CLIMSEAS

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Climate Change and Inland Seas: Phenomena, Feedbacks, and Uncertainties. The Physical Science Basis.

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Partners

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The overall aim of this programme was to create a network of international scientists working on climate change in the regions of the Aral, Black and Caspian Seas in Central Eurasia –the CLIMSEAS project area- which is viewed as one of the most active regions for climate change according to the projection of surface temperatures for all 4IPCC scenarios. The 5IPCC report has confirmed the warming trends and higher extremes and precipitation trends also depict considerable variability.

Project objectives

The main objective was to provide a sound quantitative assessment of climatic change on inland seas and their regions, as confined water bodies are particularly vulnerable to climatic and anthropogenic impacts. Given the lack of data for some regions of the CLIMSEAS area, we wanted to provide new data and analyse historical data bases to better illustrate the evolution of the seas and the atmospheric dynamics in the region. We wanted also to focus on feedback processes between the physical state of the inland seas and atmospheric forcing on a regional scale. Finally, we wanted to strengthen the objectives of nationally funded research projects on lakes and coastal regions. The methodological approaches we have used covered field experimental work, data analysis and numerical modelling. The expertise and knowledge of the partners involved in this proposal ranges from large-scale to small-scale dynamics of natural water bodies and atmosphere and includes a paleoclimate perspective.

Results

Atmospheric circulation in the area, frequency changes and total duration of large-scale synoptic processes in the Central Asia region play very important roles in adequately assessing the influence of natural and anthropogenic factors on climate change in the CLIMSEAS study region. For the Aral Sea zone, our work points to a more frequent transportation of warm tropospheric air from Iran and Afghanistan. Moreover, the possible northward shift of southern cyclones in the Aral Sea region over recent decades is reflected in pressure and temperature field configuration. The desiccation process of the Aral appears to also exercise local influence on the diurnal component of the surface wind and the diurnal thermal range which, although it shows a consistent negative or small positive trend around the north-east and western region of the Black Sea and in the north- eastern region of the Caspian Sea, actually has a positive trend greater than 1º/decade along the shores of the shrinking Aral.

Weaker and less persistent blocking anticyclones (BA) in the Atlantic European sector have been identified; meaning that the zonal flow has started to play a more dominant role. With a decreasing frequency of stationary anticyclones, a corresponding decrease in cyclonic activity on their periphery is observed. This may reduce the precipitation over the catchment area of the Caspian Sea. Further, the ridge of predominating BA types in the CLIMSEAS study region in the 1960-70s was located east of the Volga river basin but since the mid-1980s the ridge has been located on the Volga river basin. The change of the emblematic localization of blocking anticyclones may also impact the water balance of the Caspian Sea.

For the whole CLIMSEAS project area there are no significant annual trends for the total number of cyclones. It has been established that there are 50 cyclones per year in the summer and 30 per year in the winter. The south-east region of the Caspian Sea is where cyclones are most frequent. In summer there is a robust signal of the weakening of the storm track over the Caspian Sea and in winter there is a shift in the number of cyclones over the north-east of the Black Sea. On the other hand, a connection has been established between the eastern Mediterranean evaporation, the precipitation over south-eastern Europe and the CLIMSEAS region.

Significant negative trends of the total cloud cover, for the annual spring, and summer series, has been detected for the south of the Black Sea, while increasing TCC is found for the annual autumn and winter series in the north Caucasus and the west and north of the Black Sea.

There is a tendency towards an increase in the range of extreme events in the CLIMSEAS area and where the danger of such events occurring is found throughout the territory until the end of summer. While the danger of drought may be decreasing in June and August, it actually increases in July. This is vice versa for wetness propagation.

Taking a closer look at the seas, the Aral Sea is found to be a clear example of a body of water where geomorphologic processes must be taken into account for short-term predictions. Due to the decreased transversal area of the channel connecting the two lobes of the Large Aral Sea during the dissection period, high velocities were generated which in turn accelerated erosion at the bottom, which has increased to approximately 8 m in depth. The persistence of this channel has had a profound influence on the evolution of the rest of the lake as it has allowed the saltier and denser water from the Eastern Lobe to flow towards the fresher Western Lobe for several additional years. On the other hand, the vertical stratification of the Western Lobe has decreased over recent years following the desiccation of the eastern basin. The effects of the changing bathymetry on the general circulation and the internal wave field of the lake have also been studied.

In the numerical atmospheric models, the importance of the correct representation of the sea in the land-use mask and of the accuracy of the sea surface temperature has been demonstrated. Updating sea surface temperatures during forecast simulations has also been found to be relevant.

The Caspian Sea is a sensitive environment, easily perturbed by global climatic changes, such as the Allerød and Holocene warming, and the Late glacial and Younger Dryas cooling, as well as by regional changes in its hydrography, such as shifts in the Eurasian meltwater and the Volga and Amu Daryain flows.

A paleolimnological study of the north-east of the Black Sea has revealed relatively stable climatic conditions during the last 140 years, although pollen data suggests the impact of human activities on the land and adjacent sea. Equally, four short logs from the Caspian Sea have revealed changes (such as changes in marine biodiversity linked to periods of increase in the surface temperature of the sea) that have enabled instrumental records to be extended.

Field measurements from the Black Sea's Russian shelf show severe pollution. Although subject to significant variability at the interannual scales, a positive trend in the total suspended matter, nitrogen and silicon and negative in oxygen is observed. A study on the cold intermediate layer of the Black Sea indicates that it is a relevant mechanism of transfer of the climatic print to the deep part of the sea, which remains unmixed.

Potential impacts

A classification method based on the geopotential heights at 500 hPa and 1000 hPa and the temperature at 850 hPa has been developed. This method contains prognostic information on atmospheric blocking and subsequent change in the thermobaric regime not only during the blocking but also the few days after the destruction of the anticyclone.
A prognostic model for the Caspian Sea level has been created by using ECMWF interim reanalysis (ERAi) and seasonal forecast (FCST) data; mainly precipitation and evaporation for the areas of interest. Forecasts were calculated for six months ahead for each month from 1981 to 2010 and the time variability of the CSL has been demonstrated to be calculated with satisfactory accuracy.

There is a prospect of issuing long-range forecasts of basic meteorological parameters over the Black-Caspian-Aral Sea region in deterministic and probabilistic forms. The system is based on the global semi-Lagrangian absolute vorticity (SL AV) model and ERA-INTERIM reanalysis data. Forecasts of the temperature at 2m over the Black-Caspian-Aral Sea region were assessed. The CLIMSEAS forecasts meet the requirements of and are verified by the standardized surface verification systems of the Commission for Basic Systems (CBS) of the World Meteorological Organization (WMO).

The abilities of the WRF-ARW mesoscale model to forecast the temperature at 2m, the wind velocity, the sea level pressure and the dew point along the coasts of the Black and Caspian Seas has been demonstrated. Based on results from this model a hybrid method of wind gust estimation (based on either wind velocity or turbulent kinetic energy data) has been implemented for short-term wind gusts forecasts at stations around the inland seas. The WRF-ARW mesoscale model has also been used for a preliminary study of short-term blowing snowstorm predictions.

The wet and dry version of the POM hydrodynamic model with new long wave algorithms forced with high resolution fields of reanalysis meteorological variables has been implemented for the changing Aral Sea. Furthermore, a new version of the 1/30 deg DieCAST for the Black Sea is available with 30 interfacial depths which increase geometrically (at ~0, 3, 6, 10, 14, 18, 23, 29, ..., 1355, 1645, and 2000 m). The model is initialized with climatic temperature and salinity data and forced with climatological winds and surface buoyancy (heat) fluxes, with evaporation minus precipitation and with river runoff from 31 rivers.