Parallel computation of forest fires using CHRIS images

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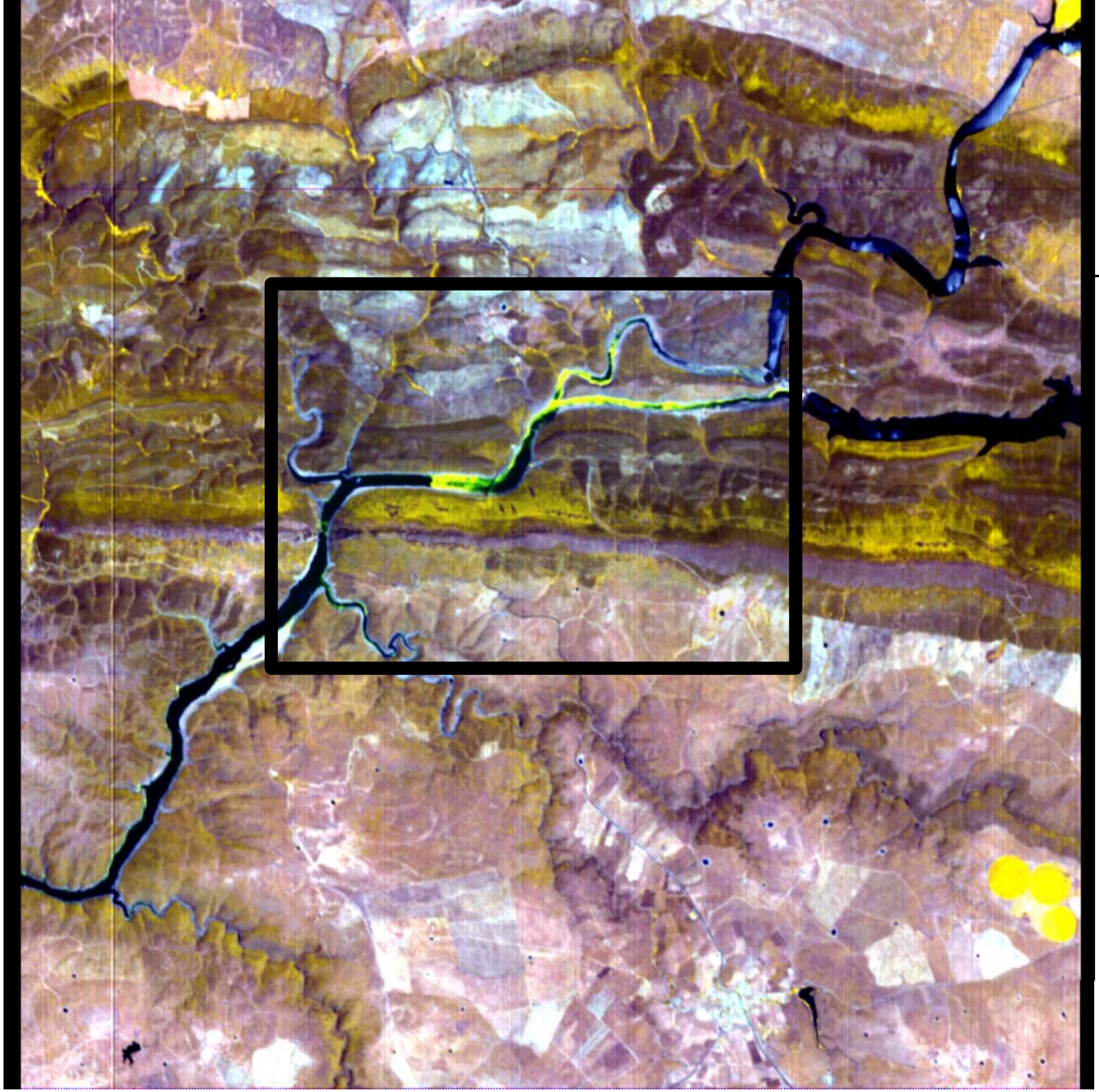

Fig 1 False colour Montfrague CHRIS PROBA image (MCPI).

Site

- Monfragüe (*Mont Fragosum*) is one of the most important sites for the preservation of the Mediterraneans ecosystem.

- Located in Spanish central-west (Extremadura) on the confluence of the Tajo and Tietar rivers, it has got a rich variety of big-sized birds (vultures, eagles...) and vegetation.

- Fire risk is specially high in this environment due to dry warm weather and human impact.

Fire Model

- Fire Hazard Models aim to compute the evolution of a forest fire on a region, expressed in terms of:
  - meteorological information,
  - DEMs, …, and
  - **vegetation distribution**

Reasons

In order to preserve this ecological environment some experiments has been done:

- Monfragüe Chris Proba Image (M.C.P.I.) acquisition.
- Image processing for fire risk estimation using M.C.P.I.:
  - Quick estimation of vegetation covers
    - Endmember extraction.
    - Abundance maps generation.
    - Endmember identification.
- Field caempaign.
  - Simultaneous field measurements
  - Airborne Hyperex camera image acquisition.

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Endmember Identification

The first image processing task made was the identification of the endmember present on the scene. In order to perform this task, the AMEE algorithm (R) was used.

- Six endmembers were obtained and labelled from 1 to 6.

- The highest abundance for endmember 1 (Fig 2) strongly correspond with Tajo and Tietar reservoirs and other water covers.

- ***Endmember 3 is more abundant next to the rivers and can be identified with soil.***

- The white shapes in Fig 3 are circular irrigated crop, which allow us to identify endmember 2 as vigorous vegetation. The higher gray levels can be identified with vigorous vegetation in the north-oriented face of the mountains.

- The areas with the highest fire risk are those that appear with higher grey levels in figure 5.

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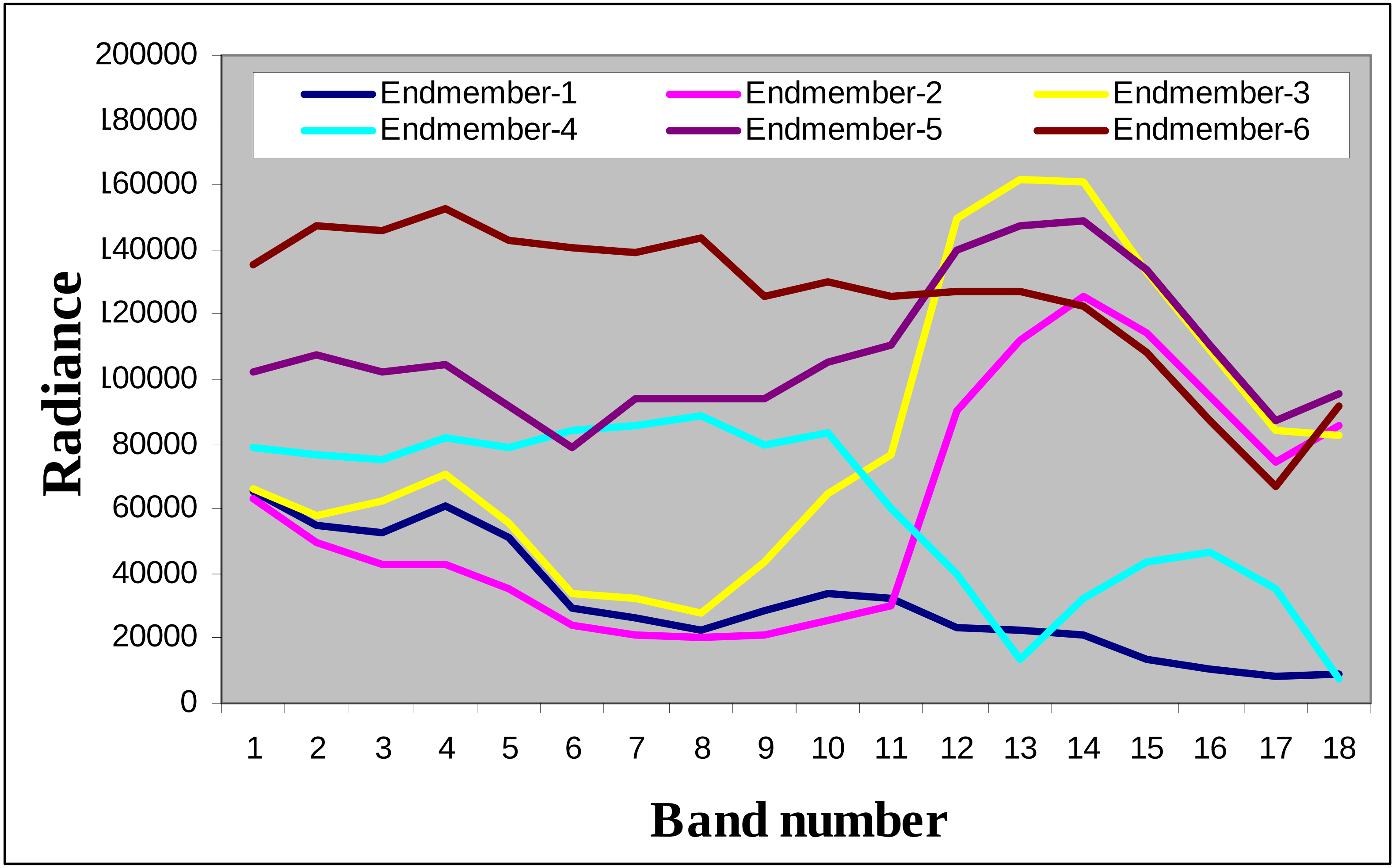


Fig 1 Endmember,s spectral signature for (M.C.P.I.) image.

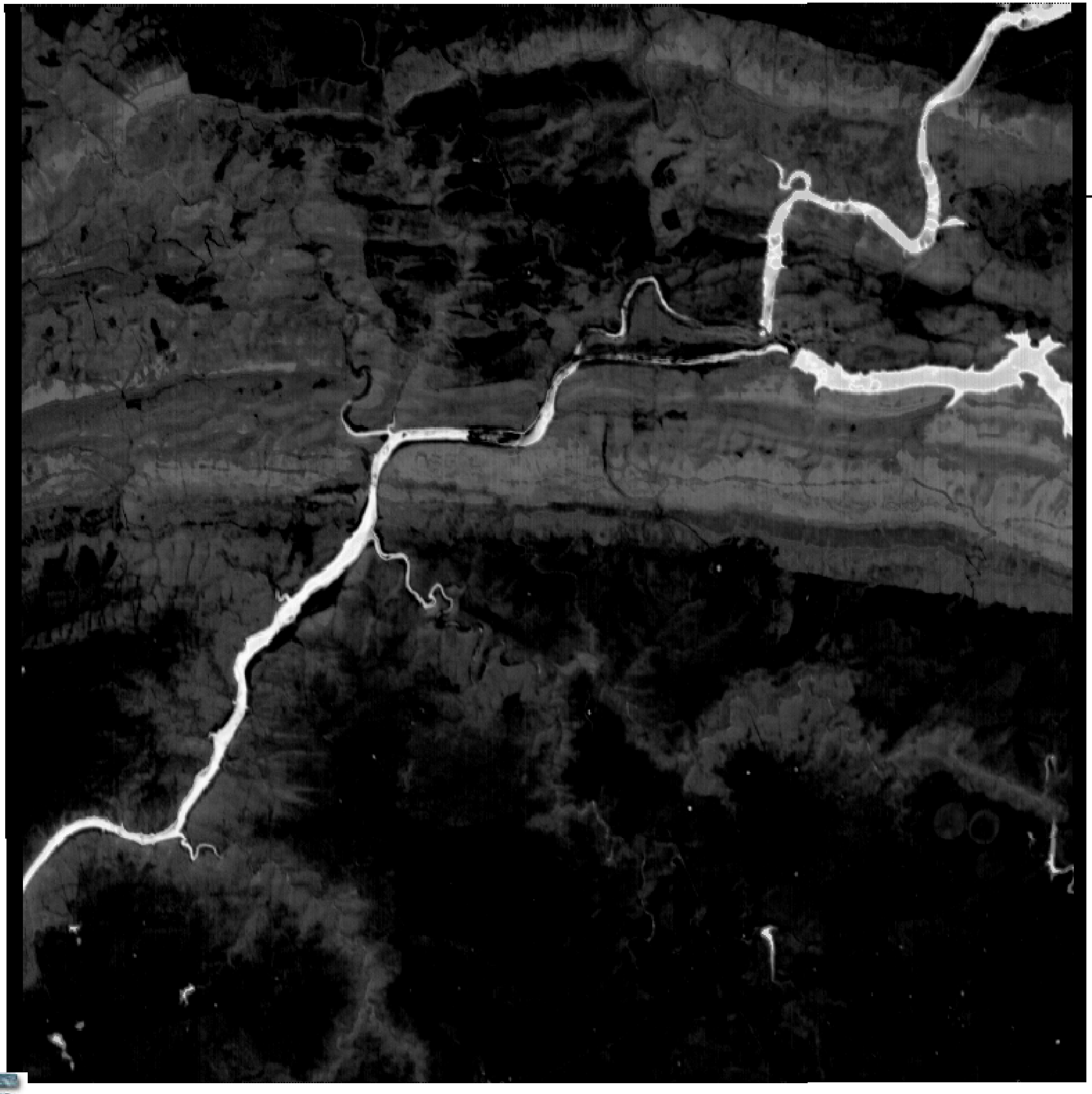


Fig 2 Abundance map for endmember 1 (water)

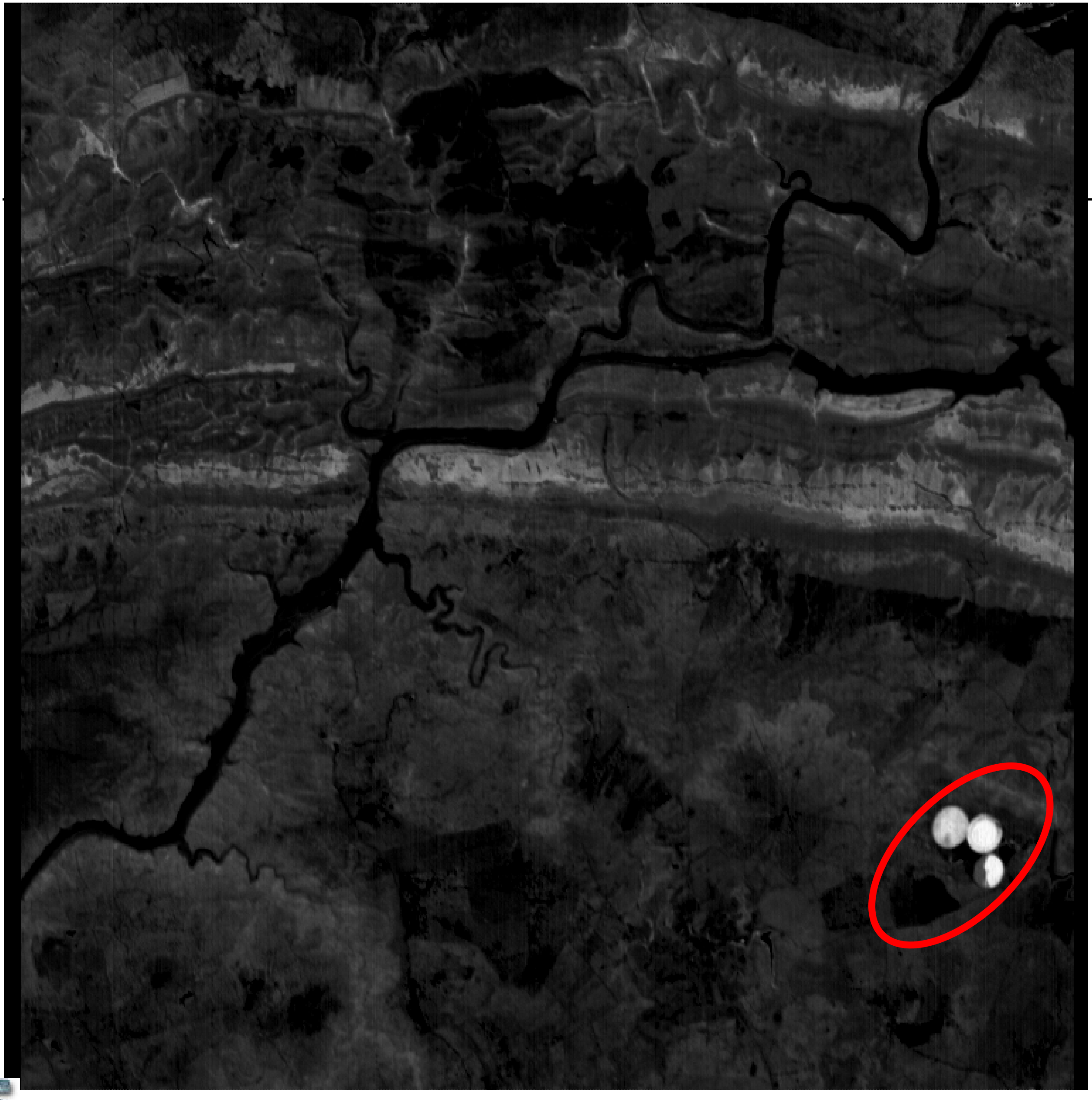


Fig 3-Abundance map for endmember 2 (crops)

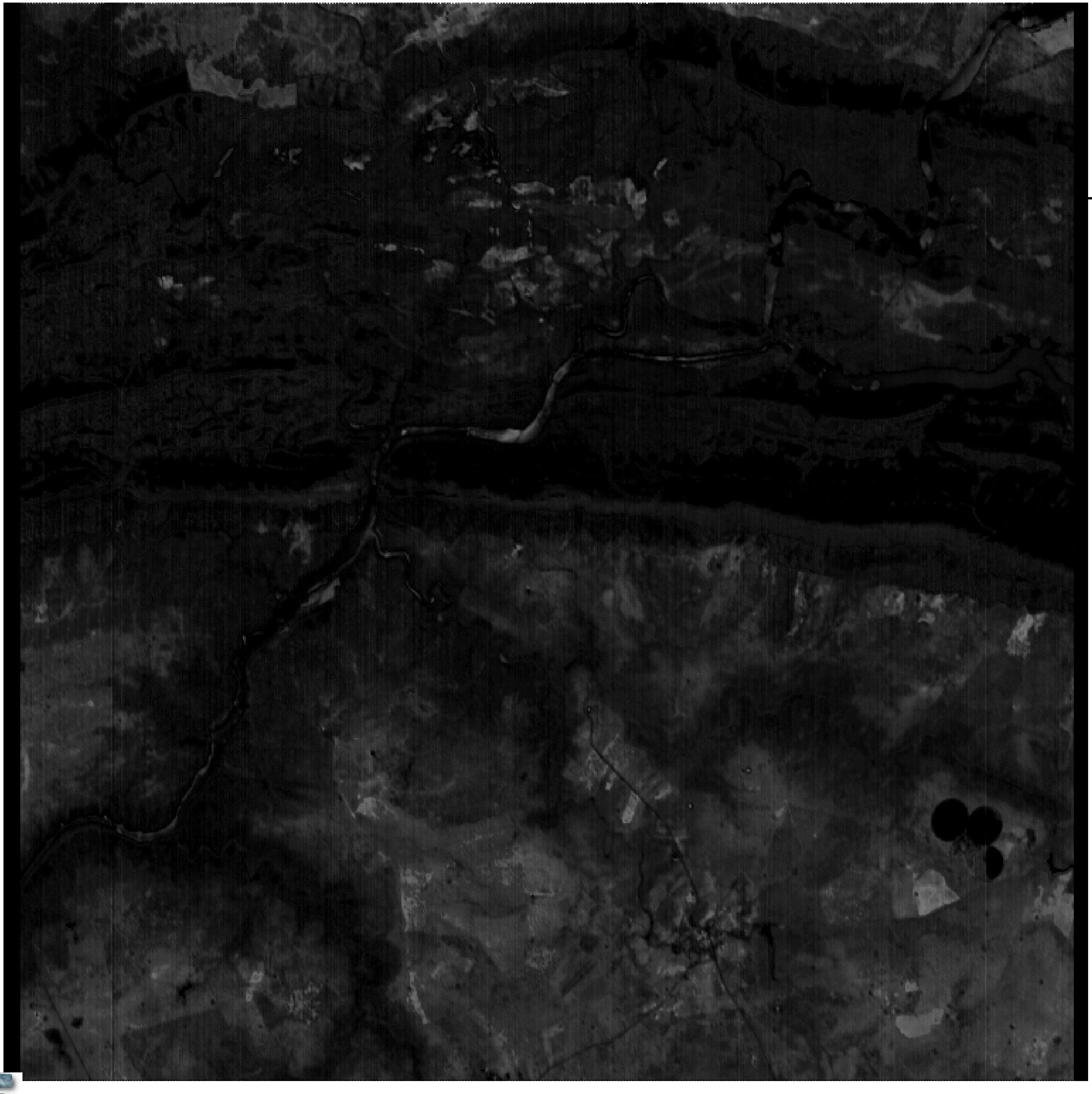


Fig 4 Abundance map for endmember 4 (soil)

Abundance map for endmember 5 (senesc. veg.)

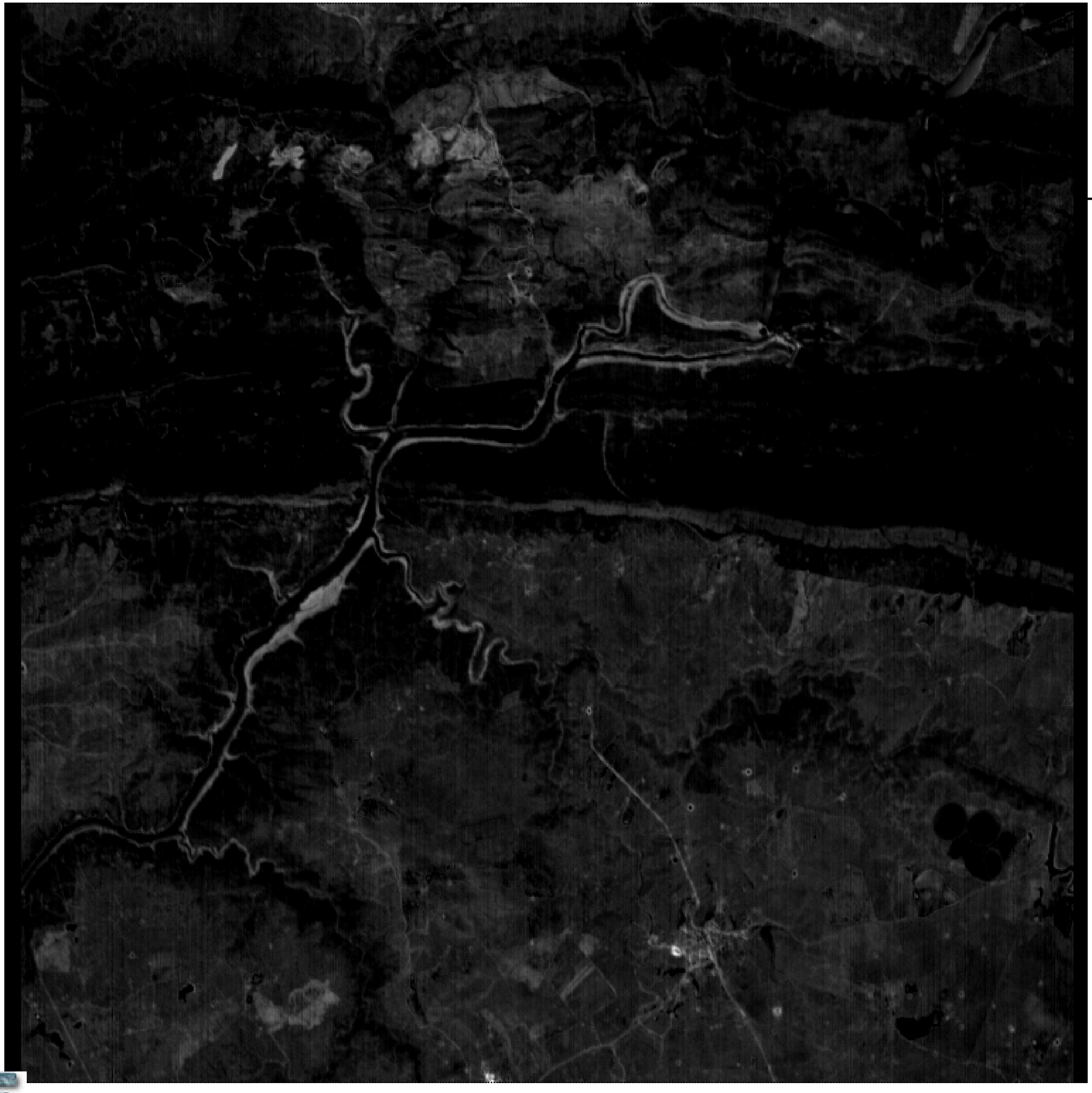


Fig 6 Abundance map for endmember 6 soil.

Image rectification

- Using multi-angular CHRIS PROBA features it is possible to compute a more accurate vegetation distribution map.
- In order to obtain this information we must georectify the five images acquired at different angles

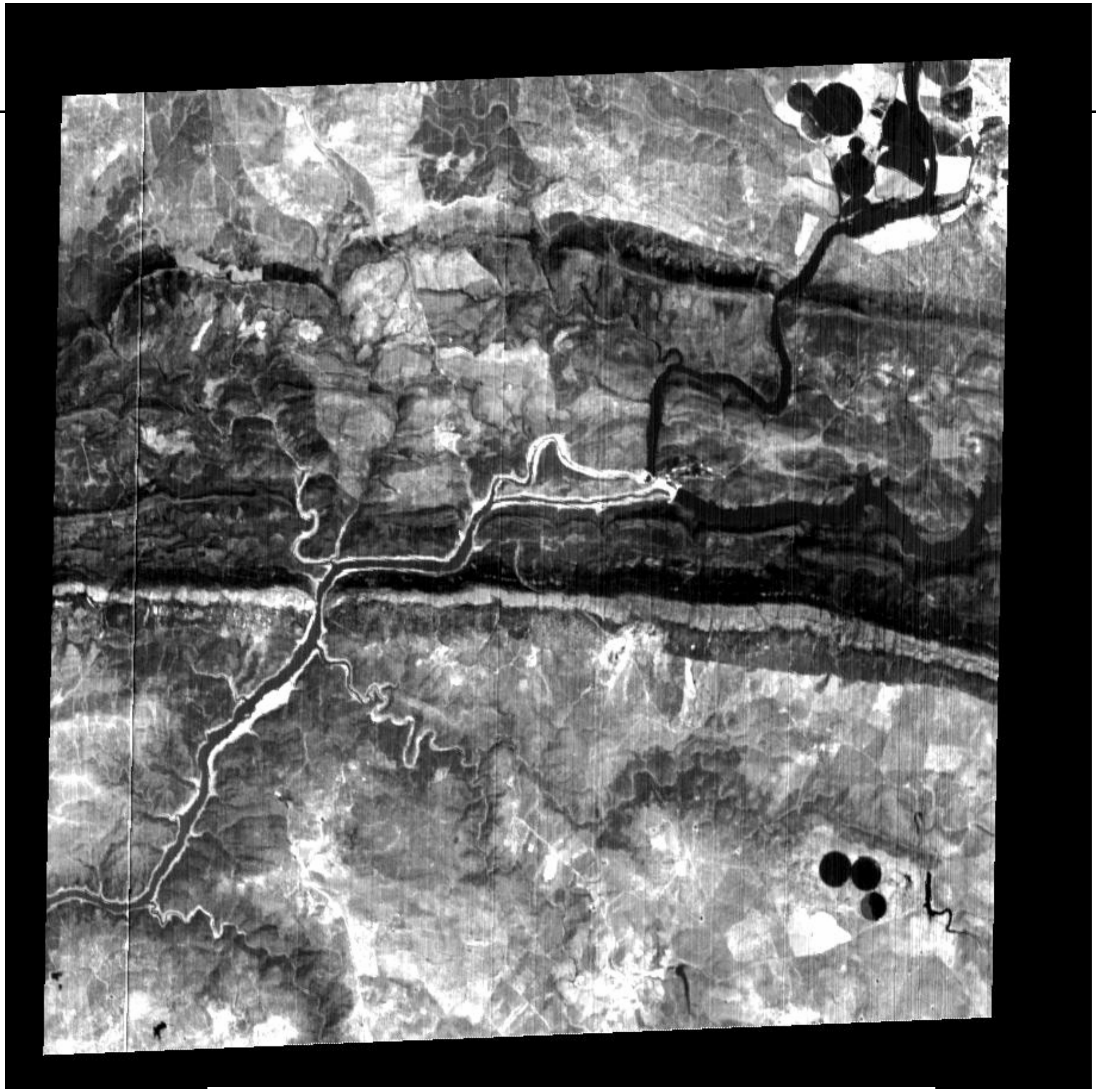


Fig. 7 Georectified M.C.P.I

Out of Nadir Georectified Images

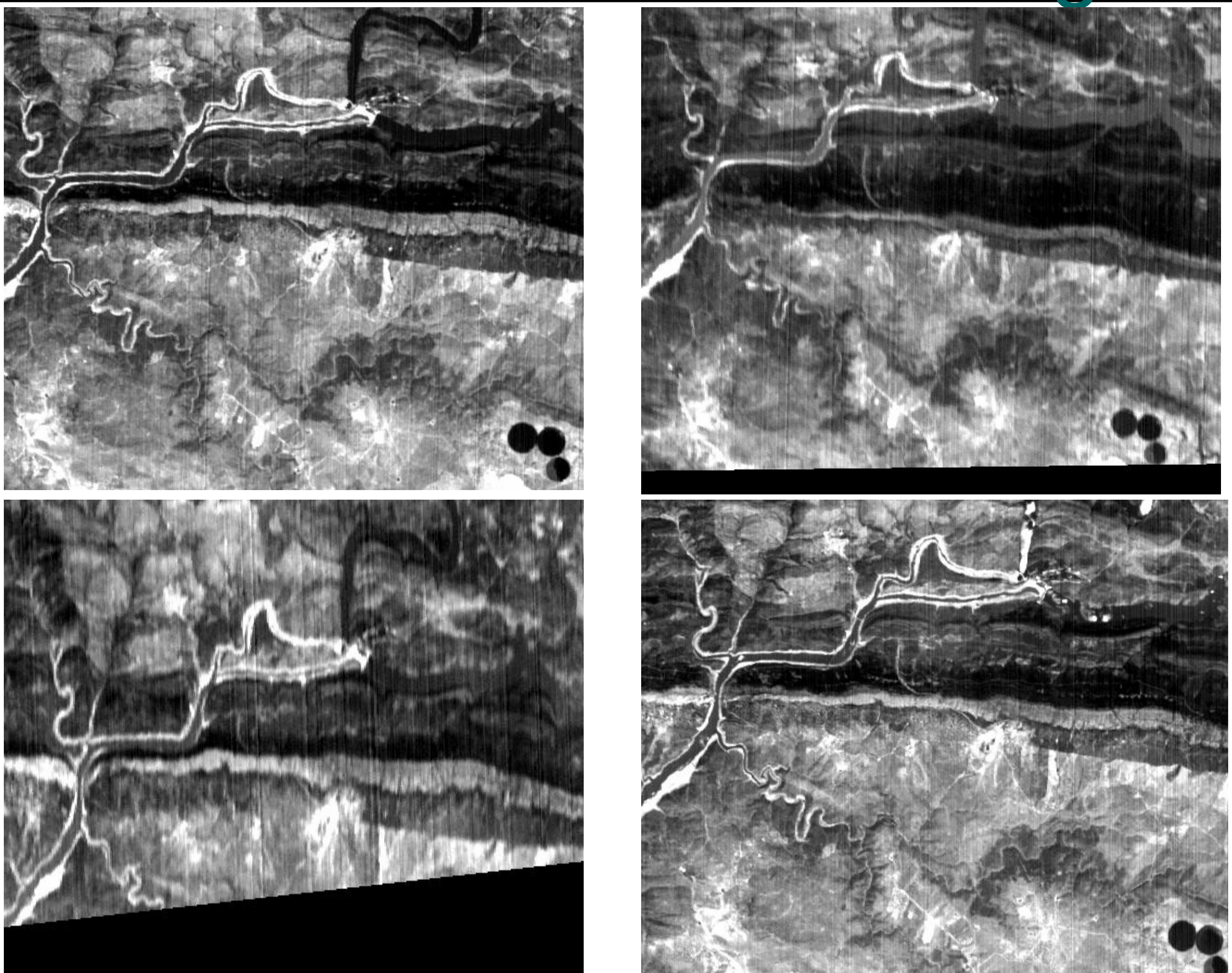


Fig. 8 Georectified M.C.P.I.'s for the four angles

Multi-angular/spectral Plot

- Collecting the spectral plots for the same point on different images (angles) we obtain the Multi-angular/spectral signature.

Plot image

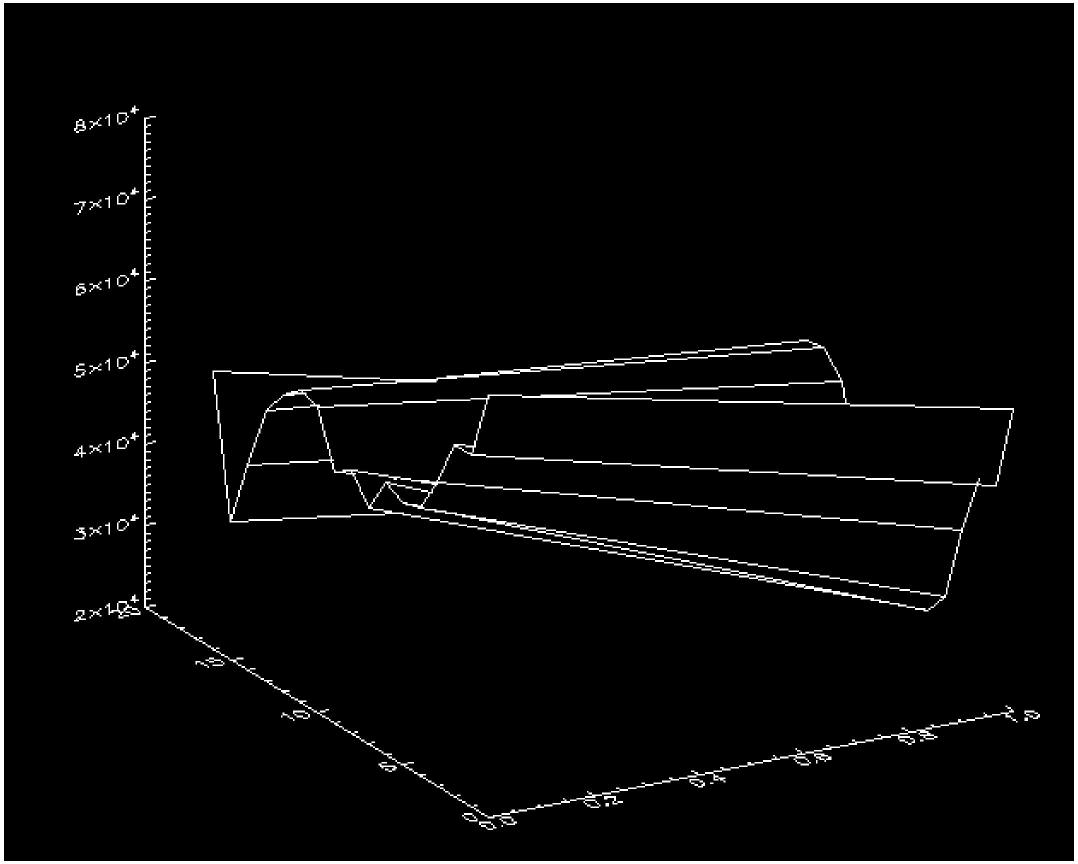


Fig. 9 Spectral surface view forGeorectified M.C.P.I.'s for the four C./P.angles

Matrix Data Structure

- In order to avoid the problems related with the simultaneous manipulation of the five different angle images a new data structure can be used.
- This data structure includes for each pixel the following information: latitude, longitude, angle of observation and spectral signatures.
- Figure 10 shows the elemental information for each pixel.

Diffuse Matrix Data Structure

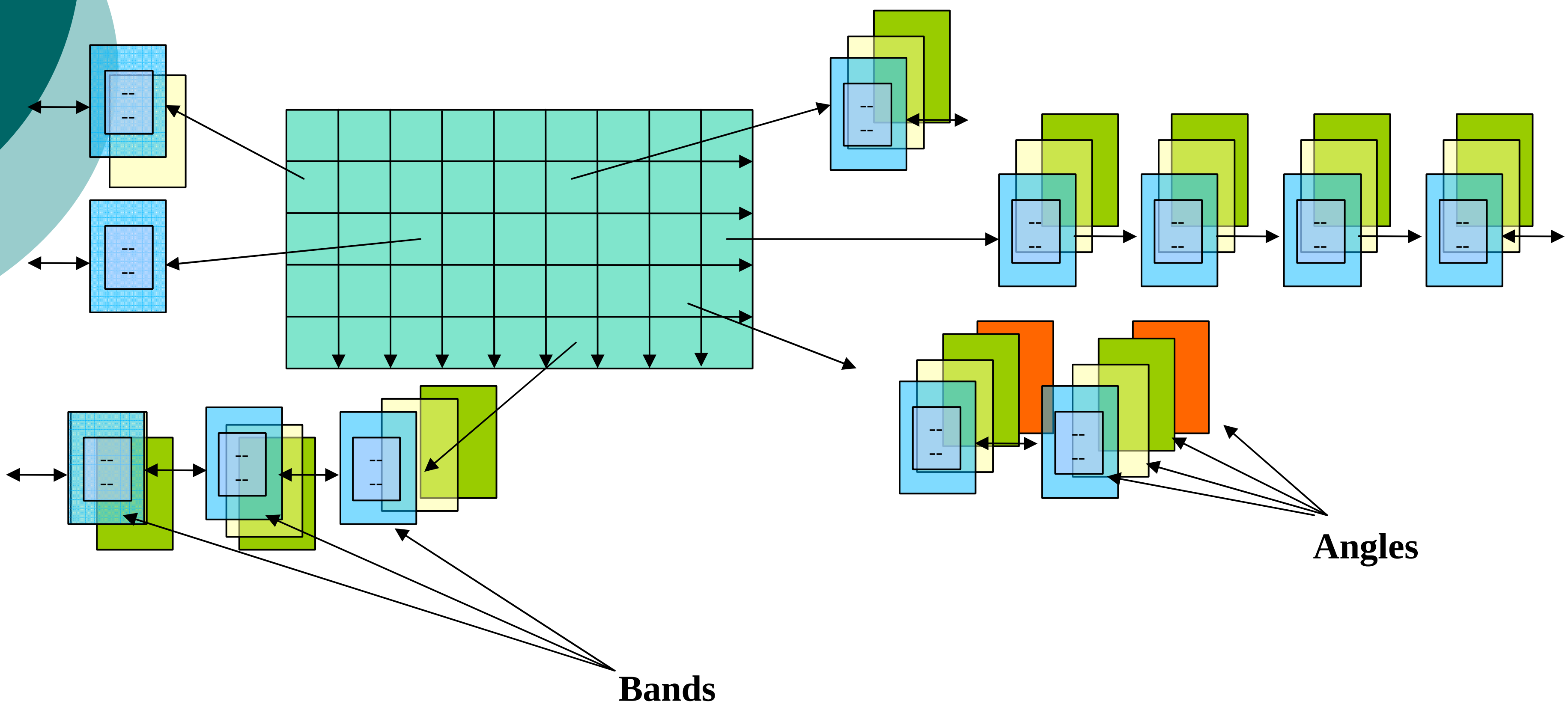
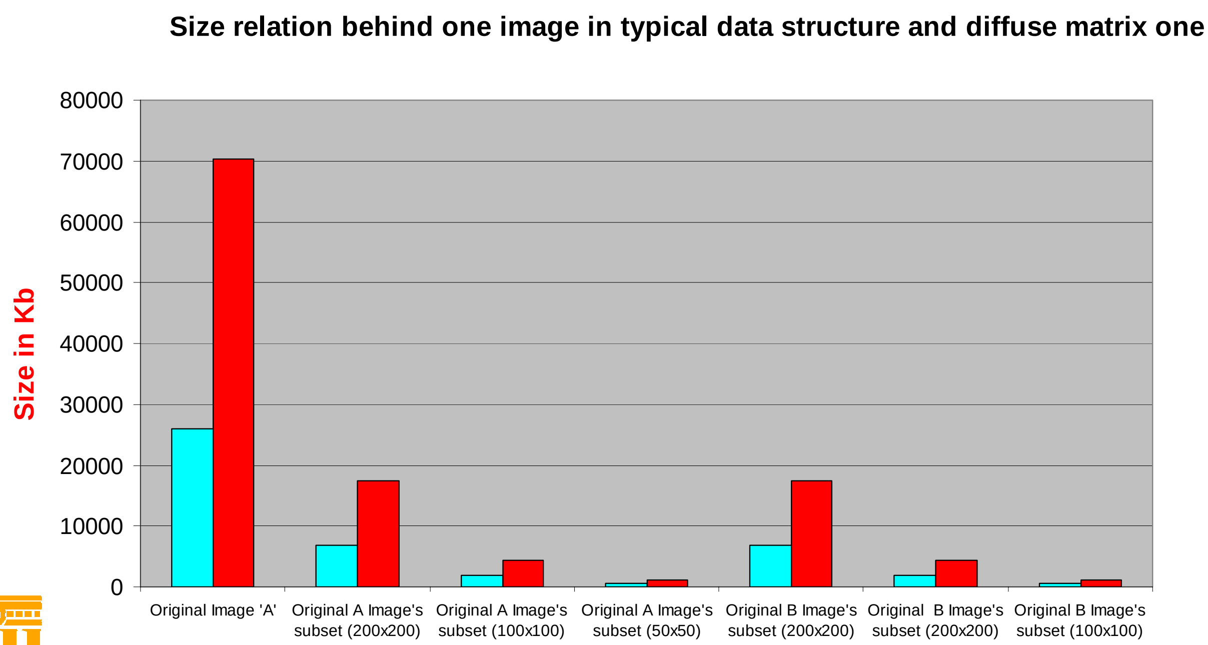


Fig 10-Diffuse Matrix Data Structure

Diffuse Matrix Size



- This figure shows diffuse matrix size (blue) and the raster image size (red) for the full image. One can clearly see that the Diffuse Matrix format can make a better use of the space in disk.

Computation Speed

- According with the image size reduction we obtain shorter computation times.
  - I.e., the complexity to process a raster image using AMEE algorithm is given by:

    samples*lines*bands*Structuring_Element_Size.
  - Using Diffuse Matrix the complexity is

    samples'*lines'*bands*Structuring_Element_Size
- With:

  samples'≤samples and lines' ≤lines.

Parallel Computation I

- Diffuse Matrix data structure allows distributed computation of the multi-angular and multi-spectral information taking into account different latitude and longitude.
- The parallelism is directly included into the data structure, allowing the distributed processing of the data transparently to the users.

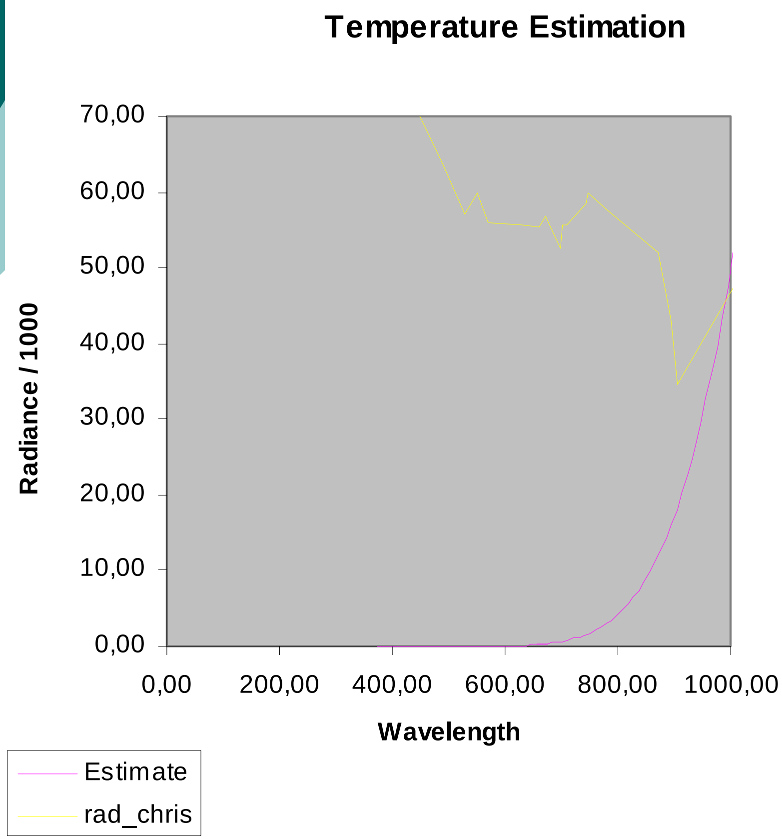
Parallel Computation II

- Users define their functions to work in latitude and longitude, independently of the division made on the image or sets of images encapsulated into the structure.
- They can access the same Diffuse Matrix concurrently.
- The inclusion of data obtained at different times, different spatial resolution, etc. expands greatly the complexity of the algorithms, and this structure ease this complexity and poses as one of the best solutions to integrate everything together and exploit the parallelism.

Temperature Estimation

- Forest fire evolution depends strongly on the temperature.
- Infrared sensors can be used to obtain an accurate measurement of the cover temperature. However, the optical spectral signature can be used to obtain a cover temperature estimated value.
- Figure 11 shows the spectral signature of a black body (according Plank's law) and the CHRIS spectral signature for a pixel of soil in the Monfragüe's image.

Estimation of cover temperature



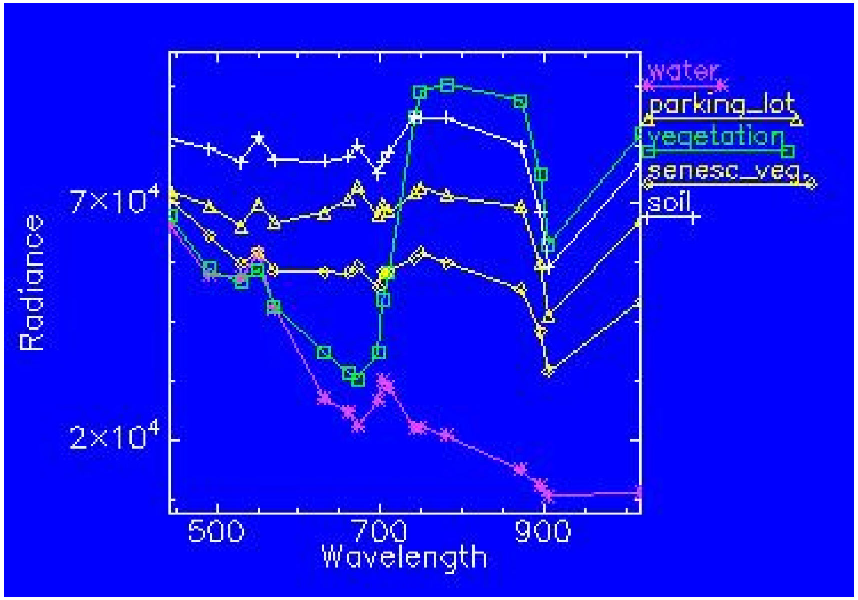
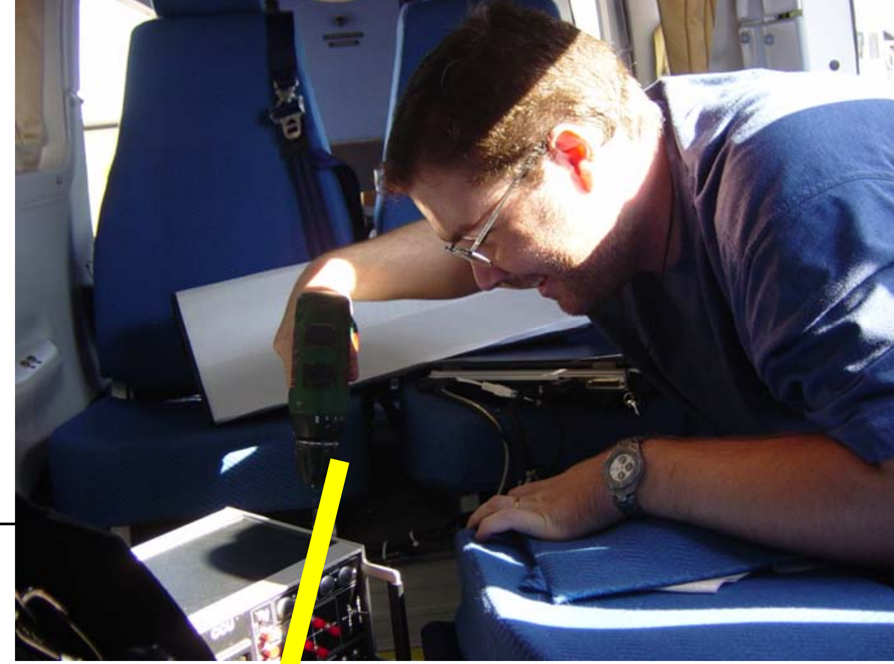
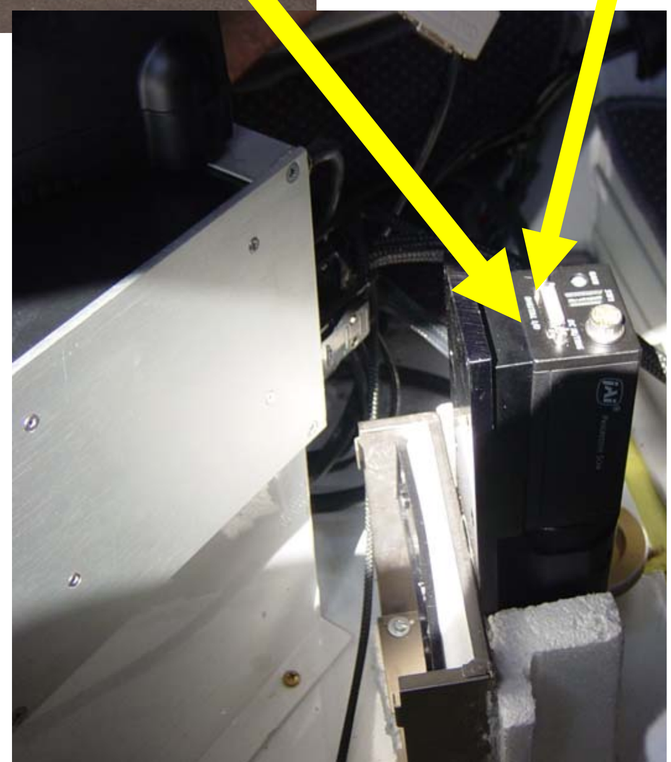


Fig. 11 – CHRIS and black body’s spectral signatures

Ground Campaing





Aircraft
Specim
camera
allocation

Conclusions

- The areas with higher fire risk (senescent vegetation) has been identified:
  - Automated endmember extraction and mixture analysis.
- Angular information has been used in order to obtain a more accurate vegetation distribution map.
- A new data structure (diffuse matrix) were introduced in order to obtain a better way of CHRIS PROBA's images parallel computation.
- A method for field temperature estimation has been discussed.

Thank you