**Draft report on ground radiometers**

Ground based radiometer used for meteorological measurements are not referred in ITU-R documentation. Question ITU-R 251/7 on ground based passive sensing was used to elaborate a working document towards a preliminary draft new Recommendation ITU-R RS.[GROUND\_PASS\_SENSORS] and this first document was agreed during April 2016 meeting of WP 7C.

During October WP7C’meeting, further modifications were proposed to this working document with the aim to upgrade the document to a preliminary draft new Recommendation.

After some discussions regarding the consideration of all kind of ground based passive sensing and the appropriate protection to apply WP7C agreed that it would be most appropriate to, in a first stage, compile information on the known ground based sensors and to gather the information on them in a preliminary draft new ITU-R Report rather than in a recommendation.

The aim of the document attached is to initiate this compilation in order to provide to the next WP7C’s meeting a working document toward a preliminary draft new Report on ground based passive sensors.

All SG-RFC members are invited to contribute to this report in time for a WMO contribution to WP7C next meeting (April 5-11th 2017).

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|  | **Radiocommunication Study Groups** |  |
| **INTERNATIONAL TELECOMMUNICATION UNION** |  |
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| WORKING DOCUMENT TOWARD A PRELIMINARY DRAFT NEW REPORT ITU-R RS.[ GROUND\_PASS\_SENSORS ] |
| Technical and operational characteristics of Ground-based passive sensors operating in 22 to 1000 GHz frequency range |

TABLE OF CONTENTS

Page

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# Keyword

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## 1 Introduction

This Report provides the technical and operational characteristics of ground-based passive sensors in the range 22-1000 GHz, used by meteorological and radio-astronomy communities.

## 2 Different usages

2-1 Meteorology/climatology

Passive microwave radiometry is a tool of fundamental importance for the Earth observation and passive sensors are designed to receive and measure natural emissions produced by the Earth’s surface and its atmosphere. Passive microwave radiometers are well suited to measure humidity and temperature profiles in the troposphere of the earth, as well as integrated quantities like the integrated water vapour (IWV) and liquid water content of clouds (LWP).

These natural emissions characterize the type and the status of a number of important geophysical atmospheric and surface parameters (land, sea, and ice caps), which describe the status of the Earth/atmosphere/oceans system, and its mechanisms:

– Earth surface parameters such as soil moisture, sea surface temperature, ocean wind stress, ice extent and age, snow cover, rainfall over land, etc.; and

– three-dimensional atmospheric parameters (low, medium, and upper atmosphere) such as temperature profiles, water vapour content and concentration profiles of radiatively and chemically important trace gases (e.g. ozone, nitrous oxide and chlorine).

This all-weather capability has considerable interest for the Earth observation because more than 60% of the Earth’s surface is usually covered with clouds. In addition to this all-weather capability, passive microwave measurements can also be taken at any time of day as they are not reliant on daylight. Passive microwave sensing is an important tool widely used for meteorological, climatological, and environmental monitoring and survey (operational and scientific applications), for which reliable repetitive global coverage is essential.

Meteorologists making detailed local forecasts or scientists investigating the planetary boundary have requirements for atmospheric sounding with better vertical resolution near the ground than can be provided by the satellite systems.

One method of providing this information is to use upward-looking passive remote sensing, with a radiometer mounted at the Earth’s surface. Radiometers are now commercially available for this purpose.

## 2-1-1 Frequency aspects

The main frequencies used for these ground-based microwave measurements are 22.235 and 183 GHz for water vapour, 111, 142, 208 and 273 GHz for ozone, 204 and 278 GHz for chlorine monoxide, 201 and 276 GHz for nitrous oxide (N2O), 203 GHz for hydroperoxyl radical (HO2), 203.4 GHz for isotopic water vapour (H218O), 206 and 269 - 270 GHz for nitric acid, 115 and 230 GHz for carbon monoxide and 266 GHz for hydrogen cyanide (HCN).

Figure 1 and 2 show the sensitivity of millimeter and sub-millimeter frequencies to atmospheric temperature and water vapour variations between 1 and 1 000 GHz. The water vapour and oxygen resonance spectral lines are indicated in the figure as well. The figures show the increasing atmospheric attenuation at higher frequencies and the sizable variability of the attenuation due to water vapour:

– Frequencies below 200 GHz are the most suitable for vertical nadir measurements of the lower layers of the atmosphere.

– Frequencies between 200 and 600 GHz are better suited for vertical nadir measurements of the higher layers of the atmosphere.

– Above 600 GHz the oxygen lines are only visible over regions with very dry atmosphere. Measurements at these frequencies are therefore typically from limb sounders and, in any case, exclusively for the top atmospheric layers.

The retrieval of atmospheric properties (e.g., ice cloud content, ice cloud altitude, rain rate, rain profiles, etc.) requires the use of simultaneous multiple frequency observations for better accuracy. Some important considerations among these bands:

– Frequencies around the water vapour resonance at 325 and 380 GHz and oxygen at 424 and 487 GHz are unique in their opacity and high enough in frequency to permit practical antennae to be used at geosynchronous altitudes, yet low enough for technology to provide practical, sensitive instrumentation.

– Use of the 380 GHz water vapour band helps avoid false alarms over super-dry air masses. Adding channels in the 380 GHz band to operational polar-orbiting satellites allows the retrieval of precipitation over snow-covered mountains and plains and in the driest polar areas where even the most opaque 183 GHz channels become transparent. The only remedy for transparency is a more opaque water vapour band and 380 GHz is the only suitable choice.

– Cloud ice and water vapour are two components of the hydrological cycle in the upper troposphere, and both are currently poorly measured. A number of missions have been proposed that focus on this technique to measure cloud ice water path, ice particle size and cloud altitude to US and European Space Agencies. Currently, these measurements focus on the 183 GHz, 243 GHz, 325 GHz, 340 GHz, 380 GHz, 425 GHz, 448 GHz, 664 GHz and 874 GHz bands. The vertical water vapour and oxygen sounding measurements are typically performed using a set of channels, composed of so-called “wings” and associated “windows”.

– The vertical sounding measurements along the “wings” of the resonance curve under investigation are performed in frequency slots (with a given bandwidth BW) at symmetrical distance (Offset) from the central resonance frequency. This allows characterizing the resonance curve slope at the various atmospheric heights and providing therefore the water vapour and oxygen vertical profiles. The required total frequency band can be defined as the maximum bandwidth (BW) plus twice the maximum offset, centred on the resonance frequency.

Figure 1



Figure 2



Although the channels for ground based remote sensing of temperature and humidity are in a similar region to passive satellite remote sensing, they are not identical to those used by satellites. At some frequencies, satellite remote sensing can safely share with terrestrial services, but ground‑based radiometers may need protection. The number of ground‑based radiometers in operation is still small, but if current developments are successful, larger numbers may be deployed in the future.

Passive remote sensing of other atmospheric constituents, e.g. ozone (in particular at 142 GHz) also benefits from a significant number of ground‑based radiometry sites.

# 2-1-2 Typical characteristics

Some typical characteristics of ground-based radiometers systems are shown below in Table 1.

Table 1

|  |  |  |
| --- | --- | --- |
| Characteristics | System A | System B |
| Platform type (airborne, ship borne, ground) | Ground | Ground |
| Channel center frequencies | 22.24 GHz, 23.04 GHz, 23.84 GHz, 25.44 GHz, 26.24 GHz, 27.84 GHz, 31.4 GHz | 51.26 GHz, 52.28 GHz, 53.86 GHz, 54.94 GHz, 56.66 GHz, 57.3 GHz, 58.0 GHz |
| Antenna type (reflector, phased array, slotted array, etc.) | Corrugated feedhorn + reflector | Corrugated feedhorn + reflector |
| Antenna diagram | Gaussian beam | Gaussian beam |
| Antenna sidelobe level (dB) | <-30 | <-50 |
| Antenna main beam gain (dBi) | 33.2 | 39.8 |
| Antenna height (m) | 1.2 | 1.2 |
| Receiver noise figure (dB) | 2 | 2.5 |
| System noise temperature (°K) | 400 | 600 |
| Minimum discernible signal (dBW) | -148 | -144 |
| Receiver RF 3 dB bandwidth (MHz) | 230 | 600-2 000 |
| Geographical distribution | worldwide | worldwide |
| Fraction of time in use (%) | 100 | 100 |

2-2 Radio-astronomy

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