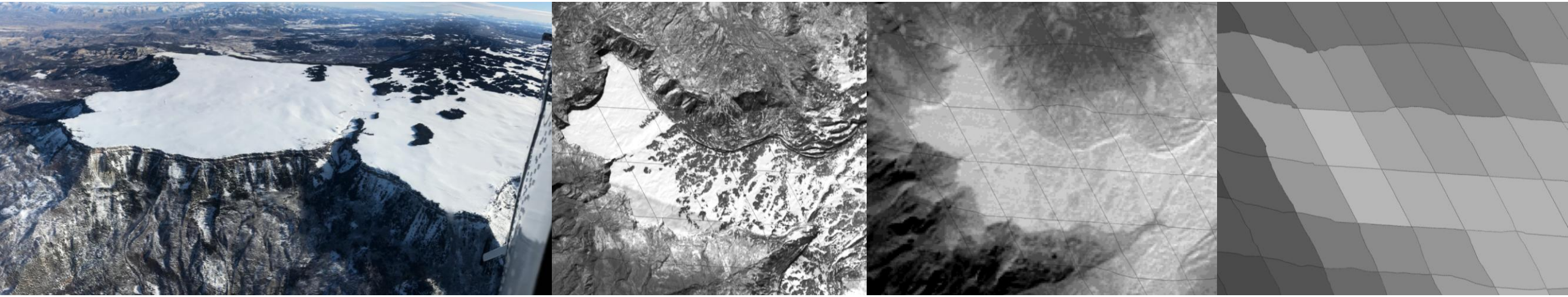
Snow Surface Temperature & Thermal Infrared Remote Sensing

Grand Mesa IOP - SnowEx 2020



Steven Pestana[1]
Jessica Lundquist[1]
Chris Chickadel[1,2]

[1.] Civil and Environmental Engineering, UW; [2.] Applied Physics Lab, UW

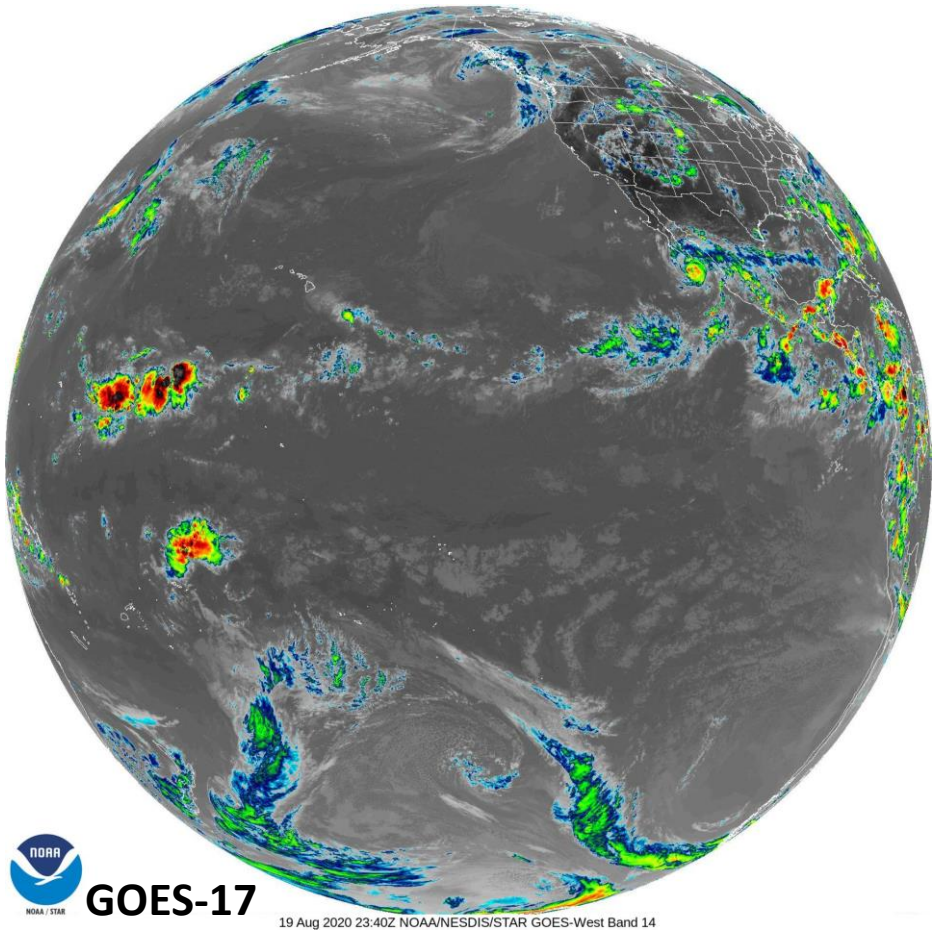
Photo credit: Chris Chickadel

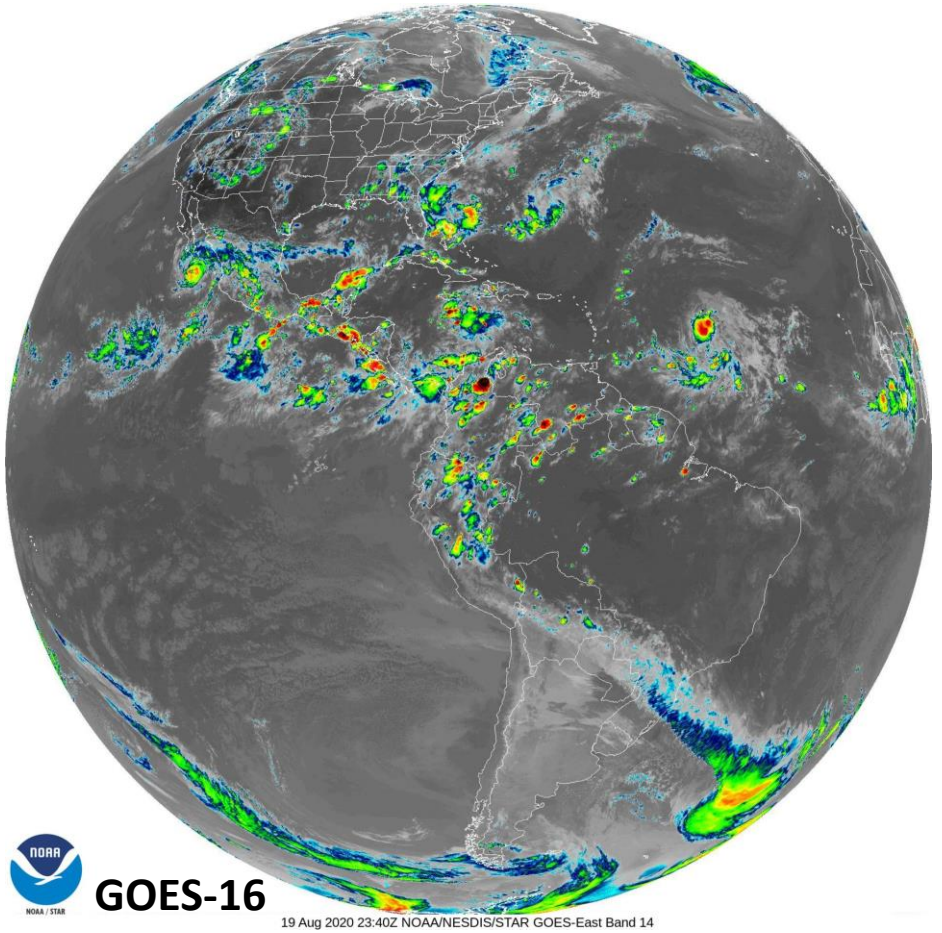
SnowEx Community Meeting: August 20, 2020

Satellite IR observations

GOES-16 & GOES-17 - ABI

Geostationary orbiting
5-minute repeat (CONUS)
10 MW-TIR bands (6 VSWIR bands)
2+ km TIR resolution (500 m-2+ km VSWIR)





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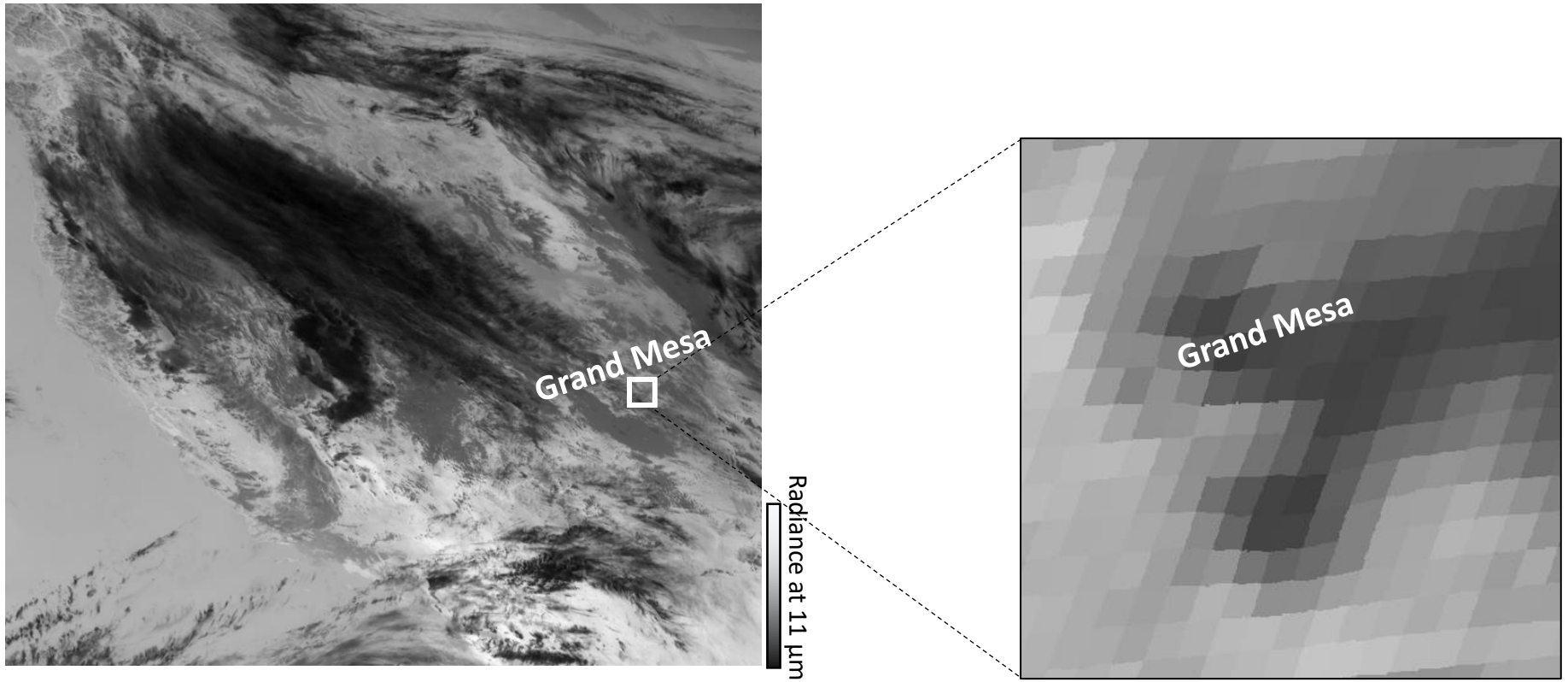

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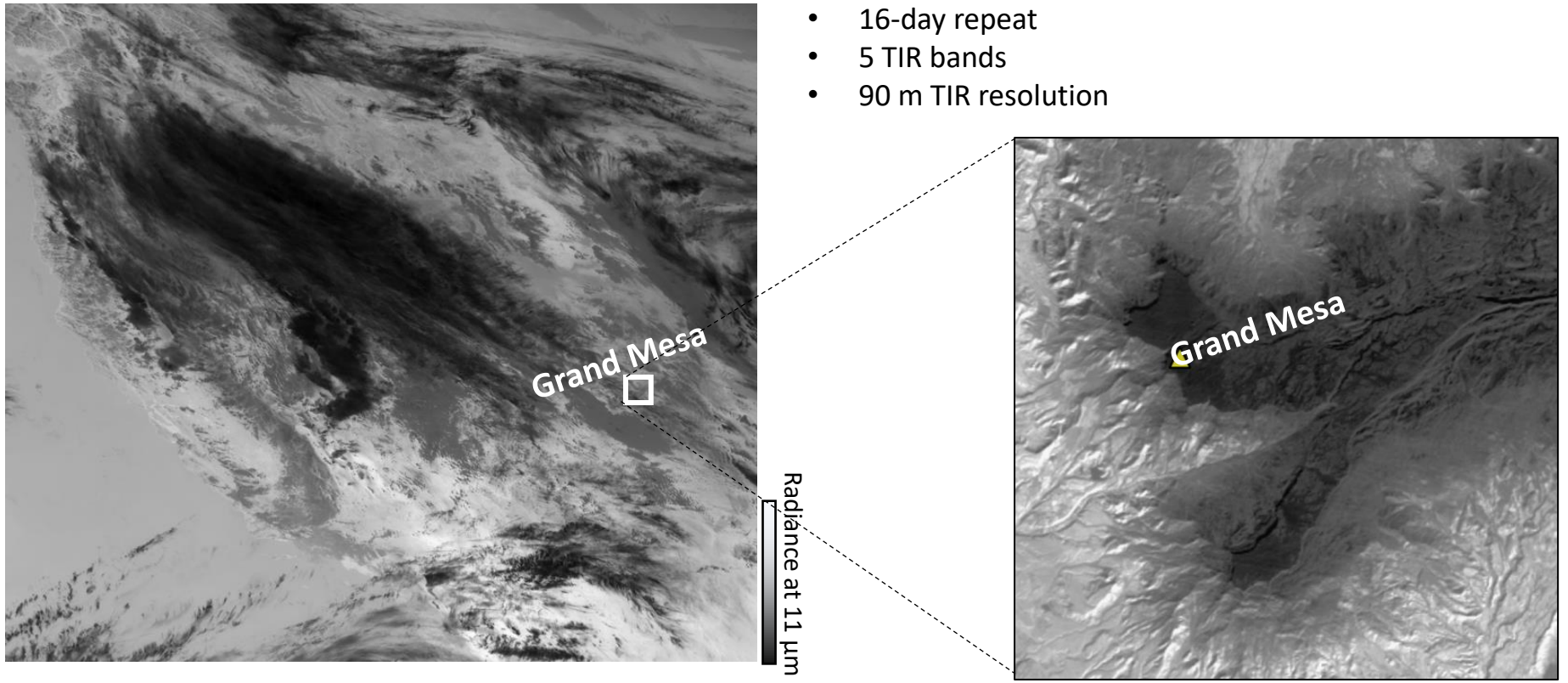
Terra - ASTER

- Polar orbiting (10:30/22:30, coincident with MODIS)
- 16-day repeat
- 5 TIR bands
- 90 m TIR resolution



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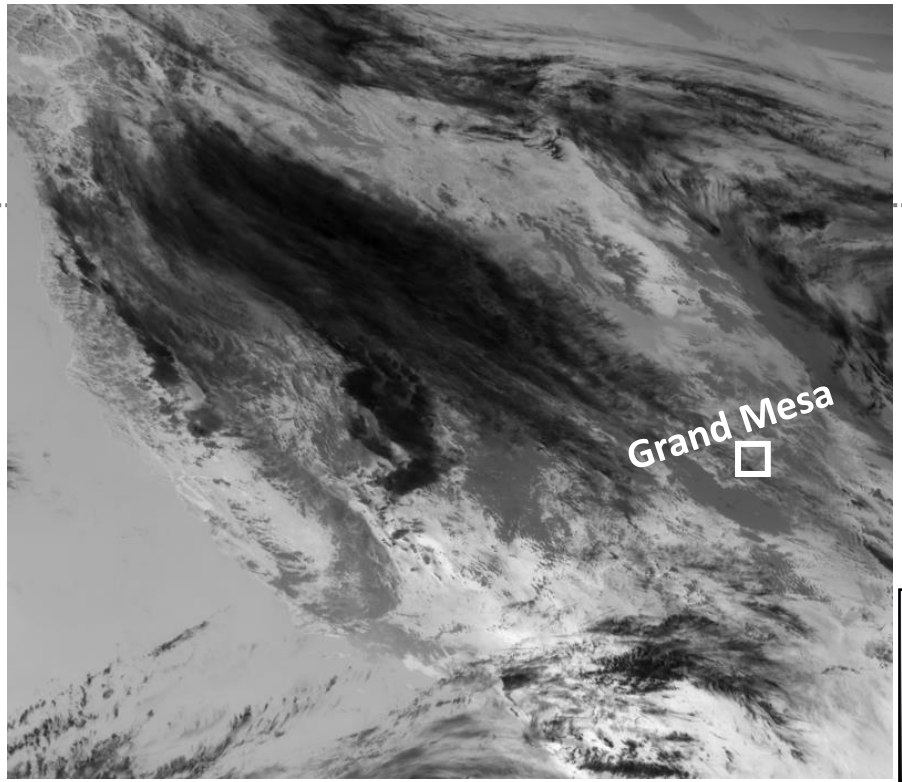
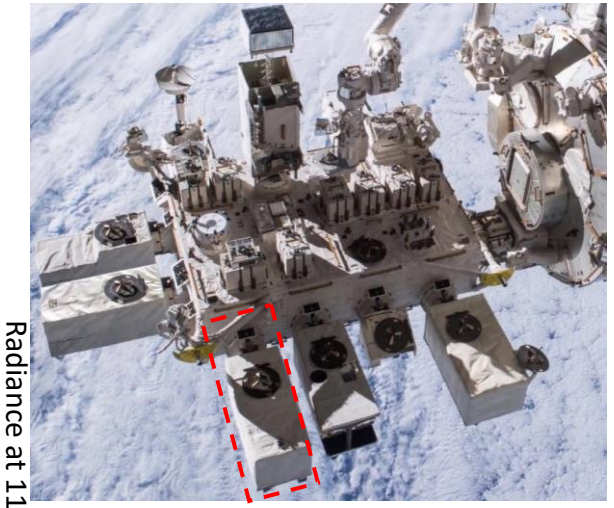


ISS - ECOSTRESS

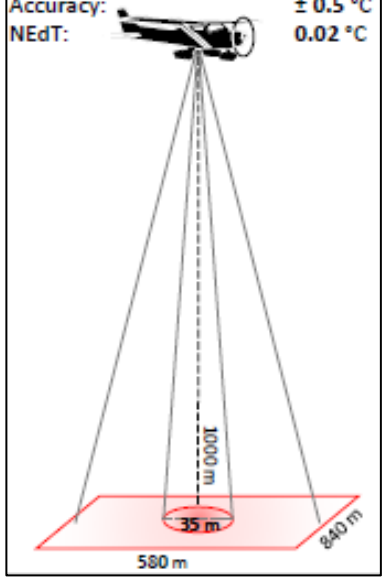
- Inclined orbit (variable overpass times)
- 4-day repeat
- 3 operational TIR bands
- 70 m TIR resolution



Airborne IR observations

University of Washington – Applied Physics Lab (APL)
Compact Airborne System for Imaging the Environment (CASIE)

TIR Camera:	DRS UC640-17
Detector Size:	640 x 480 px
Spectral Response:	8 – 14 µm
Accuracy:	± 1 °C
NEdT:	0.07 °C
(Noise Equivalent Differential Temperature)	
IR Radiometer:	KT15.85D
Field of View:	1.9° FOV
Approx. Spot Size:	35 m
Spectral Response:	9.6 – 11.5 µm
Accuracy:	± 0.5 °C
NEdT:	0.02 °C



Naval Postgraduate School Twin Otter

TIR sensor suite:

- 3 TIR cameras
- KT-15 radiometer
- Visible imagery camera

Grand Mesa IOP Observations:

- Calibrated surface temperature maps
- Visible imagery mosaics for context

Airborne IR observations

University of Washington – Applied Physics Lab (APL)
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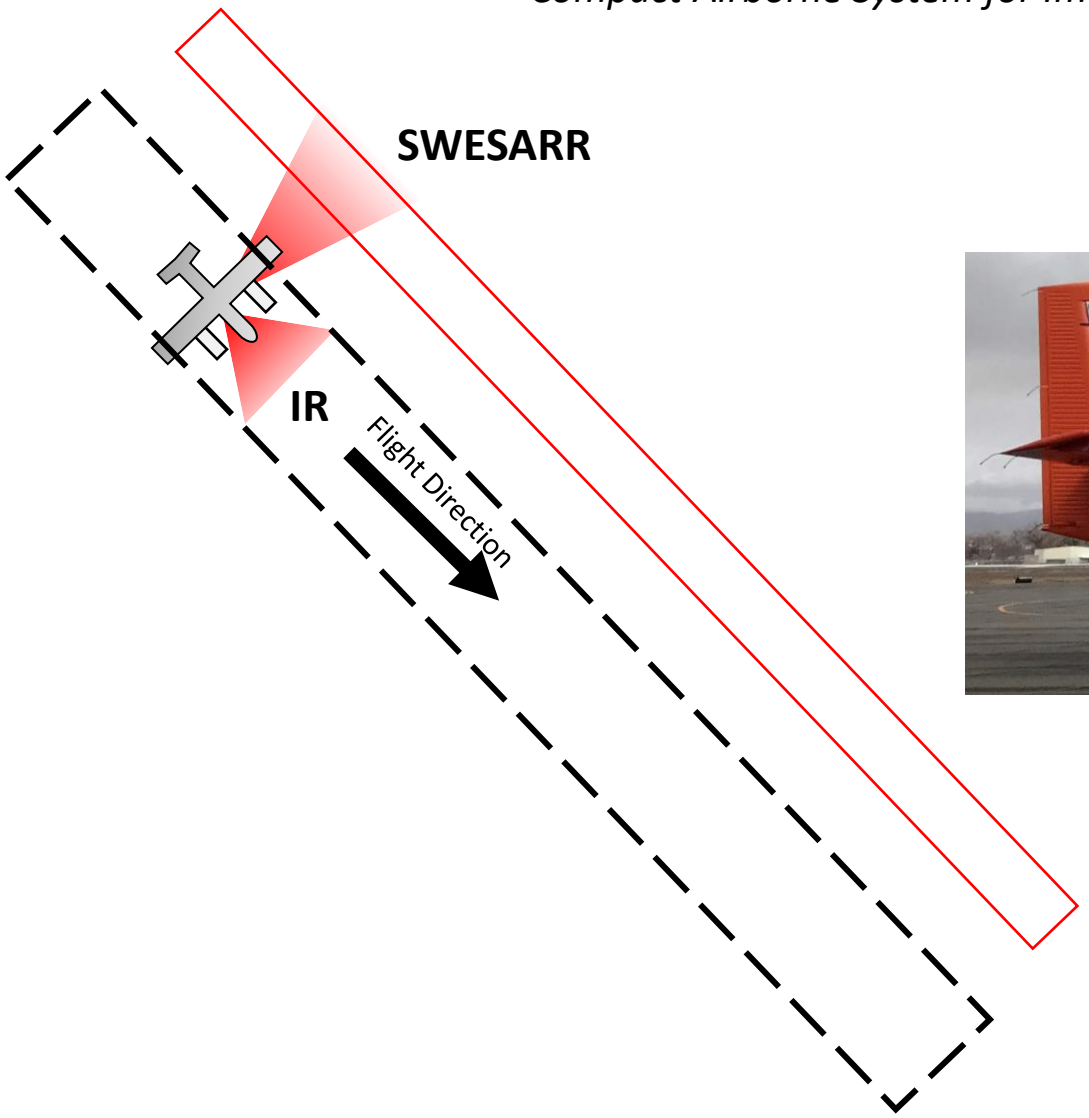
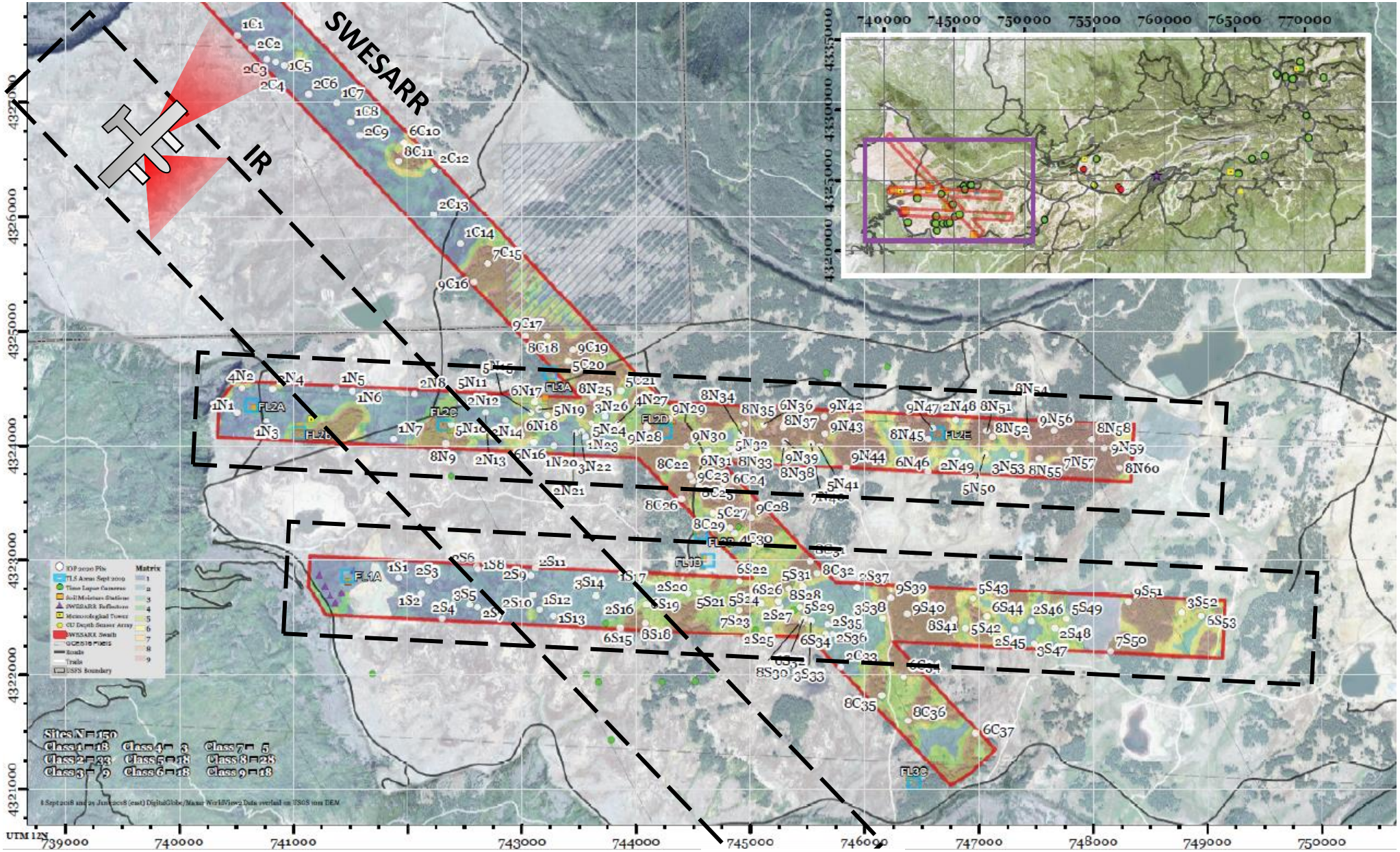


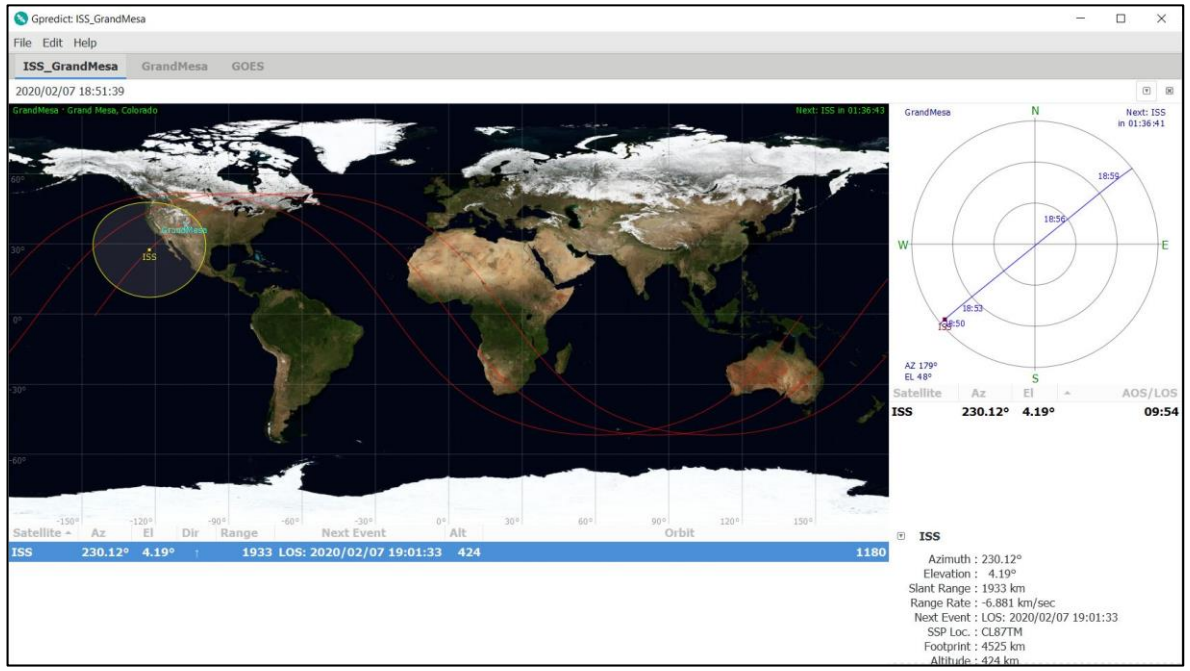
Naval Postgraduate School Twin Otter

Airborne IR observations



Grand Mesa map image and GIS files: Chris Hiemstra

Coordinating airborne and satellite observations

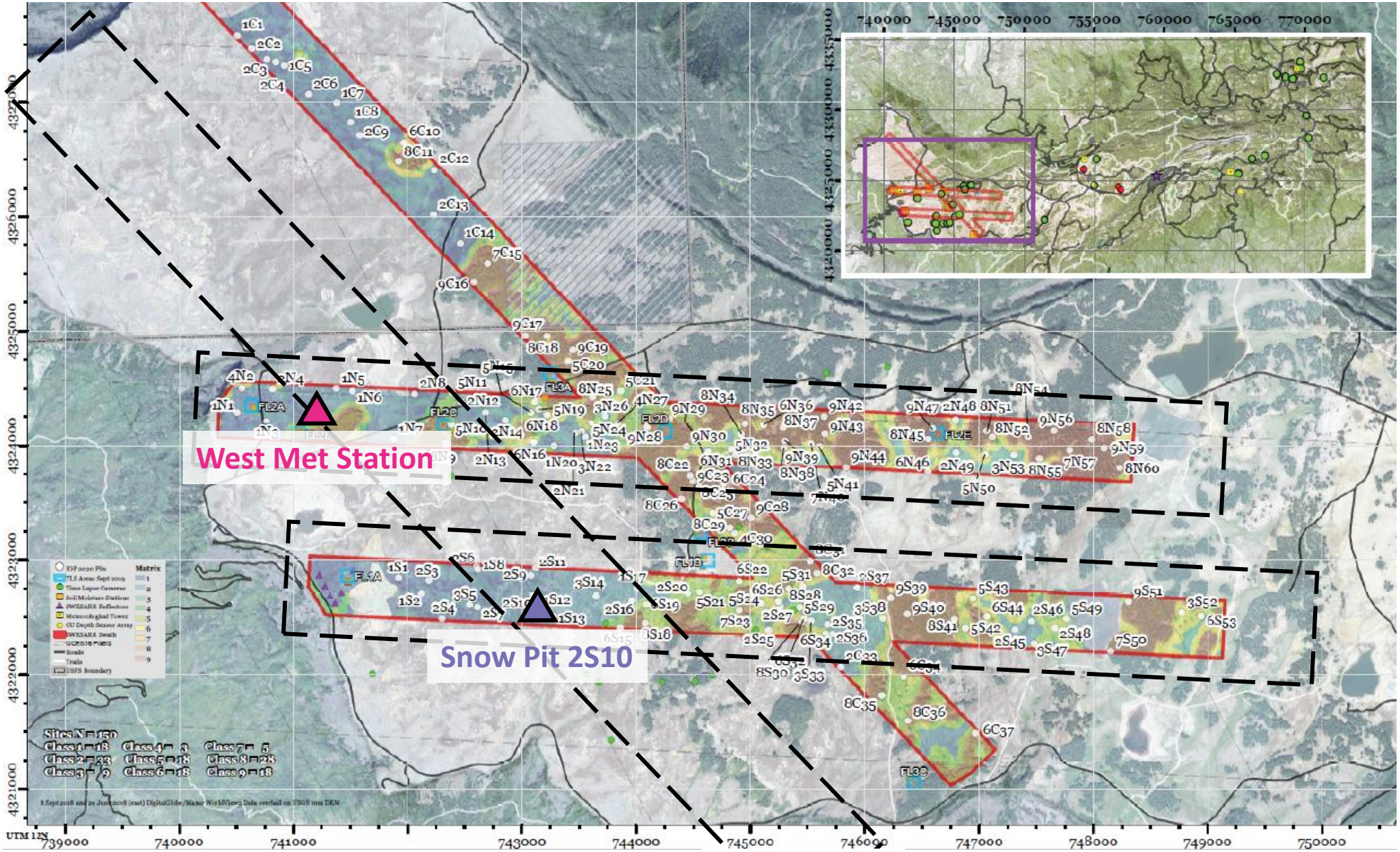


- Satellite overpass predictions
- Tasking ASTER observations
- Targeted mid-morning observations on **February 8th** and **11th**
- Hope for clear skies!

Grand Mesa IOP

Satellite Observatio	Local Date and Time (UTC-7)	Peak Elevation (degree)	Day/Night	ASTER Request Sumbitted	
ASTER (Terra)	1/16/2020 11:00	88	day	xAR ID 187161	
ASTER (Terra)	1/23/2020 11:07	87	day	DAR ID 187493	** Marked with high priority due to field campaign
ECOSTRESS (ISS)	1/26/2020 16:33	84	day		
ECOSTRESS (ISS)	1/30/2020 14:57	80	day		
Landsat 8	1/31/2020 10:45	87	day		
ECOSTRESS (ISS)	2/3/2020 13:29	65	day		
ECOSTRESS (ISS)	2/7/2020 11:55	65	day		
ASTER (Terra)	**2/8/2020 11:07**	**88**	**day**	xAR ID 187504	*** most promising for timing with airplane
ECOSTRESS (ISS)	**2/11/2020 10:22**	**65**	**day**		
ECOSTRESS (ISS)	2/11/2020 16:52	61	day		
ECOSTRESS (ISS)	2/15/2020 8:47	66	day		
ECOSTRESS (ISS)	2/15/2020 15:18	61	day		
ECOSTRESS (ISS)	2/18/2020 14:31	61	day		
ECOSTRESS (ISS)	2/19/2020 7:13	66	day		
ECOSTRESS (ISS)	2/19/2020 13:43	75	day		

Fieldwork and ground-based data collection



Grand Mesa map image and GIS files: Chris Hiemstra

Fieldwork and ground-based data collection

West Met Station

Snow Pit 2S10

Grand Mesa map image and GIS files: Chris Hiemstra

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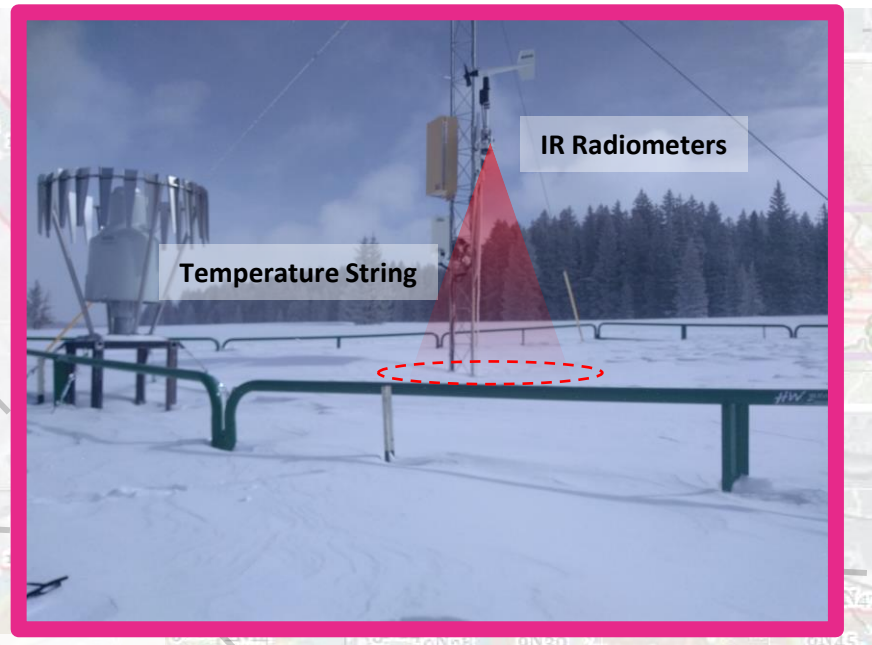

West Met Station

Snow Pit 2S10

Grand Mesa map image and GIS files: Chris Hiemstra

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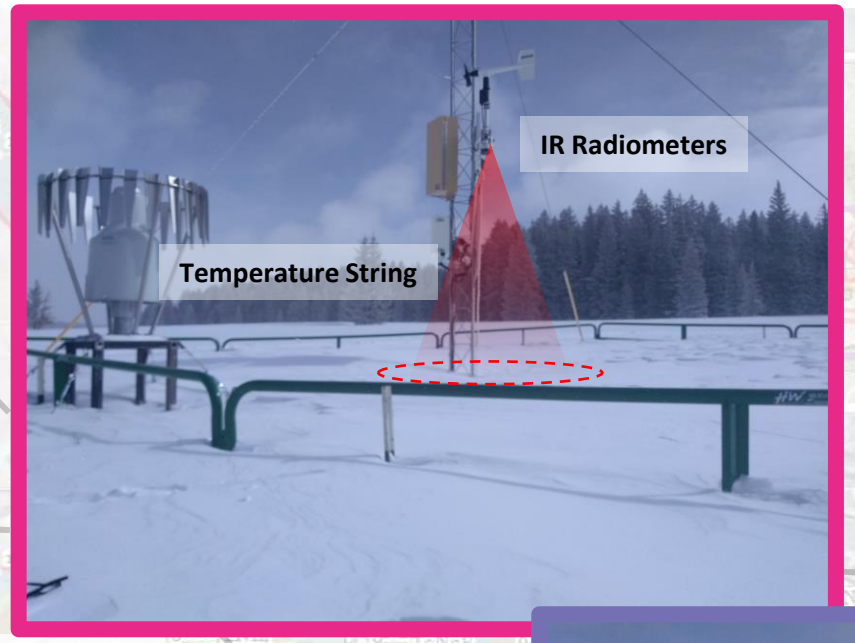

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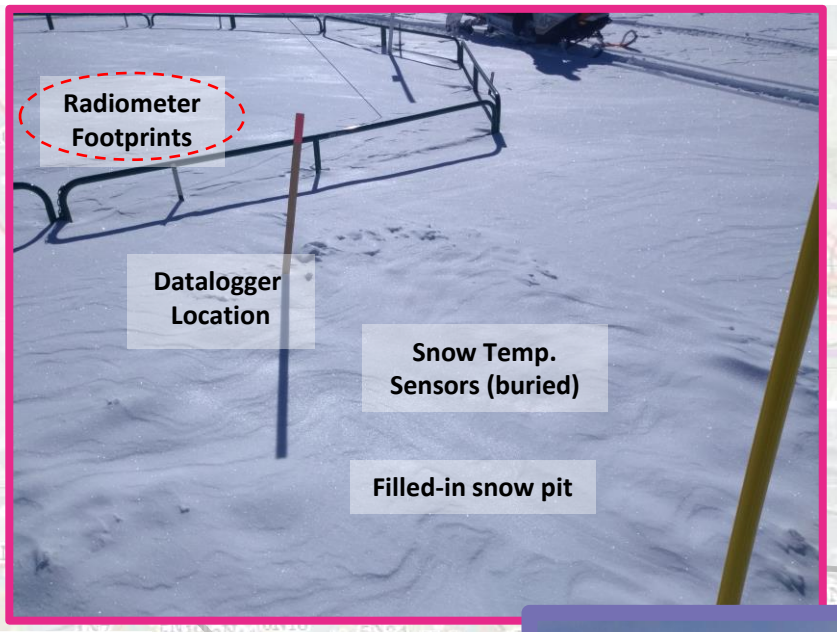

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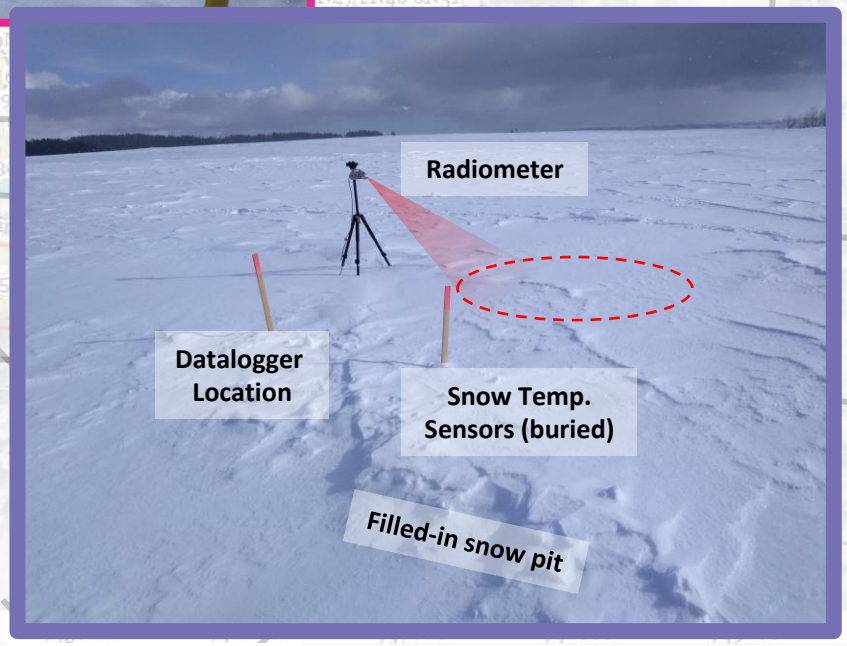
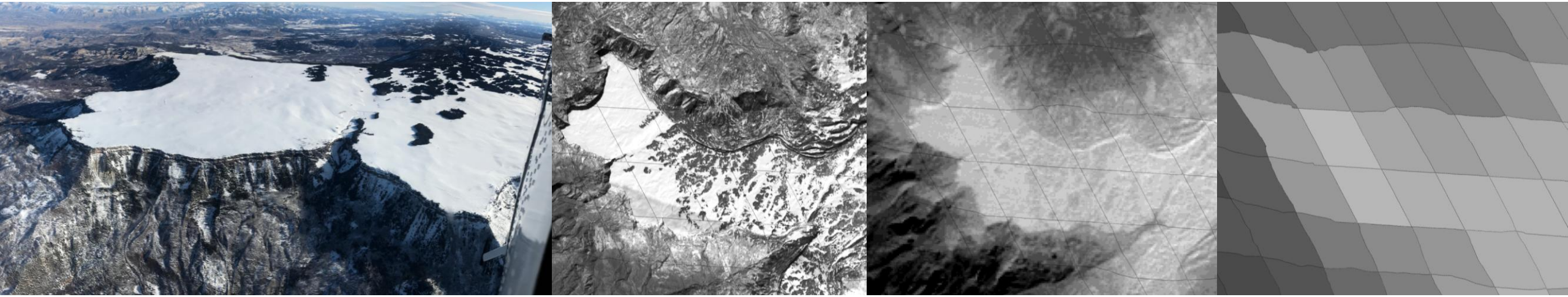


Grand Mesa map image and GIS files: Chris Hiemstra

Data & Preliminary Results



View during airborne IR & SWESARR data collection (Chris Chickadel)

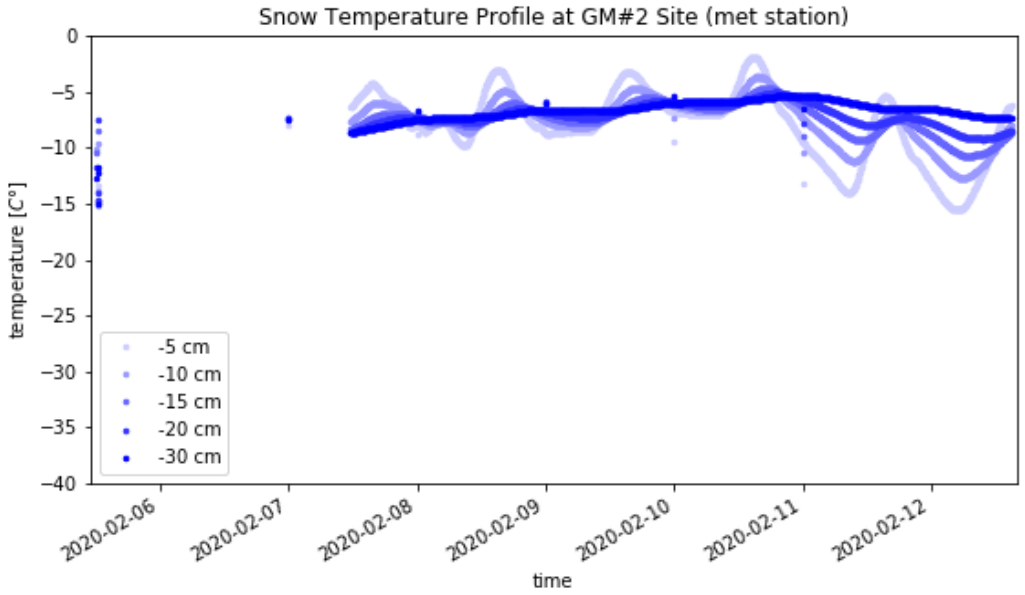
ASTER visible

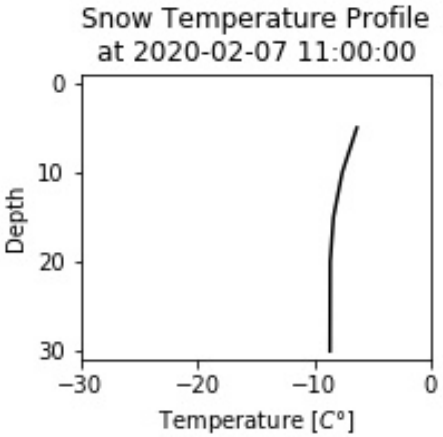
ASTER TIR

GOES-16 TIR

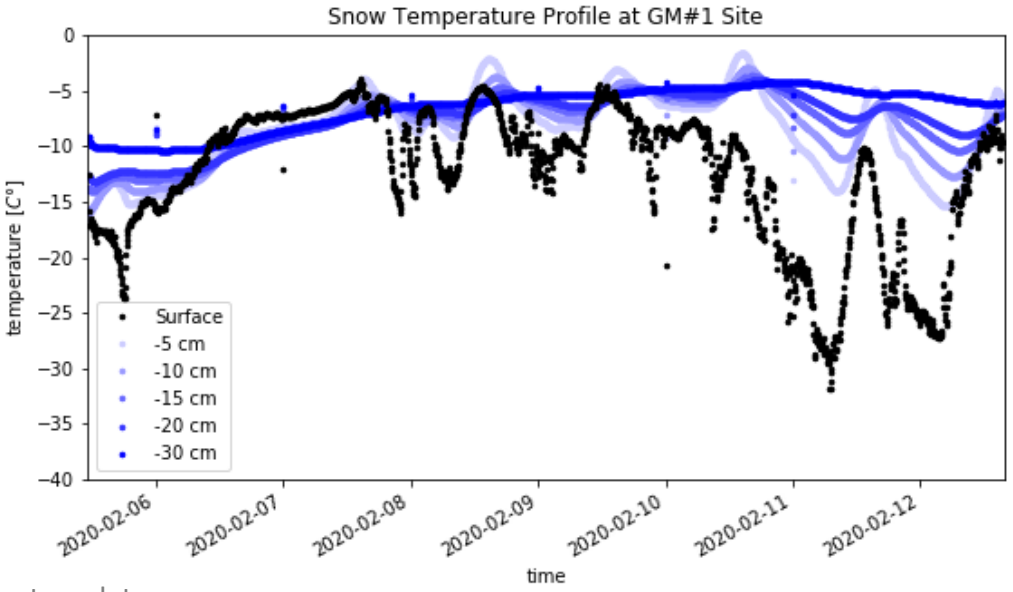
Ground-based data results

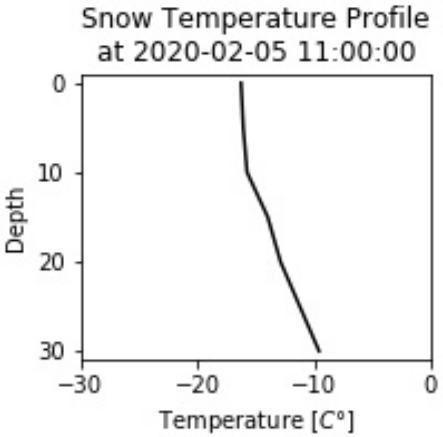
West Met Station





Snow Pit 2S10



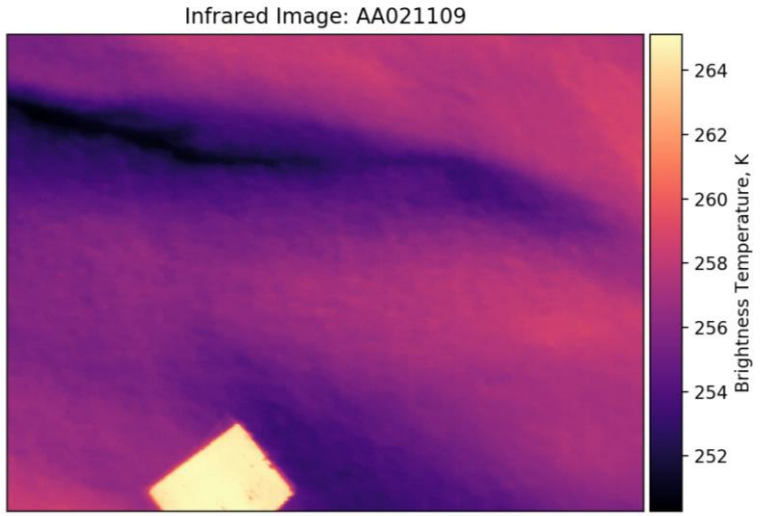


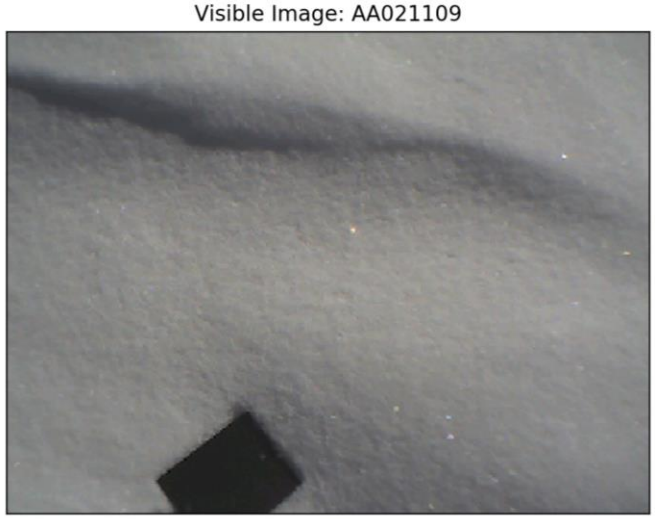
Preliminary snow-surface and depth profile temperature data:
https://github.com/spestana/snowex2020-snow-temp

Ground-based data results

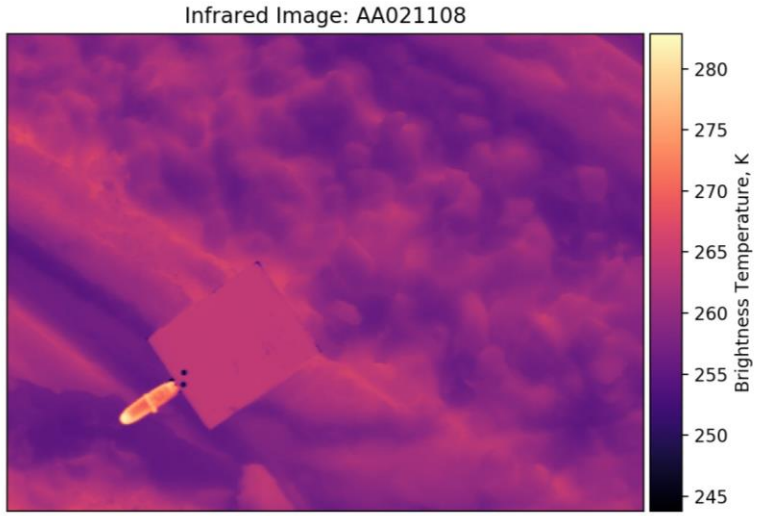
IR images of snow surface features

Sastrugi & shadows



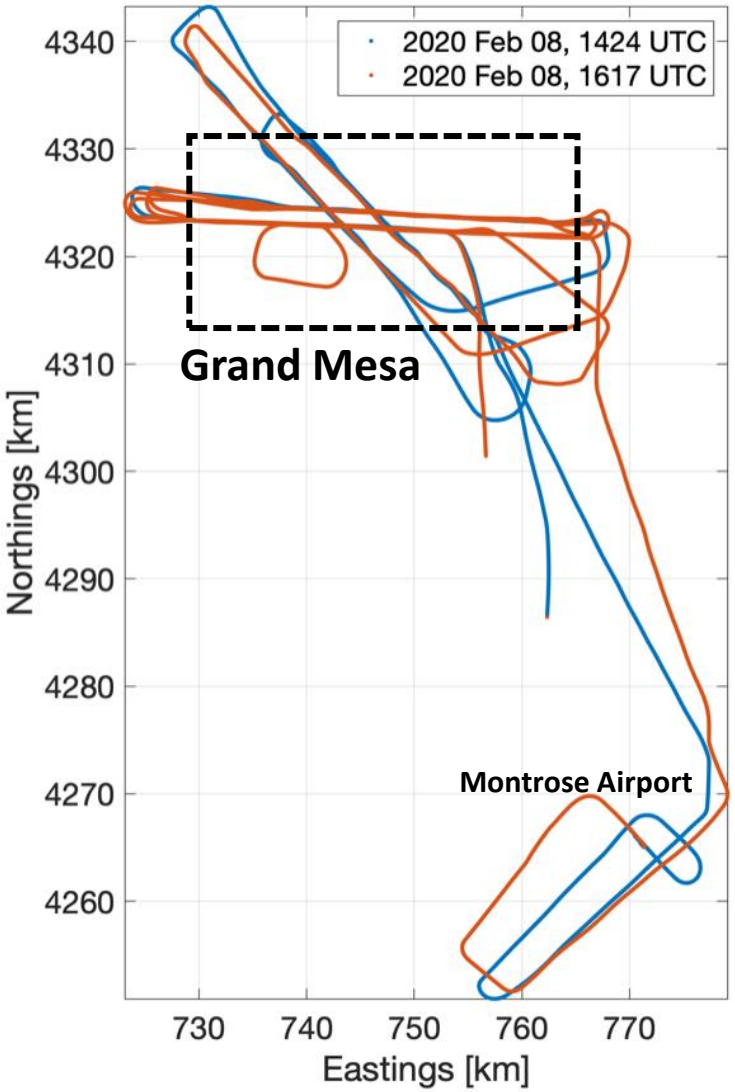


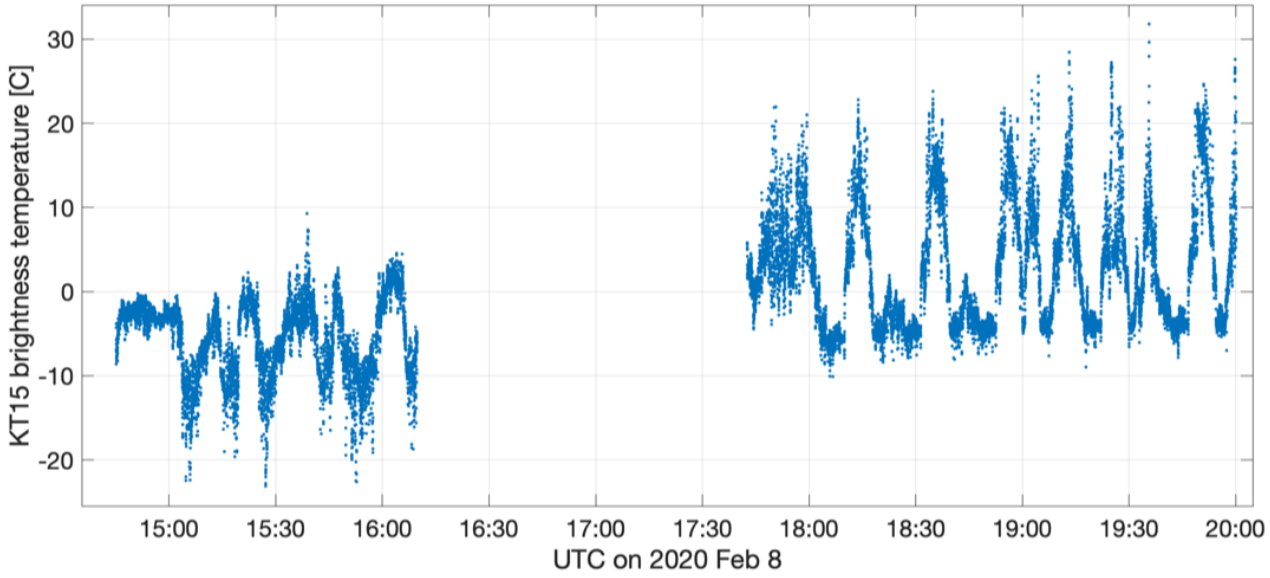
Snowmobile tracks



Preliminary handheld IR camera data:
https://github.com/spestana/snowex2020-ir-camera

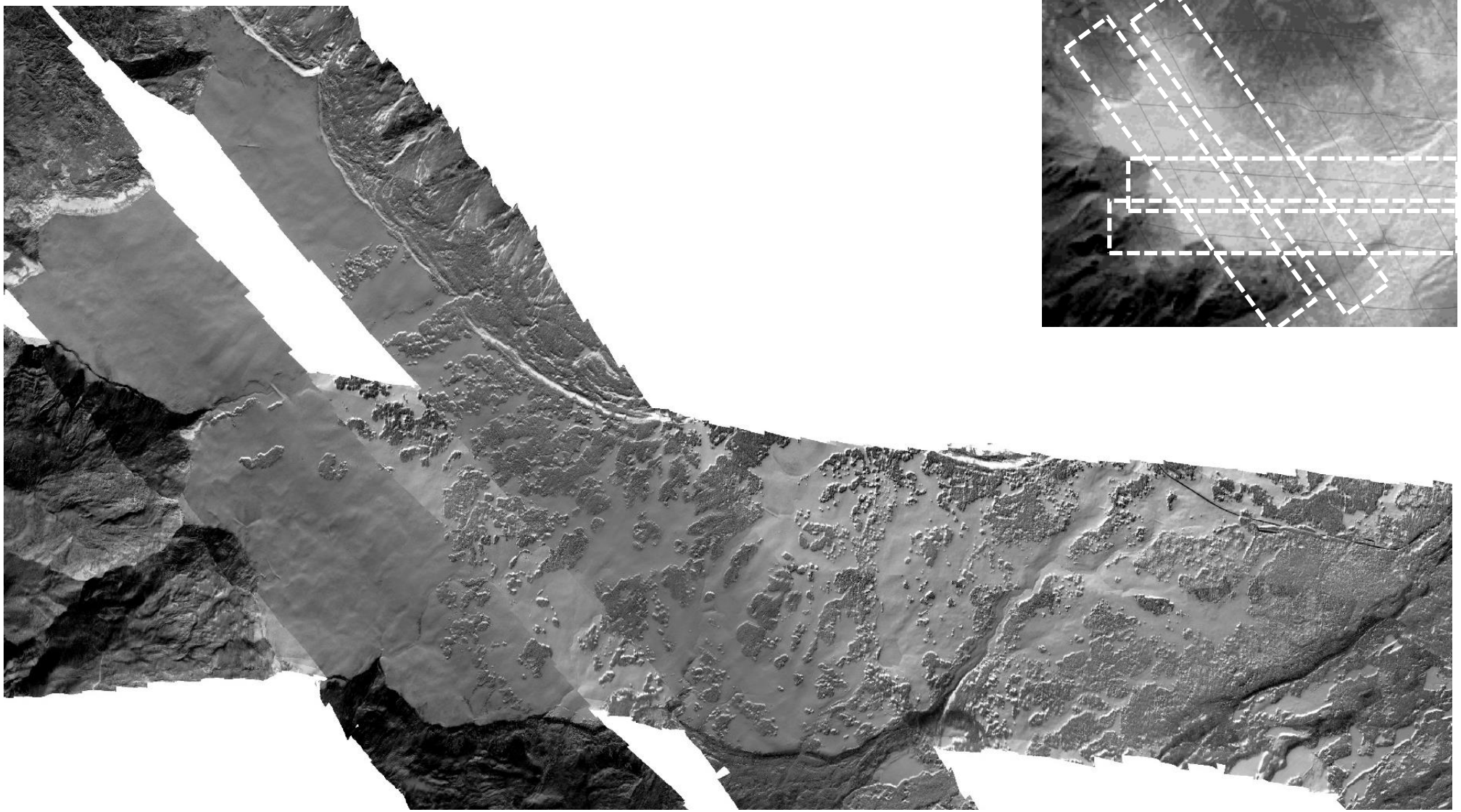
Airborne IR Radiometer





Figures and airborne IR data: Chris Chickadel

Airborne IR Images



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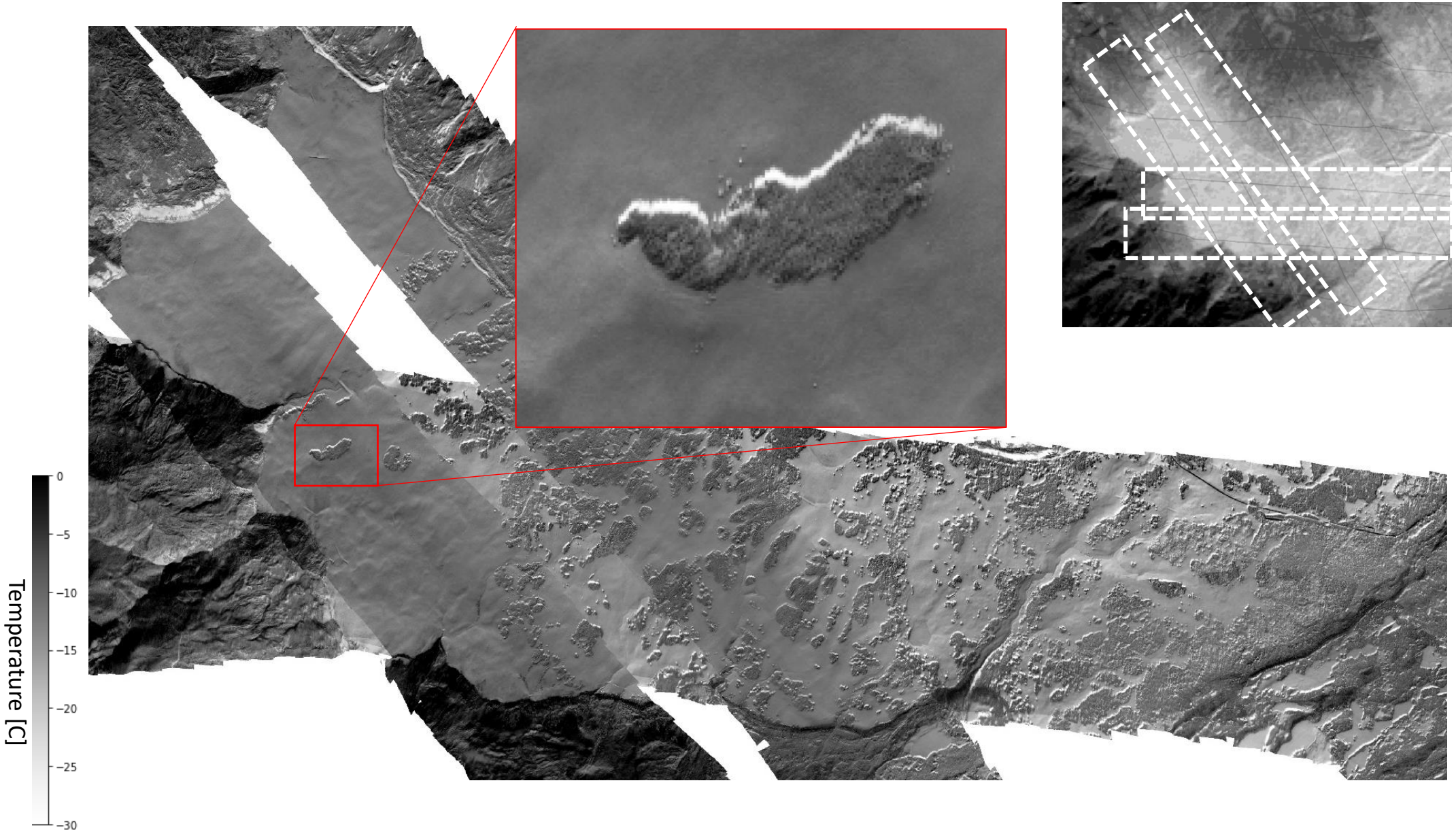

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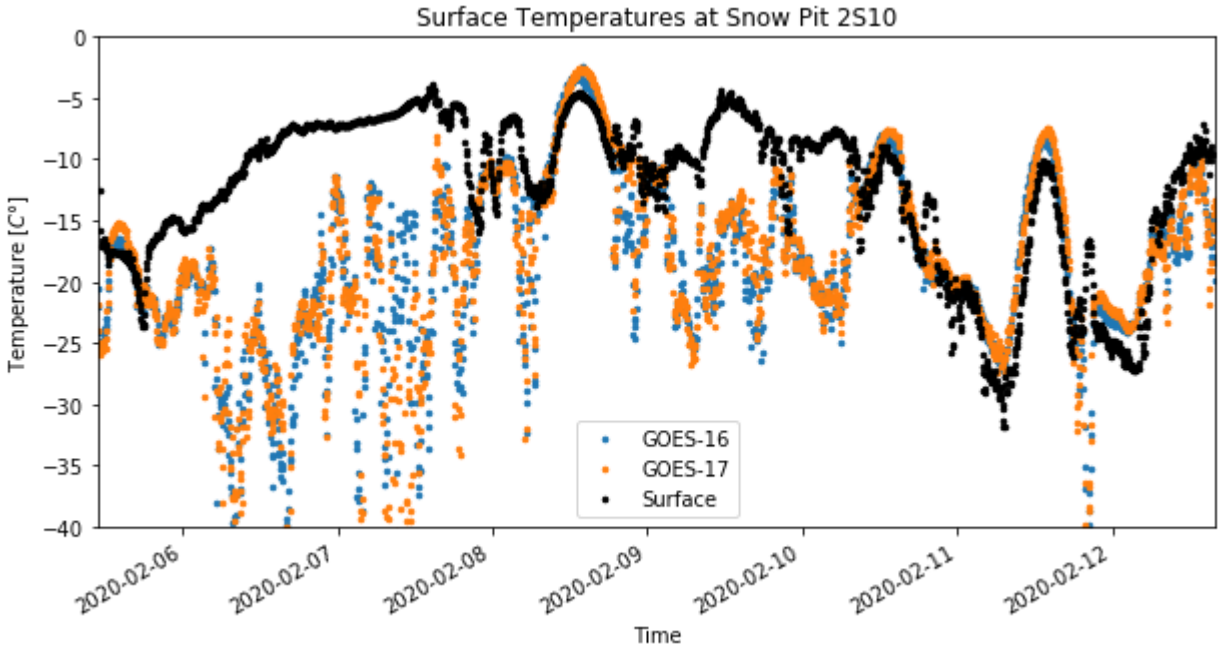
Snow Pit 2S10



Preliminary snow-surface and depth profile temperature data:
https://github.com/spestana/snowex2020-snow-temp

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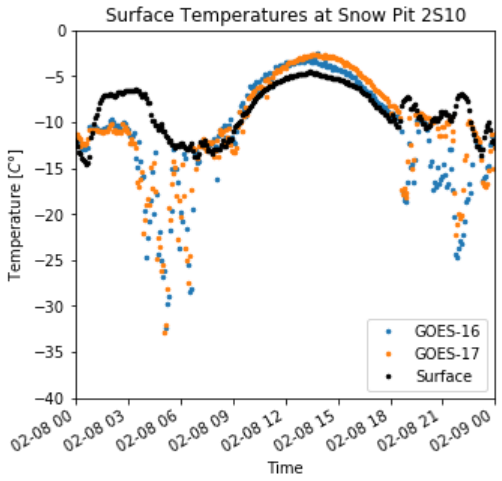

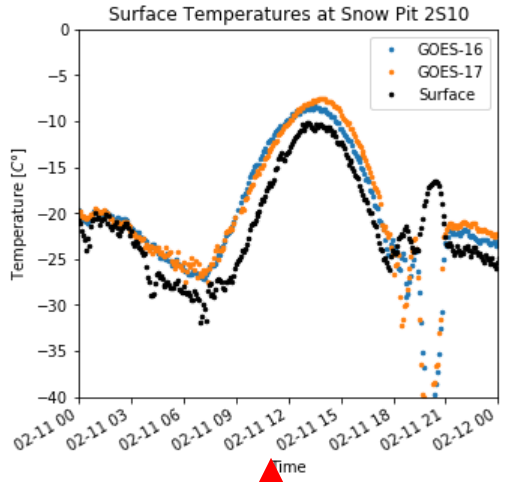

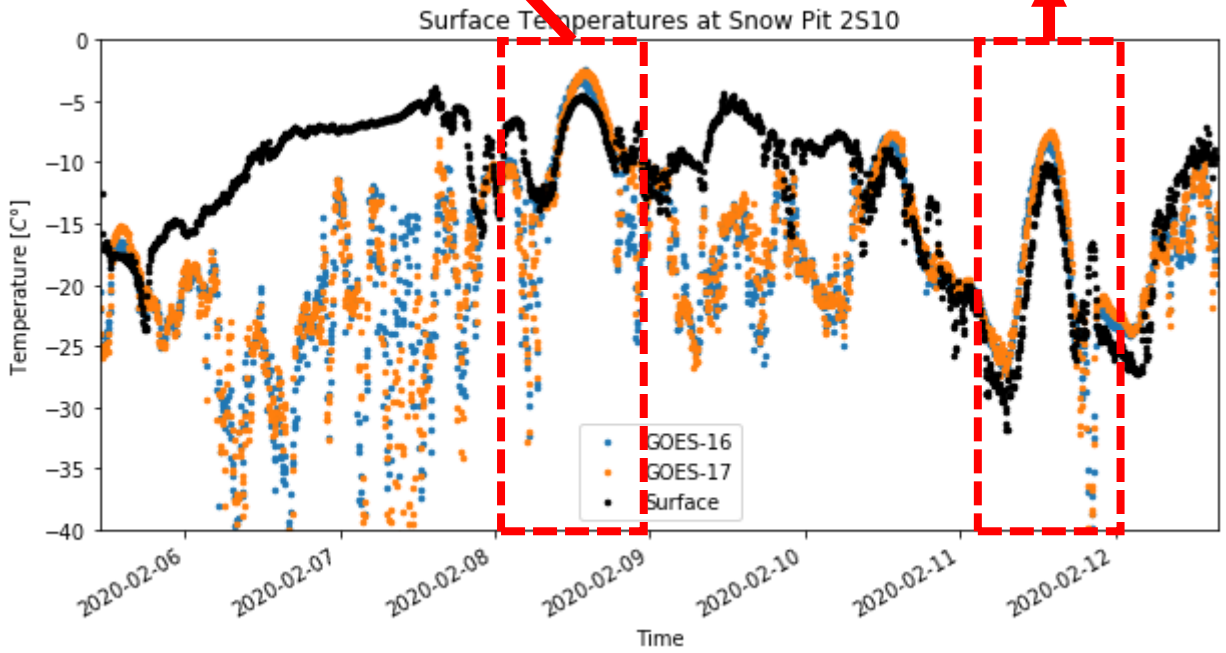

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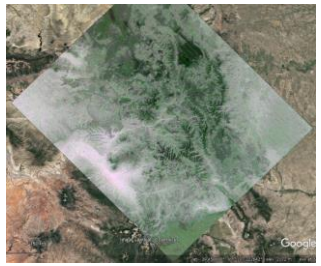

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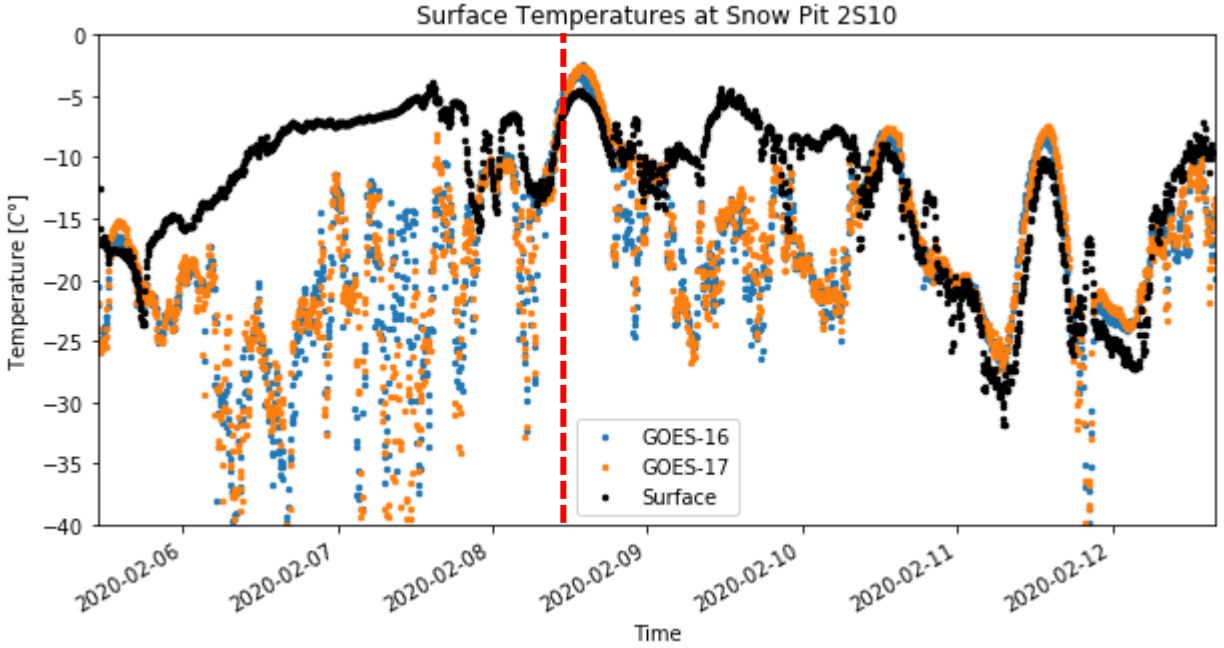

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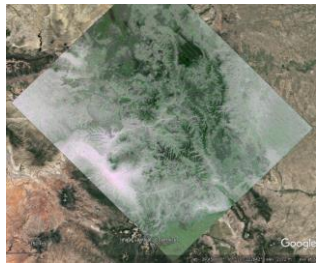

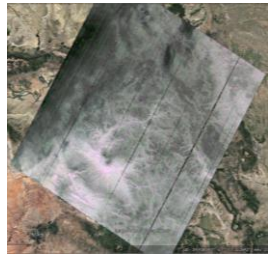

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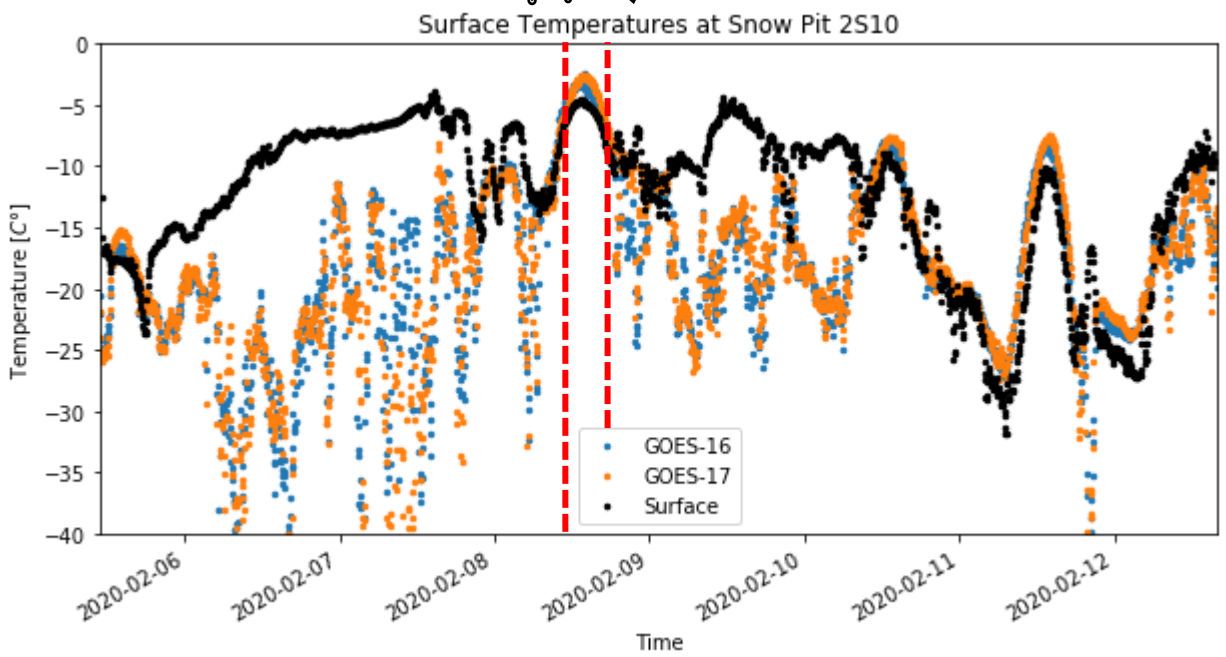

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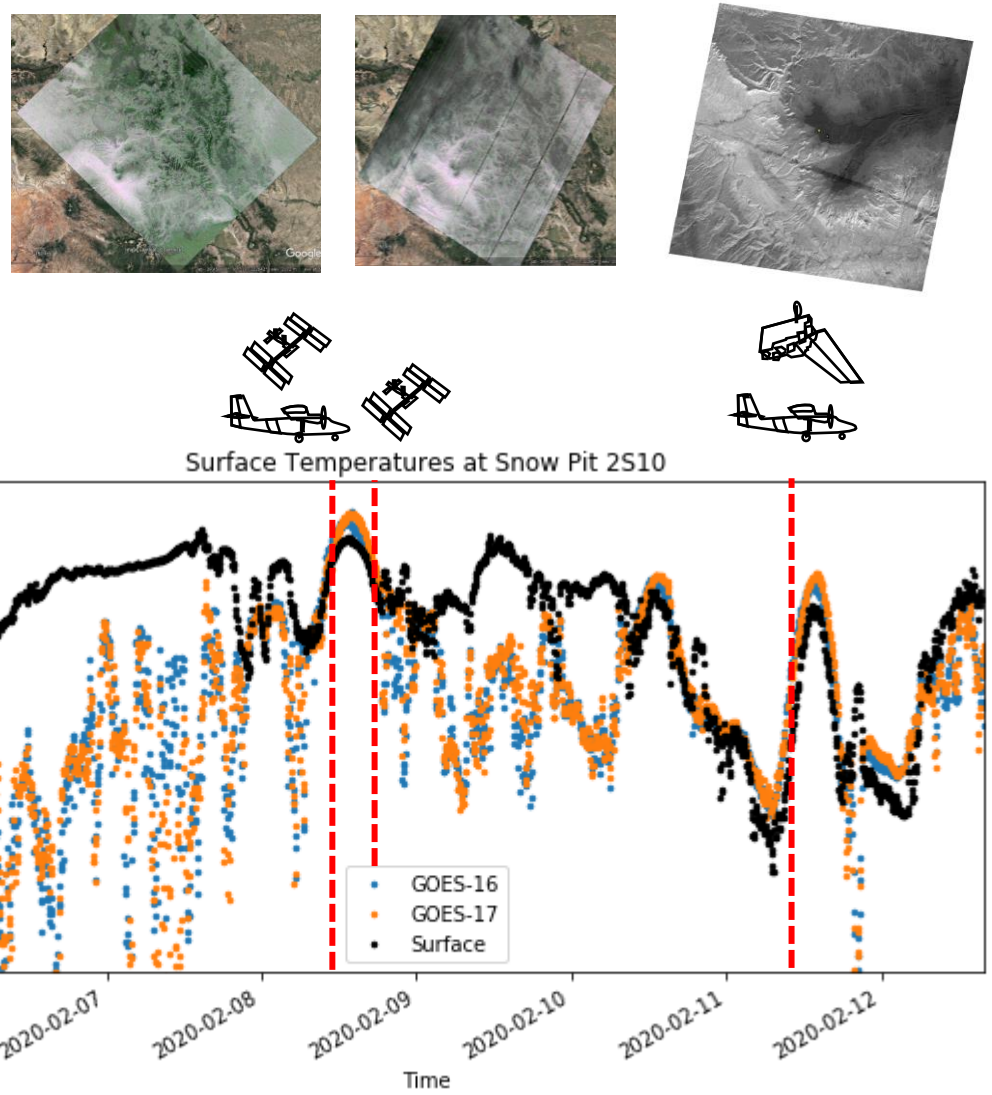

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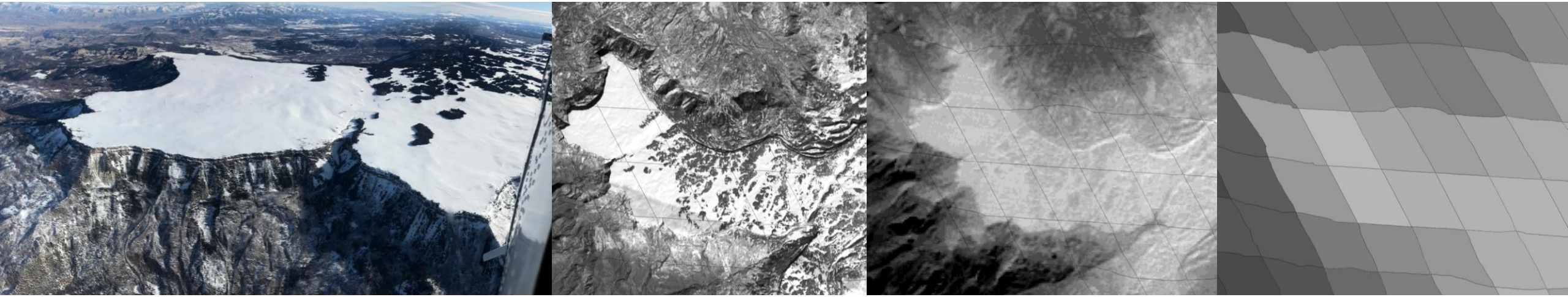
Snow Surface Temperature & Thermal Infrared Remote Sensing

Grand Mesa IOP - SnowEx 2020



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Chris Chickadel[1,2]

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Photo credit: Chris Chickadel

SnowEx Community Meeting: August 20, 2020

Snow Surface Temperature & Thermal Infrared Remote Sensing

Grand Mesa IOP - SnowEx 2020

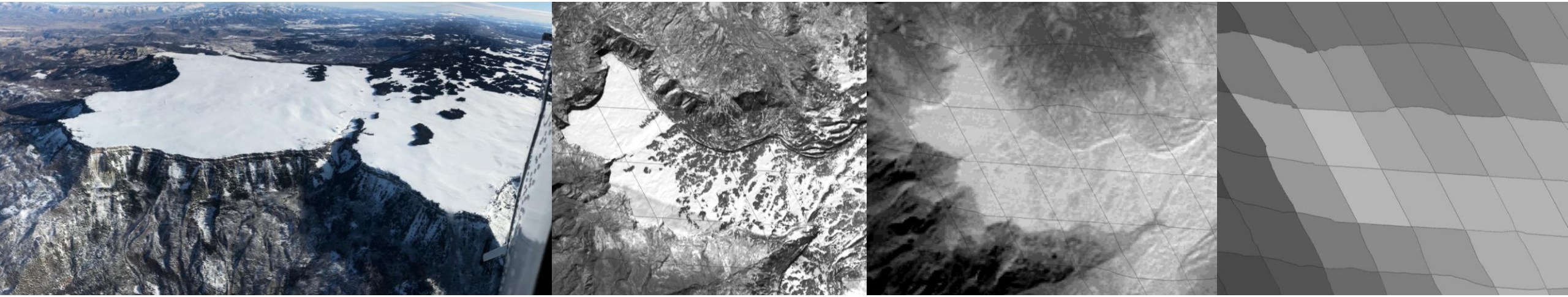

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Photo credit: Chris Chickadel

SnowEx Community Meeting: August 20, 2020

Extra Slides

Imaging Frequency:

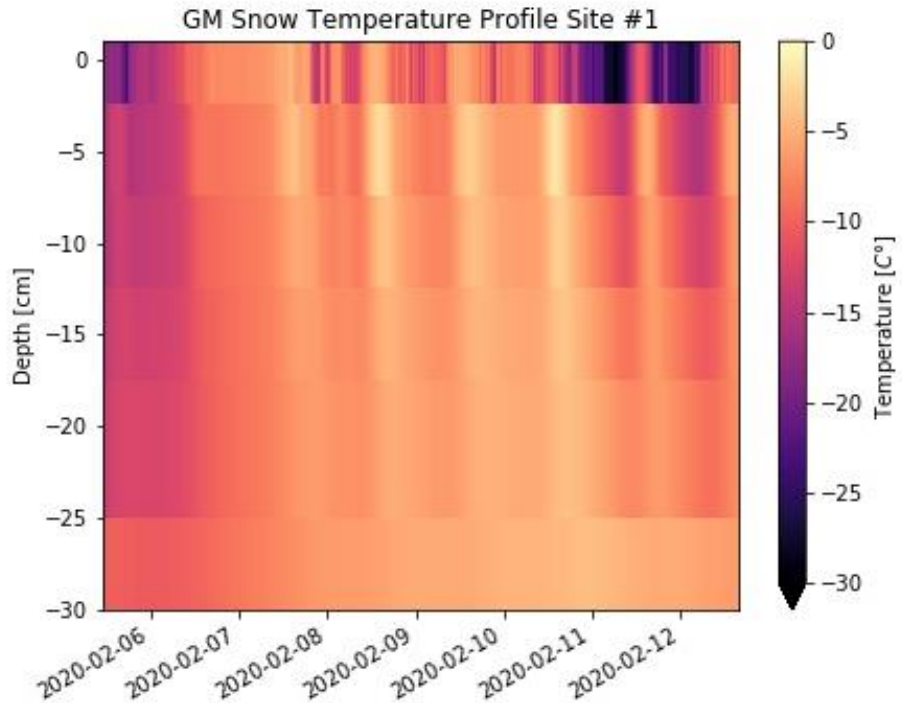
Full Disk: 10 minutes
CONUS: 5 minutes

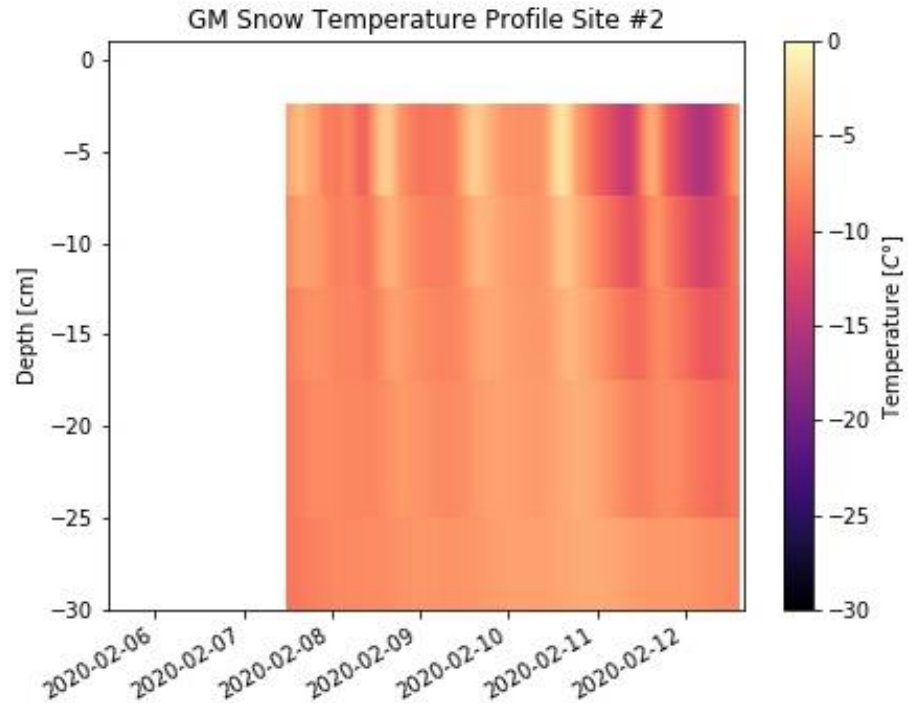
Spatial Resolution:

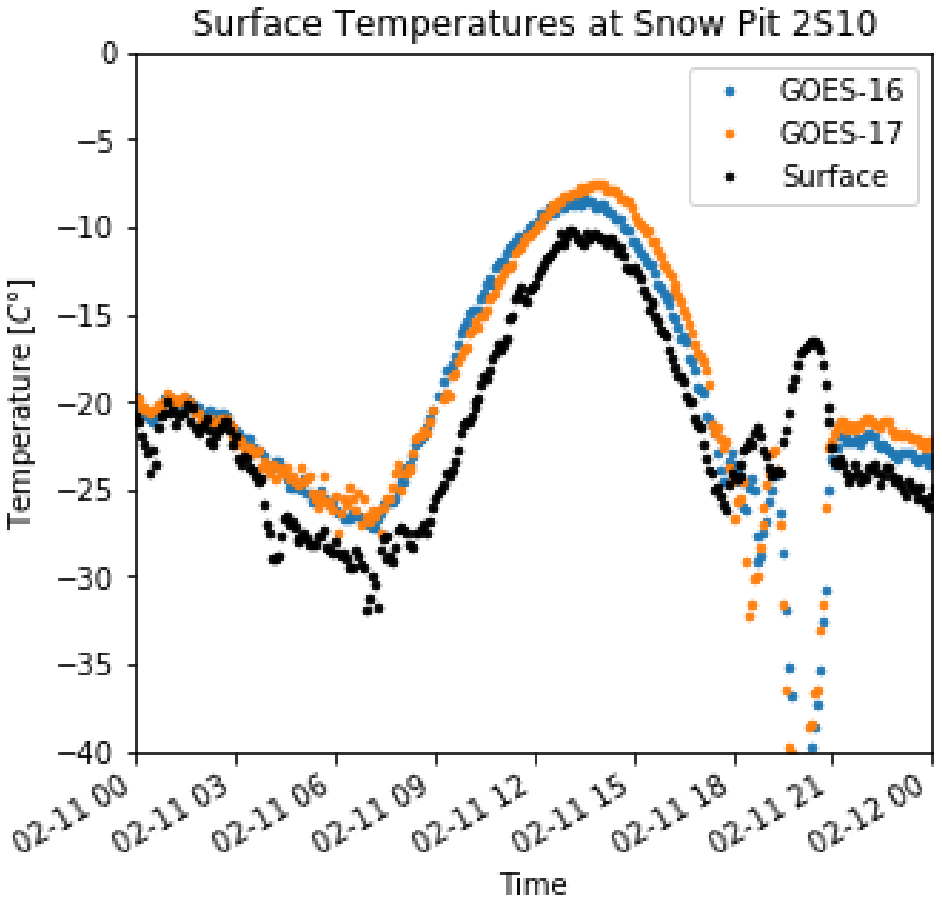
VIS: 0.5-1 km
IR: 2 km

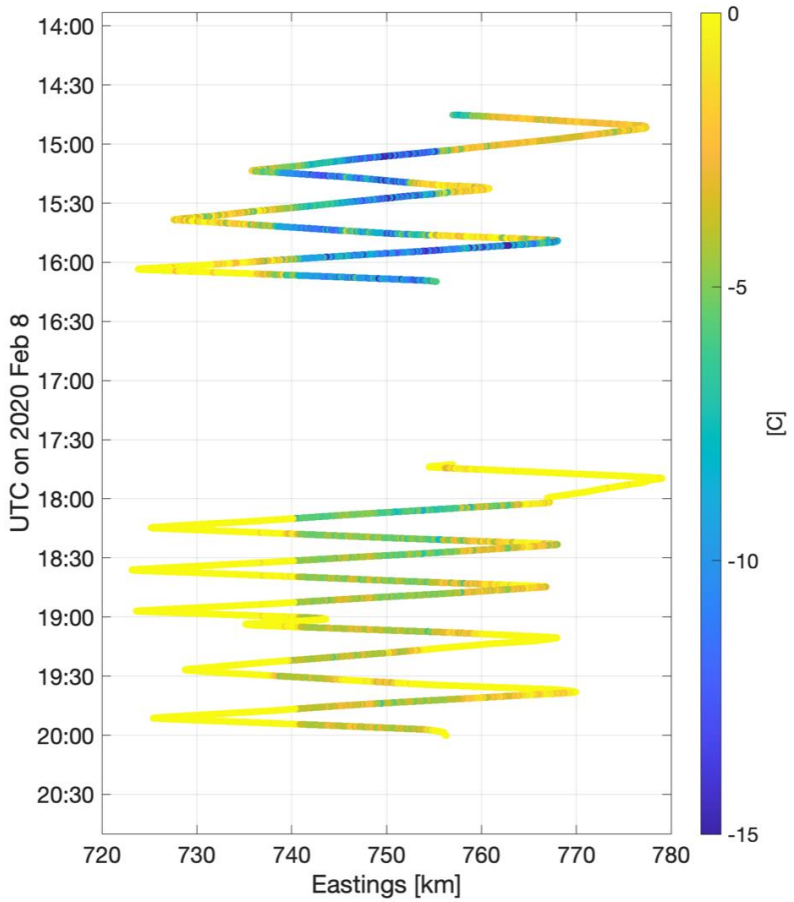
GOES ABI Bands (GOES-16, 17)

Central wavelength	Bandwidth	SNR or NEΔT @ specified input	Resolution (s.s.p.)
470 nm	40 nm	300 @ 100 % albedo	1.0 km
640 nm	100 nm	300 @ 100 % albedo	0.5 km
860 nm	40 nm	300 @ 100 % albedo	1.0 km
1380 nm	30 nm	300 @ 100 % albedo	2.0 km
1610 nm	60 nm	300 @ 100 % albedo	1.0 km
2260 nm	50 nm	300 @ 100 % albedo	2.0 km
3.90 µm	0.20 µm	0.1 K @ 300 K	2.0 km
6.15 µm	0.90 µm	0.1 K @ 300 K	2.0 km
7.00 µm	0.40 µm	0.1 K @ 300 K	2.0 km
7.40 µm	0.20 µm	0.1 K @ 300 K	2.0 km
8.50 µm	0.40 µm	0.1 K @ 300 K	2.0 km
9.70 µm	0.20 µm	0.1 K @ 300 K	2.0 km
10.3 µm	0.50 µm	0.1 K @ 300 K	2.0 km
11.2 µm	0.80 µm	0.1 K @ 300 K	2.0 km
12.3 µm	1.00 µm	0.1 K @ 300 K	2.0 km
13.3 µm	0.60 µm	0.3 K @ 300 K	2.0 km

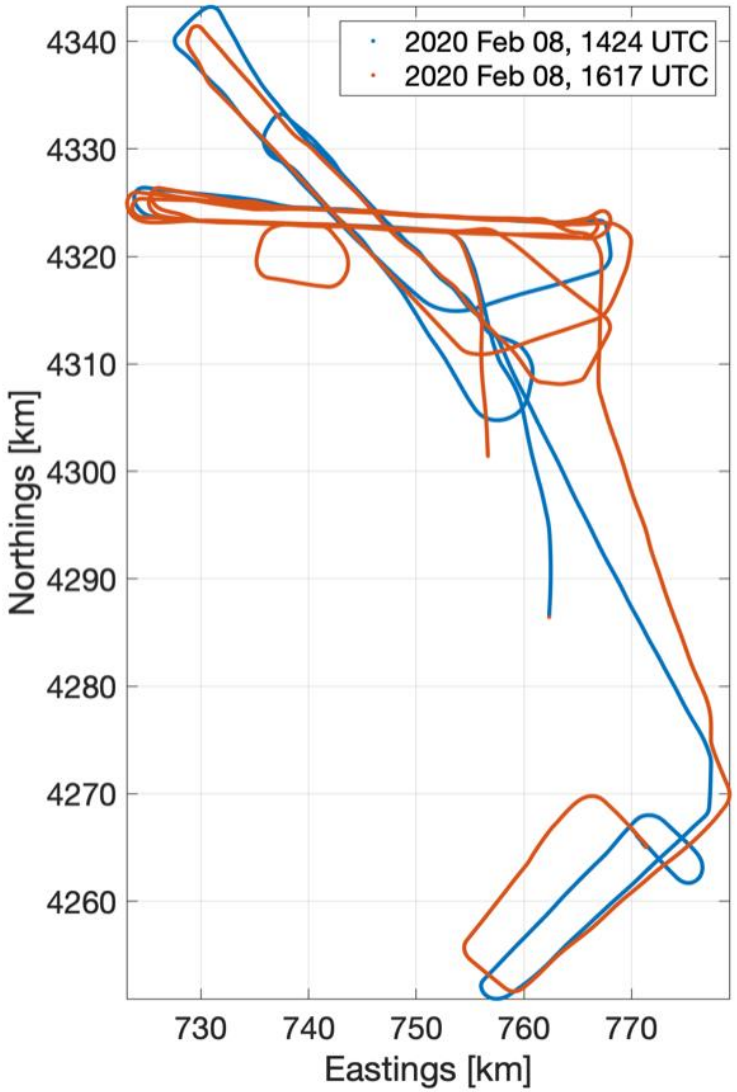

GM Snow Temperature Profile Site #1
Depth [cm]
0
−5
−10
−15
−20
−25
−30
2020-02-06
2020-02-07
2020-02-08
2020-02-09
2020-02-10
2020-02-11
2020-02-12
Temperature [C°]
0
−5
−10
−15
−20
−25
−30

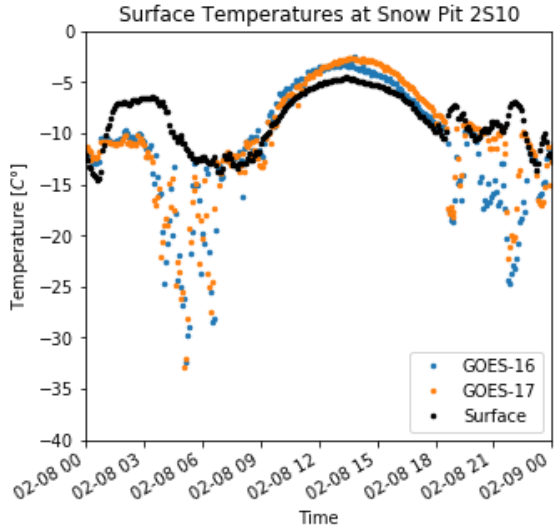

GM Snow Temperature Profile Site #2
Depth [cm]
0
−5
−10
−15
−20
−25
−30
2020-02-06
2020-02-07
2020-02-08
2020-02-09
2020-02-10
2020-02-11
2020-02-12
Temperature [C°]
0
−5
−10
−15
−20
−25
−30

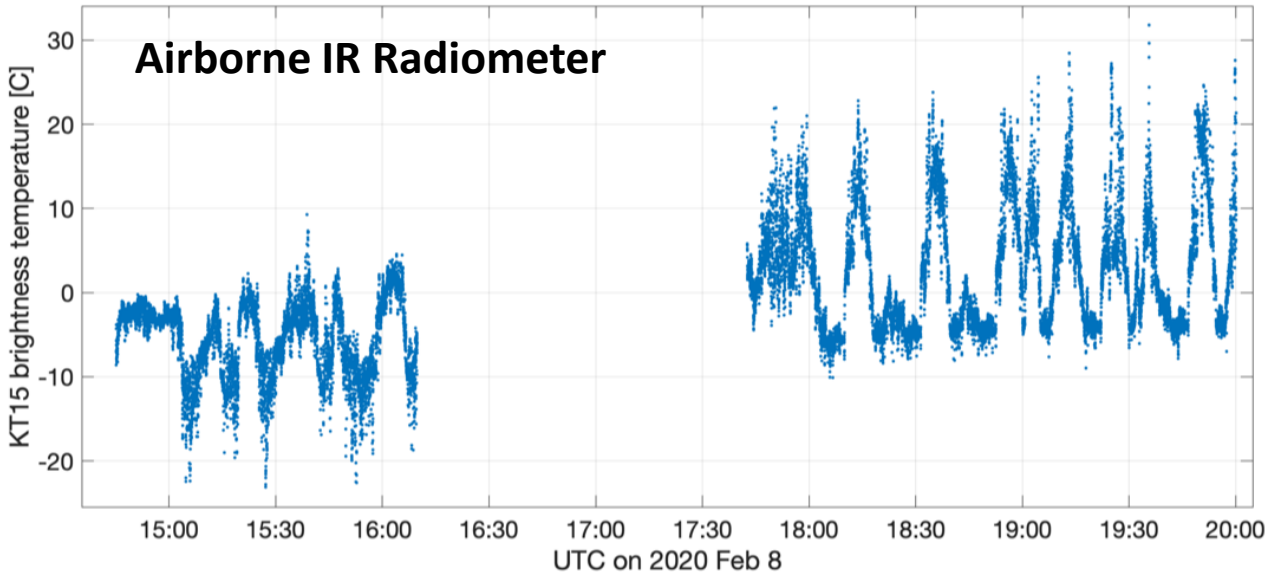

Surface Temperatures at Snow Pit 2S10
GOES-16
GOES-17
Surface
Temperature [C°]
0
−5
−10
−15
−20
−25
−30
−35
−40
02-11 00
02-11 03
02-11 06
02-11 09
02-11 12
02-11 15
02-11 18
02-11 21
02-12 00
Time



Figures and airborne IR data: Chris Chickadel







Figures and airborne IR data: Chris Chickadel