

Observed air temperature and relative humidity from small coastal watersheds in British Columbia between 2013 and 2019

Methods and metadata for air temperature and relative humidity time-series version 1.0

Emily Haughton, Bill Floyd, Ray Brunsting, and Shawn Hateley

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Introduction:

The Hakai climate and hydrometric observation network serves as the foundation for the terrestrial and aquatic science program and provides many operational uses for the general public and for air and marine traffic. Since the deployment of the first meteorological stations in 2012, the network has expanded significantly. Currently, the network of air temperature and relative humidity sensors includes 21 stations, and 63 sensors encompassing a wide geographical spread that ranges from Calvert and Hecate Islands, Rivers Inlet, and down to Quadra Island (Figure 1). Each station is outfitted with a combined air temperature and relative humidity probe (H2-SC3, Campbell Scientific Inc., Logan, UT, USA) and another air temperature probe (CS109, Campbell Scientific Inc., Logan, UT, USA) installed adjacent to the H2-SC3 probe at a minimum of 2m above ground and any surface that can emit longwave radiation or reflect solar radiation. Efforts were made to ensure the sensor was not exposed to wind so as to maximize ventilation and minimize solar loading on the sensor.

The collection of these data will further efforts to detect and track climate change–related impacts over the long term as well as further our understanding of how climate conditions vary spatially and temporally and inter-relate to one another.

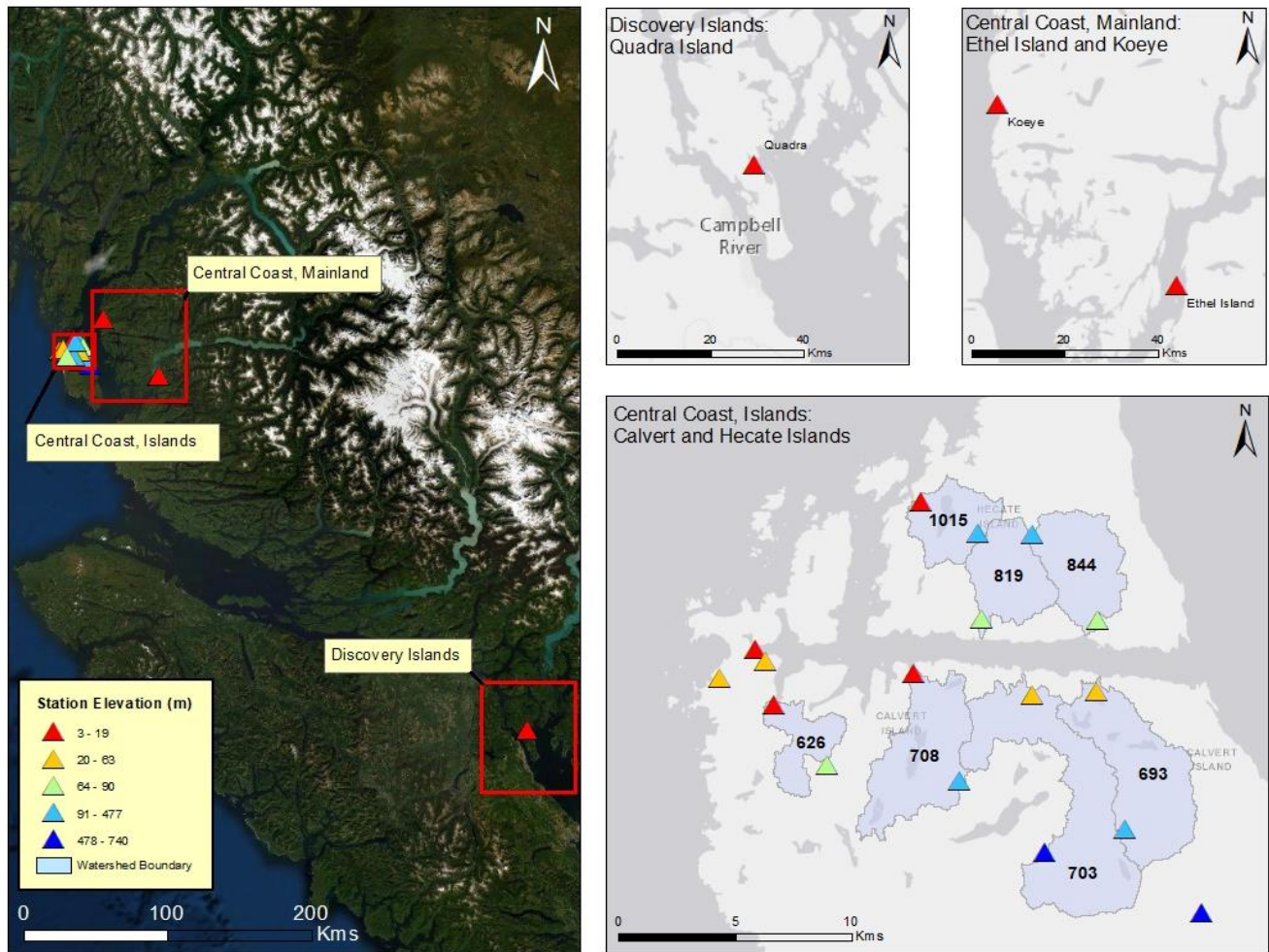


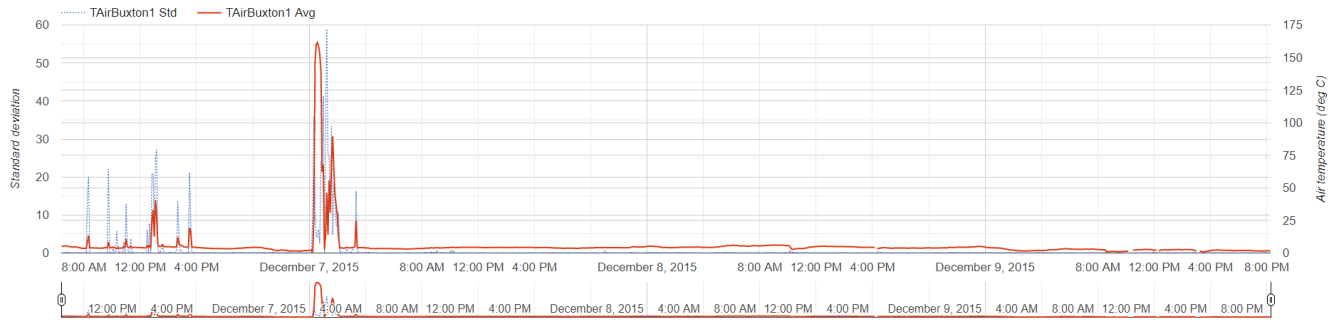
Figure 1. The locations of Hakai meteorological stations along the British Columbia coast, Canada (left). Map insets displayed on the right depict the Discovery Islands (upper right-left), Central Coast, mainland (upper right-right), and Calvert and Hecate Islands (lower right). Station symbols are coloured red to blue from lowest (3m) to highest (741m) elevation.

Methods:

The air temperature and relative humidity time-series data package was created using 5-minute average measurements that are quality controlled (QC'd), flagged and corrected where needed (Table 2) according to the steps outlined in the "[Hakai Sensor Network Quality Control \(QC\)](#)" document. A general summary of the QC process is outlined in the steps below:

1. Download annual data
2. Check for outliers:
 - Generate scatter plots illustrating temporal standard deviation (SD) distribution in air temperature
 - Investigate instances where SD differs substantially relative to the spread of the data
 - Assess/determine whether to accept or reject value
3. Check for prevalence of automated flags
 - Assess/determine whether to accept or reject
4. Range
 - Confirm data fall within realistic upper and lower bounds (i.e typically no sub-zero temperatures in summer months depending on elevation of site)
5. Persistence
 - Is there a repeated value indicative of a sensor malfunction? (i.e sustained periods of 100% RH and no rainfall)
6. Internal consistency
 - Are values realistic for a given time period?
7. Spatial consistency
 - Are data patterns consistent with what networked sensors in the same area recorded?
8. Assign flags to remaining data in accordance with "[Hakai Sensor Network Quality Control \(QC\)](#)" document
9. Re-upload to Sensor Network QC portal

a.



b.

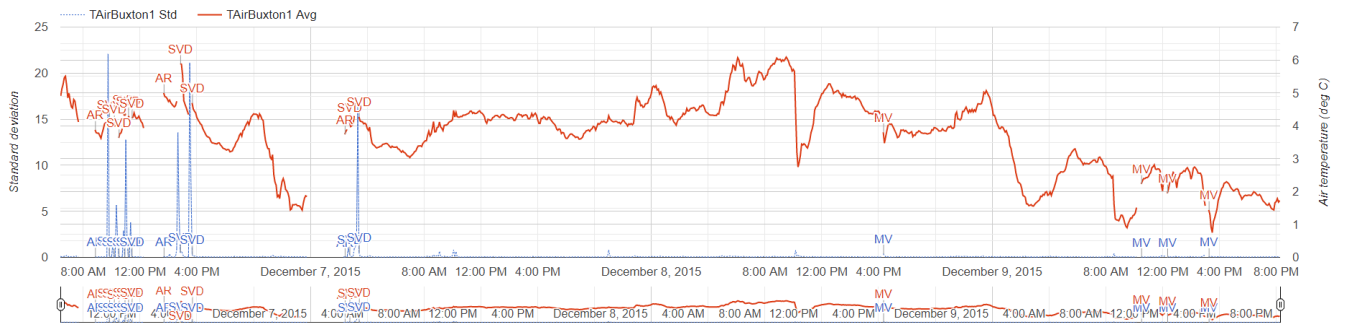


Figure 2: Time-series plots illustrating distribution of standard deviation and average of air temperature readings at the Buxton station, before data QC (a); panel (b) shows accepted air temperature data after values were removed and flagged based on standard deviation.

Summary and Examples of Commonly Assigned Flags:

SVD - Suspicious Value Delete

- Unrealistically high or low values
- Sensor malfunction
- Sensor pre-deployment
- People on site
- Abrupt changes that can't be explained by natural mechanisms

a.



b.

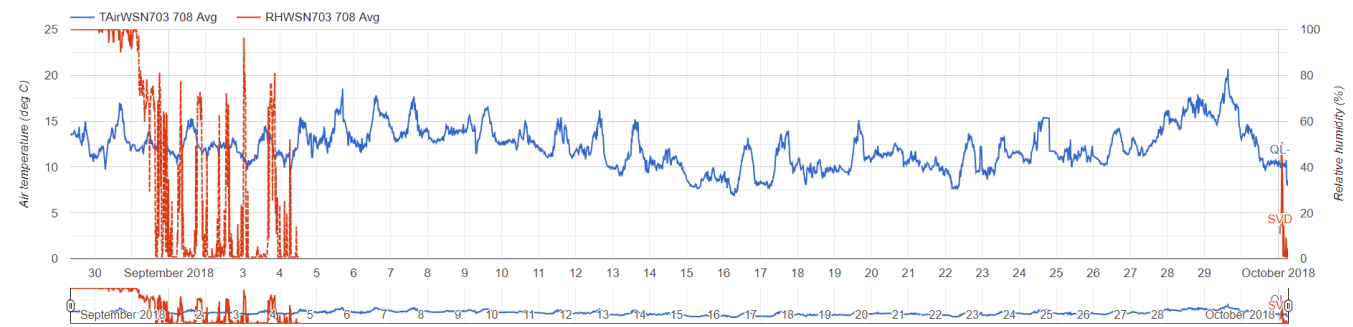


Figure 3: (a) Instance of **Suspicious Value Delete** at WSN703 station relative humidity sensor; (b) depicts post-flagging.

MV - Missing Value

- Logger off

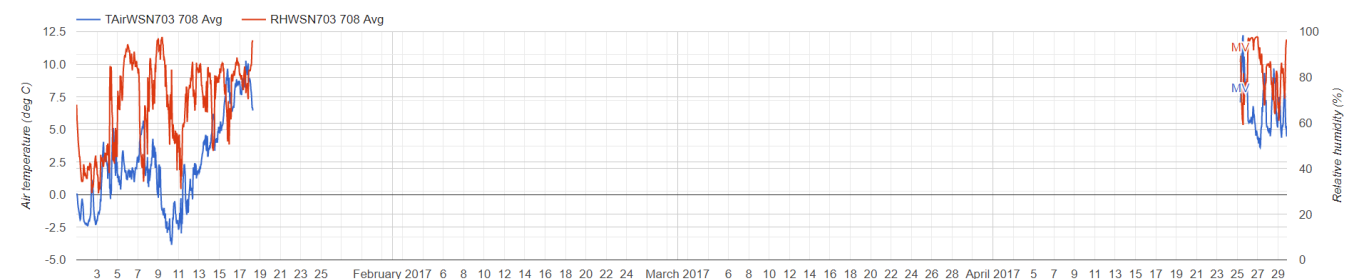
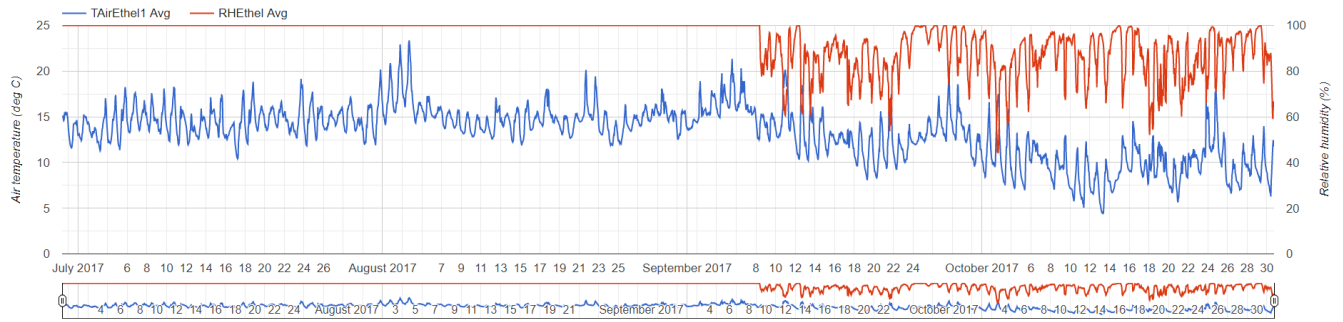


Figure 4: Instance of **Missing Value** flagging at WSN703_708 for both air temperature and relative humidity sensors.

PV - Persistent Value

a.



b.

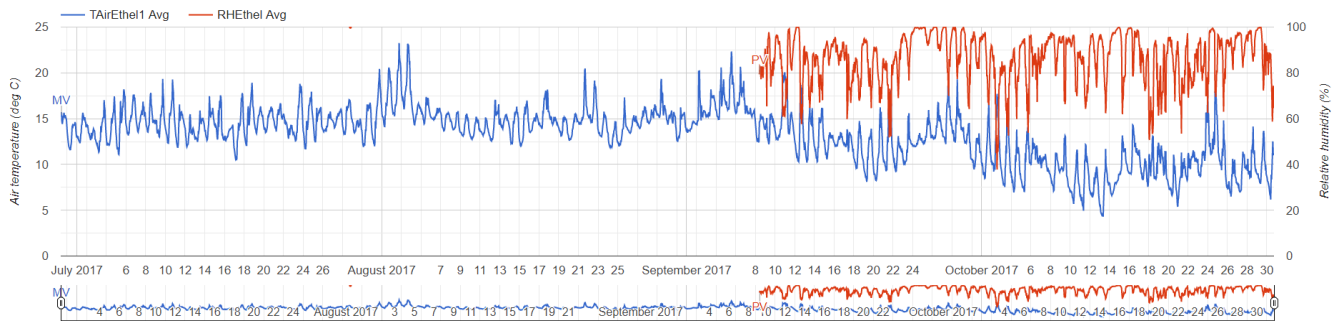
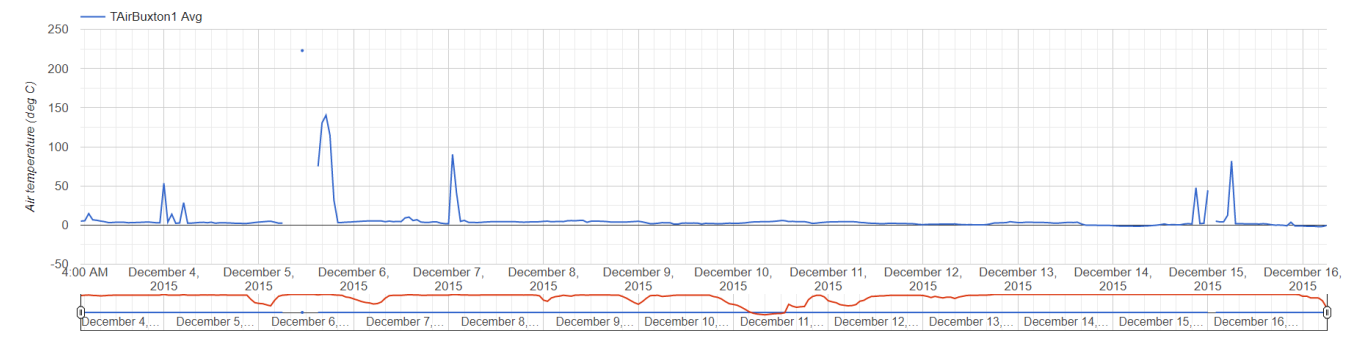


Figure 5: (a) Instance of **Persistent Value** at the Ethel Island station relative humidity sensor, while (b) depicts post-flagging.

AR – Above Range

a.



b.

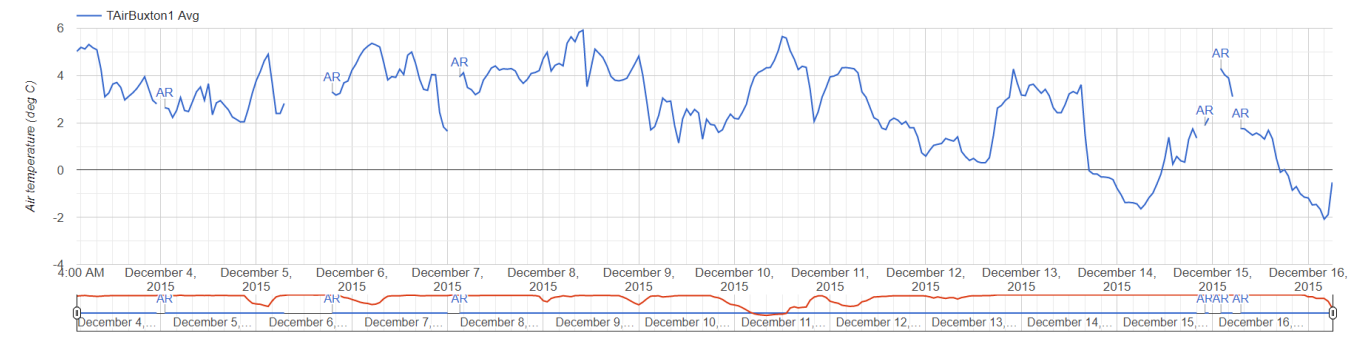


Figure 6: (a) Instance of Above Range air temperature recorded at the Buxton station, while (b) depicts post-flagging.

Summary of QAQC Results

The following tables provide a summary of the quality flags assigned per watershed (**Error! Reference source not found.**) in addition to an overview of the major issues experienced at each site (Table). The vast majority of data points were acceptable values that required no flagging or gap-filling. The majority of discarded data points were due to power outages and related sensor malfunctions affecting combined temperature and relative humidity probes at Buxton and SSN708.

Table 1: Tair and RH sensor flag allocation per watershed and site. Watershed ID text provides a hyperlink to view the data through an interactive online tool.

Site	Tair1					Tair2			RH				
	AV	SVD	MV	PV	SI	AV	SVD	MV	AV	SVC	SVD	MV	PV
Buxton	214349	104047	1225	0	0	544664	0	710	236145	0	68104	17539	0
Buxton East	517281	0	14707	0	0	133236	0	14676	0	0	0	0	0
WSN693_703	419542	10	7944	0	0	147494	0	66	419570	0	14	7912	0
SSN693	437885	13	20	0	0	437833	0	85	148073	0	0	19	0
WSN703	404694	4820	14220	0	0	146752	0	64	396531	0	7066	20037	0
WSN703_708	358632	40646	28008	0	0	147499	0	2	382165	1281	15832	28008	0
SSN708	430120	0	102989	0	0	147230	0	37	430120	0	0	102989	0
SSN626	432439	0	6321	0	0	147803	0	42	438653	0	0	107	0
WSN626	320571	0	60	0	0	147747	0	46	313690	0	3	6938	0
Reference Station	306327	0	0	104	0	124139	0	104	306327	0	0	190	0
PruthDock	440049	0	389	0	0	123881	0	360	440049	0	0	389	0
Lookout	526467	17 746	1201	0	7722	552170	0	966	549336	0	0	3800	0
SSN1015	437596	8	884	0	0	147449	0	392	437596	0	8	884	0
WSN819_1015	427074	0	663	0	0	129819	0	17740	427094	0	41	602	0
SSN819	438124	10	37	0	0	147248	0	17	438131	0	3	37	0
Hecate	425851	1179	696	0	0	147473	0	78	415364	0	0	11202	0
WSN844	340373	0	90	0	0	146746	0	0	340368	0	0	95	0
Koeve	452878	55850	39779	0	0	533176	0	15331	424054	0	0	81803	0
Ethel	534589	0	10708	0	0	534589	0	10708	1427885	0	0	7668	119684
Quadra	548371	0	4765	0	0	548371	0	4765	548371	0	0	4765	0
Sum	8413212	207346	234706	104	7722	5135319	0	66189	851522	1281	91071	294984	119684

Table 2: Summary of major issues of note at specific sites.

Site	Issue	Action	Link
Buxton	Extended power outage	Flagged as Missing Value, "MV"	Buxton – Summer 2017
Lookout	Exhibited period of warmer air temperature relative to other nearby stations	Flagged as Spatial Inconsistency, "SI"	Lookout – Sept 2016
SSN626	Unrealistic temperature spikes indicative of sensor malfunction	Flagged as Suspicious Value Delete, "SVD"	SSN626 – July 2015
WSN693_703	Extended power outage	Flagged as Missing Value, "MV"	WSN693_703 – Spring 2017
Koeye	Unrealistic temperature spikes	Flagged as Suspicious Value Delete, "SVD" and Suspicious Value Caution, "SVC"	Koeye – Dec 2015 Winter 2016
Ethel	Persistent value	Flagged as "PV" and removed	Ethel - 2017

References

Oliver, A. A., Tank, S. E., Giesbrecht, I., Korver, M. C., Floyd, W. C., Sanborn, P., Bulmer, C., and Lertzman, K. P.: A global hotspot for dissolved organic carbon in hypermaritime watersheds of coastal British Columbia, *Biogeosciences*, 14, 3743-3762, <https://doi.org/10.5194/bg-14-3743-2017>, 2017.

Appendix

Table 1. Detailed location information for the stage monitoring devices and discharge measurements at the seven studied watersheds.

Site	Elevation (m)	Latitude	Longitude
Buxton	672	51.60491	-128.01782
Buxton East	740	51.58993	-127.97523
WSN693_703	449	51.61058	-127.98708
SSN693	51	51.64417	-127.99777
WSN703	42	51.64333	-128.02277
WSN703_708	289	51.62218	-128.05065
SSN708	12	51.64856	-128.06835
SSN626	13	51.64083	-128.12194
WSN626	78	51.62624	-128.10178
Reference Station	43	51.65195	-128.1287
TSN3	49	51.65149	-128.12880
PruthDock	5	51.65455	-128.12942
Lookout	63	51.6475	-128.14318
SSN1015	17	51.69055	-128.06527
WSN819_1015	331	51.68265	-128.04332
SSN819	79	51.66194	-128.04194
Hecate	477	51.68256	-128.02278
WSN844	90	51.66138	-127.9975
Koeye	19	51.77083	-127.87944
Ethel	3	51.54844	-127.53174
Quadra	11	50.11625	-125.22211