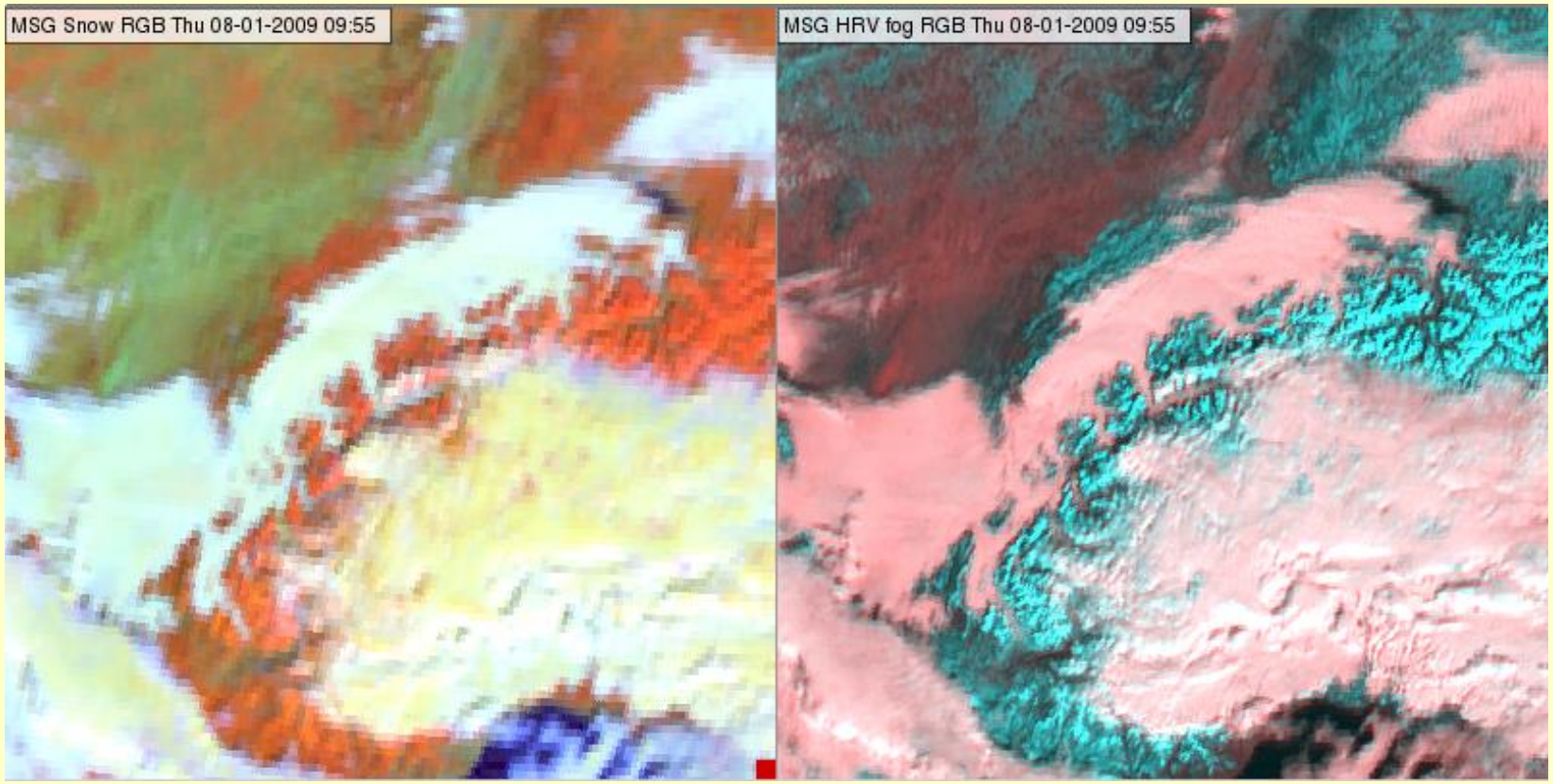
# Detection of snow with the present European geostationary RGB images

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on-line presentation on EUMeTrain Snow Event Week, 9 February 2021

# Outline

Introduction

Snow detection using solar channels - daytime

- Single solar channel
- Daytime RGBs useful for snow detection
  - HRV Fog RGB
  - Natural Colours RGB
  - Snow RGB
  - Day Microphysics RGB
  - Their comparison
- Daytime RGBs NOT useful for snow detection

Some information about snow in nighttime RGBs

Sea and lake ice

Summary

# Introduction

**visual detection** – not retrieval

**Solar channels provide the key information for snow detection**

**During daytime**

on **cloud-free areas**– **reliable snow detection**

Not seen under thick clouds

May be seen under thin clouds – depending on the transparency – one can hint **- animation** helps

At night – no snow detection - some possibility – in some special conditions

Appearance of snow on satellite imagery depends not only on the snow characteristics (fresh/old, grain size, melting, dirty,…), but also on the fact whether the snowy pixel is mixed (snow patches, partly cleared, unfrozen lakes, rivers, dark tree branches over the snow, …)

**sea/lake ice**

if covered by snow – appears like snow

if not covered by snow – darker (if melting even darker)

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Snow detection is based on solar channels

# Daytime

# Snow detection using single <u>solar</u> channel

traditional visible channel (one single visible channel)

snow is bright, (snow-free) land/sea is dark ⇨ discrimination of snow and land/sea is OK
snow is bright, clouds are bright ⇨ discrimination of snow and clouds is not evident

<u>analysing structure and animations may help</u>

HRV – high spatial resolution

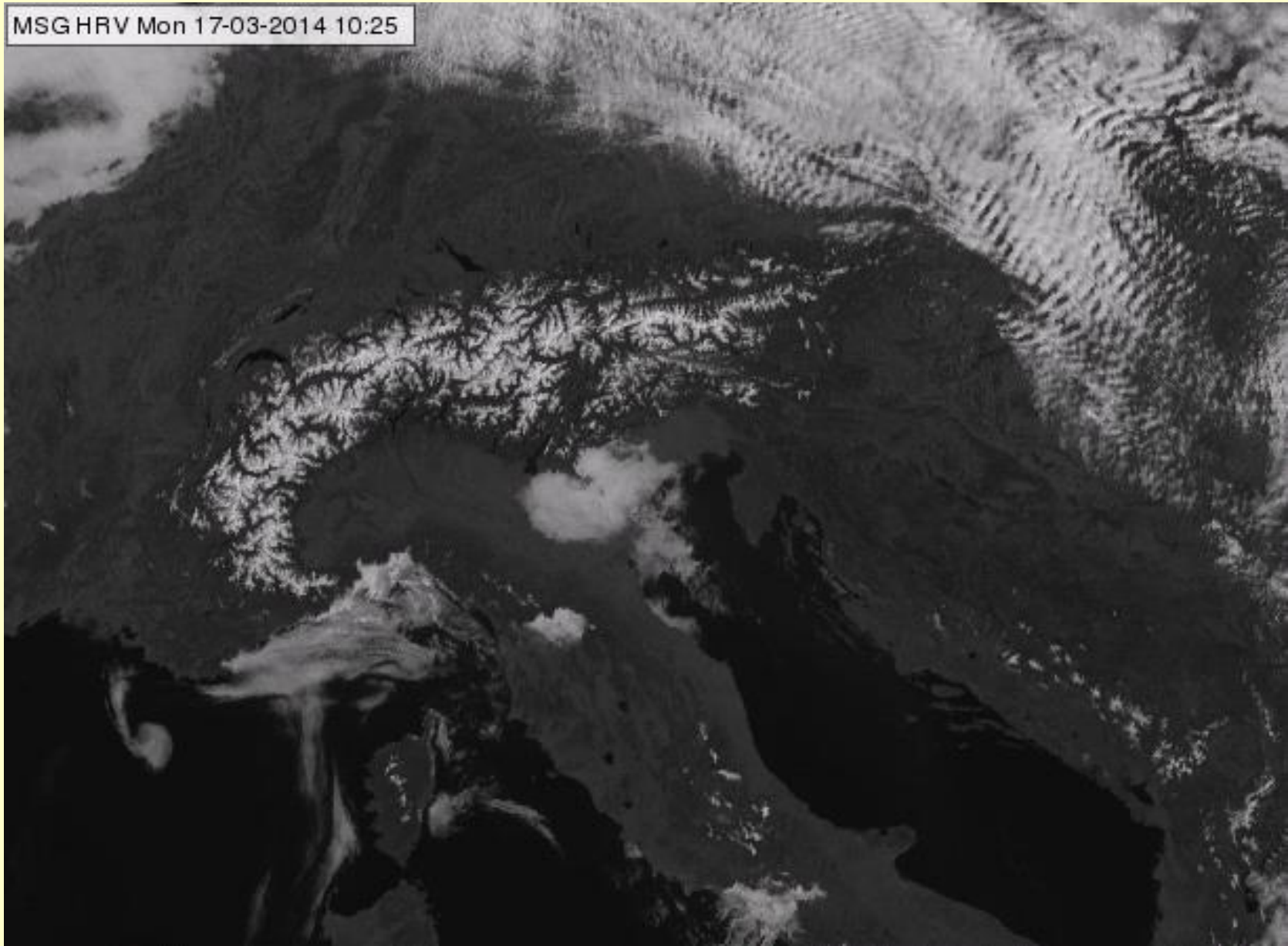
Cloud-free snowy mountains and lowlands or hills often have different appearance in the satellite imagery.

In mountainous terrain one can often see the structure of the valleys and ridges.

Snow on high mountains is usually brighter than on plains or hills (less mixed pixels, “finer” snow).

- On the ridges due to the lower temperature the fresh **fine snow** remain longer fine than in the valleys.
- less mixed pixel
  - snow cover is often thicker
  - less high vegetation (no forest), snow is less disturbed by the vegetation

In the valleys usually there are more mixed pixels: snow covered and cleared areas, melting snow, more high vegetation (dark branches, shadows).

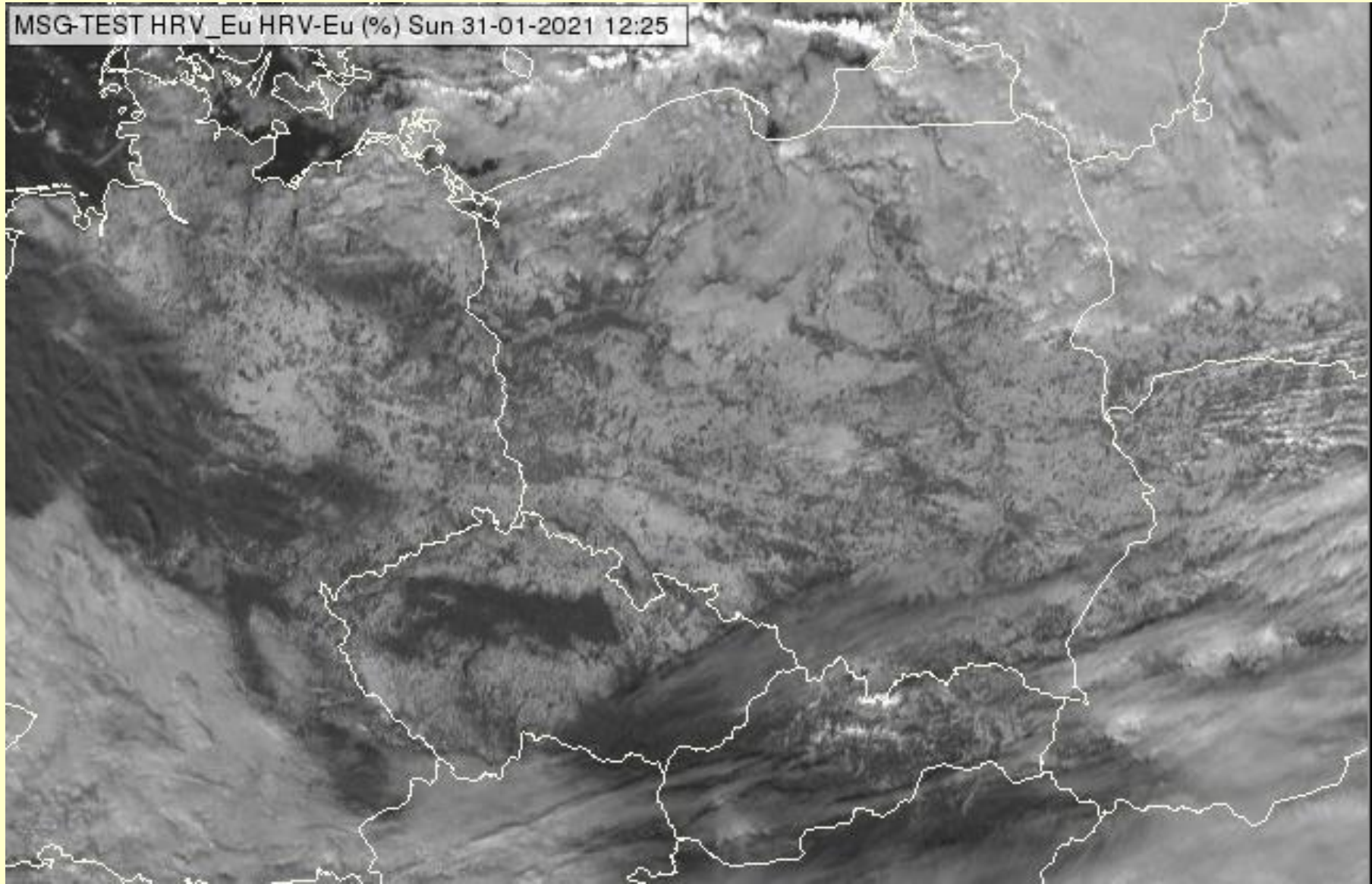


Cloud-free snowy mountains and lowlands or hills often have different appearance in the satellite imagery.

Snow on plains or hills is usually less bright than on high mountains – more mixed pixels

One can often see patches, lines or spots in it.

- Patches might be due to forest with shadows and branches not covered by snow.
- Lines might be due to rivers,
- spots due to settlements, lakes.

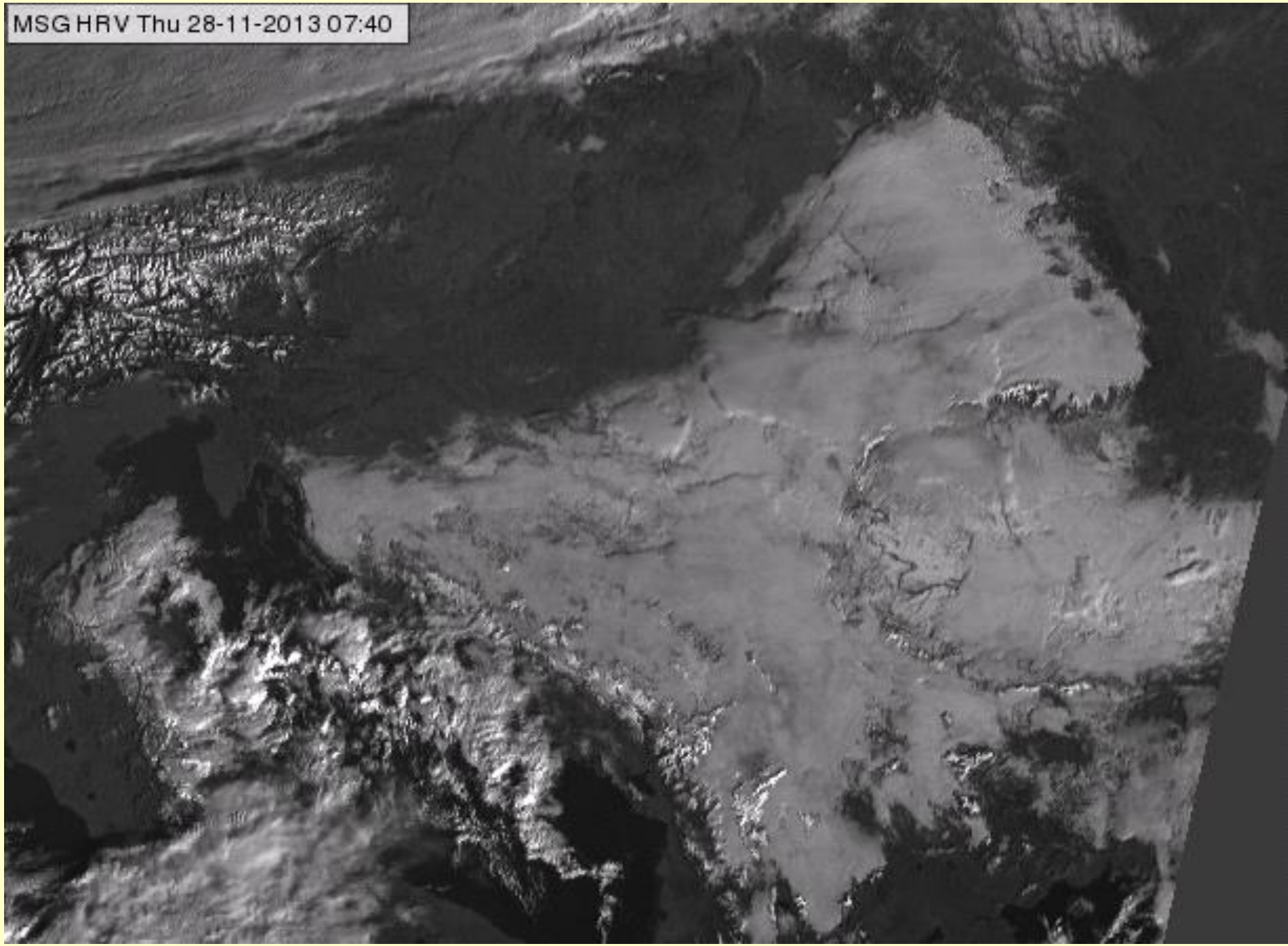


snow and clouds – both are bright.

Not easy to discriminate them <u>rapidly</u>.

Their different structures and animations may help.

However, not always and it might be <u>time-consuming</u>.



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- Single solar channel
- **Daytime RGBs useful for snow detection**
  - HRV Fog RGB
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Some information about snow in nighttime RGBs

Sea and lake ice

Summary

# RGB

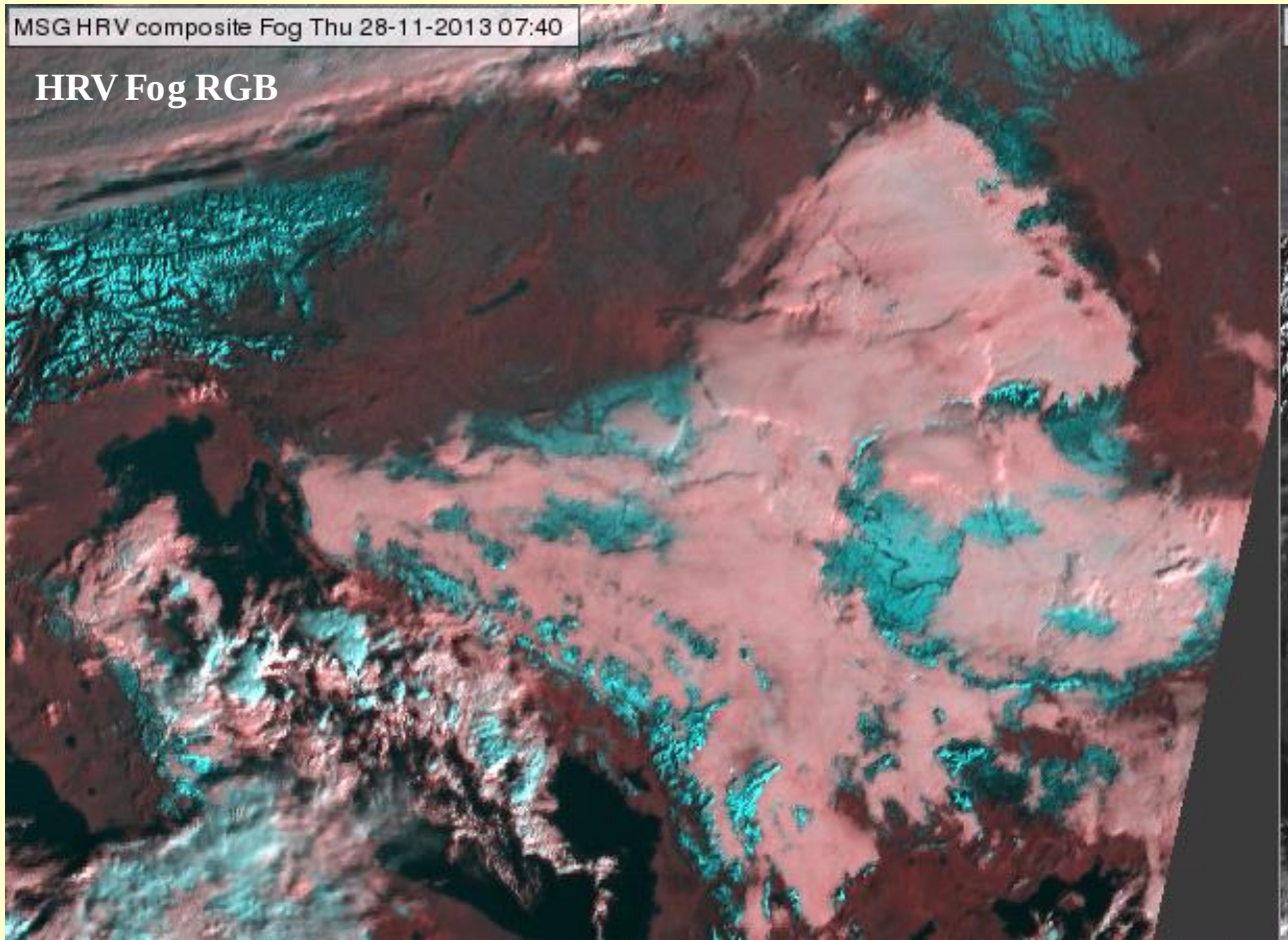
More solar channels

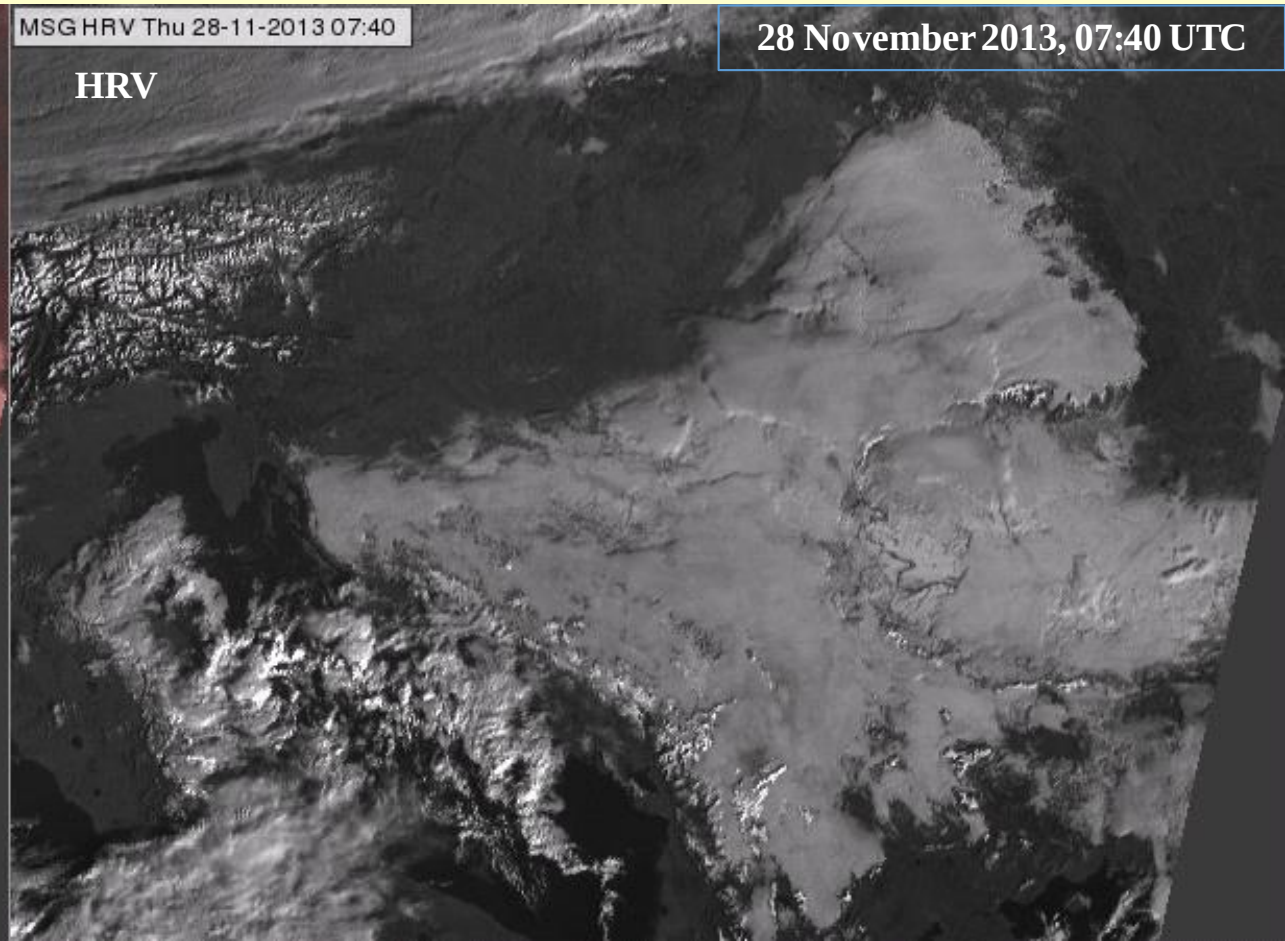
structure, movement, **spectral behaviour** together

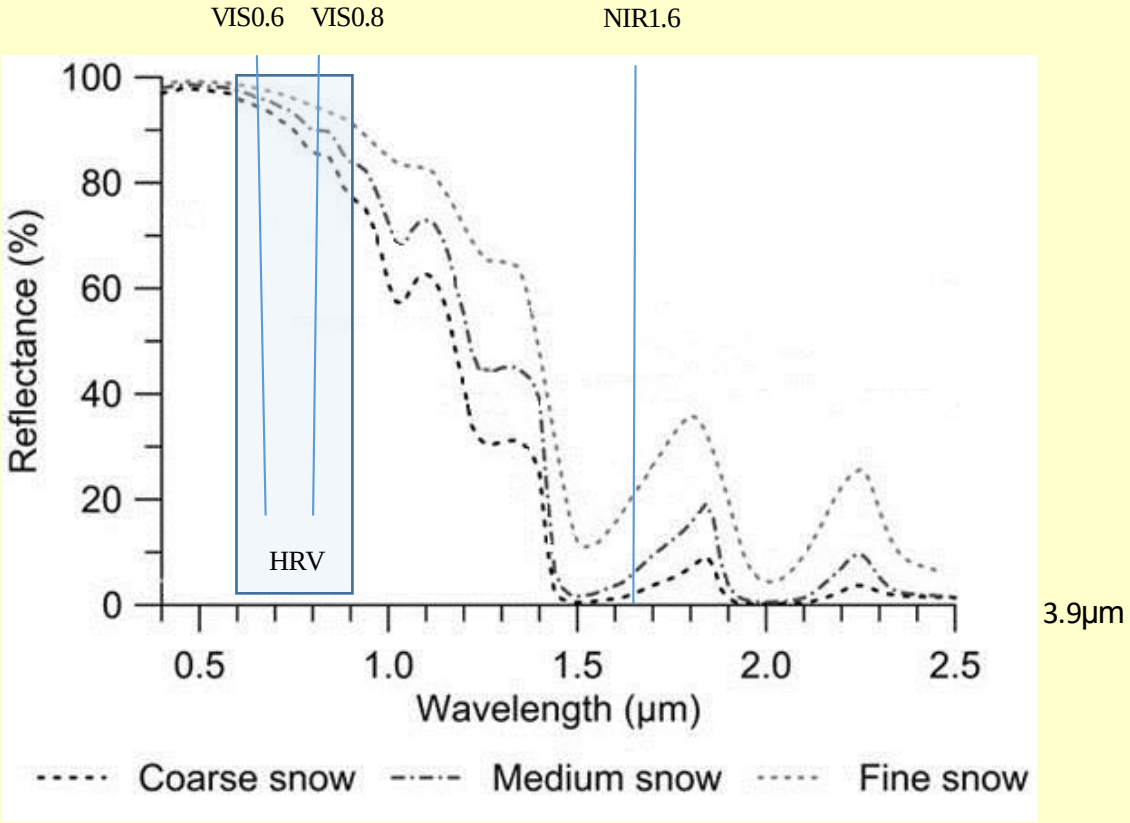
snow, land, sea, clouds have different spectral characteristics

using several channels the visual discrimination can be based on these characteristics

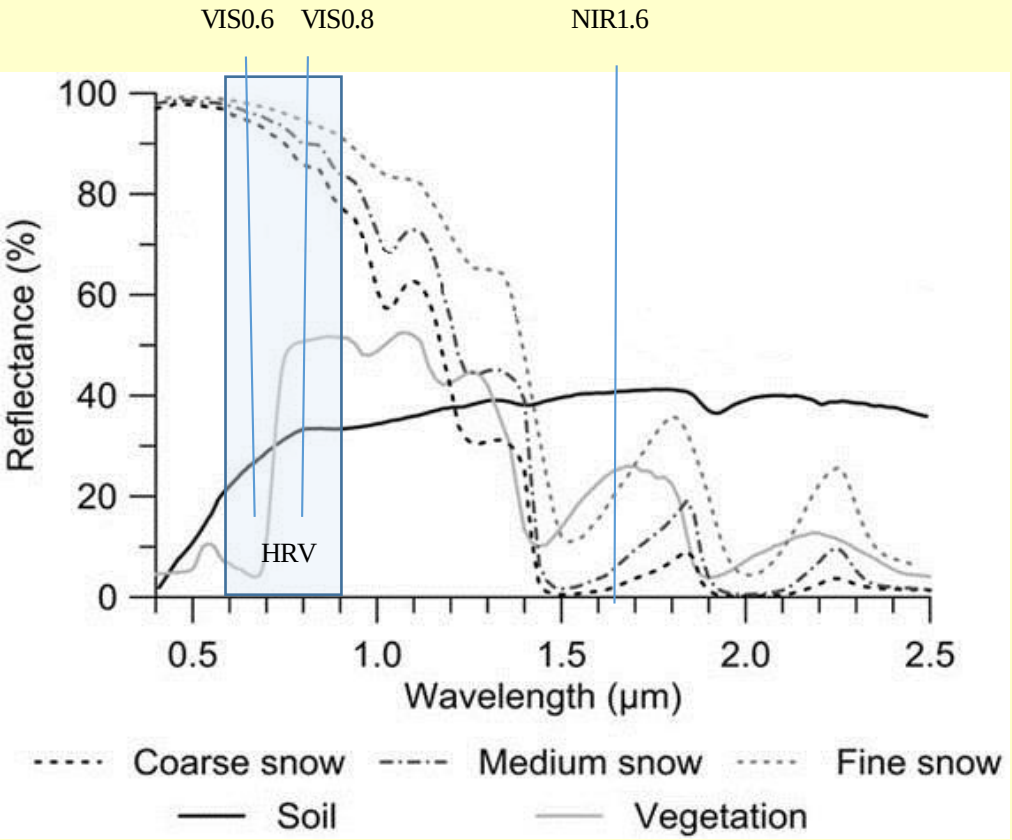
RGB – method to visualise more channels together






**Typical reflectivity spectra of snow**



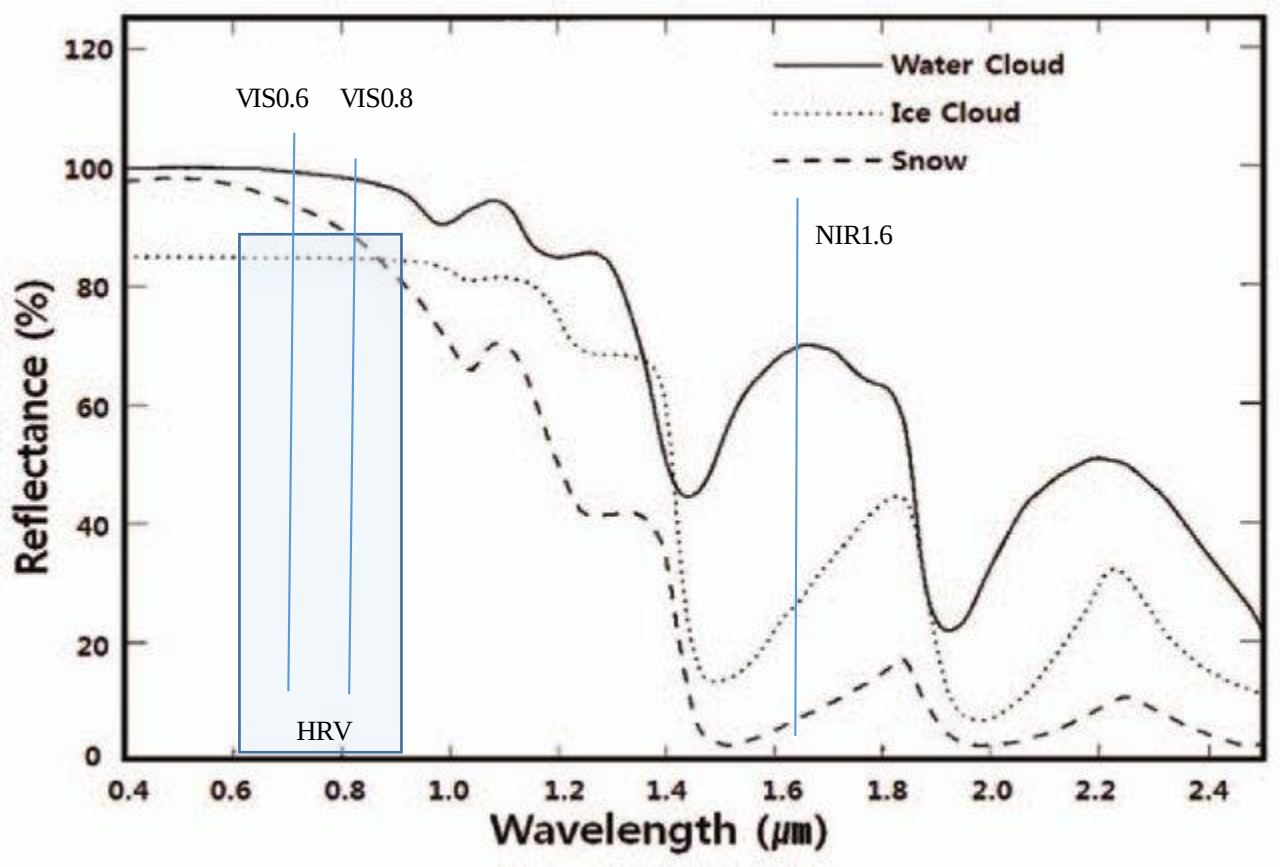

**Typical reflectivity spectra of snow, soil and vegetation**

## How to identify snow?

- high reflectivity in the VIS0.6, VIS0.8 and HRV channels
- low reflectivity in the 1.6 and at 3.9 µm channels
- we need a channel pair where the snow reflectivity is high and low

## Can we differentiate snow from snow-free land/sea?

Soil, vegetation and water has rather different reflectivity spectra than snow, e.g. they are is dark in the visible region.




## Can we differentiate snow from clouds?

- At 0.6 µm, 0.8 µm and in the HRV channel clouds and snow are bright.
- At 1.6 and 3.9 µm clouds are brighter than snow, thick water clouds are much brighter than snow, thick ice clouds are somewhat brighter than snow.

↓

The contrast between snow and water clouds will be higher than the contrast between snow and ice clouds.

**Discrimination snow and water cloud is more important.**

**Fog, stratus often forms above snowy area and they are often stationary.**

The contrast between snow and ice cloud is lower - animation may help to differentiate them.

3.9µm

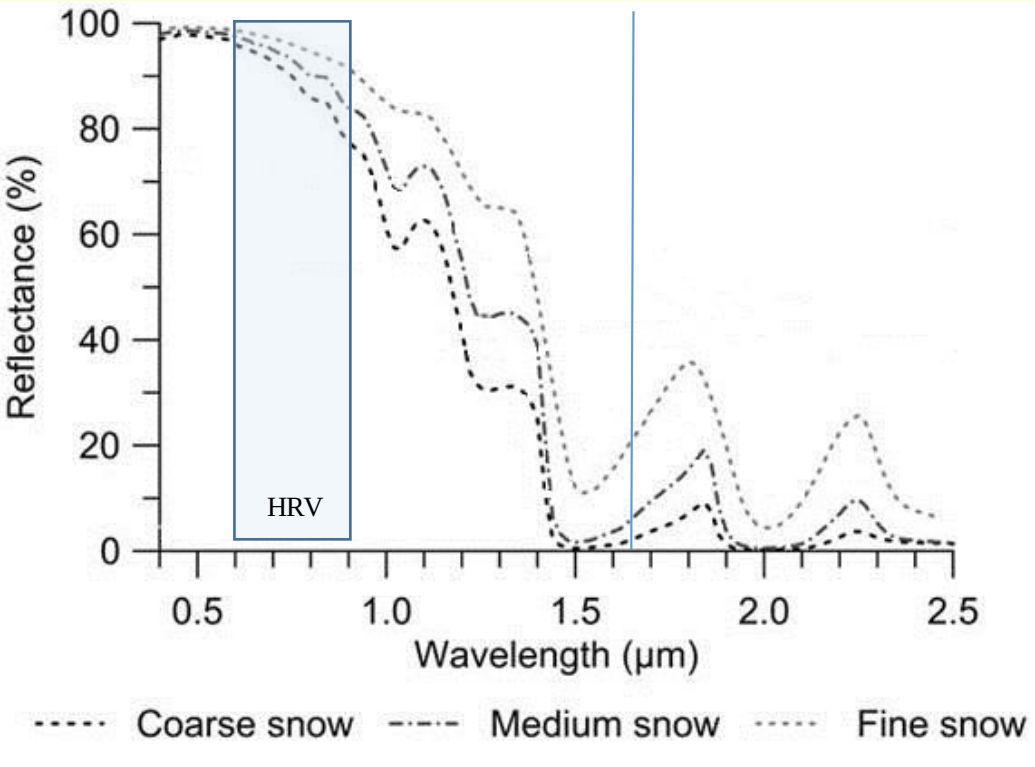
Note:

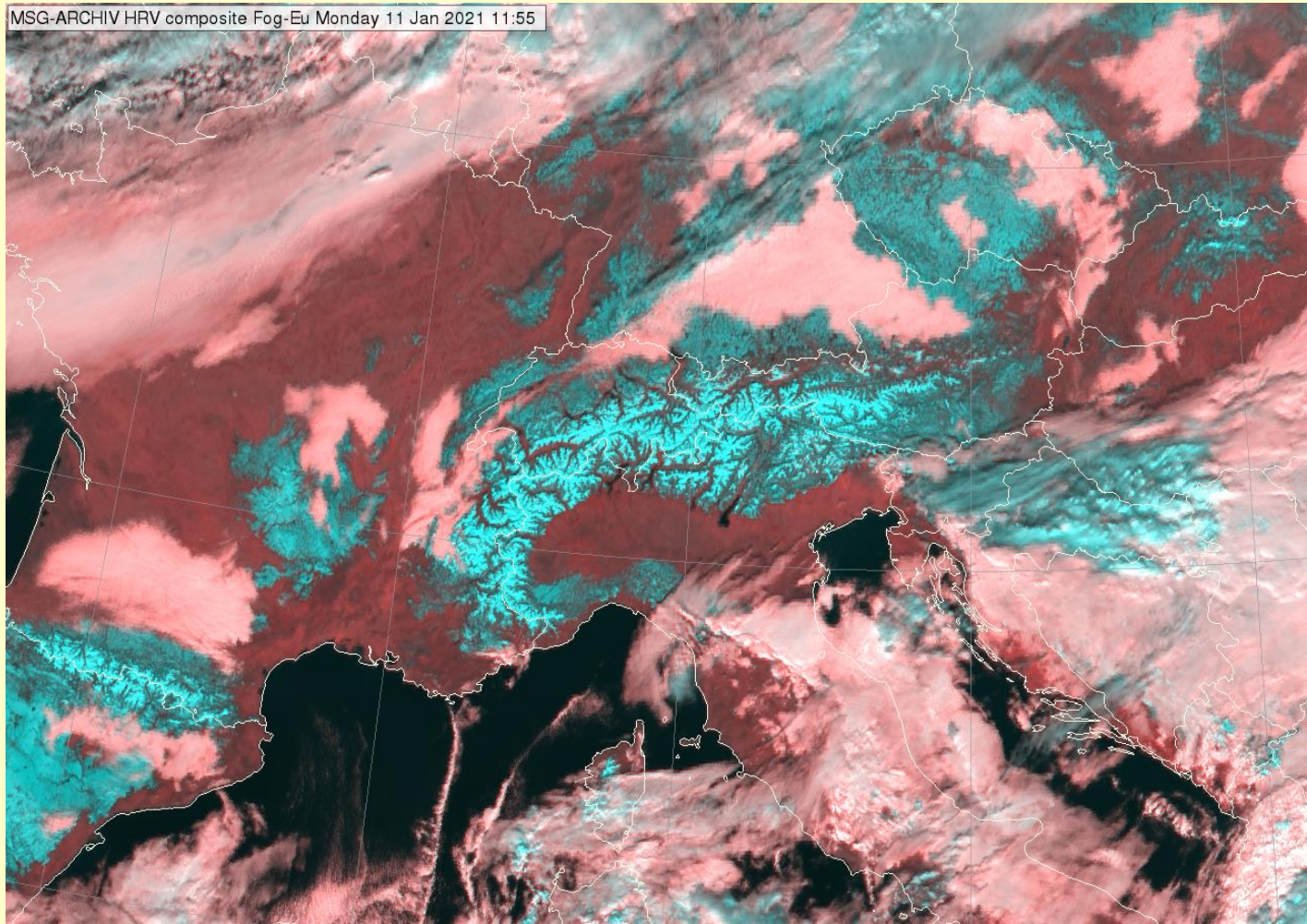
These graphs show the spectral characteristics of snow. Do not forger that in a satellite imagery there are mixed pixels as well.

# HRV Fog RGB

| Colour beam | Channel | Range | | | Gamma |
|---|---|---|---|---|---|
| Red | NIR1.6 | 0 | 70 | % | 1 |
| Green | HRV | 0 | 100 | % | 1 |
| Blue | HRV | 0 | 100 | % | 1 |

NIR1.6



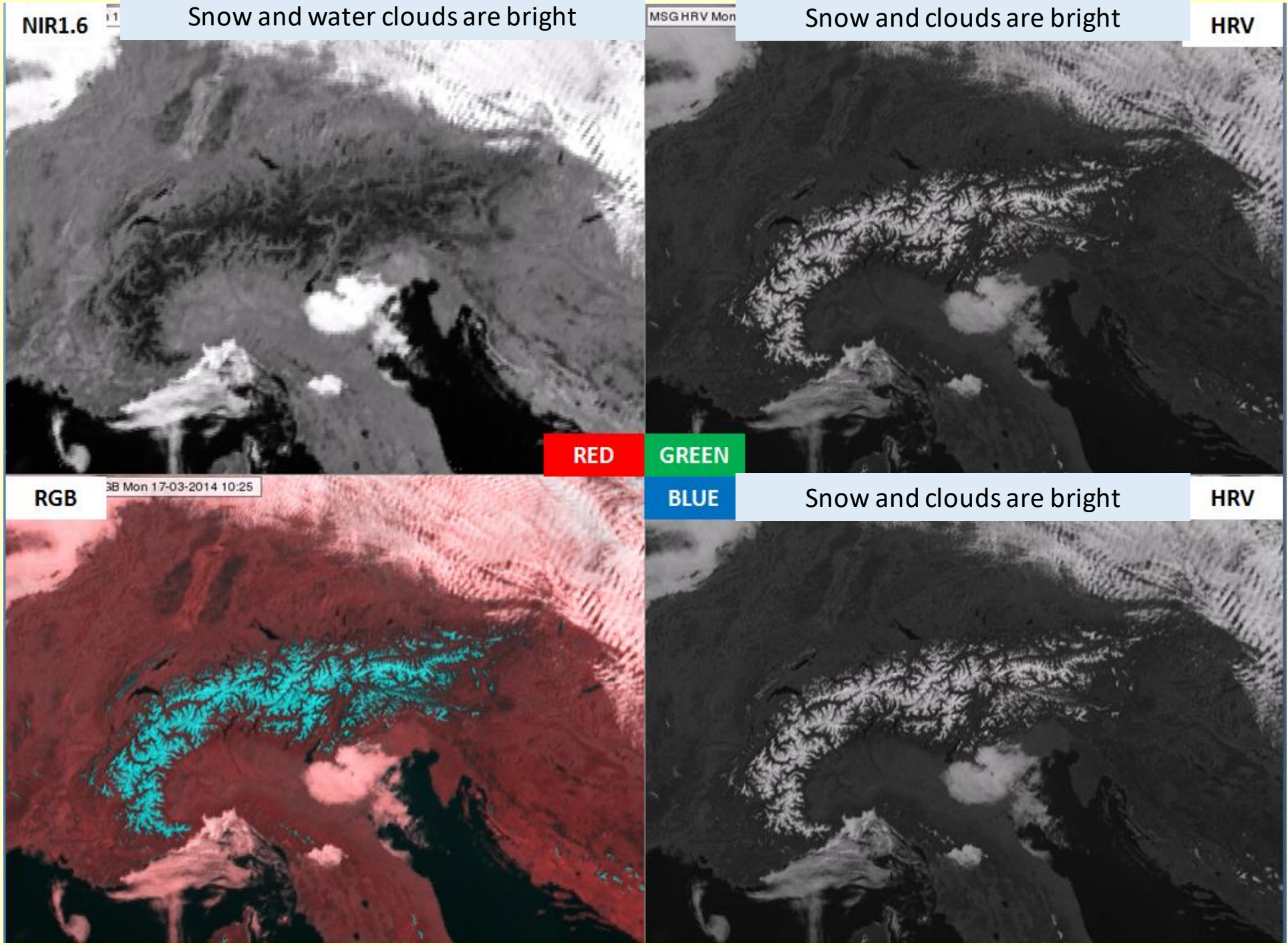



17 March 2014
10:25 UTC

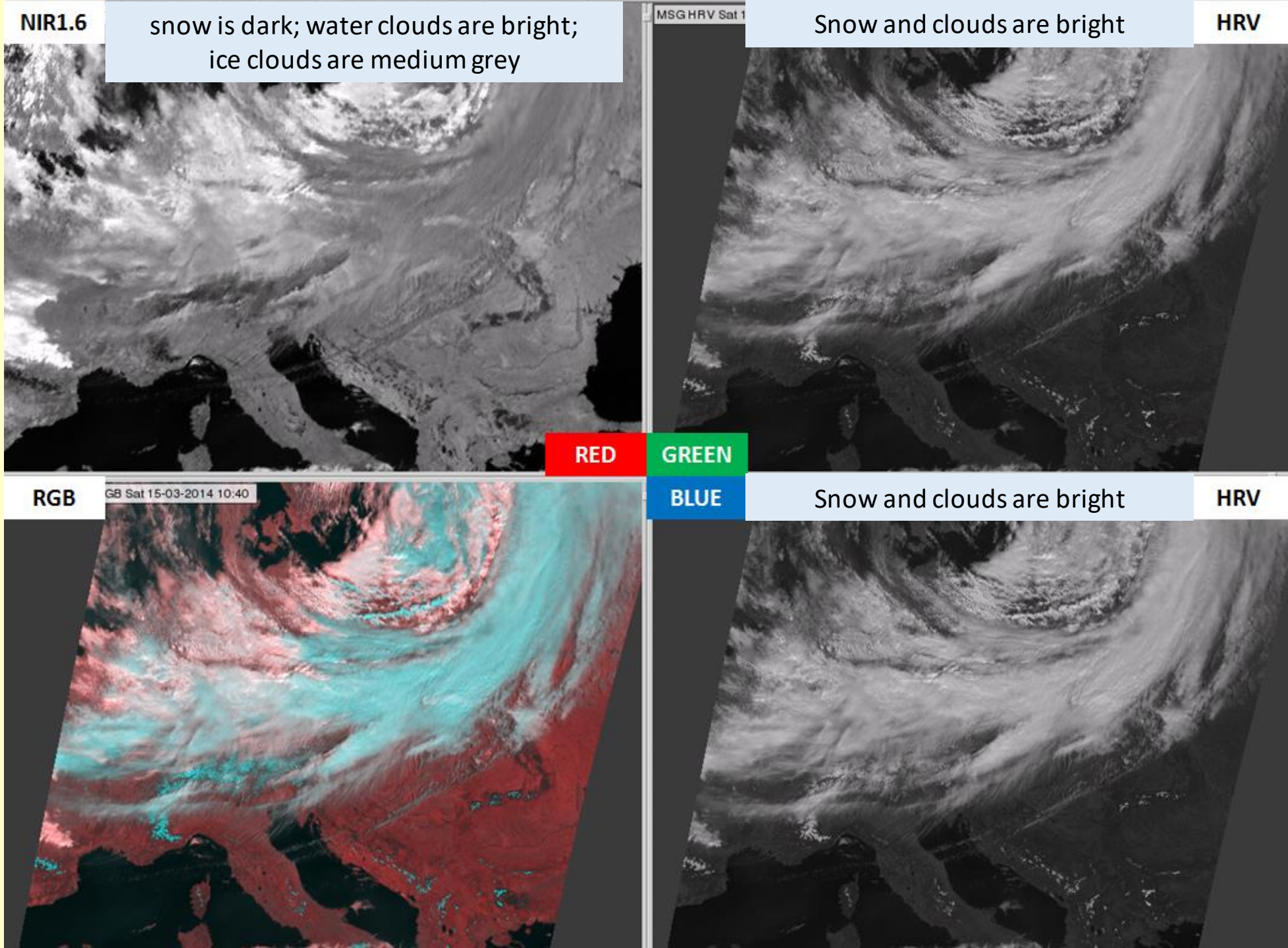
Easy to discriminate snow covered area from fog/water clouds – good colour contrast - (cyan against pink).

High spatial resolution

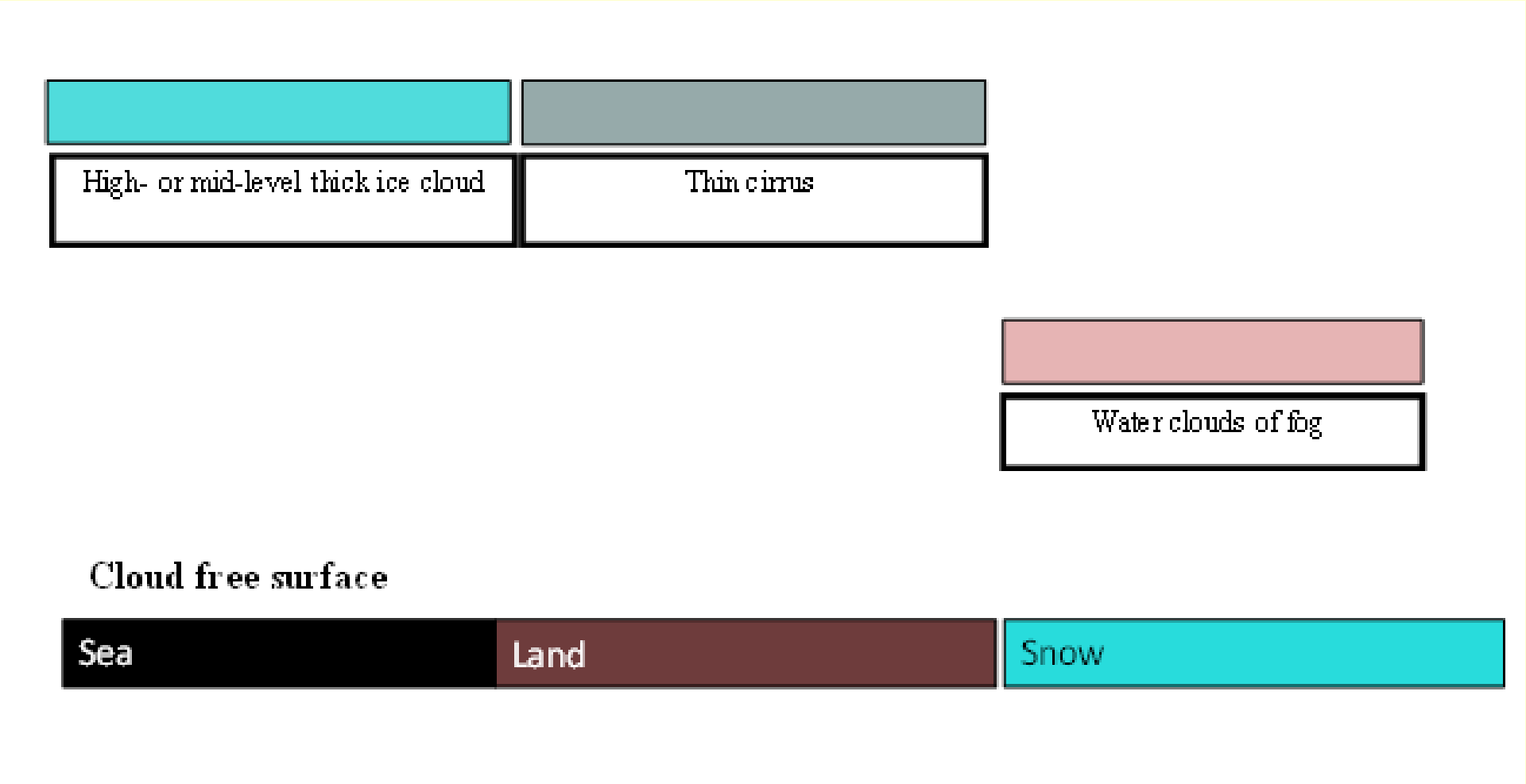
Good colour contrast between snowy and snow-free land/sea



**SEVIRI**
**15 March 2014**
**10:40 UTC**




Low colour contrast between (thick) ice cloud and snow – structure, animation may help




Typical colours of the HRV Fog RGB images

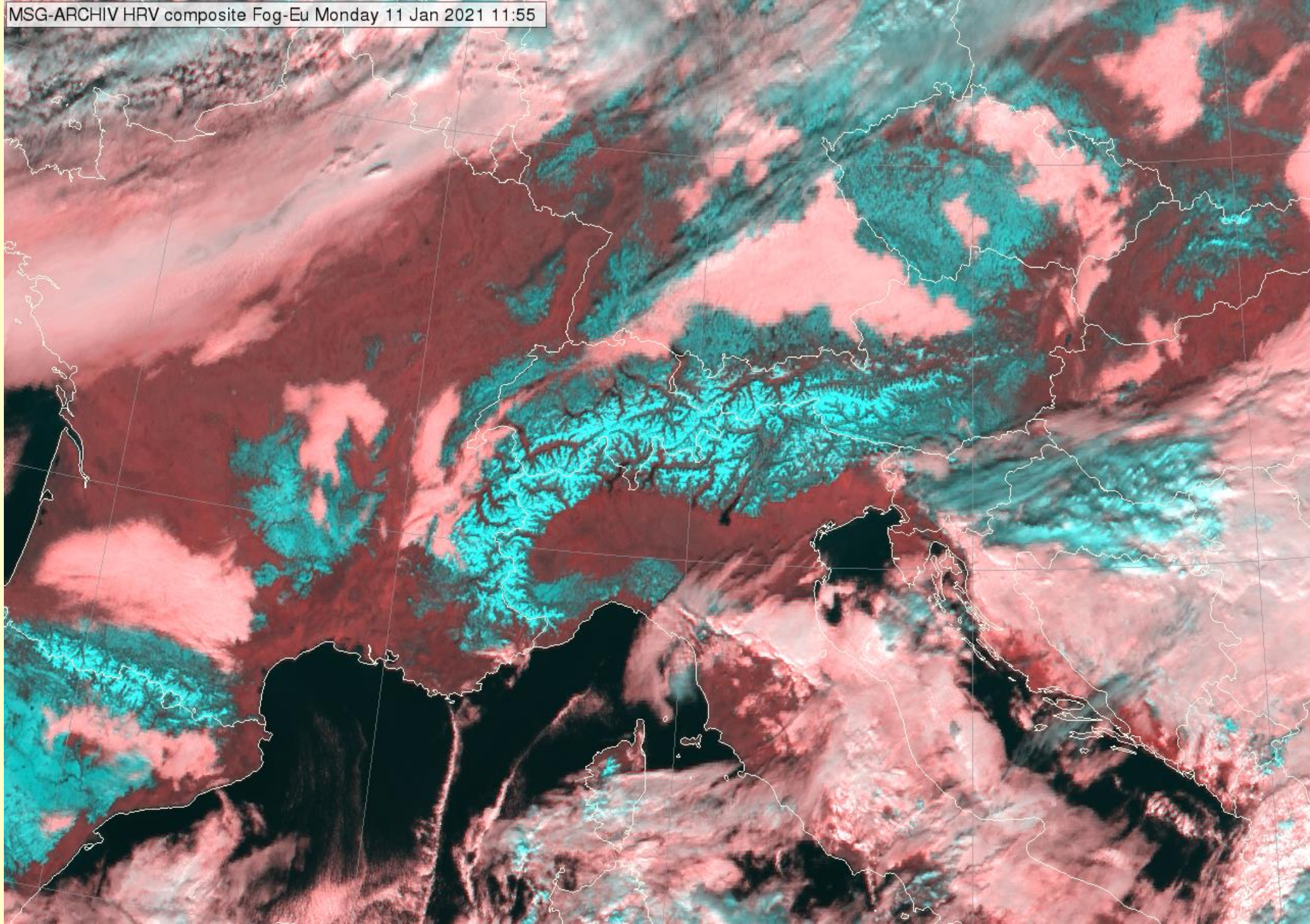
HRV Fog RGB
11 January 2021
11:55 UTC

brighter colour over high mountains

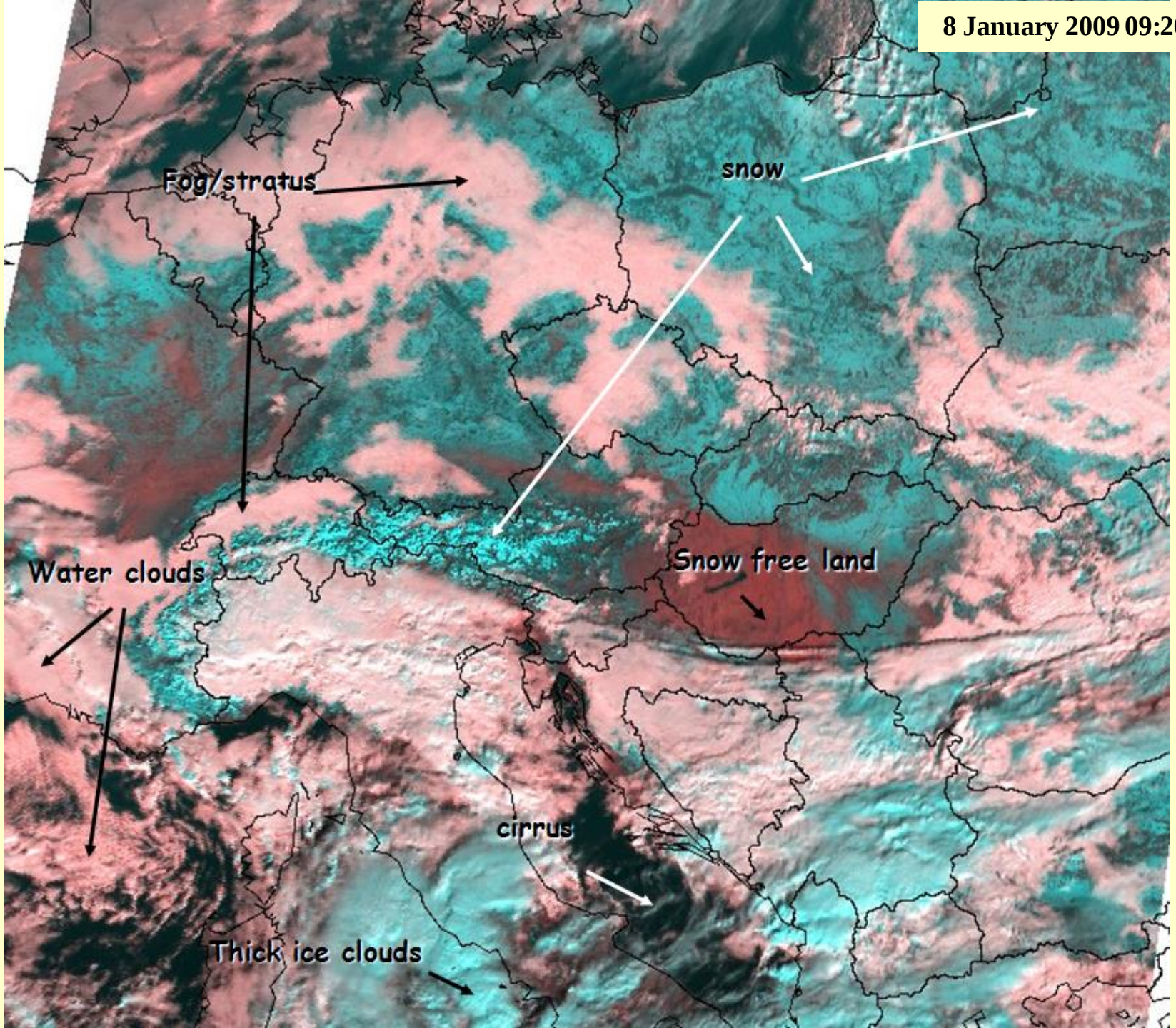
Much easier to differentiate snow covered area from fog/water clouds - good colour contrast - (cyan against pink)

fog, stratus often forms over snowy area

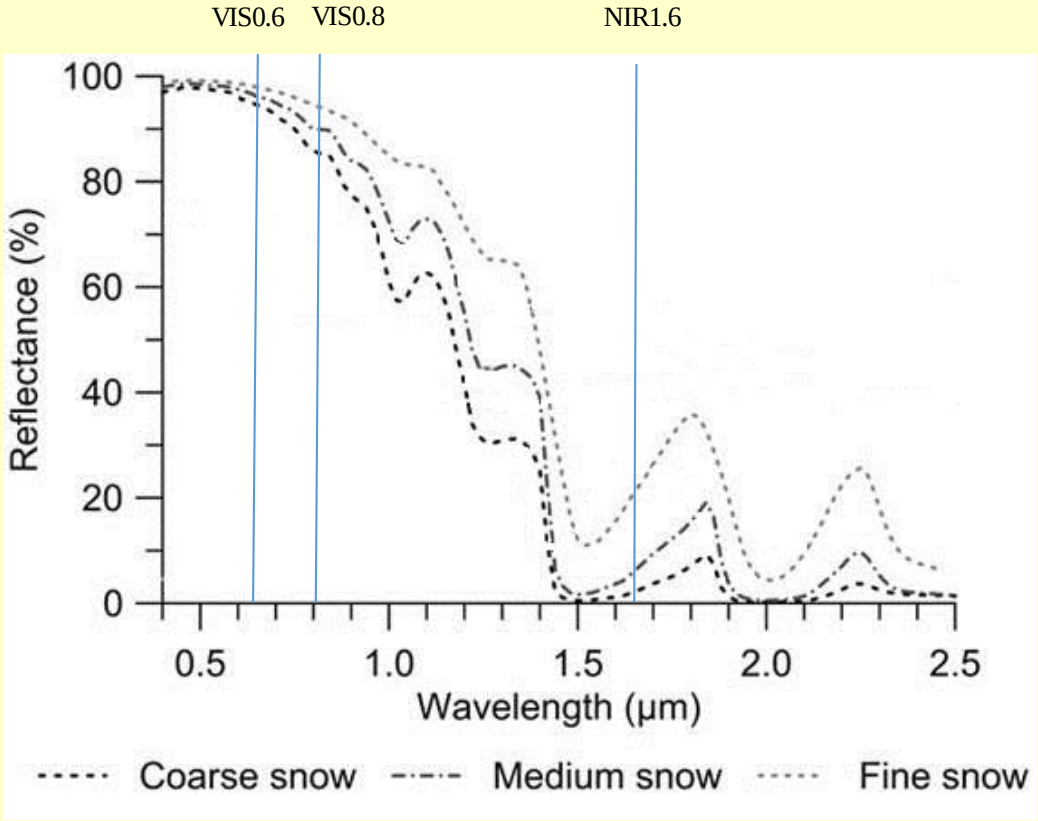
valley fog in Alps



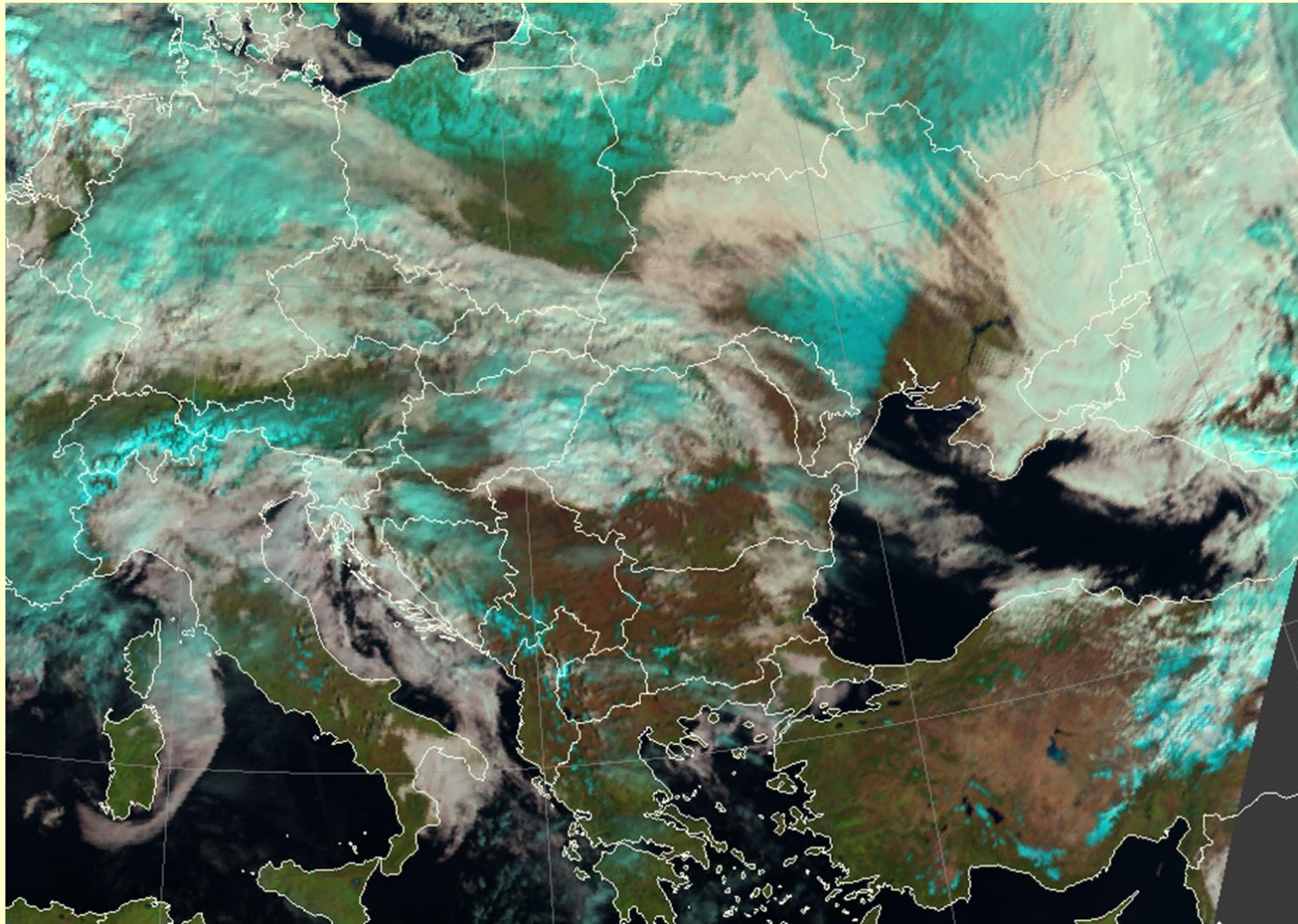
interpretation



# Natural Colours RGB




05 February 2021, 10:10 UTC

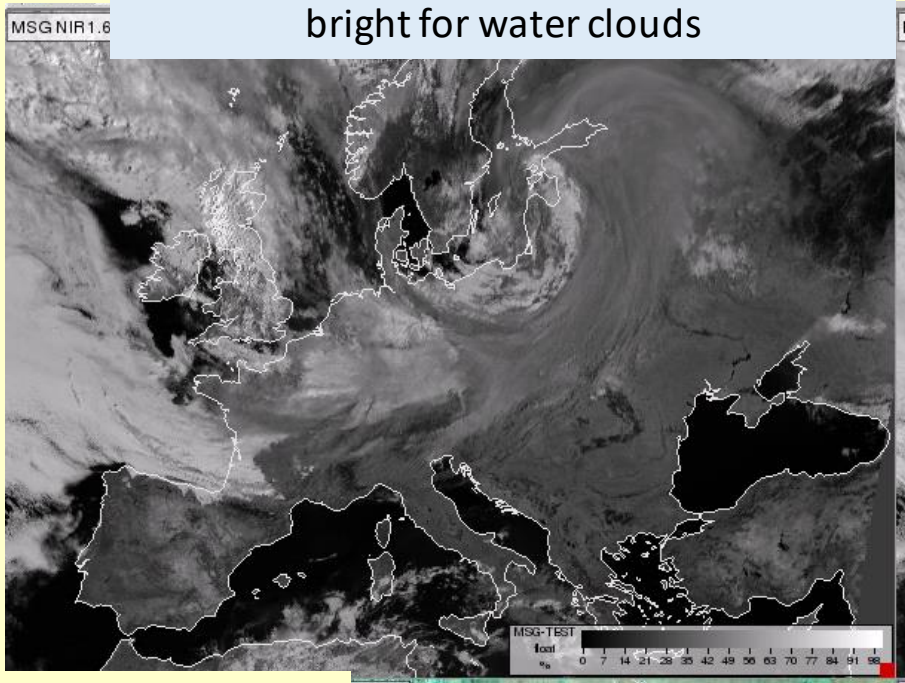


| Colour beam | Channel | Range | | | Gamma |
|---|---|---|---|---|---|
| Red | NIR1.6 | 0 | 100 | % | 1 |
| Green | VIS0.8 | 0 | 100 | % | 1 |
| Blue | VIS0.6 | 0 | 100 | % | 1 |

**SEVIRI**
**15 March 2014**
**9:25 UTC**

NIR1.6

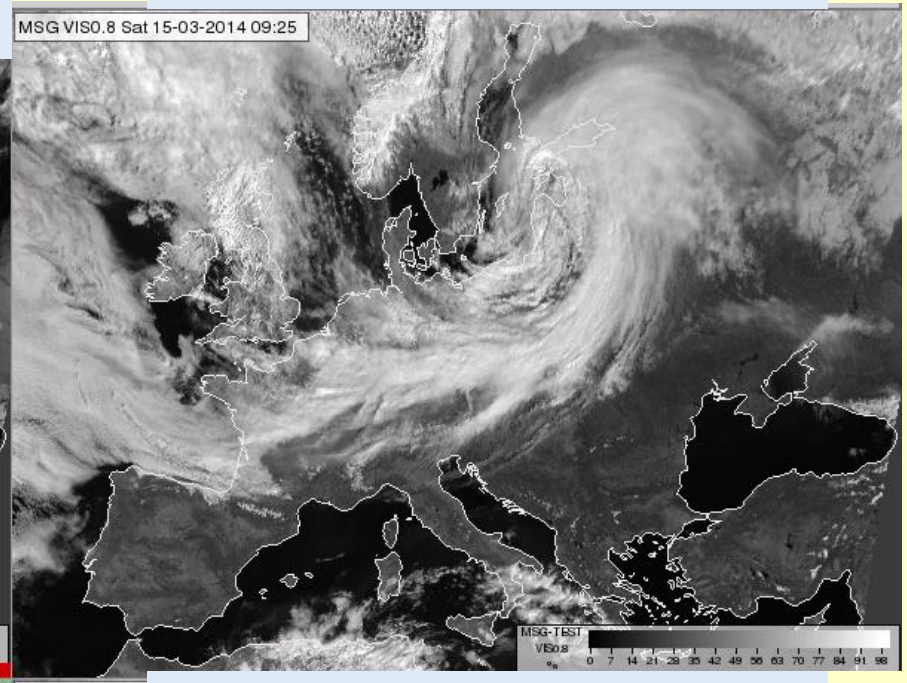
Dark for snow and ice clouds;
bright for water clouds



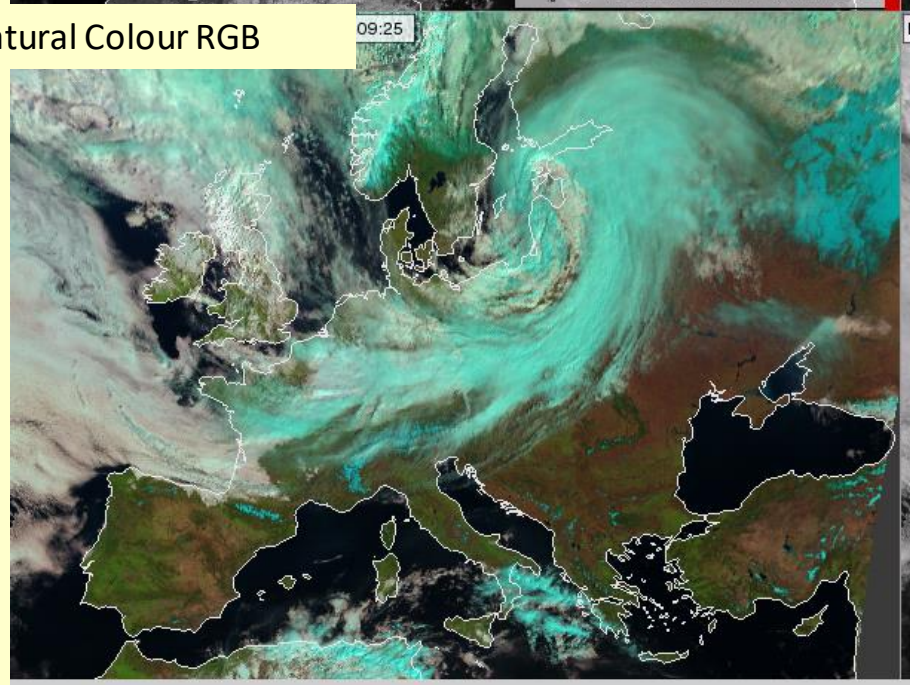

2014, 09:

Bright for snow and all clouds

VIS0.8

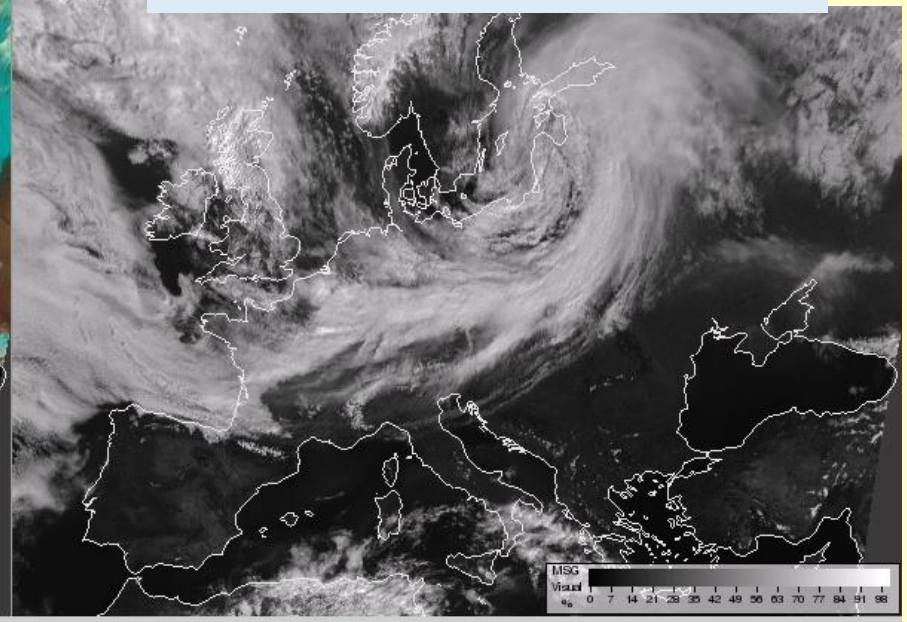



Natural Colour RGB

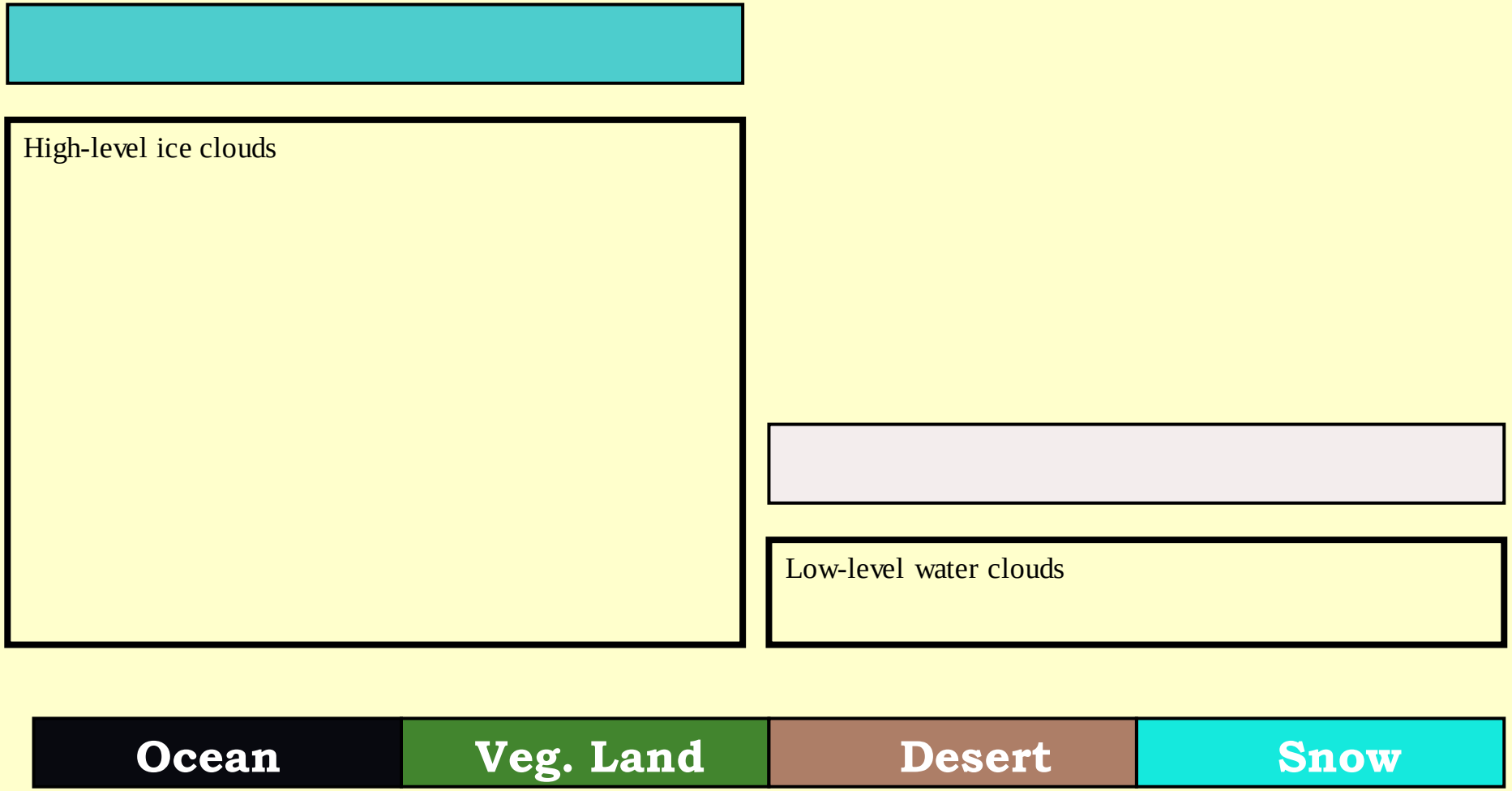



Bright for snow and all clouds

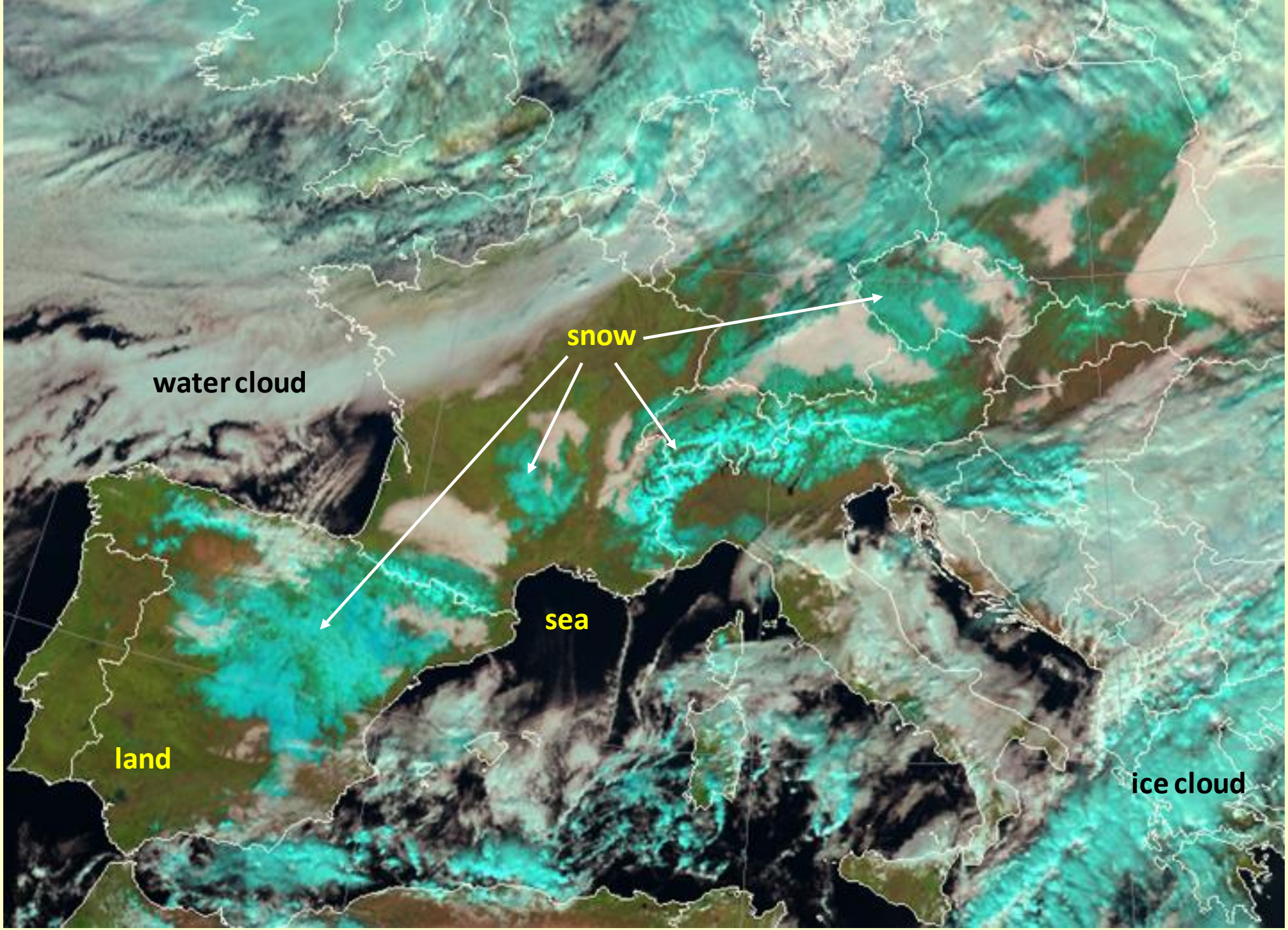
VIS0.6




Slightly different colour shade
for snow and ice cloud




Typical colours of Natural Colours RGB

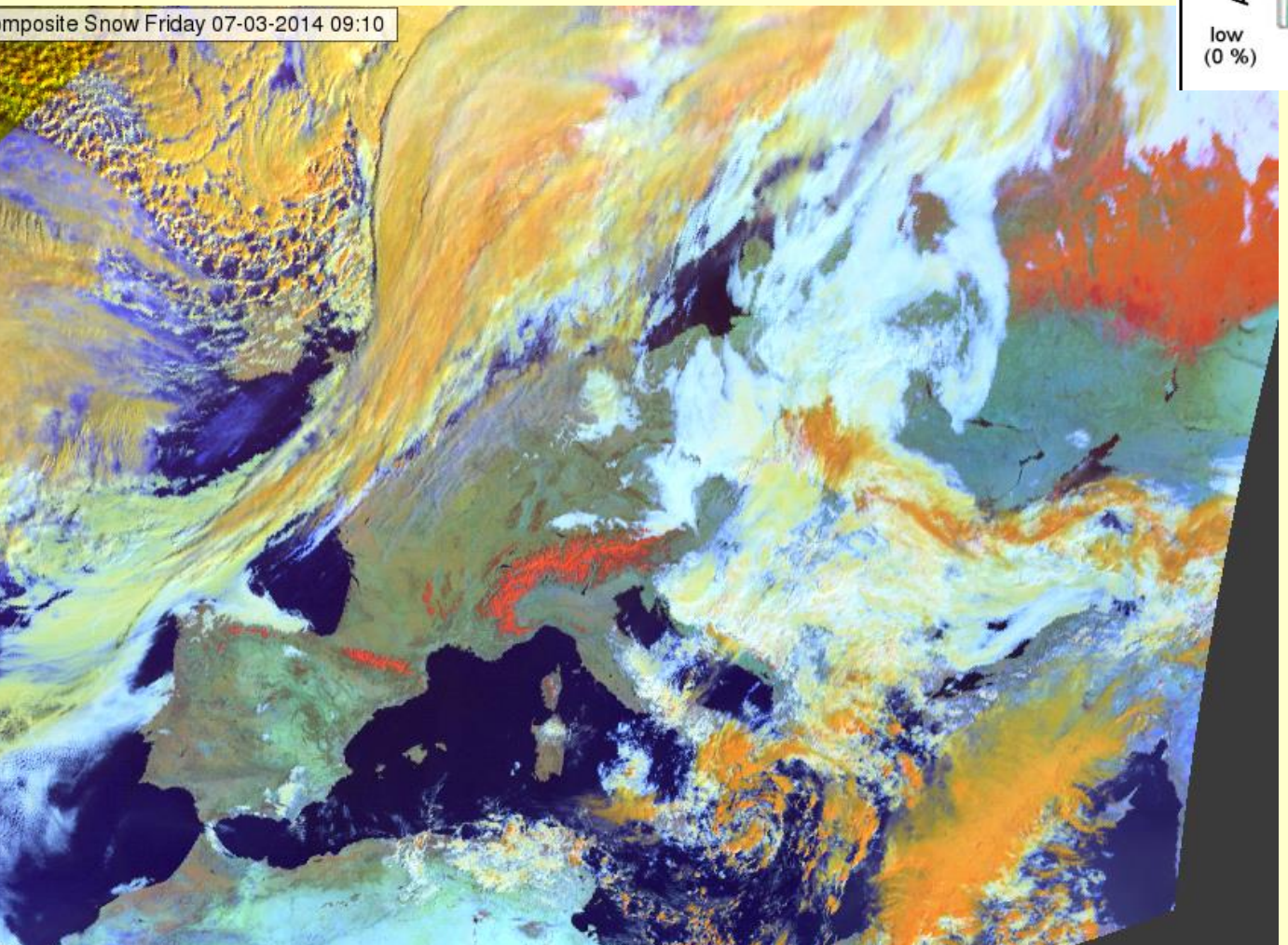


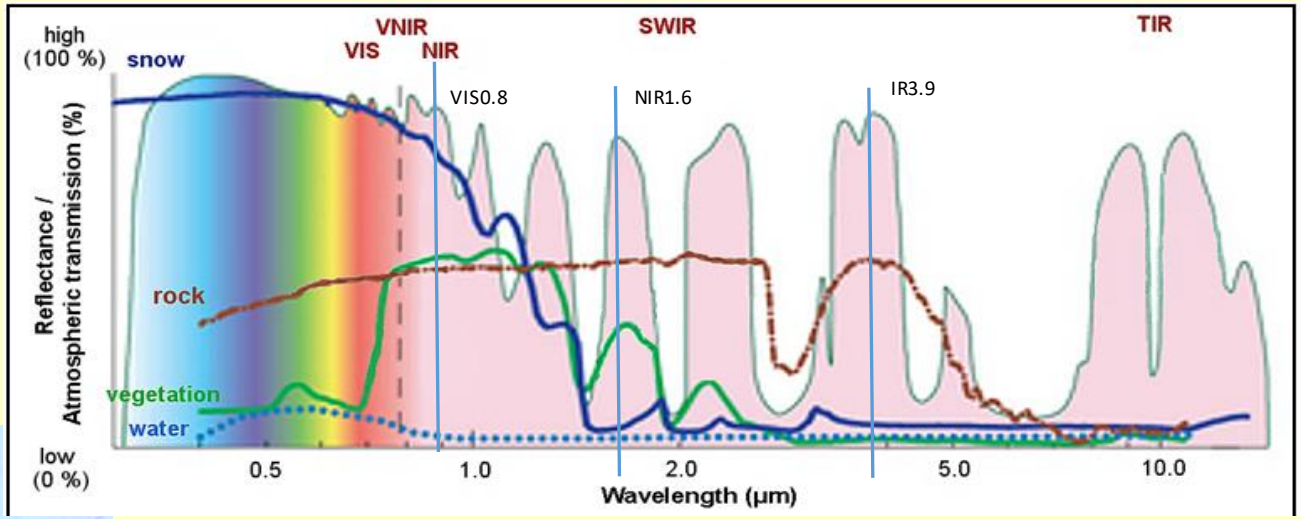

Natural Colours RGB
11 January 2021
11:55 UTC

brighter colour over high mountains

# Snow RGB

tuned for snow detection




Reflectivity spectra of different surfaces

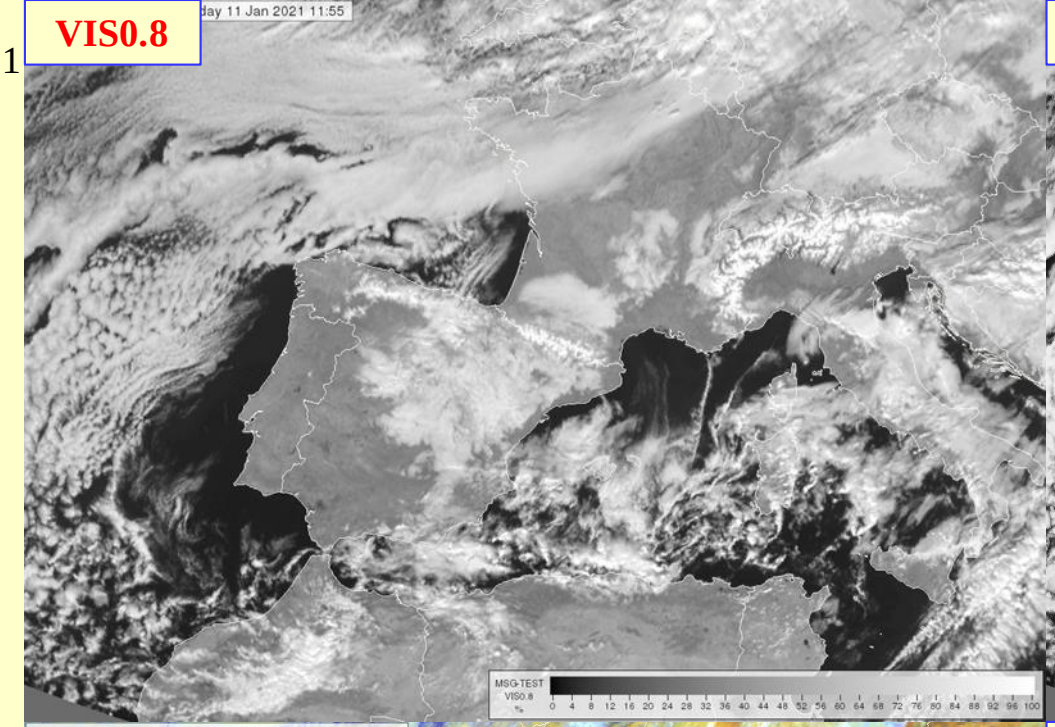
| Colour beam | Channel | Range | | | Gamma |
|---|---|---|---|---|---|
| Red | VIS0.8 | 0 | 100 | % | 1.7 |
| Green | NIR1.6 | 0 | 70 | % | 1.7 |
| Blue | IR3.9refl | 0 | 30 | % | 1.7 |

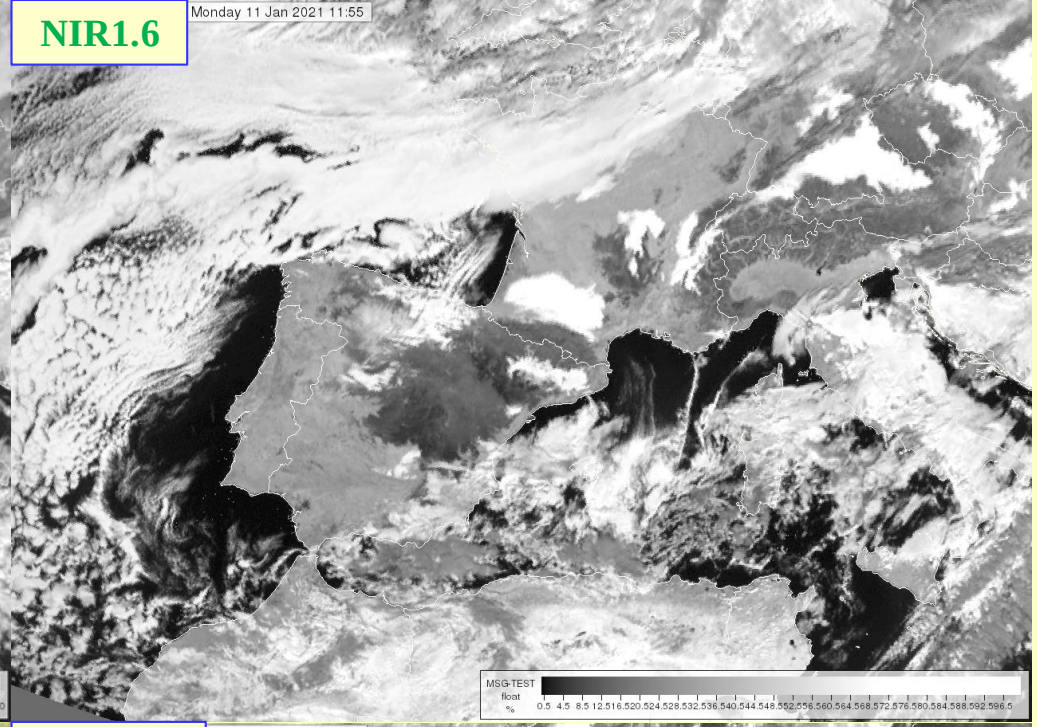
It uses two channels where the snow is dark

The 3.9 µm reflectivity is
- low for snow,
- high for thick water clouds,
- low for thick ice clouds,
- depends also on the cloud top particle size

11 January 2021
11:55 UTC

Snow and clouds are bright.

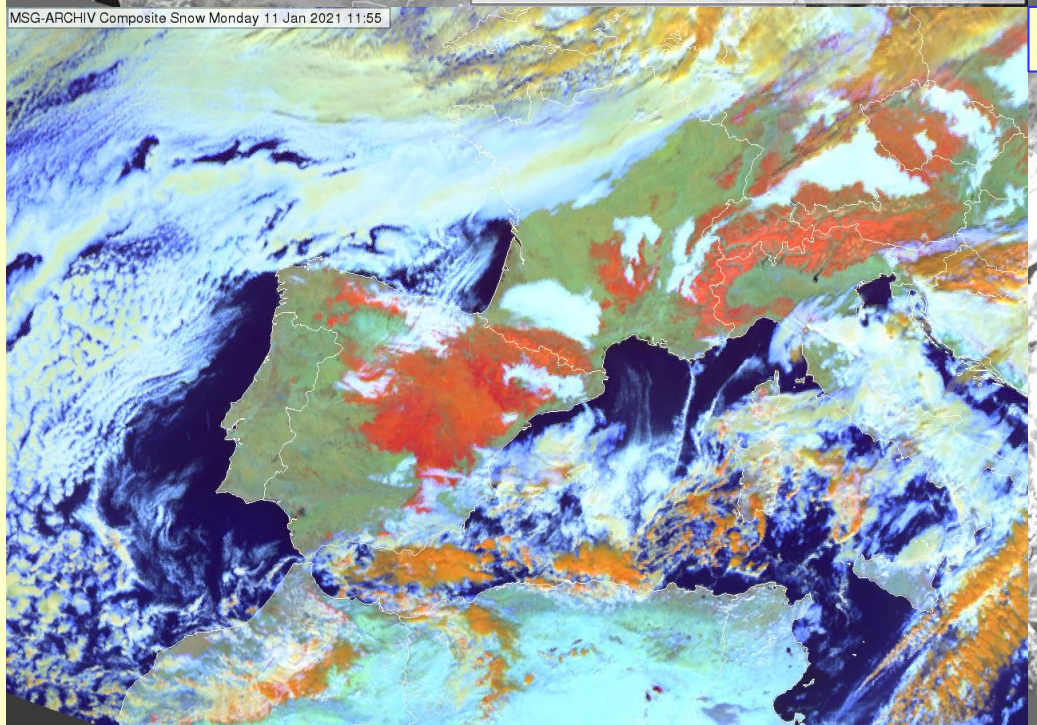


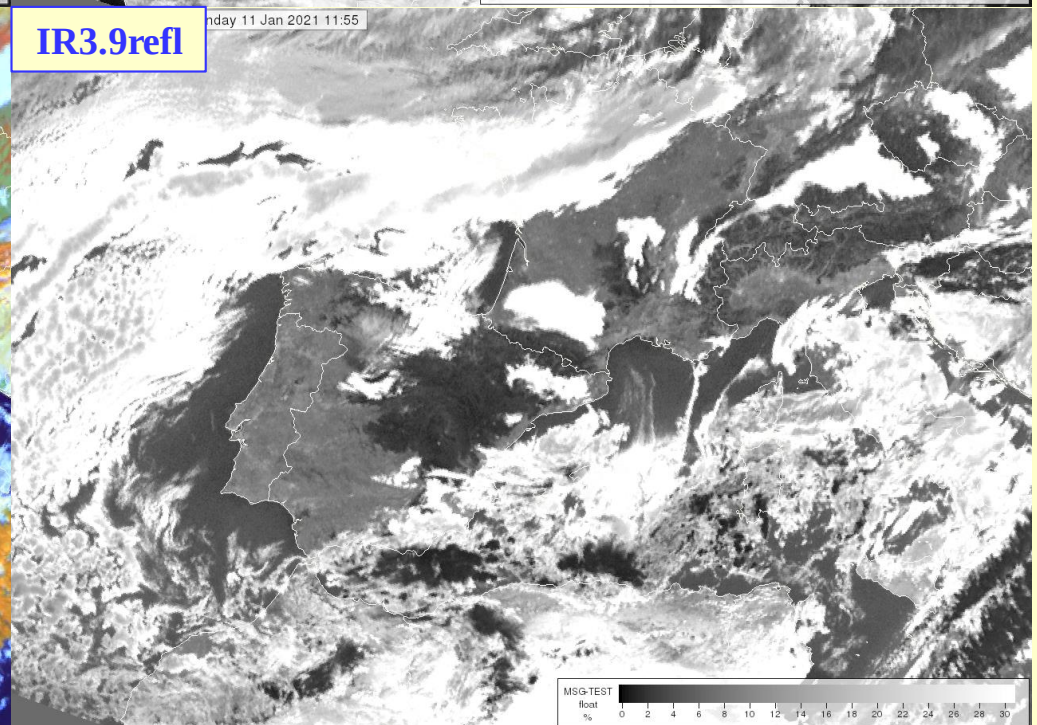




Water clouds are bright.

Snow is dark, (fine snow is relatively brighter).

Ice clouds are medium dark.



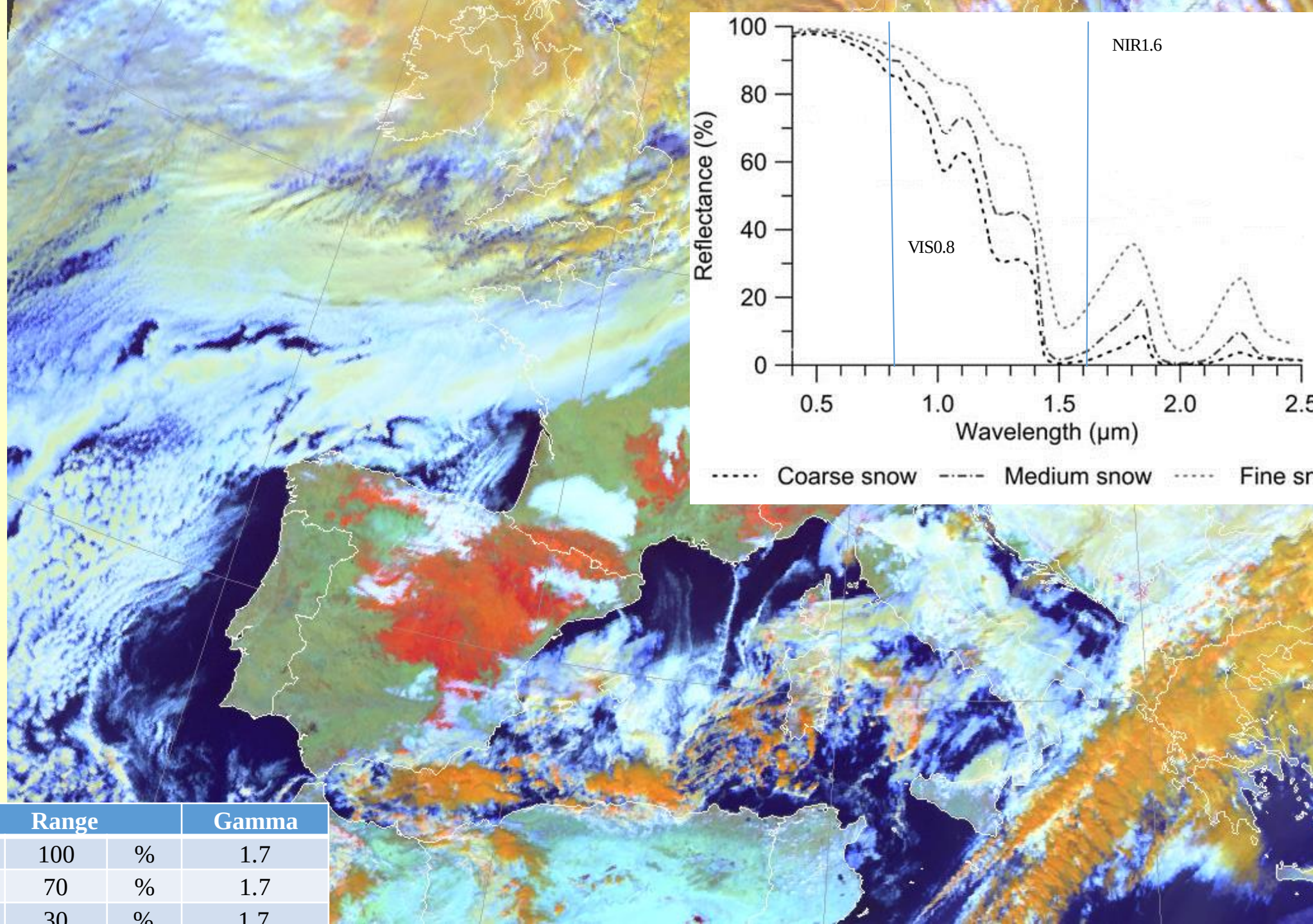




Water clouds are bright.

Snow is dark.

Ice clouds are dark.

Snow RGB
11 January 2021
11:55 UTC

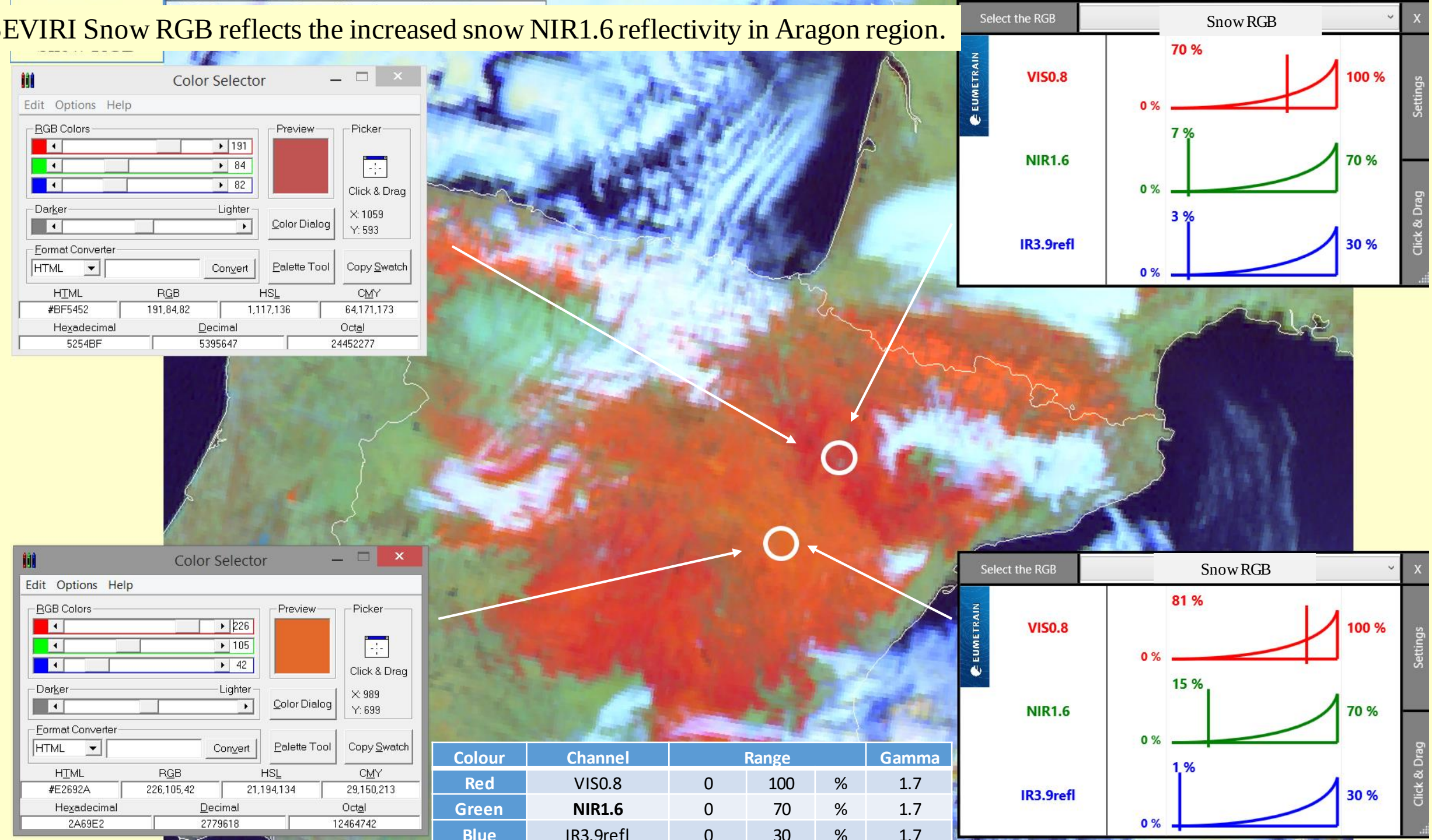




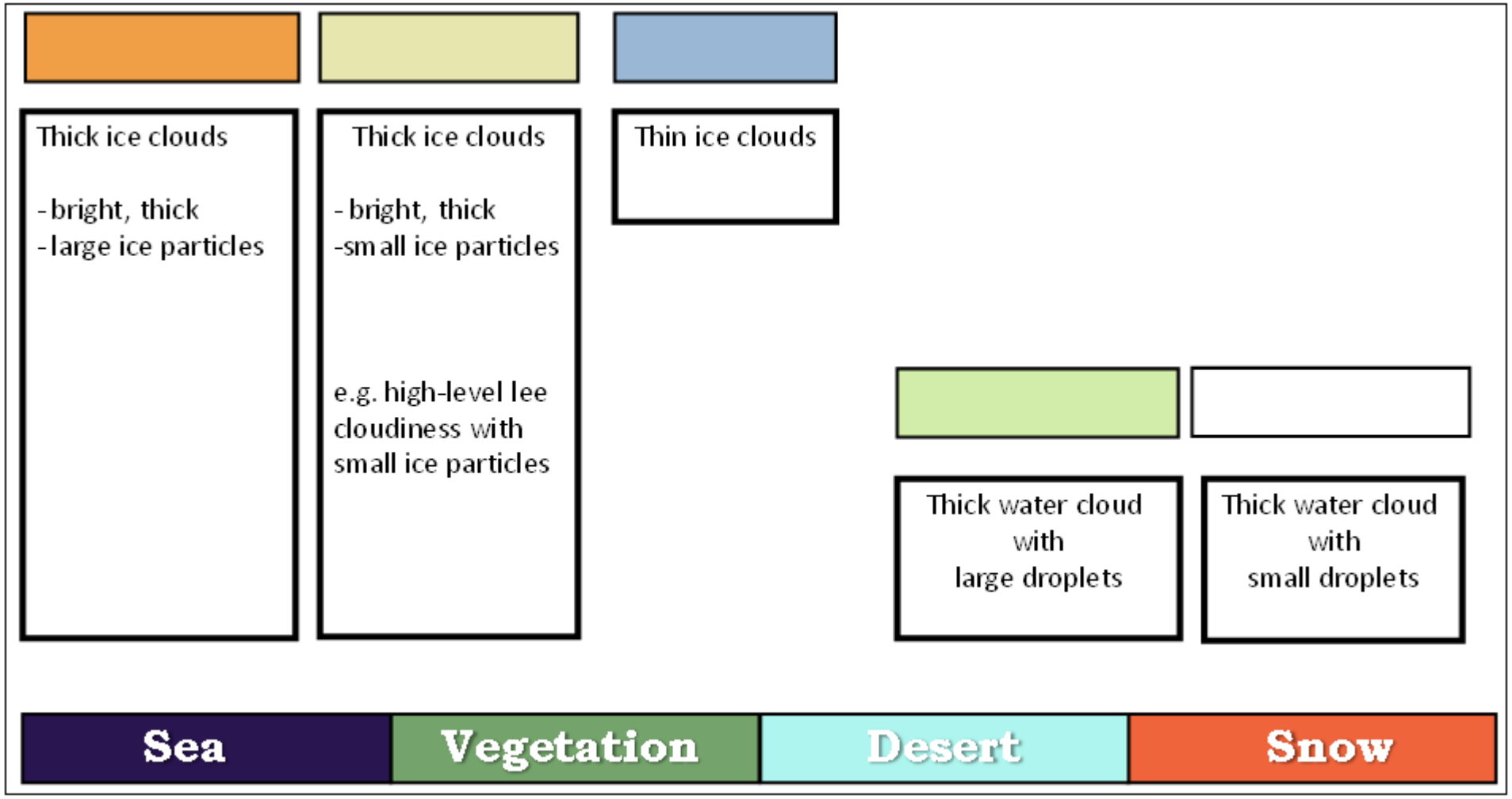

Heavy snowfall in Spain - unbroken snow cover.
Fresh, cold snow has small grain size, and so relatively high reflectivity in NIR1.6.

| Colour beam | Channel | Range | | | Gamma |
|---|---|---|---|---|---|
| Red | VIS0.8 | 0 | 100 | % | 1.7 |
| Green | NIR1.6 | 0 | 70 | % | 1.7 |
| Blue | IR3.9refl | 0 | 30 | % | 1.7 |

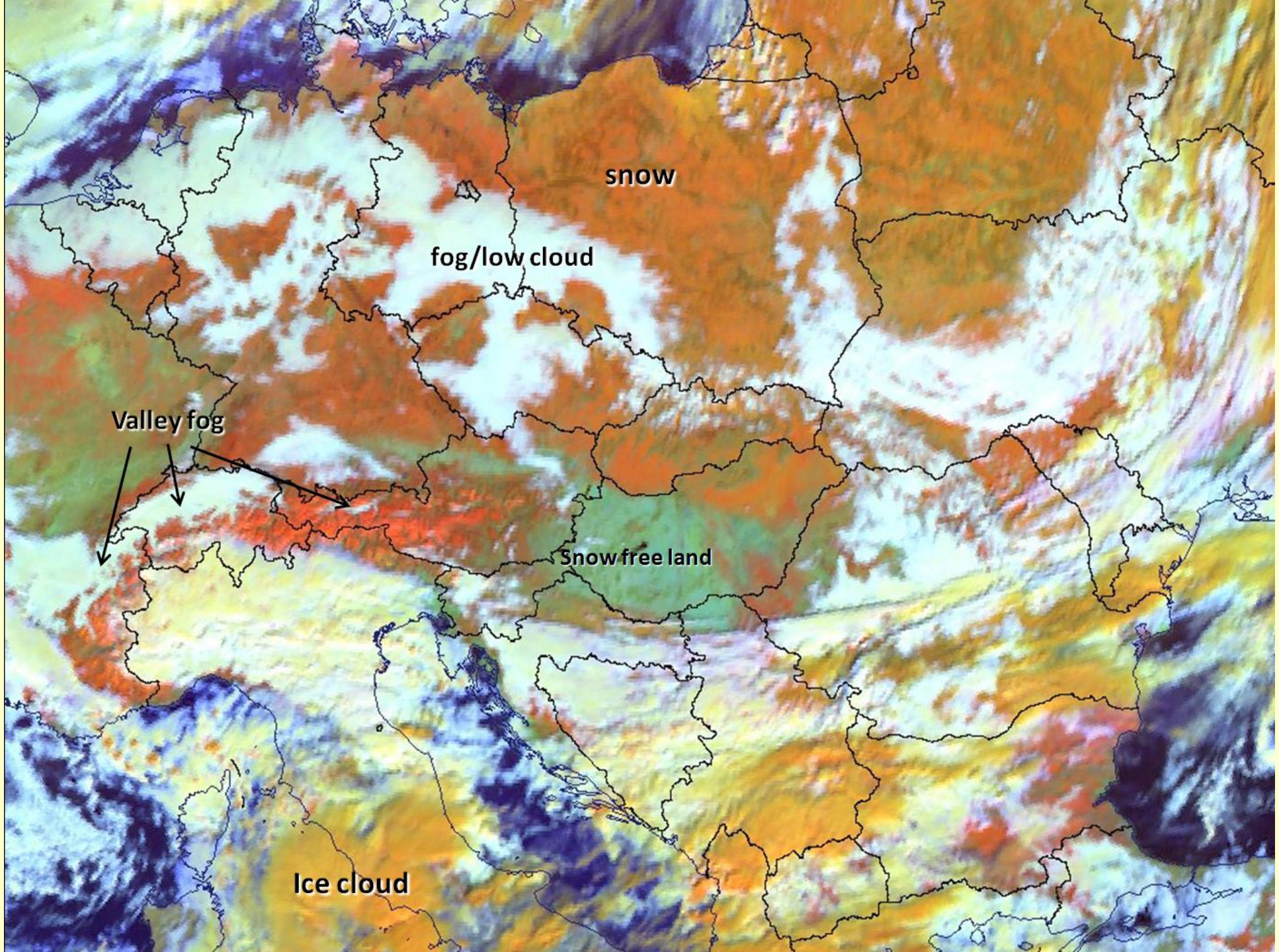
# SEVIRI Snow RGB reflects the increased snow NIR1.6 reflectivity in Aragon region.




| Colour | Channel | Range | | | Gamma |
|---|---|---|---|---|---|
| Red | VIS0.8 | 0 | 100 | % | 1.7 |
| Green | **NIR1.6** | 0 | 70 | % | 1.7 |
| Blue | IR3.9refl | 0 | 30 | % | 1.7 |

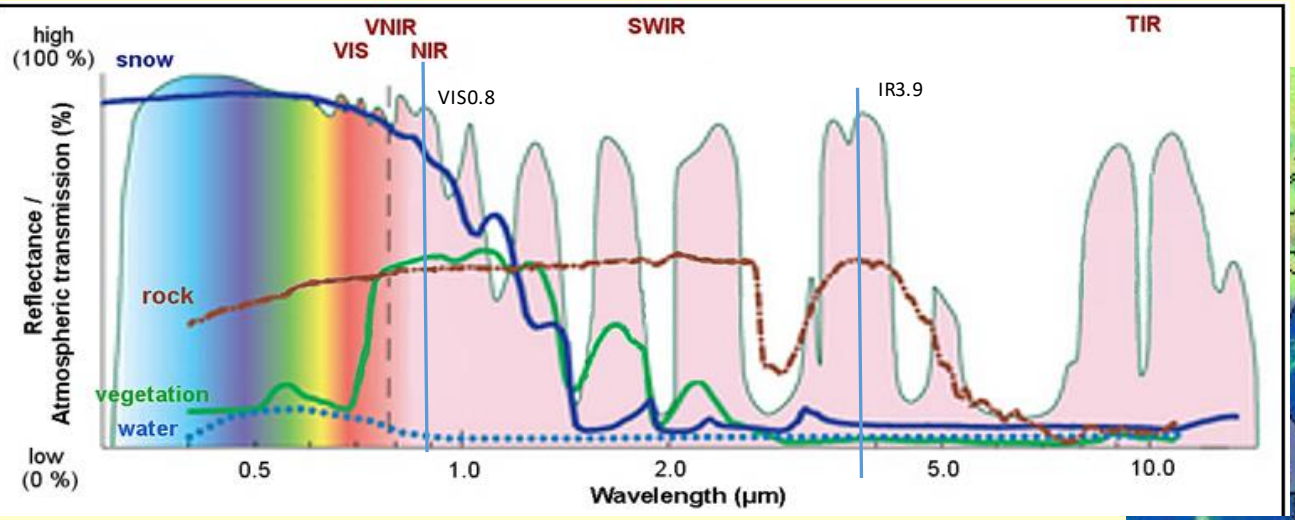



Typical colours of Snow RGB


snow
fog/low cloud
Valley fog
Snow free land
Ice cloud

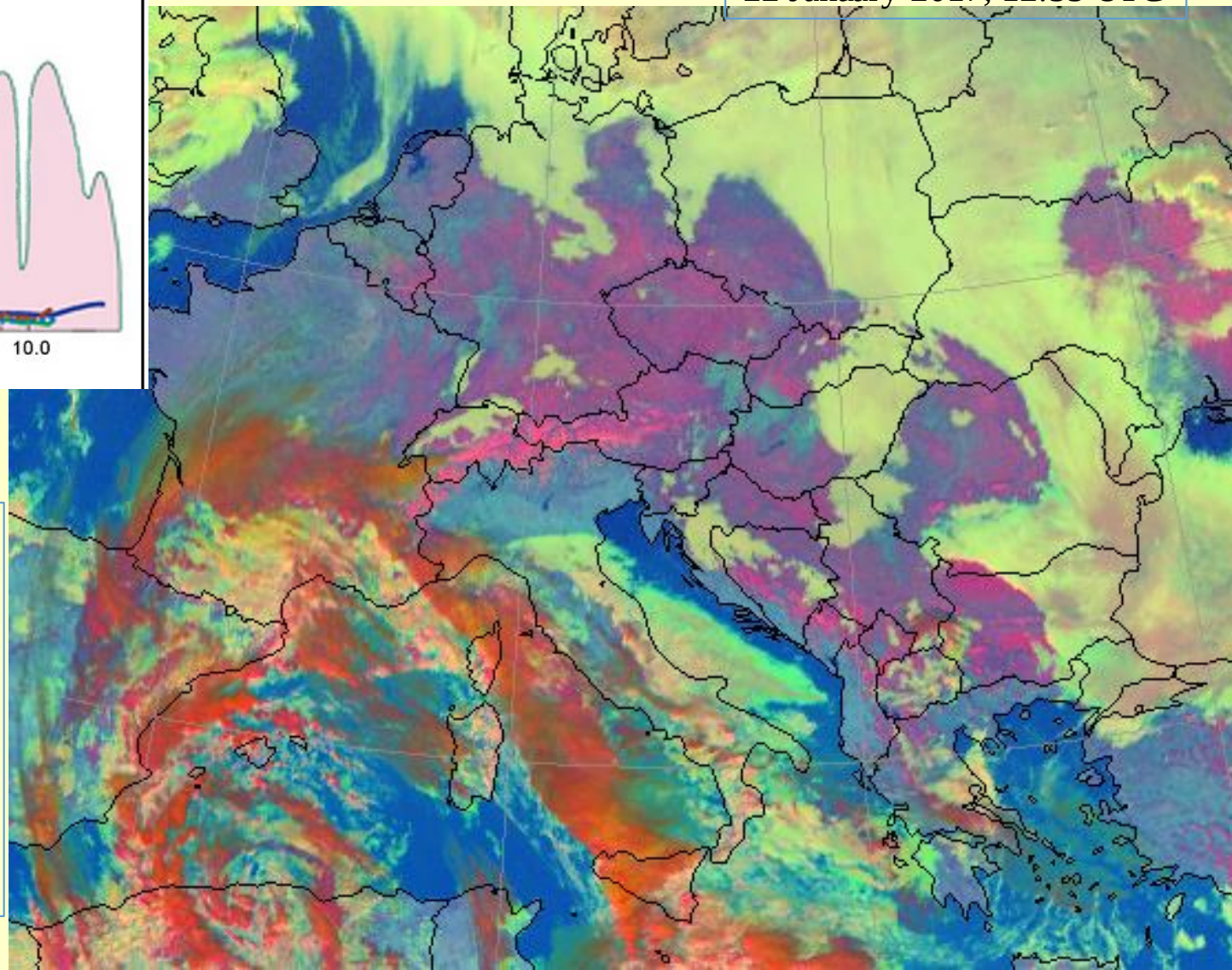
# Day Microphysics RGB

| Colour beam | Channel | Range | | | Gamma |
|---|---|---|---|---|---|
| Red | VIS0.8 | 0 | 100 | % | 1.0 |
| Green | IR3.9refl | 0 | 60 | % | 2.5 |
| Blue | IR10.8 | 203 | 323 | K | 1.0 |




Reflectivity spectra of different surfaces

22 January 2017, 12:55 UTC

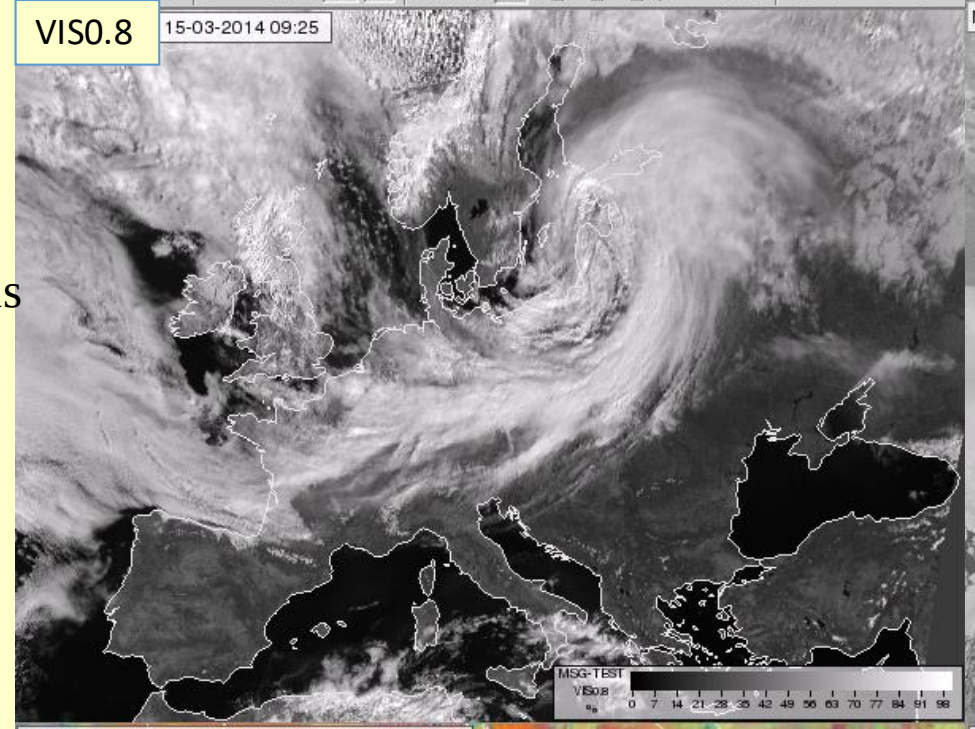


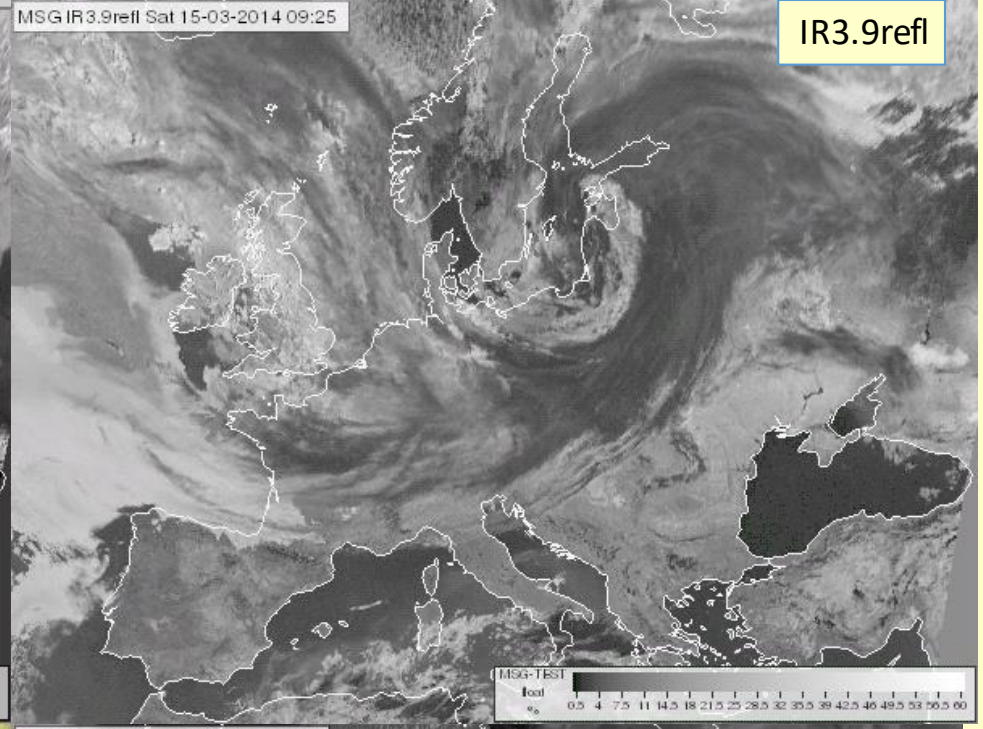
**Tuned for cloud analysis** – Complex RGB

- It combines cloud optical thickness, cloud top microphysics and temperature information.
- Thin and thick warmer and colder water and ice clouds with small and large cloud element on their top appear in different colour shades.

**Snow has separate colour, similar to the colour of a relatively warm ice cloud.**

Snow and clouds are bright.

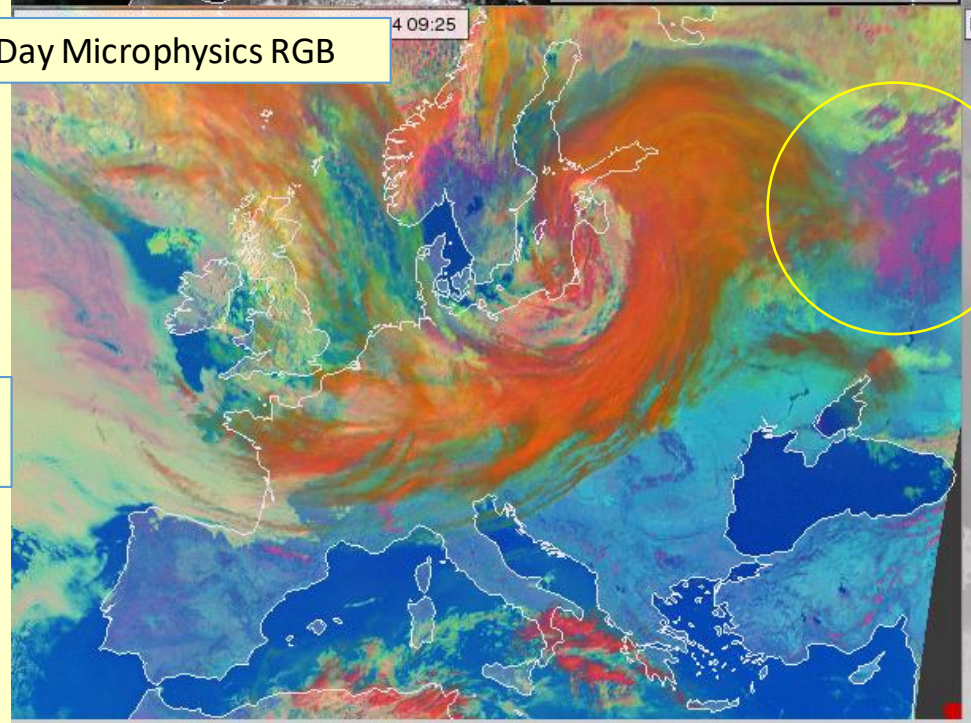


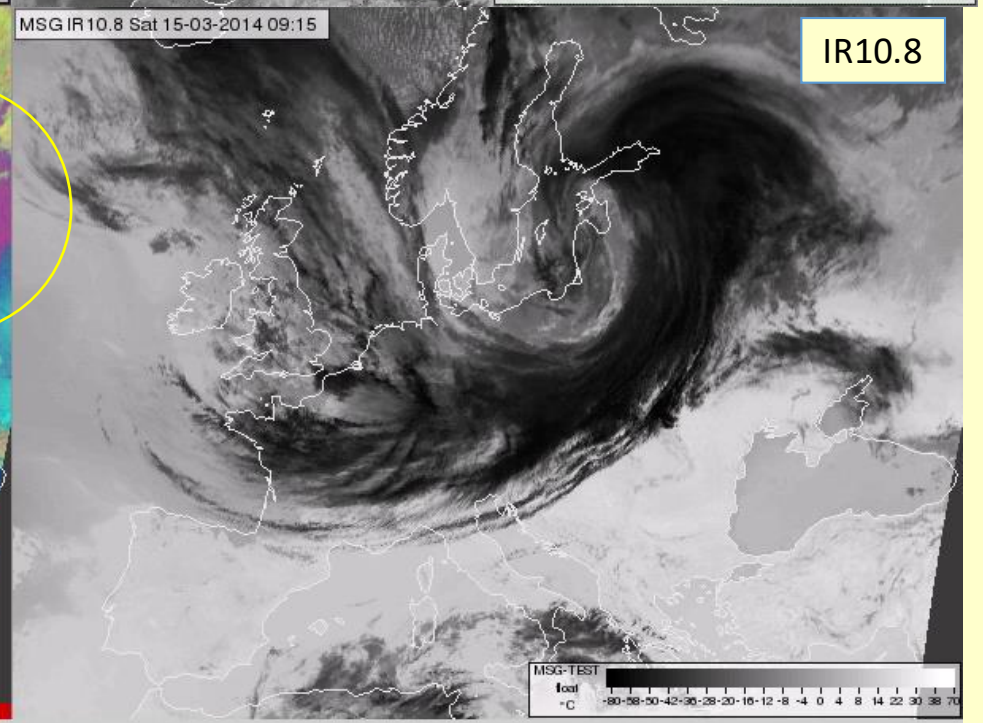




Snow is dark.

Water clouds (with small droplets) are bright.

Ice clouds (with large crystals) are medium dark.




Cold objects are dark, warm objects are bright.

14 September 2015, 07:40 UTC

| | | | |
|---|---|---|---|
| Deep precipitating cloud (precip. not necessarily reaching the ground)<br><br>- bright, thick<br>- large ice particles<br>- cold cloud | Deep precipitating cloud (Cb cloud with strong updrafts and severe weather)*<br><br>- bright, thick<br>- small ice particles<br>- cold cloud<br><br>*or thick, high-level lee cloudiness with small ice particles | Thin Cirrus cloud<br><br>(large ice particles) | Thin Cirrus cloud<br><br>(small ice particles) |
| **Ocean** | **Veg. Land** | **Fires / Desert** | **Snow** |

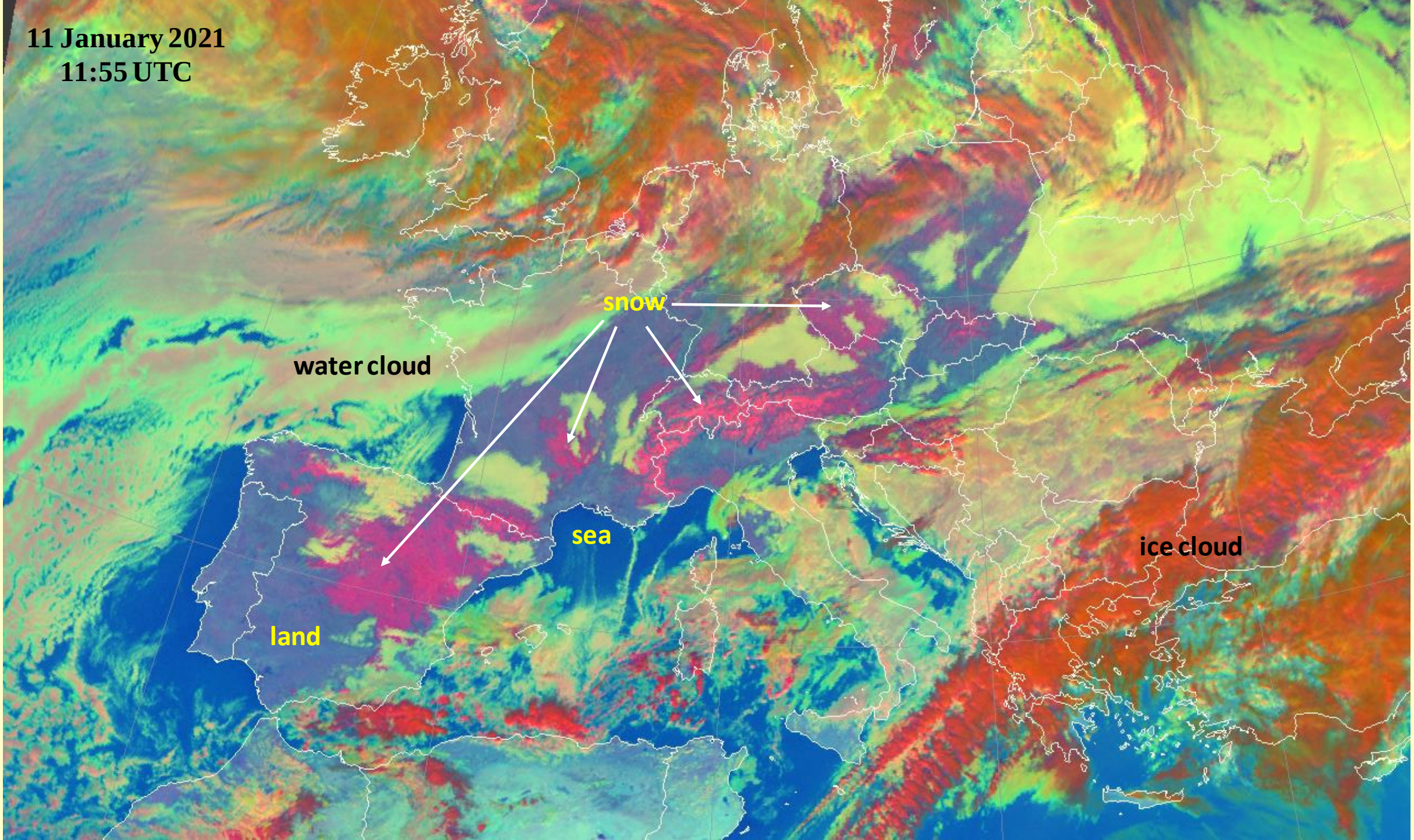
Typical colours of **high-level clouds** and surface types in Day Microphysics RGB images

| | | | |
|---|---|---|---|
| Supercooled, thick water cloud<br><br>- bright, thick<br>- large droplets | Supercooled, thick water cloud<br><br>- bright, thick<br>- small droplets | Supercooled thin water cloud with large droplets | Supercooled, thin water cloud with small droplets *<br><br>* or, in rare occasions, thin Ci cloud with small ice particles |
| **Ocean** | **Veg. Land** | **Fires / Desert** | **Snow** |

Typical colours of **mid-level clouds** and surface types in Day Microphysics RGB images

| | | | |
|---|---|---|---|
| Thick water cloud<br>(warm rain cloud)<br>- bright, thick<br>- large droplets | Thick water cloud<br>(no precipitation)<br>- bright, thick<br>- small droplets | Thin water cloud with<br>large droplets | Thin water cloud<br>with small droplets |
| **Ocean** | **Veg. Land** | **Fires / Desert** | **Snow** |

Typical colours of **low-level clouds** and surface types in Day Microphysics RGB images


11 January 2021
11:55 UTC
snow
water cloud
sea
ice cloud
land

# Outline

Introduction

Snow detection using solar channels - daytime

- Single solar channel
- **Daytime RGBs useful for snow detection**
  - HRV Fog RGB
  - Natural Colours RGB
  - Snow RGB
  - Day Microphysics RGB
  - **Their comparison**
- Daytime RGBs NOT useful for snow detection

Some information about snow in nighttime RGBs

Sea and lake ice

Summary

# Comparing the daytime RGBs recommended for snow detection

Best RGBs for snow detection:

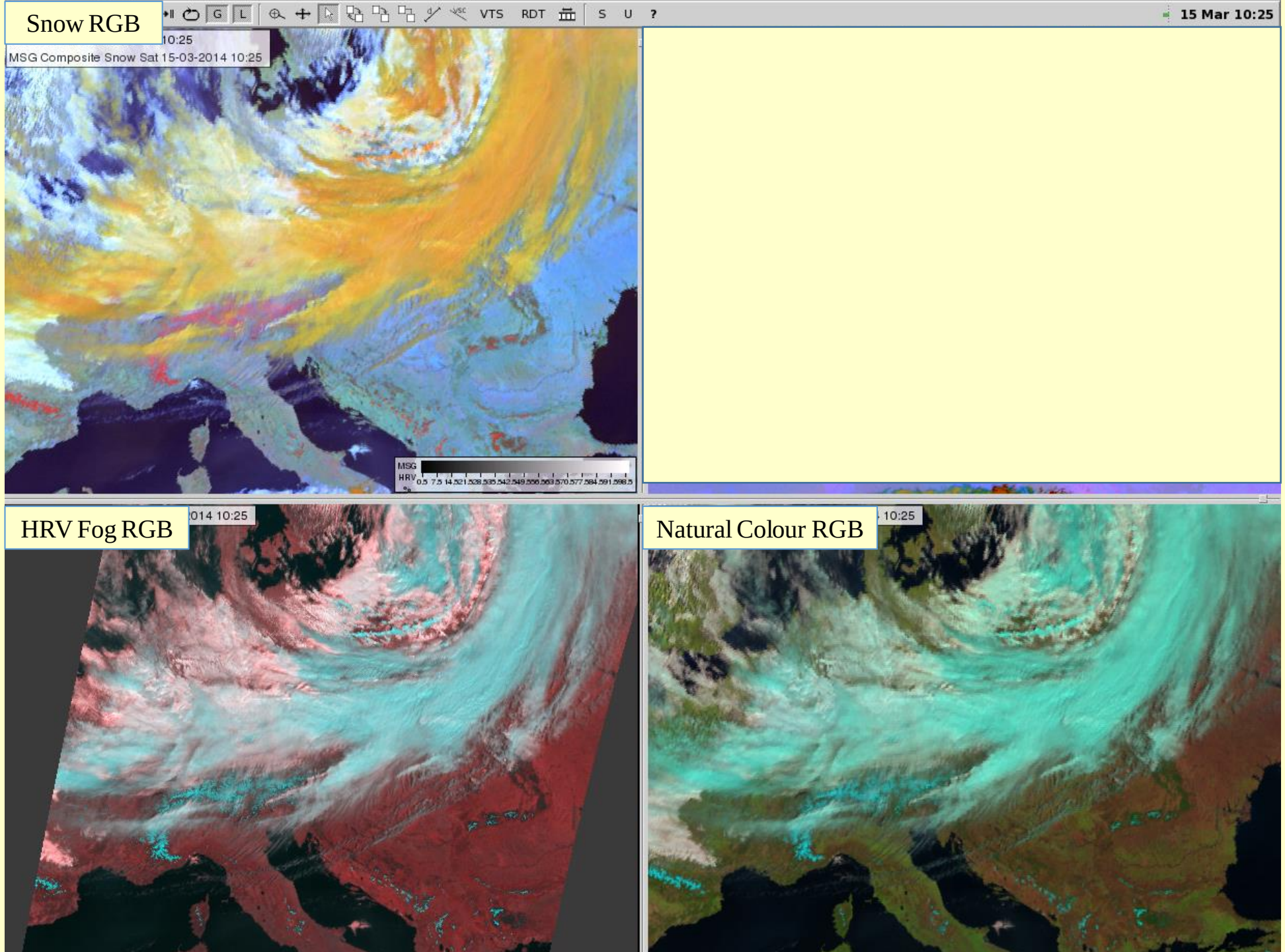
- **Snow RGB** - tuned specially for snow detection - highest colour contrast between snow and clouds, even against ice clouds
- **HRV Fog RGB** – high spatial resolution – good contrast against snow-free land and water clouds

| | Thick water cloud | Snow | Thick ice cloud |
|---|---|---|---|
| **Snow RGB** | | | |
| Day Microphysics RGB | | | |
| Natural Colours RGB | | | |
| HRV Fog RGB | | | |

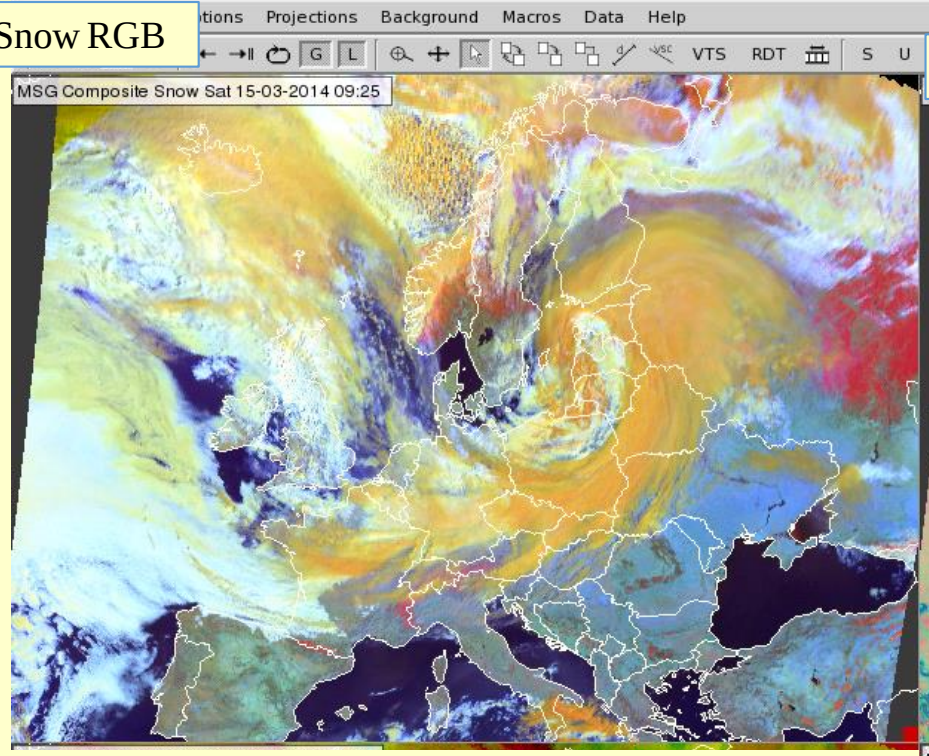
Typical colours

Notes:
Snow RGB – typical colour of thick water cloud with small droplets, thick ice clouds with large ice crystals
Day Microphysics RGB – typical colour of thick water cloud with small droplets; thick, cold ice clouds with large ice crystals

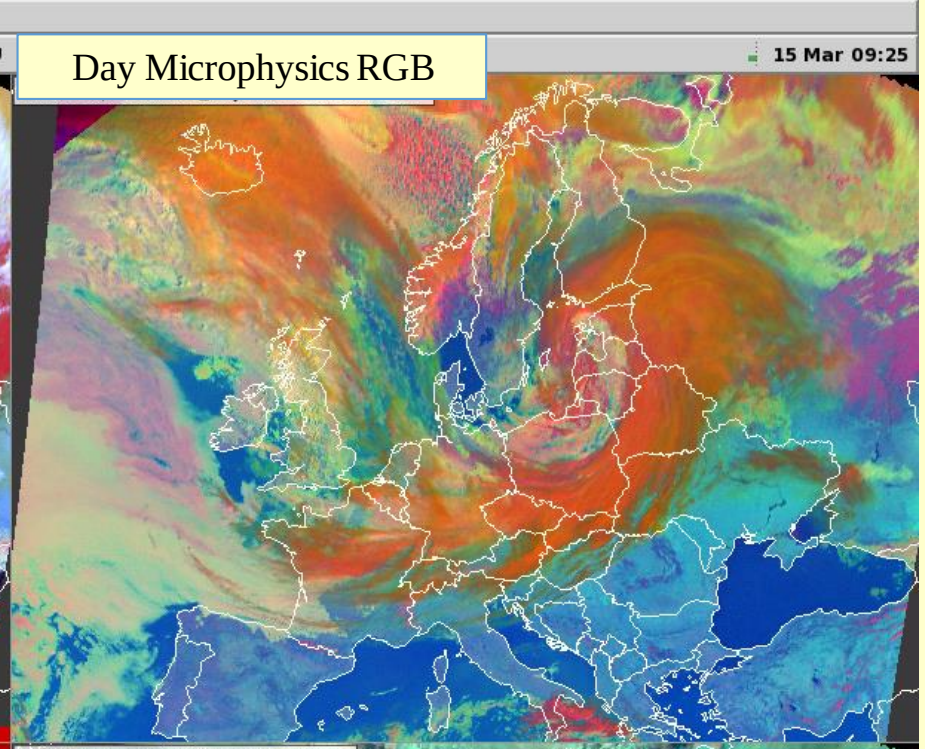
Highest colour contrast between snow and ice clouds



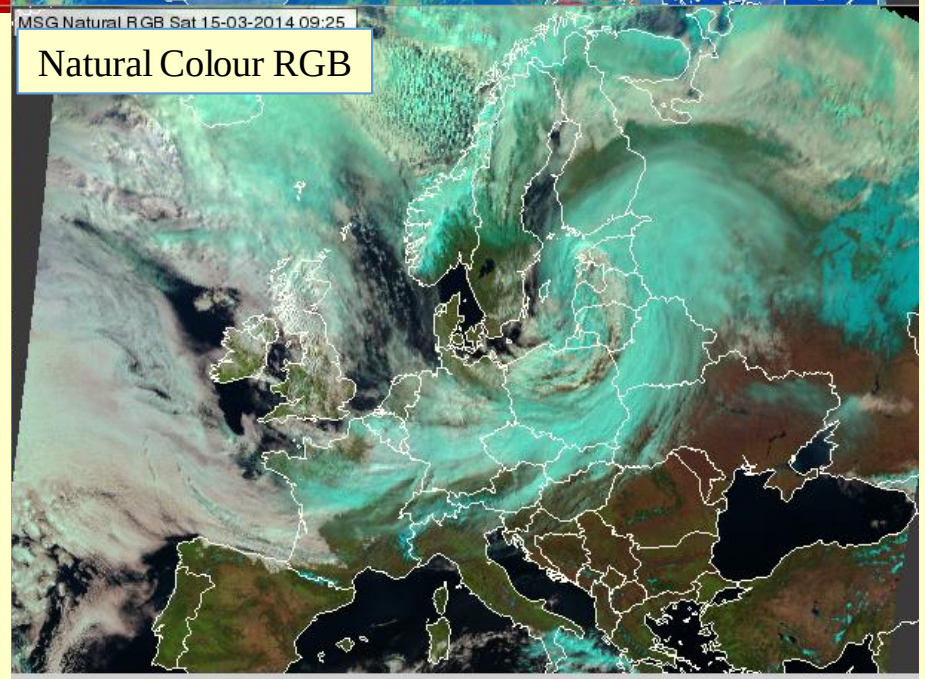
Snow RGB




Day Microphysics RGB



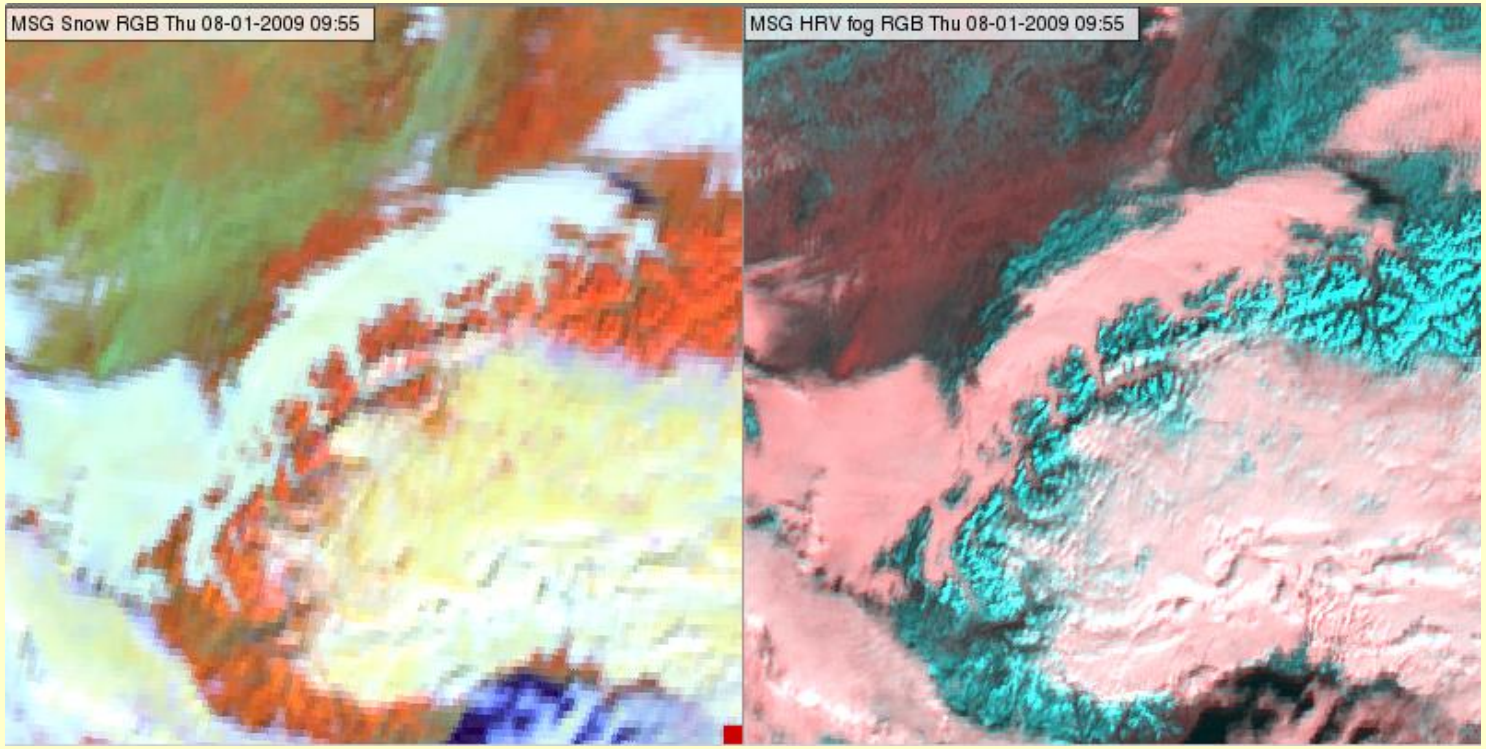
Natural Colour RGB



08 January 2009
09:55 UTC

valley fog/stratus

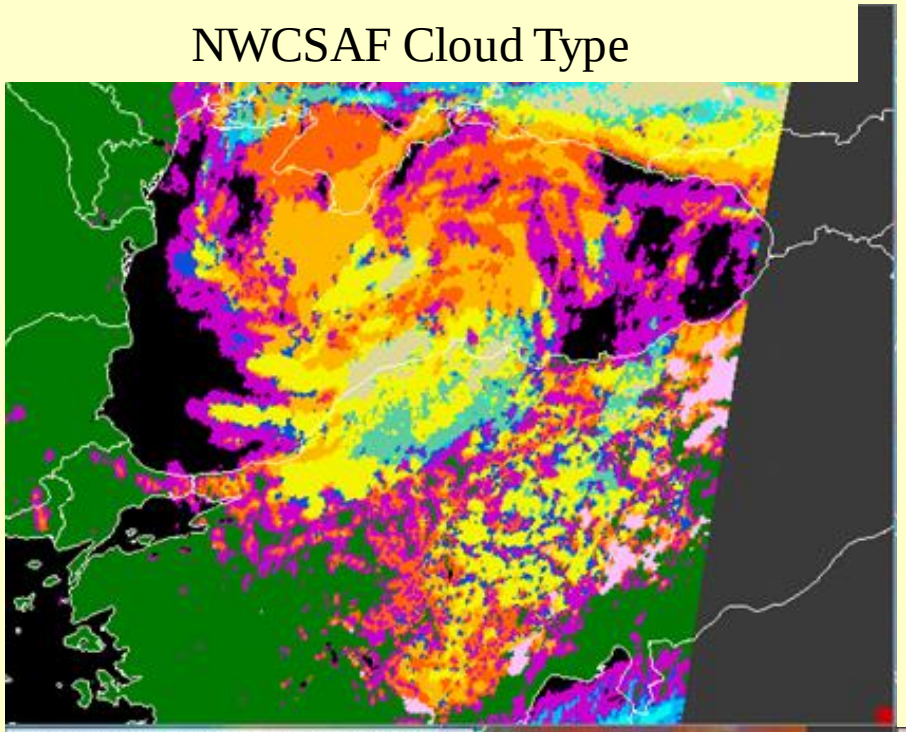
good colour contrast between fog/water cloud and snow




higher spatial resolution

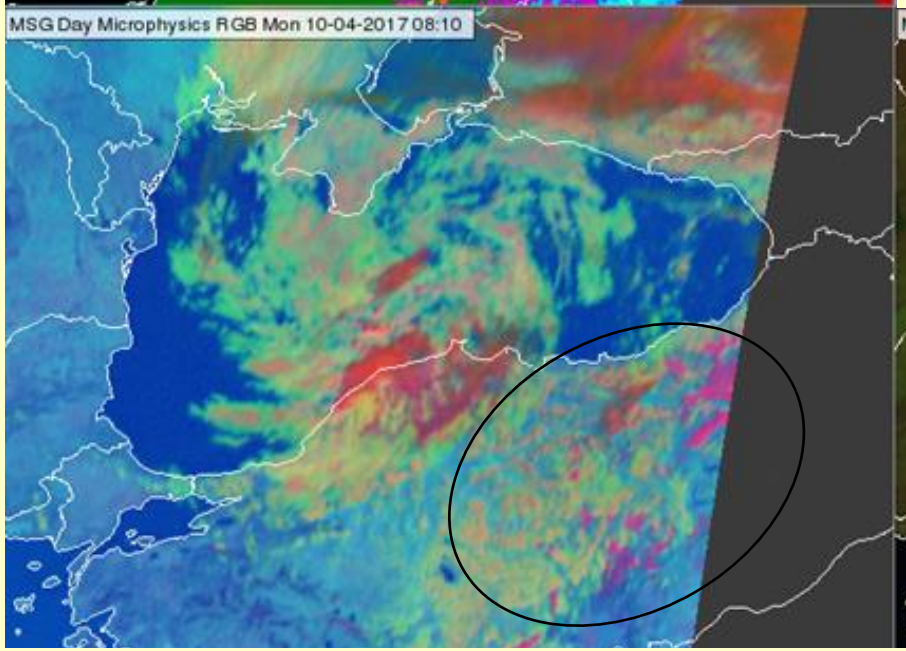
**Snow RGB** **HRV Fog RGB**

NWCSAF Cloud Type

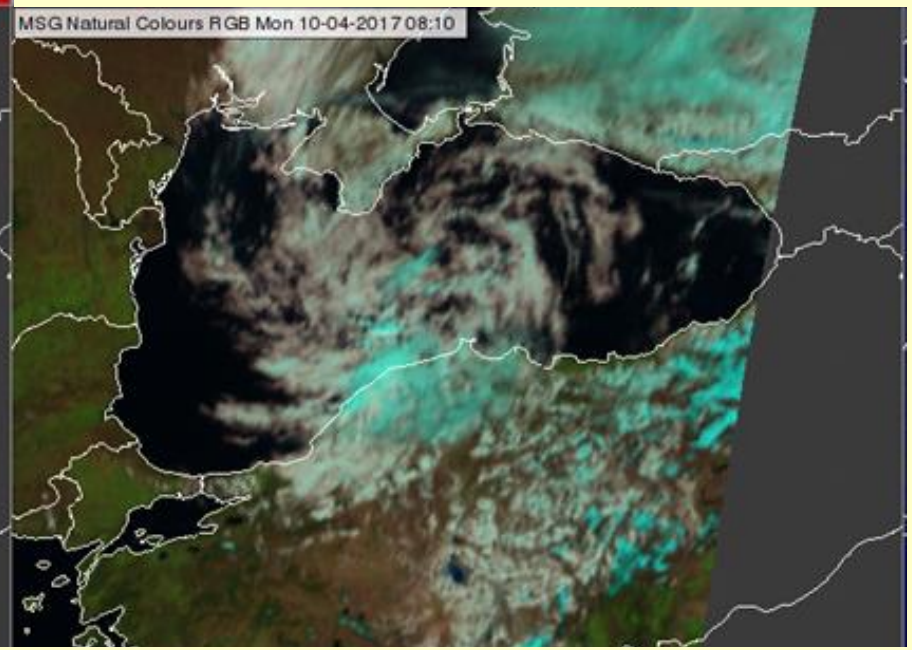


10 April 2017
08:10 UTC

snow and ice clouds (towering cumulus clouds with ice crystals on their tops) – Day Microphysics RGB and Cloud Type product differentiate them nicely

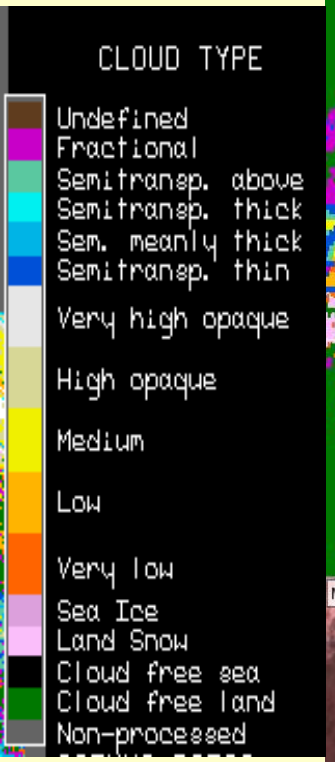


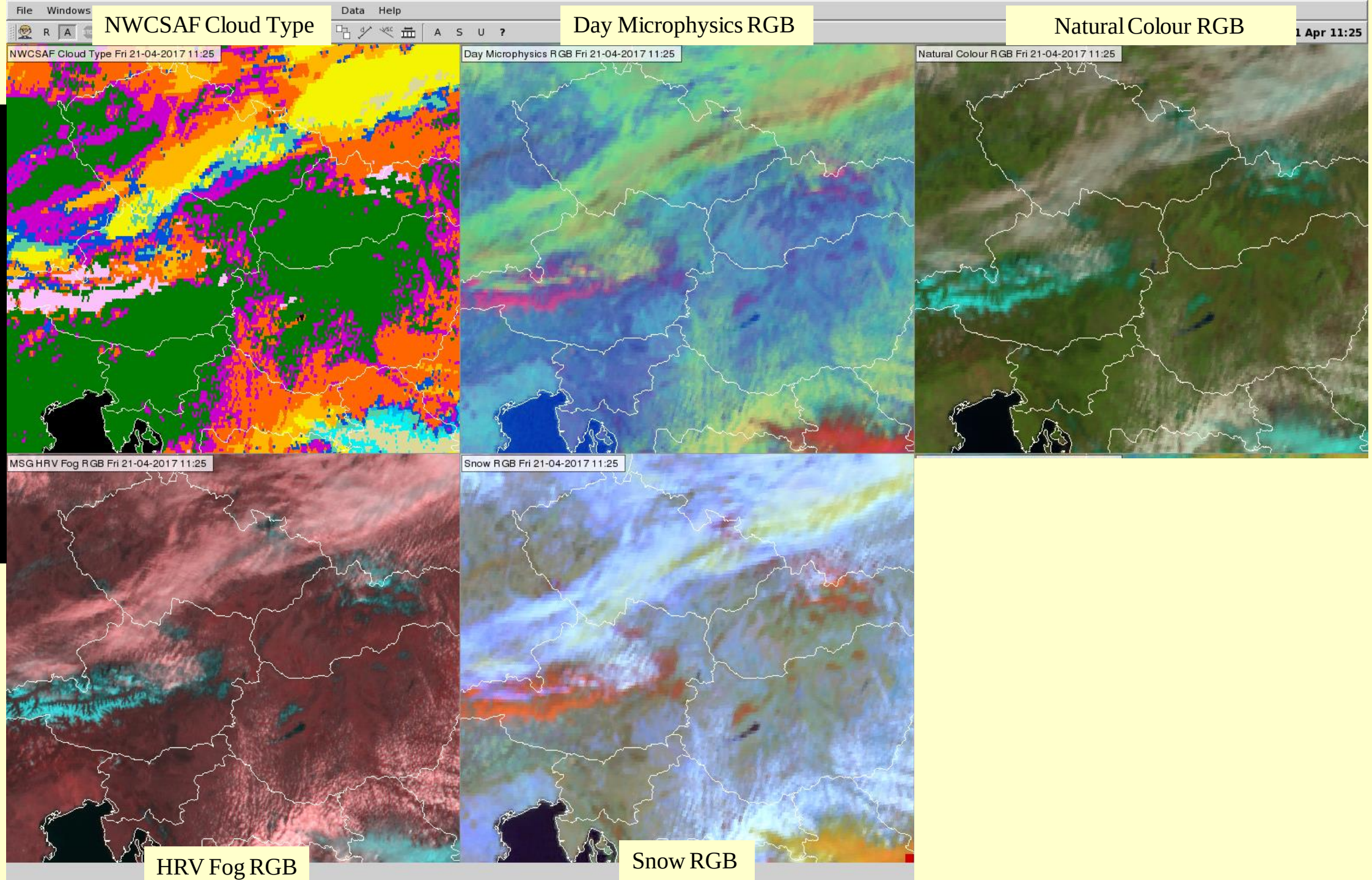

Day Microphysics RGB



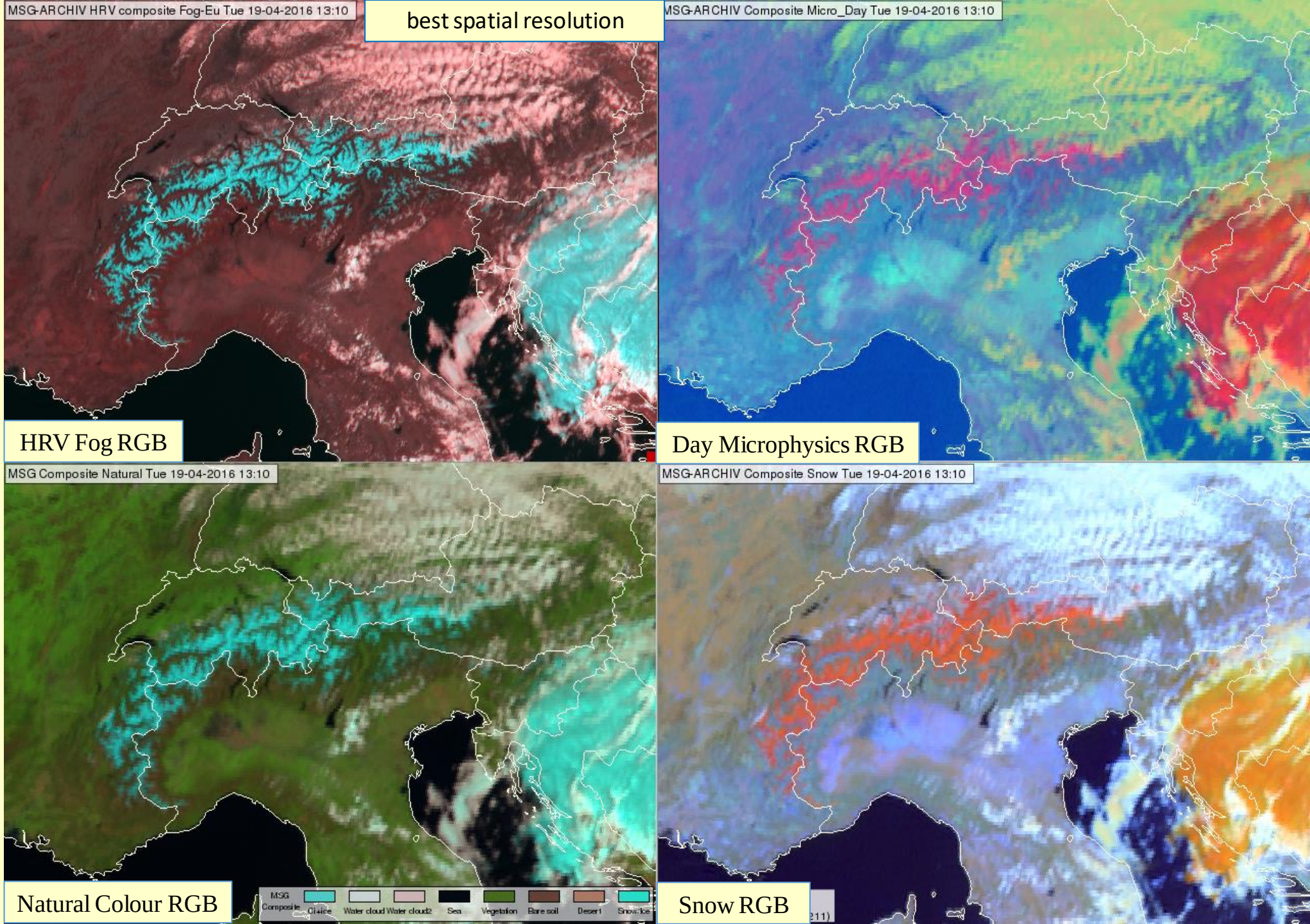

Natural Colour RGB

21 April 2017
11:25 UTC

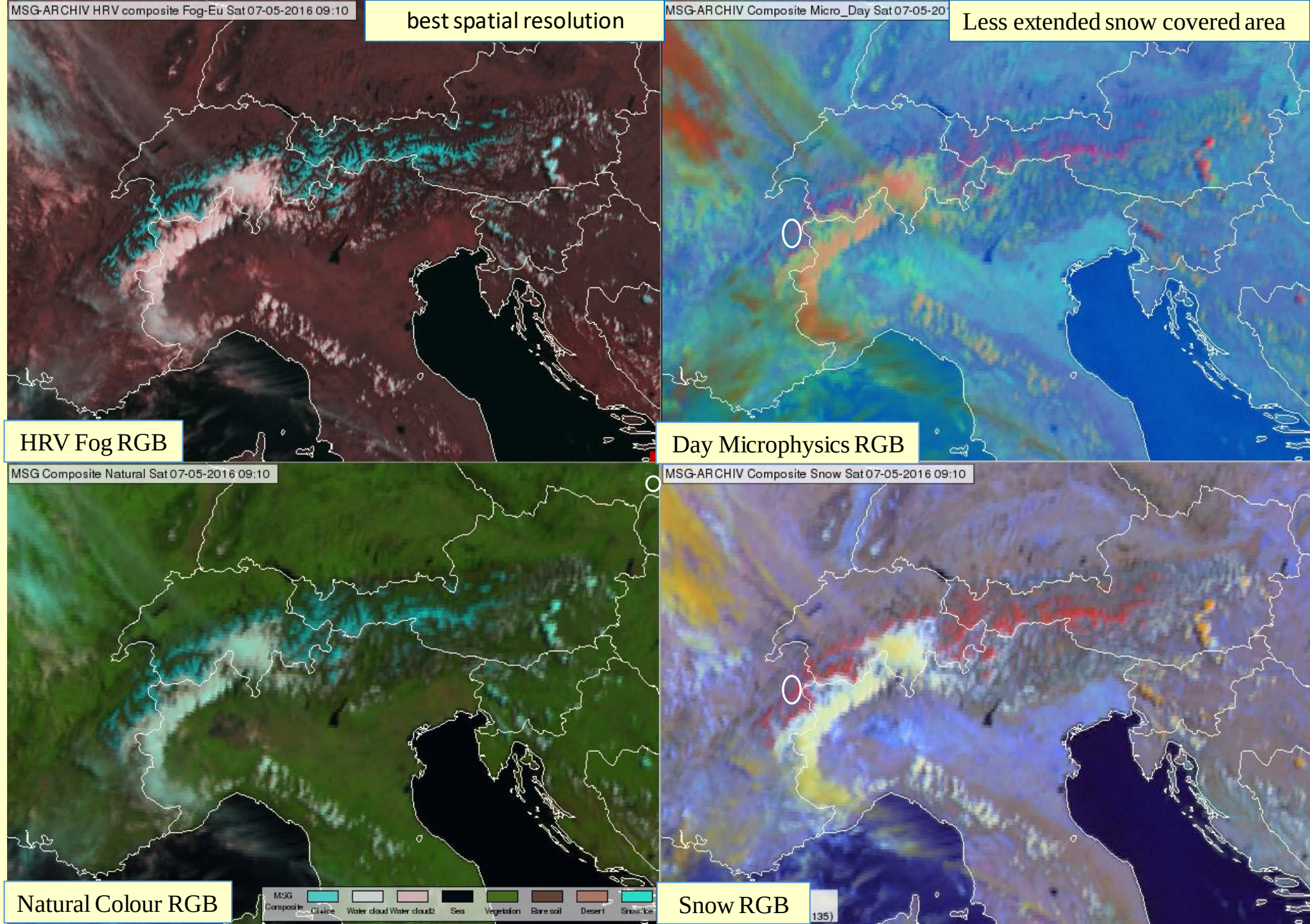


19 April 2016
13:10 UTC
Snow melting
in the Alps



07 May 2016
09:10 UTC
Snow melting in the Alps



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Snow detection using solar channels - daytime

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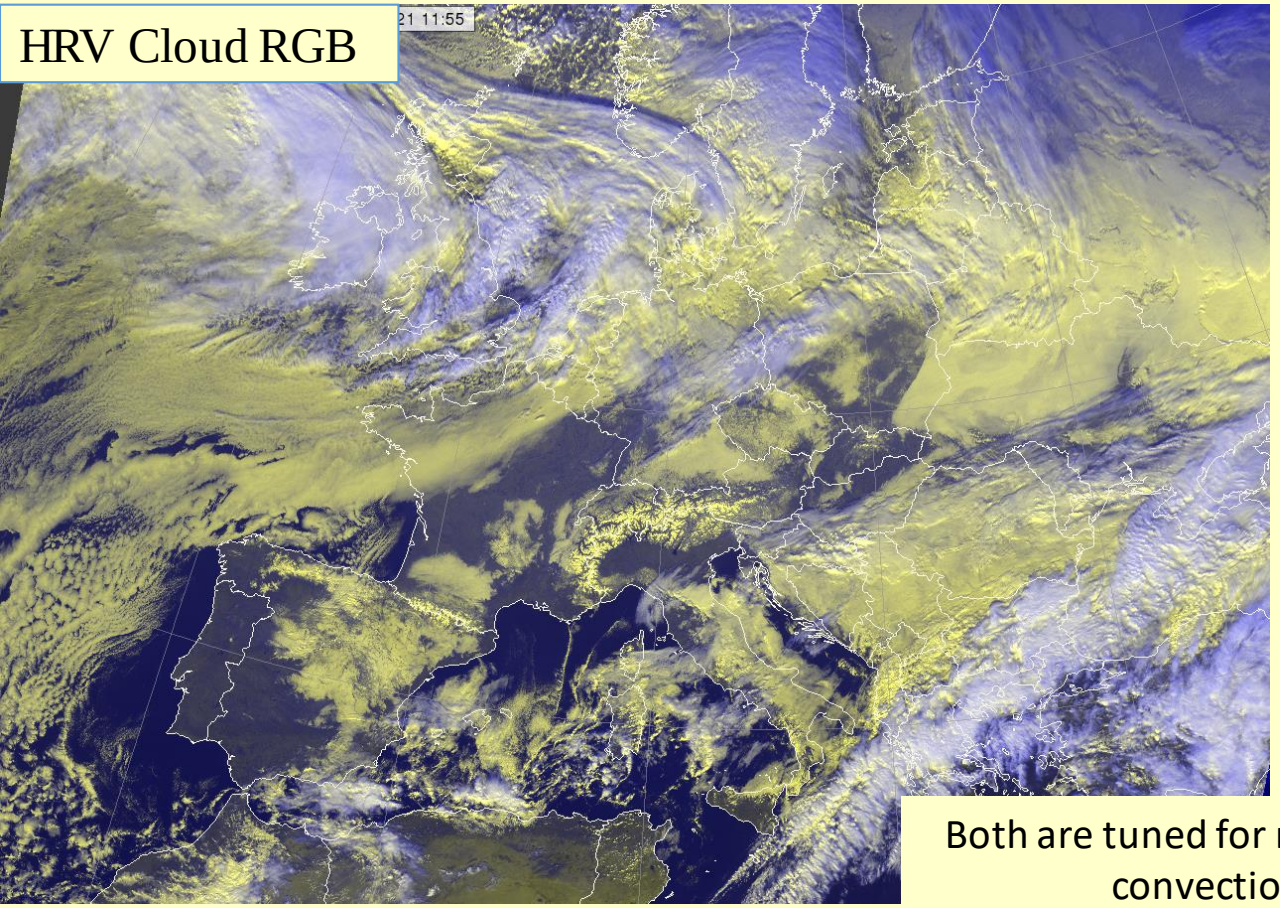
  - Their comparison
- Daytime RGBs NOT useful for snow detection

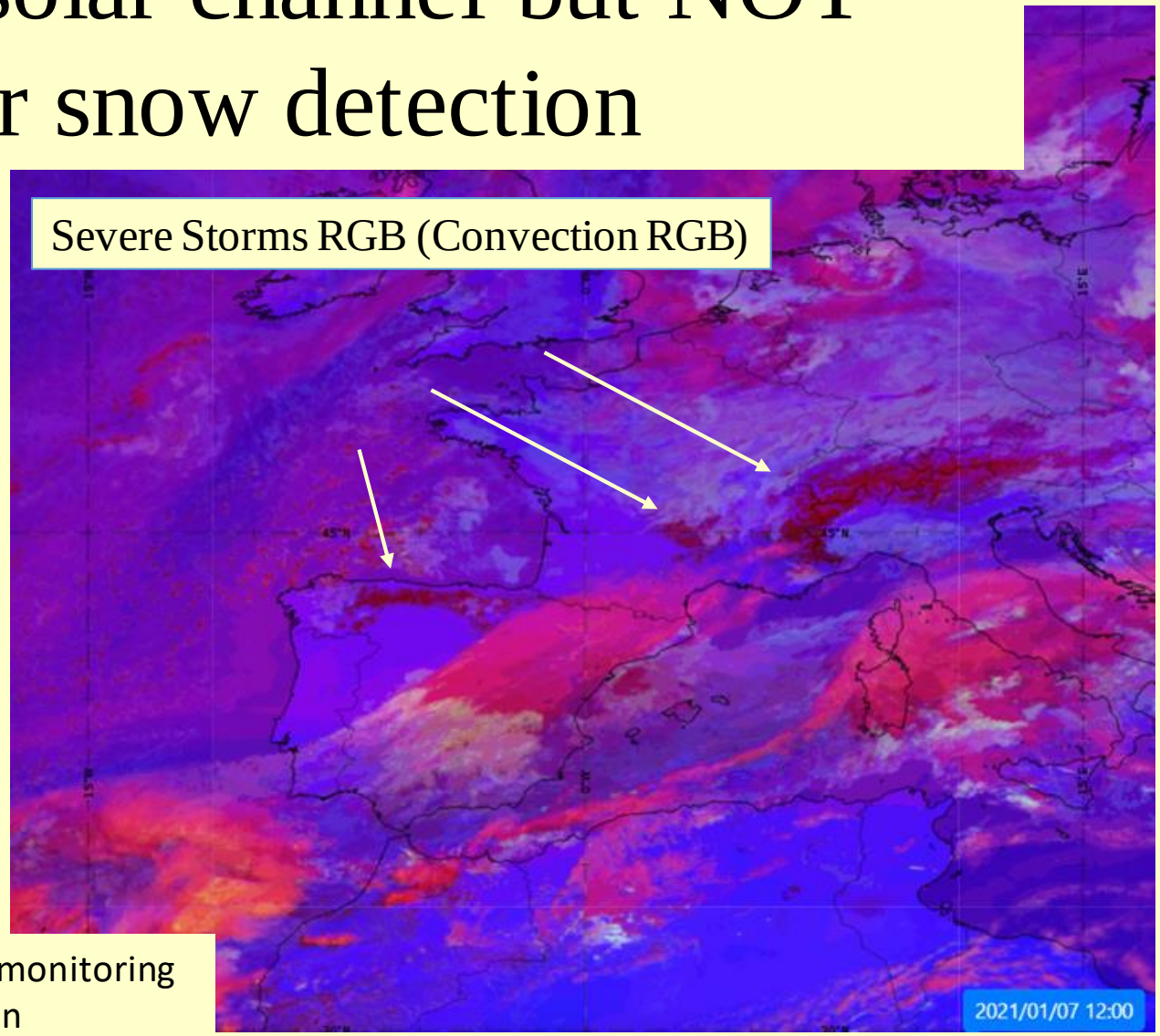
Some information about snow in nighttime RGBs

Sea and lake ice

Summary

# Daytime RGBs using solar channel but NOT recommended for snow detection




Both are tuned for monitoring convection

| Colour beam | Channel |
|---|---|
| Red | **HRV** |
| Green | **HRV** |
| Blue | IR10.8 inverted |

It does not use absorbing solar channel. Same colour for snow and warm clouds (e.g. fog/stratus).

| Colour beam | Channel difference |
|---|---|
| Red | WV6.2 – WV7.3 |
| Green | IR3.9 – IR10.8 |
| Blue | **NIR1.6 – VIS0.6** |

It is tuned for high clouds. Snow cover is seen, but not tuned for it.

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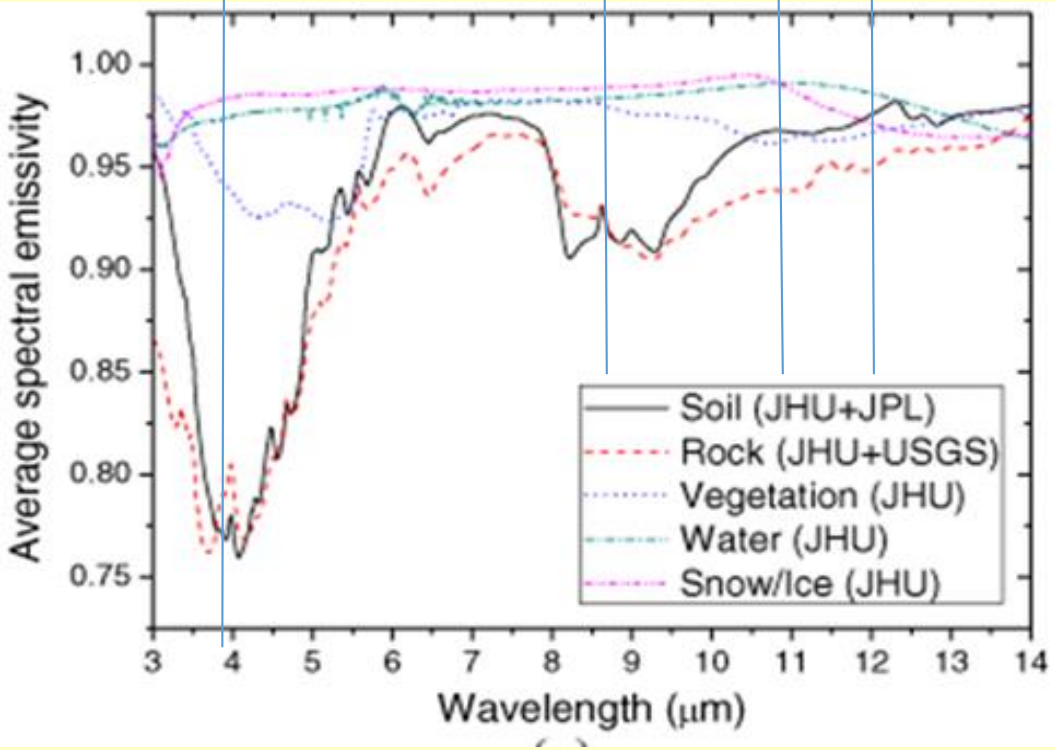
Some information about snow in nighttime RGBs

Sea and lake ice

Summary

# RGBs using only thermal infrared channels Nighttime

**At night - no snow detection**
(except very specific condition)




One (**single**) **thermal infrared channel** (located in **atmosphere window**) is not useful for snow detection (information mainly on the **temperature**)

The **(IR10.8-IR3.9)** and **(IR10.8-IR8.7)** channel differences contain information on the emissivity difference between these channels. For snow the emissivity difference is low, while for soil it is larger.

This helps to "**guess**" the presence of snow cover. It "works" only for thick, unbroken snow.

**Night Microphysics RGB and 24h Microphysics RGB** uses these differences.

23 January 2006
04:00 UTC

Snow detection at night on the Night Microphysics RGB

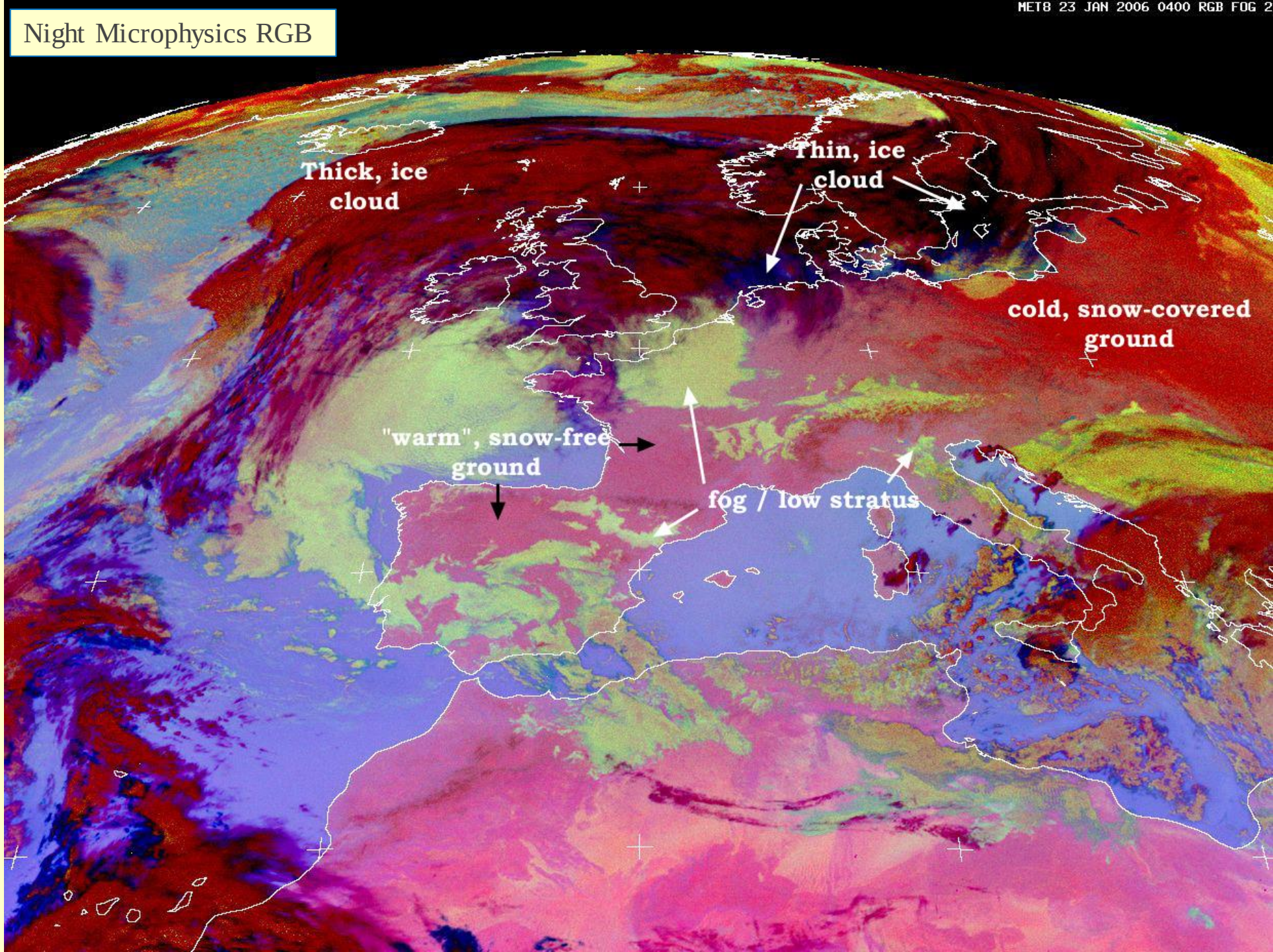
Dark reddish colour shade of cloud-free region refers to possible snow cover.

**Only in special condition:**

Snowy surface appears dark reddish only in case

- the snow is unbroken and thick, (not much disturbed by the vegetation) and
- the temperature is very low.

(Source: Jochen Kerkmann, Image Library, EUMETSAT, http://www.eumetsat.int/website/home/Images/ImageLibrary/DAT_IL_06_01_23.html)



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Some information about snow in nighttime RGBs

Sea and lake ice

Summary

# Sea and lake ice

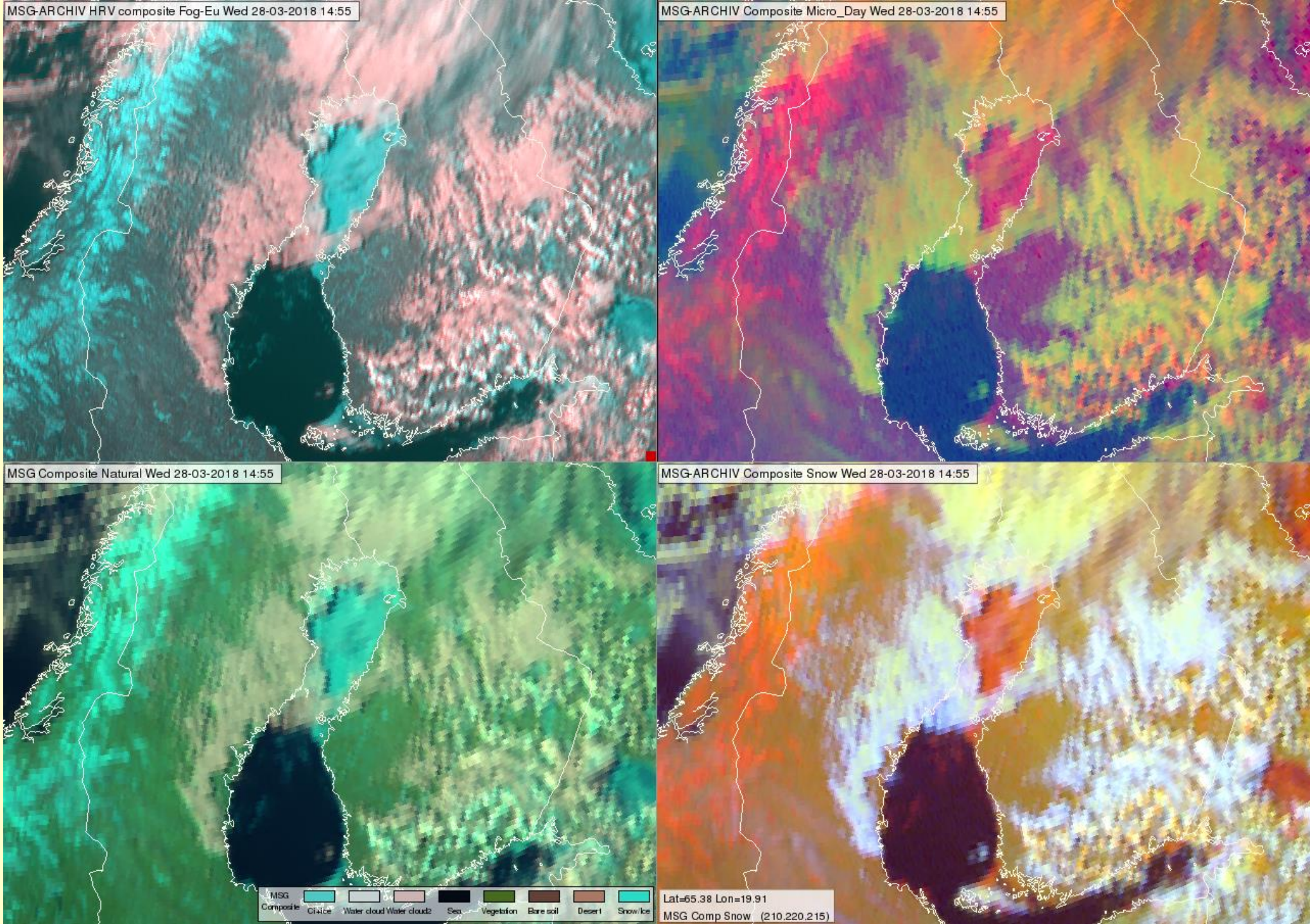
Ice covered by snow
Melting ice

HRV Fog RGB
28 March 2018
14:55 UTC

<u>Northern part of Gulf of Bothnia</u>
likely snow on ice

Drift ice in the southern part of the gulf
less seen in the Day Microphysics RGB

<u>Lake Ladoga</u>
somewhat darker
melting and/or not so much snow



HRV Fog RGB
31 March 2018
12:10 UTC

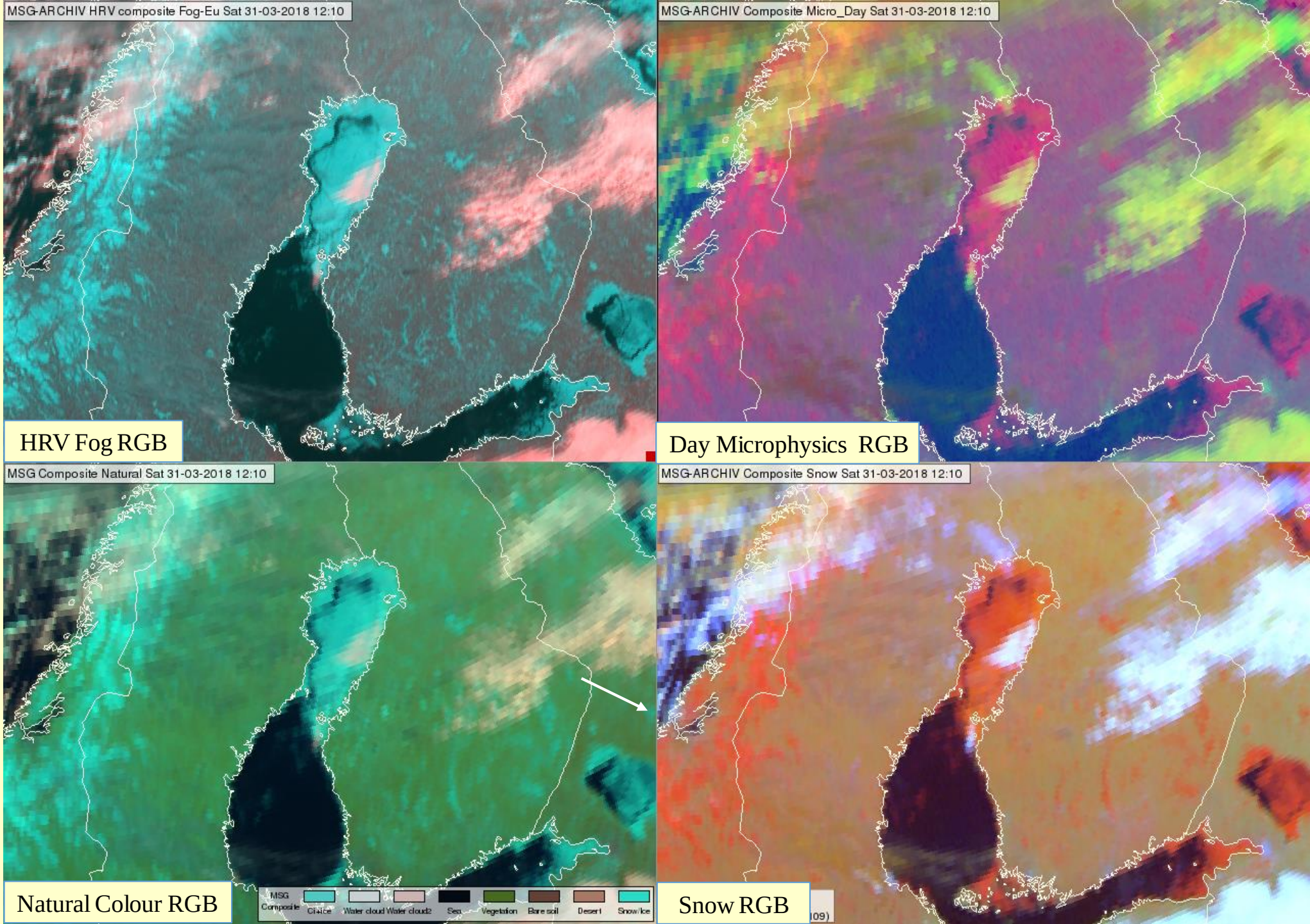
Northern part of Gulf of Bothnia
snow on ice
ship track

Drift-ice in the southern part of the gulf
less seen in the Day Microphysics RGB

<u>Gulf of Finland close to Saint Petersburg</u>
snow on ice

<u>Lake Ladoga</u>
partly covered, melting and/or not much snow

12 UTC radiosonde
Petrozavodsk $T_{surf}$=0 °C



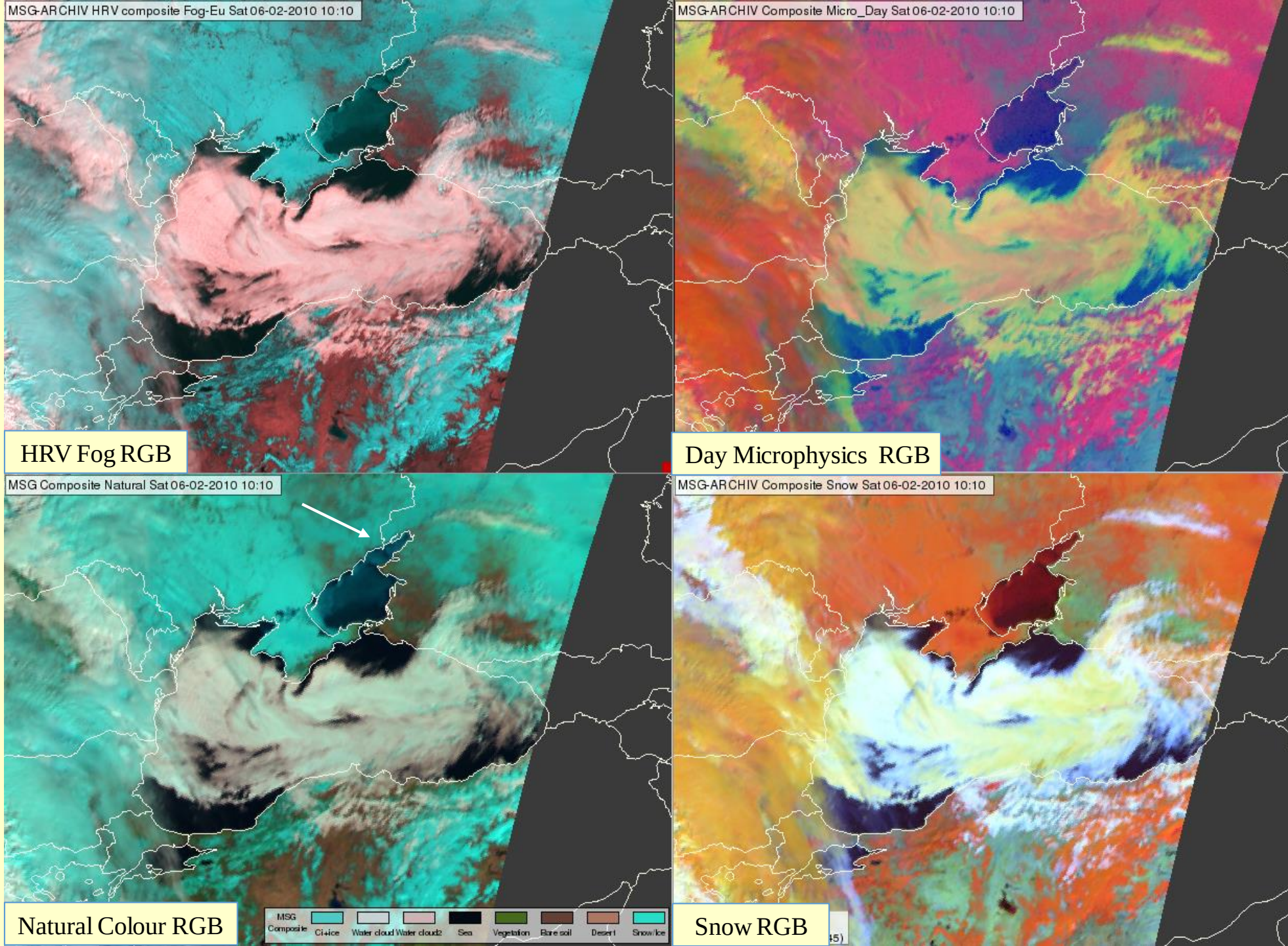
02 February 2010
10:10 UTC

Sea ice on
Sea of Azov

darker than snow on land,
least seen on
Day Microphysics RGB

melting ice

Rostov na Danu
radiosonde
00 UTC $T_{surf}$=+0.8 °C
12 UTC $T_{surf}$=+1.4 °C



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Some information about snow in nighttime RGBs

Sea and lake ice

Summary

# Summary

**Three types of characteristics help the identification**

- **typical <u>structure</u> of snow**
- **"<u>movement</u>" (animations)**
- **<u>spectral characteristics</u> of snow**

**Solar channels provide the key information for snow detection**

<u>During daytime</u>

on cloud-free areas– **reliable snow detection**

Recommended RGBs: Snow RGB, Day Microphysics RGB, HRV Fog RGB and Natural Colours RGB

Best RGBs for snow detection:

- **Snow RGB** (highest colour contrast between snow and clouds, even with ice clouds) (tunes specially for snow detection)
- **HRV Fog RGB** – high spatial resolution – good contrast against snow-free land and water clouds

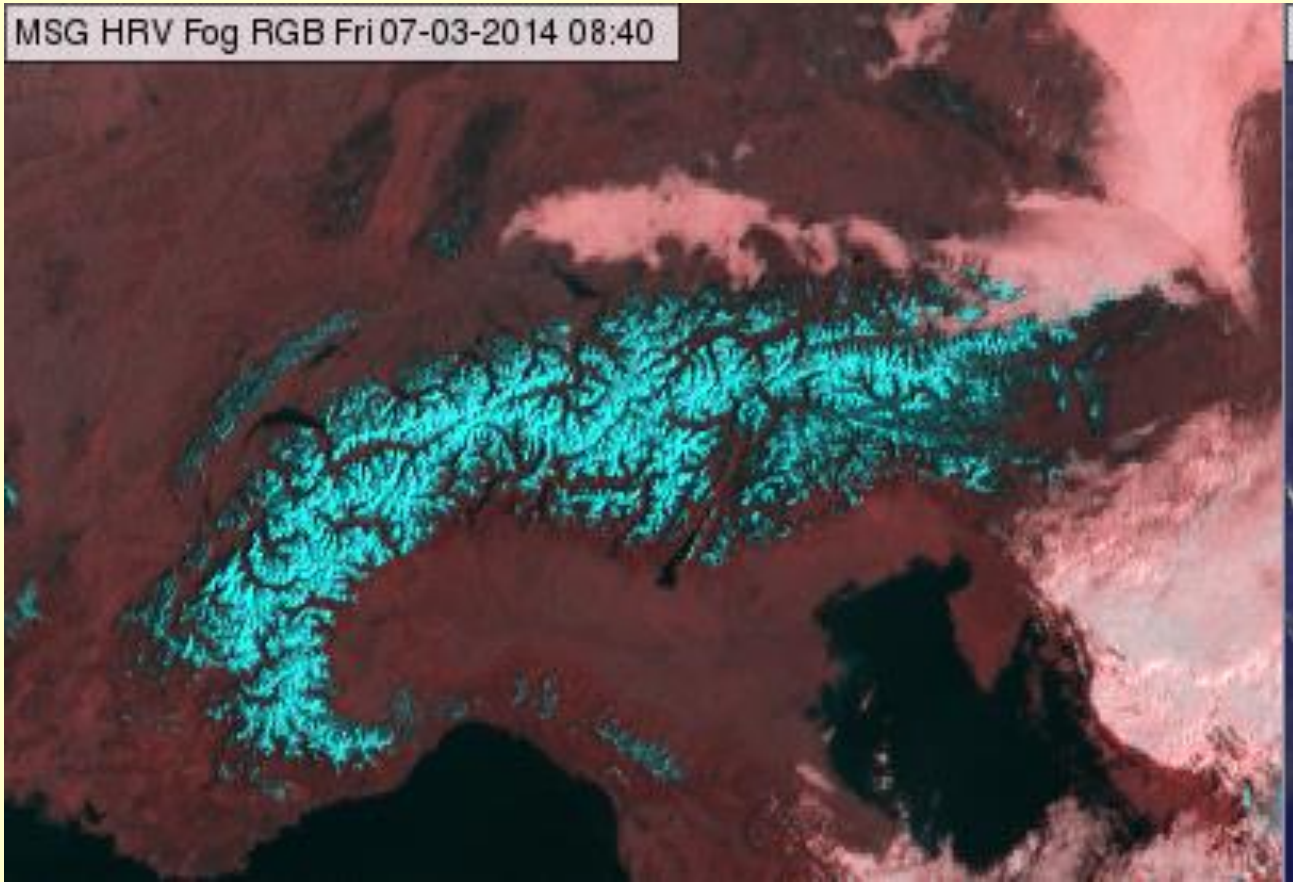
<u>At night</u> – no snow detection - some possibility – one can hint in some special conditions
(Night Microphysics RGB, 24h Microphysics RGB)

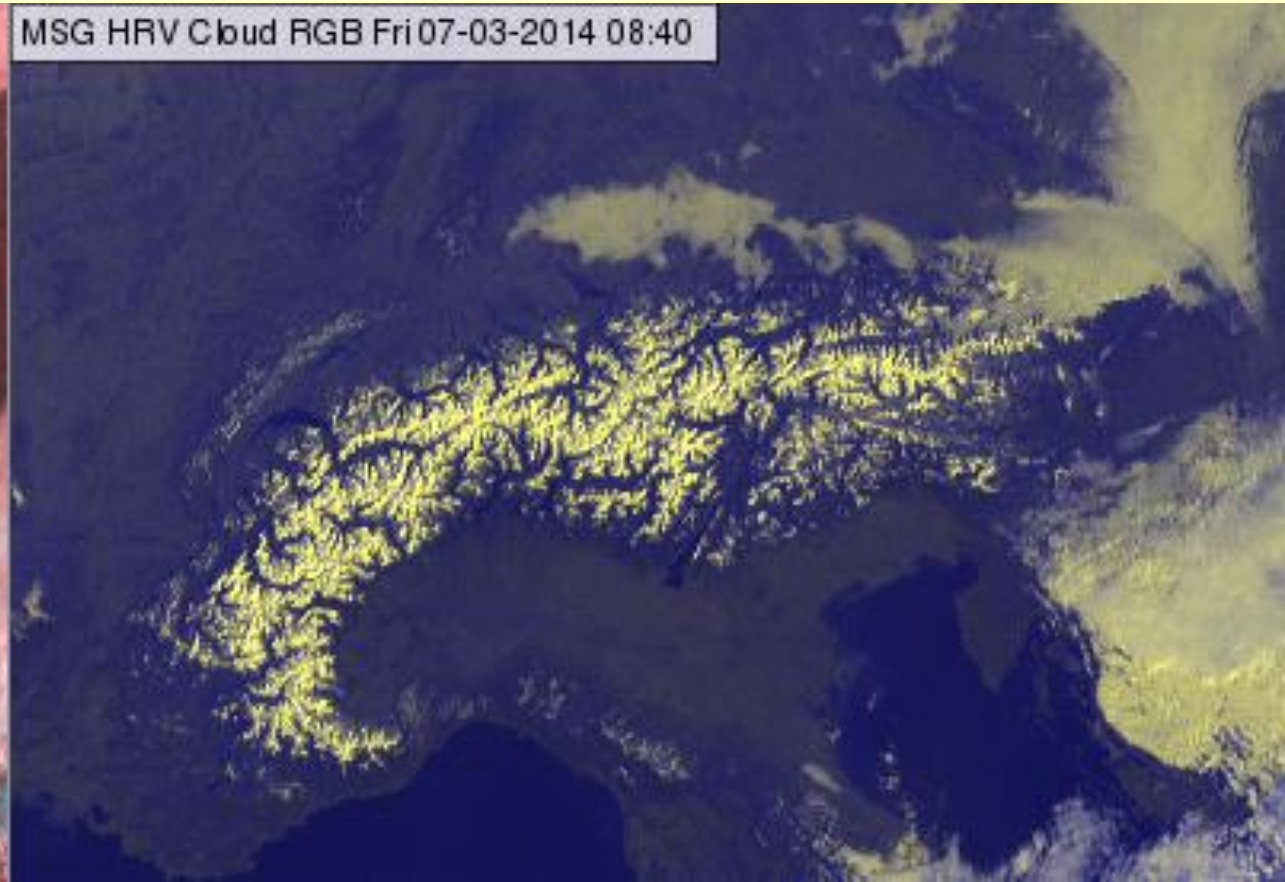
Sea/lake ice

if covered by snow – appears like snow
if not covered by snow – darker (if melting even darker)

Melting snow/ice is less seen in Day Microphysics RGB

# Thanks!


MSG HRV Fog RGB Fri 07-03-2014 08:40


MSG HRV Cloud RGB Fri 07-03-2014 08:40