

John Meriwether
Program Director/Geospace Facilities
National Science Foundation





Geospace Programs FY 2016

AERONOMY

Ruth Lieberman

\$9.3M

MAGNETOSPHERE

Janet Kozyra

\$7.1M

SOLAR-TERRESTRIAL

Illia Roussev

\$7.8M

SPACE WEATHER

Vacant

\$6.2M

FACILITIES

John Meriwether

\$14.3M

\$45.2M

Up 4% over FY 2015

Reminder: Look for Noctilucent Clouds tonight



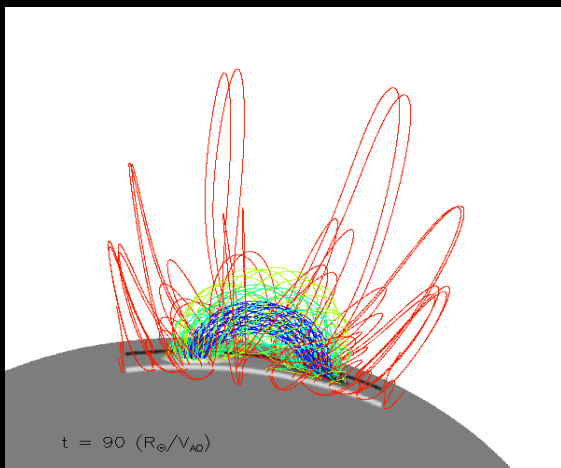
- *Clouds at extremely high altitude, about 85 km, that literally (as the name suggests) shine at night. They form in the cold, summer polar mesopause and are believed to be ice crystals. Because of their high altitude, in a very dry part of the atmosphere, noctilucent clouds are rather an enigma and are being studied by a number of people around the world.*

Advancing Fundamental Knowledge

Tackling the key science questions

This Is our charge at NSF

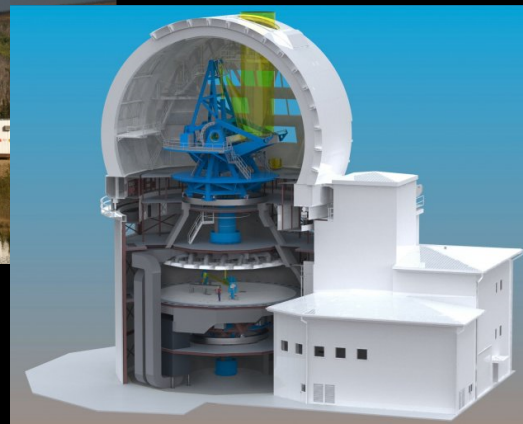
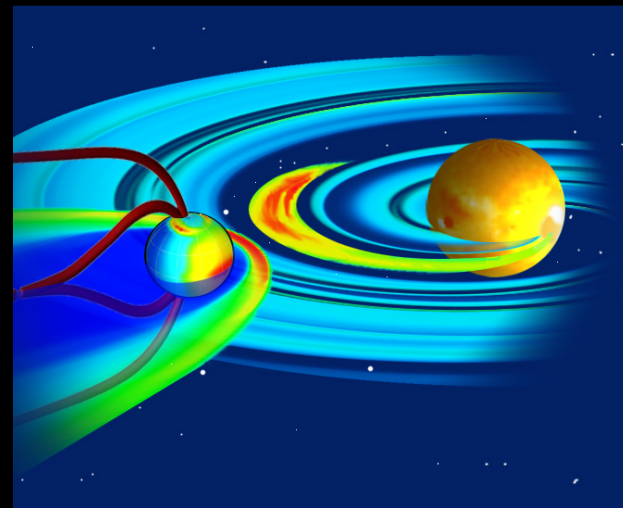
Understanding
processes



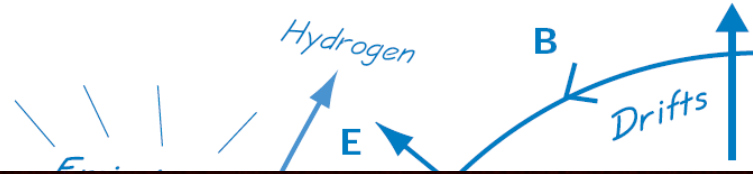
Better observations



Improved Sun to
Earth models

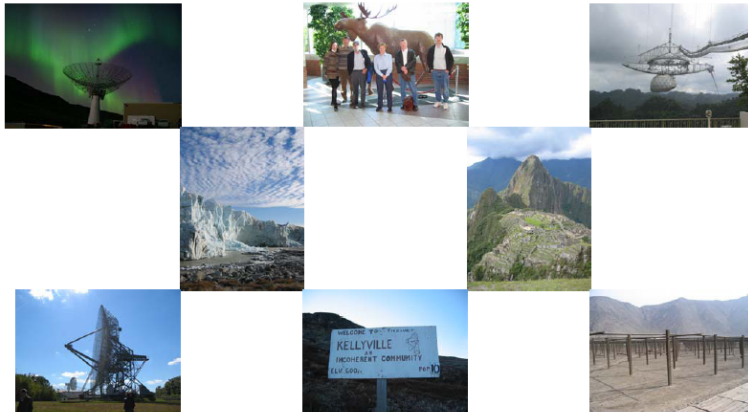


CEDAR
O
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300km

Upper Atmosphere Facilities Review Report



g Committee
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Optics Aeronomy

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SECOND PHASE III; REQUIREMENTS AND GOALS



Susan K. Avery, University of Colorado, Chair
C. Robert Clauer, University of Michigan, Co-Chair: SuperDARN
Maura E. Hagan, National Center for Atmospheric Research, Co-Chair: Millstone Hill
John D. Mathews, The Pennsylvania State University, Co-Chair: Arecibo Observatory
John D. Sahr, University of Washington, Co-Chair: Jicamarca Radio Observatory
Michael J. Taylor, Utah State University, Co-Chair: Sondrestrom Radar Facility

June, 2004

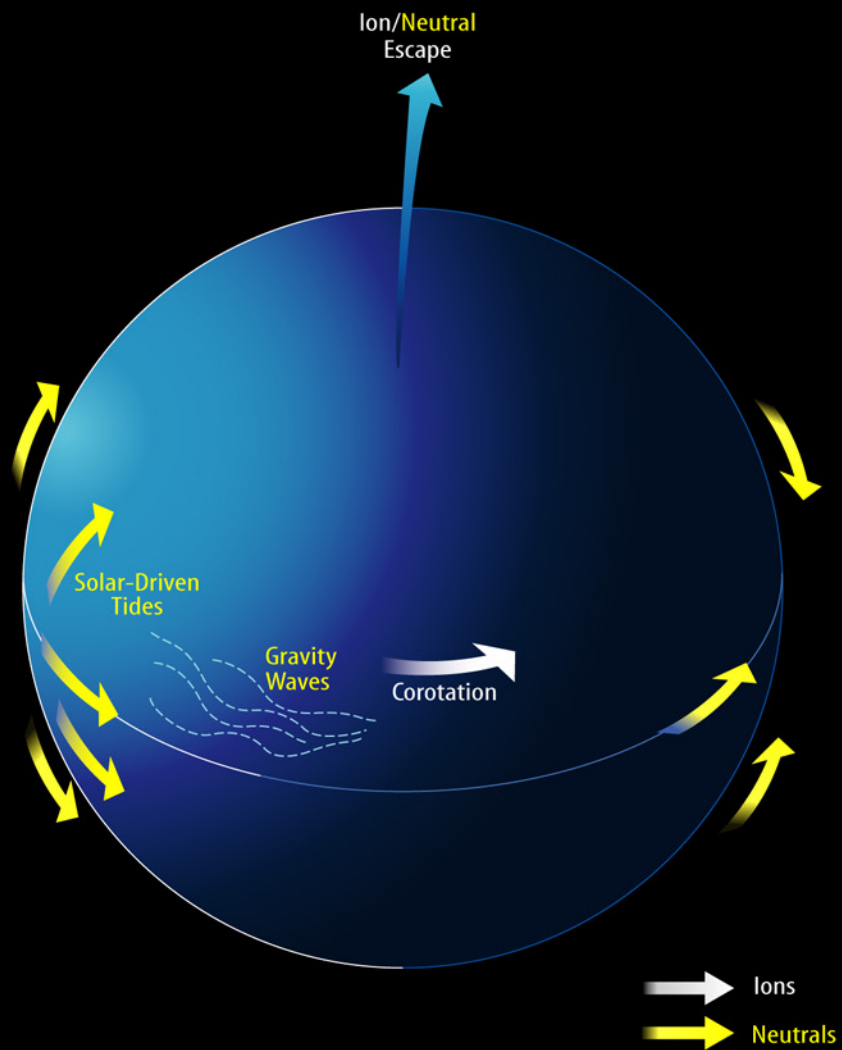
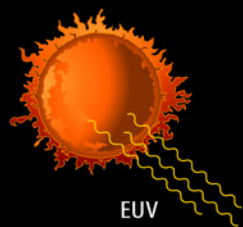
DAR lidar community
Atmospheric Sciences
ence Foundation

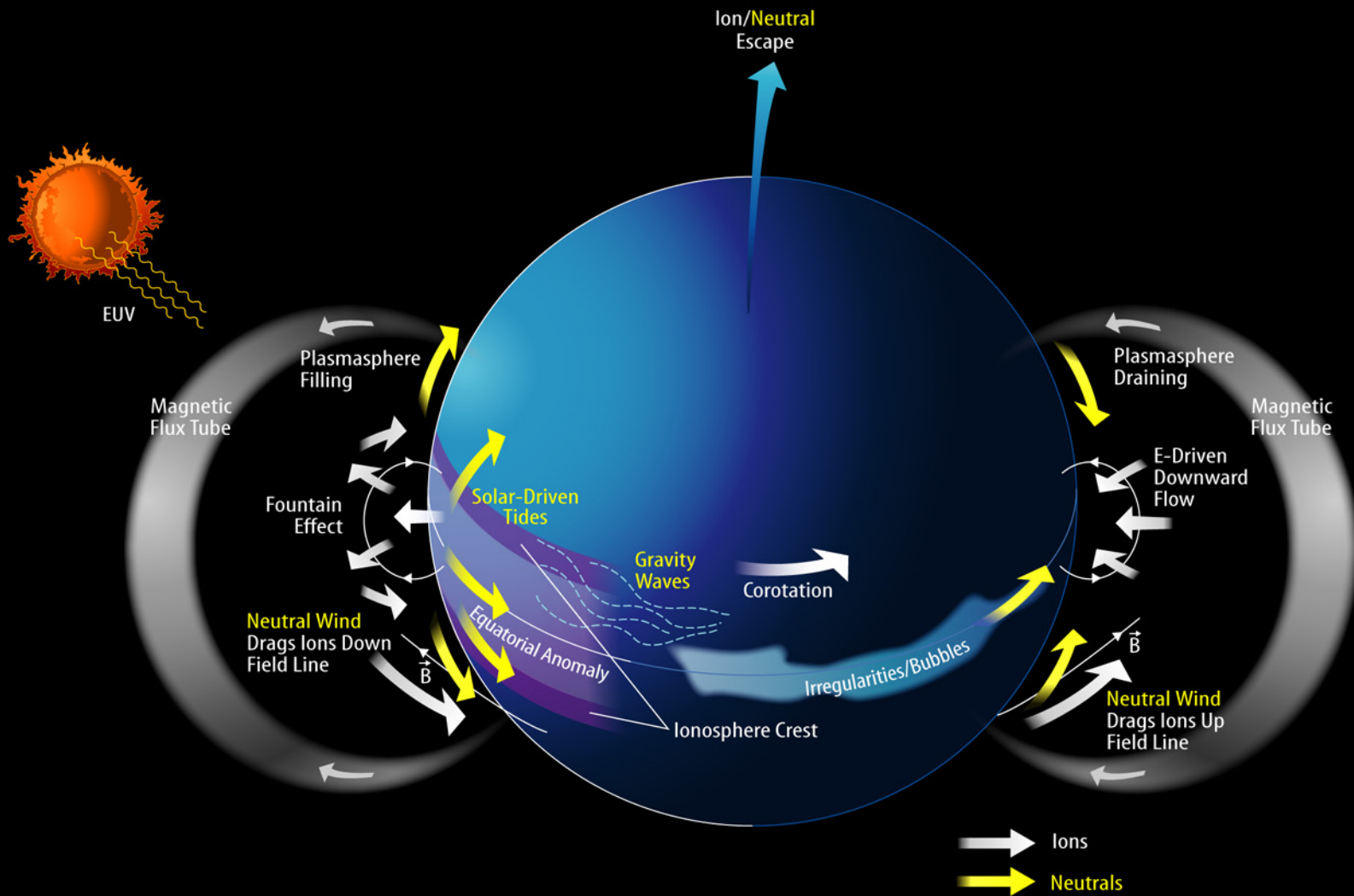
Input documents over the years

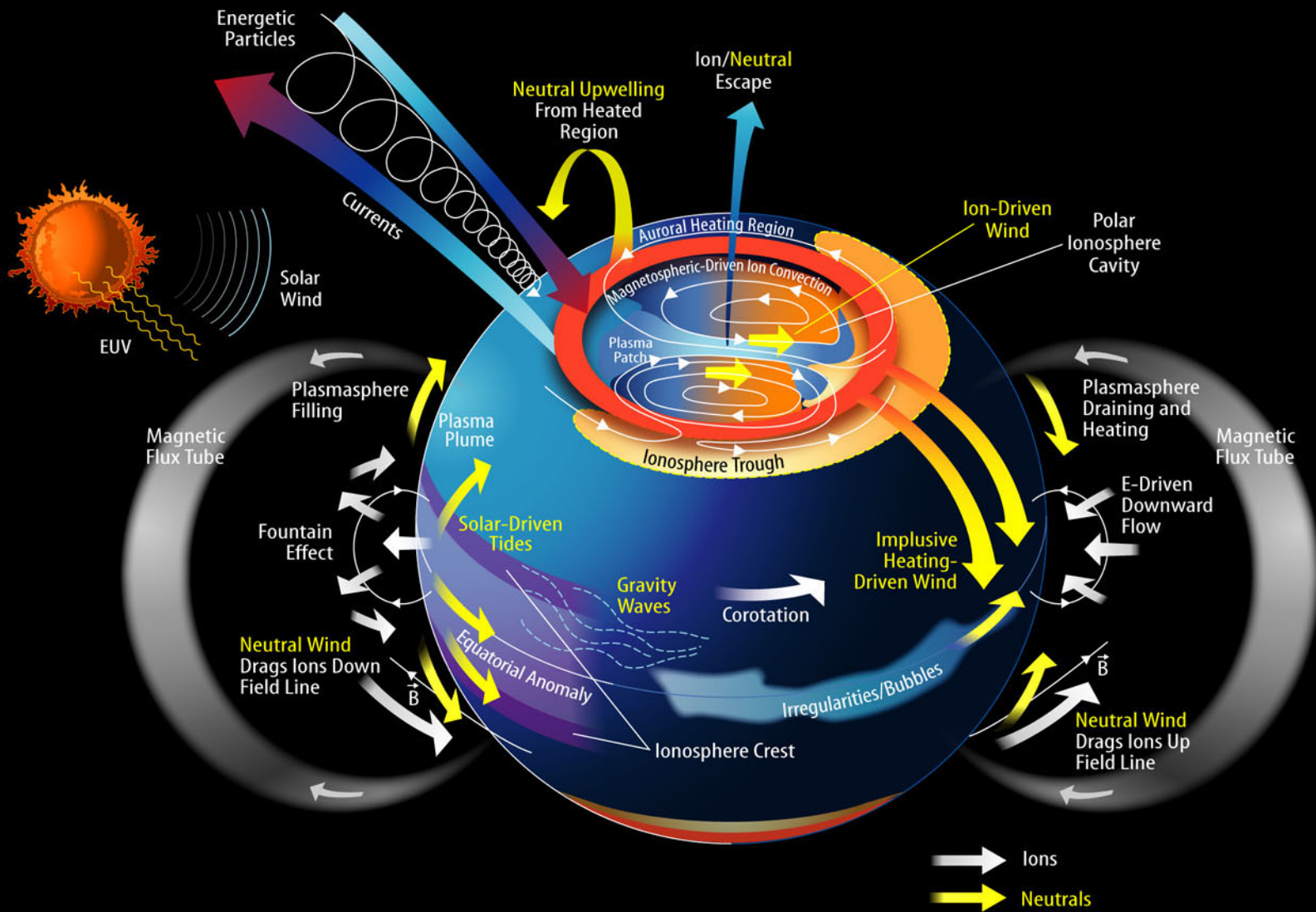
MARCH 2004

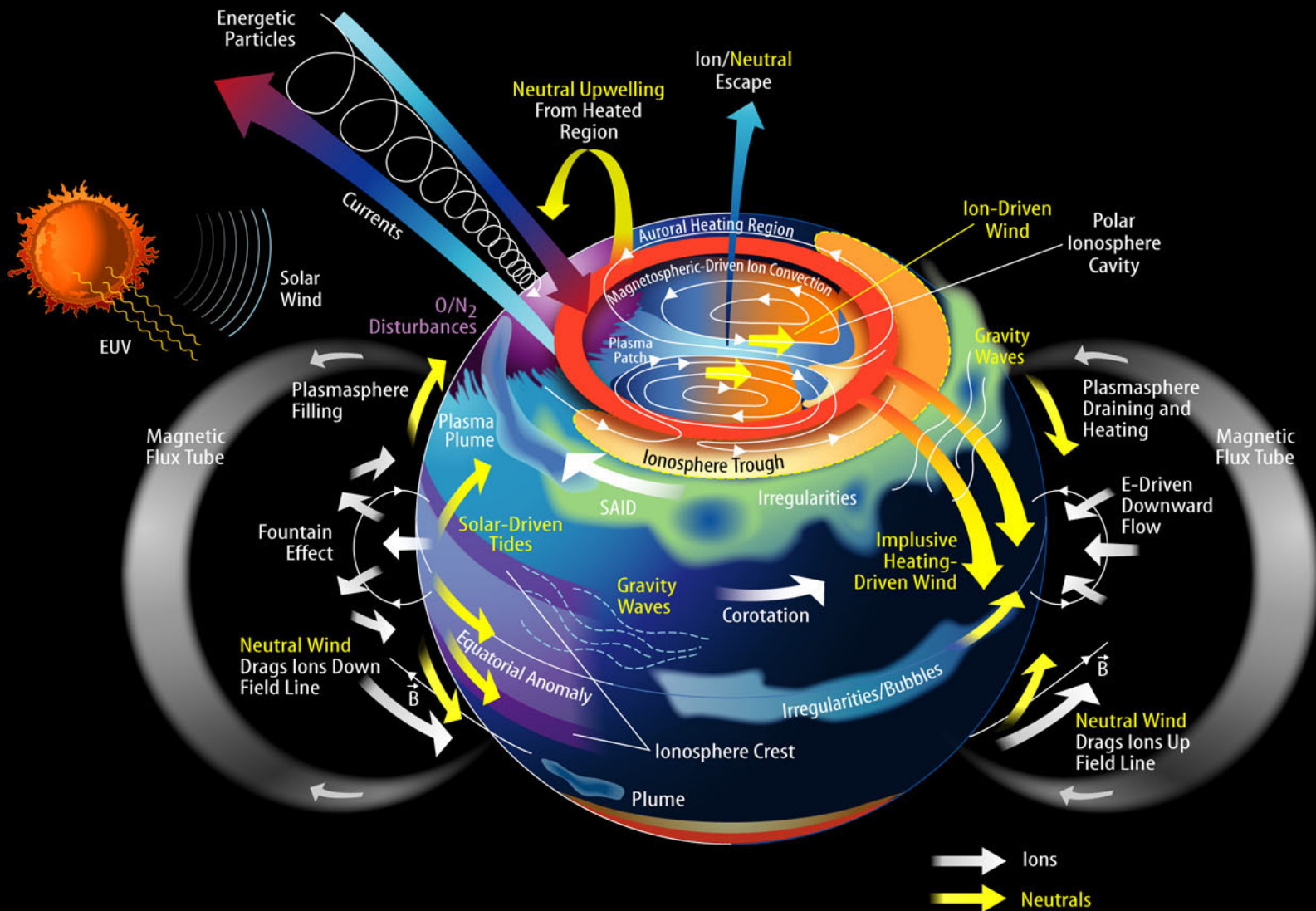
The major theme of these documents is the emphasis that geospace science is complicated!

So measurements across a variety of spatial scales are necessary to achieve an understanding of the complexities of the world that we inhabit!

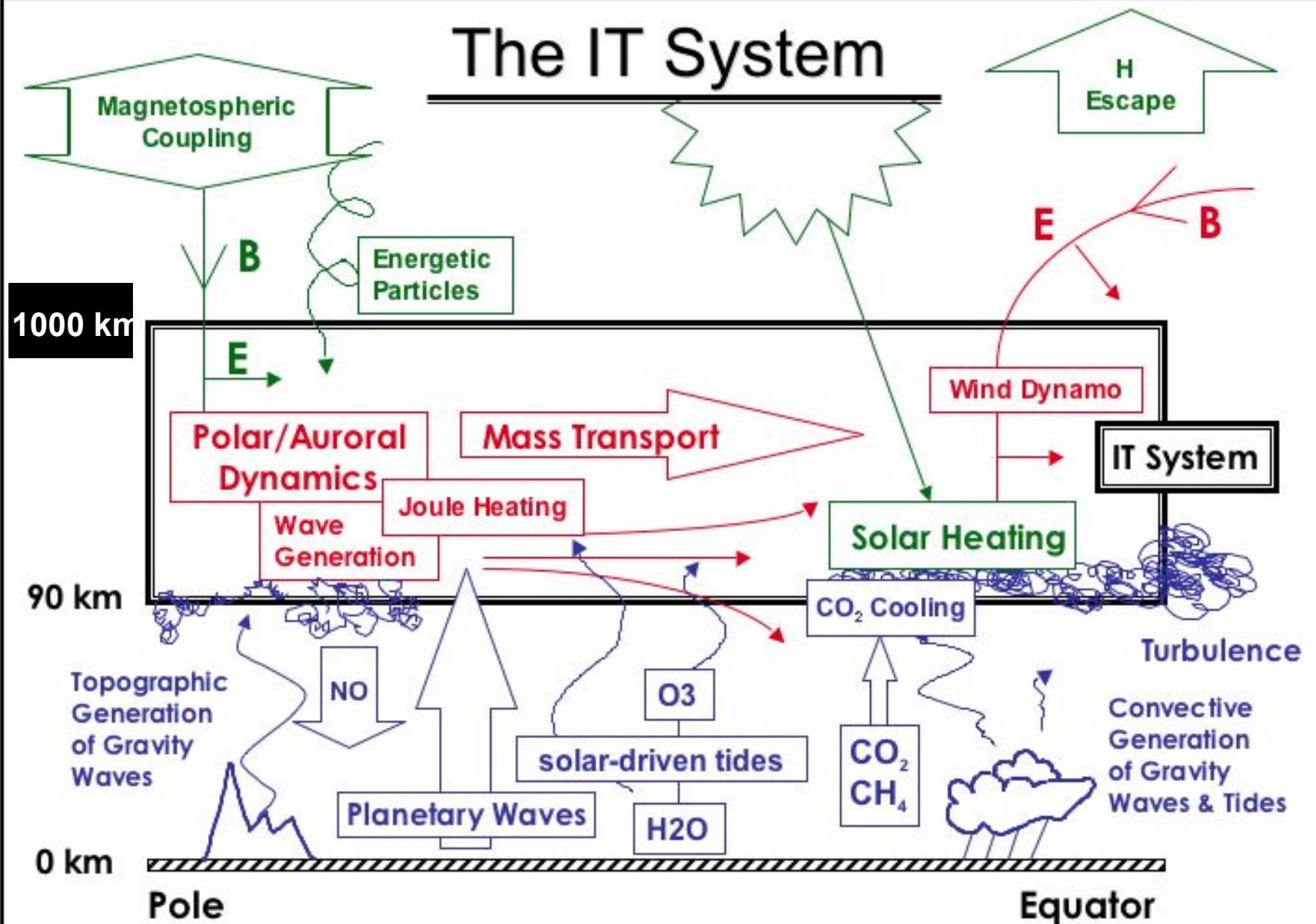


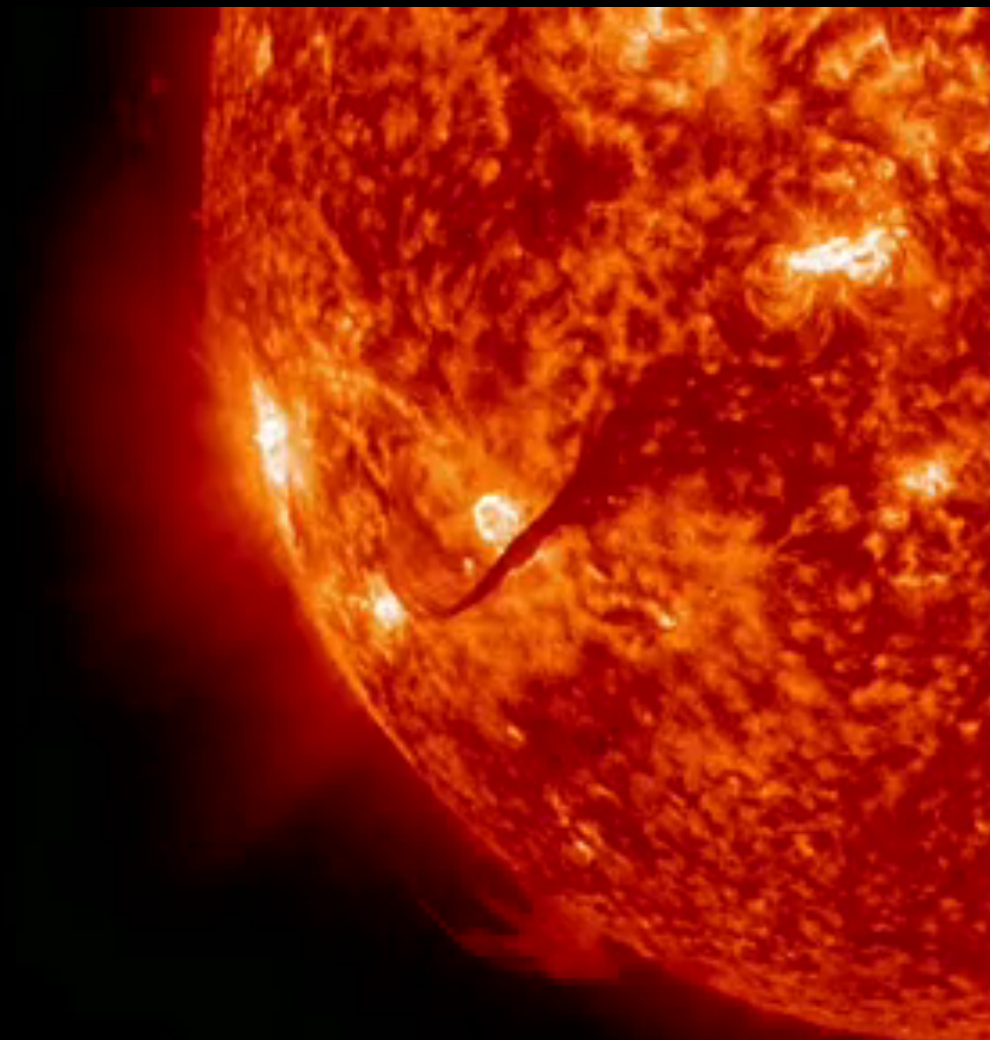






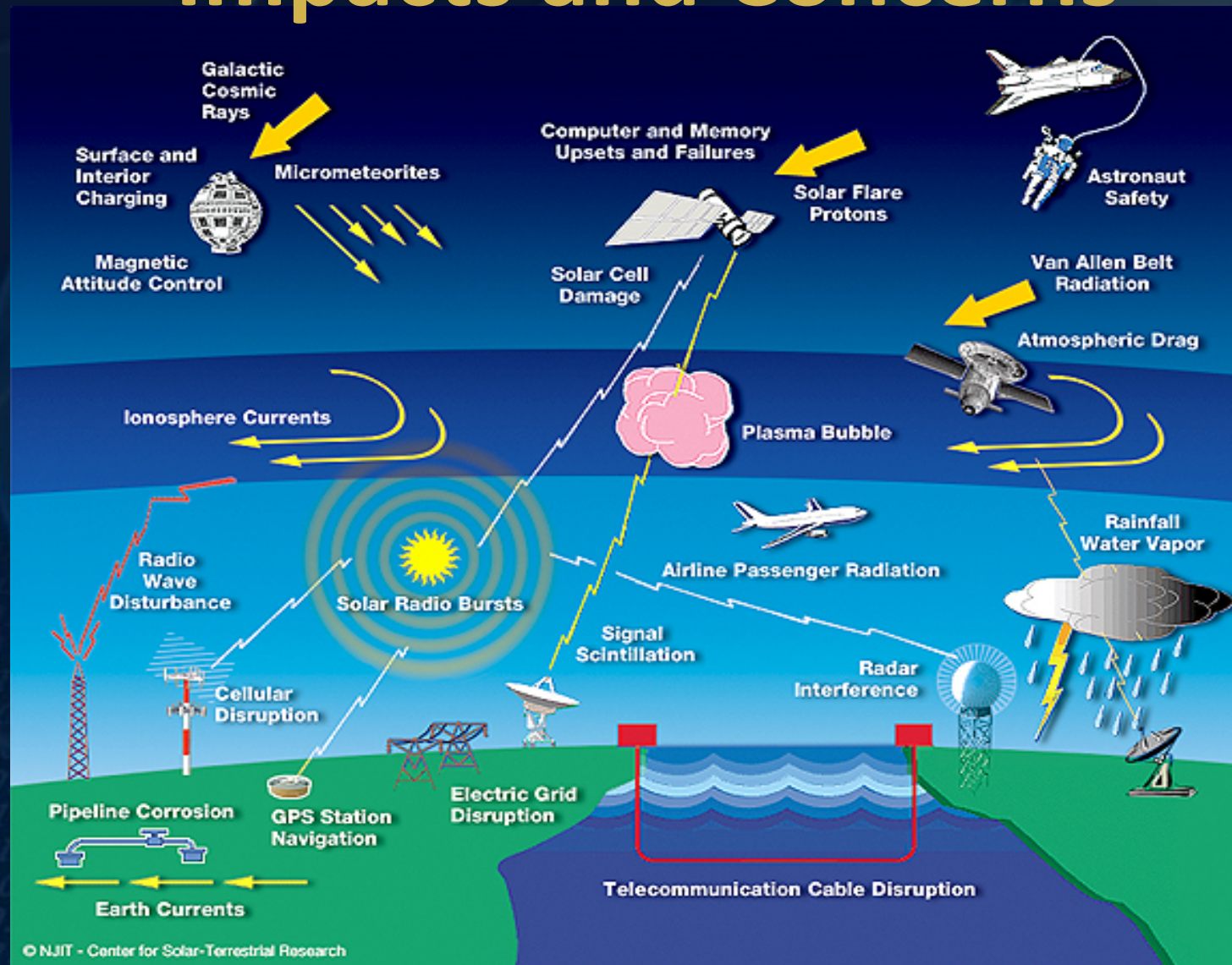
The IT System







Impacts and Concerns



Key Science Questions – Magnetosphere/ Ionosphere

- The magnetosphere/ionosphere system responds differently to CME driven storms and high speed stream driven storms.
 - How does magnetic reconnection operate at the magnetopause and in the magnetotail?
 - How are particles accelerated in the magnetosphere?
 - How does ionospheric plasma fill the magnetosphere during large storms?
 - What drives ionospheric irregularities?

The Geospace Facilities Program -- Advancing Understanding through better Observations

- Six incoherent scatter radar sites, Lidar Consortium (six institutions), Low-Latitude Ionospheric Sensor Network.
- Miscellaneous facility-related awards (facility supplements, Workshops, Summer Schools: ~1M)



ISR systems can make high quality measurements of ionospheric parameters that are of relevance locally with scales up to ± 750 km

- Jicamarca Radio Observatory of vital importance to understand complex equatorial ionospheric dynamics: measure T_i, T_e, V_i, n_e
- AO by far the most sensitive ISR (factor of 20)
 - Lower thermosphere neutral winds
 - Collaborative lidar-ISR science
 - Heating facility science
 - Incredible plasma line measurements for top side region: JV
- MHO of great value due to sub-auroral location in geomagnetic storm disturbances
 - Largest latitudinal range coverage
 - Longest record of calibrated T_i data re climate change
 - Many MIT type phenomena: SAR arcs, SEDs, SAIC, etc

Sondrestrom ISR lies typically on northern edge of nightside aurora oval

- See day-lit cusp region on dayside
- Interesting complex auroral dynamics on nightside (Semeter)
- Nightside convection pattern features Harang discontinuity
- Polar cap phenomena of patches
- Plasma entry into dayside throat
- Noctilucent cloud studies

PFISR located at Poker

- Auroral dynamics
- Rocket experiment collaborations
- Auroral gravity wave studies
- Ion-neutral coupling

RISR-N and RISR-C at Resolute Bay, CA

- Central polar cap dynamics

Jicamarca Radio Observatory



Cluster of Instruments for Equatorial and Low-latitude Observations (CIELO)

- LISN (C. Valladares, BC)
- Magnetometer chain (O. Veliz, IGP)
- Ionosondes
 - Digisonde (B. Reinish, U. Mass. Lowell)
 - VIPIR (E. Kudeki, J. Makela, Illinois)
- Beacon RXs (P. Bernhardt, NRL, Tsunoda, SRI)
- GNSS RXs (J. Morton, MU)
- CIRI Huancayo (J. Urbina, PSU)
- AMISR14 (J. Arratia, UMET) (under repair)
- FPI chain (J. Meriwether, Clemson, A. Gerrard, NJIT)
- Airglow camera (C. Martinis, BU)



The GS world is migrating toward the synergy of ISR and DASI instruments



Jicamarca Radio Observatory: Instrumentation

- The main instrument is the **50-MHz incoherent scatter radar**
 - ✓ a phased array of 9,216 crossed-dipoles. The array is
 - ✓ modular and can be subdivided into multiple sub arrays
 - ✓ multiple simultaneous pointing positions are supported, as are spaced-antenna techniques (interferometry, aperture-synthesis imaging).
 - ✓ can transmit and receive arbitrary polarizations (unique among the AGS facilities.)
- Other instrumentation:
 - Magnetometers
 - Radars: AMISR-14, digisonde, VIPIRs, ..
 - Radio instrumentation, including GPS
 - Optical instrumentation: FPIs, All-Sky imagers , etc.



Jicamarca Radio Observatory: History

- 1960–1961: Built by the **U. S. Department of Commerce**.
- 1969: Observatory turned over to the **Instituto Geofísico del Perú (IGP)**.
- US DOC (NOAA) continued to provide support for operations at Jicamarca with help from **NSF**.
- 1981: NSF began to channel its support through **Cornell University** as NOAA phased out its support.
- The NSF funding currently takes the form of a research award from AGS Facilities to Cornell.



Jicamarca Radio Observatory: Publications and Users

Publications:

2015/14/13/12/11/10: 8 (in press)/29/34/26/22/27
... plus Masters and Ph.D. theses.

Users and Visitors:

In 2014: Cesar Valladares, Terry Bullet, Gerald Lehmacher, Richard Kithil, Carlos Padin, Juan Arratia, Dustin Hickey, Joei Wroten, Anne Marie Schmoltner, Ossi Vaananen, Paul Song, Dale Lawrence, Mike Nicolls, Mike Greffen, Anja Stromme, Blanca Mendoza, Jose Valdes, Nat Gopalswamy, Abraham Chian, David Hysell, Cesar La Hoz, John Meriwether, Rebecca Robinson, Weiguo Zhang, Guillermo Rodriguez, Isabel Bibbo.

JIREP and IAESTE students; JRO & AMISR radar school students

Operation modes:

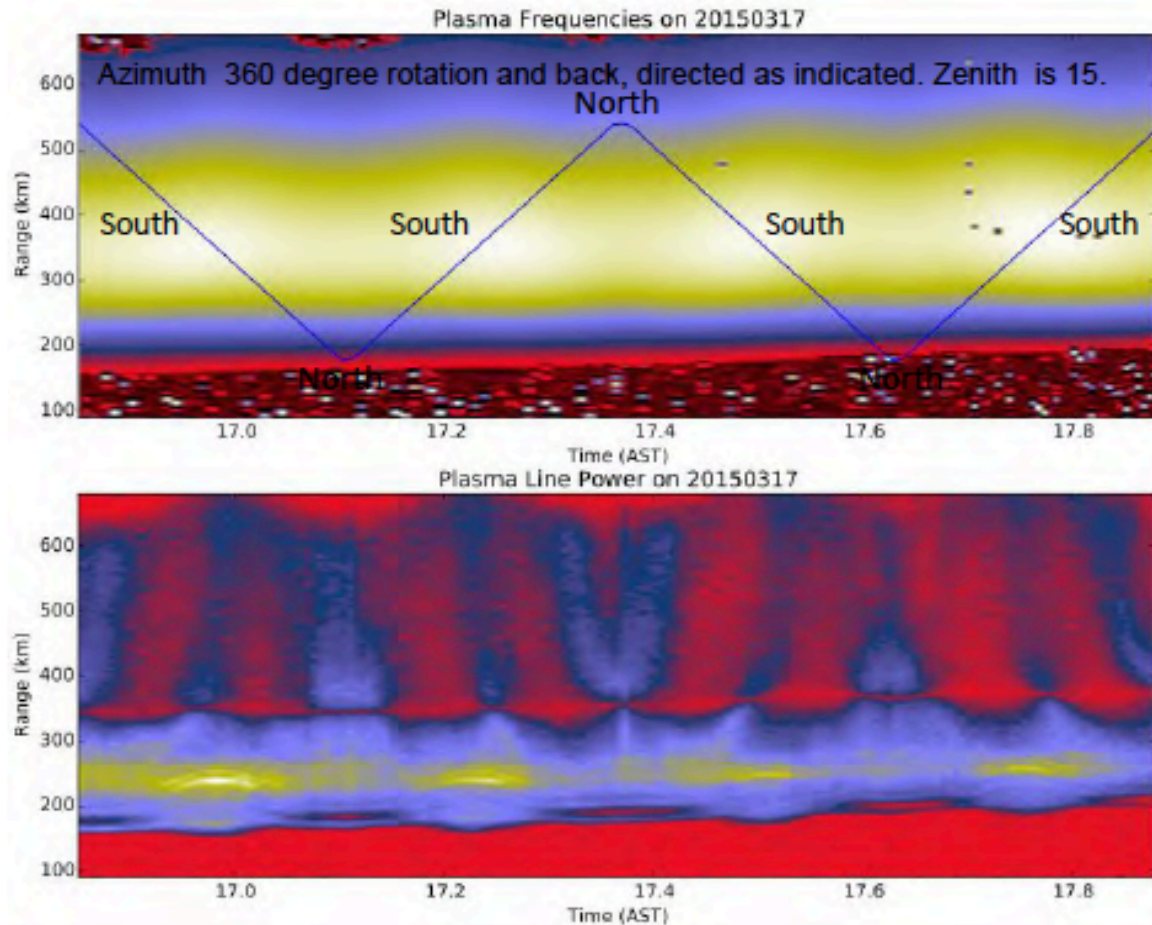
- The Jicamarca radar operates in ISR and other high-power modes more than 1,000 hours per year and in low-power mode (JULIA mode) about 5,000 hours per year.
- In addition, Jicamarca supports approximately ten independent investigations requested by different outside research teams each year.

Arecibo Observatory



Photo-Electron-Enhanced Plasma Line Studies at Arecibo

Arecibo science highlight #1 – a consequence of AO ISR sensitivity



- The top plot shows the plasma frequency measured during the March, 2015 solar storm, just a brief period in late afternoon.
- Note the unusually large densities at high altitudes. The vertical axis shows both range and azimuth angle (the line), the physical location of the gregorian dome.
- Measurement of the plasma line of incoherent scatter is far more useful than in the past because of inexpensive mass data storage and fast parallel computing.

- It provides plasma frequency measurements with accuracy exceeding 0.0002 relative accuracy, but the power in the plasma line also contains important new physical information.

- The lower plot shows this power as a function of range and time. Why is this so useful, important, and exciting?

•Carlson and Djuth have proposed solving the thermal balance problem in the F region. Is the EUV flux or the electron cooling rate the problem causing disagreement with models?

•Plasma line power is a measure of the first, while the frequency combined with temperatures from ion line measurements provide the second. A draft paper of initial results is in the submission stage.

•The interaction of solar EUV with the upper atmosphere results in identifiable features in the electron energy spectrum, and thus in the plasma line. These features are useful in their analysis. For example, the dark yellow horizontal line at about 250 km at the earlier times is such an expected feature.

•However, the brighter curved features are not expected. Their frequency is a function of the look angle to the B field. Also, the power variations in the topside, first seen in this data, are also unexpected. These need explanation.

- Publications cover the disciplines of Radio Astronomy, Planetary Science, Space Physics, and Education, with many sub-disciplines.
- **398 refereed publications from FY 2010 – FY 2014** (89 related to Space Physics data, and 309 to Radio Astronomy or Planetary Science data.)
- **Users include:**
 - ✓ Scientist users of the Gordon telescope and other site instrumentation.
 - ✓ Scientist Users of AO data based on publications
 - ✓ Users within the Space Physics community in particular.
 - ✓ Users of formal education programs
 - ✓ Citizen science
 - ✓ Tourists and Media
- The use of the Gordon Telescope during non-maintenance hours in 2010 – 2014 has been split approximately as 80% Radio Astronomy, 15% Space Physics, and 5% Planetary Science.
- AO now makes remote use of the facility possible

Millstone Hill Radar





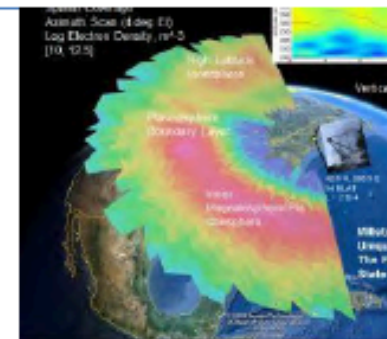
Millstone Hill Radar: History

- 1956 - 1962: **UHF radar constructed** by MIT Lincoln; first incoherent scatter obs.
- 1963: UHF system transitioned **to ionospheric research program** using zenith antenna
- 1964 - 1974: Pioneering IS observations
- 1974: Millstone Hill ISR activities **transferred from ARPA to NSF**
- 1978: MISA (**46 meter fully steerable antenna**) installed on site for wide field scanning
- 1981: **Madrigal** distributed database system begins as main data repository
- 1984-86: **Second UHF transmitter** installed from USAF surplus
- 1989: Radar/Optics ionosphere-thermosphere program begins using onsite **FPI**
- 2001: SAR arc studies, **GPS TEC** maps begin
- 2002-2007: ISRIM empirical models of all NSF ISRs; long term **ionosphere climate** studies begin
- 2008: **Whole atmosphere studies** / SSW response studies begin
- 2011: **Madrigal** becomes CEDAR community data repository system
- 2013: Global system response studies using DMSP / GPS TEC / Millstone ISR / Van Allen Probes



Millstone Hill Radar: Instrumentation

- Millstone Hill UHF Incoherent Scatter Radar:
 - ✓ 2.5 MW Transmitter, 440 MHz
 - ✓ 46m steerable antenna, 68m zenith antenna
 - ✓ 1000-2000 hrs/year
 - ✓ Unique wide-field access to the full ionospheric plasma state
- GPS Total Electron Content Global Products
 - ✓ Available 3-4 days behind realtime
 - ✓ Supported as part of Millstone Hill Geospace Facility activities
 - ✓ 2014: 145 unique community users from 71 unique institutions
- Millstone Hill Passive Optics:
 - ✓ Fabry-Perot Interferometer (separate NSF grant); 6300 A red line winds/temperatures since 2009 (also 1989-2001); green line operational
 - ✓ Allsky Imager (hosted; funded separately and operated by SSI, Boston University) 6300 A etc.
 - ✓ MIT provides site infrastructure: power, building, ethernet
- Geospace Sciences Center: Workshops, distributed instruments operations, enhanced computing facility, distributed antenna and safety control system





Millstone Hill Radar: Operating Status and Challenges

Overall Status

- Fully operational at 2.5 MW peak power
- Flexible software radar system: Raw data archival since 2001, realtime signal processing
- Ion line and plasma line profiles
- Operations hours limited only by funding

Antennas (Zenith 68 meter + MISA 46 meter)

- Antennas are both fully functional
- Full sky coverage from 46 meter antenna - *Expensive to achieve with phased array*
- MISA control system refurbished in 2012

Transmitters

- Unique transmitter license (band priority)
- Dual transmitter cabinets
- Full arbitrary timing and waveform capability
- 12 klystron tubes (~ **\$10M value**), 7 modulator tubes

Challenges

- Limited maintenance budgets (e.g. MISA coating and foundation)
- Eventual modulator upgrade cost (i.e. a solid state deck)

Millstone Hill GF Science Highlight

Upper Atmosphere Climate Change

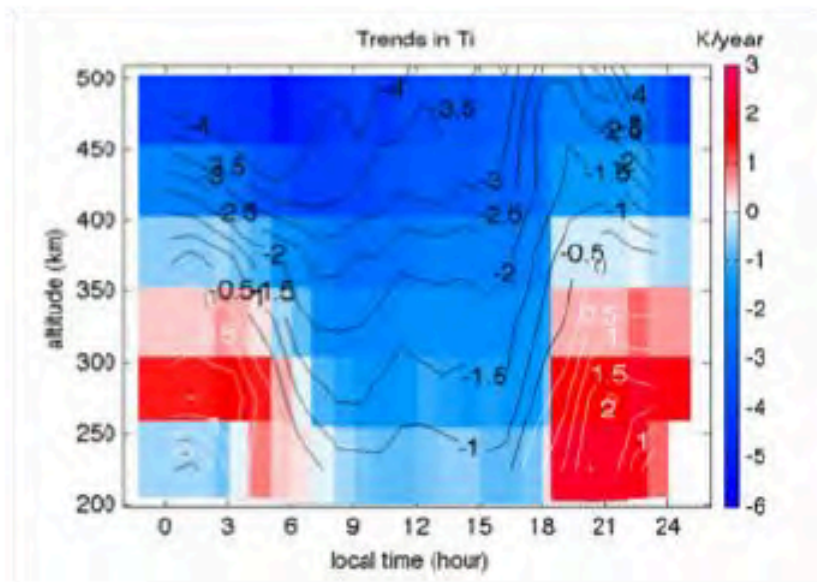
Millstone Hill long term ISR data record: 1966 - 2013,
readily available in Madrigal system

Unique monitor of thermal status of upper atmosphere

Unexpected, substantial ionospheric cooling seen; altitude
& time dependent

New mechanisms proposed for secular changes: gravity
wave modulated cooling

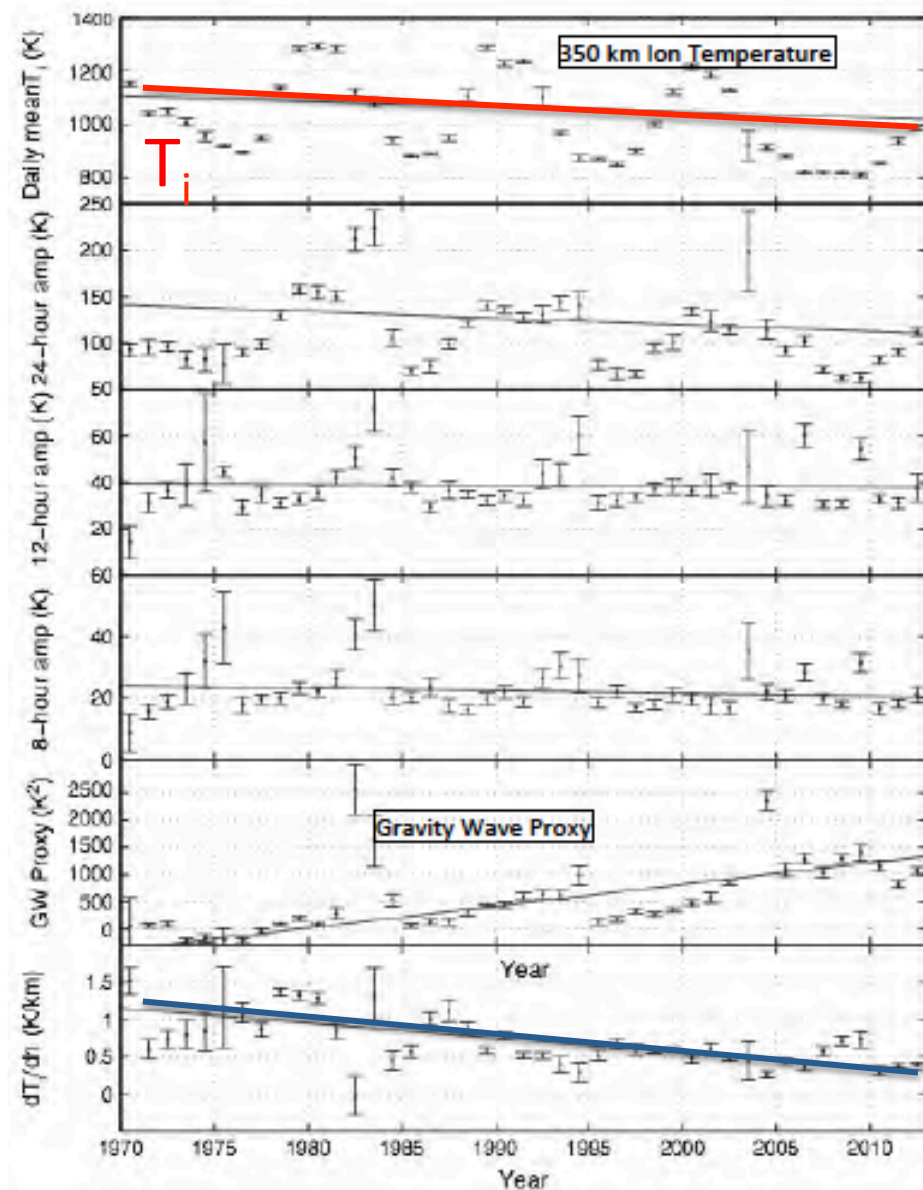
Observational challenge to modeling efforts



Holt and Zhang (2008); Zhang and Holt (2011, 2013)

NSF long term support of Millstone Hill GF is crucial

NSF AGS grants supported all science analysis



Oliver et al (2013, 2014, 2015)

Secular changes = solid line



Millstone Hill Radar: Publications and Users

Millstone Hill Publications:

2010-2015: 113 Publications

Millstone Hill Geospace Facility List of Scientific and Technical Users 2010-2015 **Information current as of March 24, 2015**

- Total Millstone Hill UHF Incoherent Scatter Radar experiment requests: **160**
- Total Millstone Hill UHF Incoherent Scatter Radar users through Madrigal: **343**
- Total GPS Total Electron Content users through Madrigal: **397**
- Total Millstone Hill FPI / Allsky Imager users through Madrigal: **53**

The on-site Millstone Hill high-resolution Fabry-Perot Interferometer neutral wind monitoring systems and all-sky imager system are provided by Scientific Solutions, Incorporated. MIT Haystack provides the optics building, site power, and network access for these instruments as a collaboratory effort with Facility operations, while funding and operations support occur under separate grants outside the main Millstone Hill Geospace Facility cooperative agreement.

Sondrestrom

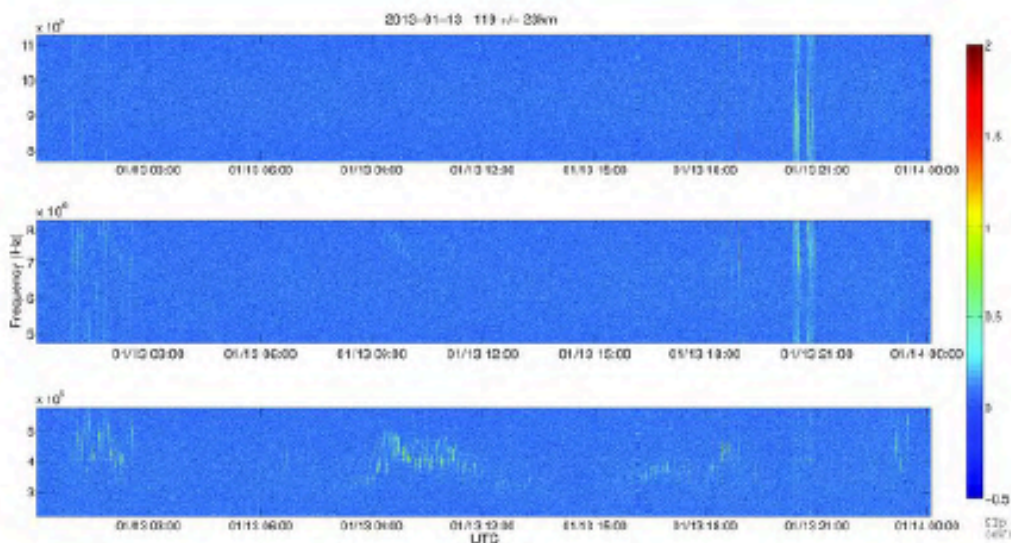




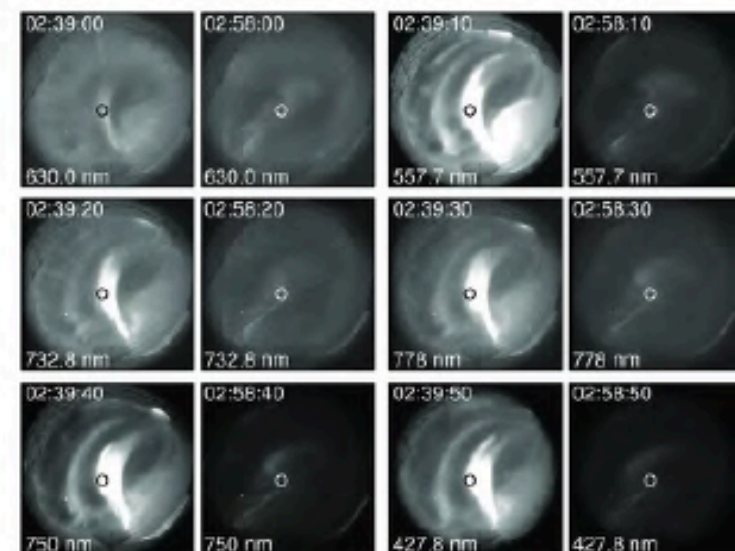
Sondrestrom: History

- 1960s: Design, construction and operation of radar at Stanford Campus, California
- 1971: Relocated to Chatanika (only 5km from current PFISR site)
- 1982: Fully transitioned to NSF and relocated to near Kangerlussuaq, Greenland, to measure the Polar Cusp region
- Upgraded reflector from 27m to 32m
- Scope of project broadened to multi-instrument facility
- 1983: Full operation of the Sondrestrom Facility starts in collaboration with Danish Meteorological Institute

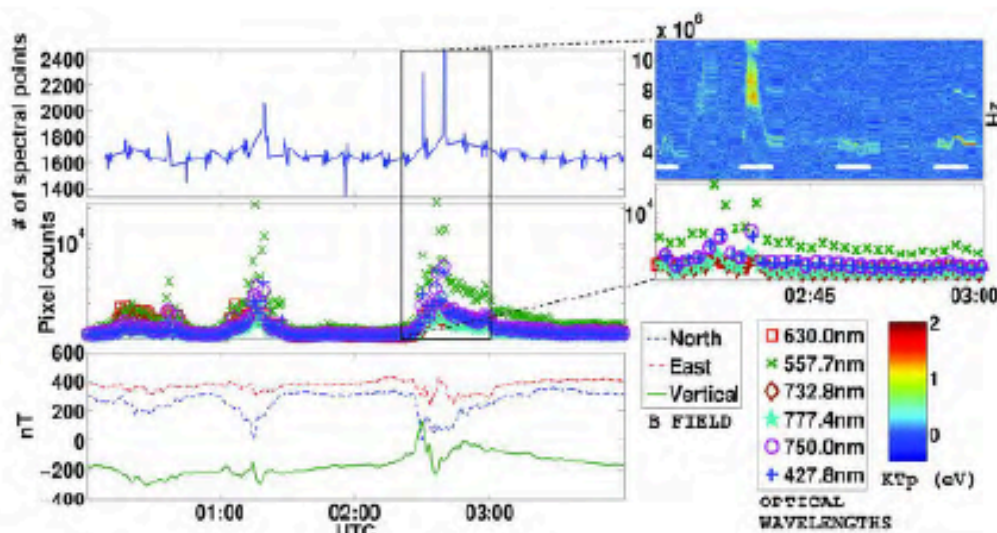
Science highlight – Bhatt et al.



(a) A 24-hr plasma line run



(b) Strong multi-wavelength optical emissions during broad plasma line occurrence



(c) A composite figure showing correlation of broad plasma lines with multi-wavelength optical emissions

Auroral plasma line studies at Sondrestrom radar in conjunction with multi-wavelength optical imager showed extremely wide-bandwidth ($\sim 2\text{-}3\text{MHz}$) plasma lines occurring during intense, multi-wavelength optical emissions. After eliminating instrumental factors, and evidence of multi-wavelength emissions associated with scintillations, we believe that the broad plasma lines result from sub-kilometer scale irregularities associated with intense auroral precipitation.



Sondrestrom: Operating Status and Challenges

The Sondrestrom Radar and facility are mostly in good repair and are annually providing above the target 1440 hours/year of ISR measurements to the science community. Several major upgrades have recently been performed, including a new power generator for radar operations in 2012.

The several-month downtime over the summer of 2010, caused by a broken klystron, was used very efficiently. An overhaul of the antenna, including resurfacing of the subreflector, tower re-cabling, gearbox repair, etc., ensured that the radar is currently in overall good repair.

SRI plans to purchase a spare klystron tube



Sondrestrom: Publications and Users

Sondrestrom Publications :

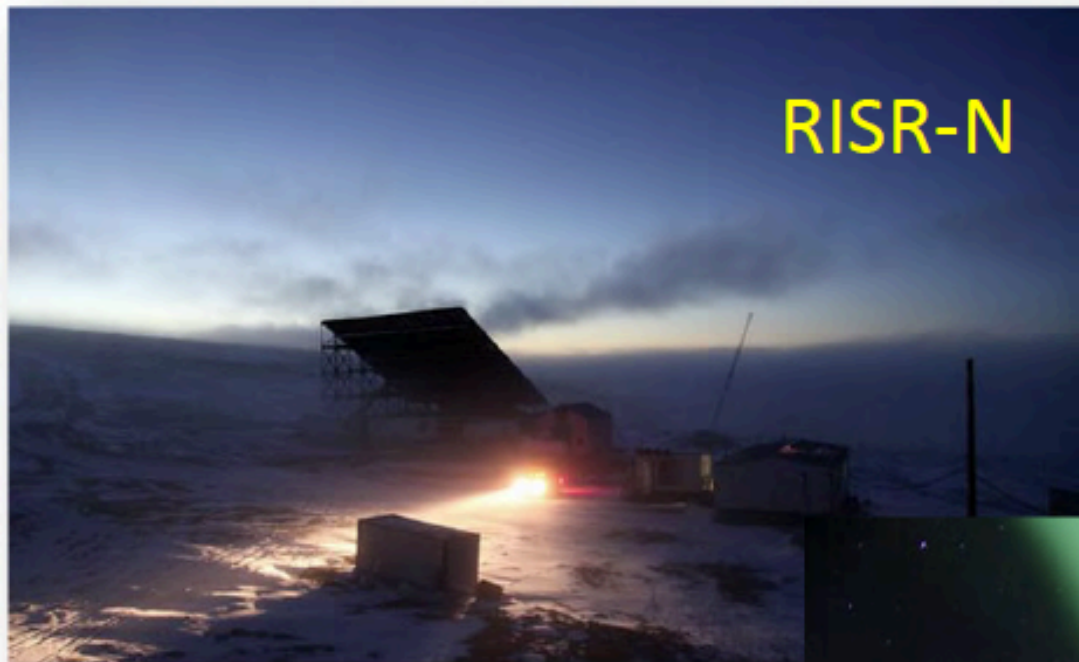
2010/2011/2012/2013/2014: : 17/14/10/11/7/

Sondrestrom Users :

- 2010 - March 2015: 83 researchers actively involved with experiments using the Sondrestrom radar.
- from 48 different institutions, 7 graduate students
- In addition to the 7 students, there were 169 students that were involved in using Sondrestrom data during the five ISR Workshops held each summer, and ~50 students using Sondrestrom data during the UNIS class “Radar Diagnostics of the upper polar ionosphere”.
- In the last five years, 156 users downloaded 788,111 datasets from the Madrigal database. This is in addition to the data that users get directly from SRI staff

AMISR

RISR-N



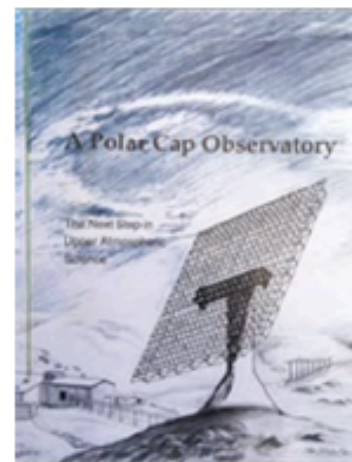
PFISR





AMISR: History

- 1989: Workshop to develop technical requirements for an ISR in the Polar Cap
- 1995: Polar Cap Observatory proposal submitted by SRI (MREFC proposal)
- 1996: PCO approved for funding by NSF
- 1997: Removed from NSF budget by Congress
- 1998: Second Workshop convened to discuss scientific justification for a portable incoherent scatter; highest priority locations were Alaska and Arctic Canada
- 2000: SRI submits proposal to build the Relocatable Atmospheric Observatory
- 2002: Project re-scoped and renamed AMISR
- 2003: SRI proposal approved by the NSB
- 2004: Construction begins
- 2006: PFISR full-face first light
- 2009: RISR-N full-face first light





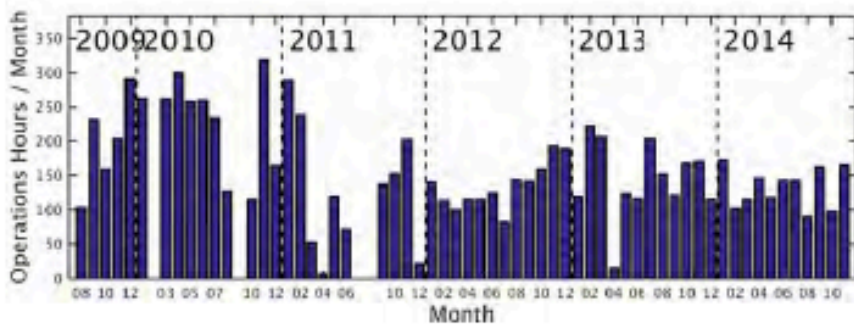
- Unmanned site
- Facility instruments include
 - VHF radar
 - FPI + camera
 - Multi-spectral ASI
 - Multi-spectral ASIs
 - Michelson Interferometer
 - GPS receivers
 - Nearby ionosonde



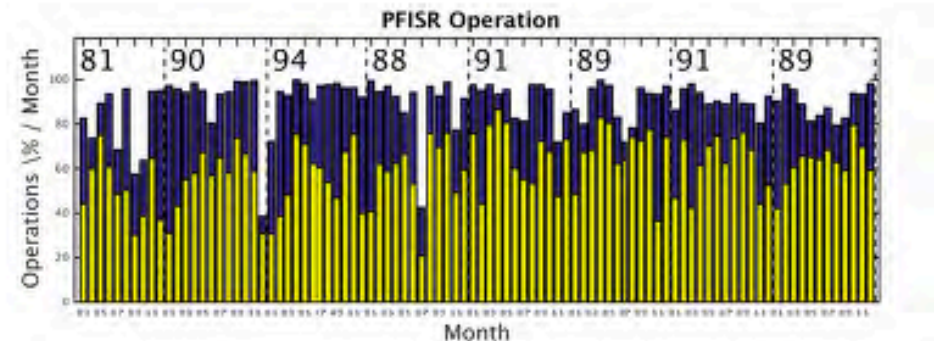


AMISR: Operating Status and Challenges

	# of panels	# of AEU's	Non-operational panels	Non-transmitting AEU's	Non-communicating AEU's
PFISR	128	4096	0	500	100
RISR-N	121	3872	5	325	226



RISR-N Total operations hours by month.



PFISR cumulative operations. Operations % by month from 2007-2014. Yellow bars correspond to low duty cycle operations; blue bars correspond to total operations.

- PFISR is operating 24/7, with high reliability and nearly no onsite supervision.
- The PF Research Range has stable, low cost power, and a skilled technical staff
- The main refurbishment requirements are amplifier replacements
- RISR-N operates reliably in a harsh environment, typically in one block of 7-10 days/month.
- The excellent support from ATCO is critical for successful operations because of the necessity to operate and maintain the large generator.



AMISR: Users and Publications

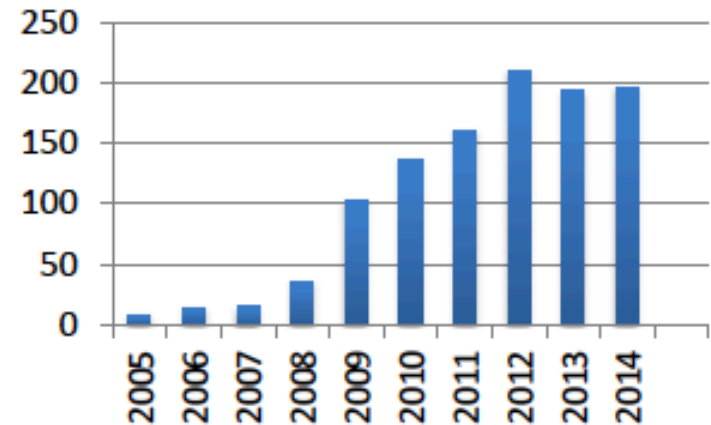
AMISR Publications :

2010/2011/2012/2013/2014/2015(\leq Feb):
19/13/18/17/19/3

Under Review: 9, Dissertations: 3

AMISR Citations per Year

(** statistics compiled using Web of Science **)



AMISR Users :

- From 2010 Through March 2015, there have been **215** researchers actively involved with experiments using PFISR and/or RISR-N.
- These researchers were from 73 different institutions, and **62** of the researchers were **graduate students**.
- In addition, there were 169 students that were involved in using AMISR data during the five ISR Workshops held each summer.

What will the Future bring to
Geospace Research in the US?

An important question that needs to be considered in these discussions is the one regarding balance!

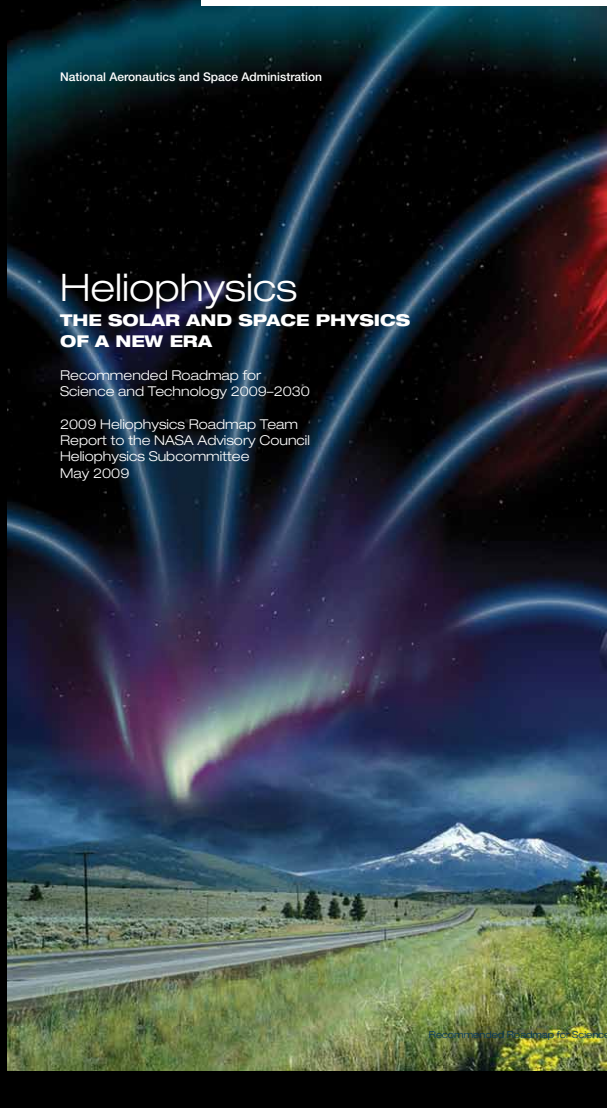
It is not widely appreciated within the Aeronomy and Space Physics community that

a transition has been underway over the past few years in which space weather instrumentation has moved away from a focus upon monolithic ISR clusters to that of regional instrumental diagnostics.

Examples abound re the importance of regional diagnostics to space weather studies:

GNSS receivers, TEC monitors, SuperMAG, AMPERE II,
SuperDARN, FPIs, aurora/airglow imagers

Decadel Survey guiding influence in Geospace community



Priority Investigations:

How are planetary thermal plasmas accelerated and transported?

How are mass and energy transferred from the heliosphere to a planetary magnetosphere?

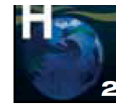
What are the roles of mass and energy flows in the behavior of planetary magnetospheres?

What is responsible for the dramatic variability in many of the state variables describing the ITM region?

How do the magnetosphere and the ionosphere-thermosphere systems interact with each other?

Decadal Survey Challenges:

Challenge 3: "Understanding the space environments of Earth and other solar system bodies and their dynamical response to external and internal influences."



Our Home in Space RFA H2:

Understand changes in the Earth's magnetosphere, ionosphere, and upper atmosphere to enable specification, prediction, and mitigation of their effects

Earth's space environment is a complex, strongly coupled system energized by an amazing range of inputs that originate with the Sun. One important input is the magnetized solar wind rushing past Earth at a million miles per hour, interacting with Earth's magnetic field to produce the magnetosphere, which accumulates and releases that energy in powerful bursts. This process accelerates magnetospheric plasma into Earth's auroral regions and heats the upper atmosphere, a well known effect of the aurora. Auroral heating sets the upper atmosphere into motion and modifies its composition and chemistry. Embedded in the atmosphere is the ionosphere, the density of which is usually driven by solar extreme UV radiation. However, its density can be strongly affected by auroral-induced changes in the atmosphere, and thus by solar wind conditions. The electric fields that develop in the magnetosphere during solar wind-induced disturbances can also strongly modify the ionosphere, drawing high-density plasma from low to high latitudes in great plumes, further enhancing the strength of geomagnetic disturbances by adding to magnetospheric pressure through high-latitude ion outflow.

The short description above shows how solar wind energy initiates a magnetic storm, with subsequent effects in the atmosphere and ionosphere that, in turn, may modify the magnetic storm strength itself. The flow of energy and mass in this strongly coupled system is an intensively studied problem with broad implications for our technologically advancing society and for basic understanding of plasma processes in planetary environments. Individual parts of the system have been the target of many focused studies, yielding a new understanding of processes occurring on a wide range of temporal and spatial scales. Equally important is to understand how these processes couple across the broad range of spatial and temporal scales in our geospace system.

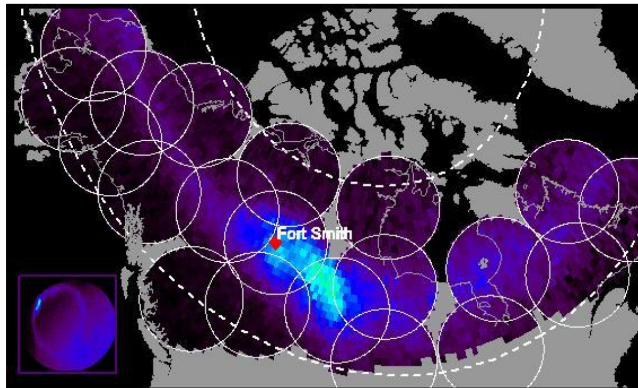
New nonlinear pathways for energy coupling have recently been discovered in geospace. Recent research indicates that the response of the atmosphere to auroral forcing depends on the total energy input and the width of the auroral curtains. Daily tropospheric precipitation in equatorial rainforests releases such a prodigious amount of heat that the tides of atmospheric energy propagating upward from these interact with other waves on wave interactions that geospace system.

Studying these questions requires a balance between ISR clusters and DASI regional arrays be established.

Examples of DASI
arrays already in place

BOX 2.3 THEMIS

The THEMIS ground array provides a current example of the synergy of space- and ground-based coordinated studies to address significant auroral-latitude processes (substorms). (See Figure 2.3.1.) Carefully planned arrays of auroral optical imagers and magnetometers provide real-time coverage of the auroral region across North America. The major THEMIS science objective is to locate and time the substorm onset as seen at ground level. At onset, the aurora intensifies and expands, and the magnetic field caused by the ionospheric current intensifies.

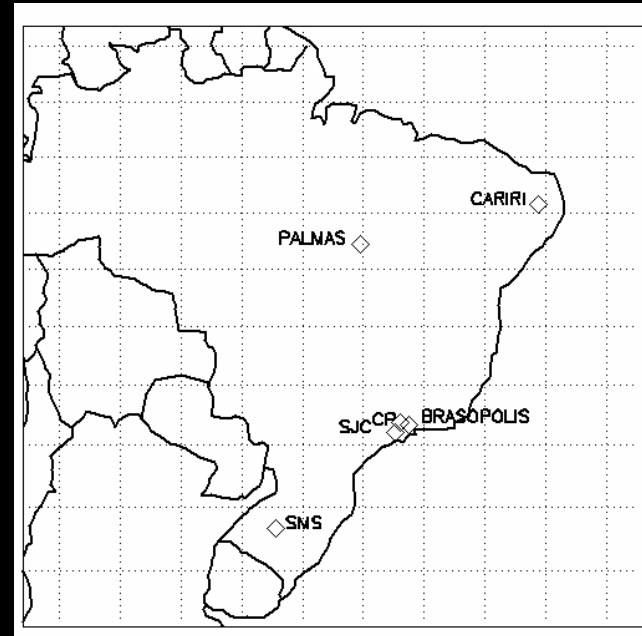
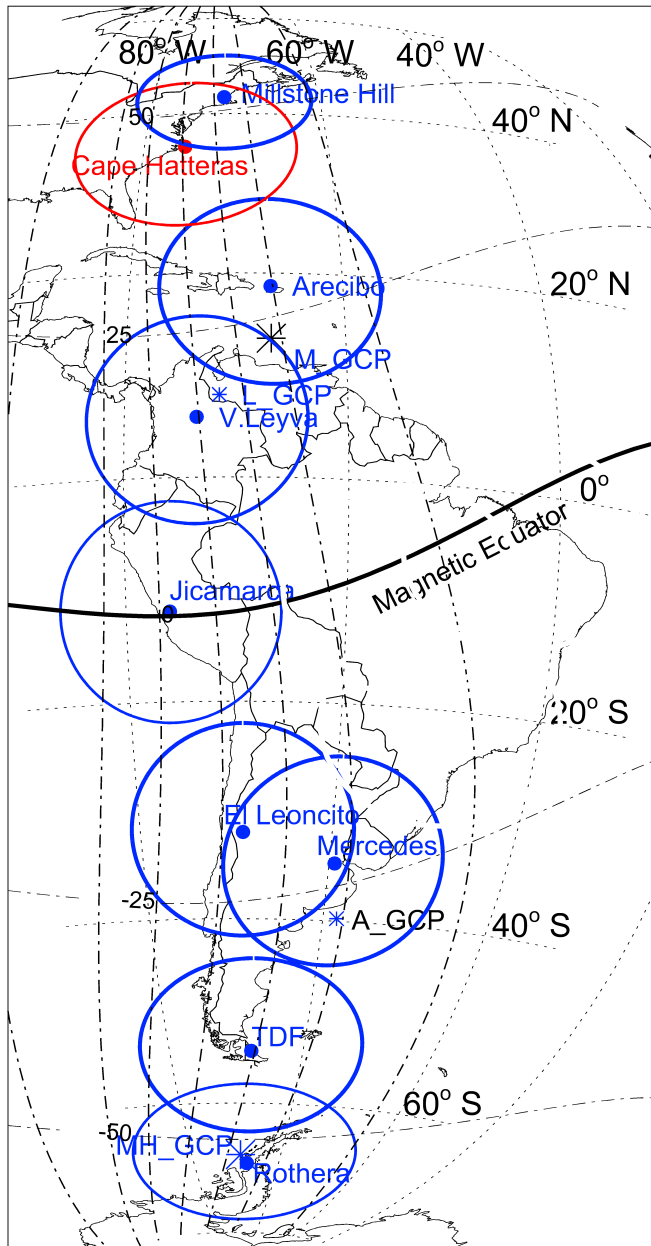


(funded by CPA)

Auroral Imagers

FIGURE 2.3.1 The rapid evolution of the aurora across the midnight sector (see illustration at pluto.space.swri.edu/image/glossary/local_time.html) provides a near-Earth image of the development of magnetospheric substorms. A distributed array of ground-based white-light auroral imagers is being deployed across North America as an essential part of the NASA THEMIS MIDEX mission. The imager array will provide high-resolution observations of auroral characteristics in the North American sector, with the specific objective of characterizing the spatio-temporal evolution of the electron aurora during expansive phase onset. Shown here is a composite figure that displays the combined field of view of the ground-based THEMIS auroral imager array (bottom) with an auroral snapshot by the ultraviolet imager on the Polar spacecraft (top). SOURCE: Images courtesy of Eric Donovan, University of Calgary; Polar UVI data provided by Kan Liou, Johns Hopkins University Applied Physics Laboratory.

Imagers



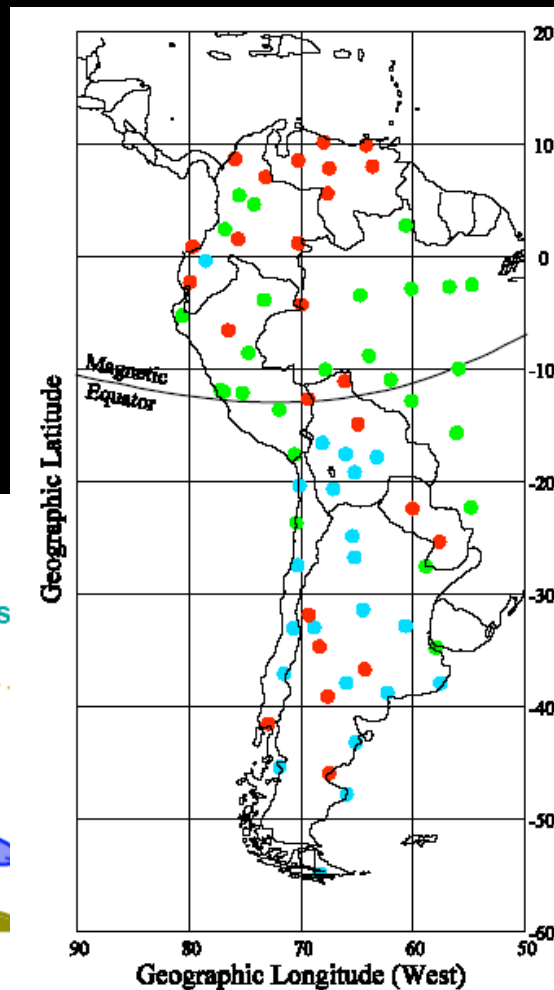
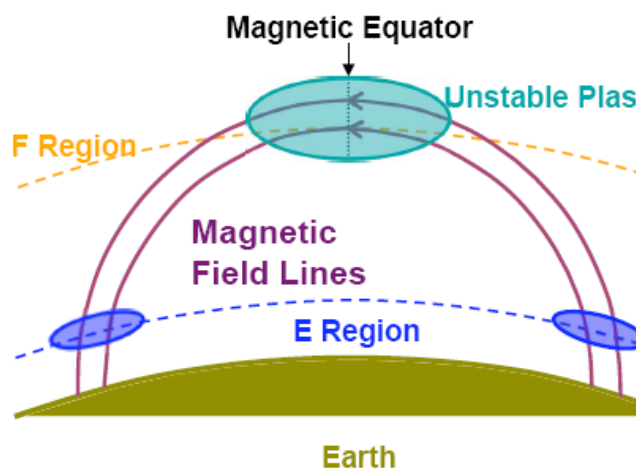
All-sky imagers : *SJC* ; Sao Martinho da Serra,
Cariri, Manaus, **Araquatinga, Cuiaba, Santa
Maria**

INPE, Brazil
UNIVAP, Brazil

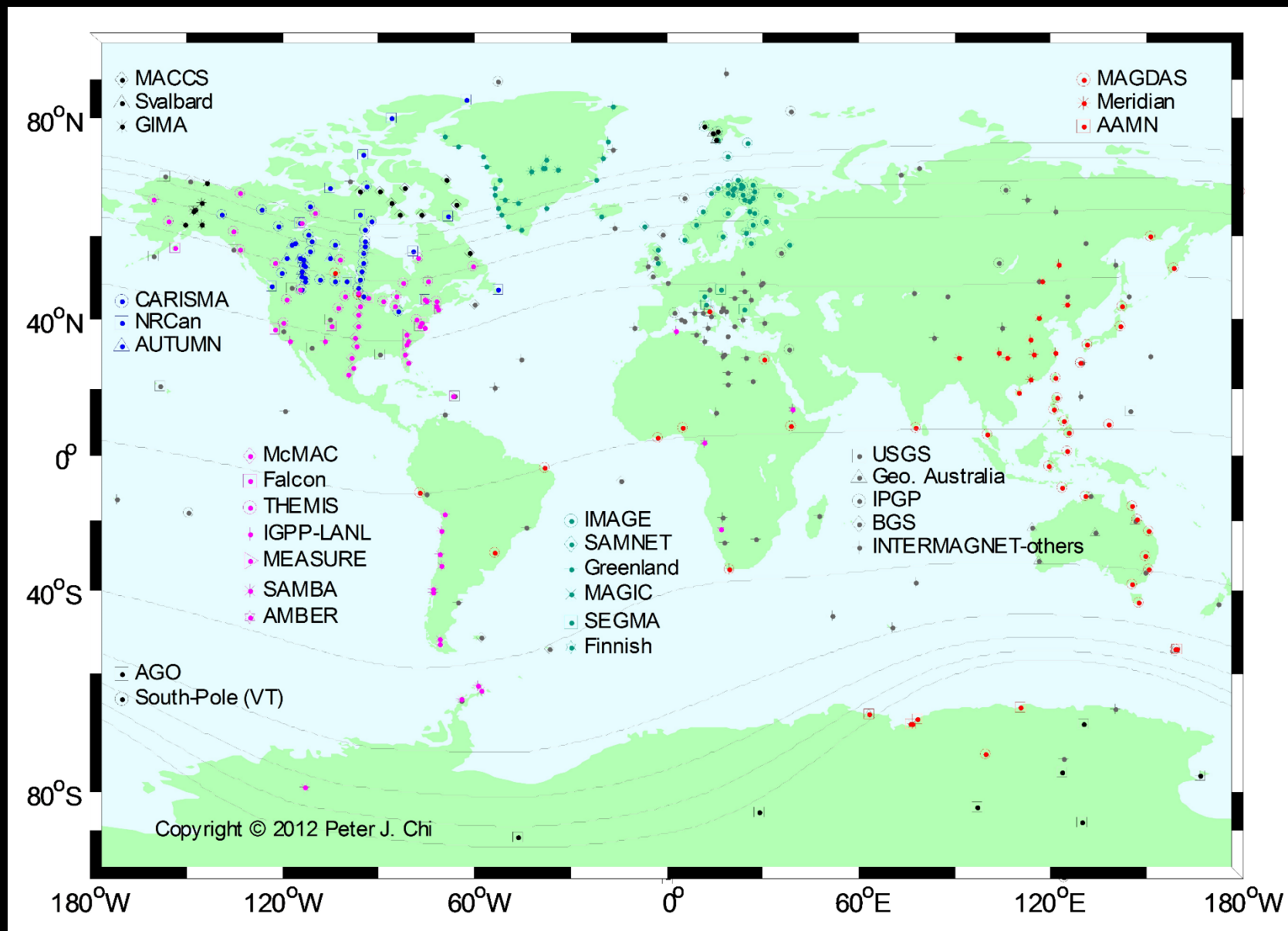
Cuiaba (15 S ; 56 W)
Santa Maria (29 S ; 54 W)

Low-latitude Ionosphere Sensor Network (LISN) C. E. Valladares, J. L. Chau, J. V. Eccles, E. Kudeki, and R. F. Woodman

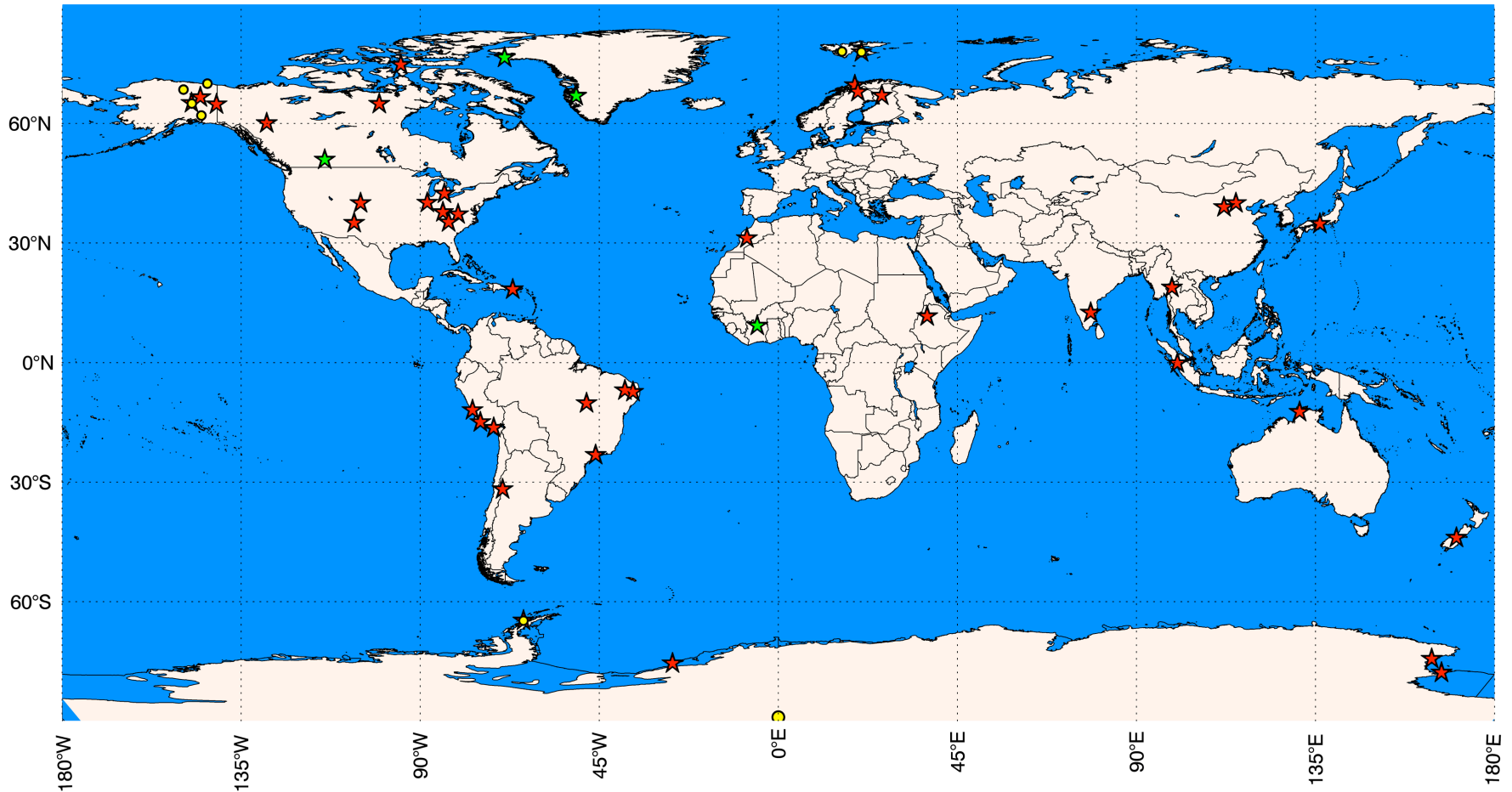
- 40 GPS receivers, 5 ionosondes and 5 magnetometers in South America
- Study variability and instability in the low-latitude ionosphere



Magnetic Observatories for Magnetospheric Research



Fabry-Perot interferometer observatories



Key Issues for the Future

- **Status quo:** how to achieve free energy to implement big ideas?
- **Future:** How best to accommodate increasing emphasis on integrative and predictive geospace science?
- **Grants programs:** Reverse trend toward declining investment in grants programs with declining proposal success ... or keep as is?
- **CubeSat program:** Continue to support the concept at NSF as interest and resources ramp-up at other agencies?
- **GS Facilities:** How to
 - Support upgrades w/o squeezing other programs?
 - Accommodate innovation and vitality?
 - Initiate a mid-scale projects line?

Bottom line: NSF is struggling to continue
the support of all US ISR facilities

We are receiving inputs!

Questions?