

## Radiological Assessment in Marine Environment for a Hypothetic Nuclear Accident based on the Database of Tidal Harmonic Constants

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### 1. Introduction

Most nuclear power plants in China are located on the coast and generally use seawater for cooling. Yellow Sea will be surrounded by these nuclear power plants. The marine dispersion of radionuclides for a nuclear accident has been an important issue since the Fukushima Daiichi accident in 2011. An oceanic radiological assessment system based on the database of tidal harmonic constants was developed and used to demonstrate a scheme for generating real-time predictions.

### 2. Background

The hydrology of Yellow Sea was mainly governed by tides and tides are semidiurnal which rise twice a day in Yellow Sea. The amplitudes vary between about 0.9 and 3 meters at the coast of China. Tides are higher at the Korean Peninsula, typically ranging between 4 and 8 meters. The speed of the tidal current is generally less than 1.6km/h in the middle of the Yellow Sea, but may increase to more than 5 km/h near the coast. The fastest tidal current reaching 20km/h occur in the Myeongyang Strait between the Jindo Island and Korean Peninsula.

Current fields are important data for estimation of pollutant transport. Tides are rise and fall of sea levels caused by the combined effects of the gravitational forces exerted by the Moon and the Sun and the rotation of the Earth. Thus tide has a periodicity. When we need to analyze these periodicity data, the standard approach is to employ Fourier series, a form of analysis that uses sinusoidal functions having frequencies that are zero, one, two, etc, times the frequency of a particular fundamental cycle. These multiples are called 'harmonics' of the fundamental frequency and the process is termed harmonic analysis. Ref.[1] introducing the Doodson Number notation to organize the hundreds of harmonics constants. This approach has been the international standard ever since. Real tide could explain by sum of following expression.

$$A\cos(\omega t + p) \quad (1)$$

Where  $A$  is the amplitude,  $\omega$  is the angular frequency usually given in degrees per hour corresponding to  $t$  measured in hours, and  $p$  is the phase offset with regard to the astronomical state at time  $t=0$ . Above equation has more term due to elliptical shape of the orbits. Not described in detail here. We know the movement of orbit thus angular frequency could be defined very accurately. The amplitude ( $A$ ) and phase offset ( $p$ ) have to change according to the space. There are several ways to get amplitude and phase offset. Harmonic analysis of direct measurement data of water level in the region of interest is most accurate way, but difficult to obtain the spatial continuity. The satellite observations have spatial continuity but the accuracy is low. Thus, numerical model generally used for acquisition of these harmonic constants. In this study, 5minutes interval DB of Ref. [2] applied for prediction of tidal currents. For more information about the model domain, model description and its validation are well described on Ref. [2].

### 3. Method

The ocean dispersion model based on the Lagrangian particle method has been developed by the KAERI and tested in Fukushima Daiichi nuclear disaster. This model has named LORAS (Long-range Oceanic Radiological Assessment System). LORAS basically consists of advection and diffusion of radionuclides in the ocean. Additionally, the radionuclides interaction with sea water, suspended sediment and bottom sediment were included in this model. The interaction between the liquid and solid phases can be formulated as probability functions. The decay of radionuclides could be described by same manner.

Oceanic current data play an important role for estimation of advection and diffusion in ocean. When we need to be evaluated the distribution of leaked radionuclides in ocean, the calculation of heavy ocean model is very inefficient in time. A compact harmonic prediction system consisted on a database of tidal

constituents was developed and used to demonstrate a scheme for generating real-time predictions. The harmonic prediction system based on the MARIE which developed by the Permanent Service for Mean Sea Level (PSMSL). The coupled model of LORAS and MARI extract harmonic constants from 5 minutes DB based on the location of radionuclides that is represented by particle. The extracted 62 harmonic constants of about amplitude and phase offset on eastward and northward direction. These values used for prediction of real time tidal current based on sum of Eq.(1). Each particles move due to these real time tidal current and they have new location at the end of each loop. Also, the radionuclides interaction with sea water and suspended matters performed in this time with decay process.

#### 4. Numerical Results

Fig. 1 shows the hypothetical leaking event at the five nuclear power plant in China. The selected five nuclear power plants include currently operating, under construction or planned. In this hypothetical event has many assumption but the selected physical parameters on range of common sense and the range of radionuclides were widely spread by these value. Particles were used in the estimate of a total of 2,000,000, each particle represent the 0.1Bq at each five nuclear power plants. The five nuclear power plants leaked the radionuclides from March 1, at the same time, and after about a month the small amount of radionuclides are reached at the west coast of Republic of Korea. The total computation time takes about 2 hours for three month forecasting.

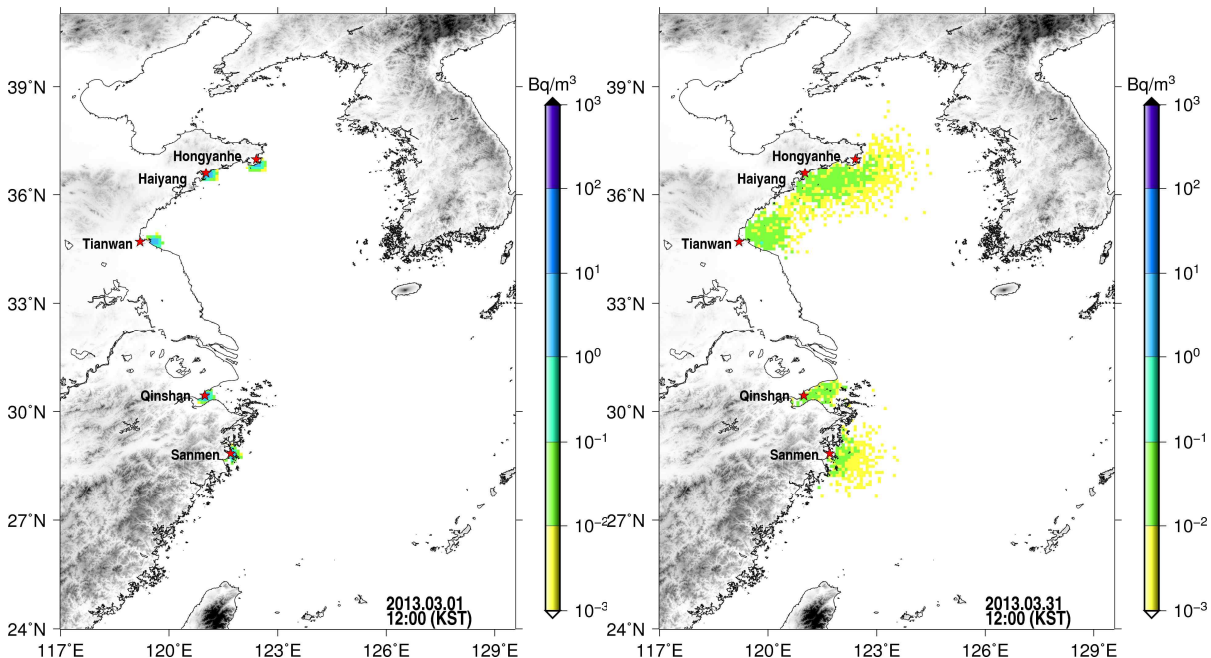


Fig.1. Numerical results for the hypothetical accident, colored area means the concentration of radionuclides in sea water.

#### 5. Summary

Reliability of predictions is the most important performance criterion. The database of harmonic constants can be improved by modifying its computational conditions, its numerical scheme and the details of its mesh system. In this paper, forecast efficiency and currents forecasts from the model-independent system were introduced. The system can also be extended to carry out oil spill event on marine ship accident.

#### REFERENCES

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