



TARTU OBSERVATORY  
space research centre



# What can fine resolution satellites provide for small colored lakes?

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✦ [www.to.ee](http://www.to.ee)



What can fine resolution satellites  
provide for small colored lakes?

- ✦ Case I & Case II
- ✦ Colored dissolved organic matter (CDOM),  
Chlorophyll (Chl) and total suspended matter (TSM)



What can fine resolution satellites  
provide for **small colored lakes**?

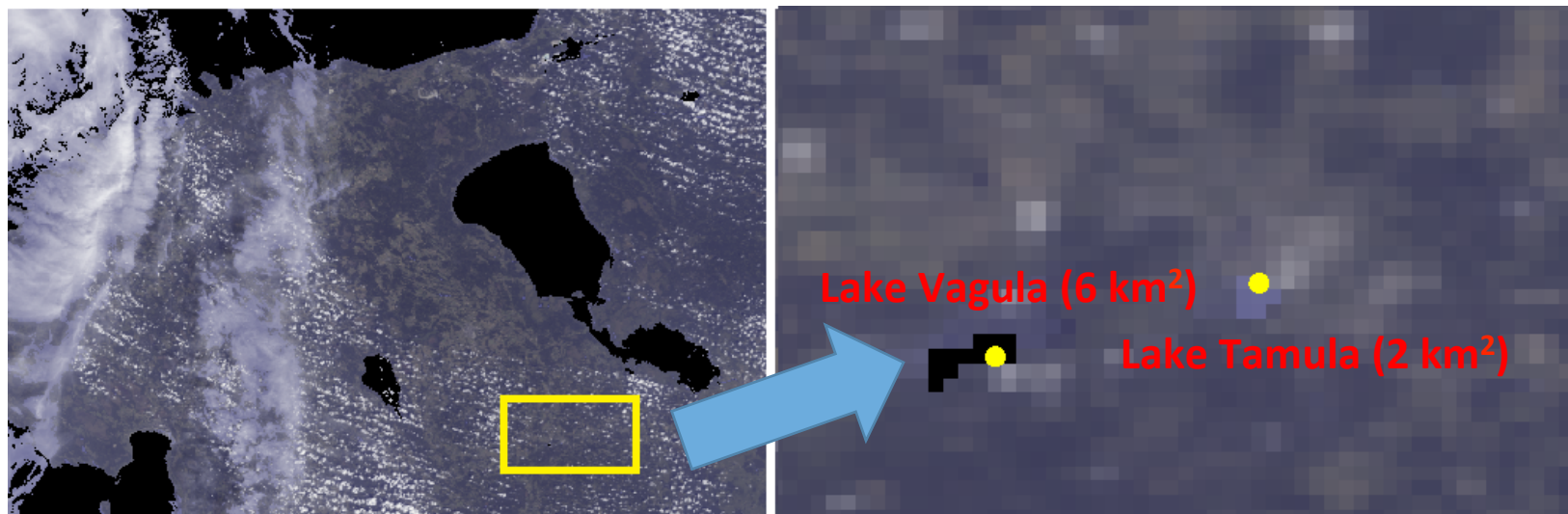
- ✦ **Case I & Case II**
- ✦ **Colored dissolved organic matter (CDOM),  
Chlorophyll (Chl) and total suspended matter (TSM)**
- ✦ **Anything below the detection capability of special  
water remote sensors (300-1000 m)**



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Chlorophyll (Chl) and total suspended matter (TSM)
- ✦ Anything below the detection capability of special  
water remote sensors (300-1000 m)
- ✦ Landsat 7 (ETM+), Landsat 8 (OLI), QuickBird,  
WorldView-1, WorldView-2, WorldView-3, IKONOS,  
SPOT 6, SPOT 7, GeoEye-1, RapidEye, Pleiades 1,  
Pleiades 2

# Estonian lakes



- ✦ All together 2084 lakes in Estonia (> 1 ha)
- ✦ MERIS pixel size 0.09 km<sup>2</sup> (9 ha)
- ✦ Lake Tamula (209ha)
- ✦ Lake Valgula (603 ha)
- ✦ \*water is masked as “black”

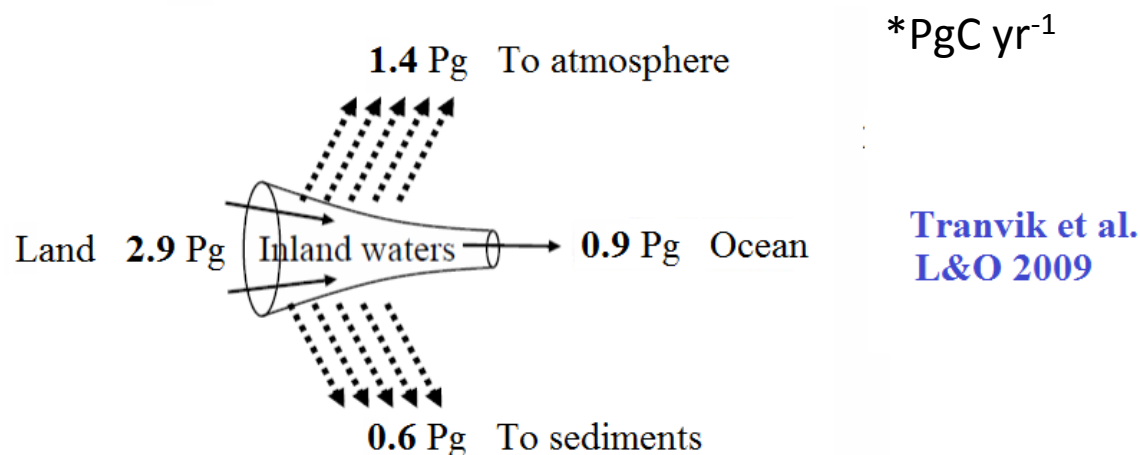


## Why it is important study lakes with RS sensors? (1)

- ✦ No government has adequate economic resources for monitoring all its own inland waters by means of traditional methodologies (*in situ*)
- ✦ Monitoring of water quality in lakes is an integral part of water resource management. It ensures the sustainable use of water and allows tracking the effects of anthropogenic influences.
- ✦ Classification of lake water clarity and type – WFD
- ✦ They take part in carbon cycle

# Why it is important study lakes with RS sensors? (2)

Land 0.9 Pg  $\rightarrow$  Inland waters  $\rightarrow$  0.9 Pg Ocean **IPCC models**



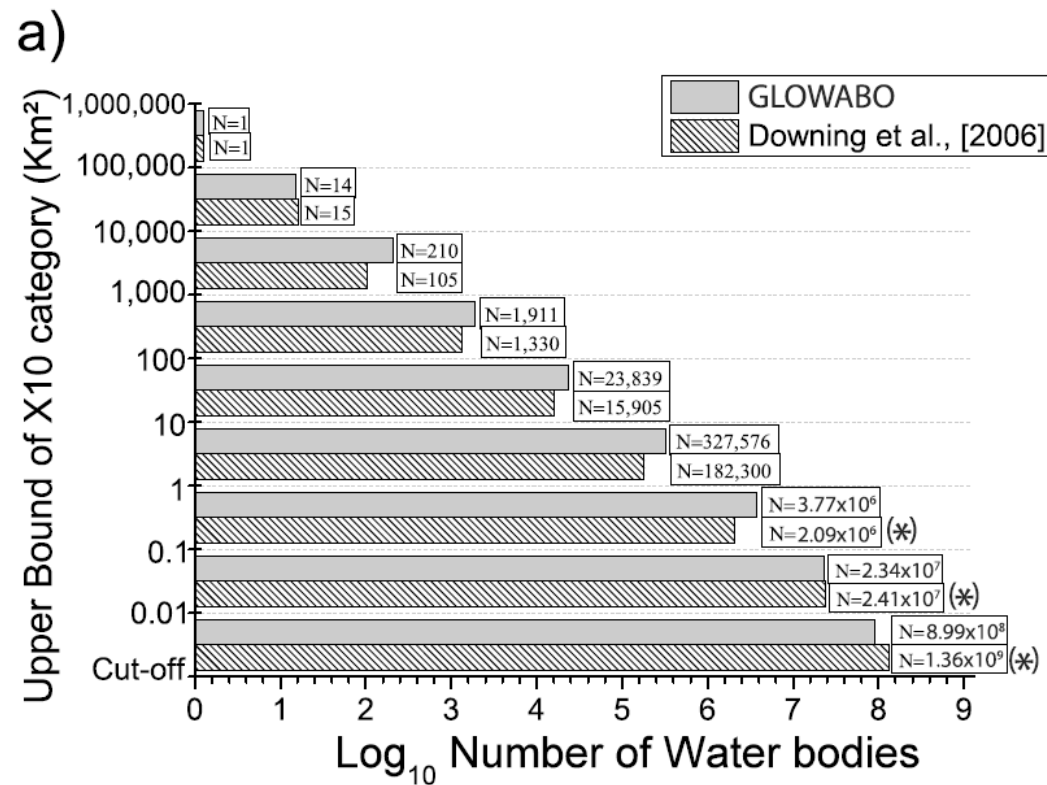
Parameters needed for determining lakes role in global carbon cycle:

- Number and volume of the lakes
- Dissolved CO<sub>2</sub> in every lake



# Counting the lakes (1)

Why high spatial resolution sensors? → Most lakes are small therefore they can not be remotely sensed by medium resolution spectrometers (MERIS, MODIS)



✦ Verpoorter et al., 2014

✦ [www.to.ee](http://www.to.ee)



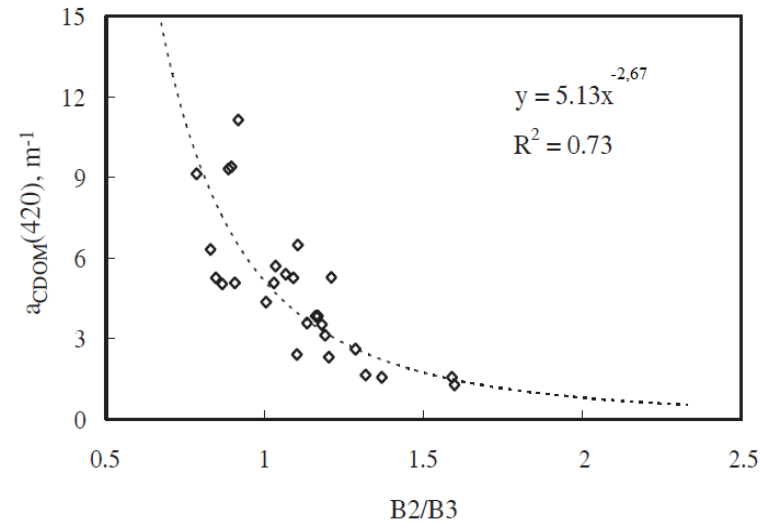


## Counting the lakes (2)

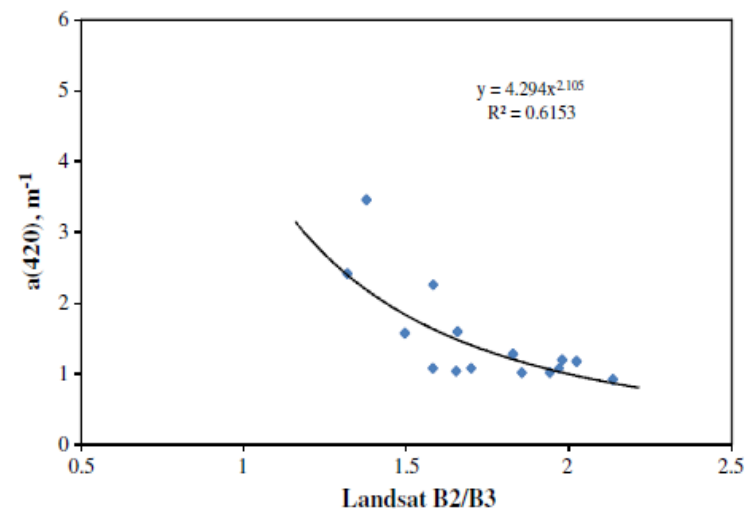
- ✦ Using Landsat 7 ETM+ sensor (~8500 scenes), an international research team counted all the lakes in the world that are bigger than 0,002 km<sup>2</sup>
- ✦ The result was 177 million lakes, covering almost 3.7% of the Earth surface (Greenland and Antartica exluded). Previous number 304 million lakes (statistical).
- ✦ The Landsat imagery was pan sharpened to have 14.25 m spatial resolution and is mosaicked into 882 nearly cloud-free tiles containing three spectral bands
- ✦ Objects smaller than 9 pixels were filtered out because water bodies smaller than this size are difficult to verify relative to image noise (i.e.,  $9 \times 14.25 \times 14.25$  m pixels)

# Mapping CDOM

- ✦ (A) - Studying Finnish and Swedish lakes (2002-2003) with ALI sensor (predecessor of Landsat 8 OLI) Kutser et al. (2004) got correlation  $R^2 = 0.73$

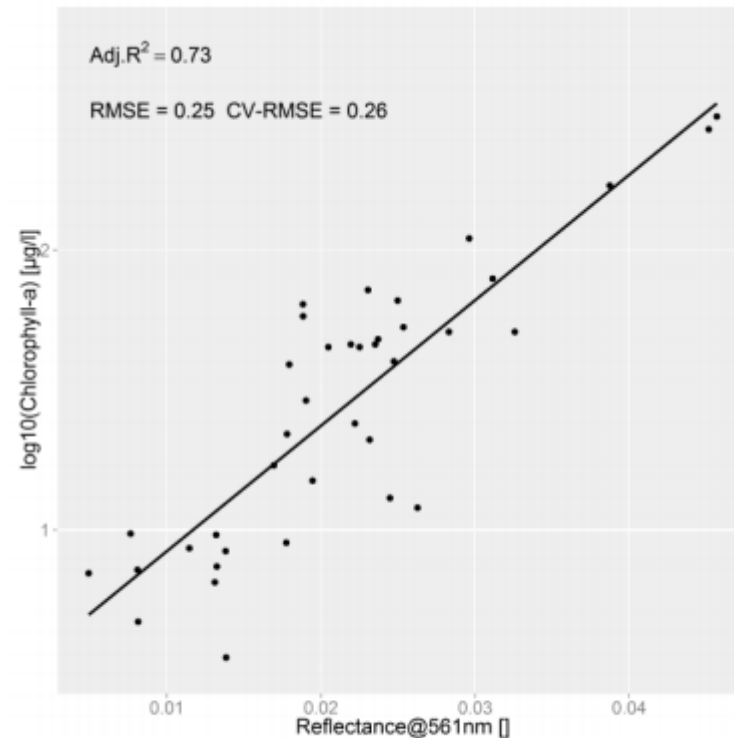


- ✦ (B) – Cloudfree images from 1984 and 2009 were used. 37 Landsat images were available for the central Sweden site and 26 images for the southern site. The dataset consists of Landsat 4, Landsat 5 and Landsat 7 imagery (Kutser, 2012).



# Mapping Chl

- ✦ Huber et al., 2014 show the potential of Landsat 8-derived chlorophyll a (chl-a) estimates to expand conventional monitoring - spatially and temporally.



*Figure 1. Regression between in situ samples of chlorophyll-a and Landsat 8 green reflectance (n=38).*



# Problems

- ✦ Atmospheric correction – atmosphere has more influence at shorter wavelengths which are important for water remote sensing (specially for CDOM measurements)
- ✦ Small size of lakes = large adjacency effects. Difficult to estimate!
- ✦ Small radiometric resolution (getting better now)
- ✦ Rare revisit time
- ✦ Actual *in situ* data about very few small lakes



# Summary

- ✦ High spatial resolution satellites can fill the gap in smaller lakes remote sensing.
- ✦ There are examples that it is possible to use some products
- ✦ Most significant problems with atmospheric correction and adjacency effect