AVIRIS Contribution at the WTC

- On the 14th of September Roger Clark of the USGS called to say there was a concern with asbestos contamination at the WTC disaster site

- Through the support of NASA HQ and others AVIRIS flew the disaster site on the 16th, 18th, 22nd, and 23rd

- AVIRIS contributed in three areas
  - Hot spot location and temperature determination
  - Asbestos mapping
  - Debris composition and distribution mapping

WTC Hot Spot Temperature Estimates
From AVIRIS Spectra

- On the 16th of September 2001 AVIRIS acquired data over the WTC disaster site.

- Preliminary analysis on the 17th showed the location of 8 hot spot zones where surface temperatures were very high indicating active fires

- In record time, Joe Boardman determined the latitude and longitude of the 8 hot spot areas.
WTC Hot Spot Temperature Estimates From AVIRIS Spectra

- The temperature and location of the hottest target in each of the zones was determined.

- At the request of the Office of Science and Technology Policy a second AVIRIS data set was acquired on the 18th of September 2001.

- Analyses from these data were provided on the 19th and show a decrease in the number and temperature of the remaining hot spots.

AVIRIS Data Set of WTC Disaster Site 010916
Hot Areas at the WTC Disaster Site at 2300 nm wavelength
Hot Spots at the WTC Disaster Site 010916

Spectra of Hot Areas at the WTC Disaster Site

Wavelength (nm)

Sensor Saturation

Radiance

- Hot Target
- Adjacent Surface
WTC Hot Spot Temperature Estimates From AVIRIS Spectra

- Temperature is estimated from the shape of the Planck function after subtracting reflected light estimate and excluding zones of saturation and strong atmospheric absorption.

- Both the temperature and fractional area of the hot spot are derived.

- The analysis has been performed on the hottest targets in the eight identified hot spot areas of the WTC AVIRIS data set acquired on 16 September 2001.

- Future analysis is planned to better account for the transmittance of the atmosphere and the emissivity of the surface.

AVIRIS Temperature Estimate
WTC Hot Spot Zone A

![Graph showing AVIRIS Temperature Estimate for WTC Hot Spot Zone A]
WTC Hot Spot Locations Temperature Estimates
From AVIRIS Spectra 010916

<table>
<thead>
<tr>
<th>Hot Spot</th>
<th>Lat/Lon</th>
<th>Temperature Estimation (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>40-42-47.18 74-00-41.43</td>
<td>928</td>
</tr>
<tr>
<td>b</td>
<td>40-42-47.14 74-00-43.53</td>
<td>827</td>
</tr>
<tr>
<td>c</td>
<td>40-42-42.89 74-00-48.88</td>
<td>921</td>
</tr>
<tr>
<td>d</td>
<td>40-42-41.99 74-00-46.94</td>
<td>791</td>
</tr>
<tr>
<td>e</td>
<td>40-42-40.58 74-00-50.15</td>
<td>710</td>
</tr>
<tr>
<td>f</td>
<td>40-42-38.74 74-00-46.70</td>
<td>700</td>
</tr>
<tr>
<td>g</td>
<td>40-42-39.94 74-00-45.37</td>
<td>1019</td>
</tr>
<tr>
<td>h</td>
<td>40-42-38.60 74-00-43.51</td>
<td>817</td>
</tr>
</tbody>
</table>

* Lat/Lon values are in WGS-84 datum, deg-min-decimal seconds
* Location accuracy should be good to ~18 feet (6 meters)

Consistency Test

- Are the fractional area and temperature independent?

- Solve for a temperature and fractional area

- Dilute the spectrum with a non fire spectrum

- Solve for temperature and fractional area again.
  - Is the temperature the same?
  - Is the diluted area correct?
AVIRIS Temperature Estimate
WTC Hot Spot Zone A

WTC Hot Spot Area A
Hottest Spectrum
Temperature Estimate: 928K
6% of the area
AVIRIS Temperature Estimate
WTC Hot Spot Zone B

AVIRIS Temperature Estimate
WTC Hot Spot Zone C
AVIRIS Temperature Estimate
WTC Hot Spot Zone D

WTC Hot Spot Area D
Hottest Spectrum
Temperature Estimate=791K
18% of the area

AVIRIS Temperature Estimate
WTC Hot Spot Zone E

WTC Hot Spot Area E
Hottest Spectrum
Temperature Estimate=710K
9% of the area
AVIRIS Temperature Estimate
WTC Hot Spot Zone F

WTC Hot Spot Area F
Hottest Spectrum
Temperature Estimate=700K
8% of the area

AVIRIS Temperature Estimate
WTC Hot Spot Zone G

WTC Hot Spot Area G
Hottest Spectrum
Temperature Estimate=1019K
1.1% of the area
AVIRIS Temperature Estimate
WTC Hot Spot Zone H

WTC Hot Spot Area H
Hottest Spectrum
Temperature Estimate: 817K
1.8% of the area
WTC Hot Spot Temperature Estimates
From AVIRIS Spectra 18 September 2001

- The hot spot zones labeled A to H are the same as in the 16th data set.
- Several additional hot spots were identified on the 18th. This may simply be due to increasing sophistication of the analysis.
- The AVIRIS data on the 18th were acquired in the afternoon under cloud cover.

Hot Spots at the WTC Disaster Site 010918

AVIRIS georectified image with hot spot zones labeled.

Hot Spot Color Scale
Red=high intensity
to
Blue=lower
Hot Spots at the WTC Disaster Site 010918

WTC Hot Spot Locations Temperature Estimates
From AVIRIS Spectra 010918

<table>
<thead>
<tr>
<th>Hot Spot</th>
<th>Lat/lon</th>
<th>Estimation (K)</th>
<th>Area%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>40-42-46.96</td>
<td>74-00-41.21</td>
<td>852</td>
</tr>
<tr>
<td>B</td>
<td>40-42-47.31</td>
<td>74-00-43.31</td>
<td>790</td>
</tr>
<tr>
<td>C</td>
<td>40-42-43.38</td>
<td>74-00-48.15</td>
<td>500</td>
</tr>
<tr>
<td>D</td>
<td>40-42-42.46</td>
<td>74-00-46.84</td>
<td>700</td>
</tr>
<tr>
<td>E</td>
<td>not seen on Tuesday</td>
<td>74-00-46.01</td>
<td>725</td>
</tr>
<tr>
<td>F</td>
<td>40-42-38.82</td>
<td>74-00-45.45</td>
<td>832</td>
</tr>
<tr>
<td>G</td>
<td>40-42-39.77</td>
<td>74-00-43.04</td>
<td>471</td>
</tr>
<tr>
<td>H</td>
<td>40-42-39.04</td>
<td>74-00-43.85</td>
<td>782</td>
</tr>
<tr>
<td>I</td>
<td>40-42-37.50</td>
<td>74-00-47.01</td>
<td>no fit</td>
</tr>
<tr>
<td>J</td>
<td>40-42-36.97</td>
<td>74-00-45.26</td>
<td>538</td>
</tr>
<tr>
<td>K</td>
<td>40-42-42.89</td>
<td>74-00-46.58</td>
<td>805</td>
</tr>
</tbody>
</table>

- Lat/lon values are in WGS-84 datum, deg-min-decimal seconds
- Location accuracy should be good to ~18 feet (6 meters)
- Temperatures and Areas are initial estimates for the hottest spectrum in each hot spot zone.
WTC Hot Spot Temperature Estimates From AVIRIS Spectra 010918

- Temperature is estimated from the shape of the planck function after subtracting reflected light estimate and excluding zones of saturation and strong atmospheric absorption.

- Both the temperature and fractional area of the hot spot are derived.

- The analysis has been performed on the hottest targets in the identified hot spot areas of the WTC AVIRIS data set acquired on 18 September 2001.

- Future analysis will better account for the transmittance of the atmosphere and the emissivity of the surface.

AVIRIS Temperature Estimate
WTC Hot Spot Zone A
AVIRIS Temperature Estimate
WTC Hot Spot Zone B

Temperature Estimate = 790K
36% of the area

AVIRIS Temperature Estimate
WTC Hot Spot Zone C

Temperature Estimate = 500K
22% of the area
AVIRIS Temperature Estimate
WTC Hot Spot Zone D

AVIRIS Temperature Estimate
WTC Hot Spot Zone F
AVIRIS Temperature Estimate
WTC Hot Spot Zone G

AVIRIS Temperature Estimate
WTC Hot Spot Zone H
AVIRIS Temperature Estimate
WTC Hot Spot Zone I

Hottest Spectrum
Temperature Estimate=762K
35% of the area

AVIRIS Temperature Estimate
WTC Hot Spot Zone K

Hottest Spectrum
Temperature Estimate=538K
7% of the area
AVIRIS Temperature Estimate
WTC Hot Spot Zone L

AVIRIS 010918
WTC Hot Spot Area I
Hottest Spectrum
Temperature Estimate=805K
0.5% of the area

AVIRIS Temperature Estimate
WTC Hot Spot Zone I

AVIRIS 010918
WTC Hot Spot Area I
Hottest Spectrum
Temperature Estimate=762K
35% of the area
Summary
WTC Hot Spot Temperature Estimates From AVIRIS Spectra

- On 16, 18, 22, and 23 of September 2001 AVIRIS acquired data over the WTC disaster site.
- Preliminary analysis on the 17th showed the location of 8 hot spot zones where surface temperatures were very high indicating fires.
- Detailed analysis was performed to determine the temperature and area of the hottest target in each hot spot zone.
- This information was provided to and used by the people on the ground.

WTC Hot Spot Temperature Estimates From AVIRIS Spectra

- The hot spot zones labeled A to H are the same as in the 16th data set.
- Several additional hot spots were identified on the 18th. This may simply be due to increasing sophistication of the analysis.
- The AVIRIS data on the 18th were acquired in the afternoon under cloud cover.
- AVIRIS data and spectra acquired in the AVIRIS spectral range provide an excellent basis for hot target temperature and fractional area determination.