**Lab 5a – RGB Combinations for Viewing Micro-physical Cloud Properties and Dust**
Paul Menzel and Jochen Kerkmann

1.   Open HYDRA from the Windows Start Menu. Inspect the scene over Italy on 29 May 2001 detected by MODIS (MOD021KM.A2001149.1030.005.2007054003907.hdf). *Start* the *Multichannel Viewer*. Display the data at full resolution by selecting a subset of the data displayed in the Hydra window (right most icon in toolbar in the Hydra window). Select a subset with clouds in the scene. The one kilometer resolution data will appear in the Multichannel Viewer window (see Figure 1).
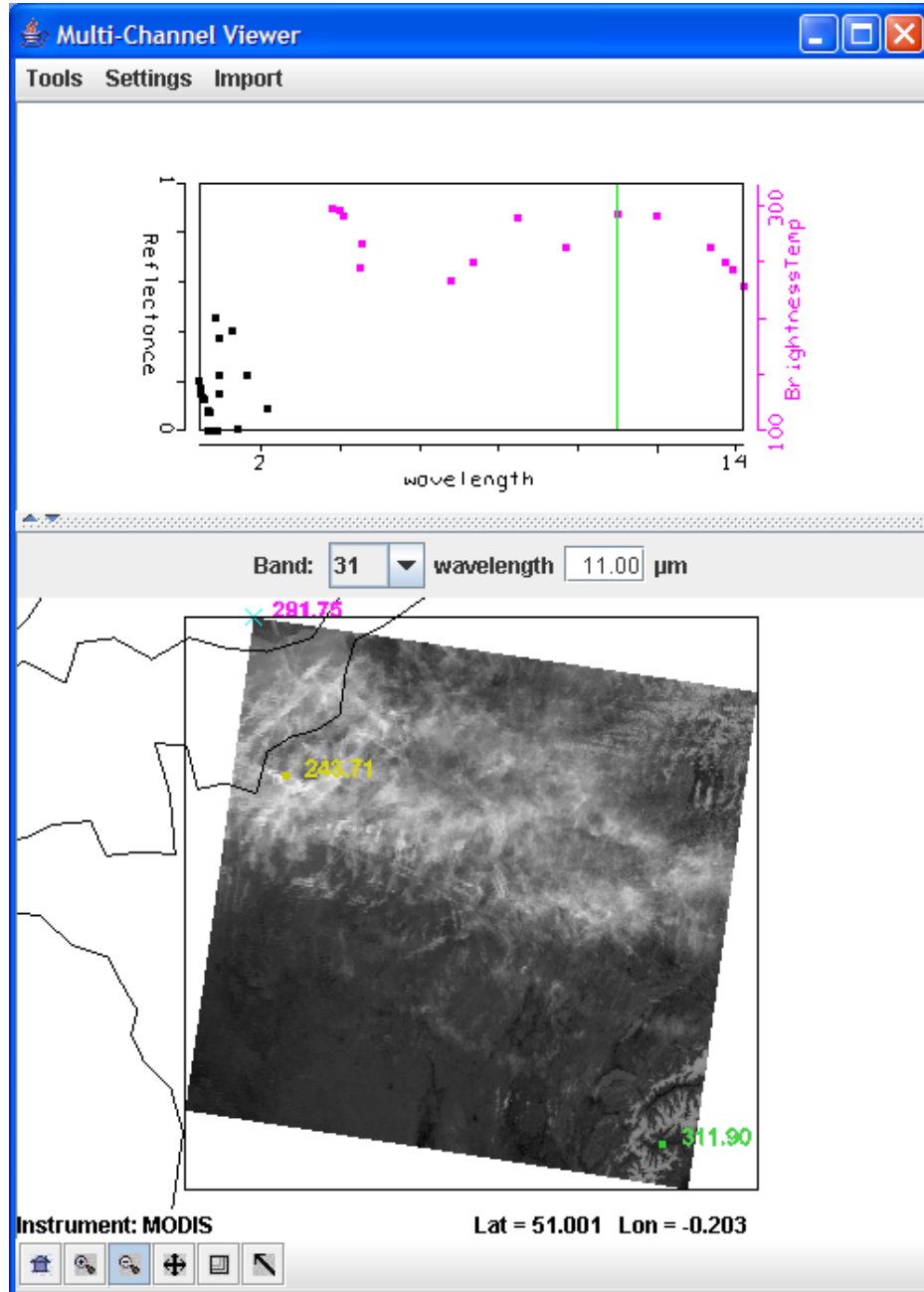
Open *Linear Combinations* (under *Tools*) and create a pseudo image of BT12.0-BT10.8 (Ch32 minus Ch31); let this be the red color in your RGB. Create another pseudo image of BT 10.8-BT8.7 (Ch 31 – Ch 29); let this be the green color in your RGB. And create a third pseudo image of BT10.8 (Ch31); let this be the blue color in your RGB. Click on *RGB* in the *Channel Combination Tool* display. The RGB display will open. Adjust the range of values for each of the colors (click on *Settings* and select *Set Color Range*) so that

R	-4 to +2
G	0 to +15
B	261 to 289

You should have an image that looks like Figure 2.
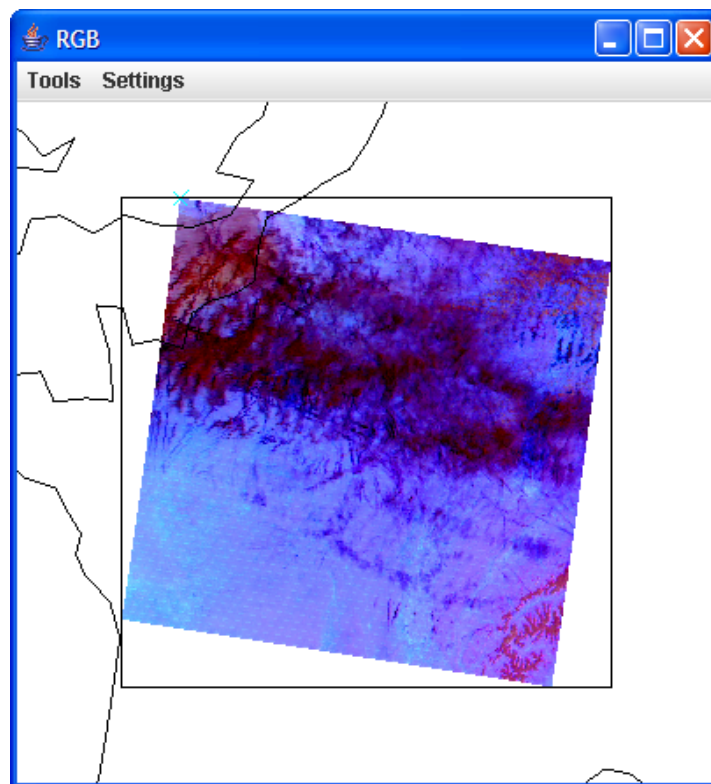
This is an RGB image designed for viewing cloud microphysics. Explain what colors you should have for high ice clouds, low water clouds, and snow on the ground.

Make a scatter plot of BT11-BT8.6 on the Y-axis and BT11-BT12 on the x-axis and explore the thresholds for water versus ice cloud.

2. Select a region over northern Africa and repeat the exercise. Explain what colors you should have dust in the air, barren ground, and clear skies over water. Try a different range of color values to enhance dust detection. Make a scatter plot of BT11-BT8.6 on the Y-axis and BT11 on the x-axis and explore the thresholds for dust and barren ground.

Lab 5b– RGB Combinations and IASI Channel Differences for Viewing SO2
HansPeter Roesli and Paul Menzel

Partially based on Retrieval of atmospheric sulfur dioxide and nitric acid using the Atmospheric Infrared Sounder (AIRS) by Scott Hannon and L. Larrabee Strow (see http://asl.umbc.edu/pub/hannon/Junk/article.pdf or the pdf file here).

1.   SO2 is present in the atmosphere at background levels on the order of 0.1 Dobson Unit (DU). One DU corresponds to a layer of 0.01 mm of a gas at 1 atm and 0°C. This faint background level is too low for AIRS and IASI to detect, but volcanic eruptions may release large amounts of SO2 into the atmosphere creating SO2 plumes of tens or hundreds of DUs that can travel long distances before diffusing away. AIRS/IASI have some ability to detect (and measure) these SO2 plumes when the gas concentration is well above background levels. AIRS/IASI channels with some sensitivity to SO2 are shown in the top panel of the figure below. It shows simulated clear-sky BT spectra for AIRS in the region of 1000-1500 cm-1 (10-6.7 um) for three SO2 profiles of 0.1, 100, and 1000 DU. The bottom panel shows the change in BT due to the change in SO2. Each year there are usually a few eruptions somewhere on the globe with SO2 plumes on the order of 100 DU, while eruptions on the order of 1000 DU are very rare (Pinatubo in 1991 was the most recent one?). Note that the gap in the spectra around 1180 cm-1 is specific to the AIRS design, while IASI has no gap in its measurement range.
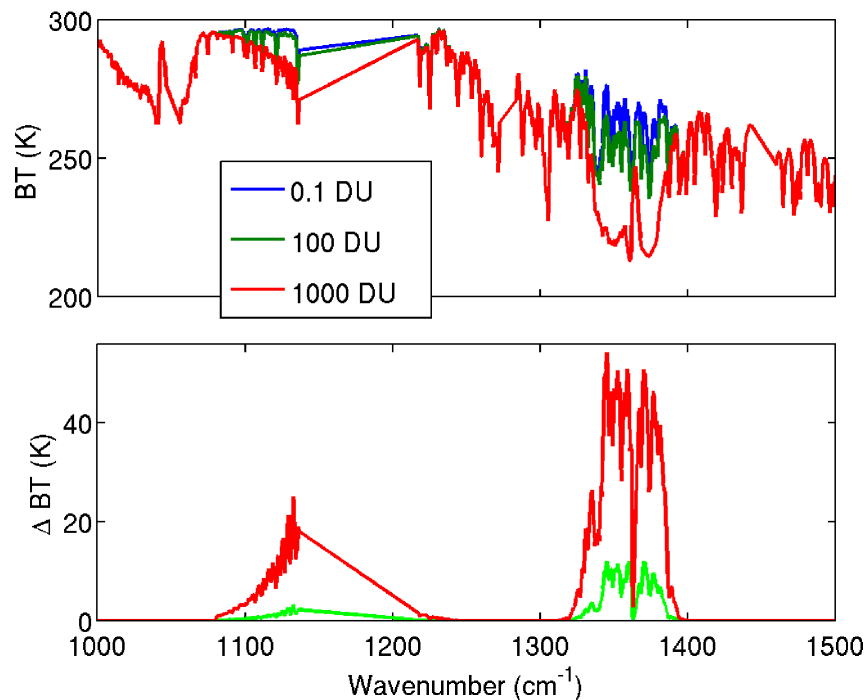

2.   As can be seen from the figure, the AIRS (and IASI) channels most sensitive to changing SO2 are located in the 1370 cm-1 region. For a typical background-level SO2 profile, the atmospheric absorption there is dominated by water vapour, but also with significant contributions by CH4 and N2O. With a careful selection of channels the CH4 and N2O can be avoided, but the water vapour affects all the 1370 cm-1 region channels.

The water vapour absorption here blocks most of the upwelling radiance originating at the surface and the lower troposphere, thereby preventing these channels from detecting low altitude SO2 plumes.

3.   Comment on the the 1100 cm-1 region channels. Why would you be able to detect SO2 plumes at lower levels, but only at very high concentrations?

4.   Based on point 2 we now test a crude SO2-detection method with Hydra. It is based on a BT difference between two IASI channels, one with strong SO2 absorption and another one with weak SO2 but with otherwise similar absorption characteristics as the strong SO2 channel. Load IASI_xxx_1C_M02_20080821200553Z_20080821214752Z_N_O_20080821215125Z.nc in Hydra. After starting the *Multichannel Viewer* subset approximately the scene as shown by the green rectangle below
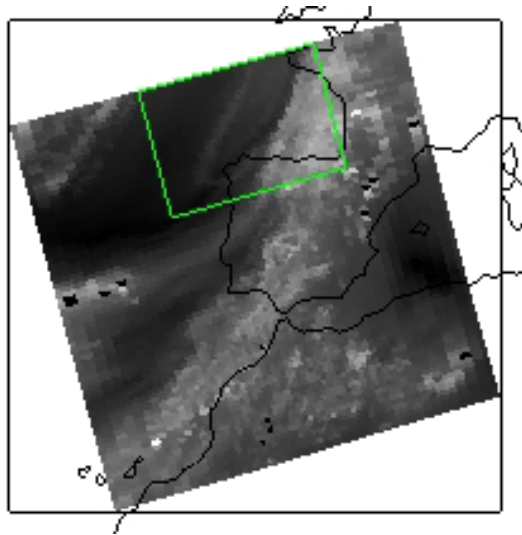
5.   Using *Linear Combinations* in the *Tools* menu create an image of the 1370 cm-1 channel. You should see a hook-like streamer west of the cloud band that covers the Bay of Biscay (close to the bottom right-hand corner). Create a second image for the 1325 cm-1 channel, a channel outside strong SO2 emission but with otherwise similar characteristics as 1370 cm-1. Compare and comment the two images (hook and cloudy/cloud-free areas)

6.   Create the scatter plot by assigning 1325 cm-1 channel to the *X-axis*, 1370 cm-1 to the *Y-axis* and clicking *Scatter* in *Linear Combinations*. Identify the SO2 signal in the plot.

7.   Create a difference picture by subtracting 1370 cm-1 from 1325 cm-1 in *Linear Combinations* and comment.

SEVIRI Spectral Bands in μm			Applications
λ_{cen}	λ_{min}	λ_{max}	
HRV	**Broadband visible 0.4 – 1.1 um**			**Surface, clouds, high resolution wind fields**
VIS0.6	**0.635**	**0.56**	**0.71**	**Surface, clouds, wind fields**
VIS0.8	**0.81**	**0.74**	**0.88**	**Surface, clouds, wind fields**
NIR1.6	**1.64**	**1.50**	**1.78**	**Cloud phase**
IR3.9	3.90	3.48	4.36	Surface, clouds
WV6.2	6.25	5.35	7.15	Water vapour, clouds, atmospheric instability, wind fields
WV7.3	7.35	6.85	7.85	Water vapour, atmospheric instability
IR8.7	8.70	8.30	9.10	Clouds, atmospheric instability
IR9.7	9.66	9.38	9.94	Ozone
IR10.8	10.80	9.80	11.80	Surface, clouds, wind fields, atmospheric instability
IR12.0	12.00	11.00	13.00	Surface, clouds, wind fields, atmospheric instability
IR13.4	13.40	12.40	14.40	High level clouds, atmospheric instability

Table: SEVIRI spectral channels and their primary applications starting with channel 1 at 0.63 u,m through channel 11 at 13.4 um. The High Resolution Visible (HRV) channel 12 is not available for viewing in HYDRA.

8. Load the SEVIRI file met9_1234567891011_2008_234_2130.area and subset to the same area (take it a bit larger) as before from about the same time. Create images of channel 6 at 7.3 um and channel 7 at 8.7 um in *Linear Combinations*.

9. Thanks to a relatively dry upper troposphere the signal of channel 6 is quite strong, but also channel 7 shows a weak response to SO2. The contrast of channel 7 is considerably enhanced when doing a difference with window channel 9 at 10.8 um as shown by the EUMETSAT standard RGB for SO2 and volcanic ash (display the image 200808212130_m9-VOLC_ma-IASI.png) and look at the middle image. Construct an RGB using the Red = BT12.0-BT10.8 (ch10-ch-9) ranging in contrast from -4 to +2 C, Green = BT 10.8-BT8.7 (ch9-ch7) ranging from -4 to +5 C, and Blue = BT10.8 (ch9) ranging from 243 to 303 C.

10. Channel 6 is used in the EUMETSAT standard Airmass RGB (display the image 200808212130_m9-AIRM.png and unintentionally shows in a reddish the hook as well. However, it is mixed somewhat with another reddish signature stemming from descending dry stratospheric air.

11.   Investigate the same case also with MODIS data from Aqua by loading MYD021KM.A2008234.1425.005.2008235174954.hdf. Use MODIS channels 28, 29, and 31 that correspond closely with SEVERI channels 6, 7, and 9.