# Evaluation of Infrared Sky Imagers at the ARM Southern Great Plains Site

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## Introduction

Nighttime cloud fraction has been and remains a critical programmatic gap in ARM's observational dataset. It has long been recognized that infrared sky imaging technology has held great promise in closing this gap. In addition, this technology has the distinct advantage that its ability to characterize clouds is identical for day or night conditions. Therefore, instrument demonstrations were conducted at the Climate Research Facility Southern Great Plains site in 2005, 2007, and 2009 to evaluate measurements of cloud fraction from different types of commercially-available infrared sky imagers.

## Background

- Infrared sky imager system installed in October 2005
  - Blue Sky Imaging All Sky Thermal Infrared Camera
  - daytime measurements significantly underestimate those from Total Sky Imager (TSI)
- Infrared Sky Imager (IRSI) Intercomparison Study conducted in September 2007
  - compared measurements from five different types of infrared sky imagers
  - results did not provide a clear solution for obtaining nighttime cloud fraction
- Upgraded All Sky Infrared Visible Analyzer demonstrated in Summer 2009
  - Solmirus Corporation made significant improvements to hardware and retrieval algorithms
  - daytime images and cloud fraction data correlate very well with TSI

## Instrument Specifications

| | Detector | Wavelength range (μm) | Field of view (°) | Min. time resolution (sec) | Min. temp. detected (°C) | Image resolution (pixel) |
|---|---|---|---|---|---|---|
| ASTIC | Ferro-electric | 8 - 14 | 180 | 30 | - 30 | 320 x 240 |
| ASIVA | Micro-bolometer | 8 - 14 | 130 | 0.5 | -150 | 324 x 256 |
| Nubiscope | Pyro-electric | 8 - 14 | 140 | 600 | -100 | - |
| CIR-4 | ? | 9 - 14 | 31 | 3 | - 60 | - |

## Objectives

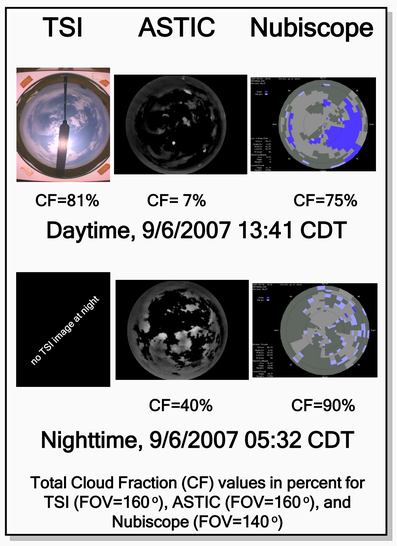
- Produce nighttime cloud fraction product
- Capture hemispheric infrared images of the sky during both the day and night
- Compare cloud fraction and cloud height data with measurements from an existing IRSI, TSI, Ceilometer (VCEIL), and Micropulse Lidar (MPL)
- Select instrument for deployment at sites

## Instruments Tested

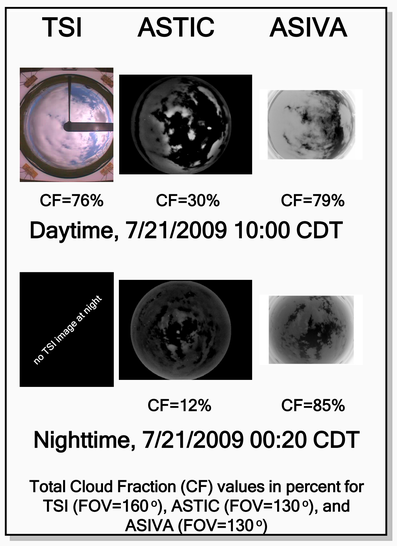
- Blue Sky Imaging All Sky Thermal Infrared Camera (ASTIC)
  - provides hemispheric sky images and cloud fraction at four fields-of-view
- Solmirus All Sky Infrared Visible Analyzer (ASIVA)
  - provides radiometric sky images, cloud percent, cloud/sky temperature, sky opacity, and water vapor determination
- Heitronics Nubiscope
  - provides cloud percent, cloud/sky temperature, cloud height, sky condition, and hemispheric cloud cover representation
- Atmos Cloud Infrared Radiometer (CIR-4)
  - provides cloud percent, cloud/sky temperature, and cloud height




## Sky Image Comparison




Total Cloud Fraction (CF) values in percent for TSI (FOV=160°), ASTIC (FOV=160°), and Nubiscope (FOV=140°)

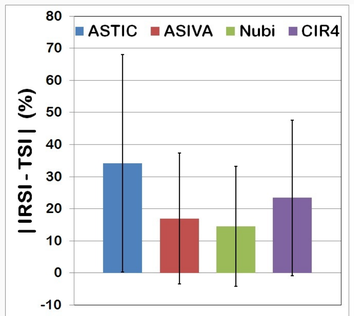



Total Cloud Fraction (CF) values in percent for TSI (FOV=160°), ASTIC (FOV=130°), and ASIVA (FOV=130°)

## Summary

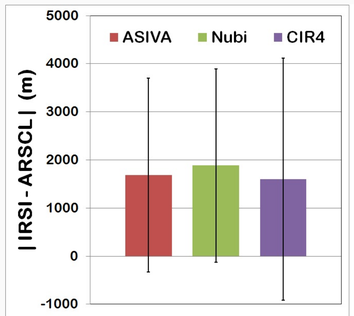
- ASTIC daytime sky images compare well with TSI but underestimates cloud fraction measurements
- ASIVA sky images and cloud fraction values correlate well with TSI
- Nubiscope cloud fraction measurements correlate very well with TSI values but has poor time resolution
- Cloud height algorithms for each instrument compared with Active Remotely-Sensed Cloud Locations (ARSCL) needs improvement
- ASIVA demonstrates considerable promise in providing nighttime cloud fraction data and additional products including cloud height, temperature, optical depth, and water vapor

## Cloud Fraction




Bar-plot of 10-minute average absolute difference from TSI of cloud fraction in percent

## Cloud Height




Bar-plot of 10-minute average absolute difference from ARSCL of cloud height in meters

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## References

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