Lake level variations from satellite radar altimetry with retracking of multi-leading edge

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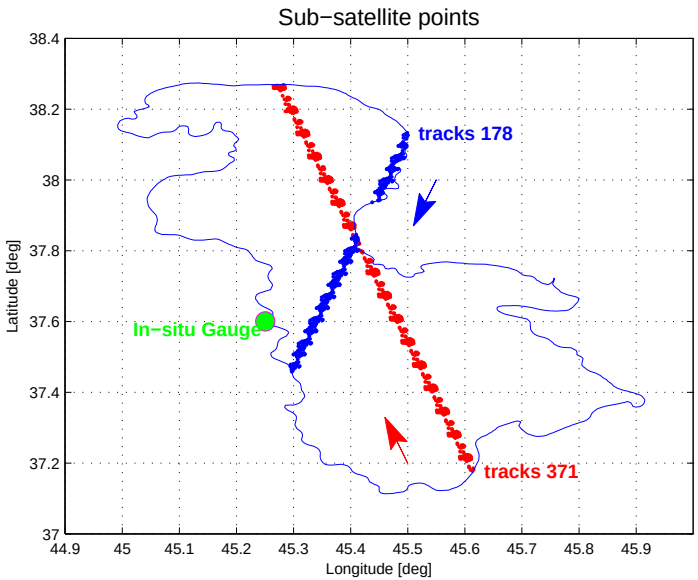
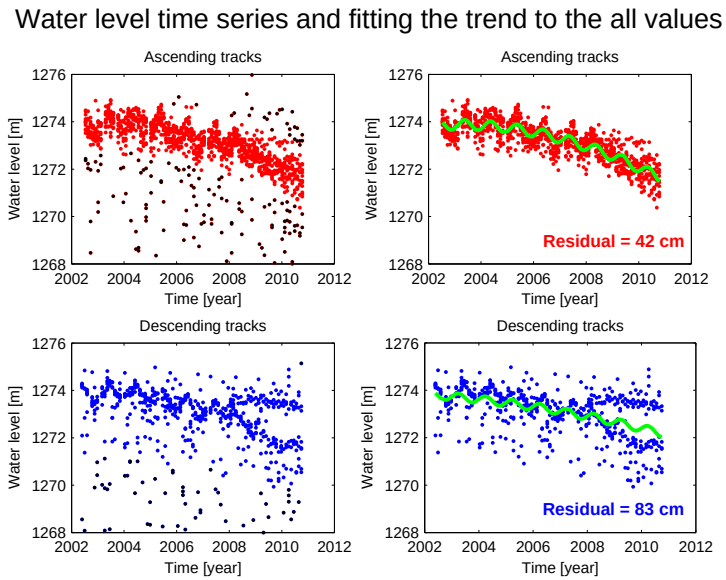
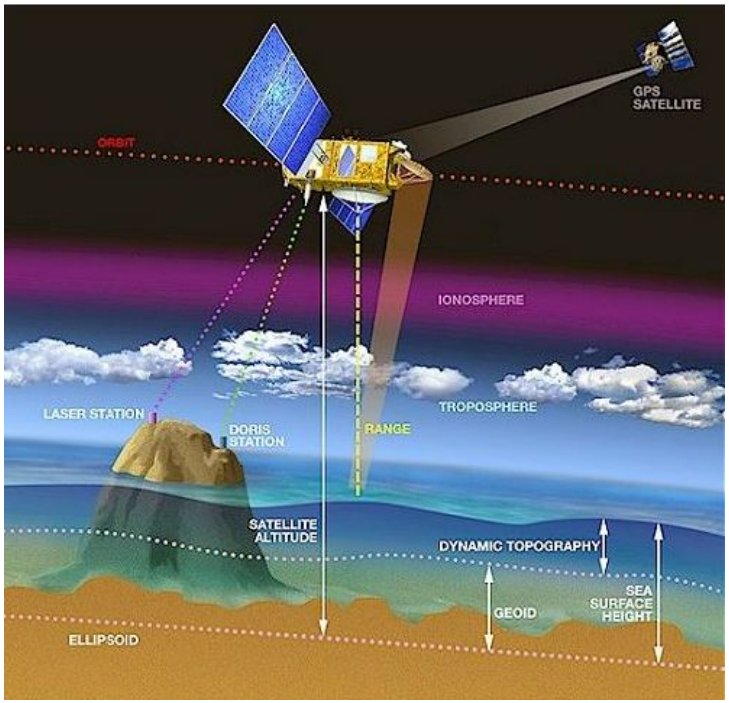
Why waveform retracking?

- Improve the quality of water level measurements
- Increase the number of reliable observations particularly in the shoreline and shallow water





RADAR principle



http://www.altimetry.info

How can we have more precise water level measurements?

- Increasing precision of range measurements
  - Use more precise range correction, e.g. corrections included in GDRs
  - *waveform retracking, i.e. calculate another range correction from SGDRs*

$$\Delta R_{\text{retracking}} = (G_{\text{r}} - G_0) \times \frac{c}{2}\tau$$

G_{r}: retracked gate, G_0: nominal retracking gate, c: light velocity, τ: pulse duration

Waveform retracking techniques

- Conventional retrackers
  - Onboard retracker (Ice-1/2 and Sea-ice)
  - Offset Center Of Gravity (OCOG)
  - Threshold
  - β- parameters
- Unconventional retrackers
  - Multi-leading edge
  - Modified waveform

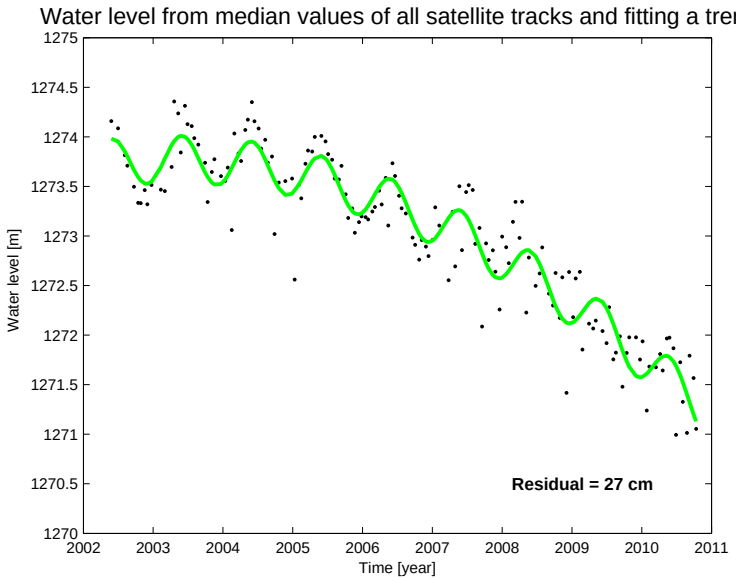
Data and area of study

RA2 Geophysical and Sensor Data Records, i.e. RA2 GDRs and RA2 SGDRs of Envisat satellite altimetry from cycle 6 to cycle 113

Envisat satellite ground tracks from cycle 92

Conventional retrackers

- Onboard retrackers:
  Water level from RA2 GDRs data using median values of water level in each satellite over pass in Ice-1 retracker algorithm

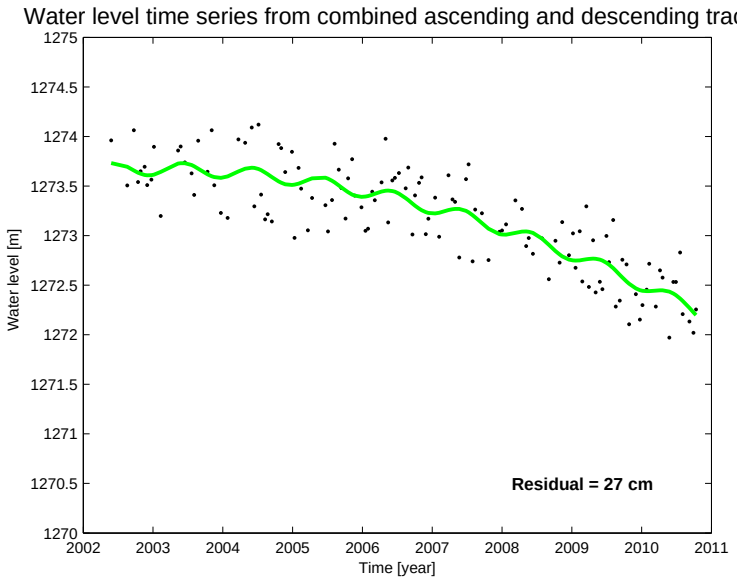


$$h(t_i) = a + bt_i + ct_i^2 + d\sin\left(\frac{2\pi}{T}t_i\right) + e\cos\left(\frac{2\pi}{T}t_i\right)$$

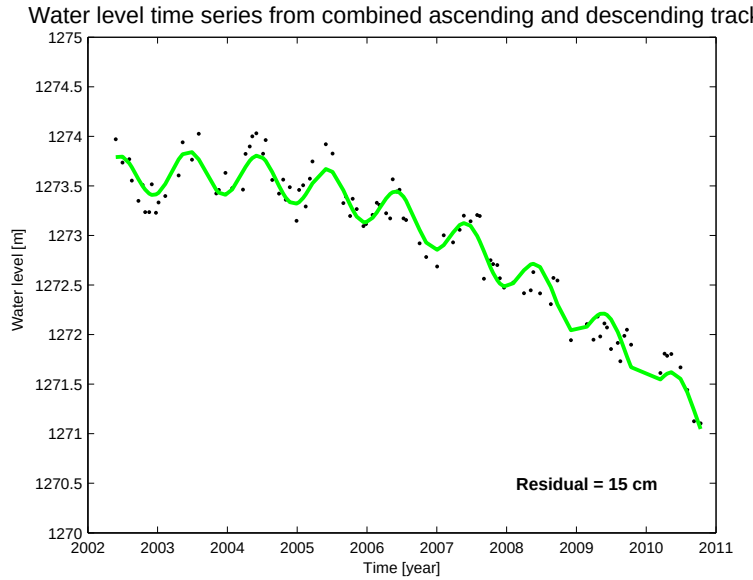
a, b, c, d and e are unknown parameters to be estimated. T is the annual period and h is the observed water height.

Conventional retrackers

- OCOG

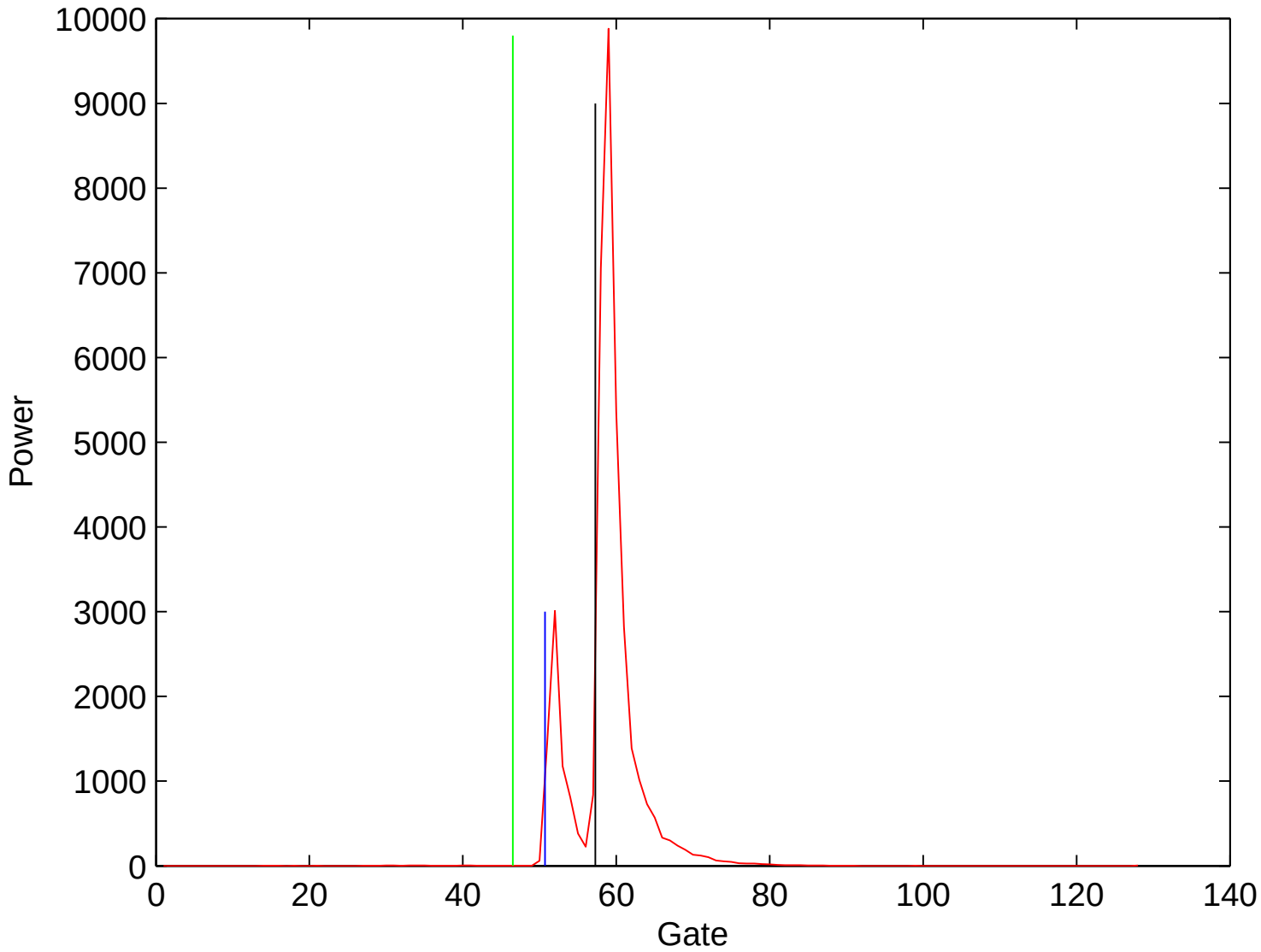


- Threshold



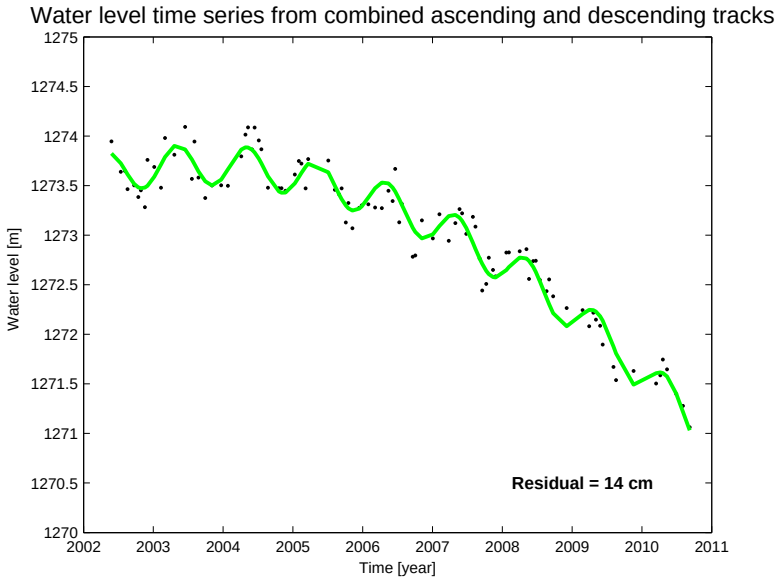
Unconventional retrackers

- Multi-leading edge



Unconventional retrackers

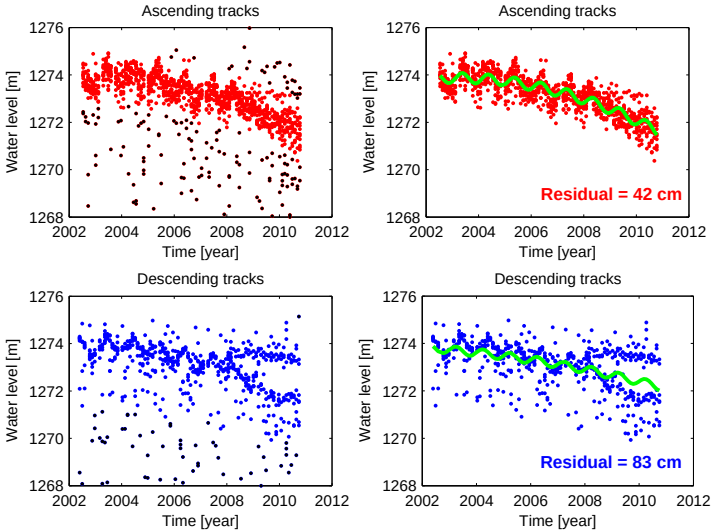
- Multi-leading edge



Comparing different retrackers

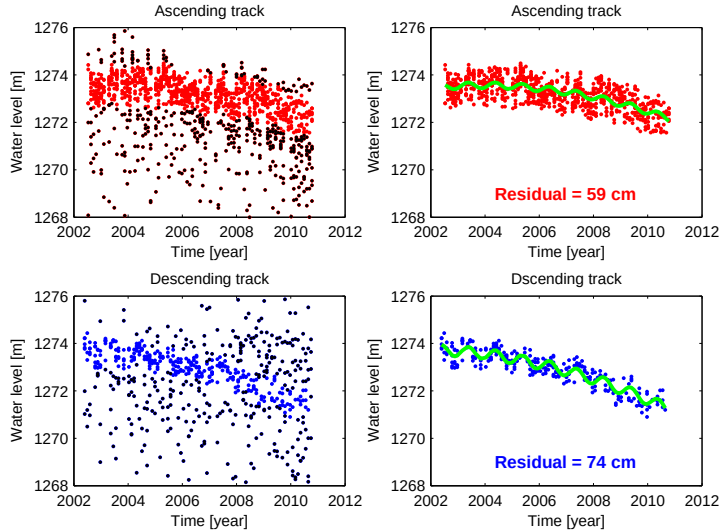
- Onboard retracker

Water level time series and fitting the trend to the all values



- Other retrackers

Water level time series based on Threshold 10 % retracker



Comparing different retrackers

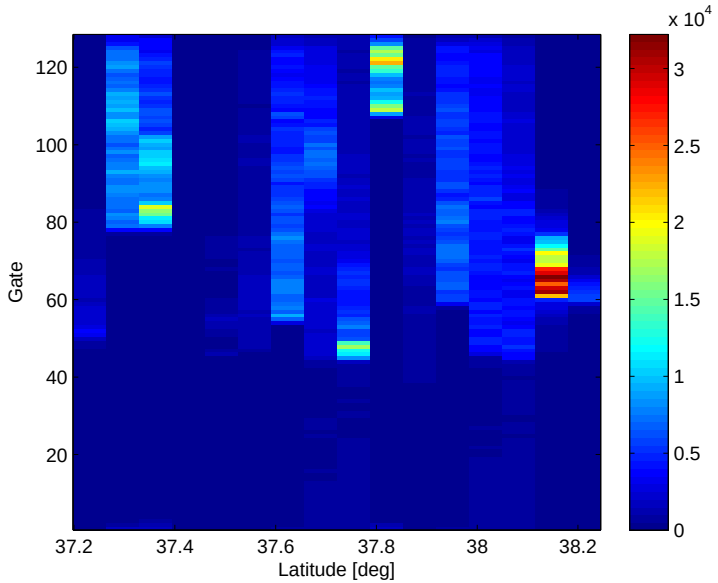
Water level standard deviation from different retrackers

retracker	standard deviation (cm)	improvement
Ice-1	27	–
OCOG	27	0 %
Threshold 10	18	33 %
Threshold 20	15	44 %
Threshold 50	17	37 %
Multi-leading edge	14	48 %

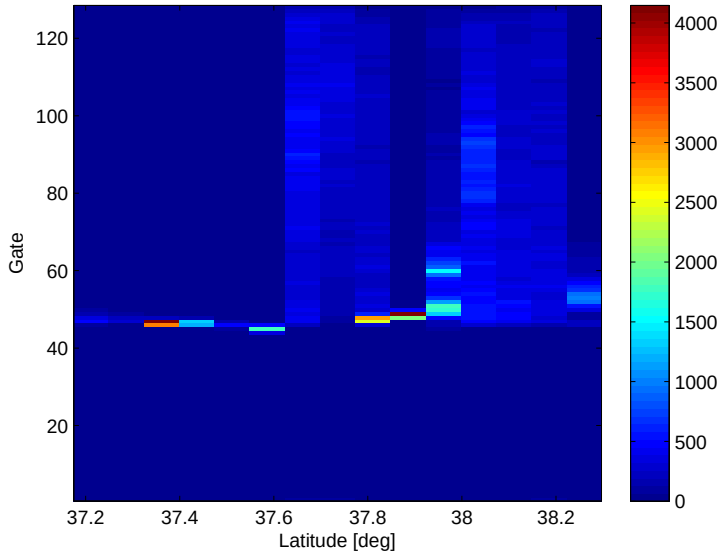
$$Improvement = \frac{\sigma_{\mathrm{Ice-1}} - \sigma_{\mathrm{Ret}}}{\sigma_{\mathrm{Ice-1}}} \times 100\ \%$$

Along track waveform variations

First ascending pass-Jun 2002

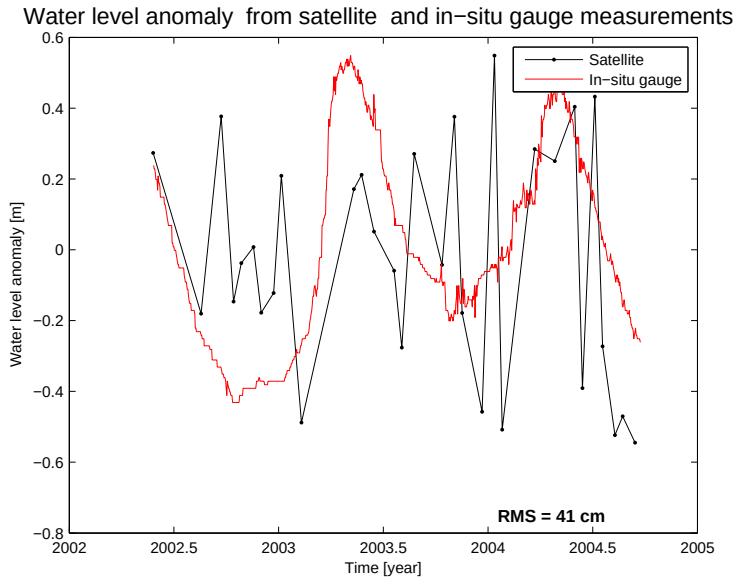


Last ascending pass- Sep 2010

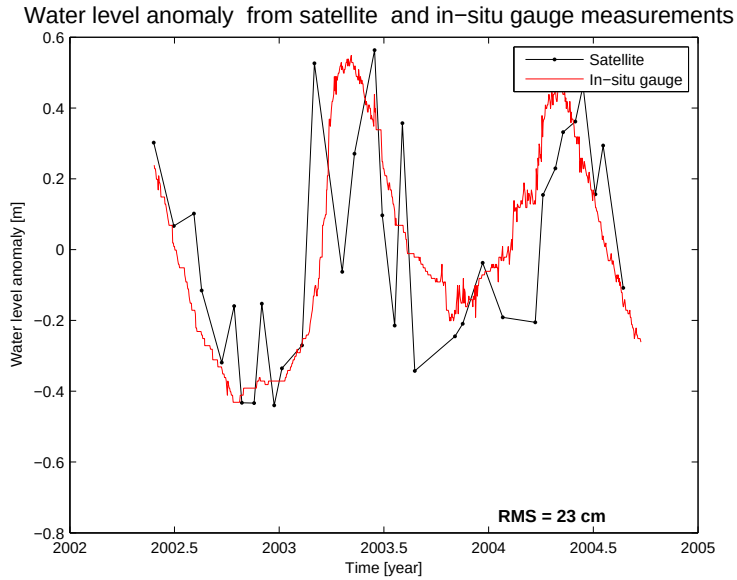


Validation

- OCOG

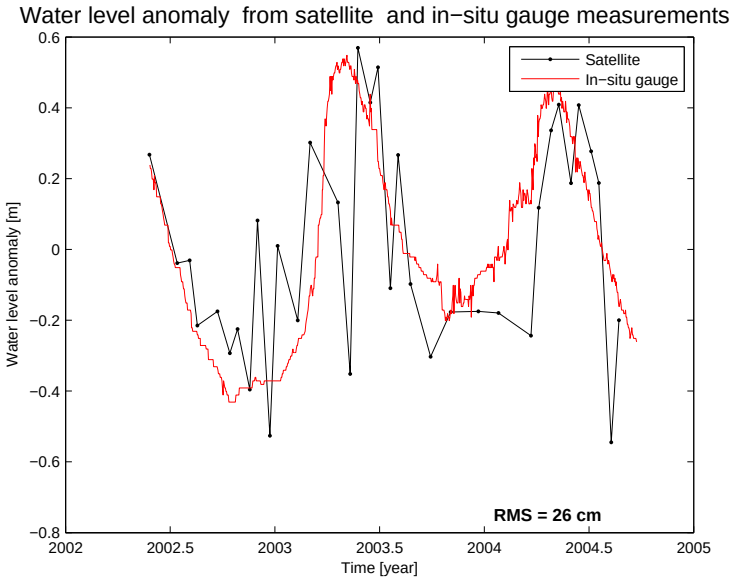


- Threshold



Validation

- Multi-leading edge



Conclusion

- Obviously waveform retracking techniques can improve the quality of altimetry data.
- Due to the land and environmental effects on the return echoes to the altimeter particularly in the shoreline the waveform retracking is necessary.
- The quality of water level is dependent on the waveform retracking techniques.
- According to the result of data processing using both RA2 GDR and RA2 MWS (SGDRs) of Envisat, multi-leading edge and threshold 20 % retrackers outperform the other retackers to determine water level variations of Urmia lake.

Works under way

- Continuing waveform retracking using:
  - β–parameter
  - Modified waveform

Thank you for your attention