

GRASS GIS 7: A theoretical and practical course

Session 1 – Advanced: image processing

Markus Neteler

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mundialis GmbH & Co. KG
<http://www.mundialis.de>





Session Objectives

- Image pansharpening
 - Exercise – Image fusion - pansharpening
- Terrain correction (radiometric correction)
- Atmospheric correction (radiometric correction)
- De-hazing of LANDSAT TM7
- Image classification
- Principal component analysis (PCA)
- Texture analysis
- Thermal remote sensing (LANDSAT)

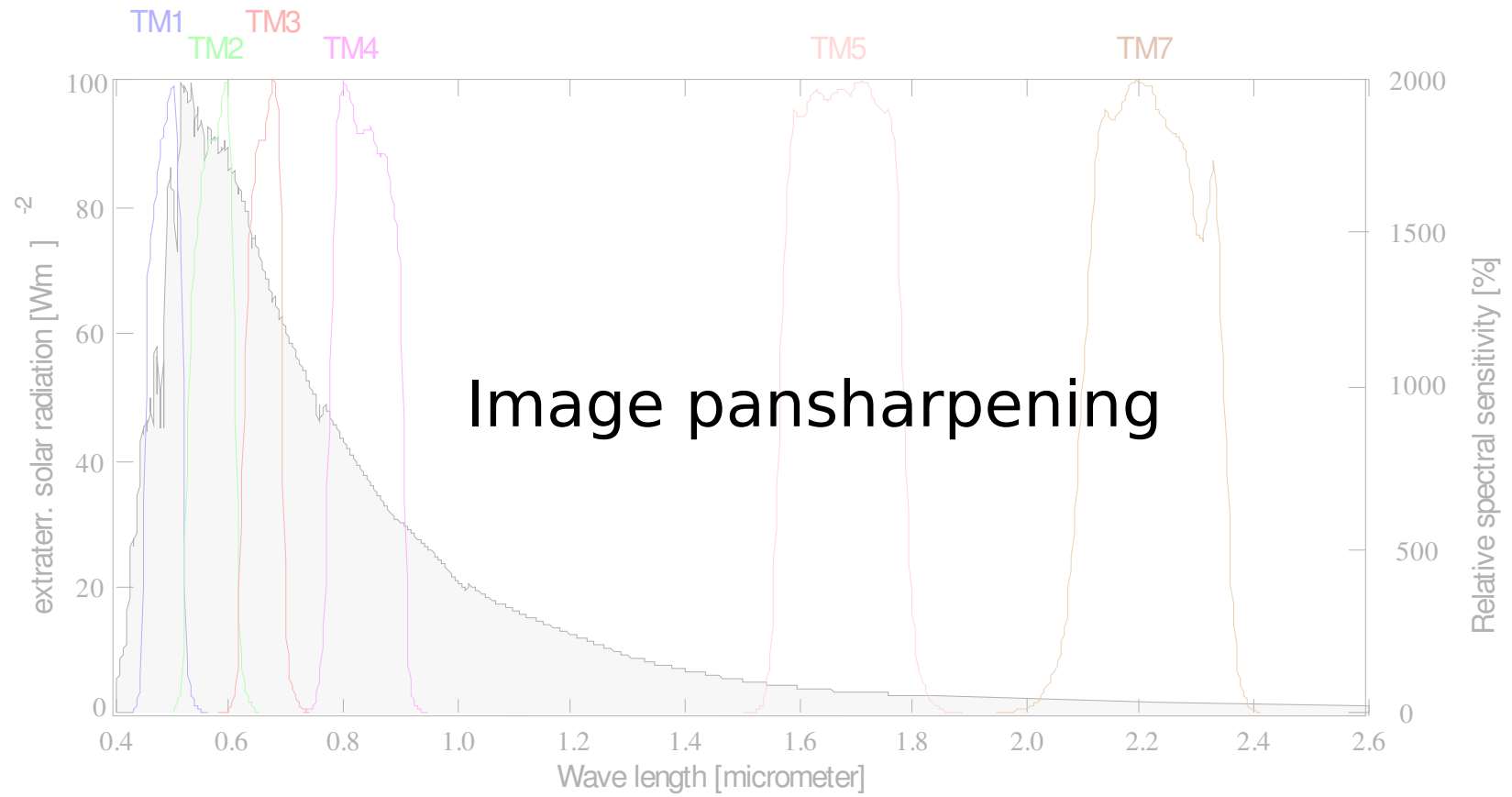




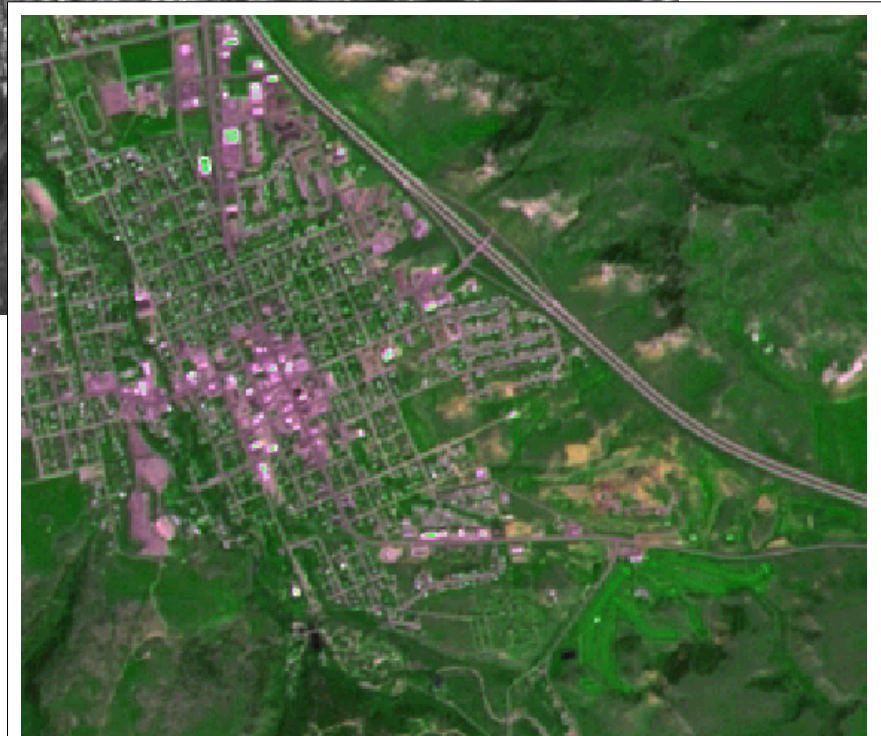
Image fusion: low res RGB + high res PAN

Image fusion:
Brovey transformation

Spot PAN at 10m



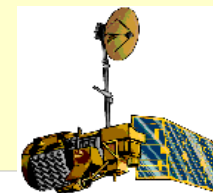
=



Spot1 (G), Spot2 (R), Spot3 (IR)
at 20m

Brovey Fusion: 10m resolution

Exercise – Image fusion - pansharpening



LANDSAT ETM: Improving the R/G/B resolution with panchromatic band

i.pansharpen [imagery, fusion, sharpen, Brovey, IHS, HIS, ↑ - □ ×]

Image fusion algorithms to sharpen multispectral with high-res panchromatic channels

Required Optional Command output Manual

Choose pan sharpening method: (sharpen=string)
ihs

Input raster map for red channel: (ms3=name)
lsat7_2002_30@PERMANENT

Input raster map for green channel: (ms2=name)
lsat7_2002_20@PERMANENT

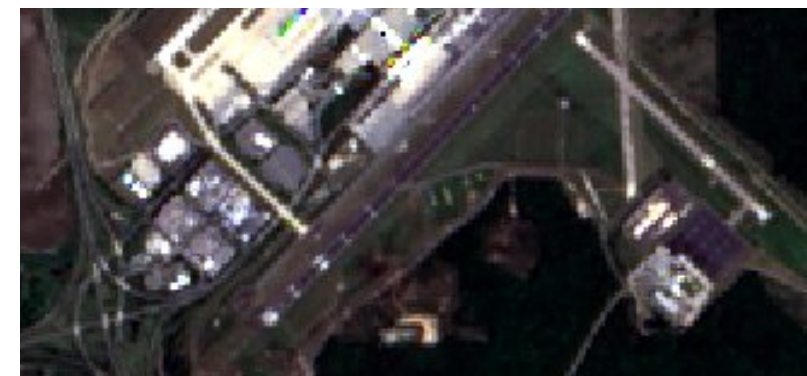
Input raster map for blue channel: (ms1=name)
lsat7_2002_10@PERMANENT

Input raster map for high resolution panchromatic channel: (pan=name)
lsat7_2002_80@PERMANENT

Prefix for output raster maps: (output_prefix=string)
lsat7_2002_pansharpened_ihs

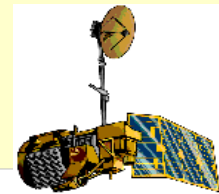
Close Run Copy Help

i.pansharpen sharpen=ihs ms3=lsat7_2002_30@PERMANENT ms2=lsat7_200

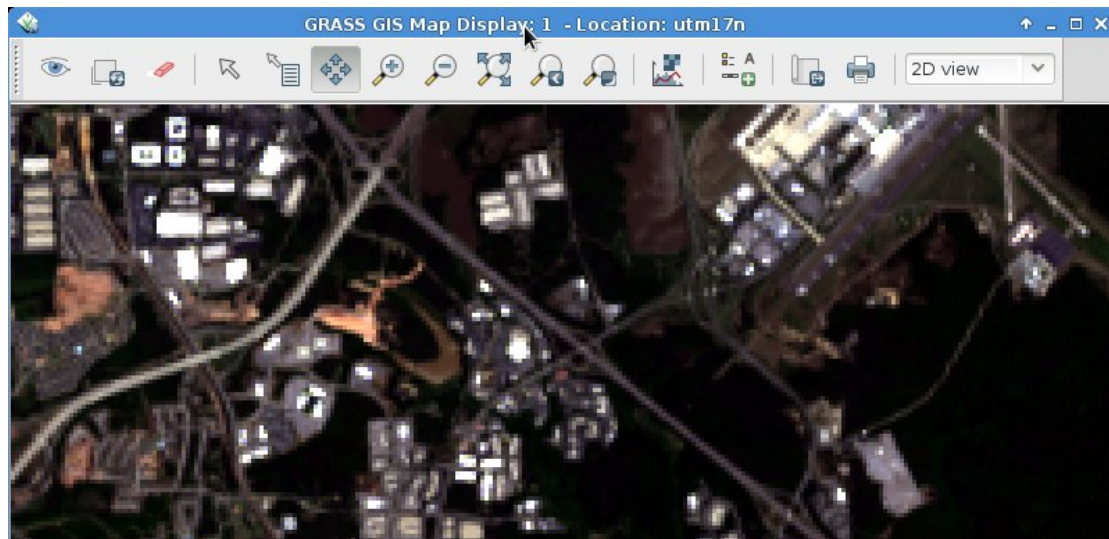


Note: This operation is CPU intensive... but the module works parallelized on multicore systems. Note: final color optimization with i.landsat.rgb

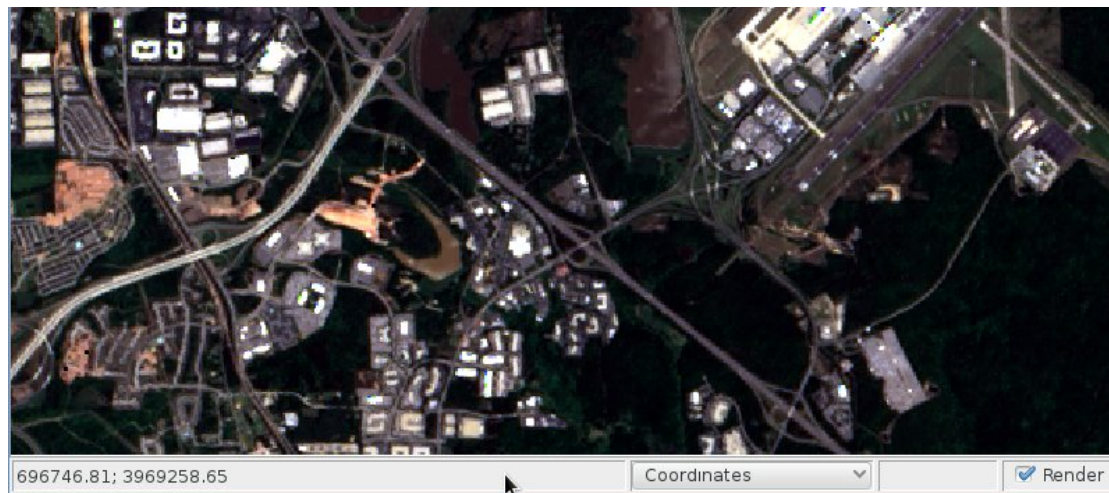
Exercise – Image fusion - pansharpening



LANDSAT ETM: Improving the R/G/B resolution with panchromatic band



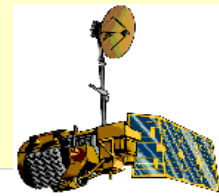
R/G/B composite at 28m



R/G/B composite at 14.25m
(IHS method, color balanced)

Note: the colors depend on the method used for pansharpening. Several methods are provided in [i.pansharpen](#)

Exercise – Image fusion - pansharpening



LANDSAT 8 – Nov 2014:

Trentino pansharpened with color preserving HPF method

Pansharpening with High-Pass Filter Addition Image Fusion Addon (i.fusion.hpf)





GRASS GIS image processing tools 1

Import:

SPOT VGT NDVI, Quickbird, Landsat, Ikonos, ERS, Envisat, GeoTIFF, Erdas, ENVI, ESRI, ...

Geocoding:

i.ortho.photo: aerial ortho photo imagery suite

i.points/i.rectify / GCP manager: Rectifies an image by computing a coordinate transformation based on the control points

Atmospheric and terrain correction:

i.atcorr: 6s - Second Simulation of Satellite Signal in the Solar Spectrum.

i.landsat.dehaze: Landsat haze removal based on Tasseled Cap #4 (Addon)

i.landsat.acca: Automated Cloud-Cover Assessment (ACCA) Algorithm from Irish (2000)

i.landsat.toar: transforms calibrated digital number of Landsat products to top-of-atmosphere radiance or top-of-atmosphere reflectance and temperature

i.topo.corr: is used to topographically correct reflectance from imagery files, e.g. obtained with i.landsat.toar, using a sun illumination terrain model

Fusion:

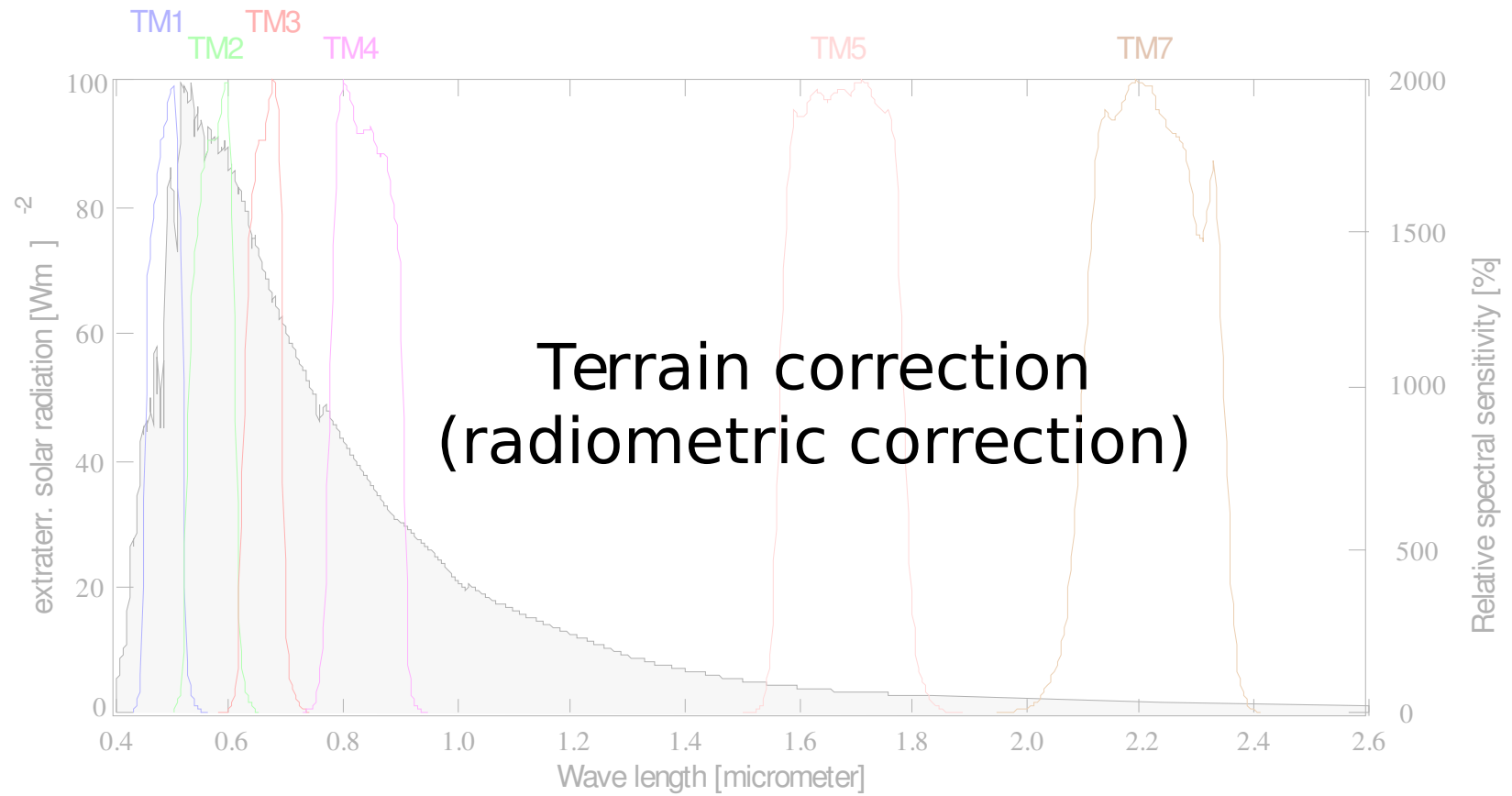
i.pansharpen: Brovey/PCA/IHS transform to merge multispectr. and high-res panchr.

i.his.rgb/i.rgb.his: Red-green-blue (rgb) to hue-intensity-saturation (his) raster map color transformation function

Visual improvements:

i.landsat.rgb: Auto-balancing of colors for LANDSAT images

i.oif: Calculates Optimum-Index-Factor table for LANDSAT TM bands 1-5, & 7





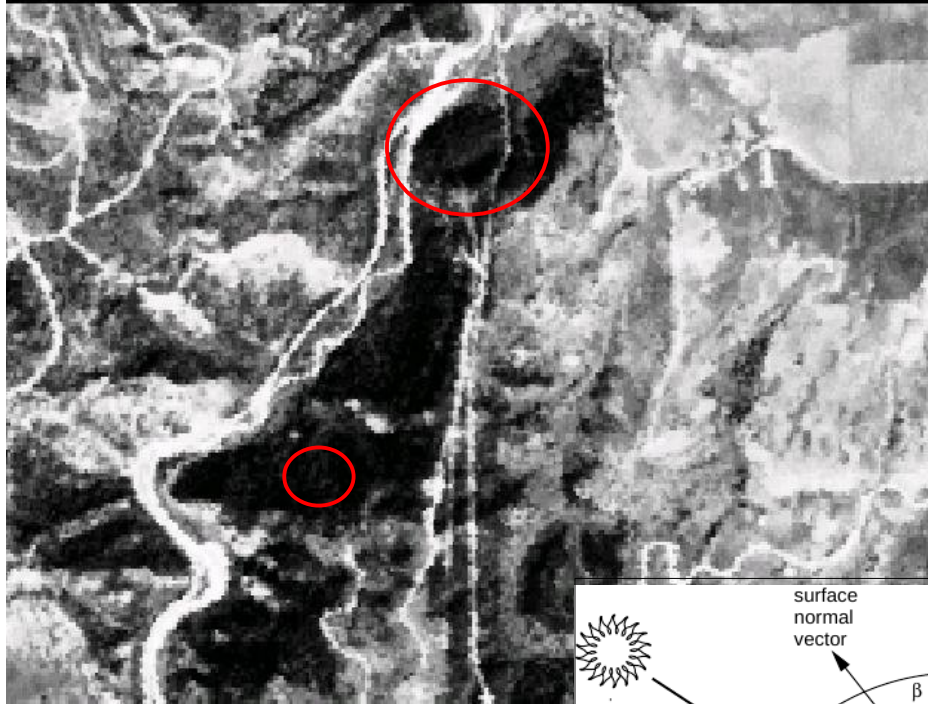
Enhancement: terrain correction

Terrain effects

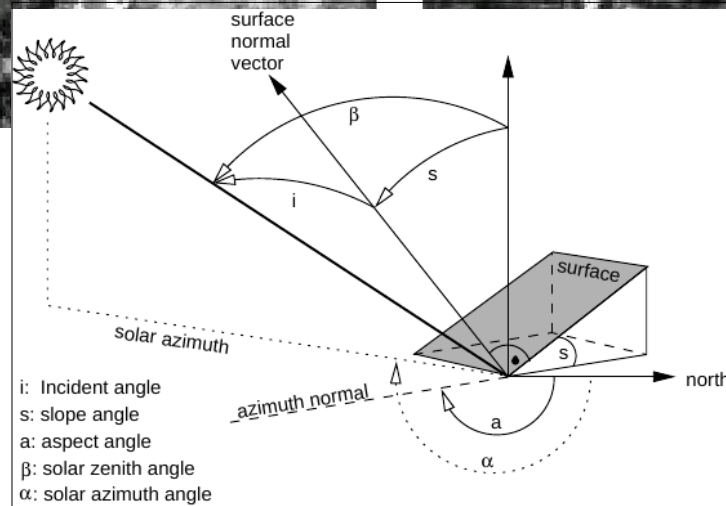
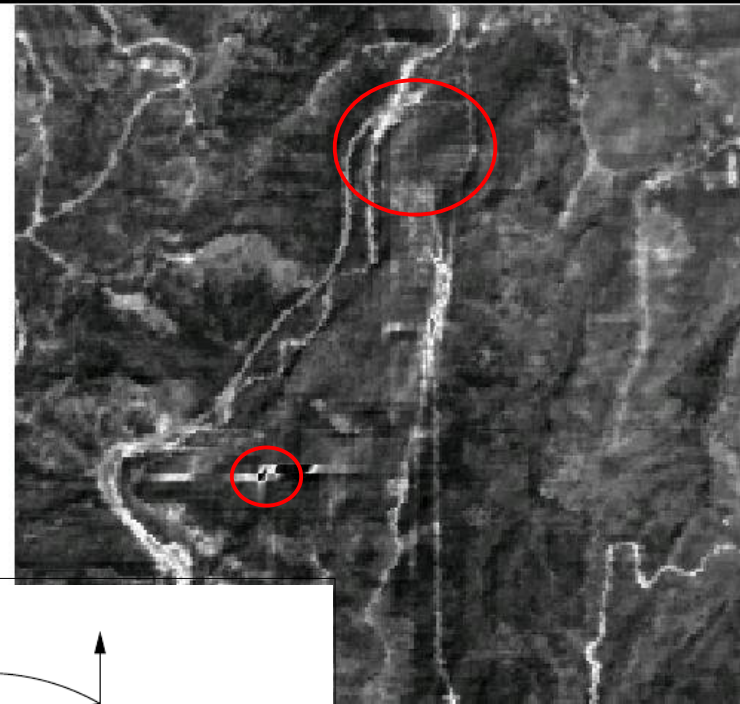
Terrain effects minimized

- ▶ Cosine or Minnaert correction to remove shadow effects

Original SPOT-1 PAN



Terrain corrected SPOT-1 PAN



*SPOT: shadow minimization
by cosine correction:
Terrain "flattening" with
i.topo.corr*



GRASS GIS image processing tools 2

Radiometric transformations:

- i.fft/i.ifft: Fast Fourier Transform (FFT) for image processing
- i.tasscap: Tasseled Cap (Kauth Thomas) transformation for LANDSAT-TM data
- i.pca: Principal components analysis

Image classification/spectral unmixing:

- i.smap: Performs contextual image classification using sequential maximum a posteriori (SMAP) estimation.
- i.segment: Identifies segments (objects) from imagery data. Hierarchical segmentation
- i.spec.unmix: Spectral unmixing (Addon)
- i.spec.sam: Spectral angle mapping (Addon)

Time series analysis:

- r.series: Output cell values as a function of the values assigned to the corresponding cells in the input raster map layers.
- r.series.interp: Interpolate raster maps located (temporal or spatial) in between input raster maps at specific sampling positions.
- r.hants: r.hants performs a harmonic analysis of time series in order to estimate missing values and identify outliers



GRASS GIS image processing tools 3

Radiometric/geometric transformations:

i.hist.match: histogram matching and mosaiking (Addon)

Edge detection

i.edge is an edge detector based on the Canny algorithm

Wavelets

i.wavelet Decomposes the time-series with the requested wavelet. Designed to make a temporal fusion from multi-sources.

Lidar:

r.in.lidar: raster binning of LAS files

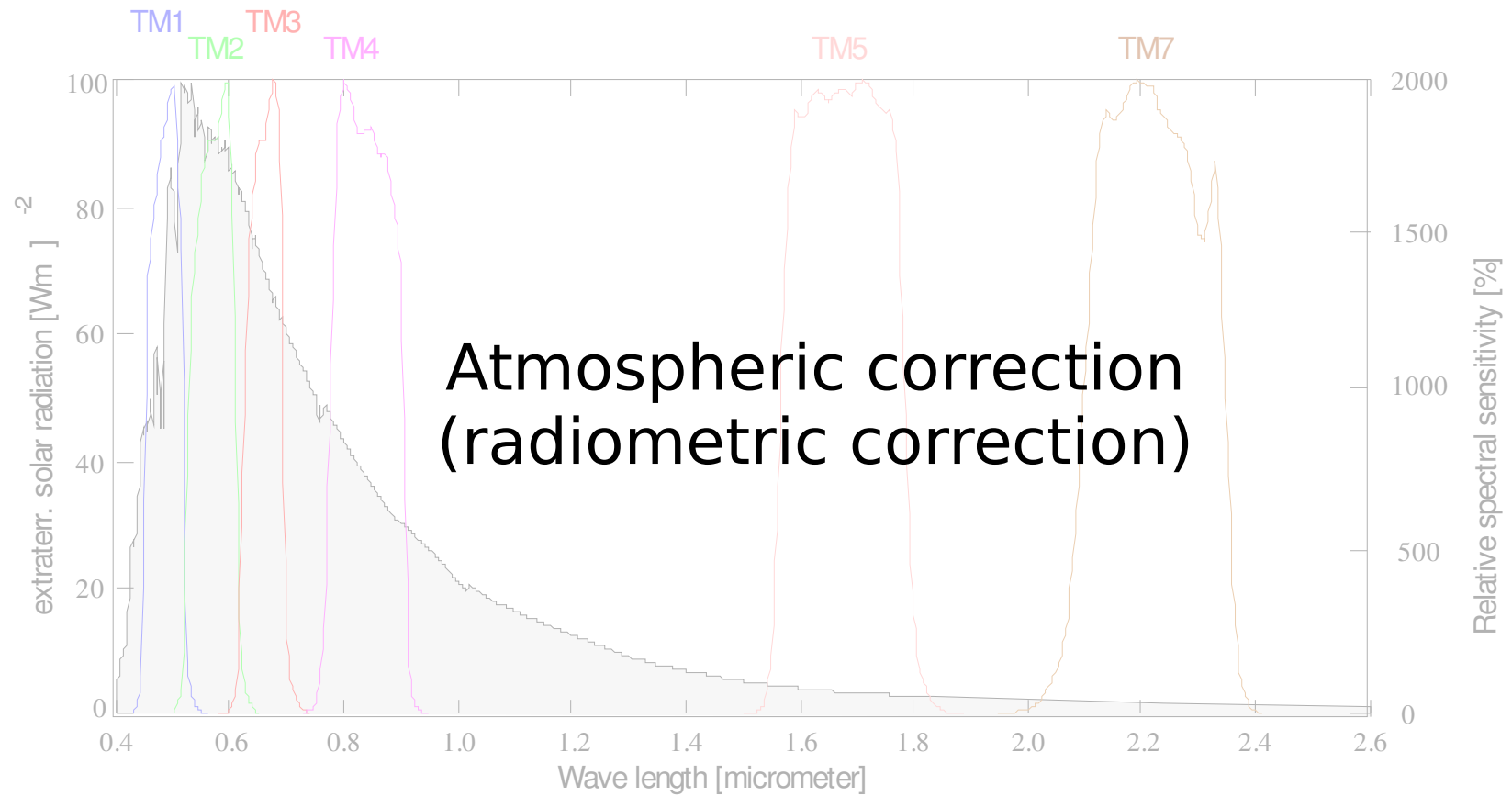
v.outlier: Outlier detection

v.lidar.edgedetection: edges are detected from last return data

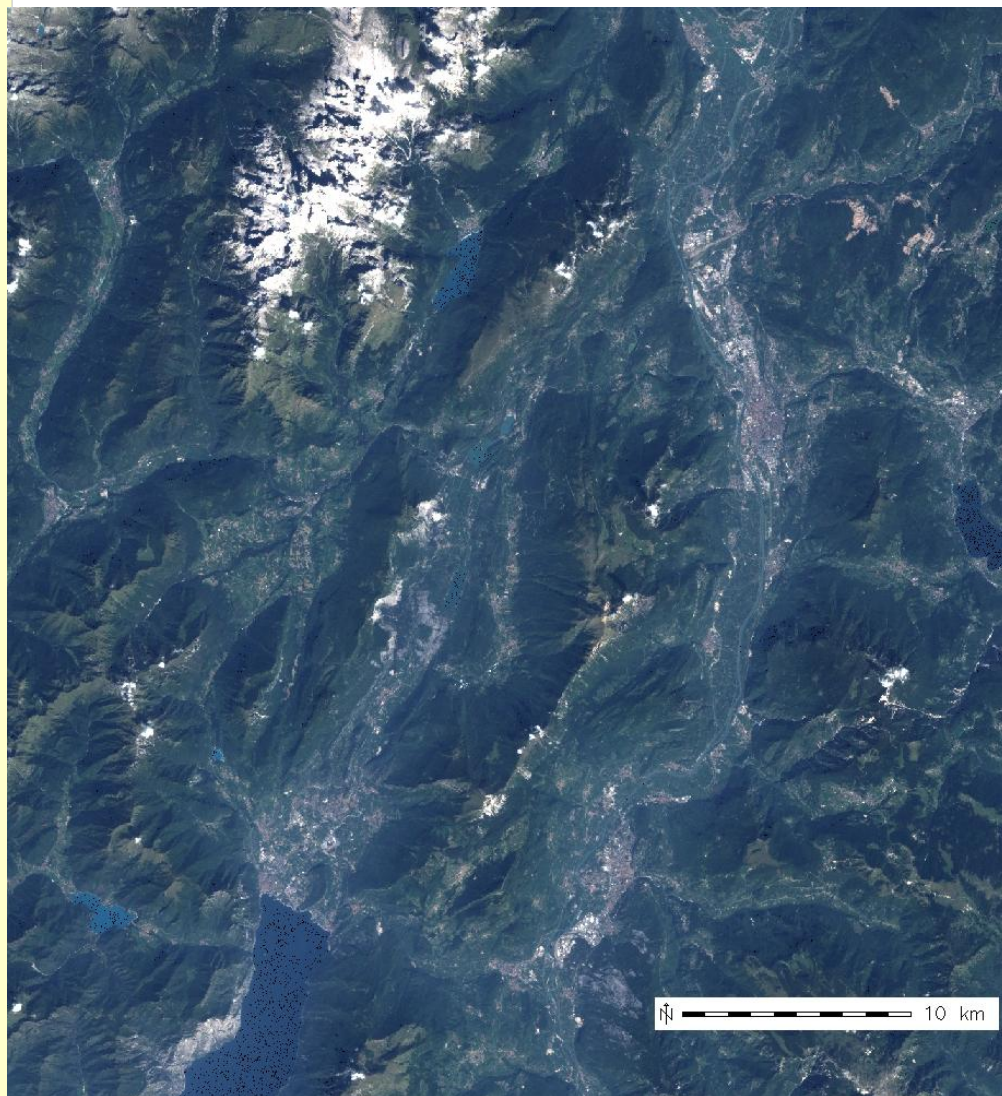
v.lidar.growing: building are generated

v.lidar.correction: post-processing

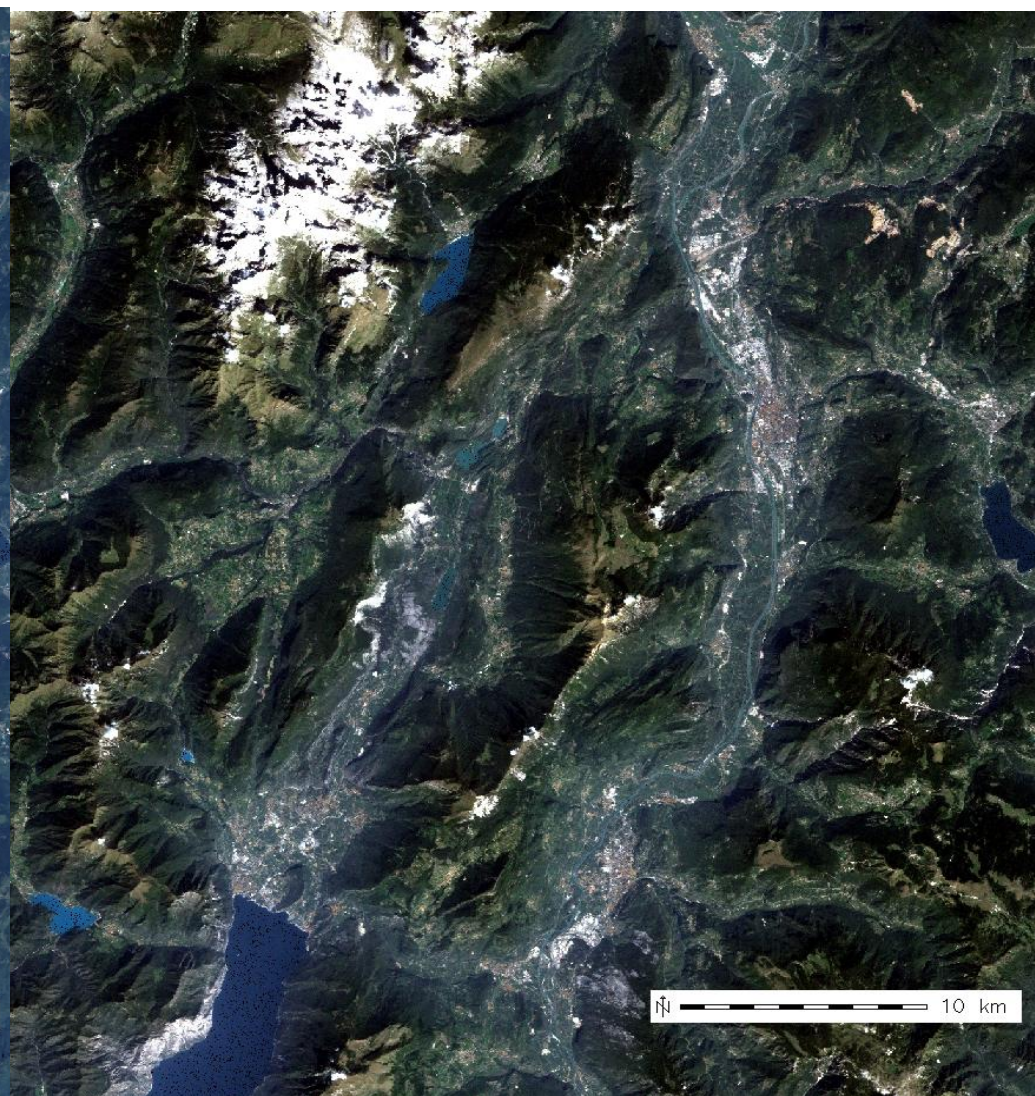
v.surf.bspline: DTM and DSM are generated



De-hazing of LANDSAT TM7



Original subset of Trentino, Italy (LANDSAT TM7, 13 Sep 1999). d.rgb view after i.landsat.rgb application.



Dehazed subset of Trentino, Italy (LANDSAT TM7, 13 Sep 1999). d.rgb view after i.tasscap, i.landsat.dehaze, i.landsat.rgb application.

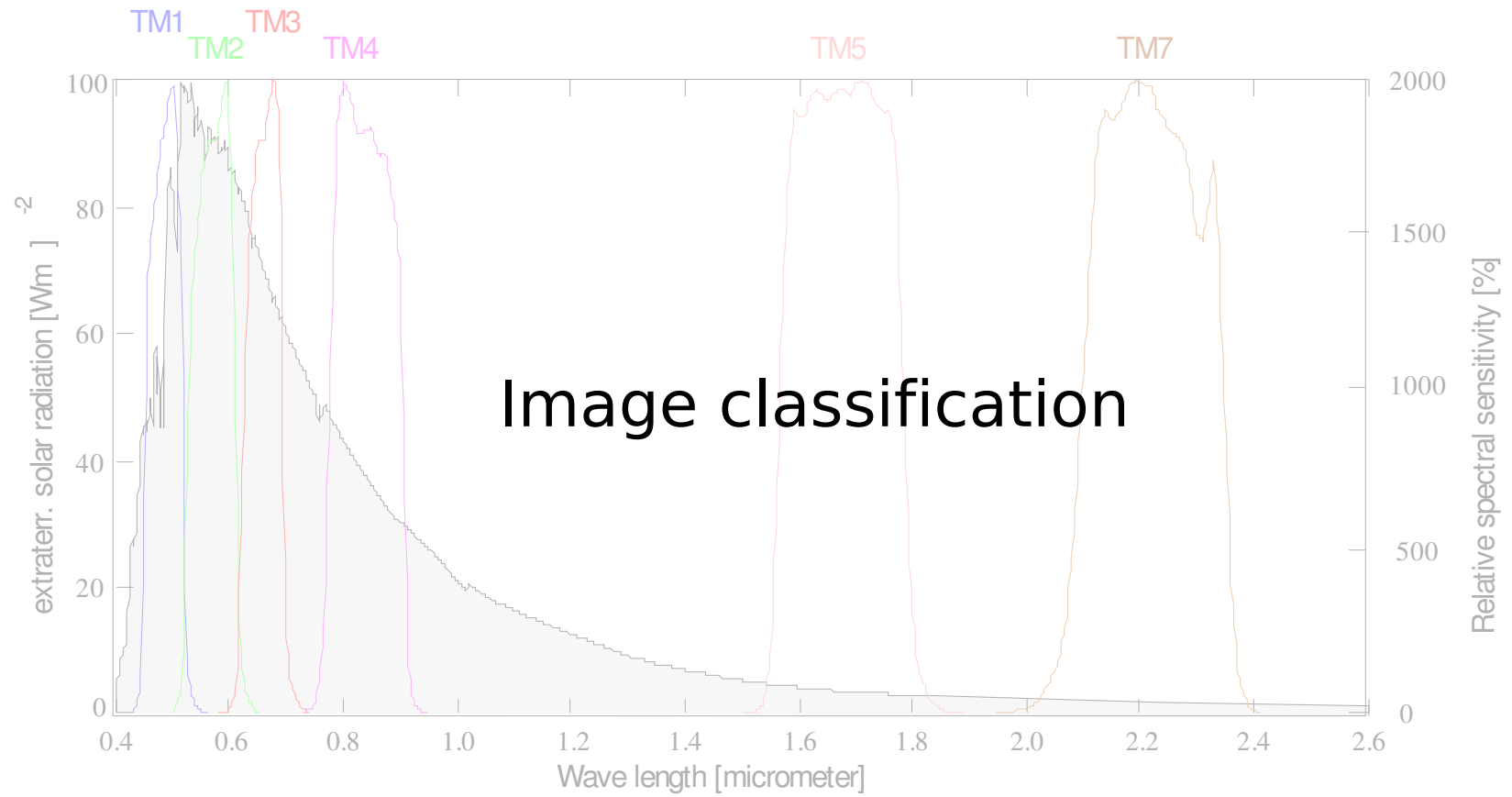


Image classification methods

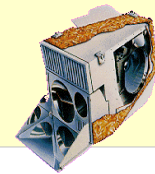
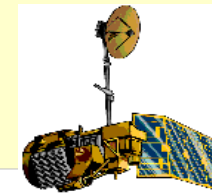


Image Classification

Unsupervised & Supervised Image Classification

- all image data must be first listed in a group ([i.group](#))

	radiometric, unsupervised	radiometric, supervised		radio- and geometric supervised
Preprocessing Computation	i.cluster i.maxlik	i.class (monitor) i.maxlik	i.gensig (maps) i.maxlik	i.gensigset (maps) i.smap

[i.segment](#) (radio-/geometric,
unsupervised)

GRASS GIS 7 Addons:

New Machine Learning based methods for the output of [i.segment](#)



Image classification capabilities

Image Classification

Supervised Image Classification with SMAP

Field1

Field2

Field3

Road

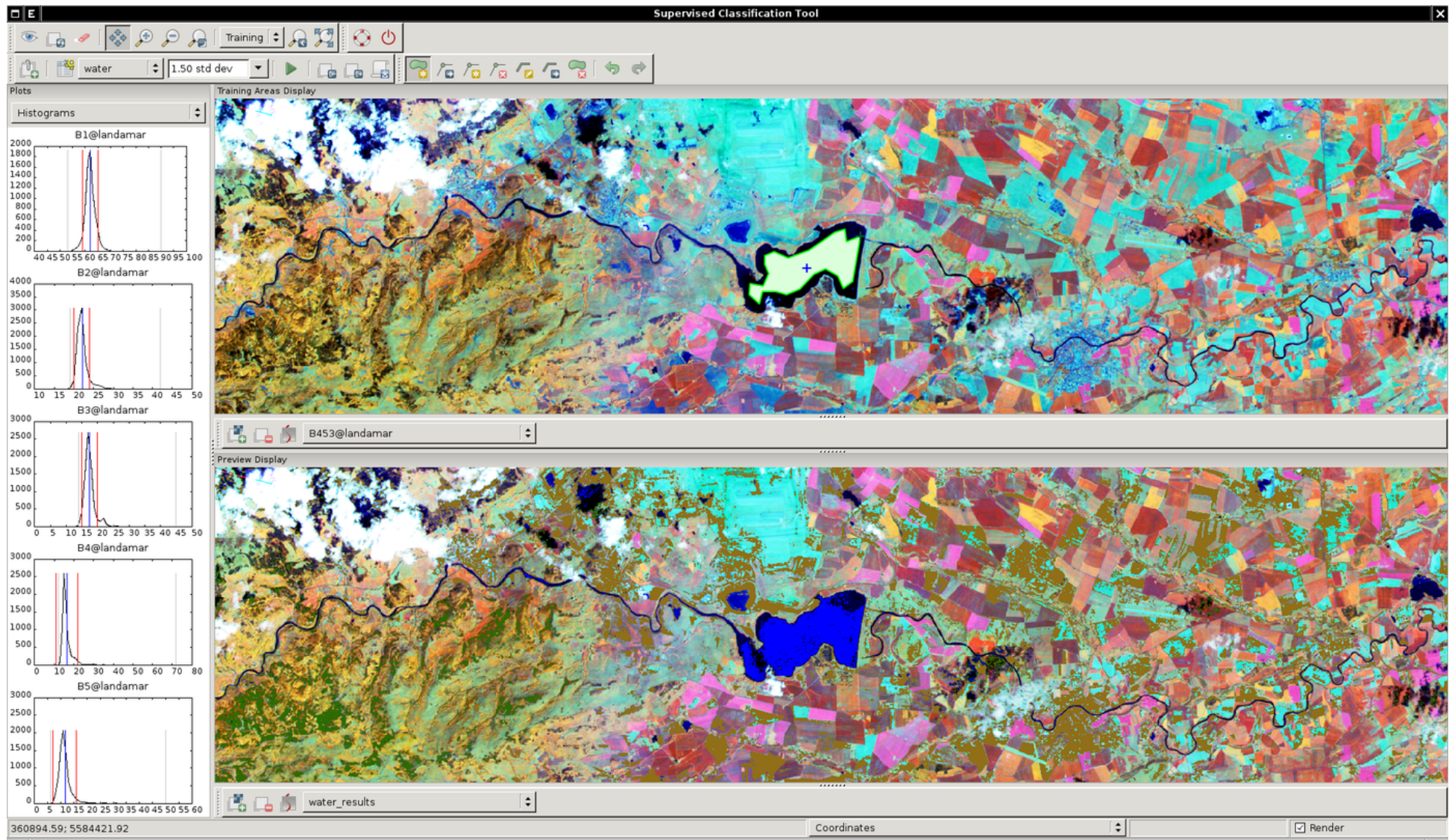


Digitizing with
wxGUI digitizer

Supervised image classification



<http://geo.fsv.cvut.cz/~landa/publications/2012/ogrs2012/poster/figures/>



Tool for supervised classification of imagery data.

Generates spectral signatures for an image by allowing the user to outline regions of interest.

Image processing capabilities

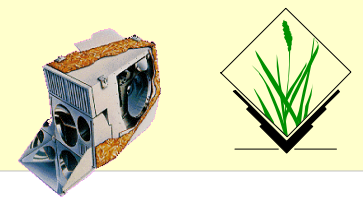
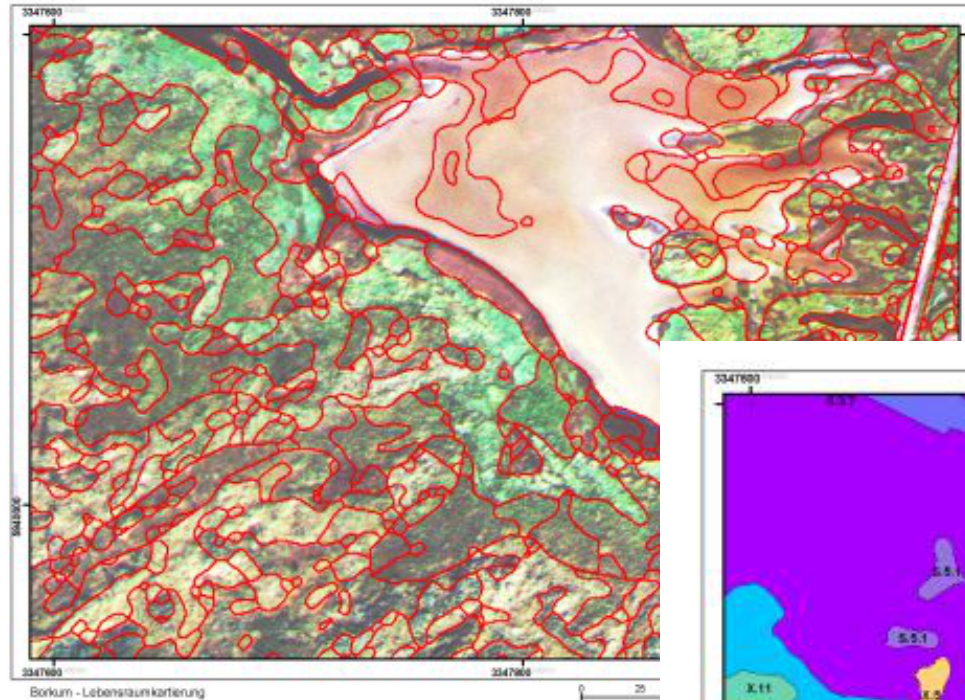


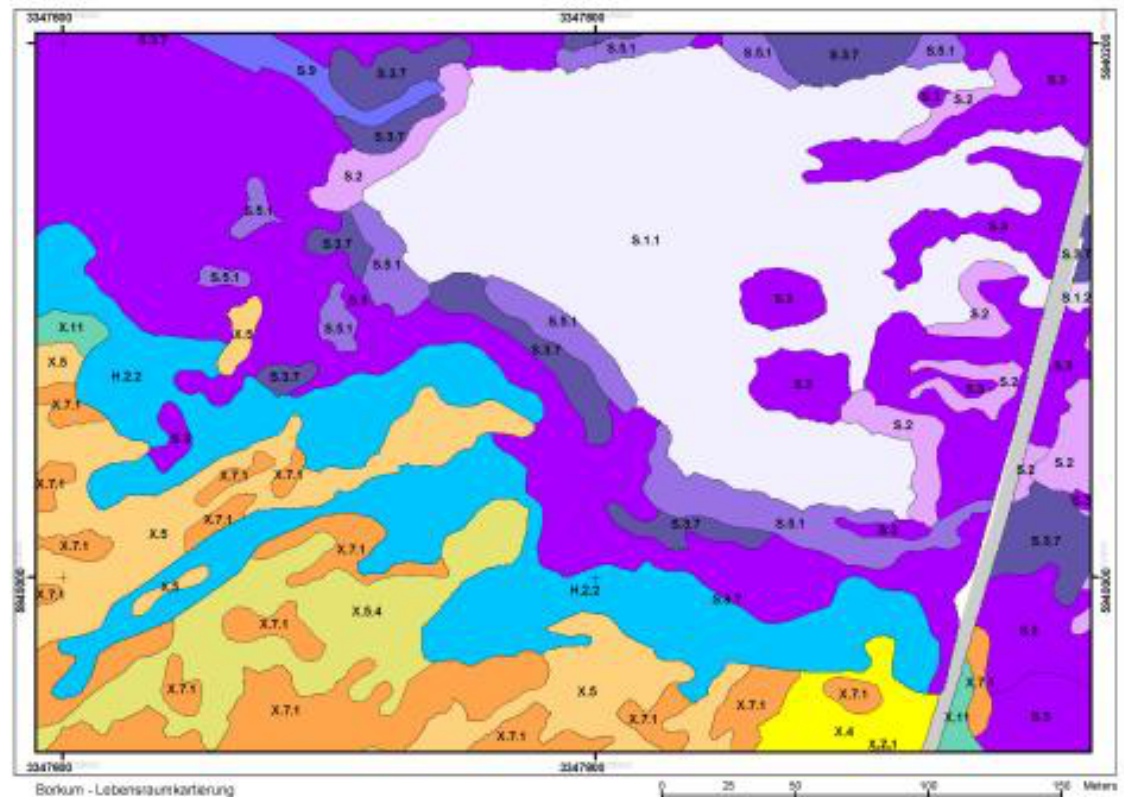
Image classification



GRASS GIS supports

- Image geocoding and ortho-rectification
- Analysis of aerial and satellite data
- Time series analysis

- Biotope monitoring from digital aerial cameras (HRSC-X and DMC)
- SMAP Classifier of GRASS



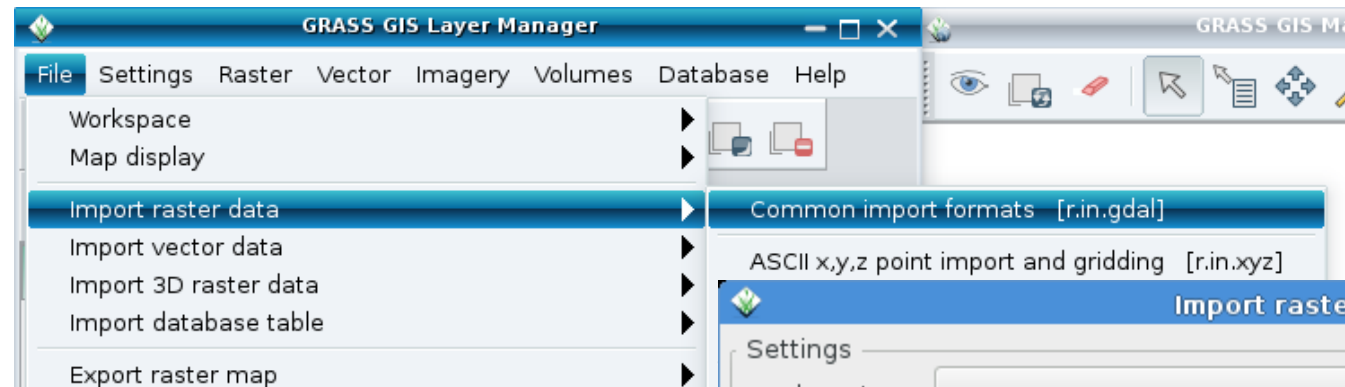


Exercise – Import of an orthophoto

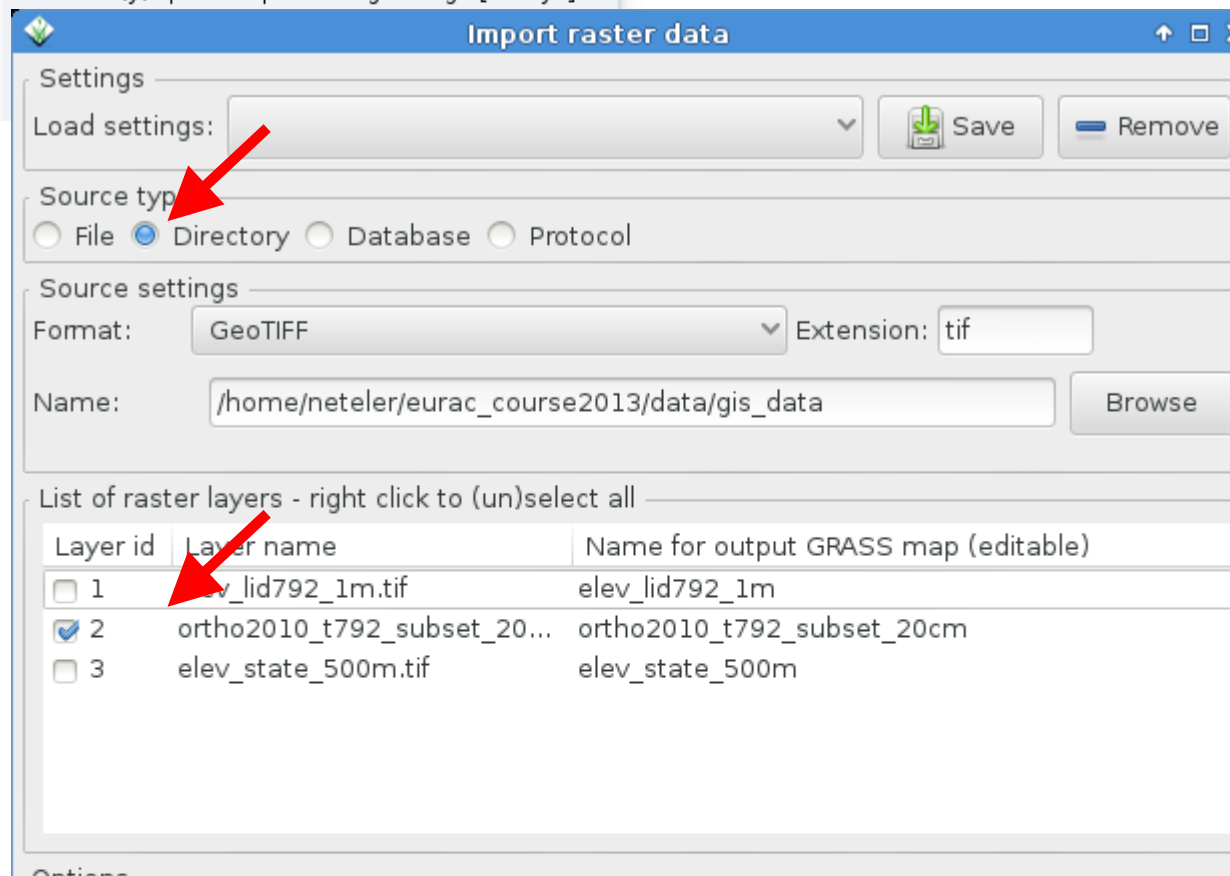
Wake, Raleigh (NC) rural area orthophoto:

http://data.neteler.org/geostat2015/north_carolina/

→ ortho2010_t792_subset_20cm.tif



Location to be used:
nc_spm_08



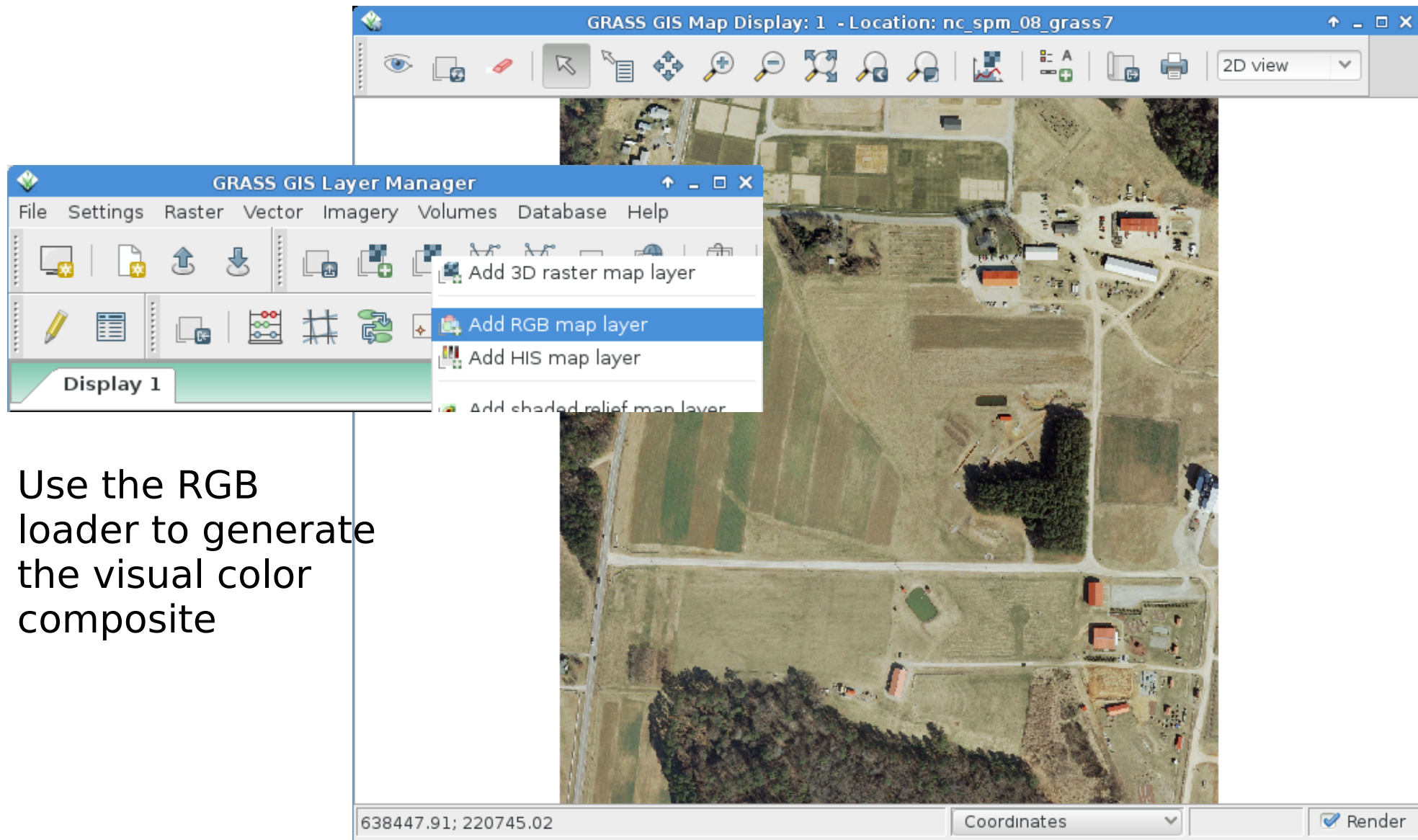
The GeoTIFF file is a
RGB multilayer file.

*Note: **uncheck** the
“Add imported layers
into layer tree”*



Exercise – Import an orthophoto

Wake, Raleigh (NC) rural area orthophoto

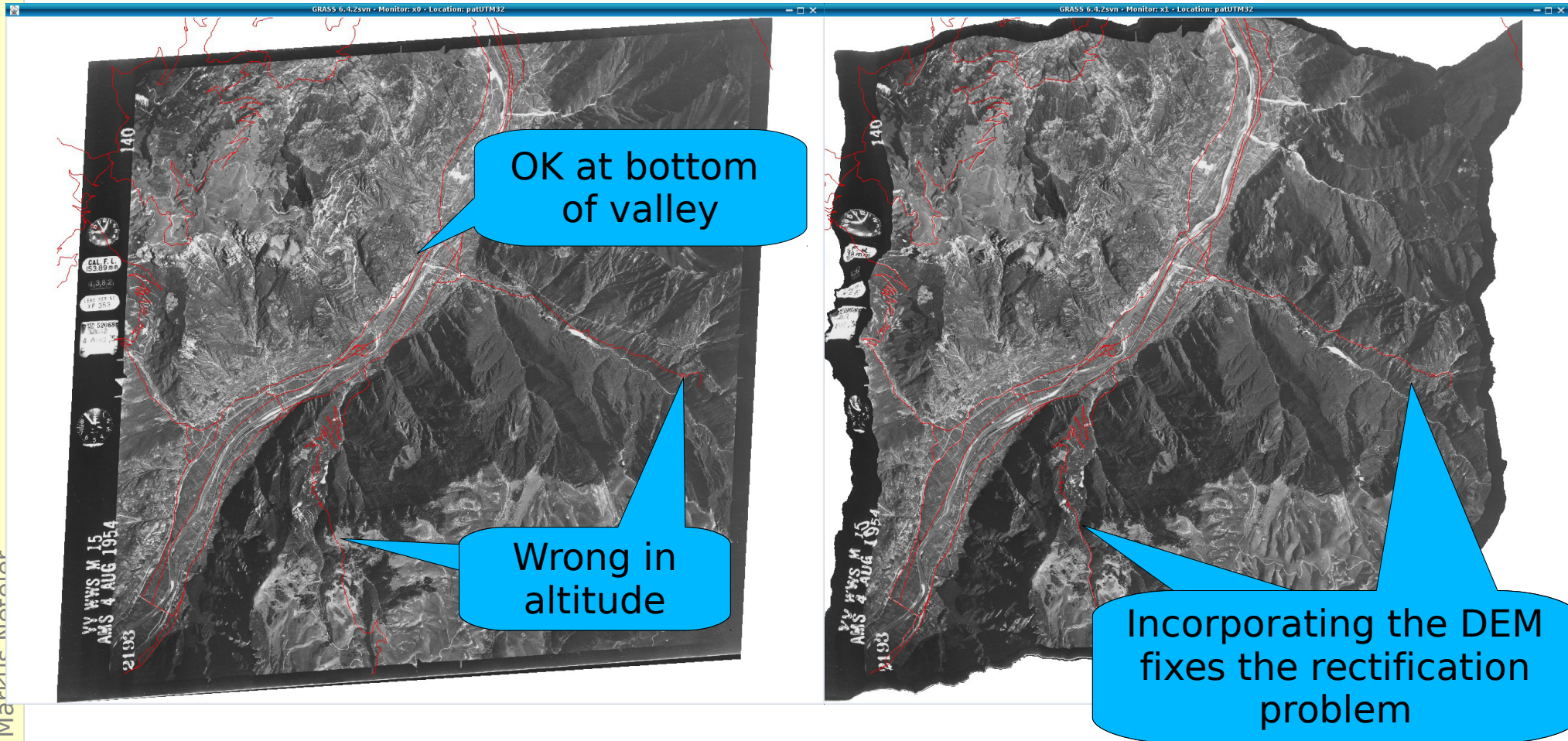


Use the RGB loader to generate the visual color composite

Sidenote: Ortho-rectification of aerial images



Why using the DEM for image rectification:

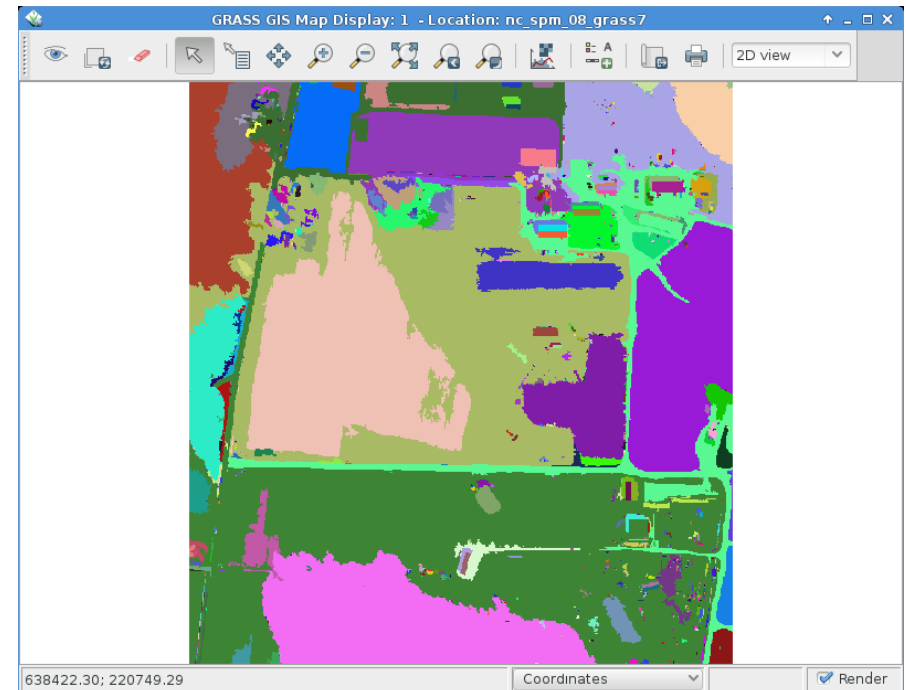
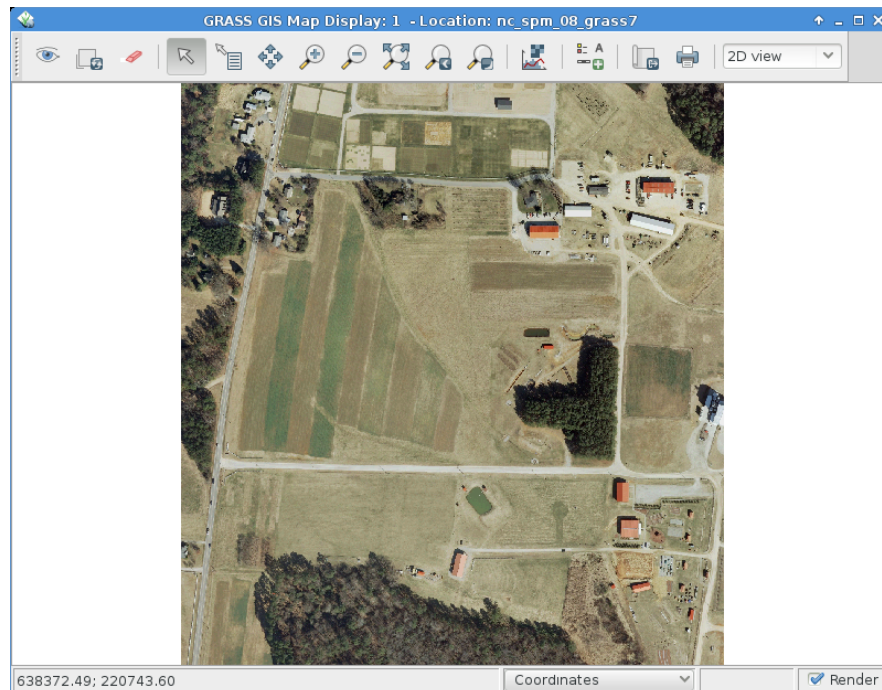


Linear 2D rectification (insufficient) Ortho-rectification (3D)

Unsupervised image classification – Segmentation



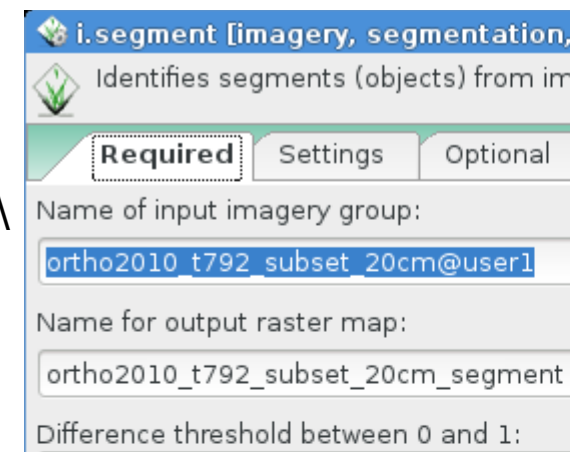
i.segment - Identifies segments (objects) from imagery data.



```
# set comp. region to orthophoto (extent) but at 1m resolution (just for speed reasons  
# in this exercise – for real work please use the true resolution)  
g.region raster=ortho2010_t792_subset_20cm.blue res=1 -p
```

```
# Note: the RGB bands are organized as a group  
i.segment group=ortho2010_t792_subset_20cm \  
  output=ortho2010_t792_subset_20cm_segment_25 \  
  goodness=ortho2010_t792_subset_20cm_seg_25_fit \  
  threshold=0.25
```

Finally vectorize with `r.to.vect`, export to SHAPE

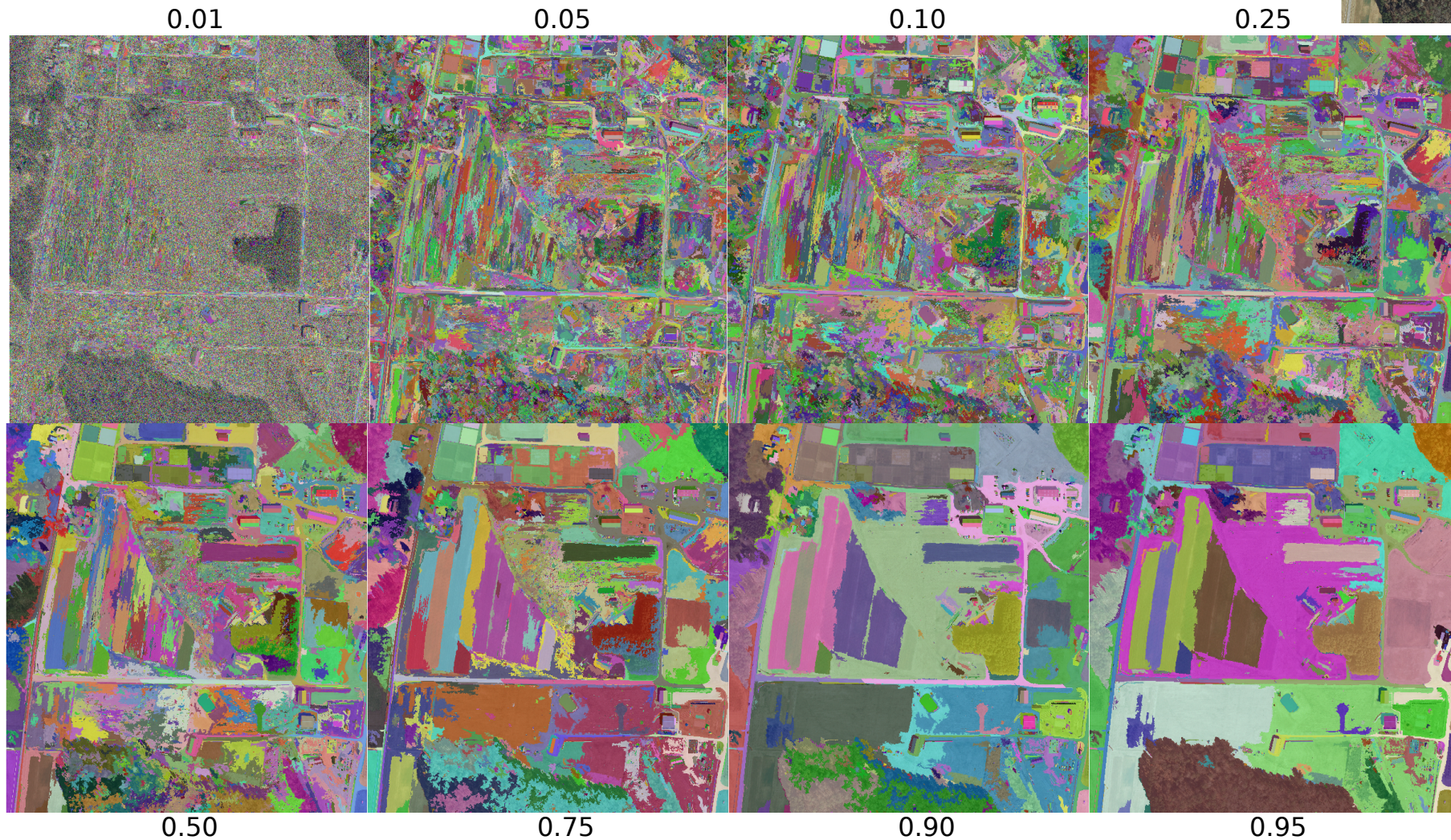


Unsupervised image classification – Segmentation



Re-use output of previous run (seed):

```
i.segment group=ortho2010_t792_subset_20cm \  
  output=ortho2010_t792_subset_20cm_segment_50 \  
    seeds=ortho2010_t792_subset_20cm_segment_25 \  
  goodness=ortho2010_t792_subset_20cm_seg_50_fit \  
    threshold=0.50
```





Supervised image classification

Tool for supervised classification of imagery data.

1

Select imagery group

Histograms

Training Areas Display

2

Select imagery group

Name of imagery group:
ortho2010_t792_subset_20cm

Name of imagery subgroup:
ortho2010

Create/edit group.

3

Create or edit imagery groups

Select existing group or enter name of new group:
ortho2010_t792_subset_20cm

☒ Edit/create subgroup

Select existing subgroup or enter name of new subgroup:
ortho2010

☒ Select all

Pattern:

List of maps:
☒ ortho2010_t792_subset_20cm.red@user1
☒ ortho2010_t792_subset_20cm.green@user1
☒ ortho2010_t792_subset_20cm.blue@user1

4

GRASS GIS Supervised Classification Tool

Training

1.50 std dev

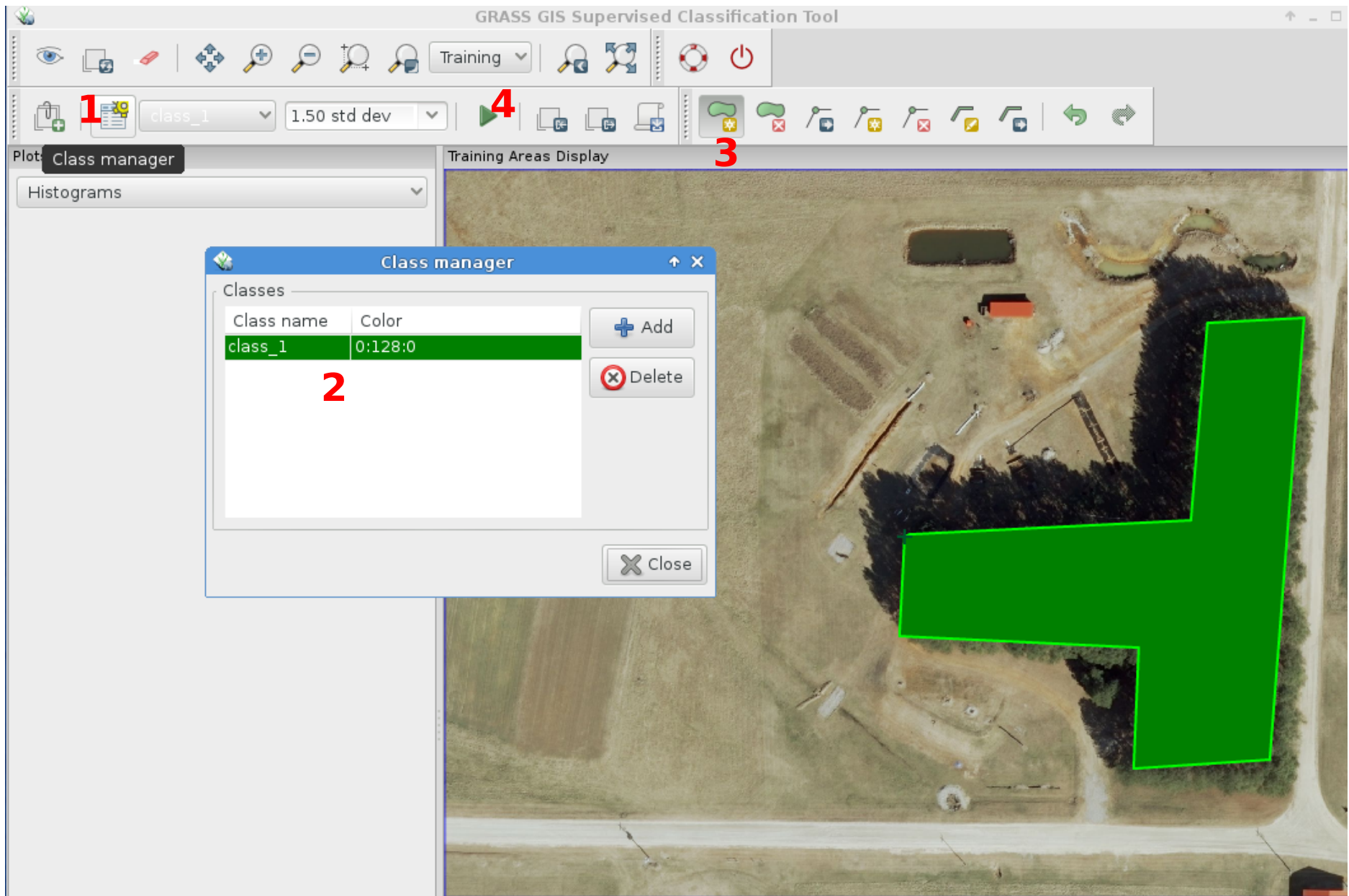
Training Areas Display

ortho2010_t792_subset_20cm

Add RGB map layer

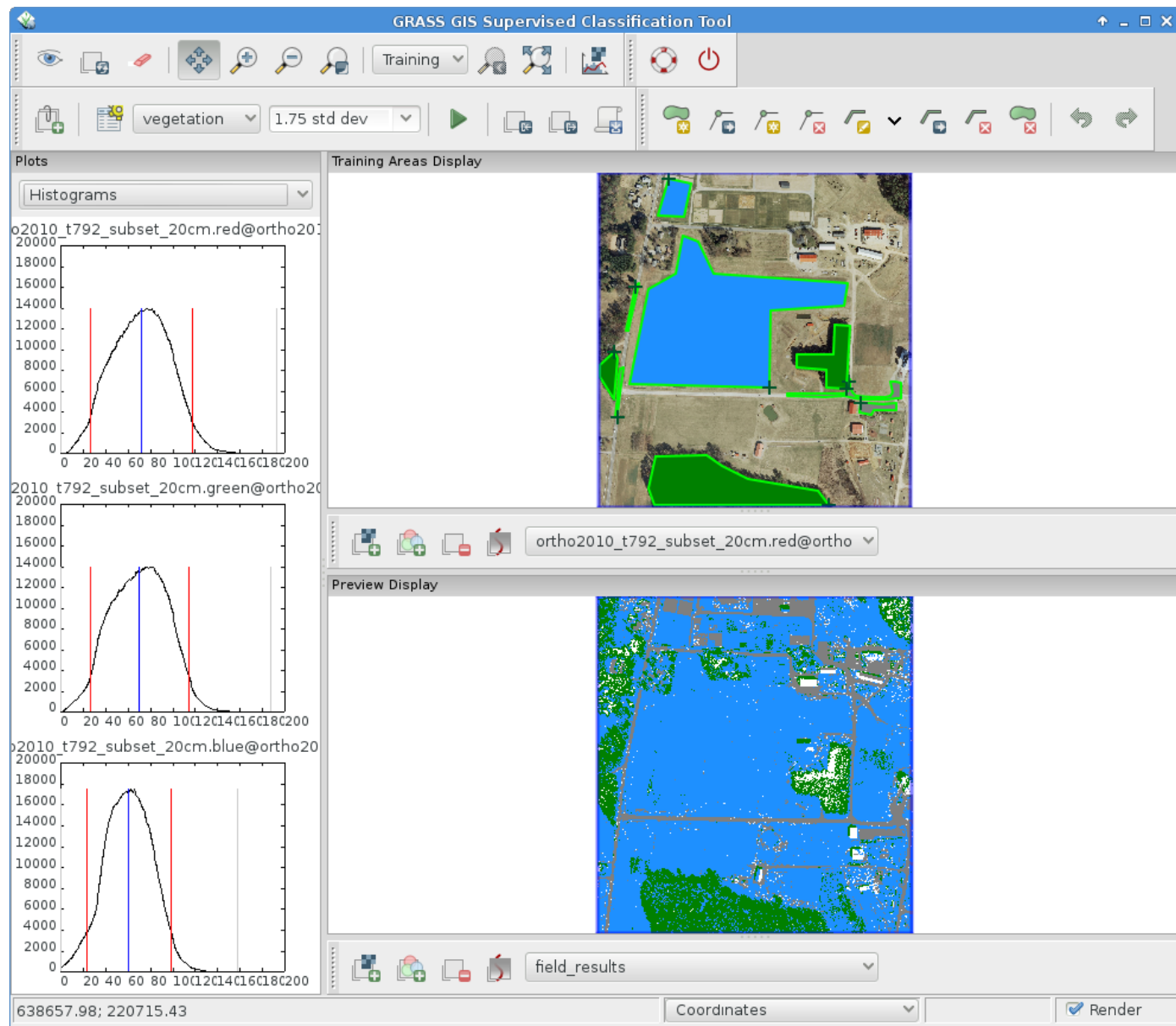


Supervised image classification

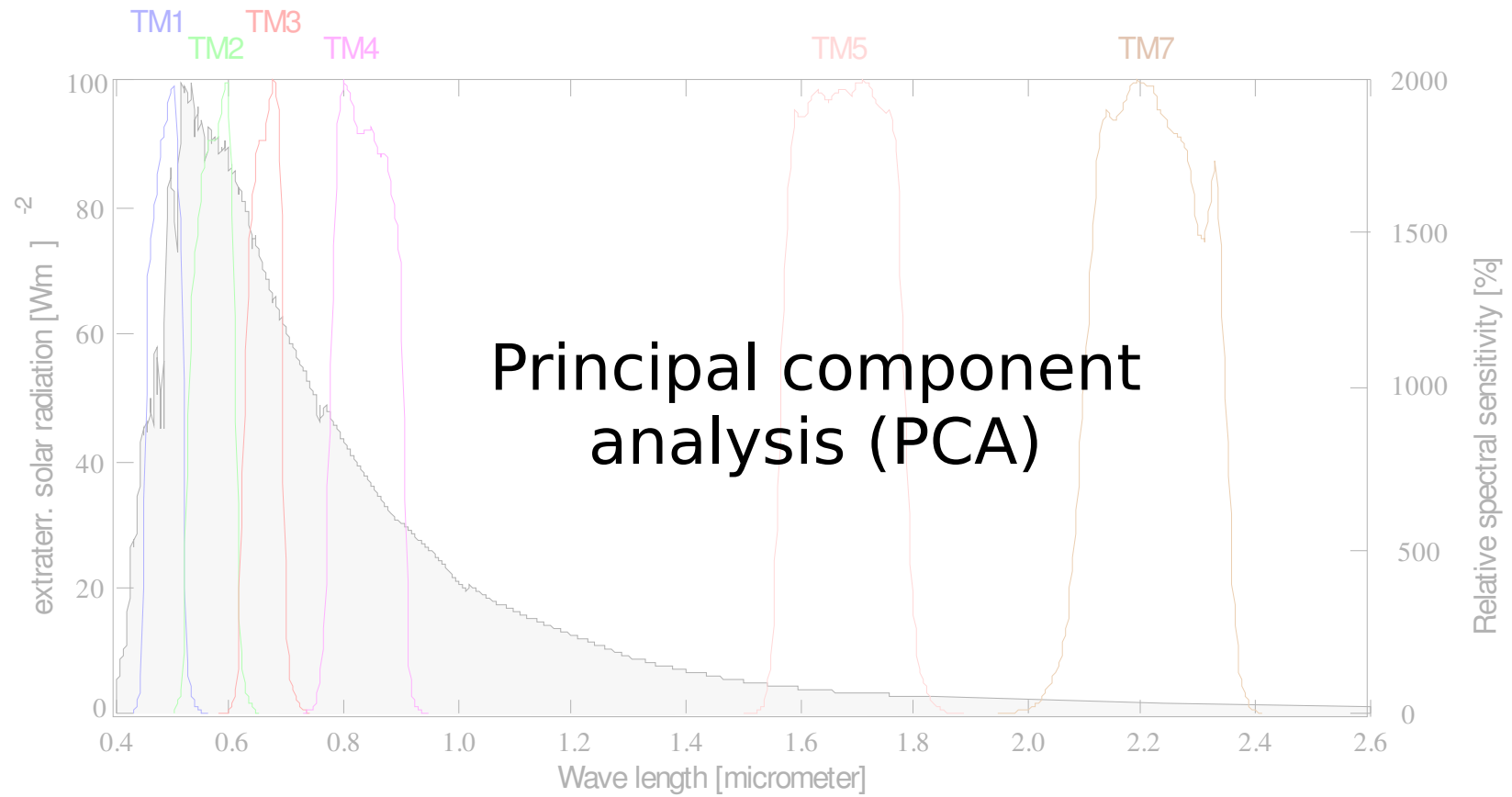




Supervised image classification

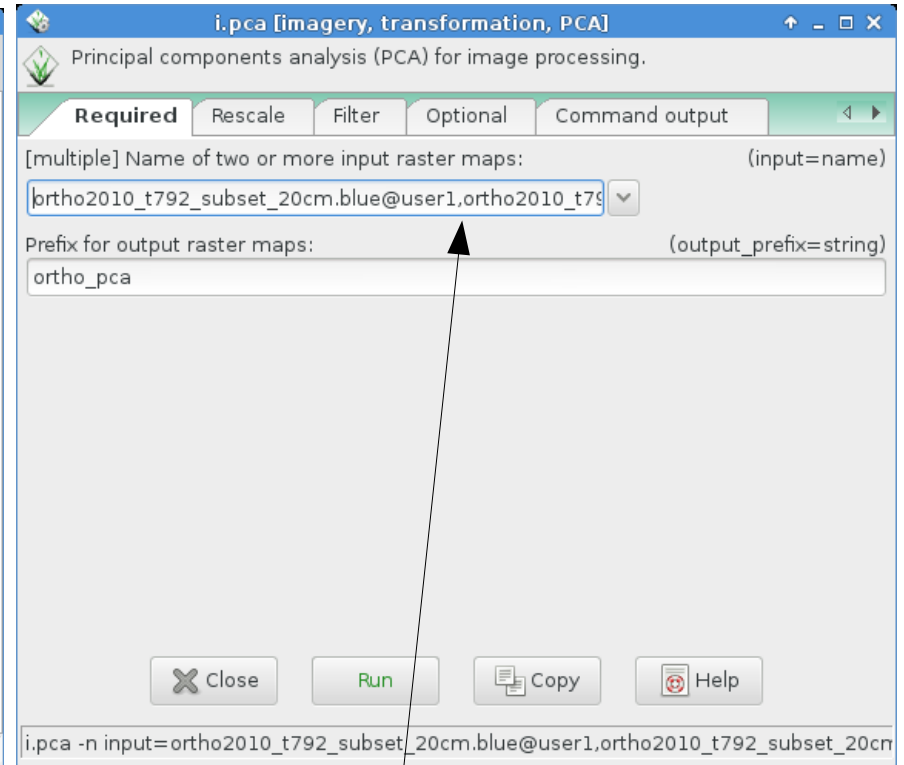
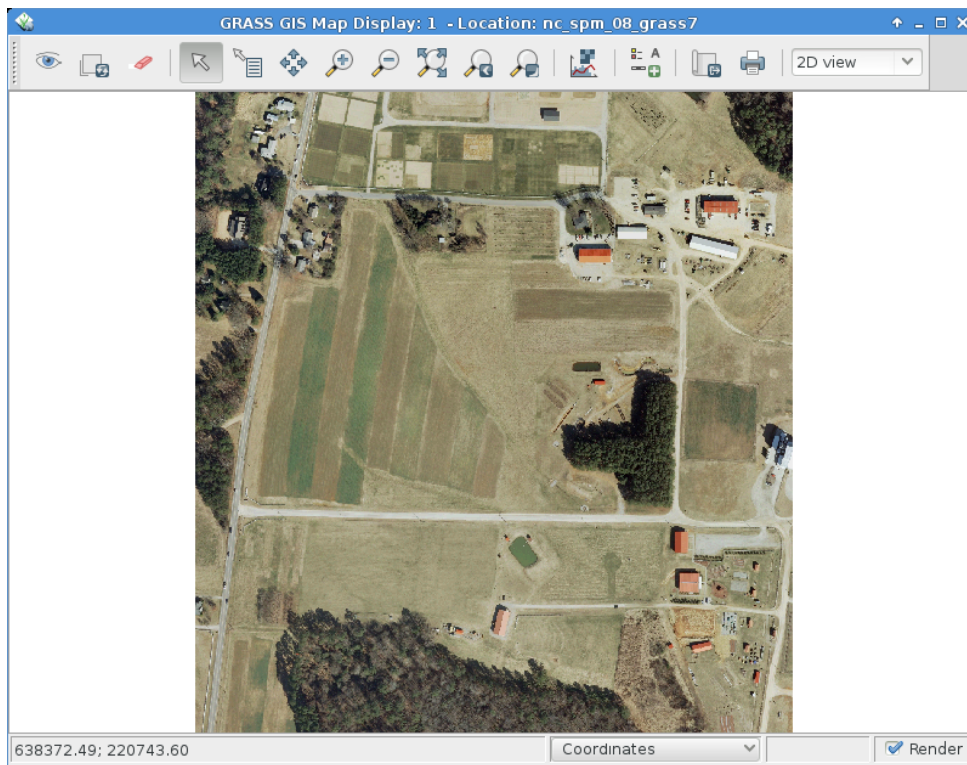


Tool for supervised classification of imagery data.
Generates spectral signatures for an image by allowing the user to outline regions of interest. Maxlik Classification and storage as separate raster map per class.





Principal component analysis



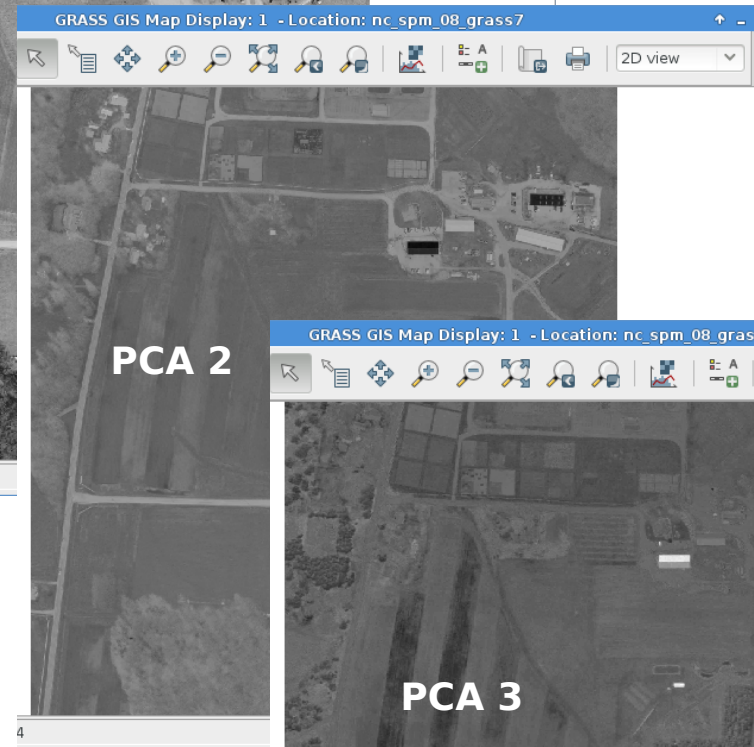
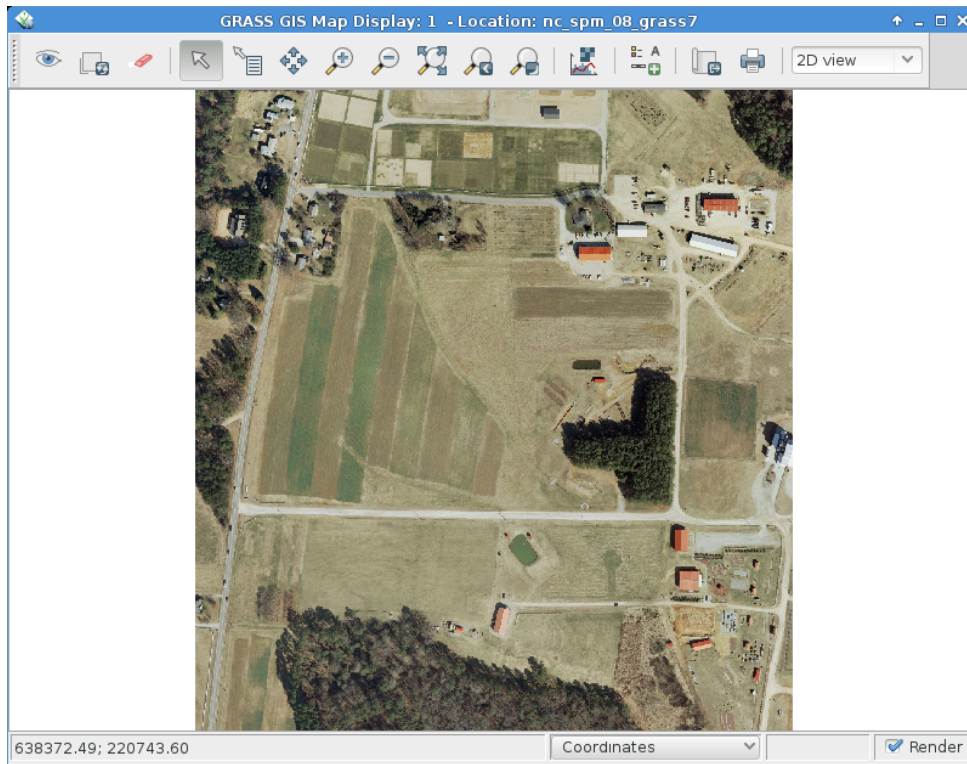
```
# set computational region to orthophoto:
g.region rast=ortho2010_t792_subset_20cm.blue -p

# note - We'll now create a PCA of 3 * 13 million pixels...

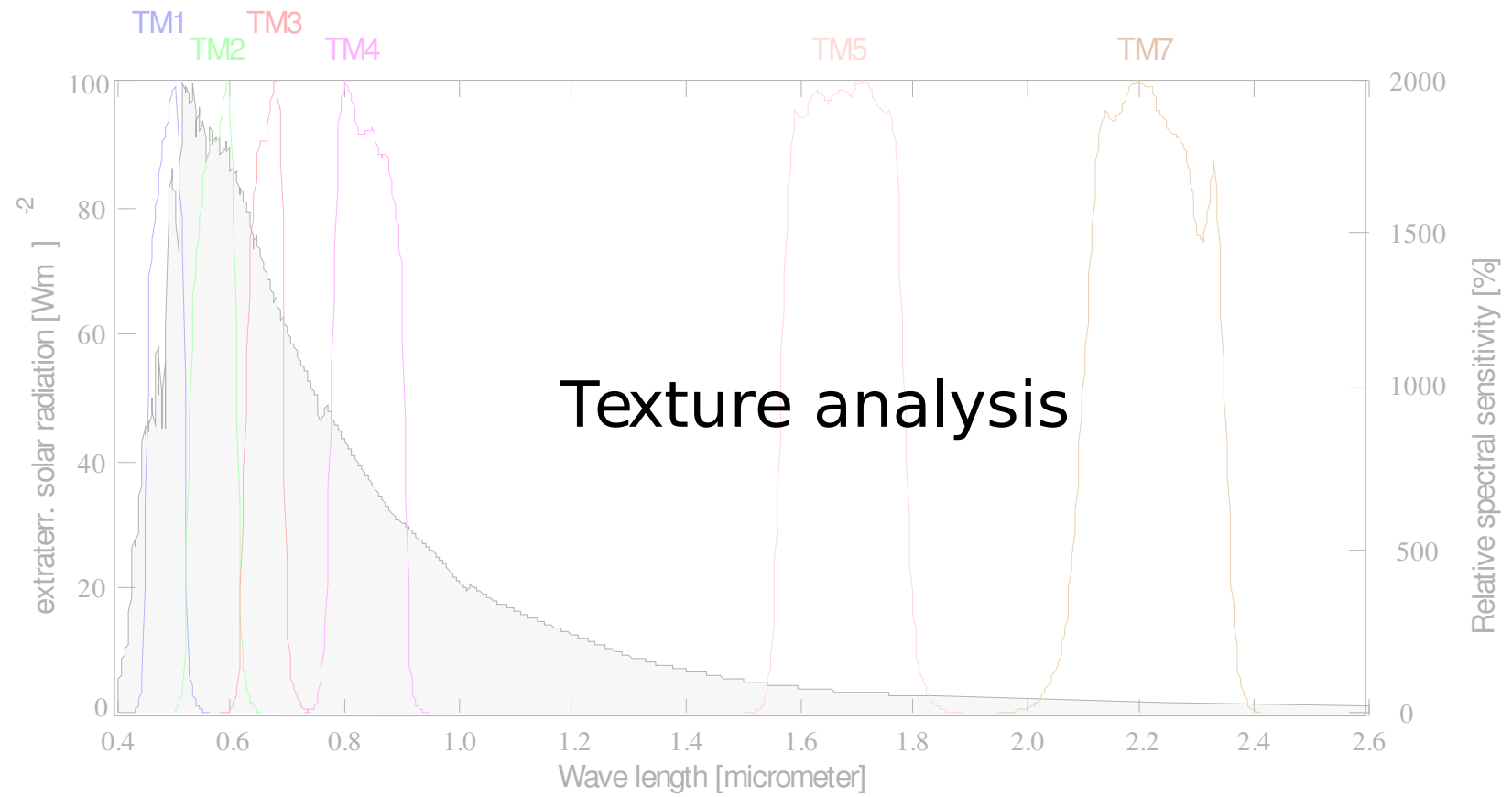
# -n Normalize (center and scale) input maps
i.pca input=ortho2010_t792_subset_20cm.blue,ortho2010_t792_subset_20cm.green,\
      ortho2010_t792_subset_20cm.red output=ortho_pca -n
```



Principal component analysis

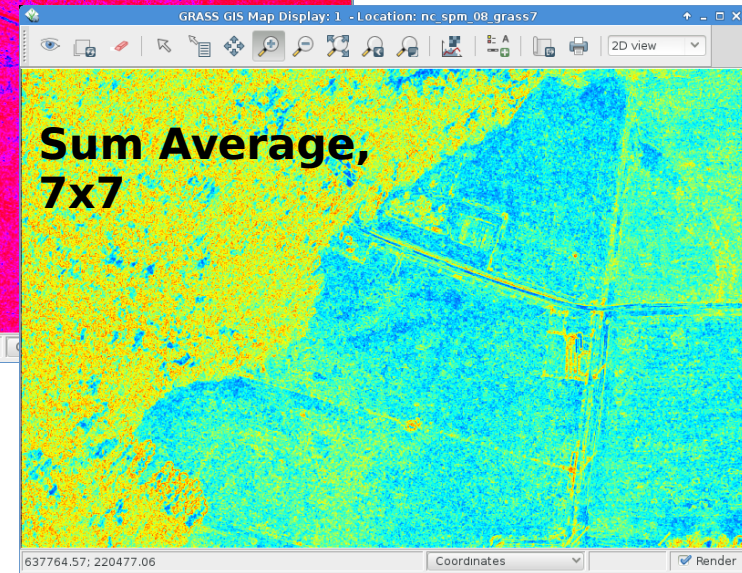
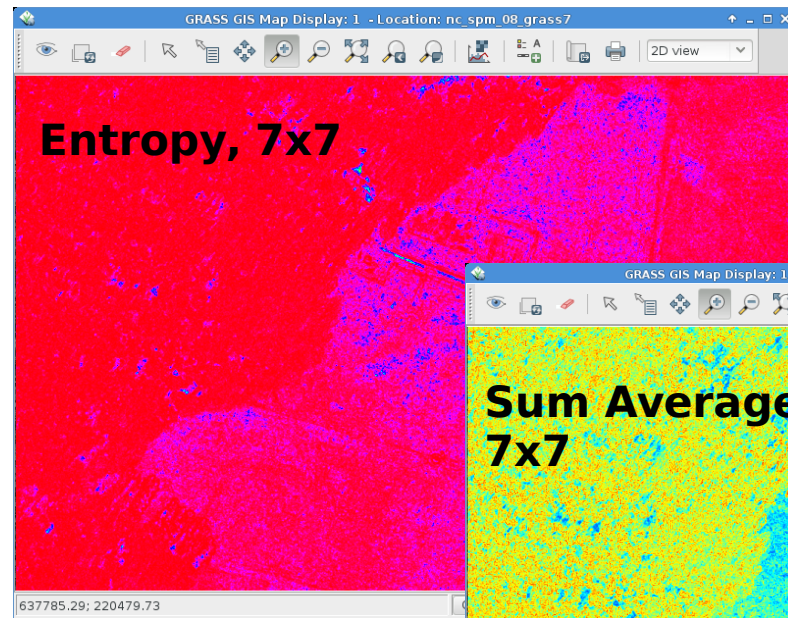
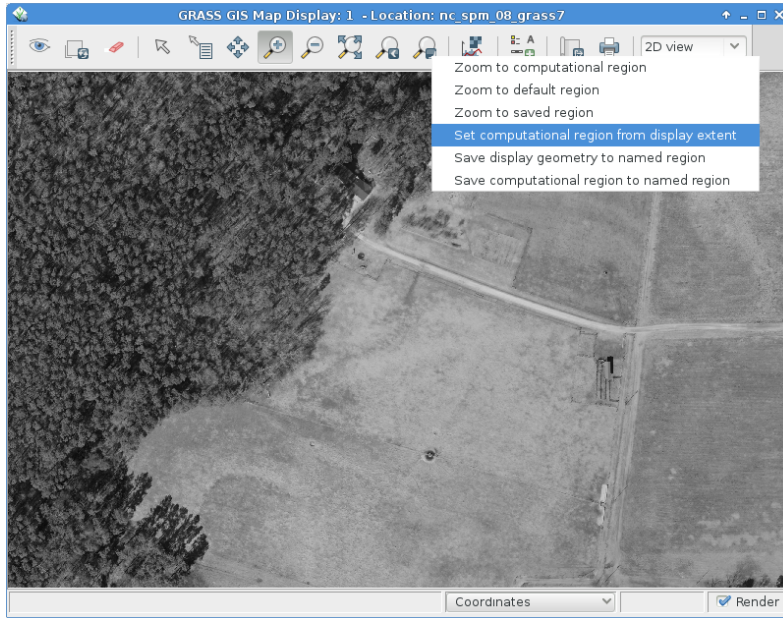


... the PCA takes only **< 10 seconds on a laptop**
for a PCA of **3 * 13 million pixels...**





Texture analysis

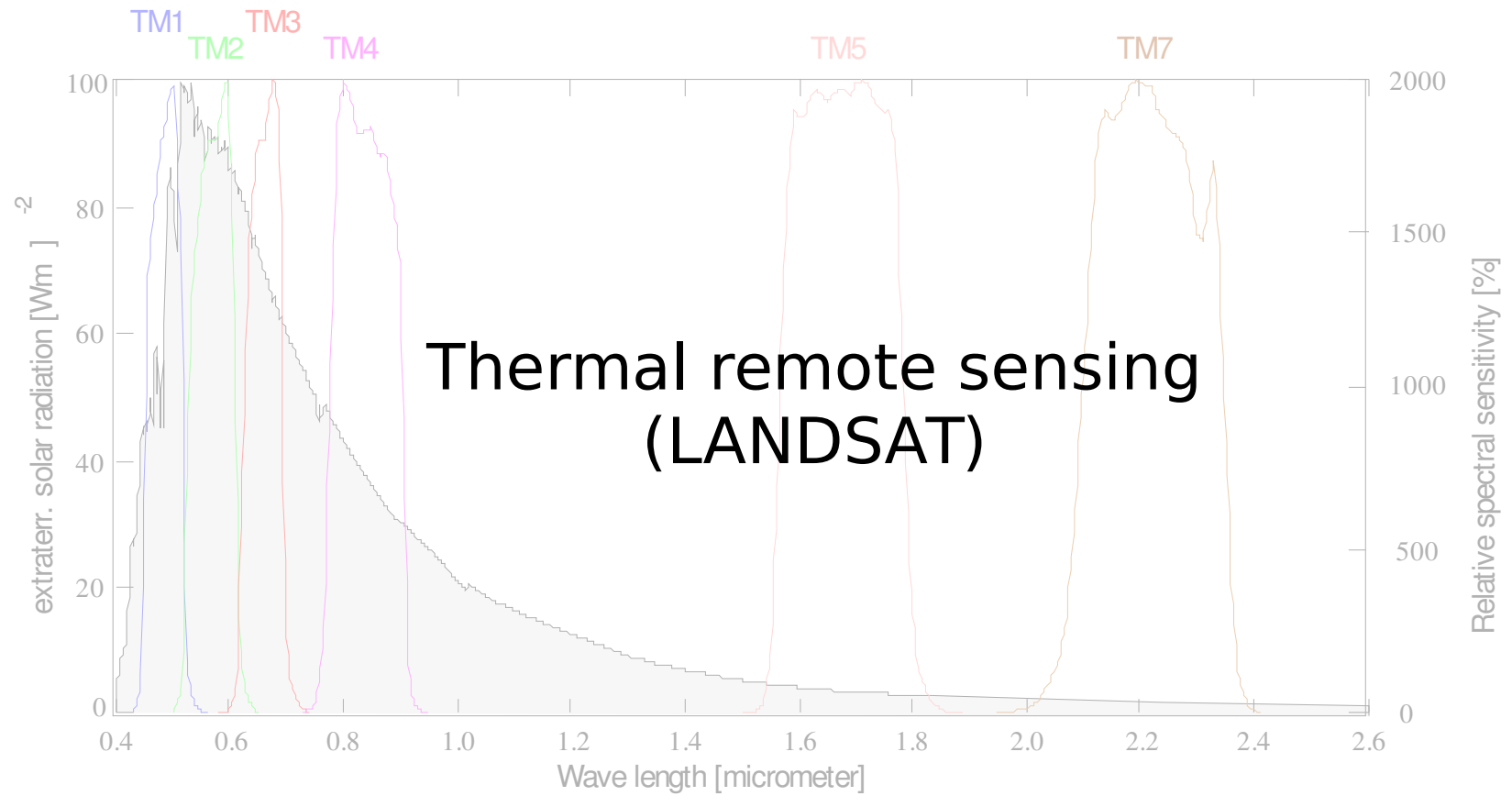


In the example, we work only in a small region since texture analysis is very CPU intensive. Zoom and set the computational region from the menu (or `g.region`) – **still 4 million cells**

```
# calculate the sum average (sa) measure, using 7x7 moving window size
r.texture input=ortho_pca.1 prefix=ortho_pca_1_tex method=sa size=7
r.colors map=ortho_pca_1_tex_SA color=bggyr
```

```
# calculate the entropy measure, using 7x7 moving window size
r.texture input=ortho_pca.1 prefix=ortho_pca_1_tex method=entr size=7
```

Texture maps may be used as synthetic channels for image classifications





Thermal remote sensing with GRASS GIS

Thermal channel: Land Surface Temperature (1)

TM6: Conversion of DN to Kelvin, then to degree Celsius

Important: conversion factors depend on satellite image age (NASA lookup tables)

```
g.region raster=lsat7_2000_61 -p
r.info -r lsat7_2000_61
  min=94
  max=167
```

*Note: the NC dataset differs
in map name and coefficients*

Note 2: simply use i.landsat.toar

```
r.mapcalc "lsat7_2000_61.rad = ((17.0 - 0.)/(255. - 1.))* \
  (lsat7_2000_61 - 1.) + 0."
r.info -r lsat7_2000_61.rad
  min=6.2244094488189
  max=11.1102362204724
```

```
# Conversion of spectral radiances to absolute temperatures (Kelvin):
#  $T = K2 / \ln(K1/L_1 + 1)$ 
r.mapcalc "temp_kelvin = 1282.71/(log (666.09/lsat7_2000_61.rad + 1.0))"
r.info -r temp_kelvin
  min=273.951770213164
  max=312.087286995184
```

Now we have a temperature map in Kelvin.



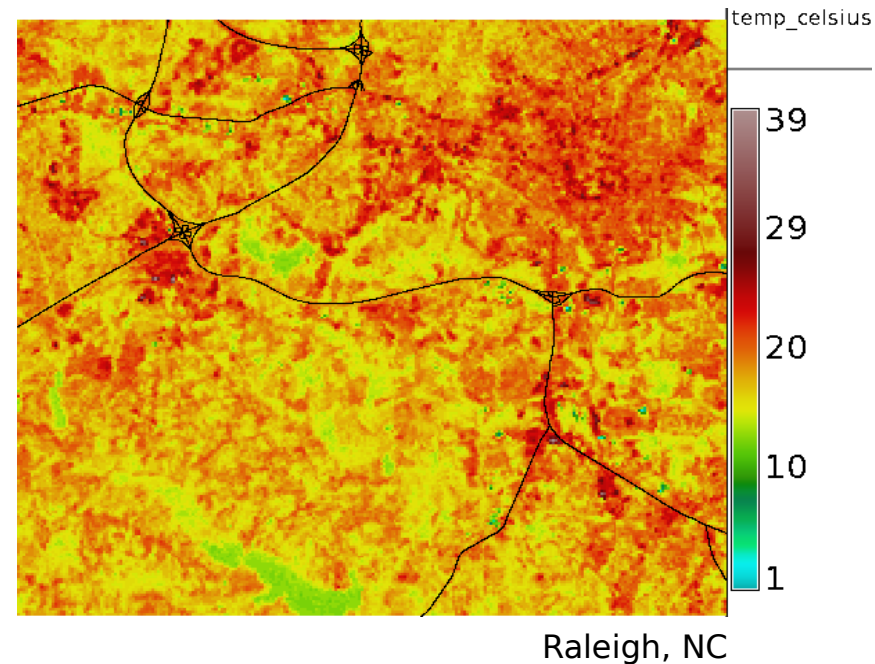
Thermal remote sensing with GRASS GIS

Thermal channel: Land Surface Temperature (2)

```
r.mapcalc "temp_celsius_03mar2000=temp_kelvin - 273.15"  
r.info -r temp_celsius_03mar2000  
min=0.80177021316365  
max=38.9372869951837
```

```
# New color table:  
r.colors temp_celsius_03mar2000 \  
    color=celsius  
d.rast.legend temp_celsius_03mar2000
```

Alternative: `i.landsat.toar` which reads the metadata file of LSAT, useful for the coefficients



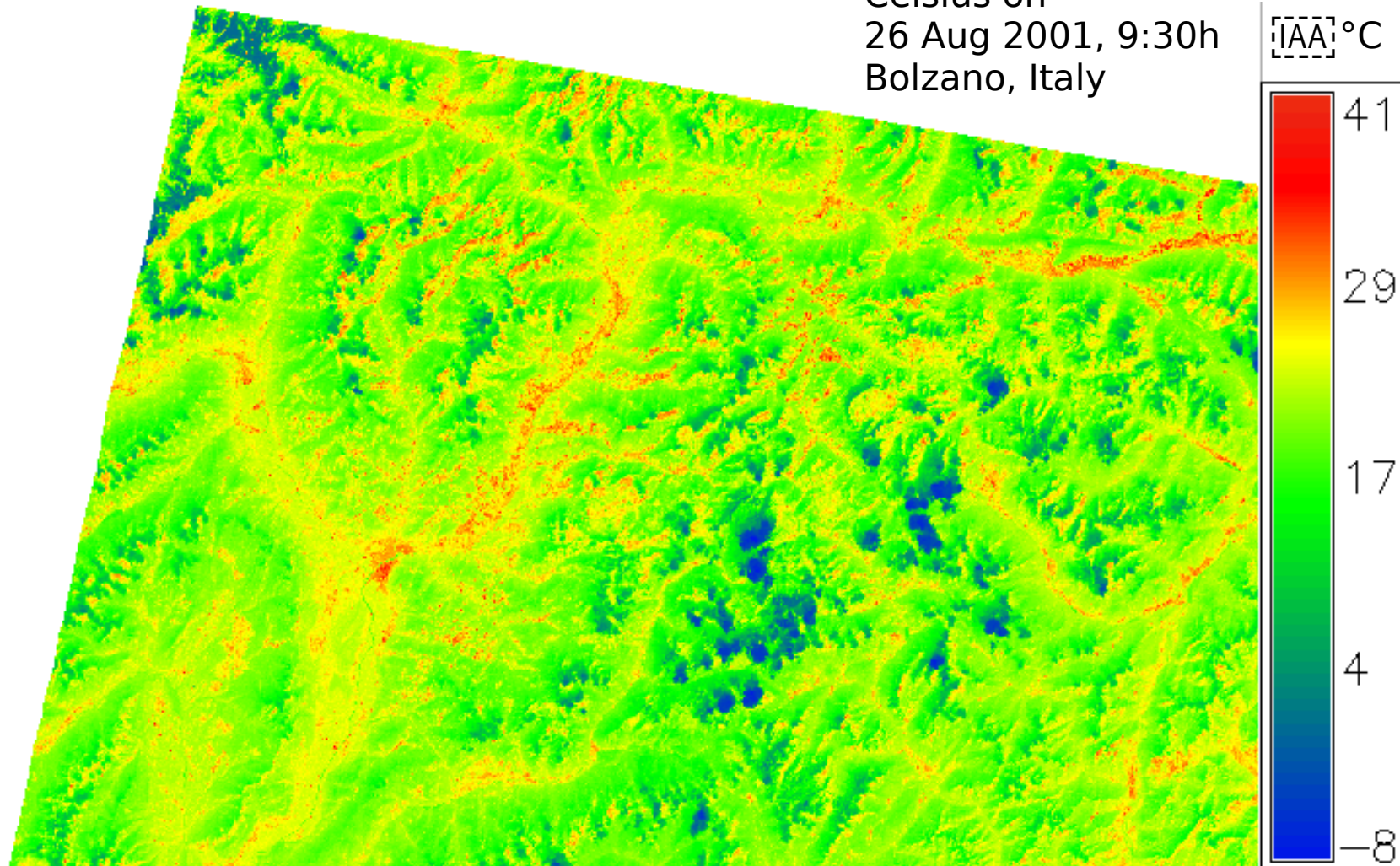
Remember: Surface temperature, not air temperature
LANDSAT overpass time at ~9:30 local solar time



Remote sensing with GRASS GIS

Thermal channel: Land Surface Temperature (LST)

Temperature in deg.
Celsius on
26 Aug 2001, 9:30h
Bolzano, Italy



Note: cold clouds are causing the low temperatures

Use `i.landsat.acca` to identify clouds and remove them