From Fragmentation to Coordination: Toward Harmonized Meteorological and Hydrological Observations in Congo Basin

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What: The workshop on harmonized meteorological and hydrological observations brought together national stakeholders and international partners to address persistent challenges related to fragmentation, sustainability, data interoperability and long-term governance of observing systems across the Democratic Republic of the Congo and the broader Congo Basin. Discussions underscored the urgent need to transition from isolated observational projects toward coordinated, interoperable, and sustainable observing systems capable of supporting climate services, research, and early warning systems.

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1. Context and background

The Congo Basin is one of the world's three major tropical convective hotspots (Jackson et al. 2009), where complex land–atmosphere interactions exert strong influence on regional and global climate systems. Despite hosting the second-largest rainforest on earth, the region remains one of the least observed globally (Todd and Washington 2004; Balas et al. 2007; Nicholson and Dezfuli. 2013; Washington et al. 2013; Camberlin et al. 2019). This persistent lack of high-quality meteorological and hydrological observations continues to constrain scientific understanding of climate processes over central Africa (Alsdorf et al. 2016), reduce the skill of numerical weather prediction and climate models, and limit the development of reliable climate services and early warning systems (Balas et al. 2007; Washington et al. 2013; Dezfuli and Nicholson, 2013; Diem et al. 2014; Maidment et al. 2015; Nicholson et al. 2018; Hua et al. 2016; Camberlin et al. 2019).

Over recent decades, progress in understanding Central African hydroclimate has relied heavily on satellite-derived datasets, atmospheric reanalyses, and climate model simulations (Washington et al. 2013; Maidment et al. 2015; Hua et al. 2016; Camberlin et al. 2019; Nicholson and Klotter 2021). Yet these products often exhibit substantial inconsistencies in rainfall magnitude, spatial distribution, seasonality, and long-term variability (McCollum et al. 2000; Nicholson and Grist 2003; Washington et al. 2013). The scarcity of sustained in situ observations for calibration and validation further amplifies these uncertainties (Tian and Peters-Lidard 2010; Awange et al. 2015), particularly for rainfall extremes and mesoscale convective systems (MCSs) (Jackson et al. 2009; Hua et al. 2019). Consequently, different datasets often yield divergent conclusions (Washington et al. 2013; Siam et al. 2014; Camberlin et al. 2019), undermining confidence in both research findings and operational applications. Heaney et al. (2016) further noted that gauge-only interpolated datasets across Central Africa often lack sufficient observational constraints to support robust local-scale analyses.

Emerging evidence also suggests that key atmospheric processes influencing central African rainfall remain poorly constrained because of sparse upper-air and surface observations. These include dry-air intrusions associated with shallow meridional circulations linked to the Saharan thermal low (Thorncroft et al. 2011; Shekhar and Boos, 2017; Zhai and Boos, 2017; Longandjo and Rouault, 2024). Similarly, the influence of biomass-burning aerosols on cloud properties, radiative processes and rainfall suppression (Wu et al. 2025; Mallet et al. 2024; Hodnebrog et al. 2016) remains insufficiently quantified.

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These scientific uncertainties are compounded by persistent institutional and infrastructural challenges. Across the Congo Basin, and particularly within the Democratic Republic of the Congo, meteorological and hydrological observing systems have frequently evolved through isolated institutional and project-based initiatives involving national agencies, research institutions, river and aviation authorities, and faith-based organization networks. As a result, observational networks often operate with heterogeneous instrumentation, inconsistent metadata standards, fragmented data management practices, limited interoperability and operational sustainability. Consequently, substantial investments in national meteorological infrastructure over recent decades have often failed to achieve their full potential or deliver lasting impacts (Vogt et al. 2024). These challenges largely stem from the absence of coordinated national frameworks for observational governance, maintenance, data exchange, quality assurance, and operational continuity, all of which are critical for sustaining effective observing systems and maximizing the value of meteorological observations.

The challenge facing the Congo Basin is therefore no longer solely the scarcity of observations, but also the lack of integration among existing observing systems. Addressing this fragmentation is now essential to unlock the full value of current and future investments, strengthen climate resilience, advance scientific knowledge, and support the delivery of reliable weather, climate, and hydrological services across Central Africa.

2. Workshop objectives and structure

In response to these scientific, operational, governance, and sustainability challenges, a national workshop on the harmonization of meteorological and hydrological observations was convened in Kinshasa on 2–3 April 2026. The workshop brought together approximately 30 participants representing national meteorological and hydrological agencies, energy, river and aviation authorities, water utilities, universities, research centres, infrastructure operators, development partners, and international organizations involved in observational and climate-related initiatives across the Congo Basin. Participants included representatives from the "Agence Nationale de Météorologie et de Télédétection par Satellite" (METTELSAT), "Institut National pour l'Étude et la Recherche Agronomiques" (INERA), "Régie des Voies Fluviales" (RVF), "Régie des Voies Aériennes" (RVA), " Régie de Distribution des Eaux" (REGIDESO), "Société Nationale d'Électricité" (SNEL), universities and research institutions, as well as international partners including the World Bank, Agence Française de Développement (AFD), and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

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The workshop pursued three principal objectives: (i) harmonizing observational protocols and technical standards across institutions;, (ii) strengthening data collection, rescue, sharing, and management practices; and (iii) improving governance, coordination, and long-term sustainability of observing systems.

The first day focused on institutional perspectives, infrastructure challenges, and operational experiences related to observing system deployment and maintenance. Presentations highlighted ongoing efforts to expand observational capacity while also revealing persistent challenges related to maintenance, calibration, telecommunications, technical support, and long-term financing.

The second day concentrated on scientific and technical discussions, including lessons learned from automatic weather station deployments, data interoperability challenges, metadata standards, calibration procedures, and strategies for strengthening coordinated observing systems. Breakout sessions enabled participants to identify common operational challenges and propose pathways toward harmonized national frameworks aligned with World Meteorological Organization standards and the Global Basic Observing Network (GBON).

3. Key Lessons Emerging from the Workshop

A major conclusion of the workshop was that observational fragmentation has itself become a major scientific and operational constraint across the Congo Basin. Participants emphasized that multiple observational initiatives continue to operate independently, often using incompatible instrumentation, differing measurement protocols, inconsistent metadata practices, and disconnected data systems.

Several participants noted that significant investments in infrastructure deployment over recent decades have frequently yielded limited long-term benefits because sustainability mechanisms were insufficiently addressed. In many cases, observing systems were established through externally funded projects without adequate consideration for maintenance capacity, spare parts availability, telecommunications, technical training, calibration procedures, or institutional ownership.

Discussions also highlighted the vulnerability of historical meteorological and hydrological archives. Large volumes of paper-based observations remain undigitized and are at risk of permanent loss due to degradation, inadequate storage conditions, and limited archival

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resources. Participants stressed that data rescue and digitization should become a core component of future observing system strategies. Another recurring theme was the urgent need for interoperable data systems and open data-sharing frameworks. Participants emphasized that data collection alone is insufficient if observations remain inaccessible, fragmented across institutions, or unavailable for operational forecasting and scientific analysis. Improved interoperability between meteorological, hydrological, aviation, river transport, and research institutions was therefore identified as a critical priority.

The workshop further highlighted the importance of strengthening collaboration between operational agencies and universities. Participants emphasized that sustainable observing systems require not only infrastructure, but also long-term scientific capacity, technical expertise, training programs, and sustained institutional coordination.

Overall, the workshop underscored the need to move beyond isolated observational projects toward integrated observing systems capable of supporting operational forecasting, climate services, disaster risk reduction, and Earth system science.

4. Toward Coordinated Observing Systems in the Congo Basin

The workshop discussions identified several priority actions to strengthen observing systems across the Congo Basin.

First, participants emphasized the importance of establishing nationally coordinated technical standards aligned with WMO and GBON requirements. These standards should include harmonized approaches for instrument selection, calibration procedures, metadata documentation, measurement frequencies, quality control, and telecommunications protocols.

Second, the workshop highlighted the need for interoperable national data platforms capable of supporting operational forecasting, climate monitoring, scientific research, and early warning systems. Participants stressed that data governance frameworks should promote accessibility, interoperability, quality assurance, and long-term archival preservation.

Third, participants emphasized that infrastructure deployment alone cannot ensure sustainable observing systems. Long-term operational continuity requires sustained financing mechanisms supporting maintenance, calibration, technical support, telecommunications, spare parts, and capacity development.

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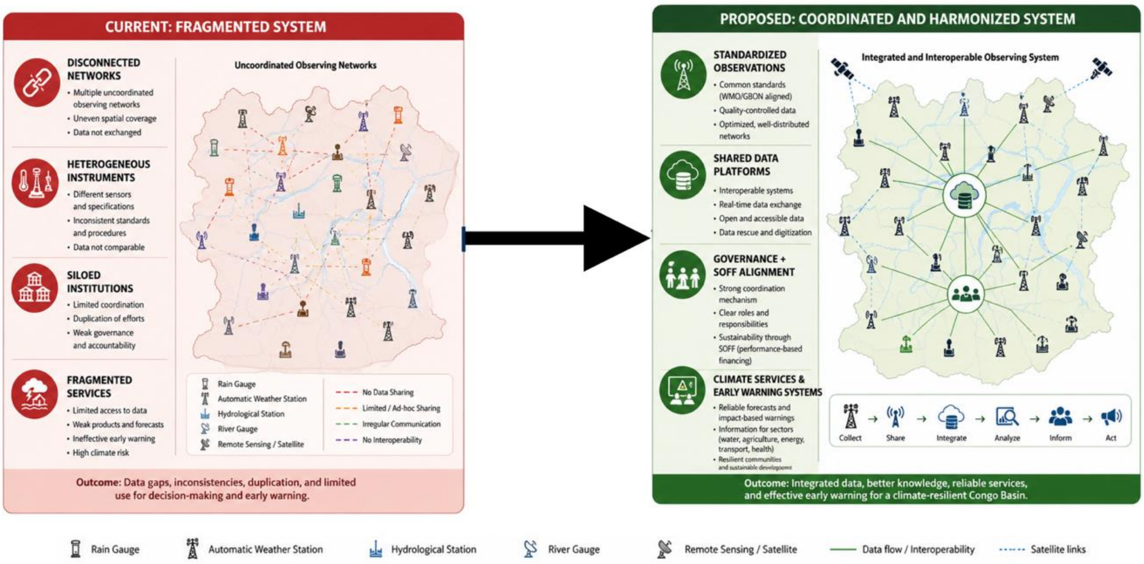

Fig. 1. Conceptual framework illustrating the collective vision of a coordinated, sustainable, and inclusive hydro-meteorological observing system for the Congo Basin, designed to support trusted climate information, early warning systems, climate resilience, sustainable development, and community well-being.

The workshop therefore identified sustainability as both a technical and governance challenge. Fourth, participants highlighted the importance of data rescue and digitization initiatives aimed at preserving historical meteorological and hydrological records. Recovering and integrating historical observations was viewed as essential for improving climate baseline analyses, trend assessments, and model evaluation.

The workshop outcomes align closely with ongoing international initiatives such as the WMO Systematic Observations Financing Facility (SOFF), the Global Basic Observing Network (GBON), and the United Nations "Early Warnings for All" initiative (Lamptey et al., 2024). Participants particularly highlighted the potential importance of SOFF's performance-based financing framework, which links financial support to the sustained delivery of high-quality observations to international exchange systems.

More broadly, the workshop emphasized that strengthening hydro-meteorological observing systems in the Congo Basin is not only a regional development priority, but also a global scientific imperative. Improved observations are essential for understanding tropical climate processes, improving weather prediction, enhancing climate resilience, and supporting global Earth system monitoring. Participants further noted that development of coordinated and interoperable observing systems could create opportunities for the Congo Basin to engage more

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actively to international programmes such as the Global network isotopes in precipitation (GNIP) and the Global network isotopes in rivers (GNIR), thereby strengthening hydrological and climate process studies across the region. The collective vision emerging from the workshop is summarized schematically in Fig. 1.

5. Conclusions and Call to Action

The Kinshasa workshop highlighted a critical shift in the observational challenge facing the Congo Basin. The issue is no longer solely the expansion of observational infrastructure, but rather the transformation of fragmented networks into coordinated, interoperable, and sustainable observing systems.

Participants emphasized that strengthening meteorological and hydrological observations in the Congo Basin is essential for improving regional climate resilience, supporting disaster risk reduction, advancing hydroclimate research, and strengthening early warning capabilities in one of the world’s least-observed tropical regions.

The workshop therefore called for:

- system-level investments prioritizing coordination, interoperability, and long-term operational sustainability;
- harmonized technical standards aligned with WMO and GBON frameworks;
- sustained operational financing mechanisms supporting maintenance, calibration, telecommunications, and technical capacity;
- interoperable and open data-sharing frameworks maximizing the scientific and societal value of observations;
- stronger integration between operational agencies, universities, and research institutions; and
- robust national leadership supported rather than replaced by international partnerships.

The workshop concluded that addressing observational fragmentation is now a prerequisite for advancing climate science, operational forecasting, and climate resilience across Central Africa. Sustained progress will require coordinated governance frameworks, operational continuity, institutional ownership, and long-term investment in both scientific and technical capacity.

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