First Balloon-borne GPS Radio Occultation Profiles from Strateole-2 Campaign

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ROC2 Campaign Results (Haase and Cao)

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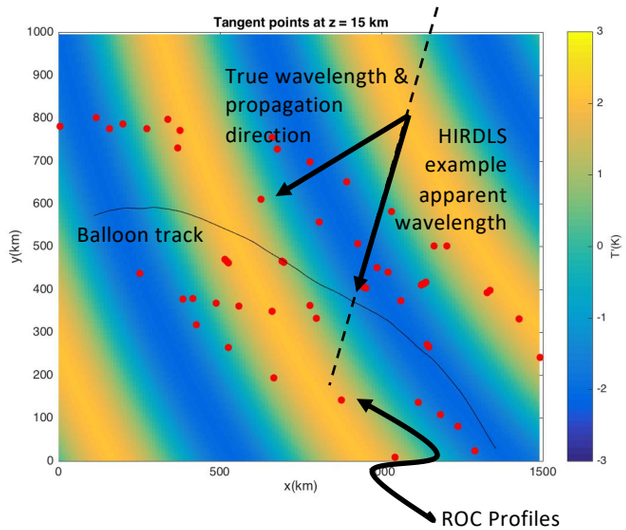
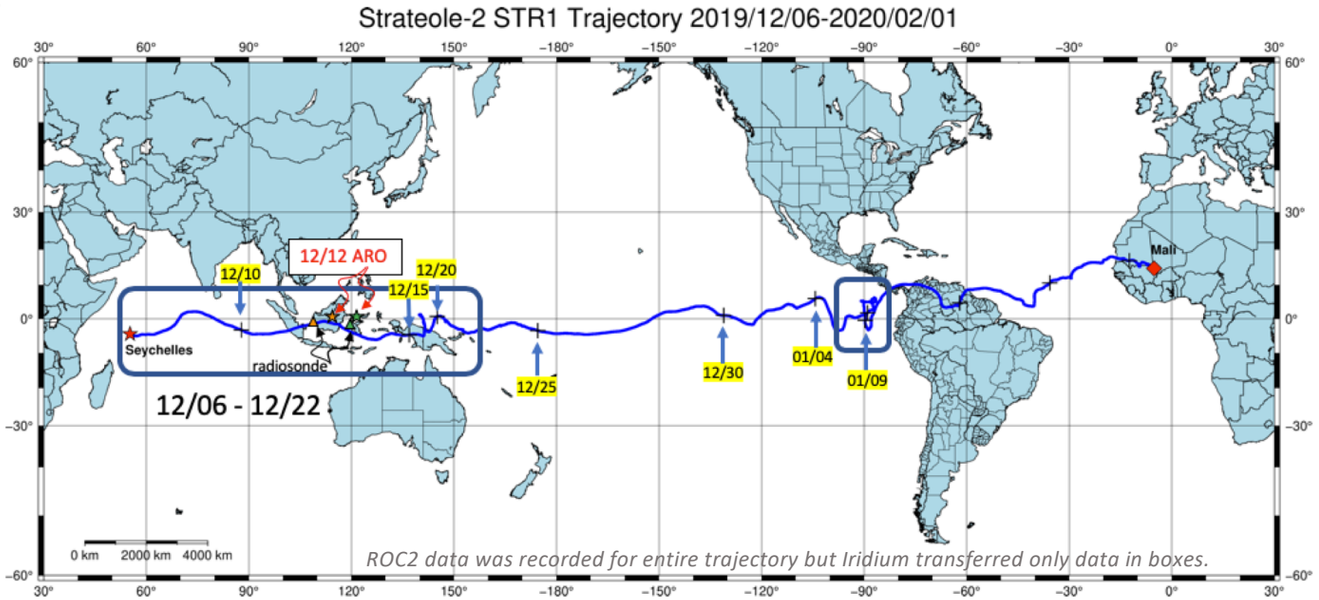
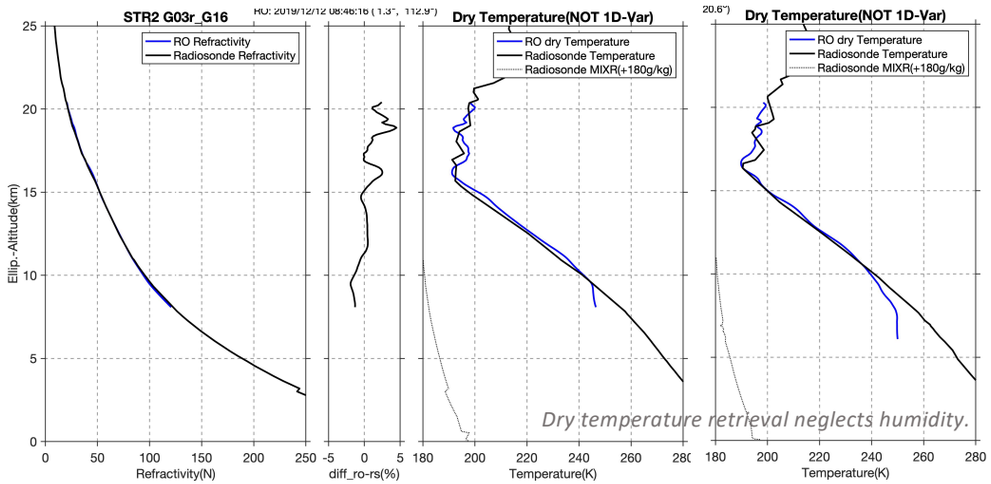
- ROC2 Goals are to densely sample thermodynamic profiles to provide 3D representation of waves.

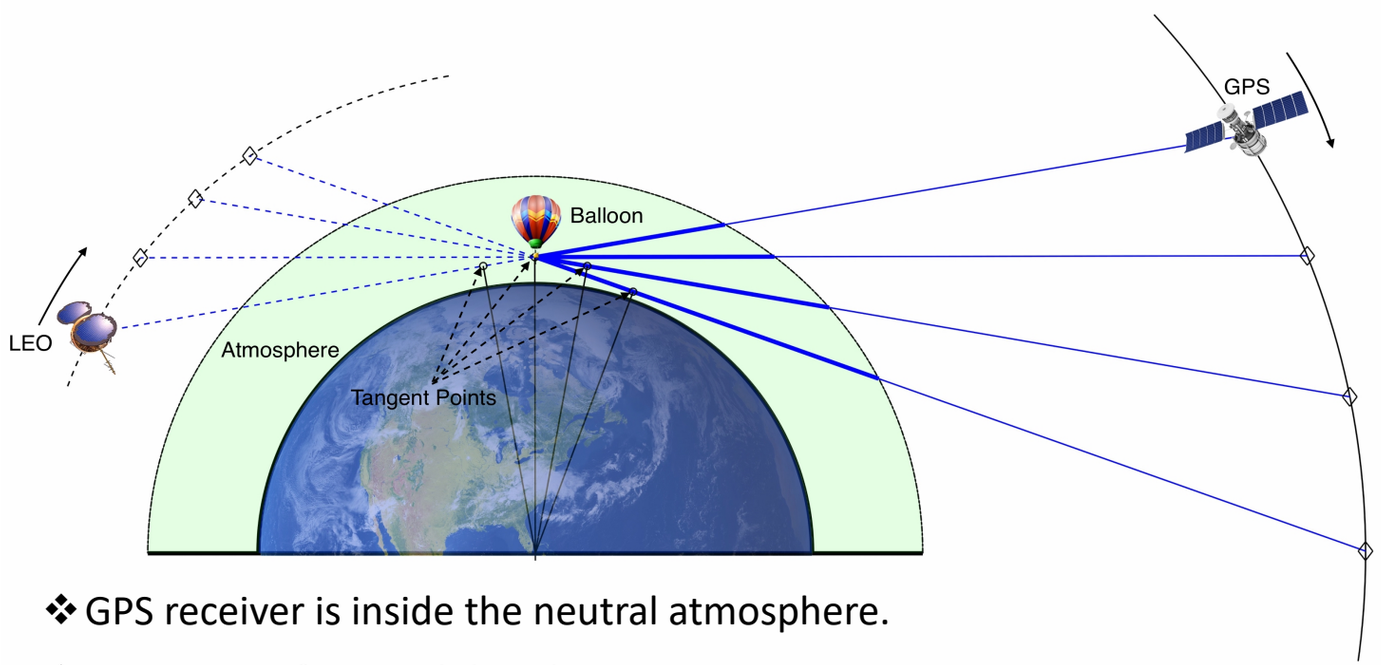




- ROC2 was flight tested in Jan 2018 and integration and Iridium comms verified in June 2019 at LATMOS
- ROC2 recovered 17 days of continuous data plus 6 additional days with expected 25 profiles per day
- Preliminary temperature retrievals show wave structure in stratosphere and are consistent with radiosonde profiles to the expected level of variability.

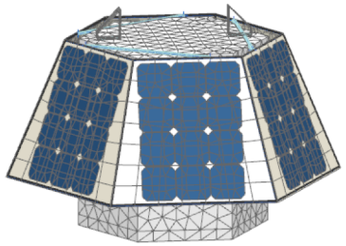


Geometry of Airborne & Balloon-borne RO

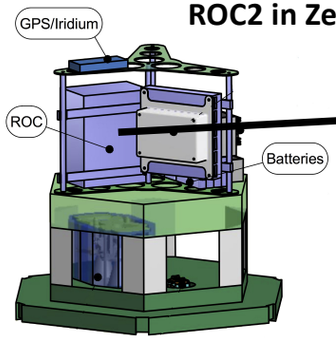


- GPS receiver is inside the neutral atmosphere.
- Geometry of ray path bending is asymmetric.
- The lowest tangent point can be ~300 km to the side of the profile top.
- Profile retrieval is possible only below flight level.
- Small errors are introduced by the profile above flight level.

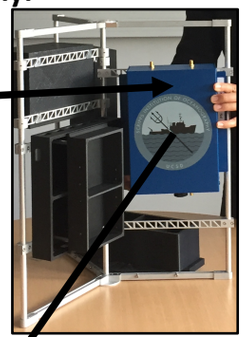
Radio OCcultation V2 (ROC2) Instrumentation

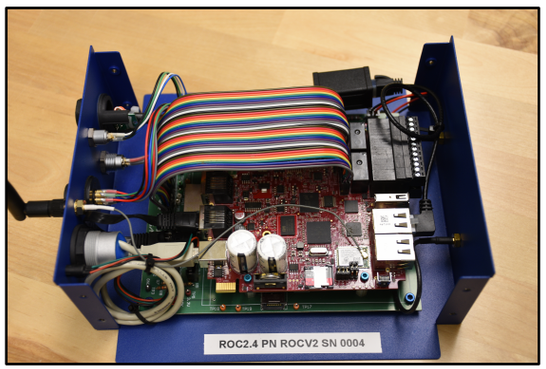


Two GNSS Antennas



ROC2 in Zephyr

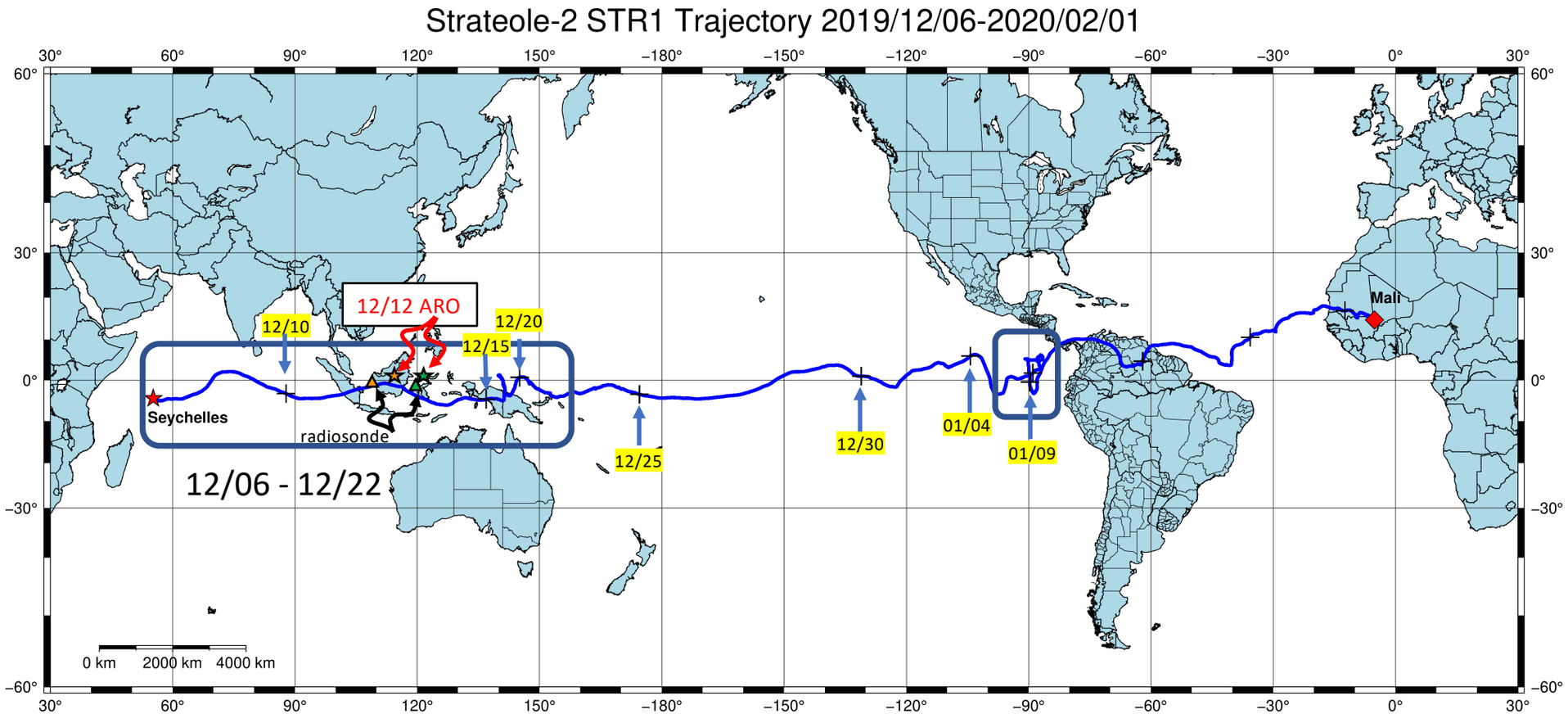




ROC2 Receiver

- Contains a multi-frequency **Septentrio AsteRx4** OEM board with 2 GNSS receivers and two side-looking avionics GNSS antennas.
- Interface with the new Zephyr gondola designed by the LMD and an Iridium communication modem for data transmission to the Mission Control Center.
- Receiver is capable of tracking all GNSS signals (GPS, GLONASS, Galileo, Beidou). However, tradeoffs will have to be made based on data rates.

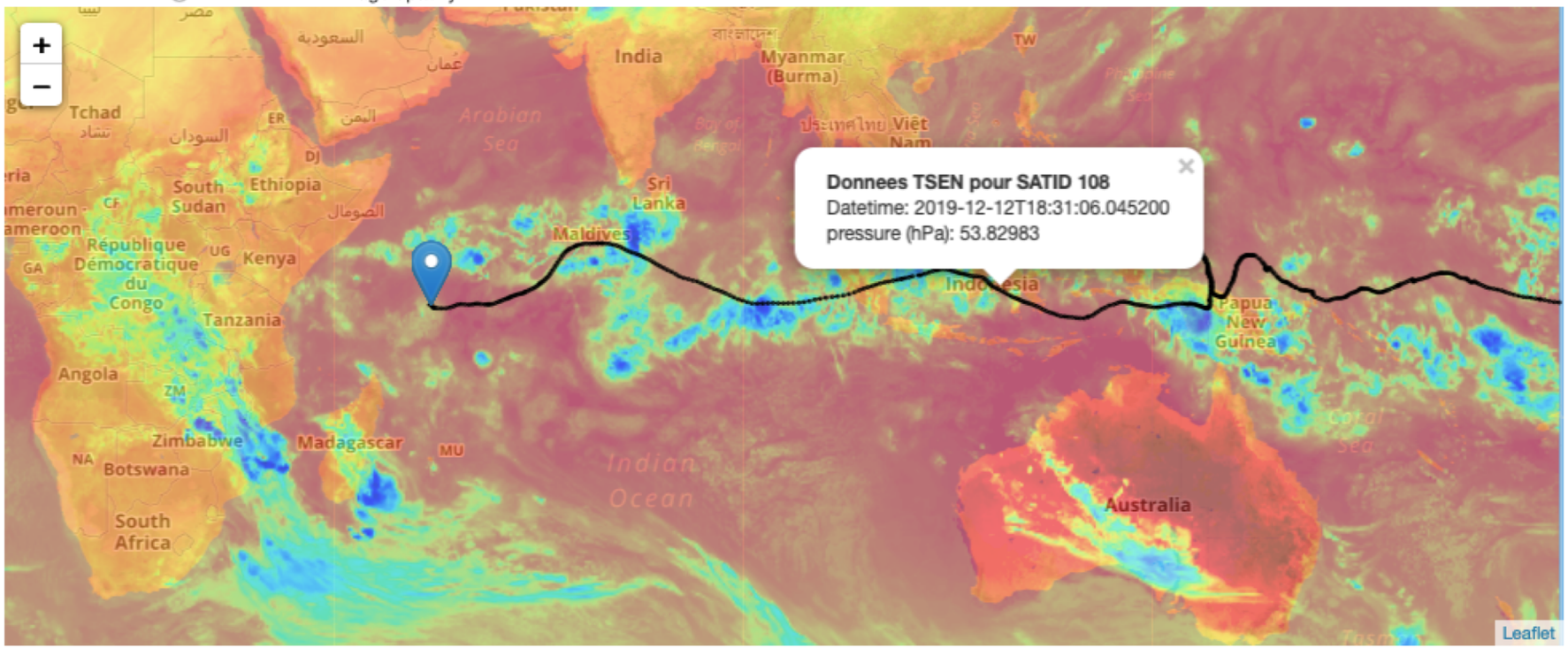
Trajectory of STR1 balloon of Strateole-2 Campaign

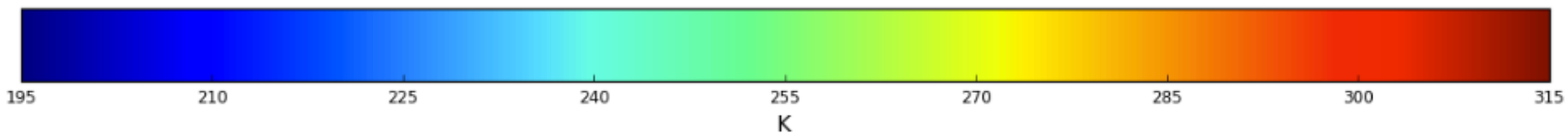


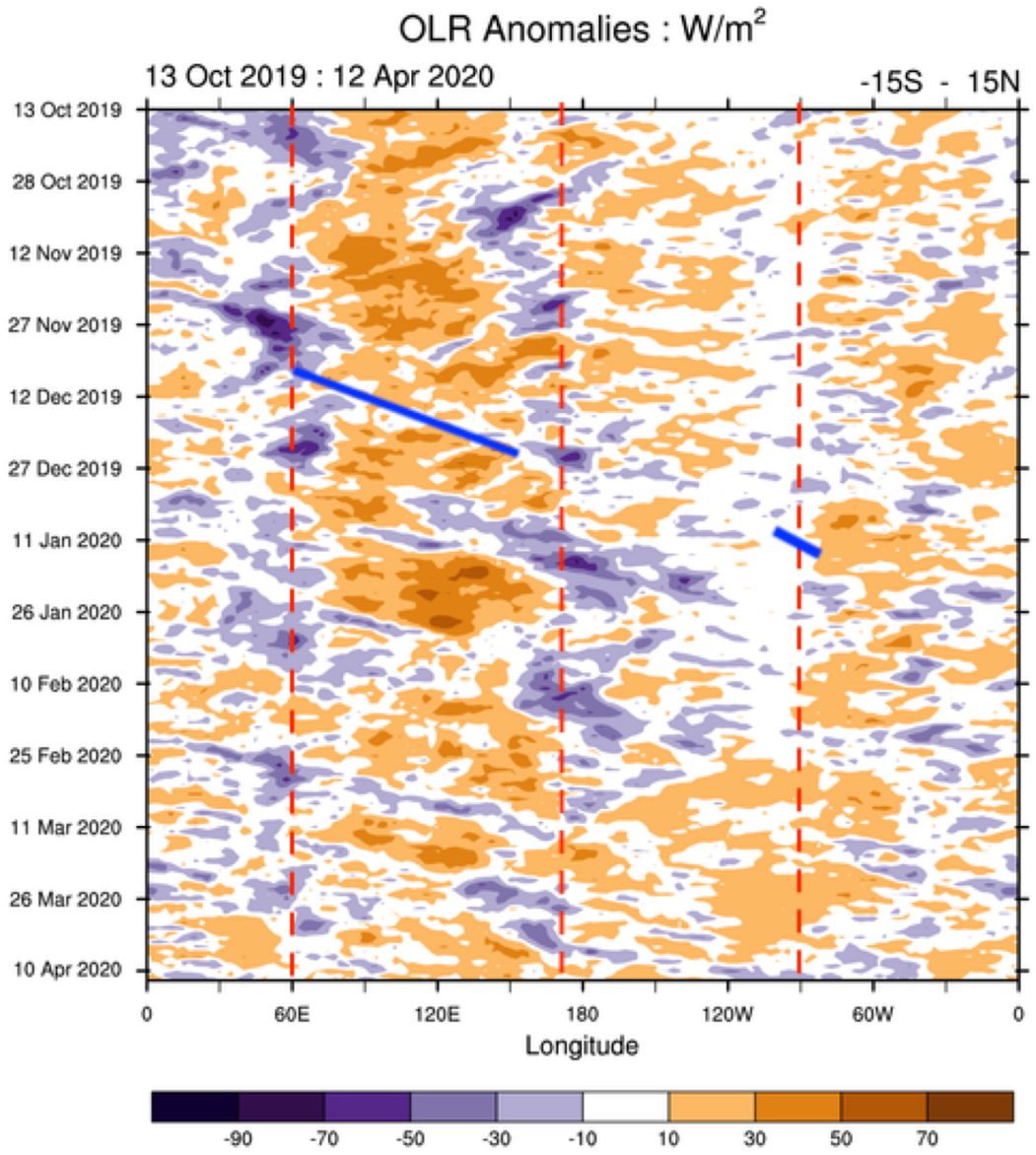
- Data recovered from Iridium link is mostly from the area in boxes, 17-day continuous part in Indian Ocean/SW Asia, some from East Pacific near South America.

Quicklook	«	ECMWF MSG	»	«	IR-108	»
Date	«	Dec 12 2019		00h00	UTC	»
Forecast date	«	2019-12-12 00:00			All Forecasts	»
Trajectories	«	Traj & Forecasts Traj of Gondolas	»	ST2_C0_06_STR1		

Image opacity

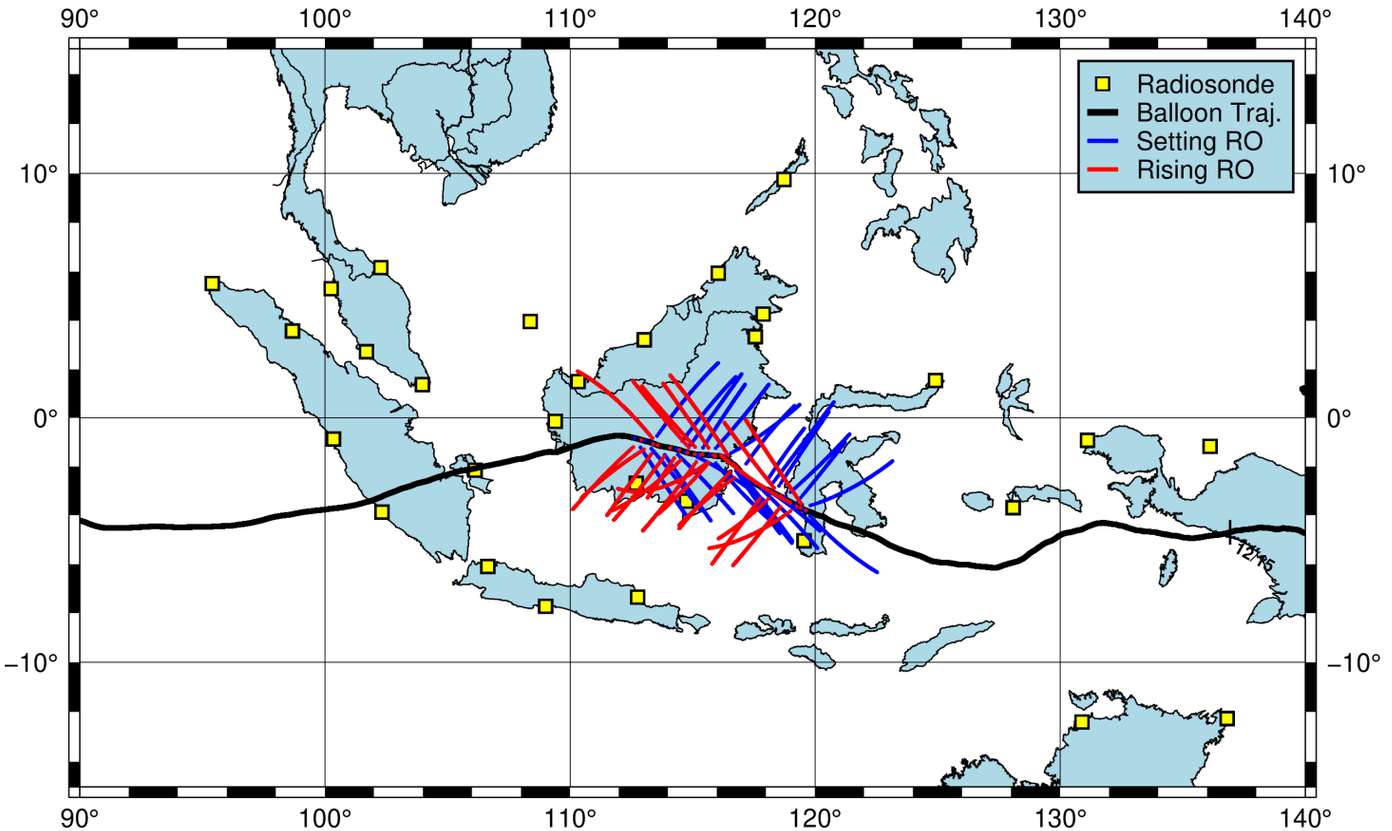




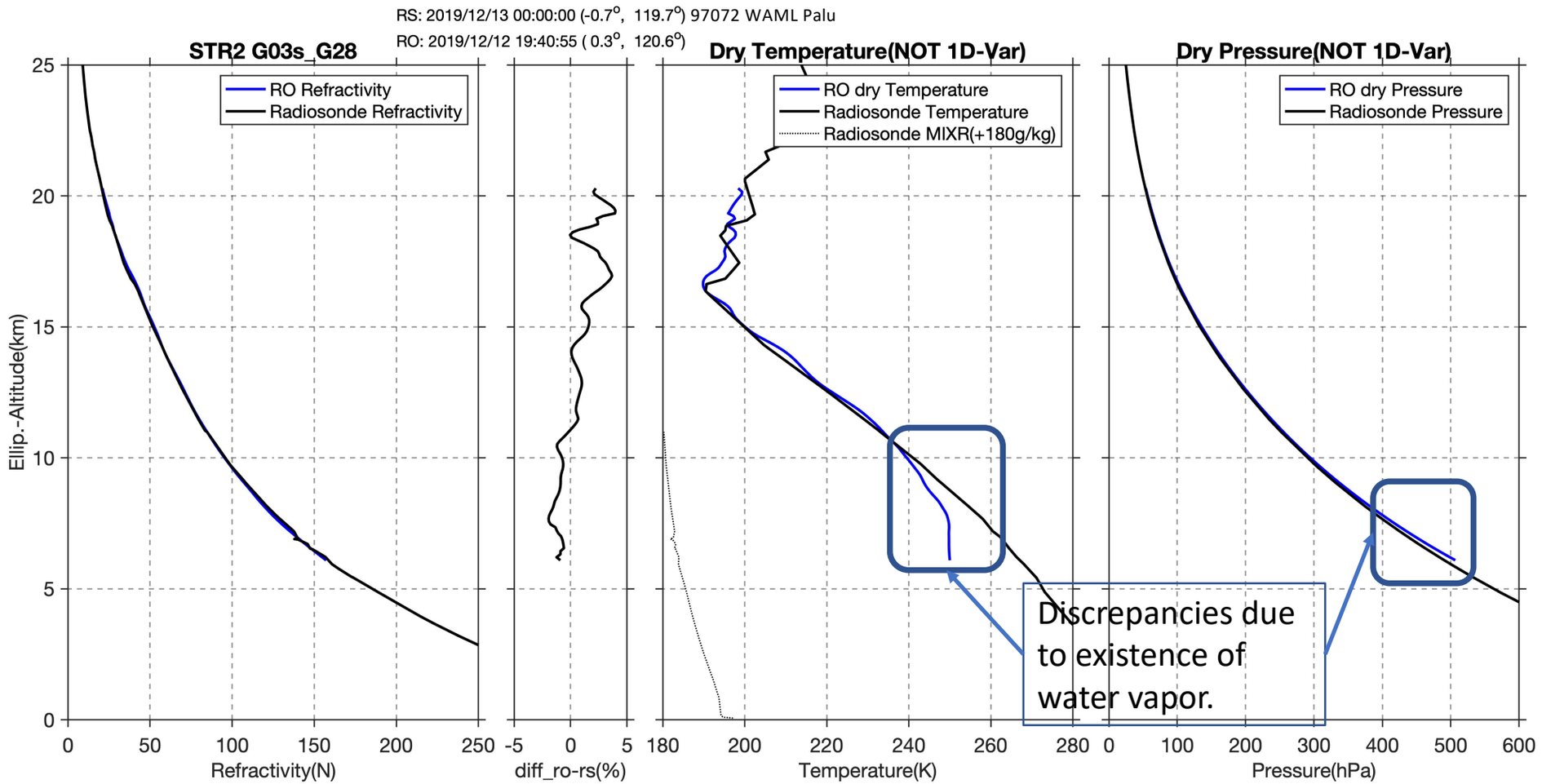


- OLR Anomalies: W/m2
- Thick blue line roughly demonstrates the part of balloon trajectory along the equator that valid data was recovered.

Coverage of occultations over one day



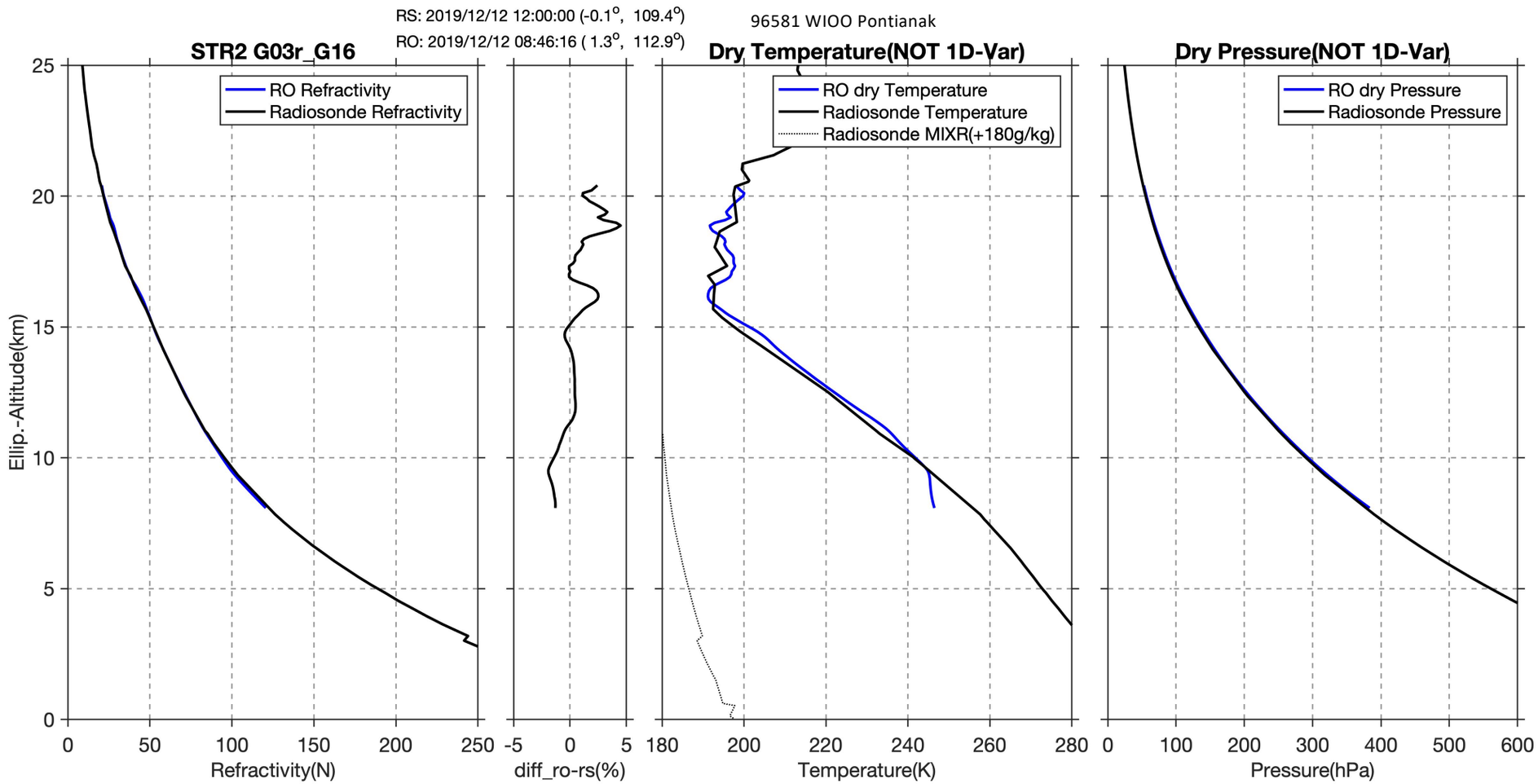
Dry Temperature Retrieved from Hydrostatic Equilibrium



2019-12-12 19:40:55 (0.3°N, 120.6°E)

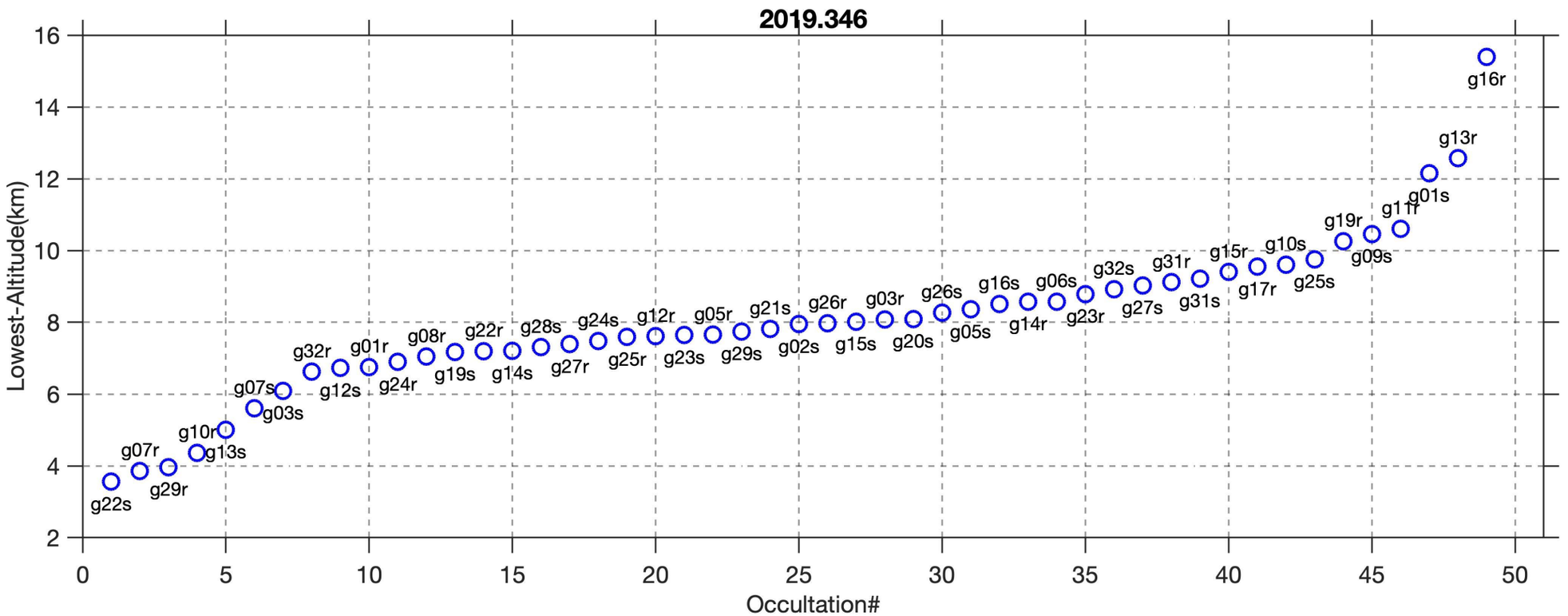
Radiosonde data selected from a nearby station.

Comparison of profile with radiosonde

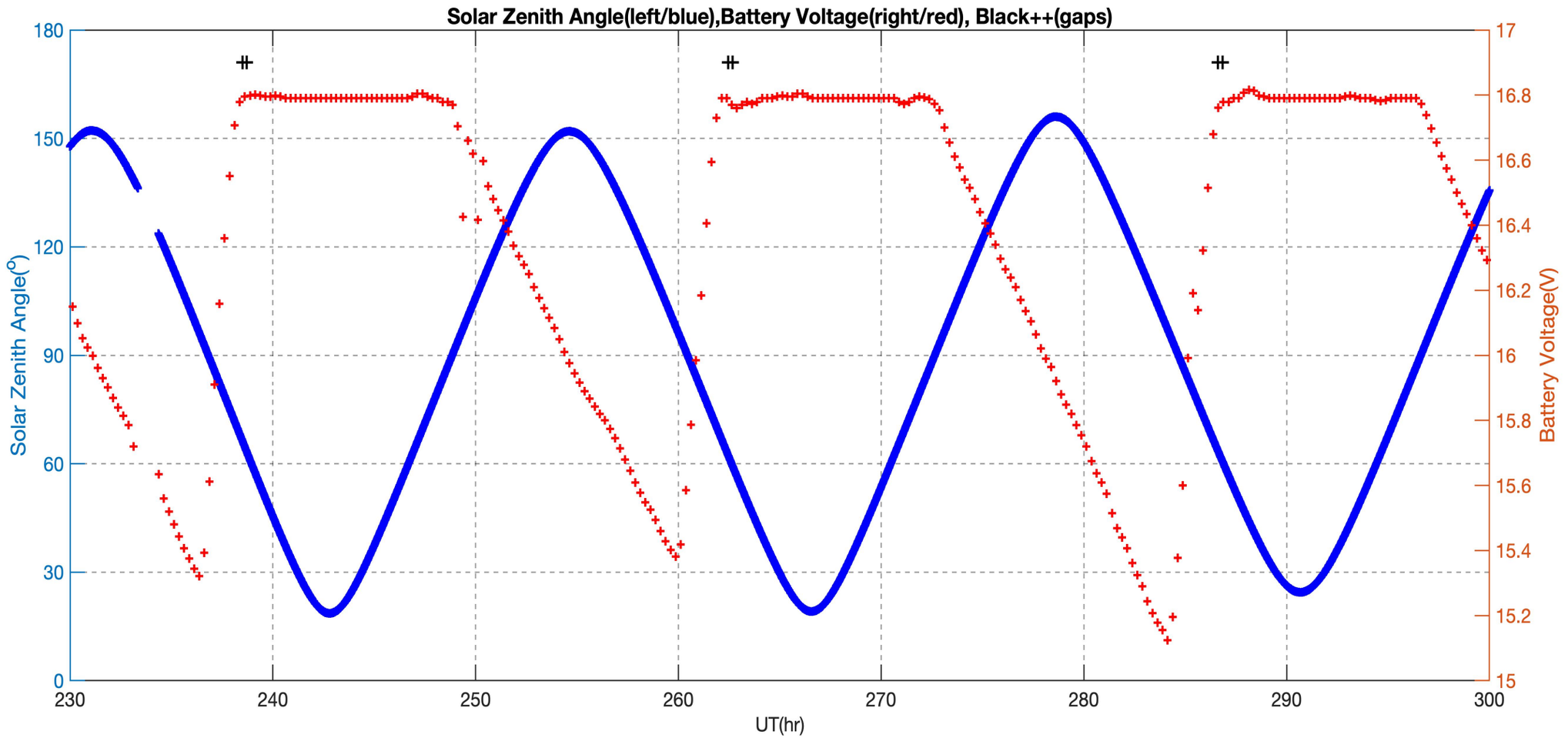


2019-12-12 08:46:16 (1.3°N, 112.9°E)

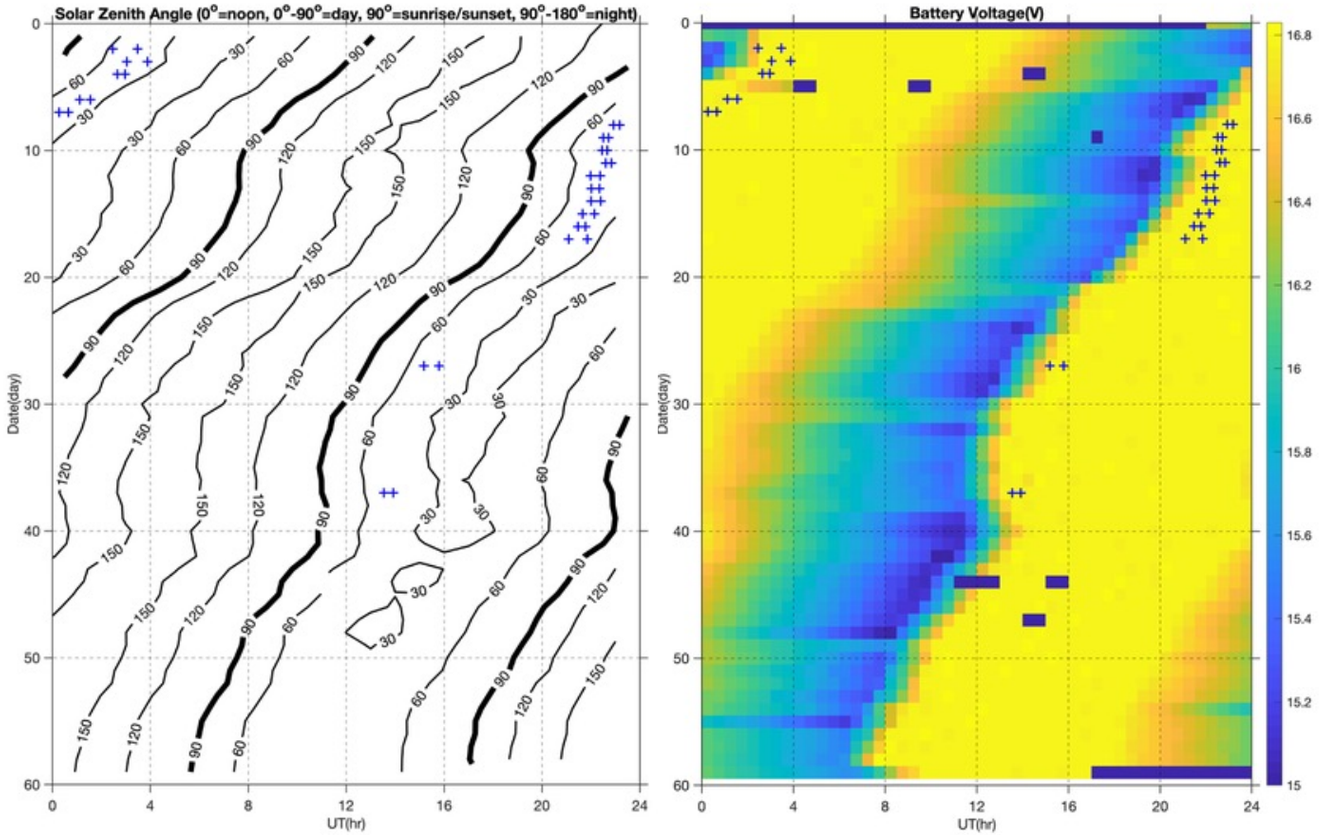
Lowest altitude of profile for each occultation



Periods when ROC2 lost GNSS tracking correlated with SZA
(EMI interference related to power management?)



Gap in GNSS satellite tracking for 1 hour each day correlated with solar zenith angle



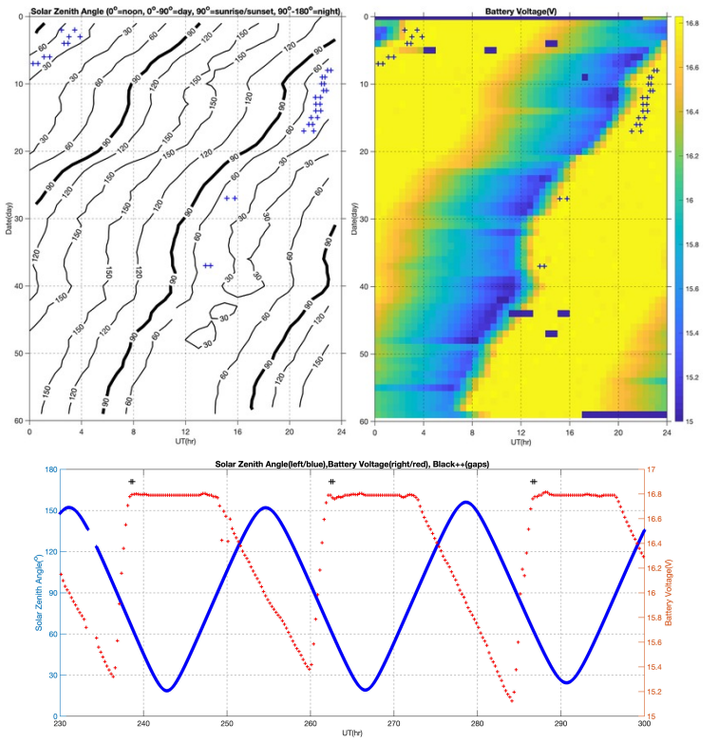
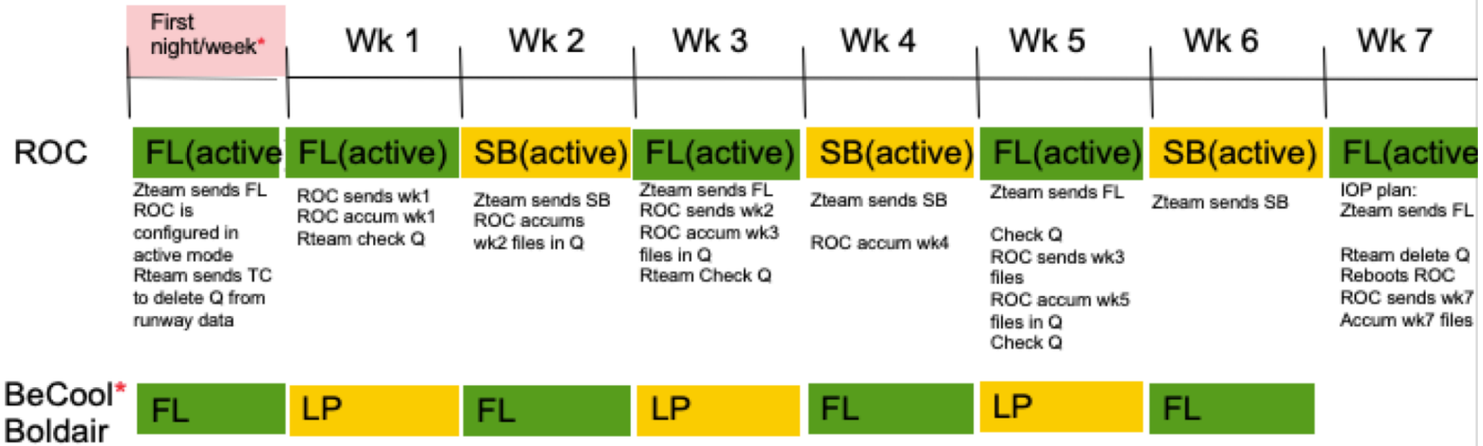


Figure 7 (top left) Solar zenith angle and (top right) battery voltage with UT time and days counted from the launch day. (bottom) The temporal series of solar zenith angle, battery voltage. The pair of crosses marks the start and end times of gaps in each day, identified from the recovered data. No crosses in other days because no data is recovered. However, there is a high probability that there are gaps in data from other dates even though we did not recover them.

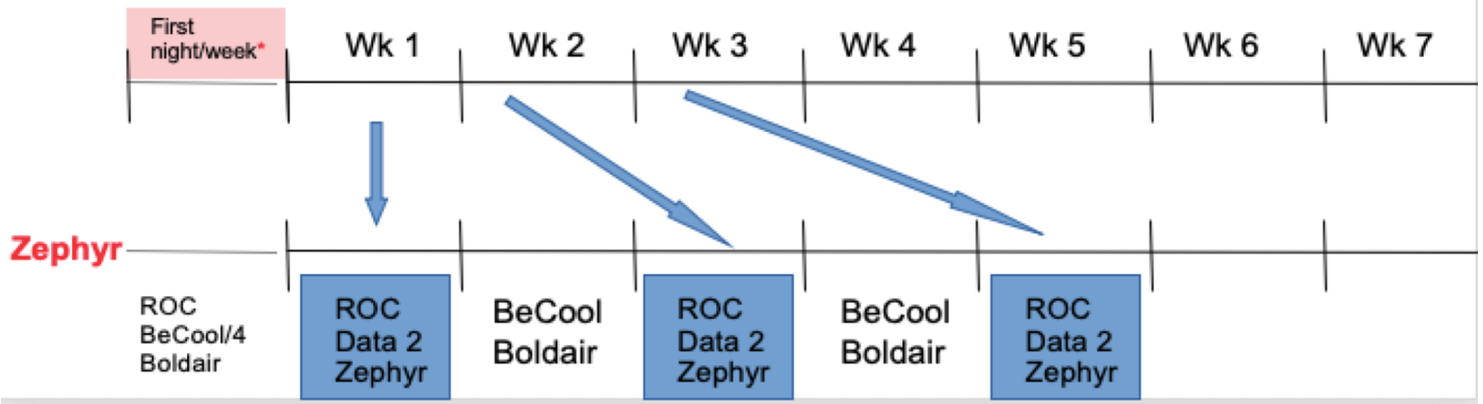
Observational cycles :

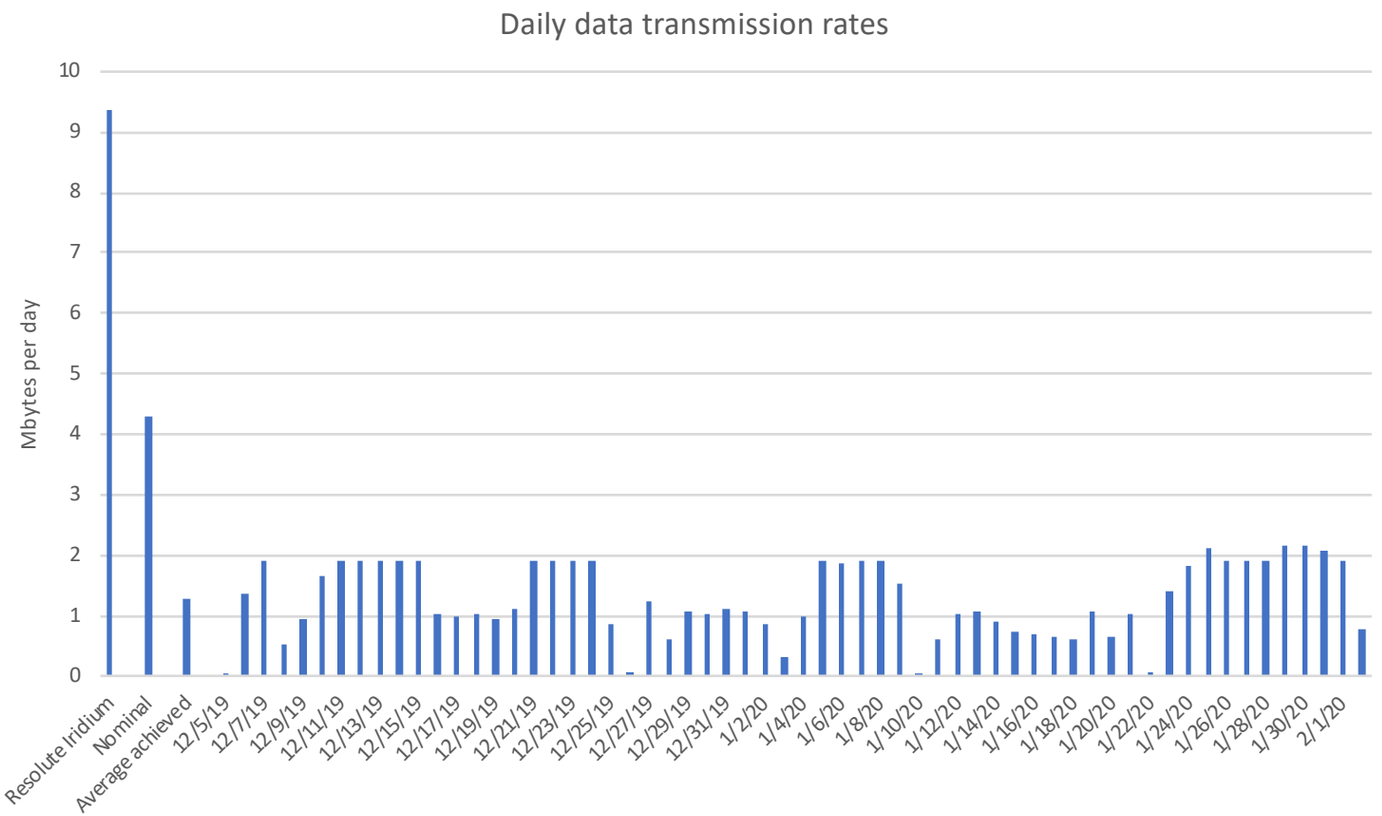
Biweekly cycles ; BeCool and Boldair can send their data together



* For additional information on configuration on first night/week, see next slide

Data sent from ROC to Zephyr :




Daily data transmission rates
Mbytes per day
10
9
8
7
6
5
4
3
2
1
0
Resolute Iridium
Nominal
Average achieved
12/5/19
12/7/19
12/9/19
12/11/19
12/13/19
12/15/19
12/17/19
12/19/19
12/21/19
12/23/19
12/25/19
12/27/19
12/29/19
12/31/19
1/2/20
1/4/20
1/6/20
1/8/20
1/10/20
1/12/20
1/14/20
1/16/20
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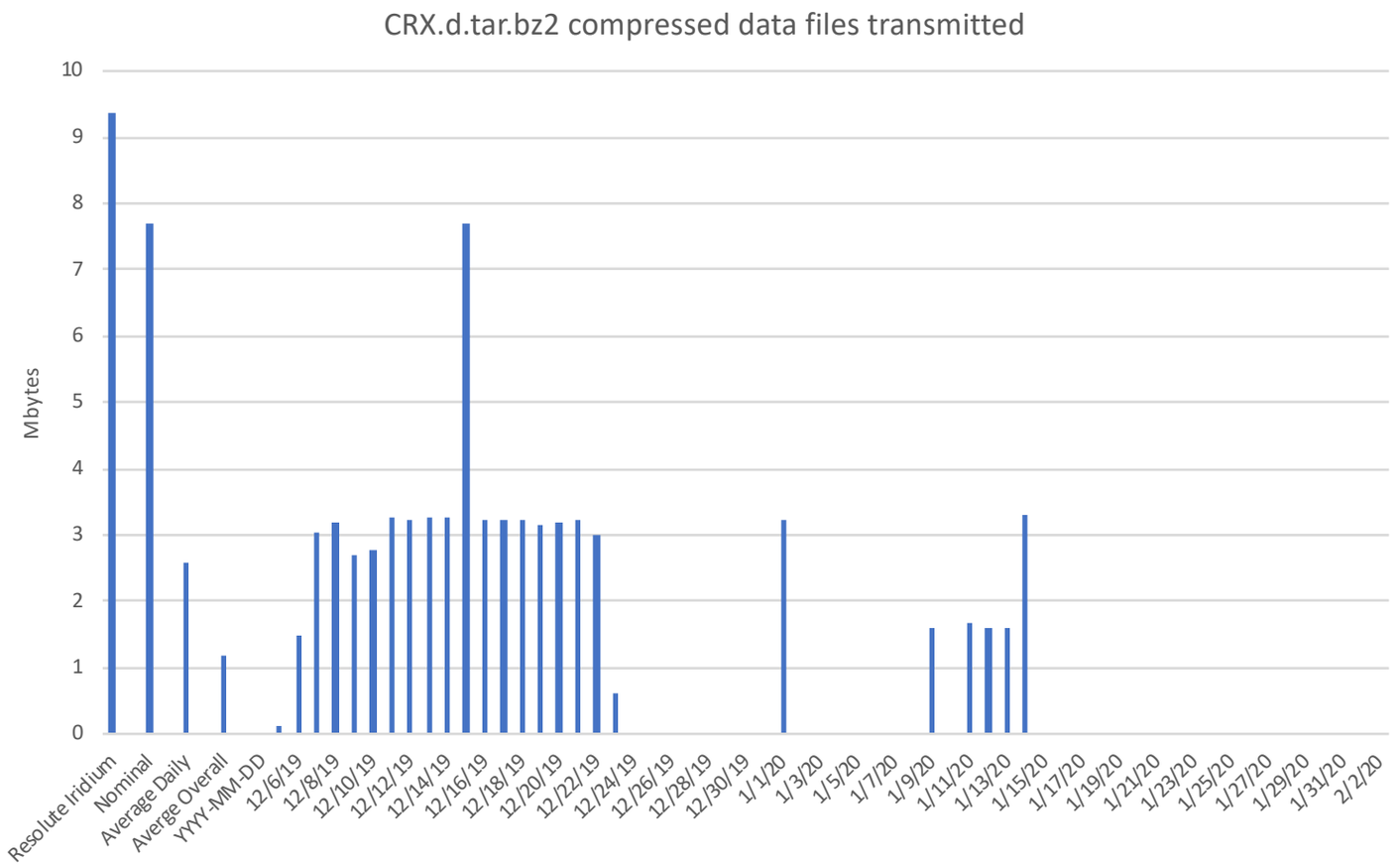
1/26/20
1/28/20
1/30/20
2/1/20


CRX.d.tar.bz2 compressed data files transmitted
Mbytes
10
9
8
7
6
5
4
3
2
1
0
Resolute Iridium
Nominal
Average Daily
Averge Overall
YYYY-MM-DD
12/6/19
12/8/19
12/10/19
12/12/19
12/14/19
12/16/19
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12/20/19
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1/31/20
2/2/20

ROC2 Campaign Results (Haase and Cao)

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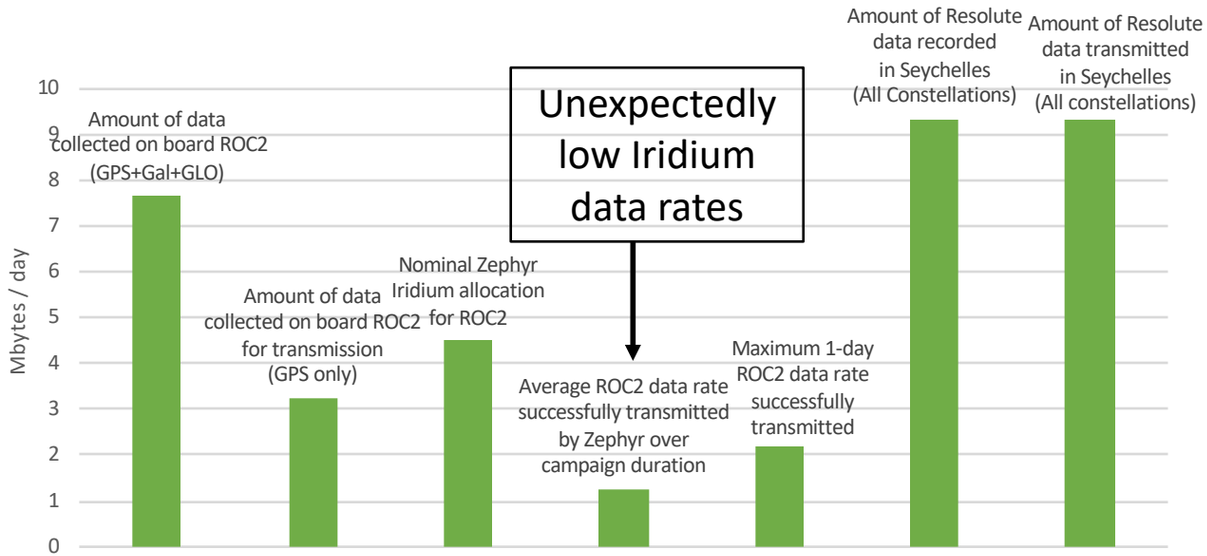
Issues encountered during campaign

- Iridium comms did not perform at nominal rate
  - Forced to send GPS only without Galileo => number of profiles reduced by half
  - Forced to alternate transmission with other instruments
  - Forced to transmit slower than recording (> half the data set not recovered
- Solutions
  - Dedicate an extra Iridium modem to ROC2 alone
  - Improve OBCZ Iridium management software
  - Fly an extra Xeos Resolute receiver with self-contained comms on spare Zephyr gondola to assure science objectives met.
- ROC2 lost GNSS tracking for ~1 hour daily periods correlated with SZA and voltage
  - 1/24 data loss
  - Loss of positioning accuracy when continuous GPS processing has a break in the middle of the day
- Solutions
  - Test switching from current regulated to voltage regulated in MC2 and measure EMI
  - Ship a ROC2 to LATMOS to perform tests in solar energy configuration



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