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Travel of Long Wave on the Surface of Tropopause and Ocean

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SUMMARY Tidal waves in the air and on the water produced by the meteorological and seithmological phenomena have been discussed in the field of hydraulics and fluid mechanics. The velocity of propagation has the same value as shallow water wave. The abnormal elevation or depression of free surface caused by earthquake or latitude variation is transmitted to the distant area, which we can observe as high "tsunami" or colourful sunset. This paper is the analysis of fetch and duration of this sort of long waves.

1 INTRODUCTION

On the surface of the ocean or tropopause, if there is a solitary wave and successive group waves, which is a sort of long wave, sometimes appear short waves in the space between free surface and ground of the earth. This phemomena can be seen by the abrupt change of barometric pressure or sea level by marinograph. Especially in the air, a train of twisted long cloud appears and at the time of sunrise and sunset, we can observe a colourful and beautiful sky. This is caused by the depression and elevation of tropopause which is produced by travelling waves from the wave source such as earthquake or cyclone. Above cited phenomena are explained hydrodynamically by the joint action of progressive wave and stationary wave. The former is the so-called long wave or shallow wave and the latter is the well-known short wave or deep wave.

2 WAVE POTENTIAL OF PROGRESSIVE AND STATIONARY WAVE IN TWO-DIMENSIONAL AND THREE-DIMENSIONAL SPACE.

Letting rectangular coordinate axes be (x,z), whose origin is located on the center of source and x-axis is placed on the free surface for direction wave propagation, and x-axis is placed vertically downward, so that free surface is expressed by Z=0, and the bottom surface is z=h, where h is the altitude of freesurface or depth of the grourd surface of the earth.

Equation of the continuity is expressed in the form as

$$\partial^2\phi/\partial x^2+\partial^2\phi/\partial Z^2=0, \tag{1}$$

where ϕ (x,z,t) is wave potential.
The boundary condition is

$$z=h,\ \partial\phi/\partial Z=0, \tag{2}$$

and

$$z=0,\ \partial\phi/\partial Z=-\partial\zeta/\partial t, \tag{3}$$

where ζ (x,t) is surface elevation.

The condition of pressure uniformity on the free-surface which combines ϕ and ζ is

$$z=0,\ \partial\phi/\partial t=g\zeta. \tag{4}$$

$$\phi=g/\sigma[a\cosh\kappa(z-h)\cdot\cos(\kappa x-\sigma t)+\sum_{i=1}^{\infty}a_i\cos k_i(z-h)\cdot e^{-k_i x}\cos\sigma t] \tag{5}$$

$$\zeta=a\cosh kh\cdot\sin(kx-\sigma t)+\sum_{i=1}^{\infty}a_i\cos k_i h\cdot e^{-k_i x}\sin\sigma t \tag{6}$$

If distribution of wave motion is symmetrical about the center of source and r is in the radial direction and θ is in the azimuthal direction of wave propargation, the equation of continuity becomes in this three-dimensional case,

$$\partial^2\phi/\partial r^2+\partial\phi/r\partial r+\partial^2\phi/r^2\partial\theta^2=0. \tag{7}$$

Boundary conditions are also the same as that of the two-dimensional case.

The solution is

$$\phi=g/\sigma(a\cosh\kappa(z-h)\cdot\{J_0(kr)\cos\sigma t+Y_0(kr)\sin\sigma t\}+\sum_{i=1}^{\infty}a_i\cos k_i(z-h)K_m(k_i r)\cos(m\theta-\sigma t)) \tag{8}$$

$$\zeta=a\cosh kh\{J_0(kr)\sin\sigma t-Y_0(kr)\cos\sigma t\}+\sum_{i=1}^{\infty}a_i\cos k_i h K_m(k_i r)\sin(m\theta-\sigma t) \tag{9}$$

from the common boundary conditions,

$$\sigma^2=g\kappa\tanh kh \tag{10}$$

and

$$\sigma^2=-gk_i\tan k_i h,\qquad i=1\cdots\cdots,\infty. \tag{11}$$

These equation have two groups of wave system. The former is the progressive type which is expressed by the first term, and the latter is stationary type which is expressed by the secand series summation terms.

3 ANALYSIS OF METEOROLOGICAL TIDE ON THE OCEAN SURFACE

In the record of marinograph at different stations there are some times peculiar departure which resembles so closely the "seiche" or undulation of sea level. If we track these sort of "tsunami" successively, we can observe the travelling velocity and decay of wave height and growth of wave length.

Figures 1 through 4 are the case of 9th February 1970. The center of low might be about 35°N and 143° E east of the Izu Island and two waves traveled westward along the south coast of the Japan Proper.

Figutes 5 through 8 are the case of 11th September 1976. The center of typhoon is located at 30° N 129° E in the Ryukyu Islands and wave traveld northward to the east and west coast of Kyushu Island.

The velocity of propagation of the continental shelf 188.99m/s (1st) or 231.66m/s (2nd) in the former and 244.95m/s (east coast) and 159.76m/s (west coast)for the latter.

Dissipation of travelling wave is to be seen in Figures 1 and 2 and Figures 5 and 6 for wave hights and wave periods.
Figures 3 and 7 show the arrival time of wave.
Figures 4 and 8 are typical records of marinograph which show the prominent shock on the sea level.

This sort of strange wave has occurred every seven years namely in 1976, 1969 ······. This period can be found in the observed data of lattitude variation, namely 7.72863 and 14.07738 years from the x-term and 7.73215 and 14.03671 years from the y-term.

4 CONCLUSION

In the air this sort of progressive wave must travel on the surface of tropopause.
Though use can see only progressive wave of the first term in Equations 6 and 9 on the surface of ocean, we are able to observe the suspended cloud pattern in the air which are written in the second stationary term of rest part of these equations.

This phenomenon is usually caused by the shock of thermodynamical origin vertically from the center of earthquake, which shocks the tropopause and then produces radially tidal waves.
Its velocity is observed as 279.10m/s (28th July) and 282.95m/s (15th Nobember). The photograph of this secen is shown in Figures 9.

The cloud floating at the sublayer under tropopause is buffetted and entangled, so that we can obtain some data prediction of earthquake by finding these special string-like cloud.

Furthermore, the abnormal increase of humidity of the air or increase of the altitude of tropopause causes the diffraction of the beam of the rising or setting sun. Which also may tell us some seismological indication of the unusual activity of earth's surface.

The author should express hearty thenks to Mrs. Y. Sato, the Assistant of his office and Mr. C. Kagita, Mayor of Nara City, for their laborious efforts of gathering data of natural observation, and many staffs of the Japan Meteorological observatory and the Japan Maritime Safety Agency for supplying and searching the marinograph records.

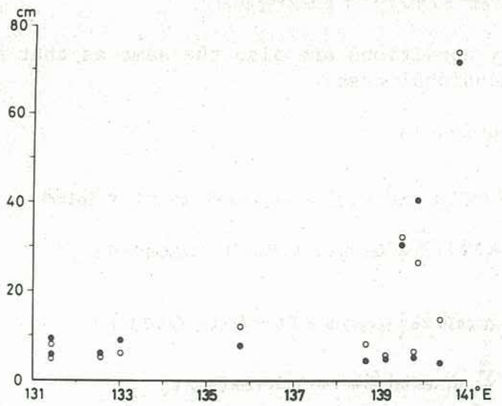

Figure 1 Observed double amplitude of wave at each station in 9th February 1970

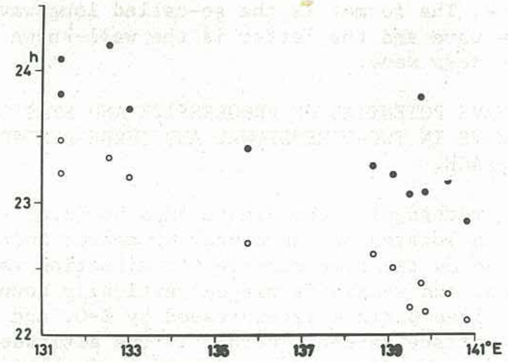

Figure 3 Arrival time of wave at each station in 9th February 1970

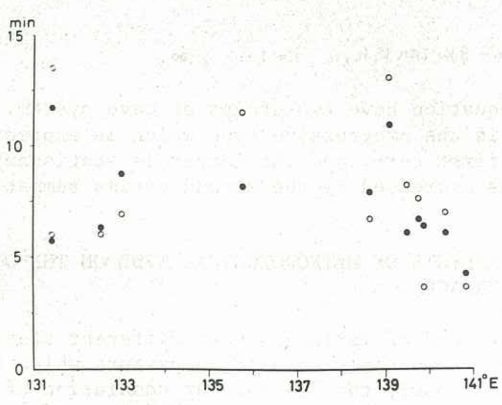

Figure 2 Observed double period of wave at each station in 9th February 1970

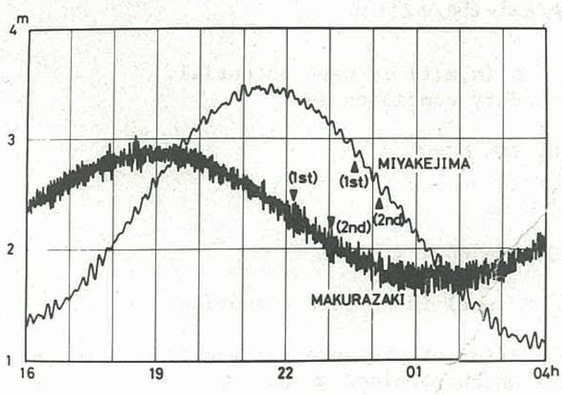

Figure 4 Typical record of marinograph in 9th February 1970

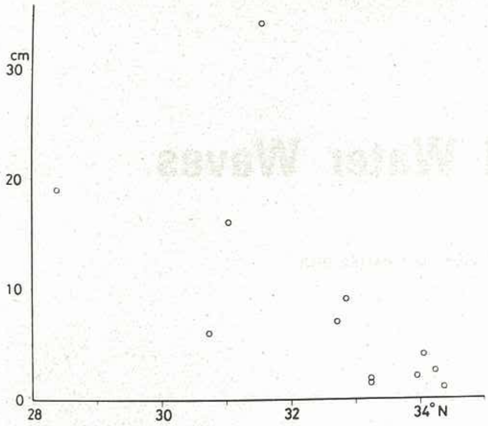

Figure 5 Observed double amplitude of wave at each station in 11th September 1976

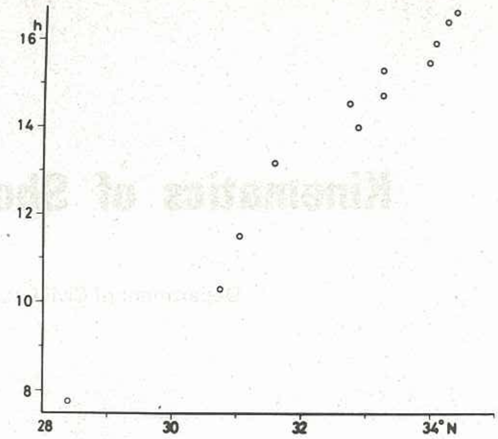

Figure 7 Arrival time of wave at each station in 11th September 1976

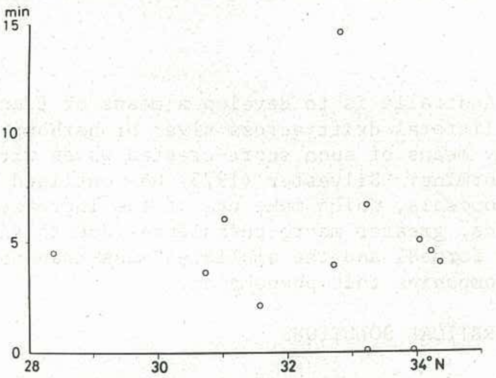

Figure 6 Observed double period of wave at each station in 11th September 1976

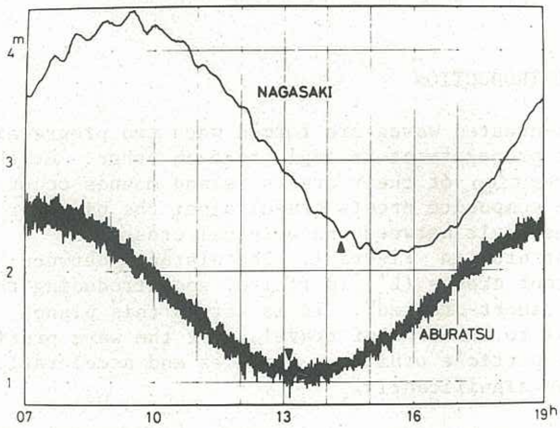

Figure 8 Typical record of marinograph in 11th September 1976

Figure 9 .Stationary cloud caused by earthquake 11th November 1976