Applications Of Remote Sensing Techniques in Water Resources Management

Oklahoma Clean Lakes And Watersheds

23rd Annual Conference, Apr 2-3, 2014

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Presentation Outline

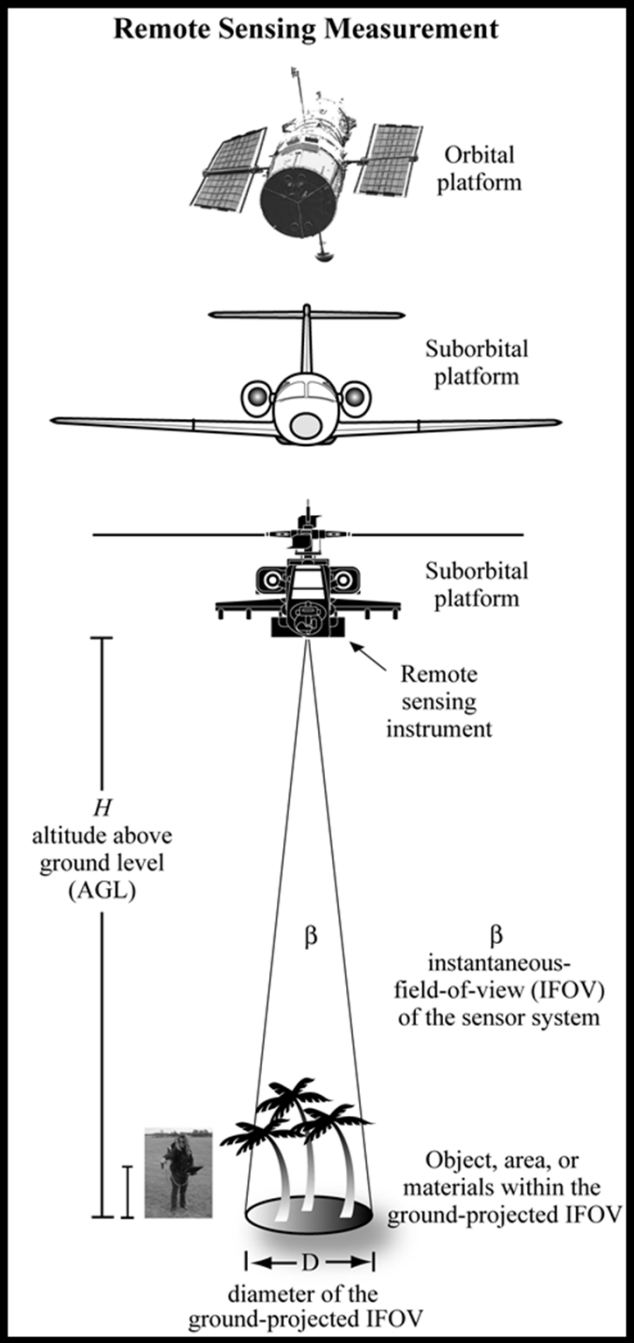
i. Introduction

ii. Change detection

iii. Spectral characteristics

iv. Thermal remote sensing

v. Sensor resolution

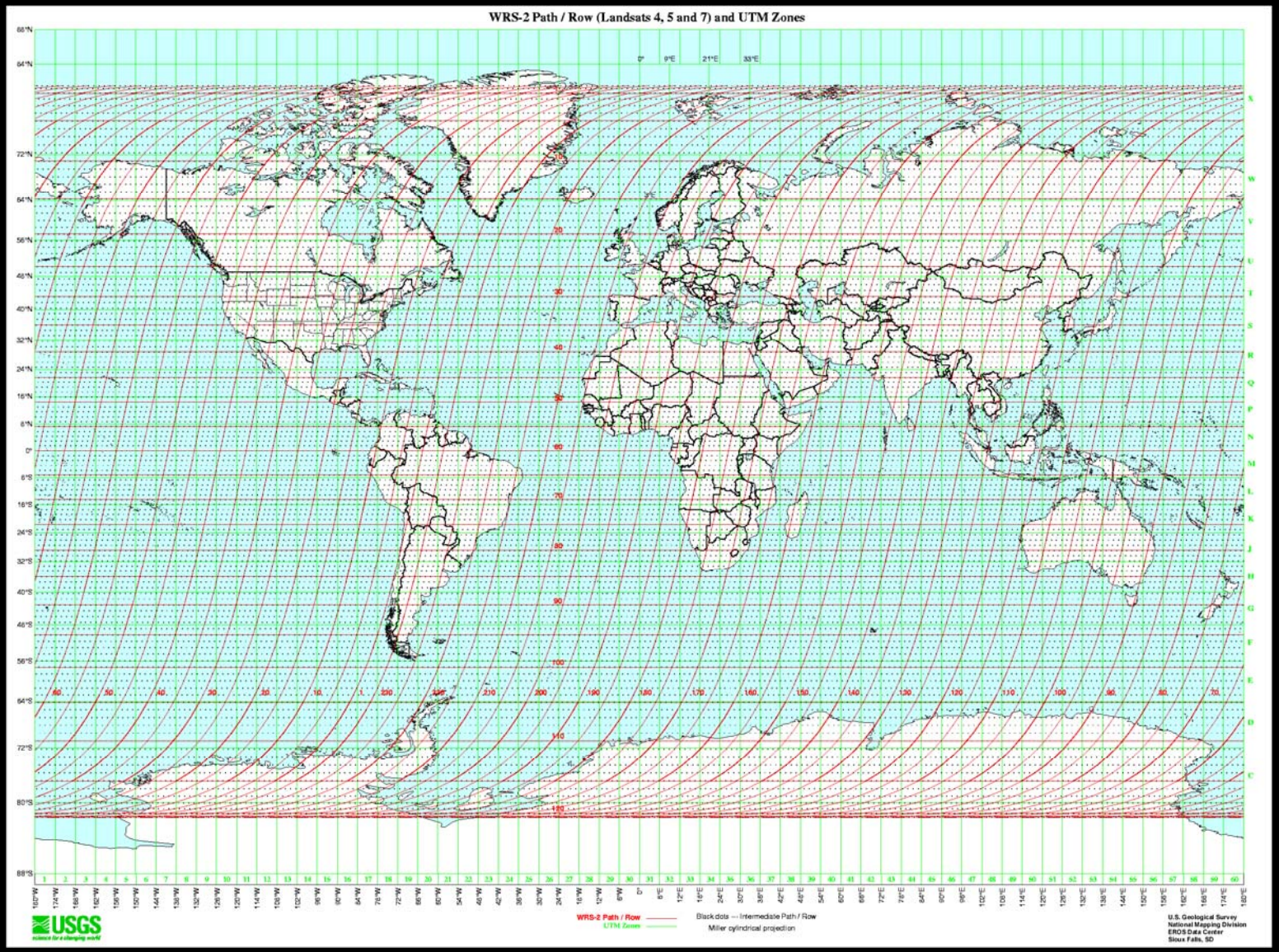


Remote Sensing

"the measurement or acquisition of information of some property of an object or phenomenon, by a recording device that is not in physical or intimate contact with the object or phenomenon under study" (Colwell, 1997).

Reference: Jensen, 2007

ii. Change Detection



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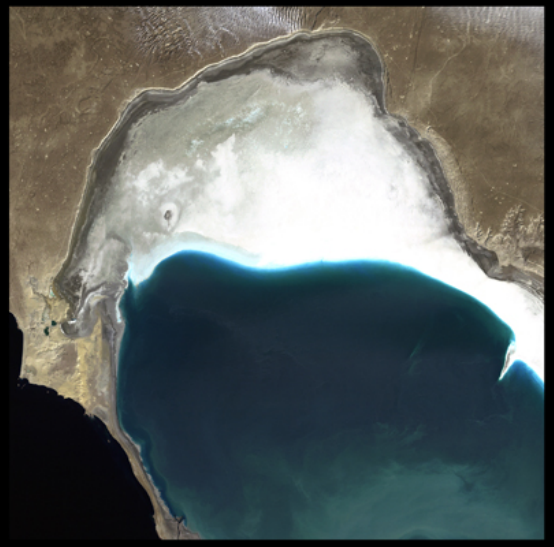
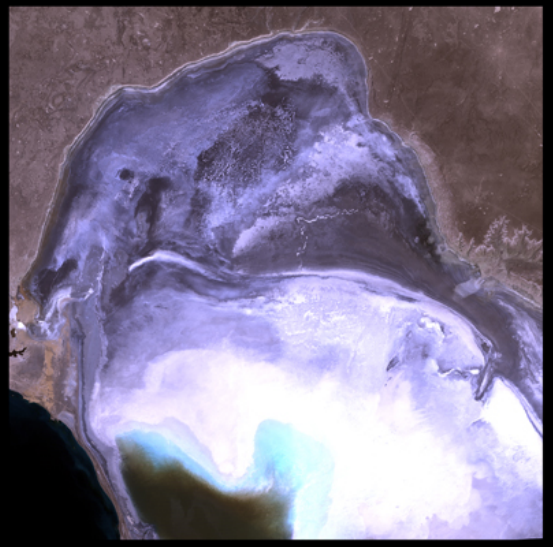


Landsat 1
December 4, 1972



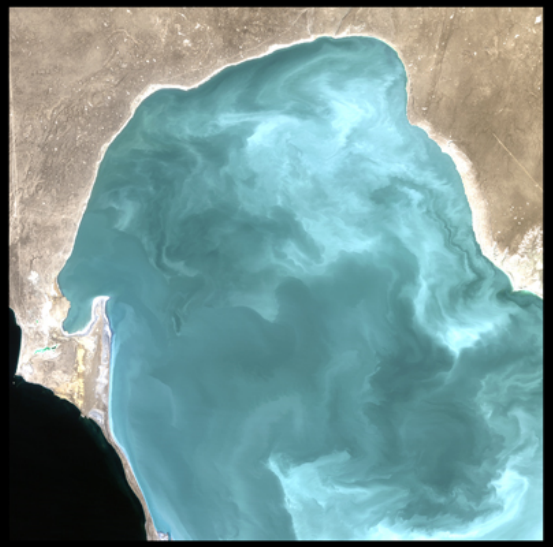
Landsat 5
September 25, 1987

Monitoring Change in the Caspian Sea

Landsat satellite data, acquired and processed by the U.S. Geological Survey and drawn from the 38+ year archive, are being used to monitor changes to a major Caspian Sea bay. The Kara-Bogaz-Gol basin on the eastern edge of the sea undergoes periodic, dramatic change in the water level. Because the basin is significantly more shallow than other near shoreline areas, the changes are more visible and affecting.

Human intervention by damming the feeder inlets has, in recent times, increased the magnitudes of change and impacted the salinity and water chemistry. In March 1980, the barrier to the Caspian was blocked. Accelerated evaporation caused a fall in the Caspian Sea water level, and the resulting "salt bowl" caused widespread problems of blowing salt, reportedly poisoning the soil and causing health problems for people hundreds of kilometers downwind to the east. In 1984 the Kara-Bogaz-Gol basin was completely dry.

In 1992, the Caspian Sea levels were rising again after the barrier was breached, and Kara-Bogaz-Gol Bay filled up again. Levels have been fairly stable the past decade.



Landsat 5
October 10, 2010

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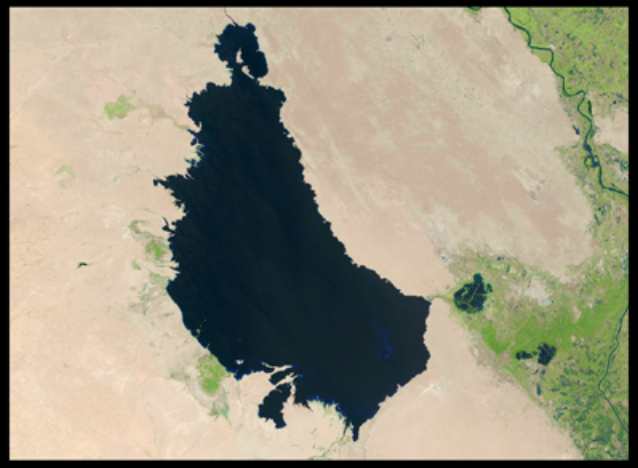
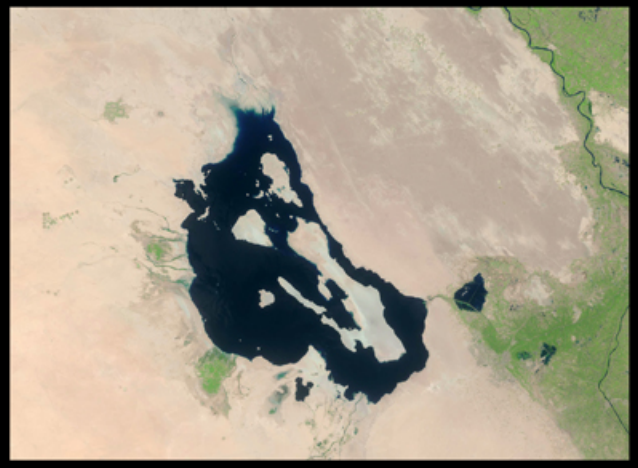


Landsat 5
July 16, 1995

0 5 10 Miles



Landsat 7
May 11, 2003

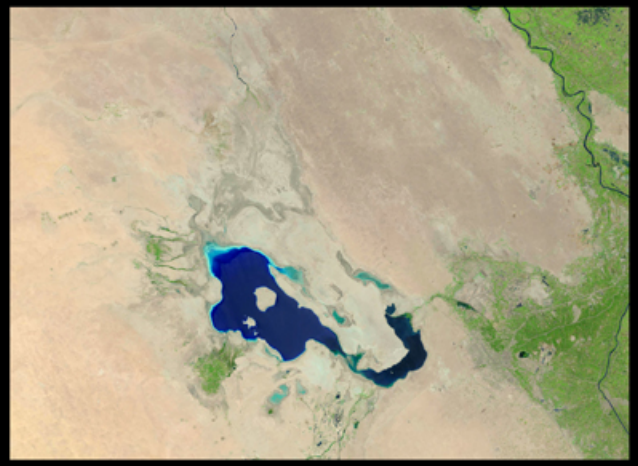
0 5 10 Miles

Bahr al Milh

Bahr al Milh (also called Lake Razazah) is a salt sea in Iraq, fed by the Euphrates River via canal.

Water levels of the shallow lake vary with the seasons; however, levels have been drastically low in the past decade, as can be seen in these Landsat images from 1995, 2003, and 2013.

The Landsat archive holds millions of images from the past 41 years, providing all users time series views of all areas of the world. Imagery from the new Landsat 8 satellite continues to add to this vast archive.



Landsat 8
June 15, 2013

0 5 10 Miles

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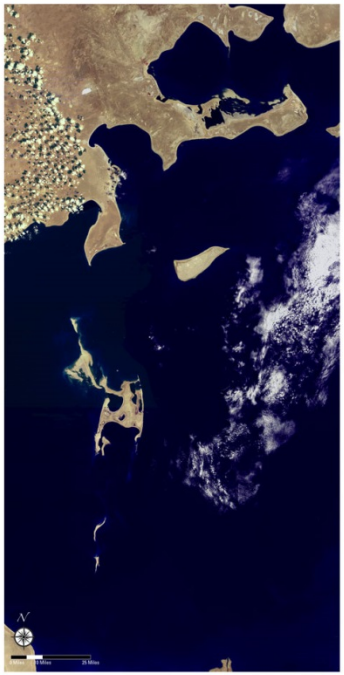
The Vanishing Aral Sea

The Aral Sea, located in Kazakhstan and Uzbekistan in central Asia, was once one of the largest inland bodies of salty reservoirs in the world and the second largest sea in Asia. Over the last 30 years, the Sea has diminished in capacity dramatically, as shown in these images captured by the Landsat series of satellites. A major factor causing the shrinkage is the drawing off by upstream feeder streams for crop irrigation. As the sea diminishes, noticeable changes in climate conditions and increasing sandstorms are affecting the area.

June 4, 1977



Landsat 2

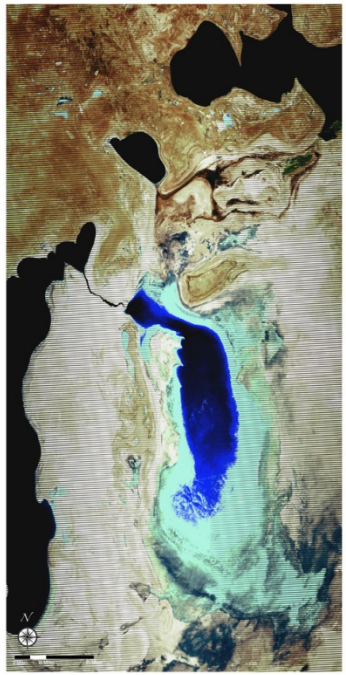
September 17, 1989

Landsat 5

May 27, 2006

Landsat 7

June 3, 2009



Landsat 7

U.S. Department of the Interior
U.S. Geological Survey

August 2009

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Three Gorges Dam on the Yangtze River, China

Landsat Thematic Mapper
Acquired April 17, 1987

Landsat Enhanced Thematic Mapper Plus
Acquired May 14, 2000

Landsat EnhancedThematic Mapper Plus
Acquired May 9, 2004

United States Department of the Interior
U.S. Geological Survey

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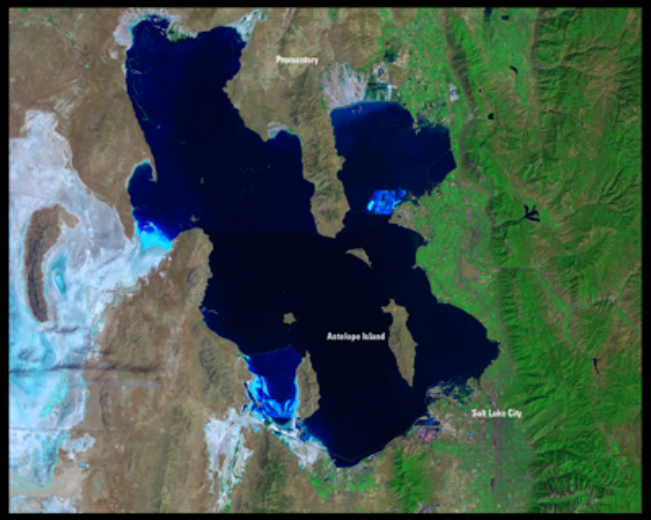

Landsat 5
August 1985

Landsat 5
September 2010

Great Salt Lake – 1985-2010

Landsat satellite imagery shows the dramatic changes in the area of the Great Salt Lake over the last 25 years. Mosaics of four satellite images were used to illustrate the changes over the full lake area. The 1985 image shows that upstream feeder streams, charged by snow melt and heavy rainfall, have filled the lake to near capacity. In the 2010 mosaic, drought conditions upstream have impacted the lake region. The Promontory Peninsula, which in 1985 had high water on three sides, is now connected to land on its eastern side. Similarly, Antelope Island is connected to marshy units near Salt Lake City.

The water levels of the Great Salt Lake change from year to year and even within single years, based on precipitation from rivers flowing into it. During below-average years, water levels drop and salinity rises. This causes the shoreline to recede and the wetlands to dry up. When precipitation is high, lake levels rise and salinity drops. The shoreline expands and wetlands get covered by salt water. This is harmful to sensitive plants and destroys wildlife habitats. Regional resource management officials used the Landsat satellite data to monitor, on a regular basis, the conditions and variable changes in the lake region.

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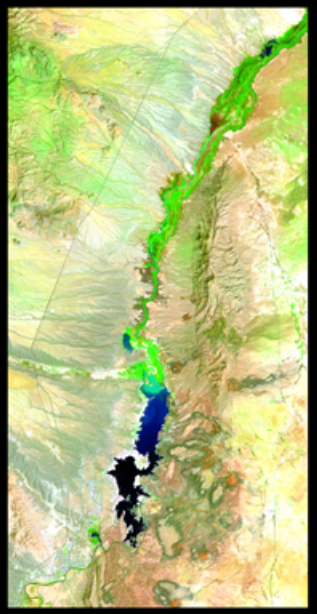
Landsat 5
August 20, 1991

0 2 4 Miles



Landsat 5
August 27, 2011

0 2 4 Miles

Elephant Butte Reservoir

Prolonged drought in the southwestern United States has affected many water bodies, such as Elephant Butte Reservoir along the Rio Grande River, north of Truth or Consequences, New Mexico. The hydroelectric reservoir has had declining water levels over the past 20 years, as indicated in these Landsat images.

In 2009, the Bureau of Reclamation established a plan to implement conservation measures to restore water levels in the reservoir.

Landsat images are useful in monitoring water bodies for change over time and provide decision makers a visual effect of the declining water levels.

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Landsat 3
March 19, 1980

0 2 4 Miles

N

Landsat 5
March 3, 1986

0 2 4 Miles

N

Cedar Bluff Reservoir, Kansas

In 1949, the Cedar Bluff Dam was constructed along the Smoky Hill River in Kansas to mainly provide irrigation to the area, but also to help with flood control, establish fish and wildlife habitats, develop recreation sites, and provide water for municipal and industrial uses.

In the late 1960's and into the 1970's, the flow of the river declined dramatically, and by the early 1980's, not enough water was available for irrigation. By 1992, all associations and activities regarding irrigation and the delivery systems dissolved, though other uses were retained.

Even though the primary use of the dam was lost, the water levels of the reservoir have increased over the years, and now is a popular recreation site, while still offering flood control and water for municipal uses and local industries.

Landsat images acquired in 1980, 1986, and 2012 show the changes to water levels in the reservoir. While levels may fluctuate from year to year, the general area of the reservoir remains high. The forty year Landsat archive provides data on the land surface variations. Data from Landsat observations are used by decision makers to determine how to best use natural resources and to monitor water body conditions.

Landsat 7
March 2, 2012

0 2 4 Miles

N

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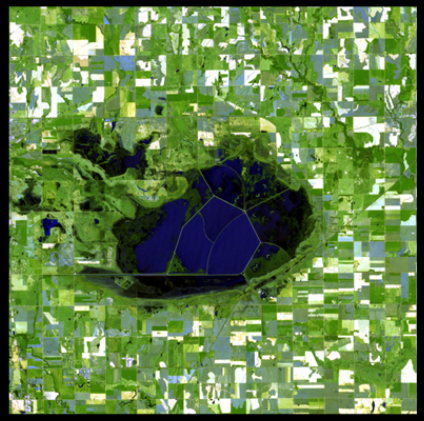
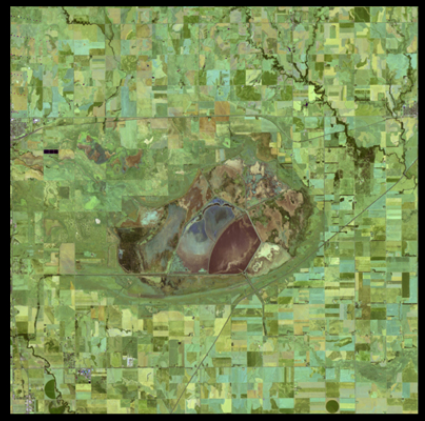


Landsat 5
June 18, 2010

Landsat 5
June 5, 2011

Landsat 7
May 30, 2012



Landsat 7
July 17, 2012

Effects of Drought

Large areas of the western United States have been affected by the drought of 2012. For example, Landsat images, acquired and processed by the U.S. Geological Survey, provide a record of the effects of the drought on the Cheyenne Bottoms Wildlife Wetlands area in central Kansas.

As the largest interior marsh in the United States, Cheyenne Bottoms provides a resting place for millions of migrating birds every fall. As the water levels dwindle and disappear, wildlife officials are concerned that the effects could be devastating for the habitat. In 2010 there was sufficient water in the wetland area; in 2011 and into the spring of 2012, the levels had already started to diminish. From May 30 to July 17 of 2012, virtually all the water had evaporated from the habitat area.

Landsat data offer objective, scientifically reliable information on the effects of climate change to land areas. In the case of the Cheyenne Bottoms Wildlife Wetlands area, Landsat data are useful to officials as they determine what actions to take to sustain a habitat for the nesting waterfowl.

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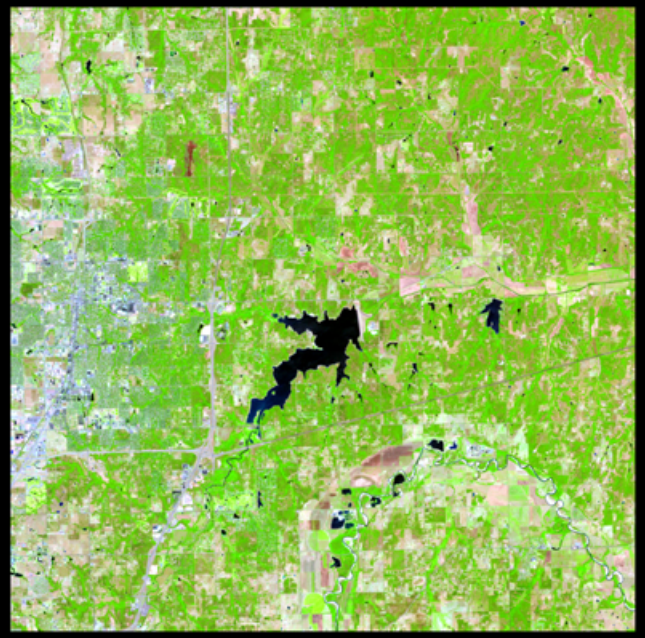
Landsat 5
August 12, 1986

0 1 2 Miles



Landsat 5
August 1, 2011

0 1 2 Miles

Arcadia Lake, Oklahoma

Arcadia Lake is a reservoir located just east of the Oklahoma City suburb of Edmond, Oklahoma.

The lake was constructed in the 1980s as part of the National Flood Control Act of 1970 and as a cooperative effort between the city of Edmond and the U.S. Army Corps of Engineers. Arcadia Lake was created to control floods in the Deep Fork River Basin, supply water to the city of Edmond, and provide recreational resources to the surrounding communities.

The lake continues to be a major recreation site for the Oklahoma City region and is a major water source for Edmond and for other Oklahoma City suburbs. There is a current lawsuit between Edmond and the U.S. Army Corps of Engineers over water allocation and costs for maintaining the reservoir.

Landsat images show the area in 1986, before the earthen dam blocked the Deep Fork River, and in 2011, with the reservoir near capacity.

Landsat imagery are useful for determining how changes to the river basin affect land use in the region and are used to monitor the general water levels in the reservoir.

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Landsat 7
June 17, 2012

0 5 10 Miles

Landsat 7
August 20, 2012

0 5 10 Miles

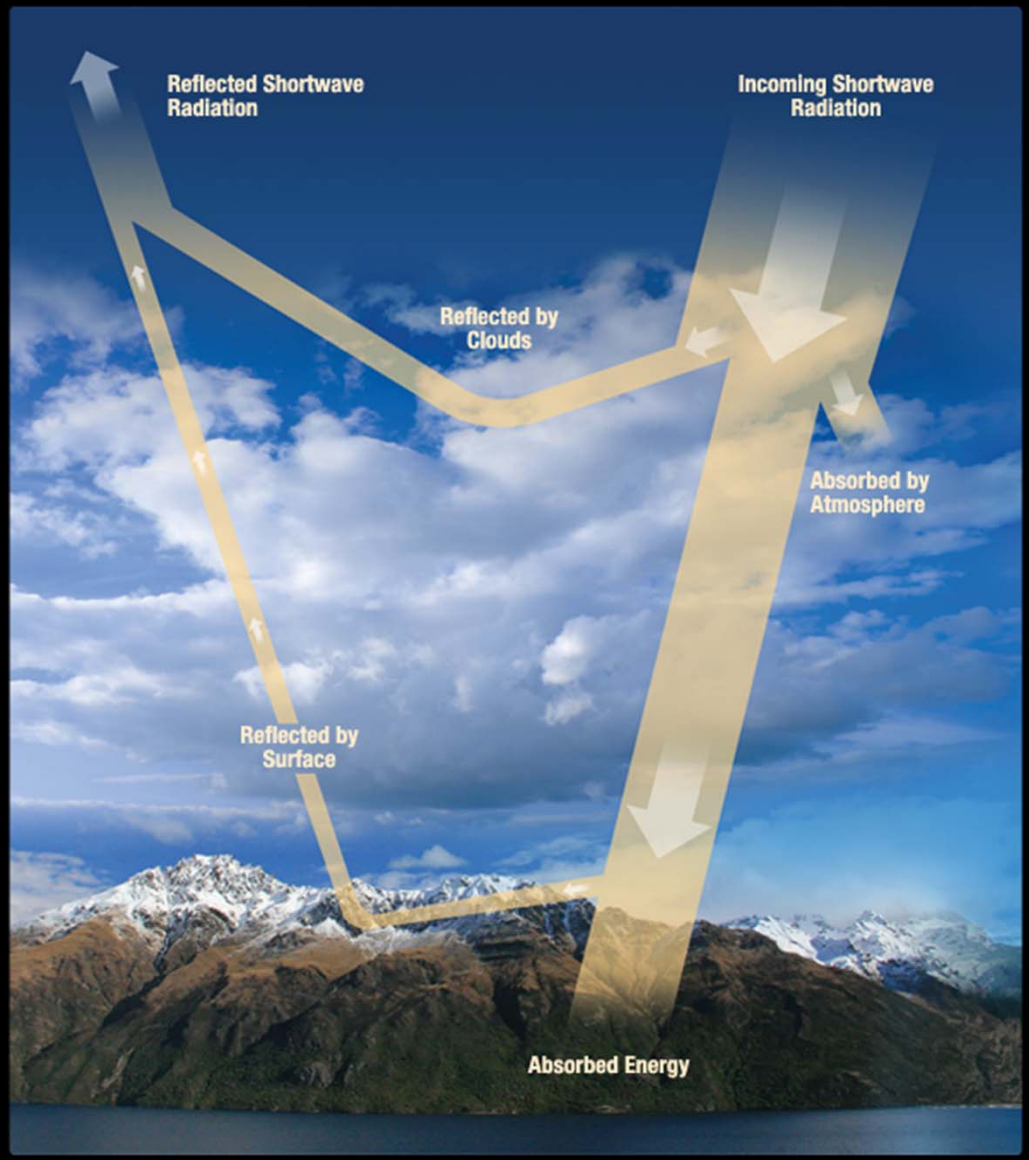
Creek County, Oklahoma fire

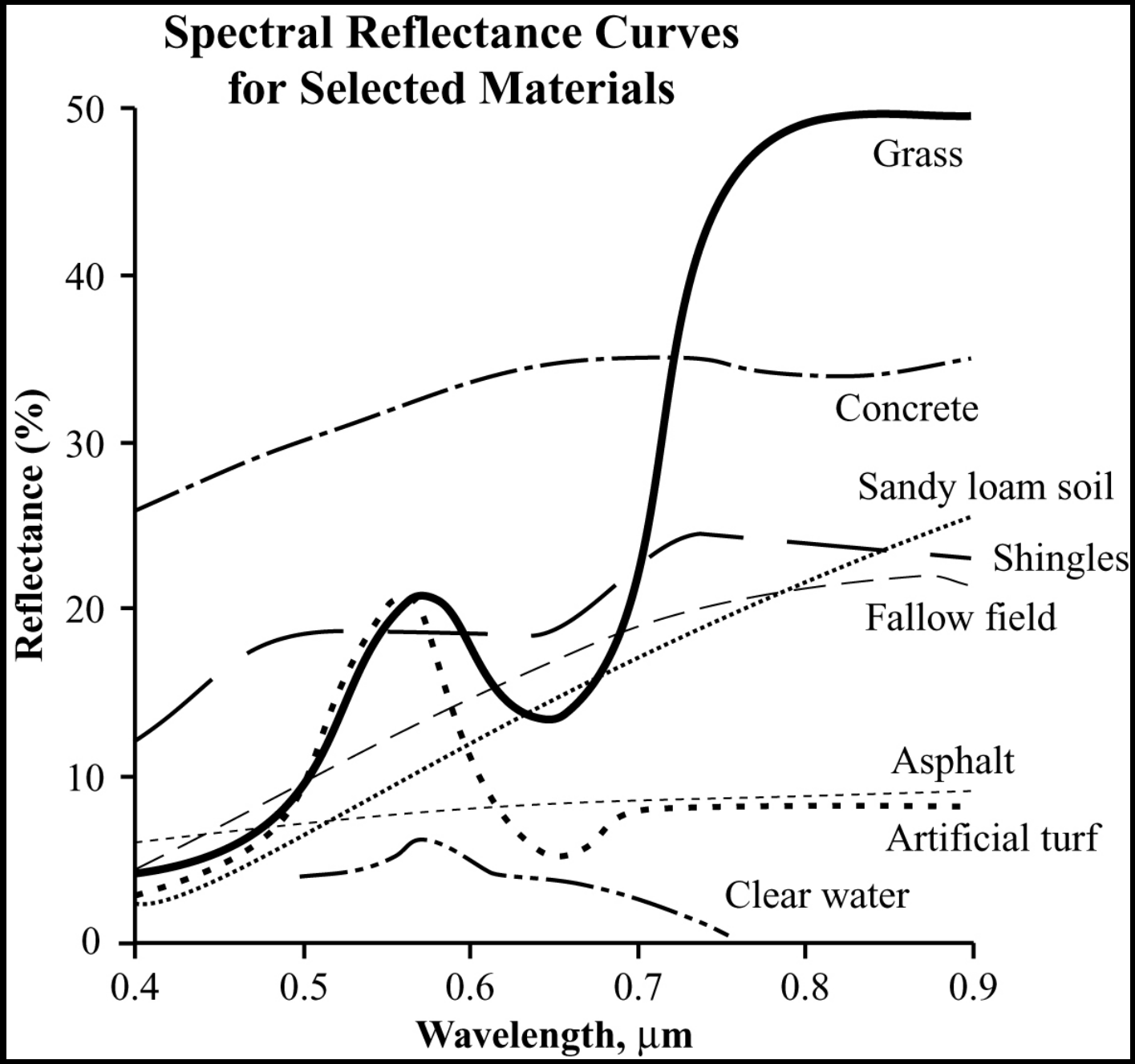
A large grass fire that started August 2 burned over 58,000 acres of grassland and destroyed over 380 homes in Creek County, Oklahoma. Residents of small towns in the path of the fire were evacuated in this drought stricken area west of the city of Tulsa. The fire was extinguished within days and residents were allowed back by the end of the month. An arson suspect has been charged for starting the fire. With daytime temperatures frequently topping 100 degrees, efforts to contain and control wildfires in western states have become increasingly difficult.

Landsat images, acquired on June 17 and August 20 of 2012, show fire scars as well as the diminished regional river and reservoir levels. The images are being used by state and regional managers to evaluate the extent of the burn and the vegetation affected by the fire.

U.S. Department of the Interior
U.S. Geological Survey

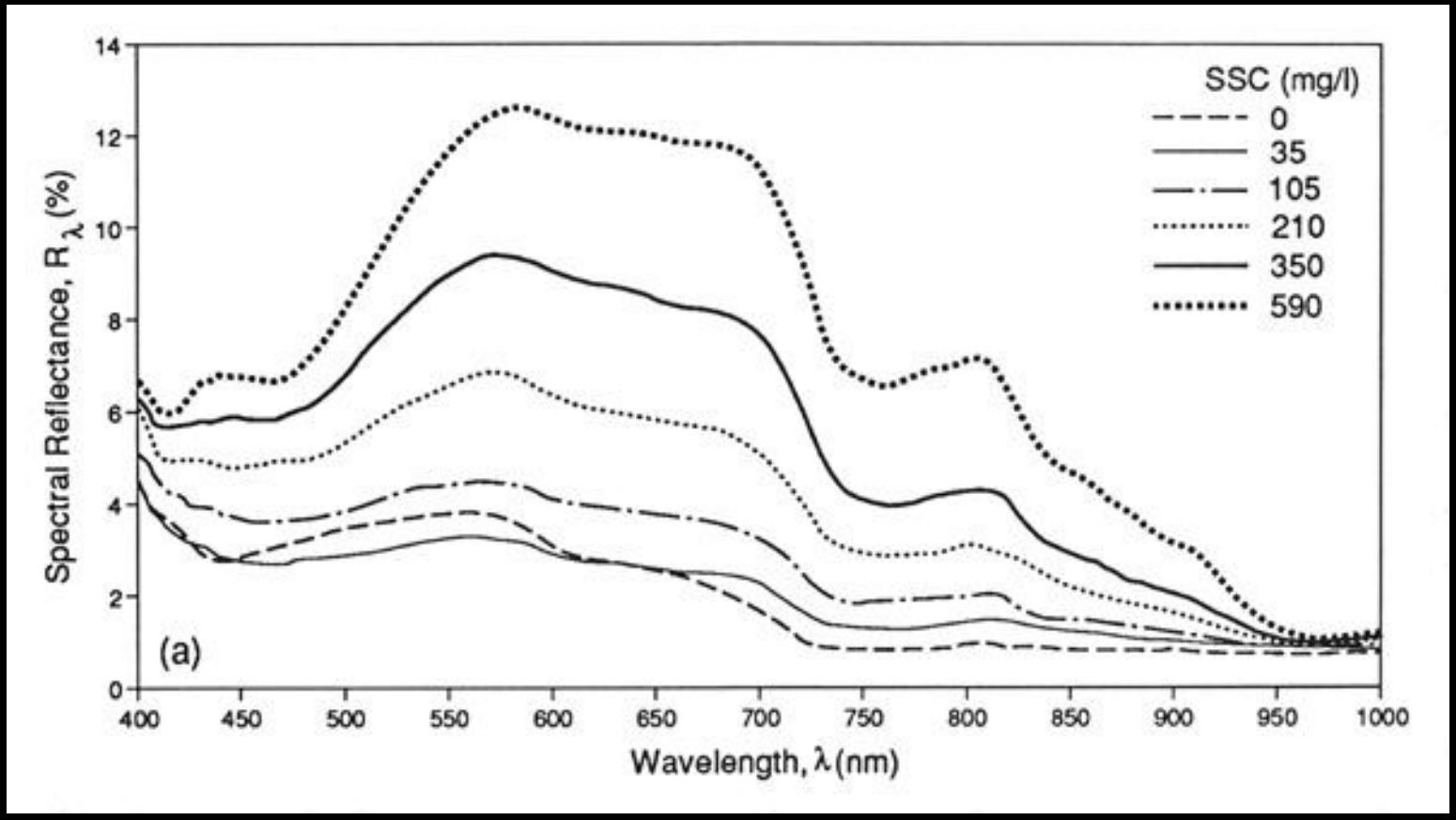
iii. Spectral characteristics

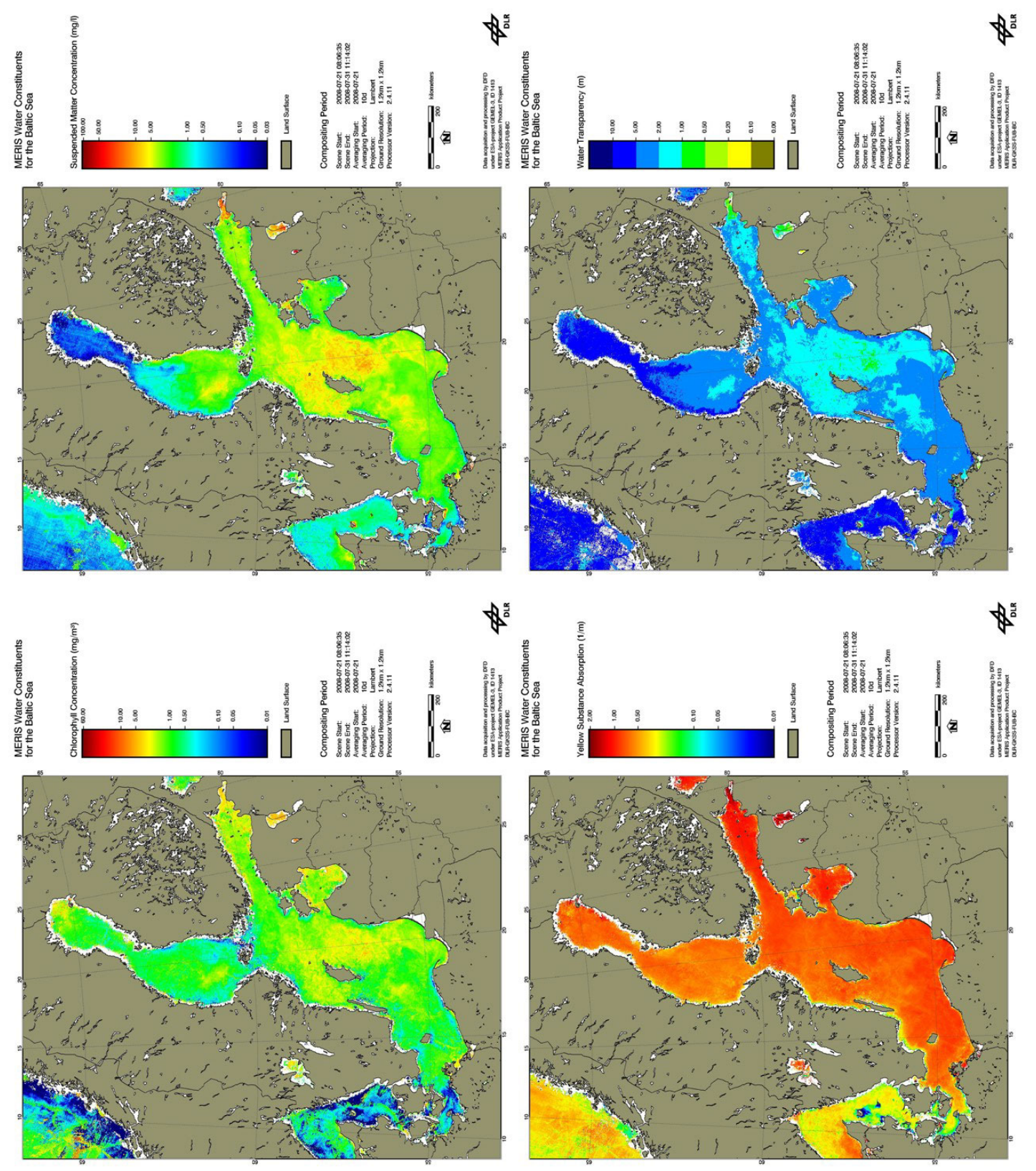




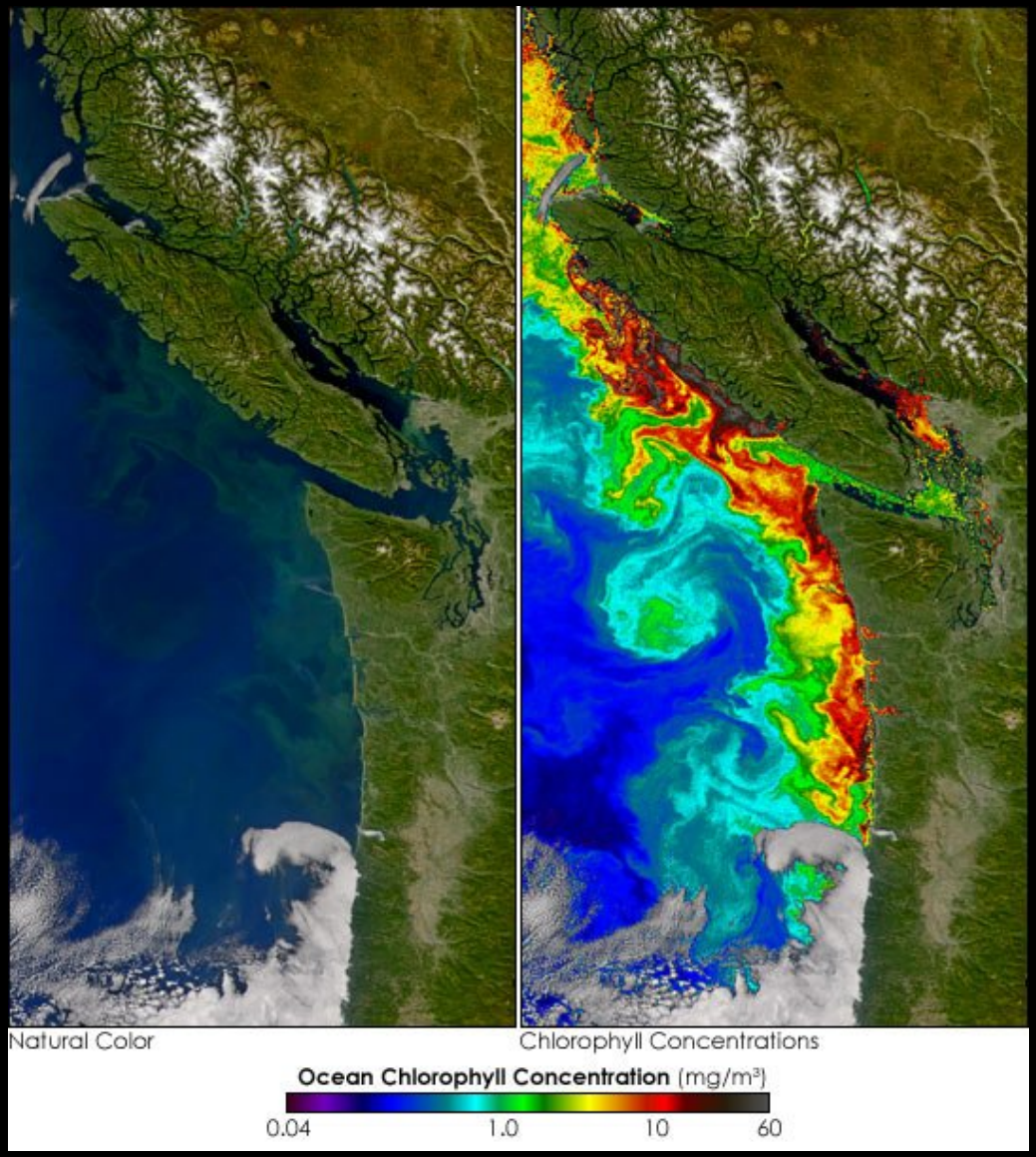
Reference: Jensen, 2007

Suspended Sediment Concentration

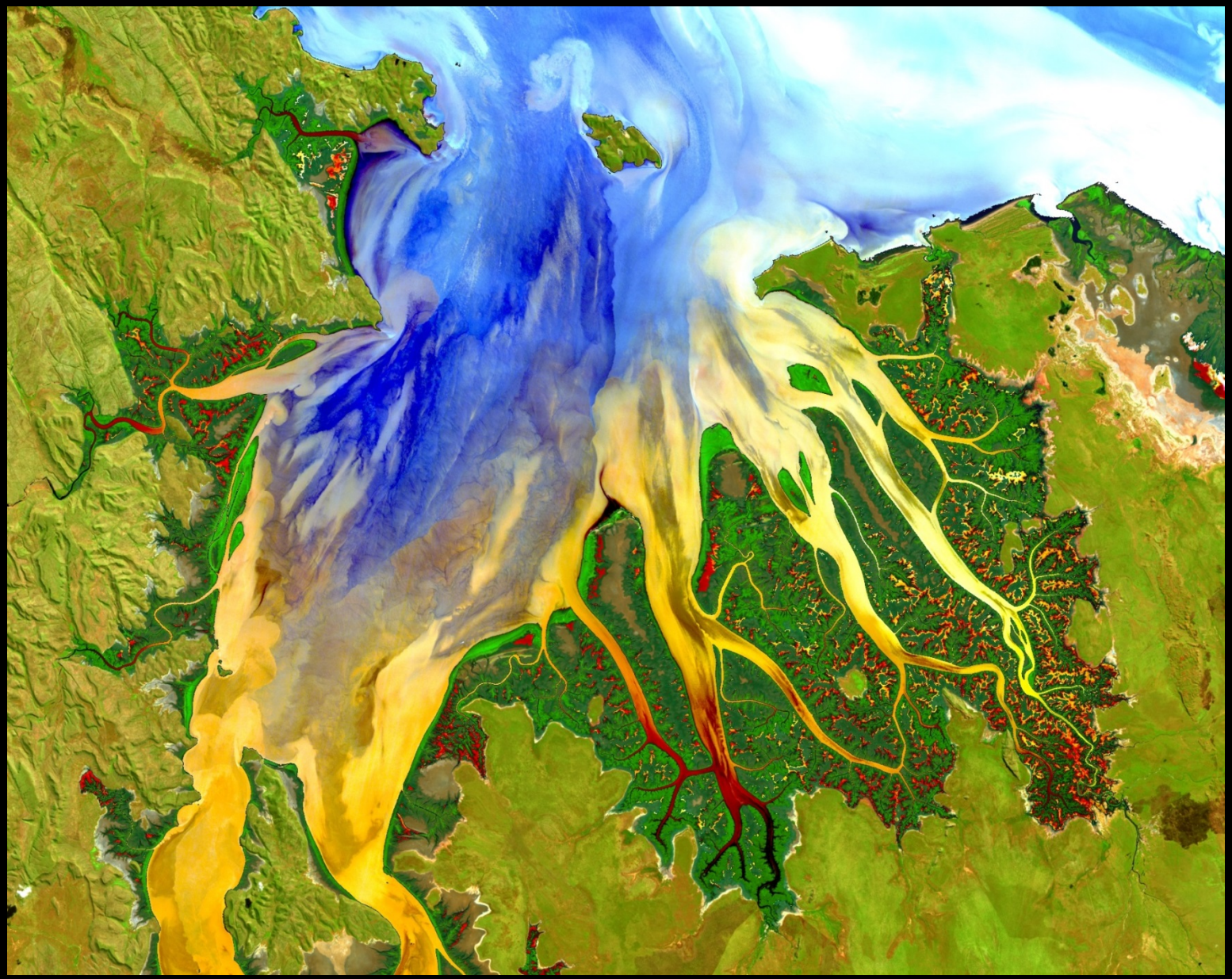



MERIS Water Constituents for the Baltic Sea
Suspended Matter Concentration (mg/l)
100.00
50.00
10.00
5.00
1.00
0.50
0.10
0.05
0.03
Land Surface
Compositing Period
Scene Start: 2008-07-21 08:06:35
Scene End: 2008-07-31 11:14:02
Averaging Start: 2008-07-21
Averaging Period: 10d
Projection: Lambert
Ground Resolution: 1.2km x 1.2km
Processor Version: 2.4.11
Kilometers
0
200
Data acquisition and processing by DFD under ESA-project GEMELS, ID 1413 MERIS Application Product Project DLR-GKSS-FUB-IEC
DLR
MERIS Water Constituents for the Baltic Sea
Water Transparency (m)
10.00
5.00
2.00
1.00
0.50
0.20
0.10
0.00
Land Surface
Compositing Period
Scene Start: 2008-07-21 08:06:35
Scene End: 2008-07-31 11:14:02
Averaging Start: 2008-07-21
Averaging Period: 10d
Projection: Lambert
Ground Resolution: 1.2km x 1.2km
Processor Version: 2.4.11
Kilometers
0
200
Data acquisition and processing by DFD under ESA-project GEMELS, ID 1413 MERIS Application Product Project DLR-GKSS-FUB-IEC
DLR
MERIS Water Constituents for the Baltic Sea
Chlorophyll Concentration (mg/m³)
50.00
10.00
5.00
1.00
0.50
0.10
0.05
0.01
Land Surface
Compositing Period
Scene Start: 2008-07-21 08:06:35
Scene End: 2008-07-31 11:14:02
Averaging Start: 2008-07-21
Averaging Period: 10d
Projection: Lambert
Ground Resolution: 1.2km x 1.2km
Processor Version: 2.4.11
Kilometers
0
200
Data acquisition and processing by DFD under ESA-project GEMELS, ID 1413 MERIS Application Product Project DLR-GKSS-FUB-IEC
DLR
MERIS Water Constituents for the Baltic Sea
Yellow Substance Absorption (1/m)
2.00
1.00
0.50
0.10
0.05
0.01
Land Surface
Compositing Period
Scene Start: 2008-07-21 08:06:35
Scene End: 2008-07-31 11:14:02
Averaging Start: 2008-07-21
Averaging Period: 10d
Projection: Lambert
Ground Resolution: 1.2km x 1.2km
Processor Version: 2.4.11
Kilometers
0
200
Data acquisition and processing by DFD under ESA-project GEMELS, ID 1413 MERIS Application Product Project DLR-GKSS-FUB-IEC
DLR

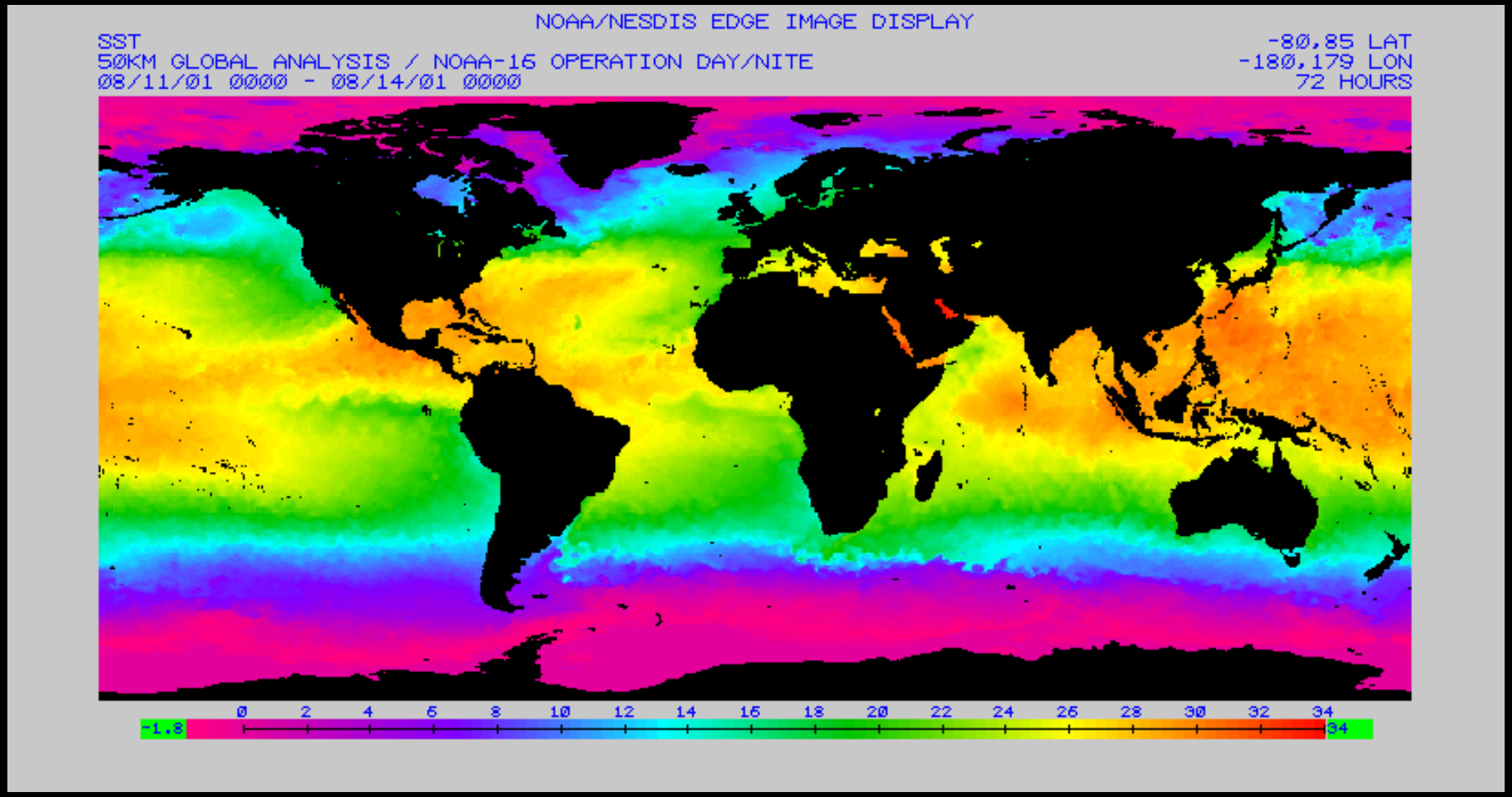
The Sea-viewing Wide Field-of-view Sensor (SeaWiFS) aboard the OrbView-2 satellite, acquired on Oct 1, 2004 over the Pacific ocean along the coast of Washington and Vancouver Island. Phytoplankton blooms are frequent in this region, and some are toxic.



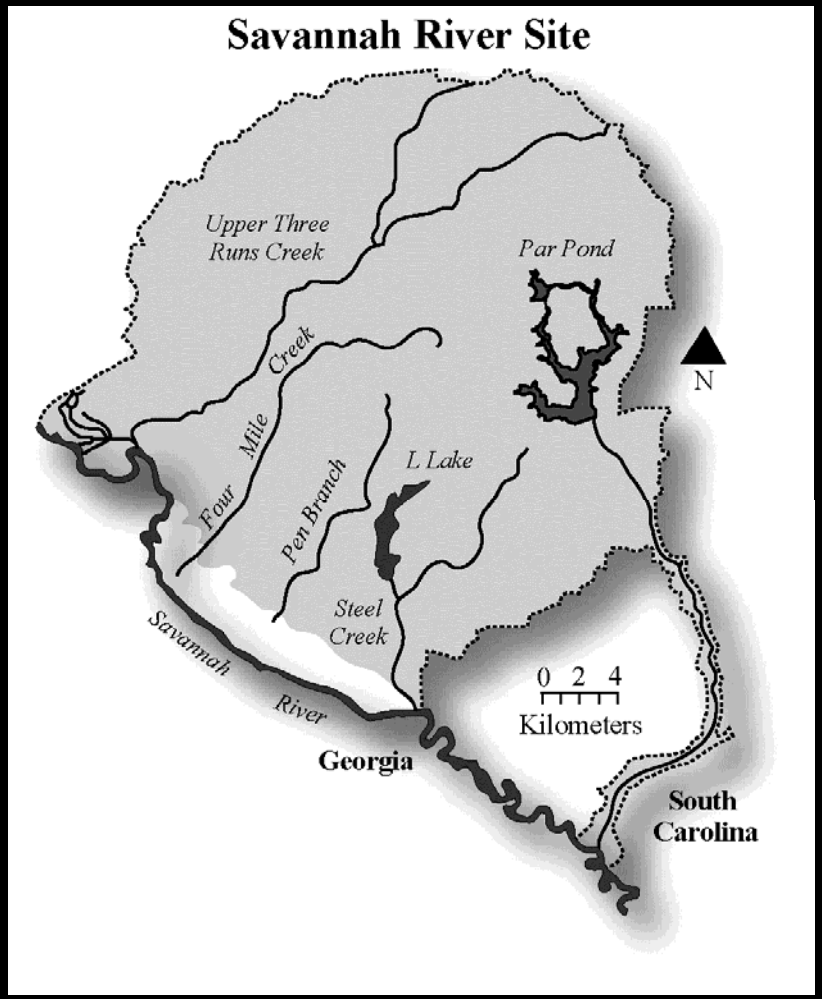
Landsat 8 scene acquired May 12, 2013 in Western Australia
Water: bands 4, 2, 1; Land: bands 6, 5, 3



iv. Thermal Remote Sensing

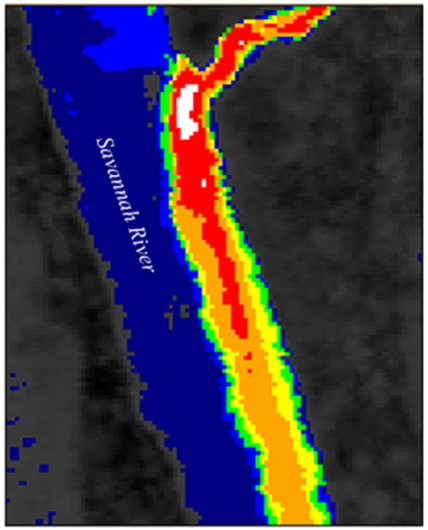


Pre-dawn Thermal Infrared Image of Effluent Entering the Savannah River Swamp System

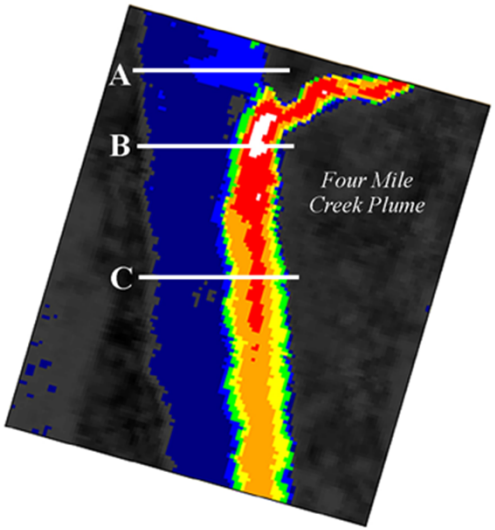


Reference: Jensen, 2007

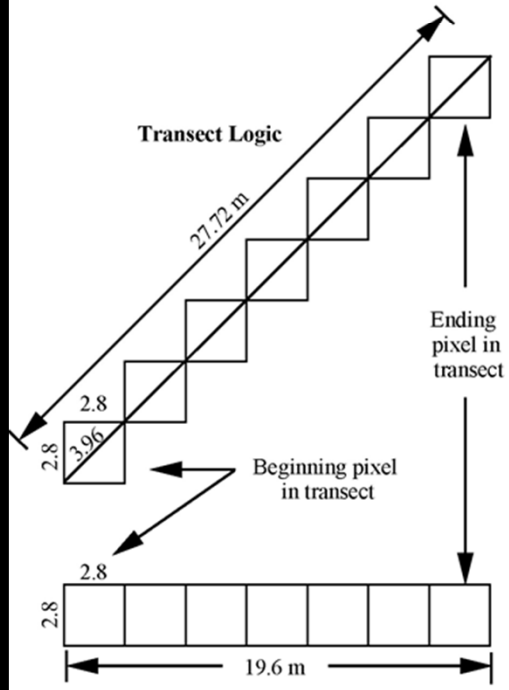
Thermal Infrared Detection of Thermal Water Pollution in the Savannah River



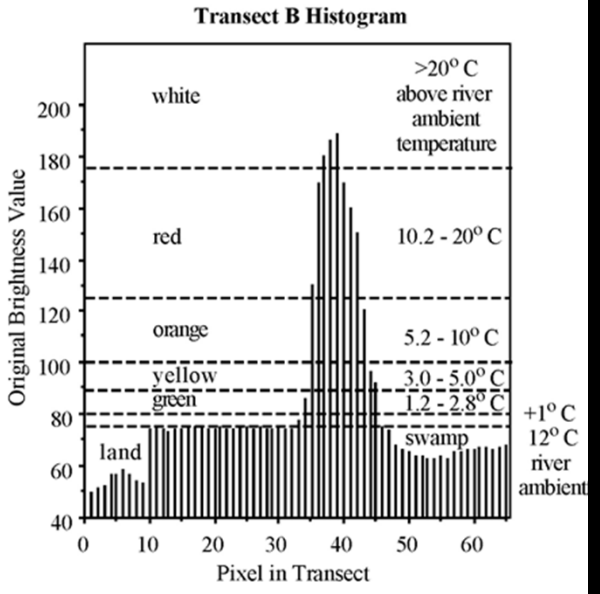
a. Density sliced predawn thermal infrared (8 - 14 µm) data.



b. Rotated 16° and transects extracted.



c.



d.

Reference: Jensen, 2007

v. Sensor Resolution

- Spatial: the size of each pixel, e.g. 1×1 m, 30×30 m.
- Spectral: the number and size of spectral regions the sensor records data in, e.g. blue, green, red, near-infrared thermal infrared, microwave (radar).
- Temporal: how often the sensor acquires data, e.g. every 16 days.
- Radiometric: the sensitivity of detectors to small differences in electromagnetic energy, levels of brightness, e.g. 2^8, 2^{10}.

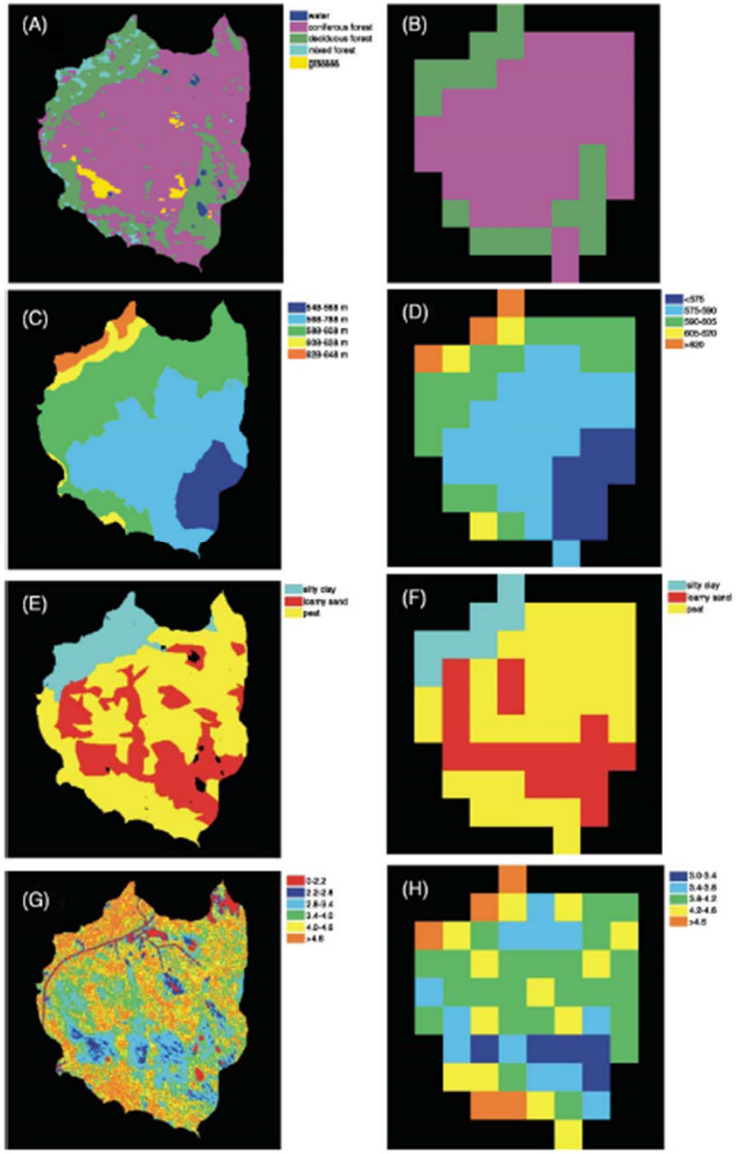
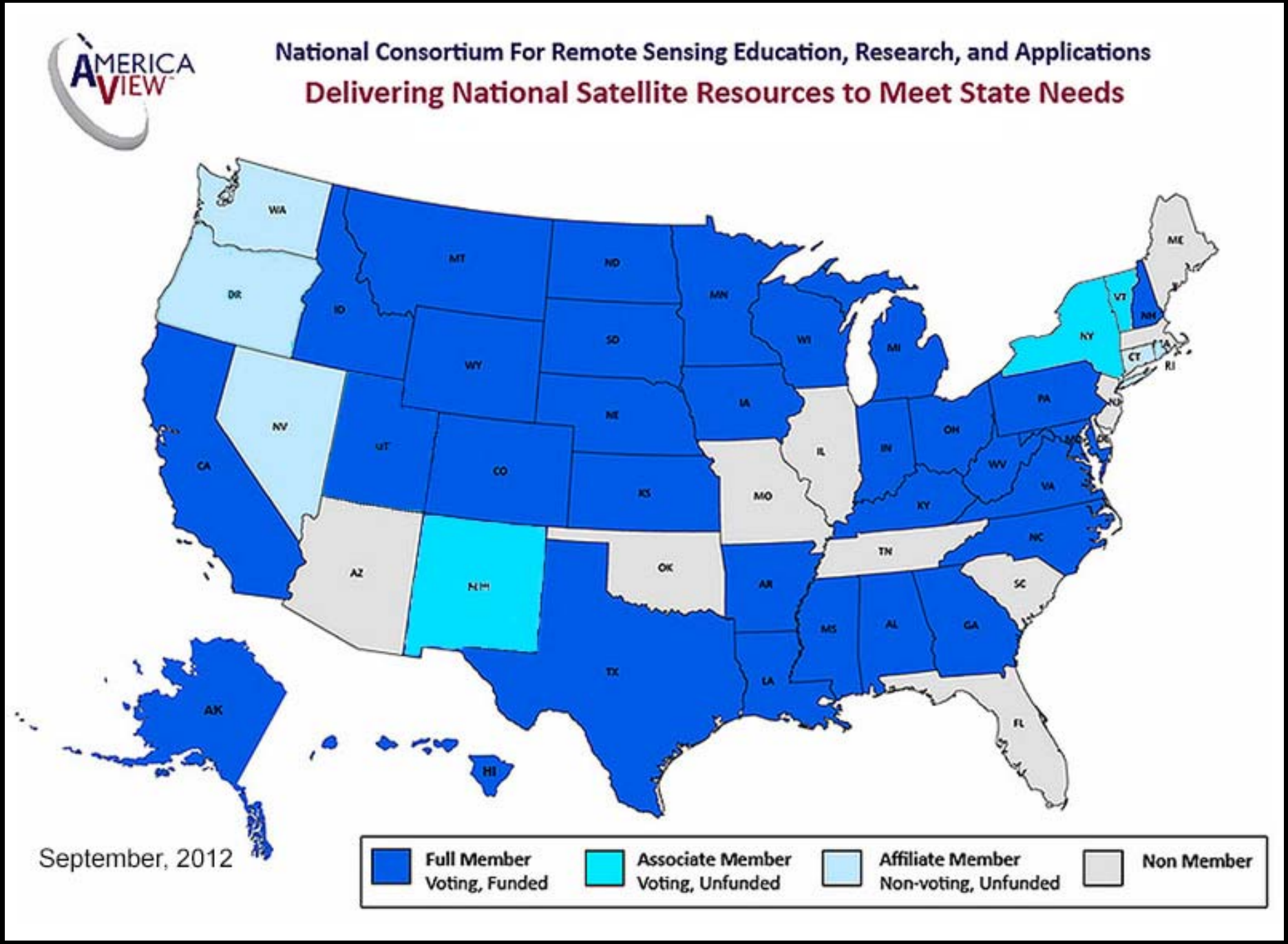


Plate 1. Watershed characteristics at 30-m and 1-km resolutions: (A) Land cover at 30-m resolution; (B) Land cover at 1-km resolution; (C) Elevation at 30-m resolution; (D) Elevation at 1-km resolution; (E) Soil type at 30-m resolution; (F) Soil type at 1-km resolution; (G) Leaf area index at 30-m resolution; (H) Leaf area index at 1-km resolution.

AmericaView (AV) is a locally controlled and nationally coordinated program to advance the availability, timely distribution, and widespread use of remote sensing data and technology through education, research, outreach, and sustainable technology transfer to the public and private sectors.


AMERICA VIEW
National Consortium For Remote Sensing Education, Research, and Applications
Delivering National Satellite Resources to Meet State Needs
WA
OR
CA
ID
NV
MT
WY
UT
AZ
CO
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MS
MI
IN
KY
TN
AL
OH
WV
GA
FL
SC
NC
VA
PA
NY
ME
VT
NH
CT
RI
AK
HI
September, 2012
Full Member
Voting, Funded
Associate Member
Voting, Unfunded
Affiliate Member
Non-voting, Unfunded
Non Member

Questions