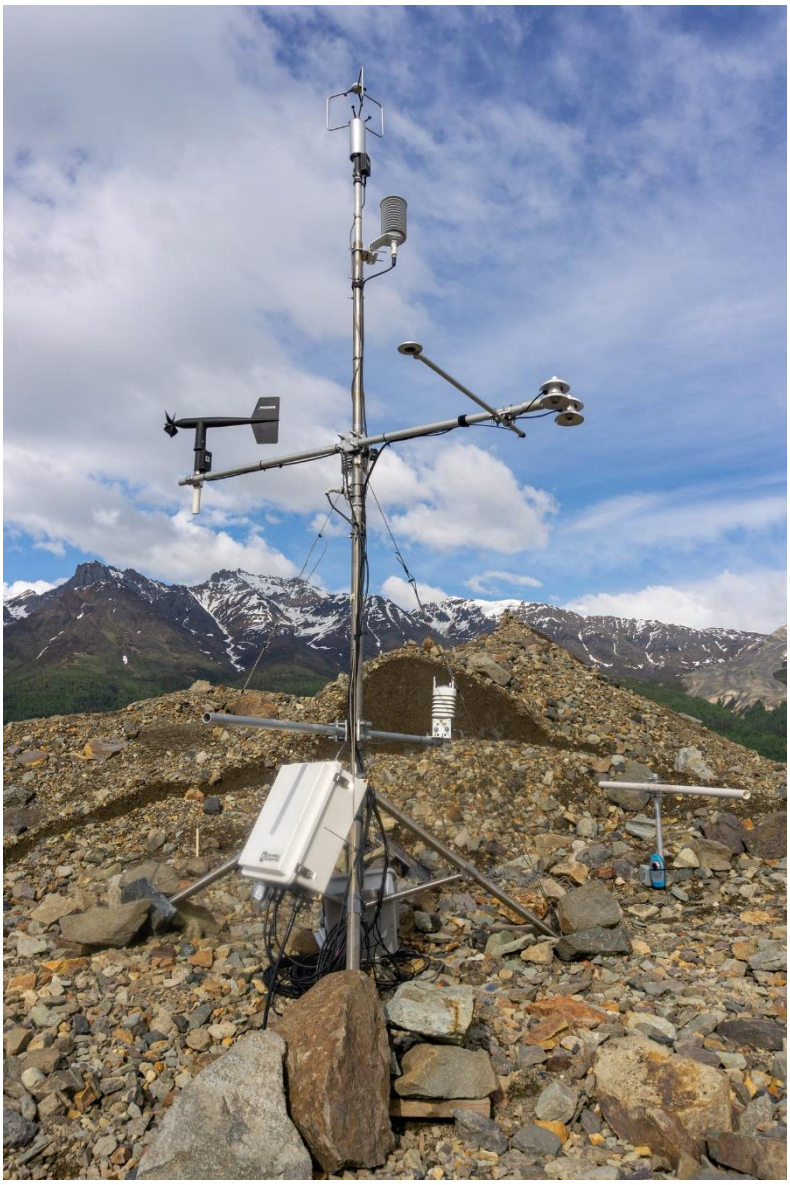
IACS WG on Debris Covered Glaciers: AWS site and data information

Basic AWS information

AWS ID	KEN
Glacier name	Kennicott Glacier
GLIMS ID/ RGI ID	G216957E61573N / RGI60-01.15645
AWS latitude (dd.dddd°)	61.4841
AWS longitude (dd.dddd°)	-142.9283
Elevation (m asl)	606
UTM zone	7
Datalogger system	2x Campbell CR1000 + CFM100
Data period (dd.mm.yyyy – dd.mm.yyyy inclusive)	28.05.2019 – 22.08.2019
Time increment of base data	1 minute
Time stamp	AKDT



Photograph date: 27 May 2019
Photograph credit: Andy Aschwanden

Estimated debris properties @AWS

Property	Value	Error	Notes
h_d (m)	0.13	±0.02	Measured on 27 May 2019
z0 (m)			
k (W m^{-1} K^{-1}) effective thermal conductivity of debris	0.75	±0.25	Anderson (submitted) estimated debris conductivity on Kennicott Glacier (Jun-Aug 2011) using simultaneous measurements of sub-debris melt, internal debris temperature, and debris thickness according to Mihalcea et al., 2006, at multiple profiles for at least one week period. The calculated conductivities for debris thicknesses between 7-14 cm ranged from 0.5 to 1 W m^-1 K^-1
phi (-)			
emissivity	0.94	±1%	Taken from Brock et al., 2010 work on Miage Glacier
lithology			Sedimentary/volcanic mix

Available validation data

TYPE	
automatic surface height change measurements at the time interval of the meteorological forcing data at the location of the AWS	-
stake measurements of surface height change at the AWS spanning the ablation season, and ideally at some time points within it	KEN_2019_VAL_subdebrismelt.csv containing: ○ YEAR: year (YYYY) ○ MONTH: month (MM) ○ DAY: day of month (DD) ○ HOUR: hour (HH) ○ MINUTE: minutes (MM) ○ CUMMELT (m) – cumulative sub-debris melt, calculated from stake readings Notes: -stake location: 40m north of AWS (“Stake #6”) -debris thickness: 9cm
dGPS measurements of surface height change at the AWS spanning the ablation season, and ideally at some time points within it	-
high resolution dDSM measurements of surface height change at the AWS spanning the ablation season, and ideally at some time points within it	-
independent measurements of surface temperature at the AWS location at any available point during the meteorological forcing data	
temperature measurements at known depths within the debris cover at the AWS location at any available point during the meteorological forcing data	KEN_2019_VAL_debristemperature.csv containing: ○ YEAR: year (YYYY) ○ MONTH: month (MM) ○ DAY: day of month (DD) ○ HOUR: hour (HH) ○ MINUTE: minute (MM) ○ TTOP: internal debris temperature (°C), close to debris surface ○ TBOT: internal debris temperature (°C), close to ice-debris interface Notes: -profile location: 40m north of AWS (@ “Stake #6”) -debris thickness: 9cm -TTOP-sensor: 8cm above ice, 1cm below debris surface -TBOT-sensor: 1cm above ice

	-on 25.06.2019 16:30 the TTOP-sensor was found uncovered and was buried again ~2cm below debris surface
	Temperature sensor: “HOBO U12 4-External Channel Data Logger” (error: ± 0.35°C from 0° to 50°C)

Station data information

Variable	Instrument	Measurement / Calculation	QC procedures	Data replacement	Estimated error
T	Vaisala WXT520	average			±0.3 at 20°C
RH	Vaisala WXT520	sample	RH>100 = 100		±3% RH at 0 to 90% RH; ±5% RH at 90 to 100% RH
FF	Vaisala WXT520	vector average			±0.3 m s^{-1} or 3%
DIR	Vaisala WXT520	vector average			±3°
P	Vaisala WXT520	average			±0.5 hPa
SWIN	NR01 4-comp. radiometer	average	SWIN<0 = 0	*AWS Gates Glacier	±10% on daily sums
SWOUT	NR01 4-comp. radiometer	average	SWIN<0 = 0	*SWIN (from AWS Gates Glacier) multiplied by 0.12 (= average albedo at AWS KEN around solar noon during entire season)	
LWIN	NR01 4-comp. radiometer	temperature corrected average		**modelled based on RH and T, following Kok et al., 2019	
LWOUT	NR01 4-comp. radiometer	temperature corrected average		***modelled based on near surface temperature at “Stake #6” 40m north of AWS and emissivity of 0.94 based from Brock et al., 2010	
PP	Vaisala WXT520	sum			±5% (+ wind induced error)
SNOW	-			Not measured, but no snow present during measurement period	
T_z		manual measurements			
RH_z					
FF_z					

Notes

Datagaps due to low battery supply for datalogger of radiation sensors (concerning only radiation measurements, all other sensors where without interruption):
11.06.2019 17:19 – 13.06.2019 9:41 (40.3h)
16.06.2019 03:21 – 18.06.2019 11:55 (56.6h)
23.06.2019 03:03 – 24.06.2019 06:55 (27.9h)
02.07.2019 22:50 – 05.07.2019 07:08 (56.3h)
10.07.2019 00:44 – 13.07.2019 12:08 (83.4h)
16.07.2019 00:14 – 18.07.2019 19:44 (67.5h)
21.07.2019 23:05 – 23.07.2019 13:19 (38.2h)

*AWS Gates Glacier ("GGLA2"): 61.6029° / -143.0132° / 1237 m a.s.l.)
https://mesowest.utah.edu/cgi-bin/droman/mesomap.cgi?state=AK&rawsflag=3
("Meso West", Department of Atmospheric Sciences, University of Utah)

** see details in:
Kok, RJ, Steiner, JF, Litt, M, et al. Measurements, models and drivers of incoming longwave radiation in the Himalaya. Int J Climatol. 2019; 1– 15.
https://doi.org/10.1002/joc.6249

*** Stake & profile #6: 40m north of AWS (61.48447° / -142.92825° / 605 m a.s.l.): used for LWout-modelling.
See also: "KEN_2019_VAL_debristemperature.csv" and "KEN_2019_VAL_subdebrismelt.csv" from the same location.

KEN AWS was tilted (between 2-13° in W-E and N-S directions) when we visited the station (on 25 June, 23 July, 22 August 2019) and the station was adjusted again after each visit. The evolution of the tilt is unmeasured and therefore not corrected for.
Due to changes surrounding KEN AWS (crevasse opening, backwasting ice cliff), the station had to be moved by approx.. 1-2m towards south at each visit (2 times during the measurement period).

All estimated errors are from the manufacturers manual. No error estimates were available from the Meso West network (GGLA2 AWS).

KEN AWS: data was aggregated from 1 minute interval to the 60 minute interval by simply averaging the datapoints (vectorial mean for DIR) and summing the precipitation total to the next full hour.

Debris temperature at Stake #6: data was aggregated from 15 minute interval by simply averaging the datapoints to the next full hour.