TANZANIA COMMUNICATIONS REGULATORY AUTHORITY

RADIO FREQUENCY BAND PLAN FOR METEOROLOGICAL COMMUNICATION SERVICES

First Version

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RADIO FREQUENCY BAND PLAN FOR METEOROLOGICAL COMMUNICATION SERVICES

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Table of Contents

Acronyms and Abbreviations

For the purpose of this document, the following abbreviation applies: -

DCS	Data Collection Systems
DCPs	Data Collection Platforms
EESS	Earth Exploration-Satellite Service
GSO	Geostationary Orbit
Non- GSO	Non- Geostationary Orbit
IDCS	International Data Collection System
MetSat	Meteorological Satellite
RR	ITU Radio Regulations
MetAids	Meteorological Aids
NAVAID	Navigational Aid
GNSS	Global Network Satellite Systems
WPR	Wind Profile Radar
VLF	Very Low Frequency (3-30 kHz)
VHF	Very High Frequency (30-300 MHz)

PART 1: Introduction

The Tanzania Communications Regulatory Authority (TCRA) Act of 2003, and Electronic and Postal Communications Act of 2010, mandate TCRA to manage, assign and promote the efficient use of the radio frequency spectrum resource in the United Republic of Tanzania.

The radio frequency spectrum is part of electromagnetic waves propagated in space and used as a communication medium for all wireless systems. The radio frequency spectrum is a scarce public resource, thus subject to transparent, predictable and coherent governing policies, legislations and regulations. Therefore, it requires proper and timely management in order to accommodate the current and future emerging technologies.

Radio frequency spectrum supports a wide range of services including meteorological services, maritime services, mobile broadband, radio and television broadcasting, satellite communication, Wi-F, amateur services, amateur satellite services, aeronautical communications, defense, emergency services and multiple applications such as two-way radio communication. These services which use radio communications underlie many aspects of our lives, therefore how spectrum is managed and made available for use is of critical importance.

The radio frequency band plan for Meteorological Communication Services is in line with the National Frequency Allocation Plan (NFAP) and frequency allocation under International Telecommunication Union (ITU) Region 1.

The weather, water and climate community relies on the radio frequency spectrum for two vital functions: (1) to observe the earth (e.g., with satellites, weather radars, and wind profilers) and (2) to transmit data about the earth system to meteorologists, hydrologists, emergency managers, and other scientists throughout the country. These uses of radio frequencies benefit a wide range of social and economic sectors by supporting operational services that protect life and property and by helping scientists on understanding of the earth system. The radio frequency spectrum is a limited resource which is subject to intense and growing competition, particularly with the rapid expansion of wireless communication.

Observations of the earth system are made using ground-based, airborne, and space-based platforms. Radio waves are reflected, absorbed, scattered, refracted, and diffracted by the atmospheric conditions that they encounter, such as clouds and precipitation. Critically, the different atmospheric conditions impact radio waves differently. Radio waves allows scientists to detect tornados, track hurricanes, and to determine a wide range of meteorological conditions such as atmospheric humidity, cloud types and amounts, wind speeds and direction, and precipitation types and amounts. Radio waves can also determine wave heights in oceans and lakes, storm surge, and ocean currents, among other conditions of the earth system.

Furthermore, determining atmospheric conditions requires the use of specific radio frequencies for which substitution is not possible.

The scientific community uses the radio spectrum in three ways: -

(i) Passive remote sensing, in which scientists measure the natural radio frequency emissions from the environment and space. This requires the use of receiver only systems. These are generally located on a space-based platform.

(ii) Active remote sensing, in which scientists emit radio waves in to the atmosphere and measure their transmission. This requires the use of both a transmitter and a receiver system.

(iii) Data transmission, in which radio waves are used to distribute information. For environmental data, this may include broadcasting information directly from a satellite to users throughout the country.

The timely and uninterrupted access to weather forecasts, climate information, and ocean conditions that these meteorological uses make possible is central to community preparedness and response to existing hazards and emerging threats.

PART 2: Scope and Purpose

This document details the Radio Frequency Bands allocated for meteorological communication services such as Meteorological Satellite (MetSat), Meteorological Aids (MetAids), Earth Exploration-Satellite Service (EESS), Space research and weather radars.

It explains on the importance of the specific radiocommunication services for meteorological and related environmental activities required for the detection and early warning of hazards and the prevention and mitigation of natural and technological (human-induced) disasters, the safety of life and property, the protection of the environment, climate change studies and scientific research. It further elaborates the concept of Meteorological Satellite (MetSat) systems, meteorological satellite services (MetSat), meteorological aids (MetAids) services, types of meteorological radars and types of weather observations.

PART 3: Recommendations related to meteorological radiocommunications services

RECOMMENDATIONS	TITLE
Recommendation ITU-R M.1849-1	Technical and operational aspects of ground-based meteorological radars
Recommendation ITU-R RS.515	Frequency bands and bandwidths used for satellite passive sensing
Recommendation ITU-R RS.577	Frequency bands and required bandwidths used for spaceborne active sensors operating in the Earth exploration-satellite (active) and space research (active) services
Recommendation ITU-R RS.1166	Performance and interference criteria for active spaceborne sensors
Recommendation ITU-R RS.2017	Performance and interference criteria for satellite passive remote sensing

PART 4: Meteorological Satellite Systems

4.1 Concept of Meteorological Satellite (MetSat) Systems

MetSat are Meteorological satellites designed and equipped with instruments for observation and monitor the Earth's atmosphere and weather conditions. MetSat commonly uses visible and infrared images as well as passive and active sensing instruments to collects a variety of data using microwave frequencies allocated for that purpose.

The raw data gathered by the instruments on-board geostationary meteorological satellites are permanently transmitted to a primary ground station of the operating agency, processed, and distributed to various national meteorological centers, to official archives, and to other users. Raw data, for example, include images of the Earth taken at several wavelengths so as to provide a variety of measurement data. Processed data are either sent back to the meteorological satellite for re- transmission as part of a direct broadcast to user stations via low and/or high rate digital signals or are directly distributed to users by using alternative means of data dissemination.

Different to geostationary MetSat satellites, where the satellite is permanently in visibility of its ground stations, the raw data acquired by the instruments on non- geostationary meteorological satellites have to be gathered and stored on-board the satellite until they can be transmitted to a primary ground station of the operating agency when the satellite passes over such a ground station. The raw instrument data are then processed by the operating agency and provided to the users by different data dissemination mechanisms. To improve the latency of the data, a subset of the data acquired by the instruments are "broadcasted" directly from the satellite and can be received by user stations when the satellite is in the visibility of such a user station which can be located anywhere. Such a service is called "direct read-out".

Meteorological satellites, geostationary and non-geostationary, also carry Data Collection Systems (DCS), namely Data Collection Platforms (DCPs) on geostationary orbit (GSO) satellites and systems such as Argos on non- geostationary orbit (non-GSO) satellites.

DCPs, typically located on ground, aircrafts, ships and floating buoys, transmit to geostationary meteorological satellites. The data collected by such DCPs are on parameters such as surface temperature, wind velocity, rainfall rate, stream height, gases in the atmosphere, and in the case of floating buoys, oceanic pollutants. They may also transmit their current position, allowing movement to be determined. In addition to the operation of regional DCP channels, MetSat operators also contribute to the International Data Collection System (IDCS) through the operation of international channels. As an additional application, a dedicated number of IDCS channels can also be allocated for use by an emergency/disaster monitoring system. Data collection platforms such as of the Argos system transmit to non-GSO MetSat satellites. When installed on buoys and floats, such platforms measure atmospheric pressure, wind speed and direction, sea surface currents and other sea parameters. Among other applications DCS on non-GSO satellites are also used to track animal movements as well as to monitor fishing fleets. The figure below shows the general architecture of a MetSat system.

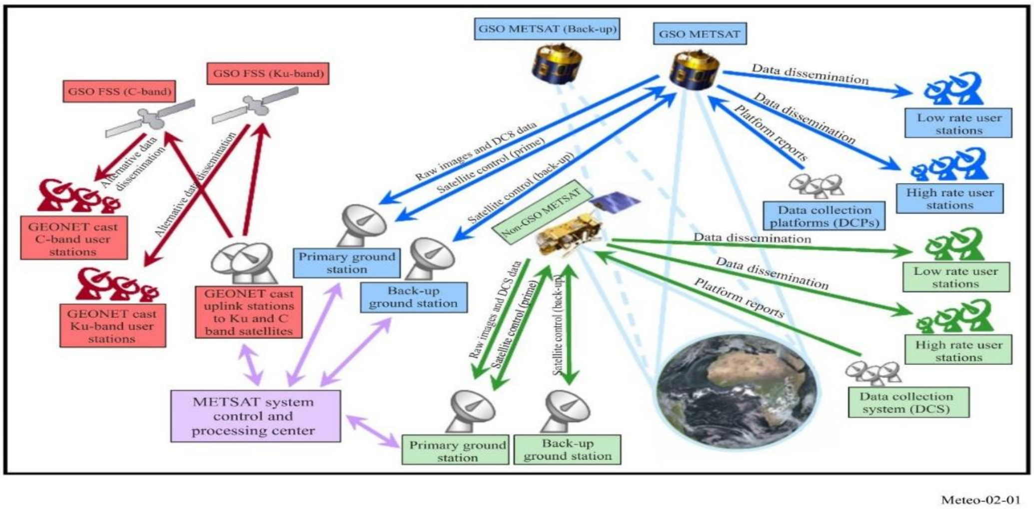

Figure 1: General architecture of a MetSat system

Source: ITU Handbook on Use of Radio Spectrum for Meteorology

4.2 Meteorological Satellite Services (MetSat)

The meteorological satellite service (MetSat) is defined in No. 1.52 of the Radio Regulations (RR) as “an earth exploration-satellite service for meteorological purposes”. It allows the radiocommunication operation between earth stations and one or more space stations, which may include links between space stations, with links to provide:

(i) Information relating to the characteristics of the Earth and its natural phenomena, including data relating to the state of the environment, obtained from active or passive sensors on Earth satellites;

(ii) Information collected from airborne or Earth-based platforms;

(iii) Information distributed to earth stations;

(iv) Feeder links necessary for the operation of MetSat and its applications.

4.3 Frequency bands allocations

The following section describes the Frequency allocations to MetSat and Earth exploration-satellite service (EESS) in National Frequency Allocation Plan (NFAP) as reflected from the ITU Radio Regulations for use by meteorological satellites for data transmissions.

Table 1: Frequency allocations to MetSat

S/N	Frequency	Allocated Service
1.	137-138 MHz (space-to-Earth)	MetSat - Primary
2.	400.15-401 MHz (space-to-Earth)	MetSat - Primary
3.	401-403 MHz (Earth-to-space)	EESS and MetSat – Primary
4.	400.15-401 MHz (space-to-Earth)	MetSat – Primary
5.	432 – 438 MHz	EESS(active) – Secondary
6.	460-470 MHz (space-to-Earth)	MetSat – Secondary
7.	1215 – 1300 MHz	EESS(active) – Primary
8.	1400 – 1427 MHz	EESS(passive) – Primary
9.	1525 – 1535 MHz	EESS - Secondary
10.	1670-1690 MHz (space-to-Earth)	MetSat – Primary
11.	1700-1710 MHz (space-to-Earth)	MetSat – Primary
12.	2025 - 2110 MHz (Earth-to-space),(space-to-space)	EESS – Primary, (Note 1)
13.	2200-2290 MHz(space-to-Earth) , (space-to-space)	EESS – Primary, (Note 1)
14.	2655 – 2670 MHz	EESS (passive) - Primary
15.	2670 – 2690 MHz	EESS (passive) - Secondary
16.	2690 - 2700 MHz	EESS (passive) - Primary
17.	3100 – 3300 MHz	EESS (active) - Secondary
18.	5250 – 5570 MHz	EESS (active) - Primary
19.	7190 – 7235 MHz (Earth-to-space)	EESS - Primary
20.	7235 – 7250 MHz	EESS - Primary
21.	7450-7550 MHz (space-to-Earth)	MetSat - Primary, limited to geostationary satellites only
22.	7750-7900 MHz (space-to-Earth)	MetSat - Primary, limited to non-geostationary satellites only
23.	8025-8400 MHz (space-to-Earth)	EESS - Primary
24.	8175 - 8215 MHz (Earth-to-space)	MetSat - Primary
25.	8550 – 8650 MHz	EESS (active) - Primary

S/N	Frequency	Allocated Service
26.	9200 – 9800 MHz	EESS (active) - Primary
27.	9800 – 9900 MHz	EESS (active) - Secondary
28.	9.9 – 10.4 GHz	EESS (active) - Primary
29.	10.6 – 10.7 GHz	EESS (passive) - Primary
30.	13.25 – 13.75 GHz	EESS (active) - Primary
31.	13.75 – 14.0 GHz	EESS - Secondary
32.	14.8 - 15.35 GHz	Space Research - Primary
33.	15.35 – 15.4 GHz	EESS (passive) - Primary
34.	17.2 – 17.3 GHz	EESS (active) - Primary
35.	18.1-18.4 GHz (space-to-Earth)	MetSat - Primary, limited to geostationary satellites only
36.	18.6 – 18.8 GHz	EESS (passive) - Primary
37.	21.2 – 21.4 GHz	EESS (active) - Primary
38.	22.21 – 22.5 GHz	EESS (passive) - Secondary
39.	23.6 – 24 GHz	EESS (passive) - Primary
40.	24.05 – 24.25 GHz	EESS (active) - Secondary
41.	25.5-27.0 GHz(space-to-Earth), (space-to-space direction in 25.25-27.5 GHz)	EESS – Primary, (Note 1)
42.	28.5-30.0 GHz (Earth-to-space)	EESS - Secondary (Note 1)
43.	31.3 – 31.8 GHz	EESS (passive) - Primary
44.	35.5 – 37 GHz	EESS (passive) - Primary
45.	37.5 - 40.5 GHz (space-to-Earth)	EESS – Secondary, (Note 1)
46.	39.986-40 GHz (space-to-Earth)	Space Research - Secondary
47.	40.0-40.5 GHz (Earth-to-space)	EESS - Primary (Note 1)
48.	40-40.02 GHz (space-to-Earth)	EESS (active) - Secondary, Space Research-Secondary
49.	40.02-40.98 GHz (space-to-Earth)	EESS (active) - Secondary

S/N	Frequency	Allocated Service
50.	40.98-41.015 GHz (space-to-Earth)	EESS (active) - Secondary, Space Research - Secondary
51.	41.015 – 42 GHz (space-to-Earth)	EESS (active) - Secondary
52.	42 - 42.5 GHz (space-to-Earth)	EESS (active) - Secondary
53.	44 – 47 GHz (space-to-Earth)	EESS (active) - Secondary
54.	47 - 50 GHz (space-to-Earth)	EESS (active) - Secondary
55.	50.2 – 50.4 GHz	EESS (passive) – Primary
56.	52.6 – 59.3 GHz	EESS (passive) – Primary
57.	65.0-66.0 GHz	EESS –Primary (Note 1)
58.	86.0 – 92.0 GHz	EESS (passive) – Primary
59.	94.0 – 94.1 GHz	EESS (passive) – Primary
60.	100 – 102.0 GHz	EESS (passive) – Primary
61.	109.5 – 111.8 GHz	EESS (passive) – Primary
62.	114.25 – 122.25 GHz	EESS (passive) – Primary
63.	130 – 134 GHz	EESS (active) – Primary
64.	148.5 – 151.5 GHz	EESS (passive) – Primary
65.	164.0 – 167.0 GHz	EESS (passive) – Primary
66.	174.8 – 191.8 GHz	EESS (passive) – Primary
67.	200.0 – 209 GHz	EESS (passive) – Primary
68.	226.0 – 231.5 GHz	EESS (passive) – Primary
69.	235.0 – 238 GHz	EESS (passive) - Primary, Space Research (passive) – Primary
70.	239.2 – 240 GHz	EESS (passive) – Primary
71.	240-241 GHz	EESS (passive) – Primary
72.	241-242.2 GHz	EESS (passive) – Primary
73.	244.2-247.2 GHz	EESS (passive) – Primary
74.	250.0 – 252.0 GHz	EESS (passive) – Primary

S/N	Frequency	Allocated Service
Note 1 − Since the MetSat is a sub-class of EESS, those allocations (for example: 8025-8400 MHz and 25500-27000 MHz) can also be used for the operation of MetSat satellites and their applications.		

PART 5: Meteorological Aids (MetAids) Services

The meteorological aids (MetAids) service is defined in No. 1.50 of the Radio Regulations (RR) as a radiocommunication service used for meteorological, including hydrological, observations and exploration. In practice, MetAids service usually provides the link between a sensing system for meteorological parameters and a remote base station. The sensing system may be carried, for instance, by a weather balloon. Alternatively, it may be falling through the atmosphere on a parachute after deployment from an aircraft or meteorological rocket. The base station may be in a fixed location, or mounted on a mobile platform.

5.1 Radio Frequency bands used for MetAids Systems

The following are the radio frequency bands used for MetAids Systems: -

- 8.3kHz – 9.0kHz
- 9.0kHz – 11.3kHz
- 2.025MHz – 2.045MHz (MetAids secondary)
- 153MHz – 154MHz (MetAids secondary)
- 400.15 - 401 MHz
- 401 - 402 MHz
- 402 - 403 MHz
- 403 - 406 MHz
- 1668.4 - 1670 MHz
- 1670 - 1675 MHz
- 1675 - 1690 MHz
- 1690 - 1700 MHz
- 35.2 - 36 GHz

5.2 Examples of MetAids sensing systems

5.2.1 Radiosondes

More than 800,000 radiosonde flights are carried out each year worldwide. The base station sites used to launch the radiosondes are usually specially equipped so that the balloons can be launched in all weather conditions. The most critical sites are equipped with emergency power supplies and accommodation so that the measurements can continue even if the local infrastructure is damaged by extreme weather or other circumstances such as an industrial accident. A typical radiosonde contains several major components: a transmitter, battery, sensor pack, and usually a navigational aid (NAVAID/GNSS e.g. GPS) receiver. The transmitter transmits the data to the receiving station. Radiosondes typically use lithium or alkaline batteries that can withstand temperatures of −90° C. The sensor pack contains the sensors that measure the atmospheric conditions such as temperature, pressure, humidity, and in special cases ozone or ionizing radiation. The sensor pack also encodes the sensor values sufficiently to transmit them to the ground station. Radiosonde systems measure winds by tracking their balloon's motion through the atmosphere. Active tracking systems use primary (tracking of a reflector for radar signals suspended below the balloon) or secondary (tracking of a transponder integrated into a radiosonde) radar tracking. Passive tracking system use NAVAID/GNSS receivers or, in some coast areas, LORAN-C re-transmitters on the payload and transmit this data to the ground station, or radiotheodolite tracking of radiosonde signals.

Figure 2: A radiosonde flight train

Source: ITU Handbook on Use of Radio Spectrum for Meteorology

5.2.2 Dropsondes

Dropsondes have components similar to radiosondes, but are built such that they can be dropped from aircraft to profile the atmosphere while descending under a parachute. See Figure 3 and 4. Since operation of a large tracking antenna is impractical on aircraft, all dropsondes are operated in the 401-406 MHz band and utilize NAVAID/GNSS for wind measurement. Operationally, dropsondes are deployed at a much higher density in space and time than radiosondes. They are primarily used in tracking and profiling tropical storms at sea. Up to 16 dropsondes may be placed in flight and tracked simultaneously. The high density of deployment necessitates the use of highly stable narrow-band transmitters, similar to those used in the denser parts of the radiosonde network. Dropsondes are also used for profiling weather phenomena or the basic atmospheric state in remote oceanic regions, and occasionally over land.

Figure 3: A dropsondes flight

Source: Handbook on Use of Radio Spectrum for Meteorology

5.2.3 Rocketsondes

Rocketsondes are a more specialized MetAids system. Like the dropsondes, they are released from rocket that has reached a high altitude and profile the atmosphere during a parachute-controlled descent. Rocketsondes may contain the same basic components as radiosondes, but the sensing packages for high altitude measurements may differ from those systems used in the lower parts of the atmosphere. Unlike dropsondes, they may employ either radio direction finding or NAVAID/GNSS for wind measurement. Most rocketsondes are launched to very high altitudes and are typically used in support of space launch operations. Because the deployment of the rocketsondes is expensive, the use of higher quality transmitters is necessary.

Figure 4: Upper Air Station at Julius Nyerere International Airport

Source: TMA

5.2.4 Lightning Detector Systems

The Lightning sensors detect the wideband (LF/VLF) electromagnetic field signature of the lightning discharge, and extract features from these transient waveforms. The sensors detect lightning with an approximate bandwidth of 1 to 350 kHz. Incoming signals are analyzed using a digital signal processing platform.

In order to detect lightning strikes, RF sensors and light pulse sensors can usefully be connected together. If such a system is pointed toward a cloud and lightning occurs in that cloud, both RF signals and light pulses will be received and the user can be sure the cause was lightning. When a lightning discharge occurs within a cloud at night, the entire cloud appears to illuminate. In daylight these intra-cloud flashes are rarely visible to the human eye; nevertheless, optical sensors can detect them. With advance in technology, lightning detection system has improved sensitivity and intra-cloud lightning detection efficiency. These improvements have led to the lightning detection systems be extensively used for Storm location, microburst prediction, Storm identification, storm tracking, storm intensity quantification and as early warning tool. Frequency used for Lightning detection system is in range of 8.3- 11.3 kHz.

PART 6: Meteorological Radars

Ground-based meteorological radars operate under the radiolocation service and are used for operational meteorology, weather prediction, atmospheric research and aeronautical and maritime navigation. Most weather are in operation continuously twenty-four (24) hours per day and play a crucial role in the immediate meteorological and hydrological alert processes. These radars represent the last line of defense against loss of life and property in flash flood or severe storms events and as such are among the best- known life savers in meteorology.

Meteorological radars are typically volume scanning, pencil beam radars which detect and measure both hydrometeor intensities and wind velocities. They are used to predict the formation of hurricanes, tornadoes and other severe weather events and to follow the course of storms on their destructive paths. Modern radars permit the tracking of large and small storms and provide information on precipitation rates, which is used by forecasters in predicting the potential for flash floods. In addition, they provide relevant information on high winds and lightning potential. Meteorological radars are also of a prime interest in aeronautical weather service in particular for detection of aircraft icing conditions and avoidance of severe weather for navigation.

6.1 Meteorological Radar Types

The first and most familiar of the radar types is the **weather radar.** These radars provide data within a volume, which is centered on its own location. Familiar to many, the output of these radars is commonly shown in television weather forecasts. Section 7.2 of this band plan, provides the listing of frequency bands which are commonly used for weather radars operations. **Wind profiler radar (WPR)** is a second type of meteorological radar. The radio frequency bands used by the WPR are typically located around 50 MHz, 400 MHz, 1000 MHz and 1300 MHz. A third, less common type of meteorological radar is **auxiliary radar** which is used to track radiosondes in flight. A fourth radar type used in meteorology is cloud radars. These radars operate normally around 35GHz and 94GHz because of relatively low atmospheric attenuation. Cloud radars are used for studying microphysical properties of clouds and other particles within the sensitivity range of the radar system.

6.2 High Frequency (HF) Radar Systems

High frequency (HF) radar systems measure the speed and direction of ocean surface currents in near real time and in high spatial and temporal resolution over a large region of the coastal ocean, from a few kilometers offshore up to about 200 km, and can operate under any weather conditions. These high quality currents data are necessary for the provision of reliable results by a variety of oceanographic applications, such as ocean circulation models, prediction of surface pollutants movement, sea rescue operations, prediction of the stress due to currents and wave action on coastal and near-shore structures, ships navigation, commercial and recreational fishery.

HF Radar measurements are based on the fact that electromagnetic radiation in the 3 – 30 MHz range scatters strongly (Bragg scattering) from ocean surface gravity waves. The returned energy spectrum thus indicates movement of ocean surface gravity waves with a wavelength of half the radar-transmitted wavelength in directions either toward or away from the HF radar site. Multiple radars are typically deployed so there is enough angular separation to resolve both the north–south and east–west velocity components.

6.3 Main Weather Radars Frequency Bands

Frequency band (MHz)	Band name commonly used in meteorological community
2700 - 2900	S-Band
5250 - 5725 (mainly 5600 - 5650 MHz)	C-Band
9300 - 9500 MHz	X-Band

Figure 5: S- Band Meteorological Weather Radar Station

Source: TMA

Part 7: Types of Weather Observations

7.1 Upper Air Observation

Upper air observation deals with the observation of atmospheric elements with the help of a balloon filled with hydrogen or helium attached to a radiosonde. This balloon is then released into the atmosphere whilst the radiosonde has already been synchronized with a computer based workstation and readings are being observed. A radiosonde is an electronic device used in the launching of a temp ascent that works in conjunction with some other equipment. The elements observed using this observation method are Temperature, Pressure, Relative Humidity, Wind speed and direction. This information is displayed on the screen of the computer. A 350grams balloon is attached to the radiosonde to carry it aloft into the atmosphere, it will burst when it attains its elastic limit and the radiosonde will begin to fall, this is what is called termination of the temp ascent.

Figure 6: Filling balloon with Hydrogen

Source: TMA Upper Air Station at Julius Nyerere International Airport

Figure 7: Launching ascent for Upper Air observation at Julius Nyerere International Airport

Source: TMA

7.2 Surface Weather Observation

Surface weather observations are the most common form of weather observation which provides the fundamental data used for safety as well as climatological reasons to forecast weather and issue warnings worldwide. The Surface weather observation collection consists primarily of hourly, synoptic (3 hours intermittently), daily, and monthly. These are archived for future reference such as research, forecast and modelling. Surface weather observations are an important aspect of meteorology as they are the basis for all weather safety messages, weather forecasts, and weather warnings worldwide. Observations can be taken manually also known as manned stations or by automatic extensions (automatic weather stations).

7.3 Satellite Weather Observation

The weather satellite is a type of satellite that is primarily used to monitor the weather and climate of the Earth. Satellites can be polar orbiting, covering the entire Earth asynchronously, or geostationary hovering over the same spot on the equator. Meteorological satellites see more than clouds: city lights, fires, effects of pollution, auroras, sand and dust storms, snow cover, ice mapping, boundaries of ocean currents, energy flows, urban areas, mountains, rugged terrains etc. Weather satellites carry instruments called radiometers that scan the Earth to form images to be used for other types of environmental information.

7.4 Remote Observations

Remote observation is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance typically from satellite. Special cameras collect remotely sensed images, which help researchers sense things about the Earth. Some examples are:

(i) Cameras on satellites take images of large areas on the Earth's surface, allowing to see much more than can be seen when standing on the ground.
(ii) Sonar systems on ships can be used to create images of the ocean floor without needing to travel to the bottom of the ocean.
(iii) Cameras on satellites can be used to make images of temperature changes in the oceans.

Some specific uses of remotely sensed images of the Earth include:

(i) Large forest fires can be mapped from space, allowing rangers to see a much larger area than from the ground.
(ii) Tracking clouds to help predict the weather or watching erupting volcanoes, and help watching for dust storms.
(iii) Tracking the growth of a city and changes in farmland or forests over several years or decades.

PART 8: Document Administration

8.1 Amendment

TCRA may from time-to-time, review, and update or modify this document to ensure its continued service and to meet the international and/or national performance requirements as necessary.

8.2 Compliance

Appropriate provisions of the TCRA Act, 2003, the Electronic and Postal Communications Act, 2010 and the Electronic and Postal Communications (Radiocommunication and

Frequency Spectrum) Regulations, 2018, shall be used for compliance of this document and effective from the date it has been published.

8.3 Publication

This document shall be published on the TCRA website https://www.tcra.go.tz for public information, compliance and reference purposes.

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