High resolution European Velocity- and Velocity Gradient field from Space Geodetic data HIRES Project

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Introduction

The topography of the continents is changing continuously because of processes active on different temporal and spatial scales, from within the deep Earth to the atmosphere. Measuring the motion of the Earth's surface is the key to understand and to put new constraints on the processes driving the motion of tectonic plates, the slow deformation of continents, the occurrence of earthquakes and the continuous interaction between the solid Earth, the oceans, the atmosphere and continental waters. Global Reference Frames like the ITRF 2005 (Altamimi et al, 2007) provide a globally well distributed set of GNSS (Global Navigation Satellite Systems) stations that defines a unique system and provides access to it for all densifications and applications. Densifications and dedicated networks are needed for the study and modeling of the changing Earth's surface over all scales in time and place. In general the data on recent crustal motion are conducted in research projects at regional scale or on dedicated areas by individual groups.

Deformations of the Eurasian/African plate boundary deformation zone and adjacent are studied e.g. in the framework of the IAG-WEGENER project earlier or for Central Europe in the CEGRN consortium (Becker et al, 2002) and many regional and local projects. Efforts have been undertaken e.g. in the GPS-Vel Project (Lavallee et al., 2001) to collect and unify GNSS data from these and all available sources in order to derive a homogeneous global velocity field. GPS velocity fields today can monitor site motions at a level of 0.5 mm/yr for the horizontal and 1 mm/yr in the vertical component. One outcome of these activities is the Global Strain Rate Map (GSRM) model (Kreemer at al, 2003), a numerical velocity gradient tensor field solution (i.e., spatial variations of horizontal strain rate tensor components and rotation rates) for the entire Earth surface. Regional studies are deriving the crustal motion and strain patterns for particular areas, like Nocquet et al. (2003) and Grenerczy et al., (2006). The strain rates can be resolved at the nanostrain or 1 ppb (10^{-9}) level, provided long enough time series or repetitive campaign data are available.

Presently the number of new continuous recording GPS networks is growing rapidly. The number of sites in Europe e.g. certainly has passed the 1000 mark. However, only a limited number of these stations can directly be used for geo-science research. Problems are the access to the data, the location and suitability of the stations and the coordinated analysis. Whereas for the International GNSS Service IGS and the European Reference Frame Group EUREF the data policy and processing strategies are clearly defined, only few other groups or regions allow for the unrestricted access to data and for the joint analysis.

What is missing to date for Europe are three things: (1) the centralized access to the wealth of GNSS data that has been and is currently gathered by the numerous institutions, regions and research groups within their individual projects, (2) the uniform and homogeneous (re-)processing of all data according to the latest models and the derivation of the related products for position time series, and (3) the perspective of a centralized European product

center for all data related to crustal motion both from GNSS and from all other sources of geodetic data on Earth-surface change, like INSAR, leveling, strain meters, among others. In addition the perspective on the future use of multiple Navigation satellite systems like GLONASS and Galileo needs preparative works and coordination.

HIRES Aims and Objectives

The objective of the HIRES Collaborative Research Project (CRP) is the derivation of a dense homogeneous highly accurate European velocity- and velocity-gradient field (strain-rate and rotation-rate) from episodic and permanent GNSS observations collected all over Europe and its boundary regions. The velocities and velocity gradients which we derive will serve as geodetic boundary values on present-day crust and mantle dynamics modeling. By this proposal, European geodesists and geophysicists contribute with valuable surface-deformation and topography-change data to the solid-Earth community and to the goals of the EUROCORES programme Topo-Europe.

Technically, the separation of local effects, regional patterns and large scale trends on the determined velocity field is only possible using a rigorously computed uniform dataset free from distortions by imperfections in modeling and reference frame definition. Such a dataset is not available in Europe presently; its compilation requires complementary efforts in data collection, quality checks and joint analyses which are feasible from the consortium of HIRES. The proposal aims at the collection of GNSS data, the development and application of uniform processing standards and the processing and distribution of the products computed by use of the Geo-Database and Analysis Centre, GEODAC (http://www.geodac.net). The HIRES strategy is based on a distributed approach in the realization of the objectives. For validation and quality checking the same data will be analyzed by three different groups. The primary sources of data will be the research groups and national survey authorities maintaining continuous networks.

Crustal deformation analysis will be done, by a tomographic inversion technique that allows for a simultaneous estimation of strain-rate, rotation rate and possible surface fault creep of active faults from the site velocity estimates (Spakman and Nyst, 2002), among other methods. Models of the velocity gradient field and surface fault creep together with the a posteriori model covariance (including a posteriori variance factor) and model resolution kernel will be used to predict the surface velocity field at any desired density and including error ellipses. Testing of surface fault-locking versus fault-creep and data outlier detection provide a feedback to the velocity estimation in the CRP and large scale mantle effects and signals in the strain field can be identified.

The vision is to enable a single seamless web/ftp access to the products which facilitates the use of them in advanced Earth science research and Topo-Europe related studies without the necessity to care about the source, reference frame or data treatment methods of the original data.

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