Advanced Ultraviolet Radiation and Ozone Retrieval for Applications

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ISSeP – NCP Wallonie – Skywin
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UWE, Wavre, Belgium
Outline

- AURORA in brief
- Copernicus Sentinels
- AURORA objectives
- Scientific aspects
- Technological aspects
- Applications
- Regional aspects
- Conclusion
The AURORA project

Proposal submitted April 2015, in response to a Call of HORIZON 2020

Positive evaluation August 2015 ⇨ negociation ⇨ Grant Agreement signed December 2015

Research Area: Leadership in Enabling and Industrial Technologies (LEIT)
Sub-programme: 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 Applications
Project duration: 36 months (Feb 1, 2016 – Jan 31, 2019)
Project funding: 3 MEuro
The AURORA Consortium

FMI (Helsinki, FI)

KNMI (Amsterdam, NL)

ECMWF (Reading, UK)

BIRA-IASB (Brussels, BE)

IFAC-CNR (Firenze, IT)

S[&]T Corporation (Delft, NL)

DATA CRAFT (Rotterdam, NL)

FLYBY (Livorno, IT)

EPSILON (Athens, GR)
The Copernicus programme

Copernicus is the European Union’s Earth Observation programme implemented by the European Commission jointly with the European Space Agency.

Copernicus is aimed to provide regular and reliable Earth observation data from space for operational applications.
Copernicus Sentinel missions

Up to now 6 families of dedicated «Sentinel» space missions

**SENTINEL-1**
Radar imaging mission for land and ocean services

**SENTINEL-2**
Multi-spectral imaging mission for land monitoring

**SENTINEL-3**
Multi-instrument mission for sea-surface topography, sea & land surface temperature and ocean & land color

**SENTINEL-4**
Geostationary mission for atmospheric monitoring

**SENTINEL-5**
Low Earth Orbit mission for atmospheric monitoring

**SENTINEL-6**
Radar altimeter for global sea-surface height
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The atmospheric Sentinel missions

Sentinel-4 and Sentinel-5 address major topics related to atmospheric composition and data requirements studies were conducted **per theme** and **per user category**.

<table>
<thead>
<tr>
<th>Theme</th>
<th>User Category</th>
<th>Protocol Monitoring</th>
<th>Near-real time data use</th>
<th>Assessment</th>
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<tbody>
<tr>
<td>Ozone Layer and surface UV radiation</td>
<td>A1</td>
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<tr>
<td>Air Quality</td>
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<td>Climate</td>
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The atmospheric Sentinels aim at filling the main gaps of current/planned operational mission, such as GOME-2 and IASI (EUMETSAT MetOp) and OMPS and CRISS (US JPSS):

- **High temporal and spatial resolution** (more cloud-free views) space-based measurements of tropospheric composition for application to **AIR QUALITY**
- **High spatial resolution and high precision** monitoring of **CLIMATE GASES** (CO₂, CH₄ and CO) and aerosol monitoring with sensitivity to the PBL.
- **High vertical resolution** measurements in the UTLS region for OZONE and **CLIMATE** applications

Comparison of spatial resolution of Sentinel-5 with heritage mission (image credit ESA)
GEOstationary (GEO)
- Hourly revisit time over Europe
- Mainly air quality
- Diurnal cycle of tropospheric composition
  ➔ Sentinel-4

Low Earth Orbit (LEO)
- Daily revisit time global coverage
- Climate, air quality, ozone & UV
- Tropospheric & stratospheric composition
  ➔ Sentinel-5
  ➔ Sentinel-5 Precursor

<table>
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<tr>
<th>Year</th>
<th>Sentinel-5p</th>
<th>Sentinel-4 - 1</th>
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<td>IRS (1)</td>
<td>LI (2,* )</td>
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<td>VII (3)</td>
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<td><strong>Sentinel-5 Precursor</strong></td>
<td>UVNS spectrometer TROPOMI (4)</td>
<td>VIIRS (5)</td>
<td>CRIS (5,* )</td>
<td>OMPS (5,* )</td>
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</table>

(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

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  

MTG = Meteosat Third Generation  
MetOp-SG = MetOp-Second Generation  
SNPP = Suomi National Polar-orbiting Partnership  
JPSS = Joint Polar Satellite System
AURORA: Scope and objectives of the project

**SCIENCE**

- to investigate the **potential of data fusion and data assimilation** to convey complementary information content of measurements acquired by the atmospheric Sentinel LEO and GEO missions into unique geophysical products.
- to focus the exploitation of the synergy between simultaneous and independent measurements of the same atmospheric target on **tropospheric ozone and UV surface radiation**.

**TECHNOLOGY**

- to reduce the complexity of **managing the high volume of data** provided by Copernicus Sentinel-4 and Sentinel-5 and **increase its quality** w.r.t. the operational outcome of individual instruments
- to develop a **prototype data processing system** and demonstrate its capability to work with simulated data in **conditions as close as possible to operational environment**.

**APPLICATION**

- to develop **two operational downstream services** (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.
AURORA: Scientific Issues
Atmospheric Ozone

Instruments monitoring atmospheric ozone from space exploit a large range of observation geometries and spectral ranges.

Due to the inherent limitation of each measurement technique, none of the existing system can cover the needs for accurate observation of ozone from the surface up to the mesosphere.

By combining innovative data fusion techniques and data assimilation, the AURORA project envisages a breakthrough in atmospheric ozone sounding, in terms of improved accuracy and vertical resolution in the troposphere.
AURORA
Overall Concept

INDIVIDUAL OZONE PRODUCTS FROM LEO AND GEO SENTINELS (UV, VIS AND TIR BANDS)

DATA COMBINATION FUSION AND ASSIMILATION

UNIQUE GEOPHYSICAL PRODUCTS FOR OZONE TROPOSPHERIC OZONE/ UV SURFACE RADIATION

DATA PLATFORM WEB-GIS PORTAL – VISUALIZATION TOOLS

PRE-MARKET APPLICATIONS

DISSEMINATION
AURORA
Data Processing Chain

SIMULATION DATABASE

- L2 GEO UV
- L2 GEO VIS
- L2 GEO TIR
- L2 LEO UV
- L2 LEO VIS
- L2 LEO TIR

GEO DATA FUSION

- GEO FUSED L2 DATA UV + VIS + TIR

LEO DATA FUSION

- GEO FUSED L2 DATA UV + VIS + TIR

DATA ASSIMILATION SYSTEM

Integrated Forecasting System

3D OZONE ANALYSES
Actual and Forecast

UV PROCESSOR

SURFACE UV RADIATION

TROPOSPHERIC OZONE PROCESSOR

TROPOSPHERIC OZONE
Technological objective

The technological **objective** is to make all the available information accessible in the most user-friendly way possible - both by project partners and by other interested scientific and commercial communities - through software interfaces deducted to each source of data, database with geographical extension (geo-database), web-services with innovative visualisation tools, automatic data access.
AURORA Technological Infrastructure

INPUT DATA (simulated satellite data, etc.)

TECHNOLOGICAL INFRASTRUCTURE (geo-database + interfaces + web-service)

WP5 and WP6

DATA FUSION tool (WP4)

DATA ASSIMILATION tool (WP4)

OZONE PROCESSING tool (WP4)

UV PROCESSING tool (WP4)

VALIDATION tools/processes (WP7)

FINAL USERS (WP8 downstream applications, scientific and commercial end-users, etc.)
### Key components of the AURORA Technological Infrastructure

<table>
<thead>
<tr>
<th>GEO-DATABASE</th>
<th>Managing an huge amount of input data, intermediate and final results. Ready access to the pre-existing source data and the new datasets generated by the AURORA tools.</th>
</tr>
</thead>
</table>
| INTERFACES  | Two different types of interfaces for user-friendly access to different sources of information in a harmonized and homogeneous way:  
• Web-service for automatic machine-to-machine data access;  
• Smart dashboards for users’ direct data access |
| THE AURORA PORTAL | A web interface to access several resources and services. The GUI acts as a central point of access to all the highly accurate data elaborated throughout the project, as well as resources and services used by the end-users, including - but not limited to- scientists, academics, public authorities, environmental agencies, public etc |
AURORA: Applications
Application objective

AURORA aims to support the development of innovative products and services during and after project lifetime.

Two applications start from pre-existing products that will be further developed thanks to AURORA’s results, gaining an high added values with respect to currently available similar solutions.

Ozone monitoring in urban areas

Personal UV dosimetry
International Links

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

- Link with GEOSS (Global Earth Observation System of Systems) and its Space Arm CEOS (Committee on Earth Observation Satellites)
- Link with ESA’s Ozone CCI (Climate Change Initiative)
- Link with FP7 smeSPIRE
- Link with US TEMPO and Korean GEMS (Geo-AQ Constellation)
- Link with CAMS (Copernicus Atmosphere Monitoring Service)
AURORA link with TEMPO and GEMS (Geo-AQ Constellation)

- GEO dedicated air quality missions: GEMS, Sentinel-4, TEMPO, ...
- LEO missions with strong air quality assets: Sentinel-5 Precursor, Sentinel-5, ...
- CEOS Atmospheric Composition Virtual Constellation

Potential interest of regions in AURORA

• Regional authorities can be a user/customer for air quality and UV services => Improve environmental monitoring.

• Regional authorities can stimulate the value adding industry in the region to develop services:
  ▪ Value adding companies can provide services with AURORA data (combined with other types of data).
  ▪ Regional authorities can be a launching customer.
  ▪ Regional authorities can form a bridge between value adders and other sectors to create value (sell services).
Use cases AURORA for inspiration

- Governments (multiple levels)
  - Improve determining priorities and policies related to air quality and UV
  - Better evaluate implemented policies (effectiveness?)

- Asthma and COPD patients
  - What is the current air quality => Shall I go outside?

- Research groups and health departments
  - What is the trend in health risks related to air quality and UV?
  - Do we have to warn people for health risks?

- Insurance companies?
  - What are the health risks and can we mitigate the risks?
  - What are ecological risks and can we mitigate the risks?
Conclusion

AURORA aims at stimulating a wider use by the scientific and industrial community of atmospheric Sentinel data by means of innovative solutions from:

**SCIENCE:** synergistic approach to the use of information from measurements.

**TECHNOLOGY:** near-real time data management and “user-friendly” access to data.

**APPLICATION:** development of “pre-market” version of applications.

**SPECIFIC OBJECTIVES:** atmospheric ozone for potential synergistic exploitation of measurements and for the interest of application-oriented developments.

**IMPACT OF THE PROJECT:**
Reduce the volume and complexity of data provided by the atmospheric Sentinel missions.
Facilitate data access by institutional and industrial end users to create services and to develop new commercial applications.
Maximize the impact by means of dedicated communication and dissemination activities, contact with existing operational services and with interested enterprises and organizations.
H2020 project cases AURORA for inspiration

• Preparation phase
  ▪ Formation of consortium: addressing science, technology and applications challenges
  ▪ Proposal writing: weight on coordinator with strong secretariat/administrative support, consortium brainstorming, clear schedule for contributions with sharp deadlines
  ▪ Selection of partners: Portfolio of potential partners building up, ad hoc selection according to required competences, proven experience...

• Collaborations
  ▪ Heritage: pioneering EC FP6/FP7 projects + ESA GSE
  ▪ During the project: see slides before
  ▪ In preparation: New opportunities coming up (H2020 Space and others, CAMS, C3S...)

Since February 1\textsuperscript{st}, 2016: 
http://www.aurora-copernicus.eu/