NASA Earth Observing System

Quantifying Changes in Carbon Pools with Shrub Invasion of Desert Grasslands using Multi-Angular Data from EOS Terra and Aqua

— introduction and preliminary results —

Carbon Pools in Desert Grasslands from EOS

— project start July 2004 —

— people —

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Carbon Pools in Desert Grasslands from EOS

Acknowledgment: This work is supported by NASA grant NNG04GK91G to EOS project EOS/03-0183-0465 under EOS/LCLUC, (program manager: Dr. Garik Gutman).

Data sets were provided by NASA EOS/EOSDIS/LaRC; NSF (grants DEB-0080412 and DEB-94-11971 to the Jornada Basin and Sevilleta NWR LTERs, respectively); and the USDA, Agricultural Research Service, Jornada Experimental Range.

overview

Goal: To improve estimates of above- and belowground C pools in desert grasslands by providing improved maps of:

- plant community type (Kremer & Running, 1993[1])
- canopy structural parameters
- soil/shrub/grass fractional cover

Approach: exploit the unique information content of multi-angle remotely-sensed data from MISR and MODIS on NASA EOS satellites.

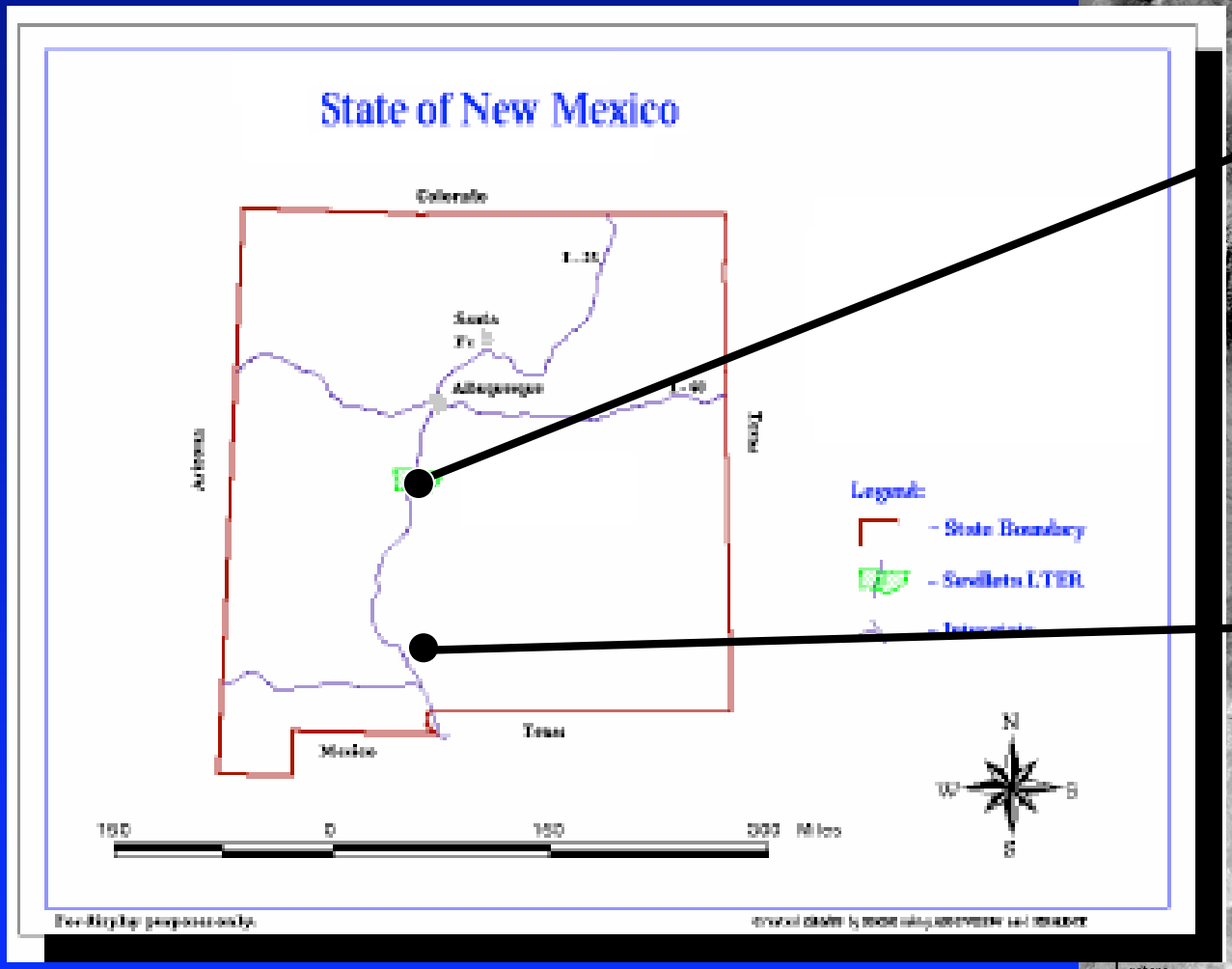
[1] See references on later slide.

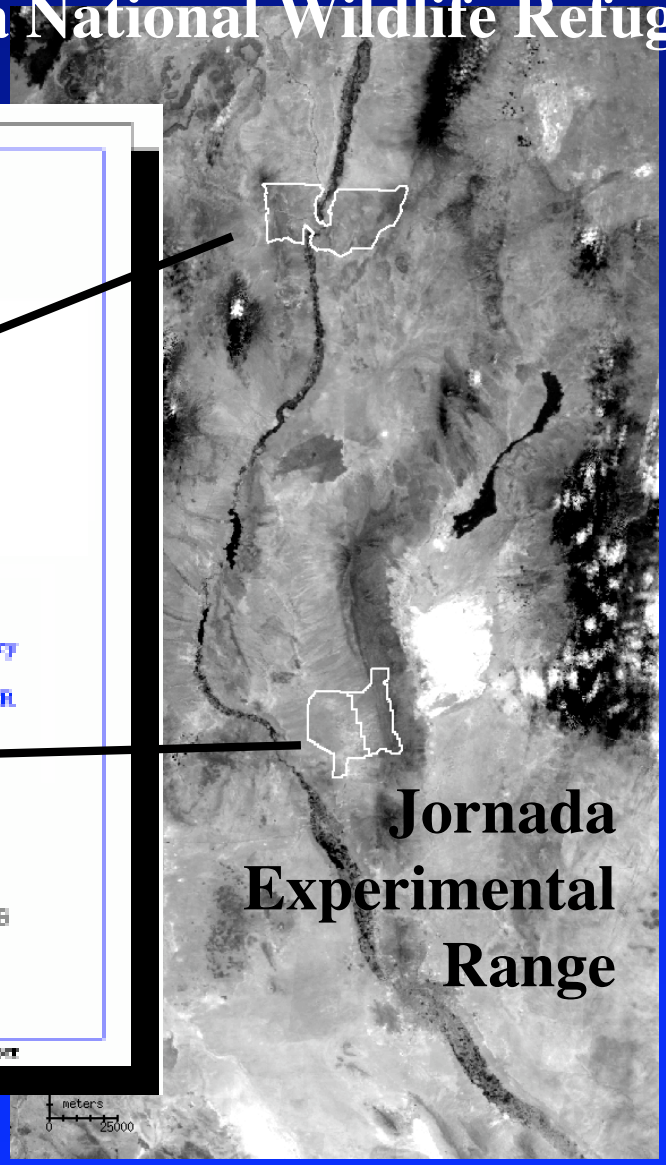
why?

1. World-wide increase in woody plant abundance in grasslands since C19th, e.g. the SW US --> changes in C pools and cycling.
2. Our ability to model biogeochemical processes depends on knowledge of cover and community type (+ other parameters).
3. Moderate resolution Earth Observation is the only technology which provides a means to map changes in community type and structure over large areas.

study area

Sevilleta National Wildlife Refuge





Jornada Experimental Range

community types

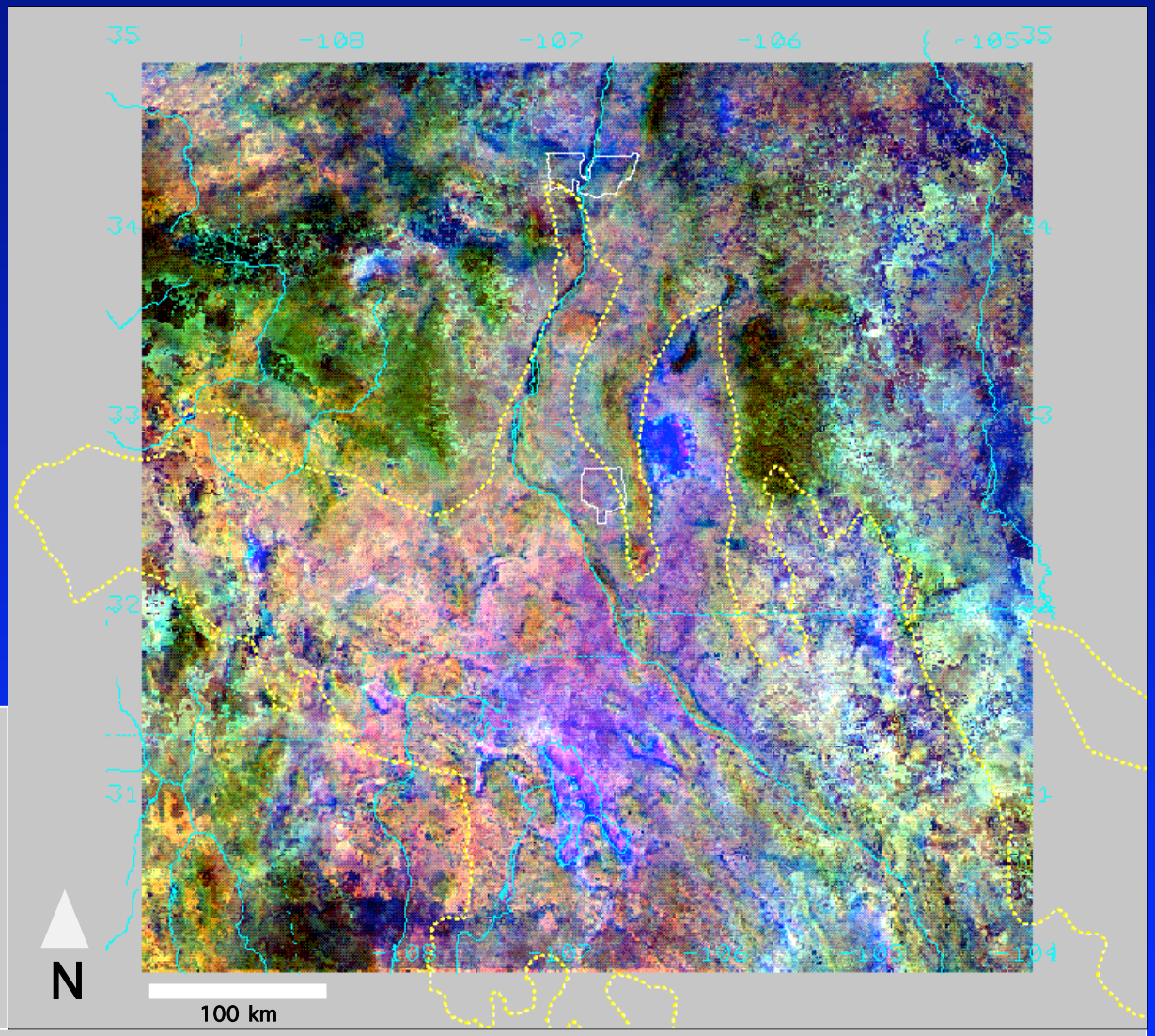
Black grama grasslands (SNWR)

The physical structure of plant communities is very different

Honey mesquite / grass transition zone (JER)

Work with the AVHRRs (AM+PM)…

Iso-Geo-Vol FCC: LiSparse-RossThin kernel weights from the AVHRR VIS BAND ONLY. The unique information content of multi-angular imagery is important.



Chihuahuan Desert northern boundary

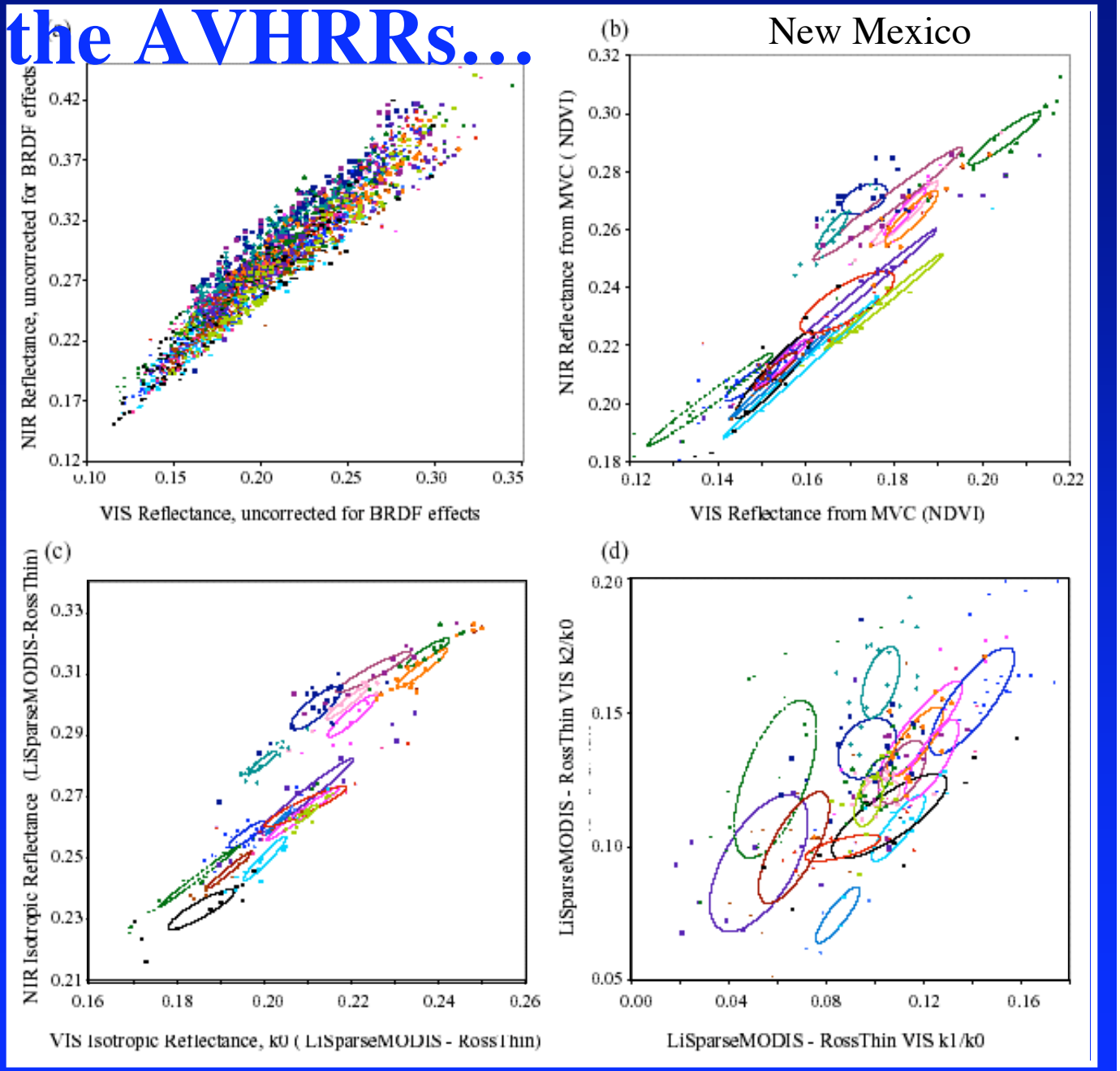
rivers and lakes

USDA-ARS Jornada Experimental Range

Kernel weights from BRDF model fitting using just the VISIBLE AVHRR channel

work with the AVHRRs…

Experiments in NM and Inner Mongolia grasslands[2] show there is great potential for exploiting the angular signal to map plant communities, *cf.* Pinty *et al.* 2002[3] & many others.



Remote Sensing Approaches

- **Kernel-driven and MPRV BRDF model inversions (both 3-parameter models)***
- **Geometric-optical models (GO) and derived models; e.g. GORT, SGM, FLAIR**
- **Empirical & derived measures: ANIX (anisotropy index); NDAX (surrogate for spectral variability of BRDF); Structural Scattering Index (Gao *et al.* 2003[4]); Clumping Index (Chen *et al.*, 2003[5]).**

*** discussed today.**

Current Work with MISR & MODIS

MISR Product: Level 1B2 Terrain Data (MI1B2T) at 275 m: red for all cameras and all bands for the An camera.

MODIS Product: MOD09 (nadir & off-nadir surface reflectance estimates at 250 m).

Bounding coordinates:

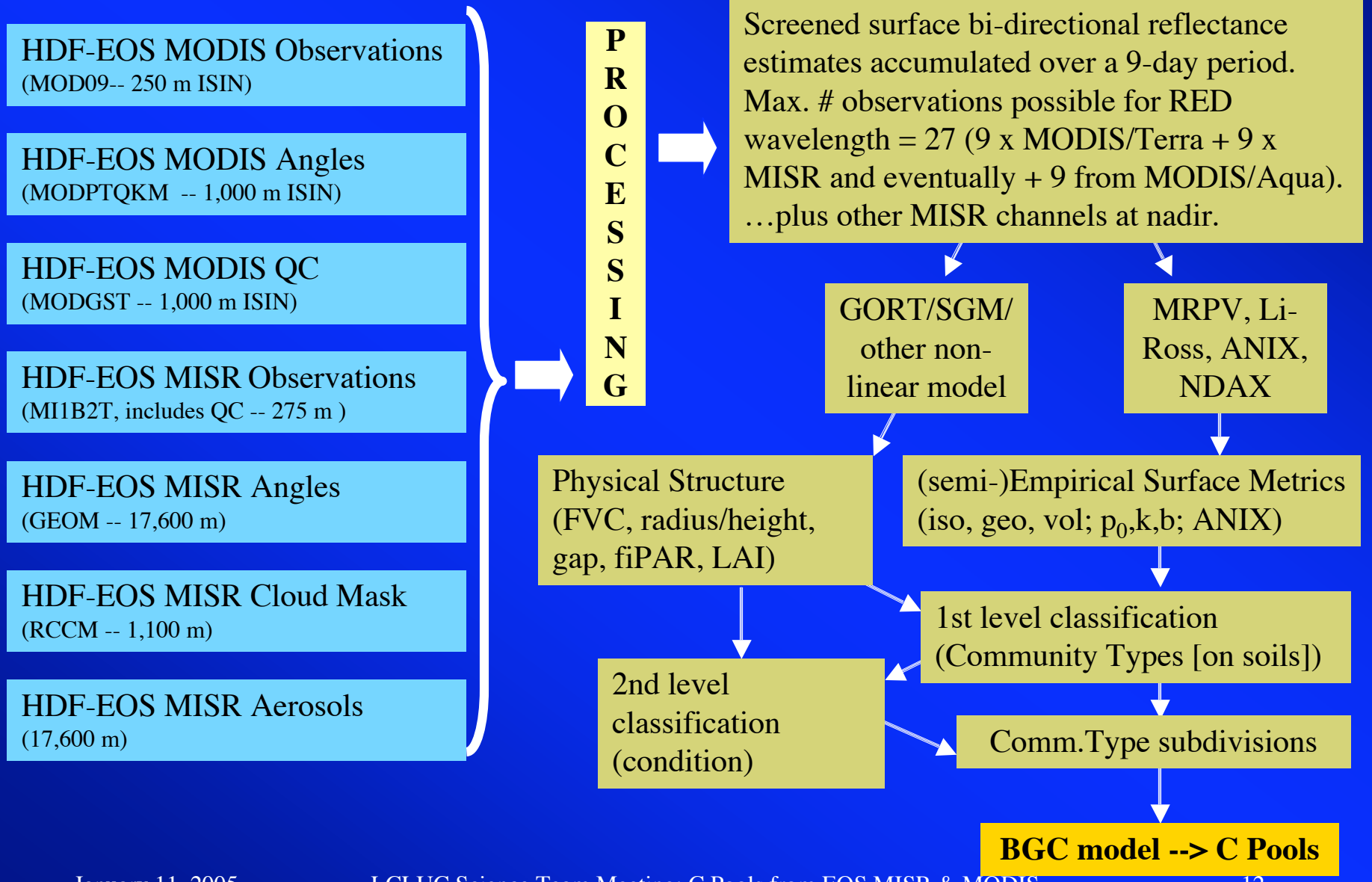
-105.5 to -111.0 degrees W

31.2 to 35.0 degrees N

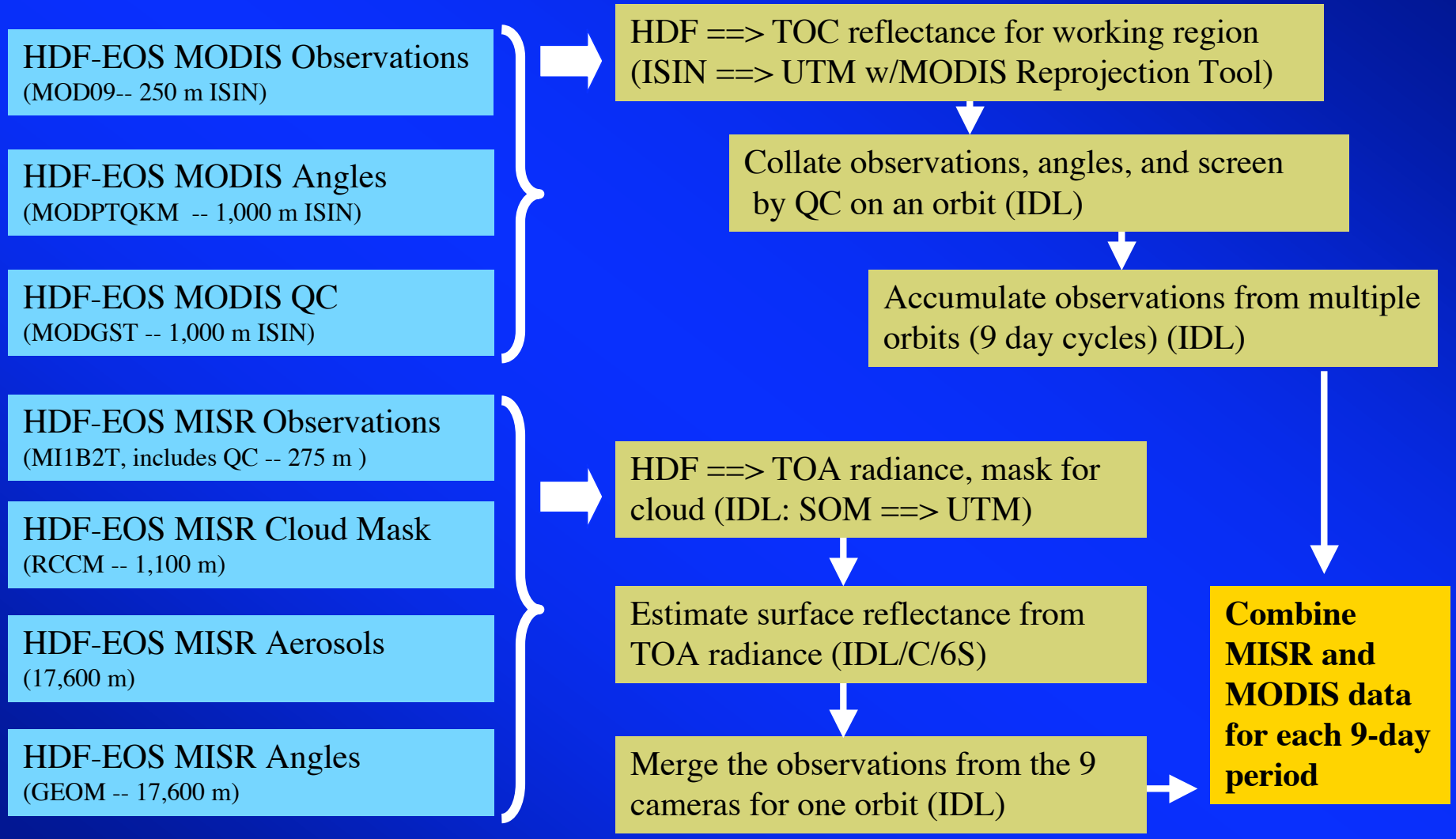
Dates:

May 15 - June 15, 2002 (end of dry season).

Current Work with MISR & MODIS



MISR & MODIS: "9x9" Processing



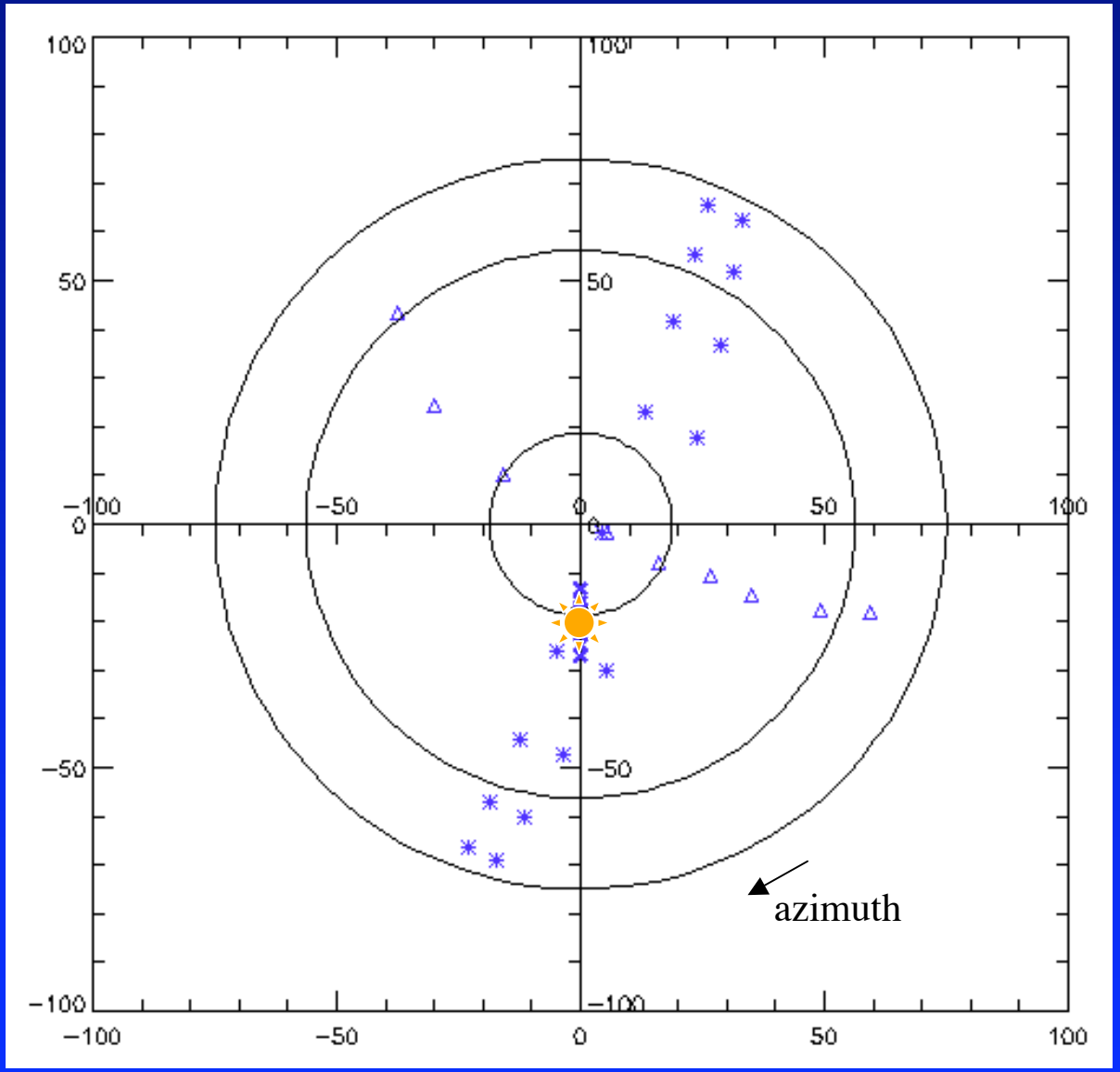
MISR & MODIS: “9x9” Data- complementarity

Angular sampling in June 2002 (9 days)

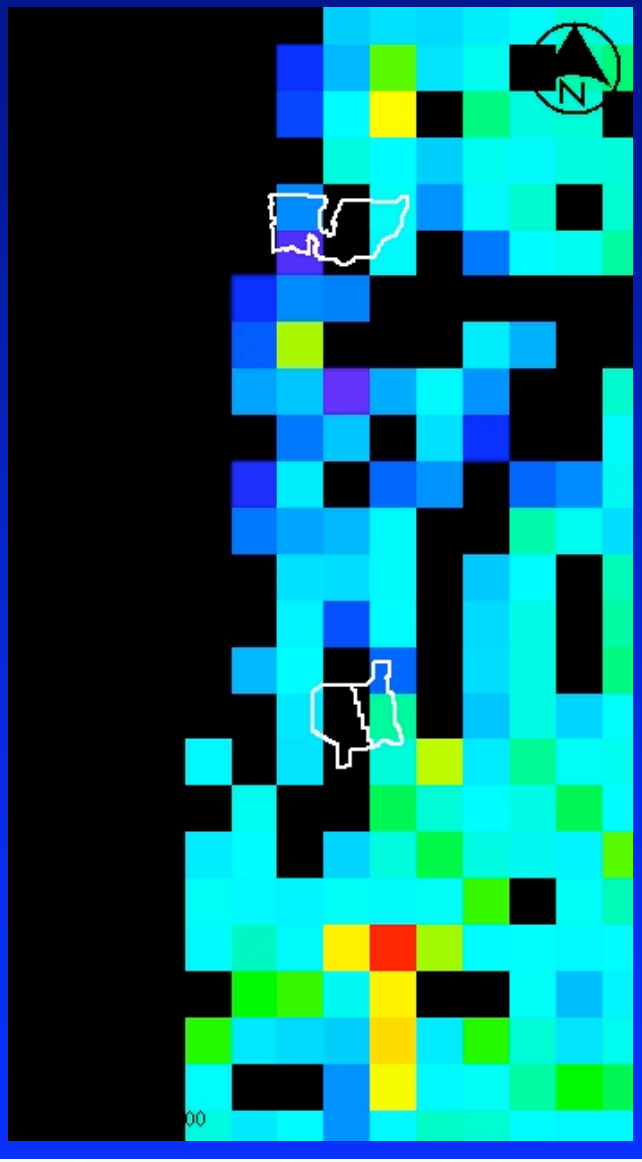
*** MISR**

□ MODIS (Terra)

☼ Sun



MISR/MRPV ρ0 and AOD (Orbit 013039)



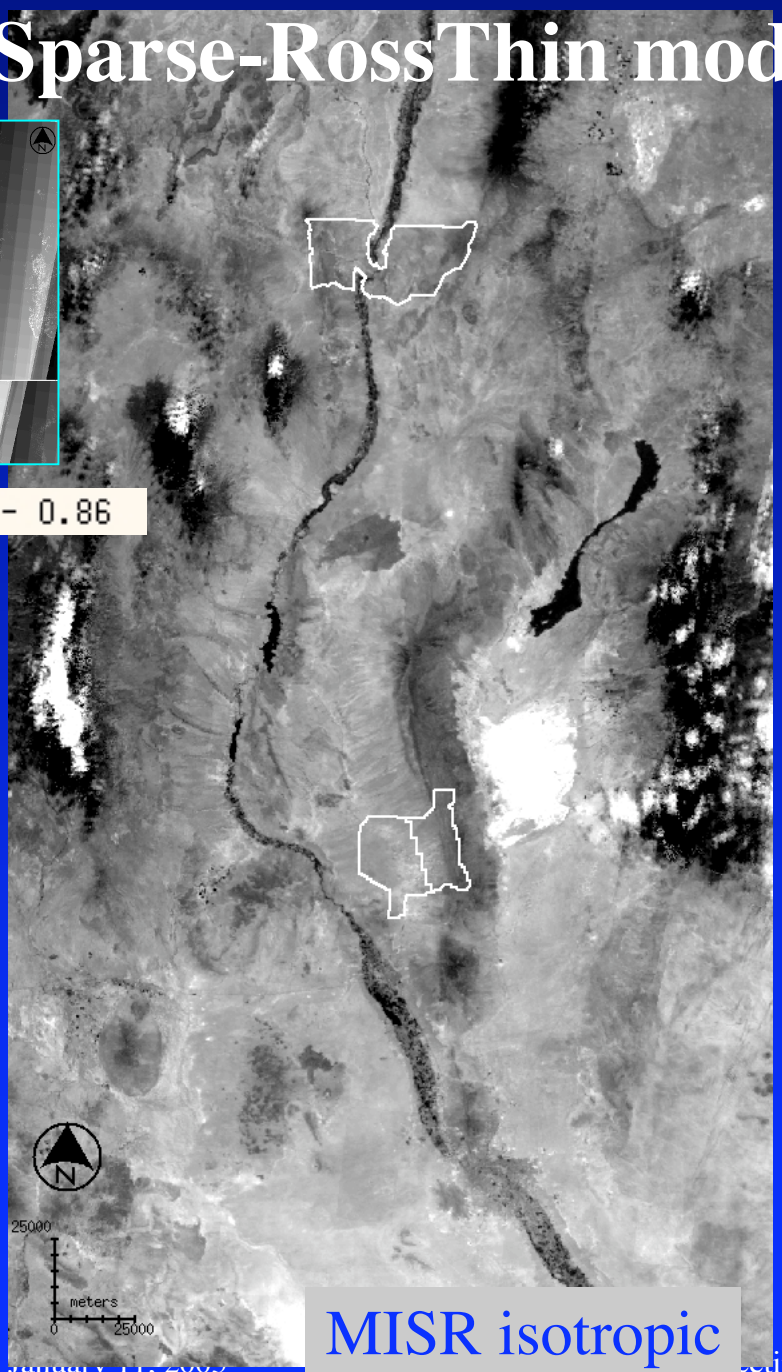
* if MISR data are missing, the AOD defaults to ~0.2 (~16 km visibility)

MISR MRPV rho0 image | MISR Aerosol Optical Depth @ 550nm (ROYGBIV = 0.251 to 0.001)

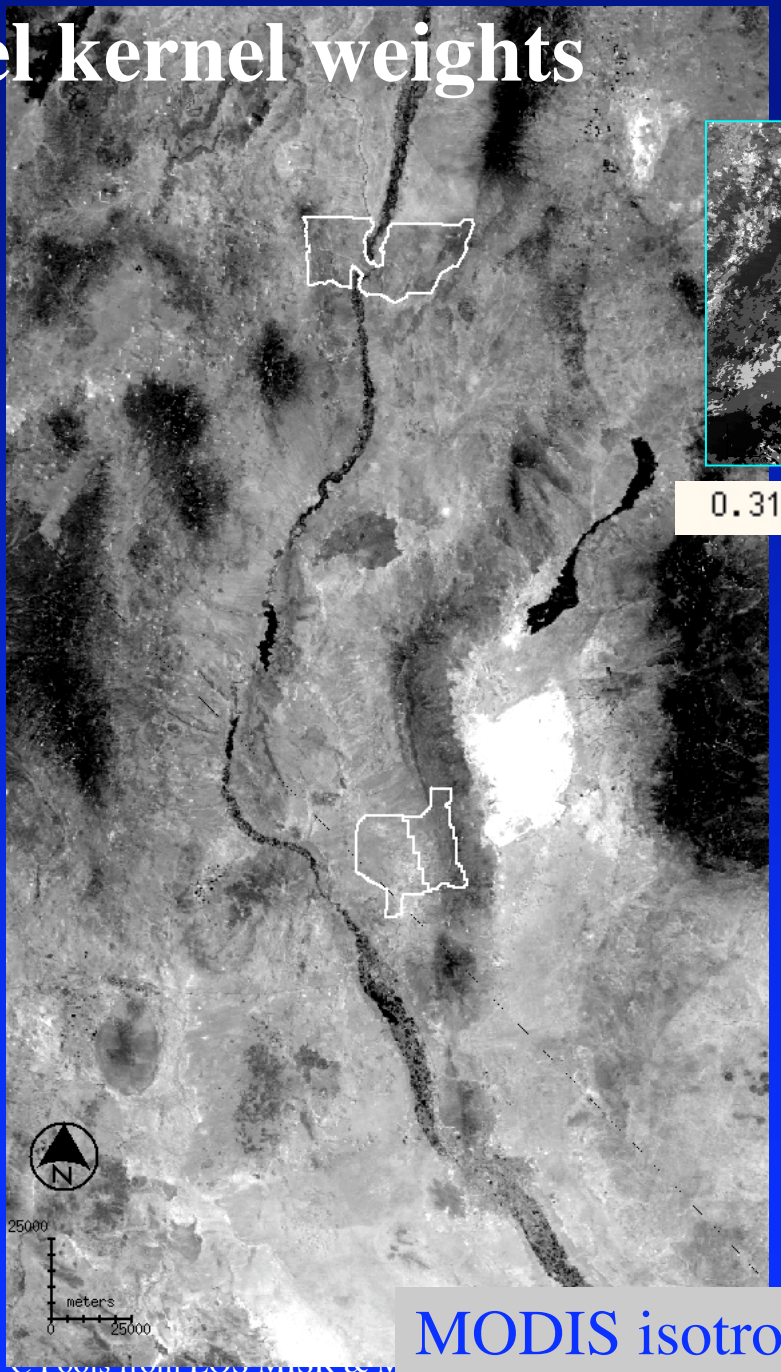
LiSparse-RossThin model kernel weights

0.35 - 0.86

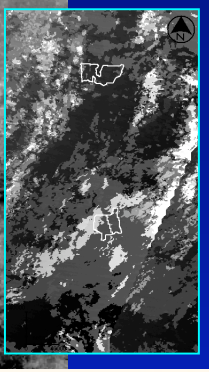
Weight of Determination -->



MISR isotropic

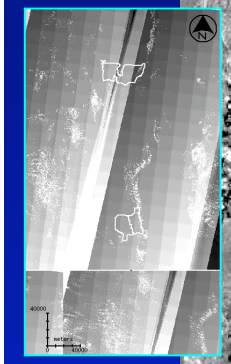


MODIS isotropic



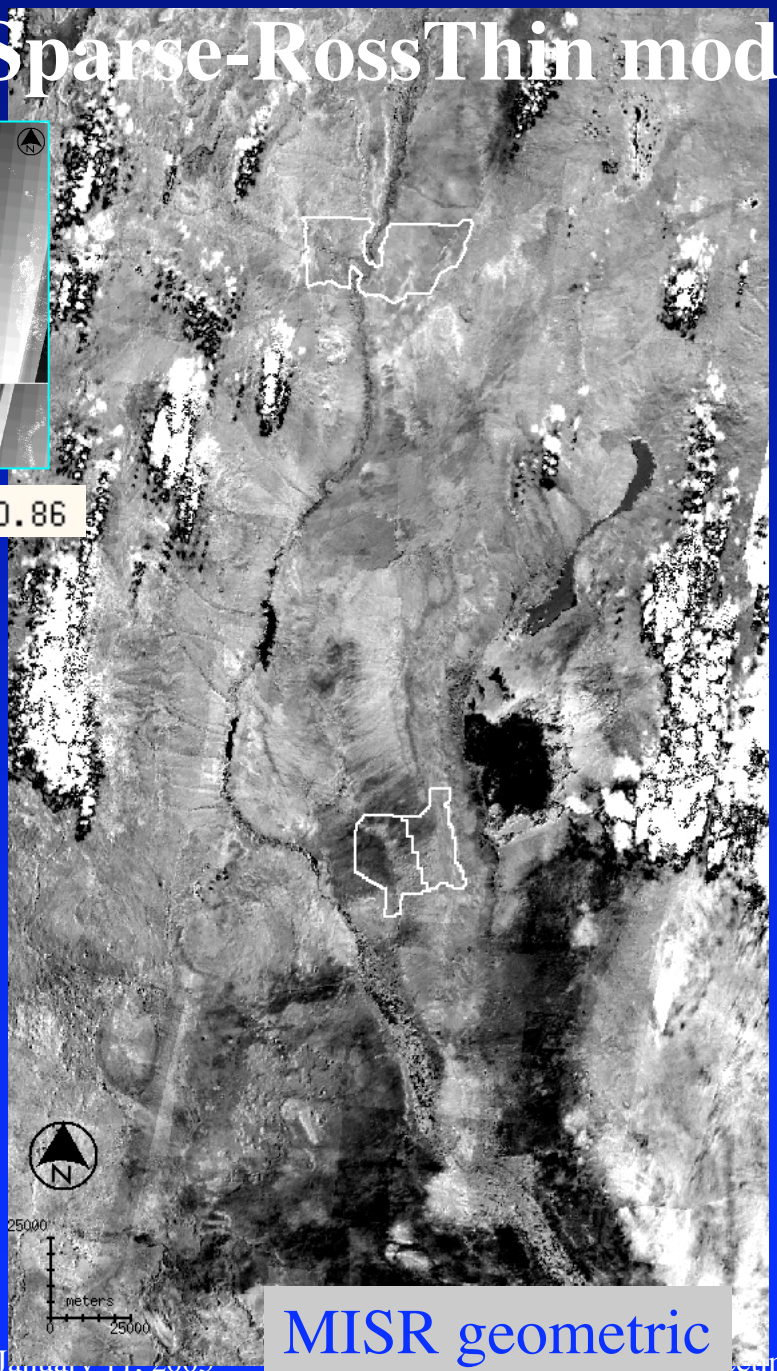
0.31 - 0.65

LiSparse-RossThin model kernel weights

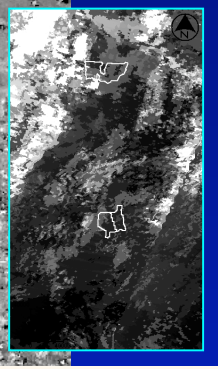


0.45 - 0.86

Weight of Determination -->



MISR geometric



0.22 - 0.66

MODIS geometric

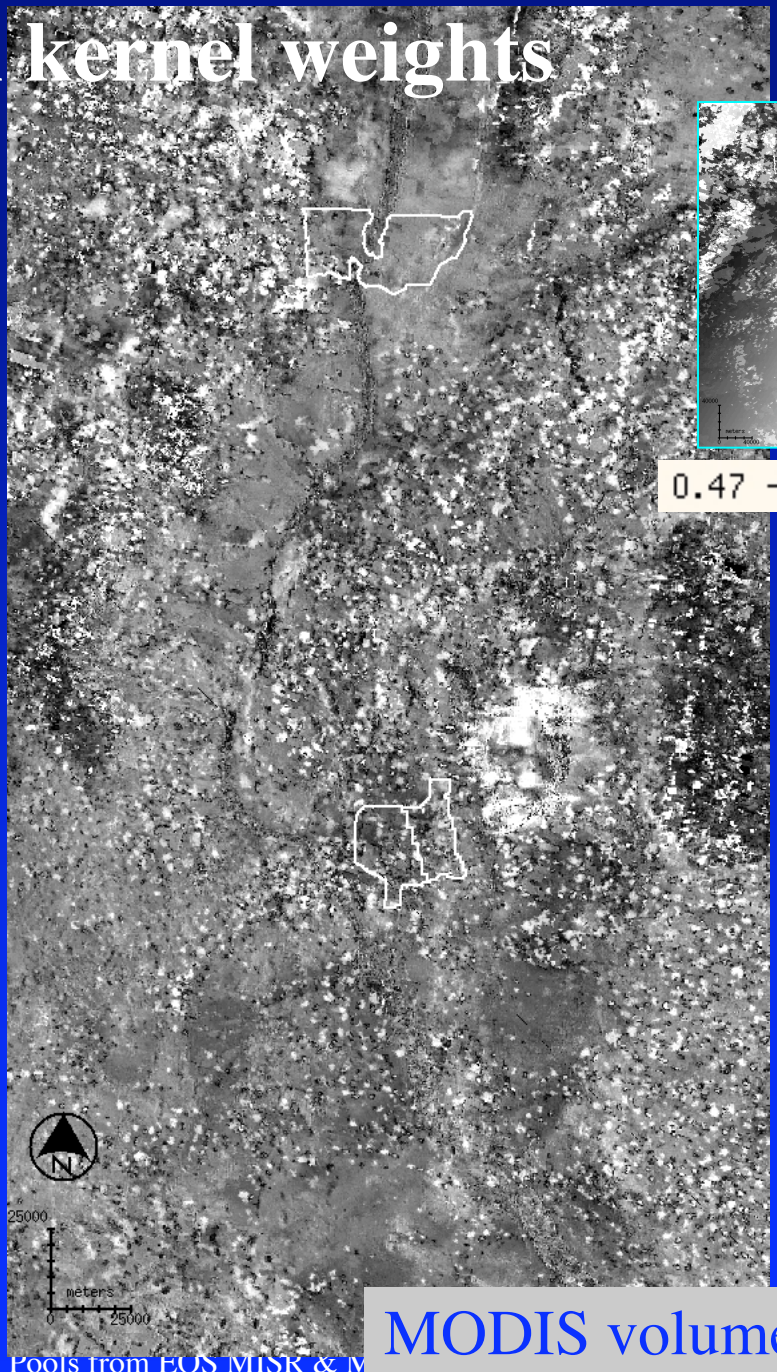
!

LiSparse-RossThin model kernel weights

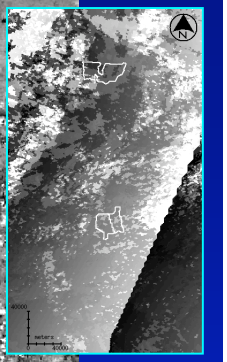
0.28 - 1.00

Weight of Determination -->

MISR volume



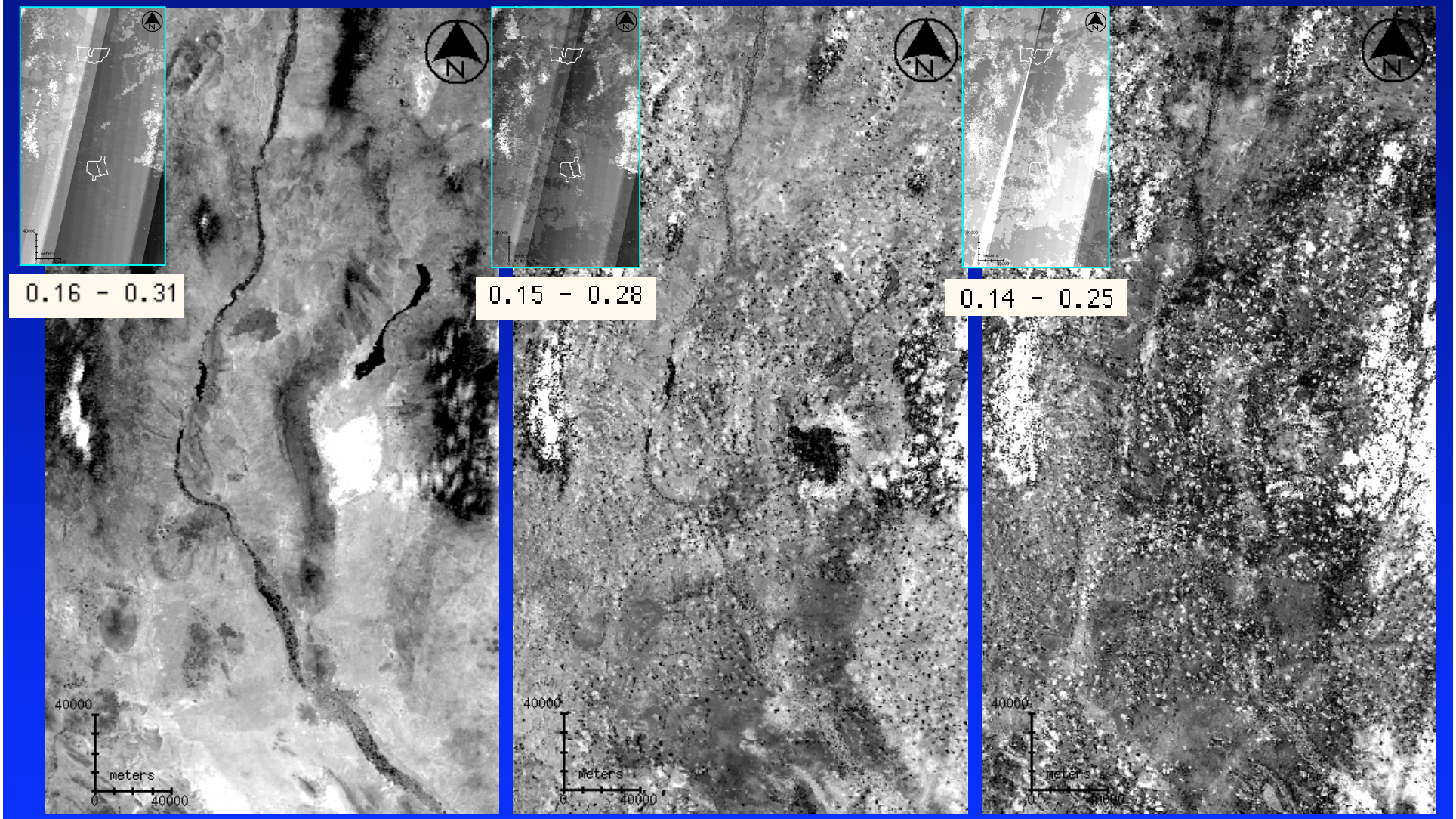
MODIS volume



0.47 - 1.17

!

LiSparse-RossThin model kernel weights



MISR+MODIS iso

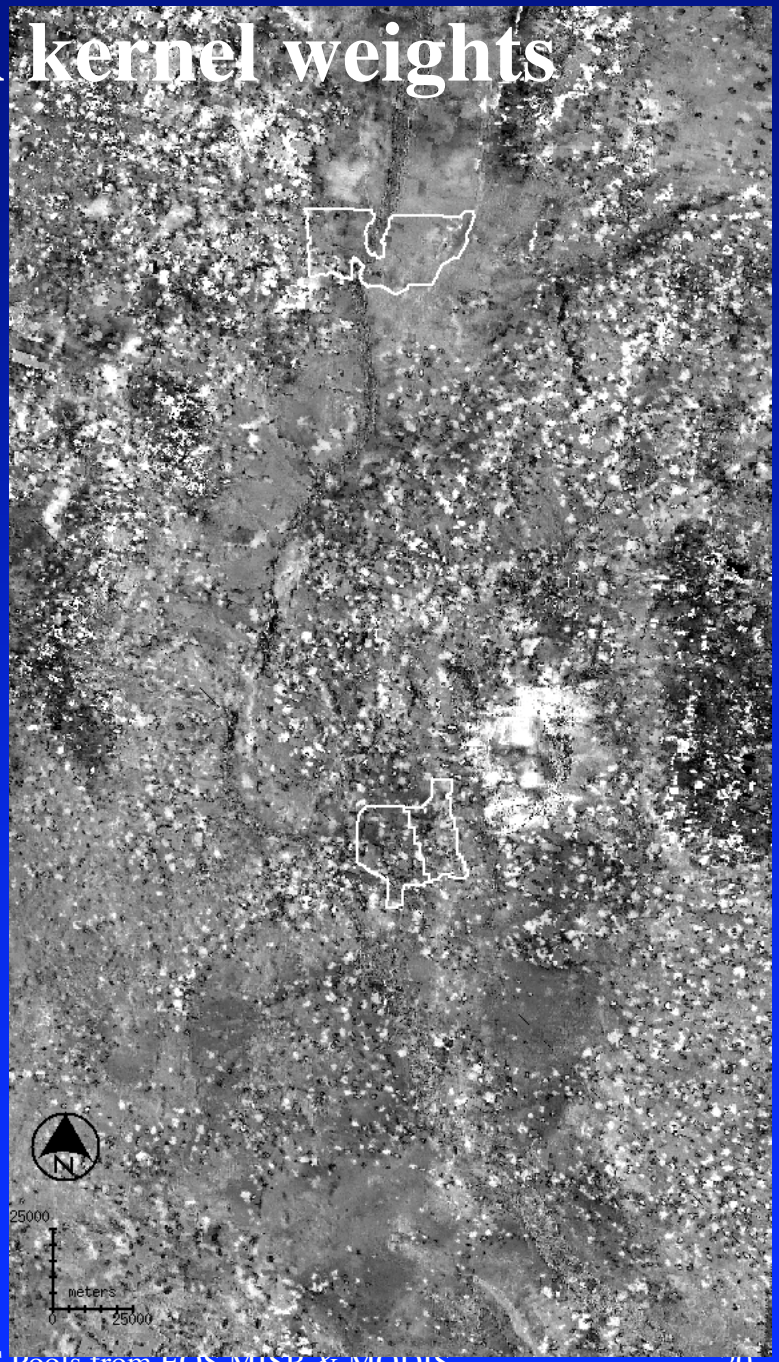
MISR+MODIS geo

MISR+MODIS vol

LiSparse-RossThin model kernel weights

Our work with MODIS shows that we have some further work to do on cloud and cloud - shadow screening.

Note that the artefacts are only apparent in the anisotropic kernel weight images.



Community Type Mapping

Jornada and Sevilleta Vegetation Maps were used to collect "signatures" from these data:

1. An camera multi-spectral (blue, green, red, NIR)
2. MRPV BRDF model parameters*
3. LiSparse-RossThin BRDF model parameters*

* Adjusted against MISR, MODIS and MISR+MODIS BRF data sets.

Community Type Mapping

Jornada Vegetation Map (Jornada LTER)

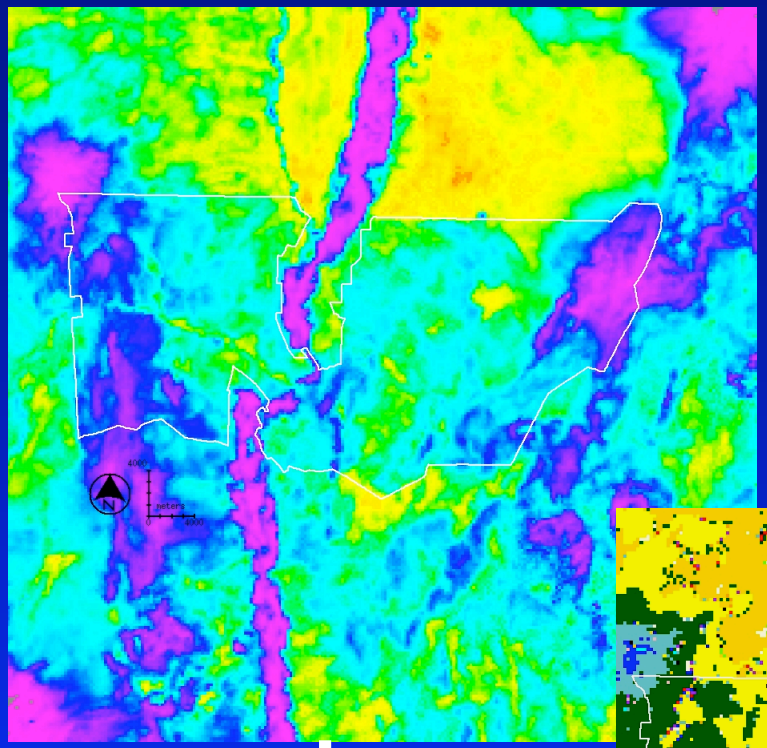
In 1998 aerial photography and field data were combined to create a current vegetation map of species composition and dominant species, including major plant communities. Using 1996 aerial photos, up to four major dominant species were estimated for each vegetation type.

Community Type Mapping

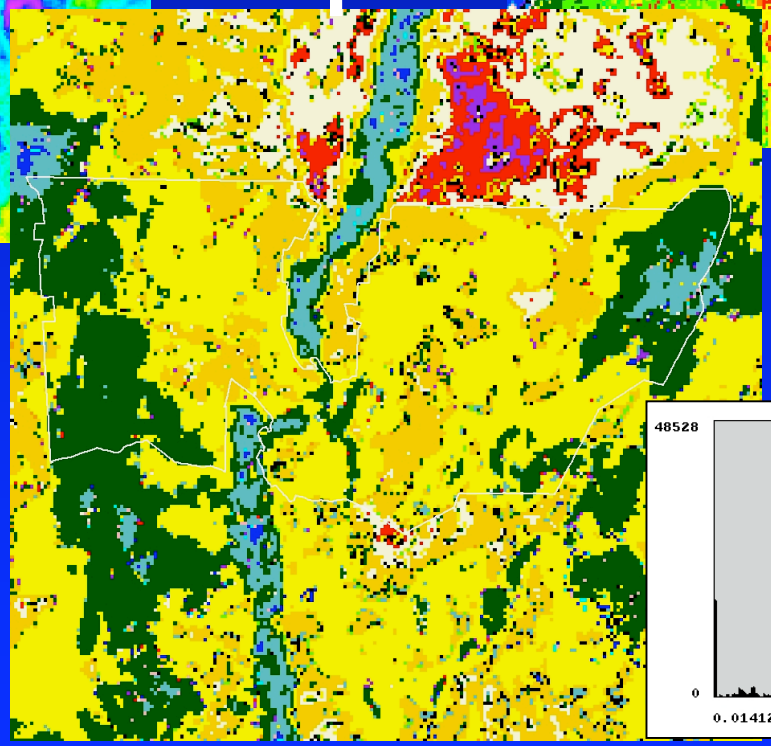
Sevilleta NWR Vegetation Map (SNWR LTER)

The map includes 13 vegetation classes derived from an unsupervised classification of 12 Landsat TM images (NDVI transformed) collected in various seasons over a seven year period from 1987. A plant classification at the association level was developed from which the initial 32 images classes were combined into the final 13 classes.

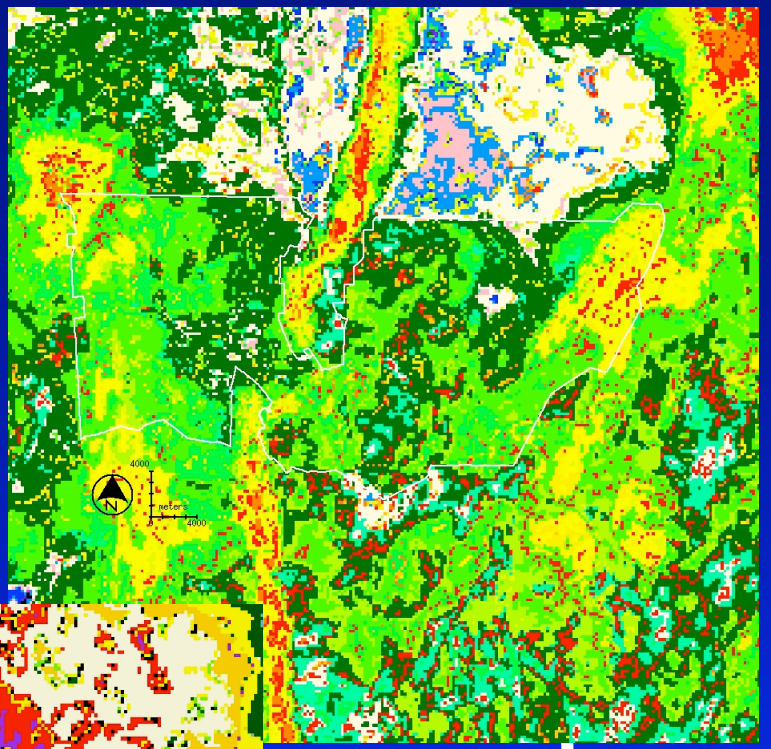
MISR/MRPV parameters



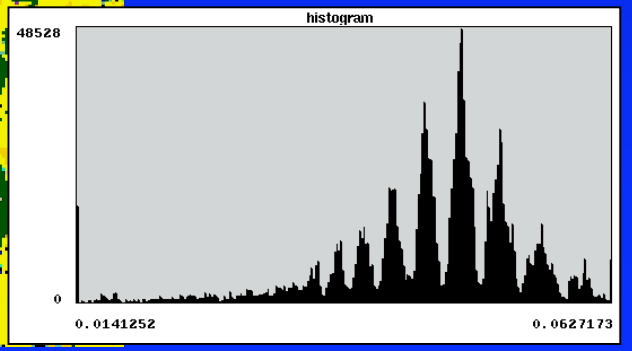
ρ_0
(magnitude)



b
(fwd or back)



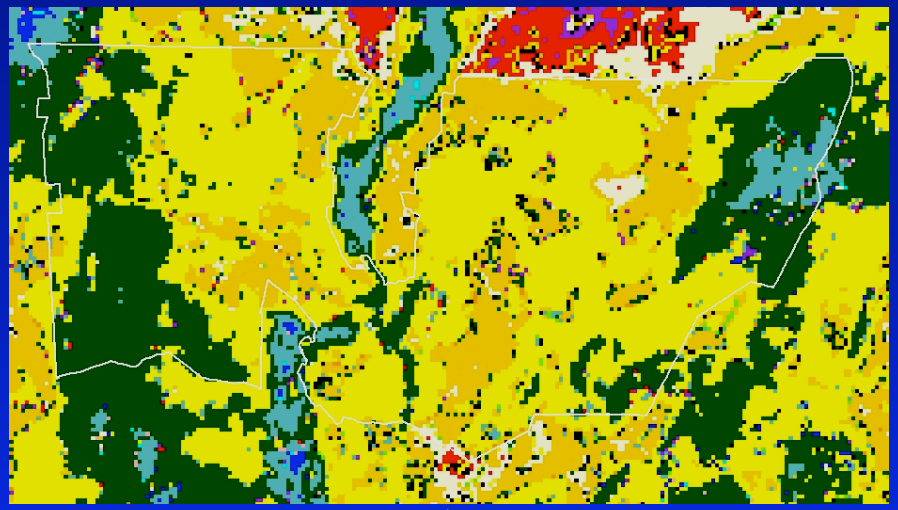
k
(bell or bowl)

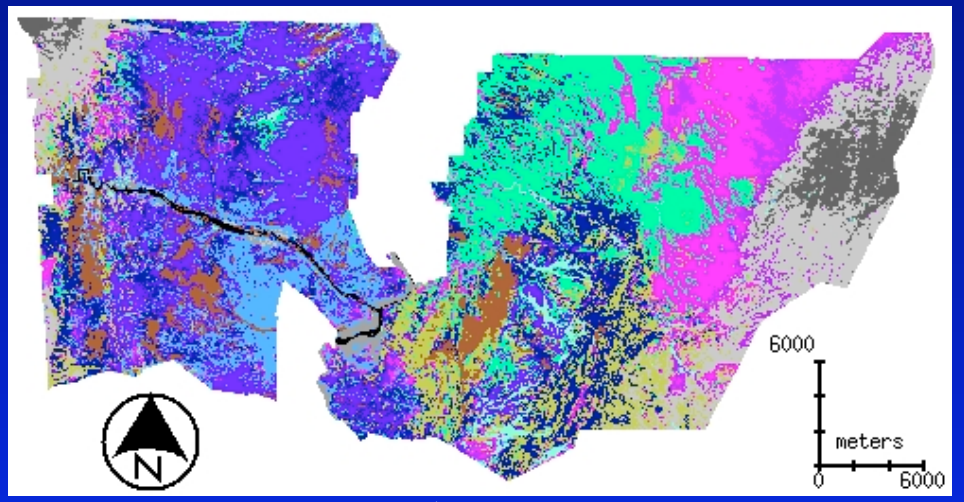


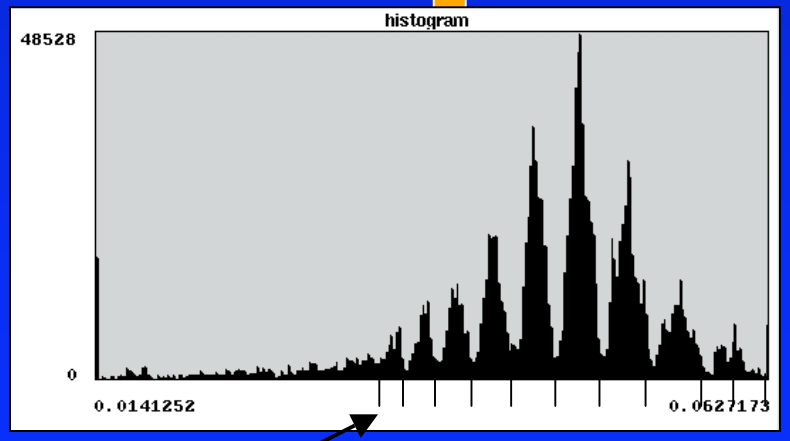
MISR_MRPV ρ_0, *b*, *k*, Sevilleta National Wildlife Refuge

MISR/MRPV parameters

MISR/MRPV b parameter: Sevilleta National Wildlife Refuge



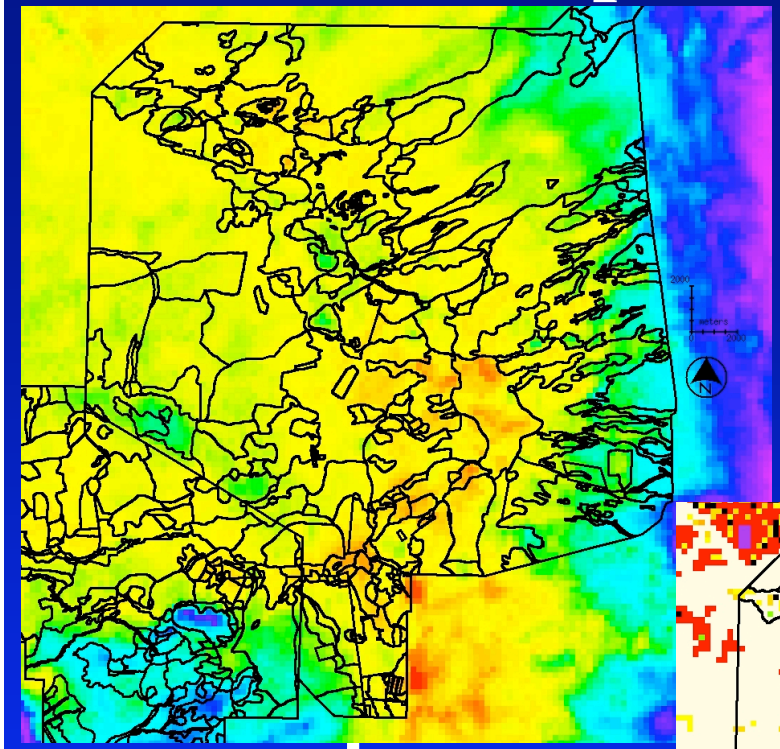




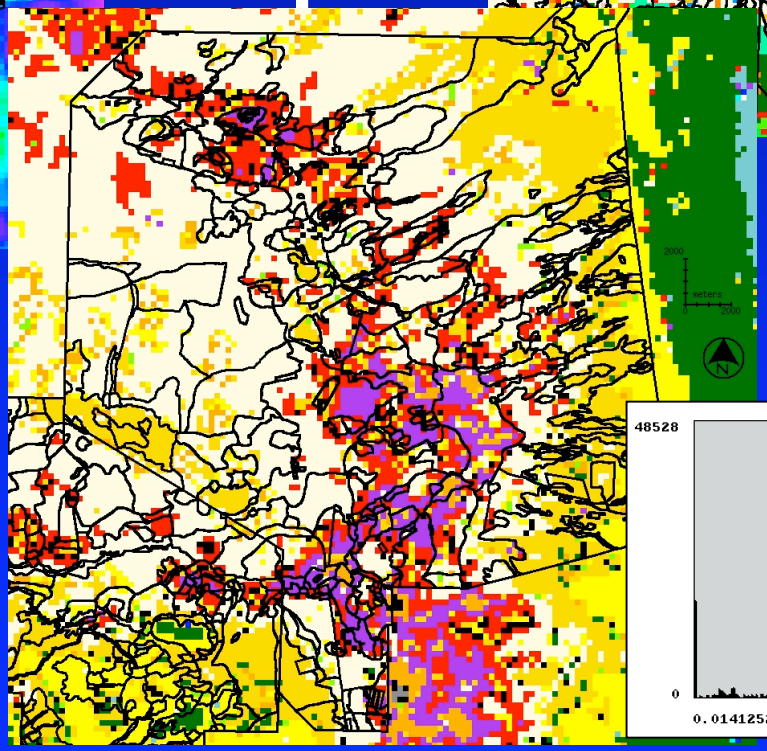
	Water or Wet Ground
	Barren or Sparsely Vegetated
	Great Basin Grasslands (Galleta and Indian Ricegrass Grasslands)
	Transition Chihuahuan and Great Basin Grasslands (Black Grama Grasslands with Galleta)
	Chihuahuan Desert Grasslands (Black Grama Grasslands)
	Transition Chihuahuan and Plains Grasslands (Black Grama Grasslands with Blue Grama)
	Plains Grasslands (Blue Grama and Hairy Grama Grasslands)
	Chihuahuan or Great Basin Lowland/Swale Grasslands (Alkali or Giant Sacaton Grasslands)
	Chihuahuan Desert Shrublands (Creosotebush Shrublands)
	Great Basin Shrublands (Fourwing Saltbush or Broom Dalea)
	Rocky Mountain Conifer Savanna (Oneseed Juniper Woodlands)
	Rocky Mountain Conifer Woodlands (Pinyon Woodlands)
	Rio Grande Riparian Woodlands (Rio Grande Cottonwood and Salt Cedar Riparian Woodlands)

Breaks (N.B. colors are not matched but distributions are similar).

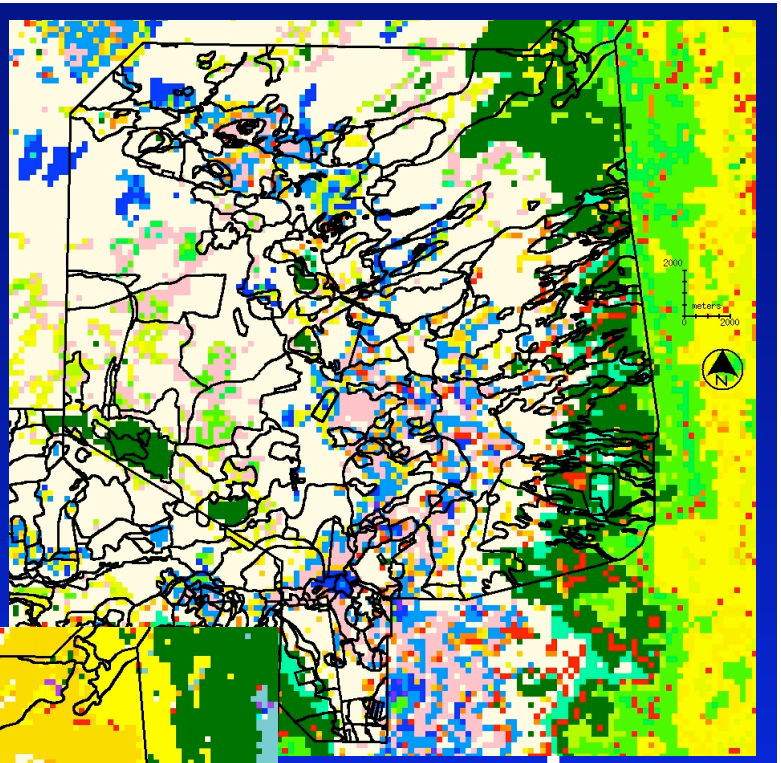
MISR/MRPV parameters



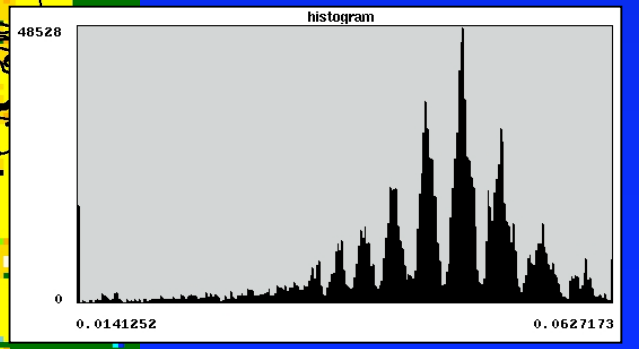
ρ_0
(magnitude)



b
(fwd or back)



k
(bell or bowl)



MISR_MRPV ρ_0, b, k
Jornada Experimental Range

Separability Analysis -- class pairs

Distance Measure: Transformed Divergence

Using Layers: 1 2 3

Taken 3 at a time

Best Average Separability: 1722.89

Combination: 1 2 3

1723

MODIS iso, geo, vol

TD<1000

Signature Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
sev_blackNbluegrama 1	0	1535	1033	1463	944	1572	1347	920	1725	697	1696	1658	1891	1981	1999	1977	1904	1770	1902
sev_blueNhairygrama 2	1535	0	1916	1536	1598	1439	892	1745	1175	1390	1998	1977	1987	1997	2000	1999	1998	1986	1999
sev_galletaNindian 3	1033	1916	0	1921	1754	1873	1877	1391	1968	1707	1949	1994	1999	2000	2000	2000	2000	1996	1991
sev_creosote_W 4	1463	1536	1921	0	1878	1007	1223	1768	1435	1673	1975	1934	1978	1983	2000	1997	1988	1894	1991
sev_creosote_E 5	944	1598	1754	1878	0	1986	860	1002	1860	394	1977	1978	1998	2000	2000	2000	1997	1997	2000
sev_saltbushNdalea 6	1572	1439	1873	1007	1986	0	1652	1702	1192	1916	1900	1874	1767	1687	1990	1944	1978	1788	1956
sev_creogramamix 7	1647	892	1877	1223	860	1652	0	1093	915	1016	1996	1955	1987	1997	2000	1998	1998	1984	1999
sev_barren 8	920	1745	1391	1768	1002	1702	1893	0	1854	799	1962	1993	1971	1996	2000	2000	1999	1981	1976
sev_blackgrama 9	1725	1175	1968	1435	1860	1192	915	1854	0	1874	2000	1886	1920	1987	1998	1983	1998	1941	1994
sev_blackgramaNgalleta 10	697	1390	1707	1673	394	1916	1016	799	1874	0	1948	1971	1994	1999	2000	1999	1995	1988	1999
jer_othershrubs 11	1696	1998	1949	1975	1977	1900	1996	1992	2000	1948	0	1924	1756	1751	2000	1998	1915	1645	1796
jer_burrograss 12	1658	1977	1994	1934	1978	1874	1955	1993	1886	1971	1924	0	1294	1764	1643	1288	698	506	1884
jer_tobosa 13	1891	1987	1999	1978	1998	1767	1987	1971	1920	1994	1756	1294	0	804	1404	873	1500	834	1836
jer_transition 14	1981	1997	2000	1983	2000	1687	1997	1996	1987	1999	1751	1764	804	0	1714	1452	1634	1111	1990
jer_creosote 15	1999	2000	2000	2000	2000	1990	2000	2000	1998	2000	2000	1643	1404	1714	0	424	1874	1457	2000
jer_blackgrama 16	1977	1999	2000	1997	2000	1944	1998	2000	1983	1999	1998	1288	873	1452	424	0	1642	1078	1987
jer_sporobolis 17	1904	1998	2000	1988	1997	1978	1998	1999	1998	1995	1915	698	1500	1634	1874	1642	0	458	1872
jer_tarbush 18	1770	1986	1996	1894	1997	1788	1984	1981	1941	1988	1645	506	834	1111	1457	1078	458	0	1686
jer_mesquitedunes 19	1902	1999	1991	1991	2000	1956	1999	1976	1994	1999	1796	1884	1836	1990	2000	1987	1872	1686	0

Separability Analysis -- class pairs

Distance Measure: Transformed Divergence

Using Layers: 1 2 3

Taken 3 at a time

Best Average Separability: 1867.11

Combination: 1 2 3

1867

MISR iso, geo, vol

TD<1000

Signature Name		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
sev_blackNbluegrama	1	0	1820	1987	2000	2000	1695	2000	2000	2000	1481	1887	1911	1328	1997	1953	1726	1876	1863	1986
sev_blueNhairygrama	2	1820	0	1999	2000	2000	1897	2000	2000	2000	1980	2000	1998	1992	2000	2000	1999	2000	1999	2000
sev_galletaNindian	3	1987	1999	0	1949	1883	1710	1855	1514	1988	1973	2000	2000	1999	2000	2000	2000	2000	2000	2000
sev_creosote_W	4	2000	2000	1949	0	1993	1999	1198	2000	1981	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_creosote_E	5	2000	2000	1883	1993	0	2000	1804	1953	1977	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_saltbushNdalea	6	1695	1897	1710	1999	2000	0	1993	1993	2000	1721	1999	1979	1962	1986	1999	1976	1995	1978	1997
sev_creogramamix	7	2000	2000	1855	1198	1804	1993	0	1580	962	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_barren	8	2000	2000	1514	2000	1953	1993	1580	0	1750	1987	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_blackgrama	9	2000	2000	1988	1981	1977	2000	962	1750	0	1999	2000	2000	2000	2000	2000	2000	2000	2000	2000
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jer_othershrubs	11	1887	2000	2000	2000	2000	1999	2000	2000	2000	2000	0	1999	1643	1821	2000	1995	1996	1982	1044
jer_burrograss	12	1911	1998	2000	2000	2000	1979	2000	2000	2000	1976	1999	0	1665	2000	547	1709	858	463	1997
jer_tobosa	13	1328	1992	1999	2000	2000	1962	2000	2000	2000	1893	1643	1665	0	1983	1741	1715	1620	1148	1974
jer_transition	14	1997	2000	2000	2000	2000	1986	2000	2000	2000	2000	1821	2000	1983	0	2000	1996	2000	2000	1595
jer_creosote	15	1953	2000	2000	2000	2000	1999	2000	2000	2000	1997	2000	547	1741	2000	0	1374	566	519	1997
jer_blackgrama	16	1726	1999	2000	2000	2000	1976	2000	2000	2000	1985	1995	[illegible]	1715	1996	[illegible]	[illegible]	917	1388	1914
jer_sporobolis	17	1876	2000	2000	2000	2000	1995	2000	2000	2000	1984	1996	[illegible]	1620	200[illegible]	[illegible]	917	[illegible]	388	1943
jer_tarbush	18	1863	1999	2000	2000	2000	1978	2000	2000	2000	1951	1982	463	1148	200[illegible]	519	[illegible]	388	0	1989
jer_mesquitedunes	19	1986	2000	2000	2000	2000	1997	2000	2000	2000	2000	1044	[illegible]	1974	1595	[illegible]	1914	[illegible]	1989	0

Separability Analysis -- class pairs

Distance Measure: Transformed Divergence

Using Layers: 1 2 3

Taken 3 at a time

Best Average Separability: 1839.1

Combination: 1 2 3

1839

MISR+MODIS iso, geo, vol

TD<1000

Signature Name		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
sev_blackNbluegrama	1	0	1672	1668	1988	1889	1277	1983	1982	1991	847	1833	1901	1768	1999	1997	1945	1909	1951	1994
sev_blueNhairygrama	2	1672	0	1962	1979	1908	1532	1893	1998	1834	1677	2000	1997	1994	2000	2000	1999	2000	2000	2000
sev_galletaNindian	3	1668	1962	0	1940	1594	1531	1929	1684	1990	1719	2000	1999	2000	2000	2000	2000	2000	2000	2000
sev_creosote_W	4	1988	1979	1940	0	1340	1895	1142	1933	1783	1974	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_creosote_E	5	1889	1908	1594	1340	0	1894	1278	1680	1913	1403	2000	1995	2000	2000	2000	2000	2000	2000	2000
sev_saltbushNdalea	6	1277	1532	1531	1895	1894	0	1932	1949	1911	1938	1978	1939	1682	1985	1997	1965	1984	1968	1973
sev_creogramamix	7	1983	1893	1929	1142	1278	1932	0	1194	948	1790	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_barren	8	1982	1998	1684	1933	1680	1949	1194	0	1847	1866	2000	1999	2000	2000	2000	2000	2000	2000	2000
sev_blackgrama	9	1991	1834	1990	1783	1913	1911	948	1847	0	1964	2000	1999	2000	2000	2000	2000	2000	2000	2000
sev_blackgramaNgalleta	10	847	1677	1719	1974	1403	1938	1798	1866	1964	0	1998	1996	1993	2000	2000	1999	1999	1999	2000
jer_othershrubs	11	1838	2000	2000	2000	2000	1978	2000	2000	2000	1998	0	1980	1421	1968	2000	1991	1962	1914	1855
jer_burrograss	12	1901	1997	1999	2000	1995	1939	2000	1999	1999	1996	1980	0	1645	2000	1866	1603	1056	1612	1969
jer_tobosa	13	1768	1994	2000	2000	2000	1682	2000	2000	2000	1993	1421	1645	0	885	1505	824	1748	847	1288
jer_transition	14	1999	2000	2000	2000	2000	1985	2000	2000	2000	2000	1968	2000	885	0	1990	1911	2000	1742	1286
jer_creosote	15	1997	2000	2000	2000	2000	1997	2000	2000	2000	2000	2000	1866	1588	1990	0	669	1973	713	1971
jer_blackgrama	16	1945	1999	2000	2000	2000	1965	2000	2000	2000	1999	1991	1603	824	1911	669	0	1806	601	1797
jer_sporobolis	17	1909	2000	2000	2000	2000	1984	2000	2000	2000	1999	1962	1056	1741	2000	1883	1886	0	1667	1890
jer_tarbush	18	1951	2000	2000	2000	2000	1968	2000	2000	2000	1999	1914	1612	847	1742	713	601	1667	0	1753
jer_mesquitedunes	19	1994	2000	2000	2000	2000	1973	2000	2000	2000	2000	1855	1969	1288	1286	1971	1797	1890	1753	0

Separability Analysis -- class pairs

Distance Measure: Transformed Divergence

Using Layers: 1 2 3

Taken 3 at a time

Best Average Separability: 1743.71

Combination: 1 2 3

1744

MISR MRPV

TD<1000

Signature Name		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
sev_blackNbluegrama	1	0	1975	1729	1829	1750	1483	1957	1935	1997	593	1897	1597	839	1614	1901	1666	1885	1734	1667
sev_blueNhairygrama	2	1975	0	1831	1956	2000	1261	1996	1852	1739	1980	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_galletaNindian	3	1729	1831	0	869	1999	457	1734	1539	1983	1266	2000	2000	1994	2000	2000	2000	2000	2000	2000
sev_creosote_W	4	1829	1956	869	0	2000	1008	1850	1541	1980	1587	2000	2000	1996	2000	2000	2000	2000	2000	2000
sev_creosote_E	5	1750	2000	1999	2000	0	2000	1976	1991	2000	1009	2000	2000	1974	1998	2000	2000	2000	2000	2000
sev_saltbushNdalea	6	1483	1261	457	1008	2000	0	1858	1417	1927	1475	2000	2000	1970	1999	2000	2000	2000	2000	1994
sev_creogramamix	7	1957	1996	1734	1850	1976	1858	0	1600	1714	1179	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_barren	8	1935	1852	1539	1541	1991	1417	1600	0	1860	1549	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_blackgrama	9	1997	1739	1983	1980	2000	1927	1714	1860	0	1919	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_blackgramaNgalleta	10	593	1980	1266	1587	1009	1475	1179	1549	1919	0	1998	1802	1578	1978	1984	1948	1988	1921	1966
jer_othershrubs	11	1897	2000	2000	2000	2000	2000	2000	2000	2000	1998	0	1996	1478	1029	2000	1992	1984	1975	294
jer_burrograss	12	1597	2000	2000	2000	2000	2000	2000	2000	2000	1802	1996	0	1487	1960	725	505	1203	351	1877
jer_tobosa	13	839	2000	1994	1996	1974	1970	2000	2000	2000	1578	1478	1487	0	501	1813	1310	1653	1364	1180
jer_transition	14	1614	2000	2000	2000	1998	1999	2000	2000	2000	1978	1029	1508	501	0	1997	1961	1980	1860	1226
jer_creosote	15	1901	2000	2000	2000	2000	2000	2000	2000	2000	1984	2000	725	1813	1997	0	281	272	584	1911
jer_blackgrama	16	1666	2000	2000	2000	2000	2000	2000	2000	2000	1948	1992	505	1310	1961	281	0	328	238	1620
jer_sporobolis	17	1885	2000	2000	2000	2000	2000	2000	2000	2000	1988	1984	1203	1653	1980	272	328	0	865	1585
jer_tarbush	18	1734	2000	2000	2000	2000	2000	2000	2000	2000	1921	1975	351	1364	1860	584	238	865	0	1753
jer_mesquitedunes	19	1667	2000	2000	2000	2000	1994	2000	2000	2000	1966	294	1877	1180	1226	1911	1620	1585	1753	0

Separability Analysis -- class pairs

Distance Measure: Transformed Divergence

Using Layers: 1 2 3

Taken 3 at a time

Best Average Separability: 1624.2

Combination: 1 2 3

1624

MODIS MRPV

TD<1000

Signature Name		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
sev_blackNbluegrama	1	0	1270	2000	219	1961	202	542	698	1089	305	1145	2000	1985	2000	1830	1705	1939	1709	2000
sev_blueNhairygrama	2	1270	0	2000	1259	1983	946	451	1267	191	1291	1963	2000	1985	2000	1997	1984	1999	1981	2000
sev_galletaNindian	3	2000	2000	0	2000	2000	2000	2000	2000	2000	2000	2000	1946	2000	1658	2000	2000	2000	2000	1597
sev_creosote_W	4	219	1259	2000	0	1983	158	472	427	1036	220	1245	2000	1983	2000	1893	1759	1926	1703	2000
sev_creosote_E	5	[illegible]	[illegible]	2000	1983	0	1956	1999	1995	1999	2000	1242	2000	1571	2000	2000	1999	1992	1917	2000
sev_saltbushNdalea	6	[illegible]	946	2000	[illegible]	1956	0	297	284	801	184	1396	2000	1959	2000	1938	1837	1966	1793	2000
sev_creogramamix	7	[illegible]	[illegible]	2000	[illegible]	1999	297	0	460	239	429	1845	2000	1999	2000	1943	1870	1992	1922	2000
sev_barren	8	[illegible]	[illegible]	2000	[illegible]	1995	284	460	0	1119	240	1797	2000	1997	2000	1997	1986	1997	1964	2000
sev_blackgrama	9	[illegible]	191	2000	[illegible]	1999	[illegible]	[illegible]	[illegible]	0	1153	1963	2000	1989	2000	1975	1914	1997	1945	2000
sev_blackgramaNgalleta	10	305	[illegible]	2000	220	2000	184	429	240	1153	0	1676	2000	2000	2000	1982	1953	1994	1951	2000
jer_othershrubs	11	1145	1963	2000	[illegible]	1242	[illegible]	[illegible]	[illegible]	1963	1676	0	2000	1171	2000	1981	1906	1795	1337	2000
jer_burrograss	12	2000	2000	1946	2000	2000	2000	2000	2000	2000	2000	2000	0	2000	830	2000	2000	2000	2000	1087
jer_tobosa	13	1985	1985	2000	1983	1571	1959	1999	1997	1989	2000	1171	[illegible]	0	2000	1786	1288	1010	634	2000
jer_transition	14	2000	2000	1658	2000	2000	2000	2000	2000	2000	2000	2000	830	2000	0	2000	2000	2000	2000	180
jer_creosote	15	1830	1997	2000	1893	2000	1938	1943	1997	1975	1982	1981	[illegible]	1786	2000	0	329	841	920	2000
jer_blackgrama	16	1705	1984	2000	1759	1999	1837	1870	1986	1914	1953	1906	2000	1288	2000	[illegible]	0	584	546	2000
jer_sporobolis	17	1939	1999	2000	1926	1992	1966	1992	1997	1997	1994	1795	2000	[illegible]	2000	[illegible]	[illegible]	0	199	2000
jer_tarbush	18	1709	1981	2000	1703	1917	1793	1922	1964	1945	1951	1337	2000	634	[illegible]	[illegible]	[illegible]	199	0	2000
jer_mesquitedunes	19	2000	2000	1597	2000	2000	2000	2000	2000	2000	2000	2000	1087	[illegible]	180	[illegible]	[illegible]	[illegible]	2000	0

Separability Analysis -- class pairs

Distance Measure: Transformed Divergence

Using Layers: 1 2 3

Taken 3 at a time

Best Average Separability: 1652.66

Combination: 1 2 3

1653

MODIS+MISR MRPV

TD<1000

Signature Name		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
sev_blackNbluegrama	1	0	1570	998	1420	1404	566	1668	1238	1786	1766	1612	1738	1686	1977	1763	1589	1908	1570	1354
sev_blueNhairygrama	2	1570	0	1568	1597	1732	1261	1259	1202	1180	1714	1976	1993	1985	2000	1999	1987	1999	1994	1996
sev_galletaNindian	3	998	1568	0	1838	1909	522	1947	1121	1915	1976	1992	1999	1995	2000	2000	1999	2000	1998	1987
sev_creosote_W	4	1420	1597	1838	0	286	1496	605	1557	1798	1076	1789	1886	1577	1963	1972	1841	1953	1937	1978
sev_creosote_E	5	1404	1732	1909	286	0	1741	798	1838	1888	722	1456	1803	916	1741	1865	1414	1749	1878	1876
sev_saltbushNdalea	6	566	1261	522	1496	1741	0	1746	430	1691	1925	1923	1969	1964	2000	1992	1972	1997	1949	1906
sev_creogramamix	7	1668	1259	1947	605	798	1746	0	1753	1567	839	1829	1947	1787	1996	1966	1742	1965	1976	1992
sev_barren	8	1238	1202	1121	1557	1838	430	1753	0	1215	1957	1989	1995	1992	2000	1999	1996	2000	1993	1995
sev_blackgrama	9	1786	1180	1915	1798	1888	1831	1567	1215	0	1928	1997	1991	1996	2000	1997	1982	2000	1994	2000
sev_blackgramaNgalleta	10	1766	1714	1976	1076	722	1925	839	1957	1928	0	1868	1997	1516	1932	1993	1856	1985	1996	1963
jer_othershrubs	11	1612	1976	1992	1789	1458	1923	1829	1989	1997	1868	0	1592	1034	1703	1447	933	1291	1573	1404
jer_burrograss	12	1738	1993	1999	1886	1803	1969	1947	1995	1991	1997	1592	0	1825	1989	435	1294	1291	241	1797
jer_tobosa	13	1686	1985	1995	1577	916	1964	1787	1992	1996	1516	1034	1825	0	327	1737	1081	1272	1842	1491
jer_transition	14	1977	2000	2000	1963	1741	2000	1996	2000	2000	1932	1703	1983	327	0	1981	1803	1712	1990	1840
jer_creosote	15	1763	1999	2000	1972	1865	1992	1966	1999	1997	1993	1447	435	1737	1981	0	708	798	373	1429
jer_blackgrama	16	1589	1987	1999	1841	1414	1972	1742	1996	1982	1856	933	1294	1081	1803	708	0	694	1314	1362
jer_sporobolis	17	1908	1999	2000	1953	1749	1997	1965	2000	2000	1985	1291	1291	1272	1712	798	694	0	1374	1698
jer_tarbush	18	1570	1994	1998	1937	1878	1949	1976	1993	1994	1996	1573	241	1842	1990	373	1314	1374	0	1333
jer_mesquitedunes	19	1354	1996	1987	1978	1876	1906	1992	1995	2000	1963	1404	1797	1491	1840	1429	1362	1698	1333	0

Separability Analysis -- class pairs

Distance Measure: Transformed Divergence

Using Layers: 1 2 3 4 5 6 7

Taken 7 at a time

Best Average Separability: 1973.94

Combination: 1 2 3 4 5 6 7

1973

MISR $MRPV_{red}$+AN_{RGBNIR}

OTD<1000

Signature Name		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
sev_blackNbluegrama	1	0	1994	2000	2000	2000	2000	2000	2000	2000	1666	2000	2000	1999	2000	2000	2000	2000	1998	2000
sev_blueNhairygrama	2	1994	0	2000	2000	2000	2000	2000	2000	2000	1993	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_galletaNindian	3	2000	2000	0	2000	2000	1970	2000	2000	1999	1948	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_creosote_W	4	2000	2000	2000	0	2000	2000	1990	2000	1994	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_creosote_E	5	2000	2000	2000	2000	0	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_saltbushNdalea	6	2000	2000	1970	2000	2000	0	1970	1986	1976	1995	2000	2000	1999	2000	2000	2000	2000	2000	2000
sev_creogramamix	7	2000	2000	2000	1990	2000	1970	0	2000	1897	1998	2000	1999	2000	2000	2000	2000	2000	2000	2000
sev_barren	8	2000	2000	2000	2000	2000	1986	2000	0	1994	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_blackgrama	9	2000	2000	1999	1994	2000	1976	1897	1994	0	1999	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_blackgramaNgalleta	10	1666	1993	1948	2000	2000	1995	1998	2000	1999	0	2000	2000	2000	2000	2000	2000	2000	2000	2000
jer_othershrubs	11	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	0	2000	2000	1896	2000	2000	2000	2000	1547
jer_burrograss	12	2000	2000	2000	2000	2000	2000	1999	2000	2000	2000	2000	0	1749	2000	1166	2000	1959	1537	2000
jer_tobosa	13	1999	2000	2000	2000	2000	1999	2000	2000	2000	2000	2000	1749	0	2000	1854	1999	1964	1943	2000
jer_transition	14	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1896	2000	2000	0	2000	2000	2000	2000	1783
jer_creosote	15	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1166	1854	2000	0	1995	1710	1462	2000
jer_blackgrama	16	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1999	2000	1995	0	1917	1877	1999
jer_sporobolis	17	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1959	1964	2000	1710	1917	0	1827	1999
jer_tarbush	18	1998	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1537	1943	2000	1462	1877	1827	0	2000
jer_mesquitedunes	19	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1547	2000	2000	1783	2000	1999	1999	2000	0

Separability Analysis -- class pairs

Distance Measure: Transformed Divergence

Using Layers: 1 2 3 4

Taken 4 at a time

Best Average Separability: 1931.71

Combination: 1 2 3 4

1932

MISR AN (R, G, B, NIR)

OTD<1000

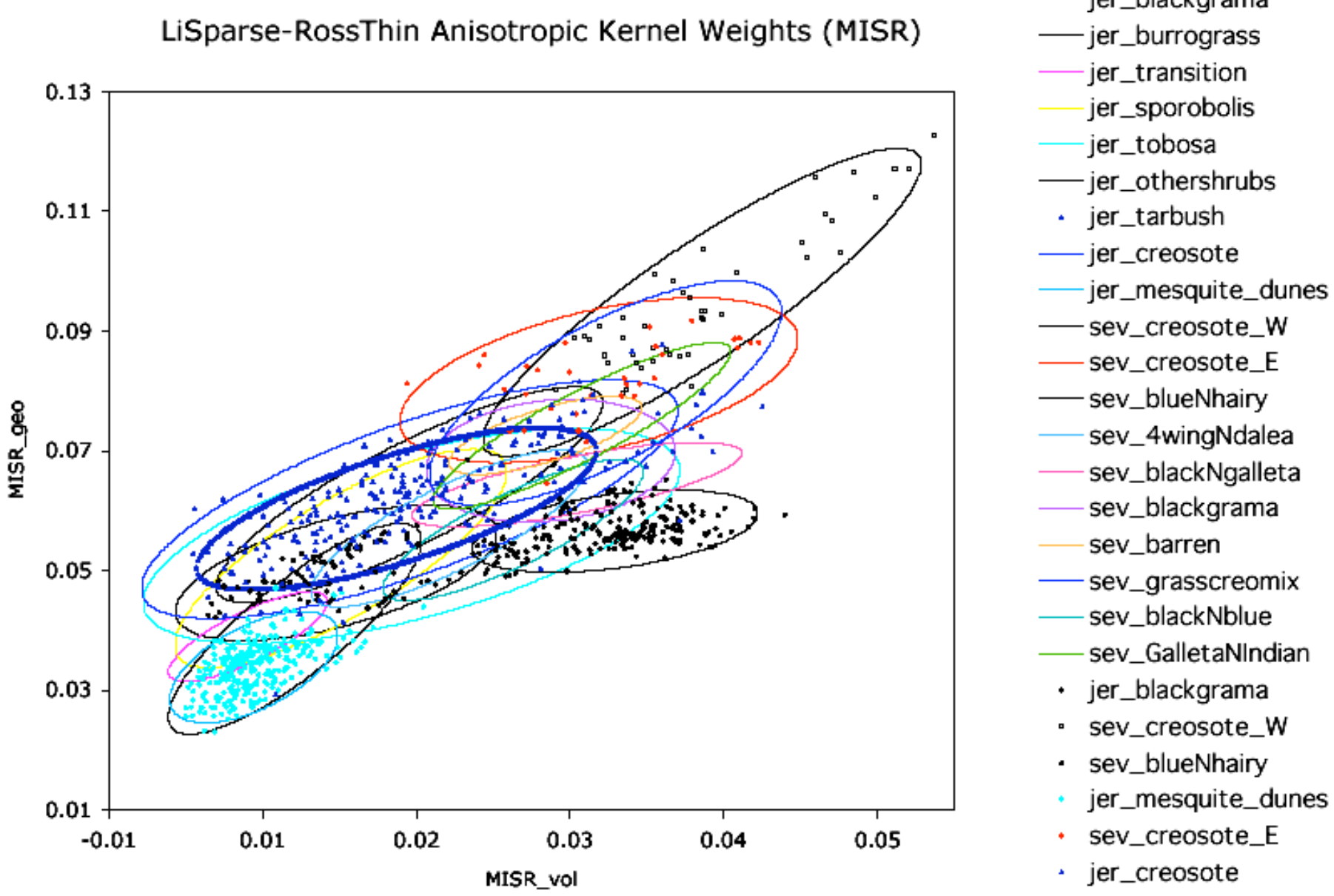
Signature Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
sev_blackNbluegrama 1	0	1844	2000	1944	2000	2000	1977	2000	2000	1625	2000	1999	1999	2000	1999	2000	1998	1985	2000
sev_blueNhairygrama 2	1844	0	1999	1999	2000	1999	1976	2000	1989	1661	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_galletaNindian 3	2000	1999	0	1941	2000	1880	1998	2000	1994	1810	2000	2000	2000	2000	2000	2000	2000	2000	2000
sev_creosote_W 4	1944	1999	1941	0	1971	1787	1844	1991	1943	1934	2000	1532	1514	2000	1948	1971	1993	1677	2000
sev_creosote_E 5	2000	2000	2000	1971	0	1995	1975	2000	2000	2000	2000	1998	1997	2000	1999	2000	2000	2000	2000
sev_saltbushNdalea 6	2000	1999	1880	1787	1995	0	1638	1952	1865	1974	2000	1974	1886	2000	1999	2000	2000	1999	2000
sev_creogramamix 7	1977	1976	1998	1844	1975	1638	0	1996	1843	1965	1999	1814	1433	2000	1949	1987	1997	1938	2000
sev_barren 8	2000	2000	2000	1991	2000	1952	1996	0	1981	2000	2000	2000	1989	2000	2000	2000	2000	2000	2000
sev_blackgrama 9	2000	1989	1994	1943	2000	1865	1843	1981	0	1995	2000	1994	1983	2000	2000	2000	2000	2000	2000
sev_blackgramaNgalleta 10	1625	1661	1810	1934	2000	1974	1965	2000	1995	0	2000	2000	1999	2000	2000	2000	2000	1999	2000
jer_othershrubs 11	2000	2000	2000	2000	2000	2000	1999	2000	2000	2000	0	2000	1990	1789	1998	1978	1994	1998	1229
jer_burrograss 12	1999	2000	2000	1532	1998	1974	1814	2000	1994	2000	2000	0	1350	2000	889	1995	1929	1438	2000
jer_tobosa 13	1999	2000	2000	1514	1997	1886	1433	1989	1983	1999	1990	1350	0	2000	1780	1998	1940	1839	2000
jer_transition 14	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1789	2000	2000	0	2000	2000	2000	2000	1411
jer_creosote 15	1999	2000	2000	1948	1999	1999	1949	2000	2000	2000	1998	889	1780	2000	0	1963	1610	1248	1999
jer_blackgrama 16	2000	2000	2000	1971	2000	2000	1987	2000	2000	2000	1978	1995	1998	2000	1963	0	1785	1612	1994
jer_sporobolis 17	1998	2000	2000	1993	2000	2000	1997	2000	2000	2000	1994	1929	1940	2000	1610	1785	0	1741	1996
jer_tarbush 18	1985	2000	2000	1677	2000	1999	1938	2000	2000	1999	1998	1438	1839	2000	1248	1612	1741	0	2000
jer_mesquitedunes 19	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1229	2000	2000	1411	1999	1994	1996	2000	0

Separability Analysis Summary (RED BAND ONLY)

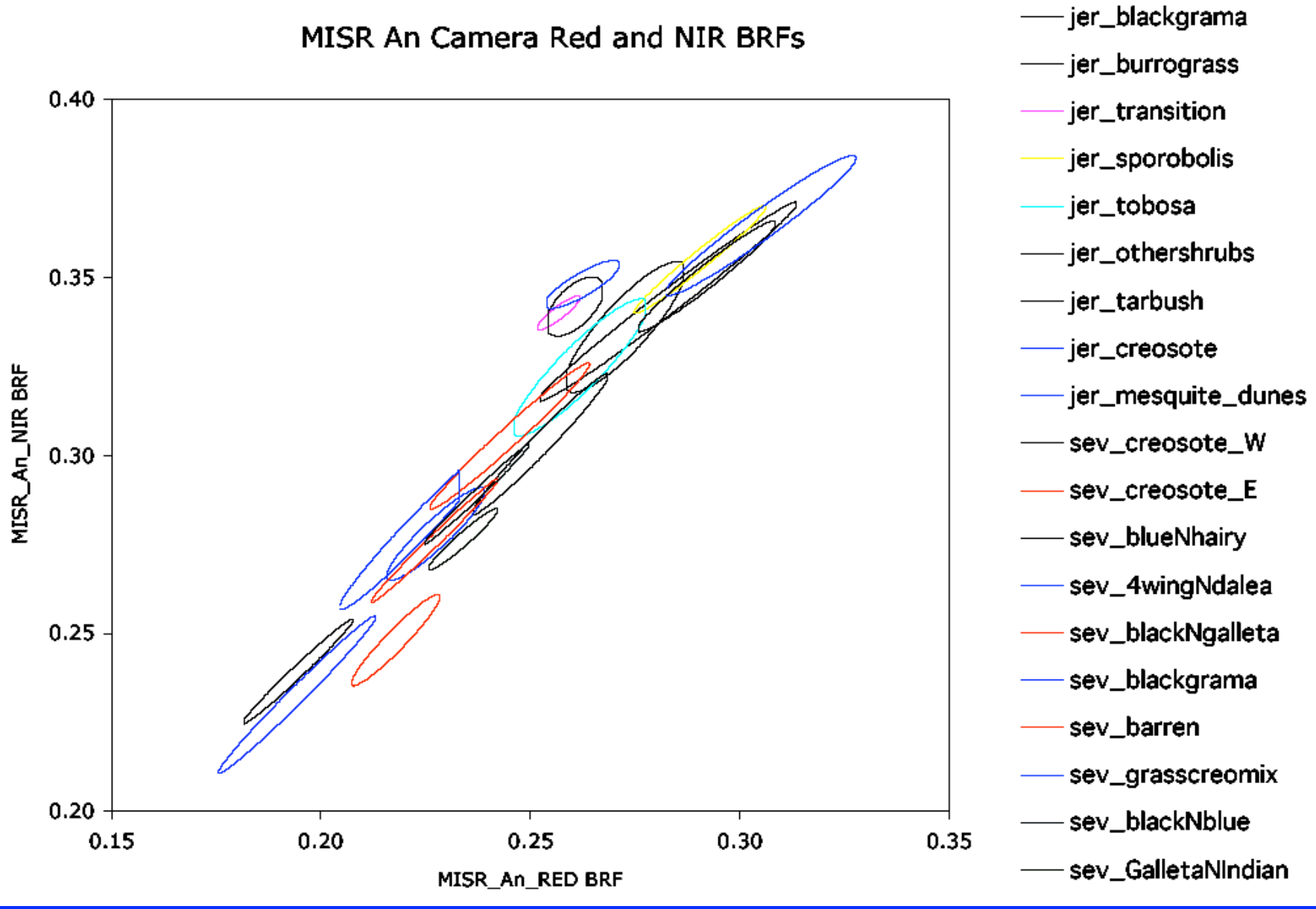
Data Set	Mean TD*	# TD<1000
MISR $MRPV_{red}$+AN_{RGBNIR}	1973	0
MISR AN (R, G, B, NIR)	1932	1
MISR iso, geo, vol	1867	7
MISR+MODIS iso, geo, vol	1839	8
MISR MRPV	1744	13
MODIS iso, geo, vol	1723	13
MODIS+MISR MRPV	1653	17
MODIS MRPV	1624	29

* transformed divergence

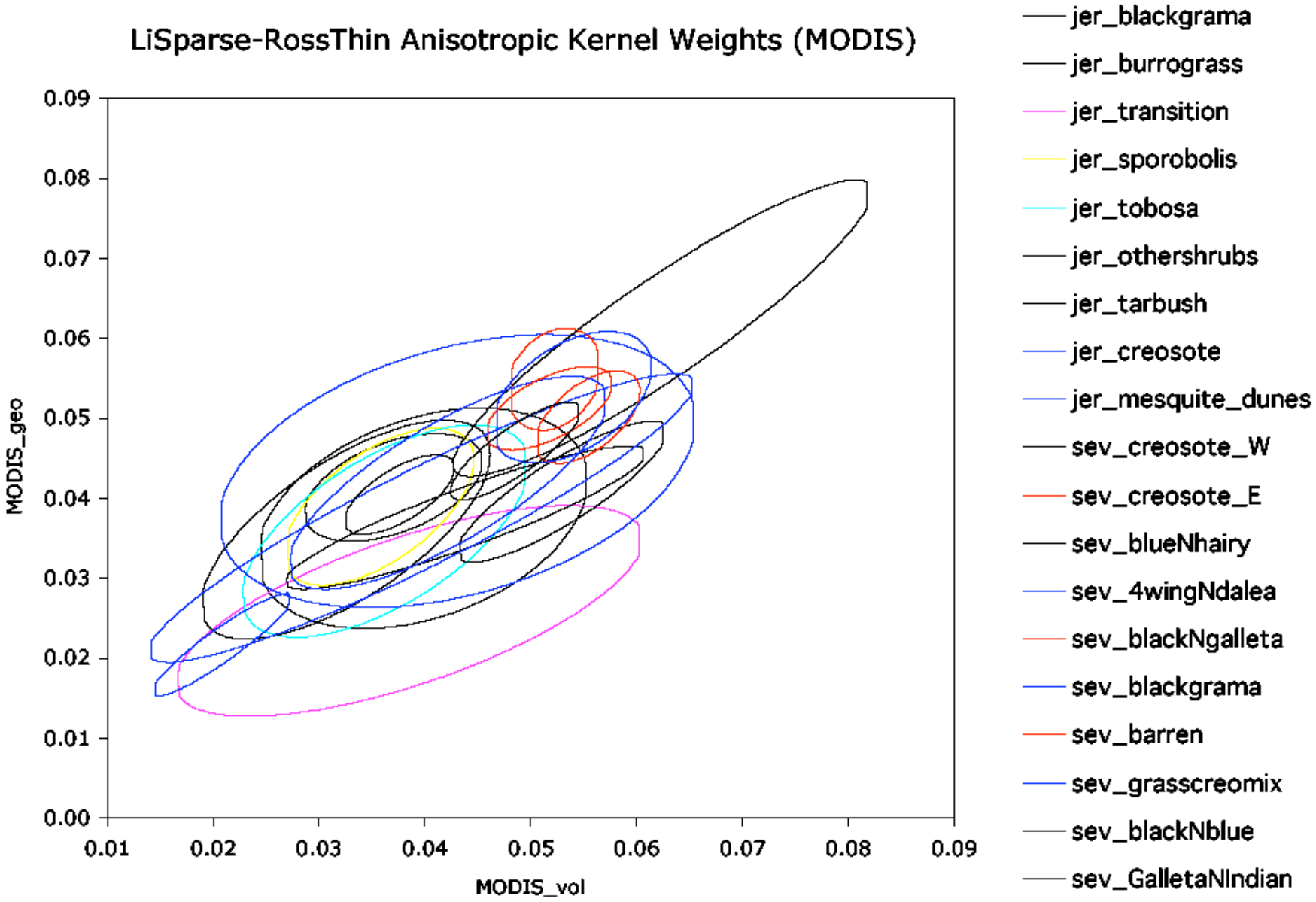
Bivariate Distribution PDFs



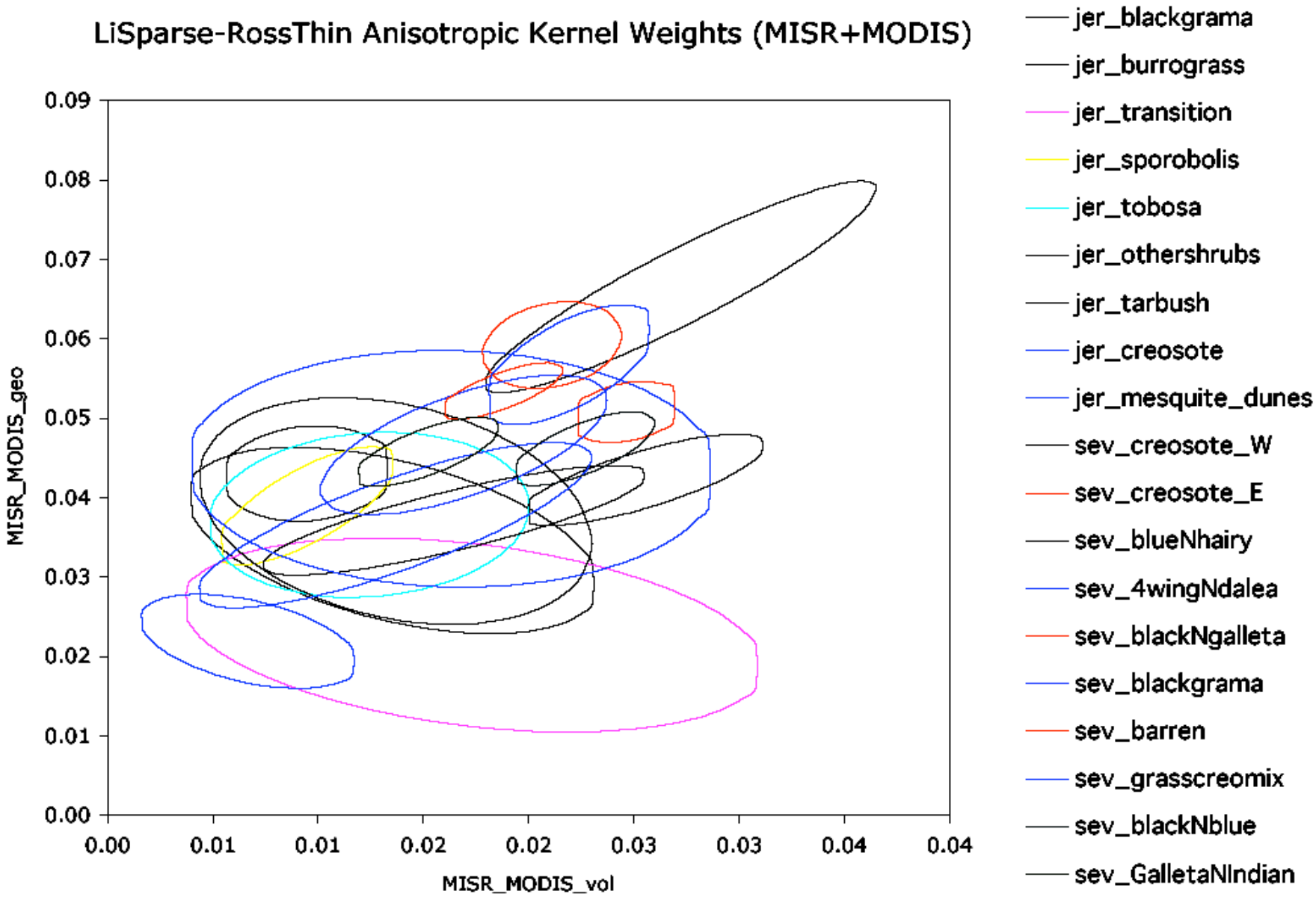
Bivariate Distribution PDFs



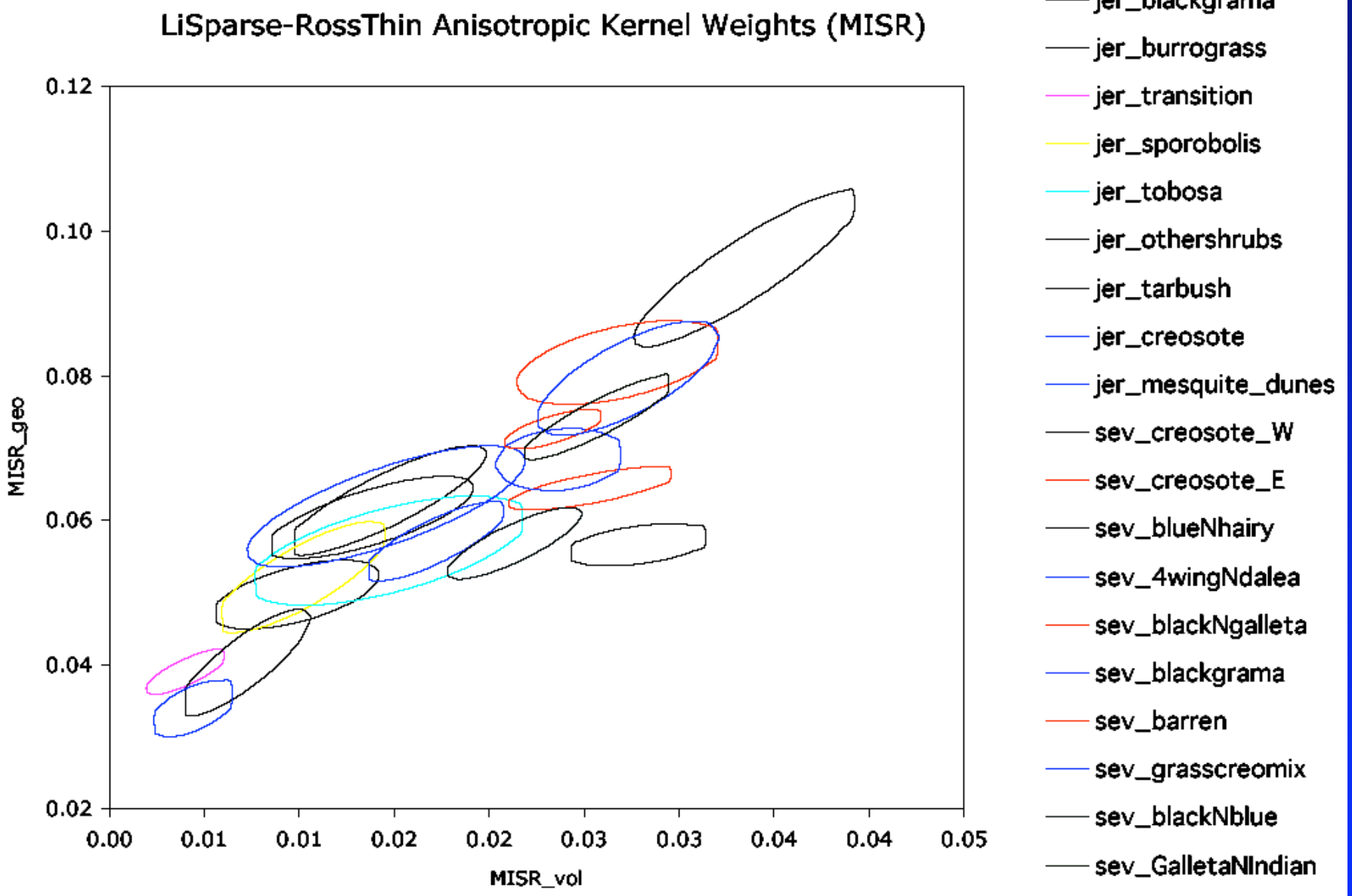
Bivariate Distribution PDFs



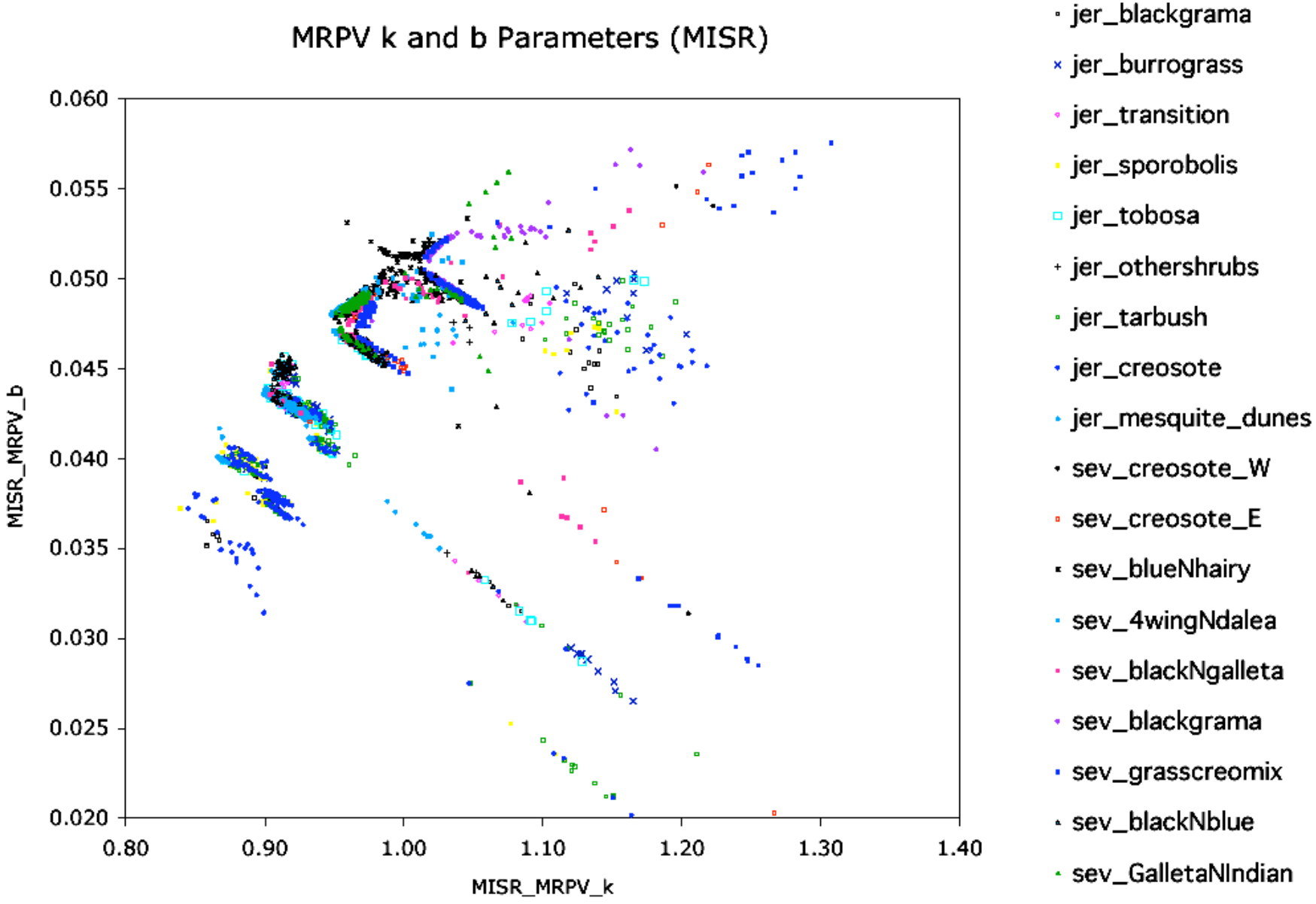
Bivariate Distribution PDFs



Bivariate Distribution PDFs



Bivariate Distribution of MRPV k and b



Contingency tests

The separability and PDF results are confirmed in contingency tests (classifications of the training sites)

--maximum likelihood

--no prior probabilities

--angular signatures via red band only

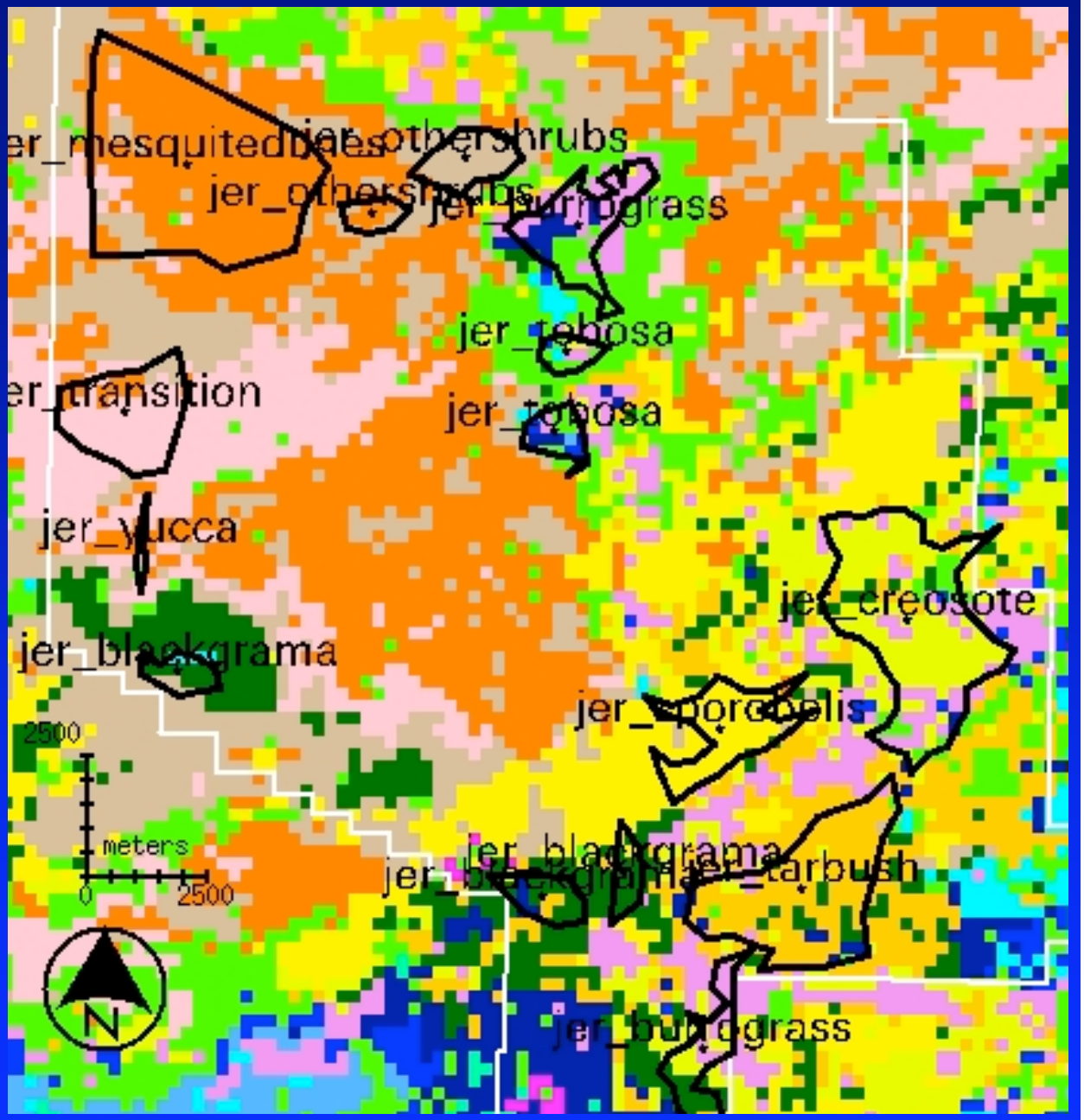
-- spectral data (MISR R, G, B, NIR)

Contingency tests

Contingency: MISR An -spectral

	jer_othershrubs
	jer_burrograss
	jer_tobosa
	jer_transition
	jer_creosote
	jer_blackgrama
	jer_sporobolis
	jer_tarbush
	jer_mesquitedunes

Other colors represent classes belonging to the Sevilleta

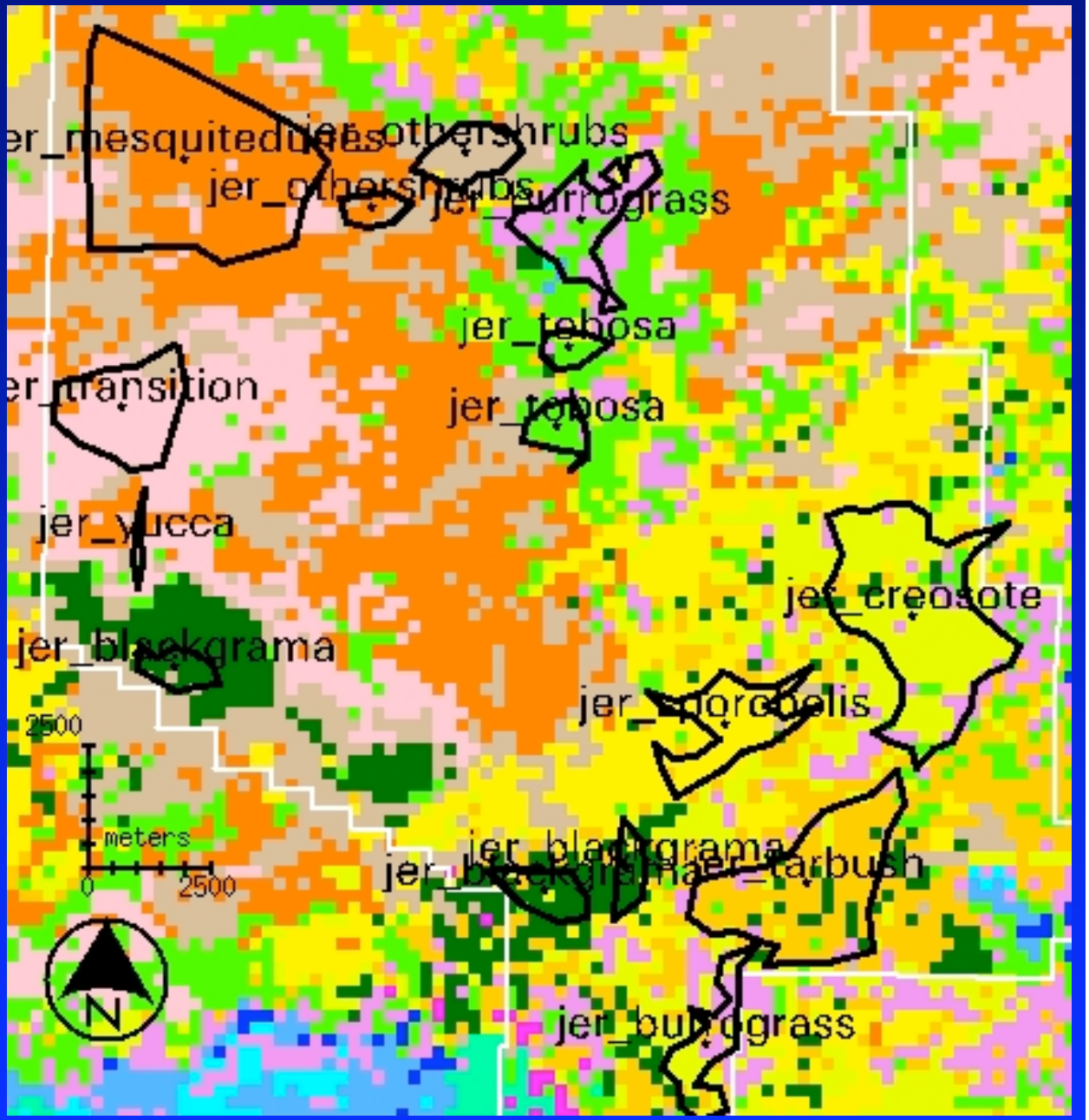


Contingency tests

Contingency: MRPV_MISR_ red band + An_all_bands

	jer_othershrubs
	jer_burrograss
	jer_tobosa
	jer_transition
	jer_creosote
	jer_blackgrama
	jer_sporobolis
	jer_tarbush
	jer_mesquitedunes

Other colors represent classes belonging to the Sevilleta

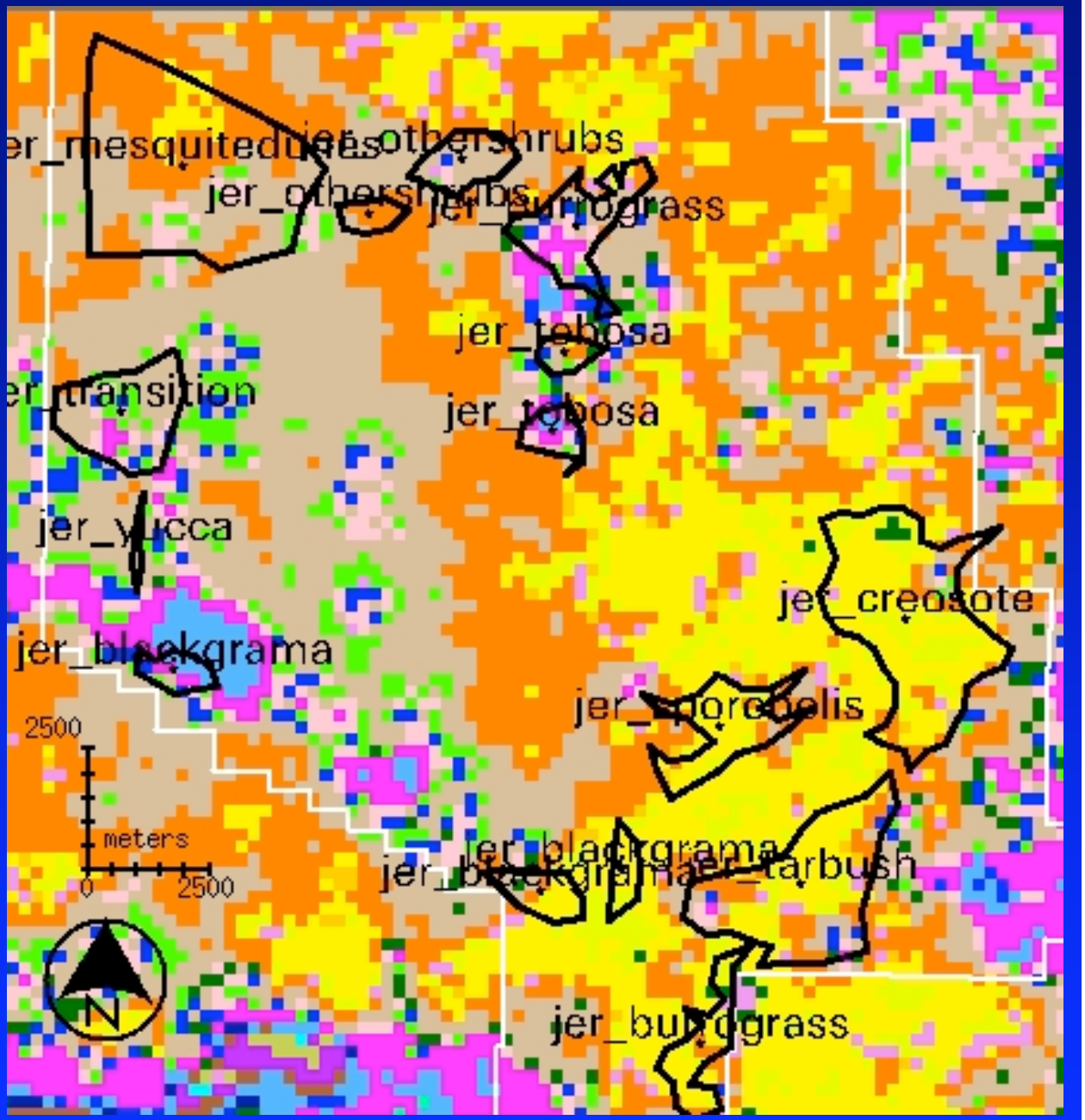


Contingency tests

Contingency: MRPV (MISR red band)

	jer_othershrubs
	jer_burrograss
	jer_tobosa
	jer_transition
	jer_creosote
	jer_blackgrama
	jer_sporobolis
	jer_tarbush
	jer_mesquitedunes

Other colors represent classes belonging to the Sevilleta

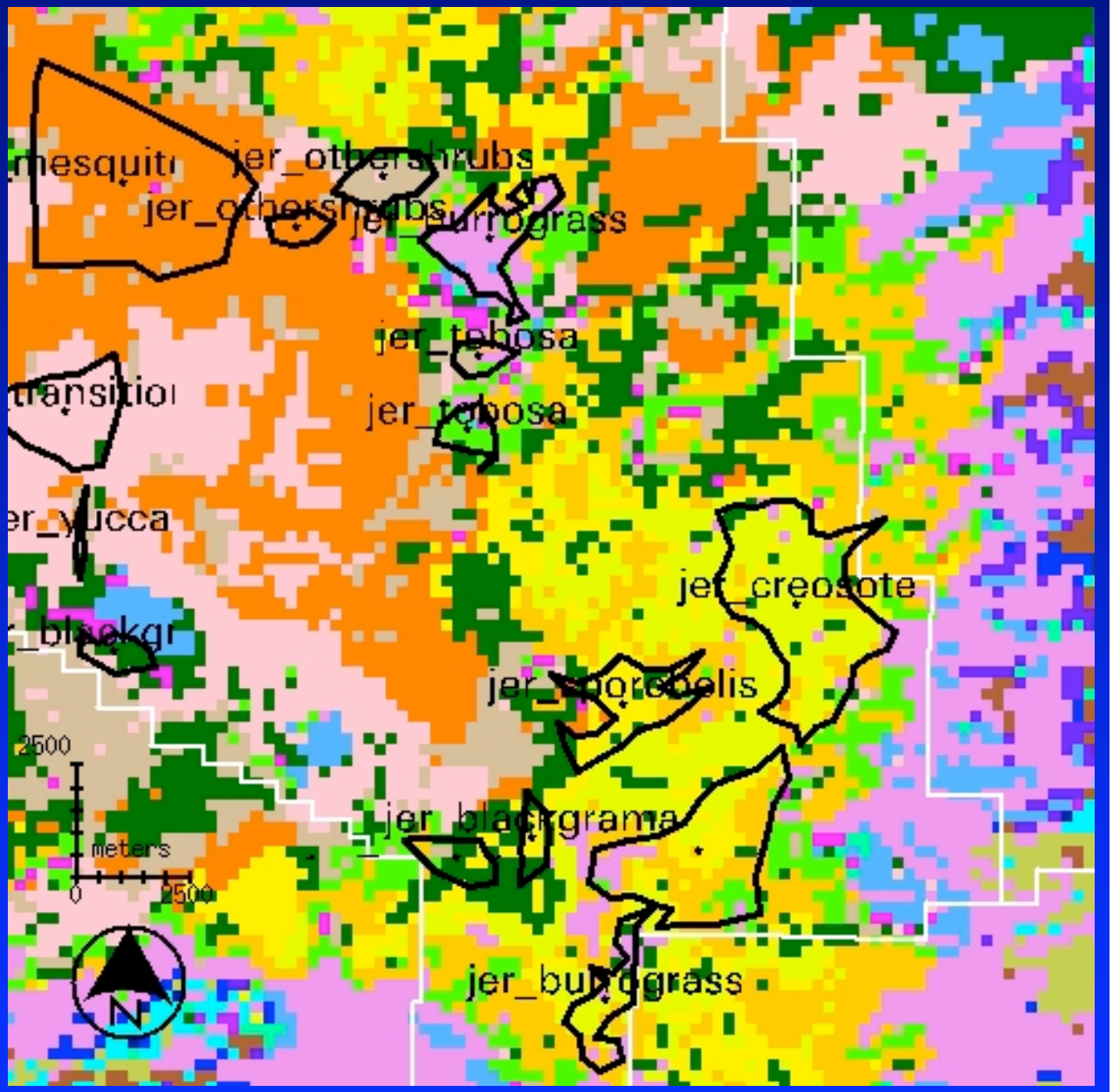


Contingency tests

Contingency: MISR (iso-geo-vol, red band)

	jer_othershrubs
	jer_burrograss
	jer_tobosa
	jer_transition
	jer_creosote
	jer_blackgrama
	jer_sporobolis
	jer_tarbush
	jer_mesquitedunes

Other colors represent classes belonging to the Sevilleta

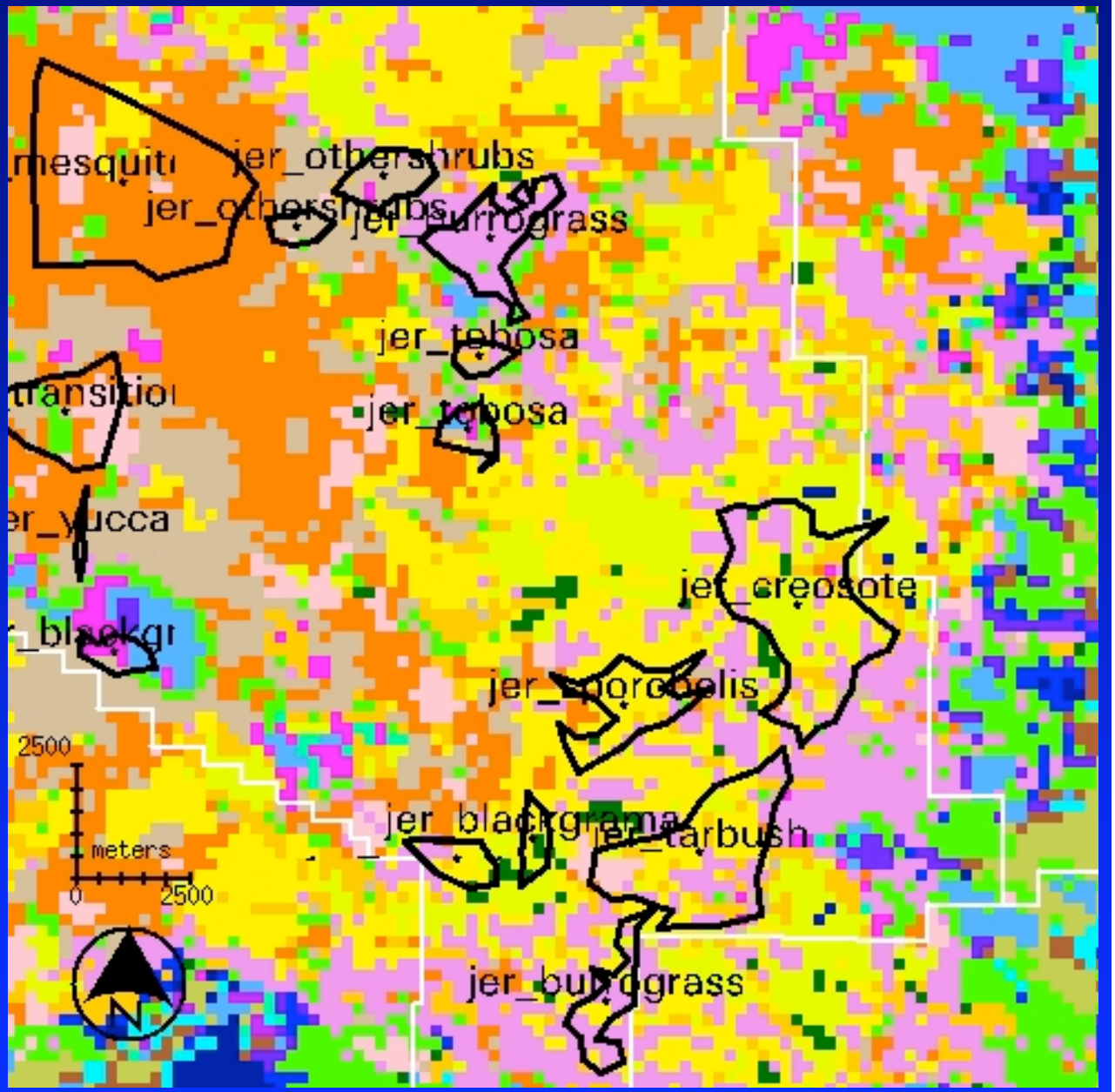


Contingency tests

Contingency:
MODIS (iso-geo-vol, red band)

	jer_othershrubs
	jer_burrograss
	jer_tobosa
	jer_transition
	jer_creosote
	jer_blackgrama
	jer_sporobolis
	jer_tarbush
	jer_mesquitedunes

Other colors represent classes belonging to the Sevilleta



CONCLUSIONS

Multiangle data from MISR and MODIS show potential for improving community type mapping. The improvements obtained are not as important as expected. This may be related to 1. the lack of variation in the solar zenith angle; 2. inadequate atmospheric correction at 70°□MISR view angles; and/or 3. cloud contamination in the daily MODIS data. We will review our processing and the Li-Ross and MRPV approaches while also investigating other methods which may be less sensitive to the angular sampling (GO modeling) and multiangle metrics (SSI, clumping index, ANIX).

Plans for Work in Immediate Future

- Incorporate NIR band data (MODIS) and model parameters.
- Investigate different combinations of MISR views.
- Improve screening for cloud and cloud shadow.
- Check atmospheric correction especially for the extreme MISR D camera views.
- Check signature distributions for normality and modify the set of classes accordingly.

Plans for Work in Medium Term

- Extend temporal sampling to the end of the wet season -- we expect this to produce better results.
- Investigate other multiangle metrics (SSI, ANIX…)
- Investigate other classification methods (SVMs).
- Incorporate soil information.
- Investigate other modeling methods (GO models; this requires e.g., that we address the background problem for GO modeling in desert grasslands).

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