

The value of Surface-Based Meteorological Observation Data: Costs and benefits of the Global Basic Observing Network

SYSTEMATIC OBSERVATIONS FINANCING FACILITY

Weather and climate information for the global public good



SOFF

Systematic Observations
Financing Facility

KEY TAKEAWAYS

1. Reliable weather forecast and climate prediction is vital for responding to the risks posed by climate change and extreme weather events. The forecasts upon which society depends would not be possible without the real-time, international exchange of observational data from all over the world. Local forecasting in any given location benefits from improved observations from all over the globe.
2. The socio-economic benefits of weather prediction are estimated to amount to at least US\$160 billion per year. Further improvements in forecasting and early warning systems could provide additional benefits of US\$30 billion per year.
3. The Global Basic Observing Network (GBON) will significantly improve the availability and exchange of surface-based observational data critical for climate prediction and weather forecasts.
4. Improvements in the international exchange of observational data through GBON can deliver benefits of over \$5 billion annually. The benefits to low- and middle-income countries are likely to be under-estimated as non-monetizable benefits are not considered for example, the potential lives saved.
5. Investing in additional surface-based observations is highly economically efficient with an estimated global cost-benefit ratio of 1:26. This means for every dollar invested, at least twenty-six dollars in socio-economic return could be realized.
6. The benefits of increasing surfaced-based observations through GBON will be felt most in regions that are most vulnerable to climate change and its impacts including Africa, South America, South-West Pacific and parts of Asia. However, given the global nature of weather and climate, benefits of GBON will be realized both in the countries where the improvements are made and across the globe.

INTRODUCING THE SYSTEMATIC OBSERVATIONS FINANCING FACILITY

The Systematic Observations Financing Facility (SOFF) will support countries to generate and exchange basic observational data critical for improved weather forecasts and climate services. It will provide technical and financial assistance in new ways – applying internationally agreed metrics - the requirements of the Global Basic Observing Network (GBON) - to guide investments, using data exchange as a measure of success, and creating local benefits while delivering on a global public good. The SOFF will contribute to strengthen climate adaptation and resilience across the globe, benefitting in particular the most vulnerable.

The creation of the SOFF is spearheaded by the World Meteorological Organization in collaboration with a wide range of international organizations, including the members of the Alliance for Hydromet Development. The Alliance unites efforts of major development and climate finance partners to close the capacity gap on high-quality weather forecasts, early warning systems and climate information.

INTRODUCTION

Good data are the foundation of good decisions. Climate change and extreme weather events are threatening lives and livelihoods, impeding global efforts to reduce poverty and promote shared prosperity.

The Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction, and the Paris Agreement all stress the importance of improving environmental monitoring and early warning systems to attain socio-economic benefits. These improvements rely on the infrastructure and capabilities of various National Meteorological and Hydrological Services. Considerable attention is now being given to strengthen the capacity of these institutions.

Improving our ability to forecast weather events and predict climate change is a foundational step in being able to manage risk effectively and make the right decisions about how and where to invest to build resilience.

All of today's weather forecast and climate analysis products rely on global-scale Numerical Weather Prediction Systems (NWP). In order to make accurate and timely weather predictions, NWP systems require good quality observational data, obtained from multiple sources from around the world. This requires nations to share their data in real time.



What does the WMO do?

The World Meteorological Organisation is a specialized agency of the United Nations with 193 Member States and Territories. WMO provides the framework for international cooperation for the development of meteorology, climatology and operational hydrology as well as to reap the benefits from their application. All WMO Member States and Territories have National Meteorological and Hydrological Services (NMHSs), whose roles are to monitor, understand and predict the behaviour of weather, climate and water and to provide related information, warnings and services.

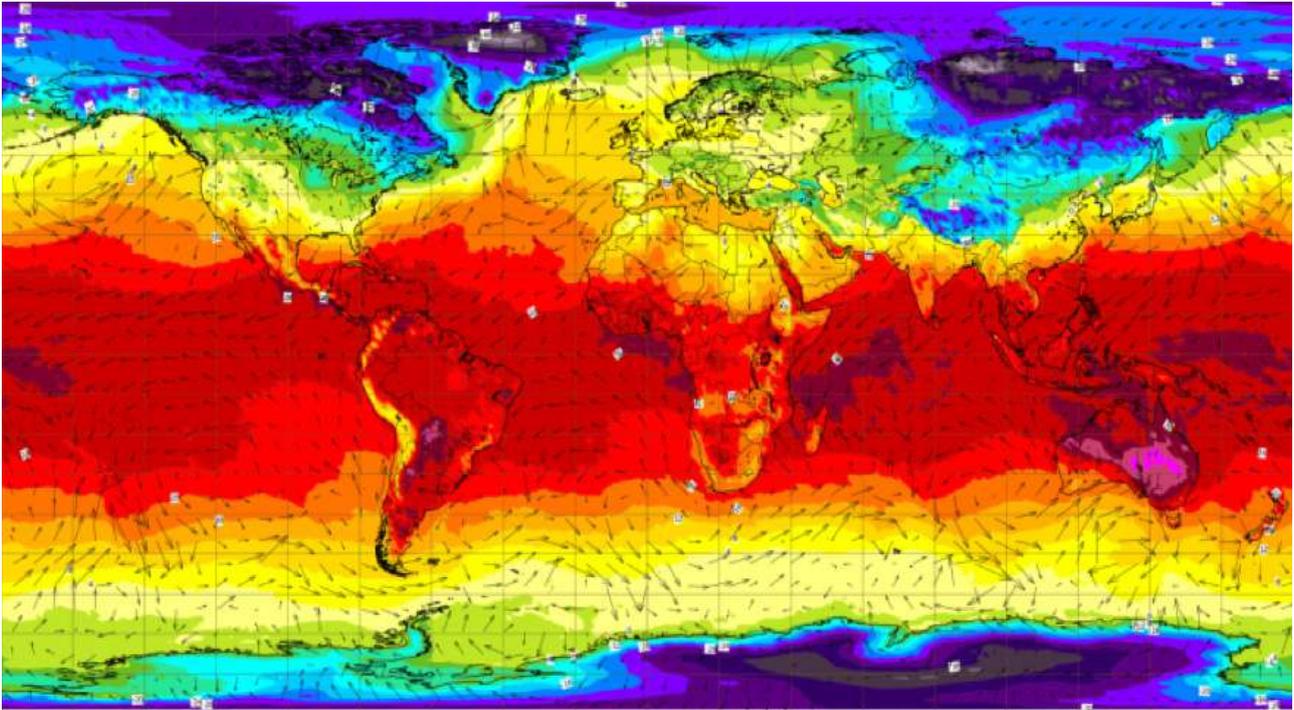


Image 1 Global NWP forecast of temperature and wind from the European Centre for Medium-range Weather Forecasts.

Whilst many regions can provide a good and robust supply of surface-based observations, in some areas of the world (notably Small Island Development States and Least Developed Countries) there are major data gaps. As such, the World Meteorological Congress established the Global Basic Observing Network (GBON) in 2019.

This information brief explains how the global system in its entirety benefits from improved surface-based observations and shows how targeted investment based on the GBON requirements can yield the highest level of improvement in weather prediction and climate analysis, greatly improving the world's capacity to respond to weather and climate risks.

THE VALUE OF WEATHER AND CLIMATE PREDICTION

Accurate weather predictions deliver economic, environmental, and social benefits. These benefits range from providing timely warnings about extreme weather events, to assessing gradual changes to baseline climatic conditions. Recent economic assessments in several countries have found strong positive cost-benefit ratios for investment in weather and climate services, typically around 1:4 – 1:36.¹ This level of improvement to economic performance will impact a wide range of sectors (see Image 2). These ratios are likely to be even higher once the full impact on lives, livelihoods, and wellbeing are included. Additional benefits may also include increasing business and capital investment, fiscal stability and reduced future credit risks, as well as ecosystem-based co-benefits.

“Economic assessments have found strong positive benefit-cost ratios for investment in weather and climate services, typically around 1:4 – 1:36”

The benefits from improving the accuracy, reliability and range of weather observations will only be realised if systems are in place to translate them into useful information, and if that information is then used to make appropriate decisions. Therefore, investment in improving forecasting must go hand-in-hand with improving capacity in service delivery, user engagement, and emergency response.



What is Numerical Weather Prediction?

Numerical weather prediction (NWP) refers to the practice of predicting the future state of the atmosphere from the present state, using computer-encoded versions of the predictive equations of atmospheric behavior. The present state is calculated from a comprehensive set of observational data from the entire global domain. The word “weather” refers to the origin of NWP as a tool for medium range prediction. The technique has since been universally adopted also for monitoring and understanding how climate has changed in the past, and how it may be evolving in the future.

How do observations affect NWP performance?

NWPs are made from compiling different types of observations from space-based observations measuring cloud winds and infra-red radiation, to temperature measurements on the ground. Different types of observations contribute to NWP performance in different ways. Improving any single one has a specific impact on NWP forecast accuracy. Impact of observations is assessed in terms of changes to forecast accuracy, defined as the level of agreement between what the forecast predicted and the observed reality. Impact is assessed using the “Forecast-Sensitivity-to-Observation-Impact” (FSOI) approach.

Minimum annual socio-economic benefits of weather prediction

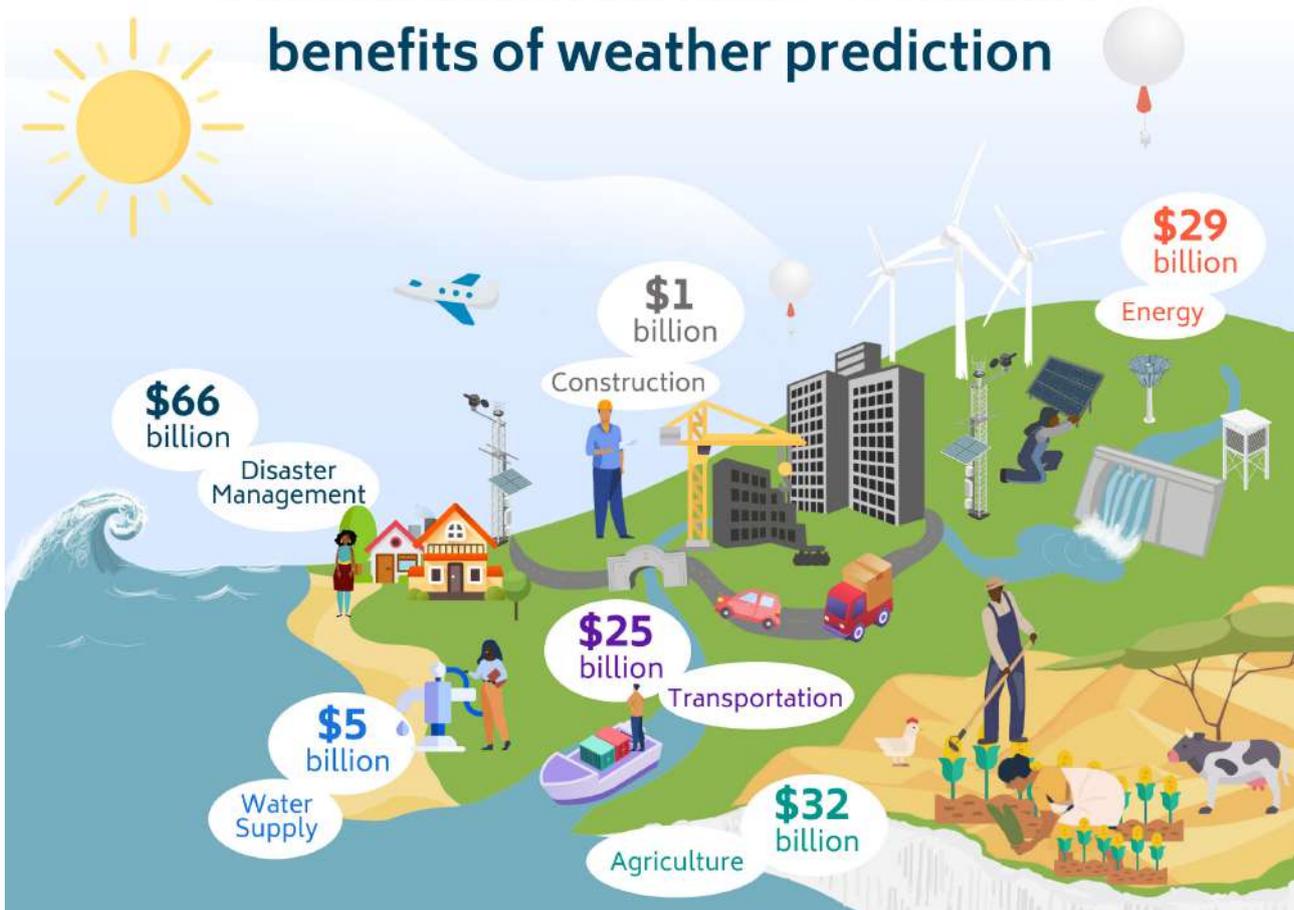


Image 2 Infographic representing the minimum annual socio-economic benefits of weather prediction.

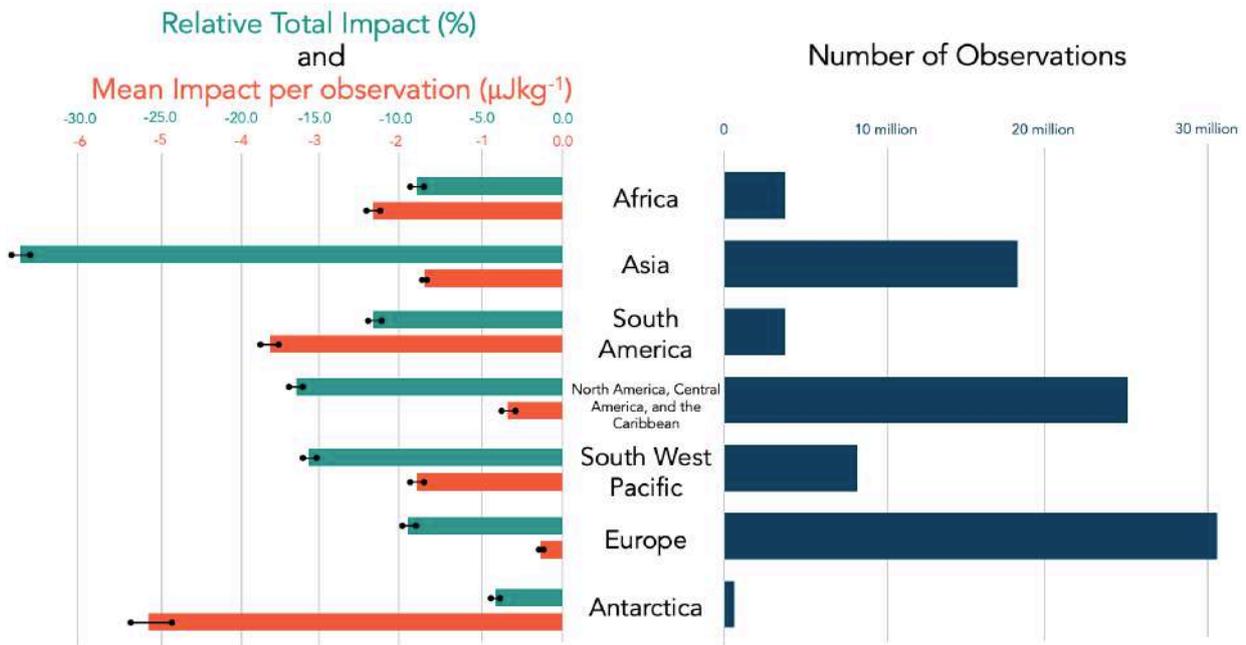


Figure 1 The impact of improving surface-based observations varies across regions.

FSOI allows us to calculate how much each observation contributes to improving the overall accuracy of forecasting. FSOI analysis shows that space-based observations are responsible for reducing forecasting errors by 75%. Space-based observations are already well shared across members and provide good quality data. However, there is great potential to improve surface-based observations.

The impact of improving surface-based observations varies across regions. The blue bars in Figure 1 show the total number of surface-based observations made in each WMO region, and the green bars indicate the relative impact those observations have on forecast accuracy. It is expected that Africa, Antarctica, South America, and the South-West Pacific will benefit greatly from having additional observations in their regions. This can be achieved by increasing the amount of information that is shared internationally, and adding additional observing systems in data-sparse areas. The orange bars show the mean impact each observation is likely to have in each region. Notably, impact per observation is lowest for Europe, suggesting that for global NWP there may be greater benefit from redeploying some of this resource elsewhere in the world.

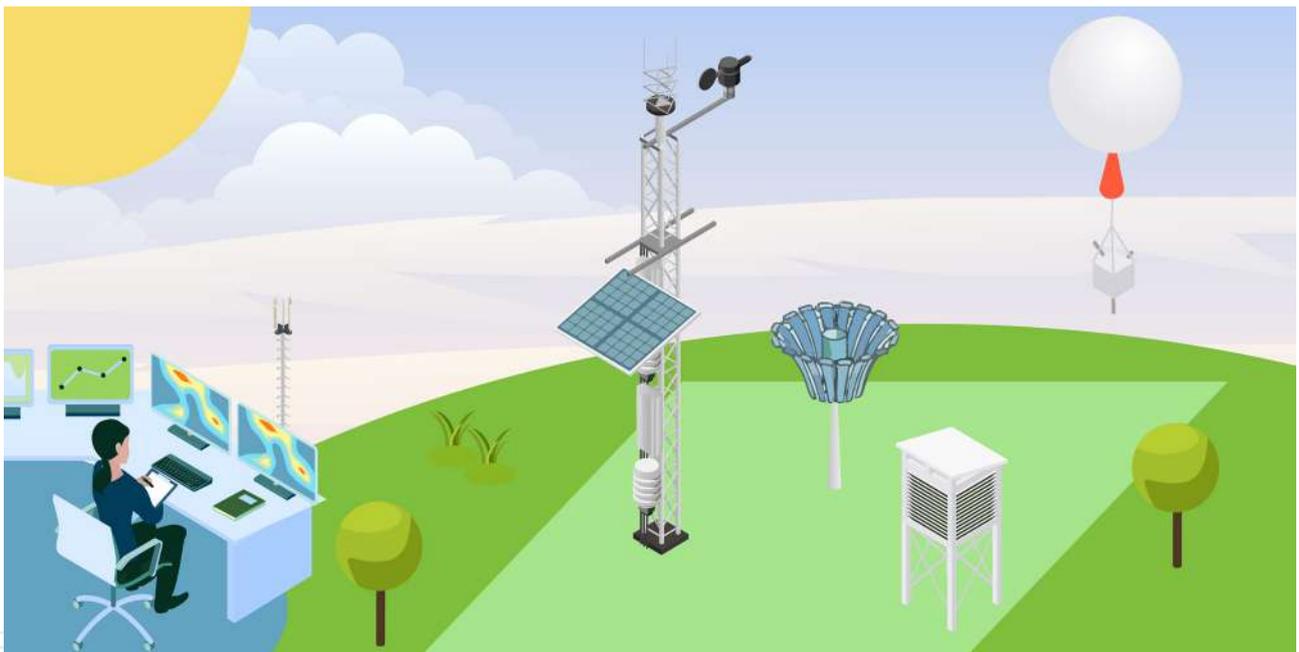


Image 3 The improved contribution of surface-based observations (surface and upper air stations) is critical for enhancing NWP.

INTERNATIONAL DATA SHARING FOR THE PUBLIC GOOD

Providing meteorological observations is usually seen as the responsibility of national governments. However, the information provided has implications at regional and global scales. Effective international exchange of observation data is therefore essential.

This data exchange is underpinned by the understanding that “you put in what you can; you take out what you need”. There is no penalty for not contributing data as it is recognised that many countries face a range of resource and capacity restraints when it comes to developing and operating surface-based observation networks.

Whilst this exchange has been working for decades, inefficiencies arise when countries do not share their observational data. Sometimes this is because countries are not collecting data, whilst in other cases data is available but not shared. The quality of the whole system is reduced as a result. The high resolution of global NWP and the need to verify the model output means that unlocking untapped data sources and the free exchange of data are vital for producing the best possible forecasts and realising the benefits.

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Many NMHSs use global NWP data to feed higher resolution models for their own areas. However, NMHSs in low - and middle-income countries are often not able to do so at a higher resolution than the leading global centres. Here, the most direct path toward improved national forecasting and service delivery is to share their observations for assimilation into global NWP models, and to then use the output of these models as the basis for their services. Even where local area models are used, they will not operate effectively unless the upstream global NWP model has access to the same observations.



Value in Practice: Improved prediction and response to Dengue Fever, Réunion

Dengue fever is a mosquito-borne tropical disease common in more than 120 countries, mainly in Southeast Asia, South Asia and South America. An estimated 100-400 million people are infected each year, and globally the incidence of dengue has increased 30-fold over the past 50 years. The prevalence of dengue is strongly influenced by weather and climatic factors, and the continued rise in global temperatures is contributing to its increase. Weather Prediction can be used to anticipate conditions likely to lead to an outbreak, and so enhance preparedness measures.

Between December 2017 and February 2018, there was a large outbreak in Réunion Island. Tropical cyclone related rainfall events and higher than average temperatures played a role in the dengue outbreak, and these conditions were signalled in European Centre for Medium-Range Weather Forecasts (ECMWF) sub-seasonal weather forecasts four weeks in advance of them occurring. Analysis and modelling of both weather conditions and mosquito populations suggest that the onset and size of the outbreak could have also been predicted two weeks in advance.

In this context, skilful predictions could have helped public health authorities to initiate an early response strategy to minimize the impact of this event. A fully functioning early warning system, however, requires regularly updated seasonal forecasts throughout the year. Investing in GBON across dengue-affected countries is an opportunity to make a substantial contribution to their adaptation and resilience.^{2, 3, 4}



What is GBON?

In 2019, the World Meteorological Congress and its 193 member countries and territories agreed to establish the Global Basic Observing Network (GBON). GBON sets out an obligation and clear requirements for all WMO Members to acquire and internationally exchange the most essential surface-based observational data at a minimum level of spatial resolution and time interval. GBON is a landmark agreement and offers a new approach in which the basic surface-based observing network is designed, defined and monitored at the global level. The detailed GBON technical requirements will be submitted to the World Meteorological Congress for its approval in 2021.

HOW MUCH BETTER CAN GLOBAL NWP GET?

There is significant scope for improvement in NWP accuracy, which will enhance the quality of weather and climate services around the world. Some scientists believe that these improvements could result in 10-day forecasts that would be just as accurate as 5-day forecasts today. Based on the minimum global socio-economic annual benefit estimate of US\$ 158 billion, such an improvement in forecasts and early warning systems could provide additional benefits amounting to US\$30 billion per year.

Full implementation of GBON will roughly double the amount of surface-based data available to global NWP. These currently contribute 17% of the impact on forecast accuracy, and doubling the available data is assessed to result in a globally-averaged reduction of 4% in forecast error.

Therefore, the potential benefits from global implementation of GBON are assessed to be around US\$5.1 billion per year.



Value in Practice: Using Weather information for humanitarian preparedness in the Philippines

The Philippines ranks third in the world for their exposure to disaster risks. At least 60% of the country's land area experiences multiple hazards, with 74% of the population exposed to their impacts. In the last few decades, there have been major advances in the observation, analysis, and prediction of high-impact weather and climate events, along with improvements in monitoring and predicting short-term high-impact weather and weather hazards, and seasonal climate variability.

Evidence shows that disaster managers have been successful in using these improved weather forecasts in cyclone prone areas of the world, and actions based on early warning systems are estimated to have saved millions of lives and avoided negative economic impacts.

However, even with recent improvements, weather forecasts still have further to go. A recent review of the use of climate and weather information for humanitarian preparedness in the Philippines identified the lack of detailed information in forecasts as a key limitation. It concluded that increasing the density of weather observation stations in the region would improve the measurement of local impacts. This would also improve the detail within NWP forecasts over the region.^{5, 6, 7}

“If implemented fully, GBON will roughly double the amount of surface-based data available to global NWP, further reducing forecasting error. The potential benefits from full implementation are assessed to be around US\$5.1 billion per year.”

WHAT DIFFERENCE CAN GBON MAKE?

While all regions would benefit from the improvements achieved through the implementation of GBON, forecasts in regions with significant populations but limited observation networks would benefit the most, particularly South America (32% of total forecast improvements), Africa (26%), South-West Pacific (17%) and Asia (16%).

The monetary benefits fall mainly to regions with a high share of global GDP. However, well-being benefits such as lives saved and poverty reduction have not been quantified, but these would likely be most significant in the lowest GDP regions of Africa, South America and the South West Pacific.

HOW MUCH WILL IT COST TO IMPLEMENT GBON IN THE COUNTRIES WITH THE LARGEST CONSTRAINTS?

Currently, the world's global observation system, including both space-based and surface-based observing systems, is estimated to cost US\$ 10 billion a year, of which around \$3 billion is for supporting global NWPs. Achieving sustained compliance with the GBON requirements calls for substantial investments and strengthened capacity in many countries.

Based on the GBON gap analysis (see 'The gaps in the Global Basic Observing Network (GBON)' information brief for more details), the estimated funding needs to support SIDS and LDCs in achieving GBON compliance for an initial five-year period correspond to USD 400 Million. Achieving GBON compliance in these countries will generate more than a 10-fold increase in data shared from upper-air stations and more than a 20-fold increase in data shared from weather stations.



Value in Practice: **Weather monitoring, forecasting and Desert Locust outbreaks**

Desert Locust plagues contribute to famines and present a threat to food security in many regions of the world. In January 2020, the FAO warned that rising numbers of Desert Locusts present an extremely alarming and unprecedented threat to food security and livelihoods in the Horn of Africa, deeming it “the worst outbreak of Desert Locusts seen in the region for decades.”

Weather affects both the breeding and the migration of locusts, so understanding the changing climate of a local area, especially rainfall, temperature and wind, is key to assessing outbreak risk. Global NWP Centres provide forecasts on a range of timescales and support local assessments. These are vital in predicting monsoon flows and the seasonal advance and withdrawal of the Inter-tropical Convergence Zone across the Sahel and the Horn of Africa which will influence the conditions for locust outbreak. However, the availability of real-time weather data is currently very limited within the vast Desert Locust habitat. Full implementation of GBON across desert areas between Mauritania and western India would provide a comprehensive real-time meteorological data source, as well as enabling a significant improvement to forecasts on all timescales from Global NWP Centres – two vital prerequisites for effective early warning systems for outbreak.^{8,9}

IS IT WORTH IT?

Improving surface-based observations coverage and sharing will lead to significant and far-reaching benefits. The global nature of NWP means that benefits will be realised in the countries where the improvements are directly made, as well as to the whole world. When comparing the benefits and costs of improving observational systems, the benefits still far outstrip the costs, with a ratio of 26:1.

Therefore, it is clear that investing to improve the global surface-based observation network is highly economically efficient. Better weather prediction, when coupled with good communication and decision-making processes, has the potential to improve the resilience of the world's population.

REALIZING THE BENEFITS OF GBON - ESTABLISHING THE SOFF

To realize GBON benefits, substantial investments and strengthened capacity in many countries are needed. The Systematic Observations Financing Facility (SOFF) is being established to provide technical and financial assistance in new – more effective - ways.

SOFF will support beneficiary countries to acquire and exchange basic observational data critical for improved weather forecasts and climate services. It will provide technical and financial assistance in new ways – applying internationally agreed metrics to guide investments - GBON, using data exchange as a measure of success, and creating local benefits while delivering on a global public good. SOFF will contribute to strengthen climate adaptation and resilience across the globe, benefitting the most vulnerable in particular.



Value in Practice: Severe weather over the Lake Victoria Basin

Lake Victoria is the largest freshwater body in Africa and home to the biggest inland fishery in the world. However, thousands of fishermen and small boat operators die on Lake Victoria each year because of the adverse weather conditions. They typically get caught in deadly storms due to the absence of an effective weather warning communication system and a lack of urgency presented by unclear warnings.

The High Impact Weather Lake System (HIGHWAY) is a campaign coordinated by WMO and funded by the UK Government to improve early warning systems and increase resilience to extreme weather events. The project has identified a range of opportunities to enhance societal wellbeing through effective forecasts and warnings. However, a recent project report has cautioned that a sustainable impact can only be achieved if there is long-term funding to maintain all observational platforms, including spare parts and consumables, a data archival system, and support for technicians, engineers and scientists to maintain the instruments and utilise the observations. The full implementation of GBON would be a key step towards achieving this.^{10, 11}



Photograph courtesy of Paul Oloo

Endnotes

- 1 WMO (2015) Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services. WMO No. 1153.
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- 3 <https://www.who.int/en/news-room/fact-sheets/detail/dengue-and-severe-dengue>
- 4 <https://www.sciencedirect.com/science/article/pii/S0013935116303127>
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- 8 http://www.fao.org/ag/locusts/common/ecg/2350/en/2016_WMOFAO_WeatherDLe.pdf
- 9 <http://www.fao.org/news/story/en/item/1258877/icode/>
- 10 Roberts, R. and Wilson, J., 2020: HIGHWAY Field Campaign Report
- 11 <https://public.wmo.int/en/media/news/highway-improves-early-warnings-lake-victoria>

SPECIAL THANKS TO:

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FURTHER RESOURCES:

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