The Abdus Salam
International Centre for Theoretical Physics

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World Year of PHYSICS 2005

H4.SMR/1642-9

"IAG-IASPEI Joint Capacity Building Workshop on Deformation Measurements and Understanding Natural Hazards in Developing Countries"

17 - 23 January 2005

# The Wegener Project: Past Experience and Present Day New Developments

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*Bologna*

# The WEGENER Project

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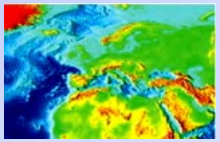
Università di Bologna

IAG-IASPEI Joint Capacity Workshop on
"Deformation Measurements & Understanding Natural Hazards in Developing Countries
Trieste, 17-23 January, 2005

# WEGENER

**W**orking group of **E**uropean **G**eoscientists for the **E**stablishment of **N**etworks for **E**arth-science **R**esearch

The idea was developed during 1982 to respond with a coordinated European proposal to the NASA's Announcement of Opportunity for the Crustal Dynamics Project.



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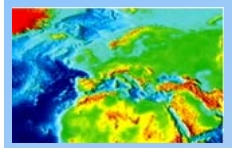
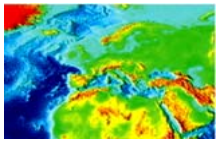
Prime objective was to initiate and to coordinate inter-disciplinary research activities directed towards the investigation of earthquake processes, the associated geodynamic phenomena and to use the results for joint interpretation.

Projects were established to study regional kinematics using SLR, GPS and absolute gravity measurements.

MEDLAS (MEDiterranean LASer) project launched in 1985. Kinematics of central-eastern Mediterranean.



# Modular Transportable Laser Ranging System - MTLRS

MTLRS at Noto, Sicily

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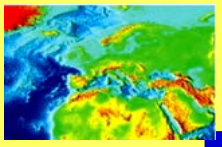
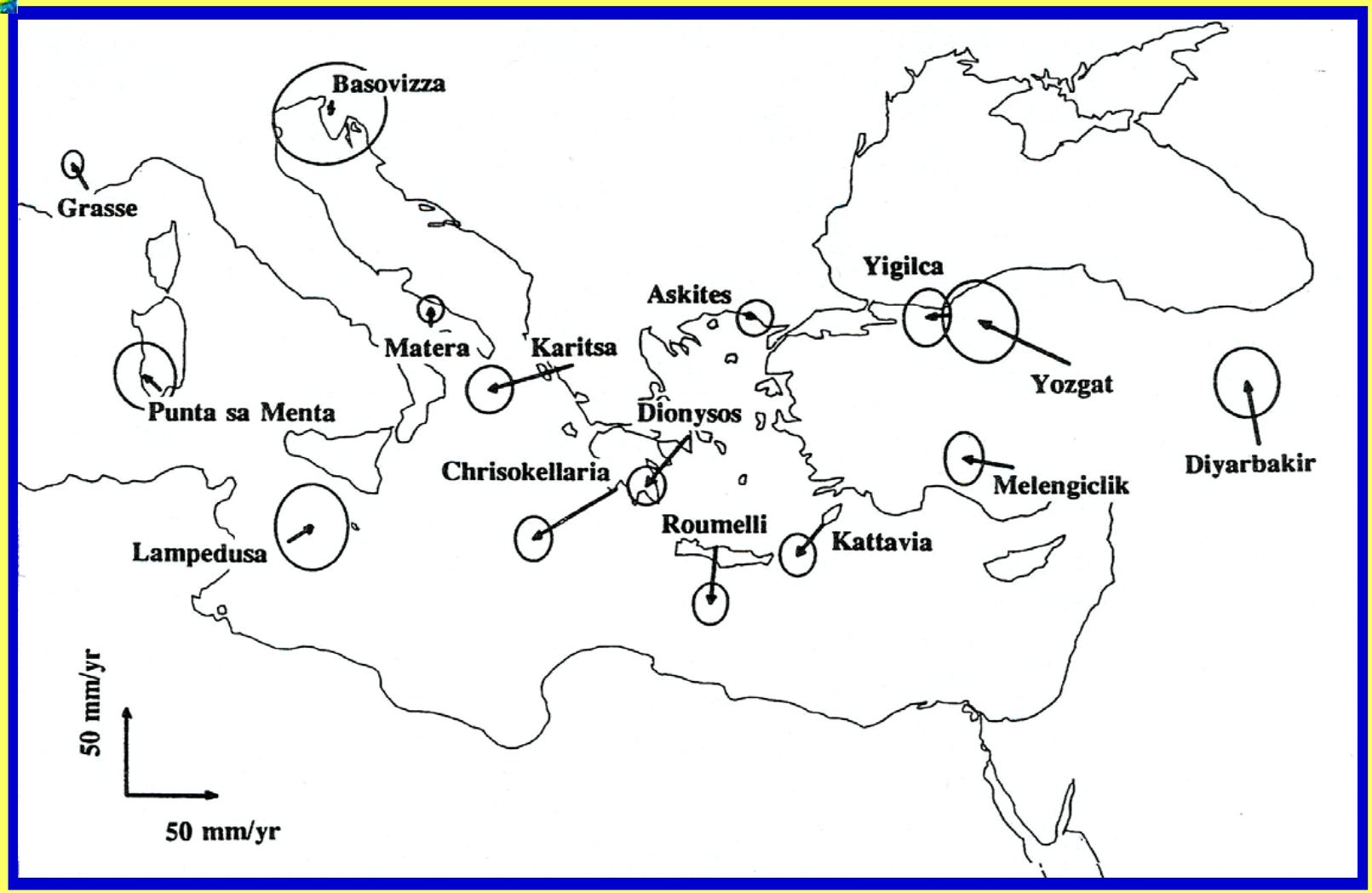


# First WEGENER results




Horizontal motions of the SLR sites in the Mediterranean (after Noomen et al., 1993, Geodynamics Series, Vol. 23, AGU)

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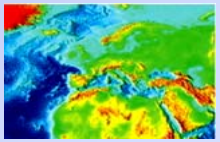
During mid 80's first GPS observation campaigns started. The idea was to use GPS to densify the large-scale SLR network.

In those years, GPS observations were episodic. Observation campaigns, lasting a few to several days, were usually repeated once per year.

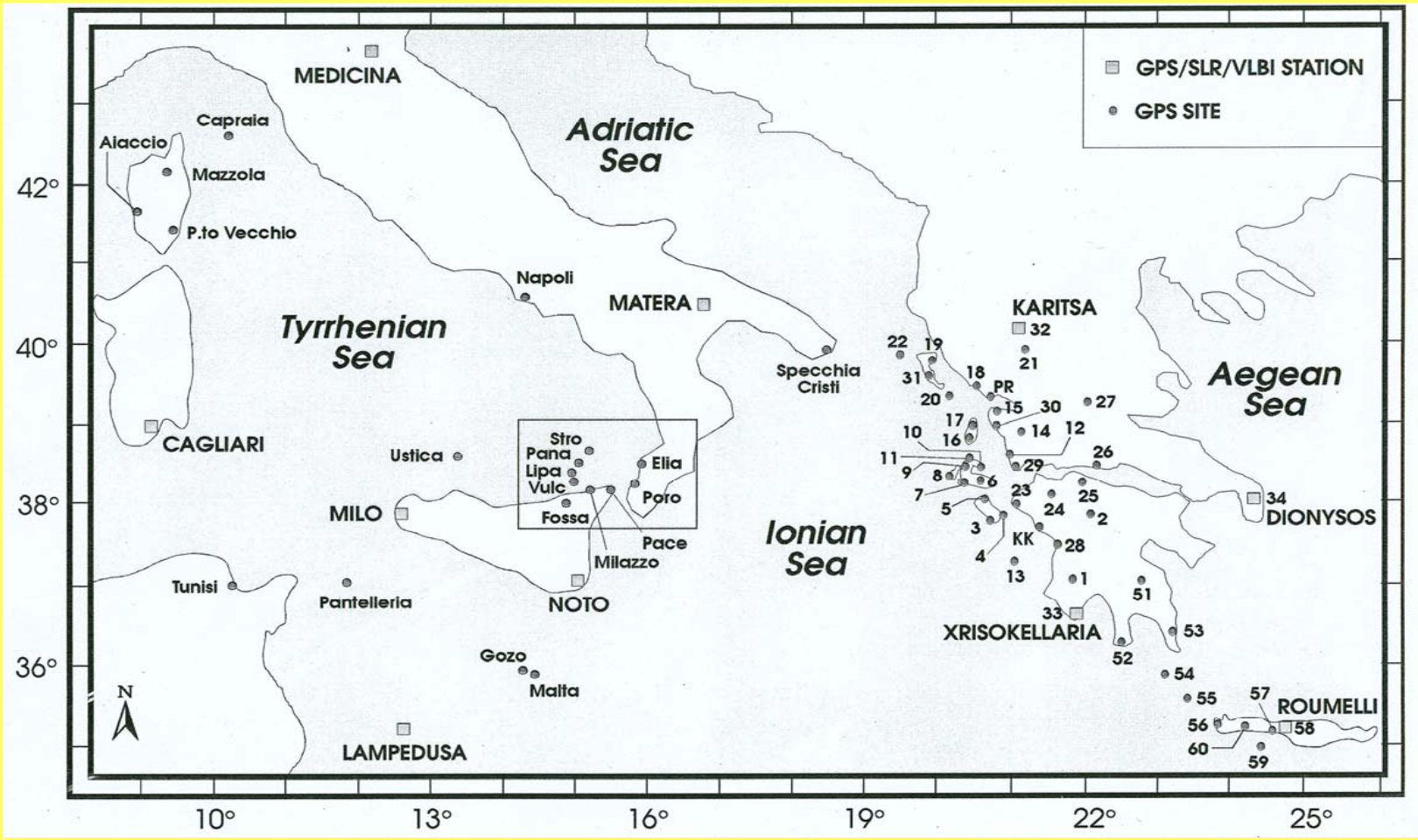
A limited number of GPS receivers (low technology compared to present day) was available.

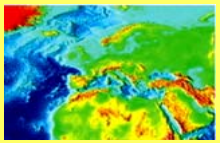
The IAG Services IGS and IERS with their products (orbits, EOP etc.) did not yet exist.



# West Hellenic Arc Tectonics And Calabrian Arc Tectonics

## WHAT A CAT



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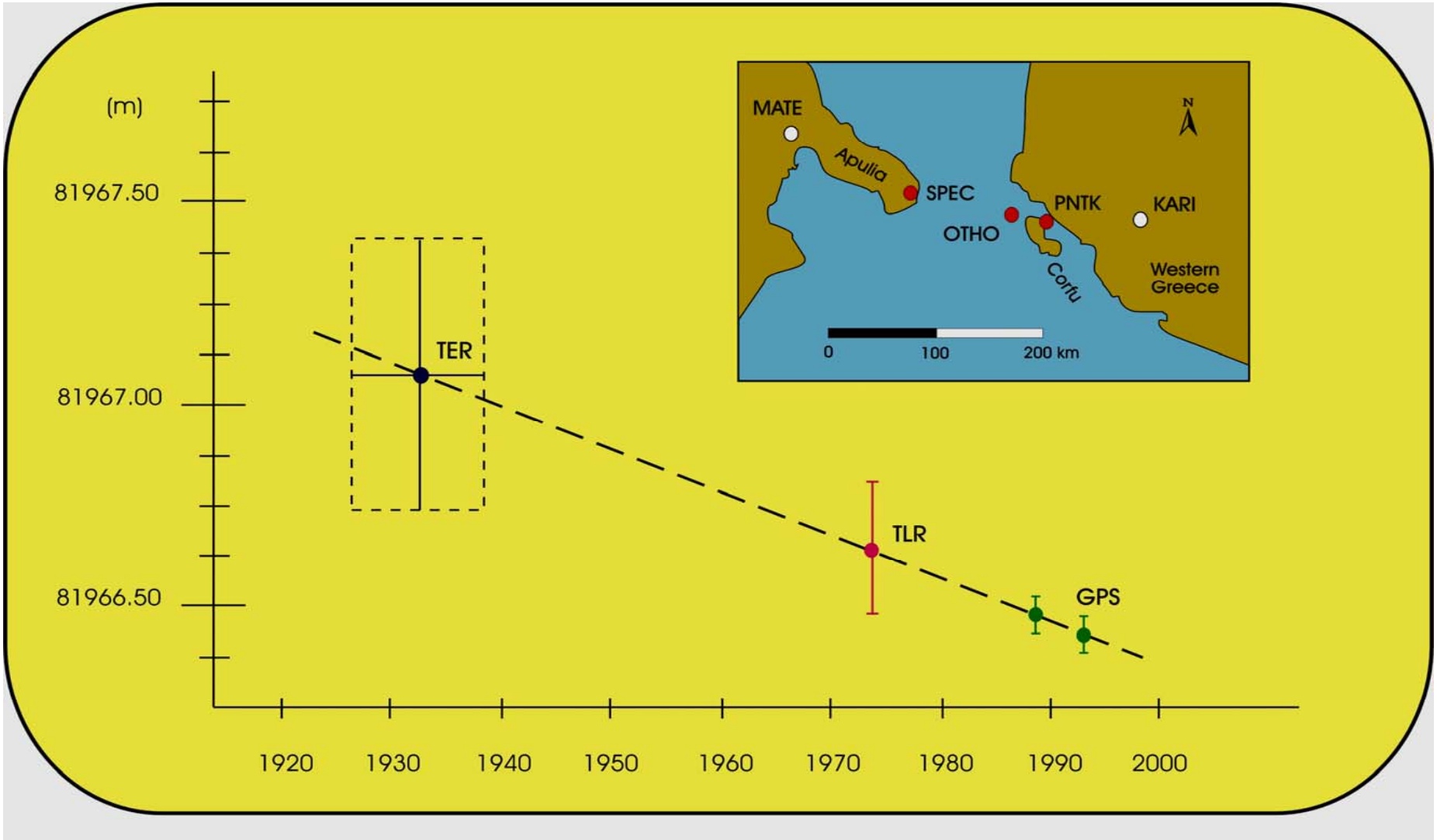


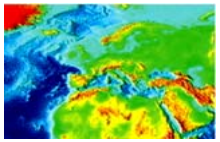

~ -10 mm/yr

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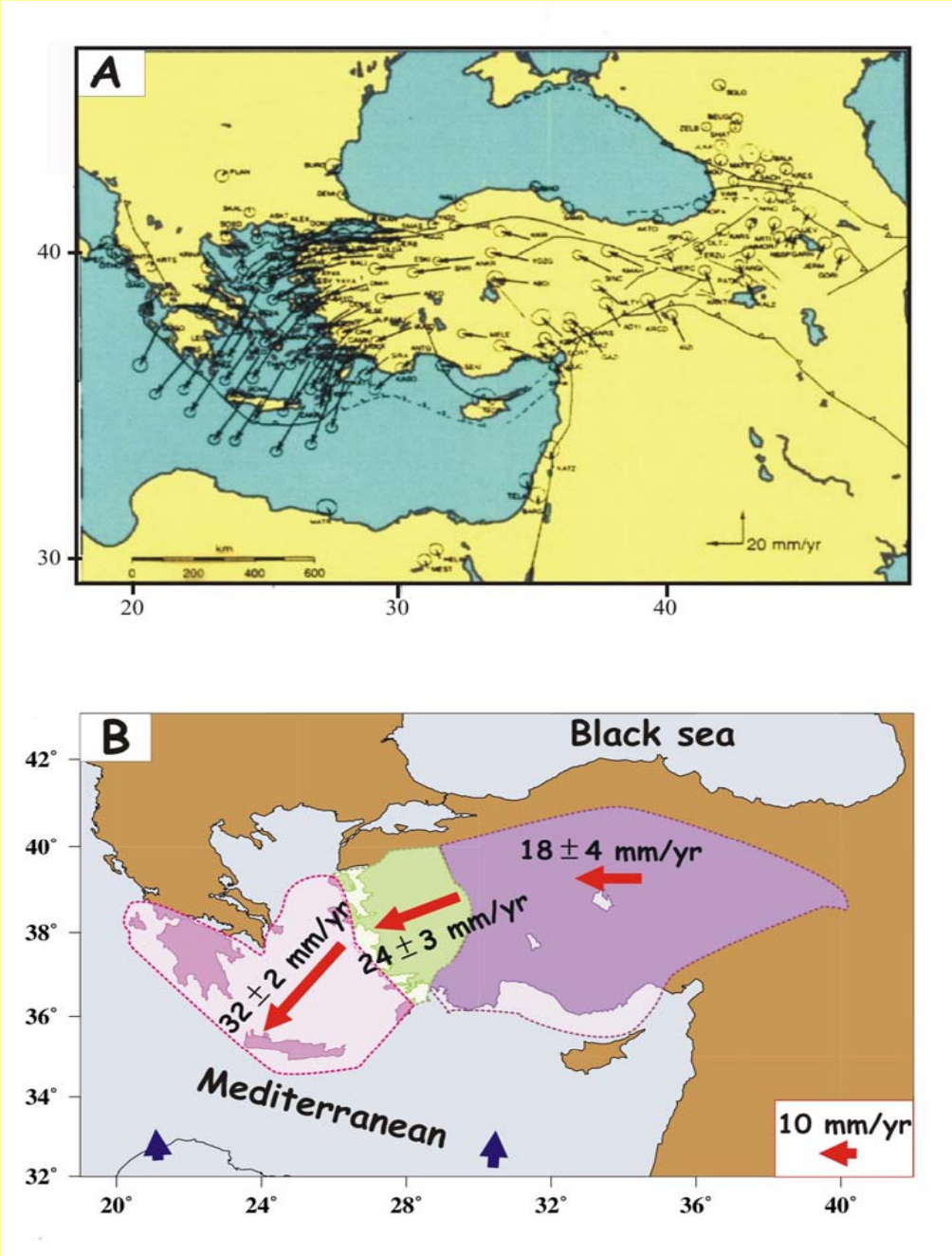
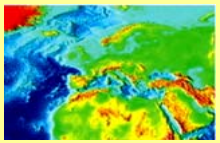



After Mc Clusky et al., 2000



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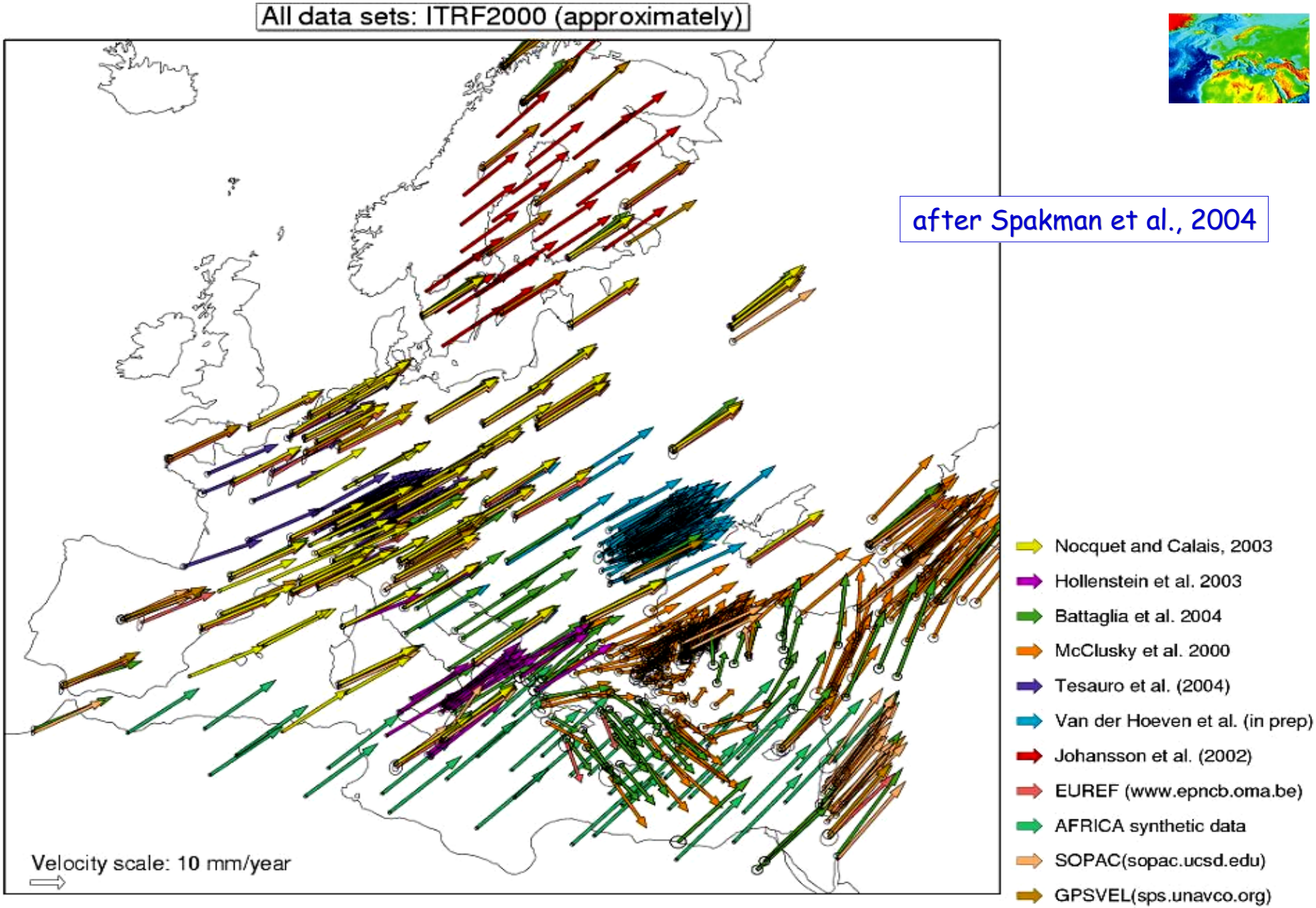
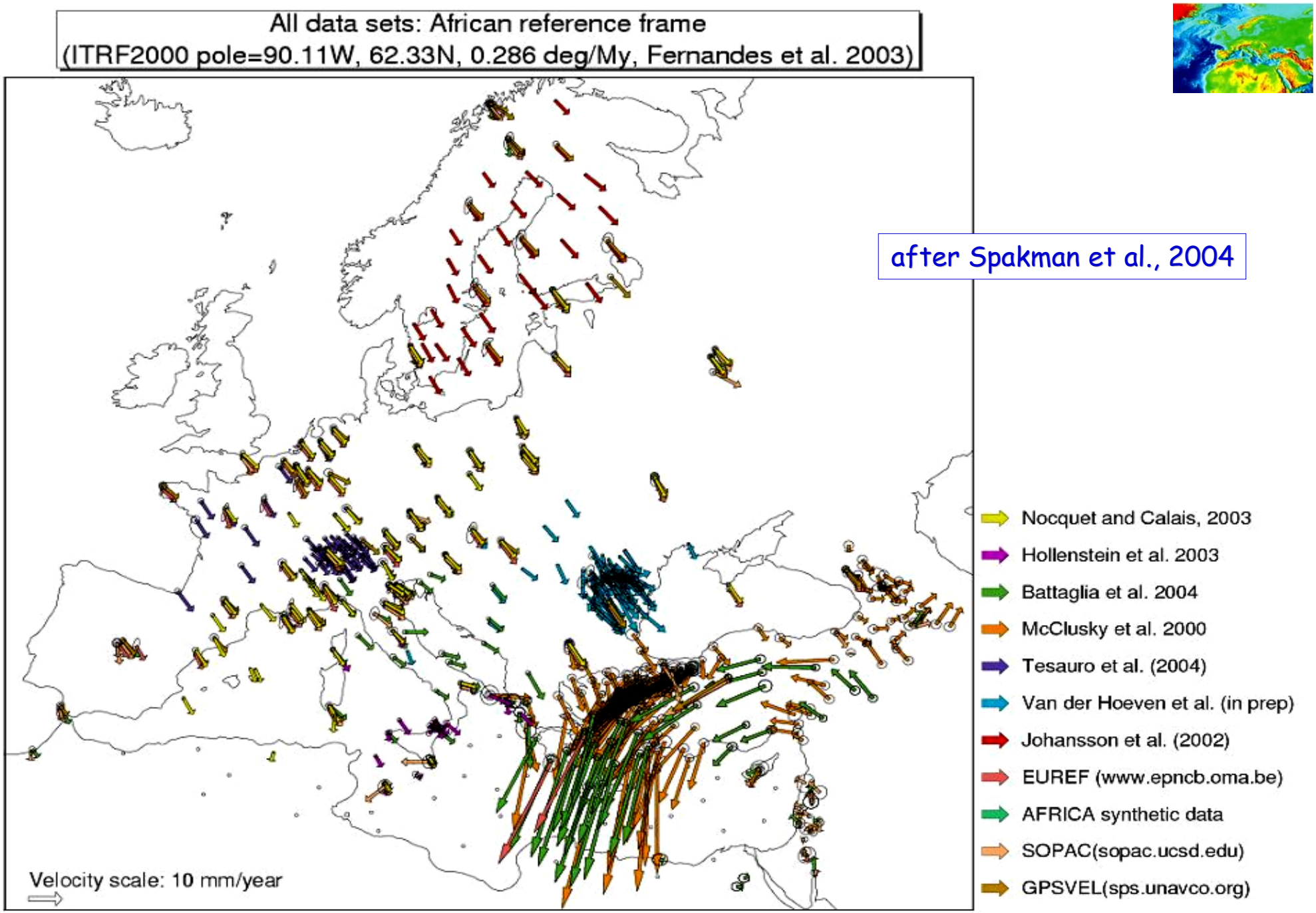
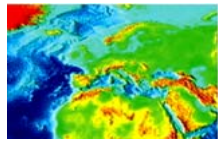


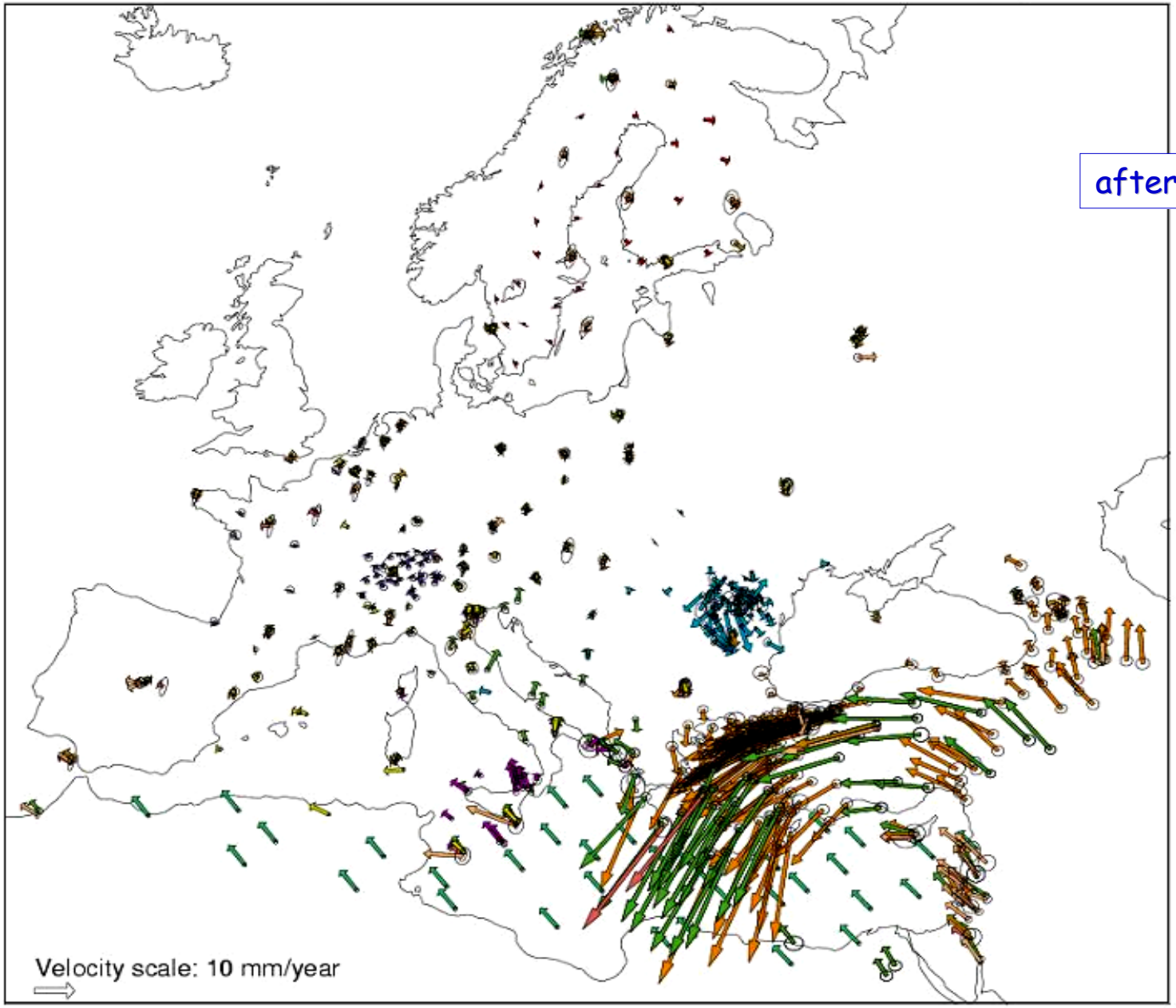

after Spakman et al., 2004


All data sets: African reference frame
(ITRF2000 pole=90.11W, 62.33N, 0.286 deg/My, Fernandes et al. 2003)
after Spakman et al., 2004
Nocquet and Calais, 2003
Hollenstein et al. 2003
Battaglia et al. 2004
McClusky et al. 2000
Tesauro et al. (2004)
Van der Hoeven et al. (in prep)
Johansson et al. (2002)
EUREF (www.epncb.oma.be)
AFRICA synthetic data
SOPAC(sopac.ucsd.edu)
GPSVEL(sps.unavco.org)
Velocity scale: 10 mm/year

All data sets: Central Europe reference frame
(ITRF2000 pole=93.41W, 60.32N, 0.273 deg/My, this study)



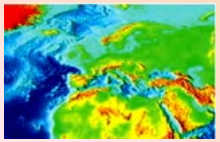
after Spakman et al., 2004




- Nocquet and Calais, 2003
- Hollenstein et al. 2003
- Battaglia et al. 2004
- McClusky et al. 2000
- Tesauro et al. (2004)
- Van der Hoeven et al. (in prep)
- Johansson et al. (2002)
- EUREF (www.epncb.oma.be)
- AFRICA synthetic data
- SOPAC(sopac.ucsd.edu)
- GPSVEL(sps.unavco.org)

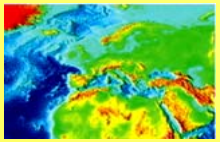
In 1991, the "WEGENER Project: Geodetic investigations related to the kinematics and dynamics of the African, Arabian and Eurasian plates" was established as Special Commission 6 (SC6) of the International Association of Geodesy (IAG).

The general study fields were identified in 1990 and 1991 to respond to NASA's DOSE (Dynamics of Solid Earth) A.O., then reviewed in 1995 when also the project was been restructured.



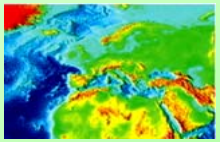
The scientific objectives of WEGENER were:

- studying three dimensional deformations and gravity along the African-Eurasian plate boundaries and in the adjacent deformation zones in order to contribute to a better understanding of the associated geodynamical processes;
- monitoring the three-dimensional deformations in a large region centered around Fennoscandia in order to determine the magnitude and extent of the present-day postglacial rebound in that area;
- investigating height variations and sea-level changes in order to identify and separate the processes contributing to these variations.



WEGENER activities included:

- improvements of the measurement techniques;
- testing of new technological means;
- proposals for new missions.



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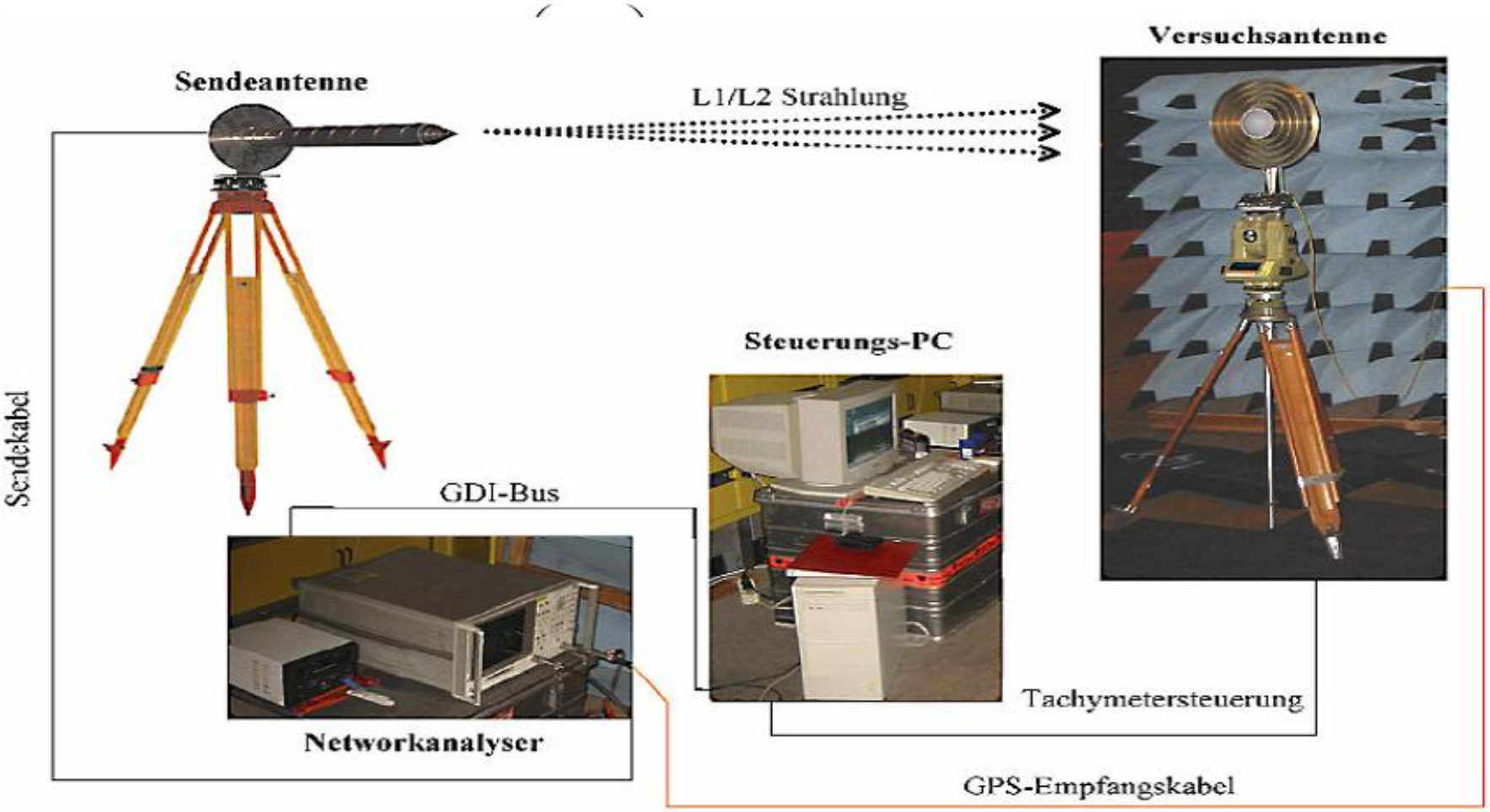
# Antenna Calibration




Antenna Calibration in Anechoic Chamber

after Becker and Kirchner, 2004

Presentation for:
WEGENER 2004
21 September 2004
Tangier, Morocco

Institute of Geodesy and Navigation
Institut für Erdmessung und Navigation

# IMPACT OF GALILEO ON GEODYNAMICS

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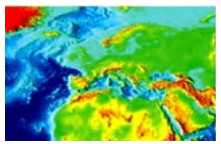
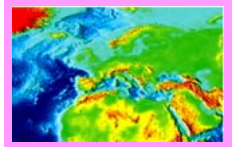
Institute of Geodesy and Navigation
University FAF Munich, Germany
*torben.schueler@unibw-muenchen.de*



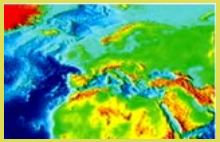
The investigation of deformations along the African-Arabian/Eurasian plate boundary included:

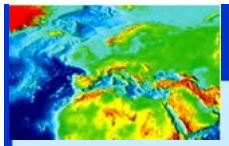
- determination of the relative plate motions in the framework of 3-D global plate motions;
- estimation of the extent of the deformation zones directly associated with the plate boundaries;
- assessment of the relative magnitudes of horizontal and vertical change and the variation of the deformations occurring across the boundary zones;
- interpretation and use of geodetic results as constraints on geodynamic models of the African-Arabian/Eurasian collision zone.



The investigation of post-glacial rebound in Fennoscandia included:

- estimation of the extent of the rebound phenomena in the Fennoscandia region;
- determination of the rate of vertical deformation and the variation of rate as a function of distance from the centers of rebound;
- analysis of the geodetic results to constrain the viscosity of the mantle and the models describing deformation of the lithosphere in response to loading.





# RESULTS FROM THE BIFROST PROJECT

Milne et al., 2001

Scherneck et al, 2003

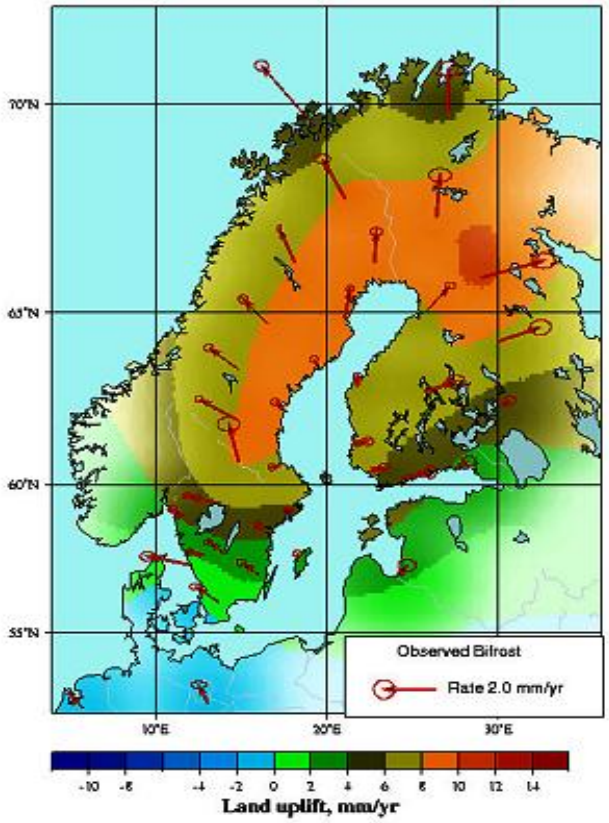
Johanson et al., 2004

## Open questions

- Can we detect GIA signal south of Fennoscandia ?

- What is its impact on the definition of a Stable Europe Reference Frame ?

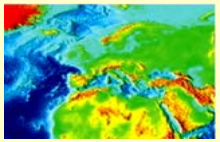
- Should we take into account GIA effect when interpreting geodetic results in Europe and the Mediterranean ?




After Nocquet et al., 2004

The investigation of height variation and changes of sea level included:

- Contributions to the establishment of a common global height datum;
- Determination of improved geoidal information for the plate boundary and Fennoscandia regions;
- Estimation of the relative magnitudes of the different factors contributing to height and sea-level variations and the relationship of changes in sea level to global change.



# Possible impacts of accelerated sea-level rise:

- coastal inundation;
- increased erosion;
- changes in circulation and salinity of estuaries and lagoons;
- increased storm damage;
- loss of wetlands;
- changes in habitat;
- increased salinity intrusion into groundwater;

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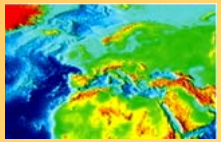

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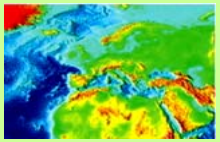
Socio-economic impacts are difficult to quantify.

For each one of the possible impacts there is an associated cost.

Examples:

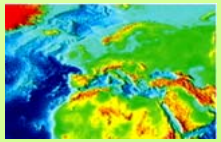
1 m rise in sea level would inundate

- 12-to-15 % of the arable lands of Egypt;
- 17 % of Bangladesh;
- loss of 20,000 km² in the United States (worth about $650 billion);

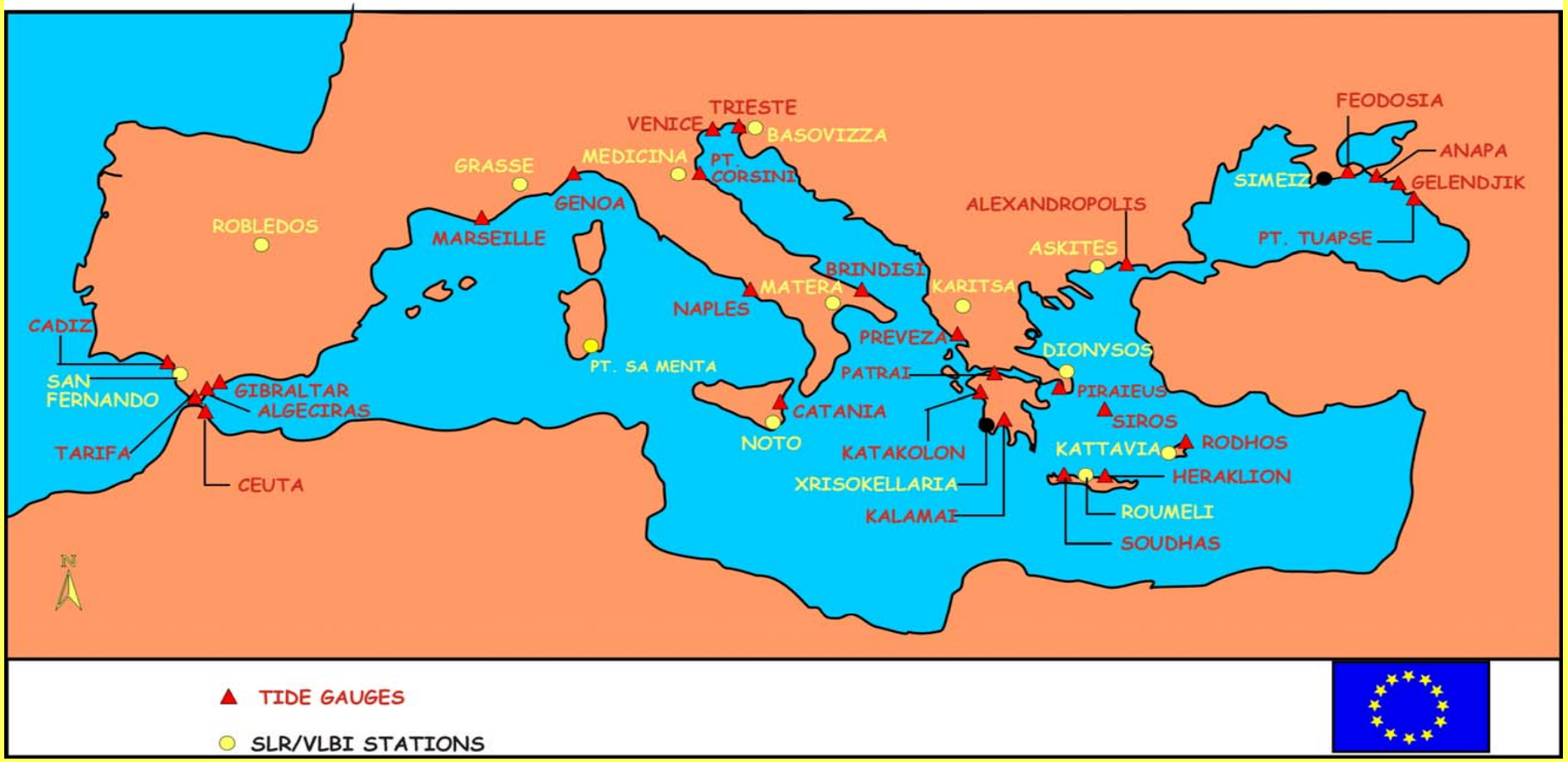


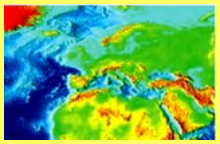
There are at least three reasons for the European Union interest in the fate of coastal zones:

- The existence of problems of a European dimension which cannot be solved by the countries separately (common natural and cultural heritage, transfers of pollutants and sediments, tourist flows, maritime safety);
- The influence of the policies and action of the Union on the development of the coastal zones (regional, transport, fisheries, environment, agriculture, energy and industrial policy);
- The need for an exchange of experience and know-how in a field where successes are still rare and where there is substantial public and political demand for the conservation of the coastal zones and their sustainable development.



# SELF PROJECTS



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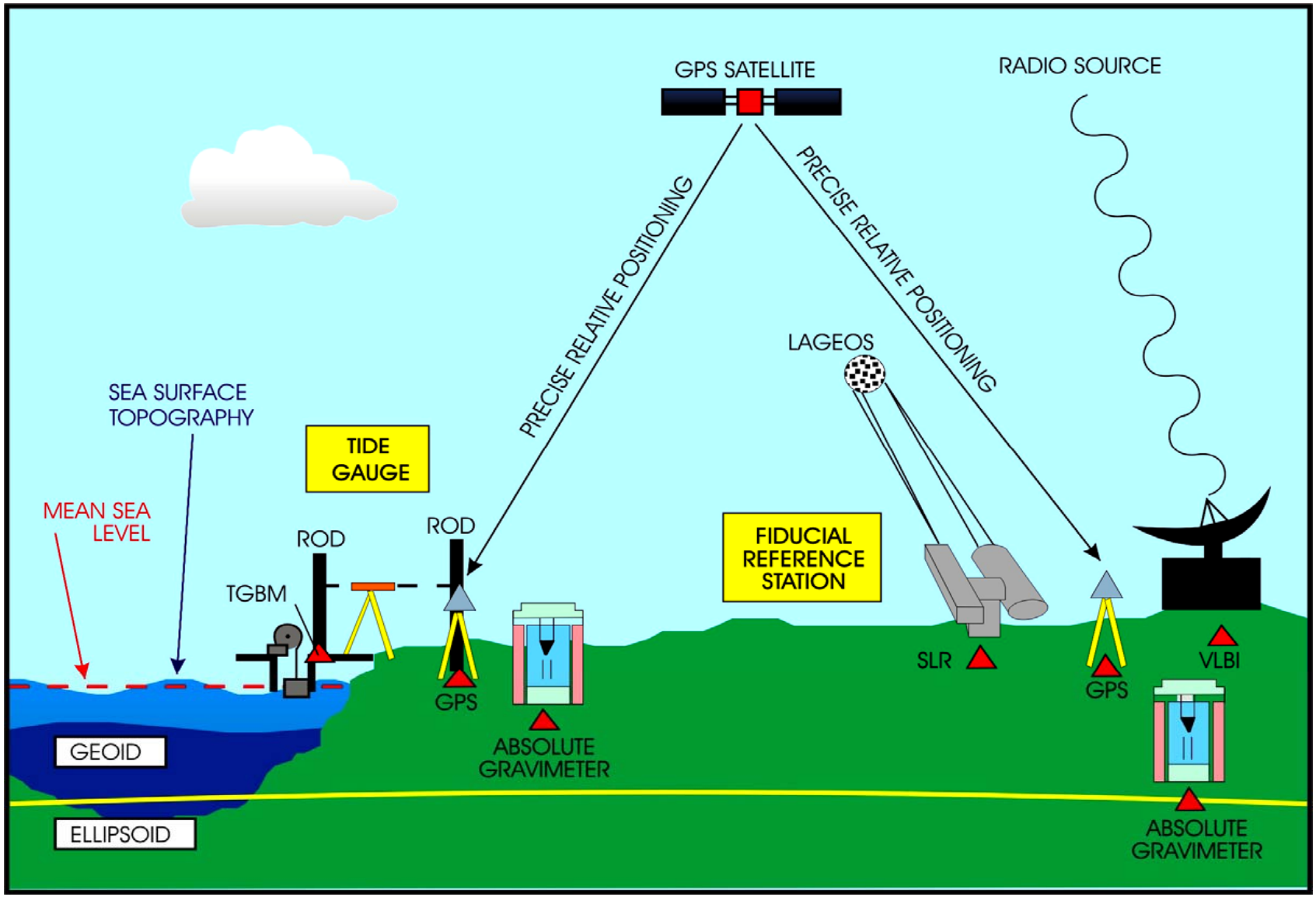


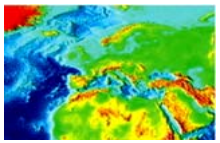

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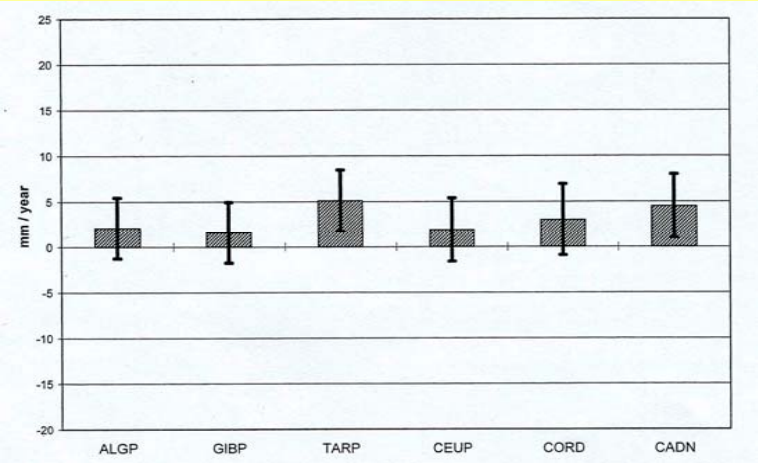
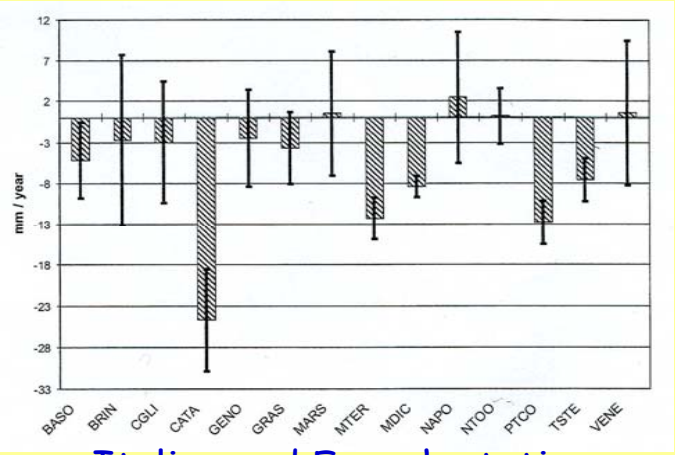
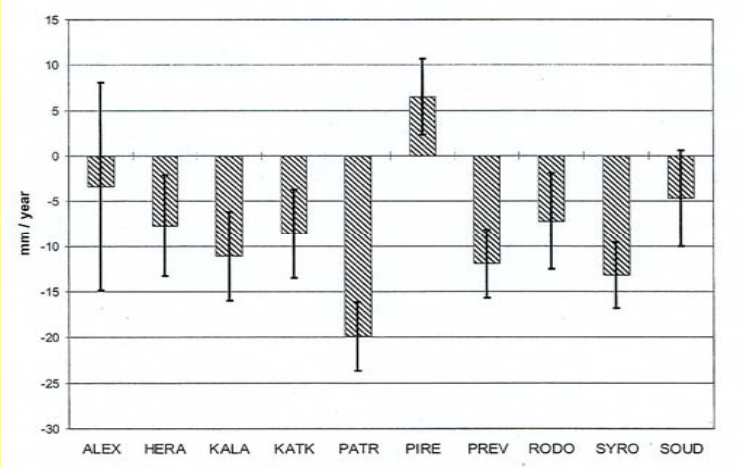
# SELF results
## Vertical variations at tide gauges by episodic GPS



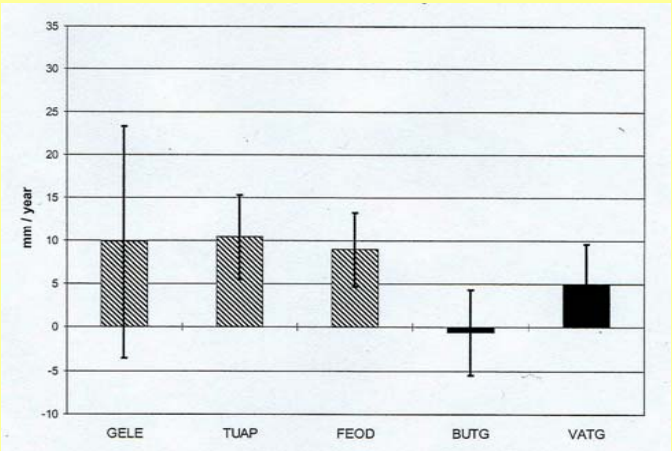

Spanish stations



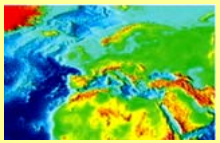

Italian and French stations




Greek stations




Black Sea Russian and Bulgarian stations



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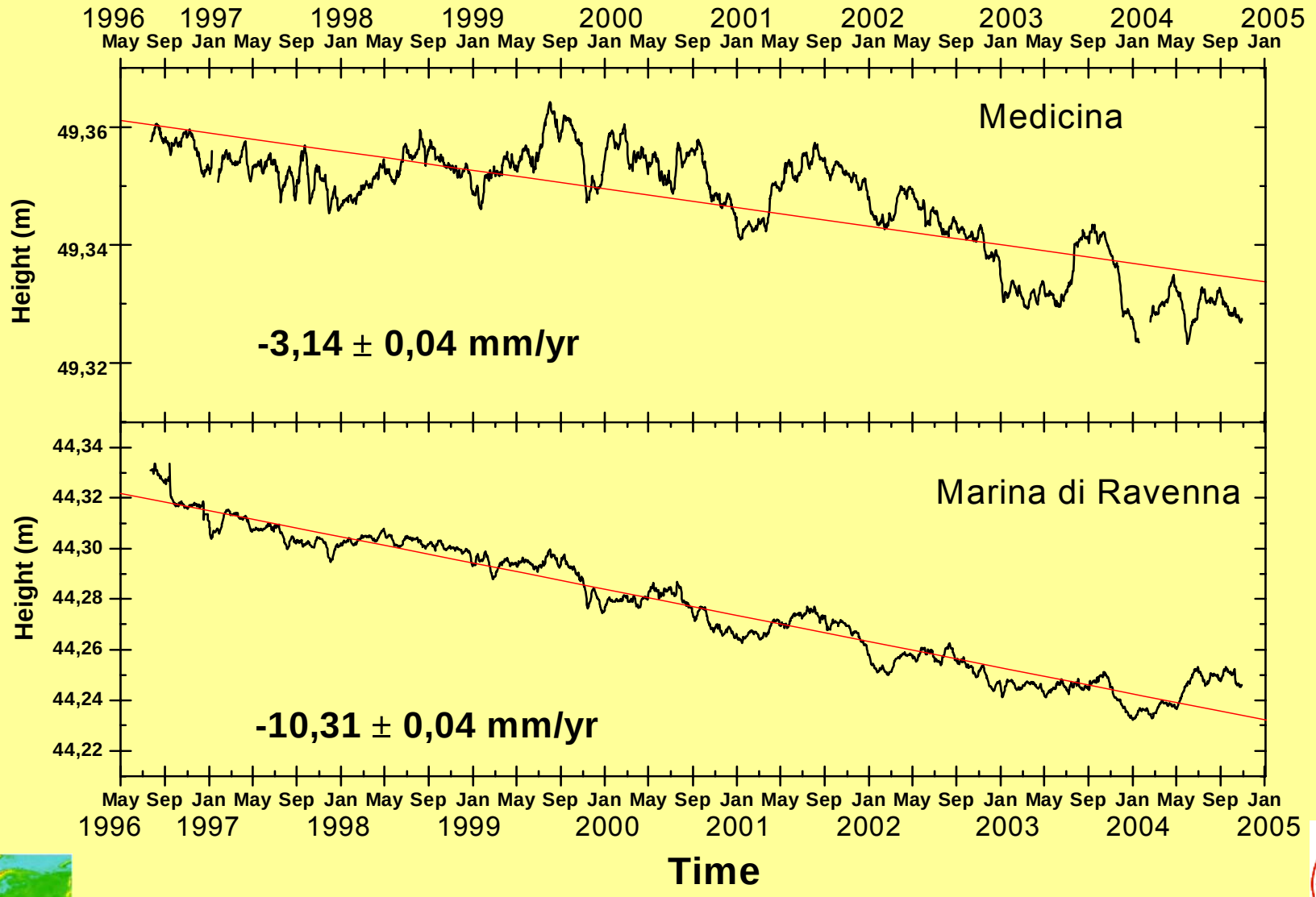
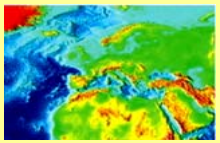
# Height variations from CGPS



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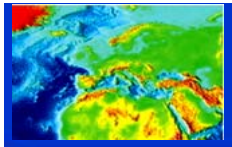
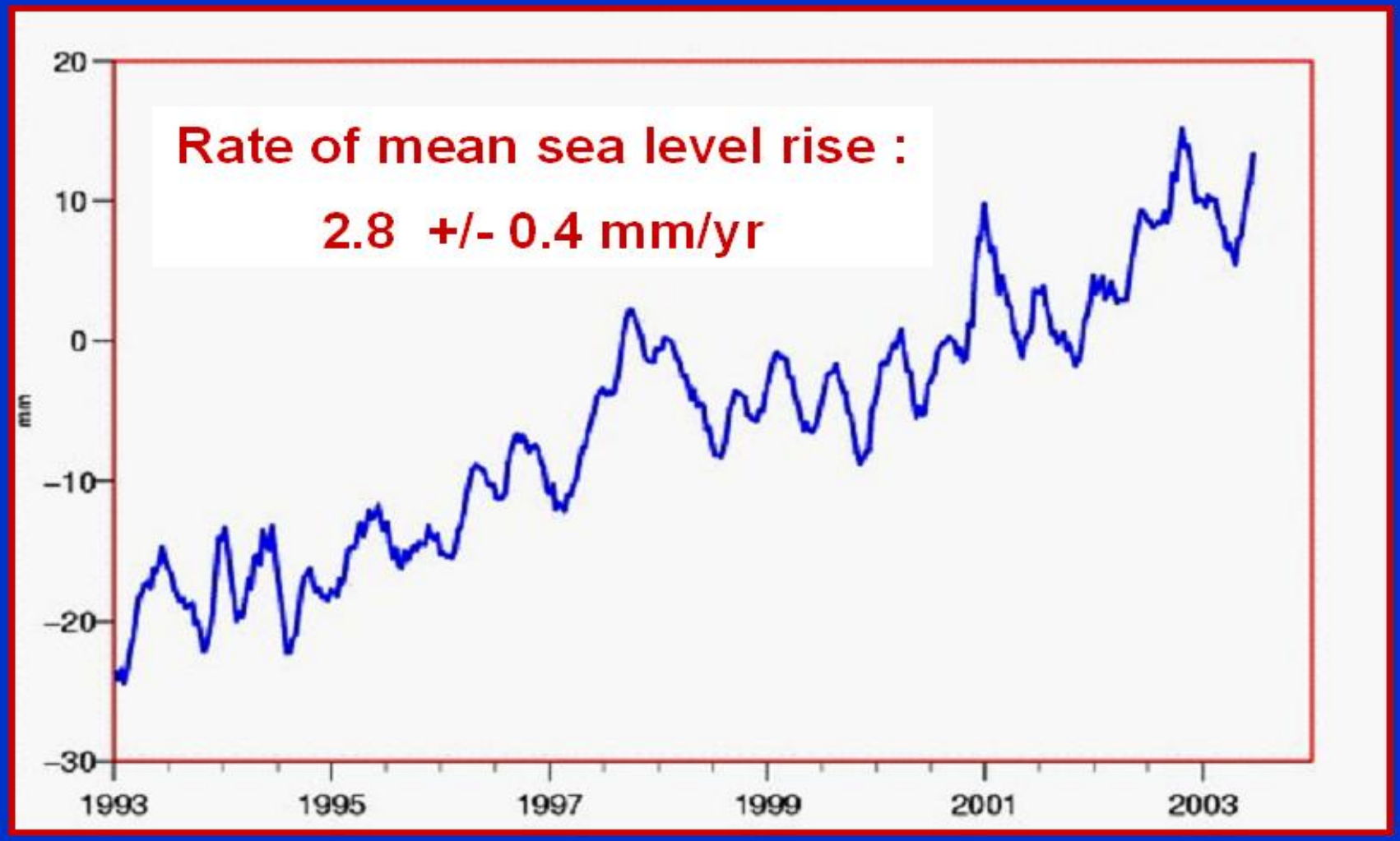
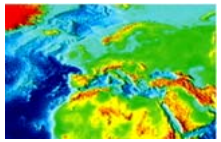


after Lombard and Cazenave, 2004

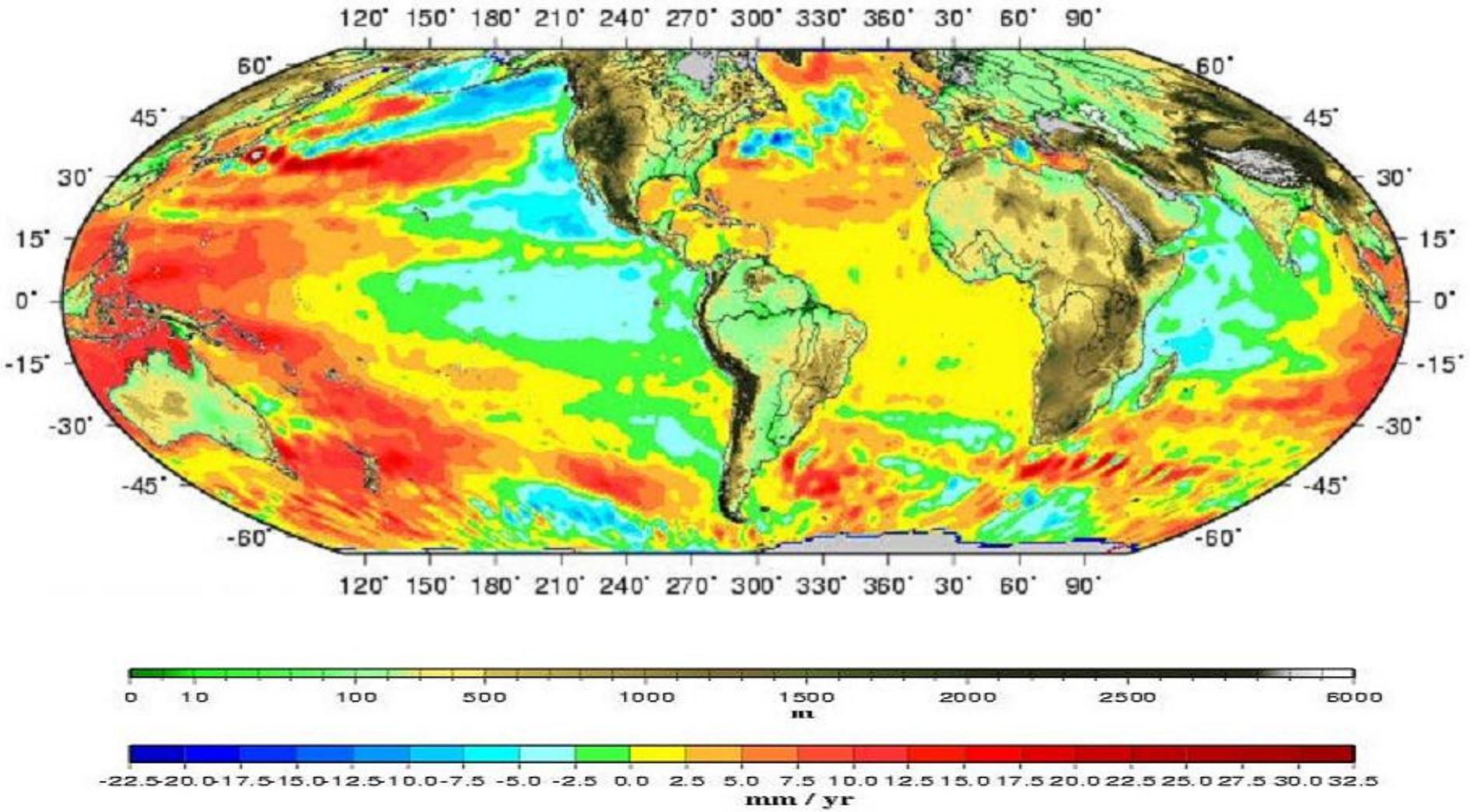
# SEA LEVEL RISE from TOPEX/POSEIDON (1993-2003)





after Lombard and Cazenave, 2004

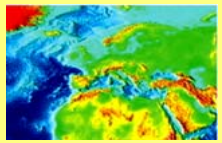
# Regional distribution of sea level trends (1993-2003) from Topex/Poseidon



# European SEA level Service ESEAS

The COST Action 40 "European Sea Level Observing System" (EOSS) has successfully initiated the establishment of the European Sea Level Service (ESEAS). The ESEAS brings together a major fraction of the previously scattered sea level observing and research resources in Europe into a coordinated research organization.

The primary scientific objective of the ESEAS-RI project is to study sea level variations at inter-annual to century time scales as well as to assess potential future changes in mean sea level. The study will be based on combined sea level observations from tide gauges (which give long time scales up to two centuries) and satellite altimetry (which give increased spatial resolution over a shorter period).



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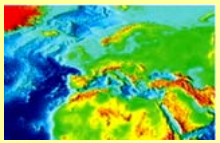
# ESEAS

In order to reach the objective, the following main steps are necessary, which in themselves constitute secondary objectives of the project:

- to investigate vertical land movement at tide gauges in order to determine absolute sea level variations at these sites;
- to give an empirical description of sea level variations on inter-decadal time scales in the North Atlantic and the semi-enclosed European seas, including the determination of secular sea level trends decontaminated for decadal variations and vertical land movements;



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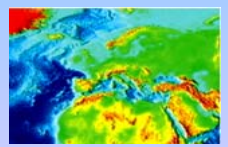
In 2004, within the new IAG structure, WEGENER has become an inter-commission project (Commissions 1 and 3).

Commission 1: Reference Frames
Commission 3: Earth Rotation and Geodynamics



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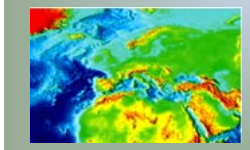
The WEGENER project aims to:

- Actively encourage the cooperation of all geoscientists studying the Eurasian/African/Arabian plate boundary deformation zone, by promoting the exploitation of synergies;
- Be a reference group for the integration of the most advanced geodetic and geophysical techniques by developing the adequate methodologies for a correct data integration and interpretation;
- Act as a forum for discussion and scientific support for geoscientists from all over the world interested in unraveling the kinematics and mechanics of the Eurasian/African/Arabian plate boundary deformation zone;
- Promote the use of standard procedures for geodetic data, in particular GPS data, quality evaluation and processing.



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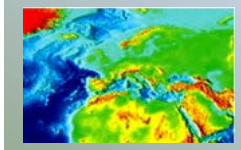
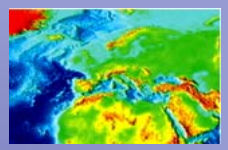
The primary goals of the WEGENER project are:

- Continue as a framework for geodetic, geophysical, geological cooperation in the study of the Eurasian/African/Arabian plate boundary zone;
- Foster the use of space-borne, airborne and terrestrial hybrid techniques for earth observation;
- Define effective integrated observational strategies for these techniques to reliably identify and monitor crustal movements and gravity field variations over all time-scales;



## Goals (cont.)

- Facilitate and stimulate the integrated exploitation of data from different techniques in the analysis and interpretation of geo-processes;
- Organize periodic meetings with special emphasis on interdisciplinary research and interpretation and modeling issues;
- Reinforce cooperation with African and Arabian countries and colleagues, which can both contribute to understanding the kinematics and dynamics of the Eurasian/African/Arabian plate boundary zone and promote the growth of such research in these countries.



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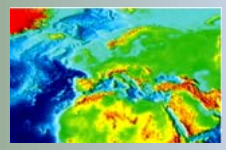
## Planned activities

- ✓ Build up a geo-database that enables access to metadata, for the WEGENER geographical area, with results and, when possible, historical data from episodic campaigns, including geodetic, geophysical and geological data, and results for strain rates, velocity fields, focal mechanisms, etc..;
- ✓ Define standards for GPS network establishment, data acquisition and guidelines for data processing and reliability checks;
- ✓ Establish a GPS analysis center specially dedicated to process permanent and episodic campaign data, not analyzed by other GPS centers, which will contribute to the development of a joint velocity field (EURO-VEL) that can support kinematics and geodynamic modeling in the WEGENER area of interest.



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# IV. GPS Permanent Networks

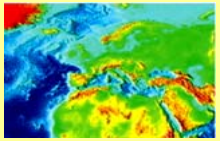
## 2. GPS Permanent Regional Network (North Algeria)

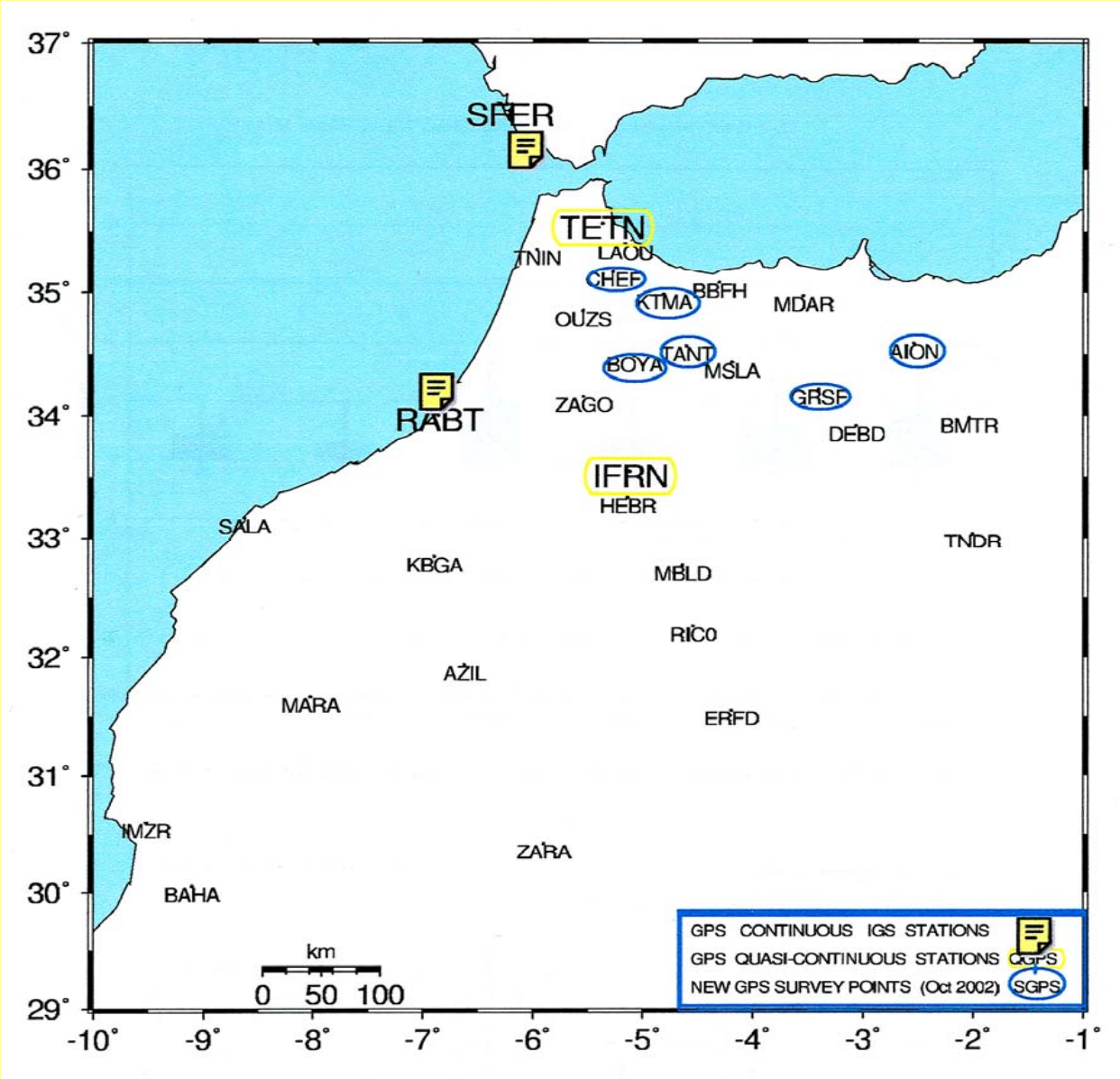

after Kahlouche et al., 2004

**24 permanent stations :**

- **(3) stations from National network : Tlemcen, Algiers, Souk-Ahras**
- **(21) Complementary permanent stations**

# Moroccan GPS network

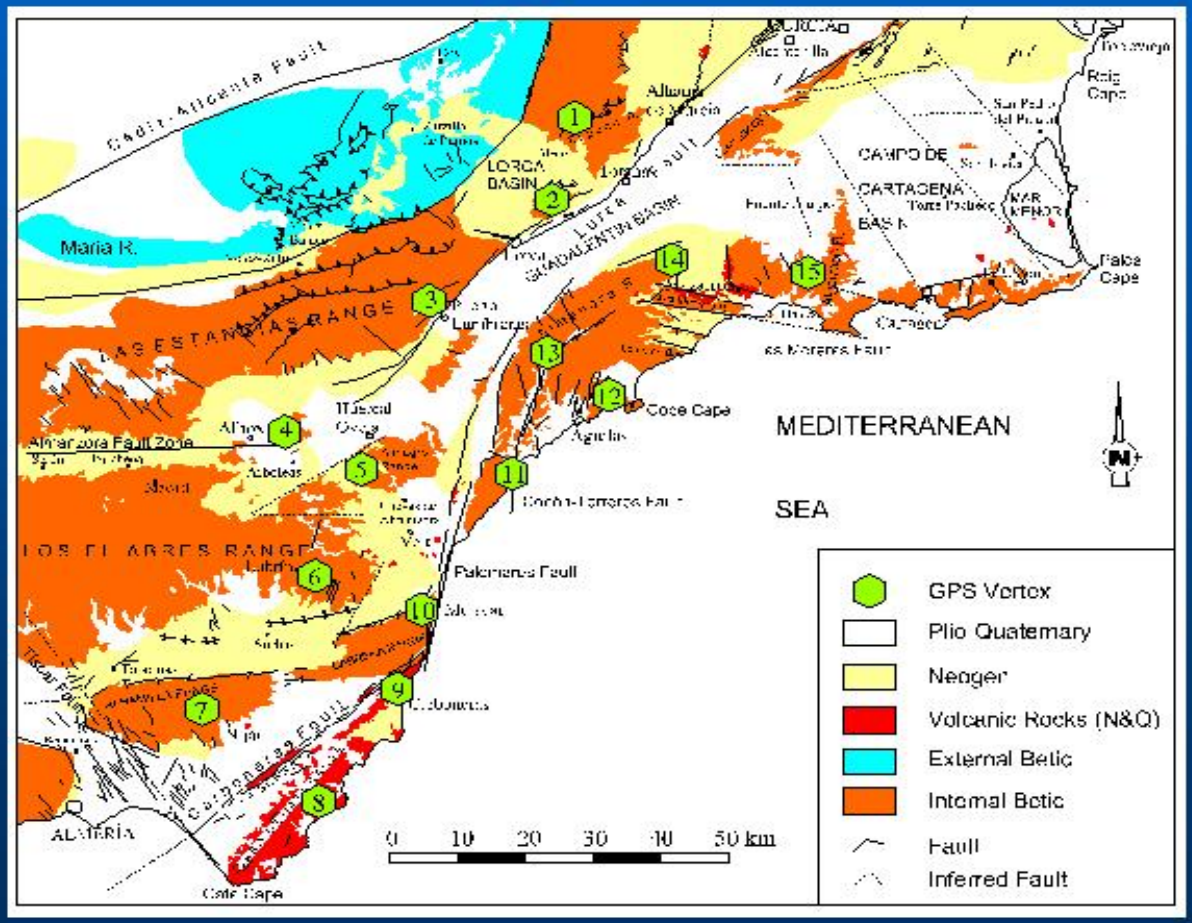





After Fadil et al., 2004

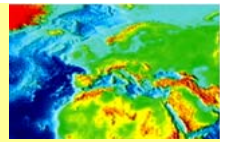
# CuaTeNeo[1] GPS Network

## [1]Cuantificación de la Tectónica actual y Neotectónica en la parte oriental de la Peninsula Ibérica




after Kharadzei et al., 2004

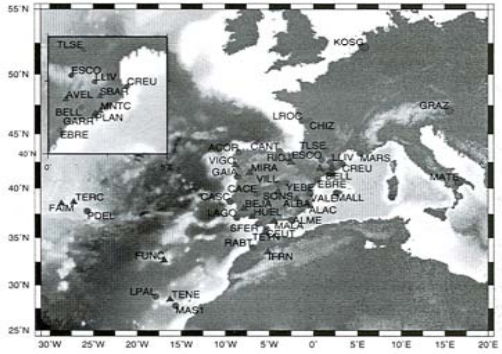
# GEODAC GEO-Database Analysis Center



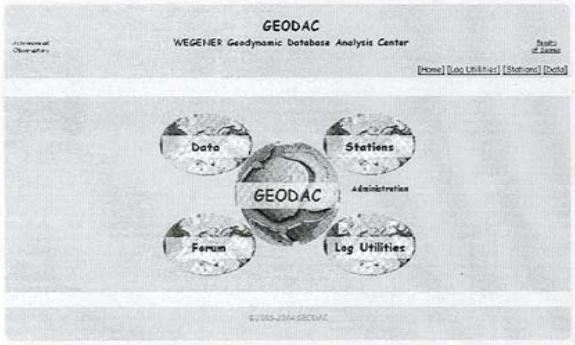
*GEODAC is a service dedicated to:*
*store, process and disseminate geodynamic data and solutions*
*for Southern Europe and North Africa (Eurasia/Nubia plate boundary region).*

GPS data analysis is a fundamental component in the GEODAC structure.

Currently, GEODAC is processing on a daily basis a network of continuously-operating stations focused on the Iberian Peninsula.



GEODAC network currently being processed




GEODAC website will be soon available at:

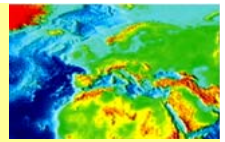
http://geodac.fc.up.pt/

(see computer presentation for details)

The WEGENER IAG Inter-Commission Project welcomes all researchers interested in the study area to contribute and use the GEODAC service.

More than just a GPS Data & Processing Center, available to the scientific community, this service is being designed to support also the several phases of acquisition, validation, processing, combination and interpretation of geo-data.

**Contact:** R.M.S. Fernandes rui@deos.tudelft.nl



# Forthcoming WEGENER General Assemblies

13th Assembly, June 2006, France

14th Assembly, 2008 Algeria

New WEGENER members are welcome!