# A High Spectral Resolution MODIS/ASTER (MODAST) Emissivity Dataset

## NASA MEaSUREs

### (Making Earth Science Data Records for Use in Research Environments)

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# Outline

- NASA MEaSUREs Project Overview
- MODIS Baseline Fit Emissivity Product (CIMMS)
- ASTER Global Emissivity Dataset (GED)
- MODIS/ASTER (MODAST) High Resolution Emissivity Dataset
- Validation/Evaluation Preliminary Results

# MEaSUREs Land Surface Temperature (LST) and Emissivity Data Products

*Goal:* Generate long-term, and well characterized Earth System Data Records (ESDRs) that are consistent across different platforms/sensors

| Products | Input Datasets | Spatial Resolution | Temporal Resolution | Bands Used | Algorithm(s) |
|---|---|---|---|---|---|
| LEO LST | MODIS (Aqua/Terra) | • 1-km<br>• 0.05° (Global) | • 10:30 am/pm<br>• 01:30 am/pm<br>• Monthly | 3 TIR (8-12 µm) | MERRA2/RTTOV TES |
| GEO LST | GOES (8-12) | 5-km (Americas) | Every 30 min | 1 TIR (11 µm) | MERRA2/RTTOV Single-Channel |
| LEO Emissivity (MODAST) | ASTER GED MODIS BF | 0.05° (Global) | Monthly | 13 and 417 (3.6-14.3 µm) | TES, Day/Night |

# The UW Global IR Land Surface Emissivity Database: Baseline Fit Method

- Based on a **conceptual model** developed from **laboratory measurements** (UCSB) of surface emissivity is applied to fill in the spectral gaps between the six emissivity wavelengths available from **MYD11**
- **10 hinge points** were chosen between 3.7 and 14.3 μm

- Adjust a laboratory-derived "baseline emissivity spectra" based on the MOD11 values for every global latitude/longitude pair

- **Result:** a monthly global emissivity database at 10 wavelengths with 0.05 degree spatial resolution

*Reference:*
*Seemann et al., 2008:*
*JAMC, 47, 108-123.*

Applications/Users:
MODIS Atmospheric Retrievals (UW,NASA)
IMAPP/AIRS retrievals (UW)
GEOCAT (NOAA/CIMSS)
Climate Monitoring SAF (EUMETSAT)
AIRS Retrieval of Dust Optical Depths (UMBC/ASL)
IASI-Metop Cal/Val (CNES, France)
IASI retrieval (EUMETSAT, UW, Neteo-France))
Retrieval of hot spot data from AATSR (ESA)
Energy balance from ASTER over glacier (Univ of Milan)
AIRS trace gas retrieval (Stellenbosch University, South-Africa, JCET-UMBC)
Education (Seoul National Univ.; NTA, Konstantin)
SEVIRI water vapor retrievals (UW, EOS)
SEVIRI aerosol retrieval (Univ Oxford)
SEVIRI cloud and ozone retrieval (EUMETSAT)
SEVIRI cloud phase, cloud top parameter retrievals (KNMI)
LST retrievals from GOES-R (NOAA NESDIS)
OSS calculations (AER)
AIRS NWP model assimilation (UKMO)

# ASTER Global Emissivity Dataset (GED)

- *ASTER Quick Facts:*
  - VIS/SWIR/TIR sensor on Terra Spacecraft (launch Dec 1999)
  - 90 m spatial resolution (60 x 60 km swath)
  - 5 TIR bands (8 – 12 micron)
  - 16 day repeat (on demand imaging)

**Global Dataset only possible after 10+year of imaging!!**

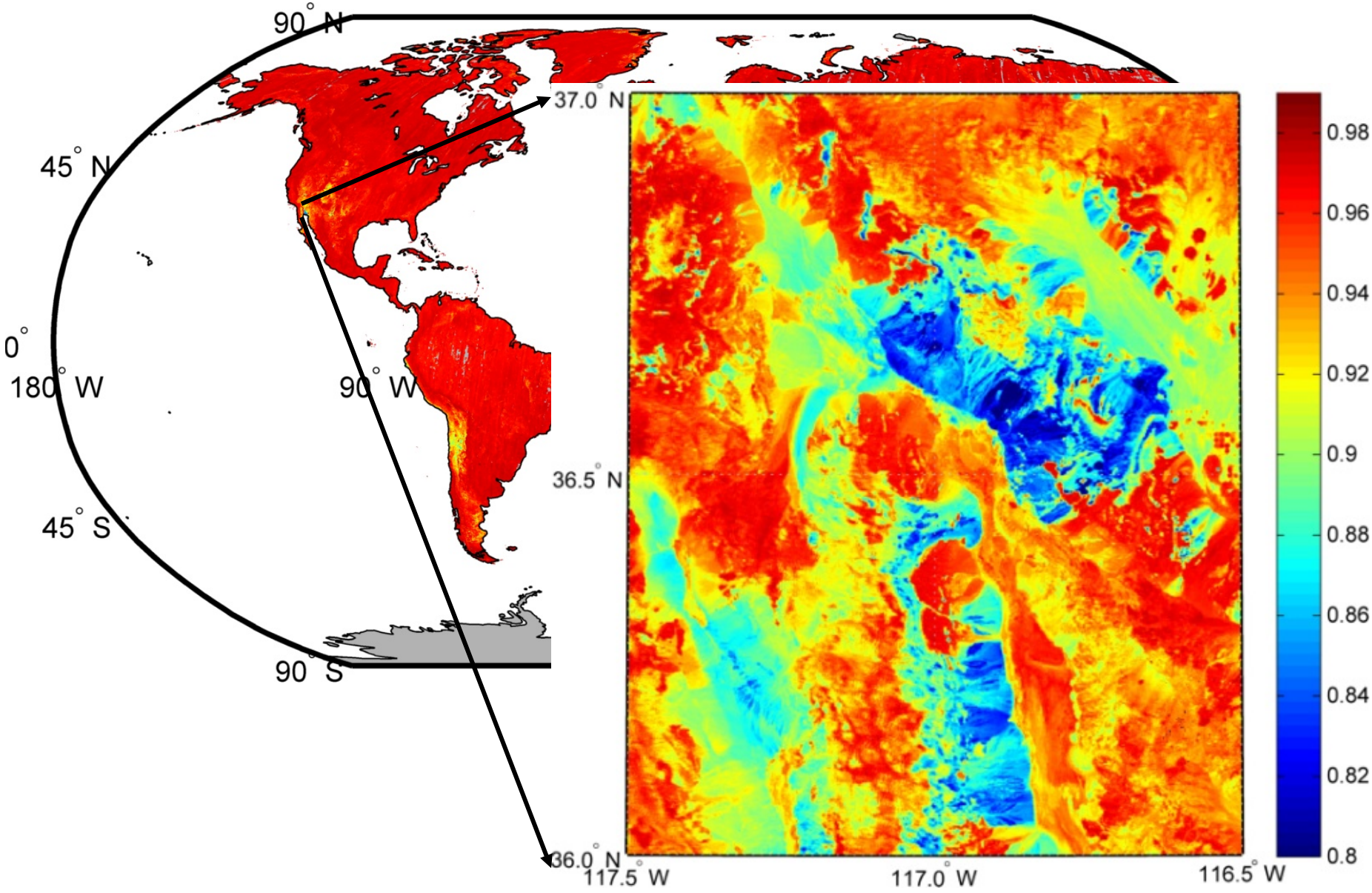
| Products | Spectral | Spatial | Temporal | Estimated Uncertainty | Availability |
|---|---|---|---|---|---|
| **GEDv3** | 5 Bands (8-12 µm) | ~100 m | Climatology (2000-2008) | ~1.5-2% | *LPDAAC |
| **GEDv4** | 5 Bands (8-12 µm) | ~0.05° | ΨMonthly (2000-2015) | ~1.5-2% | *LPDAAC (Nov 2015) **CIMMS |

Ψ GEDv4 uses MODIS NDVI/snow cover to adjust GEDv3 emissivity on monthly steps

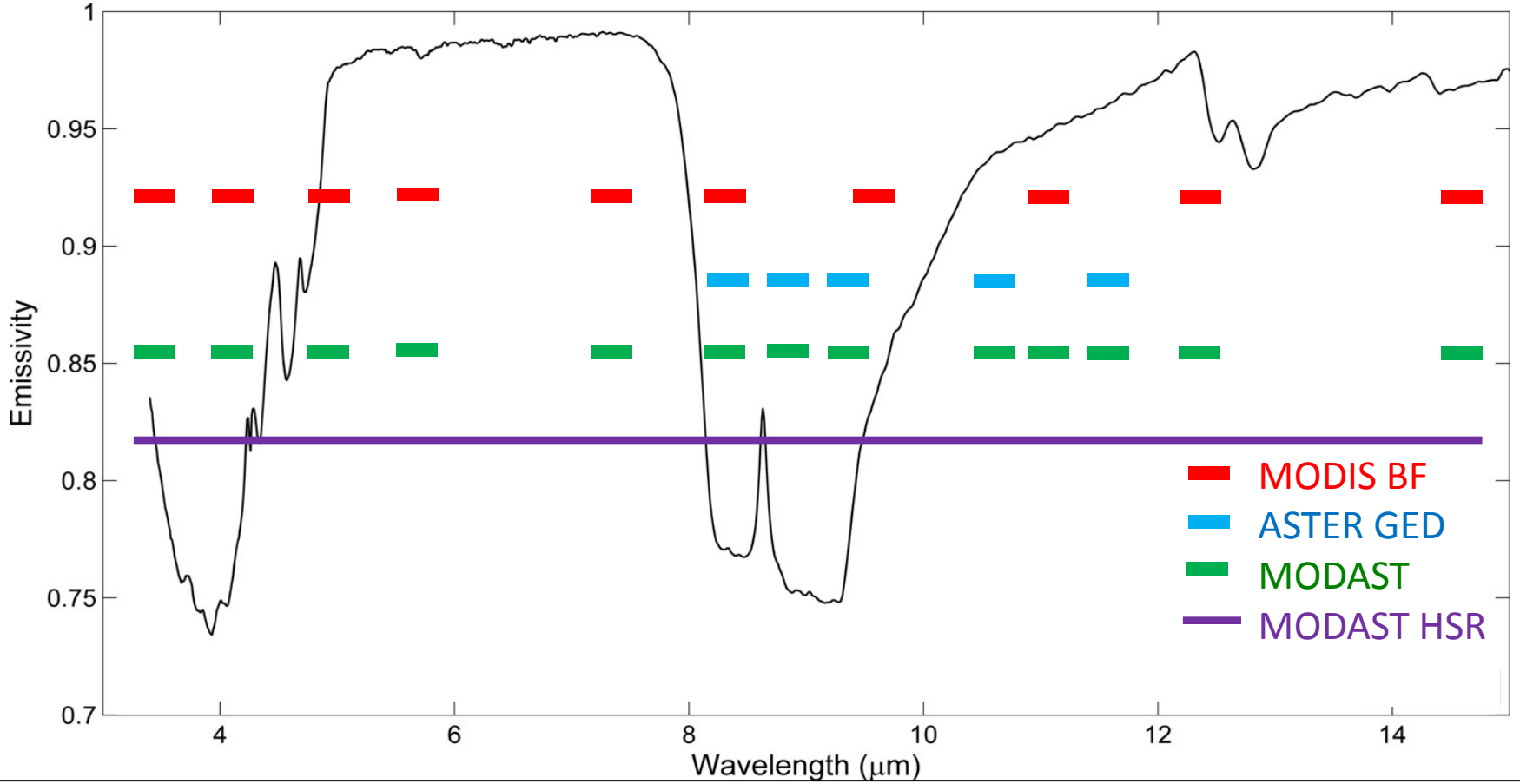
* https://lpdaac.usgs.gov/dataset_discovery/community/community_products_table
** http://cimss.ssec.wisc.edu/iremis/

*Hulley, G. C., Hook, S.J., E. Abbott, N. Malakar, T. Islam, M. Abrams, 2015, The ASTER Global Emissivity Dataset (ASTER GED): Mapping Earth's emissivity at 100 meter spatial scale, Geophysical Research Letters, 42, doi:10.1002/2015GL065564.*

# ASTER GED Emissivity – Band 11 (8.6 µm)



# MODAST Emissivity Methodology




MODIS BF: 3.6, 4.3, 5, 5.8, 7.6, 8.3, 9.3, 10.8, 12.1, 14.3

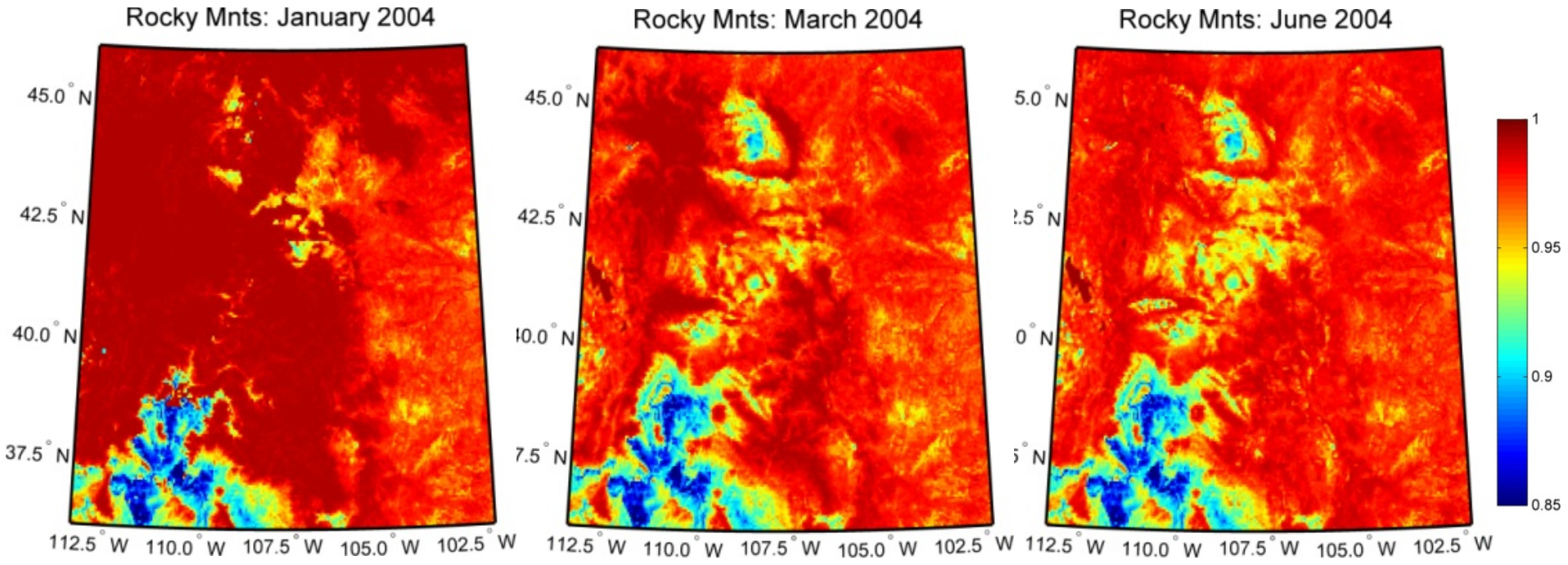
ASTER GED: 8.3, 8.6, 9.1, 10.6, 11.3

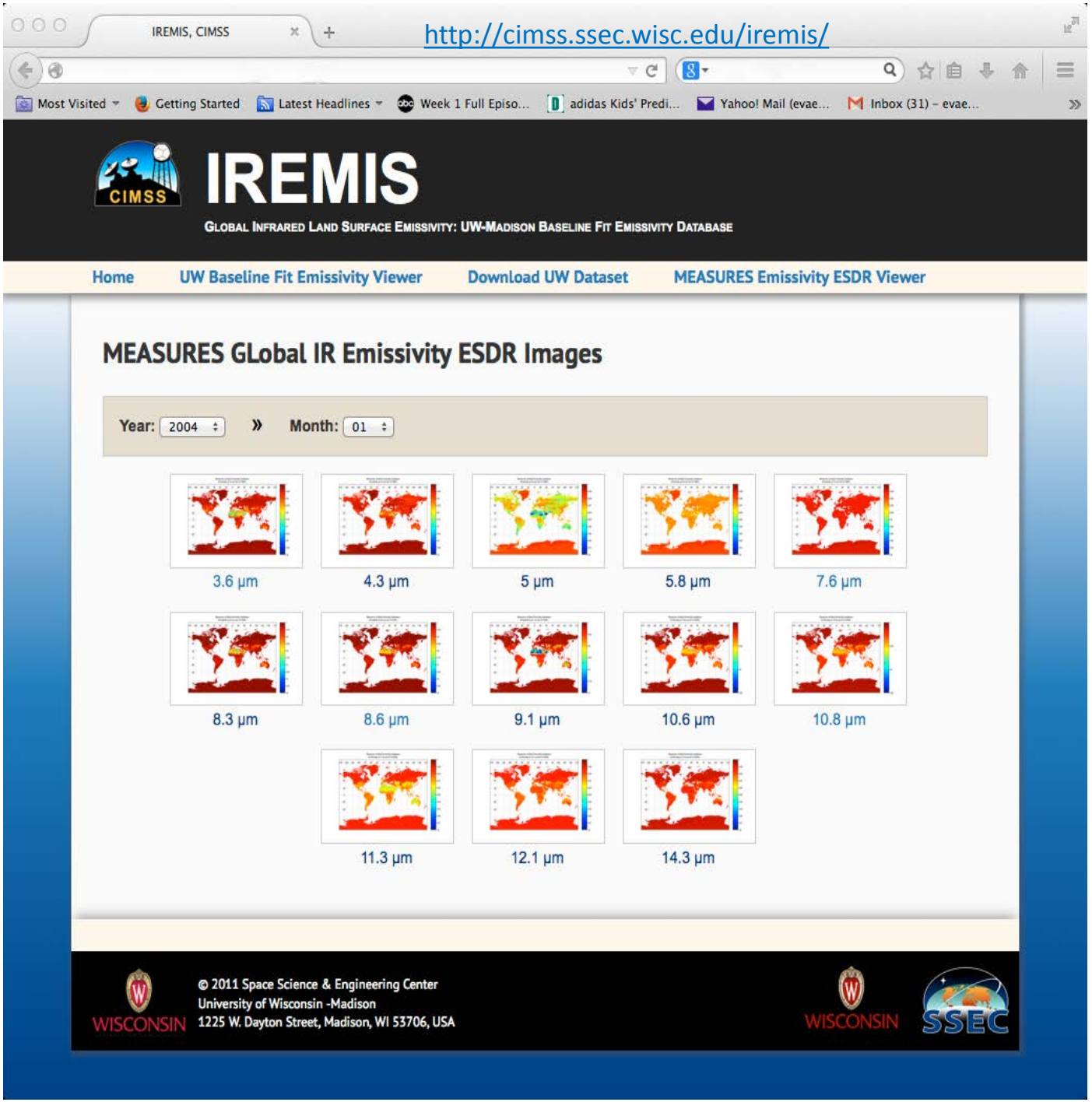
MODAST: 3.6, 4.3, 5, 5.8, 7.6, 8.3, 8.6, 9.1, 10.6, 10.8, 11.3, 12.1, 14.3

MODAST High Spectral Resolution: 417 channels from 3.6 – 14.3 micron

- PC Regression fit approach based on ASTER Spectral library
- 3 Regressions (Vegetation, Desert, Carbonates)

# MODAST Emissivity Temporal Variation
# Rocky Mountains – Snow Melt

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MEASURES Emissivity ESDR Viewer
MEASURES GLobal IR Emissivity ESDR Images
Year: 2004
Month: 01
3.6 µm
4.3 µm
5 µm
5.8 µm
7.6 µm
8.3 µm
8.6 µm
9.1 µm
10.6 µm
10.8 µm
11.3 µm
12.1 µm
14.3 µm
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# Validation/Evaluation

1. Assess seasonal changes in vegetation phenology
   - Dahra, LSA-SAF Validation site
2. Check spectral invariance over graybodies
   - Vegetation
   - Large inland water bodies
3. Check spectral shape over geologic surfaces:
   - Namib desert (quartz and hematite sand)
   - Yemen (carbonate)
   - Mauna Loa Caldera (basalts)
   - Gran Desierto (feldspars/quartz)
   - Rub Al Khali (quartz)
   - Kalahari Desert (quartz/hematite)

*Credit: ASTER Science Team

# Namib Desert – Sossussvlei, Namibia

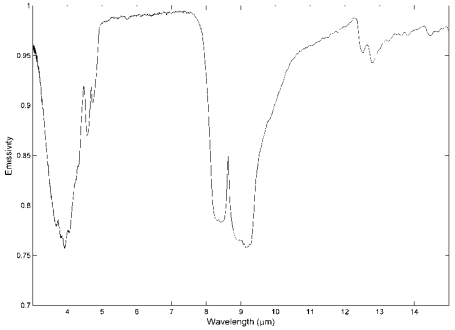
Collect Samples

Nicolet 520 FTIR spectrometer

Range: 2.5 – 15 μm

Resolution: 4 $cm^{-1}$

Estimated accuracy (0.02 K)




**Site 1: Interdune (vlei)**

**2 samples**

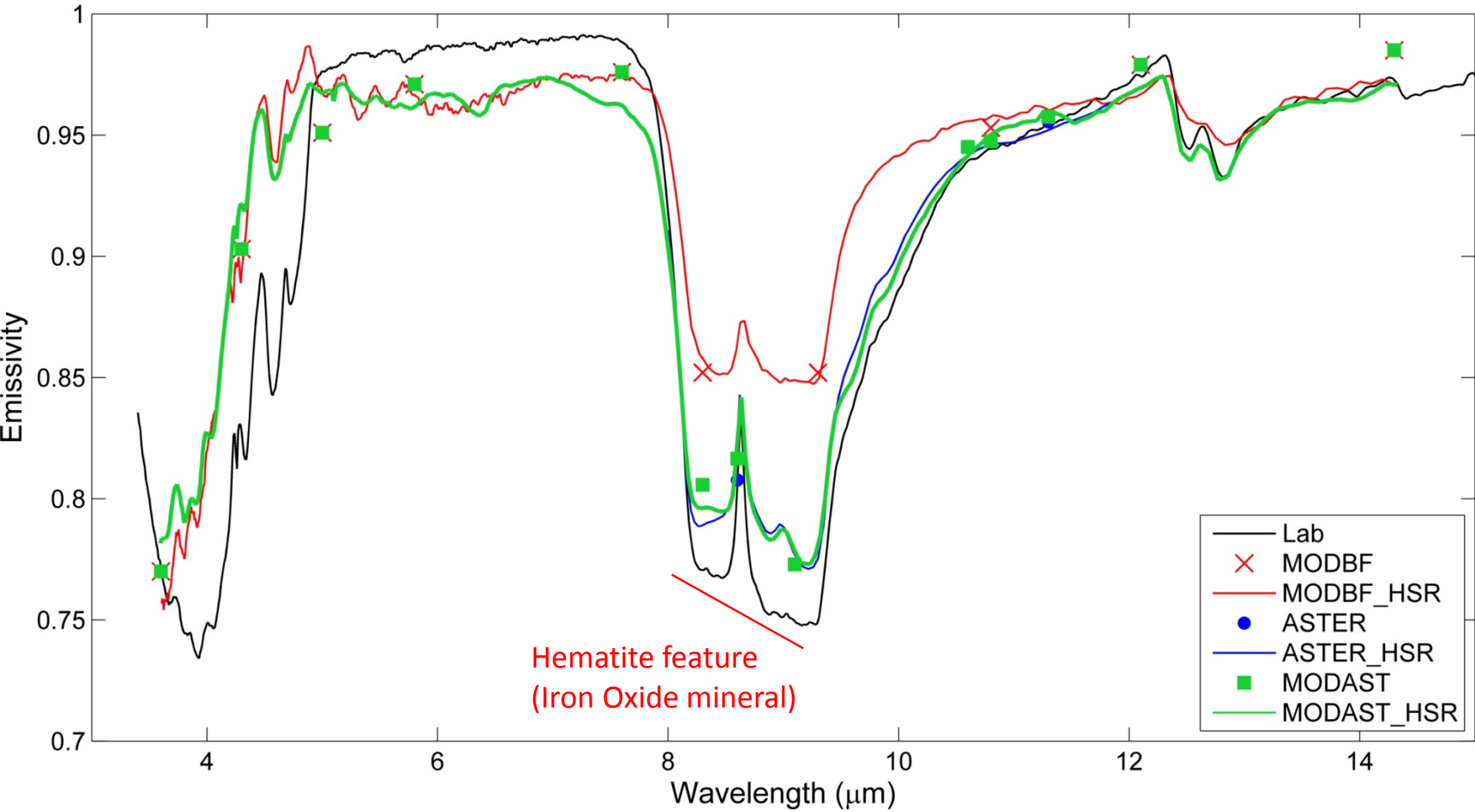
**Site 2: Dune crest**

**6 samples**

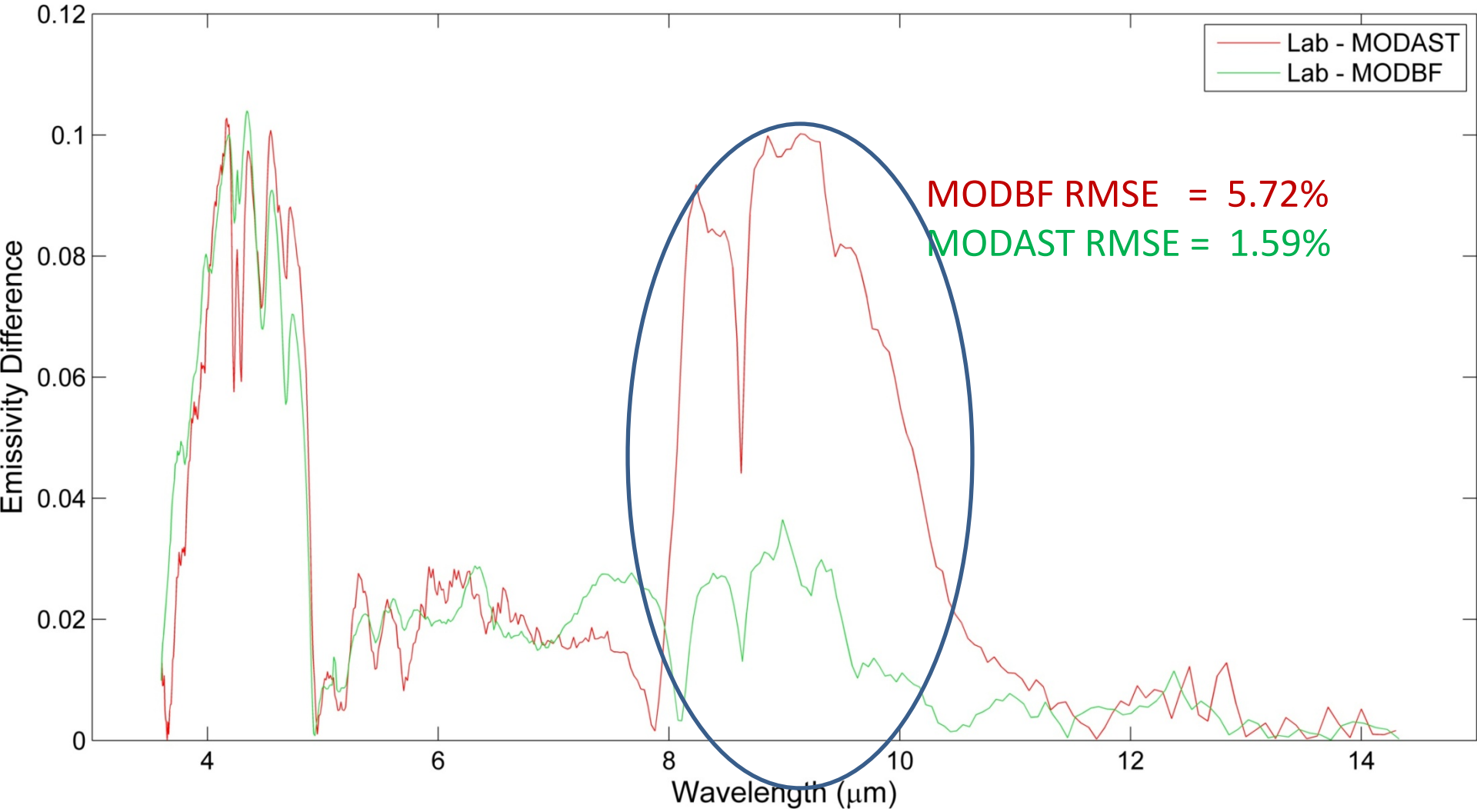
**Dead Vlei 'Flay'**

1 km

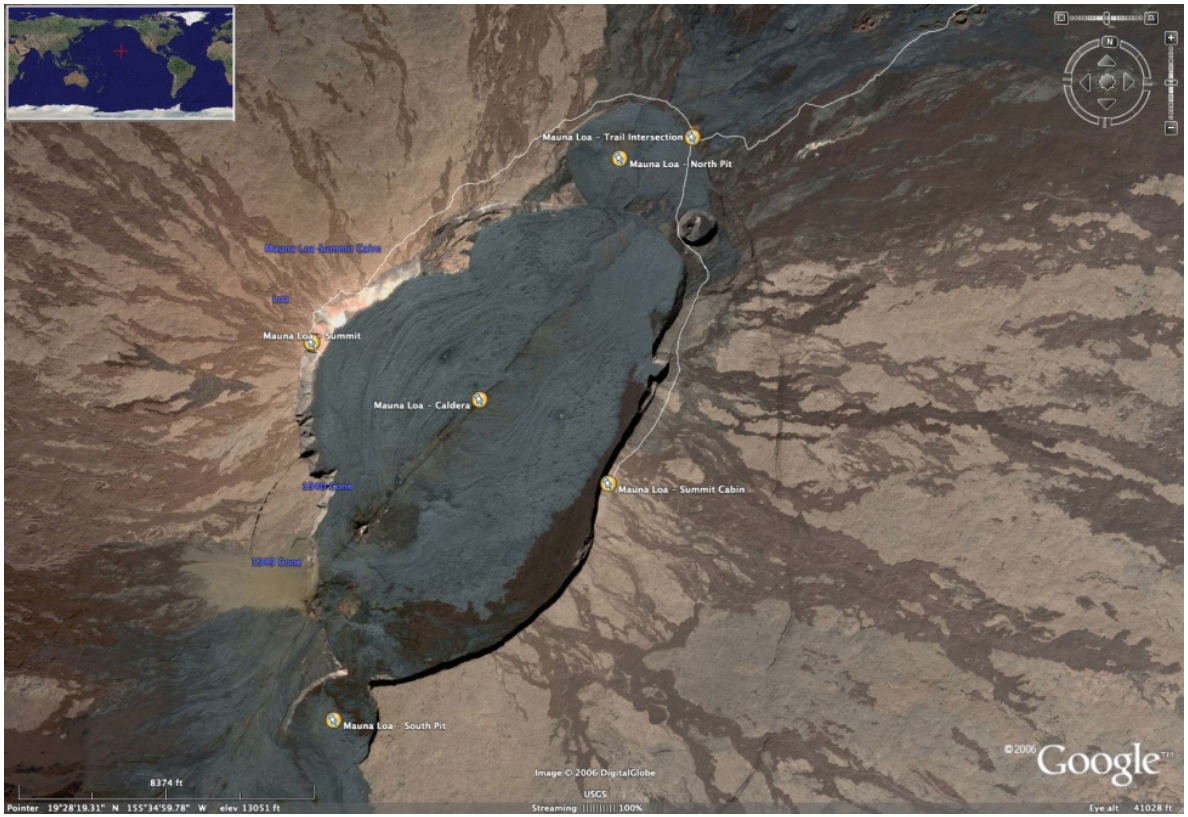
# Namib Desert (Quartz)



# Namib Desert

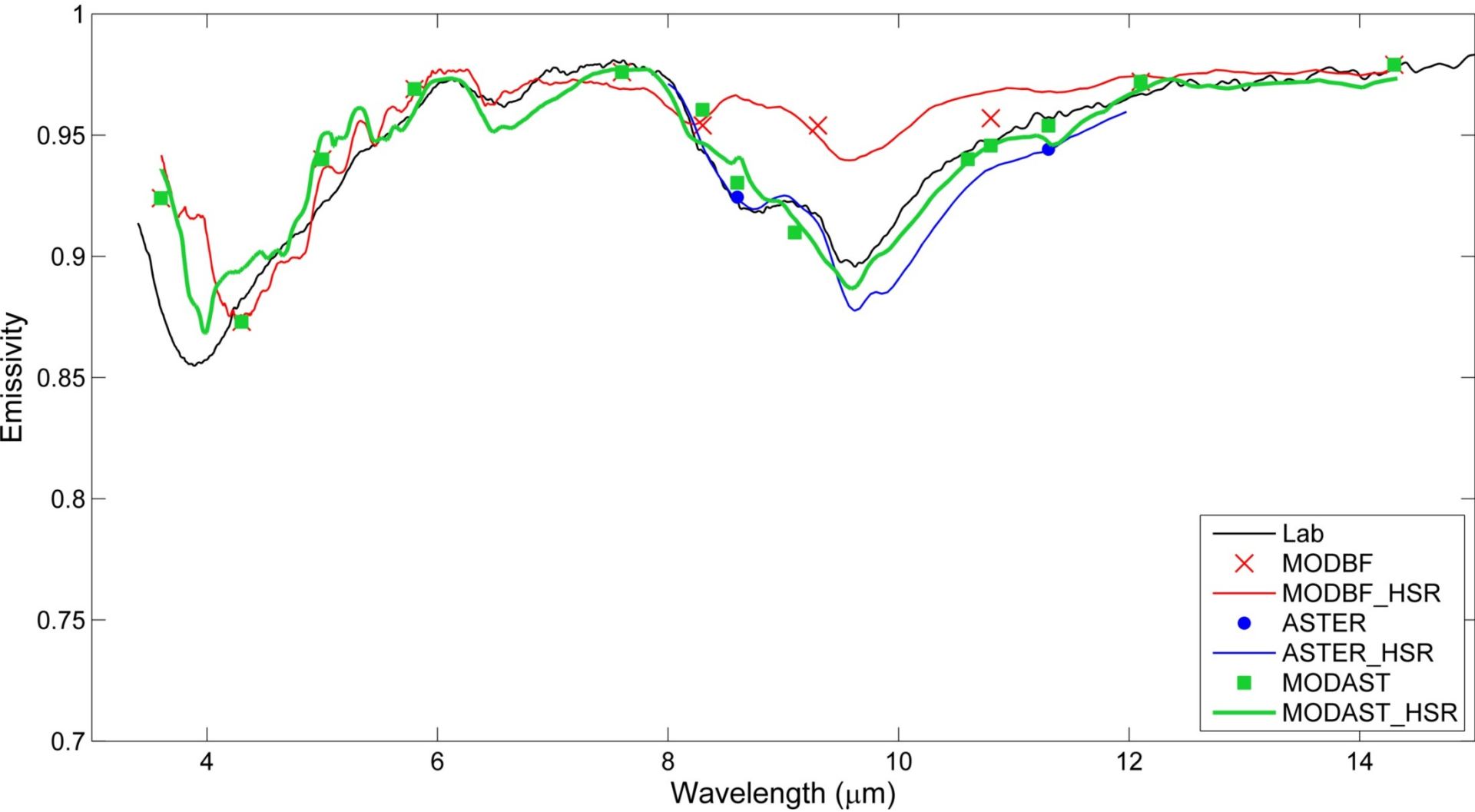


# Mauna Loa Caldera, Hawaii
# Maffic lava flow – Basalt rock

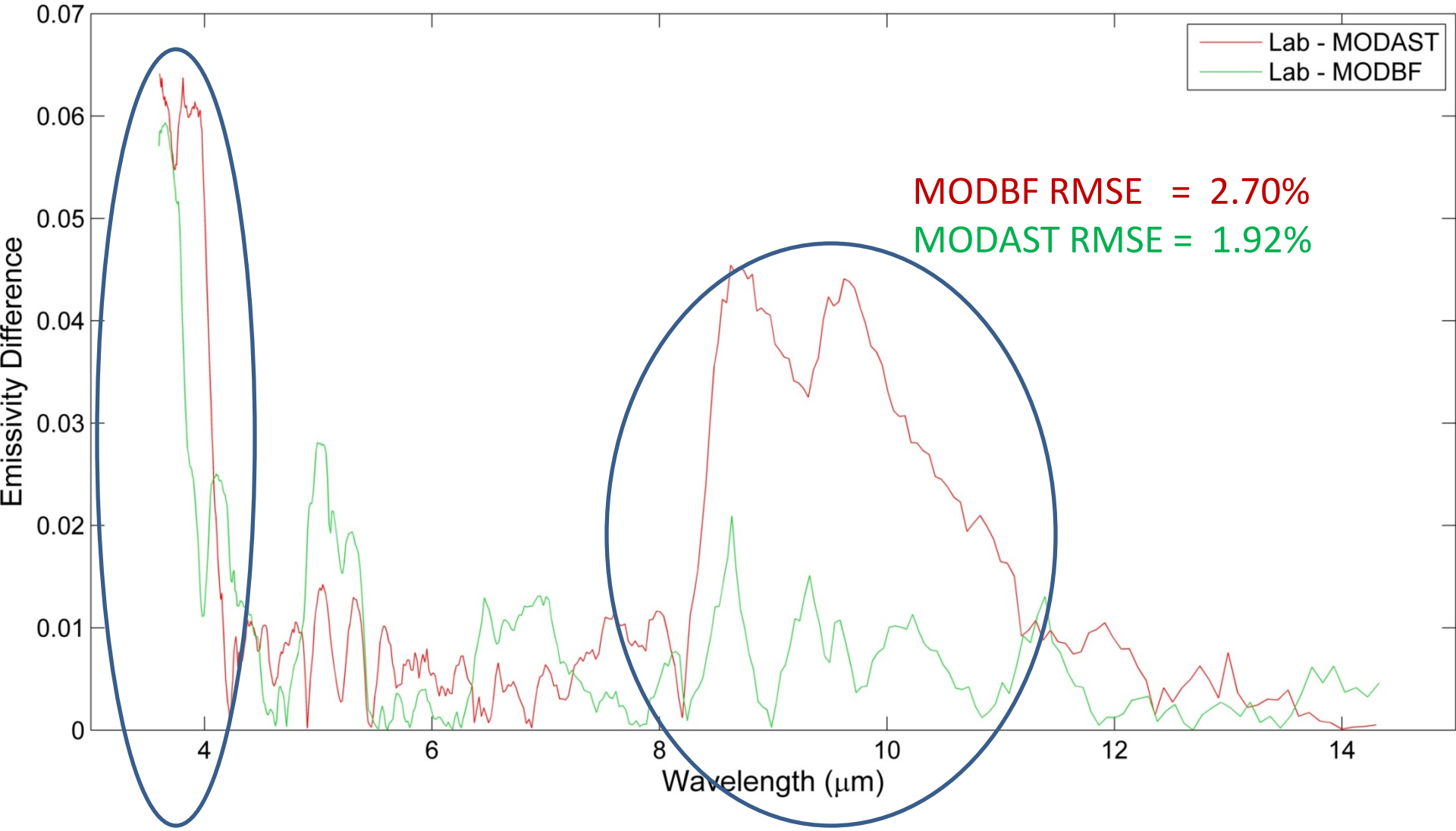



Sampled numerous times by ASTER science team at JPL since 1990's

# Mauna Loa Basalt Rock



# Sahara Desert Basalt Rock



# Next Steps …

- Run RTTOV forward simulations with IASI to compare BT differences (underway.. see E. Borbas poster)
- Continue evaluation with ground truth
- Compare with D. Zhou IASI product

Deliverables:

- Deliver first set of data to LPDAAC (Aug. 2016)
- 'Beta' product currently available for testing and evaluation
  - Contact Eva Borbas for data access
  - 2000-2015 Monthly at 0.05 degree