27.04. 2024

GBON National Gap Analysis

Systematic Observations Financing Facility

GBON Gap Analysis Report

LAO PDR

Weather and climate data for resilience

WEATHER CLIMATE WATER

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.

Date: 16 April 2025

Signature:

Albert Fischer

Director, WIGOS Branch, Infrastructure Department, WMO

GBON National Gap Analysis Report
LAO PDR

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1. Country information from the GBON Global Gap Analysis

Table I. WMO GBON Global Gap Analysis (June 2023).

A. GBON horizontal resolution requirements	B. Target	C. Reporting (GBON compliant)[1]	D. Gap to improve	E. Gap new	F. Gap total
	[# of stations]				
Surface stations Standard density[2] 200 km	**6**	**0**	**6**	**0**	**6**
Upper-air stations over land Standard density[2] 500km	**1**	**0**	**0**	**1**	**1**

The GBON Global Gap Analysis conducted by WMO in June 2023 (Table 1) revealed that LAO PDR. was suffering from limitations in its observational network. While the standard density surface stations network does exist, the network as a whole cannot be considered to be fully GBON-compliant. In summary, at least 6 of the existing stations should be improved so that Lao may reach the necessary standard density compliance. Similarly, given the already existing infrastructure, a high-density network of stations could be also explored(Annex Table A.I), with 2 already reporting stations, 18 stations that should be improved and additional 4 new stations to be installed.

[1] The rationale for classifying surface and upper-air stations as reporting is based on the WIGOS Data Quality Monitoring System (WDQMS) for the chosen time period (WMO GBON Global Gap analysis, June 2023). Stations with data availability more 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] For SIDS, for the WMO GBON Global Gap Analysis in June 2023, the EEZ area has been added to the total surface area which is the basis for the target number of stations. The standard density requirements for SIDS have been calculated with 500 km for surface stations and 1000 km for upper-air stations.

Throughout the years, and funded by various international activities in the country, the Lao National Meteorological & Hydrological Department (DMH), received numerous surface stations with different technical specifications. Thus, there exists a good opportunity to build on the already existing capacities of DMH to attain GBON targets through the implementation of a well-structured plan. The plan should capitalize on existing infrastructure, previous and on-going capacity development projects while, at the same time, adopting sustainable approaches with particular emphasis on data and infrastructure harmonization/consolidation and data integration coming from different third-party investments as well as the overall maintenance and operations activities. Considering these initial conditions, not only the standard resolution target could be achieved, but also the higher resolution could be explored should funding allow. It is to be noted that any station planning should take into proper consideration accessibility limitations due to the demanding topography of the country as well as the harsh climate conditions the stations will need to undergo.

Lao PDR does not operate any upper air station. To reach GBON compliance, an installation new upper air station would be required with proper consideration of the continuous costs of such a

station, especially in the form of consumables.

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

Table II. Assessment of existent stations per their operational status and network ownership

GBON Requirements	Existing observation stations (# of stations)			
	NMHS network		Third-party network	
	Reporting (GBON compliant) [3]	To improve	Reporting (GBON compliant) [3]	To improve
Surface land stations Standard density [4] 200km Variables: SLP, T, H, W, P, SD	**0**	**6**	**0**	**0**
Upper-air stations operated from land Horizontal resolution[4]: 500km Vertical resolution: 100m, up to 30 hPa Variables: T, H, W	**0**	**0**	**0**	**0**

[3] The rationale for classifying surface and upper-air stations as reporting is based on the WIGOS Data Quality Monitoring System (WDQMS) for the chosen time period during the development of National Gap Analysis Stations with data availability more than 80% on at least 80% of days, are considered as reporting. Other listed stations are counted as having the possibility to be improved.

[4] For SIDS, for the WMO GBON Global Gap Analysis in June 2023, the EEZ area has been added to the total surface area which is the basis for the target number of stations. The standard density requirements for SIDS have been calculated with 500 km for surface stations and 1000 km for upper-air stations.

Surface marine stations in Exclusive Economic Zones:[7] 500 km Variables: SLP, SST				
Upper-air stations operated in Exclusive Economic Zones:[5] 1000 km Vertical resolution: 100m, up to 30 hPa Variables: T, H, W				

Table III. Assessment of existing GBON stations per station characteristics. Station type: S: Surface, UA: Upper-Air; M: Marine; Owner of the station: NMHS or name of third-party; GBON variables: SLP: Atmospheric pressure; T: Temperature; H: Humidity; W: wind; P: Precipitation; SD: Snow depth; SST: Sea surface temperature; Reporting cycle: Number of observation reports exchanged internationally per day (0-24); GBON compliance: whether the station is GBON compliant or not (see GBON guide on compliance criteria).

Station name	Station type (S/UA/M[6])	Owner (NMHS/3rd party)	Funding source	GBON variable measured							Reporting cycle (obs/day)	GBON Compliant (Y/N)
				SLP	T	H	W	P	SD	SST		
VIENTIANE	S	NMHS	JICA	X	X	X	X	NA	NA	NA	8	N
PAKSE	S	NMHS	World Bank	X	X	X	X	NA	NA	NA	8	N
SAVANNAKHET	S	NMHS	World Bank	X	X	X	X	NA	NA	NA	8	N
LUANG-PRABANG	S	NMHS	JICA	X	X	X	X	NA	NA	NA	8	N
LUANG NAMTHA	S	NMHS	FAO	X	X	X	X	NA	NA	NA	5	N
PARKXANH	S	NMHS	JICA	X	X	X	X	NA	NA	NA	5	N
THAKHEK	S	NMHS	JICA	X	X	X	X	NA	NA	NA	5	N
SAYABOURY	S	NMHS	JICA	X	X	X	X	NA	NA	NA	5	N
VIENGSAY	S	NMHS	JICA	X	X	X	X	NA	NA	NA	5	N
PHPNGSALY	S	NMHS	JICA	X	X	X	X	NA	NA	NA	5	N
SARAVANE	S	NMHS	World Bank	X	X	X	X	NA	NA	NA	5	N

[5]Although GBON marine stations and stations in EEZ are not part of initial SOFF scope, peer advisors are encouraged to analyze in this step when considered relevant e.g. SIDS, the status of current marine stations for future GBON marine observations investments.

[6] Please see guidance on marine stations in Section 2 on Scope.

HOUEI-SAI *	S	NMHS	FAO	X	X	X	X	NA	NA	NA	5	N
SAMNEUA	S	NMHS	World Bank	NA	X	X	X	NA	NA	NA	5	N
PHONHONG	S	NMHS	FAO	NA				NA	NA	NA		
PLAINE DES JARRES (XIENGKHOUANG)	S	NMHS	JICA	NA	X	X	X	NA	NA	NA	5	N
OUDOMXAY	S	NMHS	World Bank	X	X	X	X	NA	NA	NA	5	N
ATTAPEU	S	NMHS	JICA	X	X	X	X	NA	NA	NA	5	N
SENO	S	NMHS	China	X	X	X	X	NA	NA	NA	5	N
THANGONE	S	NMHS		X	X	X	X	NA	NA	NA	2	N

Surface stations

DMH is operating currently 117 Automatic Weather Stations (AWSs) and 49 manual weather stations (Figure 1). These stations were installed by different implementation agencies. Namely, 71 by the Word Bank, 18 by Japanese International Cooperation Agency, 2 by China, 8 by the Asian Development Bank,15 by Food and Agriculture Organization of the United Nations and 3 by Thailand. The technical characteristics of both instruments and infrastructure of AWSs are not unified, and the observed elements and data format are therefore inconsistent. This brings an added complexity to the usage and distribution of the data.
According to the statistics of the surface stations obtained through the RWC-Beijing and based on the WIGOS Data Quality Monitoring System, which exchanged data through GTS from January to September 2023 (Figure II, Table III), Laos reported 19 surface stations with an average data delay time of 1-2h, however with limitations in data availability and all the inclusion into GTS done manually. No precipitation and snow depth data (although the latter is of lesser relevence for the Lao Climate) were reported at any of the 19 stations. Four stations transmitted data every three hours (orange dots in Figure 2); 13 stations transmitted data five times a day; and the remaining two stations four times a day . Additionally, the station Thankgone transmitted less data and was unstable during this period.

In conclusion: according to the GBON low-resolution criteria, at least 6 surface stations, providing hourly measurements on a 24/7 basis (with the following requirements: a. the minimum number of internationally available reports should be not less than 80% of the total number of Reports for the period. B. delayed reports should not conceive more than 5% of the total number. In addition, c. rejected reports, due to insufficient quality, should not conceived more than 5% of the total number of Reports) should exist and operate in Lao PDR. Therefore, although there is already an existing operational network it is not yet suited to fulfill the required criteria.

It is to be noted that during the on-site visit just two stations were visited and checked. The on-site inspection of all the stations would facilitate a more detailed assessment of the infrastructure conditions and the possible upgrading/improvement needs.

Upper-air stations

DMH does not currently operate any upper-air stations.

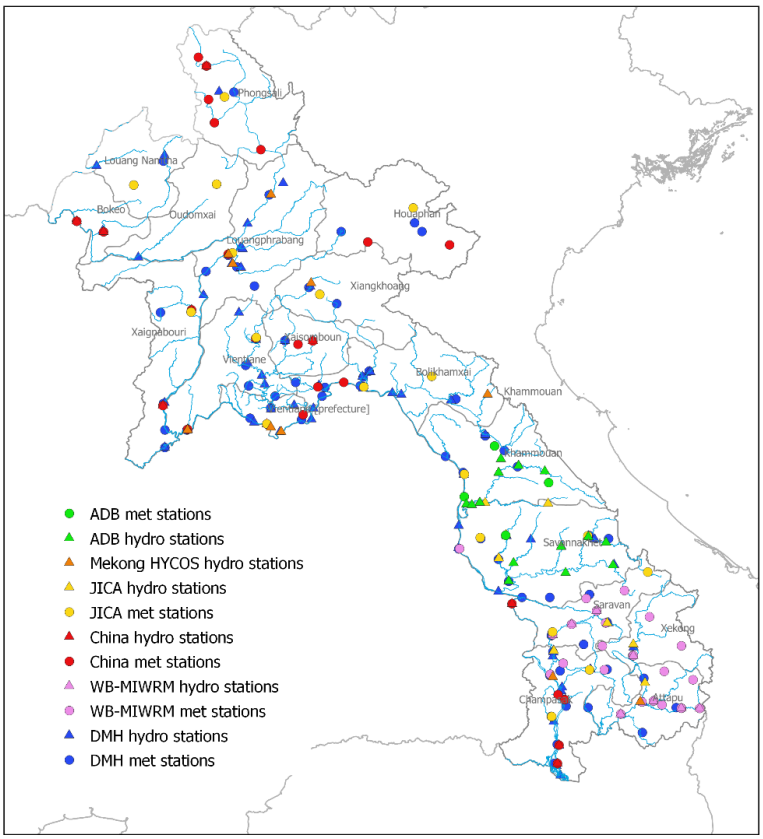

Figure 1. Automatic and manual weather stations of DMH

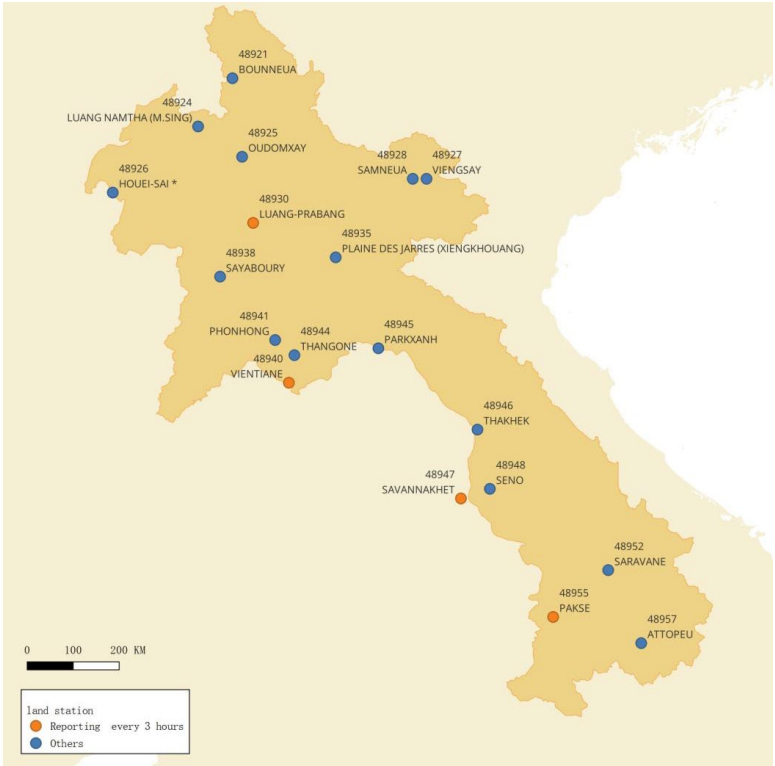

Figure 2. The distribution of Laos surface stations exchanging data by GTS. The Orange dots correspond to those stations that provide all day round information in intervals of three hours (with a delay of 1 to 2 hours). The blue dots are those stations that do transmit to GTS but only during daytime and in different intervals.

3. Results of the GBON National Gap Analysis

Surface stations

The gap analysis based on the data presented in the former sections shows that, while there is a reasonable number of (manually) transmitting stations existing, the network remains far from reaching GBON compliance. In particular, there is a limitation with the overall availability of the data as well as with the temporal resolution of the data exchange, with the highest frequency of 3 hours and just a limited amount of stations with night-time transmission. While the most essential parameters are reported (sea level pressure, temperature, humidity and wind) there is still no precipitation and snow depth data. While snow depth is not a critical parameter in these latitudes, precipitation is of critical importance. Related to the geographical distribution of the stations, clearly there is a higher density in the northern and southern areas, where most of the capacity development projects have their focus. This aspect should be considered in the selection of the 6 stations for GBON standard density surface compliance.

This analysis demonstrates that, regardless the number of existing stations, Lao PDR does not fulfil the GBON requirements in any of the stations and requires a significant investment with a detailed and well-designed national contribution. It is recommended to first focus on the upgrade of the observational elements of the existing 6 GTS surface weather stations, to reach the standard density compliance (increased observing frequency, inclusion of all parameters and reduced delays in transmission).

According to DMH's feedback, with the right level of resources, DMH could provide a supporting technical team for surface observing equipment and its installation, maintenance necessary engineering, lightning protection engineering, and other related activities. Local meteorological personnel at the station have the ability to complete the installation after suitable training, and local meteorological personnel have the ability to maintain and repair equipment provided resources are sufficient, however, personnel is limited and so are the resources in general. In general, potential challenges exist in the form of:

1- Accessibility of the stations – while the personnel located in Vientiane may have the technical capacity to perform all the necessary maintenance activities, the limited access to the stations and the resources (time and funds) required to reach them makes operational robustness a challenge. One possible approach to this challenge might be taking a 2-level maintenance plan, whereby basic maintenance actions could be performed by observers or meteorologists on-site with a limited technical knowledge and more advanced maintenance (or substitution of stations) to be performed by the headquarters staff that should be deployed with the required resources and time.

2- Maintenance, operations and data management are a challenge when the stations are of different typology and/or vendor. It is be advisable to minimize the different vendors to, on the one hand enable better purchasing options (more spare parts at potentially better price) and on the other hand facilitate that the personnel is always up to date and available to perform the daily tasks and the station maintenance. In addition, different stations may require a significant effort on data integration and data management activities that may become a potential value chain bottleneck. Accessibility and availability to spare parts may as well become an issue with multiple typologies of stations. Within the SOFF funded

activities, rehabilitation and station upgrades will aim at an harmonisation of the systems towards those that are offering better results under the experience of DMH.

3- The workforce is and will be a pivotal component in any endeavour aimed at establishing sustainable networks, especially when it relates to a critical infrastructure such as a weather service. The absence of appropriate recruitment measures would hinder any technical or investment advances.

4- Data communication and transmission – the current AWSs are not able to automatically transmit the data. In addition, different station typology does not facilitate a single solution approach.

The recommendation is to build on existing infrastructure for the achievement of GBON compliance. Table V and Figure 3 present the potential selection of the 6 stations to achieve the low density GBON compliance. The stations are distributed to cover as possible all the country. Should funding enable the exploration of high-density surface station network, the stations proposed are in Annex Table A.III.

Upper-air stations

According to GBON requirements, Lao PDR needs to operate at least a single upper-air station. Since there currently is no upper air station existing, a completely new infrastructure to build and operate it should be arranged. This would require the corresponding hydrogen production facilities and human capacity activities for the personnel operating the station. The recommended location for this station (Figure 3) would be in Vientiane international airport or the DMH Headquaters.

Table IV. Results of the GBON national gap analysis. SLP: Atmospheric pressure; T: Temperature; H: Humidity; W: wind; P: Precipitation; SD: Snow depth; SST: Sea surface temperature**.**

GBON requirements	Global GBON target	Approved national target	Reporting	Gap	
				To improve	New
	[# of stations]				
Surface land stations	**6**	**6**	**0**	**6**	**0**
Upper-air stations operated from land	**1**	**1**	**0**	**0**	**1**
Surface marine stations in Exclusive Economic Zones:[7] Density 500 km Variables: SLP, SST Observing cycle: 1h					

[7] Although GBON marine stations are not part of initial SOFF scope, peer advisors are encouraged to analyze in this step when considered relevant e.g. SIDS, the need for future GBON marine observations investments according to the GBON requirements.

Upper-air stations operated in Exclusive Economic Zones: [8] Density 1000 km Vertical resolution: 100 m, up to 30 hPa Variables: T, H, W Observing cycle: twice a day					

3.1 Recommended existing surface, upper-air and marine[10] stations to be designated to GBON

Table V. Recommended existing surface, upper-air and marine stations to be designated to GBON.

Station name	Station type (S/UA/M[11])
Recommended upper-air station	**UA**
VIENTIANE	**S**
PAKSE	**S**
LUANG NAMTHA	**S**
SAVANNAKHET	**S**
LUANG-PRABANG	**S**
SAMNEUA	**S**

[8] Although GBON marine stations are not part of initial SOFF scope, peer advisors are encouraged to analyze in this step when considered relevant e.g. SIDS, the need for future GBON marine observations investments according to the GBON requirements.
[9] Although GBON marine stations are not part of initial SOFF scope, peer advisors are encouraged to analyze in this step when considered relevant e.g., SIDS, the need for future GBON marine observations investments according to the GBON requirements.
[10] Although GBON marine stations are not part of initial SOFF scope, peer advisors are encouraged to analyze in this step when considered relevant e.g., SIDS, the need for future GBON marine observations investments according to the GBON requirements.
[11] Please see guidance on marine stations in Section 2 on Scope.

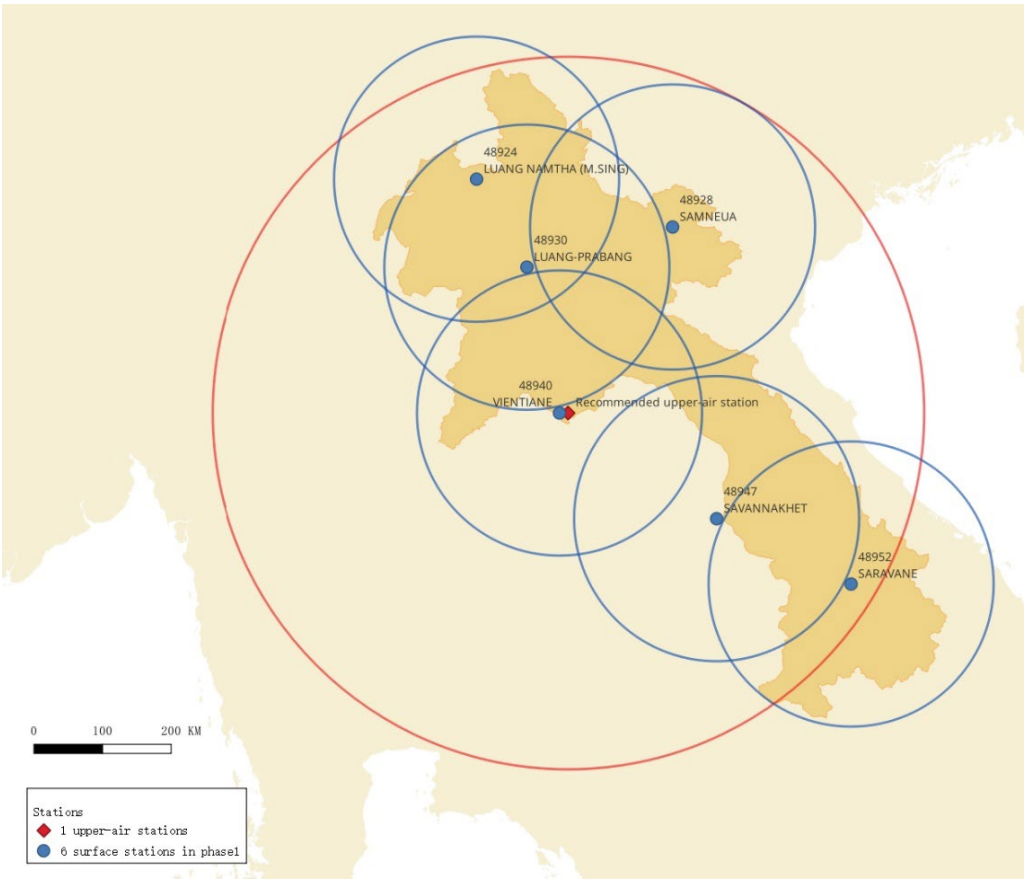

Figure 3 Map of Laos with the 1 recommended new upper-air stations (red circle) and the 6 GTS surface stations (blue dots with 200 km radius) to be improved to fulfil the standard density GBON criteria.

Remarks

SOFF aims at bringing the countries to reach GBON compliance. The gap assessment demonstrates the path forward to this compliance in terms of stations to be improved based on the existing capacities. This should be of course accompanied by the human capacity development activities to ensure a sustained approach towards M&O of the stations. It is also worth mentioning that Lao lacks well-trained meteorological experts, efforts to build in-country training capacity, in collaboration with the academy, and increase the staff deployed in governmental agencies, is also a necessary approach to achieve the target specially aiming at sustained approaches. In the particular case of the SOFF initiative, this aspect is to be included in the definition of the National Contribution Plan, where a close cooperation approach will be established with the national university. In addition, it is envisaged that there shall be end-user and stakeholder workshops to, on the one hand, to make visible the role and activities of the DMH towards international data sharing but, on the other, to further advocate for the need of additional staffing of DMH as a national critical infrastructure.

4. Report completion signatures

Peer Advisor signature	
 2025.03.12	 2025.04.14
Beneficiary Country signature	
 2025.03.21	
WMO Technical Authority screening signature	
	

Annex A – Recommended surface stations for the GBON high-resolution criteria

Table A.I. WMO GBON Global Gap Analysis from High-resolution Requirements (January 2022).

A. GBON horizontal resolution requirements	B. Target	C. Reporting (GBON compliant)[12]	D. Gap to improve	E. Gap new	F. Gap total
	[# of stations]				
Surface stations High density 100 km	24	0*	20	4	24

*Since the assessment of high resolution was done previous to the June 2023, there is an inconsistency with the reporting stations. In 2022 2 stations appeared reporting for both standard and high resolution and 0 for the newest assessment. We assume it is currently 0 based on the most recent assessment.

Table A.II. Recommended surface stations for the GBON high-resolution criteria.

Station name	Station type (S/UA)
Phongsaly	S
Sam Neua	S
Viengxay	S
Xiengkhuang	S
Luangnamtha	S
Bokeo	S
Oudomxay	S
Luangprabang	S
Saiyabouli	S
Vientiane	S
Phonhong	S
Saysomboun	S
Paksanh	S
Thakhek	S
Savannakhet	S
Sepon	S
Salavanh	S
Sekong	S
Dak Cheung	S
Pakse	S
Paksong	S
Attapeu	S