

Fractional Sky Cover Measurements for the ARM User Facility

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Introduction

To obtain retrievals of fractional sky cover over its atmospheric observatories, the ARM user facility uses Total Sky Imagers (TSI), which provide real-time processing of hemispheric visible images of daytime sky conditions. For a continuous representation of cloud life-cycles, an Infrared Sky Imager (IRSI) is also operating at the Southern Great Plains facility that captures infrared images of the sky, during both the day and night.

Background

TSIs were initially installed at the ARM sites from 2000 to 2003. The instruments were re-engineered to increase their performance in the harsh environments of the remote sites and later modified to increase imager resolution, provide site-specific imager calibration, and improve autonomous control. However, many of the parts have become unserviceable and/or are no-longer in production.

Objectives

- ▶ Assess the current status of the ARM TSIs
- ▶ Consider options for the replacement of the TSIs with newer technology
- ▶ Solicit response from the user community on requirements for image-based fractional sky cover measurements
- ▶ Select the type of instrument to be deployed at all the sites
 - visible (daytime-only) or infrared (day and night)
 - measurement frequency
 - spectral retrievals

Fractional Sky Cover Data

Data available from ARM Data Discovery Browser (<https://adc.arm.gov/discovery>).

- ▶ tsiskycover: 30-s opaque and thin cloud amounts at 160° and 100° field-of-view from TSI visible imager
- ▶ irsivis: 30-s opaque and thin cloud amounts at 160° and 100° field-of-view from IRSI visible imager
- ▶ irsiir: 30-s opaque and thin cloud amounts at 160° and 100° field-of-view from IRSI infrared imager

Visible and Infrared Sky Imagers



TSI at SGP/C1



IRSI at SGP/C1

Total Sky Imager Status

Model Number	Serial Number	Purchase Date	Current Location	State	Imager (Axis) *	Control Board *
TSI-880	102	02/01/2000	SGP/E42	Operating	211	MSP430
TSI-880	105	03/01/2001	ANX/M1	Spare	211	MSP430
TSI-880	106	03/01/2001	SGP/C1	Operating	211	MSP430
TSI-880	107	03/01/2001	SGP/C1	Failed	211	TT8
TSI-660	100	05/01/2004	ANX/M1	Reserved	211	MSP430
TSI-660	101	07/01/2005	NSA/C1	Operating	211	MSP430
TSI-660	102	07/01/2005	ANX/M1	Spare	211	MSP430
TSI-660	103	06/01/2009	MOS/M1	Reserved	211	MSP430
TSI-660	104	06/01/2009	MOS/M1	Spare	211	MSP430
TSI-660	106	08/01/2010	PNNL	Operating	211	MSP430
TSI-660	108	08/01/2013	ENA/C1	Operating	P1353	MSP430
TSI-660	109	08/01/2013	OLI/M1	Operating	P1353	MSP430

* Axis 211 network camera and Onset TT8 microcontroller are discontinued.

TSI Replacement Options

- ▶ YES TSI-660, visible only (TSI maintained to original specifications)
- ▶ Solmirus ASIVA All-Sky Infrared Visible Analyzer visible subsystem (upgradable to include IR)
- ▶ Solmirus ASIS-M1v All-Sky Imaging System, visible only
- ▶ EKO SRF-02 All Sky Camera, visible only
- ▶ CMS ASI-16 All Sky Imager, visible only
- ▶ Solmirus ASIS-M1i All-Sky Imaging System, infrared only
- ▶ Reuniwatt Sky InSight, infrared only
- ▶ Solmirus ASIVA-M7, infrared + visible (same as SGP IRSI)

Summary

- ▶ Total Sky Imagers (TSI) are aging and many parts, including camera, control board, and gearmotor, are unserviceable and/or discontinued.
- ▶ Soliciting response from science community on requirements for image-based fractional sky cover (cloud fraction) measurements.
- ▶ Evaluating options for the replacement of TSIs with newer, commercially-available technology.
- ▶ Infrared Sky Imager (IRSI) can provide other useful data products, including sky/cloud temperature (brightness and color), precipitable water vapor, cloud height, and cloud optical depth.

TSI Engineering and Base-Line Changes

- ▶ Engineering Change Order ECO-00378 to convert TSIs to more reliable system was completed on 5/16/2005.
- ▶ Base-line Change Request BCR-01003 to deploy re-engineer TSIs was completed on 8/3/2005.
- ▶ Engineering Change Order ECO-00625 and Base-line Change Request BCR-01598 to upgrade control boards was completed on 4/16/2010.
- ▶ Engineering Change Order ECO-00674 and Base-line Change Requests BCR-01680 and BCR-02031 to upgrade TSI camera and software was completed on 6/24/2011.
- ▶ Engineering Change ENG0003147 to change TSI control boards was completed on 4/11/2018.

References

- Morris VR. 2016. Infrared Sky Imager Instrument Handbook. Ed. by Robert Stafford, DOE ARM Climate Research Facility. DOE/SC-ARM-TR-182.
- Morris VR and D Klebe. 2014. "An Infrared Sky Imager for the Atmospheric Radiation Measurement Program Climate Research Facility." Presented by Victor Morris at AMS Symposium on Meteorological Observation and Instrumentation, Westminster, CO on June 10, 2014. PNNL-SA-103289.
- Morris VR. 2007. "An Evaluation of Infrared Sky Imagers for the Atmospheric Radiation Measurement Program." Presented at AGU Fall Meeting, San Francisco, CA.
- Morris VR. 2005. Total Sky Imager (TSI) handbook. U.S. Department of Energy. ARM TR-017.

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