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VLab STATUS AND PLANS

(Submitted by VLab co-chairs)

Summary and Purpose of Document

This document reports on activities within the WMO-CGMS Virtual Laboratory for Education and Training in Satellite Meteorology (VLab) along with future plans. Since IPET-SUP-3, VLab members have offered a variety of training opportunities, with highlight to training efforts addressing the new generation of satellites, as this proved to be the major training need identified by VLab members.

Furthermore, a comprehensive review and update of the Guidelines on Satellite Skills and Knowledge for Operational Meteorologists was conducted.

ACTION PROPOSED

The fourth session is invited to note the important achievements of the VLab, to provide comments, to consider the actions and recommendations below.

In particular, the session is invited to take note of the revised document **Guidelines on Satellite Skills and Knowledge for Operational Meteorologists** and to provide comments.

Appendices: A. Guidelines on Satellite Skills and Knowledge for Operational Meteorologists - Updated

B. VLab Members' Statements: How we are Meeting the Training Needs and User Requirements of Our Regions

VLab STATUS AND PLANS

1 INTRODUCTION

This document reports on the activities and plans of the WMO-CGMS Virtual Laboratory (VLab). Since IPET-SUP-3 the VLab has:

- Revised and updated the Guidelines on Satellite Skills and Knowledge for Operational Meteorologists. The updated document is available in Appendix A;
- Responded to training needs and user requirements by offering training on the new generation of satellites;
- Collaborated with WMO Education and Training Programme, ensuring training of trainers is provided for VLab members;
- Engaged with partner training providers, exchanging expertise and resources.

The VLab Management Group (VLMG) has met three times in virtual meetings (October and December 2017, and January 2018), and will have its 9th face-to-face meeting in July 2018. Further details regarding the most recent activities of VLab (since May 2017), and a short review of major training events and plans is given below.

2 MAJOR ACTIVITIES OF THE VIRTUAL LABORATORY SINCE IPET-SUP-3

VLab members investigate satellite training needs and users' requirements through various avenues, mostly according to individual organisations' procedures in place. These may include participation on WMO Coordination Groups for Satellite Data Requirements (SDR), discussions held in conferences, and training needs' surveys. Individual statements from each VLab member are included in Appendix B, explaining ways that satellite training needs and user requirements are identified and acted upon.

Besides the various regional training activities that were delivered by the VLab members and the regular offering of Regional Focus Group sessions (American and Caribbean, South African, and Australian Focus Groups), some events addressing the major training needs identified by VLab members within the last 8 months can be summarised as follows:

2.1 GOES region training

- Workshop at the Brazilian Remote Sensing Symposium on "GOES-R use" occurring in May 2017, Brazil.
- Two-day train the trainer workshop at the NOAA Satellite Conference on "Satellite Data Usage: Access through GEONETCast Americas, Display, Interpretation, and Usage in Training" occurring on 15-16 July 2017 in New York City.
- AmeriGEOSS "Training on Satellite Data: Access through GEONETCast Americas, Display, Interpretation, and Usage" occurring on 31 July - 4 August 2017, occurring in San José, Costa Rica.
- GOES-16 Workshop at Servicio Meteorológico Nacional (SMN) occurring 21-24 November 2017 in Buenos Aires, Argentina.
- GOES-16 Workshop at Dirección Meteorológica de Chile (DMC) / Chile Weather Service main office, occurring 27 November to 1 December 2017 in Santiago de Chile, Chile.

In addition, a GOES-16 Online Course was developed by CoE Argentina, where resources from COMET, VISIT and SPORT were translated to form three training modules. CoE Brazil has also been producing short videos to introduce users to new GOES-16 channels, RGBs and products.

2.2 Himawari region training

- Session in the Training Workshop at the 8th Asia/Oceania Meteorological Satellite Users' Conference (AOMSUC-8) on "Satellite data and product application" occurring in October 2017, Vladivostok, Russia.

In addition, training resources that integrate Himawari-8 data into the forecast process, case studies, material from conferences, and dissemination of feedback from Himawari-8 data use, were topics considered in many of the Australian Regional Focus Group sessions in 2017. These sessions are organised monthly by CoE Australia and also receive content contributions from JMA, KMA and BMKG.

2.3 FY-4 region training

- "2nd Training Course on Application of FY-4 Data" at the 18th Satellite Data Application in Weather Analysis and Forecasting occurring in January 2017, China.
- "10th International Training Course on the Application of Meteorological Satellite Products" occurring in June 2017, Beijing, China.
- Session in the Training Workshop at the 8th Asia/Oceania Meteorological Satellite Users' Conference (AOMSUC-8) on "Satellite data and product application" occurring in October 2017, Vladivostok, Russia.
- "Training Course for FY-4 Data Users" occurring in November 2017, China.

2.4 Training in the Meteosat region

- Middle East: annual training courses in Oman.
- Africa: courses on forecast applications in Pretoria, Nairobi and Niamey, course on Marine applications in Pretoria and Casablanca, course on climate application in Pretoria, and support to the SDS-WAS dust and WMO land application courses.
- Participants from the regions can be supported to attend relevant training and conferences.

2.5 RGB Experts and Developers Workshop

The RGB Experts and Developers Workshop 2017 was held at the headquarters of JMA in Tokyo, from 7 to 9 November 2017. The event was co-hosted by JMA, WMO and EUMETSAT. The discussions produced recommendations for the modification of current RGB recipes and ideas for new RGB recipes in consideration of sulfur dioxide, fire intensity, smoke and other variables. This workshop is organised every five years.

3 COLLABORATION:

3.1 Collaboration between Centres of Excellence and Satellite Operators

The launching of a new generation of satellites is setting a growing demand on training needs for members of all WMO Regional Associations. Close collaboration between satellite operators and VLab CoEs is driving the response to address these training needs as they are identified.

Good examples of the effectiveness of these collaborations include the **Himawari Training Campaign** which started in 2015 as an initiative of VLab CoE Australia, organising a collection of

training resources designed in house and by collaborating agencies, which is available for all at http://www.virtuallab.bom.gov.au/training/hw-8-training/ A most recent example is the coordination of training activities by NOAA and supported CoEs in Argentina, Brazil, Barbados and Costa Rica. This collaboration resulted in the delivery of many regional training events and the design of various training resources in English, Spanish and Portuguese.

Similarly, collaboration between EUMETSAT and supported CoEs is already taking place in the preparation for the transition to MTG. A recent workshop was organised by EUMETSAT (November 2017), aiming to address the training needs and expectations of the Member States NMHSs and supported CoEs affected by the transition to MTG.

3.3 WMO Education and Training Programme

VLab maintains continuous collaboration with WMO Education and Training Programme. In 2017, VLab contributed to the Online Seminar for trainers from RA III and IV by providing facilitators and coaches from CoEs Argentina, Barbados, CIRA, EUMETSAT and the VLab Technical Support Officer. The seminar was 12 weeks long and it was offered in English.

This collaboration is highly valued by VLab, as WMO-ETR is the main provider of training for trainers from CoEs and a very important supporter of training developed by VLab members.

VLab also contributed to the Global Campus initiative by taking part in the technical task team for the development of the WMOLearn Events Calendar.

3.4 Engagement with other Training Providers

Collaboration with other training providers takes place at different levels. This includes the advertising of non-VLab training events in the online Training Calendar, indication of subject matter experts for training collaborations, exchanges of technical expertise between training support officers and training project managers.

Training providers that have been most active in recent collaborations with VLab are NASA/ARSET and COMET. Representatives of these programmes have been participating in VLMG meetings and engaging in discussions regarding the update and use of the “Guidelines on satellite skills and knowledge for operational meteorologists”.

In addition, COMET’s online Translation Resource Centre, which is available in English, Spanish, and French; has been essential to VLab CoEs working on translation of training materials. The coordination with COMET’s translator has been invaluable.

4 IMPACT OF VLab TRAINING

Measuring the impact of training is a complex process that includes evaluation at various levels. While the assessment of learning outcomes during the course and the evaluation of participants’ satisfaction after attending a course are usually addressed by training providers within the VLab (see statements in Appendix B), measurements of behaviour change after course and the resulting overall value of training are not commonly performed. The main reason for this is that the later forms of evaluation include long term observations of on-the-job behaviours of staff who attended the course, which are harder to implement by the course providers, as many do not have access to the work environment of the trainee. These measurements are most commonly best implemented when educational research is paired with training in agreements acquired prior training.

Nevertheless, besides formal research to measure the impact of VLab training events on the skills and knowledge of satellite data users is not in place at the moment, it is still possible to observe that the long-term commitment to training efforts of VLab members has been providing benefits.

A good example is the continuity of initiatives such as the Regional Focus Group Discussions (RFG) that take place monthly, organised by various VLab CoEs with support of satellite operators. Current and prior participants of these sessions are trainers, forecasters, students and liaisons for information in their home offices and countries. The first VLab RFG session was organised by NOAA/CIRA back in 2004 and still counts on a high level of participation every month. Feedback received from participants of RFG sessions are always positive and often include suggestions of topics to be considered in future sessions, indicating satisfaction and will to engage in this form of training again.

Despite all the success of RFG sessions, this is only one example of positive impact of training. VLab training providers are well aware that this form of training may not suit all audiences catered by each VLab actor, and take very seriously the challenge of reaching all audiences with suitable training solutions and support.

5 REVISION OF THE GUIDELINES ON SATELLITE SKILLS AND KNOWLEDGE FOR OPERATIONAL METEOROLOGISTS

The document **Guidelines on Satellite Skills and Knowledge for Operational Meteorologists**, which was published in all WMO official languages, has been providing substantial guidance in the planning of training in satellite meteorology. With the use of the document, the need for revision of content and a more cohesive numbering of the performance components was identified.

The document (Appendix A) was revised, complemented and approved by VLab members. The updated version provides a clearer structure that allows the identification of different levels of skills, making it easier to reference them in the content of courses and certificates. It also contains a new skill, which was identified by VLab members as an important addition to the satellite skills needed by operational meteorologists.

The appended document is the proposed new version. For clearer identification of updates and new text added, please refer to https://docs.google.com/document/d/1Fz201NmbzFoknTmcWr1WbEufdBITwxcVKJcj4WG9c4U/edit?usp=sharing where all changes are highlighted.

6 FUTURE ACTIVITIES PLANNED

6.1 VLMG-9 Meeting in 2018

The next face-to-face meeting of the VLab management group (VLMG-9) will take place in the United States, from 16 to 20 July 2018. NOAA's Cooperative Institute for Research in the Atmosphere (CIRA), will be hosting the meeting in Fort Collins, Colorado.

VLMG-9 will offer the opportunity for the next VLab maturity analysis, as members prepare their self-assessments based on the evaluation of pre-defined criteria prior the meeting. VLab conducts a maturity analysis every two years, taking the opportunity of VLMG face to face meetings to discuss the outcomes and decide on actions that support the building of maturity. The outcomes of

the maturity analysis will also provide insights to be considered when drafting of the next VLab Strategy Plan (2020-2014).

In addition, the first day of VLMG-9 will be dedicated to regional discussions, providing opportunity to discuss data access, training needs and challenges shared by CoEs and satellite operators within the same region. This is an effort to strengthen regional communication and improve even more the sharing of training resources and collaboration for translation.

6.2 Plans for regional training events

VLab members will be presenting their regional training plans for this year in the report of activities that is due in March 2018.

In addition to regional activities organised by each CoE, collaboration is ongoing for the preparation of a course for trainers training on the use of RGBs. This training need was identified by VLMG in 2016. This is a joint project involving VLab CoEs Argentina, Costa Rica, South Africa, NOAA/CIRA and EUMETSAT.

7 CONCLUSION

VLab continues to make great strides in the forging of training in satellite meteorology. With the onset of a new generation of satellites, VLab is addressing new challenges as they are presented, while still working towards the achievement of the goals established in its strategy for 2015-2019.

IPET-SUP and its membership has been a strong supporter and advisory body to VLab. It is important that this support continues so that initiatives for the preparation of users of the new generation of satellites can continue.

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APPENDIX A

Guidelines on Satellite Skills and Knowledge for Operational Meteorologists[1]

[1] Although there is no reference to the term “operational meteorologist” in the WMO Convention, for the purpose of this document, the term “operational meteorologist” includes one who performs the duties of analysis, diagnosis, prognosis, and forecasting of the weather.

Executive Summary

This document describes the enabling skills that support WMO Competency Frameworks related to the use of satellite data by operational meteorologists. The skills are:

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 and derived products
6. Identify and interpret oceanic features and systems
7. Compare satellite data with numerical weather prediction (NWP) outputs

The primary focus of this document is on meteorological forecasting. More specific in-depth usage of satellite data in specialised areas such as oceanography, hydrology, climatology, and agrometeorology, are not currently considered.

The satellite skills were developed by the WMO-CGMS Virtual Laboratory for Education and Training in Satellite Meteorology (VLab), to help training centres to develop appropriate learning objectives for the satellite related elements of their courses. The WMO-CGMS VLab is a global network of specialized training centres and meteorological satellite operators working together to improve the utilisation of data and products from meteorological and environmental satellite.

Regardless of which environmental satellite produces the imagery and products used by the operational meteorologist, this document provides guidance on the skills and knowledge necessary to effectively utilise these in the forecasting process.

Background

The application of satellite data and these enabling skills supports the various existing and under development WMO Competency Frameworks. These require the operational meteorologists to:

- Analyse and monitor continually the evolving meteorological and/or hydrological situation;
- Forecast meteorological and hydrological phenomena and parameters;
- Effectively communicate the information to the users.

As these skills support the competencies, they have been designated as enabling skills rather than as competencies.

How to use this document

This document defines enabling skills as the interpretation, identification, and application satellite skills required of an operational meteorologist. It does not specify how satellite meteorology should be taught or the order in which it should be taught.

Trainers and training managers who want their courses to be aligned to the competencies can use this document to develop appropriate learning objectives for the satellite related elements of their courses. This document should be used in conjunction with the qualifications (WMO-1083[1]) and WMO competencies definitions [2].

Operational meteorologists can use the document to assess their own level of skills (e.g. novice, advanced, expert) with respect to the application of satellite data.

The performance and knowledge requirements that support these skills should be customised for each organisation, its service requirements and available satellite data. This document covers a wide range of possible skills and knowledge requirements. Any individual may require only a subset of these, according to their job requirements.

Basic knowledge

It is assumed that the user of this document has basic knowledge in satellite remote sensing and understands the following:

- Satellites include geosynchronous (GEO) and low earth orbiting (LEO) satellites with passive and active sensing.
- Imagery includes single and multiple channels and combinations of channels, including RGB (red/green/blue) displays, and derived products.
- Satellite interpretation is not undertaken 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 manipulate satellite data.
- Characteristics, limitations, and possible errors in the satellite data.

Skill 1: Identify surface features

Description

Identify geographical features, surface characteristics and conditions.

Performance components

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.

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 e.g. 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.

Skills, techniques and knowledge requirements

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 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.).

Skill 2: Identify cloud types and their characteristics

Description

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

Performance components

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 fog 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.

Skills, techniques and knowledge requirements

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. Utilize derived products.
2.f. Background interpretation of satellite image properties (scale, texture, colour, shadow, etc.).

Skill 3: Identify and interpret broadscale, synoptic and mesoscale systems

Description

Identify, locate and interpret broad scale, 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 features 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.

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.

3.2. 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, cloud streets, 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.

Skills, techniques and knowledge requirements

3.a. Use Infrared, water vapour and visible (including high resolution visible channel) and detailed conceptual models to identify atmospheric systems.

3.b. Utilize 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.

Skill 4: Identify and interpret atmospheric phenomena

Description

Identify and interpret atmospheric phenomena, their characteristics, strength and stage of evolution.

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.

4.1. Identify and locate the following:

4.1.1. Dust and sandstorms 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, Sulphur Dioxide (SO_2), and other chemical emissions.

4.1.5. Aerosol and particulate pollution.

4.1.6. Features indicating regions of clear air turbulence.

Skills, techniques and knowledge requirements

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.

Skill 5: Interpret derived fields and derived products

Description

Advanced interpretation of fields and parameters from products in analysis across all the other skills.

Performance components

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

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.

Skills, techniques and knowledge requirements

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 potential vorticity (PV) fields from the NWP products.

Skill 6: Identify and interpret oceanic and water features and systems

Description

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

Performance components

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.

Skills, techniques and knowledge requirements

Recognize and or utilize 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.

Skill 7: Compare satellite data with numerical weather prediction (NWP) outputs

Description

Identify variations (or differences) between meteorological phenomena as they appear in satellite imagery (e.g. WV imagery) and NWP model outputs (e.g. PV, Synthetic WV imagery) to assess and validate NWP outputs for the improvement of operational weather forecasting.

Performance components

For the assessment of NWP model outputs, apply meteorological concepts to the interpretation of satellite imagery, for example, compare the WV imagery with NWP outputs (e.g. PV fields, Synthetic WV imagery) and identify the differences in location and magnitude of NWP from the satellite imagery. Finally validate and adjust NWP outputs for the improvement of operation forecast.

Note that new multi-channel satellites with high temporal and spatial resolution can be used as ground truth because it represents real time atmospheric flows. Thus the contribution of satellite data to the adjustment of NWP outputs will be the highest level task based on the all dynamical concepts and observation data.

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.

Skills, techniques and knowledge requirements

7.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 system.
7.d. Utilize the high resolution satellite imagery in conjunction with NWP model output to better diagnose meteorological phenomena and improve operational forecasts.

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[1] https://library.wmo.int/opac/index.php?lvl=notice_display&id=10770#.WcqoqUyZNTY

[2] http://www.wmo.int/pages/prog/dra/etrp/competencies.php

APPENDIX B

VLAB MEMBERS' STATEMENTS: HOW WE ARE MEETING THE TRAINING REQUIREMENTS AND USER NEEDS OF OUR REGIONS

China Meteorological Administration – CMA, and VLab Centre of Excellence - Beijing

A successful training needs analysis will identify those who need training and what kind of training is needed. CMATC, also a VLab CoE in Beijing, meets the satellite related training requirements and user needs by the following ways:

- Seeking the guidance from WMO as well as RA II related documents about satellite meteorology;
- Receiving the mandates by CMA. Based on the guidance by CMA, CMATC held the training events about how to use meteorological satellite products in eco-environmental monitoring for remote sensing in 2017;
- Attending a variety of international and domestic seminars about satellite meteorology training;
- Issuing questionnaires to the users of the meteorological satellite data, products and analysis.

As for training evaluation, CMATC holds discussions with trainees of domestic and international courses. When organizing the introduction of FY-4 satellite products in 2017, for example, CMATC collected participants' comments and feedback with the aim to improve the course in the future.

European Organisation for the Exploitation of Meteorological Satellites - EUMETSAT

For the training courses in Africa and the Middle East, EUMETSAT is led by the analysis and information received from the CoEs. This is presented at the WMO RAIDEG and gathered informally as we work together on the training events. There is also a session at the EUMETSAT Africa User Forum on Training, which is led by the COEs. This allows conversation with managers from across African NMHSs on their needs. These are often wider than satellite requirements.

In Europe, EUMETSAT has completed a survey across the member states. This was based on a series of 30 semi structured interviews conducted by the EUMETSAT instructional lead. The survey led to a better understanding of the training requirements for courses and resources that are discussed with the training project EUMeTrain. In response to the survey, EUMETSAT is making some key changes to insure new training resources are more suited to the operational office (e.g. short videos and quick guides – reducing the chunk size of the resources). In addition, more detailed information about courses is provided when advertising events in the Training Calendar. The regional focus discussion is seen as useful by a very few users.

The survey also reaffirmed that users prefer more practical courses, based in the enabling skills and competencies and using activities like simulators.

The unaddressed challenge is how to teach the satellite application in the context of other data – i.e. integrated with the forecasting challenge as people do not just use one data type. Integrated training was a high priority for the users.

Japan Meteorological Agency - JMA

The Japan Meteorological Agency (JMA) identifies requirements based on user surveys and provides training events (e.g. a series of classroom training events, in which JMA experts lectured how to utilize the Himawari data and HimawariCast receiving system) and sessions in order to meet the requirements. JMA also refers to user survey results conducted by WMO and other related projects.

An example of training based on identified needs of users is the training event that has been conducted every year with the Asia Oceania Meteorological Satellite Users Conference (AOMSUC). JMA experts have been participating in these events as trainers. In these events, there is a questionnaire for the trainees, and next event is improved to match their requirements. The questionnaire is conducted by AOMSUC host organization and reported to the meeting of RA II WIGOS Project to develop support for NMHSs in Satellite Data, Products, and Training, co-chaired by JMA and the Korean Meteorological Administration (KMA).

At the latest training event held with AOMSUC-8 in October 2017, Vladivostok, Russia; JMA conducted a session for a practical training about how to utilize the RGB imagery from Himawari, in response to the users' requirement identified in the trainees' survey result at the previous event with AOMSUC-7 in 2016, Korea.

Korean Meteorological Administration – KMA, and VLab Centre of Excellence – Republic of Korea

The National Meteorological Satellite Centre (NMSC) of KMA investigates training requirements, satisfaction and fields for improvement of its services via domestic and international surveys. Four main Groups participate in these surveys: KMA forecasters and members, related domestic agencies, public users and international users.

The Human Resource Development Institute investigates training satisfaction and additional training needs and requirements after every course related to satellite meteorology that is offered to KMA forecasters and invited forecasters from RAs II and V. In terms of domestic users such as KMA forecasters and university students, NMSC distributes the surveys to investigate their needs and requirements whenever there is a course.

NMSC is committed to fulfil the requirements that are identified and works on development and delivery of training not only within KMA, but also in collaboration with international partners. The collaboration with VLab CoE Australia is a good example, as participation and presentations in the Australian Regional Focus Group sessions are organised by CoE Republic of Korea.

National Oceanic and Atmospheric Administration - NOAA

NOAA has collected international user requirement information through two venues: the WMO Coordination Group for Satellite Data Requirements and the NOAA Satellite Conference. It has also collected information from its own users through Proving Ground Activities. Training activities are at the highest in years mainly due to the launches of the next generation satellites GOES-R/16 and JPSS-1/NOAA20. Issues between both National and International users are similar: how are the data accessed and displayed, what are the new channels and capabilities, and how are they utilized. NOAA hosted 1 workshop and provided trainers and organizational support to 3 other workshops this past year for the international community:

1) Two-day train the trainer workshop at the NOAA Satellite Conference on “Satellite Data Usage: Access through GEONETCast Americas, Display, Interpretation, and Usage in Training” occurring on 15-16 July 2017 in New York City.

2) AmeriGEOSS "Training on Satellite Data: Access through GEONETCast Americas, Display, Interpretation, and Usage" occurring on 31 July - 4 August 2017, occurring in San José, Costa Rica.

3) GOES-16 Workshop at Servicio Meteorológico Nacional (SMN) occurring 21-24 November 2017 in Buenos Aires, Argentina.

4) GOES-16 Workshop at Dirección Meteorológica de Chile (DMC) / Chile Weather Service main office, occurring 27 November to 1 December 2017 in Santiago de Chile, Chile.

NOAA continues to support training development and translation efforts at COMET, training at the National Centers for Environmental Prediction (NCEP)/ Weather Prediction Center (WPC) / International Desks, and the Regional Focus Group (RFG) Monthly Weather and Climate Virtual Discussions

NOAA has also created a GOES International Training Working Group (GITWG) to assess, coordinate, and plan for training activities in response to increasing user requests. Because of the newness of the satellite capabilities, continued training activities targeted at different levels of users (intern, advanced, expert) are ongoing.

In terms of impact of training events on the skills and knowledge of satellite data users, long term commitment to training efforts has provided benefits. Two overlapping aspects in particular that have helped with sharing information and training materials on the new satellites include 1) the Regional Focus Group Monthly Weather and Climate Virtual Discussions and 2) the NCEP/ WPC / International Desks. Current and prior participants are trainers and liaisons for information in their home offices and countries. We are seeing continued high levels of interest, participation, and collaborations between countries both inside and outside of scheduled sessions.

VLab Centre of Excellence – Argentina

The launch of a new generation satellite, GOES-16, set in a huge demand on training requirements and user needs for all members in Regions III and IV. VLab CoE in Argentina, which is composed of two institutions: Servicio Meteorológico Nacional (SMN) and University of Buenos Aires (UBA), has implemented various strategies to cope with this challenge. Training needs are mostly identified via the use of surveys distributed to users.

A survey on data requirements and training needs in RA III was performed during 2017, initiative from the President of the WMO RA III and carried out by SMN member of WMO SDR for RA III and IV Training Task Team. This survey collected valuable information revealing urgent needs in most countries and some advances in others, see DropBox:
https://www.dropbox.com/sh/fawkbtmi7168jb6/AABBpZpJl7KhNDpAE1KEjf2_a?dl=0

In fulfilment of the commitment taken by the Training Task Team (SDR -RA III and IV), a Goes-R online course and a face to face workshop was proposed and carried out at SMN during 2017 for national forecasters. The training resources will be shared with Regions III and IV (Spanish) in 2018.

A Training Needs Survey on Satellite Enabling Skills, for Spanish speaking Region III and IV, was carried out in 2017. It forms part of a set of thirteen surveys based on WMO Competency Framework (approved and in draft) for different areas of NMHS. This was an initiative of SMN

Director, for Capacity Building in Region III. The results will be presented at the Conference of Directors of Iberoamerican NMHSs (CIMHET), March 2018 with the purpose of developing a Strategic Training Plan for Region III.

RGB training in Region III is also a challenge. A global survey on RGB training needs, which was organised by VLab in January 2017, is proving valuable in the planning of the VLab RGB Global course for trainers as well as any future RGB training in Region III.

The Atmosphere and Ocean Science Department (DCAO) (Faculty of Exact and Natural Sciences, UBA), also identifies requirements based on user surveys and provides classroom training events with practical training sessions in order to meet the requirements. DCAO encourages the incorporation of new subjects every year to provide an updated program for undergraduates and PhD students. In 2017, the following courses were taught: Principles of Remote Sensing for atmosphere observation, Marine Optics and Remote Sensing; and Satellite Remote Sensing and Applications to Oceanography. DCAO also delivers different courses that use satellite products to explain or visualize different case studies. At the end of each subject, all participants must respond a survey, in which they can evaluate the teaching tools and strategies used. This allows us to improve the following courses.

Continuous promotion of RFG for Americas and the Caribbean has increased the number of participants from RIII. This RFG offers monthly sessions (bilingual), becoming a great opportunity for ongoing training on the application of satellite skills and knowledge.

Another important training resource based on satellite images is the development and publication of Conceptual Models for the Southern Hemisphere (CM4SH), a WMO-VLab-Eumetsat project involving 6 CoEs. CoE Argentina published four CMs in both in English and Spanish (see https://sites.google.com/site/cmsforsh/) and developed a Workbook for forecasters (supported by WMO) on the application of CMs. The Workbook will be shared as self-directed learning resource, as well as a valuable resource to be used in future courses. The development of more Conceptual Models with their corresponding application activities are needed to cover high impact based forecast demands in Region III.

All these efforts should be considered in a collaborative coordinated GOES-16 training plan for REGION III.

VLab Centre of Excellence – Australia

The Bureau of Meteorology, as the Australian VLab Centre of Excellence, identifies requirements through surveys of forecasting staff internally, as well as through engagement with international partners when developing training content. Developments in the science of satellite meteorology are monitored in order to identify learning opportunities for operational forecasters.

Training events are conducted regularly (monthly) by the CoE using online technologies through the Regional Focus Group in order to reach students throughout RA V. Recordings of training events are made available to maximise the flexibility and accessibility of the learning resources (available at http://www.virtuallab.bom.gov.au/archive/regional-focus-group-recordings/).

International collaboration also takes place in the organisation and delivery of training by CoE Australia. The most recent Regional Focus Group in January 2018 was a partnership not only between the CoE and a local expert within a Regional Forecast Centre, but also with BMKG, Indonesia to deliver some specific uses of RGB products as well as climatic case study for Indonesia. JMA and the VLab CoE Republic of Korea are also frequent partners on the delivery of Regional Focus Group sessions.

As per the evaluation of training, participants' feedback is collected from VLab training events.

VLab Centre of Excellence - Barbados

CoE Barbados as a core member of the WMO Satellite Data Requirement Group for RAIII/RAIV (SDR), is on the SDR Task team on training requirements of its members' states. This means the CoE is in a great position to actively investigate user requirements and identify the most urgent training needs.

As the WMO RTC and VLab CoE, CIMH is working with the Task Team and NOAA to develop training activities on the use of GOES-16 images to RA III and RA IV member states. This has been a major user need during the past few years and continues to dominate the training activities organised. The CIMH Operational Aeronautical Forecaster's Course and the Aeronautical Continuing Professional Development Online Course are examples of training that includes the use of GOES-16 imagery. In 2017, these courses had participants from countries such as Barbados, Belize, Grenada, St. Lucia, Trinidad, Jamaica and the USA.

Training trainers on the use and application of GOES-16 imagery is also fundamental in these Regions and has been addressed in collaboration with NOAA and WMO, in the Train the Trainer (TtT) event preceding the NOAA Satellite conference (New York City, 2017).

CoE Barbados continues to take part in the Americas and Caribbean Regional Focus Group (RFG), which is organised by NOAA/CIRA and VLab CoEs Barbados, Costa Rica, Brazil and Argentina, on a monthly basis. The RFG sessions are utilized as a training vehicle for real time introduction of GOES-16 imagery used for operational application. These sessions are a good example of how satellite skills and knowledge are practiced and discussed by new and experienced users.

VLab Centre of Excellence - Brazil

The VLab CoE-Brazil, hosted by the National Institute for Space Research (INPE) at the Centre for Weather Forecast and Climate Studies (CPTEC), has provided training on satellite meteorology for national and regional services, as well as other countries part of Region III (South America). Our main focus since 2016 has been to prepare training for GOES-R (now GOES-16) next generation satellite imagery and products. We have gathered information on user requirements following WMO and VLab recommended guidelines such as the "GOES-R User Readiness Training Guide", and through short surveys sent out to operational meteorologists, user attending services (webpage and Facebook), and direct user contact with the GEONETCast network. We have also used feedback responses to improve each of the following training events.

An example, was a face to face training that we organized on May 2017 at the Brazilian Remote Sensing Symposium, with NOAA and INPE experts, for GOES-R and JPSS users. We used the feedback responses to improve the training material for a face to face course given to CPTEC's operational meteorologists, October 2017. This material is being further improved for a distance training planned for the first semester of 2018, for national and regional services, and an international face to face training that will be given during the AmeriGEOSS week on August 2018. With the feedbacks and requests we are gathering from our website and fan page, we are also preparing short videos to introduce general users to the new GOES-16 channels, RGBs and products. Our main challenge has been to provide short informative material that is attractive and easy to understand and that at the same time can guide the user to go beyond the same information they are used to obtaining with previous GOES imagery. Another challenge has been

to prepare users before the new multichannel products are operational and correctly adjusted for our region (RA III) (including RGBs). We are working with the Satellite Agency to overcome these issues as soon as possible.

VLab Centre of Excellence – Costa Rica

VLab CoE Costa Rica participates in the WMO Satellite Data Requirements Group for RAs III and IV. Attendance of SDR meetings has been a great source of information and establishment for further collaboration. As an example, it was during one of these meetings that an initiative to share data using the internet was created for countries with no possibility of getting a satellite receiver. This is now an ongoing project, which counts on the support of WMO-ETR.

The University of Costa Rica (UCR) also distributes a survey to countries within the region of CoE Costa Rica, in order to investigate their training needs and requirements. The most recent survey had participation from Bermuda, Antigua y Barbuda, Panamá and El Salvador. Major training needs identified were related to the use of GOES-16, but technical needs, equipment, database administration and access to satellite images were also reported as lacking. Whilst the latter have not been addressed by CoE Costa Rica due to the lack of resources, there is a great effort to address the training needs. This includes the creation of short courses and webinars by UCR.

Another way that the needs of the Region have been communicated to the CoE is through personal communications made via email and social media (e.g. Facebook and WhatsApp). These are used to share questions and requests, and have aided the planning of several courses. One example is the course on remote sensing aspects of meteorology, which will take place in 2018.

As training for the use of GOES-16 is a major need, social media groups (using WhatsApp) were created to deal with questions and answers focused on GOES. These groups are mainly focused on technical aspects of gathering data and generating products. UCR has been contributing with these groups too and creating training resources for support, like the YouTube tutorial on the use of CLASS to obtain satellite imagery (available at https://www.youtube.com/watch?v=IgoOuFQFvIs&t=48s).

VLab Centre of Excellence – Morocco

The CoE of Casablanca identifies the training requirements and user needs by more than a way. For instance, the focal point of the CoE of Casablanca is also a member of the RA-I Dissemination Expert Group (RAIDEG). Among the activities of RAIDEG is the identification of new training requirements and user needs. Furthermore, two experts from the CoE of Casablanca are members in the African Satellite Meteorology Education and Training (ASMET) team. Surveys conducted by WMO and EUMETSAT are another source for identifying training requirements and user needs.

Contacts between experts and forecasters at international meetings or during exchange of visits between experts from the CoE of Casablanca and other experts/forecasters from African countries also allow identifying user needs. It is in this context that a need has been expressed regarding how to use altimetric and scatterometric data in marine forecasting. A face-to-face French course was therefore organized conjointly by EUMETSAT and the CoE of Casablanca from 04 to 08 December 2017. Participants were from Benin, Cameroon, Comoros, Congo, Ivory Coast, Guinea, Senegal and Morocco. This course was given for the first time in French; it was intended for people who have some issues to attend English courses.

One of the evidences that this marine forecasting course has met the training requirements and the user needs is the course evaluation questionnaire carried out by the trained people at the end of the course. Responses were overall very positive; they are available on the EUMETSAT website.

Locally, The CoE of Casablanca has identified the need to train trainers. It's expected that a group of trainers will receive training at EUMETSAT in 2018.

VLab Centre of Excellence - Niger

EAMAC as a RTC is engaged in providing ab-initio and continuous training of meteorological personnel (Meteorologists and Meteorological Observers) for the benefit of most French speaking countries in Africa. As of present, training needs assessment is carried out only for ASECNA Meteorological Services in close collaboration with the ASECNA Headquarters, while training for the National Meteorological Services (with priority for ASECNA Member Countries) is carried out upon their requests, with however limited possibilities. The continuous training program include satellite meteorology, tropical meteorology, forecasting and weather watch, aerodrome weather watch, meteorological observations, etc.

As a CoE and Member of the WMO-VLab, EAMAC is engaged in providing satellite meteorology trainings for French speaking countries in RA-I in collaboration with EUMETSAT. These training events deal with the interpretation of satellite imagery and the use of satellite images and products in operational meteorology. The training needs assessment for satellite meteorology is mainly based on the recommendations of the EUMETSAT User Forum in Africa, with regards to training.

EAMAC also develops, together with other CoEs in RA-I, self-paced training modules to address some of the training needs, in the framework of the African Satellite Meteorology for Education and Training (ASMET) Program.

During the last two years, less continuous trainings were conducted, due to limited number of trainers, except for the MESA program (Monitoring for Environment and Security in Africa), for which several training events were organized in the course of 2016 and 2017, as training was identified as a high priority area by both the AU (African Union) and the EUMETSAT User Forum for a successful implementation of the program. These training events were organized for Institutions in French speaking countries benefiting from the MESA stations (NMHSs, Universities, National Environmental Agencies and Services, etc.).

In terms of perspective, EAMAC is planning to conduct some surveys in French speaking countries of RA-I, aiming to collect more user needs and expectations; this will surely open a new way of collaboration and will therefore permit a wide access to ASMET as well as EUMETSAT products through the available platforms.

VLab Centre of Excellence - Oman

Training needs in satellite meteorology have been identified by analysing feedback received from participants of the satellite application course that is organised every year by CoE Oman. After many years offering basic training in general satellite applications and knowledge, managers of NMHSs in the region of CoE Oman raised the need for more specialised training.

In response to the needs identified, training is now designed to teach aspects of satellite application focused on specific themes. As an example, the latest course was focused on convection. The course was designed to refresh and update participants' knowledge in satellite

products and their applications as well as concentrating in the theme of convection and best products to address it.

Training is usually offered in a blended format, including online and face-to-face phases in order to offer more flexibility to participants, but it is still challenging for participants to complete tasks and participate in the whole course.

Additional challenges include the difficulty in communication with other agencies in the region as well as having participants for training that includes online mode of teaching and learning (because face to face is still considered more attractive).

VLab Centre of Excellence – Russian Federation

The Advanced Training Institute of Roshydromet (ATI) investigates training requirements within the country through the distribution of a questionnaire to all regional centres (62) and territorial administrations (25) of Roshydromet. The Annual Training Plan is written based on the analysis of responses received, which includes suggestions of new training topics to be introduced as well as existing topics that need updating. Research institutions of Roshydromet (17) revise the Training Plan for final corrections and additions. Training requirements are fulfilled by courses offered either face-to-face or in a distance learning format.

Face-to-face courses may take place either at ATI premises, or at Roshydromet research institutions or research field bases. These are designed and delivered in cooperation with Planeta, with initiative coming from either side. During 2017, there were two training events initiated by Planeta, where ATI/Russian VLab CoE participated. Those were AOMSUC-8 training event in Vladivostok, and Planeta workshop in June. Training resources from face-to-face meetings and courses are stored on Russian VLab CoE website.

Distance learning courses are usually designed by ATI staff and peer-reviewed by relevant research institutions of Roshydromet. In 2017, two distance learning courses were organized: "Using satellite information in synoptic practice" and "Remote sensing methods to determine mesoscale atmospheric processes and related adverse weather phenomena". 54 people completed the courses.

New training needs recently identified in the survey conducted in 2017 include “Space Weather” and “Space Data Collection and Transmission System of Roshydromet”. Two courses are planned to address these needs: the first training course is planned in a distance learning format, and the second will be operated by Planeta, taking place in May/June 2018.

With regards to the Region, the Annual Training Plan is shared with the Commonwealth of Independent States (CIS), and it is also available on ATI website. Besides NMHSs of CIS countries are not consulted in the user needs investigation mechanism, they may join the courses that are part of the Annual Training Plan. ATI offers a quota of state fellowships for CIS countries students’ participation in these courses. Requests for ad-hoc training can also be made to ATI, which are considered and may be organized by ATI with the help of Roshydromet research institutions and other entities.

VLab Centre of Excellence – South Africa

Training needs for satellite based courses have been identified by analysing feedback received from participants of international workshops hosted at the South African Weather Service. By listening to needs voiced during the workshops and weakness identified by facilitators also gives

gravity to the training needs from a satellite point of view. Surveys conducted for the ASMET project have also given insight to the needs identified by operational forecaster, trainers and meteorologists on the African continent. Outcomes of meetings such as the WMO RGB workshop also identify training needs for satellite products. SAWS runs independent in-house surveys to gage the training needs of the operational staff on an annual basis. The results of which are used to motivate continuous training for the operational forecasters.

Taking this feedback and these outcomes from workshops, the learning outcomes for planned satellite training of University students, SAWS personnel, SADC and Africa-based users are tailored to address as many needs as possible. The annual MSG training workshop, hosted online and face-to-face, addresses regional needs from the SADC community and those of English speaking Africa. The course is designed to re-look at some basic aspects of satellite interpretation but also focuses on at least one specialist topic which helps to improve the skill of the more advanced users.

SAWS also hosts annual marine and climate courses, in partnership with Eumetsat. These courses also hold an online phase and a workshop phase. The participants are invited from all over Africa, and not just the southern African region.

The Satellite based training has in the past also included training of software and visualisation tools, such as SYNERGIE and McIdas V. Locally, we train the users in in-house software when necessary. Training via online learning platforms is becoming a more viable way of sharing information with many people. SAWS hosts a Moodle page for Satellite interpretation, where members can share interesting satellite imagery and discuss the interpretation thereof. This page is open to any interested party. Weather Briefings hosted by SAWS also aim to reach out to the African community and share not only satellite based information, but also general forecasting and weather based concepts from as many countries as possible. Network access and scheduling of participants prove to be a challenge with these sessions.