Calculation of tsunami horizontal velocity field from tsunami magnetic field
An new dataset for tsunami early warning

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Contents

- Derivation of the equation for estimating tsunami horizontal velocity fields from tsunami magnetic fields.
- Comparisons of estimated tsunami horizontal velocity fields from simulation and observation of tsunami magnetic fields with simulation results.

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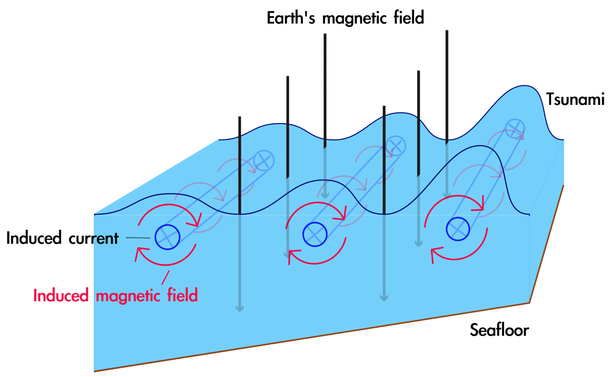
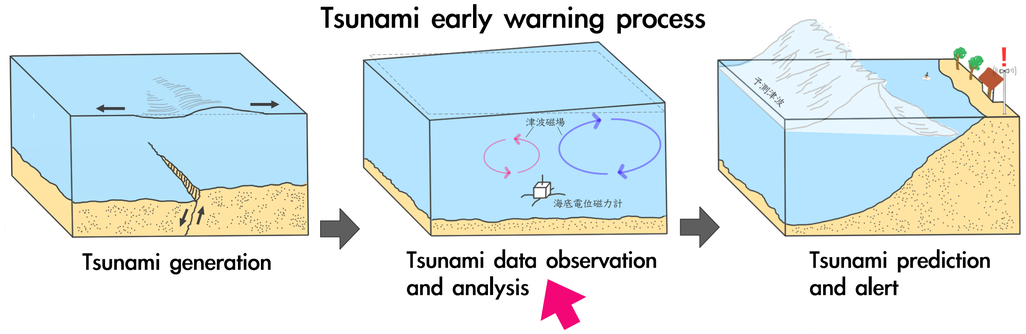
Introduction

Tsunami can generates induced magnetic field



Tsunami early warning process



This study can provide tsunami velocity field for tsunami early warning.

Methods

Maxwell's equation:

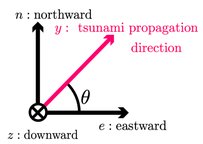
Tsunami-induced magnetic field, Tsunami velocity field, Uniform Earth's magnetic field

$$(\nabla^2 + i\omega\sigma\mu_0)\vec{b} = -\sigma\mu_0\nabla\times(\vec{V}\times\vec{F})$$

ω : angle frequency of waves　σ : conductivity of seawater
μ_0 : vacuum permeability

Linear dispersive wave equations:

$$\begin{cases} v_e = A\cos\theta\cosh[k(z-H)]e^{i(\vec{k}\vec{y}-\omega t)} \\ v_n = A\sin\theta\cosh[k(z-H)]e^{i(\vec{k}\vec{y}-\omega t)} \\ v_z = -iA\sinh[k(z-H)]e^{i(\vec{k}\vec{y}-\omega t)} \end{cases}$$



Unknown !

The Exact Equation

$$(\nabla^2 + i\omega\sigma\mu_0)\begin{pmatrix} B_e \\ B_n \\ v_{n_{Surface}} \end{pmatrix} = \sigma\mu_0\frac{\partial}{\partial z}\left(-\frac{\cosh[k(z-H)]}{\cosh(kH)}F_z - i\frac{\sinh[k(z-H)]}{\cosh(kH)}F_y\right)$$

The Approximate Equation

$$(\nabla^2 + i\omega\sigma\mu_0)\begin{pmatrix} B_e \\ B_n \\ v_{n_{Surface}} \end{pmatrix} = \sigma\mu_0\frac{\partial}{\partial z}\left(-\frac{\cosh[k(z-H)]}{\cosh(kH)}F_z - i\frac{\sinh[k(z-H)]}{\cosh(kH)}F_y\right)$$

Air: 0 S/m
Seawater: 3.3 S/m
Seafloor: 0.01 S/m

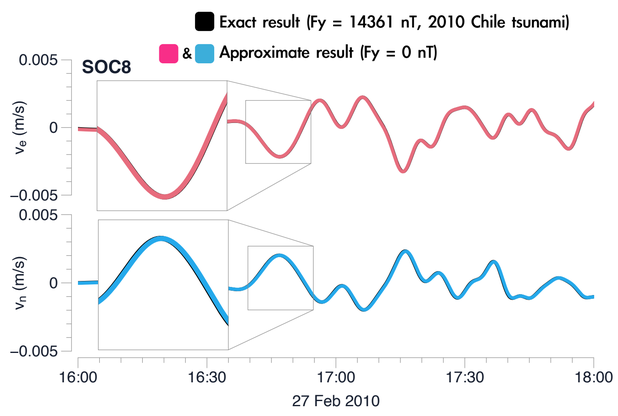
tsunami frequency, tsunami direction

$$\left(\frac{B_e}{v_e}, \frac{B_n}{v_n}\right) = A(\omega, D)e^{i\theta(\omega, D)}$$

$$\left(\frac{B_e}{v_e}, \frac{B_n}{v_n}\right) = A^*(\omega)e^{i\theta^*(\omega)}$$

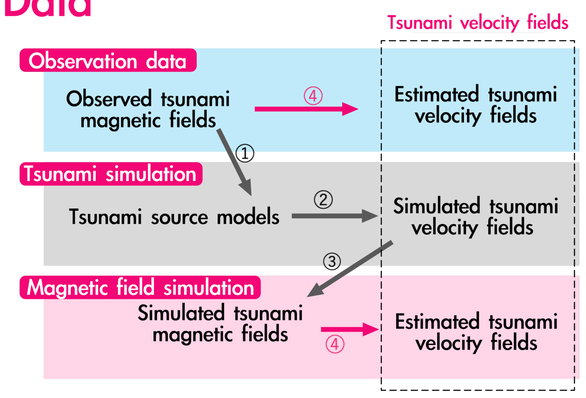
tsunami frequency

Accuracy examinations



Estimated tsunami horizontal velocities from simulated tsunami magnetic field by using exact equation and approximate equation

Data



① Tsunami source models were calculated by the method of Baba et al. (2005) using the observed tsunami magnetic fields.

② Tsunami velocity fields were simulated by JAGURS. (Baba et al. 2017)

③ Tsunami magnetic fields were calculated by TMTGEM. (Minami et al. 2017)

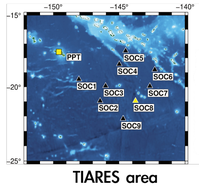
④ Tsunami velocity fields estimated by the approximate equation in this study.

Results

2010 Chile tsunami

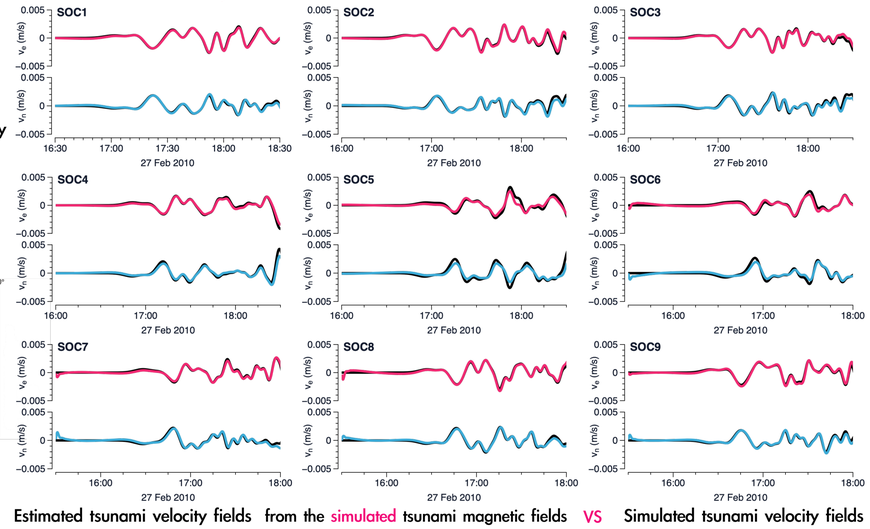
& Estimated velocity
Ve Vn

Simulated velocity



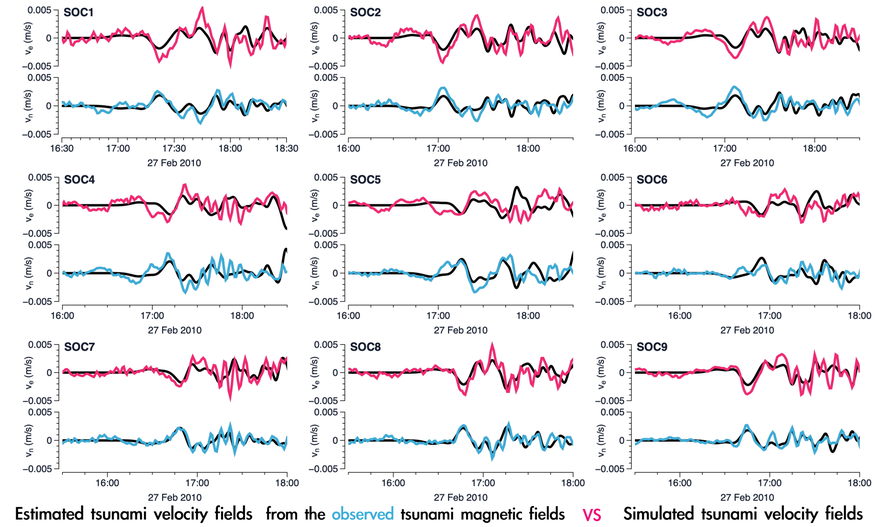
TIARES area

for simulation data



Estimated tsunami velocity fields from the simulated tsunami magnetic fields VS Simulated tsunami velocity fields

for observation data



Estimated tsunami velocity fields from the observed tsunami magnetic fields VS Simulated tsunami velocity fields

Conclusions

- We derived an equation for estimating tsunami horizontal velocities from tsunami magnetic fields.
- Compared to the simulation, our estimation equation is very accurate.

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