EUROPEAN COMMISSION

AURORA

Progetto H2020 AURORA

Sinergia tra i dati delle Sentinelle atmosferiche del programma Copernicus per prodotti avanzati relativi al profilo verticale di ozono e alla radiazione UV alla superficie

Ugo Cortesi (IFAC-CNR)
e Consorzio AURORA

Accademia dei Georgofili, Firenze, 13 luglio, 2017

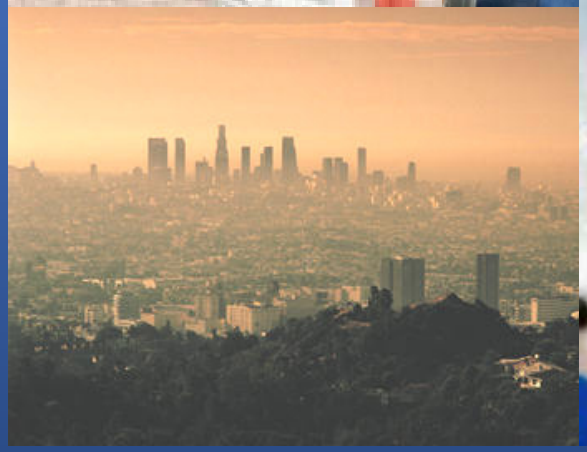
HeatShield – Cambiamenti climatici e caldo: impatti sulla salute e sulla produttività dei lavoratori impegnati in ambiti agricoli












Outline

- AURORA project
- Copernicus Sentinels
- AURORA objectives
- Scientific aspects
- Technological aspects
- Applications
- International links
- Conclusion

AURORA
in a nutshell

EU Framework Program: HORIZON 2020

H2020 Work Program: 2014-2015
Research Area: Leadership in Enabling and Industrial Technologies (LEIT)
Sub-program: Space

Call: H2020-Earth Observation-2015
Topic: EO-2-2015 Stimulating wider research use of Copernicus Sentinel Data

Project Title: Advanced Ultraviolet Radiation and Ozone Retrieval for Appiications
Project Duration: 36 months (February 1°, 2016 – January 31°, 2019)
AURORA website: http://www.aurora-copernicus.eu/

The AURORA Consortium

Institute for Applied Physics «Nello Carrara» (IFAC-CNR), Italy

Belgian Institute for Space Aeronomy (BIRA-IASB), Belgium

European Center for Medium Range Weather Forecast (ECMWF), UK

Finnish Meteorological Institute (FMI), Finland

Royal Netherlands Meterological Institute (KNMI), Netherlands

Datacraft, Netherlands

Epsilon, Greece

Flyby, Italy

Science&Technology (S&T), Netherlands

The AURORA Consortium

AURORA
Advanced Ultraviolet Radiation and Ozone Retrieval for Applications

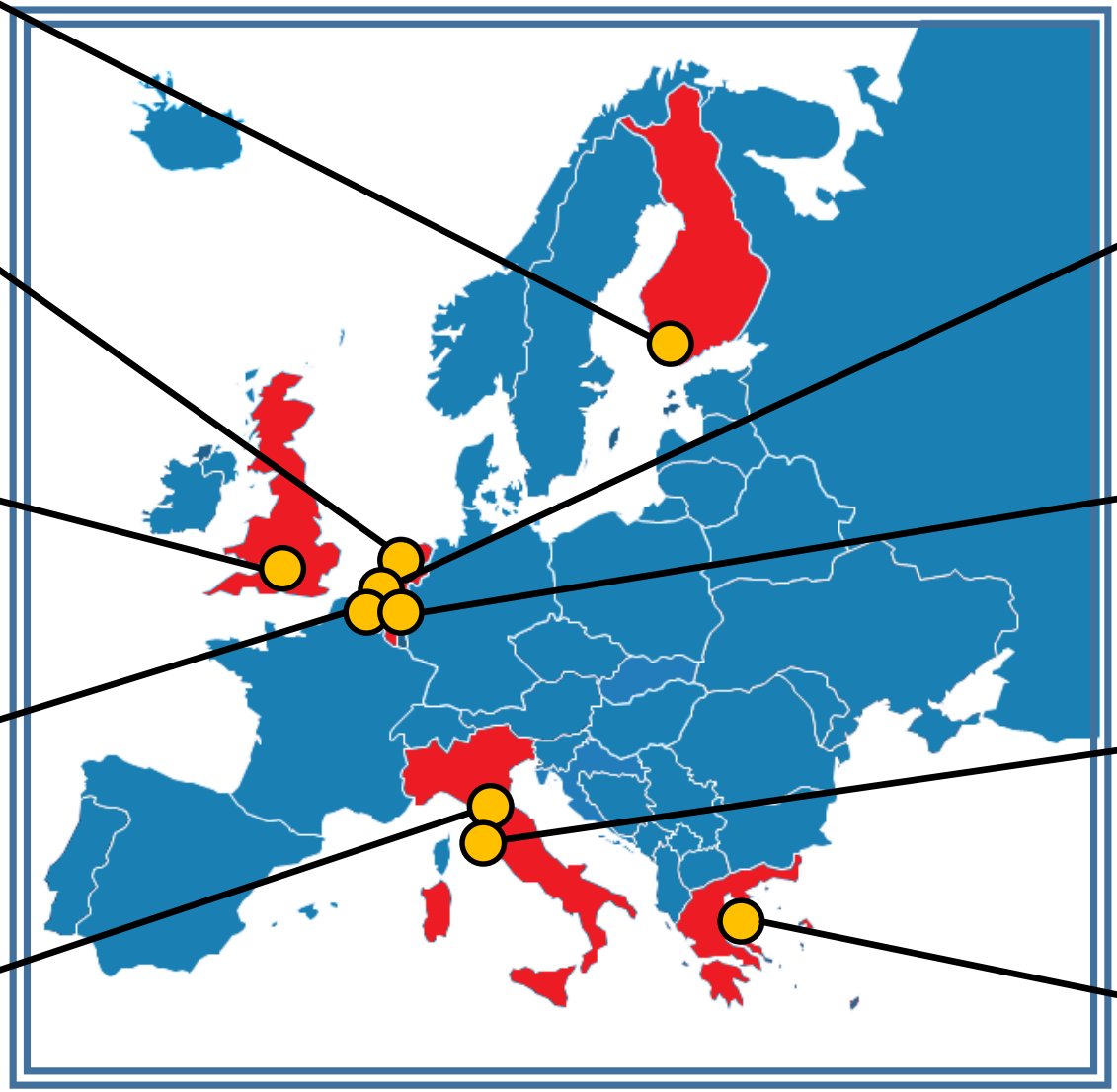
FMI
(Helsinki, FI)

KNMI
(Amsterdam, NL)

ECMWF
(Reading, UK)

BIRA-IASB
(Brussels, BE)

IFAC-CNR
(Firenze, IT)



S[&]T Corporation
(Delft, NL)

DATACRAFT
(Rotterdam, NL)

FLYBY
(Livorno, IT)

EPSILON
(Athens, EL)

Il programma Copernicus

Copernicus is the European Union Programme for Earth Observation implemented by the European Commission in partnership with the European Space Agency

http://copernicus.eu/

Copernicus aims to provide space and non-space Earth Ovservation data and accurate and reliable infomation for operational applications.

«Sentinel» missions

Six families of **«Sentinel»** space mission
Form the space component of Copernicus.

SENTINEL-1
Mission providing all weather, day and night radar imagery for land and ocean servicesi

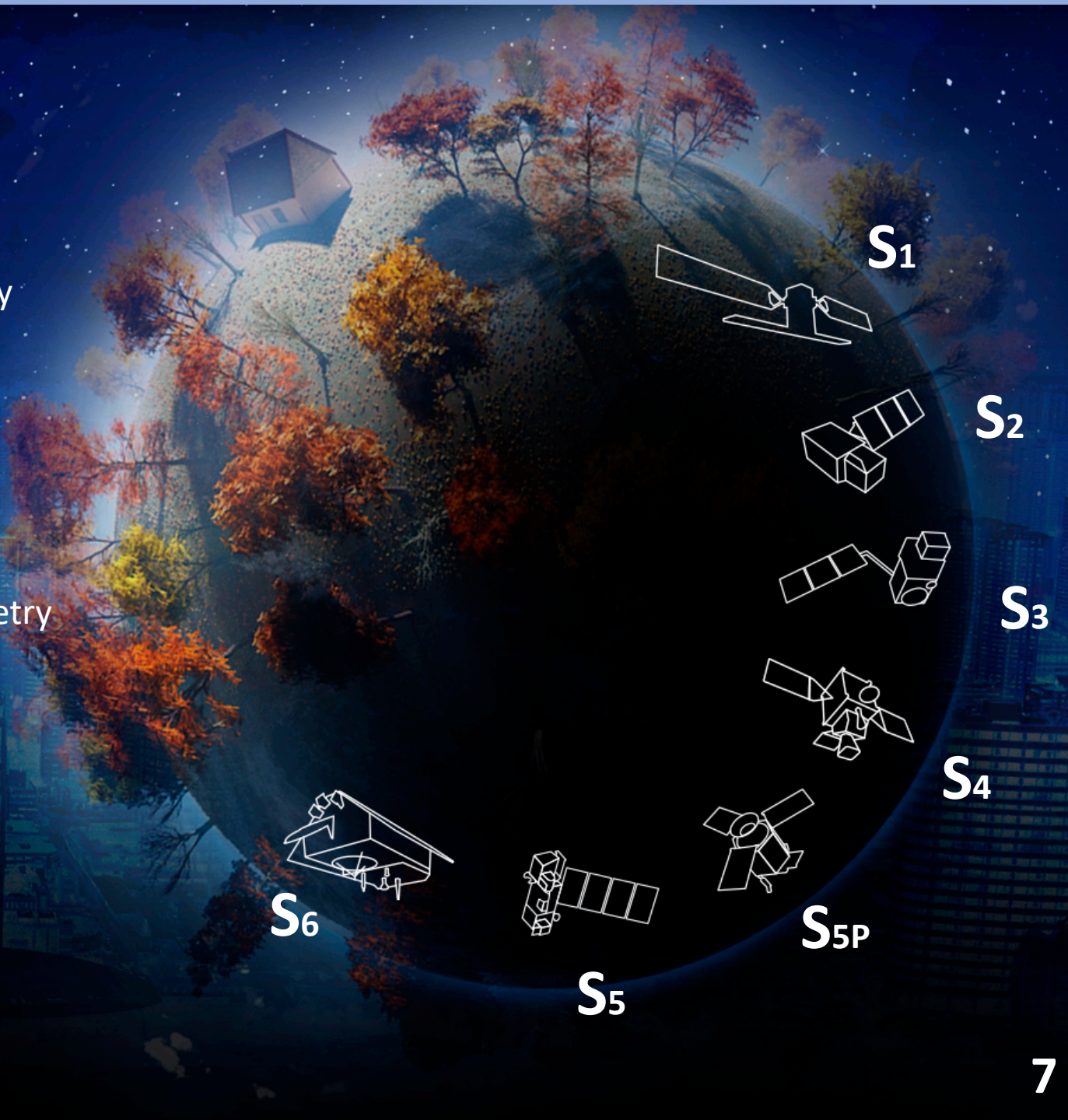
SENTINEL-2
Mission providing high resolution optical imagery for land services

SENTINEL-3
Mission providing high accuracy optical, radar and altimetry data for marine and land services

SENTINEL-4
Geostationary mission for atmospheric monitoring

SENTINEL-5
Low earth Orbit for atmospheric monitoring

SENTINEL-6
Radar altimeter for observation of the topography of the global ocean



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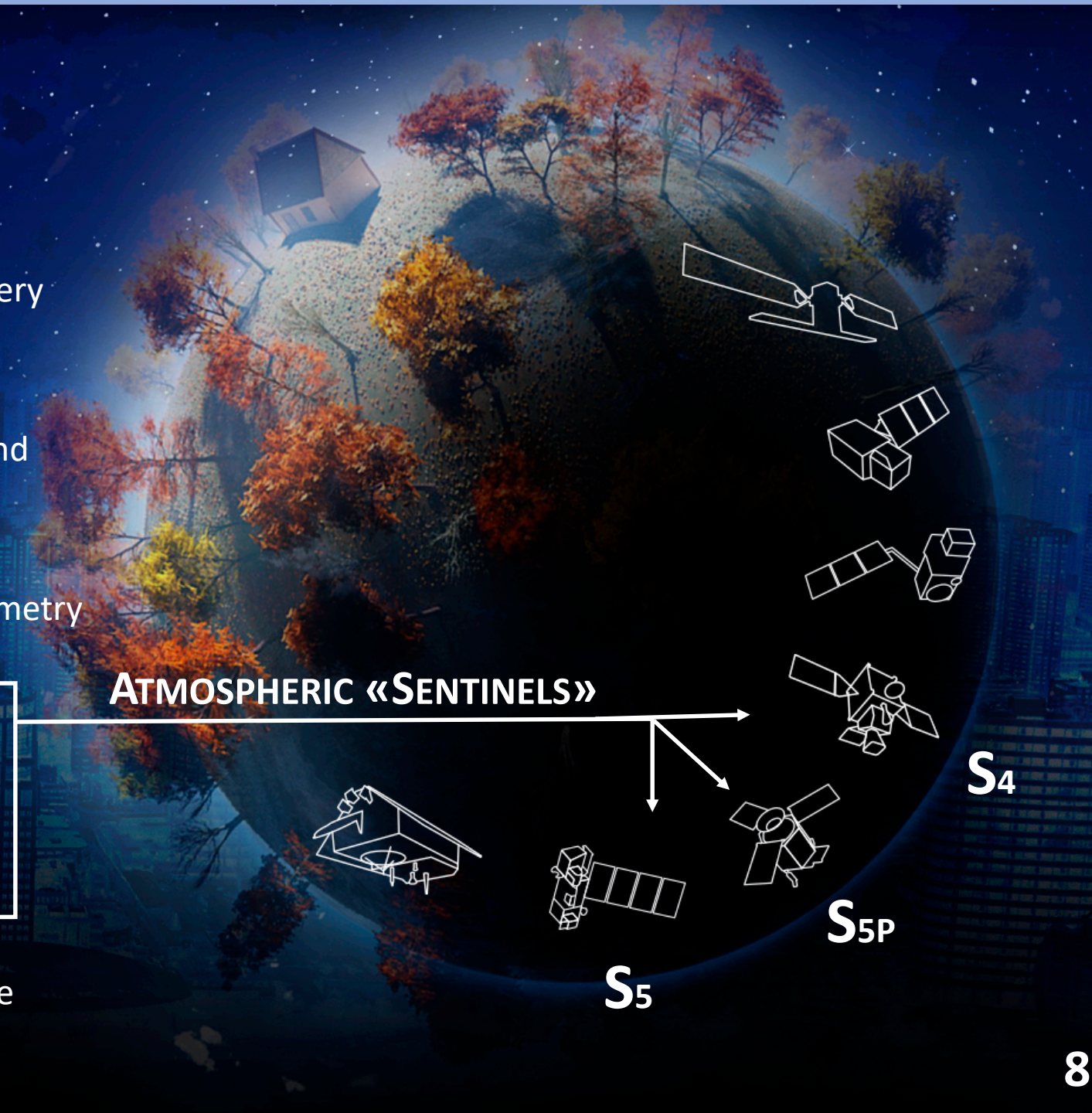
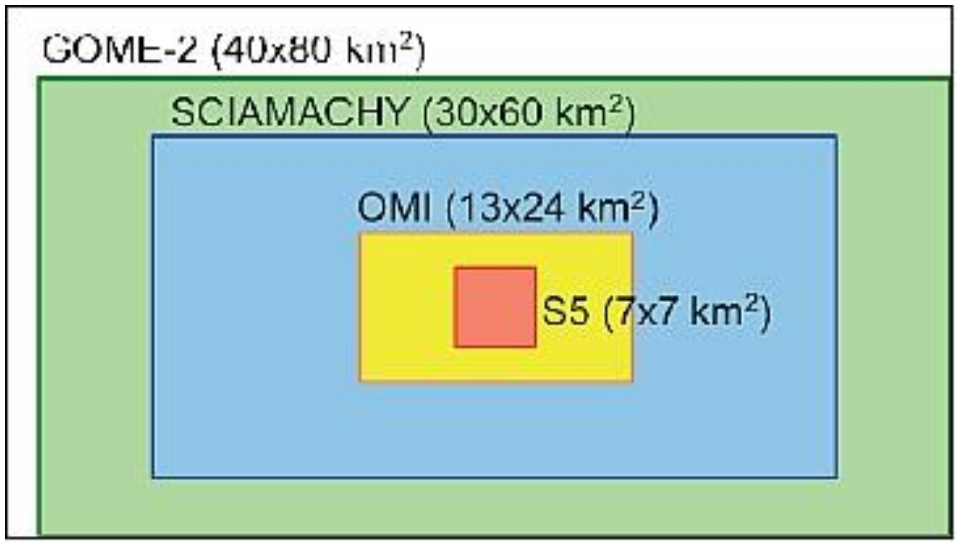


The atmospheric Sentinel missions

The atmospheric Sentinel missions aim at filling the gap of on-going operational missions, as GOME-2 and IASI (MetOp) or OMPS and CRISS (JPSS):

- **High spatial resolution** (higher number of «cloud-free» pixels)
- **High tempoeral resolution**
- **High precision**



LAUNCH DATE 2006

LAUNCH DATE 2002

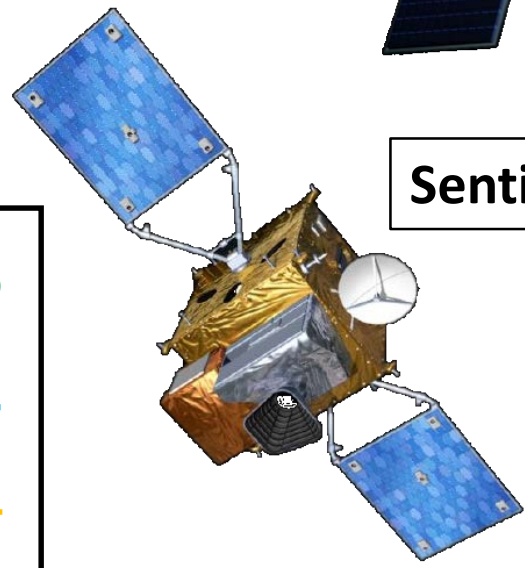
LAUNCH DATE 2004

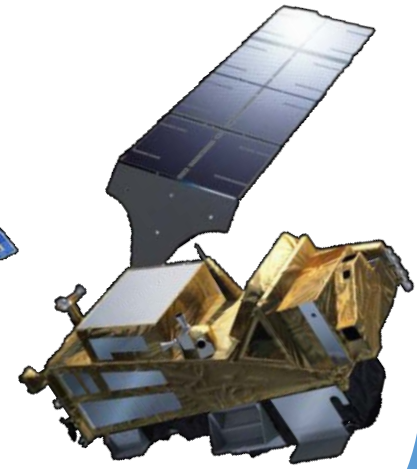
LAUNCH DATE 2021

Comparison of spatial resolution of Sentinel-5 with respect to previous missions (ESA image)

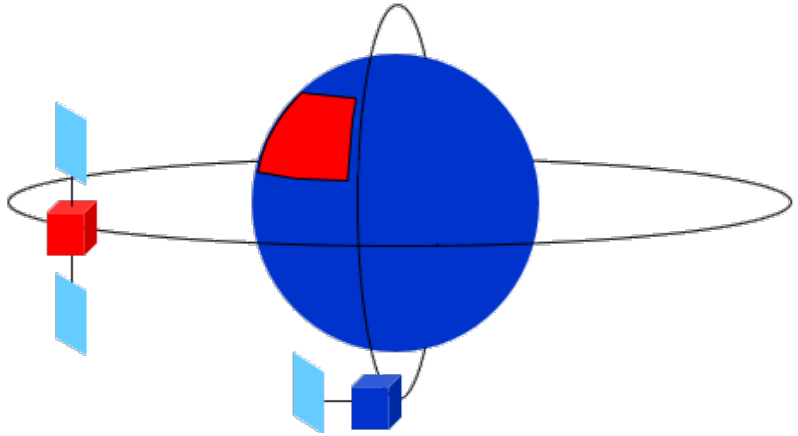
Sentinel-5p

Sentinel-4





Sentinel-5



GEOstationary (GEO)

- Hourly revisit time over Europe
- Mainly Air Quality
- Diurnal cycle of tropospheric compisition

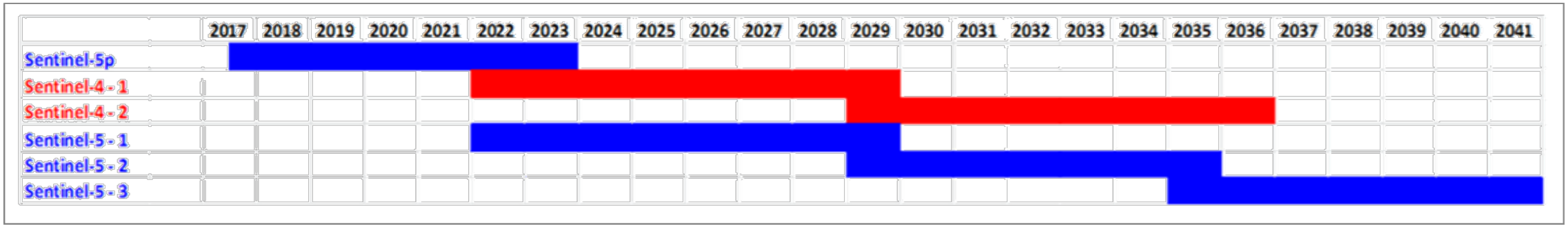
→ **Sentinel-4**

Low Earth Orbit (LEO)

- Daily revisit time global coverage
- Climate, air quality, ozone and UV
- Tropospheric and stratospheric composition

→ **Sentinel-5**

→ **Sentinel-5 Precursor**



Mission	Instrument	Utilization of data from		
		Imager	Infrared sounder	Other
Sentinel-4	UVN spectrometer (1)	FCI (2)	IRS (1)	LI (2,*)
Sentinel-5	UVNS spectrometer (3)	VII (3)	IAS (3)	3MI (3)
Sentinel-5 Precursor	UVNS spectrometer TROPOMI (4)	VIIRS (5)	CRIS (5,*)	OMPS (5,*)

(1) on MTG sounder (GEO)
(2) on MTG imager (GEO)
(3) on MetOp-SG (LEO)
(4) on dedicated platform (LEO)
(5) on SNPP/JPSS (LEO)
(*) synergy on higher data level

MTG = Meteosat Third Generation
MetOp-SG = MetOp-Second Generation
SNPP = Suomi National Polar-orbiting Partnership
JPSS = Joint Polar Satellite System

UVN = Ultraviolet + Visible + Near infrared
FCI = Flexible Combined Imager
IRS = InfraRed Sounder
LI = Lightning Imager

UVNS = UVN + Short wave infrared
VII = Visible/Infrared Imager (MetImage)
IAS = Infrared Atmospheric Sounder (IASI-NG)
3MI = Multi-viewing, -channel, -polarisation Imager

TROPOMI = TROPOspheric Monitoring Instrument
VIIRS = Visible Infrared Imaging Radiometer Suite
CrIS = Cross-track Infrared Sounder
OMPS = Ozone Mapping Profiler Suite

AURORA: Objectives of the project

SCIENCE

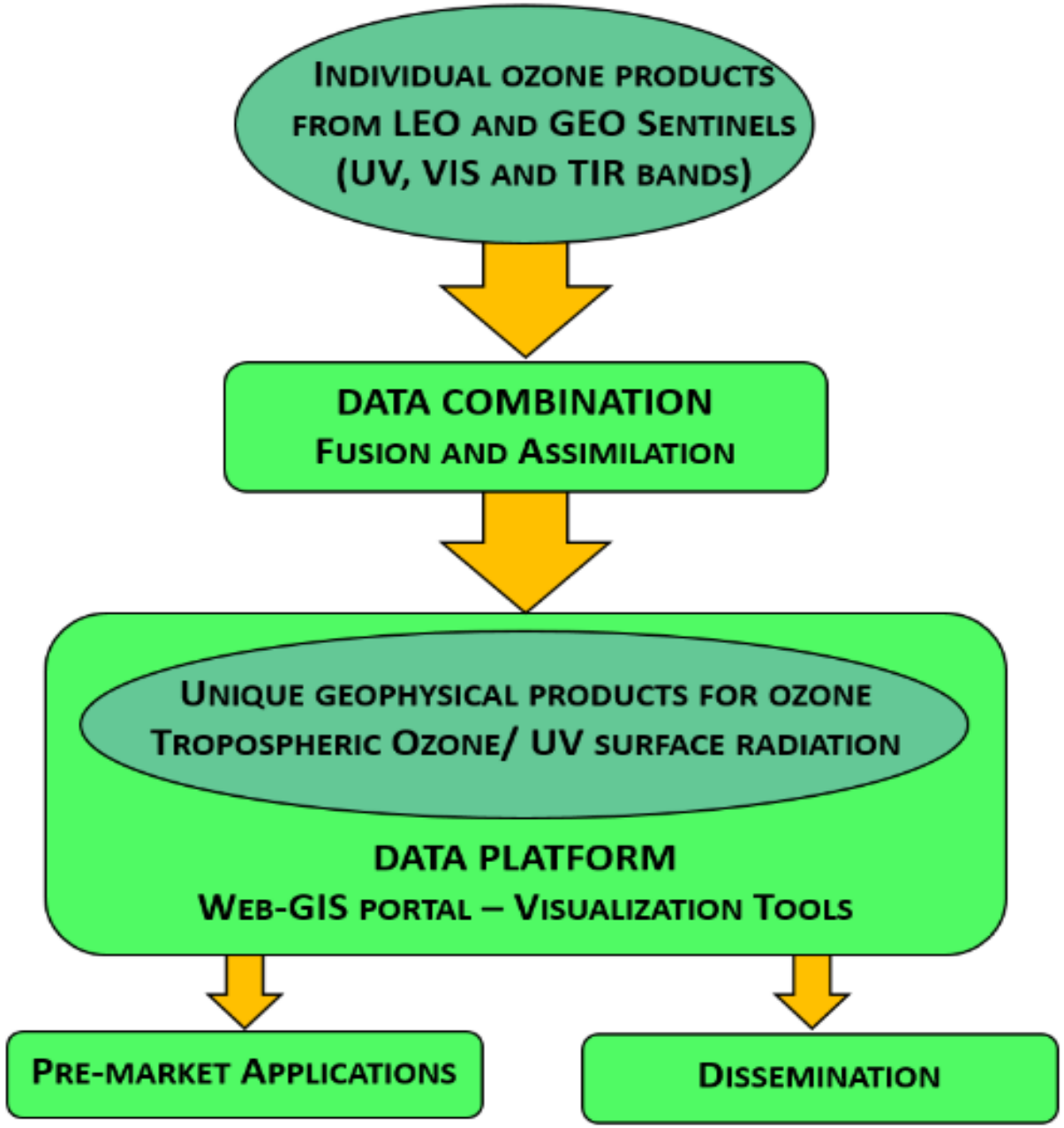
- to investigate the **potential of data fusion and assimilation** to convey complementary information of the atmospheric Sentinels measurements into unique geophysical products
- to focus the **exploitation of the synergy** between simultaneous and independent measurements of the same target on **tropospheric O3** and **UV surface radiation**

TECHNOLOGY

- to **reduce the complexity** of managing the high volume of Copernicus S-4 and S-5 data and **increase its quality**
- to develop **a prototype data processing system** and **demonstrate its capability to work with simulated data** as close as possible to the operational environment.

APPLICATION

- To develop **two operational downstream services** (innovative mobile App for UV dosimetry and tropospheric ozone monitoring application for prediction of air quality)



AURORA
Advanced Ultraviolet Radiation and Ozone Retrieval for Applications

AURORA
The overall concept

Atmospheric Scenario and Data Simulation

Atmospheric scenarios → definition of the state of the atmosphere for forward calculation and generation of S4 and S5 synthetic masurements (ECMWF).

Atmospheric scenario (4 months of data) are generated from the **MERRA 2** re-analysis, provided by GMAO at NASA Goddard Space Flight Center.

Sentinel-4 and Sentinel-5 data simulation

- LEO and GEO UV L2 products for Ozone and associated VCMs and AKMs (FMI, with contributions from KNMI).
- LEO and GEO VIS L1 and L2 data for Ozone and associated VCMs and AKMs (BIRA-IASB, with contributions from KNMI).
- LEO and GEO TIR L2 products for Ozone and associated VCMs and AKMs (IFAC-CNR).

Data Fusion

Combination of LEO+LEO, GEO+GEO (and LEO+GEO) coincident and independent measurements of the same target acquired in different spectral regions (UV, VIS and TIR).

Method: Complete Data Fusion (Ceccherini et al., Equivalence of data fusion and simultaneous retrieval, *Optics Express*, 23, 7, 8476-8488. 2015)

Simultaneous retrieval versus **data fusion**.

Equivalence of simultaneous retrieval and complete fusion
In a linear approximation, the solution obtained with complete fusion coincides with the solution obtained with simultaneous retrieval.

First results of CDF method applied to Sentinel-4 UV ,VIS,TIR data fusion

Simulated S-4 data for the atmospheric scenario from the 1st week of April 2012.
Total number of pixel analysed = 30.000 (approx.)
Number of fused UV+TIR+VIS = 99% of the total.
Number of fused UV+TIR = 1% of the total

LEFT PANEL

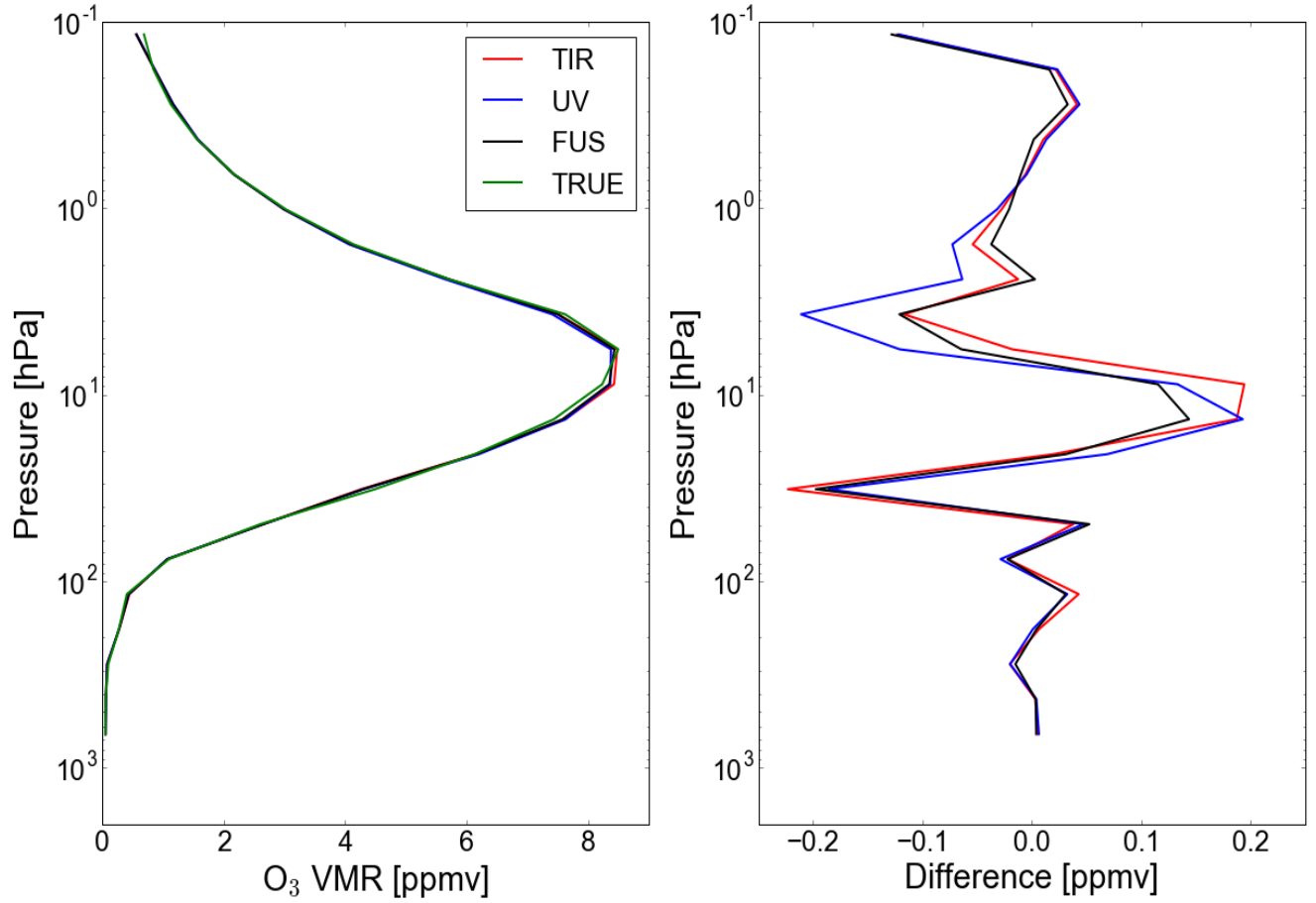
Average Ozone profile obtained from:

- **TIR measurements**
- **UV measurements**
- **Data fusion**
- **True values**

RIGHT PANEL

Average difference w.r.t. the values of the true profile of:

- **TIR measurements**
- **UV measurements**
- **Data fusion**

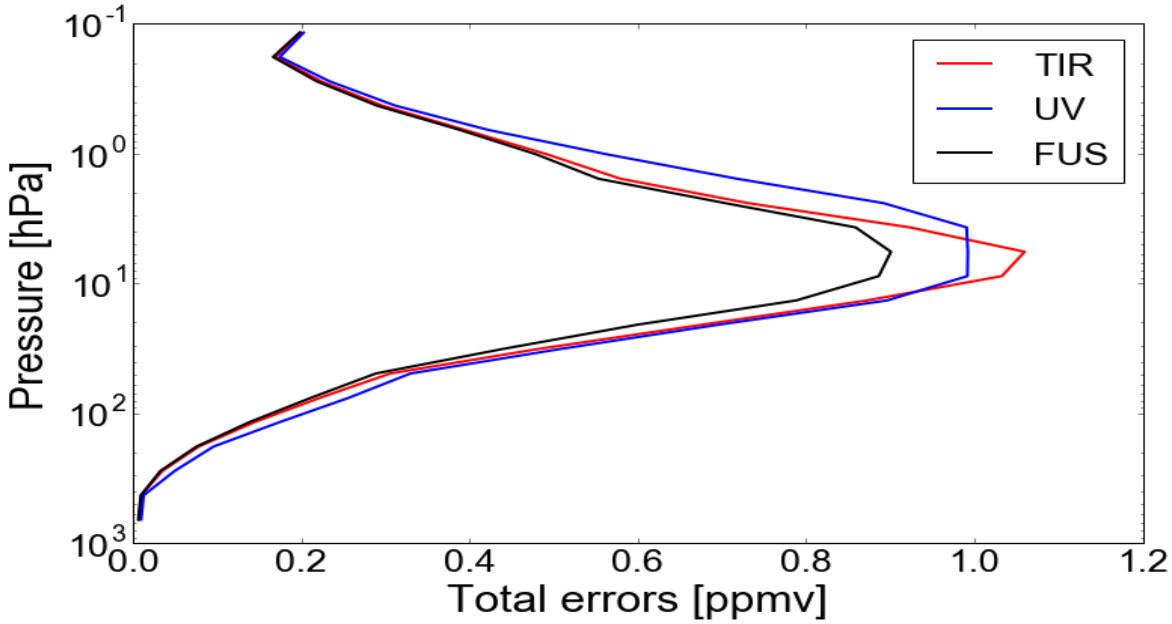


Continue … ➔

… continue ➔ First results of CDF method applied to Sentinel-4 UV,VIS,TIR data fusion

Average total errors of the Ozone profile obtained from:

- **TIR measurements**
- **UV measurements**
- **Data fusion**



Average of the number of Degrees Of Freedom of the TIR, UV and Fused profiles.
On average, the fused profile has 0.9 DOFs more than the TIR profile and 2.4 DOFs more than the UV profile.

	TIR	UV	FUS
Number of DOF	4.9	3.4	5.8

Data Assimilation

State-of-the-art Data Assimilation Systems (DASs) will be used to combine the LEO and GEO fused profiles, and contrasted with the assimilation of standard retrievals.

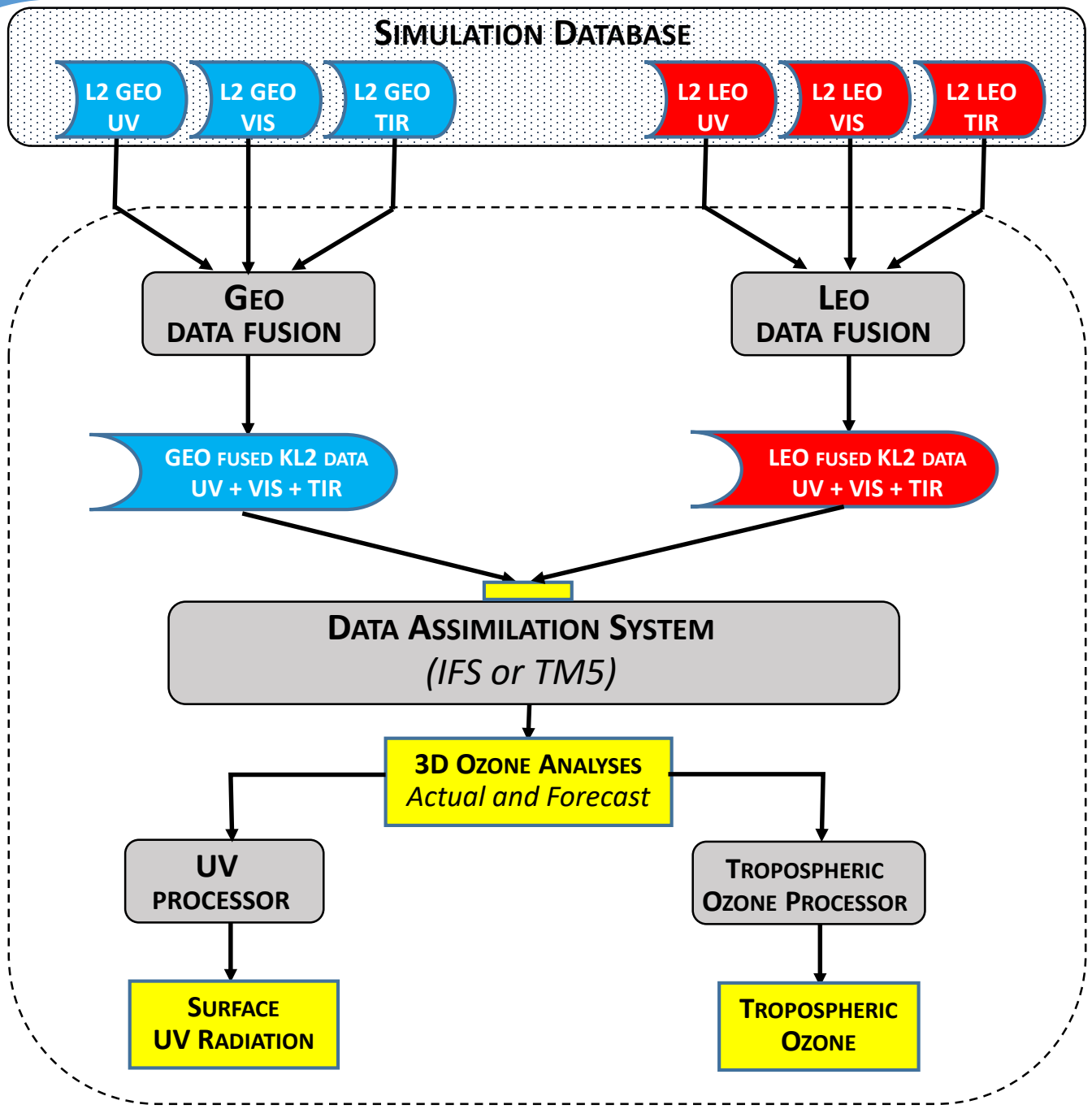
Two DASs are available to AURORA:

- ECMWF Integrated Forecasting System (IFS)
- KNMI Chemical Transport Model DAS (TM5)

Output

Ozone vertical profile ➔ Tropospheric Ozone
UV Surface Radiation

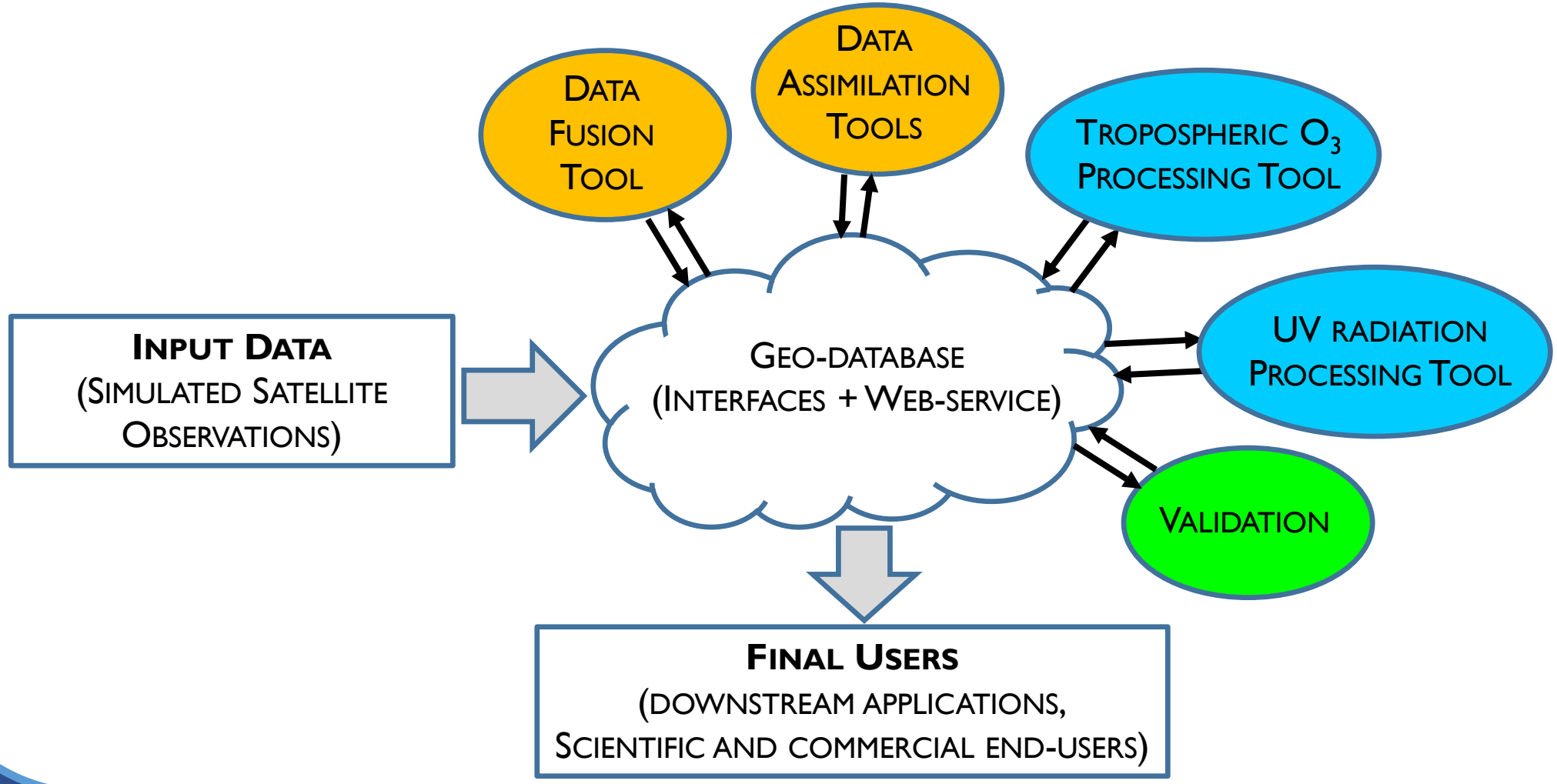
Assimilation of fused products versus assimilation of standard products



AURORA
Data Processing Chain

AURORA Technological Infrastructure

From an operational point of view, the data processing is executed in the AURORA infrastructure framework using a cloud-based architecture

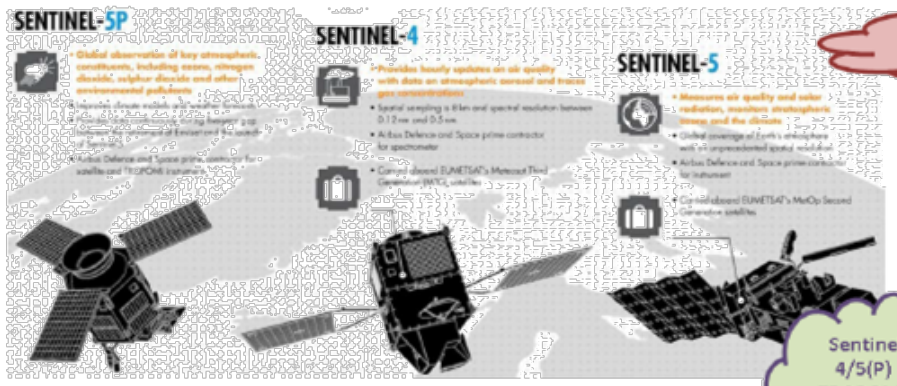


Validation

Validation Chain

- Translation of user requirements and of data/service specifications into **validation requirements**; conception of the **Product Validation Plan** (PVP).
- Performance assessment of retrieval/fusion/assimilation procedures and their resulting ozone and UV data products and associated uncertainties.
- Performance assessment of the full data processing chain and QA/validation of the final ozone and UV products using ground-based reference observations

Ref. - U. Cortesi, A. Keppens, J-C. Lambert, et al., *AURORA project: simulation and validation of synergistic products from Sentinel-4 and Sentinel-5(p)*, poster presentation, ACVE 2016, 18-20 October, ESA-ESRIN, Frscati, Italy.



AURORA services

User requirements

QA4EO VIM GUM ISO
Metrology Standards

VERSATILE QA/VALIDATION SYSTEM

Translation

QA4ECV QA System
Validation protocols

AURORA PVP

VALIDATION CHAIN
MULTI-TASTE

Selection

Co-locator

Harmonisation

Comparator

Reporting

Quality Indicators

Analysis

Sentinel-4/5(P) TROPOMI (simulation) data

Ozonesondes, UV-SRM, UV-BB-sensors

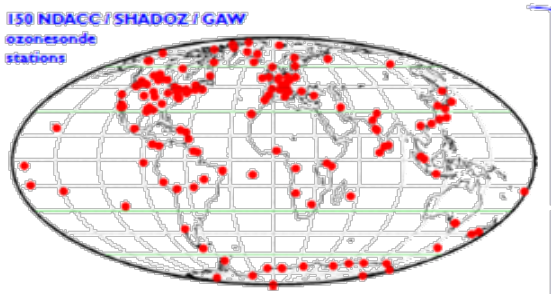
ECMWF (C-)IFS, KNMI TM5

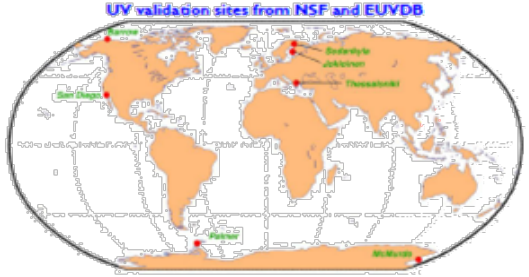
CORRELATIVE DATABASE

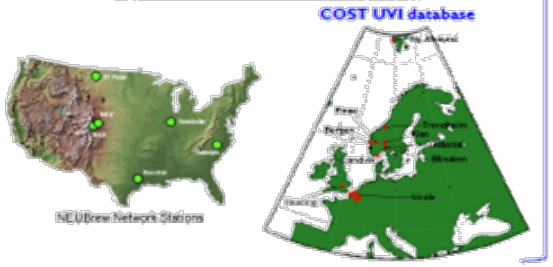
Satellites

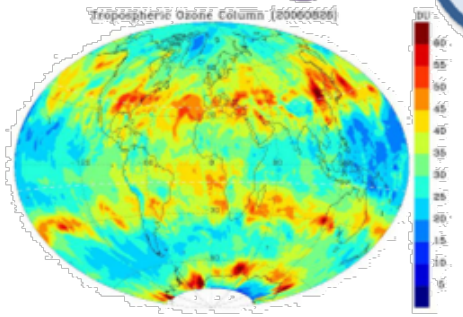
Networks

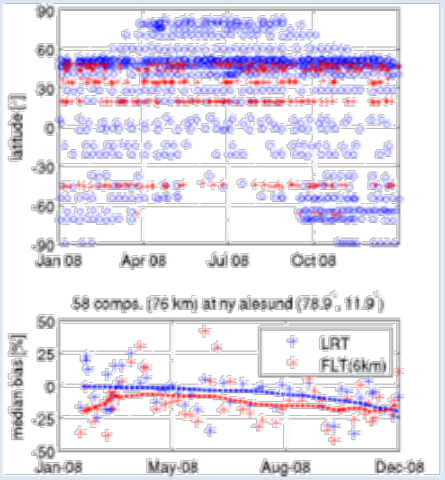
DA / CTM











BIRA-IASB FMI aeronomie.be

Science & Services

Operational services research & development

Assessment of ozone and UV products

AURORA algorithm evolution

Assessment of the AURORA data processing chain

Applications

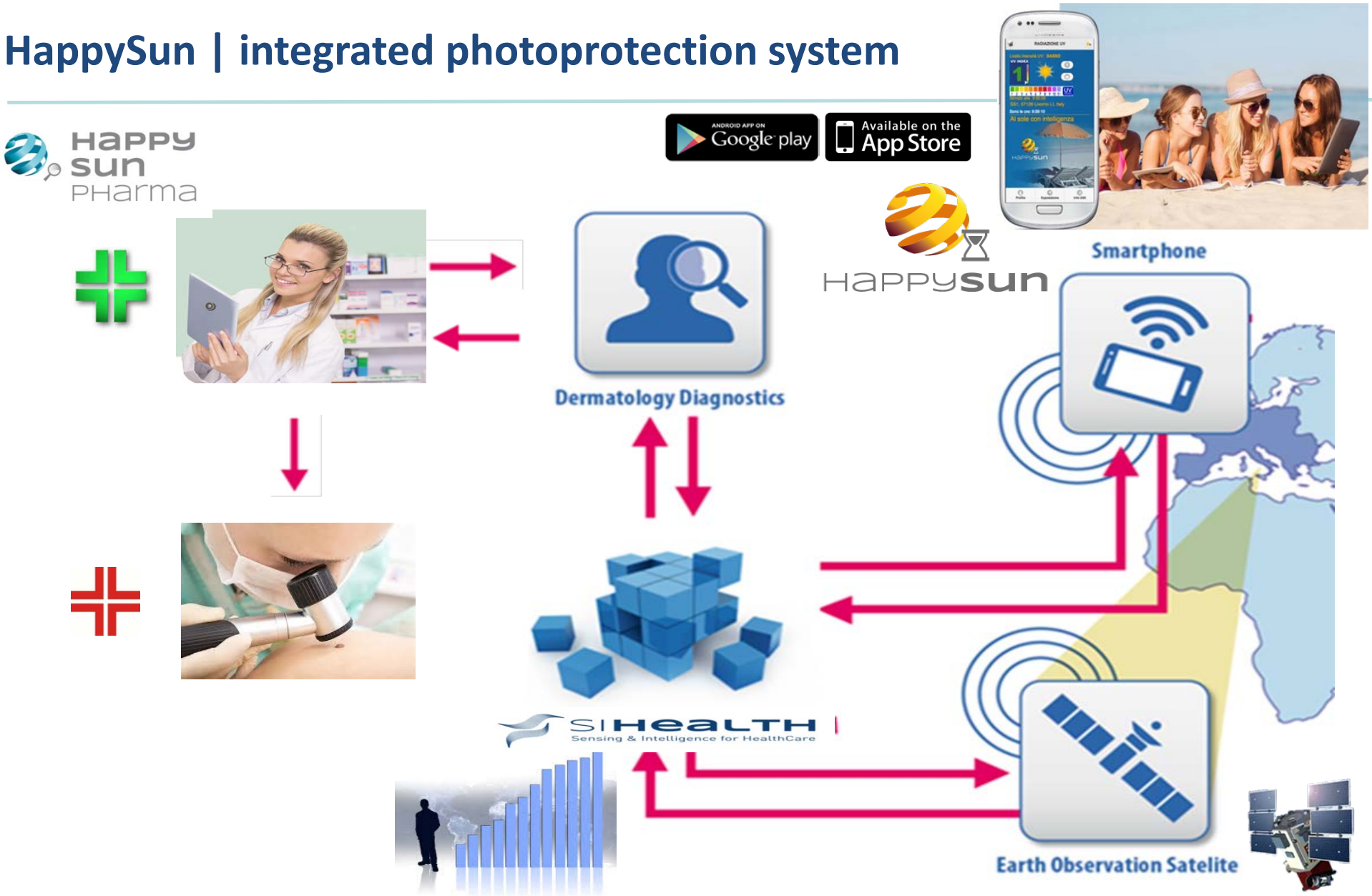
AURORA aims to develop two operational downstream services using innovative mobile App for **UV dosimetry** and **tropospheric ozone monitoring application for major cities and regional prediction of air quality** reaching a pre-market version at the end of the project.

Pre-market service on Urban Pollution Monitoring

http://www.happysun.it/

Personal UV dosimetry

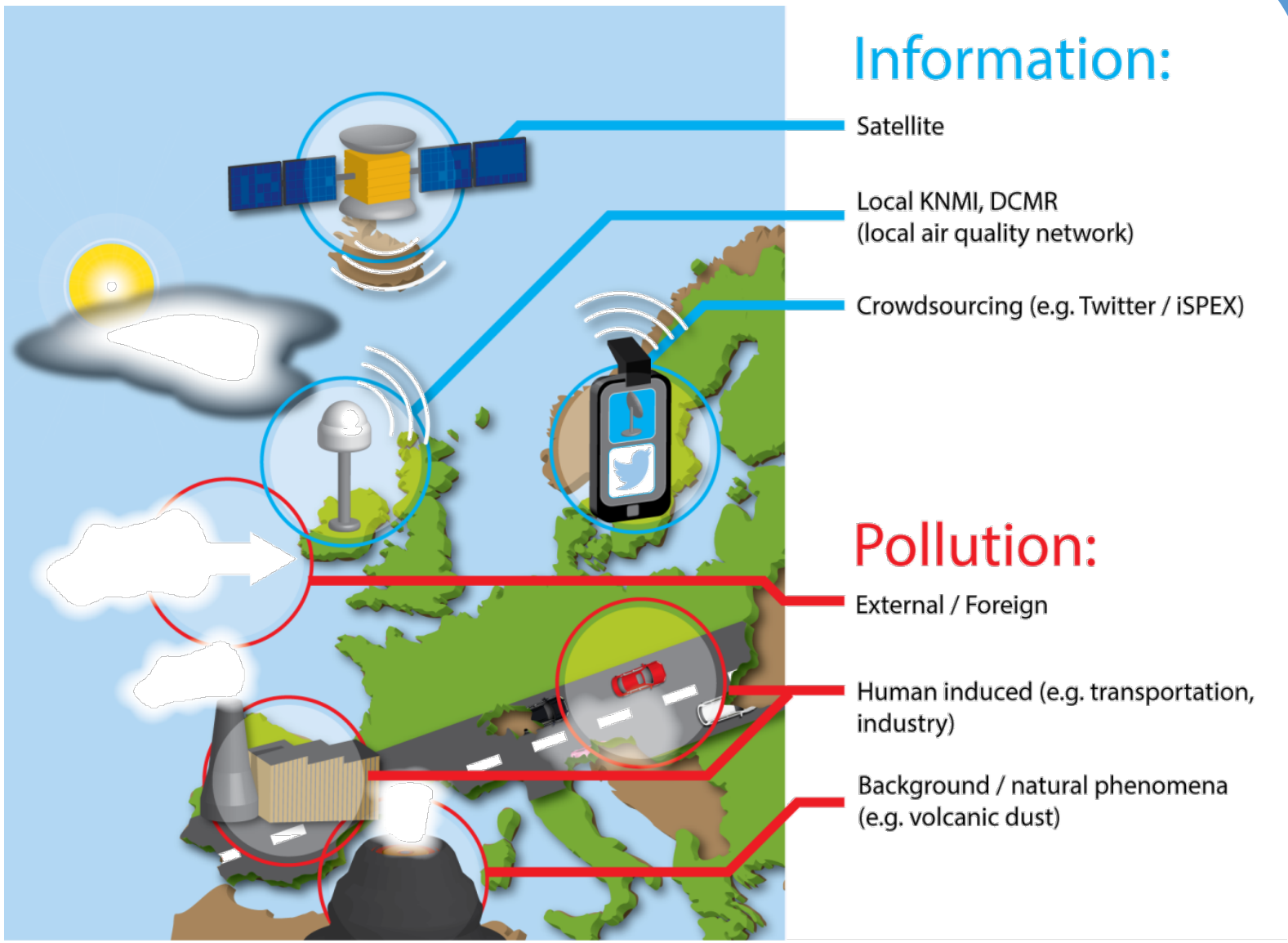
HappySun | integrated photoprotection system



Life style & Skin cancer statistics

What is AIR-Portal?

- Feasibility study both technical and economical
- Dashboard on Air Quality for both cities and citizens
- Combines various levels of monitoring data



AIR Portal and AURORA

- **Successful feasibility study:**
- Porsitive technical results
- Great interest from stakeholders
- Businnes model is positive

- **AIR-Portal currently being developed into commercial service**

- **AURORA is of great benefit:**
- Providing accurate AQ information relies on the best possible input
- Improved O3 data products will make our service more accurate
- In addition we can benefit from the joint market analysis
- Finally, the expertise of the AURORA team is invaluable.

International links

Strong links with a significant number of European and non-European projects.

- Link with **GEOSS** (Global Earth Observation System of Systems) and **CEOS** (Committee on Earth Observation Satellites)
- Link with **Ozone CCI** (Climate Change Initiative)
- Link with FP7 **smeSPIRE**
- Link with **TEMPO** and **GEMS**
- Link with **CAMS** (Copernicus Atmosphere Monitoring Service)

Thank you for your attention!

AURORA web-site: http://www.aurora-copernicus.eu/