WORLD METEOROLOGICAL ORGANIZATION

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

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ASSESS THE CURRENT AND POTENTIAL CAPABILITIES OF WEATHER RADARS FOR THEIR USE IN THE WMO INTEGRATED GLOBAL OBASERVING SYSTEM

Guidance on weather radars and radio-frequency spectrum

(Submitted by Paul Joe)

Summary and Purpose of Document

The document provides information on the issue of weather radar and radio-frequency spectrum.

ACTION PROPOSED

The meeting is invited to review the information provided in this document and agree on recommendations related to weather radar and radio-frequency interferences as well as on the need to undertake specific activities related to this topic.

Appendices:
1. Draft WMO Guidance Statement on Weather Radar/Wind Turbine Siting
2. Radio Frequency Allocations for Meteorological Operations and Research - A Policy Statement of the American Meteorological Society

Briefing Note on Weather Radars and Radio-Frequency Spectrum

(2009-11-19)

1. Issue

The weather radar spectrum has been opened to telecommunications users on non-interfering secondary basis. Proposed controls have not been adequately demonstrated to protect weather radar operations. The issue is how to protect the band for current and future meteorological use

2. Background

1. At the World Radio Conference 2002 (WRC2002), the meteorological radio-frequency bands were opened to the telecommunications industry on a non-interfering secondary use basis. The decision impacts many meteorological applications besides weather radar including radiosondes, wind profilers, telecommunications, radiometers, etc. This document focuses on weather radar issues. Weather radar is often combined with these other applications and may not always be adequately represented.
2. Each country has a National Radio-Frequency Agency (NRA) responsible for spectrum usage issues, through which, National Hydro-Meteorological Services (NHMS's) participate and present their concerns. Globally, this has not always been effective and NHMS were not always adequately consulted.
3. Dynamic Frequency Selection (DFS) was proposed as a method to avoid interference. This involves sensing whether a channel is already used (Channel Availability Check) and avoiding it if already occupied. Analysis by Canada, in preparation for WRC 2002, indicated that the proposed CAC would not be effective and proposed a 10 minute CAC (instead of 1 minute). The 10 minute CAC corresponds with the scan cycle time of Canadian weather radars and it was expected that within the 10 minutes, there would be a scan that would be detected by the DFS device. At the time, Canada was alone on the issue. Many countries were not consulted or prepared at the WRC02 meeting.
4. Frequencies made available to the telecommunications are very broad – cover all radar bands. Within a band, the spectrum is divided into channels – typically 6 to 12 of different bandwidths. Weather Radar uses a small fraction of the band. While all bands have been at risk, the current focus seems to be at C-Band (5.6GHz) by Radio Local Area Networks. Note that Ka Band (35 GHz) is used for research and spaceborne radars and radiometers and used by vehicle avoidance systems. Applications will continue to develop in both communities and increased spectrum use can be anticipated.
5. The WRC2002 assumed RLAN usage from fixed locations (homes, offices) and not from mobile platforms (planes, trains, boats nor cars). Usage guidelines must evolve to protect weather radars.
6. Devices are expected to be massively deployed. Each country has control over the band – could develop devices at different central frequencies. Device use would be un-licensed and could cross jurisdictional boundaries. There is no effective mitigation recourse once devices are released.
7. RLAN devices are available, have already created interference to weather radars and DFS functionality have been found to be disabled. This led to increased awareness and activity on this issue from NHMS, particularly in Europe. RLAN devices have crossed jurisdictional borders using slightly different frequencies allowing greater spectrum use.
8. Canada has conducted C-Band – RLAN exploratory research studies with Industry Canada and with Boeing from an airborne platform. Studies have been quoted as evidence to support industry but they were exploratory in nature and not comprehensive. Some comments:
    a. Single RLAN behaviour may not represent massively deployed RLAN networks.

b. DFS' studied uses pulse counting as the detection strategy, so detection is not instantaneous (single pulse, or rising edge of pulse)

c. DFS algorithm relies on a "weather radar model" proposed at WRC2002 which was flawed (at least, in Canada) – particularly, in pulse width sizes and repetition frequencies

d. DFS devices (Colubris) used exceeded the power detection thresholds and may not represent cost conscious systems. Focus of studies was whether RLAN thresholds were adequate.

e. DFS exit strategy is not instantaneous and will cause potential interference even if it detects and exits. There was confirmation of the need for the 10 minute CAC.

9. In Europe, EUMETFREQ was organized after WRC2002 to represent the European NHMS' as a single voice. EUMETFREQ has been active and represents all RF issues – weather radar is one. Changes to the DFS standards have been accepted for implementation in the next few years. Among other changes, a 10 minute CAC will be adopted.

10. Australia and Canada (perhaps others) have "temporarily" notched the weather radar channels of C-Band from RLAN use until the DFS have been adequately demonstrated.

11. WMO has identified RF spectrum use as an issue.

12. Guidance statement by the American Meteorological Society has recently been updated and released (Oct 2009).

13. CISCO systems has been an industry leader and have engaged EUMETFREQ and U.S., Canada, Australia and Japan in separate dialogs on mitigating potential issues. Identified issues include:

    a. A technical definition/specification of a weather radar (current and future) from a RLAN/DFS perspective (frequency usage, pulse widths, pulse repetition frequencies, scan strategies and cycles)

    b. Expanding/relaxing of technical constraints of DFS operations.

    c. Scan strategies. Industry may request that the radar conduct "clearing" scans before returning to operations. This is in fact the rationale for the 10 min CAC in Canada.

    d. Industry would like a relaxing of the "notch" or ban and also the 10 min CAC and look for mutually agreed solutions.

3. Discussion

- Weather radar is the primary user and there is pressure on the community to share the spectrum.
- The issues are global and require global solutions. Strong role for WMO.
- There are natural limitations in the consultation process, the issues continue to evolve and so require constant diligence.
- Industry would like a detailed radar specification to design their devices. There is a need to be very careful that this is not limiting in the future and so it is very difficult to do properly and needs significant vision and expertise. It may not be in the best interest of the meteorological community to publish or support such a document – may be better to engage them in discussion.
- In lieu of a comprehensive specification (CISCO realizes the WRC2002 specification is inadequate), a survey of European radars was conducted. It was incomplete, somewhat inaccurate and retrospective.
- EUMETFREQ has been successful and proposals to change DFS requirements are planned for implementation.

- There is a lack of a comprehensive test/validation plan for massive deployment under various meteorological conditions (for example, under anomalous propagation conditions).
- Mobile RLAN's have not been adequately considered.
- Little information/no testing/validation of UW Ka-Band vehicular/radar studies have been conducted.
- Perhaps the biggest issue is the lack of a mitigation process. Once devices are deployed and cause interference on a future radar, there may be little recourse.
- Weather radar is a different from other applications. They are used differently in different countries and require significant signal processing expertise to respond to Industry.
- The consultation process is complex and involves NHMS, NRA, Industry, etc.
- The AMS has published a Guidance Statement on Radio-Frequency Use which includes Weather Radar (see Appendix 2). It is used as a proposed basis for a statement by WMO.

4. Recommendations

- WMO has a strong leadership and coordination role to organize NHMS opinion on global weather radar issues. WMO is already and needs to continue to monitor and report the situation as the issues are complex and change quickly.
- Need to be proactive and have a voice and presence (at WRC as a user).
- Guidance statement should be issued specifically on weather radar and RLAN (see Appendix 1)

DRAFT

WMO Guidance Statement on

Weather Radar/Radio-Frequency Shared Spectrum Use

(adapted from AMS statement)

The WMO expresses concern over increasing pressure on weather radar-related radio frequency bands and stresses the need for adequate protection and mitigation efforts against the loss and shared use of this spectrum. The WMO addresses its concern to policy makers, to national radio-frequency administration agencies, to national hydrological and meteorological societies, to commercial vendors of telecommunication equipment and to the meteorological community.

Protection of traditional weather radar-related radio frequencies is critical to the continued function and improvement of weather sensing, monitoring, forecasting, and warning, and is therefore in the best interests of public safety and security. The meteorological community increasingly relies on remote-sensing technologies for both routine and experimental observations of weather and climate. These activities require global access to radio frequency spectrum by not only by radars but also wind profilers, microwave radiometers, and telemetry systems, as well as satellite-based passive and active sensors. The progress in weather warning services and other meteorological predictions made in recent years is largely attributable to these technologies.

Weather prediction models and localized operational forecasts increasingly depend on national networks of ground-based Doppler radars for severe weather warnings such as tornadoes, flash flooding, land-falling hurricanes, precipitation (rain, snow, hail) forecasts, aircraft icing and air traffic/weather avoidance. Worldwide, Doppler radar networks are now contending with increasing pressures on shared spectrum usage with unlicensed broadband wireless applications. As already experienced in Europe, the impacts of radio-frequency interference by wireless communications can render weather radars blind in particular directions or even over large portions of their coverage. The situation is exacerbated by the ubiquitous and unlicensed nature of these wireless applications that could lead to a total loss of the related spectrum for weather radars.

Development of new radar technologies, including adaptive scanning strategies, shorter pulses, polarization, pulse compression, frequency and phase agility is on-going. Current and planned satellite radar systems measure clouds and precipitation important for weather forecasting and global climate change research and assessment. A variety of other space-based and ground-based radio technologies are currently in experimental use and may require future radio spectrum allocations.

New communications applications make the radio frequency spectrum an extremely valuable commodity, and so the frequency bands used for operational meteorology and research are in increasing jeopardy. The WMO and the meteorological community rely on and support mandated international and national radio-frequency agencies and co-operation with the telecommunication authorities and industries to continue to protect or to share appropriately these radio frequencies. The WMO will pro-actively encourage and support these agencies' efforts to protect meteorological uses of the radio frequency spectrum. The WMO encourages national radio-frequency agencies to develop a clear definition of interference, permissible or otherwise, and a remedial process or solution if shared use becomes a problem. The WMO encourages funding and implementation of studies to determine the impact of the total or partial loss of one or more frequency bands used by current operational observing systems and by planned systems. Further, the WMO recommends the results of these studies be made available to national radio-frequency agencies and the telecommunications industry to encourage dialogue between active and passive users of the spectrum. Vigilance is necessary, as degradations of meteorological data due to intrusions or shared usages will evolve over time. Cooperation with national radio-frequency agencies, the telecommunications industry, and with other spectrum users is encouraged both to advocate support for critically important meteorological use of radio spectrum and to mitigate potential problems.

It is in all nations' best interests to protect radio frequencies essential for meteorological activities that are critical to the accurate forecasting of adverse weather. Global solutions are sought and should be advocated. The WMO will participate in international frequency management activities, to encourage their involvement and development.

Radio Frequency Allocations for Meteorological Operations and Research

A Policy Statement of the American Meteorological Society
(Adopted by the AMS Council on 1 October 2009)

The AMS expresses concern over increasing pressure on weather-related radio frequency bands and stresses the need for adequate protection and mitigation efforts against the loss and shared use of this spectrum. The AMS addresses its concern to policy makers, to national radio-frequency administration agencies, and to the meteorological community. Protection of traditional weather-related radio frequencies is critical to the continued function and improvement of weather sensing, monitoring, forecasting, and warning, and is therefore in the best interests of public safety and security. The meteorological community increasingly relies on remote-sensing technologies for both routine and experimental observations of weather and climate. These activities require global access to radio frequency spectrum by radars, wind profilers, microwave radiometers, and telemetry systems, as well as satellite-based passive and active sensors. The impressive progress in meteorological predictions made in recent years is largely attributable to these technologies.

Weather prediction models and localized operational forecasts increasingly depend on national networks of ground-based Doppler radars for severe weather warnings such as tornadoes, flash flooding, land-falling hurricanes, precipitation (rain, snow, hail) forecasts, aircraft icing and air traffic/weather avoidance. Worldwide, Doppler radar networks are now contending with increasing pressures on shared spectrum usage with unlicensed broadband wireless applications. As already experienced in Europe, the impacts of radio-frequency interference by wireless communications can render weather radars blind in particular directions or even over large portions of their coverage. The situation is exacerbated by the ubiquitous and unlicensed nature of these wireless applications that could lead to a total loss of the related spectrum for weather radars.

Wind-profiling radar systems provide otherwise unavailable details of atmospheric wind flow features, and they provide input to numerical weather prediction models. Operationally, they enable forecasters to identify wind shifts indicative of weather changes and wind shears that pose an aviation hazard and potentially life-threatening tornadic activity. Because different radio frequencies provide coverage of different altitudes in the atmosphere, each of the current wind-profiling frequencies is needed to obtain a complete vertical profile, and none could be eliminated without serious loss to atmospheric research and forecasting. Recent changes in frequency allocation for the NOAA National Profiler Network have already compromised their ability to sample adequately the planetary boundary layer.

Phenomena associated with climate variability and change, such as El Niño and global warming, are assessed through global observations made in part by microwave space-based sensors. Extending weather forecasts to timescales of a week or more for improving prediction and warnings or for economic benefits also requires such global-scale observations. These satellite sensors also track hurricanes and monitor sea ice, sea surface temperature, and soil moisture, all of which play important roles in weather and climate.

Most microwave techniques require an uncontaminated background free of radio interference, and some are centered on particular frequencies that uniquely correspond to resonances of important atmospheric molecules. Such is the case for technologies that measure water and water vapor in the atmosphere, whose measurement is essential to improve models of the storage and transfer of heat, an important aspect of weather and climate. Specifically, these measurements have been recently threatened by the development and deployment of automotive radar systems for collision avoidance.

The frequencies associated with such naturally occurring resonance phenomena cannot be changed – they are an inherent property of radio propagation through the atmosphere. Therefore maintaining clear allocation of these important portions of the radio frequency spectrum is critical.

Development of new environmental sensing technologies is of growing importance. Current and planned satellite radar systems measure clouds and precipitation important for weather forecasting and global climate change research and assessment. A variety of other space-based and ground-based radio technologies are currently in experimental use and may require future radio spectrum allocations. Finally, radio telemetry of weather data is essential to the meteorological community and, ultimately, the public at large. It is the means of transferring measurements from weather balloons and satellites to the ground and from remote sites to data analysis centers. Because of the large investment in radio telemetry systems and the generally limited resources for changing radio equipment, commercialization of the frequency bands in which this communication takes place should be approached with great caution.

Burgeoning communications applications make the radio frequency spectrum an extremely valuable commodity, and so the frequency bands used for operational meteorology and research are in increasing jeopardy. The AMS and the meteorological community rely on and support their mandated national radio-frequency agencies to continue to protect or to share appropriately these radio frequencies. The AMS will pro-actively encourage and support these agencies' efforts to protect meteorological uses of the radio frequency spectrum. The AMS encourages national radio-frequency agencies to develop a clear definition of interference, permissible or otherwise, and a remedial process or solution if shared use becomes a problem. The AMS encourages funding and implementation of studies in the U.S. to determine the impact on the U.S. economy of the total or partial loss of one or more frequency bands used by current operational observing systems and by planned systems. Further, the AMS recommends the results of these studies be made available to national radio-frequency agencies and the telecommunications industry to encourage dialogue between active and passive users of the spectrum. The AMS encourages all meteorological users of the radio frequency spectrum to notify the appropriate agencies of their use and to cooperatively advocate for their protection when necessary. Interference should be reported to the appropriate national radio-frequency agency. Vigilance is necessary, as degradations of meteorological data due to intrusions or shared usages will evolve over time. Cooperation with national radio-frequency agencies, the telecommunications industry, and with other spectrum users is encouraged both to advocate support for critically important meteorological use of radio spectrum and to mitigate potential problems.

It is in all nations' best interests to protect radio frequencies essential for meteorological activities that are critical to the accurate forecasting of adverse weather, and for climate-change assessment. Global solutions are sought and should be advocated. The AMS will participate in national frequency management activities, as well as in the World Meteorological Organization and other international agencies, to encourage their involvement and development.

[This statement is considered in force until October 2012 unless superseded by a new statement issued by the AMS Council before this date.]