Stakeholder Workshop for scoping and development of new forecast products using AMDAR data, Naivasha, Kenya, 9 - 10 May 2018

Fig. 1: Group photo of Workshop Participants

Executive Summary

AM DAR is a WMO programme that utilizes the existing aircraft avionics in the collecting of meteorological data that is then transmitted to the respective NMHS to be used for the improvement of weather forecasting applications and services.

KMD is currently engaged with KQ in the implementation of the AMDAR programme in Kenya. The AMDAR programme dovetails very well with KMD’s modernisation of infrastructure that is currently under implementation being part of the Kenya Vision 2030 flagships. To this end KMD has a team of experts charged with the delivery of some of the milestones and objectives as outlined in the projects work packages that are the main thrust of the AMDAR project in Kenya. One of the major funded activities of the project is the Development of Forecasting Applications and Products for Aviation and other sectors - which will build on the new AMDAR Programme and resulting data availability to enhance KMD
forecasting and services capabilities and also, as an additional outcome, leading to improved Kenya Airways operations and efficiencies. This component requires KMD and KQ teams to work closely together in order for the entire project to succeed as designed.

The World Meteorological Organization (WMO) in collaboration with the Kenya Meteorological Department (KMD) and Kenya Airways (KQ), organized the second workshop on Aircraft Meteorological Data Relay that was held on 9th to 10th May 2018 at the Burch’s Resort Hotel in Naivasha. The Kenya Meteorological Department was privileged to host the inaugural workshop in June 2015. This second workshop was designed to build on the outcomes of the first workshop.

**Workshop Objectives**

1. Improvement of Forecast applications and products co-produced by relevant stakeholders
2. Scoping on the new forecast products that KQ requires
3. Assimilation of AMDAR data into NWP Models
4. To propose new KMD products and applications to be developed based on AMDAR data availability

**Expected Outcomes**

- Determine new KMD products and applications to developed based on AMDAR data availability
- Determine the KQ specific aviation services to be developed
- Determine new KQ procedures to be developed for flight operations
- Determine model to be used in assimilating AMDAR data into NWP models

**AMDAR Workshop Proceedings, Naivasha, 9 -10 May 2018**

1. **Opening Remarks**

The opening Session was facilitated by Mr. Samuel Mwangi, KMD’s Deputy Director for Forecasting. He coordinated self- introductions of the participants before the official opening of the AMDAR Workshop at Burch Resort, in Naivasha.

Charles Mugah, the senior Assistant Director in charge of aeronautical services and AMDAR focal point, working with KMD gave a brief highlight on AMDAR noting expected improved weather products that will help KQ improve on efficiency.

John Nalianya, the Head of operations Control Centre (HOCC), appreciated WMO and KMD for planning a successful Workshop. He pledged support from Kenya Airways. He outlined that the expected AMDAR programme benefits included improved flight planning, improved flight safety minimal weather related flight diversions

Mr. Nalianya further reported that KQ had done AMDAR software trials on their aircrafts with a few teething challenges on B737s and KQ was awaiting software upgrades on Embraer190.
It was revealed that KQ will operate direct flight to USA from October 2018, subject to the results of the audit on the state of Kenya Airport Authority (KAA) facilities, scheduled for May 2018. Further, Mr. Nalianya envisioned better collaboration between and among KMD and aviation industry, particularly with KQ.

Mr. Dean Lockett revealed that AMDAR has been around for over 20 years. The program aims to get more current data into KMD to realize maximum benefits. The workshop is important to highlight benefits and hopes this one will be profitable to both KQ and KMD.

The KMD Director, Mr. Peter Ambenje, welcomed the participants and noted that this was an important meeting in Kenya. AMDAR is key on observations. He highlighted that upper air stations were expensive thus welcomed AMDAR due to more coverage. Most countries would love to be involved in AMDAR. So success of implementing it in Kenya will influence other countries. KMD should receive servers today (9th May 2018) for the AMDAR project. KMD is committed to implement and sustain the programme by factoring it in the recurrent budget. KMD will work closely with KQ in implementation and hoped for fruitful discussions during the workshop.

2. Guest of Honor

Hon. Mohamed Elmi, MBS, EGH, the Chief Administrative Secretary for the Ministry of Environment and Forestry represented the Cabinet Secretary (CS), Mr. Keriako Tobiko, as Guest of Honour (GoH), during the official opening of the AMDAR Workshop in Naivasha.

Reading the CS Speech, Hon. Elmi appreciated the cooperation between KQ and KMD. He further appreciated the United Kingdom Department for International Development (DFID) and the Secretary General for the World Meteorological Organization (WMO) for sponsoring the AMDAR Programme.
Honorabe Elmi confirmed that KMD has significantly improved in its weather forecasting Services, courtesy of modern technology. He confessed that some four decade ago, he preferred to consult with the traditional Elders on matters weather.

He challenged the collaborators on AMDAR Project to implement the programme successfully to achieve the intended results that demonstrate the success that can be derived from the Public Private Partnerships in Service delivery.

3. Vote of Thanks

Ms. Stella Aura, EBS, The Deputy Director for Education and Training at the Institute for Meteorological Training and Research hosted in KMD, moved a vote of thanks. She appreciated the Guest of Honour, the WMO Secretary General for supporting KMD and KQ for collaboration. She singled out the Local Organizing Committee (LOC) for a special appreciation for the well-organized Workshop. She challenged the participants and other stakeholders to expedite the implementation of the AMDAR programme to leverage on modern technology for improved weather forecasts and to enhance safety and efficiency in aviation industry. She further challenged the LOC to generate a clear and actionable Workshop Report.

Fig.3: Opening Ceremony

From left to right:

- Mr. Dean Lockett, Scientific Officer, Aircraft and Remotely-sensed Observations, WMO,
- Hon. Mohamed Elmi, MBS, EGH, Chief Administrative Secretary for the Ministry of Environment and Forestry,
- Mr. Peter Ambenje, Kenya Meteorological Department, Director
- Mr John Nalianya, Head of operations Control Centre (HOCC), Kenya Airways
4. Presentations

A. AMDAR Program in Kenya: Context and Benefits

The WMO AMDAR expert, Mr. Dean Lockett, outlined the history of AMDAR technology in aviation Industry and background context in which the Kenya KMD-KQ, Public Private Partnership, with funding from DIFD, through WMO evolved.

On the benefits of the AMDAR Program on aviation industry in general and on KMD-KQ Collaboration, in particular, Mr. Dean listed several benefits, including:

- Efficient source of high quality upper air data
- Observing system operated under Private Public Partnerships (PPP)
- Higher temporal frequency in reporting of vertical profiles
- Improved forecasting of high impact weather phenomena
- Significant impact and improvement to NWP systems
- Improved forecast skill to all weather & climate applications areas
- Compared to Satellite, the satellite covers large area volume but low accuracy and also satellite is a high-cost investment.
  - Radiosondes give high-accuracy data but it has poor coverage compared to AMDAR
  - and it is also high-cost method to collect upper air data.
- AMDAR – good coverage and volume, high accuracy low cost

The list of benefit scan continue, but in summary, Aircraft-based observations provide high-quality measurement of climate variables useful for climate applications in many sectors of life and economy.

B. AMDAR project in Kenya: Funding process

AMedar Kenya Project Manager, Mr. Chap emphasized that the Public Private Partnership, cooperation and collaboration between KMD and KQ needs to realize its intended results both for the delivery of the project outputs during the lifetime of the project and also for the sustainability once the project has ended. Chaponda’s presentation focused on the process and funding of the Project. He begun by highlighting that the Project is funded by the UK Department for International Development (DFID) via Weather and Climate Information Services for Africa Programme (WISER), through the UK Met Office. The project which will run from August 2017 through early 2020 has a funding allocation of about £ 500 Million, further supported by in-king contributions from WMO, KMD and KQ.
Chap further explained that the main goal of the Project is to improve various economic sectors of Kenya by provision of better climate and weather services by KMD to various stakeholders, including the aviation Industry. The modus operandi is to equip KQ fleet with capabilities to generate upper air data and equip KMD with ability to receive process and utilize AMDAR data.

Chap outlined and summarized key activities, required to deliver the AMDAR Kenya Project within the project timeline. This is being coordinated through four (4) work packages and some key timelines are as follows:

1. **WP1: Development of Data processing service at KMD**
   - Purchase DPS servers – completed
   - Develop DPS software – Procurement in progress
   - Establish data communication cost (Rockwell Collins) – in progress

2. **WP2: New product development and Flight operations improvements**
   - Flight operations analysis report– in progress
   - Implement the KQ plan (Aug 2018 - Sept 2019)

3. **WP3: improvement of existing forecast and product**
   - Forecast system and product Analysis report – in progress

4. **WP4: KQ Software upgrade:**
   - Software upgrade required for Embraer 190 aircraft – expected October 2018
   - Software upgrade required for Boeing B737 aircraft – expected July Aug 2018

5. **Joint Action/deliverables:**
   - KQ/KMD to provide detailed concept note/proposal on the planned activities- ASAP (Action: C,Mugah/J.Nalianya)
   - WMO to facilitate the transfer of funds to KMD (WP2 USD 43,000 remaining while WP3 USD 40,000 remaining) –ASAP (Action: M. Chap and C. Mugah)
   - Training in AMDAR System Administration (Action: WMO/KMD/KQ)

**AMDAR Programme Sustainability**

In conclusion Chap reminded participants that the current AMDAR Project is to end in Q1 2020, hence there in need to think about its sustainability beyond the Project Period. He pointed out the sustainability issues that would include: cost of running the AMDAR programme, annual processing fee, Link (communication) cost, Capacity building and other maintenance costs. Therefore, a concrete plan needs to be developed and consideration should be given to formulating a business case.

**C. K-ADPS System**

Mr. Samuel Machua explained to participants the structure and functions of the KMD AMDAR Data Processing System (K-ADPS). The System designed to receive,( Ascent, Enroute & Descent reports) quality-check, process and remit some statistic and processed messages among other details. The system is also capable of automatically, notifying operational staff of any monitored system problem.
It is envisioned that K-ADPS will be able to handle a fleet of up to 200 aircrafts and 20,000 AMDAR messages per day, probably making KMD to become RA1 AMDAR data processing Hub, Mr. Machua explained.

D. AMDAR data Assimilation Processes

Mr. Eric James, an AMDAR data Expert from NOAA, using several models, illustrated how AMDAR data can be used to enrich the models for forecasting extreme weather phenomena. Mr. James used various temporal data ‘windows’ to demonstrate data assimilation and AMDAR data denials impacts on forecast products. Some of the demonstrated model in his presentations included:

- RAP/HRRR Cloud Analysis
- Radar data reflectivity assimilation
- Aircraft Observation data assimilation (ACARS)
- Satellite atmospheric motion vectors (AMV) and
- ACARS Denial experiments , observation type (ascent, descent, enroute)

![Image](image_url)

Fig. 4: Mr Eric James, Associate Scientist III, Cooperative Institute for Research in Environmental Sciences, University of Colorado, and NOAA/OAR/Earth System Research Laboratory/Global Systems Division, Boulder, Colorado

E. Use of AMDAR Data in Forecasting Applications: (SAWS)

Mr. Luthando Masimini, Aviation forecaster from the South Africa Weather Service (SAWs) informed the workshop that the purpose of his presentation was to demonstrate the applications of AMDAR at the aviation forecasting desk. He presented some background information as that SAWS partners with SAA on the operations of SA AMDAR. It also collaborates with E-AMDAR on collection of data over the region.

In his presentation he listed some uses of AMDAR at SAWS which included; supplementing the radiosonde, data assimilation process and validation of forecast model's vertical profiles,
determination of onset, bases and vertical extent of convective clouds, surface inversions air in fog forecasting and determination of the freezing level.

Mr. Masimini shared some of challenges encountered which made it difficult to show case the SAWS own tools. They included lack of archiving capability and requirement for manual decoding of data. NOAA AMDAR website which has more functionalities than the locally developed tools was being used after access rights were granted. Some of the outputs from the website were graphically presented.

He presented methods used in producing monthly reports on AMDAR data, availability, quality and transmission problems. Main users of the reports are data providers and the participating airlines. Statistics used to develop these reports is obtained mainly from NOAA site and the Canadian Data Monitoring website.

Masimini concluded the presentation by listing the links to WIGOS reports on requirements and benefits of implementing AMDAR programme.

F. Challenges and Gaps in aviation forecast products: overview of Kenya Airways Flight Operations:

Mr. Martin Butt revealed that the data provided by the KMD is used for flight planning and flight operations for safety and legal requirement. He however, pointed out a few challenges:

- There is scarcity of MET data in some areas in Africa where we operate especially in Central Africa
  - Sometimes
- We get inaccurate Obsolete data which may impact on performance and payload
- Sluggish update of KMD website hence slow information flow for dynamic aviation stakeholders
- Information gap in volatile and dynamic Kisumu is limited to manage WX changes in the area.

G. BREAKOUT SESSIONS

The participants were divided into four specialized topical Groups to identify gaps in various aspect of AMDAR that may slow down the realization of the intended Project goals. Each group was assigned a chair and a rapporteur to capture the outcome in the brainstorming sessions during the break out. The reports from the four work group are as summarized below:

WORK GROUP 1: AMDAR DATA ASSIMILATION

This session was chaired by Eric James of NOAA and the rapporteur was John Mungai of KMD
Context:
- KMD currently not running data assimilation of AMDAR or in-situ data. Processes/steps required by an NMC to implement data Assimilation

Step 1: Evaluation of a suitable data assimilation package in the public domain, e.g. WRFDA, GSI, 3DVAR and 4DVAR.
- Infrastructural requirements for running Data assimilation packages similar to those of parallel computing of WRF
- The simple data assimilation packages include; WRFDA and the GSI which NOAA currently uses for operational and research purposes

Step 2: Requisite Skilled Human Capacity
- Familiarity on how the DA packages work, which can be achieved through seminars and workshops and exchange programs
- Open source and Online tutorials that community supported
- Critical Human resource required for operational Data Assimilation includes 2 postgrads in data assimilation and system monitoring, 2 operational Numerical modelers, 2 postgrads on verification of DA and WRF performance

Step 3: Data Formats
- The AMDAR data on the GTS is primarily on BUFR code, hence this can be directly ingested by most of the Data assimilation packages namely, GSI and the WRFDA
- The KMD AMDAR DPS (K-ADPS) has factored this component
Step 4: Data Assimilation Runtime (Tuning) Routines

- The time windows for the observation ingestion – 3DVAR uses a short time window (maybe 4 or 6 times a day) that usually ignores the AMDAR data collection period
- Community supported package with some switch setting similar to the WRF

Step 5: Verification Framework:

- This is to quantify the cost benefit of the model performance after assimilating AMDAR data into the local models

Step 6: Observations Errors/Static errors

- This varies by observation sources e.g. AMDAR profiles, AWS, radar reflectivity
- Also takes account of data representativeness including instrument error, DA errors and model background errors

Recommendations

1. Grid Point Statistical Interpolation (GSI) has strong support by the National Centre for Atmospheric Research of the University Corporation of Atmospheric Research (NCAR/UCAR) through the Development Test-beds Centres (DTC) that hold annual tutorial workshops on the use of the GSI at Boulder, Colorado. In addition little programming skill set is required to implement the GSI.

2. Model Data Assimilation Cycles to be determined by the AMDAR data coverage density for the country/region. Proposed to initially start with 12hours ‘windows’ Data assimilation cycle.

3. Capacity building in Data Assimilation, Data assimilation error analysis and WRF verification skills. For example, this could be achieved through the African Desk of NOAA which could be relocated to Boulder.

4. KMD and NOAA to have an Memorandum of Understanding (proposed) in order to fast track collaboration of the two institutions on the implementation of AMDAR Data assimilation at KMD and further developments of the NWP component

5. Conduct a baseline survey of the existing modelling infrastructure, data workflows at KMD.

6. Skilled Postgraduate personnel required to operationalize Data assimilation at NMHSs.

WORK GROUP 2: AVIATION OPERATIONS:

The session was chaired by John Nalianya and the rapporteur was Jemimah Mwembia.
Fig. 6: Working group on Aviation operations

The stakeholders included: airlines, Kenya Civil aviation Authority, Kenya Airports Authority, Passengers and the public at large, would benefit greatly by the AMDAR products in these areas:

1. Improved efficiency

Flight planning - fuel loading planning should be based on weather information so as to save on costs, choose optimal flight level, avoidance of severe weather that can potentially cause accidents, injuries and damage of aircraft, reduce crew fatigue due to increased workload when dealing with severe weather.

To enable achievement of reduced cost of fuel, there is need to assess materials/information used in developing the different forecast products and associated impact of the products and come up with ways to improve the accuracy of the forecasts (products/services). This will reduce forecast errors and save money on fuel as well as improve decision making before and after take-off.

There is need to come up or provide real time forecasts if possible to enable quick decisions to be taken in response to the needs of aircrafts and especially in airports where forecasts are currently not being generated e.g. Kisumu, Eldoret airports

Efficiency data analysis reports by aircrafts should be shared with KMD so that they can be incorporated or used to improve the forecast products and facilitate better decision making or provision of relevant advisories.
2. **Improved safety**

There is need to develop an electronic system to send messages of any observations (alerts) in the upper air which are critical to aircraft and passenger safety such as wind velocity aloft. This means a channel of communication can be opened between the stakeholders (KMD, KCAA, and KQ). For example, there is a mandatory MET reporting requirement and thus the need to implement or improve on any existing modalities or systems.

Considering that Air Traffic controllers (ATCs) often receive information from pilots on sudden change of weather parameters (e.g. storm formations, sudden wind shears etc) it is critical to consider ways of enhancing/improving time taken to relay such information to aircrafts/other related stakeholders so that appropriate decisions/actions can be taken to improve safety. For example and specifically on PIREPS, it was suggested that it can be done immediately and ATC can give the communication to KMD for further actions. At the moment, this is done manually by voice i.e. telephone.

3. **CSR {Corporate Social Responsibility}**

With more accurate weather forecasts the general public can benefit due to the use of the information for disaster risk reduction decision support.

There will be more data that will be generated throughout the country from different aircraft at different times. This data can be used to accurately predict weather patterns for different seasons to inform different sectors in the country such as farmers, disaster management organizations for early preparedness in case of extreme weather patterns such as floods, droughts etc.

With the use of improved forecasts in fuel loading will be optimized to reduce fuel burn hence lower carbon emissions.

4. **ACDM {Airport Collaborative Decision Making Unit}**

With provision of improved weather information at airports the Collaboration decision Management at airport will be enhanced and these information can be used in efficient management of traffic at the airport/airspace

Weather information should be incorporated (ACDM) and updates given. ACDM will help in early decision making around the airport. The stakeholders that include Airlines, KCAA, KAA, KMD, Ground Handling Companies and other service providers will benefit from accurate weather information provided daily in order to make timely decisions to avoid delays or costs associated with weather.
WORK GROUP 3: FORECAST PRODUCTION, AMDAR DATA PROCESSING AND APPLICATION
The session was chaired by Dean Locket and David Muchemi was the rapporteur.

Identified Gaps:
1. Data display and retrieval
2. Application of using AMDAR data from wind shear, TC and crosswinds need to be developed
3. Take-off data for more than 3 hours is a challenge due to limitations in model runs
4. Communications between KMD HQ and JKIA is not reliable
5. Tropopause not well forecasted by models and forecasters need to use other methods to determine its height.

WORK GROUP 4: CAPACITY BUILDING AND DEVELOPMENT
This working group was chaired by Dr. Richard Muita and the rapporteur was Daniel Wepukhulu.
Training
Needs Identified included:
- Must adhere to WMO guidelines/standards E.g. BIPM
- Identify suitable group

Training areas:
- Data Assimilation - Training of trainers
- Data collection, processing, analysis and QC
- Operational system management and maintenance
- Stakeholders involvement of forecast products using AMDRA
- Data base management

Research
- Application of AMDAR data in forecasting
- Use of AMDAR in different applications
- Understanding and analyzing AMDAR data in aircraft accidents investigation
- Use of AMDAR in internet based platforms
- Value addition of forecast products with inclusion of AMDAR data.
- Blending and enrich available meteorological with AMDAR data

Operation
- NWP
- Improvements of operation s at KQ
- Analysis of tehipagram and interpretation
- Climate change scenario using historical data
- Monitoring and evaluation
Communication and feedback

Recommendations

- Training, operations and research must be facilitated to ensure full benefits is realized
- Access and how to use the AMDAR data should be fast tracked for Kenya and other African countries

E) Forecast Products using AMDAR Data: Via Skype

Mr. John Nalianya of Kenya Airways chaired a session, assisted by Dean Lockett, in which three presenters delivered the presentation via Skype. The three Presenters were: Andy Fischer Aviation of Weather Center (AWC) from USA; Jonathan Blaes, the Science Operations Officer from NOAA/NWS Raleigh, North Carolina and Richard Mamrosh of National Weather Service (NWS), Green Bay in Wisconsin. Mr. Peter Mutai was the rapporteur in all the three presentation.

The three presenters focused on the use of AMDAR data in various forecast applications in USA at the Aviation Weather Centre (AWC), National Weather Service (NWS) based in Green Bay, Wisconsin and NOAA/NWS Raleigh, North Carolina.

Several cased studies and examples of the use of AMDAR data in forecast application were presented and the significant contribution in provision of accurate forecasts. The three presenters elaborated some of the the challenges NOAA forecasters face in understanding the atmospheric conditions where we have limited upper air observations.

The deployment of Water Vapour Sensing System second generation (WVSS-II) in the AMDAR in the USA AMDAR program has shown that it provides valuable data to the meteorologist that could be deployed to understand the prevailing atmospheric conditions and to validate weather forecasts.

Presentations:

(a) Andy Fischer, Aviation Weather Center (AWC), USA

The presenter gave an overview of the weather services that the AWC provide to the aviation sector in the USA. Some of the forecasting products that it provides include: convective SIGMET, Traffic flow convective forecast, ceiling visibility, aircraft icing, and aircraft turbulence. The presenter discussed the use of Water Vapour Sensing System-II (WVSS-II) data in forecasting aircraft hazards such as convection, turbulence and icing. The WVSS-II is the second generation of water vapour sensors used for the AMDAR. The WVSS-II is used around the entire continental of the USA, save for very few places like Dakota. The presenter is of the opinion that Compared to the TAMDAR, the WVSS-II is generally more versatile and a better tool for challenging high impact events with respect to population.

Mr Fischer argues that scarce upper air data in time and space leads to insufficient understanding of atmospheric conditions and difficulty in creating short-term conceptual
model of the condition of the atmosphere. The scarcity of UA data has also be shown to have impact on the accuracy of the forecast models due to insufficient dense assimilation of initial conditions. He also notes that air-Temperature, due-point temperature and wind are subject to change drastically in very small scales in time and space. Therefore the use of WVSS-II is important in providing UA data that can be used to improve and/or validate weather forecasts models.

(b) Jonathan Blaes, Science Operations Officer, NOAA/NWS Raleigh, NC

Jonathan made a presentation on the use of AMDAR Observations in Forecast and Warning Operations at the NOAA/NWS Raleigh Forecast Office. He notes that there are shortcomings in the existing traditional observations of the troposphere via the radiosonde network mainly attributed to lack of spatial and temporal density that operational Meteorologists desire. He also presented hourly statistics of AMDAR observations at the Raleigh-Durham International Airport (KRDU) and the Piedmont-Triad International Airport in Greensboro (KGO) that were calculated from June 1, 2008 through May 31, 2009. The statistics showed that the greatest frequency of observations generally occurs from Tuesday through Saturday at 600 AM, 1000 AM, 600 PM, and 1000 PM local time.

Jonathan also presented results of a study done at NWS Raleigh’s where AFDs were analyzed to identify occasions in which aircraft observations were noted from 2009-2013. From the analysis it was shown that Aircraft observations have been useful in a wide variety of forecast situations and can provide the critical piece of information needed to make a forecast or warning better.

(c) Richard Mamrosh, National Weather Service (NWS), Green Bay, Wisconsin

Richard made presentation on the Forecast Applications of AMDAR. He discussed the use of AMDAR in forecast applications including:

- Public Forecasts
- Convection, precipitation type, winter storms, floods, wind
- Aviation Forecasts
- Icing, Low Level wind shear, turbulence
- Marine Forecasts
- Winds and stability drive wave forecasts
- Fire Weather-
- Moisture availability, stability, mixing

Questions, Answers and comments:

Participants, courtesy of modern technology, were able to ask the three presenters some questions to get clarification on some issues as sampled below:

Q1- Is there any benefit in having more aircraft with WVSS-II?
A: Yes, there are great benefits. It also supplements where the National Profiler Network where data is not available.

Q2: What advice can you give on the display and analysis software for the AMDAR system to be implemented in Kenya?
A: It is recommended that the AMDAR data display and analysis software should be incorporated in the forecaster’s workstation.

Q3: How can the international users access weather advisories for airports in USA especially New York?

A: The advisories can be accessed from the AWC website (https://www.aviationweather.gov/)

Data that can be used to improve/validate model weather forecasts

In summary the three presenters demonstrated the value of AMDAR data in locating and zoning the extreme weather formation and events.

**Workshop Proceedings for Day 2:**

**KMD-KQ New Forecast Products Needs Assessment: John Nalianya, Charles Mugah**

Through guided Panel discussion, Messrs. John Nalianya (KQ) and Charles Mugah crystalized areas of concern that need urgent joint attention. The workshop participants recommended concerted effort and action in:

1. **Improved efficiency**

   It was agreed that KQ need to improve operation efficiency so that it can reduce on cost of fuel and accelerated crew fatigue. KMD need to provide Early Warning of the extreme weather event through accurate and sustained forecast products and services.

2. **Improved safety**

   It was recommended that a Rapid Communication System be developed and/or enhanced between/among KMD-KQ and ATC. Team of three comprising Nalianya (KQ), Keziah (KCAA), Charles Mugah (KMD) and Patrick M. (KQ) was formed to work on finer detail on this recommendation. The team is expected to submit their findings on or before 24th May 2018.

3. **CSR**

   Need to assess operational costs such as fuel use analysis and the information used to improve forecast products. Accurate forecast will minimize diversions and safe the environment from unnecessary pollution from extra fuel burned. It demands improved information flow.

4. **ACDM**

   Daily Central Flow Management Control Unit (CFMCU) updates and coordinated arrivals, departures Approach sequencing of aircrafts require accurate Weather information. Hence need for KQ-KMD open communication on general weather outlook of major destination airports in Kenya and other African regions. Kenya Airports Authority needs to be included in
the deliberations as a key stakeholder. Mr Nalianya (KQ) and Mr. Migiro (KMD) to explore
the subject further.

5. Competency of the aviation forecaster vis-à-vis ICAO requirements on use of AMDAR
data.

Plenary Discussions and Workshop Outcomes and Recommendations

Workshop Proceedings Recommendations

Following the Work Group brainstorming session, the identified gaps and recommendations
were summarized into action points as outlined below:

WG 1: AMDAR Data Application in NWP

1. KMD can apply the open source Grid Point Statistical Interpolation (GSI) 3DVAR
assimilation package. The GSI has a strong community support led by the National
Centre for Atmospheric Research of the University Corporation of Atmospheric Research
(NCAR/UCAR) through the Development Test beds Centers (DTC) that hold annual
tutorial workshops on the use of the GSI at Boulder, Colorado. In addition little
programming skill set is required to implement the GSI

2. Model Data Assimilation Cycles to be determined by the AMDAR data coverage density
for the country/region. Proposed to initially start with 12hours ‘windows’ Data assimilation
cycle.

3. KMD and NOAA to have an Memorandum of Understanding (proposed) in order to fast
track collaboration of the two institutions on the implementation of AMDAR Data
assimilation at KMD and further developments of the NWP component

4. Verification and validation of AMDAR data use in forecasting models. A research team to
be created to look into this activity.

5. Detailed KMD concept notes on various priority actionable activities e.g. capacity building
and including timelines

WG2: Aviation Operations

6. Improved efficiency in flight planning with improved accurate predictions and avoidance
of uplift of unnecessary extra fuel load. Avoidance of severe weather that could result in
aircraft damage hence reduced maintenance cost

7. Improved Safety resulting from accurate warning of severe weather phenomenon from
input of AMDAR data

8. Electronic (PIREP) communication channels between all the airports, KQ and KMD. A
team to be formed to look into this challenge, and the development of TORs by the team.
9. Possibility of having AWOS display and AMDAR value added products available directly to the cockpit/pilot.

10. Detailed KQ concept notes on various priority actionable activities e.g. capacity building and including timelines.

**WG3: Improve Existing Forecasts and Products**

11. Data Display and retrieval – An easy to use portal to display AMDAR data need to be developed.

12. Applications using AMDAR Data for wind shear, Thunderstorms and crosswinds need to be developed. E.g. Tephigram

13. KMD to apply for the NOAA AMDAR data account in readiness for the operational phase

14. Take-off data for more than 3 hours will continue to be a challenge due to the limitation in model runs.

15. There seems that the communication system between Airports and KMD HQ is not very reliable and needs to be strengthened.

16. Data accessibility by all stakeholders in a format that is user friendly to all stakeholders

17. Tropopause is not well forecasted by the models and forecasters need to use other methods to determine its height.

18. Redundancy of the aviation forecaster systems is needed.

**WG 4: Capacity Building**

19. Training gap for Data assimilation and application in operational use e.g. fog product

20. Competency assessment according to international standards

21. Capacity building in Data Assimilation, Data assimilation error analysis and WRF verification skills. For example, this could be achieved through the African Desk of NOAA which could be relocated to Boulder.

22. Development of joint capacity development programs for all stakeholders involved in the application and use of AMDAR data.

**Roadmap on Progressing the Recommendations**

1. Fast tracking of the MOU between KMD, NOAA and WMO in the next few months in order to establish a robust capacity building programme for data assimilation staff.

2. It was agreed that KQ need to improve operations efficiency so that it can reduce on cost of fuel and accelerated crew fatigue. KMD to provide Early Warning of the extreme
weather events through accurate and sustained forecast products and services arising from the uptake of AMDAR data. Monitoring of the feedback of current forecast products being provided to KQ for improvement of the accuracy of the early warning forecast products

3. Model Data Assimilation Cycles to be determined by the AMDAR data coverage density for the country/region. Proposed to initially start with 12hours ‘windows’ Data assimilation cycle. Data assimilation to be implemented in collaboration with NOAA experts once the AMDAR data start streaming in from the KQ aircrafts.

4. Verification and validation of AMDAR data use in forecasting models. A research team to be constituted by KMD to look into this activity in the next one month.

5. Detailed KMD concept notes on various priority actionable activities e.g. capacity building and including timelines to be completed by end of the third quarter of 2018.

6. Electronic (PIREP) communication channels between all the airports, KQ and KMD. A team to be formed by the stakeholder institutions to look into this challenge, and the development of TORs by the team in the next two months.

7. Detailed KQ concept notes on various priority actionable activities e.g. capacity building and including timelines to be finalized by end of the third quarter of 2018.

8. Data accessibility by all stakeholders in a format that is user friendly to all stakeholders. This is to be factored during the implementation of the K-ADPS

Conclusion

The meeting agreed that a fast tracking of the memorandum of understanding with the international centers of excellence such as NOAA will help in accelerating the implementation of the AMDAR data in NWP models currently operating at KMD. Meeting further agreed that there is urgent need to improve the electronic communication between the involved collaborator, namely; KQ, KMD and KCAA. Once the AMDAR data start streaming in it is expected that there will be improvement of the forecast products, will lead to efficiency in the aircraft operations and safety.
Annex 1: Participants of the Workshop for the improvement of Weather Forecasts:

1. International
   1. Mr Dean Lockett - Scientific Officer, WMO
   2. Mr Eric James - CRES Associate Scientist III, NOAA/ESRL
   3. Mr Luthando - Senior Forecaster: Aviation Operations SAWS
   4. Mr Andy Fischer, - Aviation Weather Center (AWC), USA

2. KMD Participants:
   6. Mr. Peter Ambenje - Director, KMD
   7. Ms. Stella Aura, MBS - Principal IMTR (WMO-RTC)
   8. Mr. Samuel Mwangi - Deputy Director Forecasting, KMD
   9. Mr. Benard Chanzu - Senior Assistant Director, Forecasting, KMD
  10. Ms. Bahati Musilu - OP, KMD
  11. Mr. Charles Mugah - AMDAR KMD Focal Point
  12. Mr. Samuel Machua - KMD AMDAR Team
  13. Mr. David Muchemi - KMD AMDAR Team
  14. Mr. Sospeter Muiruri - KMD, Aviation expert
  15. Mr. Peter Mutai - KMD AMDAR Team
  16. Mr. John Mungai - KMD AMDAR Team
  17. Mr. Ezekiel Muigai - Assistant Director, Forecasting, KMD
  18. Mr. Japheth Migiro - OIC JKIA, KMD
  19. Mr. Claudius Ogundu - Aviation products User, KMD
  20. Mr. Francis Wachakula - Aviation products User, KMD
  21. Mr. Nicholas Maingi - IRD, KMD
  22. Ms. Naomi G. Gicheru - JKIA, KMD
  23. Dr. Muita Richard - Research & Training, IMTR (WMO-RTC)
  24. Mr. Daniel Wepukulu - PWS/International Relations
  25. Ms. Emmah Mwangi - NWP, KMD
  26. Mrs. Christine Maonga - Customers, KMD
  27. Mr. Edward K. Ngure - Moi International Airport, Mombasa
  28. Mr. Vitalis Cosogho - Kisumu International Airport, Kisumu
  29. Mr. Elisha Chanzu - Eldoret International Airport, Eldoret

3. KQ participants:
   30. Mr. John Nalinya - Head of Operations Control Centre
   31. Mr. Joseph Munyani - Manager Flight Operations
   32. Ms. Jemimah Mwebia - Flight Operations Engineer
   33. Mr. Benson Gathiaka - Development Engineer
   34. Mr. Patrick Muisyo - Manager Flight Dispatch
   35. Mr. Moses Oduma - Aircraft Systems
   36. Capt. Martin Butt - Ag. Chief Pilot/Flight Operations, KQ
   37. Ms. Kezia Ogutu - Manager Air Traffic Services, KCAA
   38. Ms. Nancy Rotich - Kenya Airport Authority
   39. Mr. David Muhati - Kenya Civil Aviation Authority
Annex 2: Meeting Agenda and Proceedings

Tuesday 9th May 2018

8.30a.m. - Registration/ Tea, coffee
9:30a.m. - Participants and invited guests seated

Mr. Charles Mugah, Senior Assistant Director Aeronautical Meteorological Services welcomes all and introduces participants.

Mr. John Nalianya, Kenya Airways Representative

Mr. Dean Lockett, World Meteorological Organization

Mr. Peter Ambenje, Director Meteorological Service and PR of Kenya with WMO makes his remarks and invites the guest of honor to read his speech.

Hon. Mohamed Elmi, MBE, EGH, Chief Administrative Secretary, Ministry of Environment and Forestry reads his speech and officially opens the Workshop

Vote of Thanks: Stella Aura, MBS Deputy Director WMO-RTC/Institute for Meteorological Training and Research, Nairobi

STAKEHOLDER WORKSHOP FOR SCOPING AND DEVELOPMENT OF NEW FORECAST PRODUCTS USING AMDAR DATA

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Agenda Items</th>
<th>Facilitator</th>
<th>Master of Ceremony</th>
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| Day 1:
  Wednesday, 9 April 2018  | 09:00 – 09:35AM  | Registration of Participants      | IRD         | Samuel Mwangi      |
|                            | 09:35 – 10:05AM  | Official Opening Ceremony
  - Guest of Honor          | IRD
  See Subsidiary Programme | Samuel Mwangi      |
<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Presenter</th>
<th>Rapporteur</th>
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<tbody>
<tr>
<td>10:05 – 10:35AM</td>
<td>Key Note Presentation on WMO-AMDar</td>
<td>Dean Lockett - WMO</td>
<td>Ezekiel Njoroge</td>
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<td>10:35 – 11:05PM</td>
<td><strong>Health Break</strong></td>
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<tr>
<td>11:05 – 11:35PM</td>
<td>Key Note Presentation by NOAA Expert - On AMDAR Data Assimilation &amp; Application in NWP</td>
<td>Eric James - NOAA</td>
<td>Ezekiel Njoroge</td>
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<tr>
<td>11:55-12:20</td>
<td>Key Note Presentation by AMDAR Data Expert - Aviation forecasting using AMDAR data</td>
<td>South Africa Weather Service Luthando Masimini</td>
<td>Samuel Machua</td>
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<tr>
<td>12:20 – 12:40</td>
<td>AMDAR project aspects focusing on the processes and funding for developing forecast services</td>
<td>WMO</td>
<td>Claudius Ogundu</td>
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<td>12:40 – 13:00</td>
<td>Overview of K-ADPS</td>
<td>Samuel Machua</td>
<td>David Muchemi</td>
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<td>13:00 – 14:00PM</td>
<td><strong>Lunch</strong></td>
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**Parallel Break Out Sessions:**

**Session Chair:** John Nalianya

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<th>Time</th>
<th>Topic</th>
<th>Presenter</th>
<th>Rapporteur</th>
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<tbody>
<tr>
<td>14:00 - 15:30 PM</td>
<td>WG on Data Assimilation into NWP models</td>
<td>Mr. Eric James, NOAA</td>
<td>John Mungai</td>
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<tr>
<td>Time</td>
<td>Session</td>
<td>Chair(s)</td>
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<tr>
<td>10:45 – 11:00</td>
<td>Health Break</td>
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<tr>
<td>11:00 – 12:00</td>
<td>Setting Targets KMD-KQ New Forecast products Needs Assessments</td>
<td>John Nalianya - KQ</td>
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<tr>
<td>12:00 - 13:00</td>
<td>KMD-KQ New Forecasting Applications Needs Assessments</td>
<td>Charles Mugah-KMD</td>
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<td>13:00 – 14:00</td>
<td>Lunch</td>
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<tr>
<td>Time</td>
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<td>Speaker 1</td>
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<td>14:00 – 14:45</td>
<td>KMD- KQ to develop framework for new forecast products based on the need assessment</td>
<td>Samuel Mwangi</td>
<td>John Mungai</td>
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<td>14:45 - 15:45-</td>
<td>Plenary and Discussions</td>
<td>Samuel Mwangi</td>
<td>Benson Gathiaka</td>
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<td>15:45-16:15</td>
<td>Health Break</td>
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<td>16:15 – 17:00</td>
<td>Closing of Workshop</td>
<td>Peter Ambenje &amp; WMO</td>
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