Experiences with the Radiometric Calibration Test Site (RadCaTS)

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Background

- Radiometric Calibration Test Site (RadCaTS) site was developed to obtain data in absence of ground personnel
  - Modeled on reflectance-based technique
  - Attempt to retain accuracy of in-situ measurements with flexibility of PICS
  - Increased ability to trend sensors over time
- Initial cost reduction through use of existing equipment and prototype instruments
  - Cimel sun photometer (AERONET)
  - LED-based ground-viewing radiometers (GVRs)
- Recent improvements include:
  - Three new GVRs to address long-term radiometric stability
  - Correction of diffuse irradiance reported by MODTRAN

Modelled on Reflectance-Based Approach

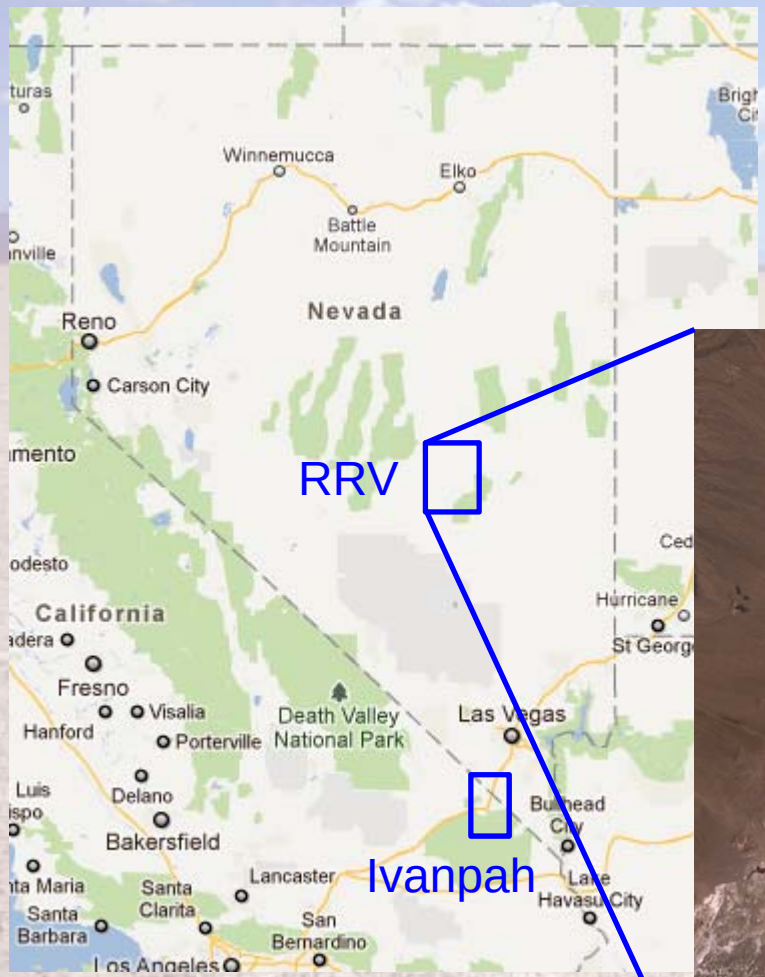
Measure site:
atmospheric data

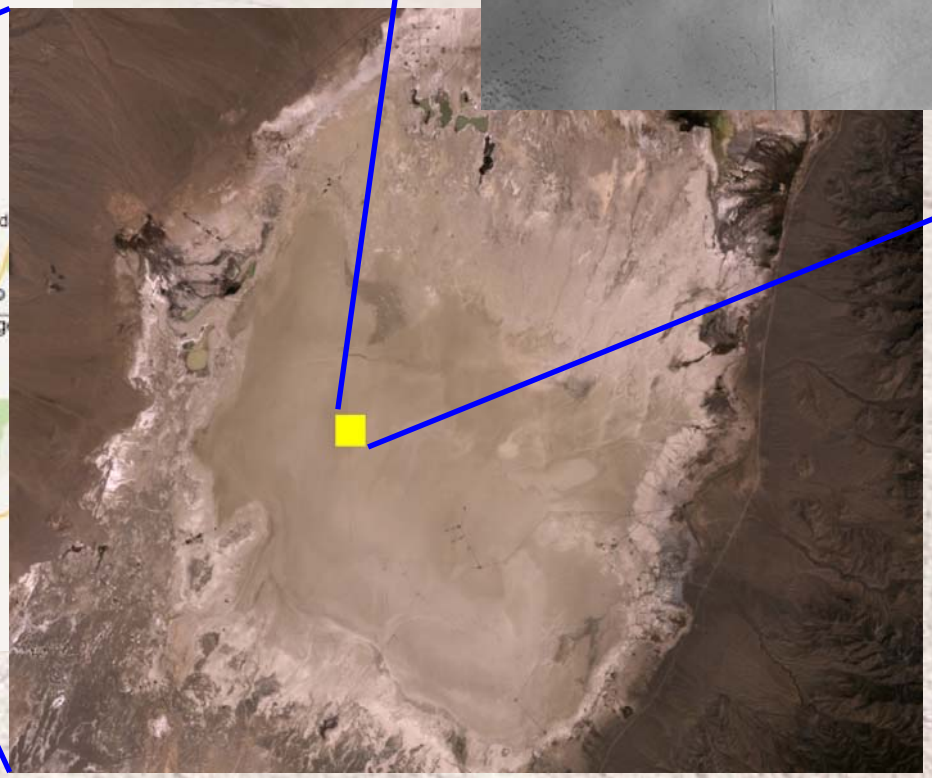
Measure site:
reflectance data

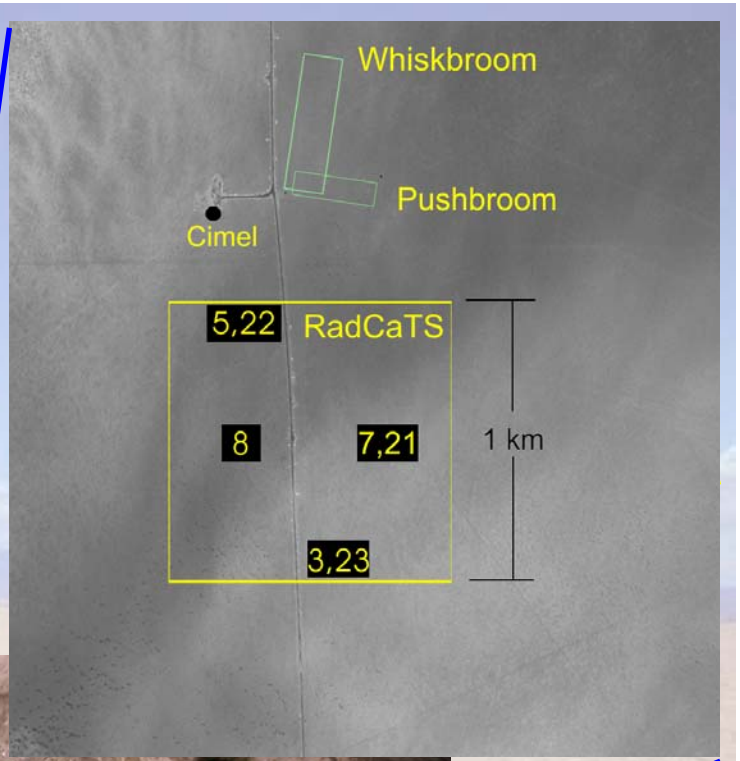
ρ based

RadCaTS

RadCaTS Layout



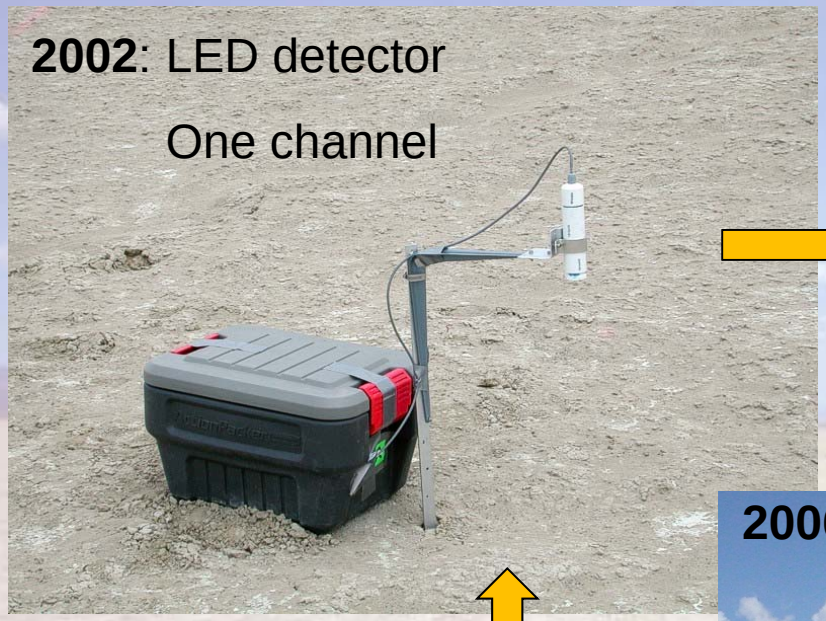




GVR Development

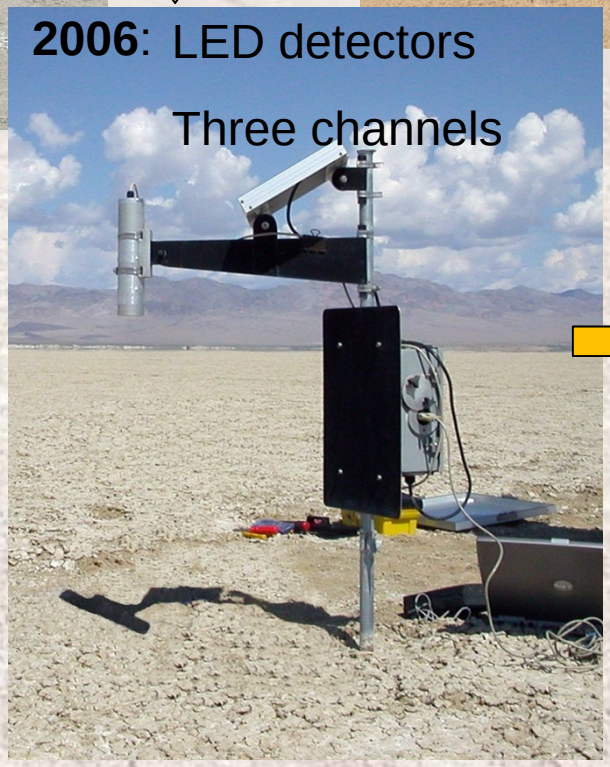
2002: LED detector

One channel



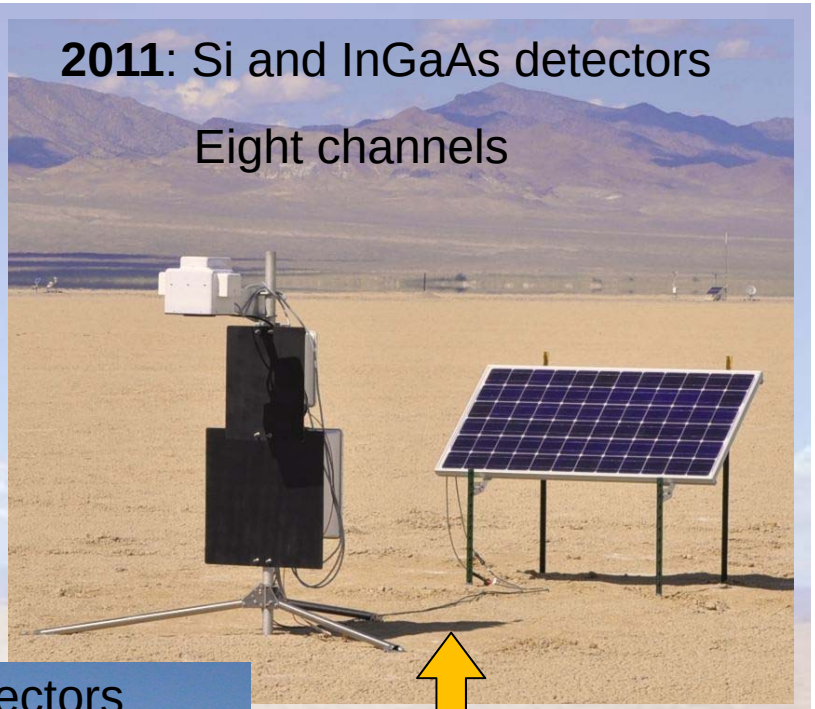
2006: LED detectors

Three channels



2011: Si and InGaAs detectors

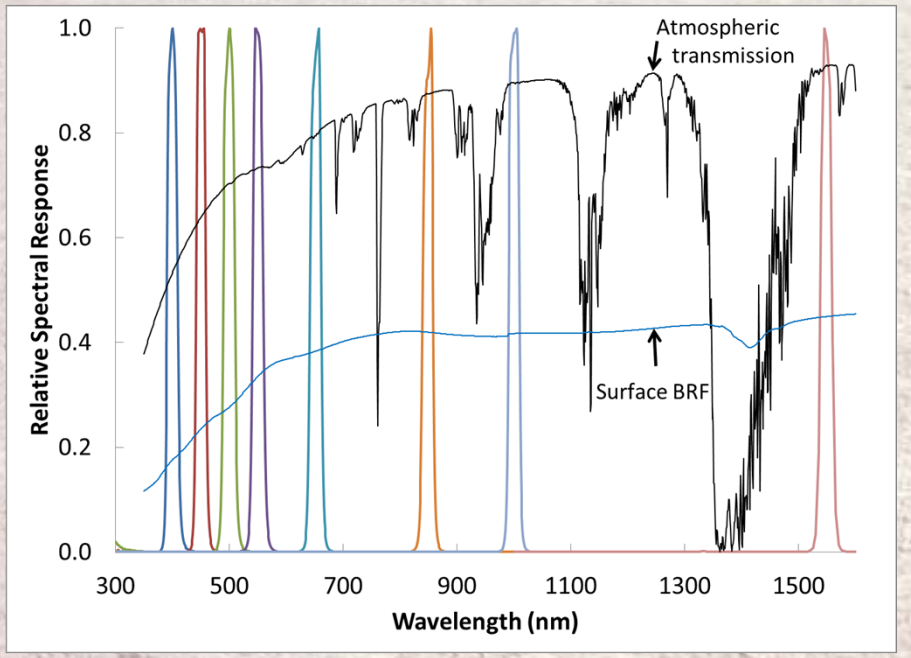
Eight channels

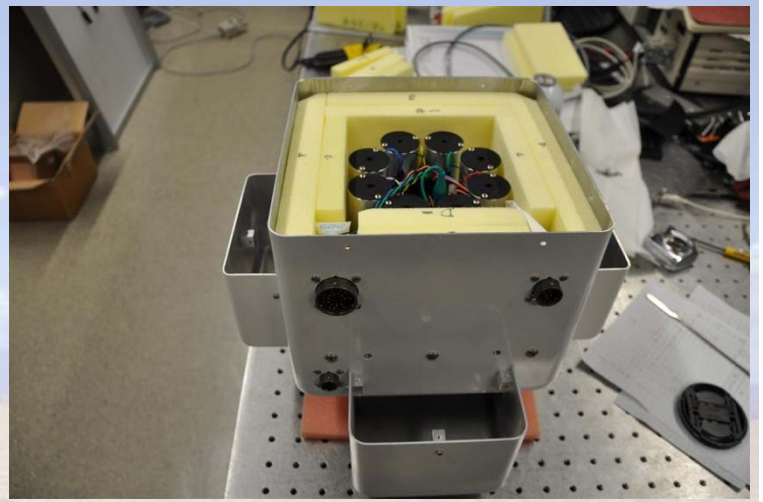


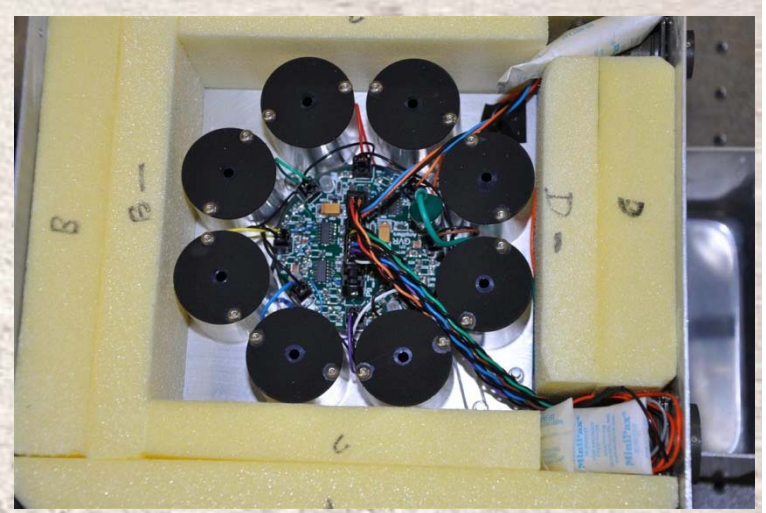
GLOBE Sun photometer

Newest GVRs

- **Design uses temperature-controlled focal plane**
  - Silicon and InGaAs detectors
  - Narrow-bandwidth interference filters
    - 8 spectral channels
    - 400, 450, 500, 550, 650, 850, 1000, and 1550 nm ($\Delta\lambda \approx 20$ nm)
  - FOV slightly smaller than previous GVRs (7 vs. 11)
  - Ambient temperature at site: -20 C to +40 C

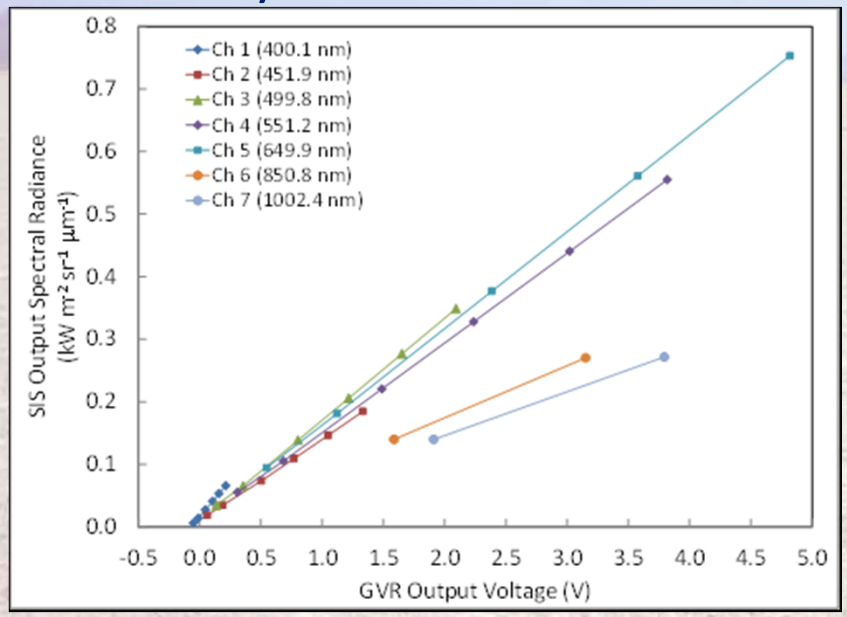


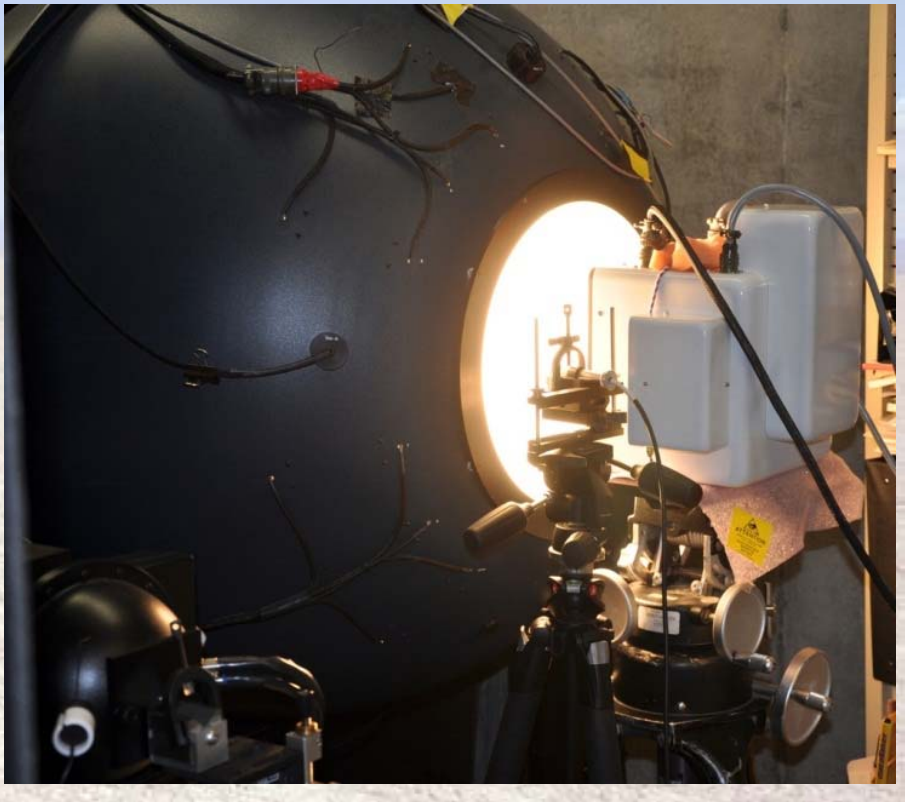




GVR Laboratory Radiometric Calibration

- **Radiometric calibration using 1-m SIS**
  - 1-10 lamps (150 W each)
  - Linearity and absolute calibration



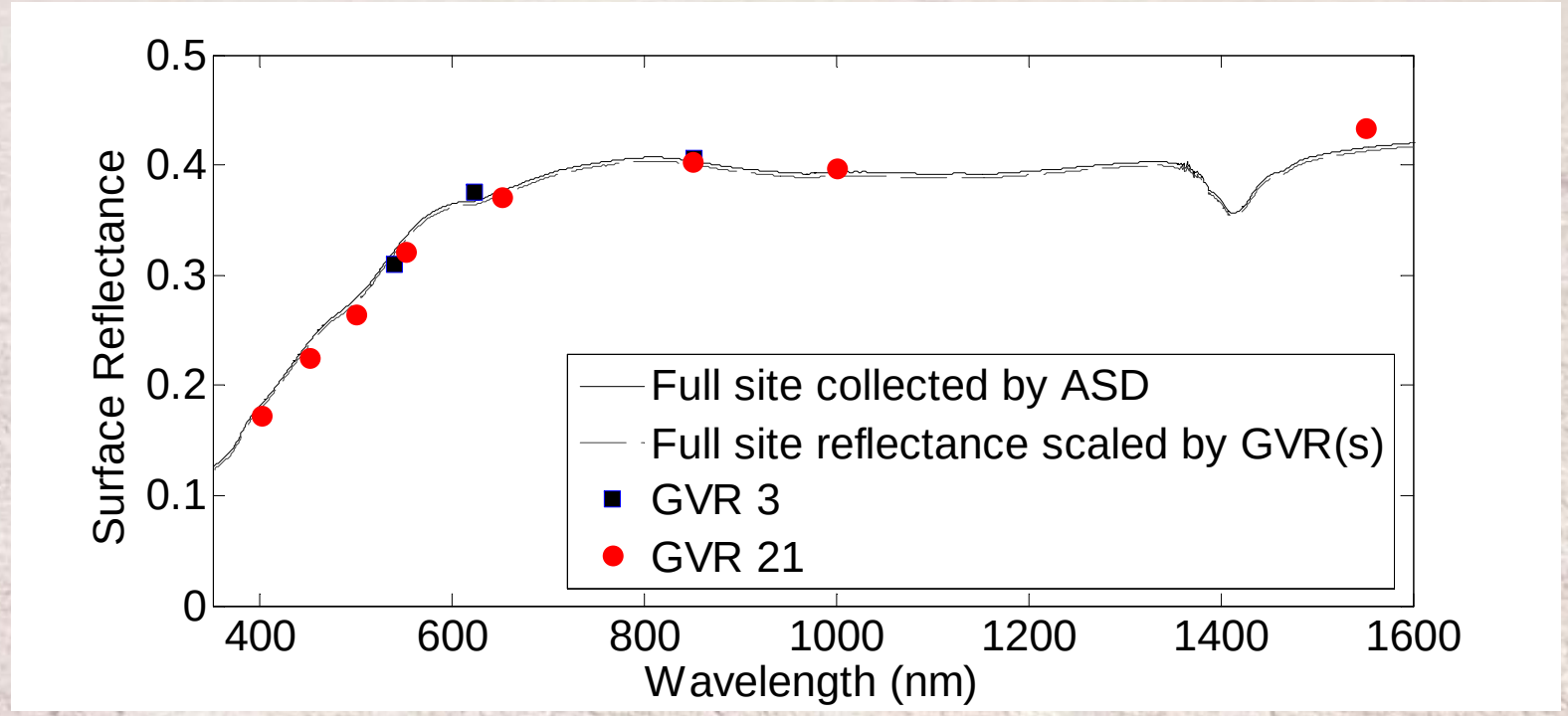


GVR channel	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Nominal wavelength (nm)	400	450	500	550	650	850	1000	1550
	Radiometric calibration coefficient ($W\ m^{-2}\ sr^{-1}\ \mu m^{-1}\ V^{-1}$)							
GVR 21	279.4	531.3	535.5	580.6	364.1	320.3	278.5	46.2
GVR 22	227.7	130.8	160.5	142.5	153.8	83.9	70.2	16.2
GVR 23	211.1	143.9	159.0	144.0	155.5	87.9	69.6	14.4

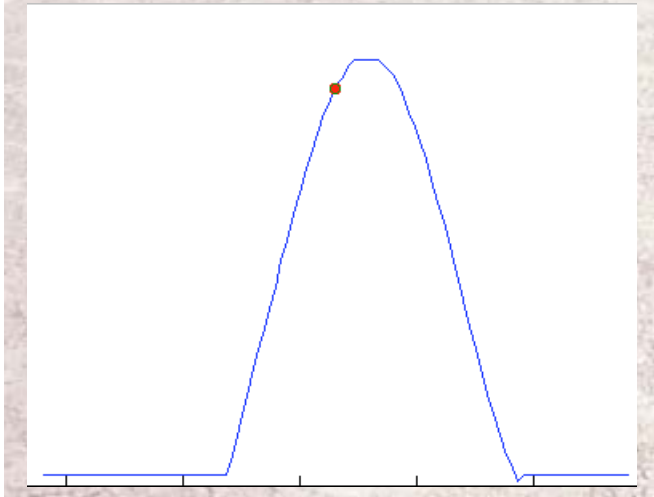
RadCaTS Surface BRF Retrieval

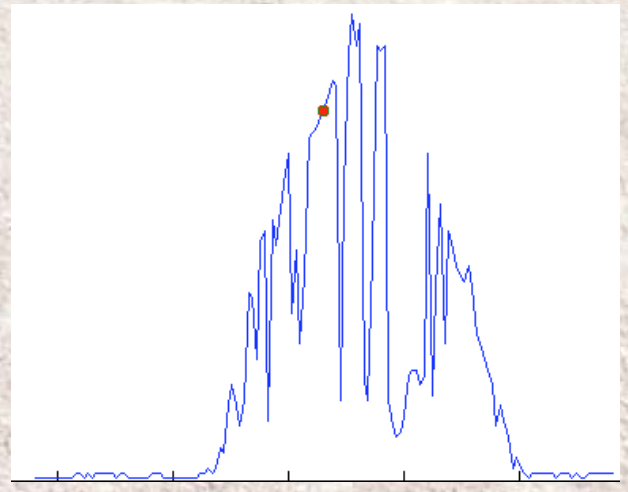
$$\rho = \frac{\pi \, C_{GVR} \, V_{GVR}}{E_0 \, \tau_{solar} \, \cos\theta + E_{sky}}$$

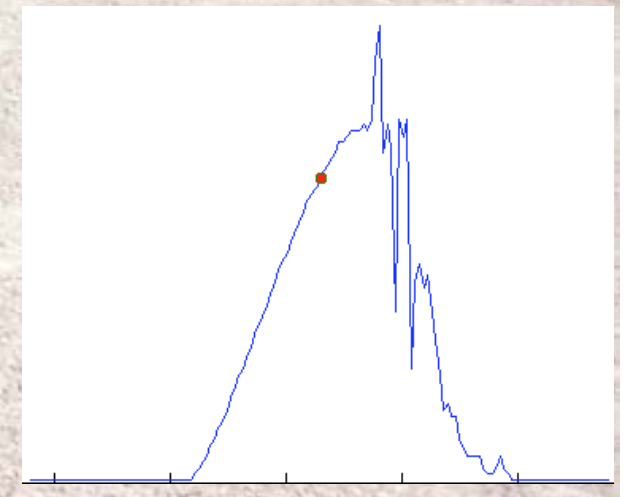
- ρ = surface BRF
- C_{GVR}= GVR calibration coefficient
- V_{GVR} = GVR output voltage
- E_0 = exoatmospheric solar irradiance
- τ_{solar} = direct solar beam transmission
- θ = solar zenith angle
- E_{sky} = diffuse sky irradiance



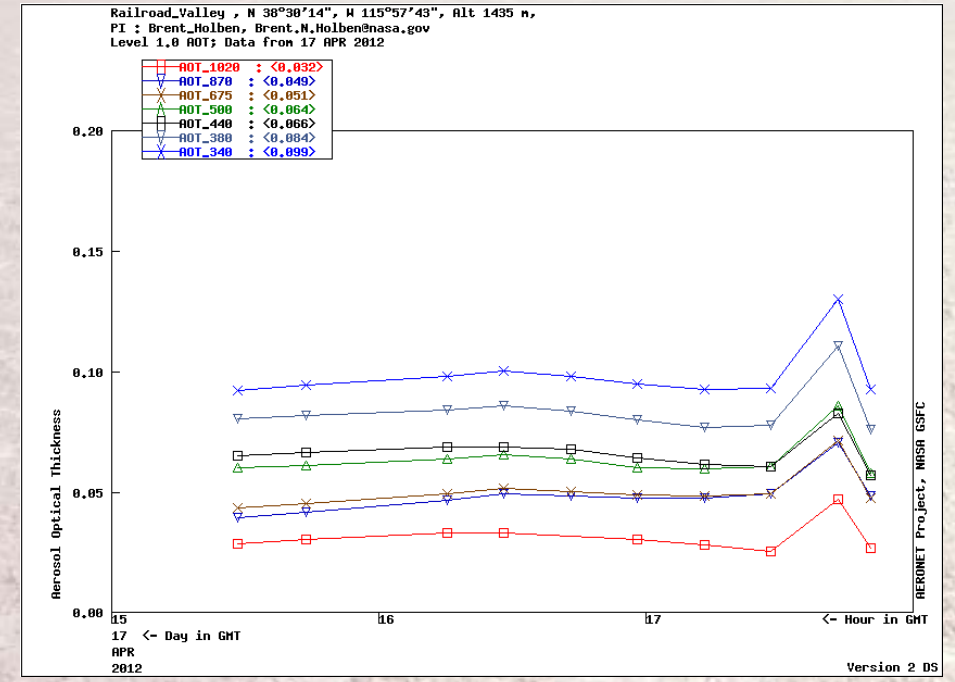
Data Quality Determination: GVR voltage

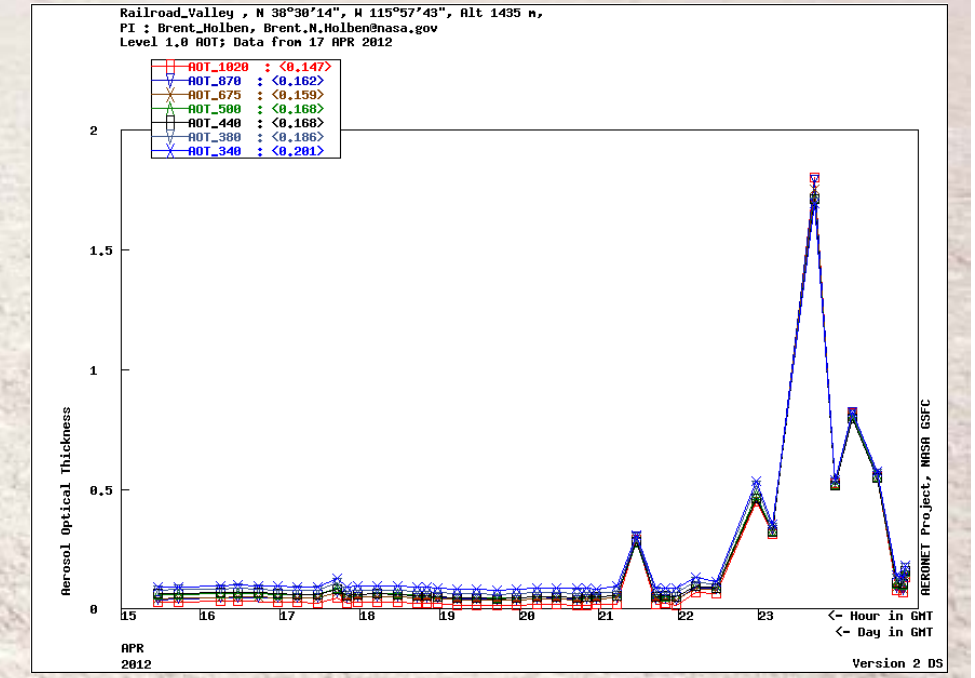






Data Quality Determination: Cimel sun photometer





Data Quality Determination: MODIS cloud mask

Sensors
- Aqua MODIS
- Terra MODIS

Choose Data

Input Files

Data File	MOD021KM.A2011168.1840.005.2011169091232.hdf
Geolocation File	MOD03.A2011168.1840.005.2011169042229.hdf
Browse Image	MOBRGB.A2011168.1840.005.2011169142804.jpg
Cloud Mask	MOD35_L2.A2011168.1840.005.2011169091953.hdf

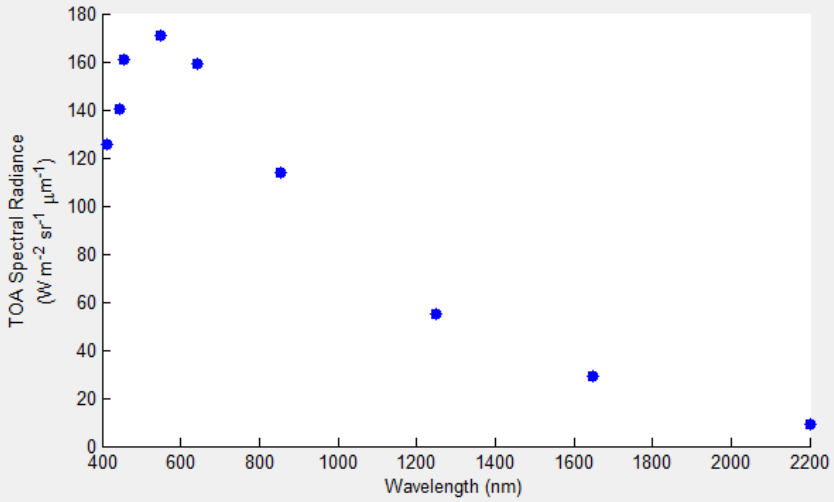
Solar and View Data

Date	VZA	VAA
2011-06-17	10.45	279.37
Time (UTC)	**SZA**	**SAA**
18:44:18	19.72	135.71

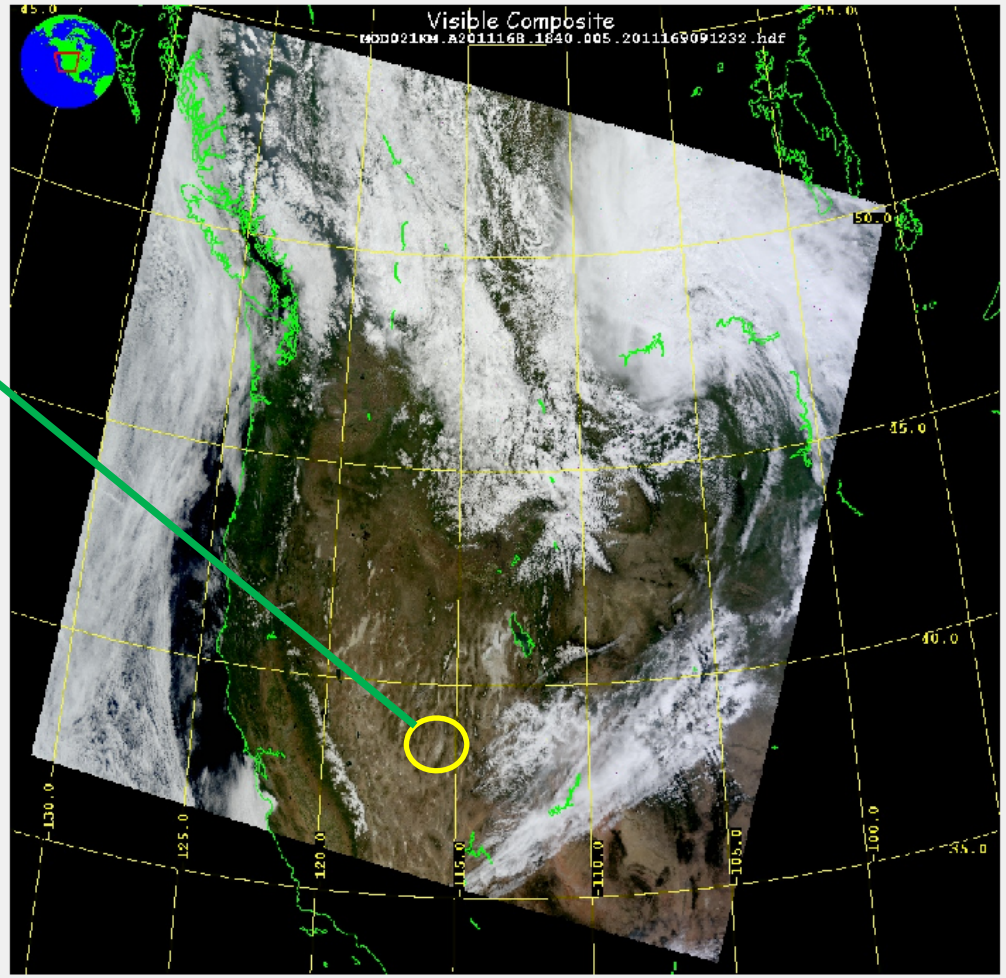
Cloud Mask Information

Cloud Mask	Sky Conditions
Cloud mask in use	Confident clear
Cirrus Detection	**Surface Type**
Thin cirrus not detected	Desert

Lat & Lon of MOD35 pixel
38.5041, -115.7003



Browse Image



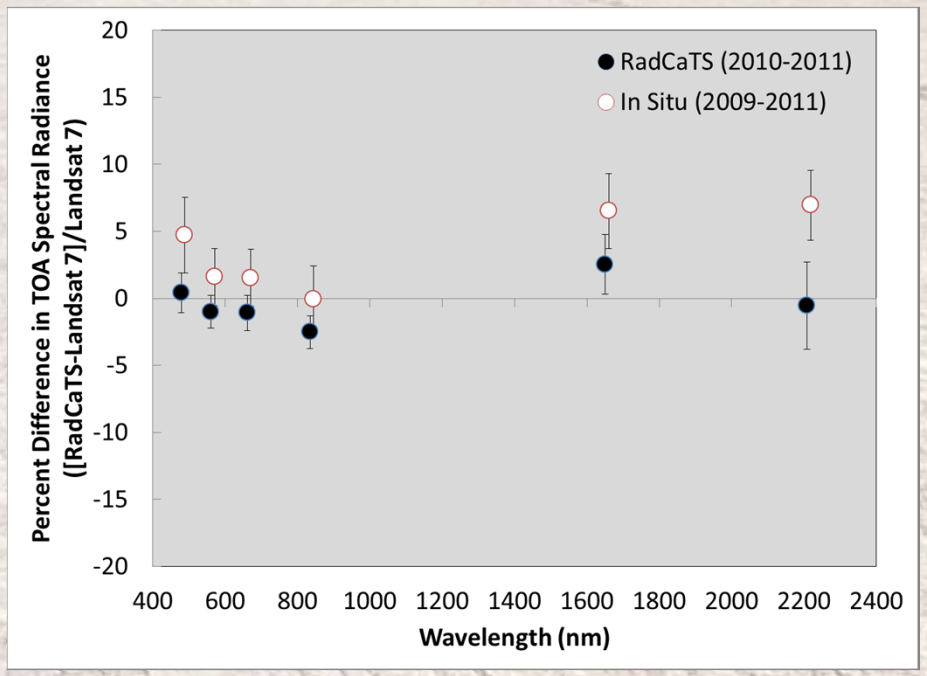
Landsat 7 ETM+, MODIS, and MISR data

- Period of study: Jun 2011 – Feb 2012

Sensor Characteristics						
	Landsat 7 ETM+		Terra & Aqua MODIS		Terra MISR (An)	
Band	λ_{center} **(nm)**	**GIFOV (m)**	λ_{center} **(nm)**	**GIFOV (m)**	λ_{center} **(nm)**	**GIFOV (m)**
1	479	30	645	250	446	275
2	561	30	856	250	558	275
3	661	30	466	500	672	275
4	835	30	553	500	866	275
5	1650	30	1244	500	-	-
6	-	-	1632	500	-	-
7	2208	30	2119	500	-	-
View angle(s)	Nadir		**Terra**: nadir, 10°, and 12° **Aqua**: 4° and 7°		Same as Terra MODIS	
Potential dates	16		**Terra**: ~50 **Aqua**: ~30		Same as Terra MODIS	
Successful dates	5		**Terra**: 8 **Aqua**: 5		Same as Terra MODIS	

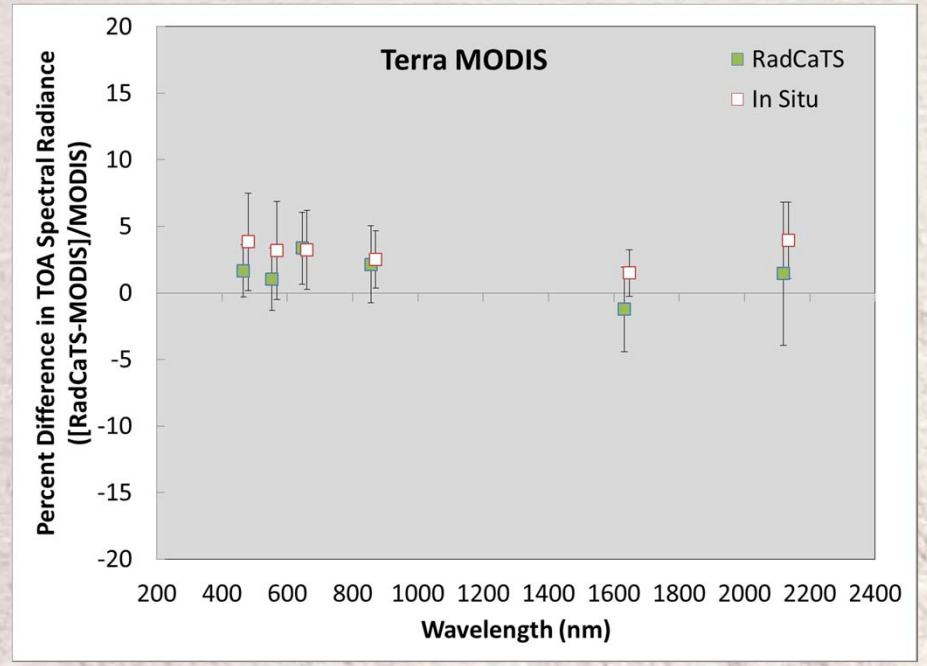
Landsat 7 Results

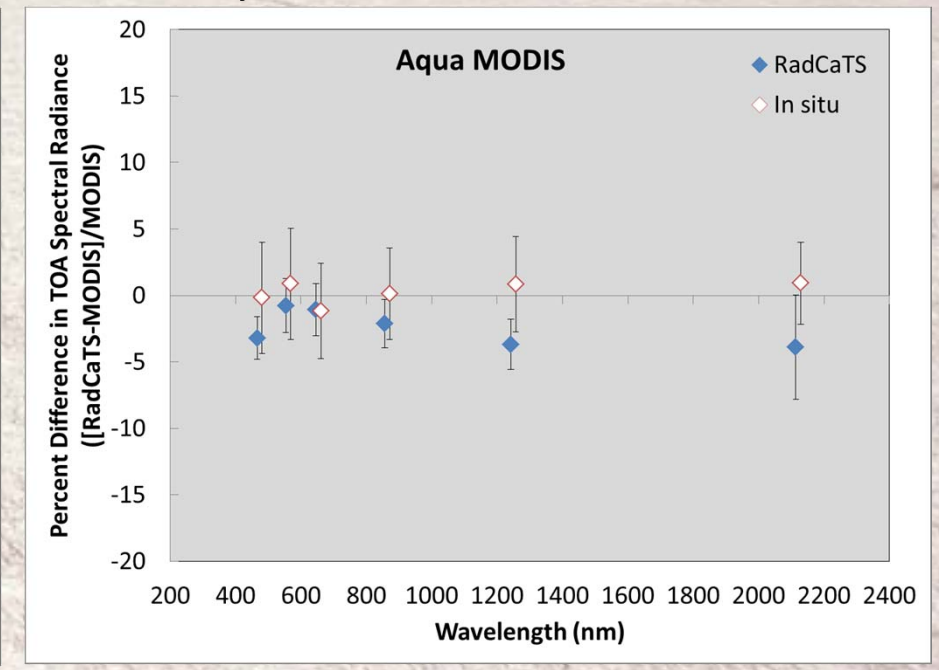
- RadCaTS has bias compared to in situ results
- 3-4 GVRs used to sample site
- Adequate spatial sampling based on previous uniformity study
- Note: three LED-GVR channels operate in Landsat 7 bands 2-4 only
- Newest GVR design (Si & InGaAs) covers bands 1-5



MODIS Results

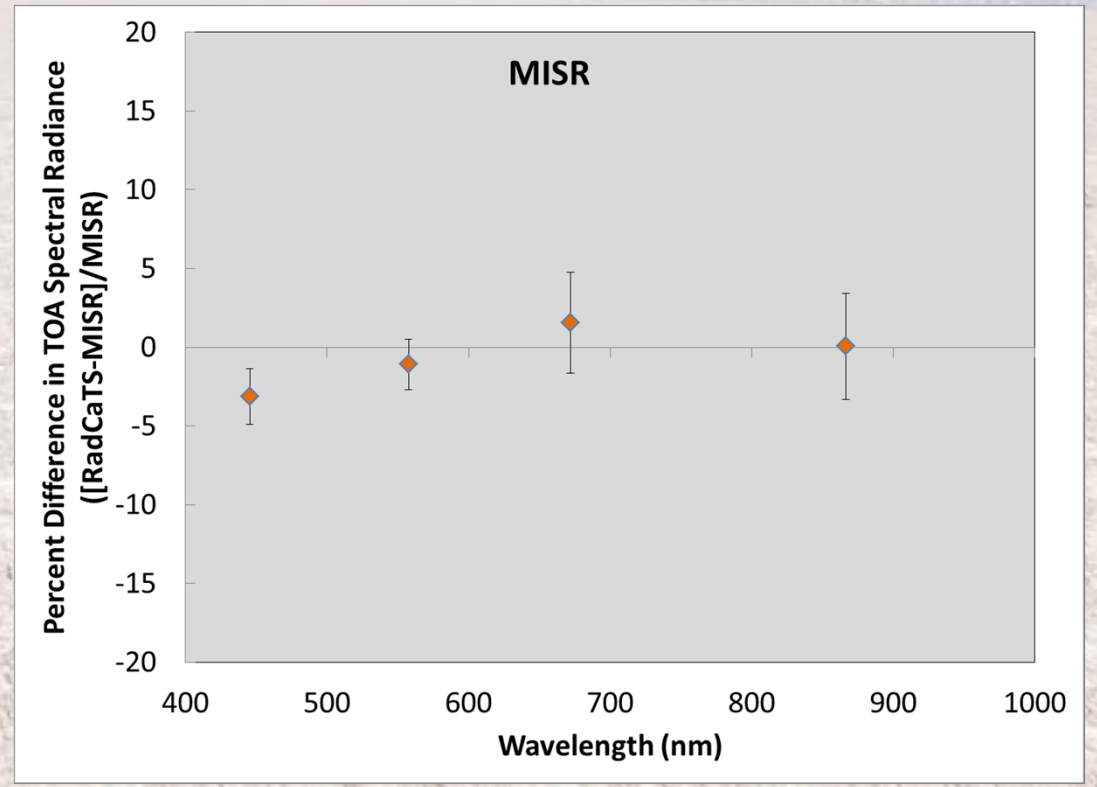
- **Summary of RadCaTS results for 2010-2011**
  - Terra MODIS Band 5 and Aqua MODIS Band 6 ignored due to noisy detectors
  - Site is adequately spatially sampled in this study
  - Previous study shows that:
    - 4 GVRs should produce BRF uncertainty of 2%
    - 2 GVRs should produce BRF uncertainty of 4%



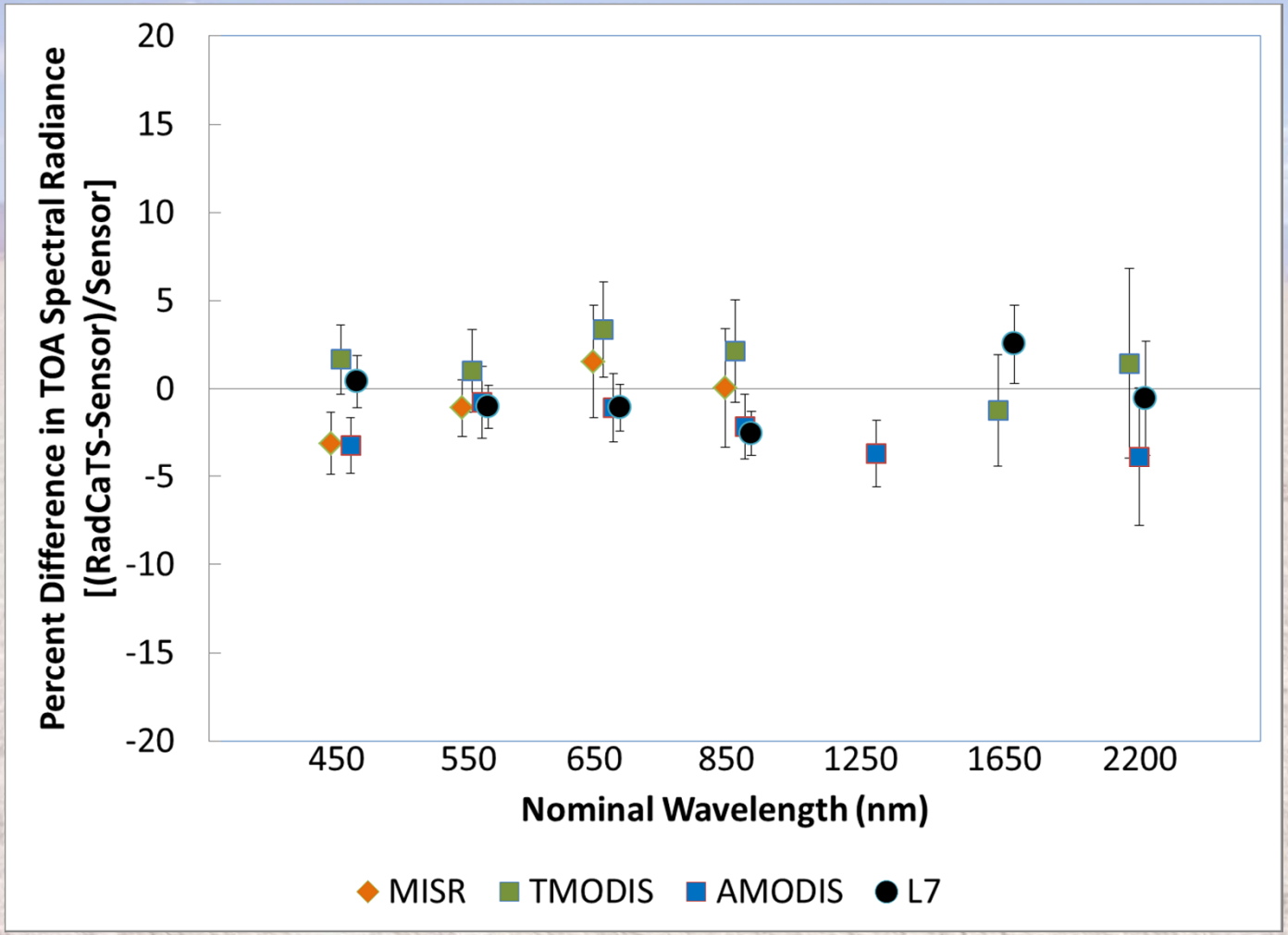


MISR Results

- Study restricted to nadir (An) camera only
- 2-4 GVRs used to sample site
- Properly spatially sampled based on previous uniformity study
- Note: three LED-GVR channels operate near all MISR bands



Summary of RadCaTS Results (Jun 2011 – Feb 2012)



Conclusions and Future Work

- Conclusions:
  - New extended-wavelength GVRs appear to provide better radiometric stability than previous GVRs
  - Diffuse irradiance correction appears to be working
  - Atmospheric analysis helps to reduce days with thin cirrus
- Future work:
  - Continue to analyze diffuse irradiance correction through field work in summer 2012
  - Comparison of BRF retrieval between RadCaTS and reflectance-based method
  - Monitor radiometric stability of new GVRs through SRBCs
  - Determine if there are scaling effects in BRF retrieval using RapidEye data (6.5 m)
  - Prepare for launch of LDCM/Landsat 8 in early 2013

Acknowledgements

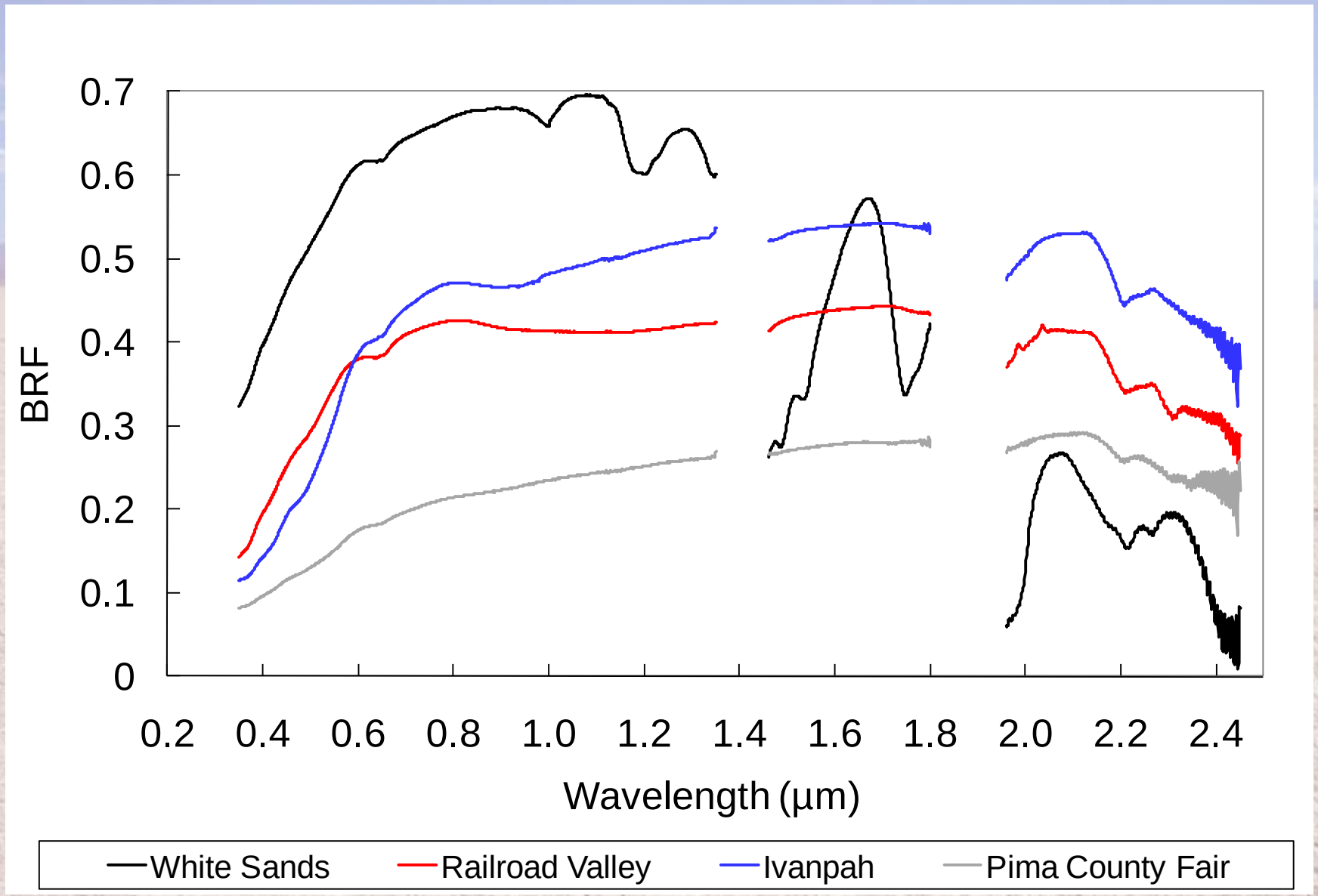
- Thank you to the Bureau of Land Management (BLM) Tonopah, Nevada, office for assistance and permission in using Railroad Valley
- This work was supported by NASA grant NXX08AC55A.

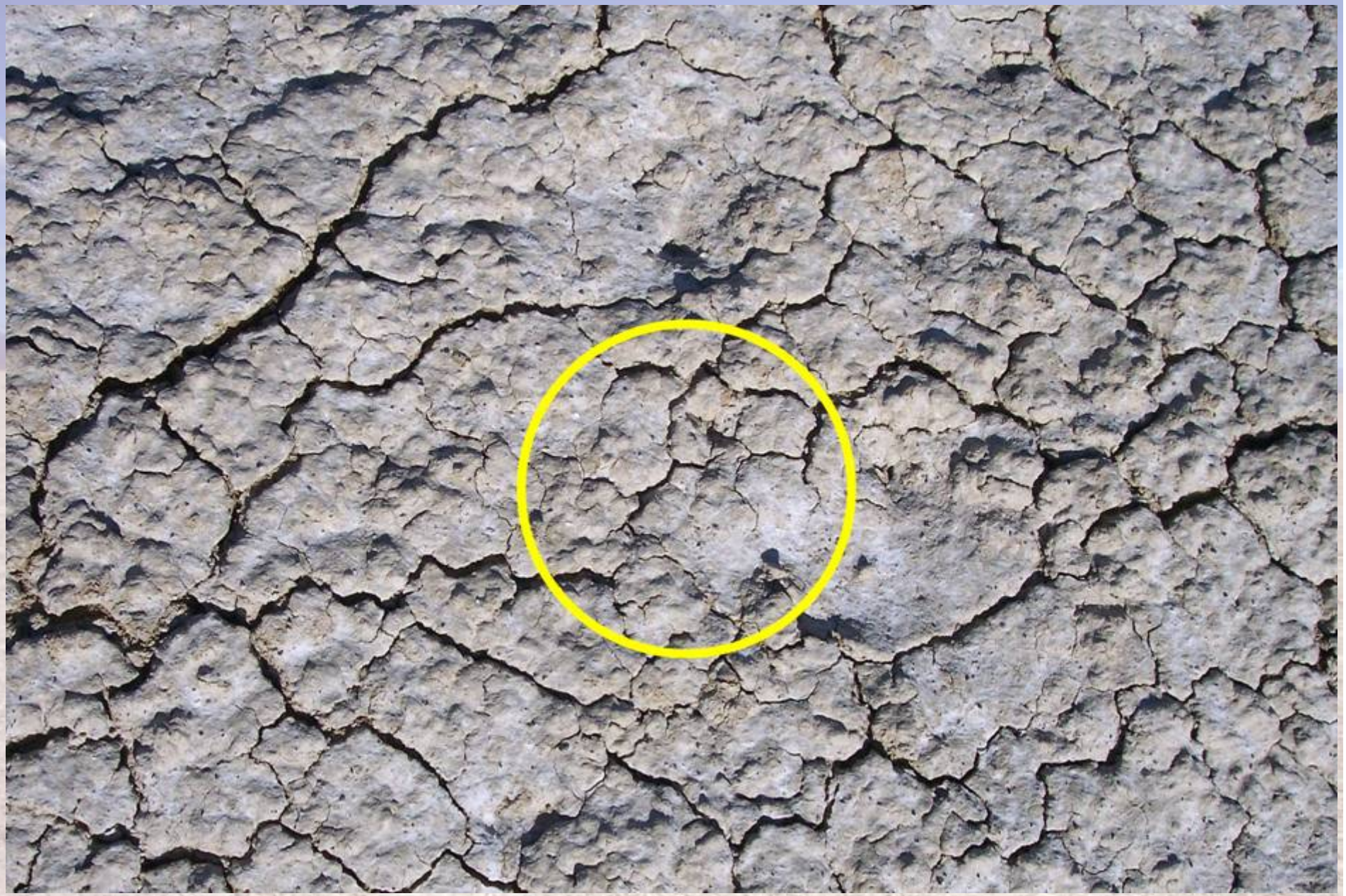
Backup Slides

Improvements to Esky Determination

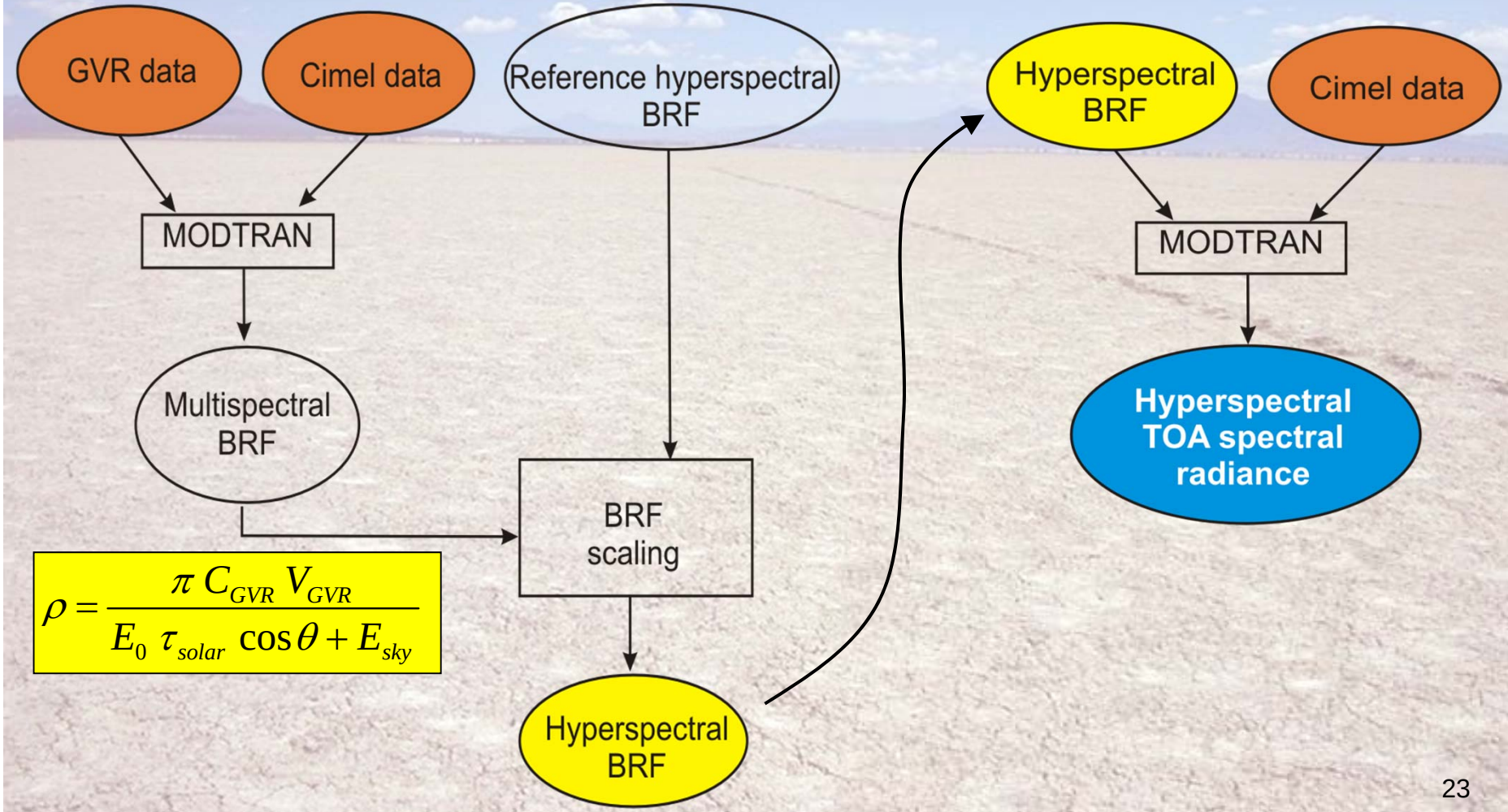
- MODTRAN5 input currently assumes clear-sky conditions
- Radiative transfer models can overestimate Esky by up to 40%
- Esky is a significant component in BRF retrieval
- E.g. a 10% uncertainty in Esky causes a 2% error in surface BRF at 400 nm
- RSG does not have instrumentation to collect hyperspectral Esky at RadCaTS
- Initial results for Esky correction were presented at SPIE:
  - **N. Leisso and J. Czapla-Myers, "Comparison of diffuse sky irradiance calculation methods and effect on surface reflectance retrieval from an automated radiometric calibration test site", SPIE 8153, (2011).**

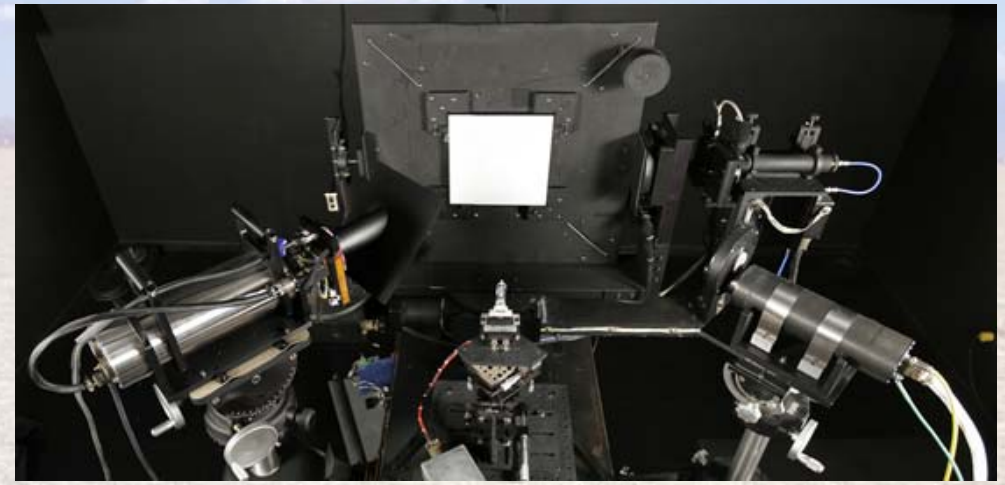
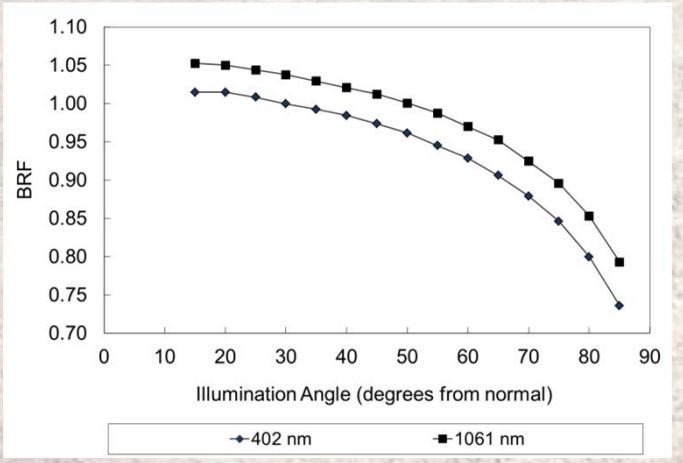
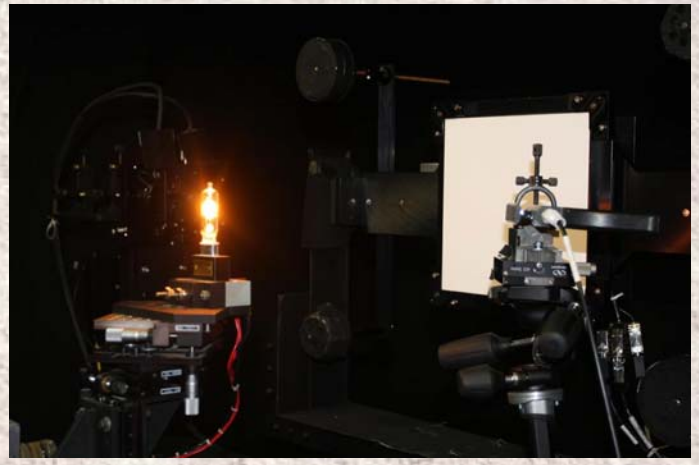
Typical Spectral Reflectance of RSG Test Sites





Surface BRF Determination and TOA Radiance



RSG Blacklab

- Used to measure BRF of reference panels
- Also used to measure calibration coefficient of laboratory radiometers using NIST-traceable reflectance standard and lamp