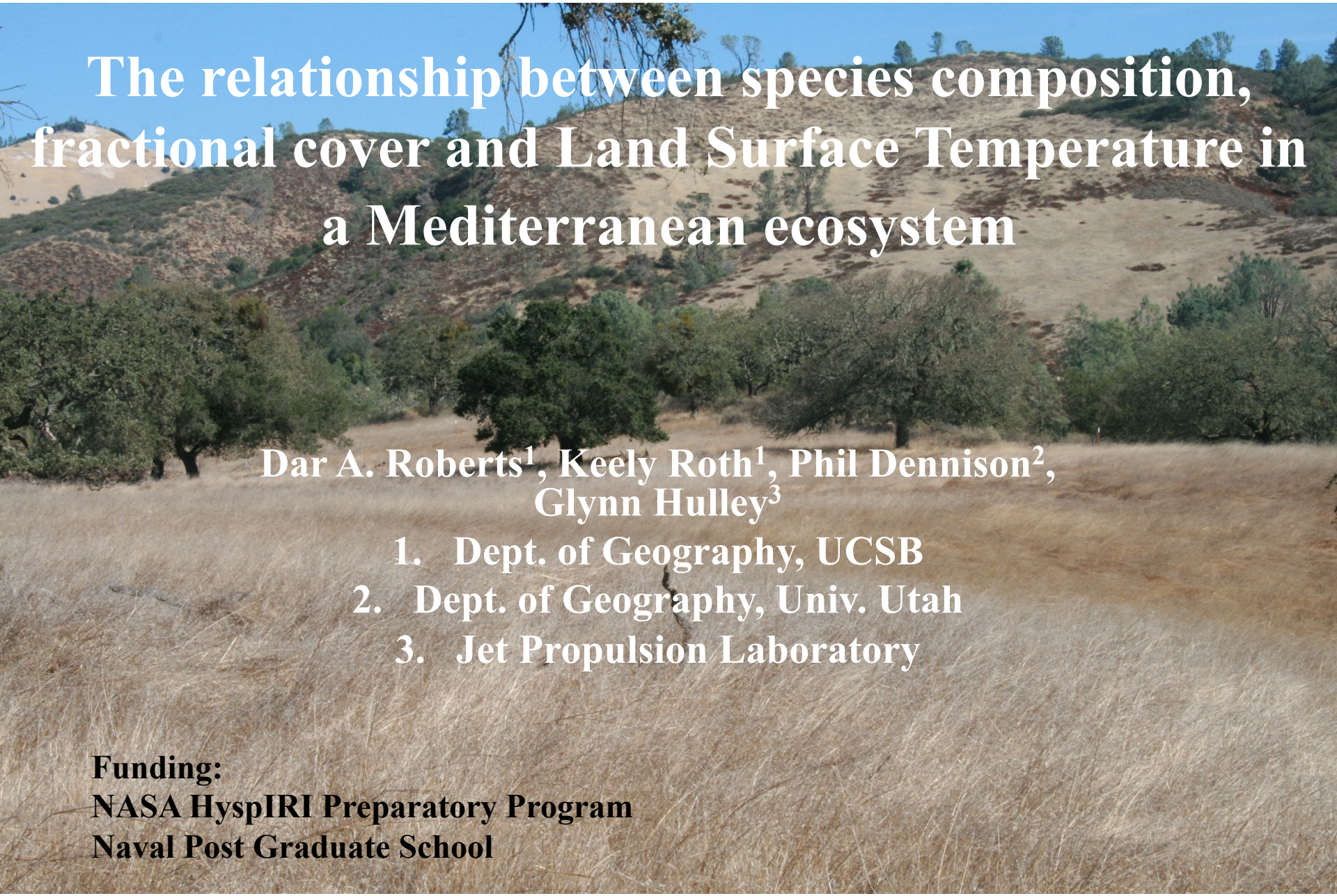

The relationship between species composition, fractional cover and Land Surface Temperature in a Mediterranean ecosystem

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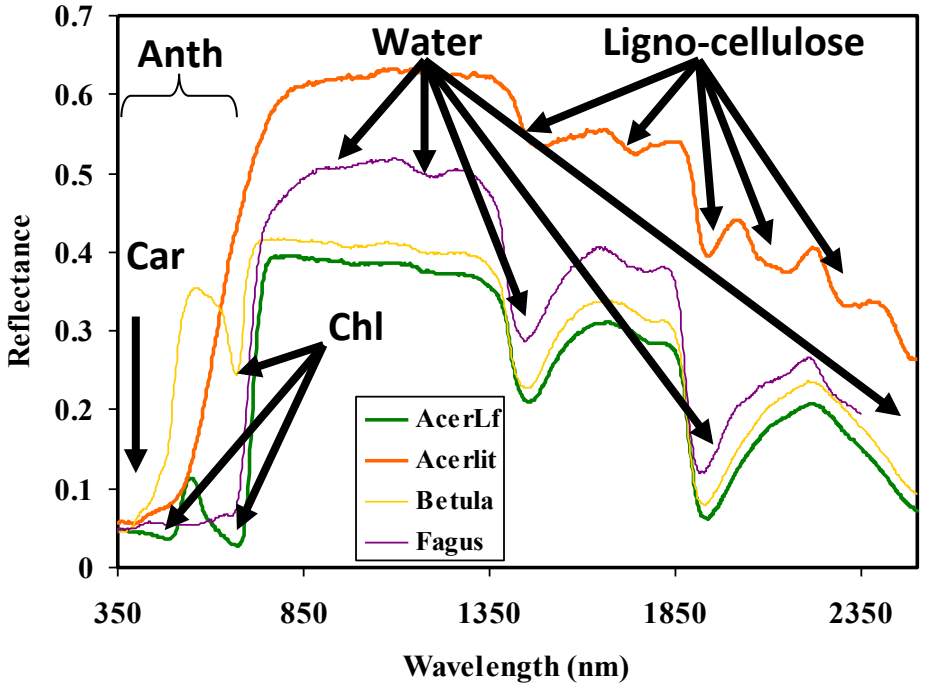
Naval Post Graduate School

Outline

- Introduction
- Research Objectives
- Study Site
- Methods
  - Preprocessing
  - MESMA
- Results
- Conclusions

Introduction

- Numerous Synergies exist between the VSWIR and TIR
- VSWIR
  - Species composition
  - Fractional cover
  - Canopy structure (LAI)
  - Canopy chemistry
  - Photosynthetic function
- TIR
  - Temperature
    - Stress measure
    - Evapotranspiration
  - Emissivity
    - Species composition
    - Canopy chemistry



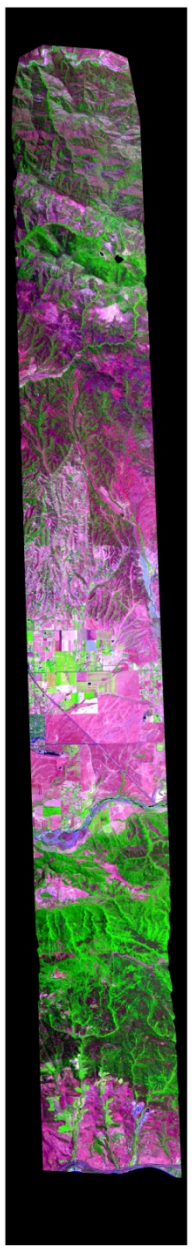
- HyspIRI will enable those synergies to be fully explored and utilized

Research Objectives

- **Explore synergies between the VSWIR and TIR using AVIRIS-MASTER pairs**
- **Research Questions**
  - **What is the relationship between species composition and land surface temperature (LST)?**
  - **What is the relationship between fractional cover and LST?**

Study Site (1)

Run 19: July 19, 2011

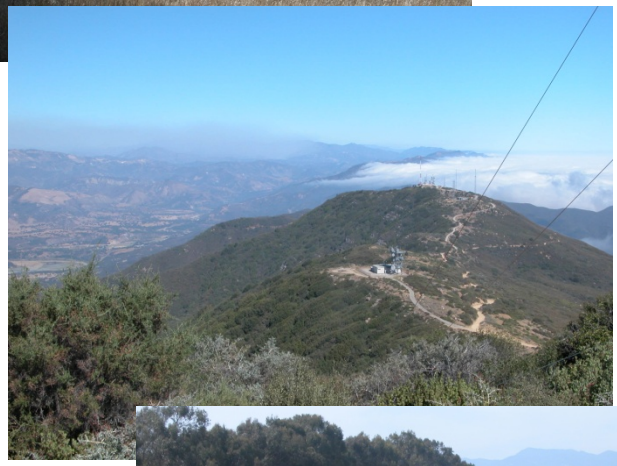


329K

295K

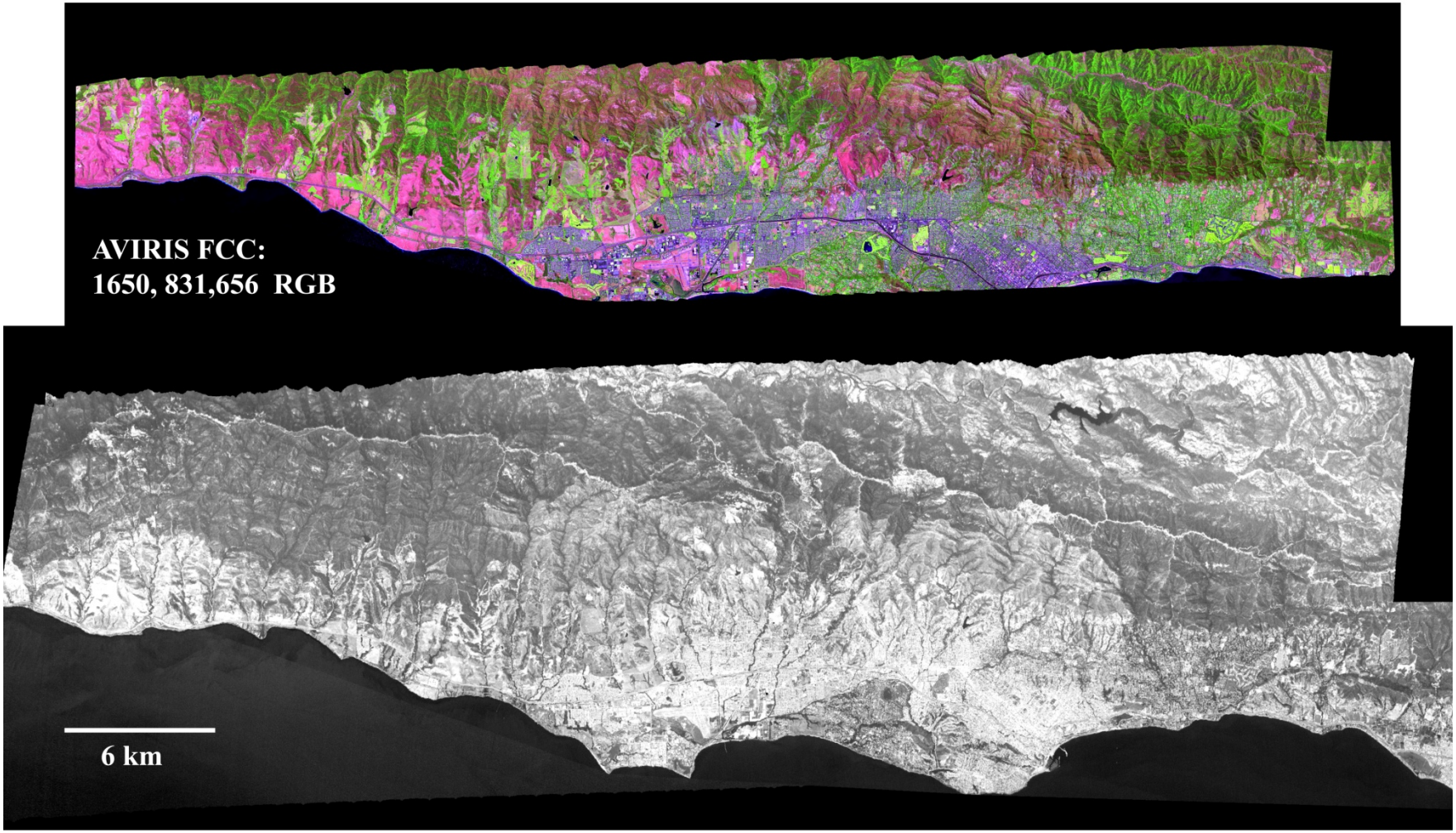
AVIRIS:
1650, 831,656 nm RGB

MASTER:
Temperature



Study Site (2)

SB Runs 21 to 22



MASTER:
Temperature

295K **329K**

Methods: Pre-Processing

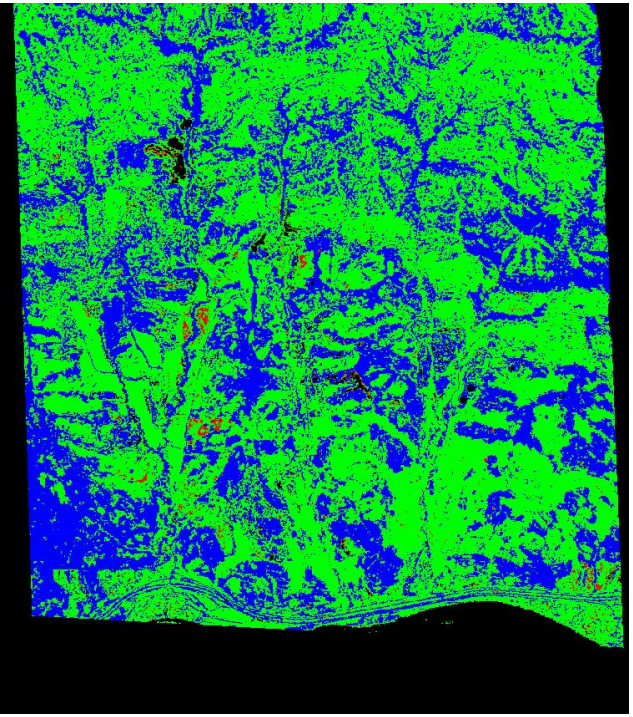
- **AVIRIS: ATCOR Surface Reflectance**
  - **Scene parameters (sensor height, location, time)**
  - **ATCOR parameters**
    - **rural, 940&1130 nm water vapor**
    - **Scan angle from GLT**
    - **Visibility 80km (default), minor adjacency correction**
- **MASTER**
  - **JPL MASTER TES online tool**
  - **Varied CO_2, Ozone, Water vapor**
    - **Tuned using emissivity from Lake Lagunita**
    - **Ozone: 0.5, CO_2: 370 ppm: Water vapor: 0.8 g (cm)**
  - **Temperature (K), Emissivity (5 bands)**
- **Both: Georectified (7.5m AVIRIS or 15 m. MASTER) to a spatially degraded DOQQ (2010)**
  - **Resampled nearest neighbor using Delaney Triangulation**

Training/Validation Spectra

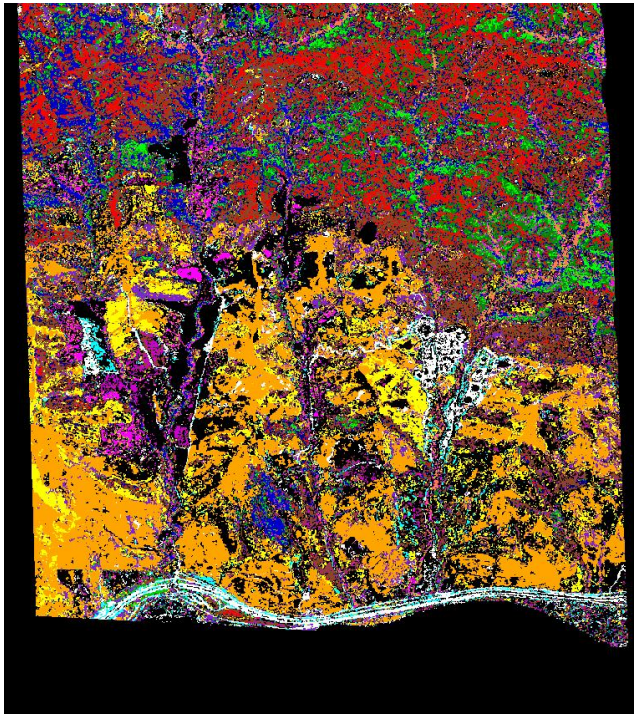
		r19		r20		r21		r22		Training	
Type	Code	Npolys	10/50	Npolys	10/50	Npolys	10/50	Npolys	10/50	Npolys	10/50
Adenostoma fasciculatum	adfa	2	20	0		1	10	25	250	28	280
Artemisia Cal/Salvia leucophylla	arcasale	13	130	0						13	130
Arctostaphylos glauca/gland	argl	1	10	0				6	60	7	70
Bacharis pilularis	bapi	1	10	8	77	11	107			20	194
Brassica nigra	brni	0	0	5	50	9	90	1	10	15	150
Ceanothus cuneatus	cecu	5	50	0				1	10	6	60
Ceanothus megacarpus	ceme	0	0	0	0	0	0	13	130	13	130
Ceanothus spinosus	cesp	6	60	0		1	10	3	30	10	100
Citrus species	cisp	2	20	0		11	106	2	20	15	146
Eriogonum fasciculatum	erfa	8	80	0						8	80
Eucalyptus species	eusp			7	70	9	90			16	160
Irrigated grass	irgr			1	10	16	160			17	170
Mediterranean Annual Grass/Forb	magf	1	10	3	30	5	50	6	60	15	150
Marsh	Marsh			8	80	10	100			18	180
Persea americana	peam					18	180			18	180
Pinus sabiniana	pisa	7	70	0						7	70
Platanus racemosa	plra	1	10	0				3	30	4	40
Quercus agrifolia	quag	1	10	0		6	60	13	130	20	200
Quercus douglasii	qudo	17	170	0						17	170
Rock	rock	2	20	0		3	30	1	10	6	60
Soil	soil	4	32	1	6	1	10	3	30	9	78
Umbellularia californica	umca	1	10	0				3	30	4	40
Urban	urban			6	60	15	150			21	210
	Totals	72	712	39	383	116	1153	80	800	307	3048
									Minimum	4	40
									Maxmum	28	280
									Mean	13.3	132.5
									Stdev	6.3	63

- Sampled 23 land-cover/species from 307 polygons
- Random training/validation (10 max, or 50%)
- Three pulls, first pull acceptable (Roth et al., 2012)

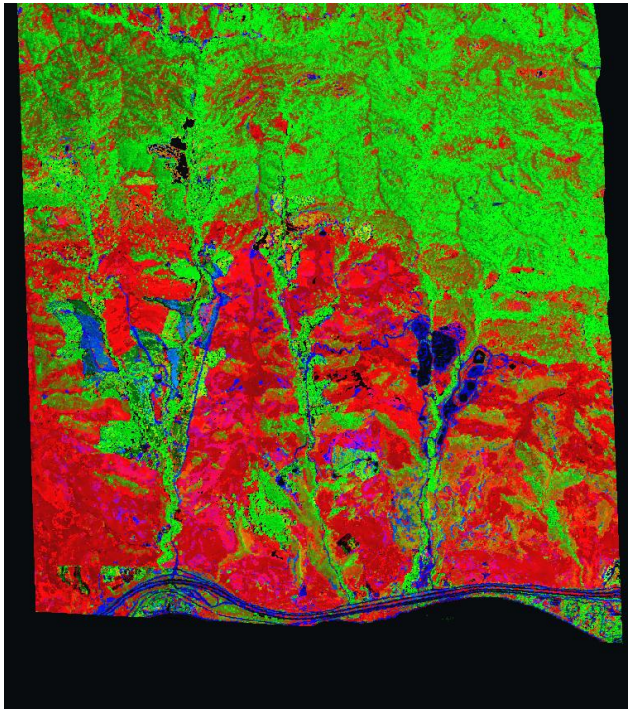
Multiple Endmember Spectral Mixture Analysis (MESMA)



Complexity: 3,2,1 RGB



Class

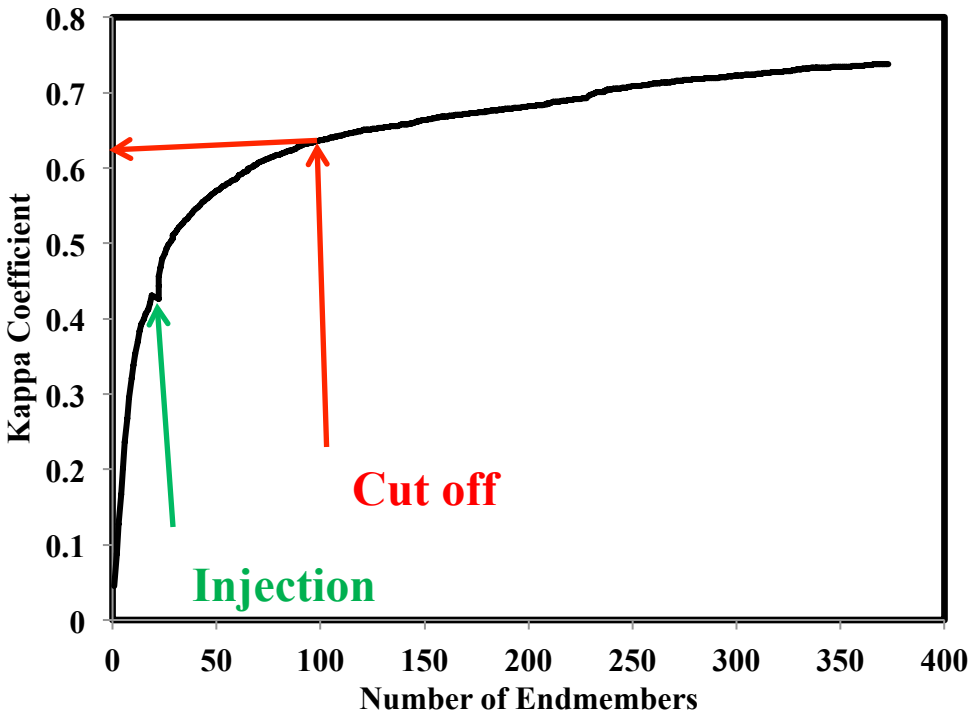


Composition: NPV-GV-Soil RGB

- Number and types of em varies per pixel
- Optimum model and complexity level based on RMS
  - 2 em =classified map
- Complexity level selected using RMS change threshold
  - 0.007

Endmember Selection: Forced Iterative Endmember Selection

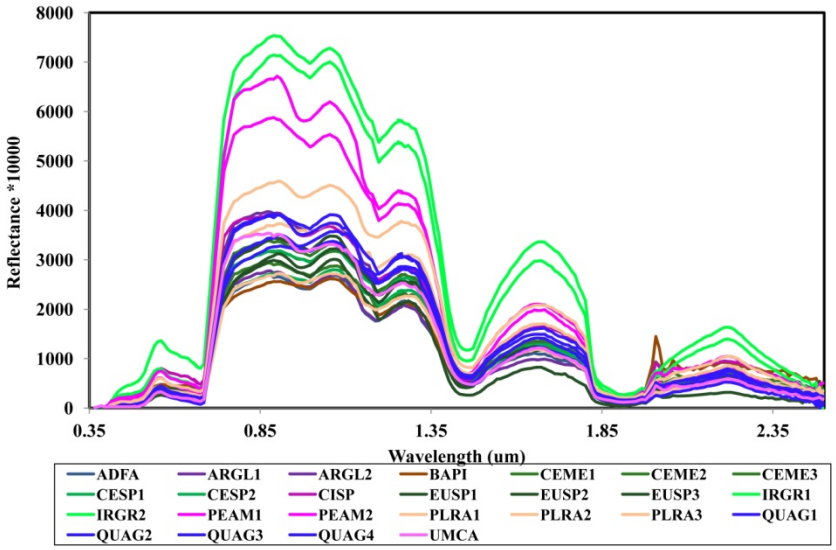
- Traditional: EAR/ MASA/COB
- Automated: Iterative Endmember Selection (IES) (Schaaf/Roth)
- Forced IES
  - Injects EMC optimal ems into IES for weak or missing classes
  - Continues until Kappa does not improve
  - Final library can be cut off at any number
    - 101

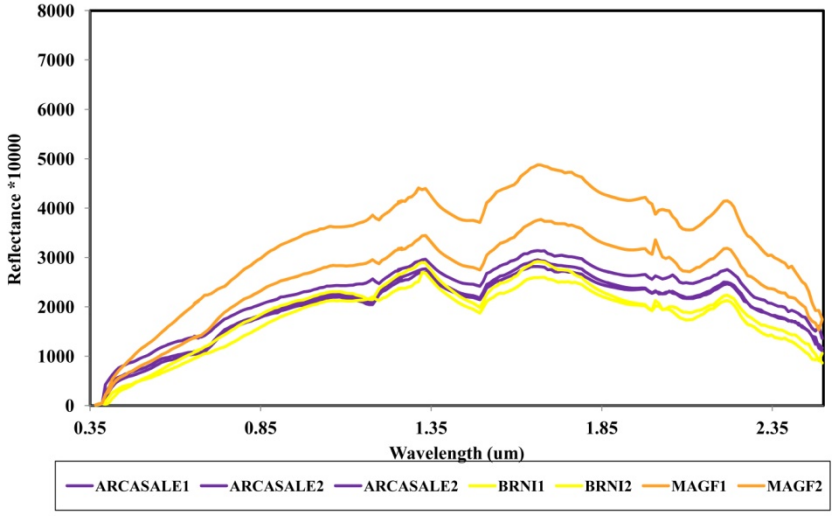


See Roth et al., 2012

Endmember Spectra

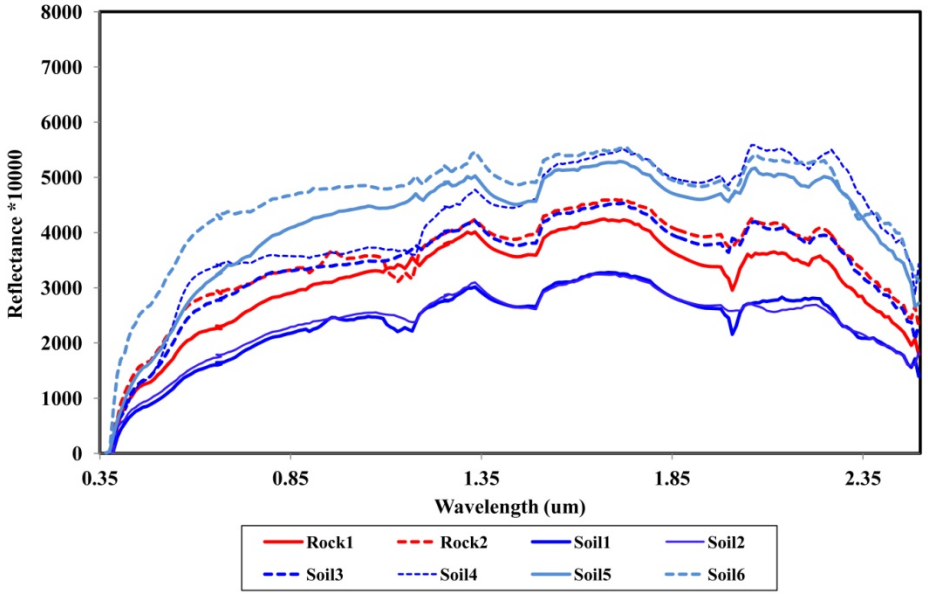
- 2em classification
  - 101 endmembers
    - 67 GV
    - 11 GV-NPV (can be either)
    - 3 Rock
    - 7 Soil
    - 13 urban
- GV
  - No mixtures, reduced redundancy
  - 25 endmembers
  - 1 to 3 per species
- NPV
  - 7 endmembers
  - 3 Arcasale, 2 brni, 2 magf

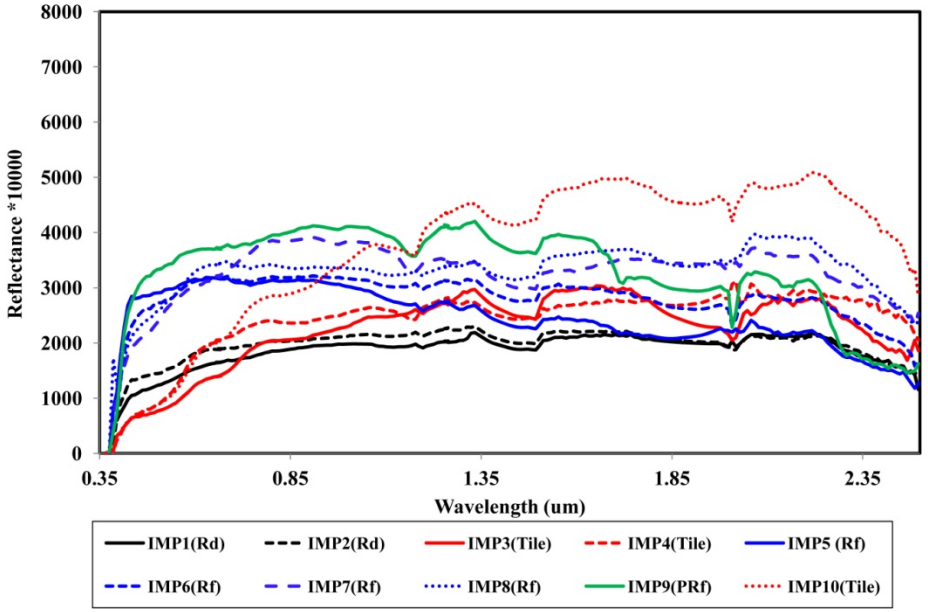




Endmember Spectra

- **Soil/Rock**
  - **8 endmembers**
  - **2 rocks**
  - **6 soils**
- **Impervious/urban**
  - **10 endmembers**
  - **2 roads**
  - **3 tile roofs**
  - **4 composite roofs**
  - **1 painted roof**





Results: Classification

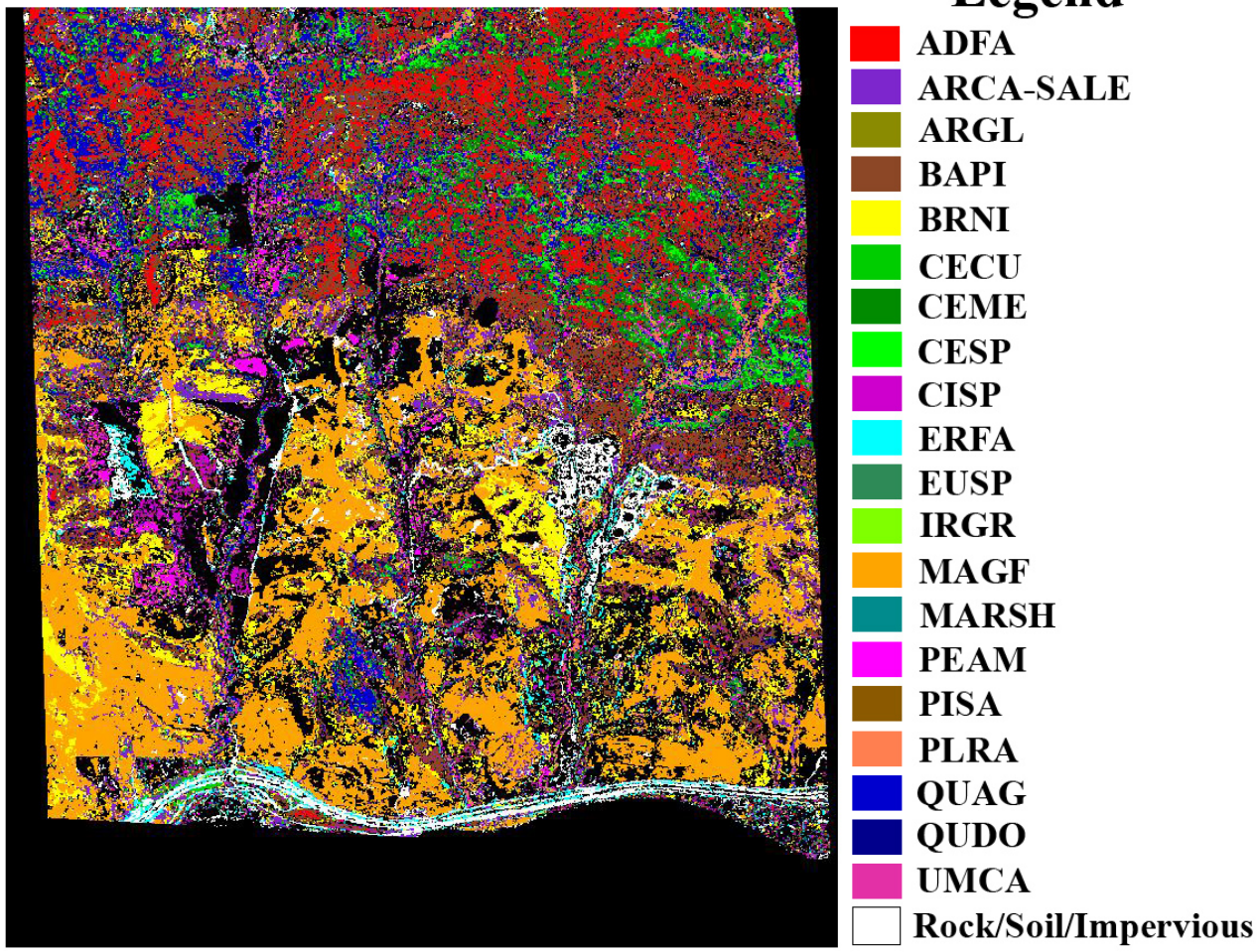
	ADFA	ARCA-SALE	ARGL	BAPI	BRNI	CECU	CEME	CESP	CISP	ERFA	EUSP	IRGR	MAGF	MARSH	PEAM	PISA	PLRA	QUAG	QUDO	ROCK	SOIL	UMCA	urban	Users
ADFA	3239	5	781	23	3	76	386	93	0	10	308	0	1	76	2	417	19	165	643	0	0	6	11	51.71
ARCA-SALE	122	3606	0	21	202	57	2	4	0	267	2	0	42	10	0	18	0	11	128	4	20	0	6	79.74
ARGL	54	0	628	0	0	16	129	44	0	0	185	5	0	0	28	1	18	33	1	0	0	10	4	54.33
BAPI	287	151	30	661	161	32	88	107	49	129	521	6	27	751	49	405	28	245	1334	0	5	6	32	12.95
BRNI	64	81	2	69	2973	7	1	1	5	107	108	67	114	83	46	111	0	14	367	0	34	0	6	69.79
CECU	54	130	2	5	0	187	6	0	0	0	18	0	0	327	0	12	0	0	38	0	2	0	4	23.82
CEME	451	0	256	7	0	42	1549	434	1	0	145	0	0	2	12	223	146	302	120	0	0	9	4	41.83
CESP	33	0	5	0	0	0	14	734	0	0	27	0	0	0	1	76	34	215	39	0	0	13	1	61.58
CISP	73	1	27	42	299	4	41	34	1053	136	159	29	2	2190	234	94	32	29	69	0	0	0	202	22.17
ERFA	104	113	6	5	24	3	8	10	8	2416	25	0	21	476	24	14	13	3	25	5	15	0	193	68.81
EUSP	15	0	20	3	1	0	76	84	0	0	3430	6	0	40	2	8	3	44	1	0	0	3	11	91.54
IRGR	0	0	0	1	350	0	1	5	46	0	20	1239	0	2	542	0	92	11	0	0	0	2	12	53.34
MAGF	12	134	2	22	958	5	0	0	2	48	47	88	2045	2	15	15	0	2	121	5	180	0	5	55.15
MARSH	78	4	11	11	2	29	33	16	36	0	121	0	1	4086	7	68	15	13	57	0	0	0	147	86.29
PEAM	22	0	38	1	48	5	40	74	1	2	332	41	0	0	5078	52	99	95	88	0	0	26	11	83.89
PISA	16	0	1	2	0	61	0	0	0	0	60	0	0	0	0	37	0	0	28	0	0	0	4	17.7
PLRA	17	0	15	1	4	0	22	36	64	0	24	11	0	0	508	5	775	110	2	0	0	19	3	47.96
QUAG	141	0	75	1	0	0	105	682	0	0	787	10	0	8	73	145	317	2641	259	0	0	319	1	47.47
QUDO	148	5	19	62	2	1	49	110	2	0	414	3	0	284	10	418	16	179	1930	0	2	8	10	52.56
ROCK	12	7	0	0	23	0	0	0	1	25	0	0	29	8	0	0	0	2	0	24	83	0	26	10
SOIL	11	39	0	0	2	0	0	13	2	37	1	0	15	78	12	0	2	0	1	22	979	0	451	58.8
UMCA	0	0	2	0	0	0	0	6	0	0	0	0	0	0	1	0	2	108	0	0	0	59	0	33.15
urban	25	5	5	0	2	2	19	22	9	2	27	1	24	437	16	7	15	1	11	1	205	0	4279	83.66
Unmodeled	8	1	0	25	817	0	0	4	141	3	134	1138	7	65	455	8	11	5	17	12	24	0	1037	0
Producers	64.96	84.21	32.62	68.71	50.64	35.48	60.3	29.21	74.15	75.93	49.75	46.86	87.84	45.78	71.37	1.73	47.34	62.46	36.56	32.88	63.2	12.29	66.24	

Overall Accuracy	0.5597
kappa	0.53515

- Model 101: Kappa 0.555, Overall 56%
- Excellent (> 85%: Green): ARCA-SALE, CISP, ERFA, MAGF, PEAM
- Very good(> 60%: Orange): ADFA, BAPI, CEME, QUAG, SOIL, Urban
- Poor (< 30%: Red): CESP, PISA, UMCA

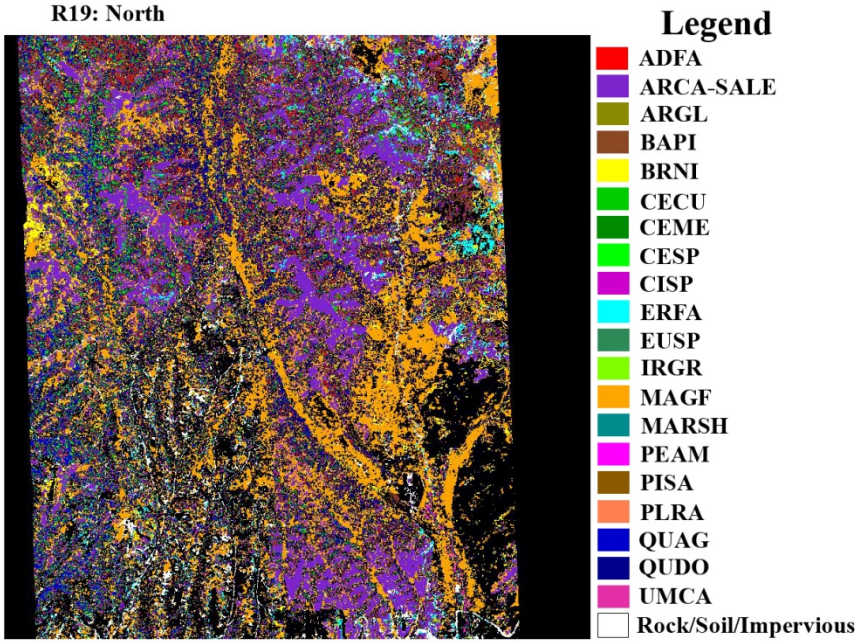
Results: Classification

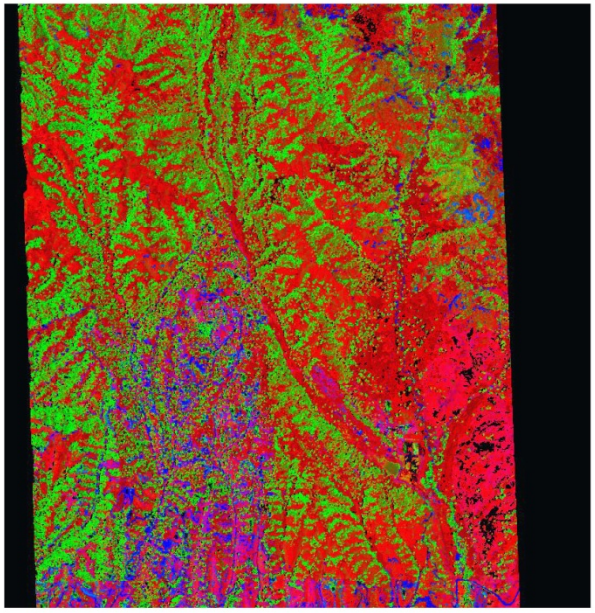
R19: South



- The map is better than the validation suggests
- All but a few classes (PISA, UMCA) are generally correct, BAPI is overmapped
- Polygon Accuracy based on most abundant: 84.7%

Class vs Composition: North





NPV, GV, Soil RGB

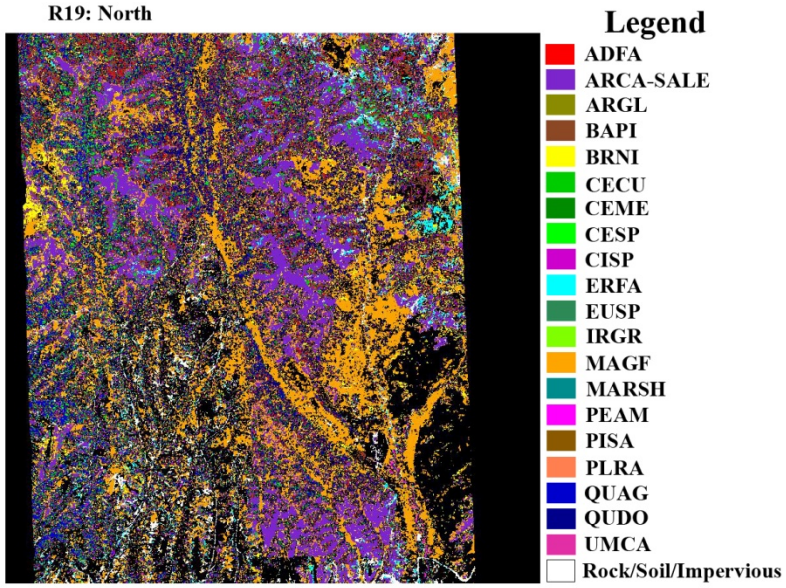
Class

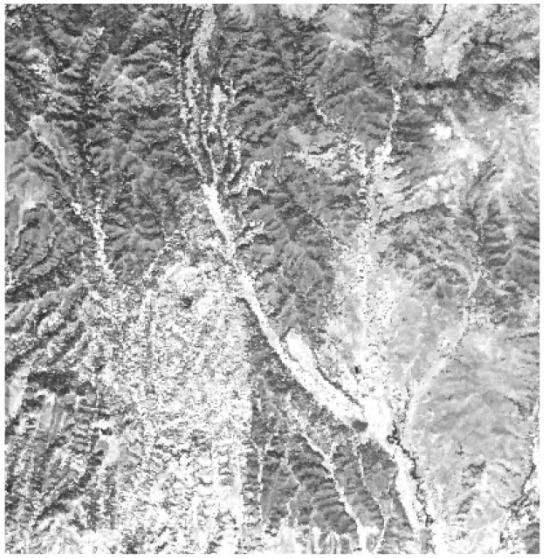
- ARCASALE
- MAGF
- ERFA
- Lesser ADFA, QUDO/QUAG
- Unclassified (bright MAGF, SOILS)

Composition

- High GV: QUDO/QUAG (in valleys)
- Mixed GV/NPV: ARCASALE/ERFA
- High NPV: MAGF/BRNI?

Class vs Temperature: North



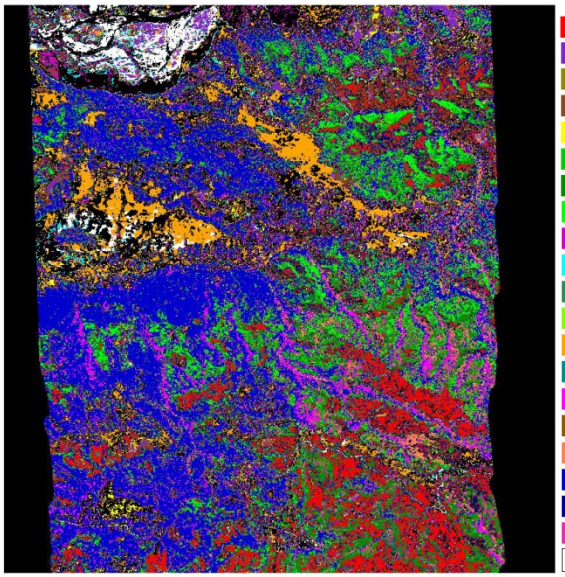


Temperature

- **Class**
  - **ARCASALE**
  - **MAGF**
  - **ERFA**
  - **Lesser ADFA, QUDO/QUAG**
  - **Unclassified (bright MAGF, SOILS)**
- **Temperature**
  - **Cool: QUDO/QUAG (in valleys)**
  - **Warm ARCASALE/ERFA**
  - **Hot: MAGF, Soils**

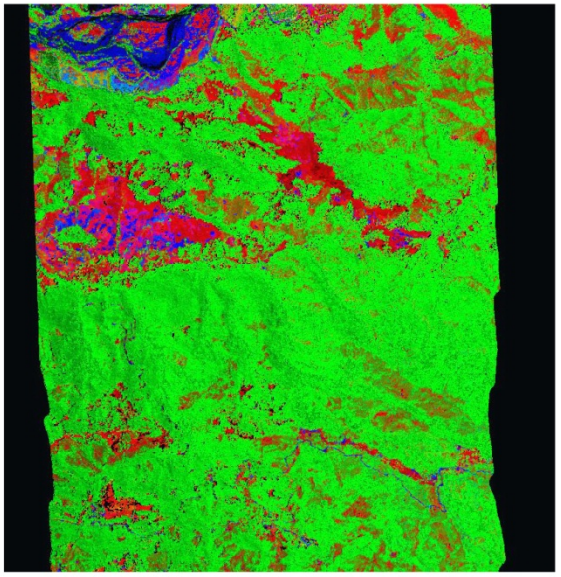
Class vs Composition: Central

R19: Central



Legend

- ADFA
- ARCA-SALE
- ARGL
- BAPI
- BRNI
- CECU
- CEME
- CESP
- CISP
- ERFA
- EUSP
- IRGR
- MAGF
- MARSH
- PEAM
- PISA
- PLRA
- QUAG
- QUDO
- UMCA
- Rock/Soil/Impervious

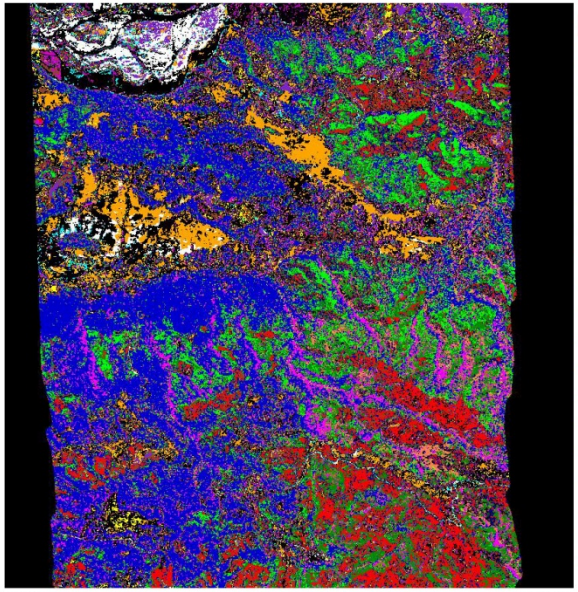


NPV, GV, Soil RGB

- **Class**
  - ADFA
  - QUDO
  - QUAG
  - CEME, CECU, CESP
  - Rock/Soil
  - MAGF
- **Composition**
  - High GV: All but MAGF and River channel
  - Mixed GV/NPV: ADFA, BAPI (higher NPV- probably something else)
  - High NPV: MAGF
  - High Rock/Soil; River channel

Class vs Temperature: Central

R19: Central



Legend

- ADFA
- ARCA-SALE
- ARGL
- BAPI
- BRNI
- CECU
- CEME
- CESP
- CISP
- ERFA
- EUSP
- IRGR
- MAGF
- MARSH
- PEAM
- PISA
- PLRA
- QUAG
- QUDO
- UMCA
- Rock/Soil/Impervious

Temperature

- **Class**
  - ADFA
  - QUAG, some QUDO
  - CEME, CECU, CESP
  - Rock/Soil
  - MAGF
- **Composition**
  - Cold: North facing slope, dominated by trees (QUAG)
  - Cool: South facing slopes, flat terrain dominated by shrubs (ADFA, Ceanothus
  - Hot: Bare rock on ridges, river channels, MAGF

Class vs Composition: South

R21 west

NPV, GV, Soil RGB

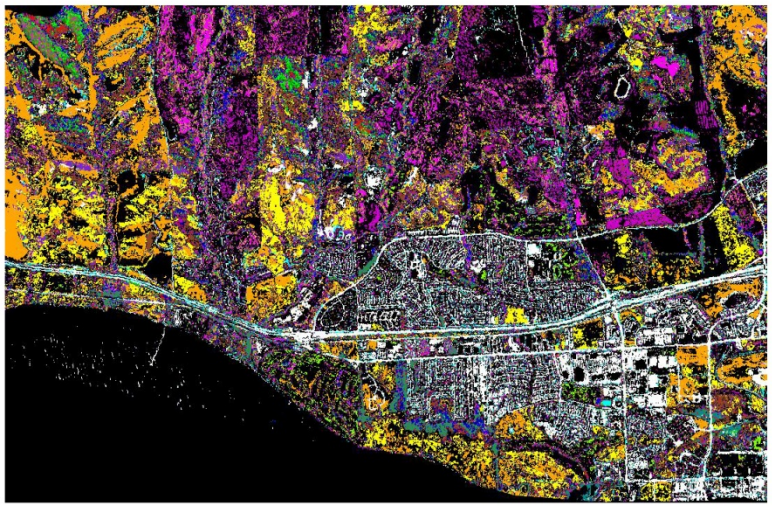
Legend

- ADFA
- ARCA-SALE
- ARGL
- BAPI
- BRNI
- CECU
- CEME
- CESP
- CISP
- ERFA
- EUSP
- IRGR
- MAGF
- MARSH
- PEAM
- PISA
- PLRA
- QUAG
- QUDO
- UMCA
- Rock/Soil/Impervious

- **Class**
  - MAGF
  - BRNI
  - EUSP
  - PEAM
  - CISP
  - BAPI
  - Urban/Soil
  - Minor Marsh
- **Composition**
  - High GV: PEAM, CISP, EUSP
  - Mixed NPV-GV: BAPI
  - High NPV: MAGF, BRNI
  - High soils/Impervious: Urban

Class vs Temperature: South

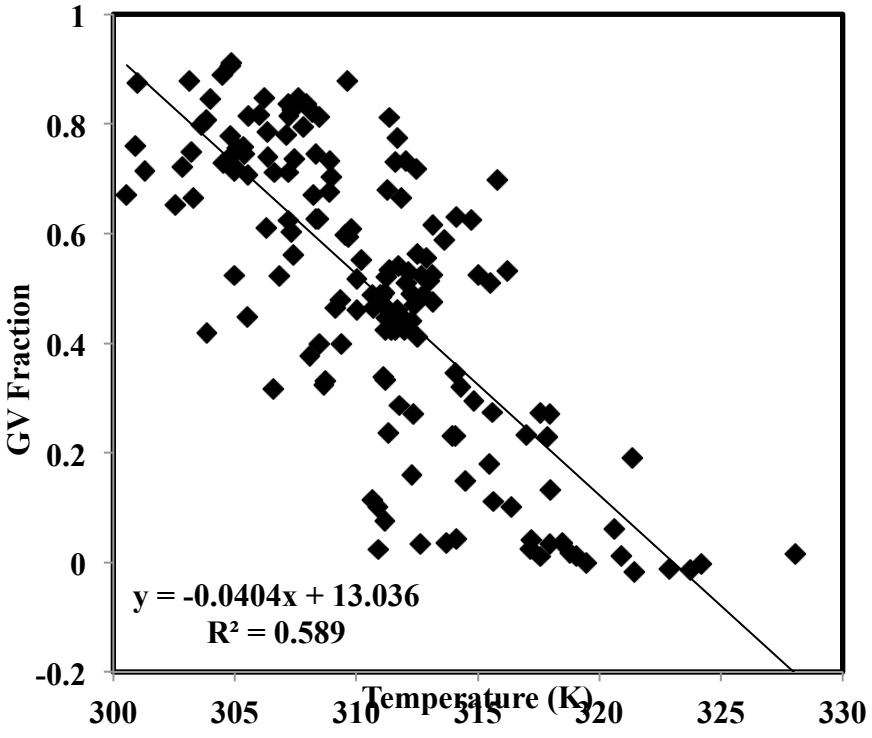
R21 west

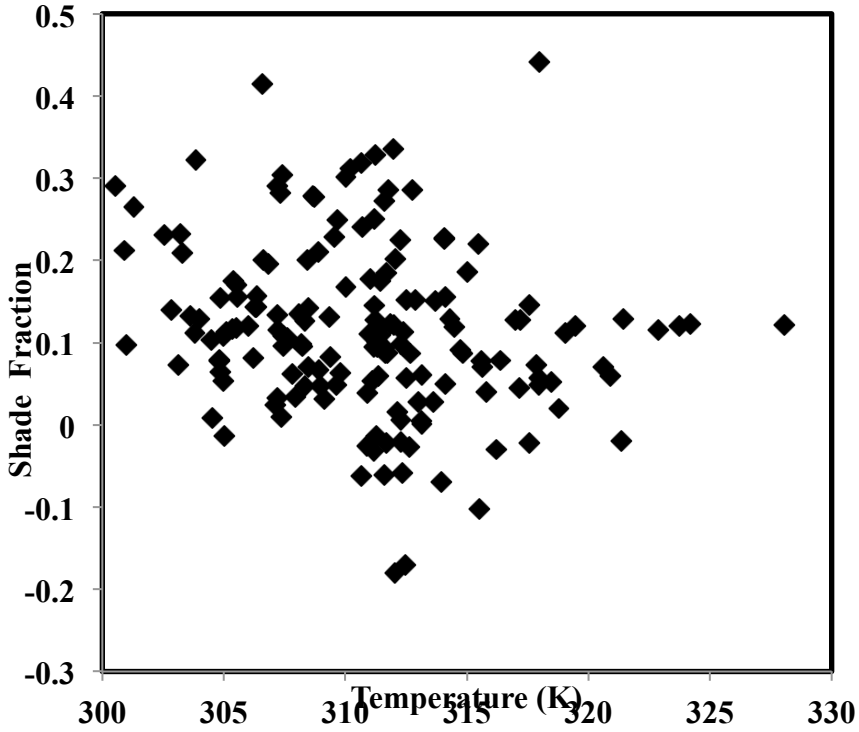


Temperature

- Class
  - MAGF
  - BRNI
  - EUSP
  - PEAM
  - CISP
  - BAPI
  - Urban/Soil
  - Minor Marsh
- Temperature
  - Cold: EUSP
  - Cool: PEAM, CISP
  - Warm: BAPI, BRNI
  - Hot: MAGF, Urban

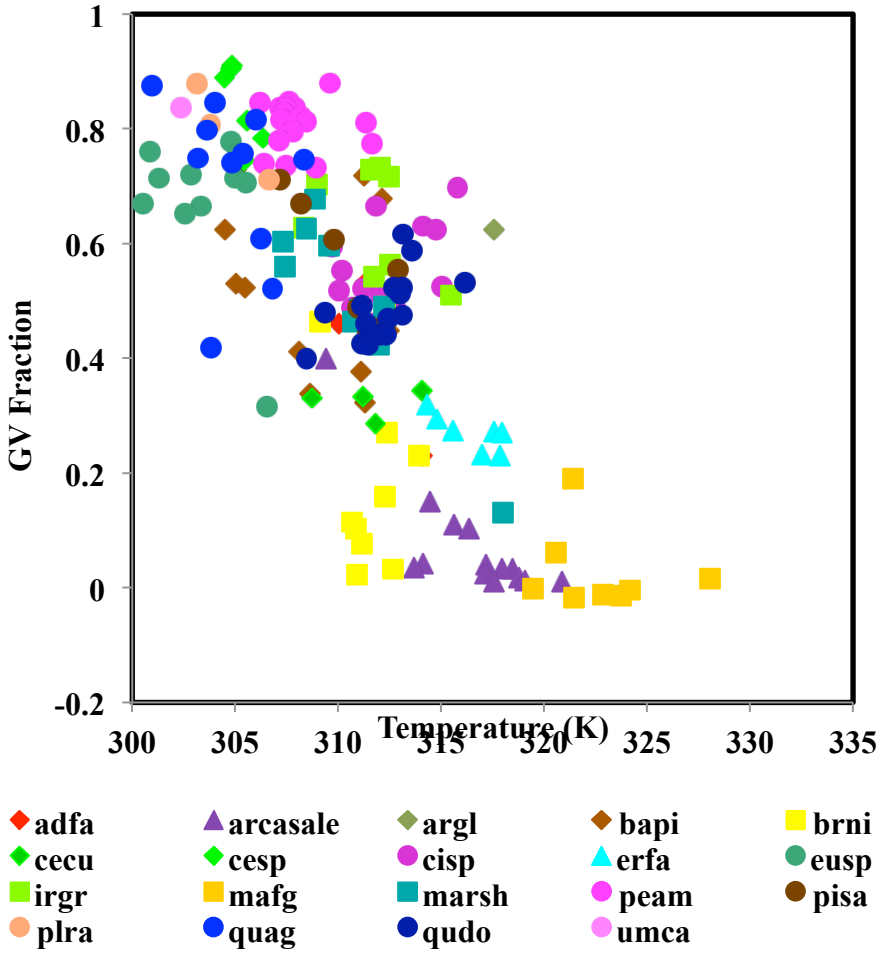
Temperature Compositional Relationships





- **GV fraction strongly inversely correlated with temperature for vegetated targets**
- **Shade fraction poorly correlated (high shade, cooler, r^2=0.04)**
  - **Shade is not just shadows, but also varies with albedo and local zenith**

Temperature Species Relationships



- Species composition strongly impacts temperature, significant clustering
- Trees (circles)
  - Coolest, high to moderate GV
- Evergreen shrubs (diamonds)
  - Warmer, high to moderate GV
- Deciduous shrubs (triangles)
  - Warm, moderate to low GV
- Forbs/grasses (squares)
  - High to low GV, warm to hot

Conclusions

- **MESMA was capable of mapping 23 species/landcover classes at reasonable accuracies**
  - **Other classifiers can do better (i.e., LDA/CDA)**
- **Plant species map out correctly in geographic space**
- **GV and temperature are inversely correlated**
- **Plant species cluster uniquely in compositional temperature space, likely resulting from functional differences**
  - **(e.g., deeply rooted, evapotranspiring cool trees vs shallow rooted partially senesced shrubs)**
- **More is coming**
  - **LDA species maps**
  - **EWT – emissivity**
  - **Water vapor TES**
  - **Full range spectroscopy**
  - **And HyspIRI!**