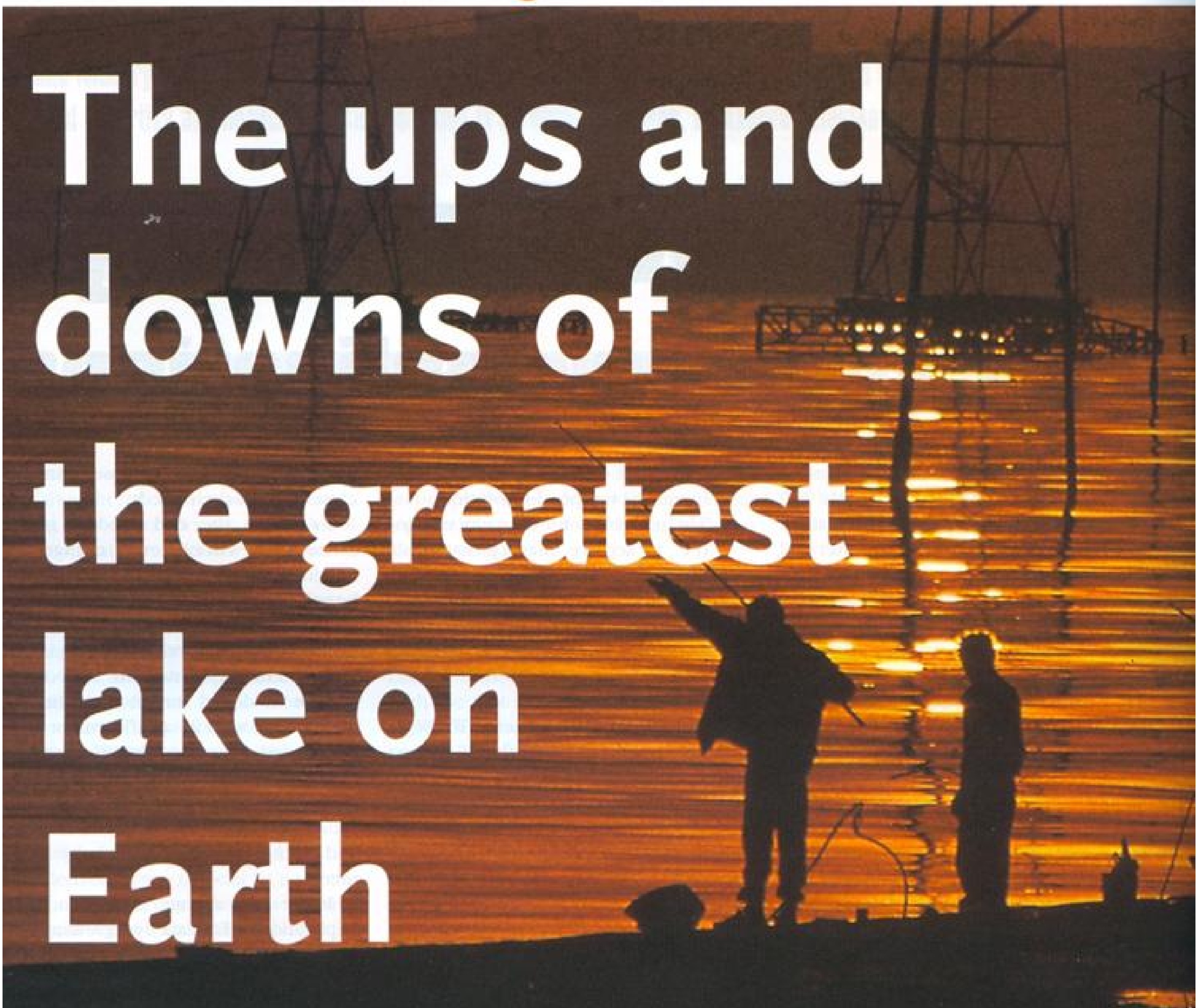
The ups and downs of the greatest lake on Earth



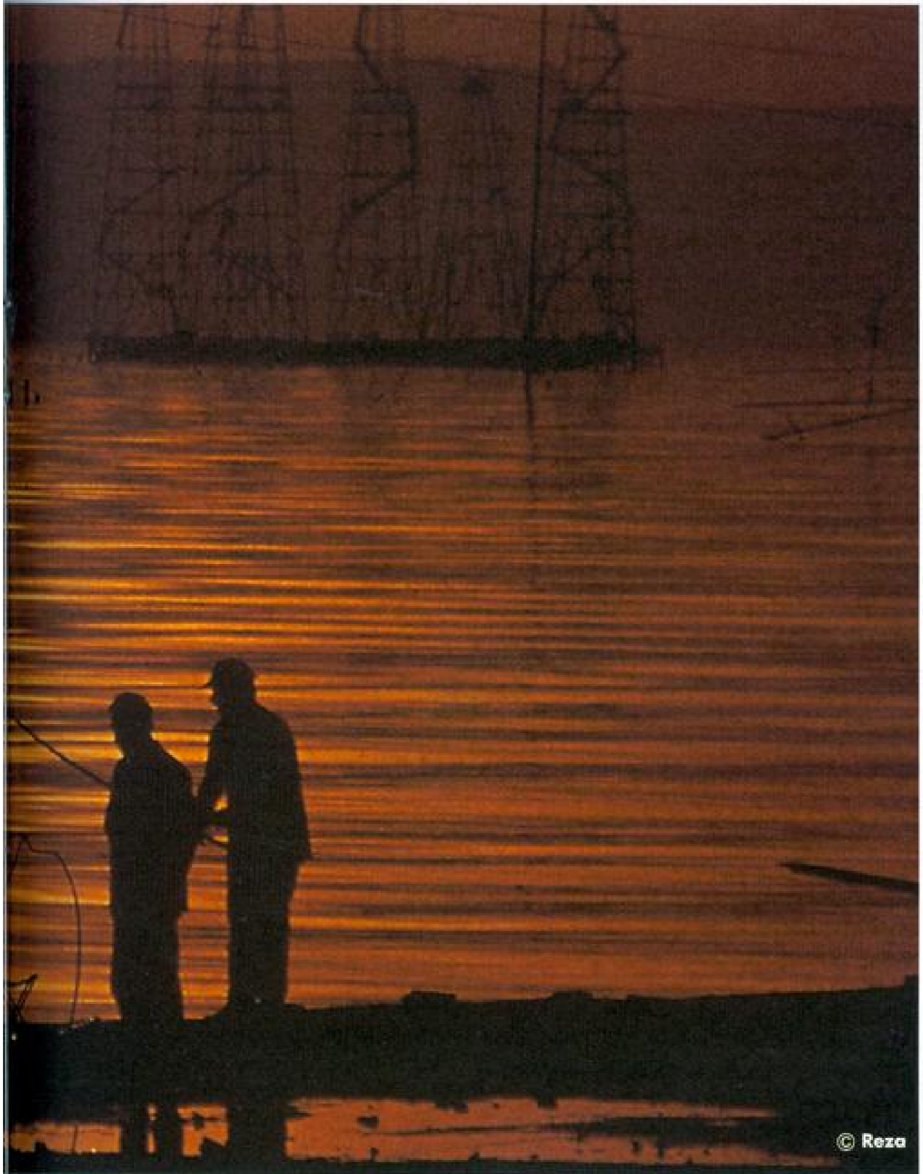
Over recent decades, fluctuating sea levels in the Caspian have wrought havoc among people and property alike. Climatic change and a careless disgregard for its ecosystem are certainly contributory factors, but the phenomena remains poorly understood. PARVIZ TARIKHI explains how remote sensing may yield answers and pave the way for greater co-operation in the region.

The largest lake on Earth, the Caspian Sea covers an area larger than Norway. Its geological structure was formed some five million years ago and successive millennia have seen it shrink and grow in size. Although now land-locked, the Caspian was once a true sea, linked to the oceans through the Black and Mediterranean Seas and the Sea of Azov.

The hegemony once exercised over its waters by Iran and the USSR has gone, and five littoral states now jostle for a share of its substantial oil and natural gas reserves. In addition to Iran, these include the Russian Federation, Azerbaijan, Kazakhstan and Turkmenistan. The total surface area of the Caspian encompasses 371,794 sq. km with a watershed extending over nearly 3.5 million sq. km. Its depth varies from six to 1,025 metres, with a mean average of 170 metres, and its water ranges from nearly fresh in north to brackish in south.

Lasting problem

As with the politics of the region, the surface level of the Caspian has see-sawed dramatically over the millennia, although why is not entirely understood. Two such major changes have been recorded since sea level records were started in the 1830s: a rise of 170 cm between 1933 and 1941 and a fall of 225 cm between 1978 and 1994. However, the following year, floods inundated 200 sq. km in Iran and forced thousands from their homes. A reported 300,000 hectares in Dagestan were also affected. From 1995 onwards, the surface level has again been slowly but unpredictably receding to a point that now threatens the economically important breeding grounds of the sturgeon.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Human activity in the present century has certainly led to a chronic degradation of soil, water, and air in the region, with the construction of dams for irrigation and industrial purposes all having their effect on tributaries that feed the Caspian. Of these, the River Volga and its basin is the most important, being the largest watershed in the Caspian region. It is also the most intensively used: of all water abstracted from natural sources in Russia, 33 per cent comes from the Volga. Other rivers, such as the Ural, and Terek, both with extensive deltas, also empty into the northern Caspian. In the south, the Sefid Rud and other Iranian rivers contribute around five per cent of all water entering the Sea.

Although the Caspian has no outlet, it is linked to the Baltic, White, and Black Seas through a network of inland waterways. This is sensitive to any change in the surface level and an estimated one million hectares, including the Volga delta, are at risk of flooding.

Prevention or cure?

Prevention is always better than cure, but the majority of the littoral states are ill-equipped to undertake ecological monitoring and many of their political systems suffer from chronic mismanagement. The politics of oil are a major factor in the equation, and a careless disregard for the environment is a feature of successive - and often abortive - attempts at offshore drilling.

Against this background, a number of concerned institutions in Iran have proposed large-scale Earth Observation studies of the Caspian, among them the Iranian Remote Sensing Centre (IRSC). Its 'Study of the sea surface rise at Caspian Sea using new generation satellite data' was first proposed in 1994 and presented in detail two years later at a workshop on Earth Science Information held in Colombo, Sri Lanka. In essence, the project envisages the creation of a model that can be used to monitor and forecast sea level changes in the Caspian and, furthermore, that the model be incorporated in a warning system.

The primary input to the model is frequent satellite-derived data of the region. But this needs to be combined with parameters relating to topography plus land-cover and land-use maps if it is to generate timely and accurate predictions. A practical, not theoretical solution is anticipated.

Data sources

Both the visible and near infrared bands in the electromagnetic spectrum can be used for the remote sensing of water bodies. Water is highly reflective in both bands and Medium Resolution Optical Imagery (MROI) as well as High Resolution Optical Imagery (HROI) are applicable as data sources.

For MROI, the obvious sensor is the NOAA's Advanced Very High-Resolution Radiometer (AVHRR) while, for HROI, three possibilities exist: Landsat-TM, SPOT, and the Indian IRS. Data acquired by Landsat-TM's High Resolution Visible and InfraRed (HRVIR) sensor has a spatial resolution of nearly 30 metres and a temporal resolution of about 16 days. SPOT has a resolution of 20 metres in the spectral and 10 metres in the panchromatic mode and has a 26-day temporal resolution, while the IRS-Pan mode has a spatial resolution of 10 metres and a temporal resolution of five days. On balance, IRS-Pan and SPOT are considered the more suitable sensors for data at high resolution.

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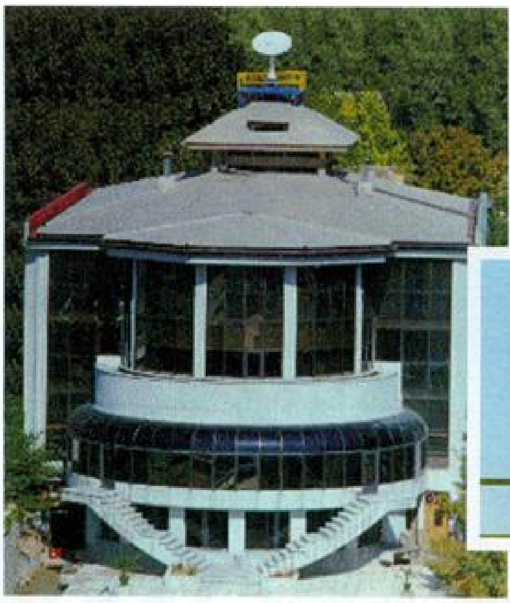

EO receiving antenna at the Iranian Remote Sensing Center in Tehran © IRSC

However, the problem of cloud cover cannot be ignored. MROI data acquired by NOAA-AVHRR has a spatial resolution of one kilometre and temporal resolution of 12 hours. Its Synethetic Aperture Radar (SAR) can, of course, acquire images in the microwave spectrum in cloud cover conditions. Other suitable sensors include the two European ERS satellites (spatial resolution of 30 metres and a temporal resolution of 16 days) and Canada's RADARSAT (spatial resolution of 25-28 metres in standard four-look mode and a temporal resolution of 24 days).

Making choices

Spatial resolution, repeat cycle and spectral characteristics are all important factors in arriving at a choice of data with which to populate the model. Sensors yielding MROI are considered particularly suitable for observing the Caspian, largely because of their flexibility under varying cloud cover and their much higher repeat rates. However, the resolution of MROI sensors (ranging from hundreds of metres to tens of kilometres) are insufficient for detailed study.

The relatively long repeat period of HROI (five to 26 days), combined with the high likelihood of cloud cover must be balanced against its ability to yield imagery down to 25 square metres - ideal for detailed studies of fluctuations in water level. A judicious combination of SAR, MROI and HROI has therefore been adopted as the most appropriate solution.

Specific sensors adopted for this purpose include NOAA-AVHRR, SPOT and IRS (for MROI and HROI data in the visible and near infrared bands) and the European ERS or Canadian RADARSAT (for data in microwave bands). The acquisition of imagery is followed

by geocoding, information extraction, modelling, quality control and forecasting.

Model making

The project study area is located in the southern coastal area of the Caspian in Iran. The project itself consists of two phases. In the first, a mathematical model will be created that determines the rate at which coastal zones are affected by a rise or fall in the surface level. Based on this model, monthly and yearly graphs will be prepared that indicate the most risky periods, i.e. those in which the probability of a rise in sea level is at its highest.

For this initial phase, multi-date high resolution SPOT or IRS imagery of the study area is needed. In addition, the model employs a variety of GIS and image analysis tools including ERDAS IMAGINE to combine remotely-sensed data with land-use, land-cover and topographic mapping and to generate a Digital Terrain Model. In the second phase, coastal zones most susceptible to inundation will be identified. The data thus acquired must, of course, be validated by ground truth.

Although the methodology has yet to be tested, considerable interest has been shown in the project, not least in its ability to encourage joint co-operation between the Caspian's littoral states, both on a commercial and environmental level. Organisations whose spheres of interest include urban planning, housing, fishing, forestry, agriculture, tourism and many more are all potentially interested in the results. G

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Coastal defences west of Novshahr, Iran © National Atlas of Iran

MROI data of Caspian region acquired by NOAA © Microsoft Encarta World Atlas 98

Fishing for answers

In trying to reconcile the dual influences of man and nature, the Caspian Sea has found its own way of maintaining equilibrium. That precarious balance is now in jeopardy as the geopolitics and economics of the region impose new pressures on an already overstretched resource. *Turn to page 30* *to find out out how remote sensing may yield answers and encourage multinational problem-solving.*

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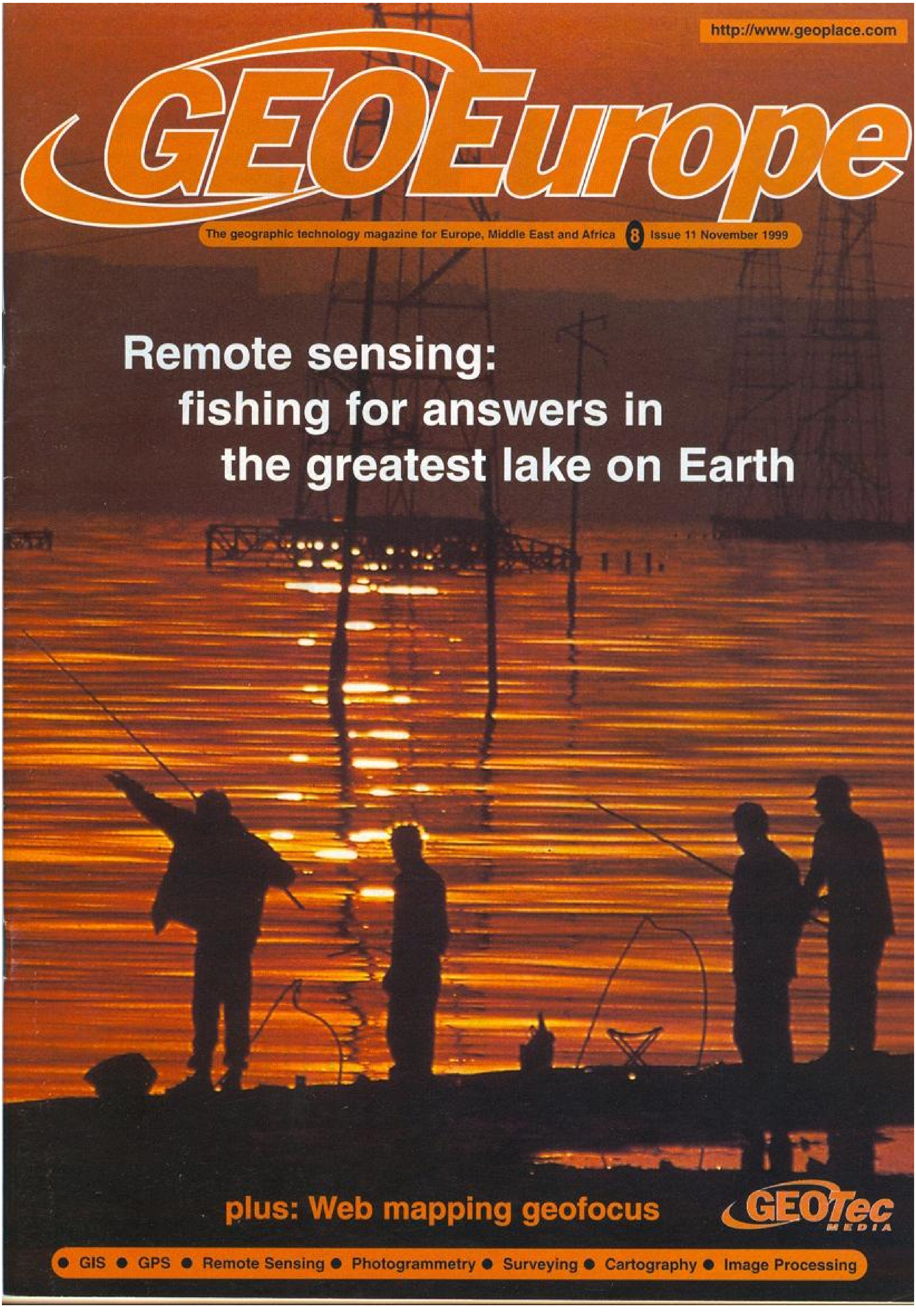

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