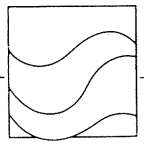
OCEANOLOGICA ACTA 1979 - VOL. 2 - N° 1



Sea surface temperatures
Remote sensing
Températures de surface
Télédétection

A comparison between sea surface temperature measurements from satellite "Noaa 4" and from airborne radiometer Aries

M. Albuisson [a], L. Pontier [b], L. Wald [c]
[a] Centre de Télédétection et d'Analyse des Milieux Naturels, École des Mines, 60, boulevard Saint-Michel, 75006 Paris, France.
[b] Laboratoire de Météorologie Dynamique, École Polytechnique, 91120 Palaiseau, France.
[c] Groupe de Recherches en Océanographie Spatiale (Gros), Laboratoire d'Océanographie Physique du Muséum, 43, rue Cuvier, 75231 Paris, France.

Received 15/6/78, in revised form 26/9/78, accepted 5/10/78.

ABSTRACT

Measurements of sea surface temperatures (Sst) in the Gulf of Lions, obtained by the satellite "Noaa 4" sensor Vhrr and by the airborne radiometer "Aries", are presented and compared. The results reveal the reliability of the Vhrr data in the range 16-20.5°C, the degree of accuracy being within 0.5°C of the relative temperatures, despite a malfunctionning of the "Noaa 4" Vhrr.

Oceanol. Acta, 1979, **2**, 1, 1-4.

RÉSUMÉ

Comparaison entre les mesures de température de surface de la mer du satellite « Noaa 4 » et celles du radiomètre aéroporté « Aries »

Une comparaison entre les températures de surface (Sst) mesurées par le détecteur Vhrr du satellite « Noaa 4 » et par le radiomètre aéroporté « Aries » dans le Golfe du Lion montre l'excellente fiabilité des données du Vhrr dans l'intervalle de températures 16-20, 5°C avec une précision de 0,5°C sur les températures relatives, en dépit d'un mauvais fonctionnement du Vhrr de « Noaa 4 ».

Oceanol. Acta, 1979, **2**, 1, 1-4.

INTRODUCTION

During the summers of 1975 and 1977, continental shelf dynamics in the Gulf of Lions were studied by a team from the Laboratoire d'Océanographie Physique of the Museum National d'Histoire Naturelle (Lop); attention was focused on coastal upwellings, which involve important horizontal thermal gradients. During the summer of 1976, sea surface layer dynamics were also studied on board the Bouée-Laboratoire "Borha II".

It was decided to complement these two *in situ* series of data with measurements from the satellite "Noaa 4" thermal infrared radiometer Vhrr. This made it possible to observe the spatial distribution of sea surface temperatures (Sst) through several meteorological situations. The data obtained enable us to determine with precision the horizontal dimensions of various coastal phenomena, and to relate them to patterns of circulation on the continental shelf (Albuisson *et al.,* 1977). The "Noaa 4" data were processed by the Centre de Télédétection et d'Analyse des Milieux Naturels (Ctamn).

In order to test the reliability and evaluate the accuracy of the Vhrr measurements, a comparison between Sst data from the "Noaa 4" Vhrr and from the Lmd airborne radiometer "Aries" was undertaken in August

1976 by the Lop and the Laboratoire de Meteorologie Dynamique (Lmd).

THE RADIOMETERS

The "Noaa" satellites are in a near-polar orbit, at an altitude of approximately 1 460 km and with a nodal period of 115 minutes. They are in a sun-synchronous orbit, and pass over the same point on the earth's surface twice daily. They are equipped with a scanning imaging Very High Resolution Radiometer (Vhrr), which has a thermal infrared channel (10-12.5 μm) situated within an atmospheric transparency range. The Vhrr image is composed, line-by-line, from a combination of the satellite's motion over the earth's surface and the scanning movement of the instrument in a direction perpendicular to the track from horizon to horizon. During its rotation, the sensor takes different standard measurements from a black body, kept at a temperature of 290 K, and a point in space opposite the sun (3 K). These standard measurements permit the conversion of the radiometer data into equivalent temperatures. The resolution of the data at the nadir is 1 km. The temperature noise at 300 is 1.5 K. The processing of the Vhrr data, including the computation of temperature, the smoothing of images, the drawing of thermographic maps and the geometrical correction (earth's spin and surface curvature), was carried out by Ctamn.

The "Aries" radiometer, designed by the Lmd (Monge *et al.*, 1976) is a scanning high resolution radiometer of similar type, which collects data in the same wavelength range as the satellite Vhrr. The beam aperture is 2.8×10^{-3} rd.

For an altitude of 1 500 m, with a scanning speed of 4.55 rotations per second and an aircraft speed of 70 m/s (the conditions of the experiment), the resolution at the nadir is approximately 15 m along the track and 2.5 m perpendicular to the track. Two black bodies remain visible throughout the mirror rotation for calibration. Accuracy results from maintaining constant temperatures on the black bodies on all sides of the measured temperature range. These temperatures were 10 and 25°C on August 3 and 20°C and 25°C on August 6. "Aries" has two sensors of different types (channels 1 and 2). The first was employed on August 3 and the second on August 6, 1976; the latter produces more noise than the former. The same radiometer is carried by the "Meteosat" satellite.

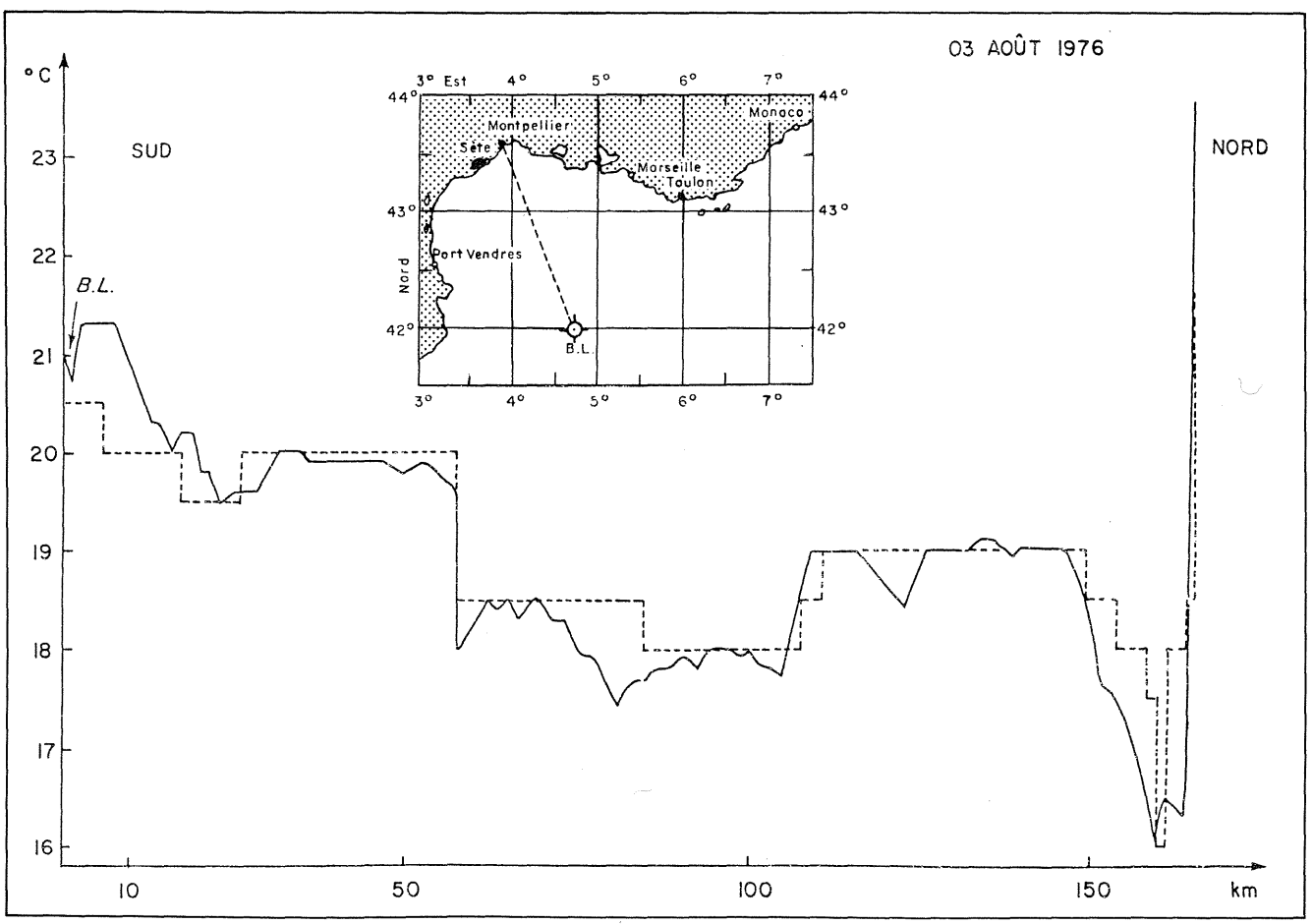
RESULTS

The experiment took place at the beginning of August 1976, between "Borha II" – 42°N/4°45'E (BL on

Figure 1

Sst profiles measured from "Aries" and "Noaa 4". Continuous line: "Aries" data (channel 1); dotted line: Vhrr data after the 1.5°C shift.

Profil des Sst mesurées par « Aries » et « Noaa 4 ». Trait plein : mesures du canal 1 d'« Aries »; pointillé : mesures du Vhrr translatées de 1,5°C.



figures)—and Montpellier beach—43°42′N/3°54′E—the two points being 180 km apart (see map: the aircraft track is represented by the dotted line). The "Aries" flights at an altitude of 1 500 m coincided with the "Noaa 4" passage over the Gulf of Lions between 9 and 10 h TU. Cloud cover was zero over this area during the two days concerned: 3 and 6 August. The inclination angle of the Vhrr sensor over the area (between 18°50 and 22°50 on August 3 and between 26°80 and 30°70 on August 6) was too slight (4° only), to permit investigation of the effect of inclination. The study was limited to measurements at the nadir of "Aries".

The aircraft track was plotted on the two Vhrr thermographic maps, drawn with an accuracy of a half Celsius degree, and Vhrr measurements were collected along this track. These measurements, together with those from "Aries", were plotted against the distance from the aircraft to "Borha II". It should be noted that the noise level of the Vhrr data was high, as a result of defective functioning of the "Noaa 4" Vhrr during the period in question. The data from "Aries" were averaged on rectangles of 710 m along the track and 240 m perpendicular to the track. Because of the noise, the Vhrr data were averaged with a bi-dimensional filter of the mobile average type conditioned by the importance of the local gradients with respect to noise (Albuisson, 1976). This provides an accuracy of 0.5°C for 3 km resolution.

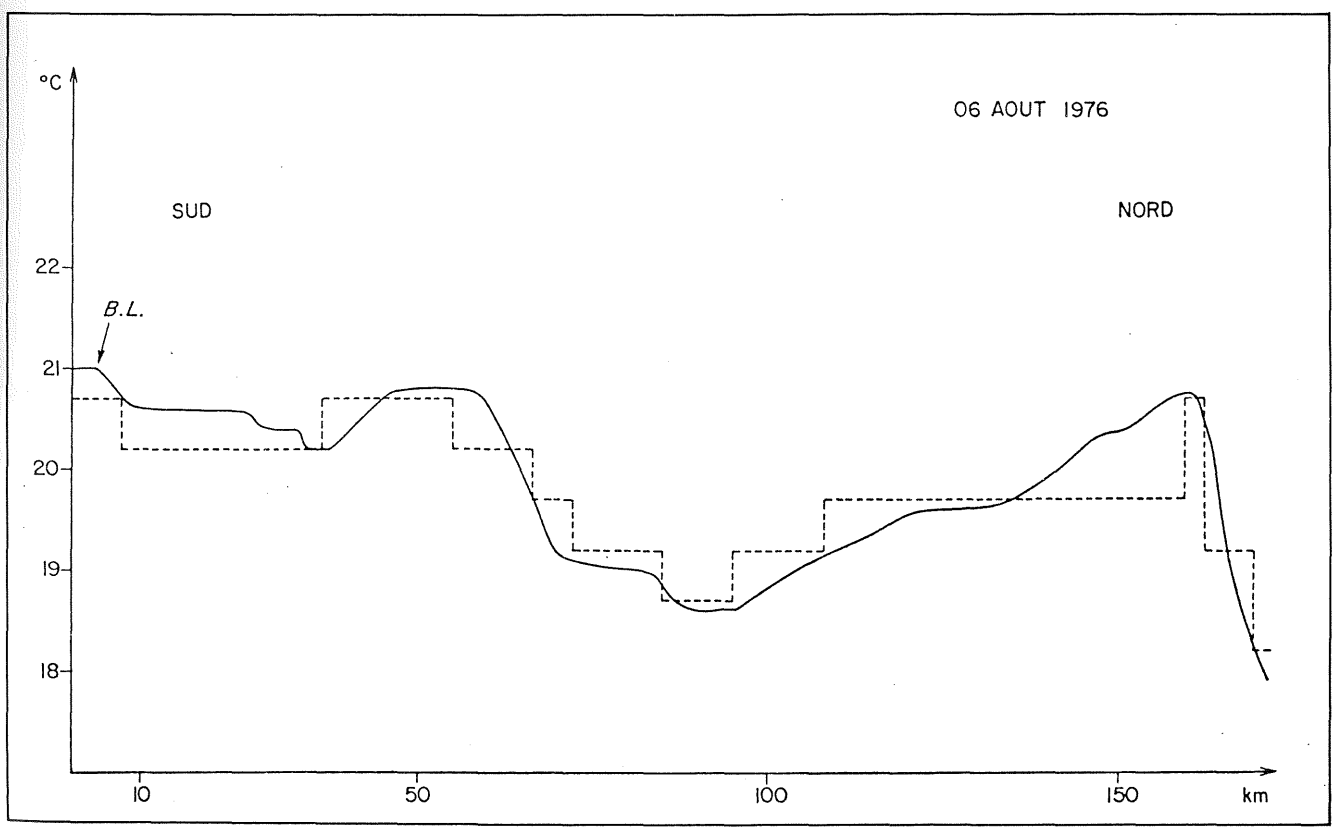
Comparison between the two data sequences shows a high degree of correlation. The horizontal profile of the Vhrr temperatures is similar to the "Aries" profile for the two flights (Figs 1 and 2). These curves indicate that the thermal horizontal gradients are measured by the Vhrr with spatial accuracy; the data show that the Vhrr measured temperatures are lower than those measured by "Aries". The difference between "Aries" temperature and the sea surface temperature measured by thermistor on "Borha II" is slight, amounting to − 0.8°C on August 3, and 0°C on August 6 (because of a temperature inversion in the lower layers of the atmosphere). On the other hand, it may be noted that a simple shift in temperature is sufficient to obtain a good correlation of the Vhrr and "Aries" curves in the "Aries" temperature range 16-20°.5C. This indicates that in this range the Vhrr yields fairly accurate *in situ* values of the thermal horizontal gradients, judging from the near accuracy (0.5°C) of the Vhrr temperatures. Our conclusion is that, in this range, the correction due to the atmosphere to be added to the Sst gradients measured by the Vhrr amounts to less than 0.5°C, which the Vhrr cannot measure.

The shifts of temperature necessary for fitting the curves are not identical: 1.5°C on August 3, and 2.7°C on August 6. There are a number of reasons for this. In the first place, moisture and atmospheric conditions in general were different on the 2 days and may account for variations in measured temperatures (Platt, 1972). Secondly the effects due to the difference of the inclination angle of the Vhrr sensor at the time of the two flights cannot be neglected. The third reason is the extreme variability of the Vhrr calibrations, which prevents extrapolation to *in situ* temperatures. Finally,

Figure 2

Sst profiles measured from "Aries" and "Noaa 4". Continuous line: "Aries" data (channel 2); dotted line: Vhrr data after the 2.7°C shift.

Profil des Sst mesurées par « Aries » et « Noaa 4 ». Trait plein : mesures du canal 2 d'« Aries »; pointillé : mesures du Vhrr translatées de 2,7°C.



account should be taken of the very defective functioning of the "Noaa 4" Vhrr during the period of the experiments.

CONCLUSION

Comparison between the data simultaneously obtained from "Aries" and the Vhrr permits evaluation of the corrections to be applied to the Vhrr data for the two days concerned. These corrections cannot, however be extrapolated to other days for the variability of Vhrr calibrations. Nevertheless, thermographic maps of the type prepared are of great interest, because they enable users to determine immediately the relative Sst, with an accuracy of 0.5°C. Vhrr data are thus shown to be reliable in the study of horizontal thermal gradients and their spatial distribution.

Acknowledgements

This project was carried out with financial assistance from the Centre National pour l'Exploitation des Océans and the Centre National de la Recherche Scientifique. The Centre d'Études de Météorologie Spatiale in Lannion graciously provided the "Noaa 4" data.

REFERENCES

Albuisson M., 1976. Traitement des thermographies des satellites Noaa, Rapport convention Cnexo 751516.

Albuisson M., Crépon M., Millot C., Monget J. M., 1977. Observations with "Noaa" Vhrr imagery of transient upwellings in the Mediterranean Sea. 28th International Aeronautical Congress, Prague.

Bernstein R. L., Breaker L., Whritner R., 1977. California current eddy formation: ship, air and satellite results, *Science,* **195**, 4276.

Monge J. L., Pontier L., Sirou F., 1976. Le radiomètre « Aries ». Rapport interne Lmd.

Platt C. M. R., 1972. Discrepancies between *in situ* and satellite measurements of sea surface temperature, *Nat. phys. Sci.,* **235**, 29.

Szekielda K. H., 1975. Cineca utilisation and evaluation of "Noaa 3" satellite sea surface temperature data. Final report under contract n° 436732 for "Noaa", August.