

Attachment 5: Activities of Department of Earth System Science and Policy

North Dakota Center of Excellence in Space Technology and Operations

2009 Functional Review: July 1 2008 – June 30, 2009

Activities of Department of Earth System Science and Policy

During the reporting period the department began efforts to survey current investigations into applications of Radio Occultation (RO) measurements that are ongoing across the research community, and which are significant to the Center. There are two premier scientific conferences at which such research activities are presented; the American Geophysical Union (AGU) meeting held in December each year, and the American Meteorological Society (AMS) meeting held in January. A representative from the department attended each of these meetings this past year. In addition to attending conferences and beginning a survey of ongoing research, other activities department activities included presentation at a local National Weather Service (NWS) meeting as well as recruitment efforts. Details follow:

AGU

At AGU, numerous presentation and poster sessions were presented on investigations into how RO of Global Navigation Satellite System (GNSS) signals, principally using the COSMIC system, can be used in studies ranging from space environment and “weather, to Earth’s climate, the atmosphere, sea surface altitude, and other phenomena. Items of specific interest included:

- Papers related to climate, meteorology, and atmospheric studies:

Ionospheric Effect on a GNSS **Radio Occultation** Climate Data Record. C Rocken, W Schreiner, S Sokolovskiy, D Hunt

Detection of Climate Change by Means of **Radio Occultation** Climatologies. B C Lackner, A K Steiner, G C Hegerl, G Kirchengast\

Minding the clocks in GPS **radio occultation** soundings: single versus double differencing. A J Mannucci, C O Ao, B A Iijima

Evaluation of Systematic and Random Errors of GPS **Radio Occultation** Bending Angles in the Neutral Atmosphere From the COSMIC/FORMOSAT-3 Mission. B Schreiner, S Sokolovskiy, C Rocken, D Hunt, B Kuo

Detection of Tropical Temperature Change Based on GPS **Radio Occultation** Within 1995 to 2008. A K Steiner, G Kirchengast, B C Lackner, B Pirscher, M Borsche, U Foelsche

Long-term Tropopause Trends as Depicted by GPS **Radio Occultation**. P W Staten, T Reichler

El Nino-Southern Oscillation : A New Atmospheric Perspective via GPS **Radio Occultation**. A L Kursinski, C Ao, M Evans, E R Kursinski

Water Vapor Tomography Using CGPS Network in Taiwan and FORMOSAT-3/COSMIC **Radio Occultation** Observations. H Hung, S Lin, R Rau

Benefits of three frequency ionospheric corrections in **Radio Occultation** soundings. J Luntama

COSMIC Observations of the Diurnal Variation of Longitudinal Structure in the Equatorial Ionization Anomaly. K F Dymond, S A Budzien, S E McDonald, C Coker, D H Chua

Estimating the true amplitude of the Southern Hemisphere storm tracks using **COSMIC** data. Y Guo, E Chang

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Water Vapor Tomography Using CGPS Network in Taiwan and FORMOSAT-3/**COSMIC** Radio Occultation Observations. H Hung, S Lin, R Rau
Practical GPS RO Temperature Precision, Paul W. Staten, T. Reichler

- Papers related to space environment, ionosphere, and space 'weather':

On the estimation of E-region density profiles using IDA4D and **COSMIC** occultations. M J Nicolls, F S Rodrigues, G S Bust, G Crowley

The diurnal/semi-diurnal and monthly variations of electron peak density and its height of the F₂ layer in the mid-latitude using **COSMIC**/FORMOSAT-3 GPS **radio occultation** measurements. J Chung, W Lee, E Kim, G Jee, J Cho, S Cho, J Park, Y Kim

Analysis on Ionospheric Electron Densities of Storm Events From FORMOSAT-3/**COSMIC** Observations. K Wang, S W Tam

FORMOSAT-3/**COSMIC** Observations of the Ionospheric Response to Geomagnetic Activities Characterized by Global Indices. C Chen, S W Tam, K Wang

Evaluation of Systematic and Random Errors of GPS Radio Occultation Bending Angles in the Neutral Atmosphere From the **COSMIC**/FORMOSAT-3 Mission. B Schreiner, S Sokolovskiy, C Rocken, D Hunt, B Kuo

Ionosphere tomography derived by FORMOSAT-3/**COSMIC** TIP and GOX data. C LIN, J Liu, C Lin, M Hsu, L Tsai, N Chen

Ionospheric electron density variations observed by FORMOSAT3/**COSMIC** during AKR experiments and the Sichuan earthquake. C Chen, J Liu, L Lee, A Wong

Comparison of Ionospheric Radiance and Electron Density Over the Auroral Oval With FORMOSAT-3/**COSMIC** Measurements. H Tsai, M Hsu, C Lin, J Liu

JPL/USC GAIM: Validating **COSMIC** and Ground-Based GPS Assimilation Results to Estimate Ionospheric Electron Densities. A Komjathy, B Wilson, V Akopian, X Pi, A Mannucci, C Wang

Seismo-ionospheric Precursors before the 12 May 2008 Mw7.9 Sichuan Earthquake observed by GIM and FORMOSAT3/**COSMIC**. Y Chen, J T Liu

AMS

There were a number of presentations on on the **COSMIC** mission specifically, and on radio occultation applications for atmospheric and climate studies in general. Items of interest included:

- Papers on the **COSMIC** mission and status:

The **COSMIC**/FORMOSAT-3 Mission: Overview and Status Ying-Hwa Kuo, UCAR, Boulder, CO; and C. Rocken, R. A. Anthes, N. Yen, and J. J. Miao

International Collaboration of Global Radio Occultation Mission for Meteorology Beyond 2011 Nick Yen, National Space Organization, Hsin-Chu, Taiwan; and J. Fong, V. Chu, C. C. Hsiao, J. J. Miao, and Y. A. Liu

Recent improvements on the operational assimilation of GPS Radio Occultation observations Lidia Cucurull, NOAA/NESDIS, Suitland, MD

COSMIC and **TIMED** combined observation of the atmospheric tides Qian Wu, NCAR, Boulder, CO; and S. C. Solomon, T. L. Killeen, and Y. H. Kuo

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The Development of an In-Situ GPS Reference System Joseph Facundo, NOAA/NWS, Silver Spring, MD; and J. Fitzgibbon and C. Bower

- Papers on the estimation of COSMIC errors:

Inter-instrument and Structural Uncertainty in Radio Occultation Data: Comparing COSMIC and GRAS Data and Retrievals Christian Marquardt, EUMETSAT, Darmstadt, Germany; and A. von Engel, Y. Andres, and F. Sancho

Global Comparisons of Atmospheric Soundings in the Lower Troposphere from COSMIC Radio Occultation, Radiosonde, and ECMWF Analysis Shu-peng Ho, NCAR, Boulder, CO; and Y. H. Kuo, W. He, D. Hunt, C. Rocken, W. Schreiner, and S. Sokolovskiy

Interhemispheric coupling of large-scale atmospheric waves in stratospheric/mesospheric temperature at middle and high latitudes: COSMIC vs MLS-AURA observations Marianna G. Shepherd, York University, Toronto, ON, Canada; and S. P. Alexander and T. Tsuda

Estimating the Uncertainty of using GPS Radio Occultation Data for Climate Monitoring: Inter-comparison of CHAMP Refractivity Climate Records 2002-2006 from Different Data Centers. Shu-peng Ho, NCAR, Boulder, CO; and G. Kirchengast, S. S. Leroy, J. Wickert, A. J. Mannucci, A. Steiner, Y. H. Kuo, C. Rocken, D. C. Hunt, W. S. Schreiner, and S. Sokolovskiy

Ionospheric Errors in COSMIC Radio Occultation Profiles Christian Rocken, UCAR, Boulder, CO; and W. Schreiner, S. Sokolovskiy, and D. Hunt

Estimates of the precision of GPS radio occultation bending angles from the COSMIC/ FORMOSAT-3 mission William Schreiner, UCAR, Boulder, CO; and B. Kuo, C. Rocken, S. Sokolovskiy, and D. Hunt

The Use of COSMIC Data to Identify Radiosonde Type Characteristics and Understand Spatial & Temporal Sensitivities in the Collocation Validation/Comparison Bomin Sun, IMSG & NOAA/NESDIS/STAR, Suitland, MD; and A. L. Reale and D. C. Hunt

- Papers on approaches to comparing the quality of different types of RO and radiosonde data:

Cross validation of water vapor retrievals from GPS radio occultations, AIRS and radiosondes A. J. Mannucci, JPL, Pasadena, CA; and C. O. Ao, E. J. Fetzer, B. A. Iijima, F. W. Irion, G. Manipon, B. D. Wilson, and T. P. Yunck

Validation of AIRS retrievals of CO₂ and comparison to chemistry transport models. Moustafa Chahine, NASA/JPL, Pasadena, CA; and E. T. Olsen, L. Chen, X. Jiang, T. Pagano, and Y. Yung

- Papers showing how the application of COSMIC data improved weather/extreme weather prediction accuracies

Impact of radio occultation observations on ensemble analyses and forecasts of tropical cyclones Hui Liu, NCAR, Boulder, CO; and J. Anderson, Y. H. Kuo, Y. Chen, and C. Snyder

Assimilation of GPS Radio Occultation Data for an Intense Atmospheric River with the NCEP Regional GSI System Zaizhong Ma, NCAR, Boulder, CO; and B. Kuo, B. Wang, W. S. Wu, S. Sokolovskiy, P. J. Neiman, and F. M. Ralph

Impacts of COSMIC GPS data assimilation on real time numerical weather prediction in Taiwan. Pay-Liam Lin, National Central University, Jhong-Li, Taiwan; and S. T. Miow and J. Y. Chen

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Impact of Ground-based GPS Precipitable Water Vapor and COSMIC GPS Refractivity Profile on Hurricane Dean Forecast Tetsuya Iwabuchi, UCAR, Boulder, CO; and J. J. Braun and T. Van Hove
Examination of the tropical cyclone environment through comparison of COSMIC with other satellite data Christopher M. Hill, Mississippi State Univ., Stennis Space Center, MS; and P. J. Fitzpatrick, Y. Lau, and H. Karan
The Impact of GPS Radio Occultation Data on Typhoon Prediction: An OSSE Study of Typhoon Shanshan (2006) Shu-Ya Chen, National Central University, Jhongli, Taiwan; and C. Y. Huang and Y. H. Kuo
The Impact of GPS Radio Occultation Data on Cyclone/Typhoon Predictions Ching-Yuang Huang, National Central University, Jhongli, Taoyuan County, Taiwan; and Y. H. Kuo and S. Y. Chen

- Papers on COSMIC applications

The impact of AIRS data, assimilated using an Ensemble Kalman filter, in WRF forecasts for the Central United States Brian J. Etherton, University of North Carolina, Charlotte, NC; and S. O. Holmberg
Univariate and multivariate assimilation of AIRS humidity retrievals with the Local Ensemble Transform Kalman Filter Junjie Liu, University of California, Berkeley, CA; and H. Li, E. Kalnay, I. Szunyogh, and E. J. Kostelich
Use of COSMIC RO data to evaluate AIRS and ECMWF temperature profiles Thomas P. Yunck, Foundation for Earth Science, Pasadena, CA; and E. J. Fetzer, C. O. Ao, G. J. Manipon, B. Wilson, A. J. Mannucci, and F. W. Irion

A more in-depth survey of current research into use of GPS RO specifically for climate systems and modeling applications will continue in the coming year.

NWS

In October 2008, the local office of the National Weather Service (NWS) hosted a meeting of all NWS offices with the local NWS Sub-Region. Attendance included the Meteorologist-In-Charge (MIC) and forecasters from about a dozen NWS offices across ND, SD, and MN, IA, with attendance by NWS Region directors from Kansas City. A background of the technology and science of GPS RO was given, as well as an overview of GeoOptics, their plans for CICERO, and of the Center of Excellence in Space Technology and Operations at UND.

Recruitment

Recruitment efforts for a post-doctoral research were also initiated during the reporting period. Several candidates did apply, but non with the requisite depth of expertise in both climate modeling and GPS radio occultation techniques. Follow-up recruitment efforts are expected to resume in the coming year.