Identification of Global Ionospheric Scintillation from Low Earth Orbit

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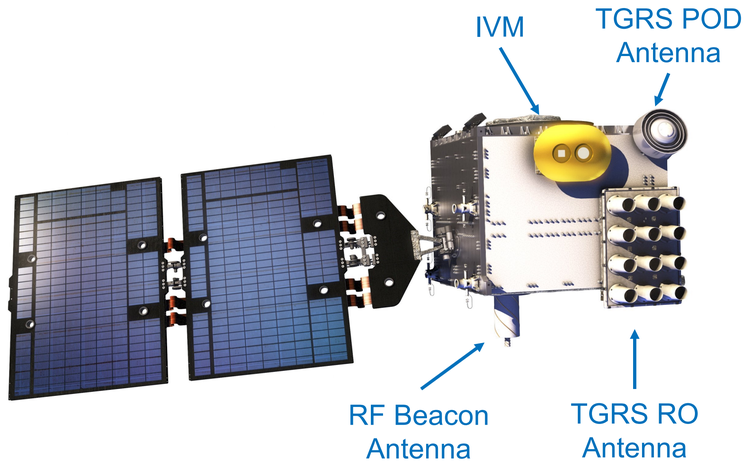
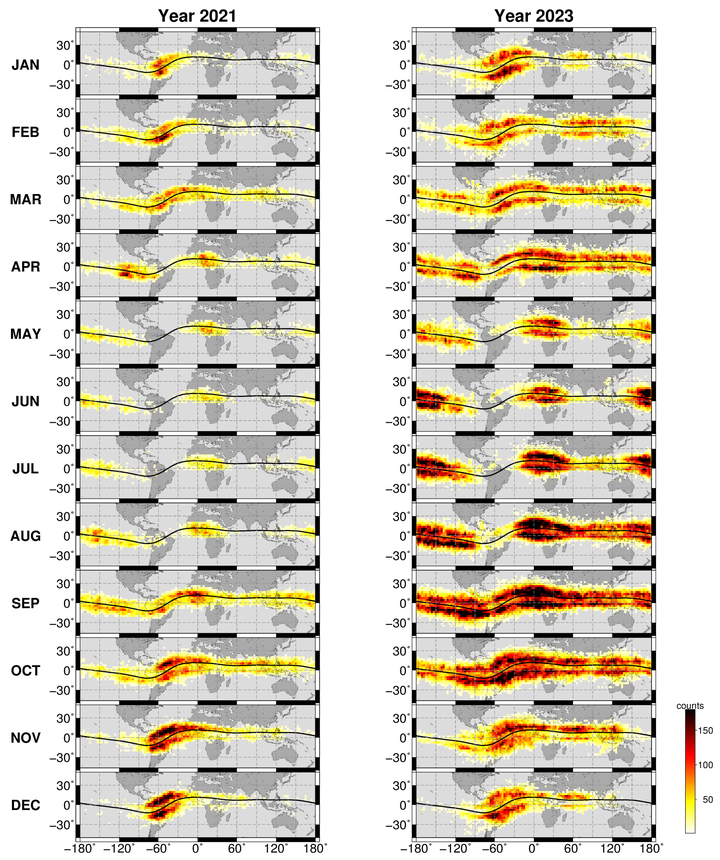
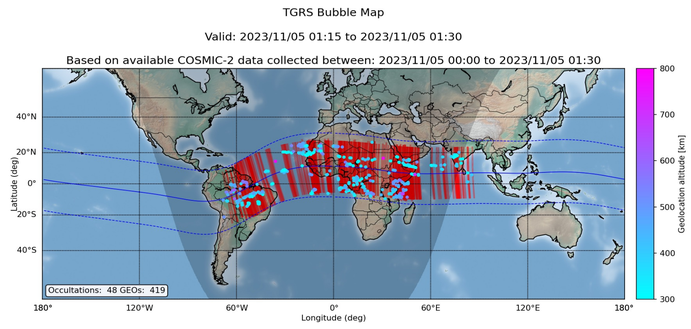
FORMOSAT-7/COSMIC-2 Spacecraft



- COSMIC-2 spacecraft orbit altitude ~530 km
- Tri GNSS Radio Occultation System (TGRS) instrument, designed by JPL collects space weather data (GPS+GLONASS) with fore and aft POD antennas
- POD antennas mounted 15 degrees from horizontal
- GPS data collected using traditional Phase Lock Loop (PLL) tracking
- GLONASS data collected using “pseudo closed loop” data derived from open loop tracking

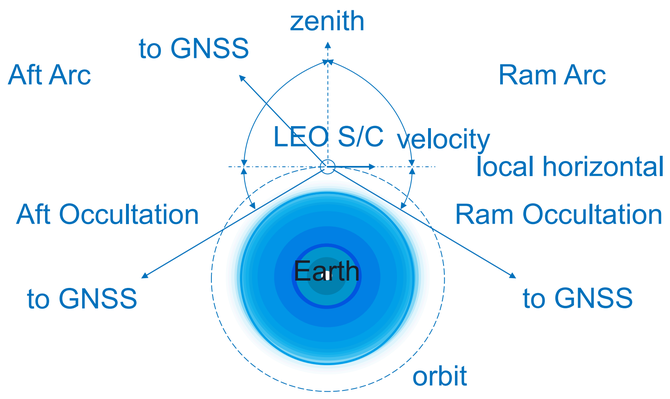
Operational Applications with Seasonal and Solar Cycle Variability





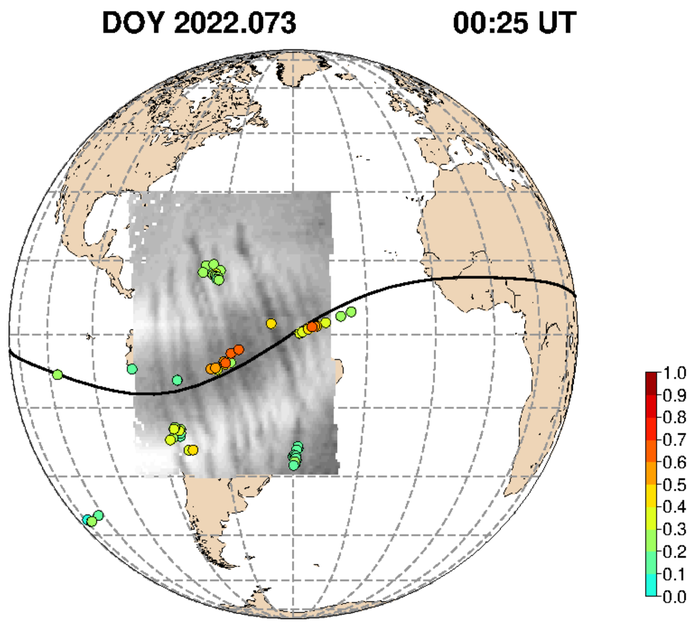
- TGRS has collected high rate scintillation data since 2021.
- Panels on left show monthly variation in the density of scintillation observed in 3° x3° grid across magnetic equator. Changes from 2021 to 2023 attributed to evolution of solar cycle 25.
- Scintillation data from all six spacecraft are combined into a bubble map product and used operationally by NOAA space weather prediction center and the United States Air Force.

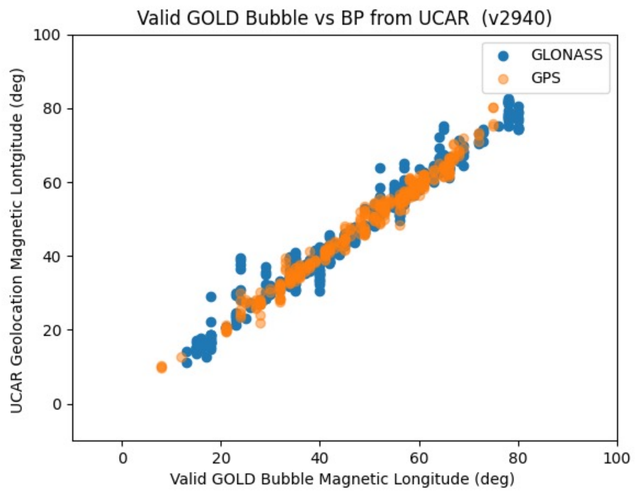
TGRS POD Field of View



- TGRS schedules tracking of ionospheric tracks from both fore and aft POD antennas.
- Ionosphere occultations defined as data collected from S/C altitude to 90 km tangent point altitude.
- Schematic of TGRS field of view geometry provided.
- Majority of POD data collected at 1-second intervals and used for POD and ionosphere TEC.
- TGRS has special high rate data collected mode (50 Hz GPS, 100 Hz GLONASS) from local horizontal to 90 km tangent point altitude when on-board S4 exceeds threshold.

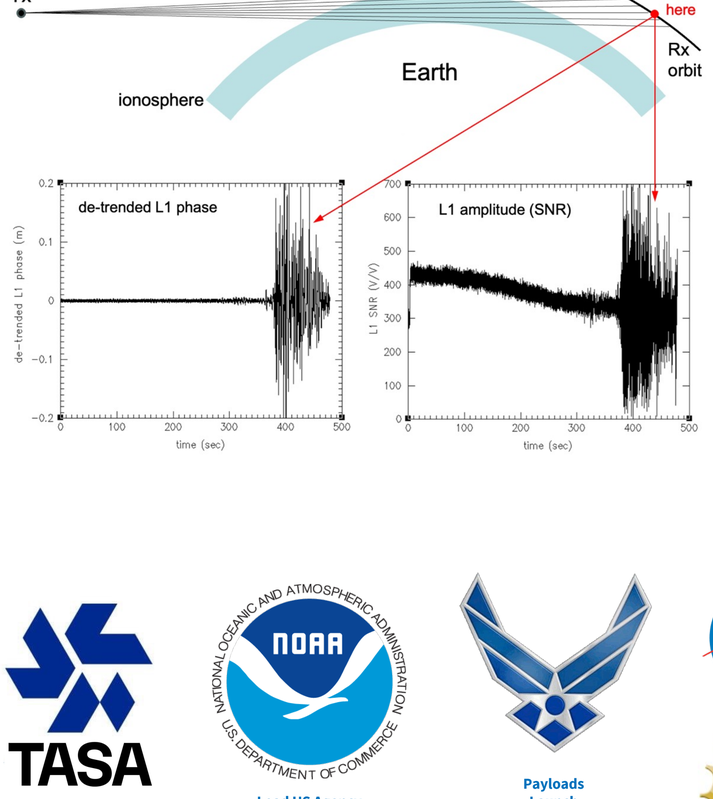
Validation of Geolocation using GOLD Imagery

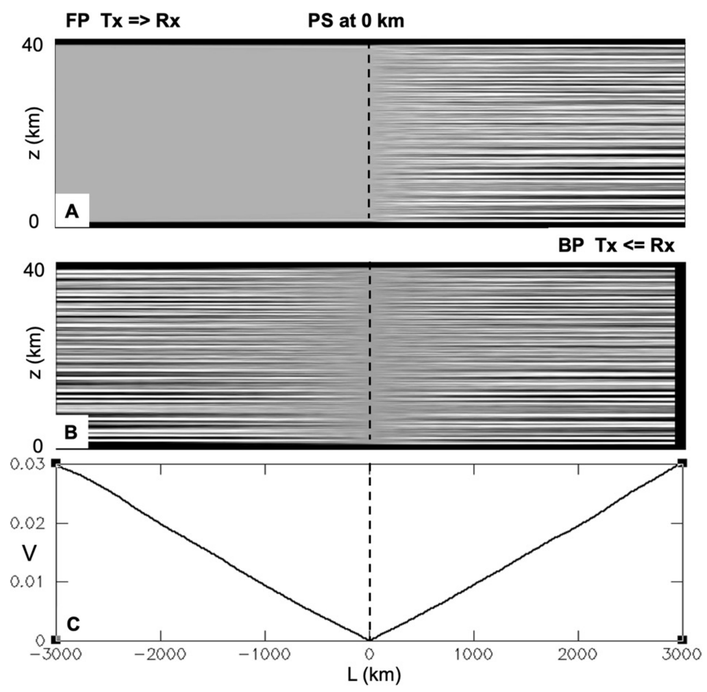




- GOLD is a NASA UV imager on a geostationary satellite over American sector.
- UCAR developed and validated GOLD bubble depletion index (Wu et al., 2023) in collaboration with Boston College, and Aerospace.
- GOLD bubbles validated using ground VHF sites in South America.
- Example GOLD image shows equatorial ionization anomaly (EIA) regions and plasma depletions across the magnetic equator.
- TGRS geolocations collected during this 30 minute GOLD image align with density depletions within GOLD images.
- Geolocations are color coded based on observed S4 value.

Geolocation Using Back Propagation





- Previous studies had assumed scintillation observed along radio occultation limb had been assigned to the ray tangent point.
- Localization of ionospheric irregularities is based upon a method called back propagation.
- UCAR has implemented an operational geolocation processing system that is largely based on the algorithm presented by Sokolovskiy et al., 2002.
- This method of geolocation is based upon a numerical solution of 2D solution of Kirchhoff’s equation using high rate phase and amplitude.
- Scintillation is geolocated at distance from TGRS when amplitude variance (V) is minimized.

References

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Science Support: UCAR, Aerospace Corporation, NASA JPL, UTD, BC, AFRL

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