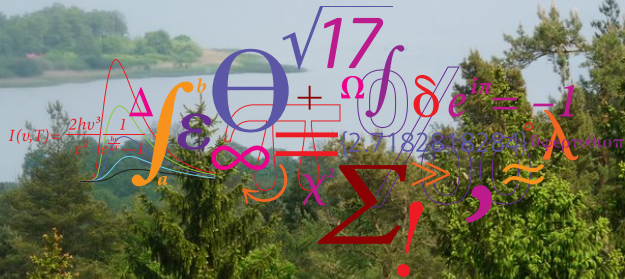


## Water level of rivers and lakes observed from space

Karina Nielsen<sup>1</sup>, Liguang Jiang<sup>2</sup>, Raphael Schneider<sup>2</sup>, Lars Stenseng<sup>1</sup>, Ole B. Andersen<sup>1</sup>, Peter Bauer Gottwein<sup>2</sup>, Per Knudsen<sup>1</sup>

<sup>1</sup>Division of Geodesy, National Space Institute, Technical University of Denmark (DTU)

<sup>2</sup>Department of Environmental Engineering, Technical University of Denmark (DTU)

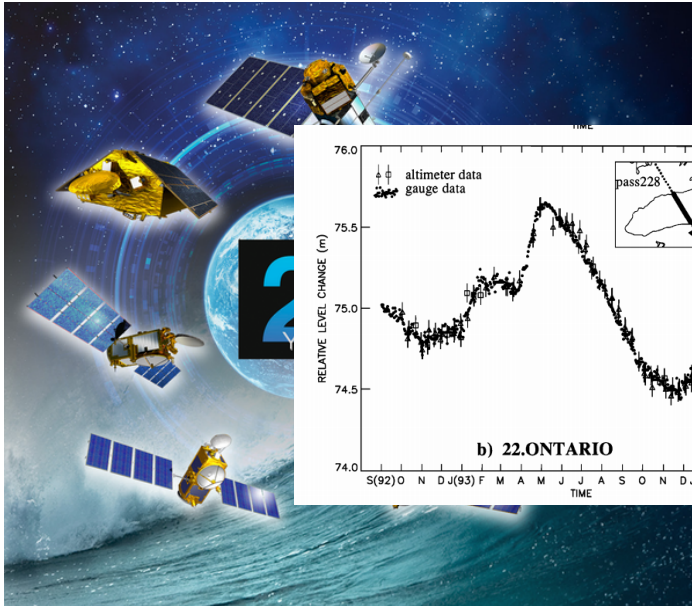


# 25 Years of satellite altimetry

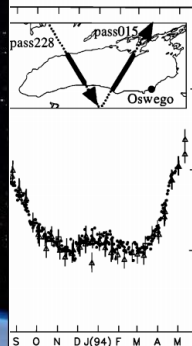




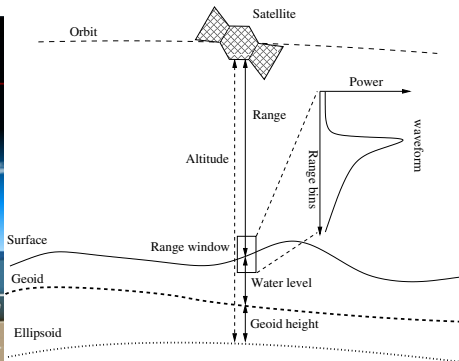
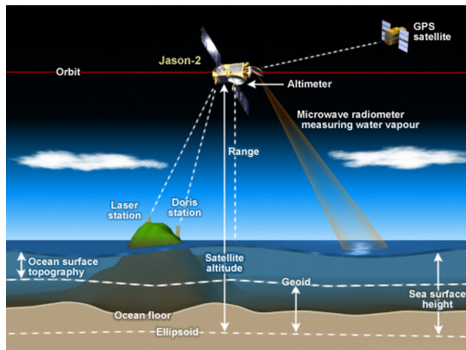
# 25 Years of satellite altimetry



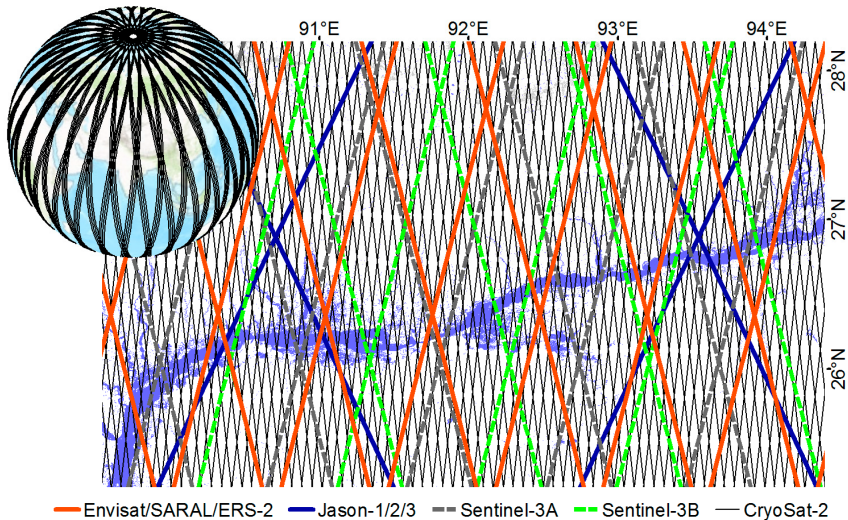
# 25 Years of satellite altimetry



# Principle of satellite altimetry

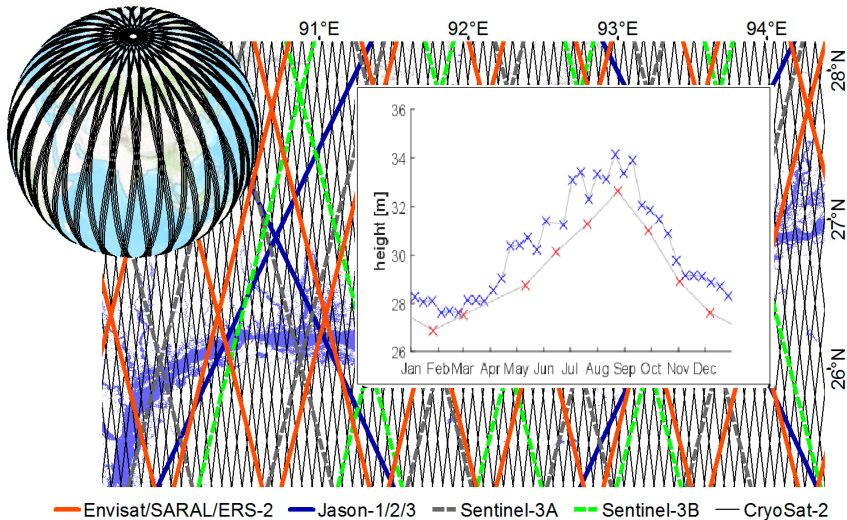


# Coverage



(Jiang et al., 2017)

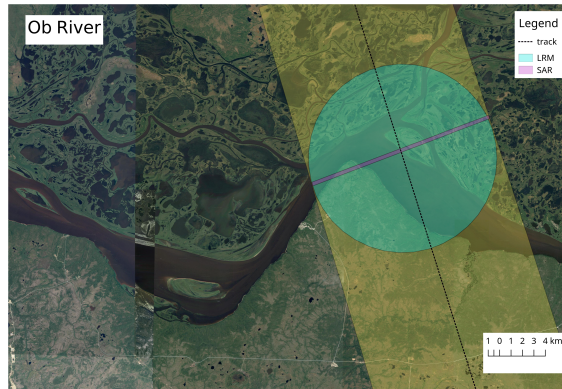
# Coverage



(Jiang et al., 2017)

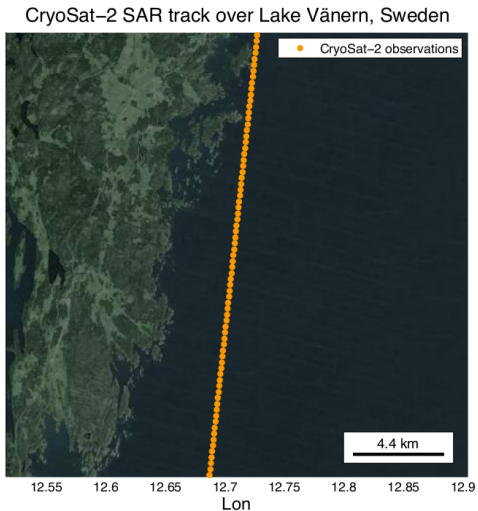
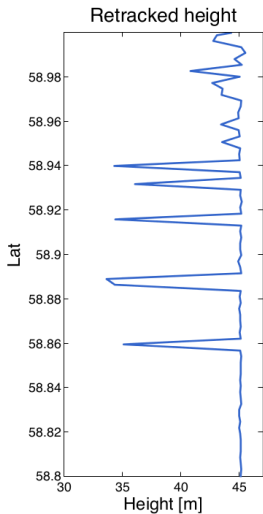


# Challenges



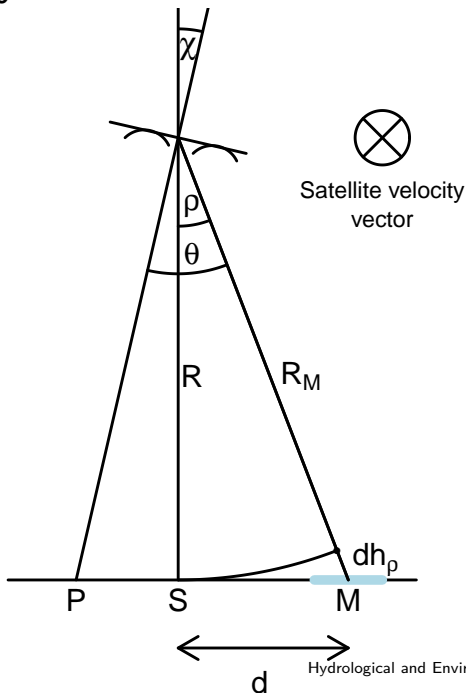
- The surface within the footprint is in-homogeneous
- Luckily, water is a good reflector
- Finding the water (masks classification)
- The waveforms might be contaminated with signals from land

## Snagging, off nadir signals



(Villadsen et al., 2015)

# The geometry of SARIn



# The benefits from the SARIn mode

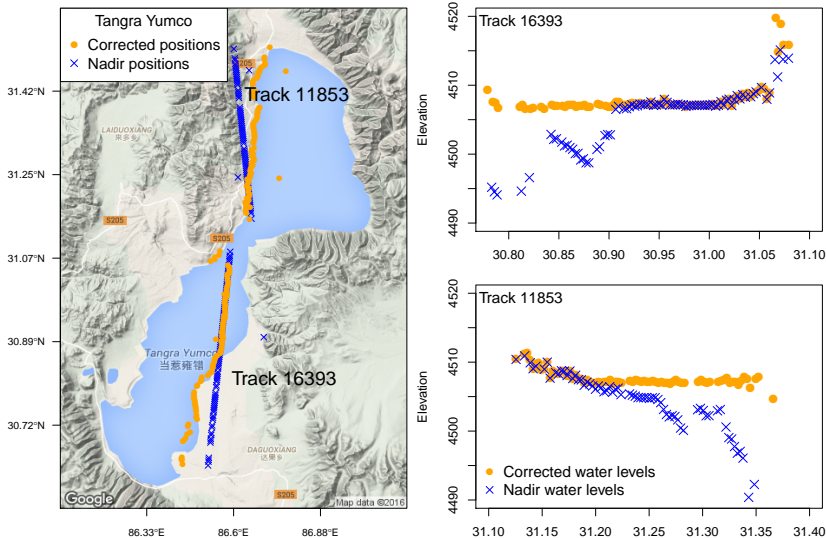
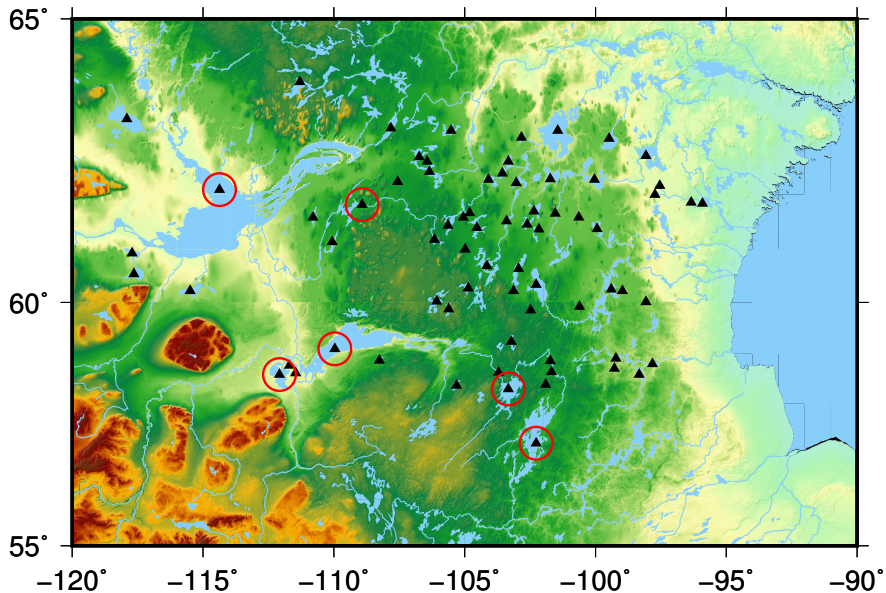


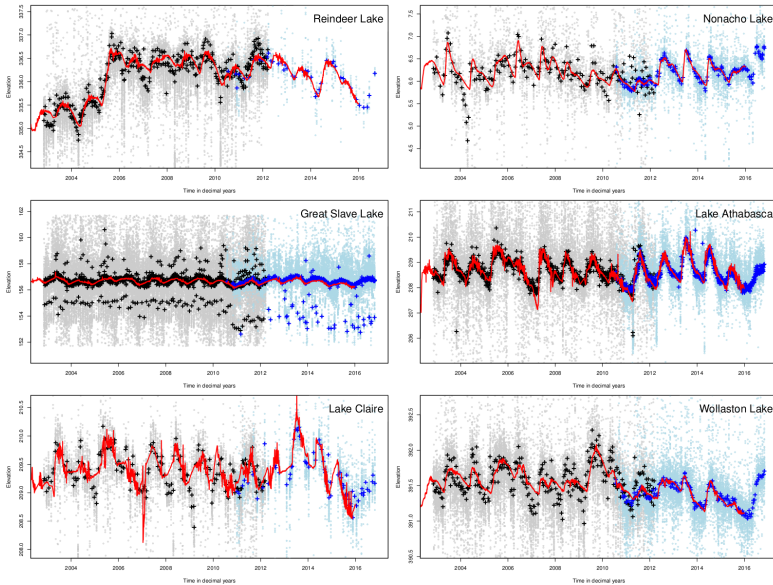
Figure : Tangra Yamco, Tibetan plateau

## Example of validation with in situ data on Canadian lakes





# Time series, Canada

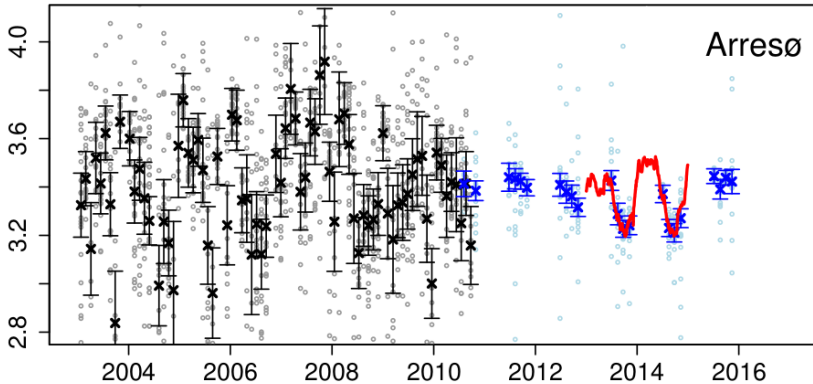


## RMS valus for CryoSat-2 and Envisat

Table : RMS valus for CryoSat-2 and Envisat

Lake	RMSE CryoSat [m]	RMSE [m] Envisat	Area [km <sup>2</sup> ]
Great Slave	0.68	0.54	27816
Athabasca	0.19	0.25	7782
Reindeer	0.12	0.19	5597
Wollaston	0.05	0.17	2272
Claire	0.20	0.23	1326
Nonacho	0.06	0.24	847

## An example from Denmark, Arresø



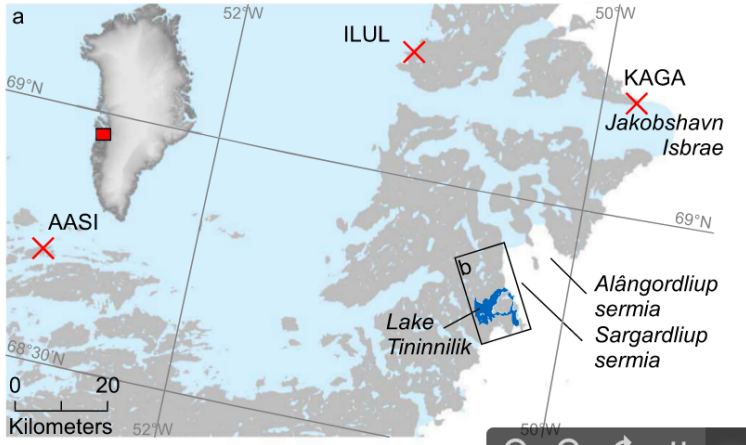
- Small lake (40 km<sup>2</sup>), here we see a clear improvement with CryoSat-2 SAR mode.
- Water level variations of just a few decimeters
- Located in a flat terrain.

# Applications and results

- Water level - Melt water lake - Kjeldsen et al., 2017
- Water level trend - The Tibetan Plateau - Jiang et al., 2017
- Water level - Po River - Schneider et al., 2017
- Water level - Mekong River - Boergens et al., 2017

Tininnilik Lake , Greenland

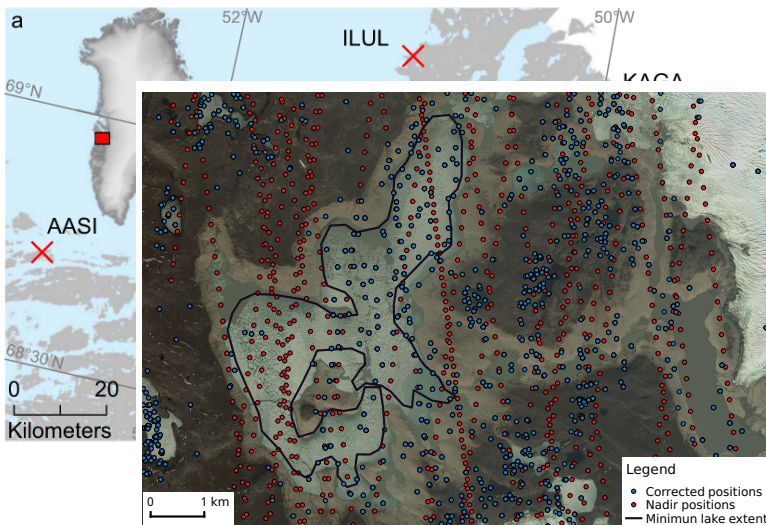
# Greenlandic melt water lake - Lake Tininnilik



Kjeldsen et al, 2017

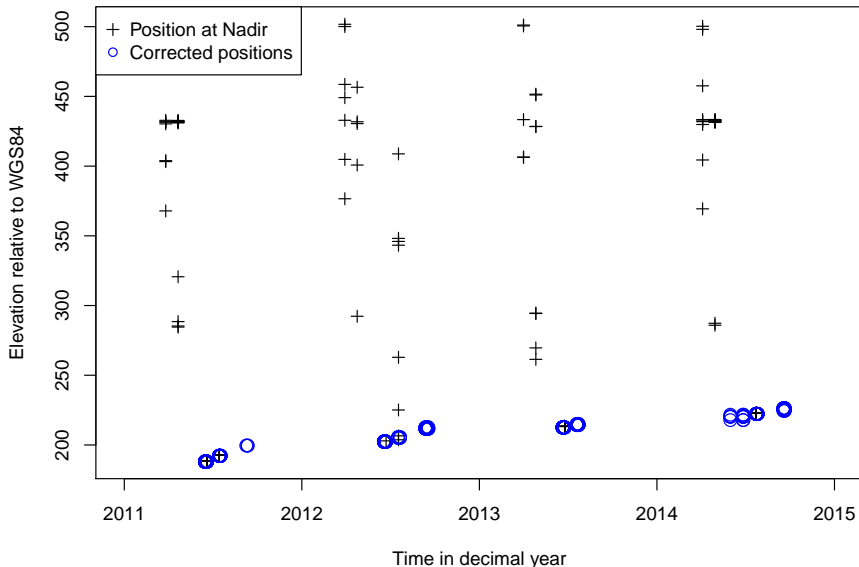


# Greenlandic melt water lake - Lake Tininnilik

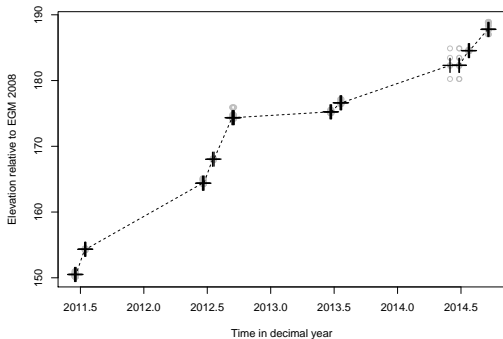


Kjeldsen et al, 2017

# Water levels, corrected and uncorrected



# Water level time series

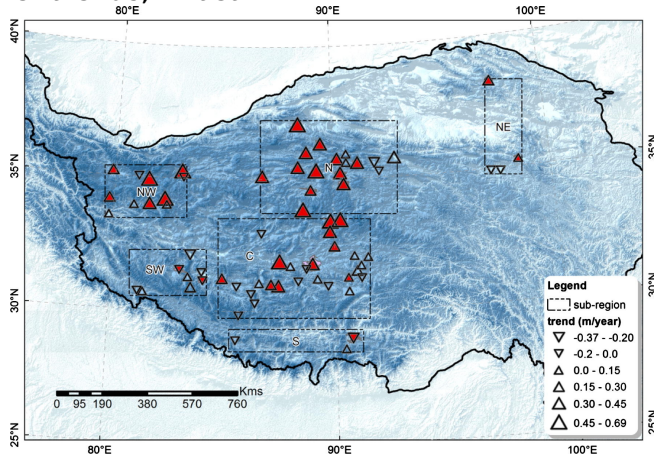


August 2010



July 2015

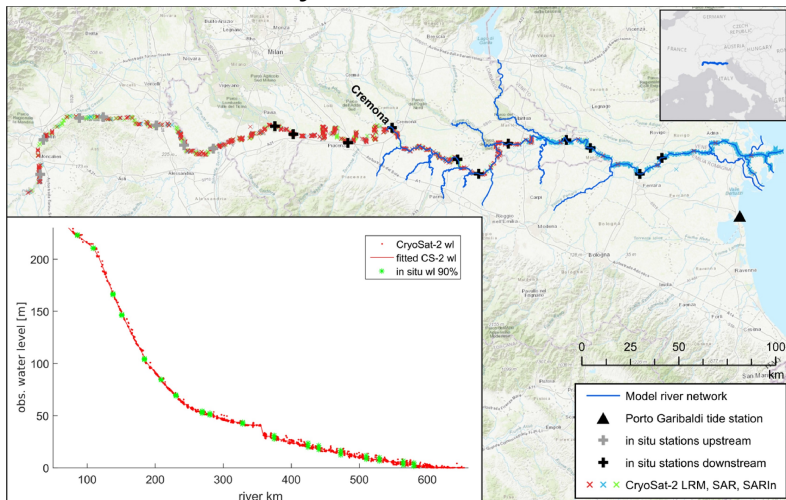
# Water level trends, Tibet



Jiang et al., 2017, *Monitoring recent lake level variations on the Tibetan Plateau using CryoSat-2 SARIn mode data*

- The Third pole, indicator of climate change
- Altimetry important, only few gauges
- 70 largest lakes above 100 km<sup>2</sup>

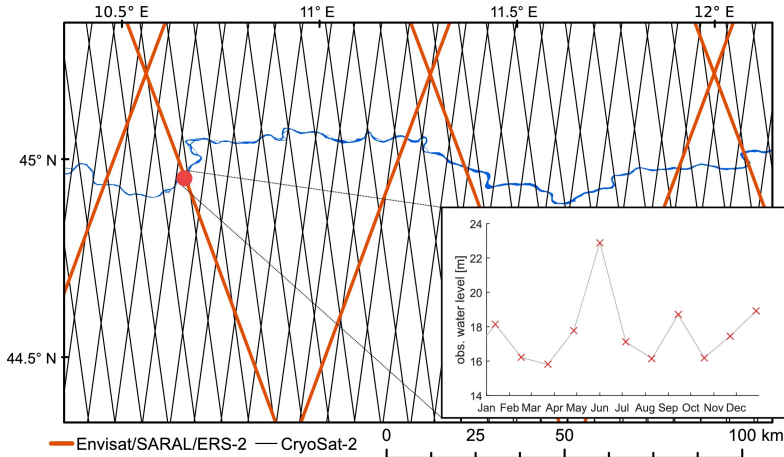
## Water level from CryoSat-2, Po River



Schneider et al., 2017, *Evaluation of multi-mode CryoSat-2 altimetry data over the Po River against in situ data and a hydrodynamic model*

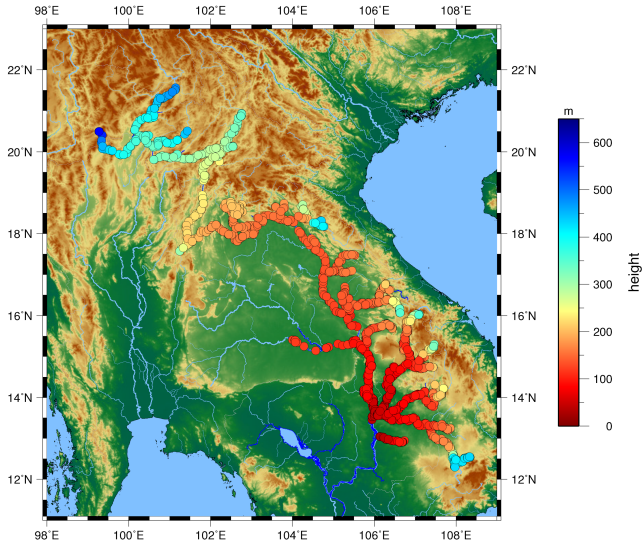


# Water level from CryoSat-2, Po River



Schneider et al., 2017, *Evaluation of multi-mode CryoSat-2 altimetry data over the Po River against in situ data and a hydrodynamic model*

# Water level from CryoSat-2, Mekong River



Boergens et al., 2017, *River Levels Derived with CryoSat-2 SAR Data Classification—A Case Study in the Mekong River Basin*

## Summary and data sources

- Satellites provide a global coverage
- The technology can be applied to targets with a widths larger than a few hundred meters
- The accuracy in terms of RMSE is between a few cm to 50 cm, depending on the size of the target and the surroundings.

### Data Sources:

<http://dahiti.dgfi.tum.de/>

<http://www.legos.obs-mip.fr/soa/hydrologie/hydroweb/>

<http://altwater.dtu.space/>

Welcome to contact me at [karni@space.dtu.dk](mailto:karni@space.dtu.dk)



Thank you for your attention :-)