QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PROCESSES DEVELOPED FOR W.A.D.F. TEMPERATURE DATA

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OVERVIEW

- Introduction
- Step1
  - Initial review tests
- Step2
  - Differences Between Hourly and Daily Data
- Step3
  - Gap filling
- Conclusion

Automated
Manual

Daily air temperature dataset

Pre-screen: Remove obviously bad values (e.g. 6999, -99999, etc).

Step 1 – Initial review of the mean, min and max data:
1. Limits test – flag values more than 2 standard deviations different from station mean
2. Rate of change test – flag values that change dramatically from one day to the next
3. No change test – flag values when there is little change over 3 days
4. Flag zeroes

Manual review of flagged data. Delete data as appropriate and document.

Step 2 - Assess statistical validity of daily mean:
1. For each day, count number of missing values in the hourly dataset.
2. For each day, compare the daily mean value with the mean calculated from the hourly data

Manual review of flagged data. Delete data as appropriate and document.

Step 3 – Gap filling:
1. Fill gaps using redundant sensors at the same station.
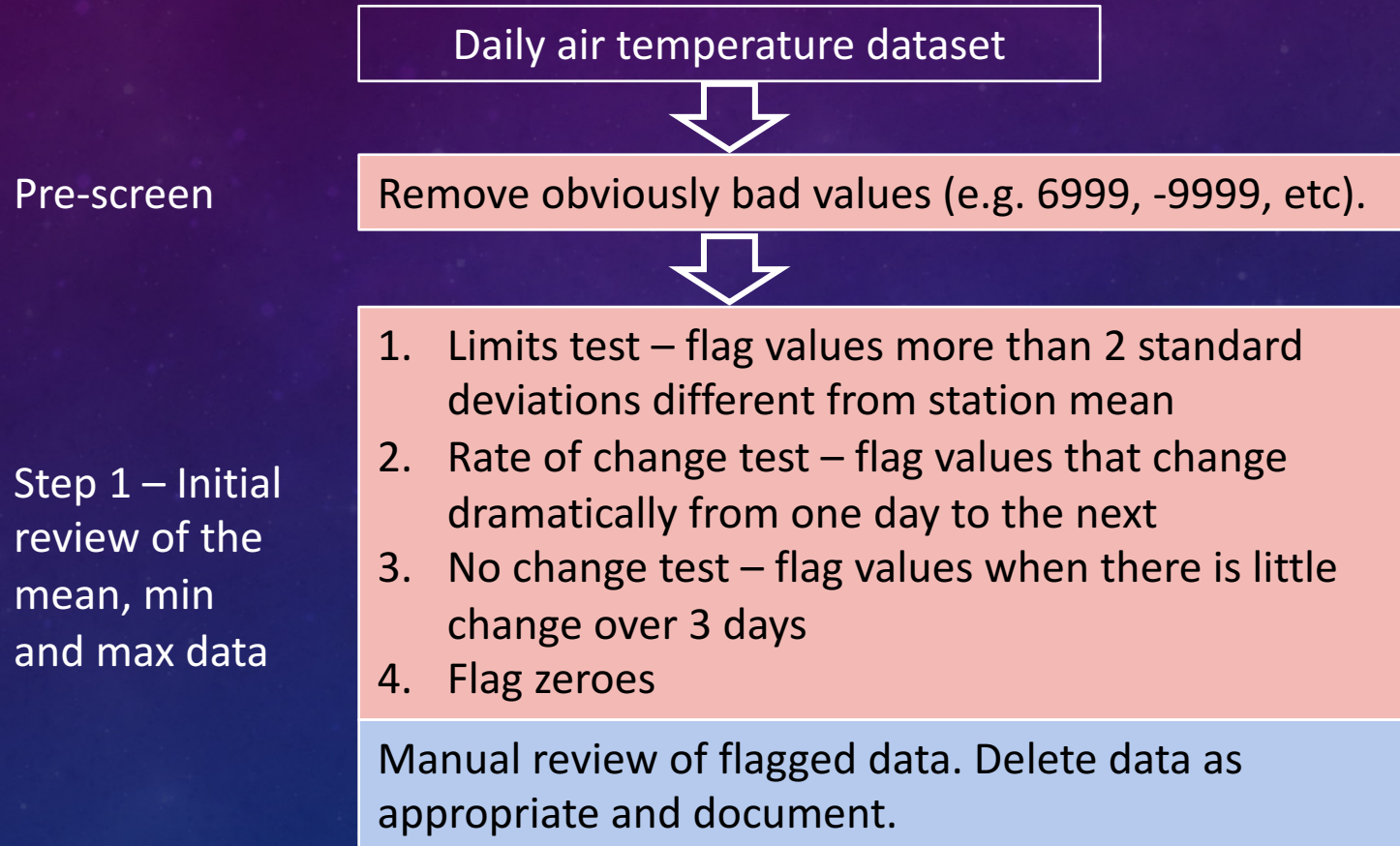2. Fills gaps using data from adjacent stations based on lapse rates.

INTRODUCTION

- Purpose: To clean daily and hourly temperature records from West Arm Demonstration Forest climate network (8 stations, 1992-present).

- Delete bad data and fill gaps which may occur because of:

  - Instrument drift, power failure, programming error, station changes, etc.

- R code used to quickly flag <u>potentially</u> bad data.

- Flags then manually reviewed and data points deleted based on expert experience.

STEP 1 – PRE-SCREEN AND INITIAL REVIEW

Automated
Manual

Daily air temperature dataset

Pre-screen

Remove obviously bad values (e.g. 6999, -9999, etc).

Step 1 – Initial review of the mean, min and max data

1. Limits test – flag values more than 2 standard deviations different from station mean
2. Rate of change test – flag values that change dramatically from one day to the next
3. No change test – flag values when there is little change over 3 days
4. Flag zeroes

Manual review of flagged data. Delete data as appropriate and document.

PRE-SCREENING

- R code deletes obvious errors.

  - Due to programming errors, sensor failure, wiring problems.

- Values set manually based on quick manual review.

  - E.g. -6999

Date	Year	JulianD	Time	Tair_Avg_C
2002-12-19	2002	353	2400	-6999
2002-12-21	2002	355	2400	-6999
2002-12-25	2002	359	2400	-6999
2003-01-02	2003	2	2400	-6999
2014-07-10	2014	191	2400	-6999
2014-07-11	2014	192	2400	-6999
2014-07-12	2014	193	2400	-6999
2014-07-13	2014	194	2400	-6999
2014-07-14	2014	195	2400	-6999
2014-07-15	2014	196	2400	-6999
2014-07-16	2014	197	2400	-6999
2014-07-17	2014	198	2400	-6999
2014-07-18	2014	199	2400	-6999
2014-07-19	2014	200	2400	-6999
2014-07-20	2014	201	2400	-6999
2014-07-21	2014	202	2400	-6999
2014-07-22	2014	203	2400	-6999
2014-07-23	2014	204	2400	-6999
2014-07-24	2014	205	2400	-6999
2014-07-25	2014	206	2400	-6999
2014-07-26	2014	207	2400	-6999
2014-07-27	2014	208	2400	-6999
2014-07-28	2014	209	2400	-6999
2014-07-29	2014	210	2400	-6999
2014-07-30	2014	211	2400	-6999
2014-07-31	2014	212	2400	-6999
2014-08-01	2014	213	2400	-6999
2014-08-02	2014	214	2400	-6999
2014-08-03	2014	215	2400	-6999
2014-08-04	2014	216	2400	-6999
2014-08-05	2014	217	2400	-6999
2014-08-06	2014	218	2400	-6999
2014-08-07	2014	219	2400	-6999
2014-08-08	2014	220	2400	-6999
2014-08-09	2014	221	2400	-6999
2014-08-10	2014	222	2400	-6999
2014-08-11	2014	223	2400	-6999
2014-08-12	2014	224	2400	-6999
2014-08-13	2014	225	2400	-6999
2014-08-14	2014	226	2400	-6999

1. LIMITS TEST

- Tests if daily mean, min and max values fall within a reasonable range.

- Algorithm:

  - For each day of the year, use the first 10 years of data to calculate the average and standard deviation for daily mean, maximum and minimum.

  - Flag data that do not fall within 2 standard deviations of the average.

- Could also use data from another station
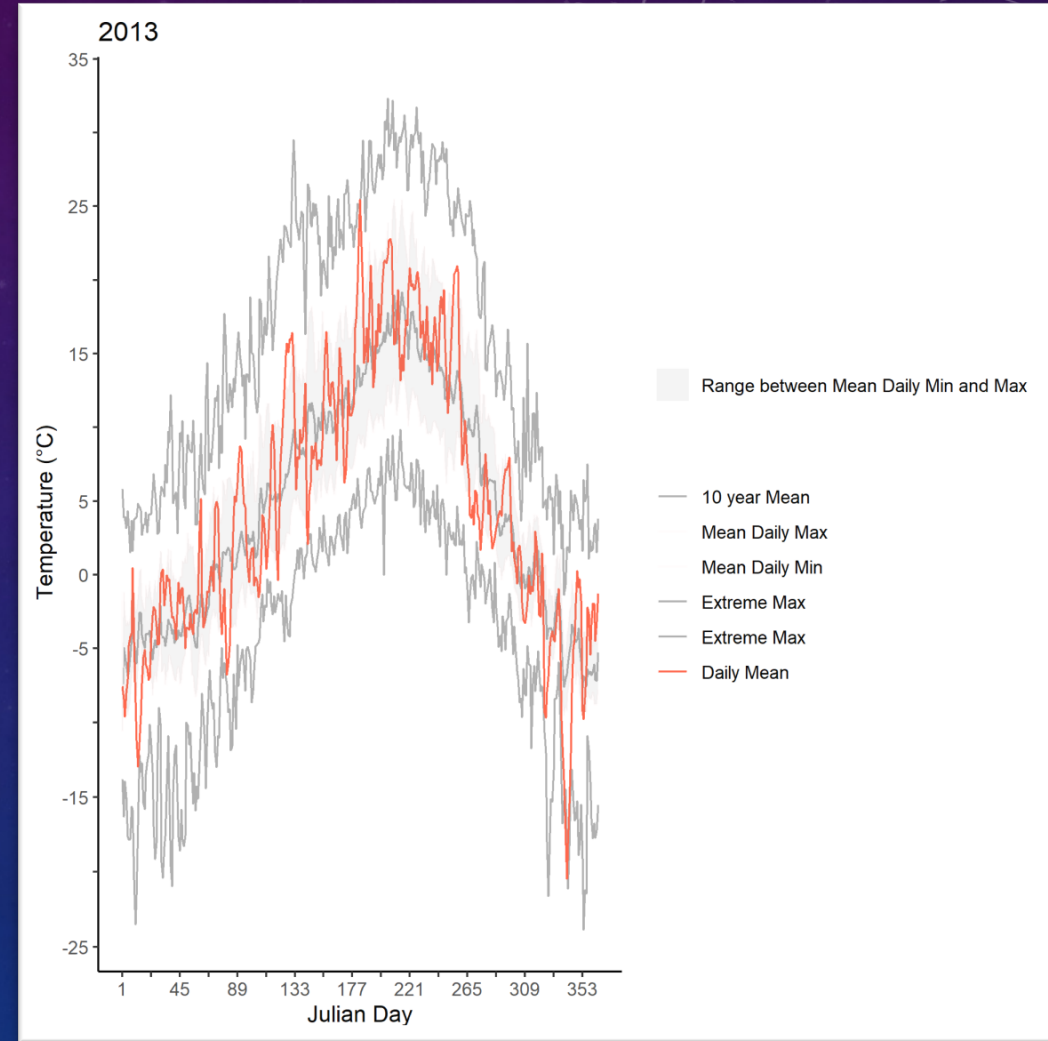
2. RATE OF CHANGE TEST

- Using other data (e.g. Environment Canada stations) to assess if the change in temperature from one day to the next is reasonable (identify spikes).

- Algorithm:

  - Calculate the difference between two consecutive values. If the difference is larger than expected, data is flagged.

  - For the WADF stations, derived max expected daily change from Castlegar climate station (1992 to 2019).

3. NO CHANGE TEST

- Identify when mean temperature changes less than 0.1°C over 2 or more days.

- Causes: Sensor malfunction, programming errors.
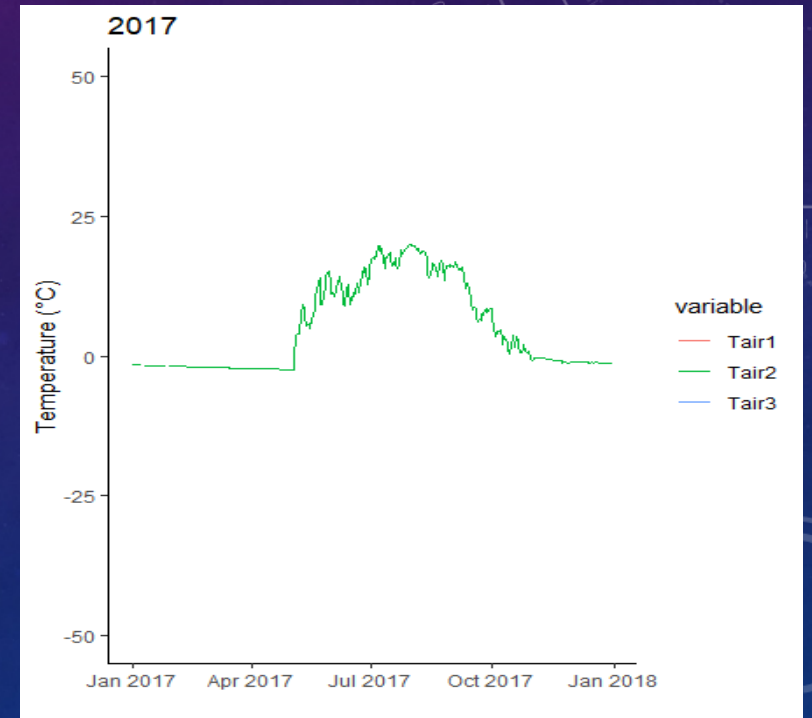
4. ZEROS FOR MIN AND MAX

- Zeros for Min and Max temperatures can result when loggers are reset due to program changes or power problems.

- Flag zero values for review.

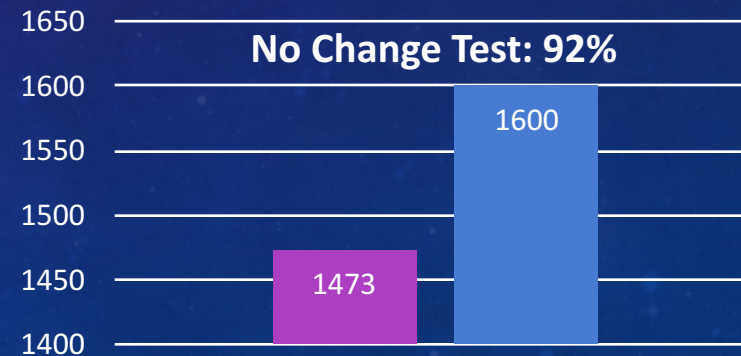|	A	B	C	D	E	F	G
1	Date	Year	JulianDay	Time	Tair_Avg_C	RH_Avg_Pct	Tair_Max_C
66	05-Mar-08	2008	65	2400	-2.7	90	3.1
67	06-Mar-08	2008	66	2400	-1.4	90	3.8
68	07-Mar-08	2008	67	2400	0.5	86	7.3
69	08-Mar-08	2008	68	2400	1.0	93	4.7
70	09-Mar-08	2008	69	2400	1.7	88	5.8
71	10-Mar-08	2008	70	2400	1.8	100	3.5
72	11-Mar-08	2008	71	2400	0.6	106	3.6
73	12-Mar-08	2008	72	2400	-1.5	89	1.9
74	13-Mar-08	2008	73	2400	-1.9	90	3.4
75	14-Mar-08	2008	74	2400	-1.6	108	4.4
76	15-Mar-08	2008	75	2400	-1.7	107	1.1
77	16-Mar-08	2008	76	2400	-1.5	87	3.1
78	17-Mar-08	2008	77	2400	-1.1	104	1.0
79	18-Mar-08	2008	78	2400	-1.5	100	3.1
80	19-Mar-08	2008	79	2400	-2.9	91	1.3
81	20-Mar-08	2008	80	2400	-2.3	97	1.7
82	21-Mar-08	2008	81	2400	-2.7	98	2.6
83	22-Mar-08	2008	82	2400	-2.0	83	2.8
84	23-Mar-08	2008	83	2400	-2.5	101	0.5
85	24-Mar-08	2008	84	2400	-3.1	69	2.2
86	25-Mar-08	2008	85	2400	-4.0	72	2.1
87	26-Mar-08	2008	86	2400	-3.6	90	-0.6
88	27-Mar-08	2008	87	2400	-4.3	84	0.4
89	28-Mar-08	2008	88	2400	-4.4	87	-0.2
90	29-Mar-08	2008	89	2400	-4.6	105	-1.7
91	30-Mar-08	2008	90	2400	-4.7	91	0.0
92	31-Mar-08	2008	91	2400	-5.6	96	0.0
93	01-Apr-08	2008	92	2400			
94	02-Apr-08	2008	93	2400			
95	03-Apr-08	2008	94	2400			
96	04-Apr-08	2008	95	2400			
97	05-Apr-08	2008	96	2400			
98	06-Apr-08	2008	97	2400			
99	07-Apr-08	2008	98	2400			
100	08-Apr-08	2008	99	2400			
101	09-Apr-08	2008	100	2400			
102	10-Apr-08	2008	101	2400			
103	11-Apr-08	2008	102	2400			

STEP 1 MANUAL REVIEW
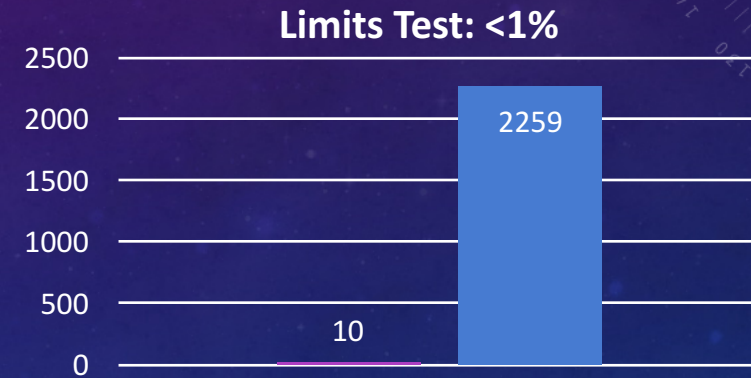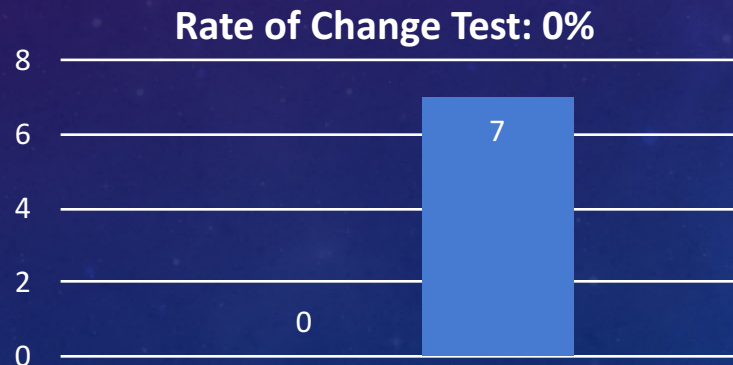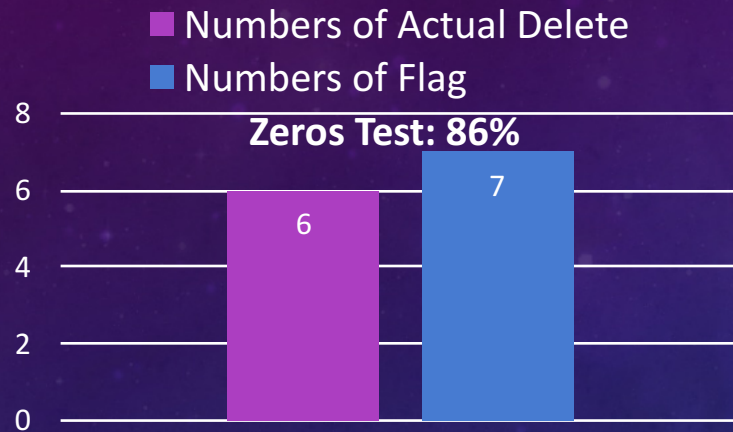
- R code outputs CSV file with original data and flags.

- Expert reviews flags and deletes bad data.

STEP 1 QA/QC EFFICIENCY: BURN STATION

- 10221 days assessed

Legend: ■ Numbers of Actual Delete ■ Numbers of Flag

Zeros Test: 86% — Actual Delete: 6, Flag: 7

Rate of Change Test: 0% — Actual Delete: 0, Flag: 7

Limits Test: <1% — Actual Delete: 10, Flag: 2259

No Change Test: 92% — Actual Delete: 1473, Flag: 1600
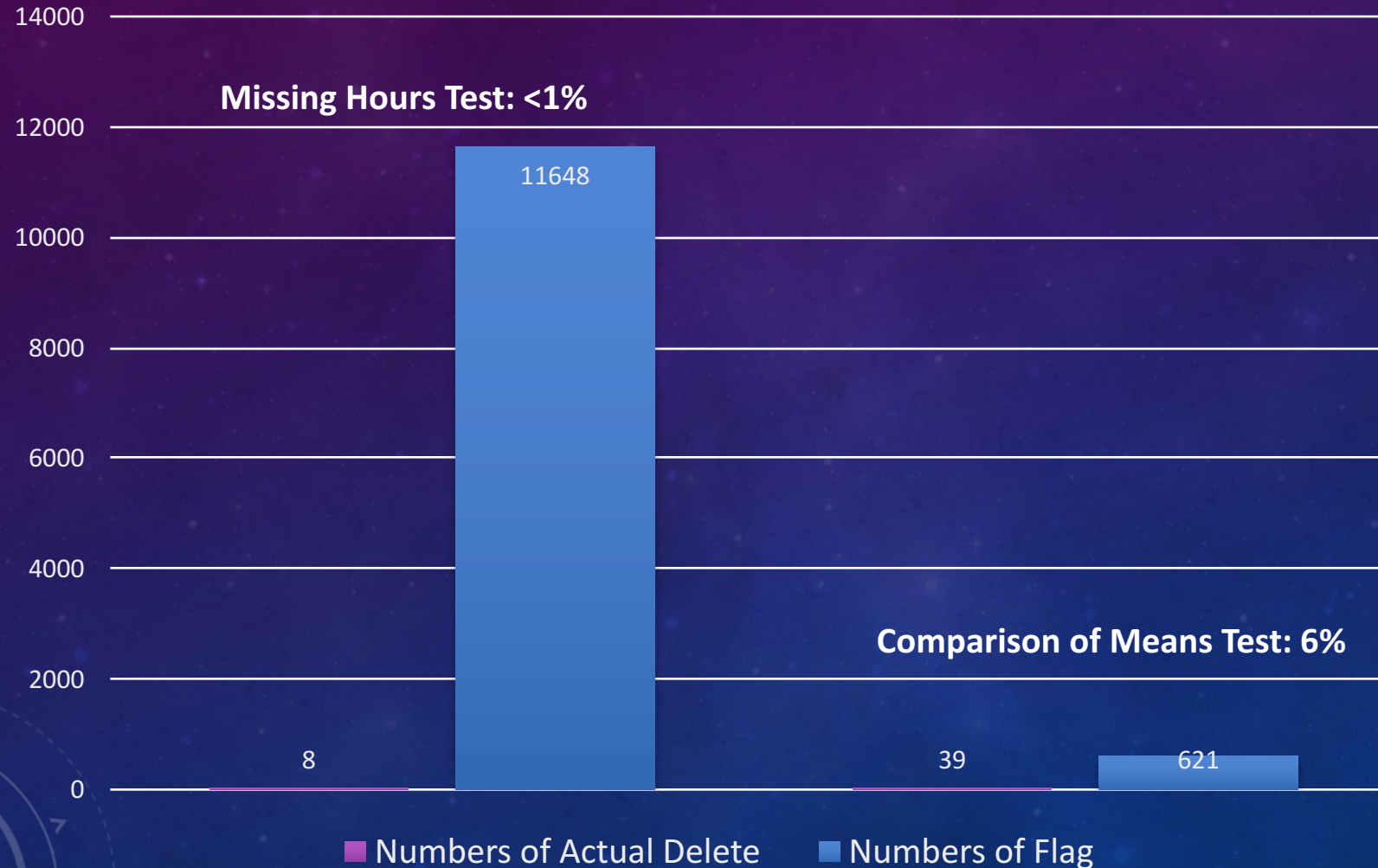
STEP 2 'STATISTICAL' TESTS

Results from Step 1

1. For each day, count number of missing values in the hourly dataset.
2. For each day, compare the daily mean value with the mean calculated from the hourly data

Manual review of flagged data. Delete data as appropriate and document.

- Uses daily and hourly data.

- Is the daily mean representative?

- If the daily and hourly means are more than 0.1°C different, it may indicate power problems, site visits, program changes or errors copying the raw data into spreadsheets.

STEP 2 QA/QC EFFICIENCY: BURN STATION

Missing Hours Test: <1%

11648

Comparison of Means Test: 6%

8

39

621

■ Numbers of Actual Delete   ■ Numbers of Flag

- Most of the days flagged were already NA in the dataset, so review was efficient

STEP 3 GAP-FILLING (OPTIONAL)

1. Fill gaps using redundant sensors at the same station.
2. Fills gaps using data from adjacent stations based on lapse rates.

- Gap-filling (where appropriate)

- Compare multiple sensors at the same location.

  - May require correction for different sensor heights, sensor types or calibration drift.

- Compare to 'nearby' stations.

  - Correct using lapse rates (effect of elevation)
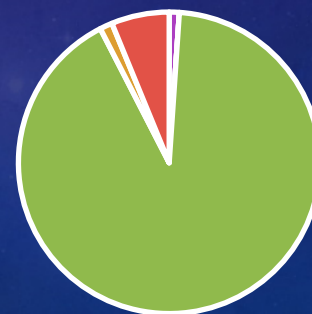
SUMMARY OF DELETED DATA (STEPS 1 AND 2)
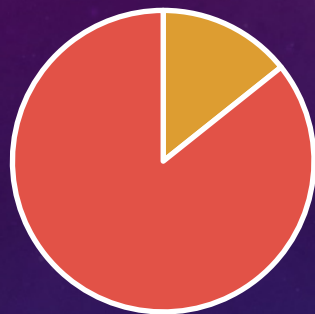
CONCLUSIONS

- Flags from some of the tests are uncommon but all are important.

  - E.g. No change test

- Automated flagging using R is efficient.

  - Easy to run as new data collected.

- Manual review steps are very important.

  - Expert opinion always trumps statistics-based assessment.

- Data is 'clean' and publishable after Step 2; gap-filling is value-added.

- R code and supporting documentation available

  - Modifications for use with other datasets doesn't require extensive R experience