ISWI Instruments Panel Discussion

Panel Members:
Ivan Dorotovic, Slovak Central Observatory, Slovakia
Keith Groves, Boston College, USA
Dinesh Manandhar, The University of Tokyo, Japan
Christian Monstein, Monstein Radio Astronomy Support, Switzerland

Panel Chair/Moderator:
Shing Fung, NASA Goddard Space Flight Center, USA

ISWI Instrumentation: Way Forward

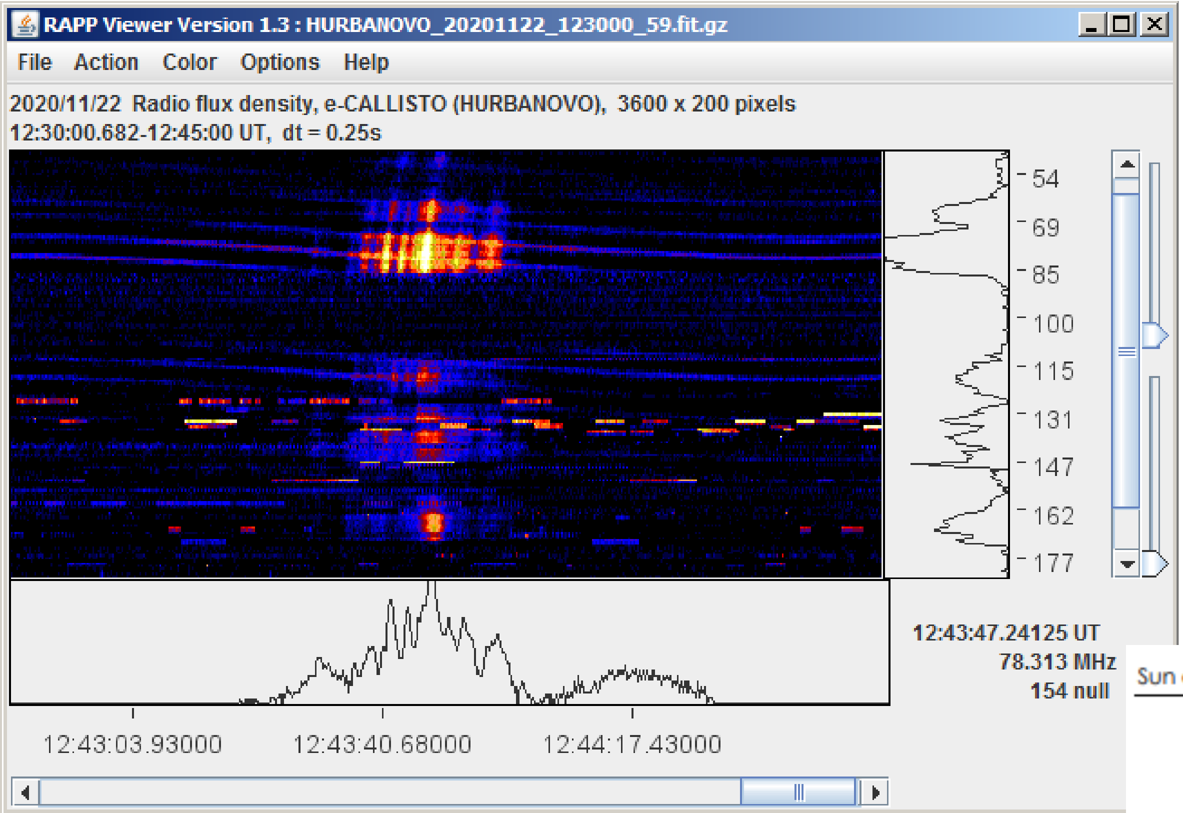
1. The current status of the instrument networks
    - Any significant gaps in instrument types and coverage?
2. Future deployments
    - How best to fill gaps identified in #1 above, or just augmentation of existing networks?
3. Problems in maintaining instruments and data flow
    - Are data collections continuous & FAIR-compliant: Findable, Accessible, Interoperable and Reusable?)
4. Recommendations from panel members' perspective

Ivan Dorotovic
Slovak Central Observatory, Slovakia

Two ISWI instruments are operational in Slovakia:

1. **CALLISTO spectrometer** in the Slovak Central Observatory in Hurbanovo – operational since **December 2011**

Data available at: http://soleil.i4ds.ch/solarradio/callistoQuicklooks/



http://newserver.stil.bas.bg/SUNGEO/00SGArhiv/SG_v9_No1_2014-pp-105-107.pdf

Sun and Geosphere, 2014; 9(1-2): 105-107 ISSN 1819-0839

Solar Radio Spectrometer CALLISTO in Hurbanovo - first results

I. Dorotovič and T. Pintér

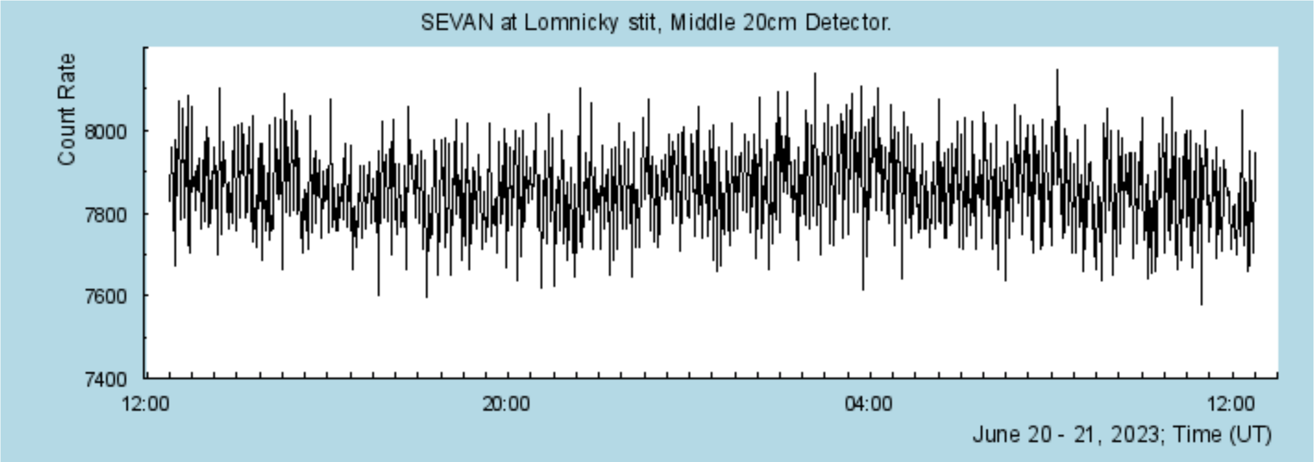
Slovak Central Observatory, Komárňanská 134, 94701 Hurbanovo, Slovak Republic;

E mail (ivan.dorotovic@suh.sk, teodor.pinter@suh.sk).

Accepted: 14 September 2013

2. SEVAN particle detector in the Department of Space Physics of the IEP SAS, Lomnicky Peak Observatory – operational since **March 2014**

Data available at: http://crd.yerphi.am/Lomnicky_stit_SEVAN_Data



Measurements of the cosmic ray intensity on Lomnický Štít commenced in **January 1958** as part of the Czechoslovak scientific program associated with the International Geophysical Year

Chum *et al. Earth, Planets and Space* (2020) 72:28
https://doi.org/10.1186/s40623-020-01155-9
Earth, Planets and Space

FULL PAPER **Open Access**

Check for updates

Significant enhancements of secondary cosmic rays and electric field at the high mountain peak of Lomnický Štít in High Tatras during thunderstorms

J. Chum[1*], R. Langer[2,4], J. Baše[1], M. Kollárik[2], I. Strhárský[2], G. Diendorfer[3] and J. Rusz[1]

https://earth-planets-space.springeropen.com/articles/10.1186/s40623-020-01155-9

❑ CALLISTO Network (Ch. Monstein)

- Automatic data collection and data flow = **operating and maintenance friendly** (e.g.in case if there is no permanent staff at the host institution).

- Automatic burst detection – it would be highly requested and very useful

- First CALLISTO spectrometers were set up in 2003 (lifetime of components?)

– the CALLISTO in Hurbanovo is in operation for 10+ years

– next generation spectrometers in the network?

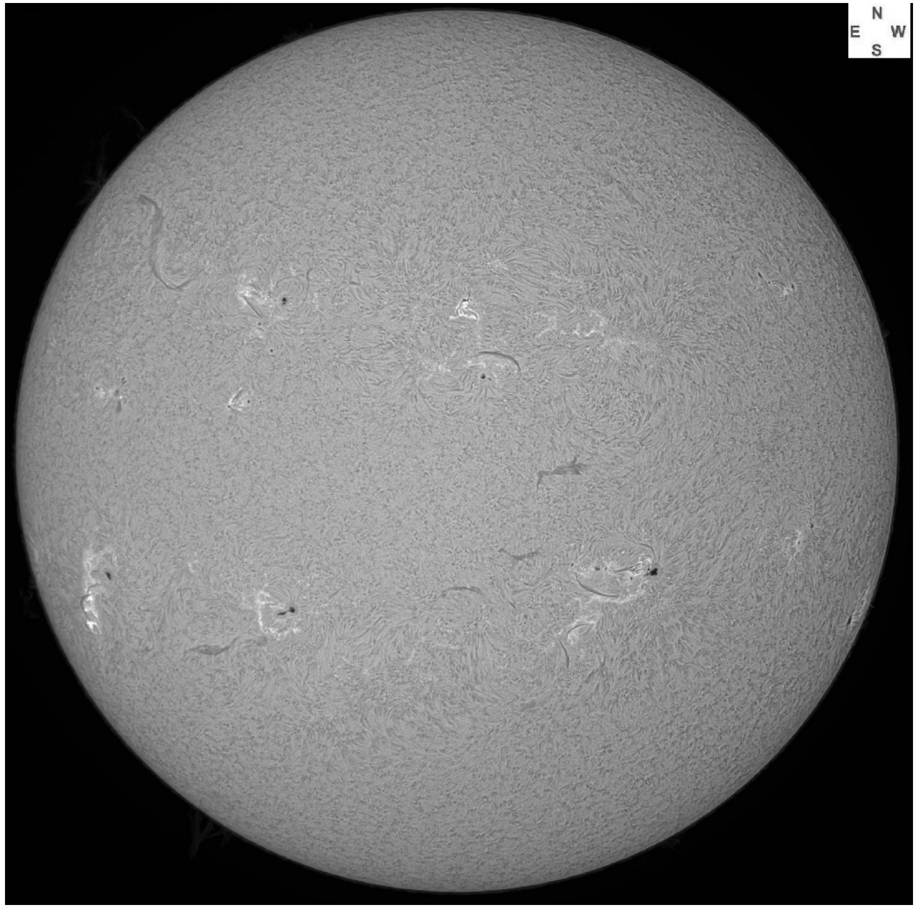
❑ SEVAN Network (A. Chilingarian)

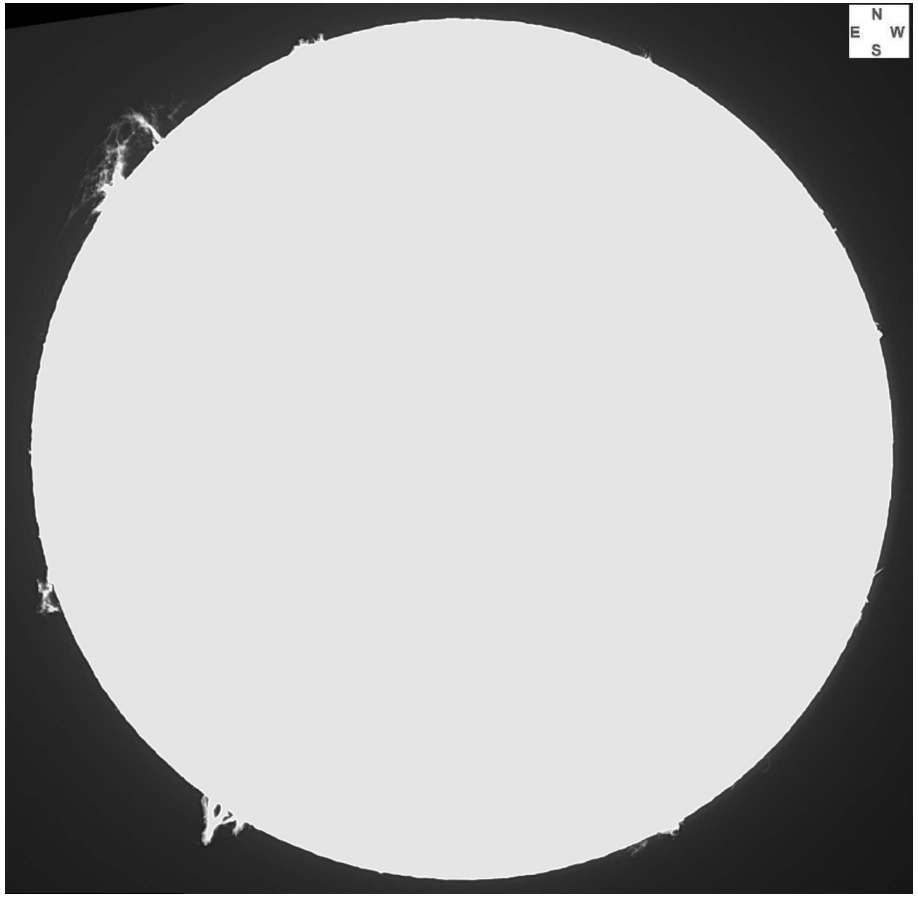
It is clear that high altitude site is preferred, not necesarily.

- Why are not installed any SEVAN detectors at other continents?
  - Lack of funding?
  - Other reasons?

❑ CHAIN Network (K. Ichimoto, S.Ueno)

LUNT H-alpha images from 2023-06-21, SCO Hurbanovo





Could be these images used as complementary data in the CHAIN network?

ISWI SCINDA Sensor

Dr. Keith Groves, Principal Investigator

Institute for Scientific Research, Boston College

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United Nations Workshop on the International Space Weather Initiative

Vienna, Austria 26-30 June, 2023

SCINDA Sensor Network Status

Instrument name: SCINDA

PI: Keith Groves

Tech Lead/POC: Keith Groves

Science objectives: Investigate low latitude ionospheric irregularities and their impacts on radio wave propagation

Measurement objectives: Monitor signals from radio beacon satellites and GNSS

Science Activity Updates

Recent science activities have focused on understanding the 3D distribution of turbulence in equatorial bubbles and associated correlation lengths and departure from uniformity, particularly as a function of altitude. These studies utilize a combination of ground-based SCINDA observations in conjunction with space-based radio occultation measurements from COSMIC-2.

Instrument and Data Product Updates

Instrument updates: SCINDA has continued without a sensor refresh for nearly 10 years. We will begin testing new GNSS receivers for suitability in the SCINDA network in 2021 and plan to deploy at least three for demonstration in 2022. We expect to deploy more thereafter along with VHF scintillation receivers where possible.

Station updates: Initially the new sensors will be deployed in South America; Africa and Asia will follow.

Data product updates: A key new product will be the true utilization of GNSS constellations to expand measurement opportunities three-fold relative to GPS-only.

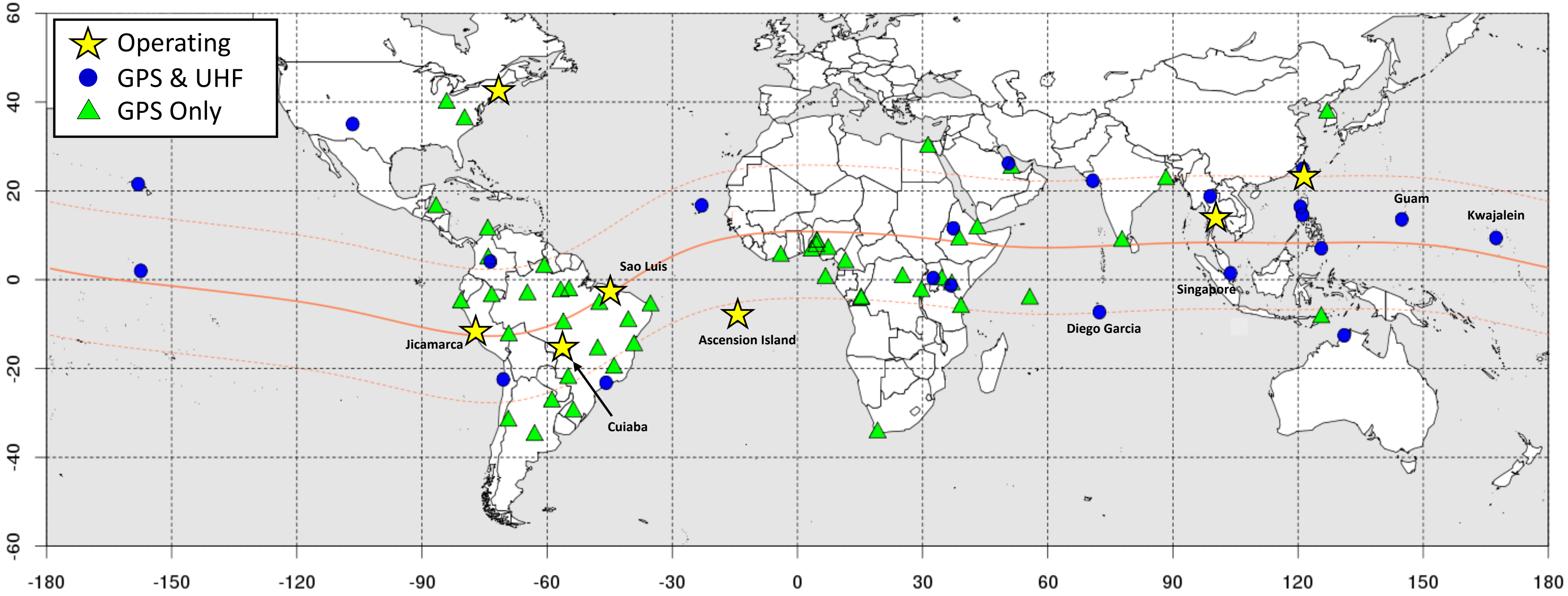
Capacity Building Activity Updates

The SCINDA program now has resources to invest in new sensors, more robust infrastructure and more reliable installations. We will be developing and demonstrating improved technologies over the next two years (2021-22) in the American sector and look to expand to other sectors thereafter.

We expect to focus on Africa and Asia/Oceania after a successful demonstration of new capabilities.

SCINDA Status June 2023

SCINDA and ISTO Sensor Locations
2006 to present



In some cases receivers have been relocated and a number of the GPS systems (Novatel 4004b) have become obsolete, but many have ceased operations for numerous reasons including infrastructure issues, unsupported hardware failures, neglect and lack of interest

Low-Cost Receivers

- As previously described, low cost ($500) receiver systems open up an exciting new range of possibilities for supporting the procurement of tens of systems for global research in space weather
- Low initial system cost is appealing to sponsoring agencies
- Experienced scientists and boat owners recognize that true "cost of ownership" consists of much more than that
- New SCINDA paradigm under academic sponsorship:
  - The goal is sustained, reliable data collection (spotty data sets are a waste of time and money)
  - Six month trial period for sensor operation; may or may not continue depending on performance and responsiveness
  - Successful sites may receive additional sensor investment
  - Maintain inventory of hot spares
  - Team will work to address infrastructure issues
  - Data will be open access within three months of collection
  - Team will include junior members with responsibility to participate in scientific collaboration

Dinesh Manandhar
The University of Tokyo, Japan

The current status of the instrument networks
Any significant gaps in instrument types?

	Ionospheric Effect	Scintillation		Cost
	TEC/ROTI Computation	Code Phase Scintillation (S_4)	Carrier Phase Scintillation (ϕ_4)	
High-End GNSS Receiver for Space Weather	Best Output	Best Output	Best Output	Very High > $15K
High-End GNSS Receiver Survey Grade	Best Output	Is it possible? Any data to compare?	Is it possible? Any data to compare?	High > $3K - $15K
Low-Cost GNSS Receiver	Acceptable Output? • Data for comparison being prepared • See the results from NetR9, PolaRx5 and F9P receivers	Is it possible? • Needs I and Q channel power output • Higher data output rate (> 20Hz) required • Stable clock with low noise (TCXO?) • Any data to compare?	Is it possible? • Requirements for S_4 + the followings: • Stable Clock (OCXO?) with low noise • Any data to compare?	Low < $1K

The current status of the instrument networks Global Spatial Coverage?

	Global Spatial Coverage	Total Number of Stations
High-End GNSS Receiver (Space Weather)	What is the current coverage? What is the required coverage? For example: One receiver every 40Km along $\pm 10^0$ Latitude. Mid-latitude and high latitude	Current Deployment: 1K – 3K? Required Deployment: 3K – 10K ? 10K- 30K ?
Low-Cost GNSS Receiver	What will be the global coverage? For example: One receiver every 10Km along the 10^0 Latitude, Mid-latitude and high latitude	Current Deployment: None? Required Deployment: 10K – 50K ? 50 K – 100K?

	Global Spatial Coverage	Receiver Type
TEC / ROTI	Is it necessary to have coverage at the same level for TEC/ROTI and Scintillation Observation?	Low-Cost Receivers may be sued for TEC/ROTI observation
Scintillation		High-End GNSS Receiver (Space Weather) might be required

Future deployments

How best to fill gaps identified in #1 above, or just augmentation of existing networks?

- Low-Cost GNSS Receiver systems will be basically used for
  - Capacity Development, Technology Promotion
  - Possibly for TEC / ROTI Observation
- However, Scintillation monitoring may require High-End Receiver (Space Weather).
- In order to reduce the total cost of High-End GNSS Receiver (Space Weather)
  - Is it possible to roughly predict global demand with time frame?
    - For example, deployment of 100 receivers globally per year for the next few years
  - The total cost of the instrument (receiver) may reduce if global demand is predictable

Problems in maintaining instruments and data flow

Are data collections continuous & FAIR-compliant: Findable, Accessible, Interoperable and Reusable?)

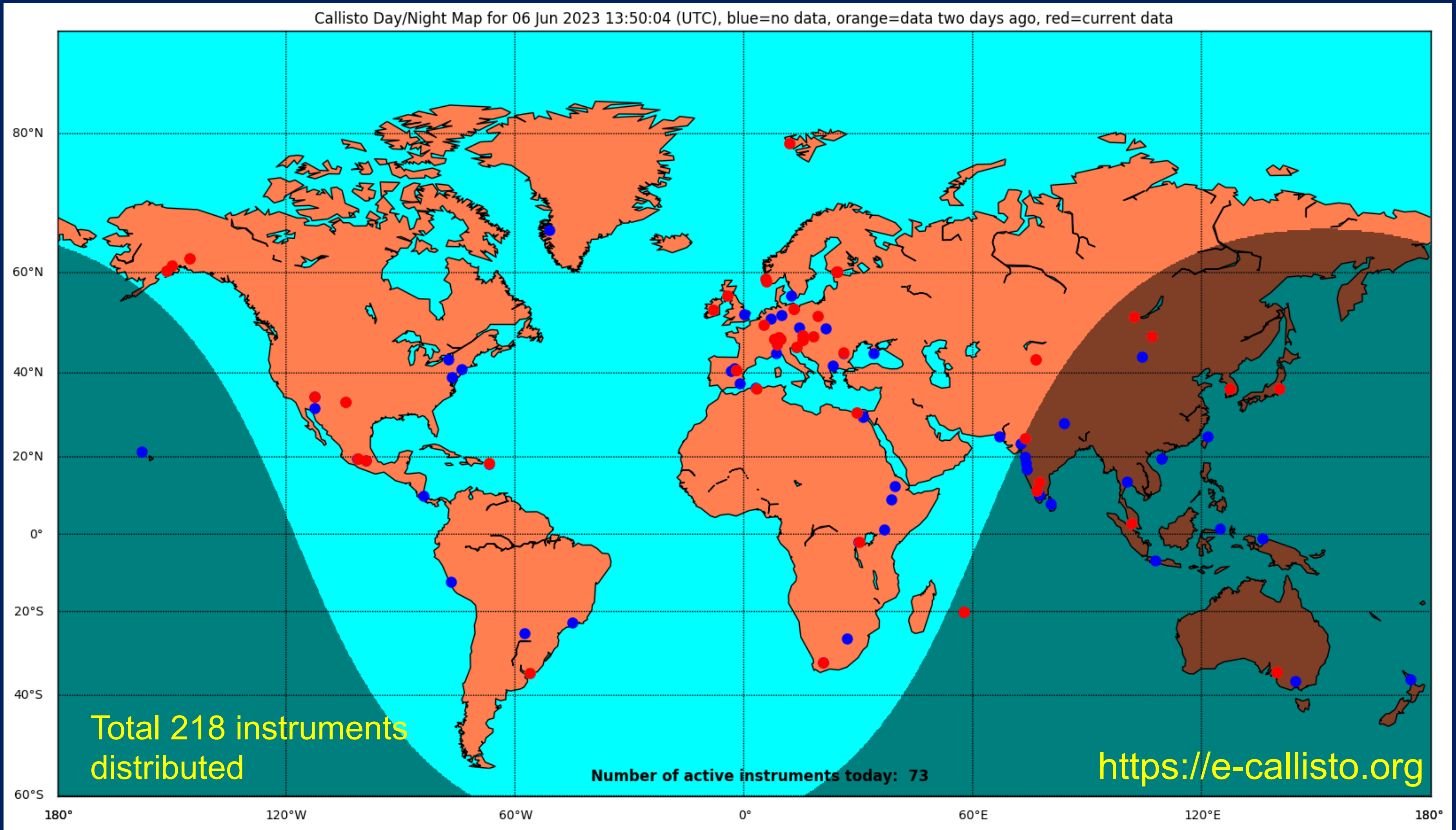
Data Logging Rate	0.033, 0.067, 0.1Hz, 1Hz, 10Hz, 20Hz, 50Hz or 100Hz?	1Hz is fine for TEC/ROTI but higher observation rate is necessary for scintillation
Data Logging Period	Continuous logging at X hour interval X = 1, 4, 6, 12 or 24 hour?	Files can be broken down into small pieces for easy handling
Data Format	Proprietary Format? Such as SBF RINEX? Version? / BINEX? Other Format?	An industry standard receiver independent format shall be used for sharing, e.g. RINEX, BINEX etc.
Data Size	How big is data file size?	A 24 hour at 1hz may be about 500MB size
Data Compression	Is data compression used? Which method? Such as Hatanaka?	Saves some data storage space and minimizes data transfer time
Data Sharing	Real-time sharing via NTRIP? File sharing after data the completion of data log?	NTRIP is efficient method to share data in real-time
File Naming Convention	Which convention is used? IGS convention?	An industry standard convention shall be used for interoperability
Data Conversion	Which conversion tool is used? Maker provided software? RTKLIB ?	Any tool is OK. I prefer RTKLIB
Data Privacy	Is it allowed to share data with foreign users?	Some countries do not allow to share raw data
Network Connectivity	Is internet available for data transfer and sharing?	Necessary for real-time data sharing
Power Supply	Is continuous power supply available?	Power supply to receiver might be serious issue for receivers in remote areas

Recommendations from panel members' perspective

- Explore the possibilities of using Low-Cost GNSS Receiver for Space Weather
  - Currently undergoing under ICG, WG-3
  - Explore HW (receivers) , Explore SW (software for TEC/ROTI, S4 etc.)
- Define data format, file format for data sharing and interoperability
- Minimize the gap between Scientific community, GNSS community and Receiver makers
  - Form a consortium to bridge the Scientific community, GNSS community and Receiver makers
- Conduct more capacity building and technology promotion with hands-on field exercise
  - Use Low-Cost GNSS Receiver System to the extent possible

Christian Monstein
Monstein Radio Astronomy Support, Switzerland

LISTO status instrument network



24/7 coverage but, lack of data from Africa, Indonesia, South America and Pacific

Conclusions, Issues, Recommendations

- Network is still growing, currently requests from different countries

- Often lack of funding as well as lack of permanent people to operate & maintain an instrument.

- Many locations are suffering from power fail, internet fail or even from war

- Geographical coverage to be improved, especially American/Pacific region

- Interference situation is getting worse worldwide, new instruments should be placed at very remote locations, not on top of the university roof.

- More science could or should be done (but is often an educational issue)

- Beside scientific workshops also dedicated technical workshops should be organized