# MIKE 11 enhancement under WAMM

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## *Introduction*

MIKE 11 is applied on a routine basis for forecasting and management of floods in many countries, see e.g. Ammentorp and Jørgensen (1998) or Refsgaard et al (1988).
The purpose of the forecasting varies from place to place, but usually falls in one of three categories:

1. inflow forecasting to reservoirs, allowing an increase of the available storage before the flood arrives
2. water level forecast along the rivers to ensure sufficient time for warning and possible evacuation
3. forecast of water availability to optimise the operation of irrigation schemes or hydropower plants

Where large and/or important areas are in danger of being inundated, MIKE 11 GIS is applied in combination with the forecast calculations to provide flood maps, showing the extent and depth of (the expected) flooding. The basis of such a map is a network of river branches on the flood plains with embankments, railways etc. represented as structures in the model.

It is normally not possible, however, to calibrate the models with respect to flow on the flood plains, as measurements are not available here. It is known that the resistance to the flow will be higher on land than in the river, but determining the actual variation of the roughness on flood plains is not possible without observations of the flooding, as it develops.

The launching of satellites with Synthetic Aperture Radar (SAR) instruments during the 1990s now provides a possibility of monitoring the spreading of floodwater from space. The capability of these active microwave systems to perform measurements through cloud cover and during the night makes them particularly interesting for this purpose.

## *MIKE 11 flood forecasting*

In the standard set-up of MIKE 11 for flood forecasting, illustrated in figure 1, two types of input are required:

- Real-time data on the meteorological and hydrological conditions at stations in the catchment
- Quantitative precipitation forecasts for the catchment area and predictions of the inflow from any upstream areas, which are not included in the model.

Based on this, MIKE 11 calculates forecasts of water level and flow in the rivers and, where required and possible, inundation forecasts presented as flood maps in GIS. The key MIKE 11 components in these calculations are:

- Rainfall-runoff models to the describe the sub-catchment runoff generated by rain or snowmelt
- A hydrodynamic model (HD) of the river system and flood plains
- An updating routine to adjust the model simulations to observations, as required, see Refsgaard or Rungø et al.

- GIS mapping of the flooding as simulated by the HD model

The operational application of MIKE 11 for flood forecasting over many years has consolidated its reliability. For the forecasting on flood plains, however, there is a risk of inaccuracy due to the lack of calibration data. An important objective of the WAMM project is, therefore, to increase the number of areas, where reliable inundation forecasts can be issued.

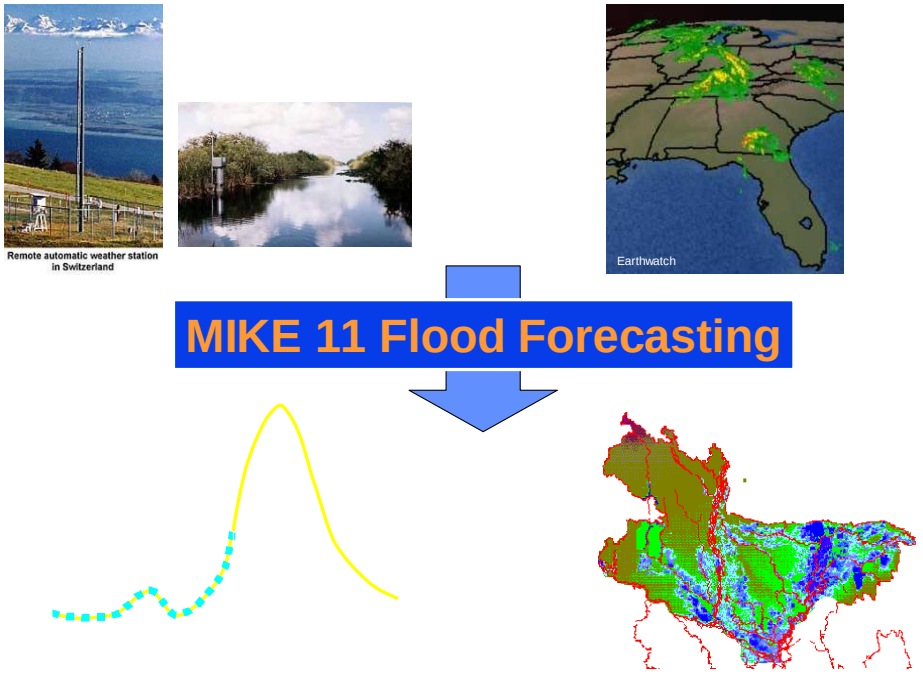


*Figure 1. MIKE 11 flood forecasting*

### *MIKE 11 Enhancement*

The software development under the WAMM project aims at improving our capabilities of answering questions such as:

- When will flood water reach a given location on land?
- How long will the inundation last / be more than a given depth?
- How much could the flooding be reduced by alternative measures including reservoir regulation, controlled flooding of selected polders etc?

To reach this goal, the following, new facilities are being developed to complement the MIKE 11 flood forecasting system:

- Facilities to utilise the SAR data on flooding for model calibration and validation. The observed and simulated flood maps will be compared and the differences highlighted, so that reasons for the deviation can be detected. These could include physical differences, such as a breached embankment, or indicate a non-perfect calibration.
  The images will have been pre-processes as described in Moeremans et al (1999). Further image processing may include merging of pixels in the different classes as illustrated below.

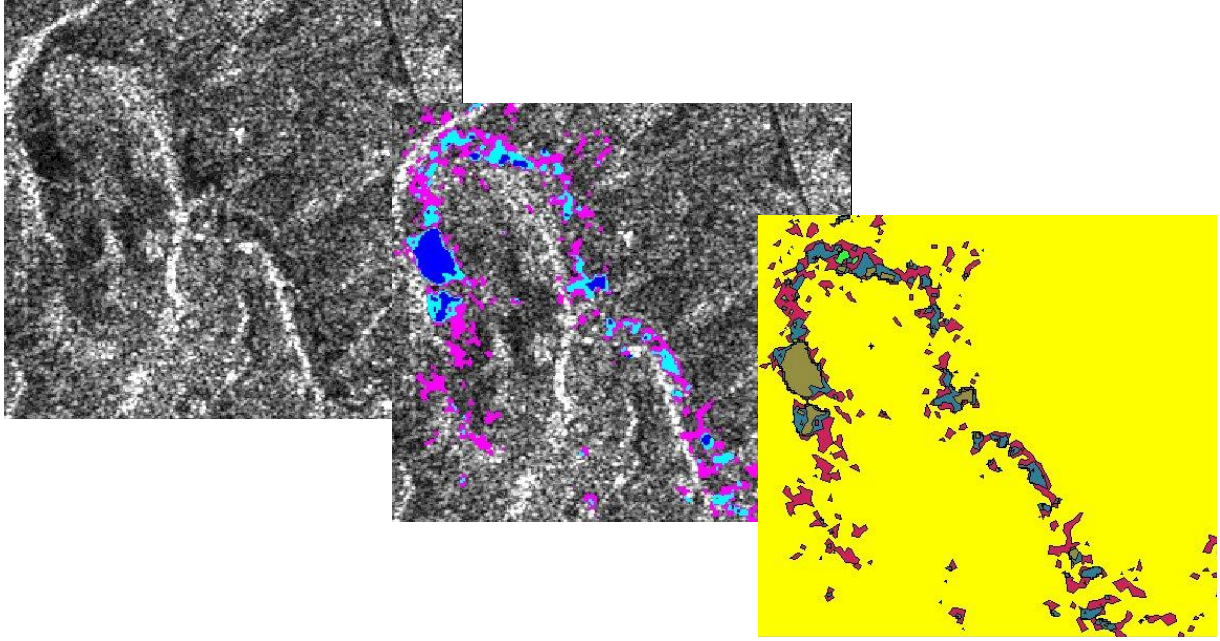

*Figure 2. Identified flooded areas are merged in ArcView*

- Facilities to utilise SAR based estimates of the soil moisture. The runoff generated from the catchment areas is strongly dependent of the prevailing soil moisture conditions. The NAM rainfall-runoff model in MIKE 11 takes this into account through its surface and root zone storages. Rainfall events, which were not observed at the raingauges, may, however, cause differences between the actual and simulated soil moisture in parts of a catchment. The SAR images provide an opportunity to update the model for such events.
- Facilities for presentation of the results in selected points as well in spatial overviews for result analysis and warning dissemination. Some existing, project specific facilities will be generalised, such as the district flood status mapping in Bangladesh, see figure 3. Other facilities include flood duration maps, inundation statistics etc.

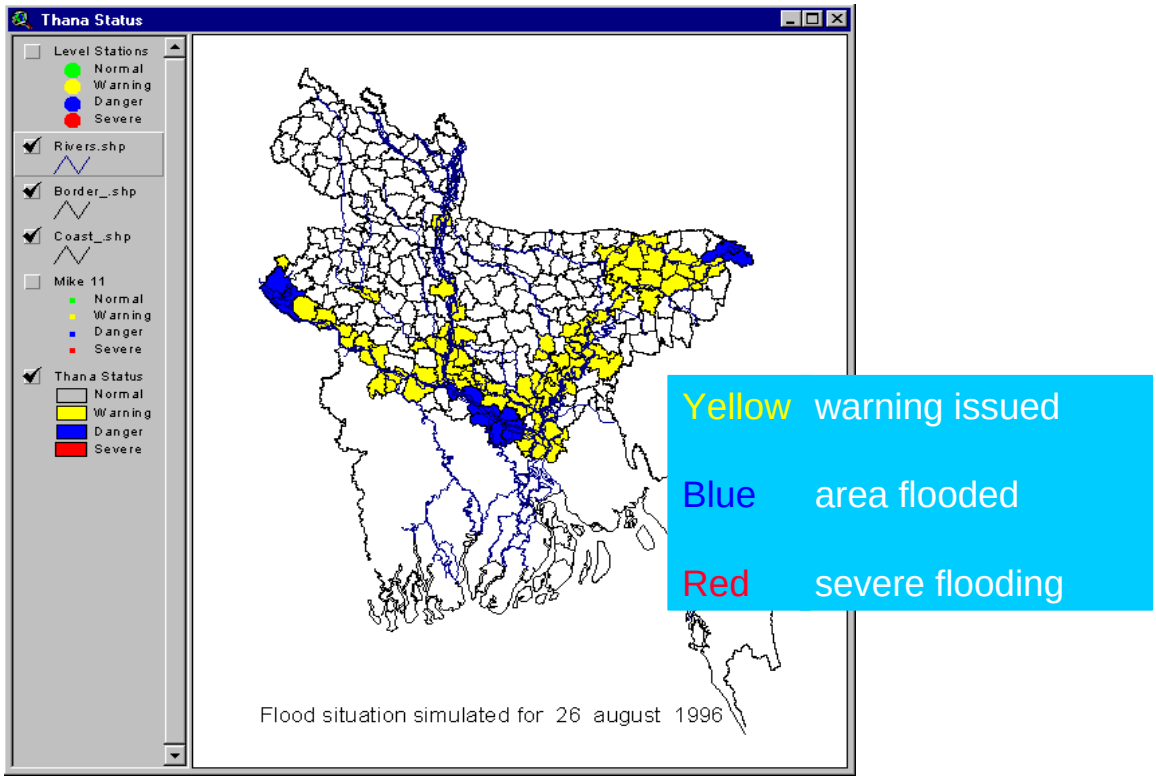


*Figure 3. Flood warning overview in Bangladesh*

## *Conclusion*

The MIKE 11 flood forecasting system combined with the additional facilities described above will constitute a Decision Support System, which can provide the user with the required information, overviews and model simulations to decide on the best possible line of actions in flood situations.

The system components will also be applicable separately to enable their use as part of other, existing flood management systems. This is important for the dissemination and widespread application of WAMM.

The structure of WAMM is shown below.

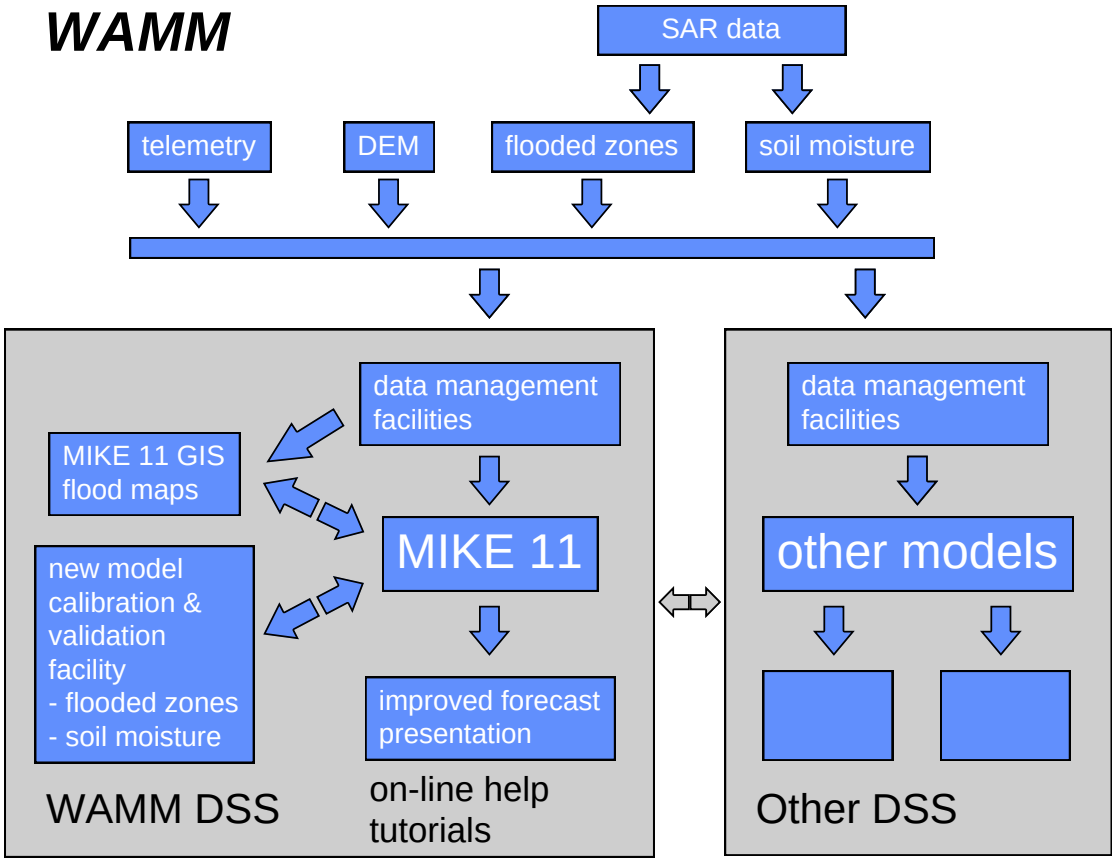


*Figure 4 structure of WAMM. The required input includes the SAR based flood maps and soil moisture estimates as well as standard telemetry and DEM data. The MIKE 11 output is extended by flood maps of high accuracy, warning overview etc.*

## *References*


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