E82-10036

CR-164772

LANDSAT IMAGERY OF THE VENETIAN
LAGOON
A MULTITEMPORAL ANALYSIS

L. Alberotanza[*], A. Zandonella[**]

* Lab. per lo Studio della Dinam.
  delle Grandi Masse (C.N.R.),
  Venezia.

**Telespazio S.p.A., Roma.

LANDSAT IMAGERY OF THE VENETIAN LAGOON
A MULTITEMPORAL ANALYSIS

L. Alberotanza[*], A. Zandonella[**]

[*] Lab. per lo Studio della Dinam.
delle Grandi Masse (C.N.R.),
Venezia.

[**] Telespazio S.p.A., Roma.

ABSTRACT

Results from a multitemporal analysis of the Lagoon's environment dynamics in its central basin by the use of Landsat images from 1975 to 1979 are presented.
Utilizing an appropriate methodology for multitemporal calibration of data in the more characteristic bands of marine phenomena, a classification was made to distinguish tide diffusion as well as industrial, agricultural, urban turbidity distributions and algae belts.
The analysis of these factors led to the conclusion that lagoon's environment becomes more and more polluted, confirming sea-truth measurements.

1. INTRODUCTION

The aim of this work was to determine the pollution diffusion, in relation to different tide conditions, in the central basin of Venice lagoon by the use of Landsat data.
To achieve this goal, a selection of images from 1975 to 1979 was performed based on the following criteria:
- same season;
- representativeness of different tide dynamics;
- similar wind conditions;
- availability of useful data.
As to the most suitable season, late spring was selected, because the atmospheric noise effect in the lagoon is reduced.
Referring to tide conditions, a short and a long range period have been considered. The former corresponding to the year 1979, with three images recorded under different tide dynamics. The latter represented by the years from 1975 to 1979 with five images recorded under similar tide dynamics.

2. METHODOLOGICAL APPROACH IN DATA PROCESSING

THE BASIC CRITERIA

The haze conditions and the complex environmental dynamics of the lagoon on one hand, the physical characteristics of Landsat bands on the other hand, have led to utilize an appropria te methodology for multitemporal calibration of the images as basic element in data processing.
This consists in the projection of these images in the same feature space, after due restoration.
The various work steps are:
- partial haze removal;
- residual striping removal;
- spectral bands selection;
- multitemporal data calibration;
- classification.

PARTIAL HAZE REMOVAL

As it is known, an increasing haze has the following effects on MSS data:
- a shifting of most signals towards brighter levels;
- a reduction in the available signal contrast, i.e, in the dynamic range encompassed by the data (refer for instance to Lambeck, 1977).

The first effect has been partially removed by a shifting of the radiance values vs. dark levels. This shift is relatively large for MSS 4 and minimum for MSS 7, considering light scat tering as a function of wavelength.
The second effect has been also partially eliminated by means of a normalization of the work images done through their projection onto a common normalized reflectance factorial space. (For the main characteristics of a normalized reflectance spa ce refer to Kauth + Thomas, 1976).

RESIDUAL STRIPING REMOVAL

After destriping processing, a residual striping has still been observed in certain subregions of the Venetian lagoon area.
This fact is normally due to the significant differences between the statistical parameters of the destriping models, com puted in the subregions and in the whole area.
To remove these residues it has been sufficient to utilize a smoothing method, based on moving average of line groups.

SPECTRAL BANDS SELECTION

It has been observed that, for marine phenomena, MSS 4 and 5 yi
eld information on circulation, turbidity distribution and bio-
mass (refer to Maul, 1973, Todisco + Zandonella, 1979).
Furthermore, MSS 6 has been proven as very effective in detec-
ting algal blooms, a phenomenon representing extremely high sur
face chlorophyll concentration (refer to Strong, 1974).
Considering these three channels and some physically signifi-
cant operations, ratio and sums in particular, the correlations
existing among them have been computed for every single lagoon
area, in relation to the most representative lagoon phenomena,
such as tide, turbidity distribution, algae belts.
Bartlett sphericity test have been interatively utilized for chan
nels selection , by evaluating the null hypothesis for which
their correlation matrix is an identity matrix (refer to Zando-
nella, 1978).
The most useful channels so determined have been MSS 4, MSS 5,
MSS 4 + MSS 5 and MSS 4/MSS 5.
So selected channels are highly correlated to different types
of turbid water and scarsely to algal blooms. This means that
during the monitoring these events have not been noticed.

MULTITEMPORAL DATA CALIBRATION

As mentioned above, the calibration criteria is based on Land-
sat data structure analysis (refer again to Kauth + Thomas, 1976
and also to Zandonella, 1980).
Apart from any consideration on the methodology utilized, which
will make the object of a separate specific work, the basic con
cept of the method consists of data projection in the same fea-
ture space.
The criteria is to find a new axis system for which the loss of
contrast variance, in relation to the principal axis of the ori
ginal reflectance spaces, is minimum.
New axis system properties are similar to those of principal com
ponents.

CLASSIFICATION

The criteria followed in the classification is based on three
main steps.
The first step has consisted in identifying the potential clas-
ses by the use of unsupervised classification, considering also
sea-truth data (refer to Zandonella, 1979). The second step has
been to utilize a supervised classification method: the Sebe-
styen quadratic classifier (refer to Sebestyen, 1962 and to Zan

donella, 1979 for the criteria of choosing the quadratic form).
As third step, the goodness of the classification has been eva-
luated both through the use of sea-truth data and through the
analysis of the one sigma dispersion ellipses of different clas
ses projected onto the first two axis of the same feature space
(see Figure 1). For this type of analysis refer for instance to
Benzècri, 1973.

3. RESULTS AND CONSIDERATIONS

The turbidities classification on one hand and the lagoon-sea
exchanges, under different tide conditions on the other hand,
allowed a comparison of the results obtained (see enclosed ima-
ge).
On May 4th, 1979 the largest turbidity diffusion was verified,
during a low range ebb tide. The NNW wind effect contributes in
conveying the waters from the northen basin towards Venice and
from the industrial zones towards the lower part of the lagoon.
On May 22nd, 1979 at the outflow beginning the situation was ve
ry similar, but a lower rate of turbidity diffusion was verifi-
ed in the southern part of the lagoon.
A wide clean water area coming from Malamocco entrance during
previous tide phase is clearly visible.
On June 27th, 1979 and June 19th, 1977 with similar tide condi-
tions and winds blowing from opposite direction, the industrial
pollution still surrounds the historical center.
A similar turbidity diffusion towards Venice was confirmed by
the May 27th, 1978 and April 28th, 1975 images, both recorded
during inflow tide having high stream speed.
On May 19th, 1976 industrial pollution still surrounded the hi-
storical centre even during the inflow and by a very low sea le
vel (below zero). The incoming clean water was gathering in a
restricted area around Malamocco inlet.
It appears from the above considerations that the lagoon areas
affected by polluting discharges are clearly identified. The con
centration of these discharges in specific lagoon areas is deri
ving from some circulation pattern enhanced in the multitempo-
ral image analysis by the tide inflow/outflow as well as in si-
tu, by traditional oceanographic measurements (refer to Albero-
tanza + Tonelli, 1978, Dazzi + Nyffeler, 1973, Nyffeler, 1976,
Comune di Venezia, 1978, Nyffeler et al., 1974, Nyffeler et al.,
1975).

4. CONCLUDING REMARKS

From the results obtained, it was possible to remark that pollu
ted waters are present between industrial zones and the histori

cal centre under any tide condition.
The flow of pollutants is continuous and involves the same areas
with variations only in the spatial distribution.
The diffusion in the lagoon of clean water from the sea   during
flood tide remains limited in restricted areas around Malamocco
entrance.
The water renewal from Lido entrance appears more limited.
In relation to the above and to the sea-truth measurements, pol-
lution concentration in a well delimited area is derived   both
from the short time interval between inflow/outflow and from the
distance between the two lagoon inlets and the industrial zones.

REFERENCES

Alberotanza, L. and Tonelli A.M.,
"Thermal roughness and texture analysis of water bodies: their
relationship with the bottom morphology".
XVIII Convegno Internazionale sullo Spazio, Rome, 1978.

Benzécri, J.P.
"L'analyse des données"
Dunod, 1973.

Comune di Venezia
"Valutazione dei limiti di accettabilità delle sostanze inquinan
ti degli scarichi versati in laguna. Definizione di un sistema di
controllo della qualità delle acque lagunari".
Tecneco, 1978.

Dazzi R. and Nyffeler F.
"Le regime des courants entre le centre historique de Venise et
la zone industrielle de Marghera".
C.N.R. Lab. per lo Studio della Dinam. delle G.M.-Technical Re-
port N. 74 (1973).

Kauth R.J., Thomas G.S.
"System for analysis of Landsat agricultural data: automatic compu
ter assisted proportion estimation of local areas".
NASA CR-ERIM 109600-67-F (1976).

Lambeck P.F.
"Signature extension processing for Landsat MSS data".
NASA CR-ERIM 122700-32-F, November 1977.

Maul G.A.
"Application of ERTS data to oceanography and marine environment".
Proceeding of COSPAR Meeting, Konstanz, May 1973.

Nyffeler F., Dazzi R., Hirel B., Alberotanza L.
"Variations spatiales et temporelles des propriétés de l'eau
dans la ville et la lagune de Venise".
C.N.R. Lab. per lo Studio della Dinam. delle G.M.-Technical Re
port N. 84 (1974).

Nyffeler F., Dazzi R., Hirel B., Alberotanza L.
"Circulation et conditions hydrologiques induites par les ap
ports d'eau douce dans la partie septentrionale de la lagune
de Venise".
C.N.R. Lab. per lo Studio della Dinam. delle G.M.-Technical Re
port N. 86 (1975).

Nyffeler F.
"Le regime hydrodynamique de la lagune de Venise: incidence sur
les phenomenes de transport".
Fonds National Suisse de la Recherche Scientifique.

Sebestyen G.S.
"Decision making process in pattern recognition".
The McMillan Company, 1962.

Strong A.E.
"Remote sensing of algal blooms by aircraft and satellite   in
Lake Erie and Utah Lake".
Remote Sensing of Environment, 3 (1974).

Todisco A. , Zandonella A.
"Correlation between Secchi depth transparency and radiance va
lues of Landsat satellite: an example from the Tiber river mo-
uth".
II Congresso Naz. sul Teleril. delle Ris. Terrestri - SITE (1979).

Zandonella A.
"Alcuni metodi fattoriali utilizzati come trasformate lineari
di immagini Landsat".
I Congresso Naz. sul Teler. delle Ris. Terrestri - SITE (1978).

Zandonella A.
"An automatic classification method for Landsat data as resul-
ting from different experiences in the Italian environment".
II Congresso Naz. sul Teleril. delle Ris. Terrestri - SITE (1979).

Zandonella A.
"Green and soil brightness indicators obtained through a Land-
sat data transformation procedure".
XX Convegno Internazionale sullo Spazio, Rome, 1980.
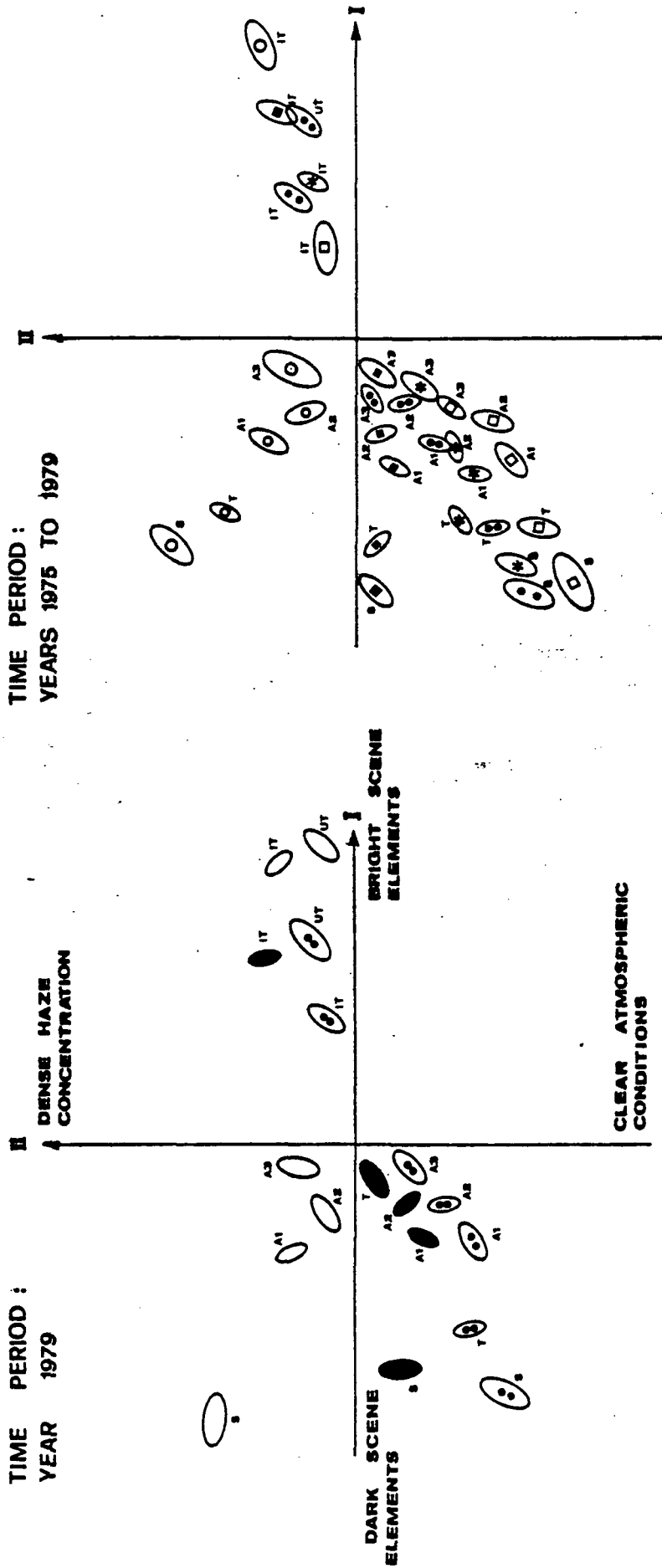
FIGURE 1 - Plot on first two factors, of a common standardized space, of one sigma disper sion ellipses of classes i dentified in different ti- me periods.

LANDSAT IMAGERY OF THE VENETIAN LAGOON
A MULTITEMPORAL ANALYSIS

L. Alberotanza[*] and A. Zandonella[*]

* Laboratorio per lo Studio della Dinamica delle Grandi Masse-CNR, Venezia
* Telespazio S.p.A., Roma

SUMMARY

Results from a multitemporal analysis of the lagoon's environment dynamics in its central basin by the use of LANDSAT images from 1975 to 1979 are presented. Utilizing an appropriate methodology for multitemporal calibration of data in the more characteristic bands of marine phenomena, a classification was made to distinguish tide diffusion as well as industrial, agricultural, urban turbidity distributions and algae belts. The analysis of these factors led to the conclusion that lagoon's environment becomes more and more polluted, confirming sea-truth measurements.
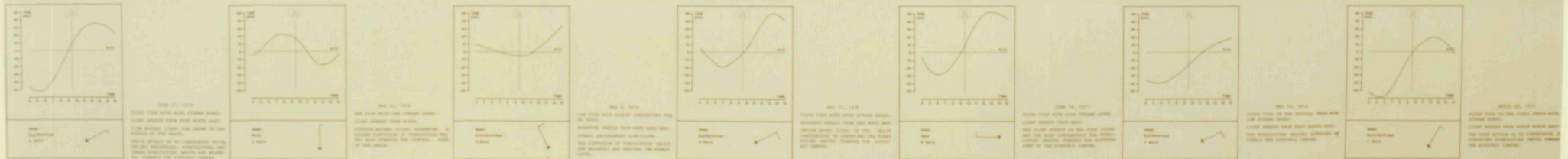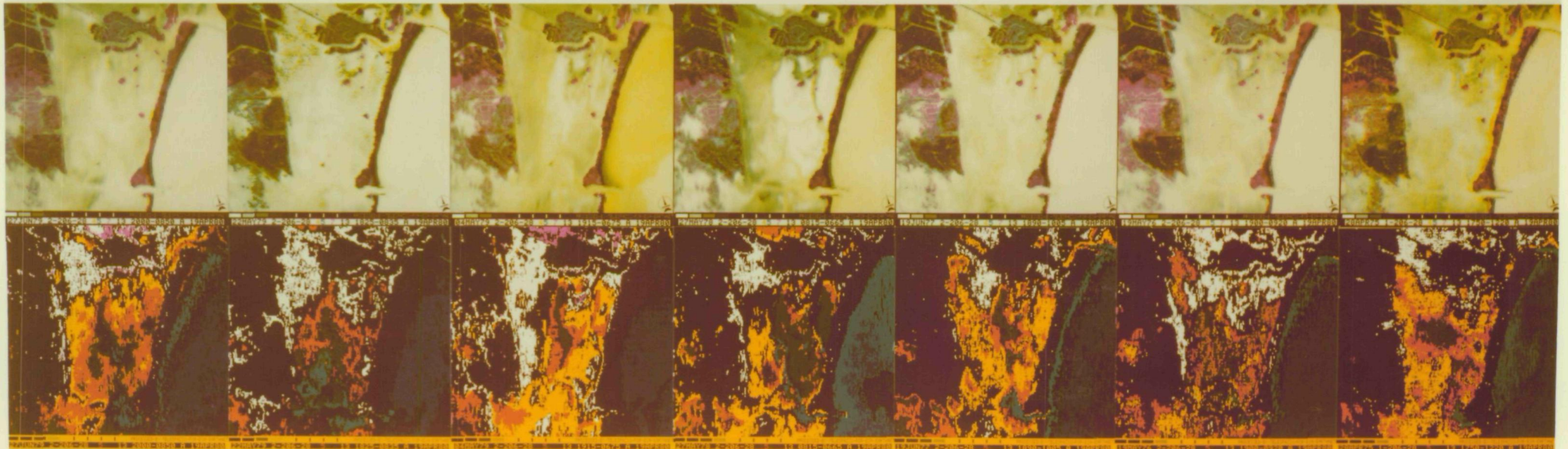
COLOR CODES:

White	· Industrial turbidity	Green	Cyan · Tide
Magenta	· Agricultural and urban discharges	· Red / Yellow | Algae belts + Bottom effects	Blue · Sea
			Black · Unclassified

CONCLUSIONS

Areas affected by industrial, agricultural and urban pollution (white and magenta) are clearly shown, in relation to the tide. Indipendently from tide inflow-outflow, industrial as well as agricultural and urban discharges are always conveyed towards the historic centre. Water renewal in the central basin is poor, as clean waters coming from the sea (cyan) gather in restricted areas distant from industrial zones.