



In-depth understanding of component temperatures over sparsely vegetated surface

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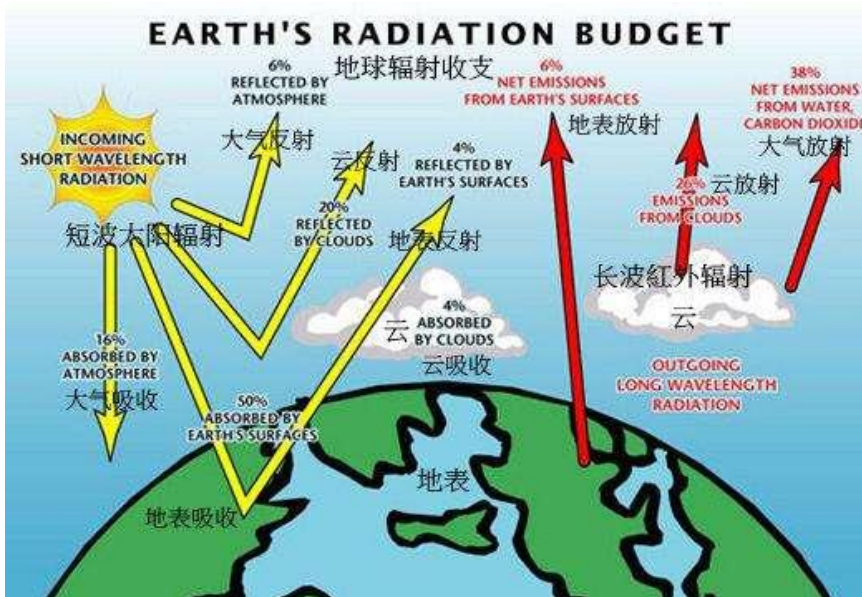
Outline



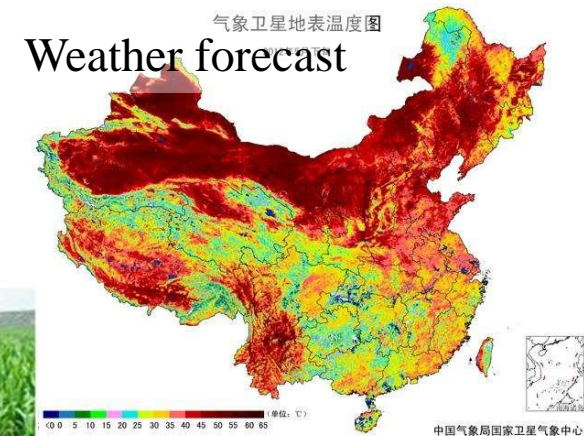
- 1. Study background**
- 2. Field experiment**
- 3. Data analyzing**
- 4. Conclusion and discussion**

1. Study background

□ Land Surface Temperature (LST)

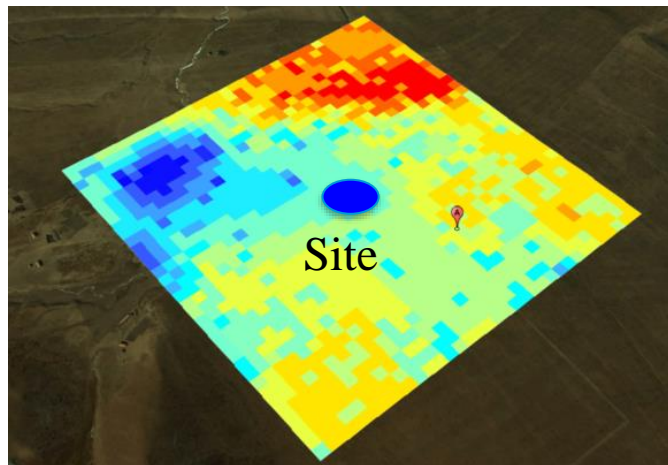


Agriculture

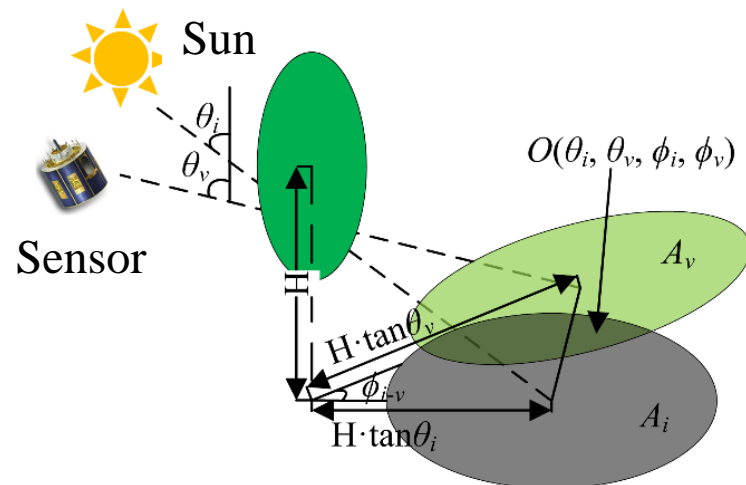


1. Study background

✓ Validation of LST over heterogeneous surface



Single-point or small area observation



Surface-sensor-sun relation

Outline



1. Study background
- 2. Field experiment**
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Experimental area



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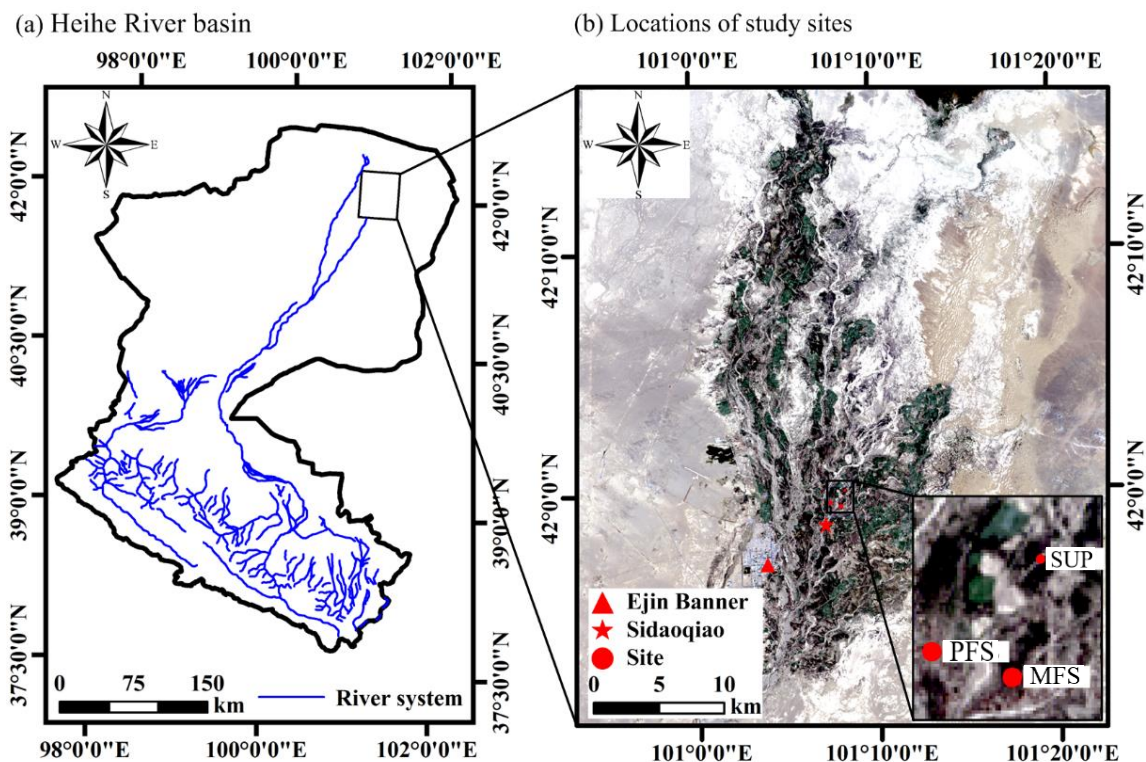


Fig. 1. Map of the experimental area and the sites.

Mixed forest site (MFS): tree, shrub and bare soil

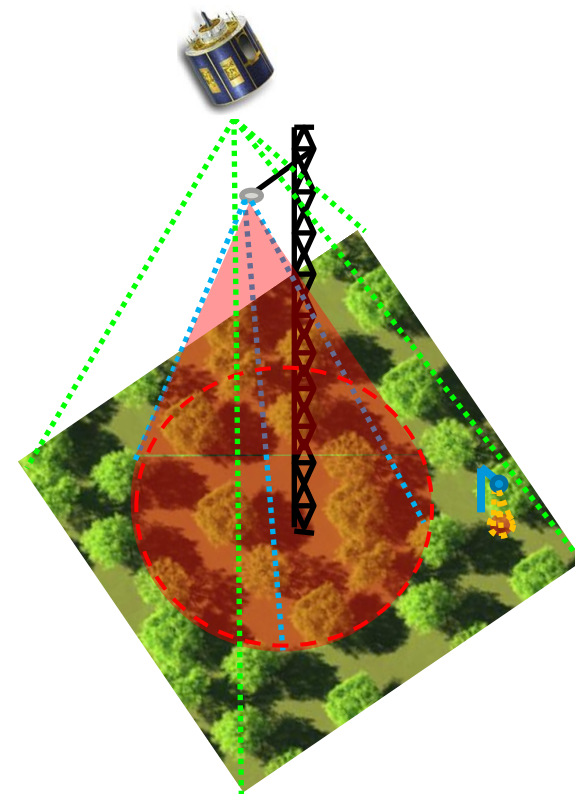
Populus forest site (PFS): tree and bare soil

Superstation (SUP): shrub and bare soil

Diameter of Filed:

~80-180m

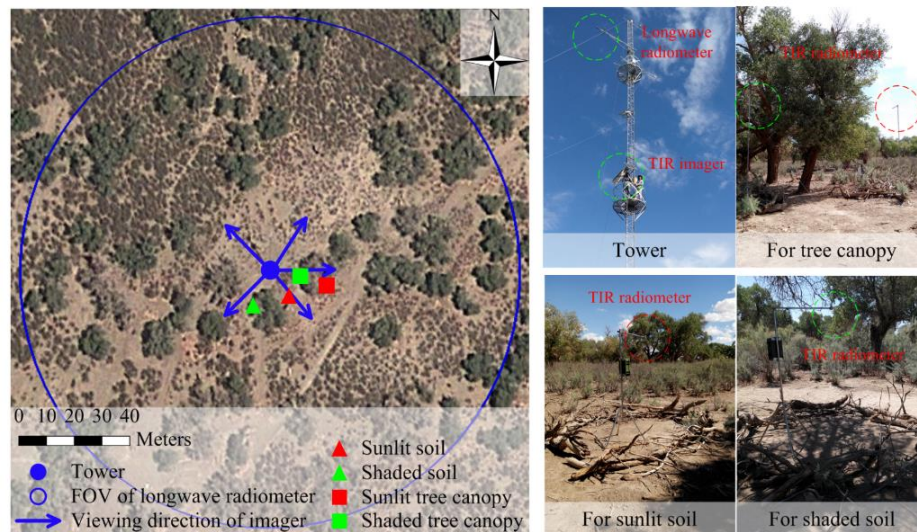
Filed of view: 150°



Satellite and longwave
radiometer

Field observation

(a) MFS site



(b) SUP site

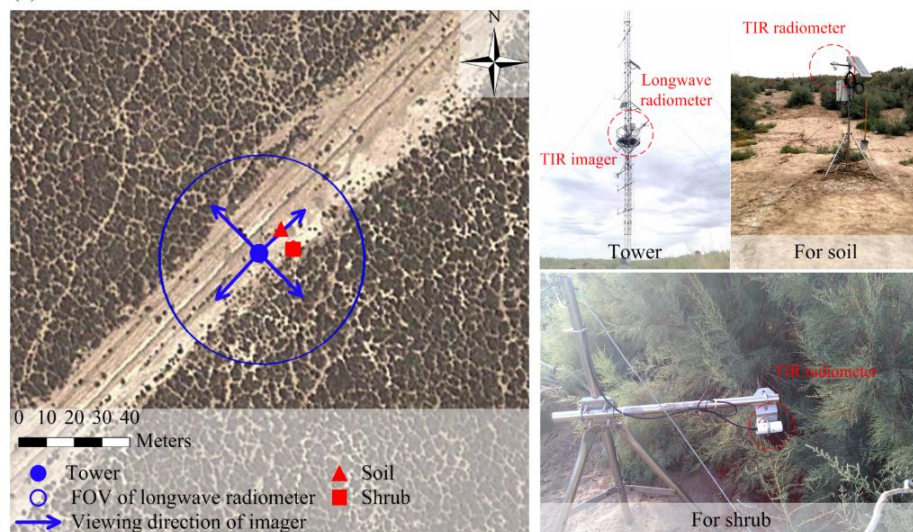


Fig. 2. Instrumentation for temperature measurements at MFS and SUP sites.

TIR imager:

Testo 890-2 and Testo 875-2i

TIR radiometer:

SI-111 and AV-IRT 3

Longwave radiometer:

CNR4 and CNR1

Field observation



Table 1. Specifications of instruments and parameters in the measurements of surface temperatures.

Site	Instrument	Response wavelength range/ μm	Field angle	Accuracy	Height/m	VZA/ $^{\circ}$	Target	Interval/min
MFS	SI-111	8-14	44°	$\pm 0.2^{\circ} \text{ C}$ (-20 to $+65^{\circ} \text{ C}$)	5	90°	Sunlit tree canopy	5
					5	90°	Shaded tree canopy	5
	AV-IRT3	6-14	7.15°	$\pm 0.5^{\circ} \text{ C}$ (-20 to 60° C)	2	0°	Sunlit soil	5
					2	0°	Shaded soil	5
	890-2	8-14	$42^{\circ} \times 32^{\circ}$	$\pm 2^{\circ} \text{ C}$	10	45°	Multiple components	-
SUP	CNR1	5-50	150°	$\pm 6\%$ (-10 to 40° C)	24	0°	Mixture of components	10
	SI-111	8-14	44°	$\pm 0.2^{\circ} \text{ C}$ (-20 to $+65^{\circ} \text{ C}$)	0.5	90°	Sunlit shrub canopy	5
					2	45°	Sunlit soil	5
	875-2i	7.5-14	$32^{\circ} \times 23^{\circ}$	$\pm 2^{\circ} \text{ C}$	10	45°	Multiple components	-
	CNR4	4.5-42	150°	$< 5\%$ (-10 to 40° C)	10	0°	Mixture of components	10
PFS	CNR4	4.5-42	150°	$< 5\%$ (-10 to 40° C)	6 and 24	0°	Mixture of components	10

Outline



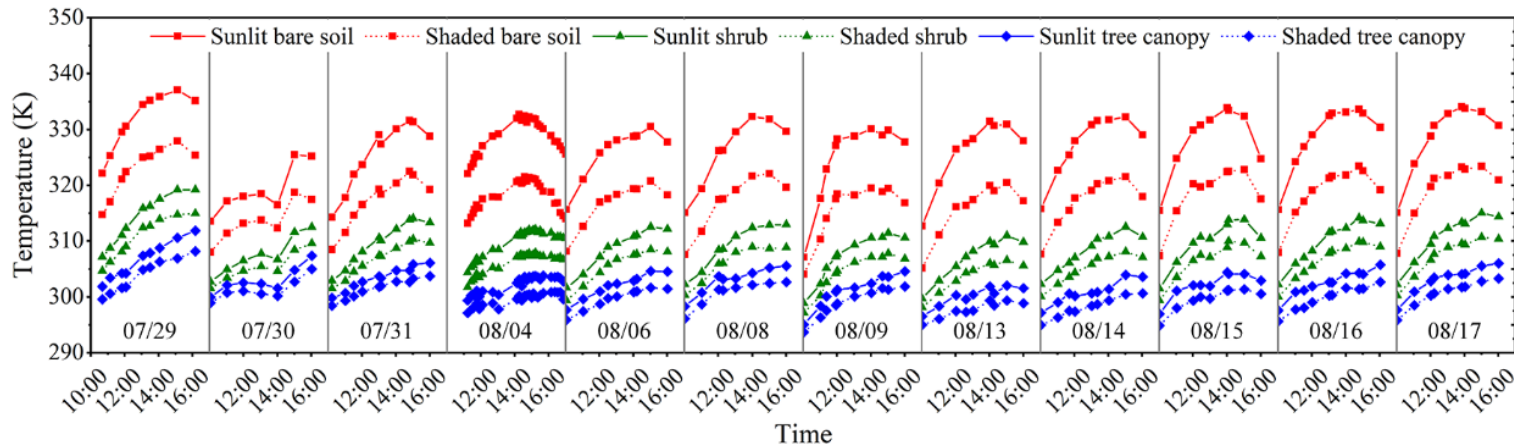
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Component temperatures (MFS)



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(a) Component temperatures measured by TIR imager



(b) Component temperatures measured by TIR radiometers

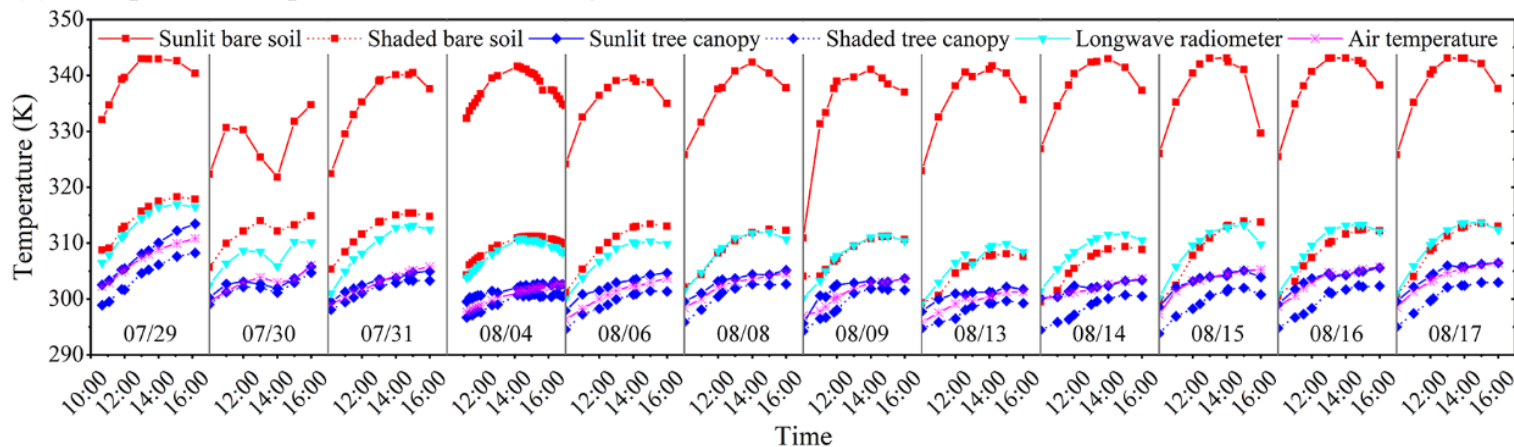


Fig. 3. Variations of component temperatures at MFS site.

Component temperatures (MFS)



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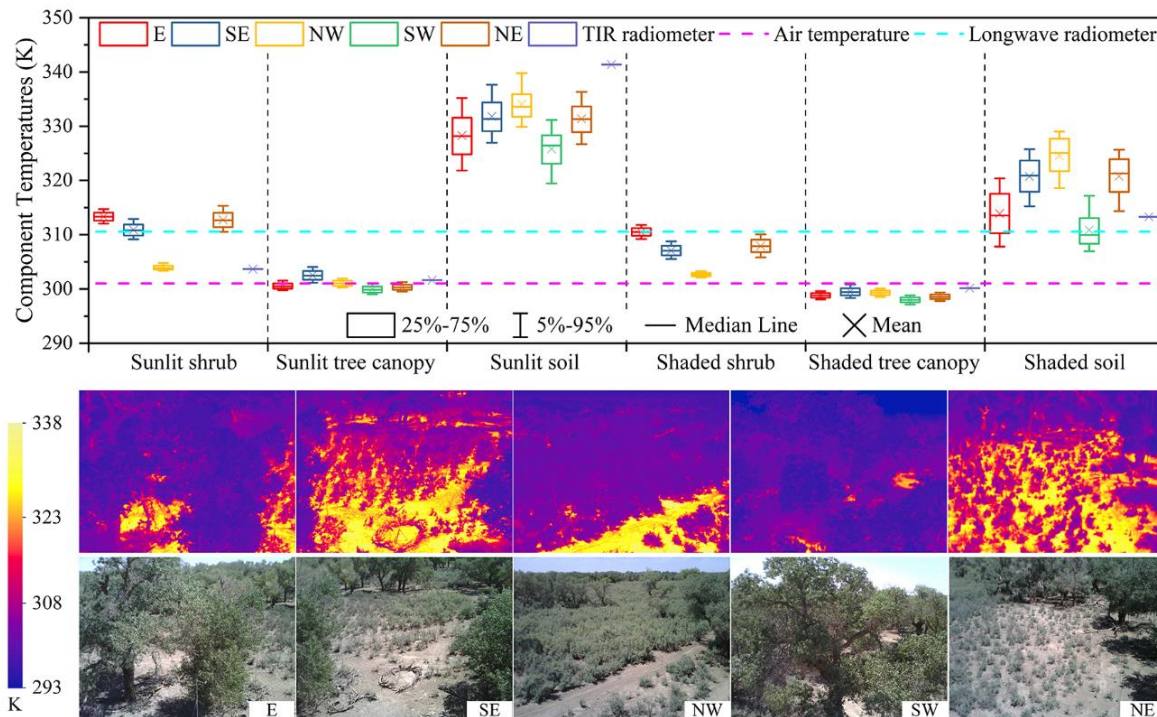


Fig. 4. Boxplots of the component temperatures, and the corresponding TIR and visible images observed by TIR imager at MFS at 14:00 on August 4, 2014.

Internal difference:

Sunlit soil, 4.2 K/3.0 - 6.7 K/4.2 K; Shaded soil, 4.7 K/3.2 - 7.3 K/4.1 K

Sunlit shrub, 0.8 K/0.5 - 2.7 K/1.5 K; Shaded shrub, 0.6 K/0.4 - 2.3 K/1.4 K

Sunlit tree, 0.9 K/0.6 - 1.6 K/0.9 K; Shaded tree, 0.8 K/0.5 - 1.3 K/0.8 K

Same component:

Sunlit soil, 325.8 - 334.1 K

Sunlit shrub, 304.0 - 313.3 K

Sunlit tree, 299.9 - 302.5 K

Different illumination:

Soil, 9.5 - 14.9 K

Shrub, 1.3 - 4.8 K

Tree, 1.8 - 3.0 K

Influence factors:

illumination time, surface character, size of shrub, etc.

Component temperatures (MFS)



Table 2. Differences between TIR imager and TIR radiometer measurements at MFS.

Observation direction	Sunlit tree canopy			Shaded tree canopy			Sunlit bare soil			Shaded bare soil		
	R^2	MBD (K)	RMSD (K)	R^2	MBD (K)	RMSD (K)	R^2	MBD (K)	RMSD (K)	R^2	MBD (K)	RMSD (K)
E	0.82	2.2	2.4	0.94	1.0	1.2	0.93	12.6	12.8	0.35	-3.6	5.0
SE	0.86	0.4	1.0	0.94	0.0	0.7	0.91	9.7	9.9	0.59	-8.3	8.8
NW	0.76	-0.2	1.3	0.69	-1.9	2.4	0.75	6.2	6.9	0.02	-12.3	13.9
SW	0.90	2.1	2.2	0.86	1.0	1.4	0.90	14.9	15.0	0.56	0.7	2.8
NE	0.64	-1.7	2.6	0.73	-2.5	3.0	0.83	9.1	9.6	0.68	-10.0	11.1
Mean	0.89	0.5	1.0	0.92	-0.5	0.9	0.96	10.5	10.6	0.56	-6.7	7.3

Component temperatures (SUP)

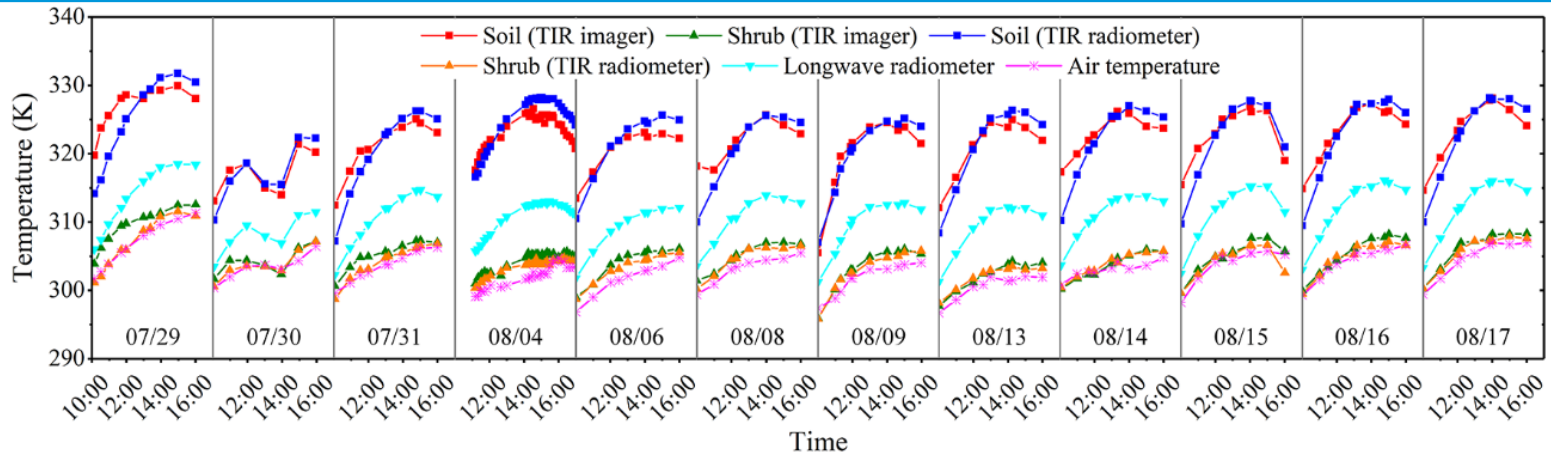


Fig. 5. Variations of component temperatures at SUP site.

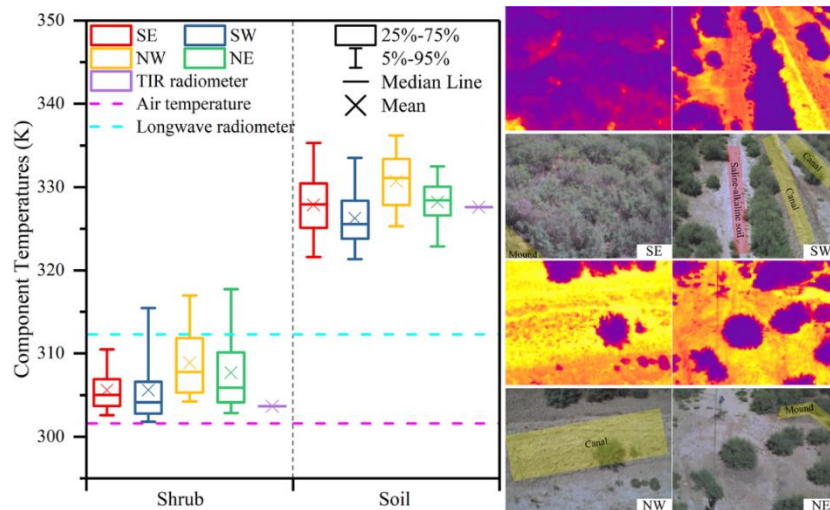


Fig. 6. Same as Fig. 5 but for SUP site.

Different direction:

Soil, 326.3 - 330.7 K

Shrub, 305.6 - 308.9 K

Internal difference:

Soil, 3.0 - 3.6 K

Shrub, 2.6 - 4.2 K;

Influence factors:

Uneven terrain, illumination time, surface character, size of shrub, etc.

Component temperatures (SUP)



Table 3. Differences between TIR imager and TIR radiometer measurements at SUP.

Observation direction	Sunlit shrub			Sunlit bare soil		
	R^2	MBD (K)	RMSD (K)	R^2	MBD (K)	RMSD (K)
SE	0.92	-0.8	1.4	0.71	6.7	8.0
SW	0.90	-0.8	1.2	0.84	0.0	2.5
NW	0.60	-7.9	8.3	0.43	-6.6	8.0
NE	0.89	-1.7	2.1	0.99	-0.3	0.9
Mean	0.92	-2.8	3.0	0.93	-0.1	1.5

Outline



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4. Conclusion and discussion



- ✓ Intrinsic characteristics, e.g. surface albedo and plant size, contribute to the temperature variability between different components and even within a single component under the same illumination condition. For TIR imager measurement performed at MFS, the mean temperature differences between sunlit bare soil, shrub, and tree canopy were 17.91 K (STD: 2.81 K) and 6.95 K (STD: 1.74 K); at SUP, the mean temperature difference between bare soil and shrub was 17.7 K (STD: 2.9 K).
- ✓ Illumination conditions, viewing direction, and instrument type significantly affect ground measured component temperatures. For the TIR imager, the largest temperature difference was obtained over bare soil under sunlit and shaded conditions, whereas the lowest difference was observed over the tree canopy.

4. Conclusion and discussion



- ✓ The component temperatures measured by the TIR radiometers differed considerably from those measured by the TIR imagers and depend on the component: at MFS, a positive difference of 14.9 K (MBD) was found for sunlit bare soil, while a negative difference of -12.3 K was found for shaded soil. The differences in component temperatures measured with the different instruments are thought to mainly arise from differences in observed target areas and viewing geometries.



Thank you!