Estimating the Caspian Sea level and Volga river runoff from satellite altimetry
The Caspian Sea presents the world’s largest isolated water reservoir, with features including its size, depth, chemical properties, thermohaline structure and water circulation enable to classify it as a deep inland sea. Currently its level is at –27 meters, it occupies an area of 392000 km², with maximum depth of 1025 m. The isolation of the Caspian Sea from the ocean and its inland position are responsible for a great importance of the outer thermohydrodynamic factors, in particular, the heat and water fluxes through the sea surface, and river runoff for the sea level variability, formation of its 3D thermohaline structure and water circulation.
Caspian Sea level variations and water balance from satellite altimetry

Seasonnal and interannual dynamic topography of the Caspian Sea from altimetry and hydrodynamical model

Caspian Sea data base and Cal/Val activities
Over the past half-century, there was a regression of the Caspian Sea until 1977 when the sea level lowered to −29 m. This drop is considered to be the deepest for the last 400 years. In 1978 the water level started to rise rapidly, and now it has stabilized near the −27 m level.

The change in the tendency of the mean sea level variations that occurred in the mid 70s, followed by abrupt rise, represents an important indicator of the changes in the natural regime of the Caspian Sea.
Temporal Variability of Sea Surface and Volga river water height, from satellite altimetry: T/P, Jason, GFO, and Envisat

- Map showing regions labeled as Northern, Middle, and Southern Parts
- Graph showing temporal variability of sea surface height
- Line graph displaying mean monthly water discharge of Volgogradskaya hydro-power station
Water Balance of Caspian Sea

Caspian Sea level above Baltic Sea

Topex/Poseidon, Jason, GFO, Envisat

+ Hypsometry curve

Total Runoff river to Caspian Sea

Runoff to Kara Bogaz Gol

Variation of volume of Caspian Sea

(E-P) deduced from altimetry and in situ data over Caspian Sea (positiv underground water of 4 km$^3$ was taken)
The rate of the Caspian Sea SSH change revealed from the T/P and J1 satellite altimetry data

(October 1992 - December 2005)

Mean SSH difference between: 1995 and 1993; 1997 and 1995, revealed from the GCRAS05 MSS Model

<table>
<thead>
<tr>
<th>Time period</th>
<th>Rate of Change, (cm/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Northern Part</td>
</tr>
<tr>
<td>1993–1995</td>
<td>18.2 ± 3.8</td>
</tr>
<tr>
<td>1995–1997</td>
<td>-18 ± 1.4</td>
</tr>
<tr>
<td>1997–1999</td>
<td>-3.6 ± 1.5</td>
</tr>
<tr>
<td>1999–2001</td>
<td>-8.7 ± 2.7</td>
</tr>
<tr>
<td>2001–2003</td>
<td>8.9 ± 4.6</td>
</tr>
</tbody>
</table>
Dynamic topography maps were used to analyze the spatial and temporal variability of the general dynamics in the Caspian Sea. They were constructed on the basis of the superposition of the sea level anomalies distribution over the climatic dynamic topography. The sea level anomalies were calculated from altimetry data.

The climatic dynamic topography (or hydrodynamic level) was calculated from three dimensional baroclinic model with free surface. Average monthly fields of temperature and salinity, climatic Volga River run-off and irregular evaporation from sea surface were taken in consideration. Also atmospheric pressure and wind fields from the regional model over the period from 1948 to 2005 were used. This model was developed in Laboratory of Sea Applied Research of Hydrometeorological Research Center of Russian Federation.
Geographical distribution of annual CSL variation deduced from 10 years (1993-2002) of Topex / Poseidon data and average seasonal variations.

Average annual variation of CSL

Annual Amplitude (m)
CASPIAN SEA DATA BASE

Altimetry Sea level
Gauges Sea level

Volga Runoff
Ural Runoff
Precipitation

Peshvoi
Kubaly
Fort Shevchenko
Shevchenko Gorda
Bektaš
Runoff to KRG
karabogargol
Kuul Mayak
Krasnovodsk
Aladja
Cheleben Estakada
Ogurchinsk

kaspiki
Tulnii
Terek Runoff
Makhachkala
Sunzai
Bairu
Jiby
Neftyanie Kamny
Sviney
Kura Runoff
Lehkonan
Sefidrud Runoff
Comparison of Satellite Data and Level Gauges Data

Correlation coefficients and RMS between average monthly data of sea level gauge measurements and SSH derived from satellite altimetry data. Red markers show correlation between data in the Middle Caspian Sea and blue markers – in the Southern Caspian Sea.

<table>
<thead>
<tr>
<th>Level gauges</th>
<th>Crossover Points</th>
<th>Whole Sea (altimetry)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Northern Part</td>
<td>Middle Part</td>
</tr>
<tr>
<td>(1) Makhachkala</td>
<td>0.876-0.859</td>
<td>0.923-0.931</td>
</tr>
<tr>
<td>(2) Fort Shevchenko</td>
<td>0.899-0.739</td>
<td>0.862-0.853</td>
</tr>
<tr>
<td>(3) Zhiloy Island</td>
<td>0.876-0.863</td>
<td>0.948-0.942</td>
</tr>
<tr>
<td>(4) Kara-Bogaz-Gol</td>
<td>0.876-0.876</td>
<td>0.943-0.942</td>
</tr>
<tr>
<td>(5) Turkmenbashii</td>
<td>0.841-0.889</td>
<td>0.951-0.960</td>
</tr>
<tr>
<td>(6) Baku</td>
<td>0.859-0.874</td>
<td>0.952-0.953</td>
</tr>
<tr>
<td>(7) Neftyanoye Kamni</td>
<td>0.861-0.850</td>
<td>0.918-0.933</td>
</tr>
<tr>
<td>(8) Knuti Mayak</td>
<td>0.880-0.831</td>
<td>0.925-0.932</td>
</tr>
<tr>
<td>Whole Sea (level gauges)</td>
<td>0.909-0.876</td>
<td>0.963-0.964</td>
</tr>
</tbody>
</table>

Correlation coefficients between average monthly data of sea level gauge measurements and sea level derived from satellite altimetry data since October 1992 till December 2005.
CASPIALT & ALTICORE Project

Installation of few new gauges along the Caspian Sea shorelines

Temporal and permanent GPS levelling

Mean altimetry profile calibrated by GPS campaign

Integrated Caspian Sea database

Sponsored by INTAS, UNESCO, GLOSS, Azerbaidjan and russian Academy of Sciences
Visit of a potential new Bottom Pressure Tide Gauge site
First results of Caspian Sea 2005 GPS Campaign
Perspectives

Improvement and interpretation of CS water balance

Study impact of:
changes in river runoff
global warming
Irrigation in the Volga basin

Assimilation of altimetry
In models for study of Dynamic topography of the CS

Geographically call changes in temperature, precipitations and level
Increasing the spatial distribution (Envisat, Altika)

Creation and maintenance of in situ and remote sensing Data base

Caspialt project
Cal/val of current and future altimetry
Enhance the international cooperation in the area of CS