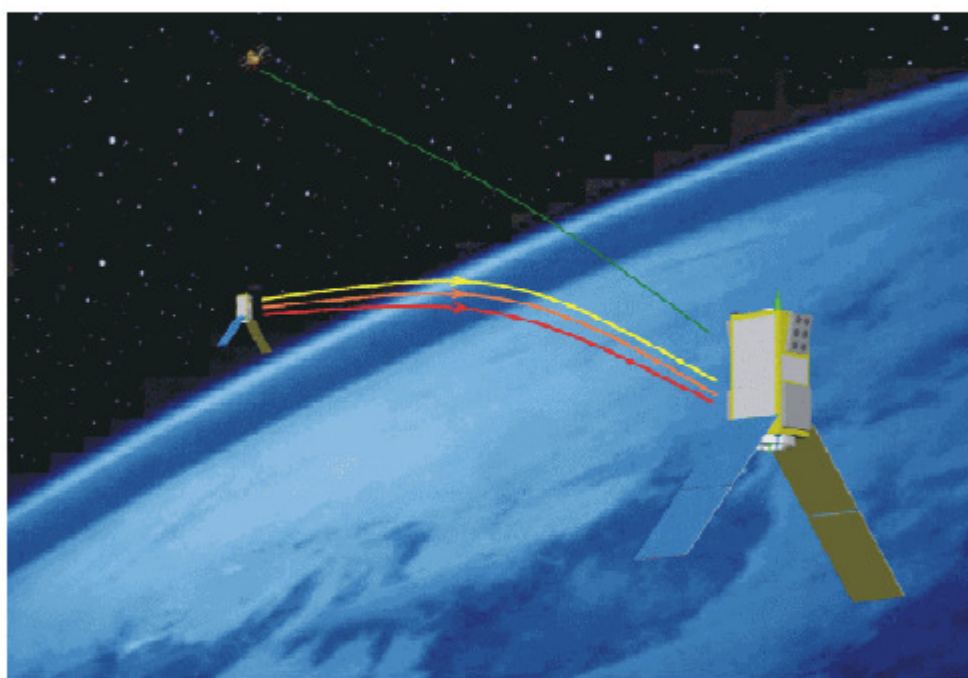


# Atmospheric Remote Sensing using Satellite Navigation Systems

Special Symposium of the URSI Joint Working Group FG

13-15 October 2003

Matera, Italy



esa



agenzia spaziale  
italiana

**LABEN**  
A FIMMECCANICA COMPANY



**Saab Ericsson Space**

# Atmospheric Remote Sensing using Satellite Navigation Systems

Special Symposium of the URSI Joint Working Group FG

13-15 October 2003

Matera, Italy

Session W1: **Imaging and Data Assimilation (Invited)**

## **Ionosphere Imaging by GPS Measurements on Champ**

*Jakowski, N.\*; Heise, S.\*\*; Stankov, S.\*; Tsybulya, K.\**

*\*German Aerospace Center, \*\*GeoForschungsZentrum Potsdam*

GPS measurements onboard the German CHAMP (CHALLENGING Minisatellite Payload) satellite provide a good possibility for operational sounding the ionosphere on global scale.

Both the radio occultation measurements in the limb sounding mode and the navigation measurements via the upward looking GPS antenna have a big potential to reconstruct the spatial and temporal distribution of the electron density in the ionosphere. At present about 150 electron density profiles from global scale are routinely retrieved by the processing system in an operational mode and are made available to the international science community via the ISDC of the GFZ Potsdam.

More than 70000 vertical electron density profiles have been obtained since the beginning of ionospheric radio occultation (IRO) measurements on 11 April 2001 by using a model assisted retrieval technique. To improve the initial guess for the inversion procedure, an assisting scale height model of the topside ionosphere in the 450 km height range is under development. Based on the accumulated IRO data set the latitudinal, local time and seasonal variations of the scale height have been obtained and a preliminary model developed.

Radio occultation data products contribute to image the average ionospheric behavior that is valuable for developing and testing ionospheric models.

To obtain information on the spatial and temporal electron density distribution above the CHAMP orbit height, the 0.1 Hz sampled dual frequency navigation measurements are used to derive the total electron content (TEC) along the ray paths between the CHAMP and GPS satellites. After assimilating these integral measurements into the Parameterized Ionospheric Model (PIM) of local electron density it is possible to reconstruct the spatial electron density distribution close to the CHAMP orbit plane. Additional link related TEC measurements e.g. from other Low Earth Orbiting (LEO) satellites like SAC-C can easily be included to the assimilation process and may improve the reconstruction results.

In combination with ground based GPS measurements both techniques can be used to model the entire ionosphere from the bottom side up to GPS orbit heights. GPS measurements on LEO satellites as CHAMP have a big capability to contribute to an operational monitoring of the ionosphere and for providing near-real-time data into forecast models for space weather applications.

## Atmospheric Remote Sensing using Satellite Navigation Systems

### Opening Session

Saab Ericsson Space Activities In Radio Occultation Programmes  
*Fritz, H.; Saab Ericsson*

Design And Development of a Radio Occultation Instrument for Atmospheric Sounding  
*Ramaoli, P.\*; Zin, A.\*; Scaciga, L.\*; Banfi, E.\*; Ghibaudi, P.\*; Di Cesare, A.\*\*; De Cosmo, V.\*\**  
*\*Laben S.p.A., \*\*AS*

### Session M1: Measurements Using Ground Based Sensors (Invited)

Determination of Atmospheric Water Vapour from GPS Measurements and ECMWF Operational Analyses  
*Hagemann, S.\*; Bengtsson, L.\*; Gendt, G.\*\**  
*\*Max Planck Institute for Meteorology, \*\*GeoForschungsZentrum*

Results of 2 Years of Near Real Time GPS Data Processing  
*Pacione, R.\*; Vespe, F.\*\**  
*\*Telespazio S.p.A., \*\*ASI*

Estimation of Ionospheric TEC using Ground-Based GPS Networks - Limitations and Accuracies  
*Skone, Susan; University of Calgary*

Use of "Supertruth" Data to Analyze Ionosphere Behavior During Geomagnetic Storms  
*Nava, B.; Radicella, S. M.; The Abdus Salam ICTP*

Characterisation of Ionospheric TEC using EGNOS  
*Sardon, E.; GMV*

### Session M2: Young Scientists (Invited)

Evaluating GPS Signal Delays Along Slant Paths – Experimental Results  
*Yin, P.\*; Watson, Robert J\*; Mitchell, Cathryn N\*; Braun, John\*\**  
*\*Univ. of Bath / Civil Aviation Univ. of China, \*\*\*University Corporation for Atmospheric Research*

Calibration of GPS Based TEC Measurements from Low Earth Orbit: An Assessment for CHAMP and SAC-C  
*Heise S.\*, Stolle, C.\*\*; Schlüter S.\*\*\*, Jakowski N.\*\*\*, Reigber Ch.\**  
*\*GFZ Potsdam, \*\*U Leipzig, \*\*\*DLR, IKN*

ISACCO(Ionospheric Scintillations Arctic Campaign Coordinated Observations) project at Ny-Ålesund  
*Alfonsi, L.\*\*; Materassi, M.\* Wernik, A.\*\*\**  
*\*Istituto di Fisica Applicata "Carrara", C.N.R., \*\*Istituto Nazionale di Geofisica e Vulcanologia, \*\*\*Space Research Center, Polish Academy of Science*

Ionospheric tomography, 3D and 4D imaging and data assimilation  
*Materassi, M.; Istituto di Fisica Applicata "Carrara"- C.N.R.*

#### Session T1: GNSS Radio Occultation (Invited)

The ESA Radio Occultation Mission ACE+: A Novel System for Benchmark Measurements on Climate Change  
*Kirchengast, G.\*; Hoeg, P.\*\*; The ESA-ACEPASS Study, Science Team\*\*\**  
*\*University of Graz,\*\*Danish Meteorological Institute,\*\*\*U.Graz-DMI-Chalmers.U.T.-U.Bremen-U.Firenze*

GPS Radio Occultation with CHAMP: Status, Results and Future Prospects of the Operational Data Analysis  
*Wickert, J.; Schmidt, T.; Beyerle, G.; Koenig, R.; Reigber, Ch.;*  
*GeoForschungszentrum Potsdam*

Errors in GNSS Radio occultation Data: relevance of the Geometry of Reference Profiles  
*Foelsche, U.; Kirchengast, G.; IGAM/University of Graz*

Performance of the Improved Abel Transform to Estimate Electron Density Profiles from GPS Occultation Data  
*Hernandez-Pajares, M.\*; Juan, J.M.\*\*; Sanz, J.\*\*; Garcia-Fernandez, M.\*\**  
*\*Technical University of Catalonia (UPC),\*\*gAGE/UPC*

Results from CHAMP, SAC/C And IOX GPS Ionospheric Occultations Obtained by the Abel Inversion And Data Assimilation.  
*Mandrake, L.\*; Hajj, G.\*; Wilson, B.\*; Iijima, B.\*; Straus, P.\*\**  
*\*Jet Propulsion Laboratory,\*\*Aerospace Corporation*

Ionospheric Radio Occultation Measurements in Oerstedt  
*Stauning, P.; Danish Meteorological Institute*

#### Session T2: Scintillations (Invited)

A Brief Review of Scintillation Theories - In Memory of Prof. K.C. Yeh  
*Wernik, A.; Space Research Center, PAS*

Results of Statistical Analysis of GPS Ionospheric Scintillation Data in Northern Europe  
*Dodson, A.; Aquino, M.; Rodrigues, F.; Moore, T.; Waugh, S.*  
*University of Nottingham*

The Scintillation and TEC Receiver in Space - CITRIS  
*Bernhardt, P.; Siefing, C.; Naval Research Laboratory*

Simulations of Scintillation Impacts on the ACE+ Water Vapour Retrieval Using the Satellite-to-Satellite Measurements  
*Hoeg, P.\*; Schwalbe Lohmann, M.\*; Olsen, L.\*\*; Benzoni, H.-H.\*; Steen Nielsen, A.\**  
*\*DMI,\*\*University of Aalborg*

#### Session T3: Novel Radio Occultation Techniques

The ACE+ Mission: Status of Preparatory Activities  
*Silvestrin, P.; Baptista, P.; Flouy, N.; Guijarro, J.; Sterenborg, G.; Wehr, T.*  
*ESA*

Advanced GNSS Receiver for Atmospheric Sounding Preliminary Design in the Framework of the ESA ACE+ Opportunity Mission  
*Franzoni, G.; Zin, A.; LABEN S.p.A.*

Atmospheric Water Vapor Estimate through M<sub>w</sub> Attenuation Measurements On Leo-Leo Satellite Configuration

Cuccoli, Fabrizio\*; Facheris, Luca\*\*  
\*CNIT-DET-UNIFI,\*\*DET-UNIFI

#### Session W1: Imaging and Data Assimilation (Invited)

Profiling Tropospheric Refractivity in a Real-Time Regional GPS Network  
Skone, S.; Nicholson, N.; University of Calgary

Ionospheric Data Assimilation 3D (IDA3D): Derivation and Results  
Bust, G.; Gaussiran II, T.; Garner, T.; ARL:UT

Ionosphere Imaging by GPS Measurements on Champ  
Jakowski, N.\*; Heise, S.\*\*; Stankov, S.\*; Tsybulya, K.\*  
\*German Aerospace Center,\*\*GeoForschungsZentrum Potsdam

Combining GPS and Ionosonde Observations to Perform Ionospheric Tomography  
Hernandez-Pajares, M.\*\*; Juan, J.M.\*\*; Sanz, J.\*\*; Garcia-Fernandez, M.\*\*  
\*Technical University of Catalonia (UPC),\*\*gAGE/UPC

#### Session W2: Space Based GNSS Radio Occultation

Consistency of Horizontal and Vertical Resolution of Meteorological Fields for GPS Radio Occultation Measurements  
Sutera, A.; Petitta, M.; University "La Sapienza"

Characterisation of the GRAS Measurement System and Data Products  
Luntama, J.-P.; Wilson, J. J. W.; EUMETSAT

GNSS Radio Occultation: from the Bending Angles to the Atmospheric Profiles  
Vespe, F.\*; Benedetto, C.\*\*; Pacione, R.\*\*  
\*Agenzia Spaziale Italiana,\*\*Telespazio S.p.A.

Analysis of the Performances in Retrieved Atmospheric Profiles with Radio-Occultation Methods by Considering Different Sources of Error and Different Processing Techniques  
Carrascosa-Sanz, C.\*; Loiselet, M.\*\*  
\*GMV S.A.,\*\*ESA/ESTEC

The methods for correcting the reconstruction data in radio occultation experiments by using regional meteorological models  
Kunitsyn, V.\*; Zakharov, V.\*; Padokhin, A.\*; Dethloff, K.\*\*; Weisheimer, A.\*\*; Gerding, M.\*\*; Neuber, R.\*\*; Rinke, A.\*\*; Hebestadt, I.\*\*  
\*M.Lomonosov Moscow State University,\*\*Alfred Wegener Institute for Polar and Marine Rese

#### Session W3: Scintillation

Effects of Ionospheric Scintillation on GPS Signals at Auroral Latitudes  
Forte, B.; Radicella, S.M.; The Abdus Salam Ictp

GNSS Satellite to Ground Channel Model Including Ionospheric Scintillations  
Strangeways, H.\*; Ghem, V.\*\*; Zernov, N.\*\*  
\*University of Leeds,\*\*University of St.Petersburg

**Session: Poster Session**

Coordinated Study of VLF Phenomena at Low Latitude Indian Ground Stations for the Determination of Ionospheric Parameters

*Gwal, A.; Barkatullah University*

Atmospheric Water Vapor Estimate through Mw Attenuation Measurements on Leo-Leo Satellite Configuration

*Cuccoli, F.; Facheris, L.\*\**

*\*CNIT-DET-UNIFI,\*\*DET-UNIFI*

Determination of Gps Satellite and Receiver Interfrequency Biases

*Dear, R.; Meggs, R.; Mitchell, C.; University of Bath*

ISACCO (Ionospheric Scintillations Arctic Campaign Coordinated Observations) project at Ny-Ålesund

*De Franceschi, G.; Romano, V.; Alfonsi, L.; Perrone, L.; Pezzopane, M.; Zolesi, B.*

*INGV*

OSSE-based Assessment of the Impact of GPS Occultation Measurements on Mesoscale QPF .

*D'Isidoro, M.; Buzzi, A.; CNR-ISAC*

On the Prediction of the Excess-Doppler Evolution for the Bandwidth Optimization of the LAGRANGE RO Receiver

*Notarpietro, R.\*; Perona, G.\*; Gabella, M.\*; Zin, A.\*\**

*\*Politecnico of Turin,\*\*Laben S.p.A.*

Validation of a New Method for Ionospheric Electron Density Reconstruction by Means of VI data.

*Miro Amarante, M.G.; Radicella, S.M.; Nava, B.; Coisson, P.*

*Abdus Salam ICTP*

A New Model Assisted Method for Ionosphere Electron Density Reconstruction

*Nava, B.; Radicella, S.M.; Coisson, P.; Miro Amarante, M.G.; The Abdus Salam ICTP*

LAGRANGE Antenna

*Valle, P.; Carinci, L.; Vegni, C.; Alenia Spazio S.p.A.*

Simultaneous Observations of the Main trough Using GPS Imaging and the Eiscat Radar

*Meggs, R.\*; Mitchell, C.\*; Howells, V. S. C.\*\**

*\*University of Bath,\*\*Rutherford Appleton Laboratory*

Optimal Kalman Filtering for Ultra-Reliable Tracking

*Lange, A.; Finnish Meteorological Institute*

Radio Tomographic Imaging of Sporadic E-Layers During SEEK2

*Bernhardt, P.\*; Selcher, C.\*; Yamamoto, M.\*\*; Fukao, S.\*\*\**

*\*Naval Research Laboratory,\*\*RASC, University of Kyoto,\*\*\*RASC, University of Kyoto*

On the use of LEO GPS Occultation Data for Augmenting the International Reference Ionosphere for the Characterization of Dynamic TEC and Electron Density Profiles.

*Opperman, B.; Hermanus Magnetic Observatory*

An Assessment of Near Real-Time and Post-Processing Strategies for Tropospheric Delay Estimation from a Planned CGPS Network in the UK

*Orliac, E.; Dodson, A.; Bingley, R.; University of Nottingham*

Water Vapor Tomography for Air Space Surveillance

*Rannat, K.\*; Lange, Antti\*\*; Miidla, Peep\*\*\**

*\*Marine Systems Institute at Tallinn Tech. Univ.,\*\*Finnish Meteorological Institute,\*\*\*Institute of Applied Math. at Univ. of Tartu*

Temporary Variations of  $\Delta N$  during the Earthquakes on GPS Data  
*Smirnov, V.\*; Russian Academy of Science*

Open Loop Techniques for GPS Signals Showing Multipath and Fading  
*Aparicio, J.M.; Rius, A.; IEEC*

Description and Assessment of an Ionospheric GPS Data Assimilation Process  
*Angling, M.; QinetiQ*

Applications of Tropospheric Parameters Derived Using the SADC GPS network  
*Combrink, A.; Hartebeesthoek Radio Astronomy Observatory*

The Equatorial Ionospheric Scintillations During Geomagnetic Storms  
*Biktash, L.Z\**

*\*Institute of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Russian Academy of Science (IZMIRAN)*

Meteorological Applications of the Swedish Ground-Based GPS Network  
*Elgered, G.\*; Gradinarsky, L.\*\*; Gustafsson, N.\*\*\*; Johansson, J.\*\*; Ridal, M.\*\*\*; Stoen, B.\*\*;*  
*\*Chalmers University of Technology, \*\*Chalmers, \*\*\*SMHI*

Determination of Errors in Finding Vertical from Slant TEC Due to Horizontal Gradients  
*Strangeways, H.; Ioannides, R.; University of Leeds*

Ground Processor Prototype (GPP) for (GPS) Atmospheric Sounding  
*Carrascosa, C.\*; Fernandez, L.\*; Salcedo, J.M.\*; Christensen, J.\*\*; Hagg, M.\*\*; Loiselet, M\*\*\**  
*\*GMV, \*\*SES, \*\*\*ESTEC*

GNSS Satellite to Ground Channel Model Including Ionospheric Scintillations  
*Strangeways, H.; Ghem, V.\*\*; Zernov, N.\*\**  
*\*University of Leeds, \*\*University of St.Petersburg*

Combining GPS And Ionosonde Observation to Perform Ionospheric Tomography  
*Garcia-Fernandez, M; Hernandez-Pajares, M; Juan, J.M; Sanz, J.*  
*Research group of Astronomy and Geomatics*

Measurement of TEC Depletions Using a Chain of GPS Receivers in South America  
*Valladares, C.; Doherty, P.; Boston College*

#### Session W4: Applications of Radio Occultation and Tomography

Near Real-time Data Assimilation of GPS ZTD and PW into a Non-hydrostatic Model  
*Faccani, C.\*; Ferretti, R.\*; Pacione, R.\*\*; Vespe, F.\*\*\**  
*\*University of L'Aquila,\*\*Telespazio Spa,\*\*\*ASI*

Diffractive Vector and Scalar Integral Relationships for Bistatic Radio-holographic Remote Sensing of the Atmosphere, Mesosphere and Terrestrial Surface from Space  
*Pavelyev, A.\*; Liou, Y.A.\*\**  
*\*Institute of Radio Engineering and Electronics,\*\*Center for Space and Remote Sensing Research*

Exploring the Use of Radio-Occultation Sounding in the Reconstruction of Mediterranean Hydrological Cycle on Numerical Grids  
*Speranza, A.; University of Camerino*

Imaging or 4D Radio Tomography of the Ionosphere and Data AssimilationW4.4  
*Kunitsyn, V.; Kozharin, M.; Nesterov, I.*  
*M.Lomonosov Moscow State University*

Total Electron Content and Electron Density Profiles Determined from Dual Frequency Receiver Data: An Evaluation of the Radiotranslucence Method for Computerised Ionospheric Tomography Applied to Data from the South African Network of Dual Frequency GPS Receivers.  
*Cilliers, P.\*; Opperman, B.\*\*; Smirnovic, V.\*\*\**  
*\*University of Pretoria,\*\*Hermanus Magnetic Observatory,\*\*\*Russian Academy of Science Moscow*

#### *Our Sponsors:*

Young Scientists support offered by URSI  
Buses from Matera/CGS/Airport and local logistics offered by ASI.  
Coffee-breaks offered by Laben  
Symposium Dinner offered by Saab Ericsson Space  
Proceedings, Web pages and Conference Bureau offered by ESA