ITU Seminar on Science Services in relation to ITU Radio Regulations and WRC-27

SESSION 9
Special radiosystems: Data collections systems, radars, radiosondes, lightning, space weather, (applications, bands, technical performance, protection)

WRC-27 agenda item

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Summary

- Data Collection Systems
- Radars, Wind Profiler Radars, Oceanographic Radars
- Radiosondes, ground based radiometers, lightning detection
- Space-Weather

Data Collection Systems (DCS)

DCS are carried by geostationary and non-geostationary Meteorological satellites

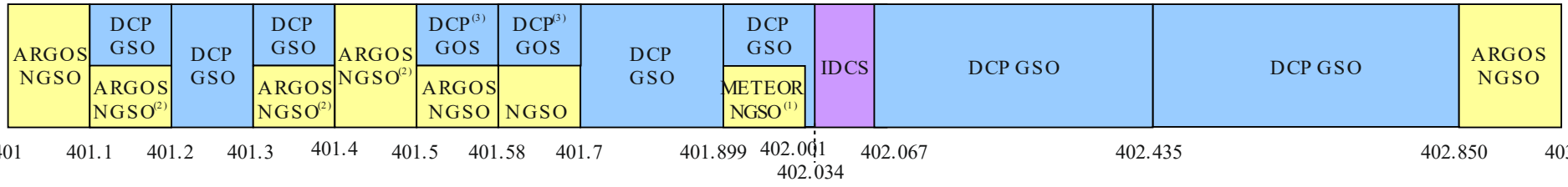
DCS, namely Data Collection Platforms (DCPs) on geostationary orbit satellite:

- typically located on ground, aircrafts, ships and floating buoys,
- data collected are :
  - on basic meteorological parameters (surface temperature, wind velocity, …)
  - also for many other related purposes, (detection of oceanic pollutants, forest fires, seismic alerting, Ttsunami warning, avalanche warning, water level monitoring,…
  - for climate research.

DCS on non-geostationary low orbit satellite:

- on buoys and floats measure atmospheric pressure, wind speed, …
- other applications to track animal movements, monitor fishing fleets, pollution, smart agriculture,…

Basic general partitioning of the band 401-403 MHz for future long-term coordinated use of DCS systems on geostationary and non-geostationary MetSat and EESS systems



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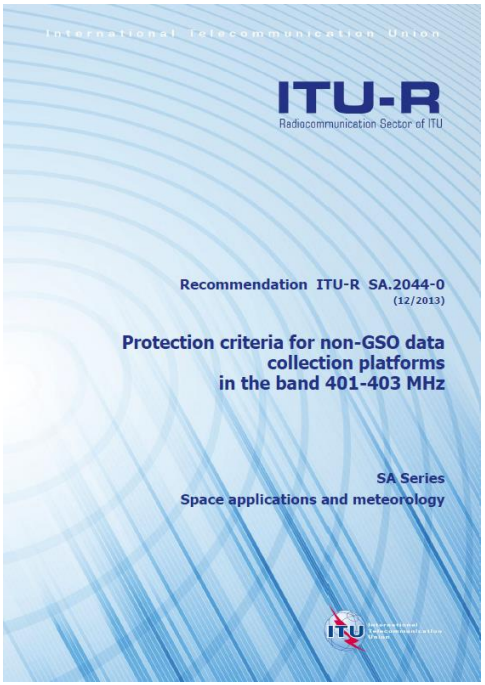
Some references/Publications

ITU-R Recommendation **SA.2045-0** on "*Basic general partitioning and sharing conditions for the band 401-403 MHz for future long-term coordinated use of data collection systems on geostationary and non-geostationary MetSat and Earth exploration-satellite service systems*"

ITU-R Recommendation **SA.2044-0** on "*Protection criteria for non-GSO data collection platforms in the band 401-403 MHz*"



Chapter 2 of the WMO-ITU Handbook on "*Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction*"

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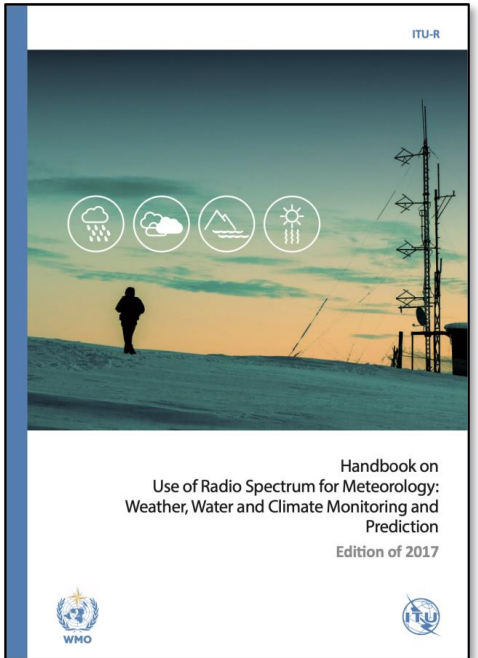


Meteorological radars: frequency bands

Meteorological radars operate under the **radiolocation service**

They can in theory be deployed in all radiolocation bands but are mainly found in three frequency bands

The choice of the band is a trade-off between mainly range, rain attenuation and data accuracy

Radar networks worldwide are in general using S-Band and C-Band whereas X-Band radars are used in specific environments or to complete global coverage

S-band
2700-2900 MHz
(see RR N° 4.423)

C-band
5350-5725 MHz
(focusing on 5600-5650 MHz, see RR N° 4.452)

X-band
9300-9500 MHz
(see RR N° 4.475B)

Scanning strategies

For a given radar, “scanning strategies” (typically of 10-15 minutes) make use of a variety of different emission schemes at different **elevations**, using sets of different **pulse width**, **Pulse repetition Frequency (PRF)** and **rotation speeds**

No typical schemes but large ranges of parameters.

Elevation ranging from **0° to 90°**

Pulse width ranging from **0.5 to 2.5 µs** (for operational radars)

Pulse repetition Frequency (PRF) ranging from **250 to 1200 Hz** (for operational radars)

PRF Fixed and staggered or **interleaved**

Rotation speed ranging from **1 to 6 rpm**

Past, current and future threats

A number of threats are facing weather radars in all bands and the interference situation may become a threshold for change.

S-Band:

- Has been targeted many times by the Mobile community for IMT usage. Denied at 3 WRC but it may come back …
- Under threat of IMT usage in the adjacent band 2500-2690 MHz (current interference, e.g. Canada,…)

C-Band:

- For about 20 years, it is under threat of WAS/RLAN 5 GHz with numerous interference cases experiences worldwide, especially in Europe. This is due to a massive deployment of non-compliant WAS/RLAN
- It is envisioned by UWB applications

X-Band:

- Targeted by Mobile community for IMT usage. It was denied at WRC-23 but may come at later stage ….
- It is also envisioned by UWB applications

Future developments

Among others, it is important to highlight a major step that relates to **solid state meteorological radars**

- For decades, **vacuum tubes (Magnetron, Klystron)** were the only solution to allow for very high power peak transmissions (several hundred kW)
- Solid State Power Amplifiers (SSPA) based on **semiconductor** technology now also allow for high power peak transmissions (several kW).
- It presents a number of advantages (Pulse agility and higher resolution and sensitivity, robustness, compactness, improved efficiency, …)
- However impact on compatibility with other services (e.g. WAS/RLAN) still need to be assessed (work ongoing in ITU under the umbrella of WMO)

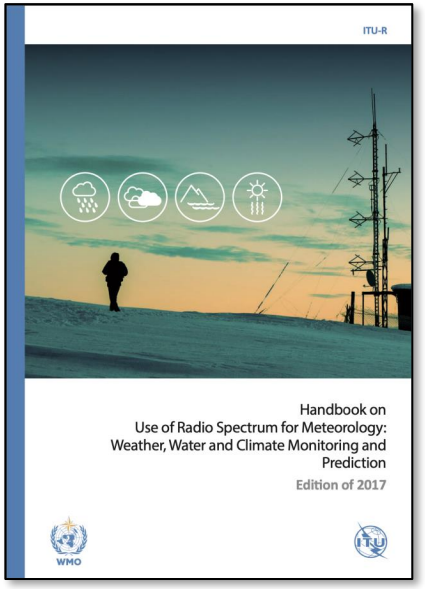
Another development relates to the possible **move of some C-band meteorological radars from 5.6 GHz to 5.4 GHz band** in order to potentially avoid interference from WAS/RLAN 5GHz.

- Although only representing a quite small frequency shift, this may represent a number of technical and regulatory challenges that need to be studied.
- Compatibility with EESS (active) needs to be taken into account.

Some references/Publications

ITU-R Recommendation M.1849-3 on "*Technical and operational aspects of ground-based meteorological radars*"

Chapter 4 of the WMO-ITU Handbook on "*Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction*"



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Wind profiler radars

Measurement characteristics depend on power, frequency and antenna size.

46-68 MHz

- *Stratosphere-troposphere measurements*
- Peak power of 250 kW, mean power of around 12.5 kW
- Large antenna: about 10,000 m^2
- Provide measurements between 3-30 km altitude

440-450 MHz

and 470-494 MHz

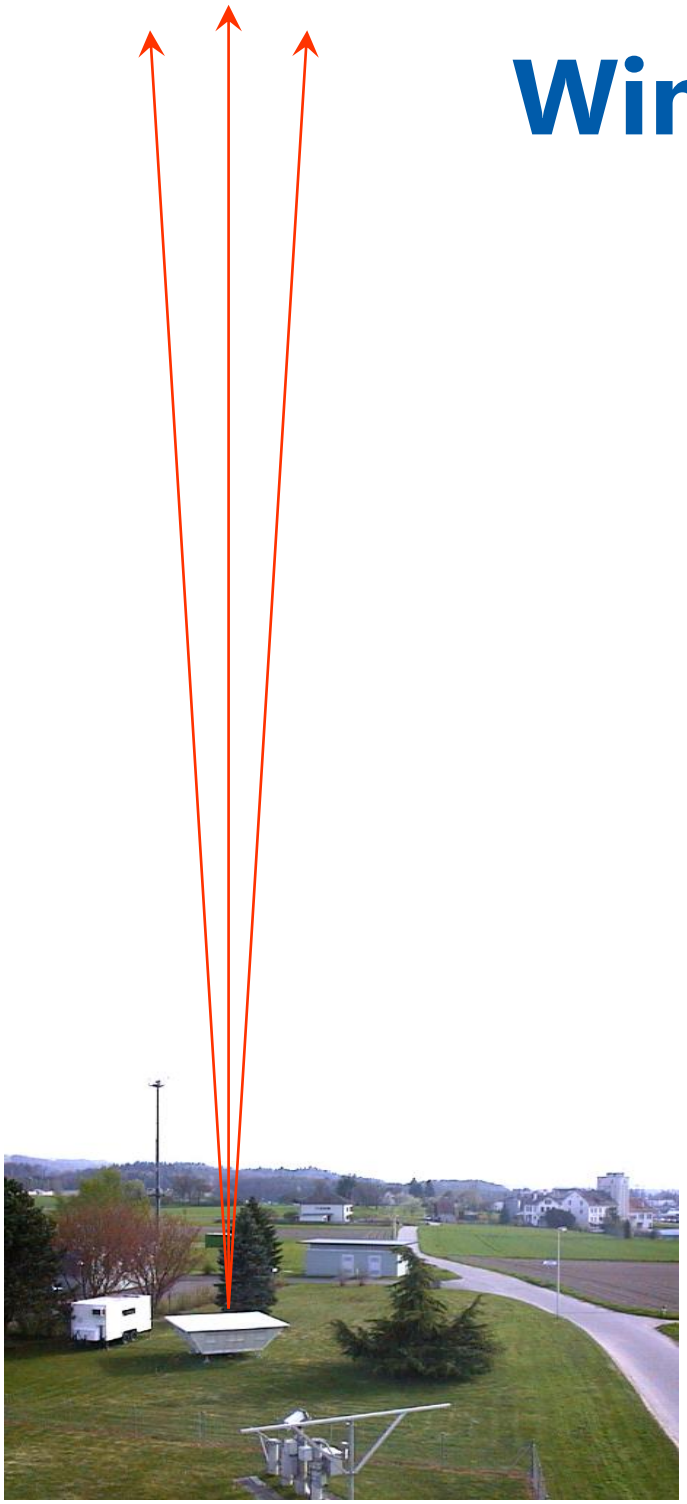
- Mean powers of 500 W for low altitude measurements and 2000 W for high altitude measurements.
- Provide measurements between 0.5-16 km altitude

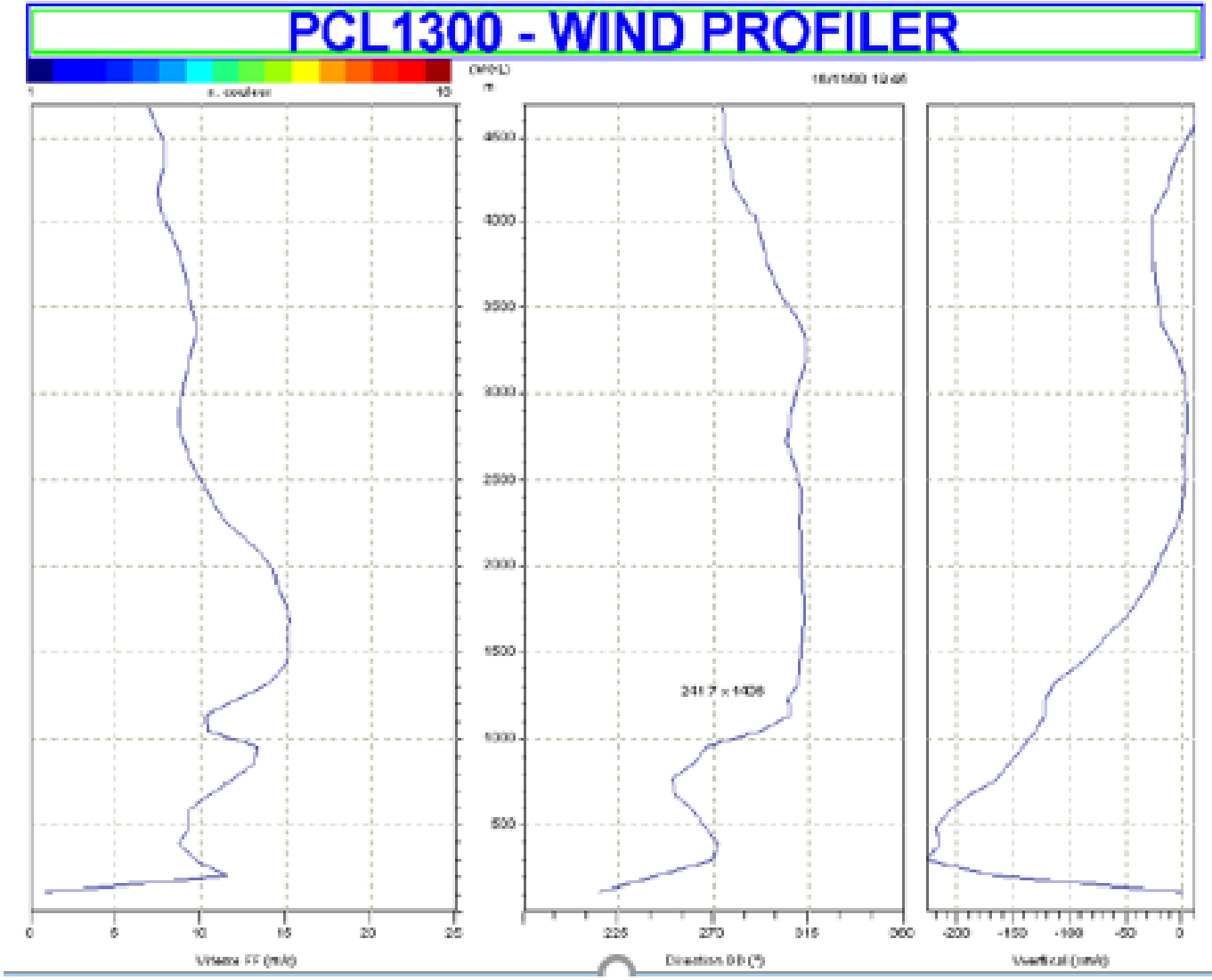
904-928 MHz, 1270-1295 MHz

and 1300-1375 MHz

- *Boundary layer measurements*
- Mean power around 50 W
- Vertical resolution about 100m
- Provide measurements between 100-3000 m altitude

Wind profiler radars





Some references/Publications

ITU-R Recommendations **M.1085, M.1226** and **M. 1227-2**

RECOMMENDATION ITU-R M.1085-1*

TECHNICAL AND OPERATIONAL CHARACTERISTICS OF WIND PROFILER RADARS FOR BANDS IN THE VICINITY OF 400 MHz

(Question ITU-R 102/8)

(1994-1997)

RECOMMENDATION ITU-R M.1226*

TECHNICAL AND OPERATIONAL CHARACTERISTICS OF WIND PROFILER RADARS IN BANDS IN THE VICINITY OF 50 MHz

(Question ITU-R 102/8)

(1997)

RECOMMENDATION ITU-R M.1227-2*

Technical and operational characteristics of wind profiler radars in bands in the vicinity of 1 000 MHz

(1997-2000-2001)

Chapter 4 of the WMO-ITU Handbook on "*Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction*"

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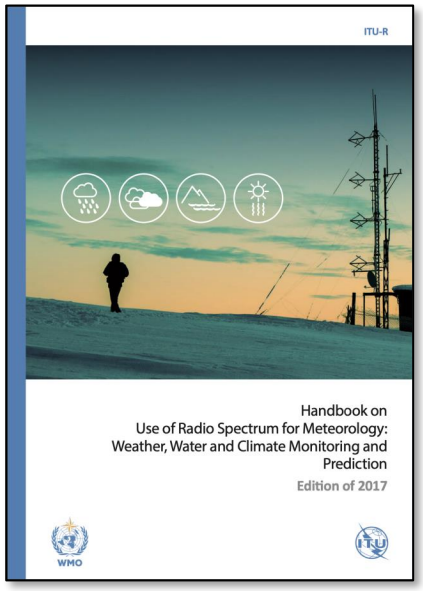


Oceanographic Radars

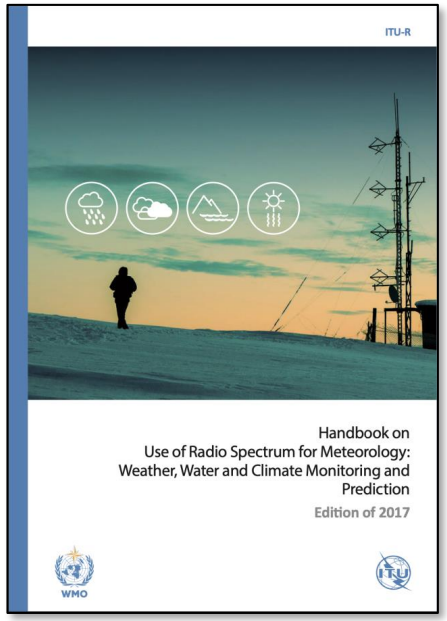
- Coastal radar that measures currents and sea state in coastal waters and bays
  - Provide a better understanding of issues like coastal pollution, fisheries management, search and rescue, beach erosion, maritime navigation, sediment transport and tsunami response
  - The technology also has applications in global maritime domain awareness.

- Prior 2012 oceanographic radars were operated without regulatory status, under Radio Regulations Footnote No. **4.4**.
- WRC-12 approved allocations in multiple frequency bands to operate oceanographic radars on a global basis:
  - with regulatory constraints.
  - With a reduction of operational bandwith from more than 10 MHz between 3 and 50 MHz to less than 3.475 MHz.

Some references/Publications

ITU-R Recommendation **M.1874-1** on "*Technical and operational characteristics of oceanographic radars operating in sub-bands within the frequency range 3-50 MHz*".

Chapter 4 of the WMO-ITU Handbook on "*Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction*".



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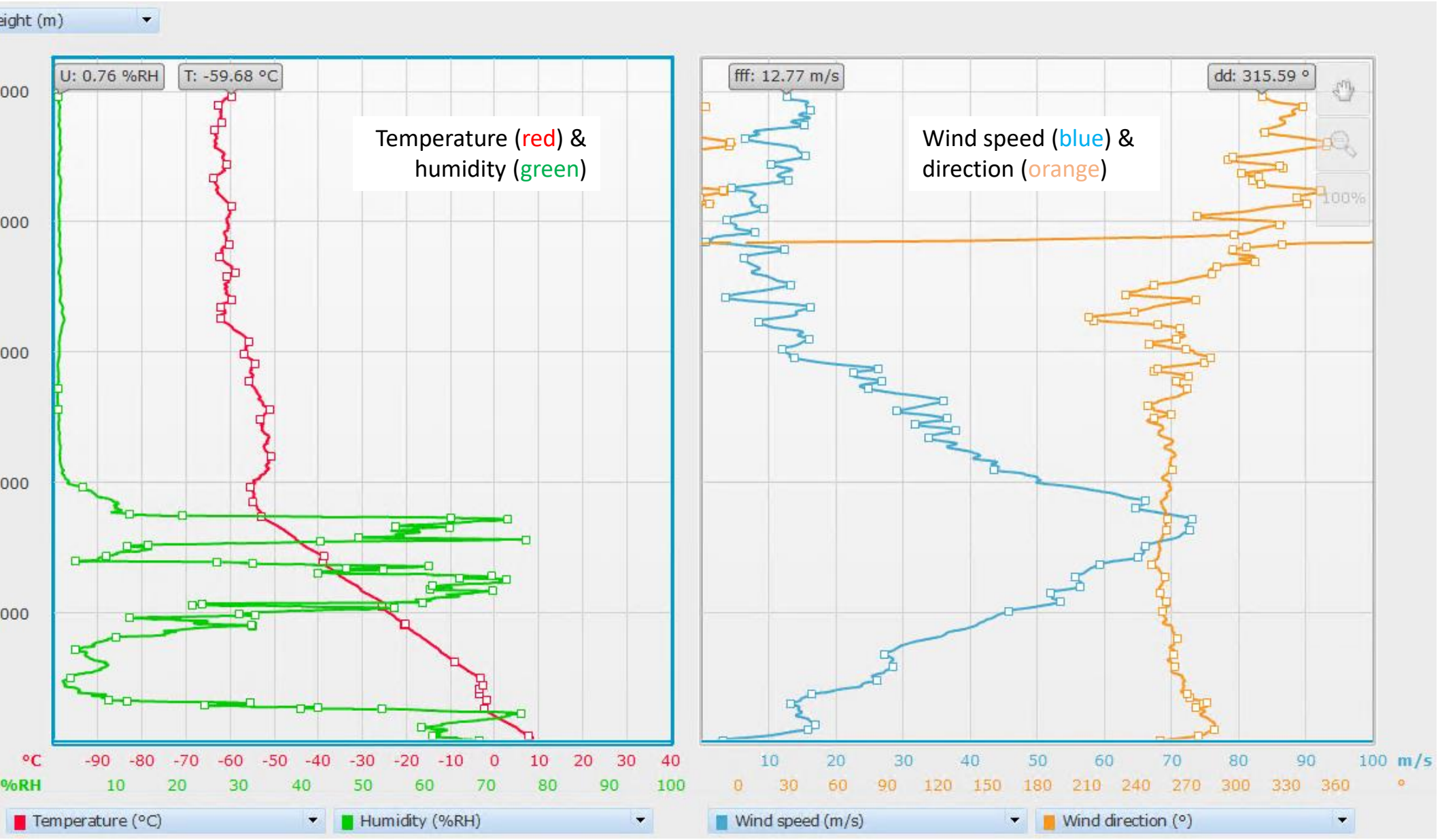
Radiosonde

Main source of high vertical resolution atmospheric measurements

- Provide vertical profiles of temperature, pressure, humidity, and wind speed/direction
- Essential for numerical weather prediction models
- *Short-term forecasts need 100m or better resolution*
- Used for weather forecasting and climate monitoring
- In situ measurements calibrate space-borne remote sensing
- Can also provide measurements of ozone, aerosol, and radioactivity

Radiosonde


eight (m)
U: 0.76 %RH
T: -59.68 °C
Temperature (red) & humidity (green)
fff: 12.77 m/s
dd: 315.59 °
Wind speed (blue) & direction (orange)
100%
°C -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40
%RH 10 20 30 40 50 60 70 80 90 100
10 20 30 40 50 60 70 80 90 100 m/s
0 30 60 90 120 150 180 210 240 270 300 330 360 °
Temperature (°C)
Humidity (%RH)
Wind speed (m/s)
Wind direction (°)

Radiosonde: how spectrum is used

Spectrum is required for **transmission of data** and **tracking of sonde location**.

Data transmitted from in-situ measurements to a base station.

A signal processing system at the base station decodes the data and generates the required atmospheric measurement data.

Two frequency bands are allocated globally for this data transmission: 400.15-406 MHz and 1668.4-1700 MHz .

400.15-406 MHz band

- **Used by most radiosondes and all dropsondes.**
- Does not need very high antenna gain to maintain the RF link (0-1 dBi).
- Requires **Omni-directional antennas** and **rosettes of Yagi antennas** or **corner reflectors**.

1668.4-1700 MHz band

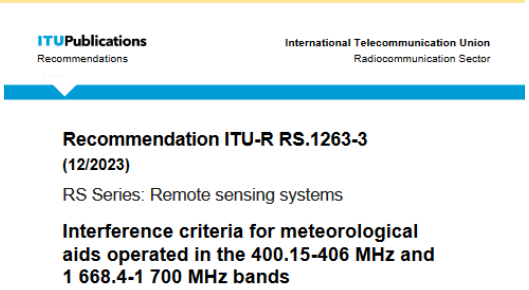
- **Tracking pedestals** equipped with **large parabolic antennas** or **phased array panels** are used to avoid path loss.
- The antenna **rotates in azimuth and elevation** to track the MetAid movement.
- **Requires higher antenna gain** than 400-15-406 MHz band (25-28 dBi).

Most radiosondes also rely on NAVAID/GNSS signals for position and derived wind measurements.

Some references/Publications

ITU-R Recommendation **RS.1165-3** on "*Technical characteristics and performance criteria for systems in the meteorological aids service in the 403 MHz and 1 680 MHz bands*"

ITU-R Recommendation **RS.1263-3** on "*Interference criteria for meteorological aids operated in the 400.15-406 MHz and 1 668.4-1 700 MHz bands*"



Chapter 3 of the WMO-ITU Handbook on "*Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction*"

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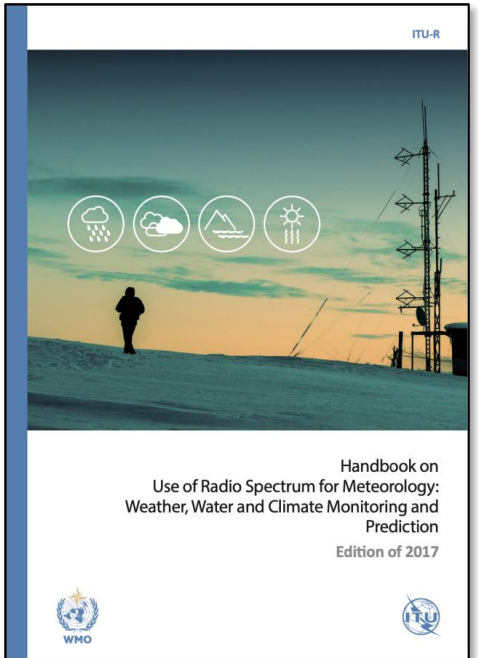


Ground-based radiometers

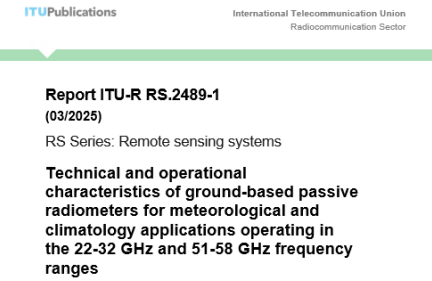
- **Use passive remote sensing to provide vertical profiles of temperature and water vapour.**
- **Similar to space-based radiometers, their location provides higher vertical resolution in the boundary layer.**

Frequency band	Application	Remote sensing protection
21-28 GHz	Water vapour profiles	21.2-21.4 GHz
		22.1-22.5 GHz
		23.6-24 GHz (5.340 applies)
		25.5-27 GHz
32 GHz	Cloud identification (window region)	**31.3-31.5 GHz (5.340 applies)**
		31.5-31.8 GHz (5.340 applies in Region 2)
50-59 GHz	Temperature profiles	**50.2-50.4 GHz (5.340 applies)**
		52.6-54.24 GHz (5.340 applies)
		54.25-59.9 GHz
183 GHz	Water vapour	174.8-182 GHz
		182-185 GHz (5.340 applies)
		185-190 GHz
		190-191.8 GHz (5.340 applies)

- ✓ Frequency bands selected to observe specific variables.
- ✓ Some of these frequency bands overlap with those used by satellite remote sensing, so benefit from the same protection.
- ✓ **Some bands protected by RR 5.340** (all emissions prohibited).

Some references/Publications

ITU-R Report **RS.2489-1** on "*Technical and operational characteristics of ground-based passive radiometers for meteorological and climatology applications operating in the 22-32 GHz and 51-58 GHz frequency ranges*".


ITUPublications

International Telecommunication Union
Radiocommunication Sector

Report ITU-R RS.2489-1
(03/2025)

RS Series: Remote sensing systems

Technical and operational characteristics of ground-based passive radiometers for meteorological and climatology applications operating in the 22-32 GHz and 51-58 GHz frequency ranges

Chapter 7 of the WMO-ITU Handbook on "*Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction*".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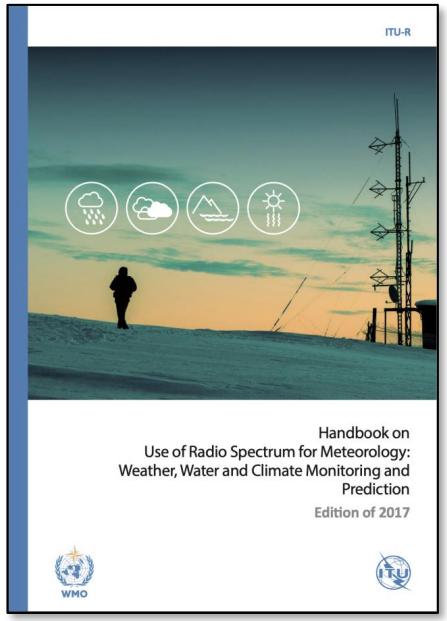

Lightning detection

- **Passive sensors** used to detect atmospheric wave associated with lightning strikes (spheric).
- Systems can detect **direction** of arrival, **time** of arrival or a combination of **both**.
- Data from multiple sites can be combined to compute location of the original lightning strike.

➢ **8,3-11.3 kHz (VLF)** frequency band used for very long-range location detection (several thousand kilometers). with sensors up to 2,000 km apart.

Allocated to Meteorological Aids service on a PRIMARY basis (shared with **Radionavigation service** in the **9-11.3 kHz** frequency band on a non protection basis ***(RR 5.54A)***.

➢ **1-350 kHz (LF)** frequency band (centred on **200 kHz**) used to cover more limited areas in detail. With sensors 100-400 km apart.

➢ **63-225 MHz (VHF)** used to detect all electrical discharges associated with thunderstorm activity within around 30 km of the sensor.

All systems also require **good communications links** and **GPS signals** to achieve required time synchronisation across sites.

Some references/Publications

Chapter 7 of the WMO-ITU Handbook on "*Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction*"

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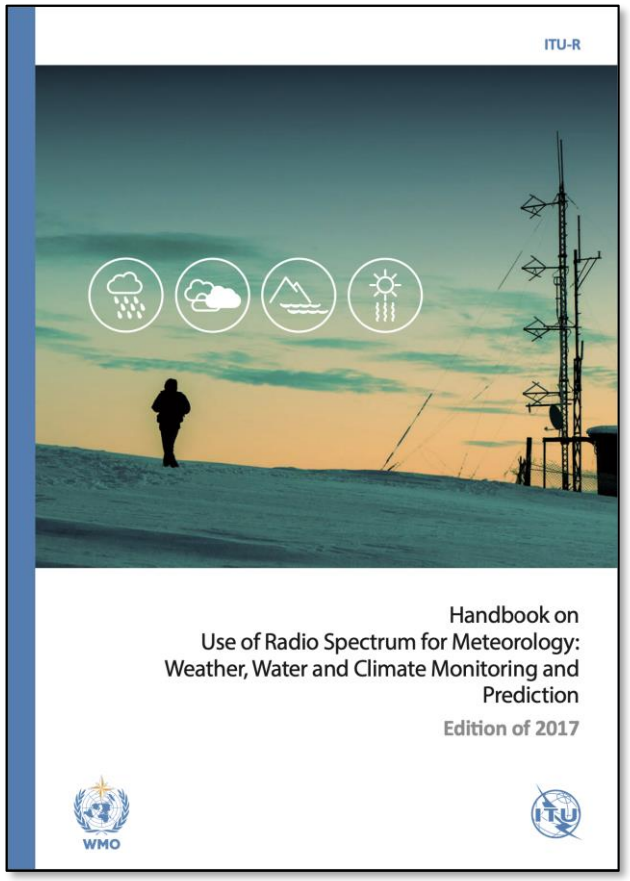


Space Weather

SW refers to the physical processes occurring in the space environment that ultimately affects human activities on Earth and in space.

SW is mainly influenced by the solar wind and the interplanetary magnetic field (IMF) carried by the solar wind plasma.

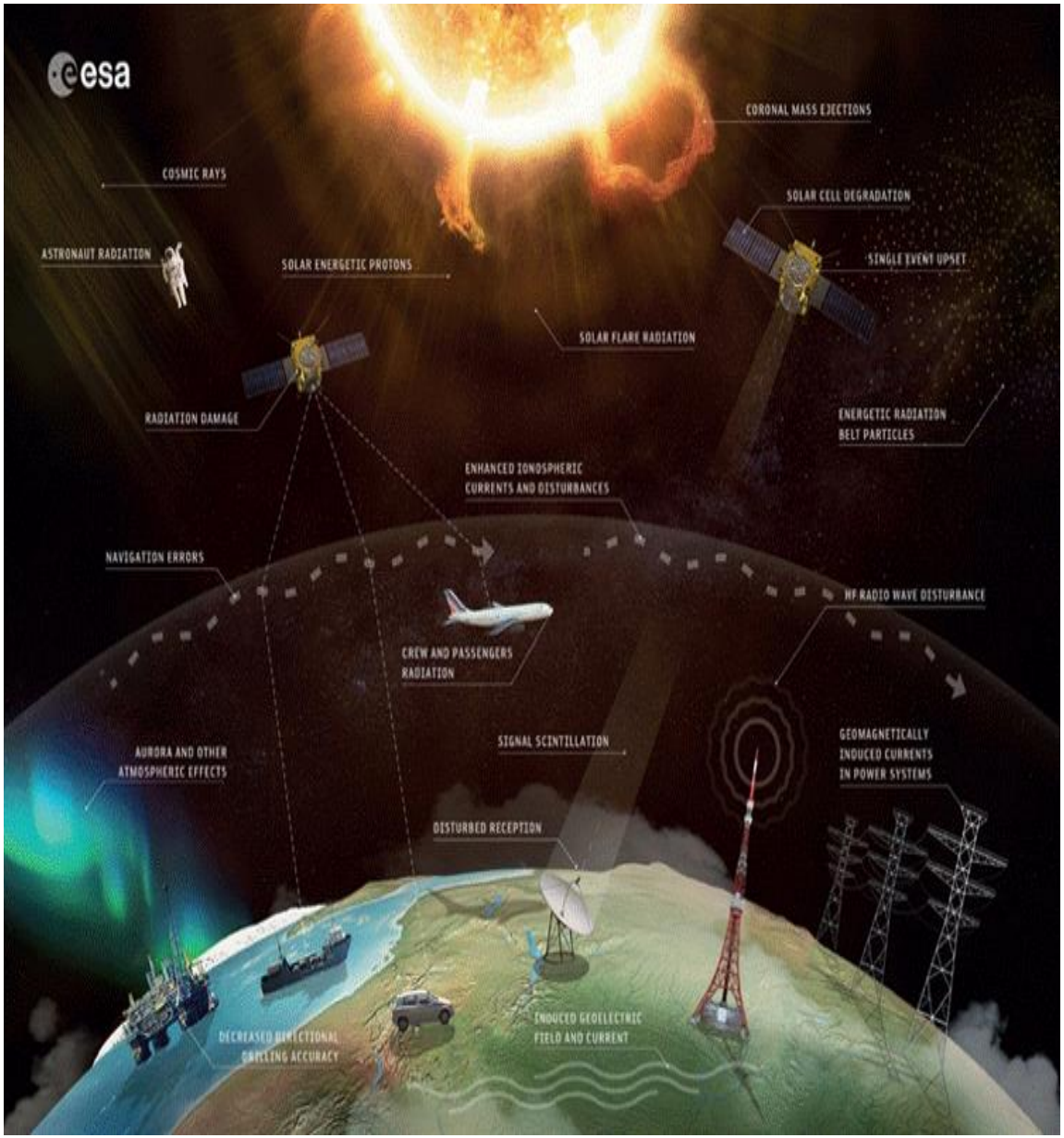
A variety of physical phenomena are associated with space weather are shown in this figure.

Space Weather

"…affects human activities on Earth and in space" – What does it mean?

Severe space weather events can results in:

- Power grid outages,
- Disruption to GNSS,
- Radio communications outages,
- Satellite damage,
- Increased radiation levels at high altitude.



Space Weather: background

- Work began in the ITU-R and WMO in 2014 to determine the radio spectrum requirements for space weather sensors that use the radio spectrum for acquiring data.

- WRC-2015 placed an item on the Preliminary Agenda of WRC-23 calling for regulatory changes to provide protection to space weather sensors that use radio spectrum.

- In the time leading up to WRC-19 work was conducted in ITU-R to develop an ITU-R Report on the technical and operational characteristics of spectrum reliant space weather sensor systems.

- Report approved prior to WRC-19 as ITU-R RS.2456.

- WRC-19 reviewed the work on the topic and included the issue on the WRC-23 agenda (ITU-R Resolution 657) and placed a subsequent item of the Preliminary Agenda for WRC-27 to resolve any remaining regulatory issues.

- ITU-R RS.2456 revision was approved in September 2023

Space Weather : at WRC-23 (1)

A- Recognition of space weather in the international Radio Regulation treaty

1- Approval of a new **WRC Resolution 675** titled :

"**Importance of meteorological aids service (space weather) applications**"

This WRC Resolution includes:

- Space weather definition: natural phenomena, mainly originating from solar activity and occurring beyond the major portion of the Earth's atmosphere, that impact Earth's environment and human activities.
- Recognition of radiocommunication service under which space weather sensor systems may operate : MetAids (space weather) allocations
- Active space weather sensor definition : system in the MetAids (space weather) by means of which information is obtained by transmission and reception of radio waves;
- Receive-only space weather sensor definition : system in the MetAids (space weather) by means of which information is obtained by reception of radio waves of natural origin, or by the opportunistic reception of transmissions of other specific radiocommunication services;

And furthermore:

- urge administrations to take into account space weather radio-frequency requirements and in particular protection of the related frequency bands;
- encourage administrations to consider the importance of the use and availability of spectrum for space weather applications prior to taking decisions that would negatively impact their operations;

2- Approval of a new Article 29 B:

"**Radio service related to space weather observations** "

Space Weather : at WRC-23 (2)

B- New WRC-27 Agenda Item on Space Weather (AI 1.17)

Approval of a new WRC-27 Agenda Item 1.17 on space weather through Resolution **682** (WRC-23): "**Consideration of regulatory provisions and potential primary allocations to the meteorological aids service (space weather) to accommodate receive-only space weather sensor applications in the Radio Regulations**"

This agenda item asks:

- To study spectrum needs and appropriate protection criteria for receive-only space weather sensors, as well as system characteristics, as appropriate,
- To conduct sharing and compatibility studies pertaining to potential new primary allocations to MetAids (space weather) in the following frequency bands for receive-only sensors taking into account that any new primary allocations to MetAids (space weather) shall not claim protection from, nor constrain the future development of, incumbent services in these frequency bands or in adjacent bands:
  - 27.5-28.0 MHz;
  - 29.7-30.2 MHz;
  - 32.2-32.6 MHz;
  - 37.5-38.325 MHz;
  - 73.0-74.6 MHz;
  - 608-614 MHz;
- To study possible regulatory provisions of the Radio Regulations to accommodate the possibility for an administration that desires to notify a receive-only space weather sensor station to be included in the Master International Frequency Register,

Space Weather: Progress in ITU-R towards WRC-27

Working Party 7C (WP 7C) designated as responsible for this Agenda Item

Working Parties 3L, 3M, 4A, 4C, 5A, 5B, 5C, 5D, 6A, 7B and 7D designated as contributive WPs

At its last meeting WP 7C, based on input contributions:

- Updated the working document toward a preliminary draft ITU-R Recommendation on SW protection criteria focused on SW sensors operating or plan to in the frequency bands listed in the Resolution 682
  - Most important document

- Updated the working document toward a preliminary draft ITU-R Report on space weather studies Document for information

- Updated the draft Conference Preparatory Meeting text for this agenda item.
  - Document for information

- Updated the working document toward a preliminary draft revised report ITU-R RS. 2456-2.
  - Document for information

Space-Weather protection criteria

Extracts of the working document toward a preliminary draft ITU-R Recommendation : ITU-R RS.[RXSW_PROTECT_CRITERIA]

For riometer

Frequency band (MHz)	Frequency fc (MHz)	Bandwidth Δf (MHz)	Minimum antenna noise temperature T_A (K)	Receiver noise temperature T_R (K)	System sensitivity		Protection criteria		
					Temperature ΔT (mK)	Power spectral density ΔP (dB(W/Hz))	Input power ΔP_H (dBW)	pfd $S_H \Delta f$ (dB(W/m²))	Spectral pfd S_H (dB(W/(m² · Hz)))
27.5-28.0	27.8	0.25	9400	200	19200	−216	−172	−181	−235
29.7-30.2	30.0	0.25	7900	200	16200	−217	−173	−181	−235
32.2-32.6	32.4	0.25	6700	200	13800	−217	−173	−182	−235
37.5-38.325	38.2	0.25	4600	200	9600	−219	−175	−182	−236
73.0-74.6	74.0	0.25	1000	200	2400	−225	−181	−182	−236

For solar flux monitor

Site name	Latitude	Longitude	Frequency (MHz)	Antenna gain (dBi)	Receive BW (MHz)	Effective aperture (m²)	Protection criteria[1] (dBW/(m² · MHz)
Learmonth (SEON)	22.2192°S	114.103°E	610	32.5	6	34.23	-164.9
San Vito (SEON)	40.6°N	17.8°E					
Sagamore Hill (SEON)	42.6323°N	70.8201°W					
Kaena Point (SEON)	21.5614°N	158.2392°W					

Space-Weather studies

Extracts of the working document toward a preliminary draft ITU-R Report: ITU-R RS.[SW_STUDIES]

In this report are detailed:

- Spectrum needs and appropriate protection criteria for each SW instrument type
- Propagation models and technical and operation characteristics
- Sharing and compatibility studies
- Notification to be included in the MIFR

Space-Weather : CPM text

Extracts of the Draft CPM text for WRC-27 agenda item 1.17

At this stage two “similar” methods are reflected

ARTICLE 5

Frequency allocations

Section IV – Table of Frequency Allocations
(See No. **2.1**)

MOD

27.5-40.98 MHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
27.5-28	METEOROLOGICAL AIDS METEOROLOGICAL AIDS (space weather) ADD 5.117 FIXED MOBILE	
28-29.7	AMATEUR AMATEUR-SATELLITE	
29.7-30.005	FIXED MOBILE METEOROLOGICAL AIDS (space weather) ADD 5.117	
30.005-30.01	SPACE OPERATION (satellite identification) FIXED MOBILE SPACE RESEARCH METEOROLOGICAL AIDS (space weather) ADD 5.117	

ADD

5.A117 The use of frequency bands 27.5-28.0 MHz, 29.7-30.2 MHz, 32.2-32.6 MHz, 37.5-38.325 MHz, 73.0-74.6 MHz and 608-614 MHz by the meteorological aids (space weather) service is limited to [ground-based] receive-only space weather sensors. (WRC-27)

Some references/Publications

Chapter 6 of the WMO-ITU Handbook on "*Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction*"

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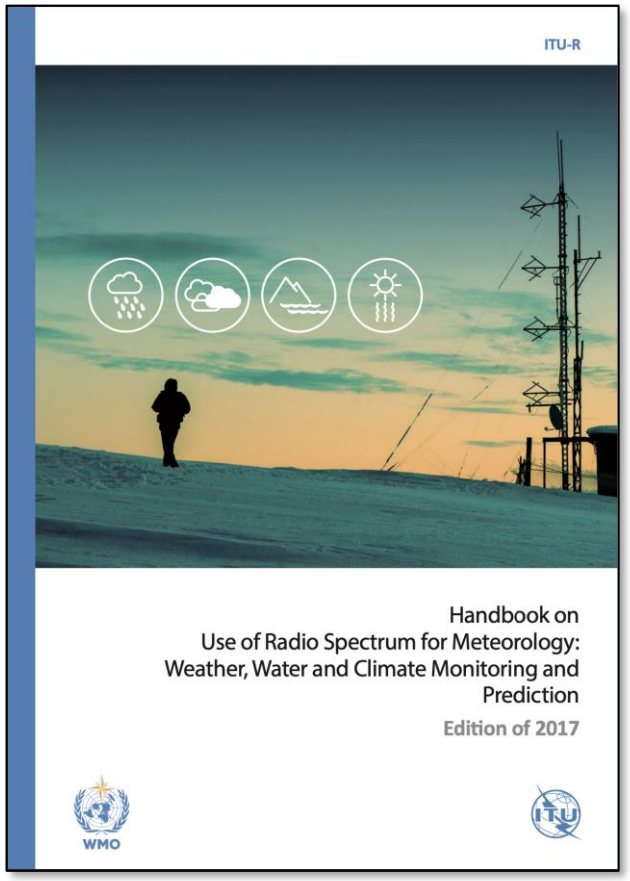

Thank you!