

**DESIGN AND JUSTIFICATION OF A FORECASTING NETWORK IN
EQUATORIAL AFRICA**

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ABSTRACT

The present state of meteorological observation networks in equatorial Africa (between 10° N and 10° S) is deficient. The spatial and temporal gaps in surface and upper-air observations severely hinder the forecasting abilities of meteorologists in the region, a region that is approximately the same size and population of the United States. Additionally, several countries do not operate a national meteorological service and those that do offer varied levels of information for the country's residents. These factors have contributed to the risk of danger from hazardous weather events, especially flooding. Each country was contacted via e-mail and provided a questionnaire to complete and return. The seven responses provided first-hand information about the present state and future desires of the national meteorological services in equatorial Africa. The solution requires a national and regional effort of scientific cooperation and committed funding to increase the number of surface observation stations and improve training of the meteorologists within the region. The result, a well-distributed observational network and well-trained professionals to interpret the data, would be beneficial for each country, its citizens, and the region as a whole.

1. INTRODUCTION

The meteorological problems in Africa are numerous and diverse. Both flash floods and seasonal flooding can devastate parts of the continent. Additionally, strong winds can create severe dust storms across the arid regions. Beyond the natural hazards, there exist significant societal issues related to weather forecasting. Many observation networks are suffering due to lack of funding or dedication. Forecasts are either not communicated to the decision makers effectively or disregarded. A regional meteorological observation network is non-existent which

makes tracking synoptic and mesoscale systems between counties near impossible. This broad range of meteorological, societal, political, and financial issues makes the problem solving approach challenging, to say the least.

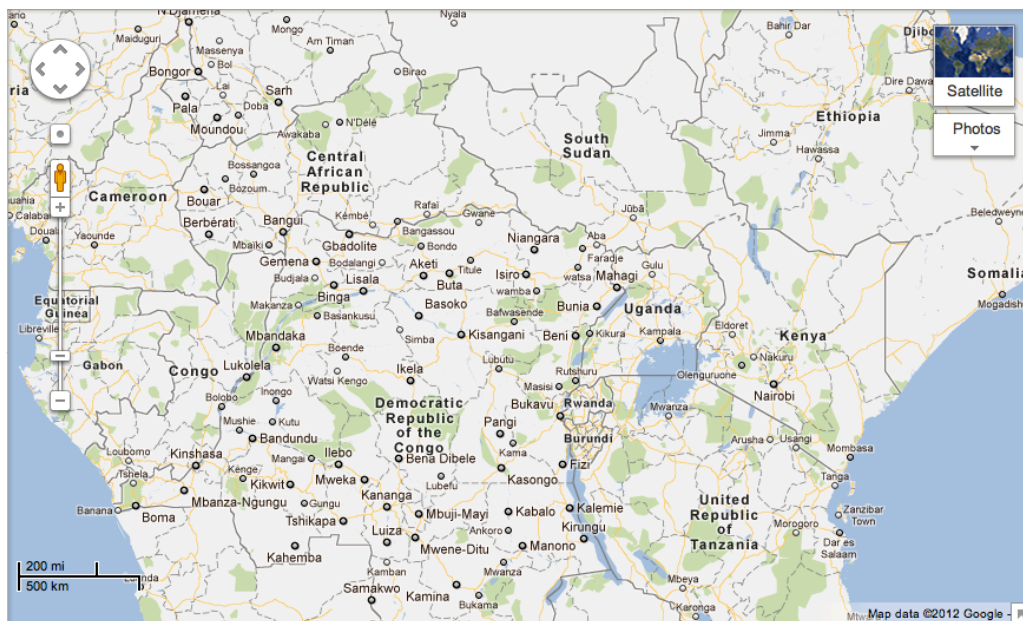


Figure 1. The region of focus- Equatorial Africa from 10N to 10S

The region of equatorial Africa that is the focus of our work consists of 13 countries. Each of these countries, as well as the current state of their development, is listed in Table 1.

According to the United Nations, the least developed countries are ones that are the poorest and weakest in the international community (United Nations, 2011). Additionally, Global Finance Magazine studied the countries of the world and determined the rankings of the poorest countries, shown in Table 1 (Global Finance, 2011). The status of development within each country correlates with the state of meteorology services. Complex geography, high values of moisture continent that can lead to heavy rainfall, and a variety of mesoscale weather events compound the forecasting problem. Because of the challenges of forecasting in the region and the poor development of meteorological services, equatorial Africa is a prime candidate for

additional research to help guide the development of meteorological services and to provide improvements in weather forecasting.

Country	Development
Central African Republic (7)	Least Developed
South Sudan	Least Developed
Ethiopia (15)	Least Developed
Somalia	Least Developed
Kenya (35)	Low Development
Uganda (21)	Least Developed
Democratic Republic of Congo (1)	Least Developed
Congo (63)	Least Developed
Rwanda (18)	Least Developed
Burundi (3)	Least Developed
Tanzania (28)	Least Developed
Gabon (128)	Medium Development
Equatorial Guinea (137)	Least Developed

Table 1. Countries of equatorial Africa, Their Current Development, and International Poverty Rank (1 as the poorest)

The Observing System Research and Predictability Experiment (THORPEX) Program, initiated in Africa in 2006 by the World Meteorological Organization, currently seeks to determine the source for many of the issues for the continent and to improve the current meteorological network status there. THORPEX has released two documents that form the basis for this research: the *WWRP/THORPEX African Science Plan* (hereafter *TASP*) and the *WWRP/THORPEX African Implementation Plan*.

TASP begins by discussing the dynamical and physical processes of east African weather and climate. By researching the atmospheric physical processes of the region, the challenges for improving predictive skill of high impact weather systems over the area were better understood.

Some of the high impact weather events that occur over eastern equatorial Africa are dry spells, flash floods, hail storms, frost, fogs, wind gusts, and torrential rainfall brought on by localized storms. The rainy season variability in equatorial Africa (Camberlin et al., 2009) was used to further distinguish important meteorological features of the region. This research provided the foundational information necessary to evaluate the observational network needs of the region.

The two main questions that *TASP* poses are: “What is the current knowledge and understanding of the dynamical and physical processes for high impact weather systems in Africa?” and “How can we improve our understanding of dynamical and physical processes and their associated phenomena that cause high impact weather?” Such general questions can be researched from many perspectives. To obtain sufficient progress and possible solutions, these questions were narrowed down to one aspect: the basic structure and effectiveness of the national meteorological services. The *TASP* also examined the observing system itself. The plan illustrated the lack of upper air observations over the region. The number of upper air observations has not improved since with only two stations in the entire area (Figure 2). In addition to minimal radiosonde launches, the density of surface observations varies widely. Observations received at the ECMWF at one synoptic time in 2012 were clustered in a few countries but non-existent in many others, leaving a gap in available surface data over large parts of central region of Africa (Figure 3).

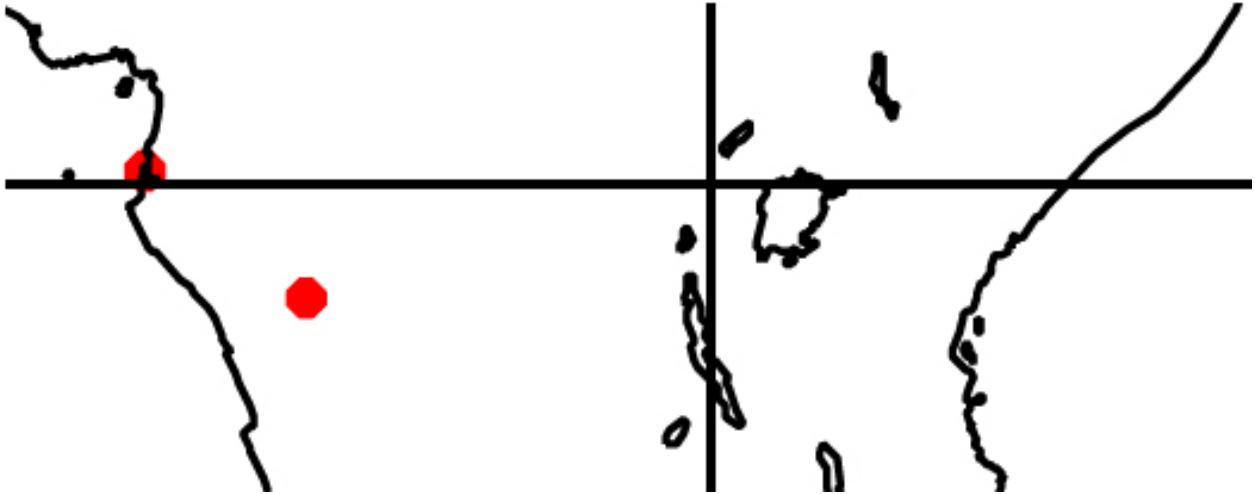


Figure 2: Temp messages from radiosonde observations received at ECMWF over a 24 hour period on May 6, 2012

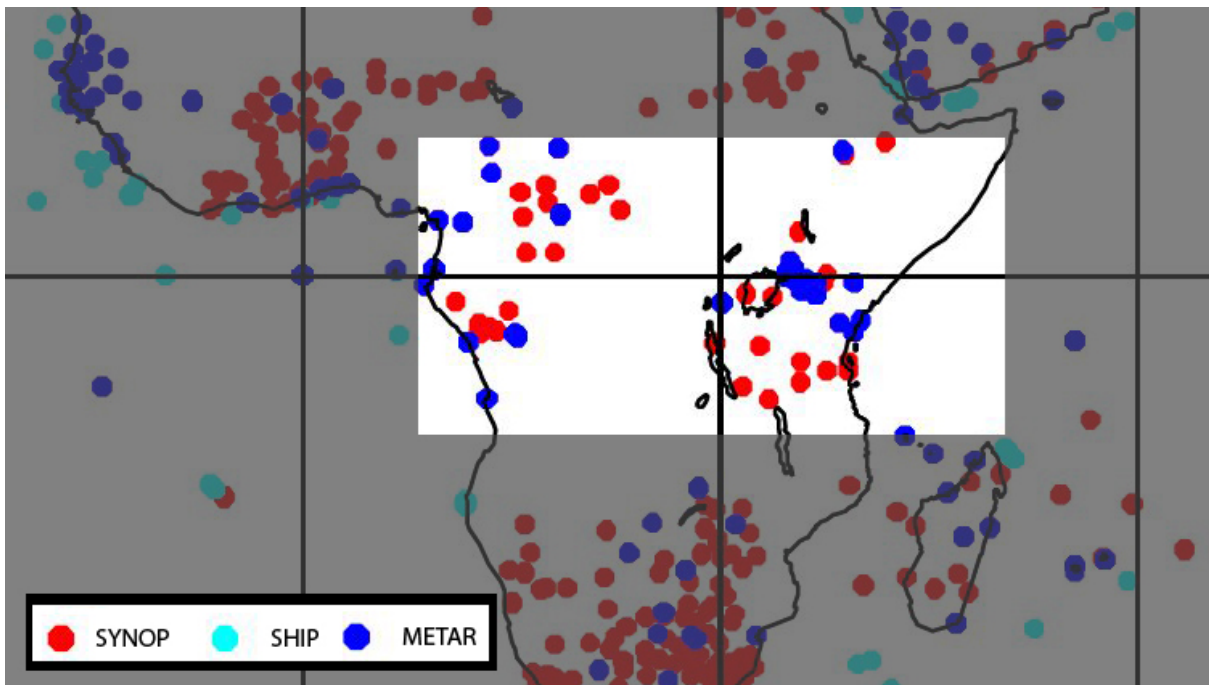


Figure 3: Surface observations received at ECMWF on April 9, 2012 at 00Z.

The East African Community's Five Year Plan, published in 2004, recognized the issues present in its countries (Kenya, Tanzania, and Uganda) in terms of meteorological network deficiencies. The study determined that 70% of natural disasters were the result of

weather/climate (East African Community, 2011). However, the five-year improvement plan laid out by the organization seems to have failed in capturing the attention of government leaders.

The *TASP* proposed that the problems of observing systems in Africa were “inadequate equipment, inadequate staff and planning, lack of consumables, use of old data formats, inappropriate telecommunications systems for exchange of data and information (often obsolete equipment are used), unable to keep up with rapid technological developments, lack of awareness by stakeholders (governments, institutions, public and private sectors) of the value of meteorological information in socio-economic development and environmental protection, and lack of inventory, coordination, and access to real time meteorological data and information.” These conclusions provide the basis for possible solutions for the region. The combination of understanding the high impact weather events that occur in the region as well as the observational network deficiencies allowed for defining a basic framework of the data needs in equatorial Africa.

The far-reaching goals of THORPEX included education of forecasters, improving observation systems, and creating better communication channels to disseminate forecasts. The desired end result was to have a group of forecasters that can dynamically communicate with a variety of impacted sectors and their respective forecasting needs (WWRP/THORPEX, 2008).

Our research is an extension of the idealistic goals of THORPEX applied to a specific region of Africa that continues to be neglected meteorologically for a variety of reasons (financial and geopolitical). Prior to THORPEX, the National Severe Storms Laboratory (NSSL) conducted limited research in western Africa. NSSL’s activities identified many of the difficulties facing meteorological services in the region. The findings emphasized the need for regional management, staff education, and improved data transmission (including standardized

formats) (AMMA, 2006). Each of these components was found to be applicable to the entire continent, not restricted to western Africa.

To determine the type of observational improvements that were necessary for the region, a combination of the meteorological phenomena typically present and current state of networks was used. Organizationally, a successful meteorological observation system requires a national and regional management approach, sufficient personnel training, and a careful determination of observing needs. By including the suggestions from prior research efforts, the potential for acceptance, and eventual success, will increase. Ultimately, a successful observation network will not only be beneficial to the weather forecasters of equatorial Africa but also other regions because the atmosphere over Africa interacts with mid-latitudes and even polar regions.

2. BACKGROUND

Because the area of focus lies directly on, just north, and just south of the equator, these countries experience what is known as the equatorial climate and some of the highest mean annual temperatures in the world. For an equatorial region like this, the average annual temperature is around 30°C (86°F) during the day and 23°C (73°F) during the night. Countries along the equator do not generally feel the variations of seasons through the changing of temperature. Rather, the seasons are based on the amount of rainfall. Countries along the equator average about 2.5-3.5 m of rainfall over a year, which consists of about 200 rainfall days. The amount of rainfall in the region is highly variable on the position of the Intertropical Convergence Zone (ITCZ) (Figure 4). The ITCZ is the most prominent atmospheric feature that is associated with the evolution of high impact weather in equatorial Africa.

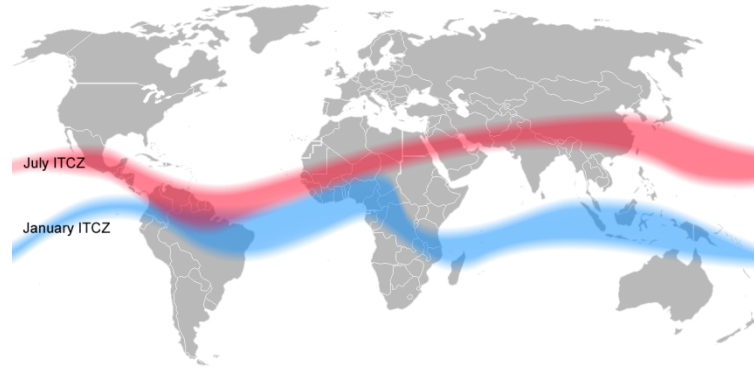


Figure 4: Position of the ITCZ in July and January

Flooding is especially of concern in equatorial Africa and the other neighboring regions. Throughout the whole continent, an estimated 6,000 fatalities occurred due to floods over the 10-year period of 2003-12 (CRED, 2012). Seasonal flooding was the main cause; accounting for about 75% of deaths, with flash flood-associated fatalities around 20%. Flooding fatalities in Africa are caused by both meteorological events and socio-economic factors (development in flood plains). Di Baldassarre et al. listed better flood forecasting as a strategy for risk reduction (2010).

Topography also plays a significant role in the dominant climate(s) of each country (Appendix A). Within the region, the elevation varies from at sea-level to 5,895 m (Mount Kilimanjaro in Tanzania). A map of the region's topography illustrates the wide range of geographical features present in the area (Figure 5).

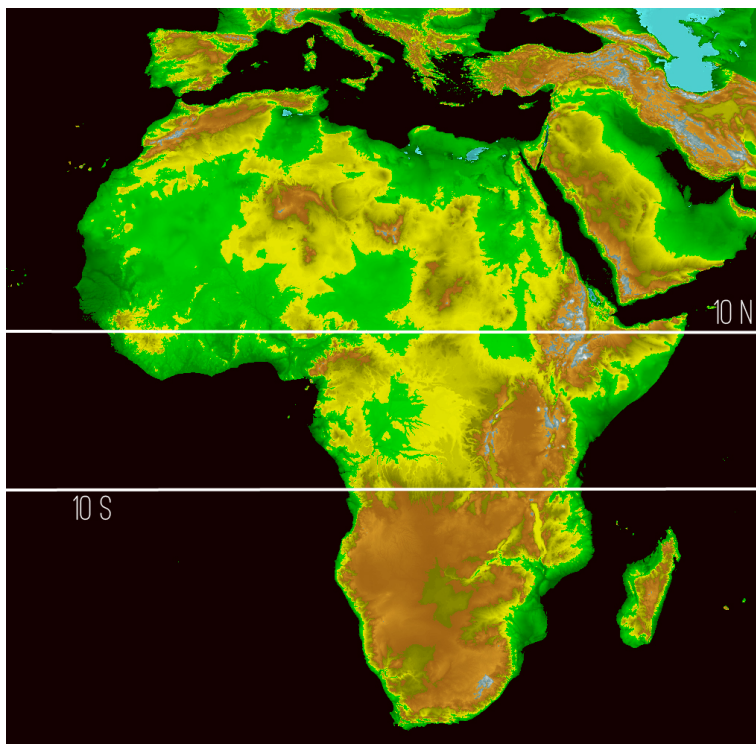


Figure 5: Topographical Map of Africa

3. METHODS

This research took place over a six-month period and was primarily completed through online information gathering via national meteorological websites, journal and resource databases, and email exchanges. Research began with an overall evaluation of equatorial Africa. This includes the basic geography, topography, climatology, etc. This knowledge was used to determine what is meteorologically and climatologically important to the region, not only the daily temperature and precipitation variability, but also severe and unusual weather events.

Once the basic meteorology of equatorial Africa was researched, it was followed by an analysis of what kind of observation network is currently in place. This consisted of looking at papers from the WMO on current observations that are being collected as well as extensive evaluations of websites for each of the countries in the region of equatorial Africa. This

evaluation consisted of looking at the availability of climatological data, finding details of observations, and determining how many and what kind of stations are in place. This allowed for the building of a map to show where network stations currently are and where there is a need for more.

A significant part of the research collected came from email exchanges from directors of each country's national meteorological service. We attempted to contact people that work for each of the national meteorological agencies, science or like-field professors at universities in the each of the countries, and other people that utilize meteorological data in their industry. We gathered the contacts for each country's directors of meteorology through the *Composition of the WMO*, a document that lists the information of each member (WMO, 2011). Because we needed to have adequate time to obtain responses from these people, we sent our emails at the beginning of our research, explaining who we were and what we intended to do with the information. This gave us the opportunity to go through all the data that we collected and analyze it for the final stage of our research.

Our emails included the purpose of our study and a questionnaire that would enable us to gather information about each country's current meteorological network. A list of ten questions comprised the questionnaire (Appendix B). When a completed questionnaire was returned to us, we were able to begin the final step of our project; the part that we hope will be the reason that our research will be effective. We hope to suggest changes and improvements to the countries of equatorial Africa so that society can benefit from the enhanced forecasts. We will also need to research what tools are available and what would be the most cost effective means of observing.

4. RESULTS

Internet research of the national meteorological services returned mixed results. The intent of retrieving websites for each national meteorological service in our region of focus was to gain an initial understanding of what is available in each country. Of the 13 countries in the region, six of them either do not have a website or an easily identifiable weather service. The websites that are available are of variable utility. Daily forecasts are largely unavailable (with Kenya as the exception). Uganda's Department of Meteorology only posts a seasonal forecast for three months with general predictions about rainfall (Figure 6). Similarly, the Democratic Republic of the Congo offers a seasonal forecast from 2003 and the daily forecast link is no longer active. Overall, the Internet presence of most national services is deficient or non-existent.

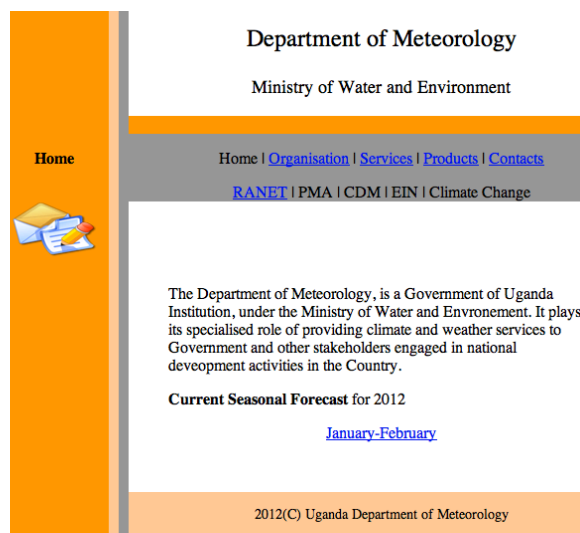


Figure 6: Uganda Department of Meteorology Website

We were able to gain contacts for each country in our region of interest, with the exception of Somalia. Somalia did not have a contact listed in the Compositions of the WMO. The first round of emails was sent out at the beginning of February. After minimal responses, we sent out another round of emails one month later at the beginning of March. The second time was much more successful, and we sent our third and final round of emails at the beginning of April.

In total, out of the thirteen countries we reached out to, we received questionnaires back for seven countries, over half of our total. The countries we received completed questionnaires from were Burundi, Congo, Ethiopia, Gabon, Kenya, Rwanda, and Uganda. The countries that we did not receive information from were The Central African Republic, Democratic Republic of the Congo, Equatorial Guinea, Somalia, South Sudan, and Tanzania. We were in contact with the director for the Tanzanian Meteorological Agency but they did not send in their questionnaire in time. We were also in contact with the President for the Regional Association of the WMO in the meteorological service for Guinea Conakry, located in West Africa who attempted to get us in contact with an employee of Equatorial Guinea's meteorological service, but we were unsuccessful in reaching them. South Sudan is a new country and therefore their Director of Meteorology is new, and we were advised that it would be difficult to be in contact with him. Although it would have been ideal to receive all questionnaires back from each country, we were pleased with receiving information from over half of our total countries. All of the responses that we received are listed in table format and can be found in Appendix C and Appendix D.

5. DISCUSSION

Africa's topography poses a significant challenge in forecasting because of its varied effects on climate. Many countries have several climate types just within their borders. The spatial variability of weather across small distances and the dominance of mesoscale events suggest a dense observational network. However, in a region where most, if not all, meteorological services are underfunded, the costs of developing a dense network would be prohibitive. A solution requires cost-effective deployment over a large region.

A common theme throughout nearly all of the questionnaire responses was the lack of observational stations. Many of the countries have less than twenty synoptic and climatological stations. For example, Uganda is approximately the size of the state of Oregon but only has 12 synoptic stations and 15 climatological stations. On the other hand, one of the more developed countries like Kenya, which is only slightly smaller than the state of Texas, has 39 synoptic stations and over 1,000 climatological stations with rain gauge measurements. In addition to the low distribution of synoptic and climatological stations throughout these nations, many have stations that are non-operational. For example, Congo has 212 rain gauge stations but only about 15% of them are functional. Many questionnaires that were completed discussed maintenance of meteorological instruments as a common theme of needed improvements. This shows that the reason for not having many observational stations in the other less developed countries is not because they are not needed, but rather because of the lack of funding.

Furthermore, from all of the responses received, only one country, Congo, reported having a working meteorological radar. All of the other countries have no meteorological radars except for Kenya and Ethiopia, but these are not functional. In equatorial countries like the ones of study, radars are exceptionally important because of the influence of rainfall, which can potentially cause significant flooding events. Having operational radars in each of these countries would be extremely beneficial, but again, funding is an issue. The radars themselves can cost over a million dollars and with installation and upkeep would be several million dollars that none of these less developed countries could afford.

Another factor that inhibits the meteorological forecasting in each of these countries is the personnel working for the national meteorological services. Many of the countries said that they would benefit from more training for their staff. Some countries require their

meteorologists to have meteorology or weather engineering degrees or a WMO 1 classification minimum, while others only require a high school diploma. Although this may not seem like suitable requirements in the United States, many of these countries only require people to attend less than ten years of formal education; so completing a university program is an unlikely occurrence. Training for meteorology personnel that the responders would like to see would be for specialized aviation and marine meteorology, specialized forecasting in tropical regions, and computer modeling.

The most serious issue facing the region is insufficient funding, as commented on by most of the survey respondents. In general, the poverty of most of the region's countries limits the national budget overall. With limited climate variation in many countries, meteorological services are deemed a lesser priority. Operational equipment suffers from lack of maintenance (as in the case of many non-functional radars or upper air observation stations). Additionally, technological advances are limited. Observations are, likewise, minimal in parts of the region. Because neighboring countries could be non-participatory in transmitting observations consistently, a regional meteorological service would suffer from lack of data outside of each country's border.

Equatorial Africa is a region affected by a variety of hazards. With limited observations and radar coverage, real-time forecasting of weather events, especially flooding rainfall, is difficult for the national meteorological services. This limited forecast ability places affected residents at a higher risk. Improved spatial and temporal coverage would offer the region's forecasters a greater opportunity to accurately forecast significant meteorological hazards for local communities.

Upper air observations are also limited within the region (two launching stations). Increasing the number of rawinsonde stations would be valuable for numerical prediction models. However, for operational, short-term forecasting, upper air data is most useful for convective environments and winter weather. Because neither of these applies consistently to equatorial Africa and the cost per rawinsonde launch is significant, support for additional upper air observations by the national governments would likely be minimal.

Based on the financial limitations and the hazards faced by equatorial Africa, an improved meteorological network should be comprised of mainly one aspect: increased spatial coverage of surface observations. Hourly measurements of temperature, pressure, humidity, winds, and precipitation would provide meteorologists with a nearly real-time picture of the local environment. Rain gauge measurements would allow monitoring of potential flooding conditions across the area. Because the spatial coverage would be increased, hazardous weather outside of a country's borders would be detected and tracked before it entered the country. This type of regional network requires significant cooperation between all countries and extensive data sharing. A radar network would also be helpful but the regional benefits of such a system would be hampered by mountain ranges in the eastern part of the region. Without positive effects for each country, unanimous support would be unlikely. High implementation costs and ongoing maintenance needs have limited operational radar use in the region in the past and would restrict regional deployment at this point as well.

These regional improvements are predicated on a strong regional alliance between each country. France operates meteorological equipment in former French colonies through a program named ASECNA (as mentioned by Congo's and Gabon's meteorologists in Appendix D). A similar approach through all of equatorial Africa would yield positive results. A joint approach

requiring equal support and representation from each country is imperative for support among each nation. Without open data sharing and a shared financial burden, any improvement strategies would be likely to fail.

6. CONCLUSION

From all of the information gathered throughout all of the research, it became very evident that creating a forecasting and observing network for equatorial Africa was a very large problem to tackle and there are multiple levels of improvements that need to be taken in order to fix it. The overall impediment to the progress in all of these countries is the inherent issue of a lack of funding. If these countries had sufficient funding, much more could be accomplished in the national meteorological services.

If enough recognition could be raised about this issue in organizations such as the World Meteorological Organization, there could be a steady avenue of money provided to these countries. If there were sufficient funding, improvements could be made to keep the current meteorological observation instruments in good condition and install more observing stations in each country, especially those with rain gauges. Since flooding events are the most detrimental to these countries rainfall is the single most vital variable to measure. Gabon and Rwanda admitted to correctly forecasting rainfall measurements as a major forecast struggle in their current meteorological network, a more dense, functioning observation network would help ease this challenge. Extreme heat also makes temperature another important measurement.

Other improvements that could be made with sufficient funding could be training of current staff members, and better communication of forecasts and other meteorological information to the private sectors in Africa and the general public. The idea of better

communication is something that could be followed up with further research. Once strong forecasting and observing networks are created, the next step is disseminating this information to the public. The type of research conducted could be replicated in a new study with similar processes and different questions to obtain a solution for communication issues within the region.

If this research was to be completed again, improvements could be made by sending out questionnaires to more contacts in order to receive multiple responses from each country. Multiple completed questionnaires for each country would allow us to gain different perspectives about the forecasting challenges and improvements needed in each country. There could have also been more contacts searched out through universities in the countries and possibly media outlets, if available. But overall, the amount of connection with the equatorial African countries was satisfactory for this research and allowed enough information to realize where the shortcomings in the region are and how to accommodate them.

Overall, there are multiple levels of improvements that need to be made to the equatorial African forecasting and observation network. Although several of those solutions were proposed here, there is a significant amount of research that needs to be done and funding that needs to be provided. This is an important topic that must be addressed in a timely manner because there are numerous people in this region who are affected by weather events, both normal and extreme, who would benefit from these improvements being implemented.

7. ACKNOWLEDGEMENTS

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APPENDIX A

The following table lists general climate characteristics for each country in our region of interest.

Country	Climate
Burundi	<ul style="list-style-type: none"> • Average Annual Temperature: (varies with altitude) 17-23 °C • Average Annual Rainfall: 150 cm • Two wet seasons (February to May and September to November) • Two dry seasons (June to August and December to January)
Central Africa Republic	<ul style="list-style-type: none"> • Tropical, ranging from humid equatorial in the south to Sahelo-Sudanese in the north • Hot, dry winters with mild to hot, wet summers
Congo	<ul style="list-style-type: none"> • Tropical, tropical jungle in the North • Country is seasonally split, half lies above the Equator and half lies below the Equator
Democratic Republic of the Congo	<ul style="list-style-type: none"> • Equatorial: Ranges from tropical rainforest in the Congo River basin • Hot and humid in much of the north and west • Cooler and drier in the south central area and the east
Equatorial Guinea	<ul style="list-style-type: none"> • Tropical; always warm, humid • The weather alternates between wet and dry seasons over the course of a year
Ethiopia	<ul style="list-style-type: none"> • Temperate in the highlands • Hot in the lowlands
Gabon	<ul style="list-style-type: none"> • Hot and humid all year • Two rainy and two dry seasons
Kenya	<ul style="list-style-type: none"> • Tropical in south, west, and central regions • Arid and semi-arid in the north and the northeast
Rwanda	<ul style="list-style-type: none"> • Mild and temperate • Two rainy seasons
Somalia	<ul style="list-style-type: none"> • Principally desert • December to February—northeast monsoon, moderate temperatures in north, and very hot in the south • May to October—southwest monsoon, torrid in the north, and hot in the south • Irregular rainfall • Hot and humid periods (tangambili) between monsoons
South Sudan	<ul style="list-style-type: none"> • Tropical, hot, and humid with seasonal rainfall influenced by the annual shift of the Inter-Tropical Convergence Zone • Rainfall is heaviest in the upland areas of the south and diminishes to the north
Tanzania	<ul style="list-style-type: none"> • Varies from tropical to arid to temperate
Uganda	<ul style="list-style-type: none"> • Tropical • Generally rainy with two dry seasons (December to February, June to August) • Semiarid in northeast

APPENDIX B

The following is the list of ten questions that composed the questionnaire sent to the thirteen countries of interest.

1. What are the most important forecasting challenges for your NMS?
2. How many forecasters work for your national meteorology service?
3. What qualifications are needed to be a meteorologist/forecaster in your country?
4. What is the current state of your observational network? In particular what is the approximate number of functioning:
 - a) Surface synoptic stations
 - b) Climatological stations with daily rainfall measurements
 - c) Meteorological radars
5. Are any upper air observations (radiosonde or pilot balloon) made routinely by your NMS? If so please describe very briefly the specific sites and kinds of observations being made.
6. What types of numerical model guidance and Internet products do meteorologists in your country use to make forecasts?
7. Are there any particular improvements would you personally like to see made to your current observational network?
8. What kind of education is most needed by your staff?
9. Are there separate meteorological services for different purposes in your country? For example, does the Civil Aviation community depend on forecasts from a specialized forecast agency, or does the military have their own forecasting staff. (This information is very important for designing possible educational activities, for example.)
10. Please feel free to provide any other comments that you wish here:

APPENDIX C

The following table is a list of the responses received from the questionnaire about the current state of each country's meteorological observing and forecasting networks.

Country	# Of Forecasters	Forecaster Qualifications	# Of Stations	Upper Air Obs?	Usage Of Numerical Models
Burundi	8	WMO Class 1	Surface synoptic stations: 6 Climatological: 12 Radars: 0	None	Synergy System (PUMA): allows satellite images every 15 minutes
Congo	5	To be an engineer in meteorology (Class 1 WMO) or equivalent	Surface synoptic stations: 18 Climatological: 12 Rain gauges: 212 Radars: 1	Two radiosonde stations, 6 pilot balloon stations with only 3 operational	ECMWF and UKMo and satellite images from the internet, weather numerical products from Meteo France and the South African Weather Bureau
Ethiopia	N/A	A degree in meteorology or related field. To be a forecaster- a diploma in meteorology or forecasting training	Surface synoptic stations: 17 Climatological stations- 1154, 37 automatic, and 4 automatic observing, Radars: One but not functional	Two stations, only one in operation. Does both radiosonde and pilot balloons once a day	N/A

Gabon	6	Weather engineering	Surface synoptic stations: 9 Climatological stations: 0 Radars: 0	None	Internet, PUMA, Synergy, AMESD
Kenya	127	Bachelor Degree in Meteorology	Surface synoptic stations: 39 Climatological stations: 1000 Radars: installed but not operational	Radiosonde observations made twice a day	HRM, WRF, COSMO, and global models from NOAA, GFS, UKMET office ECMWF
Rwanda	13	A post high school diploma in weather forecasting or degree in meteorology	Surface synoptic stations: 13 Climatological stations: 143 Radars: 0	None	Model outputs from global models: GFS, ECMWF, UKMO
Uganda	6	Bachelor degree in meteorology, math, physics, or statistics with a post graduate diploma in meteorology	Surface synoptic stations: 12 Climatological stations: 15 Radars: 0	None	UK LAM model, CTC, Indian model via the Kenya website, South African weather services, NCMRWF, RSMC model

APPENDIX D

The following table is a list of the responses received from the questionnaire about the challenges and improvements needed in each country's meteorological observing and forecasting networks.

Country	Forecast Challenges	Improvements Wanted	Education Needed	Joint Services?	Additional Comments
Burundi	No automatic weather observing system at AWOS and SADIS to receive met. Products from the WAFS. Lack of testing, calibration, and certification of instruments and equipment	Establish periodic inspection and building capacity of our staff	Training for Class 2, training for Class 1, specialization training I Aviation and marine meteorology	None	None
Congo	Reinforce the capacity of technical staff members, to improve the quality of weather forecasts	Improving of data collection system and meteorological telecommunication means, expecting to receive 6 automatic stations	Training in management on meteorological service, especially in mobilization resource, training on weather forecast in tropical regions	ASCENA is in charge of meteorological assistance to the international air navigation and military aviation in the country and manages two ground meteorological stations and radiosonde stations.	Wish to receive more numerical products in the future, as well as a supply of climatological products. Need of building capacity in order to allow the service to respond to consumer needs

Ethiopia	N/A	Want to expand automatic station networks, trying to establish one new radar station with a goal of ultimately having 4, want 1200 climatological stations	Meteorological at post graduate level, diploma level, and certificate level, computer training, information technology, networking, GIS, marketing. Short term training in satellite, radar, climate change, research, numerical weather prediction, climatology, and meteorological instruments	Partnership with the aviation sector that provides data for flights. Air force also has a meteorological staff	N/A
Gabon	Improving weather forecasts for the general public	Increase number of stations and specialized training of workers	Train more engineers and senior technicians in WMO recognized schools	ASCENA is in charge of aviation forecasts	Want specialized training for hydrometeorology, expect to increase the number of employees
Kenya	Inadequate funding, inadequate data and personnel, rapidly changing technology, specific expectation from climate	Increase the observation stations	Technical education	None	None
Rwanda	Correctly forecasting the occurrence of rain	Network to be intraconnected and interconnected with meteorological networks within EAC countries	Computing	Aviation and some services serve civil and military purposes	None

<p>Uganda</p>	<p>Insufficient weather data collection station network across the country, unreliable transmission technology of weather data from the station networks, lack of message switching system at the NMS, lack of weather radar to provide more timely weather information, lack of sufficiently trained human resources</p>	<p>Replacement of all the dominantly old observational equipment in all stations</p>	<p>Specialized training in weather forecasting, forecasting systems and development, numerical weather prediction, satellite meteorology and simulations, severe weather forecasting, and aerial weather forecasting</p>	<p>No, all meteorological services are centralized</p>	<p>Current NMS is in a transition period, hoping to receive both technical and human resource requirements</p>
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