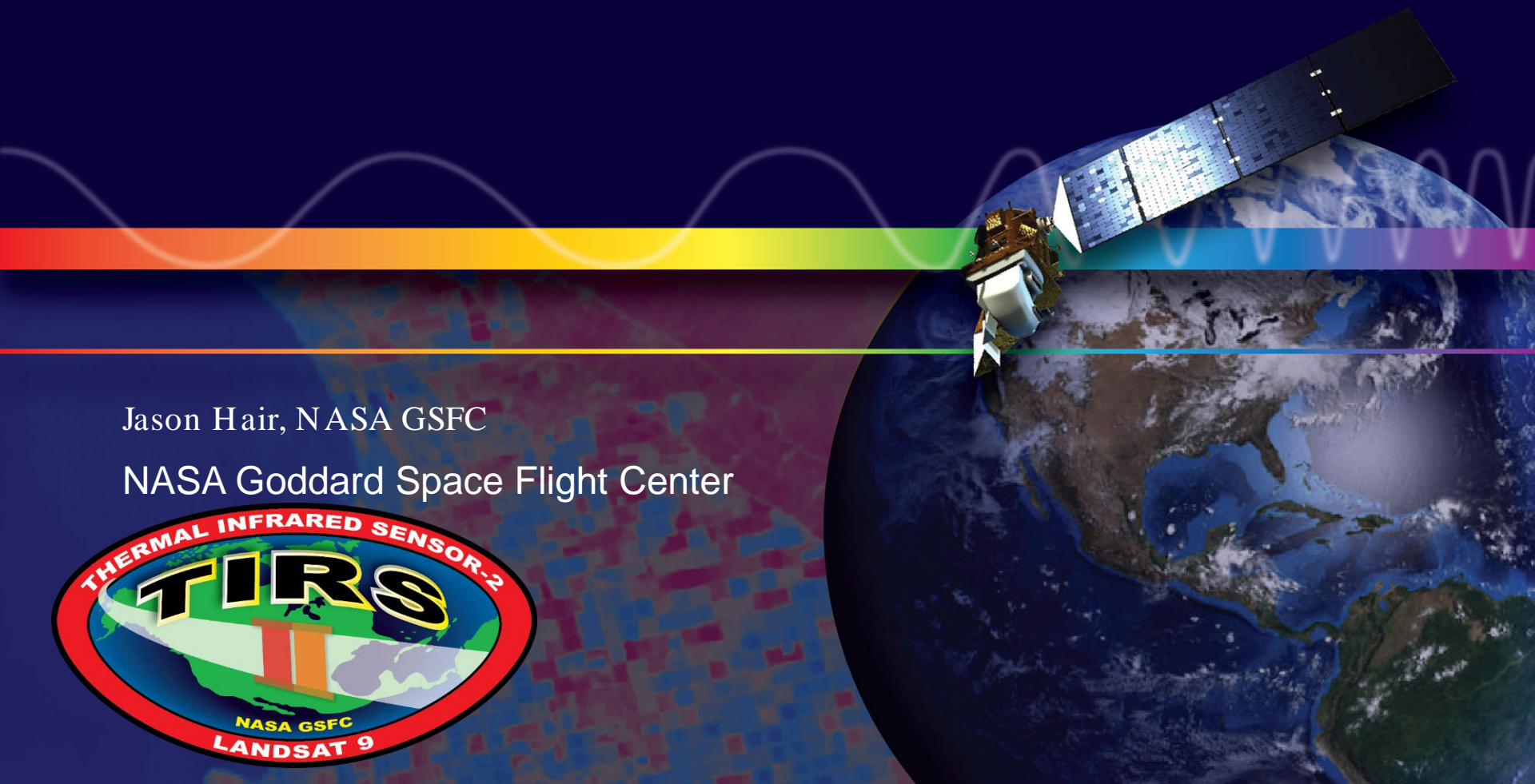




National Aeronautics and Space Administration

# Thermal Infrared Sensor - 2 • Landsat 9

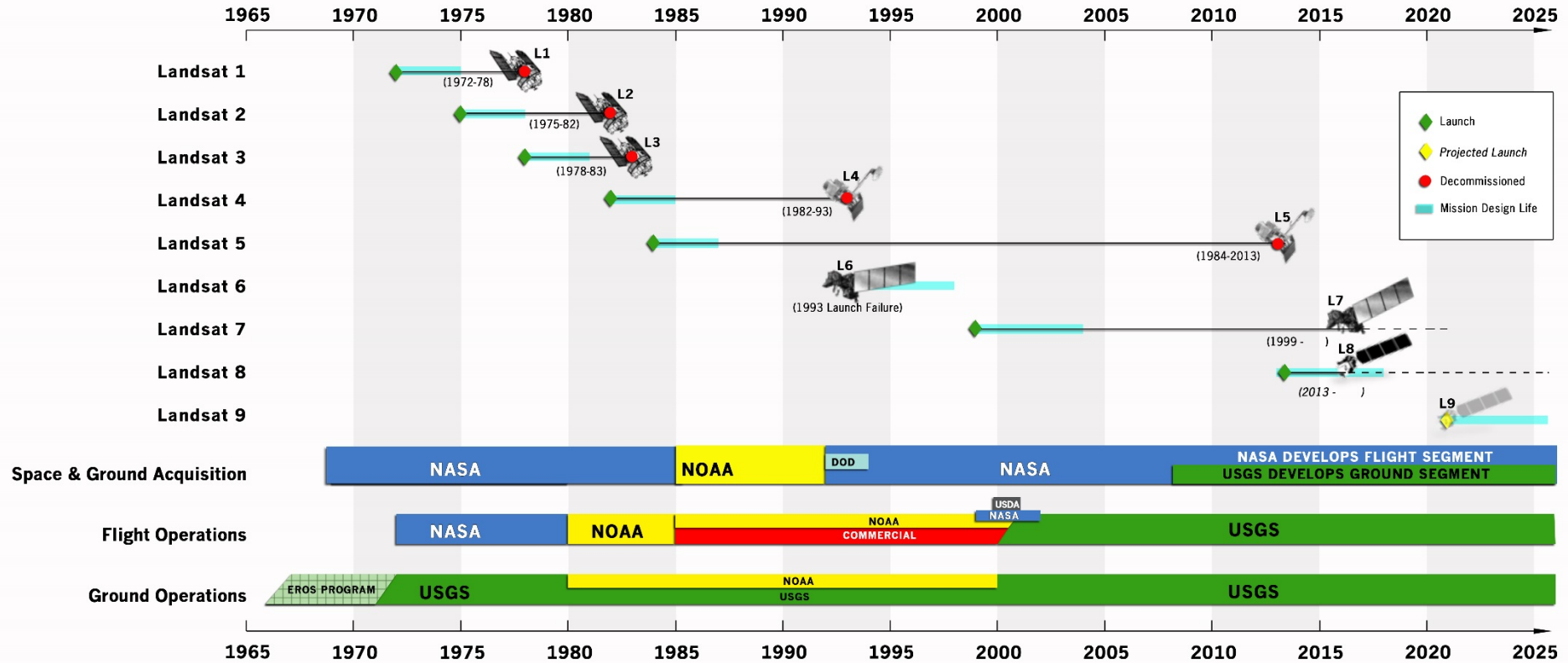


Jason Hair, NASA GSFC  
NASA Goddard Space Flight Center



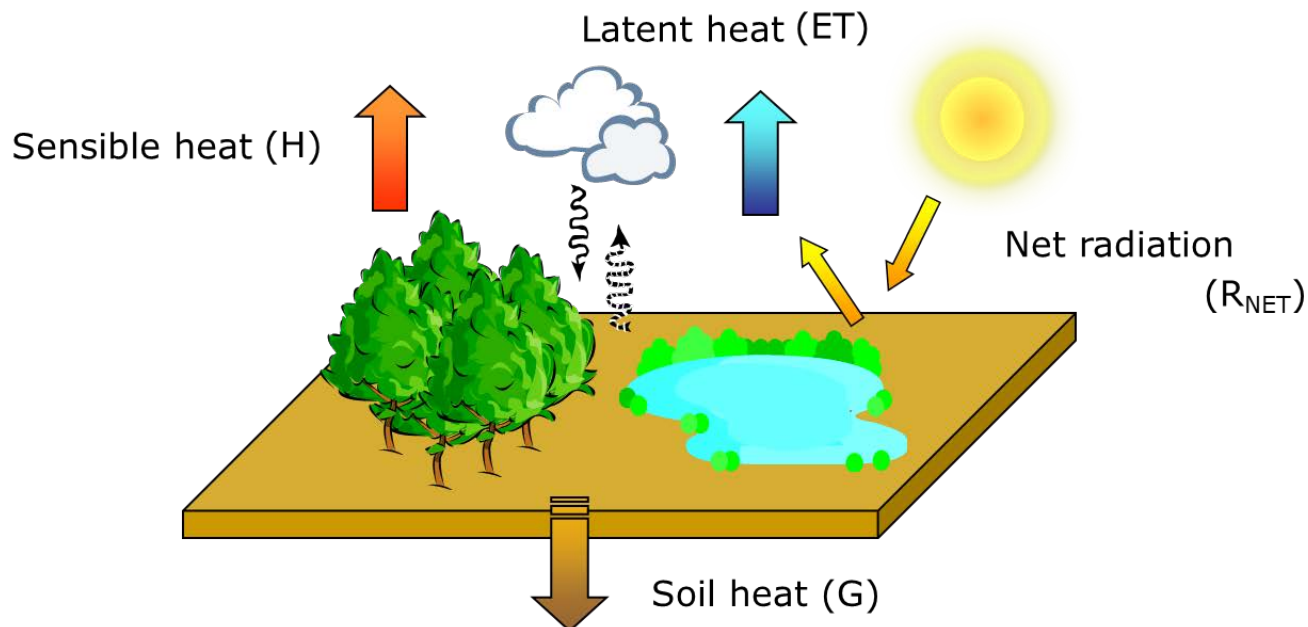


# Landsat History



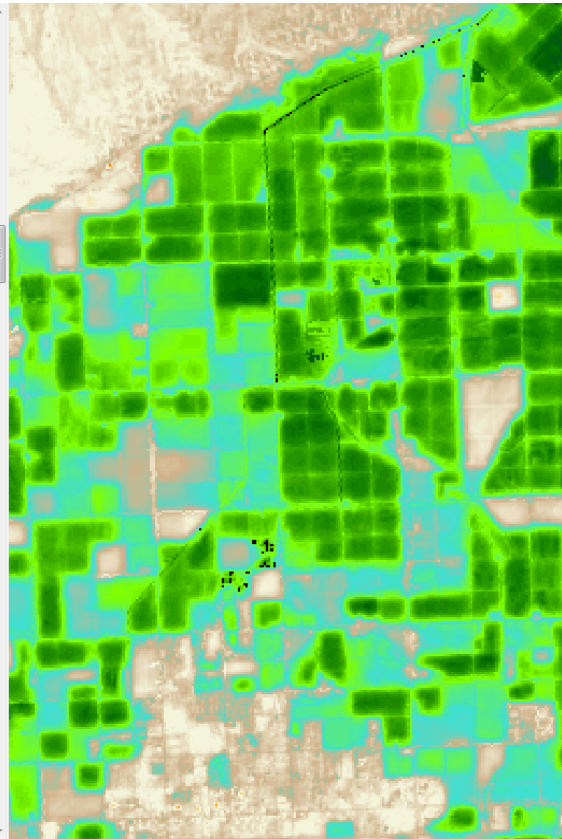
# TIRS-2 Science Objectives

- 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

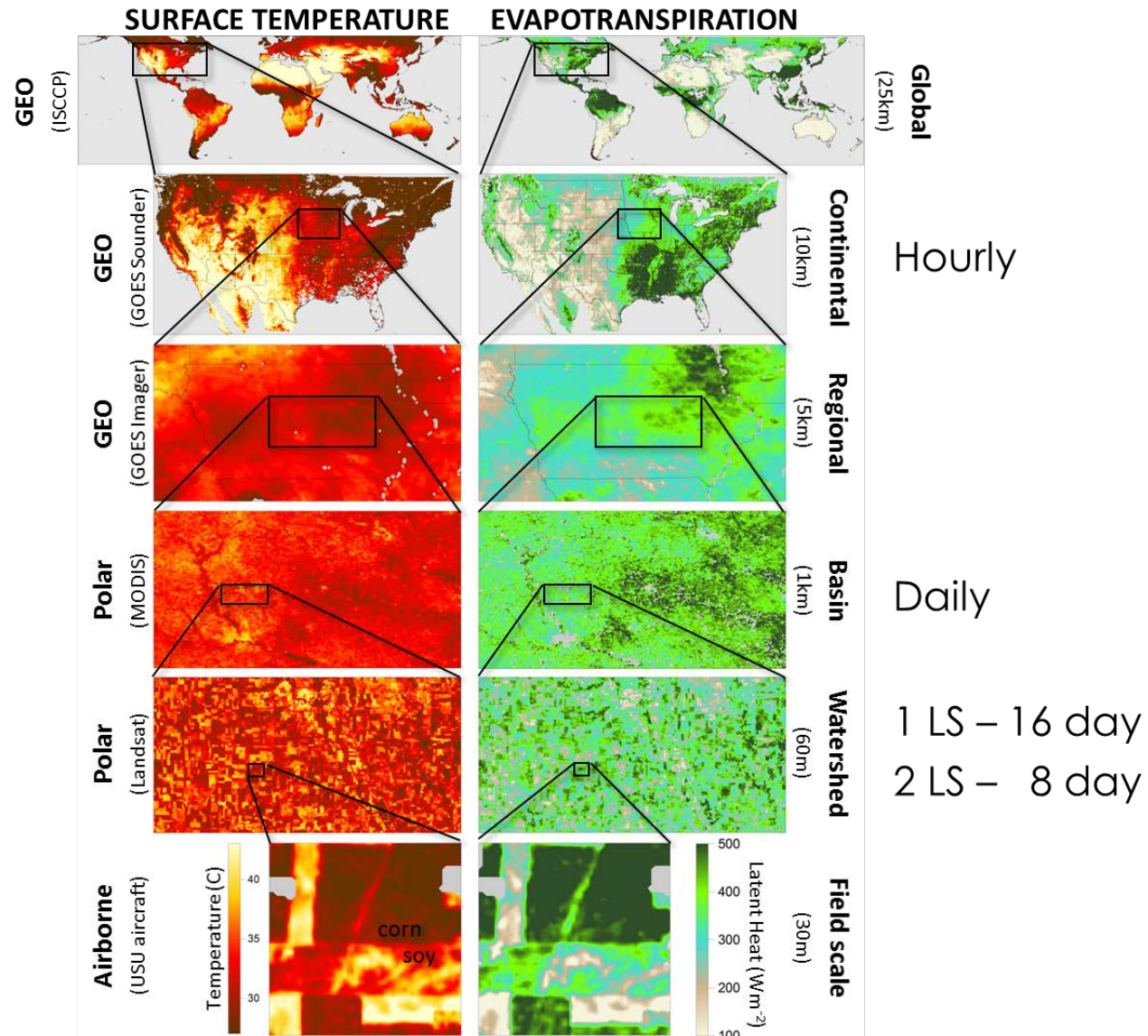




# Evapotranspiration and Surface Temperature



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





— Active fires

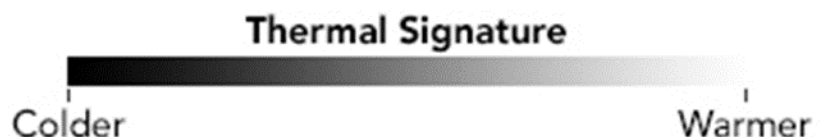
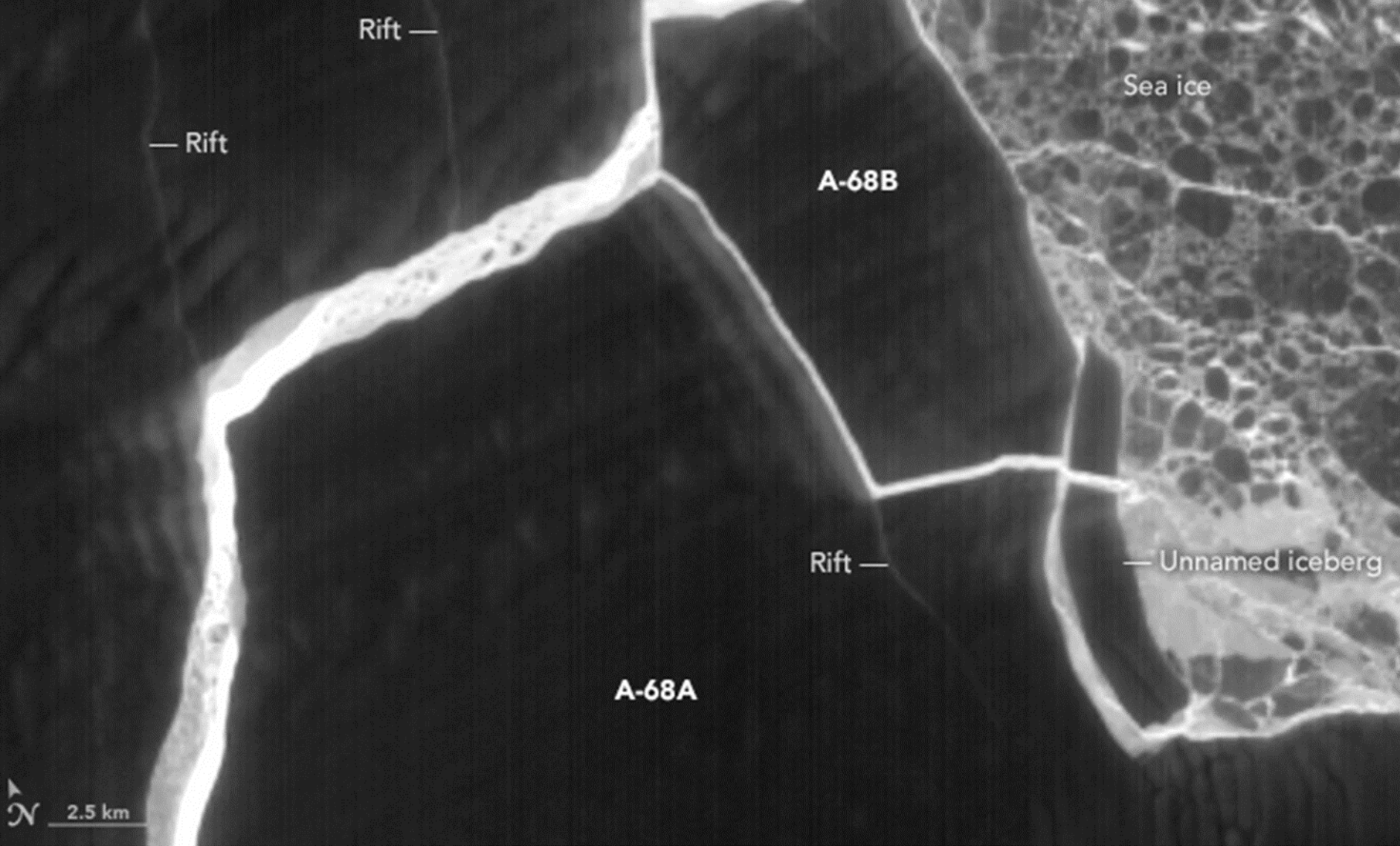
— Interstate 15

San Bernardino

5 km



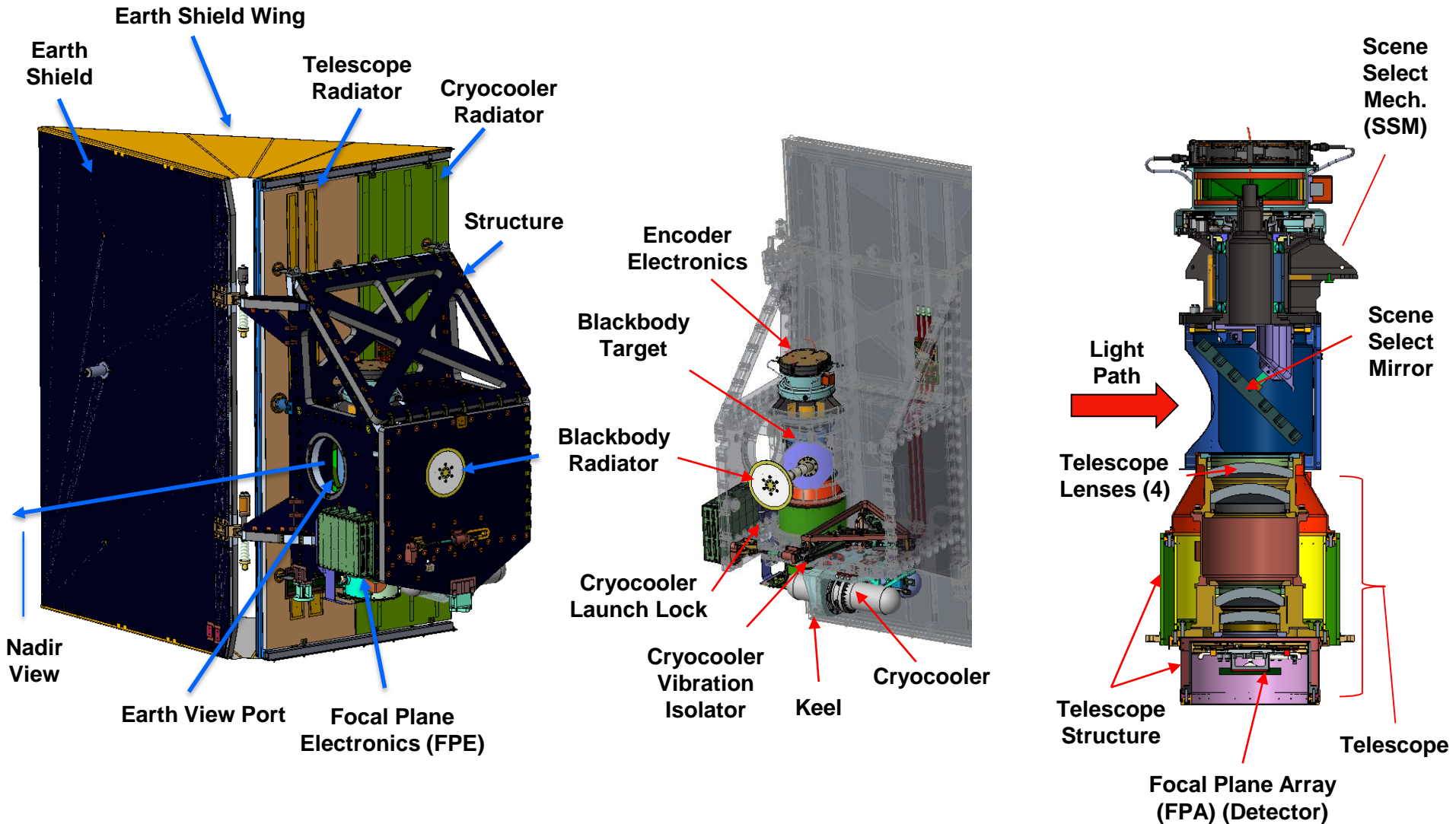
Larsen C Ice Shelf, Antarctica  
Landsat 8 / TIRS  
07/26/2017



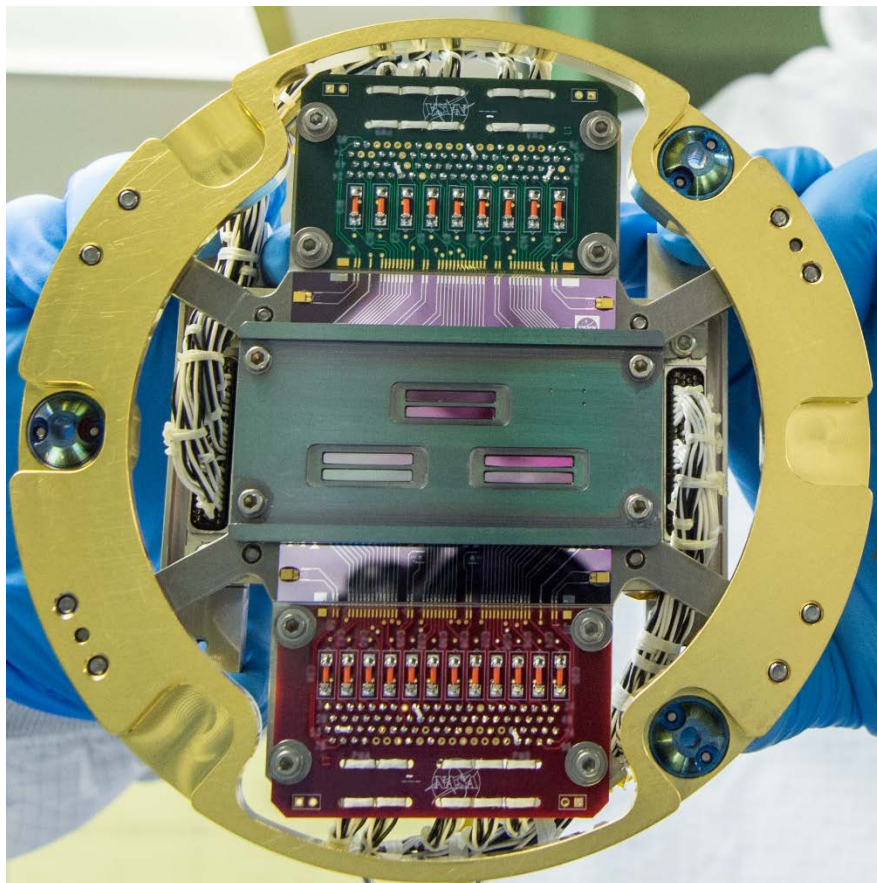




# TIRS-2 Sensor Unit Design Overview



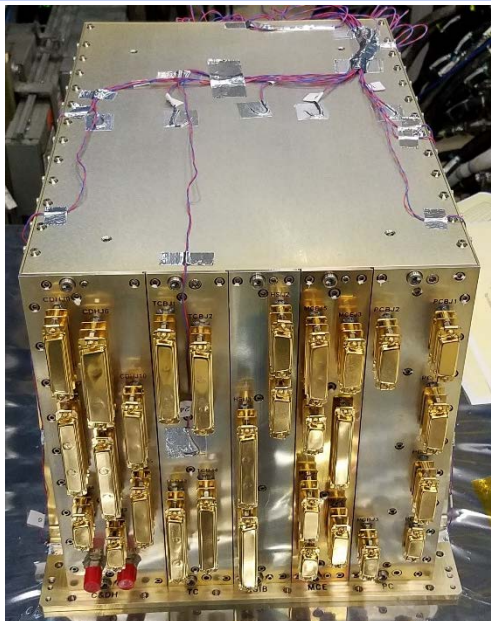
# TIRS-2 Hardware



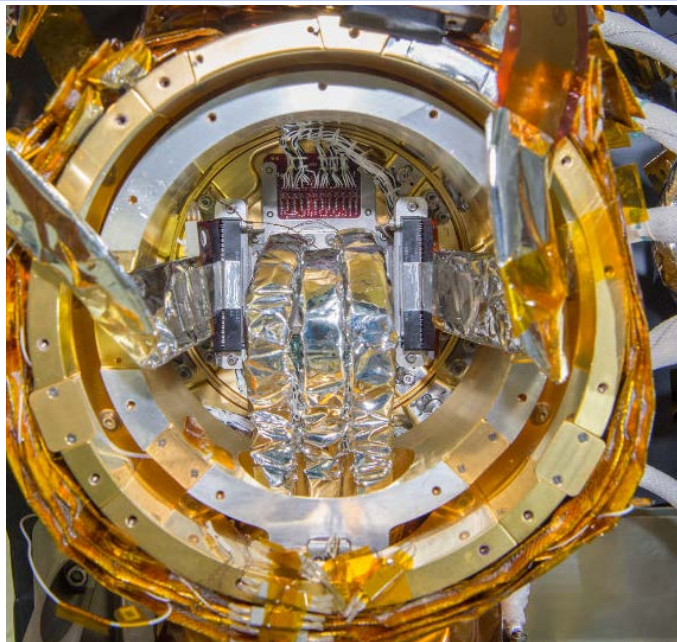
**Front of Flight Detector with Filter segments installed, showing the 3 arrays with 2 channels each**



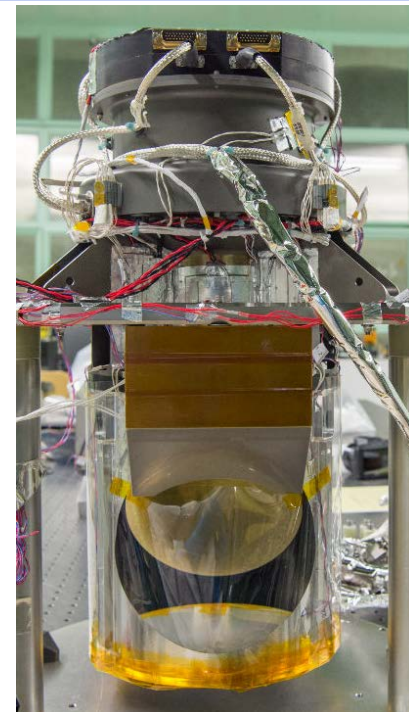
# TIRS-2 Hardware



**Flight MEB 1**



**Flight Detector Installed behind Telescope**



**Flight Scene Select Mechanism**



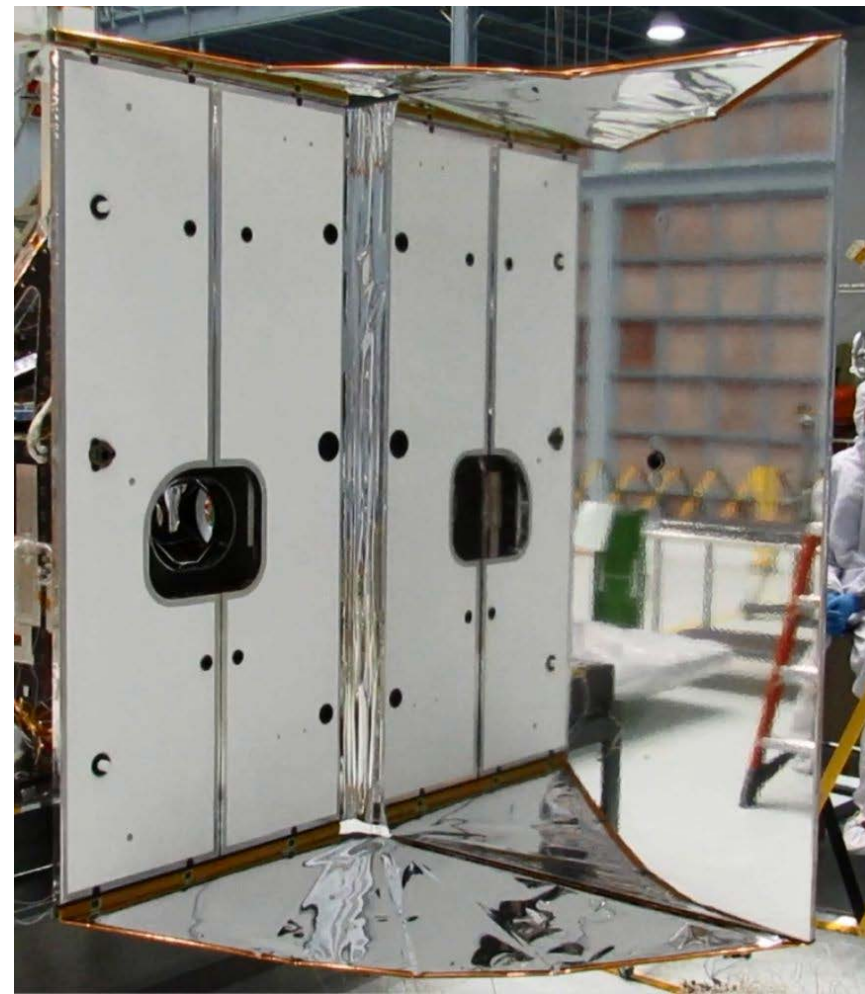
**Flight Cyocooler Control Electronics, Redundancy Switch Electronics, and Thermal Mechanical Unit at GSFC**



# 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**



# TIRS-2 Stray Light Status

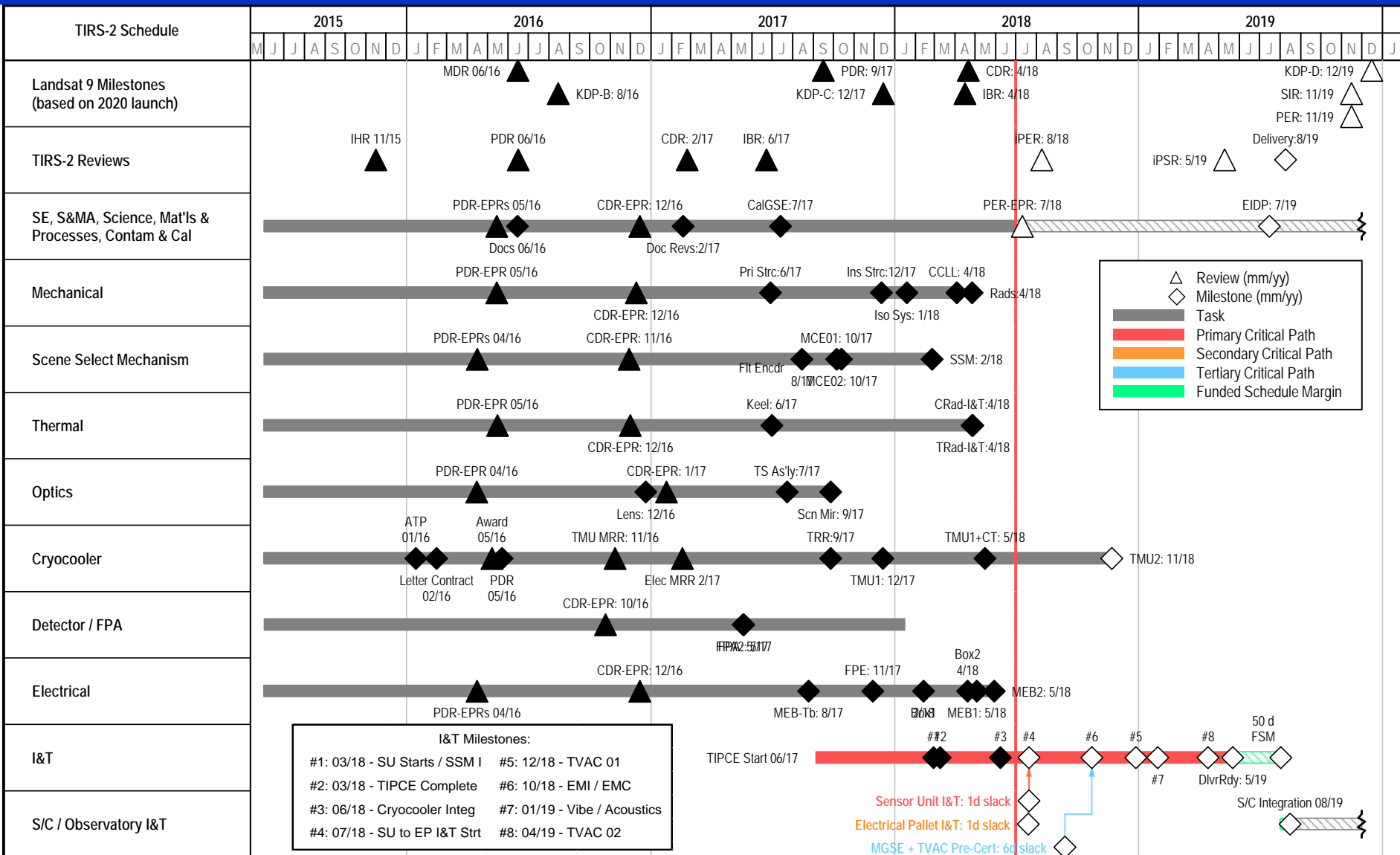


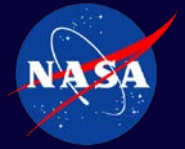
- The scattering from 13 degree annular feature seen on TIRS has been reduced by more than an order of magnitude on TIRS-2
  - A scene dependent correction for this effect was developed for TIRS which allows the observations to meet requirements
- The 22 degree annular feature observed in TIRS-2 TIPCE 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



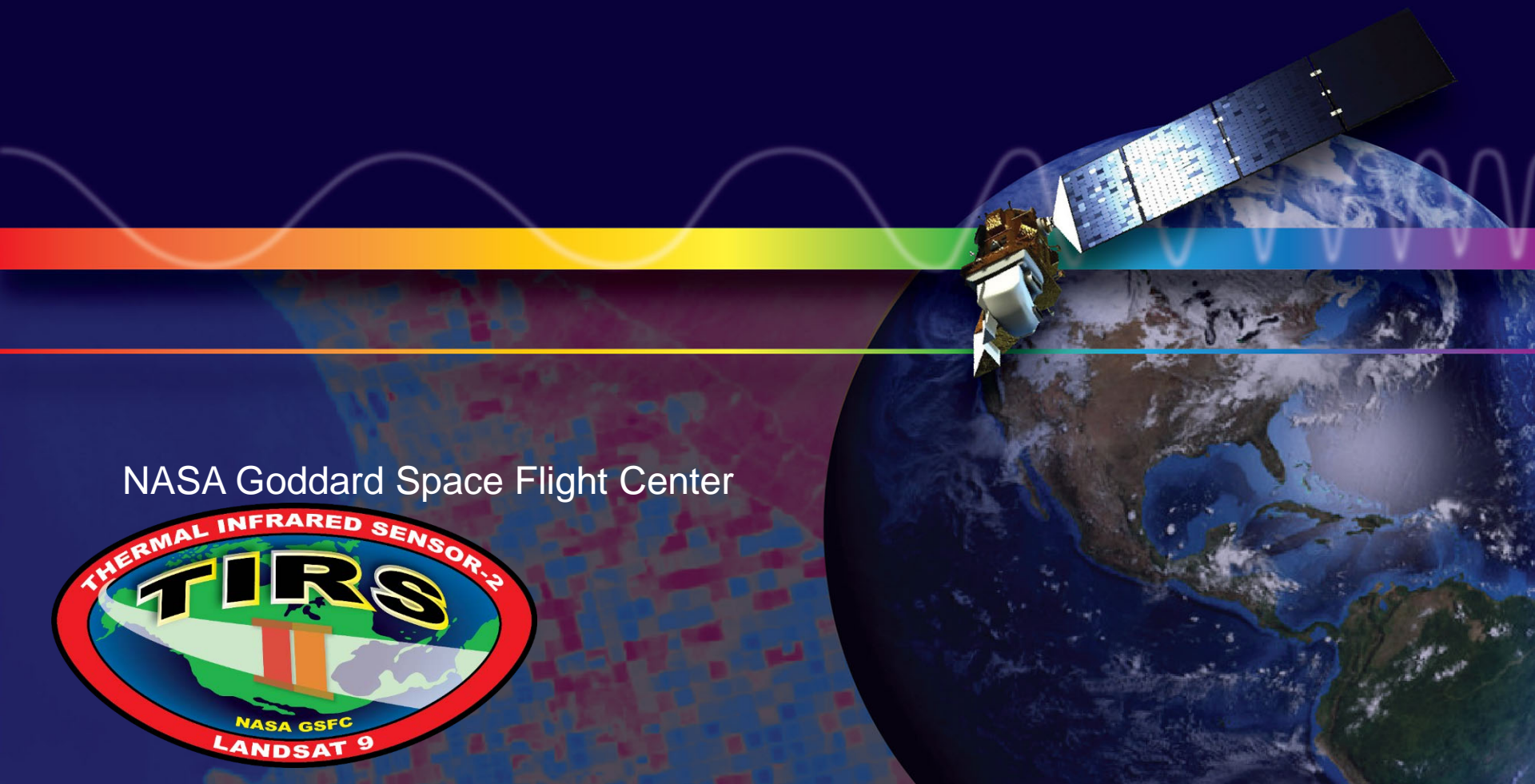


# TIRS-2 Overall Status





# Thermal Infrared Sensor - 2 • Landsat 9



NASA Goddard Space Flight Center





**Back Up**





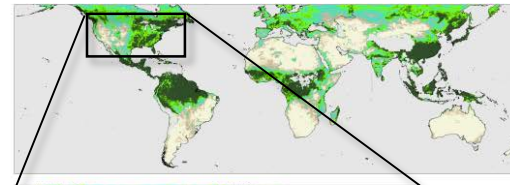
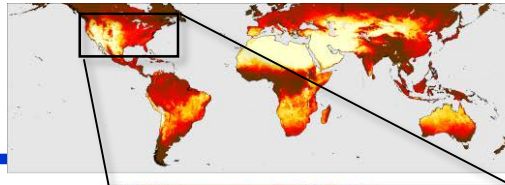
**GEO**  
(ISCCP)

**SURFACE TEMPERATURE**

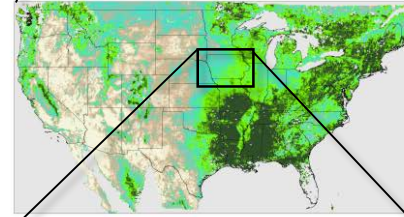
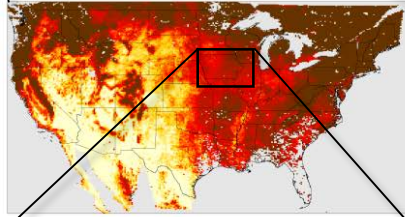
**EVAPOTRANSPIRATION**



**Global**  
(25km)



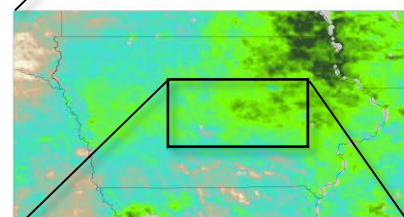
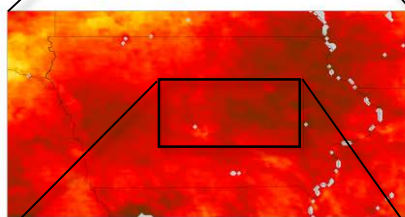
**GEO**  
(GOES Sounder)



**Continental**  
(10km)

Hourly

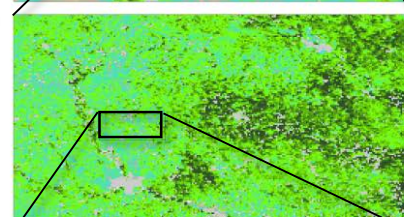
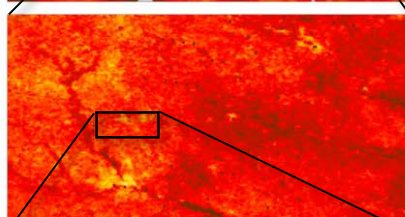
**GEO**  
(GOES Imager)



**Regional**  
(5km)

**DATA FUSION:**  
daily ET at  
field scale  
(F. Gao)

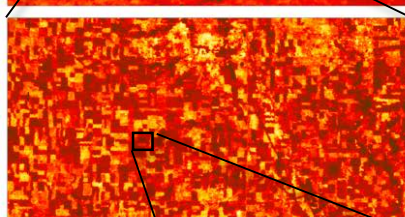
**Polar**  
(MODIS)



**Basin**  
(1km)

Daily

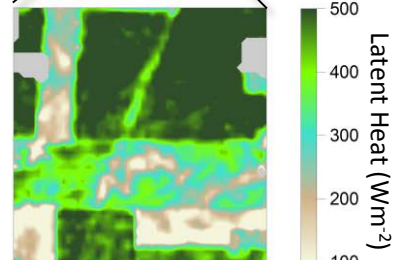
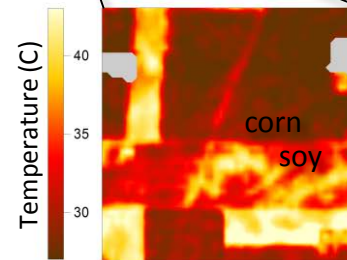
**Polar**  
(Landsat)



**Watershed**  
(60m)

1 LS – 16 day  
2 LS – 8 day

**Airborne**  
(USU aircraft)



**Field scale**  
(30m)

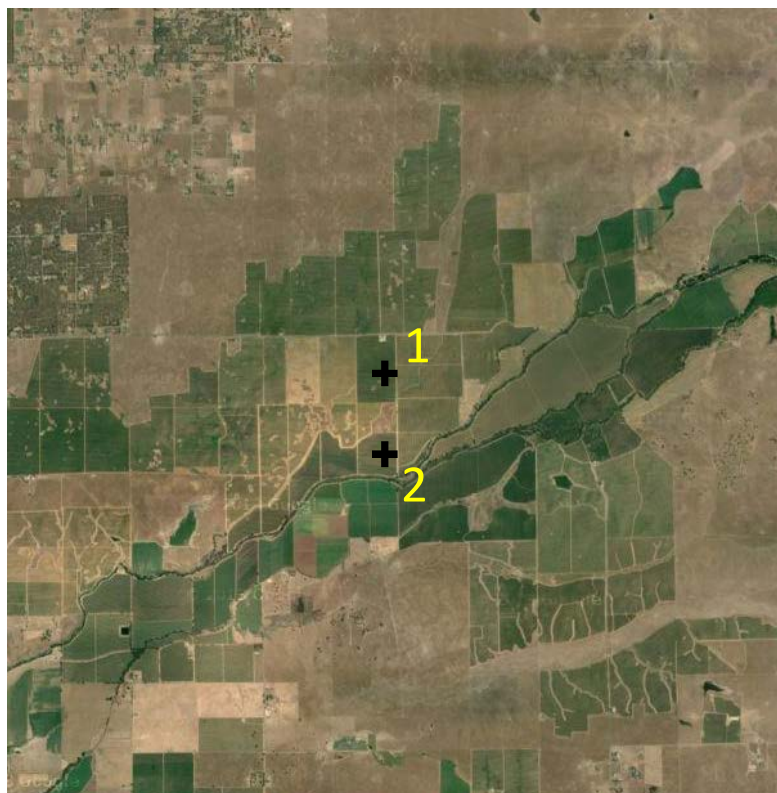
Temperature (C)  
40  
35  
30

Latent Heat (W/m<sup>2</sup>)  
500  
400  
300  
200  
100



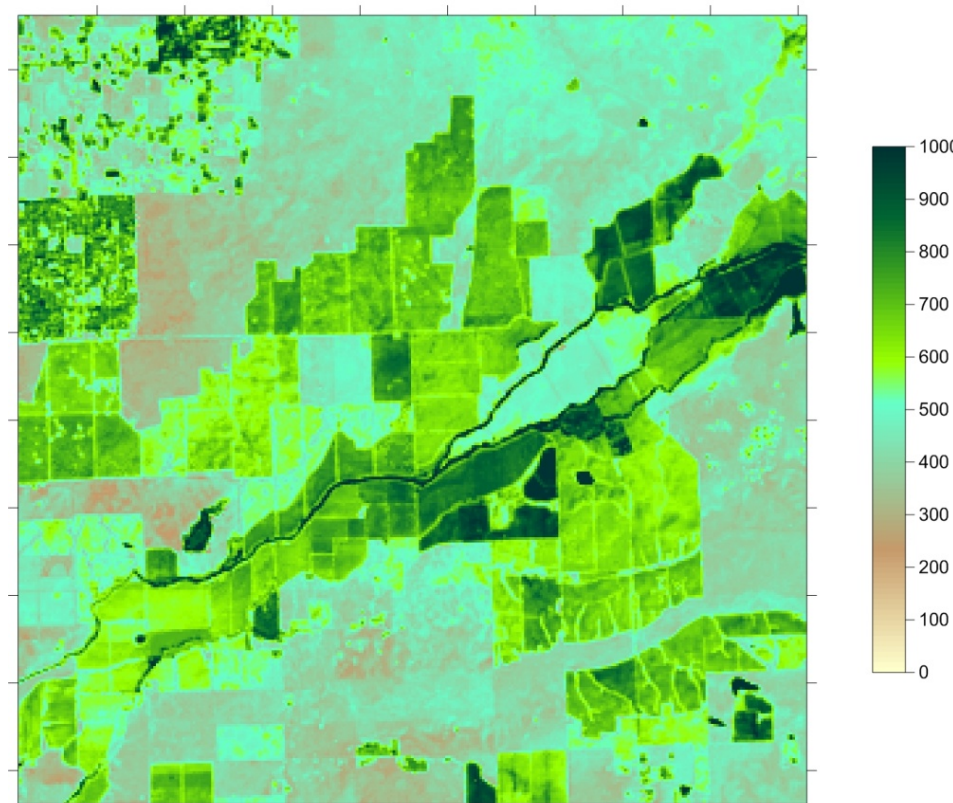
# Gallo Vineyards, Lodi CA

Irrigation management in vineyards



Cumulative ET (mm)

250



Landsat 8 - 2013

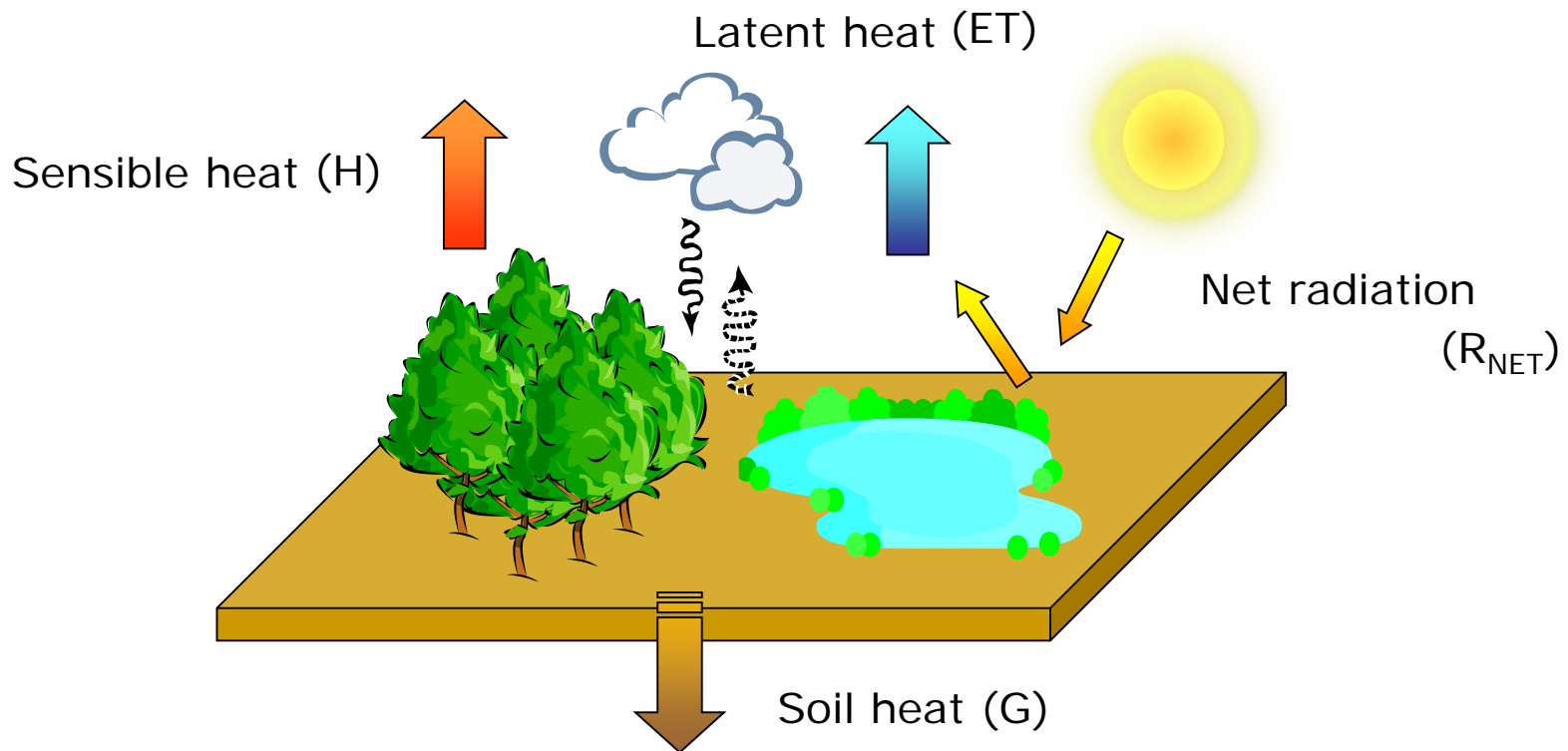
Semmens, K.A., et al.(2015). Monitoring daily evapotranspiration over two California vineyards using Landsat 8 in a multi-sensor data fusion approach. *Remote Sens. Environ.*, doi:10.1016/j.rse.2015.1010.1025



# Water Management Using Surface Energy Balance

$$R_{NET} = G + ET + H$$

$$R_{NET} = (SW_{dn} - SW_{up}) + (LW_{dn} - LW_{up})$$

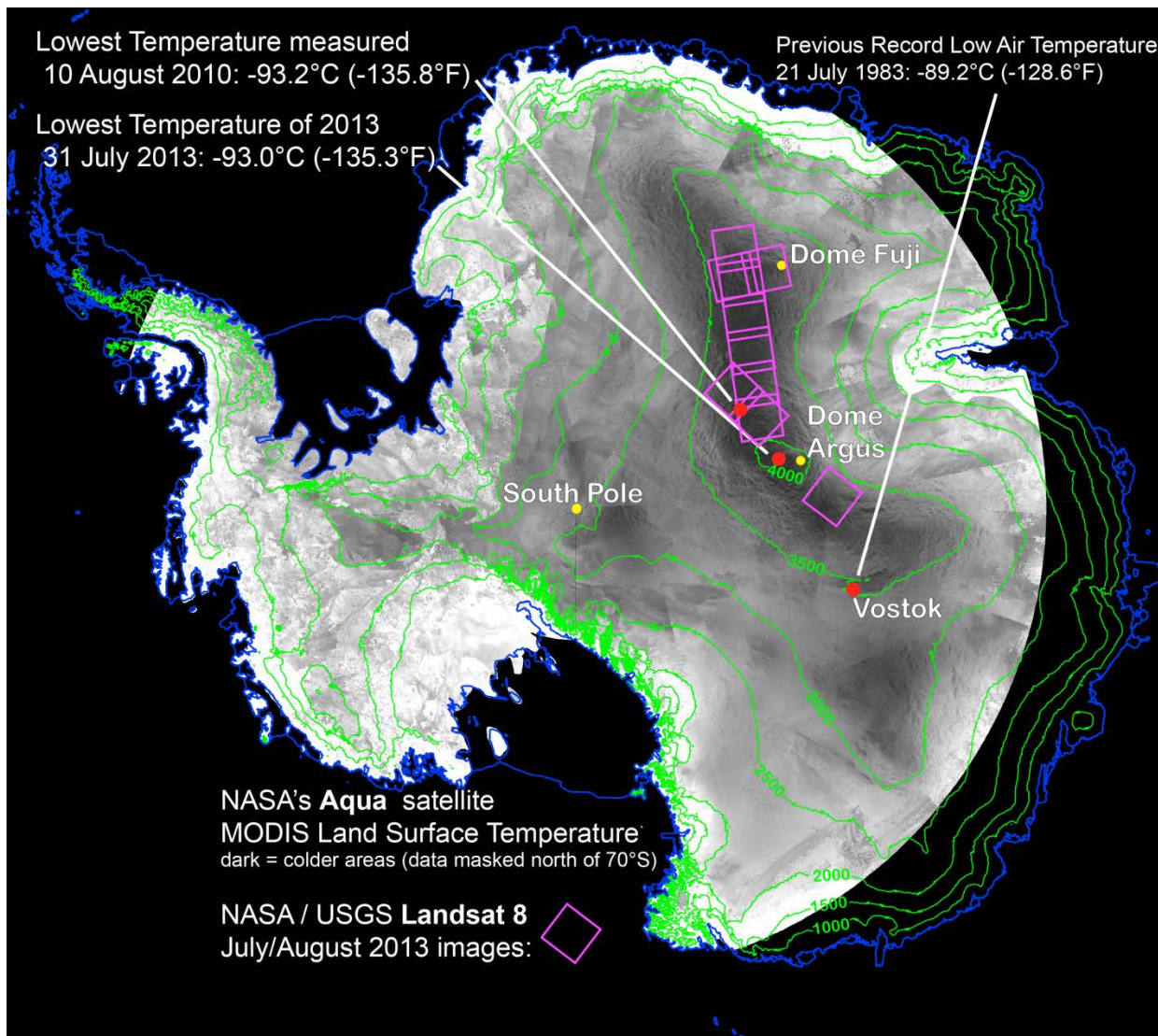


- Net Radiation is the balance between incoming minus outgoing radiation
- OLI required to calculate the SW<sub>up</sub> (short wave albedo)
- TIRS data required to calculate the LW<sub>up</sub> from surface temperature





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



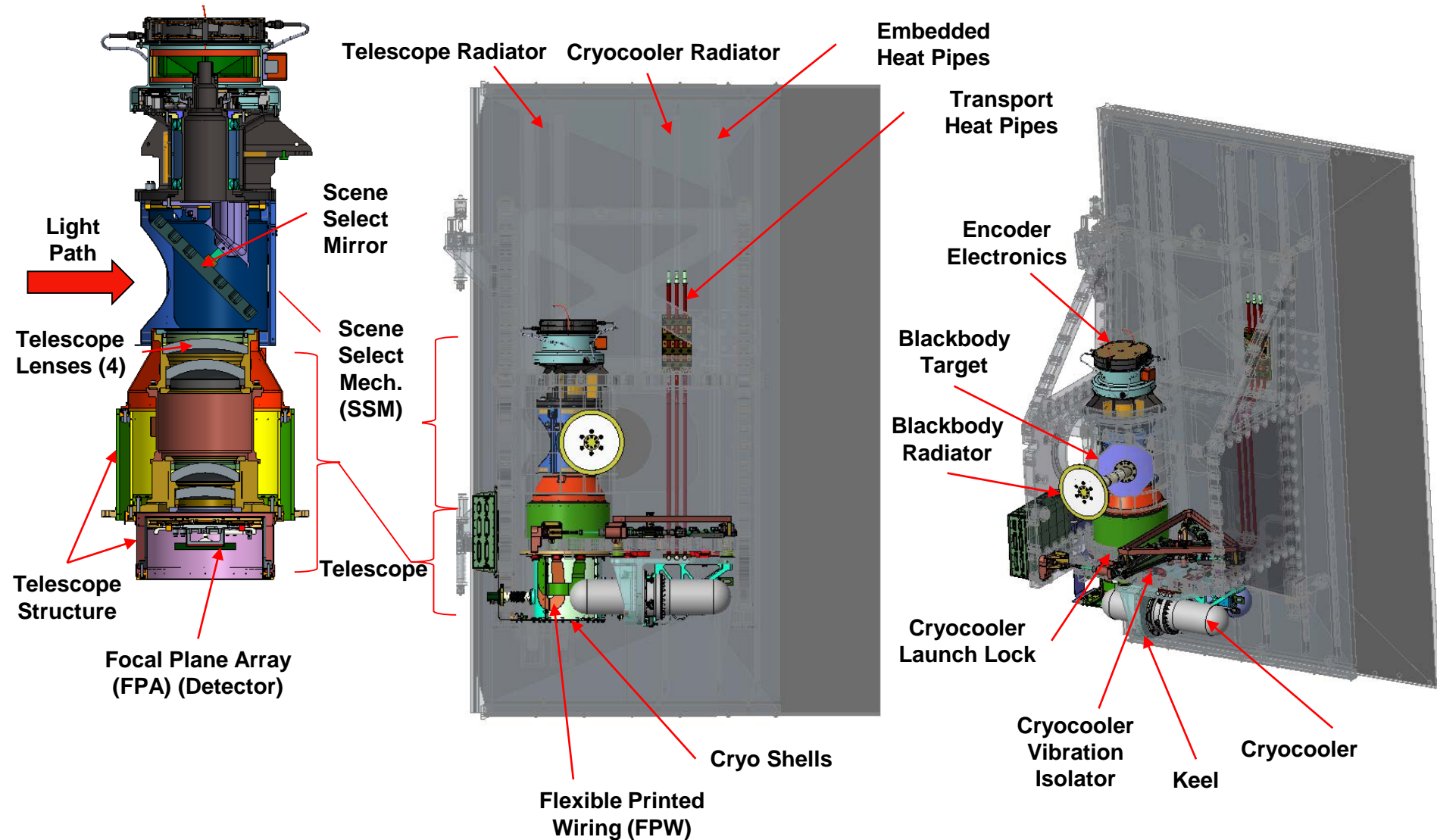
*Ted Scambos, Allen Pope,  
Garrett Campbell, Terry  
Haran*

*National Snow and Ice Data  
Center, University of  
Colorado, Boulder*

*Matt Lazzara*

*Antarctic Meteorology  
Research Center, University  
of Wisconsin, Madison*

Ultra-low surface temperatures ( $90^{\circ}\text{C}$  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.



# Overview of TIRS Sensor, con't

