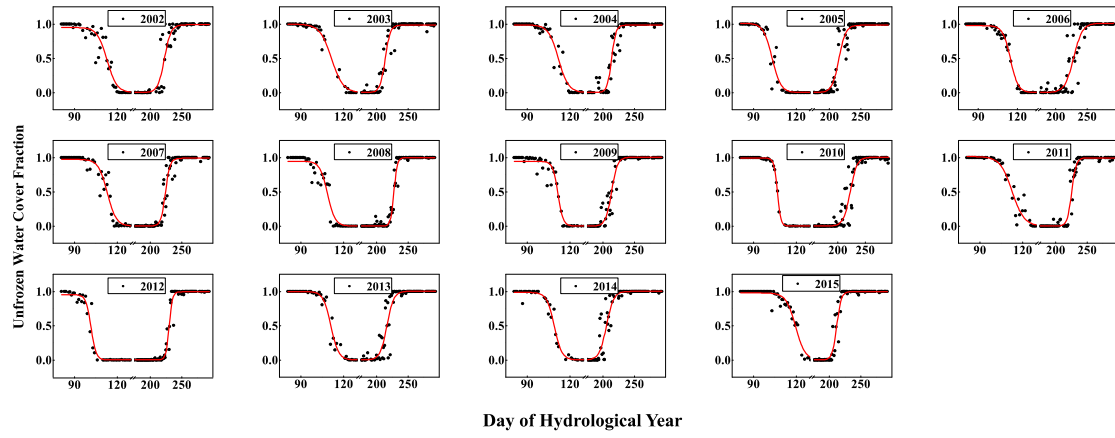
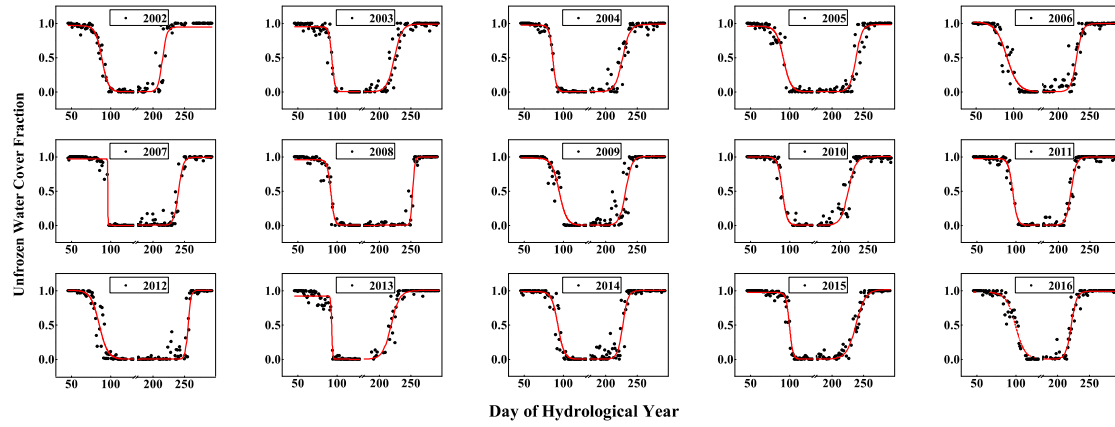


## Supplementary Materials

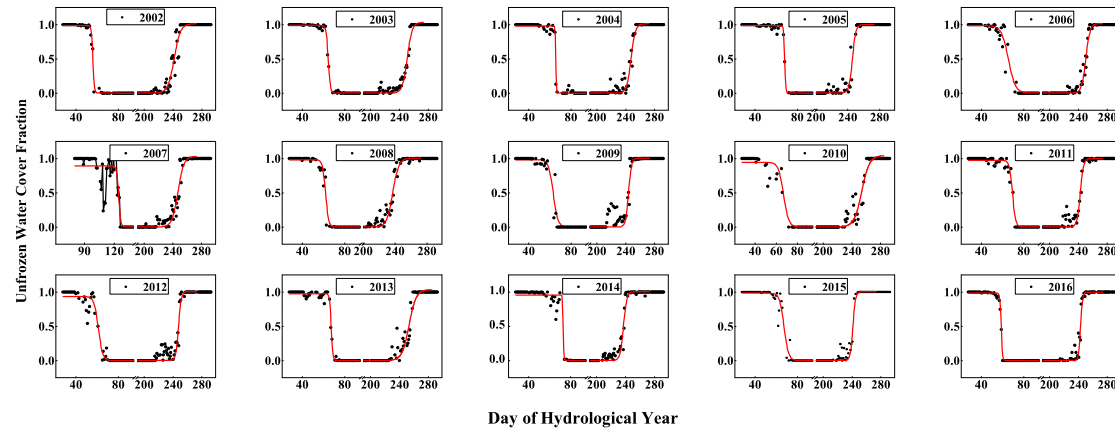
### a) Lake Qinghai



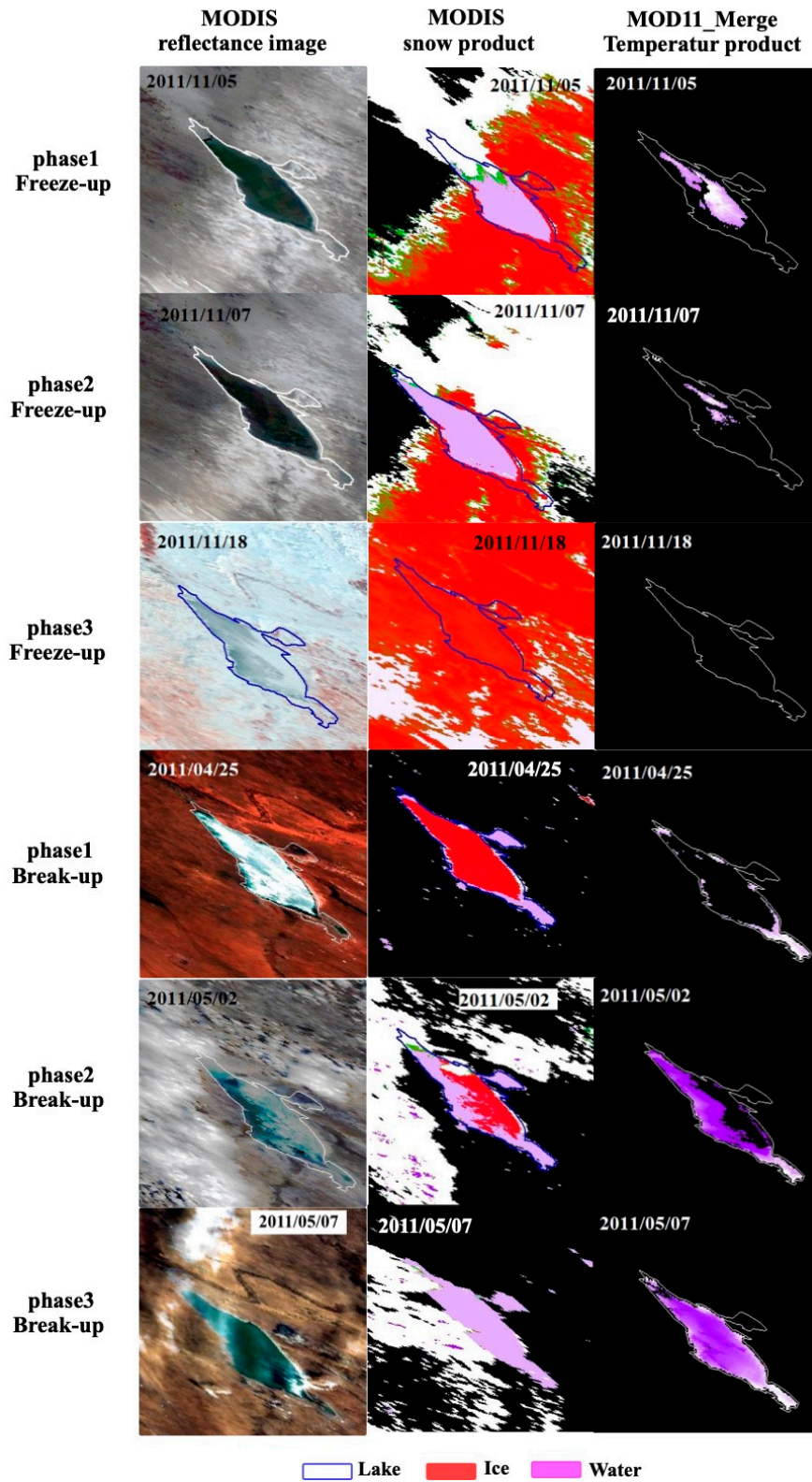
### b) Lake Ngoring



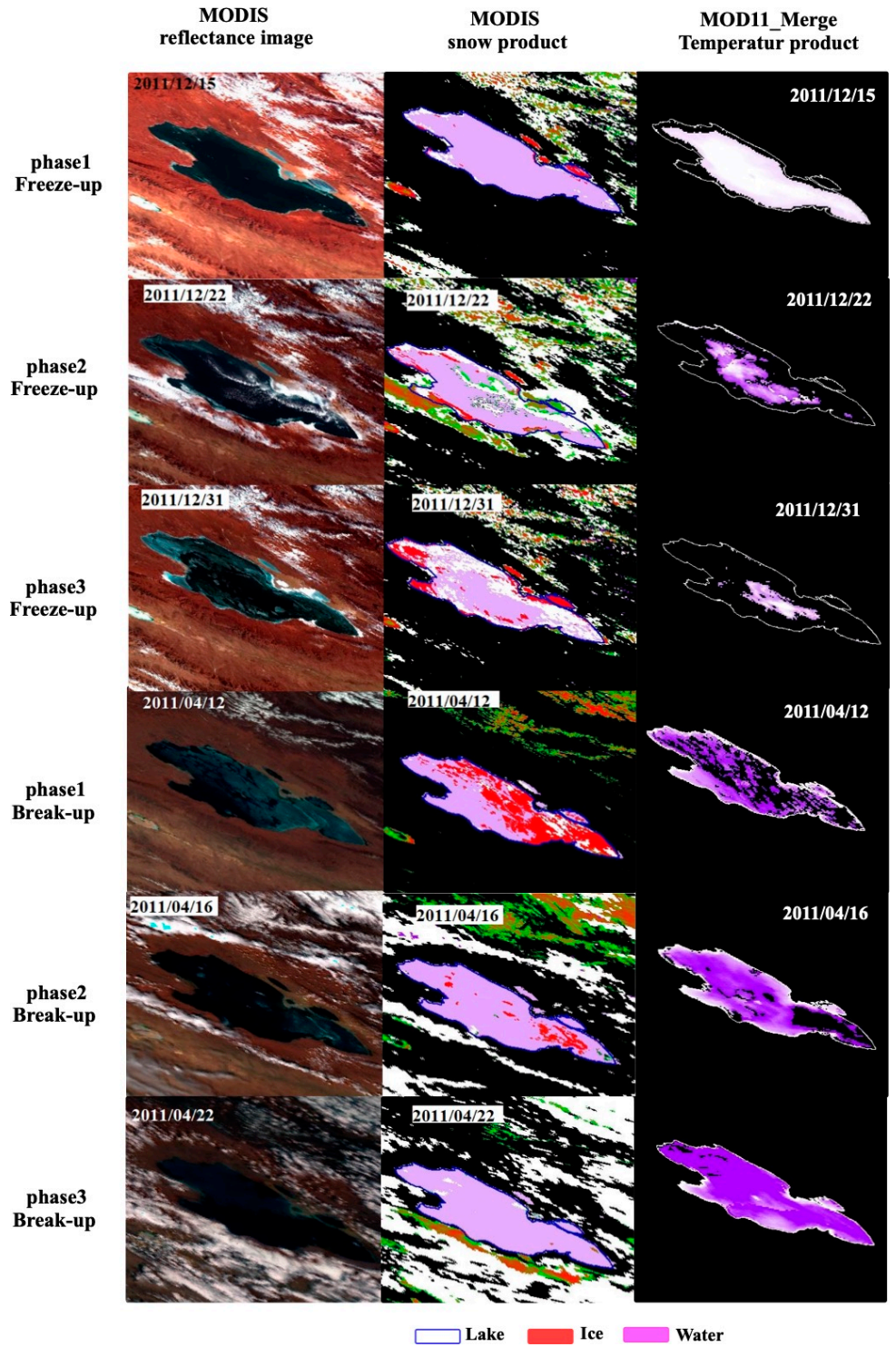
### c) Lake Hulun



**Figure S1.** The process of curve fitting of unfroze water fraction in three lakes Hulun from 2002 to 2016. The performances of logistic function fitness of unfrozen water cover fraction are good with the  $R^2$  large than 0.95 in three lakes.

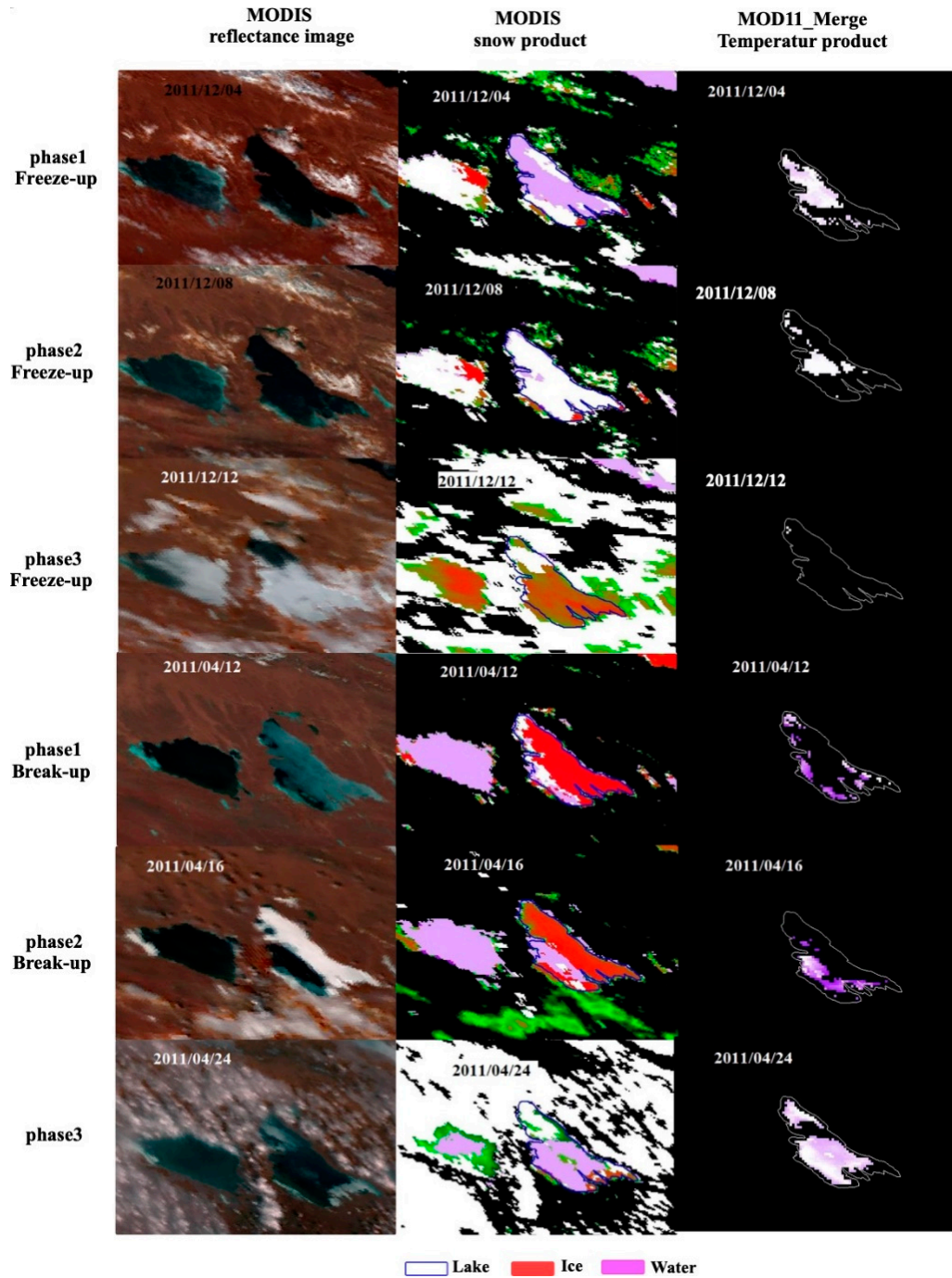


**Figure S2.** Comparison of unfrozen water fraction extraction in 2011 in Lake Hulun from MODIS reflectance image, MODIS snow product, and MOD11\_Merge data. The images in the first column are from MOD09 daily reflectance product (RGB:341).



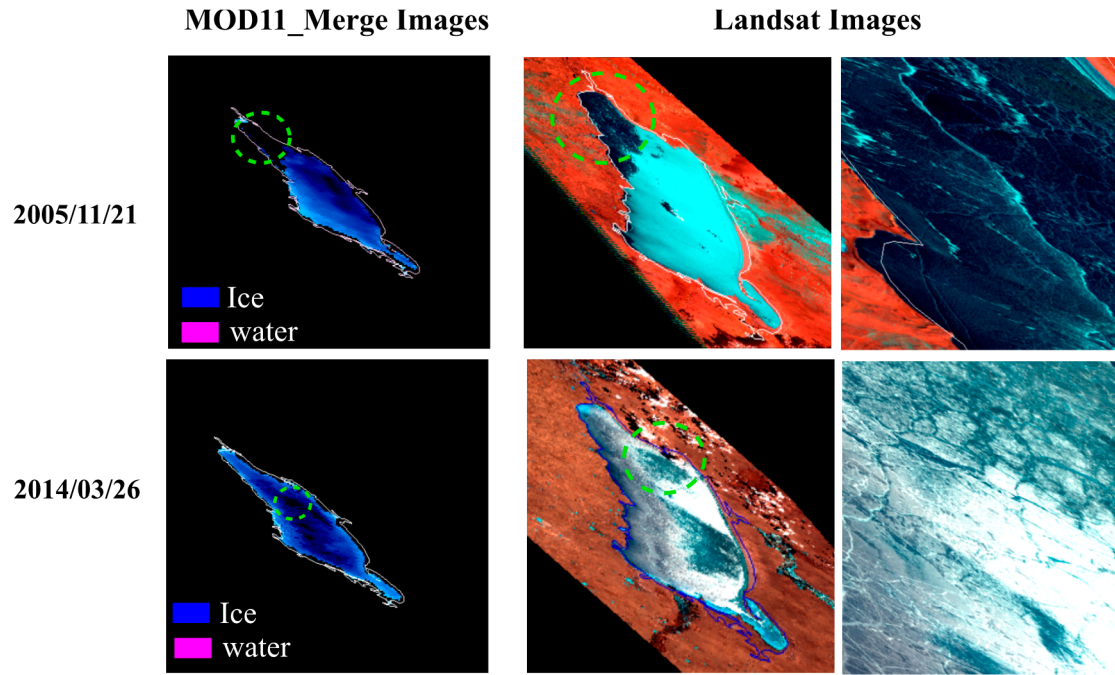
**Figure S3.** the comparison of unfroze water fraction extraction in 2011 in Lake Qinghai from MODIS reflectance image, MODIS snow product, and MOD11\_Merge data. The images in first column were from MOD09 daily reflectance production (RGB:341).



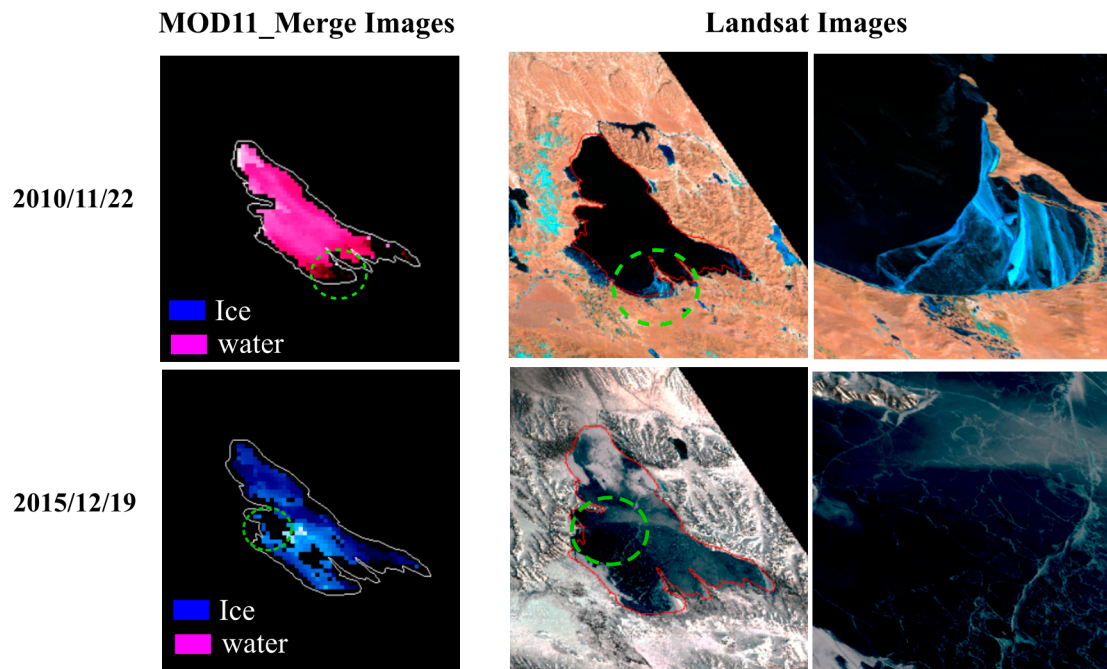


**Figure S4.** the comparison of unfroze water fraction extraction in 2011 in Lake Ngoring from MODIS reflectance image, MODIS snow product, and MOD11\_Merge data. The images in first column were from MOD09 daily reflectance production (RGB:341).

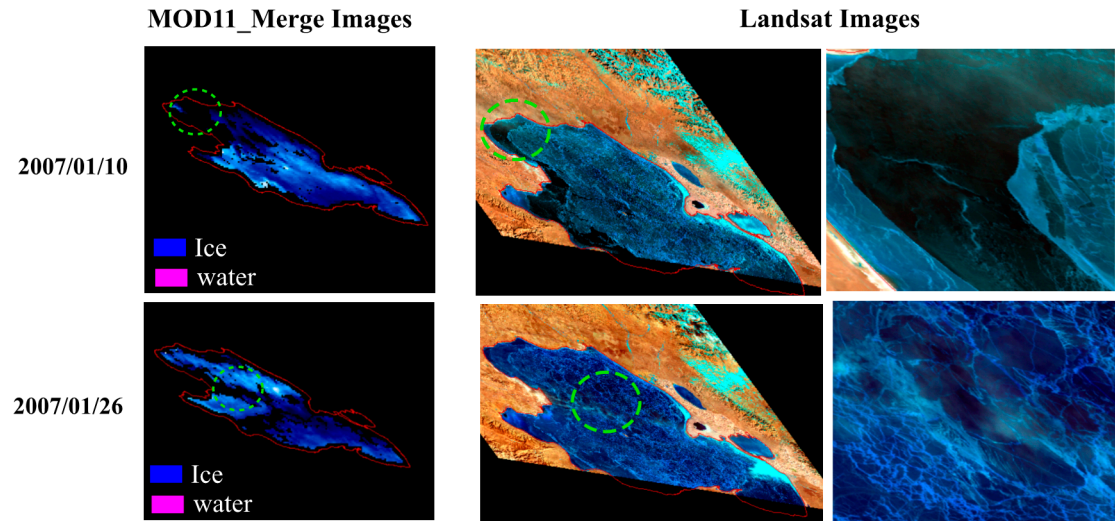




**Figure S5.** The comparison of unfroze water fraction extraction in Lake Hulun from MOD11\_Merge temperature data and Landsat images. The images in first column were the classification of water and ice based on the proposed method in this day. The images in second column represent the lake surface situation from Landsat images (RGB true color combination: band 532) at the same dates. The third column represent the green cycle area zoomed in Landsat images. The green cycles represent the difference between MOD11\_Merge and Landsat images.



**Figure S6.** The comparison of unfroze water fraction extraction in Lake Hulun from MOD11\_Merge temperature data and Landsat images. The images in first column were the classification of water and ice based on the proposed method in this day. The images in second column represent the lake surface situation from Landsat images (RGB true color combination: band 532) at the same dates. The third column represent the green cycle area zoomed in Landsat images. The green cycles represent the difference between MOD11\_Merge and Landsat images.



**Figure S7.** The comparison of unfroze water fraction extraction in Lake Hulun from MOD11\_Merge temperature data and Landsat images. The images in first column were the classification of water and ice based on the proposed method in this day. The images in second column represent the lake surface situation from Landsat images (RGB true color combination: band 532) at the same dates. The third column represent the green cycle area zoomed in Landsat images. The green cycles represent the difference between MOD11\_Merge and Landsat images.