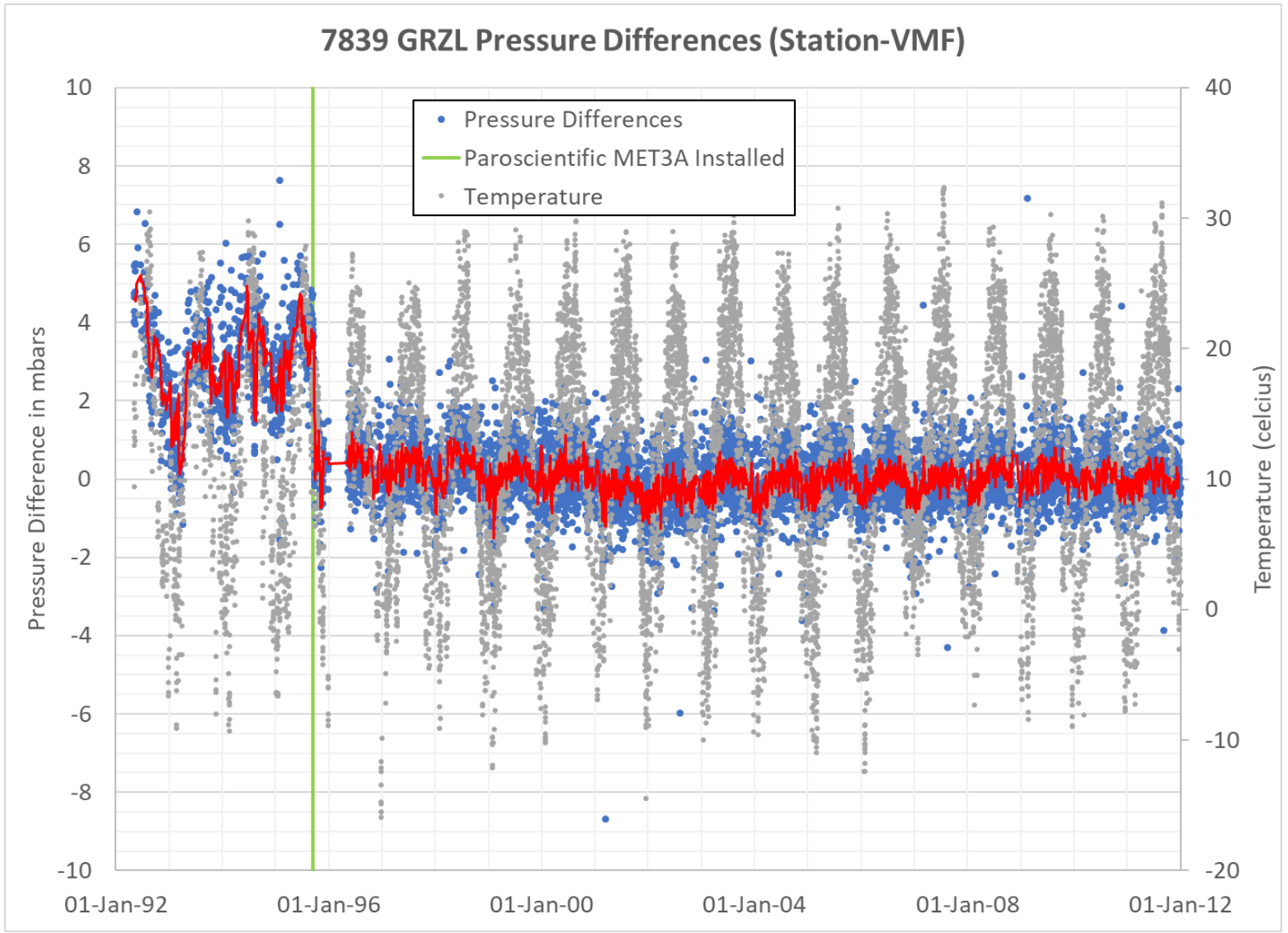
Barometric Pressure Analysis (Graz) 1992 to 2011

Van S Husson
vhusson@peraton.com
ILRS Central Bureau (CB)
ILRS Quality Control Board (QCB)
13-April-2022

Vienna Mapping Function (VMF)

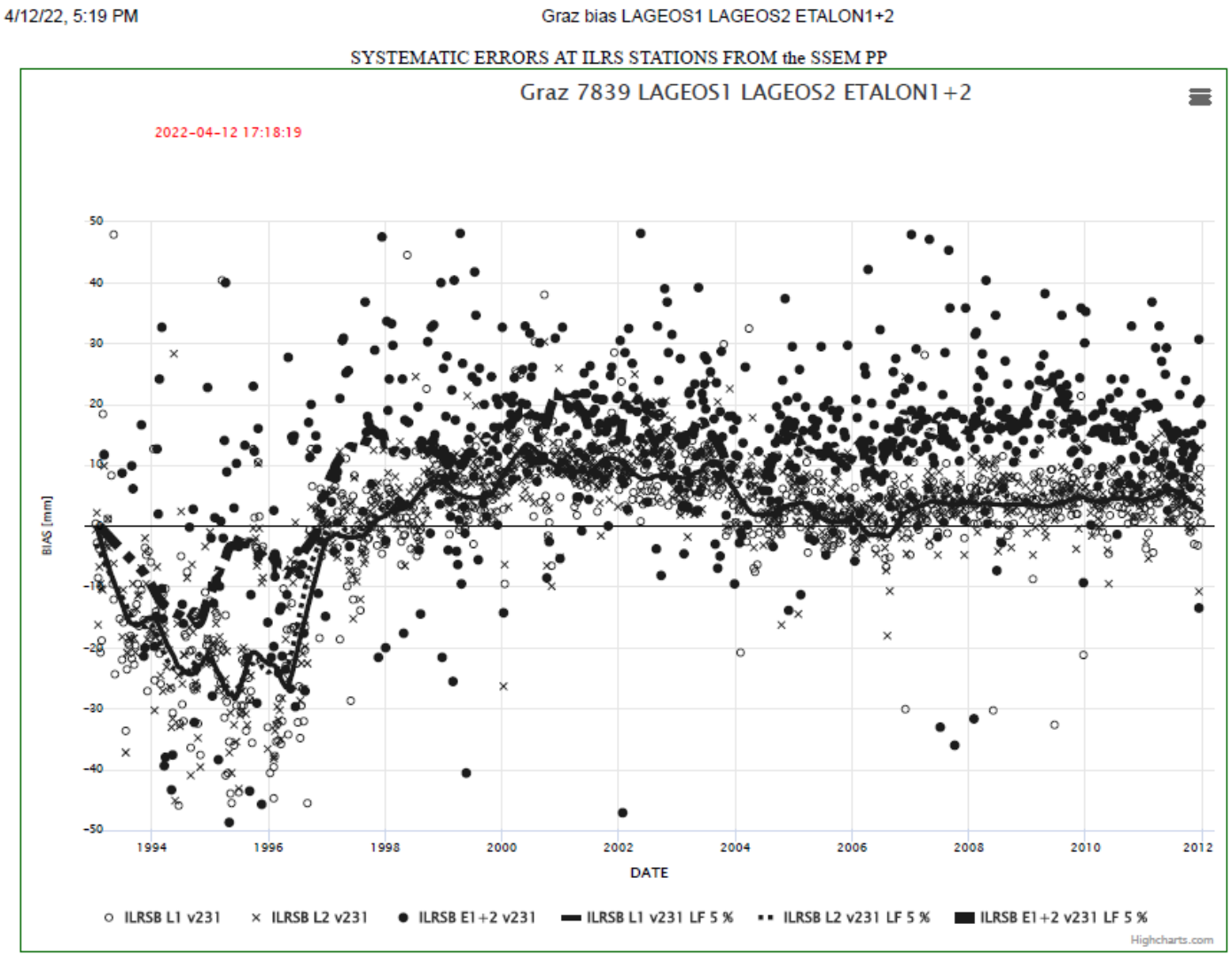
- **During the Jan-2022 Networks and Engineering Meeting, Krzysztof Sośnica gave a presentation regarding the VMF and identification of tropospheric biases in SLR data (reference: https://ilrs.cddis.eosdis.nasa.gov/docs/2022/NESC_Slides_Jan20_2022.pdf) based on the paper https://link.springer.com/article/10.1007%2Fs00190-021-01554-0 written by Mateusz Drożdżewski and Krzysztof Sośnica**
- **VMF data (January 1990 to August 2019) is available on the VMF Data Server at https://vmf.geo.tuwien.ac.at/trop_products/SLR/VMF3o/VMF3o_EI/ and VMF Data Server (tuwien.ac.at)**
  - VMF3o: the Vienna Mapping Functions for optical frequencies reference: VMF3o: the Vienna Mapping Functions for optical frequencies | SpringerLink
  - Tropospheric parameters for each day and each SLR station with 6-hour resolution
  - Based on ray-traced delays using ECMWF ERA-Interim NWM data

7839 GRZL Pressure Analysis



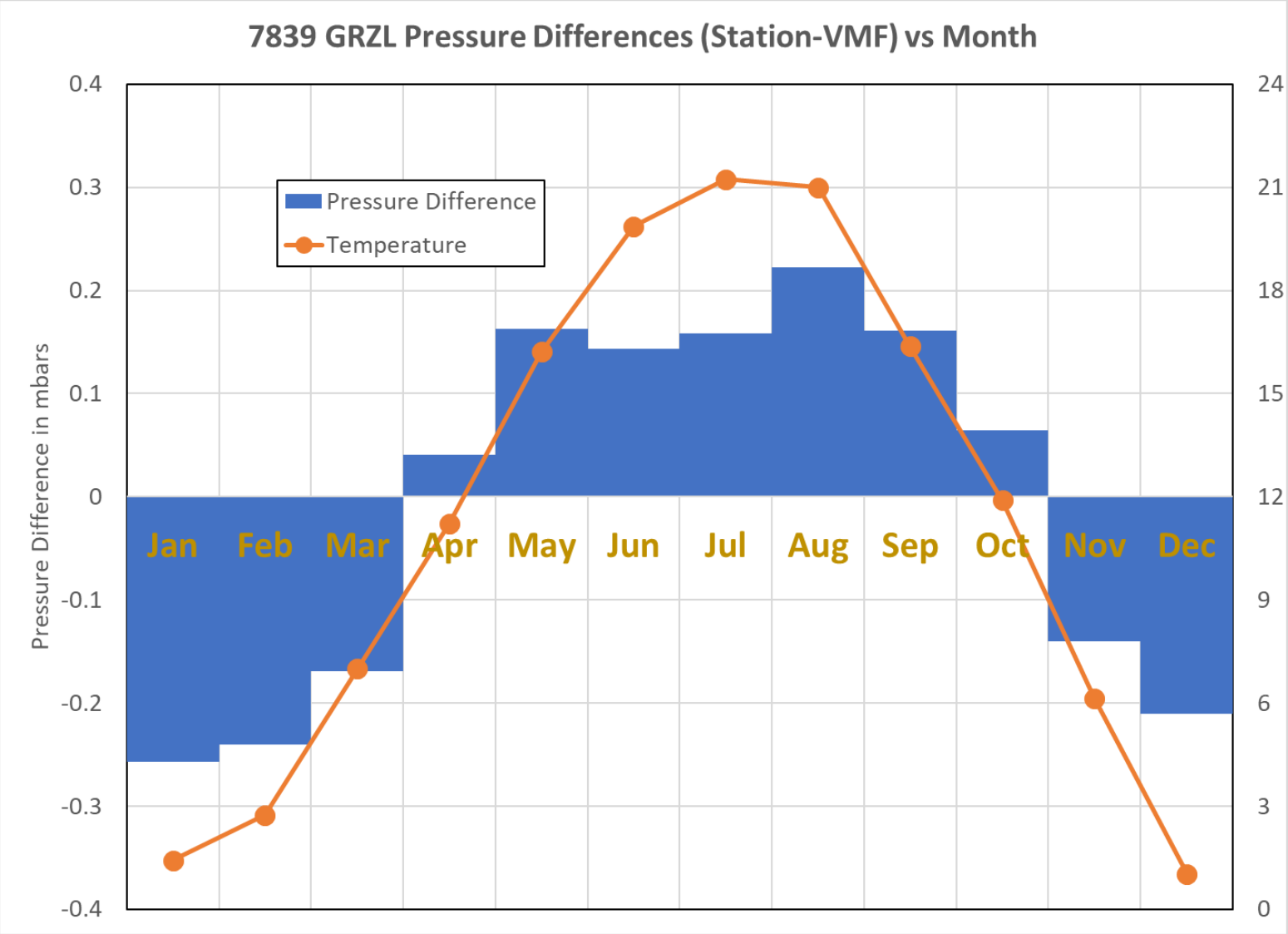
- Left Axes: Blue Dots are Graz barometric pressures from their CSTG normal point data aggregated every 6 hours minus the VMF pressures
- Left Axes: Red line is a 10-point running pressure difference
- Right axes: Gray dots are the corresponding VMF temperature
- The green vertical line is when the a Paroscientific barometer MET3A was installed, which removed the barometric error on 17-Sep-1995
- The pressure difference has an annual signal and appears to be correlated with temperature

7839 GRZL SSEM Range Biases (1993 to 2011)



- **The Graz barometric error prior to 17-Sep-1995 was a contributor to the SSEM range bias (i.e. the pressure being too high caused the tropospheric refraction correction to be too large inducing a negative range bias)**

7839 GRZL Pressure Analysis (con't)



- The pressure difference between the station's barometer and the VMF is seasonal and correlated with temperature
- What is causing the annual signal, the barometer of the VMF
- Does the source of this seasonal pressure variation really matter?

Vaisala PTB 330 Barometric Specifications

MET3 Meteorological Measurement System **MET3A Fan-Aspirated Meteorological Measurement System**

PERFORMANCE:
- Pressure Accuracy: ±0.08 hPa
- Temperature Accuracy:
  - MET3A 0.1°C
  - MET3 0.5°C
- Relative Humidity Accuracy: 2%

FEATURES:
- Plug & Play Simple Installation
- Integral Environmental Enclosure
- RS-232 Bi-Directional Interface
- Instrument Status LED Indicators

APPLICATION AREAS:
- GPS Meteorology (Precipitable Water Vapor)
- Crustal Observation - Tectonic Research
- Weather and Climate Research Studies
- Surface and Maritime Weather Observation
- Ground Based Altimeter Setting Indicators

Vaisala PTB330 Technical Data

Barometric Pressure Range 500 ... 1100 HPA

	Class A	Class B
Linearity [1]	±0.05 hPa	±0.10 hPa
Hysteresis [1]	±0.03 hPa	±0.03 hPa
Repeatability [1]	±0.03 hPa	±0.03 hPa
Calibration uncertainty [2]	±0.07 hPa	±0.15 hPa
Accuracy at +20 °C (+68 °F) [3]	±0.10 hPa	±0.20 hPa

Barometric Pressure Range 50 ... 1100 HPA

	Class B
Linearity [1]	±0.20 hPa
Hysteresis [1]	±0.08 hPa
Repeatability [1]	±0.08 hPa
Calibration uncertainty [2]	±0.15 hPa
Accuracy at +20 °C (+68 °F) [3]	±0.20 hPa

Temperature Dependence [4]

500 ... 1100 hPa	±0.1 hPa
50 ... 1100 hPa	±0.3 hPa

Total Accuracy −40 ... +60 °C (−40 ... +140 °F)

	Class A	Class B
500 ... 1100 hPa	±0.15 hPa	±0.25 hPa
50 ... 1100 hPa		±0.45 hPa

Long-term Stability

500 ... 1100 hPa	±0.1 hPa/year
50 ... 1100 hPa	±0.1 hPa/year

1) *Defined as ±2 standard deviation limits of endpoint non-linearity, hysteresis, or repeatability error.*
2) *Defined as ±2 standard deviation limits of inaccuracy of the working standard including traceability to international standards.*
3) *Defined as the root sum of the squares (RSS) of endpoint non-linearity, hysteresis error, repeatability error, and calibration uncertainty at room temperature.*
4) *Defined as ±2 standard deviation limits of temperature dependence over the operating temperature range.*

- **The Paroscientific MET3 or MET4 Specifications does NOT provide a temperature dependence but the Vaisala PTB330 does**
- **To mitigate any pressure dependency with temperature Graz moved their Paroscientific MET3 into their laser room on 20-Sep-2007**

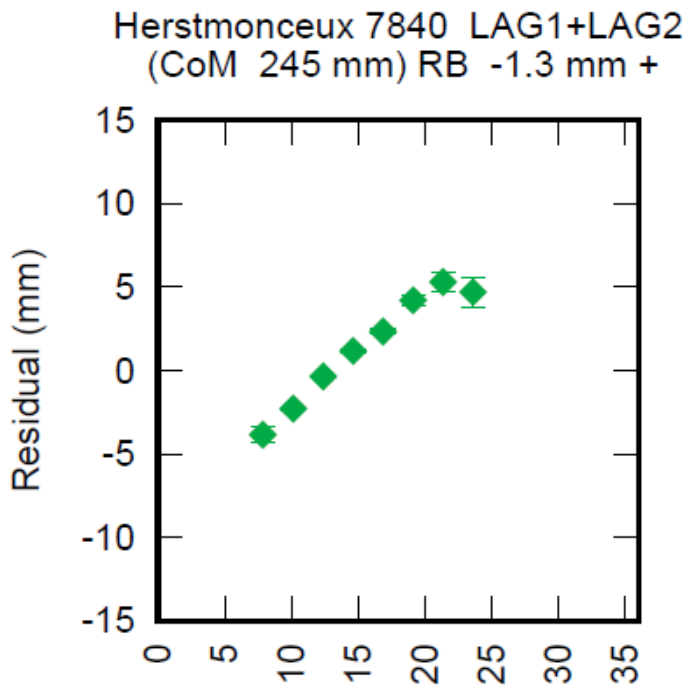
Recommendations/Summary/Conclusions/Questions

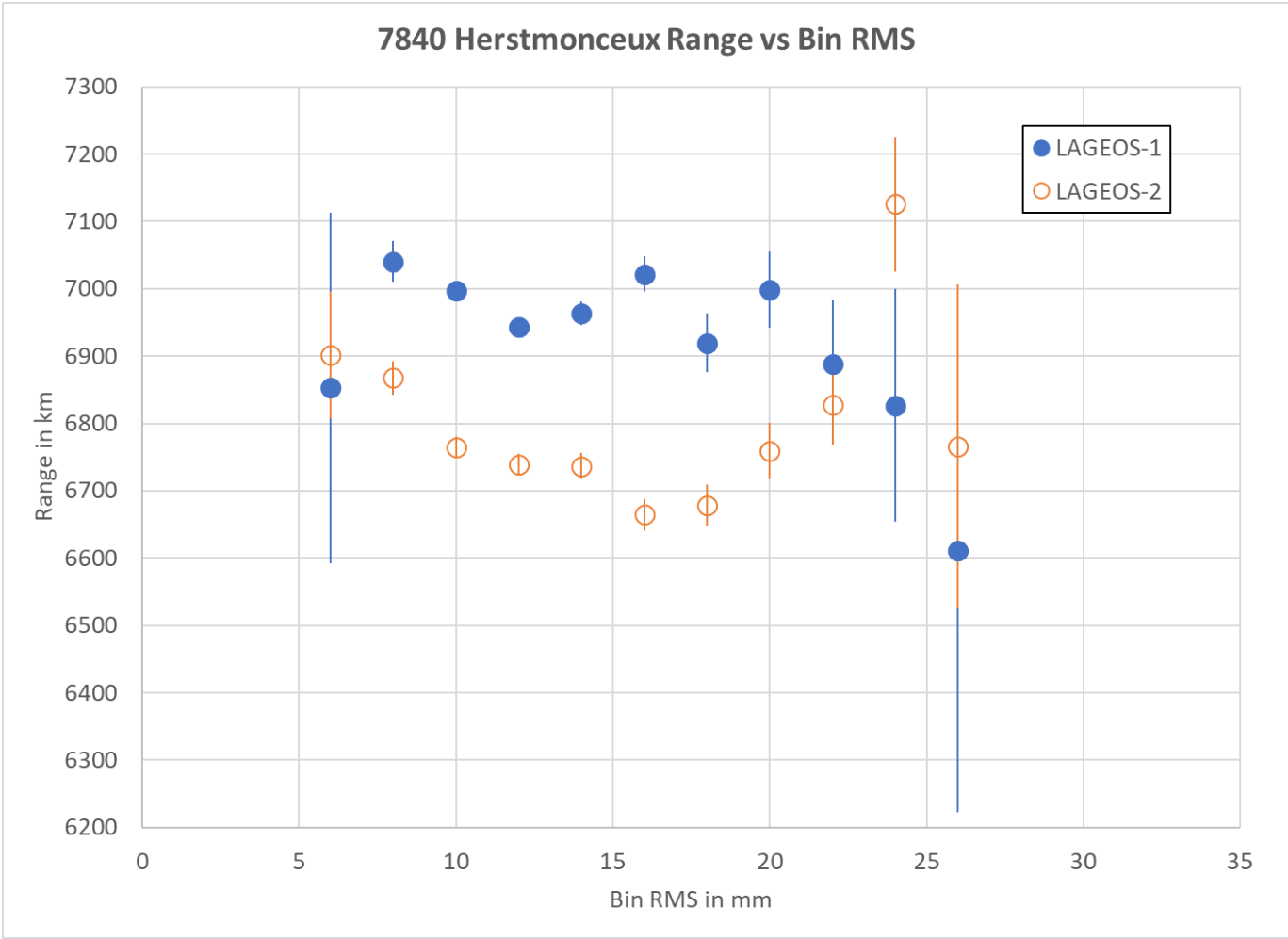
- Perform this barometric analysis on each station
- What is the best approach for modeling any barometric errors in historical data (e.g. update the ILRS Data Handling file; reprocess the data; or something else)?
- Redo the SSEM analysis after pressure errors have been removed or modeled. This will help in determining the source of the remaining biases
- What is the source of the annual signal in the pressure differences (e.g. the barometer; the VMF; or something else). Would removing this signal really matter?
- Who will maintain the VMF to keep the data current?
- Need to have new stations (e.g. Izana) added to the VMF

7840 Herstmonceux LAGEOS Bin RMS Analysis

Van S Husson
vhusson@peraton.com
ILRS Central Bureau (CB)
ILRS Quality Control Board (QCB)
13-April-2022

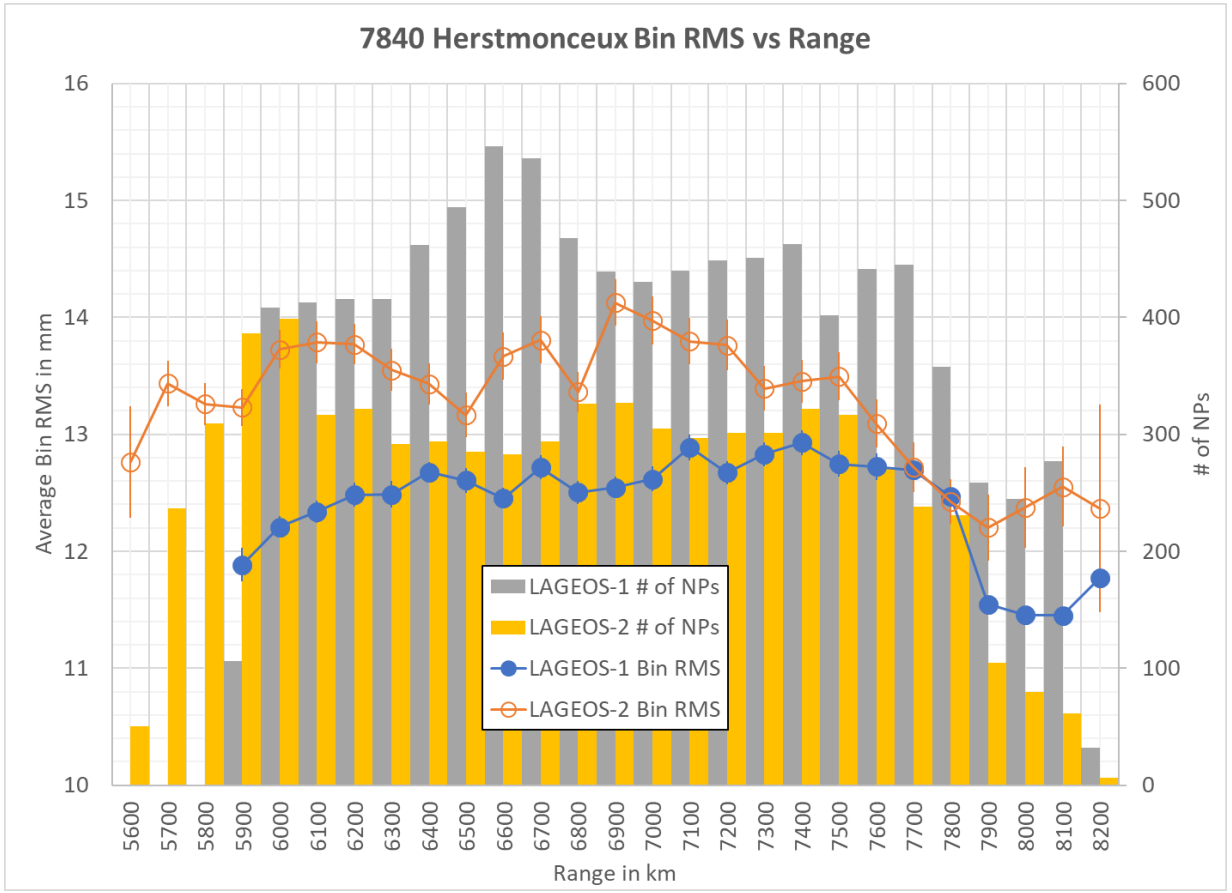
7840 Herstmonceux LAGEOS Bias and Range vs RMS

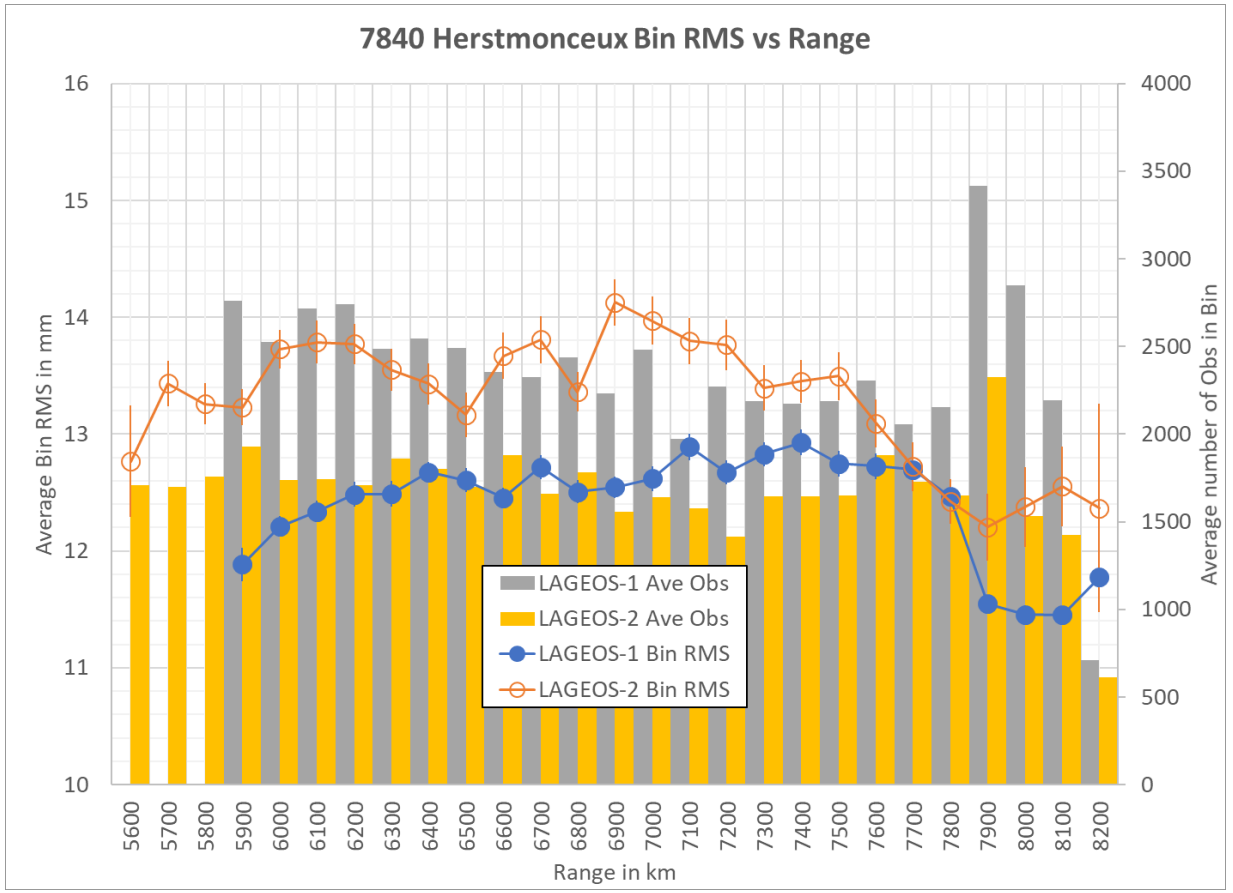




- On the left, Toshi's yearly 7840 Herstmonceux aggregate analysis; (July 2016 to June 2017)
- On the right, 7840 Herstmonceux ranges aggregated via normal point bin RMS from Jan 2016 to Dec 2017

7840 Herstmonceux Bin RMS vs Range





- 7840 Herstmonceux bin RMS aggregated via range from Jan 2016 to Dec 2017
- Bars on the left and right chart are number of normal points and number of fullrate observation at each range; respectively
- LAGEOS-2 RMSs are higher than LAGEOS-1 RMSs at almost any range