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Roberts, A orcid.org/0000-0002-4970-9032, Parker, D orcid.org/0000-0003-2335-8198, Marsham, J orcid.org/0000-0003-3219-8472 et al. (10 more authors) (2022) GCRF African Swift Nowcasting Standard Operating Procedure (SOP). Report. University of Leeds

https://doi.org/10.48785/100/96

UK Research and Innovation

GCRF AFRICAN SWIFT NOWCASTING STANDARD OPERATING PROCEDURE (SOP)

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DOI: https://doi.org/10.48785/100/96

Please cite this document as Roberts AJ, Parker DJ, Marsham JH. Fletcher JK, Gijben M, Diop, A-L, Porthuphy J, Lamptey B, Ansah S O, Adefisan E, Popoola TI, Koros D, Dione C. 2022. GCRF African SWIFT Nowcasting Standard Operating Procedure (SOP), grant number NE/P021077/1.

1. PURPOSE

This document outlines the suggested procedures for the operational production of nowcast warnings by African National Meteorological and Hydrological Services (NMHSs) developed by the Global Challenges Research Fund (GCRF) African SWIFT (Science for Weather Information and Forecasting Techniques) project. Information from geostationary satellites is routinely received by African NMHSs in near-real-time and this operating procedure outlines how this can be used to produce valuable nowcast warnings within the day-to-day operations of African NMHSs.

2. INTRODUCTION

The GCRF African SWIFT project (2017-2022) is a programme of work led by the National Centre for Atmospheric Science (NCAS) at the University of Leeds, United Kingdom. SWIFT focuses on forecasting research for sub-Saharan Africa across temporal scales from hours to a season, as well as building capacity in the UK and Africa. A major focus of the SWIFT project is the development of nowcasting capacity through the use of geostationary meteorological satellite data, with SWIFT nowcasting focused on nowcasts for convective storms .
While these data are routinely available within African NMHSs their use for nowcasting is rare and there is a need to outline the way in which nowcasting can be part of the regular operations of African NMHSs.

3. SCOPE

This document aims to describe the steps that should be taken to produce useful nowcast outputs from a dedicated nowcast desk within a NMHS. The procedures given here outline a single nowcast shift that is expected to be focussed on the most convectively active times of the year and times of the day. This document does not describe the methods by which nowcast products can be generated from raw data, but makes reference to nowcasting products (such as those from the NoWCasting Satellite Application Facility; NWC-SAF geostationary satellite software; NWCSAF-GEO). The procedures outlined indicate the recommended methods and outputs. However, the final step for successful nowcasting (dissemination of warnings) is not discussed in detail. This is due to the many different methods of dissemination available to NMHSs and the varying requirements from nowcast users based on need.

4. FLOW DIAGRAM

Below is a flow diagram indicating the activities (left) and outputs (right) from the nowcasting operating procedure. The looped section of the flowchart is indicated as having a 2 hour repeat frequency. However, it is planned that this frequency can be increased if weather conditions are rapidly developing and therefore require more updates/warnings to be made. Detailed descriptions of each of the steps in the flow diagram can be found in section 5.
There are 3 main outputs that are recommended, these are; 1) a longer-term (6-hour) outlook risk map, 2) a short term (2 hour) riskmap and 3) 2 hourly risk timelines for specific locations. Examples of each of these can be found in section 6. Each of the outputs makes use of a common risk matrix to inform users of the current and future risk from high impact weather. The risk matrix can be found and explained in section 7. These outputs can then be assembled into a single page nowcasting summary with the expectation that such a

summary should be published online or distributed to relevant stakeholders in near-real-time (section 8). Alongside this, short written nowcast bulletins summarising the information contained in the 1 page summary should also be produced to aid in communication through other dissemination methods, e.g. sms/whatsapp messaging, radio/tv alerts etc.

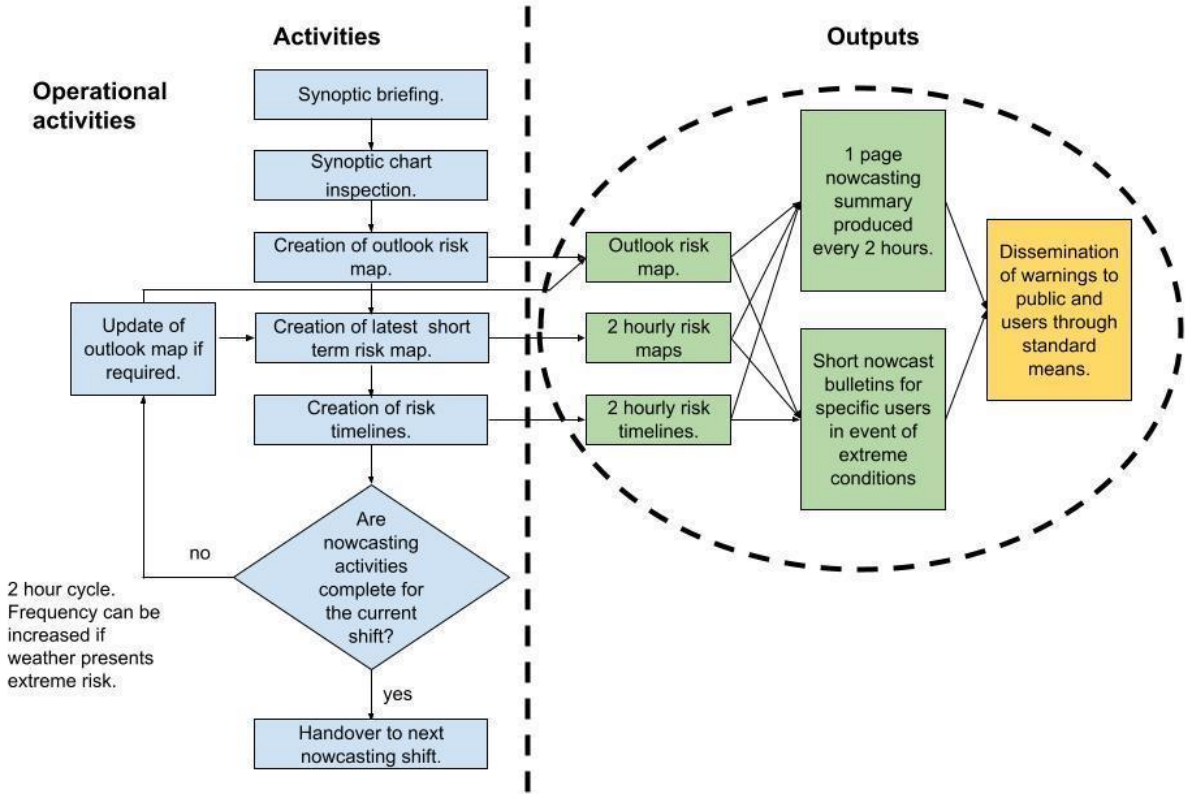

Figure 1. *Flow diagram detailing the activities and outputs recommended for the operation of a nowcasting shift. Blue colours indicate activities to be undertaken to produce specific outputs (green colour). The yellow box indicates the dissemination of outputs. This is unspecified here and should be via appropriate means (timely and through channels appropriate for the NMHS and users).*

5. DETAILED PROCEDURE

Order of procedures	Activity	Time frame	Tools	Responsibility
1	**Synoptic briefing.** Attend daily weather briefing provided by forecasters working on synoptic forecasting desk. Get information on the latest synoptic situation and how this is likely to influence extant or future storms. For example the synoptic forecasters could focus on: (1) Existing storms/high impact	Start of nowcasting shift (H0)	AV presentation equipment (for those in the same location). Computer equipped with video conferencing capacity (if nowcast and forecast desks are physically separated).	Forecasters from the synoptic forecast desk to present information. Nowcasters from the nowcast desk to be informed of the current and predicted weather conditions for the

	weather. (2) Atmospheric moisture/instability. (3) Vertical structure (jets shear). (4) Predictions for extreme rainfall and winds. A single summary map (synthetic analysis) should be reviewed, displaying important weather features to cover the whole region (possibly several indicating changes over the period of the nowcasting shift). A presentation of the forecast should be given and charts be handed over alongside a short written forecast for the nowcast period (100-200 words).		Sufficient internet connectivity. Outputs from synoptic forecasting desk.	next few hours.
2	**Synoptic chart inspection.** Inspect charts and written forecast from the synoptic working group detailing the current/short term forecast. Identify regions with high impact weather predicted and further regions where high impact weather is likely/possible. Identify high value regions at risk from current and predicted weather.	H0	Plotted synthetic analysis charts. Written forecasts for the nowcast period.	Nowcasters are responsible for investigating the synoptic forecasts.
3	**Creation of outlook risk maps.** Using forward extrapolation tools available, manual extrapolation and forecaster knowledge indicate storm movement and growth predicted for next 6 hours. ****Output**** **Create outlook risk map to cover the next 6 hours using colour coding from risk awareness matrix. This forms the first panel of the nowcasting information sheet. Short text nowcasting outlook also to be produced. Icons to be used to indicate the nature of risk.** This outlook risk map and accompanying text should be updated ready for issuance of nowcast summaries every 2 hours.	H0+1 H0+3 H0+5 H0+7 (2 hourly iterations of the nowcast cycle, however rapid cycling when conditions require should occur).	Plotted synthetic analysis charts. Written forecasts for the nowcast period. Key synoptic forecast products/imagery. Latest satellite derived imagery (Satellite channels, NWCSAF, RGBs and other available nowcasting tools)	Nowcasters are responsible for creating risk outlooks. Risk outlook maps should be updated if necessary for every iteration of the nowcasting cycle.

4	**Creation of short term risk maps.** Identify weather features with connection to high impact weather that currently exist in the latest observations. Consider the relationship of current weather to synoptic scale forecast. Create a risk map of current weather conditions based on available data and nowcasting specific products. Using forward extrapolation tools available or manual extrapolation indicate storm movement and growth predicted for next 2 hours. Storms should be identified using an alphabetically assigned letter and referred to using their letter. This will ease communication about the location and predicted development and movement of storms. This short term risk map and accompanying text should be updated ready for issuance of nowcast summaries every 2 hours. ****Output**** **Create risk map indicating near-real-time conditions and expected development in the next 2 hours using colour coding from risk awareness matrix. Short written nowcast also provided to indicate expected conditions at surface and detail nature of risks. Icons to be used to indicate nature of risk.**	H0+1 H0+3 H0+5 H0+7 (2 hourly iterations of the nowcast cycle, however rapid cycling when conditions require should occur).	Latest satellite derived imagery (Satellite channels, NWCSAF, RGBs and other available nowcasting tools) Extrapolated imagery/extrapolation tools. Tools to create risk map based on nowcasting imagery (e.g. national map of country of interest and tools to annotate map with risk regions).	Nowcasters are responsible for creating short term risk maps. Risk maps should be updated for every iteration of the nowcasting cycle.
5	**Creation of risk timelines** Key locations should be identified at the start of the nowcasting shift for which nowcasting timelines will be generated. These locations should be sufficiently important to justify nowcasting, be geographically limited and well defined. Locations for which risk timelines should be generated should also be based on local knowledge and be on	H0+1 H0+3 H0+5 H0+7 (2 hourly iterations of the nowcast cycle, however	Latest satellite derived imagery (Satellite channels, NWCSAF, RGBs, CEH cores etc.) Extrapolated imagery/extrapolation tools. List of high value/importance locations, locations of interest to nowcast	Nowcasters are responsible for the identification of important regions for which risk timelines should be generated. Once identified risk timelines should be produced every nowcast cycle.

	the importance of the locations and the meteorological risk posed to it. Factors for site identification could include population density, vulnerability and importance to nowcast clients. Create colour coded risk timelines for nowcast locations. The timelines should also identify the alphanumeric risk value from the accompanying risk matrix and enter this into the timeline. This will enable users to differentiate between events with low likelihood but catastrophic consequences and moderate consequences that are very likely to occur. Timelines should be updated every 2 hours to be ready for issuance of nowcasting summary. The locations for which timelines are generated should change based on forecasters' assessment of short term and outlook risk. ****Output**** **Risk timelines for specific areas of risk. Locations should be identified in line with needs of users as well as value to the public. Numerous locations can be identified and predictions of associated risk made on proximity and predicted development of storms.**	rapid cycling when conditions require should occur).	users. Output risk map from procedures 3 & 4.	
6	**Assembly of nowcasting 1 page summaries.** Using the template provided, create 2-hourly, 1-page nowcasting information summaries. These should include: (1) Outlook risk map to give a broad overview of expected risks over the next 6 hours. Brief written description of risks identified for this period (from procedure 3). Outlook should be updated for every 2 hourly nowcasting summary, updates will likely be minor unless observations significantly diverge from synoptic the forecast. As such this should be a quick job to perform. (2) Short term risk map with brief written nowcast for the next 2 hours (from procedure 4). This will give more	H0+1 H0+3 H0+5 H0+7	Latest satellite derived imagery (Satellite channels, NWCSAF, RGBs, CEH cores etc.) Extrapolated imagery/extrapolation tools.	Nowcasters or nowcasting support staff who are able to assemble the constituent parts of the summary into a single document ready for dissemination.

	detailed risk regions and give information on locations that will likely to experience extreme weather in the very short term. This will be updated every 2 hours and cover the period from the last nowcast summary to the next. Production of detailed and up-to-date risk regions as well as analysis of latest nowcasting information will require fast working practices to complete in a timely fashion. (3) Risk timelines for specific locations (from procedure 5). These should closely tie in with the short term risk maps and be for locations that have high value (either nationally or for specific nowcast consumers) and are at risk. It might also be appropriate to issue updated information sheets earlier than the 2 hourly schedule. This should be undertaken if there is a significant discrepancy between the predicted storm activity and observed storms. Well nowcast events (even if they pose very high risk) would not necessitate more rapid updates. ****Output**** **Nowcasting 1 page summary. Issued every 2 hours (routinely) but at irregular intervals if high risk events dictate more frequent updates.** **Once produced this can also be distributed via methods appropriate to national meteorological services.**			
7	**Production of short nowcast bulletins.** In case of severe weather that requires proactive dissemination of warnings these should be issued through the appropriate channels. Channels for warnings to be distributed should be in line with existing methods for national weather services to spread weather warnings as long as this does not incur a significant delay. Delay to nowcast warnings prevents them being useful as they cannot be acted upon. Examples of this include the issuance of warnings via national/local media (TV and radio), phone calls to specific	Throughout nowcast shift.	Nowcasting information sheets. NWCSAF/ other nowcasting products. Methods of warning dissemination to both the public and key users (these might be specific to both national met services and individual nowcast consumers).	Nowcasters are responsible for the writing of short bulletins ready for distribution to users. Distribution should be through existing channels for weather warning dissemination.

	users/stakeholders (air traffic control, agricultural co-operatives, disaster relief etc.) and SMS or whatsapp messaging. ****Output**** **Short informative warnings to be generated and issued through appropriate channels in cases of high risk/ high likelihood situations.**			

6. OUTPUTS

a. Outlook risk map

Outlook risk maps should be generated at the beginning of each nowcasting shift and should be updated as required during the course of the iterative nowcast period (as detailed in procedure 3 of section 5 and the flow diagram in section 4). Below can be found an example of the type of image that might be generated as an outlook risk map for Ghana. Regions that might be at risk within the next 6 hours should be highlighted with the appropriate risk level colouring. Appropriate weather symbols should also be used to communicate the nature of the predicted risks. This should be produced with reference both to the current weather situation obtained from nowcasting products and the forecast information provided by the synoptic forecast desk. Alongside the outlook risk map a brief text outlook should be produced. This serves to elaborate on conditions which regions are most likely to be affected and in what way.

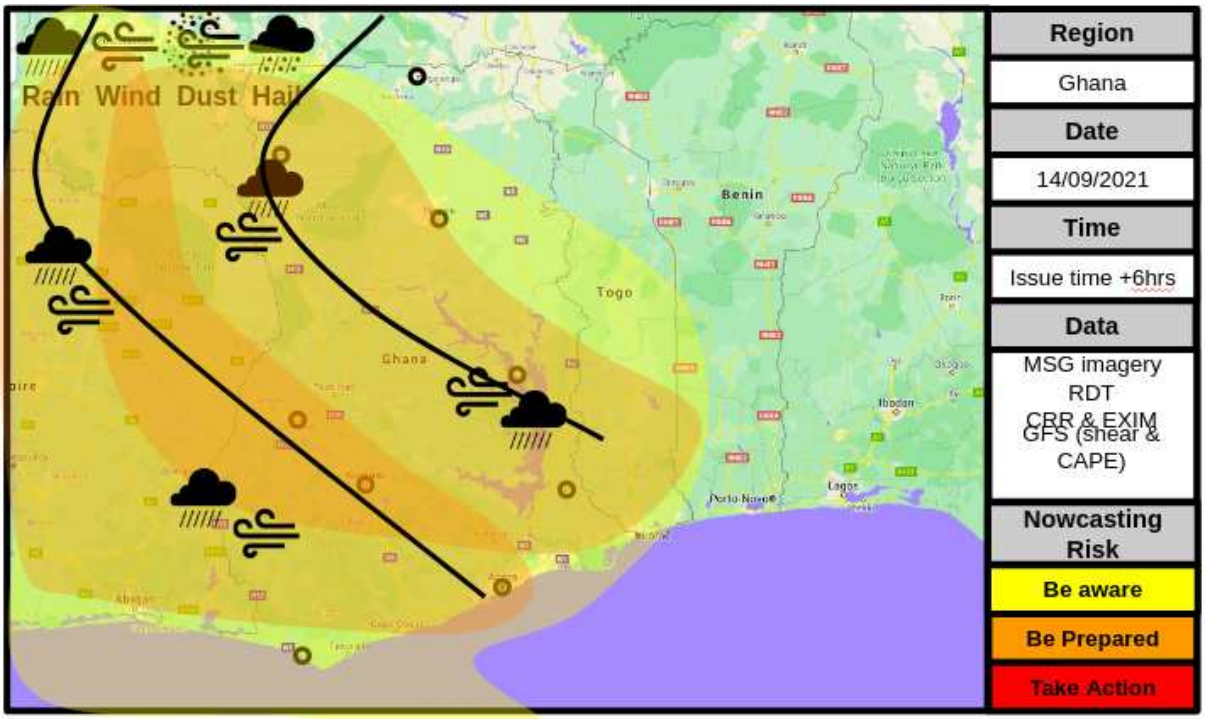

Figure 2. *Example of outlook risk map produced for Ghana for 20210914 1600 UTC.*

b. Nowcast risk map

New nowcast risk maps should be generated as part of every iteration of the nowcast period. Conditions (especially those associated with convective storms) are likely to develop significantly in a

2 hour window necessitating the production of new risk maps. Nowcast risk maps should indicate risk for the next 2 hours and be based on the information you have gathered from nowcasting products as well as the general synoptic situation. The format of the nowcasting risk map remains the same as the outlook risk map including the use of a risk colour scale and appropriate weather symbols. This is to aid in interpretation by nowcast users and to help make the generation of the suite of nowcast outputs easier. Similarly, a short written 2 hour nowcast should also be prepared alongside the nowcast risk map. This serves to elaborate on conditions which regions are most likely to be affected and in what way. It is also likely that such a written nowcast should be able to be issued as a warning (without an accompanying map) without significant modification. This will enable a wider range of routes of dissemination to nowcast users and the public if required (via radio, sms or any other voice or text only media).

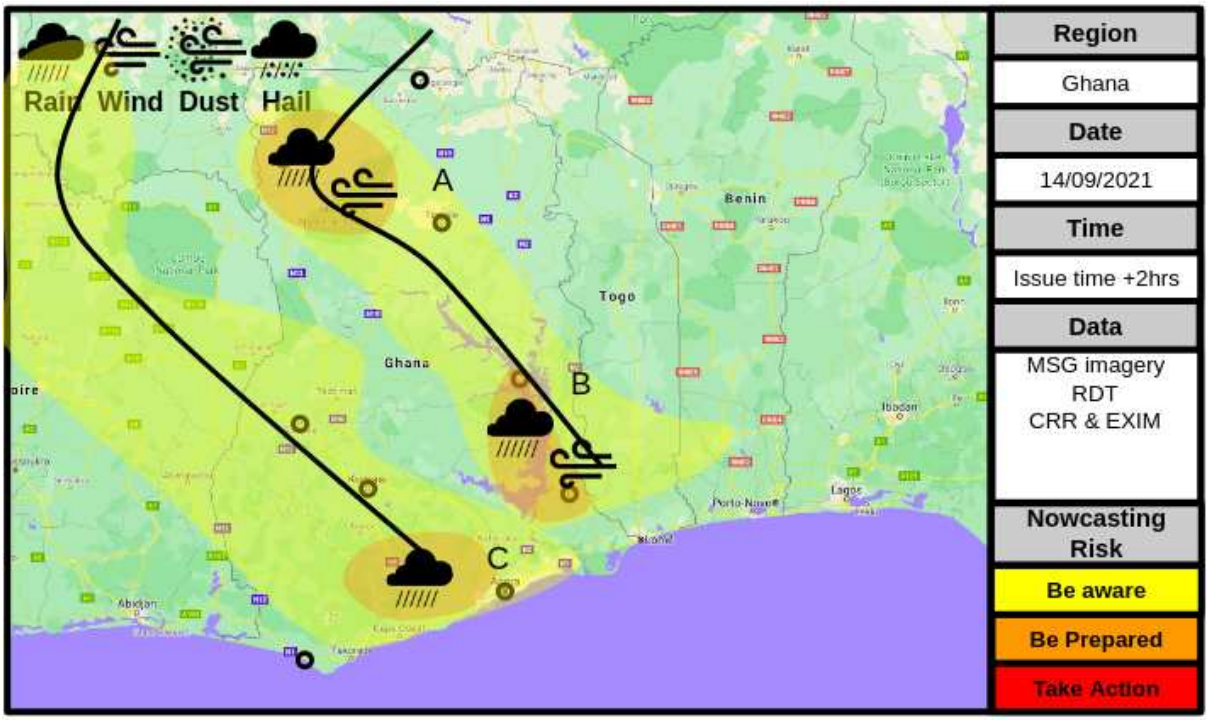

Figure 3. *Example of nowcast risk map produced for 20210914 1600 UTC. Note the time period for predictions is significantly shorter than the outlook risk map and risk regions are more detailed (associated with higher degree of certainty).*

c. Timelines

The production of risk timelines is an important step in the nowcasting workflow. These timelines enable information to be provided about the risks presented to specific locations on nowcasting timescales. The meteorological risk should be ascertained with reference to the risk matrix (section 7), and the appropriate alphanumeric code entered into each of the timeline panels (as shown below). The first sections indicate 30 minute risk windows (time labelled on table) with the outlook panel being representative of +4 to +6 hour time period. It is expected that a nowcaster on shift be able to make decisions about which locations require timelines to be generated and therefore prioritise the locations for which the greatest risk is posed. However, prior to nowcasting operations beginning it is important to consider locations of interest and produce a list of locations for which nowcast timelines could be generated. Below is a list of criteria that should be considered during the shortlisting process.

(1) Locations should be geographically limited (it should not be so broad that use and evaluation of nowcasts is meaningless e.g. A city and its surrounding suburbs/territory is a good choice while wide, poorly defined regions should be avoided).
(2) Locations should be "high value". This could be due to population density, infrastructure or importance to specific users etc.
(3) For each location it is important to consider what would constitute high impact weather. It is possible that this might change depending on the specifics of how a nowcast might be used or the time of year. For example sensitivity for heavy rainfall for one sector might be significantly different for a different user in the same area. Also when there has been little rain previously, light but persistent rain is not likely to pose a risk, however in a city that has recently flooded any additional rain might trigger further inundations.
(4) While not a requirement for nowcasting it would be advantageous in the long term if locations had a good observation network (such as rain gauges, weather stations, weather observers that reliably report etc.). This will aid in evaluation work and over time will provide evidence to help improve the production of impact based nowcasts.

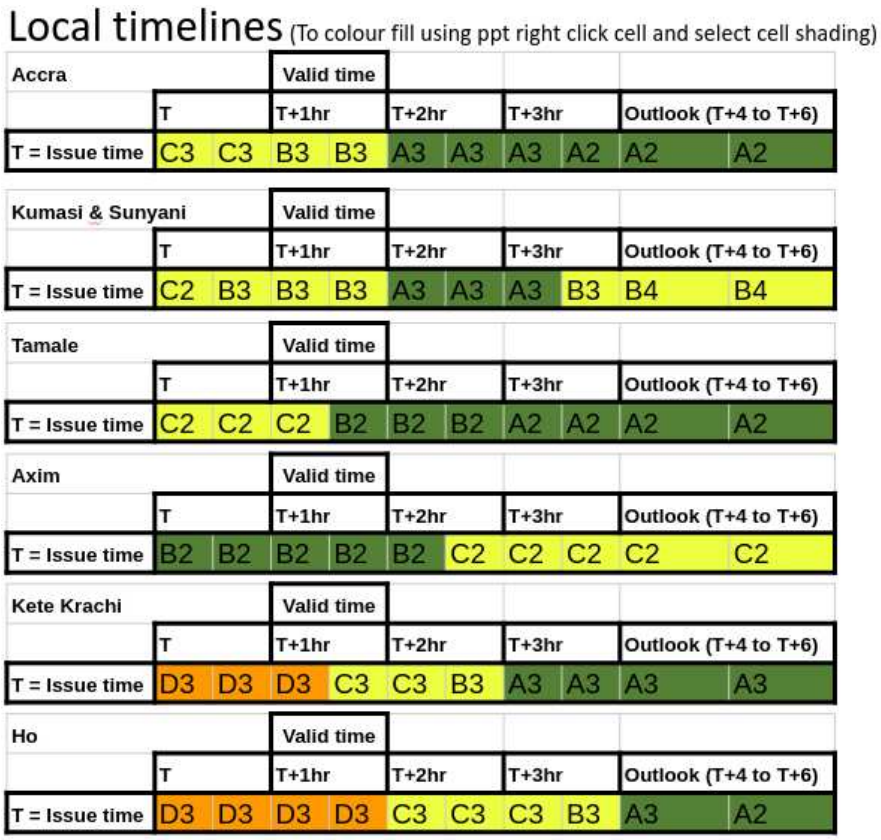

Figure 4. *Example of risk timelines produced for the same time as Figures 2 and 3 for specific locations in Ghana. Each location has weather risk indicated in 30 minute increments out to 4 hours and 2 1-hour outlook increments to a maximum period of 6 hours. Alphanumeric values in risk timeline cells are in reference to the impact risk matrix shown in Figure 5.*

7. IMPACT RISK MATRIX

Below is the risk matrix for the production of risk maps and risk timelines. This risk matrix should allow nowcasters to decide on the appropriate risk level for a given situation. In the case of risk timelines it has been decided to include an alphanumeric marker that corresponds to each of the cells in the risk matrix. This will enable users to understand the difference between the different types of warning with the same colour scheme. To understand this we have to consider that the action taken by a user might vary considerably if there is a very high likelihood of a low impact event compared with a low likelihood of a very high impact event. For example we would expect users to behave very differently to predictions of almost certain light rain compared to being on the edge of a tropical cyclone track. One of these predictions requires little to no mitigating action (maybe take an umbrella) while the other requires plans to be made in the event that the unlikely but very high impact event does occur.

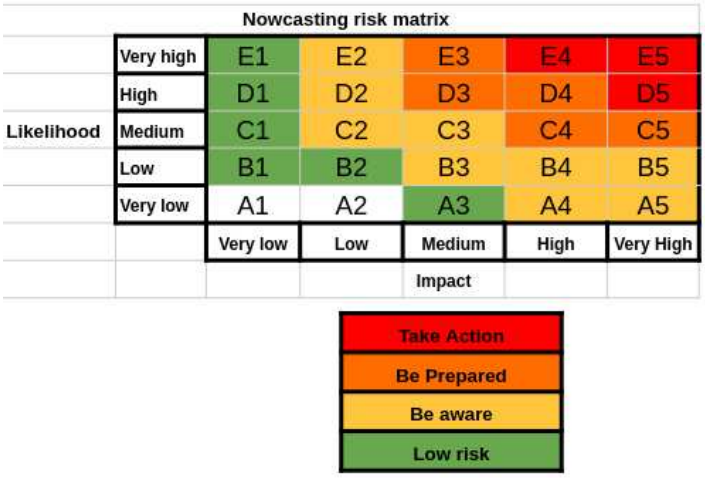

Figure 5. *Nowcasting risk matrix used to indicate what colours should be used in risk maps and risk timelines. Conditions that have very low likelihood of occurrence and low and very low impacts are to be uncoloured. Risk levels are then graduated from green to red based on both the likelihood and impact of an event. Alpha numeric values help to differentiate cells of the same colour.*

In order to understand the impact categories definitions of the different impact levels are given below.

Very low - Little to no impact is expected that everyday activities continue uninterrupted.
Low - For most there is little impact associated with this category, weather might present an inconvenience to most and only interrupt weather sensitive activities.
Medium - Interruption to daily activities is likely such as causing logistical problems and delays but generally only minor damage to property is expected.
High - Damage to property is likely and there is significant potential to cause harm to people.
Very High - Significant threat to life and property.

8. NOWCASTING INFORMATION SHEET

Below can be found an example of a nowcasting “one-pager”. This assembles the individual parts detailed above into a single document. It is expected that this can be issued every 2 hours as part of the routine nowcasting operations and distributed to users. For specific nowcast customers (e.g. from a specific sector) a tailor made product could be produced which takes into account their region of interest, level of vulnerability and the nature of meteorological risks faced. However, it is likely

much information from a standard operational nowcast could be used in more tailored products, especially the more general parts of the information sheets such as 6hr outlook

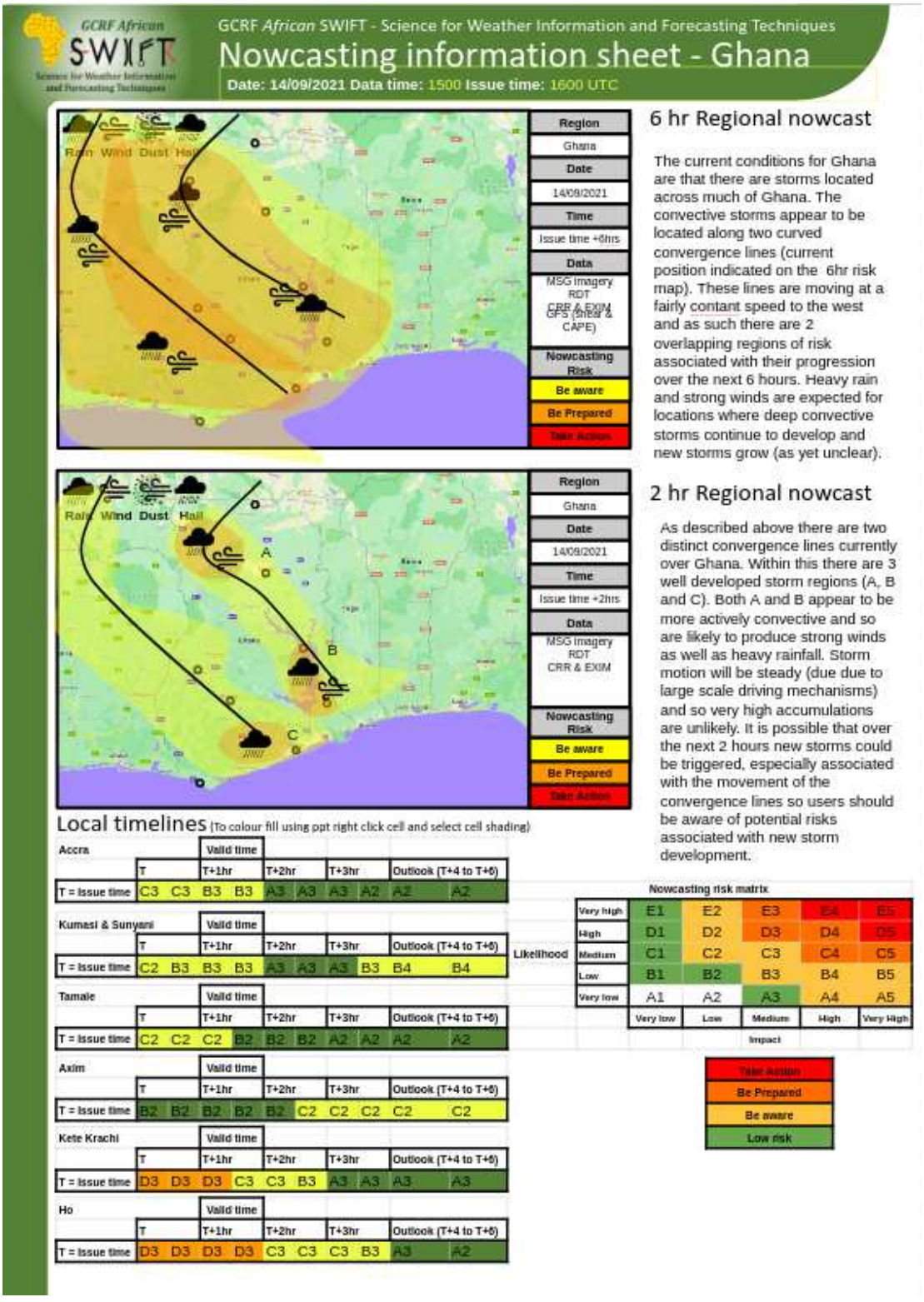

Figure 6 *Example of nowcating information sheet. A combination of outputs generated from nowcasting activities into a single easy to digest sheet. Rapid production of such sheets will enable nowcasting warnings to be disseminated to users in a timely manner in an easy to digest format.*