7.9 SATELLITE METEOROLOGY

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Background

The preliminary fourth edition of the publication WMO-No. 258 was reviewed as part of the agenda of the third meeting of the CBS OPAG IOS Expert Team on Improving Satellite Systems Utilization and Products held from 3 to 7 July 2000 in Lannion, France. The review covered the change in educational philosophy of WMO-No. 258 and the content as it related to the use of satellite derived data and products. In connection with the competency requirements discussed under section 2.2 of the publication, the review identified two main areas of satellite activities:

(*a*) Usage of satellite imagery and products by a range of staff in the professional branches for weather analysis and forecasting and climate monitoring and prediction, and in the various meteorological application and public service areas;

(*b*) Usage of satellite data and imagery by specialist staff working in satellite remote sensing areas in either a specialist Satellite Meteorology Branch (SMB), or in areas such as: research and development; information systems technology and data processing; or observations and measurements.

As discussed in section 2.2 (Training for job-competency) there are certain skill areas that cut across several operational branches of activity in any NMS. One such skill area is that of Satellite Meteorology since satellite data and products are useful for a whole range of meteorological applications – from very short range weather forecasting to climate monitoring, from measuring sea-surface temperatures to depiction of upper-level winds, etc. Satellite data comes in a variety of formats (APT, WEFAX, HRPT, SVISSR and in the future LRIT and HRIT) and can be obtained directly from satellite, via the GTS, or via other networks such as the Internet.

Staff in most branches depicted in Figure 2.2 is expected to have basic competency in the routine interpretation and use of satellite imagery and products that are used as part of their every day activities. Some of these competencies are explicitly referred to in the abbreviated descriptions of each of the main branches in Chapter 2 and reiterated as appropriate in the previous sections of this chapter. A consolidated list of satellite meteorology competencies for staff working in areas such as weather forecasting, aviation and marine application areas is included here for completeness, (see the next sub-section below).

As the use of meteorological satellite data and products within a NMS becomes more quantitative, i.e. utilized in NWP and analysis schemes and other application areas rather than as imagery alone, a small number of staff start to specialize in satellite meteorology. The last sub-section represents a first step in adding a SMB to the listing of the main branches of activity at the NMS, to reflect the more specialized use of satellite data and products. Existing satellite meteorology groups in the USA are used as a basis for some of the activities presented below.

In some NMSs, the functions of a SMB may be spread across other branches, for example:

- The reception of satellite data may be undertaken within the branch for observations and measurements;
- Calibration and navigation use within NWP suites;
- Archiving of the data, within the branch for IT and data processing;
- Development of new techniques or implementing techniques from other institutions within the branch for research and development, etc.

Core competency requirements in satellite meteorology

This paragraph outlines a suggested set of core competencies (basic skills) required by personnel working in weather forecasting and application areas, in their pursuit of the effective use of satellite data and products as described below:

(*a*) Capable of identifying the characteristics and typical uses of the different channels, either separately or in combination, available from meteorological satellites and the relevance to various meteorological application areas;

(*b*) Capable of identifying the types of products available from meteorological satellites and their utilization in various meteorological application areas;

(*c*) Able to correctly use satellite products to identify special features in relevant areas:
- Fog, ice cloud, warm water cloud, supercooled water cloud, sea ice, flooding, snow cover, etc;
- Dust, ash and other aerosols in the atmosphere;
- Volcanic eruptions;
- Fires;
- Synoptic phenomena such as cold fronts, jet streams, tropical storms, etc;

(*d*) Capable of explaining how the various channels and products can be used to identify cloud types and amounts, cloud clusters and systems; and able to associate them with different scale phenomena and with the climatology of the region;

(*e*) Able to integrate satellite data with other meteorological data to produce a diagnosis and assess the prognosis of the NWP guidance for the various application areas. Able to identify atmospheric processes that are relevant on various scales and that are revealed in satellite imagery;

(*f*) Able to digitally manipulate satellite imagery and products to create new products or change their format (projections, enhancements) to allow ease of use;

(*g*) Capable of using forecaster (or meteorological analysis) workstations to:
- Manipulate sequences of images (loops);
- Overlay meteorological observations and products;
- Identify geographical features in the imagery;
- Manipulate colour enhancements;
- Measure surface and cloud top temperatures;
- Estimate cloud top height;
- Calculate distances;
- Measure velocity of displacement of a feature;
- Measure the latitude and longitude of a feature;
- Measure the wind speed at different levels following cloud movement;
- Display sounding information;
- Estimate rainfall intensity and extension;

(*h*) Able to describe the differences between Geostationary (GEO), Low Earth Orbiting (LEO) and other orbits and describe their relevance to the various application areas.

A Meteorological Technician would be aware of the items (*a*), (*b*), (*d*) and (*f*), but would not be required to be proficient in them.

Satellite Meteorology Branch (SMB)

The mission of the SMB is to assist the other branches in the NMS with all activities associated with satellite observations and products. In addition, the SMB interacts with the SMBs of other NMS, the RMTCs, and the Virtual Laboratory for Satellite Meteorology training.

Mission and main activities

The staff of the SMB will assist with development of and transfer of new satellite-based products and techniques to the other branches of the NMS. These activities can include some or all of the following:
- Operate equipment used for tracking/ingest/calibration/navigation/archiving of satellite data and products;
- Review new products from GEO and LEO satellites;
- Create satellite-derived products and displays useful for weather forecasting (i.e. multispectral products such as fog/stratus, reflectivity, low-level moisture, skin temperature, albedo, etc.);
- Create/implement algorithms to estimate atmospheric motions and their heights by tracking cloud and water vapour displacements in sequences of satellite images;
- Implement procedures to monitor and validate the calibration of measured radiances;

- Develop and maintain operational systems to ensure accurate navigation (geolocation) of satellite data;
- Create/implement algorithms for inferring radiative and cloud properties (amount, height, thermodynamic phase, particle size, optical depth and emissivity);
- Create/implement algorithms for deriving temperature and moisture soundings from satellite radiance measurements;
- Implement new algorithms operationally;
- Optimize the use of satellite-derived mass and motion information in data assimilation and numerical weather prediction systems;
- Create satellite-derived fire, smoke, aerosols, dust, trace gases and other products for real-time monitoring and climate change studies;
- Undertake satellite-based climatological studies to improve forecasts and information to the public;
- Develop and implement systems for quality and performance monitoring of satellite data and systems;
- Develop and maintain systems for archive, browse and metadata to ensure rapid efficient access by users to satellite data and products especially for research;
- Train the NMS staff in new satellite capabilities; and
- Collaborate with the international user community to improve utilization of satellite observations.

As well as being cognisant of the core competencies associated with satellite meteorology outlined above, staff in the various functional roles in a SMB would be expected to possess additional advanced skills, which will be outlined in the next sub-section.

Advanced competency requirements

The satellite meteorology functions will involve four basic groupings of personnel:

- Management and planning of the overall programme;
- Engineering, covering the reception and transmission of the data;
- Information technology for processing the data and development and maintenance of the software systems;
- Satellite application scientists, covering the research and operational implementation requirements.

Indicative skills for each of these staff areas are outlined below. As already indicated before, there are many crossover areas between these staff groups with the actual responsibilities and tasks differing from NMS to NMS.

Management and planning

- Be familiar with the capability of current and future generations of GEO and LEO satellites and their potential application within the NMS and its wider service community;
- Review and establish new procedures for the use of satellite products within the branches of the NMS with the specific goal of providing improved services;

Engineering

- Interpret information about weather satellites and instruments, such as radiation and spectral channels; characteristics of the data: resolution, noise/signal ratio, etc.; orbital characteristics; and satellite perspective;
- Apply, where relevant, the above information to current tasks;
- Operate, as appropriate, equipment required for the tracking/ingest/calibration/navigation/archiving of satellite data and products.

Information technology

- Explain the processes for generating, quality controlling derived products from GEO and LEO satellites;
- Monitor and modify the process for displaying satellite data and products both alone, and in combination with, other products (integrated displays);
- Assist with the integration and transfer of new satellite observations and products to the other branches of activity;

- Where appropriate assist with the utilization of satellite observations and products in data assimilation and NWP systems;
- Outline the theory of, and assist with, the implementation of satellite data processing algorithms for deriving cloud properties, cloud winds, temperature and moisture soundings, land and ocean surface characteristics, etc.;
- Explain the processes for archiving and accessing the archive of quality controlled satellite data and derived products from GEO and LEO satellites.

Satellite application scientists

- Be current with, and be able to utilize products from both, GEO and LEO satellites;
- Apply physics of radiation to interpret products obtained from satellite data: laws of Planck, Stephan-Boltzmann, Wien, Beer; radiative properties of earth surfaces; radiative properties of the atmosphere;
- Interpret information about weather satellites and instruments, such as radiation and spectral channels; characteristics of the data: resolution, noise/signal ratio, etc.; orbital characteristics; and satellite perspective and apply it to current tasks where relevant;
- Explain the processes for generating, quality controlling and improving derived products from GEO and LEO satellites;
- Monitor and modify the process for displaying satellite data and products both alone, and in combination with, other products (integrated displays);
- Explain the theory of, and assist with, the implementation of satellite data processing algorithms for deriving cloud properties, cloud winds, temperature and moisture soundings, land and ocean surface characteristics, etc.;
- Where appropriate assist with the utilization of satellite observations and products in data assimilation and NWP systems;
- Interpret satellite observations and products to assist with specialized applications such as fire weather, volcanoes, hazardous material dispersion, and space weather;
- Assist satellite-based climatological studies by incorporating new and archived observations and products;
- Assist with the integration and transfer of new satellite observations and products to the other branches;
- Help to prepare and assist with training of satellite-related materials;
- Interact through the RMTCs and Virtual Laboratory for Satellite Meteorology with other groups and organizations associated with satellite meteorology.

The prediction is that activities of the SMB will continue to expand as the access to satellite data from both GEO and LEO platforms increases across the globe. The number of both platforms is also increasing, as well as the number and types of instruments on these satellites. SMB staff will be vital to the increased and effective utilization of the satellite observations and products in NMSs' operations.