CGMS

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OUTCOME OF THE WORKSHOP ON RGB COMPOSITE SATELLITE IMAGERY

The outcome of the RGB Composite Satellite Imagery Workshop, held in Boulder, USA in June 2007, is presented.

The focus of the workshop was to consider recommendations for standards and guidance in the use of this technique which would ultimately be presented and discussed in User Conferences and other forums with the general intention that this would promote wide acceptance of a common approach to the technique by the user community.

The workshop recognized that guiding principles for the generation of RGB products would be extremely valuable but that a full (prescriptive) harmonization of product definition schemes was probably impractical. The group felt that such guidance should be generic enough to be applicable to the wide range of current and future imaging instruments (with their different spectral characteristics) but also specific enough to ensure widespread commonality of approach.

To this end the workshop recommended generic schemes for different types of application areas.

The recognition of the importance of information from specific spectral bands in the generic schemes also has an implication for the choice of spectral bands to be considered for future space-born imagers.

OUTCOME OF THE WORKSHOP ON RGB COMPOSITE SATELLITE IMAGERY

1 BACKGROUND INTRODUCTION

The subject of the use of RGB compositing techniques to display satellite imagery was first considered by CGMS-33 in 2005. At that meeting CGMS noted that many schemes exist for displaying the imagery, and that interpretation was sometimes difficult for forecasters who may not be acquainted with the particular colouring. CGMS discussed a possible approach in the long-term towards standardization of RGB compositing and the development of a "toolbox" of methods and guidelines for RGB compositing. To that end, WMO convened the RGB Composite Satellite Imagery Workshop in June 2007.

2 OUTCOME OF WORKSHOP

2.1 GENERAL DISCUSSIONS

A workshop on RGB Composite Satellite Imagery was held in Boulder, USA from 5 to 6 June 2007. The report of the workshop is available on the WMO Space Programme web pages at:

http://www.wmo.int/pages/prog/sat/documents/RGB_workshop_final_report_rev1.pdf

and the main outcomes are summarized in this paper.

The workshop involved a limited number of experts from satellite operators, product developers, operational services and training centres, with a view to sharing experience and considering commonalities. The participants considered recommendations for standards and guidance which would ultimately be presented and discussed in User Conferences and other forums to promote wide acceptance of the workshop's proposals by the user community.

RGB compositing techniques offer the possibility of compressing multi-spectral information content for optimum visualization, while at the same time preserving pattern and texture of cloud and surface features as well as continuity in the time domain. Thus this technique is of great help for operational users such as forecasters, including specific applications such as the identification of snow cover, the location of stratus/fog conditions, the detection of volcanic ash and many others. Developing a harmonized approach to RGB compositing practices would stimulate the exchange of experience between operational users, sharing of products and tools and would facilitate training efforts.

The main objectives of the workshop were agreed as follows:

- To assess the need for harmonization of RGB composite imagery products for both operational applications and for training, and to highlight the consequences and benefits of such a harmonization;
- To identify which RGB schemes should be harmonized in priority, considering operational and training requirements;
- To agree on the definition of these RGB schemes on the basis of recognized physical interpretations, to qualify their expected domain of validity and to highlight any potential limitation;

- To review the suitability of present and future multi-spectral imagers spectral characteristics for these RGB schemes and express recommendations regarding future instruments, data dissemination contents and processing systems in order to secure the capability of generating these harmonized RGB products in the future.

Several of the participants presented their experiences and current practices in the use of RGB compositing. These covered the processing of data from different satellites and the use of RGB imagery products for different applications and for use in different scenarios (operational, research, training, etc). The workshop compared and contrasted these techniques in an effort to identify common elements and to consider recommendations. In addition the user perspective was explored by considering some recent feedback from forecasters in an NMHS working in an operational environment.

Despite the workshop focus being firmly on RGB products and their derivation from multi-channel imager data, the group felt it worth noting that the use of RGB products would always be complementary to – rather than a replacement of – the traditional and widely practiced methods of viewing 'basic' single-channel greyscale imagery products that have, for many years, been the standard way of displaying imagery data from three-channel radiometers (IR, VIS, WV).

The workshop acknowledged the benefits that would stem from a harmonization of RGB product definition. They recognized that guiding principles would be extremely valuable but that a full (prescriptive) harmonization of product definition schemes was probably impractical. The group felt that such guidance should be generic enough to be applicable to the wide range of current and future imaging instruments (with their different spectral characteristics) but also specific enough to ensure widespread commonality of approach.

The group felt it worthwhile to recall, and take heed of, the well-established and commonly used schemes in place for processing AVHRR and MODIS data into RGB products since these serve as the heritage to the current RGB product development.

AVHRR

RED	CH01 (0.6 μm)	CH01 (0.6 μm)	CH03B (3.7 μm)
GREEN	CH02 (0.8 μm)	CH03A (1.6 μm)	CH04 (10.8 μm)
BLUE	CH04 (3.7 μm)	CH04 (10.8 μm)	CH05 (12.0 μm)

MODIS

RED	CH01 (0.6 μm)	CH01 (0.6 μm)	CH01 (0.6 μm)	CH26 (1.3 μm)
GREEN	CH04 (0.5 μm)	CH02 (0.8 μm)	CH06 (1.6 μm)	CH06 (1.6 μm)
BLUE	CH03 (0.4 μm)	CH03 (0.4 μm)	CH31 (11.0 μm)	CH31 (11.0 μm)

The group recalled the spectral channels of the currently flying multi-spectral radiometers (i.e. those with more than the 'first generation standard' set of IR, WV and VIS) and also the Advanced Baseline Imager for next generation GOES (since RGB products are already under development based on simulated data). The group concluded that there is an issue regarding the terminology used to identify spectral channels used for RGB product development. Examples exist in which the channels used are described in terms of nominal centre frequency, wave number, channel number (different for different instruments) and also channel identification (e.g. "LWIR" = long wave infra-red). It was decided that this issue would also benefit from harmonization and the following definitions were formulated.

Channel identification	Meteosat	GOES (current generation)	MTSAT	GOES (next generation)
VIS_broad_band	0.4 – 1.2 µm			
VIS_short				0.45 – 0.49 µm
VIS_medium	0.56 – 0.71 µm	0.52 – 0.72 µm	0.55 – 0.9 µm	0.59 – 0.69 µm
VIS_long	0.74 – 0.88 µm			0.846 – 0.885 µm
NIR				1.371 – 1.386 µm
NIR	1.50 – 1.78 µm			1.58 – 1.64 µm
NIR				2.225 – 2.275 µm
SWIR	3.48 – 4.36 µm	3.78 – 4.03 µm	3.5 – 4.0 µm	3.80 – 4.00 µm
WV_upper_trop	5.35 – 7.15 µm	6.47 – 7.02 µm	6.5 – 7.0 µm	5.77 – 6.60 µm
WV_mid_trop				6.75 – 7.15 µm
WV_mid_trop	6.85 – 7.85 µm			7.24 – 7.44 µm
MWIR	8.30 – 9.10 µm			8.3 – 8.7 µm
OZONE	9.38 – 9.94 µm			9.42 – 9.8 µm
LWIR				10.1 – 10.6 µm
LWIR	9.80 – 11.80 µm	10.2 – 11.2 µm	1.03 – 11.3 µm	10.8 – 11.6 µm
LWIR_split_window	11.0 – 13.0 µm	11.5 – 12.5 µm	11.5 – 12.5 µm	11.8 – 12.8 µm
LWIR	12.4 – 14.4 µm	(1) 12.9 – 13.8 µm		13.0 – 13.6 µm

(1) GOES-12 only

2.2 WORKSHOP RECOMMENDATIONS

The workshop concluded that guidance could be captured in a table of generic approaches to the various RGB products. For each table of guidance a derived meteorological / physical parameter is suggested for each of the Red, Blue and Green components and a suggested scheme to derive these parameters from imager data at different spectral bands is given using the channel identification from the table above.

It was agreed to group the RGB products into two 'families', one focussing on atmospheric attributes, for which EUMETSAT took the lead in discussion of guidance, and the other focussing on surface attributes, for which the COMET/UCAR/CIRA experiences would provide the inspiration. The tables defined are on the following pages.

The workshop noted that the tables also implicitly infer recommendations on the channels to be preserved or implemented on future imaging radiometers. MWIR, WV, NIR and VIS_short channels, in the past rarely implemented, appear to be the favoured candidates for a wider implementation in particular in geostationary orbit.

(i) Focus on atmospheric attributes – cloud microphysics (and surface hot spots)

RED	**(LWIR_split_window – LWIR) difference** Cloud optical thickness: thin → thick* Boundary layer moisture: moist → dry	**(LWIR_split_window – LWIR) difference** Cloud optical thickness: thin → thick Cloud water content: low → high	**VIS_long** Cloud optical thickness: thin → thick
GREEN	**(LWIR – MWIR) difference** Cloud phase: water → ice Cloud optical thickness: thin → thick Surface type: rock → sand	**(LWIR – SWIR) difference** Cloud particle size: large → small Cloud phase: ice → water	**NIR / reflected part of SWIR** Cloud phase: ice → water Hot spots: no → yes
BLUE	**LWIR** Temp. of radiating surface: cold → warm	**LWIR** Temp. of radiating surface: cold → warm	**LWIR** Temp. of radiating surface: cold → warm
Focus of RGB product	**** low cloud, dust, ash-SO_2 (valid 24 hours)**	**hot spots, low cloud/fog (valid night time only)**	**convective intensity (valid day time only)**

* Arrows indicate: from no colour to full colour (here thin=black / thick=red)

** Different phenomena (low cloud, dust, ash, SO_2) require different tuning of enhancements (e.g. temperature difference range, gamma contrast enhancement)

The above three RGB schemes assign the same physical meaning to the colour beams. According to the diurnal coverage the red and green beam are assigned to the best proxy available, i.e. equivalent blackbody temperature from IR signals for the 24-hour (including dusk-dawn periods) and night time coverage, solar reflectance for daytime coverage. Goal of these RGBs is to monitor cloud type and structure (including convective intensity in daylight) and the evolution of lifted dust and ash/SO2 plumes. The first scheme excels in 24-hour coverage including dusk-dawn with only minor colour variations in identifying dust and ash/SO_2 when fine-tuned accordingly. Key to the scheme is the MWIR channel.

(ii) Focus on atmospheric attributes – air mass, potential vorticity and cloud systems

		Cloudy scene	Clear scene
RED	**(WV_upper_trop – WV_mid_trop) difference**	Cloud top temperature warm → cold*	Height of moisture layer mid-level → high-level
GREEN	**(OZONE-LWIR) difference**	Cloud top temperature, ozone content above cloud warm → cold, rich → poor	Ozone content rich/polar → poor/subtropical
BLUE	**WV_upper_trop inverted**	Cloud top temperature, upper tropospheric humidity warm → cold, dry → moist	Upper tropospheric humidity dry → moist
Focus of RGB product		**Cloud top height (colour of low cloud indicating air mass type)**	**Air mass type Potential vorticty anomaly**

* Arrows indicate: from no to full colour (here warm–black / cold-red)

This RGB scheme highlights the major cloud systems together with polar/subtropical air mass and areas of potential vorticity anomaly. It is an excellent tool for monitoring the synoptic situation. Key to the scheme is the ozone channel.

(iii) Focus on surface attributes

RED	**VIS_long**	**NIR**	**VIS_long VIS**	**VIS_long**	**(LWIR-SWIR) difference**	**NIR**
GREEN	**VIS_medium**	**VIS_medium**	**VIS_short SWIR or NIR**	**VIS_medium**	**VIS_long**	**VIS_long**
BLUE	**VIS_short**	**VIS_short**	**SWIR or (SWIR-LWIR) difference LWIR**	**VIS_short**	**VIS_short**	**VIS_short**
Focus of RGB product	**Vegetation**	**Water-Land wetness**	**Snow/ice cover and cloud properties**	**Smoke**	**Fire Hot Spots**	**Pre- and post-fire conditions**

3 CONCLUSIONS

CGMS members are invited to take note of, and to consider propagating into appropriate related activities, the generic approaches described in the workshop's conclusions. Members are further invited to note the fact that information from certain spectral bands plays an important role in the definition of widely-adopted RGB schemes and that this fact is relevant to the selection of spectral channels to be included in future space-born imagers.