Annual flood dynamics in the Volga-Akhtuba floodplain

L.M. de Bruijn[1] & M.A. Crone[1],
L.V. van den Bosch[1], O.V. Filippov[2], H. Middelkoop[1]

[1]Utrecht University, [2]Volzhsky Institute of Humanities
In cooperation with:
Wageningen University, IMARES, Deltares,
Volgograd State Fisheries Institute, WL | Delft Hydraulics, Moscow State University

Objective of NWO project:

- to quantitatively test the flood pulse concept, by analysing flood pulse dynamics in response to changes in river flow regime over different temporal and spatial scales;
- relating these to the availability of floodplain habitats for recruitment and reproduction of riverine fish species, and thereby on fish population dynamics.

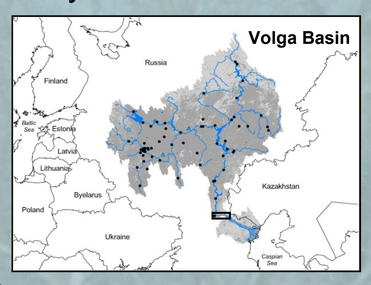
Objective of MSc researches:

To document and simulate the annual flooding pattern in the Volga-Akhtuba floodplain using:

- field observations;
- satellite image analysis;
- numerical modelling.

Study Area

The Volga-Akhtuba floodplain is situated in the Lower Volga River Basin, in Russia. The study area is about 100 by 30 kilometres.



Field measurements

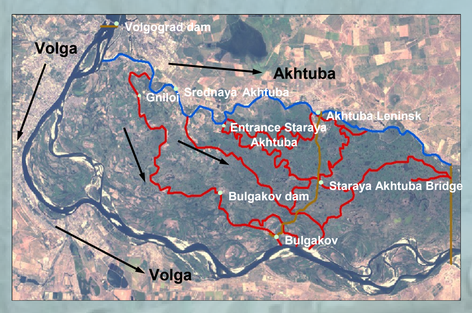
- Channel profiles
- Bridge profiles
- Dikes and culverts
- Water levels
- Flow velocity
- Absolute elevation
- Temperatures

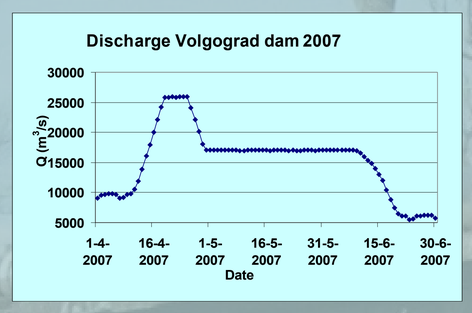
Channel profile measured with leveller

Flow velocity measurement instrument: Ottmill

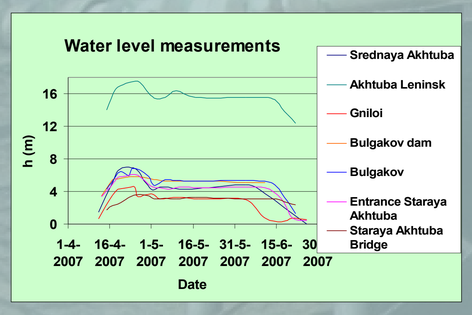
Field observations

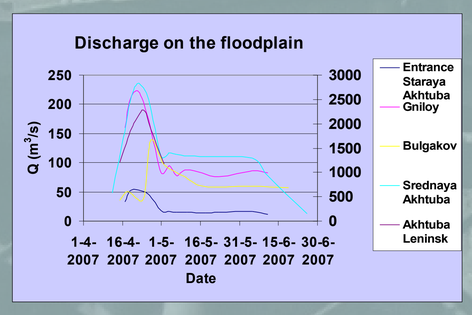
Yearly flooding of the Volga-Akhtuba floodplain caused by increase of discharge from the Volgograd dam during spring.

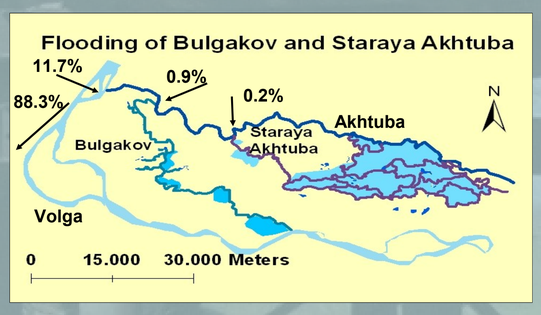




- The discharge in the Akhtuba and on the floodplain have a delay of 2-7 days, dependent on the location.
- The graphs of discharge and water level results show similar patterns.
- Bulgakov and Staraya Akhtuba are the most important channels on the floodplain: respectively 0.9 and 9.2% of the discharge enters the floodplain through these two channels.



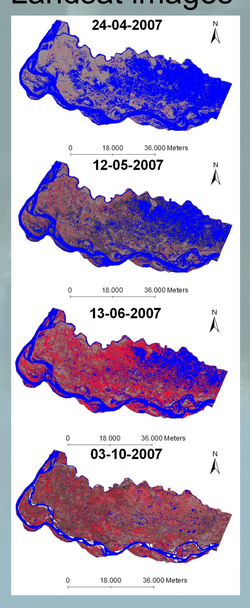




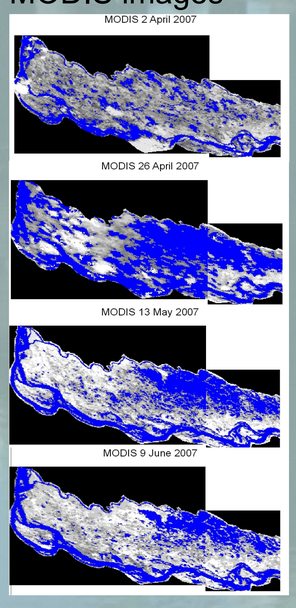
Satellite image analysis

Water classification

Landsat images



MODIS images



- During the peak flood more than 50% of the floodplain is flooded, while during low water only 12% of the floodplain is covered with water.
- The MODIS images give an underestimation of the flooded area, due to the large pixel size (227.5 by 227.5 m). A lot of lakes and channels are too small to be classified as water.
- The Landsat images have a pixel size of 30 by 30 m, therefore water bodies and channels can be distinguished.
- Bulgakov and Staraya Akhtuba are flooding respectively 5.35% and 20.4% of the total floodplain during high water stage.

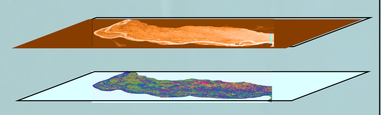
Numerical modelling

1D elements

- Floodplain channels
- Dikes and bridges
- Constructions (culverts, dams)

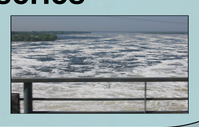
2D grids

- Elevation
- Surface roughness



Model input time series

- Inflow (Q)
- Outflow (h)



SOBEK 1D/2D model
1D channel flow + 2D overland flow
The 1D channel network is plotted on the DEM

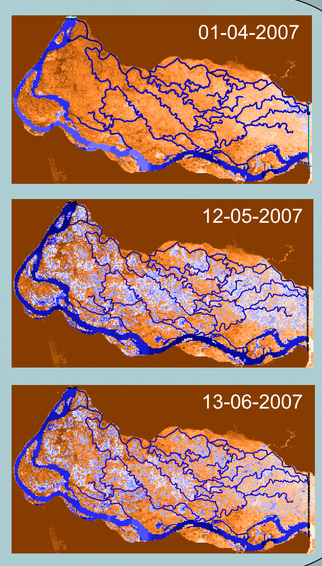
Model output

2D time series

- Inundation
- Water depths in lakes and on the floodplain

1D time series

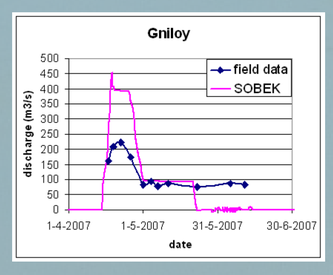
- Flow velocities
- Discharges
- Water depths in channels

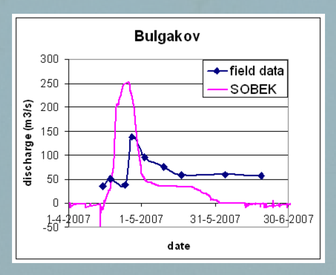


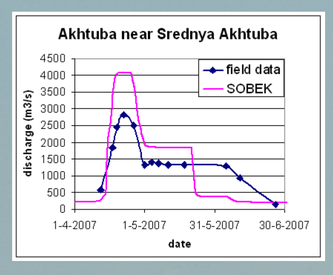
Figures: modelled 2D time series.
Water depth projected on top of DEM.

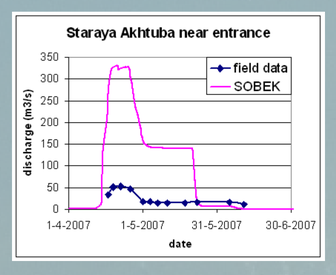
Comparison

Model results from 1D channels are compared with field observations at four locations in the floodplain. The discharge time series are taken during the flood period of spring 2007.









Conclusions

- Field observations: impression of inundation of channels, lakes and grasslands.
- Satellite images: quantification of inundated area at different time steps.
- Numerical model: quantification of water depth, discharge and inundation.
- The numerical model and the field observations show similar results for the timing of the peak discharge in 1D channels.
- Because small channels are not modelled, the discharge in the main channels is overestimated by the model.
- The models performance on 2D overland flow could be improved by using a more detailed DEM.