Geophysical Research Abstracts
Vol. 13, EGU2011-12499-1, 2011
EGU General Assembly 2011

A spatially distributed probabilistic model for forecasting river planform change of an alluvial mega-river

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River planform change has been predicted using probabilistic methods as deterministic methods are not always suitable for prediction of channel behaviour, especially for channels with high rates of planform mobility (Graf, 1984; Winterbottom et al., 2000). Historical records of channel location derived from aerial photographs and maps are a vital input to spatially-defined statistical models for estimating the probability of a given land cell being destroyed by erosion and the probability of a given channel cell being replaced by accretion. This methodology has been applied to small and medium rivers, but has not been applied to the largest rivers on Earth.

The River Ganga, one of the major rivers in India, is characterized by changes in its course over human time scales; particularly in its seaward reaches before it enters the Bay of Bengal. The river is prone to bank erosion during high discharge leading to change in its planform. Change in the planform of this river has been recorded in the historical literature and the floodplain is characterized by spill channels and older meander scrolls as remnants.

Satellite sensor data are widely used to study Earth surface processes, especially monitoring changes in the planform of large and dynamic rivers. This is due to the potentially large area coverage, synoptic view and repeatable data acquisition capability. Thus, satellite sensor data have great potential for providing standardized mapping of river planform at regular intervals. Landsat data, being freely available, have enabled time-series data analyses from as early as mid-1972. The present study incorporates time-series data from Landsat and Indian remote sensing satellite sensors to map the change in planform of the River Ganga through time and use these quantified changes as an input to a spatially-distributed probabilistic model for forecasting future planforms of the river system.

Planform maps were prepared from the time-series data using conventional data processing, taking into account the different confounding variables, such as spatial resolution, while creating a consistent time series. The planform maps were then converted into maps of transition probabilities based on the probability of individual cells changing from land to river (and vice versa), as a function of the location of the cell relative to the river, the properties of the nearest part of the river and the substratum. Besides the transition probability maps, vulnerability maps were prepared taking into consideration various dimensions such as land/agricultural value, livelihood value and infrastructure value. The two sets of maps then were combined to produce risk maps for future mitigation of the planform change hazard. The transition probability maps were used also to draw different realisations from a random field with specific models of spatial continuity to produce realistic channel patterns. We conclude that the forecasting of channel pattern can be accomplished only over a short period of time (1-5 years) because, when the channel shifts more than around five grid cells, the forecast becomes unrealistic as the approach does not include creating side channels.