ConOps
Concept of Operations
South African Flash Flood Guidance System (SAFFG)

1. INTRODUCTION

The SAFFG is a comprehensive hydrometeorological modelling system that utilizes weather information from radars, satellite and rain gauges, as well as hydrological modelling of soil moisture and flash flood guidance, to model the potential for flash floods in small river catchments. It is developed as an advanced nowcasting system to provide guidance to the SAWS forecasters for issuing flash flood alerts in these small catchments, and to provide detailed information to disaster managers in support of preparedness and response activities against flash flood events. This Concept of Operations describes the responsibilities and operational processes of the SAFFG system in SAWS.

2. BACKGROUND

2.1. Warning of Flash Floods in South Africa

Recent flooding events in the Western Cape and Eastern Cape dramatically demonstrated the devastating impact of flooding on the region. According to the CRED Disaster Database about 90% of natural disasters in Southern Africa are weather related. Of these floods are causing the most damage and result in more deaths in South Africa than any other natural disaster.

Flash floods are defined by the World Meteorological Organization as “a flood of short duration with a relatively high peak discharge” and “a flood that follows the causative event (such as heavy rain) within a few hours”. Currently flooding within 6 hours of the causative event is taken as the transition between a flash flood and a large river flood.

The South African Weather Service (SAWS) early warning system for flash floods was historically based on heavy rain warnings “with potential for flash flooding” without any knowledge which river basins are prone to flash flooding at the time. This vaguely worded warning inadvertently weakens the effect of the early warning to prompt reaction among communities at risk, or vigilance from disaster management structures at the river basins in danger of being flooded. To overcome this deficiency a tested international flash flood guidance system was implemented in regions in South Africa most prone to flash flood disasters. The SAFFG system is based on the CAFFG system that is running operationally in Central America since 2004.

2.2. Basic Description of the System

The short lead time of flash floods limits the effectiveness of traditional hydrological flood modelling. Consequently a more realistic approach followed is to pre-calculate the necessary hydrological information for each relevant small river basin to determine the amount of rain needed in a specific period over the basin that will lead to bankfull at the outlet of these basins (the FFG, or flash flood guidance, value). When this value is compared to the amount of rain falling over each basin (as estimated from real-time monitoring rain gauges, radar and satellite) the river basins in danger of flash flooding can be quickly identified through identifying areas

with excess rainfall. In other words, basins under flash flood threat are those where more rain is falling than the amount of rain in mm needed in a specified period to cause bankfull at its outlet given its hydrologic conditions. This information forms the basis of providing warnings of potential flash floods to disaster management structures.

The US National Oceanographic and Atmospheric Administration (NOAA) has developed a robust flash flood guidance system for Central America (the CAFFG or Central American Flash Flood Guidance system), based on these principles utilized since the early nineties in the USA. The CAFFG combines a number of concepts from hydrometeorology, land-surface hydrology and geomorphology to produce regularly flash flood guidance that assess the potential for flooding for these catchments, much in the same way as discussed earlier.

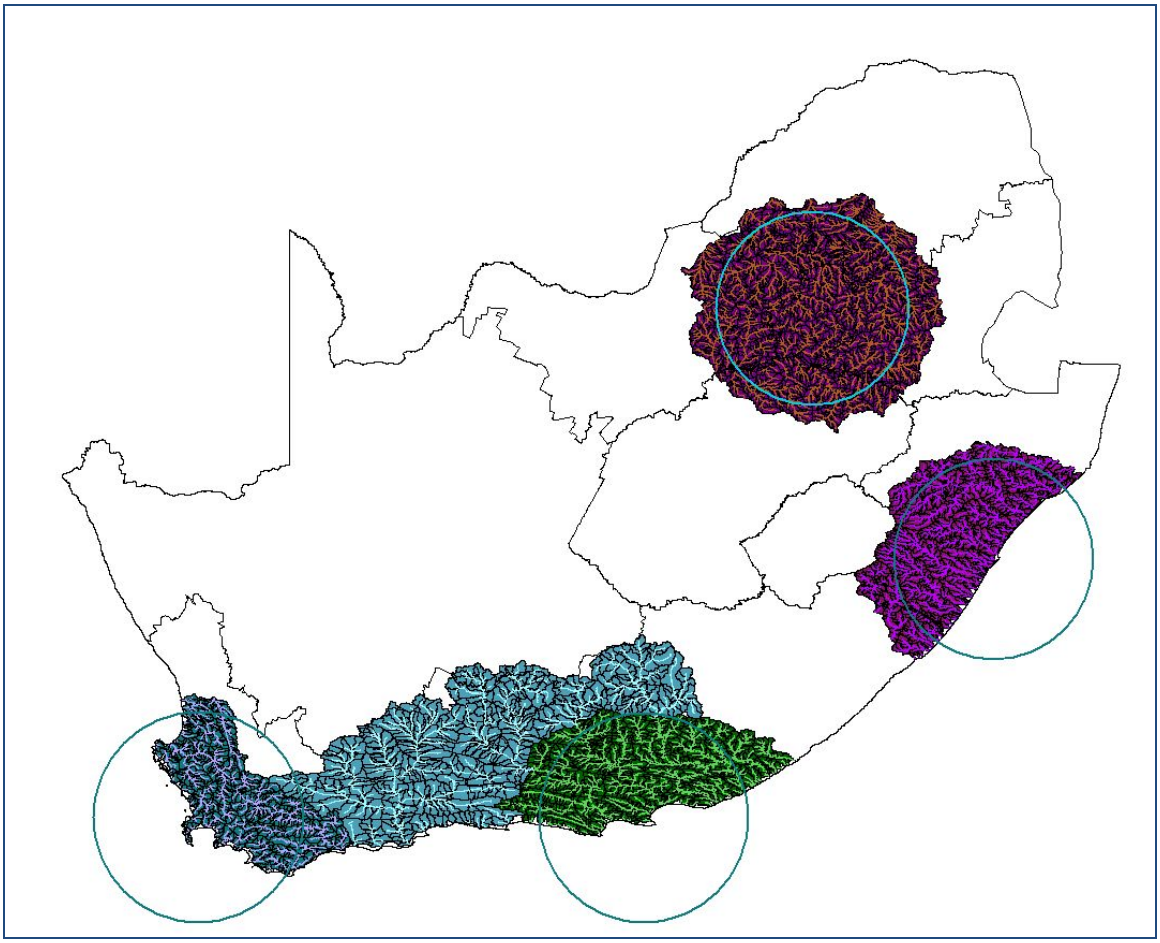

Figure 1. The SAFFG is implemented in flash flood prone regions mostly under the radar canopies of SAWS radars as shown on the map.

The proposed flash flood guidance system for South Africa (SAFFG) is envisaged to be based on the CAFFG system for Central America. Due to financial constraints the high resolution implementation will be done only under the radar canopies of the weather radars (within 150 km radius of the radar) in Gauteng, around Durban, Cape Town and Port Elizabeth, and also on the Cape South Coast (see fig 1).

Any flash flood guidance system (like the proposed SAFFG) will function at its best if it is embedded in the Severe Weather Warning System of SAWS, which is part of the integrated

national Multi-Hazard EWS (MHEWS) of NDMC. The SAFFG system will form a critical link in the chain of the early warning system for flash floods. This end-to-end warning chain addresses from the detection and monitoring adverse weather phenomena using the SAFFG system, to the issuing of warnings, the dissemination of warnings and integrating it into decision-making processes of disaster management structures to reach all communities at risk (see fig 2), and finally community based severe weather monitoring systems.

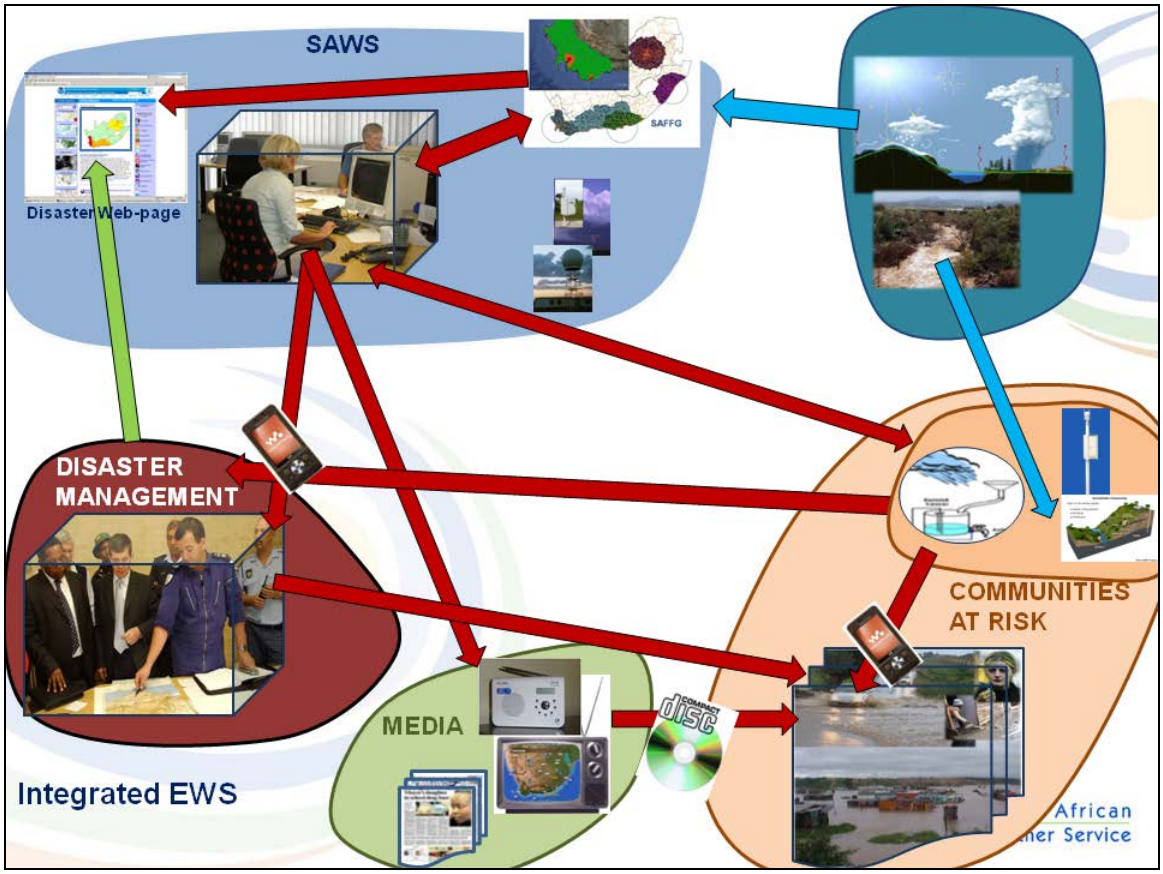

Figure 2. Early warning chain from monitoring weather hazards to issuing warnings to disaster management agencies and general public.

3. SAFFG OPERATION AND INFORMATION FLOW

3.1. Operation of the SAFFG

The SAFFG system will be operated by the SAWS under its mandate to be the sole provider of weather related early warnings (SAWS Act nr 8 of 2001), with the active support of the hydrological component of the Department of Water and Environmental Affairs, and the National Disaster Management Centre. The SAFFG system is a nowcasting system aimed to support the forecasters to issue more detailed information on flash flood potential to disaster management agencies to support their decision making. Its basic operations are:

- On an hourly basis the system on the national server in Pretoria automatically calculates the flash flood guidance value (FFG, the amount of rain needed in a given time to cause bank full at the outlet of the river basin) by running soil-moisture and run-off models for small catchments of on average 50 km2, based on all the relevant hydrological information of the

basin (including vegetation, basin's physical characteristics, land cover, etc). Rainfall measured over the previous 24 hours by rain gauges, weather radars and the MSG satellite is a key input into this calculation;

- The system compares the rain that is falling with a flash flood guidance (FFG) value for each river basin to provide information on which basins are receiving, or is about to receive, excessive rainfall compared to the FFG value for the basin;
- On a real-time basis the forecasters monitor the development of hazardous rainfall systems, validate the products of the SAFFG system, and testing the impact of possible rainfall scenarios.
- Depending on the expected rainfall patterns, a watch or warning will be issued when needed to the relevant disaster management authorities of the river basins already experiencing flooding, or those in danger of flooding in the next 1 to 6 hours.

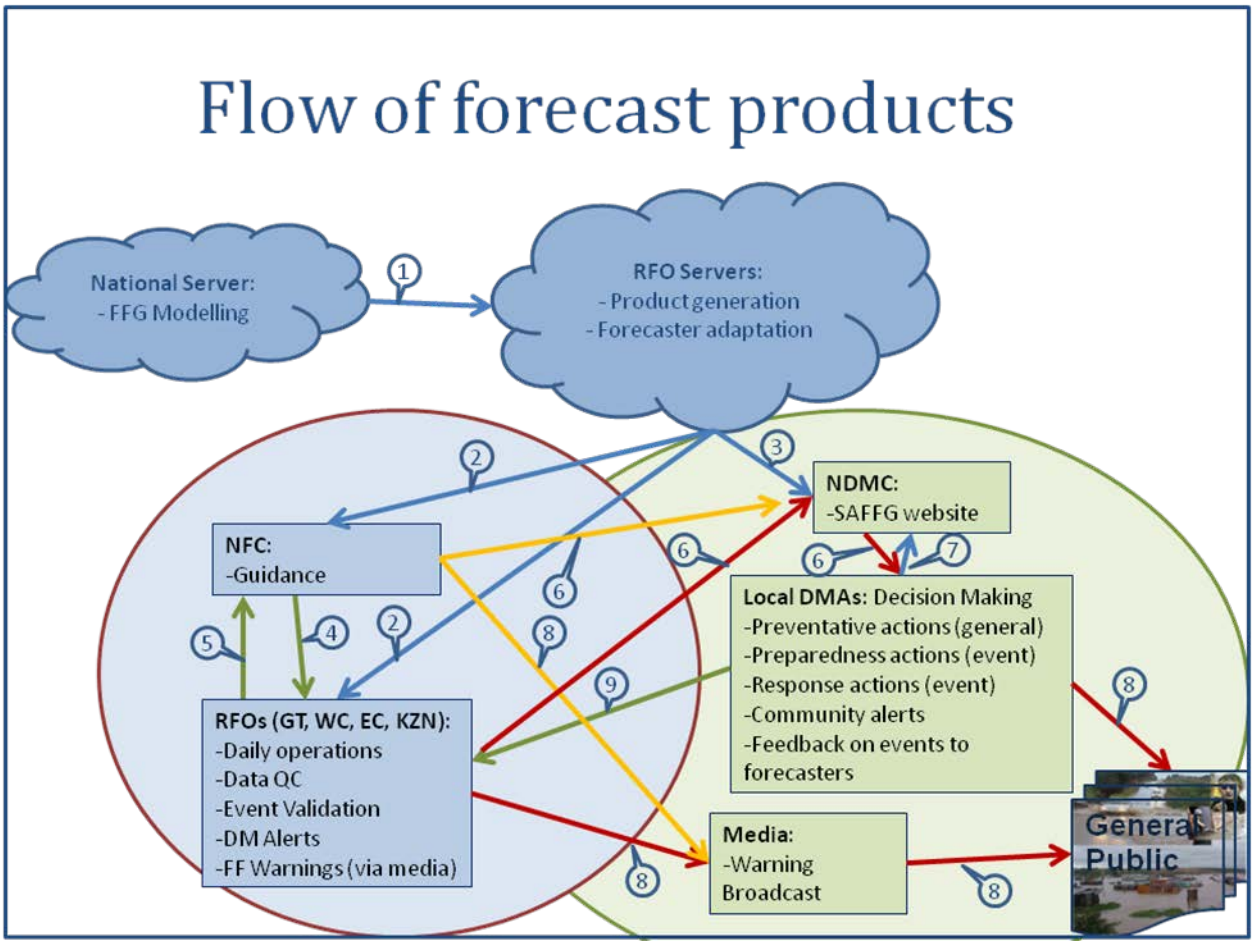

Figure 3. Flow of data products from the SAFFG modelling system to SAWS, and to disaster management structures and the media. The arrows indicate the flow of products as follows: (1) model output hourly from main server to regional servers; (2) Processed images and text files on forecaster interface to NFC and RFOs; (3) Text files to SAFFG DMA webpage at NDMC; (4) Daily guidance outlook from NFC to RFOs; (5) Feedback from RFOs to NFC on modifications and alerts; (6) Alert info from RFOs to local DMAs through SMSs and the SAFFG DMA website; (7) Access to products by local DMAs from SAFFG DMA website at NDMC; (8) Warning info from RFOs to Media and DMAs, and on to communities. Overnight NFC disseminates warning info on behalf of RFOs; (9) Feedback and validation info from DMAs to RFOs, and onwards to NFC.

3.2. Information Flow

The flow of information between the different components of the application part of the SAFFG system is described in fig 3. The main components of information flow are:

- SAFFG Modelling: The output of the SAFFG modelling is transferred (1) hourly from the national to the RFO servers where graphical products are prepared. (For this document the information flow and modelling components inside the "National Server" cloud are not described - this information is available elsewhere.)
- The forecasters at NFC and the RFOs can access and analyse the products of SAFFG through a web-based forecaster interface (2). Products are available as either images or as data in text files.
- SAFFG products are also transferred hourly as text files to the protected disaster management agency (DMA) website (3) at NDMC where they are made available to disaster managers to view or down load for their use in decision making.
- Daily guidance outlooks from the NFC are provided to the RFOs (4), while the RFOs keep NFC updated with daily feedback and information (5) on alerts (watches and warnings) issued, and any available validation information.
- Alerts issued by the RFOs (or NFC overnight) are sent to the NDMC SAFFG website from where it is disseminated to the disaster management centre by SMSs (6).
- Upon reception of a watch or warning DMAs are prompted to get more detailed information about the basin location of the hazard from the SAFFG website at NDMC (7). They can also download detailed information from the website to import in their GIS systems to compare with their own vulnerability information to identify high risk basins.
- Warnings to communities at risk are disseminated via the media and local disaster managers (8).
- Feedback and validation information are received by RFOs from DMAs (9) and sent on to the NFC.

4. RESPONSIBILITIES OF OPERATIONAL COMPONENTS

The operational components in SAWS are the National Forecasting Centre (NFC) and the Regional Forecasting Offices (RFOs) (see fig 4). The NFC has a dual function, namely as the RFO for Gauteng, and as the national guidance centre where it will also stand in overnight for the RFOs not operating a 24-hour forecasting service. The operational components outside SAWS are the National Disaster Management Centre (NDMC), and the Provincial and District Municipality Disaster Management Centres (PDMCs and MDMCs)

4.1. National Forecasting Centre (NFC) as the national guidance centre:

The SAFFG is an important technology to support the NFC in its existing role as national guidance centre. NFC has access to the national products of SAFFG as well as all other available nowcasting technology, and it operates on a 24-hour basis. The role of the NFC in the SAFFG system is:

- To provide guidance on the potential for flash floods in all regions to the RFOs;

- To stand in for the RFOs not operating 24-hours per day and provide them with the necessary feedback;
- To be responsible for the consolidation of national events validation.

4.2. Regional Forecasting Offices (RFOs):

The RFOs (including NFC for Gauteng) are in the main cities of particular flash flood prone regions and have an important role to inform and coordinate with the disaster management agencies (DMAs) in their regions, and warn the local public. Each RFO will have access to the SAFFG forecaster interface for its region from its RFO-workstation. They will also be able to adapt rainfall fields for scenario testing in their own regions. Their tasks will be:

- Daily operations on the SAFFG products for their regions providing up to date information to the PDMC and MDMCs, and issue watches and warnings in their regions;
- Perform data quality control, particularly on the ARS and AWS data in their regions;
- Responsible for event validation in their regions as part of performance validation of the SAFFG system and processes.

4.3. National Disaster Management Centre (NDMC):

The NDMC plays an important role in the dissemination of SAFFG products to disaster managers. Their roles will be:

- Host the protected SAFFG disaster management agency website where bona fide disaster managers can get access to more detailed products and also download information into their own GIS systems;
- Manage the automatic SMS and email dissemination of alerts to disaster managers.

4.4. Provincial and Municipal Disaster Management Centres (PDMC and MDMCs):

The local disaster management agencies (PDMCs and MDMCs) have to be proactive and reactive in the case of flash flood events. They need to have access to the most reliable possible information about the likelihood and location of potential flash floods in their regions to be able to make effective decisions. Their roles will be:

- Preparation for potential flooding in identified hazardous small rivers and streams by clearing blockages, etc;
- Respond to watches and warnings, for example closing bridges, evacuation, etc., at streams in danger of, or already undergoing flooding;
- Be a source of validation information on flash flood events.

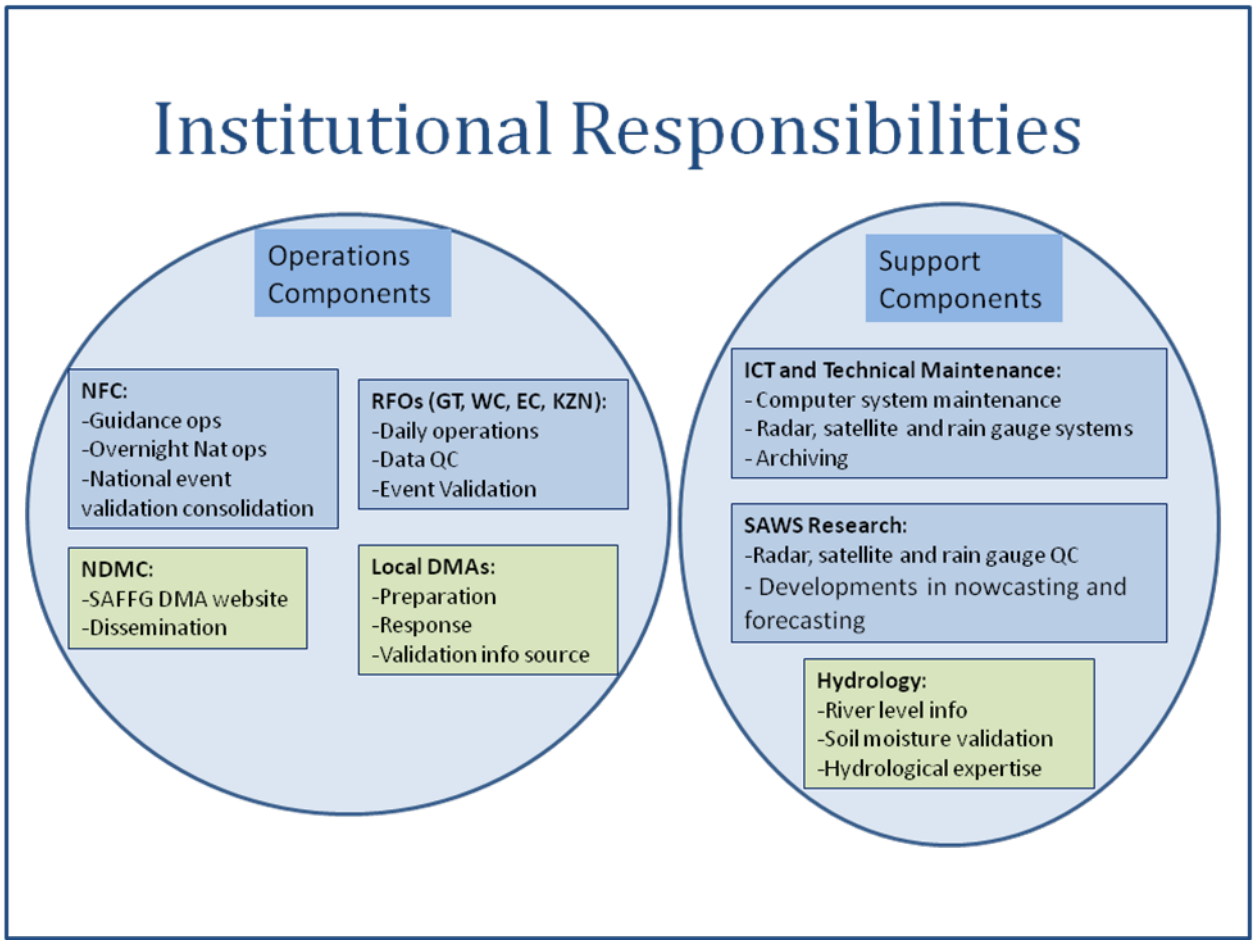

Figure 4. Institutional responsibilities for operations components of SAWS (blue) and disaster management structures (green), and for the support components of SAWS (blue) and hydrological structures (green).

5. RESPONSIBILITIES OF SUPPORT STRUCTURES

An integrated modelling system such as SAFFG will depend heavily on the support structures that ensure its continuous and effective operation. These support structures includes technical aspects, but also the availability of specialized knowledge and analysis on the scientific aspects of the system.

5.1. SAWS ICT and Technical Components

The weather and hydrological input in the SAFFG system must be of high quality, the models must run every hour 24 hours a day, 7 days a week, and the information must be available on time for effective decision making by disaster managers. To achieve this level of service delivery require professional and quality support services from the ICT staff and electronic technicians. Their roles include:

- Maintenance of the SAFFG software system and the computers on which it runs;
- Maintenance of the communication systems to ensure 24 hour operation;

- Maintenance of the radar, automatic weather station and automatic rainfall stations to ensure calibrated and high quality measurements;
- Archiving of the model products for future research and case studies.

5.2. SAWS Research

The quality of the products of the SAFFG system depends heavily on the quality and development of the meteorological input, particularly the rainfall measurements by radar and satellite, the nowcasting and forecasting tools used by forecasters when analysing a situation, and the application of meteorological information throughout the system. Therefore SAWS researchers have important roles to play:

- Regular analysis of radar, satellite and rain gauge information to determine its quality and detect possible problem areas;
- Development of enhanced nowcasting and forecasting techniques to support the forecasters and eventually the disaster managers in their decision-making processes.

5.3. DWA Hydrology

The SAFFG system is a hydrometeorological forecasting system, employing a combination of hydrological models and meteorological information and forecasting. Even though the system runs in the weather service, and is daily used by weather forecasters, collaboration between the two disciplines is important for the overall effectiveness of the system. Hydrologists provide vital information on rivers and the hydrological forcing on the system. DWA Hydrology can play the following roles:

- Provision of real-time river stage and flow information to weather forecasters;
- Validation of the soil moisture predictions in the SAFFG system;
- Hydrological expertise regarding rivers and changes in hydrological forcing in the SAFFG models when needed.

6. ROUTINE OPERATIONS

6.1. Hours of Operation

Flash floods can occur any time of day or night. The SAFFG models update the soil moisture and flash flood guidance on an hourly basis throughout the day and night to keep track with the changing conditions. Weather forecasters therefore need to be available on all hours to be able to respond to a potential flash flood threat. The NFC is operational 24 hours a day, whereas the forecasters at the RFOs in Cape Town, Durban and Port Elizabeth operate between 16 and 20 hours per day. The NFC forecasters will stand in for those RFOs not operational during certain hours of the night.

6.2. FFG Product Overview

(A brief discussion of the different products, without too much detail. I,e radar, sat, gauges rain fields are “raw” data but hourly aggregates, what is the merged MAP, ASM, why FFG and PFFG, what

is in FMAP. Different FFTs, Text files, etc. Only short summary as sort of reference. Summary of your flow chart in "what" terminology and not "how"!)

6.3. Preliminary evaluations

6.3.1. Meteorological evaluations

- *Previous, current, forecast*
- *Radar operations*

6.3.2. Hydrological evaluations

- *Stream conditions*
- *Reservoir levels*

6.3.3. Quantitative precipitation forecasts

6.4. FFG Product evaluations and applications

6.5. Information dissemination

6.6. Routine bulletins

6.6.1. Guidance bulletin

6.6.2. Daily FFG validation report

6.7. Alerts

6.7.1. DMA message (SMS/Email): Watch / Warning

6.7.2. Public bulletin: Watch / Warning

6.8. Reporting requirements

6.9. System validation

7. STAFF TRAINING

7.1. Forecaster Training

Training of SAWS forecasters are coordinated by the Training section of SAWS:

- All forecasters are expected to successfully complete the COMET Basic Hydrology Course. Certificates proving successful completion must be submitted to the Training section of SAWS.
- Training of forecasters on operational use of the SAFFG system occurs through short workshops at the RFOs repeated from time to time where necessary. Every forecaster of the RFOs impacted by SAFFG have to complete this course.

7.2. Disaster Management Training

Training of disaster managers on understanding and using the SAFFG products will be conducted through short training sessions involving laboratory exercises. These training sessions will be conducted in partnership with PDMCs in the regions, and involve disaster managers directly involved in decision making prior and during hazardous events.

8. NON-ROUTINE OPERATIONS

Operations during unusual events….

Dam failures….

9. OUTREACH

Outreach affect two different end-users, namely the general public and disaster managers:

- RFOs need to regularly meet with the disaster managers in their regions to build relations and address any shortcomings in procedures and coordination between them regarding severe weather warnings in general, and the flash flood warnings in particular.
- Raising public awareness is a joint responsibility between SAWS and the DMAs. Campaigns need to be conducted from time to time on both national and regional basis.