Constellation-Based DORIS Receiver Network for Ionospheric Data

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Overarching Science Goal: Directly image global ionosphere dynamics in near-realtime

- TIDs (e.g. large-scale AGWs launched from auroral zone)
- Structure (bubbles, sporadic-E, auroral ovals, anomalies…)
- Ionospheric response to solar input
- Ionospheric response to magnetic storms

The next leap in understanding will require improvements in data:

- Requires 3-D real-time bulk ionosphere specification
  - Add major new data source(s) to 3DVAR data assimilation
  - 1°x1° x <5km resolution at 15 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 techniques can also probe the troposphere:

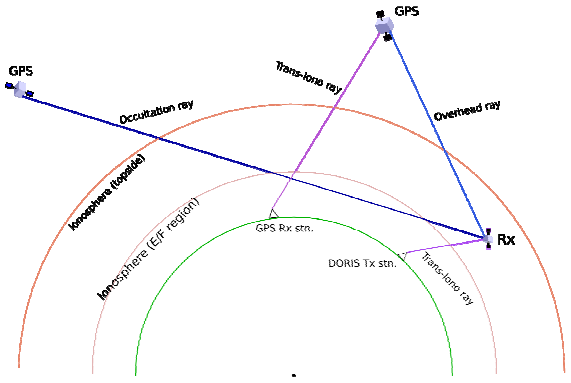
- Near-real-time tropospheric water vapor content
  - Critical input to climate and weather models

Data Source	Type	Measurement	Utility/Character	3DVAR value	Error size
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_e	normalization	low	varied
Ionosonde/sounder	point	$n_m(F_2)$, $h_m(F_2)$	normalization	high	small
Ionosonde/sounder	Virtual height	n_e profile	vertical structure	very high	n/a
Optical	Various	n2e	$n_m(F_2)$, $h_m(F_2)$	low	large

Iono. ray data is the most prolific and readily available

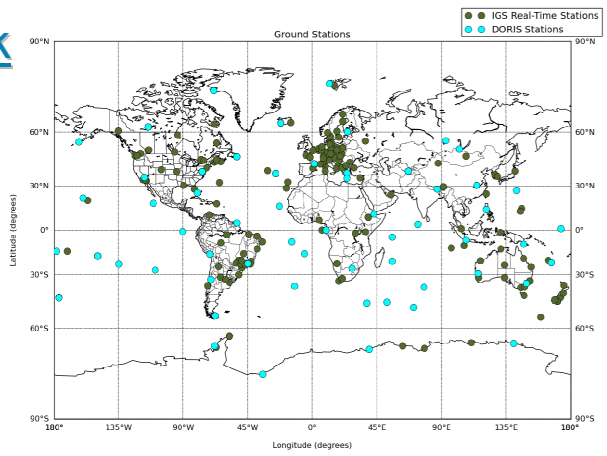
DORIS beacon data from LEO is the best choice for horizontal resolution and temporal updates

- Can image smaller features like equatorial plasma bubbles, not measured by GPS-RO
- Can measure scintillation (S4, σ_ϕ)
- More accurate relative TEC measurements using UHF/S-band frequencies (lever arm)
- Global coverage, incl. ocean regions



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



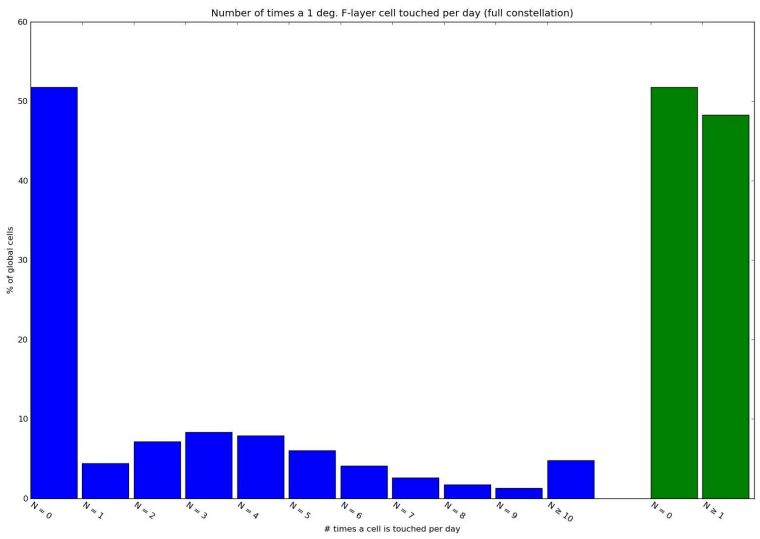
Iridium-NEXT Satellite Constellation

✧ 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

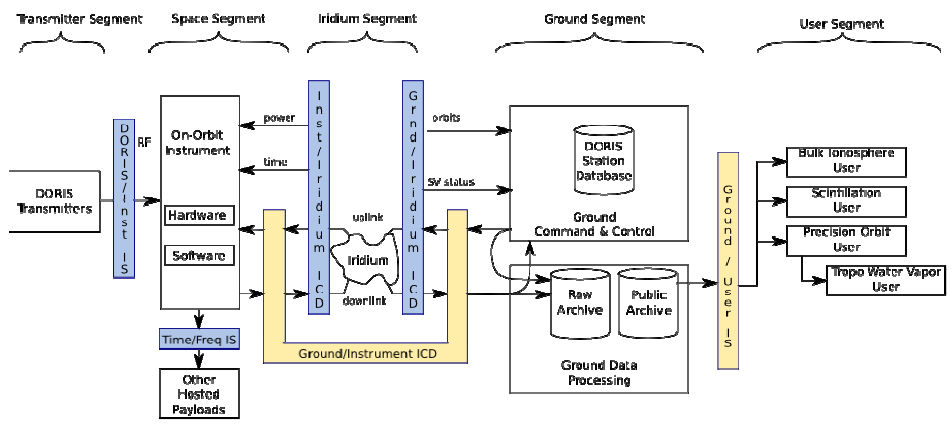
Graphic shows number and repetition of 100 km (1°) cells being influenced by data per day, assuming full constellation (is a measure of horizontal resolution capability)



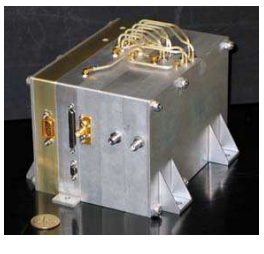
❖Distribution shows temporal update rate would be very high.
❖This would be the broadest real-time ionospheric data set ever produced.
❖Together with ground GPS data, global coverage would be essentially total.

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