THE USE OF GRAVITY FOR GIS DATA SETS OPTIMIZATION.

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ABSTRACT

It has been increasingly recognised that measurement of sea surface topography is of the fundamental importance to a wide range of research in climatology,oceanography,geology and geodesy. In order to explore information about local changes of state is important to know the fields and processes governs and accompanied such a phenomena .To improve the understanding of the state variables processes for the exploration of environmental changes time-series data usual comprise the successive control points or areas. Relationship between the ocean movements and marine geoid for different scales of events are discussed.It is shown that the water flows,e.i.sea surface topography, and gravity anomalies are interrelated.This results indicate the usefulness of the marine gravity for an optimum spatial environmental sampling strategies.

INTRODUCTION

Oceanographers describe the motion and thermodynamics of the ocean by use the equation of motion,also called Navier-Stokes equations. According to Newton's second law mass times acceleration is equal to the sum of forces acting on the mass.For a volume of fluid Newton's law is divided by the mass per volume,the density ϱ ,and written as an equation for acceleration : the acceleration due to gravity, g, the pressure, p , gradient,the Coriolis acceleration ,fv,and the acceleration due to friction,τ.

To a certain degree of approximation idealised sea surface coincides with mean sea level,i.e. reference ellipsoid. The equation of motion contain the acceleration due to gravity,g,which means only directed along a normal to the earth's reference ellipsoid.

In large-scale flow the vertical accelerations are small in the sense that it can be neglected against g. Hence,the vertical component of the Navier-Stokes equations reduces to the hydrostatic equation: $\partial p/\partial z = - g\varrho$. (1)

In many cases the simplest type of equilibrium flow is balance of the pressure gradient and the Coriolis accelerations:

$$u_g = - 1/\varrho f \partial p/\partial y, \quad v_g = 1/\varrho f \partial p/\partial x. \qquad (2)$$

The factor $f = 2\Omega \sin\varnothing$, where $\varnothing$ is latitude and rotation rate of the earth,is called the Coriolis parameter.

BACKGROUND

This flow is called the geostrophic current. It provides for the flow to follow the direction of the isobars (lines of constant pressure).

The ocean are located in an oblique field of gravitational forces.The solid earth's masses are distributed unevenly and perturbing potential of it gravity are external with respect to the world ocean .

As a results the water medium are forced by the gravity field components,which are directed along a normal z,g , and a tangent s to the mean sea level (reference ellipsoid) g_g, directed toward a reduction in N,undulation of the geoid with respect of the reference ellipsoid:

According so the acceleration of a fluid parcel

is written as

$$\frac{\partial u}{\partial t} = -\frac{1}{\rho}\frac{\partial P}{\partial x} + f\cdot v - \frac{1}{\rho}\cdot\frac{\partial \tau_{xz}}{\partial z} - g_x$$
$$\frac{\partial v}{\partial t} = -\frac{1}{\rho}\frac{\partial P}{\partial y} - f\cdot u - \frac{1}{\rho}\cdot\frac{\partial \tau_{yz}}{\partial z} - g_y \qquad (3)$$
$$\frac{\partial w}{\partial t} = -\frac{1}{\rho}\frac{\partial P}{\partial z} - g$$

North,east and vertical velocity components (u,v,w) are given in a Cartesian coordinate system with z vertical so that acceleration due to normal gravity,g,is in the negative z direction;

$g_x = g\,\partial N/\partial x = -\xi g$; $g_y = g\partial N/\partial y = -\eta\, g$;
ξ, η - deflections of vertical.

At 1 arc sec magnitude of vertical deflection the magnitude of tangential gravity force is g_S= 5.10\-3 cm/sec/sec, or 5.10\-6 normal gravity g .

We have collected different types of the water moving forces (Hasse,Dobson,1986) which are displayed in the Table 1,including accelerations due to gravity. This data indicate that the gravity information will be some time very useful for the good understanding of the moving forces in the ocean .

THE VERIFICATION

LARGE-SCALE

We first examine the performance of gravity information's in a planetary scale by applying them to formation the trajectory of a Florida current,assuming that the results of the action of gs is analogous to the geostrophic flows : the direction of the geostrophic flows is normal to the common pressure gradient.

The Coriolis acceleration vanishes at the equator, hence below equator the current caused by g_S must be coincide the isolines of geoidal undulations N.

Based on the Goddard Space Flight Center detailed gravimetric geoid from North America to Europe (Vincent,1972) ,the effect of gs were estimated and have been compared with the effect of Coriolis's acceleration at the region of the Gulf Streams Florida current trajectory with coordinates : north latitude from 30 to 37 degree,west longitude from 80 to 72 degree.

Vertical deflection components in this area were:

in the plane of first vertical - 6 arc sec and the plane of meridian - 4,5 arc sec, i.e.,"horizontal" components of gravity were 3.0 .10\-2 sm/sec/sec , and 4.2 .10\-2 cm/sec/sec. The rate of flow in this region is 0.4 - 2.0 m/sec and Coriolis accelerations 3.10\-3 - 15.10\-2 cm/sec/sec operates in the stream (Maslov,1987).

As follows from the cited estimates, gs dominates over the Coriolis acceleration and the flow has to be follow the isolines of N, which agrees well with the observations (Fig.1). In the upper latitudes Coriolis acceleration dominates over the gravity field and the mean patterns show a reversal in direction of the northwards travelling water to the right (Fig.2),which converge at mid-latitudes.

A new method of the cross - covariance function estimations for the pairs of anomalous field contours (Fig.2) are developed . In a planetary scale by this method it is shown (See Table 2) the good agreement (from 0.70 to 0.89) between the gravity anomalies and ocean currents (Worthington,1976) at the western mid-latitude Atlantic .

LOCAL-SCALE

Since geoid (potential) anomalies decrease slowly with distance r from a mass anomaly (proportional to r\-1), the shape of the geoid reflects the distribution of relatively deep-seated mass within the earth. The vertical gradient of the potential, the gravity field, decreases more rapidly (proportional to r\-2) and hence are more sensitive to shallow mass anomalies.

The theory of the local-scale circulation in the gravity anomaly area also are developed.

The results of geophysical and ocenographycal investigations for the west-south part of the Barenz sea,is shown in Fig.3 (free-air gravity,contour interval 10 mgal and the mean stationary surface flows,speed from 0,1 to 1,0 knots).

It is demostrate the evidence of the spatial currents variability (eddies), which could be associated with instabilities in the mean flow. Experimental data are indicated that the free-air gravity anomaly are related very significantly with a rings-like water motions in a given area.

CONCLUSIONS

The results have been obtained shows distinct relation between global gravity and local gravity field and oceanic processes.

They indicates how gravity field databases will be influence on the design of local and global environmental GIS data sets.

REFERENCES

Hasse,L,Dobson,F,1986.Introductory Physics of the Atmosphere and Ocean.D.Reidel Publ. Comp.,Boston, Dodrecht,Tokyo,p.3.

Maslov,I.A.,1987. Gravitational forces in the dynamics of the ocean. Report # 4 Soviet Physics-Lebedev Institute ,Allerton Press Inc.,pp.43-46.

Vinzent ,S., et al. A detailed gravimetric Geoid from North America to Euroasia.- Goddard Space Center,1972.

Worthington,J.,1976.On the North Atlantic Circulation. Johns Hopkins Oceanographic Studies, N 6.

Table 1

Magnitude of acceleration (m/sec/sec)

Scale	Inertial horis.	terms vert.	Pressure term	Coriolis term	Friction term	Gravity term
Planetary, 10\3-10\4 km	10\-8	10\-8	10\-5	10\-5	10\-8	10\-4
Regional, 10\2-10\3 km	10\-4	10\-5	10\-4	10\-4	10\-5	10\-3-10\-4
Local , 10\2 km	10\-2	10\-2	10\-2	10\-4	10\-2	10\-3

Table 2

Currents/gravity corelation

Anomaly I	cross-covariance depth dependence					
potential	4°C	4-7°C	7-1°C	1 -17°C	17°C	full flow
positive	0,700	0,871	0,885	0,70	0,894	0,850
negative	0,736	0,757	0,840	0,7 4	0,831	0,751

Temperature scale and type of circulation:

4°C- subbottom circulation,
4 - 7°C - low thermocline region,
7 - 1°C - middle thermocline region,
1 -17°C - upper thermocline region,
17°C - surface circulation.

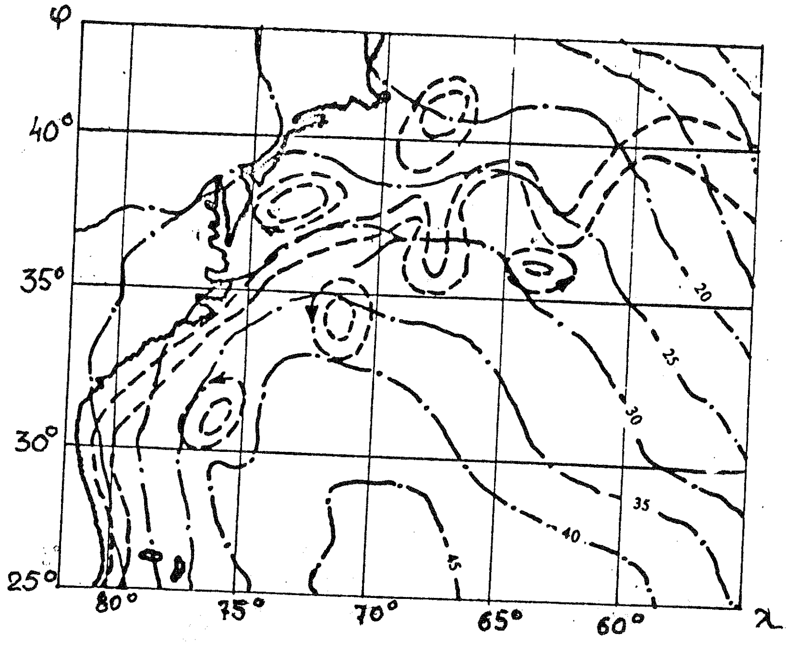
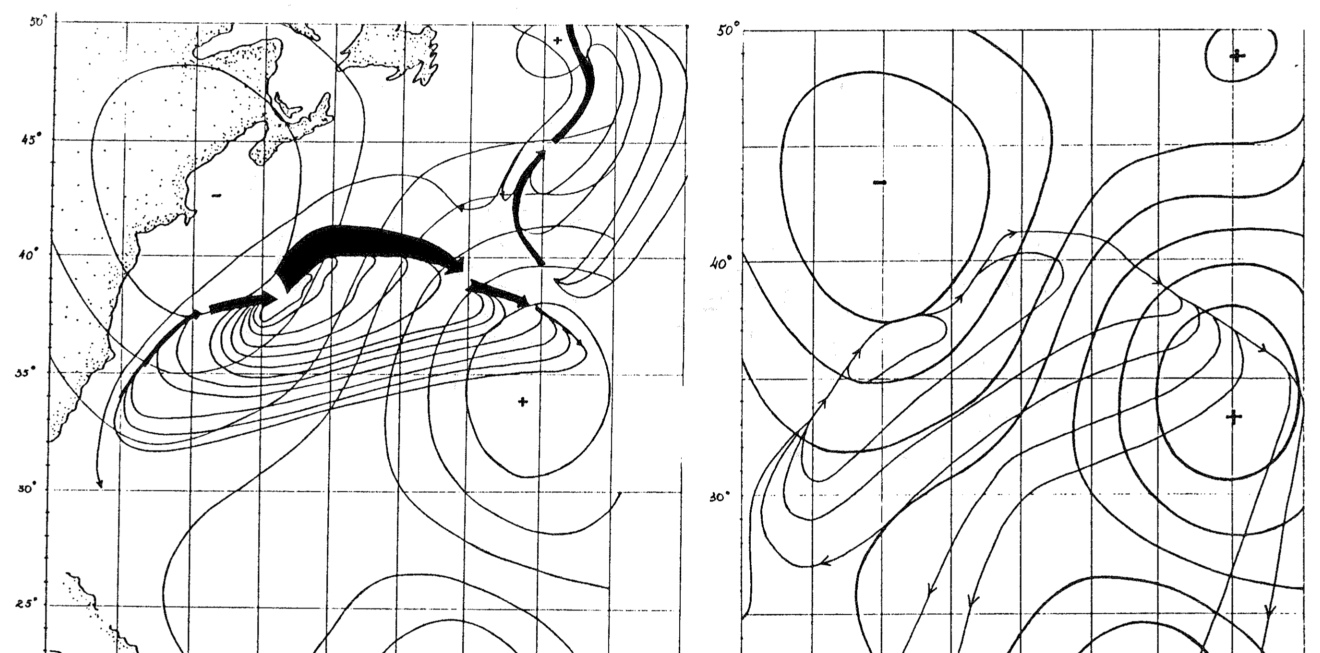


Fig. 1



$\theta < 4°C$ $\theta = 17°C$

Fig. 2

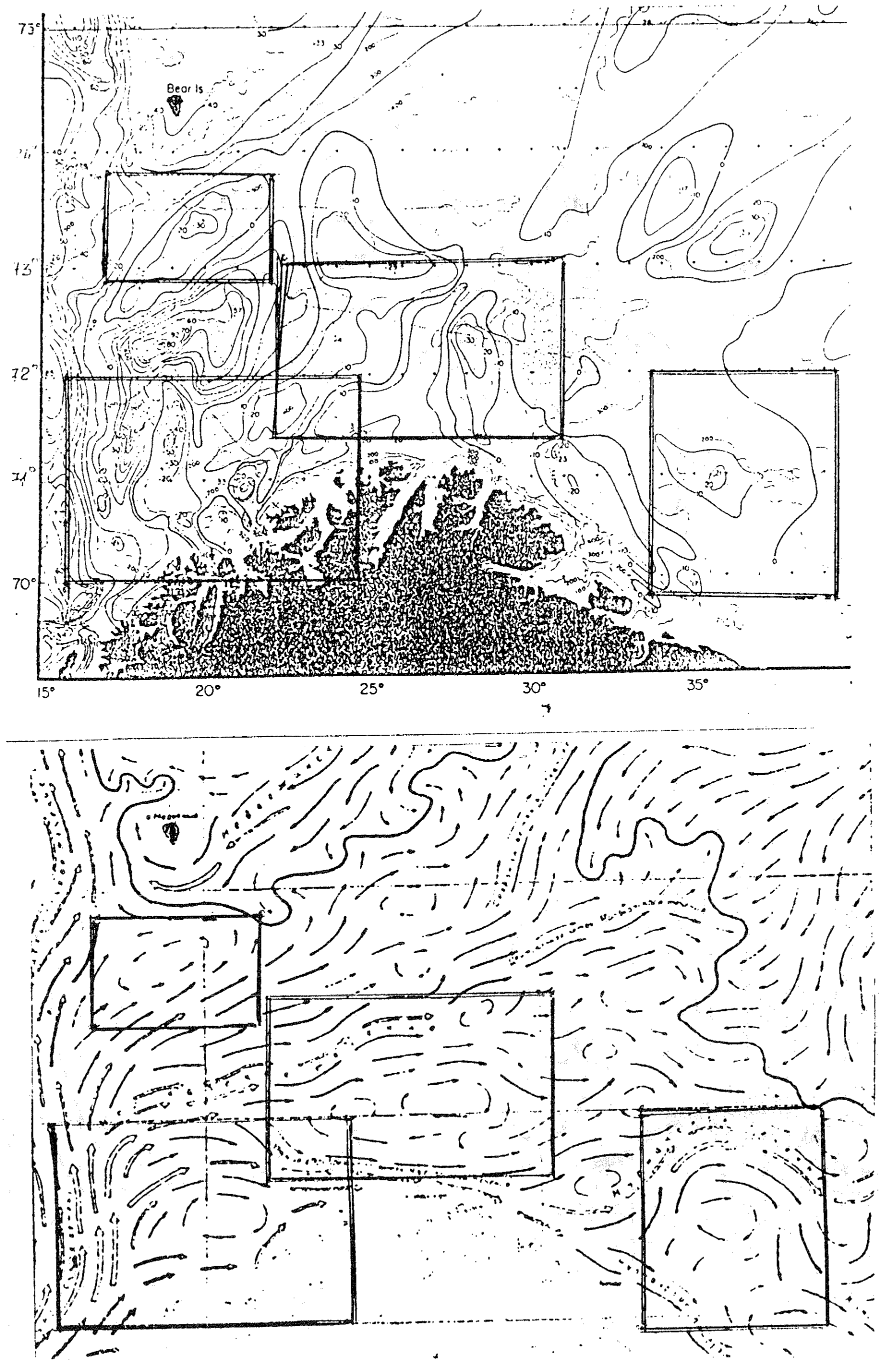


Fig. 3