Thermal Infrared Sensor - 2 • Landsat 9

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TIRS-2 Science Objectives

- Monitoring of evapotranspiration, water use on a regional and field-by-field basis in the U.S. and internationally
- Mapping urban heat fluxes for air quality modeling
- Volcanic hazard assessment, monitoring, and recovery
- Cloud detection, screening to process OLI-2 image data
- Mapping waterway thermal plumes from power plants
- Burnt area mapping / Wildfire risk assessment
- Identifying mosquito breeding areas, vector-borne illness potential
- Forestry and land use management
Evapotranspiration and Surface Temperature

Typical TIRS Evapotranspiration Data Product – Darker Green shows Fields with more Irrigation
TIRS-2 Hardware

Front of Flight Detector with Filter segments installed, showing the 3 arrays with 2 channels each
TIRS-2 Hardware

Flight MEB 1

Flight Detector Installed behind Telescope

Flight Scene Select Mechanism

Flight Cyocooler Control Electronics, Redundancy Switch Electronics, and Thermal Mechanical Unit at GSFC
TIRS-2 Hardware

Flight Structure with Thermal Hardware Installed and Earth Shield Hinges and Strong Back

Flight Radiators on Structure with Earth Shield Deployed with Wing Blankets
• The scattering from 13 degree annular feature seen on TIRS has been reduced by more than an order of magnitude on TIRS-2
  – A scene dependent correction for this effect was developed for TIRS which allows the observations to meet requirements
• The 22 degree annular feature observed in TIRS-2 TIPCE testing was not initially observed on TIRS and is not used in the correction
  – After the TIPCE results, the TIRS lunar data were analyzed again and the feature was seen in the extended approach scans at a much lower intensity than the 13 degree feature
  – TIPCE results indicate the 22 degree feature on TIRS-2 is lower than that on TIRS
• Effects of stray light have been reduced enough that TIRS-2 can meet absolute radiometric requirements without a scene-dependent correction like the one needed for TIRS
• Forward work
  – Continue to process the measured stray light results along with the optical model to determine the variance of the stray light effects from the 22 degree feature
  – Update assessments of performance relative to other requirements (e.g. NEdT) based on the higher fidelity results
• Final performance will be evaluated in flight and possible correction schemes using methodologies in place at USGS will be determined in conjunction with the Landsat cal/val and Science teams
## TIRS-2 Overall Status

### Landsat 9 Milestones (based on 2020 launch)

- IHR: 11/15
- PDR: 6/16
- MDR: 6/16

### TIRS-2 Reviews

#### SE, S&MA, Science, Mat'l & Processes, Contam & Cal

- IHR: 11/15
- PDR-EPRs: 05/16
- CDR-EPR: 12/16

#### Mechanical

- PDR: 06/16
- CDR: 2/17
- IBR: 6/17

#### Scene Select Mechanism

- PDR-EPR: 05/16
- CDR-EPR: 12/16
- MCE: 01/17

#### Thermal

- PDR-EPR: 04/16
- CDR-EPR: 12/16
- BTA: 01/16

#### Optics

- PDR-EPR: 04/16
- CDR-EPR: 12/16
- Lens: 12/16

#### Cryocooler

- PDR: 05/16
- CDR-EPR: 10/16
- Letter Contract: 01/16

#### Detector / FPA

- PDR: 05/16
- CDR-EPR: 10/16
- Letter Contract: 02/16

#### Electrical

- Sensor Unit I&T Start: 05/16
- Electrical Pallet I&T: 1d slack

### I&T Milestones:

1. 03/18 - SU Starts / SSM
2. 03/18 - TIPCE Complete
3. 06/18 - Cryocooler Integ
4. 07/18 - SU to EP I&T Start
5. 12/18 - TVAC 01
6. 10/18 - EMI / EMC
7. 01/19 - Vibe / Acoustics
8. 04/19 - TVAC 02

### S/C / Observatory I&T

- TIPCE Start: 06/17
- Sensor Unit I&T: 1d slack
- Electrical Pallet I&T: 1d slack
- MGSE + TVAC Pre-Cert: 6d slack

### Funding Schedule Margin

- #1: 03/18 - SU Starts / SSM
- #2: 03/18 - TIPCE Complete
- #3: 06/18 - Cryocooler Integ
- #4: 07/18 - SU to EP I&T Start
- #5: 12/18 - TVAC 01
- #6: 10/18 - EMI / EMC
- #7: 01/19 - Vibe / Acoustics
- #8: 04/19 - TVAC 02
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NASA Goddard Space Flight Center
Back Up
DATA FUSION: daily ET at field scale (F. Gao)

**SURFACE TEMPERATURE**
- Polar (Landsat)
- Polar (MODIS)
- Airborne (USU aircraft)

**EVAPOTRANSPIRATION**
- GEO (GOES Sounder)
- GEO (GOES Imager)

**Temporal Resolution**
- **Hourly**
  - Continental (10km)
  - Regional (5km)
  - Basin (1km)
- **Daily**
  - Watershed (60m)
  - Field scale (30m)
- **1 LS – 16 day**
- **2 LS – 8 day**
Gallo Vineyards, Lodi CA

Water Management Using Surface Energy Balance

\[ R_{\text{NET}} = G + ET + H \]

\[ R_{\text{NET}} = (SW_{\text{dn}} - SW_{\text{up}}) + (LW_{\text{dn}} - LW_{\text{up}}) \]

- Net Radiation is the balance between incoming minus outgoing radiation
  - OLI required to calculate the SWup (short wave albedo)
  - TIRS data required to calculate the LWup from surface temperature

Sensible heat (H)

Latent heat (ET)

Net radiation \( (R_{\text{NET}}) \)

Soil heat (G)
At the Other End of the Spectrum (in More Ways Than 1) – The Coldest Spot on the Earth

Ted Scambos, Allen Pope, Garrett Campbell, Terry Haran
National Snow and Ice Data Center, University of Colorado, Boulder
Matt Lazzara
Antarctic Meteorology Research Center, University of Wisconsin, Madison

Ultra-low surface temperatures (90°C and lower) occur in local topographic lows (pockets) just south of a long ice ridge. These areas routinely surpass the record temperature of the previous lowest temperature on record, at Vostok Station, Antarctica.
TIRS-2 Sensor Unit Design Overview

- Telescope Radiator
- Cryocooler Radiator
- Embedded Heat Pipes
- Transport Heat Pipes
- Encoder Electronics
- Blackbody Target
- Blackbody Radiator
- Cryocooler Launch Lock
- Cryocooler Vibration Isolator
- Keel

- Focal Plane Array (FPA) (Detector)
- Telescope Structure
- Telescope Lenses (4)
- Scene Select Mirror
- Scene Select Mech. (SSM)
- Telescope
- Flexible Printed Wiring (FPW)
- Cryo Shells
- Cryocooler

- Light Path

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NASA Logo

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Overview of TIRS Sensor, con’t