Using Multi-Mission Satellite Altimetry for Estimating Water Level Time Series of Inland Water in DAHITI

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DAHITI

- New "**Da**tabase for **H**ydrologi**c**al **T**ime Series of **I**nland Water" (DAHITI)
- Currently, it contains about 180 water level time series over lakes, rivers, reservoirs, and wetlands
- Free data access via Open Altimeter Database (OpenADB) (**http://openadb.dgfi.badw.de**)

DGFI GGE

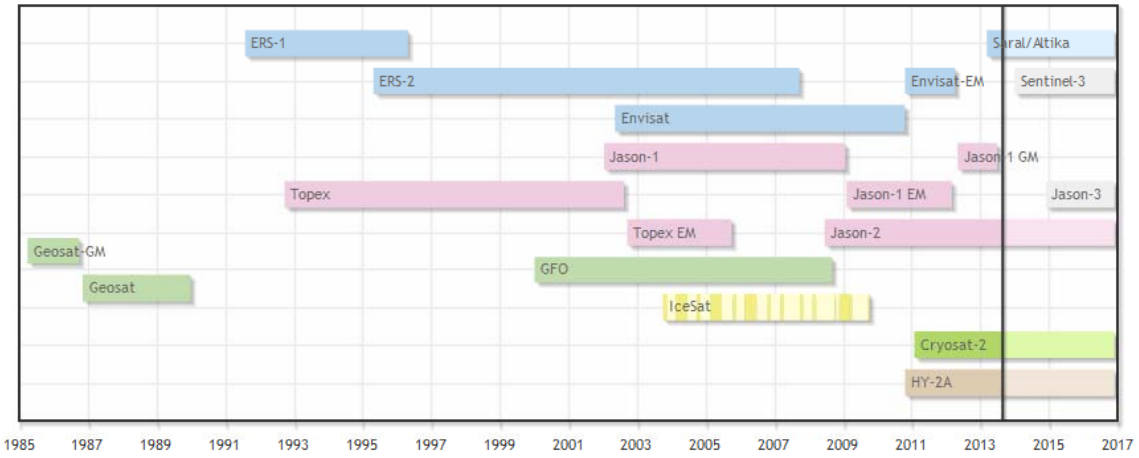
Rationale for DAHITI

What is new in DAHITI?

The DAHITI processing is based on:

- Using **multi-mission** altimeter data whenever available
- Transform ellipsoidal heights to **physical heights** using EIGEN6C2 geoid model (where water will flow)
- Assume water bodies to form an equipotential surface (equal physical heights)
- Waveform classification by „**Support Vector Machine (SVM)**“
- Outlier rejection by „**Support Vector Regression (SVR)**“
- Building a smooth space-time series by a **Kalman Filter** approach

Data Holding



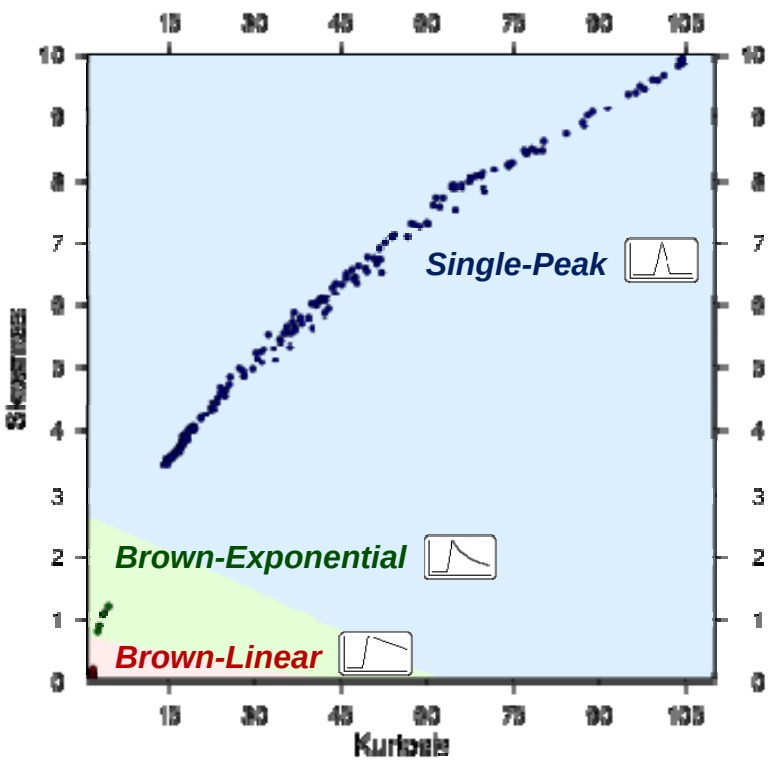
Mission	1Hz	High-frequent	Retracking
Cryosat-2 (20Hz)	✓	✓	✗
Envisat (20Hz)	✓	✓	✓
ERS-1 (20Hz)	✓	✗	✗
ERS-2 (20Hz)	✓	✗	✗
Geosat (10Hz)	✓	✗	✗
GFO (10Hz)	✓	✗	✗
HY-2A (20Hz)	✓	✓	✗
IceSAT (40Hz)	✓	✓	✗
Jason-1 (20Hz)	✓	✓	✓
Jason-2 (20Hz)	✓	✓	✓
Saral/Altika (40Hz)	✓	✓	✗
Topex/Poseidon (10Hz)	✓	✓	✗

Methodology: Preprocessing

1. Extraction of raw data from OpenADB

2. Classification (optional)

- Using method of „Support Vector Machine (SVM)“
- Three Classes (Brown-Linear, Brown-Exponential, Single Peak)
- Two Features (Kurtosis, Skewness)
- SVM model includes the decision function to assign every waveform to one class



3. Retracking (optional)

- Each waveform is assigned to a retracking algorithm

SVM-Class	Retracker	Reference
Brown-Linear	5-Parameter β-Retracker (linear trailing edge)	Zwally and Brenner, 2001
Brown-Exponential	5-Parameter β-Retracker (exponential trailing edge)	Deng and Featherstone, 2006
Single-Peak	Improved Threshold Retracker	Hwang et al., 2006

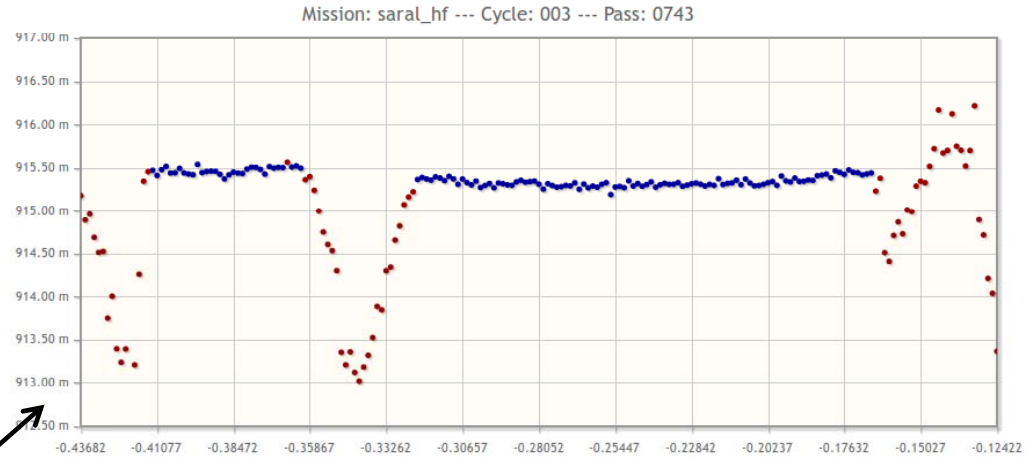
Methodology: Preprocessing

4. Physical heights estimation using original or retracked ranges

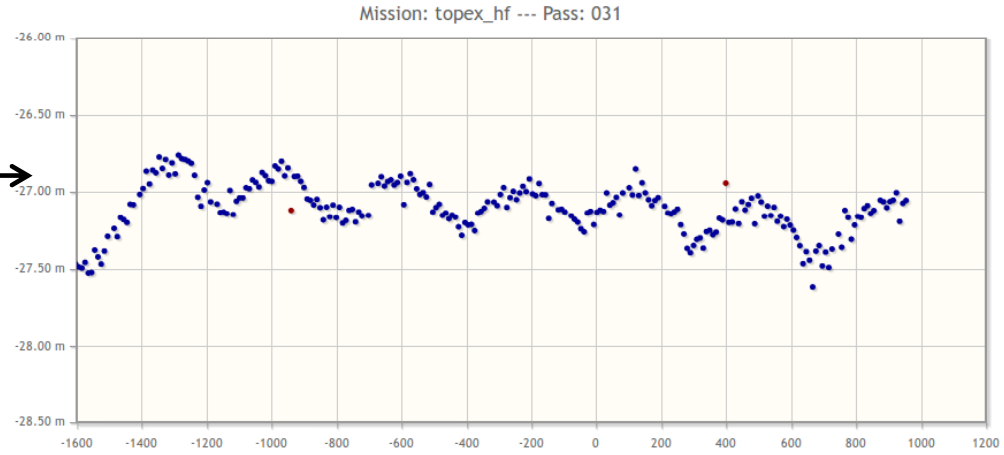
5. Calculation of standard deviations of heights along pass

6. Reject outliers

- Min/max height
- Limit of standard deviation
- Classes from classification
- „Support Vector Regression“ along pass
- „Support Vector Regression“ along mission



valid / rejected



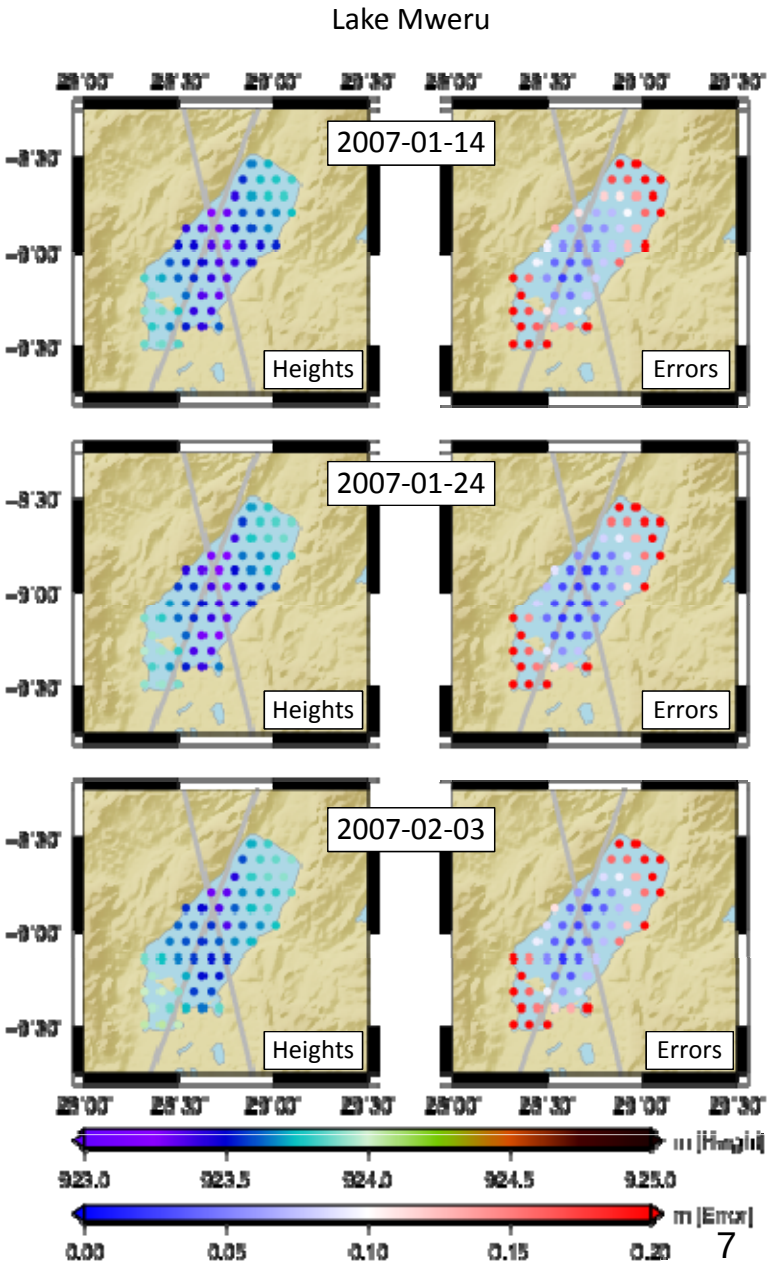
Methodology: Estimation

Kalman Filter Approach

- Input data: Physical heights and STD
- Noise and errors of data are considered
- Individual time steps (e.g. 1d, 10d, 30d)

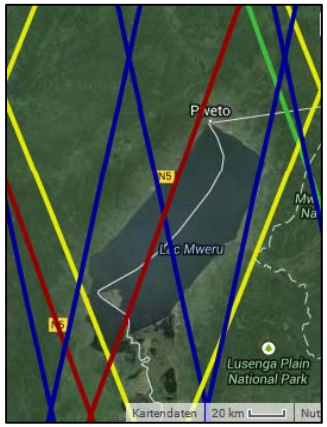
Processing

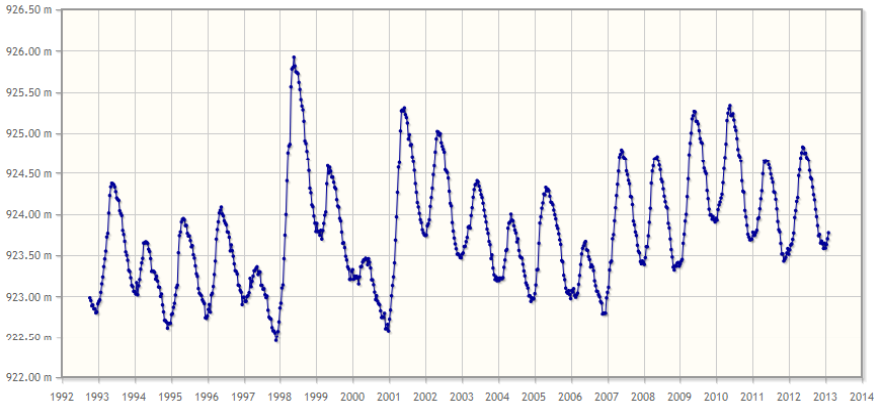
- Create hexagonal grid for target
- Interpolate heights to nearest node
- STD used for weighting the data
- New heights are estimated by weighting heights from an earlier time step and new data at current time step
- Forward and backward filtering
- Mean height of nodes is estimated considering error limit (e.g. 0.1m)



Results

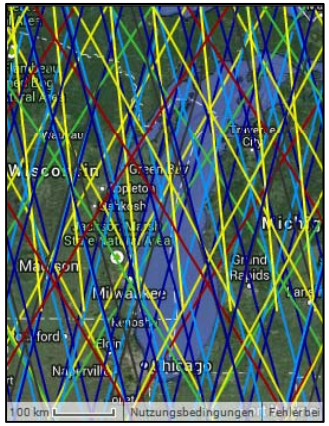
Lake Mweru (5,120 km²)

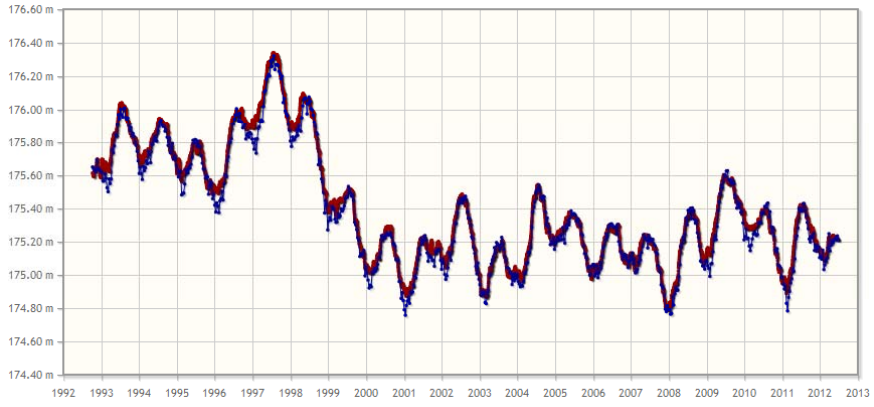




Mission	Passes
Envisat (20Hz)	0915
Jason-1 (20Hz)	*209*
Jason-2 (20Hz)	*209*
Topex (10Hz)	*209*

Lake Michigan (58,016 km²)



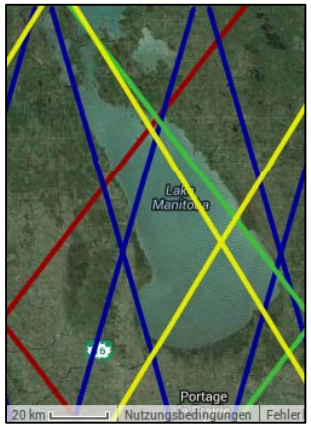


Mission	Passes
Jason-1 (1Hz)	*041, 076, 219, 254*
Jason-2 (1Hz)	*041, 076, 219, 254*
Topex (1Hz)	*041, 076, 219, 254*
Envisat (1Hz)	7, 338, 465, 551, 882, 923
Topex-EM (1Hz)	041, 076, 054
Jason1-EM (1Hz)	041, 076, 054

- Correlation with gauge (red): 0.95
- Very good absolute agreement due to same height reference (WGS84)

Results

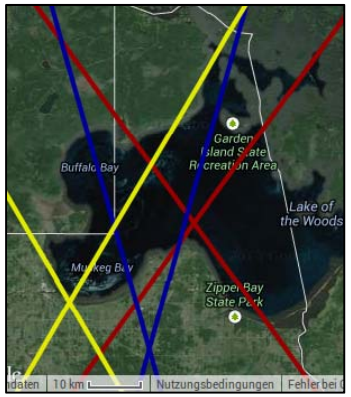
Lake Manitoba (4,700 km²)

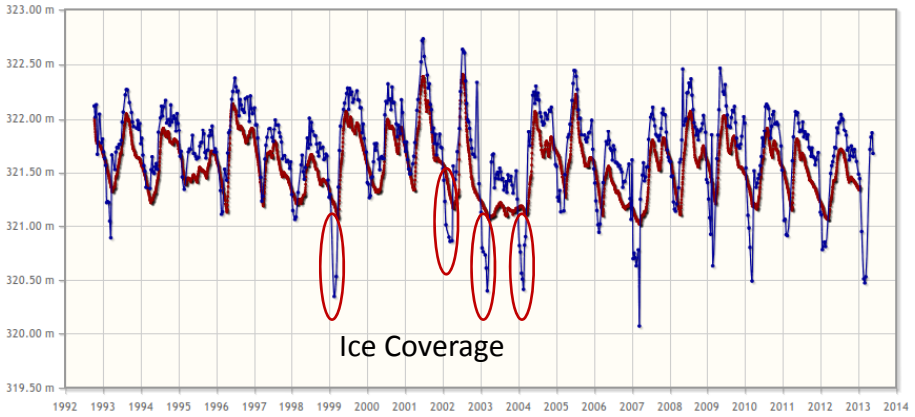


Mission	Passes
Jason-1 (20Hz)	017
Jason-2 (20Hz)	*017*

- Correlation with gauge (red): 0.81
- Offset due to unknown height reference of gauge
- Ice coverage in altimeter data visible by negative peaks

Lake of the Woods (4,349km²)



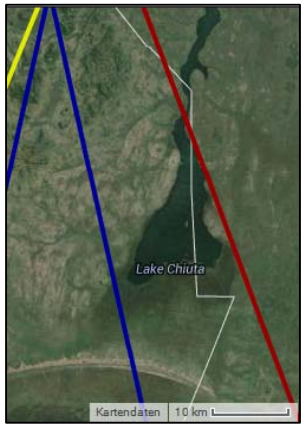


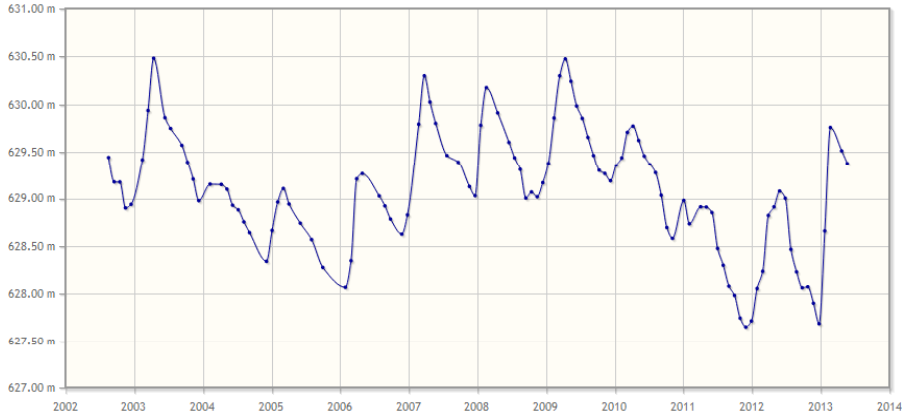
Mission	Passes
Envisat (20Hz)	0482
Jason-1 (20Hz)*	*169,178*
Jason-2 (20Hz)*	*169,178*
Topex (10Hz)	*169,178*
*retracked	

- Correlation with gauge (red): 0.82
- Offset due to unknown height reference of gauge

Results

Lake Chiuta (199 km²)

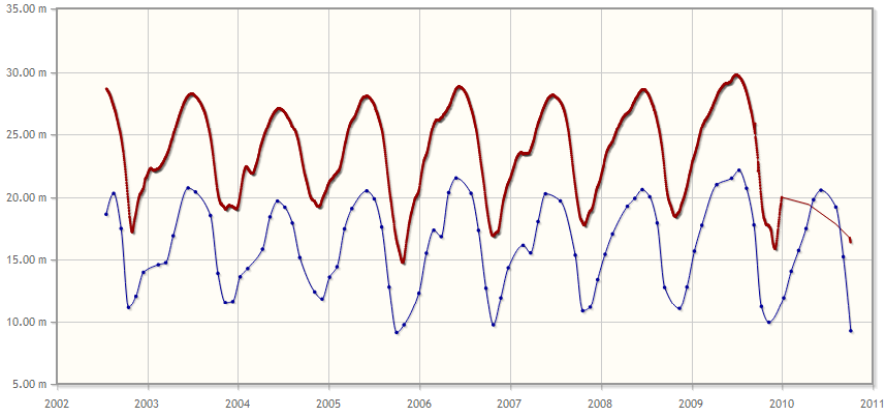




Mission	Passes
Envisat (20Hz)	571
Jason-2 (20Hz)*	044
*retracked	

- Even very good results in very small lakes and rivers

Amazon River



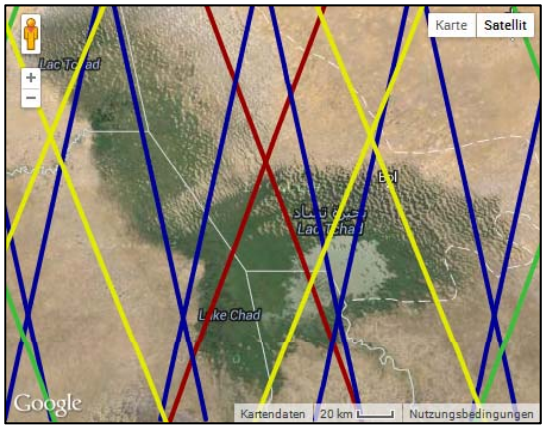
Mission	Passes
Envisat (20Hz)	564

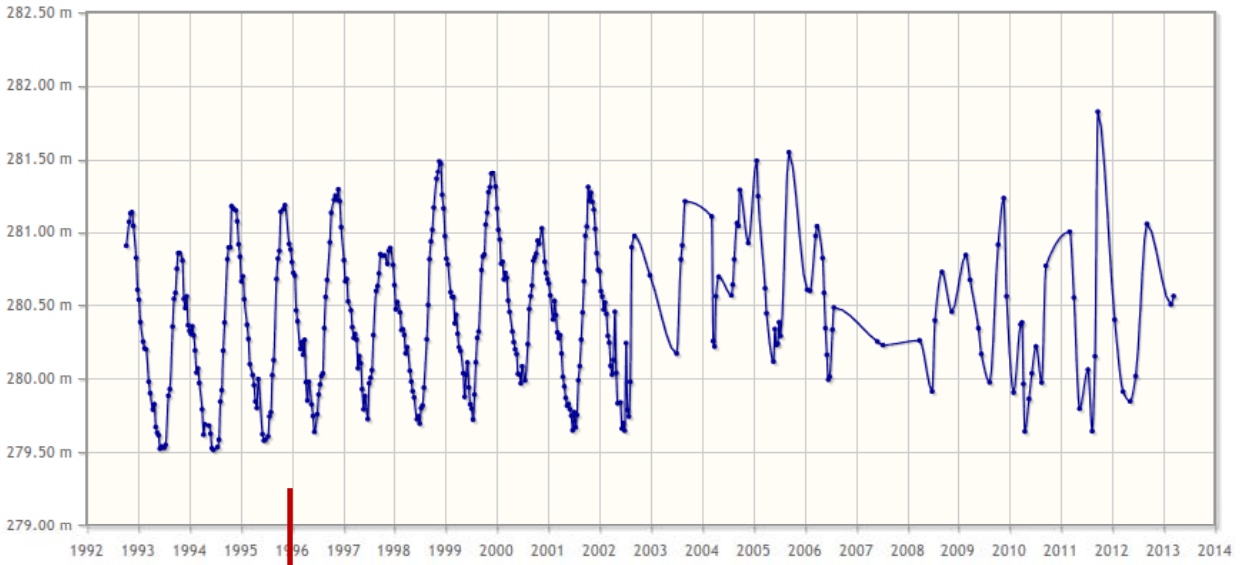
- Correlation with gauge (red): 0.98
- Offset due to unknown location and height reference of gauge

Results

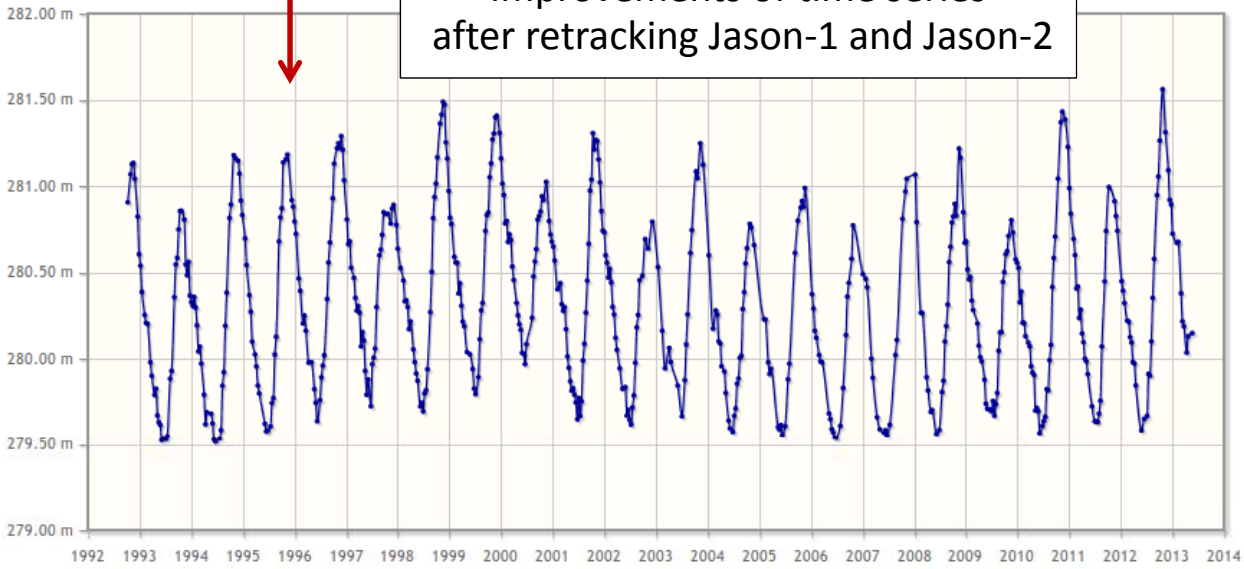
Lake Chad (1,500 km²)

Mission	Passes
Jason-1 (20Hz)	248
Jason-2 (20Hz)	248
Topex (10Hz)	248





Improvements of time series
after retracking Jason-1 and Jason-2



Mission	Passes
Jason-1 (20Hz)*	248
Jason-2 (20Hz)*	248
Topex (10Hz)	248
*retracked	

Discussion / Outlook

Discussion

- DAHITI provides promising time series of inland water for hydrological applications
- Kalman filter approach for height estimation and SVR for outlier detection leads to smooth reliable time series with high correlations with gauges
- Additional classification and retracking leads to improved results in small water bodies

Outlook

- Error assessment for the lake level heights
- Expansion of the altimeter data base with high-frequent and SGDR data
- Expansion of DAHITI by new targets
- Use more classes in the classification step (e.g. brown+peak)
- Use other/improved retracking algorithms

See you on OpenADB

http://openadb.dgfi.badw.de

Poster No. 13 (CAW):

DAHITI: A New Database of Water Level Time Series for Lakes, Rivers and Wetlands from Multi-Mission Satellite Altimetry

(Schwatke C., Dettmering D., Bosch W.)

Poster No. 28 (OSTST):

OpenADB: An Open Altimeter Database providing high-quality altimeter data and products

(Schwatke C., Dettmering D., Bosch W.)

Acknowledgement:

DAHITI holdings are based on altimetry missions operated by CNES/NASA (TOPEX, Jason-1), ESA (Envisat, Cryosat-2), USNavy/NOAA (GFO), CNES/NASA/Eumetsat/NOAA (Jason-2), and ISRO/CNES (Saral). The mission data are disseminated by AVISO, ESA, NOAA, and PODAAC. The time series of gauges are provided by NOAA Tides and Currents, Lake of the Woods Control Board, and Water Survey of Canada

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