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Complex Satellite Monitoring of the Aral Sea Region

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The Aral and Caspian Seas and Lakes of Central Asia



Aral Sea

- Lake Sarykamysh
- Caspian Sea
- Kara Bogaz Gol Bay
- Lake Balkhash
- Lake Issyk-Kul
- Chardarinskoye Res.



Motivation

Desiccation of the Aral Sea in the so-called anthropogenic period (since 1961) led not only to considerable changes in its morphometric, physical, chemical, biological and other parameters, but to disappearence of the infrastructure in the coastal zone as well, including meteo and sea level gauge stations. The current lack of reliable in situ measurements and time series for sea surface temperature (SST), sea level and ice cover parameters since the mid-1980-s may be successfully replaced by using corresponding satellite information available through the World data bases.





















Methods

Multi-Channel Sea Surface Temperature (MCSST) data (since November 1981) and data of the Pathfinder project (a joint NOAA/NASA project devoted to the production of a high quality global SST dataset from 1985 to the present) can be the base of tracing of long-term variability of SST in different parts of the Aral Sea. These data bases with high spatio-temporal resolution (1 km, daily) and temperature resolution (0.1°C) are based on measurements of Advanced Very High Resolution Radiometer (AVHRR) onboard satellites of National Oceanic and Atmospheric Administration (NOAA).



Methods

Radar altimeters from the TOPEX/Poseidon (T/P) and Jason-1 (J1) satellites provide reliable, regular, frequent, and weather-independent data for monitoring of sea level in the Large and Small Aral seas since 1992. Altimeter data and data of the Special Sensor Microwave/Imager (SSM/I) radiometer enable us to study interannual variability of ice regime of the Aral Sea.

Images from AVHRR NOAA and MODIS (onboard Terra and Aqua satellites) radiometers provide a possibility to follow the changes in the sea coastline and observe interesting phenomena in water, atmosphere and on the dried parts of the Aral Sea.

The report discusses dynamics of various parameters of the Aral Sea during its desiccation which was traced with different type of satellite information. The consideration includes changes in morphometric characteristics (shoreline, sea area and volume), sea level, SST, and ice regime. Besides, we look at phenomena associated with changes in the Aral Sea coastline and salinity, water and atmosphere dynamics, dust storms, etc.



Morphometry





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The change of the Aral Sea coastline configuration since 1957 till 2008

Mapping of changes in the Aral Sea shoreline with satellite images was initiated by Kazakh Aero-Geodesy Department (space photos from the Resurs-F satellites for 1977, 1984, and 1989, spatial resolution R~30 m).

Department of Cartography and Geoinformatics of Faculty of Geography of Lomonosov Moscow State University (MSU-SK/ Resurs-O images, R=170 m, scan swath of 600 km for 1989-1998; images obtained with digital photocamera from Russian module of International Space Station in 1999, R=50 m).

Since 2000/2002, regular images are available from the Terra/Aqua satellites, which perform daily global survey by MODIS images in visible and near infra-red bands (R=250 m).





Year	Aral Sea as a whole	Large Sea					Small
		As a whole	Western part	Eastern part			Sea
				As a whole	Basic basin	Detached reservoirs	
1957	67,100	61,200					5,900
1961	66,400	60,500					5,900
1977	54,900	50,600					4,300
1984	47,400	43,700					3,700
1989	41,500	38,400	9,400	29,000			3,100
1991	36,600	33,800	8,200	25,600			2,800
1993	36,000	33,000	7,900	25,100			3,000
1996	31,300	28,600	7,100	21,500			2,700
1997	31,200	28,100	7,000	21,100			3,100
1998	29,700	26,500	6,700	19,800			3,000
1999	29,300	26,300	6,500	19,800			3,000
2000	26,700	23,900	6,200	17,700			2,800
2001	22,100	19,400	5,500	13,900			2,700
2002	19,900	17,000	5,200	11,800			2,900
2003	19,700	16,800	5,000	11,800			2,900
2004	17,900	15,100	4,800	10,300	9,500	800	2,800
2005	16,900	14,100	4,800	9,300	8,700	600	2,800
2006	15,700	12,400	4,600	7,800	6,800	1,000	3,300
2007	12,200	8,900	4,200	4,700	4,400	300	3,300
2008	10,400	7,200	4,000	3,200	2,900	300	3,200

Table 1 Changes of the area of the Aral Sea and its parts (km²) in 1957-2008

Setting of numbers in bold reproduces the real separation of the Aral Sea into the Large and Small seas in 1989



The Aral Sea on 18 August 2008 and 16 August 2009





Image courtesy by D.M. Solovyov, Marine Hydrophysical Institute, Ukraine

The Aral Sea on 2 April 2010 (left). The shallow Large Eastern Aral Sea is flooded by water after winter snow and spring rains. By 18 April 2010 (right) this sea area became almost dry. It will completely desiccate by August 2010.





Image courtesy by D.M. Solovyov, Marine Hydrophysical Institute, Ukraine

During Liege Colloquium the Aral Sea continues to desiccate

MODIS-Terra, 250 m resolution 27 April 2010

Image courtesy by Sergey Stanichny, Marine Hydrophysical Institute, Ukraine









Time variation of the Large Aral Sea level (1992-2009) by TOPEX/Poseidon and Jason-1 satellite altimetry data









Time variation of the Small Aral Sea level (1992-2009) by TOPEX/Poseidon and Jason-1 satellite altimetry data

 \mathbb{Z}^{2}



Early 1992 - first dam. August 1992 - second dam. Since then there have been several breaks in the dam. In 1996 the local authorities began to strengthen the dam and in 1998 the International Foundation for Saving the Aral Sea started financing the construction of the Kokaral Dam. In April 22, 1999 the big strong storm raced through all territory of Kazakhstan. Unfortunately, this weather once more damaged the Kokaral dam in the Aral Sea. By September 1999 the sea level decreased by 2.5 m. In August 2005 a solid dam was constructed.



Shift of SST Seasonal Variability

Seasonal cycles of SST in the Large Sea averaged over the period 1982-2000: (a) in the western part, (b) in the eastern part. Thick (thin) solid lines correspond to averaging over 1994-2000 (1982-1993); dashed lines correspond to seasonal cycles of SST in the conventionally natural period. (\mathbf{a}) **(b)** C, C Ο F. Days Days



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Ice Cover in the Aral Sea

on 23 January and 9 March 2008





Image courtesy by D.M. Solovyov, Marine Hydrophysical Institute, Ukraine



Interannual variations of the discharge of Amu Darya (left) and Syr Darya (right) Rivers derived from precipitation integrated over its catchment area.

(a) Satellite-measured (GPCP) precipitation (km³/month); (b) gauge-measured (GPCC) precipitation (km³/month); (c) satellite-measured (T/P) level of the Large Sea (m);
Dashed line is moving average of about 1 year (13-point) period





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Atmospheric phenomena

Left: unusual wave clouds over the Aral Sea, which conform exactly to the shape of the western shore (12 March 2009).

Right: Intense atmosphere cyclone generates dust/salt storm from the Aral Sea (7 May 2007).





Dust/salt storm from the Aral Sea to the Caspian Sea MODIS/Aqua image for 29 April 2008, courtesy of NASA





What else?

- The Aral Sea surface, volume and sea level
- **Interannual variability of SST**
- **Freezing point**
- **Salinity**
- Wind surge events: flooding and dewatering
- **Upwelling and eddies**
- Amudarya runoff
- Seasonal and interannual variability of NDVI
- Seasonal and interannual changes in landscapes
- Mapping of natural complexes (marsches, solonchaks, salt crusts, sands, desert, reed vegetation, etc)
- **Desertification and salinization of soils**



Igor S. Zonn - Michael H. Glantz - Andrey G. Kostianoy - Aleksey N. Kosarev The Aral Sea Encyclopedia

The situation in and around the Aral Sea is known to be one of the worst man-made environmental crises of the twentieth century. Many are familiar with the satellite photos of the sea as it was a few decades ago and as it is today. In 1960 the Aral Sea was the fourth-largest inland withdrawal of riverine water for irrigation purposes. This publication is devoted to the unique natural feature that the Aral Sea is practically disap

pearing from Earth in the time span of a single generation. It describes the sea before it started drying-out, the actions and efforts of the Central Asian countries and the internationa unity to mitigate the socioeconomic and environmental hazard caused by this process. The encyclopedia presents environmental issues, national and international programs storical figures, history of the sea research and studies, and includes a chronology nts during the past five centuries which became the milestones in the history of the Aral Sea development and is subsequent disappearance.



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Time series of altimetric lake level variations from the USDA Reservoir Database at

http://www.pecad.fas.usda.gov/cropexplorer/global_reservoir

La base de données hydrologiques du LEGOS http://www.legos.obs-mip.fr/soa/hydrologie/hydroweb/

NASA's Earth Observatory

