P – PHYSICAL OCEANOLOGY

Hydroacoustics and their applications – PA

PA.01.

CORRESPONDENCE BETWEEN THE SEA NOISE SPECTRUM AND THE SPECTRUM OF NATURAL SURFACE SOURCES

ZYGMUNT KLUSEK
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

In the literature on sea noise, the spectrum of such noise is generally regarded as being equivalent to that of natural noise sources at the sea surface. This view is substantiated by calculations done for a sea of infinite depth [3]. Though based on the same assumptions as that in [3], the model described in the present paper is applied to a sea of finite depth. The sea bed is assumed to be a plane with acoustic properties fully described by the effective coefficient of sound reflection, dependent only on the frequency. The calculations were done using the values of this coefficient given by Volovov and other authors [3].

The differences between the spectrum of noise measured in the water and that of noises generated by sea-surface sources were found to be considerable – as high as 6 dB at a frequency of 1 kHz. There is no correspondence between these spectra in either shallow or deep basins.

PA.02.

ACOUSTIC ENERGY LOSSES ON REFLECTION FROM SELECTED SEA-BEDS OF THE SOUTHERN BALTIC

MAŁGORZATA BRZOZOWSKA, BARBARA JANUSZEWSKA
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

A coefficients of reflection of sound waves from the Baltic Sea bed were measured for three types of sediment and three angles of incidence over the frequency range 2–10 kHz (at tertial intervals). These coefficients, averaged over the whole range of frequencies, were 0.55 for fine sand with a mean grain diameter of 0.145 mm, 0.61 for sand with a grain diameter of 0.12 mm, and

0.59 for material consisting mostly of macrofauna (*Mytilus edulis, Cardium lamarcki, Macoma balthica*).

These values define the maximum acoustic energy losses sustained when the wave plane lies perpendicular to the sea bed. No distinct dependence on frequency was noted within the 2–10 kHz range. The coefficients of reflection obtained in this study are similar to the values reported by Grubnik [2] for the Caspian Sea.

PA.03.

THE EFFECT OF INTERNAL WAVES ON THE FLUCTUATIONS OF THE NOISE FIELD IN THE SEA

ZYGMUNT KLUSEK
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The mathematical model was used to study the fluctuations of natural noises in the sea due to interval waves.

The sea is represented as a three-layered medium in which the sound velocities c_1 and c_2 in the homogeneous top and bottom layers are constant, and the middle layer with linear dependence $c = c(z)$ is disturbed by a sinusoidal interval wave (Fig. 1).

Assuming the distribution of noise sources at the sea surface to be isotropic and using the eikonal equation, formulas were found for calculating the intensity of noises below the interval wave (12–14).

Examples are given of calculations of sound intensity variations at the input of the directional sound antenna placed below the interval wave for the winter and summer sound velocity profiles characteristic of the Baltic and different degrees of directivity of the surface noise sources.

PA.04.

APPLICATION OF MULTIPLE ECHO ENERGY MEASUREMENTS FOR EVALUATION OF SEA BOTTOM TYPE

ANDRZEJ ORŁOWSKI
Sea Fisheries Institute, Gdynia

Abstract

An original hydroacoustic method based on the integration of acoustic multiple echo energy and developed for analysing the physical features of the sea bed is presented. After fulfilling certain assumptions, information on sea-bed characteristics, associated with the successive echoes of the signal returned from the sea bed, can be deciphered and ascribed to various geological types of bed. The empirical data were collected during several voyages of r/v 'Profesor Siedlecki' (Argentinian shelf, Agulhas Bank, Gulf of Alaska and the West Coast of the U.S.A). The measurements of multiple bottom echoes were found to be correlated with the morphological and structural features of the sea bed. The scope and limitations of this method are also described. Some applications of the method for cartographic purposes and its possible future applications in research work are also presented.

PA.05.

THE RELATIONSHIP BETWEEN SURFACE WAVE GENERATION BY AN AIR STREAM AND WAVE ATTENUATION ON WATER COVERED WITH A MONOLAYER OF A CRUDE OIL DERIVATIVE

STANISŁAW J. POGORZELSKI, BOGUMIŁ LINDE,
ANTONI ŚLIWIŃSKI
Institute of Experimental Physics, Gdańsk University, Gdańsk

Abstract

The conditions under which a liquid loses its surface flow stability when air flows over it can be defined from the viscoelastic properties of oil monolayers, determined on the basis of acoustic investigations. The monolayer surface concentrations at which maximum stability occurs were determined. These concentrations approach those at which the maximum attenuation of a surface capillary layer is observed. The presence of a crude oil derivative on the water surface in the form of a monolayer causes the threshold stream velocity, capable of wave generation, to increase by a factor of 5–18, depending on the surface concentration of the monolayer.

PA.06.

THE EFFECT OF THE THICKNESS OF CRUDE OIL LAYERS ON THE ATTENUATION OF A SURFACE CAPILLARY WAVE

BOGUMIŁ LINDE, STANISŁAW J. POGORZELSKI,
ANTONI ŚLIWIŃSKI
Institute of Experimental Physics, Gdańsk University, Gdańsk

Abstract

The paper presents the results of investigations into the absorption of a capillary wave with a frequency of 30 Hz propagated on a water surface covered with a layer of crude oil derivatives. The relationship between the absorption coefficient and the thickness of the pollutant layer was investigated by the acoustic pulse method. The values of α determined experimentally are greater than those predicted by the Stokes theory. The applicability of the Stokes equation is considered on the basis of the physical properties characterising the petroleum derivatives under scrutiny.

PA.07.

RADIAL OSCILLATIONS OF GAS BUBBLES COVERED WITH A MONOLAYER OF SURFACE-ACTIVE SUBSTANCES IN THE NEAR-SURFACE SEA LAYER

STANISŁAW J. POGORZELSKI
Environmental Laboratory of Acoustics and Spectroscopy,
Gdańsk University, Gdańsk

Abstract

The radial oscillations of gas bubbles in aqueous solutions of surface-active agents depend on the elasticity modulus of the adsorbed monolayer and the rate of diffusive molecule exchange within the layer resulting from its deformation. The relaxation time of the diffusion was calculated for several surface-active substances present in the surface microlayer of natural waters. An estimate was made of the resonance frequency shift, and of the increase in the damping constant of the radial oscillations of a gas bubble covered with a condensed monolayer of *Extra 15* engine oil as compared with a bubble

having a clean surface for the 10^1–10^5 s^{-1} acoustic field frequency range and for bubble radii of 3–50 μm.

PA.08.

ACOUSTIC VARIABILITY OF THE CENTRAL BAY OF BENGAL FOR TOMOGRAPHY

S. PRASANNA KUMAR, Y. K. SOMAYAJULU,
T. V. RAMANA MURTHY, J. S. SASTRY
National Institute of Oceanography, Dona Paula, India

Abstract

The empirical eigenfunction approach is used to determine the dominant sound velocity structure in the central Bay of Bengal. Eigenvectors were derived from a set of two-season hydrographic data to explore the horizontal and vertical variability of the acoustic field. The first three energetic eigenfunctions account for more than 99% of the variance in the data set. The first eigenfunction, which accounts for more than 97% of the variance, represents the mean sound velocity profile and its spatial variability. The second eigenfunction represents the layer of maximum variability and its spatial variations. The third eigenfunction represents the high-frequency fluctuation. This analysis demonstrates that the variability in the acoustic field is primarily controlled by the temperature field. However, in the upper layers salinity plays a dominant role. These statistical descriptions of sound speed variability are useful for mapping mesoscale variability in the Bay of Bengal using the techniques of acoustic tomography.

PA.09.

STATISTICS OF UNDERWATER ACOUSTIC SIGNALS SCATTERED BY A ROUGH WATER SURFACE COVERED WITH A LAYER OF OILY SUBSTANCES

STANISŁAW J. POGORZELSKI
Environmental Laboratory of Acoustics and Spectroscopy,
Gdańsk University, Gdańsk

Abstract

The statistical distributions of the amplitude of an acoustic signal scattered at a rough water surface covered with various layers of oily substances with various physical properties were examined under laboratory conditions. The statistical parameters describing the distributions are presented in the form of two-dimensional dependences on the velocity of an air stream in a wind tunnel and the thickness of the oil film. The relationship between the statistical parameters, and the molecular weight of a fraction and thickness of the oil layer on the surface was estimated empirically for a wide range of air stream velocities.

PA.10.

ACOUSTIC DETECTION OF GAS BUBBLES IN THE SEA

JOANNA SZCZUCKA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The acoustic determination of the concentration of gas bubbles in the sea is based on the phenomenon of resonant backscattering. A bubble of a definite size resonates with an incident acoustic wave of a precisely defined frequency, inversely proportional to the bubble radius. The number of bubbles of various dimensions can be determined from the backscattering intensity of various sound frequencies. The *in situ* values enabled the dependence of the number of bubbles on their size and the depth to be approximated and the effect of bubbles on sound propagation conditions in the Baltic to be evaluated.

PA.11.

SOUND SCATTERING AT 30 kHz AND ITS RELATIONSHIP TO THE LARGE-SCALE CIRCULATION PATTERN IN THE GREENLAND SEA

MAREK OSTROWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Simultaneous measurements of temperature and acoustic reverberations at 30 kHz in the Greenland Sea in August 1989 show the acoustic scattering regime to be dependent on the large-scale circulation pattern in this region. Two major cyclonic gyres encountered during the measurements are clearly visible on the scattering records.

PA.12.

NON-RESONANT GAS BUBBLES IN SOUND BACKSCATTERING AND ATTENUATION IN THE SEA

JOANNA SZCZUCKA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Backscattering and absorption of sound energy by gas bubbles in the sea are dominated by bubbles of resonant size, so the experimental determination of bubble concentration in the sea is based on the resonance approximation. The resonance algorithm was re-examined in order to find the reasons for the visible discrepancies between the bubble size spectra obtained by optical and acoustic methods (in particular in the small radii area). Some theoretical distributions were chosen and compared with the distributions inferred from the resonant calculations. It was shown that using very high insonifying frequencies to estimate the density of very small bubbles can lead to a significant overestimation of the bubble population.

PA.13.

THE INFLUENCE OF CRUDE OIL SPILLS ON THE SEA SURFACE ON ULTRASOUND SCATTERING

STANISŁAW J. POGORZELSKI
Environmental Laboratory of Acoustics and Spectroscopy,
Gdańsk University, Gdańsk

Abstract

The statistical properties of ultrasonic signals scattered by a rough sea surface of clean water and such a surface covered with a spill of petroleum derivatives were examined under open-sea conditions. Obtained using a free-drifting lightweight buoylike acoustic system and artificial oil slicks spread over the Baltic Sea surface in preliminary at-sea experiments carried out in calm waters, the results confirmed the previous laboratory findings and predictions of high-frequency scattering theory. The system allows the movement of the edge of the oil spill to be detected. Simultaneous analysis of all the statistical parameters of the scattered signal distribution may be a starting point for determining the fraction weight of the substance in question, its thickness, and the form of oil contamination (monolayer, thick layer or individual dispersed spots).

PA.14.

ASPECTS OF THE PHYSICAL PROPERTIES AND THE VISCO-ELAS-TIC FEATURES OF THE SEAWATER – OIL SYSTEM

S. SAEID KHALIFA, STANISŁAW J. POGORZELSKI,
BOGUMIŁ LINDE, ANTONI ŚLIWIŃSKI
Institute of Experimental Physics, Gdańsk University, Gdańsk

Abstract

The influence of the physical properties of commonly-used oils entering the marine environment from various sources on the visco-elastic features of seawater samples was examined under laboratory conditions. The physical properties of the seawater samples collected from the Baltic Sea were determined as well. The visco-elastic features of seawater samples in the presence of oil films, the surface pressure – area $(\pi - A)$ isotherm during compression and dilation, and the surface pressure – time $(\pi - t)$ dependence were examined by means of the Langmuir trough system. The elasticity modulus ε, the reversibility R and the relaxation time τ were computed from the above dependences.

PA.15.

DETECTION OF OIL DERIVATIVES ON A SEA SURFACE BY STATISTICAL ANALYSIS OF SCATTERED ACOUSTIC SIGNALS

S. SAEID KHALIFA, BOGUMIŁ LINDE,
STANISŁAW J. POGORZELSKI, ANTONI ŚLIWIŃSKI
Institute of Experimental Physics, Gdańsk University, Gdańsk

Abstract

The statistical amplitudes of ultrasonic signals scattered from clean sea surfaces and surfaces contaminated by crude oil films with different *in situ* physical properties are described by means of the probability density function of the scattered signal amplitude distribution. The scattered signals data in specular geometry were collected at a carrier frequency of 10 MHz. The fluctuation coefficient η – a measure of the signal amplitude variability – and the parameters A_1 and A_2 – the asymmetry and flattening coefficients – describe the deviation of the statistical distribution from the normal in the presence of oil films and are referred to those coefficients obtained from clean surface scattering.

PA.16.

THE ATTENUATION OF SHORT SURFACE WIND WAVES BY MONOLAYER OIL FILMS

S. SAEID KHALIFA, BOGUMIŁ LINDE,
STANISŁAW J. POGORZELSKI, ANTONI ŚLIWIŃSKI
Institute of Experimental Physics, Gdańsk University, Gdańsk

Abstract

The damping effect of short surface waves of active monolayer oil films with different physical properties was investigated under natural conditions in the Gulf of Gdańsk. The spectra of the scattered acoustic signals amplitude from clean and covered sea surfaces was analysed in the frequency range of 1–40 Hz. Short capillary and gravity surface waves were damped by monolayer oil films with visco-elastic properties at a relatively

constant wind velocity $(1.7\text{--}2.3 \text{ m s}^{-1})$. Within such a monolayer 'static and dynamic properties' can exist which give rise to additional viscous damping (Maragoni effect). For a better comparison, the computed damping ratio $k(f)$ in the same frequency range is presented.

PA.17.

CHARACTERISTIC PROPERTIES OF BOTTOM BACKSCATTERING IN THE SOUTHERN BALTIC SEA AT ULTRASOUND FREQUENCIES

ZYGMUNT KLUSEK, JAROSŁAW TĘGOWSKI, JOANNA SZCZUCKA
Institute of Oceanology, Polish Academy of Sciences, Sopot

ANTONI ŚLIWIŃSKI
Institute of Experimental Physics, Gdańsk University, Gdańsk

Abstract

The experimental results of an investigation into bottom reverberation in the Polish economic zone of the Baltic Sea were used to determine the fundamental relationship between the parameters of backscattered signals, and the type of bottom and sediments. Numerous examples of the spatial distribution of these parameters are given.

PA.18.

THE INFLUENCE OF VISTULA WATER ON THERMODYNAMIC AND ACOUSTIC PARAMETERS IN THE GULF OF GDAŃSK

EUGENIUSZ KOZACZKA, GRAŻYNA GRELOWSKA,
PAULINA BITTNER
The Polish Naval Academy, Gdynia

ALFRED GRELOWSKI
Department of Oceanography, Sea Fisheries Institute, Gdynia

Abstract

The article discusses the results of investigations into the influence of water from the river Vistula on the thermodynamic and acoustic conditions

in the Gulf of Gdańsk. On the basis of monthly temperature and salinity distributions averaged over 15 years, the annual variation in selected thermodynamic and acoustic parameters was determined at station ZN2 off the Vistula mouth and at station P110 in the central part of the Gulf.

In order to find the best way of calculating the area influenced by Vistula water, the spatial distributions of density, compressibility, expansion, specific heat, speed of sound and the nonlinearity parameter B were determined. Depending on the meteorological and hydrological conditions in a given year, the spread of Vistula water is reflected by the distributions of several parameters. Analysing a number of parameters together seems to be the most suitable way of estimating this spread. The present analysis also allows the origin of the Gulf waters to be studied. These investigations can be used to forecast conditions for the propagation of finite-amplitude acoustic waves in the area where Vistula water interacts with the seawater in the Gulf of Gdańsk.

PA.19.

MIGRATION PATTERNS OF ACOUSTIC SCATTERERS IN THE SOUTHERN BALTIC SEA

JOANNA SZCZUCKA, ZYGMUNT KLUSEK
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Echosounding records made at a fixed point of the Gdańsk Deep at different seasons (spring, summer, autumn, winter) were used to determine the seasonal and diurnal migration patterns of plankton layers in connection with thermohaline conditions. Apart from some seasonal differences, a major, common pattern of vertical migrations at sunrise and sunset was observed. The width and scattering strength of the layer formed at night in the water column depends on the temperature gradient in the thermocline. The differences in the total energy backscattered by biological aggregations at different frequencies allow inferences to be drawn about the dominant size of scatterers.

PA.20.

THE DIURNAL MIGRATION PATTERN OF PLANKTON IN THE GULF OF GDAŃSK DURING STORM-INDUCED ONSHORE – OFF-SHORE BOTTOMWATER TRANSPORT (Communications)

ZYGMUNT KLUSEK, KRZYSZTOF PORAZIŃSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

This paper describes a front carrying warm and salt water, changing the depth of the thermocline and halocline in the Gulf of Gdańsk, measured by *in situ* (CTD) and remote sensing (acoustic sounding) methods.

Current studies and modelling – PC

PC.01.

DENSITY CURRENTS IN THE BALTIC

ZYGMUNT KOWALIK, SABINA TARANOWSKA
Department of Oceanology, Institute of Geophysics, Polish Academy of Sciences, Sopot

Abstract

A steady-state diagnostic numerical model is used to describe the density-driven circulation in the Baltic Sea. Equations of geostrophic flow were adopted for calculations, assuming the density to be known from observations. The currents in the geostrophic equations are a superimposition of barotropic and baroclinic flows. The baroclinic portion is generated by pressure due to density stratification, the barotropic portion is caused by sea level slope. To describe the distribution of the sea level slope, the equations of geostrophic flow are vertically integrated and reduced to one single equation for the stream function. The solutions of the stream function equation are discussed for the various boundary conditions. One possible solution is to incorporate the measured currents and transport along the transect as the boundary condition for the stream function. The average density field in the Baltic Sea is constructed for the month of August based on 14 years of observations (1954–1968). The vertical density distribution depicts the two-layer structure resulting from advective exchange with the North Sea. The calculations of sea level distribution in the entire Baltic depict a slow sea level rise from South North. The density-driven currents show a well organised structure in the deeper layers, close to the bottom, where currents achieve speeds of 4–5 cm s^{-1} as a result of inflow from the North Sea. However, the movement does not follow one direction: eddies occur near both the bottom and the free surface, which suggests steering of the movement by the bottom and free surface slopes.

PC.02.

A SYSTEM OF HYDRODYNAMIC EQUATIONS FOR CERTAIN OCEANOGRAPHIC PROBLEMS IN POLAR REGIONS AND THE STABILITY OF ITS SOLUTION

ZYGMUNT KOWALIK, NGUYEN BICH HUNG
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Hydrodynamic equations are determined in a Cartesian co-ordinate system (the plane (x, y) of which passes through the parallel of latitude φ_o) by stereographic projective transformation. This system of hydrodynamic equations enables its solution in polar regions to be found.

A finite-difference method for the problem is described and the stability conditions of this scheme are discussed.

PC.03.

AN IMPORTANT APPLICATION OF LASER-DOPPLER ANEMO-METRY IN OCEANOGRAPHY: CURRENT MEASUREMENTS

GEORGES LESPINARD
Institute of Mechanics, Grenoble University, Grenoble

Abstract

After a summary of the physical principles of the laser-Doppler anemometry involved in both reference beam and fringe pattern methods, some possibilities of obtaining the sign of the velocity are discussed. The main difficulties due to the indirect nature of optical methods are examined and a possible device for detecting signal drop-outs is described in some detail.

In the second part, two laser-Doppler anemometers built in the Institut de Méchanique de Grenoble, and their applications to measurements of tide-currents in the rotating model of the English Channel and to the kinematic description of gravity waves are presented. Finally, the international *in situ* experiments of Stareso (1975), where an L.D.A. was tested in pure seawater yielding satisfactory results, are also mentioned.

PC.04.

WIND-DRIVEN CIRCULATION IN THE BALTIC SEA (A HOMO-GENEOUS BASIN)

ANDRZEJ JANKOWSKI
Department of Oceanology, Polish Academy of Sciences, Sopot

ZYGMUNT KOWALIK
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Abstract

The article describes the use of the MTSL method in surveying the wind circulation in the Baltic Sea. This method is based on the numerical solution of a linearised system of non-stationary equations for mass transport and sea level (9–11) with time-constant exciting forces (wind tangential stress). The system of equations has to be solved numerically in time until the appearance of steady motion.

Assigning physically correct boundary conditions to the sea level is complicated and the H–N scheme is therefore applied in numerical calculations; its grid enables boundary conditions to be assigned only to the components of mass yields normal to the boundary.

The stability criteria of the numerical scheme for the shortest waves link the time step to the grids dimensional step, the sea depth and the friction coefficient at the sea bed (15–17). Preliminary calculations have proven that the scheme is convergent for other wavelengths as well (Fig. 2).

The current velocity components were calculated on the basis of an analytical relationship (23), obtained by integrating the stabilised equations of motion (1, 2) using boundary conditions (6, 8).

The results of these preliminary calculations (Figs. 3, 4 and 5) illustrate the vertical structure of the integral components of the current velocity and also drift and gradient components for westerly and southerly winds of constant velocity 10 m s^{-1}.

PC.05.

WATER EXCHANGE BETWEEN THE BALTIC AND THE NORTH SEA BASED ON A BAROTROPIC MODEL

ZYGMUNT KOWALIK, ANTONI STAŚKIEWICZ
Institute of Meterology and Water Management, Maritime Branch, Gdynia

Abstract

The paper considers a model of storm surges in the Baltic and the North Sea, presented in the form of perpendicular parallelepipeds joined by a channel. It is based on the vertically averaged equations of motion and continuity.

The purpose of the model was to investigate various processes resulting from wind action and in particular to elucidate the water exchange passing through the connecting channel. Simultaneously, tests were undertaken to characterise the effect of the open boundary conditions in the North Sea on the general water circulation and the influence of the Danish Straits on Baltic Sea processes.

The basic numerical experiment was based upon calculations carried out during a constant westerly wind with a speed 10–12 m s^{-1}. Under these conditions the inflow into the Baltic lasted around 18 days.

The mean water level changes in the Baltic indicate that in investigations into storm surge phenomena, the basin can be considered a closed basin for periods of around 24 h only.

The numerical modelling tests were done with and without filtration. In the latter, eddy generation was due to the shortest waves and small shear stresses at the bottom, leading to slowly increasing instability.

PC.06.

SPECTRAL ANALYSES OF VECTOR MAGNITUDES BY THE ROTARY COMPONENTS METHOD (RCM) AS EXEMPLIFIED BY CURRENTS IN THE BALTIC SEA

ZYGMUNT CATEWICZ
Department of Oceanology, Polish Academy of Sciences, Sopot
ZYGMUNT KOWALIK
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Abstract

A rotary-component method for analysing vector time series has been developed in recent years by Fofonoff (1969), Gonella (1972) and Mooers (1973). In this paper the method is applied to study current-velocity time series in the Baltic. For a given angular frequency, the rotary velocity is split into clockwise (u_-) and anticlockwise (u_+) motion. The rotary component of the velocity obtained enables the negative, clockwise spectrum W_- and positive, anticlockwise spectrum W_+ to be computed. The total spectrum, a measure of mean kinetic energy, is equal to $W_c = W_+ + W_-$. The above

spectra and such characteristics as the rotary coefficient, mean orientation and stability of orientation of the major axis of ellipse have been computed for the current-velocity time series at selected points in the Baltic.

A complete analysis of rotary spectra was obtained from measurements performed in the Gotland Deep at 14 m, 40 m and 100 m depths. The main period due to inertial oscillations appears at all depths. The 12 h tide occurs near the inertial oscillation. The rotational nature is confirmed by the high value of the rotary coefficient, which is equal to $+1.0$ at every depth examined. The characteristics of rotary spectra at other points in the Baltic vary greatly. It seems that this phenomenon can be related to the influence of local conditions on the flow.

PC.07.

EFFECT OF BOTTOM FRICTION ON THE STRUCTURE OF WIND-DRIVEN CIRCULATION

ANDRZEJ JANKOWSKI
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper describes the practical use of the MTSL method (Mass Transport and Sea Level) for surveying a steady wind circulation in a homogeneous water basin. This method is based on a system of unstabilised equations for the mass yields and the sea level (2.1–2.3), which is integrated over time with constant exciting forces (wind tangential stress).

The linear relationship between the stress and the components of the mass yield (2.10) is taken to be the boundary condition.

The theoretical analysis of the method used [3] has shown that the stability criteria (2.14–2.15) of the numerical scheme depend on the friction coefficient at the sea bed, the basin's depth and the dimensional step of the grid. The last two quantities depend mostly on the capacity of the EMC memory and the basin's size; only the friction coefficient at the sea bed can be chosen freely.

The variants of choice of this parameter considered in the paper (p. 3) link this coefficient with that of eddy viscosity in the vertical, which enables the influence of both quantities to be estimated not only on the rate at which dynamic processes establish themselves, but also on the mass yield, sea level, surface currents or the vertical distribution of current components.

An idealised rectangular basin with a given bed profile was selected for the research. The calculations were made for a wind blowing along a vertical axis OY (Fig. 2) with constant velocity 10 m s^{-1}.

The results of calculations of the mass yields, the sea level and the wind currents for a number of selected friction coefficients at the sea bed and viscosity in the vertical are shown in Figs. 3–13.

For a full evaluation of the role of both parameters in forming the vertical structure of the current components apart from the integral components (Fig. 14), the drift (Fig. 15) and gradient (Fig. 16) components are also considered.

These results enable not only the role of both coefficients, but also the influence of their variability in the basin and their mutual correlation to be evaluated.

PC.08.

A H–N MODEL FOR THE CALCULATION OF STEADY WIND- AND DENSITY-DRIVEN CIRCULATION IN THE BALTIC SEA

ANDRZEJ JANKOWSKI
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The theoretical principles of a hydrodynamic-numerical model (H–N) are described and the computation results of flows in a constant-density sea basin were performed.

The H–N model is based on a non-stationary, linearised system of equations of motion (with a constant vertical turbulent momentum exchange coefficient), the continuity equation and hydrostatic equations, in which flows are generated by time-constant exciting forces (wind tangential stress and a stress generated by the spatial non-homogeneity of the density of water).

The sea level is determined from a numerically calculated system of equations for the mass transport and sea level, and the horizontal components of the current from an analytical Ekman-type solution.

The uniqueness of the solution to the system of equations for mass transport and sea level with assigned boundary and initial conditions was demonstrated.

The preparation of the numerical grid, bathymetry and the wind field for the requirements of the H–N model is discussed, as are the results

of calculated wind flows for a westerly wind of constant velocity and the computed wind field for August.

With the aid of the linearity of the H–N model equations, the influence of the pressure gradient and the circulation caused by inflows from the main Baltic rivers on steady wind flow fields in the Baltic could be evaluated. It was shown that in the presence of strong winds the influence of river water inflows on the water circulation in a sea area of homogeneous density can be neglected.

PC.09.

VARIABILITY OF WATER FLOW IN EZCURRA INLET

ZYGMUNT CATEWICZ
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Ezcurra Inlet (King George Island) was the location of oceanographic investigations during the Antarctic summer of 1978. The research constituted a part of the programme of the second Polish Antarctic Expedition at the Arctowski Station.

The main aim of the work involved investigating the variability of currents as compared with other parameters, such as sea level, winds, temperature and salinity. Good correlation between the sea level oscillations and the currents was found. The oceanic water occurring in the inlet has a uniform temperature and salinity from the surface down to the bottom. Influenced by ocean-induced tidal processes, the basin is characterised by the components O_4, K_1, M_2, S_2. A tidal wave of a given length, period and amplitude of oscillations penetrating the inlet causes the formation of a tidal current, closely associated with the tidal periodicity. The variable depth and cross-section of the inlet cause of characteristics of these waves to change.

The two-dimensional distributions of current pulsations are elliptical in shape. The dimensions of the ellipses differ considerably at various points of the inlet. On the other hand, the vertical profiles are characterised by the relatively uniform nature of the current pulsations. Oscillation periods corresponding to tidal processes were isolated on the basis of spectral analysis of the currents. The current amplitudes reach their maximum values for a 24-hour period, particularly at the entrance to the fjord. Considerably lower amplitudes were found for periods of 12, 8 and 4 hrs. On the basis of rotational components, the motion of currents was determined

as bidirectional (along the axis of the inlet). This is due to the shape of the fjord, among other factors. Such a character of the motion is confirmed by the rotation coefficient, the value of which is close to zero. A tidal wave moves in one direction during one half-period, and in the opposite direction during the other.

A visible counterclockwise eddy is observed in the energy maxima of currents with 8- and 4-hour period. These currents contribute very little energy to the current spectrum compared to tidal currents with 24- and 12-hour periods, especially the former.

PC.10.

HARMONIC ANALYSIS OF TIDES IN ADMIRALTY BAY

ZYGMUNT CATEWICZ
Institute of Oceanology, Polish Academy of Sciences, Sopot
ZYGMUNT KOWALIK
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Abstract

The components of tides in Admiralty Bay were determined following harmonic analysis of sea-level oscillations recorded during 29 days.

Four main tidal components were found to predominate: $M2, S2, K1, O1$. Semi-monthly tides (MSF) were also found to occur. The tides in the bay are semi-diurnal and irregular. The mean height of semi-diurnal tides 2 $(M2 + S2)$ is 158 cm, that of the diurnal tide 2 $(K1 + O1)$ is 123 cm.

PC.11.

AN H–N MODEL FOR THE CALCULATION OF STEADY WIND- AND DENSITY-DRIVEN CIRCULATION IN THE BALTIC SEA. PART 2. DENSITY-DRIVEN CIRCULATION IN THE SUMMER SEASON

ANDRZEJ JANKOWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The article is a continuation of the author's paper [7] and presents the application of the H–N model for calculating steady density flows in the Baltic in the summer. The density field of water was worked out using

a method of parametrising the vertical temperature and salinity distribution [8] from observations [1, 11] of the temperature and salinity fields in August.

The results of the calculations are shown as maps of mass yields, sea level and current vectors at the surface and the bed of the Baltic. Vertical distributions of the components of the current velocity vector complete the spatial picture of the field of flows.

Analysis of the wind and density flows obtained indicates that the water density field and the sea bed topography are the most important factors in the formation of current fields, especially in deeper water.

Comparison of these calculated currents with the field measurements made on board lightships has shown a certain agreement as regards velocities; however, the directions of the calculated and measured currents showed a greater divergence.

The correlation of eddy vectors on the fields of mass yields and currents with regions of low or high concentrations of nutrients suggests that the results of model calculations could be used to estimate the transfer of passive substances in the Baltic.

PC.12.

INFLUENCE OF WATER EXCHANGE BETWEEN THE BALTIC SEA AND THE NORTH SEA ON STORM SURGES IN THE BALTIC

ZOFIA CHILICKA, ZYGMUNT KOWALIK
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Abstract

The influence of water exchange between the Baltic Sea and the North Sea on storm surges in the Baltic is studied in this paper. Calculations were carried out for a westerly wind with a constant velocity of about 20 m s^{-1} in a time interval of 33 hours.

Two situations were considered: the first treated the Baltic as a closed sea, while the second considered the basin as consisting of the Baltic Sea and the North Sea connected by the Danish Straits.

The principal conclusion to be drawn from this paper is that to disregard the influence of water exchange in the central Baltic, the Gulf of Riga, the Gulf of Finland and the Gulf of Bothnia in a time interval longer than 24 h leads to considerable errors. In the Danish Straits and in the southern

Baltic, the influence of water exchange is considerable even during the first 12 h of a storm.

PC.13.

VERIFICATION OF A CERTAIN NUMERICAL MODEL WITH THE REAL STORM SURGE OF DECEMBER 1976 IN THE BALTIC SEA

ZOFIA CHILICKA
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Abstract

A numerical model of storm surges in the Baltic and the North Sea taking into account the water exchange between these two seas was verified with the real storm surge of 22nd to 28th December 1976. The results obtained from numerical calculations were compared with the observed water levels. The water volume balance during this storm surge in certain areas was calculated.

Water exchange between the North Sea and the Baltic Sea should be included in studies of storm surges in the Baltic.

PC.14.

WATER MASS EXCHANGE BETWEEN THE GULF OF GDAŃSK AND THE BALTIC SEA

ANDRZEJ JANKOWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

A general picture of water movements in the Gulf of Gdańsk is discussed on the basis of the results of H–N models of the steady wind-driven circulation in the Baltic Sea. Depth profiles of the current speed components at the open boundary (Rozewie–Taran) complete the spatial scheme of the water mass exchange between the Gulf of Gdańsk and the Baltic Sea. The

results presented in the paper were calculated for homogeneous seawater and a homogeneous field of W, N, NW and NE winds.

PC.15.

CURRENTS IN THE COASTAL ZONE OF THE AFRICAN SHELF OFF SAINT LOUIS

ZYGMUNT CATEWICZ, RYSZARD SIWECKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Current measurements were made in the shallow zone of the African shelf off Saint Louis (Senegal) between May 1980 and the end of January 1981. Three characteristic periods with a different current structure were distinguished:
(i) the first period (May, December, January and probably February, March, April) is characterised by velocities of 15 to 33 cm s^{-1} and a pronounced southward current,
(ii) the second period (June, July, August) is characterised by low velocities and the absence of a predominating current direction, with the exception of June, when north-flowing currents predominate,
(iii) the third period (September, October, November) is characterised by high current velocities in both directions, to the north and to the south.

All these situations are due to the influence of the trade-winds and their spatial-temporal changes.

In the current spectra, semi-diurnal components (M2 – 12.42 h and S2 – 12.0 h) are predominant. The mean velocities of the semi-diurnal tidal current, calculated from eq. (2) (M2 + S2), vary from 5.4 to 2.1 cm s^{-1}. The predominant type of current in this area is the semi-diurnal irregular tidal current. Tidal characteristics (amplitude and phase shift) are subject to deformation as a result of changing depths (among other factors).

PC.16.

STATISTICAL LINEAR DEPENDENCES BETWEEN NEAR-SHORE CURRENTS IN THE GULF OF GDAŃSK AND THE ATMOSPHERIC PRESSURE FIELD OVER THE BALTIC

ANDRZEJ WRÓBLEWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The computations were based on the introduction of linear relations between the dynamic discrete input and output processes. These dependences were used to relate the anemometric characteristics to the vector components of currents. The regression method was applied together with empirical orthogonal functions, enabling the effect of the wind vectors on the phenomenon analysed to be presented. The results obtained indicate the real possibility of forecasting the currents in the Gulf of Gdańsk after a suitable measurement programme has been carried out.

PC.17.

FLOW ACROSS THE SOUTHERN AND EASTERN BOUNDARIES OF THE NORWEGIAN SEA

CZESŁAW DRUET, ANDRZEJ JANKOWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The thermohaline structure of sea water is discussed on the basis of the CTD vertical soundings carried out during the cruise of r/v 'Oceania' in summer 1988 in the Norwegian Sea. Estimates of the volume exchange of heat and water between the Norwegian Sea, the Atlantic Ocean and the Barents Sea are presented. Some ideas about the geostrophic circulation in the regions of observation are given.

PC.18.

A REVIEW OF METHODS FOR DETERMINING ABSOLUTE VELO-CITIES OF WATER FLOW FROM HYDROGRAPHIC DATA

PAWEŁ SCHLICHTHOLZ
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Methods for estimating the geostrophic velocity field from hydrographic station data are reviewed in this paper. The dynamic concepts of most of them are investigated, beginning with the so-called 'dynamic method' and ending with a three-dimensional variational inverse scheme. A short comparison of the most useful procedures in the context of their applications is given at the end.

PC.19.

VERTICAL WATER CIRCULATION IN THE SOUTHERN BALTIC AND ITS ENVIRONMENTAL IMPLICATIONS

ANDRZEJ JANKOWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

A simple method of estimating the vertical current vector velocity component w based on the water shear stress vorticity equation is presented and briefly discussed. Spatial distributions of the mean climatic values of w for selected months calculated from the averaged multi-year observations of atmospheric pressure and water density (diagnostic approach) in the southern Baltic Sea are investigated. The results show the existence of 'permanent' (during the year) zones of upwelling and downwelling in the region of the Baltic Deeps related to the clockwise and anticlockwise gyres observed on the charts of calculated horizontal currents. These characteristic features of the horizontal and vertical water movements in the region of the Gdańsk and Bornholm Deeps may be important for the ecological, biological and geological understanding of the region as well as in the context of the pollution problem, especially during stagnation periods.

Diffusion, turbulence and random processes – PD

PD.01.

HYDROMECHANICS OF WASTEWATER AND HEATED WATER DISCHARGE INTO A COASTAL ZONE, AND RELATED PROBLEMS

RYSZARD ZEIDLER

Institute of Hydroengineering, Polish Academy of Sciences, Gdańsk

Abstract

The paper deals with the hydromechanical factors controlling the circulation and dispersion of wastewater in the coastal environment. For the sake of better design of the discharge facilities, biochemical, thermal and other phenomena have been discussed as well. The near field of initial dilution, adjacent to the wastewater diffuser is described along with the far field, controlled primarily by turbulent diffusion.

The effect of currents and waves in the near field is exhibited as an exponential dilution of wastewater, with the exponents related analytically to water velocity and wave parameters. In the absence of thermal factors, *i.e.* for wastewater circulation and dispersion, one can make use of the variety of approaches and relationships given in Chapters 2 (currents and advection) and 3 (turbulent diffusion in the nearshore zone). For heated water departing from a cooling system, the Stolzenbach-Harleman algorithm (1971) is accompanied by the author's simplified yet reliable empirical formulae quantifying its behaviour and parameters in the near field subject to thermal impacts.

Based on the author's vast database stemming from far field measurements using fluorescent and float tracers, eddy diffusivities are shown to grow almost linearly with the seaward distance from the shoreline. The analytical forms proposed for those diffusivities, together with advection formulae, have been used to solve the semiempirical equation of turbulent diffusion. One of the important properties inherent in that solution is the entrapment of wastewater at the shoreline.

In the presence of waves, additional dispersion is directly proportional to the square of the wave height and the relative depth of water, and inversely proportional to the wave period. A relationship is put forward to link the spectral properties of dispersion (or eddy diffusivities) to the free surface wave spectrum. The interaction between waves with such properties and

nearshore currents is regarded as being responsible for accelerated dispersion and sheds light on the limited applicability of the 4/3 law in the nearshore zone.

The quantitative postulates presented for the vertical diffusion, in three layers with an exponential decay at the free surface, make up the scheme of nearshore dispersion and pave the way for the design of waste- and heated-water discharge systems in a quasi-deterministic framework (microscale fluctuations on top of regular plumes of discharged matter). This framework is further expanded by the application of the Fourier transform to irregular fields of nearshore currents, including mesoscale eddies.

The paper also discusses biochemical and biological aspects, such as results of the author's field studies on Coli lifetime *vs.* concentration (the half-life time rising from 0.5 h at high concentrations to 1.5 h at lower concentrations), and presents the field and laboratory techniques employed by the author in his nearshore diffusion studies.

PD.02.

THE ESTIMATION AND ACCURACY OF RANDOM PROCESS CHARACTERISTICS

RYSZARD ZEIDLER, STANISŁAW MASSEL
Institute of Hydroengineering, Polish Academy of Sciences, Gdańsk

Abstract

The correlational and spectral characteristics of a random process should be calculated in such a way as to minimise the errors due to their randomness, *i.e.* the discrepancies in relation to the real characteristics of the parent population. The analysis of these data processing discrepancies and errors performed in this paper enables the parameters of these characteristics to be selected. This choice must ensure that the quantisation step maximises the ratio of the time series length T to the elementary spectral band $m \Delta t$. The maximum frequency f_N analysed should be three or four times greater than the highest frequency discovered in the record of the process. The selected value of m should be greater than $\frac{3}{\alpha \Delta t}$ and should fulfil the conditions of relationships (3, 8); moreover, m should be sufficiently large for αT to be very much greater than unity.

The accuracy of the Fourier transform was analysed for various forms of the correlation function. It is important that the correlation function be extended to the intersection with the x-axis.

Optimum weighting of the correlation function and the spectral density is desirable. The relationship between the optimum weight function and the form of the correlation function is illustrated by eq. (18).

The results of the classic spectral analysis and Fast Fourier Transform (FFT) are compared in Fig. 3 and discussed in the text.

Additionally, the confidence intervals of fundamental characteristics are defined and specific errors are discussed.

PD.03.

SEA TURBULENCE SPECTRUM

RYSZARD ZEIDLER
Institute of Hydroengineering, Polish Academy of Sciences, Gdańsk

Abstract

Small-, meso- and large-scale vortex formations are distinguishable in the sea turbulence spectrum, and range in size from magnitudes defined by molecular forces to those controlled by the dimensions of whole seas. Every 'regular' mean movement of seawater is linked to its own vortex cascade, and further cascades result from the interaction of average movements and vortices. With the aid primarily of dimensional analysis and probability theory, universal formulas for the spectral density functions of turbulent pulsations of various physical magnitudes can be derived for many of the physical factors determining the nature of turbulence. Although all these formulas can be confirmed experimentally, the convergence of measurement data and analytical formulas is no basis for concluding that a factor considered dominant by the formula is actually present in nature. It is pointed out that the form of the turbulence spectrum may vary broadly and be difficult to predict in the neighbourhood of energy inflow bands. This is especially significant in the shore zone, where at least two factors generating turbulence can occur, namely wind-generated waves and morphological circulation. The energy inflow bands may partially overlap here, so that the spectral density functions are highly variable. It is thus recommended that turbulence be measured along with as many hydrometeorological parameters as possible.

PD.04.

ON THE USEFULNESS OF THE COX NUMBER IN INVESTIGATIONS ON THE INTENSITY OF TURBULENT HEAT EXCHANGE PROCESSES IN THE SEA COASTAL ZONE

CZESŁAW DRUET, RYSZARD SIWECKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper presents the results of measurements of fine structure of the temperature field carried out during the 'Kamchiya–79' experiment on an stationary platform situated at a depth of 6 m.

The usefulness of the Cox number for estimating the turbulent heat exchange processes for various wind directions and various wind-generated circulations of water masses is discussed and evaluated.

PD.05.

FUNCTIONAL FORMALISM FOR EQUATIONS OF THE OBERBECK-BOUSSINESQ TYPE OF THE DEVELOPED THERMOHALINE TURBULENCE

ANDRZEJ ICHA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper presents a statistical description of weak turbulent convection in a linearly stratified, binary fluid. The problem of thermohaline turbulent convection is formulated by using the mutual characteristic functional of the velocity, temperature and salinity fields. Differential equations, with functional derivatives are given for two types of functionals $i.\ e.$ STCF and SCF. The equations comprise – as a specific case – a formula given by other authors [1, 23, 24].

PD.06.

THE RESISTANCE LAW IN A SHALLOW SEA

RAFAŁ LEWANDOWICZ
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Abstract

Assuming a two-layer structure of turbulence in a homogeneous shallow sea, expressions describing the geostrophic coefficient of bottom friction u_*/G and the angle between the geostrophic current vector and the tangential stress vector at the bottom were obtained as functions of non-dimensional parameters.

PD.07.

A STATISTICAL APPROACH TO THERMOHALINE TURBULENT CONVECTION

ANDRZEJ ICHA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper presents a statistical analysis of the turbulent motion of a viscous, incompressible fluid subject to thermohaline convection. The analysis is in the spirit of the works of Yoshizawa, who introduced a new perturbation method for solving hydrodynamic equations. The results obtained in this paper generalise the formulas of the above author and enable us to obtain general expressions for the velocity, velocity-temperature, and velocity-salinity coveriances. In particular, the Reynolds stress, temperature flux and salinity flux are evaluated in the inertial-range turbulence.

PD.08.

CHARACTERISTICS OF TURBULENT HORIZONTAL HEAT EX-CHANGE IN SUBSURFACE LAYERS OF THE SOUTHERN OCEAN. PART 1. THE ATLANTIC

CZESŁAW DRUET, RYSZARD SIWECKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Characteristics of turbulent horizontal heat exchange in the subsurface
layer of the Atlantic Ocean have been prepared on the basis of data from
the First GARP Global Experiment (EGGE) in the form of maps of the
average surface temperatures of the southern hemisphere edited throughout
1979 with a five-day averaging step. The assumptions and the procedure
of numerical calculations are presented. The results of computations are
shown in terms of maps of isolines of horizontal heat exchange coefficient
for a one-year period (1979) and for four seasons.

PD.09.

CHARACTERISTICS OF TURBULENT HORIZONTAL HEAT EX-
CHANGE IN SUBSURFACE LAYERS OF THE SOUTHERN OCEAN.
PART 2. THE INDIAN AND PACIFIC OCEANS

CZESŁAW DRUET, RYSZARD SIWECKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

This paper is the second part of a study already published [4], dealing
with the coefficients and scales of turbulent horizontal heat exchange in the
subsurface layer of the Southern Ocean. These characteristics were based
on an atlas of surface currents [1, 2] and maps of isolines of mean climatic
temperature values in the subsurface ocean layer, prepared by the Marine
Environmental Data Service in Ottawa [3] from the data recorded by floating
oceanographic buoys and satellite techniques during the First GARP Global
Experiment (FGGE), carried out between December 28, 1978 and December
21, 1979. The above study [4] presents basic equations, assumptions and
empirical data, which form the basis of the method chosen by the authors
for determining the turbulent horizontal heat exchange coefficients in the
subsurface ocean layer and linear horizontal dimensions (scales) of thermal
eddy structures occurring in this layer. In addition, the study also presents

the characteristics of turbulent heat exchange for the southern hemisphere of the Atlantic Ocean.

PD.10.

A MODEL OF DAILY TEMPERATURE CHANGES IN THE UPPER SEA LAYER TAKING SUPERFICIAL AND BULK POLLUTION WITH PETROLEUM SUBSTANCES (DKTz-3) INTO CONSIDERATION

GRAŻYNA KARBOWNICZEK-GRATKOWSKA
Medical Physics Division, Pomeranian Medical Academy, Szczecin
ANDRZEJ ZIELIŃSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper presents a mathematical model of daily temperature changes in the upper sea layer taking into account the time-variable appearance of superficial and bulk pollution by petroleum substances. The model utilizes the expression for the transmission of radiation in the sea given by Czyszek (1985). The effect of temporary pollution was taken into account by modifying the coefficient of seawater absorption. The calculations were performed for the southern Baltic. The effect of pollution by petroleum substances on the evolution and depth of the daily thermocline was examined.

General hydrology – PG

PG.01.

GENERAL REMARKS ON THE 1972 ANNUAL MEETING OF THE AMERICAN GEOPHYSICAL UNION (SAN FRANCISCO)

MIECZYSŁAW LASKA
Department of Oceanology, Institute of Geophysics, Polish Academy of Sciences, Sopot

PG.02.

SEVERAL PROBLEMS OBSERVED IN INVESTIGATIONS ON THE COOLING OF NUCLEAR POWER STATIONS SITUATED ON THE COAST OF A TIDAL SEA

GABRIEL CHABERT d'HIÈRES
Institute of Mechanics, Grenoble University, Grenoble

Abstract

Energy demands led electric power station designers to make use of seawater as a coolant. The problems of dispersion are still little-known; it has, however, been observed that in seas with strong tides, drift currents are the basic factor to be considered. As the measuring of such currents is a delicate matter, only numerical or physical models can constitute the basis for hypothetical definitions.

Several measurements conducted on a hydraulic model of the English Channel are presented in this paper. They include instantaneous fields of velocity, trajectories and discharge concentration fields.

PG.03.

OCEANOGRAPHIC INVESTIGATION OF EZCURRA INLET DURING THE 2nd ANTARCTIC EXPEDITION OF THE POLISH ACADEMY OF SCIENCES (PAS)

JERZY DERA
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The article characterises the natural phenomena of Ezcurra Inlet on King George Island on the basis of a preliminary analysis of the results of the 2nd Antarctic Expedition (PAS) during the Antarctic summer 1977–1978. The following are covered: weather conditions; aspects of hydrodynamics; ice flow; the temperature, salinity and oxygen content of the water; nutrients; suspended matter and water transparency; solar radiation and the underwater light fields; pigments, phytoplankton and primary production; zooplankton and its bioluminescence.

PG.04.

THE APPLICATION OF A PARAMETRIC METHOD FOR THE VERTICAL DISTRIBUTION OF TEMPERATURE AND SALINITY TO DETERMINE SEAWATER DENSITY FIELDS

ANDRZEJ JANKOWSKI, SABINA TARANOWSKA
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

This paper discusses the application of the methods of modelling vertical temperature and salinity distributions to determine the density fields of Baltic water. In order to serve model studies of the steady wind-driven circulation in August. The Baltic has a complex vertical temperature and salinity structure; therefore a parametric method for vertical distributions in a multi-layer sea, after Felzenbaum's (1974) idea, was applied.

Four temperature and four salinity models were considered. The vertical temperature and salinity structure was approximated by means of polynomials of the z argument. The polynomial coefficients were calculated from experimental data using boundary conditions at the sea surface, sea bottom and interfaces. The methods of preparing the input parameters for calculations of vertical temperature and salinity profiles were discussed. The water density was calculated by means of the Mamayev formula. The effect of temperature and salinity on density and of the approximation errors of temperature and salinity on the density approximation error were investigated.

Comparison of the results of calculations with experimental data indicates that although the parametric method considers only the vertical structure of temperature, salinity and density, it does not distort their horizontal distribution. Maximum errors in temperature approximation did

not exceed 25% and in salinity 5–8%, thus those in the density calculations were of the order of 5–10%. The density fields obtained were sufficiently smooth, which is essential in numerical models of circulation.

The results of those investigations indicate the advantages and suitability of the parametric method for the vertical distribution of temperature and salinity when determining the density field in the Baltic.

PG.05.

PUCK BAY – ONE OF THE HYDROLOGICAL PECULIARITIES OF THE BALTIC

LILIANA KLEKOT
Research Institute on Environmental Development, Warsaw

Abstract

Hydrological observations were conducted in Puck Bay during 1968–1971. Attention was paid mainly to the physico-chemical conditions in the inner Bay. This is unique owing to its varied bottom topography, relatively large area and shallow depth, and because it is separated from the rest of the bay by an underwater sand bar which stretches for a distance of about 12 km. The water was found to be transparent to the bottom at almost all stations. The salinity is about 7 PSU, fluctuating between 4.3 and 8.1 PSU. The oxygen concentration is high about 100%. The water temperature changes rapidly due the influence of the air temperature. The mixing and exchange of water is vertical, and reaches to the bottom; mixing with water from the Gulf of Gdańsk occurs simultaneously. Measurements of temperature, salinity and oxygen content indicate that these processes are constant, their intensity changing with the seasons. The basic factor affecting the exchange and mixing of the water is the wind, while the bay's specific character – open to surface currents but partially isolated from near-bottom currents, is influenced by the underwater sand bar.

PG.06.

AN ATTEMPT TO DETERMINE THE DYNAMICS OF WATERS IN THE REGION OF INTERACTION OF THE BRAZIL AND FALKLAND CURRENTS

ANDRZEJ MAJEWICZ
Department of Oceanography, Sea Fisheries Institute, Gdynia

Abstract

The article describes the dynamics of the waters in the frontal zone of the Brazil and Falkland currents down to a depth of 2000 m on the basis of oceanographical research in the Argentine Basin in May 1978. Two cyclonic vortices (Fig. 2 – axes B and C) and one anticyclonic vortex (Fig. 2 – axis A) were found to be present where the eddy motion reached down to a depth of at least 1500 db. An attempt was made to calculate from geostrophic current velocities the flow balance at each side of a prism (Fig. 4, Tab.). Inflows of water into the basin were noted at the northern and western sides of the prism, whereas outflows were recorded at the eastern (max. value) and southern (min. value) sides. The positive overall balance between inflow and outflow ($+14\ 217\ \mathrm{km^3\ h^{-1}}$ for the entire prism) suggests that a constant, though slow subsidence of water is occurring in the vicinity of the subtropical convergence.

PG.07.

PRELIMINARY DETERMINATION OF THE OCCURRENCE AND MOVEMENT OF WATER MASSES IN THE REGIONS OF SOUTH GEORGIA, THE SCOTIA SEA AND THE ANTARCTIC PENINSULA

ALFRED GRELOWSKI, MARIANNA PASTUSZAK
Department of Oceanography, Sea Fisheries Institute, Gdynia

Abstract

The paper discusses the occurrence and movement of water masses in the region of South Georgia, the Scotia Sea and the Antarctic Peninsula in the period December 1978–March 1979. Measurements of physical parameters were carried out at 147 stations and a STD Bissett–Berman probe was lowered down to 2000 m. The distribution and coverage of the area with oceanographic stations allowed geostrophic currents to be calculated and water masses and their movements to be defined. In the South Georgia region both the water masses and the current system were variable over the period studied. Four types of water masses were distinguished there: inshore waters, waters from the Bellingshausen Sea, waters from the Weddell Sea, and mixed waters originating from the convergence of the above water masses. Transects encircling the Scotia Sea region and showing the vertical distribution of temperature enabled identification and description of the particular water masses there. Based on calculations of geostrophic currents in the 0–2000 m layer it was possible to determine the water balance in the Scotia Sea region. Along the coast of the Antarctic Peninsula, waters

carried in by the West Wind Drift current mixed with waters originating from the Weddell Sea.

PG.08.

THE HYDROLOGICAL CHARACTERISTICS OF THE SHELF WATERS IN THE GULF OF ALASKA (SUMMER 1977)

ANDRZEJ FURTAK, ANDRZEJ MAJEWICZ
Department of Oceanography, Sea Fisheries Institute, Gdynia

Abstract

The paper discusses the hydrological conditions in the shelf waters in the Gulf of Alaska in summer 1977. The investigations were carried out from 4 July to 3 August at 157 stations, mostly located on 22 transects perpendicular to the slope. Temperature, salinity and oxygen content were measured at standard depth at each station.

With regard to dynamic processes, the weather conditions, sea floor morphology and shore line, as well as local processes such as the flow of melt waters into the Gulf, three hydrological regions with the following distinguishing features could be delineated (Fig. 1): one with a vertical circulation in the surface layer (Type A and weak Type D – Fig. 3), another where the inflow of melt waters reduce the salinity of surface waters (Fig. 5B and C) and where deep waters simultaneously well up on to the slope, and a third where tidal currents meet the waters of the Alaska Current (beyond the shelf at stations 156 and 157 – Figs. 7 and 8).

Comparative analysis based on T–S curves of long-term average values shows that in summer 1977 the shelf waters in the northern part of the Gulf of Alaska from the surface to a depth of 125 m were warmer and more saline (Fig. 9). This indicates that the winter previous to these investigations was atypical, *i.e.*, there was little melt water flowing into the Gulf that summer. When considering the hydrological conditions of this area, one must chiefly bear in mind the surface salinity, and the 32 PSU isohaline in particular, which forms the boudary between inshore and oceanic waters.

PG.09.

SMALL-SCALE STRATIFICATION OF THE DENSITY FIELD AND ITS INFLUENCE ON THE CONCENTRATION OF SUSPENDED MATTER

CZESŁAW DRUET, RYSZARD SIWECKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The article presents the results of empirical investigations conducted
during a cruise of the research vessel 'Profesor Siedlecki' in the Baltic
in July 1980. These aimed to establish the relations between various
characteristics of small-scale stratification of temperature, salinity and
velocity fields, and the distribution structure of vertical suspension. Details
are given of the hydrometeorological background to the experiment, the
small-scale temperature field structure, and the correlations found between
the distributions of selected parameters characterising the dynamics of the
small-scale stratification of the upper water layer (Cox number) and the
chlorophyll a concentration.

PG.10.

SOME STATISTICAL CHARACTERISTICS OF SEAWATER TEMPER-
ATURE VARIATIONS ON THE POLISH BALTIC COAST

ANDRZEJ WRÓBLEWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

In the present paper the periodic structure of seawater temperature
variations is determined, the usefulness of the AR(1) process analysed,
and the distribution functions of the temperature range variations in
individual summer months computed using the Monte Carlo method.
The computations were based on the series of daily water temperature
measurements at the stations at Międzyzdroje, Mielno, and Władysławowo
made in 1961–1970, and on monthly mean values for these stations from
1950 to 1984. The computations were carried out with the optimum use
of the results for a short period forecast with a 24-hour lead time and the
characteristics of the summer season in mind.

PG.11.

PATCHINESS OF HYDROPHYSICAL FIELDS IN THE LIGHT OF DATA FROM THE PEX′86 EXPERIMENT OBTAINED AT ANCHORED STATIONS

CZESŁAW DRUET, RYSZARD SIWECKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Time-variable characteristics of hydrophysical temperature, salinity and density fields were recorded at anchored stations during the PEX′86 international experiment of Baltic countries. Forms of patchiness of the marine hydrophysical fields and of hydrodynamic sources of their formation and development were identified. The hydrodynamic sources forming the patchy structures of seawater temperature, salinity and density fields are discussed, and structures recognisable as forms of patchiness at the anchored stations of the PEX′86 experiment are identified.

PG.12.

THE APPLICATION OF EOF IN THE ANALYSIS OF THE VARI-ABILITY OF WATER TEMPERATURE, SALINITY AND DENSITY IN SELECTED REGIONS OF THE NORWEGIAN SEA

ANDRZEJ JANKOWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The results of applying empirical orthogonal functions (EOF) to the decomposition and approximation of vertical profiles of seawater tempera-ture, salinity and density are presented. The calculated empirical orthogonal functions were used to analyse the spatial and temporal variability of hydrophysical parameters along two hydrographical transects in selected regions of the Norwegian Sea.

PG.13.

SALINITY VARIATIONS AS AN EFFECT OF GROUNDWATER SEEP-AGE THROUGH THE SEABED (PUCK BAY, POLAND)

HALINA JANKOWSKA, MACIEJ MATCIAK,
JACEK NOWACKI
Institute of Oceanography, Gdańsk University, Gdynia

Abstract

CTD vertical soundings carried out in 1992 and 1993 have revealed near-bottom salinity inversions in the deep part of Puck Bay. The general pattern of water circulation does not appear to explain the observed phenomena. In the authors' opinion it is a submarine groundwater discharge which influences the salinity regime, producing slightly less saline bottom water layers.

PG.14.

THE ARCTIC FRONT: STRUCTURE AND DYNAMICS

JAN PIECHURA, WALDEMAR WALCZOWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

During summer expeditions of r/v 'Oceania' to the Arctic Seas, the Arctic Front has been crossed and investigated each time since 1987. The 1993 cruise initiated more detailed investigations of this phenomenon. In the area delimited by longitudes $2°41'$W and $3°05'$E and latitudes $70°54'$N and $72°32'$N, five CTD transects were done with the CTD cast every 5 or 2 nm on each transect.

The location and direction of the front have been defined. The geostrophic component of the general circulation shows good agreement with the earlier data: a strong current (up to 40 cm s^{-1}) on the Atlantic side of the front, about zero velocity in the middle and a weak current (5–10 cm s^{-1}) on the Arctic side of the front. The steepest horizontal gradients were ca 0.5°C

km^{-1} (temperature) and *ca* 0.04 PSU km^{-1} (salinity). The data reveal the complicated structure of the front with its intrusions, meanders and gyres.

PG.15.

THE VISTULA RIVER DISCHARGE FRONT – SURFACE OBSERVA-TIONS

MACIEJ MATCIAK, JACEK NOWACKI
Institute of Oceanography, Gdańsk University, Gdynia

Abstract

The spreading of Vistula river water has been studied on the basis of surface spatial distributions of water properties. The horizontal divergence field of the gradient of a given property is analysed to find the main directions of surface water transport. This shows that advection in the direction perpendicular to the frontal line is weak. Examples of salinity, temperature (AVHRR/SST), density and nutrient concentration fields in the area adjacent to the river mouth are discussed.

PG.16.

INTERANNUAL VARIABILITY IN THE HYDROPHYSICAL FIELDS OF THE NORWEGIAN-BARENTS SEAS CONFLUENCE ZONE

JAN PIECHURA, WALDEMAR WALCZOWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Every summer since 1987 (except 1990), the Institute of Oceanology has conducted oceanographic research in the area between Norway and Spitsbergen, and between 12 and 17°E from on board r/v 'Oceania'.

The data collected show quite substantial, interannual variations in physical properties and transport. In the north-east corner of the area investigated (close to Storfjord) surface-water temperatures differed by > 6°C (2.6°C in summer 1993 and 8.8°C in summer 1992) and salinity by > 1.5 PSU.

The depth of the thermocline and temperature gradients fluctuated, as did the depth of the maximum salinity layer. Water transport across the

15°E meridian in the upper 1000 m layer calculated by geostrophic methods varied from 2.6 to 8.9 Sv eastwards and from 1.1 to 5.1 Sv westwards.

The largest variations were observed in the surface waters and in the north-eastern and south-eastern parts of the confluence zone, *i.e.* in the areas most strongly influenced by Barents Sea waters. In the areas occupied by Norwegian-Atlantic waters and in deeper layers, conditions were much more stable.

PG.17.

DENSE BOTTOM WATERS IN STORFJORD AND STORFJORDRENNA
(Communications)

JAN PIECHURA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

On the basis of published information and our previous data, special attention was paid to the presence of dense bottom waters around the south-eastern tip of Spitsbergen during the 1995 'Oceania' cruise. Such waters, with a temperature of 1.6–2.0°C below zero, a salinity around 35 PSU and a density of 28.00–28.16, were recorded in Storfjordrenna and Storfjord. In Storfjordrenna this type of water appeared in separate bodies with a relatively large vertical extension, which was most probably caused by an eddy-type of circulation.

PG.18.

THE POSITION OF THE SEASONAL THERMOCLINE IN SOUTHERN
BALTIC WATERS POLLUTED WITH CRUDE OIL

JADWIGA MROZEK-LEJMAN,
GRAŻYNA KARBOWNICZEK-GRATKOWSKA
Marine Physics Department, Szczecin University, Szczecin

Abstract

The paper deals with the formation of the thermocline and the mixed layer in a sea polluted with crude oil when the natural optical parameters of eutrophic seawater are seasonally variable. Differentiation of the degree

of eutrophication of the seawater is expressed in terms of the concentrations of chlorophyll and yellow substances. The occurrence of crude oil pollution is taken into account by modifying the time-variable absorption coefficient of the seawater – crude oil system. The variability in the absorption spectra of natural seawater in the spring – summer season is estimated on the basis of investigations of seasonal changes in the chlorophyll concentration in the southern Baltic.

Numerical simulations were carried out for Baltic and Gulffax crude oil using the one-dimensional integral DKTz–2 model. The computations were performed for monthly average values of parameters determining the state of the southern Baltic environment collected over several years. Experimentally found crude-oil optical parameters (light refraction and absorption coefficients) were applied, as were the variability with time of these parameters and that of the crude oil layer thickness.

The results of the numerical simulations show that the increase in the volumetric concentration of crude oil in the upper sea layer causes the thermocline to be formed closer to the water surface. Simultaneously, the thickness of the mixed layer decreases but its temperature rises. If a crude oil layer appears on the water surface, the trend of the changes is the same.

Air-sea interaction – PI

PI.01.

ON THE EFFECT OF AIR-SEA INTERACTION ON THE DIFFUSION
AND REMOVAL OF AIRBORNE PARTICULATE MATTER

CZESŁAW GARBALEWSKI
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

PI.02.

THE CHARACTERISTICS OF AIR-SEA INTERACTION DURING THE
EKAM–1973 EXPERIMENT

CZESŁAW DRUET, PETER HUPFER, OLEG KUZNETSOV
Institute of Hydroengineering, Polish Academy of Sciences, Gdańsk

Abstract

The research programme of the first international coastal expedition
of CMEA Baltic states was conducted during the period from 15 May to
30 June, 1973, in the coastal zone of the southern Baltic, in the region of
Zingst (GDR) (Fig. 1). The prime aim was to obtain preliminary data on
the characteristics of the interaction between the sea and the air in the
coastal zone. A summary of the programme details and assumptions of
the expedition was given in Druet, Hupfer, Kuznetsov (1974), the results
of collective research being published in the form of papers, in a special
report issued by the Polish institution co-ordinating national research under
problem 2.7/CMEA – the Sea Fisheries Institute in Gdynia.

This paper summarises the more important research results of the
experiment.

The fundamental aim of this research was the preliminary, empirical
discernment of the main characteristics of the hydro- and aero-physical
fields, which form and change under the influence of the interaction between
the sea and the air, also to obtain empirical data to verify certain formulae
and methods of their theoretical prediction. Fig. 2 gives a diagram of the
location of measurement points and the recording apparatus comprising the
experimental basis of the work.

PI.03.

THE POSSIBILITY OF USING SEA-SALT NUCLEI IN THE ATMO-SPHERE TO EVALUATE THE ROUGHNESS PARAMETER OF THE SEA SURFACE

CZESŁAW GARBALEWSKI, HENRYKA BEREK
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Abstract

On the basis of experimental results the dependence of sea-salt nuclei concentration in the surface air layer over the Baltic Sea on the roughness parameter z_o of the sea surface was investigated. By eliminating the effect of the advection factor in the analysis, one can prove the occurrence of a local dependence of q_a on z_o over this basin (Fig. 2). Comparison of the experimental relationships q_a *vs* z_o with the calculated values of z_o for typical sea-salt nuclei concentrations q_a over the Baltic under various wind speed conditions points to the importance of q_a as a correction parameter in evaluating the dependence of z_o on wind speed (Fig. 4). It should be noted, however, that the Baltic Sea does not afford better evidence for this method because of its low salinity. Nevertheless, the results are generally positive.

PI.04.

A STUDY OF TURBULENT FLUX OF AIRBORNE PARTICULATE MERCURY PASSING FROM THE ATMOSPHERE INTO THE SEA

CZESŁAW GARBALEWSKI, HENRYKA BEREK,
ANNA BRZEZIŃSKA, ANNA TRZOSIŃSKA, DANUTA WIELBIŃSKA
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Abstract

The turbulent flux of airborne particulate mercury transported to the sea was investigated in the Gulf of Gdańsk. Mercury concentrations in the air just above the sea surface were thus measured in the Gulf and at shore stations. With the aid of aerological and synoptic data, turbulent mixing around the measurement points was also studied. The magnitude of the flux was calculated from an estimation of the mixing layer depth, and from the self-purification constant determined from studies on condensation nuclei in the Baltic. These values were compared with the concentrations of mercury measured in the air and the surface layer of the sea, and also with experimental sedimentation data on airborne mercury in the study

area. The measurements were performed using cold vapour flameless atomic absoprtion.

The turbulent air-sea transport of mercury was found to vary by one order of magnitude between May and October 1974. Fluctuations of a similar magnitude are reported in the mercury concentrations in the air and the surface layer of the sea.

The large difference in effective diffusion velocity of mercury fallout in air and water at the air-sea interface should alone be sufficient to produce maximum concentrations of mercury in the surface film of the sea. Maximum concentrations were confirmed by means of special measurements.

PI.05.

MECHANISMS OF AIR-SEA PARTICULATE TRANSPORT OVER THE BALTIC SEA

CZESŁAW GARBALEWSKI, HENRYKA BEREK
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Abstract

An almost enclosed basin, the Baltic is particularly important as regards its toxicant budget. No component of this budget should be disregarded, even if it seems to be of negligible proportions, because the cumulative effect of compositional changes to it will be a long-term disturbance of the quasi-stationary equilibrium.

In view of the above, a structural model has been analysed which seeks to explain the role that the various components play in transporting airborne phases out to sea. A number of transport mechanisms are assessed, not only planetary ones, but also those characteristic of natural synoptic circulations indicated by sea salt nuclei carried from the Atlantic to the Baltic.

Local mechanisms transferring toxic substances from the air to the sea have been subjected to particular scrutiny. An example is the transfer of lead from the air to the Gulf of Gdańsk. Analysis has shown that offshore winds, some of which are land breezes, locally ventilate conurbations and carry admixed particles out to sea.

PI.06.

A METHOD TO INVESTIGATE THE DYNAMICS OF THE CONTENT OF METALS IN THE AIRBORNE COMPONENT OF MASS EXCHANGE BETWEEN SEA AND ATMOSPHERE OVER THE BALTIC SEA

CZESŁAW GARBALEWSKI, HENRYKA BEREK
Institute of Meteorology and Water Management, Maritime Branch, Gdynia
ALEKSANDRA FOŁDZIŃSKA
Analytical Chemistry Division, Institute of Nuclear Research, Warsaw

Abstract

The atmospheric aerosol was sampled from large volumes of air using a spiral impactor, and these samples were large enough to be analysed by neutron activation. At the same time their disperal characteristics were analysed under optical and electron microscopes. An original, electron microscopic procedure for examining metalliferous particles demonstrated experimentally that both non-metalliferous and metalliferous particles were present in the air over the Baltic, the latter containing various amounts of metals. Using the example of mercury concentration differences, it was shown that in the coastal zone it was chiefly the macroparticle component that caused the mercury concentration in the air to rise, whereas over the open Baltic this increase was due to the pre-submicro-particle component.

PI.07.

FLUCTUATIONS IN THE ATMOSPHERIC DUST CONTENT ABOVE THE CENTRAL ATLANTIC AND TRANSFER OF DUSTS FROM THE SAHARA

CZESŁAW GARBALEWSKI
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Abstract

The fluctuations in the dust content of the air just above the sea surface in the central Atlantic were examined in a 24 h cycle, the experiments being conducted from the Soviet r/v 'Musson' during the GATE-74 Tropical Atlantic Experiment. The air was sampled with a four-cascade impactor and analysed photometrically. The dominant dust content fluctuation period was *ca* 1.7×24 h.

The dust content was found to increase two days after sandstorms in the Ahaggar area of the Sahara had been recorded on satellite photographs. The dust clouds were carried a distance of ca 3500 km to the measurement area at ca 65 km h^{-1}, the velocity characteristic of the zonal winds blowing from the northern equatorial zone in the lower stratosphere.

Modern satellite photography at visible and IR wavelengths is capable of outlining only the principal dust cloud. That part of this cloud comprising smaller, though measureable concentrations of dust carried over the ocean from the Sahara is very much larger in area.

PI.08.

A METHOD FOR STUDYING THE CONTRIBUTION OF HEAVY METALS IN MARINE AEROSOL DEPENDING ON THE PARTICLE SIZE DISTRIBUTION

LONGINA FELKIER, ANNA BRZEZIŃSKA
Institute of Meteorology and Water Management, Maritime Branch, Gdynia
CZESŁAW GARBALEWSKI
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper attempts to explain the effect of the physical and chemical properties of dispersion systems on the efficacy of diffusion and air-sea metal exchange. To this end the aerosol was sampled with a spiral impactor on two different substrates: one – a celluloid tape coated with polyacrylic resin, the other – microscopic reticule coated with a gold film.

The former was used to determine the cadmium and mercury content, the latter to find the mercury content in the different aerosol particles.

These techniques enabled the physical and chemical properties of the sampled particles to be examined simultaneously. The aerosol was investigated with the aid of a Beckman atomic absorption spectrophotometer, a bi-compound monitor for determining mercury, and dispersion measurements, which revealed differences in the distribution of mercury and cadmium concentrations, associated with three types of particle size distribution, between the coastal zone at Gdynia and the open Baltic.

Electron microscopy was used to investigate the presence of metalliferous and non-metalliferous particles in the air over the Baltic. This showed them to contain various amounts of mercury.

PI.09.

MEAN SPATIAL DISTRIBUTION OF BASIC PHYSICAL CHARAC-
TERISTICS AND SOURCE REGIONS OF PARTICLE EMISSION FROM
THE OCEAN SURFACE

CZESŁAW GARBALEWSKI

Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The oceanic distribution of relative source and sink regions of the
'mechanical evaporation of water' has been investigated. Based on the
concept of an emission layer composed of particle transformation and
transfer sublayers, a model has been developed describing particle emission
from open-sea areas (beyond the breaker zone). The model's parameters
(including the emission coefficient c_ρ, dependent mainly on air and seawater
densities, the resistance coefficient c_D, the roughness parameter z_o and the
dimensionless dynamic factor $\xi = \frac{Re_s}{M}$, where Re_s is the Reynolds number
for the surface, $M = \frac{u_{10}}{u_*}$, u_{10} is the wind speed at the standard height
of 10 m and u_* is the friction velocity) have been defined from long-term
figures contained in data sets relating to the climates of seas and in maritime
atlases.

A first attempt has been made to obtain a basic outline of the
mean monthly oceanographic fields of the roughness parameter ($\overline{z}_o$), the
dimensionless wind factor ($\overline{\xi}'_{10}$) and the sea salt flux ($\overline{Q}_{10}$). It was found
that areas with the highest values of z_o occurred 1) in areas of storm
activity in western transfer zones, 2) when trade winds intensify over the
open ocean and 3) in connection with the monsoon circulation over the
Indian Ocean. Thus extensive sources of marigenic particle emission are
dominant in January in the band of median latitudes over the Atlantic
and Pacific, and in July over median latitudes in the southern hemisphere,
particularly between New Zealand and Tierra del Fuego. The calculated
mechanical evaporation Q'_{10} varied between 0.08 and 0.83% with respect
to direct sea-surface evaporation. The highest potential values of $\overline{Q}'_{10}$ were
obtained in western transfer zones. The distributions of $\overline{Q}_{10}$ and $\overline{Q}'_{10}$ in the
Indian Ocean were found to vary substantially.

The Baltic Sea in January forms, as it were, an extension of the north
Atlantic field of parameter $\overline{\xi}'_{10}$, although it is principally the northern Baltic
that comes within the compass of the dominant $\overline{\xi}_{10}$ values. In July, $\overline{\xi}'_{10}$ is
several times lower than that measured at the same latitudes in the Atlantic.

In general, the Baltic Sea is a sink rather than a source area with respect to the Atlantic centre of marigenic aerosol emission.

PI.10.

CHARACTERISTICS OF VARIATION OF METEOROLOGICAL ELEMENTS IN EZCURRA INLET DURING THE POLISH ACADEMY OF SCIENCES' SECOND ANTARCTIC EXPEDITION FROM 20 DECEMBER 1977 TO 16 MARCH 1978

JÓZEF KOWALEWSKI, DANUTA WIELBIŃSKA
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Abstract

On the basis of shipborne measurements a description is given of the hydrometeorological conditions in Ezcurra Inlet (King George Island, South Shetland Islands) in the austral summer, 20 December 1977 to 16 March 1978, during the 2nd Antarctic Expedition of PAS (Polish Academy of Sciences). The synoptic situations occurring in the Antarctic Peninsula region are briefly reviewed and significant values of atmospheric pressure and its trends at the Arctowski station are given. Special attention is paid to the wind directions and speed in the Ezcurra Inlet and a comparison is made with wind conditions at the nearby Arctowski station. The peculiarities of both wind and air temperature behaviour in the Ezcurra Inlet are stressed and illustrated by some values. Information is provided on the nature of the relative humidity, visibility, clouds and precipitation recorded in the inlet. The variation in sea surface temperature is outlined and some results of waves and sea-ice observations mentioned.

PI.11.

TRANSPORT OF IODINE AND MERCURY CONTAINED IN SUBMICRONIC AEROSOL PARTICLES OVER RELATIVELY CLEAN SEAS (THE ANTARCTIC) AND POLLUTED ONES (THE BALTIC)

LONGINA FELKIER
Institute of Meteorology and Water Management, Maritime Branch, Gdynia
CZESŁAW GARBALEWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The air-sea exchange of iodine and mercury contained in the aerosol was studied with respect to the submicronic particle size distributions by reactive trace analysis using electron microscopy.

PI.12.

THE CHARACTERISTICS OF AEROSOL FORMATION OVER THE SEA AS AN INDEX OF THE CLIMATIC ACTIVITY OF THE OCEAN

CZESŁAW GARBALEWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The problem of estimating oceanic active centres is presented using the Atlantic Ocean as an example. A synoptic analysis of these centres is carried out on the basis of the foam coverage of the ocean and aerosol emission. The possibilities of applying these methods in such an analysis are discussed in connection with the growing needs of modelling the climatic variability of the ocean and atmosphere.

PI.13.

MODELLING THE GENERATION OF MARINE AEROSOLS AT THE SEA SURFACE

EDWARD C. MONAHAN
Marine Sciences Institute, Connecticut University, Connecticut

Abstract

The development of a model for the estimation of the local, instantaneous rate of sea spray production is presented.

PI.14.

THE ROLE OF LOW-FREQUENCY WATER WAVES ON MOMENTUM TRANSFER BETWEEN THE ATMOSPHERE AND OCEAN IN THE NEAR-SHORE REGION

JANUSZ KRZYŚCIN
Institute of Geophysics, Polish Academy of Sciences, Warsaw

Abstract

Using the Gent and Taylor model, modifications of air-sea interaction in a coastal region by low-frequency ocean surface waves were calculated. The model equations consist of the wave kinematics equations and the wave energy equation. The latter equation parametrises energy sources (wind, surface water current) and energy dissipation by the sea bottom. The model equations were used to find changes in the long waves in the near-shore region. The method of numerical calculations is based on the method of characteristics.

The results show that significant changes in the drag coefficient of momentum are caused by waves propagating in a direction opposite to that of the local wind. When waves are generated by a local wind (the direction of the long wave is along the wind), the drag coefficient is due mainly to high-frequency surface waves. The type of sea bed material and surface currents modify long wave propagation. As a consequence, these induce changes in the drag coefficient in the near-shore region.

PI.15.

SYNOPTIC VARIABILITY IN THE CHARACTERISTICS OF AEROSOL FORMATION FACTORS IN THE NORWEGIAN SEA

CZESŁAW GARBALEWSKI, JANUSZ KLAJNERT
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Synoptic fluctuations of the activity of oceanic regions in the quasi-meridional profile (within *ca* 2°–15°E) in the sector from the Norwegian Sea to about 76°N are examined. The work aims at the problem of evaluating

changes in the climatic activity of the ocean on the basis of characteristics determining the oceanic whitecap coverage (W). The spatial and temporal changes of W over the period July–August 1987 and the related fluctuations in aerosol water characteristics and in heat exchange between whitecaps and the atmosphere are estimated. The results are discussed and verified on the basis of the average climatic characteristics of the region and the contribution of the Arctic front to their formation.

PI.16.

MULTIFREQUENCY LIDAR INVERSE PROBLEM IN ATMOSPHERIC AEROSOL STUDIES FOR SIMPLE MARIGENIC AEROSOL MODELS

JACEK PISKOZUB
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The multifrequency lidar inverse problem in aerosol research is discussed. Two models of marigenic aerosols are presented for water and water/salt aerosol ensembles. The Tikhonov functional solution method of the inverse problem for both models is described. The algorithms for calculating the scattering medium optical parameters and the size-distribution functions of the aerosol are discussed. The numerical simulations performed to test the inverse problem solution algorithms are described and a brief discussion of the results is given.

PI.17.

NITROGEN AND PHOSPHORUS EXCHANGE IN THE AIR-SEA CONTACT ZONE

LUCYNA FALKOWSKA, JERZY BOLAŁEK
Institute of Oceanography, Gdańsk University, Gdynia

Abstract

The paper describes a method of collecting samples of sea surface film. The enrichment factors of the microlayer towards nitrogen (0.37–4.92) and phosphorus (0.45–1.48) compounds have been calculated. Aerosol

enrichment factors in the sea surface film are presented, and the respective magnitudes of the effective nitrogen and phosphorus fluxes from the air to the seawater have been estimated at 35.7 and 1.15 μg m^{-2} h^{-1}.

PI.18.

PRELIMINARY APPLICATION OF LIDAR TO MEASUREMENTS OF THE MARINE AEROSOL CONCENTRATION IN THE ATMOSPHERE OVER THE GULF OF GDAŃSK AT SOPOT

TYMON ZIELIŃSKI, KRZYSZTOF KORZENIEWSKI,
LUCYNA FALKOWSKA
Institute of Oceanography, Gdańsk University, Gdynia

Abstract

    This paper presents the results of preliminary measurements of aerosol concentrations above the Gulf of Gdańsk for various altitudes and for various distances from the shore. The measurements were carried out by means of the FLS-12 lidar system from the coast at Sopot in June 1992.

PI.19.

HEAT FLUXES BETWEEN SEA AND ATMOSPHERE VERSUS WHITE-CAP COVERAGE

TOMASZ PETELSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

    Heat fluxes computed from meteorological data H are compared with whitecap coverage measured during AREX–87, 91, 92 cruises. The relation between heat flux and whitecap coverage falls to a minimum within the positive heat fluxes. The same relation $H(W_c)$ was obtained earlier by numerical modelling. This study demonstrates that aerosol emission does affect air-sea heat exchange.

PI.20.

AEROSOL FLUXES IN THE BREAKER ZONE OF THE GULF OF GDAŃSK

TYMON ZIELIŃSKI
Institute of Oceanography, Gdańsk University, Gdynia

Abstract

This article presents the results of calculations of concentrations, fluxes and velocities of aerosol particles produced in the process of wave breaking. The calculations were carried out using experimental data collected during lidar-based investigations of marine aerosols above the breaker zone of the Gulf of Gdańsk. The sounding profiles obtained were used to determine aerosol concentration and size distribution functions on which the flux and velocity calculations were based. The comparative method introduced by Potter (1987) was used to derive these parameters.

PI.21.

MARINE AEROSOL FLUXES IN THE COASTAL ZONE – BAEX EXPERIMENTAL DATA

TOMASZ PETELSKI, MARIA CHOMKA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

This paper presents the results of investigations designed to determine the exchange processes between the sea and the air above the coastal zone. The calculations were carried out using experimental data collected by impactor measurements of the marine aerosol above the coastal zone during the Baltic Aerosol Experiment – I and II (BAEX–I, II).

Hydrooptics and optical modelling – PO

PO.01.

IRRADIANCE IN THE EUPHOTIC ZONE OF THE SEA

JERZY DERA
Marine Station, Institute of Geophysics, Polish Academy of Sciences, Sopot

Abstract

This monograph deals with the nature of underwater irradiance as an ecological factor, mainly as a parameter of marine photosynthesis, and contains many results of experiments carried out by the author.

The monograph is divided into five chapters under the following headings:

1. Operational definitions of the optical properties of the sea (p. 11).

2. Seawater components, modifying the underwater light field (p. 18).

3. Attenuation of light entering the sea (p. 27).

4. Fluctuations of underwater irradiance (p. 54).

5. The influence of irradiance on the primary production of organic matter in the sea (p. 69).

Apart from these, Chapter 6 contains conclusions indicating the biological aspects of the optical phenomena discussed. The last part is a supplement comprising a short description and illustrations of some of the measuring instruments used by the author in his work.

PO.02.

AN ANALYSIS OF UNDERWATER VISIBILITY IN THE SEA, BASED ON THE EXAMPLE OF THE GULF OF GDAŃSK

JERZY OLSZEWSKI
Department of Oceanology, Institute of Geophysics, Polish Academy of Sciences, Sopot

Abstract

The influence of the natural light field and the optical properties of seawater on the parameters of underwater visibility are discussed theoretically and illustrated with experimental results. The devices constructed for the investigations are described and the results obtained are presented. Considerable attention is given to visibility in coastal waters, taking the Gulf of Gdańsk as an example. The polarisation method for enhancing the image contrast in the water is also analysed in detail on the basis of the other methods of improving the image quality described. The paper is divided into three chapters:

1. Analysis of the mechanism of image transmission in the sea.
2. Results of investigations of image contrast and image detection range in the Gulf of Gdańsk.
3. Utilisation of the effect of light polarisation for the improvement of image contrast in sea water.

The conclusions, presented in Chapter 4, sum up some important points of the earlier chapters.

PO.03.

EXPERIMENTAL STUDY OF THE COMPOSITE PARTS OF LIGHT-BEAM ATTENUATION IN THE WATERS OF THE GULF OF GDAŃSK

JERZY DERA
Department of Oceanology, Polish Academy of Sciences, Sopot

LUDWIK GOHS
Institute of Marine Research, GDR Academy of Sciences, Warnemünde

BOGDAN WOŹNIAK
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

As a result of comprehensive hydrooptical studies carried out in the Gulf of Gdańsk and adjacent waters in 1972–1975, empirical linear relationships between the various components of light attenuation in seawater were established. The mean statistical percentage of absorption and scattering in the total attenuation of light was determined, as were the proportions of absorption and scattering due to suspended matter and of absorption due to yellow substances. Light wavelengths of 425, 525 and 725 nm were used. In addition, preliminary values were found of the mean mass coefficients of attenuation due to suspended matter and the mean mass coefficients of

absorption due to yellow substances, converted to the content of soluble organic carbon in the water.

PO.04.

EXPERIMENTAL STUDY OF SHORT-PERIOD IRRADIANCE FLUC-
TUATIONS UNDER AN UNDULATED SEA SURFACE

JERZY DERA, JERZY OLSZEWSKI
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The natural downward irradiance fluctuation under a wind-roughened sea surface during sunny and cloudless weather were measured and statistically analysed for various degrees of water turbidity and surface roughness. The experiments were performed in two series – one in the coastal region of the southern Baltic, the other in the Atlantic off Morocco and in the Mediterranean off Spain.

With reference to the first series of experiments, the power spectra of the fluctuations and the statistical distributions of their amplitudes were compared with the relevant spectra of sea surface roughness at the measurement stations (Figs. 1–6). A number of regularities were found concerning the nature of light fluctuation spectra and its changes with respect to surface roughness and solar elevation.

The second part of the paper, covering the second set of experiments, presents a statistical analysis of large amplitude fluctuations, surveyed in open, well-insolated oceanic and Mediterranean waters using a specially-developed measurement technique. Fig. 7 illustrates and explains the measured parameters of this process, Figs. 8–14 show the results of the second series of experiments. Among other things, the occurrence of instantaneous irradiances under a wind-roughened sea surface was demonstrated. These irradiances exceed the average value by three, four and sometimes even five times, and last from a few to several tens of milliseconds. The statistical frequency distributions of such flashes are given, as is their duration in waters of different turbidity, and at different depths and degrees of surface roughness.

PO.05.

THE BASIC OPTICAL PROPERTIES OF THE WATER IN EZCURRA INLET

JERZY OLSZEWSKI

Institute of Oceanology, Polish Academy of Sciences, Sopot

Oceanologia 1984, no. 15, pp. 111–139.

Abstract

The paper presents the results of part of the optical research carried out during the Second Polish Antarctic Expedition (20 Dec. 1977 – 10 Mar. 1978) in Ezcurra Inlet. The aim of the research was to define the typical values and variability intervals of the ray attenuation coefficient c and the diffusional downward irradiance attenuation coefficient k_d. The results are presented in tabular form.

Analysis of the results for the 525 nm light wavelength showed a strong, irregular temporal variability in the parameters over short (< 1 h – Figs. 1 and 2) and longer (10 days – Figs. 3 and 9) periods; during the second half of the research, however, the average values of these parameters in the euphotic zone were found to have increased. The average vertical profile of the light beam attenuation coefficient for the whole research period, together with the corresponding probability distributions approximated by eq. (2) (Figs. 4 and 5), showed that this coefficient decreases rapidly with depth from 1.29 m^{-1} at the surface to 0.76 at 30 m, below which the c changes became inconsiderable (0.76 ± 0.03 m^{-1}).

Further analysis demonstrated good linear correlation between the light beam attenuation coefficients (Figs. 6 and 7, eq. (3)) and the irradiance (Fig. 13, eq. (7)) at three light wavelengths (425, 525, 600 nm), which enabled *i.a.* the mean shape (approximated by eq. (4)) of the entire attenuation coefficient spectrum to be reconstructed (Fig. 8). The main features distinguishing the reconstructed spectrum in comparison to the Baltic c spectrum (Fig. 8) was the distinctly smaller increase in c with the decrease in the light wavelength and the slight shift of the minimum towards the short waves. Such a shape can be explained by the considerably smaller amount of yellow substance than in the Baltic and a correspondingly higher concentration of inorganic suspended matter.

This conclusion is supported by the investigation of the attenuation coefficient and the associated range of the euphotic zone (eq. (5)). High values of the attenuation coefficient close to the surface showed that the range of the euphotic zone was exceptionally large (approx. 24 m) (Fig. 9). This is because *ca* 80% (Fig. 14) of the entire attenuation is due to dispersion

by suspended matter. This last optical feature can be considered the most characteristic of this water basin.

PO.06.

THE INFLOW OF SOLAR ENERGY AND THE IRRADIANCE OF THE EUPHOTIC ZONE IN THE REGION OF EZCURRA INLET DURING THE ANTARCTIC SUMMER OF 1977–1978

BOGDAN WOŹNIAK, RYSZARD HAPTER, BARBARA MAJ
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The object of this study was the natural irradiance of the euphotic zone in the seawater of Ezcurra Inlet in the summer of 1977–1978. The experimental work was carried out on board r/v 'Antoni Garnuszewski' during the 2nd Polish Antarctic Expedition. The results were used to analyse separately the sea-surface irradiance, the irradiance attenuation coefficient in the water and the energy characteristics of light fields within the euphotic zone.

The periodic temporal variability of the magnitudes characterising the irradiance fieldas during daylight hours and the corresponding 24 h light energy doses for the particular days of the study period were defined.

The fluctuations in the natural light fields in this basin were found to be due to characteristically strong temporal variations both instantaneous and diurnal in the optical conditions of the air and sea, affecting not only the spectral content of the radiation diffusing into the sea but also absolute energy values.

PO.07.

A METHOD OF MEASURING THE SIMPLIFIED DIRECTIONAL DISTRIBUTION OF RADIANCE

JERZY OLSZEWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

A method of measuring the angular distribution of radiance in a light field simplified to an axially symmetrical one is described. The principle of the optical system used to make the measurement is described. The

possibility of reproducing of the radiance of a point source is examined and its connection with the geometry of the proposed system is determined.

PO.08.

VERIFICATION OF A MODEL OF UPWELLING RADIANCE ABOVE THE SEA SURFACE

JERZY OLSZEWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

A model of upwelling radiance above the sea, utilising a combination of single and simplified multiple scattering effects, is considered with respect to its credibility. Some results of computations of the vertical diffuse reflection of radiance are compared to the results obtained using the Monte Carlo technique. The comparison shows quite good agreement between the two models.

PO.09.

POLARIMETRIC MEASUREMENT OF VERDET CONSTANTS IN AQUEOUS SOLUTIONS OF SALTS

JÓZEF HELDT, JAN SZCZEPAŃSKI
Institute of Physics, Gdańsk University, Gdańsk
GRAŻYNA KOWALEWSKA, ANDRZEJ ZIELIŃSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

A static method for measuring the angle of polarisation was used to determine the molar rotation and Verdet constants of salts, components of synthetic seawater, synthetic seawater and a sample of natural seawater collected from Gulf of Gdańsk *vs.* the wavelength. It was shown that the total angle of polarisation is an additive value.

PO.10.

SOLAR RADIATION AT THE BALTIC SEA SURFACE

ADAM KRĘŻEL
Institute of Oceanography, Gdańsk University, Gdynia

Abstract

A semi-empirical model for computing monthly solar radiation totals at the Baltic sea surface was carried out. Readily available meteorological data such as atmospheric pressure, water vapour pressure and cloudiness, measured near the sea surface, constituted the input parameters. In comparison to well-known, simplified empirical computation methods, the present model specifies a local atmospheric parameter effect on incoming solar radiation at the sea surface. Using mean monthly values of these meteorological parameters for 10 years (1965–1974), monthly totals of global solar radiation were calculated for 23 meteorological stations in the Baltic area. On the basis of these calculations and the actinometric data collected at 6 existing stations, the distributions of mean monthly solar radiation totals at the Baltic surface were interpolated for every month in a year.

PO.11.

LIGHT SCATTERING IN CRUDE OIL-SEAWATER COLLOIDAL SYSTEMS

JADWIGA MROZEK-LEJMAN
Pedagogical University, Szczecin

ANDRZEJ ZIELIŃSKI, TADEUSZ KRÓL
Institute of Oceanology, Polish Academy of Sciences, Sopot

KONRAD WITKOWSKI
Institute of Physics, Gdańsk University, Gdańsk

Abstract

A method of determining time-dependent changes in the structure of crude oil solutions in artificial seawater as a function of selected physical parameters is presented. The changes indirectly reflect some of the self-purification processes of a marine environment polluted with soluble

and emulsified crude oil derivatives. Laboratory-tested for colloidal solutions of crude oil in artificial seawater, the method utilises light scattering for determining the concentration and average size of oil droplets.

PO.12.

MAXIMUM EFFECTS OF SUNLIGHT FOCUSING UNDER A WIND-DISTURBED SEA SURFACE

JERZY DERA, DARIUSZ STRAMSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The intense fluctuations of natural (downward) irradiance E within the green spectral range (525 nm) caused by the focusing of solar beams by the surface waves have been experimentally examined in the uppermost few metres of the photic zone in different sea and oceanic areas. The frequency of underwater light flashes, *i.e.* irradiance pulses that exceed the mean irradiance $\bar{E}$ by a factor of more than 1.5, is as high as about 200 min^{-1} at a standard depth of 1m. The decrease in frequency with increase in flash intensity was found to be exponential, so that the frequency of the strongest flashes ($E > 5\bar{E}$) is at most of the order of 1 per minute. The most probable duration of underwater flashes (on the 1.5 $\bar{E}$ level) at 1 m depth appears to lie between 10 ms and 30 ms. The probability of the density function of flash durations is skewed and in many cases shows quite close agreement with a log-normal distribution. As water depth increases, the intensity of irradiance fluctuations becomes smaller and the flash durations tend to increase. The focusing of sunlight under a wind-disturbed sea surface was found to be most effective in clear waters under clear skies with high solar altitudes and light winds between 2 and 5 m s^{-1}, which correspond to a relatively smooth water surface.

PO.13.

THE POSSIBILITY OF REMOTE EVALUATION OF SOME OPTICAL PROPERTIES OF SEAWATER

JERZY OLSZEWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

A simple method of remotely evaluating the ratio of back-scattering to absorption of light in seawater is presented. Two basic concepts have been developed: one deals with the remote determination of surface effects using the measurements in the near infrared as reference point, while the other involves the measurement of the azimuthally averaged angular distribution of incident radiance.

PO.14.

THE EFFECT OF CRUDE OIL POLLUTANTS ON THE DIFFUSIVE REFLECTANCE OF THE OCEAN

KRZYSZTOF MAŁACHOWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot
JADWIGA MROZEK-LEJMAN
Marine Physics Department, Szczecin University, Szczecin

Abstract

The contrast between a clean and a volumetrically contaminated ocean has been numerically determined for natural red light ($\lambda = 630$ nm) on the basis of laboratory measurements of optical parameters of emulsions and solutions of crude oil in seawater. Strongly absorbing crude oil emulsions decrease the quantity of light reflected by the ocean, whereas the crude oil solutions increase the diffuse reflection of radiance in that they raise the quantity of backscattered light.

PO.15.

THE POSSIBLE APPLICATION OF A POLARIMETRIC METHOD FOR DETERMINING SALINITY IN SEAWATER

ANDRZEJ ZIELIŃSKI, GRAŻYNA KOWALEWSKA
Institute of Oceanology, Polish Academy of Sciences, Sopot
JÓZEF HELDT, JAN SZCZEPAŃSKI
Institute of Physics, Gdańsk University, Gdańsk

Abstract

The paper presents a static polarimetric method used for measuring the angle of polarisation of synthetic seawater as a function of wavelength and salinity. It has been proven that the total rotation angle of the plane of polarisation has – in the case of synthetic seawater – the property of additivity. This permits the polarimetric method to be used to determine seawater salinity. The conditions under which the method can be used are discussed.

PO.16.

THE EFFECT OF DAYLIGHT DIFFUSENESS ON THE FOCUSING OF SUNLIGHT BY SEA SURFACE WAVES

DARIUSZ STRAMSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

By assuming that, in view of sunlight focusing by surface waves, only a direct component of underwater irradiance varies in time, a simple theory is developed for the statistics of flashing light as a function of daylight diffuseness. The results show little variation of flash characteristics with diffuseness, if this is below 0.5–0.6, when compared with that for higher diffuseness. A particularly abrupt decrease in frequency and maximum intansity of underwater flashes is found for diffuseness greater than 0.7–0.8. Simultaneous measurements of the diffuseness of surface irradiance and underwater flashing light within the green spectral band made in the Baltic are used to demonstrate
(i) the range of diffuseness values to be expected under a clear sky,
(ii) the variability of diffuseness with time of day and from day to day, and
(iii) the effect of changing diffuseness on the frequency distribution of flash intensity.

PO.17.

A MECHANISM FOR PRODUCING FLASHING LIGHT UNDER A WIND-DISTURBED WATER SURFACE

DARIUSZ STRAMSKI, JERZY DERA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

By means of a simple numerical analysis the focusing effect is re-examined in the context of recent experimental data on near-surface strong flashes of irradiance. For relating this unusual optical effect to surface wave dimensions, the variations in light intensity as a result of the focusing produced by the realistic profile of short-fetch wind-generated water waves are calculated. The theoretical predictions compare well with the experimental data. These results, together with additional approximate calculations, are sufficient to deduce that small, smooth waves with a steepness of the order of 10^{-2} and a length of several centimetres, *i.e.* in the gravity-capillary transition region, may be of direct importance in the problem of underwater flashing light. Recalling the earlier theory of Schenck (1957), the importance of short, steep gravity waves of up to 1 m or so in length is also suggested. The validity of theoretical predictions is demonstrated by measurements of flashing light in a short-fetch water tank with steadily generated surface waves exposed to sunlight.

PO.18.

THE LIGHT-ABSORBING CAPACITY OF PHYTOPLANKTON IN THE GULF OF GDAŃSK IN MAY 1987

B. V. KONOVALOV, G. A. BELAYEVA
P. P. Shirshov Institute of Oceanology, USSR Academy of Sciences, Moscow
O. D. BEKASOVA
A. N. Bach Institute of Biochemistry, USSR Academy of Sciences, Moscow
A. KOSAKOWSKA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

In order to estimate the efficiency of marine phytoplankton photo-synthesis by a direct method, the natural variability of phytoplankton characteristics reflecting its light absorption capacity was studied. Thus, the absolute and specific phytoplankton spectral absorption coefficients and their mean values for the PAR range, as well as the pigment index $I_{441/675}$ were studied. Light absorption was measured on natural marine phytoplankton from the Gulf of Gdańsk. Two hundred and thirty samples drawn from ten depths between 0 and 30 m every six hours during several days were analysed. The absolute values of the absorption coefficient were observed to vary by a factor of almost 15 from 0.057 m^{-1} to 0.85 m^{-1} (at 441 nm) and from 0.038 m^{-1} to 0.55 m^{-1} (at 675 nm). Phytoplankton absorption coefficients, normalised by the chlorophyll concentration, were equal to 0.021 ± 0.004 m^2 (mg Chl a)$^{-1}$ at 675 nm and 0.033 ± 0.007 m^2 (mg Chl a)$^{-1}$ at 441 nm. At 675 nm the value of the absorption coefficient exceeded its mean value within the PAR range 1.2 ± 0.12 times on average. A negative linear correlation was found between the specific absorption coefficients at 675 nm and the Chl a concentration, the slope of the regression line increasing with depth.

The pigment index $I_{441/675}$ varied from 1.29 to 2.04. The value of $I_{441/675}$ averaged for each depth increased steadily with depth, starting from 5 m.

PO.19.

FLUORESCENCE VARIABILITY OF DISSOLVED AND SUSPENDED SUBSTANCES OF BIOLOGICAL ORIGIN IN THE GDAŃSK BASIN DURING THE INTERNATIONAL ECOLOGICAL EXPERIMENT 'SOPOT′87'

G. S. KARABASHEV, S. A. KHANAYEV, A. Y. PETROSOV
Atlantic Branch, P. P. Shirshov Institute of Oceanology, USSR Academy of Sciences, Kaliningrad

Abstract

The fluorescence variability of chlorophyll and dissolved organic matter, temperature and light scattering were investigated with a submersible fluorometer at two stations in the Gdańsk Basin in spring 1987. It was established that water motion played a key role in the daily and short-term variability of these parameters. The correlation estimates showed

that the chances of predicting the distribution of these compounds from measurements of temperature or other abiotic factors were poor under the experimental conditions. In order to improve the understanding of variability of ecosystem parameters in the Gdańsk Basin it is necessary to obtain a series of 3-dimensional distributions of oceanological characteristics covering the area under study.

PO.20.

A STUDY OF BALTIC WATER OPTICAL TRANSPARENCY

JERZY DERA, SŁAWOMIR SAGAN
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The spatial and temporal variability in the light beam attenuation coefficient in the visible light spectrum in the southern Baltic is presented. This coefficient varied from about 0.3 m^{-1} to 4.5 m^{-1} at 425 nm. The results of *in situ* measurements collected during the international PEX′86 experiment as well as the results of measurements performed by the authors during several cruises in 1986–1988 were used to prepare a set of optical characteristics of the region in question. Some earlier literature data were also taken into account. On the basis of theoretical formulae and other empirical investigations, the contribution of absorption and scattering to light attenuation were estimated at the selected wavelengths. The possibility of estimating of the underwater visibility from attenuation coefficient data is also explored.

PO.21.

COMPARISON OF TWO SPECTROPHOTOMETRIC METHODS OF CHLOROPHYLL a DETERMINATION IN SEAWATER SAMPLES (Communications)

O. D. BEKASOVA
A. N. Bach Institute of Biochemistry, USSR Academy of Sciences, Moscow
B. V. KONOVALOV
P. P. Shirshov Institute of Oceanology, USSR Academy of Sciences, Moscow

A. KOSAKOWSKA, S. KACZMAREK Institute of Oceanology, Polish Academy of Sciences, Sopot

Oceanologia 1990, no. 28, pp. 123–126, (no abstract).

PO.22.

OPTICAL ABSORPTION PROPERTIES OF PHYTOPLANKTON IN VARIOUS SEAS

BOGDAN WOŹNIAK, MIROSŁAWA OSTROWSKA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

This is a review of the experimental data concerning the absorption properties of marine phytoplankton. On the basis of our own and accessible literature data, the spectra and absolute magnitudes of the light absorption coefficients by phytoplankton, as well as their connections with the chlorophyll a concentration recorded in different areas of the World Ocean have been characterised.

Also analysed are the similarities and differences in phytoplankton absorption properties measured *in vivo* and *in vitro* in acetone extracts of phytoplankton. In this way many empirical correlations between the *in vitro* and *in vivo* spectra were determined. This facilitated the development of a semi-empirical, mathematical model of living phytoplankton absorption properties on the basis of the known optical properties of its extracts in acetone.

Using this semi-empirical model and pigment distribution data for different seas (Woźniak and Ostrowska, 1990), the typical features of light absorption by phytoplankton in different biological types of seas were determined.

PO.23.

A FLUORESCENCE *IN SITU* METHOD FOR DETERMINING THE CHLOROPHYLL a CONCENTRATION IN THE SEA

MIROSŁAWA OSTROWSKA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper presents a statistical analysis of experimental data concerning the effect of chlorophyll a concentration and optical depth in a sea on artificially induced phytoplankton fluorescence. Certain empirical correlations were found between these quantities. They were applied in the development of fluorometric methods of determining the chlorophyll a concentration on the basis of the *in situ* fluorescence. The results of the preliminary experimental validation of these methods are also presented.

PO.24.

ELIMINATION OF THE SURFACE BACKGROUND IN CONTACTLESS SEA INVESTIGATIONS

JERZY OLSZEWSKI, MACIEJ SOKÓLSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

A method of surface background elimination in contactless optical investigations of the marine environment has been developed and verified under natural conditions. The method utilises the properties of the time plot of upward radiance changes over a wind-disturbed sea surface, thereby enabling the surface reflected radiance to be instantaneously cut off with a black screen. It was established that the method is very efficient and enables the radiance to be determined from below the surface during the normal motion of a vessel under moderate hydrometeorological conditions.

PO.25.

SOLAR RADIATION VARIABILITY OVER THE BALTIC SEA DUE TO WEATHER CONDITIONS

JERZY DERA, ANNA ROZWADOWSKA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The variability of solar radiation flux reaching the southern Baltic Sea surface is analysed. Fluctuations on various time scales, from milliseconds

to years, are considered. Statistical characteristics of solar energy flux variability are given. The characteristics are based on meteorological and actinometric data, as well as on modelling of solar radiation transfer through the atmosphere.

PO.26.

OPTICAL CLASSIFICATIONS OF THE SEAS IN RELATION TO PHYTOPLANKTON CHARACTERISTICS

BOGDAN WOŹNIAK
Institute of Oceanology, Polish Academy of Sciences, Sopot

VADIM N. PELEVIN
P. P. Shirshov Institute of Oceanology, USSR Academy of Sciences, Moscow

Abstract

The paper compares and analyses the optical and bio-optical classifications of natural marine basins most often quoted in the literature, as well as an attempt to estimate their accuracy. The authors present two original classifications, worked out from statistical analyses of experimental downward irradiance attenuation spectra. The phytoplankton effect and the influence of other optical components on this downward irradiance attenuation is also discussed. A quantitative description of phytoplankton resources in the basin as related to selected components of the light attenuation coefficients in the water column is given.

PO.27.

ALGORITHM FOR ESTIMATING PRIMARY PRODUCTION IN THE SEA FROM SATELLITE SENSING

VADIM N. PELEVIN
P. P. Shirshov Institute of Oceanology, USSR Academy of Sciences, Moscow
BOGDAN WOŹNIAK
Institute of Oceanology, Polish Academy of Sciences, Sopot
OLGA J. KOBLENTZ-MISHKE
P. P. Shirshov Institute of Oceanology, USSR Academy of Sciences, Moscow

Abstract

The article presents an algorithm for determining primary production in the sea from multispectral, optical data obtained by satellite sensing. Unlike algorithms proposed by other authors, a number of less precise correlations between 'extremely distant' physical and biological parameters have been replaced by relationships based on marine plant physiology. In particular, the algorithm applies a semiempirical mathematical model of light absorption by the photosynthetic apparatus specific to various natural phytocoenoses. The algorithm also combines the statistically generalised correlations between the efficiency of phytoplankton photosynthesis and optical depth.

PO.28.

GREEN LIGHT PENETRATION DEPTH IN PUCK BAY
(Communications)

MACIEJ MATCIAK, ADAM KRĘŻEL
Institute of Oceanography, Gdańsk University, Gdynia

PO.29.

SOME OPTICAL PROPERTIES OF SURFACE WATERS IN THE
NORTH-WESTERN TROPICAL ATLANTIC

ADAM KRĘŻEL
Institute of Oceanography, Gdańsk University, Gdynia

MAREK KAMIENIECKI
Institute of Marine Sciences, Szczecin University, Szczecin

Abstract

The colour of the ocean, photosynthetically active radiation (PAR) and some optical properties of the surface waters of the north-western Tropical Atlantic were measured during the cruise of r/v 'Akademik Vernadski'

in June and July 1987. The superposition of the downwelling irradiance attenuation coefficients in the blue (425 nm), green (535 nm) and PAR (400–700 nm) spectral bands in the spatial distribution of optical water types in the region are presented (Fig. 5). Except for the area directly influenced by the Amazon river, the waters in the region were found to be extremely clear, *i.e.* belonging mainly to classes I to IB in Jerlov's classification.

The colour indices obtained from measurements of sea surface spectral reflectance were compared with the chlorophyll *a* concentration in the optical penetration depth layer. The low chlorophyll concentration and its small variability were probably the reason why these dependences were weak in comparison to those previously reported for Class 1 waters.

If the cloudiness does not exceed 7, the maximum possible daily PAR ranges from 1200 to 1800 μE m^{-2} s^{-1} just under the sea surface, from 500 to 800 μE m^{-2} s^{-1} at a depth of 10 m, and from 250 to 400 μE m^{-2} s^{-1} at 25 m (Fig. 8).

PO.30.

BIO-OPTICAL RELATIONSHIPS FOR ESTIMATING PRIMARY PRODUCTION IN THE OCEAN

BOGDAN WOŹNIAK, JERZY DERA
Institute of Oceanology, Polish Academy of Sciences, Sopot

OLGA J. KOBLENTZ-MISHKE
P. P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow

Abstract

Numerous empirical data from 9 large Polish–Russian research expeditions and other smaller expeditions to various regions of the World Ocean in 1978–1991 were used to compile this first approximate model of statistical relationships, chiefly between the concentration of chlorophyll *a* and the solar irradiance just below the sea surface on the one hand, and the vertical distribution of chlorophyll *a*, phytoplankton absorption spectra, downward irradiance attenuation spectra, the quantum yield of photosynthesis, as well as other mean diurnal characteristics of primary production in waters of different trophicity on the other. These model relationships served to work out an algorithm for computing the vertical distributions of light energy and

primary production characteristics in particular types of sea water from data on chlorophyll *a* concentration and irradiance at the sea surface.

Verification of these model formulas with the aid of empirical data from a variety of sources has shown that they provide good results – the mean statistical errors with respect to *in situ* measurements range from *ca* 10% to 80%, depending on the characteristic in question.

In order to improve the accuracy of this algorithm, a much larger number of statistical data will be needed, and closer attention will have to be paid to the effect of nutrients and other environmental factors on the characteristics being assessed. This algorithm could be especially useful in the remote sensing of primary production in the ocean.

PO.31.

SPATIAL AND TEMPORAL CHANGES IN SOME OPTICAL PARA-METERS IN THE SOUTHERN BALTIC

JERZY OLSZEWSKI, SŁAWOMIR SAGAN, MIROSŁAW DARECKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The spatial and temporal changes of the light beam attenuation coefficient and colour index, measured in the southern Baltic in 1987–1990, are presented. Noticeable regularities in the changes, suggesting some spatial – seasonal classification of the waters investigated, are pointed out and discussed. Grouping the results into separate spring and autumn sets, as well as into open and coastal water sets, yields a quite good correlation between blue, green and red light beam attenuations, and between the depth of the euphotic zone and the colour index.

PO.32.

WATER TRANSPARENCY IN THE POLISH ZONE OF THE BALTIC SEA (Communications)

ANNA TRZOSIŃSKA
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Abstract

Statistical analysis of water transparency measurements using the Secchi disc indicated a significant decrease in transparency in 1957–1990. The intensity of this negative trend varied according to region, season and period. The general decrease in water transparency expressed by modals ranged from about 3 m in the Gulf of Gdańsk and open-sea water of the southern Baltic to over 3.5 m in the Pomeranian Bay and shallow coastal areas of the central Polish coast.

In the Gdańsk Deep the mean coefficient of the negative trand in water transparency was very high (-0.08 m y^{-1}) and statistically significant in the growing seasons of 1957–1990, thus indicating a close relation with the eutrophication of the entire Baltic Sea.

PO.33.

RADIANCE REFLECTANCE OF HOMOGENEOUS PLANE PARALLEL LAYERS

JOACHIM DOMSTA
Institute of Mathematics, Gdańsk University, Gdańsk

Abstract

A differential equation for the radiance reflectance is derived. It is valid for horizontally homogeneous vertically stratified layers, *i.e.* when the inherent parameters depend on the depth only. The considerations apply to any monochromatic radiation with arbitrary angular distribution; the azimuthal invariance is not required. For homogeneous layers, where the inherent parameters are depth-independent, a formula is given for the radiance reflectance in the dependence of the 'bottom' reflectance.

Some problems related to possible applications, *e.g.* when solving the 'direct' problems of evaluating the radiance of the light field in water bodies, are presented in a brief discussion.

PO.34.

FOCUSING OF SUNLIGHT BY SEA SURFACE WAVES: NEW RESULTS FROM THE BLACK SEA

JERZY DERA, SŁAWOMIR SAGAN
Institute of Oceanology, Polish Academy of Sciences, Sopot

DARIUSZ STRAMSKI
Department of Biological Sciences, Southern California University, Los Angeles

Abstract

Under clear skies, strong fluctuations in the downwelling irradiance E_d prevail in shallow water as a result of the focusing and defocusing of sunlight by surface waves. Such temporal fluctuations were measured in the Black Sea, usually at a depth of 1 m, from a fixed platform located 600 m off the coastline. Thresholding analysis was applied to 109 time-series records of $E_d(525$ nm$)$, each of which lasted 10 min. The frequency of occurrence of intense foci flashes (intensity exceeding the time-averaged irradiance $\bar{E}_d$ by $> 50\,\%$) decreased exponentially with increasing flash intensity. The frequency and intensity of flashes, hence the slope of the exponential relationship, both varied with wind-wave conditions and atmospheric illumination. The best conditions for wave focusing were characterised by light winds of 2 to 5 m s^{-1}, solar elevation $> 40°$, and diffuseness of surface irradiance $< 40\,\%$. Then, at a depth of 1 m, flashes $> 1.5\,\bar{E}_d$ occurred at rates as high as 6 Hz. The most intense flashes exceeded $\bar{E}_d$ 5-fold at rates of 10^{-3} Hz. These results, consistent with our previous observations, substantially improve the database on still poorly-documented wave focusing effects.

PO.35.

THE AEROSOL OPTICAL THICKNESS OF THE ATMOSPHERE OVER THE NORWEGIAN SEA OBTAINED FROM DIFFERENT EXPERIMENTAL DATA

JOLANTA KUŚMIERCZYK-MICHULEC
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The aerosol optical thickness at visible wavelengths for the marine aerosol is analysed. Several methods prior to atmospheric correction are compared for the case when the only known optical parameter is one of the following: irradiance, visibility, relative humidity or aerosol size distribution. Experimental data measured in 1987–1989 and 1991–1992 in the Norwegian and Arctic Seas are used to verify the theoretical models.

PO.36.

THE INFLUENCE OF THE MARINE AEROSOL ON ATMOSPHERIC EXTINCTION

JOLANTA KUŚMIERCZYK-MICHULEC
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The simulations presented in this paper were carried out for a range of wavelengths from $0.3\,\mu$m to $1\,\mu$m. Two different size distributions of the marine aerosol are assumed, both represented by the modified gamma function. The parameter values are calculated on the basis of experimental data. Next, modified gamma functions are used to calculate the extinction, scattering and absorption efficiencies. The main result of this paper is that the choice of size distribution of marine aerosols influences the values but not the shapes of functions.

PO.37.

THE LIGHT SCATTERING MATRIX OF *CHLORELLA VULGARIS* CELLS AND ITS VARIABILITY DUE TO CELL MODIFICATION

KONRAD WITKOWSKI
Institute of Experimental Physics, Gdańsk University, Gdańsk

TADEUSZ KRÓL, MARIA ŁOTOCKA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Laboratory light scattering measurements were performed for suspensions of axenic cultures of the unicellular alga *Chlorella vulgaris*. 10 functions constituting the scattering Müller matrix were measured at three incident light wavelengths ($\lambda = 633$ nm, 514 nm and 488 nm) for live cells and for cells whose internal structures had been chemically or mechanically modified. For medium scattering angles ($30° \leq \theta \leq 120°$) the scattering process is strongly influenced by submicron intracellular structures which are both absorbent and optically anisotropic.

Some of light scattering characteristics display a distinct correlation with the physiological evolution stage of a live cell culture.

PO.38.

THE INHOMOGENEITY OF VERTICAL DISTRIBUTIONS OF SUSPENDED MATTER IN THE SEA – CONSEQUENCES FOR REMOTE SENSING

KATARZYNA BRADTKE, ADAM KRĘŻEL
Institute of Oceanography, Gdańsk University, Gdynia

Abstract

The influence of the vertical variability of suspended matter $C(z)$ within the optical penetration layer on the reflectance $R(\lambda)$ over the sea surface in the southern Baltic and the Gulf of Gdańsk were analysed. Using Gordon and Clark's model the value of reflectance $R(620)$, taken to be representative of AVHRR channel 1, was calculated. Various vertical seston profiles obtained after previous analysis of real distributions of suspended matter in the surface layer of the sea were taken to be input parameters.

The variability of vertical seston distribution on $R(620)$ was found to be negligible except when the surface concentration exceeded 8 mg dm^{-3} and rapidly decreased with depth. In order to estimate the seston content of the sea surface layer using optical remote sensing methods, the best results should be achieved when comparing reflectance with the 'optically-weighted concentration' defined by Gordon and Clarke (1980). Except in areas close to river mouths and other terrestrial sources of seston in the Baltic, the

vertical variability of suspended matter within the optical penetration layer (typically a few metres) is rather small. This means that surface measurements of seston concentration can be used to calibrate the $C = f(R)$ relationship.

Using AVHRR channel 1 data it is possible in the southern Baltic to record surface changes in suspended matter concentration of the order of 0.5 mg dm^{-3}.

PO.39.

FLUOROMETRIC METHOD FOR DETERMINING THE THICKNESS OF A CRUDE OIL FILM FORMED ON THE WATER SURFACE

RADOSŁAW GĄSOWSKI, JADWIGA MROZEK-LEJMAN
Marine Physics Department, Szczecin University, Szczecin

Abstract

An active remote method for determining the thickness of a crude oil spill on a seawater surface was worked out and tested in the laboratory. In this 'fluorometric' method, the differences in optical and fluorescence properties of various types of crude oil were employed.

For selected types of crude oil, experimental pattern curves characterising the dependence of the fluorescence intensity signal I_f on the thickness of crude oil layer d were determined for the fluorescence signal at $\lambda_f = 700$ nm, which approximately related to the sensitivity maximum. A He–Ne laser was used as the exciting source. The results of pattern curve measurements were approximated by the theoretical function $I(d)$. Values of the constant of the function $I(d)$ for particular kinds of crude oil provided the data base for further calculations of the crude oil film thicknesses on the water surface. The method of calculating the thickness of crude oil films formed on the surface of artificial seawater of various salinities on the basis of recorded values of fluorescence signals is presented. The results show that the method introduced in this paper is suitable for practical application.

PO.40.

THE INFLUENCE OF AN OIL-FILM COVERED SEA SURFACE ON THE REFLECTION AND UPWARD TRANSMISSION OF LIGHT

ZBIGNIEW OTREMBA
Physics Division, Maritime Academy, Gdynia

Abstract

This paper presents the results of investigations focused on the influence of oil spills on the optical properties of the sea surface. The model of light transmission and reflection from the triple air-oil-water layer system is presented. The mathematical equations include the complex refractivity of various oils previously identified in the laboratory. Upward transmission and reflectivity dependences on wavelength and angle of incidence were investigated, as were the temperature and thickness of oil layers. The results show that the short functions of the three above-mentioned parameters oscillate rapidly. Several functions were identified after averaging over thickness. The investigations were carried out with the intention of using their results in a model of the upward light field over an oil-polluted sea surface.

PO.41.

A SEMI-EMPIRICAL EXPRESSION FOR THE SOLAR SPECTRAL DIFFUSE IRRADIANCE AT THE SEA SURFACE

JOLANTA KUŚMIERCZYK-MICHULEC
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

A simple, semi-empirical expression, valid in the visible spectrum for calculations of the solar diffuse irradiance, is presented. This relation is based on experimental data collected on cloudless days in 1993 and 1994 over the southern Baltic Sea. In order to illustrate the accuracy of the proposed formula, the aerosol optical thickness is calculated. The semi-empirical diffuse irradiance model can be used to make accurate calculations of the solar spectral diffuse irradiance and the aerosol optical thickness.

PO.42.

THE APPLICATION OF THE OPTICAL CLASSIFICATION OF WATERS IN THE BALTIC SEA (CASE 2 WATERS) (Communications)

SŁAWOMIR KACZMAREK, BOGDAN WOŹNIAK
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

In this study, the spectral values of the diffuse attenuation coefficients for downwelling irradiance $K_d(\lambda)$, which were measured in the visible spectrum in the Baltic Sea, are compared with similar spectra obtained theoretically on the basis of the classification of the optical properties of Case 1 Waters developed by Woźniak. The analysis of 481 pairs of spectra $K_d(\lambda)$ shows that in order to use this classification for a description of Baltic waters, it is necessary to introduce into it a new component $\Delta K(\lambda)$ $[\mathrm{m}^{-1}]$, which may be approximated by

$$\Delta K(\lambda) = 0.0716 e^{-0.0117(\lambda - 550)},$$

where λ [nm] is the wavelength.

The form of the equation approximating the $\Delta K(\lambda)$ spectrum and the value of the exponential factor suggest that the term $\Delta K(\lambda)$ is related to a high concentration of allogenic yellow substance in the Baltic Sea.

PO.43.

THE ASSIMILATION OF LIGHT ENERGY BY MARINE PHYTO-PLANKTON. PART 1. THE LIGHT ABSORPTION CAPACITY OF THE BALTIC AND BLACK SEA PHYTOPLANKTON (METHODS; RELATION TO CHLOROPHYLL CONCENTRATION)

OLGA J. KOBLENTZ-MISHKE
P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow

BOGDAN WOŹNIAK, SŁAWOMIR KACZMAREK
Institute of Oceanology, Polish Academy of Sciences, Sopot

B.V. KONOVALOV
P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow

Abstract

This paper discusses the significance of the light absorption capacity of marine phytoplankton as a measure of the photosynthetically active phytoplankton biomass, and as a means of calculating the energy flux at the input of the production process; its necessity in evaluating the efficiency of phytoplankton photosynthesis and working out models of primary production in the sea is stressed.

The methods worked out by the authors of this paper and by other specialists are reviewed, and the values of light absorption by phytoplankton obtained during five cooperative cruises to the Baltic and Black Seas are compared with data published by other authors. These values demonstrate good agreement with the results of modelling light absorption by phytoplankton inhabiting waters of different productivity.

PO.44.

A METHOD FOR THE CONTINUOUS MEASUREMENT OF THE DIFFUSIVITY OF THE NATURAL LIGHT FIELD OVER THE SEA (Communications)

JERZY OLSZEWSKI, JOLANTA KUŚMIERCZYK-MICHULEC, MACIEJ SOKÓLSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

This paper discusses a method of measuring the diffusivity of the atmospheric natural light field continuously and automatically even on board a ship in motion. The idea of this method is to remove cyclicly from the photodetector's field of view successive parts of the horizon (one of them including all direct solar radiation), and is implemented by means of a strip diaphragm with fixed dimensions, rotating automatically around the optical axis of a cosine collector.

The usefulness of the strip method was justified on the basis of a comparison with the disc method (the Sun covered by a disc) and comparative error analysis.

PO.45.

ANALYSIS OF TEMPORAL AND SPATIAL VARIABILITY OF 'YELLOW SUBSTANCE' ABSORPTION IN THE SOUTHERN BALTIC

PIOTR KOWALCZUK, SŁAWOMIR KACZMAREK
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The value of the yellow substance absorption coefficient in the visible-light spectrum is a very important characteristic used in the optical classification of seawaters. The absorption of yellow substance also needs to be included in algorithms for the remote detection of optically-active seawater constituents. This paper presents the results of an analysis of yellow substance absorption coefficient data, a_y, collected during 11 cruises in the southern Baltic. The statistical distribution of the value of a_y ($\lambda = 400$ nm) and the value of the yellow substance absorption spectrum slope coefficient are analysed. The range of spatial and temporal variability of these parameters is discussed, and the auto-correlation matrix of the absorption coefficient measured at different wavelengths is analysed. Particular attention is given to selected wavelengths, essential in evaluating the influence of changes of a_y on the spectral reflectance.

PO.46.

DETERMINATION OF THE STRUCTURE OF AN OIL-SEAWATER EMULSION FROM MEASUREMENTS OF LIGHT ATTENUATION

MARIAN STOŃ
Institute of Physics, Pedagogical University, Słupsk

Abstract

The effect of the statistical distribution parameters of nonabsorbing particles on the transparency of polydispersive systems is described. A method of inverting the transmission spectra into the size distribution of scattering particles is presented. It was tested on an emulsion of Baltic crude oil in artificial Baltic seawater and was found to provide useful information on the structure of emulsions containing particles $< 1\ \mu$m in size.

PO.47.

INFLUENCE OF CLOUDS ON THE BROADBAND SPECTRAL IRRADIANCE AT THE BALTIC SURFACE

ANNA ROZWADOWSKA
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

On the basis of downward irradiance data in the ultraviolet, visible and infrared spectral intervals as well as of meteorological observations collected during several cruises to the Baltic, the influence of clouds and solar zenith angle on the broadband spectral composition of solar radiation reaching the Baltic surface is analysed. The relation between the atmospheric transmittance of total irradiance and solar zenith angle, and the ratios of broadband spectral irradiance to the total for both visible and infrared radiation have been estimated by polynomials.

PO.48.

THE AEROSOL OPTICAL THICKNESS OVER THE BALTIC SEA

JOLANTA KUŚMIERCZYK-MICHULEC, MIROSŁAW DARECKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The results of applying empirical orthogonal functions (EOF) to the decomposition and approximation of spectra of the aerosol optical thickness are presented. The aerosol optical thickness is calculated on the basis of the experimental data of the direct and diffuse irradiances collected on cloudless days in 1993 and 1994 over the southern Baltic Sea. The main finding is that the amplitude of aerosol optical thickness in the visible spectrum is dependent on air temperature.

PO.49.

THE STANDARD CZCS ALGORITHM: FOUND TO BE INAPPRO-PRIATE FOR THE ATMOSPHERE OVER THE BALTIC SEA

JOLANTA KUŚMIERCZYK-MICHULEC
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

In the standard CZCS atmospheric correction method the aerosol radiance is derived on the assumption that the water-leaving radiance at 670 nm is zero. This assumption, justified for water whose reflectance is determined solely by absorption (Case 1 Waters), gives rise to errors where the reflectance of the water is significantly influenced by scattering (Case 2 Waters), *e.g.* the Baltic Sea. The values of the aerosol radiance are too high and those of water-leaving radiance too low in comparison with the experimental ones. The relative error for the aerosol radiances (normalised to their values at 670 nm) decreases with wavelength from 60% at 443 nm to 13% at 550 nm.

PO.50.

MATHEMATICAL SPECTRAL MODEL OF SOLAR IRRADIANCE RE-FLECTANCE AND TRANSMITTANCE BY A WIND-RUFFLED SEA SURFACE. PART 1. THE PHYSICAL PROBLEM AND MATHEMATI-CAL APPARATUS

SŁAWOMIR B. WOŹNIAK
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

A spectral model of solar irradiance reflectance from and transmittance through a wind-ruffled sea surface is developed in two papers. This, the first paper, discusses the mathematical apparatus of the model. Dependences for sea surface slope distribution (based on Cox and Munk, 1954) and the foam coverage of the sea surface (based on Gordon and Jacobs, 1977), both these distributions having been modified by the author, were used in the modelling. Being direct functions of a dynamic factor, $i.e.$ the mean height of the waves $\bar{H}$, they take the influence of environmental (hydrometeorological and geometrical) factors into account. The Snell and Fresnel laws were applied to the light transmission through the surface. Polarisation effects were neglected.

Waves, tidal oscillations and sea level studies – PW

PW.01.

SPECTRAL DENSITIES OF LONG-PERIOD OSCILLATIONS IN THE LEVELS OF THE BALTIC SEA

ANDRZEJ WRÓBLEWSKI
Department of Oceanology, Institute of Geophysics, Polish Academy of Sciences, Sopot

Abstract

Calculations based on sea level measurements at Kołobrzeg confirmed the fact that periodic oscillations of 0.5, 1, 3, 5–6 and 11 years occur in the Baltic. The one-year period showed the greatest amplitude of oscillation; this was followed by the 0.5-year period, which was, however, much weaker. The remaining periods displayed no distinct regularity. The relationship between the 11-year period and the changes in solar activity represented by Wolf numbers given in previous studies (Kowalik and Wróblewski, 1973) was confirmed by the analysis of the data from Kołobrzeg.

Analyses of the periodicity of air temperature, atmospheric pressure, rainfall, riverine outflow and other geophysical elements, carried out on the basis of published results, showed that no coherent equivalent was found in the oscillations of the phenomena studied so far and or in the long-term fluctuations in Baltic water levels.

To explain this divergence, it was assumed in accordance with the dynamics of these phenomena that long-term oscillations of the Baltic Sea levels depend primarily upon the mean annual distribution of wind speeds and directions above the sea basin and neighbouring waters. The action of this factor is supplemented by other aspects of water level dynamics which are of secondary importance.

PW.02.

SEICHES IN THE ŚWINA STRAITS CONNECTING THE POMERANIAN BAY WITH THE SZCZECIN LAGOON

ZYGMUNT KOWALIK
Department of Oceanology, Institute of Geophysics, Polish Academy of Sciences, Sopot

Abstract

Tide gauge measurements of water levels have shown, among other things, the existence of periodic oscillations of levels in the Świna straits. The role of these changes in the dynamics of the straits, as well as their origin, are discussed in this paper.

Assuming that the straits can be illustrated in the form of a system of canals, as in Fig. 2 – the periods of the system were calculated on the basis of the equation of motion and continuity, after which the distribution of the amplitudes of standing waves along the whole length of particular branches of the canal was computed. The solution to this problem was obtained by means of a computer.

In the next stage, utilising tide gauge measurements, the distributions of spectral density of energy were calculated at periodic intervals similar to periods of natural oscillations. The existence of two fundamental maxima in the spectral density was noted – with periods of about 60 minutes and about 110 minutes. These periods are very similar to those calculated theoretically. From this and the cross-correlation calculations it can be concluded that these maxima belong to seiches – natural oscillations of the standing wave type.

Based on data concerning seiche waves obtained from tide gauge records, the influence of these waves on currents in the straits was also analysed.

PW.03.

KINEMATIC CHARACTERISTICS OF WIND WAVES

STANISŁAW MASSEL
Institute of Hydroengineering, Polish Academy of Sciences, Gdańsk

Abstract

The interaction between the sea and the air has been indicated by the exchange of energy at the interface. On the surface, this exchange causes strong wave motion. Our knowledge of sea surface dynamics has been considerably improved by recent research. The most important parameters of this surface have been described, and approximated by statistical and spectral theories of wind waves.

It was generally assumed that the linear theory of potential waves, for kinematic characteristics as well, did not differ much from observed reality. However, more detailed research recently conducted has indicated the necessity to revise this opinion. Non-linear effects of the motion have

been visible to a much greater extent for kinematic characteristics than in the case of free surface oscillations.

One cause of non-linear effects is turbulence, which is particularly strong in the upper layer of the sea. Within the hypothesis of the so-called weak interaction, wave motion may be analysed regardless of the influence of turbulence, which, however, leads to some results which contradict noted facts. Because of the above, in the range of wave oscillation which is different from unity, neither the high value of the Reynolds stress at the surface nor the coherence function can be explained. For the ranges of frequency determined, the law of velocity decreasing with depth differs from that which results from linear theory.

The results of field investigations show substantial differences not only of a quantitative nature. Wave motion of this kind ceases to be potential. To describe this, the complete solution of the Navier-Stokes equation system should be considered. Such an analysis for elementary waves has been applied in this paper. Great divergences occur between potential and vortex waves, especially in the upper sea layer, and disappear with increasing in depth. The coefficient of turbulent viscosity has been assumed constant. Assuming that wave motion is the sum of infinite numbers of elementary waves, the author derived formulae for orbital velocity spectra in respect of the turbulence effects.

The considerations presented in the paper form the first stage in the solution to the problem. The value of the turbulent viscosity coefficient was the most difficult to assume. Very little was known about its physical nature and therefore its constant value could only be assumed as an approximation. To avoid this difficulty, a scheme of work which excludes direct definition of the coefficient value is suggested in this paper.

PW.04.

METHODS OF PREDICTING WATER LEVEL VARIATIONS AND WIND-GENERATED CURRENTS

ZYGMUNT KOWALIK
Department of Oceanology, Institute of Geophysics, Polish Academy of Sciences, Sopot

Abstract

The main focus of the paper are two approaches to the prediction of the shallow water dynamics:

a) a numerical solution to hydrodynamic equations and,

b) stochastic treatment of the recorded data-set.

Hydrodynamic-numerical methods have been applied to the Baltic Sea. Figs. 13–20 illustrate the structure of the wind-driven currents and transport. Using a diagnostic approach and a water-density structure computed from measurements, density-driven currents for the Baltic Sea are presented in Figs. 34 and 35. In the wind-driven and density-driven currents the major results of the computations show a clear dependence of the flow on bathymetric steering. Sea level changes are forecast by means of two approaches, *i.e.*, the hydrodynamic-numerical method and the stochastic method. The latter approach is based on transfer functions. The input to the transfer function is the wind distribution in time and space, the output is the predicted sea level distribution. Historical data are used to establish transfer functions. Periodic sea level changes in the Baltic Sea are investigated with the help of power spectra (Figs. 47–56). The most interesting data are the 159-year series of sea level observations at Świnoujście. The major oscillation in this long series is related to a 6-year periodicity (Fig. 56).

PW.05.

PROBABILITY OF MAXIMUM ANNUAL BALTIC SEA LEVELS AT NOWY PORT, KOŁOBRZEG AND ŚWINOUJŚCIE

ANDRZEJ WRÓBLEWSKI
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper deals with the probability calculations of the highest annual Baltic levels in three ports on the Polish coast. Computations were performed taking into consideration the highest annual sea levels in Nowy Port (1886–1939, 1946–1971), Kołobrzeg (1867–1943, 1946–1971) and Świnoujście (1901–1944, 1948–1971). These data were referred to a uniform level –500 N.N.$_{55}$. The dynamic processes responsible for the occurrence of the highest annual sea levels are accorded general treatment. The probability computations were executed by means of type III Pearson curves recommended for inland water constructions in Poland. The Pearson frequency distribution is given by eq. (3). Parameter estimations were

computed by means of the maximum probability method in connection with the computing of the lower boundary of distribution by eq. (8). Computations of the lower boundary of the distribution were performed by equating to the mode value of the distribution given by eq. (4). The conformity of empirical and theoretical distributions was proved by the χ^2 test.

PW.06.

TRANSFORMATION OF WAVES AND FORMATION OF SAND BARS IN SURF ZONES

BARBARA BOCZAR-KARAKIEWICZ

Institute of Hydroengineering, Polish Academy of Sciences, Gdańsk

Abstract

The non-linear structure of wind waves approaching a shore has been examined in terms of a deterministic model for a regular wave train, which transforms its shape and structure under shallow-water conditions.

The concept of the method is based on conclusions resulting from Druet, Massel and Zeidler's stochastic analysis of wave records, which detected a transformation of energy spectra of the wind waves and a concentration of energy in some distinct bands of its spectral frequencies. Their results have also shown that the main contribution to the energy of wind waves is from components of a relatively narrow frequency band $\omega_{\max}$. These components behave as a quasiperiodic wave train with a random coefficient modulating its amplitude with a frequency $\omega_{\max}$.

On the strength of these conclusions in the present paper a wind wave entering the surf zone is examined on the shape of a regular, initially sinusoidal shallow water wave train $\left(\frac{L}{H} \geq 10, \ L - \text{wave length}, \ H - \text{water depth} \right)$ of finite height $\left(\frac{h}{H} \geq 0,1, \ h - \text{wave height} \right)$ propagating over three different sea bed configurations.

Preliminary analysis over a bed of constant depth ($H = \text{const}$) has shown that the main properties of the wind-wave transformation result from an energy flux between the main component $\omega_{\max}$ and its higher harmonics $n\omega_{\max}$ (n =2, 3 ...). This energy flux is space-periodic for $H = \text{const}$. It is responsible for the changes of the shape in the energy spectra of the the wind waves as detected in the fields.

The transformation mechanism results from a quasi-resonant interaction among the components of the wave train, as predicted quantitatively by Philips.

It was found experimentally that under breaking conditions the main features of transformation are conserved in the breaker zone and the reformed wave profile.

The main analysis for beds with uniform and non-uniform slopes has shown that the transformation of the wind-wave structure under such conditions becomes quasi-periodic in space. This means that the energy flux between the main components of the wind waves varies nearly periodically in space (with a space period L_t; L_t – space period for H = const). The loss of strong periodicity is connected with changing water depth in which the law of constant energy flux must be obeyed.

From the non-linearity of the process an additional increase in energy arises in the components $n\omega_{max}$ (n = 2, 3 ...). Therefore the amounts of energy in the bands of $n\omega_{max}$ (n = 2, 3 ...) increase constantly as the waves approach the shore.

Over sloping beds it was also found that the spatial rhythm of multiple breaking and reformation of waves is closely connected with the quasi-periodicity of the energy transfer among the main components of the wind waves. Hence the location of breaking regions can be predicted for known characteristics of the wind waves entering the surf zones.

For a bed in the form of a typical multi-bar profile the analysis showed that the transformation of the wind waves becomes more intensive in comparison with the uniform slope case. This modification results from the interaction between the space-periodic wave and respective multi-bar bed configuration.

A hypothesis about sand bar formation is formulated on the basis of the results obtained for sloping beds: the bars are the result of mutual bedwave interaction according to the rhythm of the non-linear space-periodic transformation of the main wave train of wind waves over a movable bottom.

An approximated method is given allowing the distribution of wave breaking and wave-reformation regions in the surf zone, to be forecast as well as the respective location of bars and troughs of the bed profile for known characteristics of the wind waves entering the surf zone and for given values of the mean slope of the bed in the near-shore sea region.

PW.07.

COMPUTATION OF DAILY MEAN LEVELS OF THE BALTIC IN THE GULF OF GDAŃSK BY MEANS OF WEIGHTING FUNCTIONS

ANDRZEJ WRÓBLEWSKI
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The mean daily sea levels in the Gulf of Gdańsk are calculated for the tide gauges at Nowy Port and Hel on the basis of weighting functions. The first step in the computations was to determine the anemobaric elements having a significant coherence with the computed sea levels. The selection of input processes for this system of computations is shown in Fig. 2, the distribution of the measurement stations covered by this analysis in Fig. 1. Following the computations, the vertical component of the Oslo–Hel and Świnoujście–Hel pressure gradient and the longitudinal component of the wind at Hel were taken to be input processes. The spectral density of the input and output processes, and the multiple coherence between them is shown in Fig. 3. The spectral densities of the analysed realisation series computed by FFT were used to define the transition functions, and subsequently the weighting functions of the computation system used here. Since the use of correlated input processes allows for a better reproduction of the output process, the results of the computations are given for only this assumption. The weighting functions and the partial coherences in the three inputs – one output model are shown in Fig. 4. The results of the sea level computations are compared to the measurement data in Figs. 5, 6 and 7. The sea levels computed for Nowy Port from the sea levels and longitudinal wind component at Hel and the Oslo–Hel gradient show very good agreement with the measurements. This proves that calculating sea levels at one point in a basin is readily transferable to other points, thereby forming a system enabling sea levels in the Galf of Gdańsk to be predicted spatially and temporally. Fig. 8 shows the calculated spectral densities of the differences between the daily means and sea level data with a 4-hour quantisation step. These data illustrate the action of the mean daily filter, and indicate the possibility of a probabilistic prediction of the random variable of the sea level differences analysed here.

PW.08.

WAVE ACTION ON A FLAT ACCRETION BEACH

BORYS SHULYAK
Department of Geography, USSR Academy of Sciences, Moscow

Abstract

A theoretical basis for the quantitative estimation of the effect of waves and sea bed slope on shore-line variation is presented. The dimensionless

coefficients μ, ε, and χ, having been used ever since previous experimental studies of beach changes during storms, are now analysed more thoroughly, and the following relationship is given:

$$\mu = \left|\frac{\delta x}{\delta H}\right|_{h,\lambda} = \operatorname{ctg}\alpha.$$

The coefficient μ reflects the purely geometrical correlation between the vertical, as well as horizontal elements of sea bed slope and swash.

The relationships for the coefficients ε and χ are more complex:

$$\varepsilon = \left|\frac{\delta x}{\delta h}\right|_{H,\lambda} = \frac{1}{2}\left(\frac{3}{2}\frac{\chi\lambda(t)}{aH_3}\right)^{\frac{1}{2}},$$

$$\chi = \left|\frac{\delta x}{\delta\lambda}\right|_{H,h} = \frac{h(t)}{4}\left(\frac{3}{2}\frac{\chi}{aH_3\lambda(t)}\right)^{\frac{1}{2}}.$$

It has been shown that the changes in the location of a shore line and their rates can be presented as regular physical relationships between the parameters of beach transformation processes and storm characteristics.

The expressions for changes in x through finite time intervals are:

$$x_a = \int_0^t \Theta\left[\frac{1}{a}\frac{dH}{dt} + \frac{1}{2}\left(\frac{2}{3}\frac{\chi\lambda}{aH_3}\right)^{\frac{1}{2}}\frac{dh}{dt} + \frac{h}{4}\left(\frac{3}{2}\frac{\chi}{aH_3\lambda}\right)^{\frac{1}{2}}\frac{d\lambda}{dt}\right]dt,$$

$$x_b = 2\int_0^t \Theta\left[\frac{1}{a}\frac{dH}{dt} + \frac{1}{2}\left(\frac{3}{2}\frac{\chi\lambda}{aH_3}\right)^{\frac{1}{2}}\frac{dh}{dt} + \frac{h}{4}\left(\frac{3}{2}\frac{\chi}{aH_3\lambda}\right)^{\frac{1}{2}}\frac{d\lambda}{dt}\right]dt.$$

The formulae presented in this study can be used in practical applications. They hold true for shore-line changes in the case of negligible longshore currents and uniform shore configuration.

The paper also contains an example of the computations of swash zone limits and the rate of their variation for conditions assumed within the model considered here.

PW.09.

ESTIMATION OF SWASH PARAMETERS

BORYS SHULYAK
Department of Geography, USSR Academy of Sciences, Moscow

Abstract

The results of two-dimensional analysis are presented for swash due to breaking waves on filtering beach.

The relationships obtained for swash parameters permit the swash limit $M(x_d, z_d)$, maximum and mean velocities of water particles in swash flow,

$V_3(t), \bar{\bar{u}}_3$, duration of motion, T and other parameters to be correlated with the parameters of breaking waves:

$$V_3(t) \approx \frac{3}{2} \left(\chi ag^2 h^2 \lambda H_3^{-1} \right)^{\frac{1}{4}} - (2\,gax)t^{\frac{1}{2}},$$

$$\bar{\bar{u}}_3 \approx \frac{1}{2} \left(\frac{1}{6} \chi ag^2 h^2 \lambda H_3^{-1} \right)^{\frac{1}{4}},$$

$$T \approx \left(1 + \frac{1}{2}a^2 \right) \left(\frac{3}{2} \chi \frac{h^2}{a^3 g^2 H_3} \right)^{\frac{1}{4}}.$$

Approximated as they are, the relationships still have interesting practical implications, particularly because of their contribution to a possible mathematical model of transformation of an accretion due to sea waves.

PW.10.

A TWO-DIMENSIONAL NUMERICAL MODEL FOR TIDAL MOTION IN THE SEA

NGUYEN BICH HUNG
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper describes a two-dimensional smoothing operator applied in the solution of a parabolic system of hydrodynamic equations (11, 12, 13) in order to construct a numerical model (20, 21, 22) allowing the shortest waves to be eliminated. If these components were reinforced, they would give rise to instability or would prolong convergence.

The stability of the model is tested using von Neumann's criterion. Practical stability condictions are formulated:

$$\tau \leq \frac{1}{\sqrt{2g}\,D} \qquad (R = 0, \quad A = 0, \quad f = 0),$$

$$\tau \leq \frac{1}{R + \frac{2A}{l^2}} \qquad (R \neq 0, \quad A \neq 0, \quad f \neq 0),$$

$$\tau \leq \frac{l^2}{2A} \qquad (R = 0),$$

$$\tau \leq \frac{1}{R} \qquad (A = 0).$$

Computations to test the model are performed with and without the smoothing operator.

The smoothing operator is demonstrated to be of great practical utility in the stability process in question.

PW.11.

LONG-WAVE THEORY AND OCEANOGRAPHY

JEAN-PIERRE GERMAIN
Institute of Mechanics, Grenoble University, Grenoble

Abstract

Investigating wave propagation problems, oceanographers commonly use the linearised theory, which fails, however, in the case of a large relative wave length. As a consequence, one has to resort to the long-wave theory, based upon several physical assumptions. One of these deals with the distribution of the velocity field along a vertical line that is independent of altitude. Unfortunately, this assumption becomes too restrictive as soon as boundary conditions have to be taken into account. An example is given, which shows how these problems may be solved by modifying the classical theory of shallow water.

PW.12.

THE APPLICATION OF A PHYSICAL MODEL IN ACCURATE STUDIES OF TIDES IN A LITTORAL SEA

CHRISTIAN le PROVOST
Institute of Mechanics, Grenoble University, Grenoble

Abstract

A theoretical analysis of the generation and the propagation of shallow water tides led us to establish a new method of studying the components of the whole tidal spectrum by small groups of generating waves: the fundamental wave and its harmonics, the fundamental wave and a secondary wave, with all their harmonic and interaction waves. We present here the principal points of this method, and we illustrate it by studying the tides in the English Channel on a physical, reduced model of that sea. This study allows us to characterise all the significant components of this tide with good precision. Regardless of the oceanographic interest of these results,

this application is useful because it shows the very powerful contribution of hydraulic tidal models in such a study.

PW.13.

A THEORETICAL AND EXPERIMENTAL STUDY OF WAVES IN A STRATIFIED ROTATING MEDIUM

GABRIEL CHABERT d'HIÈRES, JEAN-LOUIS SUBERVILLE
Institute of Mechanics, Grenoble University, Grenoble

Abstract

This paper deals with the study of the properties of small oscillations of free-surface, non-homogeneous perfect fluids confined in basins subjected to a rotary movement about a vertical axis. Details are given of the various waves encountered and the respective effects of the basin geometry, the fluid stratification and the rotation.

Laboratory experiments carried out using a two-layer fluid in a revolving basin of parallelepipedal form confirm the theory. The solution is expressed by the superimposing of Kelvin waves and type 2 Poincaré waves. All these waves are reproduced experimentally to within a few tenths of a mm. accuracy for amplitudes and to within a few degrees for phases. A film shows the linear phenomenon and its deformations when the amplitude increases or the depths of the two liquids become very different.

PW.14.

THE NUMERICAL SIMULATION OF THE NON-LINEAR PROPAGATION OF A LONG WAVE IN A CHANNEL OF CONSTANT DEPTH. COMPARISON OF SEVERAL METHODS OF FINITE DIFFERENCES

CHRISTIAN le PROVOST, MELIO SAENZ
Institute of Mechanics, Grenoble University, Grenoble

Abstract

The numerical integration of the complete equations of tidal waves in shallow waters presents some difficulties arising from the advective terms of the dynamic equations and the non-linear terms of the continuity equation. The behaviour of some finite difference algorithms is compared with reference to the exact solution of a particular problem: the non-linear propagation of a long wave in a channel of constant depth and infinite

length. The analytical solution is obtained by the method of characteristics. The different algorithms considered are the characteristic, the diffusive, the Lax-Wendroff, and the implicit Preissmann schemes. Some conclusions on the accuracy of each of these algorithms are presented.

PW.15.

GENERAL COMMENTS ON THE EXPERIMENTAL ASPECT OF RE-SEARCH ON THE PROPAGATION OF WAVES OVER OBSTACLES. CASE-STUDY – A SCREEN

CLOVIS MARCOU
Institute of Mechanics, Grenoble University, Grenoble

Abstract

We give a brief analysis of research conducted by the Fluid Mechanics Laboratory (Institut de Mécanique de Grenoble) in recent years, on the propagation of gravity waves over structures such as steps or screens (submerged and semisubmerged).

Solid, diaphragm-type structures, consisting of one semisubmerged screen placed near the free surface, and one totally submerged screen placed at the bottom of the channel, with a variable opening between them, were studied in particular.

The theoretical analysis was considered in comparison with the publications of Tuck (1971), Guiney (1972), Mei and Black (1969), Wiegel (1960).

We have commented on the experimental study of transmission and reflection coefficients, conducted in our laboratories by E. Mansard (1976) with wide variation of the most important parameters:

– relative depth h/λ of the axis of the diaphragm,

– relative depth H/λ of the waves,

– relative opening of the diaphragm $2a/h = \mu$.

Comments and explanations are given to justify the reduced interval of wave steepness

$$(\gamma_{00} = \frac{2A_{00}}{\lambda} \leq 2.5\%).$$

The experimental results are in accordance with the theories of Tuck and Noye-al.

PW.16.

INTERACTIONS BETWEEN A SHALLOW-WATER WAVE AND A MOV-
ABLE BED

BARBARA BOCZAR-KARAKIEWICZ
Institute of Hydroengineering, Polish Academy of Sciences, Gdańsk

Abstract

The present paper concerns the non-linear structure of wind waves in
the surf zone and their interaction with the movable bed in this zone.

The results were obtained by means of a few simple models.

On the first group of models it was found that a progressive, regular and
shallow-water wave train representing the significant wave in the wind wave
spectrum was characterised by a spatial period $L_t > L$ (L – wave length). It
was found that the bar and trough topography in surf zones with the same
spatial periodicity, L_t, results from interaction between the rhythmically
oscillating wave and the movable and deformable shape of the bed.

On a second group of models it was shown that for a deformable bed
the previously neglected wave reflection becomes important, causing the
formation and further development of a dune configuration in a spatial scale

$$\lambda = \frac{1}{2} L < L.$$

On a third experimental model it was found that the bar and trough
configuration is a final equilibrium state. This state is reached after several
transient states of wave motion and corresponding bed configurations:
partially standing wave regimes with dune topographies or progressive waves
with bar and trough topographies. A qualitative analysis of the phenomena
was conducted by means of results obtained on the two previous models.

PW.17.

PROPAGATION OF TRANSLATION WAVES IN OPEN CANALS OF
PUMPED-STORAGE PLANTS

STEFAN BEDNARCZYK
Institute of Hydroengineering, Technical University, Gdańsk

Abstract

In the pumped-storage plants built in Poland, the equipment generally consists of reversible pump-turbine units and the water is brought to them by open canal from the upper or lower reservoir.

The alternating work of hydraulic machines in these plants is the main cause of translation waves which form in the canals. These waves are both simple and complex in nature. At the moment of formation of positive waves, their profiles are fairly gentle. This is described by equations (1) and (2). Oscillation waves form some distance from the power plant (Figs. 2 and 3). Two mathematical models of these waves were formulated. The model of the first approximation was given by equations (4), (6), (7). The model of the second approximation, in which hydraulic losses in wave motion were taken into account, is given by equation (9). The negative waves always have a gentle profile, described in parabolic canals by equation (16). The dissipation of waves and the decrease in their hydraulic parameters are described by equations derived from St. Venant equations. Equation (19) describes the unsteady flow of the head of the negative wave, and equation (23) that of the head of the positive wave. As was observed during field investigations, the most dangerous waves are the complex ones that occur during an emergency change-over from pumping to the energy generation (turbine work). The results of such investigations are shown in Fig. 9.

PW.18.

INVESTIGATIONS ON THE INFLUENCE OF SEA STATE ON THE COURSE OF A RIVER FLOOD WAVE

JÓZEF GERINGER
Institute of Hydroengineering, Technical University, Gdańsk

Abstract

The paper presents the results of the computer simulation of the propagation of a flood wave in a river with an outflow to the sea, with a simultaneous storm swell in the littoral zone of the sea. This problem concerns most of Poland's rivers and particularly the Piastowski channel linking Szczecin to the Baltic.

A mathematical model based on the numerical solution of equations for transient, slow-changing motion in an open channel was applied using explicit numerical schemes.

This method may be useful in designing and operating hydroengineering equipment and for water economy.

An example is also given of the application of a mathematical model to calculate the transient motion in Abidjan lagoon, this being treated as a one-dimensional problem.

PW.19.

STATISTICAL CHARACTERISTICS OF WIND WAVES, DETERMINED FROM AERIAL PHOTOGRAPHS

JERZY ONOSZKO, ALBERT MIKOTEIT, MARIA WIEJACHA
Institute of Hydroengineering, Technical University, Gdańsk

Abstract

During investigations of the spatial structure of wind waves, single aerial photographs (from one camera) were taken of Puck Bay (Fig. 1). The photographs showed a distinct spatial image of the distortion of the free surface (wave crests and troughs), but without any information as to the height of these distortions. To interpret the photographs, the various wave crests were approximated to the ellipses – the shorter axes of which corresponded to the wave lengths (L) and the longer ones to the crest lengths (G).

Following a statistical analysis of wave lengths, it was found that the empirical curves of wave length distribution on two photographs (each contained about 700 distinguishable waves) were almost identical. They were very similar to the empirical distribution given in Zdanowicz (1963). They differ substantially from the theoretical curve given by Głuchowski, but are very close to the theoretical curve of wave period distribution given by Longuet Higgins (1975).

Correlations between wave lengths and their directions, and between wave lengths and crest lengths, were also considered. On the basis of the photographs analysed, a non-linear regression function (fourth-degree curve) between the length of waves and their direction, and a linear function between the length of waves and that of crests were found.

PW.20.

STATISTICAL AND SPECTRAL CHARACTERISTICS OF WIND WAVES IN SHALLOW WATERS

CZESŁAW DRUET
Department of Oceanology, Polish Academy of Sciences, Sopot
STANISŁAW MASSEL
Institute of Hydroengineering, Polish Academy of Sciences, Gdańsk

Abstract

Intensive investigations into wave generation, interaction or decay have been conducted during the last twenty years. The theories of wind wave generation by Phillips and Miles, nonlinear interaction mechanism by Hasselmann and the forecasting procedures developed during the JONSWAP experiment afford us a better understanding of the wind wave phenomena.

However, as yet, much less is known about wave motion in shallow water. The wind wave spectrum within the coastal zone is strongly influenced by changing depth. This transforms of the wave profile, its breaking, the generation of longshore currents, edge waves, long period oscillations and so on. All these phenomena are strongly nonlinear from the analytical point of view.

This paper provides a brief account of the basic results of field investigations carried out in the shallow water zone by the Institute of Hydroengineering of the Polish Academy of Sciences during the last few years.

The most complex investigations were carried out during the 'Lubiatowo 74' International Expedition.

The breaker zone at Lubiatowo is a typical multi-underwater bar zone. The wave metres were situated at several points within the 0–6.5 m depth range.

The wave spectra are narrow-band, with the energy concentrated around one frequency. As a result of wave breaking, the energy gradually decreases, while the peak frequency remains unchanged. In many spectra second peaks are clearly visible; their frequency is associated with the double basic frequency. The mechanism of the generation of such energy distribution has still not been explained in full.

The processes of energy transformation and dissipation, typical of the shallow water zone, can only be described by nonlinear equations with wave-wave interaction terms. Therefore, within the the framework of statistical formulations, the function of the probability density for the sea surface elevation is not Gaussian.

The presence of the skewness and kurtosis coefficients in the probability distribution formula also causes some deviation from the classical formulas for the distribution function for other characteristic wave parameters.

Based on the above analysis, some guidelines have been formulated for the computation of mean wave characteristics in the surf zone.

The detailed presentation of these problems is given in the paper *Transformation of wind waves in the surf zone* by C. Druet, E. Bittner,

S. Massel in MIR Rep. Ser. R, no. 2a *Properties and transformation of hydrodynamical processes in the coastal zone of a nontidal sea.*

PW.21.

STABILITY ANALYSIS FOR VARIANTS OF THE SYSTEM OF FINITE DIFFERENCE EQUATIONS FOR LONG WAVES

ZOFIA CHILICKA
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper presents an analysis of the stability and accuracy of approximation by the method of finite differences of the differential equation system (1–5) describing the phenomenon of long waves in shallow seas.

The assessment of the accuracy of the numerical solution was based on the Godunov and Riyabenki theorem, which states that for a stabile scheme the accuracy of the solution is of the same order as the approximation of the equation. The order of the approximation of system considered was investigated for three schemes: explicit on the Platzman grid (17–19), explicit on the grid in Fig. 1 (14–16), and explicit-implicit with explicit computation on the grid in Fig. 1 (9–11). The two first schemes mentioned are of the same order of accuracy in time and of the second order in space, while the explicit-implicit scheme with explicit computation is of the second order in space, the order of the approximation in time being close to two.

In the second section the stability was studied by the von Neuman method. The results obtained, depending on the way certain parameters are assigned, summarised in third section.

As the conclusion of these considerations, the explicit-implicit scheme with explicit computation has been accepted as the most appropriate from the point of view of the stability studies. This conclusion would appear to be important when taking into account the fact that many cases were considered, including those which have not yet been studied.

PW.22.

EDGE WAVES ON SHEAR FLOW

PHAM VAN NINH
Department of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Edge waves on the surface of free shear flows are considered with respect to the linear theory of shallow water. An equation is obtained for the raising of a free surface at any velocity distribution and any bottom profile. The possibility that edge waves exist for a linear velocity distribution and a wide range of bottom profiles is demonstrated. By approximating the bottom profile with a broken line, the problem is solved for calm water: quasi-edge waves are obtained as the only solution ensuring hydrodynamic continuity. Two variants of this solution for such waves are put forward: a precise solution for a linear velocity distribution, and an approximate one for a polynomial velocity distribution.

A number of effects of shear flow are also discussed.

PW.23.

CONSTRUCTION OF A NUMERICAL MODEL OF STORM SURGES WITH A REFINED GRID

ZOFIA CHILICKA, ZYGMUNT KOWALIK
Institute of Hydroengineering, Polish Academy of Sciences, Gdańsk

ZYGMUNT WIERZBICKI
Institute of Meteorology and Water Management, Maritime Branch, Gdynia

Summary

A numerical model of storm surges with a local refined grid. Three methods of approximating boundary conditions were applied at the edges of areas with different grid steps: linear interpolation, interpolation using cubic spline functions, and the irregular grid technique. The computations were performed in a hypothetical basin in order to select the most suitable method. The last-mentioned was chosen, and applied to the interpolation of boundary conditions in the model of storm surges in the Baltic Sea that allows for the exchange of water with the North Sea.

The investigation were performed with respect to changes in level and volume transport components in two variants – with and without filtration. In fact, the level hardly changed, and when no filtration was applied vortices associated with the shortest waves were formed, which led to gradually increasing instability.

PW.24.

STOKES WAVES ON SHEAR FLOW

PHAM VAN NINH
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

Third-order Stokes waves on arbitrary shear flow are described schematically. A comprehensive example is given for the linear velocity profile. It is shown that Stokes waves can propagate on shear flow if linear sinusoidal waves exist on this flow.

PW.25.

THE INFLUENCE OF EARLY STAGES OF DEVELOPMENT OF WIND WAVES ON THE EFFECTIVE ROUGHNESS OF THE FREE WATER SURFACE

CZESŁAW DRUET, RYSZARD SIWECKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper presents the results of measurements of high-frequency wind waves carried out during the 'Kamchiya 79' experiment in various anemobaric situations on an immovable platform situated at a depth of 6 m.

Spectral and frequency characteristics of wind waves are discussed and a dimensionless estimator of the function of the high-frequency wind-wave energy spectrum is formulated. The spectra on both slopes of the carrier wave are compared.

Correlations between wind velocity, variance of high-frequency waves, the Reynolds number and the stage of development of the wind waves are presented.

PW.26.

NON-LINEAR ATTENUATION OF GRAVITY WIND WAVES

ANDRZEJ NAGUSZEWSKI, STANISŁAW MASSEL,
WOJCIECH TRAPP
Institute of Hydroengineering, Polish Academy of Sciences, Gdańsk

Abstract

The non-linear attenuation of wind-induced wave motion is considered. The experimental data shows that low frequencies are damped more slowly than is predicted by linear theory. The opposite behaviour is observed in the high frequency range. The non-linear perturbation scheme developed here offers a theoretical base for understanding this non-classical attenuation mechanism.

PW.27.

STEEPNESS OF WIND WAVES IN THE HIGH-FREQUENCY BAND UNDER CONDITIONS OF SWELLING

JANUSZ KLAJNERT
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper analyses the dependence of the steepness of high-frequency surface wind waves on the parameters of a carrier wave and the dynamic conditions in the near-surface air layer, directly influencing the generation of wind waves. Special attention is paid to differences in the steepness of high-frequency waves spreading over various elements of a carrier wave.

The results indicate differences in the steepness of high-frequency waves between the troughs and crests of the same carrier waves. It is demonstrated that the steepness of wind waves in the high-frequency band is very sensitive even to momentary changes in wind velocity, and that its value is influenced mainly by the mean height of high-frequency waves.

PW.28.

SEA LEVEL AND STORM SURGE FORECASTING IN THE SOUTHERN BALTIC

ANDRZEJ WRÓBLEWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper presents an application of the multiple regression of dynamic systems and empirical orthogonal functions to sea level forecasting at five Polish ports on the Baltic coast with a lead time of 24 h. An assumption of the sea level changes approximated by superimposing long- and short-period oscillations has been employed. The sea level and atmospheric pressure data were attributed to these oscillations by the use of a recursive low-pass filter. The hindcast characteristics obtained, as well as the computations based on independent measurement data, indicate the effective operation of the model during everyday sea level changes and storm surges.

PW.29.

THE EFFECT OF THE ATMOSPHERIC PRESSURE FIELD ON SEASONAL BALTIC SEA LEVEL OSCILLATIONS

ANDRZEJ WRÓBLEWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The paper comprises a numerical analysis of a time series of Baltic monthly mean sea levels to determine the seasonal changes. The influence of the atmospheric pressure field on the data analysed was characterised by computing the isolated static effect of the atmospheric pressure and wind-driven level variations. The inverted barometer rule under Baltic sea level conditions was computed and compared with a theoretical formula. The computations were carried out by the use of empirical orthogonal functions (EOF) and a linear dynamic system of stable parameters, as well as estimations by the spectral density and Kalman methods. Basic sea level data were collected from the measurement period 1901–1937.

PW.30.

ANALYSIS AND FORECAST OF LONG-TERM SEA LEVEL CHANGES ALONG THE POLISH BALTIC SEA COAST. PART 1. ANNUAL SEA LEVEL MAXIMA

ANDRZEJ WRÓBLEWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The present paper constitutes the first part of a study devoted to the analysis and long-term forecast of sea levels along the Polish coast of the Baltic. The work focuses on annual sea level maxima. The computations were based on measurements made at Świnoujście (1901–1990), Kołobrzeg (1867–1990) and Gdańsk (1886–1990). The statistical characteristics of the calculated time series are presented. The occurrence of a trend and variations in its statistical significance in the course of measurements are analysed. The periodic structure of the measurement series is investigated and their independence, which should be equivalent to the random data, is verified. The seasonal distribution of annual maxima is demonstrated and relevant conclusions are drawn. Several procedures were applied for estimating the probability distribution. The final computations were performed by the maximum likelihood method and Gumbel's distribution.

PW.31.

ANALYSIS AND LONG-TERM FORECAST OF SEA LEVELS ALONG THE POLISH BALTIC SEA COAST. PART 2. ANNUAL MEAN SEA LEVELS – FORECAST TO THE YEAR 2100

ANDRZEJ WRÓBLEWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

This is the second part of the analysis and long-term forecast of sea levels along the Polish Baltic Sea coast. The first dealt with annual sea level maxima; the present paper covers mean annual sea levels. The computations were based on measurements made at Świnoujście, Kołobrzeg and Gdańsk from 1901 to 1990. The statistical characteristics of the time series examined

are presented and the occurrence of a trend and variations in its statistical significance in the course of measurements are analysed. The periodic structure is described and the data is analysed by means of empirical orthogonal functions (EOF). Mean sea level forecasts to the year 2100 were computed by extrapolating the linear trend and applying variable confidence limits. The height of the quantiles 0.01 and 0.001 of the maximum sea level distribution computed in the first paper is determined on the assumption that the mean sea level will continue to rise to the year 2100.

PW.32.

SEA SURFACE SLOPE DISTRIBUTION AND FOAM COVERAGE AS FUNCTIONS OF THE MEAN HEIGHT OF WIND WAVES

SŁAWOMIR B. WOŹNIAK
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

The article discusses problems of the statistical description of a wind-ruffled sea surface for optical modelling purposes. A new parameter, namely the mean height of the waves $\bar{H}$, is used in both the slope distribution of the ruffled sea surface and the foam coverage of the surface. Unlike the parameter used up to the present, *i.e.* the wind speed over the sea surface v, the mean height of the waves $\bar{H}$ is connected with a large number of hydrometeorological and geometrical factors modifying the state of wave motion of the sea (*e.g.* the wind fetch D, the sea depth h, the shape of the coastal region *etc.*). A theoretical basis for applying this new parameter and modifying dependences for the slope distribution and the foam coverage of the ruffled sea surface is given. In addition this paper contains an initial verification of the ideas presented with the small number of data available in the literature.

PW.33.

ESTIMATION OF THE PERIOD OF FREE OSCILLATIONS (SEICHES) IN THE KIRRBUCHT

KURT FRISCHMUTH
Department of Mathematics, Rostock University, Rostock

ANDRZEJ JANKOWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

An attempt was made to estimate the periods of the main seiches in the Kirrbucht, a shallow water basin with an irregular coastline. A quasi-linear hydrodynamic-numerical model of the storm surges (wind-driven circulation) in a shallow density-homogeneous basin was used. The results of calculations of sea level oscillations generated in the basin in response to a temporally and spatially constant wind field (stress) were treated as a time series in order that the seiche periods could be calculated. The standard discrete Fourier transformation was applied to estimate amplitude spectra. The periods of the three significant modes were found to be equal to 3.21 min, 4.94 min and 6.59 min. The latter two are probably fundamental ones: they are the transverse and longitudinal modes respectively. The influence of non-linear terms and lateral friction on the seiche periods is also discussed.

PW.34.

SEASONAL FORCING OF BALTIC WATER VOLUMES BY THE METEOROLOGICAL FIELDS OVER THE BASIN FROM 1896 TO 1970

ANDRZEJ WRÓBLEWSKI
Institute of Oceanology, Polish Academy of Sciences, Sopot

Abstract

This paper discusses the seasonal oscillations of the meteorological fields influencing the seasonal changes in the Baltic water balance. Mean monthly atmospheric pressure data (1896–1970) from eight stations located around the Baltic were taken to be the basis for the computations. Six horizontal components of the atmospheric pressure gradients were selected for use in the subsequent computations. The mean monthly water volumes in the Baltic were computed by the method presented by the author in an earlier publication (Wróblewski, 1992a). In the next step, the selected horizontal components of atmospheric pressure gradients were expanded into EOFs. The first three amplitude expansion functions of the wind field had more significant coherences with changes in the Baltic water volumes than the

corresponding EOF functions of the atmospheric pressure field. The spectral and statistical analysis of these functions and gradients was computed in order to detect their periodic structure and statistical characteristics. The multiple input stochastic dynamic system was used in the analysis. The most important result is the demonstration that the solar annual period is distinct in the wind-field components influencing the sea's seasonal dynamics. The solar semi-annual period is not well marked. The mean atmospheric pressure over the Baltic has a weak seasonal structure and practically does not force the water volume changes.