Constellation-Based DORIS Receiver Network for Ionospheric Data
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Overarching Science Goal: Directly image global ionosphere dynamics in near-real-time
- TECs (e.g., large-scale AGWs launched from auroral zone)
- Structure (patches, sporadic-E, auroral ovals, substorms...)
- Ionospheric response to solar input
- Ionospheric response to magnetic storms

The next step in understanding will require improvements in data:
- Requires 3-D quasi-real-time ionosphere specification
  - Add major new data source(s) to 3DVAR data assimilation
  - 1°x1°x<1km resolution at 16 min. or higher cadence
  - Studies of dynamics and small-scale structure
- Study climate, specify weather
- Requires real-time scintillation maps

Compelling need for better ionospheric data sources
- Ionospheric imaging technique can also probe the troposphere
- Near-real-time tropospheric water vapor content
- Critical input to climate and weather models

Data Source | Type | Measurement | Utility/Character | 3DVAR value | Error size
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GPS overhead Ray (MEO->LEO) | TEC | topside | low | large
GPS occultation Ray (MEO->LEO) | TEC | vertical structure | med | large
GPS ground Ray (MEO->Gnd) | TEC | bulk, horiz. structure | high | varied
LEO beacon Ray (LEO->Gnd) | TEC | bulk, horiz. structure | very high | small
Ground beacon Ray (Gnd->LEO) | TEC | bulk, horiz. structure | very high | small
In-situ point | n_F2 | normalization | low | varied
Ionosonde/sounder point | n_F2, h_F2 | vertical profile | vertical structure | very high | n/a
Optical | Various | n2e | n2e(F2), n2e(F1) | low | large

Iono. ray data is the most prolific and readily available

DORIS beacon data from LEO is the best choice for horizontal resolution and temporal updates
- Can image smaller features like equatorial plasma bubbles, not measured by GPS-IGRIS
- Can measure scintillation (n2e, n2e)
- Better coverage than GPS
- Fast temporal updates
- Proven data source for iono. and tropo. measurements

DORIS Beacon Network
- ~60 stations, global coverage
- Dual-band, phase-coherent
- Need only passive Rx
- 25x better freq. spread than GPS
- Better coverage than GPS
- Fast temporal updates
- Proven data source for iono. and tropo. measurements

Iridium-NEXT Satellite Constellation
- 66 SVs in 6 planes
- 780 km (LEO) orbit
- 101 min. orbital period
- Hosted payload opportunity
- Real-time comms
- All infrastructure provided
- Extremely low cost/value

DORIS-Iridium Orbit Simulations
- Construct irregular 100 km constant-spacing global grid, consider F-layer (350 km) pierce points

Graphic shows number and repetition of 100 km (1°) cells being influenced by data per day, assuming full constellation (is a measure of horizontal resolution capability)

Distribution shows temporal update rate would be very high.
This would be the broadest real-time ionospheric data set ever produced.
Together with ground GPS data, global coverage would be essentially total.

Science System Design
System design serves multiple science and user communities (iono. structure & dynamics, scintillation, troposphere)

Rx design using APL’s existing flight-heritage Frontier SDR with ARL low-profile dual-patch antenna and DSP for iono. TEC, scintillation and data output to perform O.D. and get tropospheric water vapor content
- SWaP: < 5 kg, < 5 W, < 1U