

CA18235 PROBE

Deliverable 1.3

Recommendations for addressing the weaknesses identified

WG1 chairs: Henri Diémoz and Simone Kotthaus

Contributors: Claudia Acquistapace

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1. CONTEXT

Through its diverse expertise and involvement in numerous applied scientific studies, the PROBE community is in a powerful position to meet many of the user requirements (PROBE Deliverable 1.2) that have been formulated following exchange with different stakeholders. However, a set of weaknesses has been identified that hamper the exploitation of ABL profiling data and procedures by end-users. These can be summarised into the following shortcomings:

- a) **A lack of documentation and accessibility.** Many users do not know which data, tools, and knowledge do exist and where to find respective information.
Example: Which are the state-of-the-art retrieval tools available to derive a certain product?
- b) **No clear formulation of innovation pathways.** It is critical for the community, both internally and also for exchange with stakeholders, that common innovation objectives are identified and benchmarking targets are clearly communicated.
Example: Which shortcomings of current tools need to be addressed? What are the key performance indicators that demonstrate a new method presents an improvement?
- c) **Need to further improve synergy and collaborations between operational measurement networks,** including strategies to upscale and implement novel products and study areas.
Example: A new tool has been developed as a collaboration between academia and potentially one operational network. How can operational networks implement such novel products effectively?

Finally it should be noted that PROBE (and certain preceding COST actions) have acted as a catalyst for scientific development, knowledge exchange and outreach with a clear impact on a strong European ground-based remote sensing community. This function has been clearly identified as a user-need that will persist after the end of the action.

2. RECOMMENDATIONS

To address the shortcomings that have been identified ([Context](#)), WG1 has developed specific recommendations that can be grouped into effective strategies for dissemination (Section 2.1), innovation support (Section 2.2), and the continued development of a vital European ground-based remote sensing community (Section 3.3).

2.1. DISSEMINATION

It is recommended that PROBE puts a clear focus on the careful documentation of its broad ground-based remote sensing expertise, an efficient dissemination of expert tools and data, as well as a communication of research findings that is tailored to the interests of various stakeholders. To achieve these goals, PROBE should create a **centralised document repository** as a knowledge hub that persists beyond the duration of the action. This PROBE knowledge hub should aim to function as a link between multiple operational measurement networks, academia, and end-users.

The repository should be created on an accessible and flexible platform (such as [Zenodo](#), a trusted service that is widely used in the scientific community). It should include all relevant PROBE deliverables, reports (SWG, VMG, STSM, etc.) and other documentation (e.g. standard operating procedures). It should be the aim to add links to external resources (incl. measurement guidelines, white papers, code repositories, etc.) where possible. It is critical that the repository is guided by the [FAIR Guiding Principle for Scientific Data Management and Stewardship](#), which stand for Findability, Accessibility, Interoperability, and Reusability. These outline a set of guidelines for effective

data management and sharing, particularly in the context of digital assets. Here's a breakdown of each principle:

- **Findability:**
 - Ensure data can be easily located by both humans and computer systems
 - Implement clear and unique identifiers for datasets
 - Enhance metadata to improve search and discovery
- **Accessibility:**
 - Make data readily available to users and machines under well-defined conditions
 - Provide clear access protocols and permissions
 - Establish repositories or platforms for easy access to datasets
- **Interoperability:**
 - Facilitate seamless integration of data with other datasets and systems
 - Use common standards and formats to enhance compatibility
 - Promote the exchange of data between different research communities
- **Reusability:**
 - Make data comprehensible and usable for diverse purposes
 - Provide detailed documentation and contextual information
 - Encourage open licences to maximise the potential for future research and applications

It is considered strategic for PROBE to adhere to these principles to enhance the impact of the action and to promote collaboration, innovation, and the knowledge exchange among communities. A platform like Zenodo offers a dedicated tool that promotes open science. It enhances findability by providing a centralised repository for research outputs, complete with persistent identifiers like DOIs for unique and easily discoverable datasets. It also ensures integration with other repositories, such as github. By joining e.g. the Zenodo community, PROBE will contribute to a collaborative ecosystem that encourages the sharing and reuse of valuable research data, methods, and knowledge.

2.2. INNOVATION PATHWAYS

The PROBE expert network combines two very valuable components that are absolutely critical to enhance innovation. Firstly, standards are being defined for the quality and uncertainty of ground-based remote sensing observations and advanced products, taking into account measurement related factors as well as those linked to data processing procedures. Secondly, PROBE has identified a set of critical topics where innovative scientific research and instrument development are expected to have applied impacts. Now it is critical that this knowledge on **important innovation objectives** and respective state-of-the-art procedures are documented carefully, following the FAIR principles outlined above. To foster continued innovation also after the end of the action, it is recommended that data and tools should be associated with a set of **key performance indicators (KPI)**.

- **Organisation:**
 - Documentation should be organised to align with clearly identified innovation pathways.
 - Information needs to be findable both from the perspective of end-users and future developers (choose meta information, document structure, and document titles wisely).
 - Links between innovation in measurement technology and processing or exploitation should be clearly highlighted where appropriate.
- **Uncertainties and limitations:**
 - Any data set or analysis tool should be associated with uncertainties and limitations wherever possible.
 - New developments should explicitly be encouraged by stating shortcomings of current “best-estimates”.
 - Analysis tools should provide well-documented code repositories (e.g. link github to Zenodo repository). These should include reference data that can be used for benchmarking by future innovations to effectively quantify improvements.

- **Impact and application:**
 - Innovation is fostered by demonstrating capabilities. To encourage the use of ground-based remote sensing data by diverse end-users and to support instrument operators in the exploitation of novel data, capabilities should be presented in the form of clearly identified use cases. The information needs to be accessible and understandable by users with a wide range of backgrounds.
 - It is recommended to extract key examples from detailed scientific reports and make them available in short, illustrative formats that can be shared easily.
 - Scientific publications from the PROBE network should be placed in a prominent location in the PROBE document repository, highlighting the contributions in the PROBE Copernicus Special Issue (AMT, GMD).

2.3. VITAL EUROPEAN GROUND-BASED REMOTE SENSING COMMUNITY

It is recommended to discuss the future support of a vital European ground-based remote sensing community with different actors, including established operational instrument networks (ACTRIS, E-PROFILE), national meteorological and hydrological services, environmental agencies, space agencies (ESA) and various academic partners. It is critical to develop a strategy both for the maintenance of established connections and collaborations but also for the continued promotion of atmospheric boundary layer profiling in adjacent communities and for future applications (e.g. urban environments, complex terrain, air quality, and many others).

The community should agree on a procedure for the efficient implementation and upscaling of novel instruments, correction and quality-control procedures, as well as novel tools that derive advanced data products. Given many instruments are participating in more than one operational network, it is important for standard operating procedures to be aligned between measurement networks.

A first step was taken recently with the aim to create dedicated working groups that are open for anyone to join but have strong support from both ACTRIS and E-PROFILE. To date, working groups for the following topics are listed: **Radar Doppler Spectra, Atmospheric Boundary Layer, Cloud in situ & remote sensing, Aerosols Cloud Interactions, Model and Observation Intercomparison, and Atmospheric remote sensing in Urban Environments**. It is recommended that an organisational strategy (with potential funding support) should be formulated for the implementation of these working groups. To have a visible impact, it is recommended that this initiative should have a clear branding and identify indicators that ensure credibility.

Ongoing and future projects and initiatives provide promising opportunities for community development and should be encouraged to participate in these discussions.

- **TEAMx:** TEAMx is an international research initiative that aims at improving our understanding of atmospheric processes over mountains (<http://www.teamx-programme.org/>)
- **PANAME:** The PANAME initiative (“Paris region urbaN Atmospheric observations and models for Multidisciplinary rEsearch”) is a coordination effort involving several research projects that aim to better understand the atmospheric dynamics and composition in the Paris region (<https://paname.aeris-data.fr/>) for many different applications, such as air quality, weather and climate, human health, or urban planning
- **RI-URBANS:** RI-URBANS is a Horizon 2020 project aiming at demonstrating how Service Tools from atmospheric Research Infrastructures (RIs) can be adapted and enhanced to better address the challenges and societal needs in European cities concerning air quality (<https://riurbans.eu>). The topics include vertical profiling for AQ purposes
- **FRM4Radar phase 2:** The rationale of this ESA funded project is to establish an observation network for validation, verification and calibration of EarthCARE cloud profile measurements based on ground-based, high-quality remote sensing observations (<https://geomet.uni-koeln.de/forschung/frm4radar>)

- **GIVE proposal for EarthCARE Cal/Val:** GIVE is a coordinated initiative to bundle the expertise of the German atmospheric research community. It aims at the validation of the entire chain of EarthCARE L1 and L2 products and the evaluation of related algorithms and instrument calibrations.