

## Marine wind data presentation using wind transition matrix

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One of the methods to simulate the random wind behaviour through time is to use historical wind data presented in the form of wind transition matrix. Here it is assumed that, the probability that the wind will shift from one direction to another depends upon the direction from which the wind is presently blowing. The percentage cumulative wind transition matrix of the order of  $49 \times 49$  has been presented for the data obtained by the wind monitoring system. These observations were obtained at a coastal site north of Goa.

The marine wind monitoring system has been developed for long term unattended measurements for use at remote coastal sites, ocean surface platforms and on board research vessels. This system has an open and modular configuration and was interfaced to a variety of sensors to assess relative performance of vector averaged winds, gust, air temperature and barometric pressure<sup>1</sup>. In this paper the wind transition matrix, percentage probability wind transition matrix and cumulative probability wind transition matrix have been presented, for the wind parameters measured by CUP type wind anemometer. The stability factor for the month of April and May have been presented.

Aanderra wind speed sensor consisting of a 3 CUP rotor was used. The sensor has a magnet and reed switch assembly to sense the rotations and a built-in averaging circuit that operates<sup>2</sup> over the averaging intervals from 8 sec to 3 h. The range of the wind sensor is 0-60 m. sec<sup>-1</sup> with an accuracy of 0.2 m. sec<sup>-1</sup>. The threshold speed is between 30-50 cm. sec<sup>-1</sup>. The direction sensor uses a damped vane, that is magnetically coupled to a compass coil and is energized by a voltage signal which latches the arm on a pivoted magnet on to a potentiometer track. After the measurement the compass coil is de-energised and the follower magnet is free to rotate. The life time of a potentiometer is thereby improved as there is no continuous contact of the arm with the track, however, the fastest sampling rate is limited to once every few seconds. Presently, sampling rate was limited to once every 10 sec. The range of the wind direction sensor is 0°-360° with an accuracy of + 5° and with a threshold speed of < 30 cm. sec<sup>-1</sup>.

The wind data obtained from the wind monitoring system is an hourly average. All wind speeds of intensity < 0.2 m. sec<sup>-1</sup>, irrespective of the direction

have been grouped as calm. Hence the first row and the first column of the wind transition matrix<sup>3</sup> represents calm (Table 1). Each of the 8 wind directions (N, NE, E, SE, S, SW, W, NW) are further categorised into 6 different sub-groups depending on the wind speeds as shown below:

- a)  $0.2 < \text{wspd} < = 2.5$
- b)  $2.5 < \text{wspd} < = 5.0$
- c)  $5.0 < \text{wspd} < = 7.5$
- d)  $7.5 < \text{wspd} < = 10.0$
- e)  $10.0 < \text{wspd} < = 12.5$
- f)  $12.5 < \text{wspd} < = 16.5$

where wspd is the windspeed in m.sec<sup>-1</sup>.

The wind transition matrix<sup>3</sup>, percentage probability wind transition matrix and the cumulative probability wind transition matrix for the months of April and May '89 are presented as examples (Table 1). The percentage stability factor (SF) was calculated by using the formula,

$$\text{SF} = (\text{Sum of diagonal elements} / \text{sum of all the elements}) \times 100$$

The percentage SF for April and May are 59.4 and 59.25 respectively.

One application of the wind transition matrix is to determine the various probable wind series that might occur, during the period for which offshore oilspill risk is to be analysed. During these analyses different probable wind conditions have to be generated at different locations and at different instances of time.

In order to simulate various possible wind series that might occur, subsampling a long historic wind time series has to be made by choosing arbitrary starting dates. This however assumes that only wind



transition sequences, that have occurred in the past can happen in the future. These shortcomings are rectified by generating various probable wind series using the cumulative probability wind transition matrix (Table 1).

This matrix is constructed from the historic wind record and assumes that wind can be modelled as a Markov process<sup>4</sup> in which, likelihood of, wind speed and direction in the next interval depends only on the current wind speed and direction. Hence the variations in the wind is represented as a first order Markov process, i.e. the wind in one time-step is a random function of the wind in the previous time-step. The individual elements of the percentage cumulative wind transition matrix (Table 1) are the probabilities that a particular wind velocity will be succeeded by another wind. The longer the historic data set, better will be the resolution of the cumulative probability wind transition matrix. To generate the wind series one has to assume a particular wind state (i.e. choose a particular number from a particular row of the cumulative probability matrix), and then generate a random number and check the corresponding value on the same row, which is closer to this random number. The corresponding column is then obtained for this new location. This value gives the wind state for the next instance, which is the first element of the wind series. The previous value obtained is used as a seed to generate the next element

of the wind series. This procedure is continued to obtain other elements of the wind series.

Wind transition matrix could be used to determine the maximum probable wind state, that might occur during the next time step. It is recommended that large historic wind data should be presented in the cumulative probability wind transition matrix. This format allows presentation of large amount of data in a limited space. Transition matrices can be used to generate several possible wind series that might occur in the region. This finds application in studies of oilspill risk analysis.

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#### References

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