Incoherent Scatter Radars for System Science and Operational Applications

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The Current State of the Geospace Facilities

Currently:

- Most of the funding from goes to large ISR facilities
- The facilities make fairly localized measurements
- Most facilities operate on a campaign basis, not continuously
- Processed data is not available in real time
- Coordinating the multiple facilities is difficult; few World Day opportunities per year

The priorities of the geospace community are shifting towards:

- Multi-scale systems science
- Global data assimilation
- Ionospheric now-casting for operational applications
- Long term trends, upper atmospheric climate change

Questions:

1. How do we change the way we use our existing facilities to better meet the community needs?
2. How should we plan future facilities?

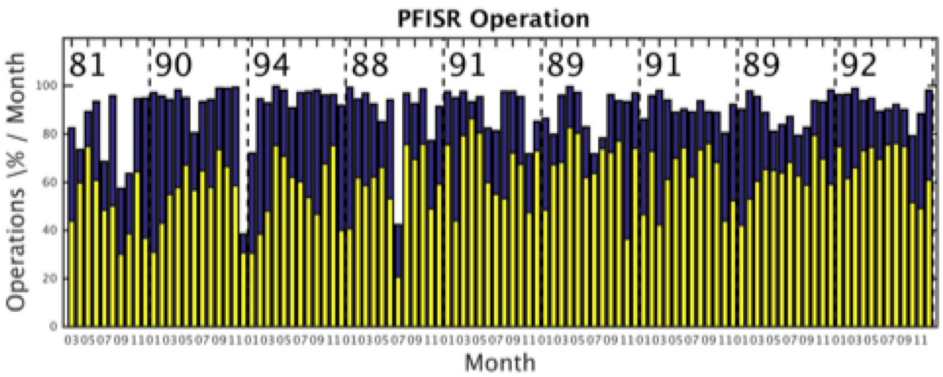
Technical Requirements for an Operational System

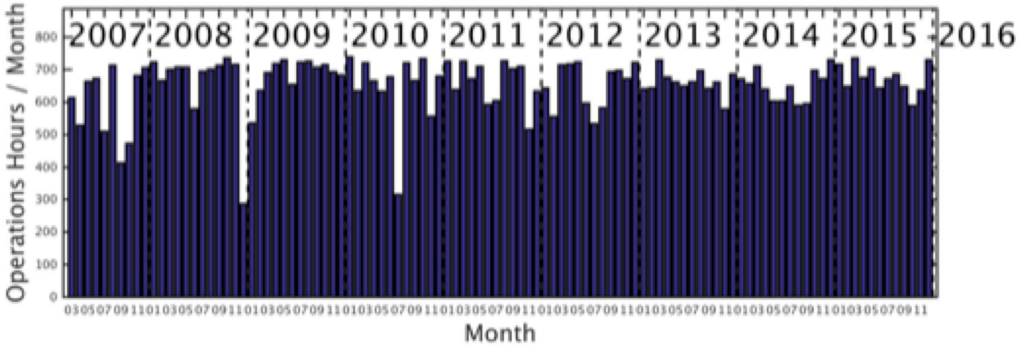
1. Function automously and be able to deploy and operate large networks.
2. Operate continuously and reliably.
3. Produce qualtity controlled, calibrated data in real time with minimal latency.

The Poker Flat Incoherent Scatter Radar (PFISR) already meets most of these technical requirements.

PFISR Reliability

PFISR Historical Operations through 2015





PFISR 2016 Stats:

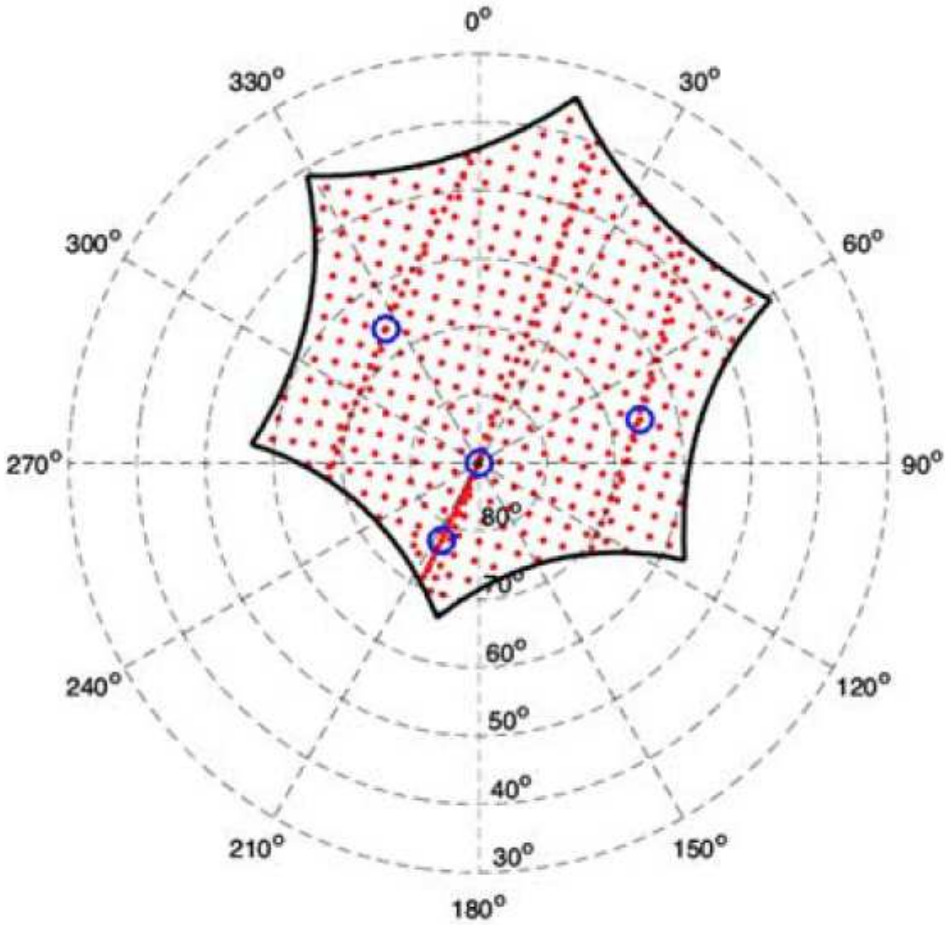
- 8459.57 total hrs of operations
  - High duty cycle: 2040.23 hrs
  - Low duty cycle: 6419.34 hrs
- $\frac{8459.57 \text{ hrs}}{8784 \text{hrs/leap year}} = \mathbf{96.3\%}$

For Comparison: NOAA FY2017 Budget Estimates submitted to Congress: Deliverable of the National Weather Service Observations Program:

- "Support operations of 122 NEXRAD systems at 96 percent availability."

Happy 10$^{\text{th}}$ Anniversary of the PFISR IPY Modes!

- PFISR runs continuously, and defaults to the IPY mode when not running another user-requested experiment.
- The International Polar Year (IPY) modes are low-duty cycle modes.
- IPY began on 2007-03-01, and it is still going after 10 years!



PFISR Real Time Data Analysis System

- Prototype real-time data analysis system deployed February 2017 in support of rocket campaign.
- System employs a dedicated server (32-cores, 64 GB RAM) installed in the PFISR OCC.
- Software achitecture built using the Data Transport framework developed by Todd Valentic at SRI.
- System is fully mode-agnostic. Only relies on meta-data in the experiment files.

Photo Credit: Terry Zaperach

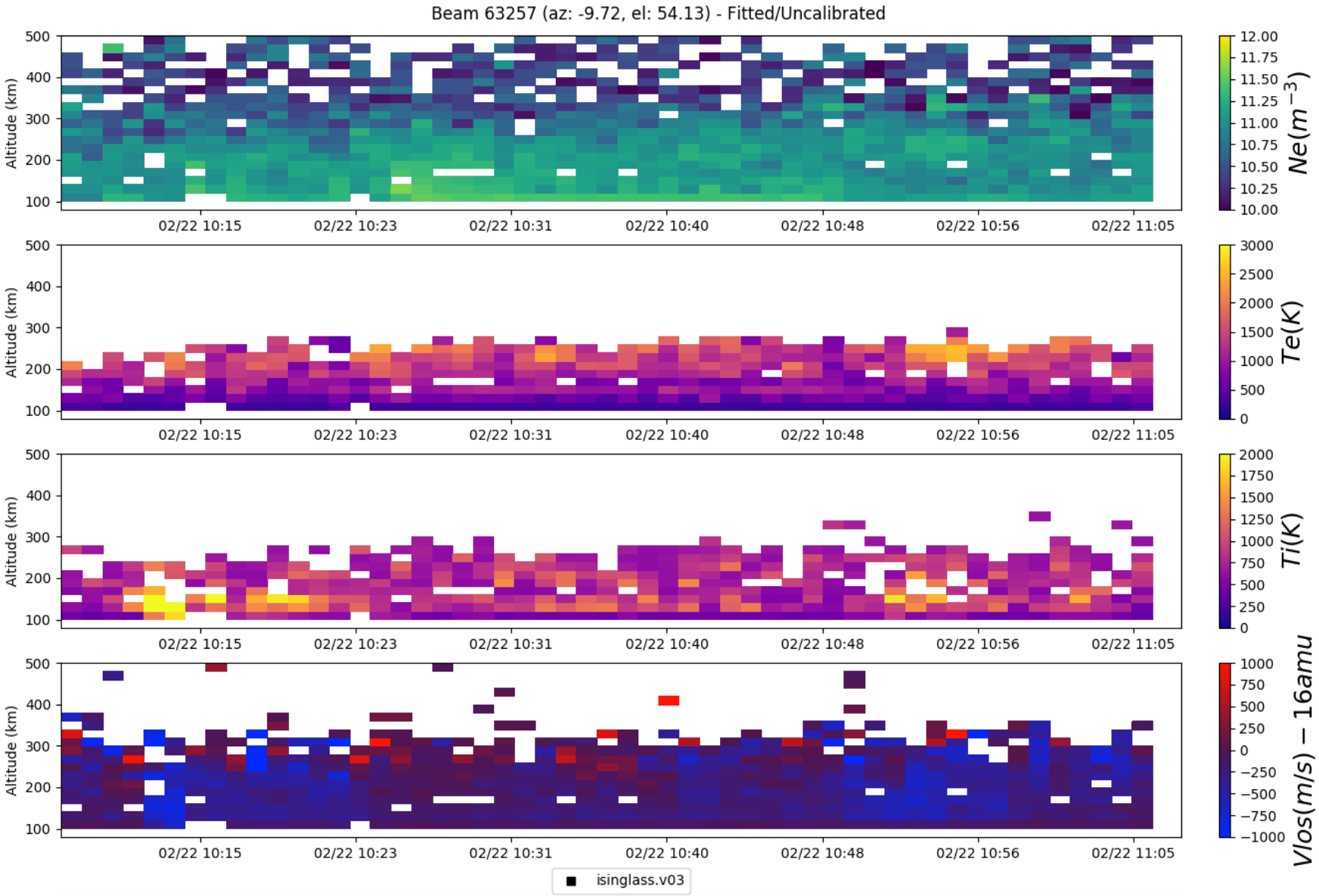
PFISR Real Time Data Products

- Low-level SNR, uncorrected N_e, V_{los}
- Fitted ACFs for N_e, T_e, T_i, and V_{los}
  - Uses same fitting code used to produce Madrigal data products.
  - Requires pre-computed ambiguity functions to be included in the experiment metadata.
  - Produces error estimates on fitted parameters and goodness-of-fit metrics.
  - Uploads calibration constants determined from bi-weekly plasma line experiments.
  - Algorithm sped up by fitting every beam and every range gate in parallel.
- Derived vector electric fields and E-region neutral winds
  - Follows Heinselman and Nicolls (2008) algorithms.

Standard integration time is 60s.

See Ashton Reimer's poster on Wednesday for examples and demos.

Real Time Data Analysis Example



Future Directions: Near Term

Expand PFISR real-time capabilities

- Refine automatic quality control of PFISR real time data
- Continue working on automated interference mitigation strategies
- Establish a server to publicly distribute PFISR real time data
  - Would data assimilation modelers want to use it?

Future Directions: Medium Term

Investments in existing NSF facilities (Innovation and Vitality?):

- Implement continuous ISR operations at RISR
  - Real time server already shipped to RBO
  - Continuous operations requires upgrades to power infrastructure (e.g. a new smaller generator)
- Implement continuous perp-**B** ISR measurements at Jicamarca
  - Requires 100 kW solid state tranmitter for unattended operations

International Collaboration:

- EISCAT has decided to move forward with EISCAT_3D (target completion 2021)
- Continuous measurements are a key part of the EISCAT_3D science plan

Future Directions: Long Term

- Future facilities should be planned for networked operations, continuous real time data production, and interoperability
- Networks of autonomous ISRs are technical feasible to deploy if the funding could be secured
- Coupling across multiple scales from local to global identified as an important observational gap during the first Quo Vadis meeting
- Large networks could have operational applications as part of a national space weather strategy