An Integrated approach for the Validation and exploitation of Atmospheric missions

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Atmospheric composition measurements from space

Independent validation

Access to ground-based data, high quality, relevant coverage

<table>
<thead>
<tr>
<th>Network</th>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>EARLINET</td>
<td>aerosol profiles (troposphere)</td>
</tr>
<tr>
<td>AERONET-EU</td>
<td>aerosol column</td>
</tr>
<tr>
<td>CLOUDNET</td>
<td>cloud profiles (troposphere)</td>
</tr>
<tr>
<td>EUSAAR</td>
<td>near surface aerosol &amp; trace gases</td>
</tr>
<tr>
<td>PANDONIA</td>
<td>trace gases column</td>
</tr>
<tr>
<td>ICOS</td>
<td>carbon fluxes</td>
</tr>
<tr>
<td>TCCON</td>
<td>column-averaged CO₂, CH₄, N₂O, HF, CO, H₂O, and HDO</td>
</tr>
<tr>
<td>NDACC</td>
<td>aerosol, clouds, trace gases, greenhouse gases (stratosphere)</td>
</tr>
</tbody>
</table>
Goal

• Set up of
  – a **hub** to collect, handle, archive, and exploit in a **synergetic** way **observational data**, as provided by the future integrated atmospheric composition ground-based network infrastructure, for the **validation** of ESA and Copernicus missions

• Synergy
  – LIRIC, GARRLiC: aerosol from lidar + photometer
  – GRASP: aerosol and land surface from various remote sensing observations
  – Other ....
Goal

**Existing facilities**

<table>
<thead>
<tr>
<th>EARLINET</th>
<th>AERONET</th>
<th>PANDONIA</th>
<th>AC satellite missions</th>
</tr>
</thead>
</table>

**Synergy**

<table>
<thead>
<tr>
<th>Multi-platform</th>
<th>Multi-instrument</th>
<th>Multi-species</th>
<th>Multi-parameter</th>
</tr>
</thead>
</table>

**One-stop shop for AC missions & models**

- Tuning algorithms & parameterizations
- Monitoring the products quality on long-term

**Exploration**

- New techniques
- New algorithms
- New data products
Structure

Web portal: storage, processing, visualization

- Standardized radiometer data
- Satellite data
- Additional data sources
- Standardized photometer data
- Standardized lidar data
- Specialized algorithms
- Combined algorithms (GRASP)
Challenges

- **Coordination** of the LIDAR, photometer and spectrometer network operations, including centralized archiving and processing.

- Development of **standard procedures** (best practice and schedules) for calibration and operation of the instruments.

- Development of a **data aggregation and processing system** providing advance environment for applying cutting-edge algorithms, flexibility and convenience to user data analysis.

- Development of **algorithms** addressing the evolution of single measurement techniques, as well as the development of synergistic approaches combining multiple measurement techniques.
→ **Good operation**: recommend best practices and requirements for automatic/autonomous LIDAR operation, and document QA procedures, taking into account QA4EO guidelines (calibration → signal quality assurance).

→ **Reliable data products**: develop tools to easily integrate new lidar stations to EARLINET’s centralized processing system (Single Calculus Chain → data quality assurance).

→ **Synergy with other sensors**: develop data formats and communication protocols to harmonize lidar data exchange, and feed GRASP.
→ **Good operation**: document photometer calibration tools and operation procedures for sun/sky/polar/lunar photometer calibration and quality assurance

→ **Increase data quantity**: document possible new observation protocols to increase aerosols retrievals frequency (night time, cloudy)

→ **Reliable data products**: investigate, design and describe new calibration procedures (travelling master with ESA radiometric calibration labs, AOD-radiance transfer method, comparability test with GAW-AOD)

Run the Pandonia network in an operational mode from 2017 and to reach compatibility with the planned data-processing hub.

Make Pandora “ready” for use with GRASP algorithm in order to retrieve Aerosol properties.

Equip one Pandora with polarization filters to infer the degree and angle of polarization from sky radiance measurements.

Figure: part of the preparation for Aerosol retrievals is to improve the radiometric stability of the Pandoras. A recently developed ‘fiber guide’ is being tested (top panel). First results seem to show that it has a positive effect. The ratios to a sun photometer (bottom panel) are more stable with the fiber guide (green dots) than without it (red dots).
Implementation of GRASP

Generalized Retrieval of Aerosol and Surface Properties
Implementation of GRASP

• Development of a prototype software for automated data control and processing

• Allow a variety of retrieval options to:
  – combine observations
  – change the retrieval assumptions
  – select the retrieval regimes, modes and content of output generation

• Preparing and linking the data (lidar, photometer) to the inputs of GRASP

• Demonstrate the use of data from AERONET/PHOTONS and EARLINET
**SYNERGY**

GARRLiC/GRASP for ground-based observations

Lidar + AERONET

Lopatin et al. 2013
SIZE DISTRIBUTION

Minsk 13Aug2010 smoke event

- Blue circles: Fine mode
- Red squares: Coarse mode
- Green triangles: Aeronet retrieval

Size distribution, $dV(r)/dr$:

Radius, $\mu$m:

- $\tau_{440} = 0.46$
- $\tau^f_{440} = 0.42$
- $\tau^c_{440} = 0.04$

Minsk 02Jun2008 dust event

Size distribution, $dV(r)/dr$:

Radius, $\mu$m:

- $\tau_{440} = 0.36$
- $\tau^f_{440} = 0.19$
- $\tau^c_{440} = 0.17$
REAL PART OF REFRACTIVE INDEXES

Minsk 13Aug2010 smoke event

Minsk 2Jun2010 dust event

Wavelength, µm

Real part of refractive index
VERTICAL DISTRIBUTIONS

Concentration profiles

SSA profiles
WOULDN’T BE NICE TO HAVE ALL IN ONE PLACE?

+ a “playground” for new algorithms

Profiles, column data, satellite data, combined products
Aerosols, trace gases, ...
Web portal

- Integration of the software components in a backend processing infrastructure
  - Runtime environment (hardware + software stack) to run individual software packages and collect input data
  - Webservice to manage software components:
    - Upload a new or updated software component including executables, configuration and auxiliary files
    - Create, view, modify processing chains
    - Test software components and full processing chains by automated integration tests
    - Upload new and update integration tests (executables with test data)
Web portal

• Setup of a platform for remote sensing data validation
  – Web service to execute and monitor software components
  – Framework to facilitate the usage of data for validation purposes for scientists:
    • Include verification algorithms
    • Include data visualization algorithms
    • Register data streams and/or upload data to be validated
<table>
<thead>
<tr>
<th>Station name</th>
<th>Coordinates</th>
<th>Facilities</th>
<th>Lidar</th>
<th>Photometer</th>
<th>Radiometer</th>
<th>GRASP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bucharest</td>
<td>44.35N 26.03E 93m</td>
<td>Aerosol, ozone, and water vapour lidars, sun/lunar photometer, Pandora-2S, microwave radiometer, optical laboratory</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Lille</td>
<td>50.61N 3.14E 60m</td>
<td>Aerosol and water vapor LiDARs, photometers (sun/sky/lunar/polarization, AERONET), UV spectro radiometer (ozone, NDACC), FTIR, calibration site (optical labs), Infrared scanning radiometer, aerosol in situ optical measurements, particle counter, aerosols sample for chemical analysis, Solar and Infrared radiative fluxes</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Innsbruck</td>
<td>47° N 11° E 616m</td>
<td>Pandora, double-monochromator scanning spectrometer with polarization capability, photometers, optical laboratory</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Izaña</td>
<td>28° N 16° W 2360m</td>
<td>Pandora, radio- &amp; ozone-sondes, Brewer triad, FTIR, photometers, optical laboratory</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Carpentras</td>
<td>44.08N 5.06E 100m</td>
<td>AERONET sun calibration site (sun/sky/lunar/polarization), solar and infrared radiative fluxes.</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Dakar</td>
<td>14.39N -16.96E 12m</td>
<td>Aerosol LiDAR, photometers (sun/sky/lunar/polarization, AERONET), FTIR (temporary), Infrared Scanning Radiometer, aerosol in situ optical measurements, TEOM, Solar and Infrared radiative fluxes</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Frascati</td>
<td>42° N 13° E 185m</td>
<td>Pandora, sun photometer</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

• Addressing the need for a long-term atmospheric composition hub:
  – Concentrating data from ground-based networks
  – Operating single-instrument and synergetic data processing algorithms
  – Facilitating
    • Cal/Val for atmospheric composition missions: S3, S5p, ADM-Aeolus, EarthCARE
    • Model verification and data assimilation

• Use of existing facilities, new common standards
  – Calibration of instruments (moving reference)
  – Compatible data formats and variable definitions
  – Easy to use check-up and analysis tools

• Integration of new technologies
  – (Pseudo)continuous measurements (sun/lunar photometer, Pandora)
  – New data products (polarization)
  – Combined retrievals (GRASP)
Looking forward for the future

Thank you.