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Baikal ice and snow cover from radar altimetry and radiometry

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The state of ice cover, and the freeze-up and break-up dynamics of lakes are good indicators of large-scale climate changes. We demonstrate the potential of combination of satellite altimetry and radiometry for studies of lake ice and snow cover on the example of lake Baikal in Siberia. We show the synergy of the combined use of passive and active microwave satellite data - simultaneous active and passive observations available from the recent satellite altimetry missions (TOPEX/Poseidon, Jason-1, ENVISAT and Geosat Follow-On), complemented by the SSM/I passive data. We propose an methods for ice discrimination and snow height estimation based on a combined use of the data from the four altimetric missions and SSM/I and validate it using available in situ observations. We have applied this approach to the entire satellite dataset and have defined specific dates of ice formation (first appearance of ice, formation of stable ice cover, first appearance of open water, complete disappearance of ice) and associated uncertainties. Using these satellite-derived estimates we have reliably extended up to the 2004 the existing time series of ice events in the Southern Baikal and provided new information on Middle and Northern Baikal, where no recent ice cover observations are available.

These data show recent (since the 1990ies) tendency for colder winters, manifesting in earlier ice formation, later ice break-up and increase of ice duration. Complementing the ice cover dataset by ERA40 air temperature data we further analyse how ice regime is influenced by thermal factors (air temperature), and how this influence is further affected by dynamic (wind field, currents) and other (bathymetry, precipitation etc)

factors . We estimate the relation between air temperature parameters and the timing of ice events (ice formation and fast ice duration) and show that thermal factor has the stongest impact on ice regime. Dynamic and other factors interfere with the thermal influence, resulting in an increase or decrease of ice formation dates and ice duration comparing to the relation that takes into account only influence of air temperature. Finally, we stress the necessity to have lake-wide assessment of ice regime for climate research and summarise the potential influence of various environmental factors on ice conditions of lake Baikal.