

# IMPROVING GNSS-DERIVED ELLIPSOIDAL HEIGHTS USING OBSERVED METEO DATA

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## Abstract

Geodesy Engineering produces 3d coordinates (X,Y,H) and this science is infrastructure engineering. While geodesy engineering is used for the purpose of commercial activities that's multidisciplinary sciences such as building, bridge, barrage, road build's, architecture, geographic information systems, transportation, communication; but it is also aimed to be used for the purpose of scientific researches that's meteorological and Earthquake Researches. The trueness of the coordinate directly effects multidisciplinary sciences conducted by Geodesy engineering. Study for Improvement of Ellipsoidal heights was firstly applied by Dr.Seyit Ali Yılmaz in Europe and positive improvements has been obtained but according to the PhD supervisors of Dr.Seyit Ali Yılmaz, more applications of Global Navigation Satellite System (GNSS) measurements should be done in different climate conditions. All scientific studies of concern to this proposal have been referred to Improvement Ellipsoidal Heights, which acronym is "IEHs".

**Anahtar kelimeler:** Geodesy Engineering; GNSS; Scientific Researches; Height Coordinate; Tropospheric delay effect

## 1. GNSS Sciences

GNSS measures which can be determined X,Y Coordinates about 0~1 cm. are high sensitive's while ellipsoidal heights is very poor approximately 3~5 cm if no long grid is especially about 5~20 km<sup>[1,2]</sup>. This sensitiveness is very important for scientific works such as fine meteorological weather forecast or prediction of earthquake researches.

The proposed IEHs will improve the availability of excellent, trained Multidisciplinary engineering for European scientific researches, will be seed of innovative long-term research and education in meteorological and it will make a major contribution to earthquake researches. As known; prediction on the earthquake researches is very important for human life. On the other hand; meteorological forecast is also very important for different fields such as agricultural products and long term forecast prediction. Because of tropospheric delay effect, earthquake and long term meteorological forecast researches use 3d GNSS coordinates which are very sensitive X and Y coordinates except H ellipsoidal results<sup>[3,4,5,6,7]</sup>.

Agreed on some principles with Prof.Dr.C.Satirapod, he sent an invitation letter from Department of Survey Engineering Chulalongkorn University Bangkok Thailand to do postdoctoral researches.

## 2. Excellence

### 2.1. Quality, innovative aspects and credibility of the research

#### 2.1.1 Introduction, objectives and overview of the research programme

**Introduction of the proposal:** Coordinate Science very old matter of fact is in as much as humanity. Geodesy science approach coordinates. Actually present all the engineering sciences as building sectors, architecture, navigation, transportation geography information system (gis) very popular sector last decades. That means, geodesy science is multidisciplinary engineering science. 90's years advanced limitless improvement global navigations satellite system-gnss<sup>[8]</sup>. Finished the gnss measures; must be process; to coordinate count, by way of computer that suitable software programmes. Many business firms created to software programmes to this process technique<sup>[9]</sup>. Anyway; gnss coordinates as are suitable for commercial applications except that Scientific researches such as earthquake researches, meteorological researches<sup>[10]</sup>. On the other hand; Because of could not interfere from external to Tropospheric effect values; commercial programmes not suitable or need to improvement for Scientific Researches<sup>[11]</sup>.

**One of the reasons of the Ellipsoidal height's sensitive poorness:** The troposphere is the lowest layer of the atmosphere. Its thickness is approximately 18 km at the equator whereas it decreases 8 km towards the poles. Atmosphere which is the densest of the troposphere by containing 75% of the total mass compared to the other layers of the atmosphere is a significant error source in determining the point location. Since the troposphere is the layer that isn't ionised or called neutral its effect on GNSS signals can't be eliminated by phase combinations occurred from L1 and L2 carrier waves of GNSS receivers as in ionosphere layer<sup>[12]</sup>. Tropospheric layer contains %90 dry component and %10 wet components that is mainly problem wet component<sup>[13]</sup>. Tropospheric delay effect is a function of temperature, relative humidity and pressure and it is related with the height of the measuring point. The effect of neutral (non-ionized) atmosphere to electromagnetic waves transmitted in radio frequency is called tropospheric delay effect (or tropospheric refraction)<sup>[14]</sup>. This effect causes slowing down or a deflection of the electromagnetic wave. Saastamoinen and Hopfield

models with atmospheric parameters independent of time and the actual meteorological conditions are widely used in the evaluation of observation of Global Navigation Satellite Systems (GNSS) in Tropospheric delay calculation. In meteorological applications, it is very hard to represent the location and time distribution of water vapour in atmosphere. The numerical estimation quality of Precipitable Water: PW depends on the correct determination of atmospheric humidity dispersion<sup>[15]</sup>. Tropospheric effect must be analyzed to gns measures and used to be Gamit software Programme to Scientific Researches. Ellipsoidal Heights results counted only 3~5 cm. sensitive's however X, Y Coordinates 0~1 cm<sup>[16]</sup>.

**The main objectives are;** improvement the ellipsoidal height sensitive's (retrenchment: IEH's) by gns measurements to scientific works such as:

- Meteorological researches
- Earthquake researches (multidisciplinary)
- Renovation to the CORS (Continuously Operating Reference Stations) points in all Europe (interdisciplinary)

The main challenge is; although developed some techniques such as mapping functions (Global mapping functions, Vienna mapping functions) could not eliminate to the tropospheric delay effect.

Innovative aspect: Dr. Yilmaz developed first time new technique is innovative project measure that of air temperature, pressure and humidity simultaneously statically gns measurement<sup>[17]</sup>. He was directed by Supervisor which name Assoc.Prof.Dr. Muzaffer Kahveci constructed and managed Cors points in Europe end of the 1990's years. Anyway Assoc.Prof.Dr.M.Kahveci directed to Dr. Yilmaz of Cors point's renovation with sensor measure values for scientific researches.

State of the art Project, IEH's is multidisciplinary subject that, infrastructure engineering present 3d coordinates to all engineering applications are multidisciplinary subject. Because of non-commercial aim of the IEH's is via important for scientific works provide service of infrastructure engineering to the multidisciplinary works such as meteorological and earthquake researches. Therefore beyond the state of art IEH's project present scientific service and should be supported for science.

**Objectives: Contribution for Europe,** In case of desired results, the greater returns multidisciplinary state of art this project Europe will gain scientific excellence and very big prestige via important scientific subjects with the IEH's such as:

- **Long time basis on the Meteorological forecasts;Current method:** The limited of only 1~5 days the weather forecast current technology % 95 rightly, launch the sphere balloons 2 times in a day and very expensive method.
  - **Earthquake researches:** Importance of the IEH's project for the Earthquake Research Instituties to do seismic works need to truly ellipsoidal heights. As known Earthquake researchers use to gns coordinates for seismic applications; are very important highly sensibility.
- Contribution of beyond of the state of art IEH's project for Europe:**

- Long time basis on meteorological weather forecasts to product for planting and farming
- Cheapest
- Trueness
- Present to sensitive 3d coordiantes for earthquake researches
- Launched in airspace the satellites by Europe Countries had an very big investment for

knowledges of need it. Consequently the trueness of the gns coordinates expectation is very normal obtained by satellite. IEH's project is beyond the state of art excellent project will cover the expectations.

Overview the action: Dr. Yilmaz, will set up equipment's as suitable region in Thailand at the hexagonal shapes about 200 km<sup>2</sup> heights different as possibility from each other totally 10 points to the research meteorological sensor measurement. In addition prepare gns devices, that provided to Department of Survey Engineering, rent a car for each points to use to accumulator car's to energy by meteorological sensors which measure temperature, pressure and humidity simultaneously gns devices. Prof.Dr. Satirapod who is the Supervisor, will help to find to the researcher 10 expert for each points, measurement continue about 8~12 hours nonstop start and finish simultaneously<sup>[18]</sup>. All the gns results will saved to internal disks that mounted gns devices, however meteorological sensor results, will saved appropriate folder which name rinex into the hard disk by computer ready for in the field. When finished the field measurements, will start the same time official studies as process, with suitable programme the gamit software. Next step is coordinate accounts (X, Y, and H). Process, results and compare with existing techniques which; mapping functions and standard tropospheric models.

### 2.1.2 Research methodology and approach

ImportingtheexpertspeciallyfromThailandinspecificfieldsisv erybeneficialfor Europe thescientifictransferof knowledgandexperience Dr.Yilmaz'simpressivebackgroundand experiencewillindisputablyadvancethescientificexcellenceof Sencuk-Geodesy Lab.withregardstothe collaborativeresearchprojects.The researcherwilltransferhisexpertise and great ideas on thegns measurement techniques and data process specifications of the state of art the project.

**Research Methodology and approach:** The principal scientific aim of the project, improve the ellipsoidal height sensitive's to use different method gns measurements simultaneously meteorological sensor datum are the multidisciplinary projects as meteorological or earthquake researches. First time Dr.Yilmaz tested before in Europe and improve to ellipsoidal height sensitive's 3~5 mm. but not enough and need to more test region that different climate country to improve results more 3~5 mm. he believes that a consortium uniting European experts in geodesy together with a well-structured research and training plan provides the best approach to tackle this aim are **innovative activities proposed.**

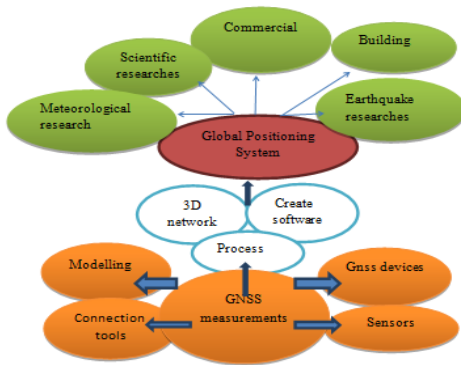


Figure 1: GNSS timetable steps

### 2.1.3 Originality and innovative aspects of the research programme

Although gnss coordinates are suitable for commercial applications, not enough to scientific researches especially for ellipsoidal heights. Gnss systems have been used to many sectors since last 25-30 years, which are used to communication, navigation, building, marina, and much more, useful, cheaper, practical and very fast are Multidisciplinary system. This system must be improved for scientific researches especially meteorological and earthquake researches. The main reason is atmospheric layer contain %90 dry component can modeling and %10 wet components that wet component is very difficult to modeling<sup>[19,20,21,22]</sup>. Until now, the standard tropospheric modeling is used to determine the coordinates.

The main challenge is that, although mapping functions and standard tropospheric model values (1013, 18 °C) are used to for all the different conditions, carry the tropospheric delay error.

Novel Concepts and innovative approaches: First time Dr. Yilmaz will use to meteorological sensor modeling in different advanced techniques and make them fully conversant with the interdisciplinary challenges in this field. Due to improvement gnss sensitive's, one of the states of art multidisciplinary research is earthquake predictions are vitally important to humanity.

Multidisciplinary1- Earthquake researches: Considering tectonic faults; gnss coordinates should have high limit sensitive data bank to be analyzes excellence to earthquake prediction and earthquake risk regions. Will do true analyses, will be save someone's life possibility. Considering that, after earthquake consisted disaster landscape; will not be able to hard prediction severe economic crisis. If thought for some Countries; about millions or billions dollars economical invoice with human life; will be the greatest care about positive contribution to earthquake predictions for humanity.

Multidisciplinary2- The state of art project is important to Meteorological researches to weather forecast. In

case of IEH's will make a major contribution to meteorological researches. Many Europe Countries launched to balloon to the sphere 2 times in a day, morning and evening, for meteorological purposes<sup>[23]</sup>. Due to work with this balloon which name radiosonde tools, done weather forecast in Europe countries cost of about 300 Euros per balloon. Radiosonde tools that work with balloon and mounted to radio to disposable measured temperature, pressure and humidity, during to rise free atmosphere broadcast to ground stations. Accounted to in Turkey region launched total 8 cities 16 balloons only for one day. For 365 days total account about 6.000 balloon cost 300 euro, totally about 1.750.000 Euro per country is very high cost launched the sphere irreversible, unlike gnss signals at no cost. On the other hand; because of the weather events (wind, thunder, and storm exc.) absolutely changed the route this balloons after launched, cannot serve correct position. These balloons can do weather forecast for 1~5 days, but limited to 10~14 days period of time and cannot monthly period of time. Compared with gnss signals the balloons; shown the gnss signals much more advantages, that; cost, validity, truly to refer and fastness.

One of the other challenge is, the tropospheric delay effects move to from on stock mapping functions, the researcher is believe that; gnss method and simultaneously meteorological datum (pressure, temperature and humidity) measurements will repair the fault.

Approach or method: Dr. Yilmaz would like to beyond state of art project that, improve to ellipsoidal heights sensitive to use measure to meteorological data's (temperature, pressure, humidity) instead of mapping functions or standard tropospheric model using<sup>[24,25,26,27]</sup>.

Interdisciplinary Approach: In case of improve to the ellipsoidal height sensitive, may be renovation Cors (Continuously Operating Reference Stations) statically points for in Europe countries to use all multidisciplinary engineering works<sup>[28,29]</sup>.

### 2.2. Clarity and quality of transfer of knowledge/training for the development or the researcher in light of research objectives

While the Researcher chosen this multidisciplinary method; educated to him supervisor Assoc.Prof.Dr. Muzaffer Kahveci is best of Geodesy, Space Geodesy and Bernese software programme best user in the world. He still works supervisor in Turkish Satellite TURKSAT. He directed to the Researcher about Geodesy Sciences, gnss measurement technics and important to Ellipsoidal Heights for Multidisciplinary subjects.

Quality of transfer of knowledge's: In addition, the Researcher contacted with Dr. Robert King; work is Department of Earth Atmospheric and Planetary Sciences MIT Harvard University USA, written by Gamit Software Programme to improvement to using meteorological sensor data's simultaneously gnss measurements<sup>[30]</sup> are innovative approach of the object. Dr. Yilmaz will transfer to all knowledge's learned from Dr. Robert King Department of Earth Atmospheric and Planetary Sciences MIT Harvard University USA and The Supervisor Prof.Dr. Satirapod scientific project results to Europe with all experiences by way of conferences, symposiums, scientific workshops planned in the workpackages shown table 2.1.b. all details 2.4.

Clarity and quality of knowledge: Instead of commercial software's, gamit software is, alternatively used to scientific researches, created to by Harvard University USA, Dr. Robert King mentioned above. Although; changed all the different points that are heights, temperature and humidity values normally commercial programmes use to standard tropospheric model values (1013, 20 °C)<sup>[31,32,33,34,35]</sup>. This mean is ignoring the changeability weather conditions. So; tropospheric effect will be ignoring too. That means; ignore to natural events in the tropospheric layer. So; provided to ellipsoidal height results give error for scientific researches that is the main challenge ideas of Dr. Yilmaz.

Transfer of knowledge: Dr. Yilmaz will test to in Thailand different measurement technics, because of a tropical climate to IEH's project to improvement scientific researches as meteorological or earthquake researches are multidisciplinary method. Because, he need to more datum for car one step further beyond state of art IEHs project. Earthquake predictions are of vital importance inside jeopardy belts in the countries, meteorological weather forecast also important for all over the World.

**As mentioned alternative approach to ellipsoidal heights,** Dr. Yilmaz, has been invited to by Prof. Dr. C. Satirapod in Thailand Bangkok Department of Survey Engineering Chulalongkorn University to do researches. Prof.Dr.Satirapod interested in this project application method and guaranteed of source the University provided to practice about improvement ellipsoidal heights.

**He will transfer his scientific and cultural experiences as state of art that explained clarify workpackages (table 2.1) to Bangkok Chulalongkorn University field works and official works than**

Due to applications current state of art method in Thailand; Europe will be achieve very big profits. Finished to the IEH's project should be repeated all the Cors points (Continuously Operating Reference Stations CORS). Although technological advances, built 90's years that Cors points and still use these, should be repeat with meteorological sensors.

Knowledge Transfers: During to Post-Doctoral researches Dr.Yilmaz; will apply the main challenge aim, with prof. Dr.Satirapod, has many scientific publishes measurement techniques, the beyond state of art project in Thailand-Bangkok. Finished to IEH's project of Department of Survey Engineering Chulalongkorn University in Thailand Dr.Yilmaz will transfer all the test results to only Europe for multidisciplinary researches. He will go to the Far East test-purpose, need to different climate region share to excellence scientific opportunities for Europe. Dr. Yilmaz travelled to many countries in Europe and Far East countries; he has excellence experience their cultural life, will transfer both share wide scientific knowledge and high cultural level that, belonging to Europe style. This application method will be excellent experience for the researcher with current state of art the project.

Originality innovative aspect is the IEH's project, making a huge contribution;

- Multidisciplinary scientific researches as meteorologic and earthquake researches
- Repeat to Cors points (Continuously Operating Reference Stations) to be unerror especially ellipsoidal height but scientific non commercial.

Disciplined and ordinary; Dr. Yilmaz; will be reference to Thailand Scientist, while apply to Geodesic engineering applications. He would like to show European People's specifically experiences, and would like to be cultural bridge to exchange ideas between East and West. Dr. Yilmaz believes that; transfer to his experiences to go Thailand.

Department of Survey Engineering Chulalongkorn University has much Geodesic equipment. This experience will teach to the researcher, different measurement techniques and different comments. The researcher would like to live this experience all his in life. Dr. Yilmaz needs to Marie S. Curie actions to carry out his experience, projects and European high cultural standard.

Obtained to results; Dr. Yilmaz will transfer to his own intelligence about topical multidisciplinary engineering join to relating topics.

- Conference
- Gns Workshops
- Symposiums.

Shown the workpackages list (Table 2.1)

### 2.3. Quality of the supervision and the hosting arrangements

Excellent supervision is the key prerequisite for the success of **IEHs** with respect to achievement of the scientific goals as well as to the formation of a new generation of innovative and independent researchers. **IEHs** will have a clearly identified supervisor and the research topic of the fellow chosen to fit into the core competences of the supervisor. The supervisor acts as direct advisor and meets with Dr. Yilmaz at least on a weekly basis to discuss all issues regarding the project and goals/objectives.

Prof.Dr. Satirapod, within **IEHs** is excellent scientist and has sufficient expertise to offer the Dr.Yilmaz appropriate support and provide for the necessary progress and review procedures, as well as the necessary feedback mechanisms. Coming from various organisations, countries and sectors the supervisor has of course different experiences in terms of leadership in research projects, industrial/academic research, or faculty duties. His complementary skills and experiences is combined in the supervisory board and the supervisory panels which will increase the overall supervision quality of the project and will be a benefit for Dr. Yilmaz an overview of the qualifications and experience of the supervisor biography is given in below. The details of biography honors, awards and research funds are shown page number 17-18.

#### Prof. Dr.ChalermchonSatirapodBiographie:

Chalermchon Satirapod graduated with a Bachelor of Engineering (Surveying) and Master of Engineering (Surveying) from Chulalongkorn University, Thailand, in 1994 and 1997 respectively. He joined the Department of Survey Engineering at Chulalongkorn University as a lecturer in late 1994. In early 1998 he joined the Satellite Navigation and Positioning (SNAP) group as a Ph.D. student. After he finished his Ph.D. studies in early 2002, he has been back to work as a lecturer at Chulalongkorn University. His research interests are data processing techniques and quality-assured

GPS surveying for a range of static applications. He has won several best paper prizes in Australia, U.S.A. and Thailand.

Dr. Yilmaz will set up equipment's as suitable region in Thailand-Bangkok. All the time course will take long times with supervisor share each other any experiments. During to this time, researcher will explore work method between Thailand people and Europe experts, methodical approach solving methods and Thailand cultural life. Because of the research intimate people, the research will learn many experiments as cultural differences, temporal works, disciplinary works, sense capacities, even taste of foods. Due to both of field works and official works, inasmuch as appealed to different engineering subjects this research is proof multidisciplinary method.

### 3. IMPACT

#### 3.1. Enhancing research- and innovation-related human resources, skills, and working conditions to realize the potential of individuals and to provide new career perspectives

Innovative scientific research training combined with a transferable skills research program is of critical importance for excellent career prospects of Dr. Yilmaz. In the European Area there is a growing demand for highly skilled personnel to boost innovation and academia-business interactions. Primary aim improves to the ellipsoidal height sensitive to help multidisciplinary researches. This innovative measure technique will apply first time in our knowledge's static GNSS measurement techniques, simultaneously meteorological sensor data's; according to specific technics; will measure in air temperature, and pressure, humidity. So until now in determining the coordinates with GNSS used to be classical techniques; will change if reach desired limitations. In case of desired sensitive after IEH's application, will play vitally role to interdisciplinary method. **The close contact with meteorological corporations and earthquake research corporations will provide the Dr. Yilmaz with an innovative and unique research programme, preparing him for future research activities in the scientific researches.**

At a scientific level, Dr. Yilmaz will receive unique training on an interdisciplinary research topic. The research program fosters an intense collaboration of all fellows via, night science meetings, a joint measurement campaign and workshops to encompass all scientific aspects of IEHs.

Dr. Yilmaz will experience the impact that his scientific results have in published papers conferences also as discussion topics at workshops, training session and during multidisciplinary researches. Transferable skills capabilities, including skills in scientific communication, scientific approach capability and leadership, are crucial for a successful career in academic or/and scientific research. The research program also provides the researcher with training in important entrepreneurial skills as well as intellectual property rights. The multidisciplinary interaction of IEHs will improve the career prospects of Dr. Yilmaz's cross-cultural and social competences. This complementary research will clearly improve the career prospects of Dr. Yilmaz's and significantly to his scientific career steps. Graduate Marie-Sklodowska-Curie fellows will have an excellent opportunity to gain a European Post-

Doctoral as well as receiving interdisciplinary training on the basis European co-operation, as recommended in the external European training process.

**IEHs** is promoting excellence and helps to make Europe's research and innovation system more competitive on a global scale. **IEHs** will improve the availability of a highly skilled workforce for European scientific researches and multidisciplinary engineering researches, maintaining the leading role of Europe in the knowledge based scientific excellence.

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