Lab: Moisture boundary cases

1. New McIDAS-V skills:
    a. Difference images (difference of split window channels)
    b. Plotting transects
    c. Plotting model (ECMWF) GRIB data

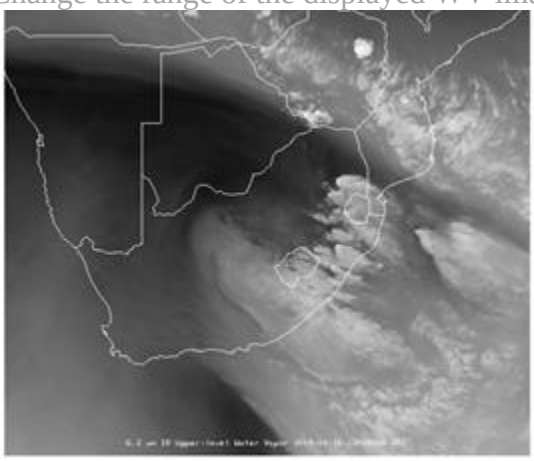
2. Key concepts:
    a. Look at dust and atmospheric moisture in solar and thermal (infrared) bands
    b. Detection of atmospheric moisture in IR bands (split window difference)
    c. Detection of atmospheric moisture in VIS bands (VIS0.96 – VIS0.86 difference)

I. CASE IN SOUTHERN AFRICA (note: this case we will cover if time allows – move to case II)

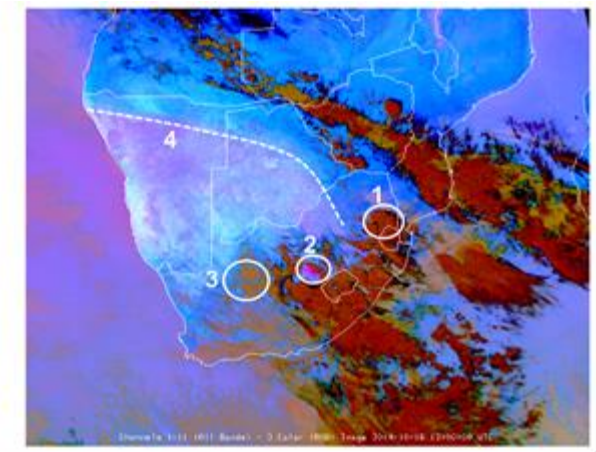
Here are step-by-step instructions for this lab (key questions are in yellow):

1. Read the local SEVIRI HRIT data for 16 October 2014, 12:00 UTC

    a. Open McIDAS-V
    b. Let us first analyze the synoptic situation of this case (in terms of conceptual models)
    c. In the **Data Explorer** window, load the SEVIRI **WV6.2** (temperature) data from: **2014-10-16 12:00:00 UTC** for a large African area from 10 to 50 deg South (do not forget to put magnification to 1 (full resolution)).
    d. Change the range of the displayed WV image to **210 to 260 K.** It should look like this:



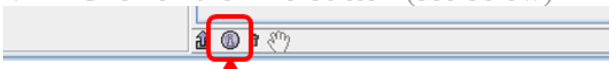
    e. Also load the **SEVIRI RGB → AIRM** (Airmass RGB) for the same area (is already selected)
    f. You can easily identify some conceptual models Which ones?
    g. Now, load the **SEVIRI RGB → DUST** (Dust RGB) and the **SEVIRI RGB → NCOL** (Natural Colour RGB) for the same area (is already selected)
    h. For the NCOL RGB, select **minrefl=0** and **maxtrefl=80** (high range, this is a midday image)
    i. The Dust RGB image should look like this:



Questions: Can you identify the features 1 to 4? Toggle the 2 RGB images. Are all 4 features visible in the Dust RGB also visible in the Natural Colour RGB?

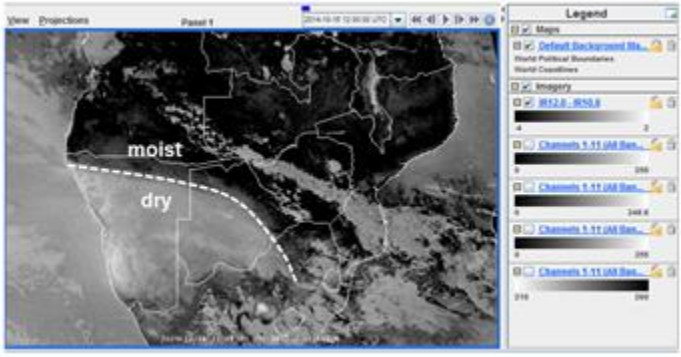
2. Generate the red component of the Dust RGB image (IR12.0 – IR10.8)

   a. Go to the **Field Selector** tab in the **Data Explorer** window
   b. Select **Formulas** in the **Data Sources** panel
   c. In the **Fields** panel, select **Miscellaneous → Simple difference a-b**
   d. Select **Imagery → Image Display** in the **Displays** panel
   e. Click **Create Display**, and a new window pops up
   f. For Field a select **Channels 1-11 → 12.0 um IR → Temperature**
   g. For Field b select **Channels 1-11 → 10.8 um IR → Temperature**
   h. Click **OK**
   i. The difference IR12.0 – IR10.8 (the red component of the Dust RGB) is now displayed
   j. Change the range to **-4…+2** K
   k. It is useful to change the label of displayed image and in order to do so, click on the text of this layer to display the **Layer Controls**
   l. Click on the **Info button** (see below)



Click here to show display panel properties

   m. Change the **Legend Label** to "IR12.0 – IR10.8"
   n. Click **OK**
   o. Now, the difference image should look like this:



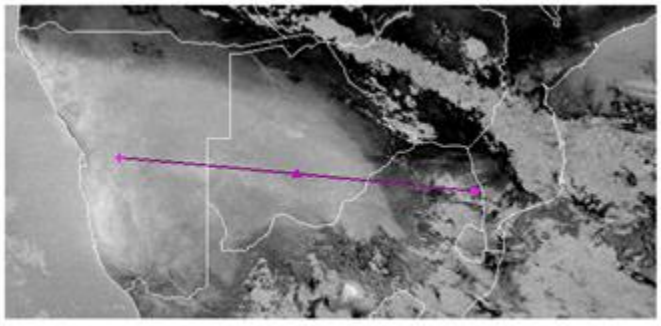
Question: There is a moisture boundary running across northern Namibia, Botswana and South Africa. Please, read some typical values of the IR12.0 – IR10.8 difference for the dry and the moist area!

p. To do this, hold down the mouse wheel and move the cursor across the image
q. The lat/lon and temperature/reflectivity information appears on the bottom of the display window
r. Read and note the BTD (brightness temperature difference) values of the IR12.0 – IR10.8 image

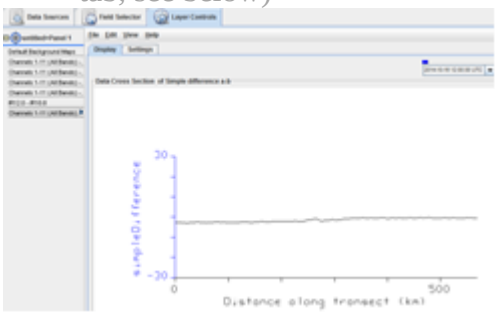
Question: What is the largest (negative) value that you get in the moist (cloud-free) area? Hint: colour enhancement helps.

3. Plot a data transect for the IR12.0 – IR10.8 difference from dry to moist airmass

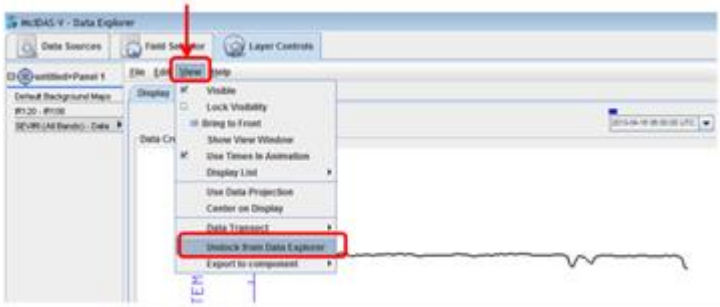
a. Go to the **Field Selector** tab in the **Data Explorer** window
b. Select again **Formulas** in the **Data Sources** panel
c. In the **Fields** panel, select **Miscellaneous → Simple difference a-b**
d. Select **Data Transect** in the **Displays** panel (at the bottom)
e. Click **Create Display,** and a new window pops up
f. For Field a select **Channels 1-11 → 12.0 um IR → Temperature**
g. For Field b select **Channels 1-11 → 10.8 um IR → Temperature**
h. Click **OK**
i. A cross-section indicator appears in the McIDAS map window (see below, eventually you have to zoom out to see it!)



j. And the values of the cross-section appear in the **Data Explorer** window (in the **Layer Controls** tab, see below)

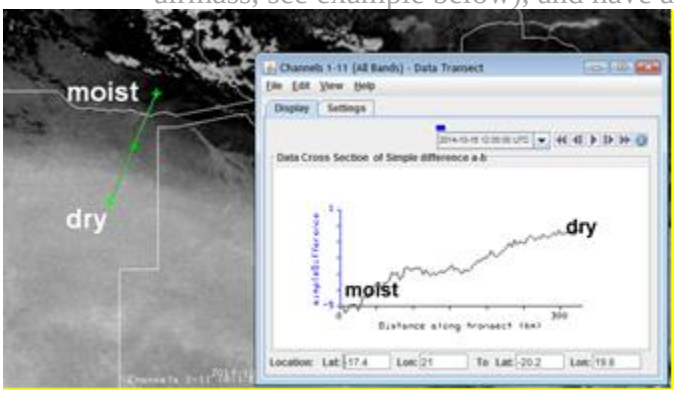


k. To get a separate window for the cross-section data, in the **Layer Controls** tab select the **View → Undock from Data Explorer** (see below)



l. And change the vertical scale of the transect as indicated below. In the new **Data Transect** window, click the **Settings** tab and then press **Change** next to the **Vertical Scale** and change the range to **-5** to **+1** K and click **OK**

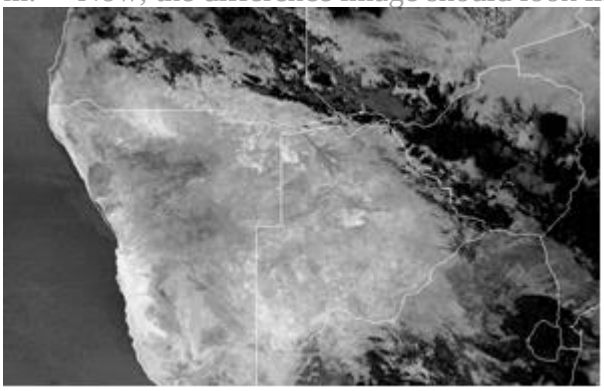
m. Last but not least, drag the endpoints of the cross-section to the desired positions (from dry- to moist airmass, see example below), and have a look at the result



Question: This display shows the cross-section of the IR12.0 – IR10.8 difference. Why does it change from around 0 to -5 K when moving from the dry to the moist airmass?

4. Generate the Green component of the Dust RGB image (IR10.8 – IR8.7)

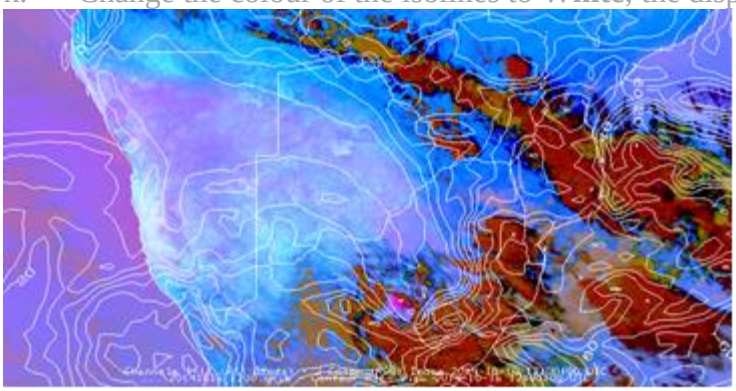
a. Go to the **Field Selector** tab in the **Data Explorer** window
b. Select **Formulas** in the **Data Sources** panel
c. In the **Fields** panel, select **Miscellaneous → Simple difference a-b**
d. Select **Imagery → Image Display** in the **Displays** panel
e. Click **Create Display**, and a new window pops up
f. For Field a select **Channels 1-11 → 10.8 um IR → Temperature**
g. For Field b select **Channels 1-11 → 8.7 um IR → Temperature**
h. Click **OK**
i. The difference IR10.8 – IR8.7 (the green component of the Dust RGB) is now displayed
j. Change the range to **0…+15** K and select a black/white colour scale from **Satellite → Group1 → GAM25.** This colour scale is black/white with a Gamma enhancement of 2.5.
k. Click **OK**
l. Change the label of the displayed image to the "IR10.8 – IR8.7"
m. Now, the difference image should look like this:



Question: Can you see the moisture boundary in this difference image? Why are sandy desert surfaces so bright (white) in this image? Why are ice clouds black? Toggle this difference image and the IR12.0 – IR10.8 difference image (and the Dust RGB).

5. Compare Dust RGB (and IR12.0 – IR10.8 difference) image to model moisture fields. In order to do that, open the ECMWF 12 UTC analysis for this case (GRIB data).

   a. Display the Dust RGB as top image
   b. In the map window, navigate to **File → Open File**
   c. Open the file "**20141016_1200.grib**" under
      /data/Weather/Summer-School-Bracciano-20-29_June_2022/McV DATA/ecmwf
      (if you see an empty folder, set **Files of Type** to **All Files**)
   d. Click **Open**, wait. Note that you will not have new imagery appearing at this point.
   e. Go to the **Data Explorer** window and select the **Field Selector** tab
   f. Select the **...\20141016_1200.grib** data under **Data Sources**
   g. Under the **Fields** panel, select **3D grid → Relative Humidity**
   h. Under the **Displays** panel, select **Plan Views → Contour Plan View**
   i. Select **850 hPa** under the **Level** tab
   j. Click: **Create Display,** wait
   k. Change the colour of the isolines to **White**; the display should look like this:



Question: Does the model field (rel. humidity at 850 hPa) match the satellite info (Dust RGB)? Check also the rel. humidity of other pressure levels.

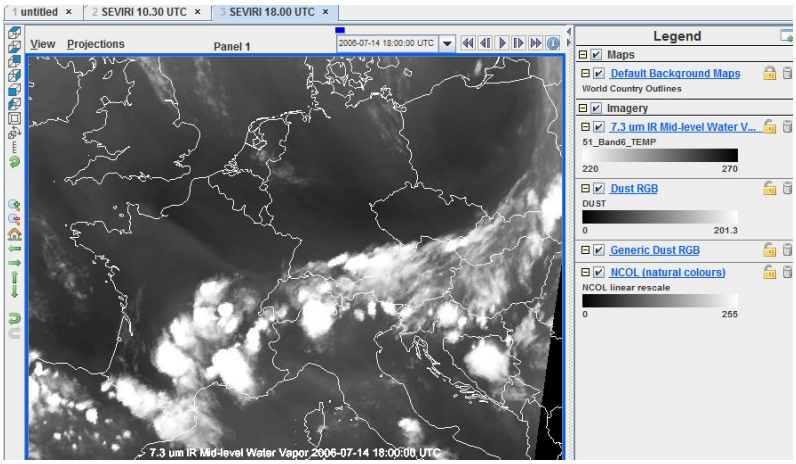
   l. Try to display other model fields, like specific humidity, geopotential or relative vorticity.
   m. Display the WV6.2 image and check which humidity field (which pressure level) matches best with the WV6.2 image?
   n. Load and display the WV7.3 image (range 220 to 280 K) and check which humidity field (which pressure level) matches best with the WV7.3 image?

When you have completed the tasks, check the case from 16 October 2014 on our web:
Dust storms over South Africa

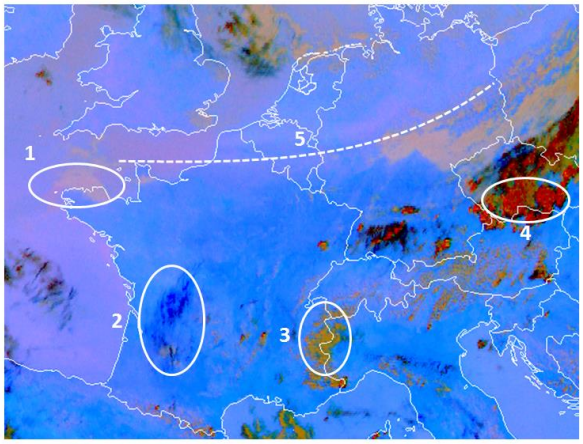
II. CASE IN EUROPE (main case for this lab – start with this one!)

6. Display SEVIRI imagery on 14 July 2006 over Europe

a. Close and re-open McIDAS-V
b. In the McIDAS-V window, go to **File → Open File**
c. Open the bundle "moisture_europe_20060714.mcvz" under **/data/Weather/Summer-School-Bracciano-20-29_June_2022/McV DATA/bundles**
d. Select **Merge with active tab(s)** (default option) and **Write to temporary directory.** Click **OK** when error message appears
e. In the first **Select input** window select minrefl 0 and maxrefl 50
f. In the second **Select input** window select minrefl 0 and maxrefl 20
g. Wait until all frames are loaded, the display window should look like this (WV7.3 image is in front):



h. First, let us look in detail at the 10:30 UTC images (see SEVIRI 10.30 UTC tab), look at the Dust RGBs (both) and the Natural Colour RGB.



Questions: Can you identify the features 1 to 5? Toggle the 2 RGB images. Are all 5 features visible in the Dust RGB also visible in the Natural Colour RGB?

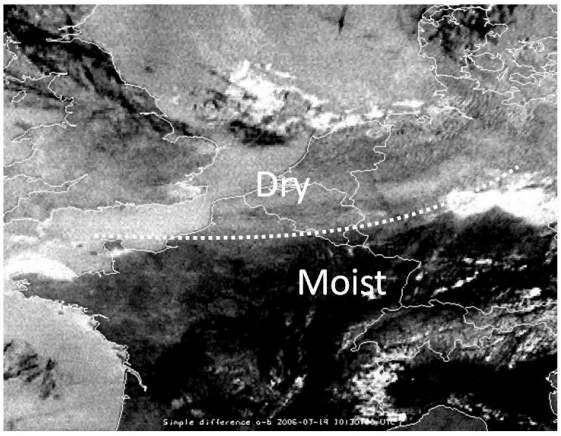
i. To investigate feature 5, we can look at the Generic Dust RGB and enhance it by changing the ranges
j. Go to the **Data Explorer** Window and select the **Layer Controls** tab
k. On the left side, select the Generic Dust RGB of Panel 1
l. Change the red range to [-3, 0], the green range to [0, 5] and the blue range ton [273, 300].

Remember, each time you change a value you have to click Enter!

m. Is this modified Dust RGB better than the standard Dust RGB? Toggle the 2 images.

7. Analyse the Difference IR12.0 – IR10.8 (red component of Dust RGB)

a. In the map window, select **File → New Display Tab → Map Display → One Panel**
b. A new McIDAS-V window tab will appear (untitled)
a. Rename this new tab to "Difference IR12 – IR11" (double click the tab for renaming)
c. Go to the **Field Selector** tab in the **Data Explorer** window
d. Select **Formulas** in the **Data Sources** panel
e. In the **Fields** panel, select **Miscellaneous → Simple difference a-b**
f. Select **Imagery → Image Display** in the **Displays** panel
g. Click **Create Display**, and a new window pops up
h. For Field a select the first(!) FD-MET data → **12.0 um IR**
i. For Field b select the first(!) FD-MET data → **10.8 um IR**
j. Click **OK**
k. The difference IR12.0 – IR10.8 (the red component of the Dust RGB) is now displayed
l. Change the range to **-3…0** K, the difference image should look like this:



Question: There is a moisture boundary running across France and Germany. Please, read some typical values of the IR12.0 – IR10.8 difference for the dry and the moist area!

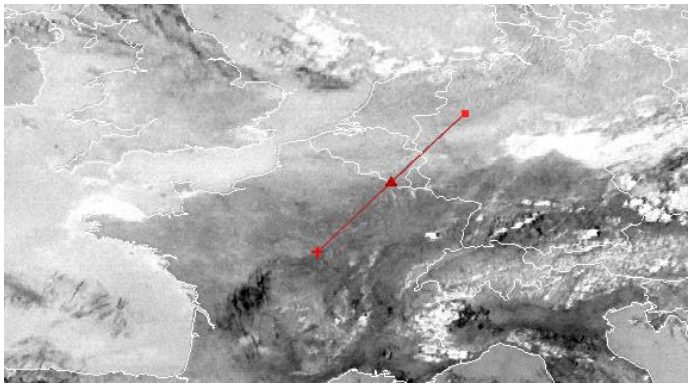
m. To do this, hold down the mouse wheel and move the cursor across the image
n. The lat/lon and temperature information appears on the bottom of the display window
o. Read and note the BTD (brightness temperature difference) values of the IR12.0 – IR10.8 image

Question: What is the largest (negative) value that you get in the moist (cloud-free) area? Hint: colour enhancement helps.

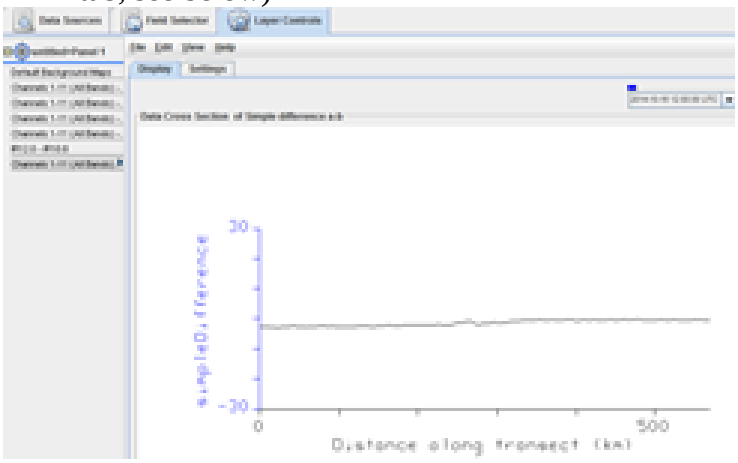
8. Plot a data transect for the IR12.0 – IR10.8 difference from dry to moist airmass

a. Go to the **Field Selector** tab in the **Data Explorer** window
b. Select again **Formulas** in the **Data Sources** panel
c. In the **Fields** panel, select **Miscellaneous → Simple difference a-b**
d. Select **Data Transect** in the **Displays** panel (at the bottom)
e. Click **Create Display,** and a new window pops up
f. For Field a select first(!) **FD-MET → 12.0 um IR**

g. For Field b select first(!) **FD-MET → 10.8 um IR**
h. Click **OK**
i. A cross-section indicator appears in the McIDAS map window (see below, eventually you have to zoom out to see it!)



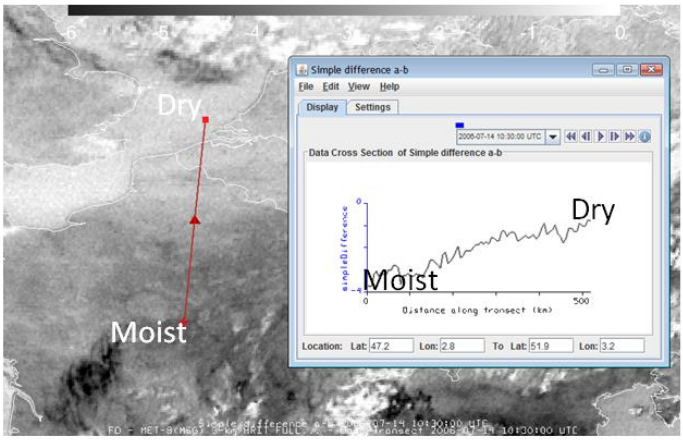
j. And the values of the cross-section appear in the **Data Explorer** window (in the **Layer Controls** tab, see below)



k. To get a separate window for the cross-section data, in the **Layer Controls** tab select the **View → Undock from Data Explorer** (see below)

l. And change the vertical scale of the transect as indicated below. In the new **Data Transect** window, click the **Settings** tab and then press **Change** next to the **Vertical Scale** and change the range to **-4** to **0 K** and click **OK**

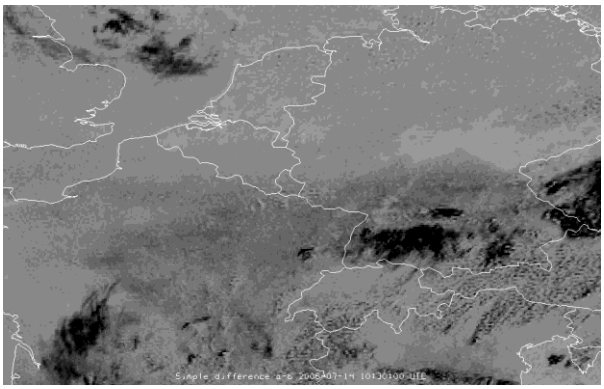
m. Last but not least, drag the endpoints of the cross-section to the desired positions (from dry- to moist airmass, see example below), and have a look at the result



Question: This display shows the cross-section of the IR12.0 – IR10.8 difference. Why does it change from around -1 to -4 K when moving from the dry to the moist airmass?

9. Generate the Green component of the Dust RGB image (IR10.8 – IR8.7)

a. Go to the **Field Selector** tab in the **Data Explorer** window
b. Select **Formulas** in the **Data Sources** panel
c. In the **Fields** panel, select **Miscellaneous → Simple difference a-b**
d. Select **Imagery → Image Display** in the **Displays** panel
e. Click **Create Display**, and a new window pops up
f. For Field a select first **FD-MET → 10.8 um IR**
g. For Field b select first **FD-MET → 8.7 um IR**
h. Click **OK**
i. The difference IR10.8 – IR8.7 (the green component of the Dust RGB) is now displayed
j. Change the range to **0…+15** K and select a black/white colour scale from **Satellite → Group1 → GAM25.** This colour scale is black/white with a Gamma enhancement of 2.5.
k. Click **OK**
l. Change the label of the displayed image to the "IR10.8 – IR8.7"
m. Now, the difference image should look like this:



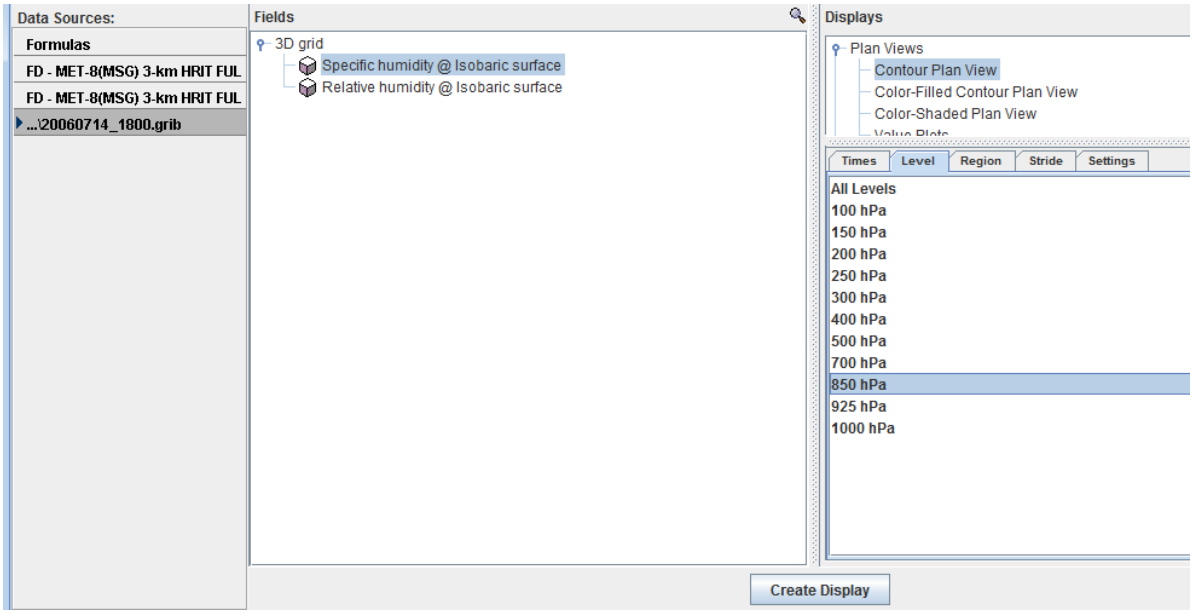
Question: Can you see the moisture boundary in this difference image? Why are ice clouds black? Toggle this difference image and the IR12.0 – IR10.8 difference image.

10. Situation at 18:00 UTC

    a. Now, let us look in detail at the 18:00 UTC images (see SEVIRI 18.00 UTC tab), look at the Dust RGBs (both) and the Natural Colour RGB.
    b. As you can see, deep convective clouds only developed in the moist airmass (no convection in the dry, stable airmass). Can you see the moisture boundary?
    c. To better see the moisture boundary, enhance the Generic Dust RGB, by changing the ranges
    d. Go to the **Data Explorer** Window and select the **Layer Controls** tab
    e. On the left side, select the Generic Dust RGB of Panel 2
    f. As before, change the red range to [-3, 0], the green range to [0, 5] and the blue range ton [273, 300]. Remember, each time you change a value you have to click Enter!
    g. Is this modified Dust RGB better than the standard Dust RGB? Toggle the 2 images.
    h. Now, check if the moisture boundary is visible in the WV7.3 image?
    i.

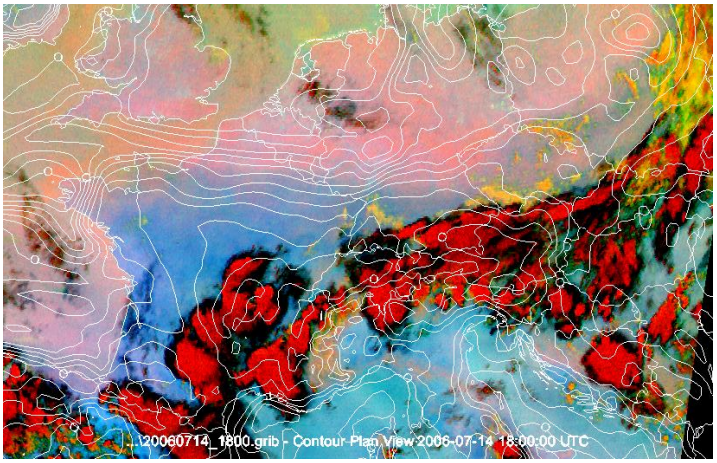
11. Compare the enhanced Dust RGB to model moisture fields. In order to do that, open the ECMWF 18 UTC analysis for this case (GRIB data).

    a. Display the Generic Dust RGB as top image
    b. In the map window, navigate to **File → Open File**
    c. Open the file "**20060714_1800.grib**" under **/data/Weather/Summer-School-Bracciano-20-29_June_2022/McV DATA\ecmwf** (if you see an empty folder, set **Files of Type** to **All Files**)
    d. Click **Open**, wait. Note that you will not have new imagery appearing at this point.
    e. Go to the **Data Explorer** window and select the **Field Selector** tab
    f. Select the **...\20060714_1800.grib** data under **Data Sources**
    g. Under the **Fields** panel, select **3D grid → Specific Humidity**
    h. Under the **Displays** panel, select **Plan Views → Contour Plan View**
    i. Select **850 hPa** under the **Level** tab



j. Click: **Create Display,** wait

k. Change the colour of the isolines to **White** (under **Layer Controls**, **Color Table**, choose **System → Solid colors** → White)**.** You may also change the contour interval (left click on the legend label to get the layer controls where you can change the Contour interval). The display should look like this:



Question: Does the model field (specific humidity at 850 hPa) match the satellite info (Generic Dust RGB)?

l. Try to display the relative humidity (at different levels)

m. Display the WV7.3 image and check which humidity field (which pressure level) matches best with the WV7.3 image?

12. Look at this case in MODIS IR data

a. In the map window, select **File → New Display Tab → Map Display → One Panel**

b. A new McIDAS-V window tab will appear (untitled)

c. Rename this new tab to "MODIS" (double click the tab for renaming)

d. In the **Data Explorer** window, select the **Data sources** tab

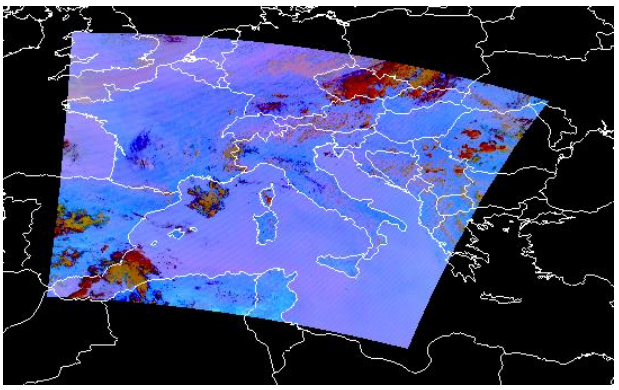
e. Select Imagery under Satellite in the panel on the left side

f. Select Server: <LOCAL-DATA>

g. Select the Dataset: MODIS

h. Click Connect and wait

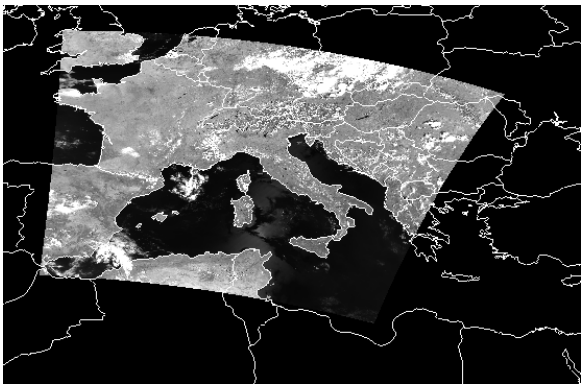
i. Select the Image Type: Level 1B Data
j. Go to the Absolute tab and select the image at **2006-07-14 10:20:00 UTC**
k. Click Add Source and wait
l. In the Field selector tab, select Formulas
m. In the Fields panel, select **SEVIRI RGB → DUST**, click Create Display and a new window pops up:
n. Field IR8.7: select 8.5288 um Cirrus Cloud Water Vapour → Temperature, wait
o. Field IR10.8: select 11.0186 um Surface/Cloud Temperature → Temperature, wait
p. Field IR12.0: select 12.0325 um Surface/Cloud Temperature → Temperature, wait, Do not click Ok!!!
q. Resize the Field Selector window – make it bigger so that you can see the Times, Region and Advanced tabs of the 3rd bottom panel
r. Make sure that Magnification is set to maximum
s. Make sure that Region is the full region (if not already set)
t. Click Ok, wait
u. Zoom in to Europe. The resulting image should look like this:



Question: can you see the moisture boundary in this MODIS image?

13. Look at this case in MODIS VIS data

a. In the Field selector tab, instead **Formulas** go to the **Level 1B Data (All Bands)**
b. Select **0.8567 um → Reflectance** under the Fields panel (MODIS band 2) and wait
c. Select Imagery → Image Display in the Displays panel
d. Select the Advanced tab and put the Magnification slider to the maximum
e. Go to the Region tab and select the entire region (this is the default, so do not change)
f. Click Create Display, wait
g. Change the range to 0.0 to 0.5. The resulting image should look like this:

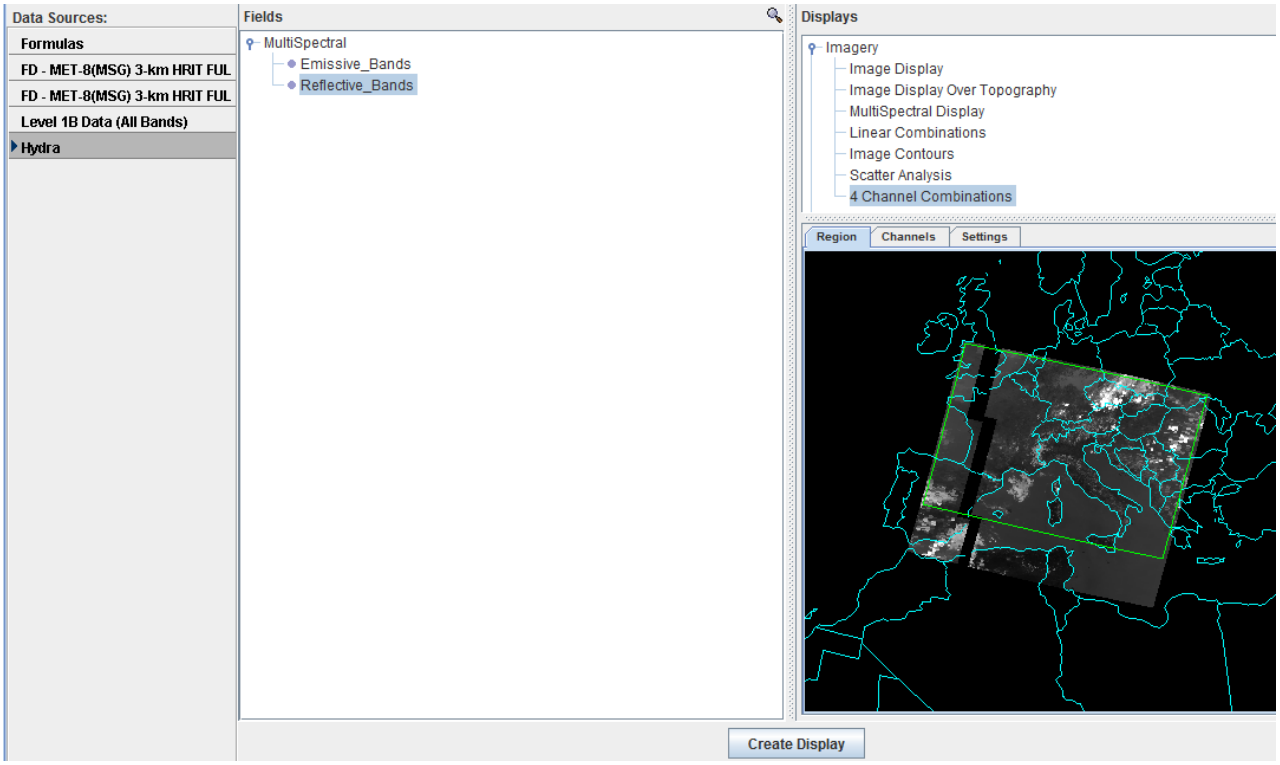


Question: can you see the moisture boundary in this 0.8 micron MODIS image?

h. Now, open the **0.9361 um → Reflectance** under the Fields panel (MODIS band 19)
i. Change the range to 0.0 to 0.2.

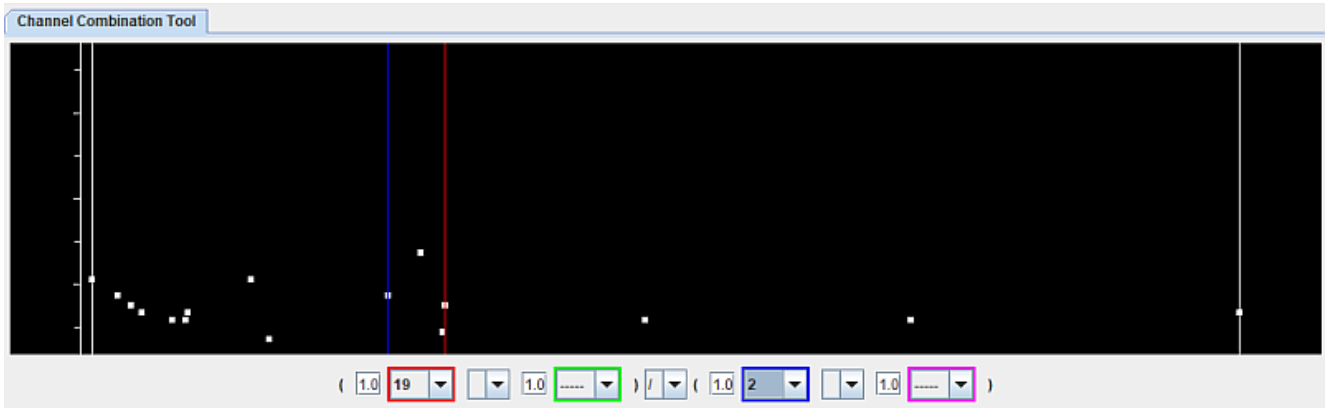
Question: can you see the moisture boundary in this 0.9 micron MODIS image?

j. To create a better contrast between dry and moist airmasses, let us create a SMT (solar moisture transmittance), linear combination of 0.8 and 0.9 micron channels.
k. In the Data Explorer window, select **Data Sources → Satellite → HYDRA**
l. Then select again the MODIS data MOD021KM.A2006195.1020.006.2014220115736.hdf (in Data modis)
m. Click Add Source in the lower right corner
n. In the Fields tab, select **MultiSpectral** and highlight **Refelctive_Bands**
o. Then in the Displays window, select **4 Channel Combinations** and carefully select the region inside the MODIS granule (see example below) to get a full resolution image.
p. click **Create Display**



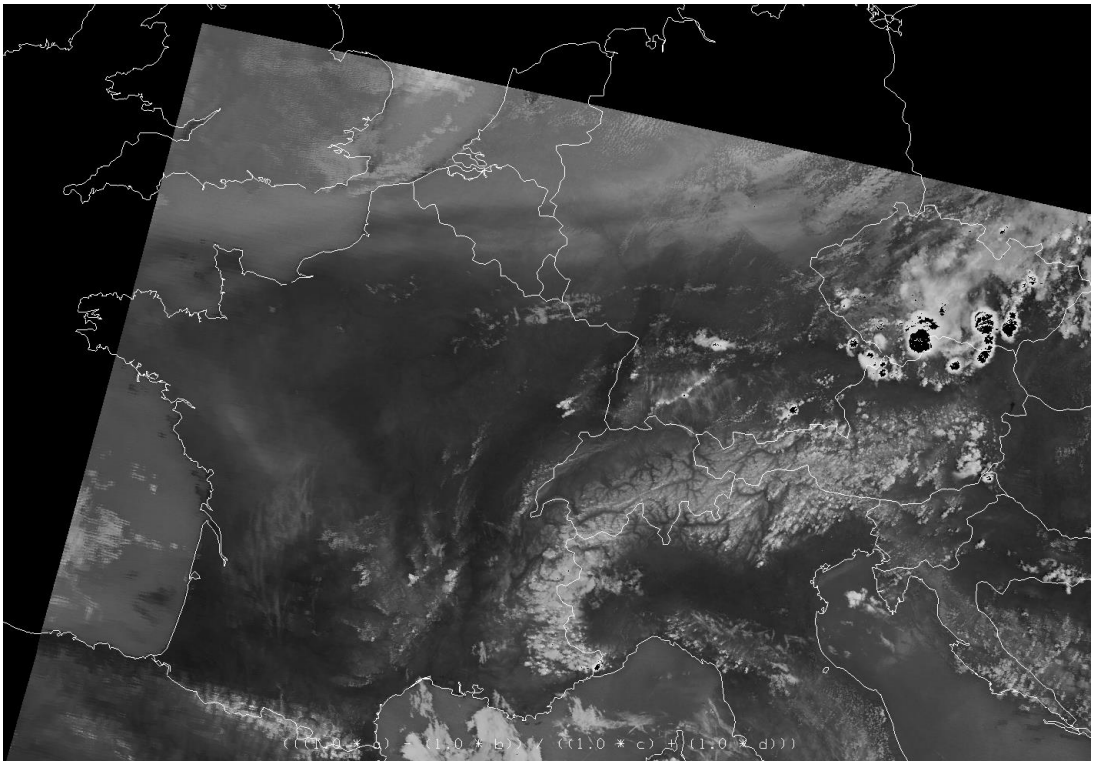
q. You get an option to select channels to make the SMT (solar moisture transmittance) index.

r. The SMT (solar moisture transmittance) formula you should enter below the black plot is: **(band 19 (blank)) / (band 02 (blank))**



s. Now click **Compute New Field**
t. Go to the Field Selector tab and you will see the new formula (under MultiSpectral)
u. Click that and make sure that **Image Display** is highlighted under Imagery in the Displays window
v. Click Create Display
w. Change the range to **0.0 to 1.0** (grayscale colour table)

The result should look similar to this:



Question: can you see the moisture boundary in this SMT difference? Why did we visualize the SMT difference and not a single 0.9 micron channel?

Can you read some values of this SMT difference in the dry and the moist airmasses ?

x. Extra task: If you have time, you may display the 1.3820 micron band (band 26 of MODIS). This channel is available on the Flexible Combined Imager (FCI) of MTG (Meteosat Third Generation). What do you see?