WORLD METEOROLOGICAL ORGANIZATION

Joint Meeting of
CBS Expert Team on Surface-based
Remotely-Sensed Observations
(First Session)
and
CIMO Expert Team on Remote Sensing
Upper-air Technology and Techniques
(Second Session)

Geneva, Switzerland, 23-27 November 2009

CBS-CIMO Remote Sensing/
Doc. 4.1(5)

(16.XI.2009)

ITEM: 4.1

Original: ENGLISH ONLY

REMOTE SENSING SYSTEMS (SUCH AS GPS, MICROWAVE, AND INFRARED RADIOMETERS, LIDARS, ETC.) FOR THEIR USE IN WIGOS

Report on the suitability and operational aspects of micro-wave radiometry

(Submitted by Arkadiy Koldaev)

Summary and Purpose of Document

The document provides a report on the suitability and operational aspects of micro-wave radiometry.

ACTION PROPOSED

The meeting is invited to review the material provided in this document. The meeting will further be invited to identify whether it is suitable as guidance to Members of whether additional activities need to be carried out to provide appropriate guidance on micro-wave radiometry to Members.

Report on the suitability and operational aspects of microwave radiometry (MWR)

By Dr. Arkadi Koldaev,
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List of Contents

Fundamental background of MWR

The lack of resolution along the path of sounding : All the data are collected as an integral along the path.
The main aim of all MWR system is in the attempt to overlap this difficulty or with angle scanning or with frequency scanning

6.Sounding of the media parameters except temperature

7.Thermal sounding

4.The real physical objects may not have full absorption in the specific range of electromagnetic spectrum. In this case the "Brightness temperature" will not be equal to thermodynamic temperature of the physical object. The coefficient, which rely the thermodynamic temperature with "Brightness temperature" is called "Grayness coefficient": Tb=Tt*Gc And namely this "Grayness coefficient" allow us to get information about the physical object remotely. The point is that Tb can be measured by microwave radiometer, Tt is usually known from routine meteorological measurements, but Gc is defined by the physical mechanism of radiation emission by the different natural objects. So, the information about physical structure of the sounding object is inferred into the Grayness coefficient.

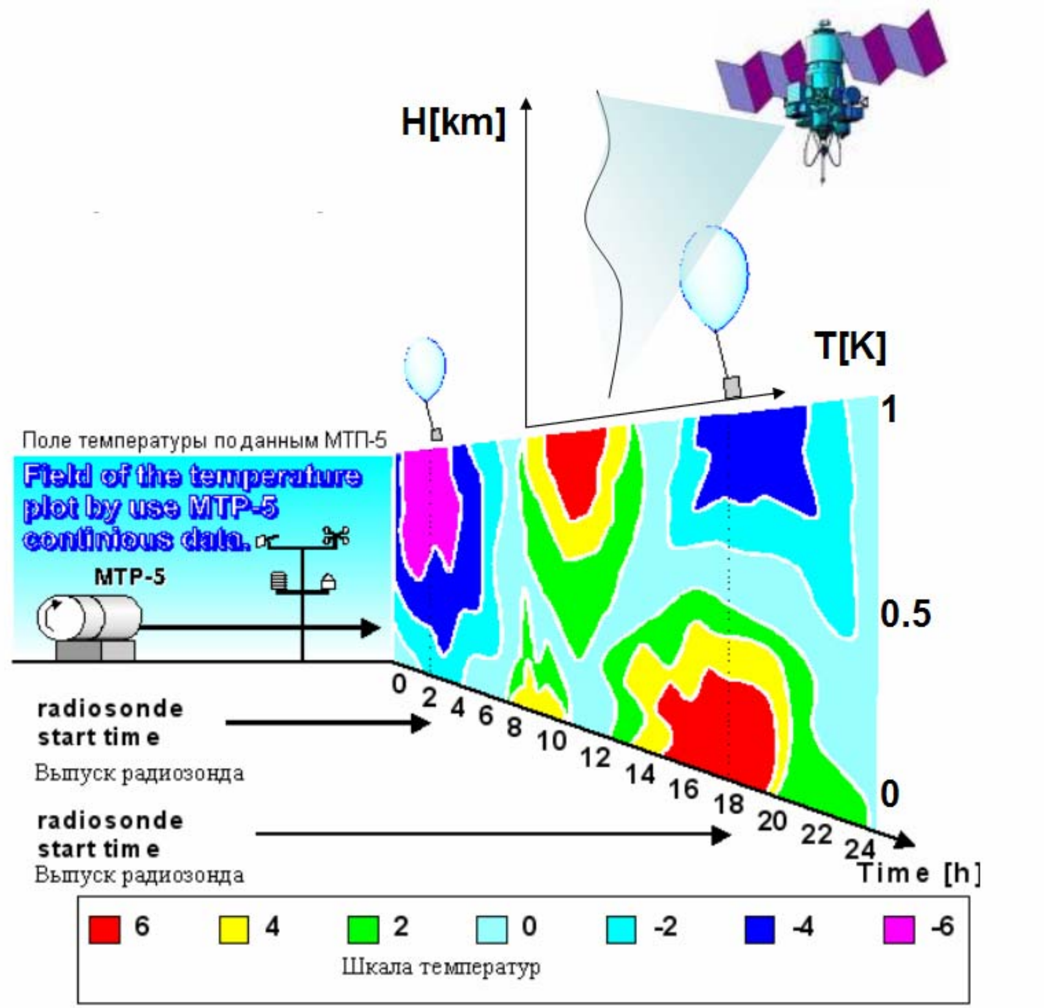
5.Just one special case, when we are interesting with thermal sounding of the atmosphere (remote temperature profiling), we have to work at the frequencies where Gc = 1, thus the Brightness temperature will be equal to thermodynamic one

3.Due to definition, the "Brightness temperature" is equal to thermodynamic temperature of the "Black Body". The "Black Body" is physical object absorbing 100% of electromagnetic radiation in the specific rang of electromagnetic spectrum

2.The spectrum of thermal radiation emission has always the same shape according to Einstein expression, and the total radiation power depends only on the thermodynamic temperature, so for the convenience of utilization it was introduced the definition of the "Brightness temperature"..

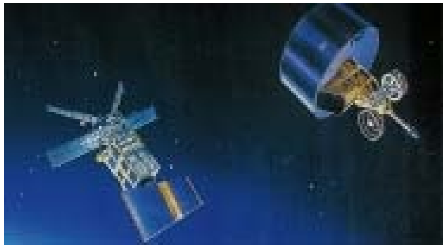
1. "Any physical body, with thermodynamic temperature over 0 Kelvin, MUST radiate electromagnetic waves." output of Kirgoff Law

The role of MWR in GOS and WIGOS

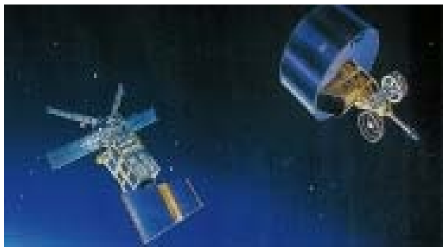


1. The space based instruments
2. The surface based instruments
3. Instruments on the mobile platforms

Suitability of MWR for the GOS-WIGOS Vision 2025 aims depending on the location

Place of installation (location)	Good for:	Badly for:
 Space based instruments	-atmospheric temperature and humidity profiles from 3km and up; - wind at the sea surface, -salinity of the sea -atmospheric composition -cloud amount -sea ice -total column water vapour -sea/land surface temperature	-atmospheric temperature and humidity profiles from ground up to 3km -atmospheric wind profile -cloud water content -precipitation -soil moisture
 Surface based instruments	-cloud water path - integral precipitation -atmospheric wind profile up to 3km -atmospheric temperature and humidity profiles from ground up to 3km -cloud amount - total column water vapour -icing and turbulence	-cloud liquid water profiling -humidity and temperature profiling over 3km -cloud base and clod top
 Instruments on the mobile platforms (aircrafts)	-cloud water path - integral precipitation -atmospheric wind profile up to 3km -atmospheric temperature and humidity profiles from ground up to 3km -cloud amount - total column water vapour cloud liquid water profiling - humidity and temperature profiling over 3km -cloud base and clod top -icing and turbulence - wind at the sea surface, -salinity of the sea -atmospheric composition -sea ice	-Long term seasonal 7/24 sets of measurements

The operational aspects of MWR for the GOS-WIGOS Vision 2025 aims depending on the location

Place of installation (location)	Features of operational environment	Proposed actions
 Space based instruments	-Very expensive projects -There are just a few (less then 10) - Very special space conditions -Operational aspect is the main parameter of suitability - The instruments are fully automated and unmanned by definition	- To expand activity on International Space Station for installation of MWR with many spectral channels and multi beam sounding (tomography) - Follow the progress of space technology for other type of space instrumentation of unmanned satellite
 Surface based instruments	Environment limitations: -Rain, snow, freezing drizzle, wet snow; - Fast environment temperature change (condensation) - Wind chilled with icing - Dielectric challenge of the environment - Human factor limitations: - High level educated personal - Misinterpretation of the data without long term experience - Complex methodic of regular calibration.	Implementation of the space technologies based on the same philosophy , but much more cost effective: -development of the unmanned systems with “on line” row data transfer to the collecting centers with qualified personal -limiting environmental factors use to be minimized by proper engineering, or at least use to be recorded for automotive data quality control -all automotive calibration process use to be sustainable, and must support uniformity of observational data flow
 Instruments on the mobile platforms (aircrafts)	-There are just few research aircraft and one train equipped with MWR -MWR installed on rail road coach “TROIKA” has the same limitation as Surface based instruments. -research aircrafts owned by NOAA, NCAR, MSC, Roshydromet, have permanent MWR systems on board with more or less understandable environmental limitations as: vibration, condensation, icing/moisturizing, temperature instability of VHF parts, interference with aircraft/airport radio systems. - other “Project-used” research aircrafts have temporary MWR installations depending on the tasks of the project and the verification of their data is a special scientific task - the main advantageous of aircraft based MWR are not utilized on regular base by any national weather service	- Development of the principles of utilization of regular flights for installation of special equipment (as MWR for instance) and negotiation of these principles with ICAO. As a basic idea could be completely autonomic module type system (like recent “Black Box”) which is installed on the aircraft just before flight, and is returned back to the airport meteorological service after flight – all information is recorded inside the module and is processed by the professionals, -calibration of the instruments before and after flights made in the laboratory.

The key role of operational aspects for wide implementation of surface based MWR in GOS

The tables with the disturbing factors from for ground based microwave system

PROBLEM	SOLUTION
Precipitation problem for antenna system	Automated cleaning system adjusted for specific precipitation type
“Black body” quality control: termal equilibrium with the environment, precipitation, direct sun and windshield factor	Black body in weatherproof housing
Termo-stabilization of the microwave system’s operation volume.	Automated control and maintaining the whole system’s stable temperature
Manual calibration during “clear sky” conditions.	Automated regular calibration procedure under any weather conditions with a built-in “black body”
Expert control of environmental conditions acceptable for proper calibrations	Automated monitoring of “clear sky” conditions
Commonly, the systems are not portable	Portable, easy-to- install system with a possibility of autonomous power supply and data transmission via radio modem.

Example of the microwave systems *good* adopted for operational aspects of surface based instruments

radiometrics

Radiometric Profiler (TP-2500)

KIPP & ZONEN
SINCE 1830

Two wavelength Radiometrics instrument for LWP and

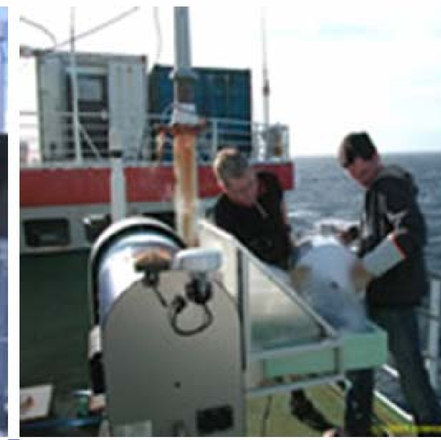
potal water vapour (20 GHz and 30 GHz)

One wavelength Kipp&Zonen instrument for temperature profiling (60 GHz)

Example of the microwave systems *badly* adopted for operational aspects of surface based instruments

radiometrics

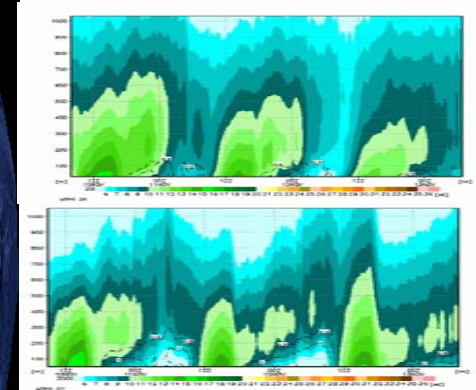
Radiometer Physics GmbH

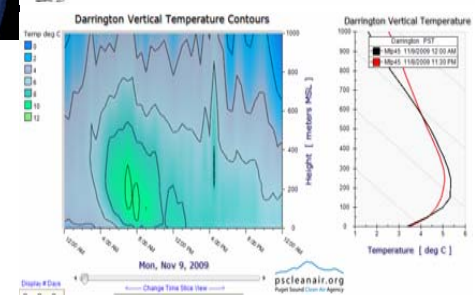


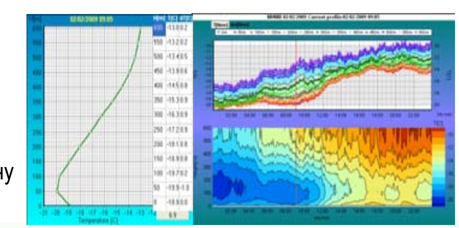
MP-3000A Hyper-Spectral Temperature, Humidity and Liquid Water Profiler.

Two bands, 22-31 GHz (7 channel filter bank humidity profiler and LWP radiometer) and 51-58 GHz (7 channel filter bank temperature profiler)

Operational aspects of the observational net of surface based MWR instruments (MTP-5 net is presented as an example only)





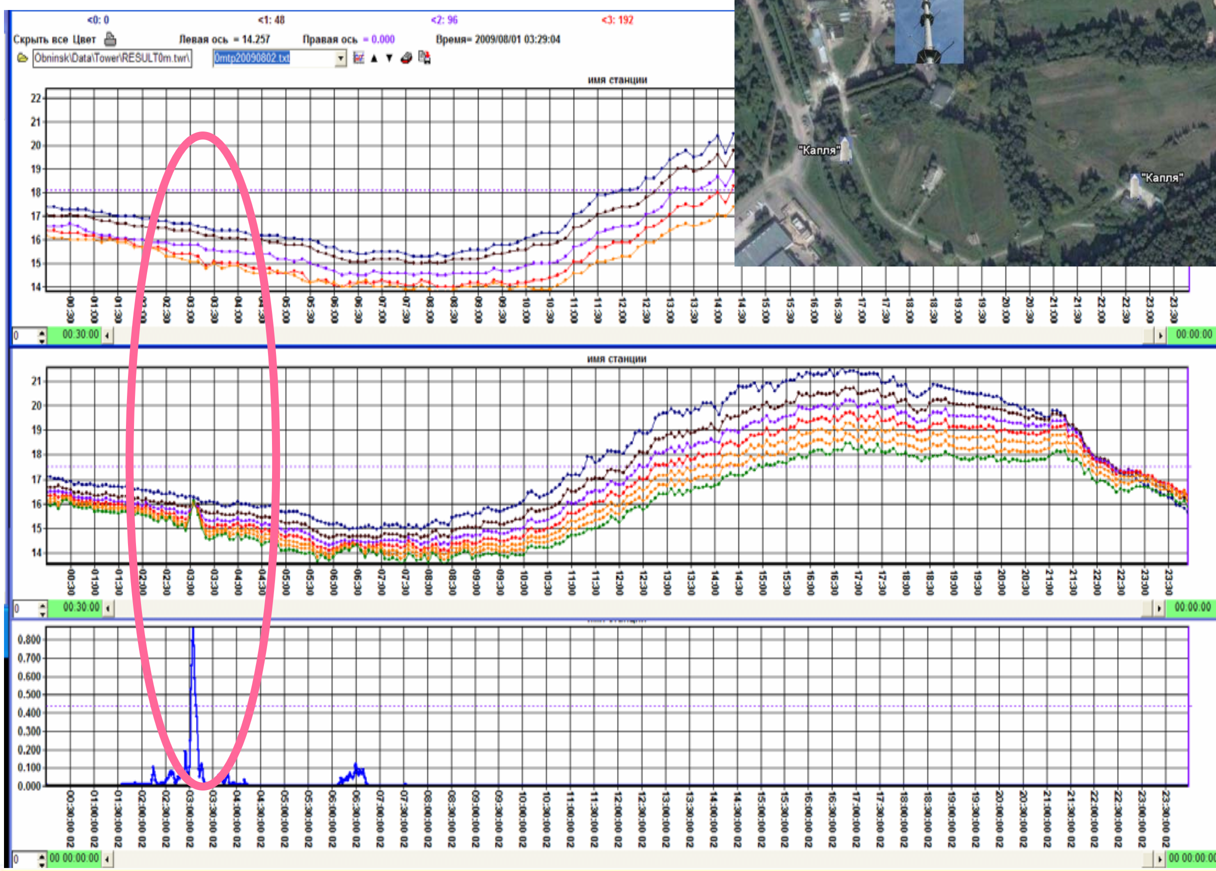


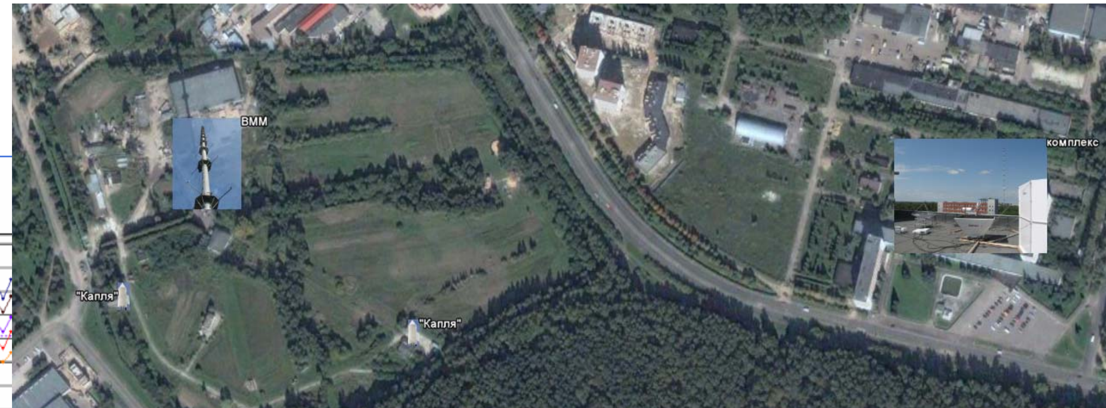
World-wide MTP-5 net and feature of the common data exchange and data base

NL Kipp&Zonen	IT Italy Project Automation, Leini Turino	AU Australia	RU Krasnoyarsk
Fr Strasbourg	IT Italy waiting to be installed at Fiumicino airport, Rome	CH China in Beijing	RU Norilsk
US PSCA	JP Japan NIES	CH China in Beijing	RU Cheliabinsk
US PSCA	JP Japan National Defence College	RU Московское Метео Бюро	RU Samara
IT Italy CNR Rome	JP Nuclear Fuel Limited Kipp&Zonen	RU Msc МГУ	RU Kazan
IT Italy ARPAV Padova	KR Korea	RU Тушино Мосэкомониторинг	RU Novosibirsk
IT Italy ARPAV Belluno	TW Taiwan EPA	RU Orenburg	RU Уфа
IT Italy ARPAV Rovigo	TW Taiwan EPA	RU Астрахань (DIEM)	RU Питер ГГО
IT Italy ARPAP Turino	TW Taiwan EPA	RU N.Nov Верхне Волжское УГМС	RU Ростов-на-Дону
IT Italy IRIDE Moncalieri Turino	SP University of Madrid	RU Арзамас	RU Хабаровск

Experimental study of the limitations for MTP-5 routine operation

Obninsk experiment – Summer2009





Vision of operational aspects of aircraft -based MWR

Module –made system with potential for tomography

Example: Canadian 4.9GHz system on Tween Otter

Additional topics to be proposed for inclusion into Vision 2025 GOS-WIGOS

1. Global air stream mapping with the use of multi channel MWR imager
2. Spaced based MWR wind profilers
3. Retrieving of vertical structure of atmosphere (temperature, water vapor, cloud liquid content, liquid precipitation) by means of MWR space and airborn tomography