SATELLITE SKILLS AND KNOWLEDGE FOR OPERATIONAL METEOROLOGISTS

LEVEL 1 - Skills	LEVEL 2 - Performance components	LEVEL 3 - Performance components detailed	Skills, techniques and knowledge requirements
1. Identify surface features	**1.1.** Identify terrain and geographical features.	**1.1.1.** Discriminate between land and water (oceans, seas, lakes, rivers, inlets). **1.1.2.** Distinguish mountainous from low lying regions. **1.1.3.** Differentiate natural vs human modified areas.	To be contextualised depending on the local circumstances: **1.a.** Application of Infrared (including water vapour (WV)), visible, and microwave channels. **1.b.** Application of multi-channel RGB imagery and products. **1.c.** Application of products and derived products (lighting, LEO Flood and moisture products, land, etc.), particularly for longer term monitoring such as drought. **1.d.** Background interpretation of satellite images (scale, texture, colour, shadow, etc.).
	1.2. Identify surface characteristics and conditions, including dry/wet, different vegetation types and clear areas, sand and desert.	**1.2.1.** Identify vegetation free areas and vegetation types. Identify different types of desert surface, for example, sand, desert pavement. **1.2.2.** Identify areas of recent burning. **1.2.3.** Identify hotspots (fires, volcanic activity, etc). **1.2.4.** Identify areas of recent volcanic ash cover. **1.2.5.** Identify areas of flooding. **1.2.6.** Identify areas of drought.	
	1.3. Identify snow/ice cover and analyse its extent.	**1.3.1.** Discriminate between cloud and snow. **1.3.2.** Identify frozen rivers and lakes. **1.3.3.** Identify sea ice.	
2. Identify cloud types and their characteristics	**2.1.** Identify stratiform, cumuliform and cirriform cloud regions and individual cloud types and their characteristics. **2.2.** Identify Cumulonimbus clouds, their intensity, organisation and stage of development. **2.3.** Identify fogs and discriminate between fog and low cloud. **2.4.** Identify contrails and ship trails. **2.5.** Deduce cloud top heights based on brightness temperatures, surface observations and sounding data (observed, satellite derived and numerical models). **2.6.** Identify clouds made of water droplets, ice particles or a mixture. **2.7.** Discriminate between clouds with small or large cloud particles.		**2.a.** Distinguish cloud types and characteristics (thick, thin, multi-layered, top height, developing, decaying) based on texture, albedo, brightness temperature and synoptic and mesoscale context. **2.b.** Interpret brightness temperatures and deduce cloud thickness. **2.c.** Use RGB products to identify fog and night microphysics, shadows on visible imagery and animation to identify valley fogs as well as meteorological situational awareness and surface and aircraft observations. **2.d.** Use RGB products and/or microphysical parameters to identify clouds composed of different phases and clouds with small or large cloud particles. **2.e.** Utilise derived products. **2.f.** Interpret the background interpretation of satellite image properties (scale, texture, colour, shadow, etc.).
3. Identify and interpret broadscale, synoptic and mesoscale systems	**3.1.** Identify and locate the following broadscale systems and features:	**3.1.1.** Intertropical convergence zones, monsoon and trade wind regimes. **3.1.2.** Westerly regimes with embedded cyclones and anticyclones. **3.1.3.** Polar and tropical easterlies and systems. **3.1.4.** Broad scale waves. **3.1.5.** Zonal, meridional flows, mobile and blocking systems. **3.1.6.** Upper and low level circulations. **3.1.7.** Low level moisture boundaries.	**3.a.** Use infrared, water vapour and visible (including high resolution visible channel) and detailed conceptual models of each atmospheric systems. **3.b.** Utilise the Dvorak tropical cyclone enhancement and techniques to deduce tropical cyclone intensity. **3.c.** Use RGB products (Airmass RGB, Microphysics RGB, etc) to identify atmospheric systems and use for operational forecasting.
	3.2. Identify and locate the following synoptic scale systems and features:	**3.2.1.** Anticyclones. **3.2.2.** Cyclones, tropical cyclones and lows, extratropical and polar lows, at upper and lower levels. **3.2.3.** Jet streams, convergence and frontal zones, conveyor belts, dry slots. **3.2.4.** Troughs, ridges and cols, deformation axes, waves. **3.2.5.** Cloud regions – stratiform, stratocumulus, cumulus (cold outbreaks, trade cumulus), cloud bands and cloud shields. **3.2.6.** Cold pools and thermal shear.	
	3.3. Identify and locate the following mesoscale scale systems and features:	**3.3.1.** Local thermal and topographic circulations including land and sea breezes, katabatic and anabatic winds, foehn winds, mountain waves, banner clouds, island and peninsula effects (including Karman Vortices and v-shaped wave clouds), heat lows and troughs, lake effect snow. **3.3.2.** Convective environments and areas of instability, convective initiation, inhibition and the breakdown of inhibition. **3.3.3.** 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. **3.3.4.** Convergence lines (mesoscale boundaries and interactions, dry lines, cloud streets). **3.3.5.** Low level jets. **3.3.6.** Gravity waves and bores.	
4. Identify and interpret atmospheric phenomena	**4.1.** Identify and locate the following:	**4.1.1.** Dust and sand storms and plumes and areas of raised dust. **4.1.2.** Fires and smoke. **4.1.3.** Moisture features, precipitation types and amounts. **4.1.4.** Volcanic ash particulates, Sulfur Dioxide (SO_2) and other chemical emissions. **4.1.5.** Aerosol and particulate pollution. **4.1.6.** Features indicating regions of clear air turbulence.	**4.a.** Discriminate between dust/sand, cloud, and smoke; day and night, over land (particularly desert surfaces) and water, using single, multi-channel, and RGB imagery. **4.b.** Locate fires, their intensity, and probable movement. **4.c.** Distinguish precipitation type and amount (convective, stratiform and deep versus shallow precipitation) using satellite channels including microwave channel data. **4.d.** Identify and analyse volcanic emissions to determine the areal extent, height, thickness, and temporal evolution of the ash cloud, SO_2, and other constituents using single, multi-channel, and RGB imagery. **4.e.** Correctly identify pollutants and atmospheric constituents (SO_2, NO_2, etc.) in RGB composites or products. **4.f.** Use the appropriate RGB to identify ozone rich regions in the middle and upper atmosphere. **4.g.** Identify Clear Air Turbulence (CAT) signatures using single channel (including water vapour channels), multi-channel, RGB composites, and synthetic satellite imagery.
5. Interpret derived fields and derived products	**5.1.** Correctly interpret and appropriately integrate:	**5.1.1.** Surface temperatures. **5.1.2.** Vertical temperature and moisture profiles. **5.1.3.** Atmospheric winds. **5.1.4.** Cloud type, cloud top temperature. **5.1.5.** Total and liquid precipitable water. **5.1.6.** Vegetation and fire danger indices, soil moisture.	**5.a.** Recognise the strengths and weaknesses of single channel, multi-channel, RGB products and satellite derived products/fields and how they complement other meteorological information. **5.b.** Describe the impacts of satellite observations on Numerical Weather Prediction (NWP) outputs. This will include the use of water vapour (WV) synthetic imagery mapped against poential vorticity (PV) fields from the NWP products.
6. Identify and interpret oceanic and water features and systems	**6.1.** Interpret sea surface temperature fields and their characteristic broad scale, synoptic and mesoscale patterns. **6.2.** Interpret sea surface wind data. **6.3.** Identify and interpret sea state data and relate this to wave height and swell. **6.4.** Identify and interpret oil slicks and their evolution. **6.5.** Identify and interpret pollution (including runoff, algal blooms, etc.). **6.6.** Identify and interpret areas of sun glint and dark zones. **6.7.** Identify and interpret sea-ice, its extent, movement and characteristics (young and old sea ice, sea ice undergoing ablation and containing melt ponds). **6.8.** Identify and interpret ocean currents and eddies and regions of ocean upwelling.		Recognise and or utilise the following: **6.a.** Sea surface temperature limitations, including cloud cover, skin temperature, deeper temperatures. **6.b.** Sea surface wind limitations, including wind direction ambiguities, wind speed inaccuracies, rain effects. **6.c.** Sea state measurement limitations and errors based on active microwave sensors and aperture radar. **6.d.** Sea ice detection methods using microwave sensors, synthetic aperture radar and multispectral infrared imagery, RGBs, and derived products. **6.e.** Relationship between sun glint, dark zones and ocean surface (windy or calm) conditions. **6.f.** Multispectral infrared imagery and products to distinguish between sun glint and cloud characteristics.
7. Compare satellite data with numerical weather prediction (NWP) outputs	**7.1.** Evaluate basic NWP output fields using satellite data and model output. **7.2.** Identify and assess various weather features by integrating satellite and NWP products. **7.3.** Deduce when and how to use satellite imagery to address NWP limitations. **7.4.** Use NWP information to enhance the understanding of the features shown in the satellite images. **7.5.** Use satellite data in conjunction with NWP at different stages of the analysis and forecast process.		**7.a.** Have a basic understanding of the atmospheric dynamics. **7.b.** Have a basic understanding of NWP outputs and their limitations. **7.c.** Understand the dynamical relationship between satellite imagery and NWP outputs for the diagnosing of synoptic scale atmospheric circulation systems. **7.d.** Utilise high resolution satellite imagery in conjunction with NWP model output to better diagnose meteorological phenomena and improve operational forecasts.

The full document describing the "Guidelines on Satellite Skills and Knowledge for Operational Meteorologists" is available at https://www.wmo-sat.info/vlab/satellite-skills/