Commercial RO Data Processing Status and Product Validation

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Outline

- NOAA Commercial Data Program (CDP) RO missions
- Operations overview
- Neutral atmosphere and ionosphere product metrics
- New functionality
- Data availability and downloads
- Summary

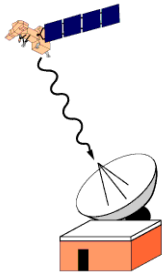
Missions and Products

- NOAA Commercial Weather Program Delivery Order (DO) #3
  - From 2021-09-14 to 2022-03-15
  - Spire data
- NOAA Commercial Weather Program DO #4
  - From 2022-03-16 to 2023-01-15
  - GeoOptics and Spire data
- Data is processed by UCAR/CDAAC and sent to weather/space weather centers in near real-time
- So far in 2022
  - GeoOptics = 1 satellite, Spire = ~28 satellites

Neutral atmospheric profiles delivered in NRT (PDA & 557WW)	Abs TEC files delivered in NRT (SWPC & 557WW)
Spire: ~1,392K Geooptics: ~43K	Spire: ~1,080K Geooptics: ~61K

Data Processing Overview

GeoOptics and Spire level0 and level 1 data



PDA NOAA

D P C

Research Community

SWPC

PDA NOAA

Global Telecomm System

- BoM (Australia)
- Canada Met
- DWD (Germany)
- ECMWF
- CWB (Taiwan)
- NOAA JCSDA
- NOAA NCEP
- JMA (Japan)
- Meteo France
- UKMO (UK)

GNSS ground data (NTRIP real-time and files)
IGS orbit products
NOAA GFS Forecast

AF 557WW

NCEI and NCAR Quasar Archive

Monitoring NRT Processing

https://proxy-leo-a-ch.cosmic.ucar.edu/cdaac/internal/cdaacOps/dayDumpsSpire.cgi?mission=spireert;sats=0

Most Visited | Index of /cdaac/logi... | COSMIC 2 Downlink... | COSMIC 2 Downlink... | COSMIC 2 Downlink...

CDAAC Internal | Mission: COSMIC-2 | Mission: KompSat 5 | Mission: PAZ | Mission: SPIRE | Mission: SPIREE | Mission: GEOOPT | Mission: GEOOPTE | GNSS Status | Payloads COSMIC-2 | Clock Monitoring

SPIREERT PROCESSING STATUS

| Green - Ok | Orange - In Progress | Purple - Failed to Produce Products | Red - Failed to Process |

SUMMARY	DOWNLINKS RECEIVED (DDDD.YYY.LEOID.DUMPID)
Total per Satellite: FM 99: 133 atm / 0 ion FM 102: 71 atm / 0 ion FM 103: 78 atm / 0 ion FM 104: 198 atm / 0 ion FM 106: 284 atm / 0 ion FM 115: 207 atm / 0 ion FM 117: 221 atm / 0 ion FM 118: 90 atm / 0 ion FM 119: 167 atm / 0 ion FM 120: 74 atm / 0 ion FM 122: 371 atm / 0 ion FM 124: 301 atm / 0 ion FM 125: 305 atm / 0 ion FM 126: 130 atm / 0 ion FM 127: 205 atm / 0 ion FM 128: 86 atm / 0 ion FM 129: 48 atm / 0 ion FM 132: 230 atm / 0 ion FM 133: 101 atm / 0 ion FM 134: 194 atm / 0 ion FM 135: 116 atm / 0 ion FM 141: 108 atm / 0 ion FM 143: 152 atm / 0 ion FM 148: 28 atm / 0 ion FM 149: 190 atm / 0 ion FM 150: 125 atm / 0 ion Total for the Day: 4214 atm / 0 ion	2022.154 (2022-06-03): Total # of SPIREERT downlinks: 335 2022.154.099.00 2022.154.099.01 2022.154.099.02 2022.154.099.03 2022.154.099.05 2022.154.099.06 2022.154.099.07 2022.154.099.08 2022.154.099.09 2022.154.099.11 2022.154.099.12 2022.154.099.14 2022.154.099.15 2022.154.102.00 2022.154.102.01 2022.154.102.03

DAAC 4.7 — System's install type: leo-a-ch

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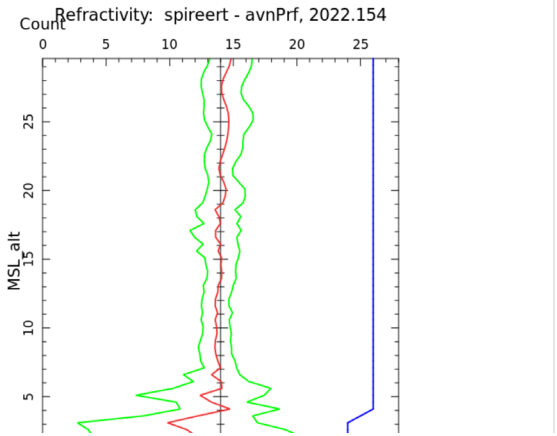
Internal | Mission: COSMIC-2 | Mission: KompSat 5 | Mission: PAZ | Mission: SPIRE | Mission: SPIREE | Mission: GEOOPT | Mission: GEOOPTE | GNSS Status | Payloads COSMIC-2 | Clock Monitoring

LEO DUMP DETAIL FOR SPIREERT: | DATE: 2022.154 | LEO ID: 099 | DUMP ID: 05 | ATM OCCS: 0 | ION OCCS: 0 |

STATS and ATTITUDE PLOTS

Plots



DATA REPORT

Reports

Atmospheric Data Types

File-Type	Jobs Success/Failure	Rate Suceess/Failure	Error Messages	Job Latency	Total Latency
leoOrb	1 / 0	100 % / 0 %	All jobs succeeded	23.61 sec	43.50 sec
occTab	3 / 0	100 % / 0 %	All jobs succeeded	1.78 sec	48.03 sec
atmObj	12 / 0	100 % / 0 %	All jobs succeeded	0.71 sec	50.85 sec
conPhs	26 / 0	100 % / 0 %	All jobs succeeded	10.89 sec	3756.15 sec
atmPrf	26 / 0	100 % / 0 %	All jobs succeeded	64.53 sec	3858.04 sec
avnPrf	26 / 0	100 % / 0 %	All jobs succeeded	33.42 sec	3920.06 sec
wetPf2	26 / 0	100 % / 0 %	All jobs succeeded	17.50 sec	3945.34 sec
bfrPrf	26 / 0	100 % / 0 %	All jobs succeeded	10.94 sec	3957.89 sec

Ionospheric Data Types

File-Type	Jobs Success/Failure	Rate Suceess/Failure	Error Messages	Job Latency	Total Latency
arcTab	1 / 0	100 % / 0 %	All jobs succeeded	1.45 sec	47.72 sec

Ops monitoring:

- Level 0 data delivery
- Raw data outage notifications
- RO data processing
- RO data delivery to operational centers

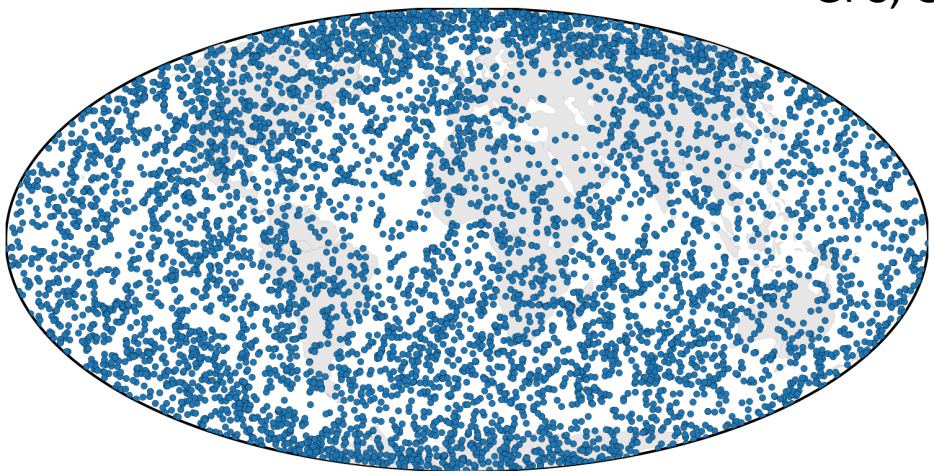
Neutral Atm. Coverage (2022-07-01)

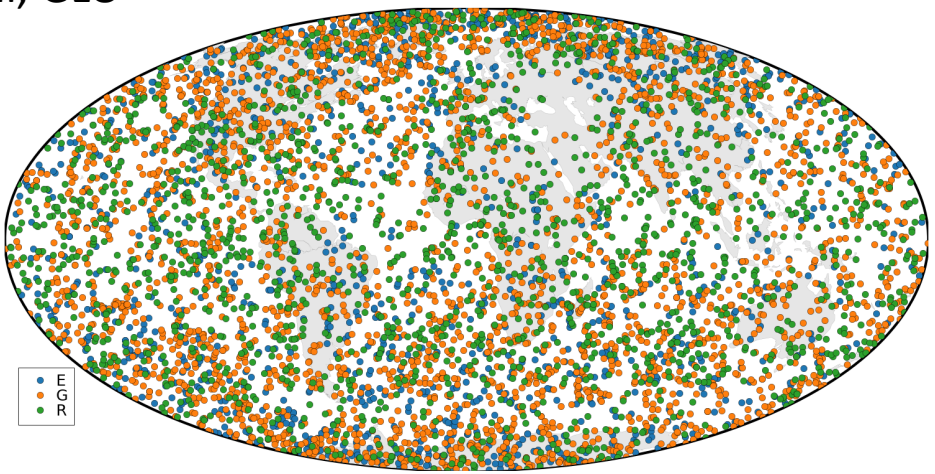
All Occultations

Color Coded by GNSS

Spire

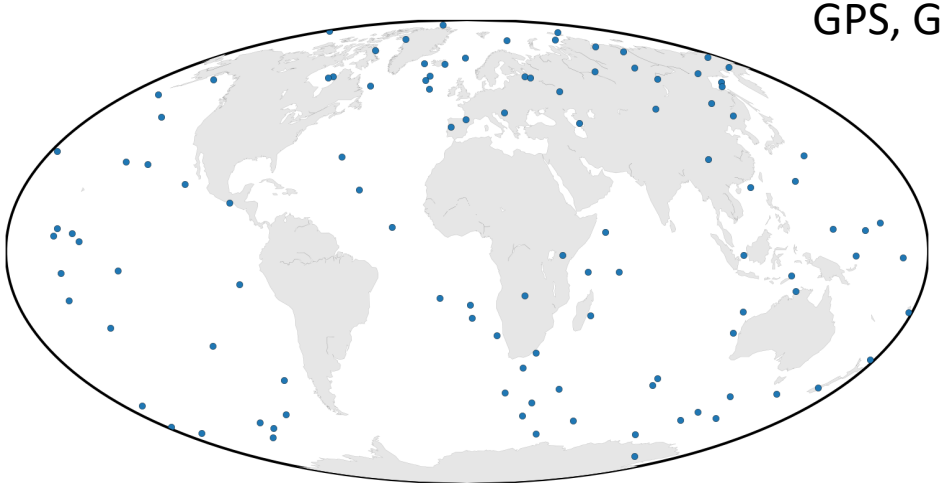
GPS, Gal, GLO

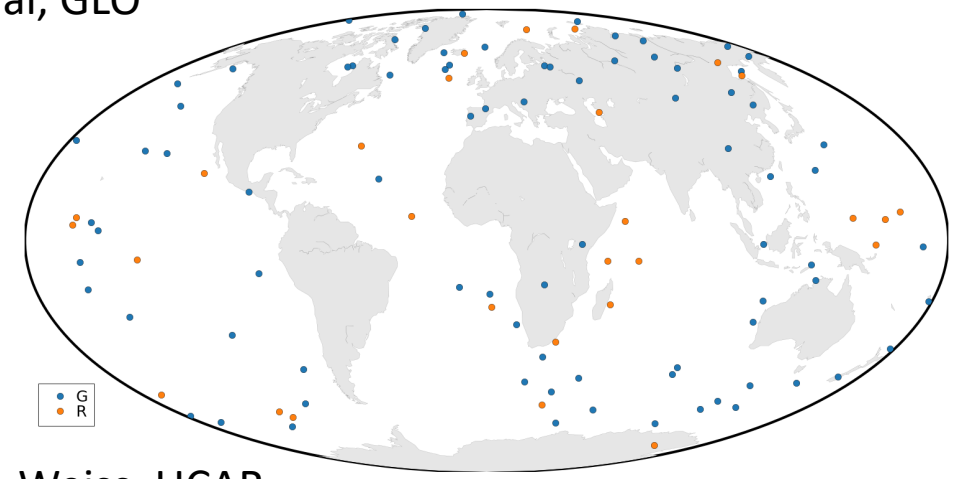




GeoOptics

GPS, Gal, GLO

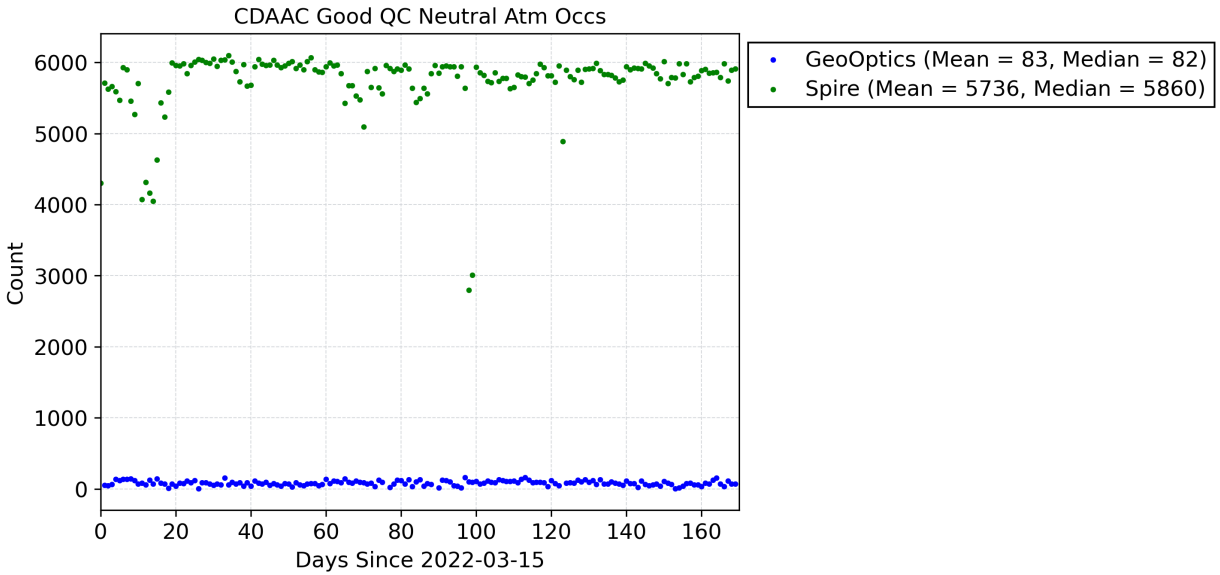


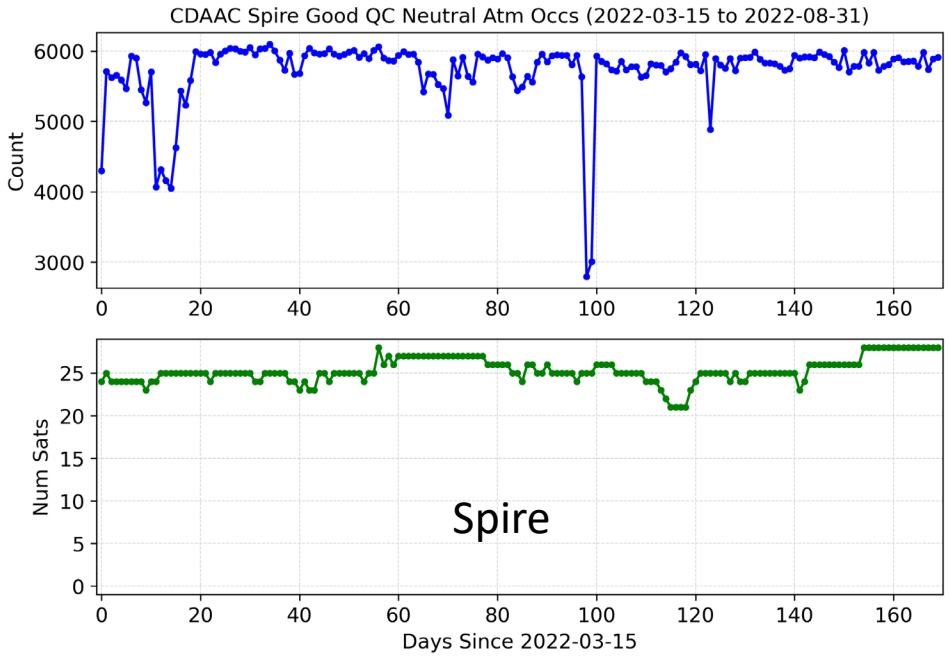


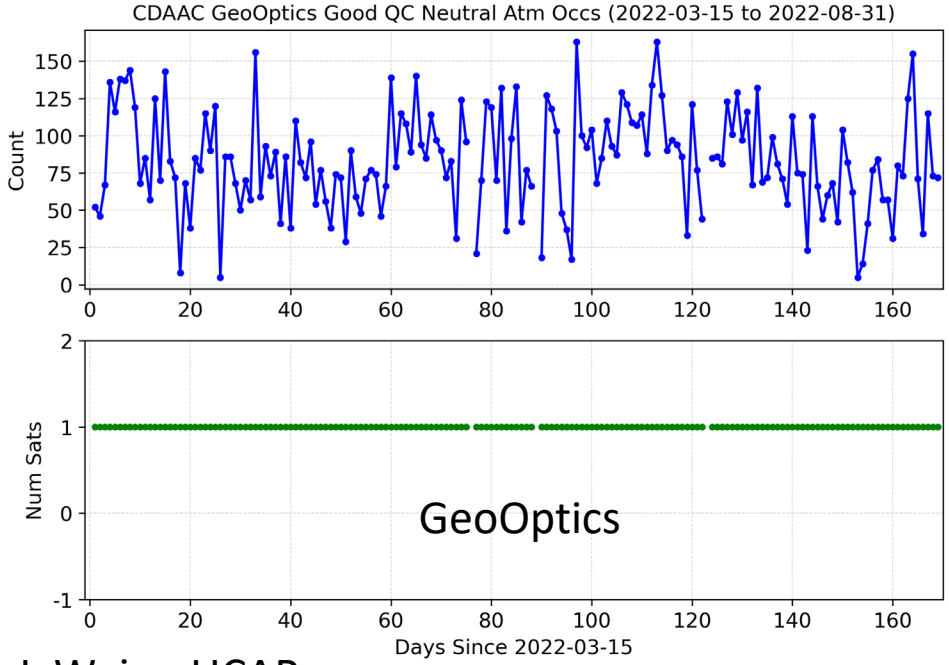
Courtesy J. Weiss, UCAR

DO4 QC'd Profile Counts

Note:
Counts show standard CDAAC QC, these differ from "compliant" counts (see IROWG 2022 McHugh presentation)



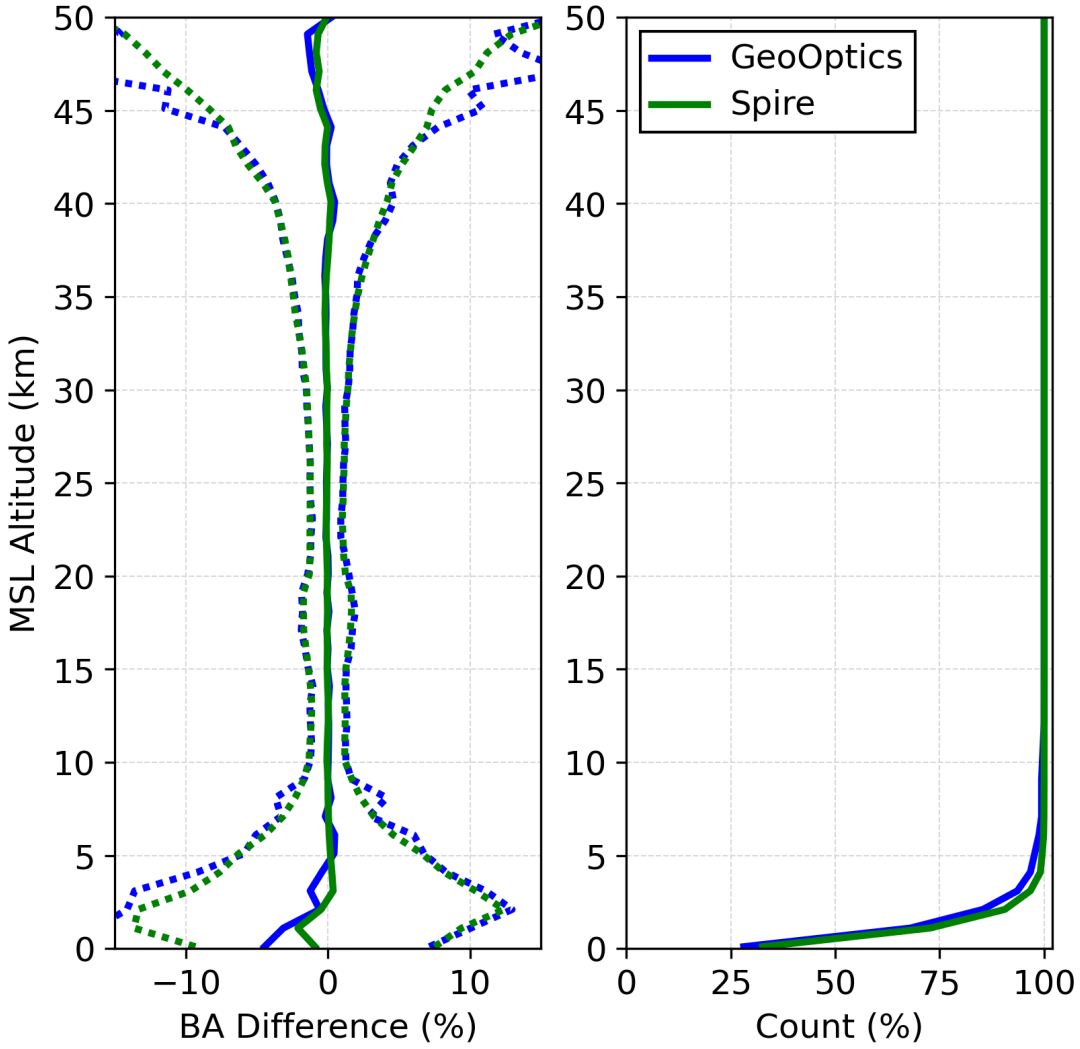




Courtesy J. Weiss, UCAR

Bending Angle Metrics

- Near real-time profiles compared to ECMWF short-term forecast
- 2022-08-28 to 2022-09-03
- Number of profiles included
  - GeoOptics, 484
  - Spire: 39,495

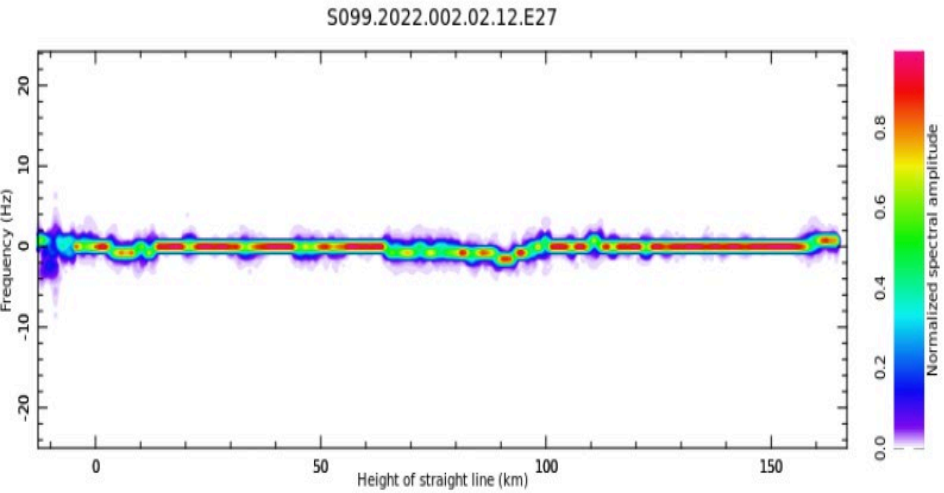


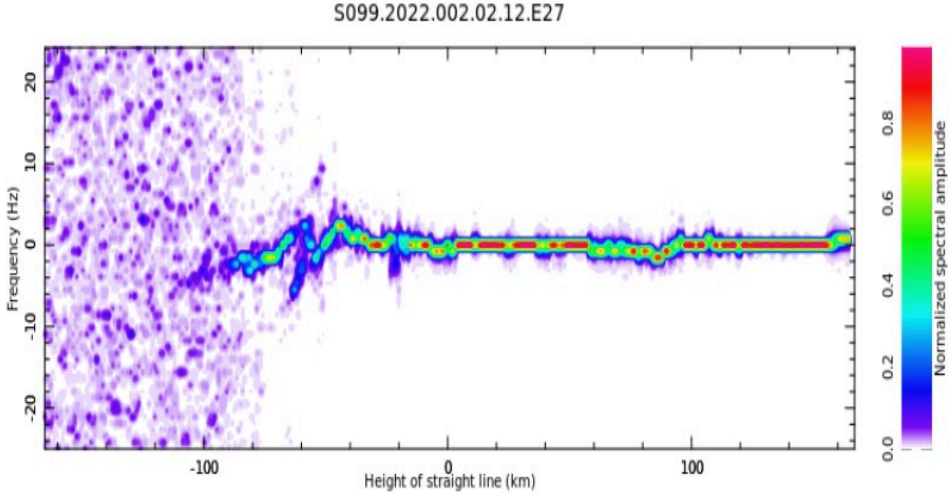
New Functionality

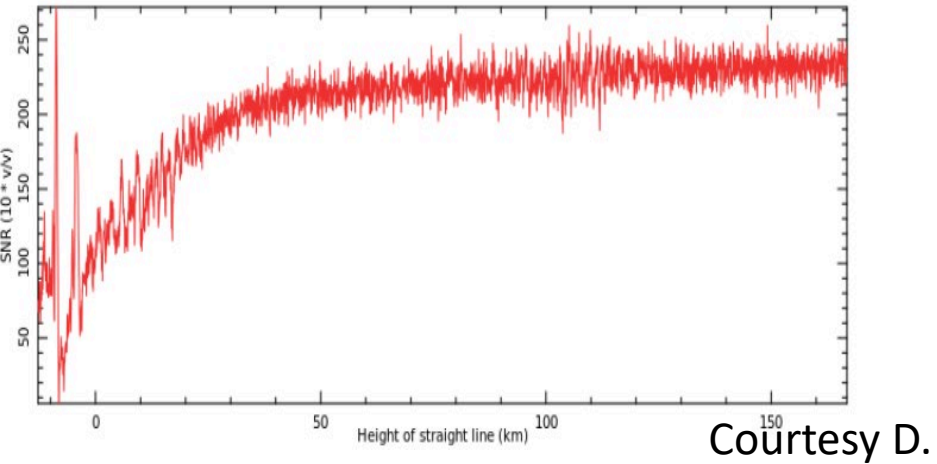
- Since DO3, processing GPS, GLONASS, and Galileo (new for us) occultations
- Since DO4, handling multiple RO reference links
  - Like many missions, Spire processing is done in single difference mode to remove effects of LEO clock
  - Spire schedules observations such that sometimes more than one reference link is needed to span an occultation
  - CDAAC implemented capability to process occs with multiple reference links for DO4
    - Implemented in excess phase processing
      - Cycle through all GPS PRNs to find segments of reference link data
      - Segments then assembled and phase-leveled into one sequence which are applied to the high rate occultation data
    - Thanks to Spire for helpful technical discussions
  - Results in ~9% additional occultations each day

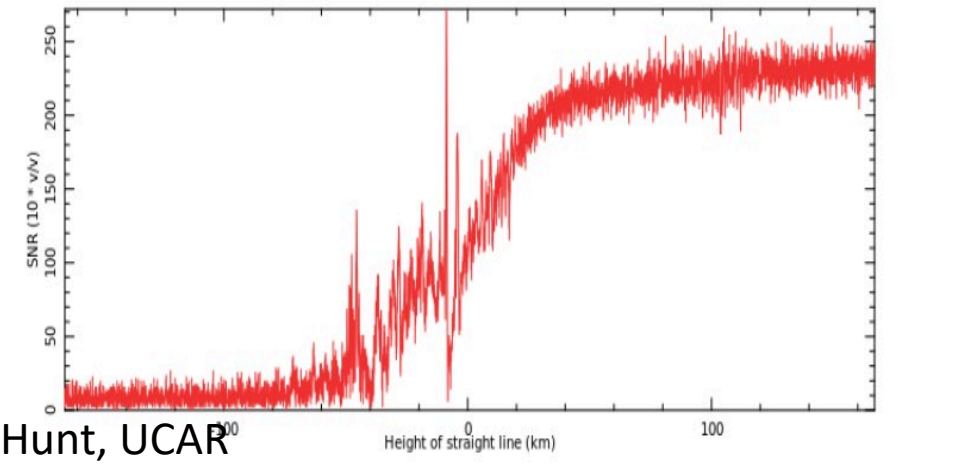
Dual Ref Link Example

- Spectrograms for two occultations shown
- Single ref link on left, multi ref links on right
  - Note deeper penetration in the multi ref link case





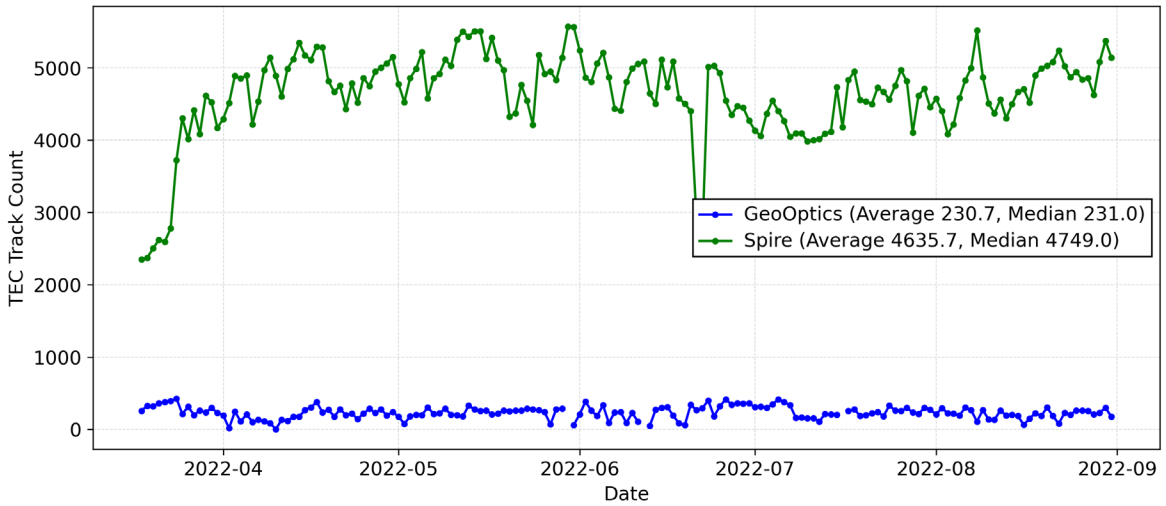




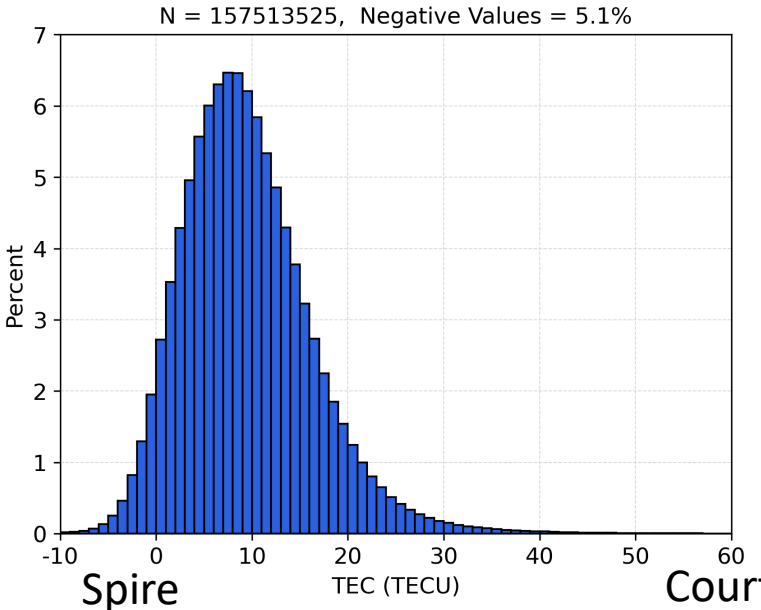
Courtesy D. Hunt, UCAR

Total Electron Content Metrics

- DO4 TEC track counts

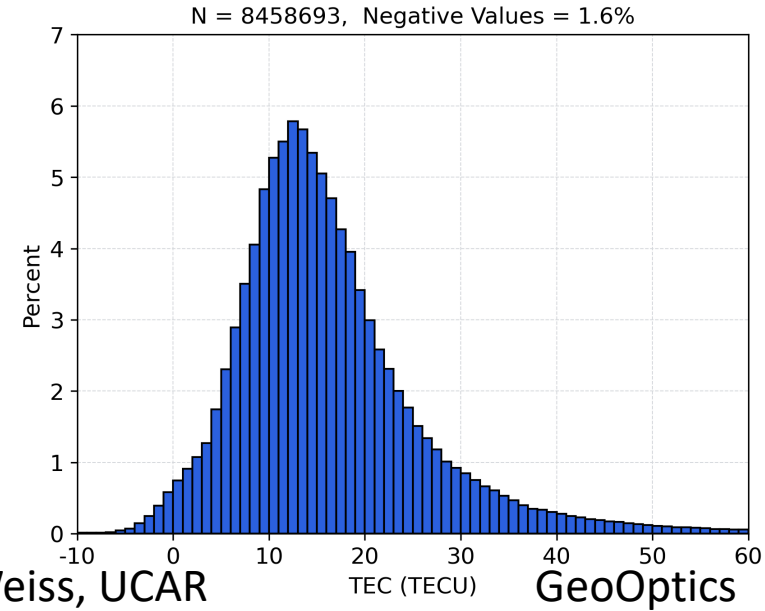


- TEC distributions



Spire

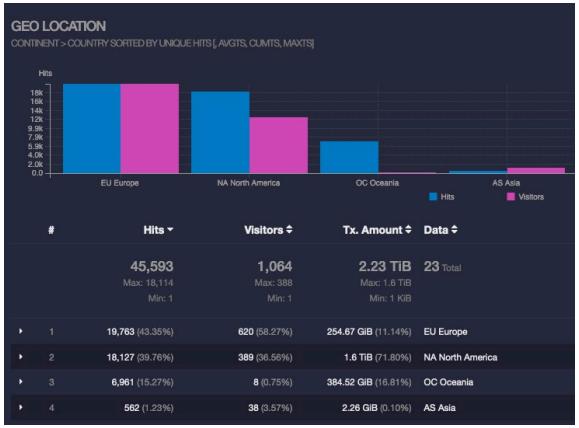
Courtesy J. Weiss, UCAR



GeoOptics

Data Availability and Downloads

- All data, intermediate and higher level products published openly after 1 day delay
  - Per NOAA CDP data policy
    - Note, could change for future delivery orders
  - Easily scriptable https downloads
  - Daily tar file by mission and file type
- Spire data
  - https://data.cosmic.ucar.edu/gnss-ro/spire/noaa/nrt/
- GeoOptics data
  - https://data.cosmic.ucar.edu/gnss-ro/geoopt/noaa/nrt/



Month 2022	Downloads Spire & GeoOptics (TB)
March	0.215
April	1.15
May	1.05
June	2.04
July	1.78
August	2.23

Summary

- NOAA CDP provides significant volume of commercially sourced RO data products to operations and science communities
- CDAAC operational processing, delivery, and monitoring of neutral atmospheric and space weather products routine
- Incremental improvements enhance quantity and quality of products
  - E.g. Galileo RO, dual reference links
- Products made openly available to the research community after delay
- Recently commenced space weather pilot expected to develop additional ionosphere products for future operational use

Thank you and credits

Willie Lopez

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Thank you!

NOAA
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GeoOptics