The University NAVSTAR Consortium: Global Positioning for Geosciences Research

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1 - Abstract

Academic investigators established the University NAVSTAR Consortium (*UNAVCO*) a decade ago to support their use of global positioning for crustal deformation research. More recently, the International Association of Geodesy established the International *GPS* Service for Geodynamics (*IGS*) to develop and operate an international *GPS* tracking network for geodetic and geophysical research applications. As a result of continuing improvements in *GPS* surveying accuracy and the establishment of *GPS* tracking networks, a variety of geoscience research opportunities are emerging. This paper describes *UNAVCO* and introduces some new opportunities for geosciences research using global positioning.

2 - Global Positioning Satellites and Networks

Soon after the space age began, it was recognized that satellite orbits provide a valuable reference frame for global navigation. Today, the 24-satellite Global Positioning System (*GPS*) operated by the U.S. Department of Defense is the most widely used system, followed by the Russian *GLONASS* system. These systems may be augmented in the future by commercial low Earth orbit communication and positioning satellite services.

Reference frames of satellite orbits and the Earth's crust can be linked using ground-based tracking networks. The first global *GPS* tracking network was established more than 15 years ago, includes five tracking stations and is used to determine *GPS* orbits with an accuracy of about 10 m. More recently, the *IGS* established a second global network including more than 50 tracking stations, to support geodetic and geophysical *GPS* applications (e.g. Zumberge et al, 1994). The *IGS* network provides high accuracy *GPS* orbits (~10 cm), allowing users to place *GPS* monuments in the International Terrestrial Reference Frame with centimeter accuracy. *IGS* orbits are available within 2 to 3 weeks via anonymous ftp or World Wide Web. The *IGS* includes more than 50 international organizations.

3 - UNAVCO and Crustal Deformation Research

Scientists from seven universities formed the University NAVSTAR Consortium (*UNAVCO*) in 1984. The Consortium's original scientific goal was to use signals broadcast by global positioning satellites to map deformation of the Earth's crust with unprecedented accuracy and spatial coverage. In pursuit of this goal, the Consortium acquired *GPS* receivers, established a facility to manage their optimal use, and began to support academic investigators using *GPS* for crustal deformation research.

Since that time the *UNAVCO* Consortium, its Facility, and the science associated with them have undergone continuous growth. The Consortium now includes 63 institutions, more than a third of them international, and the Facility manages more than 120 *GPS* receivers. The Facility has supported more than 150 major experiments involving *GPS* measurements of crustal deformation in worldwide locations (Figs. 1-9).

Governance of *UNAVCO* is based on a Memorandum of Understanding between members and its managing institution, the University Corporation for Atmospheric Research. Member Representatives elect a Steering Committee to provide program guidance and establish policy. *UNAVCO* is supported through peer-reviewed grants from the U.S. National Science Foundation (*NSF*) and National Aeronautics and Space Administration (*NASA*). Additional information regarding *UNAVCO* can be obtained via its Home Page on the World Wide Web.

4 - Multi-Disciplinary Use of Global Positioning

High accuracy *GPS* positioning has been improved by two orders of magnitude during the past decade, and now millimeter accuracies are being routinely achieved. In addition, continuous global positioning satellite tracking networks are being established by the *IGS* and other local, regional and international organizations to provide basic infrastructure for space-age navigation, surveying, science, engineering, and atmospheric sensing. These networks, including 400 currently operating and 1400 proposed tracking sites (Table 1), present opportunities for tectonic, earthquake, volcano, Earth rotation, sea-level, satellite altimetry, glaciology, meteorology, global climate, ionosphere, hydrology and ecology studies (e.g. Ware and Businger, 1995). Many of these applications are described in the report: *Geoscientific Research and the Global Positioning System* (1994). This report is available as an Acrobat file online.

Table 1: Estimated number of sites operating and proposed in various tracking networks. Regional networks address civil and scientific applications in localized areas, national networks address aviation and coastal navigation, and international networks contribute to global tracking objectives

NETWORKS	CURRENT SITES	PROPOSED SITES
Regional	70	360
National	250	875
International	75	125
Subtotals	395	1360
Total Current and Proposed		1755

Some new applications for *GPS* networks are rapidly developing. For example, tracking sites designed for geodetic positioning can be equipped with surface meteorological (*surface met*) sensors that record pressure, temperature and humidity. Data from such sites can be analyzed to provide accurate estimates of precipitable water vapor (*PWV*). *PWV* data are valuable for meteorological research and weather forecasting (Bevis et al, 1992; Kuo et al, 1995; Rocken et al, 1995) and for climate studies (Yuan et al, 1993; Elliott and Gaffen, 1995). A global climate monitoring instrument could be created by equipping *IGS* sites with *surface met* sensors. A prototype *surface met* package designed for use at *GPS* tracking sites and applications for *GPS*-sensed *PWV* will be discussed during this *IGS* workshop (Rocken et al, 1995).

Another new application for the *IGS* network is double differencing of network and orbiting *GPS* receiver data to sense atmospheric path delays. These delays can be converted to atmospheric refractivity, temperature, and moisture profiles (Ware, 1992). A demonstration of this concept was initiated in April, 1995, with the successful launch of a Turborogue receiver modified for use in space as a part of the *GPS/MET* project (Ware et al, 1993). Information including procedures for accessing data can be found on the *GPS/MET* Home Page. The *GPS/MET* data are expected to be useful for weather research and forecasting (Kuo et al, 1995) and for climate studies (Gaffen et al, 1991; Yuan et al, 1993).

5 - References

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A - Figures

Fig. 1. UNAVCO Archive, 1,400 monuments & 5,600 station-days since 8/92.

Fig. 2. Central Asia, 150 monuments archived since 8/92.

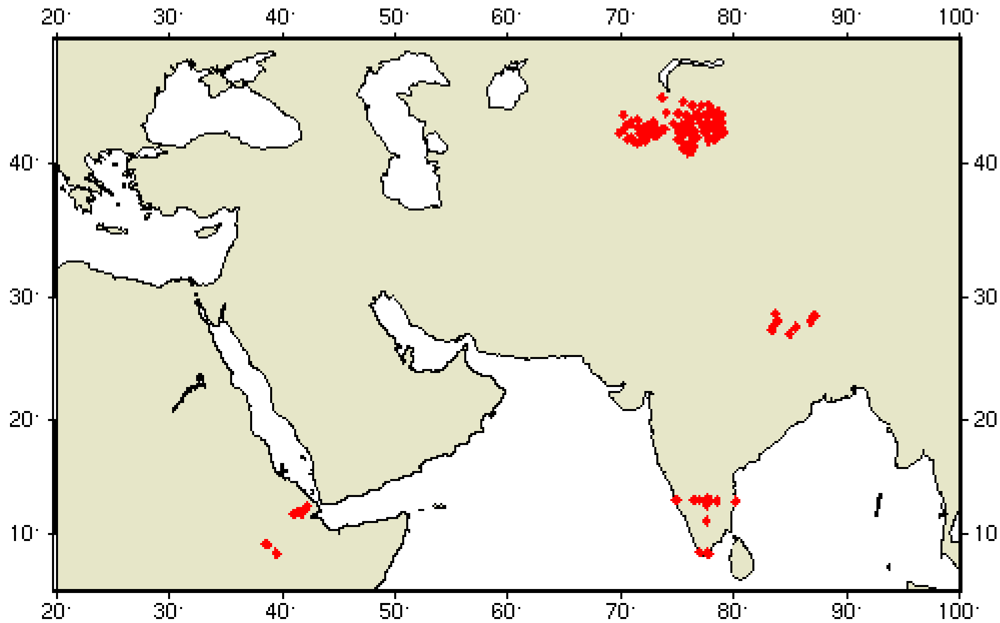

Fig. 3. South America, 425 monuments archived since 8/92.

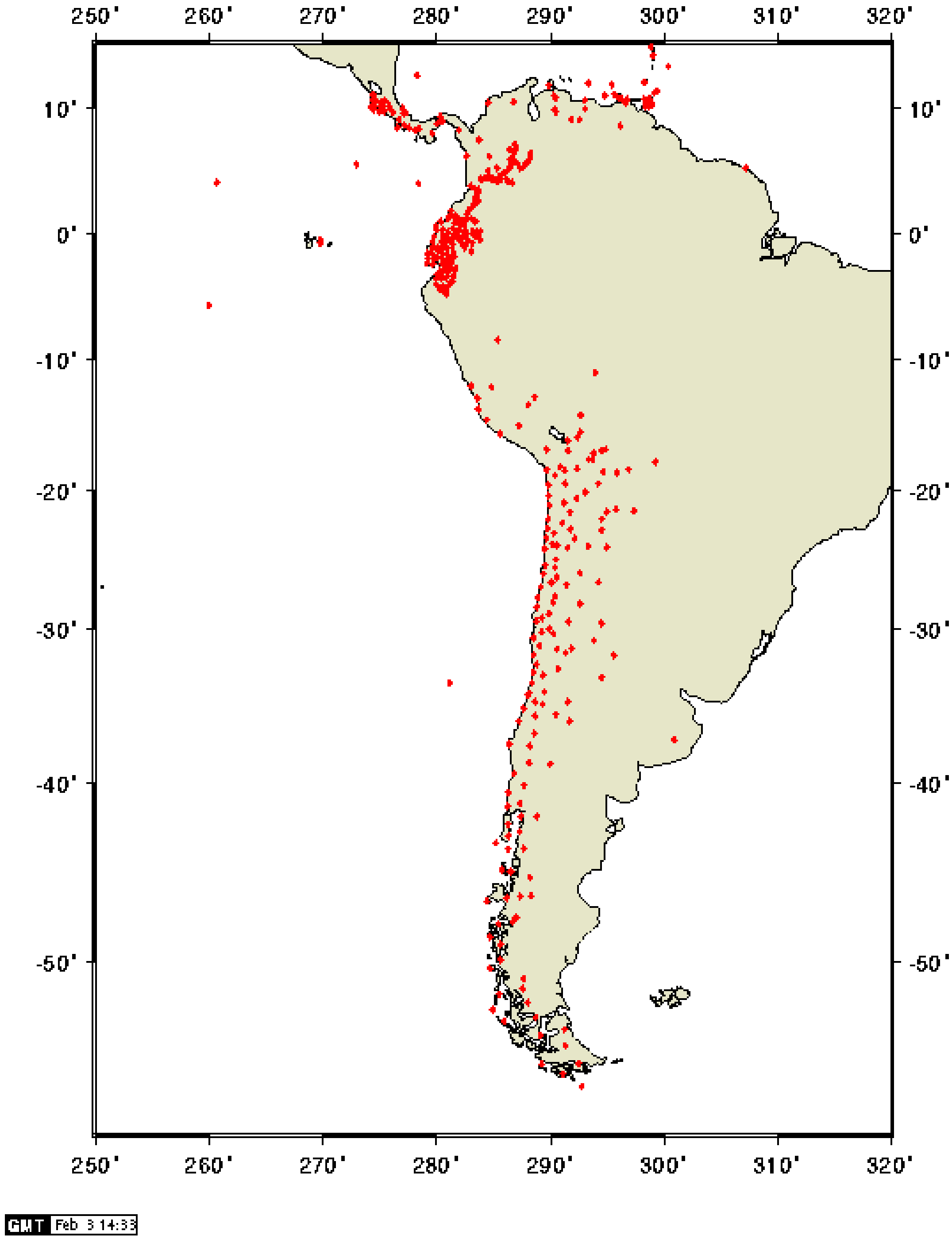

Fig. 4. Central America / Caribbean, 197 monuments archived since 8/92.

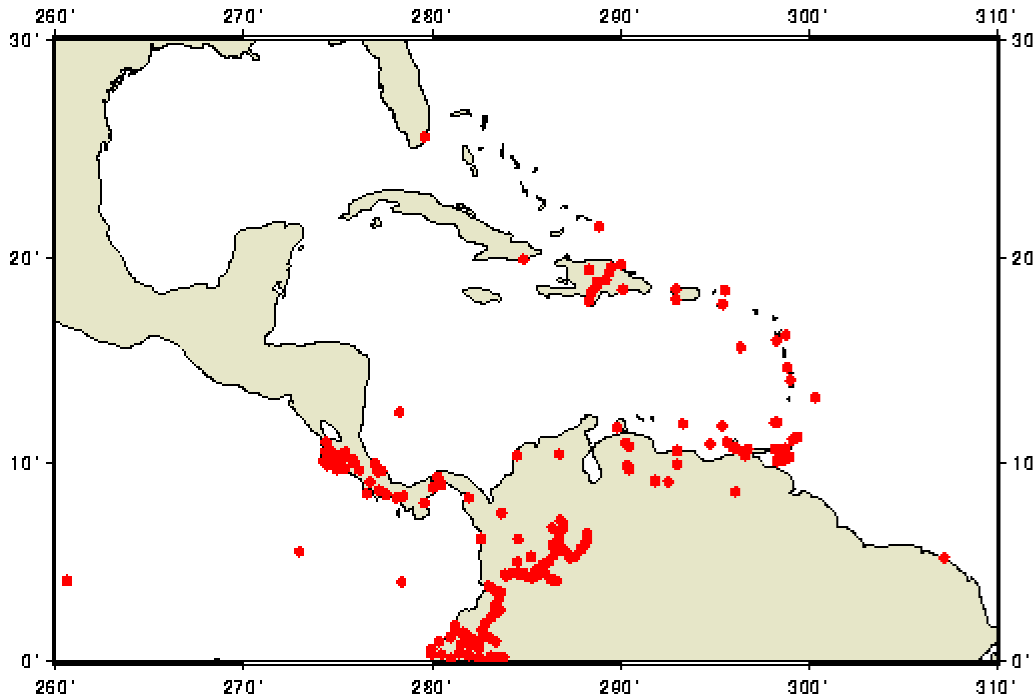

Fig. 5. Iceland, 41 monuments archived since 8/92.

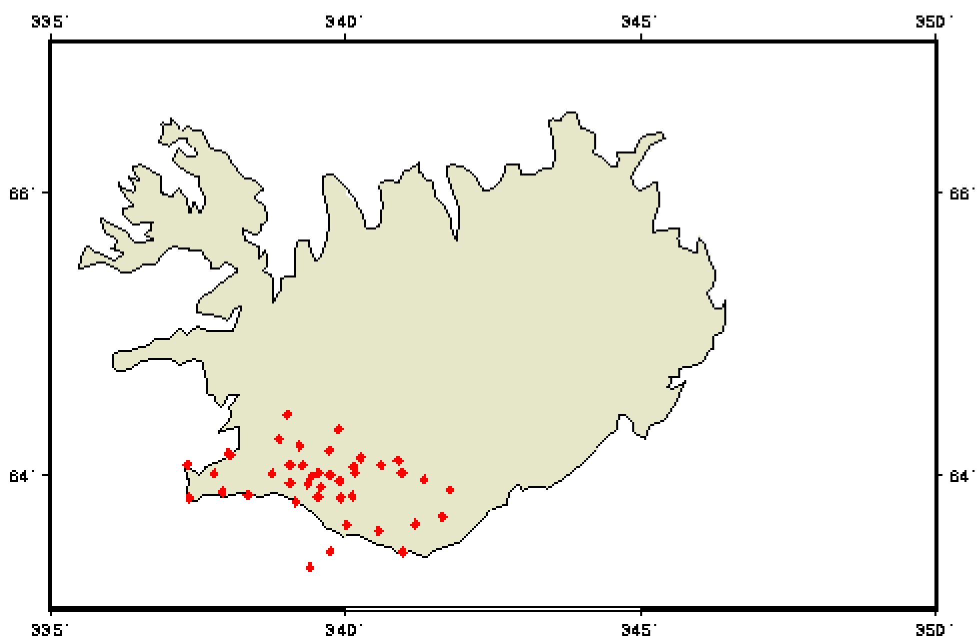

Fig. 6. Indonesia, 262 monuments archived since 8/92.

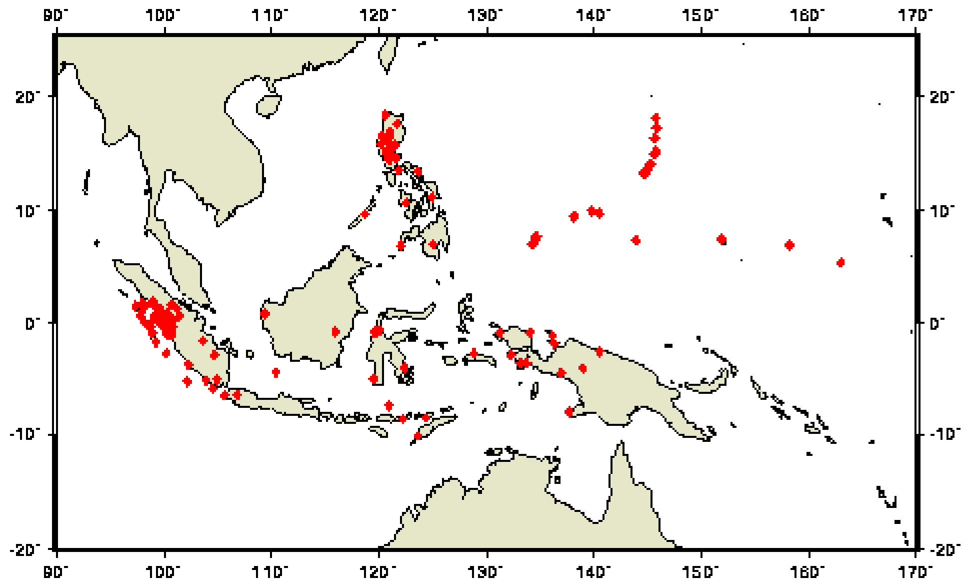

Fig. 7. New Zealand, 161 monuments archived since 8/92.

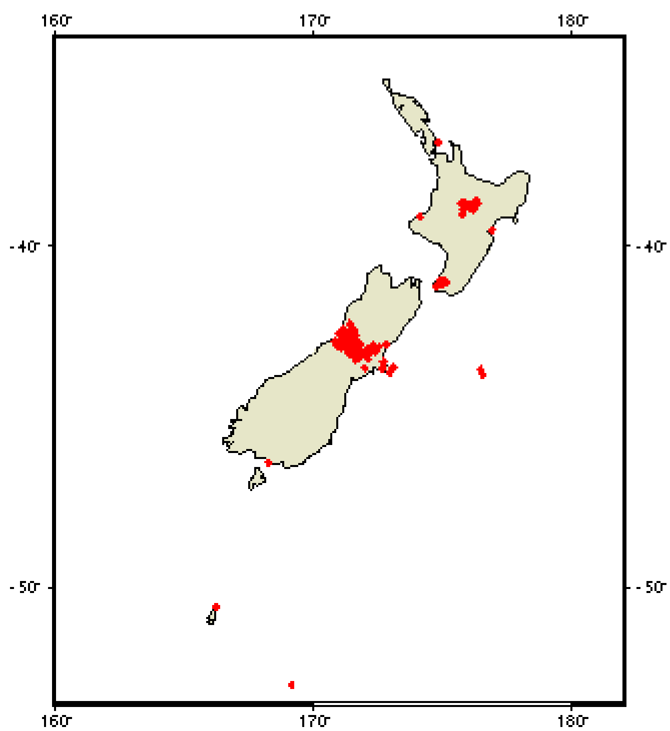

Fig. 8. North America, 334 monuments archived since 8/92.

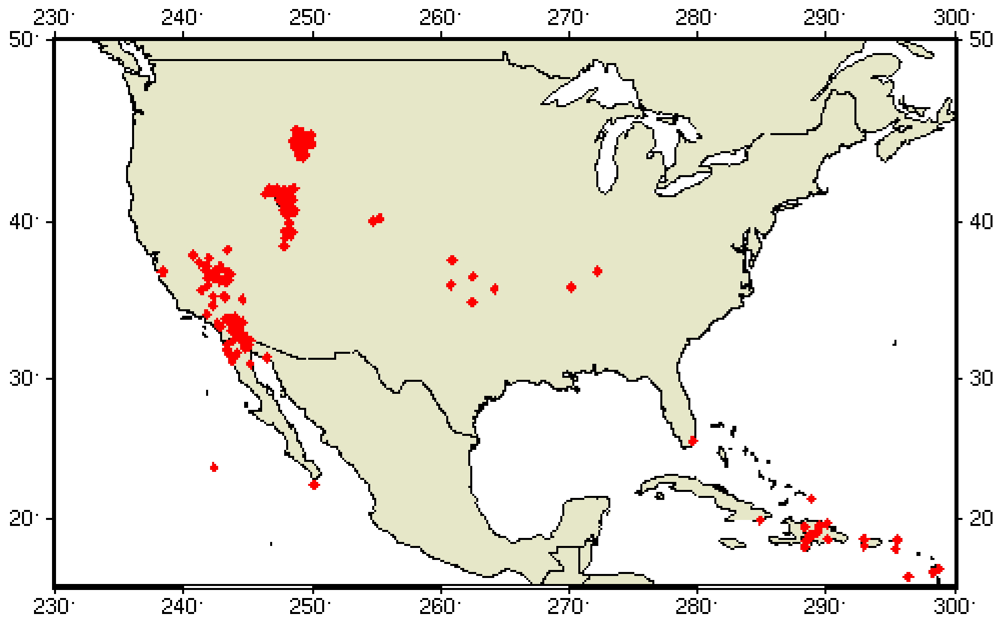

Fig. 9. Western United States, 294 monuments archived since 8/92.