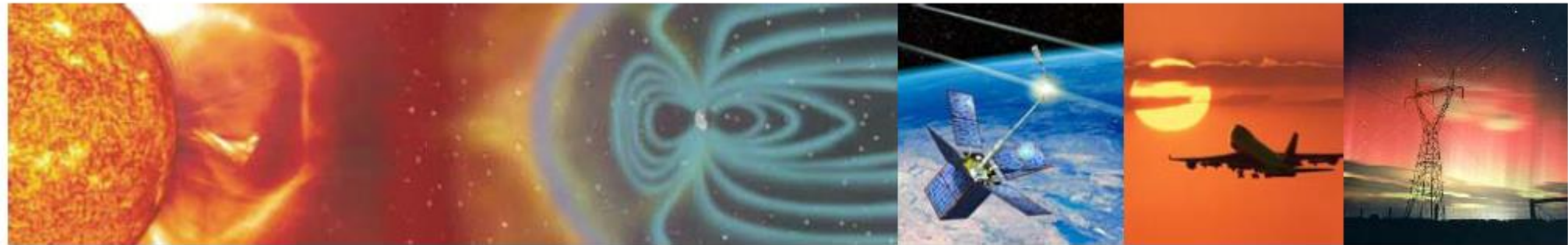


Building on Today's Space Weather
Foundation:
International Space Weather
Initiative

Nat Gopalswamy
NASA Goddard Space Flight Center

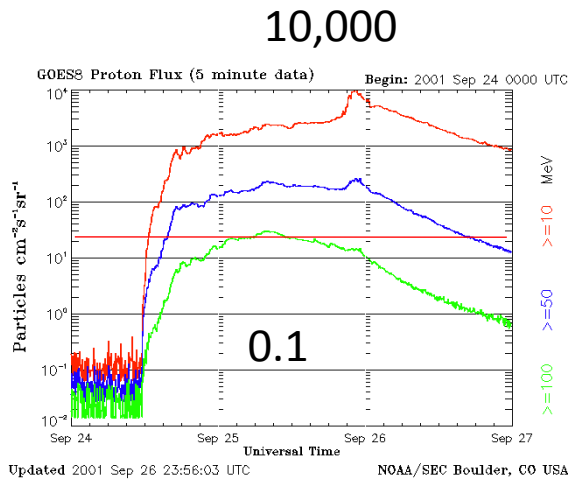


Principles of the ISWI Instrument Program

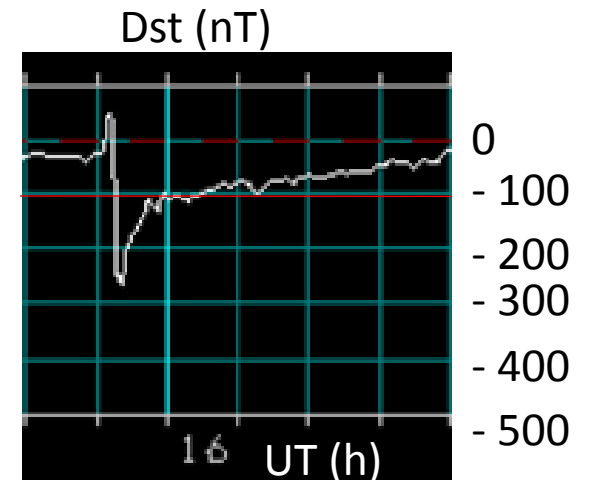
- The lead scientist or principal investigator funded by his/her country provides instrumentation (or fabrication plans) and data distribution system
- The host country provides the workforce, facilities, and operational support typically at a local university
- Host scientists become part of the science team
- All data and data analysis activity are **shared**
- All scientists in the team participate in publications and scientific meetings where possible

ISWI Instruments Measure Source & Impact of Space Weather

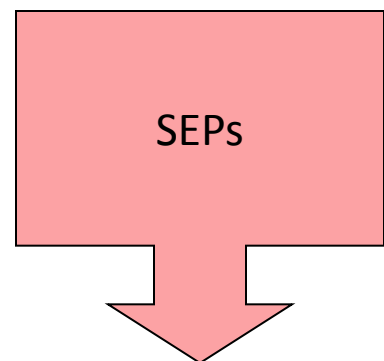
Also solar flare effects



CMEs
CIRs
from the Sun

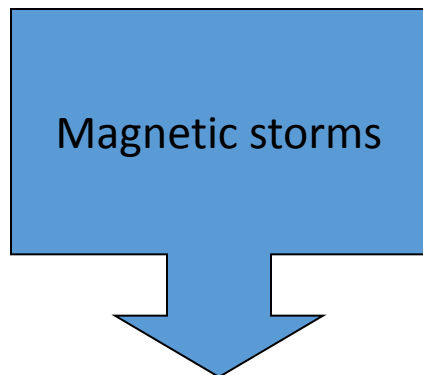


Radio telescope network
H-alpha Telescope network
Particle detector networks



Space systems
Airplanes
atmosphere

Combine with remote-sensing
space- and ground-based
measurements

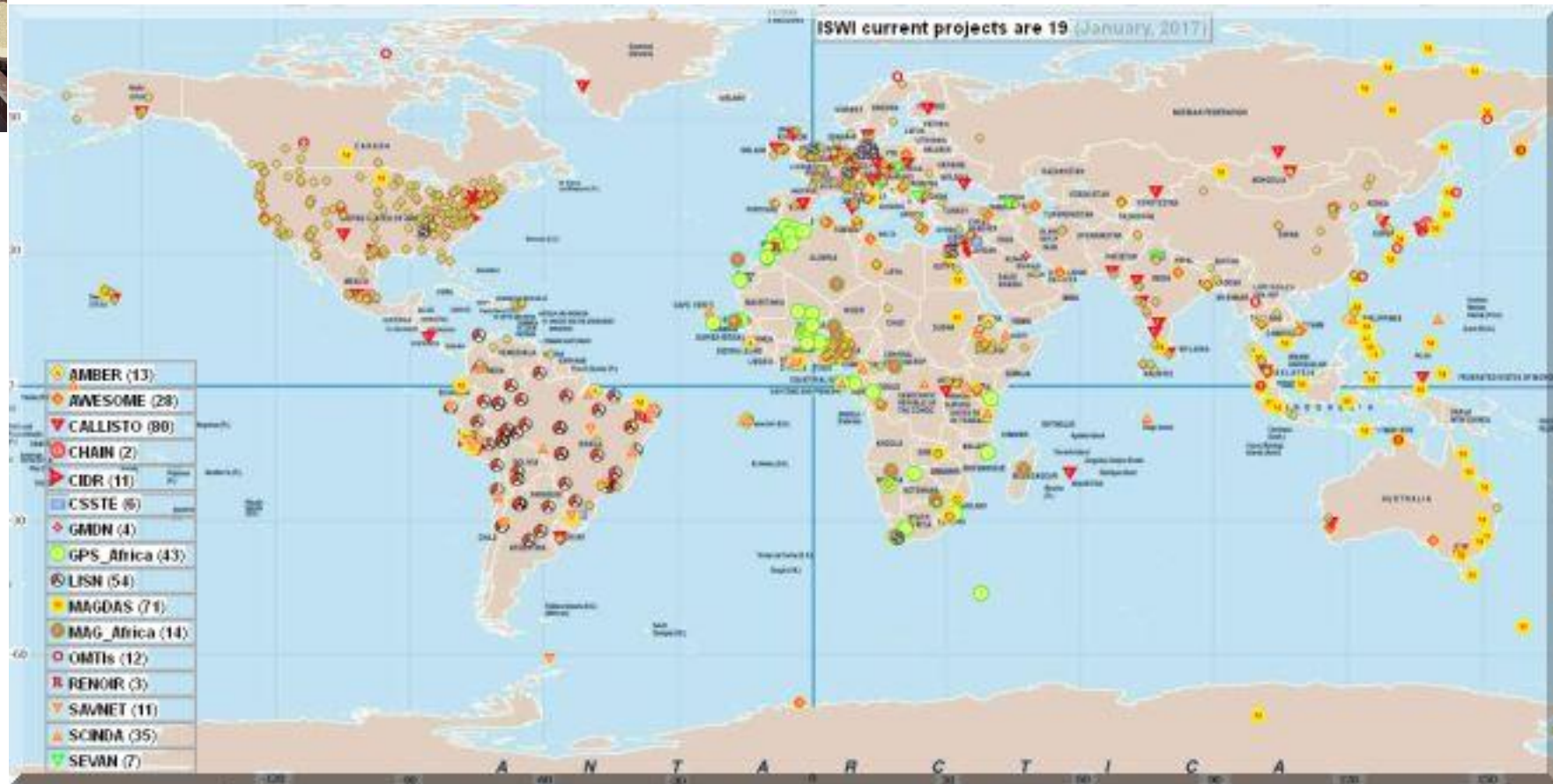


Space systems
Magnetosphere
Ionosphere
Atmosphere
Ground

Combine in-situ and
space measurements









magnetometer networks
GPS receiver networks
VLF receiver network
Atmospheric instruments

ISWI Instrument Sites



- Scientists from developing and developed nations work together in deploying and operating space weather instruments (currently there are more than 1000 deployments in more than 100 countries)
- Students and faculty participate at all levels of the instrument project and science
- 18 instrument networks from 8 countries (USA, Germany, Japan, Brazil, France, Israel, Armenia, Switzerland)

ISWI Instrument Providers by Country

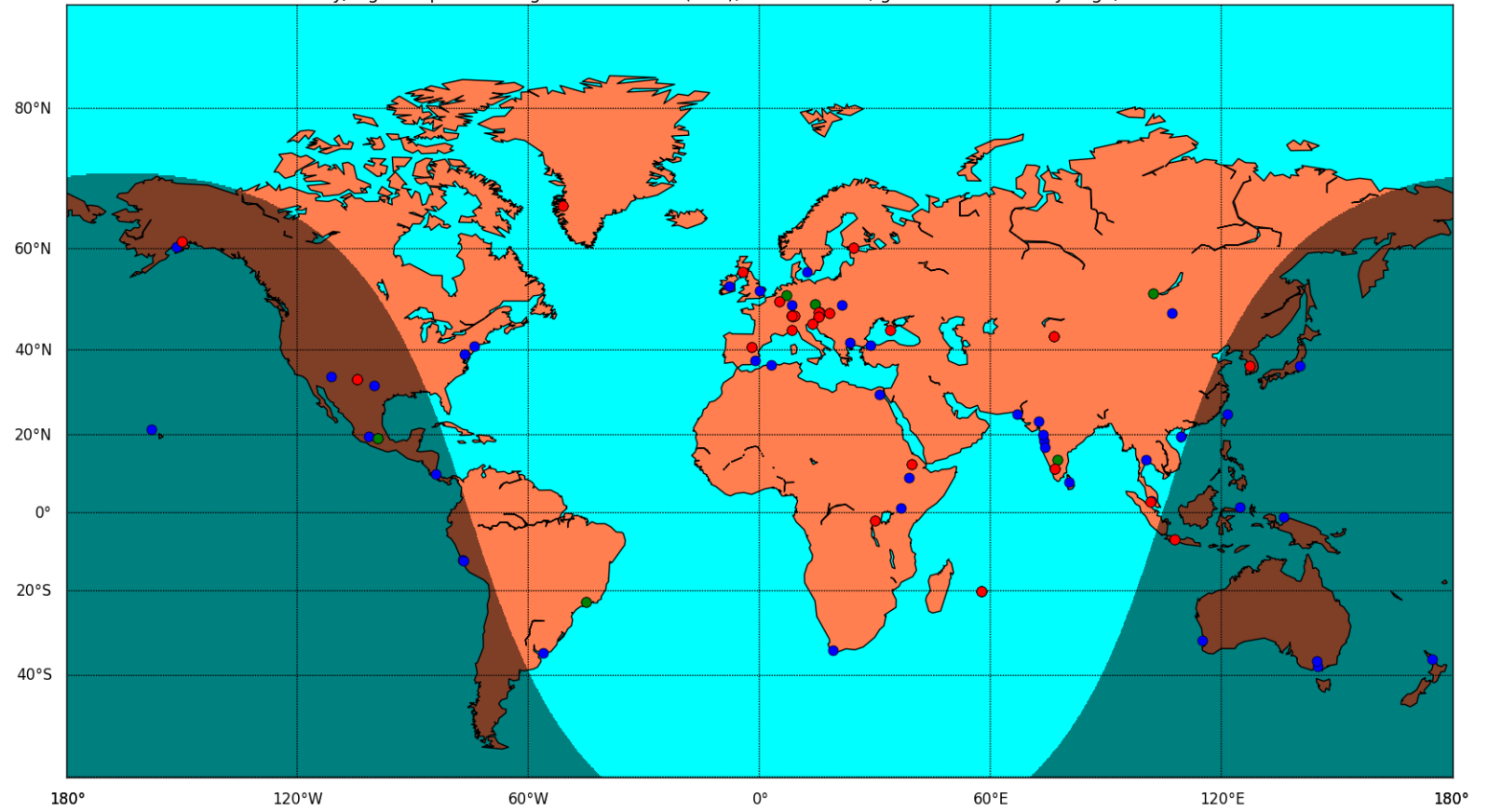
| Country | Instrument / Organization |
|--|---|
|  ARMENIA | SEVAN Aragats Space Environmental Center, Alikhanian Physics Institute |
|  BRAZIL | SAVNET AFINSA Presbyterian Mackenzie University - Sao Paulo, Brazil |
|  FRANCE | African Dual Frequency GPS Network CETP&CNRS |
|  GERMANY | Solar Flares detected by Ionospheric Effects Institute of Communications and Navigation at DLR Neustrelitz Global Ionosphere Flare Detection System German Aerospace Center |
|  ISRAEL | ULF/ELF/VLF network Tel Aviv University |
|  JAPAN | CHAIN / Kyoto University GMDN / Shinsu University MAGDAS / ICSWSE, Kyushu University OMTIs / Nagoya University |
|  SWITZERLAND | CALLISTO Institute of Astronomy, ETH-Zentrum in Zurich |
|  UNITED STATES | AMBER / University of California - Los Angeles AWESOME&SID / Stanford University CIDR / University of Texas at Austin, USA RENOIR / University of Illinois SCINDA / Air Force Research Laboratory (AFRL) LISN BU/ASI |

CALLISTO (Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory)



<http://www.e-callisto.org/>

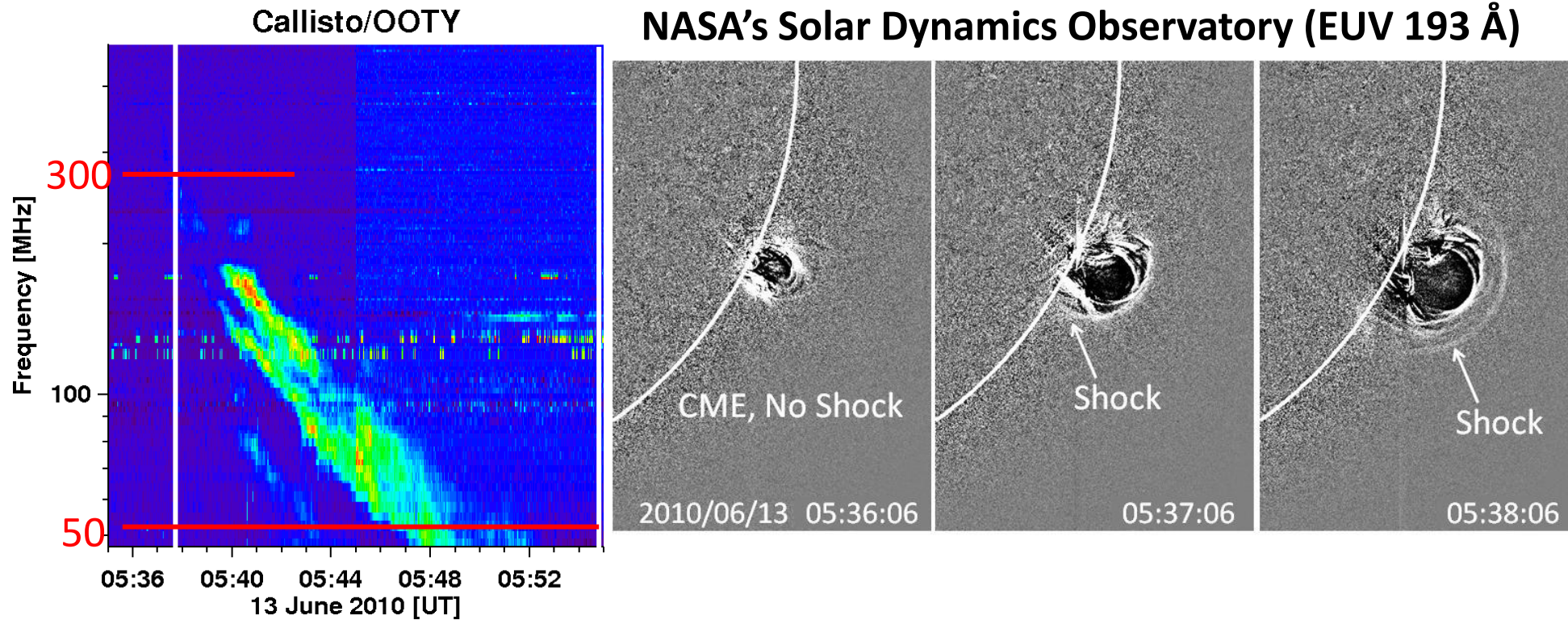
Callisto Day/Night Map for 01 Aug 2017 11:07:33 (UTC), blue=no data, green=data two days ago, red=current data



- Shocks and electron beams from the Sun
- Full coverage of the Sun with high redundancy
- Opportunity for hands-on experience



Type II Radio Bursts Indicate CMEs near the Sun



The radio burst starts at the time of shock formation seen in EUV images of the associated CME
Emission frequency indicates distance from the Sun

Scintillation Network Decision Aid (SCINDA)

- Provides information on ionospheric conditions (e.g., scintillation) and hence forecasts communication degradation and outage in the equatorial region.
- Radio signals up to a few GHz frequency are affected
- The region affected corresponds to about 1/3 of the surface of the globe
- Important for transequatorial flights



K. Groves, C. Carrano, C. Bridgwood, P. Doherty (Boston College)
C. Valladares et al. (UT Dallas)

SCINDA
LISN, another ISWI network

Data Utilization and Operational Use

- ISWI data are currently used for Space Weather science
- The ISWI SC has recently adopted an open data policy and Rules of the Road for data use (Steering Committee Meeting, UN/Vienna, Feb 19, 2016)
- All ISWI data will be made **accessible, available and independently usable**
- This means data can be used by any space weather service that needs data on any aspect of the Sun-Earth space ([S. Fung's talk on Friday](#))
- Training provided to individual instrument groups in small capacity building workshops

Summary

- The IHY/ISWI instruments form a vast network of instruments deployed in more than 100 countries (more than 1000 units deployed)
- There are 18 instrument groups and the number is growing
- ISWI instruments and data are featured in most of the UN workshops on ISWI
- The instrument networks provide opportunity for higher-level education and science (several PhDs awarded)