

# living planet symposium

BONN  
23–27 May  
2022

TAKING THE PULSE  
OF OUR PLANET FROM SPACE

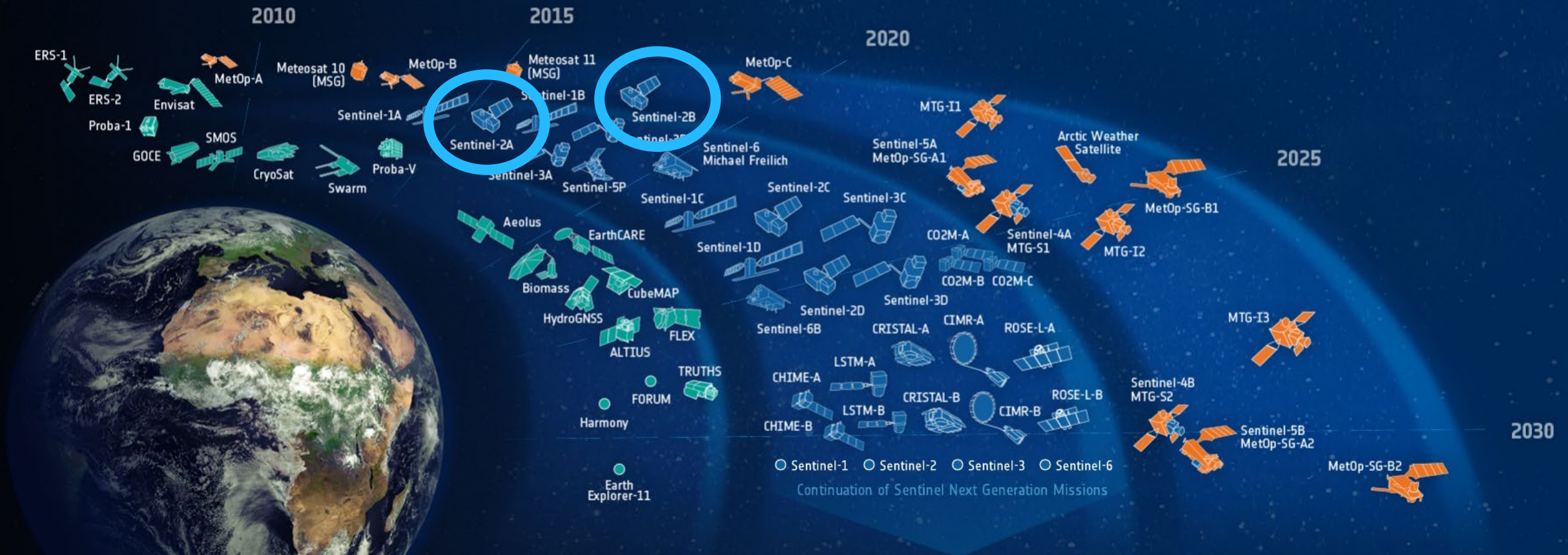


## The Copernicus Sentinel-2 Next Generation mission: enhanced continuity of high spatial resolution multi-spectral imagery

Marco Celesti, Matthias Drusch, Patrick Griffiths, Simone Rafano Carna, Arnaud Heliere, Roman Windpassinger, Armin Loescher

26/05/2022

# ESA-developed Earth Observation missions



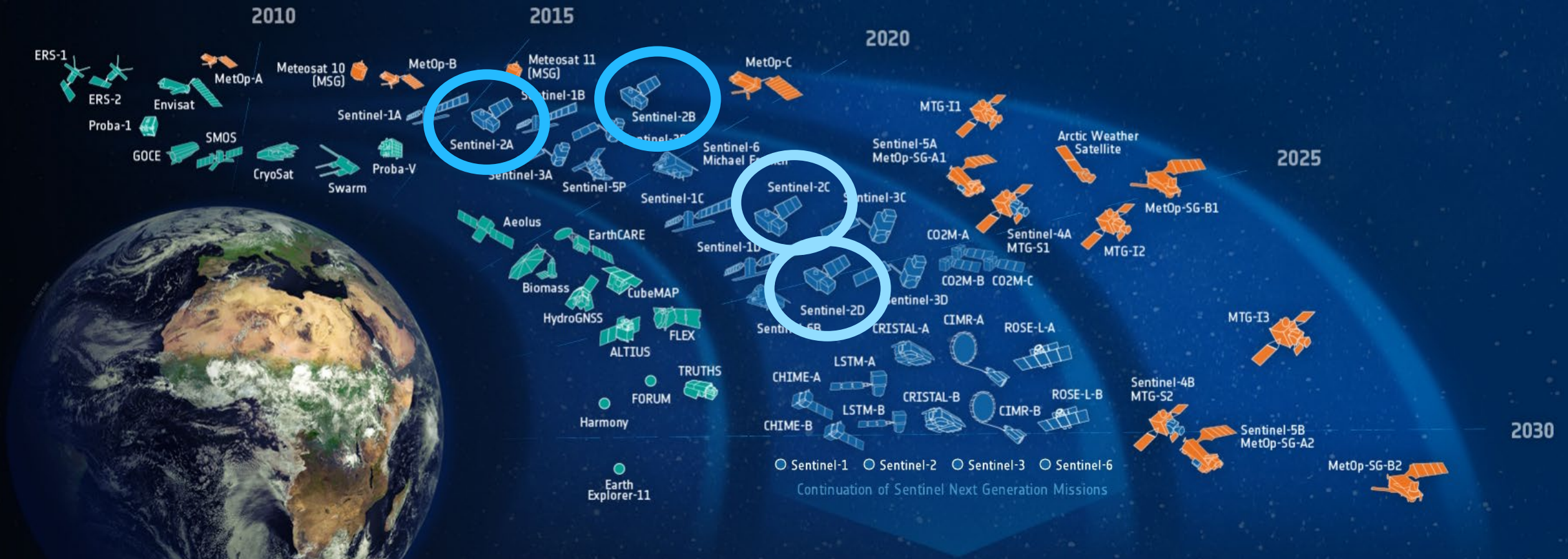
Science

Copernicus

Meteorology



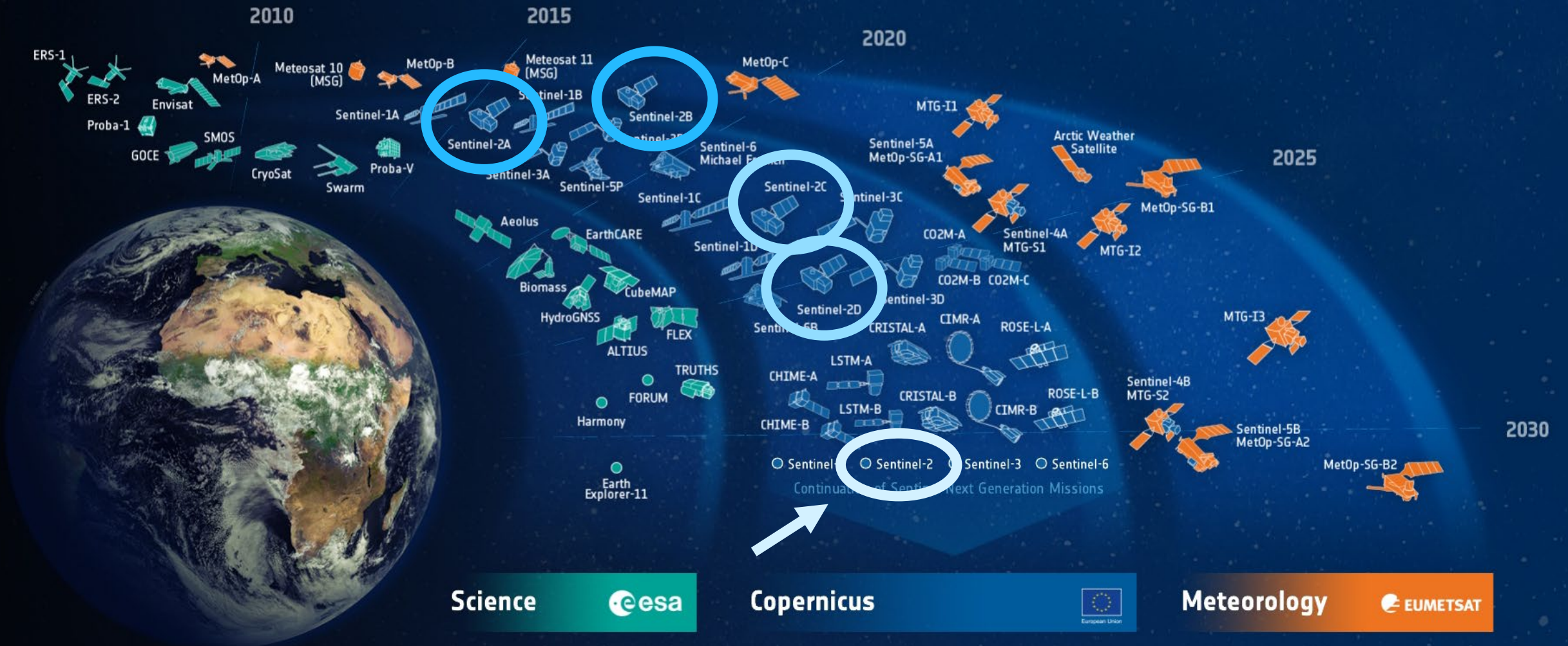
# ESA-developed Earth Observation missions



Science 
Copernicus 
Meteorology



# ESA-developed Earth Observation missions



## Mission Statement:

*Sentinel-2 NG will be the European wide-swath, moderately to high-resolution, multi-spectral imaging mission, exhibiting high radiometric accuracy, and designed to provide a high revisit frequency, thus maximising the number of cloud free acquisitions, and with a focus on land and coastal areas.*

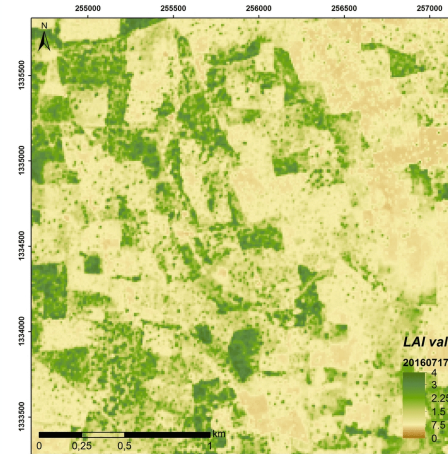
- Sentinel-2 Next Generation (Sentinel-2 NG) will ensure enhanced continuity of service for the current Sentinel-2 products
- Free-flyer carrying a single instrument → Advanced Multi Spectral Imager (AMSI)
- Complementary and synergetic to other Copernicus Missions (e.g., CHIME, LSTM, S-3 NGO)
- High degree of coordination with Landsat Next

# Standing on the shoulder of giants: Sentinel-2

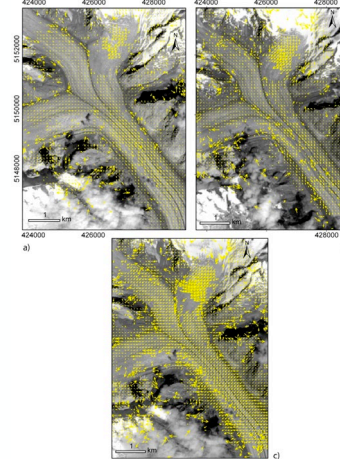


- ✓ Broad range of applications and high data quality satisfying needs from Copernicus Services (e.g. CLMS, CMEMS, CEMS), national services, scientific and commercial users

Type	Code	Description	Users
Core Products	Level-1B	Top-of-atmosphere radiances in sensor geometry	Expert users
	Level-1C	Top-of-atmosphere reflectances in cartographic geometry	All users
	Level-2A	Surface reflectances in cartographic geometry	
Pilot Products	Level-2H	Harmonised Landsat-8+Sentinel-2 surface reflectances in cartographic geometry	ON demand
	Level-2F	Fused Landsat-8+Sentinel-2 surface reflectances in cartographic geometry	

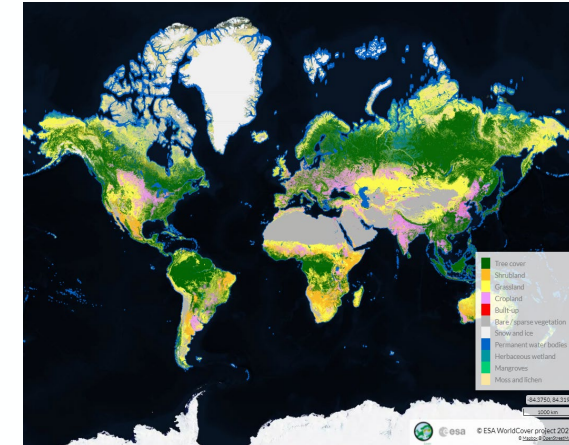


ESA Sen2-Agri

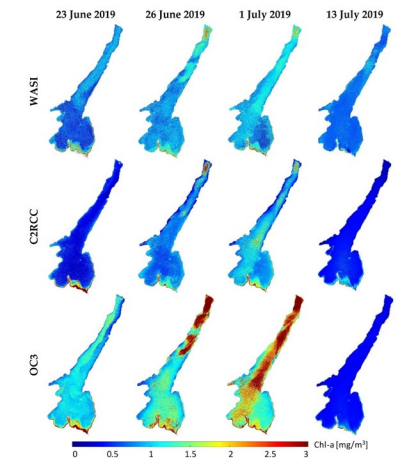


Kaab et al. (2016)

<https://doi.org/10.3390/rs8070598>



ESA WorldCover 10 m 2020 (w/ S1)



Niroumand-Jadidi et al. (2021)

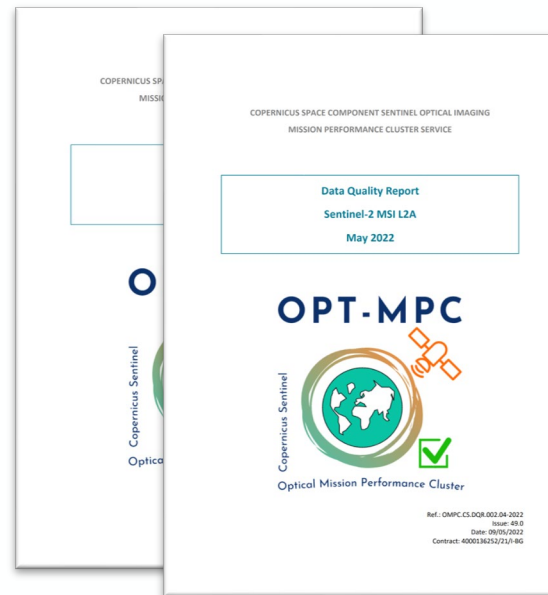
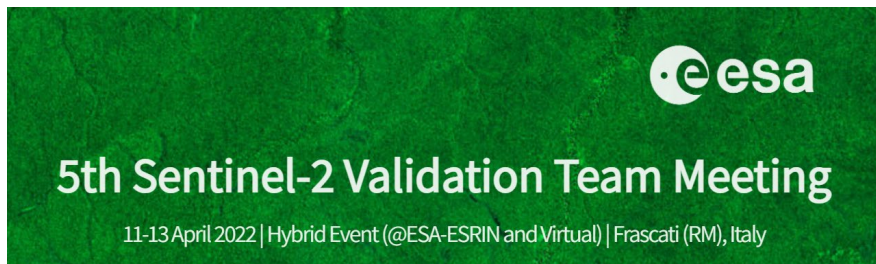
<https://doi.org/10.3390/rs13122381>



# Standing on the shoulder of giants: Sentinel-2



- ✓ Broad range of applications and high data quality satisfying needs from Copernicus Services (e.g. CLMS, CMEMS, CEMS), national services, scientific and commercial users
- ✓ Good health of both Sentinel-2A and Sentinel-2B satellites

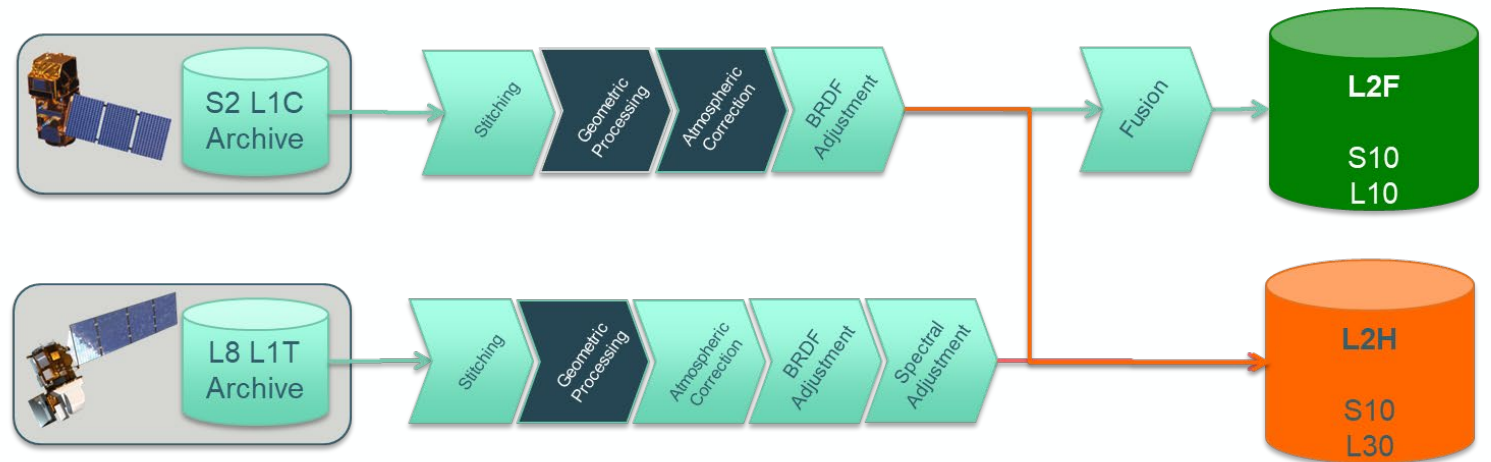
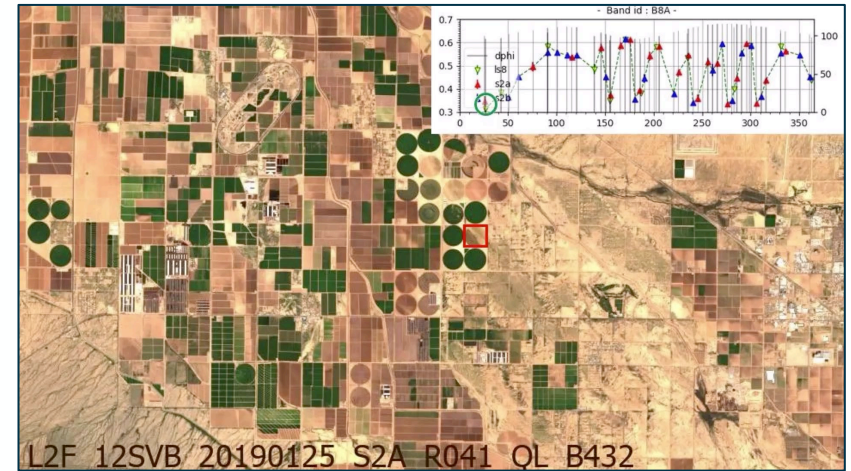


<https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2/mission-status>



# Standing on the shoulder of giants: Sentinel-2

- ✓ Broad range of applications and high data quality satisfying needs from Copernicus Services (e.g. CLMS, CMEMS, CEMS), national services, scientific and commercial users
- ✓ Good health of both Sentinel-2A and Sentinel-2B satellites
- ✓ Increasing interoperability with Landsat





# Standing on the shoulder of giants: Sentinel-2

- ✓ Broad range of applications and high data quality satisfying needs from Copernicus Services (e.g. CLMS, CMEMS, CEMS), national services, scientific and commercial users
- ✓ Good health of both Sentinel-2A and Sentinel-2B satellites
- ✓ Increasing interoperability with Landsat
- ✓ Level-2A compliance with CARD4L (CEOS ARD for Land - Surface Reflectance)



CEOS Analysis-Ready Datasets

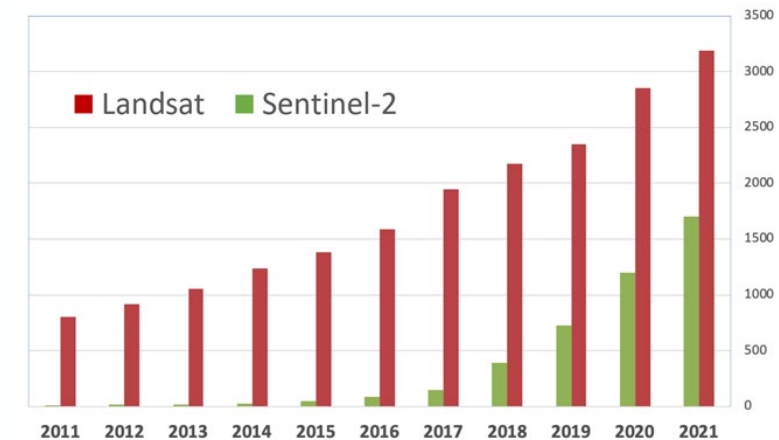
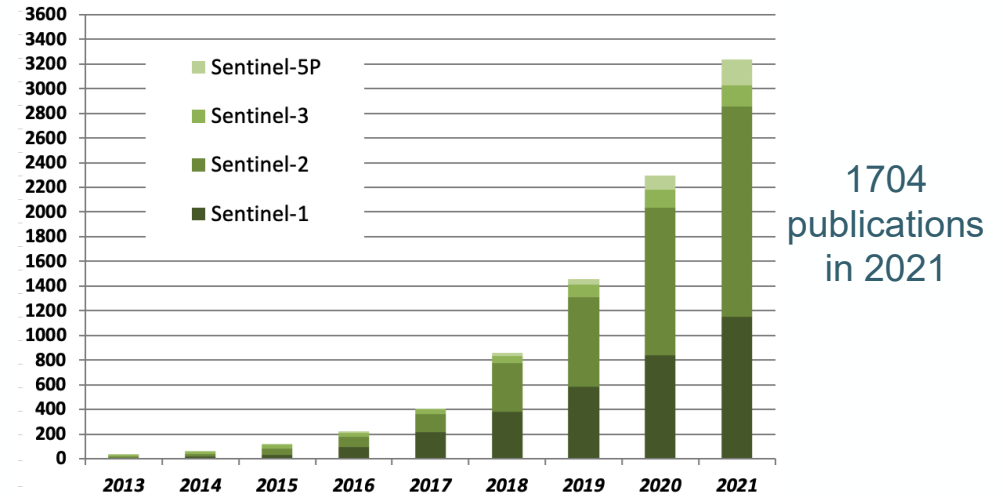
The following table summarises all of the satellite EO datasets that have been assessed as CEOS Analysis Ready Data (CEOS-ARD). DOI links are provided for access, along with links to further information, sample products, and the completed CEOS-ARD self-assessment and peer review outcome documents.

Product	CEOS-ARD Type	PFS Version	Agency	Mission(s)	Threshold Specification	Target Specification	Access (DOI)	Info	Self Assessment
Landsat Collection 2	Surface Reflectance	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	81%	Landsat 4-5, 7, 8	<a href="#">Link</a>	<a href="#">PDF</a>
Landsat Collection 2	Surface Temperature	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	83%	Landsat 4-5, 7, 8	<a href="#">Link</a>	<a href="#">PDF</a>
Sentinel-2 Level-2A	Surface Reflectance	v5.0	ESA	Sentinel-2A, 2B	100%	Not assessed	<a href="#">Link</a>	<a href="#">Link</a>	<a href="#">PDF</a>
EnMAP	Surface Reflectance	v5.0	DLR	EnMAP	100%	Not assessed	TBA	<a href="#">Link</a>	<a href="#">PDF</a>

<https://ceos.org/ard>

# Standing on the shoulder of giants: Sentinel-2

- ✓ Broad range of applications and high data quality satisfying needs from Copernicus Services (e.g. CLMS, CMEMS, CEMS), national services, scientific and commercial users
- ✓ Good health of both Sentinel-2A and Sentinel-2B satellites
- ✓ Increasing interoperability with Landsat
- ✓ Level-2A compliance with CARD4L (CEOS ARD for Land - Surface Reflectance)
- ✓ Top European EO mission both in terms of scientific peer-reviewed publications and distributed data volume



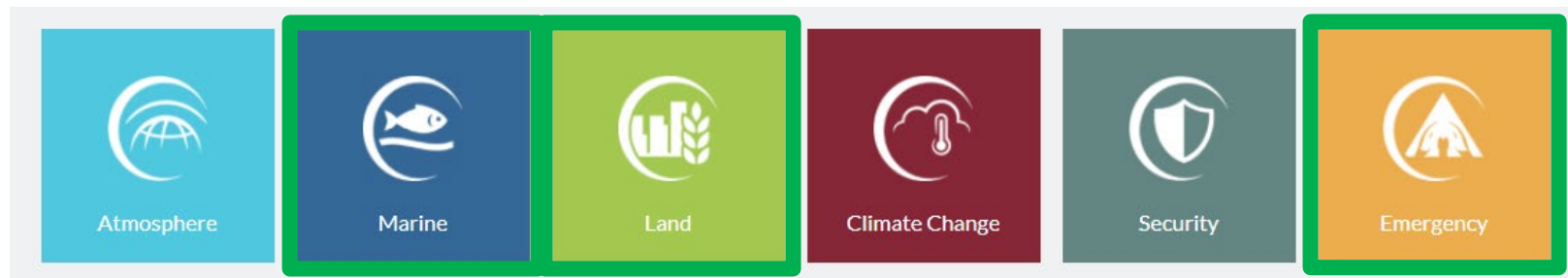
Method: Based on Elsevier SCOPUS database  
Courtesy of F. Gascon (ESA)

## Users Requirements by EC as formal input to ESA activity

- Baseline continuity with Sentinel-2
- Improved temporal and spatial resolution
- Improved cloud/cloud shadows detection
- Same SNR (wrt S-2) and improved radiometric resolution
- Low data latency
- Panchromatic / VHR capabilities

## Providing support to:

- Green Deal
- CAP / GEOGLAM
- EU Forest Strategy
- EU Biodiversity Strategy
- EU Soil Strategy
- EU Water Framework
- ...



- Systematic and gap-free acquisition over land and coastal areas
- Solar Zenith Angle  $\leq 87^\circ$  (G) /  $85^\circ$  (T)
- Geometric revisit time  $\leq 2$  days (G) / 3 days (T)
- Data latency for Level-2A products  $\leq 1.5$  hours (G) / 3 hours (T)
- Observation Zenith Angle  $\leq 16^\circ$
- High radiometric accuracy (absolute and relative)
- Very high geolocation accuracy and multi-temporal coregistration

VHR needs will not be addressed directly by Sentinel-2 NG (i.e. no panchromatic onboard) due to overall system constraints

→ Upon request by EC, ESA will initiate a study in 2022 to evaluate a Hybrid Constellation approach

# Sentinel-2 NG: Key Mission Requirements (2/2)



Band	SSD Goal	SSD Threshold	Center Wavelength	Bandwidth	Main purpose(s)	Priority rating
1	30	60	443	20	Atmospheric correction, Chl retrieval	1
2	5	10	490	65	Reference Blue band	1
3	5	10	560	35	Reference Green band	1
4	5	10	665	30	Reference Red band	1
5	10	10	705	15	LAI, Chl	1
6	10	10	740	15	LAI, Chl	1
7	10	10	783	20	LAI, Chl, Turbidity	1
8	5	10	842	115	Reference NIR band	1*
8a	5	10	865	20	As B8 but less sensitive to WV	1
9	30	60	945	20	Atmospheric correction	1
10	30	60	1375	30	Atmospheric correction	1
11	10	10	1610	90	Snow/Ice/Cloud sep., burned areas	1
12	10	10	2190	180	Green/Brown LAI, separation of Soil/Vegetation, Burned areas	1**
0	10	10	412	15	Improved Chl retrieval, Chl/CDOM separation, aerosol	2
2a	10	20	520	15	Carotenoids (medium/long term)	2
3a	5	10	620	20	Cyanobacteria detection	2
12a	10	20	2100/2130	50	Green/Brown LAI, NPV, sep. of Soil/Vegetation, burned areas, Methane	2
12b	10	20	2210	50		
12c	10	20	2260	50		
3b	5	10	650	20	Ref. for cyanobacteria detection	3
9a	10	10	985	20	Liquid water / improved WV	3
0W			381	15	Improved retrieval of pigments	4
1a	5	10	470	20	Improved retrieval of pigments	5
6a	10	10	763	10	Cloud height determination	5

\* Lower priority if B8a is provided at 5 m SSD

\*\* Lower priority if B12a/b/c are provided at 10 m SSD

# Sentinel-2 NG: Key Mission Requirements (2/2)



Band	SSD Goal	SSD Threshold	Center Wavelength	Bandwidth	Main purpose(s)	Priority rating
1	30	60	443	20	Atmospheric correction, Chl retrieval	1
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3	5	10	560	35	Reference Green band	1
4	5	10	665	30	Reference Red band	1
5	10	10	705	15	LAI, Chl	1
6	10	10	740	15	LAI, Chl	1
7	10	10	783	20	LAI, Chl, Turbidity	1
8	5	10	842	115	Reference NIR band	1*
8a	5	10	865	20	As B8 but less sensitive to WV	1
9	30	60	945	20	Atmospheric correction	1
10	30	60	1375	30	Atmospheric correction	1
11	10	10	1610	90	Snow/Ice/Cloud sep., burned areas	1
12	10	10	2190	180	Green/Brown LAI, separation of Soil/Vegetation, Burned areas	1**
0	10	10	412	15	Improved Chl retrieval, Chl/CDOM separation, aerosol	2
2a	10	10	680	20	Carotenoids (medium/long term)	2
3a	5	10	620	20	Cyanobacteria detection	2
12a	10	20	2100/2130	50	Green/Brown LAI, NPV, sep. of Soil/Vegetation, burned areas, Methane	2
12b	10	20	2210	50		
12c	10	20	2260	50		
3b	5	10	650	20	Ref. for cyanobacteria detection	3
9a	10	10	985	20	Liquid water / improved WV	3
0W			381	15	Improved retrieval of pigments	4
1a	5	10	470	20	Improved retrieval of pigments	5
6a	10	10	763	10	Cloud height determination	5

Heritage bands from Sentinel-2

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6	10	10	740	15	LAI, Chl	1
7	10	10	783	20	LAI, Chl, Turbidity	1
8	5	10	842	115	Reference NIR band	1*
8a	5	10	865	20	As B8 but less sensitive to WV	1
9	30	60	945	20	Atmospheric correction	1
10	30	60	1235	20	Atmospheric correction	1
11	10	10	1375	100	Snow/Ice/Cloud sep., burned areas	1
12	10	10	2100	100	Green/Brown LAI, separation of Soil/Vegetation, Burned areas	1**
0	10	10	412	15	Improved Chl retrieval, Chl/CDOM separation, aerosol	2
2a	10	20	520	15	Carotenoids (medium/long term)	2
3a	5	10	620	20	Cyanobacteria detection	2
12a	10	20	2100/2130	50	Green/Brown LAI, NPV, sep. of Soil/Vegetation, burned areas, Methane	2
12b	10	20	2210	50		
12c	10	20	2260	50		
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6a	10	10	763	10	Cloud height determination	5

Proposed additional bands

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8	5	10	842	115	Reference NIR band	1*
8a	5	10	865	20	As B8 but less sensitive to WV	1
9	30	60	945	20	Atmospheric correction	1
10	30	60	1375	30	Atmospheric correction	1
11	10	10	1610	90	Snow/Ice/Cloud sep., burned areas	1
12	10	10	2190	180	Green/Brown LAI, separation of Soil/Vegetation, Burned areas	1**
0	10	10	412	15	Improved Chl retrieval, Chl/CDOM separation, aerosol	2
<b>2a</b>	<b>10</b>	<b>20</b>	<b>520</b>	<b>15</b>	<b>Carotenoids (medium/long term)</b>	<b>2</b>
3a	5	10	620	20	Cyanobacteria detection	2
<b>12a</b>	<b>10</b>	<b>20</b>	<b>2100/2130</b>	<b>50</b>	<b>Green/Brown LAI, NPV, sep. of Soil/Vegetation, burned areas, Methane</b>	<b>2</b>
<b>12b</b>	<b>10</b>	<b>20</b>	<b>2210</b>	<b>50</b>		
<b>12c</b>	<b>10</b>	<b>20</b>	<b>2260</b>	<b>50</b>		
3b	5	10	650	20	Ref. for cyanobacteria detection	3
9a	10	10	985	20	Liquid water / improved WV	3
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2a	10	20	520	15	Carotenoids (medium/long term)	2
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12a	10	20	2100/2130	50	Green/Brown LAI, NPV, sep. of Soil/Vegetation, burned areas, Methane	2
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# Sentinel-2 NG: Activities and Timeline

- Two industrial studies running in parallel
- Sentinel-2 NG Ad-Hoc Expert Group (AHEG) regular meetings since May 2021
  - Experts from scientific institutes, companies, Copernicus Services, EC, ESA
  - Consolidating the Mission Assumptions and Technical Requirements Document (MATER)
  - Supporting the preparation of a first version of the Mission Requirements Document (MRD)

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  - Consolidating the Mission Assumptions and Technical Requirements Document (MATER)
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- Currently in Phase 0
- Start of Phase A expected in mid-2023
- All numbers TBC

**Armin Loescher, Marco Celesti, Matthias Drusch, Arnaud Heliere, Clement Albergel, Constantin Mavrocordatos, Dirk Schuettemeyer, Ferran Gascon, Francisco Reina, Zoltan Szantoi, Olivier Arino, Patrick Griffiths, Philippe Martimort, Pierluigi Silvestrin, Simon Jutz, Simone Rafano Carna, Roman Windpassinger**

**European Space Agency**

**Michel Massart, Peter Strobl**

**European Commission**

**Alexandre Arnal, Antonio Reppucci, Carsten Brockmann, Else Swinnen, Emma Woolliams, Emilio Chuvieco, Jean-Francois Pekel, Jose Moreno, Ludvig Forslund, Marie Weiss, Olivier Hagolle, Paolo Gamba, Pierre Defourny, Zhuoting Whu**

**Sentinel-2 NG AHEG Members**

- Draft of Mission Requirements Document and System Requirements Document
- Draft of Science Support Plan
- KO of Phase 0 Scientific Support Study
  - Consolidate Mission Requirements and their traceability to Users Requirements and Applications
  - Update Reference Scenarios and Reference Radiances (in particular for proposed new bands)

**A call for the Sentinel-2 NG Mission Advisory Group will be opened before Phase A**



[Advisory Group Membership site – Earth Observation Advisory Groups \(esa.int\)](#)

# Thank you for you attention!



Marco Celesti  
CHIME and S2 NG Mission Scientist  
[Marco.Celesti@esa.int](mailto:Marco.Celesti@esa.int)

