

Satellite Skills and Knowledge for Meteorologist Forecasters

Interpretation of satellite imagery is not an end in itself but contributes to higher order forecaster competencies. In particular, it forms part of “Analyse and continuously monitor the weather situation” and “Forecast ... phenomena and parameters”.

Thus we have designated the satellite interpretation requirements as contributing skills rather than as competencies in their own right

Satellite interpretation skills

Interpret satellite imagery data and derived fields to support analysis, diagnosis, prognosis, and forecasting.

Elements

1. Identify surface features
2. Identify cloud types and their characteristics
3. Identify and interpret broad scale, synoptic and mesoscale systems
4. Identify and interpret atmospheric phenomena
5. Interpret derived fields
6. Identify and interpret oceanic features and systems

Application conditions

Satellite interpretation should always be considered in conjunction with other observation types, numerical guidance and conceptual models. These will provide a context for the interpretation and, in turn, the satellite data contributes to the full analysis.

The performance and knowledge requirements that support these skills should be customised based on the particular context of the organisation, its service requirements and available satellite data. This document covers the full range of possible skills and knowledge requirements. Any individual will require only a subset of these, according to their needs.

Meteorologists in different locations or performing different job tasks will have access to different satellites with their particular characteristics and to various display and manipulation systems and tools. They will also be dealing with a variety of local meteorological systems and phenomena.

The focus of this document is on meteorological forecasting. Other uses of satellite data, for example, research, oceanography, hydrology, climatology and other specialist areas, will be considered separately in other documents.

Context

In addition to the general competencies of a meteorological forecaster, the following conditions and background skills and knowledge will apply.

General conditions

- Imagery includes single and multiple channels and combinations of channels, including RGB displays, derived quantitative products (processed satellite data blended with NWP data) and synthetic satellite imagery from numerical model predictions.
- Satellites include geosynchronous and polar orbiting satellites with passive and active sensing.
- Satellite interpretation does not happen in isolation but occurs within the context of all other observations, guidance and situational awareness

- Systems, features and phenomena of interest will be dependent on the required forecasting tasks and location.

Access, select, display and manipulation of satellite data

The forecaster will be able to:

- Access data from geostationary and polar orbiting satellites
- Select the most appropriate channels or combinations of channels for the task at hand
- Display and manipulate the imagery as individual or combined channels, singly or with animation
- Apply enhancements to imagery
- Access and display derived data

Characteristics, limitations and possible errors in the satellite data

The forecaster will take into account factors affecting data quality and characteristics, including:

- Satellite resolution (time, horizontal, vertical), channel
- Position of the satellite sub-point – resolution, parallax errors
- Time of scan for different parts of the image
- Satellite sensitivities, precision, accuracy and wavelength characteristics
- Variations due to sun angle

How to use this document

This document specifies the satellite interpretation skills required of a meteorological forecaster. It does not specify how satellite meteorology should be taught. This will vary according to many circumstances, including the particular job tasks required; whether it is taught as part of a short course, a full initial course or independent learning; and, whether it is a separate subject, integrated with other data sources and theory as part of a meteorological systems approach, or a combination by initially teaching background satellite theory then an integrated systems approach.

In any case it is recommended that the training be activities based with the following sequence used for development:

1. Set your training goals. These are the required job skills from this document (and/or higher level competencies). This is what the forecaster needs to do.
2. Identify any sub-tasks required to achieve this. If all of these sub-tasks are learned the job task will be achieved.
3. Identify learning activities for each sub-task. If the activities are well chosen, we can be confident that, when successfully completed, the learner will be able to perform the job tasks.
4. Unlike in the conventional approach, only now do we identify the knowledge and skills that are required to enable someone to perform the learning activities. Note that these are *essential* knowledge and skills only. Any extra content that is in the “nice to know” category, or that we think they might need one day, has been shown to decrease overall learning and should not be included.

Learning guide

It is envisaged that a learning guide will accompany these guidelines. It will include details of techniques, channel combinations, possible learning activities, etc. These will be updated as new understanding, techniques and tools become available, whereas the skills in this document will remain more constant.

Element 1. Identify surface features

Description

Identify geographical features, surface characteristics and conditions

Performance components

1. Identify terrain and geographical features
 - Discriminate between land and sea.
 - Distinguish mountainous from low lying regions.
 - Locate rivers and river valleys.
 - Identify lakes.
 - Differentiate natural vs. human modified areas .
2. Identify surface characteristics and conditions, including dry/wet, different vegetation types and clear areas, sand and desert
 - Discriminate between areas of vegetation and areas of drought
 - Identify different types of desert surface e.g. sand desert pavement
 - Identify areas of recent burning
 - Identify areas of flooding
3. Identify snow cover and analyse its extent
 - Discriminate between cloud and snow.

Skills, techniques and knowledge requirements

To be added at a later date

Element 2. Identify cloud types and their characteristics

Description

Identify cloud types and features including height and temperature of tops, thickness and microphysics.

Performance components

1. Identify stratiform, cumuliform and cirriform cloud regions and individual cloud types and their characteristics (thick, thin, multi-layered, developing, decaying) based on texture, brightness, brightness temperature and synoptic and mesoscale context.
2. Identify Cumulonimbus clouds, their intensity and their stage of development.
3. Identify fogs and discriminate between fog and low cloud
4. Identify contrails and ship trails
5. Deduce cloud top heights based on brightness temperatures, surface observations and sounding data (observed, satellite derived and numerical models)
6. Use cloud microphysical parameters to identify clouds made of water droplets, ice particles or a mixture
7. Discriminate between clouds with small or large cloud particles

Skills, techniques and knowledge requirements

To be added at a later date

Element 3. Identify and interpret broad scale, synoptic and mesoscale systems

Description

Identify and interpret broadscale, synoptic and mesoscale atmospheric systems, their characteristics, strength and stage of evolution and deduce atmospheric dynamical and thermodynamical properties

Performance components

For each system, select and apply conceptual models to locate and identify the system, its orientation, strength and stage of evolution, including precursor signatures, taking into account departures from climatological or idealised models. (Categories are not exclusive and some feature relate to more than one category.)

Note that a full analysis or prediction involves all available data and guidance and is a higher order competency. Thus, the satellite interpretation task is not an end in itself but, in conjunction with other data, contributes to this higher level task.

1. Broadscale systems and features:

- Intertropical convergence zones, monsoon and trade wind regimes
- Westerly regimes with embedded cyclones and anticyclones
- Polar easterlies and systems
- Broadscale waves
- Zonal, meridional flows, mobile and blocking systems
- Upper and low level circulations

2. Synoptic scale systems and features:

- Anticyclones and cyclones (including rapid cyclogenesis), including tropical cyclones and depressions, extratropical and polar lows and cyclones, at upper and lower levels
- Jet streams, convergence and frontal zones, conveyor belts
- Troughs, ridges and cols, deformation axes, waves
- Cloud regions – stratiform, stratocumulus, cumulus (cold outbreaks, trade cumulus), cloud bands and shields
- Cold pools and thermal shear

3. Mesoscale scale systems and features:

- Local thermal and topographic circulations including land and sea breezes, katabatic and anabatic winds, foehn winds, island and peninsula effects (including Karman Vortices and v-shaped wave clouds), heat lows and troughs
- Convective cells and cloud systems (including pulse convection, multicells, supercells, squall lines, mesoscale convective complexes and systems) and associated mesoscale features including outflow boundaries and storm top features.
- Mesoscale boundaries and interactions, dry lines
- Low level jets
- Gravity waves

Skills, techniques and knowledge requirements

To be added at a later date

Element 4. Identify and interpret atmospheric phenomena

Description

Identify and interpret atmospheric phenomena

Performance components

For each phenomenon, locate and identify it and determine its strength, characteristics and, when appropriate, stage of evolution.

Note that a full analysis or prediction involves all available data and guidance and is a higher order competency. Thus, the satellite interpretation task is not an end in itself but, in conjunction with other data, contributes to this higher level task.

Phenomena include:

- Dust and sand storms and plumes and areas of raised dust
- Fires and smoke
- Precipitation types and amounts
- Volcanic ash particulates and chemical emissions
- Aerosol and particulate pollution
- Features indicating regions of clear air turbulence

Skills, techniques and knowledge requirements

Dust, and sand storms

- Conditions - detect dust over land and water, night and day
- Discriminate between dust, cloud, smoke and desert surfaces.
- Use Dust RGB products

Fires and smoke

- Discriminate between natural and industrial hotspots

Pollution

- Pollutants include SO₂, NO₂, etc.
- Discriminate between natural and anthropogenic pollution

Volcanic ash

Identify and analyse In particular:

- Volcanic emissions including ash, SO₂
- Determine the areal extent of the ash cloud, its height and its temporal evolution.
- Use Volcanic Ash RGB

Precipitation

- Precipitation type (convective, stratiform, deep versus shallow precipitation) using appropriate satellite channels including microwave channel data

Other aerosols

- Use the (EUMETSAT) Airmass RGB to identify ozone rich regions in the middle and upper atmosphere

CAT

- Identify CAT signatures

Element 5. Interpret derived fields

Description

Interpret fields and parameters

Performance components

Interpret fields and parameters in order to integrate them with other data, observations and guidance as input to analysis and diagnosis.

1. Derived fields include:

- Surface temperatures
- Vertical temperature and moisture profiles
- Atmospheric winds
- Cloud type, cloud top temperature
- Total and liquid precipitable water.
- Vegetation and fire danger indices

Skills, techniques and knowledge requirements

To be added at a later date

Element 6. Identify and interpret oceanic features and systems

Description

Identify and interpret oceanic features and systems relevant to meteorological forecasting. (Note that oceanographers would require more skills, not covered here.)

Performance components

1. Interpret sea surface temperature fields and their characteristic broadscale, synoptic and mesoscale patterns.
2. Interpret near surface wind data.
3. Identify and interpret sea state data and relate this to wave height and swell.
4. Identify and interpret oil slicks and their evolution
5. Identify areas of sun glint
6. Identify and interpret sea-ice, its extent, movement and characteristics (young and old sea ice, sea ice undergoing ablation and containing melt ponds).
7. Identify and interpret ocean currents and eddies and regions of ocean upwelling

Skills, techniques and knowledge requirements

To be added at a later date