

GLOBAL ITU/WMO SEMINAR · SPECTRUM USE FOR METEOROLOGY

MetAids and additional meteorological radiocommunication systems

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Contents

THE METEOROLOGICAL AIDS SERVICE

A radiocommunication service used for meteorological, including hydrological, observations and exploration (RR No. 1.50)

Meteorological services depend on complementary observations of the atmosphere to support forecasts, warnings and climate monitoring. Spectrum enables these observations to be made, transmitted and shared.

1

Radiosondes

High-resolution profiles through the atmosphere

Direct measurements of temperature, humidity, pressure and wind that support forecasting, climate monitoring and satellite observations.

2

Ground-based microwave radiometers

Continuous profiles close to the Earth's surface

Passive observations of temperature and water vapour that add detail on rapidly changing conditions in the lower atmosphere.

3

Lightning detection

Timely information on thunderstorm activity

Ground and satellite systems locate and monitor lightning to support severe-weather awareness and warning services.

1

Radiosondes

Radiosondes form the core of the global upper-air observing network, providing direct measurements through the atmosphere.



What radiosonde observations deliver

Numerical weather prediction

Profiles of temperature, humidity and wind are essential inputs to numerical weather prediction, from nowcasting to longer-range forecasting.

The highest vertical resolution

Radiosondes have provided high-resolution atmospheric profiles for decades. Short-term forecasting requires vertical resolution of 100 m or better.

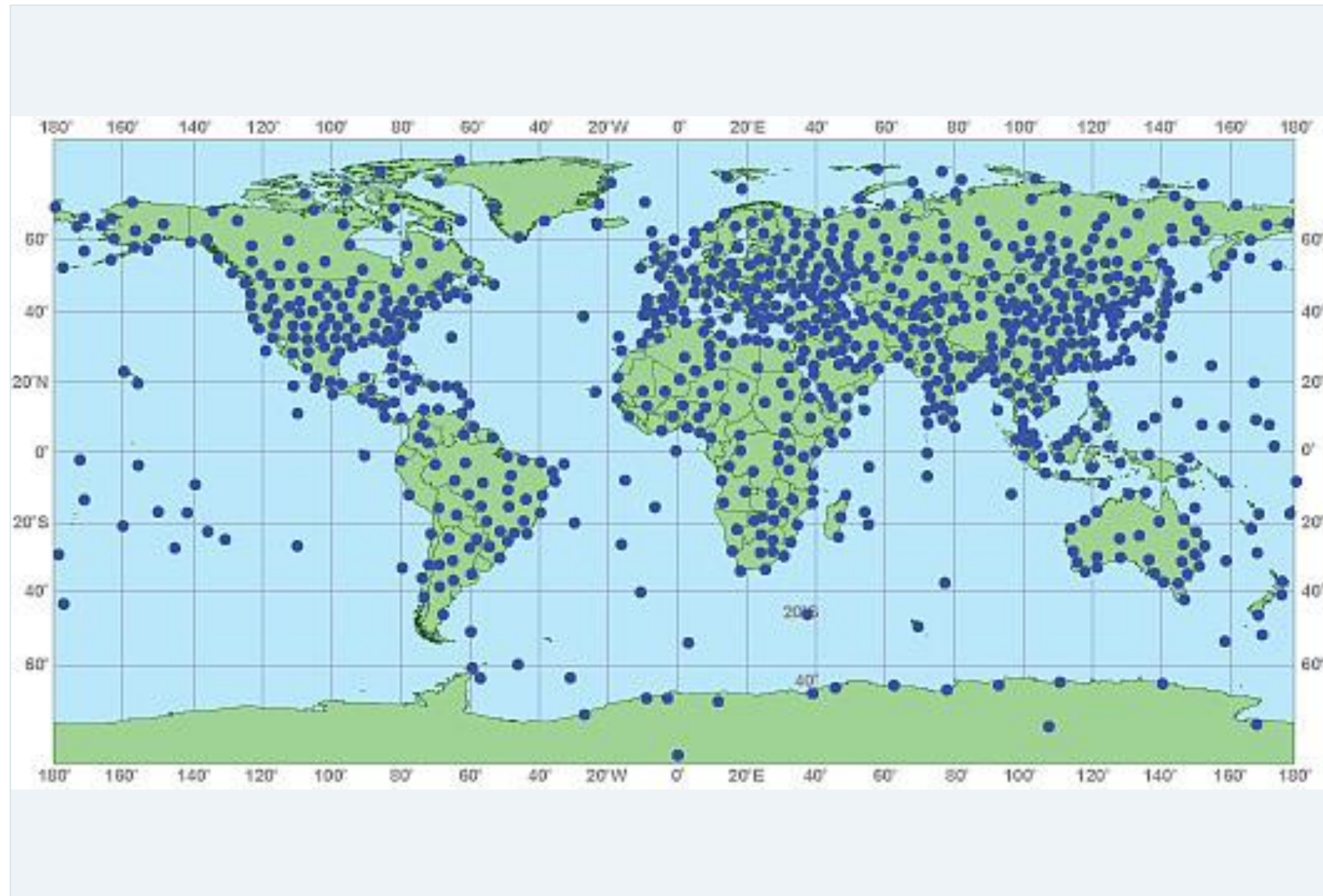
Climate monitoring

Long-term records support climate monitoring and a wide range of atmospheric research.

Reference for satellites

These in situ measurements are essential for calibrating space-based remote sensing, in particular passive sounders.

How radiosonde observations are coordinated and shared



Locations of radiosonde observations worldwide. Image: NOAA

Synchronised worldwide

Recommended launches twice daily at 0000 and 1200 UTC, forming the global WIGOS upper-air network. Many countries launch more often.

Network density

WMO requirements support global coverage, with observations typically made at least twice daily and profiles extending high into the atmosphere.

Shared rapidly for global forecasting

Observations are rapidly exchanged internationally in standardised meteorological formats for use by forecasting centres worldwide.

Why radiosondes depend on spectrum

Spectrum is required for **two distinct functions**: data transmission, and tracking of the radiosonde's location. The instrument is normally expendable — the radio link is the only path from sensor to forecaster.

FUNCTION 1

Data transmission

In situ measurements are transmitted to a base station, where a signal processing system decodes the data and generates the atmospheric measurement data.

Two bands allocated globally for this purpose:

400.15–406 MHz

1 668.4–1 700 MHz

FUNCTION 2

Tracking the sonde

Location information is required to determine wind speed — and sometimes pressure — as the radiosonde ascends. Most radiosondes rely on NAVAID/GNSS signals for position and derived wind.

GNSS frequencies that may be used:

1 575.42 MHz (L1)

1 227.6 MHz (L2)

Why radiosondes require two frequency bands

Distinctive features and current sharing conditions mean each band does something the other cannot.

400.15–406 MHz

REACH AND SIMPLICITY

- Lower propagation loss — important in regions with high wind speeds and long slant ranges.
- Allows simpler, smaller receive antennas.
- Winds measured by GNSS; Radio-direction finding at the lower band would require a significantly larger antenna.
- This band is used by most radiosondes.

1 668.4–1 700 MHz

COST AND OPERATIONAL INDEPENDENCE

- Reduces the cost of the expendable device.
- Enables operation independent of international NAVAID/GNSS systems, which may not be available in some circumstances.
- Chosen by some administrations for budgetary or resilience reasons.
- Limited by line of sight.

The two bands support different operational needs, therefore MetAids operations **cannot rely on the availability of a single band** — retaining both is crucial to sustaining successful meteorological operations.

How reliable radiosonde observations are protected

The MetAids service has a primary allocation worldwide in both bands, establishing regulatory recognition and protection, but effective operation still depends on a number of factors.

National and international coordination

While the MetAids service is allocated on a primary basis, other primary services share parts of the bands, requiring national and international coordination. Other radiosondes and co-allocated services can constrain the channels available in practice.

Interference and signal blockage

Nearby transmissions or physical obstacles can interrupt the link between the radiosonde and receiving station. Appropriate national coordination and safeguarding measures may also be required.

Dependence on positioning signals

Blocking, jamming or spoofing of Global Navigation Satellite System signals can affect position and derived wind observations, reducing or interrupting the usable data received from the radiosonde.

Protecting the weather service requires appropriate allocations, effective coordination and resilient network design.

What ground-based radiometers deliver

Ground-based radiometers provide continuous information on the lower atmosphere, where conditions can change rapidly and satellite observations typically provide less vertical detail.

Temperature and water vapour profiles

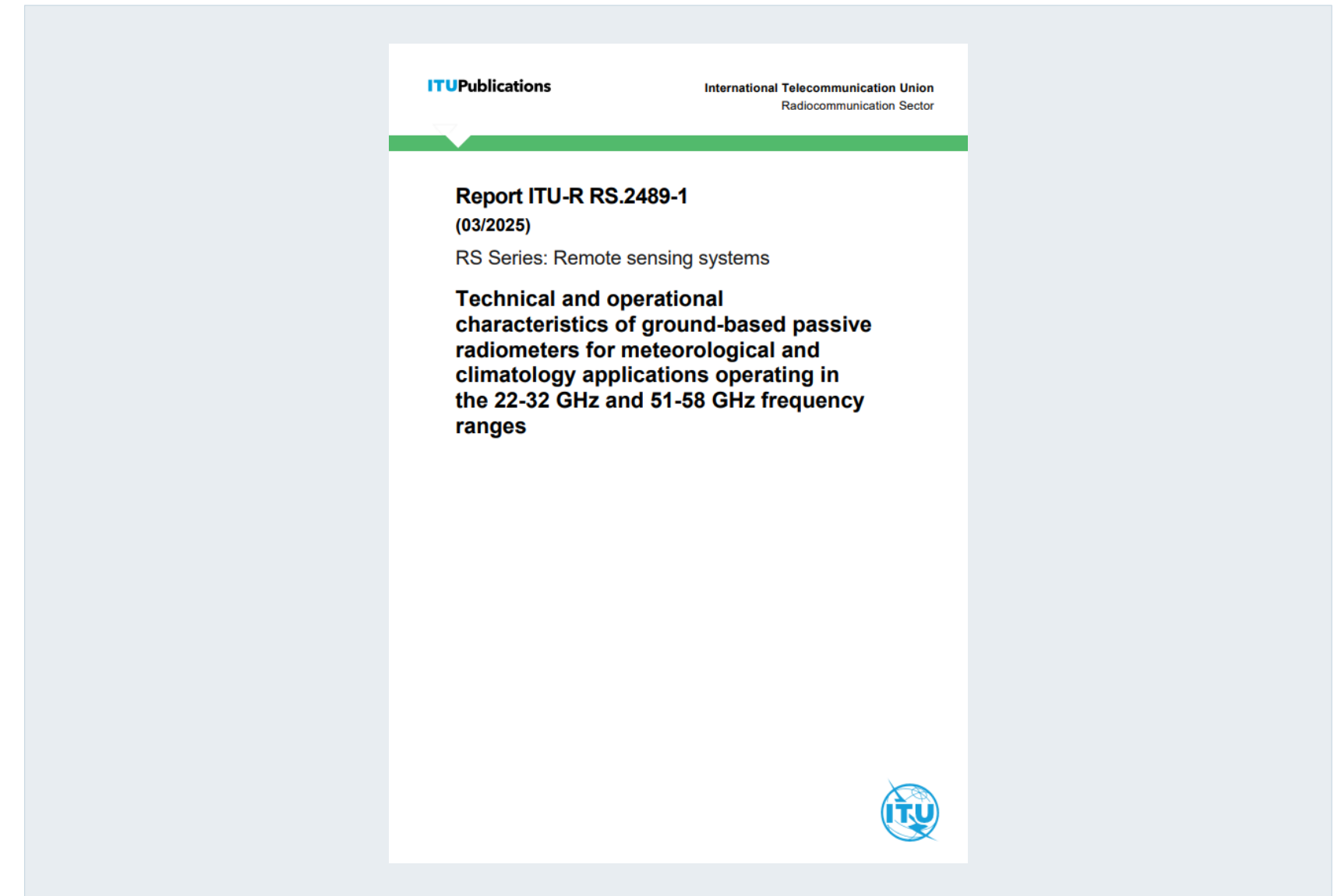
Continuous passive observations provide information on the vertical structure of the lower atmosphere.

Detailed local observations

High vertical and temporal resolution can capture changes in the boundary layer between other observations.

Supporting forecasting and monitoring

Measurements can support local forecasting and derived indices, including indicators of thunderstorm potential.



Report ITU-R RS.2489-1 (03/2025) — technical and operational characteristics of ground-based passive radiometers in the 22–32 GHz and 51–58 GHz ranges.

Why radiometers depend on specific frequencies

Frequencies are selected according to the absorption and emission characteristics of the atmospheric variables being observed. Some overlap with those used by satellite remote sensing and **benefit from the same protection**; in other bands ground-based radiometers are **not protected on an international basis**.

FREQUENCY	APPLICATION	REMOTE SENSING PROTECTION
21–28 GHz	Water vapour profiles	21.2–21.4 · 22.1–22.5 · 25.5–27 GHz · 23.6–24 GHz — RR 5.340 applies
32 GHz	Cloud identification	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 and 52.6–54.24 GHz — 5.340 applies · 54.25–59.9 GHz — primary EESS (passive)
183 GHz	Water vapour	174.8–182 · 185–190 GHz · 182–185 and 190–191.8 GHz — 5.340 applies

RR No. 5.340 prohibits all emissions in specified frequency bands, providing particularly strong protection for passive observations.

As networks grow, effective sharing and careful siting will remain important.

3

Lightning detection

Accurate, timely lightning information supports weather monitoring and warnings, with clear links to public safety on land, at sea and in the air.



What ground-based lightning detection delivers

Lightning produces electromagnetic emissions that can be detected passively. Multiple precisely timed observations from three or more sites allow a network to determine where activity is occurring.

How it works

Reliable communications and precise timing allow meteorological services to monitor the location and development of lightning activity.

Applications

Lightning detection provides important information for public safety and operational decision-making, including aviation, transport and wildfire management.

All systems require **reliable communications links** from remote sites, and **GNSS signals** for the precise time synchronisation needed to locate lightning activity.



Antenna and amplifier from the UK Met Office LEELA lightning detection system.

Why lightning detection requires multiple frequency bands

8.3–11.3 kHz

VLF · VERY LONG RANGE

- Lightning signals can be detected over very long distances, allowing sensors to be spaced up to around 2,000 km apart.
- Enables detection across large areas with widely spaced sensors.
- Useful where broad geographical coverage is required.

Around 200 kHz

LF · REGIONAL DETAIL

- The most widely used operational systems. Provides more detailed lightning location over regional-scale networks.
- At these frequencies, a cloud-to-ground discharge shows a pronounced leading edge that can be timed accurately.

Around 60–66 MHz

VHF · CHANNEL MAPPING

- Detects electrical discharges within thunderstorms.
- Provides much more detailed information on lightning activity close to the sensor network.
- Storms must stay within line of sight for all the activity to be observed.

Meteorological Aids has a primary allocation at 8.3–11.3 kHz, limited to passive use under RR No. 5.54A. In 9–11.3 kHz. Specific sharing conditions apply with Radionavigation in 9–11.3 kHz. Regulatory recognition does not remove all interference risk; lightning detection systems can still be vulnerable to interference and signal disruption.

High-power transmitters nearby can overwhelm node signals. Low levels can be notched out; widespread interference is extremely detrimental.

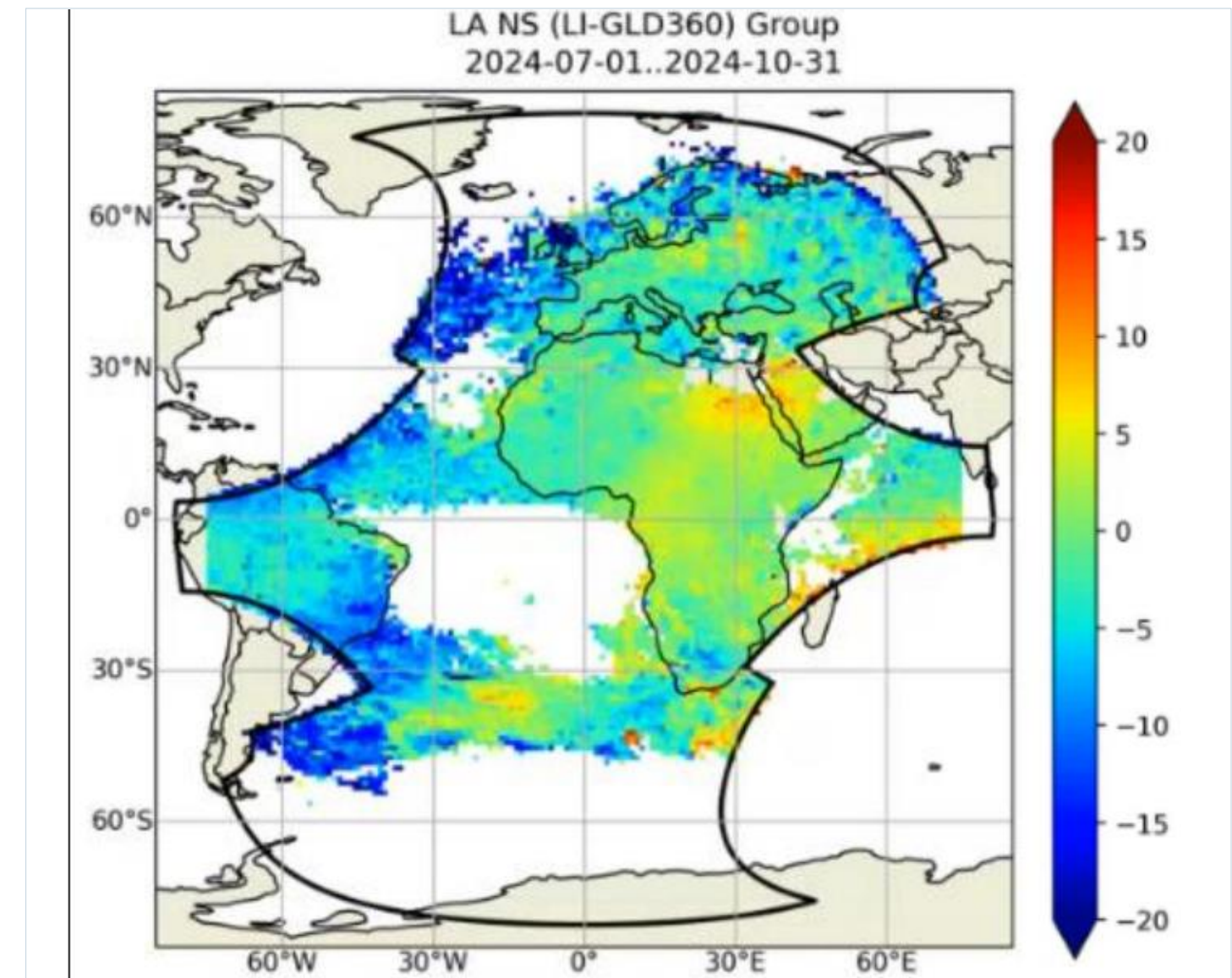
GNSS jamming or spoofing can put a node in the wrong location. A resilient network lets other nodes compensate when one is withdrawn.

How satellite and ground-based lightning observations complement each other

The **Meteosat Third Generation Lightning Imager** detects lightning flashes from geostationary orbit, providing wide, continuous coverage — reliable data over a much larger area than ground-based systems.

Lightning Imager data is downlinked at 26 GHz. Processed products are disseminated via EUMETCast at Ku band in Europe and C band in Africa.

Ground-based and space-based detection are complementary: Satellite observations provide broad, continuous coverage, while ground-based networks provide complementary high-detail information within regional networks.



LI Group north-south mean location accuracy (km), July–October 2024, relative to GLD360 locations. Source: EUMETSAT.

Key Messages: Spectrum enables essential meteorological observations

Protecting spectrum access helps protect the observations that underpin forecasts, warnings and climate services.

Complementary observations

Radiosondes, ground-based radiometers and lightning systems provide different information about the atmosphere across different spatial and temporal scales.

Different spectrum requirements

Spectrum enables data transmission and tracking, passive remote sensing, lightning detection, precision timing and dissemination of observations.

Protection and coordination

International allocations and provisions such as RR No. 5.340 provide essential foundations, but effective sharing, interference management and resilient system design remain important.

Thank you.

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