DIGITAL RF

DigitalRF provides an HDF5 based format for RF voltage level data recording
- Supports multiple channels and sub-channels (e.g. polyphase output)
- Absolute time stamps relative to epoch in samples
- O(1) lookup and access for RF data
- Extensive utilities and display tools (e.g. ringbuffers, snapshots, plots, etc).
- C (write), Python (read / write), matlab (read)

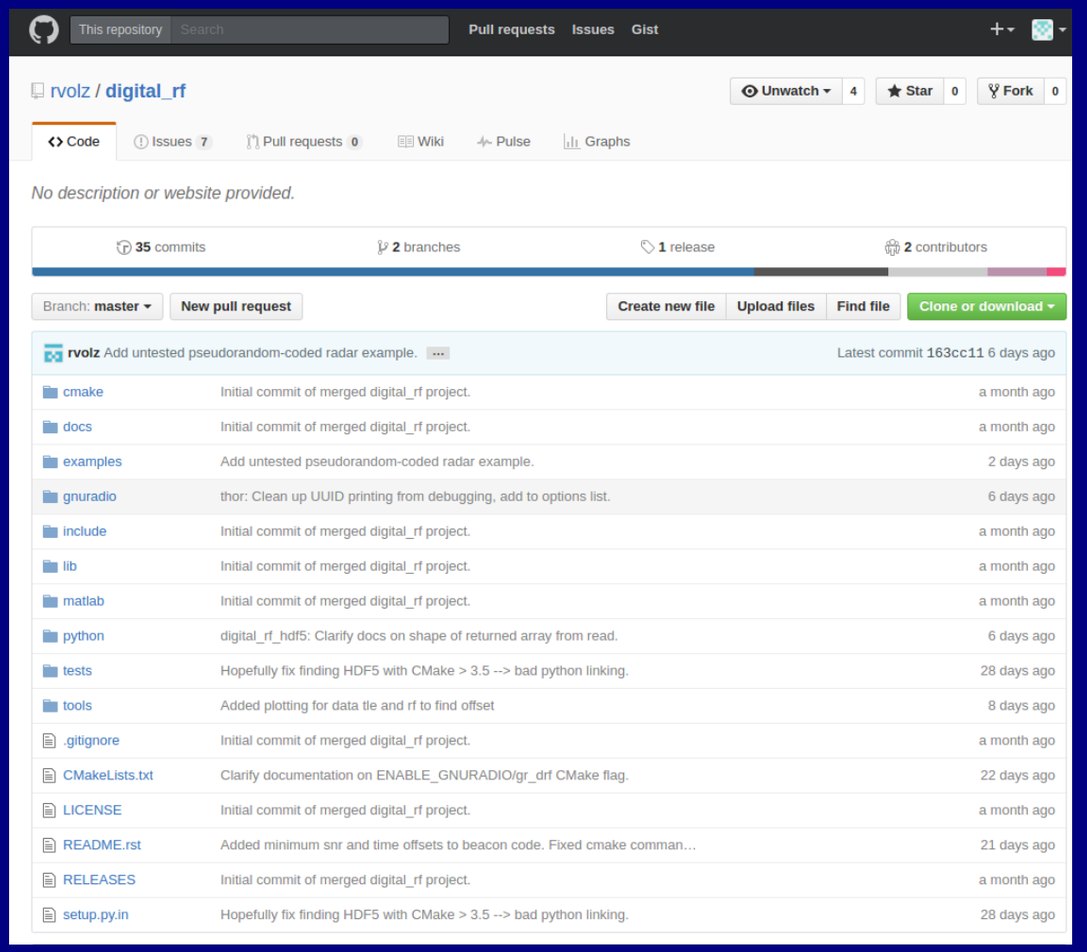
Digital Metadata provides an HDF5 based metadata format
- Dictionaries (nested) with Python Numpy compatible types
- Used for sampler and higher level metadata

gr-drf
- Gnu Radio Digital RF interface block

Thor (The Haystack Observatory Recorder)
- Gnu Radio based (gr-drf) data acquisition script
- gr-drf compatible radios
- Command line oriented

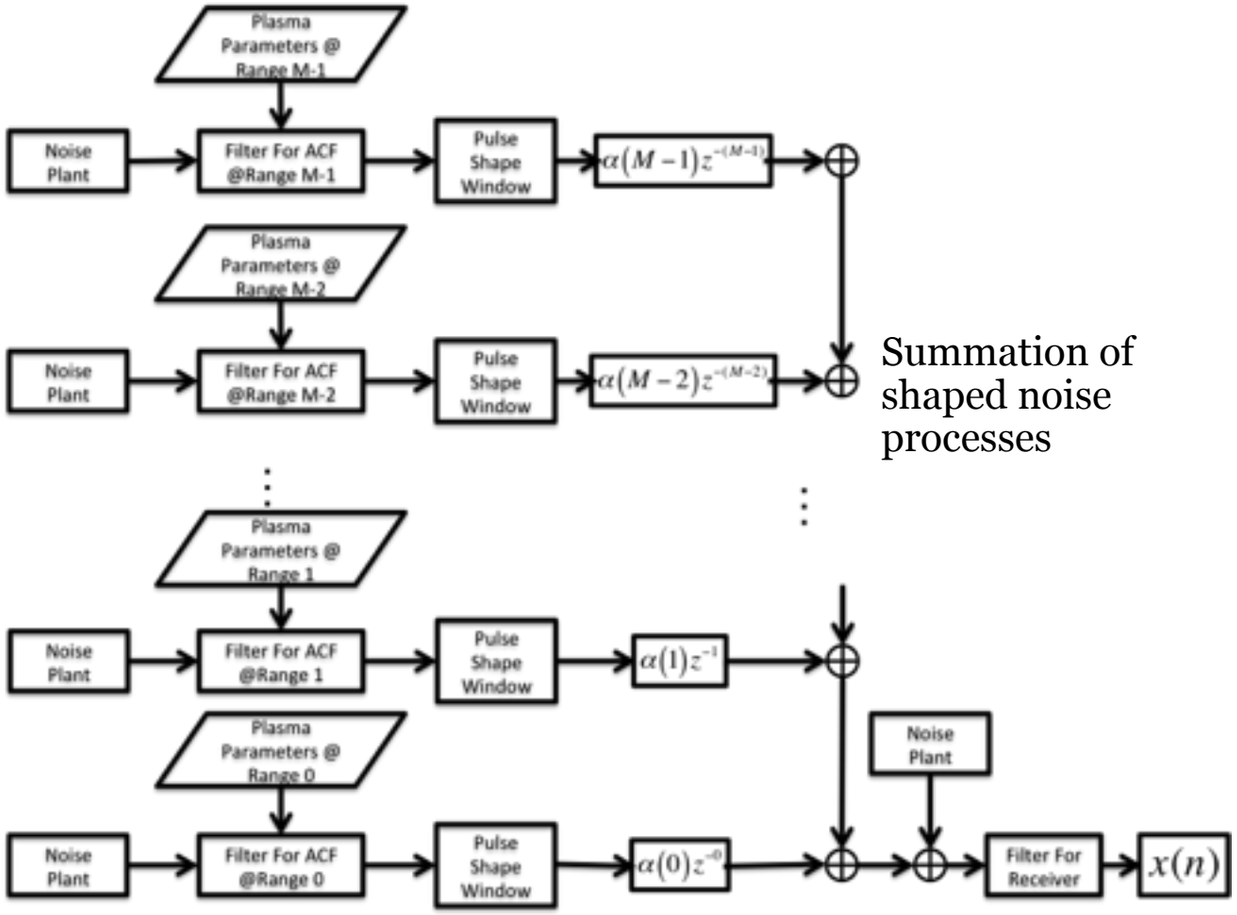
Open Source by MIT under a BSD License!

https://github.com/MITHaystack/digital_rf



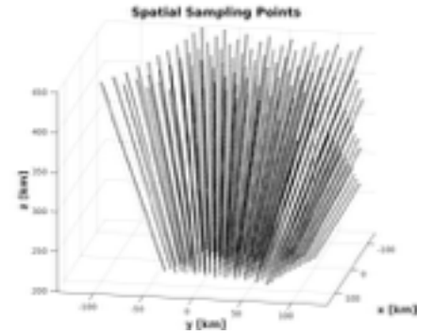
SimISR

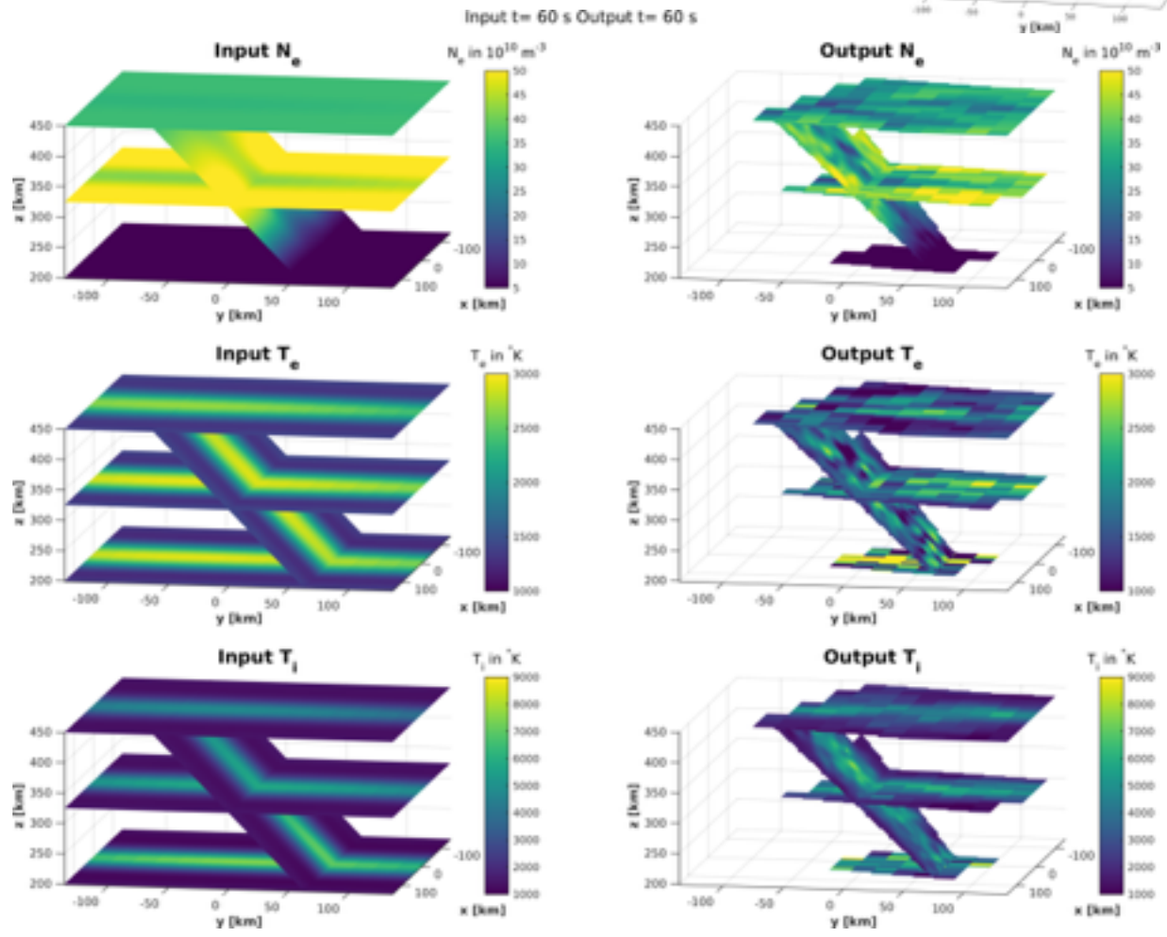
Creates voltage level radar data



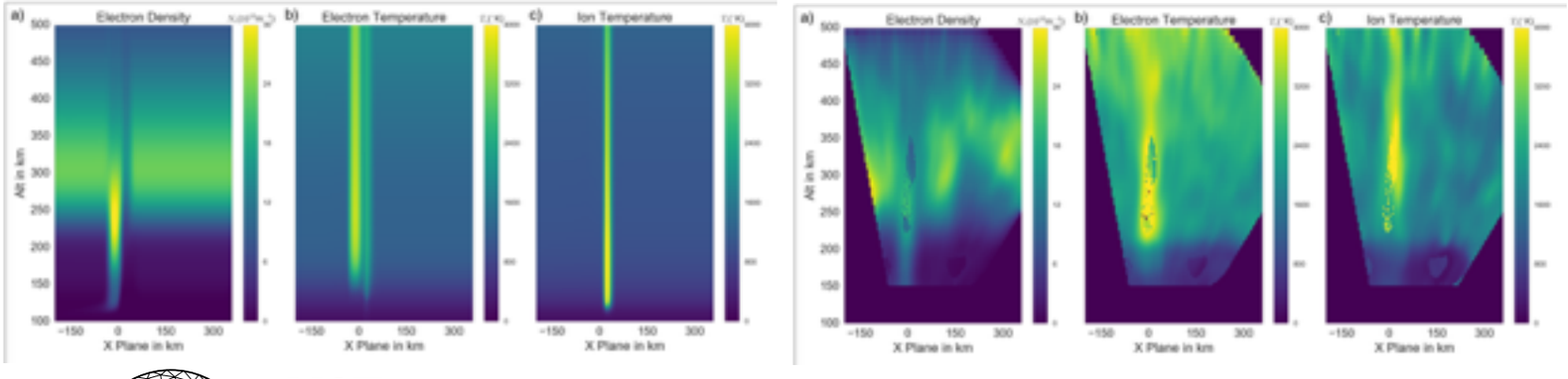
Summation of shaped noise processes

Spatial-temporal sampling study

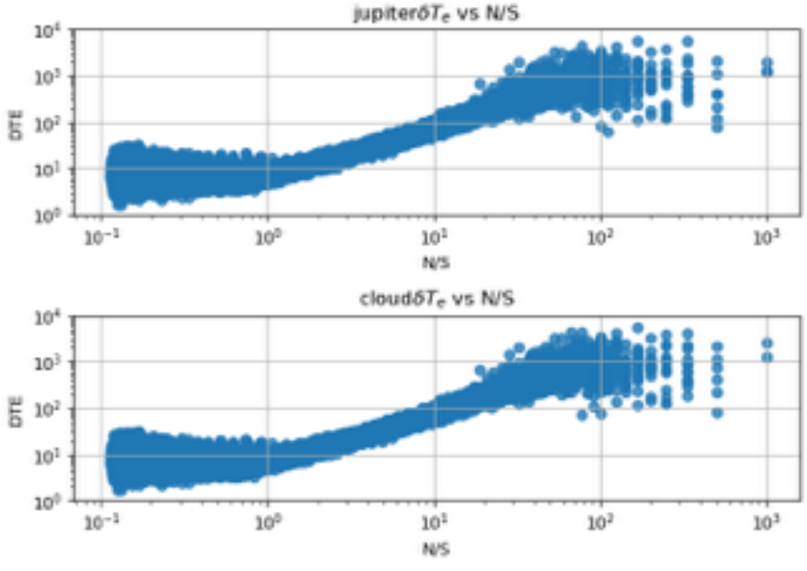




Deconvolution study



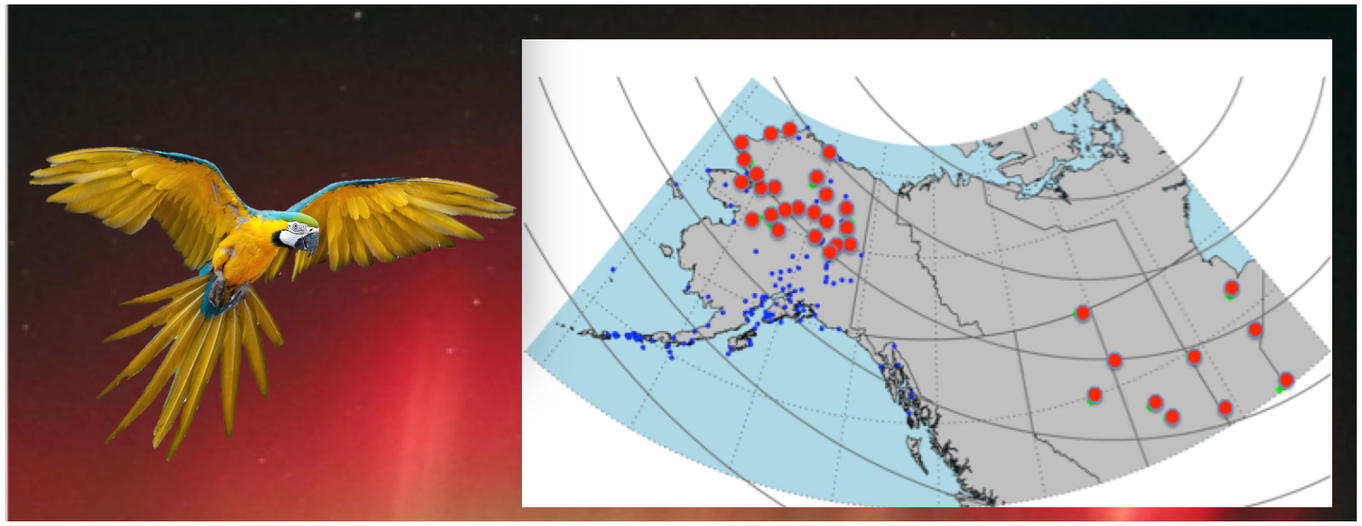
Error study

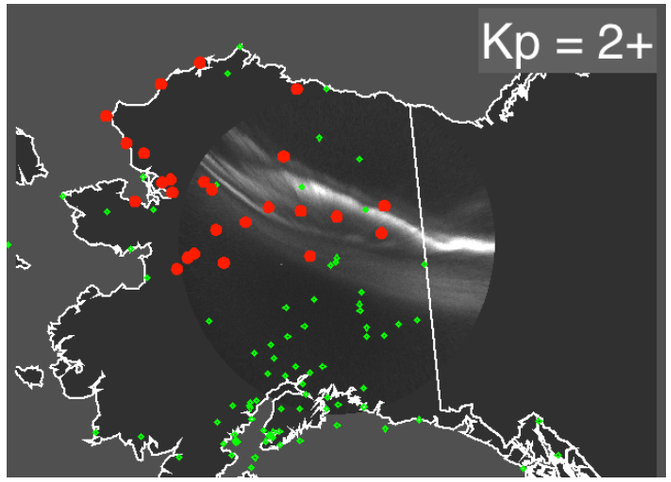


MIT HAYSTACK OBSERVATORY

SPACE WEATHER MONITORING – 35 New GNSS receivers

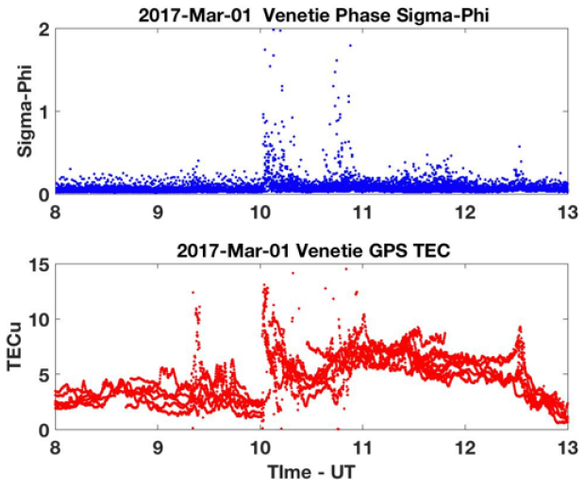
MRI Collaborative: Development of Monitors for Alaskan and Canadian Auroral Weather in Space (MACAWS)





MIT
HAYSTACK
OBSERVATORY

1 March 2017 ~10 UT



AERO

AURORAL EMISSIONS RADIO OBSERVER

- **Many partners**
- **Flight qualification of novel space borne radio directional sensor**
- **Excellent discovery science for auroral physics**

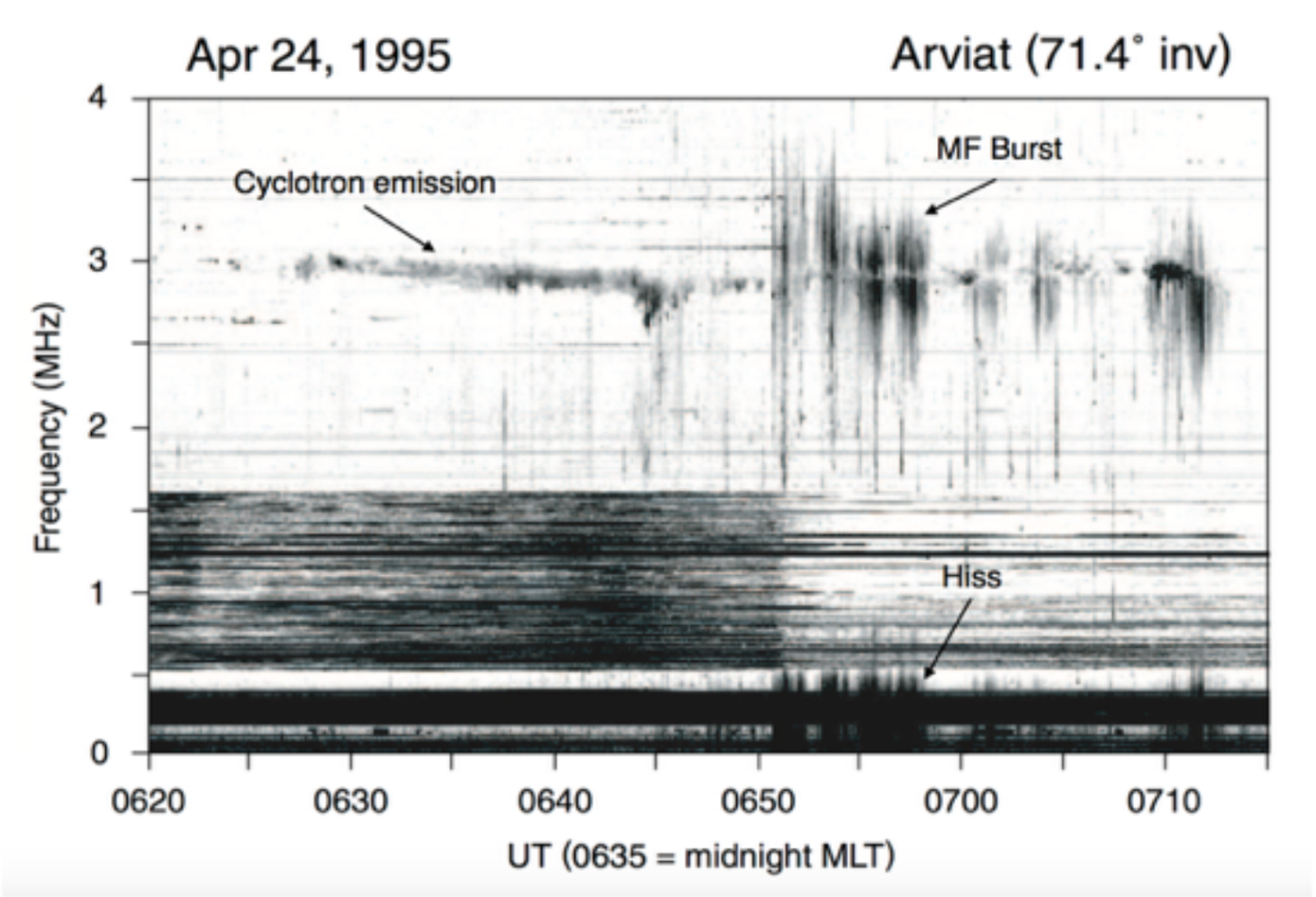
MIT HAYSTACK OBSERVATORY · MIT Lincoln Laboratory · MIT Aeronautics and Astronautics · MOREHEAD STATE UNIVERSITY · DARTMOUTH · MERRIMACK COLLEGE · NASA

The Auroral Emission Radio Explorer (AERO)

AERO
AURORAL EMISSIONS
RADIO OBSERVER

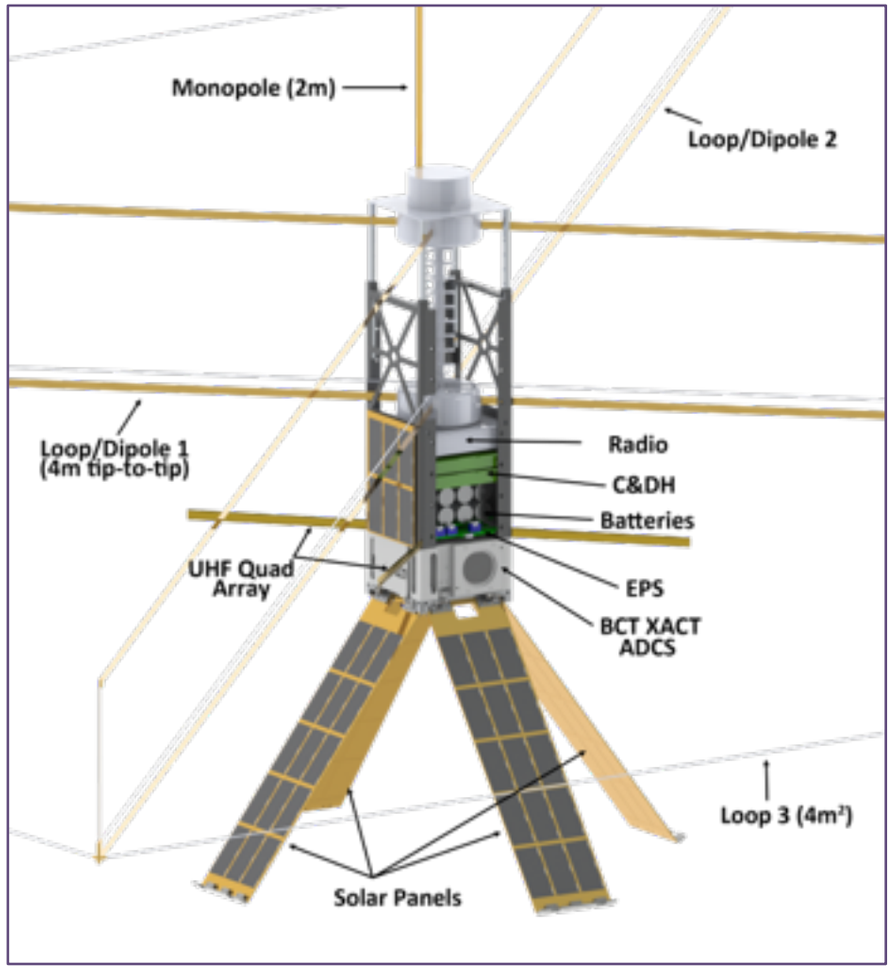
Dr. Philip J. Erickson, Principal Investigator

The Auroral Emission Radio Observer (AERO) is a 90-day CubeSat mission in polar orbit that will qualify and validate a novel electromagnetic vector sensor (VS) while answering key scientific questions about the nature and sources of auroral radio emissions. *These questions cannot be addressed from the ground due to shielding by the ionosphere*.

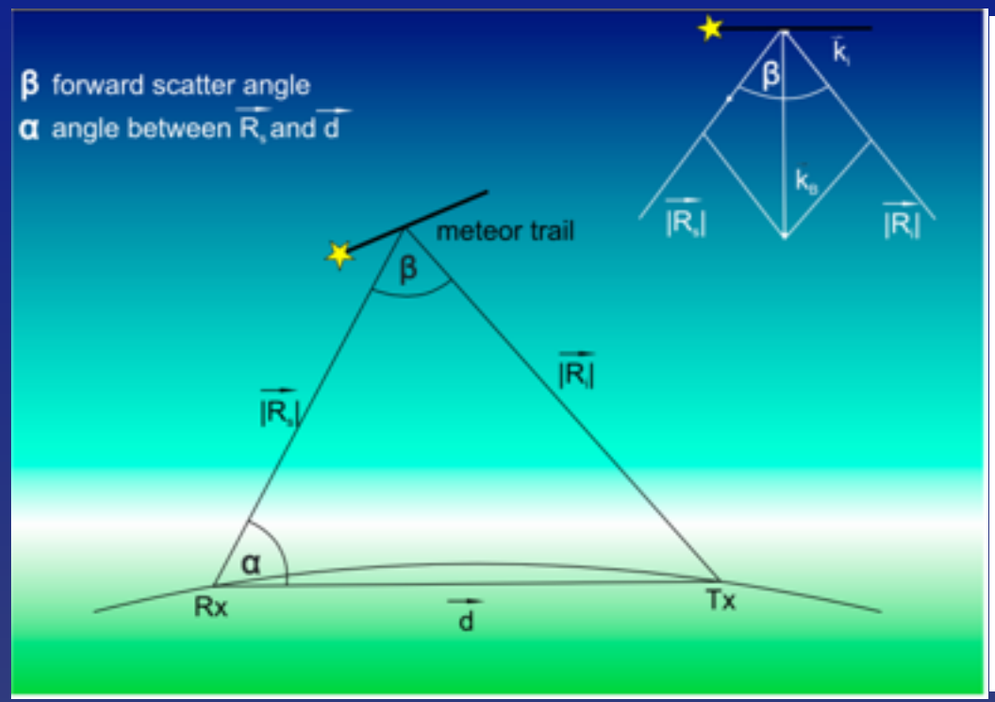


Labelle, 2006

Angle of Arrival, EM Characterization



SIMONe: MIMO Meteor Radar for Fine Scale Neutral-Ion Coupling Science



Stober et al 2015

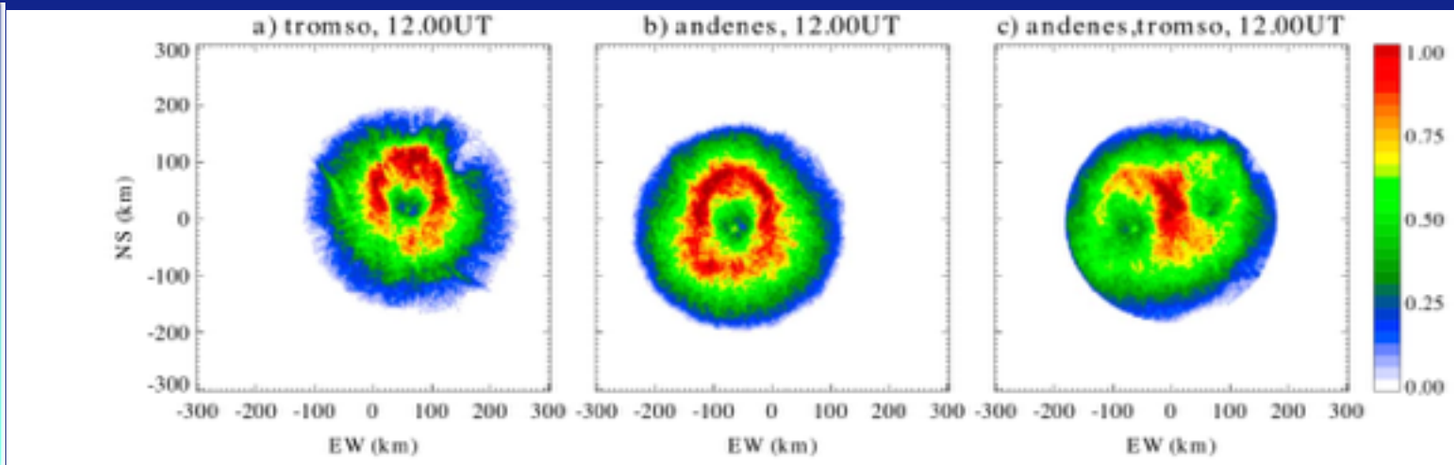
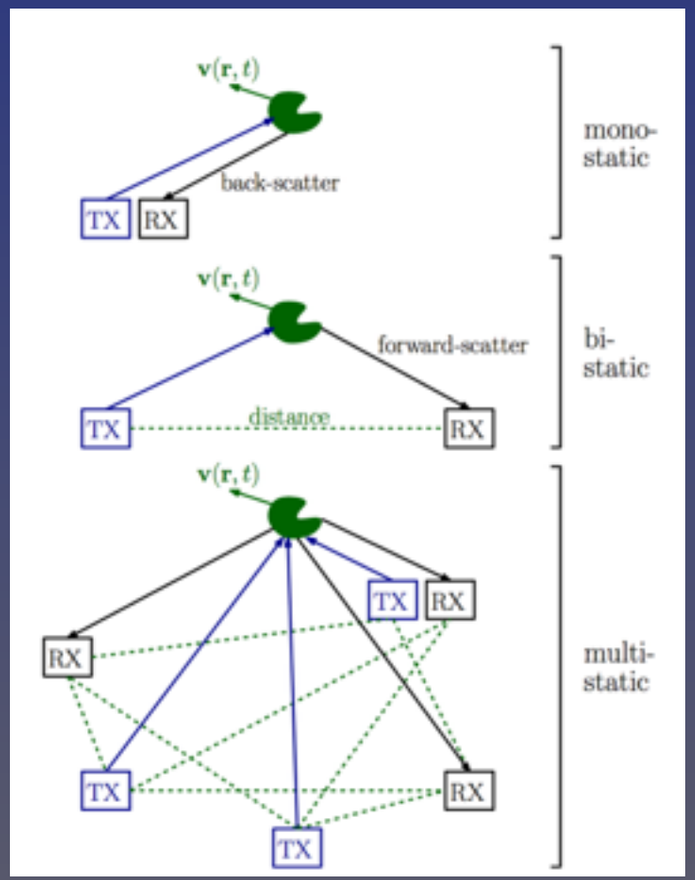


Figure 1. Horizontal daily distribution of meteor detections during June 2015 observed (a) only with Tromsø, (b) only with Andenes, and (c) with the combination of Andenes-Tromsø. In all three cases, the distributions are plotted on a geographic grid centered around the midpoint between Tromsø and Andenes. Note that the stations are located at the center of each distribution in Figures 1a and 1b, respectively. The colors represent normalized counts in linear scale. Note that a two-step selection procedure has been applied (see text for details).

- VHF meteor scatter monitoring network
- Uses orthogonal CW coding, multiple-in multiple-out approach
- Software defined radar listens to all transmissions simultaneously
- Modest TX power
- Advanced sparse mathematical analysis

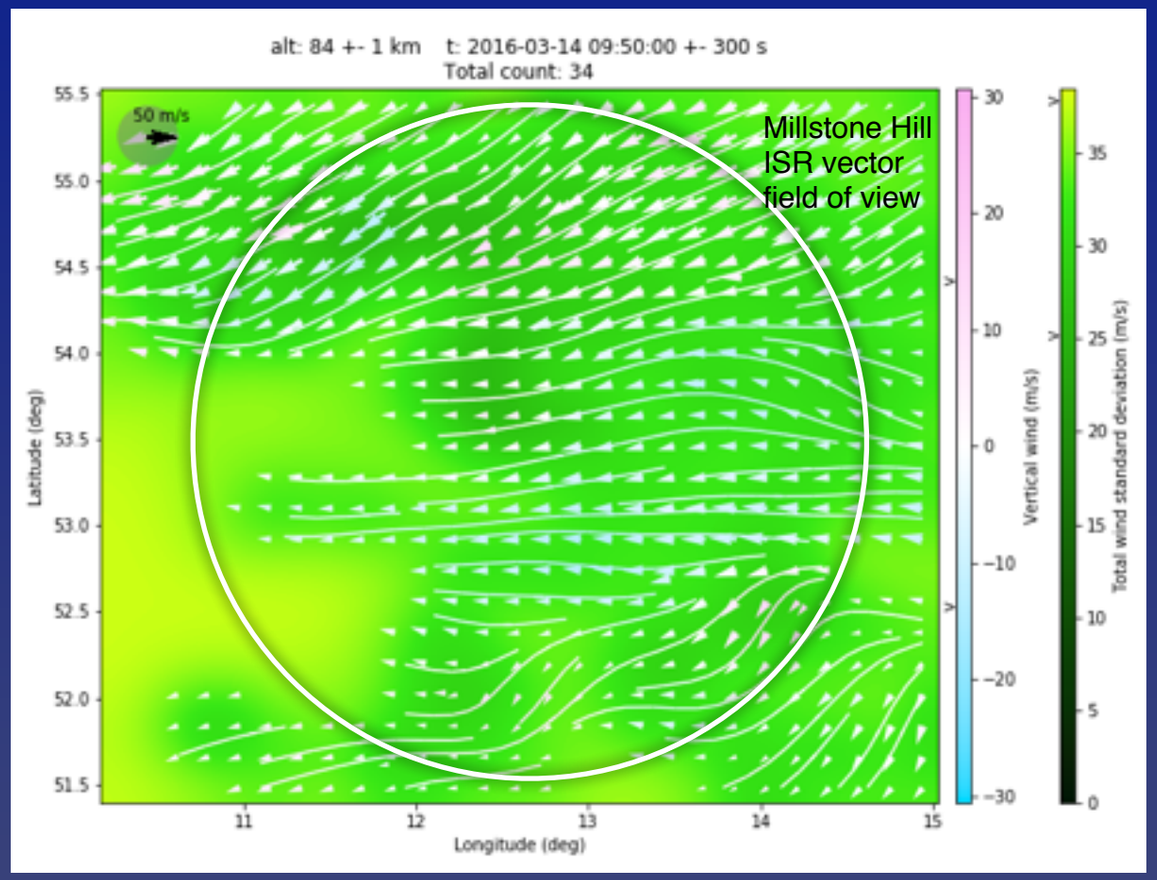
NSF MRI: Haystack + IAP (Kühlungsborn Germany)

Chau et al 2017

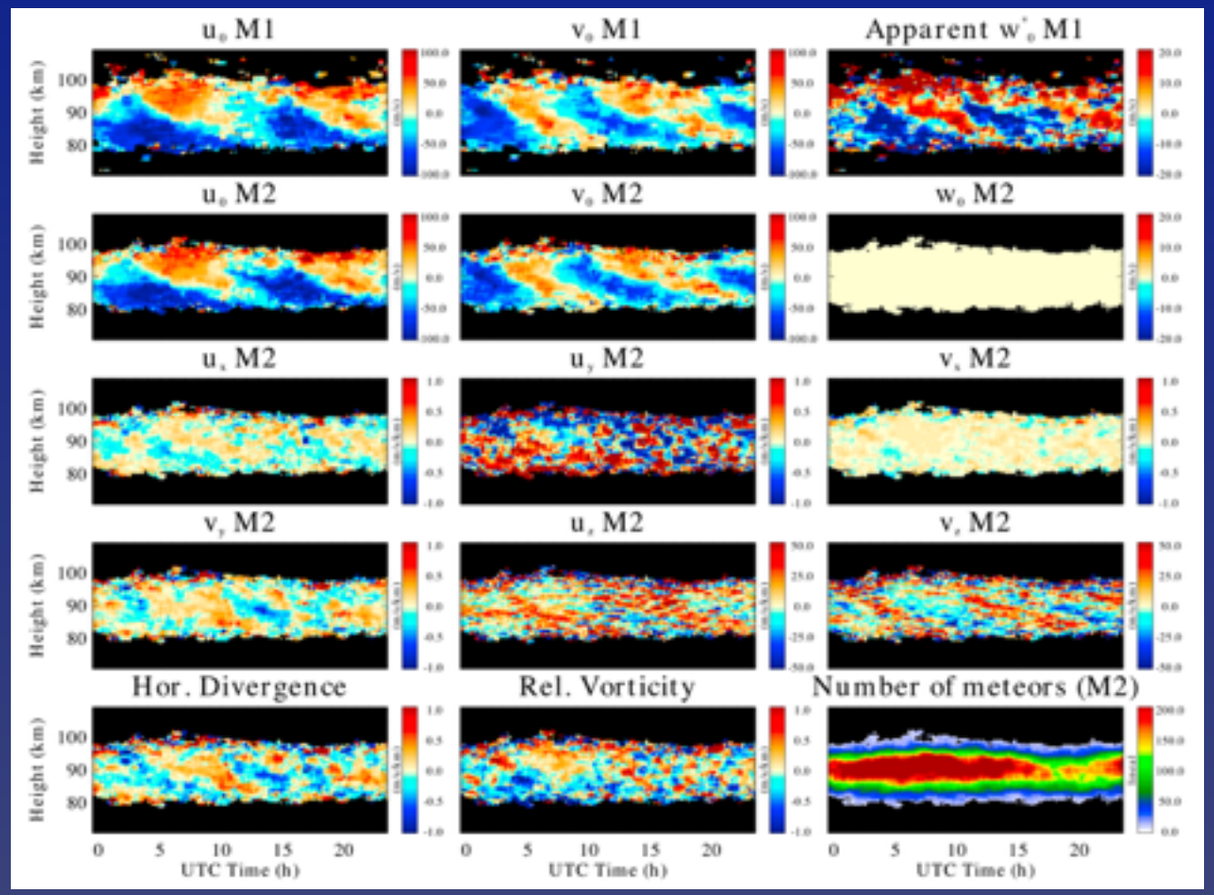


Pfeffer et al 2015

SIMONe: MIMO Meteor Radar for Fine Scale Neutral-Ion Coupling Science



R. Volz, Haystack



Chau et al 2017

- Approach is tested in Europe; algorithms (hard!) already developed
- Powerful when combined with IS radar diagnostics
- Addresses critical and forefront community science: neutral-ion coupling

Geospace Community Collaboration, Outreach

July 2017 Incoherent Scatter Radar School
28 students, 10 faculty
Arecibo, PR

Graduate student interactions, collaborations:

MIT EAPS, Aero/Astro
BU (strong ties with ECE)

Boston College	Dartmouth
Virginia Tech	Stanford
UNH	U of Calgary
Merrimack College	U Mass Boston

more …

Community Leadership:

- Technical sessions at all leading conferences: AGU, CEDAR, GEM, URSI, others
- Journal Reviewers
- Special Conference Co-organizers
- Journal Associate Editors (e.g. JGR)

International Collaborations

(China, Brazil, Finland, Perú, Ukraine, Germany, Japan, etc.)

Sponsored visits,
joint papers, etc.

New Connections: Public Outreach

HamSCI: Citizen Science Initiative for Ionospheric Research

The Bridge Between Radio Amateurs and Space Physicists

HamSCI
Ham Radio Science Citizen Investigation

Xenia 2018
HamSCI Forum

Ethan Miller K8GU
ethan@k8gu.com
Phil Erickson W1PJE
w1pje@arrl.net

ARRL
The national association for AMATEUR RADIO

AGU100 ADVANCING EARTH AND SPACE SCIENCE

Geophysical Research Letters

RESEARCH LETTER
10.1029/2018GL077324

Special Section:
New Understanding of the Solar Eclipse Effects on Geospace: The 21 August 2017 Solar Eclipse

Key Points:
- Large-scale citizen science experiment probes eclipse-induced ionospheric changes
- Eclipse effects are observed ±0.3 hr on 1.8 MHz, ±0.75 hr on 3.5 and 7 MHz, and ±1 hr on 14 MHz
- Observations are consistent with an eclipse-induced weakening of the D, E, and F ionospheric regions

Modeling Amateur Radio Soundings of the Ionospheric Response to the 2017 Great American Eclipse

N. A. Frissell[1], J. D. Katz[1], S. W. Gunning[1], J. S. Vega[1], A. J. Gerrard[1], G. D. Earle[2], M. L. Moses[2], M. L. West[3], J. D. Huba[4], P. J. Erickson[5], E. S. Miller[6], R. B. Gerzoff[7], W. Liles[8], and H. W. Silver[9]

[1]Center for Solar-Terrestrial Research, New Jersey Institute of Technology, Newark, NJ, USA, [2]Virginia Tech, Blacksburg, VA, USA, [3]Department of Mathematical Sciences, Montclair State University, Montclair, NJ, USA, [4]Plasma Physics Division, Naval Research Laboratory, Washington, DC, USA, [5]Haystack Observatory, Massachusetts Institute of Technology, Westford, MA, USA, [6]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA, [7]Applied Statistical Consulting, Atlanta, GA, USA, [8]Independent Consultant, Reston, VA, USA, [9]American Radio Relay League, Newington, CT, USA

Abstract On 21 August 2017, a total solar eclipse traversed the continental United States and caused large-scale changes in ionospheric densities. These were detected as changes in medium- and

700,000+ Licensed US Amateurs
~5% are Highly Technical
Haystack engaged at national level
NSF Geospace Facilities emphasized