ILRS QCB Meeting
May 14, 2020
9:00 am
Agenda

- Briefing on ASC Meeting on May 11 (10 min) — Erricos Pavlis.
- Station Briefings – focus on new/CORE sites (5 - 10 min each)
- What is happening? Projected operations?
  - Japan Network — Toshi Otsubo
  - AGGO Station — Stefan Riepl
  - Yebes Station — Jose Rodriguez
- The path to improved data Integrity (30 min) — Peter Dunn
  - Process and Benefits
  - Identify course of action
  - What is the relationship between the C/M corrections derived by Jose (and others) and any correction that we would make for skew, kurtosis, etc)
- Station data: Recent Issues (15 min) — Van Husson

- Other issues to be discussed at another time: Alternate method/studies for computing NPs

International Laser Ranging Service

# ILRS Quality Control Board

Erricos C. Pavlis and Cinzia Luceri

ILRS Analysis Coordinators

QCB Virtual Online Meeting
May 14, 2020

# ILRS ASC - Analysis Activities

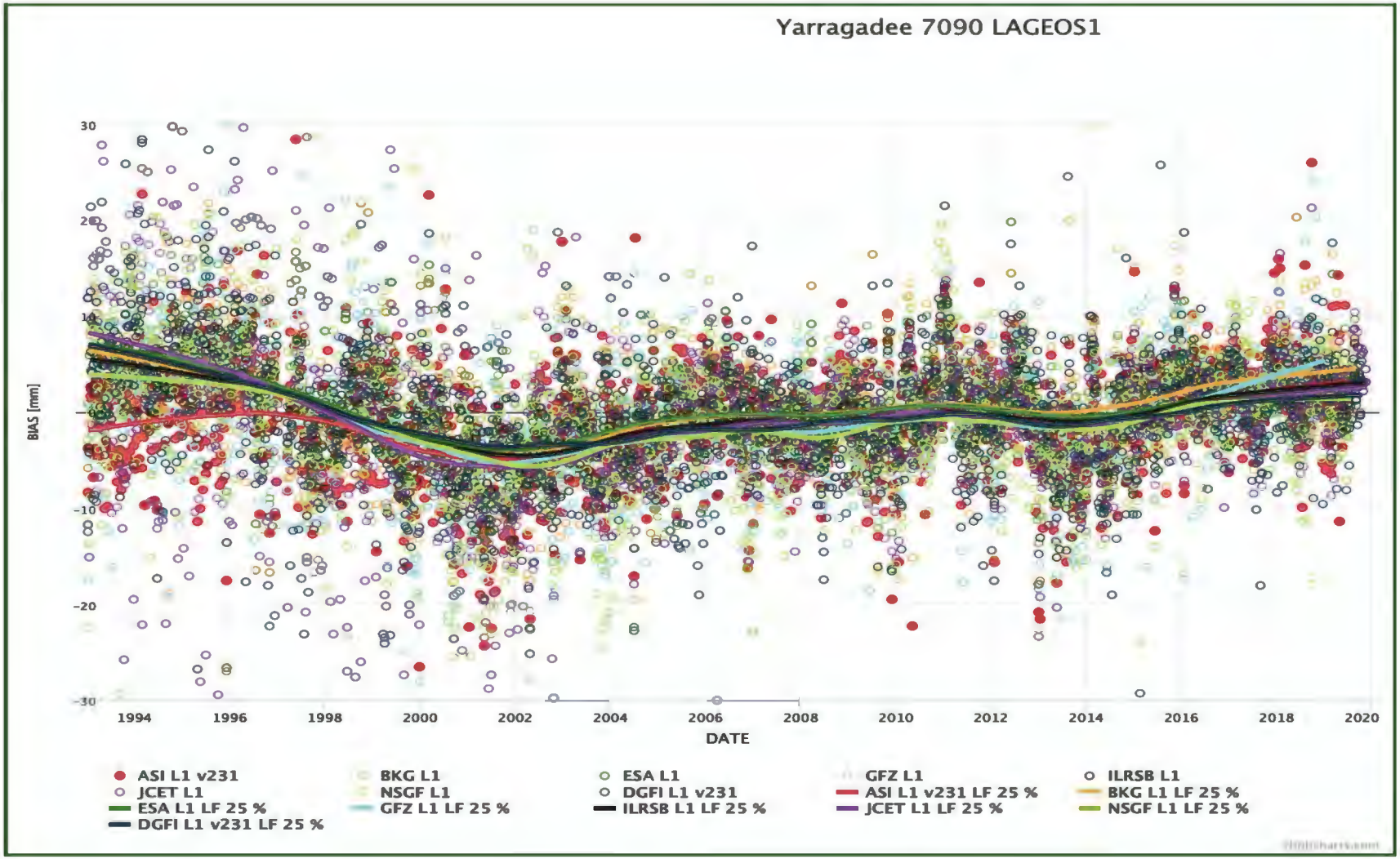
- Preparations for contributing to the development of ITRF2020 are on schedule (*any delay due to COVID-19 should be absorbed easily to stay on-schedule!*)

- New operational approach in handling error sources adopted at the ASC meeting in Canberra, November 2018, now fully implemented:

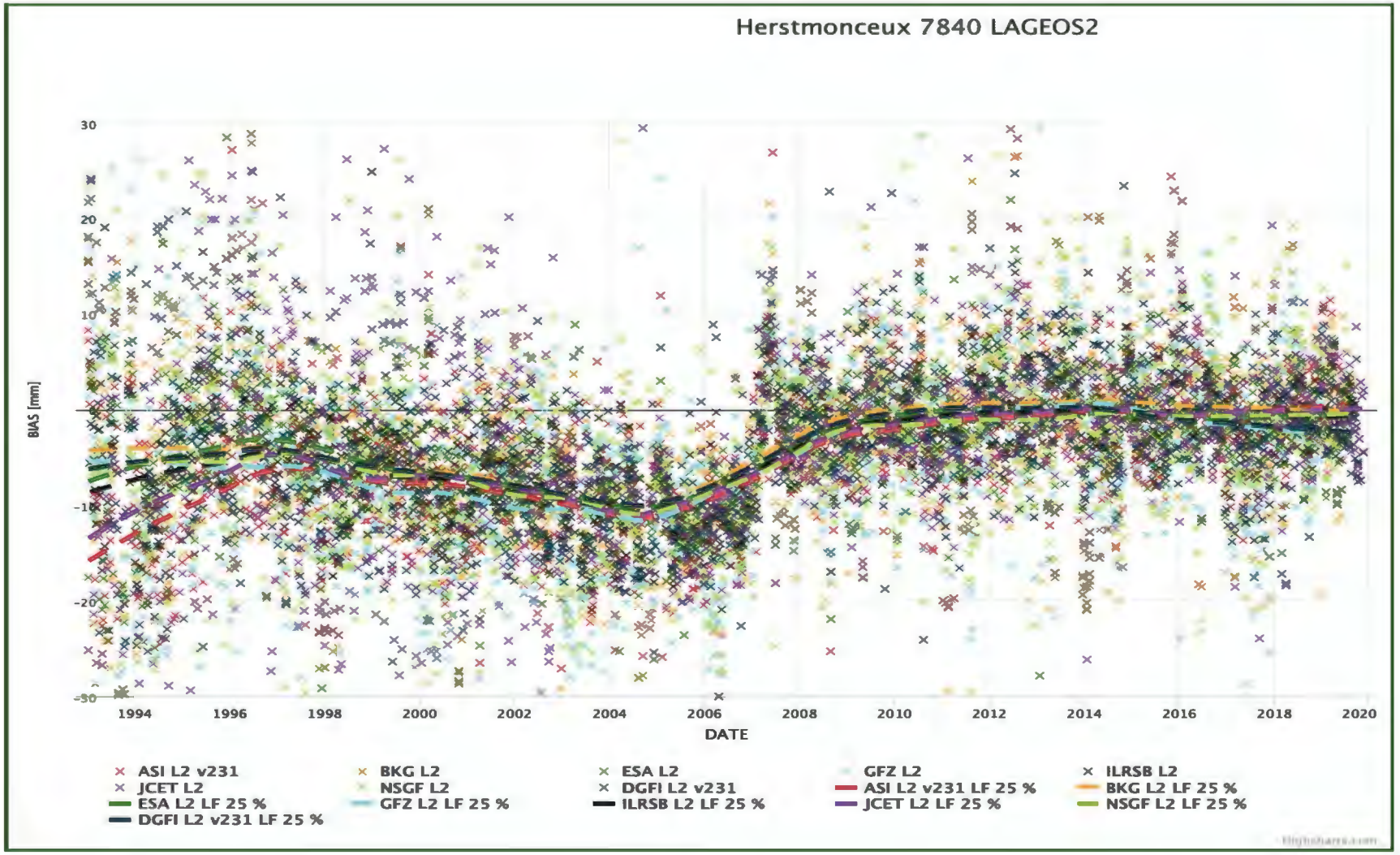
  - Allowance for estimation of systematic errors simultaneously with all other parameters to eliminate biases in station positions/velocities;

  - Adopted & implemented the new target signature model (also known as "CoM correction") for all current ground systems, recently released by NSGF (November 2019) with a minor update (2020);

# Yarragadee, 7090, SSEM Results

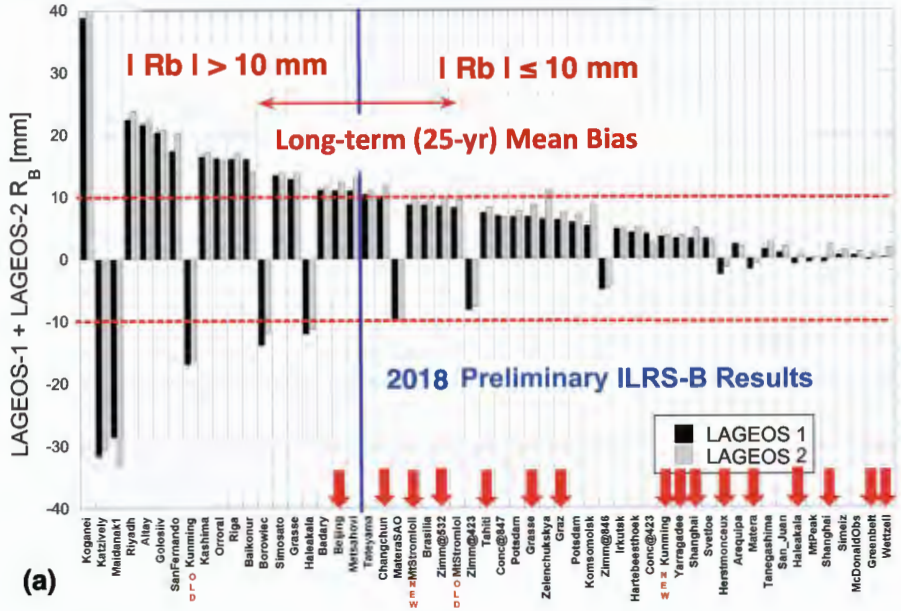


# Herstmonceux, 7840, SSEM Results

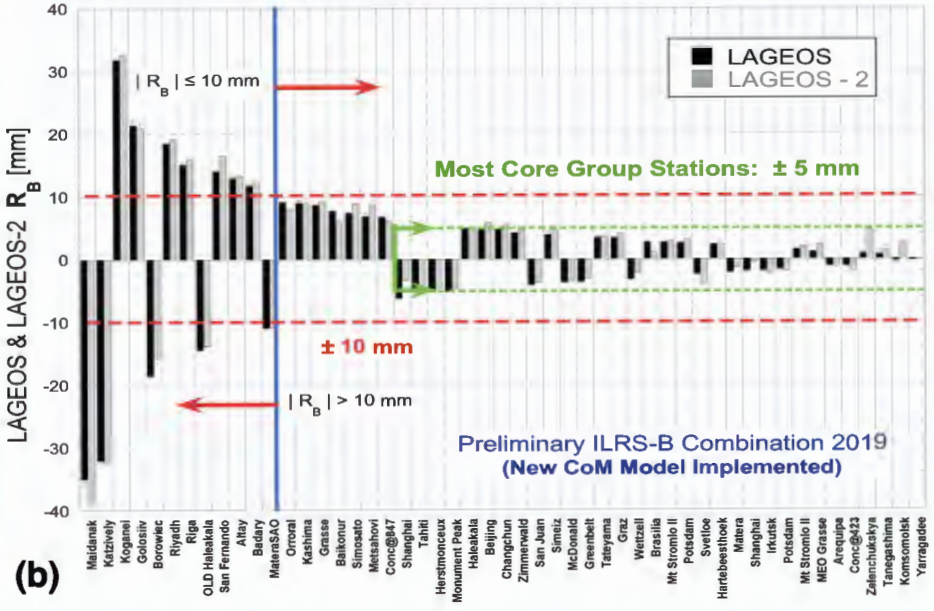


# Long-term Biases 2018 vs. 2020

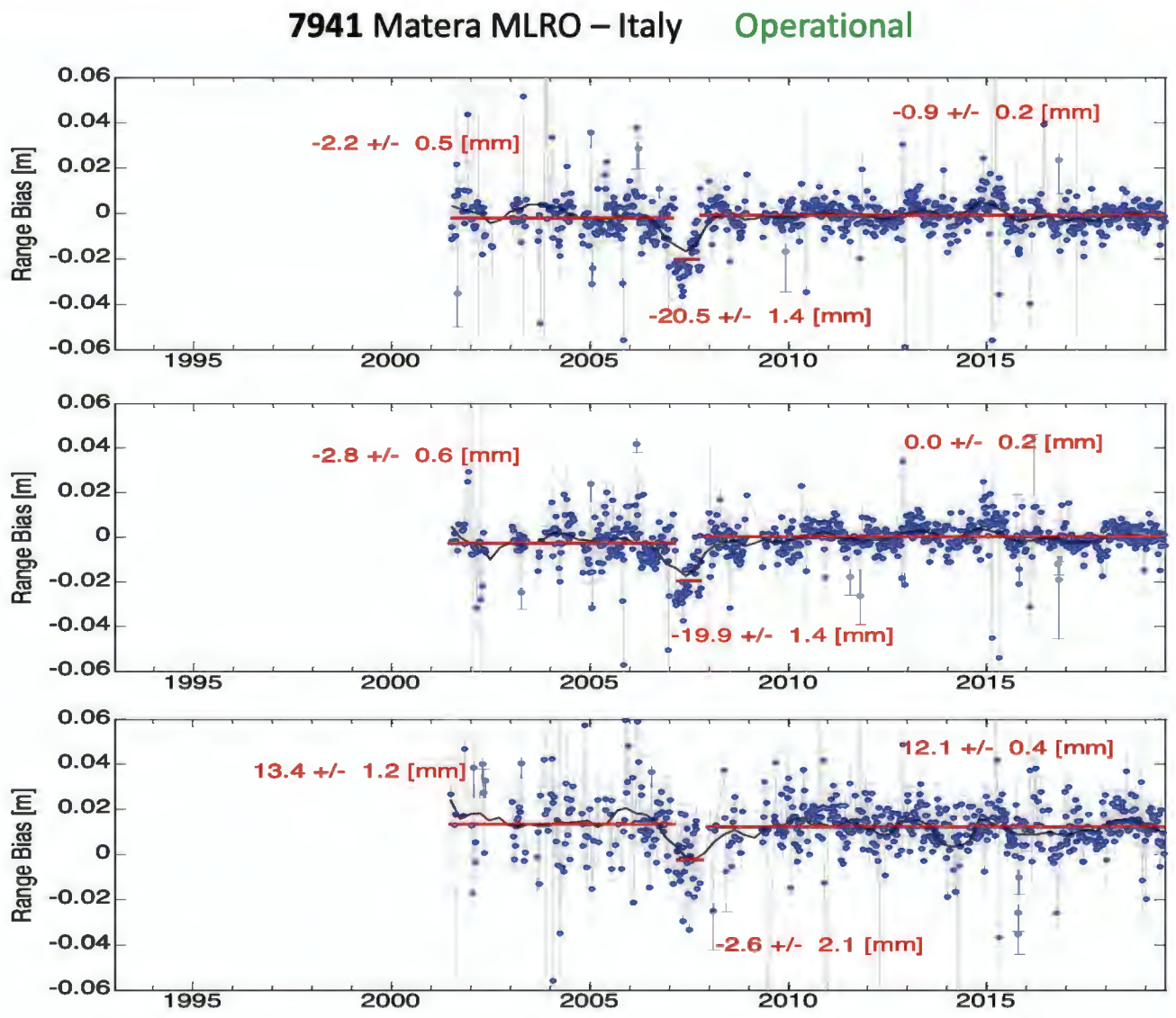
## 2018 Analysis of v230 Series




## 2019/20 Analysis of v230 Series



# Discontinuity Identification Step



# Summary & Schedule

- The ILRS ASC group is completing the systematic error modeling step that is a prerequisite to initiating Repro2020;
- A test combination with one year of LARES SINEXs is the next step, which is also a prerequisite to initiating Repro2020;
- Upon successful completion of the above (~August), the ACs will start Repro2020, from 1993 to present (complete by October/November). Test submission to ITRS and reprocessing of the early years 1983-1992;
- The CCs will be combining yearly batches as they become available (to identify issues and clarify problems with the ACs);
- Towards the end of January 2021 the last two months of 2020 will be reanalyzed and recombined, to complete the product delivery.

# GGOS Japan Uniting Space Geodetic Activities in Japan

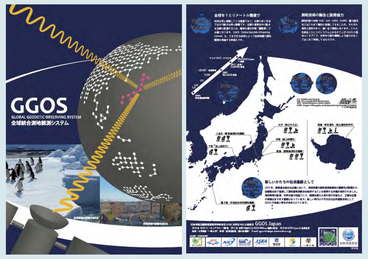
EGU General Assembly 2020, 5 May 2020
Session G2.1, D1749 EGU2020-3244

Toshimichi Otsubo [1] , Basara Miyahara [2], Yusuke Yokota [3], Shinobu Kurihara [2], Hiroshi Munekane [2], Shun-ichi Watanabe [4], Takayuki Miyazaki [2], Hiroshi Takiguchi [5], Yuichi Aoyama [6], Koichiro Doi [6], Yoichi Fukuda [7] (moved to [6] in April 2020), Koji Matsuo [2], Takaaki Jike [8], Takehiro Matsumoto [5] and Ryuichi Ichikawa [9]

[1] Hitotsubashi University, Japan; Email: t.otsubo@r.hit-u.ac.jp, [2] Geospatial Information Authority of Japan, [3] Institute of Industrial Science, the University of Tokyo, [4] Japan Coast Guard, [5] Japan Aerospace Exploration Agency, [6] National Institute of Polar Research, [7] Kyoto University, [8] National Astronomical Observatory of Japan, [9] National Institute of Information and Communications Technology

## GGOS Japan: 6 Years Old Now

2013 Establishment as “GGOS Working Group (of Japan)”: Chair Matsuzaka, Secretary Otsubo.
Since then,it has organised:
“GGOS” Sessions in JpGU & JP Geod Soc meetings.
GGOS-related sessions in international meetings.
Our own meetings once or twice per year.
2014 Site list sent to GGOS. Updated in 2017.
2015 New chair Otsubo, and new secretary Miyahara.
2017 GGOS Sp. Issue in 測地学会誌 (JP Geod Journal)
2017 Became the first GGOS Affiliate.
2018 Leaflet (designed by M Mizoe & T Otsubo) →
2018 Hosted GGOS Days 2018 Tsukuba.
2019 Renamed: “GGOS Japan”, Launch the website.
http://ggos.org/en/ggos-affiliates/ggos-japan/
2019-2023 Miyahara: serving as GGOS President
(Invisible) Consultative activities with institutes/stations.



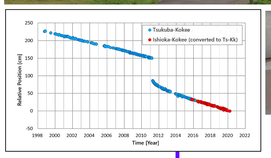

## GGOS Japan: Ongoing activities

Hosting meetings and sessions
2020.1 GGOS Japan Meeting in Kyoto University →
2020.7 GGOS Session in JpGU+AGU Joint (Virtual) Meeting
Supporting domestic meetings in space geodesy
2020.3 (ppd) ILRS Technical Meeting in Dodaira
2020.4 (ppd) IVS TDC Meeting in Kashima
Promoting Data DOIs
2019.9 Dedicated small workshop in Tsukuba
2019.10 Yokota: joined “DOIs for Geodetic Data Sets" WG of GGOS
Exchanging local survey know-hows for ITRF2020
Intensive local survey at Ishioka →
2020.3 (ppd) Dedicated small workshop in Tsukuba

** ppd: postponed due to the coronavirus pandemic.*

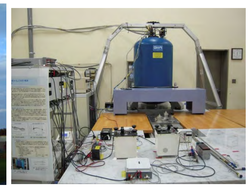
## 石岡 Ishioka (2016-)

- Transferred from Tsukuba; VGOS observation since 2016.
- Co-location observation between VLBI and GNSS every year.
- Introducing superconducting filter into QRFH for mixed-mode observation.




## 水沢 Mizusawa (1992-)

- Recording rate of regular geodetic K-band VLBI observations upgrade to 2-Gbps in 2018.
- Started a test to extend the geodetic observation network to the East Asian VLBI Network.
- GNSS and SG are continuously operated.



## 昭和 Syowa (1989-)

- Best equipped geodetic site in Antarctica.
- Implement of absolute gravity measurement in 2018.
- VLBI high rate sampling of 1Gbps since 2019.

VLBI GNSS 重力計

VLBI GNSS 重力計

VLBI GNSS重力計

VLBI GNSS

VLBI SLR GNSS

SLR GNSS

SLR GNSS

## 鹿嶋 Kashima (1977-2020)

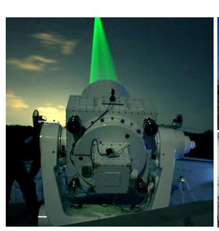
- VLBI technology development and observations since 1977.
- Kashima 34m antenna was damaged by typhoon No.15 (Faxi) in Sep. 2019. For safety reason, its main reflector panels were removed.
- 34m and 11m antennas to be dismantled in 2020.

## 種子島 Tanegashima (2004-)

- SLR observations since 2004.
- Remote operation from Tsukuba Space Center.
- Developing new kHz SLR in Tsukuba Space Center by April 2021.

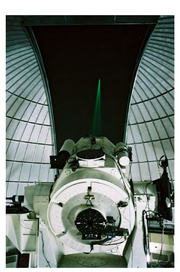
## 下里 Shimosato (1982-)

- Continuously performing SLR observations since 1982.
- A laser oscillator with pulse repetition rate up to 1 kHz has been installed in 2018.
- The latest co-location survey between GNSS (SMST) and SLR (SISL) was operated in 2020.



## 小金井 Koganei (1990-)

- SLR and VLBI observations since 1990 and 1993 respectively.
- GNSS station KGNI has been operated since 1996 and it was joined in IGS network on July of 1997.
- SLR 1.5m telescope also used for space communications such as OICETS, SOCRATES and ISS-SOLISS.



**Acknowledgement:** GGOS Japan is established under the IAG Subcommittee that is one of the IUGG subcommittees in Science Council of Japan. In addition to the authors, this poster is indebted to Yu Takagi (GSI) and Mamoru Sekido (NICT). Our activities are largely helped by GGOS and we look forward to working with GGOS and global-geodesy colleagues all over the world.

# AGGO Station – Current Status

- VLBI, GNSS, Gravimetry (absolute and superconducting), time and frequency keeping, meteorological sensors and hydrological measurements operational
- SLR in the process of modernization.
- AGGO provides data to the corresponding International Services.
- In January/February 2020 AGGO participated in absolute gravity measurements at the Patagonian icefields with FG5 and CG5.
- Plans for 2020/2021:
  - Start SLR operation;
  - Installation of tide gauge, water vapour radiometer, and ceilometer;
  - Extension of solar power supply and improvements in the energy supply;
- The cooperation BKG-CONICET is under negotiation for the continuation of the shared operation of AGGO for next 10 years.
- The lockdown of the corona virus resulted in a temporary shutdown of the non-automated operation procedures of AGGO. Operation will be resumed as soon as it is possible.

# Yebes Observatory
## Intro and operational update

José Rodríguez, Yebes (IGN)
ILRS QCB 14th May 2020

# Yebes Observatory

- **Located in Yebes (~60 km from Madrid)**
- **Funded by IGN (National Geographic Institute)**
- **ICTS status: Singular Scientific infrastructure**

# Yebes Observatory


## VLBI antennas

**40 m astro + geodesy**

**13 m VGOS**


## Gravimetry

**FG5, SG**


## Electronic labs anechoic chamber

# Yebes Observatory


- **Centre of excellence for the design and building of VLBI receptor packages and equipment**
  - **Ishioka**, Japan (GSI). Tri-band receiver, VGOS control SW
  - **Ny-Alesund**, Norway (NMA). Tri-band receiver + control SW
    + 2 broadband receivers
  - **Metsahovi**, Finland (FGI). Broadband receiver
  - **RAEGE** (Atlantic Network of Geodynamic and Space Stations)
  - Other equipment and upgrades for several stations (Wettzell, O'Higgings...)

# Yebes Observatory

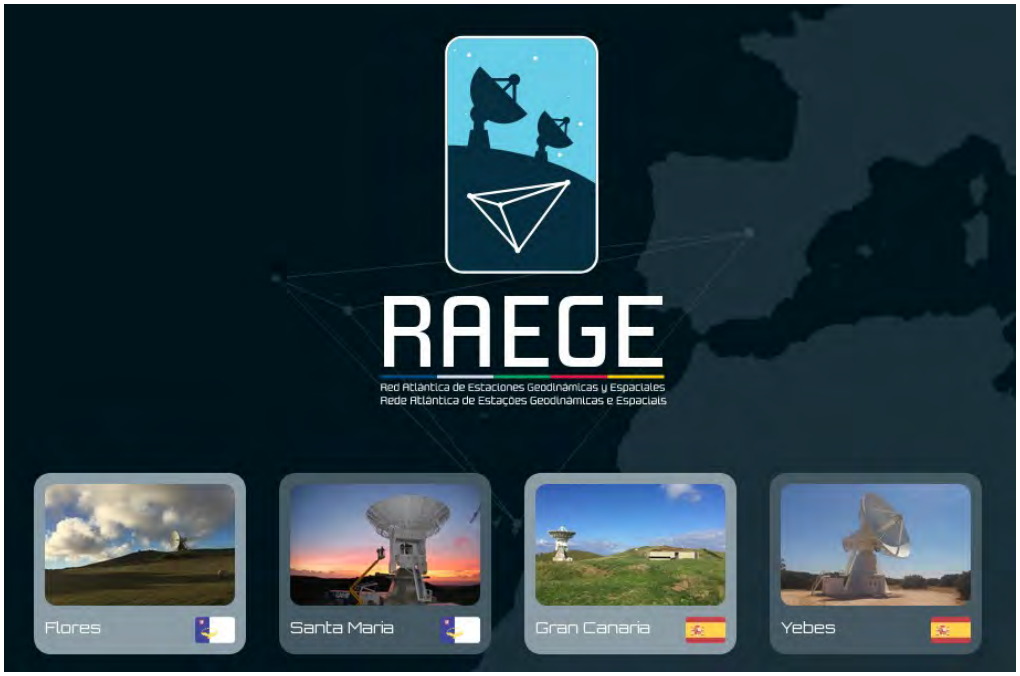
- **Involved in multiple international projects and collaborating with many international partners**








# Yebes Observatory




- **RAEGE (Atlantic Network of Geodynamic and Space Stations)**
  - 4 sites on 3 tectonic plates
  - Yebes (SP), Gran Canaria (SP), Flores (PT), Santa Maria (PT)
  - VGOS antennas, GNSS, gravimeter, seismometer

# Yebes Observatory – SLR

- **Turnkey project for an SLR station**
- **Separate building contract**
- **Deadline for delivery: 3 years**
- **Public tender to be announced this year**
- **SLR station will make of Yebes a GGOS Core Site**

# COVID-19 impact

- **All staff working from home since mid-March**
- **Except a few cases of critical workers whose presence is required sporadically (HW problems)**
- **Astro+geodetic VLBI and gravimetry obs. continue**
  - Communications protocol updated to allow multiple simultaneous connections to antennas
  - Operators can input schedules and monitor systems remotely
- **Gradual lifting of lockdown measures just started**
- **Region-based: Guadalajara among first ones to open up**
- **Expected to prioritise working from home for 2 months**

# Thank you

**Husson, Van (Peraton) (US Person)**
to Mike, Jason, Erricos, me, Evan, Oscar, Randall, Carey, Rivers

10:51 AM (1 hour ago)

Hi Mike,

All the Russians stations including stations in the Ukraine (Simeiz and Katzively are in the Crimea and are now in Russia) are providing 40 calibration records and 50 session record( See Table below); There are some minor format issues (e.g. some processing statistics are always zero, but if not available/computed should be a -1, many stations do not subtract 3 from kurtosis), but other stations have similar issues.

I can follow up with these stations next week.

Regards, Van

| | | Calibration Info | | | | | | Session Info | | | | | Bin Info | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | Location Name, Country | 40 record | Shift | RMS | Skew | Kurtosis | Peak-mean | 50 record | RMS | Skew | Kurtosis | Peak-mean | Kurtosis | Contact |
| 1824 | Golosiiv, Ukraine | ✓ | 0 | ✓ | ✓ | -3 | ✓ | ✓ | ✓ | ✓ | -3 | ✓ | -3 | Mykhaylo Medvedskyy |
| 1868 | Komsomolisk-na-Amure, Russia | ✓ | 0 | 0 | -1 | -1 | -1 | ✓ | ✓ | ✓ | -3 | ✓ | -3 | Shargorodsky Victor |
| 1873 | Simeiz, Ukraine | ✓ | 0 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | -1 | -1 | Andriy Dmytrotsa |
| 1874 | Mendeleevo 2, Russia | ✓ | 0 | ✓ | 0 | 0 | 0 | ✓ | ✓ | ✓ | -3 | ✓ | -3 | Igor Ignatenko |
| 1879 | Altay, Russia | ✓ | 0 | 0 | -1 | -1 | -1 | ✓ | ✓ | ✓ | -3 | ✓ | -3 | Shargorodsky Victor |
| 1886 | Arkhyz, Russia | ✓ | -1 | 0 | -1 | -1 | -1 | ✓ | ✓ | ✓ | -3 | ✓ | -3 | Shargorodsky Victor |
| 1887 | Baikonur, Kazakhstan | ✓ | -1 | 0 | -1 | -1 | -1 | ✓ | ✓ | ✓ | -3 | ✓ | -3 | Shargorodsky Victor |
| 1888 | Svetloe, Russia | ✓ | 0 | 0 | -1 | -1 | -1 | ✓ | ✓ | ✓ | -3 | -1 | -3 | Iskander Gayazov |
| 1889 | Zelenchukskya, Russia | ✓ | 0 | 0 | -1 | -1 | -1 | ✓ | ✓ | ✓ | -3 | -1 | -3 | Iskander Gayazov |
| 1890 | Badary, Russia | ✓ | 0 | 0 | -1 | -1 | -1 | ✓ | ✓ | ✓ | -3 | -1 | -3 | Iskander Gayazov |
| 1891 | Irkutsk, Russia | ✓ | 0 | ✓ | 0 | 0 | 0 | ✓ | ✓ | ✓ | -3 | ✓ | -3 | Igor Ignatenko |
| 1893 | Katzively, Ukraine | ✓ | ✓ | ✓ | -1 | -1 | -1 | ✓ | ✓ | -1 | -1 | -1 | -1 | Andriy Makeyev |
| 7503 | Hartebeesthoek, South Africa | ✓ | -1 | ✓ | -1 | -1 | -1 | ✓ | ✓ | ✓ | -3 | ✓ | -3 | Roelf Botha |
| 7407 | Brasilia, Brazil | ✓ | -1 | ✓ | -1 | -1 | -1 | ✓ | 0 | 0 | 0 | 0 | -3 | Parkhomenko Natalia |

| Legend | |
|---|---|
| ✓ | Compliant |
| -1 | Not available |
| 0 | Zero value always supplied |
| -3 | 3 needs to be subtracted |

From these and tests on numerous other passes we conclude that:

- for a single-photon station there is often a significant difference of the peak from the 3 × rms-rejection mean
- the 1 × rms-rejection mean usually agrees with one or other of the smoothing peak and Pearson peak, and often with both.

## 6. Recommendations

In conclusion we recommend the following:

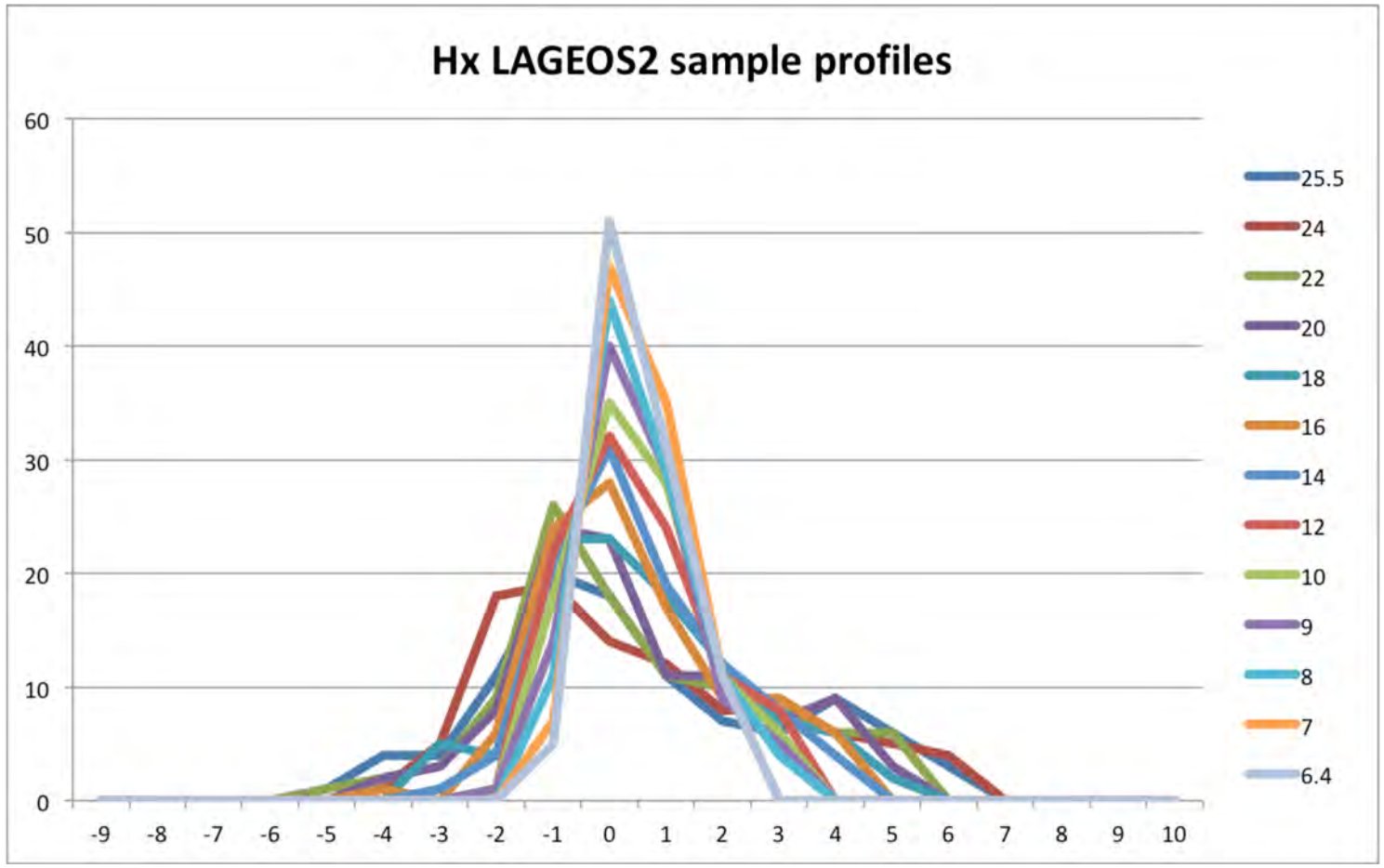
a) the ranges to a calibration target or the trend-removed data from a whole satellite pass should be screened at an iterated 3 × rms level, and in the process determine *rms* and *mean* of the retained data

b) the skewness and kurtosis of the retained data should be determined

c) using this fixed value of *rms* a second determination of the mean should be made using an iterated 1 × *rms* rejection. This provides an estimate of *peak*. Then the bias of the calibration or pass is $bias = peak - mean$

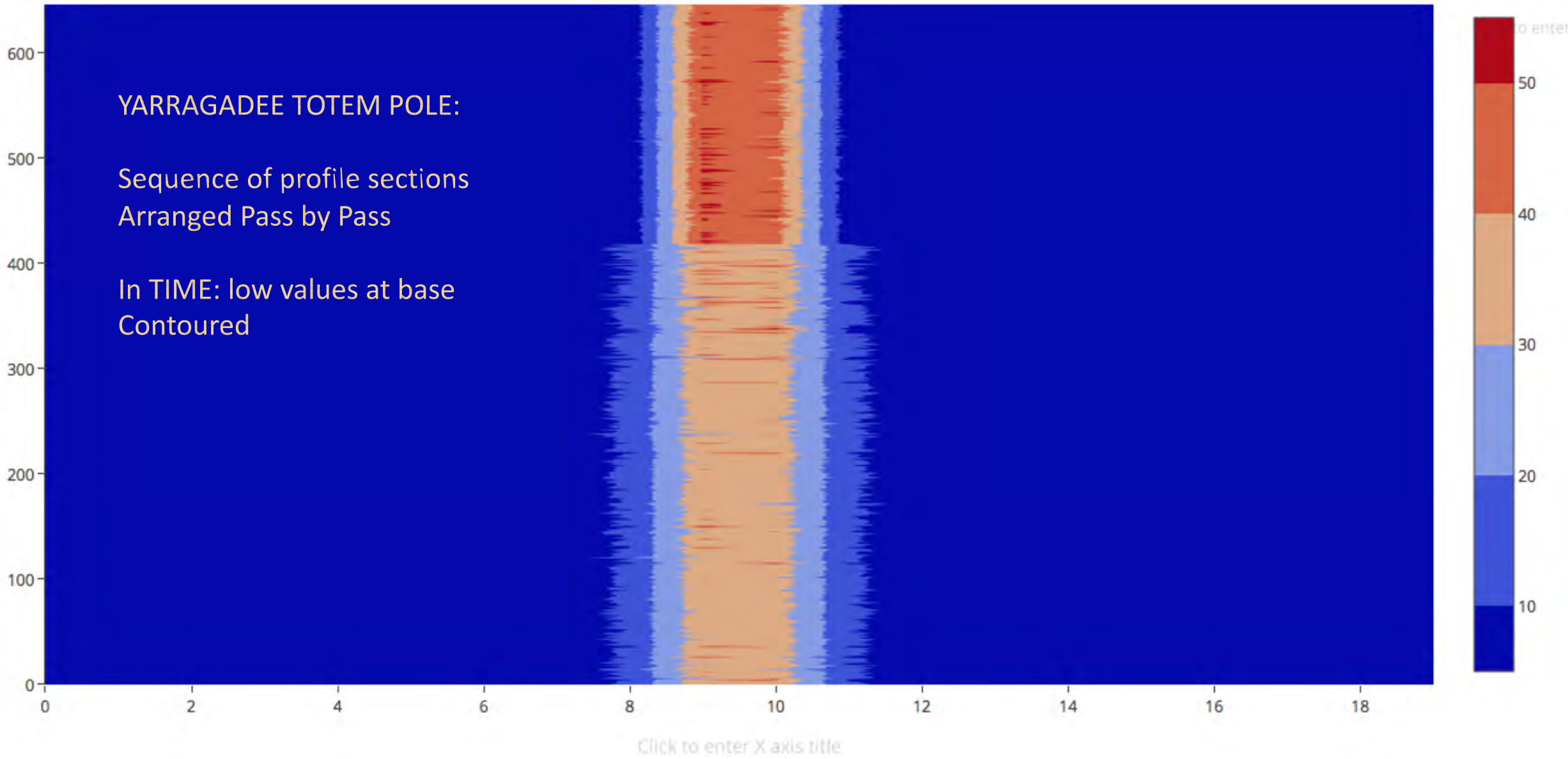
d) for a calibration run, use the value of *peak* as the calibration value

e) for a satellite pass, form normal points from the screened data within each bin in the usual way, but add the correction *bias* to the normal point.

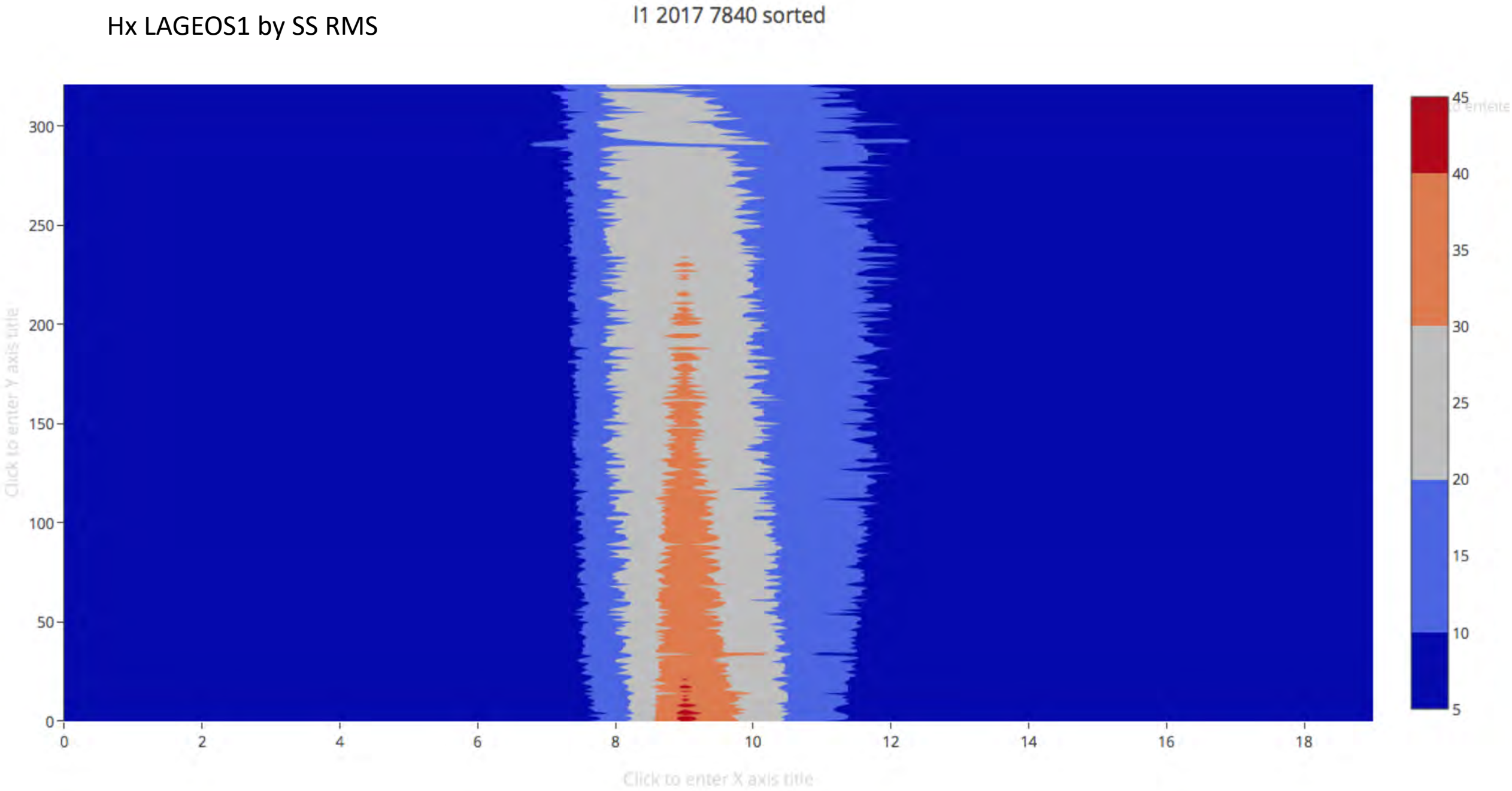

Hx LAGEOS2 sample profiles
60
50
40
30
20
10
0
-9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10
25.5
24
22
20
18
16
14
12
10
9
8
7
6.4

```
h1 CRD 1 2019 12 12  8
h2 GODL      7105  7 25 3
h3 lageos1    7603901 1155      -1 0 1
h4  1 2019 12 12  7 14  0 2019 12 12  7 40 22  0 0 0 0 1 0 2 0
c0 0  532.000 std la1 mcp ti1
c1 0 la1 Nd:Yag    532.00      5.00     100.00  150.0 15.00    1
c2 0 mcp MCP-PMT    532.000  12.0 2800.0  31.0 analog 400.0  1.00  80.0 30.00 none
c3 0 ti1 SRS_FS740 SRS_FS740 Cybi_ETM na   -1.0
60  std 7 1
40 26040.400553399999 0 std      -1      -1  -1.000    82034.0     -7.0   15.0  -1.000  -1.000   -1.0 2 2 0
20 26102.601 1029.90 272.00  53. 0
11 26102.600551799998     0.057281844339 std 2  120.0     7   40.0   0.747  -1.208     -1.0   1.17 0
20 26231.401 1029.90 272.00  53. 0
11 26231.400552600000     0.056285116457 std 2  120.0     12   52.0  -0.632  -0.317     -1.0   2.00 0
20 27107.401 1029.80 272.10  53. 0
11 27107.400553799998     0.054292397065 std 2  120.0     4   37.0  -0.058  -1.065     -1.0   0.67 0
20 27187.201 1029.80 272.10  53. 0
11 27187.200552599999     0.054538529293 std 2  120.0     12   44.0   0.298  -1.135     -1.0   2.00 0
20 27305.801 1029.70 272.10  53. 0
11 27305.800552600002     0.055028311379 std 2  120.0     4   64.0   0.011  -1.985     -1.0   0.67 0
20 27425.601 1029.70 272.20  53. 0
11 27425.600554699999     0.055666808912 std 2  120.0     5   26.0  -0.780  -0.684     -1.0   0.83 0
20 27542.001 1029.80 272.50  53. 0
11 27542.000551500001     0.056417279910 std 2  120.0     7   26.0  -0.760  -0.590     -1.0   1.17 0
20 27604.201 1029.80 272.50  53. 0
11 27604.200555300002     0.056867768217 std 2  120.0     3   22.0   0.287  -1.500     -1.0   0.50 0
50 std   45.1  -0.285   3.021   -1.0 0
```

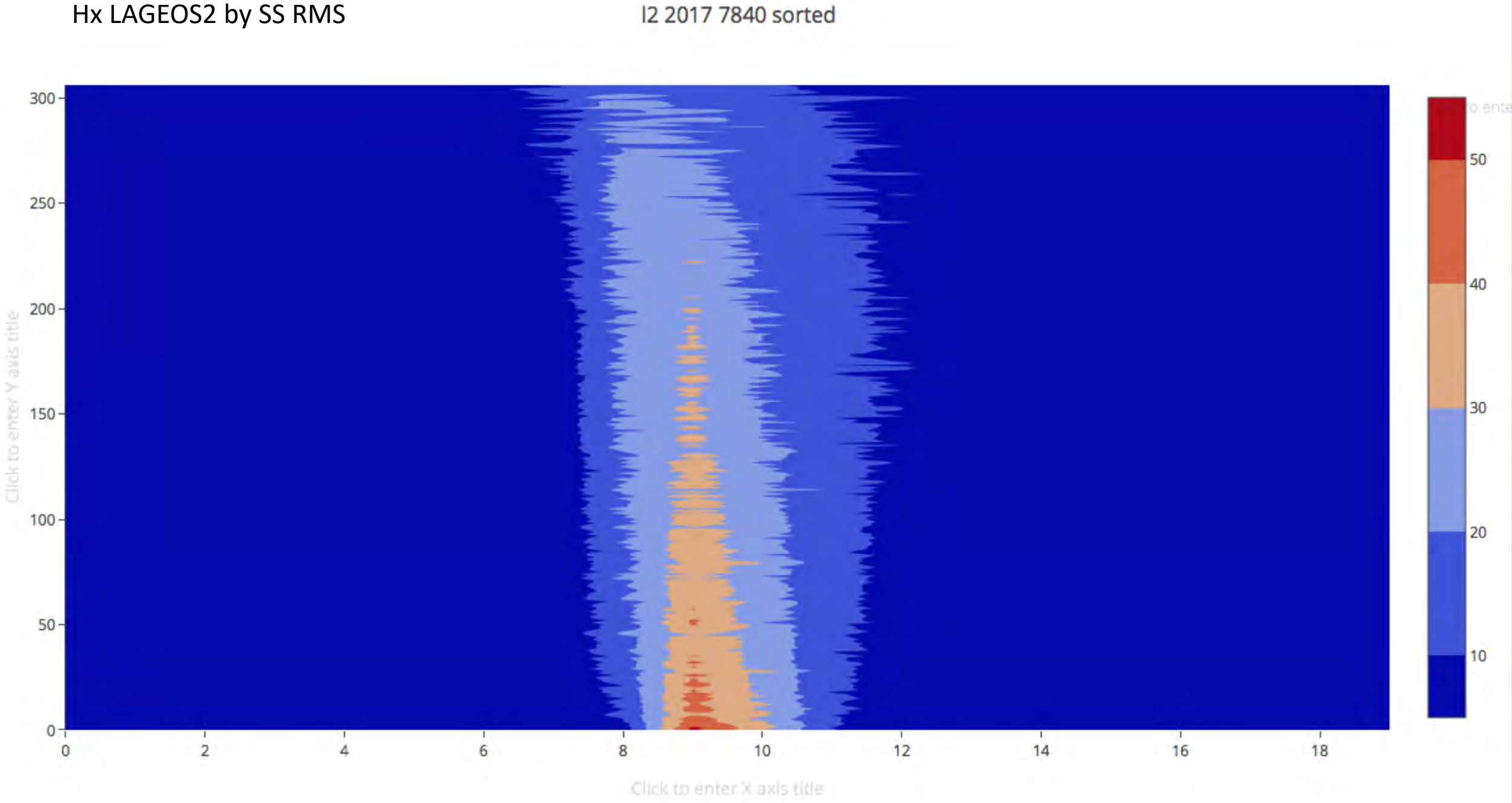
l1 2017 7090 by pass

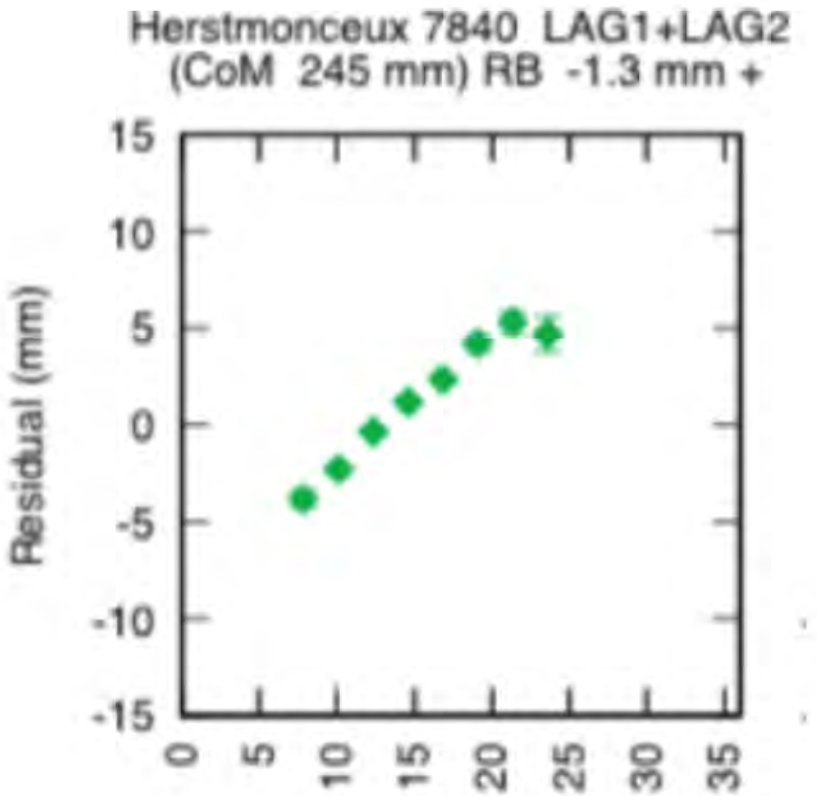


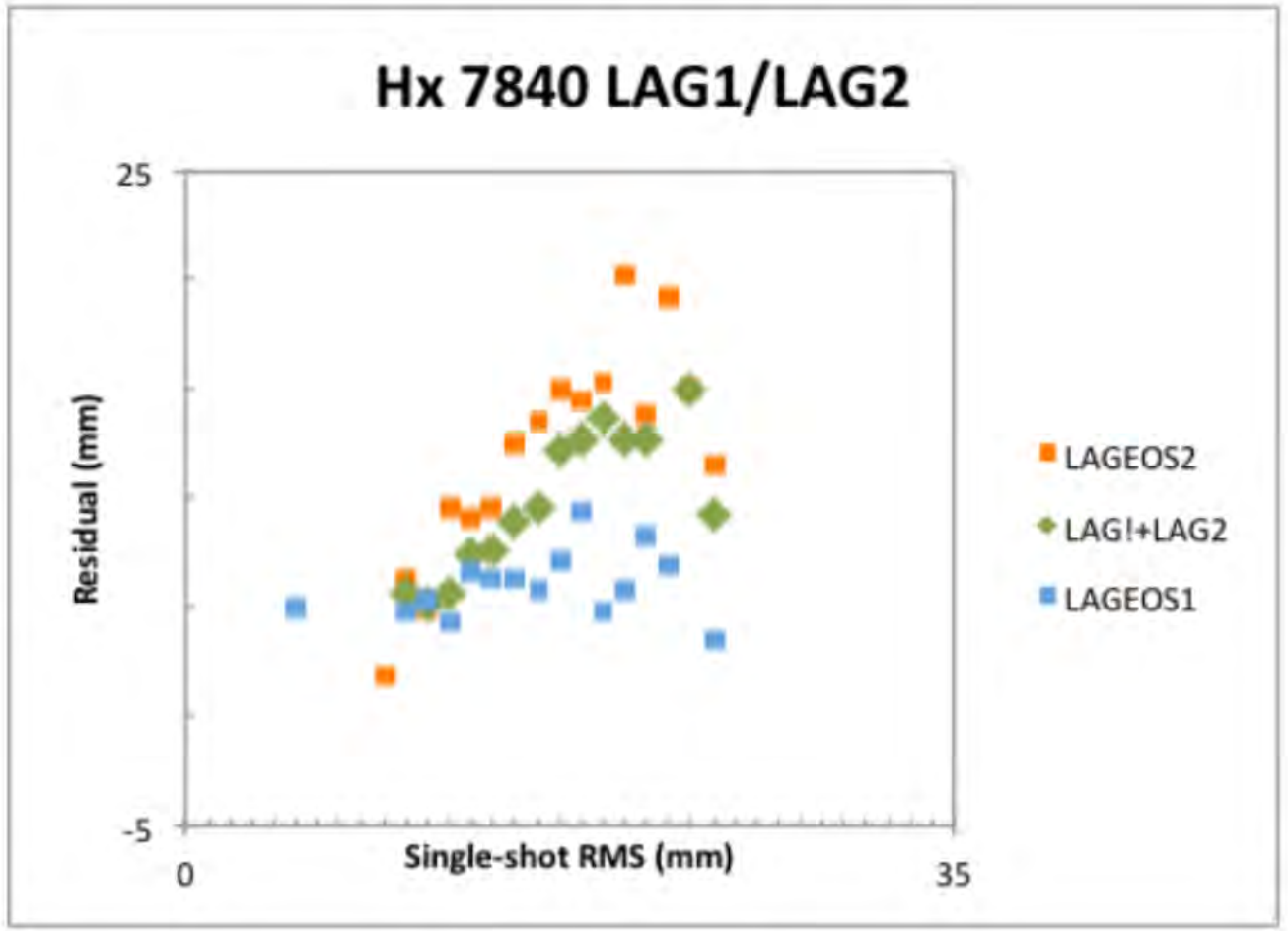
Hx LAGEOS1 by SS RMS



Hx LAGEOS2 by SS RMS




Herstmonceux 7840 LAG1+LAG2
(CoM 245 mm) RB -1.3 mm +
Residual (mm)
15
10
5
0
-5
-10
-15
0
5
10
15
20
25
30
35


Hx 7840 LAG1/LAG2
Residual (mm)
25
-5
0
Single-shot RMS (mm)
35
LAGEOS2
LAG!+LAG2
LAGEOS1

Excel File Edit View Insert Format Tools Data Window Help — 100% — Sun 12:10 PM — Peter Dunn

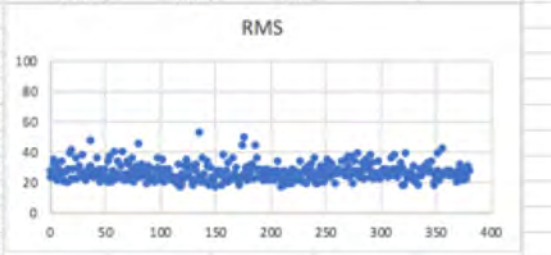
lares crd 2019 KS (7840)

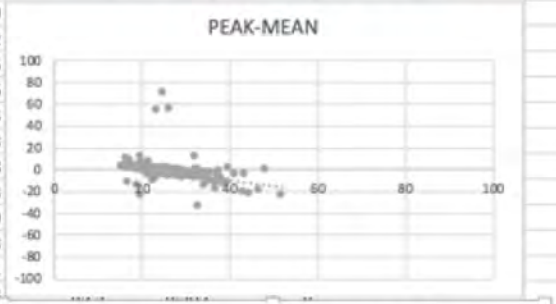
Home | Insert | Page Layout | Formulas | Data | Review | View

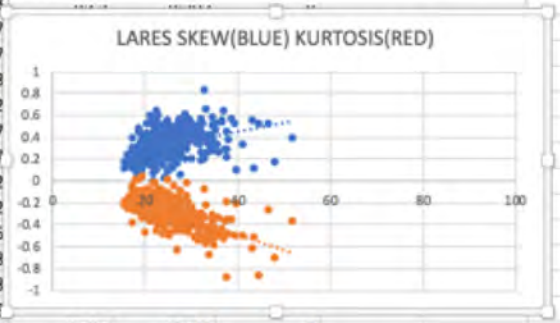
Paste | Font | Alignment | Number | Conditional Formatting | Format as Table | Cell Styles

Chart 2

| | A | B | C | D |
|---|---|---|---|---|
| 1 | RMS | SKEW | KURTOSIS | PEAK-MEAN |
| 2 | 21.9 | 0.309 | -0.11 | -0.5 |
| 3 | 27 | | | |
| 4 | 24.6 | | | |
| 5 | 33.5 | | | |
| 6 | 31.8 | | | |
| 7 | 31.2 | | | |
| 8 | 20.7 | | | |
| 9 | 23 | | | |
| 10 | 27.5 | | | |
| 11 | 22 | | | |
| 12 | 19.8 | | | |
| 13 | 32.9 | | | |
| 14 | 20.2 | | | |
| 15 | 25.5 | | | |
| 16 | 19.6 | | | |
| 17 | 26.4 | | | |
| 18 | 27.3 | | | |
| 19 | 18.8 | | | |
| 20 | 38.3 | | | |
| 21 | 39.9 | | | |
| 22 | 21.3 | | | |
| 23 | 27.1 | | | |
| 24 | 21.3 | | | |
| 25 | 21.7 | | | |
| 26 | 34.7 | | | |
| 27 | 28 | | | |
| 28 | 22.2 | | | |
| 29 | 29.7 | | | |
| 30 | 23.7 | | | |
| 31 | 37.2 | | | |
| 32 | 25.2 | | | |
| 33 | 22.6 | | | |
| 34 | 25.8 | | | |
| 35 | 19.8 | | | |
| 36 | 22.8 | | | |
| 37 | 28.8 | 0.194 | -0.444 | -1 |
| 38 | 29.7 | 0.549 | -0.279 | -6 |
| 39 | 47 | 0.517 | -0.277 | -20.5 |



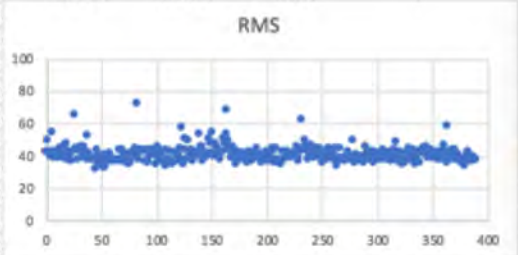



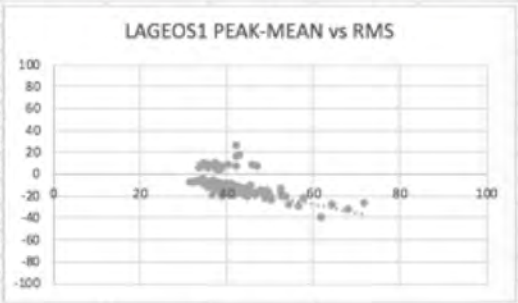

Sheet1 | Ready

Clipboard | Font | Alignment | Number | Conditional Formatting | Format as Table | Cell Styles

G13 RMS

| | A | B | C | D |
|---|---|---|---|---|
| 1 | RMS | SKEW | KURTOSIS | PEAK-MEAN |
| 2 | 42.4 | 0.592 | -0.298 | 24.3 |
| 3 | 49.5 | | | |
| 4 | 41.9 | | | |
| 5 | 42.2 | | | |
| 6 | 39.8 | | | |
| 7 | 54.6 | | | |
| 8 | 42.2 | | | |
| 9 | 39 | | | |
| 10 | 42.8 | | | |
| 11 | 41 | | | |
| 12 | 41.8 | | | |
| 13 | 39 | | | |
| 14 | 41.4 | | | |
| 15 | 44.7 | | | |
| 16 | 40 | | | |
| 17 | 44.8 | | | |
| 18 | 38.5 | | | |
| 19 | 46.2 | | | |
| 20 | 47.1 | | | |
| 21 | 37.2 | | | |
| 22 | 42.7 | | | |
| 23 | 40.3 | | | |
| 24 | 37.7 | | | |
| 25 | 36.5 | | | |
| 26 | 43 | | | |
| 27 | 42.9 | | | |
| 28 | 64.8 | | | |
| 29 | 44.4 | | | |
| 30 | 43.2 | | | |
| 31 | 37.8 | | | |
| 32 | 44.6 | | | |
| 33 | 43.7 | | | |
| 34 | 45.6 | | | |
| 35 | 39.3 | | | |
| 36 | 45.4 | | | |
| 37 | 38.5 | 0.553 | -0.395 | -11.5 |
| 38 | 42.2 | 0.549 | -0.425 | -14.5 |
| 39 | 37.8 | 0.591 | -0.424 | -13 |



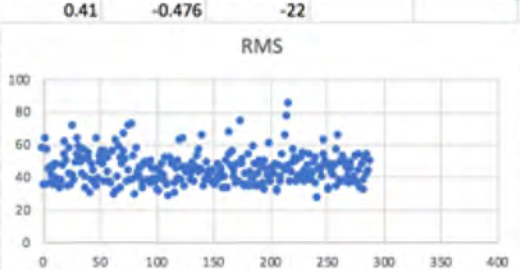


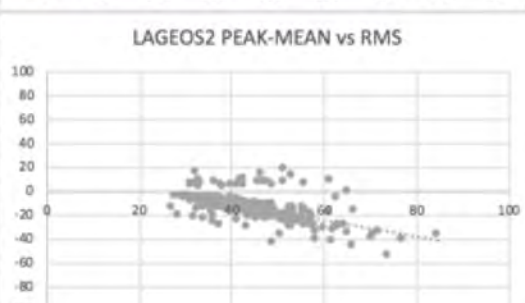
Sheet1 | Ready

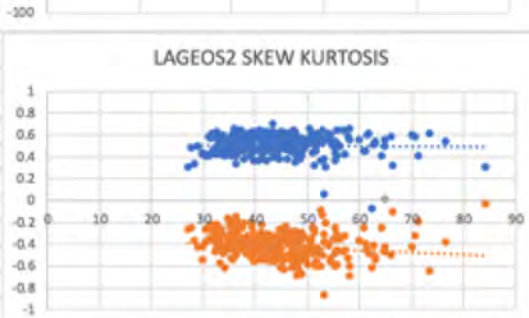
Clipboard | Font | Alignment | Number | Conditional Formatting | Format as Table | Cell Styles | Cells

G1

| | A | B | C | D |
|---|---|---|---|---|
| 1 | RMS | SKEW | KURTOSIS | PEAK |
| 2 | 57.4 | 0.41 | -0.476 | -22 |
| 3 | 34.3 | | | |
| 4 | 34.2 | | | |
| 5 | 63.2 | | | |
| 6 | 55.9 | | | |
| 7 | 44 | | | |
| 8 | 45.5 | | | |
| 9 | 35.6 | | | |
| 10 | 40 | | | |
| 11 | 45 | | | |
| 12 | 34.8 | | | |
| 13 | 47.7 | | | |
| 14 | 46.8 | | | |
| 15 | 38.5 | | | |
| 16 | 37.8 | | | |
| 17 | 32.1 | | | |
| 18 | 36.8 | | | |
| 19 | 37.1 | | | |
| 20 | 45.9 | | | |
| 21 | 53.6 | | | |
| 22 | 61 | | | |
| 23 | 49.7 | | | |
| 24 | 33.4 | | | |
| 25 | 57.3 | | | |
| 26 | 41.1 | | | |
| 27 | 34.3 | | | |
| 28 | 70.8 | | | |
| 29 | 40 | | | |
| 30 | 37.1 | | | |
| 31 | 48 | | | |
| 32 | 62.6 | | | |
| 33 | 53 | | | |
| 34 | 58 | | | |
| 35 | 47.9 | | | |
| 36 | 51.2 | | | |
| 37 | 41.3 | | | |
| 38 | 56 | | | |




Sheet1 | Ready | 100%

GRZL L2 CRD 2019

Search Sheet

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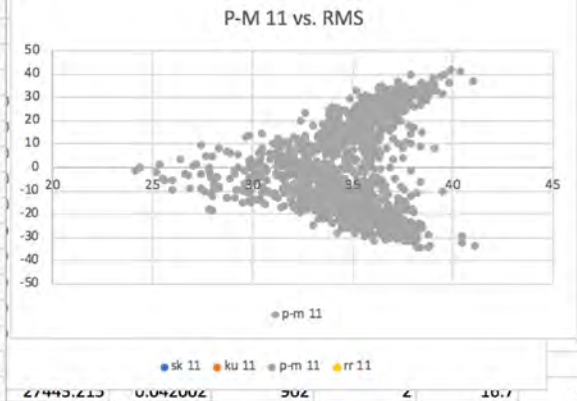
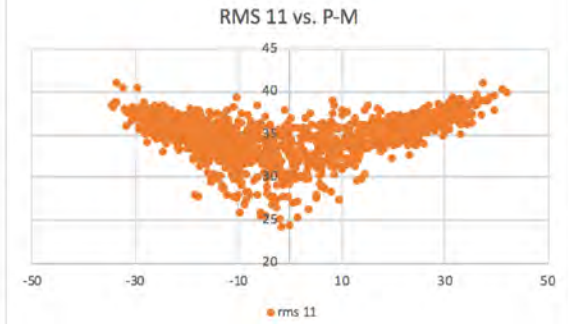
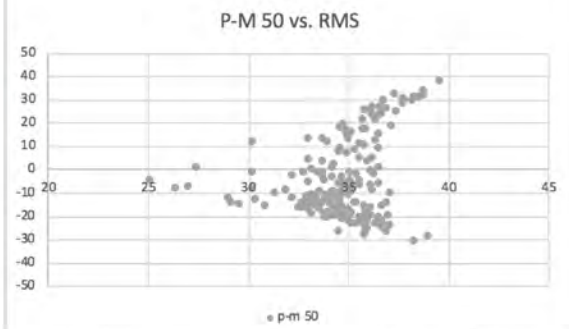
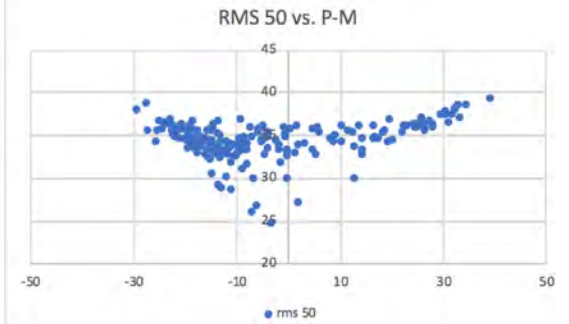
Paste | Cut | Copy | Format | Calibri (Body) | 12 | Wrap Text | General | Merge & Center | Conditional Formatting | Format as Table | Cell Styles | Insert | Delete | Format | AutoSum | Fill | Clear | Sort & Filter

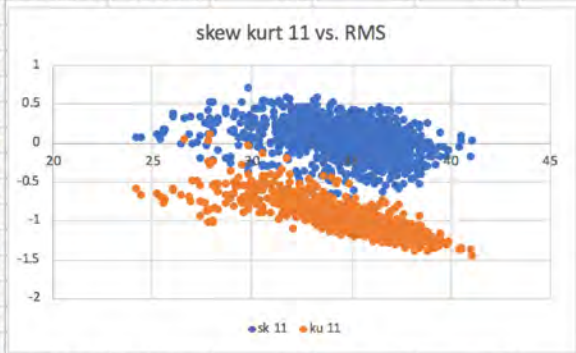
AK1

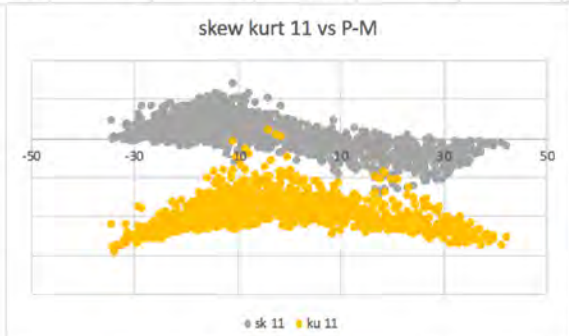


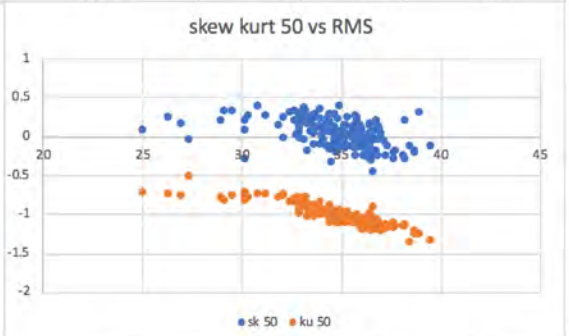



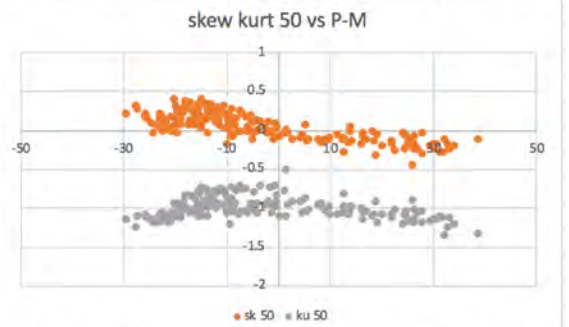



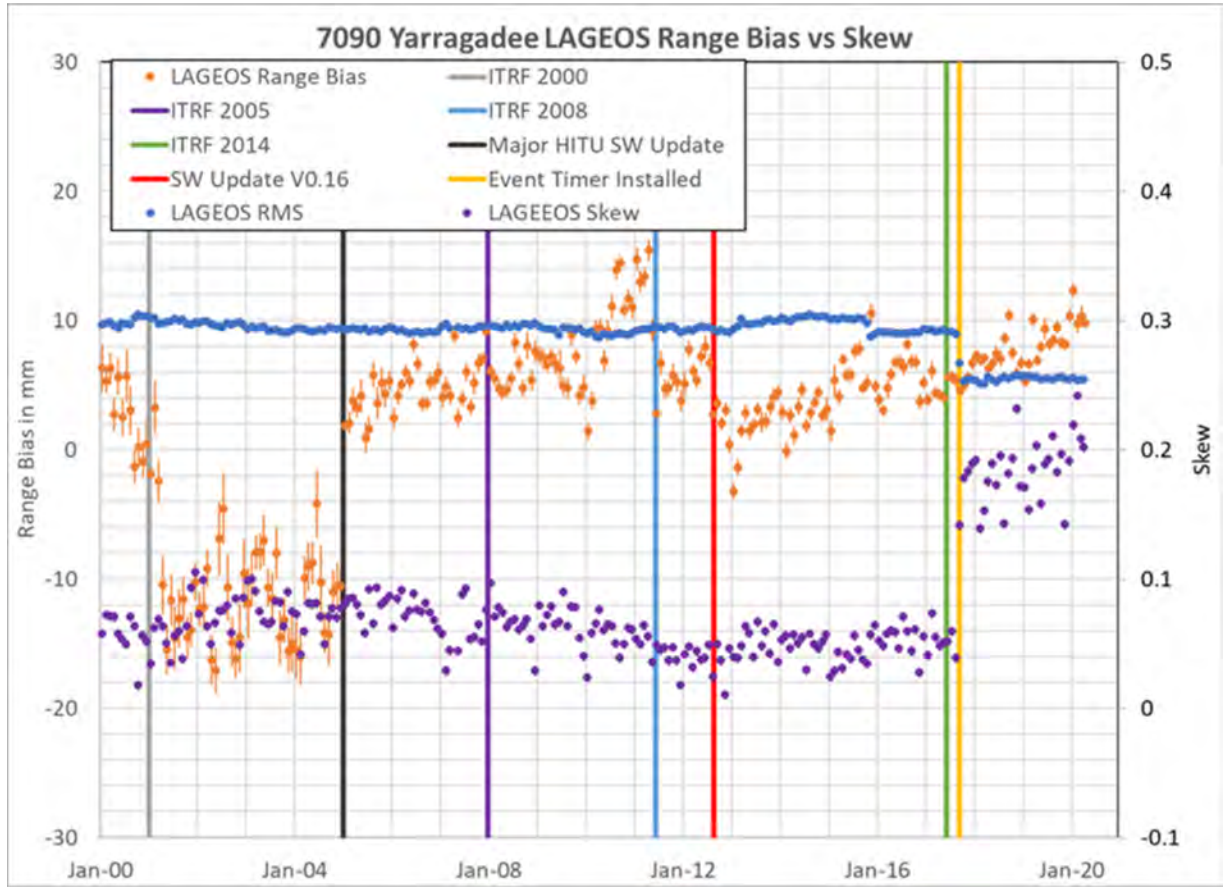




| | P | Q | R | S | T | U | V | W | X | Y | Z | AA | AB | AC | AD | AE | AF | AG | AH | AI | AJ | AK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | p-m 11 | npts 11 | rms 11 | sk 11 | ku 11 | p-m 11 | rr 11 | | | | p-m 50 | rms 50 | sk 50 | ku 50 | p-m 50 | | | |
| 16 | | | | | | 798 | 36.1 | -0.272 | -0.94 | 11.6 | 0.3 | 0 | GRZL | 50 | -4.1 | 35.5 | -0.012 | -1.056 | -4.1 | 1 | 40 | 56707 |
| 17 | | | | | | 4806 | 34.7 | -0.492 | -0.689 | 16.7 | 2 | 0 | GRZL | 50 | 12.3 | 35.5 | -0.113 | -1.048 | 12.3 | 1 | 40 | 58011 |
| 32 | 34357.639 | 0.0460698 | 902 | 2 | 32.6 | 614 | 37.3 | -0.122 | -1.141 | 32.6 | 0.3 | 0 | GRZL | 50 | -14.8 | 35.7 | 0.041 | -1.081 | -14.8 | 1 | 40 | 36403 |
| 33 | 34536.713 | 0.0436942 | 902 | 2 | 33.3 | 303 | 38.7 | -0.289 | -1.201 | 33.3 | 0.1 | 0 | GRZL | 50 | -22.4 | 36.3 | 0.001 | -1.159 | -22.4 | 1 | 40 | 38976 |
| 34 | 34894.713 | 0.0399964 | 902 | 2 | 11.3 | 2272 | 31.8 | -0.221 | -0.788 | 11.3 | 0.9 | 0 | GRZL | 50 | 34.3 | 38.7 | -0.193 | -1.209 | 34.3 | 1 | 40 | 1449 |
| 35 | 34984.563 | 0.0393346 | 902 | 2 | -3.2 | 14650 | 32.9 | -0.053 | -0.887 | -3.2 | 6.1 | 0 | GRZL | 50 | 30.2 | 37.7 | -0.18 | -1.129 | 30.2 | 1 | 40 | 1500 |
| 36 | 35104.804 | 0.03864 | 902 | 2 | 21 | 14614 | 35.2 | -0.22 | -1.028 | 21 | 6.1 | 0 | GRZL | 50 | 16.4 | 36.4 | -0.022 | -1.138 | 16.4 | 1 | 40 | 29266 |
| 37 | 35221.297 | 0.0381875 | 902 | 2 | 26.7 | 9862 | 36.5 | -0.266 | -1.072 | 26.7 | 4.1 | 0 | GRZL | 50 | -20.8 | 36.6 | -0.008 | -1.156 | -20.8 | 1 | 40 | 31207 |
| 38 | 35314.46 | 0.0379879 | 902 | 2 | 23.2 | 2423 | 35.9 | -0.213 | -1.051 | 23.2 | 1 | 0 | GRZL | 50 | 14.2 | 34.9 | -0.133 | -0.981 | 14.2 | 1 | 40 | 37765 |
| 39 | 49256.865 | 0.0445468 | 902 | 2 | 11.5 | 162 | 35.8 | -0.226 | -0.906 | 11.5 | 0.1 | 0 | GRZL | 50 | -22.4 | 35.2 | 0.05 | -1.102 | -22.4 | 1 | 40 | 38469 |
| 40 | 49416.679 | 0.042966 | 902 | 2 | 27.2 | 423 | 37 | -0.459 | -0.867 | 27.2 | 0.2 | 0 | GRZL | 50 | -16.3 | 32.9 | 0.246 | -0.845 | -16.3 | 1 | 40 | 1650 |
| 41 | 49482.086 | 0.0424166 | 902 | 2 | 26.6 | 539 | 36.2 | -0.487 | -0.86 | 26.6 | 0.2 | 0 | GRZL | 50 | -13.4 | 32.6 | 0.213 | -0.828 | -13.4 | 1 | 40 | 3819 |

Sheet1

Ready

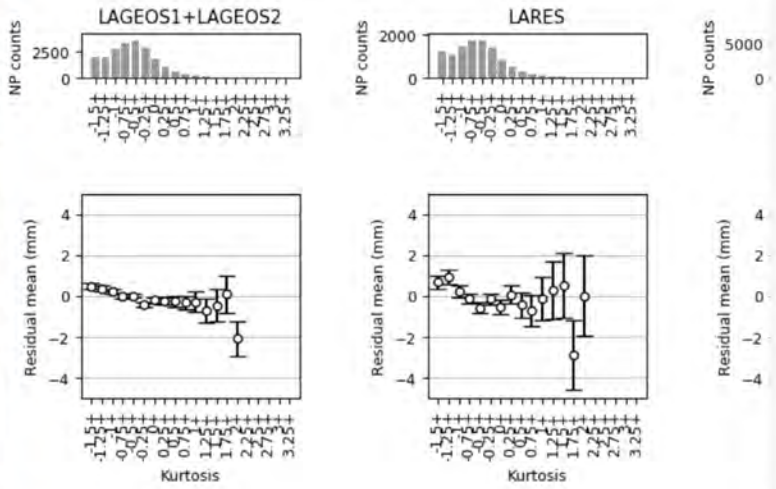
99%


7090 Yarragadee LAGEOS Range Bias vs Skew
LAGEOS Range Bias
ITRF 2000
ITRF 2005
ITRF 2008
ITRF 2014
Major HITU SW Update
SW Update V0.16
Event Timer Installed
LAGEOS RMS
LAGEEOS Skew
Range Bias in mm
Skew
30
20
10
0
-10
-20
-30
0.5
0.4
0.3
0.2
0.1
0
-0.1
Jan-00
Jan-04
Jan-08
Jan-12
Jan-16
Jan-20

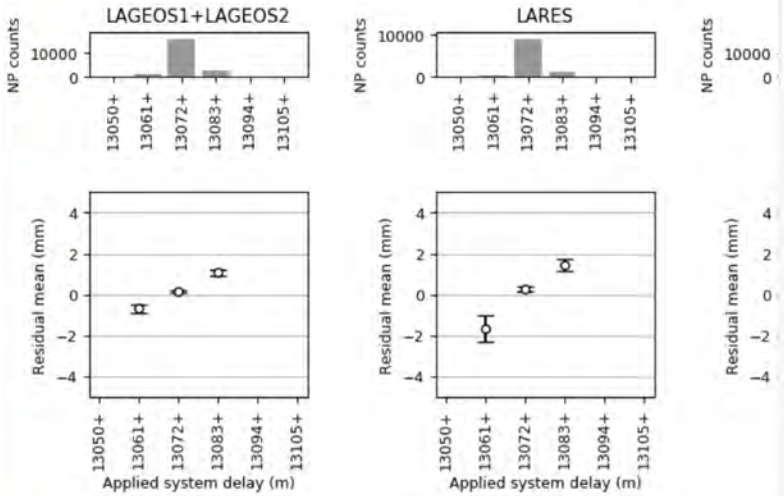
Safari File Edit View History Bookmarks Develop Window Help 100% Sun 12:58 PM Peter Dunn

Not Secure — geo.science

## 7090: wrt Kurtosis




## 7090: wrt System delay (1)




7090 LIL@ bias and kurtosis