A radiometrically-accurate HysplRI dataset created for arid land surfaces using combined ASTER and AVIRIS data

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Outline

- **Arid land measurements**
  - climate relevance and importance of HyspIRI
    - dust composition, radiative cooling impact
    - thermal inertia → soil moisture → sediment mobility
- **Data analysis**
  - simple resampling vs. super-resolution
- **Target: Lunar Lake, NV**
  - site description, data sets
- **Preliminary results and future possibilities**

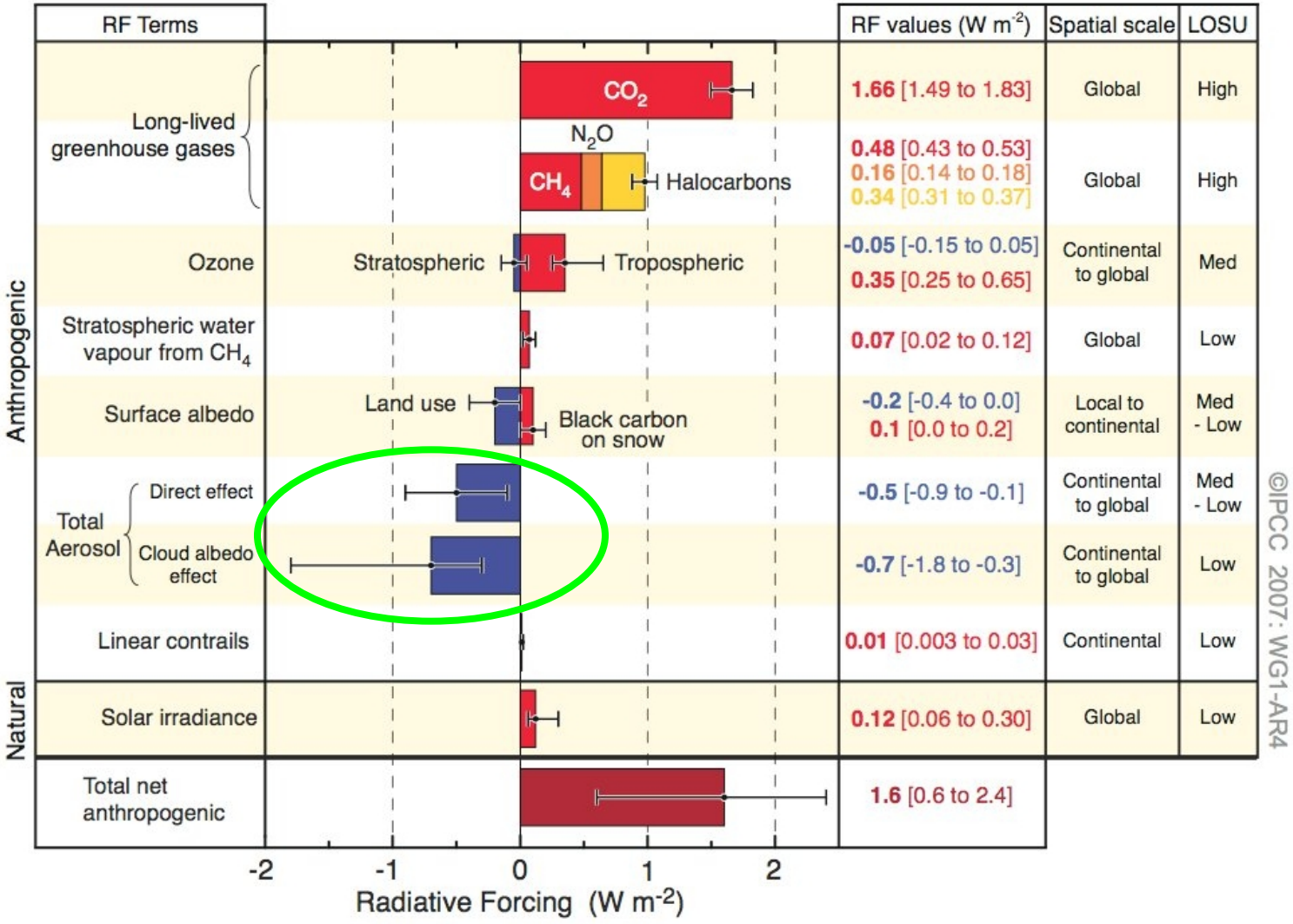
Overarching Questions

- **Can HyspIRI be used effectively to monitor trends for arid lands?**
  - *<u>example:</u> soil composition, soil moisture, albedo, dust properties → impact on local/regional climate, ...*
- **Will the proposed spatial and spectral resolution of HyspIRI be adequate for these studies?**
  - *can we accurately (and quantitatively) simulate HyspIRI's spatial/spectral resolution pre-launch??*
- **Conclusion: *yes***

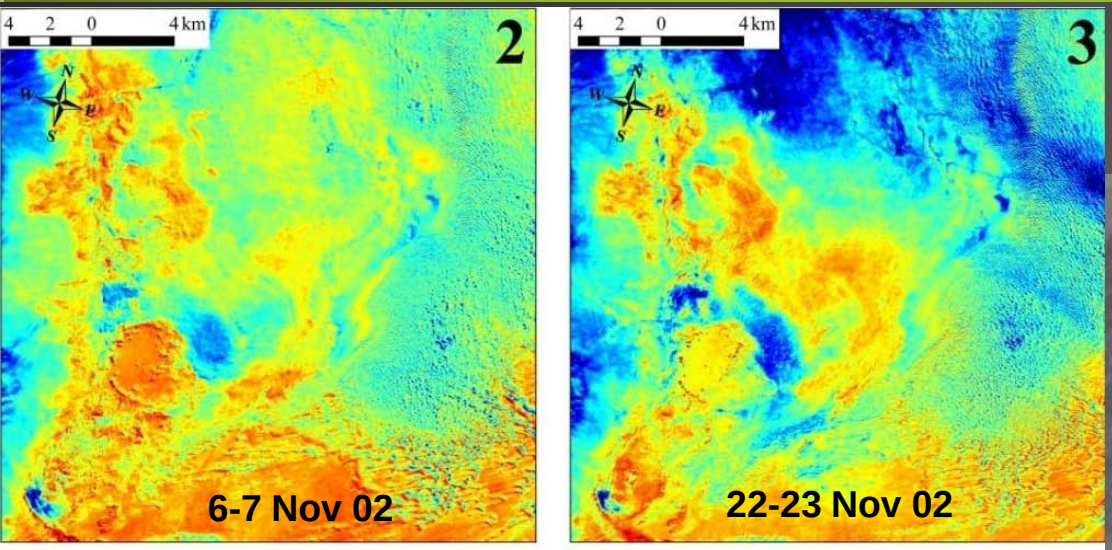
Why Focus on Arid Lands?

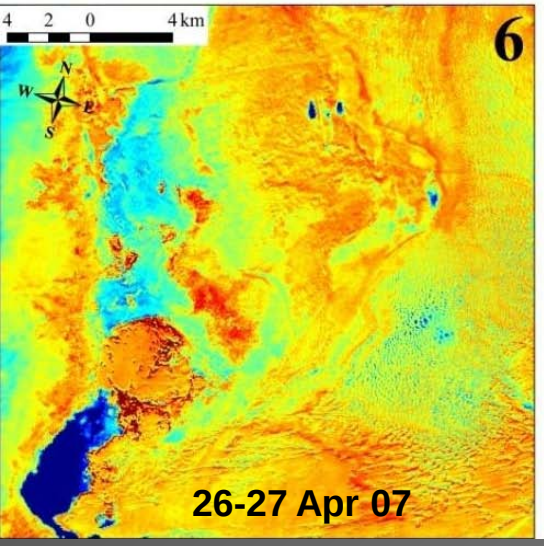
- **Climate and geologic relevance**
  - shorter-term: radiative forcings of dust?, soil moisture
    - *example: at the last HyspIRI workshop I presented the work using thermal inertia → soil moisture → sediment mobility*
      - using ASTER, one of the driest periods at White Sands was captured two days prior to one of the largest dust plumes in the region
  - longer-term: movement of dunes as indicators
- **Excellent conditions for VSWIR/TIR data**
- **Large database of global sites over the decadal time scale**
  - ASTER, Landsat TM, AVIRIS, MASTER, etc.

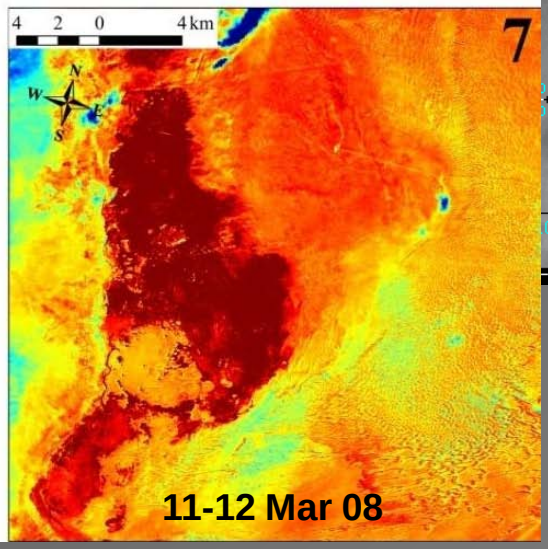
Radiative Forcing Components

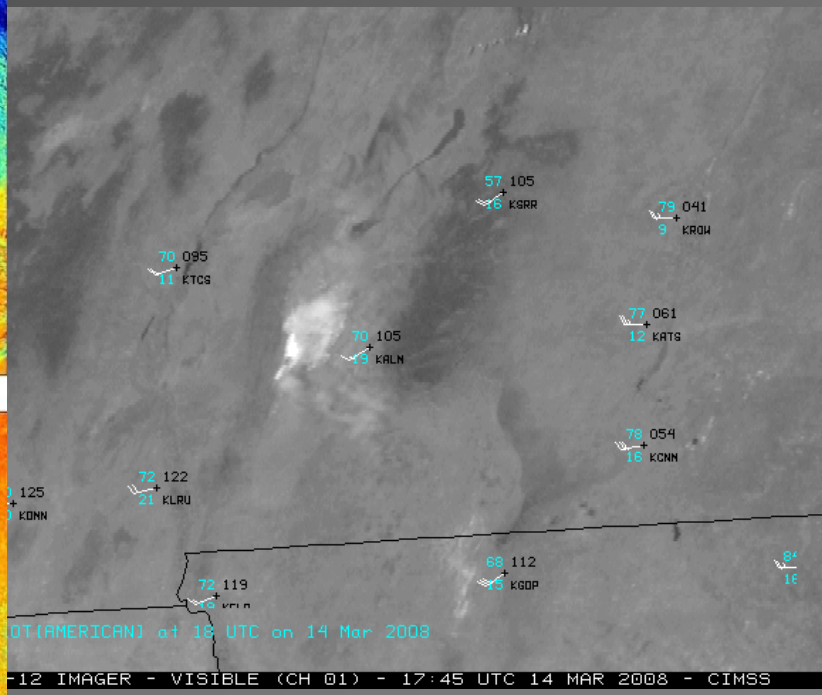


Previous Work: *ASTER & GOES*









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[Scheidt et al., 2010]

soil moisture (9% - 25%)

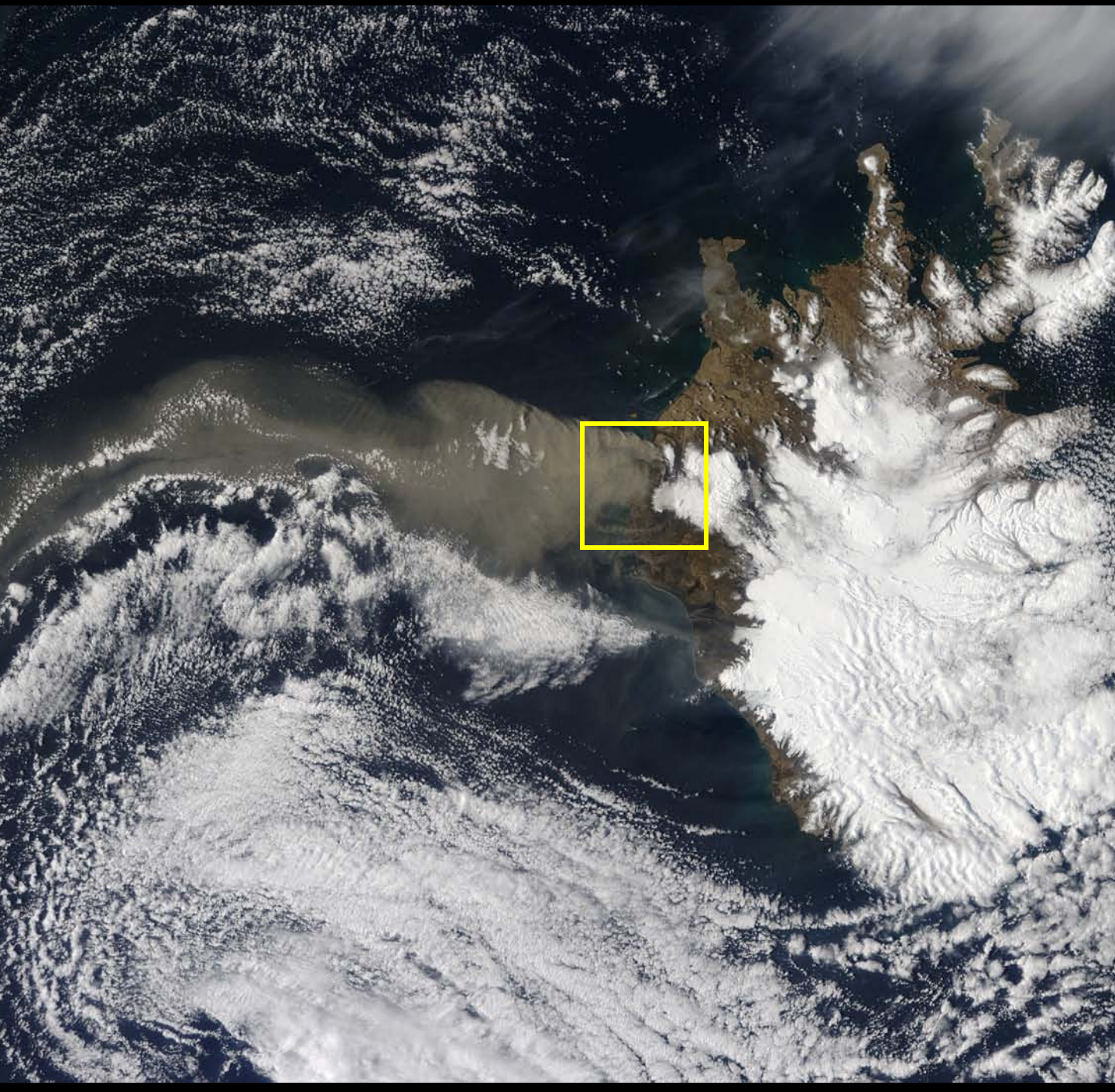
Larger Scale Dust Emissions?

- **Uncertainty**
  - direct vs. indirect radiative impact of dust loading
  - direct:
    - aerosols directly affect radiance
  - indirect:
    - aerosols affect clouds that affect radiance

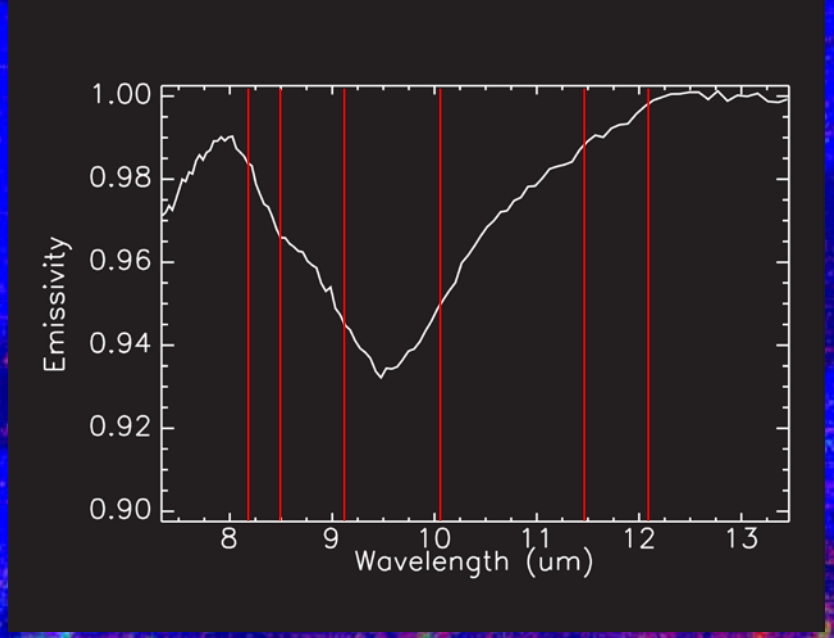
MODIS (Libya 29 Sept. 2007)

  - what is the mineralogical composition of dust and dust source areas?
  - how does this affect local/region climate variations?

Eyjafjallajökull Volcano *(MODIS)*



Eyjafjallajökull Volcano (ASTER)



ASTER Thermal IR plume composition
silicate ash (red); water vapor (green); ice (blue)
19 April 2010 (12:51 GMT)
processed: IVIS Lab, Univ. of Pittsburgh
NASA/GSFC/METI/ERSDAC/JAROS,
and U.S./Japan ASTER Science Team

Quantitative Simulation of HyspIRI

- **Super-Resolution Approach/Assumptions:**
  - surfaces in a scene are covered by similar materials
  - and similar setting *(e.g., atmosphere, lighting, temp.)*
- **Therefore, radiance spectra are assumed similar across a wide spectral area**
  - if two regions are dissimilar in one spectral range (i.e. VNIR), they are probably different in another (i.e. TIR)
  - take advantage of the higher spatial resolution data
    - use the PSF to create radiometrically-accurate data at the higher spatial resolution
      - manipulate that data at different spatial/spectral resolutions

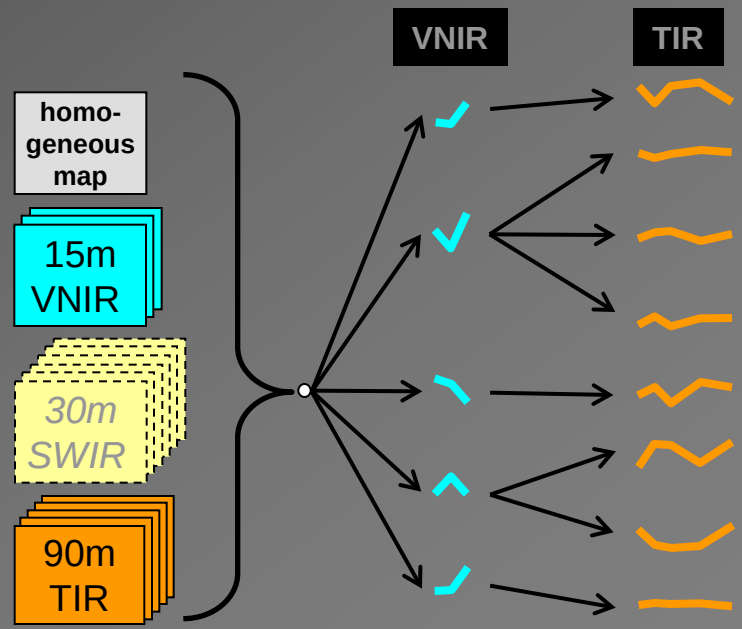
[Tonooka, 2005; Hughes and Ramsey, 2010]

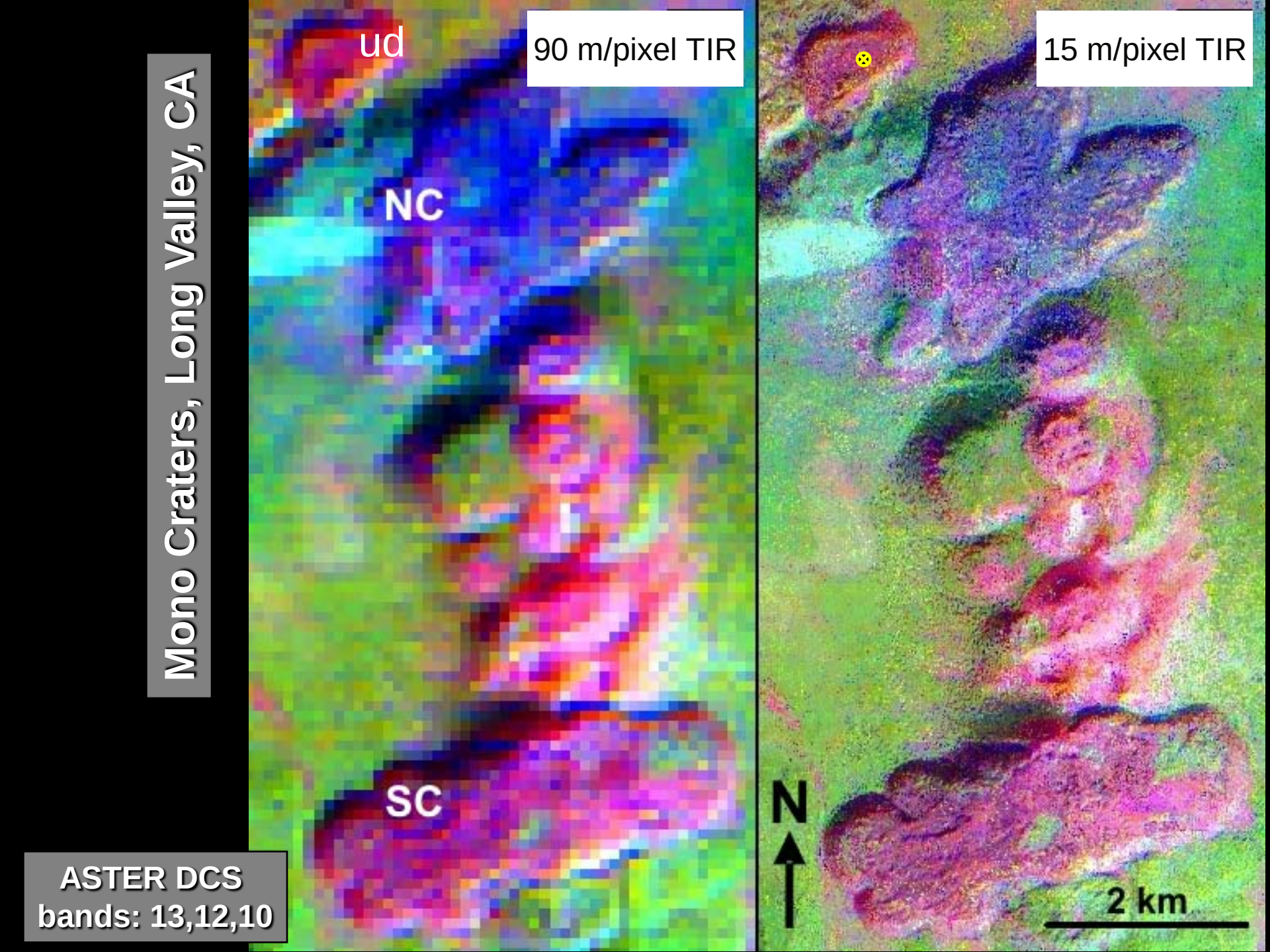
Super-Resolution

- **What is not**
  - *not* spectral component substitution
    - *i.e., pan resolution sharpening*
  - *not* simple pixel resampling
    - *leads to averaging inaccuracies/biases*
  - steps *(greatly simplified)*:
    - resample high resolution data to same scale as low resolution bands using the instrument PSF
    - determine homogeneity of re-sampled pixels
      - calculate average standard deviation across all bands for the spectral range

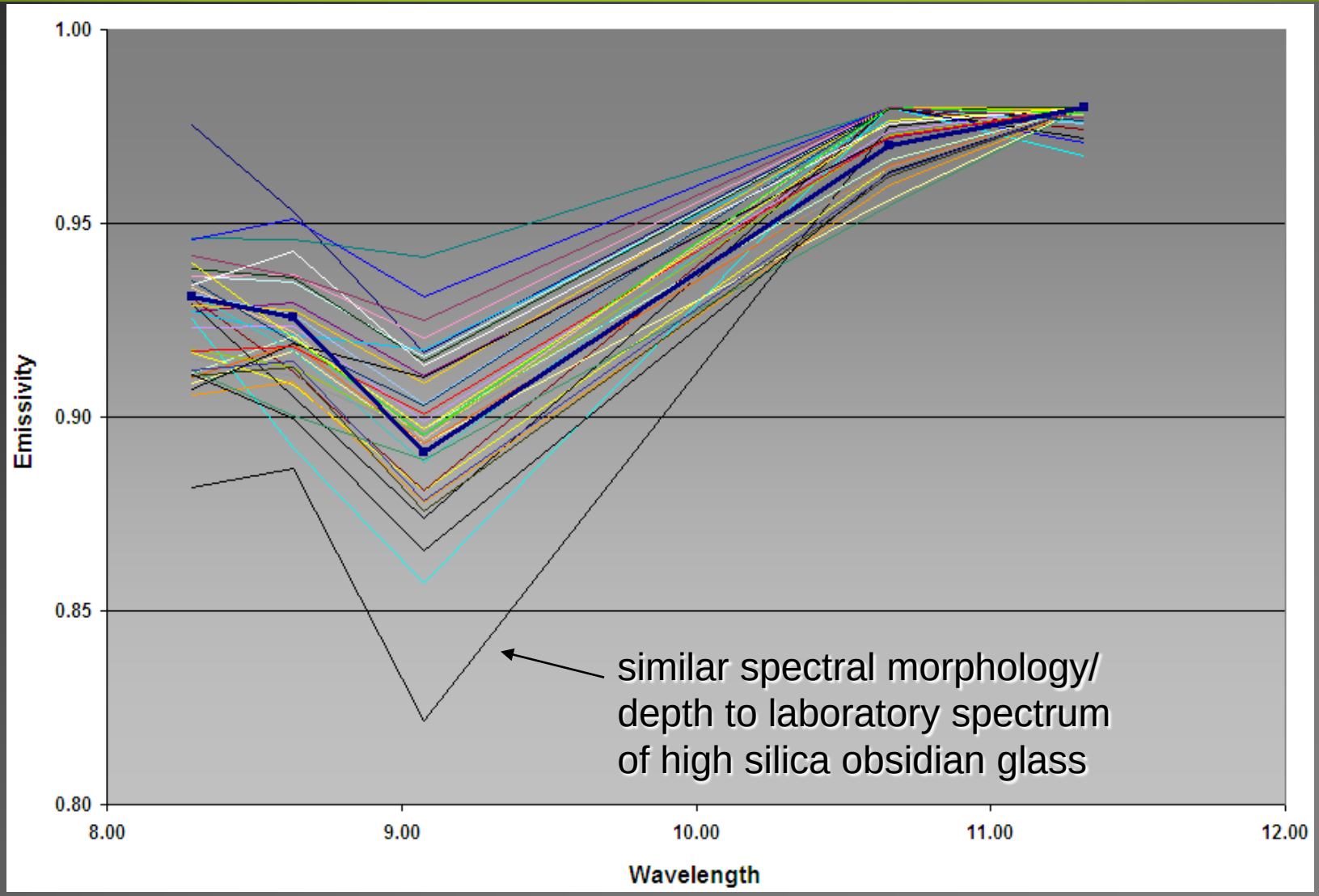
Super-Resolution

- **What is it?**
  - steps (con't):
    - create a cluster tree of re-sampled pixels using ISODATA classification
      - Mahalanobis distance (MD) calculated for each class
    - generate the super-resolved image by remapping TIR spectra to each new higher resolution pixel
    - radiometrically correct super-resolved image
      - compared to original image
      - assure that it is fully-reversible




Mono Craters, Long Valley, CA
ud
90 m/pixel TIR
15 m/pixel TIR
NC
SC
N
2 km
ASTER DCS
bands: 13,12,10

Results: upper dome

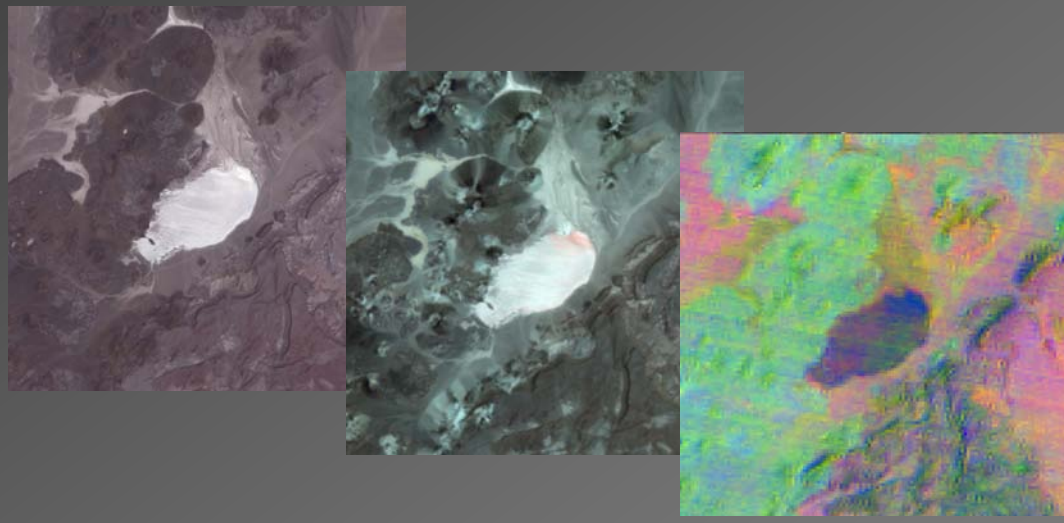


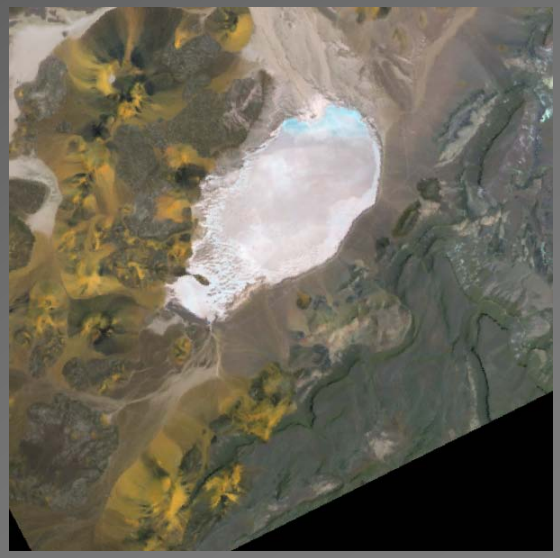
Test Site: Lunar Lake Playa, NV

- **Setting:**
  - 2km x 4km playa
  - radiometric cal/val target
  - low topography
    - spatially uniform
  - high reflectance > 0.7 μm
    - variations of < 0.5% reflectance
  - surrounded by basalt rich hills
    - mixing gradient at boundary
  - AERONET site

Test Site: Lunar Lake Playa, NV

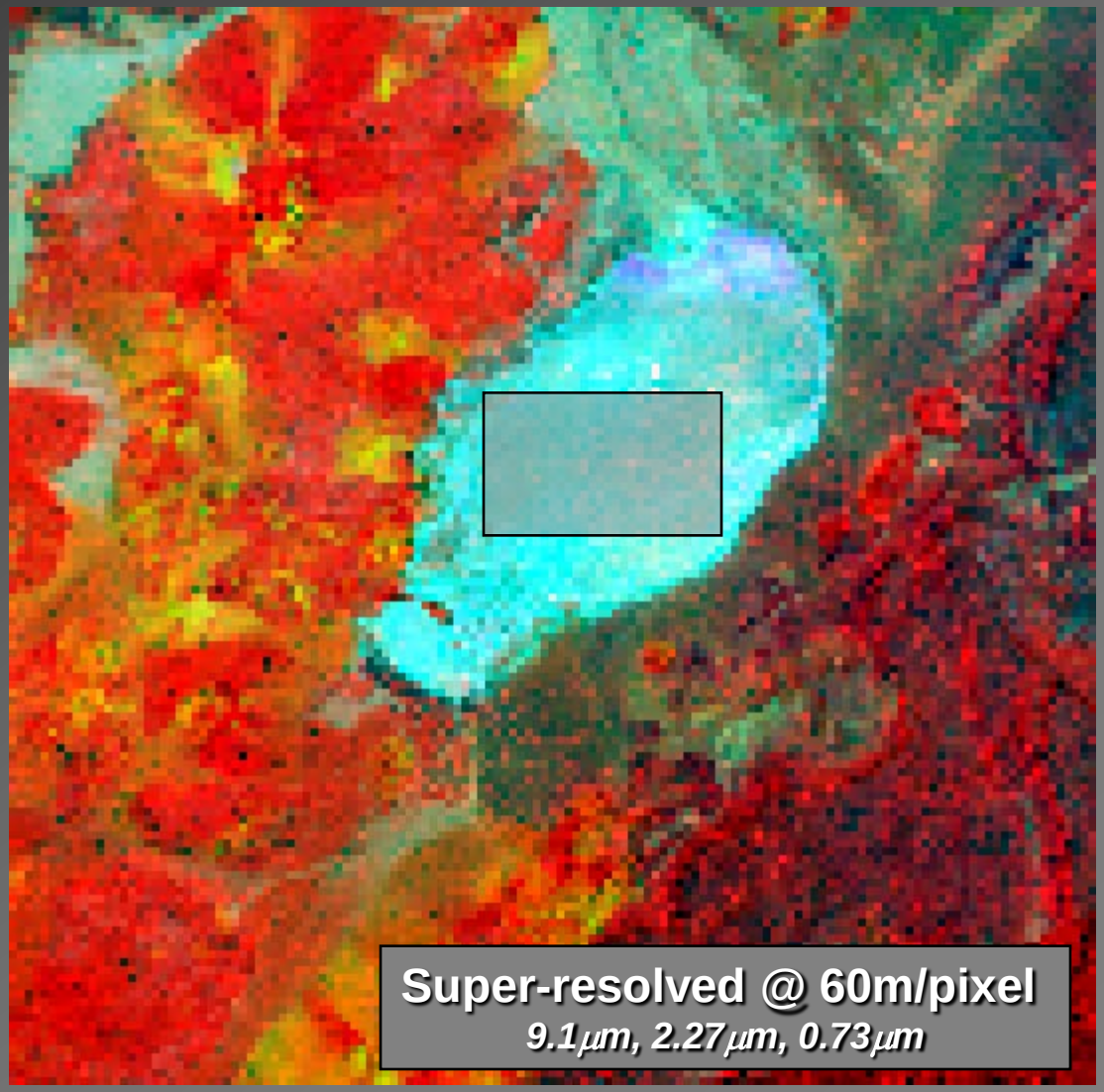
- **Data:**
  - ASTER
    - 2003-06-27 18:44:40
    - 15/30/90 m/pixel
  - AVIRIS:
    - 1997-06-23 18:31:04
    - ~ 20 m/pixel
  - super-resolved area
    - 9.1 km^2
      - 151 x 151 60m pixels



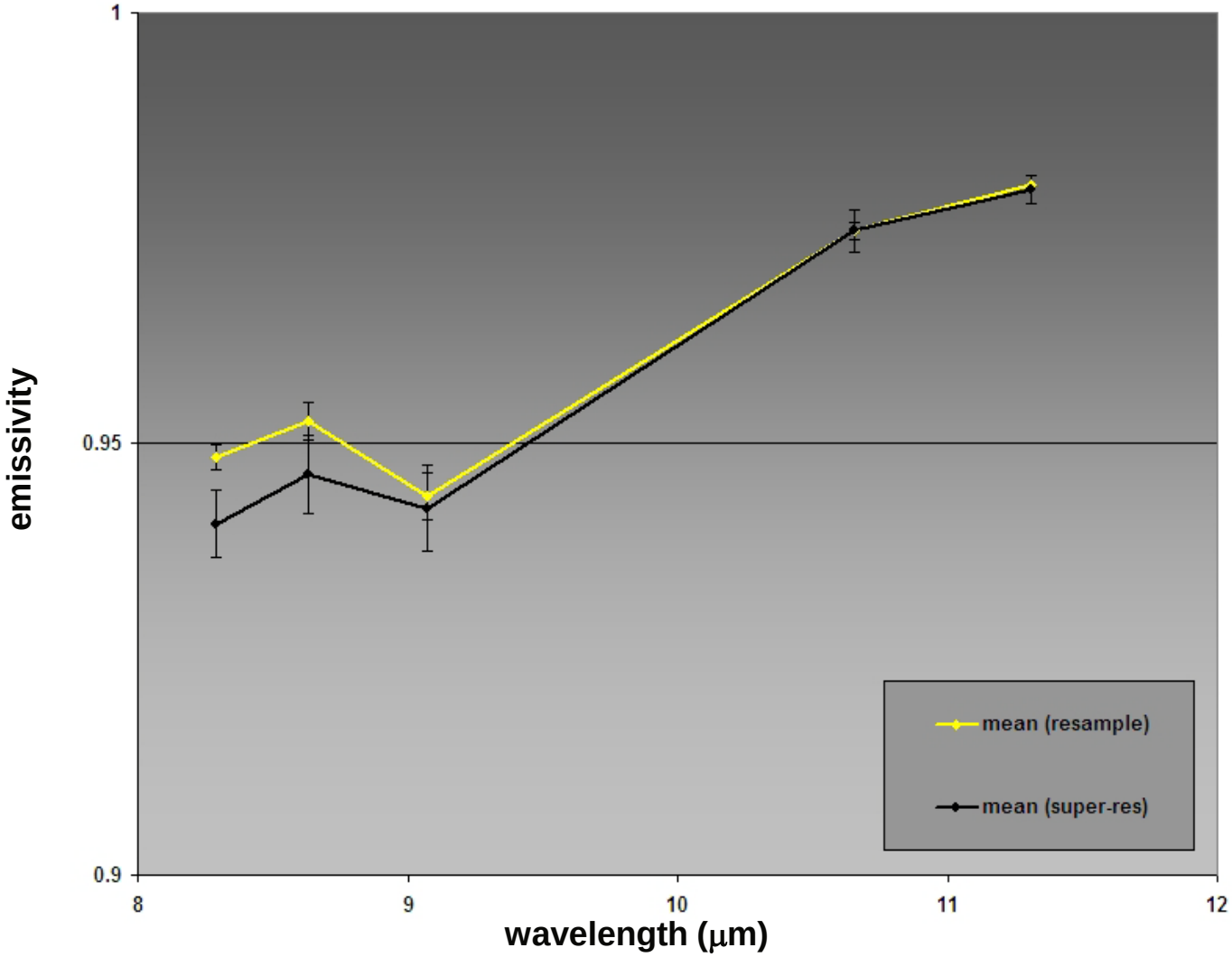


Results: ASTER + AVIRIS

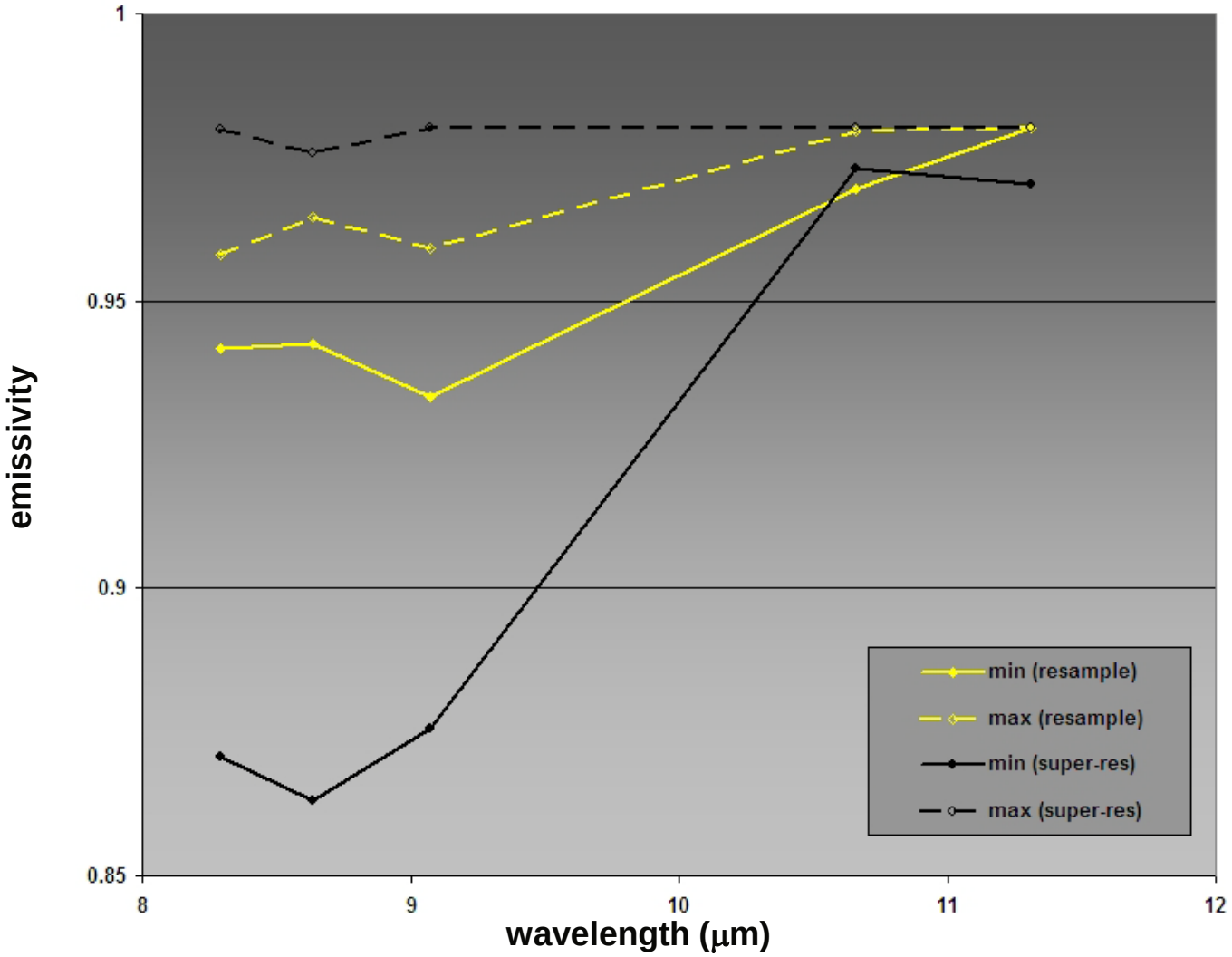
- **ASTER VNIR**
  - used to super-resolve ASTER SWIR & TIR data to 15 m/pixel
- **ASTER TIR & AVIRIS data**
  - then super-resolved to 60 m/pixel HyspIRI resolution



Spectral Variance: Playa



Spectral Variance: Playa



Conclusions & Future Work

- **Arid land surfaces**
  - provide an excellent target for HyspIRI validation
    - global significance, climate/geologic/natural hazard implications
      - estimate aerosol composition, soil moisture, albedo
      - excellent monitoring potential at a high spatial/temporal resolutions

- **Quantitative datasets are critical**
  - preliminary results for the super-resolution approach
  - further validation needed
    - ongoing after two field campaigns to Lunar Lake, NV
    - expand the approach to fully integrate AVIRIS (and MASTER) in the super-resolution process
      - assess the spectral leveraging against the time difference between data acquisitions