Active Sensing Applications and Future Challenges

WMO-ITU Training Workshop on Use and Management of Radio Spectrum for Meteorology

3 & 4 March 2025

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EESS Terminology Explained (Pg 1 of 2)

- There are several relevant definitions in the Radio Regulations:

1.51 *Earth exploration-satellite service:* A *radiocommunication service* between *earth stations* and one or more *space stations*, which may include links between *space stations*, in which:

– information relating to the characteristics of the Earth and its natural phenomena, including data relating to the state of the environment, is obtained from *active sensors* or *passive sensors* on Earth *satellites*;
– similar information is collected from airborne or Earth-based platforms;
– such information may be distributed to *earth stations* within the system concerned;
– platform interrogation may be included.

This service may also include *feeder links* necessary for its operation.

1.182 *active sensor:* A measuring instrument in the *earth exploration-satellite service* or in the *space research service* by means of which information is obtained by transmission and reception of *radio waves*.

1.183 *passive sensor:* A measuring instrument in the *earth exploration-satellite service* or in the *space research service* by means of which information is obtained by reception of *radio waves* of natural origin.

EESS Terminology Explained (Pg 2 of 2)

- **EESS** – Links operated in the Earth-to-space, space-to Earth and space-to space directions for Earth observation data transmission and/or tracking, telemetry and control of satellites

- **EESS (passive)** - Satellite-borne sensors that conduct Earth observations through reception of natural emissions from the Earth's surface and atmosphere
  - Of interest are radiation peaks indicating the presence of specific chemicals, or the absence of certain frequencies indicating the absorption of the frequency signals by atmospheric gases

- **EESS (active)**- Satellite-borne sensors that conduct Earth observations through reception of intentionally transmitted signals that are reflected by the area under measurement
  - Normally the signal is transmitted and the reflected signal is received by the same satellite however this not always the case

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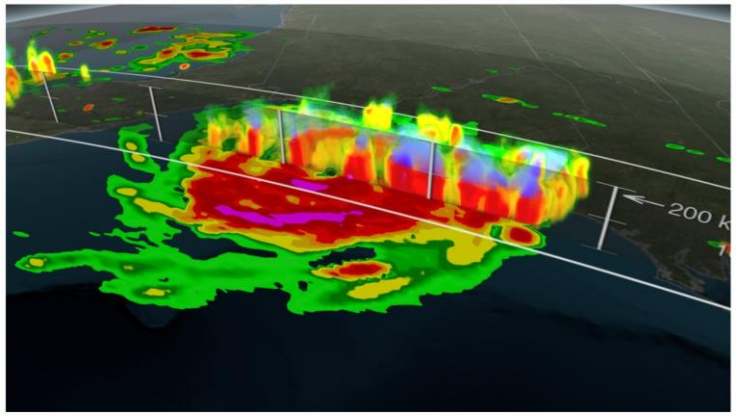
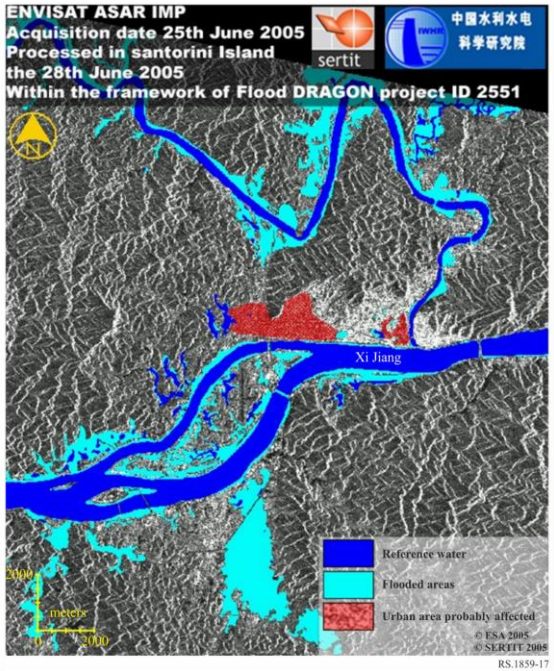
Why Are Active Sensors Important?

- Example uses for active sensor data:
  - Meteorological data for input for weather prediction
  - Oceanography
  - Climate data
  - Land use data for land management
  - Remote sensing for disaster management



GPM observations of Hurricane Arthur on 3 July 2014



Flooding of the Xi River, affecting the city of Wuzhou in Guangxi Province Reference data are from Landsat; flood data are from ASAR on Envisat

Active Sensor Types

Synthetic aperture radars (SAR) – Sensors looking to one side of the nadir track, collecting a phase and time history of the coherent radar echo from which typically can be produced a radar image of the Earth's surface.

Altimeters – Sensors looking at nadir, measuring the precise time between a transmit event and receive event, to extract the precise altitude of the Earth's ocean surface, including coastal and inland waters.

Scatterometers – Sensors looking at various aspects to the sides of the nadir track, using the measurement of the return echo power variation with aspect angle to determine the wind direction and speed on the Earth's ocean surface, including coastal and inland waters. Backscatter is also used to look at all land surfaces, providing Earth's surface conditions such as soil moisture and rain over land.

Precipitation radars – Sensors scanning perpendicular to nadir track, measuring the radar echo from rainfall, to determine the rainfall rate over the Earth's surface and three-dimensional structure of rainfall.

Cloud profile radars – Sensors looking at nadir, measuring the radar echo return from clouds, to determine the cloud reflectivity profile over the Earth's surface.

Remote Sensing For Managing Natural Disasters

Objective / Technology	SAR Imagery	InSAR Imagery	Active MW Imagery	Radar Altimetry	Radar Scatterometry	Precipitation Radar	GPS Radio Occultation	Passive MW Imagery	Passive MW Sounder	Geo. Visual and IR Imagery	Optical Imagery	Multispectral Optical Imagery	IR Imagery
Coastal Hazards	X										X		
Drought	X		X	X	X			X		X	X	X	
Earthquakes	X	X					X				X		
Extreme Weather					X	X	X	X	X	X	X		
Floods	X		X		X	X	X	X	X		X		
Landslides	X	X									X	X	
Ocean Pollution	X											X	
Pollution											X	X	
Sea/Lake Ice	X							X			X		
Volcanoes	X	X						X			X	X	X
Wildland Fires								X			X	X	X

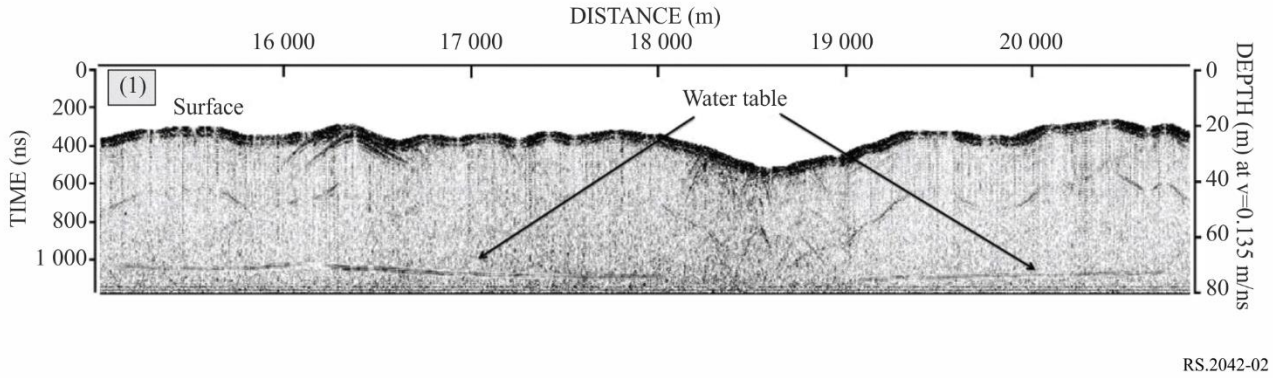
Frequencies Allocated to the EESS (active)

Frequency Band as Allocated in Article 5 of the Radio Regulations	Application Bandwidths				
	Scatter-ometer	Altimeter	Imager	Precip. radar	Cloud profile radar
40-50 MHz					
432-438 MHz			6 MHz		
1 215-1 300 MHz	5-500 kHz		20-85 MHz		
3 100-3 300 MHz		200 MHz	20-200 MHz		
5 250-5 570 MHz	5-500 kHz	320 MHz	20-320 MHz		
8 550-8 650 MHz	5-500 kHz	100 MHz	20-100 MHz		
9 200-10 400 MHz	5-500 kHz	300 MHz	20-1200 MHz		
13.25-13.75 GHz	5-500 kHz	500 MHz		0.6-14 MHz	
17.2-17.3 GHz	5-500 kHz			0.6-14 MHz	
24.05-24.25 GHz				0.6-14 MHz	
35.5-36 GHz	5-500 kHz	500 MHz		0.6-14 MHz	
94-94.1 GHz					0.3-10 MHz
133.5-134 GHz					0.3-10 MHz
237.9-238 GHz					0.3-10 MHz

WRC-23 Agenda Item 1.12

WRC-23 Agenda Item 1.12 considered creation of and EESS (active) frequency allocation to allow the operation of a space-borne radar sounder in 40-50 MHz.

- The planned satellite-borne radar sounder operating in the EESS (active) will be used to:
  - Measure ice thickness over land masses
  - Locate aquafers in desert regions



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Outcome of WRC-23 Agenda Item 1.12

- Global secondary allocation to the EESS (active) in 40-50 MHz created with additional regulatory restrictions.
- Operations within the polar regions subject to:
  - The mean power flux density (pfd) limit shall not exceed:
    - −147 dB(W/(m2 · 4 kHz)), under clear sky propagation conditions, for more than 0.05% of the time within a 24-hour period
    - −136 dB(W/(m2 · 4 kHz)), under clear sky propagation conditions
  - Transmission time limited to no more than 90 minutes per 24-hour period.
- Operations outside the polar regions subject to:
  - The pfd level per spaceborne radar sounder produced at the surface of the Earth shall not exceed −189 dB(W/(m2 · 4 kHz)), under free-space propagation conditions
  - The pfd may be exceeded over the territory of any administration subject to obtaining explicit agreement from that administration.

EESS (active) Concerns on the WRC-27 Agenda

- **Agenda Item 1.4**- Possible new allocations to FSS in 17.3-17.7 GHz and to BSS in 17.3-17.8 GHz in Region 3
  - Adjacent EESS (active) allocation in 17.2-17.3 GHz
  - No identified use of this EESS (active) allocation – makes protection difficult
- **Agenda Item 1.8-** Possible Radiolocation Allocations in 231.5-275 GHz and Identifications in 275-700 GHz
  - The bands selected for study could overlap the 237.9-238 GHz frequency band
  - Sharing between EESS(active) and radiolocation is generally easier than other inter-service sharing

Additional Resources

- Handbook: Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction
- Handbook: Earth Exploration-Satellite Service
- Recommendation ITU-R RS.1166 - Performance and interference criteria for active spaceborne sensors
- Recommendation ITU-R RS.1859 - Use of remote sensing systems for data collection to be used in the event of natural disasters and similar emergencies
- Recommendation ITU-R RS.1883 - Use of remote sensing systems in the study of climate change and the effects thereof
- Recommendation ITU-R RS.2105 - Typical technical and operational characteristics of Earth exploration-satellite service (active) systems using allocations between 432 MHz and 238 GHz

Thank you

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