Water Storage Changes in the Aral Sea using Multi-mission Satellite data

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Agenda

- Introduction and study area
- Changes in water level from satellite altimetry
- Changes in horizontal extent of the water body using Landsat
- Water mass variations from the GRACE gravity field mission
- Conclusions
- Outlook
Background

- Distribution of water on Earth

  - Freshwater 3%
  - Saline (oceans) 97%

  - Other 0.9%
    - Ground water 30.1%
    - Icecaps and Glaciers 68.7%
  - Surface water 0.3%

  - Fresh surface water (liquid)
    - Lakes 87%
    - Swamps 11%
    - Rivers 2%

- Depletion of water resources

- Poor knowledge of terrestrial water system (http://swot.jpl.nasa.gov)

Source: http://ga.water.usgs.gov/edu/waterdistribution.html
Study Area and its background

The Aral Sea is located in at 45° N and 60° E.

Until 1960, it was the fourth largest lake on Earth.
Changes in the water level of the Aral Sea
Water level change

- Altimetry:

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Revisit</th>
<th>From</th>
<th>Until</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Envisat, RA2</td>
<td>35 days</td>
<td>January 2004</td>
<td>July 2010</td>
<td><a href="http://envisat.esa.int">http://envisat.esa.int</a></td>
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<tr>
<td>GFO</td>
<td>17 days</td>
<td>January 2004</td>
<td>September 2008</td>
<td><a href="http://ibis.grdl.noaa.gov/SAT/gfo">http://ibis.grdl.noaa.gov/SAT/gfo</a></td>
</tr>
<tr>
<td>IceSAT</td>
<td>91 days</td>
<td>January 2004</td>
<td>October 2009</td>
<td><a href="http://icesat.gsfc.nasa.gov/icesat/">http://icesat.gsfc.nasa.gov/icesat/</a></td>
</tr>
</tbody>
</table>

- Required atmospheric and multi satellite bias corrections applied

- Compared with In-situ observations.
Changes in the Aral Sea

2004

2009

0 10 Kilometers

Jason 1
Icesat
GFO
Envisat
Changes in the water level of South Aral

East Sub basin receded 3m
Changes in the water level of South Aral

West Sub basin suffered 4m
Dike Kokaral dam increased the water level by nearly 2m.
Changes in the surface area of the Aral Sea
Changes in the surface area

- Variation in the extent of the Aral Sea is largest in the east sub basin.
- Size of the north basin is rather stable.
- Significant increase in size due the 2010 re-flooding
Changes in the surface area

Geometric change w.r.t 2004 size

% Area w.r.t. 2004 spring

Years

Geometric change w.r.t 2004 size

East Sub Basin
North Aral
West Sub Basin
Whole Aral Sea
Changes in the water mass from GRACE
Changes in the water mass from GRACE

- 79 monthly GRACE gravity field solutions
Comprehensive changes (Altimetry with GRACE)

GRACE (blue) with water level variation (red and black)
Comprehensive changes (Geometrical with GRACE)

GRACE (blue) with coastline variation (red)
Conclusion

- Good correspondence of long term signals of desiccation and subsequent refilling in all data sets.

- Clear seasonal signal pattern is also visible.

- Multi-mission approach is good for monitoring the hydrological condition under various aspects.

- For this region, surface water provides the major contribution to the GRACE signal.

- The GRACE signals provides a comprehensive hydrological state of this region.
Outlook

- 3D-approach for volume changes: Intersection of Bathymetry with waterlevel and extent to get water volume.

- Estimation of constant level per lake from different altimetry mission.

- Comparision with the hydrological models.

- Comparision with the regional GRACE model.