



SERVICES IN THE COMMERCIAL SECTOR

SPACE WEATHER SHORT COURSE

AMS 2013

January 6, 2013

W. Kent Tobiska

President, Space Environment Technologies

Director, USU Space Weather Center

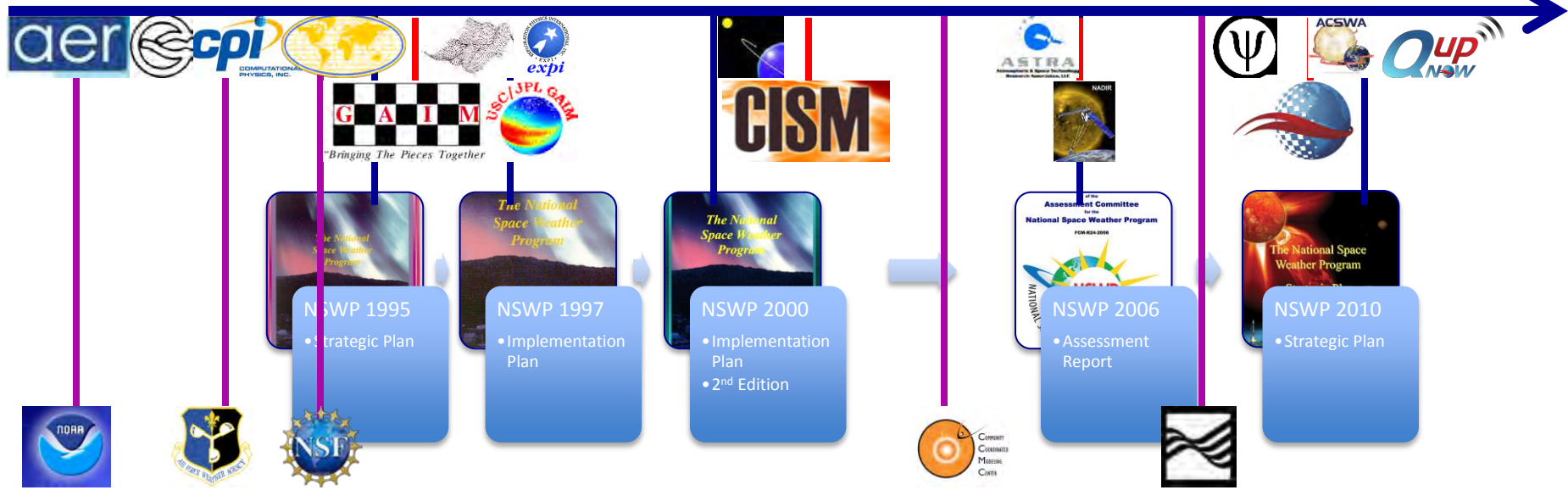


Commercial space weather activity

- **National Space Weather Program** (1995, 1997, 2000, 2006, 2010)
- **Agencies** (NOAA SWPC, AFWA, NSF, NASA CCMC, USGS)
- **Academia** (GAIM MURI, CISM, NADIR MURI, USU SWC)
- **Industry** (AER, CRC, CPI, SEC, SSI, EXPI, SET, ASTRA, PSI, Q-up)

AER/CRC/CPI/SEC SSI EXPI SET ASTRA PSI ACSWA Q-up

NOAA SWPC/AFWA/NSF 1995 GAIM MURI CISM NASA CCMC NADIR MURI USGS USU SWC 2010 2012



January 6, 2013

Services in the Commercial Sector



Commercial Space Weather History

Vendors Association concept

- Inquiries in 1980s, led by T. Gray (consultant)
- Discussions in 1990s, led by V. Raben (Raben Systems, Inc.)
- Formed in 1995, led by T. Tascione (Sterling Software)
 - ✓ Initiated “line-in-sand” discussions between commercial entities and NOAA SEC

Space Weather Vendors Association (SWVA)

- Re-formed in April 1999, led by A. Foster, L. Plumber (AIAA)
- 27 individuals from government, FFRDCs, commercial, academia
 - ✓ “communicate among ourselves and provide a POC so SEC can refer customers”

Commercial Space Weather Services Association (CSWSA)

- Evolved in February 2000, led by J. Kappenman (Metatech)
- 35 individuals from government, commercial, academia
 - ✓ “foster growth of operational space weather services”
 - ✓ SEC agrees to establish a “Space Weather Providers Yellow Pages”

Commercial Space Weather Services Interest Group (CSWSIG)

- Further evolved in 2001, led by J. Kappenman (Metatech); shortened to CSWIG in 2002
- 20 individuals from commercial organizations
 - ✓ 2002: Irish Space Weather initiative proposed
 - ✓ 2004: CSWIG contributes to AMS Fair Weather Report; supports SEC transition into NWS as SWPC
 - ✓ 2007: “space weather wire” server proposed; ESWDS became operational in 2008
 - ✓ 2009: R2O community discussion organized in response to SWPC-NCAR SpWx Prediction Testbed; SWPC Interest Group organized in 2009

American Commercial Space Weather Association (ACSWA)

- Created in 2010, Exec. Committee G. Crowley/ASTRA, D. Intriligator (CRC), B. Schunk (SEC), K. Tobiska (SET)
- 5 commercial, 1 academic organizations; growth to 11 organizations in 2012
 - ✓ 2010-2012: Continued CSWIG-SWPC summits
 - ✓ 2010-2012: ACSWA Presentations at SWEF; SWW and AMS roundtable discussions
 - ✓ 2010;2012: National Geographic TV show; TV awards by William Shatner’s Moving America Forward
 - ✓ 2011: Recommendations to SWPC to expand its capabilities through funding a NOAA SBIR; first award in 2012
 - ✓ 2012;2013: ACSWA sponsors USA Today ad on SpWx; sponsors the AMS SpWx short course



Commercial SpWx Drivers and Successes

1977-1994: what role for a commercial sector?

- ✓ What role for space environment information services can commercial units provide?

1995-2000: “line-in-sand”

- ✓ 1995: Space Weather is defined by NSWP
- ✓ 1995-2000: NOAA SEC sets up 3 CRADAs (CIRES, Sterling Software (MSM), and Space Environment Technologies (S2K)) and the “line-in-the-sand” discussion is born

2001-2010: establishing a healthy industry

- ✓ 2001: NOAA SEC establishes a “Space Weather Providers Yellow Pages”
- ✓ 2002: Irish Space Weather initiative excites the prospect of commercial space weather
- ✓ 2004: AMS Fair Weather Report recognizes commercial SpWx sector
- ✓ 2008: ESWDS becomes operationally used by commercial SpWx service providers
- ✓ 2009: Utah ARRA funds USU SWC for the commercialization of ionospheric products
- ✓ 1990-2012: example commercial products (AURIC, STK-SEET, LCPF, SIP, ESIR, CORHEL, CAPS/ES4D, smartphone apps, CASES, Q-upNow)

2011-2013: growth of the commercial space weather enterprise

- ✓ 2011: ASTRA launches DICES satellites to measure SpWx SEDs
- ✓ 2012: Q-up organizes as a spin-off company from USU Space Weather Center
- ✓ 2013: SET begins commercial solar and geomagnetic operational forecasts for USAF



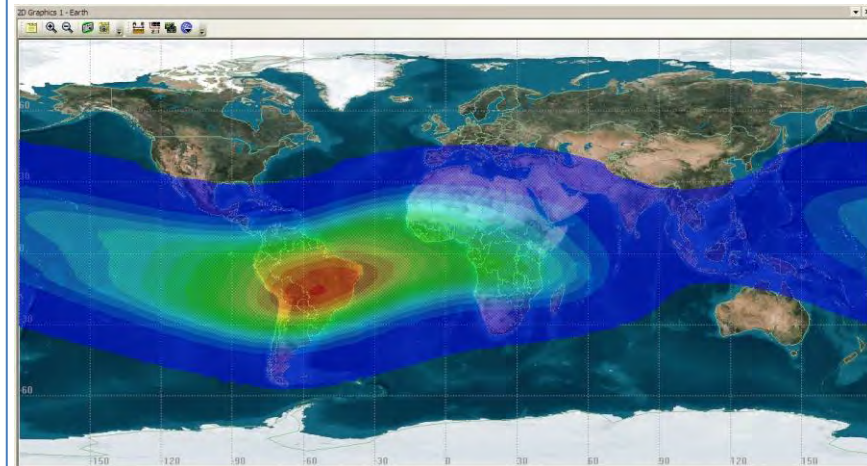
WHO WE ARE

- **AER was established** in 1977
- **Core expertise:** Science and engineering to solve space weather, atmospheric / meteorological / climate and other environmental challenges
- **AER** is a member of the Verisk Analytics family of companies

PRODUCTS AND/OR SERVICES

- AER SEET / STK-SEET
- Space weather R&D
- Weather and environmental analysis and forecasting
- Numerical modeling, climate impacts and adaptation
- Remote sensing
- Software development

PRODUCT HIGHLIGHT: STK-SEET



2-D View in STK-SEET of South Atlantic Anomaly Protons

CONTACT INFORMATION

Atmospheric & Environmental Research
(AER)

131 Hartwell Avenue

Lexington MA, USA 02421-3126

1.781.761.2288

www.aer.com



Atmospheric and Space Technology Research Associates



WHO WE ARE

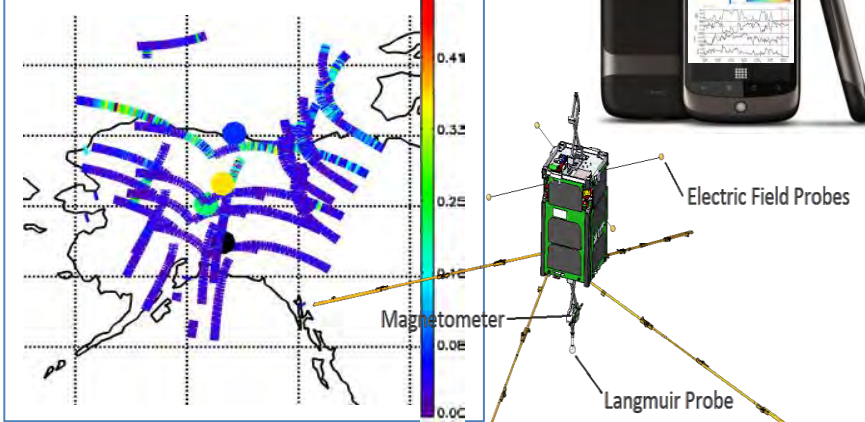
- **Small Business:** established 2005
- **Offices and labs:** in Boulder, Colorado
- **Core Expertise:** space physics, *hardware* (development and deployment of ground and space-based instrumentation), and *software* (modeling, simulation, data-assimilation)
- **Customers include:** DoD, NASA, NSF, private companies and universities

PRODUCTS AND/OR SERVICES

- **CASES/GAMMA:** Ionospheric Space Weather Monitors for Total Electron Content and Scintillation (based on GPS signals): Ground, buoys or Cubesats
- **TIDDBIT:** Traveling Ionospheric Disturbance Mapper
- **Cubesat Missions:** DICE and DIME Cubesat Missions
- **Cubesat Instrumentation**
 - ✧ UV Ionospheric Imaging System
 - ✧ Ionospheric Electric Field Probes
 - ✧ Topside Ionospheric Sounder
 - ✧ Remote Sensing Thermospheric Neutral Wind Profiler
- **Phone Apps for Space Weather**
- **Operational Space Weather Modeling:** ionosphere-thermosphere modeling, forecasts, nowcasts, historical analyses.

HIGHLIGHTS: Real-time Ionospheric Scintillation Monitoring, Ionospheric Specification/Forecast via Phone Apps, DICE Cubesats

Realtime Scintillation Monitoring in Alaska



CONTACT INFORMATION

- **Address**
5777 Central Avenue
Boulder, CO 80301
www.astraspacenet
- **Technical**
Geoff Crowley; 210-834-3475
gcrowley@astraspacenet
- **Administrative**
Steve McCormick
smccormick@astraspacenet





WHO WE ARE

- **Small Business Established** in 1984
- **Facilities** in VA and CO
- **Modeling & Simulation** of the ionosphere, thermosphere, & auroral zone
- **Core Expertise** in satellite instrument algorithms, sensor modeling, satellite ground processing systems, and calibration/validation (cal/val)

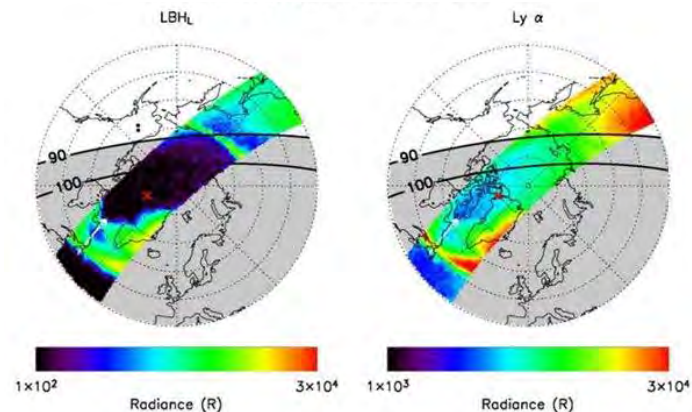
PRODUCTS AND/OR SERVICES

- **AURIC:** upper atmospheric radiance model
- **PIM:** a fast global ionospheric and plasmaspheric model
- **Satellite Data Ground Processing Systems:** software architecture, design, and development, including development of interfaces between space weather instruments and ground data processing software (e.g., JMAPS, JPSS)
- **Cal/Val** of space weather instruments (e.g., GOES EUVS, DMSP SSUSI, DMSP SSJ/5)
- **Ionospheric Specification** from GPS measurements



SERVICE HIGHLIGHT: SSUSI aurora images

SSUSI F16 Auroral Images



CONTACT INFORMATION

- **Address**
8001 Braddock Rd, Suite 210
Springfield, VA 22151
<http://www.cpi.com>
- **Technical**
Scott Evans; 703-764-7501
evans@cpi.com
- **Corporate**
Steven L. Berg; 703-764-7501
berg@cpi.com



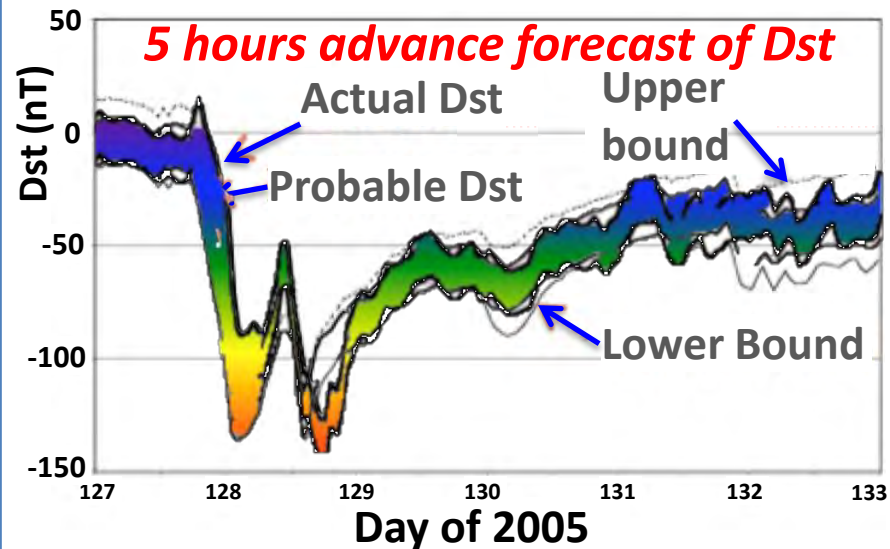
WHO WE ARE

- **Small Business:** woman-owned
- **Incorporated in CA:** 1978
- **Core Expertise:** space physics, computer science, simulations, modeling, and predictions for operational excellence
- **Service Provider to:** spacecraft, aviation, astronauts, space-tourism, ground-based electric power, pipe lines, drilling

PRODUCTS AND/OR SERVICES

- **Operational Space Weather:** modeling, forecasts, nowcasts, and historical analyses
- **Solar & heliospheric activity:** coronal mass ejections, solar wind (including speed, pressures), shock waves, interplanetary magnetic field, Bz, solar energetic particles
- **Impacts:** geomagnetic, heliospheric, solar-interplanetary, solar-terrestrial, solar-planetary

SERVICE HIGHLIGHT: Dst forecasts



CONTACT INFORMATION

- **Address**
P.O. Box 1732
Santa Monica, CA 90406
www.CarmelResearchCenter.com
- **Director**
Dr. Devrie Intriligator
310-453-2983
crcsmca1@yahoo.com

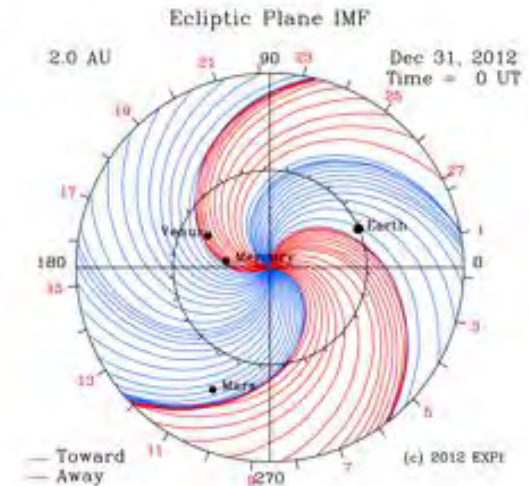
WHO WE ARE

- **Small Business:** service-disabled veteran owned
- **Core Expertise:** real-time forecasts of CME and shock arrival time at Earth immediately following significant solar activity
- **Service Provider to:** NASA and DOD customers

PRODUCTS AND/OR SERVICES

- **Services:** develops space models and tools for operations; performs numerical modeling, simulations and data visualization; conducts space weather analyses; provides space environment conditions for spacecraft anomaly assessments
- **Products:** real-time forecasts of solar wind conditions & shock/CME arrival; licensing of HAFv3 solar wind model to operational and research users

SERVICE HIGHLIGHT: solar wind now



CONTACT INFORMATION

- **Address**
Suite 37-105, 6275 University Dr. NW
Huntsville, AL 35806
<http://www.expi.com>
- **Point-of-Contact**
Dr. Ghee Fry
256-971-4080
info@expi.com



WHO WE ARE

- **Employee-owned Company**
- **Founded** in 2008
- **Customers include: DOD (Air Force, DTRA, NRL), NASA, NSF, private companies (e.g. Lockheed, SAIC) and universities (e.g. UC Berkeley, Stanford, University of New Hampshire)**

EXPERTISE AND/OR SERVICES

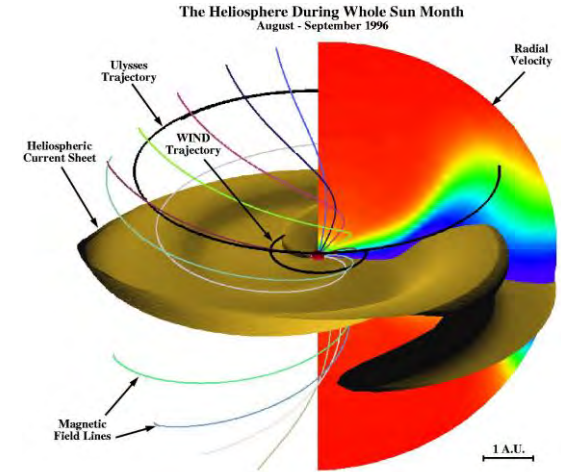
- **Computational Physics**
- **Massively Parallel Computing (MPI, OpenMP)**
- **Data Analysis**
- **Visualization Software**
- **Solar and Heliospheric Physics**
- **Space Weather**
- **CORHEL (suite of models delivered to AFRL, CCMC, CISM)**



Predictive Science, Inc.

SERVICE HIGHLIGHT: CORHEL corona and heliosphere

Quantitative modeling of the solar corona and solar wind



CONTACT INFORMATION

- **Address**
9990 Mesa Rim Road, Suite 170
San Diego, CA 92011
www.predsci.com
- **Technical**
Jon Linker; 858-450-6489
linkerj@predsci.com
- **Administrative**
Lierin Schmidt; 858-450-6494
lierin@predsci.com



WHO WE ARE

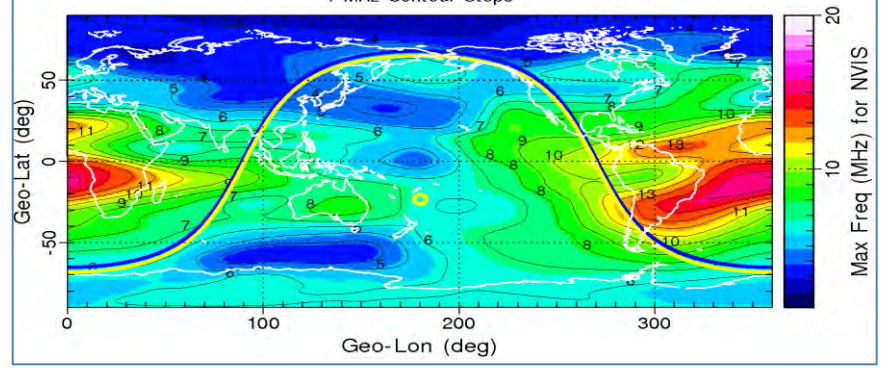
- **Small Business Established** in 2011
- **Facilities** in UT
- **Service provider** of real-time and forecast HF radio propagation frequencies, GPS correction maps, and historical data
- **Core Expertise** in global HF ray-tracing and operational GPS correction maps

PRODUCTS AND/OR SERVICES

- **HF:** Mode 1 point-to-point global ray-tracing for real-time users
- **HF:** Mode 2 enterprise solutions for en-route primary and secondary frequency availability
- **HF:** NVIS real-time and forecast for regional emergency responder use
- **GPS:** real-time operational correction maps for single-frequency users

SERVICE HIGHLIGHT: real-time and forecast HF radio propagation

NVIS for 2012/12/27 0000 UTC
Generated by the USU Space Weather Center
1 MHz Contour Steps



CONTACT INFORMATION

- **Address**
1247 Mountain Rd.
Logan, UT 84321
<http://q-upnow.com>
- **Technical**
Bob Schunk; rws4405@yahoo.com
W. Kent Tobiska; ktobiska@spacewx.com
- **Administrative**
Shawna Johnson
grandmautah@gmail.com



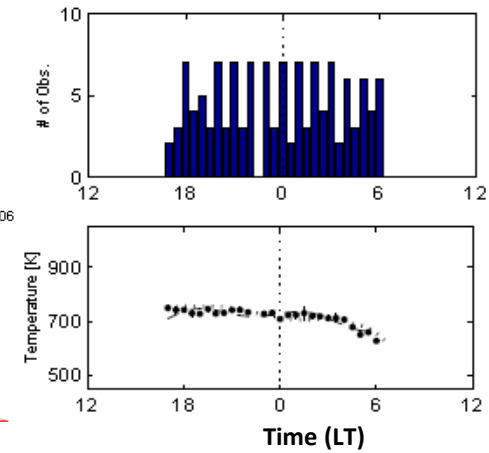
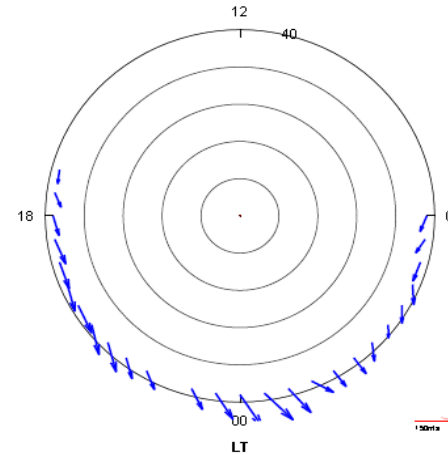
WHO WE ARE

- **Small Business Established** in 1995
- **Facility equipment operator/Data Provider** Thermospheric neutral temperatures and Doppler winds at the Arecibo and Millstone Hill Observatories
- **Core Expertise:** SSI develops **novel** technology for monitoring the near **earth** space environment from the ground and space

PRODUCTS AND/OR SERVICES

- Small form factor high luminosity interferometers for space based remote sensing
- Ground based neutral atmosphere sensors, including imagers, spectrographs and Doppler imagers
- Remote, autonomous **ground based** sensing stations that monitor TEC and the neutral thermosphere
- Provides a server based automatic data collection, archive and analysis system

SERVICE HIGHLIGHT: FPI Wind & Temperature



CONTACT INFORMATION

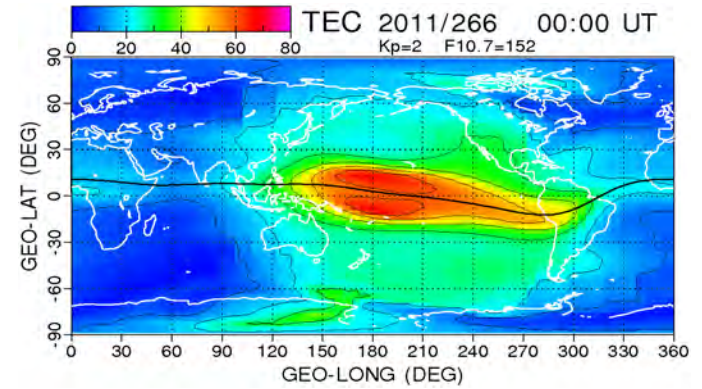
- **Address**
55 Middlesex Street
North Chelmsford, MA 01863
<http://www.sci-sol.com>
<http://www.neutralwinds.com>
- **Technical Contact**
John Noto; 978-251-4554
noto@sci-sol.com



WHO WE ARE

- **Small Business Established** in 1989
- **Software and Hardware** developer for space science and weather needs
- **Core Expertise** in modeling and data analysis for space weather forecast and specification including instrument deployment with automated data collection and analysis

SERVICE HIGHLIGHT: Ionospheric forecast and specification



PRODUCTS AND/OR SERVICES

- **IFM, IPM:** Ionospheric Forecast Model & Ionosphere Plasmasphere Model
- **IDED-DA:** Ionosphere dynamics and electrodynamics with data assimilation
- **DDDR:** Data-Driven D Region Model
- **ESIR:** Expert System Ionogram Reduction
- **HF Prop:** HF propagation Studies
- **RDST:** Real-time Storm Time Indices

CONTACT INFORMATION

- **Address**
Space Environment Corporation
221 N. Gateway Dr., Suite A
Providence, Utah 84332-9791
<http://spacenv.com>
- **Company President**
Robert W. Schunk
sec@spacenv.com
435-752-6567 (Voice)
435-752-6687 (FAX)



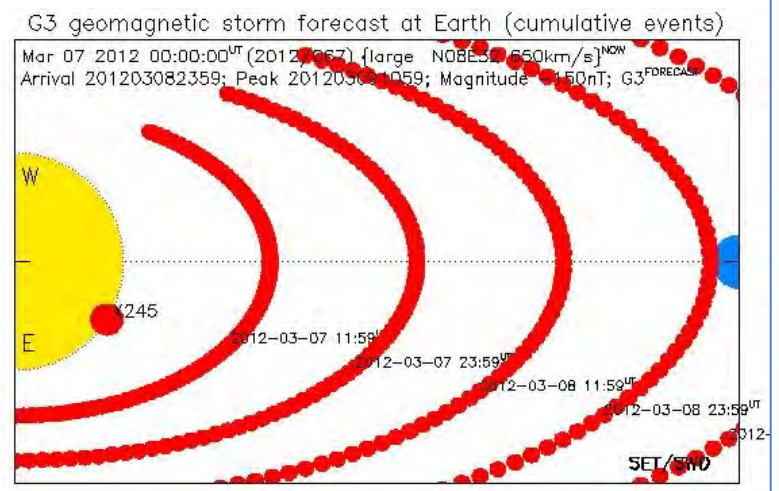
WHO WE ARE

- **Small Business Established** in 2001
- **Personnel** in CA, UT, CO, AZ, MA
- **Service provider** of operational space weather forecasts, nowcasts, and historical data
- **Core Expertise** in solar irradiances, Dst index, thermospheric densities, GEO charging on s/c, and aviation radiation

PRODUCTS AND/OR SERVICES

- **SIP:** Solar Irradiance Platform
- **LAPS:** JB2008 solar and geomagnetic indices' forecasts
- **GAPS:** GEO surface charging and deep dielectric discharge probabilities
- **MAPS:** operational Dst forecasts
- **RAPS:** aviation radiation database for frequent flyers and air crew
- **SpaceWx** app (along with USU SWC)

SERVICE HIGHLIGHT: Dst forecasts



CONTACT INFORMATION

- **Address**
 1676 Palisades Dr.
 Pacific Palisades, CA 90272
<http://spacewx.com>
- **Technical**
 W. Kent Tobiska; 310-573-4185
ktobiska@spacewx.com
- **Administrative**
 Hollie Richards; 435-230-2001
hrichards@spacewx.com



The Next Decade for SpWx Challenges

- **We know that**
 - hazards to our technology clearly exist from space weather, such as
 - Communication outages
 - Navigation position uncertainties
 - Radiation dose to air crew & frequent flyers
 - if unmitigated, space weather hazards create additional stresses during emergencies that compound disasters
 - an example occurred during the 2005 Gulf Coast Hurricane Katrina recovery from August 29 through September 9

Example: Hurricane Katrina

Katrina

+

Solar Flare

=

Hazard



Aug. 29, 2005



Sept. 7, 2005
(4th largest flare
in history)



Loss of ship-to-
helicopter
communications



Commercial SpWx is growing this Decade

- **A paradigm shift is occurring ...**
 - space weather hazard mitigation for disasters and emergencies requires coordinated multi-institutional contributions for effective responses
 - **commercial Space Weather** is creating the shift by providing services and products that:
 1. rapidly advance hazard mitigation for technologies and operational systems;
 2. integrate government, university, and industry operational platforms using modularity and common practices/standards;
 3. enable rapid prototyping, tailored applications; and
 4. train and educate stakeholders, policy-makers, & public.

A view of Earth from space, showing the blue and white clouds of the planet on the left. The sun is rising over the horizon in the center, creating a bright glow and lens flare effect against the dark background of space.

JOIN US!

America's commercial space weather companies are providing operational space weather solutions for 21st Century challenges and are reducing space weather risks