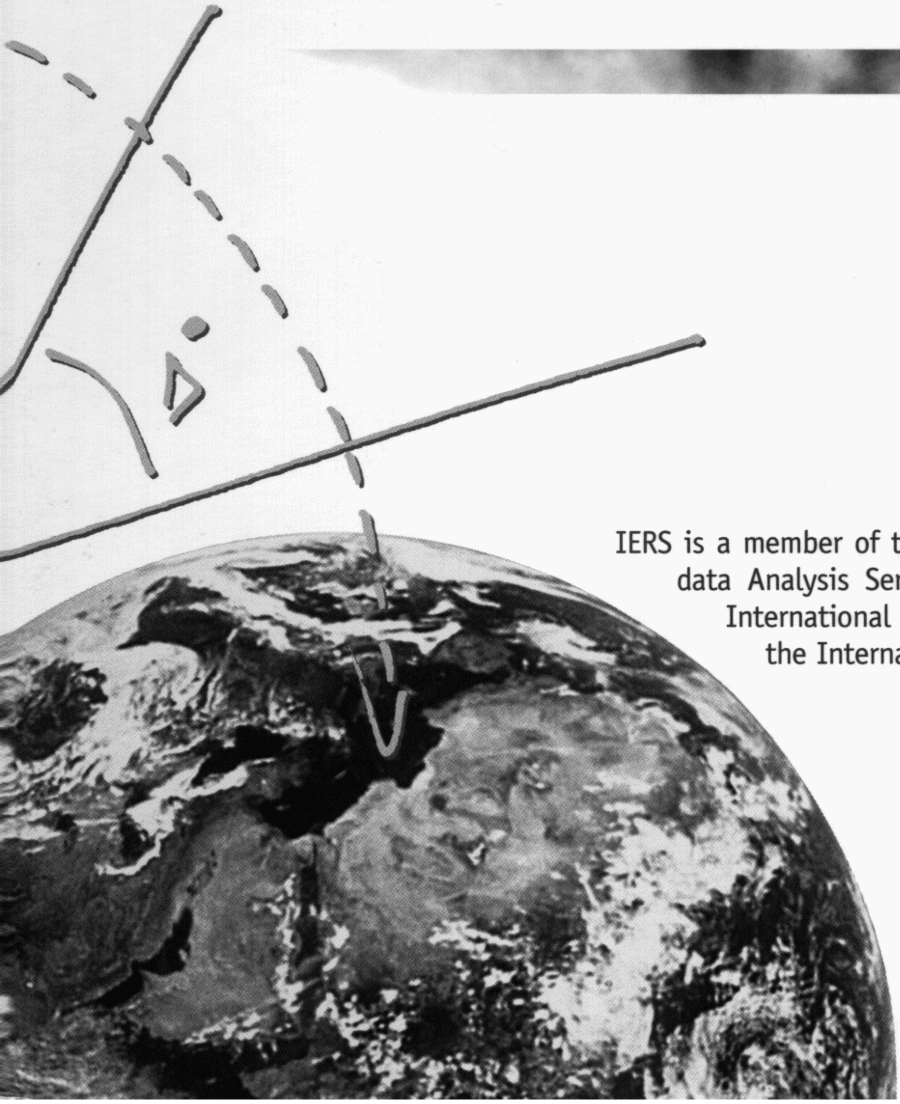
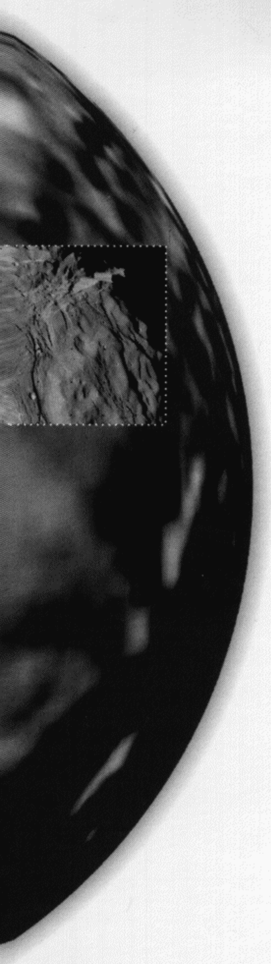
International Earth Rotation Service (I.E.R.S)

Service International de la Rotation Terrestre

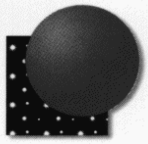


IERS is a member of the Federation of Astronomical and Geophysical data Analysis Services (FAGS). It was created in 1988 by the International Union of Geodesy and Geophysics (IUGG) and the International Astronomical Union (IAU).



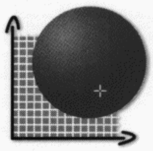
IERS Missions

Provide celestial reference frame as required for



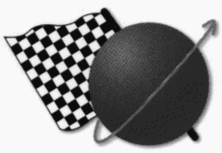
- International Astronomical Union needs
- Earth orientation determination
- Astronomical and geophysical research

Provide terrestrial reference frame as required for



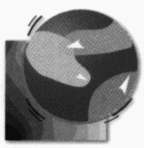
- Earth orientation determination
- Artificial satellite orbit determination
- Terrestrial positioning
- Monitoring of sea level and other geodynamical processes

Provide Earth orientation data as required for



- Terrestrial and space navigation/positioning
- Artificial satellite orbit determination
- Astronomical and geophysical research

Provide permanent information on the fluid Earth layer for



- Dynamics of the atmosphere and ocean
- Hydrological mass balance
- Dynamics of the liquid core
- Variations of the Earth's centre of mass and geopotential field
- Understanding of the rheological properties of the solid Earth

IERS Organisation

The IERS makes use of the precise space geodesy techniques : VLBI, LLR, GPS, SLR, and DORIS.

The activities involve the voluntary contributions of many groups throughout the world that interact closely with each other in **improving the techniques for the acquisition and processing of the data** and in **using the results for scientific investigations.**

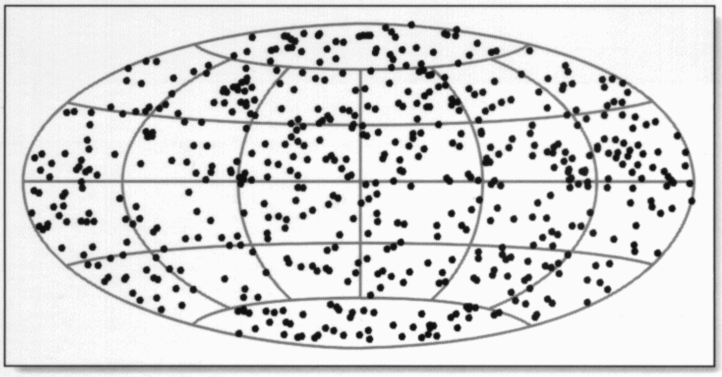
The observations are collected in networks organized under the responsibility of **the IERS Technique Coordinating Centres.** They are archived in data centres and distributed to **Analysis Centres.** Some of the centres contribute, in operational mode, earth-orientation data to **the Sub-Bureau for Rapid Service and Predictions** and to **the Central Bureau.** Most Analysis Centres produce global solutions based on many years of observations. The Central Bureau combines the various types of results to obtain the global IERS products.

The operations include some overlap and redundancy in order to insure the permanent availability and the long term consistency of the products. **A special effort is made to optimize the colocation of stations of the various techniques.**

Results are disseminated to the user community in **Bulletins, Annual Reports, Technical Notes** and **electronically accessed data bases.** The **IERS Conventions** describe the models that are used in the data analysis. The distribution includes about 1000 institutes in over 60 countries: space-geodesy and astronomical observatories, geodetic institutes, universities, time services.

The IERS monitors the global mass motions and angular momentum of the fluid constituents of the Earth.

IERS Astronomical Products



The International Celestial Reference System (ICRS)

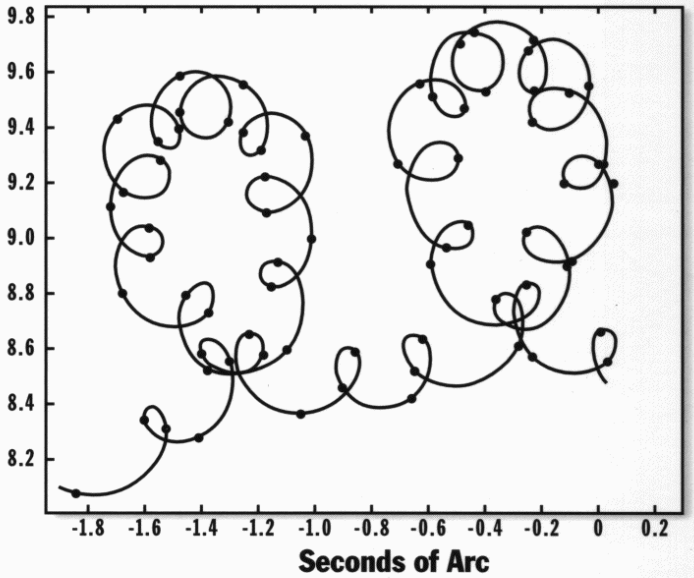
The International Celestial Reference System (ICRS) is defined and maintained by the IERS. It is adopted as the reference for solar system ephemerides used in planetary navigation. **The galactic Hipparcos reference frame is tied to the ICRS.**

The **ICRS** is accessible by the **International Celestial Reference Frame (ICRF)** which consists of coordinates of compact extragalactic radio sources observed with **VLBI**. Its current realization contains about 500 extragalactic objects, mostly quasars and galactic nuclei, spanning distances up to 12 billions lightyears. Half of these objects have positions known within ±0.4 milliarcseconds. It is extended and improved as new information becomes available, while maintaining the stability of its reference directions within ±0.02 milliarcseconds.

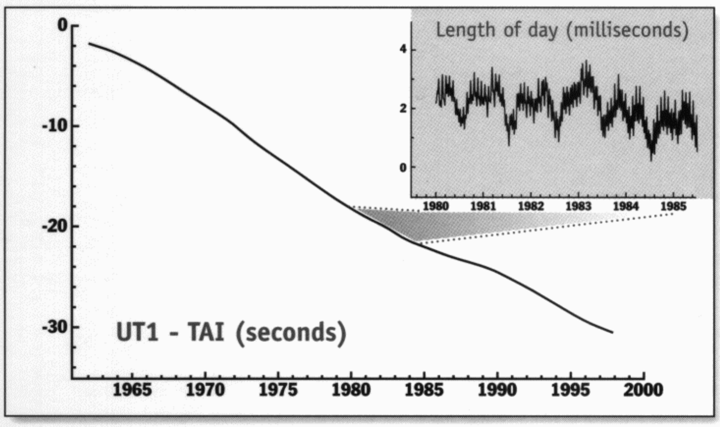
The International Celestial Reference System

Precession and Nutation is the motion of the rotation axis in space that results from the response of non-rigid Earth to the gravitational action of the Moon, Sun and planets, as well as from free rotational modes. The figure shows a detail of the motion, with fortnightly loops superimposed on the annual ones. The long-term components, such as the precession constant and the 18.6 year oscillation that can give unique information on the structure and properties of the solid Earth, are not yet known with adequate accuracy.

Precession and Nutation



UT1 Universal Time



Universal time (UT1) is the time of the Earth clock, which performs one revolution in about 24h. The excess revolution time is called length of day (LOD). It is measured as differences with the atomic time scale TAI (Temps Atomique International). The variations of UT1 are in part of tidal origin and contain valuable information about the global Earth properties. They also reflect the variations in atmospheric and oceanic circulation as well as the liquid core dynamics. They are non-stationary, hence hardly predictable. **IERS** therefore has to maintain both long-term homogeneity and high rate and rapid turnaround observations and analysis. The current accuracy of UT1 and LOD determinations is 0.02 ms.

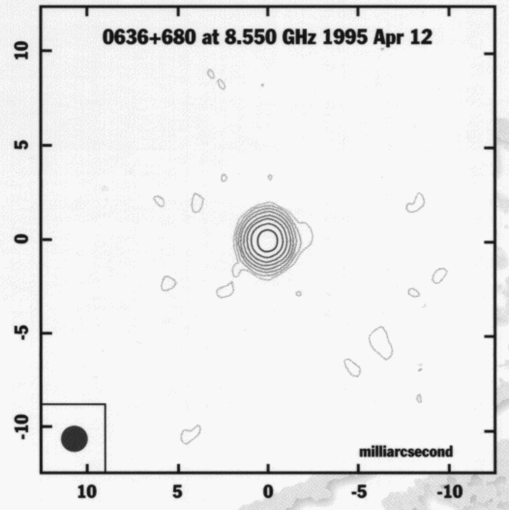
The Observation Progra

IERS relies on a variety of observing programs by the major techniques of space navigation, space geodesy
coordinated use by IERS is an efficient means for propagating unified references into extragalactic and ga

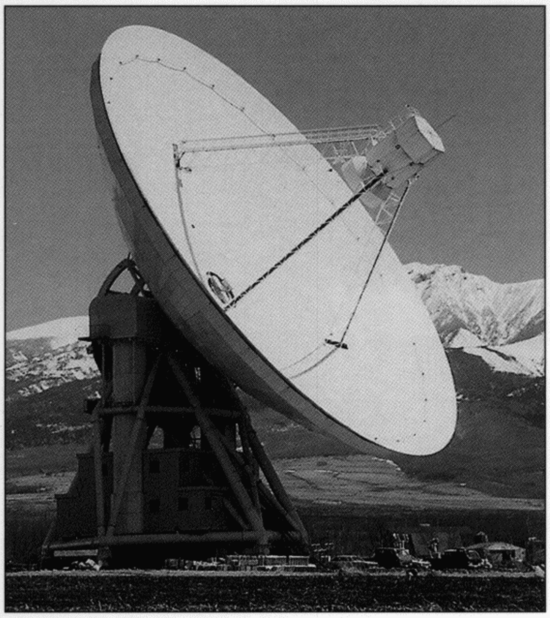
VLBI

Very Long Baseline radio Interferometry

defines and maintains the extragalactic celestial frame. It holds together the International Celestial and Terrestrial Reference Systems. It provides the long-term monitoring of universal time, precession and nutation.



One of the extragalactic radiosources regularly observed with VLBI to maintain the ICRF. The lines show levels of radiated energy. The position of the light centre of this object is measured with an accuracy of 0.0002 ".

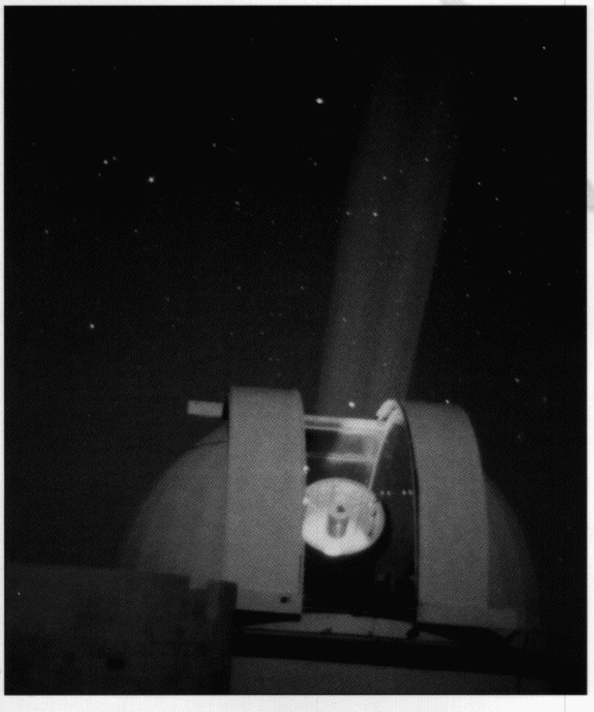


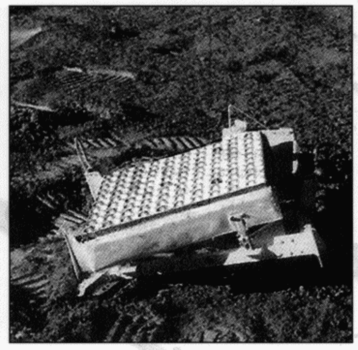
The VLBI antennas used for IERS have diameters ranging from 9 m to 70 m. They are operated in several tens of sites. The precision of observations of the interferometric time delay is 10 picoseconds.

LLR

Lunar Laser Ranging

In addition to its value for lunar sciences and the theory of gravitation, LLR is a key IERS technique to determine the orientation of the dynamical frame of the Solar System in the ICRS.





Laser reflector arays were deposited on the Moon by the Apollo and Lunakhod missions. Their areas are about 1 m^2. Four of them are ranged regularly.

Laser stations are used to range the Lunar reflectors (three stations) or artificial satellites (several tens of stations). The ranging accuracy is 1 mm to 1 cm.

SLR

Satellite Laser Ranging

provides the lon
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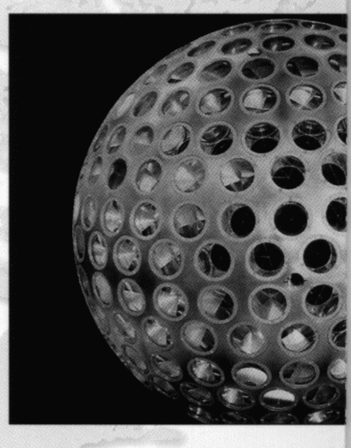
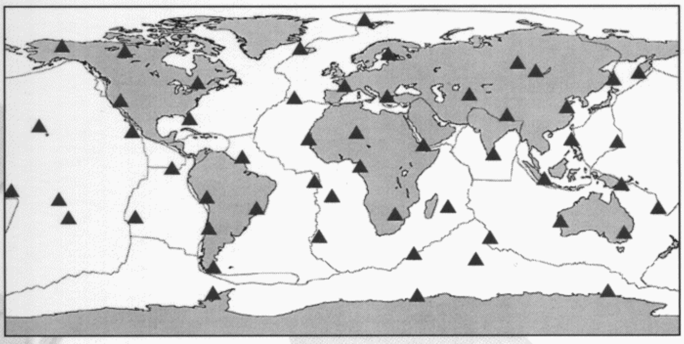
ring of the gravit
is the only satell



ms that support IERS

d astrometry, as well as on world climate centres. These techniques have many other applications. Their ctic research, in solar system investigations, and in global studies of the planet and its environment.

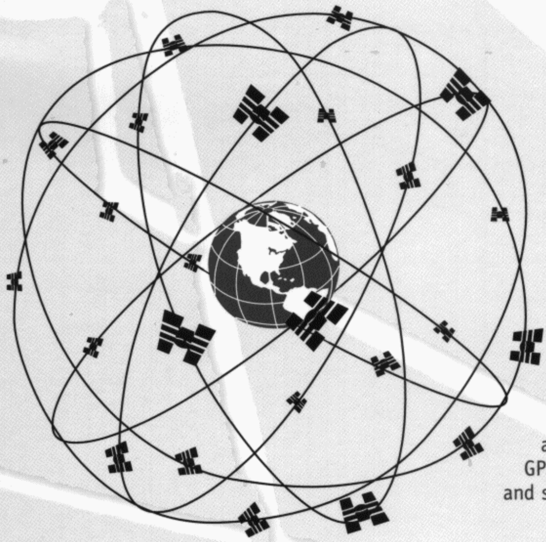


DORIS

Doppler Orbit determination and Radiopositionning Integrated on Satellite

provides the long term monitoring of the plate motions and of the mean sea level in the ITRS. Among its strengths are a globally distributed and homogeneous network, and the long term commitment of the sponsoring agency.

DORIS is a radioelectric system operated by CNES. The permanent ground segment includes 49 beacons globally distributed. The space segment collects Doppler observations of the beacons. DORIS is the nominal orbitography system of several current and planned space oceanography missions, with altitudes of 1000-2000 km.



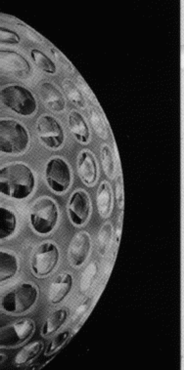
GPS

Global Positioning System

A worldwide network of GPS stations is operated jointly with the International GPS Service for Geodynamics (IGS) or global applications of interest to IERS. Polar motion and the high-frequency variations of universal time are determined daily. A major strength of GPS for IERS is the capability of fine and accurate densification of the ITRS.

GPS is a radioelectric system operated by the US Department of Defense. It includes 24 satellites at an altitude of 20 000 km. At least four satellites are visible simultaneously at any time from most locations in the world. GPS positioning is used in a wide variety of civil and scientific applications.

erm stability for polar motion, for the tie arth's center of mass, and for the monito- eld and slow deformations of the Earth. It technique with a passive space segment.

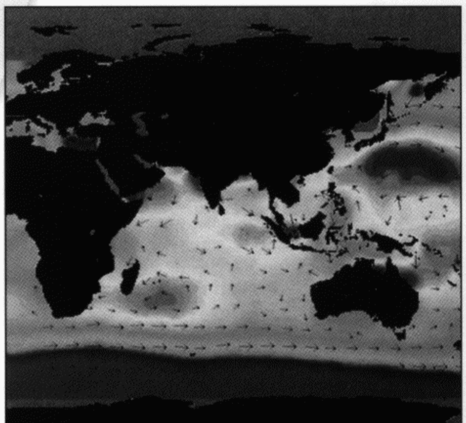


Lageos is the major SLR target used for IERS. It is a 60 cm diameter metallic sphere covered with retroreflectors, cruising at an altitude of 6000 km. It was launched in 1976 by NASA and will remain an excellent geodetic target for tens of thousands years.

MGGF

Monitoring Global Geophysical Fluids

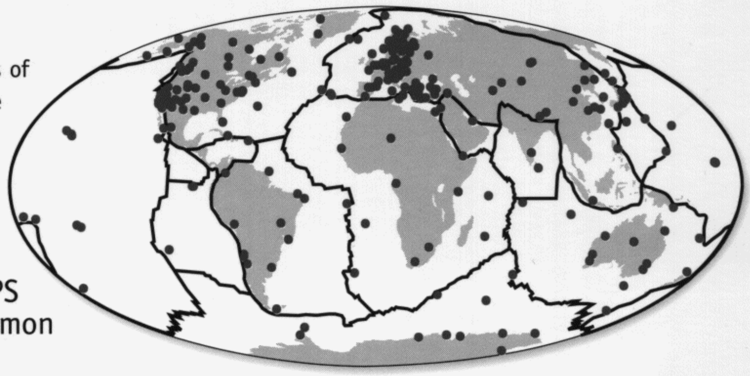
The major Earth system fluid components, i.e., the atmosphere, hydrosphere, and the core participate in forcing motions of the Earth, including universal time and motion of the pole in space and in the Earth, and to modify the Earth's gravitational field and the motion of the centre of mass. Moreover, effects of the ocean tides comprise a special type of forcing by the oceans. Ancillary aspects of properties of the fluids such as the atmosphere, must be considered to properly interpret signals derived from the techniques of space geodesyrelevant to the IERS mission. The Coordinated Monitoring Global Geophysical Fluids by the IERS centres consists of receiving or calculating, distributing, archiving, and analyzing data related to each of the fluids for Earth rotation-related purposes.



The International Terrestrial Reference System

The International Terrestrial Reference System (ITRS) is defined and maintained by the IERS. The ITRS is accessible by sets of coordinates and velocities of space geodesy observing sites, the International Terrestrial Reference Frame (ITRF). It is made geocentric through the use of Earth satellite observations. It is tied to the extragalactic reference system through the use of VLBI. A key aspect of this combination is the colocation of observing stations of the various techniques at common sites, either in a permanent mode or by repeated occupations.

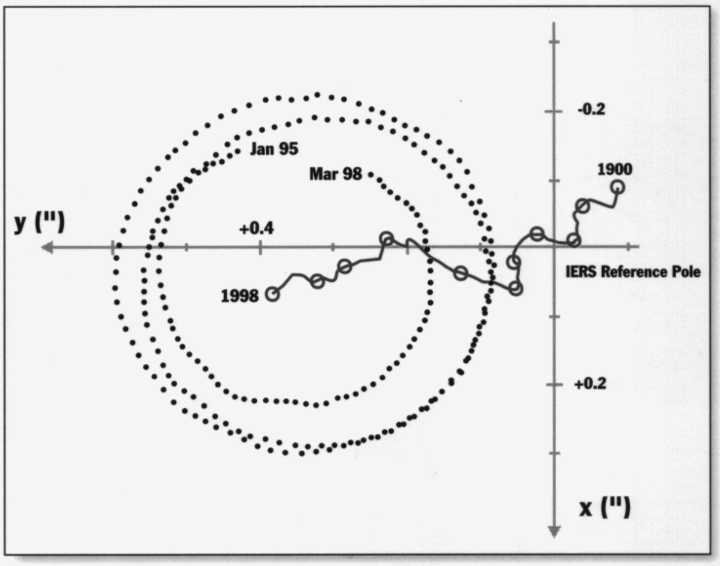
The latest realization of the ITRF gives coordinates of 300 sites with an accuracy of 1 to 3 cm, and site velocities within 2 to 8 mm/year. It samples all the major tectonic plates and most of the small ones. The figure shows the continents and plate boudaries, and the IERS sites.

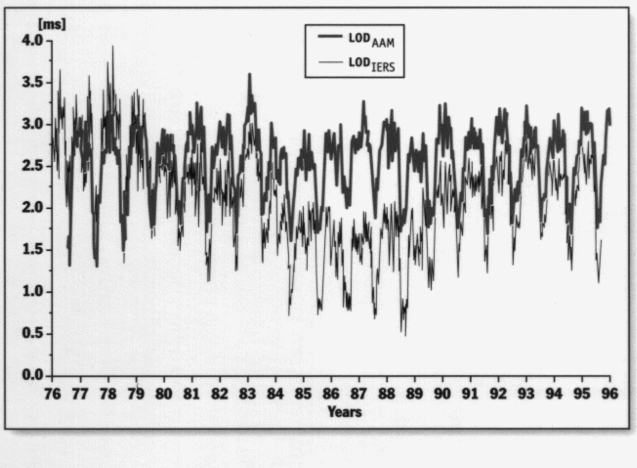


The ITRF is densified with regional GPS networks using some sites in common with it.

Polar motion

Polar motion. The rotation axis of the Earth moves relative to the crust in a complex manner. A free oscillation with period about 430 days and an annual oscillation forced by the seasonal displacement of air and water masses, beating whith each other, give the characteristic pulsating shape of the motion. The mean pole has an irregular drift in the direction to 80° West. Short-term irregularities are produced by the mass motions such as those in the atmosphere. Daily measurements of polar motion have a precision of 1 cm.

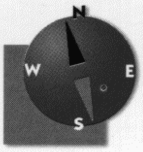




Fluid layers dynamics

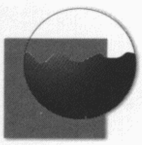
LOD variations. They include variations induced by the tides of the solid Earth and oceans (not shown) and by the changes in the atmospheric angular momentum (AAM). The atmospheric excitation can be split into a seasonal term, residual oscillations with pseudo-periods ranging from days to months, and large anomalies like the one associated with the 1982/83 **El Niño** event. The dynamical influence of the liquid core of the Earth and the climatic variations in the atmosphere account for slow variations.

The Users of IERS



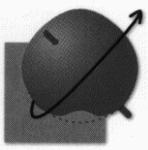
From positioning to navigation

The IERS Earth orientation, terrestrial and celestial references are the basic references in positioning, navigation, orbit maintenance and solar system navigation.



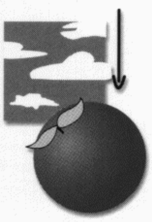
Terrestrial references for geodynamics

The IERS terrestrial references are adopted in an increasing number of scientific and operational programs. Typical applications are the use as underlying reference for national spatial reference systems, tectonic studies based on repeated campaigns, tying of tide gauges for the monitoring of the world ocean level, and support for space oceanography missions.



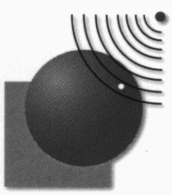
Geophysics

Rotation is a major feature of our planet's motion. Its complex irregularities reflect the dynamic exchanges among the solid, viscous, liquid and gaseous layers of the Earth. They give information about these various constituents that cannot be obtained easily, if at all, by other means.



Climatic change

The IERS makes available global parameters that describe the dynamics of the fluid layers of the Erath. The satellite geodesy programs used in the IERS give access to the time variations of the Earth's shape, as well as the redistribution of masses in the planet. This makes it possible to investigate global phenomena such as mass redistributions in the atmosphere, oceans and solid Earth.

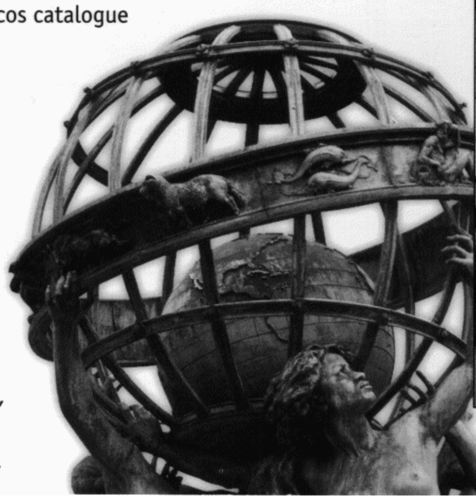


Celestial references for astronomy and astrophysics

IERS extragalactic reference directions are the standards recommended by the International Astronomical Union. Other celestial reference frames of general use, such as solar system ephemerides and the Hipparcos catalogue are tied to it.

World time synchronization

IERS is involved in international time service activities. Its terrestrial references are the standard for atomic clock comparisons using satellite links. It is responsible for issuing announcements of leap seconds in UTC (Coordinated Universal Time) that will keep it within ±0.9 seconds of UT1, the universal time based on the Earth's rotation.



Access to **IERS**

Centres and Publications

Central Bureau : Earth Rotation and Celestial Frame

Observatoire de Paris, France

contact: IERS Central Bureau 61 av. de l'Observatoire 75014 Paris - France

Tel: 33 (0) 1 40 51 22 26 • Fax: 33 (0) 1 40 51 22 91

e-mail address : iers@obspm.fr • Anonymous ftp : 145.238.100.28 (hiers.obspm.fr)

World Wide Web : http://hpiers.obspm.fr

Terrestrial Frame Section

Institut Géographique National, France

e-mail address : boucher@ensg.ign.fr

World Wide Web : http://lareg.ensg.ign.fr/ITFR

Sub-Bureau for Rapid Service and Predictions

National Earth Orientation Service, USA

e-mail address : ser7@maia.usno.navy.mil

Anonymous ftp : 192.5.41.22 (maia.usno.navy.mil)

World Wide Web : http://maia.usno.navy.mil

VLBI Coordinating Centre

National Earth Orientation Service, USA

e-mail address : cma@gemini.gsfc.nasa.gov

LLR Coordinating Centre

OCA / Centre d'Etudes et de Recherches Géodynamiques et Astronomiques, France

e-mail address : mignard@ocar01.obs-azur.fr

University of Texas at Austin, USA

e-mail address : pjs@astro.as.utexas.edu

GPS Coordinating Centre

Jet Propulsion Laboratory, USA

e-mail address : William.Melbourne@jpl.nasa.gov

SLR Coordinating Centre

Center for Space Research, University of Texas at Austin, USA

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DORIS Coordinating Centre

Institut Géographique National, France

e-mail address : Pascal.Willis@ensg.ign.fr

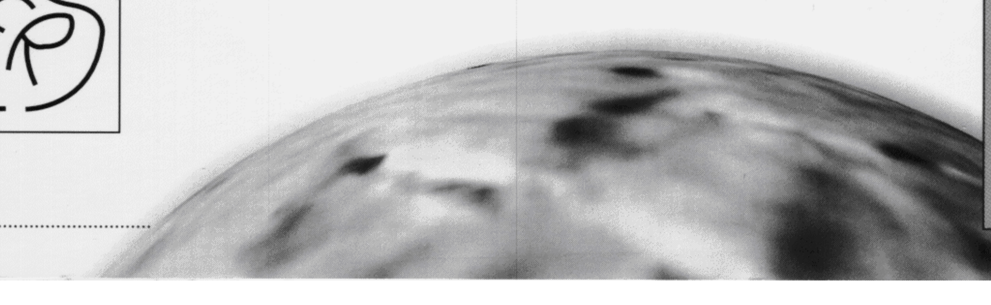
World Wide Web : http://lareg.ensg.ign.fr/DORIS

MGGF Coordinating Centre

NASA Goddard Space Flight Center, USA

e-mail address : chao@denali.gsfc.nasa.gov

World Wide Web : http://cddisa.gsfc.nasa.gov/926/mggf/index.html



Distribution per country (January 1998)

Algeria	1
Argentina	9
Australia	22
Austria	7
Belgium	10
Bermuda	1
Brazil	13
Bulgaria	4
Canada	28
Canary Islands	1
Chile	4
China	41
Colombia	2
Croatia	2
Czech. R	6
Denmark	4
Ecuador	1
Egypt	1
Finland	4
France	77
Germany	69
Greece	4
Hong-Kong	2
Hungary	5
Ireland	1
Island	1
India	4
Indonesia	5
Iran	2
Israel	3
Italy	29
Japan	26
Kenya	1
Korea, Rep. of	6
Latvia	2
Lithuania	1
Luxembourg	2
Malaisya	3
Mongolia	1
Mexico	2
Netherlands	13
New Zealand	8
Nigeria	2
Norway	9
Pakistan	1
Philippines	1
Poland	9
Portugal	5
Romania	1
Russia	23
Saudi Arabia	4
Slovakia	2
Slovenia	1
South Africa	5
Spain	17
Sri-Lanka	1
Sweden	9
Switzerland	10
Turkey	7
Ukraine	10
United Kingdom	43
USA	205
Uzbekistan	1

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