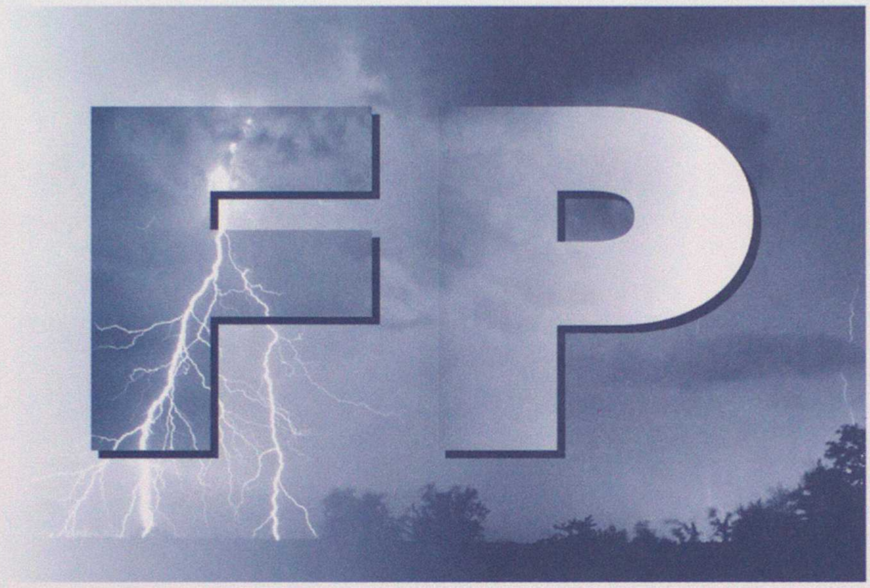
Forecasting **Products**



Research and Development

Forecasting Research
Technical Report No. 308

False colouring satellite images with the RGB-technique and proposal for a new fog image

by

A. Grantinger

November 1999

The Met.Office

Excelling *in weather services*

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The Met. Office
NWP Division
Room 344
London Road
Bracknell
Berkshire
RG12 2SZ
United Kingdom

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Tel: 44 (0)1344 856245 Fax: 44 (0)1344 854026 e-mail: jsarmstrong@meto.gov.uk

Forecasting Systems 3

False colouring satellite images with the RGB-technique

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Proposal to a new fog image

By A. Grantinger

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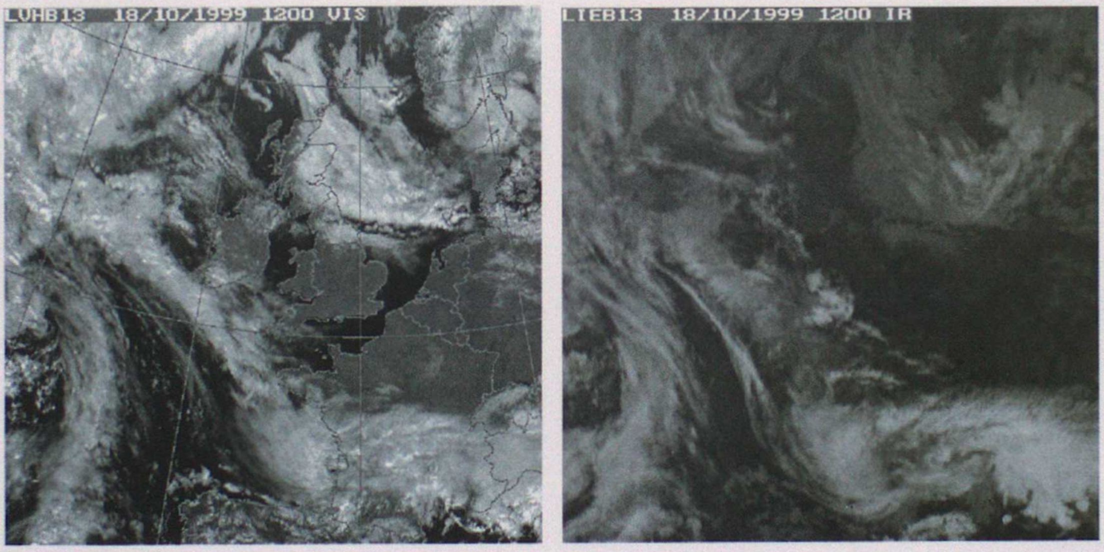
1. Introduction

A report is written to explain and show examples of how the RGB technique is used in satellite imagery. The report also shows examples of RGB images, how they are to be interpreted and how they can, during night-time, be used as improved fog channel images[1].

The basic way of visualise satellite images at present is to use different shades of grey to represent pixel values. This will give images in black and white and the most used satellite images of this type is visible (VIS) and infrared (IR), see figure 1.
Since the different spectral channels of the satellite imager have their own special characteristics, the satellite images will show different things. E.g. the VIS-channel works like an ordinary photograph and shows the cloud just as if the viewer would have seen them from space and the IR-channel shows the temperature, where the very cold cloud stick out from the warmer surface of earth.

Since most display systems are able capable of displaying coloured images, the different images from the satellites imager can be coloured instead of using grey-shades. This process is called *false-colouring* or *pseudo-colouring*. One technique is to enhance the IR image, to give a certain IR brightness a certain colour.



(a) *(b)*

Figure 1. Satellite images from the Meteosat 18th October 1999, 1200z. (a) is a visual image and is like a normal black and white photograph. (b) is a InfraRed image and is like a picture of the temperature, where warm is dark and cold is white.

2. The RGB technique

A more useful technique is to combine several images from different spectral channels and create multispectral images. These images can also be coloured and so-called RGB-images (Red, Green and Blue) can be created. This will give images from

[1] This report can also be seen at the following link (Met Office intranet) http://hrcd01/~agrantin/reports/rgb_report/RGB_fog_channel.html

three original spectral channels shown in only one colour image. The differences between the original images now show up as colour differences. Each pixel value will be composed of the three colour components red, green and blue where the intensity of each component is determined by the original input pixel value.

An example of the RGB-technique can be seen in figure 2. Instead of two black and white VIS and IR images from the Meteosat satellite the same images can be combined to a colour image where different colours defines different types of cloud. Figure is combined by two VIS images, one red and one blue, and a green IR image.

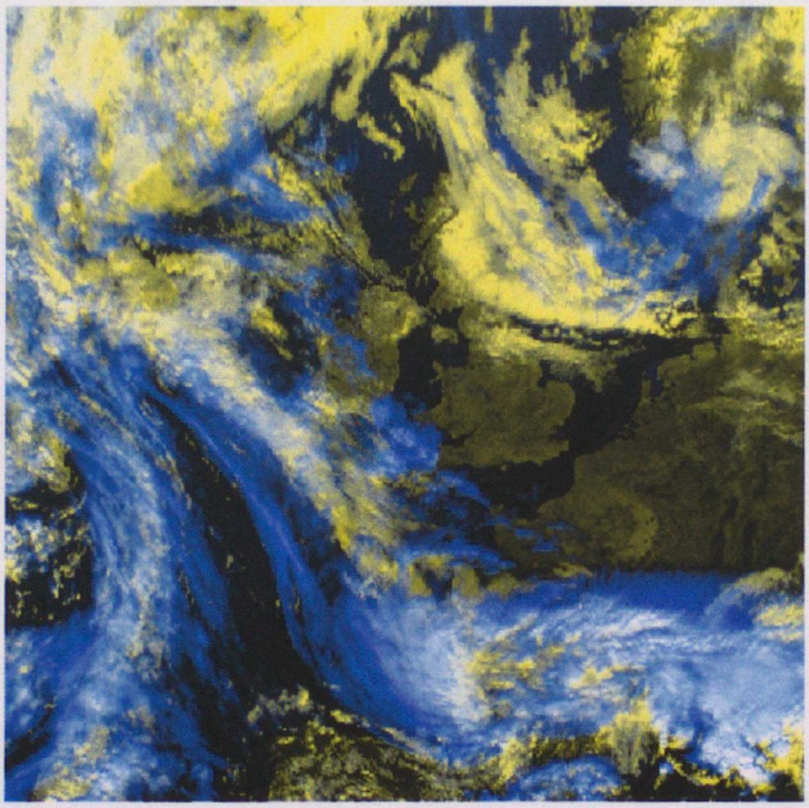


Figure 2. The RGB image from Meteosat 18th October 1999, 1200z. The visual image is given a red and a green colour and the infrared channel a blue colour.

To enhance the images even more a histogram equalisation operation is performed on the images before they are 'coloured and combined' through the RGB-technique.

An image's pixel value can vary from 0 to 255, but pixels from all values are not always represented in the image. The histogram equalisation operation distributes the pixel values evenly (same amount of pixel values within a limited pixel value interval) over the entire pixel range. This method increases the contrast near the peak of the histogram, where most pixels in the image are found. Although, the contrast near the tails of the histogram is lost.
The above example of RGB-image is just the beginning. Since the Meteosat imager just have one type of VIS and IR channel, the RGB-images from it is somewhat limited. The AVHRR, the polar orbital satellites imager, is more advanced and has two channels in the visible spectrum, two in the infrared spectrum and one in the near infrared spectrum (NIR). This gives more possibilities for combinations of images.

The analogous image to figure 2 made from the AVHRR is shown in figure 3. This image is combined of the channel 1, 2 and 4 (N.B. not the same time as figure 3).

Figure 3. Multispectral image made from channel 1,2 and 4 from the NOAA polar orbital satellite, 19th October 1999, 1533z. Note the differences between cloud tops over the continent.

With the AVHRR's three different infrared channels an RGB-image made for night-time can be made. This image has the same characteristics with different colours for different types of cloud (pixel values). Figure 6a below gives an example of the night-time RGB-image.

3. Subjective interpretation of multispectral images

The RGB-images combine the information in ordinary black and white satellite images and give much more information for a skilled and well-experienced analyst. To describe the colours in the daytime RGB-images we may use figure 5 below. Here, arrows denote contributions from each spectral channel to each colour component and the lengths are the intensity or radiance in each component.

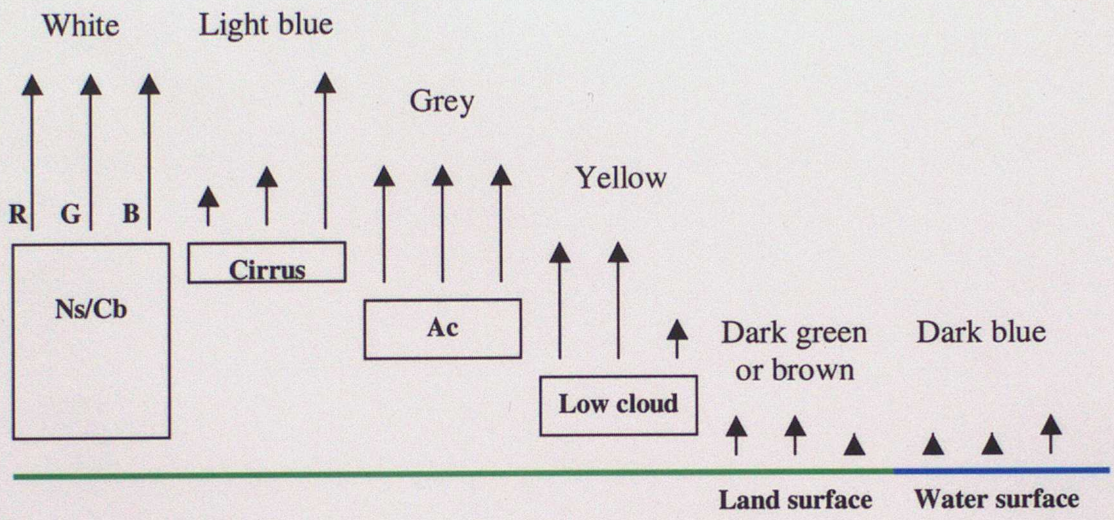


Figure 5. Typical daytime colour appearance of some types of clouds and surfaces in RGB images based on NOAA AVHRR channel 1,2 and 4. Similar for Meteosat images, where the VIS channel is used twice combined with the IR channel. (Karlsson, 1997)

Figure 5 shows that thick frontal clouds have high intensity from all three channels and the clouds therefor become white. High thin cirrus does not appear well in the VIS channels but good in the IR channel and become therefor bluish. In the same way become alto-cumulus greyish and low cloud yellowish, there the IR channel does not contribute much in the latter. With the RGB technique images become almost three dimensional, making it easier to see differences between different cloud types, cloud tops and structure and texture in cloud patterns. Table 1 shows the main colour characteristics in these types of RGB images during daytime (see figure 3).

Table 1. Colour appearance in RGB composites with AVHRR channel 1,2 and 4 during daytime. (Karlsson, 1997)

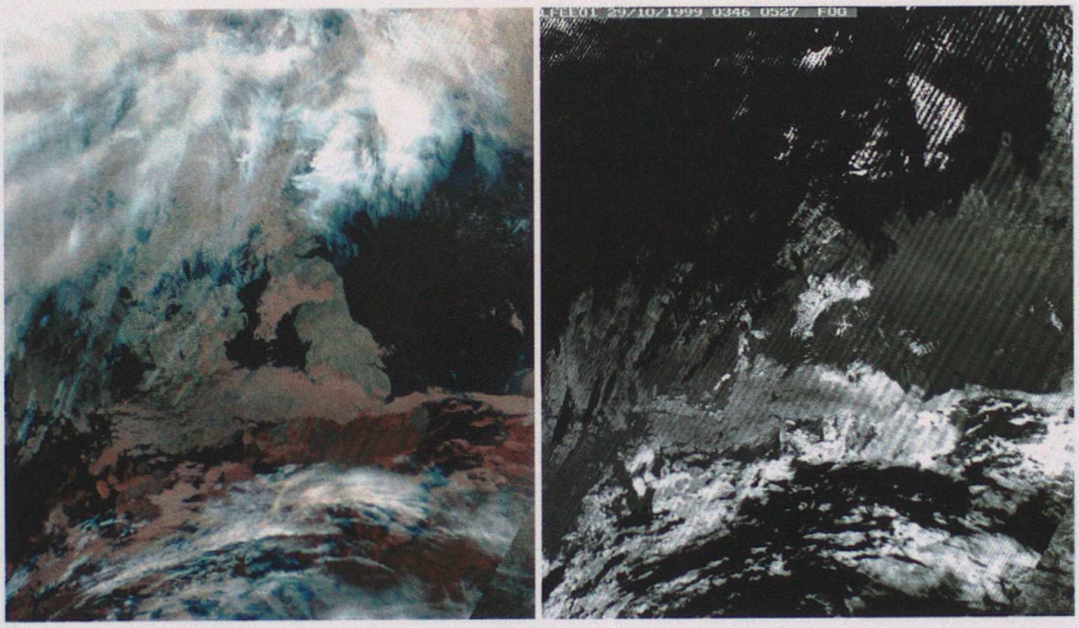
Cloud or Surface	**Cloud Appearance**
Thick and cold clouds, e.g. Frontal	White or bluish-white
Thin and cold clouds, e.g. Ci	Blue
Middle level clouds, e.g. Ac	Variable grey (yellowish – bluish)
Low level clouds, e.g. Fog or St/Sc	Yellow or yellowish – white
Land surfaces	Dark brown or green
Ocean surfaces	Dark blue or black
Ice and snow	Yellowish – white

The colour guide is only a rough description, which is valid exclusively in situations with good illumination conditions (i.e. at high sun elevations/low solar zenith angles).

The RGB colours from table 1 are approximately valid also for RGB images based on Meteosat VIS/IR images. The only difference here is that land areas change in colour from dark green to dark brown (see figure 2). Areas with sparse vegetation (e.g. desert areas) become slightly yellow in appearance.

4. RGB images during night-time; a new fog image

Since RGB images made from channel 1,2 and 4 are not possible to obtain during night, when the VIS channels are both dark, an image made by combining channel 3, 4 and 5 becomes extremely useful. This will give, in the same way like during day-time, an almost three dimensional image where the cloud types, formations and tops will appear distinctively (see figure 6a). Compared with the normal IR image the contrast between land and water surfaces will become very clear and the orography will appear clearly.



(a) *(b)*

Figure 6. (a): RGB image made from AVHRR channel 3,4 and 5 from 0527z 29th October 1999. The dark area over south of England is widespread fog. (b): Met Office's fog channel at the same time. Fog and low stratus become white. See Annex 1 for a detailed comparison.

The image will also have the same information that the Met Office's fog channel has (see figure 6 a and b); the low stratus and fog that become white in the fog channel will appear distinctively as dark red in the RGB image (see figure 6). See Annex 1 for a detailed comparison between the night-time RGB image and the Met Office's fog channel.

Table 2 shows the appearances of cloud in RGB images made from AVHRR channel 3, 4 and 5.

Table 2. Colour appearance in night-time RGB composites with AVHRR channel 3,4 and 5. (Karlsson, 1997)

Cloud or Surface	**Cloud Appearance**
Thick and cold clouds, e.g. Frontal	White or reddish-white
Thin and cold clouds, e.g. Ci	Bluish white
Middle level clouds, e.g. Ac	Light red
Low level clouds, e.g. Fog or St/Sc	Dark red
Land surfaces	Grey or light grey (if very cold)
Ocean surfaces	Grey or very dark red
Ice and snow	Grey or light grey (if very cold)

5. Summary

The advantages with the RGB technique in satellite imagery are many. Not only are they nicer to look at but they hold more information for the forecaster or analyst to extract. They give almost a three-dimensional view of the cloud and cloud formations, where differences in layers and cloud tops are easily seen.

In night-time images the three-dimensional effect is still there, giving possibility to see the different cloud types, and the contrast between land and water surfaced is distinct. The images can be used as the old Met Office fog-channel to find areas with fog or low cloud but also give information about the rest of the clouds.

Although there are many advantages with RGB images, there are a few disadvantages as well. The use of ordinary black and white Meteosat IR images is more valuable in animations since they are using the same basic appearance at any time of day. Rapid cloud developments will change the set of pixel values and the histogram equalisation might change the colours slightly from one image to another. The RGB images also have a disadvantage at sun elevations between 2-6°, i.e. sunrise and sunset. During this time the differences between AVHRR channel 3 and 4 disappear, making it difficult to separate low clouds from cloud free surfaces.

Finally; the Autosat team in the Met Office has now begun to produce these different RGB images and update them regularly. The latest images can be found at the following sites on Met Office intranet: http://tigger/false_colour.html or http://hrcd01/~agrantin/Aviationpage.html

Literature

Karlsson, K-G, 1997: An introduction to Remote Sensing in Meteorology, SMHI

Annex 1: Comparison between an RGB image and the Met Office fog channel.

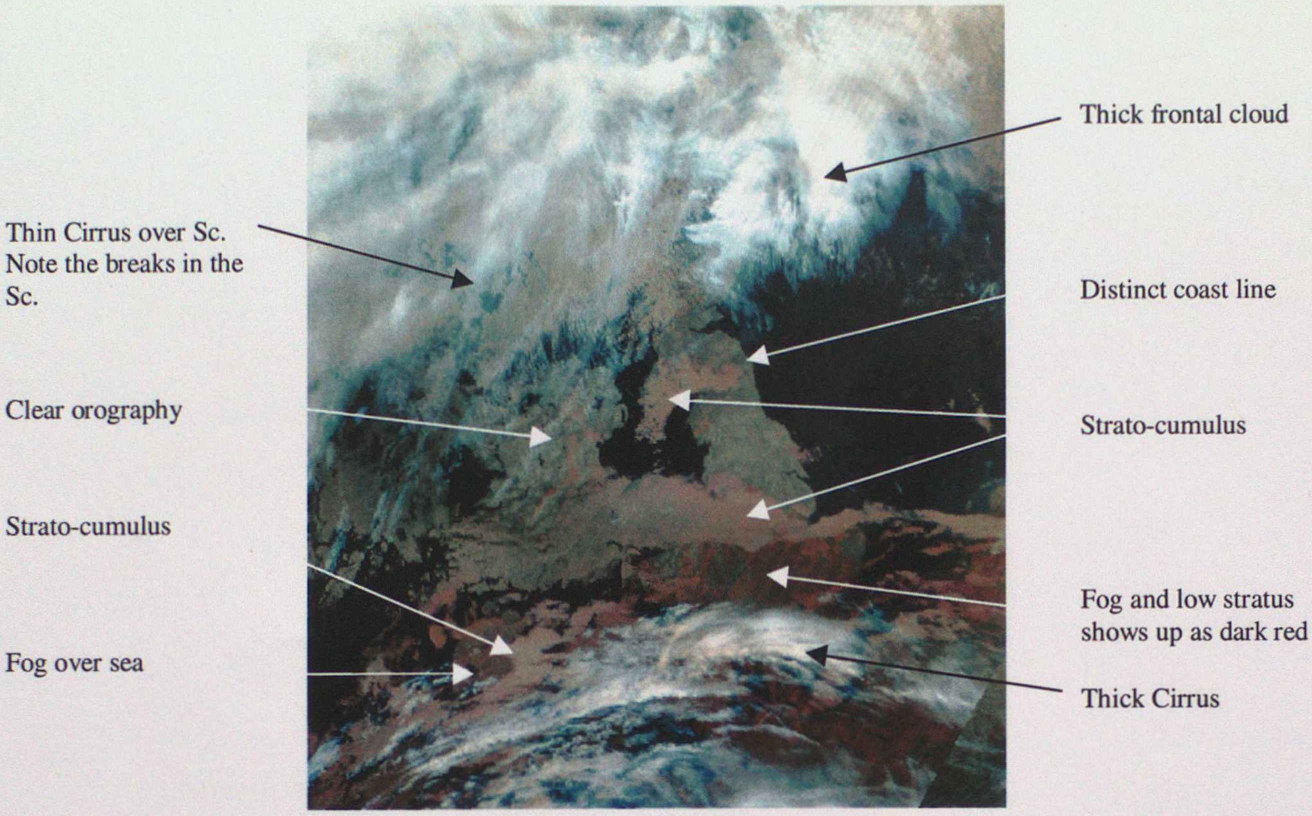


Figure 7. RGB image made from AVHRR channel 3, 4 and 5. 29th October 1999, 0527z.

Figure 8. The Met Office fog channel (difference between AVHRR channel 3 and 4) from the same time as in figure 7.