GPS and LIDAR Education at the University of Houston

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NCALM
The National Center for Airborne Laser Mapping
University of Houston • University of California, Berkeley

UNIVERSITY of HOUSTON
COLLEGE of NATURAL SCIENCES & MATHEMATICS

Outline

- Department of Earth and Atmospheric Sciences at UH
- NSF TUES Project at UH (DUE#1243581)
- Current GPS and LIDAR Courses at UH
- Needs and feasibility of teaching GPS & LiDAR at undergraduate level courses
- Class projects and activities at UH
- Summary and Thoughts

The University of Houston, TX

- The **University of Houston** (**UH**) is a state research university and the flagship institution of the University of Houston System. Founded in 1927, UH is Texas's third-largest university with nearly **41,000** students.

- The Carnegie Foundation classifies UH as a Tier One research university

- March 29, 2012-Houston- the University of Houston has been designated an **Hispanic-Serving Institution** (HSI) by the U.S. Department of Education Office of Postsecondary Education.

Department of Earth and Atmospheric Sciences, UH

Degrees:

B.S., M.S., and Ph.D. degrees in Geology, Geophysics and Atmospheric Sciences

B.S. in Environmental Sciences

B.A. in Earth Sciences.

Professional M.S. programs in Petroleum Geology and Petroleum Geophysics.

GIS Certification Program

Table 1: Numbers of EAS majors enrolled in Fall Semesters 2001 to 2014, by degree program. Data from UH Statistical Handbook.

Semester	Fall 2001	Fall 2002	Fall 2003	Fall 2004	Fall 2005	Fall 2006	Fall 2007	Fall 2008	Fall 2009	Fall 2010	Fall 2011	Fall 2012	Fall 2013	Fall 2014
Graduate														
Atm Sci MS								1	3	5	8	11	7	2
Atm Sci PhD											4	4	10	13
Geology MS	24	37	36	49	47	47	55	57	79	91	119	131	97	71
Geology PhD	19	21	26	17	30	32	30	29	19	21	21	28	33	41
Geophysics MS	11	16	12	18	27	34	44	48	61	88	110	104	80	77
Geophysics PhD	16	16	24	27	28	26	25	20	30	35	44	46	56	55
Total Graduate	**70**	**90**	**98**	**111**	**132**	**139**	**154**	**155**	**192**	**240**	**306**	**324**	**283**	**259**
Undergraduate														
Geology	46	45	48	47	66	89	106	128	138	167	211	195	202	209
Geophysics	16	10	6	6	10	28	34	50	50	65	75	87	107	130
Earth Sci	8	7	9	12	11	14	10	18	20	23	24	16	15	13
Env Sci						5	13	25	48	75	96	100	95	95
GIS										1	5	5	3	3
Pre-Grad											2	5	12	7
Total Undergrad.	**70**	**62**	**63**	**65**	**87**	**136**	**163**	**221**	**256**	**331**	**413**	**408**	**434**	**457**
EAS Total	**140**	**152**	**161**	**176**	**219**	**275**	**317**	**376**	**448**	**571**	**719**	**732**	**717**	**716**

The largest geoscience department in North America!

Earth and Atmospheric Science, UH

Table 15: Total number of tenured/tenure track faculty in EAS, YF2010-2015.						
Fiscal Year (FY)	FY10	FY11	FY12	FY13	FY14	FY15
# of Faculty	25	27	27	28	30	33

Tenured/tenure-track faculty: 33+2
Undergraduates: > 400
Graduates: 200-300

Standard Teaching Load: 5 courses per 2 years!
Large classes!

Fieldwork is a major component of all degree programs!

NSF TUES Track 1: Integrating GPS and LiDAR Into Undergraduate Geoscience Education at UH

09/1/2013---08/31/2017

- New course development

GEOL4332/6324 Geoscience Applications of GPS and LiDAR

GEOL4355 Geophysics Field Camp (GPS&LiDAR, 1/8)

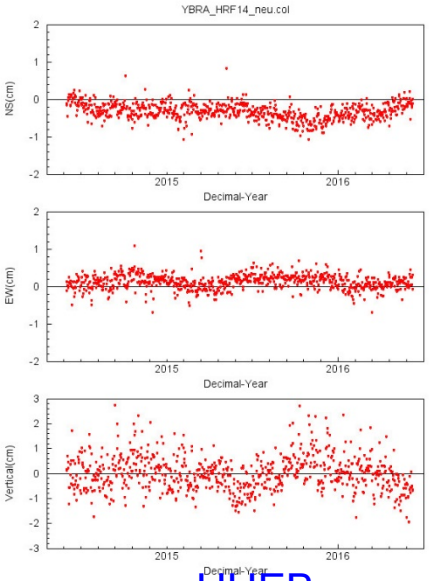
- Building Infrastructure for GPS Education

Install a Continuously Operating Reference Station (CORS) at the Yellowstone Bighorn Research Association (YBRA) field camp in Montana.

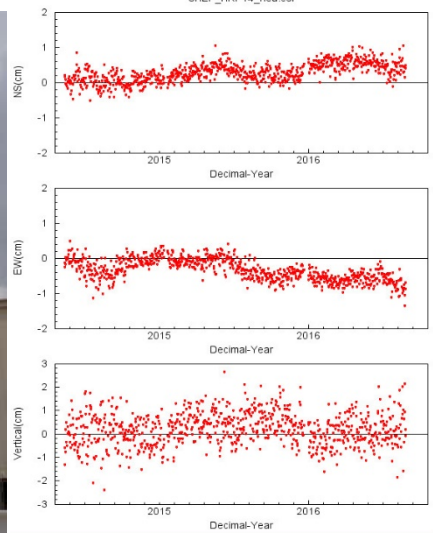
YBRA was established and run by Princeton University from 1937 to 1991, and then by the University of Pennsylvania from 1992 to 2007 (Sisson et al., 2009). UH became the manager of the long-lived YBRA geology field camp in 2008. Over 300 students use this facility each summer!

Install a CORS in the UH campus.

YBRS

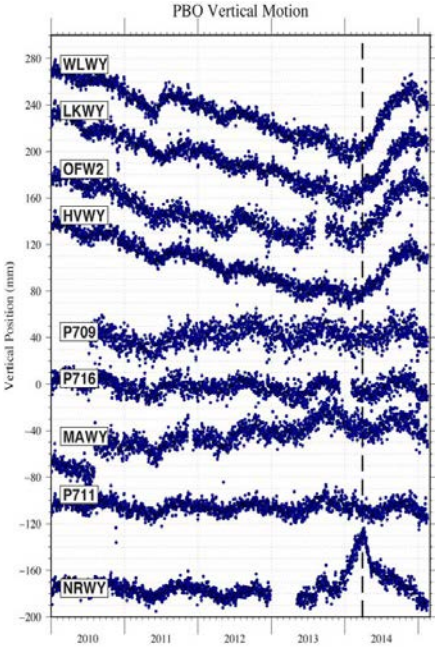


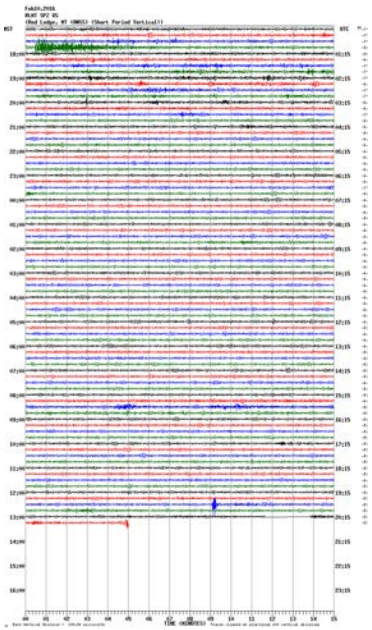
UHEB

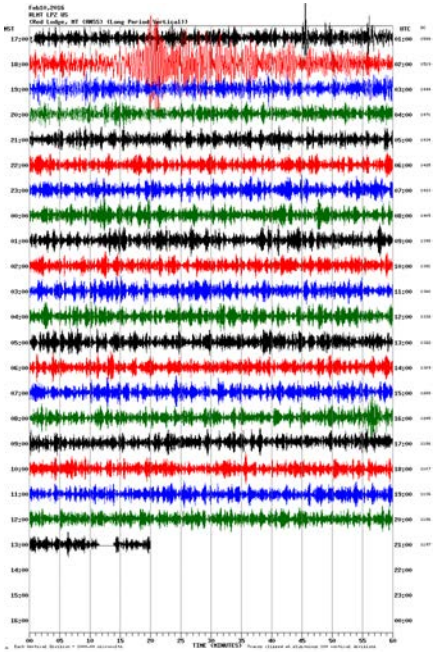


YBRA: Yellowstone Bighorn Research Association

A great field camp for geoscience education!







Faculty Expertise Development

Since GPS and LiDAR techniques have become fundamental research tools in the geosciences, it is natural to integrate these new technologies into undergraduate introductory-level and majors-level courses. In order to implement the new tools into these courses, instructors should become competent in GPS and LiDAR technologies. Unfortunately, most faculty members were educated at the time before GPS and LiDAR became scientific tools.

The specific objectives of this workshop include (original sentences in the proposal):

- Engaging new and potential geoscience educators who have interests in GPS and LiDAR,
- Influencing and training geoscience core-course educators to integrate GPS/LiDAR into their educational activities (Physical Geology, Global Plate Tectonics, Introductory Geophysics, Seismology, Geological Engineering, and Natural Hazards)
- **Demonstrating the feasibility of teaching high-accuracy GPS and LiDAR techniques to undergraduates as an independent course or as a part of conventional geoscience core courses**,
- Exploring available educational materials, software/tools, and resources related to GPS and LiDAR.

GPS & LiDAR Courses at UH

- **GEOL4332/6324 Geoscience Applications of GPS and LIDAR**

  An elective course for geology, geophysics, petroleum engineering, and Civil Engineering majors at UH.

  2014 Spring: 38+15 students; 2015 Spring: 56+12 students;

  2016 Spring: 85+7 students; 2017 Spring: 50 + 6??

- **GEOL4355 Geophysics Field Camp (GPS/LiDAR, ¼-1/8)**

  A required core course for Geophysics majors. Freeport Beach, TX!

  2012, 2013, 2014: 32-35 students; 2015 summer: 63 students;

  2016 summer: 64 students

- **GEOL4330 Introduction to Geophysics**

  A core course for both geology and geophysics majors.

  2012 Fall: 140 students; 2014 Fall: 96 students; 2016 Fall: 121 students

  (1 lecture for GPS, 1 lecture for LiDAR, 1-day field trip to UHCC)

- **GEOL6323 Satellite Positioning and Geodesy**

  (graduate level, each fall semester, 10--20 students)

New Graduate Program (M.S., Ph.D.) at UH
Geosensing Systems Engineering & Sciences

NCALM THE NATIONAL CENTER FOR AIRBORNE LASER MAPPING

- **CEE Core Courses**
- CIVE 5380/6380: Introduction to Geomatics and Geosensing (3 cr)
- CIVE 6382: Lidar Systems and Applications (3 cr)
- CIVE 6384: Satellite Altimetry and Interferometric Synthetic Aperture Radar (3 cr)
- CIVE 6386: Survey Measurements and Analysis (3 cr)
- CIVE 6393: Geostatistics (3 cr)
- CIVE 7342: Engineering Geographic Information Systems (3 cr)
- CIVE 7380: GNSS/INS and Augmented Systems for Positioning and Navigation (3 cr)
- CIVE 7397: Physical Geodesy (3 cr)
- **ECE Core Courses**
- ECE 6337: Introduction to Stochastic Processes (3 cr)
- ECE 6342: Digital Signal Processing (3 cr)
- ECE 6364: Digital Image Processing (3 cr)
- ECE 6397: Multi-Dimensional Image Processing (3 cr)
- **EAS Core Courses**
- **GEOL 4332/6323: Geoscience Applications of GPS and Lidar (3 cr)**
- GEOL 6324: Satellite Positioning and Geodesy (3 cr)
- GEOL 6325: Remote Sensing (3 cr)

Needs of teaching GPS & LiDAR at undergraduate level

- Global Positioning System (GPS) is a satellite-based navigation system that was developed by the U.S. Department of Defense in the early 1980s.

  New disciplines:

  GPS plate tectonics, GPS Seismology, GPS glaciology, GPS meteorology, GPS Geodesy

- Light Detection and Ranging (LiDAR) is a remote sensing technique that uses short pulses of light to measure the distance to, or other properties of, a target. In recent decades, LiDAR technology has been widely used in many disciplines, such as archaeology, geography, geology, geomorphology, seismology, forestry, atmospheric physics, airborne laser swath mapping (ALSM), and laser altimetry. LIDAR has quickly become a very attractive method for geoscientists to obtain "***bare earth***" surface models.

- GPS and LiDAR have become fundamental research tools in geoscience research communities. However, they have not yet been systematically integrated into current geoscience curriculum, particularly at the undergraduate level.

Feasibility of Integrating GPS and LiDAR into Undergraduate Curricula

Are GPS & LiDAR teachable contents for undergraduates in a large class environment?

- **Community Support**

UNAVCO

Open Topography

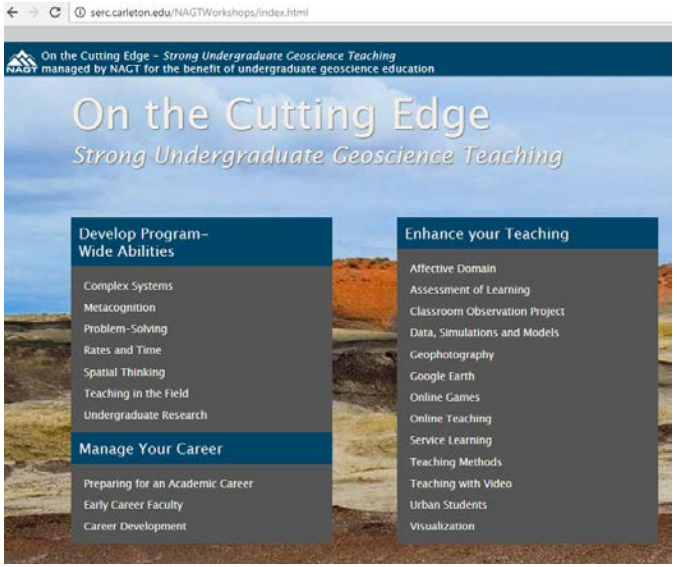
NCALM

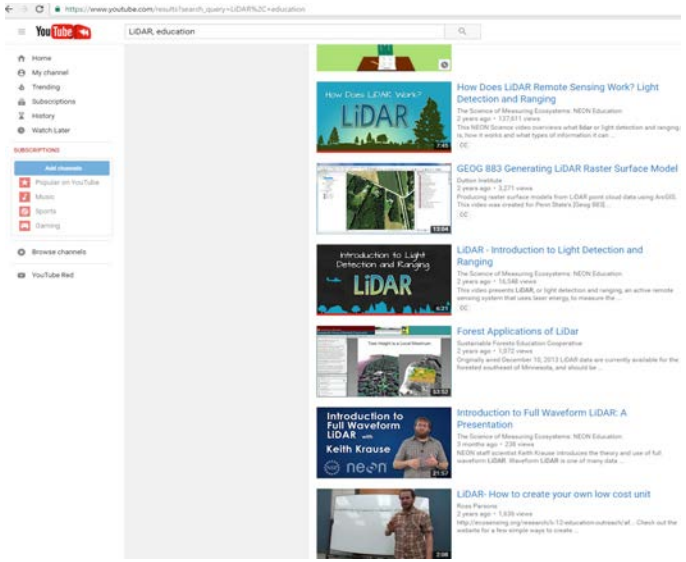
Science Education Resource Center (SERC) at Carleton College

YouTube

- **Free software for GPS & LiDAR data processing**

- **Support from your department**





Feasibility

Availability of GPS and LiDAR Equipment

UNAVCO

Community Projects Instrumentation Data Software Science Education

Request Support

UNAVCO provides GPS equipment and engineering support to NSF-EAR, NSF-OPP, and NASA-SENH funded investigators. Data archiving and community. Investigators are encouraged to contact UNAVCO prior to proposal submission and to request the use of UNAVCO support directly to be submitted with the proposal. Highest support priority is given to projects requesting UNAVCO support in their proposal.

Complete this form to request support from UNAVCO. Once you have submitted your request, a confirmation e-mail will be sent to you. When your request is approved, primary UNAVCO contact.

Please visit the appropriate FAQ pages for more information about the extent of services offered within each of the following programs:

- Support FAQs

For equipment repairs, click here.

* *Required fields or N/A if Not Applicable*

UNAVCO Equipment Loan Program

Project Type: *

(Check all that apply)

GPS/GNSS
- Campaign Survey
- Post-Processed Kinematic
- Permanent Station
- Real-Time Data Streaming
- Meterological Instrumentation (GPS Met Packs)

Borehole Geophysics
- Strainmeter
- Tiltmeter
- Seismic
- Pore Pressure/Environmental Data
- San Andreas Observatory at Depth (SAFOD)
- Cuttings and Core Samples

Geodetic Imaging
- InSAR
- Terrestrial Laser Scanning (TLS)
- Airborne Laser Scanning (ALS)

Education and Outreach
- Education and Outreach

Other
- Other

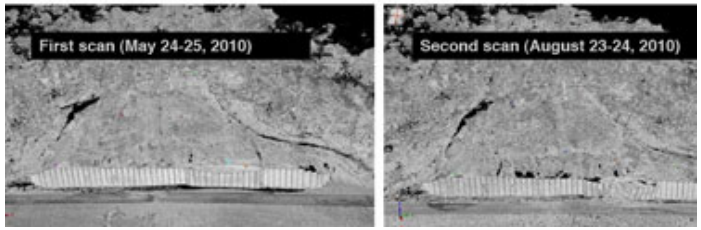
Support Requested: *

(Check all that apply)

Proposal Planning, Budgeting and Letter of Support
- Technical
- Broader Impacts
- General Proposal Support

Pool Equipment Loan
- GPS/GNSS Equipment Loan
- Terrestrial Laser Scanning (TLS) Equip

RECINTO UNIVERSITARIO DE MAYAGUEZ
UNIVERSIDAD DE PUERTO RICO



Delineating and defining the boundaries of an active landslide in the rainforest of Puerto Rico using a combination of airborne and terrestrial LIDAR data

Guoquan Wang, James Joyce, David Phillips, Ramesh Shrestha & William Carter

Landslides
Journal of the International Consortium on Landslides

ISSN 1612-510X
Volume 10
Number 4

Landslides (2013) 10:503-513
DOI 10.1007/s10346-013-0400-x

Landslides

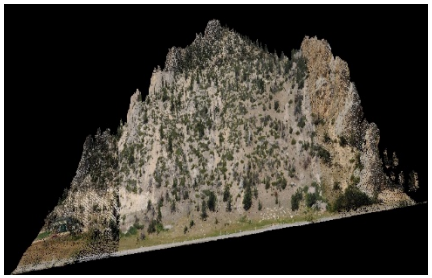
Supported by UNAVCO LIDAR team!
Dr. David Phillips

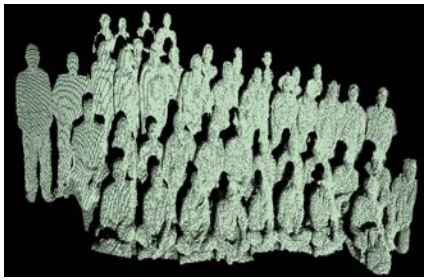
Feasibility

UNAVCO Support to UH Field Camp

Mr. Cristopher Crosby (2012)

Mr. Ken Austin (2013, 2014)

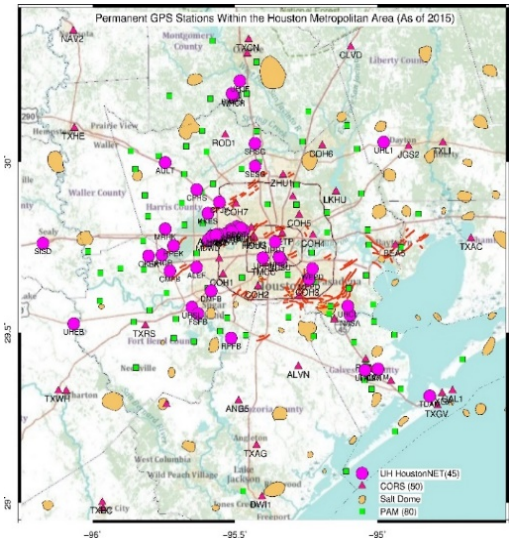




Ms. Marianne Okal (2015)

Feasibility

HoustonNet (50 Permanent GPS Stations)



NSF MRI (Major Research Instrumentation Grant--HoustonNET). MRI: Acquisition of GPS Equipment for Establishing a Continuously Operating Dense GPS Network in Houston Metropolitan Area for Urban Natural Hazards Study (September 1, 2012---August 30, 2016).

PI: Guoquan Wang, Co-PIs: Shuhab Khan (Geosciences), Barry Lefer (Atmospheric Science), Thomas Hsu (Civil Engineering), Ramesh Shrestha (Geodetic Imaging).

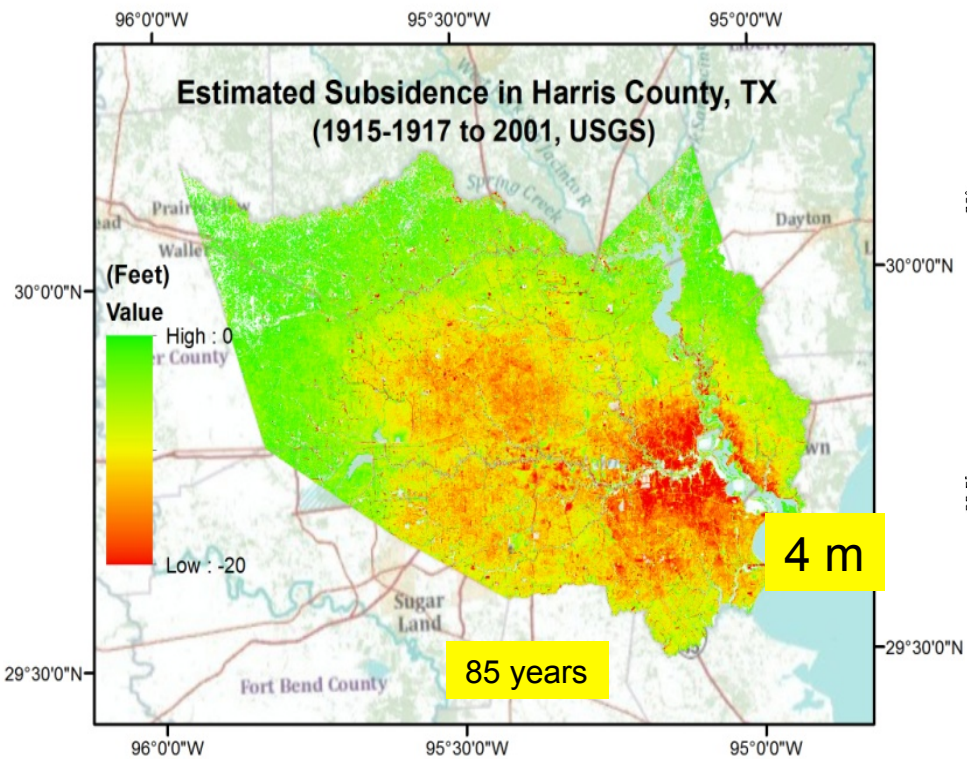
RTK GPS: A Trimble R10-to-R10 RTK Set

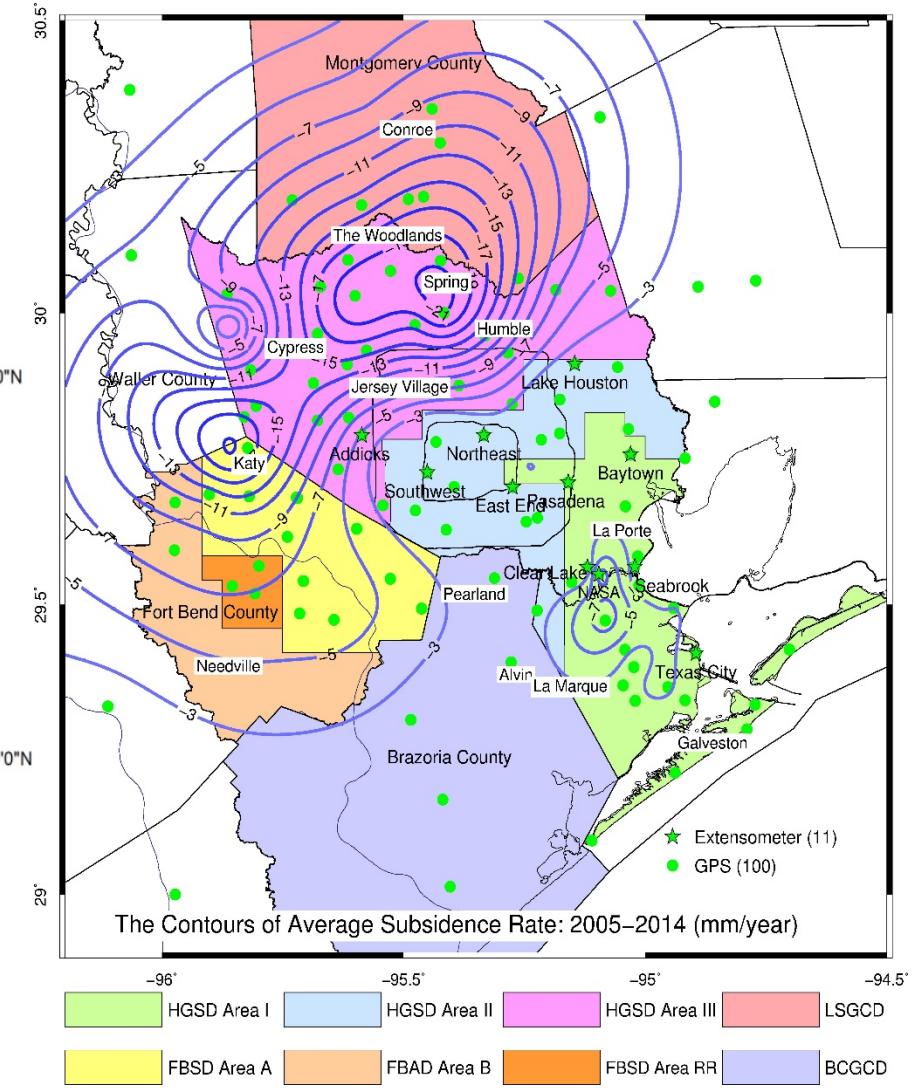
TLS: Riegl VZ-2000

Feasibility

Houston Subsidence Study

Recent Subsidence Mapping (2005-2014)





165 GPS (> 2 years) +11 Extensometers

USGS
science for a changing world

GPS Data Processing: A Barrier to Implementing GPS Into Undergraduate Curriculum

- **Sophisticated "scientific" software packages, GIPSY/OASIS, GAMIT/GLOBK, and BERNESE.**
- **Free Online Post Processing**

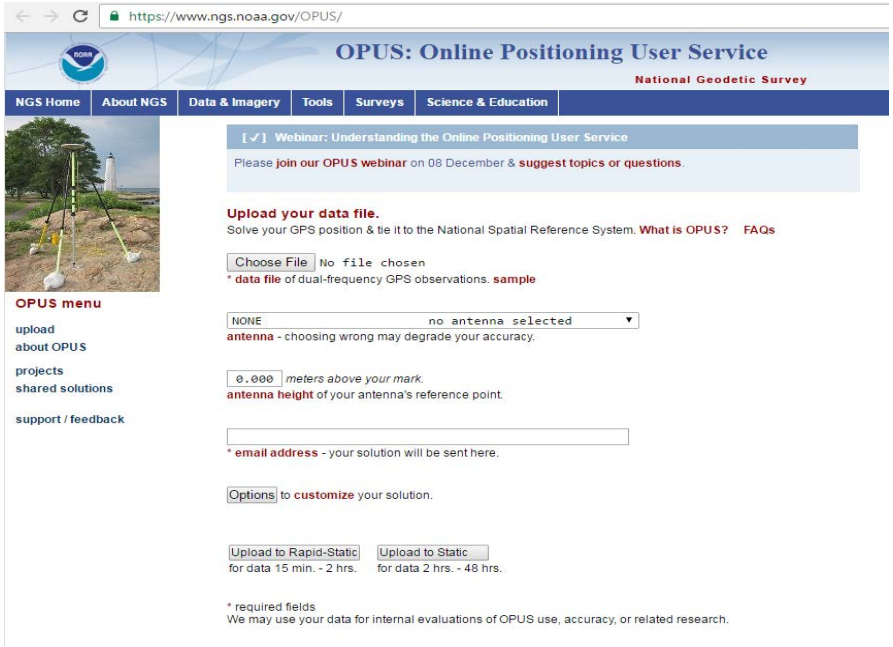
OPUS: Online Positioning User Service, National Geodetic Survey, U.S.
CSRS-PPP: Canadian Spatial Reference System, Natural Resources Canada
AUSPOS: Geoscience Australia
APPS: Jet Propulsion Laboratory
SCOUT: Scripps Orbit and Permanent Array Center (SOPAC), University of California, San Diego
GAPS: University of New Brunswick
MagicGNSS: GMV
CenterPoint RTX: Trimble Navigation

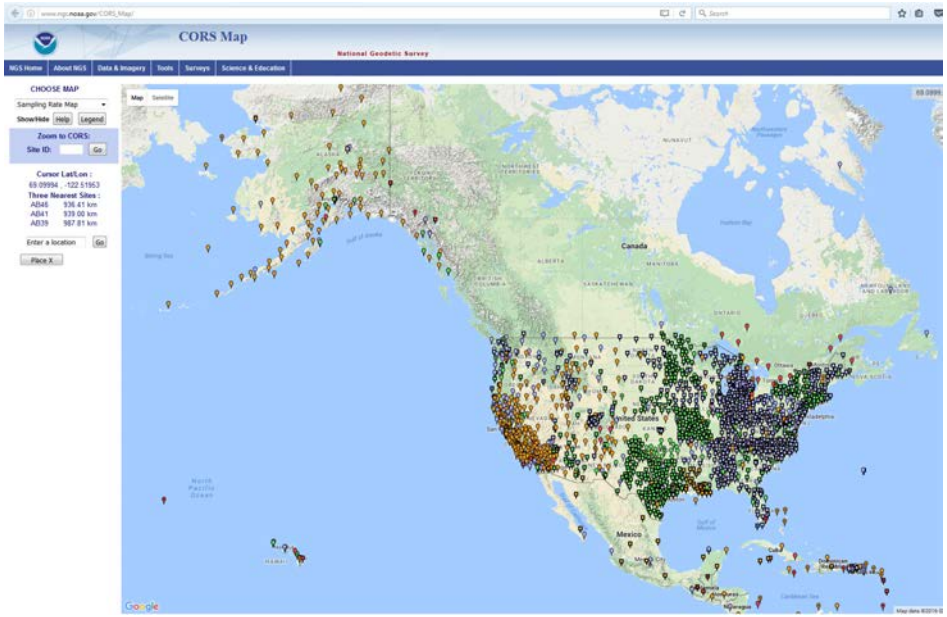
Using online GPS processing services, a GPS learner can speed through the complex aspects of data processing and focus on the scientific applications of high-precision GPS.

GPS Data Processing

OPUS: Online Positioning User Service

National Geodetic Survey





OPUS

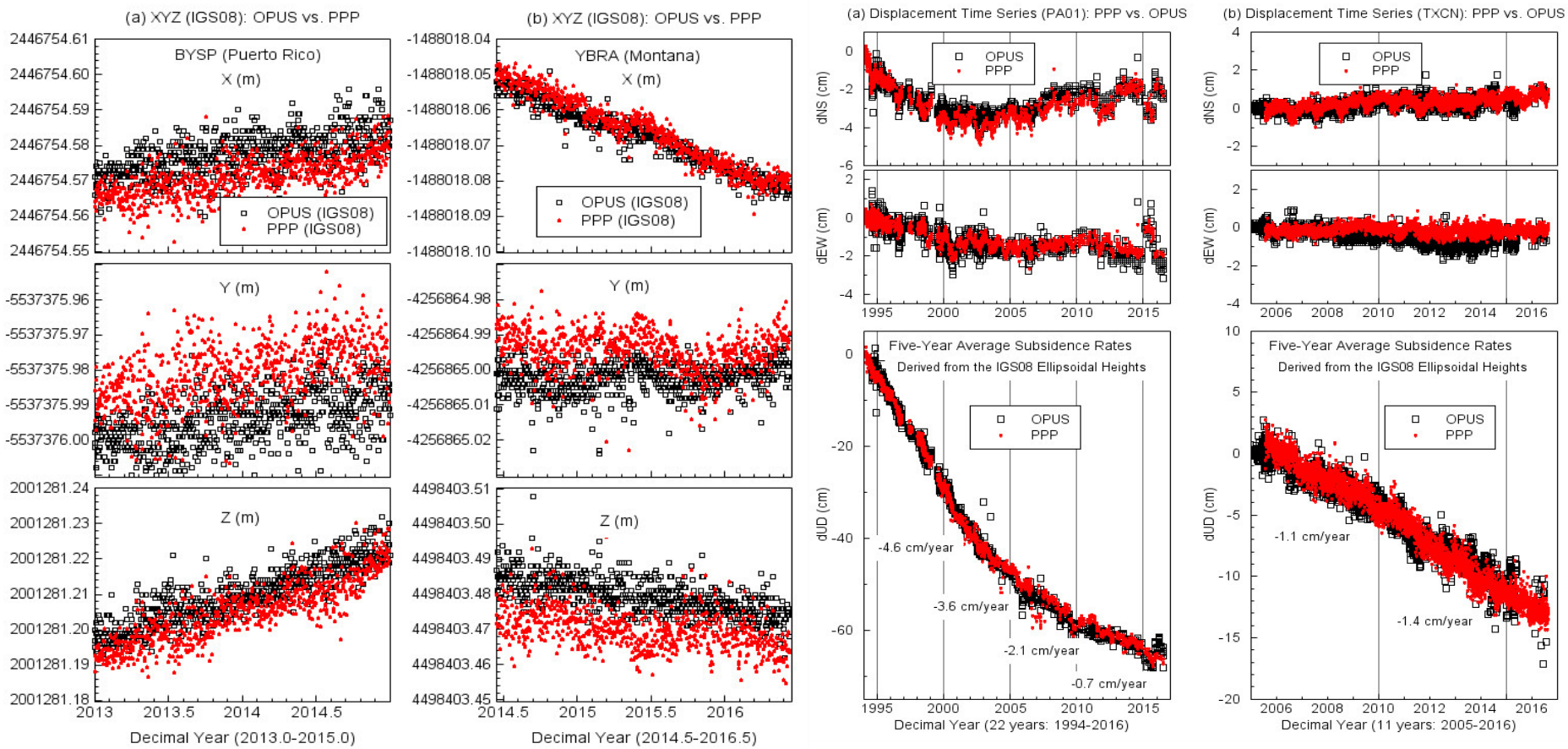
CORS

GPS Data Processing

```
From: opus <opus@ngs.noaa.gov>
Date: Wed, Oct 30, 2013 at 6:14 PM
Subject: OPUS solution : ponc0010.10o OP1383174725858
To: guoquan.wang2011@gmail.com

 FILE: ponc0010.10o OP1383174725858

 1008   NOTE:  Antenna offsets supplied by the user were zero.  Coordinates
 1008   returned will be for the antenna reference point (ARP).
 1008
                            NGS OPUS SOLUTION REPORT
                            ========================
All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

      USER: guoquan.wang2011@gmail.com              DATE: October 30, 2013
RINEX FILE: ponc0010.10o                            TIME: 23:13:47 UTC

  SOFTWARE: page5  1209.04 master51.pl 072313      START: 2010/01/01  00:00:00
 EPHEMERIS: igs15645.eph [precise]                  STOP: 2010/01/01  23:59:00
  NAV FILE: brdc0010.10n                        OBS USED: 56966 / 57966   :  98%
  ANT NAME: TRM49700.00     NONE              # FIXED AMB:   160 /   171   :  94%
ARP HEIGHT: 0.000                              OVERALL RMS: 0.014(m)

 REF FRAME: NAD_83(2011)(EPOCH:2010.0000)              IGS08 (EPOCH:2010.0014)

         X:      2402010.943(m)   0.004(m)           2402010.230(m)   0.004(m)
         Y:     -5570892.015(m)   0.006(m)          -5570890.229(m)   0.006(m)
         Z:      1962746.838(m)   0.002(m)           1962746.663(m)   0.002(m)

       LAT:   18  2 27.38253      0.003(m)        18  2 27.39648      0.003(m)
     E LON:  293 19 27.61636      0.004(m)       293 19 27.61814      0.004(m)
     W LON:   66 40 32.38364      0.004(m)        66 40 32.38186      0.004(m)
    EL HGT:          172.488(m)   0.006(m)               170.606(m)   0.006(m)
 ORTHO HGT:          211.874(m)   0.011(m) [ H = h-N (N = GEOID12A HGT)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 19)         SPC (5200 PRVI)
Northing (Y)  [meters]     1996261.239           222994.948
Easting (X)   [meters]      746058.574           174342.122
Convergence   [degrees]     0.72020301          -0.07582182
Point Scale                 1.00034859           0.99999955
Combined Factor             1.00032146           0.99997243

US NATIONAL GRID DESIGNATOR: 19QGV4605896261(NAD 83)
                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DI4790 PUR5 PUERTO RICO 5 CORS ARP         N182746.703 W0670401.046   62406.1
DH9349 PRMI MAGUEYES ISLAND CORS ARP       N175813.419 W0670243.337   39924.7
DF8978 ZSU1 SAN JUAN WAAS 1 CORS ARP       N182552.804 W0655936.513   84100.1
                 NEAREST NGS PUBLISHED CONTROL POINT
TV1246      PENUELAS USGS 1934             N180222.211 W0664207.818    2810.5
```

GPS Data Processing

OPUS vs. PPP



GPS Data Processing

OPUS for Horizontal Subcentimeter-Accuracy Landslide Monitoring: Case Study in the Puerto Rico and Virgin Islands Region

Guoquan Wang[1] and Tomás Soler, M.ASCE[2]

Abstract: This study demonstrates the usefulness of an approach based on the Online Positioning User Service (OPUS) provided by the National Geodetic Survey (NGS) of the National Oceanic and Atmospheric Administration (NOAA) to process Global Positioning System (GPS) data and conduct long-term landslide monitoring in the Puerto Rico and Virgin Islands region. Continuous GPS data collected at a creeping landslide site during 2 years were used to evaluate different scenarios for landslide surveying: continuous or campaign, long duration or short duration, morning or afternoon (during different weather conditions). OPUS uses the Continuously Operating Reference Station (CORS) network managed by the NGS as control points and user-collected data to solve for the position of the occupied station (rover). In July 2011, there were 19 NGS CORS sites in the Puerto Rico and Virgin Islands region. This dense GPS network provided a precise and reliable reference frame for subcentimeter-accuracy landslide monitoring in this region. OPUS static solutions (OPUS-S) for sessions as short as 4 h, and OPUS rapid static solutions (OPUS-RS) for sessions as short as 15 min, can achieve subcentimeter horizontal accuracy if the collection of data during extreme weather conditions is avoided. The uncertainty (peak-to-peak error) reported by a single OPUS-S solution differs from the "true" accuracy by a factor of 1.7 for the horizontal components and 1.3 for the vertical component. The uncertainty reported by a single OPUS-RS solution differs from the accuracy by a factor of 1.4 for horizontal components, while the uncertainty of vertical component statistically agrees with the vertical accuracy. This study also indicates that rainfall events can seriously degrade the performance of high-accuracy GPS. Field GPS landslide surveying should avoid rainfall episodes when accompanied by thunderstorms and the passage of detrimental weather fronts. Once appropriate precautions are taken, the results of this investigation show that OPUS-S and OPUS-RS are ideal alternative tools for subcentimeter-accuracy landslide monitoring. **DOI: 10.1061/(ASCE)SU.1943-5428.0000079.**

Case Study

Using OPUS for Measuring Vertical Displacements in Houston, Texas

Guoquan Wang, M.ASCE[1]; and Tomás Soler, M.ASCE[2]

Abstract: The Houston area has been suffering from subsidence for several decades. Therefore, continuously operating reference stations (CORS) in this area may have experienced considerable vertical displacements. The Online Positioning User Service (OPUS), provided by the National Geodetic Survey (NGS), uses CORS as references in its data processing. This study investigated what effects, if any, the subsidence experienced by these CORS around Houston contributes to the accuracy of OPUS vertical results. Our OPUS results were determined from three long-term (over 10-year) blocks of continuous data using Global Positioning System (GPS) stations located in different parts of the Houston area. The OPUS results were compared with the vertical measurements from the precise point positioning with single receiver phase ambiguity (PPP-SRPA) solution implicit in the *GIPSY/OASIS 6.1.2* software. This particular study indicates that OPUS achieves 1.0-cm vertical accuracy for daily sessions (24 h) in the region around Houston, which is comparable to the OPUS accuracy previously reported in other investigations. Subsidence as slow as 0.5 cm/year can be detected by analyzing OPUS results spanning 5 or more years of data. Our main conclusion is that the subsidence experienced by NGS CORS in the Houston area does not considerably affect the accuracy of OPUS vertical results. For those users who require a few centimeters of vertical accuracy for daily sessions, OPUS is a good choice, because users do not need to establish any control stations and do not need to install any GPS software packages on their local computers. **DOI: 10.1061/(ASCE)SU.1943-5428.0000103.**

CE Database subject headings: Global positioning systems; Texas; Land subsidence; Displacement.

Author keywords: Accuracy; CORS; GPS; Houston; OPUS; Subsidence.

Case Study

Measuring Land Subsidence Using GPS: Ellipsoid Height versus Orthometric Height

Guoquan Wang, M.ASCE[1]; and Tomás Soler, M.ASCE[2]

Abstract: Global positioning system (GPS) technology has been frequently used to monitor geological hazards associated with ground deformations, such as long-term landslides and subsidence. When GPS data are processed, they yield ellipsoid heights, which are the distances above a smooth ellipsoid surface. However, orthometric heights are often used in practical surveying and engineering applications. Orthometric height is a physical quantity that refers to the surface of the geoid. In this study, a more practical alternative definition of orthometric height is used. This approximation is the one commonly implemented in practical surveying and engineering applications to compute relative orthometric height values. This well-known procedure computes orthometric heights by combining GPS-measured ellipsoid height and a geoid model. Any type of orthometric height is a physically based quantity. GPS alone, which is a geometric technique, cannot directly measure orthometric heights. This study investigates the vertical displacements (subsidence or uplift) derived independently from ellipsoid heights on one hand and modeled orthometric heights (computed from GPS and a geoid model) on the other hand and compares the results. Long-term GPS observations at a subsidence site in Houston, Texas, and a landslide site in Ponce, Puerto Rico, are investigated as examples. The major conclusion derived from this study is that, in practice, directly GPS-obtained ellipsoid heights and GPS-derived orthometric heights determined using GPS and a geoid model will result in the same subsidence measurements. Hence, ellipsoid heights derived from GPS observations, which are geometric quantities, could be directly used to measure long-term subsidence without the need of performing leveling techniques. It was further concluded that the choice of the software packages for GPS data postprocessing [Precise Point Positioning (PPP) and/or Online Positioning User Service (OPUS)] was not critical for tracking long-term subsidence rates. However, users should avoid mixing the ellipsoid heights calculated by different software packages or by different versions of the same software package processed at different times. **DOI: 10.1061/(ASCE)SU.1943-5428.0000137.**

Case Study

Interpreting *OPUS-Static* Results Accurately

Tomás Soler, M.ASCE[1]; and Guoquan Wang, M.ASCE[2]

Abstract: The *Online Positioning User Service* (*OPUS*) operated by the National Geodetic Survey (NGS) has consolidated into a very attractive tool for surveyors, engineers, and the academic community to procure precise/accurate positions from global positioning system (GPS) observations. The *OPUS* utility continues to be improved since it was successfully launched in 2000. In general, each update results in better reliability of the precision and accuracy of *OPUS* solutions. However, necessary software modifications could also introduce certain biases, some significant, complicating the interpretation of *OPUS* results, particularly for applications that rely on high-accuracy absolute positions. This article concentrates on the interpretation of *OPUS-Static* solution reports primarily in relation to the transformation of reference frames and geoid models, which are two basic scientific ingredients in practical geodetic-surveying enterprises. One-year continuous GPS observations collected at a landslide site in Puerto Rico were uploaded to *OPUS-Static* on April 20, 2011; October 30, 2013; and April 29, 2015. The *OPUS* solutions obtained at these three dates were compared. This case study indicates that very considerable changes in orthometric height and horizontal coordinates could occur among *OPUS* outputs processed at different dates. *OPUS* users who focus on absolute positional coordinates should pay special attention to the periodic updating of reference frames and geoid models by NGS. **DOI: 10.1061/(ASCE)SU.1943-5428.0000191.**

Author keywords: Accuracy; Geoid model; IGS08; NAD 83; *Online Positioning User Service* (*OPUS*); Orthometric heights; Reference frames.

Journal of Surveying Engineering

GPS Data Processing

JOURNAL OF GEOSCIENCE EDUCATION **61**, 202–212 (2013)

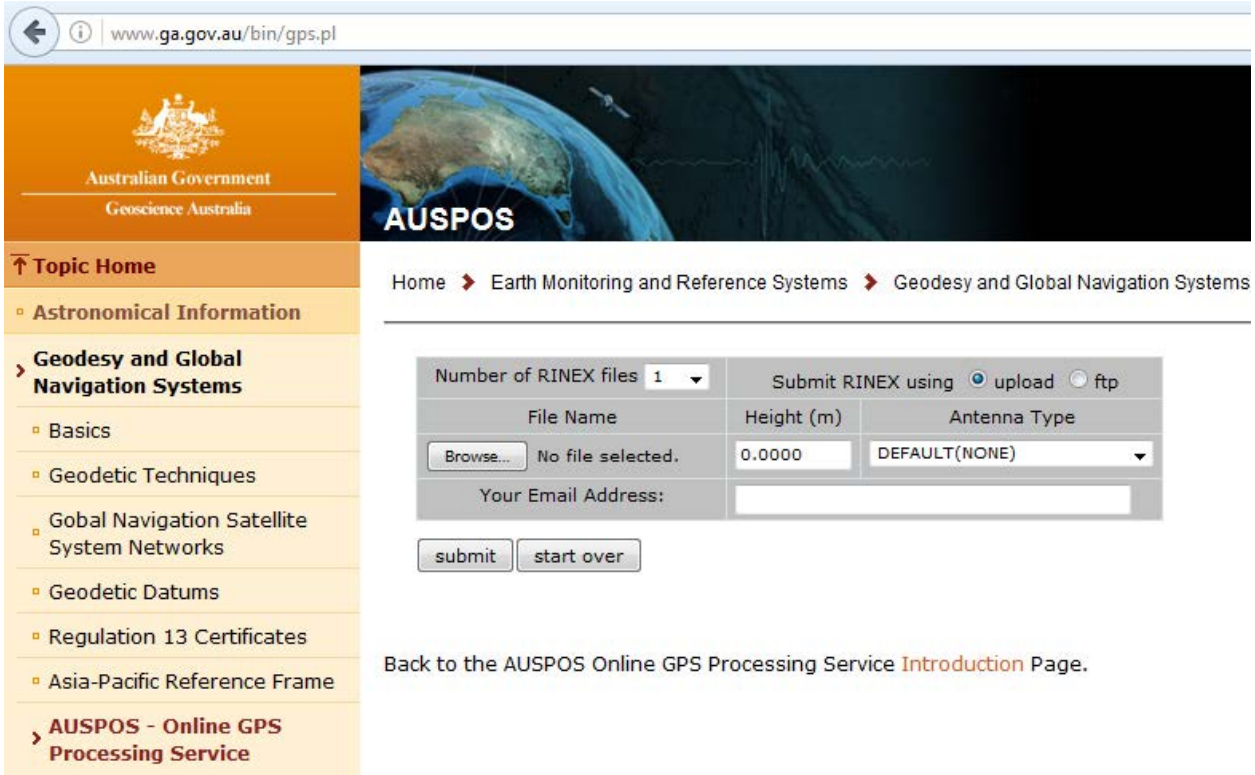
Teaching High-Accuracy Global Positioning System to Undergraduates Using Online Processing Services

Guoquan Wang[1,a]

ABSTRACT

High-accuracy Global Positioning System (GPS) has become an important geoscientific tool used to measure ground motions associated with plate movements, glacial movements, volcanoes, active faults, landslides, subsidence, slow earthquake events, as well as large earthquakes. Complex calculations are required in order to achieve high-precision positions and thereby high-accuracy displacement measurements. It is difficult to familiarize undergraduates with the complex data processing within a period of one semester. Several national organizations offer free online GPS processing services. Using these online services, a GPS beginner can bypass the complex aspect of data processing and focus on applications of the high-accuracy GPS technology. This paper introduces the author's experience using Online Positioning User Service, provided by the National Geodetic Survey (NGS) and Automatic Precise Positioning Service, provided by the Jet Propulsion Laboratory (JPL) in teaching two undergraduate courses, Applications of GPS in Geosciences and Geological Hazards, at the University of Puerto Rico at Mayaguez. Two class projects, "Where is My House?" and "GPS Landslide Monitoring," were designed to practice GPS data collection, processing, and analysis. The enrollments of the two courses were about 10 senior undergraduate students. Online GPS data processing helped both the instructor and students in teaching and learning the intricacies of GPS data processing, understanding different reference frames and coordinate systems, and familiarizing local permanent reference stations. Students who had taken the GPS classes often help professors in the geology department and other departments to survey field sites with centimeter-level accuracy. [DOI: 10.5408/12-295.1]

AUSPOS: Geoscience Australia



It is great for processing static data outside of US!
The report is a 10-page PDF file!

GPS Data Processing

APPS: Automatic Precise Positioning Service

Jet Propulsion Laboratory
California Institute of Technology

GDGPS

+ View the NASA Portal

JPL HOME | EARTH | SOLAR SYSTEM | STARS & GALAXIES | TECHNOLOGY

- Home
  - Unique Features
- About GDGPS

Welcome to APPS!
The Automatic Precise Positioning Service
of the Global Differential GPS (GDGPS) System.

APPS is now using GIPSY 6.4

APPS Options	
Processing Mode	(●) Static ( ) *Kinematic*
Measurement Type	( ) Single Frequency (●) Dual Frequency
Orbits/Clocks used	JPL Final: Data prior to **2016-11-26** JPL Rapid: Data from **2016-11-26** to **2016-12-06** JPL Ultra R/T: Data from **2016-12-06** to **present**
L1 Code	( ) *CA Code* (●) P Code
Model Pressure Data?	( ) *Yes* (●) No
Elevation Dependent Data Weighting	(●) Flat ( ) Sin ( ) Sqrt(sin)
Advanced Options	7.5 *Elevation Angle Cutoff* 300 *Solution Output Rate (seconds)*

Browse... No file selected.

Reset Upload

Jet Propulsion Laboratory
California Institute of Technology

+ View the NASA Portal

JPL HOME | EARTH | SOLAR SYSTEM | STARS & GALAXIES | TECHNOLOGY

UHCC201510170000F.15O

Lat: 29.38934727 **Lon:** -95.04345213 **Height:** -21.2681 (m)

APPS Results	
2015-10-17.UNAV.sum.Z	README
2015-10-17.UNAV.ninjalog.Z	README
2015-10-17.UNAV.pfs.Z	README
2015-10-17.UNAV.stacov.Z	README
2015-10-17.UNAV.tgz	

Run APPS Again

FIRSTGOV Your First Click to the U.S. Government

+Privacy Policy

Contact: apps @ gdgps.net
Page Created: 09 Dec 2015
JPL Clearance: CL 08-3321

CSRS-PPP

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Natural Resources Canada

Canada

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Energy | Mining/Materials | Forests | Earth Sciences | Hazards | Explosives | The North | Climate Change

Home → Earth Sciences → Geomatics → Geodetic Reference Systems → Tools and Applications → Precise Point Positioning

Precise Point Positioning

Help for CSRS PPP (**Updated 2016-07-12**)

Profile | Sign out

Email for results (required)

gwang@uh.edu

Processing mode

Static | Kinematic

NAD83 | ITRF

Epoch (Adopted)

Vertical datum

CGDV28(HT2_0)

More options

RINEX observation file (required) (.zip, .gzip, .gz, .Z, .??O)

Browse... No file selected.

Submit to PPP

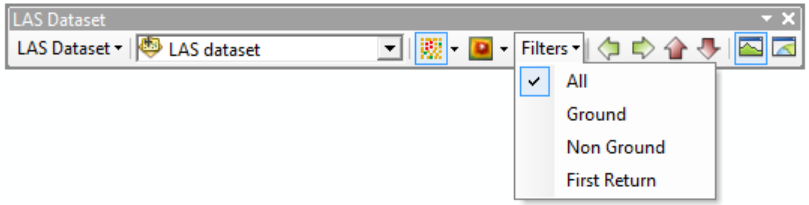
ArcGIS V10.1 and up

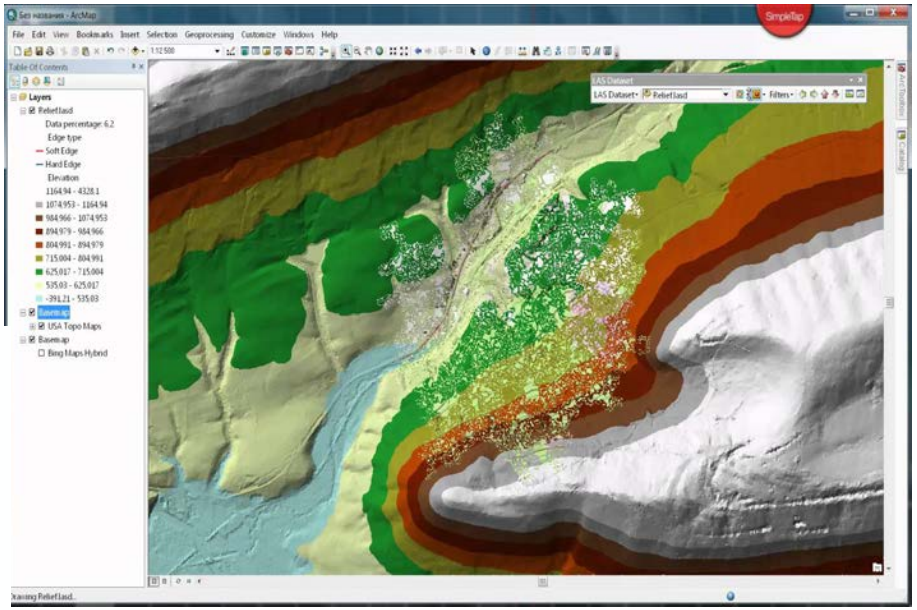
ArcGIS reads LAS files natively, providing immediate access to LiDar data without the need for data conversion or import.

2D, 3D view

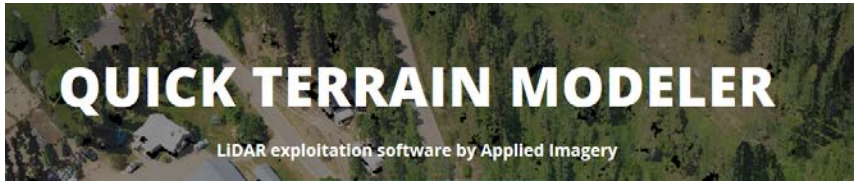
DEM, contours, maps, profiles

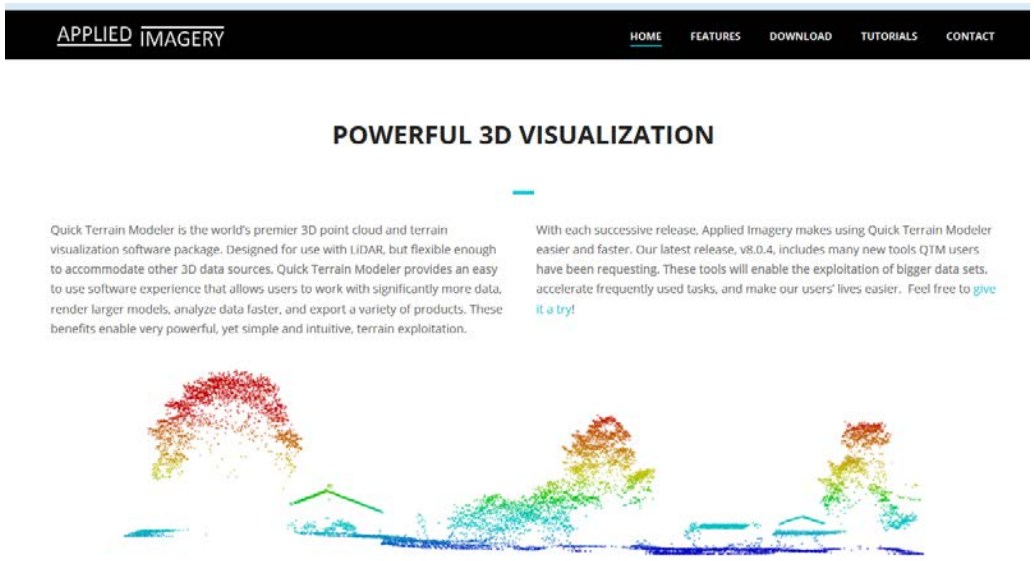
LAS Dataset toolbar—Filter options





Quick Terrain Modeler



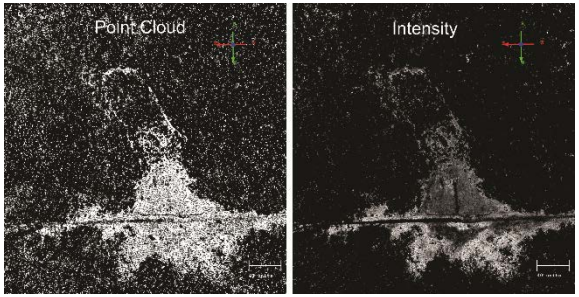


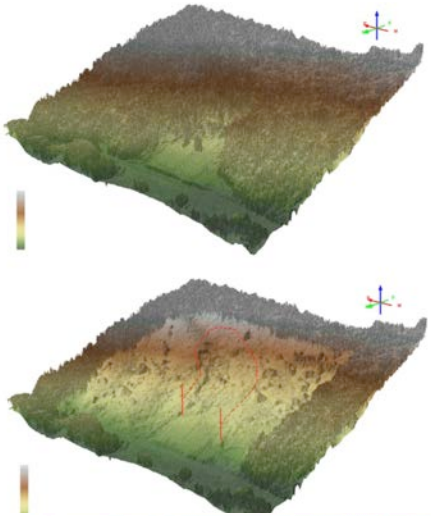
QUICK TERRAIN MODELER

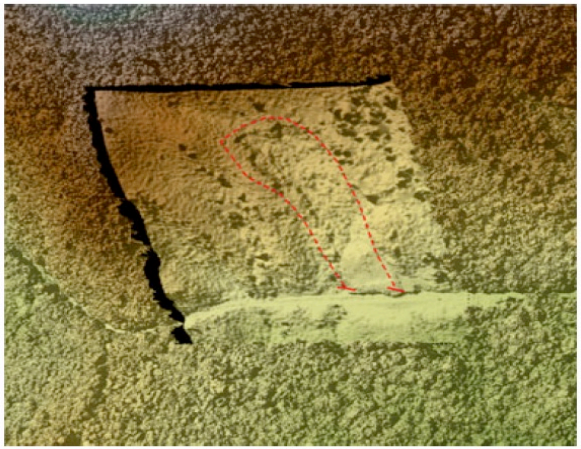
Request A Free Trial License

QUICK TERRAIN READER

Free Viewing Software



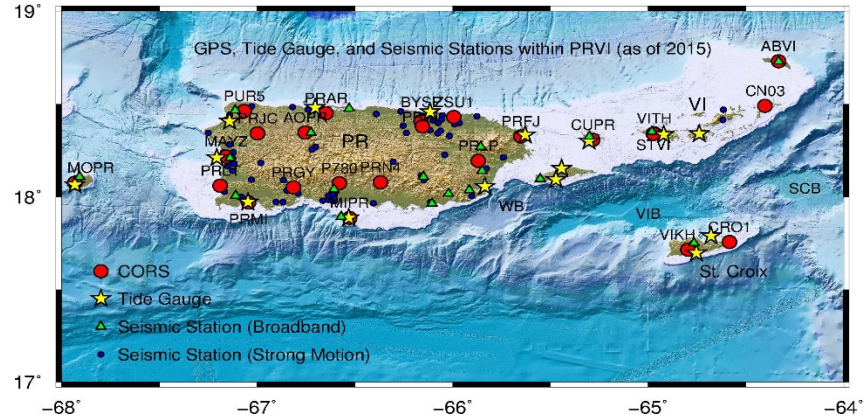


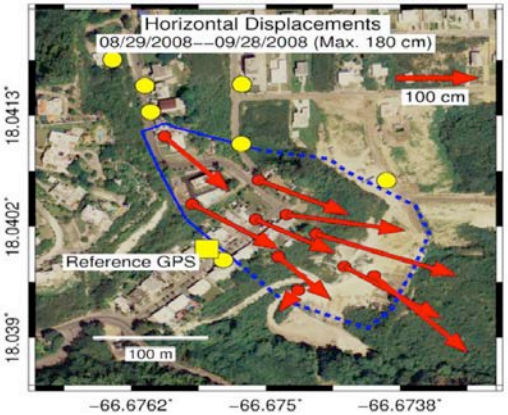


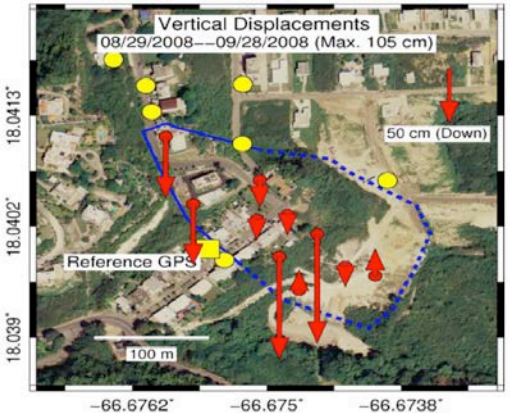
Class Projects and Activities

Field trip

All students like field trips!!







Class Projects and Activities

GPS & LiDAR and Subsidence Education at the University of Houston Coastal Center (UHCC)

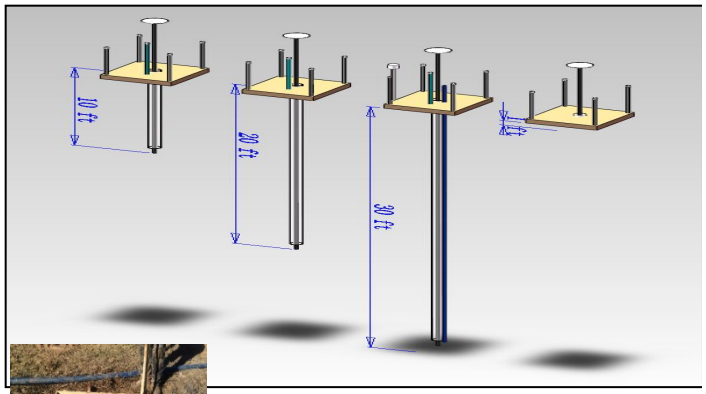
Floating GPS: measuring groundwater level

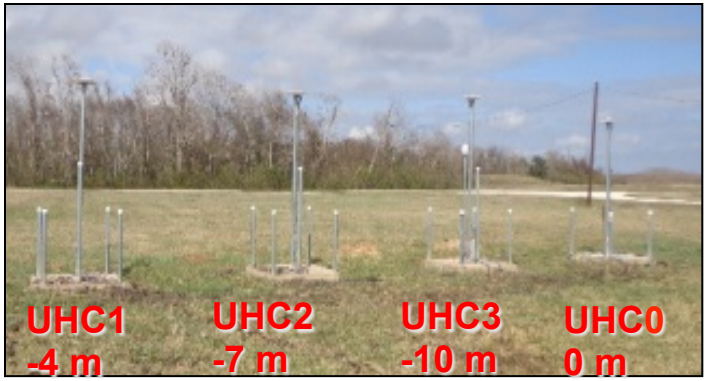
Unexpected Results from UHCC Vertical GPS Array

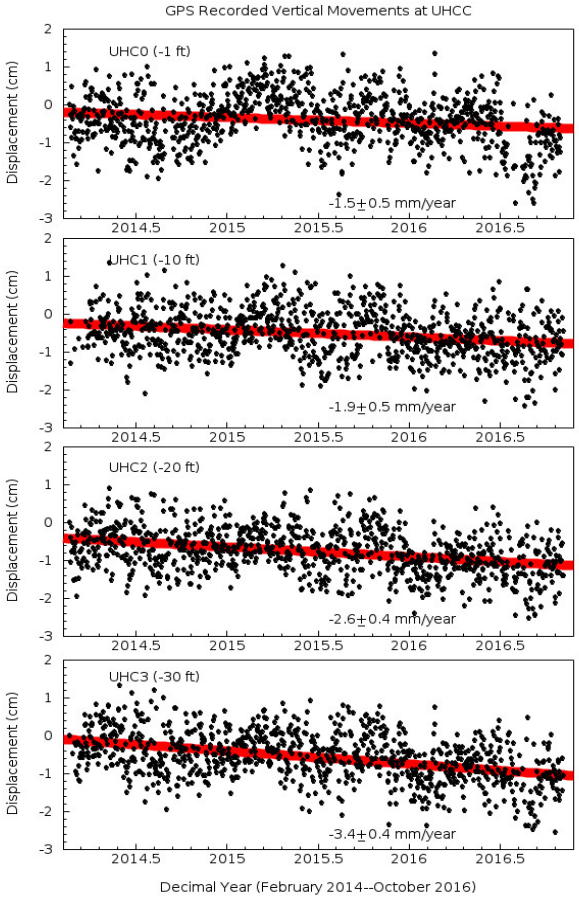
Design Purpose: Measuring aquifer compaction at different depths
Total subsidence:UHC0 > UHC1 > UHC2 > UHC3

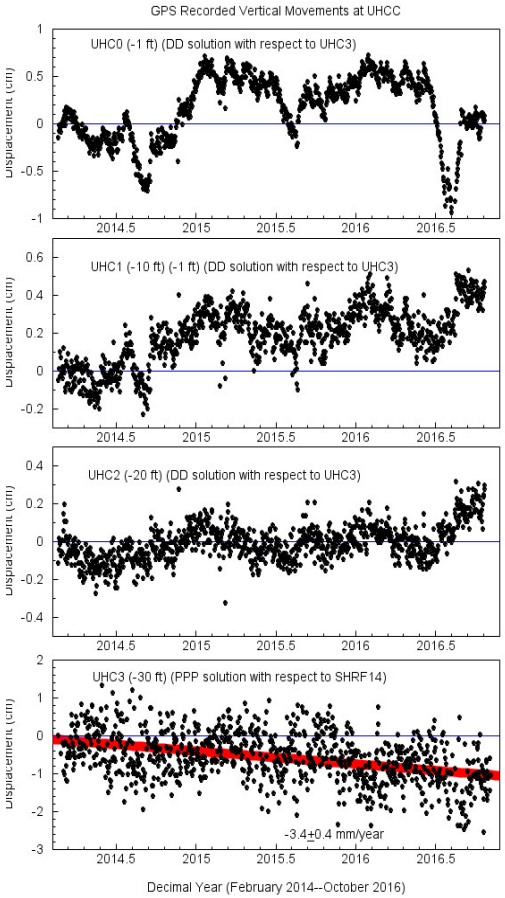
compactionmeter

Observed Results:
Total Subsidence: UHC3 > UHC2 > UHC1 > UHC0
Results: Top aquifer does extension/inflation??





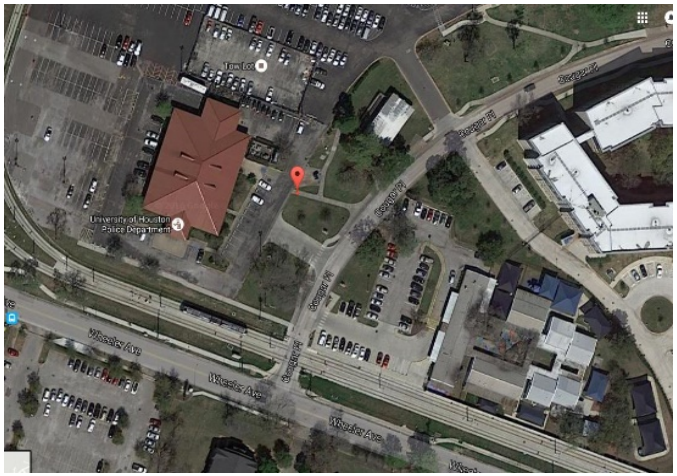




Class Projects and Activities

Static, Rapid Static Surveying

UPR:Where is my House (4-hour static surveying)?
UH: Surveying benchmarks in campus.



Data Processing:
OPUS
AUSPOS
TEQC—cut to 1-hour segments

Class Projects and Activities

Kinematic GPS

GPS Seismology: post-processing high-rate earthquake data

Plot the kinematic displacement time series at CONZ from the 2010 Malue, Chile Earthquake (M8.8).

Driving tracking!

Real time kinematic GPS surveying!

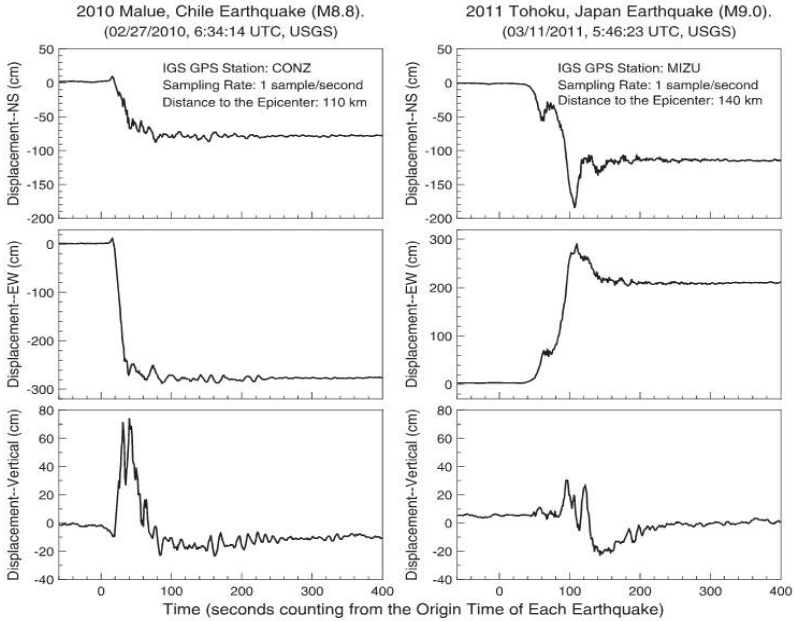


FIGURE 7: Three component GPS seismograms recorded at International GNSS Service (IGS) GPS station CONZ during the 2010 Maule, Chile Earthquake (*M* 8.8) and at IGS GPS station MIZU during the 2011 Tohoku, Japan Earthquake (*M* 9.0).

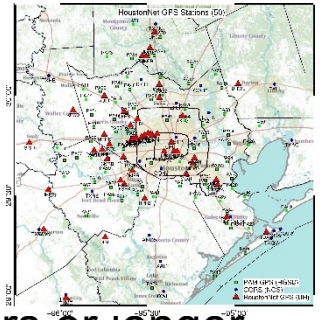
ellipsoidal) do not affect the landslide study. OPUS outputs really help students to understand the correlation between absolute and relative measurements

ONLINE KINEMATIC PROCESSING

High-rate GPS has been recognized as a new technology useful in measuring strong earthquake ground motions and with the potential of identifying tsunamigenic earthquakes and being employed in global tsunami early warning system (e.g., Blewitt et al., 2006, 2009; Crowell et al., 2009; Allen and Ziv, 2011; Wright et al., 2012). Many researchers

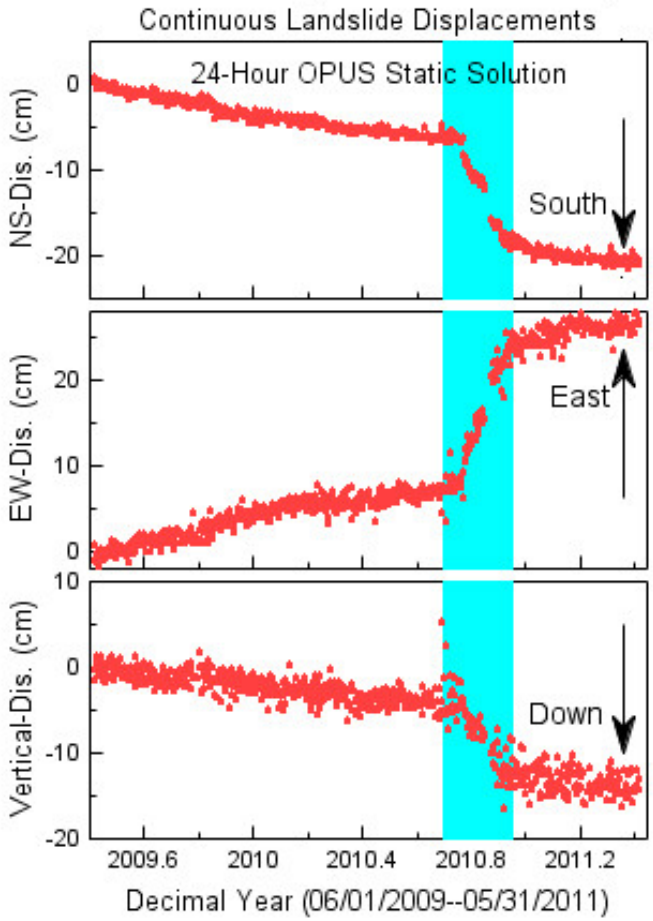
demonstrate the new seismic sensor to geosciences students. High-rate (1-sample per s) GPS data collected during large earthquakes such as the 2010 Maule, Chile Earthquake (*M* 8.8) and the 2011 Tohoku, Japan Earthquake (*M* 9.0) were used in the recent GPS classes. APPS, operated by NASA's JPL, was applied for post-kinematic GPS data processing. Students can obtain nice seismograms from high-rate GPS data recorded during large earthquakes by using APPS without knowing so much about the details of kinematic GPS data processing. Figure 7 shows two examples of three-component GPS seismograms recorded during the Chile and Japan Earthquakes. Almost all students can produce a

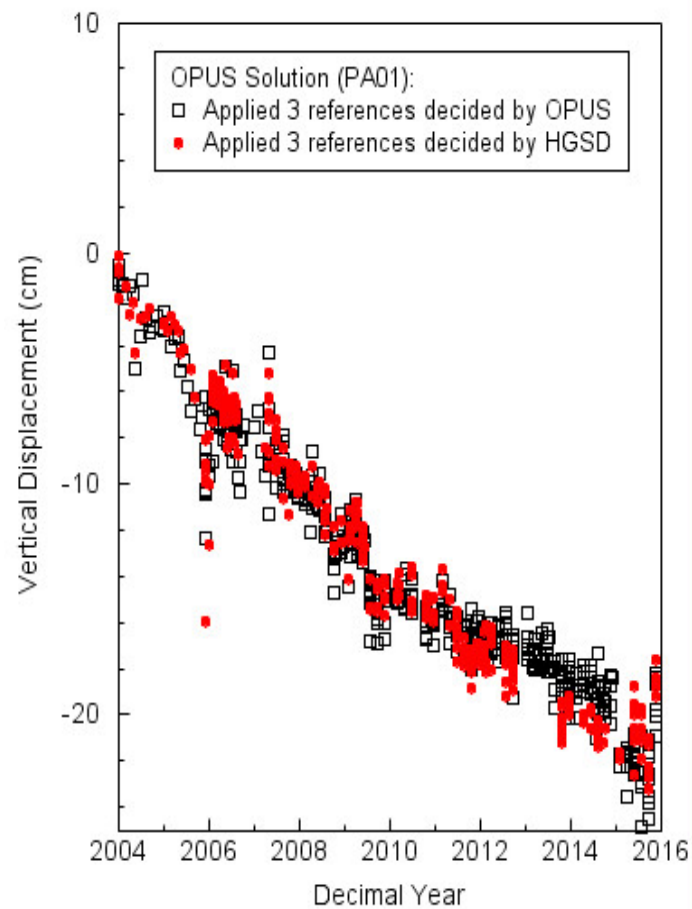
Class Projects and Activities



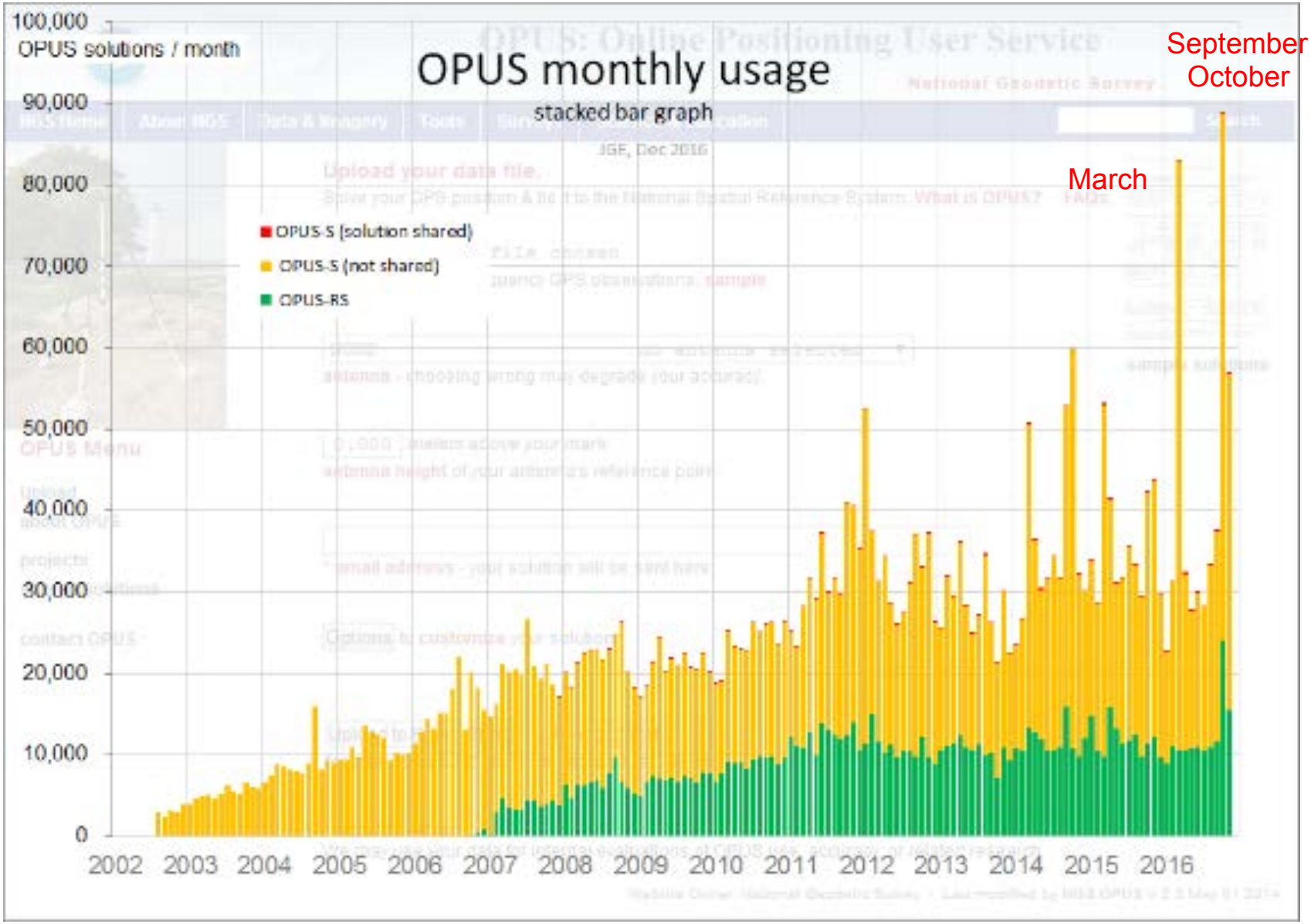
Landslide or Subsidence Monitoring

Research Project: Monitoring subsidence using GPS
Each student was assigned one or two stations (with a 2 years or longer history near his/her neighborhood.





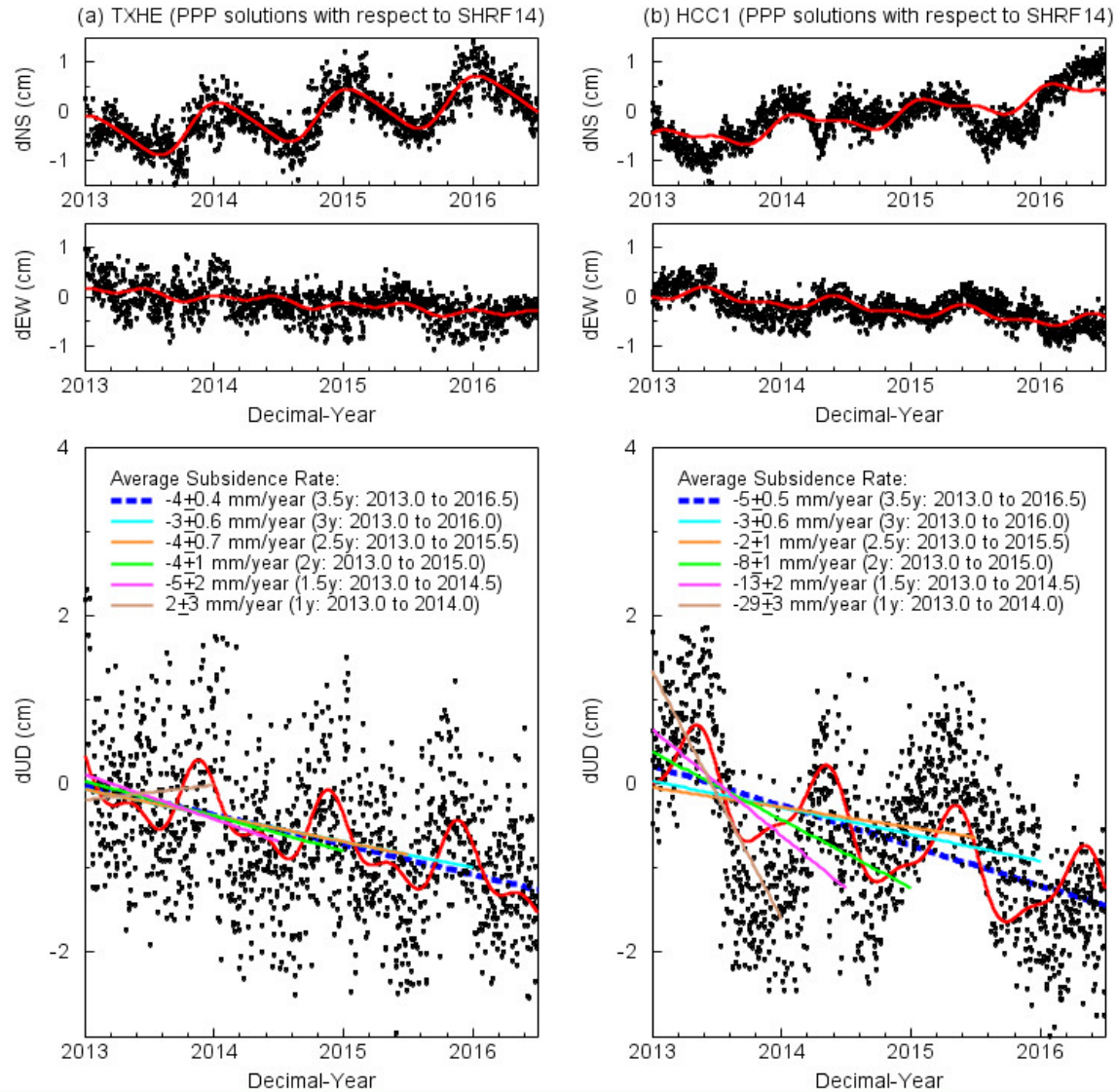
Class Projects and Activities



http://www.ngs.noaa.gov/OPUSI/Plots/OPUS.jpg

What did students learn from this project?

- Skills for handling large datasets.
- Writing simple shell scripts!
- Excel!
- Plotting publication quality figures!
- Understanding the ACCURACY of GPS
- Site velocity
- Seasonal ground deformation

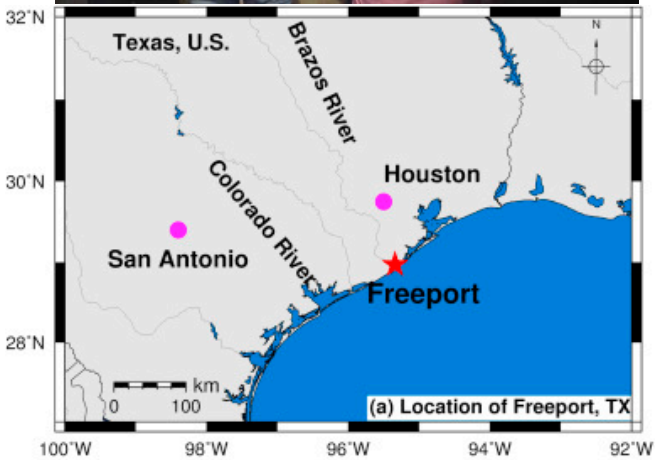


Class Projects and Activities

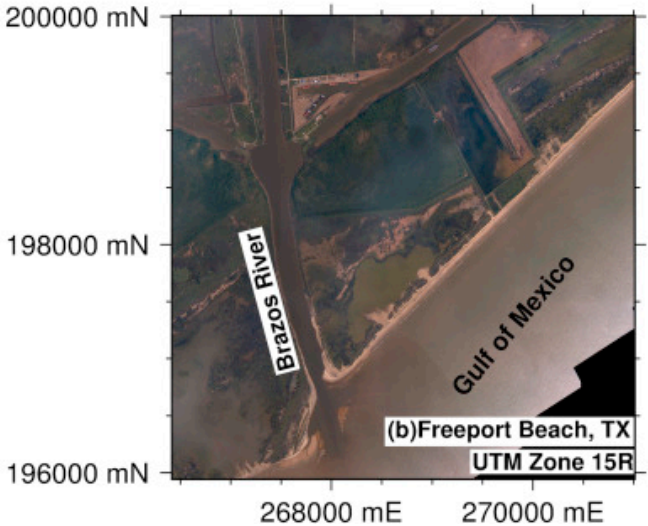
1-day GPS & LiDAR Field Camp

GEOL4355 Geophysics Field Camp:
Coastal Dune Erosion Study

- Static GPS Surveying
- RTK GPS Surveying
- TLS Scanning

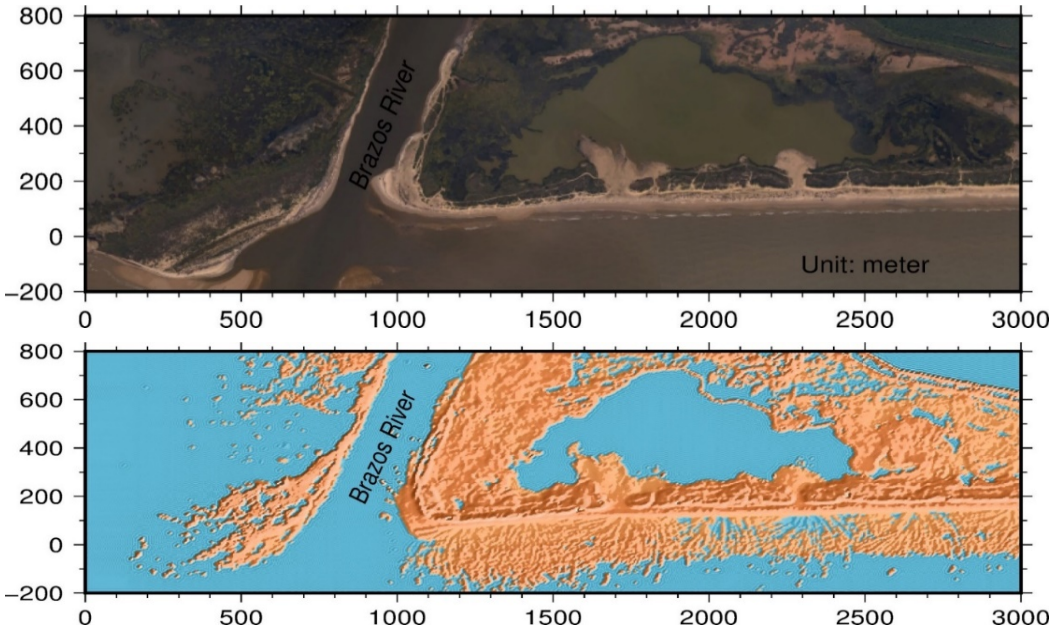


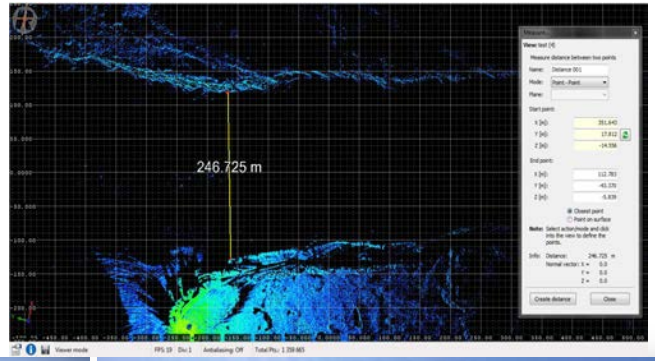
What is a CORS?

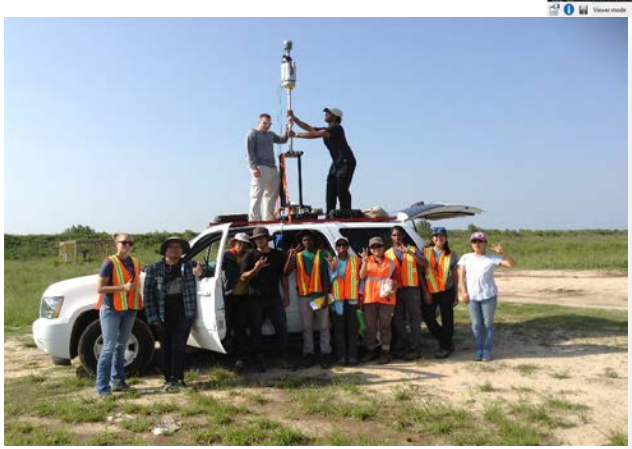


Class Projects and Activities

Coastal Erosion Study







NSF IRES: International Research Experience for Students

Firefox File Edit View History Bookmarks Tools Window Help

US-China Collaboration on Land...

ires.nsm.uh.edu

US-China Collaboration on Landslide Research and Student Training

NSF IRES Program at UH

Home | Faculty & Mentors | Program Activities | Apply | About UH & CUG

Dr. Guoquan (Bob Wang)
Associate Professor
University of Houston
gwang@uh.edu

2017 Summer Program

- Brochure
- Schedule - Summer Program
- Schedule - Chinese Language & Culture Course

2016 Summer Program

- Brochure
- Schedule - Summer Program
- Schedule - Chinese Language & Culture Course
- Introduction to 2016 Attendees
- Weekly Reports:
  - Week 1 (June 13–18)
  - Week 2 (June 19–25)
  - Week 3 (June 26–July 3)
  - Week 4 (July 4–10)
  - Week 5 (July 10–15)
  - Week 6 (July 17–23)
  - Week 7 (July 24–30)
  - Week 8 (July 31–Aug. 5)
- Videos:
  - Beijing Geology Museum
  - CUG Activities
  - CUG Zigui Field Camp
  - Huangtupo Landslide
  - Visiting Three Gorges Dam
- UH News Reports:
  - UH Awarded $246K NSF Grant For

Welcome!

US-China Collaboration on Landslide Research and Student Training
September 1, 2015 — August 31, 2018
Second Summer Program: June 12, 2017 — August 5, 2017. Apply now!!

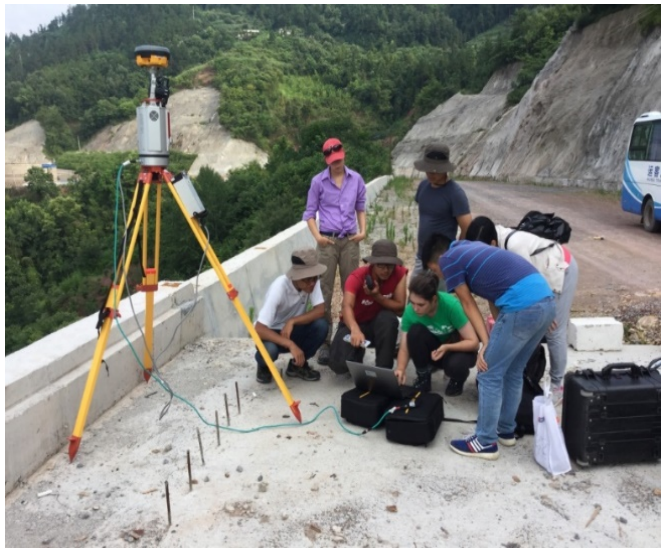
Overview

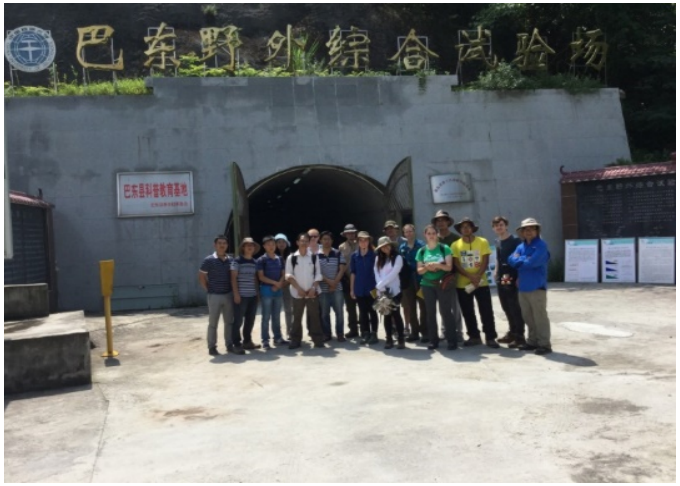
Welcome to the IRES: US-China Collaboration on Landslide Research and Student Training program. This International Research Experience for Students (IRES) program is hosted by the University of Houston (UH) in U.S. and the China University of Geosciences (Wuhan) in China. This program is funded by a National Science Foundation (NSF) Award (OIA:1460034) for a three year period (September 1, 2015 — August 31, 2018).

The IRES program will support 18 U.S. students (two graduates and four undergraduates per year) to conduct advanced landslide research in the Three Gorges area in China during the summers (eight weeks) of 2016, 2017, and 2018. The IRES students will attend a two-week intensive Chinese language and cultural course at the main campus of the China University of Geosciences (Wuhan) and then conduct a five-week field investigation in the Three Gorges Reservoir area. The field investigations will be supervised by Dr. Guoquan (Bob) Wang at the University of Houston (UH) and three professors at the China University of Geosciences (CUG), Drs. Huiming Tang, Hanwen Zhou, and Changqian Ma. The eight-week-long collaborative project is designed to expose U.S. students to the international landslide research community at an

NSF IRES at UH

GPS-LiDAR and Landslide Investigation in China (2016 Summer)





Summary & Some Thoughts

- GPS & LiDAR are teachable contents for undergraduate level courses!
- Community support is essential for integrating GPS & LiDAR into geoscience curricula at nation wide.
- It is not shame to treat GPS/LiDAR data processing somehow as a black or gray box. Use online GPS data processing!
- All students like field trips! Add a field component in your course.


Thank you!