Lake Ice Detection from VIIRS Data

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OVERVIEW

Ice cover on lakes plays an essential role in the physical, chemical, and biological processes of freshwater systems (e.g., influences vertical mixing), and it also has many economic implications (e.g., for hydroelectricity). Variability and trends in the seasonal pattern of lake ice dynamics represent robust and direct indicators of climate change. Satellite remote sensing has proven its great potential for detecting and measuring the ice cover on lakes. Therefore, within the framework of the Global Climate Observing System (GCOS) Swiss project, "Integrated Monitoring of Ice in Selected Swiss Lakes," the Remote Sensing Research Group of the University of Bern (RSGB) aims:

to retrieve lake ice phenology dates from data acquired in the fine-resolution imagery (I) bands (1–5) of the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor.

The thermal I-channel of the VIIRS sensor (I05), which combines a high temporal resolution (~2 times per day) with a reasonable spatial resolution (375 m), is an advantage in comparison to AVHRR and MODIS.

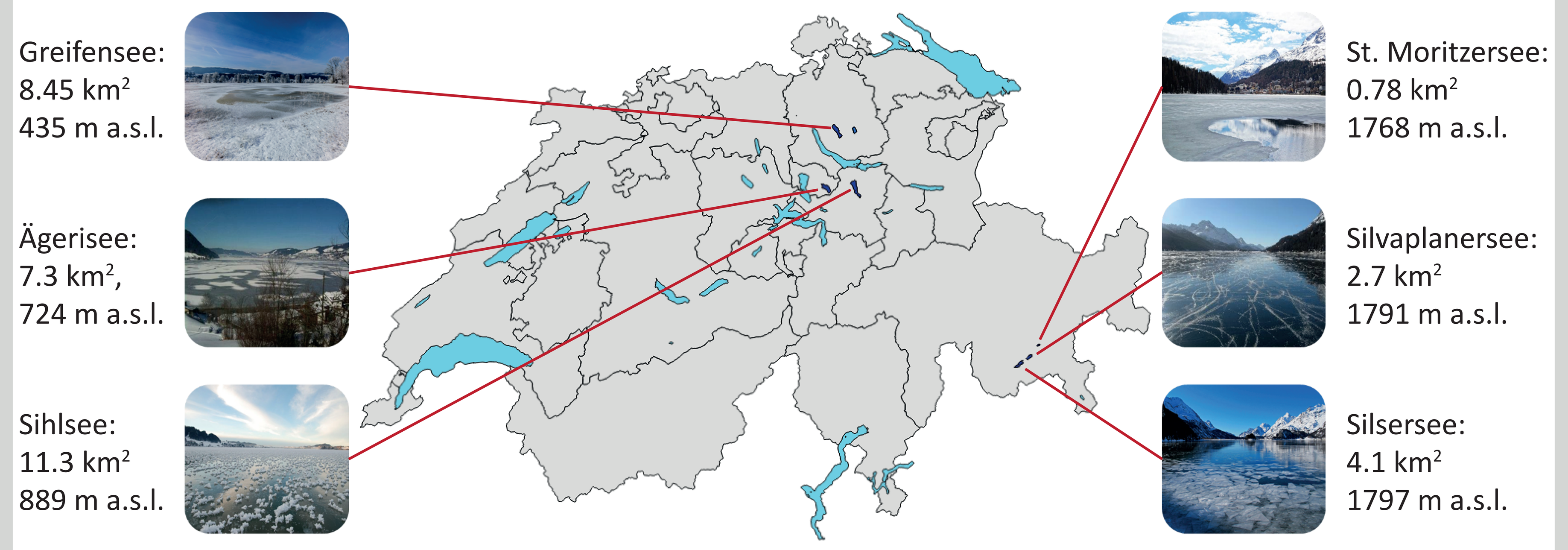


Figure 1. The six target lakes have variable area, altitude, and surrounding topography and freeze at least once statistically between 50% and 100% of the winters.

DATA & METHODS

VIIRS Imagery (I) Band Sensor Data Record (SDR)

Data files
- Calibrated sensor radiometric data (radiance, reflectance, and brightness temperature)
- 5 channels with spectral bands in the VIS, NIR, SWIR, MWIR, and LWIR regions

Geolocation files
- GIMGO (Ellipsoid Geolocation)
- GITCO (Ellipsoid Terrain Corrected Geolocation)

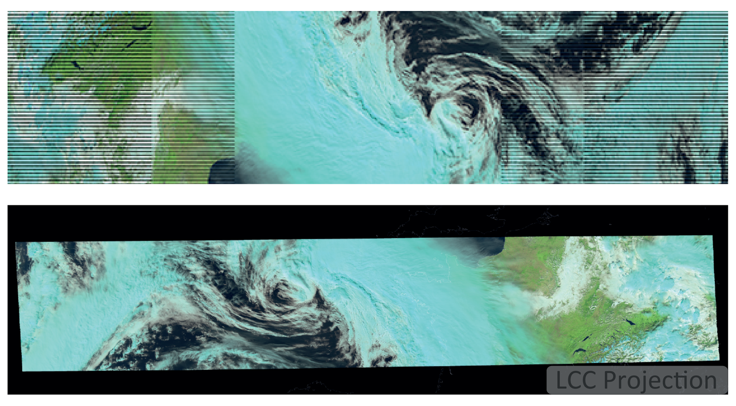
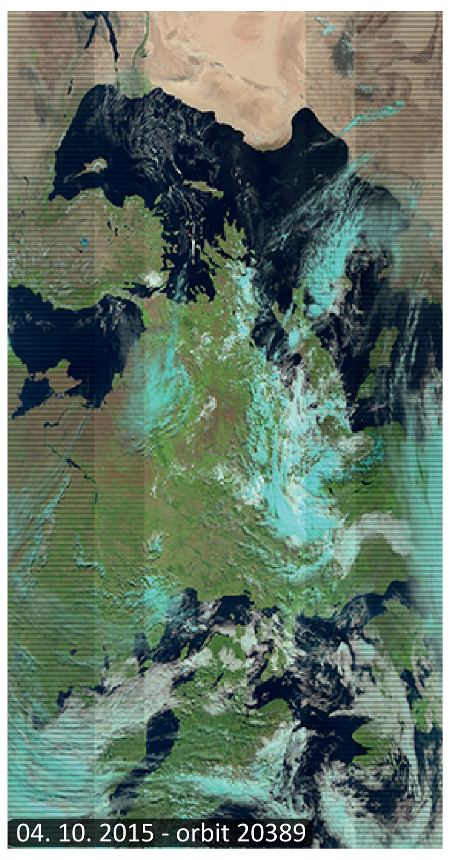


Figure 2. Granule with data plotted with no mapping, and with "pixel-trim" fill values (top) and granule with data plotted to Lambert Conformal Conical (LCC) projection, and with "pixel-trim" fill values removed (bottom).



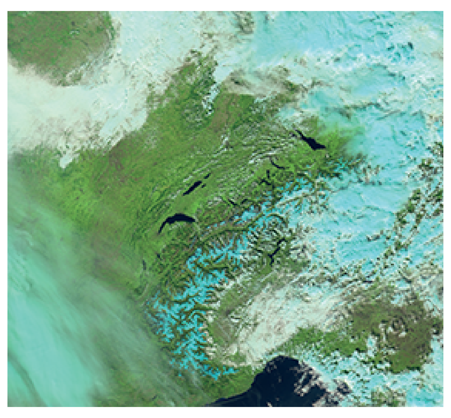


Figure 3. Subset of interest in UTM zone 32N projection (above) extracted from 8 granules (left) as available from the CLASS archive.

Lake Surface Water Temperature and Lake Ice Phenology Retrieval

The **LSWT retrieval** algorithm applied in this study is a physical mono-window (PMW) model based on the Radiative Transfer for the Television Infrared Observation Satellite Operational Vertical Sounder code (RTTOV). Atmospheric profiles from ECMWF ERA-interim are utilized to run RTTOV and simulate top-of-atmosphere (TOA) brightness temperatures (BT) for temperatures ranging from T_{skin} minus 5 K to T_{skin} plus 15 K. Coefficients resulting from linear regression between the range of temperatures and simulated TOA BTs (Figure 6) are used to derive the LSWT from the BT measured at the sensor level.

The **lake Ice phenology** dates (e.g., timing of freeze-up and break-up) are obtained by applying a threshold method on the LSWT retrievals and NIR reflectance values.

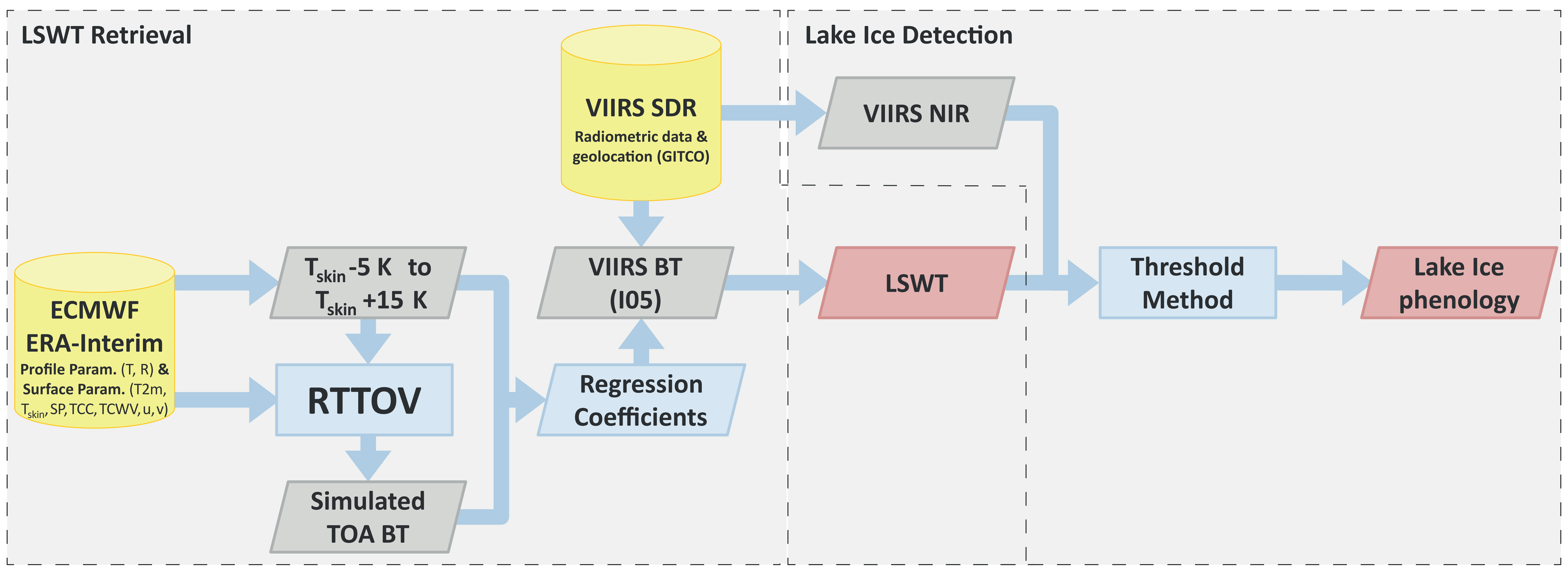


Figure 4. Flowchart of the physical mono-window (PMW) model and lake ice phenology retrieval.

PRELIMINARY RESULTS

Geolocation Accuracy

There is a clear difference between data projected using GIMGO and GITCO, especially in the mountainous rugged terrain. The data projected based on the terrain-corrected geolocation information GITCO matches closely with lake masks derived from Open Street Map data.

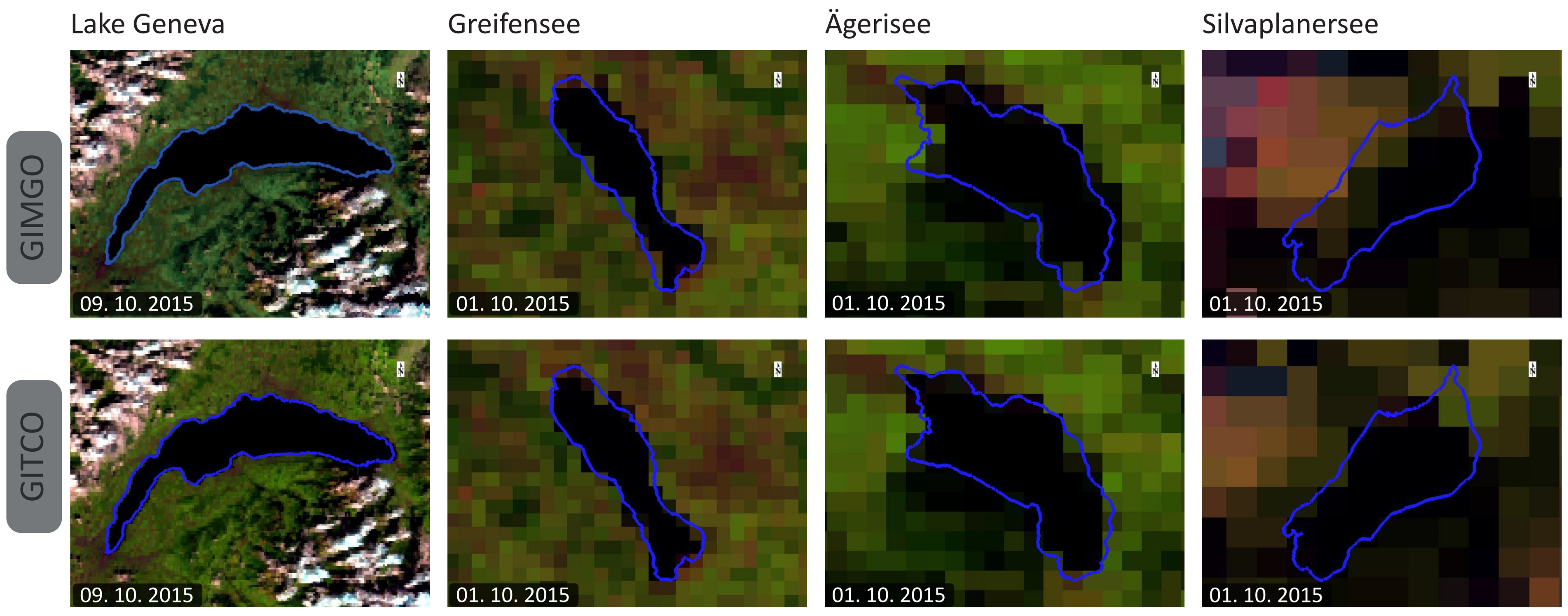


Figure 5. Examples of lakes and surrounding topography projected onto UTM zone 32N using geolocation information GIMGO (top) and GITCO (bottom) together with OSM lake masks in the same projection.

Brightness Temperature Simulations & PMW Coefficients

With the PMW model RTTOV is run for each satellite acquisition. Figure 6 illustrates examples of TOA brightness temperatures simulated using atmospheric profiles from ECMWF ERA-interim for 3 days. For both target lakes Lake Geneva and Greifensee the RTTOV brightness temperature simulations show reasonable results.

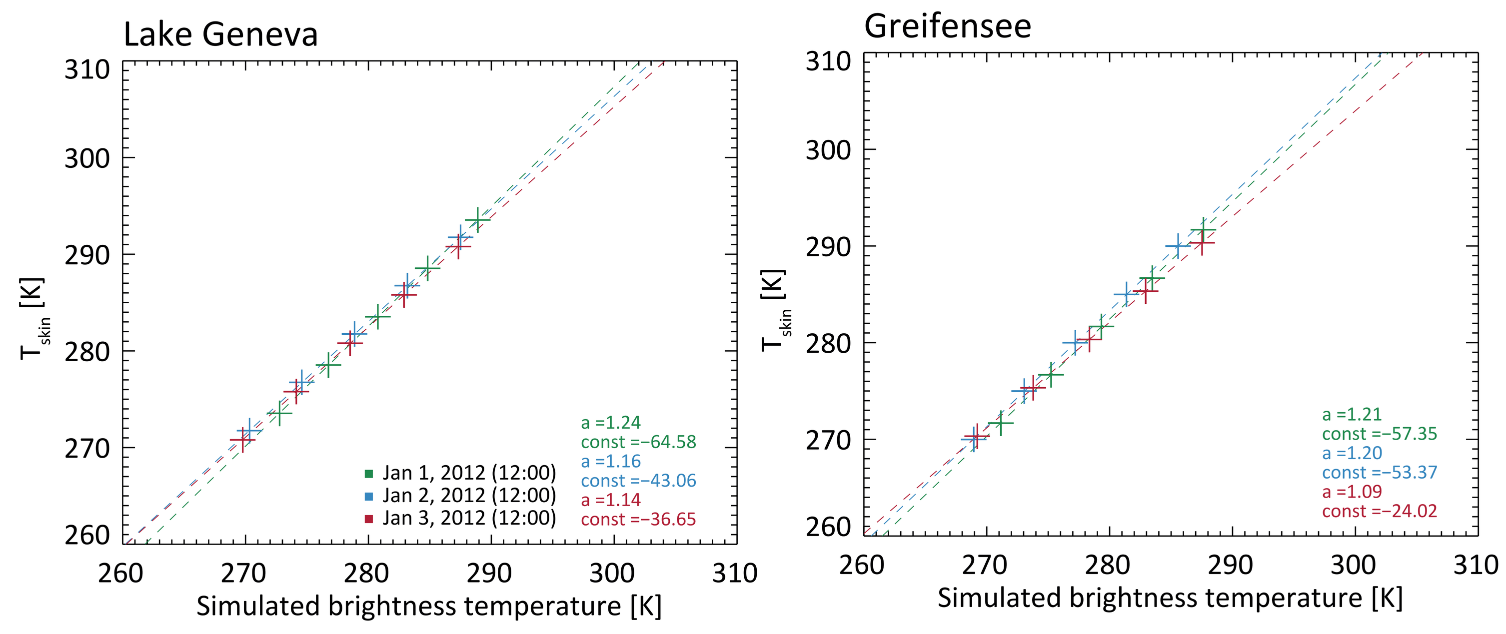


Figure 6. Brightness temperatures simulated for Lake Geneva and Greifensee for January 1 to 3, 2012.

CONCLUSION & OUTLOOK

- Data projected using the terrain corrected geolocation information GITCO shows a high accuracy → only GITCO will be applied for further processing.
- First brightness temperature simulations and PMW coefficients resulting from the RTTOV runs with configurations for VIIRS are reasonable.

- LSWT retrieval using coefficients resulting from PMW model.
- Implementation of VIIRS cloud masks.
- Validation of LSWT retrievals with temperature measurements (KT15.85 IIP).
- Development of threshold method to extract timing of phenological events.

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