Trakia Journal of Sciences, Vol. 3, No. 7, pp 24-27, 2005

Available online at:
http://www.uni-sz.bg

ISSN 1312-1723

Original Contribution

SATELLITE RESEARCHES OF TEMPERATURE ANOMALIES ON THE BLACK SEA SURFACE

A. Manev[1]*, K. Palazov[1], St. Stoianov[2], St. Raykov[1]

[1]Solar Terrestrial Influences Laboratory, Bulgarian Academy of Sciences,
[2]Space Research Institute, Bulgarian Academy of Sciences

ABSTRACT

This paper presents an analysis of the short-term temperature anomalies on the Black Sea surface for a period of eleven consecutive years. The NOAA daily satellite temperature maps are used as a basis for the investigation. Statistical analysis of the anomaly phases has been carried out and the peculiarities of their dynamics are described.

Key words: satellite, ocean, temperature, Sun

INTRODUCTION

The anomalies of the sea surface temperature are very often connected with anomalies of the processes in the above-sea atmosphere and the synoptic conditions The investigation of that type of processes requires application of satellite remote methods for investigation of the Earth's space. Only by such observations it is possible to perform monitoring of large territories with sufficiently good time resolution. In the last years data of the NOAA and TOMS satellites have been actively used. These systems submit daily maps of the sea surface temperature of the whole globe and maps of the ozone layer thickness. Unified special remote-sensing equipment is assembled on board several satellites. These are spectrophotometers operating in different areas of the infrared, visible and ultraviolet spectrum, adjusted for space performance. Such equipment is described in [1],[2]. Simultaneously two (sometimes even four) operative satellites are always in flight at polar solar-synchronous orbits. The orbits of the NOAA satellites are selected so as one and the same area to be observed at least four times daily. After that the data are processed on the earth and are submitted to the researchers in ready calibrated form. This is how the TOMS satellites operate, too.

The ultraviolet high-resolution spectrophotometer AVHRR operates in two "visible" (0.58 and 0.725 mkm) and three "infrared" (3.55, 10.3 and 11.5 mkm) ranges. Its spatial resolution is 1X1 km. After being processed on the earth, the images are then enlarged to 9.5 X 9.5 km resolution. The contact temperature on the sea surface is determined on the basis of the infrared radiation registered by the spectrophotometers by applying multi-channel methods [2]. The achieved precision is of the order of 0.3-0.4^{o}C. The measurement error of the temperature differences does not exceed 0.15^{o}C.

One of the basic problems faced by the remote methods for determination of the sea surface temperature is the presence of cloudiness, which does not let the infrared earth radiation through. A primary task of the research is the application of a restoring procedure to the pixel values, "disturbed" by the clouds. This procedure helps restore the temperature fields where low cloudiness exists. The restoration precision was proven to be no worse than 0.6^{0}C [3].

The Black Sea is a water basin, very suitable for studying the interaction between the atmosphere and the ocean. The basin is comparatively large, closed and, at the same time there are no conditions for horizontal transfer of water masses between regions with very different synoptic conditions. As a result of its geographic latitude, four typical seasons exist – winter, spring, summer and autumn. Under strict control of the observation conditions it is possible to analyze anomalous

***Correspondence to**: *A. Manev, Solar Terrestrial Influences Laboratory, Bulgarian Academy of Sciences,.Akad.G.Bonchev Str., Bl.3, Sofia; E-mail: amanev@abv.bg*

changes of the sea surface temperature and to search relations with other significant external physical factors of interaction.

Figure 1 show the annual temperature course of the whole sea surface in the examined years. The daily data are formed as average by the temperatures of all fields with sizes 9x9 km, located next one another and covering the whole sea surface. The dense gray line represents the average daily temperature for a 9-year period, excluding the year whose diagram is shown with a narrow line.

The typical strongly expressed seasonal character of the daily temperatures is the result of the sea geographic latitude. The bigger spring increase gradient is clearly expressed as well as the slower sea cooling in autumn. The continuous anomalies in 1994, 1996 and 1997 are explicitly seen in the investigated period as well as the continuos and hot summer of 1994 and the quickly cooling autumns of 1996 and 1997, respectively. The entire year 1997 was with more abrupt spring-autumn changes. Cold winters are noticed for 1992, 1993, 1994 and 1995. Years 1998 and 1999 are some of the warmest in the analyzed interval, in contrast to 1997, which is the coolest. The large time interval of these changes determines them as long-term, typical seasonal anomalies whose appearance is due to significant climate-forming factors.

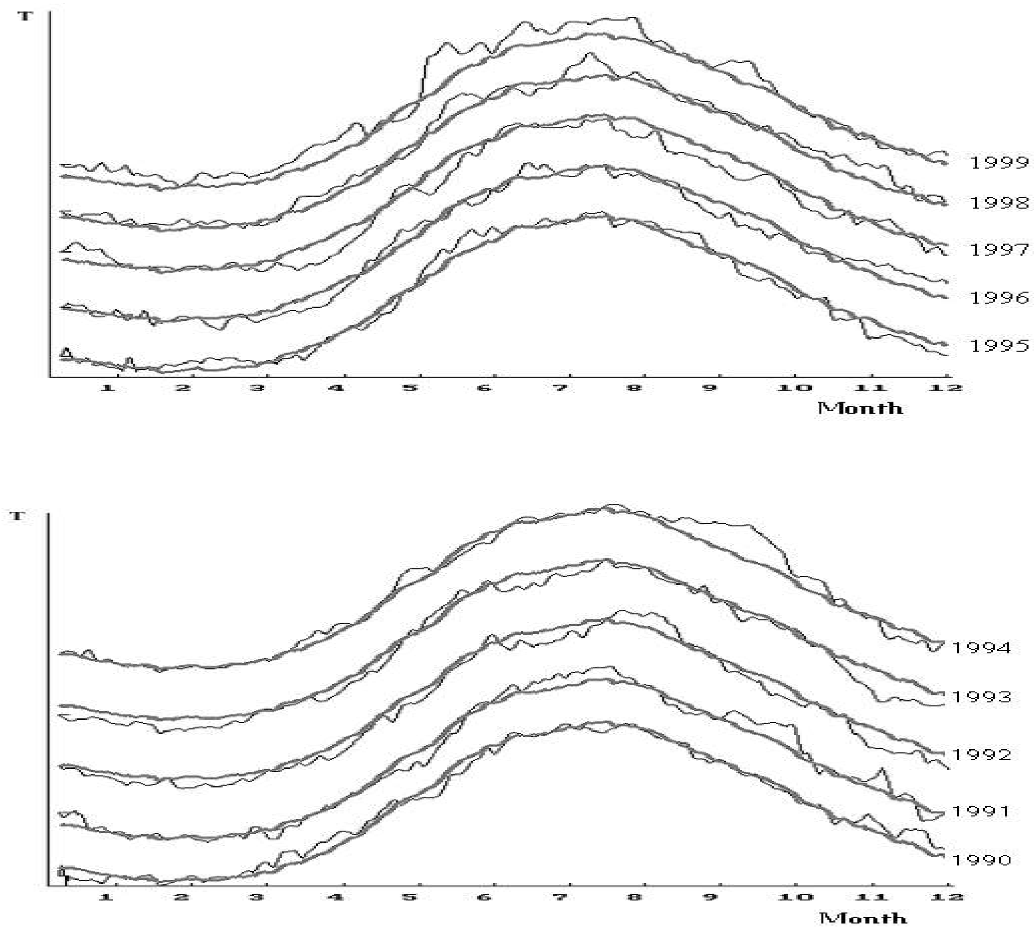

Figure 1. Annual temperature course of the whole sea surface in the examined years

Besides the annual and seasonal variations, short-term abrupt temperature deviations are also observed. They focus special attention as a result of their relation to the extreme atmospheric changes and the physical conditions of the Earth-Sun relation. Short-term anomalies are such anomalies, which appear and disappear for no more than 10 days. In the investigated 10-year period, 46 anomalies with such duration were registered in the spring, summer and winter period or, for the time from the 114-th to the 340-th day of the year. Short-term anomalies in the late autumn, in the winter and the early spring are not analyzed, due to different factors, impeding their identification – thick cloudiness, abrupt negative atmospheric changes as a result of atmospheric fronts, etc. The present analysis is restricted only to the abrupt warming of the surface.

Table 1: **Statistical parameters of the anomalies**

Parameter	***Unit***	***Average value***	***Statistical error***	***Alteration range***	***Statistical deviation***
Duration of the entire anomaly	day and night	7.60	0.26	4 - 10	1.769
Duration – 1st phase	day and night	4.23	0.20	2 - 7	1.383
Duration–2nd phase	day and night	3.67	0.17	1 - 7	1.192
Increase gradient of 1st phase	$\frac{K^0}{day}$	0.353	0.0517	0.25 - 0.41	0.0853
Decrease gradient of 2nd phase	$\frac{K^0}{day}$	0.350	0.0479	0.26 - 0.48	0.0959
Relative peak value	K^0	1.386	0.1631	0.87 - 1.85	0.3648
Beginning of the anomaly	day	190.8	5.95	114 - 340	37.67

The average duration of the short-term anomalies is 7 to 8 days. The following characteristics were accepted and analyzed for all short-term anomalies: duration of the whole anomaly and duration of the temperature increase and decrease; increase and decrease gradients, relative pixel value. The relative pixel value is determined by temperature increase above the level of the temperature that would have been such if the anomaly did not exist – approximated value. The relative pixel value changes within the range 0.87-1.85^{0}C and with a view to the maximum error in the temperature determination (0.6^{0}C) it will guarantee the reliability of the determined anomalies.

Table 1 contains the obtained results after the statistical processing. The average duration of the short-term anomalies is from 7 to 8 days. Asymmetry is registered in the temperature increase and decrease duration of the order of 0.6 days and nights on behalf of the first one - the phase of the temperature increase. The explanation of this asymmetry is connected with the larger number of anomalies in the spring as compared to the summer and autumn. The spring anomalies are 39% of all registered anomalies and the autumn ones are 20%, respectively. The anomalies in the spring are characterized by a longer first phase while in the autumn the water cooling after an anomaly peak is longer. Such asymmetry is not observed in the heating and cooling gradients. The increase and decrease gradients are equal to absolute values of 0.35^{0}C for a day and a night. The values of the two gradients are almost equal and this is an expected result, due to the conservative character of the thermodynamical characteristics of the sea water.

In addition, a sudden parameter displayed during the analysis. It turned out that the distribution of the short-term anomalies is not equal in time. The probability for the appearance of such an anomaly is largest within the interva 1 4 – 16 June.

The short-term anomalies in the performed investigation were registered as such by averaging the temperature on the whole Black Sea surface. With this averaging many local effects are “blurred” and a sufficiently general picture is being analyzed. Despite this, the short-term anomalies are clearly displayed and are subject to further analysis. In subsequent investigations the dynamics of the temperature increase on the sea surface will be examined. The spatial resolution of the AVHRR radiometer, assembled on the NOAA platforms is 9x9 km. It is relatively rough as compared to the resolution of the equipment on board the geostationary satellites. Yet, taking into account the size of the local temperature anomalies on the Black Sea surface, this resolution is adequate. For the long-term anomalies this averaging is not crucial and the slower meteorological and climatological factors are easily registered.

REFERENCES

1. Жеков Ж.“Приложение на техническста оптика в космическите изследвания”, изд. Марин Дринов, 2004 г., София.
2. NOAA/NASA, 1998, AVHRR, Sea Surface Temperature Data Set, User's ReferenceManual, Version4.1, February 23

3. МаневА. и сътр. “Възстановяване на температурните полета на повърхността на Черно море по данни от оперативни спътникови наблюдения”, сб. докл. “Юбилейна научна сесия 2001 “40 години от първия полет на човек в Космоса”,12-13 април.2001г, гр. Долна Митрополия, Том II, стр. 186-191.