CA18235 PROBE

Deliverable 1.2

Report on user-requirements from different stakeholders

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1 Context

1.1. Engagement with stakeholders

As discussed in PROBE Deliverable 1.1, the action is engaging with a diverse list of stakeholders from academia, industry, operational agencies, sustained research structures and other end-users. These utilise ground-based remote sensing observations for a range of application domains, such as sensor development, forecasting and process understanding of meteorology, climate, hydrology, air quality, etc and related hazards, renewable energy applications, building engineering, and urban planning. To better characterise the user requirements of these stakeholders, WG1 exploited several activities within the PROBE action and beyond.

Milestone 1.1) A dedicated PROBE stakeholder workshop was organised in Evora, Portugal, in October 2022. Several stakeholders were invited to present their requirements for ground-based remote sensing data and technical expertise, covering a range of fields from Doppler wind lidar observations for renewable energy, urban atmosphere research for micro-climate and air quality applications, urban planning consultants, Environment agencies for air quality and weather prediction, as well as geoengineering applications.

In addition, discussions with stakeholders were conducted at several occasions, such as meetings of the EUMETNET initiative E-PROFILE, the European research infrastructures ACTRIS and ICOS as well as project meetings of the EU H2020 projects RI-URBANS (ACTRIS) and PAUL (ICOS-cities), or the FESSTVal campaign. WG1 conducted a specific interview with IEA Task 32 and a dedicated PROBE VMG summarised the user requirements from the perspective of an environmental agency that is starting to enhance their ground-based remote sensing profiling network.

1.2. Stakeholder groups

Based on the results of the stakeholder engagement activities, a clear structure of the PROBE user community was identified:

a) **End-users:** Those with an interest in high-quality observations and products describing the physical and /or chemical state of the atmospheric boundary layer.
b) **Product developers:** Those working on high-quality data products that can be obtained from the profile observations.
c) **Operators:** Those operating ground-based remote sensing instruments. This ranges from the use of one single sensor, over the operation of multi-sensor networks to research infrastructures and instrument manufacturers.

In addition, several stakeholders highlight the value of remote sensing observations for purposes of dissemination and capacity building (incl. teaching, outreach).

2 User needs

We found that users from different groups are often interested in similar products and have similar requirements independently of the exact field of application.

All output (incl. documents, code, data) should have the following official characteristics:

1. be accessible
2. be traceable (DOI)
3. be versioned with clear status (draft, final)
4. include list of authors
5. include contact details
6. include keywords

In the below tables we list data products, documentation, and guidelines that describe the needs of PROBE stakeholders, adding an indication of the respective maturity.

Table 1: Profile data and advanced products

Data products	Maturity
Vertical profiles of physical quantities	
● Temperature	Mature
● Humidity	Mature
● Horizontal wind speed and direction	Mature
● Vertical wind	Mature
● Turbulence (variance, TKE, eddy dissipation rate)	Developing
● Aerosol derived properties (particle backscatter, extinction, mass concentration)	Developing
● Aerosol type / higher layer identification	Novel
Atmospheric boundary layer heights	
● Aerosol-derived	Mature
● Turbulence-derived	Developing
● Thermodynamic (including strength of T-inversion)	Developing
● Synergy (e.g. bulk Richardson number)	Developing
Atmospheric stability indicators	
● Turbulence-derived	Development
● Thermodynamic	Development
● Synergy	Novel
Atmospheric boundary layer characteristics	
● Low-level jet detection	Mature
● Source of turbulence (cloud-driven, surface-driven)	Mature
Cloud and precipitation characteristics	
● Cloud base altitude	Mature
● Cloud top	Developing
● Melting layer	Developing
● Cloud water/ice content	Mature
Alters	
● Wind gusts	Developing
● Fog	Mature
● Icing	Developing

There is general interest in **indicators of uncertainty**.

- Quantitative uncertainty measures are especially important for users in data assimilation, but also model evaluation, and applications related to public health and public safety (e.g. ash concentrations for air traffic).
- For certain products, absolute quantification of uncertainty is still subject to ongoing research.

Those products are of great interest at high temporal and vertical resolution. With increasing model capabilities, also network data with dense spatial horizontal coverage are in demand.

Table 2: Instrument operations

Instrument operations	Status
Choice of sensor	
● Sensor type capabilities, limitation, maintenance requirements	Mature
● Model specific capabilities and limitations, maintenance requirements	Mature
● Sensor / model inter-comparison overview	Developing
● Continued and timely evaluation of novel sensors	Developing
● Continued and timely evaluation of novel products	Developing
Installation and network design, operations	
● Recommendations for sensor placement	Developing
● Recommendations for site identification and network design	Developing
● Official and traceable standard operating procedures (SOPs)	Developing
● Guidelines for maintenance and calibrations	Mature
● Guidelines for installations and troubleshooting	Mature
● Guidelines for sensor setup (incl. e.g. scanning strategies) and data acquisition (resolutions, settings)	Developing
● Forum to exchange and discuss sensor issues (especially for novel sensors and products)	Novel
● Tracking of firmware updates	Mature
● Description of algorithms/retrievals integrated in the instrument firmware	Developing
● Software to support data transfer	Novel
● Tools to support quicklooks and tracking of housekeeping data (in near real-time)	Developing

Table 3: Operational networks

Diverse sensor networks	Maturity
Network products	
● Data harmonisation (across diverse sensor networks, instrument models, brands…)	Novel
● Calibrated, corrected data products with quantified uncertainty	Novel
● Impact assessment (combination of sensors, density of network, novel products, …)	Novel
● Exploitation of synergy (e.g. at supersites with many different sensors)	Novel
Mature processing tools	
● Approved procedures (quantified uncertainty, with scientific publication or official scientific report)	Novel
● Key performance indicators (KPI) - why is the tool approved by the specific network?	Future
● Well-documented, efficient scripts (mostly python), traceable in github	Novel

Table 4: Capacity building and outreach

Capacity building and outreach	Maturity
Documentation	
● Impact studies should communicate novelty based on well-defined use cases	Novel
● Prepare output with different levels of detail for different audiences, using visuals where appropriate	Novel
● Identification of output that can be used for teaching or outreach applications	Novel
Outreach and knowledge exchange	
● Interactions within institutions: how to communicate the value of ABL products to decision levels?	Novel
● Connection between communities (e.g. ABL profiling for air quality, urban climate, complex terrain)	Novel
● Identification of expertise and tools available, required, developed by different communities	Novel
● Who are possible users? How to identify and approach potential users?	Future
● Identification of business opportunities and connection to other communities	Future

Table 5: Development and innovation.

Development and innovation	Maturity
Tool development	
● Clear guidelines and standards for novel tools defined by KPI (e.g. new retrieval needs to be better than standard X) □ important to foster innovation	Novel
● Interaction with industry: how can scientific tools be transformed into user-friendly tools with API (as required e.g. by wind energy industry)	Novel
● Technological innovation through close collaboration with instrument manufacturers	Developing