MODIS and AIRS Workshop

7 April 2006 Pretoria, South Africa

LAB 4

Lab on AIRS retrievals, spectral signatures, and SO₂ detection.

This Lab was prepared to provide practical insight into high spectral resolution infrared observation from AIRS.

Exercise 1 Atmospheric absorption.

The goal of this exercise is to gain an understanding of water vapor molecular absorption and its spectral characteristics in the infrared portion of the spectrum

1. Open **Hydra** and load AIRS.2005.08.28.103.L1B.AIRS_Rad.v4.0.9.0.G05241172839.hdf. Under **Start** open the **MultiChannel Viewer** . Engage the reference spectrum icon (look under **Tools** and find **Reference Spectrum** and click on). Using Hydra again load the AIRS retrievals for this scene found in AIRS.2005.08.28.103.atm_prof_rtv_npc030.hdf (leave the Multichannel Viewer with the AIRS data open). Under **Variables** select **Air Temperature Profiles** and under Tools turn **Reference Profile** on. In Multi-Channel Viewer, using the arrows in the bottom tool bar select one FOV directly in the cloud in ther eastern Black Sea and another FOV nearby in clear skies.

(a) Observe the characteristic spectral signature of an opaque cloud in the Multi-Channel Viewer (see Figure 1 of Lab4). Now observe the temperature profiles for the two FOVs in the Hydra AIRS level 2 Products Window (see Figure 1). What can you infer about the height of the opaque cloud?

(b)Why?

(c) Inspect the temperature retrieval image for various pressure levels (in the Hydra AIRS level 2 Products Window use the first arrow in the bottom tool bar to move the horizontal green line to different pressure

levels); the pressure level where the retrieval field shows large contrast over the cloud is indicative of its height.
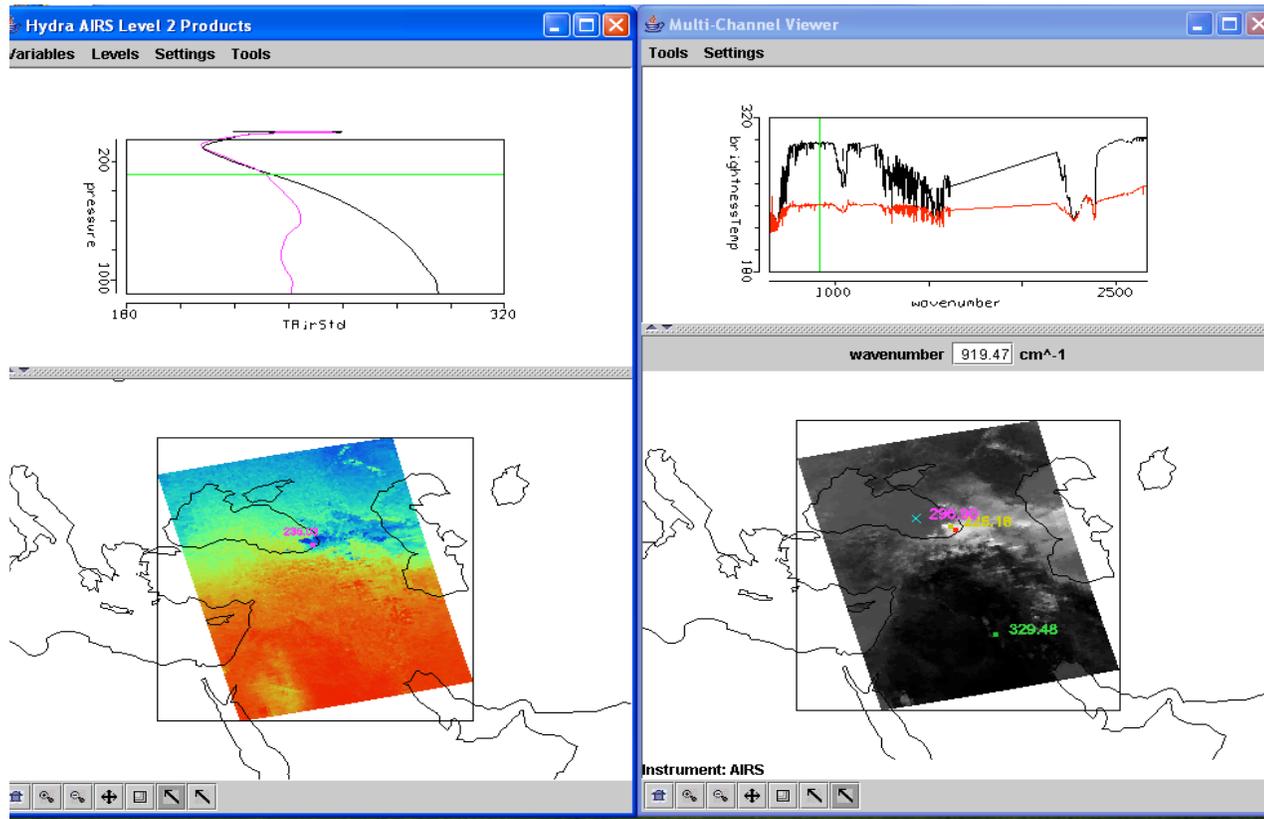

Figure 1. (right) MultiChannel Viewer display with reference spectrum on showing cloudy and clear sky AIRS spectra over the Black Sea. (left) AIRS temperature profile retrievals in clear and cloudy FOVs and the 300 hPa temperature retrieval field for the granule.

1b. Explore the spectra and the inferred height of several other clouds in the scene. Record their location and your estimate of their height.

2. In the Hydra AIRS level 2 Products Window, under *Variables* select *Water Vapor Profiles.*

(a) Inspect the moisture retrieval image for 900 hPa. The western Black Sea appears to have more low level moisture than the eastern part. In the Multi-Channel Viewer display two spectra, one for a FOV in the moister region and one in the drier region. Zoom in on the two spectra at 870 cm-1 (click on the icon third from the right in the bottom tool and then click and drag over the appropriate part of the spectrum – repeat until full resolution of the absorption lines in the IR window are apparent). You should have something that looks like

Figure 2. Does the on-line off-line brightness temperature difference in this part of the spectrum agree with the inference from the retrieval field?
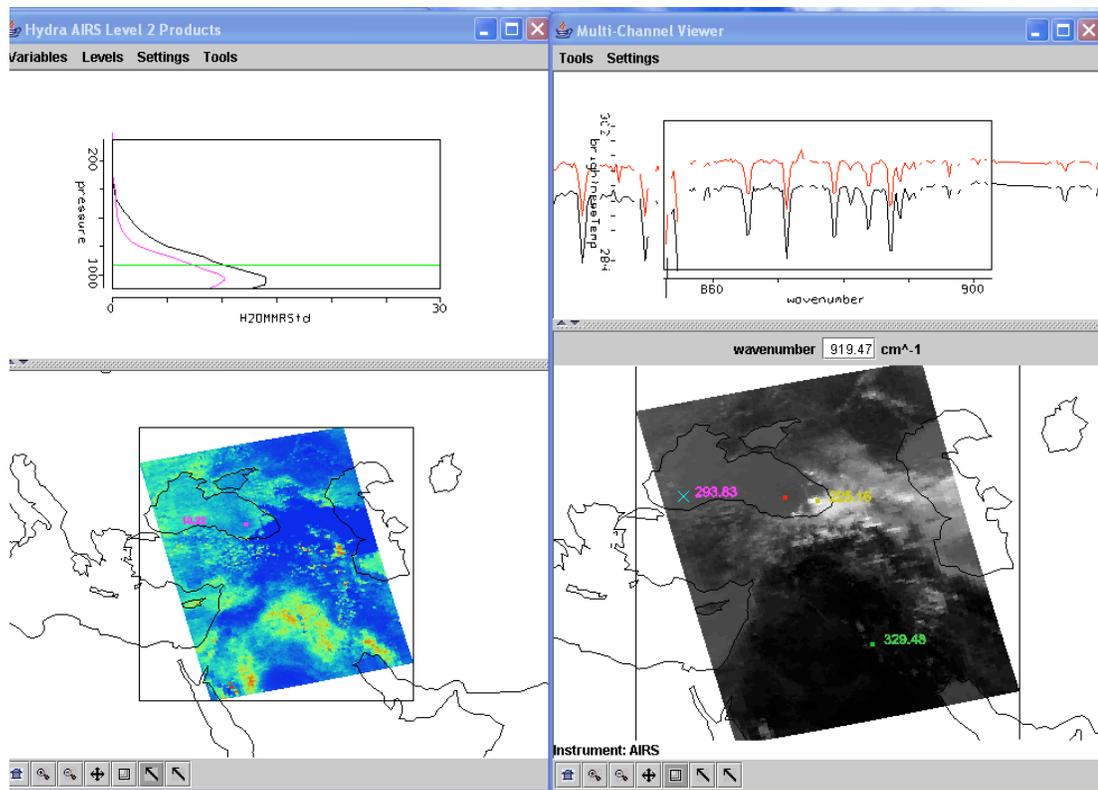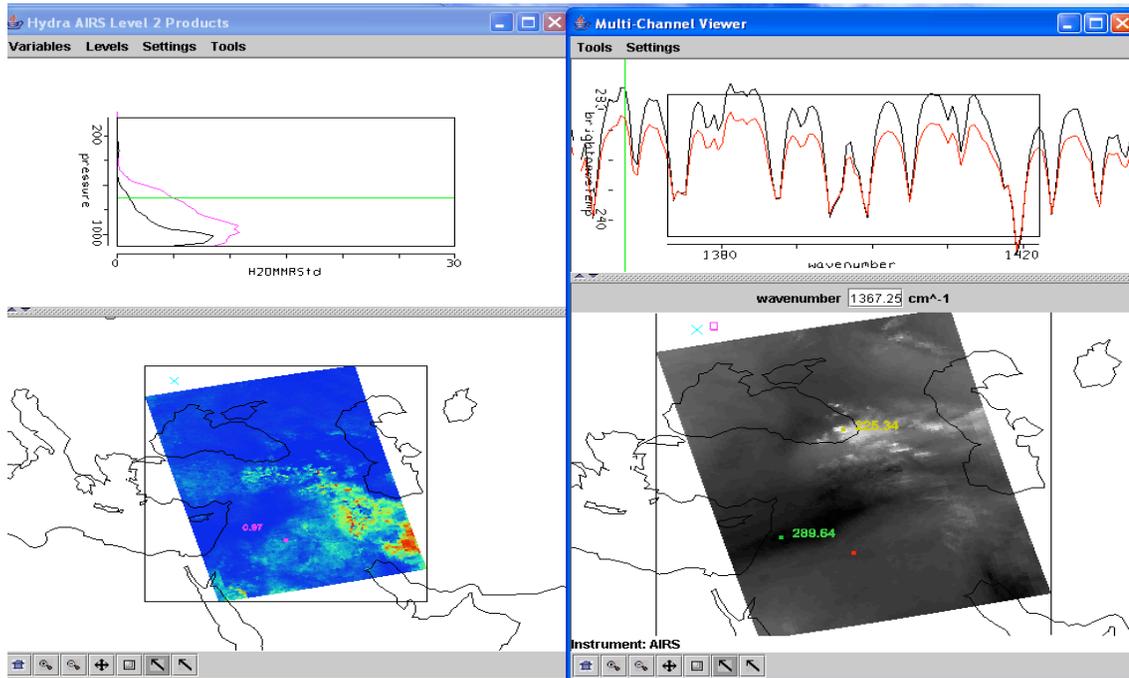
(b)Explain?

Figure 2. (right) MultiChannel Viewer display with zoom in on IR window spectra near 870 cm-1 over FOVs in eastern and western Black Sea. (left) AIRS water vapor profile retrievals in the two selected FOVs and the 900 hPa water vapor retrieval field for the granule.

3. Repeat your investigation of atmospheric water vapor by displaying 1443 cm-1 measurements in the Multi-Channel Viewer. There is a dry band south of the Black Sea. Display the spectra and the water vapor profiles in and out of the dry band. Zoom in on the spectra between 1380 and 1420 cm-1. See Figure 3.

(a) Does the on-line off-line brightness temperature difference in this part of the spectrum agree with the inference from the retrieval field?

(b) Explain?

Figure 3. (right) MultiChannel Viewer display with zoom in on H_2O spectra between 1380 and 1420 cm-1 over FOVs in and out of the dry band south of the Black Sea. (left) AIRS water vapor profile retrievals in the two selected FOVs and the 700 hPa water vapor retrieval field for the granule.

4. Repeat the exercise using the granule over South Africa:
AIRS.2006.02.18.118.L1B.AIRS_Rad.v4.0.9.0.G06049152650.hdf
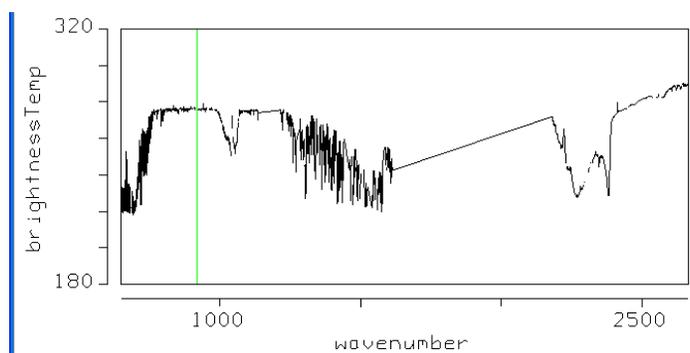and try to verify if your conclusions still holds true. If not explain why.

Exercise 2 Reading Spectra

The goal of this exercise is to gain an understanding of how to quickly extract information from high spectral resolution infrared spectra.
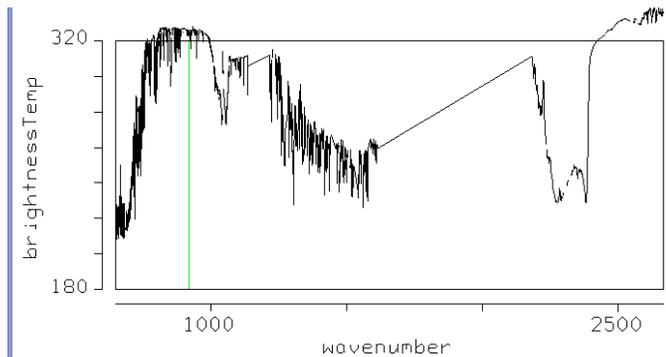
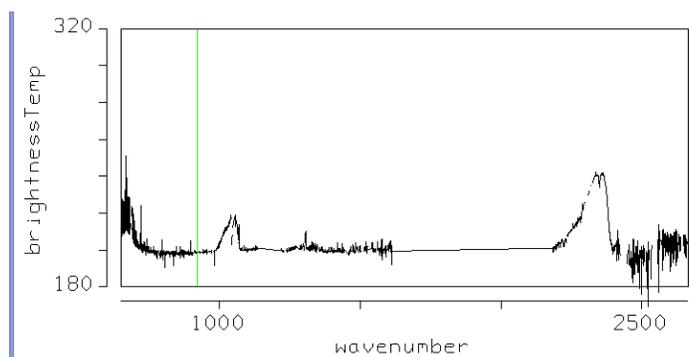1. For each figure select the correct answer(s)
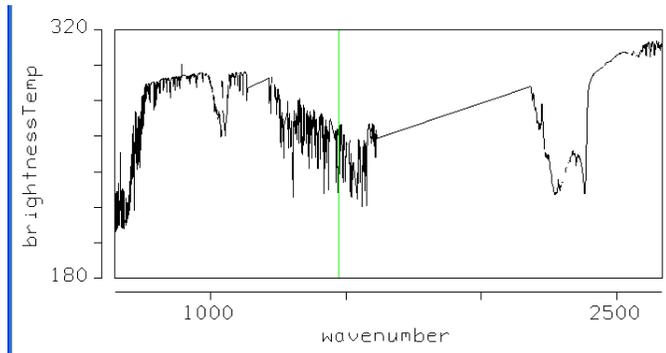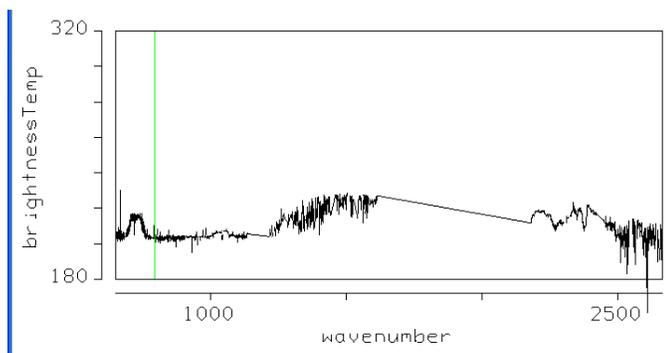

1) DAY, NIGHT, OCEAN, ICE, CLOUD

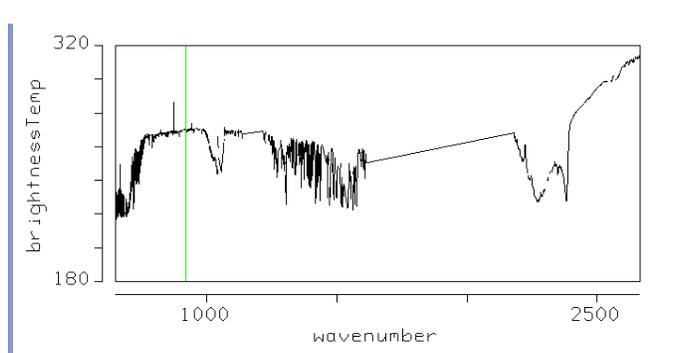

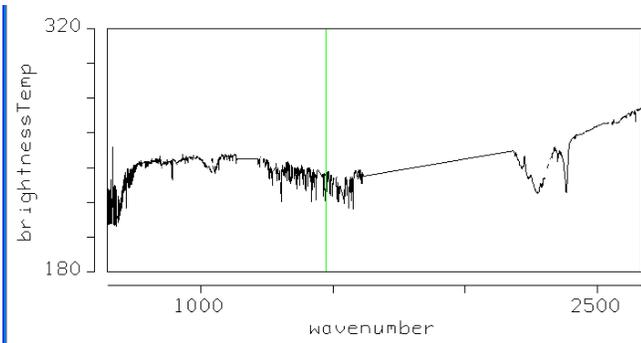2) NIGHT, OCEAN, DESERT, CLOUD

3) CLOUD, NIGHT, OCEAN, DESERT
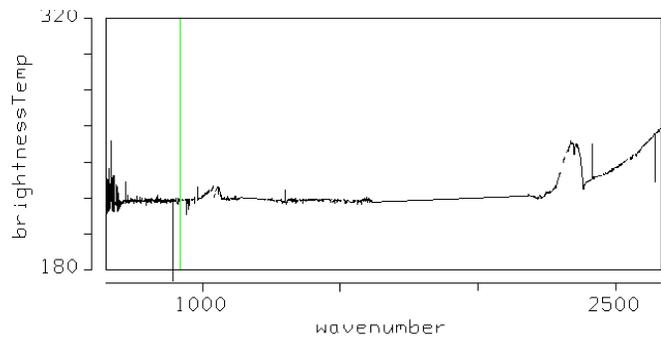

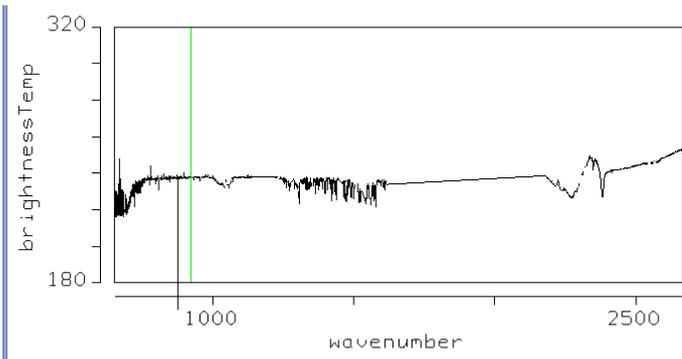4) DAY, NIGHT, OCEAN, ICE, CLOUD

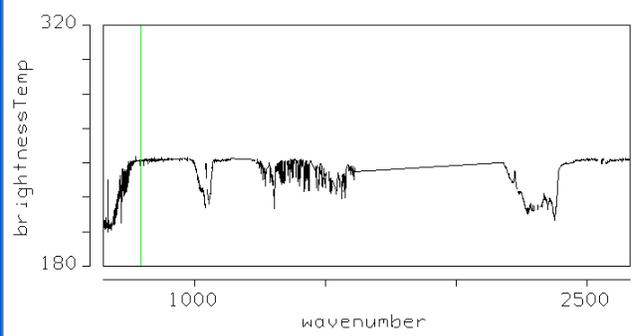5) CLOUD, OCEAN, ICE, NIGHT

6) OCEAN, ICE, CLOUD

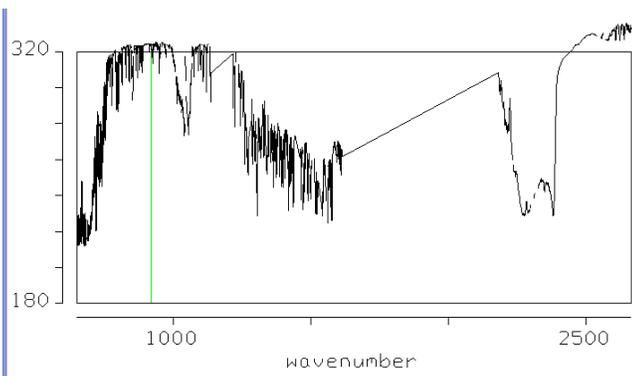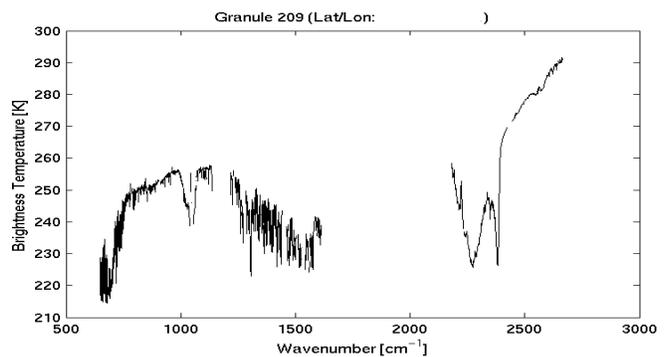7) DAY, CLOUD, OCEAN

8) ICE, OCEAN,NIGHT

9) LOW, CLOUD, HIGH CLOUD

10) DAY, HIGH CLOUD, OCEAN

11) LOW, CLOUD, DESERT, OCEAN

12) OCEAN, ICE, DAY, HIGH CLOUD

Exercise 3 SO₂ Detection

The goal of this exercise is to gain an understanding of trace gas detection using high spectral resolution infrared data.

4. Using **Hydra** load AIRS.2002.10.28.123.L1.AIRS_Rad.v2.6.10.3.A02302200913.hdf. This granule includes the eruption of Mount Etna on 28 October 2002 (see Figure 4a).
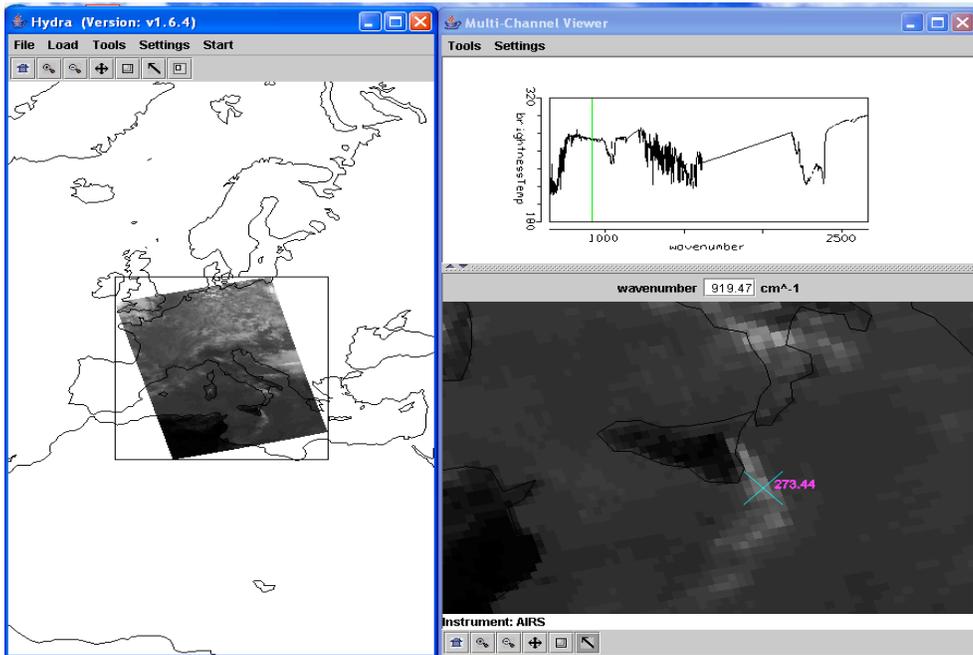

Figure 4a. AIRS measurements over eruption of Mount Etna on 28 October 2002
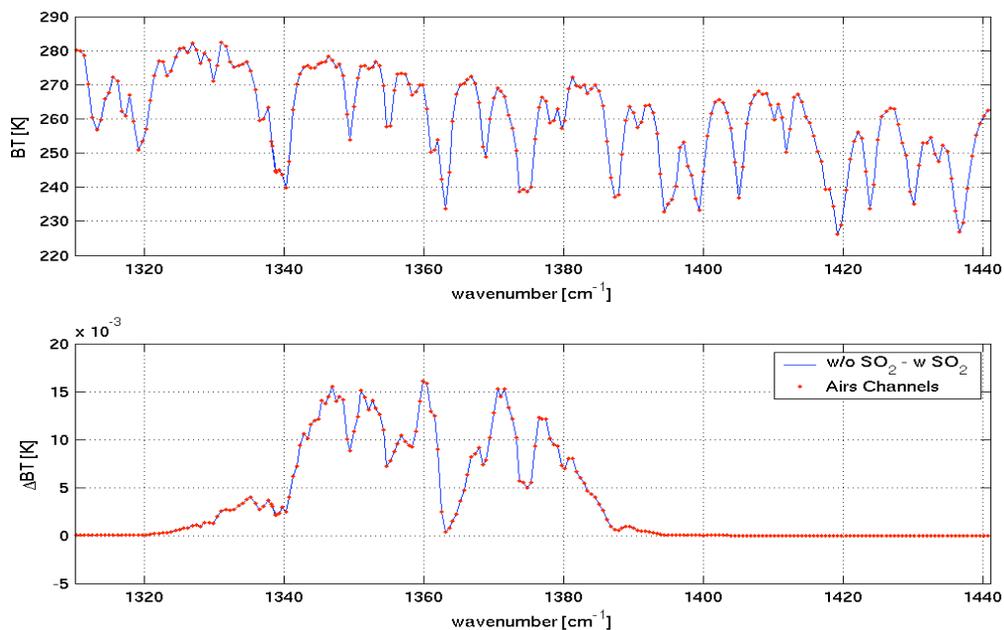

Figure 4b. (top) Simulated AIRS spectrum from 1320 cm^{-1} to 1441 cm^{-1}. (bottom) Differences between the simulated AIRS spectrum with and without climatological amounts of SO$_2$. The bottom plot simply indicates the

position of the SO_2 absortpion lines.

(a) Using **Combine Channels** calculate the difference between two wavenumber, AAAA.A and BBBB.B, that could be used to detect SO_2. How would you determine the optimal values for these wavenumbers?

(b) With a broadband instrument like AVHRR we would have used the difference 833.3 minus 909.0 cm-1 (12 – 11 microns). Map this difference into a different *pseudo channel*. How do the two figures compare?

(c) Select a single spectrum over the smoke plume. Verify that the spectrum has a peak around 1227.3 cm-1. Calculate the difference between 1123.0 and 1227.3 wavenumber, and map it onto the Y axes. Now calculate the differece between 1376.886 and 1414.008 and map it onto the X axes (this last combiniation represents the best estimate we could determine for AAAA.AA and BBBB.BB). Explain the differences between the pseudo-channels with the help of the scatter plot.

(d) Map the difference [(BT1123.0 – BT1227.3) – (BT1376.886 – BT1414.008)] to the X axis and 907.68 (window channel) to the Y axis. Get a scatter plot and look at the pseudo-channel mapped onto the X axis. Try to describe and explain what you observe in the pseudo-channel with the help of the scatter plot.

5. Using Hydra load AIRS.2002.10.28.123.atm_prof_rtv_npc030.hdf which contains the AIRS retrievals for this scene (leave the Multichannel Viewer with the AIRS data open). Under *Variables* select *Air Temperture Profiles*. Under Tools turn *Reference Profile* on. In the Multichannel Viewer turn *Reference Spectrum* on also. Using the arrows in the bottom tool bar select one FOV directly in the ask plume and another FOV nearby in clear skies. Observe the characteristic spectral signature of ash in the Multi-Channel Viewer. Observe the temperature profiles for the two FOVs in the Hydra AIRS level 2 Products Window.

(a) What can you infer about the height of the ash plume? Why? *Inspect the temperature retrieval image for various pressure levels (in the Hydra AIRS level 2 Products Window use the first arrow in the bottom tool bar to move the horizontal green line to different pressure levels); the pressure level where the retrieval field shows large contrast over the ash plume is indicative of its height.*

6. Consider the AIRS measurements in the CO2 region of the spectrum (see Figure 4). In the spectral regions where the red dots indicate the AIRS channel the online channels are warmer than the offline channels, can you explain why? In the spectral region where the magenta circles indicate the AIRS channels the on-line channels are colder than the off-line channels, what is the difference between the two spectral regions?
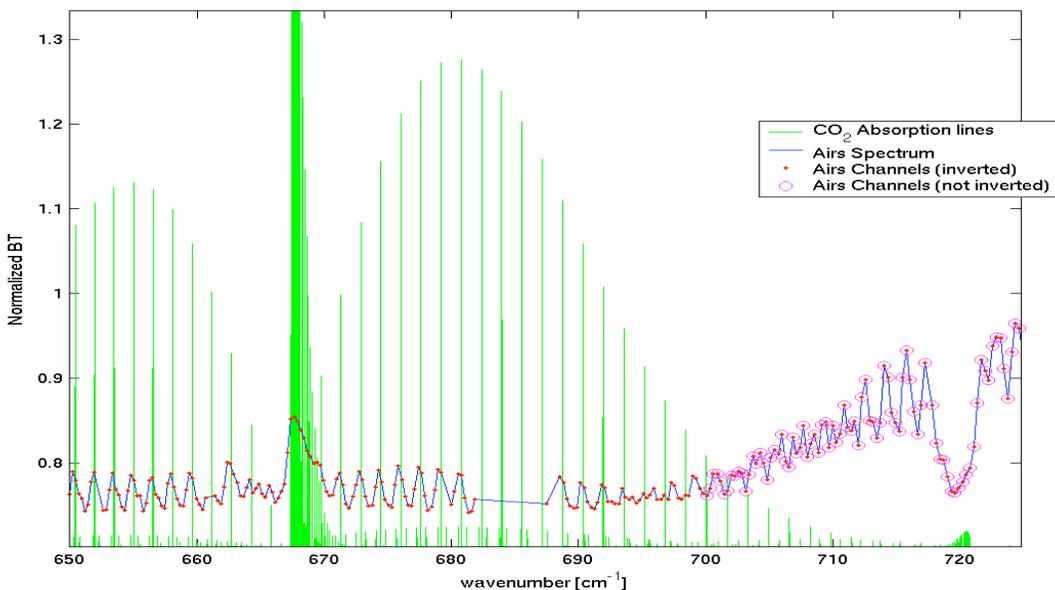

Figure 4. AIRS normalized spectrum (blue) and locations of CO2 lines (green).

(a) Using figure 4, plot a map of the tropopause temperature for the granule over Italy (determine wich channel in your opinion has the peak of the wighting function at the tropopause, and explain how did you select it)