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CHEBUSEV COEFFICIENTS OF THERMOHALINE STRUCTURE IN THE SEA REGION OF CENTRAL VIETNAM

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ABSTRACT From the multi-daily observations of temperature and salinity at some stations in the sea region of Central Vietnam we recognize that: the vertical thermohaline structure may be approximated by polynom of Chebusev. The calculated results, based on the real data of temperature and salinity collected by the "Bien Dong Regular Survey Project" in summers of 2000 and 2001, have shown that: quantity of cases, in which error between calculated and observed data is less than 0.1°C and 0.1‰, make up more than 93% of all observations. The polynomial coefficient A_0 is the average field of thermohaline structure and A_1 is a vertical mean gradient of temperature and salinity of the research station. This method may be used for data processing, schematizing, modelling and forecasting in oceanography.

HE SO CHEBUSEV CUA CAU TRUC NHIET-MUOI VUNG BIEN TRUNG BO VIET NAM

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TOM TAT Tren cô sô cac chuoi so lieu quan trac nhiet ño va ño muoi theo ño sau tai tram lien tuc mot ngay ñem ô vung bien mien Trung trong mua he nam 2001, 2002 (Döï an khao sat ñònh ky Bien Ñong) ta thay rang: cau truc nhiet-muoi theo ño sau co the bieu dien xap xæ bang ña thöùc Chebusev. Ket qua tính toan vôi so lieu nhiet-muoi thöïc ño ô vung bien mien Trung Viet Nam cho thay: Cac tröôøng hôïp sai so nhiet ño va ño muoi theo tính toan so vôi thöïc ño nho hôn 0,1°C va 0,1‰ chiem töông öùng la 93% va 100% tong so ño. He so A_0 mieu ta tröôøng trung bình cua cau truc nhiet-muoi, con A_1 thöïc chat la gradient trung bình theo phöông thang ñöùng cua nhiet ño va ño muoi ô vung nghien cöùu. Phöông phap nay co the öùng dung trong xöû ly so lieu, sô ño hoa, mo hình hoa va döï bao cac qua trình trong hai dööng hoc.

I. INTRODUCTION

Observations of temperature and salinity in the Vietnamese sea have just been carried out since the time of the establishment of the Indochina Service of Fisheries (now, it's the Institute of Oceanography in Nha

Trang) [4]. However, these "classical" observations had been mainly undertaken with waterproof and inversing mercury thermometers, water bottles and taken back to laboratory for analysis, so that these measurements can not be done at many horizons, in many times and at many stations for a survey; it's too expensive and difficult.

Since 1990 up to now, owing to the modern multiparameter self-recording equipment (AST-500, Mark III CTD, Shuttle, etc...) so observations of thermohaline structure have been done more favourably and exactly. On the basic of the observed data of vertical thermohaline distribution at some time - continuous stations belonging to the Project "Bien Dong Regular Survey" in 2000 and 2001, there are series of thermohaline data by depth to 50 m at four mooring stations offshore in the sea region of Central Vietnam [3, 5].

At present time, in the modelling and forecast, the approximate method has been used by polynom or private function as the functions of co-ordinate in anywhere. More commonly used to approximate to the observed data by algebraic polynom of Chebusev, it's generally used in the Russia and other countries [1, 2, 3]. In this paper, Chebusev polynom is used to approximate to vertical thermohaline structure in the sea of Central Vietnam; in fact, we have calculated the Chebusev coefficients of these observed data.

II. DATA AND METHOD OF STUDY

The curve-lines of vertical thermohaline structure represented by polynom of Chebusev are sum of simple curve-lines, each of them describes a real practical distribution of water temperature and salinity in the sea [3]. Approximation of one-parametric function by Chebusev polynom is given in the equation:

$$F(x)=A_0\varphi_0 + A_1\varphi_1 + A_2\varphi_2 + ... + A_l\varphi_l \quad [1]$$

where:

A_l - polynomial coefficient of Chebusev,

φi - polynom of parabola form with degree i (i = 1, 2, 3, . , n)

$\varphi_0 = 1$

$\varphi_1 = x - [(n + 1) / 2]$

$$\varphi_2 = \varphi_1^2 - [(n^2-1)/12] \quad [2]$$

$$\varphi_{k+1} = \varphi_1 \varphi_k - [k^2 (n^2 - k^2)\varphi_{k-1}]/[4(4k-1)] \quad [3]$$

Here n – quantity of knot (highest degree of polynom) where there is a value of function F(x), x – order point obtained the number 1, 2, 3, . . . , n.

The characteristics of curve-line distribution F(x) have to be shown with polynomial coefficients and it has been defined by the value of function F(x) and polynom of parabola forms. They have the formula:

$$A_i = \frac{\sum F(x)\varphi_i \quad (x)}{\sum \varphi_i^{\,2}(x)} \quad [4]$$

If so, the first term $A_0\varphi_0$ is the arithmetical mean of series - it's an average of temperature and salinity of the station; the second term is a linear variation of the function - decrease and increase of temperature and salinity with the depth; the ensuing terms are changes of parabola types with rank i. The physical meaning of represented curve-lines from first to sixth degree may be known in the paper [1] and [3] by author.

The demonstration of necessary and enough accuracy of polynomial coefficients should be seen in the calculated and observed curve-lines F(x). This work presents some results of approximate calculations using the thermohaline database, which have been measured in the Project "Bien Dong Regular Survey" in 2000 and 2001 [5]. The coordinates of four mooring stations used in our study are: St. 8: $\varphi = 17^o14'N$, $\lambda = 107^o00'E$; St. 14: $\varphi = 15^o43'N$, $\lambda = 108^o 43'E$; St. 20: $\varphi = 13^o30'N$, $\lambda = 109^o22'E$; St. 25: $\varphi = 10^o25'N$, $\lambda = 108^o48'E$.

III. THE CALCULATED RESULTS

Owing to the temperature and salinity data series observed at mooring stations: 8, 14, 20 and 25 [5] in Junes of 2000 and 2001, the author has calculated polynomial coefficients of Chebusev for the series of vertical thermohaline distributions by depth from the surface to 50 m deep with 11 knots (n = 11). The accuracy between calculated and observed results of 88 series of temperature and salinity is shown in tables 1 and 2.

Table 1: Accuracy ∇T between the calculated and observed temperatures

Temperature	∇T [°C]	< 0.05]*	[0.05]÷<[0.10]	> [0.10]	*Accuracy of AST-500
Series	44	25	16	3	
Ratio	%	57	36	7	

Table 2: Accuracy ∇S between the calculated and observed salinities

Salinity	∇S[‰]	< [0.05]*	[0.05]÷<[0.10]	> [0.10]	*Accuracy of AST-500
Series	44	41	3	0	
Ratio	%	93	7	0	

From tables 1 and 2, we recognize that: the vertical thermohaline structure in the sea of Central Vietnam may be approximated by polynom of Chebusev with high accuracy (< 0.05°C and < 0.05‰) for 57% cases of temperature and 93% of salinity; the biggest error of temperature (|0.15|°C) and salinity (|0.07|‰) has been only met once in 44 cases, making up 2.2%. The error of temperature in some cases is bigger than in comparison with salinity, that's the influence of dynamical or upwelling process.

Table 3: Calculated polynomial coefficients of Chebusev on temperature

St.	A_0	A_1	A_2	A_3	A_4	A_5	A_6
8	25.31	-0.53180	0.00818	0.01039	-0.00948	0.01932	-0.00037
14	25.21	-0.67680	0.01527	0.01799	-0.01167	-0.02759	-0.00025
20	26.22	-0.59889	-0.01395	0.00443	-0.01281	-0.01330	-0.00026
25	27.56	-0.35509	-0.01551	0.01456	0.01676	-0.01944	-0.00149

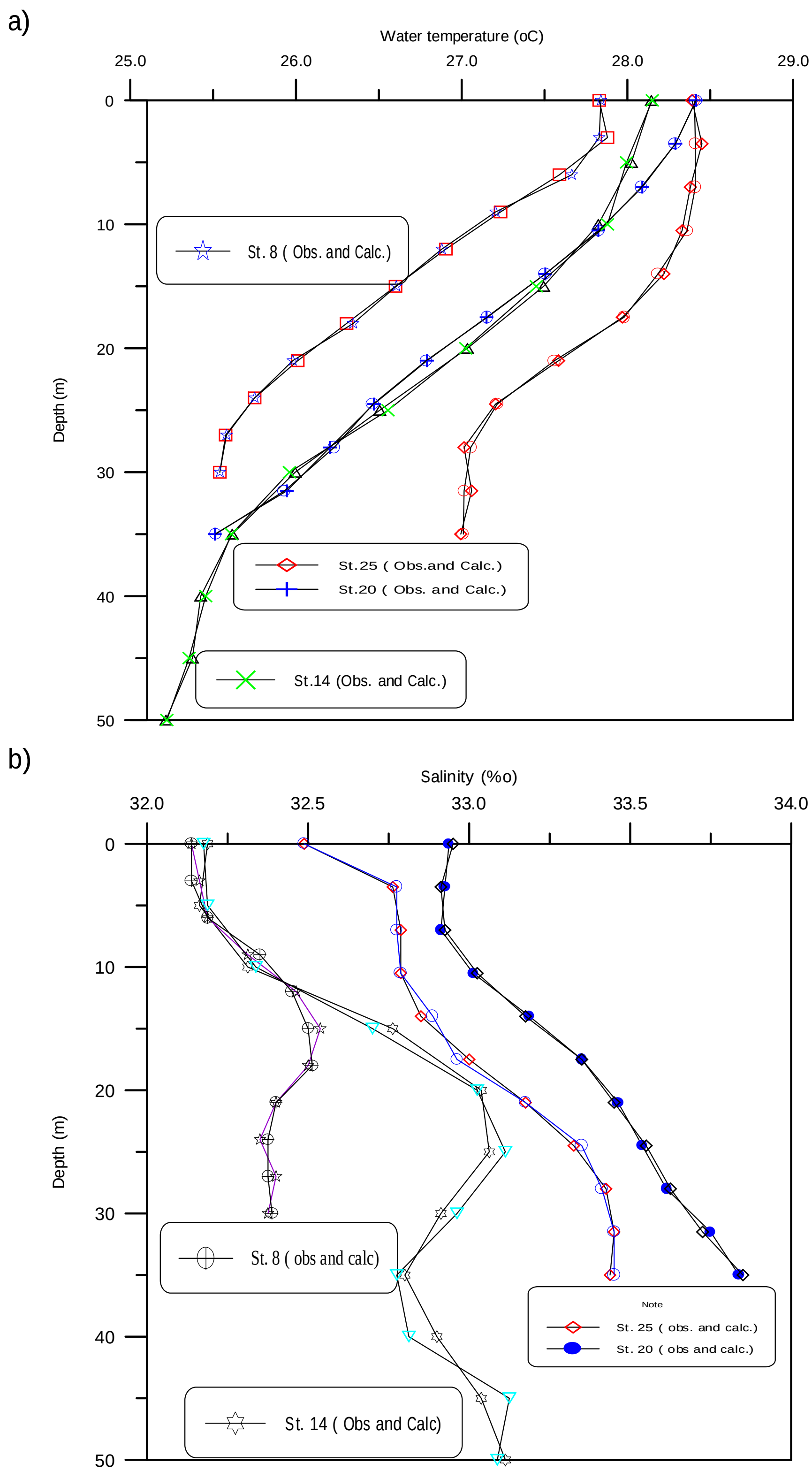

Fig. 1: The vertical curve-lines of observed and calculated temperature (a), and salinity (b) at the stations: 8, 14, 20 and 25 [5]

Table 4: Calculated polynomial coefficients of Chebusev on salinity

St.	A_0	A_1	A_2	A_3	A_4	A_5	A_6
8	32.68	0.02107	-0.00732	-0.00005	0.00770	-0.00205	-0.00037
14	33.00	0.07139	-0.01136	0.00198	0.01662	-0.01708	-0.00091
20	33.46	0.08155	0.00255	-0.00174	0.00450	0.00144	-0.00026
25	33.24	0.07872	-0.00089	-0.00114	-0.00849	0.00817	-4.1E-05

As similar to other oceanographic phenomena (tide, time displacement of temperature, and so on...), on the basic of series of thermohaline observations, it's possible to calculate the polynomial coefficients of Chebusev (A_i) for data series of each month, season, year at each station (or sea region).

Tables 3 and 4 expound the calculated results of Chebusev polynomial coefficients on temperature and salinity at four stations in the sea region of Central Vietnam in summers of 2000 and 2001. The values of column A_0 describe the mean temperature and salinity of water column, that reflects the distributive rule at the geographic and latitudinal features. The values of column A_1 make their great contribution in formation of the thermohaline structure, the temperature decreases and the salinity increases with the depth in different extents. The coefficient Ai in the ensuing columns is usually smaller than A_1, that proves that the other processes have not worth role in formation of thermohaline structure field except some places; for example: at station 14, the coefficients $A_2 \div A_5$ are still valuable in comparison with others. The dynamical phenomena offshore Da Nang (St. 14) [5] may be a main reason of creating this knotty thermohaline structure. From tables 3 and 4, it's able to see a great advantage of the approximation by Chebusev's polynom for describing thermohaline structures. It's easy to be used for data processing to filter out small disturbances for schematizing of oceanographic processes in the thermo-dynamical models and forecast. The values of coefficients show a role of each contribution component in thermohaline structure at different regions. Figures 1a and 1b describe the vertical distributions of calculated and observed temperature and salinity with depth at four stations in the sea regions of Central Vietnam in summers of 2000 and 2001.

IV. CONCLUSION

The approximate method by polynom of Chebusev may be used for schematizing of thermohaline structure. The application of this method for the sea region of Central Vietnam gives a rather good result.

The cases of error between calculation and observation less than 0.1°C and 0.1‰, make up more than 93% of all observations.

The polynomial coefficient A_0 itself denotes the average field of thermohaline structure in the region. The value of coefficient A_1 in fact is a vertical mean gradient of temperature and salinity of the research station and so on.

This method is able to be applied for data processing, schematizing oceanographic processes in modelling and forecasting.

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