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The GEOSCOPE program: its data center

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Abstract

The purpose of the GEOSCOPE program was the installation of about 20 stations well distributed worldwide (in particular in the southern hemisphere), in the standard configuration defined by the FDSN (VBB 24 bit, continuous recording at 20 samples/s (sps)). The installation is almost complete. The effort has been focused on the accessibility of data from our Data Center. Data can be obtained either on line through the WWW GEOSCOPE server (http://geoscope.ipgp.jussieu.fr), or through our anonymous ftp, or through CD-ROM production or through the IRIS/SPYDER system for large earthquakes. In the near future easier ways will be available, such as autoDRM (automatic Data Request Management) and NetDC requests (Networked Data Centers, protocol proposed by the IRIS DMC of Seattle).

Keywords: Broad-band seismology; Data centers

1. Introduction

The GEOSCOPE Program was launched in 1982 (Romanowicz et al., 1984, 1991) by the National Institute of Sciences of Universe (INSU), a department of the French National Center of Scientific Research (CNRS), at the instigation of the Institute of Physics of the Earth of Paris (IPGP). It was the first program to undertake establishment of a worldwide network of three component seismic stations with digital recording in a broad frequency band. The program started with BB-recording in combination with 12-bit datalogger resolution (Wielandt and Streckeisen, 1982). Later, GEOSCOPE shared with IRIS the implementation of VBB and 21–24-bit digitizers, fulfilling requirements of station design combining high quality seismometers and excellent recording systems (Wielandt and Steim, 1986).

Several French institutions, EOST (School and Observatory of Sciences of the Earth of Strasbourg), DRED (Direction of Research and Doctoral Studies), ORSTOM, IFRTP, TAAF, CEA-DASE and different foreign institutions support the program, and help it to play an important role in promoting the new approach of broadband seismology.

Many countries have since developed the same type of networks, IRIS/GSN in the United States (Butler, 1994), MedNet in Italy (Boschi and Morelli, 1994), POSEIDON/PACIFIC 21 in Japan, GEOFON in Germany (Hanka and Kind, 1994), ANSN in Australia (Jepsen, 1994), CNSN in Canada (North,

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1994), CDSN in China (Chen et al., 1994) and all such activities are coordinated by the Federation of Digital Seismographic Networks (FDSN; Dziewonski, 1994); its objectives are to coordinate site locations (Engdahl, 1994), to develop minimum standards in the cooperating Federation Stations, to improve the quality of data and to facilitate the data exchange between the different Data Centers (Ahern, 1994; Dost, 1994a,b; Roult and Montagner, 1994).

The main scientific objectives of the GEOSCOPE program were first to further investigate the internal structure of the earth, and second to study the mechanisms involved in earthquakes generation and better understand the rupture processes causing earthquakes. The explosion of broadband seismology with an increasing number of networks and stations providing an increasing volume of high-quality data made necessary to think about a rapid development of mass storage systems in order to provide better communication facilities. Getting data very rapidly after earthquakes is now absolutely necessary for all geophysicists, and the priority is the rapid exchange of data. These new goals correspond to the philosophy sustaining the development of the GEOSCOPE Data Center.

The new challenge is GEOSCOPE 2000 with the definition of a new concept of geophysical observatory (new acquisition chain, multiparameters recording) and available data in real-time (Montagner et al., 1998).

2. GEOSCOPE: present status of the network

The Data Center of Paris is archiving data from 28 stations, 25 permanent «GEOSCOPE» stations and three «contributing» ones.

2.1. Twenty-five permanent «Geoscope» stations

- 17 Stations maintained by the Technical Division of INSU (Saint-Maur, near Paris): ATD, CAN, KOG, HDC, HYB, INU, KIP, PEL, PPT, RER, SCZ, SEY, SPB, SSB, TAM, UNM, WUS. Among these 17 stations, all of them are now operating in VBB configuration (triggered BH channel at 20 samples/s (sps), continuous recording of LH channel at 1 sps, VH channel at 0.1 sps).
- 6 stations maintained by EOST (Strasbourg): AIS, CRZF, DRV, ECH, NOUC and PAF. All stations are now in VBB configuration; the last one was AIS, in February 1997 with a STS2 recorded continuously at 20 sps. NOUC is maintained by DT/INSU, ORSTOM and EOST.
- 2 stations maintained by ORSTOM in Africa, BNG and MBO in VH/LH/MH configuration (VH in m/s/s with continuous recording 0.1 sps, LH in m/s/s with continuous recording 1 sps, MH in m/s and triggered 5 sps). These both stations will be transformed (and could be moved in another place because of their high seismic noise level at long periods), as soon as possible.

2.2. Three ‘contributing’ Geoscope stations

- 1 station maintained by ORSTOM in Vanuatu Islands, PVC installed in June 1994 in BRB configuration, in VBB configuration since March 1995.
- 1 station maintained by IPGP (Seismotectonic group) in Chile, ICC in VBB configuration, installed in June 1995, operational since April 1996.
- 1 station maintained by Centro de Geofisica de Universidad de Lisboa (Portugal), EVO, in VBB configuration since February 1996.

Data from these three stations are also available from our juke-box. Any technical detail is referenced in the GEOSCOPE station-book (Morand and Roult, 1994, 1996).

The location of all present, future and «contributing» GEOSCOPE stations is presented on Fig. 1. The evolution of the network since 1982 and its present status are presented on Table 1 and Fig. 2, with the different steps of configuration (VH only, MH/VH, BH/MH/LH/VH). Table 2 gives the correspondence between the GEOSCOPE and the SEED channel namings.

Sixteen stations are remotely accessible (teletransmitted by phone line). In case of large events, data from these stations are recovered by DT/INSU in St. Maur (Fig. 1, green dots) and made available at the Data Center in Paris within 1 or 2 days.

In the present VBB configuration, some data are lost in stations due to the imperfection of the triggering criteria. In parallel to the classical recording in station (VBB configuration described previously),

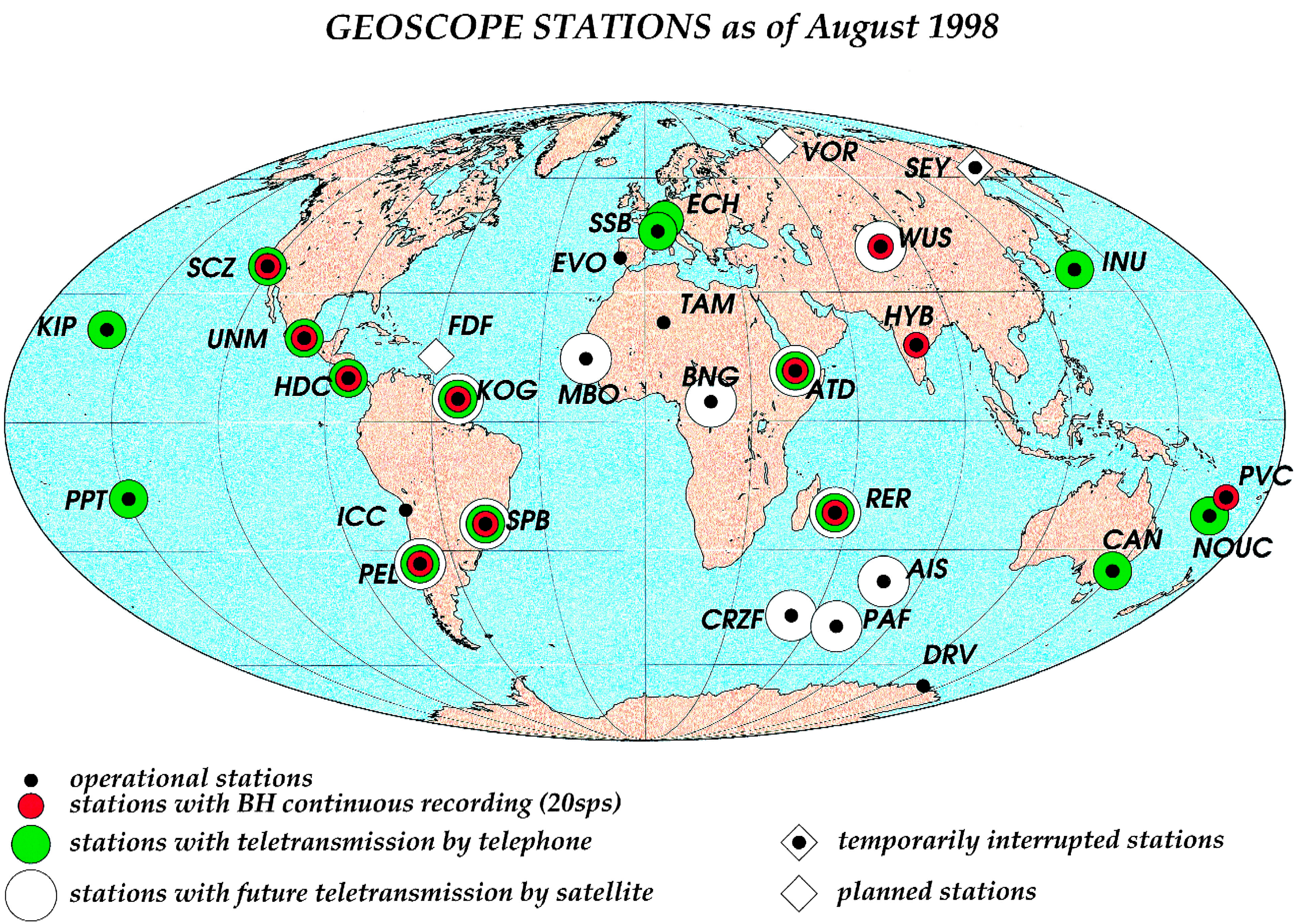

Fig. 1. The GEOSCOPE network as of August 1998. black dots: location of all present operational stations. red dots: location of stations with continuous recording of BH channel (20 sps). green dots: location of stations with teletransmission by phone line. white dots: location of stations with future teletransmission by satellite. white triangles: location of planned stations.

Table 1
GEOSCOPE stations as of August 1998

	Station	Location	Latitude	Longitude	Elevation (m)	Started VLP m/s/s	Started BRB/VLP m/s m/s/s	Started VBB/VLP m/s m/s	Temporarily interrupted or stopped	Station
	AIS	New Amsterdam Island	37.797 S	77.569 E	35.9		25-Dec-1993			AIS
RA	ATD	Arta tunnel, Djibouti	11.530 N	42.847 E	610.0			7-Jul-1993		ATD
	BNG	Bangui, Centrafrica	4.435 N	18.547 E	378.0	11-Dec-1987	12-Sep-1988			BNG
RA	CAN	Canberra, Australia	35.321 S	148.999 E	650.0			27-Nov-1987		CAN
	CRZF	Port Alfred, Crozet Islands	46.430 S	51.861 E	140.0	13-Mar-1986	20-Jan-1988	28-Nov-1993		CRZF
	DRV	Dumont d'Urville, Antarctica	66.665 S	140.010 E	40.0	1-Feb-1986	01-Feb-1988	25-Jan-1991		DRV
RA	ECH	Echery, France	48.216 N	7.158 E	580.0			8-Nov-1990		ECH
RA	HDC	Heredia, Costa Rica	10.000 N	84.112 W	1150.0			8-Mar-1997		HDC
	HYB	Hyderabad, India	17.417 N	78.553 E	510.0			15-Jan-1989		HYB
RA	INU	Inuyama, Japan	35.350 N	137.029 E	132.3			4-Mar-1987		INU
RA	KIP	Kipapa, Hawaii, USA	21.423 N	158.015 W	70.0		17-Apr-1986	26-May-1988		KIP
RA	KOG	Kourou, French Guyana	5.207 N	52.732 W	10.0			4-Jul-1994		KOG
	MBO	MBour, Senegal	14.391 N	16.955 W	3.0	1-Sep-1985	30-Nov-1987			MBO
RA	NOUC	Port Laguerre, New Caledonia	22.101 S	166.303 E	112.3	21-Mar-1988	08-May-1989	2-Nov-1992		NOUC
	PAF	Port aux Français, Kerguelen	49.351 S	70.213 E	17.0	1-Jan-1983	28-Jan-1988	28-Dec-1992		PAF
RA	PEL	Peldehue, Chile	33.146 S	70.675 W	660.0			4-Oct-1995		PEL
RA	PPT	Papeete, Tahiti	17.569 S	149.576 W	340.0	31-May-1986	24-Nov-1986	5-Oct-1991		PPT
RA	RER	Rivière de l'Est, La Réunion	21.159 S	55.746 E	834.0		10-Feb-1986	4-Jul-1990		RER
RA	SCZ	Santa Cruz, California, USA	36.598 N	121.403 W	261.0	11-Jun-1986	27-Sep-1987	27-Sep-1991		SCZ
RA	SPB	Sao Paulo, Brazil	23.592 S	47.432 W	85.0			17-Jun-1996		SPB
RA	SSB	St. Sauveur Badole, France	45.279 N	4.542 E	700.0	2-May-1982	14-Jan-1985	22-Apr-1987		SSB
	TAM	Tamanrasset, Algeria	22.791 N	5.527 E	1377.0	16-Nov-1983		11-Mar-1990		TAM
RA	UNM	Unam, Mexico, Mexico	19.329 N	99.178 W	2280.0			6-Jun-1990		UNM
	WUS	Wushi, Xinjang, China	41.199 N	79.218 E	1457.0			31-Oct-1988		WUS
Contributing GEOSCOPE stations										
	EVO	Evora, Portugal	38.532 N	8.013 W	0.0			7-Feb-1996		EVO
	ICC	Mine Santa Rosa, Chili	20.284 S	70.035 W	950.0			1-Apr-1996		ICC
	PVC	Port Vila, Vanuatu	17.740 S	168.312 E	80.0		1-Jun-1994	24-Mar-1995		PVC
Old GEOSCOPE stations (interrupted)										
	Station	Location	Latitude	Longitude	Elevation (m)	VLP m/s/s	BRB/VLP m/s m/s/s	VBB/VLP m/s m/s	Temporarily interrupted or stopped	Station replaced by
RA	AGD	Arta grotte, Djibouti	11.529 N	42.824 E	450.0	09-Mar-1985	06-Aug-1987		9-Dec-1990	ATD
RA	CAY	Cayenne, French Guyana	4.948 N	52.317 W	25.0	22-Jul-1985	9-Dec-1985		29-Sep-1991	KOG
RA	HDC2	Heredia, Costa Rica	10.027 N	84.117 W	1253.2	25-Sep-1987	25-Sep-1987		1-Mar-1989	HDC
	NOC	Nouméa, New Caledonia	22.284 S	166.432 E	5.0	8-Dec-1985			27-Oct-1987	NOUC
	PCR	Plaine des Cafres, La Réunion	21.196 S	55.578 E	1520.0	25-Jul-1982			9-Feb-1986	RER
RA	SEY	Seymchan, CEI	62.933 N	152.373 E	206.0			21-Sep-1990	27-Jan-1994	SEY
	WFM	Westford, Massachusetts, USA	42.611 N	71.491 W	87.5	17-May-1984	9-Apr-1986		26-Apr-1994	closed

RA = Remotely Accessible.

Historic evolution since 1982.

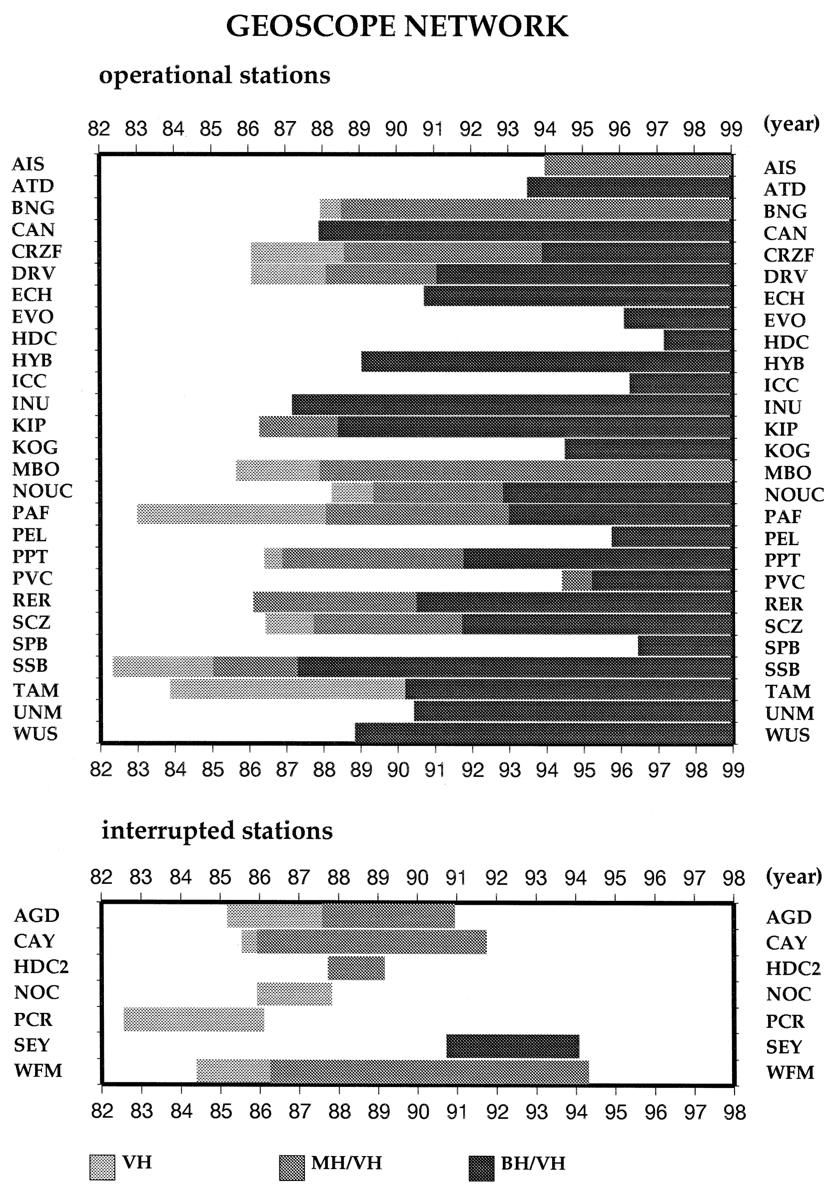

Fig. 2. Data configuration for GEOSCOPE stations from 1982 up to now. Top: available stations. Bottom: interrupted stations.

seismic data are also continuously recorded on a magneto-optical disk at 20 sps. This method designed by the Technical Division at Saint-Maur has been implemented since 1992 in 10 stations, UNM, SCZ, ATD, WUS, KOG, HYB, PEL, SPB, HDC and RER (Fig. 1, red dots). It gives satisfactory results. The system will be implemented in other stations in the next years. An eleventh station, PVC, maintained by EOST is also recording continuously the VBB channel.

Since 1997, in all stations the time reference is given by a GPS clock. In the future (Montagner et al., 1998) a satellite transmission system will be installed in 10 stations, in cooperation with the french military agency CEA/DASE (see white dots on Fig. 1, and chapter 5-7 on the future).

Table 2
GEOSCOPE instrument acronyms, equivalence between GEOSCOPE and SEED namings

Geoscope instrument acronyms

GEOSCOPE naming	Channel	Band-pass	Sampling rate	SEED naming	Units
VLP	Very long period	150–3600 s	0.1 sps for stations in BB/VLP configuration	VH	m/s** 2
VLP	Very long period	20–360 s	0.1 sps for stations in VBB configuration	VH	m/s
LP	Long period	3–360 s	1 sps	LH	m/s
HGLP	Long period	20 s–3600 s	1 sps	LP	m/s** 2
BRB	Broad band	1 Hz–360 s	5 sps	MH	m/s
VBB	Very broad band	5 Hz–360 s	20 sps	BH	m/s

In terms of siting locations, the aim of the GEOSCOPE program is almost fulfilled; we plan to install only two new stations.

(1) Russia: We explored the possibility for installing a station in a northern site near Vorkouta with our colleagues at IIEPTMG (Moscow). It will be done in 1998.

(2) West Indies: We plan to install a STS2 or a STS1 in West Indies, in VBB configuration.

After the installation of these two last stations, our goal is to complete the transformation of all the stations in VBB configuration (with the Quanterra 24 bit or the delta-sygma 20^{+} bit digitizers) in order to improve their quality (both African stations, BNG and MBO are still in BRB/VLP configuration).

3. The GEOSCOPE Data Center

The GEOSCOPE Data Center is organized since 1992 around the master piece of the Center, a juke-box of 300 Gbytes. All incoming data are stored on the juke-box after time corrections using comparisons between reference GPS clock and internal clock time, data quality control and determination of the corresponding instrumental responses.

The media on which the data are stored depend on the date of data; we get three different media, on CD-ROM for data spanning time from 1982 to 1991, on a disk for recent teletransmitted data, and on the juke-box for all data from the beginning of the network in 1982 up to now.

The next page and Fig. 3 summarize the different freeways for getting the data.

In order to facilitate the exchange of data with the scientific community, the juke-box is open to external users and data are easily available through anonymous ftp (ftp geoscope.ipgp.jussieu.fr) or through the WWW GEOSCOPE server (http://geoscope.ipgp.jussieu.fr). The CD-ROM production is separate from the juke-box, and CDROM are skipped by normal mail way.

All recent earthquakes with magnitude greater than 6.3, or with smaller magnitude but with particular scientific interest (location, focal depth, . . .) are teletransmitted to the Data Center at St. Maur, from 16 Geoscope teletransmitted (by phone line) stations. The corresponding data are made available at the Data Center in Paris within one or two days, for two channels, the VH channel (continuous recording with 0.1 sps), the MH channel (triggered with a sampling rate of 5 sps) and for two stations (HDC and KIP) the BH channel (continuous recording with a sampling rate of 20 sps).

All GEOSCOPE existing data from the beginning of the network in 1982 up to now are available from our juke-box. The delay of six months for incoming data from some stations (for example stations located in the Indian Ocean) is due to their accessibility by boat only a few times in a year.

The next challenge of the GEOSCOPE Data Center is to produce the CD-ROM for years 1992–1998 and to make the access to data to the whole scientific community easier. For example, the autoDRM (automatic Data Request Management) procedure described by Kradolfer (1994) will be implemented but adapted to work in SEED format (Standard for Ex-

Fig. 3. The GEOSCOPE WWW homepage http://geoscope.ipgp.jussieu.fr.

change of Earthquake Data). The new procedure called NetDC (Networked Data Centers), whose concept was established by IRIS, in cooperation with other Data Centers, IRIS, GEOFON, ODC (ORFEUS Data Center), UC Berkeley, will be developed also.

4. Data distribution

The four main highways to get the GEOSCOPE data are summarized in the following table.

*W*elcome to the *W*onderful *W*orld of Geoscope Data

FOUR INFORMATION HIGHWAYS TO GET THEM

1—CDROM
Thirty CD-ROM have been distributed worldwide so far. They span the period from March 1982 to December 1991. The reading software is available on every CDROM.

2—The anonymous ftp (ftp geoscope.ipgp.jussieu.fr)

2-1. Recent events of magnitude greater than 6.3 or of particular interest are immediately teletransmitted, from 16 stations remotely accessible (by phone line). These data are available (in seed format) within one or two days, in the directory ‘DATAGEOSCOPE’.

2-2. On the juke-box, all existing data from 1982 to 1997 are available. You can get them through an automatic procedure described in the README file.
ftp geoscope.ipgp.jussieu.fr.
cd INFO-GEOS
get README

3—GEOSCOPE autoDRM (Data Request Management)
You can send your request by e-mail, for all the data available on the juke-box. The format of your request is described later. The data are transferred to a disk and you can retrieve them through anonymous ftp.

4—WWW server (http://geoscope.ipgp.jussieu.fr). See Fig. 3.
Follow the different options. You will find everything you need about the GEOSCOPE program, general information on the GEOSCOPE Program and on the GEOSCOPE group. The « station-book » is on line, with the positions of the stations, the type of sensors, the instrument responses since the beginning of the network in 1982. You can get quasi real-time data for one station, the SSB station (in France). You can do requests from the juke-box database. You can see plots of recent teletransmitted events and get the corresponding data files and the local seismicity. You can obtain the plots of seismic noise levels for all channels and all stations for the year 1995, a list of softwares, the last scientific results of the GEOSCOPE group, links with the other french seismological servers, links with the whole scientist community.It is easy.

PLEASE TRY AND SEE

If you have any problem or suggestion, send it to www.geos@ipgp.jussieu.fr

4.1. CDROM production (for data from 1982 to 1991)

All data from March 1982 (julian date 82.061) to December 1991 (julian date 91.365) are now written on CD-ROMs in SEED format (GEOSCOPE version) and the whole collection is distributed worldwide (without charge) to about 200 users (scientists or laboratories). Thirty CD-ROMs are now available. The CD-ROM#0 and 00, spanning the period from 1982 to 1987, have been produced in 1996. The CD-ROMs produced in 1997 (CD-ROMs #22 to 28) are sent with a new reading software called *reader97* in order to take into account all small errors found on data of previous CD-ROMs (errors on poles and zeroes, or on time corrections, errors on stations location, or on azimuth of sensors, or on sensitivity). The best advice we can give to GEOSCOPE CD-ROMs users is to always extract the reading software from the last CD-ROM received (to be sure to take into account the last version of ERRATA files).

In 1991, the increasing number of stations and of continuous channels was so high that CD-ROM #21 for example only covered 10 days of data instead of 4 years of data for CD-ROM#00 as it can be seen on Fig. 4. It is not possible to produce CD-ROMs with the whole quantity of continuous channels, VLP(VH) at 0.1 sps and LP(LH) at 1 sps; since the production of CD-ROM #22 and for the following CD-ROMs, the LP(LH) channel data (continuous recording at 1 sps) correspond only to events mentioned in USGS global seismicity catalog. The length of these LH files depends on the corresponding magnitude of the events (2 h length for a magnitude 5.5 event, and 11 h for a magnitude 8 event). In the future, we wish to do a better selection by including a procedure of real post-time detection well adapted for each station (in order to be sure not to loose some small events not reported in any seismicity catalog). We plan also to produce higher-density CD-ROMs as DVD-ROMs.

4.1.1. Anonymous ftp for recent events

The remote accessibility is possible in 16 GEOSCOPE teletransmitted stations (green dots on Fig. 1), the list is the following: ATD, CAN, ECH, HDC, HYB, INU, KIP, KOG, NOUC, PEL, PPT, RER, SCZ, SPB, SSB, UNM.

You can get data for all recent events with magnitude greater than 6.3 or with particular interest (location, focal depth, etc.) within one or two days. For that do the following procedure:

ftp geoscope.ipgp.jussieu.fr	
user:	*(enter 'anonymous')*
password:	*(enter your name)*
cd DATAGEOSCOPE	
ls	to see all present files
get vene97190.vh.seed.gz	Venezuela 1997 July 9th, VH channel
get vene97190.mh.seed.gz	Venezuela, 1997 July 9th, MH channel
get vene97190.bh.seed.gz	Venezuela, 1997 July 9th, BH channel (HDC, KIP)
get geopz	poles and zeroes file
get geoloc	positions of the stations
quit	

The data files are in SEED format and compressed (gzip). Since May 1998 our files are written

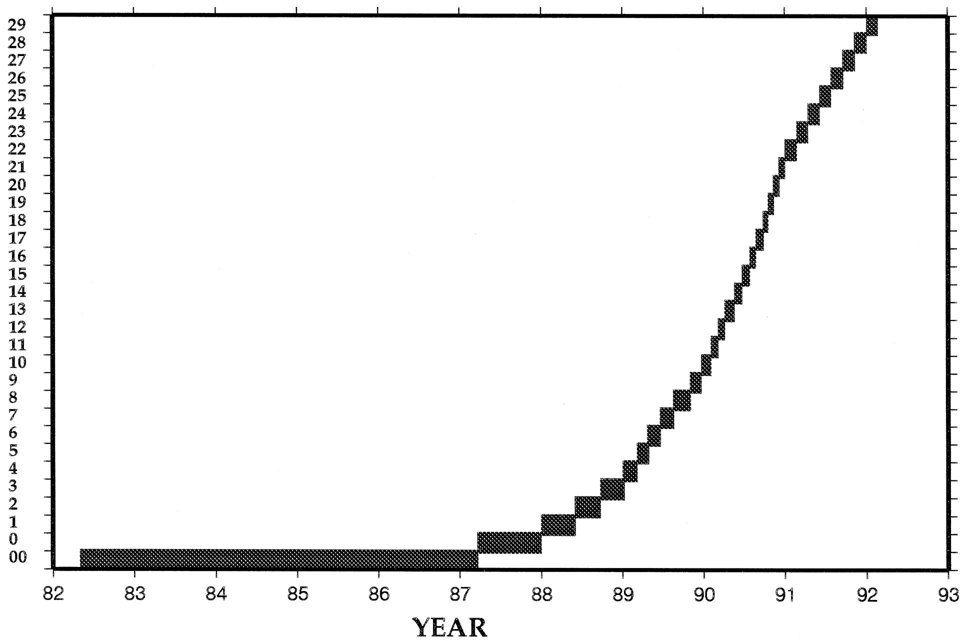

Fig. 4. The CD-ROM production.

in exactly the same SEED format than the one described by the FDSN and IRIS. They will be able to be read with the reference code «rdseed» maintained by IRIS, and all IRIS tools (evalresp...) usable.

4.1.2. Immediate use of the GEOSCOPE database (anonymous ftp for data spanning time from 1982 to present (Fig. 5)

You can retrieve the 'README' file. It will give you a short presentation of the request file.

ftp geoscope.ipgp.jussieu.fr or *ftp 134.157.27.6*

user:	*anonymous*
Password:	*remote_loginname*
> cd	*INFO-GEOS*
> get	*README*
> get rqgeos	(program preparing your request)

The data are in SEED format, easily readible with the rdseed software provided by IRIS.

4.2. The GEOSCOPE AutoDRM (for data spanning time from 1982 up to now, Fig. 5)

You can get data from the juke-box by sending an automatic Data Management Request. It is not the same autoDRM as the one described by Kradolfer (1994). It is a very simple autoDRM.

In the future we plan to install the extended autoDRM, but only with data distribution in SEED format. *Please do the following*

1—you send a message to the Geoscope Data Center

mail geoscope@ipgp.jussieu.fr
rqgeos

SSB RER atd bng	stations (uppermost or lowermost case)
VLP lp brb BH	channels (uppercase or lowercase; SEED or GEOSCOPE naming)
1982,122,10,02	starting time
1982,125,11,40	ending time
97,192,00,00	starting time
97,192,15,30	ending time
1 or 2	1 to know the existing data files, 2 to get the data
people@earth.universe	your e-mail address

2—an e-mail message is sent to inform you of the completion or the failure of your request.

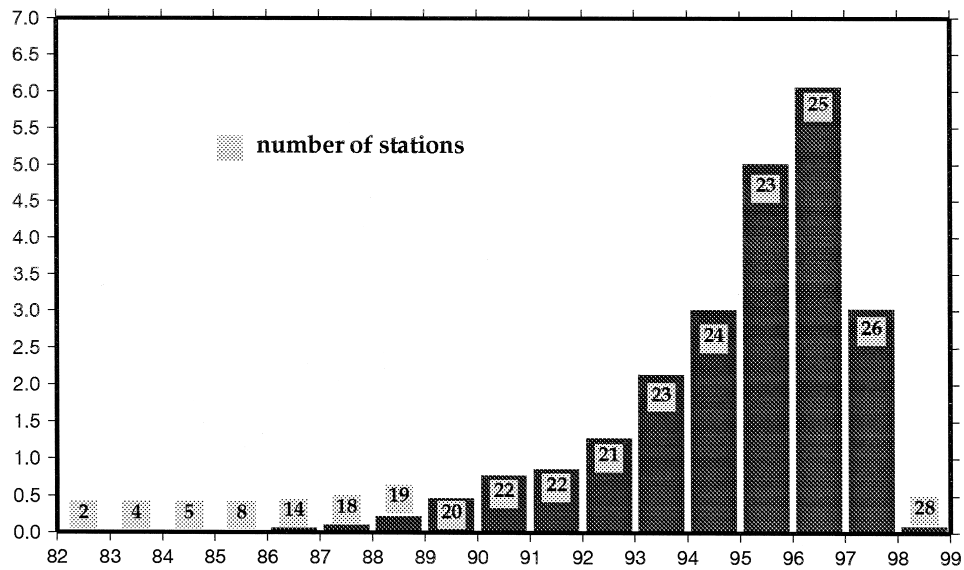

Fig. 5. The instrumental response of the vertical component at WUS station from 1988.305 to present.

3—you can get your data through anonymous ftp as in the last procedure > ftp geoscope.ipgp.jussieu.fr
> cd consulte
> get seism... (if option 2)
> get data... (if option 1 or 2)

The data are in SEED format. Use the same software called rdseed as in the previous paragraphs.

4.3. WWW server http://geoscope.ipgp.jussieu.fr

Of course the easier way for getting data is the Geoscope server, but this way is not always the faster. The homepage is shown in Fig. 3. The GEOSCOPE server provides a complete information on the GEOSCOPE program and on the GEOSCOPE Data Center. The different possibilities of data access are well documented, and a very easy direct access to data spanning time from 1982 to 1998 is proposed.

5. GEOSCOPE activities and facilities

5.1. The GEOSCOPE station book

Contact: michel@geoscop.geoscop.fr and groult@ipgp.jussieu.fr.

On the GEOSCOPE WWW server the totality of the GEOSCOPE station-book is provided; it is updated as soon as there is a modification in a station. Each station is described since its beginning with basic information about the parent organization, the network affiliation, the geology, the vault conditions, the site description, the evolution of instrumentation, the available sensors, the different channels, the dates of upgrade, the sensitivities in the flat part of the band-pass of the instrumental responses. The GEOSCOPE station book is a part of the FDSN station book created by IRIS DMC.

Two photographs of the site and of the sensors are generally provided; you can find all the curves of instrumental responses of the GEOSCOPE stations, for each component (Vertical, North–South and East–West), for each channel VH, LH, MH and BH, for each period of time since the beginning of the network in 1982 (Morand and Roult, 1994, 1996).The file of poles, zeroes and sensitivities is available, and the corresponding plots (in gif and ps format) are easily available (Fig. 6). The GEOSCOPE station book is available either from the WWW server (updated version) or in a paper version (Morand and Roult, 1996).

5.2. Continuous VBB (BH) channels in eleven stations

Contact: fouassie@geoscop.fr and guivene@ipgp.jussieu.fr.

In parallel to the classical recording in a station (triggered BH channel), seimic data are also continuously recorded on a magneto-optical disk at 20 sps. This method, designed by the Technical Division at Saint Maur in cooperation with the french military agency (CEA) is now implemented in 10 stations (red dots on Fig. 1) allowing to be sure not to loose some data with the triggering system. The PVC

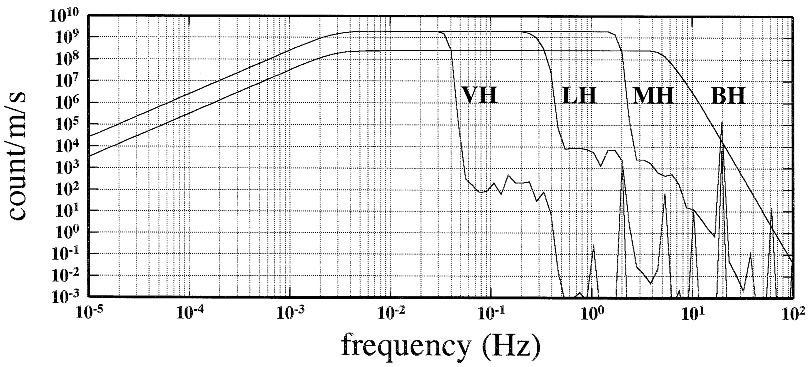

Fig. 6. The GEOSCOPE data available on the juke-box.

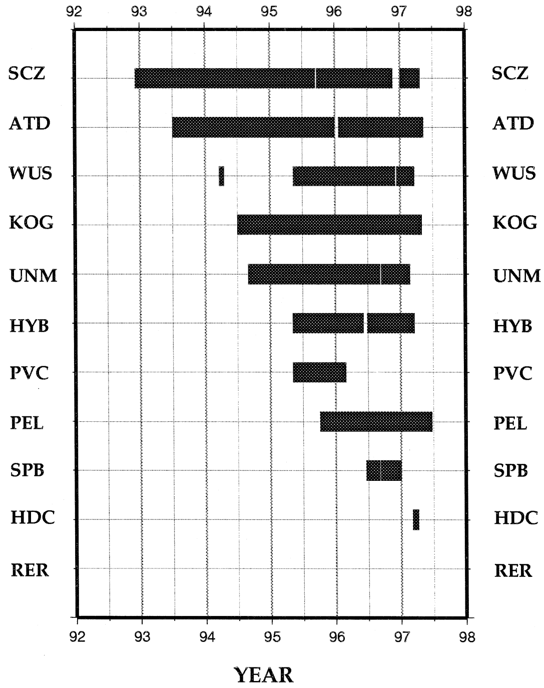

Fig. 7. Stations with available continuous BH data (20 sps).

station located in the Pacific Ocean and maintained by our colleagues of EOST in Strasbourg and ORSTOM in Nouméa (New Caledonia) corresponds to a continuous recording of BH channel at 20 sps. All the corresponding data are written on the juke-box and easily available to the GEOSCOPE data users (Fig. 7) through the different procedures.

5.3. The seismic noise level plots of all GEOSCOPE stations during the year 1995

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The estimate Power Spectral Density have been computed using the method of Chave et al. (1987). The data selection and plots method are derived from a package of MATLAB functions provided by Luciana Astiz from IRIS DMC (Astiz and Kreager, 1998). All figures are easily available (in postscript format) on the GEOSCOPE WWW server (Stutzmann et al., 1999).

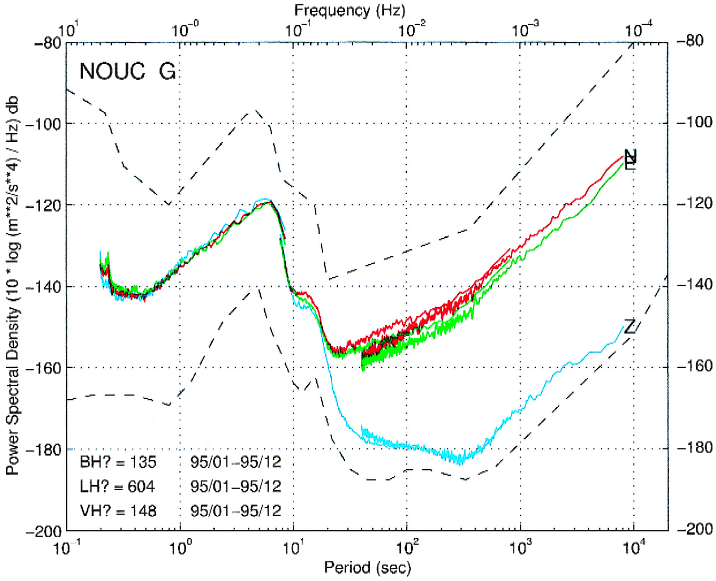
The different examples shown correspond to NOUC station, in New Caledonia.

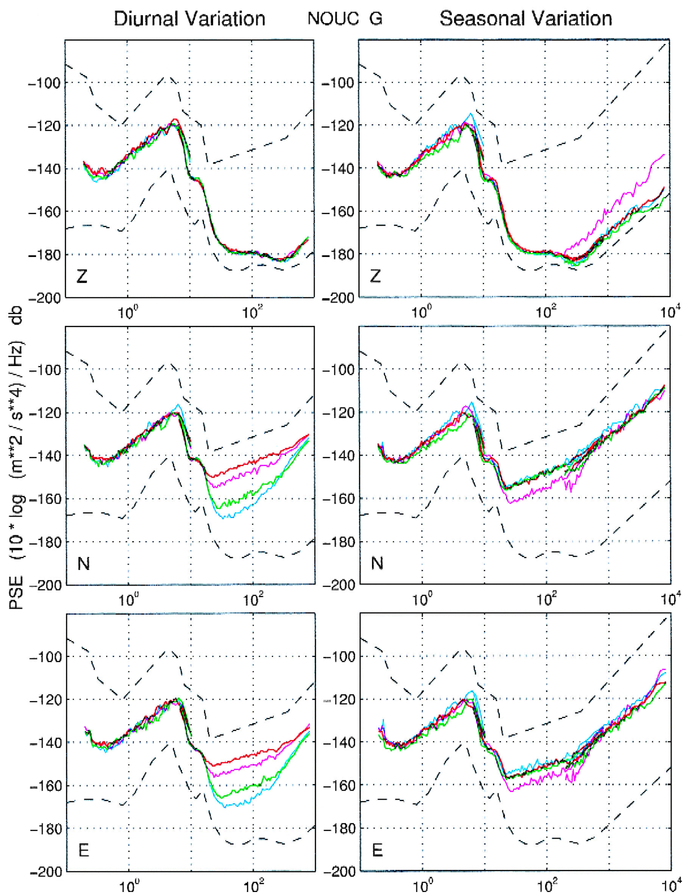
First the annual seismic noise level (Fig. 8 with the Estimate Power Spectral Density presented for the three channels VH, LH and BH, for the three components, Vertical, North–South and East–West. Low noise and high noise levels curves are plotted in dashed lines from Peterson (1993).

Of course the noise level is very low for the vertical component, and higher for both horizontal components, because of the well known stronger sensitivity of horizontal components to variations of pressure. Horizontal components are very sensitive to pressure, vertical components much less (see Beauduin, 1996). Vertical components are more sensitive to temperature because of the spring. The vertical sensors are always in vacuum in order to minimize the pressure effects; some of the horizontal ones are in vacuum, but sometimes only light vacuum. Sensors are installed on a glass plate and are covered with a permalloy shielding (vertical only), with an aluminum shielding and with a glass bell, in order to minimize external effects. Most of glass plates are put on a sand bed (around 2 cm thick); a styrofoam box covered with aluminum is put over each sensor as a protection against fast changes in temperature and air flow.

Second, the diurnal and seasonal seismic noise level (Fig. 8) with the Estimate Power Spectral Density presented for the 3 components, Vertical, North–South and East–West, and respectively for both channels BH and LH (for the diurnal variation on the left) and for the three channels BH, LH and VH (for the seasonal variation on the right). Some very interesting features appear from these figures. For example, on the East–West component diurnal variation (on the left, at the bottom), the noise is

Fig. 8. Seismic Noise at NOUC station during year 1995. Top figure: annual seismic noise level plots: The number of sequences used for each channel is printed in the lower left corner. High and low noise levels are plotted in dashed line from Peterson (1993). blue: Vertical component; red: North–South component; green: East–West component. Bottom six figures: Seismic noise level plots for the three components (top: Vertical component; middle: North–South component; bottom: East–West component). On the left: diurnal variations for channels BH and LH. blue curve: 0–6 h; pink curve: 6–12 h; red curve: 12–18 h; green curve: 18–24 h. On the right: seasonal variations for channels BH, LH and VH. blue: first quarter; pink: second quarter; red: third quarter; green: fourth quarter.


Frequency (Hz)
NOUC G
Power Spectral Density (10 * log (m**2/s**4) / Hz) db
BH? = 135 95/01–95/12
LH? = 604 95/01–95/12
VH? = 148 95/01–95/12
Period (sec)
N
E
Z


Diurnal Variation
NOUC G
Seasonal Variation
PSE (10 * log (m**2 / s**4) / Hz) db
Z
N
E

very low during the night, and is growing at dawn when the wind arises, is maximum during afternoon and is decreasing later on. The local known wind is well seen on our curves.

As for the seasonal variation, on the vertical component (on the right, at the top), the noise is higher during the second quarter of the year (from April to June), which is the period of maximum of trade-winds on the New Caledonian region. The effect is higher on the vertical component than on the horizontal ones.

These features demonstrate that it is now absolutely necessary to install in each station a set of microbarometers and microthermometers, in order to get measurements not only of the pressure and of the temperature but also of the gradient of pressure and temperature, in order to take these effects into account (Beauduin, 1996; Beauduin et al., 1996a,b) and to remove them, enhancing the signal to noise ratio. The concept of geophysical observatory is very important (Montagner et al., 1998) and it represents the near challenge.

5.4. The French SSB station recorded in quasi real-time data

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Data are received from the GEOSCOPE SSB station located in Massif Central in France at the GEOSCOPE Data Center in Paris in quasi real-time. Every hour we get data for three 20-min length files, for the MH channel (in fact the BH channel decimated at 5 sps).

In the future we will get data for the BH channel. The data are immediately and automatically stored on a disk, and the corresponding plots available on the GEOSCOPE WWW server. Data are stored during two days. An example is shown on Fig. 9. The interest is to get immediately and continuously data from the french station. The procedure will be implemented in other stations, if the local institution in charge of the station (University or Research Center) is not too far and is interested in the rapid acquisition of local data.

5.5. GEOSCOPE CMT determination

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A simple inversion method (Gouget, 1996) for the fundamental mode Rayleigh wave spectra has made possible the rapid determination of the mechanism and the seismic moments of events large enough to excite several successive wave trains. The aim was to develop a routine method to retrieve source parameters in a laterally heterogeneous Earth model. This method of inversion of CMT is valid for any Earth model (laterally homogeneous or heterogeneous). The demonstration is done that a correct CMT can be retrieved by using few stations, and that in a laterally heterogeneous Earth, geometrical fault parameters are more finely determined than in a spherical Earth. An example of such an inversion is shown for the Minahassa event of November 25th, 1997 teletransmitted from 11 GEOSCOPE stations whose data were provided within 2 days after the event, in Fig. 10. This will be done routinely for all teletransmitted events with magnitude greater than 6.8.

5.6. The NETDC procedure

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The basic idea of NETDC is to make the access to data transparent to the user. The user should not bother about where to ask for data, the routing of the data request should be solved by the coordinating data centers. Actually different Data Centers are providing GEOSCOPE data. For example our data are available in the GEOSCOPE Data Center in Paris, in the IRIS DMC (Data Management Center) of Seattle, in the ODC (Orfeus Data Center) of de Bilt in Netherlands for the european stations, in Oxford University (UK) for the complete collection of CD-ROMs.

The NETDC procedure will avoid duplication of broadband data in several Data Centers, with the necessity to take into account possible errata on data sometimes found a few years after; of course data are instantaneously upgraded in the GEOSCOPE Data Center of Paris.

The explosion of new networks in the past decade, the increasing influx of seismic data, the necessity for dissemination of large datasets to the seismic community leads to the need of a new form of distribution with cooperative environment between the different participating data centers.

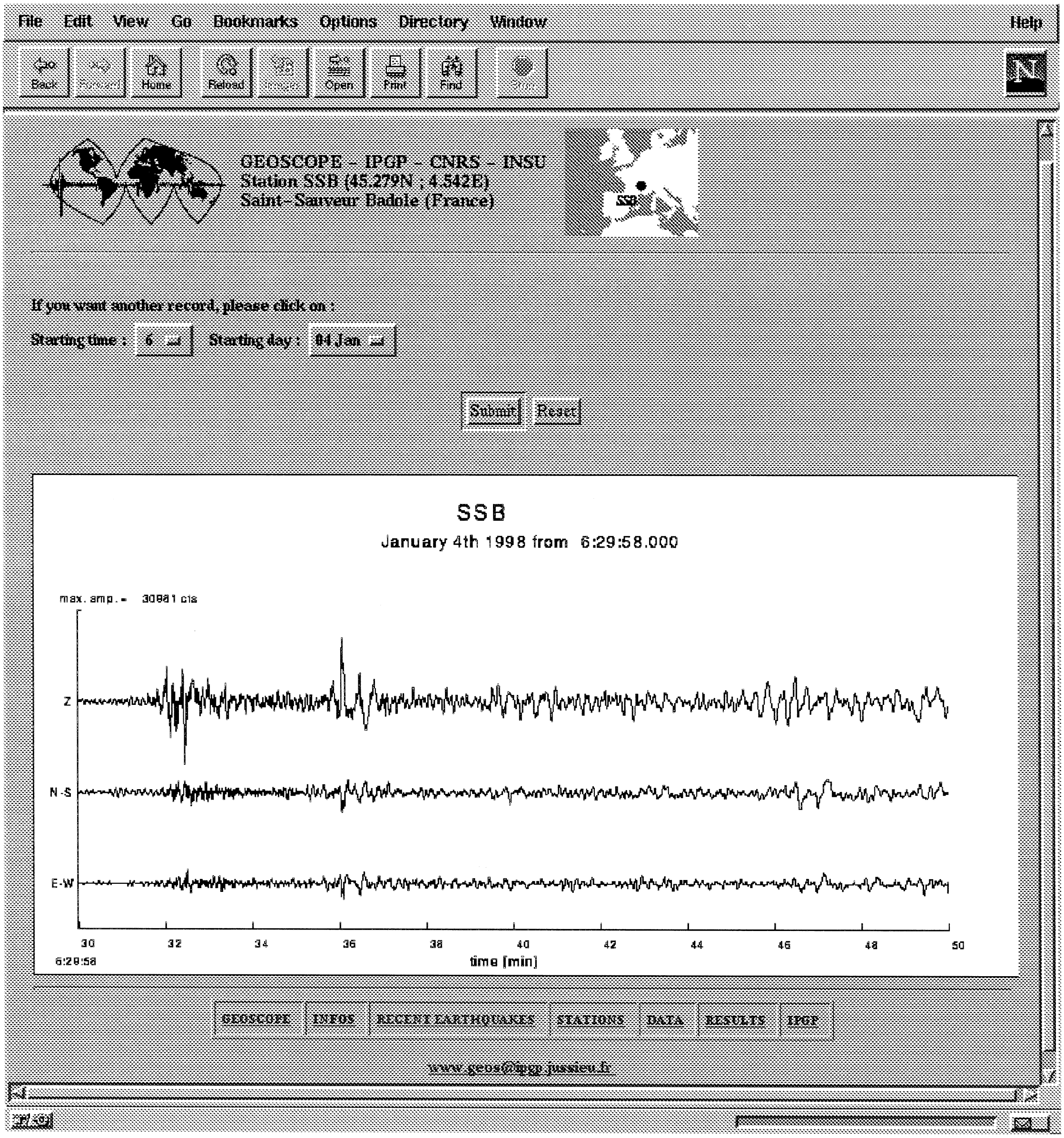

Fig. 9. SSB station (in Massif Central, France) in quasi real-time. Each record corresponds to 20 mn length of MH channel (decimated BH channel).

The NETDC (Networked Data Centers) procedure answers this question, with the possibility for any scientist to get data from any Data Center in the world. The corresponding protocol was designed by IRIS (Ahern et al., 1995; Casey and Ahern, 1996 personal communication) and actually the INVENTORY information is working in a few institutions, the IRIS DMC in Seattle, the GEOSCOPE Data Center in Paris (netdc@ipgp.jussieu.fr), the GEOFON Data Center in Potsdam (Germany) and the NCEDC (Northern California Earthquake Data Center) at UC Berkeley. The concept is the following: each site maintains its own seismic network, but is also able to access to all the data offered by the other

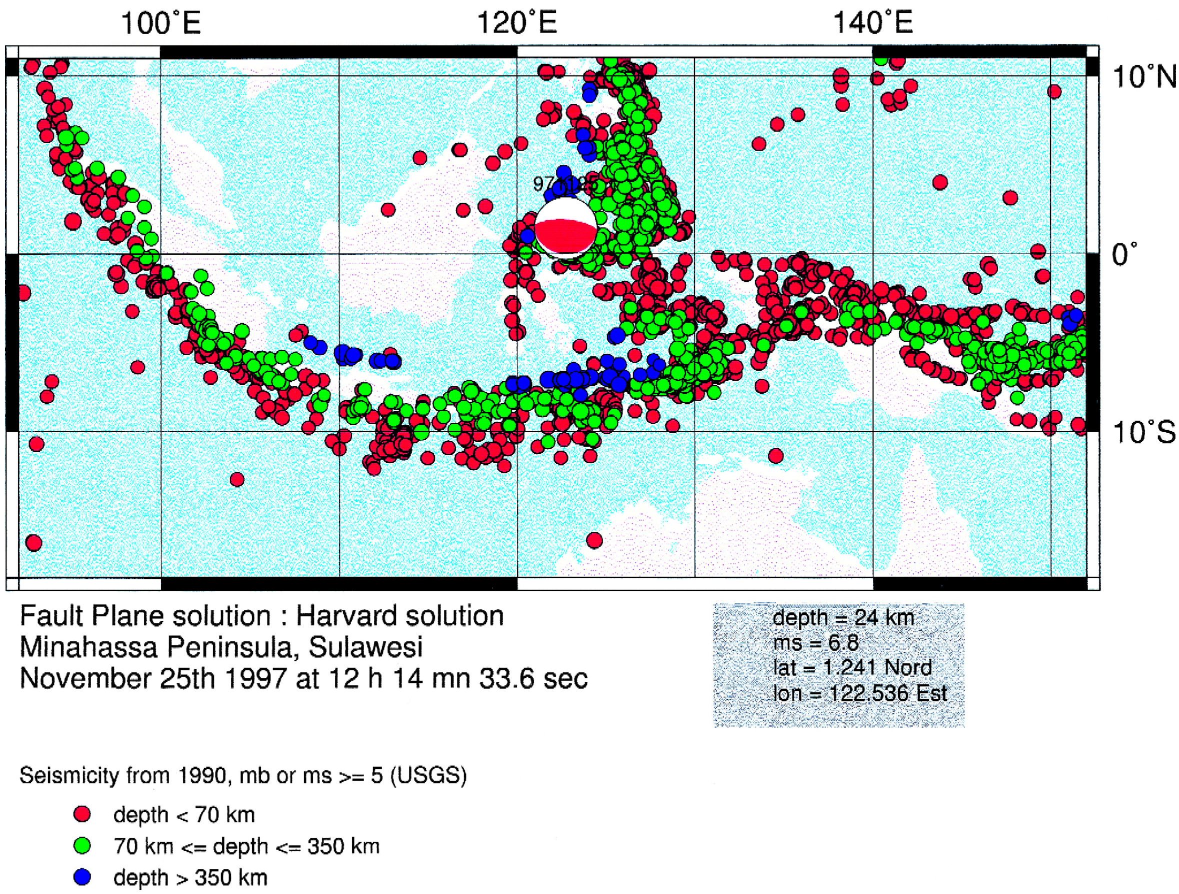

Fig. 10. Example of GEOSCOPE CMT determination. Event of Minahassa Peninsula of November 25th, 1997.

networked data centers (through Internet). The scientist may request data from a single point of contact access information. This procedure has to be encouraged and implemented in many Data Centers.

5.7. The future

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In the future all GEOSCOPE stations will be equipped, not only with seismometers but also with microthermometers, microbarometers, inclinometers, POS sensors, short period seismometers, GPS. The new acquisition chain designed by DT/INSU in Saint Maur and the manufacturer AGECODAGIS in Toulouse (France) is able to provide recordings from 22 channels. These 22 channels correspond to 6 main channels in 24 bit for ground velocity and POS measurements (recorded continuously at 20 sps and triggered at 80 sps for the STS2 seismometer), and 16 auxiliary channels in 16 bit continuously recorded with a sampling rate of 1,6 s. This new concept is called GEOSCOPE 2000.

In the framework of the Test Ban Treaty, some stations of the GEOSCOPE network have been chosen to be teletransmitted by satellite in real-time, and 10 stations will be equipped in that purpose with help of the french military agency CEA/DASE in the next years (white dots on Fig. 1). Three stations with high noise level, KOG, MBO and BNG have to be moved in quieter sites before installation of satellite teletransmission. WUS station equipment will be installed through a direct cooperation between GEOSCOPE and the SSB (State Seismological Bureau) of Beijing in China. AIS station in the Indian Ocean will be equipped during 1998 in the framework of the cooperation between IRIS and GEOSCOPE.

6. Conclusion

The GEOSCOPE data are now well known worldwide, and the number of users and of requests is increasing with time. Fig. 11 shows the comparison of the country access to GEOSCOPE data for year 1996, through the GEOSCOPE WWW server and through our anonymous ftp. Of course the procedure by anonymous ftp is more often used, with a volume of 53 gigabytes for year 1996 instead of 2 gigabytes through the WWW server for the same year, certainly because of the higher rapidity by the first procedure. French scientific community seems to prefer the convivial WWW procedure, but not foreign users, certainly because of easier way in case of multiple requests. American people is the most important group of users. Our statistics are underestimated; GEOSCOPE data are also available in other Data Centers as IRIS DMC in Seattle (data from 1982 to 1995, except year 1994), in the ODC Center (Orfeus) in the Netherlands for the European stations, and in Oxford University in UK (for the CD-ROM data), so some GEOSCOPE users and requests are not taken into account in our statistic plots.

With the deployment of local, regional and global networks in the past 10 years, the amount of high quality digital seismic data has exponentially increased; the seismologist community is now wishing an easy access to these data, and it is absolutely necessary to answer to new problems involved by the seismic data storage and retrieval. New standardized protocols have to be discussed in order to serve the scientific community with a greater scope of data, and with coordinated access tools.

The purpose of the GEOSCOPE Program for the next decade is not to increase the number of stations, but to provide the seismologist community with high quality data, not only seismic data but also other geophysical data (pressure, temperature, etc.) in order to increase the signal to noise ratio. The challenge of the GEOSCOPE Data Center is to offer to the seismic community a performing central data archiving system, to get a clear and easy distributed data request processing and to provide new services management.

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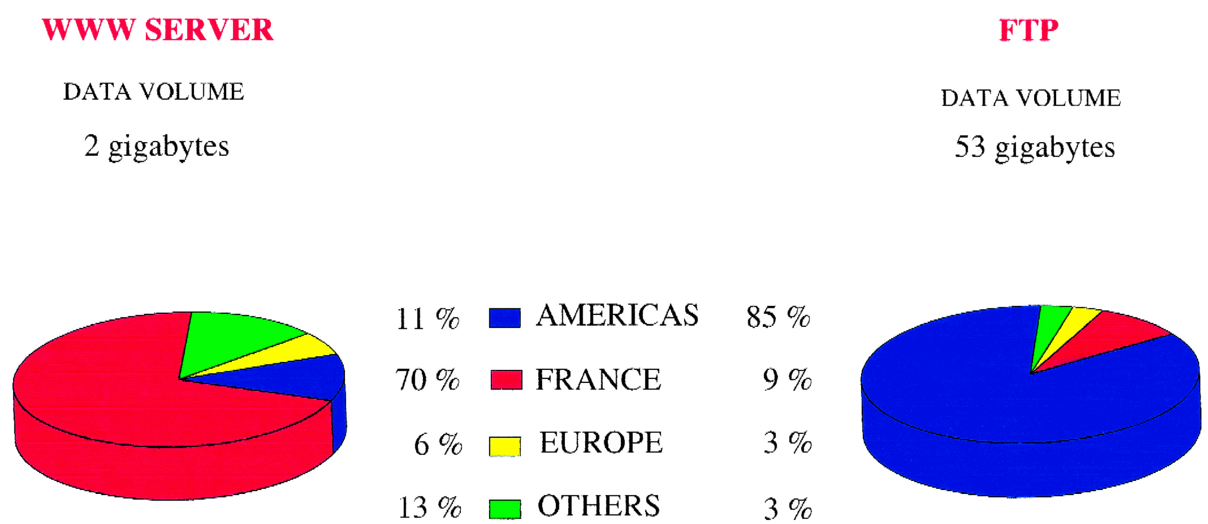

Fig. 11. Country access to GEOSCOPE data for year 1996. Left: through the GEOSCOPE WWW server (http://geoscope.ipgp.jussieu.fr). Right: through the GEOSCOPE anonymous ftp (ftp geoscope.ipgp.jussieu.fr).

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