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Monitoring the spatial and temporal dynamic of annual floods in the Niger Inner Delta using MODIS satellite imagery

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Background

Flooding of large alluvial plains provides a vital resource for ecosystem services and rural livelihoods (crops, fisheries, livestock). Difficulties to monitor the flood of such wetlands due to issues of scale, heterogeneous land use and flat topography ==> Objective is to develop a method to detect and follow annual floods in the Niger Inner Delta (4M ha wetland) combining the improvements in remote sensing with field data



Fig 1: Livestock and fishermen on the Niger Inner Delta, Mali



Fig 2: Location of the Niger Inner Delta within the Niger River Basin

Materials and methods

- MODIS 8-day composite satellite images, 500m resolution
- MNDWI-NDMI composite index, constant thresholds
- Three K-means classified Landsat 30m images used for threshold calibration
- Hydrologically relevant grid overlaid
- MRTbatch to crop, project and extract geotiff files
- ENVI IDL programme to automate procedure on 526 images of 2000-2011, producing image of the flood and statistics on % of flooded pixels per grid cell for each image
- Cloud interference evaluated as % of cropped image area using LDOPE and IDL (14 images per year removed)
- Stage measurements at 15 hydrological stations to correlate and validate the results

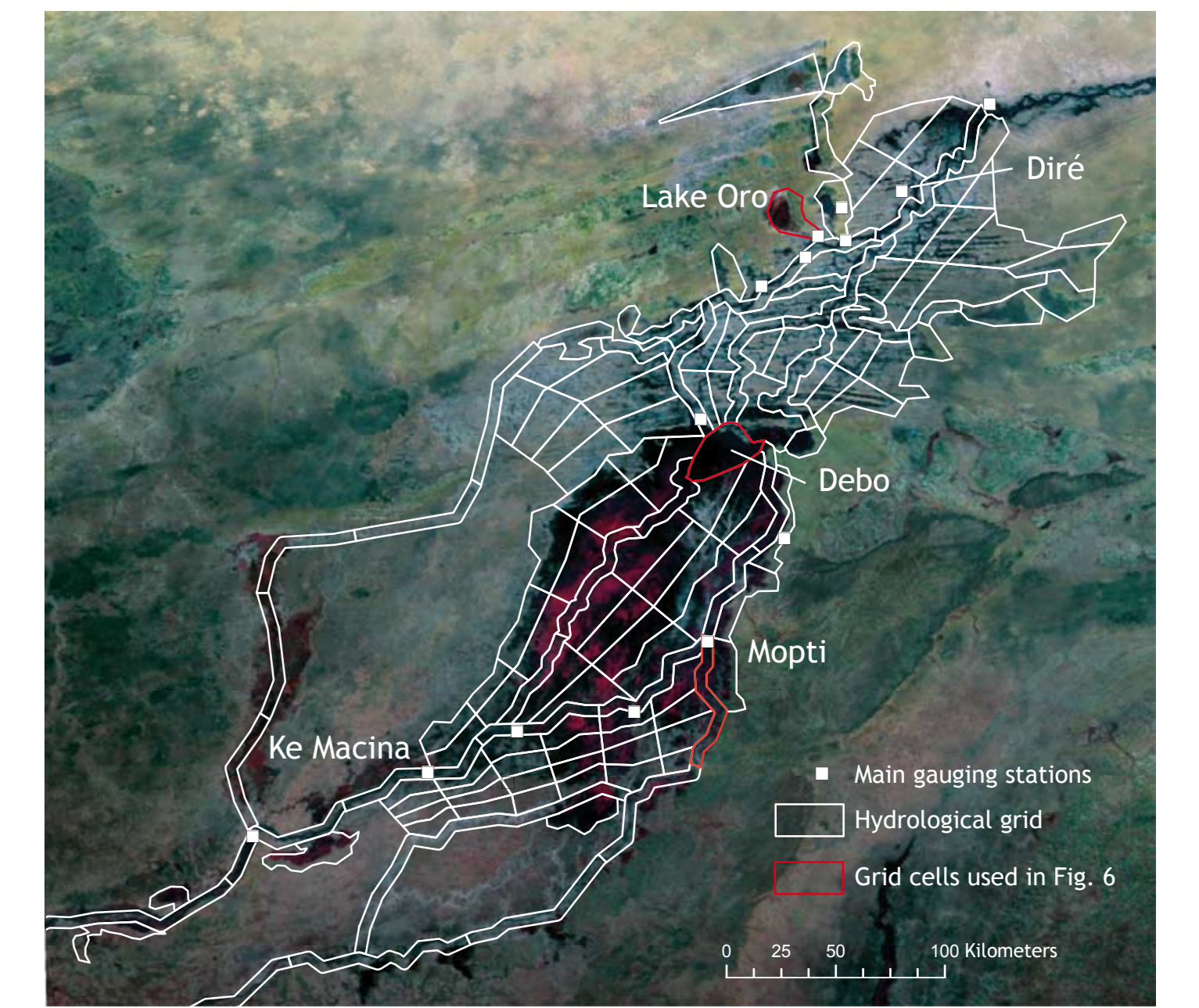


Fig. 3: MODIS FCC image of the Niger Inner Delta, the main gauging stations and the hydrological grid



Fig. 4: Stage measurements at the Office du Riz de Mopti

Results

Spatio-temporal dynamic of the flood



Fig. 5: Progress of the flood in the Niger Inner Delta during 2008-2009 monitored from MODIS

Spatial variations in the timing and duration of the flood

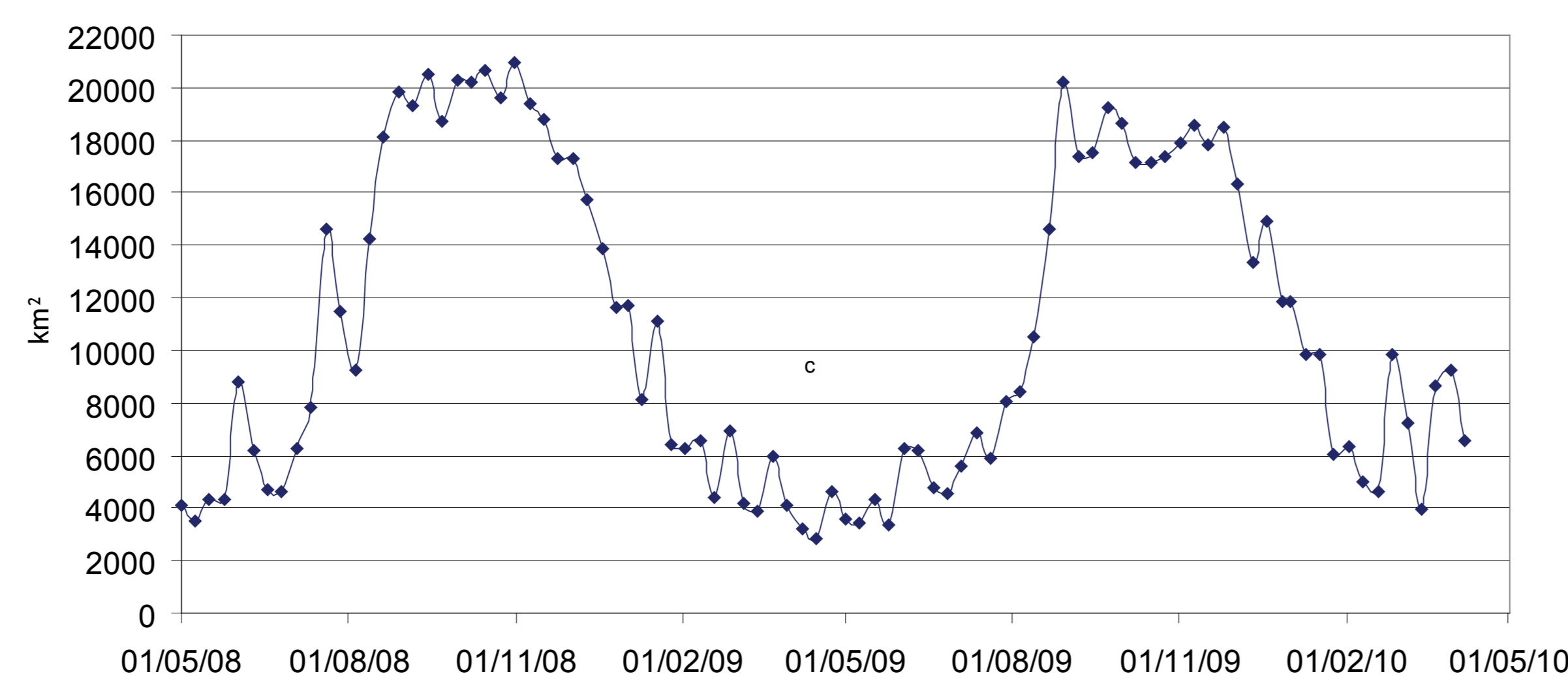
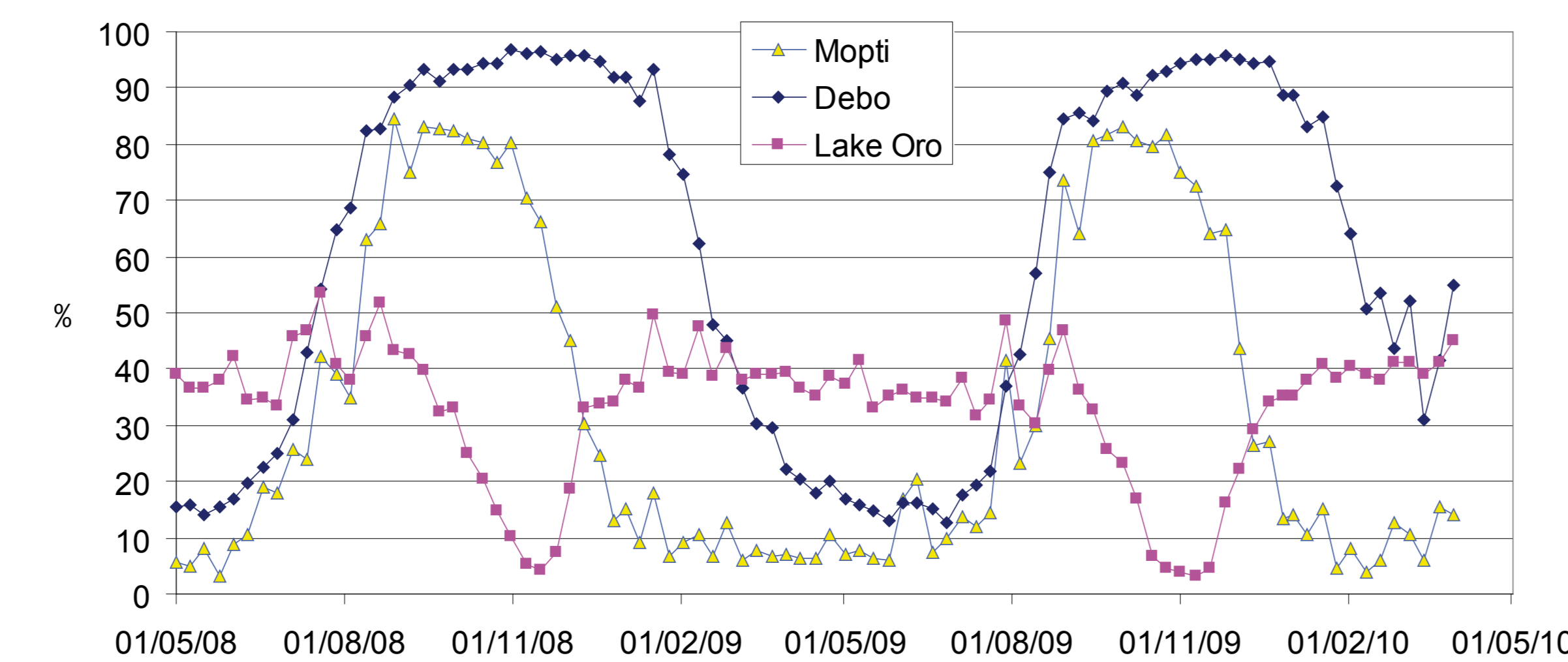


Fig. 6(upper): Variations in % of flooded area over 2008-2010 for 3 grid cells: Mopti on the Niger River, Lake Debo a central floodplain and Lake Oro in the North
Fig. 6(lower): Variations in km² for the sum of the Inner Delta grid cells over 2008-2010

Hydrological correlations for grid cells and the whole delta

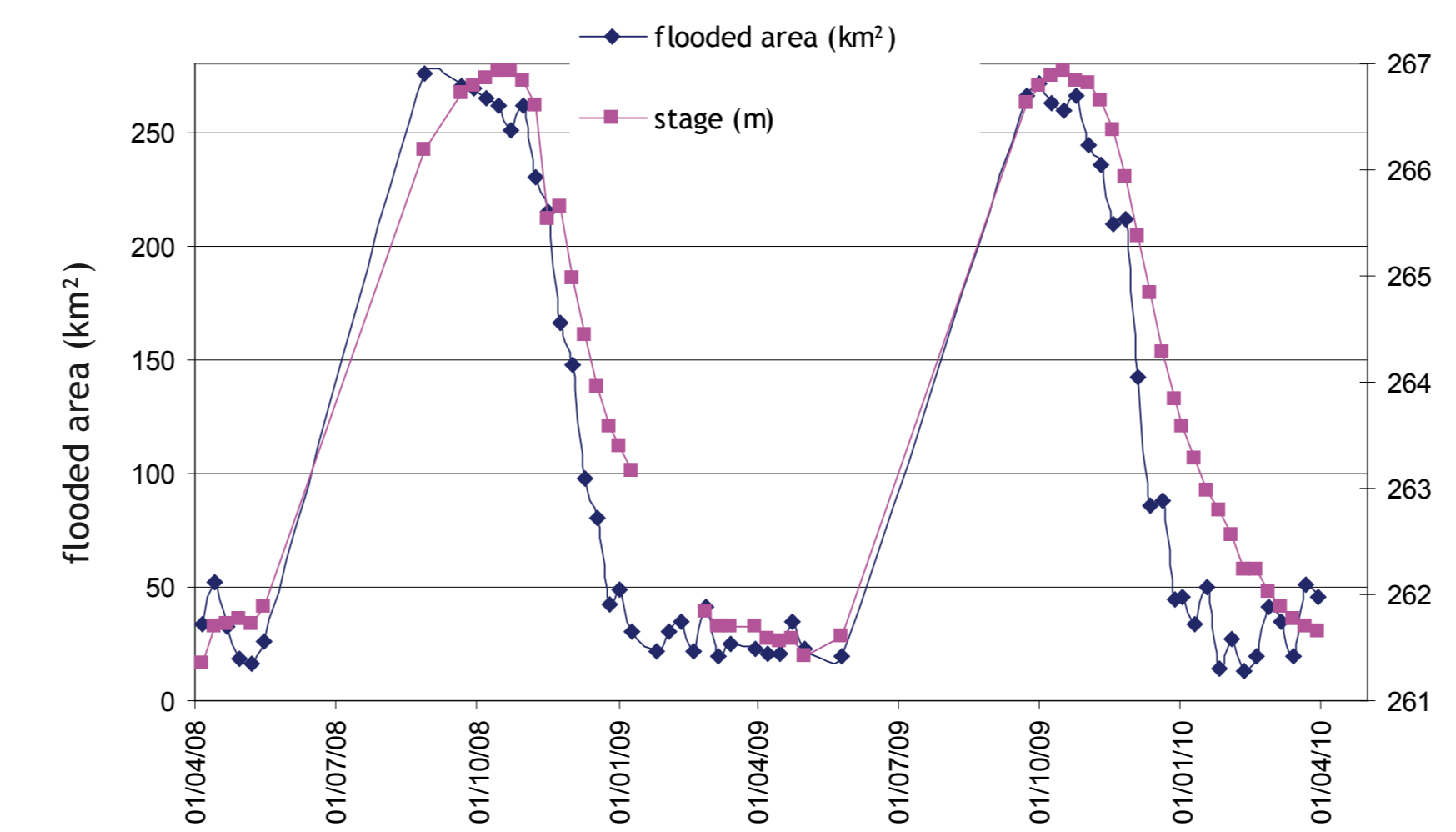


Fig. 7(a): Comparison between remotely sensed flooded areas in Mopti grid cell and Mopti stage levels over 2008-2010

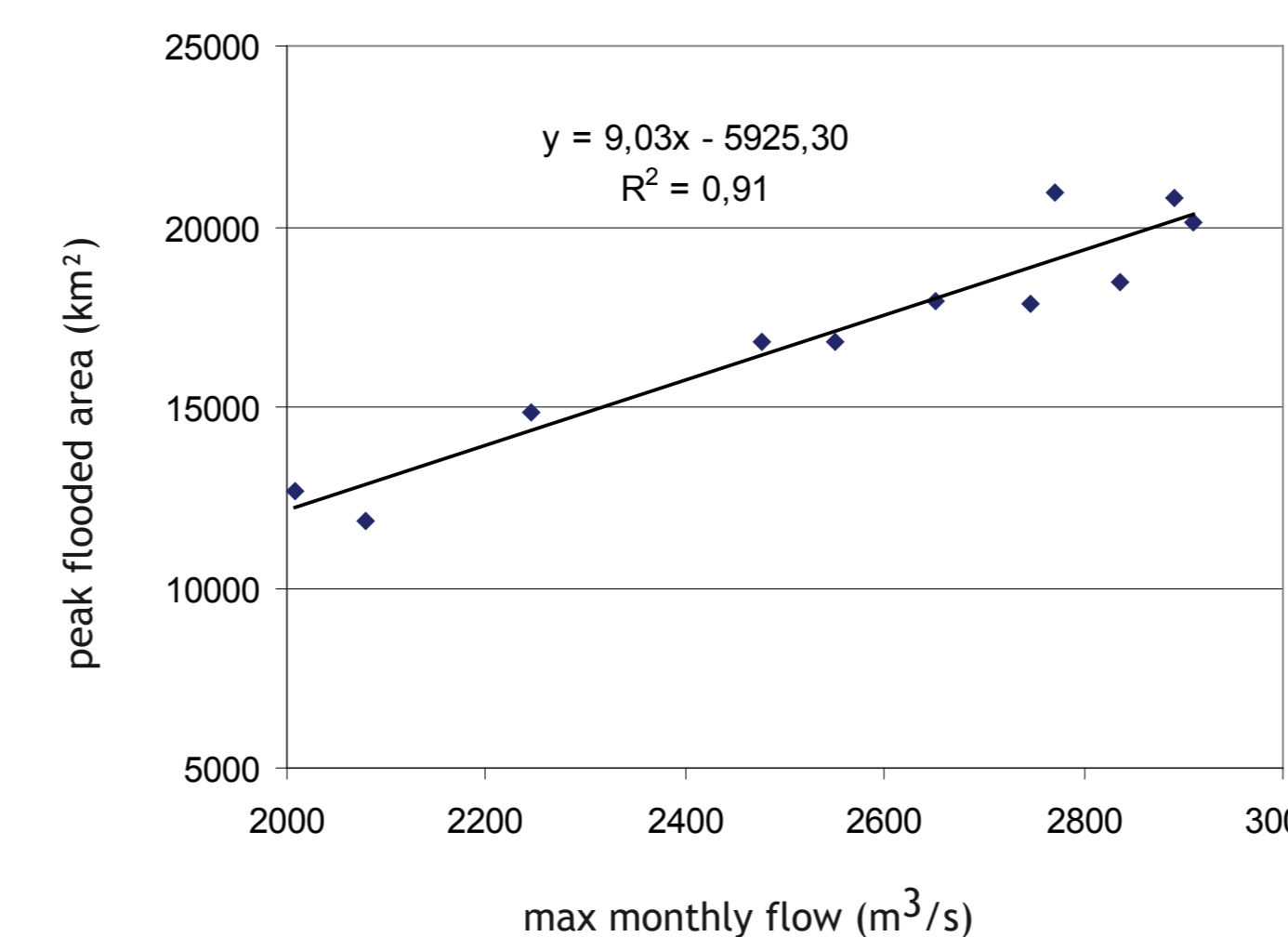


Fig. 8(a): Correlation between max monthly flow at Mopti and peak remotely sensed flooded areas for the whole Inner Delta over 2000-2011

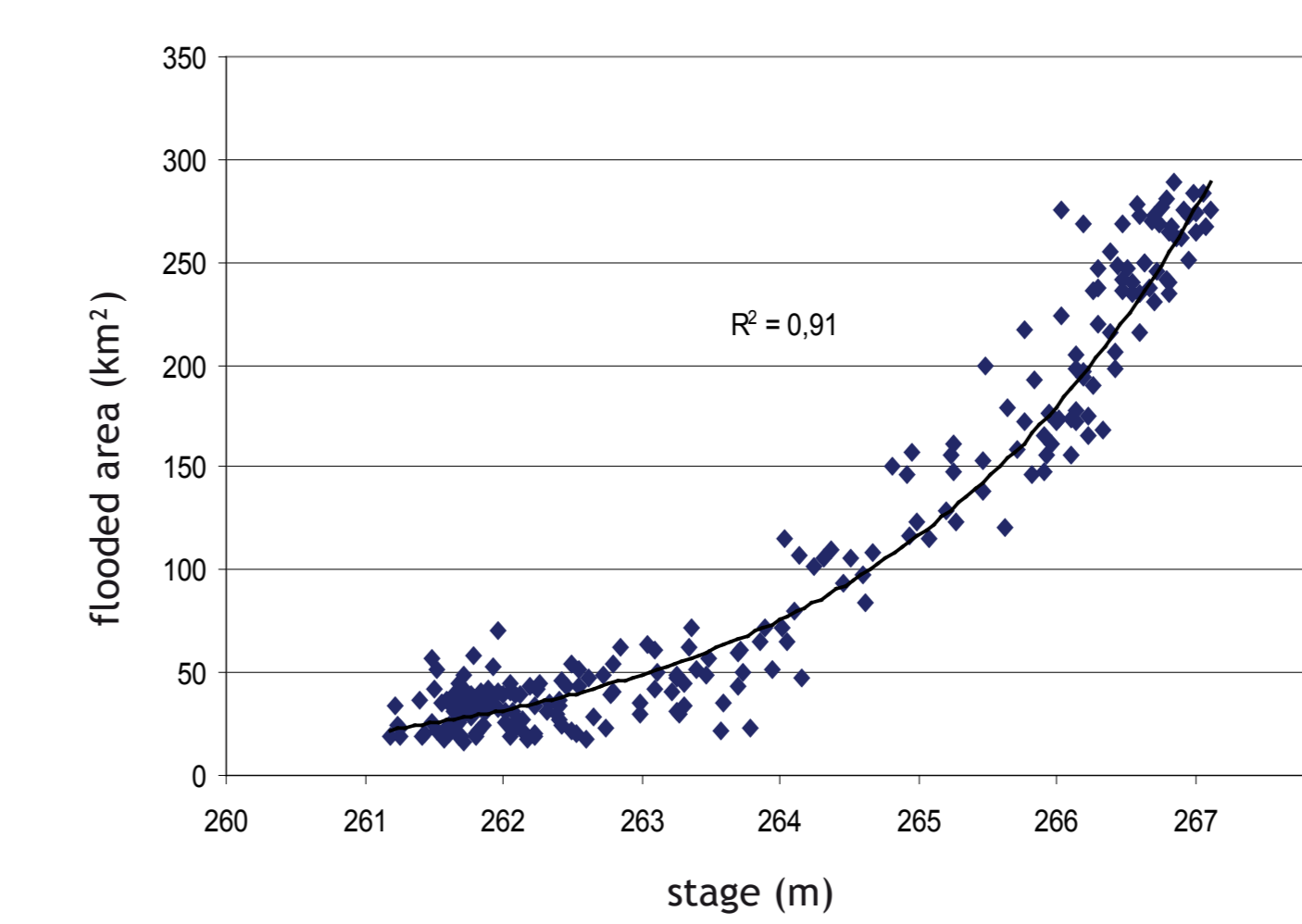


Fig. 7(b): Correlation between remotely sensed flooded areas in Mopti grid cell and Mopti stage levels over 2000-2011

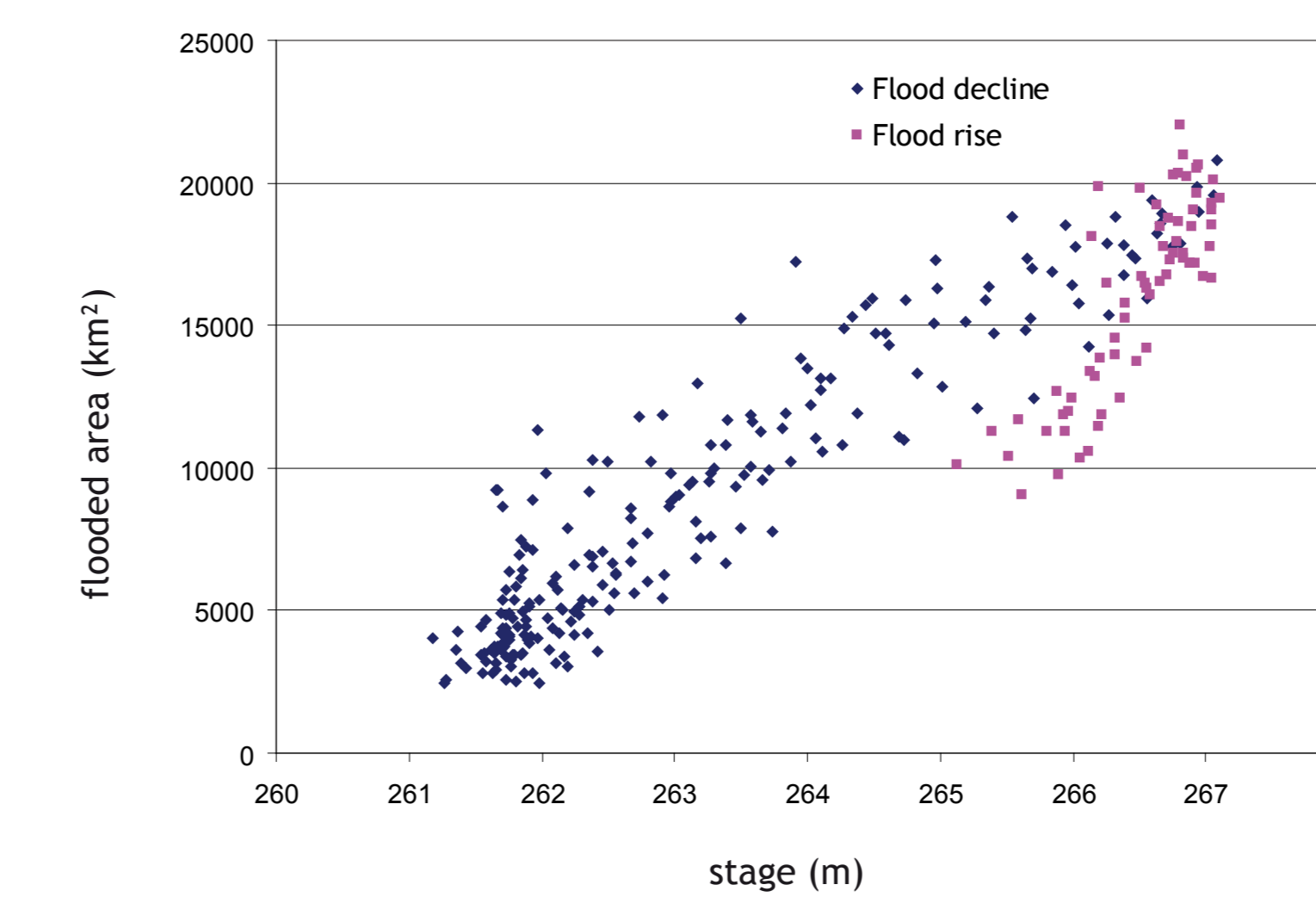


Fig. 8(b): Correlation between stage levels at Mopti and remotely sensed flooded areas for the whole Inner Delta over 2000-2011

Conclusions

- Automated method successful in monitoring the flood peak and its subsequent decline.
- Results per grid cell highlight the spatial differences in hydrological behaviour, with a significantly delayed and prolonged flood in the downstream areas.
- Maximum simultaneously flooded areas vary from 11,700 km² to 21,000 km² over 2000-2011.
- Good correlations (at the grid cell and whole delta level) between stage data and remotely sensed flooded areas validate the method.
- Relationships obtained notably allow the estimation of the total flooded area from a single stage measurement.
- A 300 m³/s reduction in peak flow due to the Fomi dam could reduce the peak flooded area in the Inner Delta by over 3,000 km²