Background Paper

Spectrum management for meteorological services

Radio spectrum is a finite resource critical for numerous communication services, including meteorological radio services. These services are essential for weather observation, forecasting, and warnings, and they rely on radio spectrum to deliver real-time data and information for public safety, environmental monitoring, and climate science. The efficient use of spectrum for meteorological purposes is indispensable for the functioning of national and global weather systems, enabling
Meteorological radio services encompass a broad range of systems and technologies that rely on radio frequencies to transmit and receive data related to atmospheric conditions.

The radio spectrum is essential for meteorological services because it enables to collect the transmission of large amounts of data between various devices and systems. Key contributions of spectrum to meteorological radio services include:

- ***Dedicated Exclusive Frequency Bands:*** The satellite observations are based on the well-known physical phenomenon that all bodies in nature have a unique emission characteristic, which allows their presence to be detected at the observation site. On the other hand, the absence of radiation at certain frequencies helps determine the presence of specific gases in the atmosphere, their quantity, and location. Since not all frequencies are suitable for observation the proper selection of spectrum for passive sensors and protection from interference are critical to achieve the required measurement quality.
- ***Real-time Data Transmission***: Weather forecasting requires up-to-date information about atmospheric conditions. Spectrum enables the real-time transmission of data from weather stations, satellites, radars, and other observation platforms to forecasting centers, where it is analyzed and used to generate accurate predictions.
- ***Global Monitoring***: The frequency spectrum supports global communication networks for meteorological data, allowing different countries and organizations to share weather data, forecasts, and warnings. This is crucial for understanding and predicting global climate patterns, particularly with regard to climate change and its impacts.
- ***Public Safety and Emergency Management***: Meteorological radio services, particularly those related to storm and disaster warnings, play a key role in ensuring public safety. They provide early warning systems for hurricanes, floods, tornadoes, and other extreme weather events, enabling authorities to issue evacuation notices and other safety measures.
- ***International Collaboration***: Meteorological data often crosses national boundaries, making international cooperation on spectrum allocation and usage critical. For example, the World Meteorological Organization (WMO) and the International Telecommunication Union (ITU) work to harmonize spectrum use to ensure effective global meteorological monitoring and communication.

The allocation and management of spectrum for meteorological services are regulated by international agreements, national governments, and regional bodies. Key elements of spectrum allocation include:

- ***International Regulation***: The ITU, a specialized agency of the United Nations, plays a central role in coordinating the global use of radio frequencies. The ITU's World Radiocommunication Conferences (WRC) address spectrum management issues, including the allocation of frequencies for meteorological services, and ensure that spectrum resources are shared in a way that minimizes interference between different services.
- ***National and Regional Coordination***: Countries also have their own regulatory bodies, such as the Federal Communications Commission (FCC) in the U.S. or the European Conference of Postal and Telecommunications Administrations (CEPT) in Europe, which manage national spectrum use. These bodies work to ensure that meteorological services receive priority access to necessary frequencies, especially in the context of growing demand for spectrum from telecommunications, satellite, and other industries.

Several challenges complicate the effective use of spectrum for meteorological services:

- ***Increased Spectrum Demand***: As the telecommunications sector expands, demand for spectrum in many frequency bands is escalating. 5G networks, satellite broadband services, and other technologies are competing for the same spectrum bands that meteorological services rely on. This can lead to congestion, interference, and limitations on the quality and reliability of meteorological data transmission.
- ***Spectrum Scarcity***: The finite nature of the radio spectrum means that effective allocation is critical. While meteorological services are often granted priority access, they must share spectrum with other essential services, such as public safety communications and military applications. Balancing these competing needs requires careful management and international cooperation.
- ***Interference***: Meteorological services, especially weather radars and satellites, are vulnerable to interference from other radio services. For example, transmissions from commercial satellites, aircraft, or mobile networks can disrupt weather radar signals, leading to inaccurate or incomplete weather data. Managing such interference is a significant challenge, requiring technical solutions, regulatory oversight, and coordination between different service providers.

To ensure the continued effectiveness of meteorological services, the following measures must be taken:

- ***International Cooperation***: Global challenges such as climate change and extreme weather events require international collaboration. Continued cooperation through the ITU, WMO, and other international bodies will be essential to ensuring that spectrum remains available for meteorological services and that these services can operate without interference.
- ***Public Awareness***: Raising awareness about the importance of meteorological radio services, particularly among policymakers and industry stakeholders, is crucial. It will help ensure that spectrum allocation decisions prioritize public safety and environmental protection, particularly in the context of climate change.

To ensure that meteorological services continue to function effectively, the efficient management and allocation of spectrum is crucial. Policymakers, regulatory bodies, and international organizations should work together to address the growing demand for spectrum and mitigate interference, ensuring that meteorological radio services can operate seamlessly for the benefit of society as a whole. More effective communication of the added value of the economic and societal benefits provided by existing and future meteorological observations needs to be developed. Future spectrum management must be based on careful balance of

public and private interests to define a worldwide harmonized way for efficient spectrum use and requires more active involvement of meteorological agencies in the decision-making process.

The regular WMO-ITU workshop is intended to support preparation to World Radiocommunication Conference 2027. The following topics are to be discussed:

- ***Overview of WMO and ITU activities for Earth observation and meteorology***, and meteorological and hydrological infrastructure that underpins weather and related environmental services worldwide.
- ***Radio technologies of Earth observations and meteorology***: A general overview of existing radio systems and new technological development will be considered.
- ***Economic value of Earth observation, Societal Benefits, and Empowering Decision Making***.
- ***Impact of RFI on spectrum use for Earth observation***: The situation with the degradation of measurements and interference cases, especially in passive bands, should be highlighted, and possible ways to keep the spectrum clean, such as regulation, monitoring, reporting, enforcement, to be discussed.
- ***Results of WRC-23 and preparation for WRC-27***: Lessons to be learned for future conferences are to be discussed to improve preparation for the next WRC. Preliminary discussion of agenda items of the future WRC targeted at defining interests and potential threats to the spectrum used by Earth observation and meteorological agencies to define priorities and strategies for the next study cycle.