**W O R L D M E T E O R O L O G I C A L O R G A N I Z A T I O N**

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**ANNUAL JOINT WMO TECHNICAL PROGRESS REPORT ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM (GDPFS) INCLUDING NUMERICAL WEATHER PREDICTION (NWP) RESEARCH ACTIVITIES FOR 2014**

**Tanzania Meteorological Agency (TMA)**

**United Republic of Tanzania**

# TABLE OF CONTENTS

Introduction

[National Contributions and/or Consortia]

**1. Summary of highlights**

TMA runs the non-hydrostatic WRF models at 15-km resolution. The 5Km horizontal resolution is from the nested domain from the 15 Km resolution. TMA is also running COSMO Model (ICON) in testing mode for 48 hours with the resolution of 7km and 2.9km. It is expected that ICON model will be operational in the end of October 2015 after the completion fast internet connection (optic fibre) which is in the final stage of installation. Furthermore, TMA is now running Wave Watch III (WWIII) wave Model for the marine forecasts over Indian oceans and major Lakes (Victoria, Nyasa). After successful, converting TAC messages to a single bufr bulletin, TMA is expecting to start running COSMO and WRF data assimilation (3-DVar and 4-DVar) in one year to come.

TMA as Regional Forecasting Support Center continued to provide Severe Weather Forecasting guidance for the Lake Victoria Basin. The center has the responsibility to interpret information received from global NWP centres, prepare daily guidance products (up to five days) for forecasters in all countries (Rwanda, Uganda, Kenya and Tanzania) around Lake Victoria and share through video conferencing.

In terms of human resources, TMA has seven NWP experts - three PhD holders, two Master degrees and two Bsc. Degrees in various areas such as surface physics, data assimilation using 3-DVar, 4-Dvar and borgus for tropical cyclones over south-west Indian ocean

**2. Equipment in use at the Centre**

TMA acquired a high performance computing platform; the cluster computer with 16 computing nodes, with the following configuration:

* 16 -computation nodes; each with 2-socket, 8-core Sand Bridge Intel e5530 2.6 GHz processors, 32GB DDR3-1333 Memory, (2) 146GB 10K RPM SAS, interconnected via Infiniband (Total 192 Cores)
* 1- Master cluster node /Head node (dual-socket, quad-core Intel E5-2609 2.4 GHz, 32GB DDR3-1333 memory, 2 x 146GB 15K RPM SAS HDD) to manage;
* 1- IBM DS3500 Storage subsystem with 25.2 TB of storage (Raw) using 42 x 600 GB SAS 10K RPM drives

**3. Data and Products from GTS in use**

Synoptic observations and upper air observation, including satellite are used on a daily basis for forecasting and verification. Pre-processing procedures such as data acquisition and decoding are not fully automated and this becomes a blocking mechanism for data assimilation in the daily operational runs.

* SYNOP
* SHIP
* BUOY

**4. Forecasting system**

**4.1 System run schedule and forecast ranges**

 **Short- and medium-range forecast**

At TMA NWP system runs based on 00UTC and 1200UTC analyses for the forecast length of 48 to 78 hours depending on the type of the model. WRF (Weather and Research forecasting model) runs for 48 hours with the resolution of 15km for the (course domain) bigger domain and for 5km (for the nested one) for smaller one. Sometimes 72 hours forecast is also conducted depending on the atmospheric situation. WWIII (Wave Watch III model) for the forecasts of wave height, speed and direction for the marine forecasts over Indian ocean, Lake Victoria and Lake Nyasa, which runs for 72 hours, initialised at 00UTC. Initial boundaries condition for WRF are generated from NCEP GFS at 0.5x 0.5 degree.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Model** | **Version** | **Resolution** | **Forecast length** | **Initial and** **boundary** **conditions** | **Comment** |
| WRF | 3.6 | 5-15km | 48-54 hours | NCEP | Daily run |
| COSMO |  | 7 – 14 Km | 48 – 72 hours | DWD | Daily |
| WRF BOGUS  | 3.0 TC track | 10 km | 48-72 hours | NCEP | During TC |
| WWIII | 3 | 15km | 72 hours | NCEP/GFS | Daily run |

**Long-range forecast**

No operational runs

### 4.2 Medium-range forecasting system (4-10 days)

#### 4.2.1 Data assimilation, objective analysis and initialization

**4.2.1.1 In operation**

TMA is currently not doing data assimilation in operational basis but is doing it under test.

 The models under data assimilation tests are WRFDA (3DVARS and 4DVARS) and COSMO.

**4.2 Medium range forecasting system (4-10 days)**

4.2.1 Data assimilation, objective analysis and initialization

4.2.1.1 In operation

 No operational runs

4.2.1.2 Research performed in this field

 In progress

4.2.2 Model

4.2.2.1 In operation

 No operational runs

4.2.2.2 Research performed in this field

 In progress

4.2.3 Operationally available Numerical Weather Prediction (NWP) Products

 No operational runs

4.2.4 Operational techniques for application of NWP products (MOS, PPM, KF, Expert Systems, etc.)

4.2.4.1 In operation

 No operational runs

4.2.4.2 Research performed in this field

 In progress

4.2.5 Ensemble Prediction System (EPS) (Number of members, initial state, perturbation method, model(s) and number of models used, number of levels, main physics used, perturbation of physics, post-processing: calculation of indices, clustering)

4.2.5.1 In operation

 No operational runs

4.2.5.2 Research performed in this field

 No

4.2.5.3 Operationally available EPS Products

 No

**4.3 Short-range forecasting system (0-72 hrs)**

4.3.1 Data assimilation, objective analysis and initialization

4.3.2.1 In operation

 No operational runs

4.3.2.2 Research performed in this field

 In progress

4.3.2 Model

4.3.2.1 In operation

 No operational runs

4.3.2.2 Research performed in this field

 No

4.3.3 Operationally available NWP products

4.3.4 Operational techniques for application of NWP products (MOS, PPM, KF, Expert Systems, etc..)

4.3.4.1 In operation

 No operational runs

4.3.4.2 Research performed in this field

 No

4.3.5 Ensemble Prediction System (Number of members, initial state, perturbation method, model(s) and number of models used, perturbation of physics, post-processing: calculation of indices, clustering)

4.3.5.1 In operation

 No operational runs

4.3.5.2 Research performed in this field

 No

4.3.5.3 Operationally available EPS products

 No

**4.4 Nowcasting and Very Short-range Forecasting Systems (0-12 hrs)**

4.4.1 Nowcasting system

4.4.1.1 In operation

 Current TMA is using products available on Synergie system

4.4.1.2 Research performed in this field

No

*Note: please also complete the CBS/PWS questionnaire on Nowcasting Systems and Services, 2014)*

4.4.2 Models for Very Short-range Forecasting Systems

4.4.2.1 In operation

 No operational runs

4.4.2.2 Research performed in this field

 No

**4.5 Specialized numerical predictions (on sea waves, storm surge, sea ice, marine pollution transport and weathering, tropical cyclones, air pollution transport and dispersion, solar ultraviolet (UV) radiation, air quality forecasting, smoke, sand and dust, etc.)**

4.5.1 Assimilation of specific data, analysis and initialization (where applicable)

4.5.1.1 **In operation**

TMA runs 72 hours of Wave Watch III operationally over South Western Indian Ocean and Lake Victoria for marine weathering and sea waves. The model is initiated by surface winds and temperature from Global Forecasting System model from NCEP.

4.5.1.2 **Research performed in this field**

TMA conducted research on marine weather especially the validation of a wave model WW III against satellite altimetry data over the South Western Indian Ocean domain. The results show that the model is relatively good in forecasting the significant wave height despite of lack of actual observations

4.5.2 Specific models (as appropriate related to 4.5)

4.5.2.1 In operation

 No operational runs

4.5.2.2 Research performed in this field

No

4.5.3 Specific products operationally available

 No

4.5.4 Operational techniques for application of specialized numerical prediction products (MOS, PPM, KF, Expert Systems, etc.) (as appropriate related to 4.5)

4.2.4.1 In operation

 No operational runs

4.2.4.2 Research performed in this field

No

4.5.5 Probabilistic predictions (where applicable)

4.5.5.1 In operation

 No operational runs. Uses available product on SWFDP Portal

4.5.5.2 Research performed in this field

 No

4.5.5.3 Operationally available probabilistic prediction products

 Heavy rainfall, strong winds and large waves

**4.6 Extended range forecasts (10 days to 30 days) (Models, Ensemble, Methodology)**

4.6.1 **In operation**

TMA is operationally issuing the 10 days (Dekad) outlook on every 10, 20 and 31 or 30 of every month and 28 or 29 of February for the following 10 days

TMA is operationally issuing the 30 days (Monthly) outlook on every 31 or 30 of every month and 28 or 29 of February for the following month

Methods used in preparation of the extended forecasts are prepared by using statistical tools and downscaling of Global Circulation Models. Tools used: CPT tool, GeoCOF tool, SYSTAT tool, etc

Models used: Dynamical models from NCEP, ECMWF, UK-met, etc.

4.6.2 Research performed in this field

No research already completed.

4.6.3 Operationally available EPS products

Precipitation, Wind speed, Temperature and Waves

**4.7 Long range forecasts (30 days up to two years) (Models, Ensemble, Methodology)**

4.7.1 In operation

- TMA is operationally issuing seasonal weather forecasts (3 months outlook)

- Methods used in preparation of the extended forecasts are prepared by using statistical tools and downscaling of Global Climate outlook.

-Tools used: CPT tool, GeoCOF tool, SYSTAT tool, etc.

-Model products used: Dynamical models from NCEP, ECMWF, UK-met, Global leading centres, etc.

4.7.2 Research performed in this field

 - Climate variability

 - Determination of homogeneous zones

4.7.3 Operationally available products

-Precipitation

 -Temperature during JJA

**5. Verification of prognostic products**

**5.1 Annual verification summary**

-TMA performs verification of daily and seasonal weather forecasts. The daily forecast is 78% (POD) on average correct while the seasonal forecast is 86% on average correct.

-TMA is also testing MET v4 (Meteorological Evaluation Tool version 4) so that can be used for WRF model daily forecasting.

**5.2 Research performed in this field**

There is no research already done.

**6. Plans for the future (next 4 years)**

**6.1 Development of the GDPFS**

6.1.1 Major changes in the operational DPFS which are expected in the next year

 Switch from using PC to the using CLUSTER COMPUTER

6.1.2 Major changes in the operational DPFS which are envisaged within the next 4 years

On the cluster computer, run PRECIS Model from climate simulations

**6.2 Planned Research Activities in NWP, Nowcasting, Long-range Forecasting and Specialized Numerical Predictions**

**6.2.1 Planned Research Activities in NWP**

**6.2.2 Planned Research Activities in Nowcasting**

-TMA is finalizing to create a network of seven radars. As of now TMA have one radar in Dar ES Salaam

 and the second one is under way of installation in Mwanza region. Thus the presence of a network of

 seven radars, TMA is planing to use COSMO and WRF models to do research on nowcasting.

-Severe convective storm formation in the country

-TMA is planning to do research on determination of models’ accuracy and different season of the year

-Storm surge evolution and forecasting

-With the help of cluster computer TMA is planned to do research in the area of forecast for marine and

 coastal inundation (i.e. waves and storm surges). This research will be done using the WAVE WATCH III

 wave model.

**6.2.3 Planned Research Activities in Long-range Forecasting**

 -Determination of intra-seasonal dry and wet spells

 -Determination of onset and cessation of rainfall season

 - Determination of new rainfall predictors

6.2.4 Planned Research Activities in Specialized Numerical Predictions

**7. Consortium *(if appropriate)***

**7.1 System and/or Model**

7.1.1 In operation

 No operational model

7.1.2 Research performed in this field

No

**7.2 System run schedule and forecast ranges**

**7.3 List of countries participating in the Consortium**

**7.4 Data assimilation, objective analysis and initialization**

7.4.1 In operation

 No

7.4.2 Research performed in this field

No

**7.5 Operationally available Numerical Weather Prediction (NWP) Products**

Mean Sea Level Pressure, 10Meter winds, SkewT, precipitation, Relative Humidity

**7.6 Verification of prognostic products**

**7.7 Plans for the future (next 4 years)**

**7.7.1 Major changes in operations**

TMA intends to start giving climate projection in collaboration with UK Met office. First by using

 PRECIS model, we will reconstruct climate conditions since 1851 to 2011 and then after that we will run

PRECIS model based on different scenario, from 2011 to 2100.

TMA will start using MET (Meteorological Evaluation Tools) to verify our WRF output against observed

 so as to find out how good is WRF model, the model TMA used daily

  **7.7.2 Planned Research Activities**

-TMA by using the mention model above (PRECIS model), do research on the climate change over

 Tanzania

TMA intends to carry out research into the level of air quality in some cities such as Dar Es Salaam to

evaluate the quality of air. This exercise will be done by putting some measuring equipment of air quality

 first. And the data acquired will be the initial input (Initial condition) to the WRF model and make

 simulation of the air quality using WRF (Chemistry) model later. This simulation will help as guidance

 relating to air pollutions over Tanzania.

**8. References**

###### EXPLANATORY NOTES

**to the suggested contents of Annual Joint WMO Technical Progress Report on the Global Data-Processing and Forecasting System (GDPFS) and Numerical Weather Prediction (NWP) Research Activities**

 The WMO progress report will be jointly compiled annually by the WDS and AREP Departments of the WMO Secretariat on the basis of contributions from WMO Members and/or GDPFS centres.

 The publication will begin with an introduction prepared by the WMO Secretariat explaining the major purposes of the publication with the appropriate references.

 Each individual contribution should contain appropriate parts of the following items.

**1.** **Summary of highlights**. This should reflect the major changes in the data-processing and forecasting system during the last year.

**2.** **Equipment in use at the centre**. This paragraph should contain information on the major data-processing units, especially in the large centres. Here and in the following paragraphs the information for the first national contribution to the Progress Report should be given in a complete form to avoid too many references. In the next contribution, the information can be restricted to the indication of major changes during the year being reported on.

**3.** **Data and products from GTS in use**. It is suggested that only the bulletin headings with the basic information (SYNOP, SHIP, TEMP, SATEM etc.) and the types of products (GRID, GRIB, facsimile charts etc.) received through the GTS or other means and used at the centre will be indicated in this paragraph. The daily statistics for each type of bulletin and the product should be included, if such statistics are available. For example, SYNOP-500, TEM-600, GRID-20.

**4.** **Forecasting system**. There are several aspects of this system since some centres run several models which have different approaches to the data assimilation, use different numerical techniques and so on. Consequently, this paragraph is divided into several sub paragraphs.

**4.1*****System run schedule***. It is suggested that the general structure of a prognostic system should be described in the paragraph with an indication of models in operational use, including those for specialized applications, the run schedule and the forecast ranges.

**4.2-4.6** These sub-paragraphs are a series of similarly structured texts describing different operational sub-systems of a numerical weather forecasting system: Medium-range forecasting :(section 4.2); Short-range forecasting (section 4.3); Nowcasting and very-short-range forecasting (section 4.4), Specialized numerical predictions for various sector specific applications, including sea waves, storm surge, sea ice, marine pollution transport and weathering, tropical cyclones, air pollution transport and dispersion, solar ultraviolet (UV) radiation, air quality forecasting, smoke, sand and dust, etc. (section 4.5), extended-range forecasting (section 4.6) and long-range forecasting (section 4.7). Each sub-paragraph contains the same components starting with data assimilation and objective analysis, description of the model, of operational techniques for application of NWP products, and a section on Ensemble Prediction Systems if used for that range. List of products available for WMO members should be indicated. All sub-paragraphs should include information regarding any performed research activities in the related field.

 The list of suggested items in each sub-paragraph is given for 4.2 (it is assumed that for 4.3-4.7 they will be similar).

**4.2 *Medium range forecasting system (4-10 days).***

4.2.1 *Data assimilation objective analysis and initialization*

*4.2.1.1 In operation*

* Assimilated data,
* Assimilation cycles, including cut-off time,
* Method of analysis (e.g. 3 D-VAR, 4D-VAR)
* Analysed variables
* First guess
* Coverage
* Horizontal resolution
* Vertical resolution (levels)
* Initialization (non linear normal mode, diabatic etc.)

*4.2.1.2 Research performed in this field*

4.2.2 *Model*

*(If no model is operationally runs for this time range, indicate, if any, the other GDPFS centre and its model from which you use products)*

*4.2.2.1 In operation*

* Basic equations
* Independent variables
* Dependent variables
* Numerical technique (in horizontal, vertical and in time), hydrostatic or non hydrostatic
* Integration domain (in horizontal and vertical)
* Horizontal and vertical resolution
* Time step
* Orography, gravity wave drag, bathymetry (ocean models)
* Horizontal diffusion
* Vertical diffusion
* Planetary boundary layer
* Treatment of sea surface earth surface and soil
* Radiation
* Convection (deep and shallow)
* Atmospheric moisture
* Boundaries
* Type of ocean model (deep and shallow waters)
* Source of input (e.g. wind etc.) data (ocean models).

*4.2.2.2 Research performed in this field*

4.2.3 Operationally available *Numerical weather prediction products*. This item should contain a brief description of variables which are outputs from the model integration and the list of products available for WMO Members on Internet and on GTS. *(If no model is operationally runs for this time range, indicate the list of products, if any, you use from another GDPFS centre)*

4.2.4 *Operational techniques for application of NWP products*. This item should include only a brief description of automated (formalized) procedures in use for interpretation of NWP output (MOS, PPM, Kalman filter, Expert System, etc.) for example, “the MOS from ECMWF NWP is used to derive extreme temperatures and daily precipitation”.

*4.2.4.1 In operation*

*4.2.4.2 Research performed in this field*

4.2.5 *Ensemble Prediction System* *(Number of members, initial state perturbation method, number and different models used, perturbation of physics, post-processing: calculation of indices, clustering).* This item should be a brief but clearer description of the techniques used for the ensemble prediction system, including the main post-processing techniques applied.

*4.2.5.1 In operation*

*4.2.5.2 Research performed in this field*

*4.2.5.3 Operationally available EPS products.* This item should contain a brief description of variables which are outputs from the EPS integration and the list of products available for WMO Members on Internet and on GTS.

**5.** **Verification of prognostic products**. Centres producing standard scores are requested to produce an annual summary for insertion in the WMO Progress Report on the GDPFS. The recommended content of this summary is given below:

**VERIFICATION SUMMARY FOR INCLUSION IN THE ANNUAL WMO PROGRESS REPORT**

**ON THE GDPFS**

|  |  |  |
| --- | --- | --- |
| RSMC error | Z 500 | NH, SH: against analysis4 extra tropical standard area: against observations |
| RMS vector wind error | W 250 | Same areas |
| RMS vector wind error | W 250 | Tropics: against analysis  |
| RMS vector wind error | W 850 | Tropical standard area: against observations  |

Forecast range: 1, 3 and 5 days

All values to be the average of the monthly values over the year.

For ensemble system, provide annual and seasonal averages of the Brier Skill Score at 24, 72, 120, 168 and 240 hours for Z500 and T850.

**6. Plans for the future *(next 4 years)***

***6.1*** ***Development of GDPFS.***

*6.1.1* Indicate major changes in the data processing and forecasting system which are expected in the next year.

*6.1.2* Indicate major changes in the data processing and forecasting system which are envisaged within the next 4 years.

***6.2 Planned Research activities in NWP, Nowcasting, Long-range Forecasting and*** *Specialized Numerical Predictions****.***  Indicate your planned research and development efforts in the area of understanding of physical processes, models, EPS and other techniques for the next 4 years.

*6.2.1* Planned Research Activities in NWP

*6.2.2* Planned Research Activities in Nowcasting

*6.2.3* Planned Research Activities in Long-range Forecasting

*6.2.4* Planned Research Activities in Specialized Numerical Predictions

**7. Consortium *(if appropriate)***

There are a number of GDPFS Centres participating in Consortia. Those Centres participating in and/or responsible for a Consortium should indicate it in this item. Details on the system and/or model developed and/or operated by a Consortium, including approaches to the data assimilation, use of different numerical techniques and so on, should be reported in sub-paragraphs 7.1-7.7, using a similar approach as described in item 4.

7.1 *System and/or Model*

*7.1.1 In operation*

*7.1.2 Research performed in this field*

7.2 *System run schedule and forecast ranges*

7.3 *List of countries participating in the Consortium*

7.4 *Data assimilation, objective analysis and initialization*

*7.4.1 In operation*

*7.4.2 Research performed in this field*

7.5 *Operationally available Numerical Weather Prediction (NWP) Products*

7.6 *Verification of prognostic products*

7.7 *Plans for the future (next 4 years)*

*7.7.1 Major changes in operations*

*7.7.2 Planned Research Activities*

**8. References:** Give references to the sources where more detailed descriptions of different components of the data processing and forecasting system can be found, including WEB sites addresses.