Δελτίο Ελληνικής Γεωλογικής Εταιρείας τομ. XXV/4, 303-314, 1991
Πρακτικά 5ου Επιστημονικού Συνεδρίου, Θεσσαλονίκη, Μάϊος 1990
Bulletin of the Geological Society of Greece vol. XXV/4, 303-314, 1991
Proceedings of the 5th Congress, Thessaloniki, May 1990

THE POSSIBILITY OF IDENTIFICASION OF SAND-CLOUDS AND PREDICTION OF COLOURED RAIN OVER GREECE BY MEAN OF SATELLITE IMAGERY

T. A. Charantonis*, T. J. Makrogiannis** and A. A. Flocas**

A B S T R A C T

In the present work, and on the basis of case study of 02 Feb. 1986, it is shown that, by making use of VIS and IR satellite images, it is possible to identify sand-clouds coming from the Sahara entering the Mediterranean.When the sand-clouds enter the Greek area, they usually produce coloured rain over some areas.

By studying the successive pictures it is possible to estimate the velocity of the cloud to give a forecast of all the time of possible rainfall. It is also verified, yet once more, that the cause of the creation of the cloud is usually a barometric low initiated in the Sahara, and that the type of circulation in the troposphere is S-SW.

INTRODUCTION

The term "coloured rain" is used to describe the rain which is characterized by droplets having an obvious hue which can be seen either during the fall or after evaporation. As already known, the phenomenon of coloured rain is mainly due to some suspended sand-cloud. Some part of the grains of this sand become condensation nuclei of the surrounding water vapor and fall to the ground as raindrops, provided that atmospheric conditions favour this fall. These raindrops also carry the rest of the grains. After the evaporation of the droplets, every surface in the open air is covered by numerous spots , round mostly, of 0.1-0.2 cm diameter and light-yellow colour. An examination shows that these spots consist of extremely fine-grained dust.

In Greece, this phenomenon appears mostly during spring and sometimes after mid January (Angouridakis, 1971; Karoulias, 1976; Prezerakos,1985; Karapiperis and Tataris, 1963). The phenomenon is also known in other European areas (Fille, 1986; George, 1981; Tullet, 1978; Noualet, 1983).

The type of circulation for all cases of coloured rain in the Greek

* National Meteorological Service. Athens, Greece.
**Aristotle University of Thessaloniki. Department of Geology.
540 06 THESSALONIKI, GREECE.

area is a S-SW flow throught the Troposphere. The Sub-tropical Jet stream goes over the Greek area having a S-NE direction. More specifically, this phenomenon is due to a barometric low which is created in the Sahara, South of the Atlas and is known as "Saharian or Atlas Depression" (Karoulias, 1976; Prezerakos, 1985).

Such a synoptic situation in that area will result to strong winds, potential instability, and therefore strong upward movements. Thus, we have the creation, of dust-storms or sand-storms and large amounts of particles in the form of dust or Sand-clouds stirre up to a few tens of meters or a few hundreds of meters. Thinner grains ascend to greater heights (~3 Km or more, Karoulias, 1976; Fille, 1986; Tullet, 1978; Noualet, 1983). These sand clouds move with the depression aided by the jet-stream.

In the present work our interest is mainly focus sed on the ability of identifying sand clouds by making use of satellite pictures, and on the fore-cast of coloured-rain falling in the Greek area.

General Features

The analysis of satellite pictures of many cases of coloured rain has shown that, during the initial stage of formation and progress of the barometric low and while is still in the area of the Sahara in North Africa, it is very difficult to identify sand-clouds for the following reasons:

a) Visible images

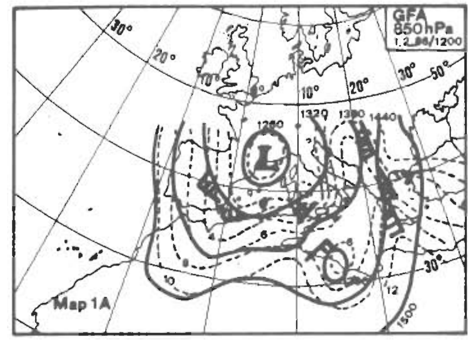
In the initial stage, when the cloud is still over the African conti-nent, the cloud exhibits almost the same refflectivity (in the visible band) as the ground below which makes remote sensing almost impossible.

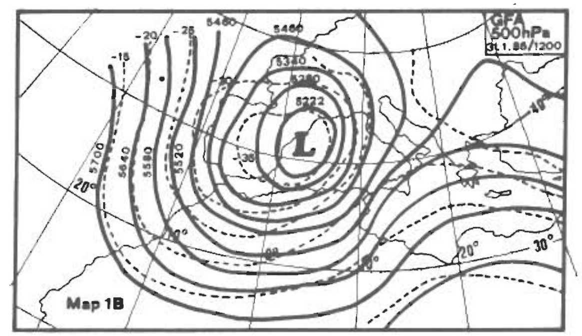
b) Infra-red images

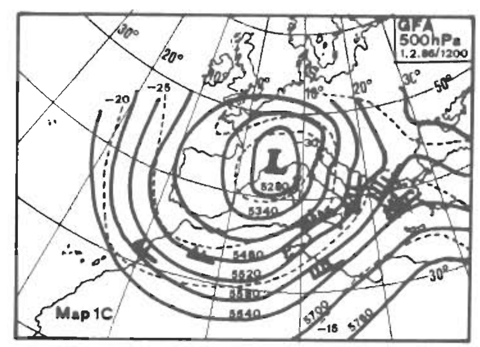
In the initial stage, because the cloud has not yet gained enough height, it does not exhibit any significant temperature difference with the ground below and therefore the radiometer of the meteorological satellite accepts almost the same amounts of energy both from the cloud and the ground below. The result is great difficulty in identifying the cloud in these pictures. When the barometric low following its usual trajectories (Karoulias, 1976; Prezerakos, 1985) enters the Mediterranean area, usually after 2-3 days, it becomes easier to identify the specific cloud and to foreast possible coloured rain in the Greek area. We distinguish two cases:

a) Visible images

In this phase, sea has very small reflectivity which can be seen in pictures of black or dark grey background. This is of course the case provi-ded that the sea appears wavy and this happens usually because of intense south







Map 1A,1B,1C: Synoptic situation on 31-1-86 and 1-2-86

Χάρτης 1Α,1Β,1Γ: Συνοπτική κατάσταση για την 31-1-86 και 1-2-86 winds blowing in this area because of the presence of the barometric low.

The cloud on the other hand exhibits a relatively high reflectivity which depends on the density and the size of sand grains it carries, and so it appears in pictures of white or light grey background. This contrast of backgrounds cases the process of identification (Fig. 3).

b) Infra-red images

In this phase, the temperatures inside the area of the cloud are $< -20^{o}C$ while at M.S.L. they are $15\text{-}17^{o}C$. This temperature difference is maintained throughout the 24 hours and thus the identification of the sand cloud becomes possible throughout the day, since there is great contrast (black-white) in satellite pictures.

It should be noted in these cases that the limits of the sand-cloud are almost impossible to define because there are no intense gaps of the concentration of sand grains (Fig. 4). Thus it follows that the recognition-indentification of this cloud and the forecast of possible coloured rain becomes easier when for the same time there are images both in the visible and in the infra-red bands.

1. Case study on Feb. 2, 1986

In this section we will study a case of coloured rain in the Athens area on 2-2-86. Our study will include both synoptic analysis and remote sensing.

SYNOPTIC ANALYSIS

a) Circulation at 850 hPa level

As we observe (map 1A) during the D-1 day there are two low systems- one in the Marseille area (primary) and one in the Tunisia-Libya area (secondary). This secondary low system is accompanied by a thermal low system ($+6^{o}C$) and a thermal ridge which covers the Greek area. This thermal low obviously creates instability in the lower and more favorable evaporation conditions in the Mediterranean. These water vapour cool as they rise up because of adiabatic expansion and finally condense. A large part of the sand grains that existed there because the necessary condensation nuclei of these vapour.

b) Circulation at 500 hPa level

Synoptic analysis at this level both in the D-2 and D-1 days of the phenomenon (map 1b and 1c) is almost the same with only some differences related to the values of the centre of the low (5222 and 5280 gpm) and to the temperature values ($-35^{o}C$ and $-30^{o}C$). Accepting that sand clouds are at almost the same height we find out the large temperature difference (temperature con-

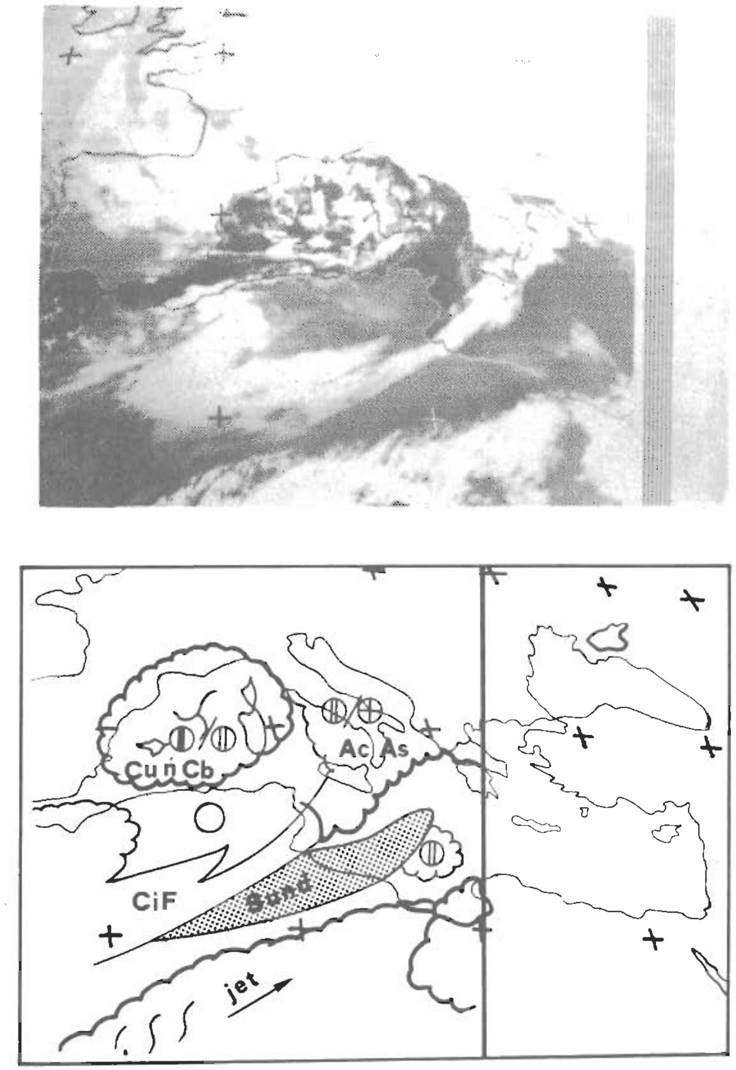
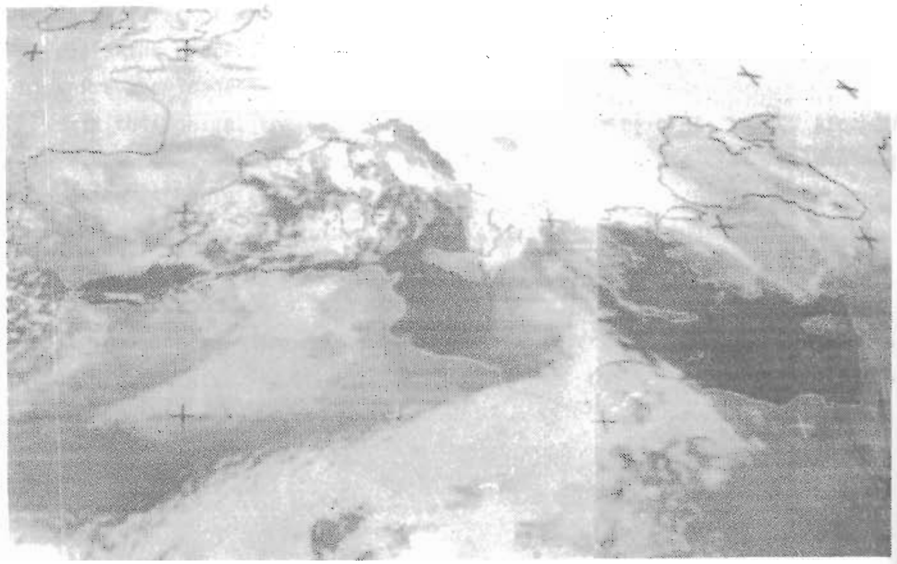


Fig. 1. Satellite image (IR) and nephanalysis on 31-1-1986/2400 GMT

Εικ. 1. Δορυφορική φωτογραφία (IR) και νεφανάλυση για την 31-1-1986/ 2400 GMT

N: cloudiness, ○ : for $N \leq 1$, ⦶ for $2 \leq N \leq 3$, ⦷ : $4 \leq N \leq 7$, ⊕ : for N=8 ,
ʃʃʃ: for special clouds



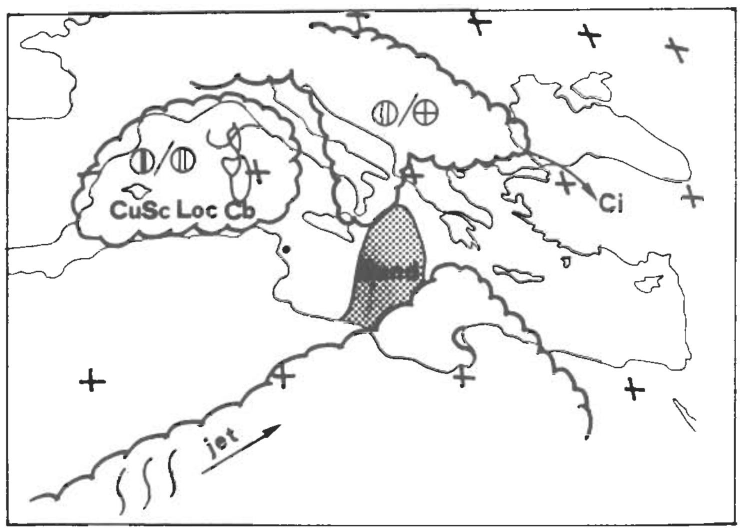


Fig. 2. Satellite image (IR) and nephanalysis on 1-2-1986/0600 GMT.

Εικ. 2. Δορυφορική φωτογραφία (IR) και νεφανάλυση για την 1-2-86/0600

METEOSAT II 1-2-1986/0900 GMT (IR)

a

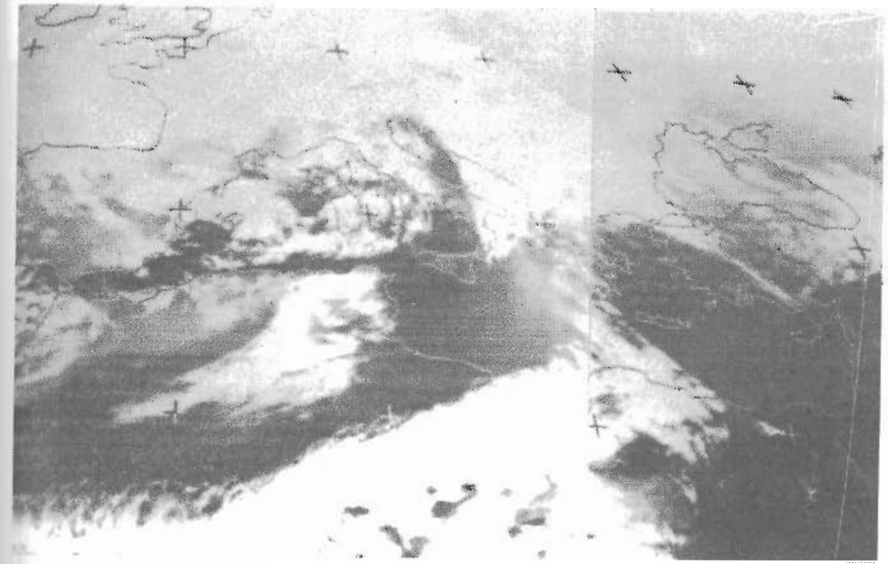


Fig 3a

METEOSAT II 1-2-1986/0900 GMT (VIS)

b

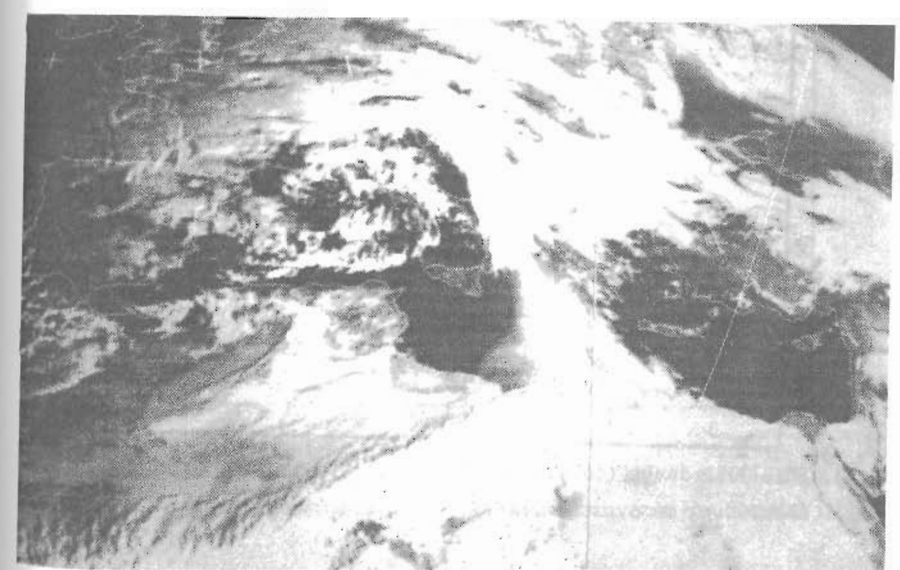


Fig 3b

METEOSAT II 1-2-198. 1030 GMT (VIS)

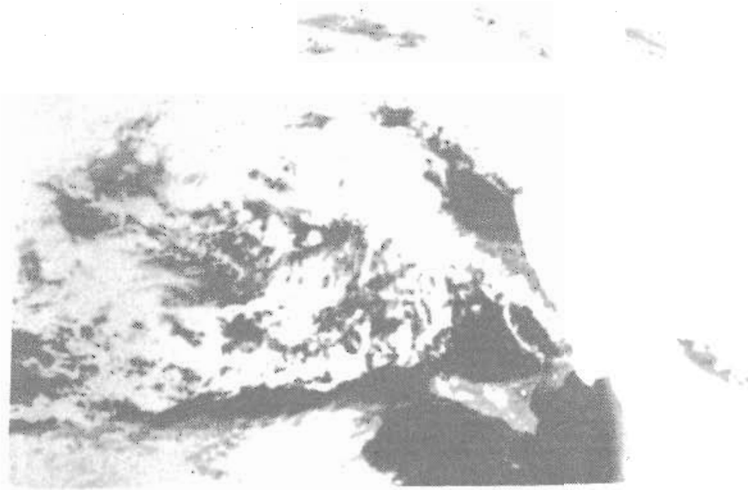


Fig 3c

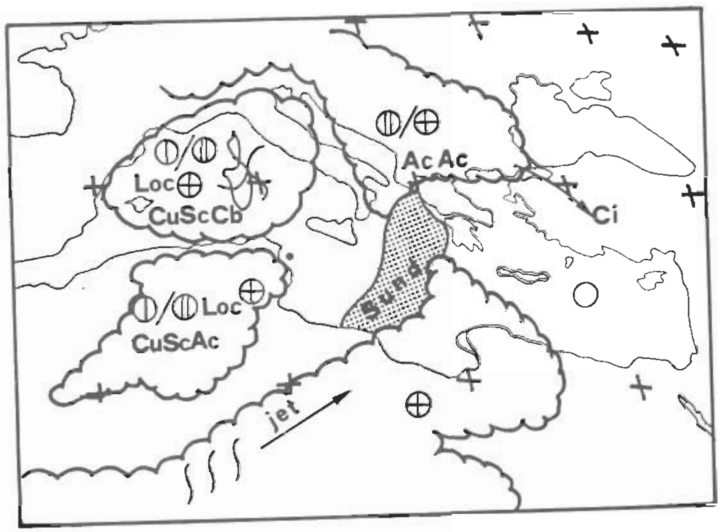
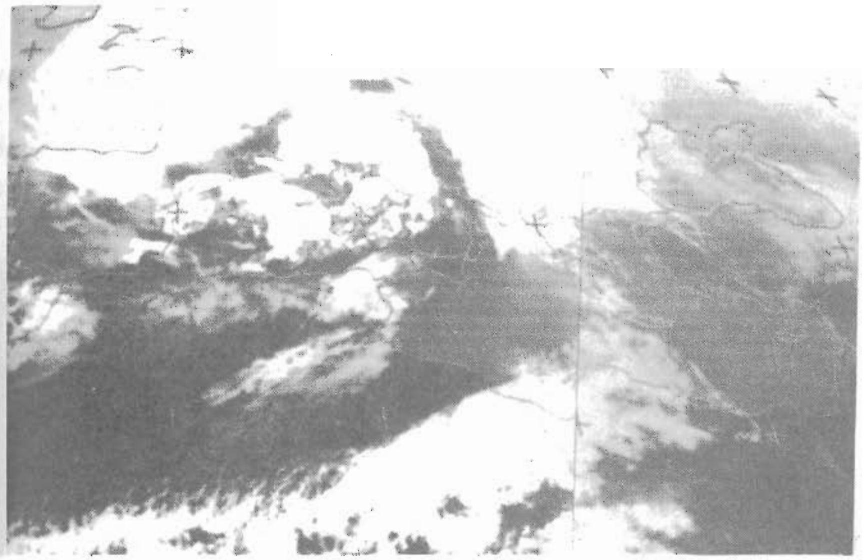


Fig. 3. Satellite image (IR+VIS) and nephanalysis on 1-2-1986/0900 GMT

Εικ. 3. Δορυφορική φωτογραφία (IR+VIS) και νεφανάλυση για την 1-2-86/0900



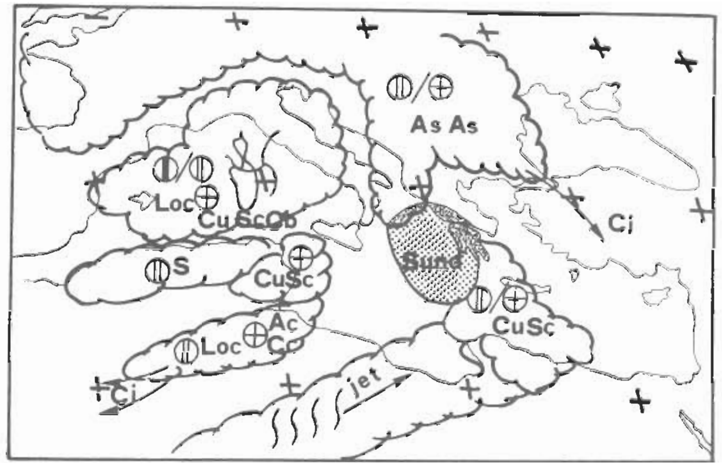


Fig. 4. Satellite image (IR) and nephanalysis on 1-2-86/1200 GMT

Εικ. 4. Δορυφορική φωτογραφία (IR) και νεφανάλυση για την 1-2-86/1200 GMT

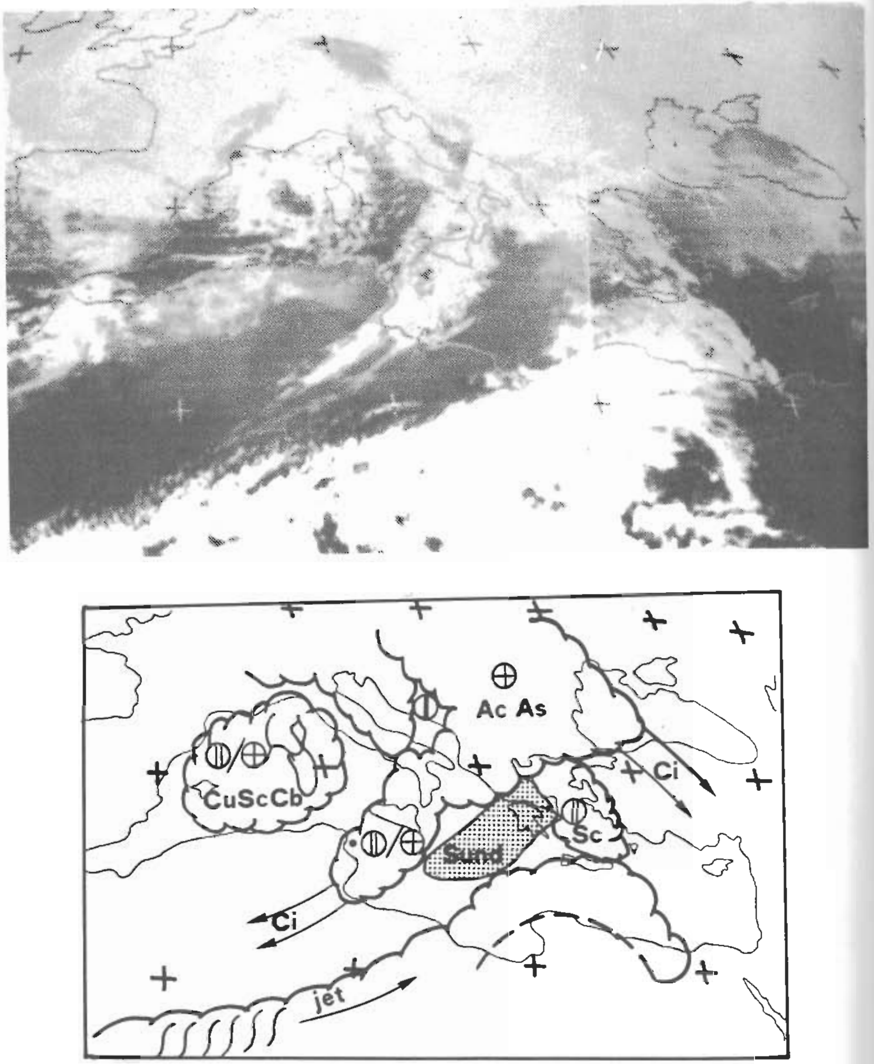


Fig. 5. Satellite image (IR) and nephanalysis on 1-2-86/1730 GMT
Εικ. 5. Δορυφορική φωτογραφία (IR) και νεφανάλυση για την 1-2-86/1730 GMT

trast) with the surface of the sea so that there's definite contrast in the colours of satellite pictures.

Satellite images

On the basis of the nephanalysis of satellite images (Fig. 1) it is found that the wanted sand-cloud at this day and hour is situated north of the 30^{0}N over Libya and one part of it has entered the Mediterranean over the Sirtis. Six hours later (Fig. 2) this sand-cloud has advanced to the north and a large part found over the Mediterranean south-west of Greece. Three hours later, as comes out from nephanalysis (Fig. 3a, Fig. 3b and Fig. 3c) the northenest position of this sand-cloud is over the area of the Ionian sea and has approached the west coastline of Greece.

Three hours later (Fig. 4) this cloud is now covering a part of the Greek area. Five and half hours later (Fig. 5) this sand-cloud has moved NE and is now covering a large part of the Greek area.

The observation has shown that during the night of 1-2-86 and the morning of 2-2-86 we had coloured rain in the area of Attiki-Athens. Obviously the cause was the sand-cloud which has been described above.

It is therefore concluded from the analysis that satellite pictures can definitely include evidence for the correct diagnosis and forecast of coloured rain in Greece when of course the dominant synoptic situation is favorable as in the case of 1-2/2/1986.

CONCLUSIONS

It may be concluded that by using satellite images from meteorological satellite , it is possible to identify a sand-cloud coming from the Sahara and entering the Mediterranean. This is accomplished with the aid of a specific synoptical situation. The satellite images are certainly trustworthy tools in the hands of the forecaster who can they forecast any possible coloured-rain in the Greek area.

On the basis of successive images it is possible to find the velocity of the cloud and it is also possible to the time of possible coloured-rain fall in the area.

These clouds contain a large amount of sand grains as condensation nuclei of the existing water vapour. This condensation becomes move intense because of the influence of Greek mountains.

REFERENCES

ANGOURIDAKIS, V. (1971). A case of coloured rain in the area of Thessaloniki. - *Meteorologika*, No 14, Univ. of Thessaloniki.

FILLE, R.F. (1986). Dust deposits in England on 9 Nov. 1984. *Weather*, Vol. 41, No 6, pp. 191-195, London.

GEORGE, D.J. (1981). Dust fall and instability rain over Northern Ireland on the night of 28-29 Jan. 1981. *Weather*, Vol. 36, pp. 216-217, London.

KARAPIPERIS, L. and TATARIS (1963). Coloured rain during the 15 and 22 March of 1962. *Proc. of Acad. Athens*, Vol. 38, pp. 300-308.

KAROULIAS, A.S. (1976). The Saharian Depressions. *Meteorologika* No 57, Univ. of Thessaloniki.

NOUALET, A. (1983). Utilisation des images de meteosat-Genese et evolution d'une tempete de sable sur l'ouest africain.

PREZERAKOS, N.G. (1985). The NW African Depressions affecting the South Balkans. *J.O.C.*, Vol. 5, pp. 643-654, London.

TULLET, M.T. (1978). A dust fall on 6 March 1977 - *Weather*, Vol. 33, No 2, pp. 48-52, London.