



EXPLORE THE CLIMATE

Multispectral Hemispherical Radiometric Camera

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IDEAS-QA4EO

Content

- 01 **Cimel general presentation**
- 02 **Existing instruments**
- 03 **Instruments in R&D**
- 04 **MHR project**



CIMEL General presentation

Cimel Electronique

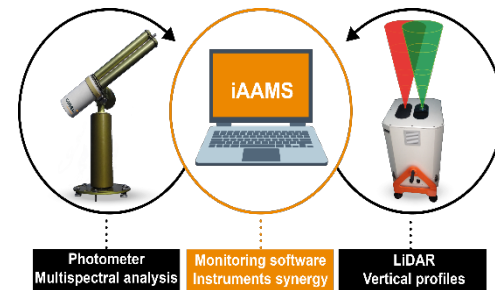
French manufacturer of optical remote sensing solutions for atmospheric and Earth Surface monitoring.
More than **50 years** experience, **30 persons**.



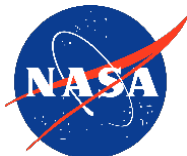
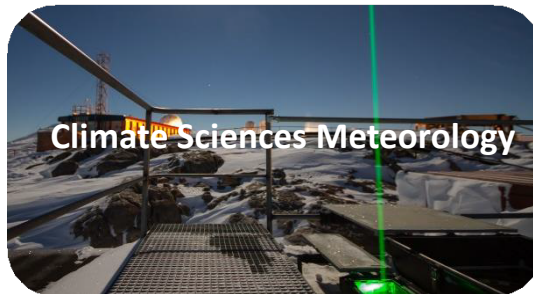
Photometers



LiDARs

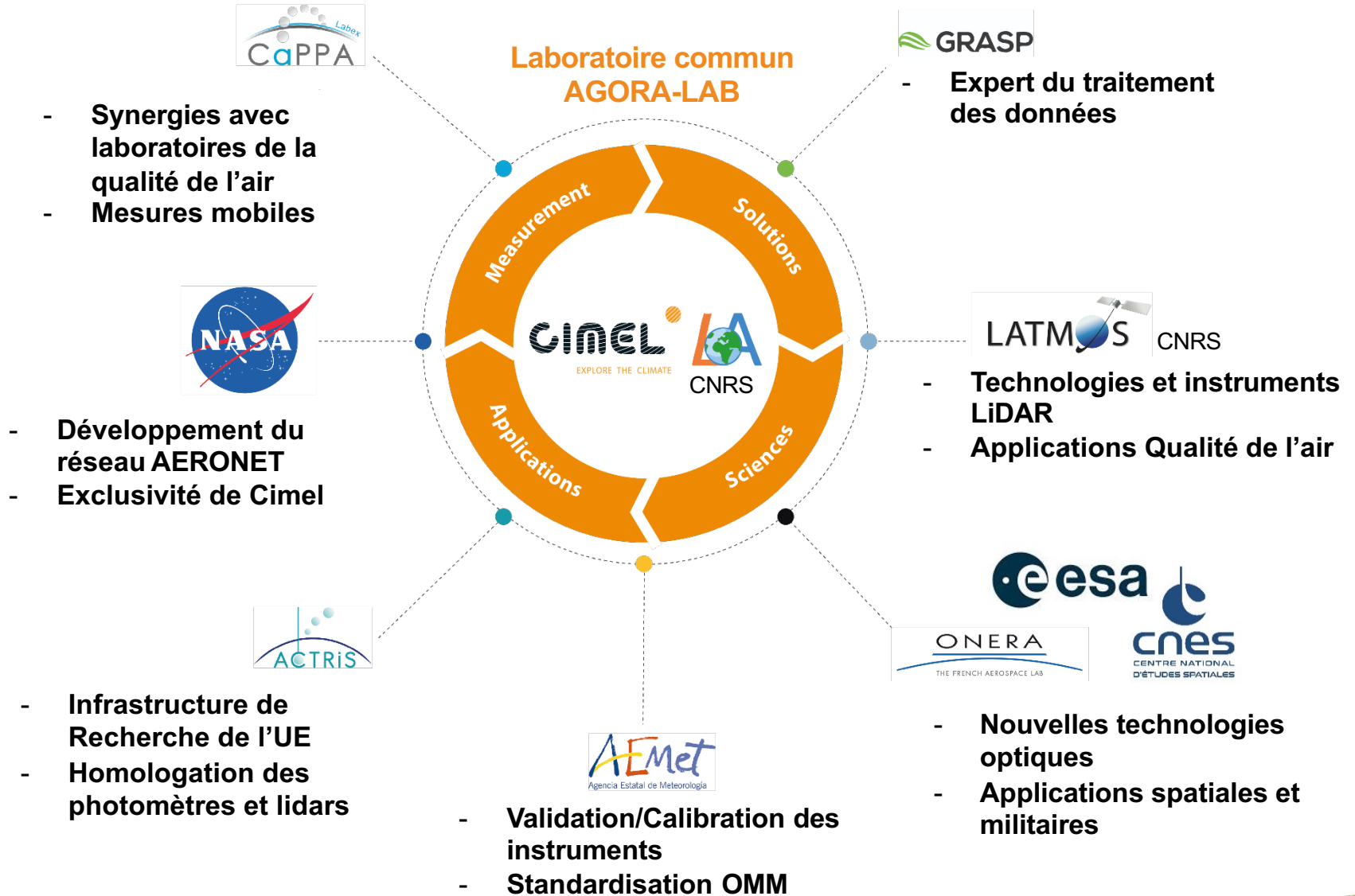


AAMS



Our core mission is to be the link between the **industrial world** and the **Scientific Research Community**

CIMEL's ecosystem





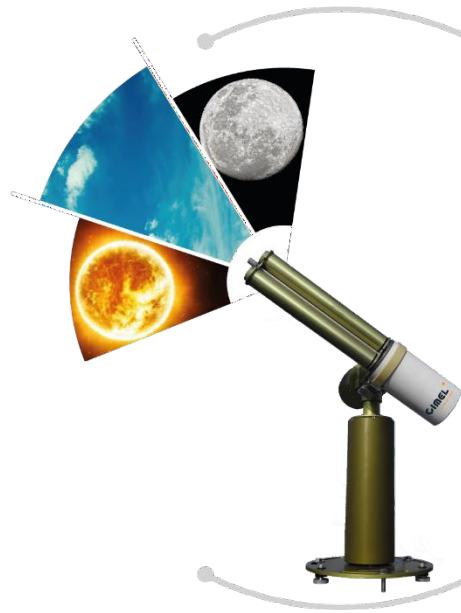
Existing instruments

Photometers

CE318-T

CE318-T

Multispectral analysis



Aerosol quantification (AOD)



Atmospheric analysis & climate studies



Satellite calibration & data validation



Site validation of solar power plants

Day and night AOD measurements

Complementary to the LiDAR

Fully autonomous & user-friendly

Harsh environmental conditions

Customisable (filters, scenarios...)

Product models

- Standard
- Polarised
- Lunar
- Ocean Colour
- Lake Colour
- "BRDF"

Automatic aerosol LiDAR – CE376



→ Up to **10 km** by day

Micro-pulse LiDAR

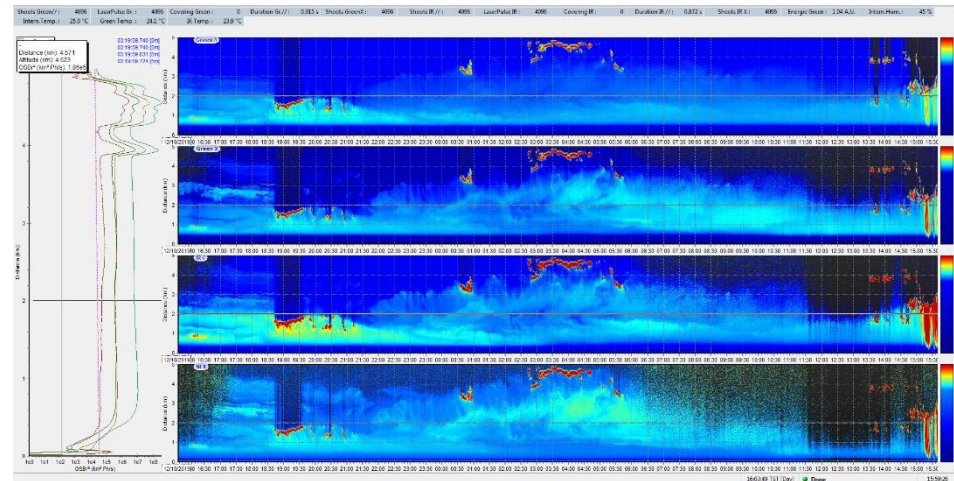
- **2 wavelengths**
- **Eye-safe**
- Stationary & Mobile
- Real time & continuous (day & night)

Technical specifications

Laser	Green: frequency doubled Nd:YAG NIR: pulsed laser diode
Wavelengths	Green: 532 nm NIR < 850 nm
Temperature	+15°C to +25°C without thermal enclosure -20°C to +45°C with thermal enclosure
Dimensions	710 x 450 x 650 mm
Weight	35 kg

Applications

- ✓ Research
- ✓ Meteorology
- ✓ Air Quality
 - Natural sources
 - Urban pollution
 - Industrial sites monitoring



Aerosol vertical profile quicklook (PR2) - iAAMS monitoring software

High power research LIDAR

CE710

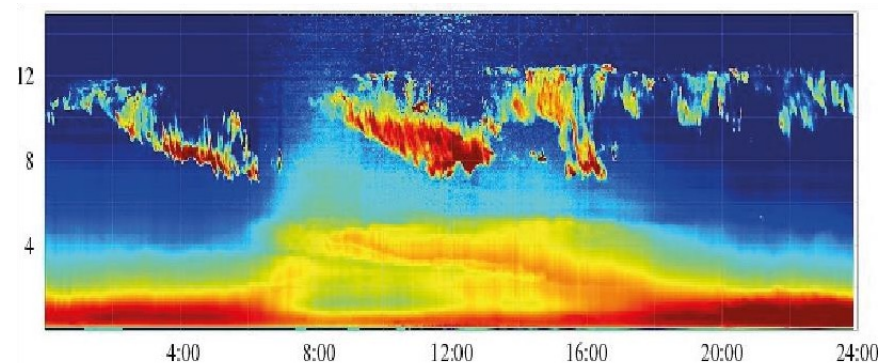
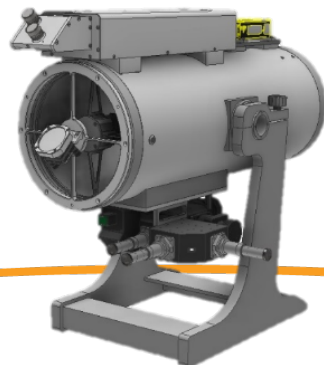
RAMAN LiDAR

- High power
- Stationary, vertical or slant
- **Customizable** and scalable up to **15 channels** (filters, polarization, fluorescence, laser source,...)
- **Robotized** alignments
- Suitable for **ACTRIS** validation guidelines



Applications:

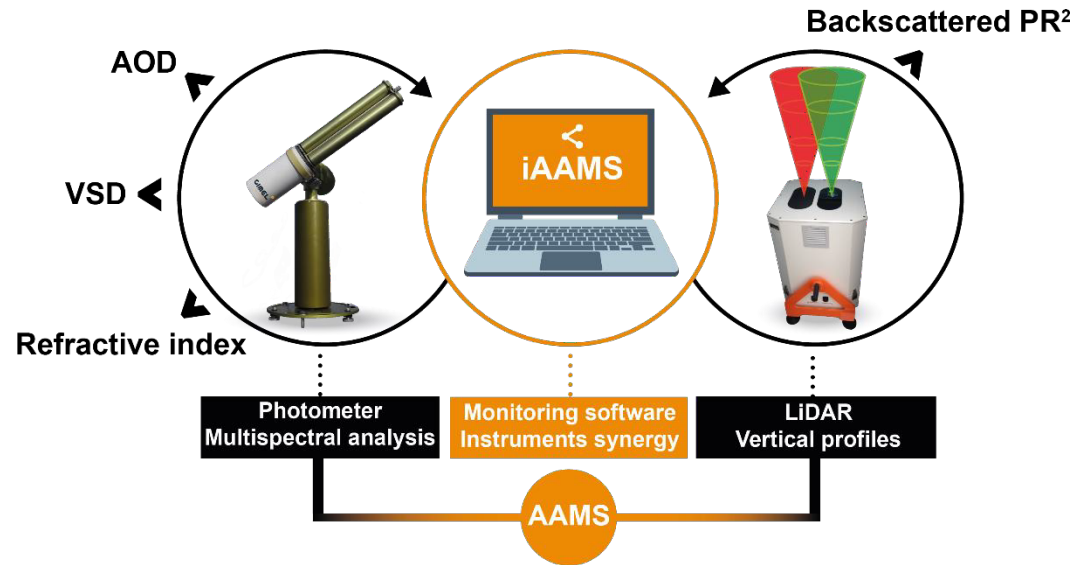
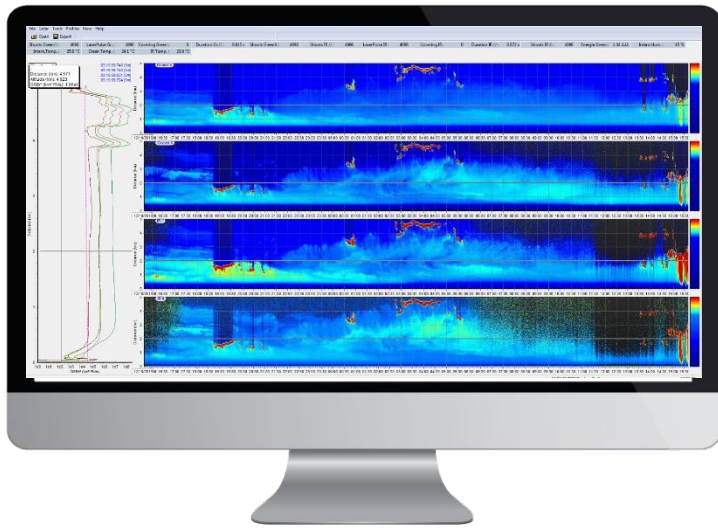
- ✓ Research / Cal/Val / Meteorology



AAMS

Automatic Aerosol Monitoring Solutions

➔ Synergy between CE318-T & Cimel LiDARs



Continuous measurement (Day & Night)

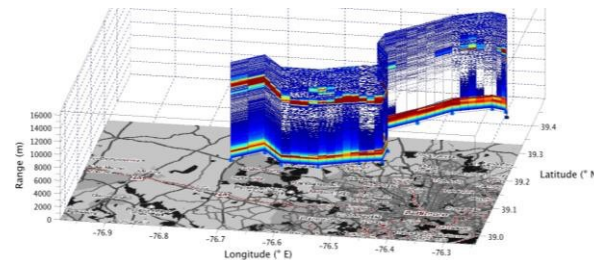
Real time data analysis

Automatic & integrated system

Easy to install / Mobile

Turnkey solution

- Characterization of aerosol types
- Vertical profile of Mass concentration



➔ Extinction & Backscatter profiles
3D analysis



Products in R&D

Instruments in R & D

Cost effective, robust instruments for network operation

- **Hyperspectral** photometer (CNES)
- Photometer extension to **UV and O₃** measurement
- **CO₂ hyperspectral** photometer
- Micropulse DiAL for **Water Vapor** profiles in the PBL
- Micropulse DiAL for tropospheric and PBL **Ozone profile**

Hyperspectral radiometer

Current project

- Funded by CNES, since 2022
- Objective: Cost-effective, operational for continuous monitoring, large spectral range, suitable for BRDF validation and vicarious calibration
- Status: Prototype available **end of 2024** for validation at La Crau



Targeted performances

- Spectral band : 350 – 2500 nm
- Spectral resolution
 - <2 nm up to 1100 nm,
 - <5 nm up to 1700 nm,
 - <10 nm max up to 2500 nm
- Sun and Sky/Ground/Moon measurements
- Calibration : Bougher-Langley + SI traceability on radiances
- Total field of view identical to the photometer: 1.3°
- Signal-to-Noise Ratio >100, excluding absorption bands
- Max measurement time : 6 s → for a map of 900 angles = 2 h

Hyperspectral radiometer



System specifications

- Light two-axis robotization, to be put on top of a 10 m mast → Vicarious Calibration
- Local raw data pre-processing, storage and transmission of data by mobile comm / IP...
- Low power (on solar panel)

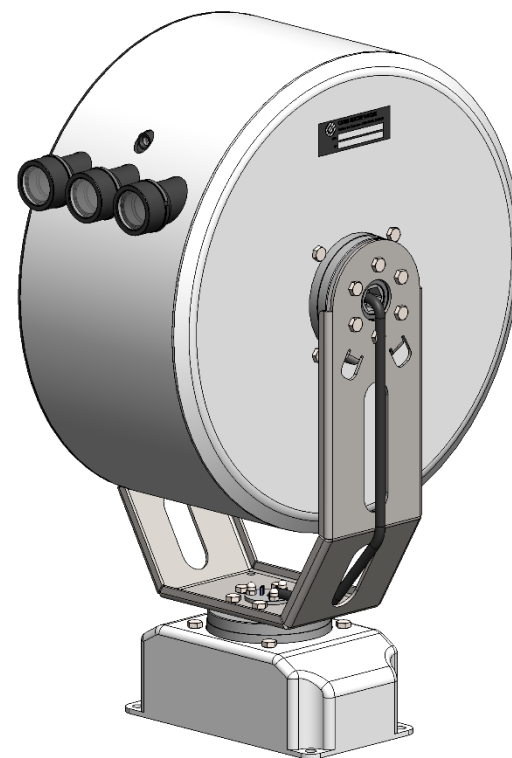
Challenges

- Thermal regulation with low power consumption
- Performance in 1700 to 2500 nm range
- Straylight ?

Project proposed in QA4EO-2

Optimized optical design to improve

- Temperature dependence
- Spectral dependence of FOV
- Spectral straylight
- Signal to Noise Ratio



Photometer extension to UV and O₃ measurement

Objectives

Expand AERONET multi-spectral photometer capabilities

- Extend AOD measurements in the UV down to 300 nm for better retrieval of aerosol absorption properties
- Monitor Total Column Ozone (TCO)

Status

- Preliminary study shows there is enough sensitivity
- Proposal under QA4EO-2

Many challenges

- Get enough Signal to Noise ratio
- Algorithms to retrieve Total Concentration in Ozone
- Compromises on filter band specifications
- High out-of-band filter rejection
- Avoid self-fluorescence of filters
- Correct the temperature dependence

Other improvement projects

- Aerosol profiling
- Mobile instrument

CO2 Hyperspectral photometer

Objectives

A new hyperspectral Sun photometer

- Dedicated to CO2 total column and profile
- Cost-effective for continuous observation
- Application : **emission and sink control**, carbon credit certification

Status

- Detection technology : Sensitivity proven by **POC**
- Experience in CO2 retrieval

Many challenges

- Get enough Signal to Noise ratio
- Algorithms to retrieve Total Concentration in CO2
- High sensitivity detection system
- Eliminate spectral straylight

Micropulse DiAL for Water vapor profiles in the PBL

Project

- Objective : a new cost-effective micro-pulse DiAL for water vapor.
- Targeted performance : 5 km range day and night
- Eye-safe

Status

- Collaboration started between CIMEL, LCF (Orsay) and LATMOS (CNRS)

Solution

- DiAL approach (Differential absorption LiDAR)
- DiAL wavelength: 828 nm : ON and OFF very close
- Also measurement of aerosol backscatter

Micropulse DiAL for LOW TROPOSPHERE Ozone

Objectives

- New low cost micro-pulse DiAL for tropospheric & PBL O₃.
- Applications : Air quality and meteorology, Research

Status

- Collaboration between CIMEL, LCF and LATMOS.
- POC has been succesful
- 1 doctorant

Solution

- DiAL approach
- Two wavelengths : 266 – 289 nm (obtained by a hollow fiber)





MHR Camera

IDEAS-QA4EO

Multispectral Hemispherical Radiometric (MHR) camera

Objective : A new « MHR camera »

- An *in situ* Multispectral Hemispherical Radiometric Camera
- Design for in-air and in-water applications in rough environments
- Radiometrically calibrated and characterized
- Applicable for unattended operations at fixed locations or on mobile platforms
- Target price < 50 k€

Context

- Funded by **ESA** IDEAS-QA4EO
- **JRC Marine Optical Laboratory** supporting radiometric calibration and characterization
- Benefitting from **previous Cimel experience** with the CE600 submarine camera (2005 – 2015)

Multispectral Hemispherical Radiometric (MHR) camera

Status

- 35 scientists interviewed
- Report on applications delivered
- List of requirements
- System design : running

Project outline

- 2 prototype cameras characterized and calibrated → June 2025
- Validation campaigns in the 3 domains → Sept 2025 to mid-2026
- Camera commercially available for order → beginning 2027

Multispectral Hemispherical Radiometric (MHR) camera

Main applications: Earth Observation Cal/Val and Research in 3 observation domains

Land (Vegetation/Snow)	Ocean and in-land waters	Atmosphere
Validation and inter-calibration of satellite data products	Validation of satellite ocean color data products	Determination of the sky radiance distribution
Determination of the in-air upward and downward radiance fields	Determination of the in-water upward and downward radiance fields	Assessment of radiative transfer models , Cloud mapping + classification
Characterization of the BRDF of natural surfaces	Characterization of the BRDF of natural waters	Aerosol optical and physical properties retrieval

Other applications

- Earth Energy Balance
- Canopy Validation
- Air pollution monitoring
- Night light pollution
- Ground-to-space laser communications
- Astronomy

MHR CAMERA

Main Technical Specifications

Instrument features

- 184° full-angle field-of-view (fisheye)
- Combination of 2 cameras for full spherical field (under water)
- Radiance dynamics suitable for daylight applications over natural waters
- Sky radiance measurement at 2° from Sun
- Measurement of direct Sun irradiance (attempted)
- Measurement time per spectral band between 0.1 s up to 1 s for low radiance signals
- Temperature stabilized
- Small size to minimize self-shading for in-water applications

Output data products

- Absolute radiance distribution at 12 spectral bands: 380 to 1100 nm
- Radiometric uncertainty less than 5% (k=1)
- Angular resolution less than 1°
- Polarization is a possible option

MHR CAMERA

Main Technical Specifications

Calibration and characterization

- **Radiance** calibration performed using standards traceable to **NMI**
- Geometric characterization
- Roll-off dependence
- Linearity of response
- Polarization sensitivity

Field operations

- Automated with remote control
- Data storage and transfer via internet/telecom in near-real time
- Suitable for deployments at fixed locations or on mobile platforms.
- 12 volts power via a single cable for data and power

Environmental ranges

- Outdoor temperature from - **30°C to 50°C**
- Depth up to 100 m for in-water applications

MHR CAMERA

Main Identified Technical CHALLENGES

- 2 switchable systems : for both aerial and marine applications
- Achromatic design in the whole band 340-1100 nm
- Thermal management of
 - Optics → radiometric stability
 - Sensor → SNR optimization
- Low self-shading (very compact)
- Direct Sun measurement ?
 - with no saturation
 - Radiometric measurement

CONCLUSION

General objective

- Develop **high quality reference** instruments for research and cal/val
- **Operational and cost effective**
- ➔ Collaborative projects to develop data processing and validate in the field

Improvement of existing instruments

- **Photometer** : Aeronet improvements (**UV, profiling, mobile**)
- **High power Lidars**: Remote controlled calibration for **automatic operation**
- **Micro lidars**: robust **mobile** compact, **synergy** retrievals with photometer

New technologies ➔ mock-ups

- Cost effective DiAL Lidar for **Ozone TC**
- Cost effective DiAL Lidar for **Water vapor TC**
- Cost effective **CO2 TC** hyperspectral photometer

Under development ➔ Prototypes

- **Hyperspectral** radiometer up to **2500 nm** ➔ 1st prototype in dec. 2024
- **MHR camera** ➔ prototype calibrated in S1 2024 ➔ Validations

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