Gemini Observatory
Dome Temperature Rate of Change

1 Motivation

Conversations with Gemini South engineers earlier this year, initiated a review of the Dome temperature rate of change.

- In ICD-G0013 the maximum rate of change (to the 95th percentile) is 0.8°C.
- There was a task on the GPI list of things to verify the environmental conditions of GPI (GPI.PreAR.061). In particular the description reads: "The ICD specifies that Gemini's operational environment has 0.8C/h in temperature change. With the current chillers and energy saving incentive, this is closer to an average of 3C/h which must be addressed by Gemini. Gemini should consider cooling the dome to within 1C of the night temperature. This is a directorate decision as it will impact energy/cost saving."
- When notified of this GPI task and the implications, the Gemini Systems Engineer notified the GHOST instrument build team of a possible change request, to reflect the correct value for the maximum rate of change. Activities then commenced to determine the correct value.

2 Steps Taken

1. The Gemini Instrument Engineer John White identified temperature sensors in the Dome located close to the ISS, as they would be expected to have the most accurate depiction of temperatures experienced by the instruments. These included two air sensors and two surface sensors located on the lower truss.

2. Tom Cummings provided a data dump from the Gemini Engineering Archive for the four sensors at each site, over the past five years. The data was provided in .csv file format.

- Air sensors used: ws:tpAtLtMx, ws:tpAtLtPx
- Surface sensors used (on lower truss): ws:tpStLtMx, ws:tpStLtPx

3. Kathleen Labrie did a statistical analysis of the data using Python pandas. The results are below and show that over the past ~6-8 years, the air temperature maximum hourly rate of change is a maximum of 1.1°C (GN) and 1.13°C (GS) and over the course of one year the air temperature maximum hourly rate of change is 1.24°C (GN) and 1.25°C (GS). All of these values are to the 95th quantile, the standard used in the Gemini Environmental ICD G0013, and spurious data were removed.

4. This analysis suggested **a new value of 1.3°C** for the air temperature maximum hourly rate of change, which is a change of +0.5°C from the previous value. Gemini will submit a formal change request to AAO to update the value.

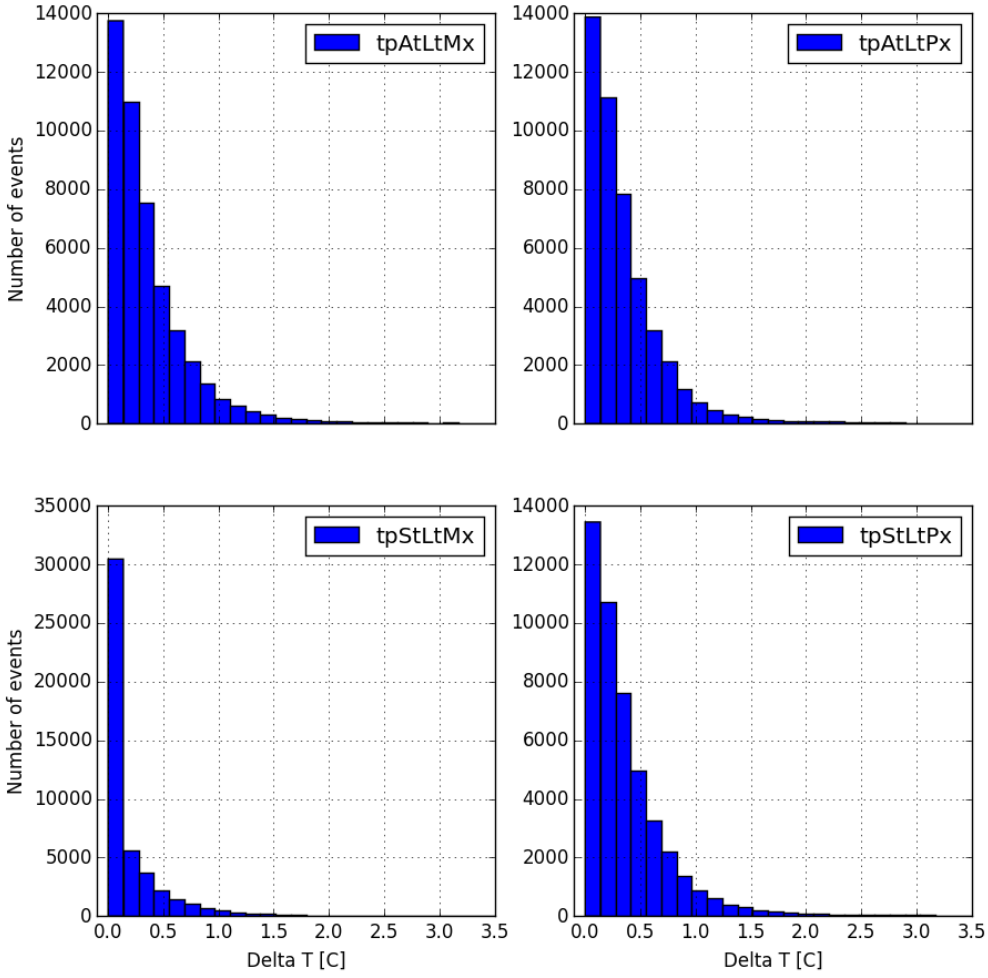
5. The results were discussed with the GPI team and Engineering Ops. This elicited the information that **a larger temperature rate of change may be seen over a shorter time period when the Dome is opened or closed**. Instruments with large thermal gradients (e.g. GPI) are impacted by this, as it will take several hours to thermalize afterwards. See Section 4. Follow on Work for details.

3 Results

3.1 Gemini North

	AtMx	AtPx	StMx	StPx
count	54262.000000	54250.000000	54262.000000	54262.000000
mean	0.332686	0.336638	0.216587	0.206225
std	0.369351	0.371939	0.211471	0.193229
min	0.000000	0.000000	0.000000	0.000000
25%	0.109574	0.112621	0.078333	0.078000
50%	0.225333	0.228833	0.162333	0.157196
75%	0.402696	0.410333	0.281857	0.271462
95%	1.098102	1.097120	0.621833	0.569319
max	6.343500	8.030833	6.370667	3.009167

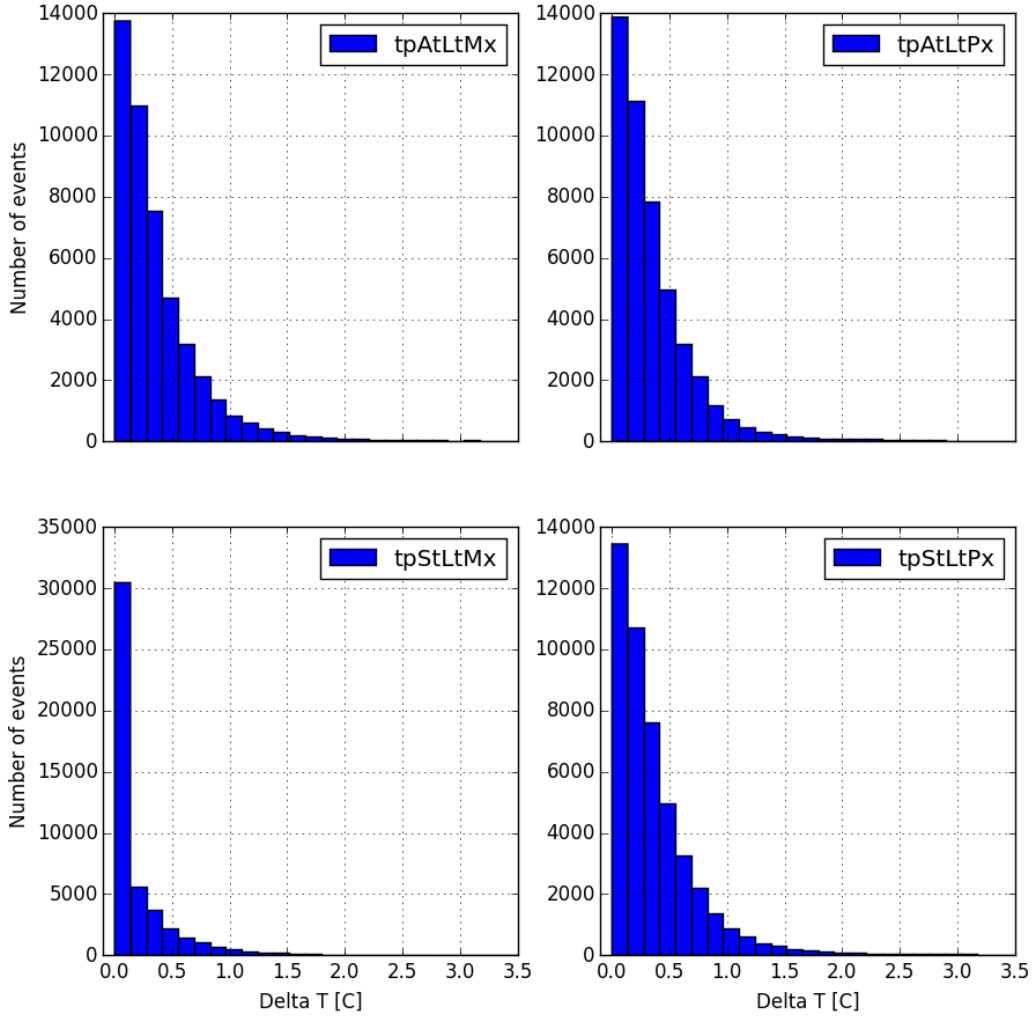
GN Histogram of hourly temperature variation



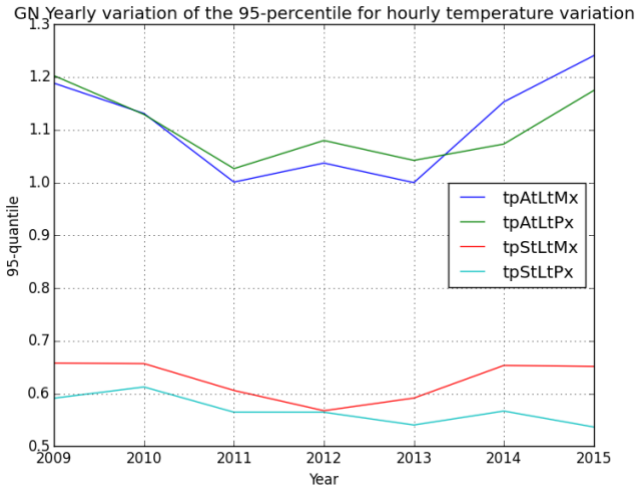
3.2 Gemini South

	AtMx	AtPx	StMx	StPx
count	47032.000000	47024.000000	47032.000000	47030.000000
mean	0.386243	0.366336	0.196704	0.392400
std	0.469832	0.438529	0.437371	0.471837
min	0.000000	0.000000	0.000000	0.000000
50%	0.257946	0.254667	0.005993	0.265417
75%	0.493026	0.470425	0.253262	0.504193
85%	0.680504	0.638750	0.420833	0.686667
95%	1.132377	1.021649	0.855833	1.135505
max	13.663889	12.933333	13.790000	13.301111

GS Histogram of hourly temperature variation

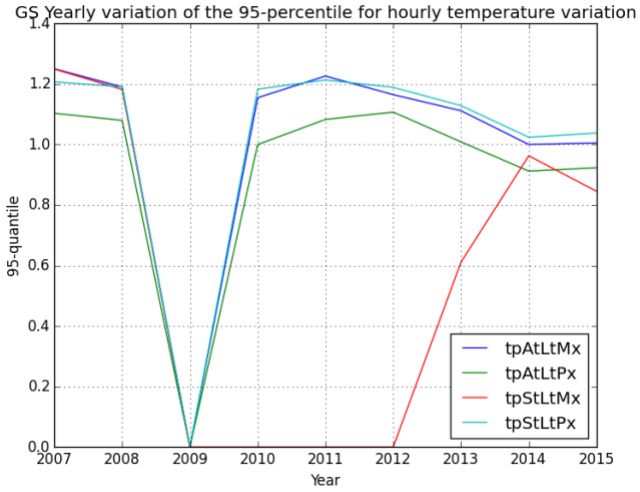


3.3 Gemini North Yearly Variation



		AtMx	AtPx	StMx	StPx
2009	**0.95**	1.188376	1.202599	0.657776	0.591144
2010	**0.95**	1.130933	1.129115	0.656731	0.612389
2011	**0.95**	1.000875	1.026433	0.605824	0.564567
2012	**0.95**	1.036934	1.079712	0.567414	0.564508
2013	**0.95**	0.999863	1.041967	0.591333	0.540341
2014	**0.95**	1.152977	1.073034	0.653225	0.566695
2015	**0.95**	1.240613	1.174584	0.651363	0.536565

3.4 Gemini South Yearly Variation

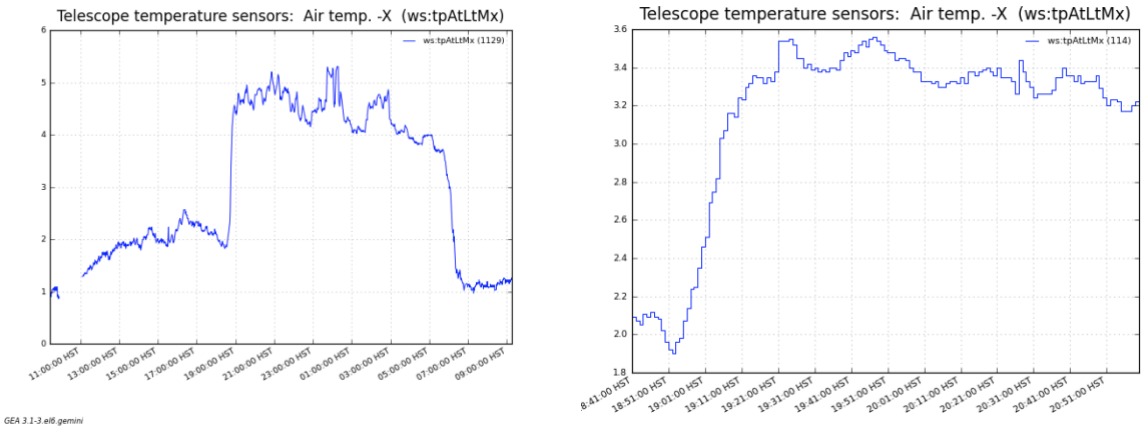


		AtMx	AtPx	StMx	StPx
2007	**0.95**	1.250167	1.103333	1.249250	1.207133
2008	**0.95**	1.190375	1.079854	1.182062	1.190688
2009	**0.95**	0.000000	0.000000	0.000000	0.000000
2010	**0.95**	1.154789	0.999841	0.000000	1.182910
2011	**0.95**	1.226318	1.082988	0.000000	1.213257
2012	**0.95**	1.164895	1.107190	0.000000	1.188936
2013	**0.95**	1.111740	1.008949	0.611000	1.128594
2014	**0.95**	1.000232	0.912162	0.962781	1.024112
2015	**0.95**	1.005292	0.923260	0.845732	1.037944

4 Follow on Work

The Gemini dome is opened prior to the start of nighttime observations in order to allow time for internal and external temperatures to equalize. The dome is opened by opening the shutters and possibly the vent gates depending on the weather conditions. When this occurs, **the temperature rate of change can be higher than the hourly value mentioned above, over a shorter time period (< hour).** A similar effect is seen in the morning when the dome is closed. The reasons for this are discussed below.

➔As follow on work, we will statistically model the rate of change to determine what the maximum may be. One example is shown below.



On the left is the daily change in temperature. On the right, we zoom into the spike around 19:00:00 HST, and can correlate the temperature change with Top Shutter sensor data indicative of opening for the night.

The reason for these differentials is related to the dome air and chiller systems, and to operational procedures.

- During the day, Air Handling Units (AHUs) and chillers keep the Gemini dome around a set temperature. They are turned off when the operators open the dome. If the set temperature is very different from the temperature at twilight, a large differential is experience when the dome is opened.
- In the morning, the operators close the dome and turn on the AHUs and chillers.

➔The second follow on work is to make a recommendation to Gemini Engineering-Ops, to investigate ways to decrease the differential between the inside and outside temperatures at the time of dome opening. **It is expected that the solution would have scientific benefit, because GPI is very sensitive to the thermal gradient, and would have cost benefit through energy savings.**