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High-Latitude Influence on Equatorial Space Weather

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Motivation

- One high latitude influence on equatorial space weather is the impact of traveling ionospheric disturbances (TIDs) on the formation of equatorial plasma bubbles (EPBs)
  - Model simulations (e.g., Krall *et al*. 2011, 2013a,b) have demonstrated that Electrified MSTIDs can trigger EPB formation
- The February 2019 ISR World Day experiment (ISR Bubbles) was designed to provide a coordinated set of observations that could provide some answers to the question of how TIDs originating at high latitude affect the day-to-day EPB formation

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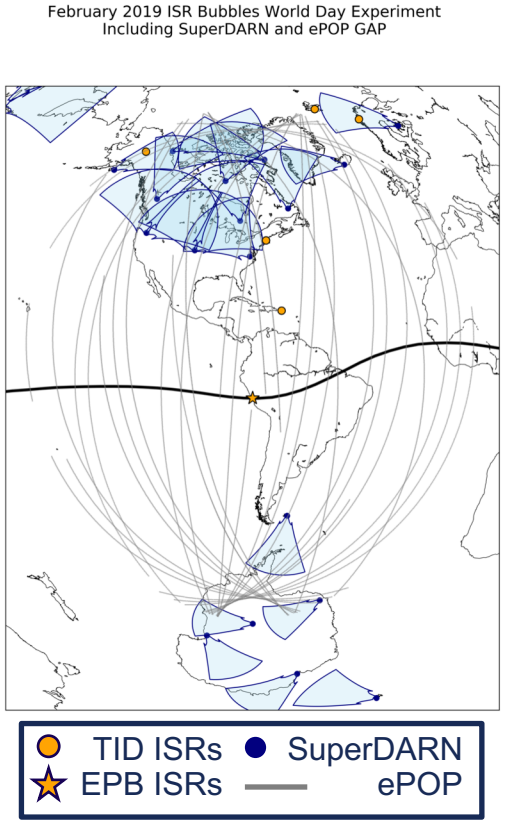
Questions about TIDs

1) What are the typical characteristics of TIDs that propagate equatorward from high latitudes?
   a) How far equatorward do they propagate?
   b) What differences are seen between electrified TIDs and atmospheric gravity wave (AGW) TIDs?
   c) How do longitude, hemisphere, season, local time, solar cycle, etc. affect the characteristics?
2) Do electrified and AGW TIDs affect EPB formation differently?
3) Which TID propagation characteristics have the largest influence on EPB formation?
4) How important are the conjugate characteristics of TIDs on EPB formation?

ISR Bubbles WD Experiment

- Ran from 2-6 February 2019
- High- and mid-latitude ISRs ran in modes to detect TID propagation
  - Included PFISR, EISCAT, Arecibo, and Sondrestrom
  - RISR-N/-C were undergoing maintenance
- The equatorial Jicamarca Radio Observatory ISR ran in a bubble detection mode
- Coordinated with SuperDARN and ePOP to improve coverage of TID propagation over the Americas



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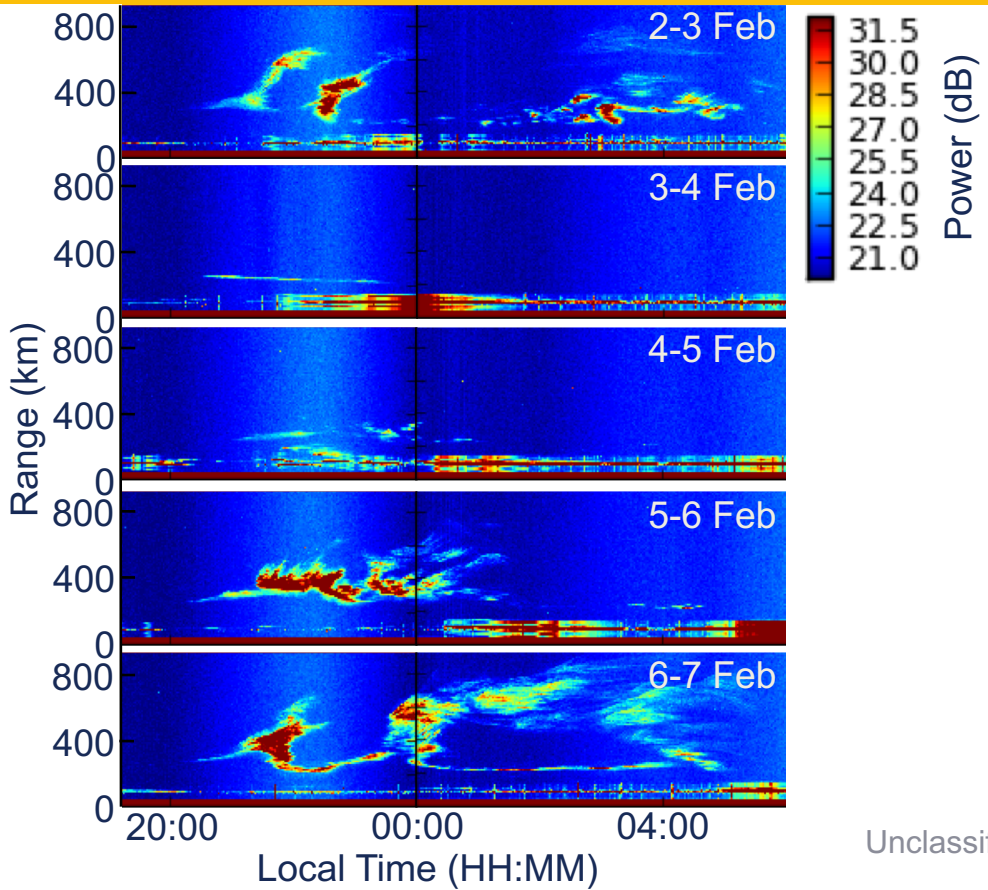
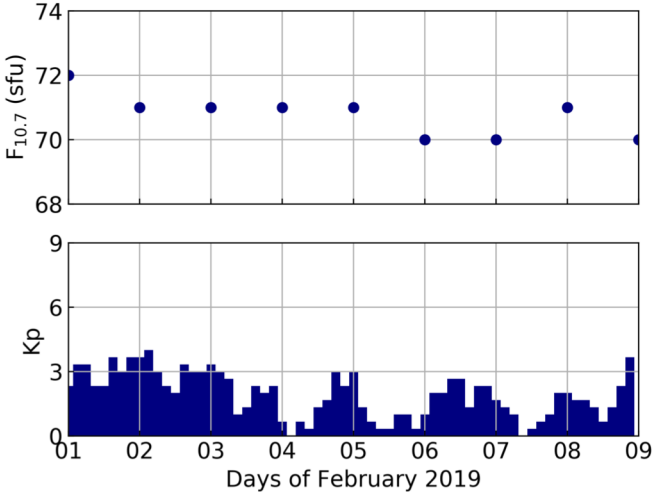
Initial ISR EPB Results



- Results from JRO show day-to-day variations that include differences in the occurrence, formation time, and duration
- Little activity seen in solar and geomagnetic indices



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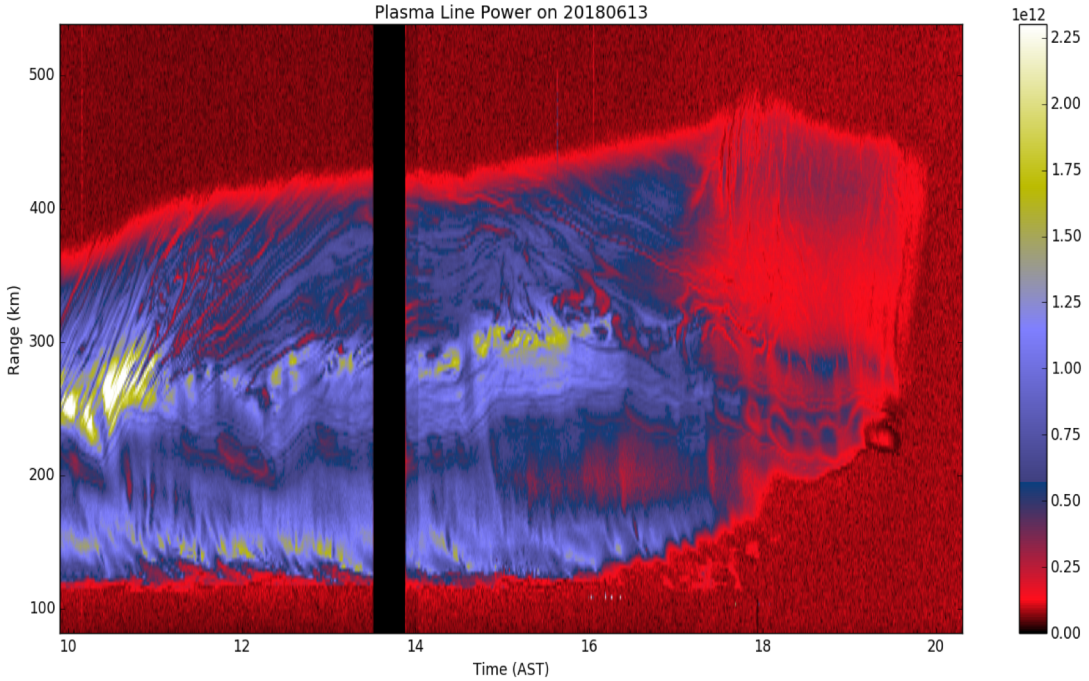
Initial ISR WD TID Results

- ISRs are an effective tool for detecting and studying TIDs.
- PFISR, Arecibo, MIT, and EISCAT radars were used to observe MSTIDs during the 2019 ISR WD.
- Using plasma line measurements, Arecibo measurements show that waves are often present at mid-latitudes
  - Figure is an example from a different experiment



Plot courtesy of Mike Sulzer

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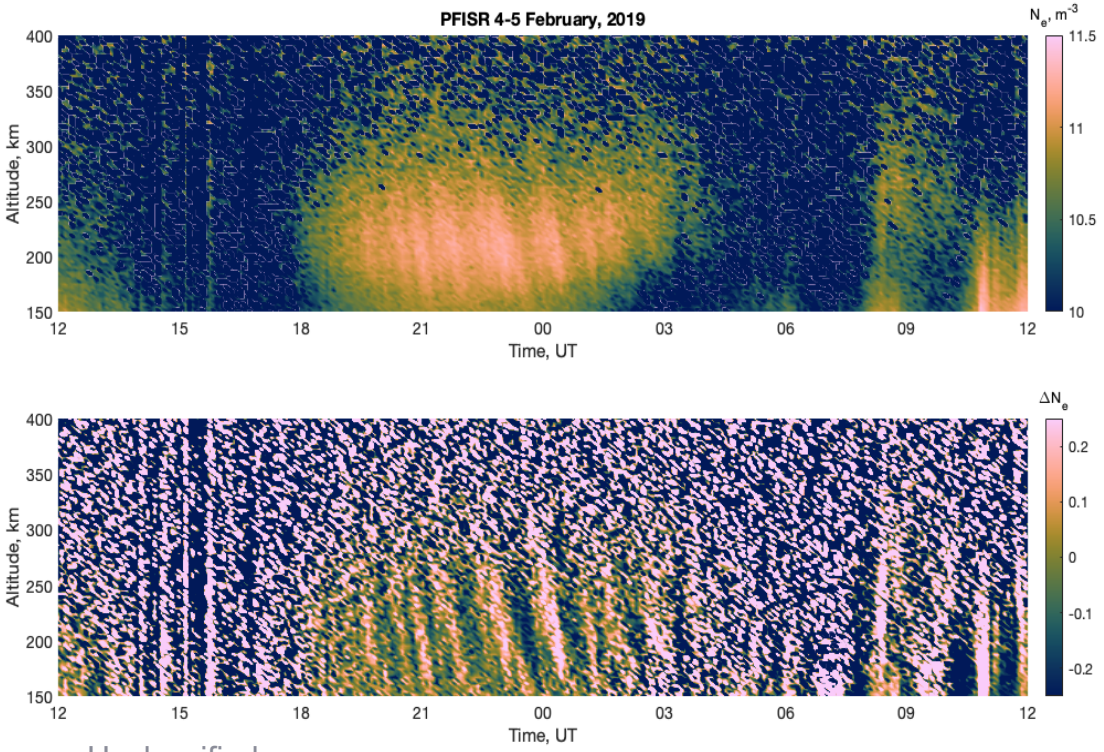
Initial ISR WD TID Results

- First result from PFISR data show clear evidence of TIDs in uncalibrated density.

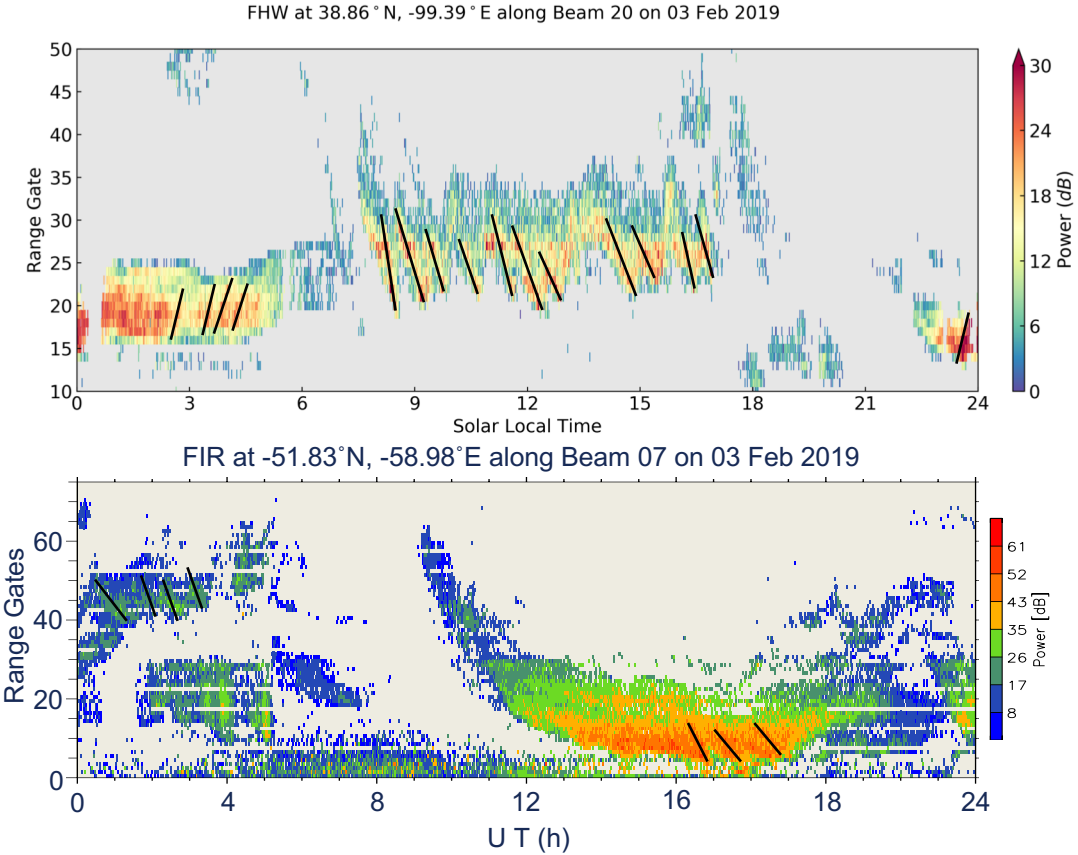
$$\Delta N_e = \left(N_e - \bar{N}_e\right) / \bar{N}_e$$

- 120 minute periods and longer have been filtered out.
- TID signatures (on right) have periodicity of ~60 minutes.



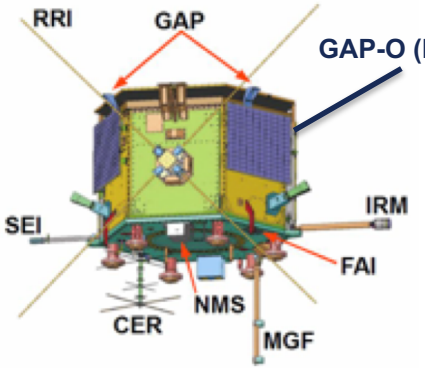
Initial SuperDARN Results

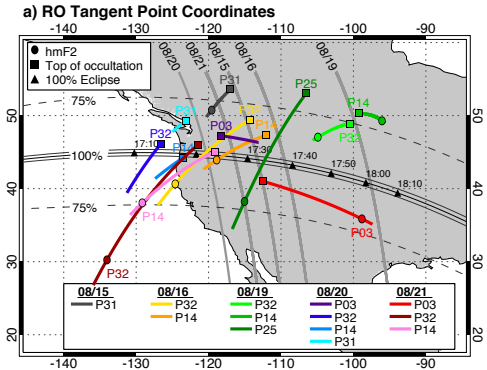
- Initial Results from SuperDARN show daily occurrence of MSTIDs in the groundscatter
  - These are seen in radars at high and mid-latitudes
  - Present in the northern and southern hemisphere
  - Both hemispheres seem to show equatorward propagation
  - Black lines highlight some of the obvious TID signatures



Initial ePOP Results

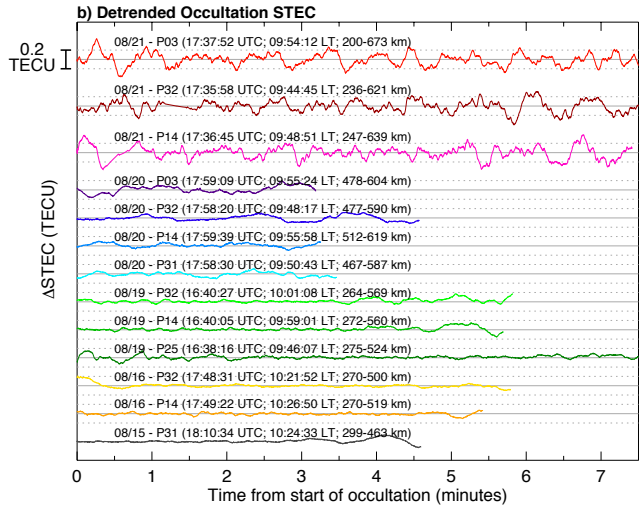
- e-POP GPS receiver instrument (GAP) has a proven track record of studying TIDs using radio occultation techniques.
  - GAP (**G**PS **A**ttitude, Positioning, and **P**rofiling experiment)
- Occultations (GAP-O) during 4 “pole-to-pole” tracks were executed.
  - A baseline dataset in days surrounding the World Day was also collected.
- Example include TIDs detected during the 2017 eclipse (shown on right).





TIDs during the eclipse

No TIDs before/after eclipse



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Summary

- We have a lot of questions
- We have a data set that can be used to answer some of these questions
  - Having more days would be useful
  - Having more coverage in Europe and Africa would be useful

Acknowledgements

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