2025-04-02

Systematic Observations Financing Facility

GBON National Gap Analysis

Haiti

Systematic Observations Financing Facility

Weather and climate data for resilience

Screening of the National Gap Analysis (NGA) of Haiti

WMO Technical Authority screens the GBON National Gap Analysis to ensure consistency with the GBON regulations and provides feedback for revisions as needed. *The screening of the NGA is conducted according to the SOFF Operational Guidance Handbook, version: 04.07.2023 and the provisions in Decision 5.7 of the SOFF Steering Committee.*

Following iterations with the peer advisor and beneficiary country, WMO Technical Authority confirms that the National Gap Analysis is consistent with GBON regulations. While the WMO GBON Global Gap Analysis identified the need for 1 surface stations and 1 upper air station over land to meet the GBON horizontal requirement, the **WMO Technical Authority confirms the NGA results which indicate the need for 3 surface land stations and 1 upper air stations based on specific national circumstances.**

Date: 16 April 2025

Signature:

Albert Fischer

Director, WIGOS Branch, Infrastructure Department, WMO

GBON National Gap Analysis
Haiti

ISO 3166-1 Alpha-3: HTI

Beneficiary Country Focal Point and Institution	Marcelin Esterlin - *esterlinm@yahoo.fr* Unité Hydrométéorologique d'Haïti **UHM**
Peer Advisor Focal Point and Institution	Frédéric P.A. Vogt - *frederic.vogt@meteoswiss.ch* Alexander Haefele - *alexander.haefele@meteoswiss.ch* Federal Office of Meteorology and Climatology **MeteoSwiss**

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Disclaimer

All information in this document, including Uniform Resource Locators (URLs), is valid as of 2025-04-02, unless otherwise specified. This file was compiled using the 2024/10/22 - v1.0 soffreport LaTeX class. Dates are specified in accordance with the ISO 8601 standard.

1 Country information from the GBON Global Gap Analysis

The country-specific results of the World Meteorological Organization (WMO) baseline Global Basic Observing Network (GBON) global gap analysis for Haiti, communicated to MeteoSwiss by the Systematic Observations Financing Facility (SOFF) Secretariat on 2024-10-03, are presented in Table 1.

Table 1: GBON Global Gap Analysis for Haiti.

A. GBON horizontal resolution requirements	B. Target	C. Reporting (GBON compliant)†	D. Gap to improve	E. Gap new	F. Gap total
	[# of stations]				
Surface land stations Horizontal res.: 200 km	1	0	1	0	1
Upper-air stations on land Horizontal res.: 500 km	1	0	0	1	1

† The rationale for classifying surface and upper-air stations as reporting is based on the WMO Integrated Global Observing System (WIGOS) Data Quality Management System (WDQMS) for the chosen time period (WMO GBON Global Gap analysis, June 2023). Stations with data availability larger than 80% on at least 80% of days are considered as reporting. Other listed stations are counted as having the possibility to be improved.

2 Analysis of existing GBON stations and their status against GBON requirements

The primary surface network in Haiti is comprised of 5 Automatic Weather Stations (AWSs) located on the country's main airports. These stations, first setup in 2015-2016 (with the technical support from the Cuban Meteorological Institute) and subsequently refurbished in 2018 as part of the 10-year/6.5 MCAD project "Haiti Weather Systems Programme: Climate Services to Reduce Vulnerability in Haiti"[1] by Environment and Climate Change Canada (ECCC), are designed to transmit their data to Haiti's National Meteorological and Hydrological Services (NMHS), in french *Unité Hydrométéorologique d'Haïti* (UHM) via General Packet Radio Service (GPRS). A single AWS also relying on GPRS technology for data transfer was purchased (alongside a few hydrological stations) with financial support from the World Food Programme (WFP) in 2020 and installed in Fort-Liberté. Since 2021, none of these stations share data with UHM due to several technical, connectivity, and financial issues. An Automatic Weather Observing System (AWOS), currently the only UHM-owned AWS to be connected to the electric grid with a generator as backup, has been deployed at the airport of Port-au-Prince in 2018 with the support of MétéoFrance International under the umbrella of the "Haiti Weather Systems Programme" of ECCC. These make up the 7 stations "to improve" (in terms if GBON compliance) mentioned in Table 2. As of 2025-04-02, none of these stations are registered as GBON stations.

This list does not include the AWSs deployed by UHM in collaboration with several Non Governmental Organizations (NGOs), Civil Society Organizations (CSOs), and private entities throughout the country. These other stations do not have long distance data communication system setup, and instead rely on in-situ data download by a human operator. It does not include the 24 AWS of the "Centre national de l'information géo-spatiale" (CNIGS) either, in view of their age, lack of spare parts, and support from the manufacturer being no longer available. We refer the reader to Delphin Léveillé et al. (2020) for a detailed description of these different networks.

As of 2025-04-02, there are no upper-air and no marine (surface or upper-air) stations in Haiti.

3 Results of the GBON National Gap Analysis

The outcome of the GBON National Gap Analysis for Haiti is summarized in Table 4.

As illustrated in Fig. 1, we find that 3 surface (land) station sites are sufficient to achieve GBON compliance at the country level (see Table 5 for details). Accounting for planned/existing GBON stations in neighboring countries (Cuba, Dominican Republic, Turks and Caicos Islands) of which the area of influence A^*_{inf} overlaps with Haiti, a 1-site solution (which corresponds to the baseline GBON target estimate, see Sec. 1) with a station in Port-au-Prince results in a mean

[1] https://wmo.int/media/news/ten-year-project-modernizes-haitis-meteorological-and-hydrological-service

Table 2: Assessment of HTI stations per their operational status and network ownership.

GBON Requirements	Existing observation stations (# of stations)			
	NMHS network		Third party network	
	Reporting (GBON compliant)	To improve	Reporting (GBON compliant)	To improve
Surface land stations Horizontal res.: 200 km Variables: SLP, T, H, W, P, SD	0	7	0	0
Upper-air stations on land Horizontal res.: 500 km Vertical res.: 100 m, ≥30 hPa Variables: T, H, W	0	0	0	0
Surface marine stations in EEZs Horizontal res.: 500 km Variables: SLP, SST	0	0	0	0
Upper-air stations in EEZs Horizontal res.: 1000 km Vertical res.: 100 m, ≥30 hPa Variables: T, H, W	0	0	0	0

Table 3: Assessment of characteristics for existing AWSs. The reporting cycle is reported according to WDQMS, and accounts for data transmission issues towards the Global Telecommunication System (GTS). Nominally, all these stations perform measurements at an interval of 10 min or less. The funding source refers to the original purchase & installation act.

Station name	Type	Owner	Funding source	GBON variable measured							Reporting cycle	GBON compliant ?
				SLP	T	H	W	P	SD	SST	[obs/day]	
Port-au-Prince	surface	UHM	ECCC	×	×	×	×	×			0	No
Port-au-Prince (AWOS)	surface	UHM	ECCC	×	×	×	×	×			0	No
Cap-Haitien	surface	UHM	ECCC	×	×	×	×	×			0	No
Jacmel	surface	UHM	ECCC	×	×	×	×	×			0	No
Les Cayes	surface	UHM	ECCC	×	×	×	×	×			0	No
Jérémie	surface	UHM	ECCC	×	×	×	×	×			0	No
Fort-Liberté	surface	UHM	WFP	×	×	×	×	×			0	No

Table 4: Results of the GBON National Gap Analysis

GBON Requirements	Global GBON target	Approved national target	Reporting	Gap	
				To improve	New
Surface land stations Horizontal res.: 200 km Variables: SLP, T, H, W, P, SD Observing cycle: 1/1 h	1	3	0	3	0
Upper-air stations on land Horizontal res.: 500 km Vertical res.: 100 m, ≥30 hPa Variables: T, H, W Observing cycle: 2/24 h	1	1	0	0	1
Surface marine stations in EEZs Horizontal res.: 500 km Variables: SLP, SST Observing cycle: 1/1 h	1	1	0	0	1
Upper-air stations in EEZs Horizontal res.: 1000 km Variables: T, H, W Observing cycle: 2/24 h	0	0	0	0	0

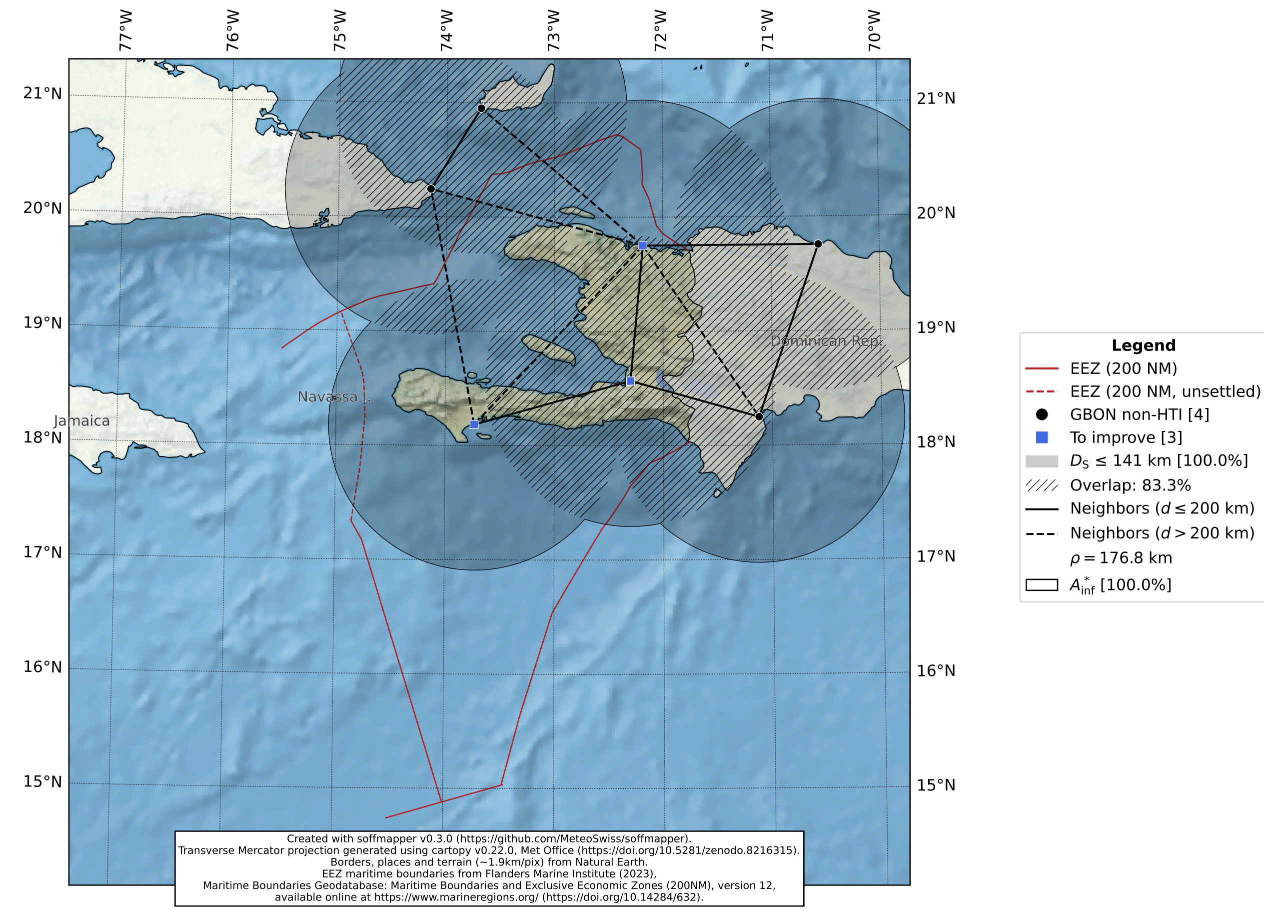


Figure 1: Network of 3 surface (land) stations (blue squares) sufficient for Haiti to meet the low-density GBON horizontal resolution requirement. The corresponding network horizontal resolution is $\rho = 176.8$ km. This measurement accounts for existing/proposed GBON stations in neighboring countries (black circles). Neighboring stations (as defined in Appendix A.2) are connected by straight black lines (continuous, if the stations are closer than 200 km from one another, dashed otherwise). A disk with a radius $R^*_{\mathrm{inf}} = 141$ km (see Appendix A.1) is drawn around each station. The resulting network baseline area of influence is $A^*_{\mathrm{inf}} = 100.0\%$ of the country area.

distance between (neighboring) stations of $\rho = 220.6$ km (see Appendix A.2 for details): larger than the GBON low-density horizontal resolution requirement of 200 km. The addition of 1 additional surface station in Les Cayes (to cover the South-West arm of Haiti) brings the network horizontal resolution down to $\rho = 214.8$ km. It is only with the addition of a third station in Cap-Haïtien (to cover the Northern part of the country) that the network horizontal resolution falls below the GBON requirement of 200 km. The associated country coverage factor is $A^*_{\mathrm{inf}} = 100\%$ (see Appendix A for the definition of A^*_{inf}). One should note that the addition of 2 additional stations (compared to the baseline estimate) also makes sense from a meteorological perspective, as they contribute to cover well-populated areas subject to distinct local climates.

We present in Fig. 2 a network map of 1 new upper-air station sufficient to meet the GBON horizontal resolution of $\rho_{\mathrm{GBON}} = 500$ km. This objective is consistent with the regional GBON design for the Caribbean that has been approved in March 2025 at the 19$^{\mathrm{th}}$ session of the Regional Association IV (see Fig. 3).

At the local level (i.e. accounting for upper-air stations in Jamaica and the Dominican Republic), the addition of an upper-air station in Port-au-Prince does make a clear difference, by reducing the upper-air network resolution from 736 km down to 368 km. At the regional level (see Fig. 3), its inclusion brings the network resolution down from 558 km to 534 km. Thus, on both scales, the inclusion of this station in the regional network is not superfluous in terms of the GBON targets. Furthermore, looking at the area of influence of the different upper-air stations, not including Port-au-Prince would leave a gap (the only one) between the East and West areas of the regional network, with several islands to the North of Haiti falling outside the network stations' nominal area of influence (including, e.g., the Turks and Caicos Islands).

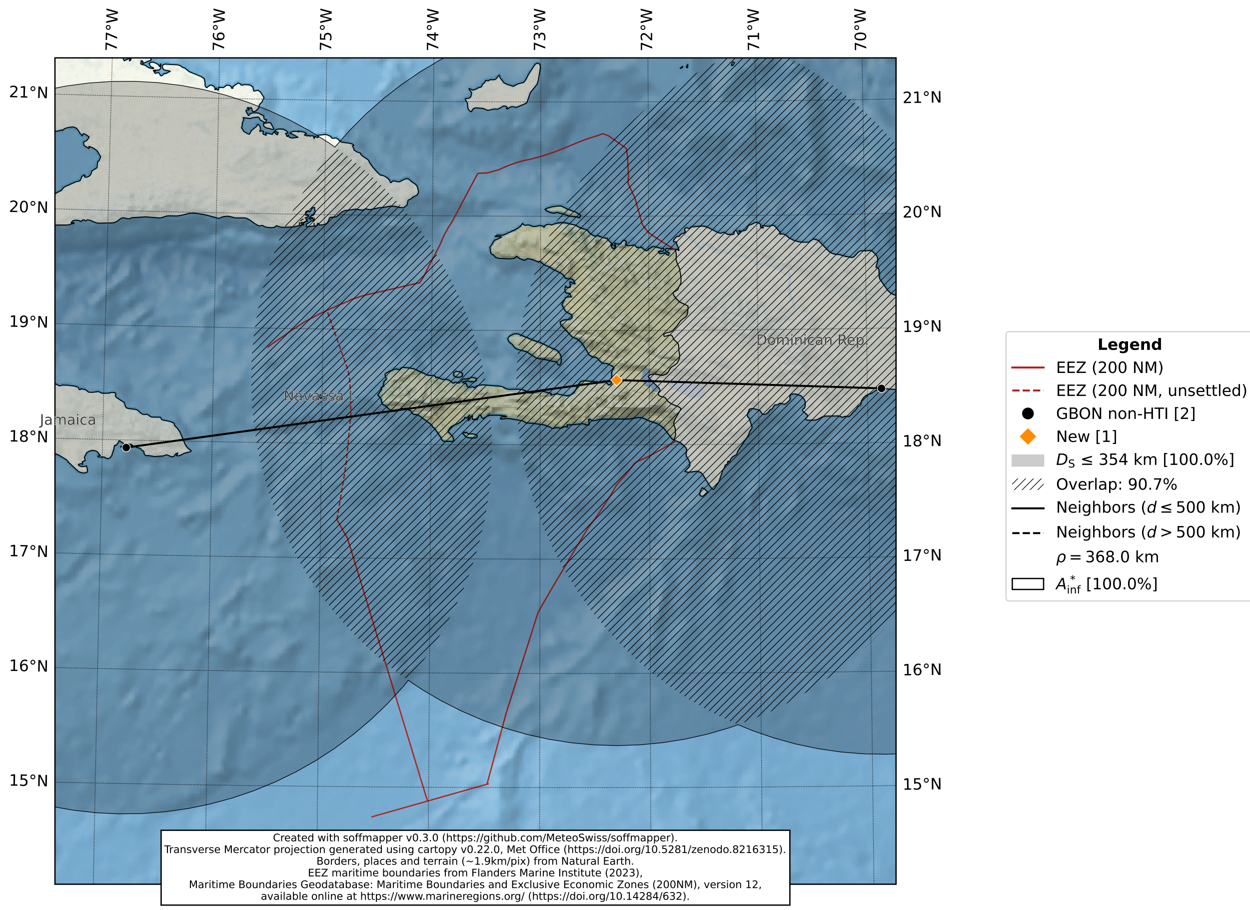


Figure 2: Same as Fig. 1, but for the new upper-air station (orange) sufficient for Haiti to meet the low-density GBON horizontal resolution requirement. The corresponding network horizontal resolution (accounting for near-by upper-air GBON stations) is $\rho = 368.0\,\text{km}$, with a baseline area of influence of $A^*_{\text{inf}} = 100.0\%$ derived using a station radius of influence of $R^*_{\text{inf}} = 354\,\text{km}$ (see Appendix A.1). Without an upper-air station in Haiti, the GBON horizontal resolution in the region would be $736\,\text{km} > 500\,\text{km}$.

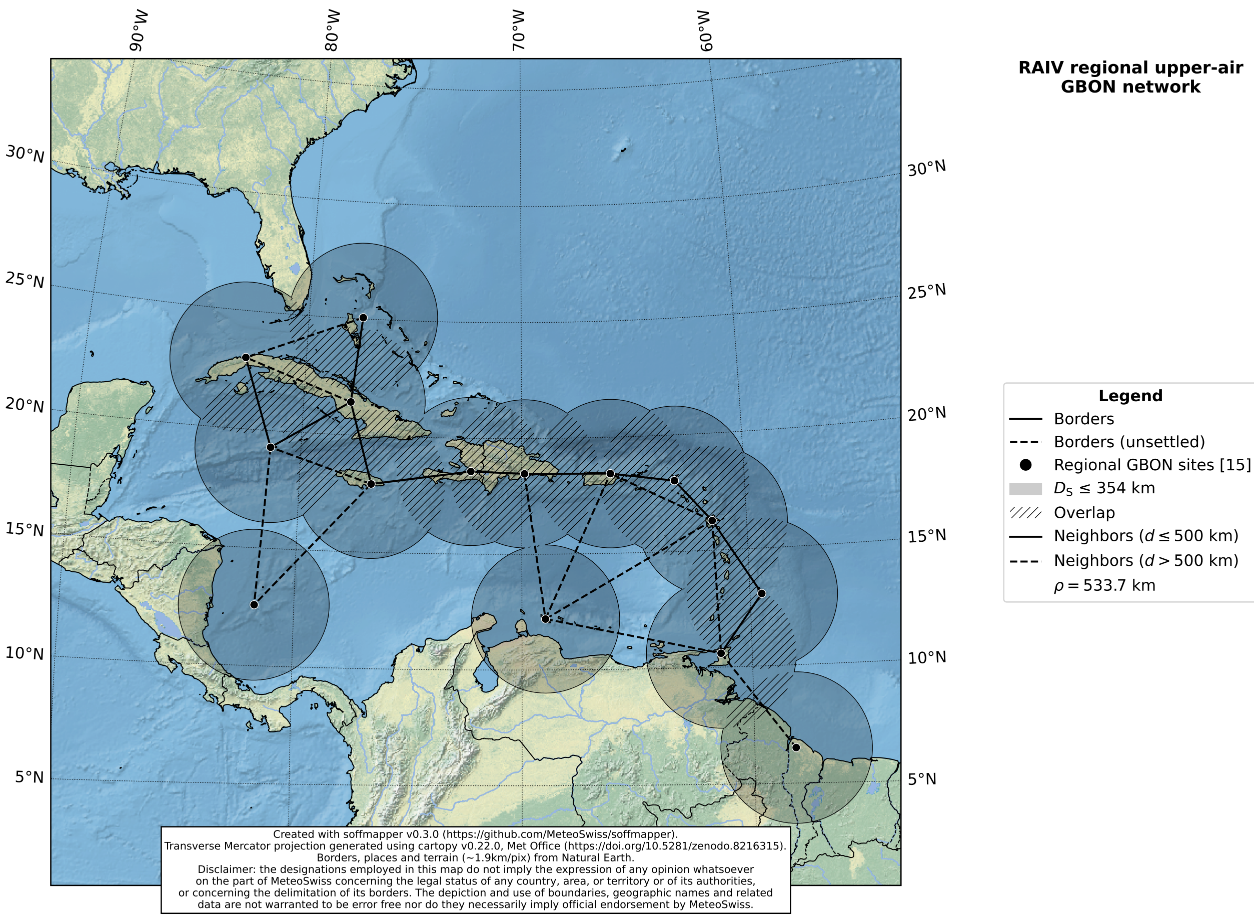


Figure 3: Same as Fig. 2, but for the entire RAIV regional GBON network for upper-air stations. At the regional level, the network horizontal resolution is $\rho = 533.7\,\text{km}$. Without an upper-air station in Haiti, the GBON horizontal resolution would be $557.8\,\text{km}$.

The size of Haiti's Exclusive Economic Zone (EEZ) could eventually warrant the installation of 1 GBON surface (marine) station for compliance purposes. However, the size of the EEZ does not warrant the existence of an upper-air marine station for GBON compliance purposes.

3.1 Recommended existing surface, upper-air and marine stations to be designated to GBON

We present in Table 5 the list of stations recommended to become operational before being designated to GBON, in order for Haiti to meet the low-density GBON requirements. **We note that Haiti is currently subject to severe, wide-spread security threats and active armed clashes with/between gangs. This list should therefore be considered a long-term goal, with any SOFF investments in a given station requiring that UHM and its personnel gain stable, safe, long-term access to the station site.** This list is assembled based on the data available at the time of writing. The need to alter the suggestion of a specific site (in favor of a neighboring one) may arise over time, as the local geo-political, security, economical, and connectivity situation evolves.

Table 5: Recommended surface, upper-air and marine stations to become operational before being designated to GBON, in order for Haiti to meet the low-density GBON requirements.

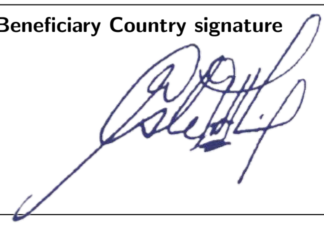
	Province	Station name	Type	Latitude	Longitude
1	Ouest	Port-au-Prince	Surface/Upper-air	18.580	-72.304
2	Sud	Les Cayes	Surface	18.271	-73.784
2	Nord	Cap-Haïtien	Surface	19.736	-72.193

4 Report completion signatures

Peer Advisor signature

Payerne, 5 April 2025

Beneficiary Country signature



Port-au-Prince, 8 April 2025

WMO Technical Authority screening signature

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List of acronyms

AWOS	Automatic Weather Observing System
AWS	Automatic Weather Station
CNIGS	"Centre national de l'information géo-spatiale"
CSO	Civil Society Organization
ECCC	Environment and Climate Change Canada
EEZ	Exclusive Economic Zone
GBON	Global Basic Observing Network
GPRS	General Packet Radio Service
GTS	Global Telecommunication System
NGO	Non Governmental Organization
NMHS	National Meteorological and Hydrological Services
SOFF	Systematic Observations Financing Facility
UHM	Haiti's NMHS, in french *Unité Hydrométéorologique d'Haïti*
URL	Uniform Resource Locator
WDQMS	WIGOS Data Quality Management System
WFP	World Food Programme
WIGOS	WMO Integrated Global Observing System
WMO	World Meteorological Organization

Appendix A Assessment metrics for national networks of GBON stations

This Appendix was initially published as Appendix A of the National Gap Analysis for the Democratic Republic of Congo. It is reproduced here verbatim, for the sake of clarity of the present document.

A.1 Network baseline area of influence A^*_{inf}

Let us begin by introducing the concept of a radius of influence for GBON stations:

Definition 1. The **radius of influence** R_{inf} of a given GBON station corresponds to the maximum horizontal distance between the station and any geographical location situated closer to this station than any other GBON station.

As per this definition, the radius of influence of a given GBON station is solely determined by the spatial distribution of the network stations. It evidently does not mean that the measurements of a given GBON station will be *representative* of all the locations situated up to the radius of influence. The representativity of specific measurements is dependent on the geophysical variable under consideration, and can be heavily influenced by numerous variables: for example, by the local terrain composition and topography.

We shall refer to ρ_{GBON} as the *GBON horizontal resolution*, as defined in WMO (2021) (article 3.2.2.7, note 4, p.52; see also WMO, 2023). As per these regulations, GBON-designated stations should not be located more than ρ_{GBON} apart, on average.

A so-called *baseline* GBON gap analysis has been performed by the WMO for all SOFF beneficiary countries (see Sec. 1). This analysis relies on the assumption that GBON stations are being distributed on a regular, orthogonal, two-dimensional grid[2] (see Fig. 4). Under this specific premise, all stations have the same **baseline radius of influence** of:

$$R^*_{\text{inf}} = \frac{\sqrt{2}}{2}\rho_{\text{GBON}} \qquad (1)$$

The standard GBON horizontal resolutions of 200 km and 500 km (for surface and upper-air stations on land, respectively) translate into baseline radii of influence of $R^*_{\text{inf},200} \approx 141$ km and $R^*_{\text{inf},500} \approx 354$ km.

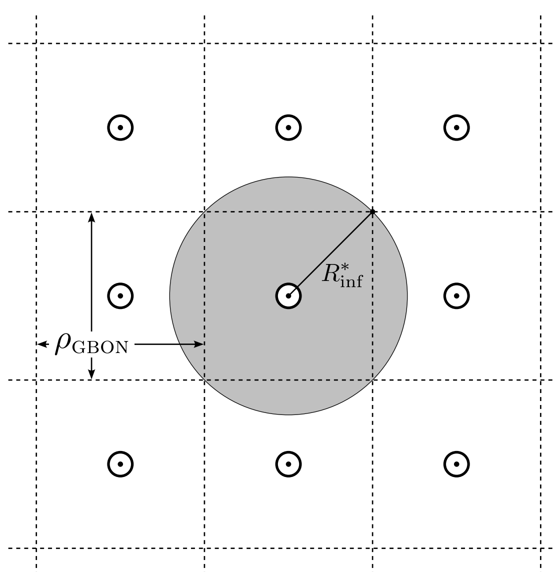

Figure 4: Schematic network of GBON stations (dot-circled symbols) distributed on a regular, orthogonal, two-dimensional grid. This theoretical setup is used to derive baseline GBON gaps by the WMO. Each grid cell has a size of $\rho_{\text{GBON}} \times \rho_{\text{GBON}}$. With this distribution of stations, any point in the plane is located at most R^*_{inf} away from any GBON station.

[2] The WMO Technical Authority confirmed, on 2024-01-08, that the baseline GBON gap is obtained by dividing the surface area of a given country by $(\rho_{\text{GBON}} \times \rho_{\text{GBON}})$.

In our analysis, we rely on this concept of baseline radius of influence $R^*_{\rm inf}$ to derive the network baseline area of influence:

Definition 2. The **baseline area of influence** $A^*_{\rm inf}$ of a network of GBON stations corresponds to all the zones situated within a distance of at most $R^*_{\rm inf}$ from any GBON station in the network.

We express $A^*_{\rm inf}$ as a percentage of the country surface area when considering national networks. Given Eq. 1, one can see that the WMO (indirectly) requires a value of $A^*_{\rm inf} = 100\,\%$ when performing a baseline GBON gap analysis.

This metric provides a useful indication of what surface area *might* be located too far from any GBON station in a given network. It must be stressed, however, that achieving $A^*_{\rm inf} = 100\,\%$ is not a formal GBON requirement per se. The meteorological importance of spatial gaps in the baseline surface coverage of a given GBON network must be evaluated against the actual measurement representativity of the nearest GBON stations (given the local population density, terrain topgraphy, regional climatology, etc . . .).

A.2 Network horizontal resolution ρ

The GBON compliance criteria are not defined in terms of the network baseline area of influence $A^*_{\rm inf}$, but rather in terms of its horizontal resolution ρ:

Definition 3. The **horizontal resolution** ρ of a network of meteorological stations, in the GBON sense, is equal to the average separation between (neighbor) stations (WMO, 2021, 2023).

The main difficulty in measuring ρ for a real network of irregularly-distributed stations lies in the identification of *neighbors*. Fortunately, the Voronoï tessellation technique provides us with a natural, logical, and straightforward means to do so.

Performing a Voronoï tessellation of stations consists is subdividing the surface of the Earth into a series of cells. Each cell, one per station, contains all the locations situated closest to a given station than any other. We present in Fig. 5 an illustration of this method on the plane, but the same concept can be applied on the Earth geoid. The cell boundaries are comprised of sites located at the same distance from two near-by stations. Voronoï cells thus provide for a natural definition of stations in geometric proximity from one another:

Definition 4. Two meteorological stations within a given network are deemed to be **in geometric proximity** from one another if their respective Voronoï cells share a common vertex.

Pairs of stations in geometric proximity can be identified directly by means of a Delaunay triangulation, which corresponds to the dual graph of the Voronoï tessellation (see Fig. 5). Doing so directly on the Earth geoid is feasible, but one can also exploit the characteristics of Stereographic projections to transpose the problem in two-dimensions (see e.g. Saalfeld, 1999; Gallier, 2011), which is easier to handle from a computational perspective. The use of a Stereographic projection (to convert stations longitudes and latitudes) is paramount to ensure that the list of station pairs found to be in geometric proximity in the (projected) plane is exactly applicable to the Earth geoid.

The use of Delaunay triangulation in a geographically-limited area of the Earth (e.g. for a network of GBON stations at a national level) implies the assembly of a convex hull. Some stations might then be deemed to be in geometric proximity from one another (despite being located several hundreds of kilometers apart) on the basis that their Voronoï cells are in contact (sometimes literally) on the other side of the Earth. In practice, one would hardly consider such stations to be *neighbors*, which we define as follows instead:

Definition 5. Two meteorological stations are **neighbors** from one another if they are in geometric proximity from one another according to Definition 4 and:

1. no other station in the network is located closer than them to the mid-point location of the Great Circle arc connecting them, or
2. they are located within a polygon formed entirely by network stations that are neighbors from one another.

Thinking in terms of Voronoï tessellation, the first sub-clause implies that the Great Circle arc connecting two neighbor stations must only cross their own two Voronoï cells, and none other. The second sub-clause ensures that this selection criteria is only used to cull Delaunay vertices in the outer regions of the network (see Fig. 5).

Having identified pairs of neighbor stations throughout a given network, it is then straightforward to compile the list of associated horizontal separations (measured along Great Circles on the Earth), and compute the network horizontal resolution ρ as their average. A network of GBON stations would then be formally compliant with the GBON regulations if $\rho \leq \rho_{\rm GBON}$.

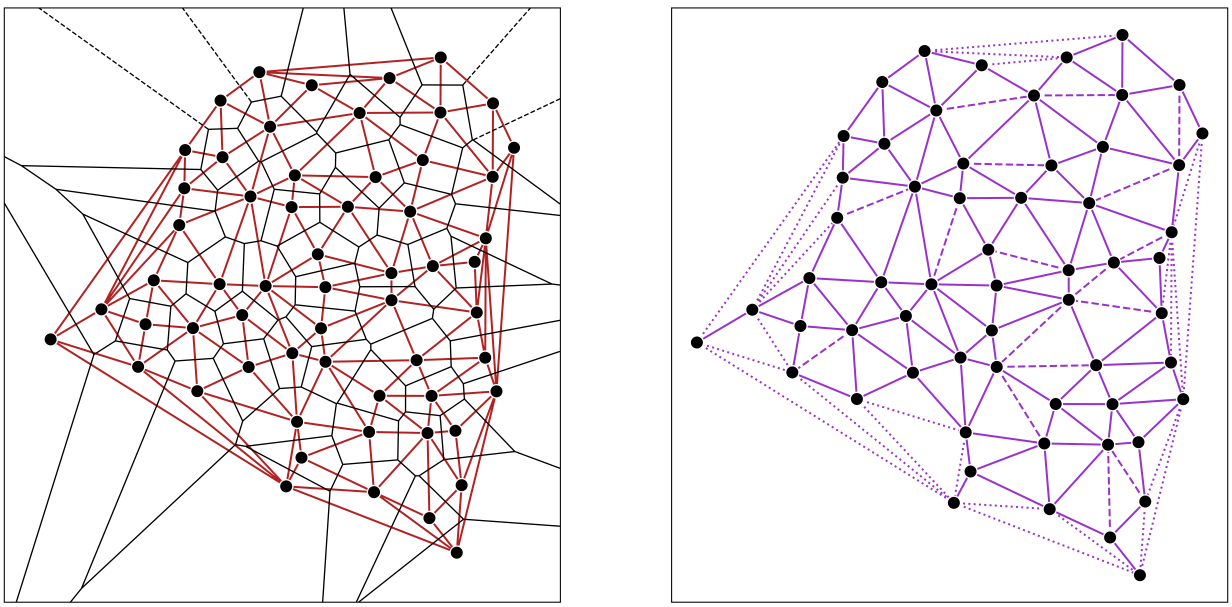

Figure 5: Left: illustration of the Voronoï tessellation (black lines) in the two-dimensional plane, for a network of 59 stations (black points). Voronoï cells provide for a natural means to identify sites in geometric proximity. All sites in geometric proximity from one another are connected by red lines, which are identified by means of Delaunay triangulation. Right: sites in geometric proximity but that are not *neighbors* according to Definition 5 are connected by dotted lines. All other connections indicate neighbor sites. Dashed connections indicate cases for which both sub-clauses 1 and 2 of Definition 5 are true.