

IDENTIFICATION OF ICE PHENOMENA ON ZEGRZE RESERVOIR WITH THE USE OF RADAR SATELLITE IMAGES

Abstract

In the study it was examined possibility of using satellite radar images from Sentinel-1 mission in detecting and recognition of ice phenomena at Zegrze Reservoir. Zegrze Reservoir was created by damming Narew river. It is used for electric energy production and water supply of Warsaw. Maximum head at the dam in Dębe is 7.10 m, on average it is about 6.8 m. Back water of the Zegrze reservoir reach Pultusk town Narew river – km 63.3, and on Bug river to Popowo village – km 17.0. Reservoir has a volume of 89.9 hm³, area 33 km², length about 40 km, average depth 2.86 m, coast line is 219 km long. Zegrze reservoir is supplied by tree rivers Bug, Narew, Rządza and Żerań Canal. Catchment area closed by the Dębe dam is 69.7 thousand km². Long term (years 1951–2010) average discharge of Narew river at Zambski Kościelne gauge is 139 m³·s⁻¹, and of Bug river at Wyszaków gauge is 162 m³·s⁻¹. Reservoir retention time is short equal 3–4 days. Data from years 1961–1990 of suspended sediment measurements have shown that Bug river in Wyszaków gauge suspended sediment transport is in the range 153,000–24,500 Mg·year⁻¹, while at Narew river – Ostrołęka gauge is much smaller – 31,300 Mg·year⁻¹. Denudation rate calculated for the period of years 1951–1990 at Narew river – gauge Ostrołęka is 1.4 Mg·year⁻¹·km², and at Bug river – Wyszaków gauge is 3.2 Mg·year⁻¹·km². To understand the reservoir hydrology it had been used a two-dimensional hydrodynamic model CCHE2D. Results of hydrodynamic modeling shows that Bug river carry a high concentration flux of suspended sediment which enters main part of the reservoir and then is a subject of sedimentation and dilution. Water from Narew river at the confluence with Bug river do not mix and currents of both rivers flow parallel only in lacustrine part of the reservoir there are good conditions for mixing under the influence of waves and wind drift. This pattern of current was confirmed by hyperspectral images recorded with the use of AISA i HySpex aerial scanners. Pattern of parallel streams of Narew and Bug rivers which do not mix with each other is often observed at multispectral images, for example Sentinel-2 image recorded on 31 VIII 2017. Transport of sediments and mixing of water from Narew and Bug rivers is influenced by the wind field which disturbs flow lines especially in lacustrine part of the reservoir. In the hydrodynamic model CCHE2D it was simulated an influence of wind field of cardinal directions N, S, W, E and force 1 m·s⁻¹. In case of wind direction S, W, E in both lacustrine basins it can form circulation. This circulation pattern is important in case of sediment transport and frazil ice flow as well as in the phase of ice break-up. Still the main current in the old Narew river thalweg is maintained. In case of N wind the main current is shifted toward southern coast of the reservoir and shaped by the geometry of small and large lacustrine basins. Ice phenomena definitions and run on inland waters of Poland was presented. Field examples were used in description of different ice forms. New source of remote sensing data are satellite SAR Sentinel-1 images. GRDH and SLC products were converted to color composite. On the images from Winter of 2018 following ice classes were identified: free water, shore ice, frazil ice, ice cover, consolidated ice. Back scatter values were compared for these classes using images of GRDH and SLC products. On the example of Bug river it was tested use of GRDH product images for creation of ice reports and use of the information on ice jam location on hydrological measurements of water stages. In case of Sentinel-1 images better information brings GRDH product. It has a lower memory volume and is easy in processing. In RGB

composition it is possible in a short time obtain overview of ice cover on a long reach of the rivers and reservoir. SLC product has higher spatial resolution but due to the process of image processing with the use of speckle reduction filters the image was less clear.

Key words: Zegrze Reservoir, Bug, Narew, ice phenomena, satellite images, SAR, Sentinel-1