MINISTERIO DE FOMENTO

CEDEX
CENTRO DE ESTUDIOS Y EXPERIMENTACIÓN DE OBRAS PÚBLICAS

Title:

"Use of CHRIS for Monitoring Water Quality in Selected Reservoirs. 2005/06 Activities" (AO 2830)

Authors:

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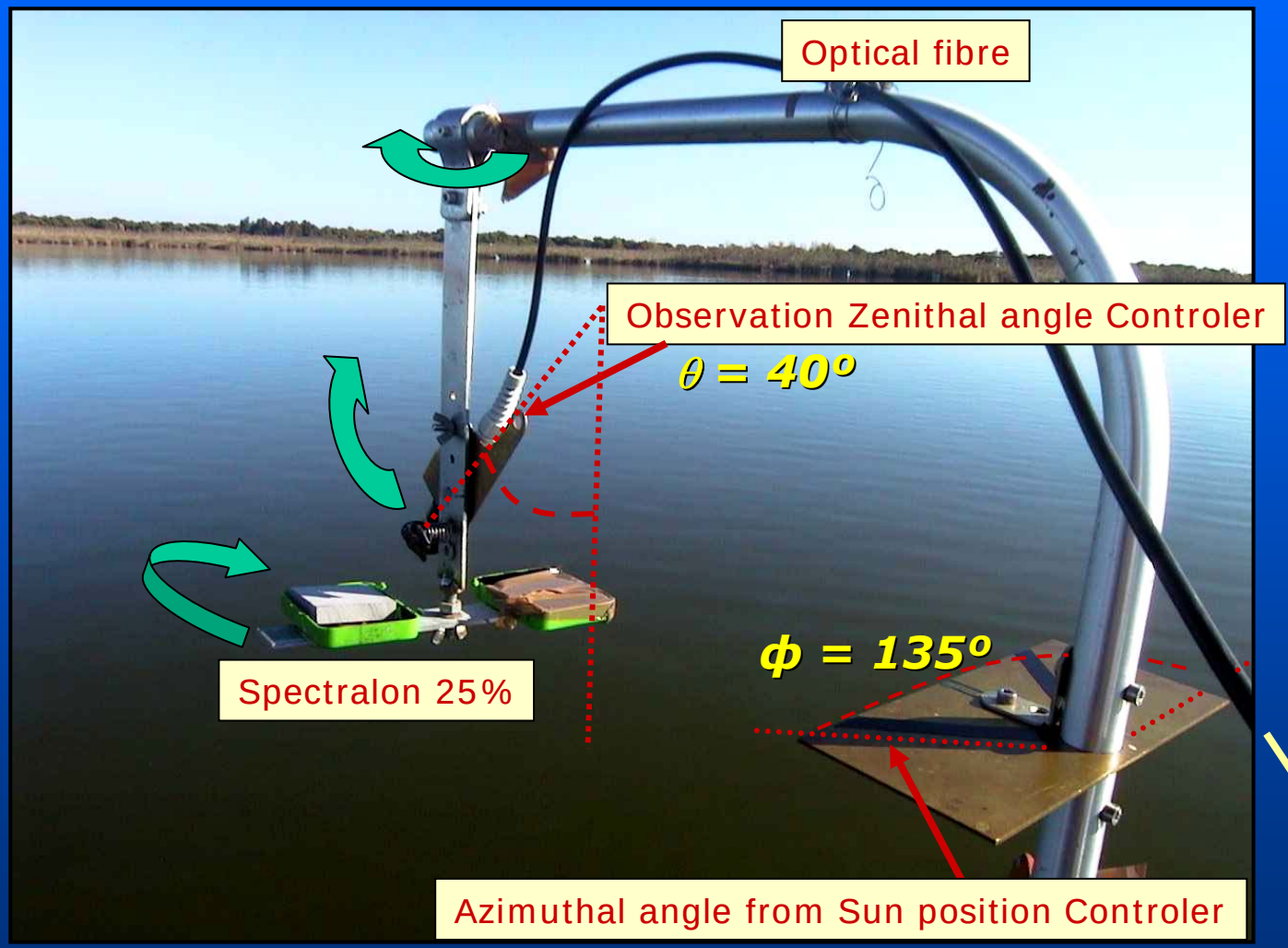
Centre for Hydrographic Studies of CEDEX (Spain)

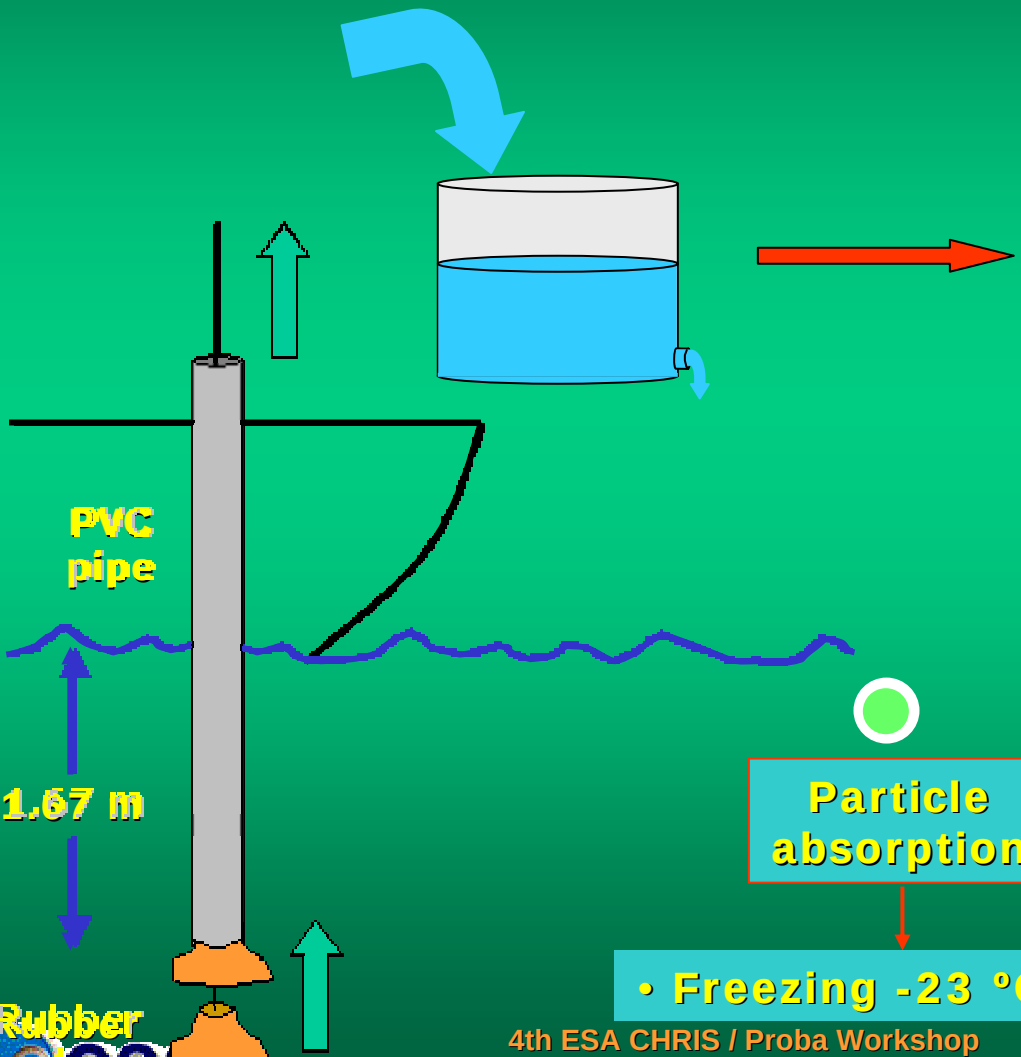
Topic/subtopic : *Water Quality, Photosynthetic pigments, Remote sensing*

Above Water Measurement Device



ASD Spectro-radiometer on the working boat

4. SUBSAMPLING FROM INTEGRATED SAMPLE



Suspended solids

Phytoplankton

Filtration for CDOM

- Nucleopore filters 0.22 µm
- Freezing -23 ºC

Vacuum filtration

- 150 mm Hg
- 6 Filters GF/F 25 mm

Particle absorption

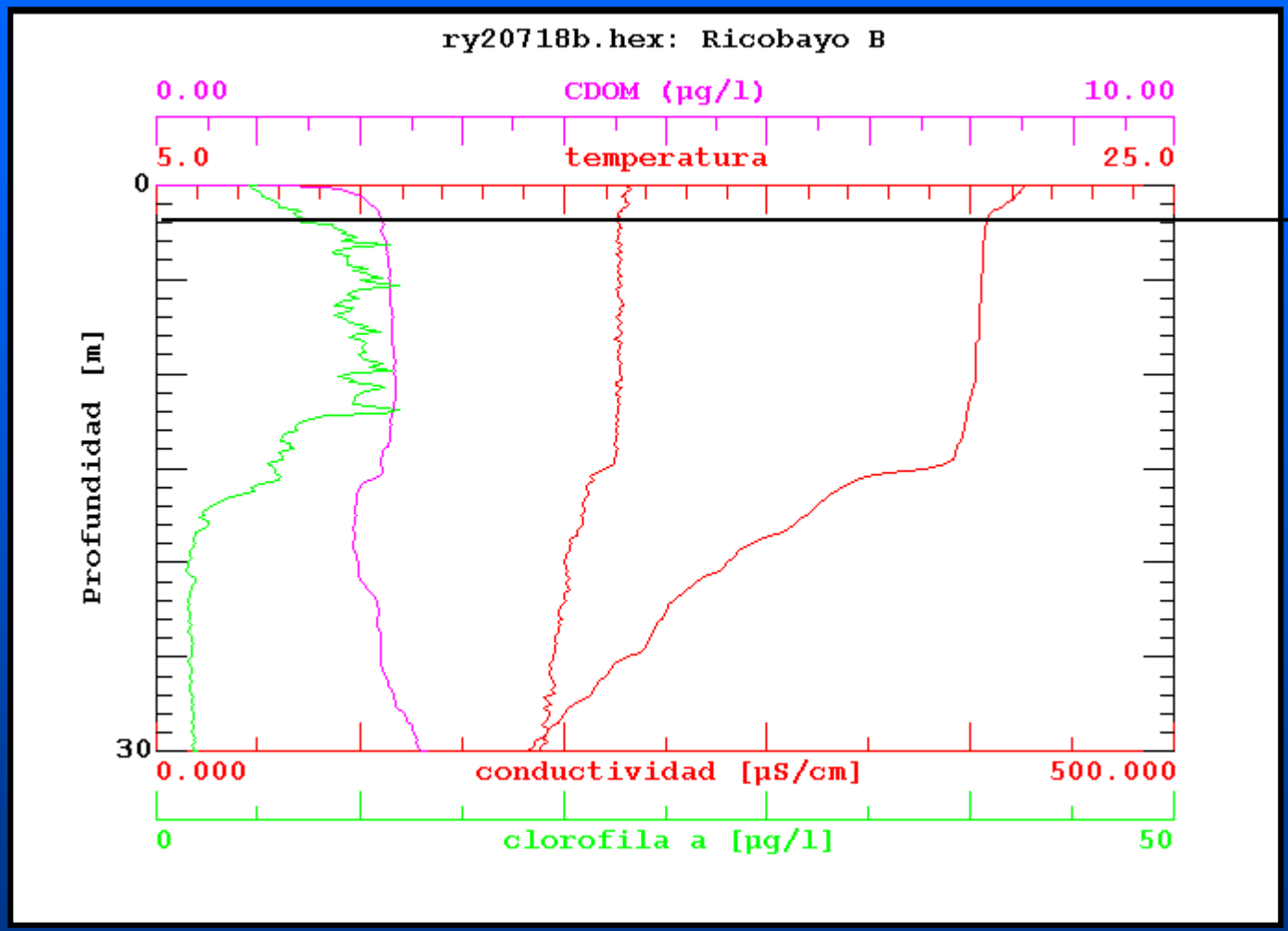
- Freezing -23 ºC

Phycobilines calibration

HPLC

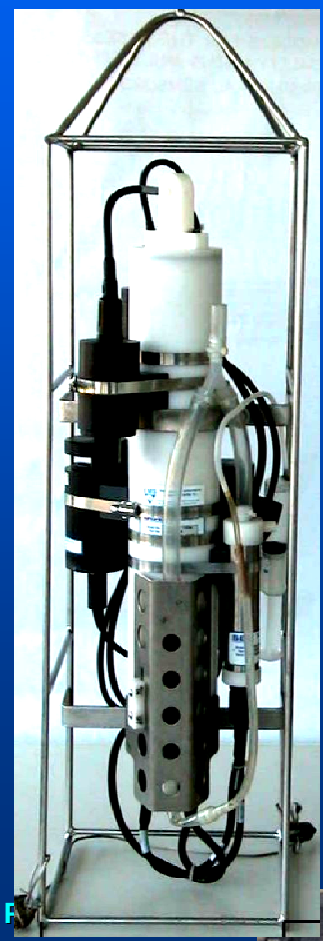
- Drying
- Liquid N^2 freezing

TYPICAL MULTIPARAMETRICAL PROBE PROFILE (1)

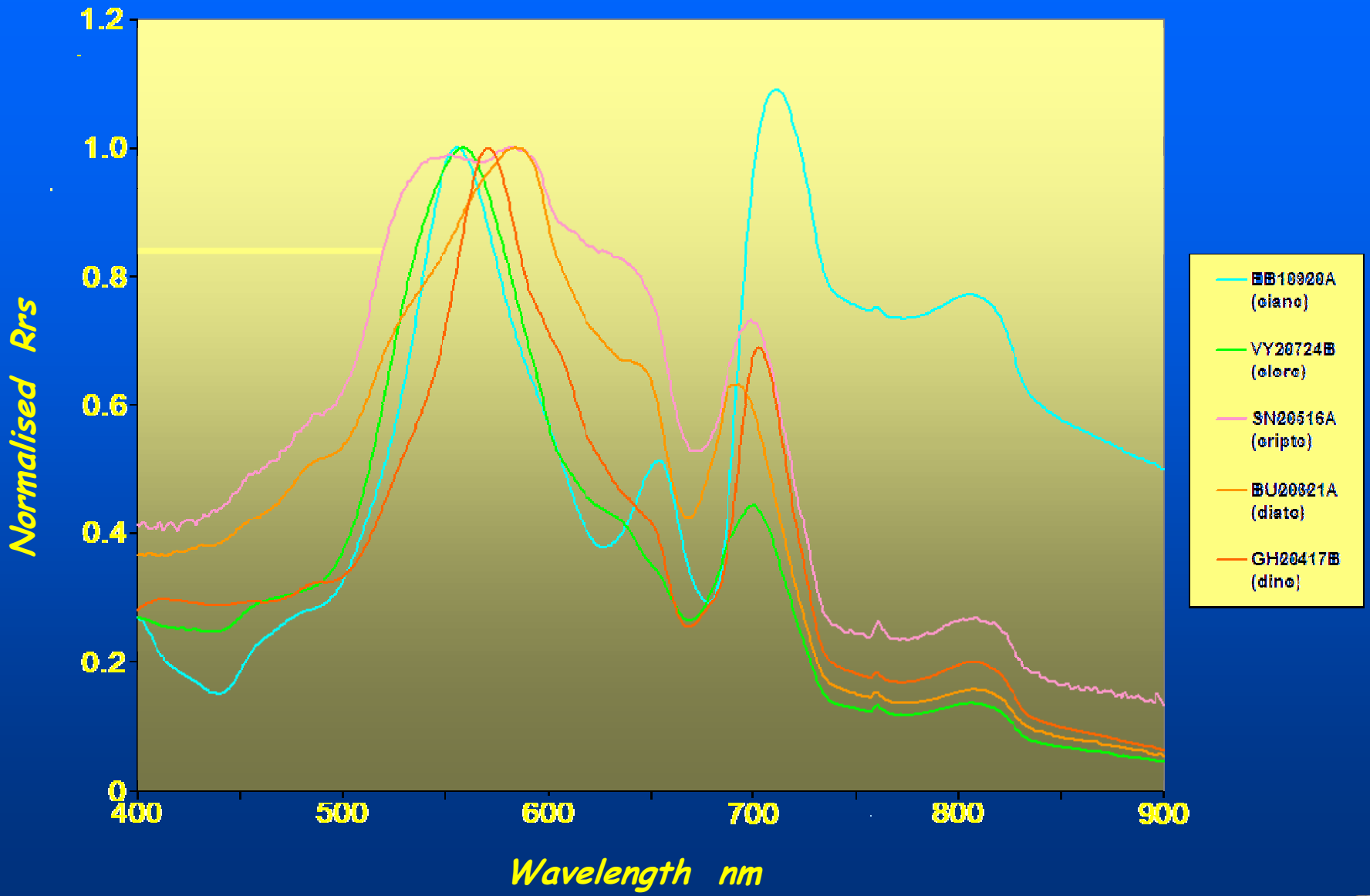


INTEGRATED SAMPLE

Cond.230,2 µS/cm
Temp. 21,7 ºC
[chl a] 6,3 µg/l
[CDOM] 2,1 µg/l



Some spectra from algal communities with a dominant group



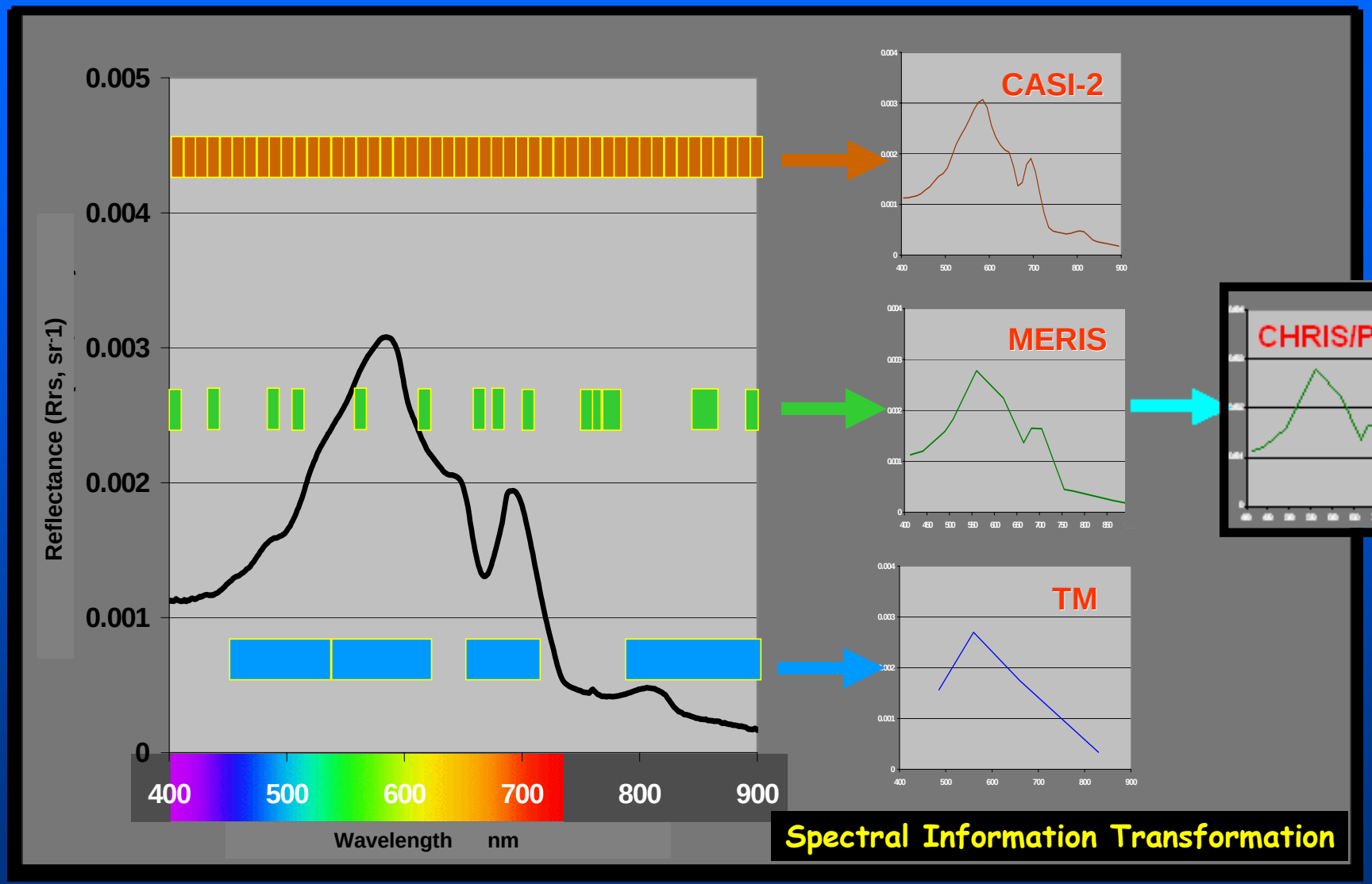
As an initial approach to algorithm development, we have examined the relationships between ratios of MERIS bands and pigment concentrations through statistic analysis.

The band selection process was based on the spectral properties of each pigment and a peak analysis of the Rrs spectra.

CHRISProba Water Bands. Full Swath, High Resolution

Band	Detectors	From / To	λ mid	Width
W1	17-24	405.6 415.2	410.5	9.6
W2	41-45	438.0 446.8	442.4	8.8
W3	65-68	485.6 494.8	490.2	9.2
W4	73-76	504.5 514.8	509.6	10.3
W5	81-83	525.6 534.2	529.6	8.6
W6	91-93	556.1 566.3	561.2	10.2
W7	94-95	566.3 573.4	569.8	7.7
W8	99-101	584.6 596.4	590.4	11.8
W9	107-108	617.5 626.6	622.0	9.0
W10	113-114	645.7 655.8	650.7	10.1
W11	117-118	666.3 677.2	671.7	10.9
W12	119	677.2 682.8	679.9	5.6
W13	120	682.8 688.5	685.6	5.7
W14	123-124	700.2 712.4	706.3	12.2
W15	131	751.9 758.9	755.3	7.0
W16	134-135	773.4 788.4	780.8	15.0
W17	145-146	863.1 881.3	872.1	18.3
W18	159-161	1002.7 1035.5	1019.0	32.9

This *three-level data* has enabled us to *compare them with the L2* imagery. The comparison could be useful for improve the understanding level of representativity of fit.



Chlorophyll-a fit equation:

$[Chla] = 9.981\ e^{5.6743\ (W14-W12)/(W14+W12)}$ $R^2 = 0.8003$

Phycocyanin fit equation:

$[Phyc] = 46.478\ e^{5.1864\ (W14-W9)/(W14+W9)}$ $R^2 = 0.9211$

(W14 center corresponding with MERIS 9)

(W9 center corresponding with MERIS 6)

CHRIS-PROBA Objectives:

- Use the CHRIS imagery for Mapping of Chlorophyll-a and Phycocyanin concentration, temporal and spatial distribution, testing several algorithms for both and for other Phytoplankton pigments.

- Validation of Algorithms developed for MERIS bands and tested the past year in Rosarito reservoir.

- Testing and improvement of MERIS atmospheric correction models, using the Univ. of Valencia software, applied last years.

- Use the multiangular capabilities of PROBA to improve as possible the model accuracy and study the Fresnel reflectance effects.

2004

2005

Proposed Area of work for 2004 - 2005 : Rosarito reservoir

Tietar river, Tajo river basin,

central Spain

Center image Coordinates:

Lat: 40º 06' 06" N Lon: 05º 16' 47"W

ROSARITO reservoir

2006

Proposed Areas of work for 2006 :

Valmayor reservoir (Aulencia river, Tajo river basin, central Spain)

and Albufera of Valencia (Mediterranean coastal lake close to Valencia)

PROBA/CHRIS request for acquisitions -

Name of PI	Ramón Peña-Martínez
Project Name	Use of CHRIS for Monitoring Water Quality in Selected Reservoirs
Project ID (from EOPI)	AO-2830

Site 1	
Name of site	Valmayor Reservoir
Center coordinates (decimal degrees)	40.553732; -4,052252
Altitude of site (metres above sea level)	831
Preferred date or time range for data take	april - september (field work associated, it will be coincident if is known the acquisition date 1 day before at least.
Mode(s)	2 water
Multi-angle 5-image set or nadir-image?	Yes
Any additional information/Remarks	Cyanobacteria assesment algorithm (MERIS & CHRIS) validation. Specific research of angular differences in the several image sets.

Site 2	
Name of site	Albufera of Valencia
Center coordinates (decimal degrees)	39.335423; -0.340947
Altitude of site (metres above sea level)	0
Preferred date or time range for data take	march - october (field work associated, it will be coincident if is known the acquisition date 1 day before at least.
Mode(s)	2 water
Multi-angle 5-image set or nadir-image?	Yes
Any additional information/Remarks	Cyanobacteria assesment algorithm (MERIS & CHRIS) validation. Specific research of angular differences in the several image sets. Very high pigment concentration levels.


VALMAYOR reservoir


ALBUFERA of Valencia


ALBUFERA of Valencia

ALBUFERA of Valencia

CHRIS/Proba image set acquisition during 2005 -2006

ROSARITO reservoir 2005.10.05

VALMAYOR reservoir

2006.06.16

ALBUFERA 0f Valencia

2006.06.24

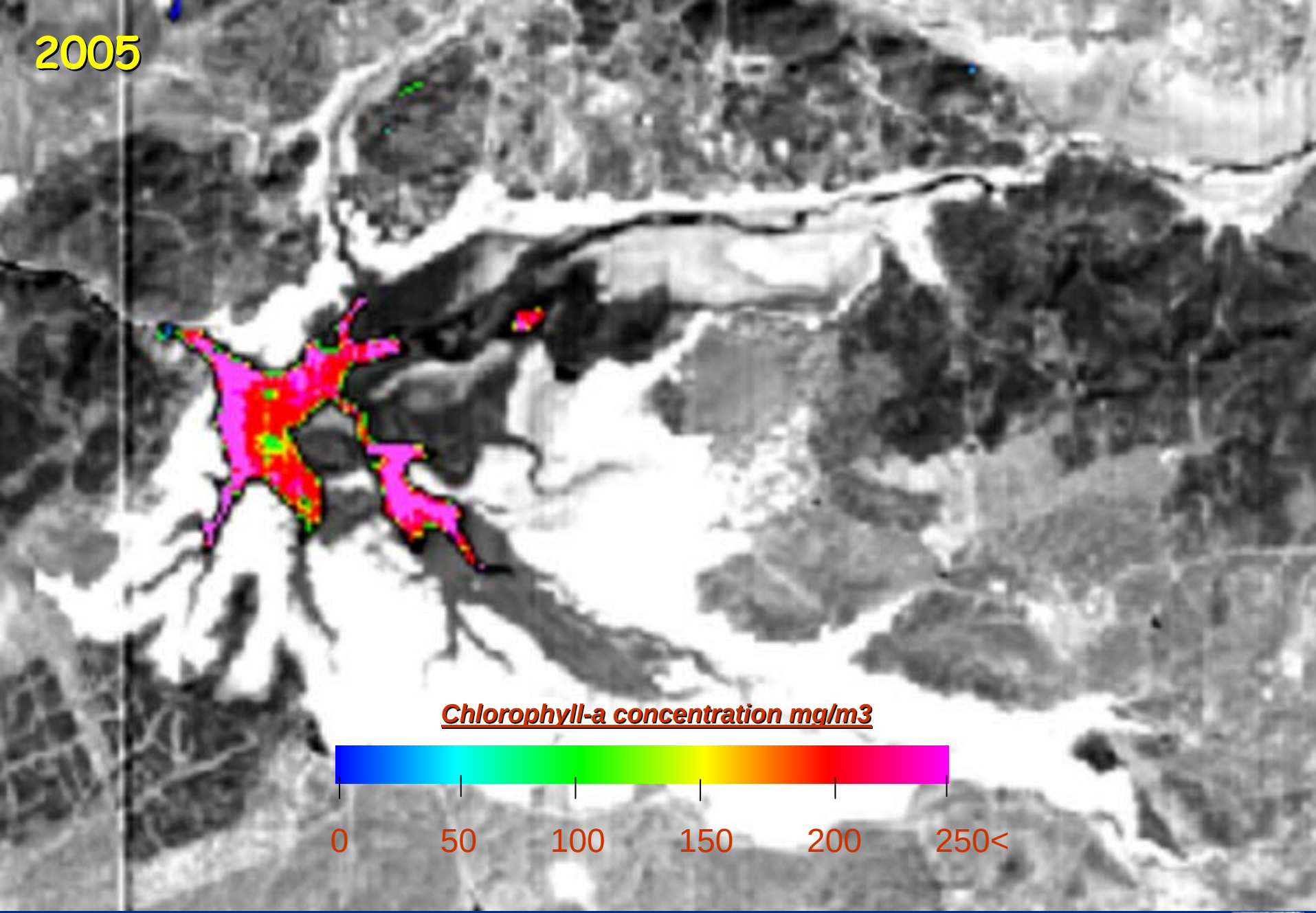
ALBUFERA 0f Valencia

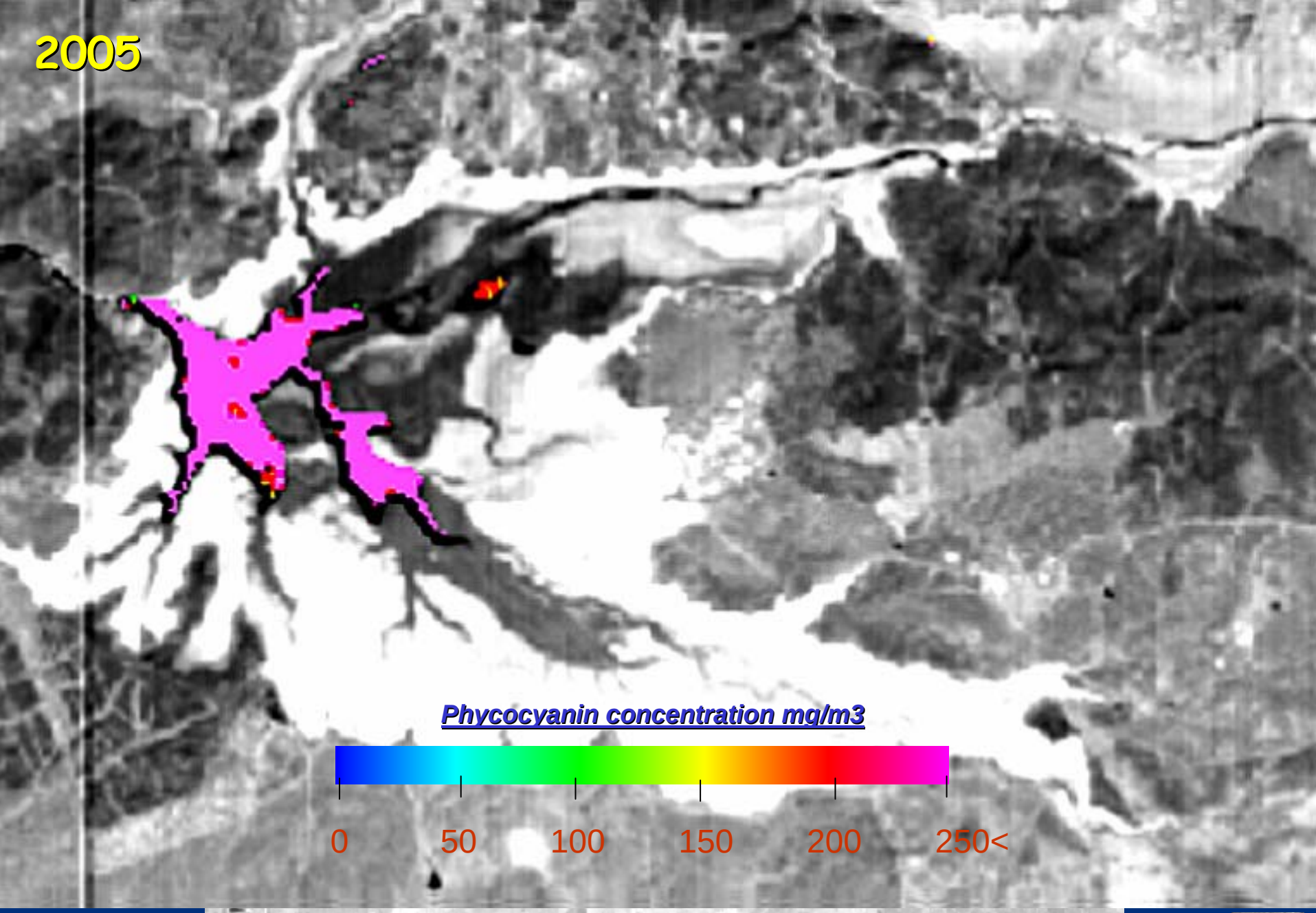
2006.08.14

Some results from the CHRIS/Proba operations related to this Project since the 3rd Workshop

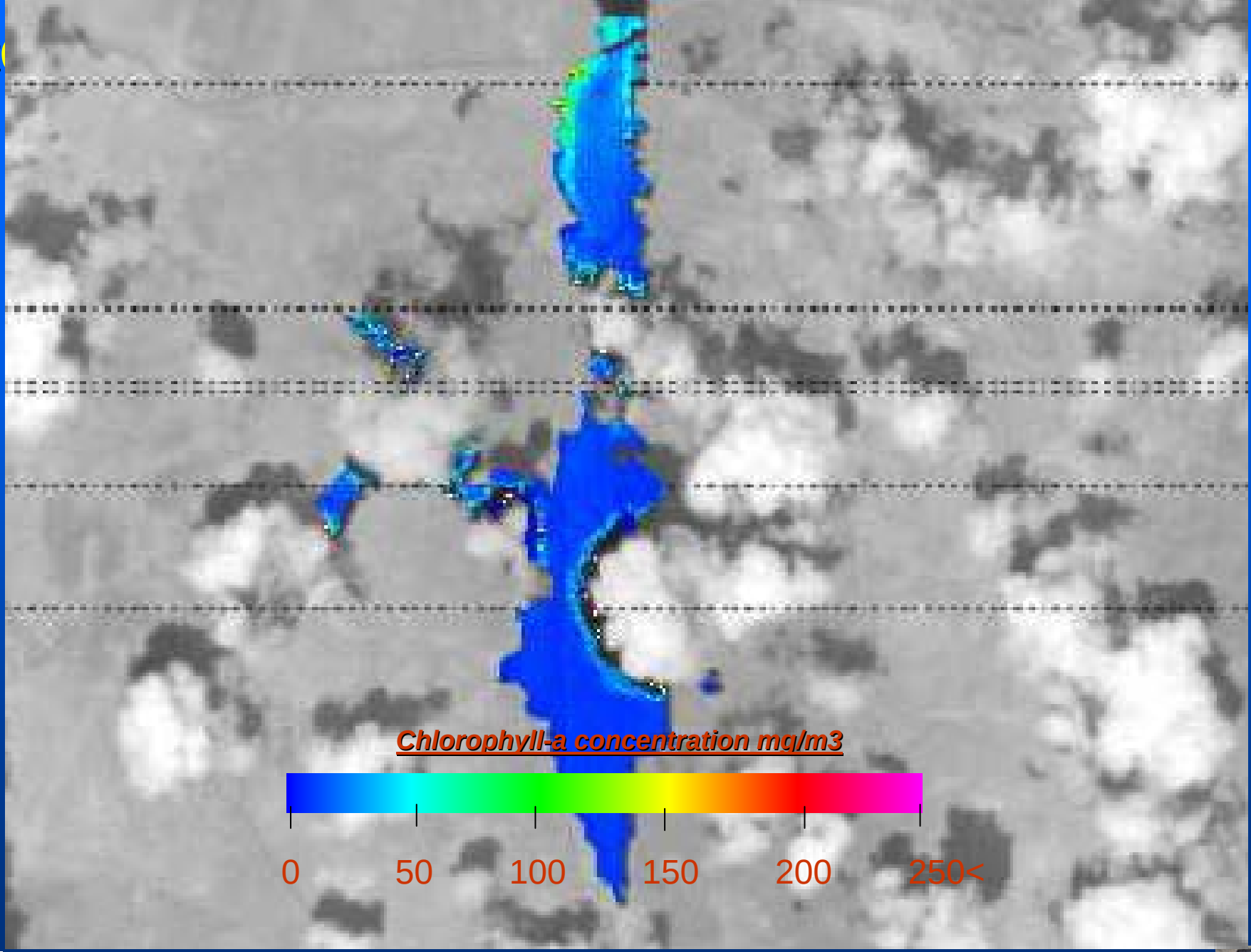
2005 -2006

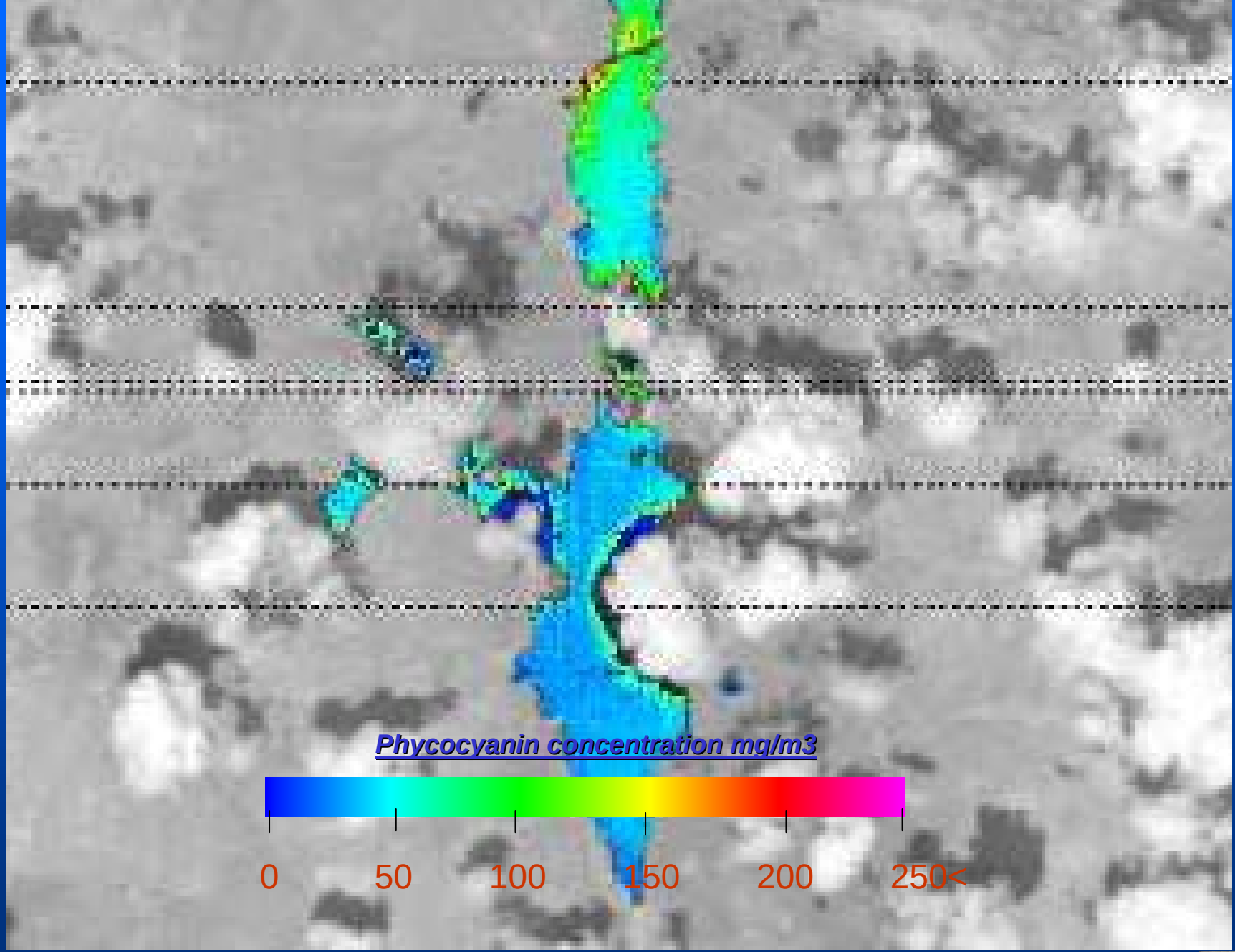

ROSARITO reservoir

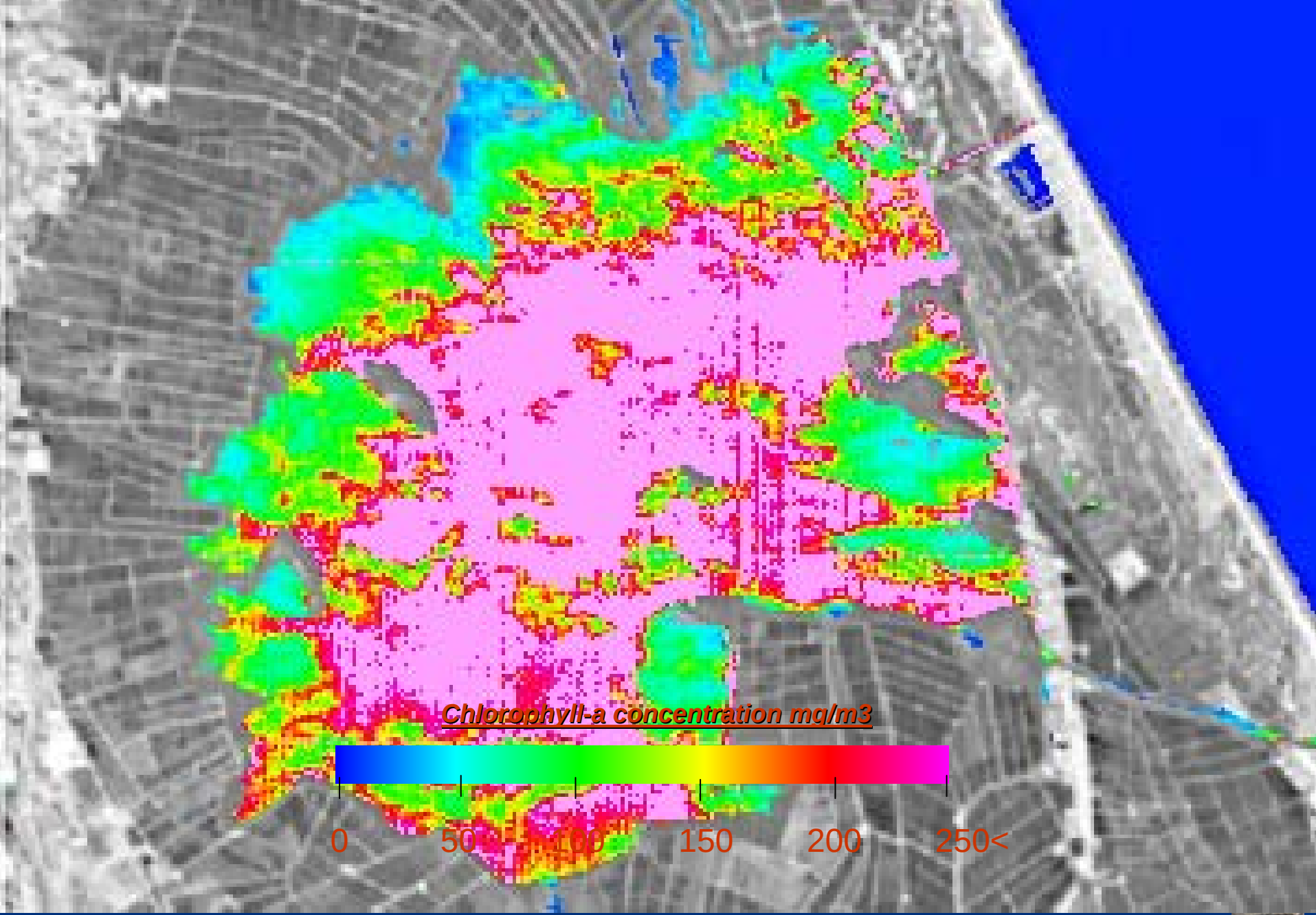

2005
Chlorophyll-a concentration mg/m3
0
50
100
150
200
250<

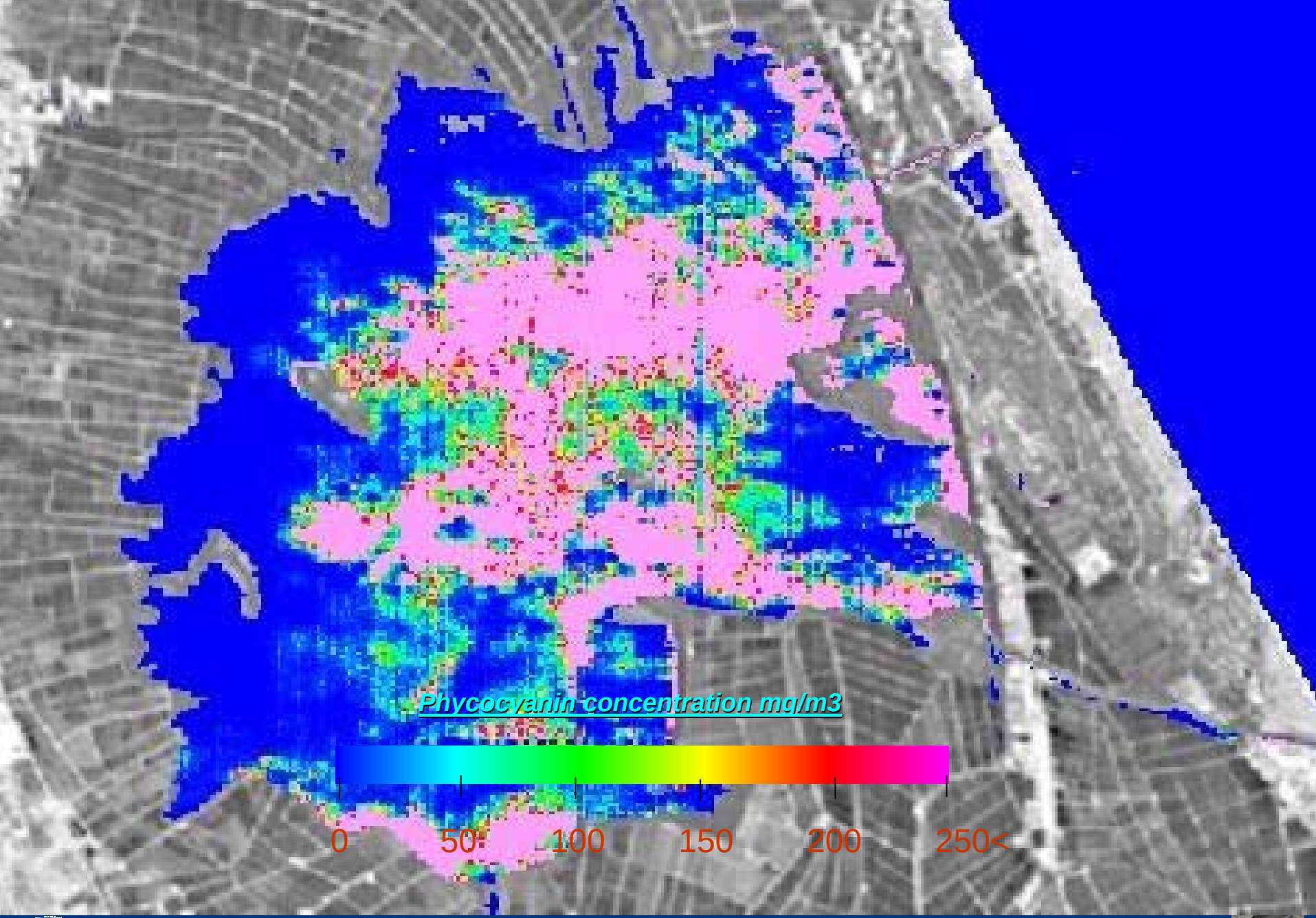


0 50 100 150 200 250< [PC] (mg/m^3)


Chlorophyll-a concentration mg/m3
0
50
100
150
200
250<


Phycocyanin concentration mg/m3
0
50
100
150
200
250<


Chlorophyll-a concentration mg/m3
0
50
100
150
200
250<


Phycocyanin concentration mg/m3
0
50
100
150
200
250<

2006

ALBUFERA de Valencia 2006.08.14 (0º)

CONCLUSIONS about pigment mapping:

- The activity during 2005, limited to 1 image set with the reservoir at very low level, and the activity in this year 2006, taking 1 image set over Valmayor reservoir with important cloudy areas, and steps will be must be identify andthe 2 taken images over Albufera of Valencia, both cloud free, and the nxt planned acquisition (next week?), etc., shows the application of atmospheric correction (UV) and the pigment algorithms improved after the synergy MERIS / CHRIS.

- This acquisitions will provide to expand and to complete the study on the influence of angular observation on the biological parameters.

Some results from the preliminary study on relationship between the reflectance level and the observation angle in the CHRIS/Proba multiangular image sets

2006

2006

Objectives:

-To find any relationship between the reflectance level and the observation angle in the CHRIS/Proba multiangular image sets.

Study steps:

1st approach (2005-2006)

-Preliminary study on relationship between the reflectance level and the observation angle working on the information taken from CHRIS/Proba multiangular image sets.

2nd approach (2006-2007)

-Taking radiometric measurements on water bodies controlling the angular positions of the Spectro-radiometer optical fiber to reproduce the CHRIS image set nominal angles. Taking : Coincident measurements with some acquisitions and Campaign of systematic observations in water bodies.

1st approach (2006)

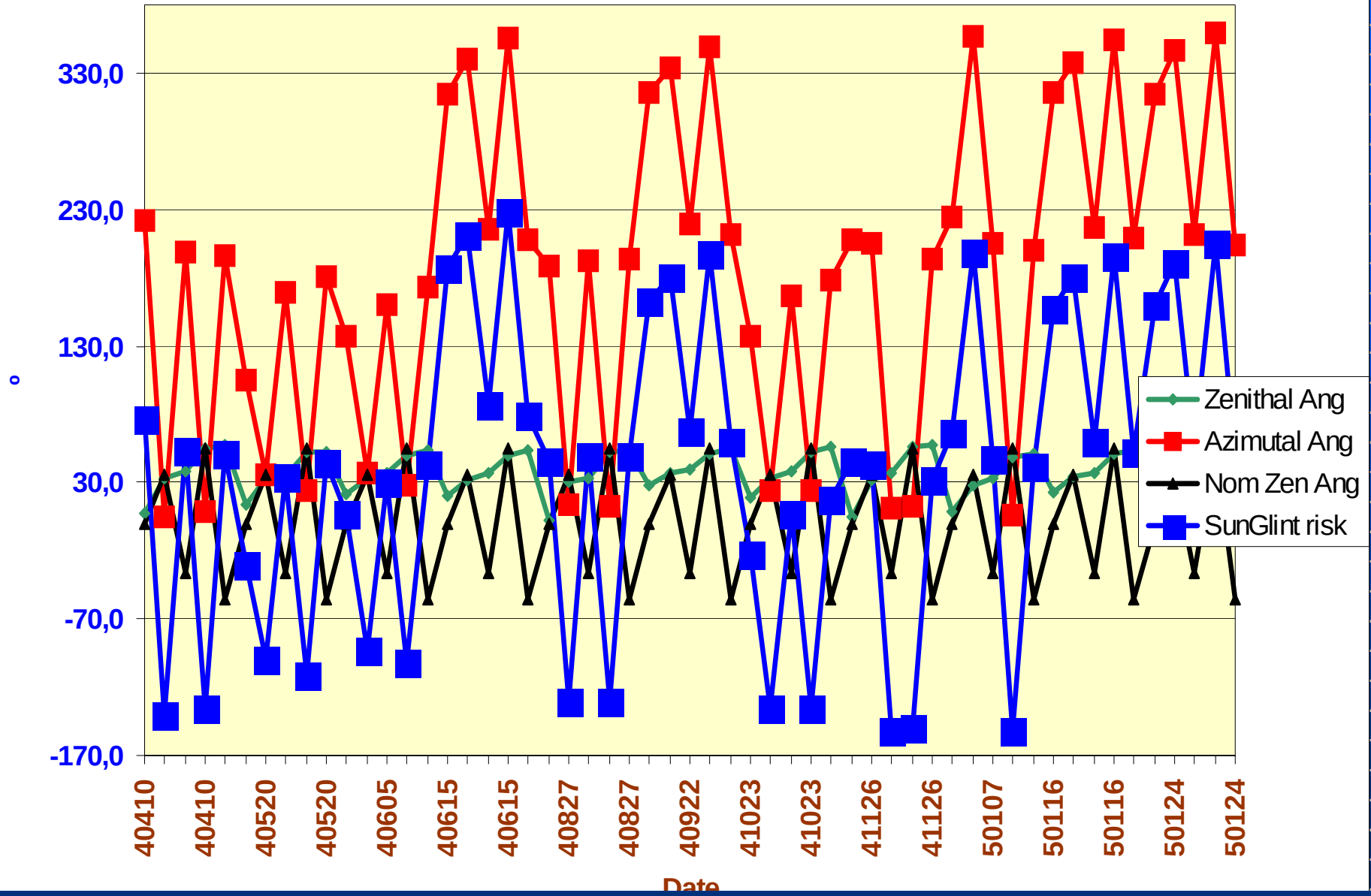
-Preliminary study on relationship between the reflectance level and the observation angle working on the information taken from CHRIS/Proba multiangular image sets.

1.- Geo-referencing images of angular acquisitions making it coincident with the best available geographical reference (RMS ≦ 0.2).

2.- Verification of the best fit and best coincidence of pixel position as possible.

3.- Pixel spectral comparison between the different angle images.

CHRIS/Proba image angles

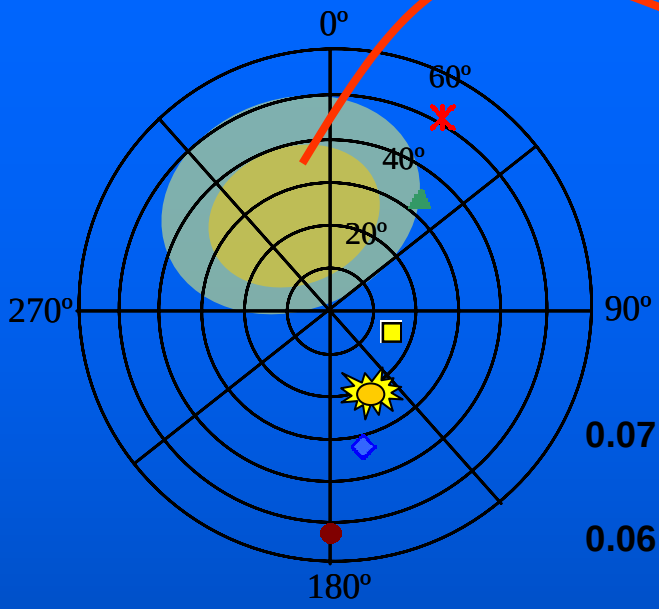


1st approach (2006)

-The first part of the study on reflectances in relation with the nominal image centre angle was to consider the same sampling point used for monitoring. But with possible geographical position errors.

-The second step is to consider the correct position, geo-referenced with the best available geographical reference for each date (RMS ≤ 0.2 pixel).

1st approach (2006).- First part



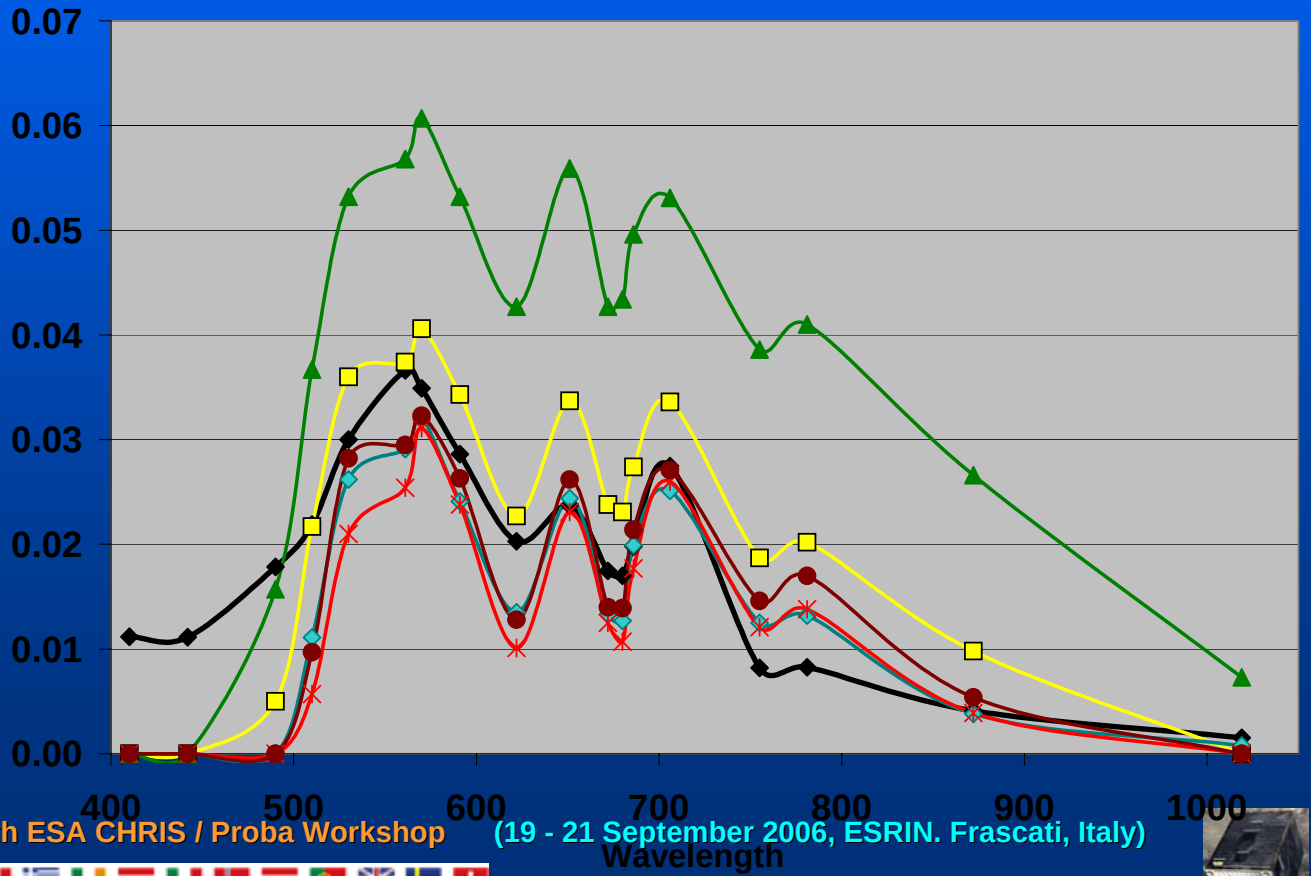
SUN GLINT RISK

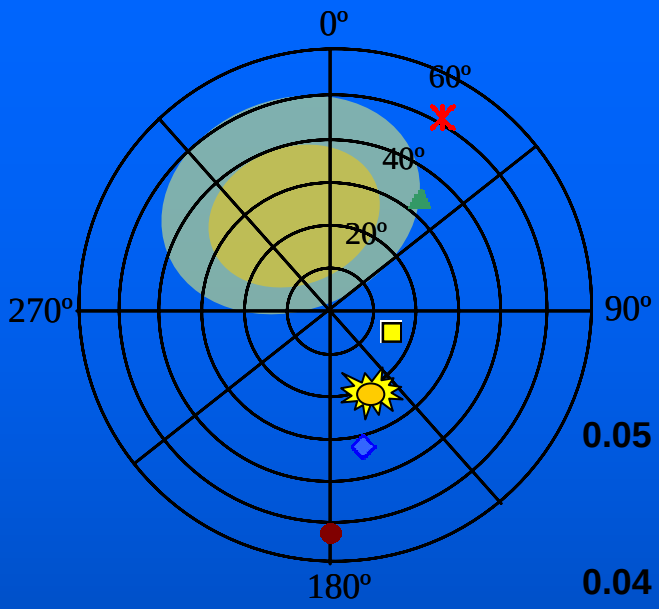
20/05/2004

ZENITH AND AZIMUTH ANGLES OF IMAGERY

0º	4123
+36º	4124
-36º	4125
+55º	4126
-55º	4127
ASD	Field

REFLECTANCE AT SAMPLING POINT *A*



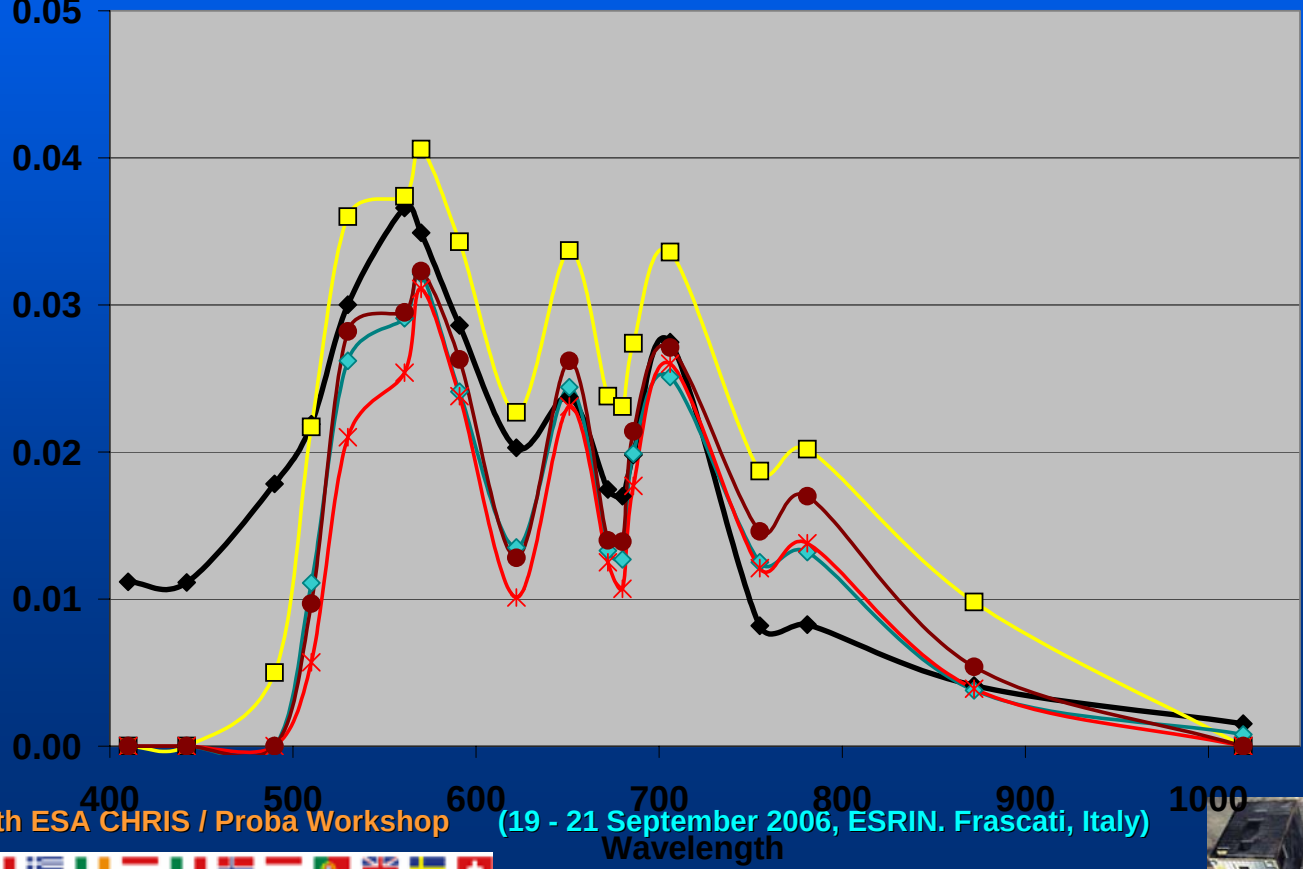


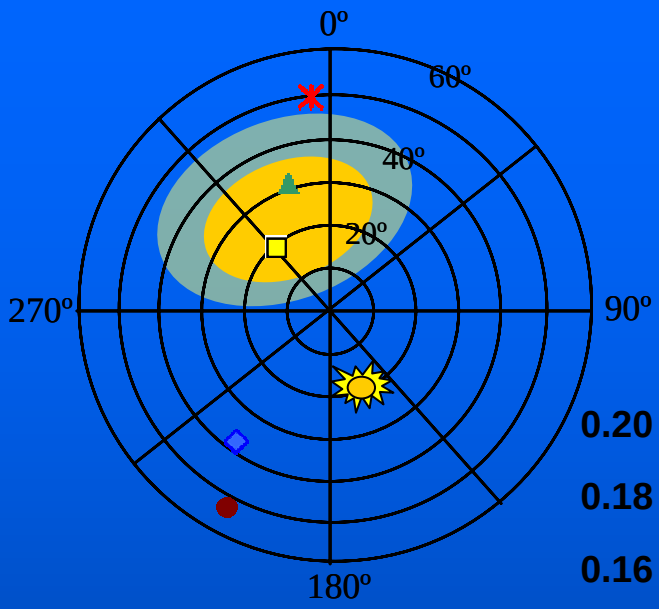
ZENITH AND AZIMUTH ANGLES OF IMAGERY

0º	4123
+36º	4124
-36º	4125
+55º	4126
-55º	4127
ASD	Field

20/05/2004

REFLECTANCE AT SAMPLING POINT *A*
SUN GLINT FREE IMAGERY



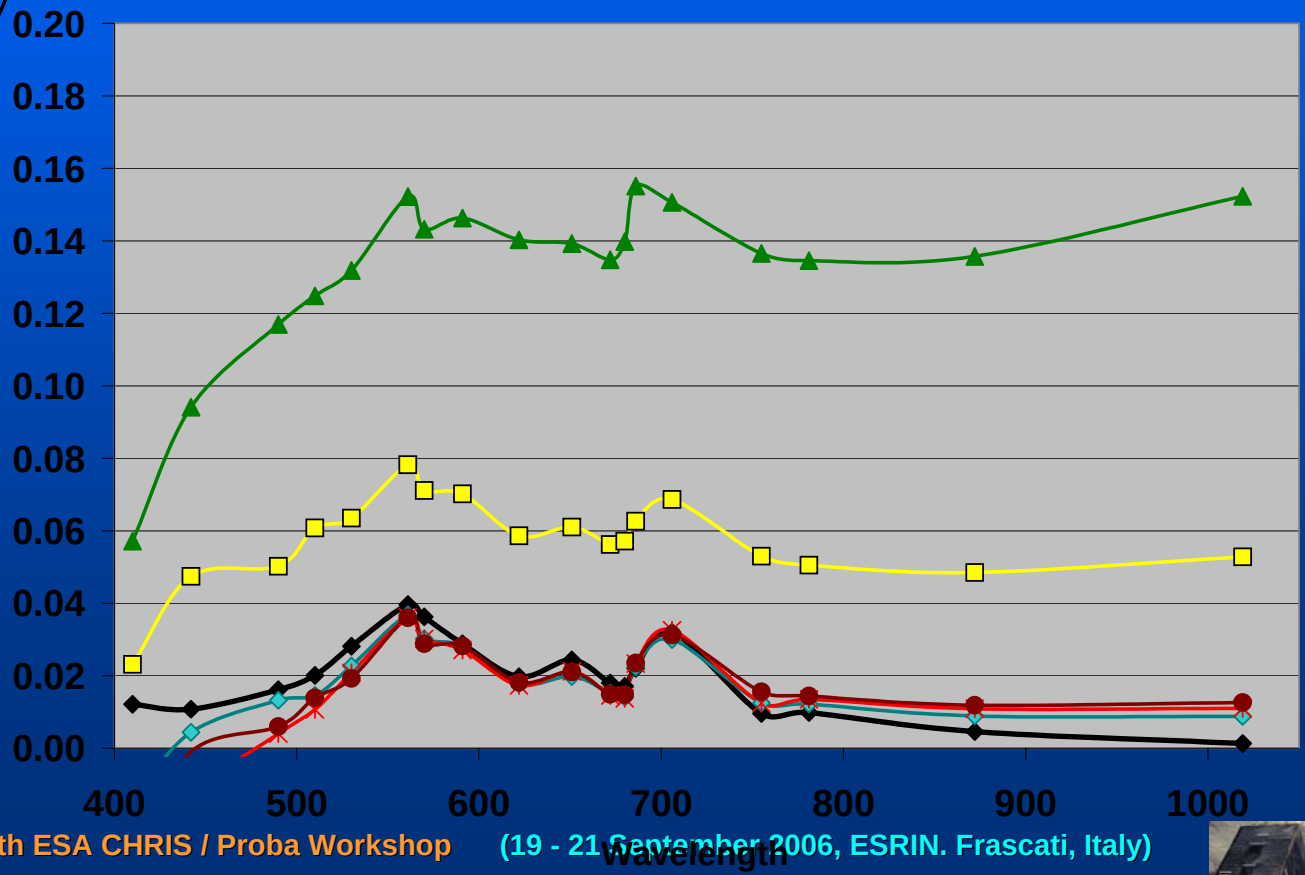


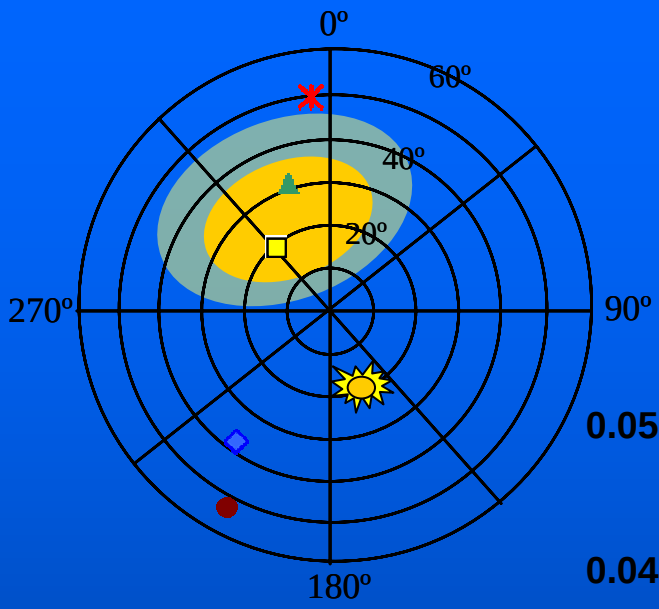
15/06/2004

ZENITH AND AZIMUTH ANGLES OF IMAGERY

0º	422C
+36º	422D
-36º	422E
+55º	422F
-55º	4230
ASD	Field

REFLECTANCE AT SAMPLING POINT *A*



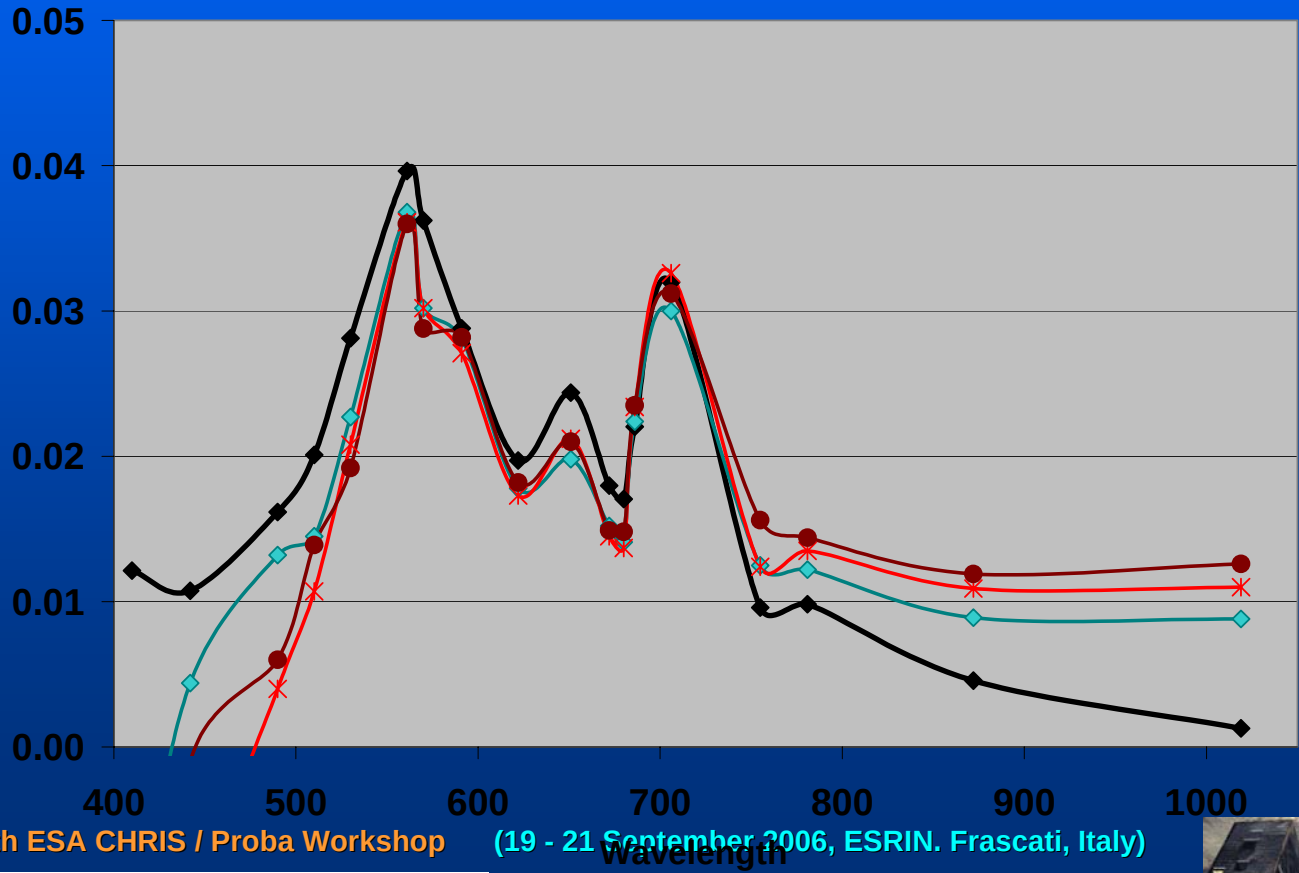


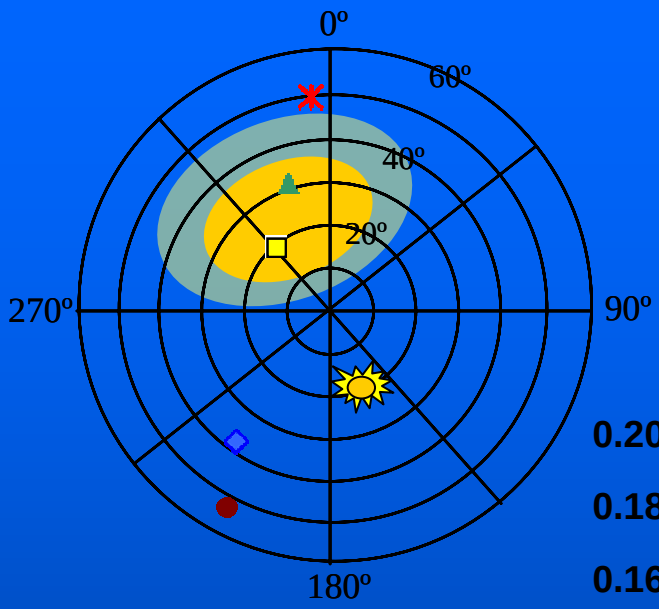
ZENITH AND AZIMUTH ANGLES OF IMAGERY

0º	422C
+36º	422D
-36º	422E
+55º	422F
-55º	4230
ASD	Field

15/06/2004

REFLECTANCE AT SAMPLING POINT *A*
SUN GLINT FREE IMAGERY



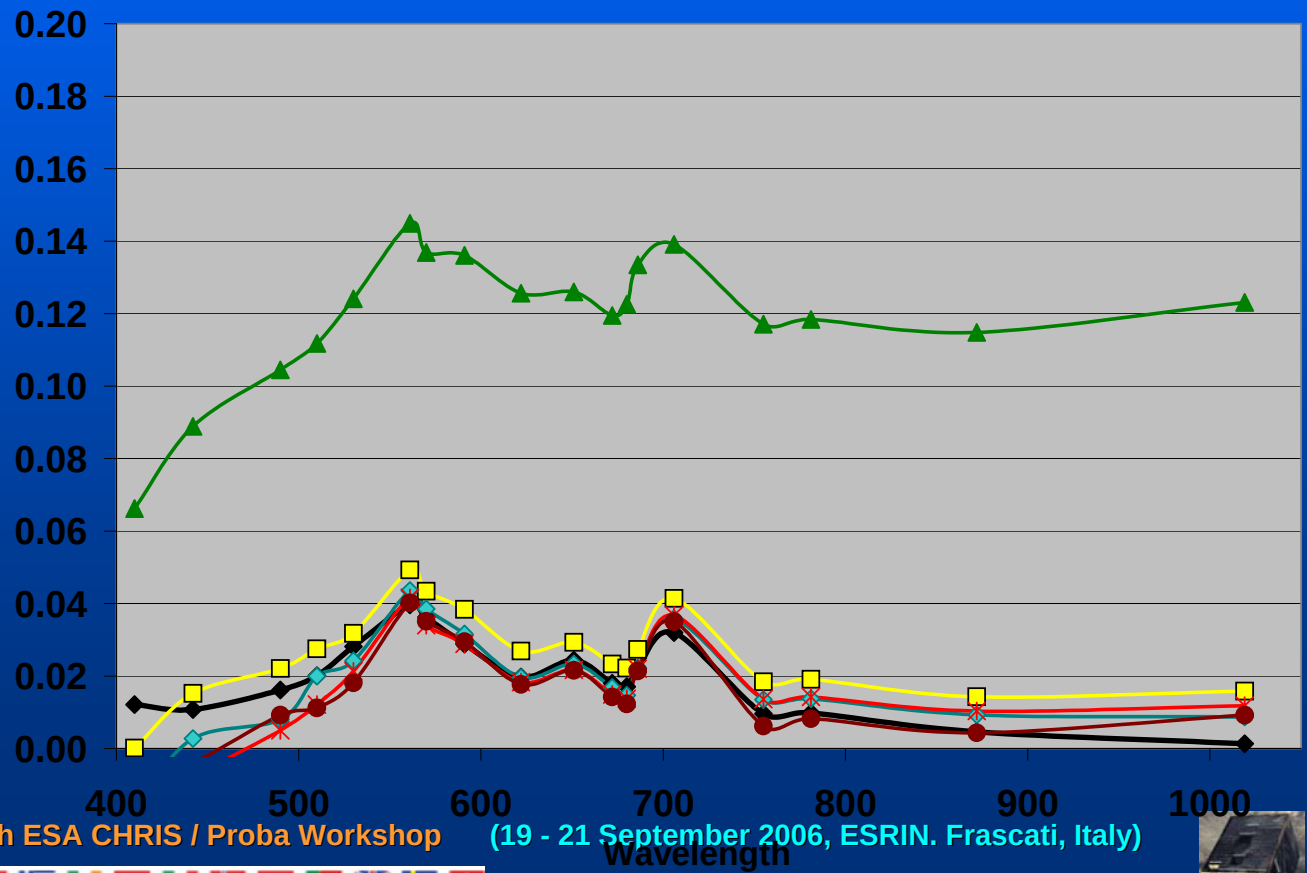


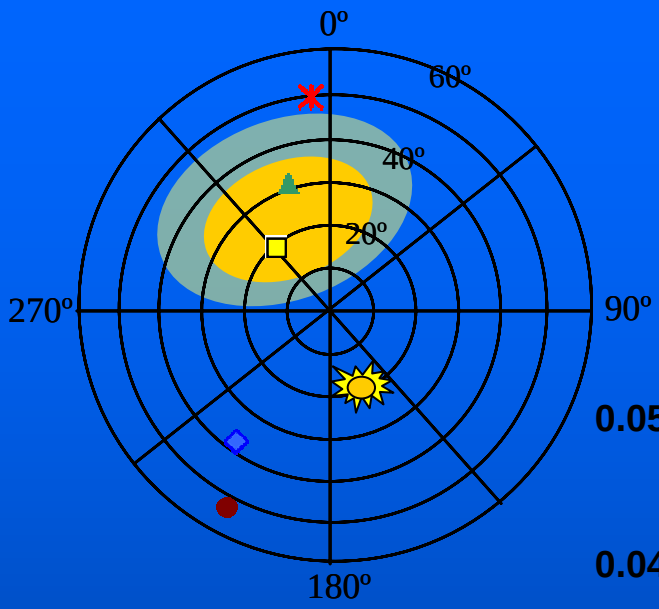
15/06/2004

ZENITH AND AZIMUTH ANGLES OF IMAGERY

0º	422C
+36º	422D
-36º	422E
+55º	422F
-55º	4230
ASD	Field

REFLECTANCE AT SAMPLING POINT *C*



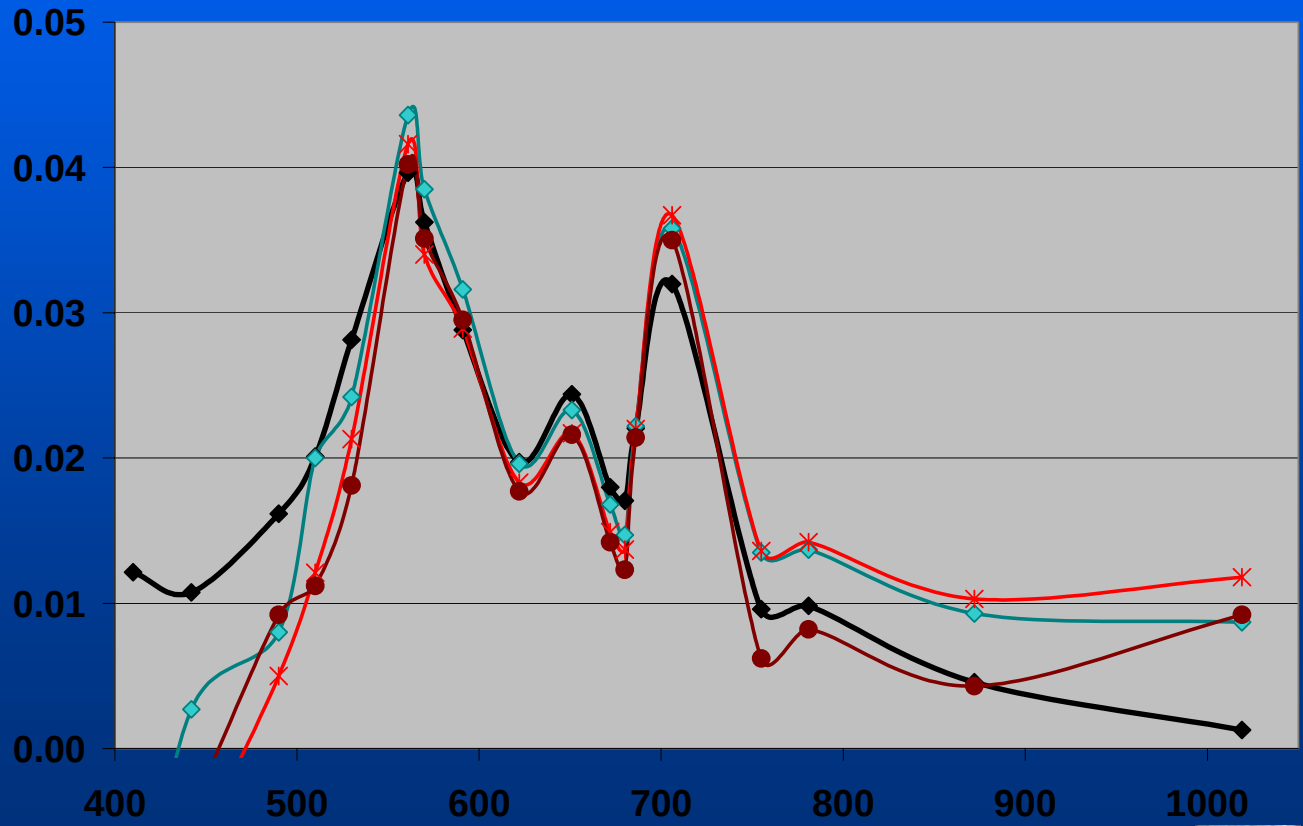


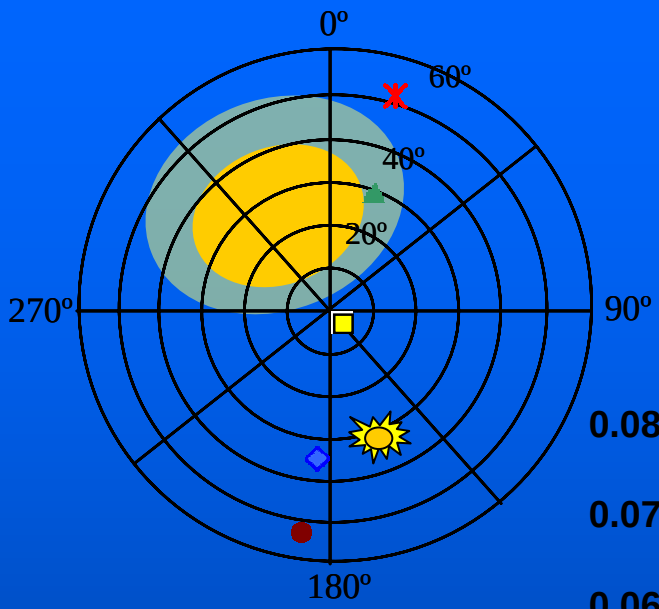
ZENITH AND AZIMUTH ANGLES OF IMAGERY

0º	422C
+36º	422D
-36º	422E
+55º	422F
-55º	4230
ASD	Field

15/06/2004

REFLECTANCE AT SAMPLING POINT *C*
SUN GLINT FREE IMAGERY



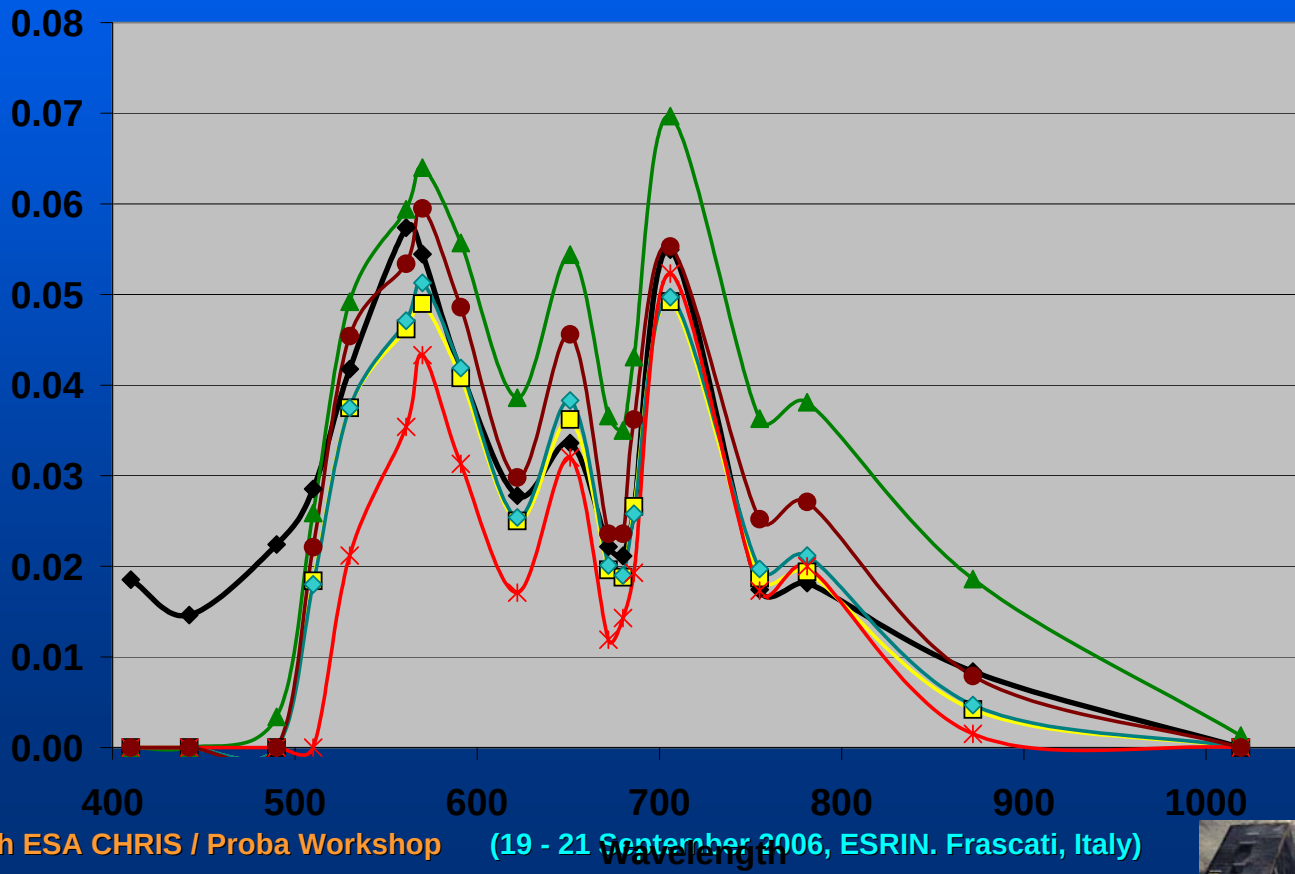


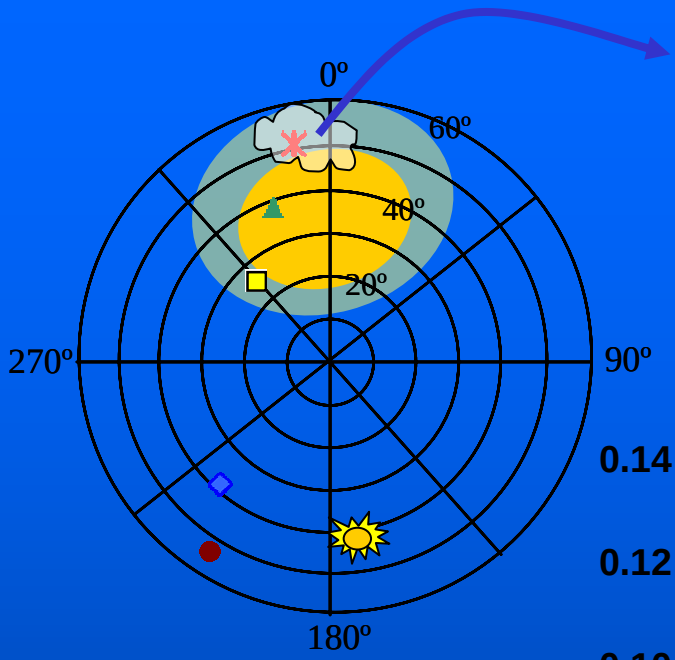
ZENITH AND AZIMUTH ANGLES OF IMAGERY

0º	452E
+36º	452F
-36º	4530
+55º	4531
-55º	4532
ASD	Field

27/08/2004

REFLECTANCE AT SAMPLING POINT *C*





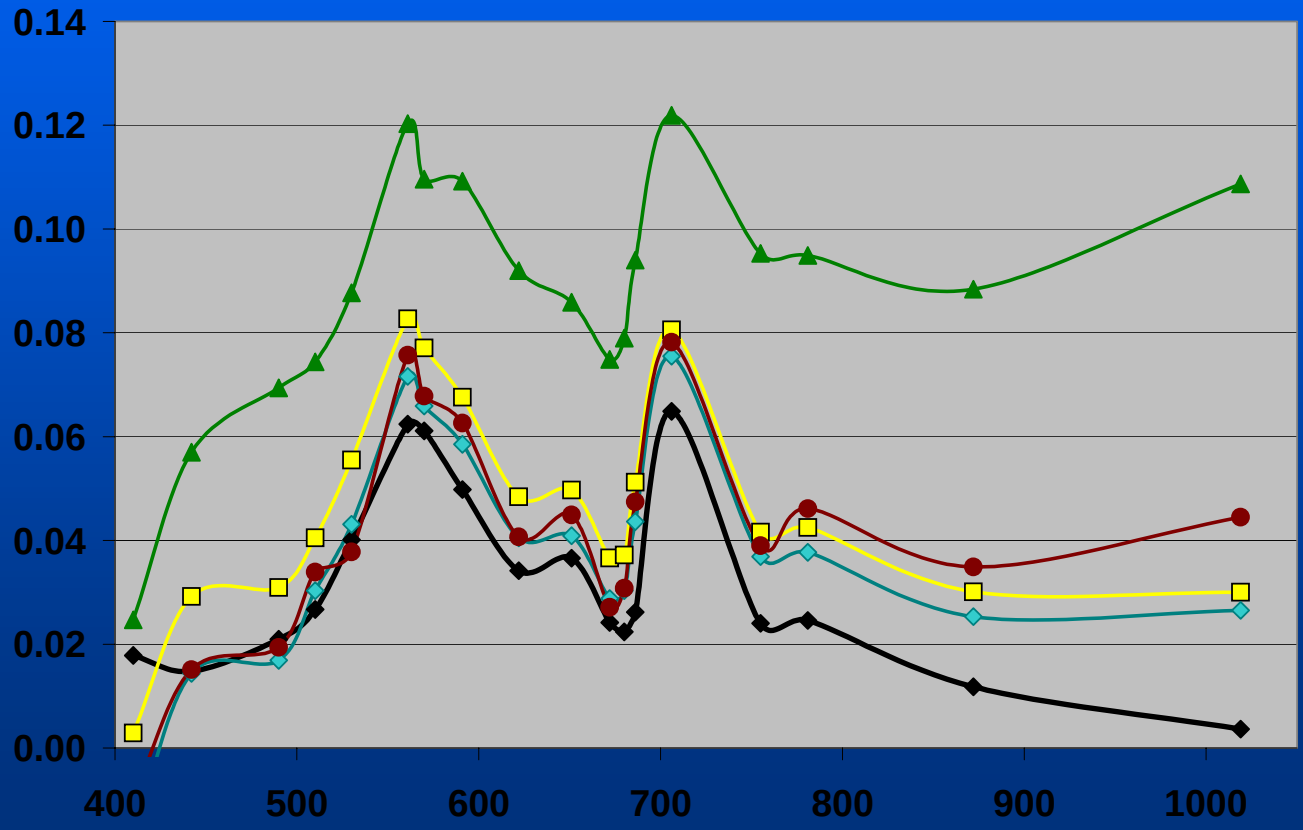
CLOUDY IMAGE

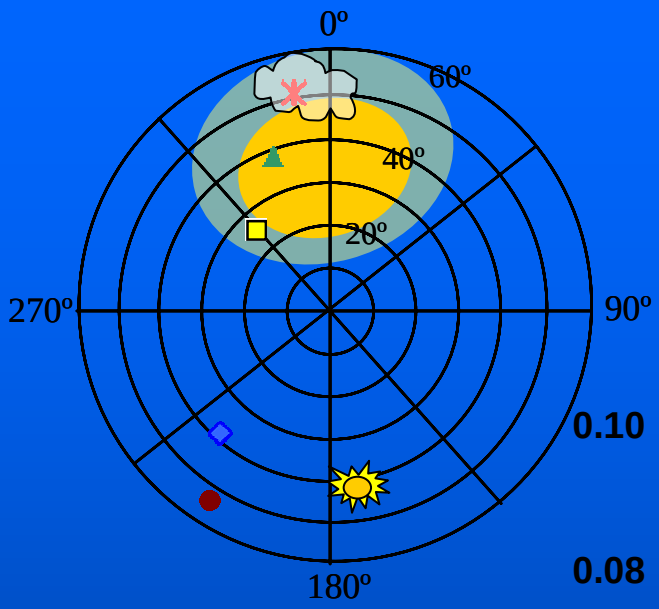
22/09/2004

ZENITH AND AZIMUTH ANGLES OF IMAGERY

0º	4696
+36º	4697
-36º	4698
+55º	4699
-55º	469A
ASD	Field

REFLECTANCE AT SAMPLING POINT *B*



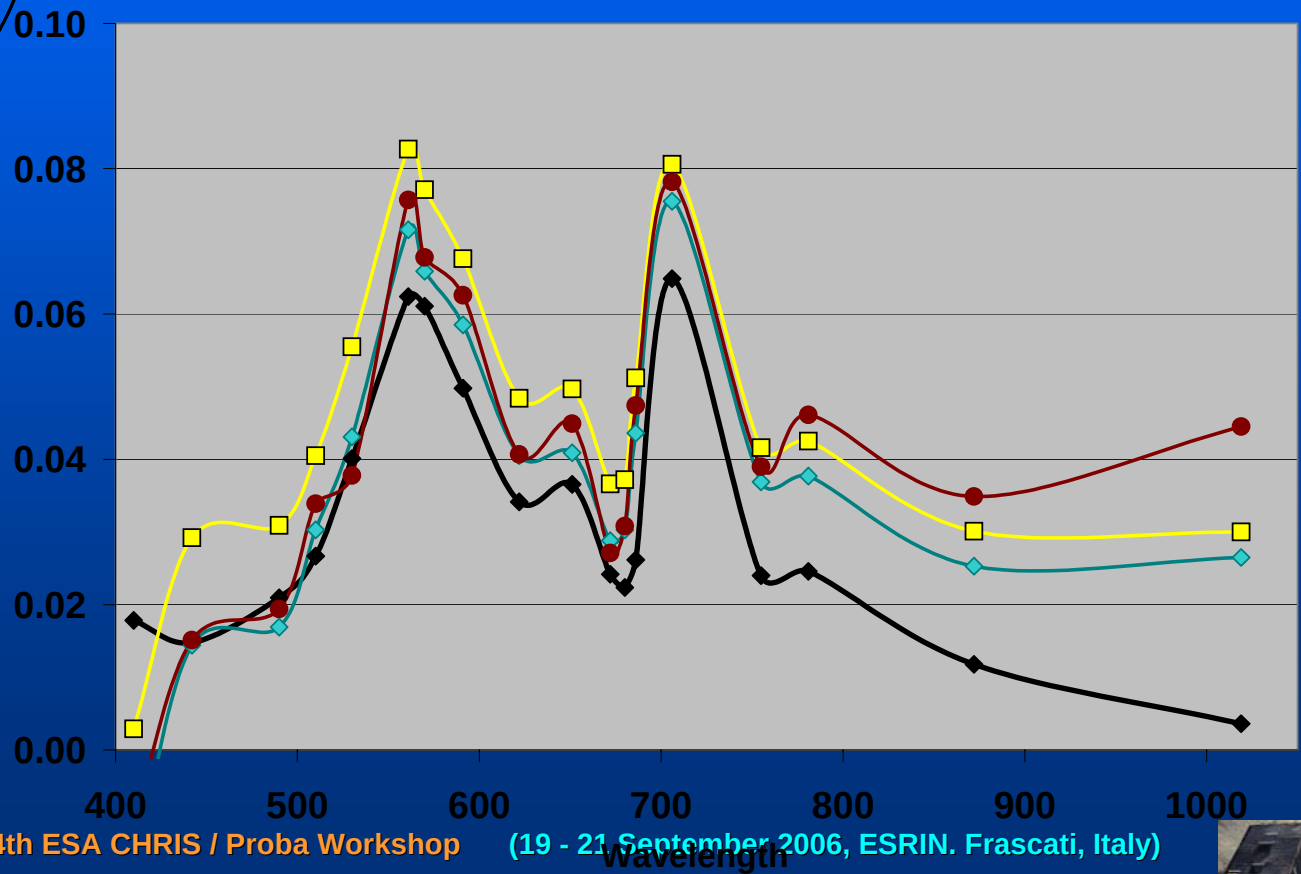


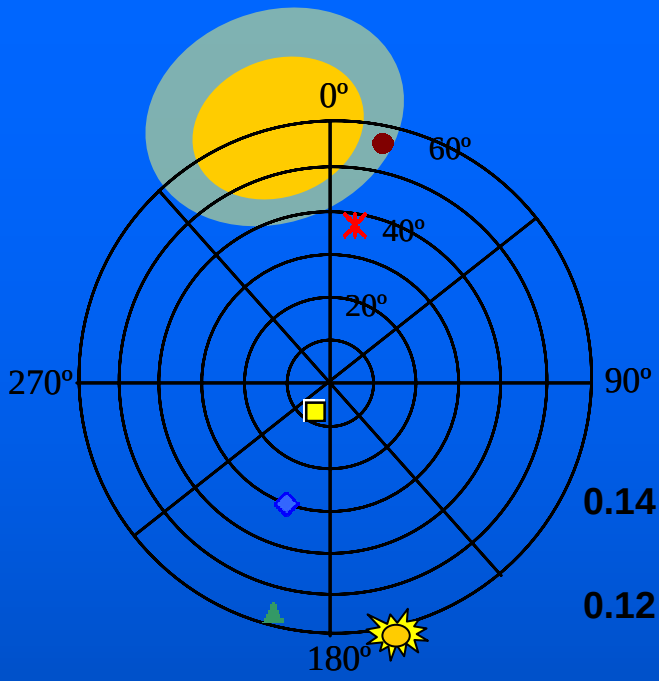
ZENITH AND AZIMUTH ANGLES OF IMAGERY

0º	4696
+36º	4697
-36º	4698
+55º	4699
-55º	469A
ASD	Field

22/09/2004

REFLECTANCE AT SAMPLING POINT *B*
SUN GLINT FREE IMAGERY



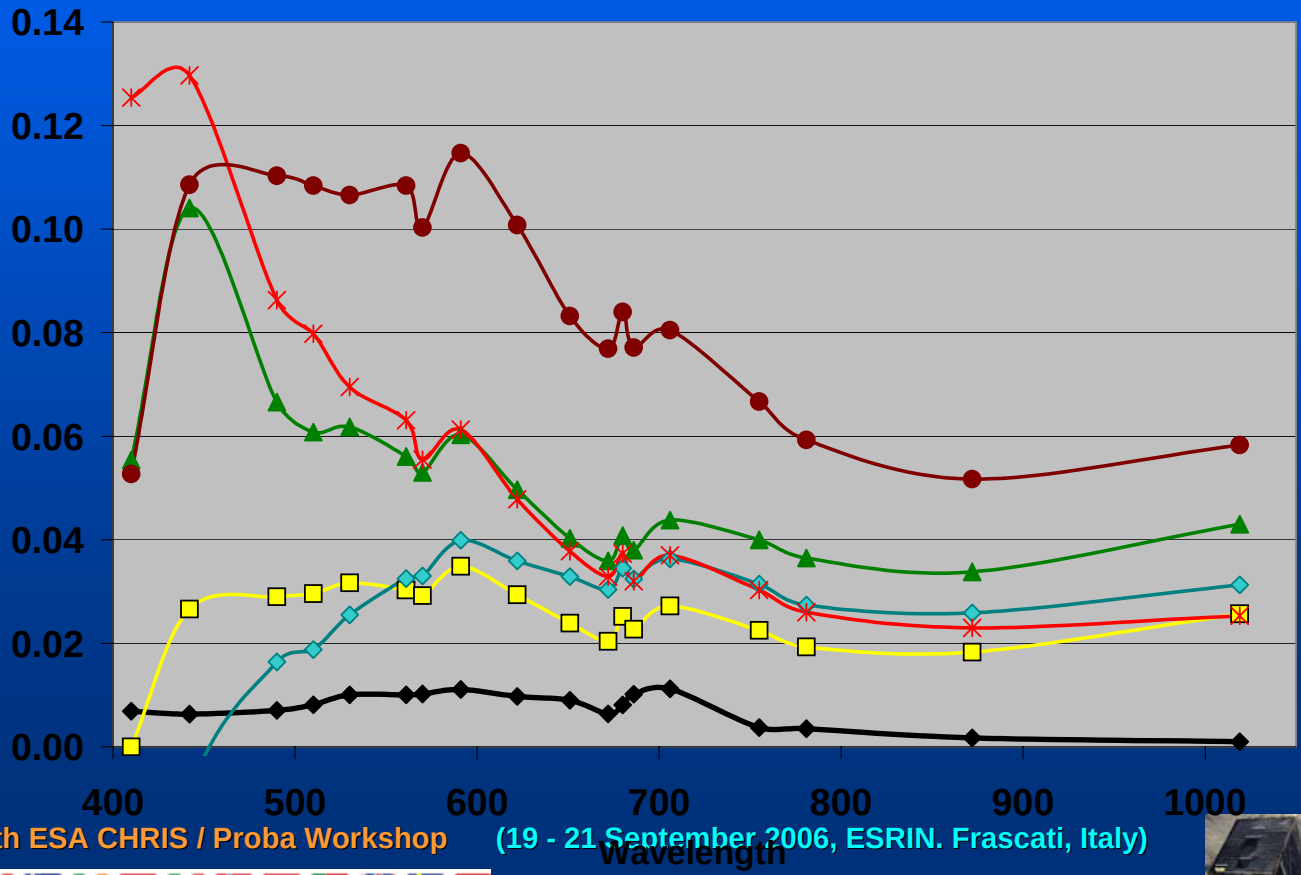


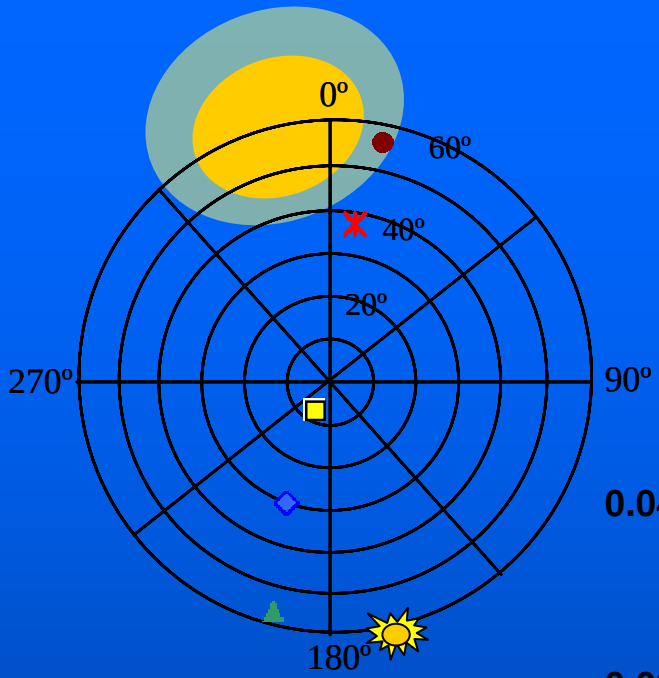
ZENITH AND AZIMUTH ANGLES OF IMAGERY

0º	4A56
+36º	4A5A
-36º	4A57
+55º	4A58
-55º	4A59
ASD	Field

26/11/2004

REFLECTANCE AT SAMPLING POINT *B*



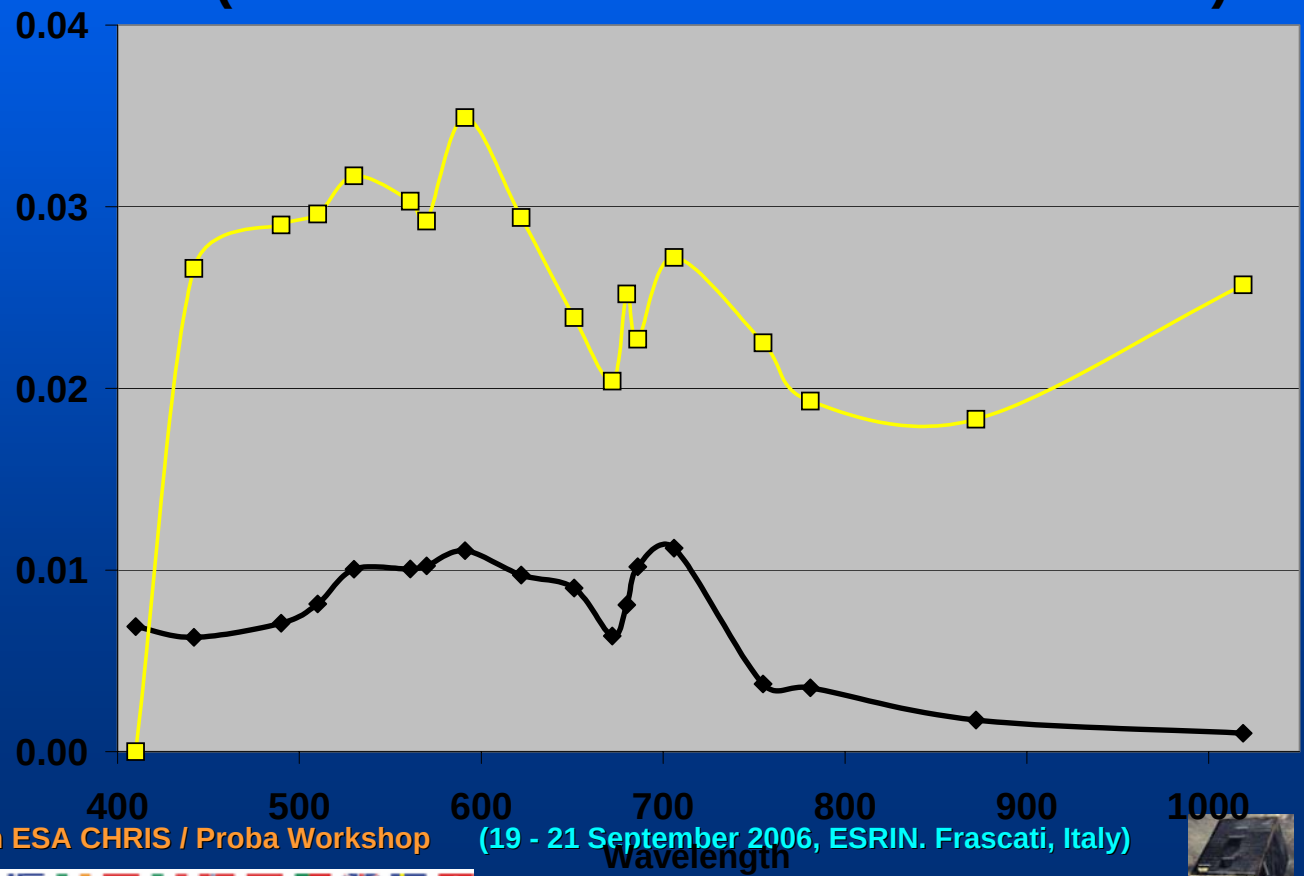


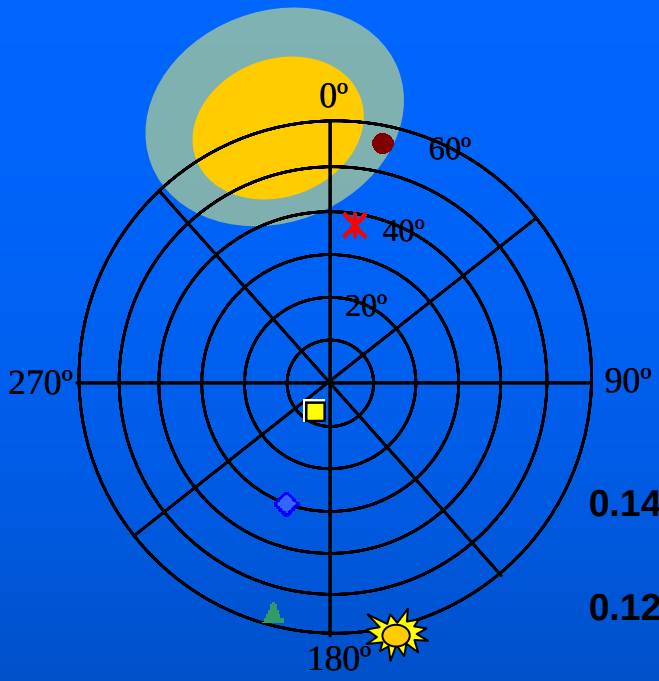
ZENITH AND AZIMUTH ANGLES OF IMAGERY

0º	4A56
+36º	4A5A
-36º	4A57
+55º	4A58
-55º	4A59
ASD	Field

26/11/2004

REFLECTANCE AT SAMPLING POINT *B* (*ZENITH* "nadir" IMAGE AND FIELD DATA)



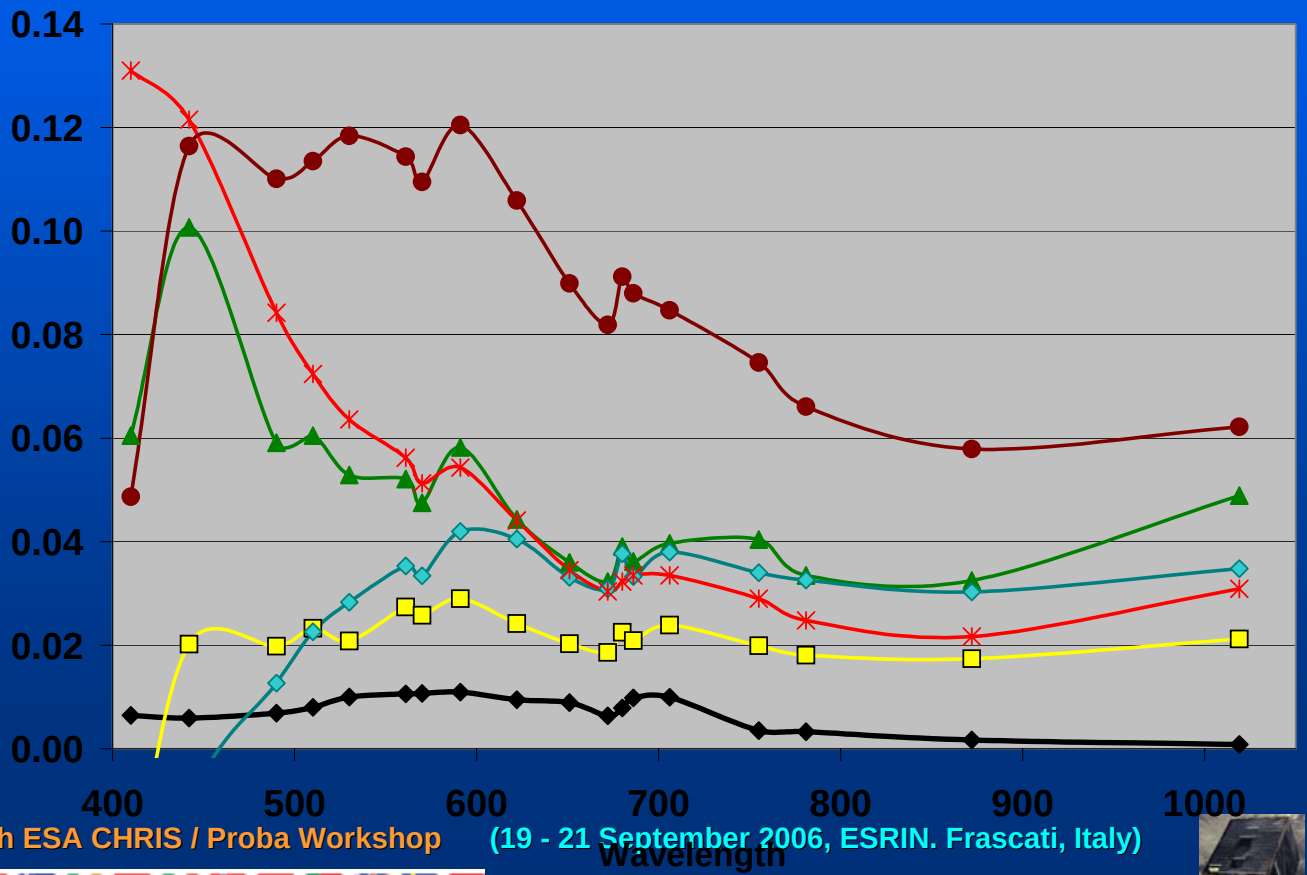


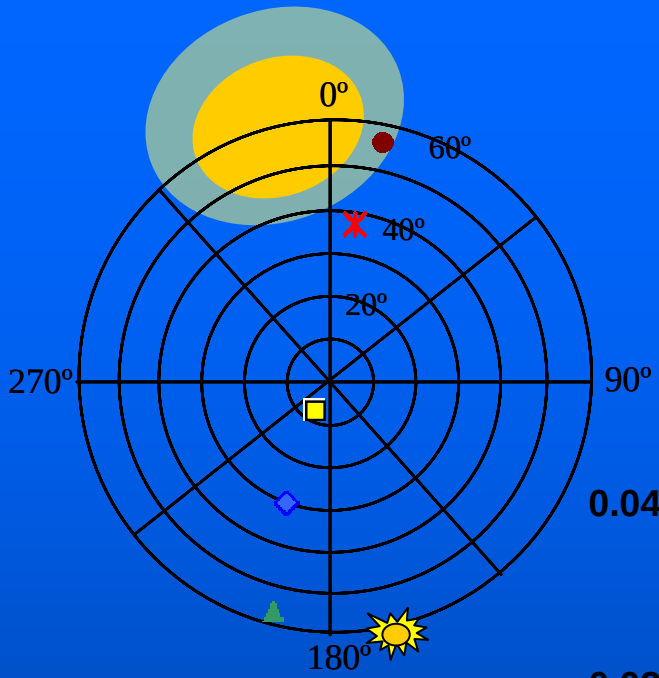
ZENITH AND AZIMUTH ANGLES OF IMAGERY

0º	4A56
+36º	4A5A
-36º	4A57
+55º	4A58
-55º	4A59
ASD	Field

26/11/2004

REFLECTANCE AT SAMPLING POINT *D*



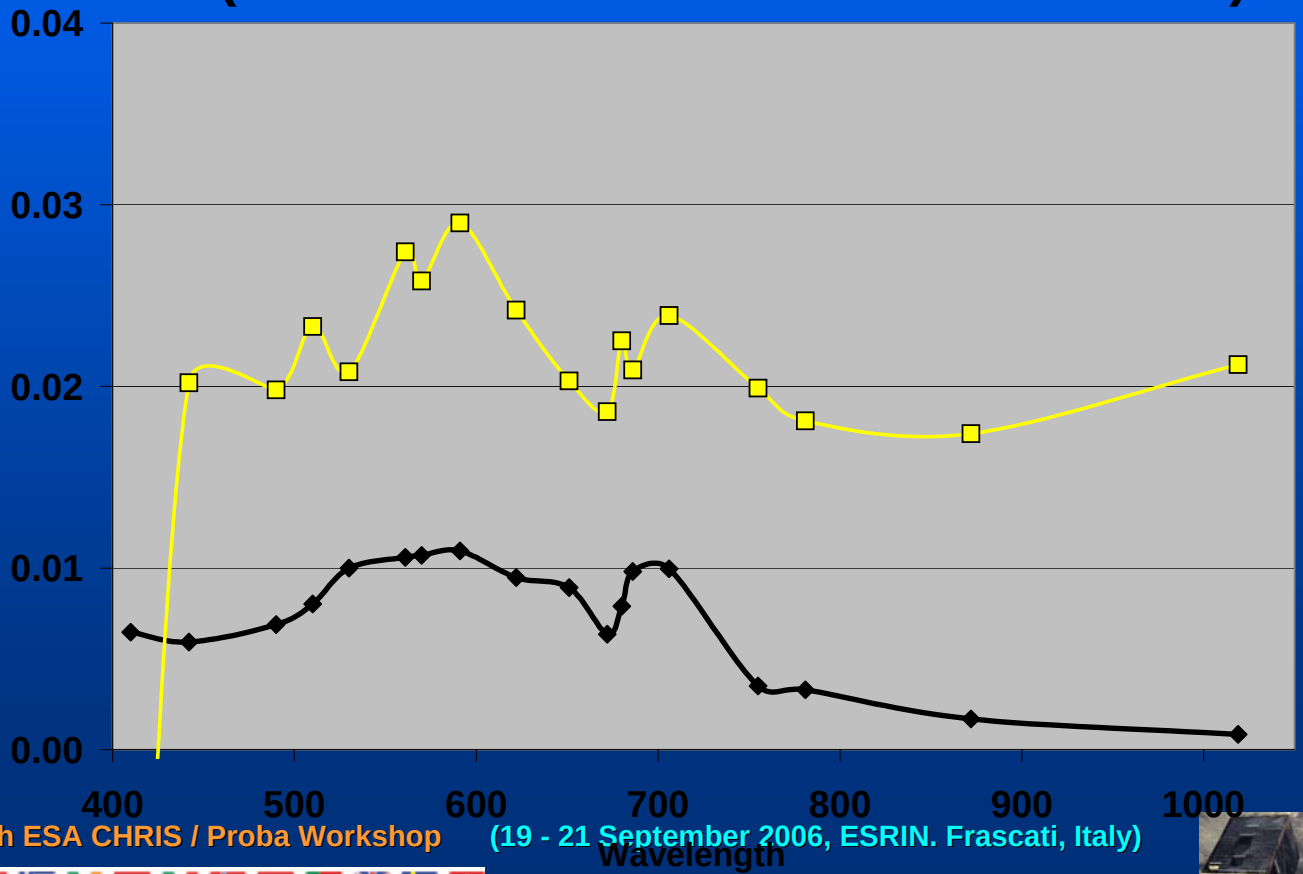


ZENITH AND AZIMUTH ANGLES OF IMAGERY

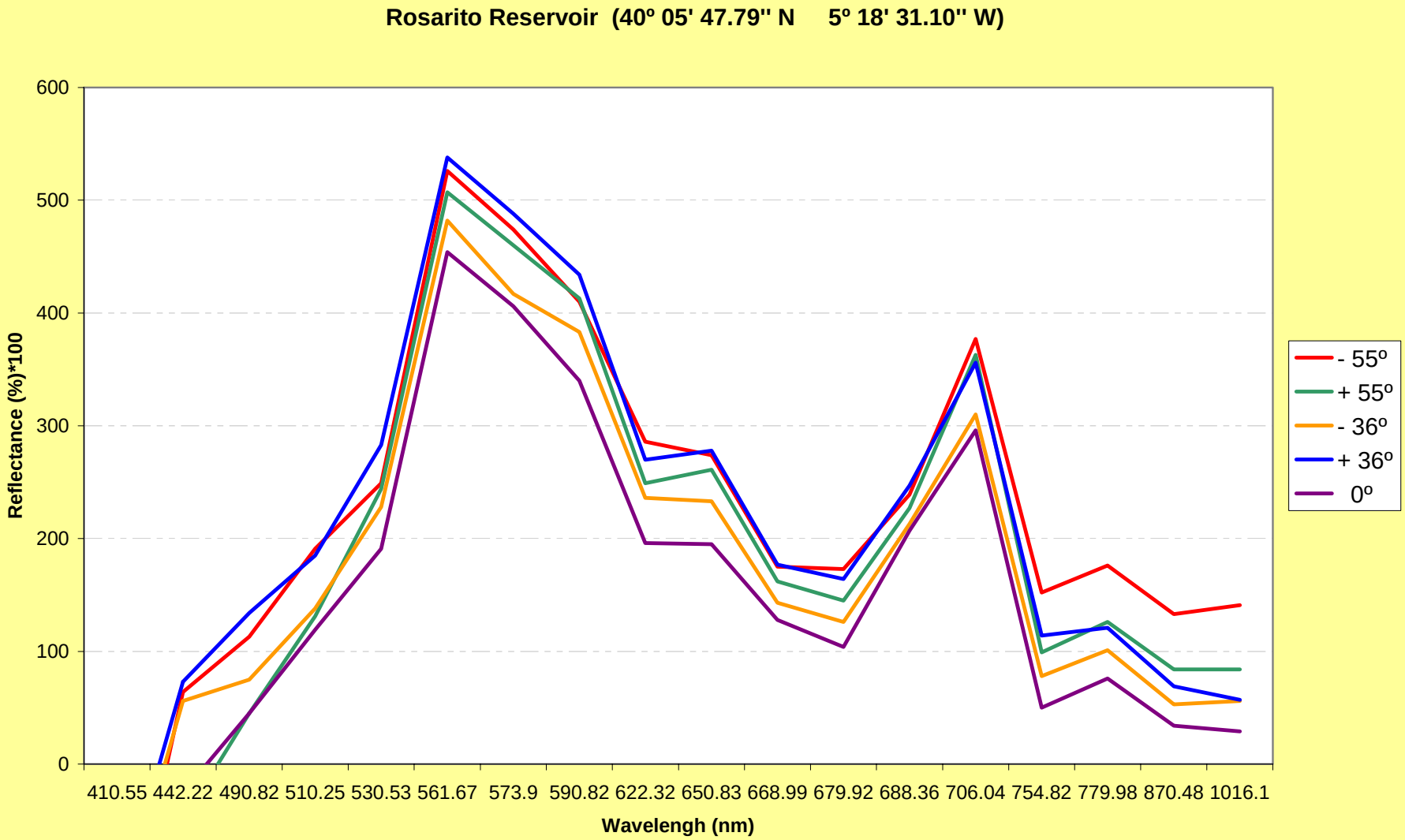
0º	4A56
+36º	4A5A
-36º	4A57
+55º	4A58
-55º	4A59
ASD	Field

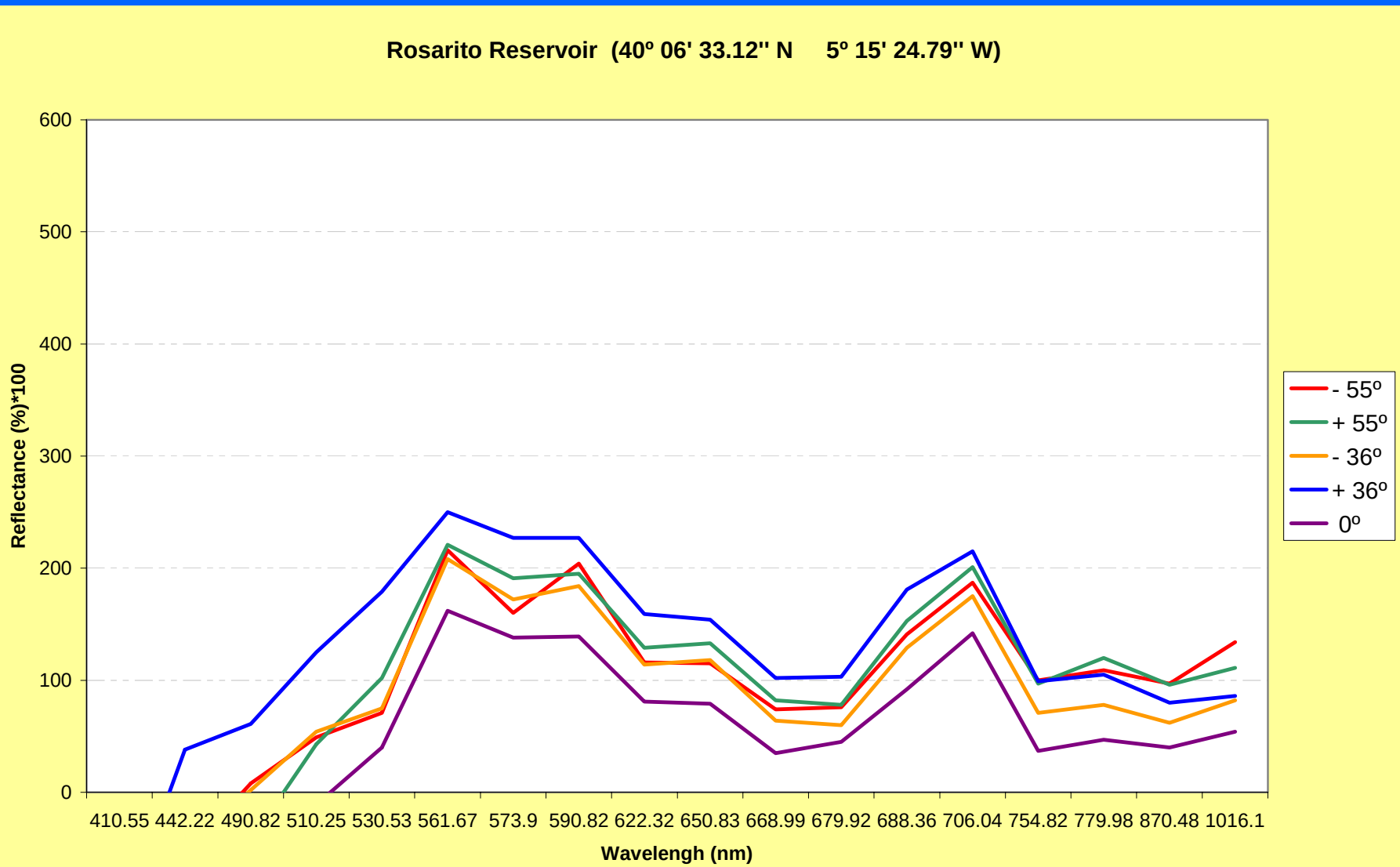
26/11/2004

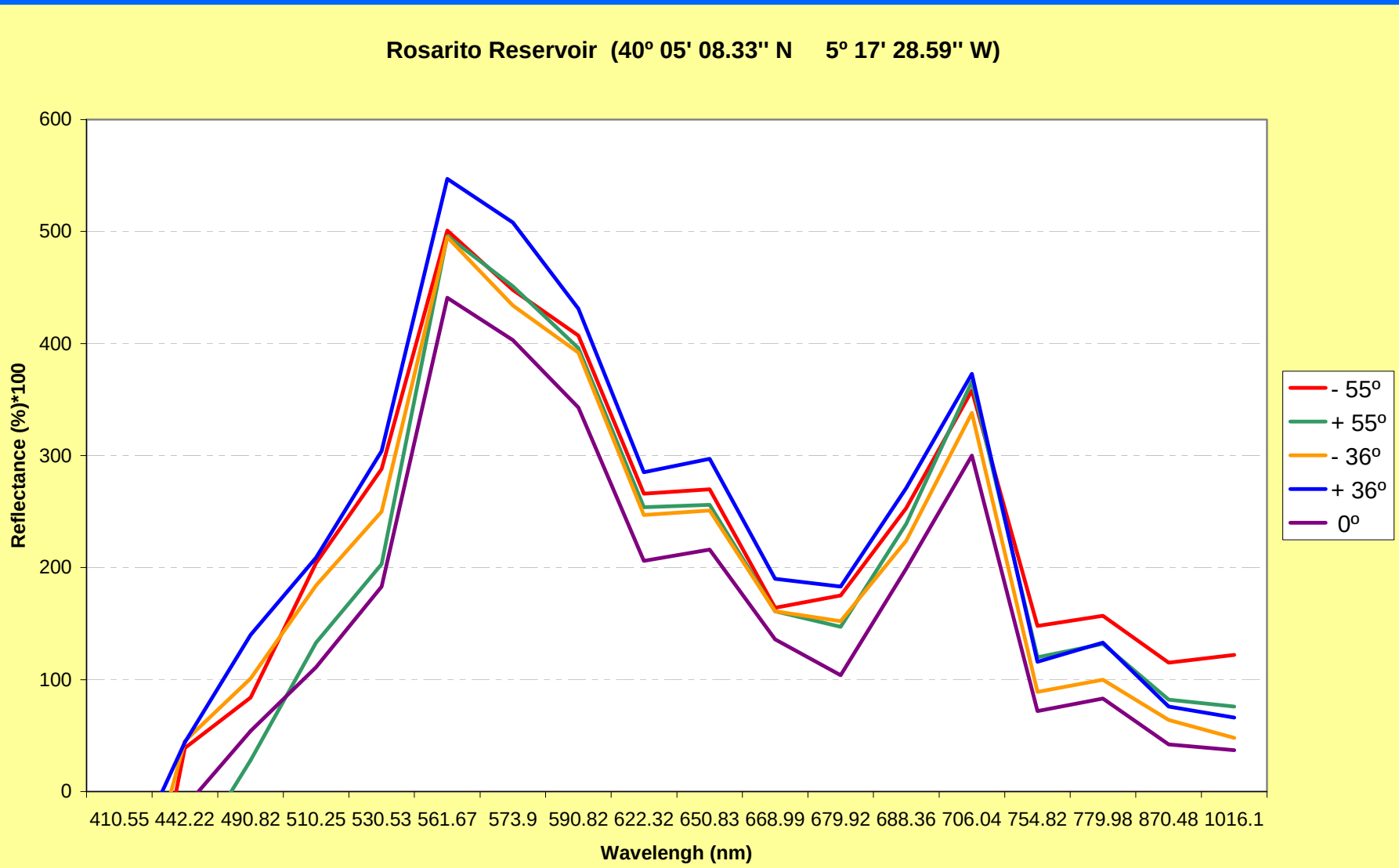
REFLECTANCE AT SAMPLING POINT *D* (*ZENITH* "nadir" IMAGE AND FIELD DATA)

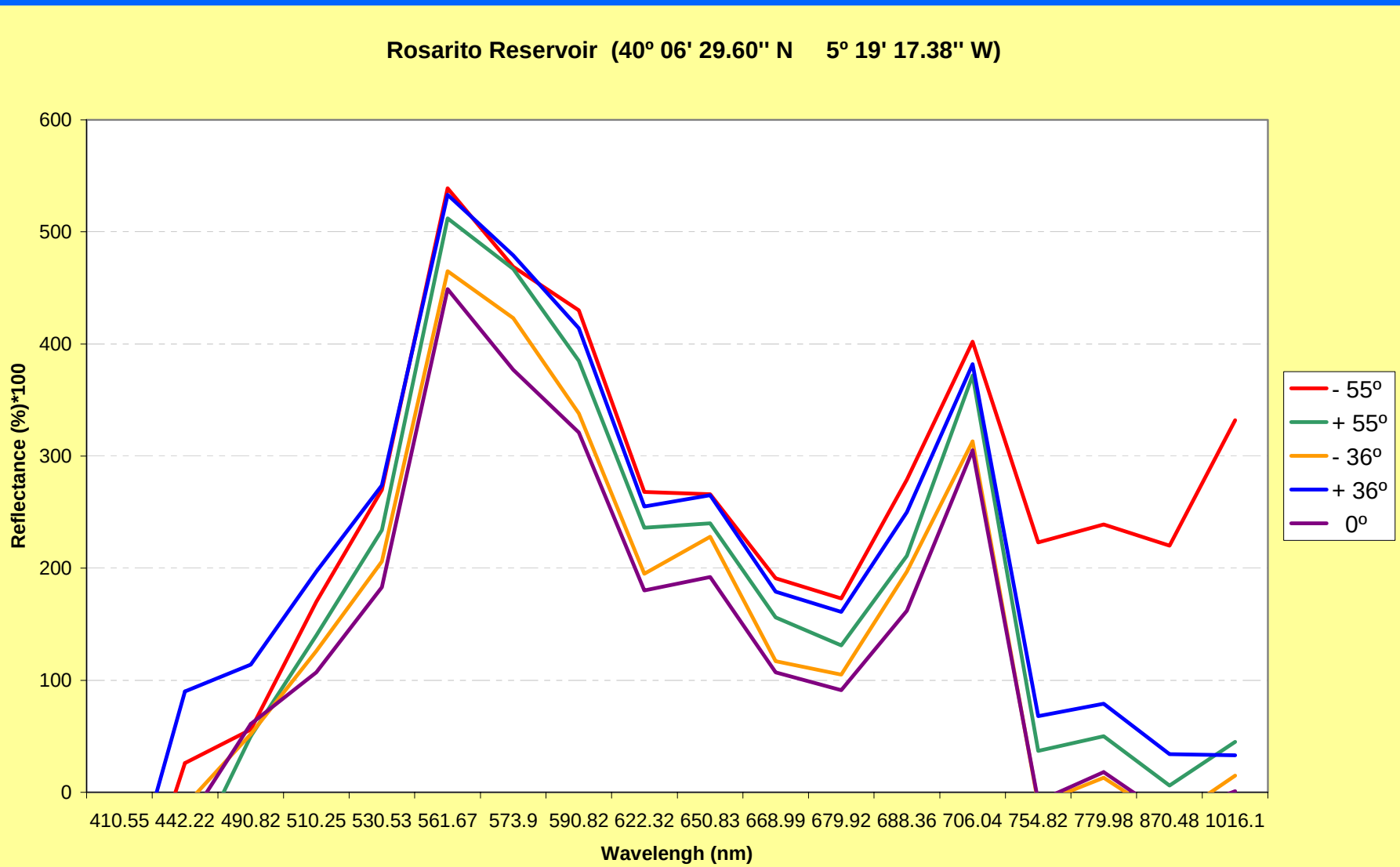


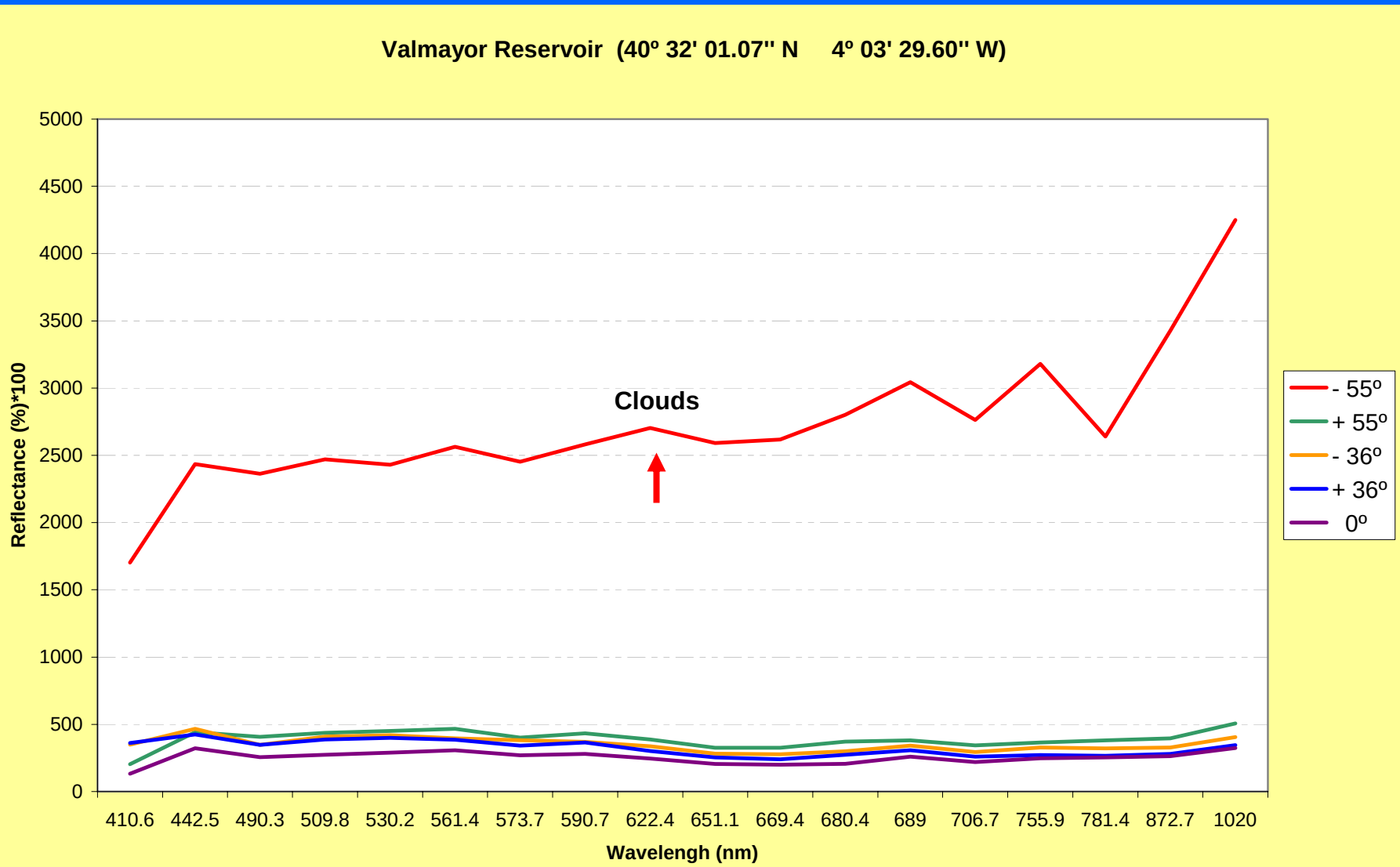
1st approach (2006).- Second part

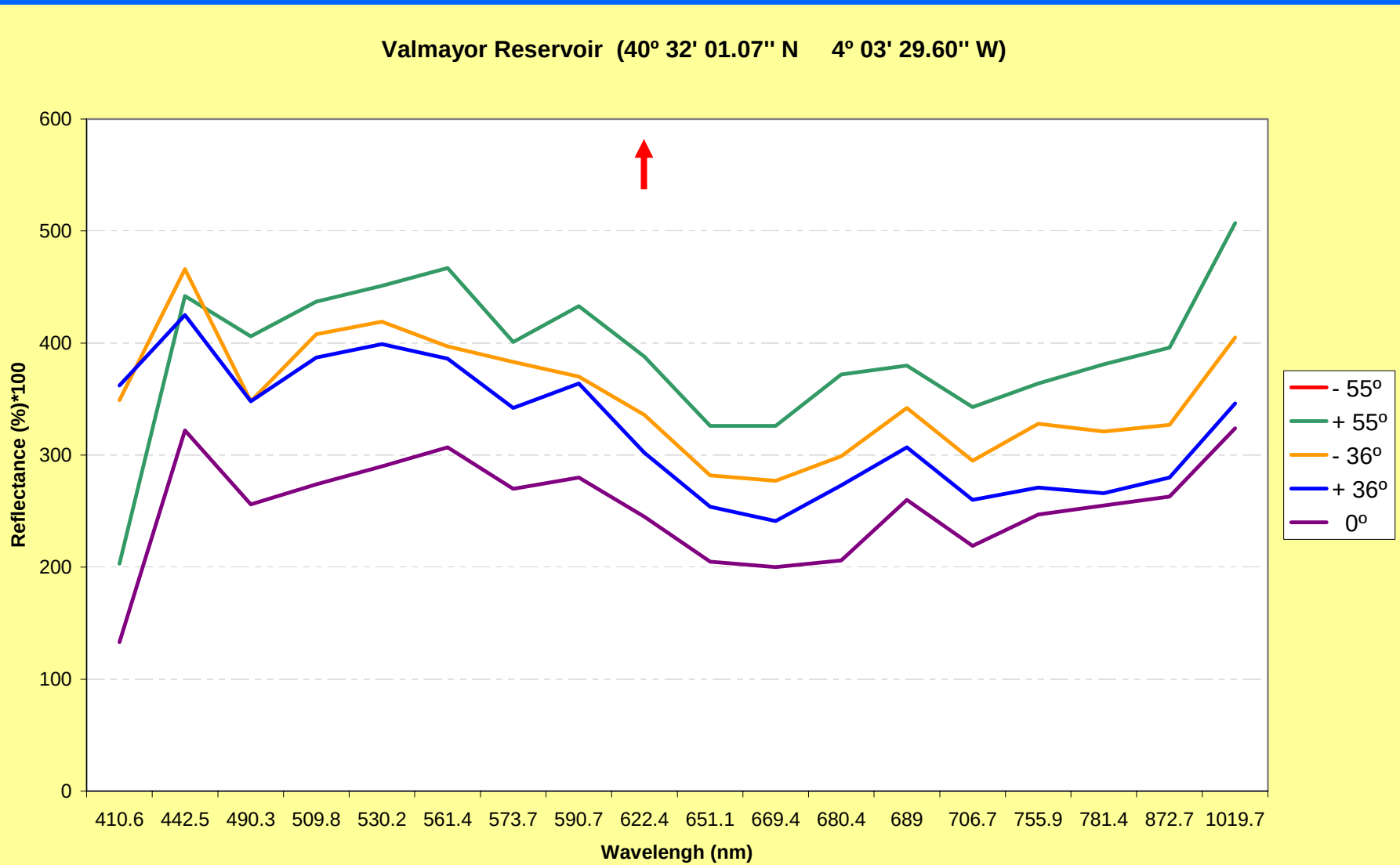


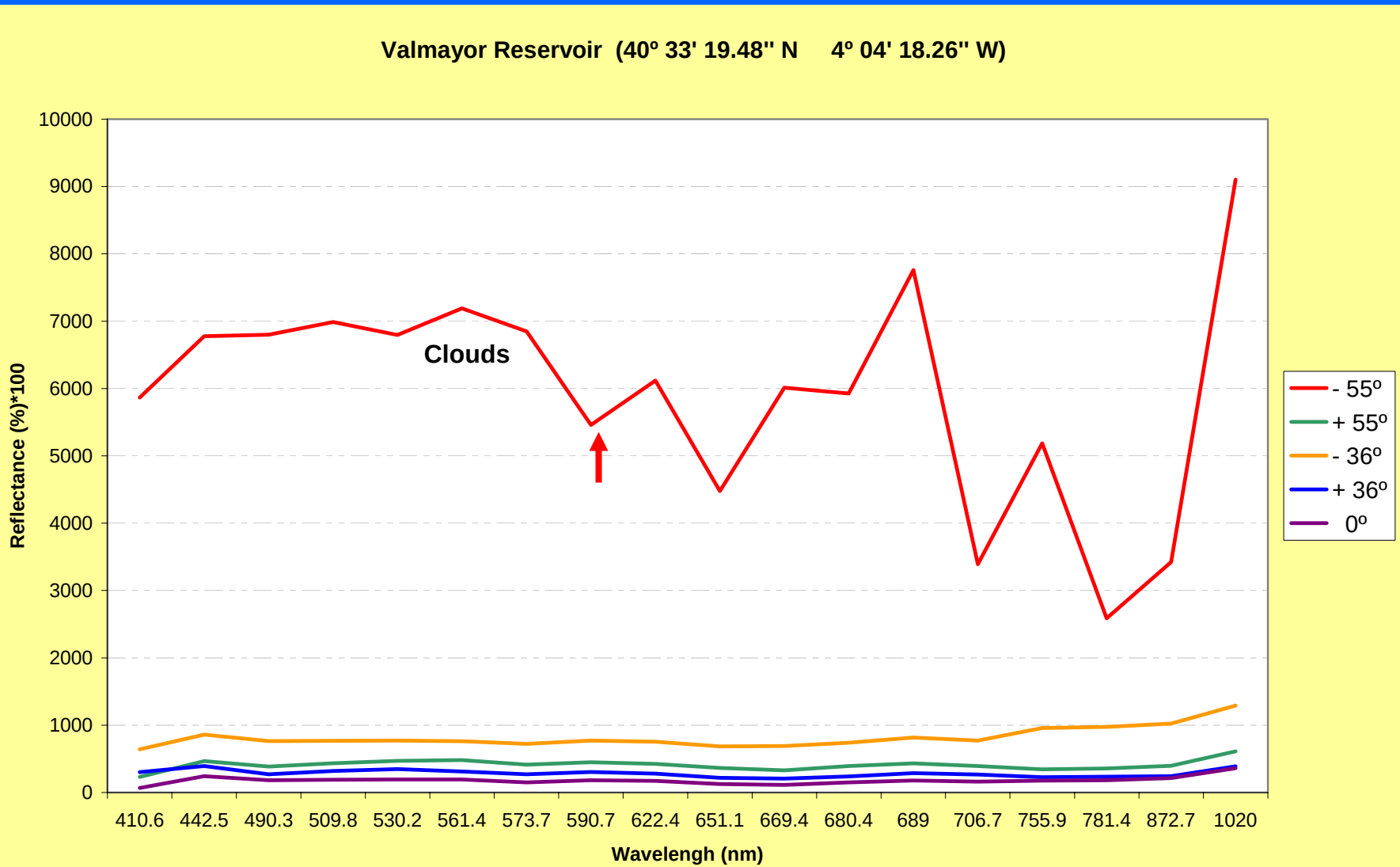

Rosarito Reservoir (40º 06' 33.12'' N 5º 15' 24.79'' W)
Reflectance (%)*100
600
500
400
300
200
100
0
410.55 442.22 490.82 510.25 530.53 561.67 573.9 590.82 622.32 650.83 668.99 679.92 688.36 706.04 754.82 779.98 870.48 1016.1
Wavelengh (nm)
- 55º
+ 55º
- 36º
+ 36º
0º

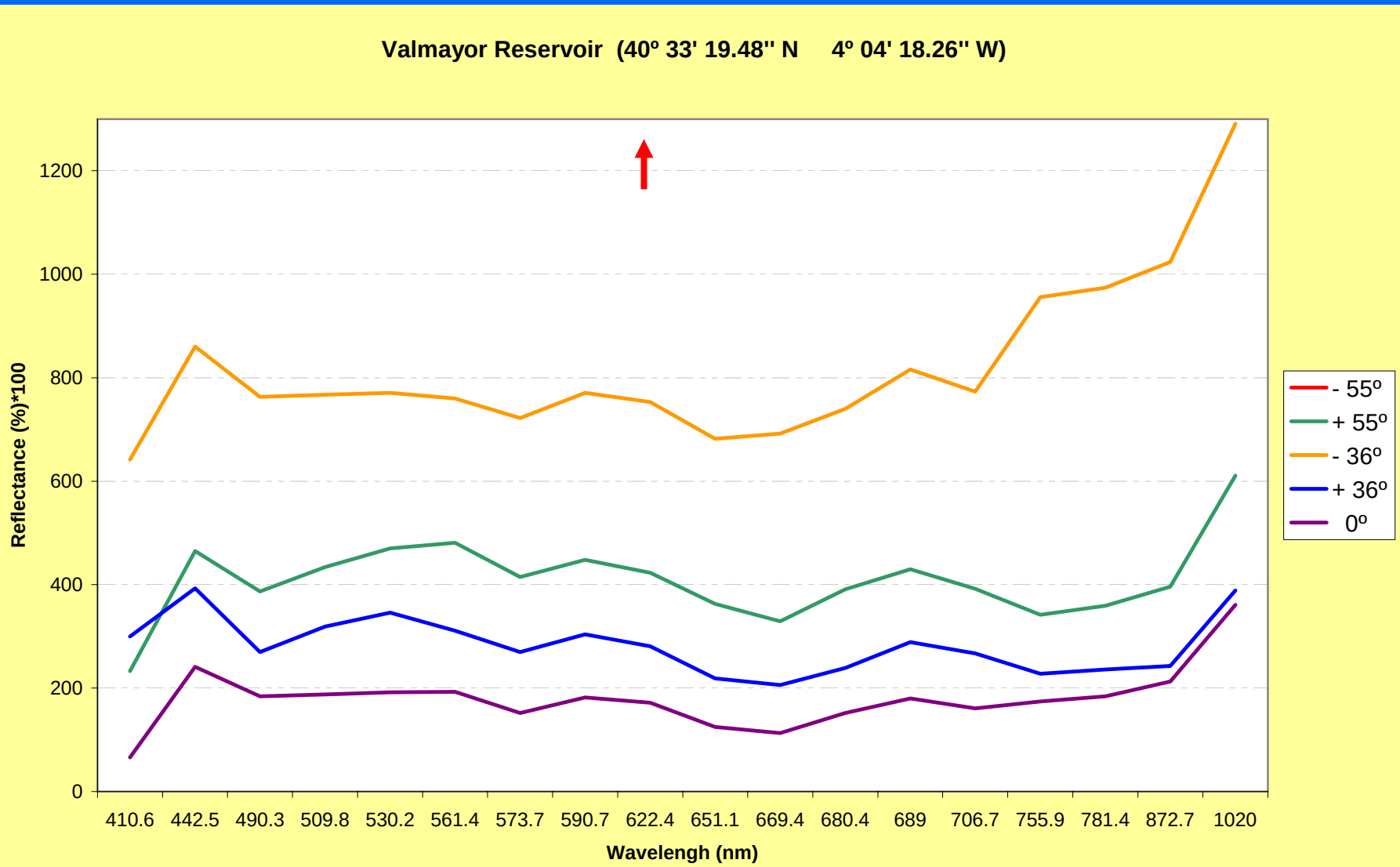

Rosarito Reservoir (40º 05' 08.33'' N 5º 17' 28.59'' W)
Reflectance (%)*100
600
500
400
300
200
100
0
410.55 442.22 490.82 510.25 530.53 561.67 573.9 590.82 622.32 650.83 668.99 679.92 688.36 706.04 754.82 779.98 870.48 1016.1
Wavelengh (nm)
- 55º
+ 55º
- 36º
+ 36º
0º


Rosarito Reservoir (40º 06' 29.60'' N 5º 19' 17.38'' W)
Reflectance (%)*100
600
500
400
300
200
100
0
410.55 442.22 490.82 510.25 530.53 561.67 573.9 590.82 622.32 650.83 668.99 679.92 688.36 706.04 754.82 779.98 870.48 1016.1
Wavelengh (nm)
- 55º
+ 55º
- 36º
+ 36º
0º

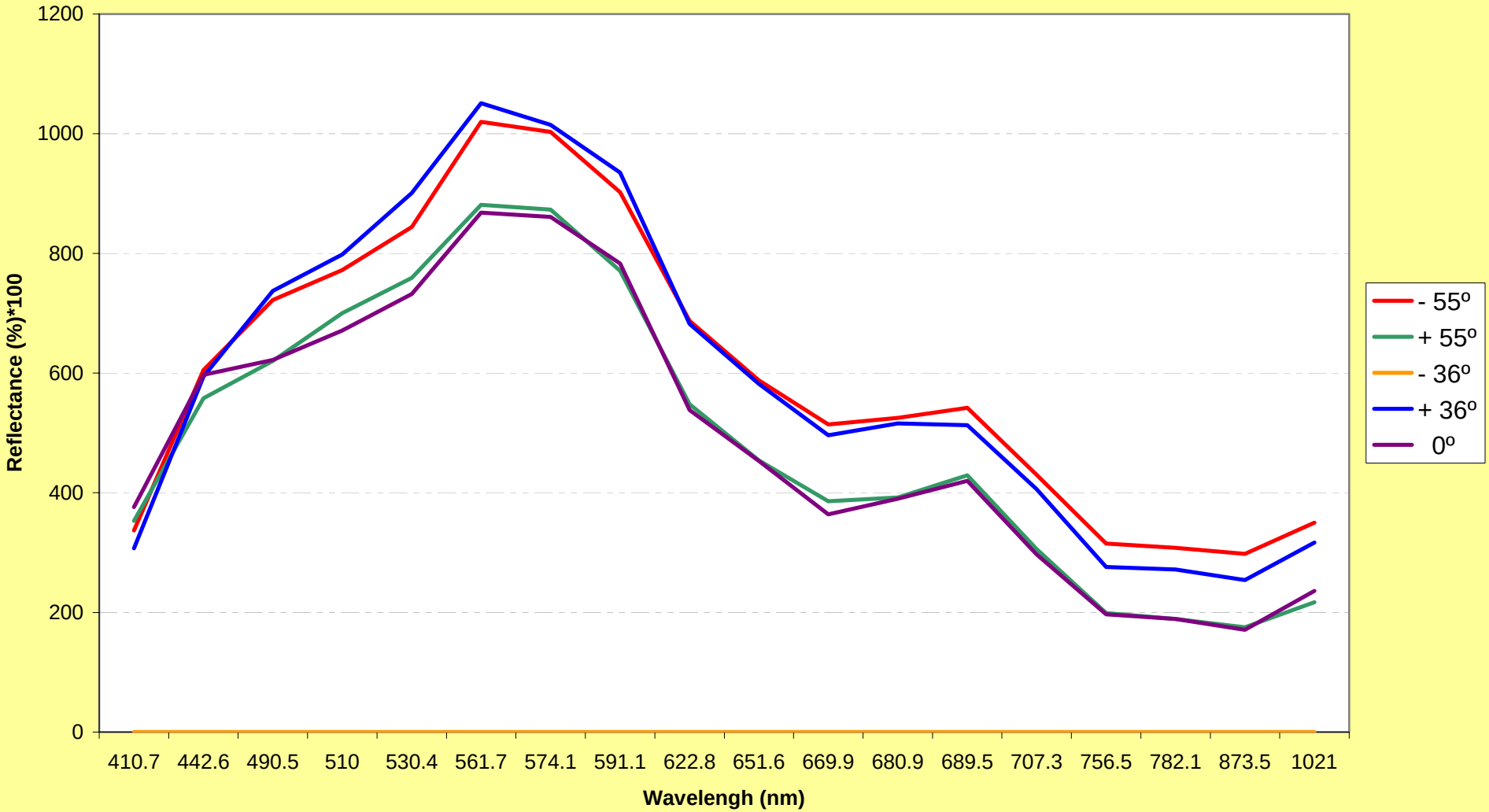

Valmayor Reservoir (40º 32' 01.07'' N 4º 03' 29.60'' W)
Reflectance (%)*100
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Clouds
410.6
442.5
490.3
509.8
530.2
561.4
573.7
590.7
622.4
651.1
669.4
680.4
689
706.7
755.9
781.4
872.7
1020
Wavelengh (nm)
- 55º
+ 55º
- 36º
+ 36º
0º

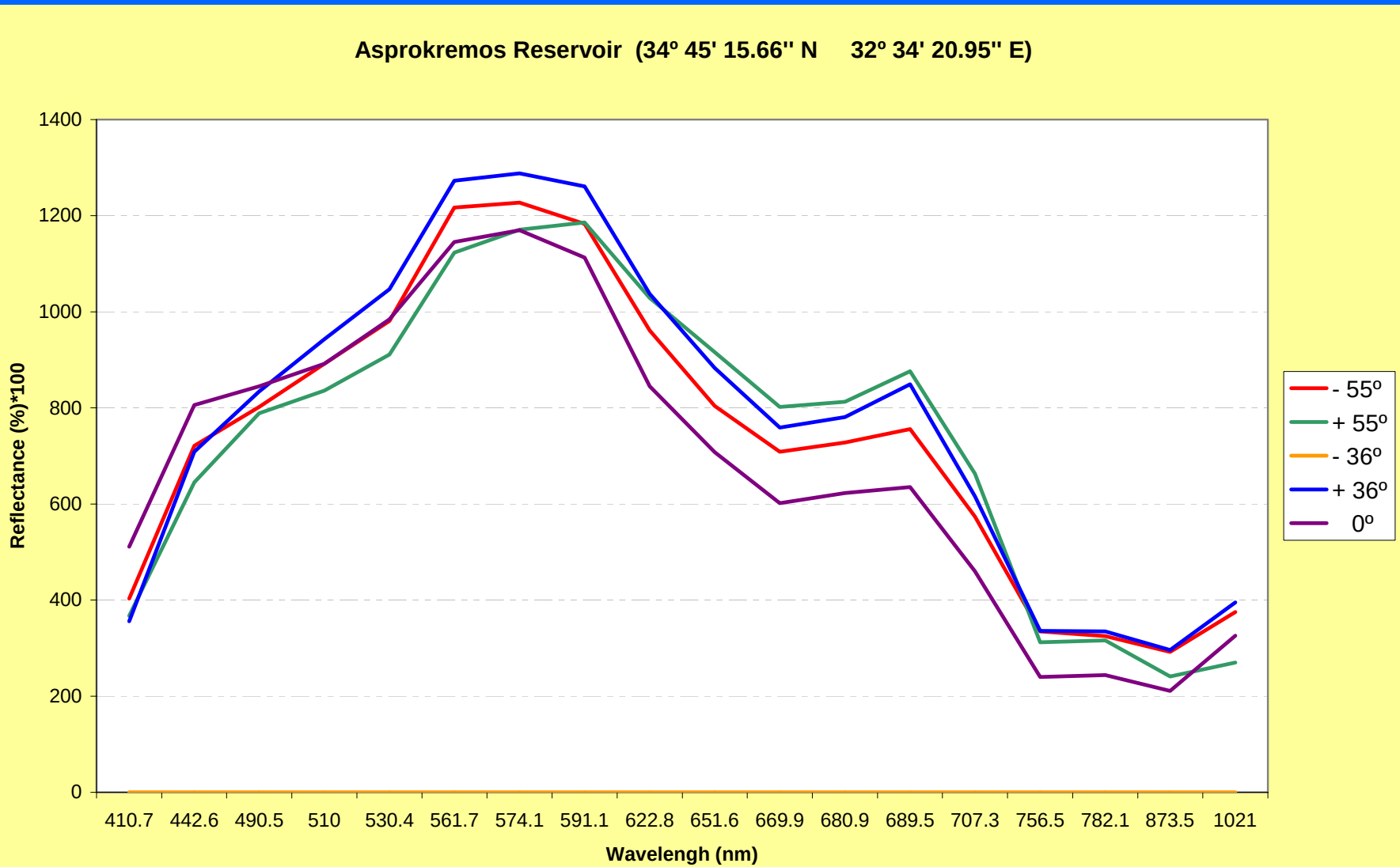

Valmayor Reservoir (40º 32' 01.07'' N 4º 03' 29.60'' W)
Reflectance (%)*100
600
500
400
300
200
100
0
410.6
442.5
490.3
509.8
530.2
561.4
573.7
590.7
622.4
651.1
669.4
680.4
689
706.7
755.9
781.4
872.7
1019.7
Wavelengh (nm)
- 55º
+ 55º
- 36º
+ 36º
0º


Valmayor Reservoir (40º 33' 19.48'' N 4º 04' 18.26'' W)
Reflectance (%)*100
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Clouds
410.6
442.5
490.3
509.8
530.2
561.4
573.7
590.7
622.4
651.1
669.4
680.4
689
706.7
755.9
781.4
872.7
1020
Wavelengh (nm)
- 55º
+ 55º
- 36º
+ 36º
0º


Valmayor Reservoir (40º 33' 19.48'' N 4º 04' 18.26'' W)
Reflectance (%)*100
0
200
400
600
800
1000
1200
410.6
442.5
490.3
509.8
530.2
561.4
573.7
590.7
622.4
651.1
669.4
680.4
689
706.7
755.9
781.4
872.7
1020
Wavelengh (nm)
- 55º
+ 55º
- 36º
+ 36º
0º

Asprokremos Reservoir (34º 44' 43.38'' N 32º 33' 52.89'' E)




Asprokremos Reservoir (34º 45' 15.66'' N 32º 34' 20.95'' E)
Reflectance (%)*100
1400
1200
1000
800
600
400
200
0
410.7
442.6
490.5
510
530.4
561.7
574.1
591.1
622.8
651.6
669.9
680.9
689.5
707.3
756.5
782.1
873.5
1021
Wavelengh (nm)
- 55º
+ 55º
- 36º
+ 36º
0º

PRELIMINARY CONCLUSIONS about multiangularity study:

The main angular effect observed is, quantitatively, the "sun glint-induced" increasing the reflectance.

- Initially, in sun glint free imagery, not found a clear trend in the reflectance spectra for the different observation angles.

- Further analysis, carried out in the last months, shows, in general terms, that the spectra corresponding to the image sets with angles ±36° and ±55° have reflectance level higher than the near-nadir images. But that results can be caused partially by the pixel deformation due to higher angle (progessively longer and bigger area of reflectance integrated in the pixel).

- No clear other effect in the reflectance level.

- Next steps must be to identify and estimate the influence on radiometry of angular observation, and, in addition, to model the geometrical difference due to the pixel position in the frame.

2nd approach (2006-2007)

-Taking radiometric measurements on water bodies controlling the angular positions of the Spectro-radiometer optical fiber to reproduce the CHRIS image set nominal angles.

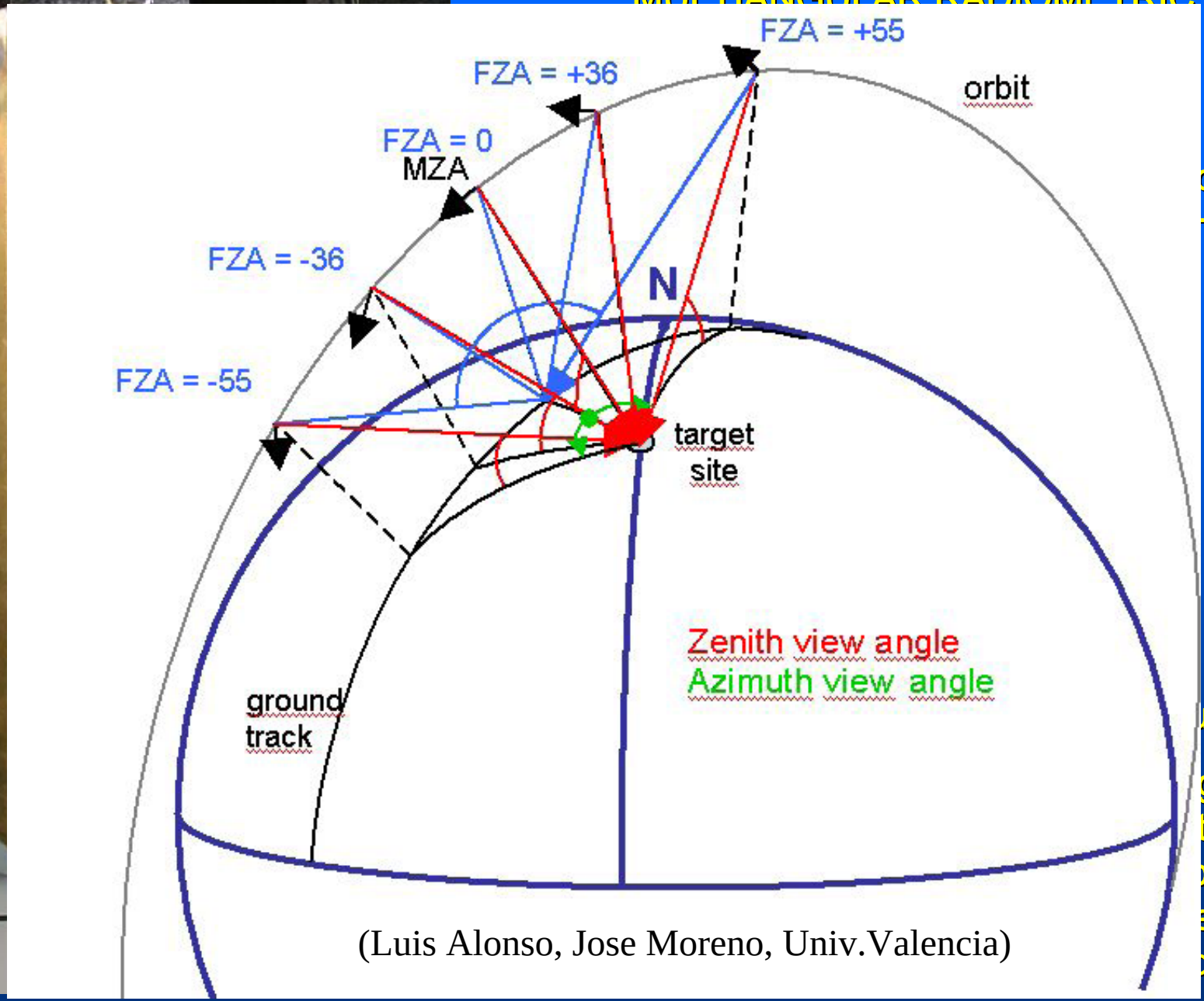
Taking :

Coincident measurements with some acquisitions.

Campaign of systematic observations in water bodies.

-For that purpose CEDEX has planned the work in the reservoirs using a device to sure the repeatability of angular conditions for the measurements.

MULTIANGULAR RADIOMETRIC



(Luis Alonso, Jose Moreno, Univ.Valencia)

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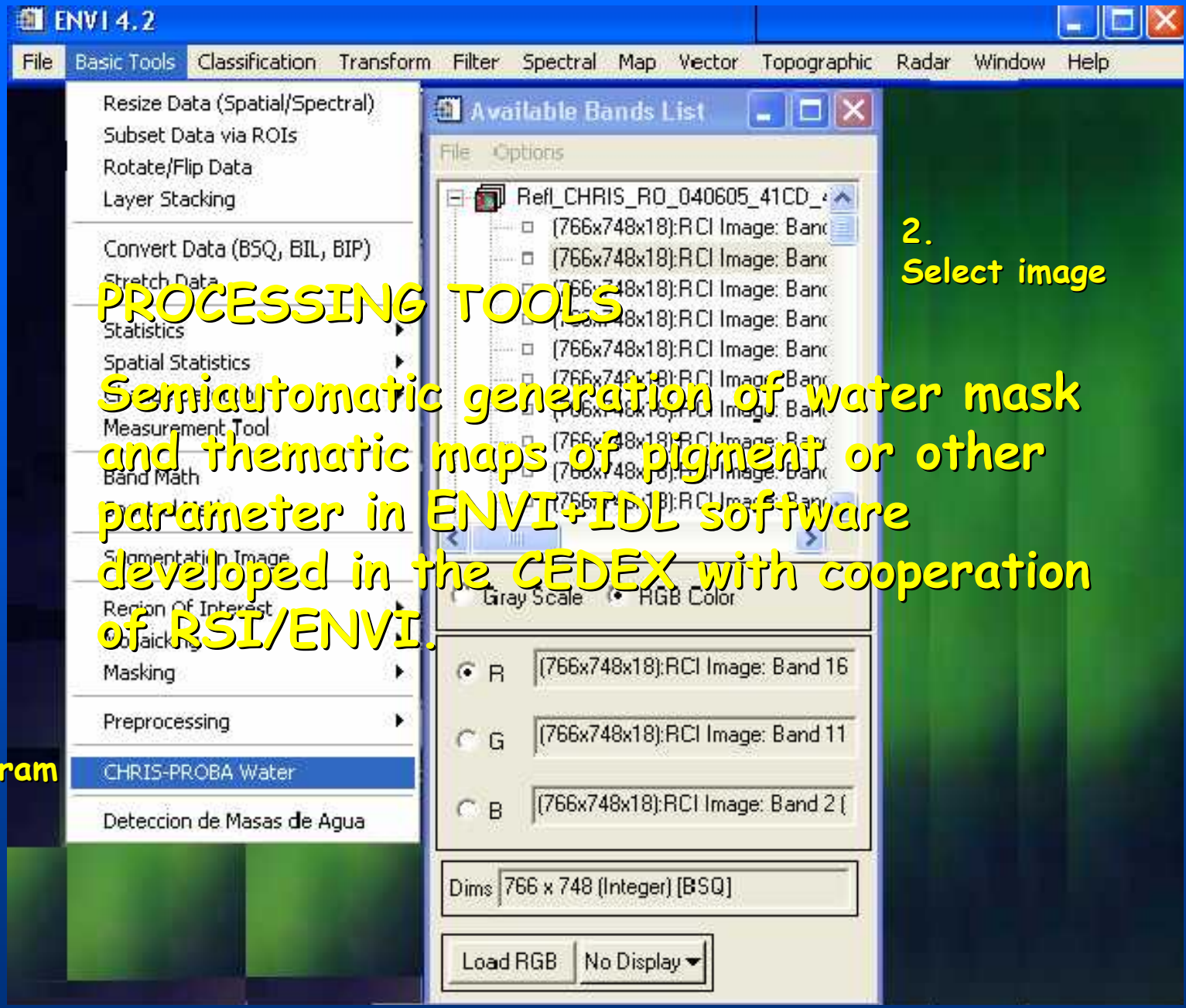
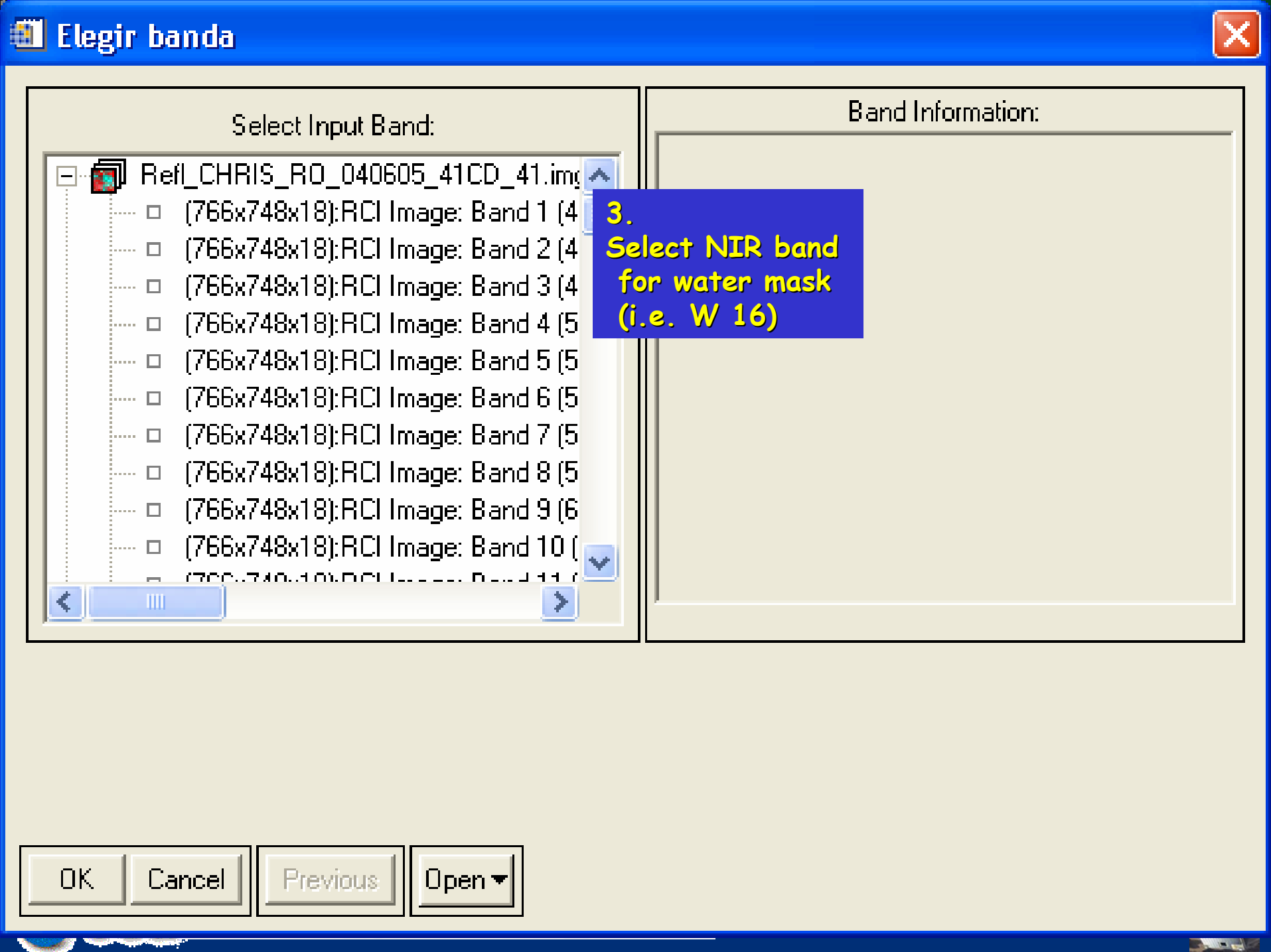


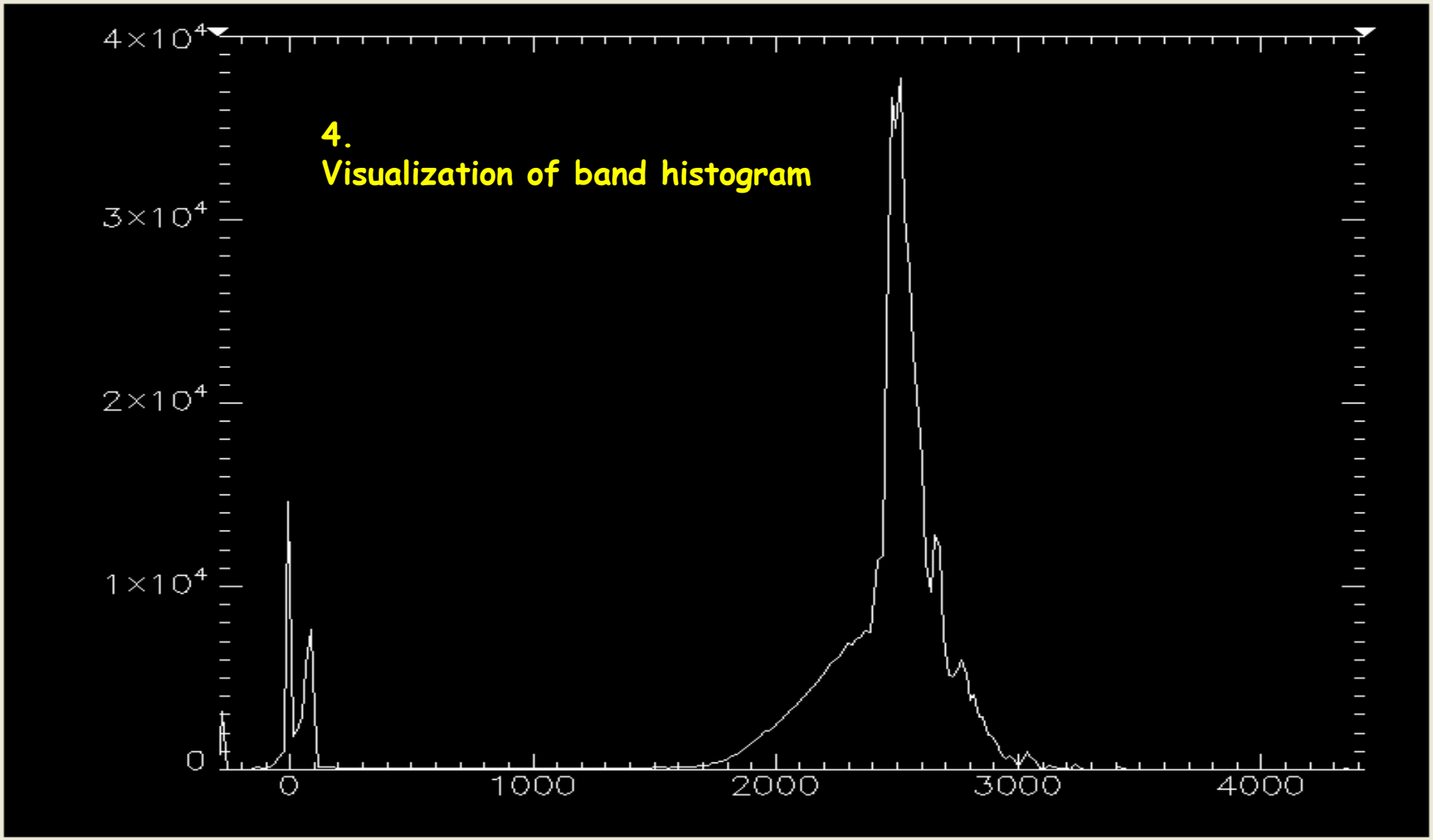
PROCESSING TOOLS

Semiautomatic generation of water mask and thematic maps of pigment or other parameter in ENVI+IDL software developed in the CEDEX with cooperation of RSI/ENVI.

1. Select program

2. Select image


Elegir banda
Select Input Band:
Refl_CHRIS_RO_040605_41CD_41.img
(766x748x18):RCI Image: Band 1 (4
(766x748x18):RCI Image: Band 2 (4
(766x748x18):RCI Image: Band 3 (4
(766x748x18):RCI Image: Band 4 (5
(766x748x18):RCI Image: Band 5 (5
(766x748x18):RCI Image: Band 6 (5
(766x748x18):RCI Image: Band 7 (5
(766x748x18):RCI Image: Band 8 (5
(766x748x18):RCI Image: Band 9 (6
(766x748x18):RCI Image: Band 10 (
Band Information:
3.
Select NIR band
for water mask
(i.e. W 16)
OK
Cancel
Previous
Open



4.
Visualization of band histogram

Mascara de agua

Output Result to (•) File ( ) Memory

Enter Output Filename [Choose]

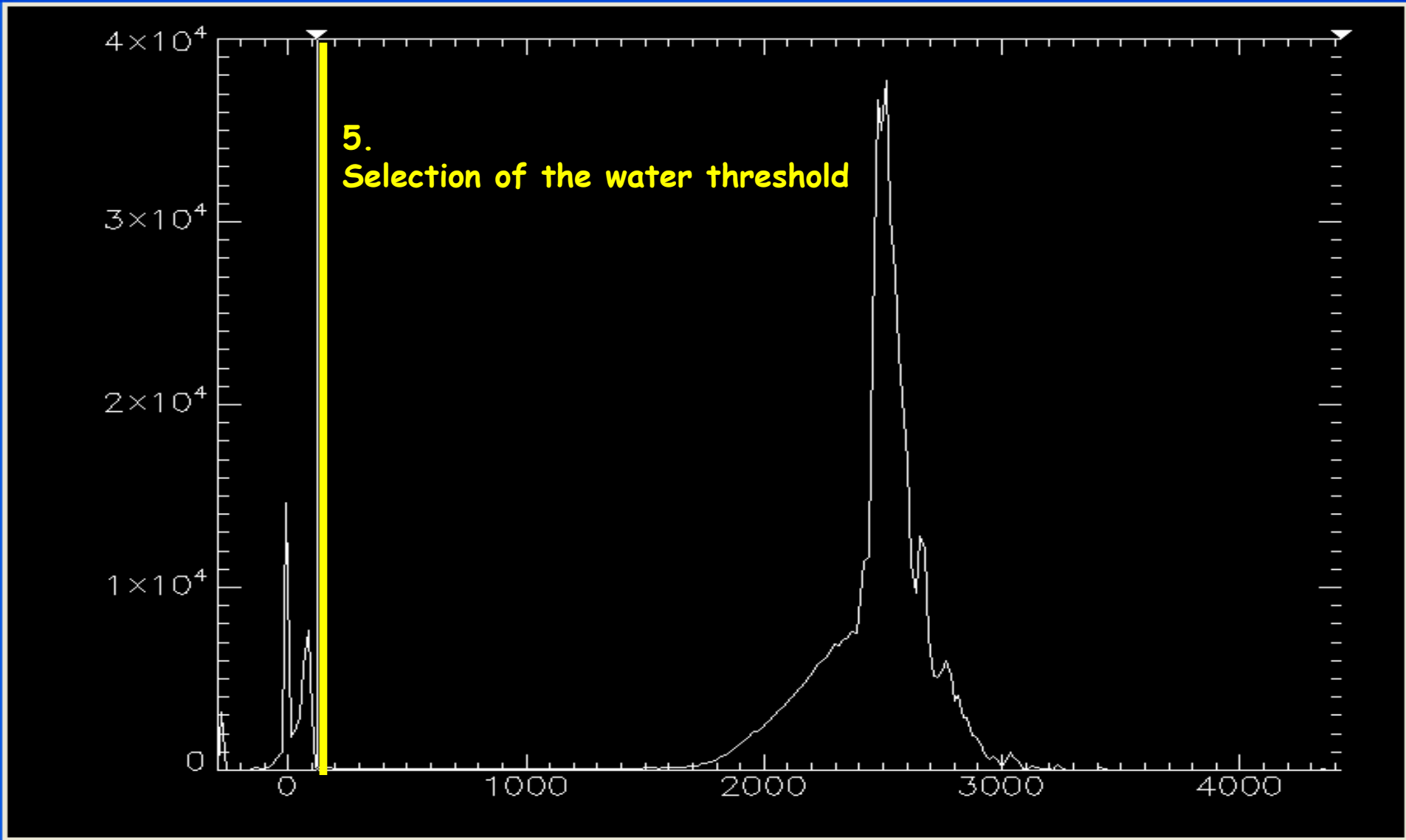
Clorofila y Ficocianina

Output Result to (•) File ( ) Memory

Enter Output Filename [Choose]

[OK] [Cancel]

Parametros



Mascara de agua

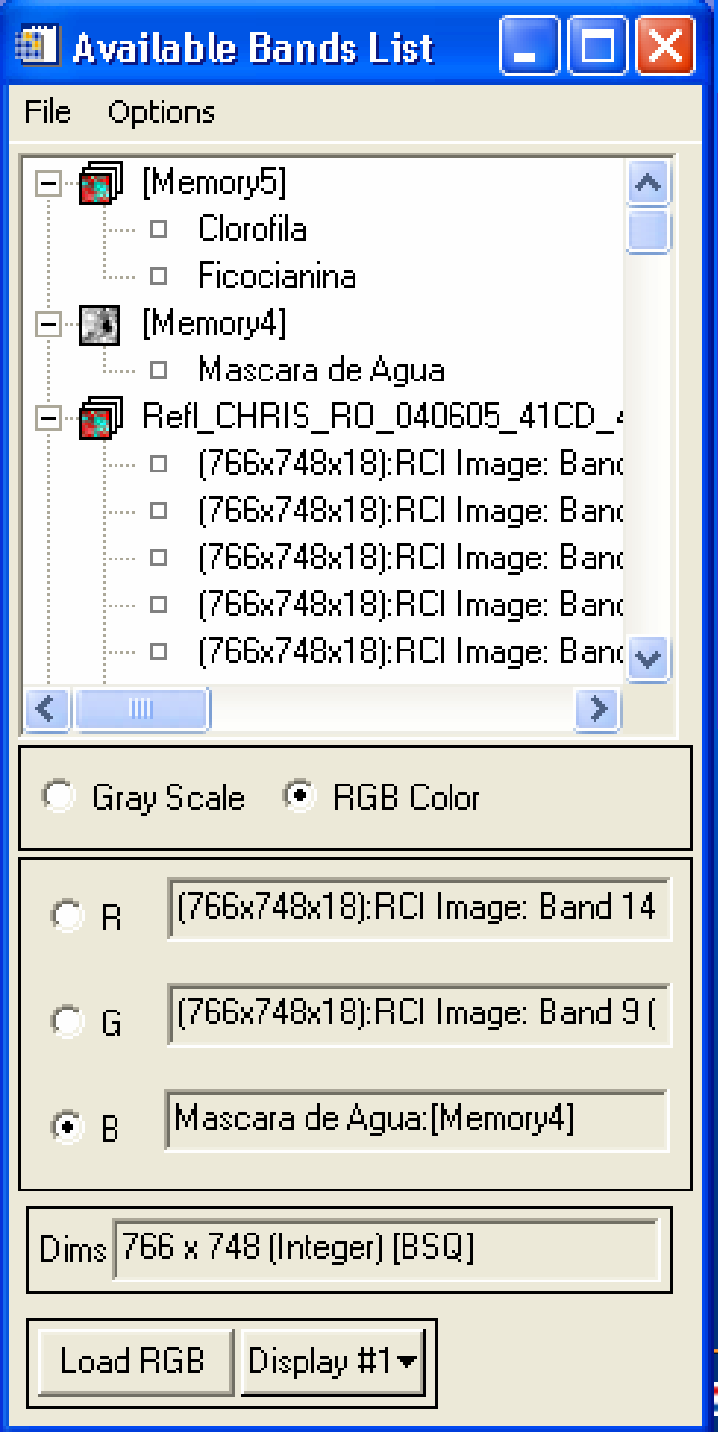
Output Result to File Memory

Clorofila y Ficocianina

Output Result to File Memory

6.
Selection of the exit type (to file or to memory)

OK Cancel



7.

Chlorophyll-a map
Phycocyanin map

Water mask

Available to recover, viewing, copy, etc.

MINISTERIO DE FOMENTO

CEDEX
CENTRO DE ESTUDIOS Y EXPERIMENTACIÓN DE OBRAS PÚBLICAS

Title:

"Use of CHRIS for Monitoring Water Quality in Selected Reservoirs. 2005/06 Activities" (AO 2830)

Authors:

Peña-Martínez, Ramón (PI); Domínguez-Gómez, José-Antonio; Ruiz-Verdú, Antonio

Centre for Hydrographic Studies of CEDEX (Spain)

Topic/subtopic : *Water Quality, Photosynthetic pigments, Remote sensing*