of the Arctic Ocean and its variability. Presently, we are beginning to perform a coordinated simulation of the Arctic Ocean of the last 50 years using available forcing data sets from atmospheric re-analysis products. During our workshop in May 2001, we defined the protocol to be followed by all groups to carry out the 50-year experiment. This takes into account model forcing data sets, model physical parameters, integration procedures, as well as data-interchange format, just to name a few considerations. The complete protocol is available on our Web site (http://fish.cims.nyu.edu/project_aomip/simulations/50_year_runs/overview.html). At a later date, we will extend this work by examining Arctic Ocean data of the entire 20th century (100-year model run) using a blend of observed and proxy atmospheric data. In this manner we will begin to understand climate variability from the early 20th century and how it may differ from that of more recent times.

Currently, symbiotic modeling intercomparison projects are addressing other aspects of the Arctic climate system, for example, the sea-ice cover (the Sea Ice Model Intercomparison Project (SIMIP)) and the western Arctic region (the Arctic Regional Climate Model Intercomparison Project (ARCMIP)). Collectively, all of these intercomparison projects reflect a significant research effort toward improving the representation of the Arctic region in global climate models. At present, the AOMIP group consists of a core of eight principal investigators and a large number of co-investigators. We recently made agreements with other modeling groups to also carry out the 50- and 100-year AOMIP experiments and are actively seeking additional AOMIP participants to perform the AOMIP experiments or to carry out diagnostic studies on the AOMIP model-generated data sets resulting from the 50- and 100-year simulations.

Further AOMIP background as well as technical and scientific plans can be obtained from the AOMIP Web site: http://fish.cims.nyu.edu/project_aomip/overview.html.

Acknowledgments

Funding for the AOMIP is provided by the International Arctic Research Center, University of Alaska-Fairbanks, under the auspices of the United States National Science Foundation and the National Oceanographic and Atmospheric Administration.

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Eurasia-Africa Plate Boundary Region Yields New Seismographic Data

PAGES 637, 645-646

The tectonic plate boundary between Eurasia and Africa is complex, in that it cannot be characterized as a single discrete plate boundary. Deformation near this plate boundary varies from trans-tensional in the Azores archipelago, through strike-slip in the eastern Atlantic basin, to overall compressional between the European and African continents, with extensional sub-domains in the Mediterranean Sea. This complex pattern of deformation, related plate motion, and underlying driving forces leads to strong variations in seismic hazard throughout the region. A better understanding of the plate boundary processes requires knowing crust and upper mantle structure in the region, which is best investigated with three-component, broadband seismic data. To investigate the region's three-dimensional crust and upper mantle structure, we are carrying out a multi-institutional project (MIDSEA) involving seismologists from 10 countries on the northern, southern, and western sides of the plate boundary.

Within this multinational project, 25 three-component, broadband seismic stations were installed in the plate boundary region. Their locations were carefully selected to complement the coverage provided by existing networks (for example, MedNet, GEOFON) and stations in the region. The data obtained are being analyzed for three-dimensional structure of the crust and upper mantle in the plate boundary region. Preliminary results indicate that crustal thickness varies spatially by dozens of kilometers and that uppermost mantle structure is dominated by low seismic velocities.

Plate Boundary

The tectonic plate boundary region between Eurasia and Africa extends from the Azores triple junction with the North American plate to the easternmost Mediterranean Sea. Uncommonly, the plate boundary does not manifest itself as a relatively focused zone of seismicity and surface deformation. Surface deformation, seismicity patterns, and earthquake focal mechanisms indicate a wide, branched plate boundary region with strong spatial variations in the type, amount, and frequency of faulting [*McKenzie*, 1970]. Moreover, the plate boundary has changed location, shape, and character throughout geological time [*Dercourt et al.*, 1986]. Tectonic evolution in the western part of the plate boundary region, from the Azores to the Mediterranean Sea, is characterized by steady Cenozoic accretion of young lithosphere to both plates at the Mid-Atlantic Ridge, hot spot activity in the Azores, strike-slip along parts of the Gloria fault, and distributed deformation, including reverse faulting, in the easternmost Atlantic basin and adjacent continental margin.

Tectonic evolution in the eastern part of the plate boundary region—the Mediterranean—is dominated by slow convergence between Africa and Eurasia, which created paleo- and Neogene arcuate orogenies such as the Alps, Carpathians, Betics and Rif, Calabria and Apennines, Hellenides and Dinarides, and Maghrebides. For Calabria (southern Italy) and the Hellenides (southern Greece), this convergence is accommodated by the subduction of Mesozoic oceanic lithosphere. During this overall convergent period, episodes of relatively fast extension, related to trench migration and back-arc opening, have formed the Algero-Provençal, Tyrrhenian, and Aegean basins.

This complex evolution and current geodynamic processes yield a heterogeneous pattern of stress and strain in the plate boundary region, which leads to strong spatial variations in seismic hazard. Fundamental to understanding the present and past geodynamics of this region is knowledge of the three-dimensional structure of the crust and upper mantle in the region, which is as complex [*Meissner et al.*, 1987; *Wortel and Spakman*, 2000] as the surface observations described above. Seismograms from three-component broadband instruments carry more information on three-dimensional crust and upper mantle structure than any other type of geophysical data collected at the Earth's surface. Consequently, the number of such seismological stations in the plate boundary region is large.

Seismography

The first permanent, three-component, broadband seismic station near the Eurasia-Africa plate boundary (ANTO) was installed in Ankara, Turkey, in 1978 as part of the Global Seismographic Network (GSN). During the 1980s, temporary broadband stations of the mobile NARS network were installed as far south as Spain, followed by the installation of a permanent broadband station in southern Algeria as part of the global GEOSCOPE network. One decade after the installation of ANTO, the MedNet project [*Boschi et al.*, 1991] was initiated and the first permanent stations of MedNet were installed on both sides of the Mediterranean part of the plate boundary [*Giardini et al.*, 1992]. The purpose of MedNet has been to use the broadband data for research purposes, as well as for monitoring seismic hazard in the Mediterranean region.

By 1995, eight MedNet stations had been installed throughout the region. Around this time, the GEOFON program [*Hanka and Kind*, 1994] was launched with the installation of permanent as well as mobile broadband stations, primarily in eastern European and Mediterranean countries. During the same period, a second GSN station was installed in Spain, while Portugal, Spain, and France installed individual stations in their respective countries, including one in Corsica. One GSN station in the Azores and more than 60 broadband stations in the Mediterranean region were operating by 1999. From then on, more and more mobile broadband stations have been deployed in the region for limited periods of time; an inventory of these is maintained at the ORFEUS site at http://orfeus.knmi.nl.

However, data availability for some of the permanent and temporary stations varies and the geographical coverage is far from uniform. This non-uniformity poses problems for the assessment of seismic hazard through spatial variations in, for example, the detectability of seismicity and the reliability of hypocenters and focal mechanisms. In addition, seismological research into Mediterranean upper mantle structure has shown that the non-uniformity limits the resolution of the derived models for seismic velocity.

Our primary goal is to derive more complete models for the crust and upper mantle structure in the Eurasia-Africa plate boundary region. To do so, we must improve the distribution of three-component, broadband seismic stations in the region. This can be achieved, on the one hand, by eventually using a network of ocean bottom seismometers in the waters of both the Mediterranean Sea and the mid- and eastern Atlantic Ocean; and on the other hand, by better coverage of the land parts of the Eurasia-Africa plate boundary region.

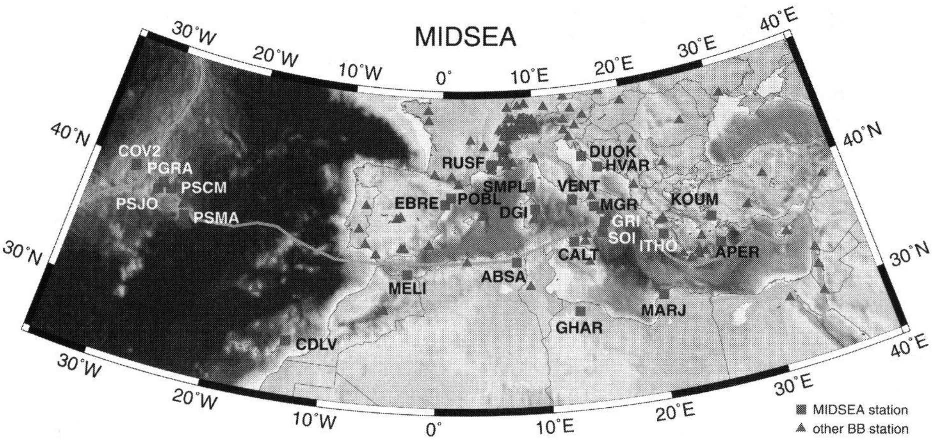


Fig. 1. This topographic map shows the configuration of MIDSEA stations (squares) and other seismic stations (triangles) in the Eurasia-Africa plate-boundary region. MIDSEA is a multinational project with participating organizations from three continents. A rough approximation of the Eurasia-Africa plate boundary is provided by the NUVEL-1 model (pink line) [DeMets, 1990]. *Original color image appears at the back of this volume.*

We have complemented presently existing seismic stations in the plate-boundary region with a temporary network of 25 three-component, broadband seismic stations (Figure 1). Target locations for our new stations were regions on all sides of the plate boundary that are far from existing broadband stations in the region. With our new stations, we have not only increased the number of stations in the region, but have also smoothed the heterogeneity in coverage.

MIDSEA

The aim of the 25-station seismic network is a mantle investigation of the deep suture between Eurasia and Africa (MIDSEA). The temporary stations of the MIDSEA network were sited to optimize station coverage for investigating crust and upper mantle structure along the Eurasia-Africa plate boundary. Consequently, many of the MIDSEA stations are located on islands, as well as in northern Africa (Figure 1). Each MIDSEA station will operate for a period of 1 to 2 years some time between June 1999 and April 2002. Twenty-two of the 25 stations are equipped with broadband STS-2 sensors and the remaining three have CMG3T sensors. The data acquisition systems used are MARS88, RefTek, Titan, Quanterra, and Orion.

The data recorded by the stations are locally stored, regularly recovered, and shipped to one of the four data processing centers: The Federal Institute of Technology (ETH, Switzerland), Géosciences Azur (CNRS/UNSA, France), the National Institute of Geophysics and Volcanology (INGV, Italy), and the Department of Terrestrial Magnetism of the Carnegie Institution of Washington (DTM, USA). These organizations are also the main MIDSEA partners, representing Switzerland, France, Italy, and the United States. The other MIDSEA partners are the National Observatory of Athens (NOA, Greece);

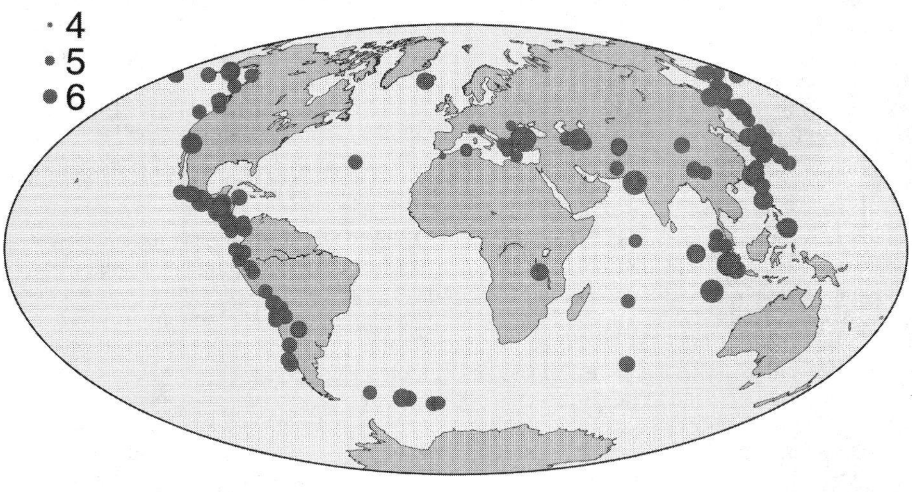
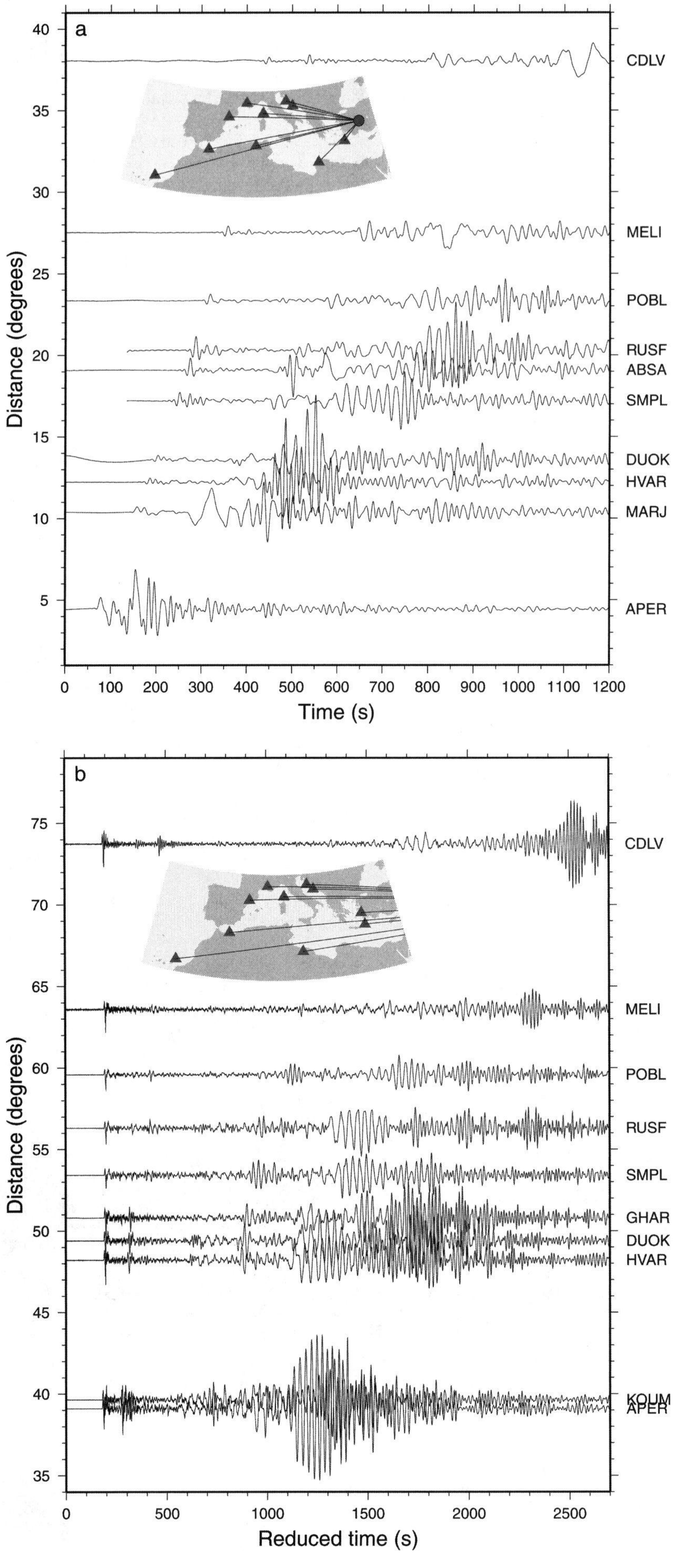


Fig. 2. This map of the distribution of earthquakes is used to investigate three-dimensional crust and upper mantle structure in the Eurasia-Africa plate-boundary region. The numbers in the legend represent an earthquake's magnitude on the Richter scale.



the University of Zagreb (Croatia); the Ebre Observatory, the Institute of Catalan Studies, the Lanzarote Cabildo, the San Fernando Naval Observatory (ROA), and the Universidad Complutense-Madrid (Spain); the Institute of Meteorology (Portugal); the Research Center for Astronomy, Astrophysics, and Geophysics (CRAAG, Algeria); and the Libyan Center for Remote Sensing and Space Sciences (LCRSSS, Libya). The Institute of Catalan Studies and ROA are locally processing the data recorded at stations POBL and MELI, respectively.

Despite the temporary character of the MIDSEA network, some of the station sites have proven to be excellent locations for the operation of more permanent stations. For example, one MIDSEA station on Sicily was recently converted to a permanent MedNet station, and two of the MIDSEA stations in northern Africa are now operating jointly with the GEOFON program, providing a longer-term perspective for these broadband stations. Simple noise analysis shows that noise levels at seismic frequencies are close to the low-noise model of Peterson [1993] for some of the sites that will continue to operate narrower band sensors in the future (Algeria, Croatia, Greece, and Lanzarote). The Greek and Croatian island sites show a very low microseismic noise level, while the Atlantic island sites show significant levels of microseismic noise. As usual, long-period noise is higher on the horizontal components than on the vertical components. For some sites, cultural noise above 5 Hz increases during the day.

The MIDSEA project can be monitored through http://www.sg.geophys.eth.ch/midsea.

The stations in the Azores (Figure 1) are the most recent additions to the MIDSEA network. Along with one broadband station managed by the Institut de Physique du Globe in Paris and another broadband station managed by the University of Lisbon, these stations also represent the coordinated seismic experiment in the Azores (COSEA), which aims to investigate the hot spot origin of the Azores Archipelago.

New Data

The MIDSEA, three-component, broadband seismic stations have recorded many regional and teleseismic earthquakes. Figure 2 shows the global distribution of some of the recorded earthquakes that have actually been used to date for investigating the crust and upper-mantle structure along the Eurasia-Africa plate boundary. This figure also illustrates the central position of the plate boundary region with respect to teleseismic earthquakes from the circum-Pacific ring.

Among the largest earthquakes recorded by MIDSEA stations are the 1999 Taiwan and

Fig. 3. Shown here is a MIDSEA vertical component seismogram section for (a) the regional mb = 5.1 earthquake on December 15, 2000, in Turkey; and (b) the teleseismic mb = 6.9 earthquake on January 26, 2001, in southern India. The timing of the records in (b) was reduced with a velocity of 16 km/s. The records in (a) are converted to ground displacement and filtered.

Hector Mine earthquakes, the 2000 Volcano Islands earthquake, the 2000 series near Papua New Guinea, and the 2001 El Salvador earthquake. Significant regional earthquakes recorded include the 1999 Izmit-Duzce series, the 1999 Athens earthquake, and the 2000 earthquake in northern Algeria. Figure 3 shows MIDSEA seismograms for a significant regional earthquake last year in Turkey, and for the large teleseismic earthquake in southern India in January 2001. Before analysis, all seismograms are carefully and interactively checked for quality. This guarantees that a maximum amount of optimal-quality data can be used for investigating three-dimensional Earth structure.

Crust and Upper Mantle Structure

Preliminary results from MIDSEA seismogram analysis confirm the existence of a widespread low-velocity zone beneath the Mediterranean region. As a result of this discrepancy with the globally averaged iasp91 model the regional record sections (for example, Figure 3a) show clear, high-amplitude *P* arrivals only beyond 17° in epicentral distance. The depth to the top as well as to the bottom of the low-velocity layer varies throughout the region. Within this low-velocity zone, we image high-velocity anomalies that are possibly related to lithosphere that subducted during the convergence between Eurasia and Africa [*Wortel and Spakman*, 2000].

Analysis of three-component teleseismic MIDSEA records shows that the crust in subregions of continental collision, such as the Croatian margin, is over 40 km thick. Continental crust in regions that experienced extension, such as the Aegean Sea and the Alboran and Valencia margins, is up to 30% thinner than 30 km. To date, the thinnest crust beneath MIDSEA stations is found for station CDLV in the Atlantic basin.

Preliminary analysis of split shear waves shows a stable pattern of direction and size of anisotropy in southern France and a complex pattern of fast directions and splitting delays for southern Italy. The pattern emerging from the denser station configuration in southern Italy is possibly related to the presence of a fragmented lithospheric slab in the upper mantle and asthenospheric flow induced by slab retreat.

Locally, the MIDSEA data are being used for a study of attenuation structure, noise characterization for sites of senior seismographs, and for determining focal mechanisms of regional events. Completed data analyses will be submitted for publication in professional geophysical journals.

Through the improved station configuration in the region, project MIDSEA will be able to provide a more complete three-dimensional model of crust and upper mantle structure in the Eurasia-Africa plate-boundary region than is presently available. This model is envisioned to characterize three-dimensional seismic velocities, radial and transverse anisotropy, and discontinuity structure. Such a model, and its comparison with regional geology and tectonics, will improve our understanding of the geodynamic processes involved in long-term, slow convergence between two enormous tectonic plates.

The complete MIDSEA event data set will be submitted to the ORFEUS Data Management Center (http://orfeus.knmi.nl) for distribution.

Acknowledgments

The temporary MIDSEA network could not have been installed and maintained without the generous permission of Luis Felipe Alberca, Luís Mendes Victor, Joaquin Naverán, Luísa Senos, and George Stavrakakis. Technical assistance provided by Azzouz Amrani, Christoph Baerlocher, Claudio Chiarabba, Abdala Elmelade, Winfried Hanka, Orlando Hernandez, Pio Lucente, Antonis Papardoukakis, Antonio Pazos, Beat Rinderknecht, Stefan Wiemer, and Peter Zweifel has been crucial to the success of this project. We also greatly appreciate additional support from Ivo Allegretti, Miljenko Betale, André Blanchard, M. Cattaneo, B. Castello, P. D'Anna, Timos Hatzilagos, George Helffrich, David James, Sotiris Kouvelakis, Mohamed Mansour, Krešo Maric, C. Maron, Nikša Novak, F. Pirro, José Prian Nieto, Georges Roumbos, Christian Schmid, Daniel Winiger, Kurt Wylegalla, and Panagiotis Zagoritis. Financial support for MIDSEA comes from the Swiss National Science Foundation, with additional support from the Carnegie Institution of Washington, the French National Scientific Research Center and the University of Nice at Sophia-Antipolis, and the Italian National Institute of Geophysics and Volcanology. Local financial support was provided by the Libyan Center for Remote Sensing and Space Sciences; the Ministry of Science and Technology of the Republic of Croatia; La Casa de los Volcanes of Lanzarote (Spain); the Institute of Catalan Studies (Spain); the Ministry of Science and Technology of Spain; the Algerian Research Center for Astronomy, Astrophysics, and Geophysics; and the National Observatory of Athens. Figures were created using the generic mapping tools (GMT).

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Budget Increases for U.S. Science Agencies

PAGES 637–638

The majority of the appropriations bills for the U.S. federal budget for fiscal year 2002 have been signed by President George W. Bush, and the overall outlook for science looks good. A number of science agencies received healthy increases that are above the figures proposed by the Bush administration earlier this year.

The appropriations bill for Veterans Affairs, Housing and Urban Development and Independent Agencies (H.R. 2620) is one of the most important, as it funds both NASA and the National Science Foundation (NSF). Signed into law by the president on November 26, the "VA-HUD" bill provides NASA with a budget of $14.8 billion. This is an increase of $540 million, or 3.8%, above FY01 levels, and 1.9% above the administration's request of $14.51 billion. The increment for NSF's $4.79-billion budget for FY02 is $372.5 million, an increase of 8.4% above the previous year's funding. This amount is $319 million more than the agency requested. The Bush administration requested an increase of only 1.3%.

Also, on November 5, the president signed the Interior and Related Agencies appropriations bill (H.R. 2217), which funds the U.S. Geological Survey. The USGS also fared well, receiving $914 million for FY02, a 3.6% increase over the previous fiscal year.

Rep. Sherwood Boehlert (R-N.Y.), chair of the House of Representatives Science Committee, applauded the final fiscal year 2002 budget numbers for research and development, as demonstrated in H.R. 2620. "I am pleased with the [funding] trend. It is recognition of the importance of.... investing in the science enterprise, and I fully expect the 2003 budget—now in preparation in the administration—will treat science very well."

NASA Budget Details

NASA's FY02 budget includes $1.573 billion for the Earth sciences, an increase of $88.8 million above the previous fiscal year, and

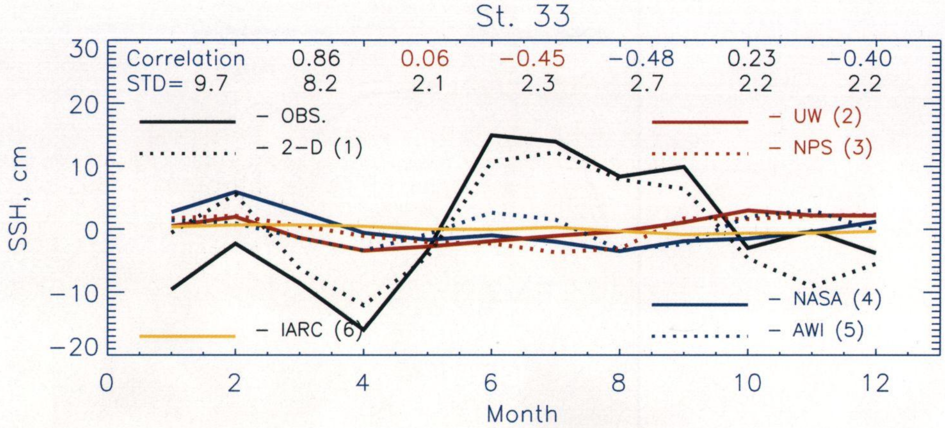

Fig. 3. Seasonal sea-level variability from observations (black solid line) and model results in centimeters are shown. The black dotted line shows results from a barotropic, two-dimensional coupled ice-ocean model; red solid and red dotted lines depict sea-level variability from UW model and NPS models, respectively; blue solid and blue dotted lines show variability of sea level in the GSFC and AWI models, respectively. The yellow solid line shows sea-level change in the IARC model. Numbers in the upper part of each figure show the correlation coefficients between observations and two-dimensional UW, NPS, GSFC, AWI, and IARC models from left to right, respectively. The lower line shows the standard deviations (denoted STD) between observations and model results in the same order.

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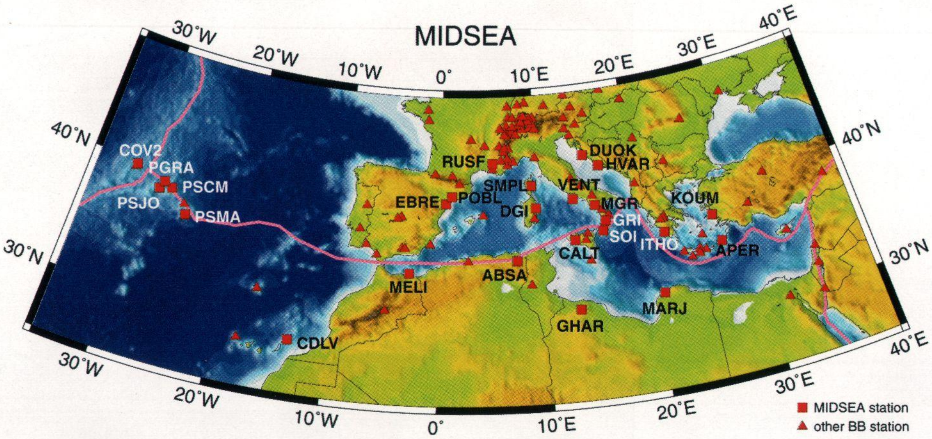

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Fig. 1. This topographic map shows the configuration of MIDSEA stations (squares) and other seismic stations (triangles) in the Eurasia-Africa plate-boundary region. MIDSEA is a multinational project with participating organizations from three continents. A rough approximation of the Eurasia-Africa plate boundary is provided by the NUVEL-1 model (pink line) [DeMets, 1990].