ESA-JAXA Pre-Launch EarthCARE Science and Validation Workshop

13 – 17 November 2023 | ESA-ESRIN, Frascati (Rome), Italy

Science and Cal/Val Campaigns – Overview

S. Gross and J. Delanoë (and all PIs)

Needs from L2-developers

- Lidar measurements of **Mie and Rayleigh signal** preferable
- Simultaneous **lidar measurements of low depol and high depol measurements**
- Depolarization measurements at 355 nm (532 would work with potential additional uncertainties during conversion)
- **Macrophysical properties** (PBL height, multi-layer aerosol scenarios, broken clouds and aerosols, multi-layer cloud scenarios
- Run L2 algorithms on **airborne and ground-based** measurements
- Simulation of **non-EC products** e.g. to compare with measurements at different wavelengths
- Extinction and IWC/LWC needed (for simulations / closure)
- AOT measurements from ground (e.g. AERONET) and satellite (e.g. MODIS, VIIRS, …)
- Ground-based **remote sensing along flight track**
- **Imager** measurements
- **Synoptic** observations
- **In-situ** measurements (underflights along EC flight track)
- **Airborne microwave** measurements
- **Polarization radar** measurements and **precipitation radar** scans

—> Different meteorological conditions, different clouds, different aerosol situations

Proposals including campaign activities – airborne

AOID/EVID	PI	activities	location	time
38188/03	Wandinger	Airborne campaign dedicated to EC validation (PERCUSION) with **EarthCARE-like payload on HALO** – potential of **combined with ATR42 measurements**	Cape Verde, Barbados Europe	Summer/Fall 2024
		Airborne **lidar and in-situ** measurements on **HALO** during **ASCCI** and **lidar** measurements during **NAWDIC**	High-Latitudes	Early 2025
			Extratropical NA	2026
		Airborne **in-situ** measurements on **HALO** during **HALO-South** (not funded for validation)	Southern Ocean	Fall 2025
		EarthCARE-like payload on HALO for ACI (STACCATO) and for measurements in the Arctic regions (CONIDA)	Subtrop. SA	Fall 2027
			High-latitudes	2028
38810/10	Delanoë	Airborne **EarthCARE-like + in-situ measurements** for ACI and EC validation (MAESTRO) combined with HALO and during NAWDIC as opportunity campaign	Cape Verde	Summer 2024
			Extra-tropical NA	2026
38935/19	Josset	Airborne lidar measurements (not funded yet)	Not defined	Not defined
39205/26	Tanelli	Airborne radar measurements	Not defined	Not defined
?	Nicolae / Stachlewska	Airborne campaign with MULTIPLY (multi-wavelength HSRL) system	Romania / Mediterranean	Not defined
39821/31	Qu	Airborne 94 GHz radar, 355 nm backscatter lidar and radiometer measurements on Convair-580	Arctic/North America	Proposed campaign before EC launch
39873/32	Hostetler	Airborne HSRL-2 measurements (also in combination with ground-based measurements in the Mediterranean)	Not defined	Not defined
			Mediterranean	Not defined
60799/35	Phillips	Airborne radar measurements	??	??

O : Day 4: Th., 16 Nov 12:18,12:30, 12:42, 15:03 & P16-22

O : Day 4: Th., 16 Nov 12:42 & P22

P34

O : Day 4: Th., 16 Nov 9:54 & 16:18 & P57

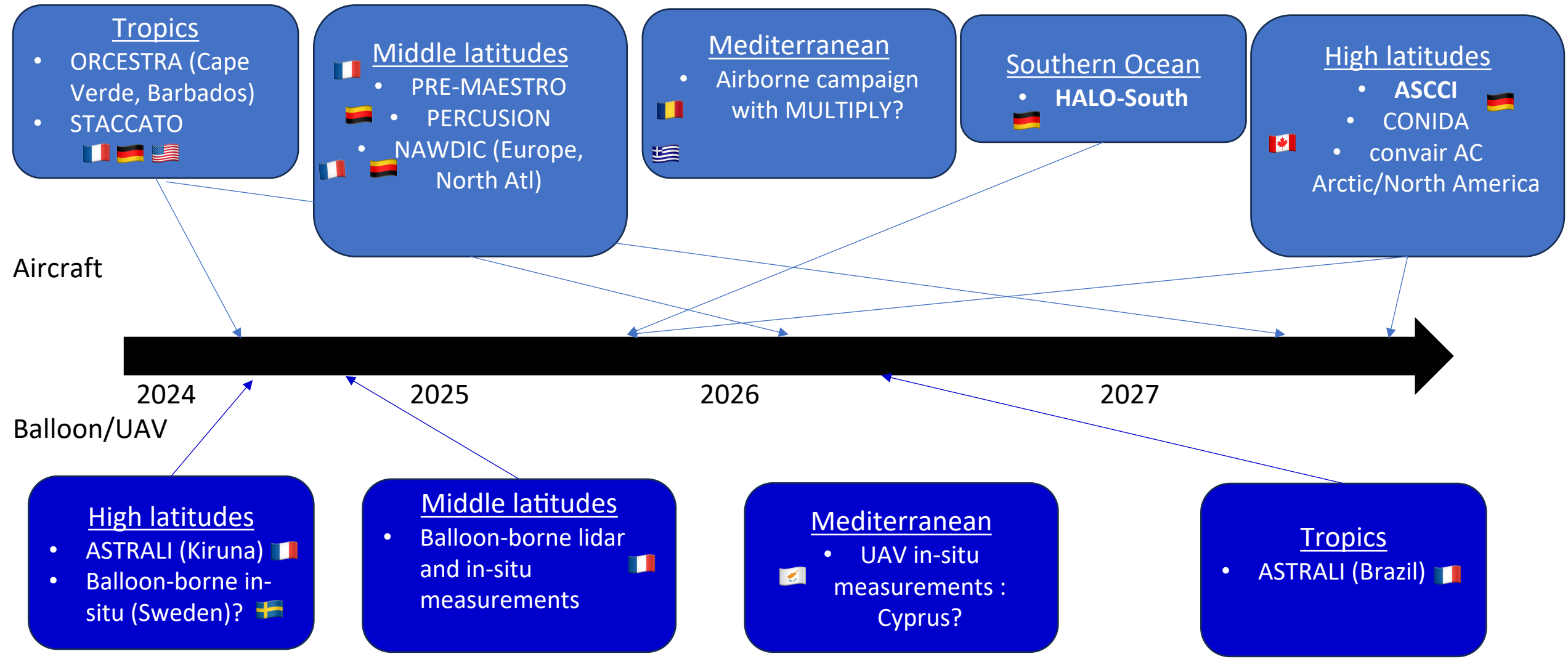
O : Day 4: Th., 16 Nov 9:42

O : Day 4: Th., 16 Nov 2023 9:30 & P37

Proposals including campaign activities – balloons and UAVs

AOID/EVID	PI	activities	location	time
38810/10	Delanoë	**Balloon-borne lidar radar X + W-Band radar** O : Day 4: Th., 16 Nov 12:42 & P22	Kiruna/ Brazil	June 2024 - 2026
38809/09	Renard	**Balloon-borne lidar** measurements O : Day 4: Th., 16 Nov 11:48 & P21	Launch site in France	2024
39067/20	Hu	**UAV** measurements with **dropsondes, radiometer and THz Radar and lidar** for cloud observations P29	Chinese South Sea	Every summer
51515/33	Voelger	**Balloon-borne in-situ** measurements (in combination with ground-based lidar) P38	Northern Sweden	On occasion
91949/33	Mamouri	UAV in-situ measurements (in combination with ground-based lidar, radar and radiometer measurements) P44	Cyprus	??

⚠ Only fully identified are included



Proposals including campaign activities – ground based

AOID/EVID	PI	activities	location	time
38810/10 O : Day 4: Th., 16 Nov 12:42 & P22	Delanoë	**Mobile ground systems – BASTA (W-Band radar) and BALI (scanning BASTA + ulidar)**	mobile	Already running (on demand)
		Scanning **C-Band (POLDIRAD) and W-Band (BASTA)** radar	Southern Germany	Starting 2022
38623/04	Genthon	**Ceilometer measurements "on hold"**	Antarctica	To be updated
38909/18	Gausa	**Radar and lidar measurements**	Northern Norway	To be updated
51515/33	Voelger	**Lidar** measurements (in combination with balloon in-situ measurements) P38	Northern Sweden	On occasion
39183/23	Amiridis	Ground-based PANGEA station (**lidar, cloud radar, MWR, Radiation**) O : Day 4: Th., 16 Nov 10:24 & P32	Eastern Mediterranean	ongoing
	Sicard	**Lidar** deployments during different campaigns	Not defined	Not defined
	Stachlewska	**Lidar measurements** in Poland and possibility for campaign participation in Romania O : Day 4: Th., 16 Nov 16:18	Eastern Mediterranean	ongoing in Poland
38188/03 O : Day 4: Th., 16 Nov 15:03, 12:42 & P16	Wandinger	**Cloud Radar, MW-Lidar, MWR, Radiation measurements**	Cape Verde	ongoing
			Melpitz	ongoing
			Antarctica	2022-2024
		Mobile **LACROS** system (Radar, MWL, Radiation)	New Zealand	2025

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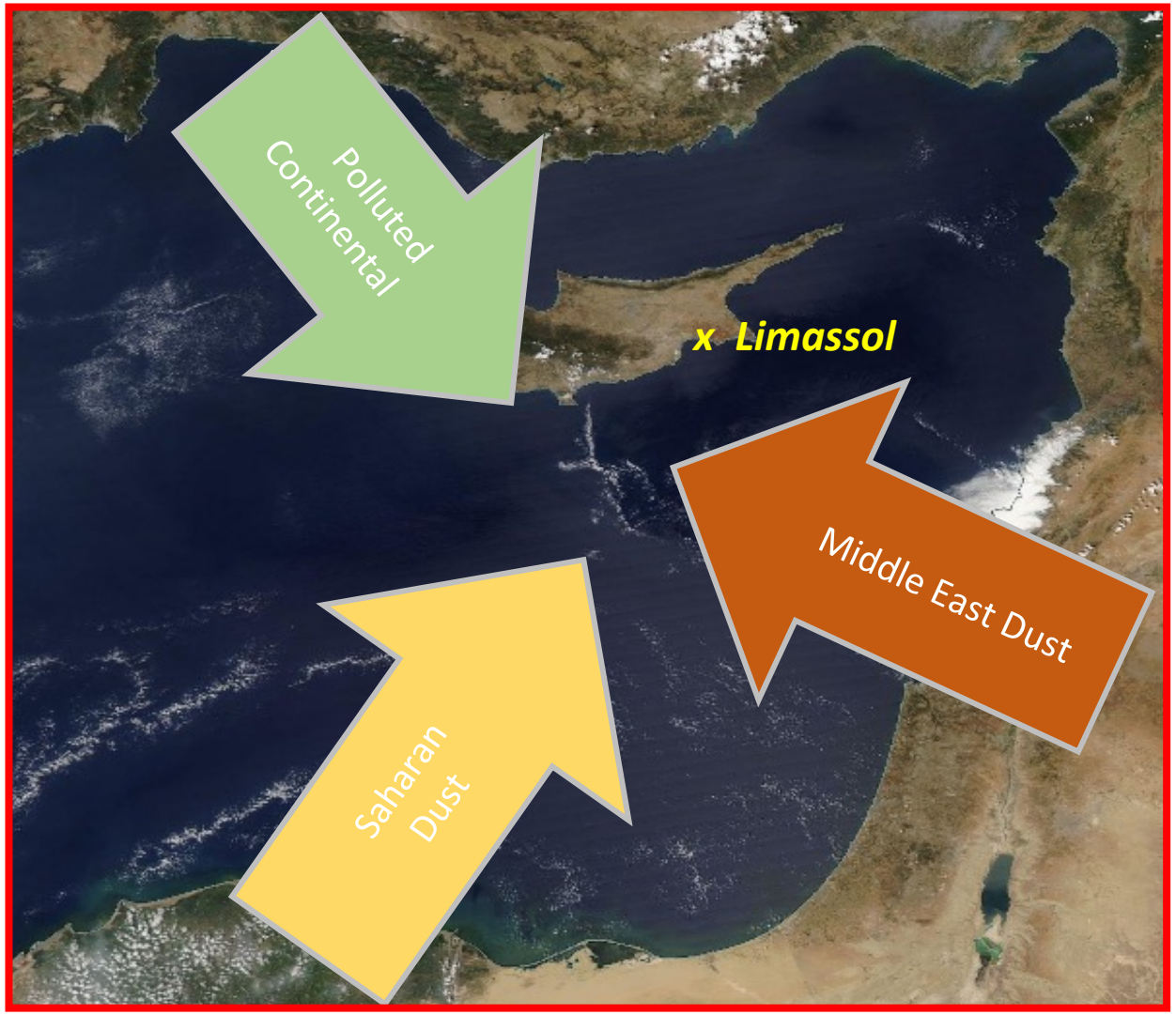
A few illustrations

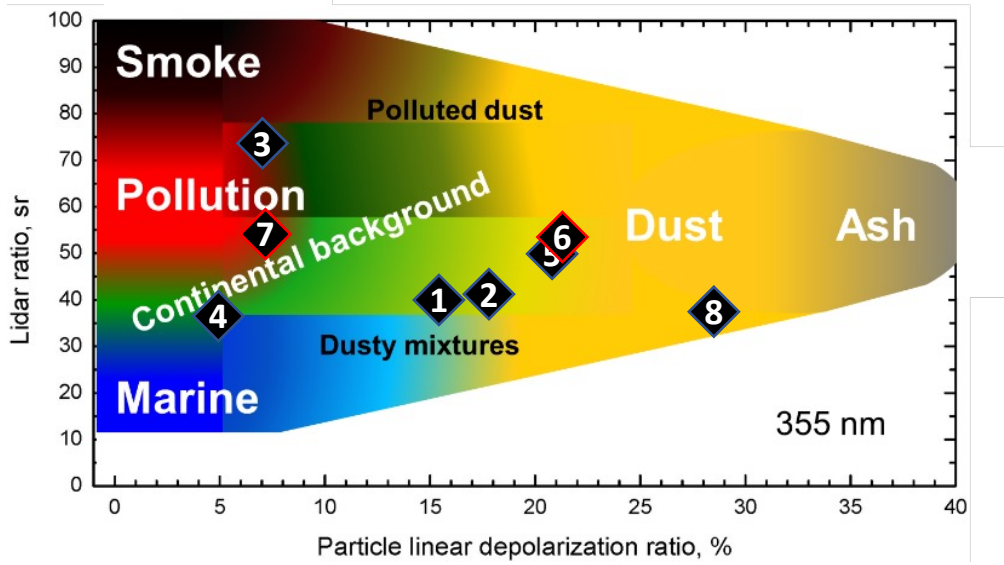
Proposed EarthCARE validation in the Eastern Mediterranean – Lidar, radar and UAVs (in-situ)



Combining ongoing ground-based remote sensing measurements with UAV in-situ measurements

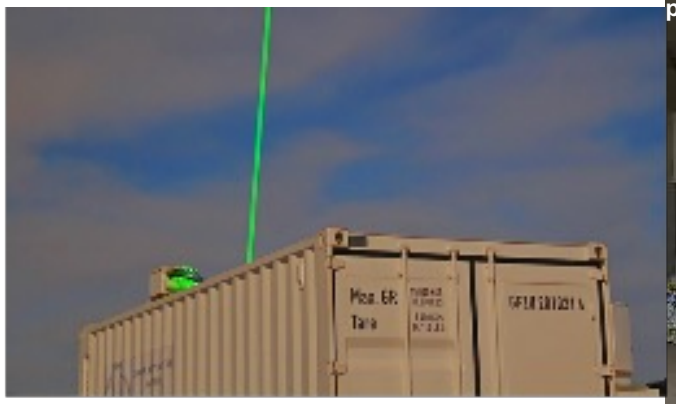
Requirements

- Heavy aerosol load
- Small box in Eastern Mediterranean



Proposed EarthCARE validation in the Mediterranean – ground-based lidar, radar and possibility for airborne measurements

PANGEA
PANHELLENIC GEOPHYSICAL OBSERVATORY FOR CLIMATE STUDIES



Measurements in PANGEA **since September 2018**

- AERONET station
- Polly XT-NOA EARLINET lidar:
  3 backscatter coefficient (355, 532,1064nm)
  2 extinction coefficient (355, 532nm)
  2 depolarization ratios (355/387, 532/607nm)
  1 water vapor mixing ratio (407/387nm)
  + near field channels
- Real time quicklooks (https://polly.tropos.de/)
- Products in EARLINET database

- Combination with other ground-based stations intended
- airborne RS and in-situ measurements in planned at different periods with different airplans

Proposed EarthCARE validation in the Mediterranean – MULTIPLY airborne and ground-based lidar/radar measurements

MULTIPLY is an ESA-ESTEC project for the development of a novel multi-wavelength HSRL system (3b + 2a + 3d) for both ground based (ready in 2022-phase 1) and airborne operation (phase 2: 2023-2024).
Partners: National Institute of Research and Development for Optoelectronics (Romania), Max-Plank Institute (Germany), National Observatory of Athens (Greece), Warsaw University (Poland)

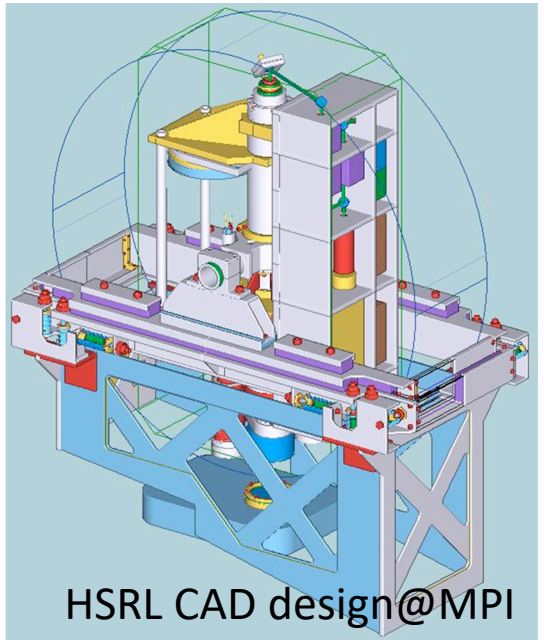
Target of the HSRL: better than EarthCARE specifications

- raw signals:
  - 7.5 m vert. res.
  - 50 m horizontal res.
  - 1-1.5% accuracy
- backscatter
  - 7.5 m vert. res.
  - 500 m horizon.res.
  - 10% accuracy
  - detectability 0.0005-0.0008
- extinction
  - 100 m vert. res.
  - 5000 m horizontal res.
  - 10-15% accuracy
  - detectability 0.02-0.05
- depolarization
  - 7.5 m vert. res.
  - 500 m horizontal res.
  - 10% accuracy
  - detectability 0.02

Main features: 3β + 3α + 3d

- Implementing Fabry-Pérot Interferometers for HSR filtering at 355 and 1064 nm
- Implementing iodine filtering technique at 532nm
- Narrow field-of-view receiving
- Low laser pulse energy (to conform the eye-safety requirements).
- High laser pulse repetition rate (to increase the total number of sounding photons emitted to
- measure individual lidar profile).
- Decoupling spectral separation unit (interferometers, iodine filter) from telescope with optical
- fibers (to allow better mechanical stability).
- Implementing extra telescopes for depolarization channels.
- Additional “near”-range telescope (to extend dynamic range).

ATMOSLAB – C 90 GTx own by *National Institute of Aerospace Research “ELIE CARAFOLI” (Romania)*.


HSRL CAD design@MPI

Proposed EarthCARE validation in the subtropics –airborne EarthCARE-like measurements

Validation strategy

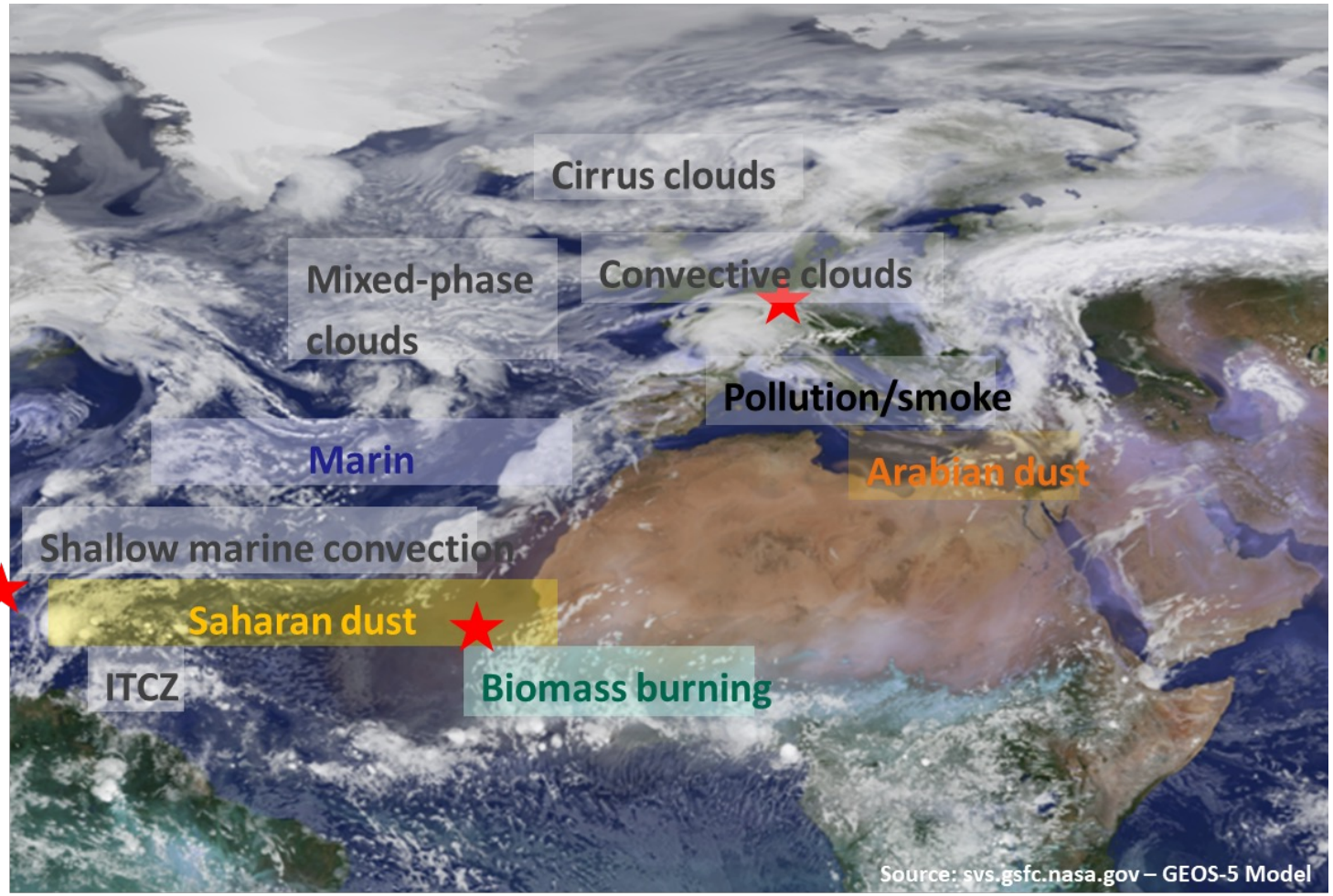
Campaign period – August to November 2024

Campaign locations

- Germany: Dedicated validation flights
- Barbados: ITCZ, Trades
- Cape Verde: ITCZ, Trades

Campaign duration:
9 weeks of active measurements

- ~246 flight hours (incl. transfer)
- ~ 5-6 flights / 50 flight hours from Oberpaffenhofen (6 underpasses)
- ~ 10 flights / 100 flight hours from Barbados (8 underpasses)
- ~ 10 flights / 96 flight hours from Cape Verde (9 underpasses)



Proposed EarthCARE validation in the subtropics – airborne EarthCARE-like measurements

Airborne tandem-platforms

HALO

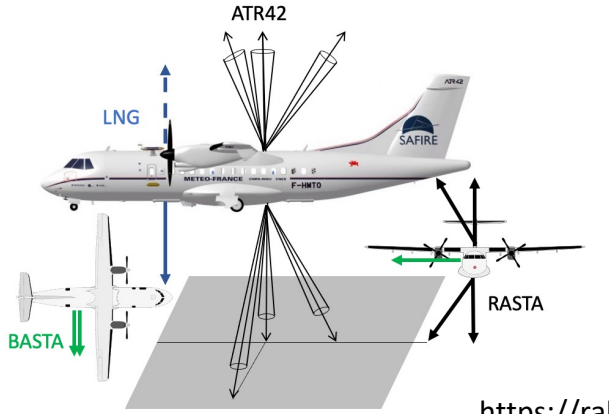
Aircraft:

- Modified Gulfstream G550 business jet
- Endurance: **> 10 flight hours**
- Maximum cruising altitude: **> 15 km**

Payload:

- **High spectral resolution lidar** (532 nm) and water vapor DIAL
- **Doppler Cloud Radar** (35 GHz)
- Hyper-spectral **radiometer (specMACS)**
- **Microwave** radiometer
- Radiation measurement (IR measurements newly added)

SAFIRE



https://rali.aeris-data.fr/

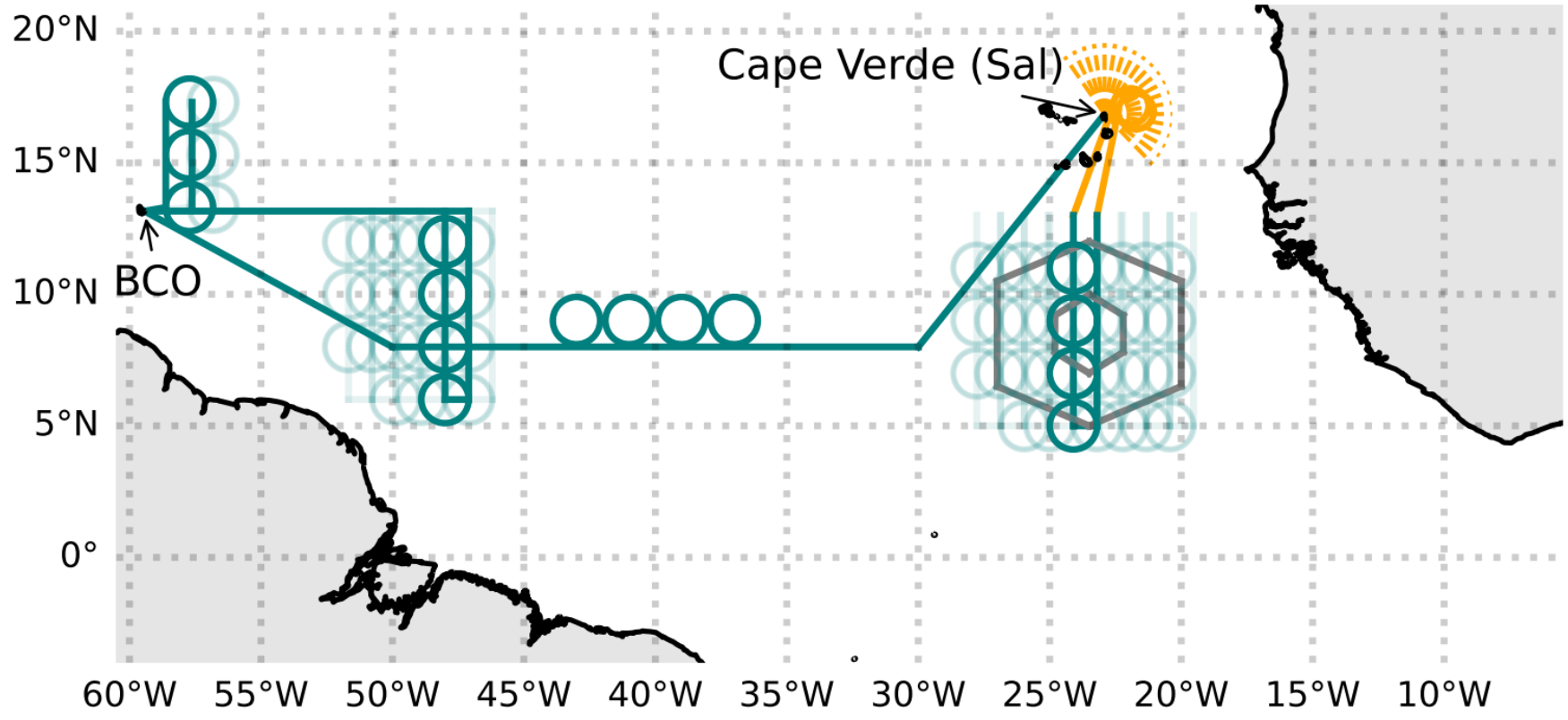
Aircraft:

- ATR 42-320
- Endurance: **4.5 (max 6) flight hours**
- Maximum cruising altitude: **7.5 km**

Payload:

- **High spectral resolution Doppler lidar** (355 nm)
- **2 Doppler Cloud Radar** (95 GHz), 6 antennas (3 up/ 3 down)
- Sideward looking W-band Doppler radar/ 355nm lidar
- IR radiometer
- **Large in-situ payload**

Validation strategy in tropics / sub-tropics



- It is planned to have **co-located flights with French ATR** out of Cape Verde. (**MORECALVAL – J. Delanoë**)
- ATR will be equipped with **radar-lidar + in-situ** payload
- Measurements will be supported by shipborne measurements (**BOWTIE – Julia Windmiller**)

→ **Each flight will incorporate an EarthCARE underflight**

Proposed EarthCARE validation campaign – Go-South-II

Lidar Observations of Spatio-TEmporal Contrasts in Clouds and Aerosols in Lauder NZ

Leipzig Aerosol and Cloud Remote Observations System (LACROS)
Instruments: PollyXT mutiwavelength polarization Raman lidar, HALO Doppler lidar
Location: Bluff (Invercargill, southern tip of South Island)
Schedule: Planned for boreal spring 2021. Postponed due to COVID-19.
Now: 2025 together with HALO-South

Lauder Atmospheric Research Station
(NIWA: National Institute of Water and Atmospheric Research (Taihoro Nukurangi) of New Zealand)
Unique ~30 year lidar data set with polarization lidar data since 2009
(532 nm, 532 nm depolarization, 1064 nm, DIAL)

Goal: evaluate inter-hemispheric contrasts in the cloud-relevant properties of aerosols and impacts on the microphysical properties of clouds

Summary

- Activities planned in the **high-latitudes, mid-latitudes, Mediterranean and Tropics**
- Joint effort **combining ground-based remote sensing with airborne remote sensing and in-situ measurements** at different locations
- Multiple aircraft campaigns (**different WL, combined RS and in-situ**) needed and planned
- **Limited availability of aircraft in-situ measurements** especially for aerosol measurements