Land Surface Temperature Monitoring LSTM Mission

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EUROPEAN UNION
opernicus
Europe's eyes on Earth
esa
The Sentinel
family grows
From a family of 6
To a family of 12
THE EUROPEAN SPACE AGENCY

PROGRAMME OF THE EUROPEAN UNION

esa

Food Security and Water Management

Monitoring Land and Natural Resources

CHIME

ROSE-L

LSTM

CIMR

Combatting Climate Change

Safeguarding the Arctic

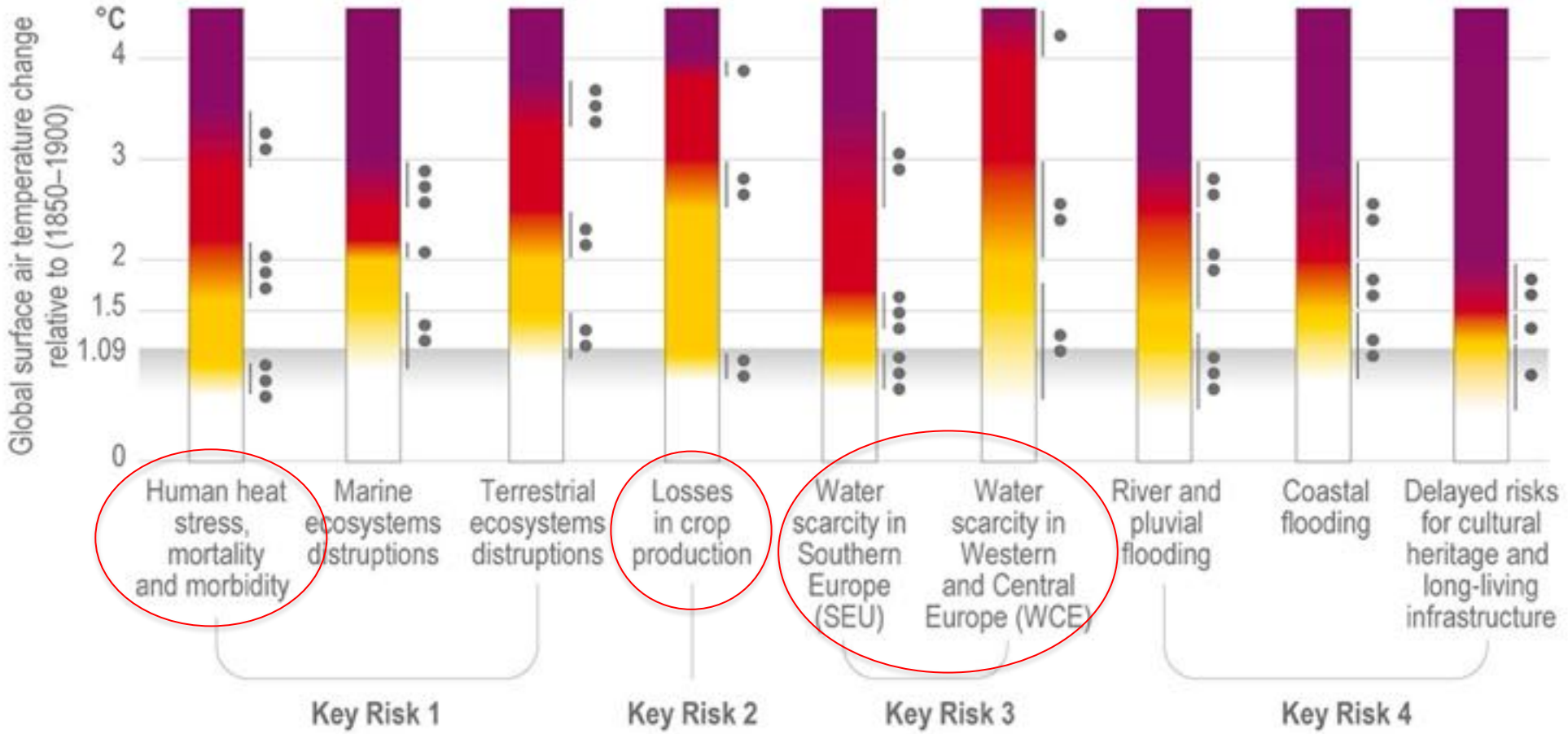
CO2M

CRISTAL

Strengthening Copernicus Space with the Sentinel Expansion Mission observations

Climate Change Impact & Adaptation

Key risks for Europe under low to medium adaptation



level of additional risk to society and ecosystems as a function of global temperature change. Confidence is provided for the change of risk level at given temperature ranges.

3 Key Climate Risks addressable by LSTM

Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the IPCC Sixth Assessment Report

LSTM Mission Objective

LSTM Mission Objective:

Provide high spatio-temporal resolution Thermal Infra-Red observations over land and coastal regions ***in support of agriculture management services,***
and a range of additional applications

LSTM Mission Key Features & Requirements

Key requirement*	
Geometrical revisit	2 days/2 satellites
Local time	13:00 (Europe) & night observations
SSD	50 m (37m at nadir)
Spectral Bands	5 TIR, 4 VNIR, 2 SWIR
Nominal swath	687 km, at 651 km altitude
Acquisition system	Whiskbroom scanner
Geo-location L1c	0.5 SSD (GCP) / 1 SSD (without GCP)
MTF	0.2-0.3
Data latency (L2)	6-12 hours
NeDT	< 0.15 K
ARA	< 0.5 K

User requirement**
Evapotranspiration (goal)

- Accuracy 15% [mm/day]
- Precision 5%
- Field scale [0.5 ha]
- Daily observations

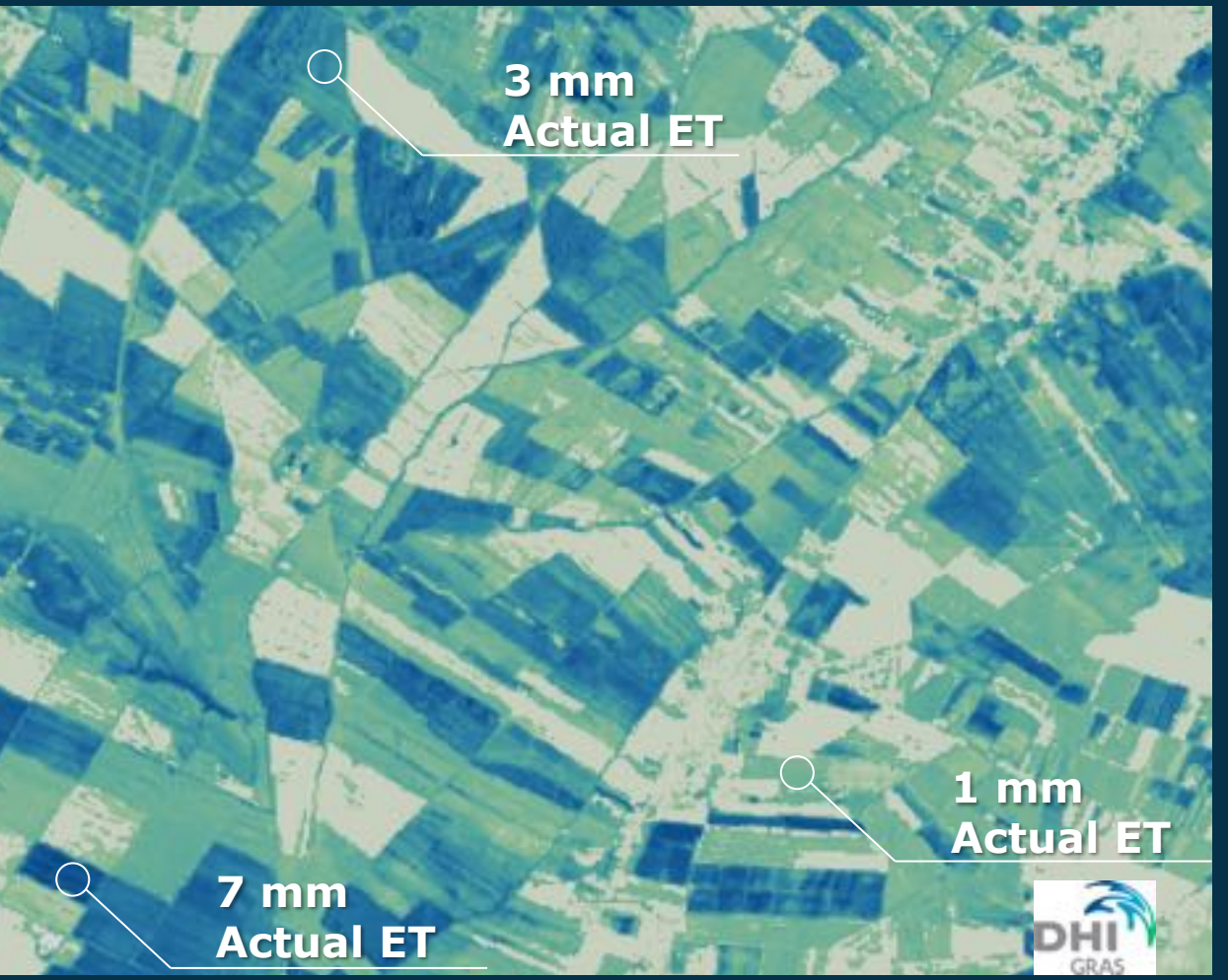
LST observations**

- 50 meters resolution
- 1-3 days revisit
- 1-1.5 K LST accuracy

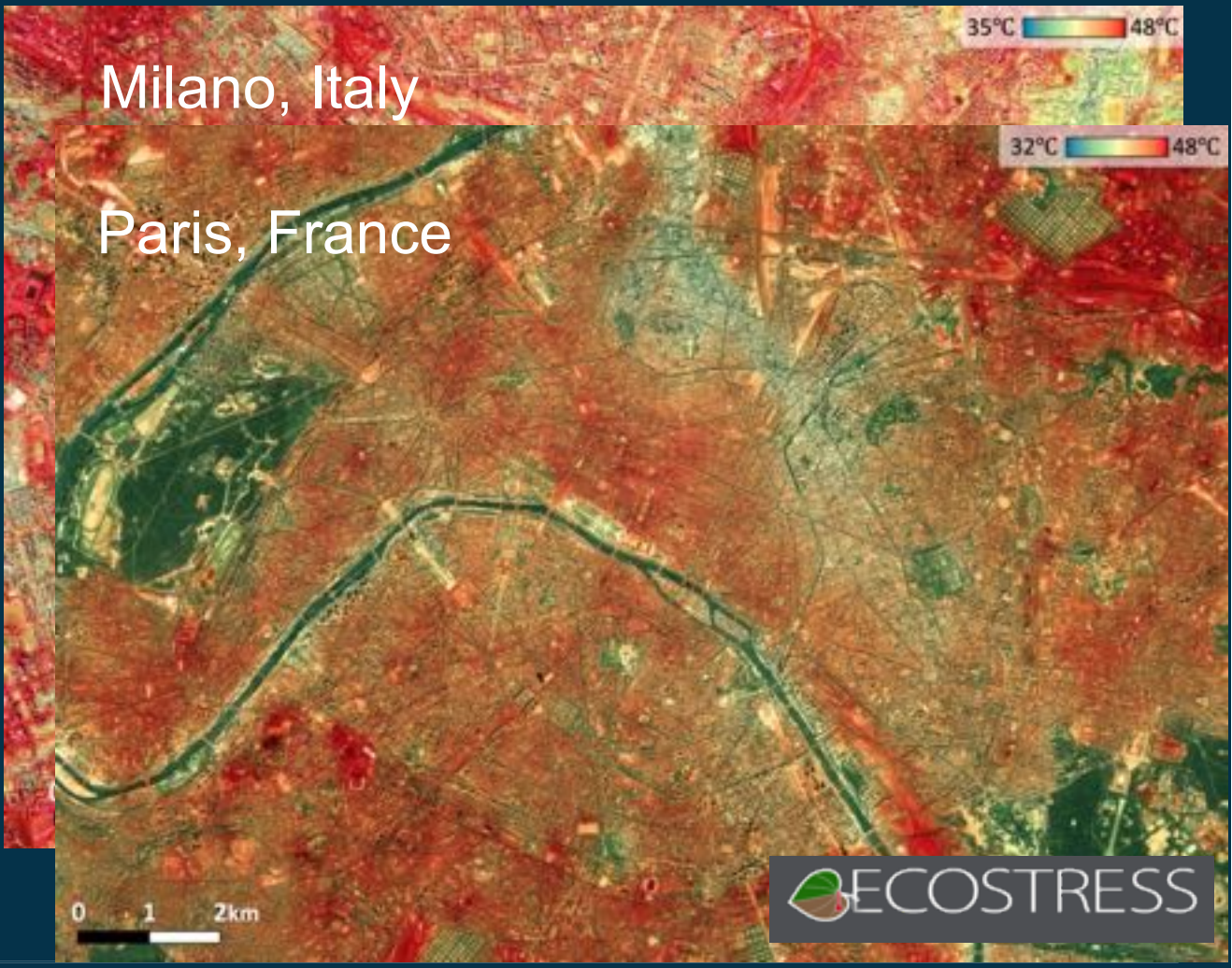
* Copernicus LSTM Phase B2/C/D/E1 System Requirements Document
**Mission Requirement Document V3
https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_Sentinel_Expansion_missions

LSTM Applications & Services

Water Productivity for sustainable agriculture



Urban Planning for Urban Heat Island



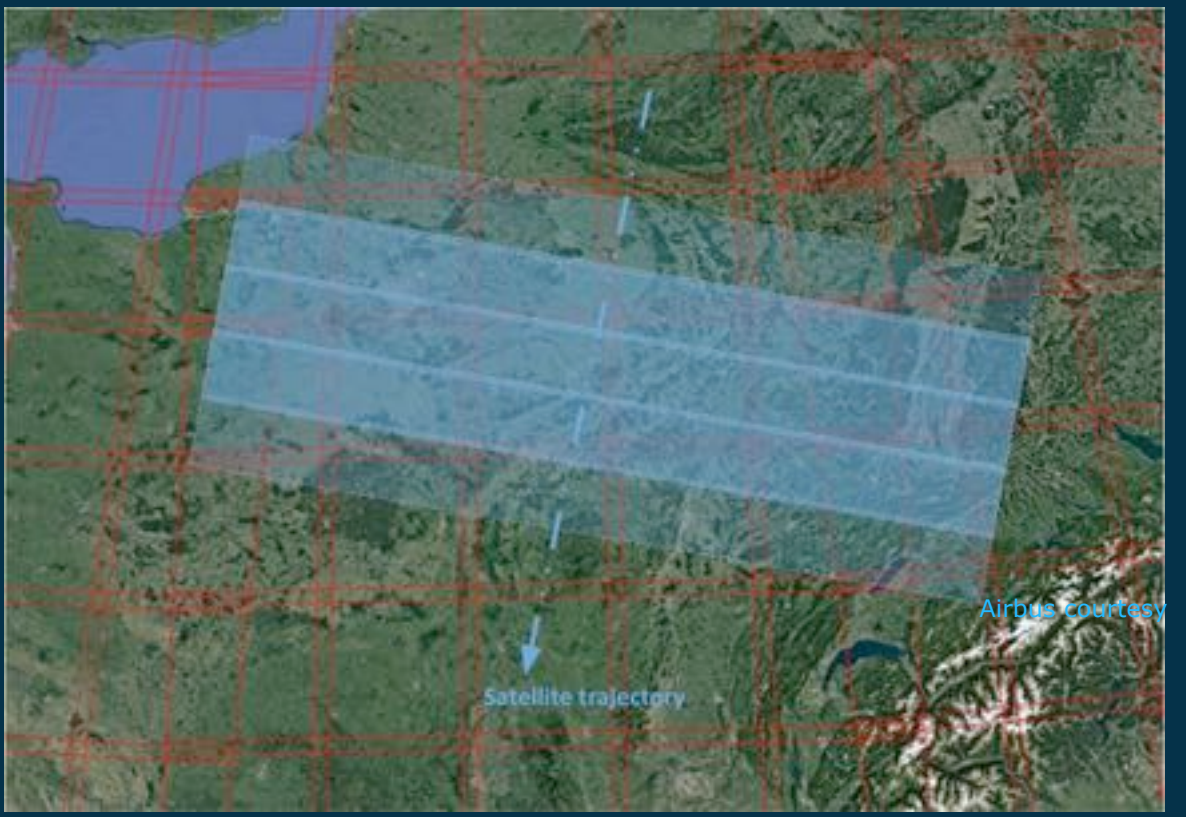
LSTM Data Products & Latency

The LSTM Level-1c products:

- Radiometrically & geometrically calibrated TOA radiance
- Top of atmosphere brightness temperature

The LSTM Level-2a products:

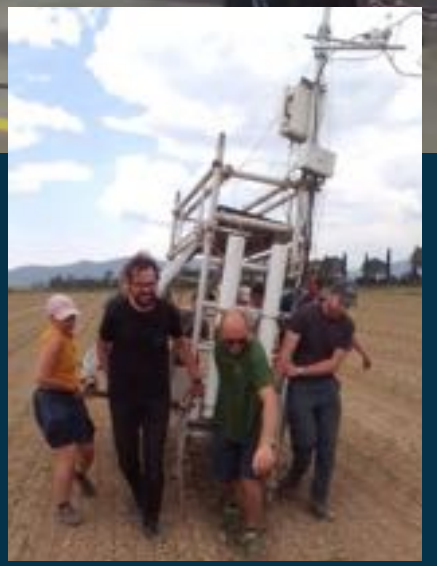
- Land Surface Temperature
- Land Surface Emissivity per TIR spectral band
- Bottom of atmosphere surface reflectance
- Total Column of Water Vapor (intermediate product required for LST retrieval)
- Cloud mask (intermediate product provided as a quality flag)



Maximum Data Latency

- Level-1c: 3 hours (goal) & 6 hours (threshold), highest priority over Europe and Africa.
- Level-2a (LST): 6 hours to 12 hours (TBC), highest priority over Europe and Africa.

LSTM 2021/23 Airborne Campaigns

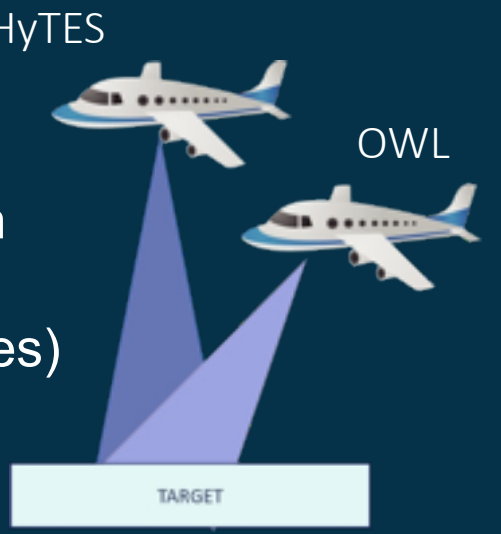


Objectives:

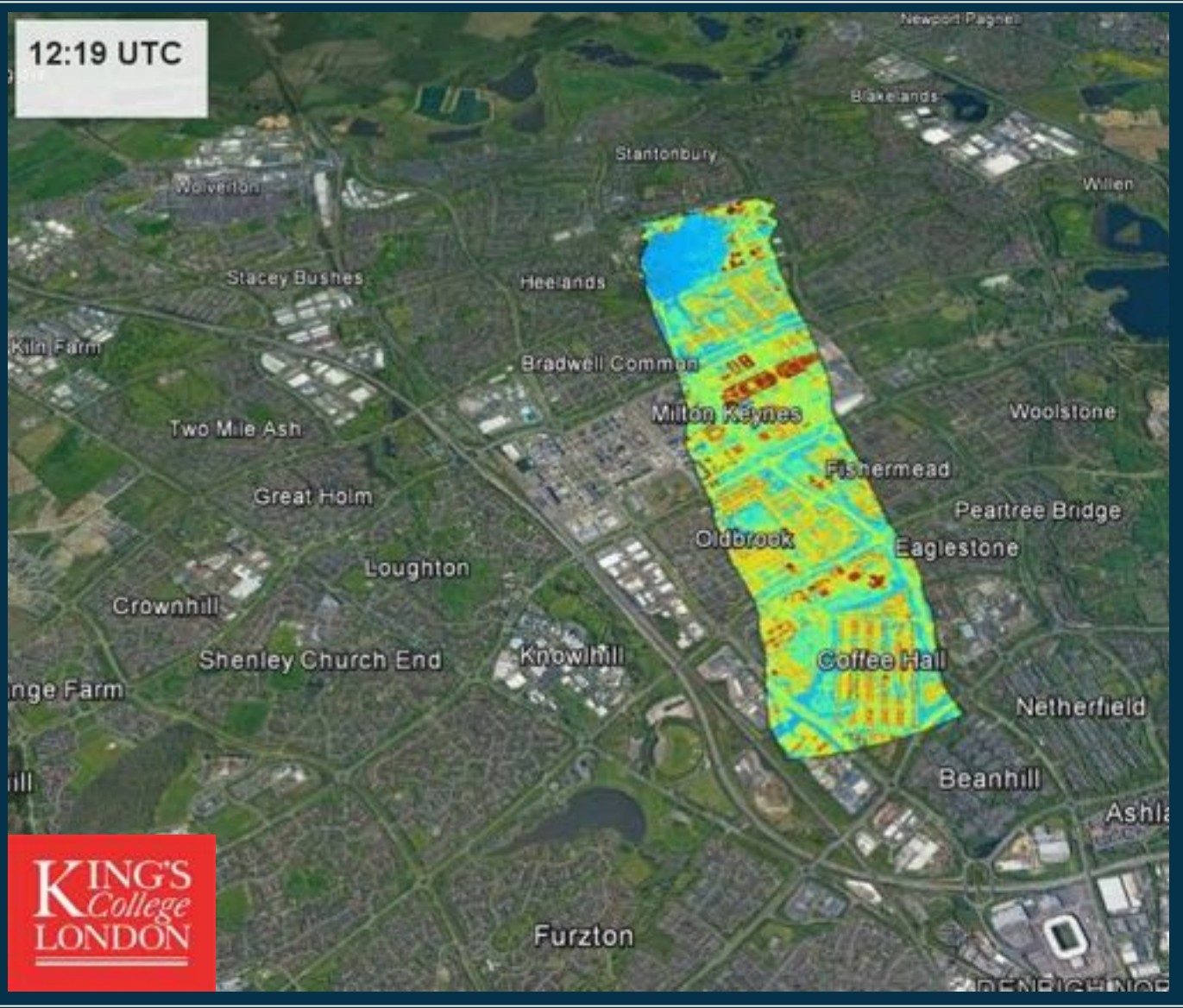
- Supports LSTM, SBG & TRISHNA missions
- Directionality experiments
- Urban & nighttime overflights
- Links to GEWEX LIASE & Methane campaign
- Coordinated ECOSTRESS acquisitions
- Open data policy fostering community exploitation

Campaigns:

- 2021: July/August
  - HyTES in UK and Sweden
  - TASI in Spain (LIASE)
- 2023: (foreseen with 2 airplanes)
  - focus on Italy & France
  - May & June



Airborne Campaigns: Thermal Directionality



Milton Keynes 22/07/21

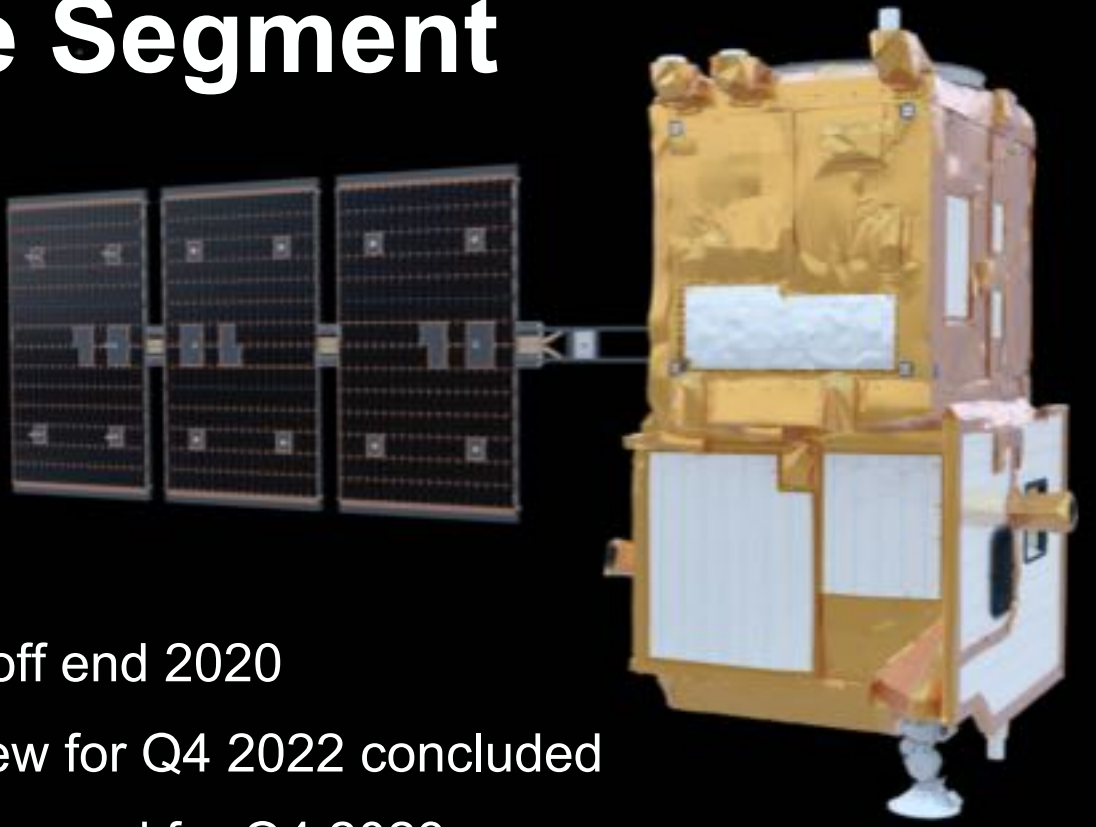
3 sets of parallel lines

1. Along solar principal plane
2. Along the perpendicular to solar principal plane
3. Along LSTM proposed orbital path

Parallel lines designed to have measurements over target at:
nadir,
+6, -6,
+12, -12,
+15, -15,
+18, -18 degrees VZA

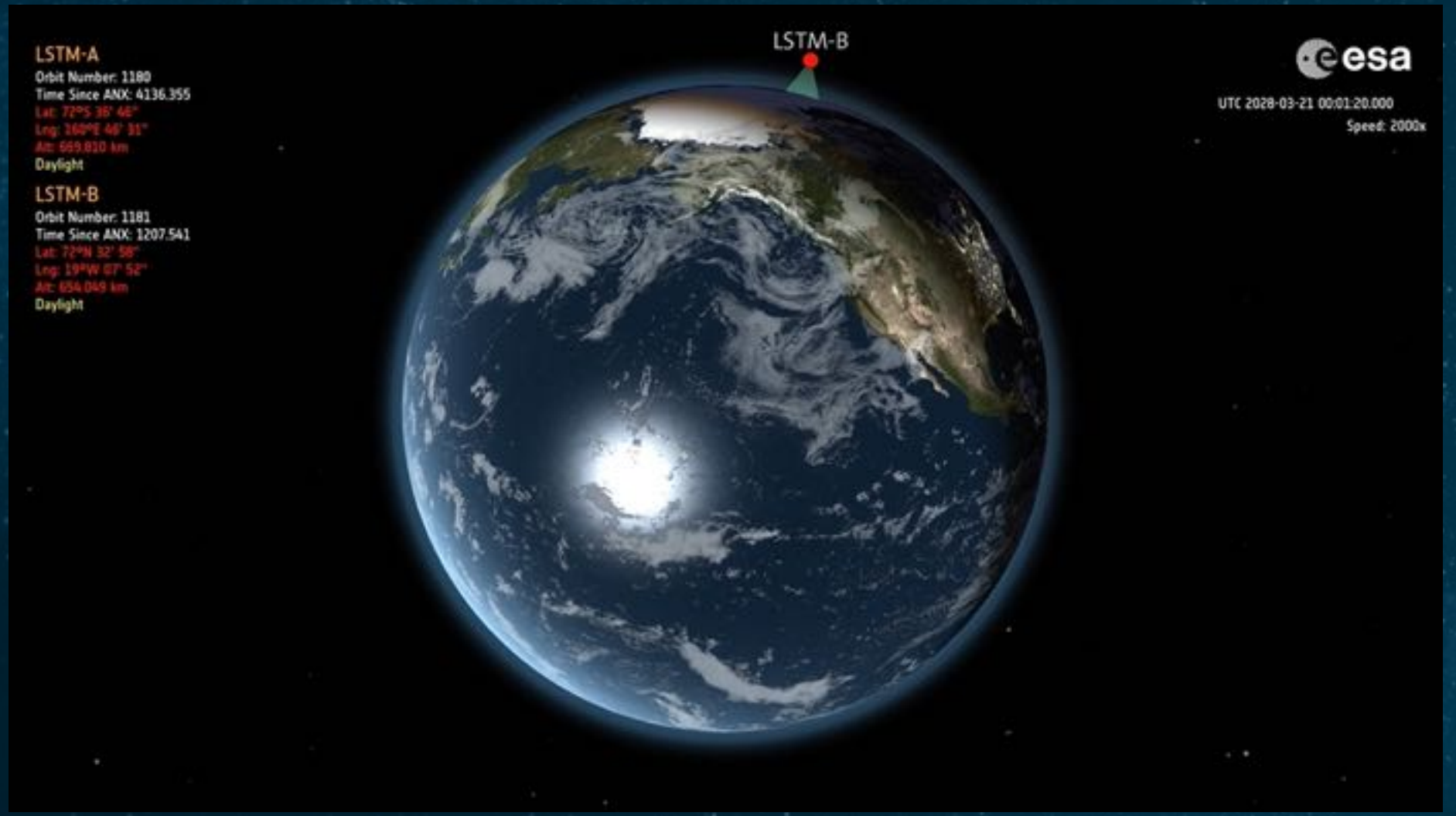
Cloud-free weather requirements

LSTM Space Segment



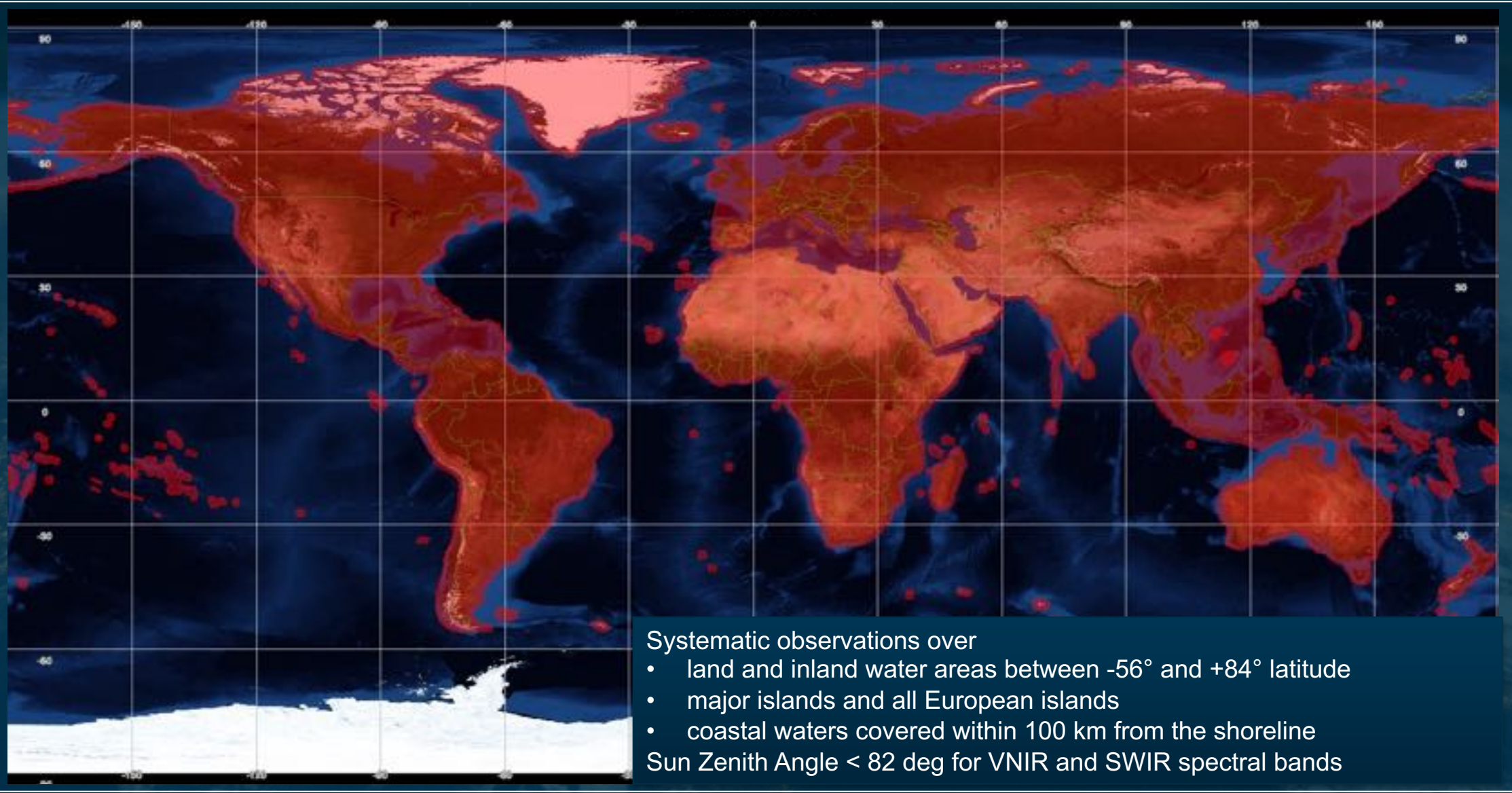
- LSTM phase B2 Kicked-off end 2020
- Preliminary Design Review for Q4 2022 concluded
- Critical Design Review planned for Q4 2023
- Prototype Flight Model QAR: End 2028

LSTM Mission Constellation



- 2 satellites
- MLST 12:30 at descending node
- Altitude ~ 651Km
- Revisit time 2 days
- SSD 50 m (37 at nadir)
- Geolocation accuracy, 25 m (with GCPs, 50 otherwise)
- Elevation angle 27.7 deg
- Max OZA ~ 30 deg

LSTM Acquisition Mask

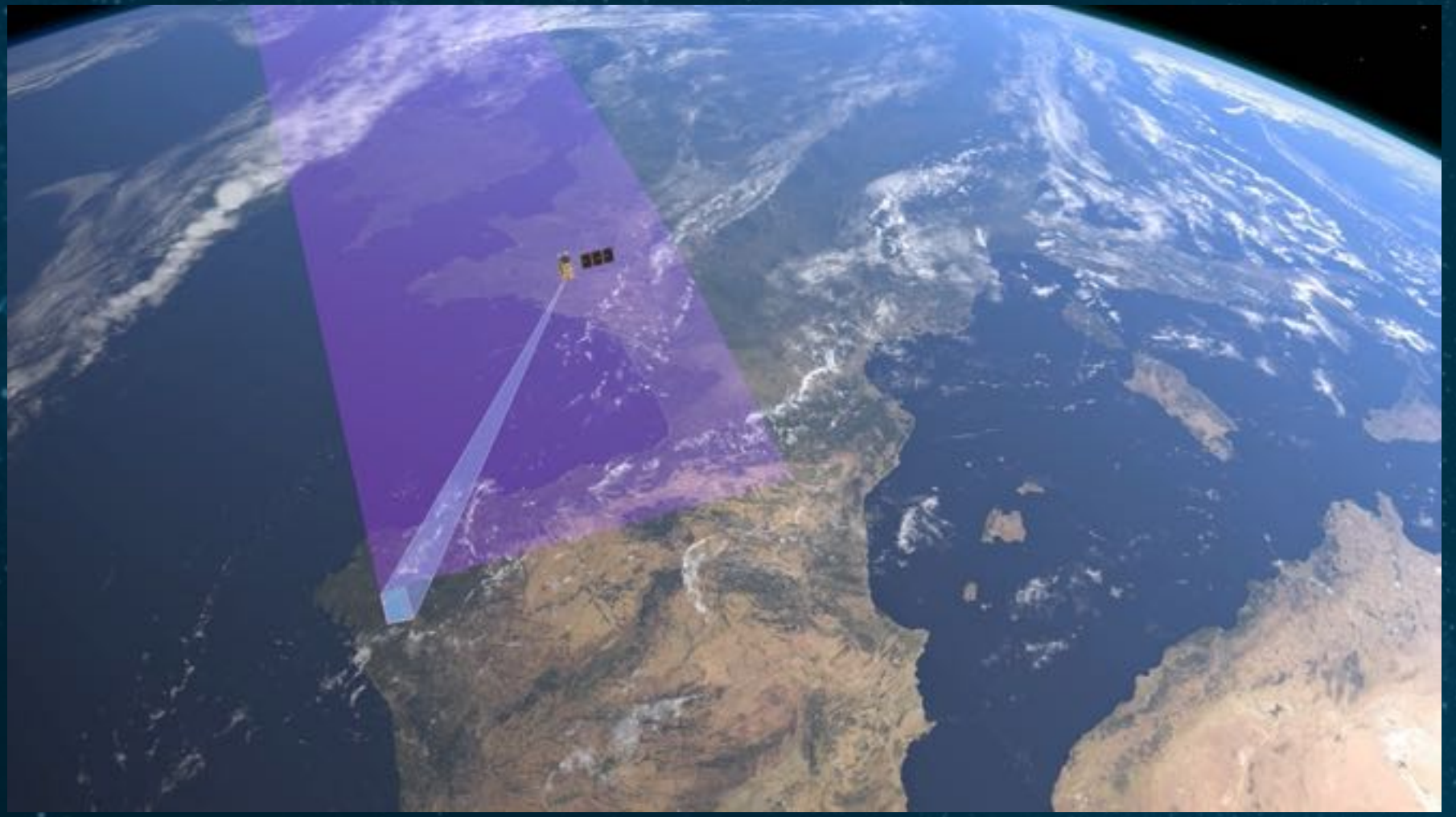


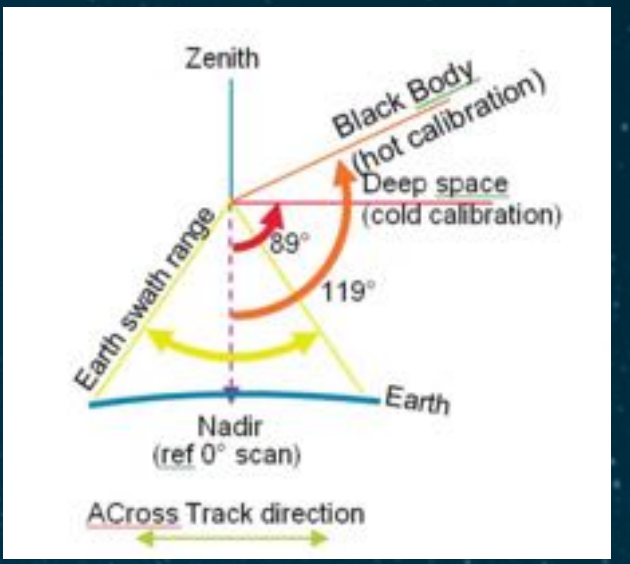
Systematic observations over

- land and inland water areas between -56° and +84° latitude
- major islands and all European islands
- coastal waters covered within 100 km from the shoreline

Sun Zenith Angle < 82 deg for VNIR and SWIR spectral bands

Wiskbroom acquisition concept



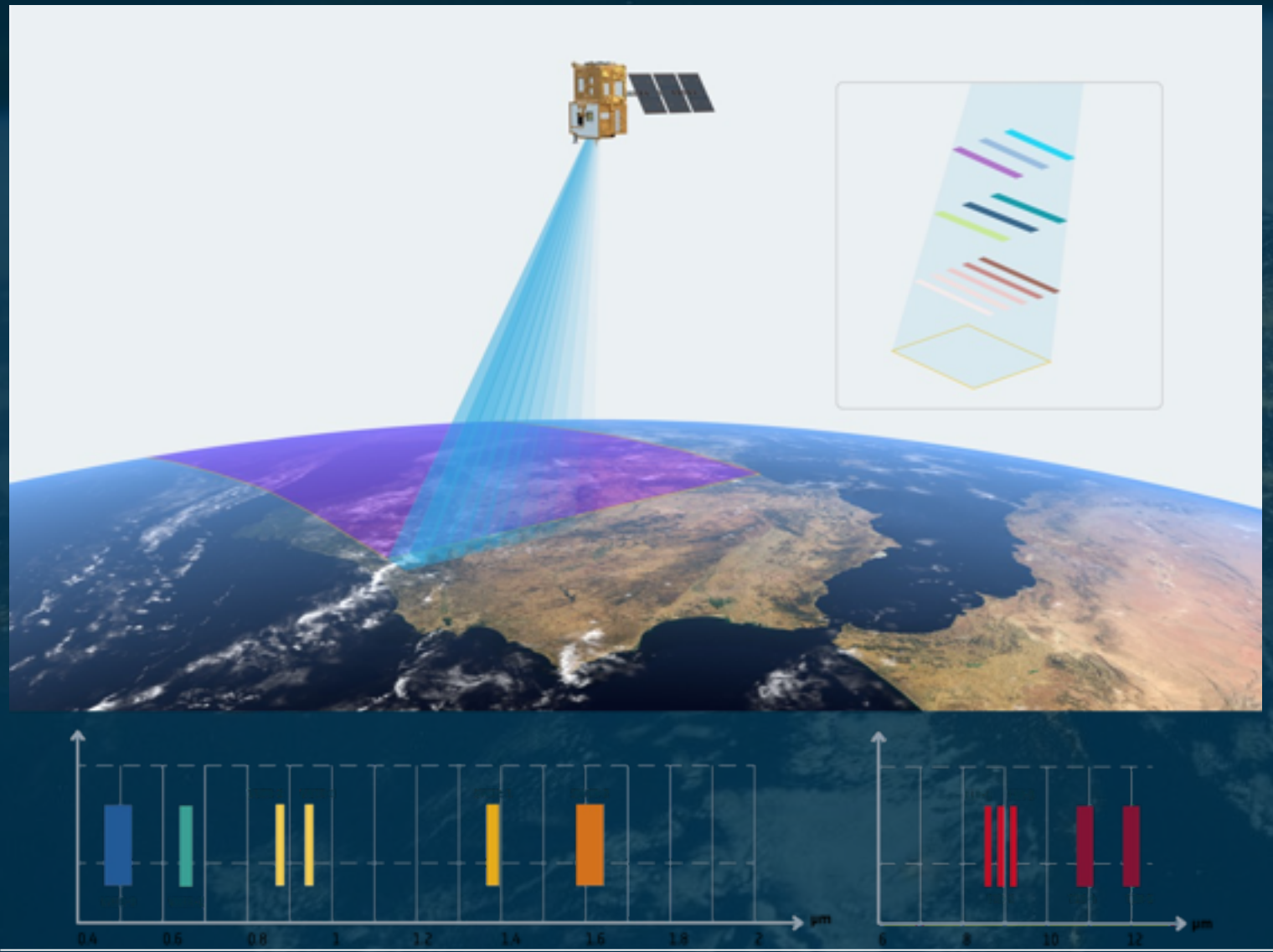


Picture: The LSTM instrument: design, technology and performance Francois Bernard et al. ICSO conference 2022

Instantaneous Field of View

Total Swath ~ 727 km swapped in ~4.5 seconds, Useful swath ~ 670 km

LSTM Instrument



- 11 Spectral Bands: one aperture 3 optical paths
- On board calibration: Deep space port, Black body
- MTF 0.2 – 0.3
- NeDT < 0.15k @ 300K
- ARA 0.5 K

VNIR0	0.490 µm
VNIR1	0.665 µm
VNIR2	0.865 µm
VNIR3	0.945 µm
SWIR1	1.380 µm
SWIR2	1.610 µm

TIR1	8.600 µm
TIR2	8.900 µm
TIR3	9.200 µm
TIR4	10.900 µm
TIR5	12.000 µm

INDUSTRIAL CONSORTIUM

AIRBUS Defense and Space S.A.U (ES)

is the Satellite prime with ~30 lower level subcontractors for the platform units and system support

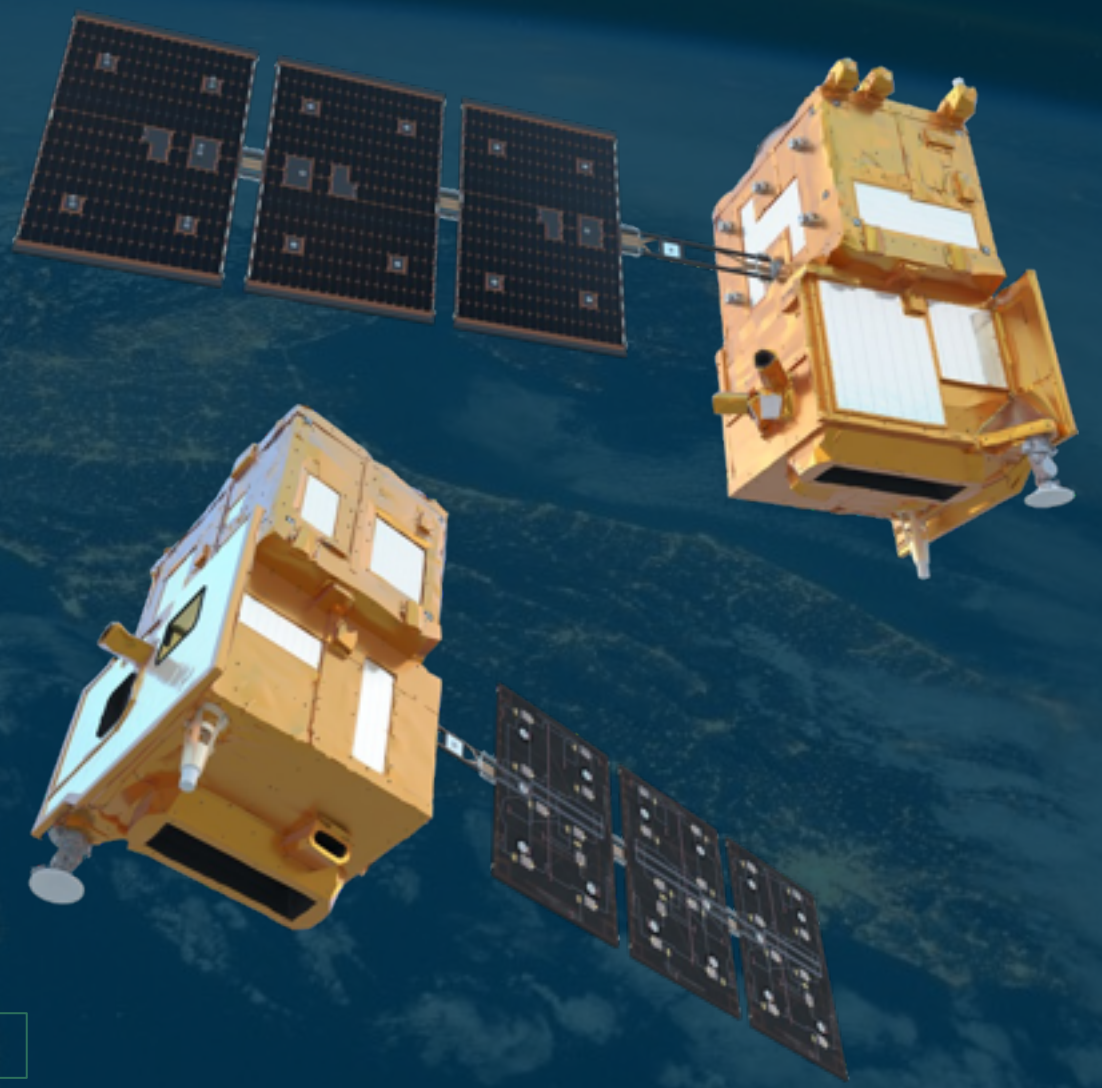
Supported by AIRBUS Defense and Space GmbH (DE)

for platform engineering support and common units procurement

AIRBUS SAS (FR)

is the Instrument Prime, with ~30 lower level subcontractors for the instrument units

SME's: 36% of the total consortium



International collaboration

Three missions harmonized as one
- Long Data Series
- Improved Revisit ➔ up to daily

TRISHNA
SGB
LSTM - A
LSTM - B

Synergies:
- Product Harmonization, ATBDs
- Orbit Coordination
- In-flight inter-comparison
- Common CAL/VAL approach
- Airborne Campaigns

Thank you for your attention