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HIGH-IMPACT WEATHER (HIW) FORECASTING IN GHANA: CHALLENGES AND PROSPECTS OF THE NOWCASTING SATELLITE FACILITY (NWCSAF) FOR IMPROVED EARLY WARNING AND DECISION-MAKING

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ABSTRACT

Accurate weather forecasting and nowcasting are essential tools of modern society, which bring benefits to human safety and livelihoods, along with countrywide economic development and prosperity. Challenges with effective early warning systems in-country and within the sub-region have been amplified by a lack of advanced technological resources and, to an extent, human resources. With the advent of the Nowcasting Satellite Facility (NWCSAF), Ghana stands a great advantage from exploiting the resource. In this paper, we discuss the challenges and prospects of the NWCSAF to improve nowcasting and also early warning systems within the country. We further highlight a case event of inundation and discuss the NWCSAF's ability to capture the event and its prospects for replication. This study has shown that there is vast

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potential for early warning system improvement that can be harnessed from NWCSAF, which can serve the greater good of improving general livelihood and socio-economic growth and development. Effective use of the NWCSAF will support measures to address the Sustainable Development Goals **13 (Climate Action)** and **17** (**Partnership for the Goals**) .

Keywords: NWCSAF; Nowcasting; Impact-Based Forecasting; West African Meteorology; Ghana

INTRODUCTION

Despite the numerous societal impacts of weather events, our current ability to assess extreme weather events and their impacts is limited not only by the rarity of the event **(Done et. al., 2015)** but also by a limited understanding and a lack of capacity to track the development and migration of the event, as well as the underlying physical processes **(Anaman et al., 2017)**. Therefore, this challenge is driving fresh approaches to assess high-impact weather and climate **(Done et. al., 2015; Zhongming et. al., 2017)**. By definition, "high impact weather (HIW)" emphasizes the consequences of severe weather. Recent years have seen a shift from simply providing forecasts that focus on meteorological conditions alone, to issuing forecasts that incorporate information about their associated impacts **(Guido et al., 2020)**. Most National Meteorological and Hydrological Services (NMHSs) have begun exploring the Impact-Based Forecasting (IBF) approach to HIW based on the World Meteorological Organization (WMO) guidelines on Multi-hazard Impact-based warning services. IBF is the structured approach for combining hazard, exposure, and vulnerability data to identify risk and support decision-making. The ultimate objective is to encourage early action to reduce damages and loss of life from natural hazards. Scientific advances in technology and capacity have improved weather forecasting and warnings of hydrometeorological multi-hazards with accuracy and lead time to support the safety of life and property and enable appropriate action to be taken by government, economy, and the public **(WMO, 2015)**.

Rapid rates of population growth, human encroachment, urbanization, deforestation, and land-use changes are contributing factors to extreme weather events which are threats to livelihood, especially in vulnerable regions **(Lambin et al., 2003; Ahmed and Dinye, 2011; Seto et al., 2012; Güneralp et al., 2017; Acheampong et al., 2018; Awotwi et al., 2018; Addae and Oppelt, 2019; Osei et a., 2019; Herrmann et al., 2020; Wemegah et al., 2020)**. These, therefore, impose a huge toll in terms of socioeconomic, environmental, and ecological impacts. Such high vulnerability is associated with diverse natural hazards and risks, poor (or non-existent) preventive and adaptive capabilities, and fragile governance. Around the world, high-impact weather events continue to present a serious threat to lives and livelihoods **(Shi et. al., 2021; Kjellstrom et. al., 2013),** with the greatest impacts felt in African communities where there is limited adaptive and responsive capacity. Every year, high-intensity weather events result in devastating losses of life and damages to land, property, and infrastructure. Effective forecast and early warning systems can play an important role in reducing the harm caused by these events. However, for continuous improvement in the science of weather forecasting to support disaster risk reduction, forecast information must be communicated in a way that is easily accessible, understandable, and serves as useful input into decision-making processes. This raises the need for an effective early warning system to help identify and communicate such events as quickly as possible.

According to **Ebi and Schmier (2005) and Waidyanatha (2010)**, an early warning system can be implemented as an integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, and information communication systems which comprise sensors, event detection, and decision subsystems. They work together to forecast and signal disturbances that adversely affect the stability of the physical world. This allows the response system to prepare for adverse events and minimize extreme weather impacts. Early warning systems need to actively involve the communities at risk and facilitate public education and awareness to be effective. Improving the accuracy of weather forecasts and the quality and timeliness of weather early warning systems is critical for people's safety and vital economic sectors, including aviation, agriculture, energy, water, and emergency response **(Shilenje, 2015)**.

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The goal of the Global Challenges Research Fund - African Science for Weather Information and Forecasting Techniques (GCRF African SWIFT; hereafter termed SWIFT) project (*https://africanswift.org*), in partnership with African NMHSs and Research Institutions (Universities), was to improve nowcasting and weather forecasting techniques, as well as, build the requisite capacity to enhance livelihood and socio-economic development in Africa. As such, the Nowcasting Satellite Application Facility (NWCSAF) was provided to the Kwame Nkrumah University of Science and Technology (KNUST) and the Ghana Meteorological Agency (GMet) to support nowcasting research, operationalization, and automation within the country. A similar set-up, comprising of satellite dishes (existing ones at some NMHSs, such as GMet) with accompanying data retrieval and processing software was installed in partnering institutions across East and West Africa for the same reasons.

In this paper, we present some relevant information on the challenges and prospects of the NWCSAF resource for improved early warning in Ghana. The paper is structured as follows: the introduction is provided in **Section 1** . Next, the operational procedure of NWCSAF is discussed in **Section 2**, with a case observation of a High-impact rainfall event highlighted in **Section 3,** and a discussion on the challenges and prospects of the NWCSAF in Ghana given in**Section 4**. The study will demonstrate the application of NWCSAF in Ghana via two methods; (i) Impact-Based Forecast (IBF) evaluation with user observations of the September 14 - 15, 2021 thunderstorms in Ghana and (ii) Dynamics-Aerosol-Chemistry-Cloud Interactions in West Africa (DACCIWA) optical rain gauge network evaluation of October 6 - 7, 2020 heavy rainfall in Kumasi, Ghana. Finally, the conclusion is provided in **Section 5**.

THE STATE OF NOWCASTING IN GHANA

The destruction caused by HIW events, such as thunderstorms and floods, makes lives and properties vulnerable (Roberts et al., 2021). Hence, the high frequency of these events means there is a need to improve the forecast and forecast skills for HIW events in Ghana and across Africa. Additionally, data availability varies the process of nowcasting within the African sub-region. This informs the three criteria for nowcasting in Africa, similar to global standards:

1. **Nowcasting includes analysis of near-real-time observations to** describe current weather conditions.
2. **Nowcasting forward-propagates observed weather features** by extrapolation and sophisticated methods using a wide range of data and dynamical understanding.
3. **Nowcasting requires continuous monitoring** made possible by a rapid workflow of data acquisition, processing, and the dissemination of warnings and updates.

Prior to SWIFT, nowcasting had been operational in Ghana but performed via alternative means, including integration of numerical weather prediction (NWP), satellite imagery, and near-real-time ground observations. The use of nowcasting resources and tools such as the NWCSAF and IBF were hitherto not implemented. Limitations of the earlier approach included a longer time to assess the products and the need for experience to demystify the products. The latency of producing such nowcasts had some marginal impact on citizen confidence in issued forecasts as on some occasions, the issue times coincided with or were fairly close to the event occurrence.

The dawn of SWIFT implied that the resource would be effectively harnessed over the continent to support the improvement of nowcasting. Aside from South Africa, which had operationalized NWCSAF in Africa, Ghana was the first among the collaborating African partners of SWIFT to operationalize the NWCSAF resource for in-country nowcasting improvement. This was coupled with (i) nowcast skill enhancement through NWCSAF verification and (ii) user community engagement via co-production. The benefits of operationalizing nowcasting in Ghana with locally-hosted resources are numerous, including but not limited to:

1. Competent delivery of in-country nowcasting leading to extended service support to other institutions, in terms of installation of the NWCSAF and the provision of nowcasting information for other neighboring countries.

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2. Capacity building for forecasters and researchers on the use of the NWCSAF products and its applications for nowcasting weather predictions and scientific research.
3. Impact-based research (IBF) which focuses on the hazards associated with weather and how to relay information through research and other communicative means for better policy and decision making. During Testbed3, new skills for IBF generation, in accordance with the WMO multi-hazard and IBF guide, were adopted for enhanced HIW communication.

OPERATIONAL PROCEDURE OF THE NWCSAF

General Operation

The NWCSAF receives data from the **3520 Atlantic Bird 2 (8.0W)**satellite via the newly installed receiving dish in KNUST (positioned on the Whitaker Building; latitude 6.6733 N, longitude 1.5666 W and altitude 264 MSL; **See Figure 1a**) and the existing dish in GMet (positioned on the ground of its premises; latitude 5.6512 N, longitude 0.1643 W and altitude 71 MSL; **See Figure 1b**) with a 15-minute latency.

Local (In-house) Operations

Satellite data reception is performed by the TBS Data Services (Figure 1c) via a 3848.V.9892 transponder at a frequency of 3848 MHz, with vertical polarity and a symbol rate of 9892 KSps. With the EUMETSAT (European Meteorology Satellite) Tellicast Multicast Distribution System Client 2.14.5 (Figure 1d), a general overview of the data reception via defined channels and other ancillary properties are visualized in-house. The NWCSAF requires geostationary satellite data to process. Data from EUMETSAT Meteosat Second Generation (MSG-II) positioned at 0.0 degrees longitude is used in this instance. The encrypted data is decrypted using the xRITdecompress executable file upon reception. Checks for both the prologue and epilogue files from the source directory are performed before decompressing the files that fall within their time interval. The SAFNWCTM application allows for the processing of the decrypted data alongside inherent application-dependent processes and simulates the atmospheric state over the defined region. An in-house built, visualization interface aids in visualizing the atmospheric state over the observation region (centered on Ghana). After processing and visualization, the data is archived on a local machine in its raw format.

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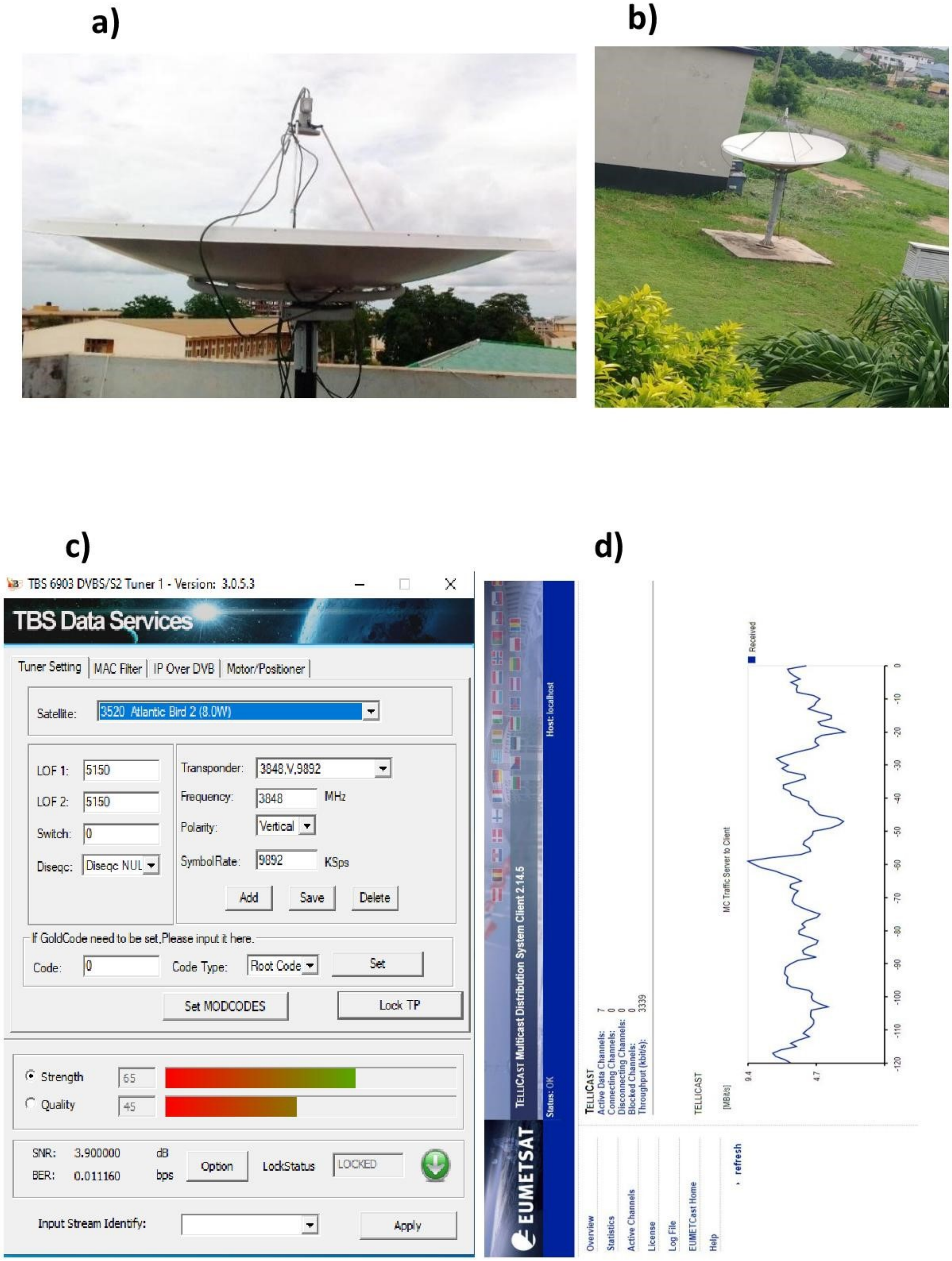

Figure 1: NWCSAF satellite dishes mounted at **(a)**KNUST, Kumasi, **(b)** GMet, Accra and the data reception process comprising **(c)** TBS Data Service showing connectivity and properties and **(d)** satellite data transfer process via the Tellicast interface.

CASE STUDIES

This section presents case assessments of nowcasting approaches adopted in Ghana with accompanying new technologies. These include the impact-based forecast (IBF) and Nowcasting Satellite Facility (NWCSAF) approaches. The NWCSAF products used herein include the rapidly developing thunderstorms (RDT), convective rain rate (CRR), and precipitating clouds per pixel (PC-Ph).

4.1 Impact-Based Forecast Evaluation: September 14 - 15, 2021

With the increase in the frequency of HIWs, due to climate variability and change, posing threats to vulnerable communities, stakeholders need timely weather information for early warning, preparedness, and response in order to protect lives and properties. Therefore, the provision and effective communication of these sets of information necessitated the IBF evaluation from user perspectives. This was to assess the accuracy, relevance and user understanding of the IBF for enhanced future utilization and operationalization. Moreover, testbeds and co-production workshops were organized by African SWIFT partners to build capacity for forecasters, researchers, and users on nowcasting in Ghana **(Figure 2)**. The primary goal was to enable forecasters to collaborate with researchers in nowcast generation for users while also evaluating the nowcasts collaboratively.

Figure 2: A group photo of forecasters, researchers and users who participated in the co-production workshop (SWIFT Testbed3) in Accra, Ghana from 13th - 24th September 2021.

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At the weather briefing sessions of the Testbeds, forecasters briefed the users on the produced forecast while the users sought clarification on the issued forecasts. The IBF template on the likelihood and impacts of the nowcasts served as a base for interpreting the forecast and informing decision-making. The weather briefing session was held virtually via Zoom to discuss the forecasts before disseminating them to the users via emails and social media platforms.

A sample assessment of the IBF-based forecasts and associated supplementary sampling information from the 14th to 15th of September 2021 is provided below. As shown in **Figure 3**, a total of 28 and 20 participants were present for the Weather briefing sessions on the 14th and 15th, respectively. The users completed an online survey using Google Forms to provide feedback on the forecast performance in their locality. During the SWIFT Testbed-3, participants were sampled from different agencies/sectors across the country, including Academia, Agricultural, Energy, Disaster Risk Management, Aviation, Water, Security, Non-governmental Organisations (NGOs), and many others**(Figure 3a)** . A total of 27 and 22 participants evaluated the forecasts for the respective days. The number of evaluators exceeded the number of participants who took part in the weather briefing**(Figure 3b)** . Some participants sent their observations via the feedback medium but could not attend the session for various reasons.

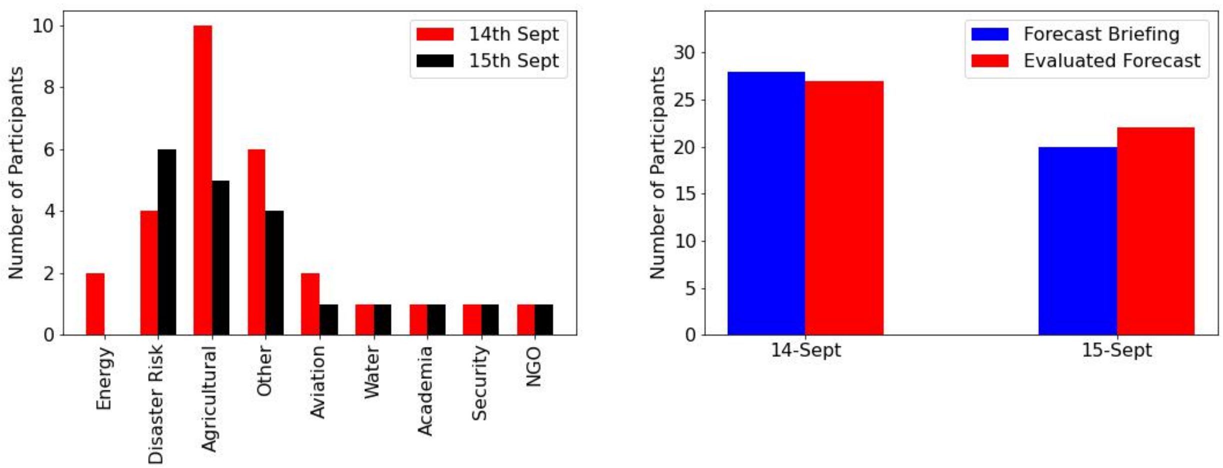

Figure 3: User groups (by sector) that participated in the forecast evaluation on the 14th and 15th of September 2021 **(a)** and a comparison of participants engaged in the weather briefing session to those that evaluated the forecast **(b)**.

As shown in **Figures 4a and 4b** , predominant weather forecasted across the country for the 14th and 15th of September 2021 were rains (71.4%; 57.1%), thunderstorms with rains (14.3%; 14.3), and cloudiness (10.7%; 23.8%) respectively. Also, sunny conditions were forecasted for over 3.6% of the spatial coverage on the 14th, and misty conditions (4.8%) were forecasted for the 15th of September.

From the user responses for forecast evaluation **(Figure 4c and 4d)** , on the 14th, rainfall (64.3%) was primarily observed across the country, followed by cloudiness (21.4%) and a few observations of windy, thunderstorm, sunny and misty conditions accounting for 3.6% each. On the 15th of September 2021, rainfall and cloudiness accounted for 47.6% and 38.1% of the observations, respectively. Few observations of thunderstorms with rains, sunny and misty conditions were made, accounting for 4.8% each of the observations.

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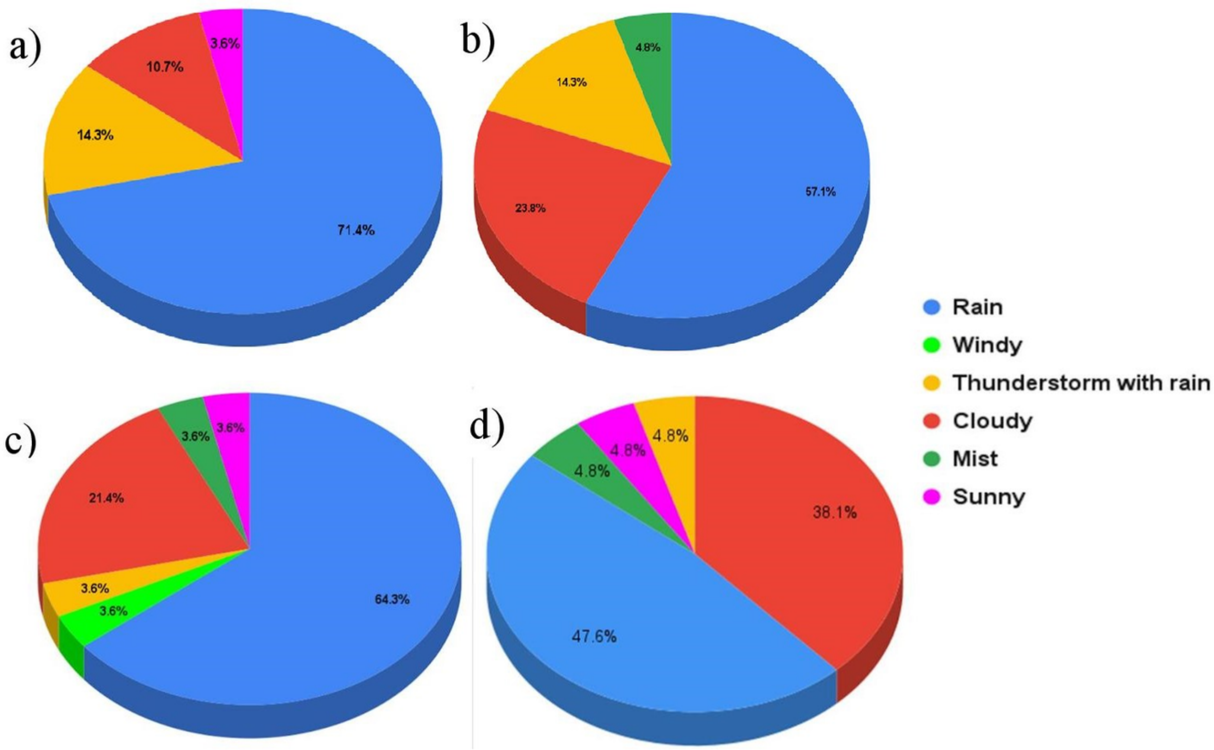

Figure 4: Issued forecasts (a,b) and actual weather conditions experienced by the users (c,d) on 14th and 15th September 2021, respectively.

In tandem with the evaluations from the forecast and user observation feedback, an accuracy comparison was conducted with respect to what was received by the RDT profiles for the specified days. Thunderstorms (TS) of different classifications were observed over the country **(Figure 5)** . The central and west coasts of Ghana were dominated by matured TS on 14th, with few clusters of growing and decaying TS mostly in the country's northern parts and east coasts. Similarly, varying TS clusters were found over the country, with a huge concentration of growing and decaying TS in the central portions of the country and matured TS in the northern parts.

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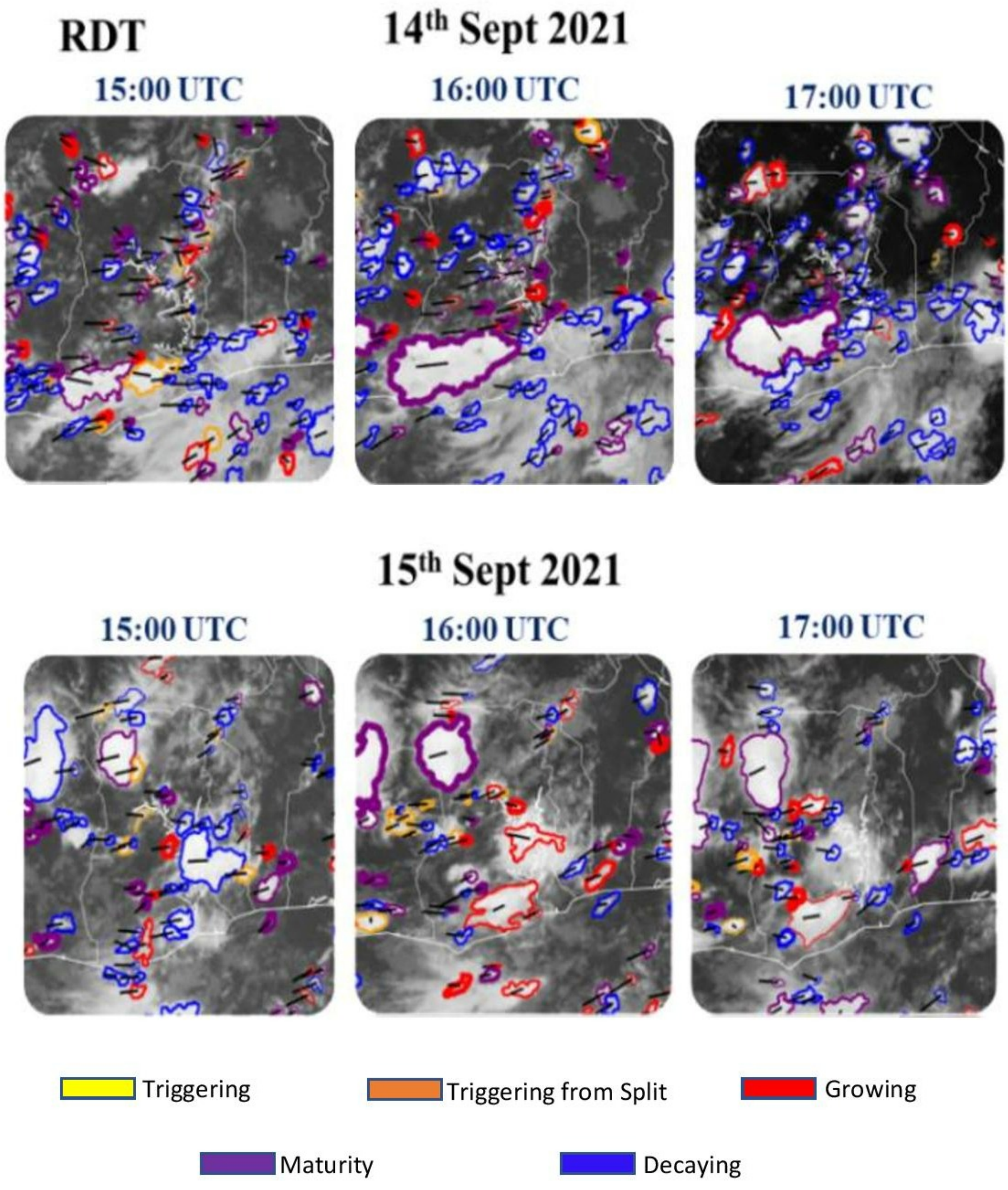

Figure 5: NWCSAF RDT products retrieved from 1500 UTC to 1700 UTC on (a) 14th September 2021 and (b) 15th September 2021.

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4.2 NWCSAF Skill Assessment of High-Impact Rainfall Event in Kumasi: October 6 - 7, 2020

From the evening of 6^{th} October 2020 till the late morning of 7^{th} October 2020, huge thunderstorm cells which persisted over greater parts of the country produced a high-impact rainfall event, causing floods over parts of the Ashanti region. For instance, on the Kwame Nkrumah University of Science and Technology (KNUST) campus in Kumasi, the rains led to an overflow of the River Wewe (latitude 6.6778°N and longitude 1.5680°W, located on campus), inundation of parts of the campus, and a cut-off of the bridge which connects Ayeduase (neighboring township) to the inner campus**(see Figure 6)**. Transport along the stretch of road had to be diverted, leading to vehicular traffic in the early hours of October 7, 2020.

Figure 6: Overflow of River Wewe (KNUST, Kumasi), which led to a traffic diversion and temporary bridge closure during the morning of 7th October 2020, due to long hours of rains and overflow of its banks. The image was taken approximately 2 hours after the rains.

Figure 7a highlights ground observation from 4 functioning DACCIWA optical rain gauge networks. The results indicate that the rains started at 1800 UTC on the 6th of October 2020, spanning approximately 10 hours over the region and lasting into the early morning of the following day. A spatial diagram of the region is shown in **Figure 7b**. An approximate hourly total spatially-averaged rainfall of 100 mm was accumulated over the region. This explains the observed inundation and the overflow of the river bank. A continuous build-up of the rains potentially exceeded the ground and river holding capacity, resulting in the overflow. Considering the accumulated rains for the observation period alone, we recount that the rains that fell between the 1800 UTC and 0500 UTC period from October 6 to 7, 2020, accounted for an excess of 90% of the rains accumulated within the two days **(Figure 7a)**.

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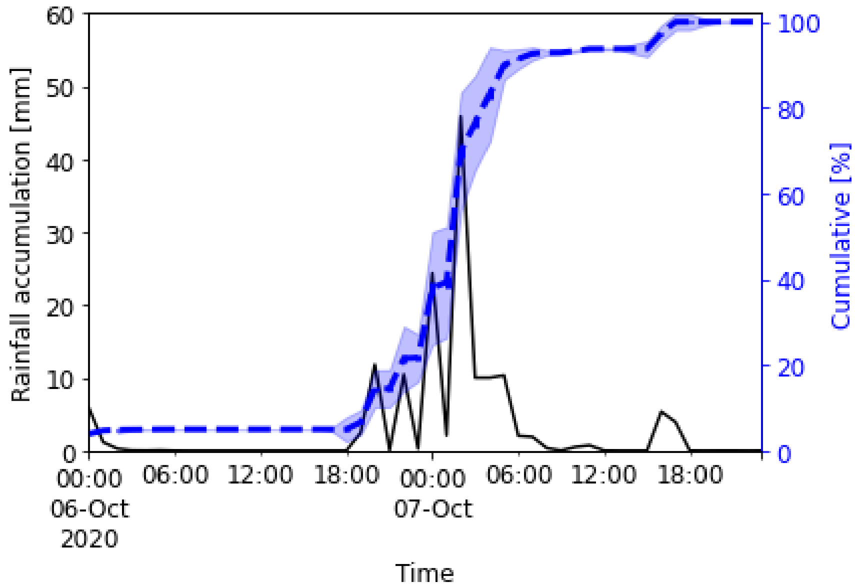

Figure 7: Hourly rainfall accumulation summed from 4 functioning DACCIWA optical rain gauge networks for the observation period (6th - 7th October 2020). The left panel **(a)** shows the rainfall accumulations in black continuous lines, as well as the cumulative distribution of rains in blue, and with a shaded portion signifying the standard error in hourly rainfall accumulation. The right panel **(b)** details the respective station locations*(adapted from Figure 1 of Deliverable 6.3; Project No: 603502 (kit.edu))* .

As evidenced in **Figures 8a and 8b**, the RDT profiles captured pockets of developing TS cells tracking off central Togo and Benin and moving westward into Ghana. The developing TS cells, which marked extensive cloud pixels with a 20% - 60% probability of providing rains **(Figures 8c and 8d)**, accounted for the rains observed on the ground **(Figure 8e and 8f)**. At 1800 UTC, the systems over the region were observed to be triggering. Observably, the precipitable water content (which can be inferred from the precipitating cloud pixels; PC-PH) for the day shows a dominant presence of precipitating clouds close to the border of Togo and Benin, propagating along a transect within the southern parts of the country. Coupling with oceanic moisture transport inland (a typical monsoonal feature (Nkrumah et.al., 2022)) aids in the formation and maturity of precipitating clouds fuelling the quantified rains for the period. Despite the great strides and observation so far, the effectiveness of the NWCSAF in capturing a series of rainfall events, as observed on the ground by the gauge network, is currently being validated using a network of optical rain gauges deployed in the Ashanti Region during the DACCIWA project. Skill assessment for the HIW is presented in **Table 1**.

Skill metric assessment of the performance (usability and resourcefulness) of the NWCSAF, in tandem with DACCIWA optical rain gauge data, was performed as such. First, spatial means of rainfall data were summed at 15-minute time intervals (time window). This procedure was performed on the basis that the Ashanti Region was marked as a uniform region; as such, the spatial means mark the presence or otherwise of a rain system located over the region. Afterward, as provided in the contingency table, the various skill metrics were computed between the NWCSAF rain events and the DACCIWA optical rain gauge events.

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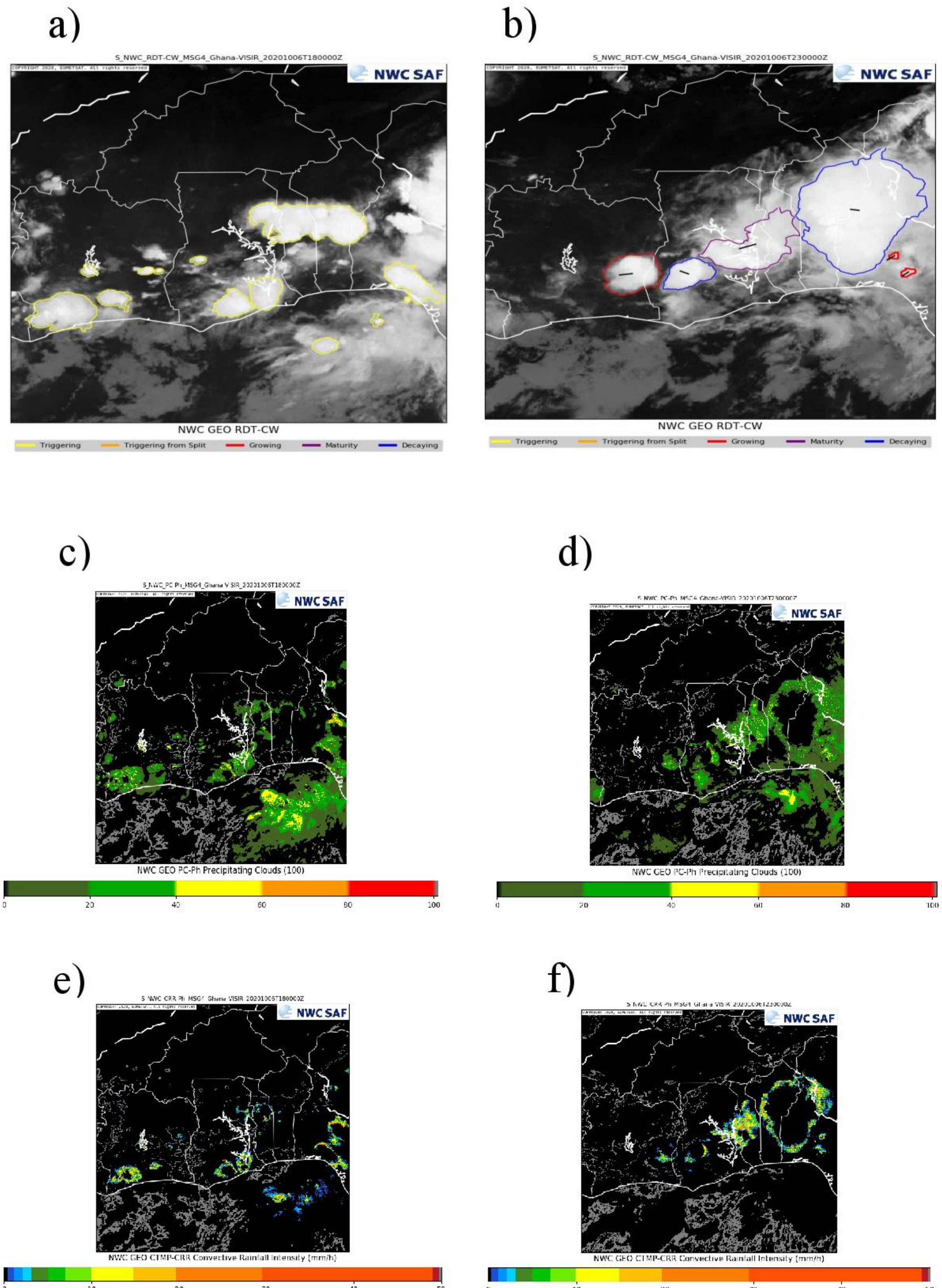

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Figure 8: NWCSAF product capturing rapidly developing thunderstorm convection-warning **(a, b)** , precipitating clouds per pixel **(c, d)** and convective rainfall rate per pixel**(e, f)** over the Guinea Coast region at 1800 UTC and 2300 UTC respectively on October 6, 2020.

Table 1: Contingency table showing the skill metrics for NWCSAF - DACCIWA comparisons of the October 6-7, 2020 rainfall event.

Total Events	174		
Hits	38	**Miss**	18
Correct Rejection	98	**False Alarm**	20
Probability of Detection (%)	67.85	**False Alarm Rate (%)**	16.95
Percent Correct (%)	78.16		

From **Table 1** , a total of 174 events that spanned the hours of 0000 GMT on 6th October to 2100 GMT on 7th October 2020 were assessed. Rainfall hits, which translates as the number of rainfall events from NWCSAF that were equally recorded on the ground by the optical rain gauges, were a total of 38 (approx. 21.8% of total) events. On the other hand, the total rainfall events that NWCSAF missed were a total of 18 (approx. 10.3% of total) events. The false alarms, which represent rains indicated by NWCSAF but not observed on the ground by the optical rain gauges, were a total of 20 (approx. 11.5% of total) events. Additionally, the total number of correct rejections, which show the correspondence of no rain events by both NWCSAF and the DACCIWA optical rain gauges, was a total of 98 (approx. 56.3% of total) events. The summation of hits and miss provide a total number of actual rainfall events. Multiplying this total by the aggregation time window ($\boldsymbol{\Sigma_{H+M} \times 15\ \mu\iota\nu\varsigma}$) provides the total time or duration (in minutes) for the rainfall event(s) within the observation period. Hence, we estimate the rainfall event or series of events within the observation period to span a total of 840 minutes (14 hours) which denotes approximately 32.2% of the observation period.

Regarding the performance, NWCSAF was observed to be resourceful and quite great in capturing rainfall events on the ground. By magnitude, the probability of NWCSAF detecting rain events over the study domain (POD, also termed as hit rate) was 67.85%, with a false alarm rate of 16.95% and a percentage of correctness (proportion of true events and non-events) of 78.16%.

DISCUSSION: PROSPECTS OF THE NWCSAF AND IMPACT OF NOWCASTING IN GHANA

- Maureen

Without a doubt, the NWCSAF resource has numerous benefits for the Ghanaian community, spanning the operationalization of Nowcasting, Advanced Research in Atmospheric Sciences, satellite data, and supporting IBF for high-impact weather events. It is evident that in the interim, the primary usage of the NWCSAF resource will serve to improve the early warning system for the country, thereby (i) improving livelihood (ii) support and improving the Nowcasting skill of forecasters and Researchers on NWCSAF products , and (iii) advancing the adaptive and responsive capacities of the populace to the changing weather events.

Since the fruitful completion of the NWCSAF installation, the resource has aided in monitoring various HIW events over the country. Currently, the Meteorology and Climate Science Department, KNUST, uses the NWCSAF with other observation products to provide forecast information to the university community through its social media portals. Moreover, steps are underway to integrate the NWCSAF resources of both KNUST and GMet to facilitate the issuance of reliable nowcast information and early warning for high-impact weather events, especially in this recent phase of recurring extreme weather events. To improve weather and climate services in the country, GMet is looking forward to mainstreaming co-production into it operations.

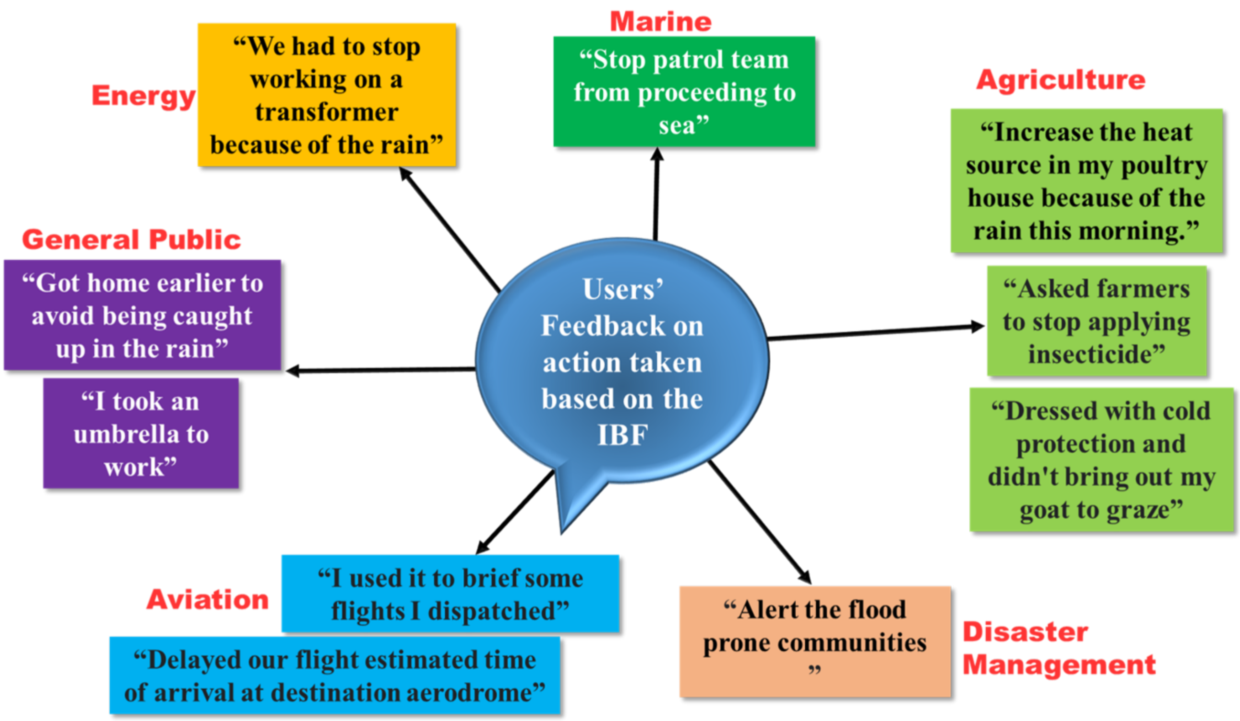

Figure 9: Impact of nowcast on user decision-making from some stakeholder groups based on the IBF issued.

Also, in line with existing Memorandum of Understanding (MoU) signed by both parties, the Meteorology and Climate Science Programme is liaising with (GMet) in ways that broaden our synergistic competencies and enhance integrated, academia-corporate research to improve general livelihood, as well as, improve the citizen's trust in issued forecasts.

Advanced Collaboration Between University and Operational Centers

- Gloria & Loretta

- Joint Installation, Research, and User Training: GCRF African SWIFT partnership has built in-country self-reliance capacity in the installation of the NWCSAF as KNUST helped install GMet NWCSAF. This initiative could help Ghana extend these services to other countries within the sub-region in the installation and usage of NWCSAF. This system aid KNUST students in their Forecasters' Web Club forecasting for preparation and take action during flooding. Forecasters and researchers were actively engaged with users via training, co-production, and co-evaluation with users on nowcasting, synoptic forecasting, and sub to sub-seasonal forecasting to improve weather and climate services. These have led to collaborative research and publications in understanding the dynamic of tropic forecasting and identifying new tools and skills for enhancing forecasting. For example, a new IBF template was co-develop and used by GMet in operations.

With the workshops organized by the African SWIFT partners to build capacity for forecasters and re-

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searchers, a Forecaster's Web(unit) has been established in KNUST in collaboration with GMet to provide daily weather forecasts to the university populace so as to inform policy action. With the introduction of this unit, the university community will be in the know of the necessary actions to take to prevent the flooding of the banks of river Wewe.

- Joint Development of Meteorological Application Softwares/Applications (VizKit) Increase in climate variability increases the demand for the weather forecast. The Vizkit tool was co-developed by the forecasters and researchers to aid the understanding and visualization of the issued forecasts based on the feedback from the users on the forecast technical terminology. Weather icons were used to communicate weather forecasts.

- Increase in the number of interns from the university to the agency: With the existing collaboration between KNUST and the operational center (GMet), students in their second year undertake an internship role at GMet to learn about the field work and also familiarize themselves with duties of an operational meteorologist. The number of students uptake by the Agency have increased over the years.

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THE OPERATIONAL CHANGES SO FAR AND PLANS GOING FORWARD

Jeffrey & Maureen

Through the introduction of the NWCSAF, IBF, and user engagement via the Testbed-3, both institutions have made reforms in their operations and research. For instance, GMet has intensified its forecast dissemination to include regular nowcasts and IBF to its major stakeholders for early warning and disaster risk reduction. Also, on the KNUST Campus, the Meteorology and Climate Science department has formed a Forecasters' WEB - KNUST (ForWEB, KNUST) club, which constitutes undergraduate students mandated to issue regular forecasts to the university community and its environs. This is to improve their practical knowledge and skill in forecasting as well as inform their research activities. ForWEB-KNUST also has a responsibility of engaging in schools and community outreach as a means of empowering people to be involved in citizen science.

CONCLUSION

In this paper, we highlight the nowcasting prospects and advancements over the country, with the introduction of the NWCSAF resource and IBF techniques. The working principles of the NWCSAF and IBF have also been briefly presented. We further used rainfall data from the DACCIWA optical rain gauge to infer the onset, duration, and cessation of the rainfall event. Generally, the assessments have shown the ability of the NWCSAF to be effectively used for nowcasting and improving early warning systems within the university and the country as a whole to inform policy action on changing weather events.

With GMet mandated as the sole agency with rights to issue weather forecasts and provide weather updates in Ghana, the Meteorology and Climate Science programme (KNUST) is identifying formidable pathways to liaise with GMet under the framework of their existing MoU and as part of the legacy of the SWIFT project to disseminate forecast products within the university community and its environs, with a potential for improving countrywide, operational nowcasting and early warning systems.

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Appendix