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

Shirzad Roohi
(shirzad.roohi@gis.uni-stuttgart.de)

and

Nico Sneeuw

University of Stuttgart, Germany
Institute of Geodesy
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*

\[
\Delta R_{\text{retracking}} = (G_r - G_0) \times \frac{c}{2} \tau
\]

- $G_r$: retracked gate, $G_0$: nominal retracking gate, $c$: light velocity, $\tau$: pulse duration
Waveform retracking techniques

- Conventional retrackers
  - Onboard retracker (Ice-1/2 and Sea-ice)
  - Offset Center Of Gravity (OCOG)
  - Threshold
  - $\beta$- 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

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

Where \( a, b, c, d \) and \( e \) are unknown parameters to be estimated. \( T \) is the annual period and \( h \) is the observed water height.
Conventional retrackers

- OCOG

- Threshold

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

- Multi-leading edge
Unconventional retrackers

- Multi-leading edge

Water level time series from combined ascending and descending tracks

Residual = 14 cm
Comparing different retrackers

▶ Onboard retractor

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

Water level time series based on Threshold 10 % retracker

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

Water level standard deviation from different retrackers

<table>
<thead>
<tr>
<th>retracker</th>
<th>standard deviation (cm)</th>
<th>improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice-1</td>
<td>27</td>
<td>-</td>
</tr>
<tr>
<td>OCOG</td>
<td>27</td>
<td>0 %</td>
</tr>
<tr>
<td>Threshold 10</td>
<td>18</td>
<td>33 %</td>
</tr>
<tr>
<td>Threshold 20</td>
<td>15</td>
<td>44 %</td>
</tr>
<tr>
<td>Threshold 50</td>
<td>17</td>
<td>37 %</td>
</tr>
<tr>
<td>Multi-leading edge</td>
<td>14</td>
<td>48 %</td>
</tr>
</tbody>
</table>

\[
\text{Improvement} = \frac{\sigma_{\text{Ice-1}} - \sigma_{\text{Ret}}}{\sigma_{\text{Ice-1}}} \times 100 \%
\]
Along track waveform variations

First ascending pass-Jun 2002

Last ascending pass- Sep 2010

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

▶ OCOG

Water level anomaly from satellite and in-situ gauge measurements

RMS = 41 cm

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

▶ Threshold

Water level anomaly from satellite and in-situ gauge measurements

RMS = 23 cm
Validation

- Multi-leading edge

![Graph showing water level anomaly from satellite and in-situ gauge measurements over time. The graph displays the time in years ranging from 2002 to 2005 on the x-axis and the water level anomaly in meters on the y-axis. The RMS error is 26 cm.]
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:
  - $\beta$–parameter
  - Modified waveform
Thank you for your attention
References


G. J. Yun, C. Xiaotao, G. Y. Gang, S. Jialong and H. C. Way, 2009, Lake level variations monitored with satellite altimetry waveform retracking, IEEE journal of selected topics in applied earth observations and remote sensing, 2, 2, 80–86.


References


