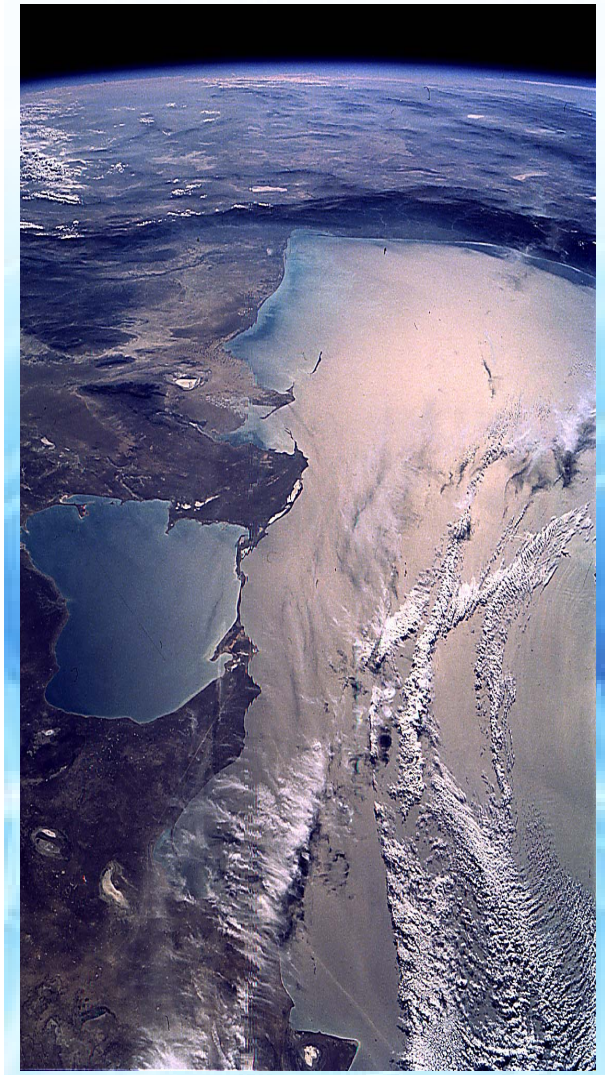


Andrey G. Kostianoy
P.P. Shirshov Institute of Oceanology,
Russian Academy of Sciences

Sergey A. Lebedev
Geophysical Center, Russian Academy of Sciences
State Oceanographic Institute

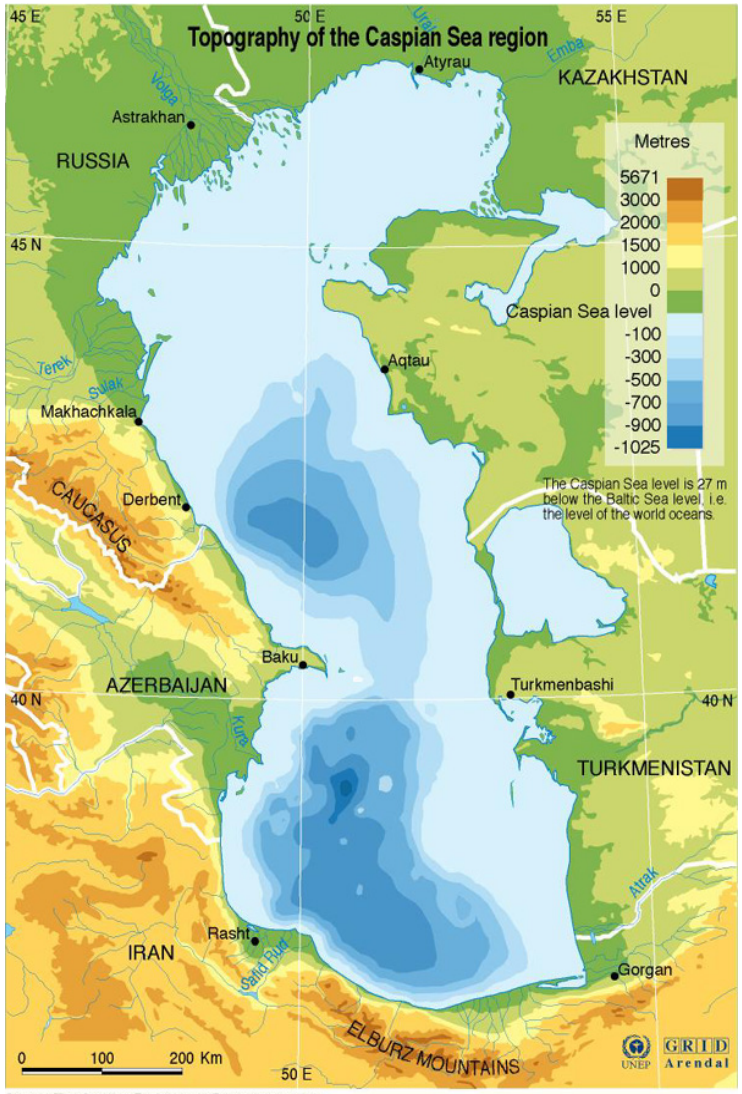
Jean-François Crétaux & Stephane Calmant
Legos, Toulouse, France

Stephano Vignudelli
CNR, Pisa, Italy

Estimating the Caspian Sea level and Volga river runoff from satellite altimetry

Second Space for Hydrology Workshop, Nov 12-14, 2007, Geneva

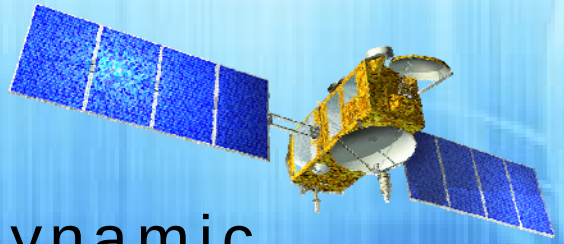
The Caspian Sea



Source: The Caspian Environment Programme, 2002.

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 km^2, 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

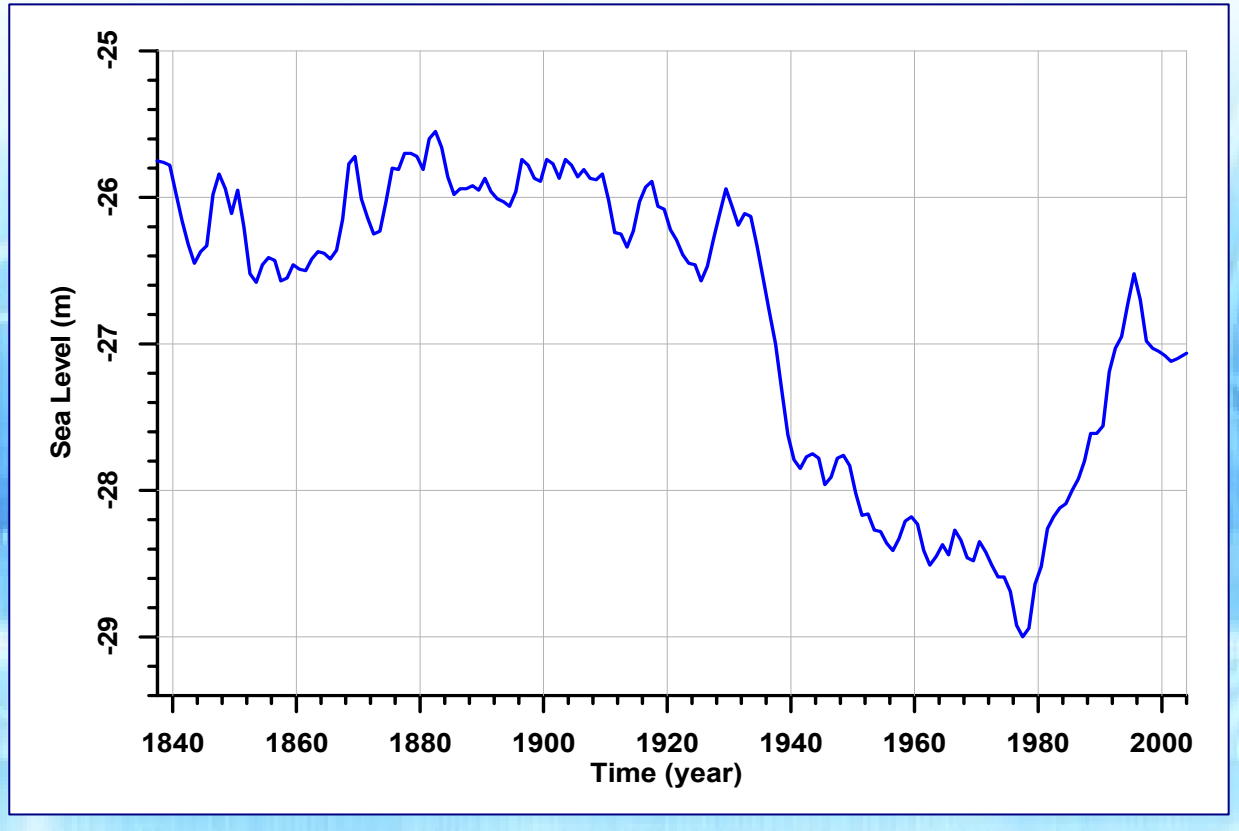


Seasonnal and interannuel dynamic
topography of the Caspian Sea from altimetry
and hydrodynamical model

Caspian Sea data base and Cal/Val activities

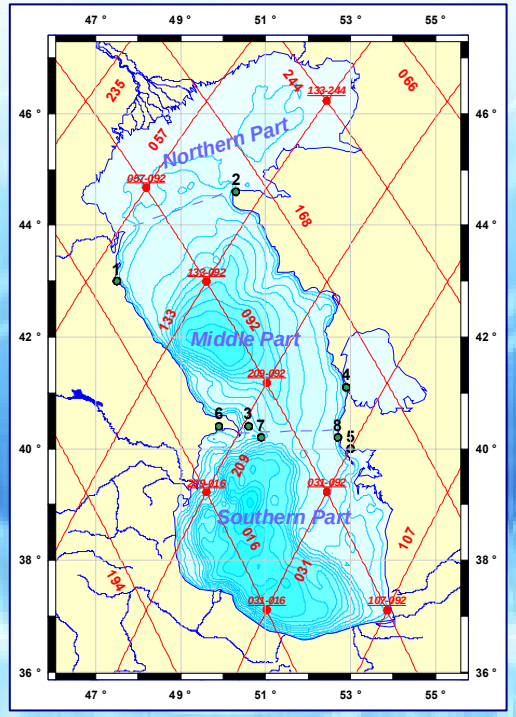
The Caspian Sea Level Variation

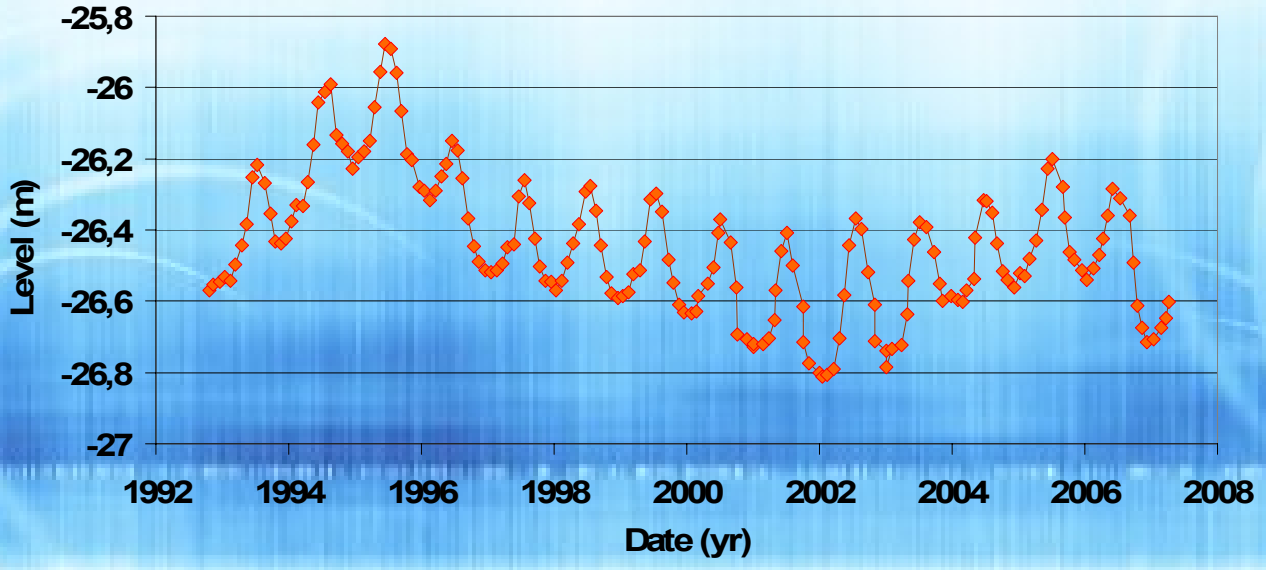
Over the past half-century, there was a regression of the Caspian Sea until 1977 when the sea level lowered to −29 m. This drop is considered to be the deepest for the last 400 years. In 1978 the water level started to rise rapidly, and now it has stabilized near the −27 m level.

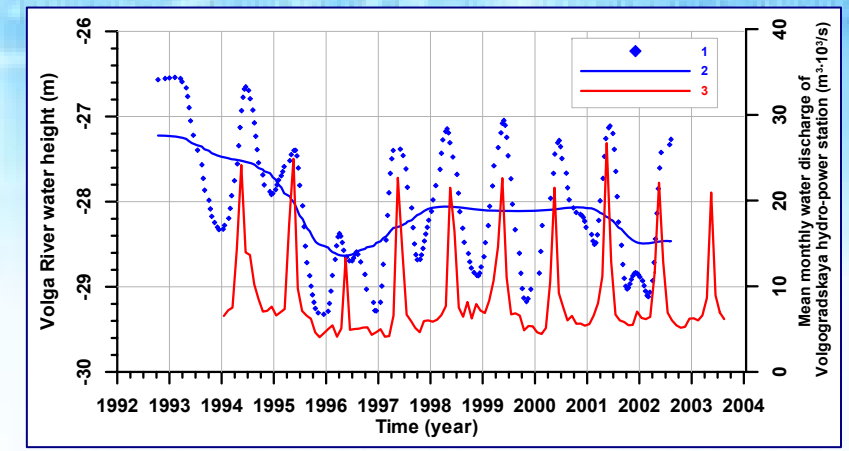


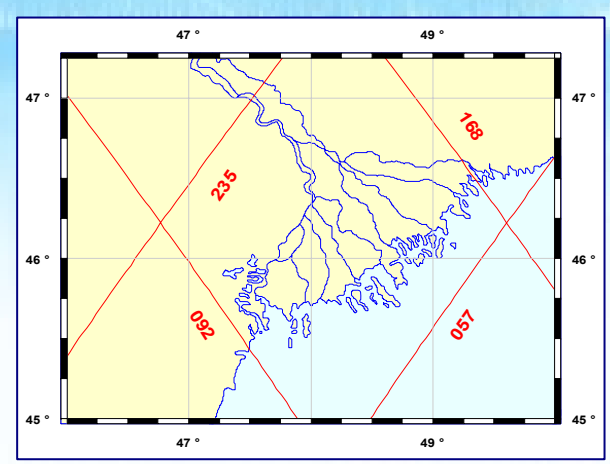
The change in the tendancy of the mean sea level variations that occured In the mid 70s, followed by abrupt rise, represents an important indicator of The changes in the natural regime of the Caspian Sea

Temporal Variability of Sea Surface and Volga river water height, from satellite altimetry: T/P, Jason, GFO, and Envisat

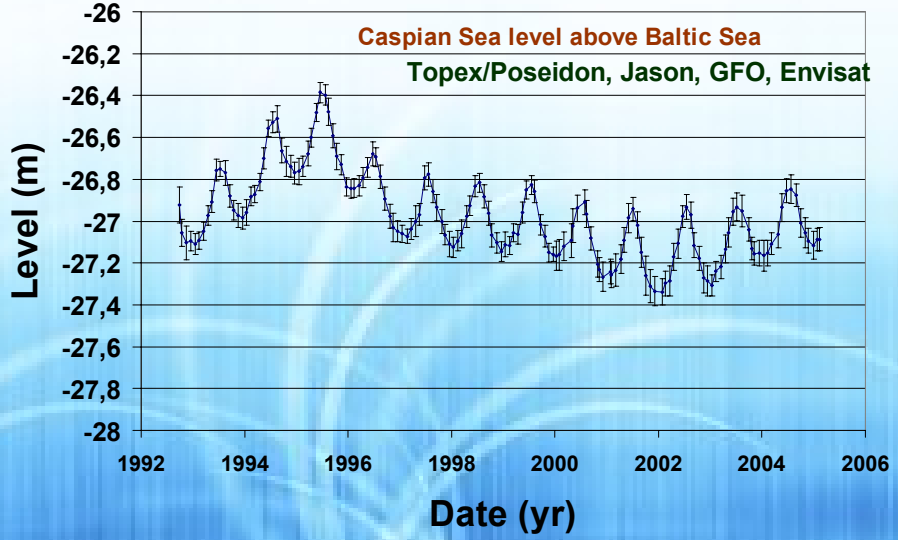




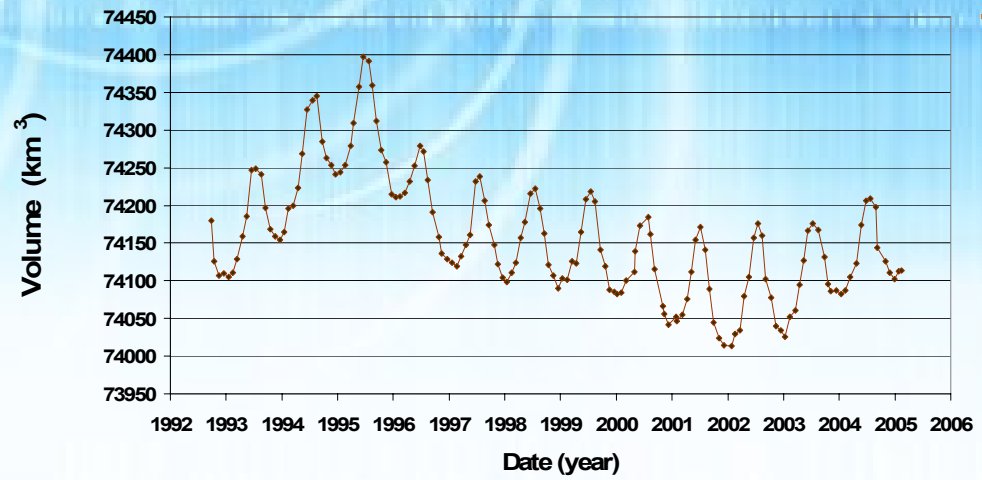


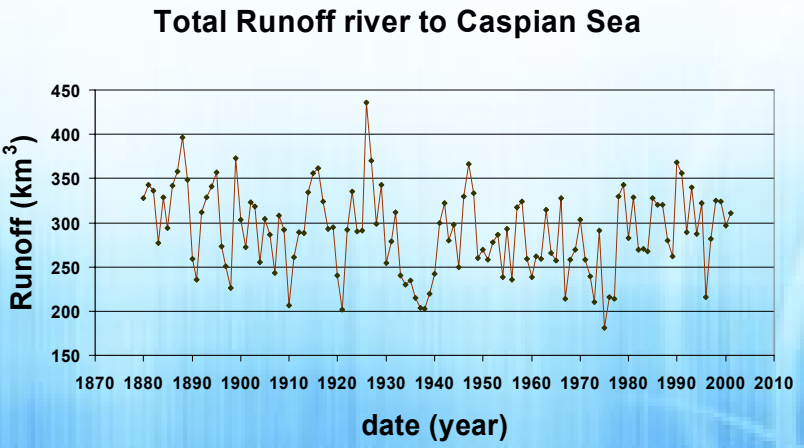


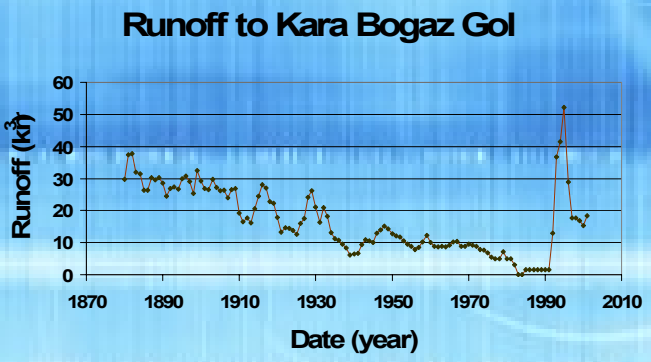
Water Balance of Caspian Sea

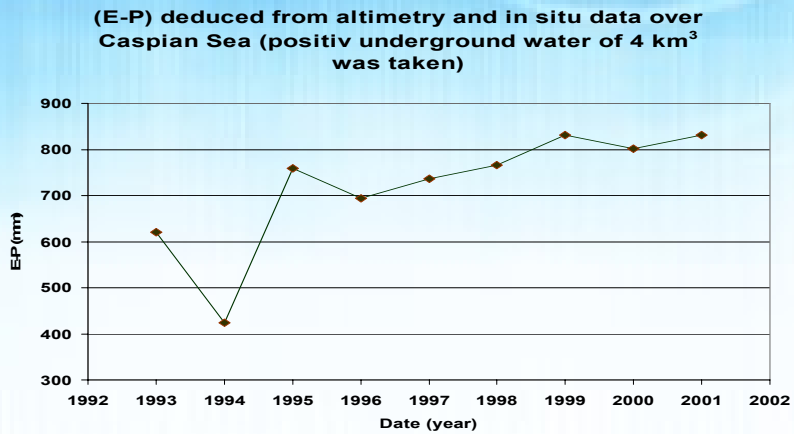


+ Hypsometry curve

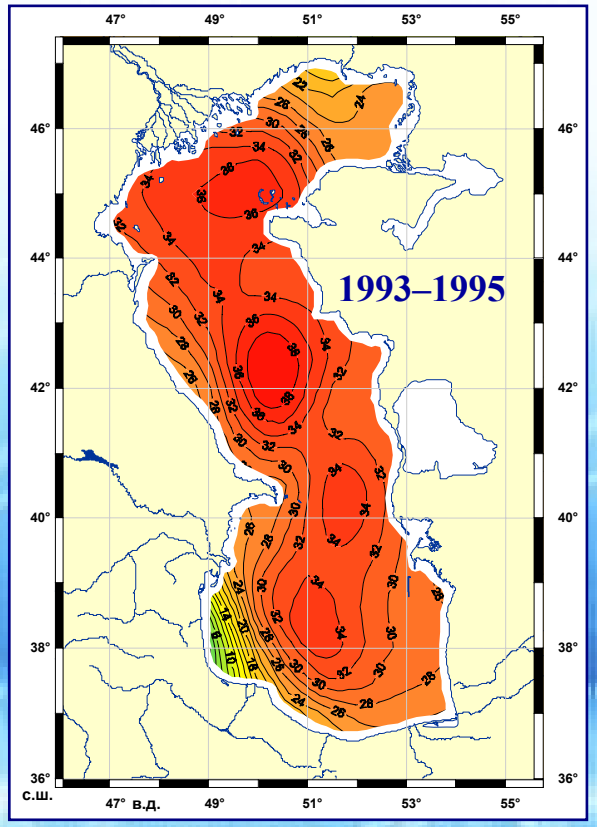


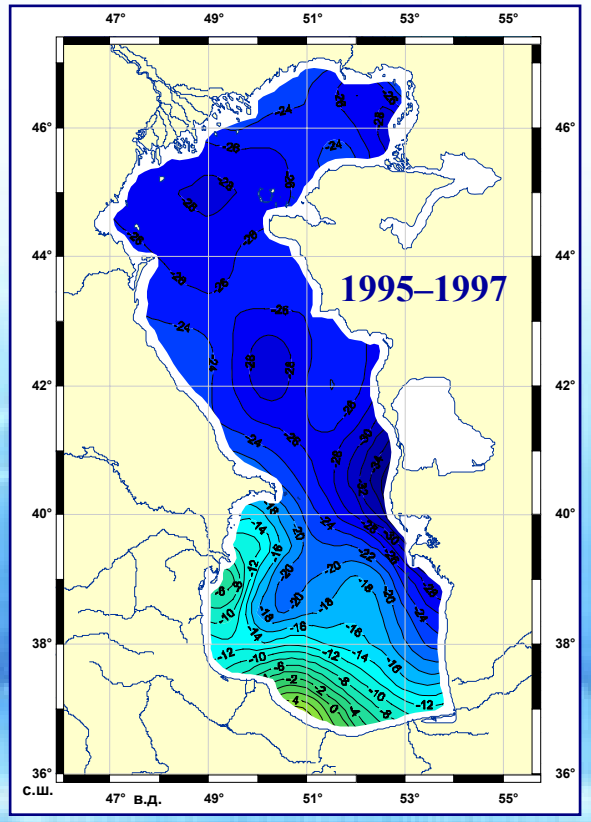






The Caspian Sea Level Rate





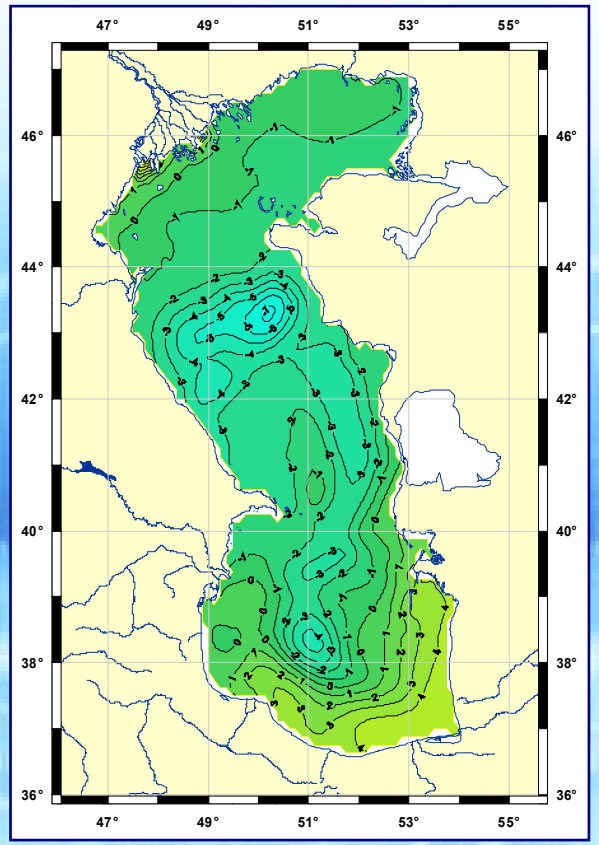
Mean SSH difference between: 1995 and 1993; 1997 and 1995, revealed from the GCRAS05 MSS Model

The rate of the Caspian Sea SSH change revealed from the T/P and J1 satellite altimetry data

(October 1992 - December 2005

Time period	Rate of Change, *(cm/yr)*			
	Northern Part	Middle Part	Southern Part	Whole Sea
1993 –1995	18.2 ± 3.8	22.8 ± 2.5	20.9 ± 4.9	21.1 ± 4.1
1995 –1997	-18 ± 1.4	-13.9 ± 1.8	-18 ± 5.6	-24 ± 5.0
1997 –1999	-3.6 ± 1.5	-6.2 ± 1.7	-5.4 ± 4.3	-5.3 ± 3.2
1999 –2001	-8.7 ± 2.7	-8.4 ± 1.7	-12 ± 2.4	-9.3 ± 2.9
2001 –2003	8.9 ± 4.6	7.0 ± 5.3	10.6 ± 6.3	9.1 ± 4.4

Analysis of Spatial and Temporal Variability of Dynamic Topography



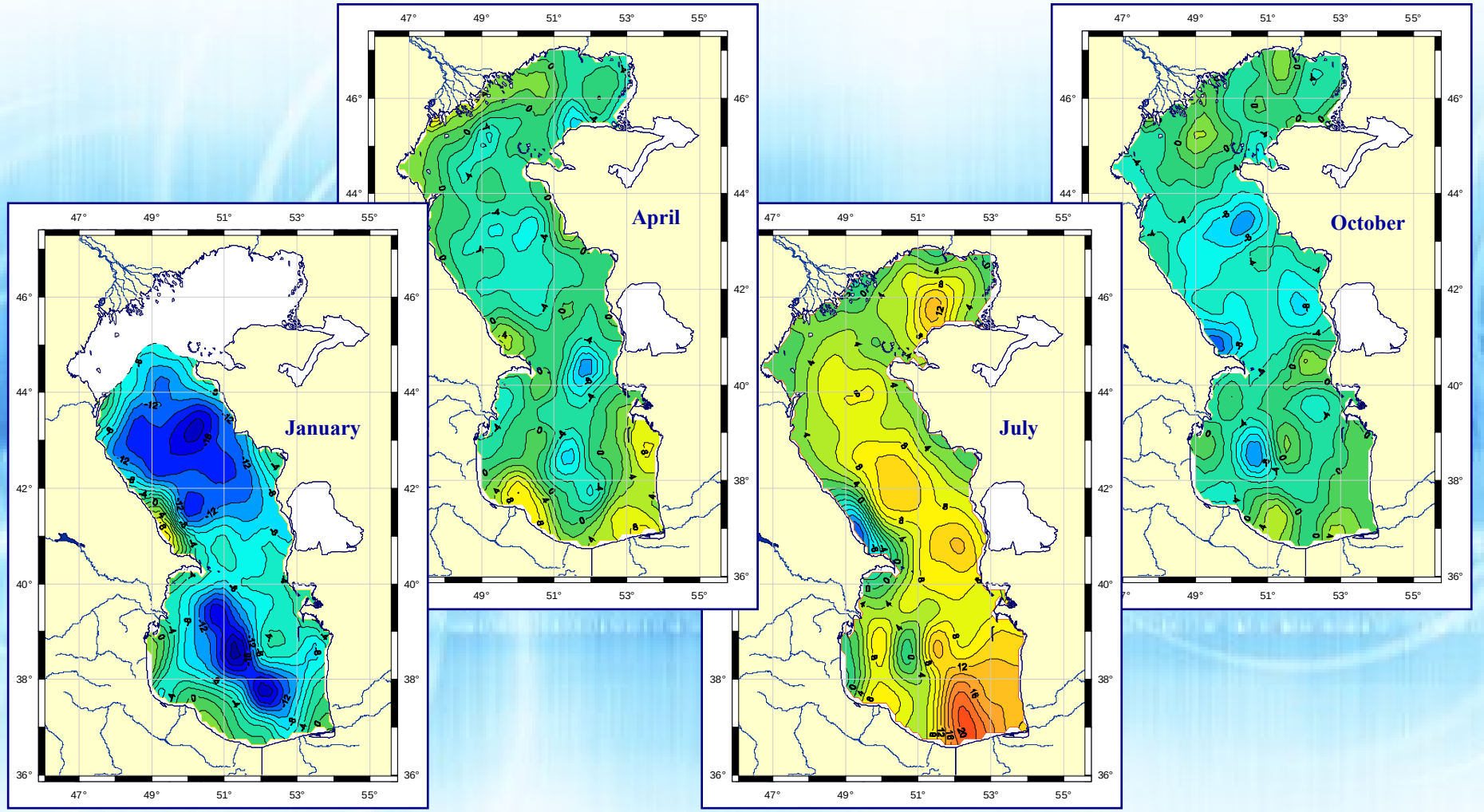
Averaged dynamic topography (cm) from numerical hydrodynamic model (Popov, 2004)

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.

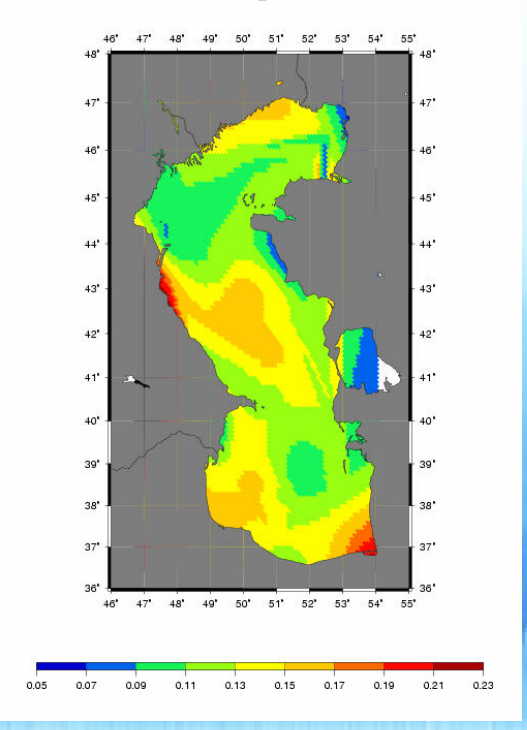
The climatic dynamic topography (or hydrodynamic level) was calculated from three dimensional baroclinic model with free surface. Average monthly fields of temperature and salinity, climatic Volga River run-off and irregular evaporation from sea surface were taken in consideration. Also atmospheric pressure 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.

Dynamic Topography Seasonal Variability

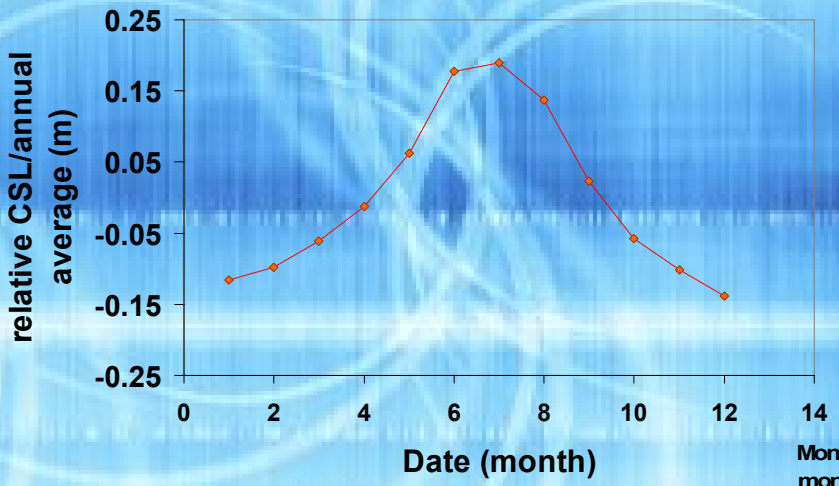


Geographycal distribution of annual CSL variation deduced from 10 years (1993-2002) Of Topex / Poseidon data and average seasonal variations

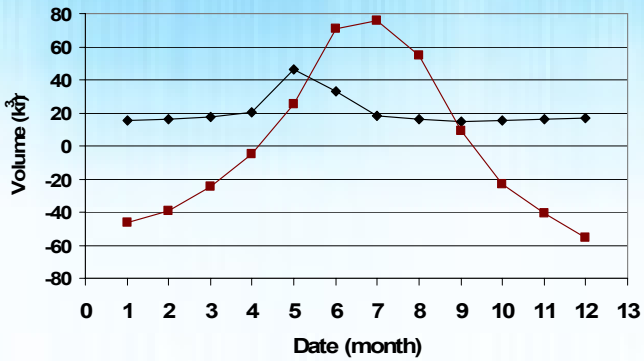
Annual Amplitude (m)

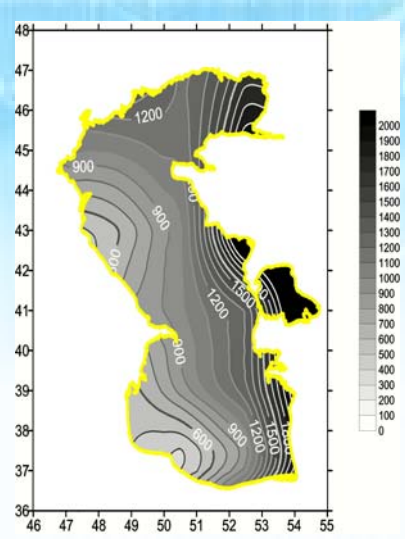


Average annual variation of CSL

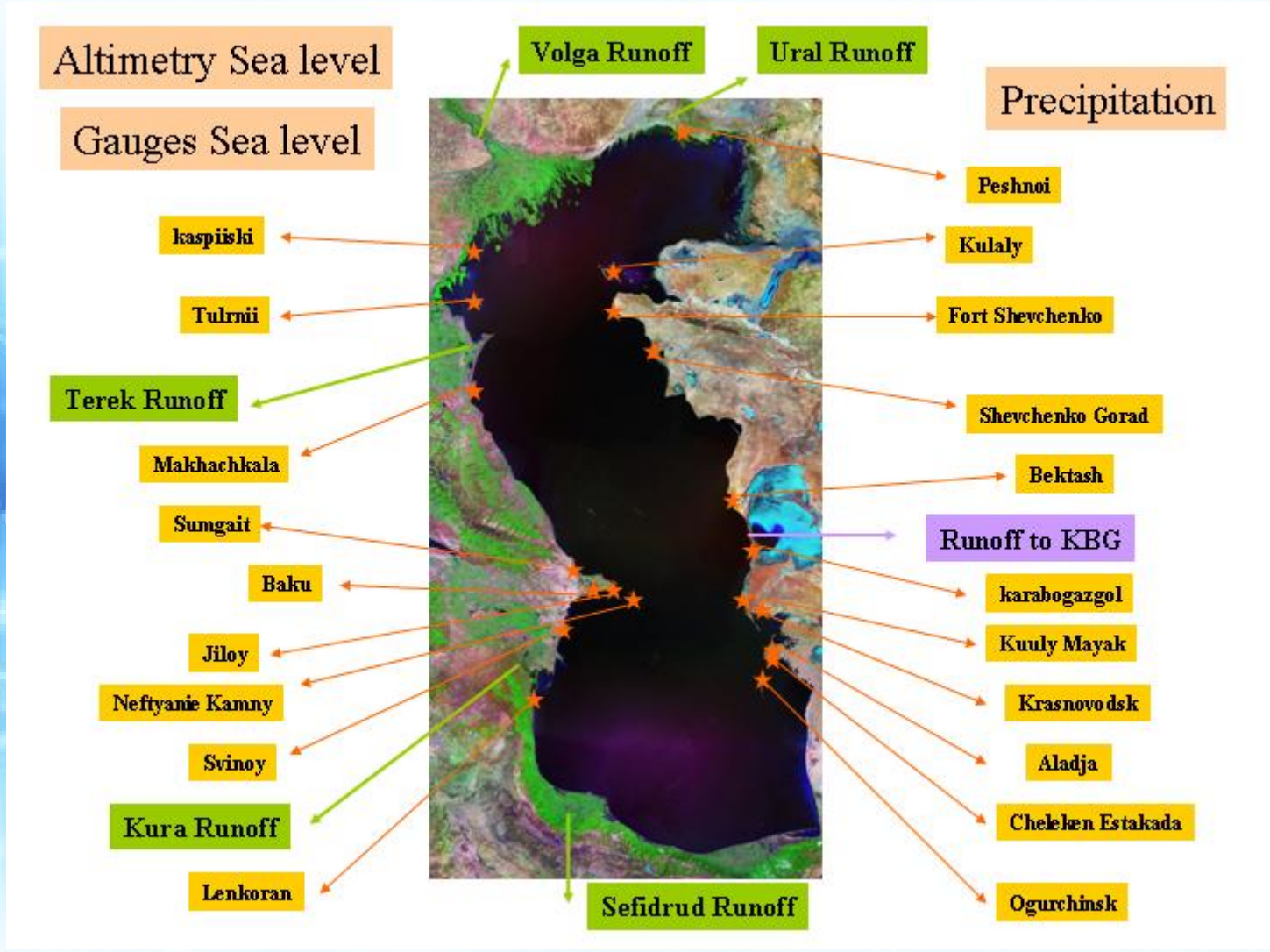


Monthly CS volume / annual average (Red) and monthly average Volga river Discharge (Black)

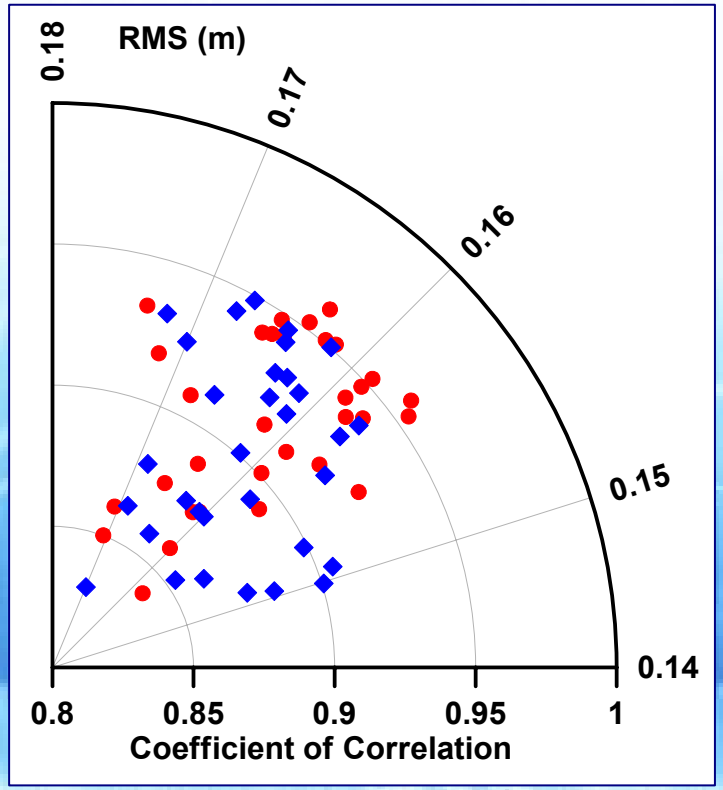




CASPIAN SEA DATA BASE



Comparison of Satellite Data and Level Gauges Data

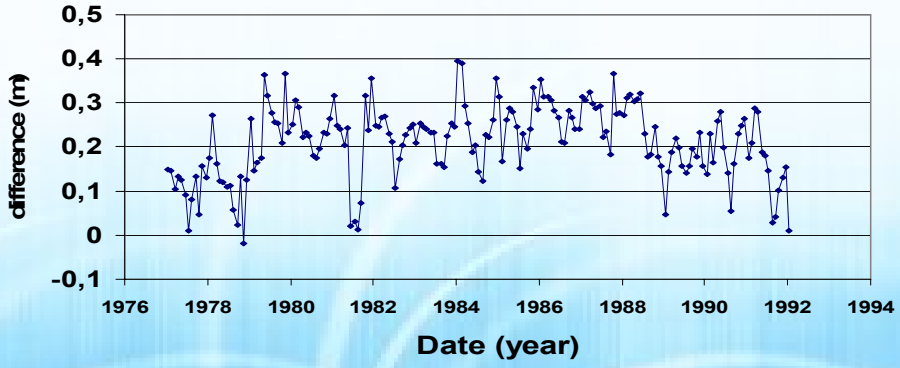


Correlation coefficients between average monthly data of sea level gauge measurements and sea level derived from satellite altimetry data since October 1992 till December 2005

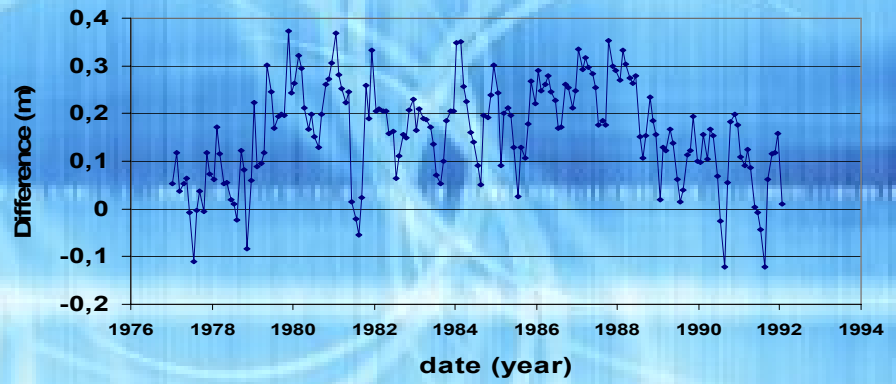
Correlation coefficients and RMS between average monthly data of sea level gauge measurements and SSH derived from satellite altimetry data. Red markers show correlation between data in the Middle Caspian Sea and blue markers – in the Southern Caspian Sea

Level gauges		Crossover Points							Whole Sea *(altimetry)*
		Northern Part		Middle Part		Southern Part			
		057-092	133-244	133-092	209-092	209-016	031-092	031-016	
Middle Part	(1) Makhachkala	0,876	0,859	0,923	0,931	0,918	0,931	0,892	0,938
	(2) Fort Shevchenko	0,899	0,739	0,862	0,853	0,901	0,883	0,874	0,906
	(3) Zhiloy Island	0,876	0,863	0,948	0,942	0,932	0,931	0,901	0,950
	(4) Kara-Bogaz-Gol	0,876	0,876	0,943	0,942	0,941	0,948	0,901	0,953
Southern Part	(5) Turkmenbashi	0,841	0,889	0,951	0,960	0,913	0,919	0,892	0,941
	(6) Baku	0,859	0,874	0,952	0,953	0,925	0,954	0,937	0,958
	(7) Neftyanyye Kamni	0,861	0,850	0,918	0,933	0,914	0,948	0,908	0,940
	(8) Kuuli Mayak	0,880	0,831	0,925	0,932	0,922	0,942	0,912	0,946
Whole Sea *(level gauges)*		0,909	0,876	0,963	0,964	0,956	0,966	0,936	0,978

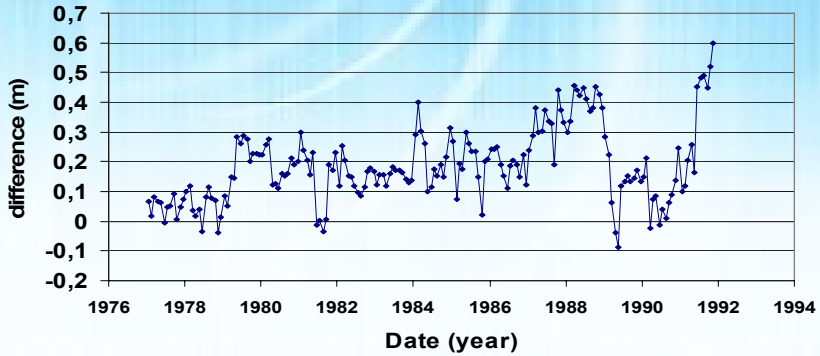
Makhashkala - Krasnovodsk



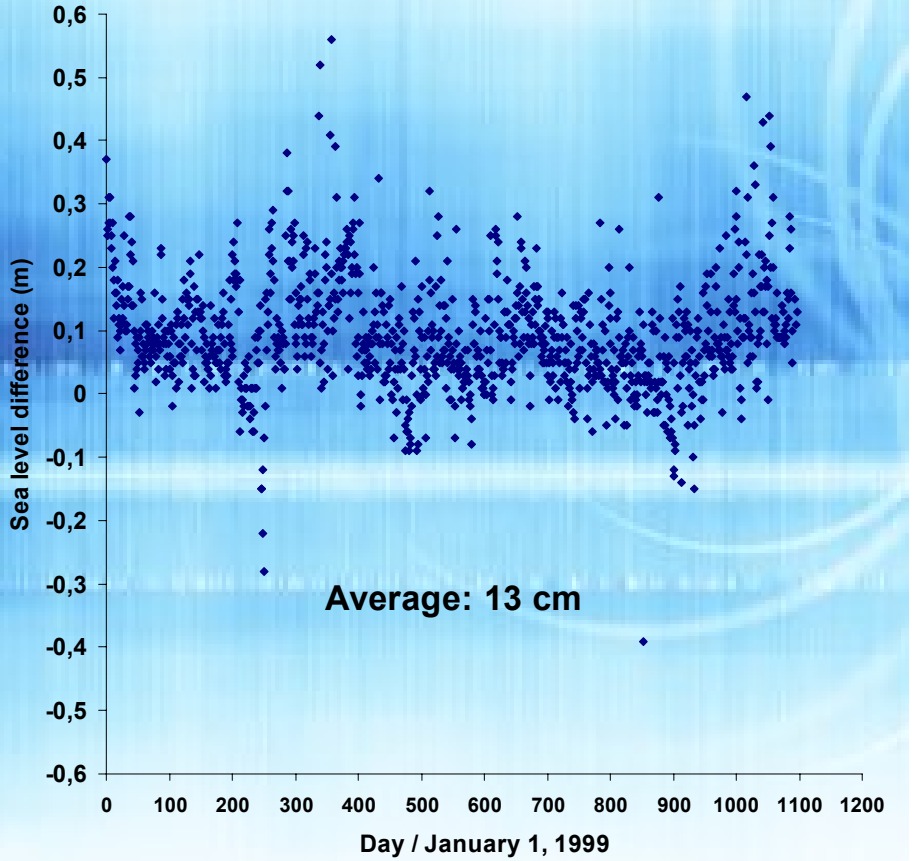
Makhashkala - Ogurshink



Makhashkala-Kulaly



Jilov - Baku

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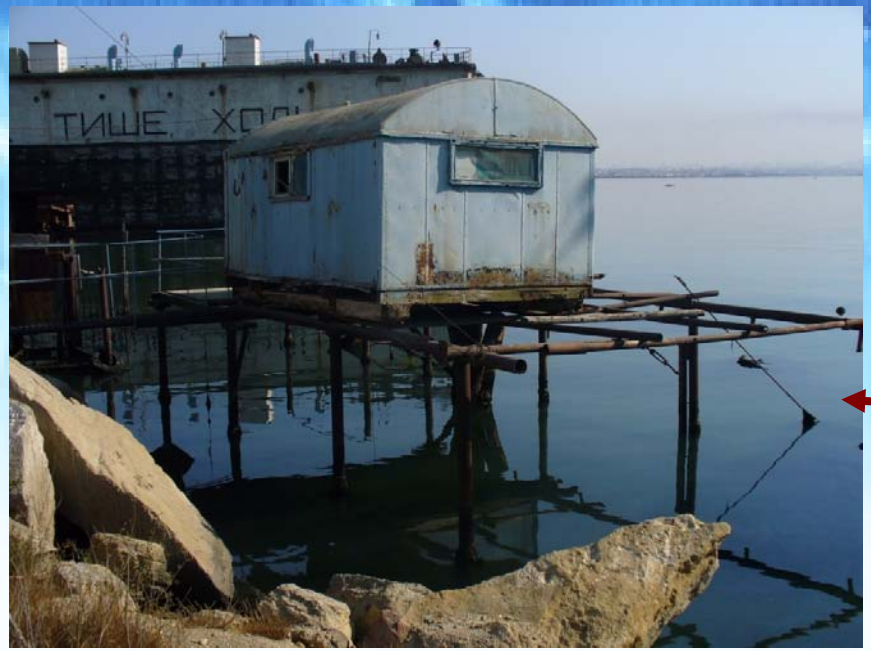
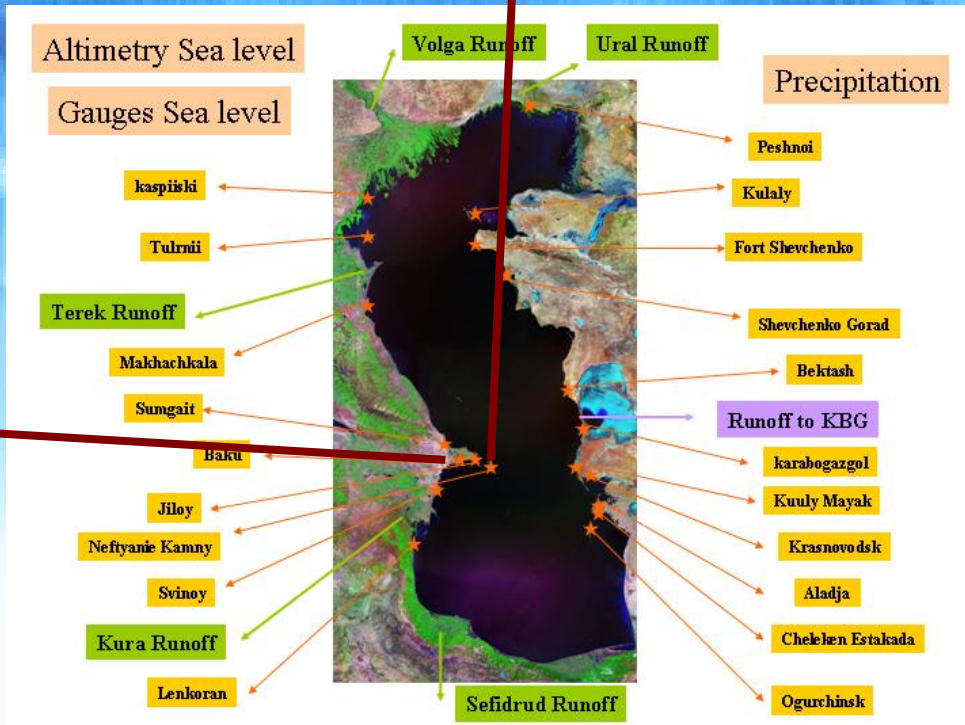



Altimetry Sea level
Gauges Sea level
Volga Runoff
Ural Runoff
Precipitation
kaspiiski
Tulrnii
Terek Runoff
Makhachkala
Sumgait
Baku
Jiloy
Neftyanie Kamny
Svinoy
Kura Runoff
Lenkoran
Sefidrud Runoff
Peshnoi
Kulaly
Fort Shevchenko
Shevchenko Gorad
Bektash
Runoff to KBG
karabogazgol
Kuuly Mayak
Krasnovodsk
Aladja
Chelekæn Estakada
Ogurchinsk

CASPIALT & ALTICORE Project

Installation of few new gauges
along the Caspian Sea shorelines

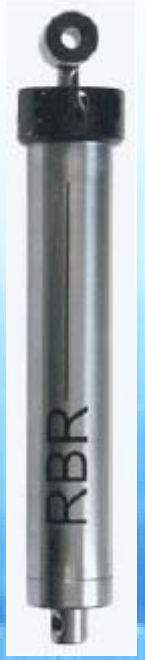
Temporal and permanent GPS levelling

Mean altimetry profile calibrated
by GPS campaign

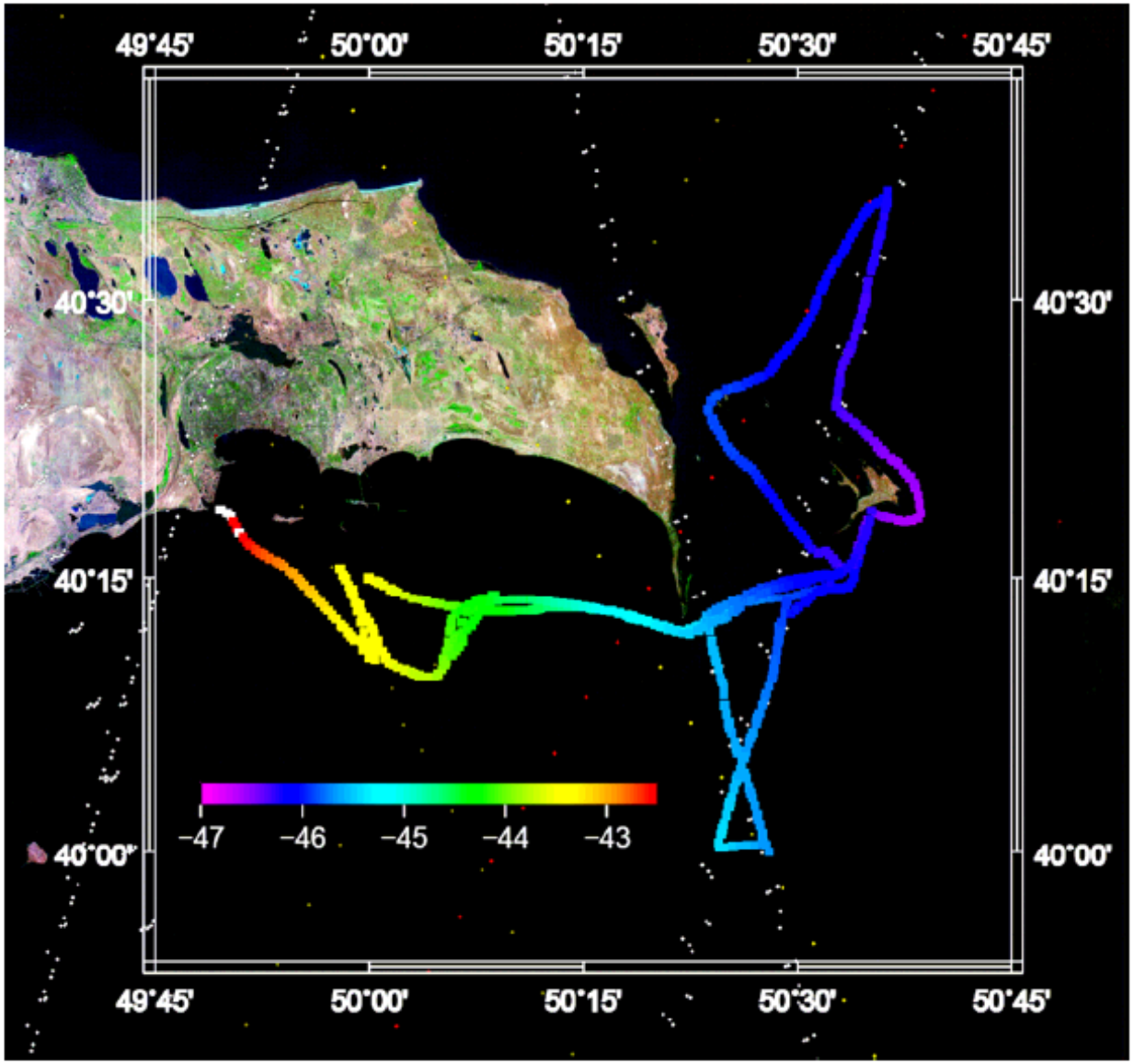
Integrated Caspian Sea database

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

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

Creation and maintaince 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