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EARLY WARNING SYSTEM FOR OIL SPILL USING SAR IMAGES

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ABSTRACT

A successful combating operation to a marine oil spill is dependent on a rapid response from the time the oil spill is reported until it has been fully combated. In order to optimize the decision support capability of the surveillance system for oil spill contingency planning, a GIS database have been integrated with the detection tool. This paper demonstrate the parallel activities on remote sensing and GIS which can be done for solution of old age problem on oil spill. An automatic oil spill detection tool was established and information on the exact position and size of the oil spill then visualized in GIS environment. The system offer opportunities for integration of oil drift forecast models by prediction of wind and current influence on the oil spill for risk assessment.

INTRODUCTION

The concept of oil spill contingency planning is refer to several activities for creating an immediately response programs such as detection, assessment and evaluation, management, clean up and so on when an oil spill happens by accidental or human error. Remote sensing, GIS (Geographic Information System), GPS (Global Position System), software analysis and programming languages are the example of tools that could be applied for any contingency planning. Geomatical oil spills contingency planners are difference due to different application tools, location and strategy, which are, considered for the plan. It looks like activities of architectures for planning the schools; the objectives are same but the results are several kinds of schools for different type of student groups, field, age and so on. Figure 1 is the schematic of one contingency planer based on oil spill detection and trajectory simulation. In this contingency planner the tools are satellite based SAR image and GIS, which are supported by EASI programming interface. The main components of this contingency are early warning system and trajectory simulation for oil spill based on oceanographic and metrological data. There are a lot of studies have been done on oil spill contingency. Hinds Hugh and Rupert Mendds (1977) have published oil spill contingency planning and Mikala Klint (1995) implemented a national marine oil spill contingency plan for Estonia by using GIS and recently several activities have been carried out to develop contingency planning by employing an oil spill trajectory model through sea current simulation such as Assilzadeh (1999) and Toh (1992) who have developed computer modeling of oil spill, based on wind and sea surface currents in the West Coast of Malaysia. Integration of remote sensing and geographic information system has been found a powerful tool for brings real time contingency planning. These elements of contingency planner are subjected in this paper to demonstrate their application in early warning system and trajectory simulations for oil spill.

MATERIALS AND METHODS

GIS and remote sensing is supported by EASI programming language to create early warning system and automatic trajectory simulation for oil spill. The first steps of the plan are satellite based oil spill early warning system, which is important requirement for any contingency planning. One of the main advantages with a satellite-imaging sensor, such as Radarsat-SAR, is the ability to cover large areas of the Earth's surface in a short time. This satellite can send data at any time during the day or night and give us cloud free images. The system has been created to extract oil spill based on texture analysis of radar image using PCI Modeler interface. This method gives us automatically and immediately information about spills area and polluted area from radar image (Diagram 1). The texture measures used by this program are based on R.M. Haralick, et al. and R. W. Conners, et al. who were demonstrated application of textural features for image classification. Texture is one of the important characteristics used to identify objects or regions of interest in an image. Unlike spectral features, which describe the average tonal variation in the various bands of an image, textural features contain information about the spatial distribution of tonal variations within a band. The texture of an image is related to the gray level joint probability distribution, which is approximated by the co-occurrence matrix.

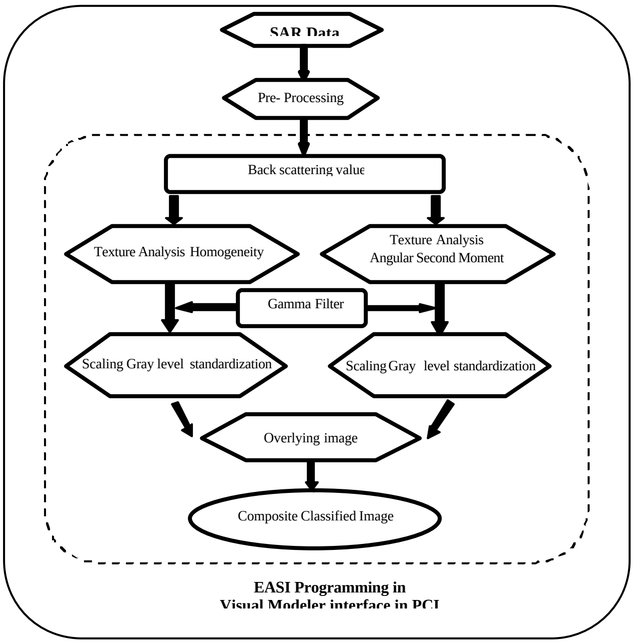

Diagram 1. An early warning system; for oil spill using Visual Modeler in PCI software.

Some of the textural measures relate to specific textural characteristics of the image, such as the texture element size and the contrast. Others characterize the complexity and nature of gray level transitions, which occur in the image. Even though these features contain information about the textural characteristics of the image, it is hard (if not impossible) to identify which specific textural characteristic is represented by each of these features. To solve a specific problem (for example, to separate oil spill from other objects in sea water, in a radar image on ground of a different texture) the usual approach is to compute all different texture measures and to use the measure, which provides the best result. For oil spill detection Homogeneity and Angular Second Moment were found as two effective texture analyses for oil spill detection and classification. Particularly, the amount of dispersion that the gray level co-occurrence matrix (GLCM) elements have about the diagonal, characterizes the texture of the local region. In Homogeneity the texture measure is high when GLCM concentrates along the diagonal. In Angular Second Moment the texture measure is high when the GLCM has few entries of large magnitude and low when all entries are almost equal. This is a measure of local homogeneity. For texture analysis the output channels should be 32-bit real type. To extract detailed information about oil spill, scaling radar standardized the texture values. Scaling performs a linear or nonlinear mapping of image gray levels to a desired output range. This program is typically used to scale data from "high" resolution (32 and 16-bit) channels to "low" resolution (16 and 8-bit) channels. Gamma map filter was applied on radar data to remove high frequency noise (speckle) while preserving high frequency features. The steps of this process were modeled in EASI Visual Modeler to analysis automatically the spilled oil in SAR image (Figure 2).

Short-range trajectory modeling is the most important objective for oil spill emergency response; therefore it should be done on real time to give day- to -day support oil spill contingency plan at a specific spill. GIS can be employed as a powerful tool for analyzing and visualizing model, and potential impacts. Combining both current and wind effects, the relationship of the center mass of the slick movement. Our simulations assumed more than hundred spills occurring in each of the four seasons of the year from each launch area. The time evolution of an oil spill trajectory can be obtained by a simple integration of the following equation:

$$r(t) = r(t_0) + \int_{t_0}^{t} \overline{V_{oil}}(t')dt' \qquad \text{Equation1}$$

Combining both the current and wind effects, the relationship of the movement of the center of mass of the water (Figure 3). These factors can be expressed as:

$$V_{water} = dr/dt = \mathrm{U}c + 0.035\,\mathrm{U}w \qquad \text{Equation 2}$$

Regardless the physical properties of oil and water, the size of the spill and its spreading tendency, the resultant vector may be estimated as:

$$\overline{V}_{oil} = (0.035\ Uw)`\overline{Kw} + (0.56\ Uc)`\overline{Kc} \qquad \text{Equation 3}$$

Where $\overline{V}_{oil}$ is spill drift velocity; Uw, wind speed at sea surface; Uc, current speed near the surface; $\overline{Kw}$, unit vector in the direction of wind drift and $\overline{Kc}$, unit vector in the direction of current (Pgkurup, 1983).

$$WF = Uw \,/\, V_{10} \qquad \text{Equation 4}$$

WF is the wind factor. Most meteorological observations for wind speed are taken at 10m above the sea surface. The velocity of wind at the surface (Uw) and the wind velocity at l0 m (V_{10}) are related by a wind factor (WF) such that the wind factor can be evaluated by following formula where ? is the latitude of the spill. Figure 4 shows the constriction of slick drift vector.

$$WF = 0.04/(V_{10}/\sin ?)^{1/2} \qquad \text{Equation 5}$$

Oceanographic data contain wind speed over surface water, wind direction over surface water, net current speed and net current direction over the study area was associated in GIS and the position of oil spill based on X, Y projection are situated as a point layer on the radar image, situated as base map in the interface. Programming the model with EASI could enable us to receive to the much more near real time tools for oil spill contingency and decision-making based on GIS and remote sensing.

RESULTS AND DISCUSSIONS

Texture analysis calculated a set of texture measures for all pixels on SAR image. Two different texture algorithms were applied on the image to get detailed information related to spilled area. Figure 4 presents the effect of Homogeneity and Angular Second Moment texture algorithm on oil spill image. The results can be described by profile of grey value in figure 5. The attribute gray level of the original image after converting to 8 bit is presented in channel 1. It is noisy and poor in describing the spill area. The result after effect of texture can do better description related to Spill area. These two effects convert the noisy grey value profile of channel one to two sharp and clarify region in channel 2 and 3. Overlying these channels yield a composite image of spilled oil in two different colors. Figure 3 describes the schematic of oil spill trajectory modelling based on oceanographic and meteorology information. This model is installed on GIS to visualise time to time the new position of spilled oil based on weather and sea condition. User needs to input these data and the exact coordination of oil spill on the base map, then run the program to find the new positions of spilled oil. As default the system prompt to calculate the new positions of hypothetical spill over each grids in the study area after 3, 6, 9 and 12 hours (Figures 6).

CONCLUSION

This paper demonstrate the parallel activities on remote sensing and GIS which can be done for solution of old age problem on oil spill. These techniques focused on different part of contingency planning such as oil spill detection, modeling oil spill, and finally atomization of spill detection and trajectory simulation in GIS environment.

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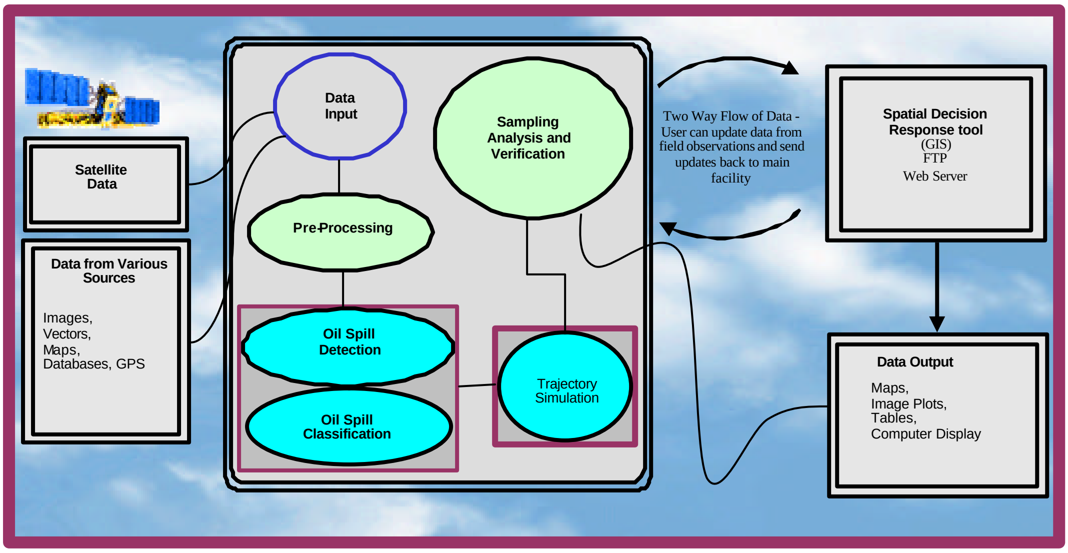

Figure 1. Oil spill contingency planner based on remotely sensed data and GIS for the Straits of Malacca.

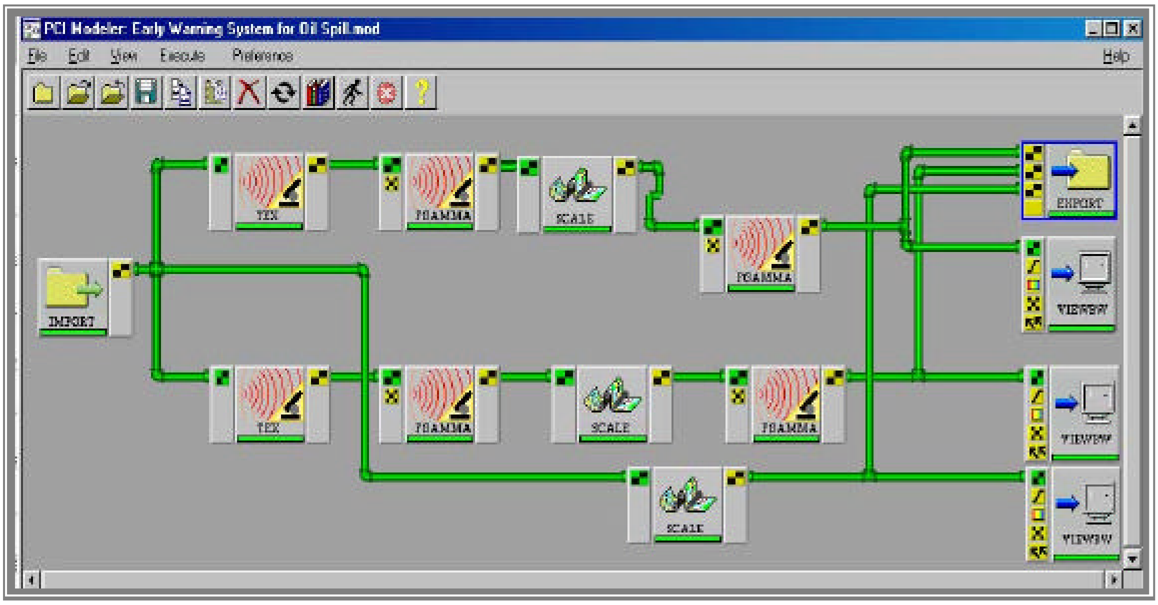

Figure 2. Schematic of Visual Modeler program in PCI for automatic detection and classification of oil spill

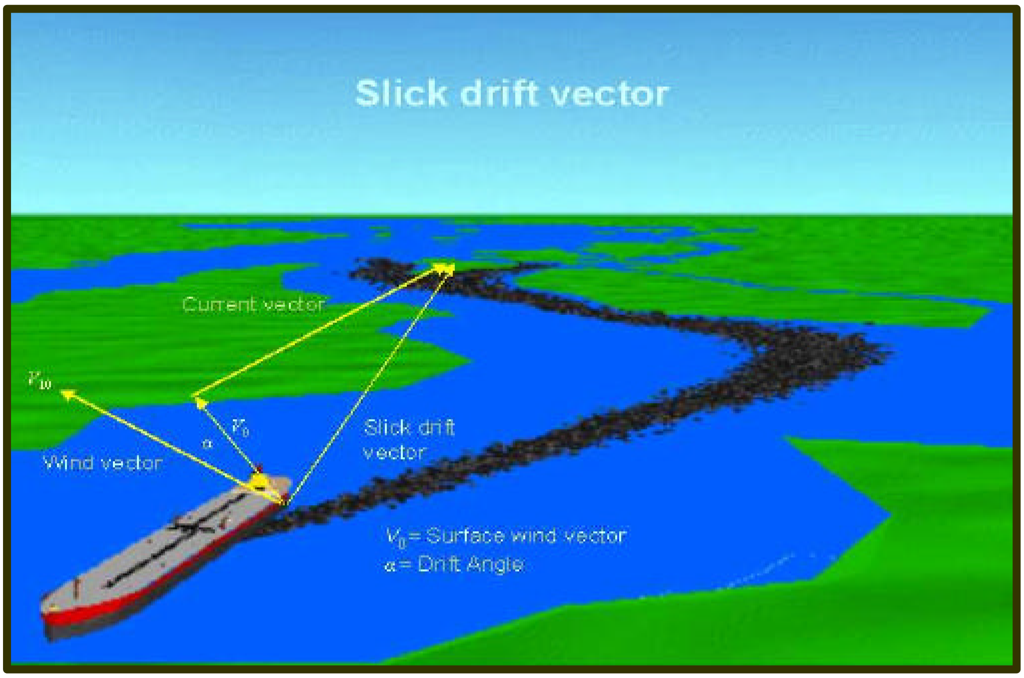

Figure 3. Schematic of oil spill trajectory modeling based on wind induced current and net current.

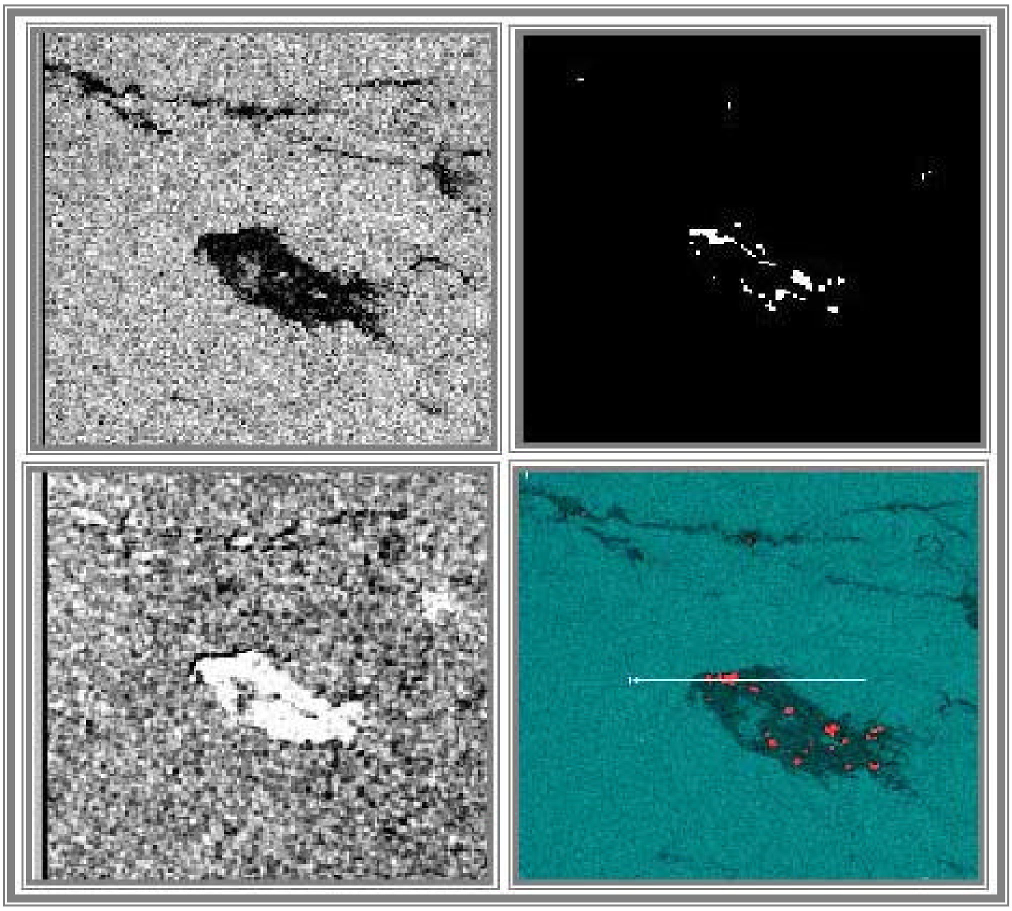

Figure 4. Two different reactions on raw image (upper left) using EASI command in PCI Visual Modeler to classify spill area in two classes; oil spill region (Upper right), and pollution area (Lower left). Lower right is composite image by overlying channels to classify spill area and pollution area.

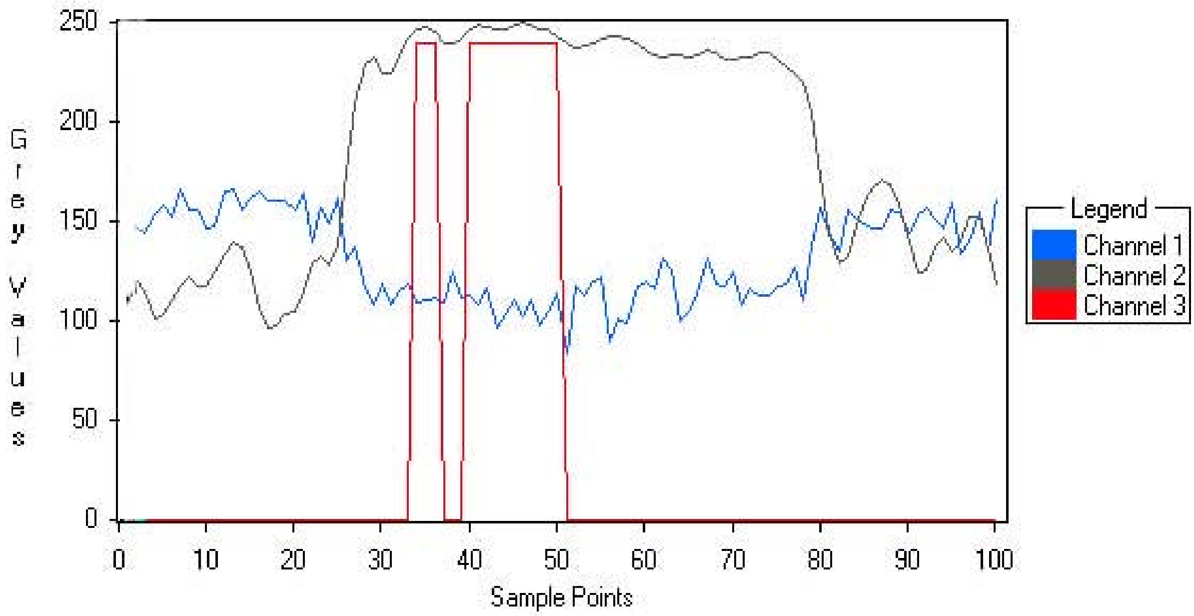

Figure 5. Grey values of original image (Chanal1) and attribute values after Homogeneity (Channel 2) and Angular Second Moment (Channel 3) texture analysis Channel 2 specify the whole polluted area and channel 3 rectify only very high-polluted area (Spilled area).

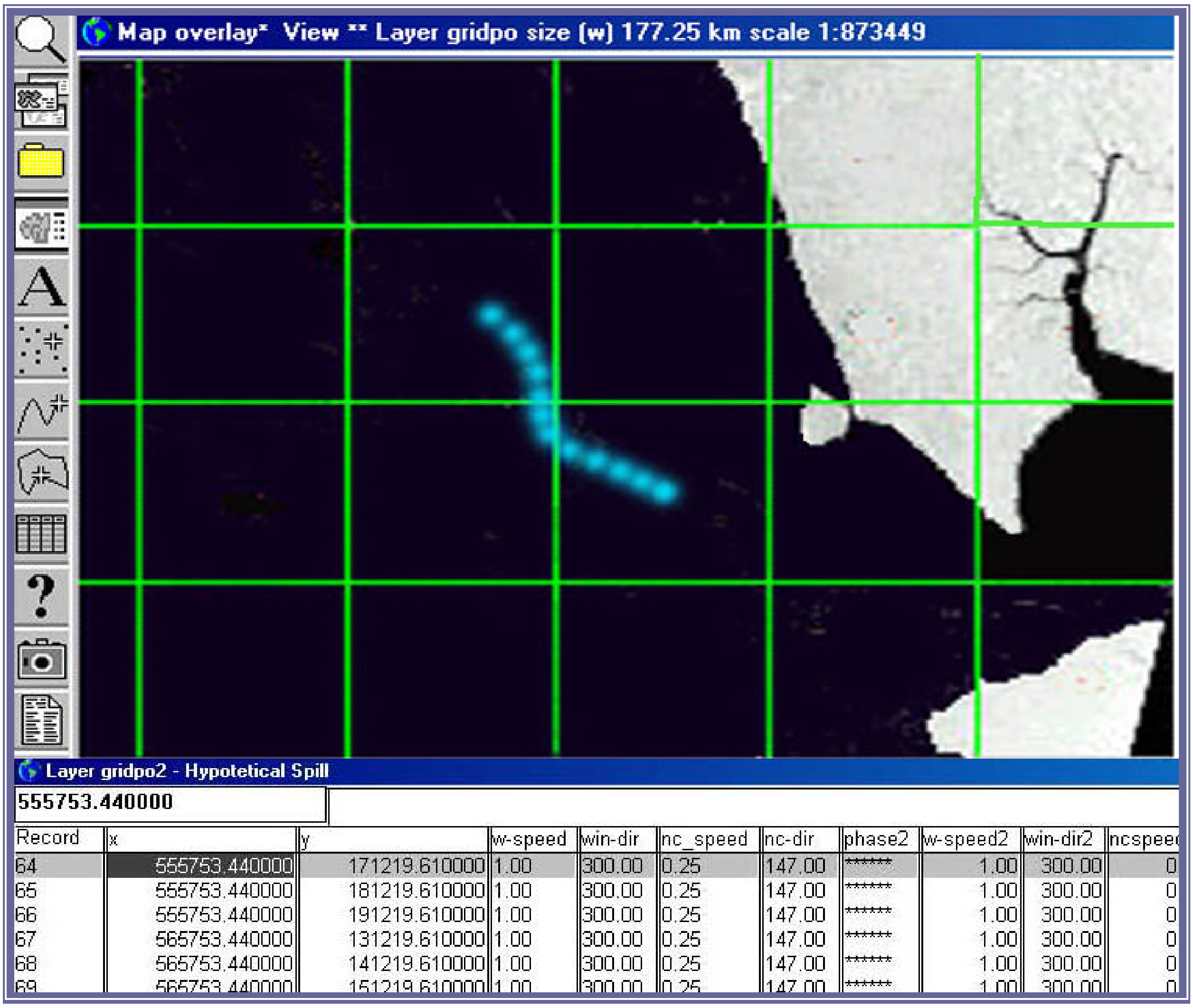

Figure 6. Simulated new positions of hypothetical spill over each grid in the study area after desired time