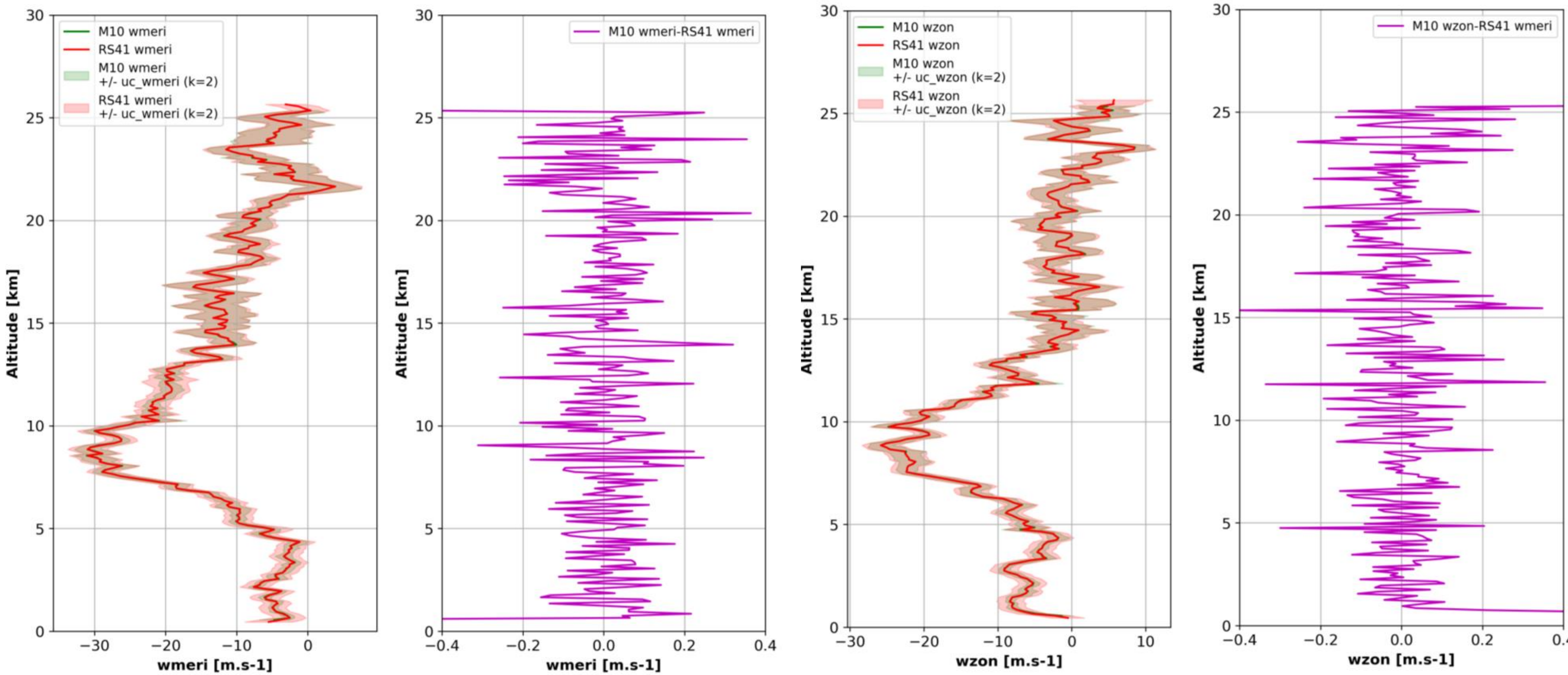
- Time: 11s for removing the pendulum motion
- Altitude: 40m for removing the noise



Validation of M10 results (1/2)

M10 GDP versus RS41 GDP during MeteoSwiss campaign (7 multiple-payload flights)

19 March 2021, Day Flight: Zonal and meridional wind

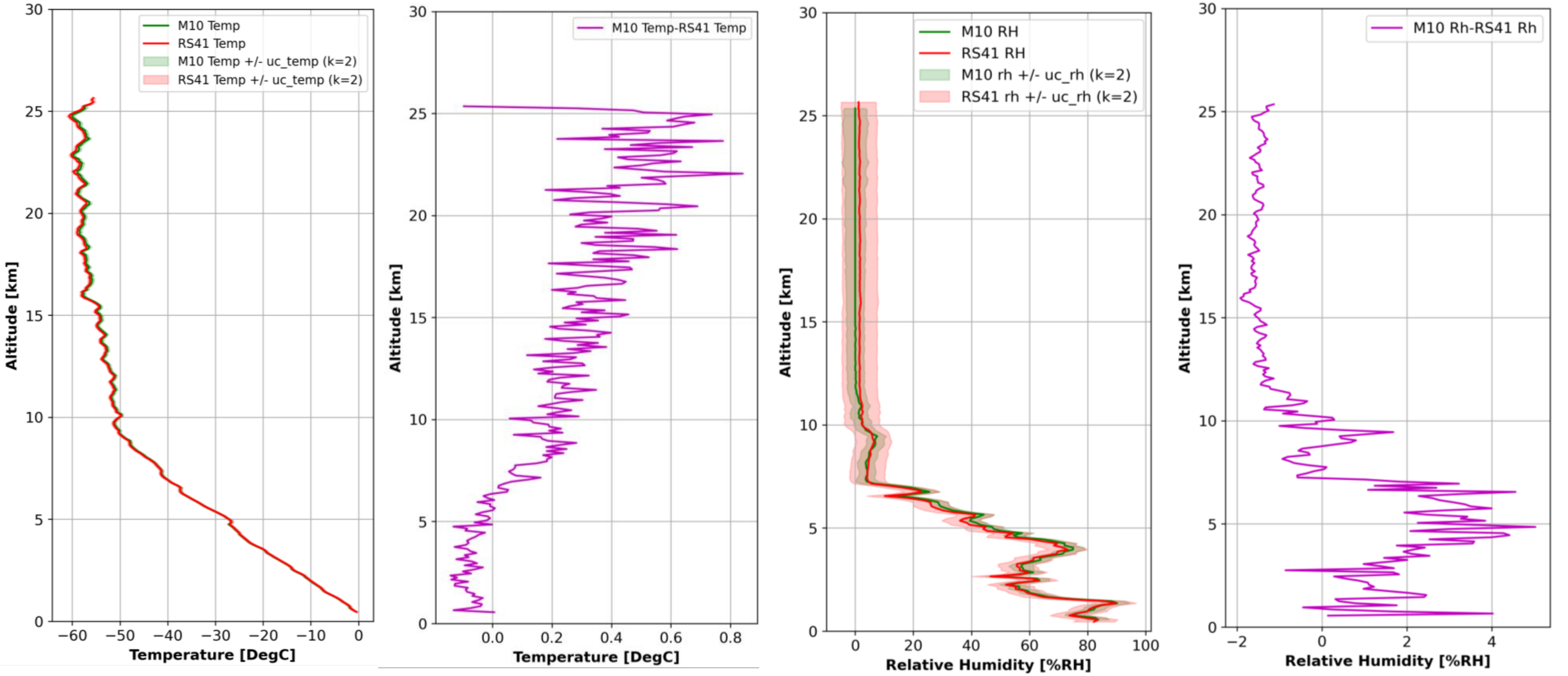


Good consistency between M10 and RS41, with maximum difference of ±0.2 m/s for both zonal and meridional wind

Validation of M10 results (2/2)

M10 GDP versus RS41 GDP during MeteoSwiss campaign (7 multiple-payload flights)

19 March 2021, Day Flight: Temperature and relative humidity



Good correlation between M10 and RS41, with maximum difference of ±0.6 Deg C for temperature (Triple flight) and 4% for relative humidity

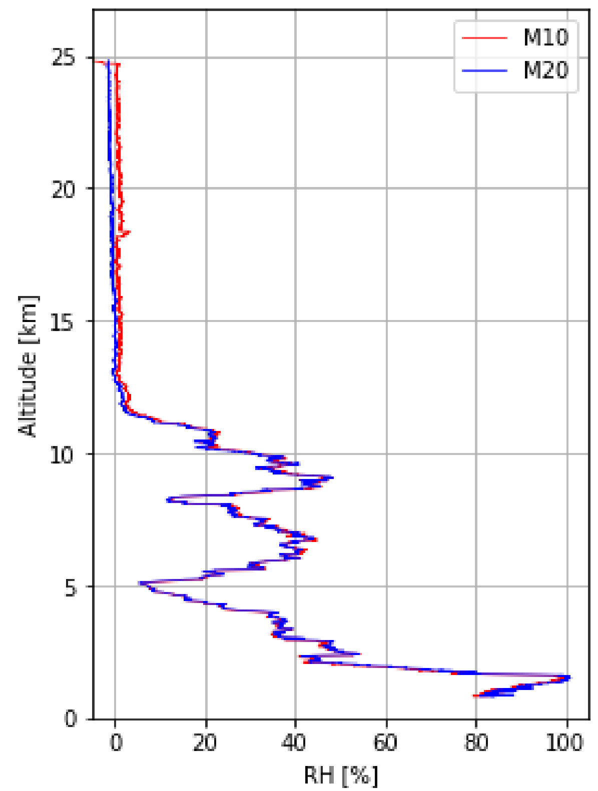
M20 Gruan Data Product (1/3)

M20 New generation of M10 radiosonde

M20 launched in Nimes Météo-France site
(200 flights, 2 flights per day since July 2021)

Lightweight compact	• Ultra light radiosonde (36g) • Simplified storage
Economic	• No parachute needed • Save up to 20% of gas
Heated Humidity sensor	• Humidity sensor fitted with a de-icing device
Compatible Robotsonde	• Automatic balloon launcher system (up to 24 radiosondes)
Environment Friendly	• Reduced environmental impact (less batteries, less polluting surface)

Comparison between M20 and M10 in flight



The M20 response is the same as the M10 during the whole flight profile

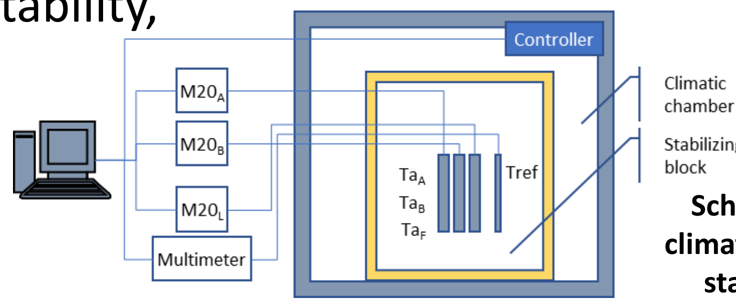
M20 Gruan Data Product (2/3)

Temperature Calibration Experiment

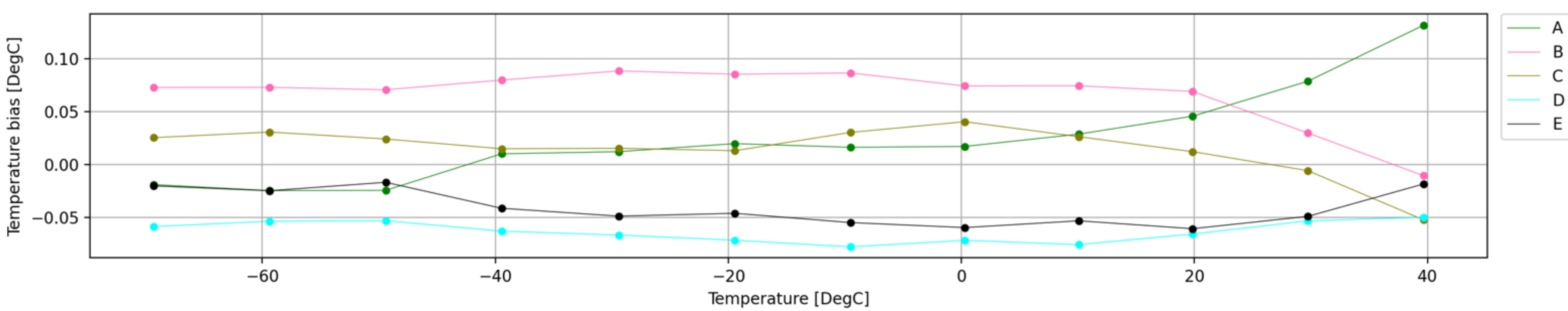
- Calibration tests made @LMD/Ecole Polytechnique (Same methodology as for M10)
- Measurements made from +40 -> -70°C per 10°C steps, stabilized for at least 3 hours
  - Reference PT100 calibrated u_{ref} 0.09 K (k=2)
  - Taking into account : linearity, repeatability, reproducibility, resolution, ref repeatability, ref resolution
  - **Result :** **0.214 K** (k=2)

    ≠ **0.228 (k=2) (M10)**

Climatic chamber @ LMD/Ecole Polytechnique



Schematization of climatic chamber, and stabilizing block



Example of mean results for 5 radiosondes, mean on 3 hours of stabilization per steps

M20 Gruan Data Product (3/3)

Temperature Calibration uncertainties

Data resolution: 10s

Total numbers of measurements points : 32 400

Uncertainty calculation carried out following the methodology from Duvernoy et al. 2015 WMO Report n°119 (Same methodology as for M10)

Parameter	Name	Description	Standard uncertainty [°C] k=1	Type	Data field in product
$u(T_{a\text{-}lin})$	Uncertainty of temp_raw linearity	Maximum bias from reference	0.150/√(3)	B	-
$u(T_{a\text{-}repe})$	Uncertainty of temp_raw repeatability	Standard deviation of mean stabilized values	0.045	B	-
$u(T_{a\text{-}repro})$	Uncertainty of temp_raw reproducibility	Maximum standard deviation along all stabilized values	0.075/√(3)	B	-
$u(T_{a\text{-}reso})$	Uncertainty of temp_raw resolution	Minimum difference between two indications	0.020/√(12)	B	-
$u(T_{ref\text{-}cal})$	Uncertainty of Tref calibration	Calibration certificate including the PT100 and the acquisition system	0.045	A	-
$u(T_{ref\text{-}repe})$	Uncertainty of Tref repeatability	Standard deviation of mean stabilized values	0.016	B	-
$u(T_{ref\text{-}reso})$	Uncertainty of Tref resolution	Minimum difference between two indications	<0.003/√(12)	B	-
$u(T_{a\text{-}cal})$	Uncertainty of Ta_raw calibration	Composition of $u(T_{a\text{-}lin})$, $u(T_{a\text{-}repe})$, $u(T_{a\text{-}repro})$, $u(T_{a\text{-}reso})$, $u(T_{ref\text{-}cal})$, $u(T_{ref\text{-}repe})$, $u(T_{ref\text{-}reso})$	0.107	B	temp_cal_uc

Perspectives

- Validate GRUAN certification of M10 radiosonde
- Design campaigns for the calculations of ARL M10 uncertainties with Météo-France
- Schedule an experimental campaign in Lindenberg lead center in the framework of M20 GDP
    - The radiation correction in the wind channel
    - The double flux set up for timelag uncertainty
    - The use of the SHC for RH uncertainties
- Launching of the next French Météo-France operational site with M20 in the south of the pacific ocean, FAA, Polynésie
- Participation of Meteomodem in UAII2022, with the M20 radiosonde as candidate, and hopefully with the M10 as reference.

GRUAN

Questions?

Thank you for your attention

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METEO FRANCE

AERIS

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