Band ratio review – in a nutshell

Band ratioing = Divide the DNs in one band by the DNs in another band for each pixel to create a new data channel

Purposes:
a. Spectral slope enhancement – highlight the difference between two adjacent bands (cancel out what is similar)
b. Suppress / reduce topographic effect – shadow
c. Include as channel input for classifications
d. Use for thematic analysis / display

Related image arithmetic:
- Band addition, subtraction and multiplication

Catalyst Focus tools:
Raster calculator, or RTR, ARI algorithms

Indices

Ratios

... enhance albedo contrasts by reducing inter-band similarities

e.g. Near-IR / Red ... to identify vegetation

Ratio Vegetation Index (RVI) = **NIR / Red** > 1 = vegetated

* RVI can create high values (if Red Band DN is low)

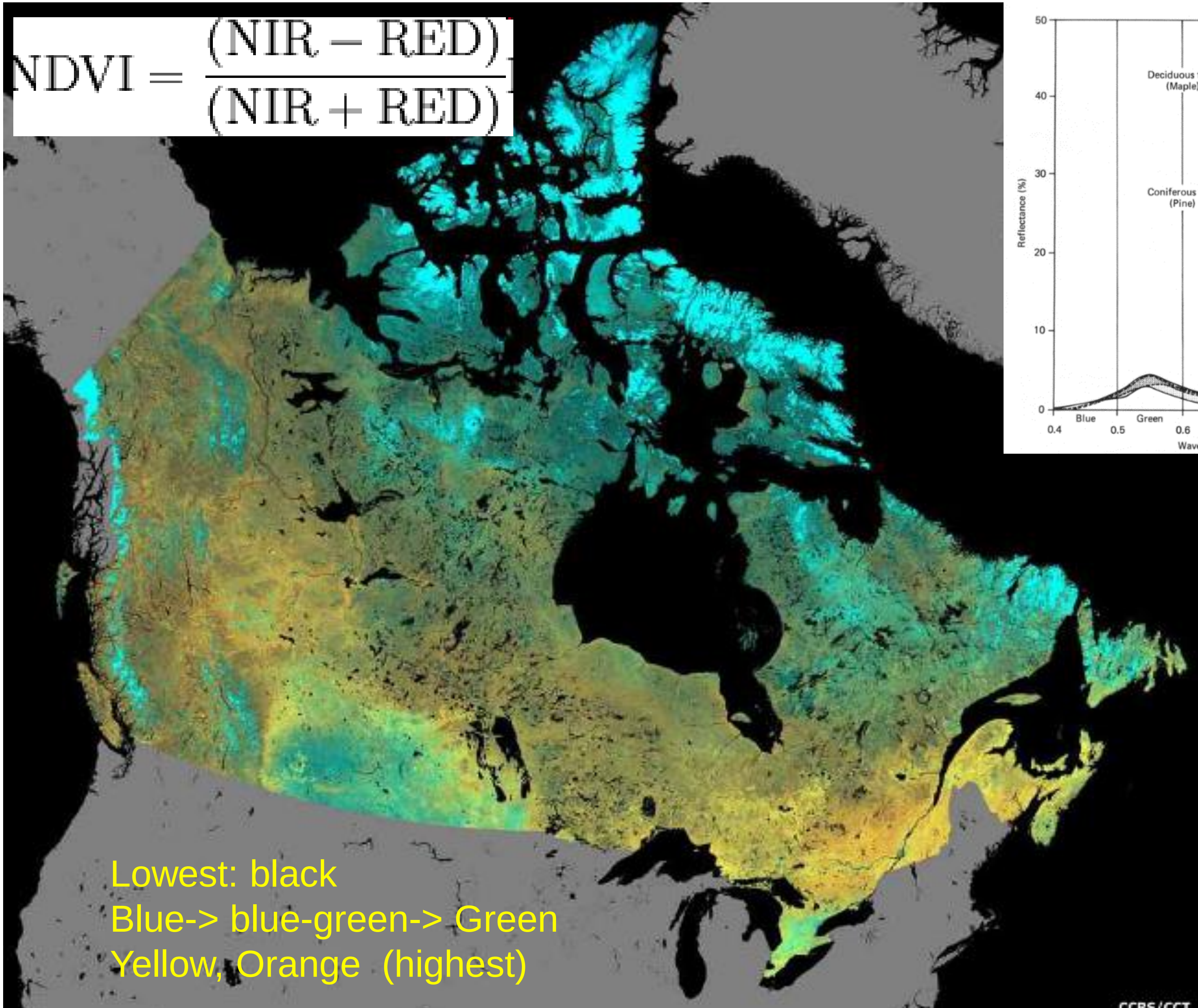
Difference Vegetation Index (DVI) = **NIR-Red** > 0 = vegetated

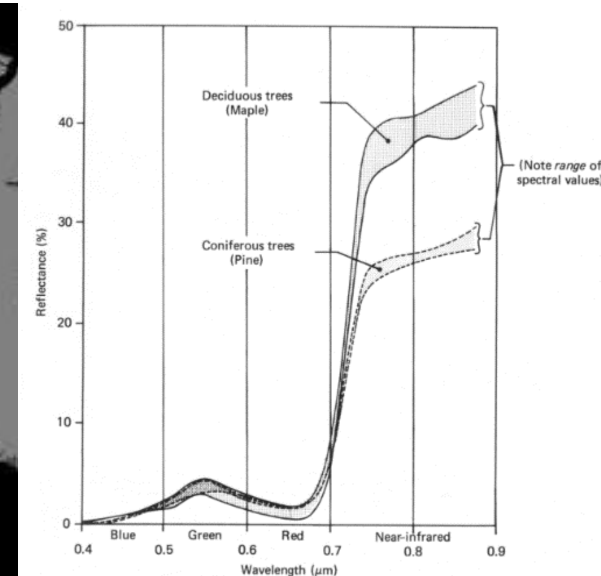
* DVI is heavily influenced by different lighting

'Combining' these two creates the most common vegetation index, involving subtraction, addition and division ... and 'normalization'

Normalised Difference Vegetation Index: NDVI

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$





Max= 1.0

Min= -1.0

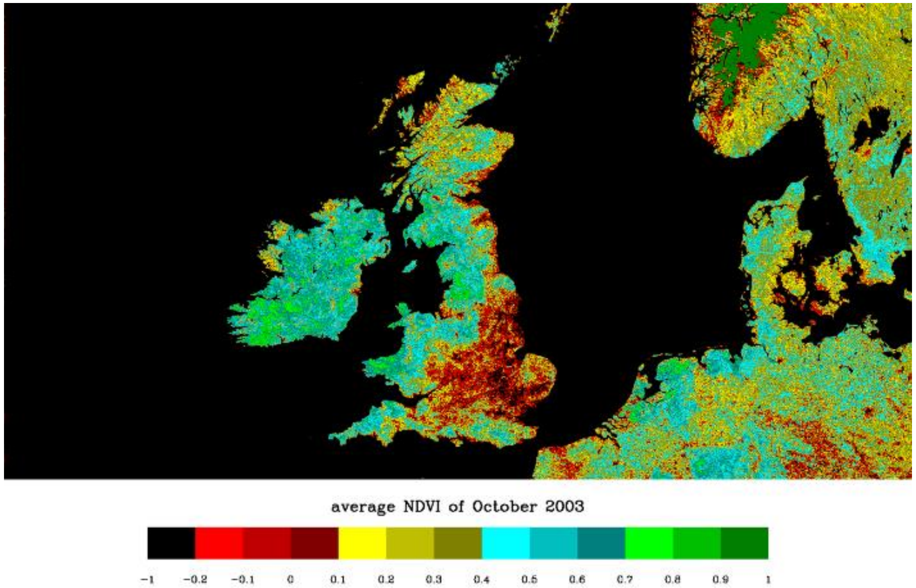
Normalized difference vegetation index (NDVI)

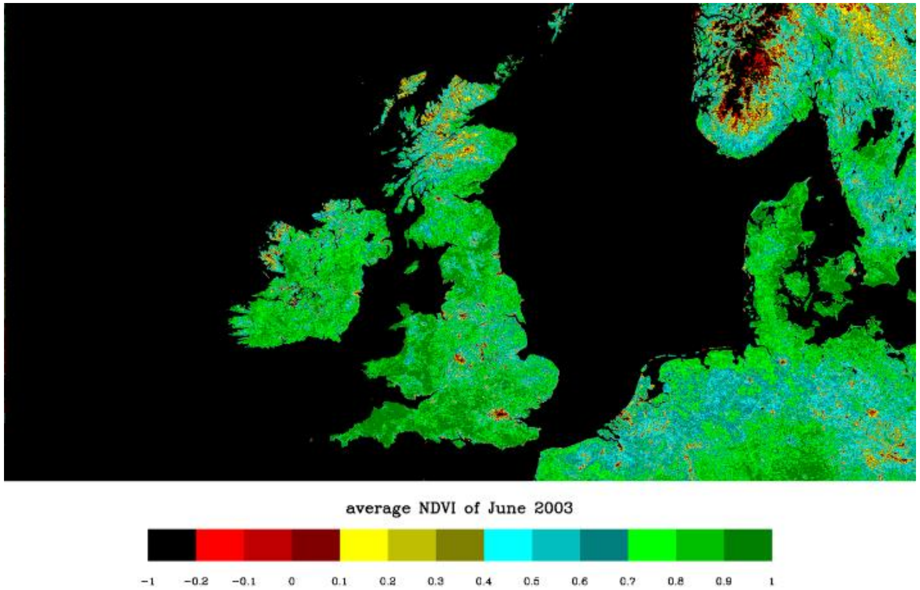
First developed 1973 – using AVHRR and Landsat MSS sensors

NDVI = (NIR-Red) / (NIR + Red) **– index values range from -1.0 to +1.0**

Vegetation indices enhance the vegetation signal, while minimizing the impact of solar radiation and bare soil – first used to map spring green-up

The standard range -1 to +1 enables comparison between places and time

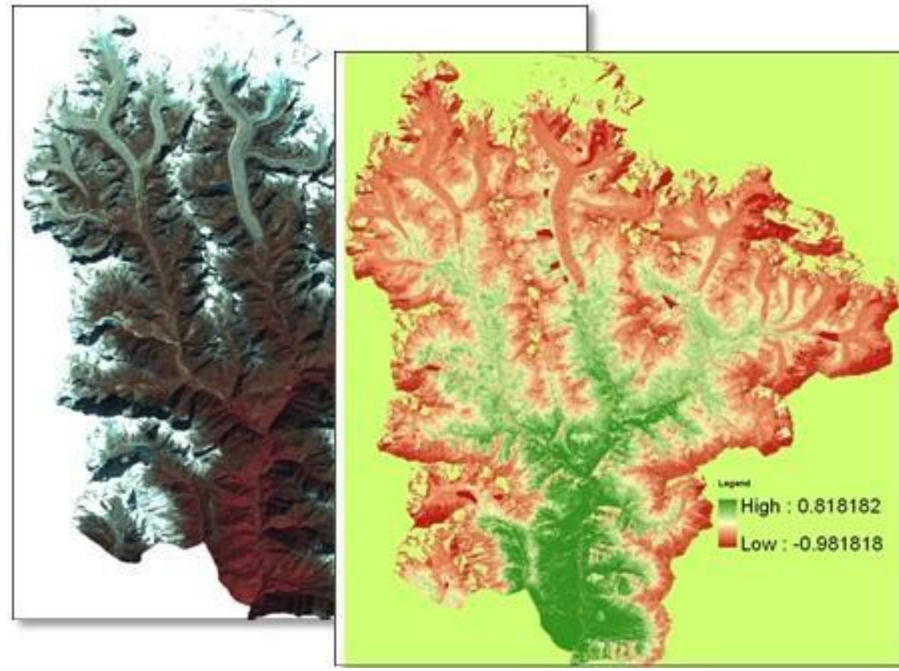




Normalised Difference Vegetation Index NDVI

Division compensates for differential illumination and yields values between
-1 and 1, … in a 32 bit channel

= a close estimate of **biomass** also referred to as ***greenness***



- Negative values of NDVI (values approaching -1) correspond to water.
- Values close to zero (0 to 0.1) = barren areas of rock, sand, or snow.
- low, positive values represent shrub and grassland (~ 0.2 to 0.5),
- high values indicate temperate and tropical rainforests (0.6 to 0.9)

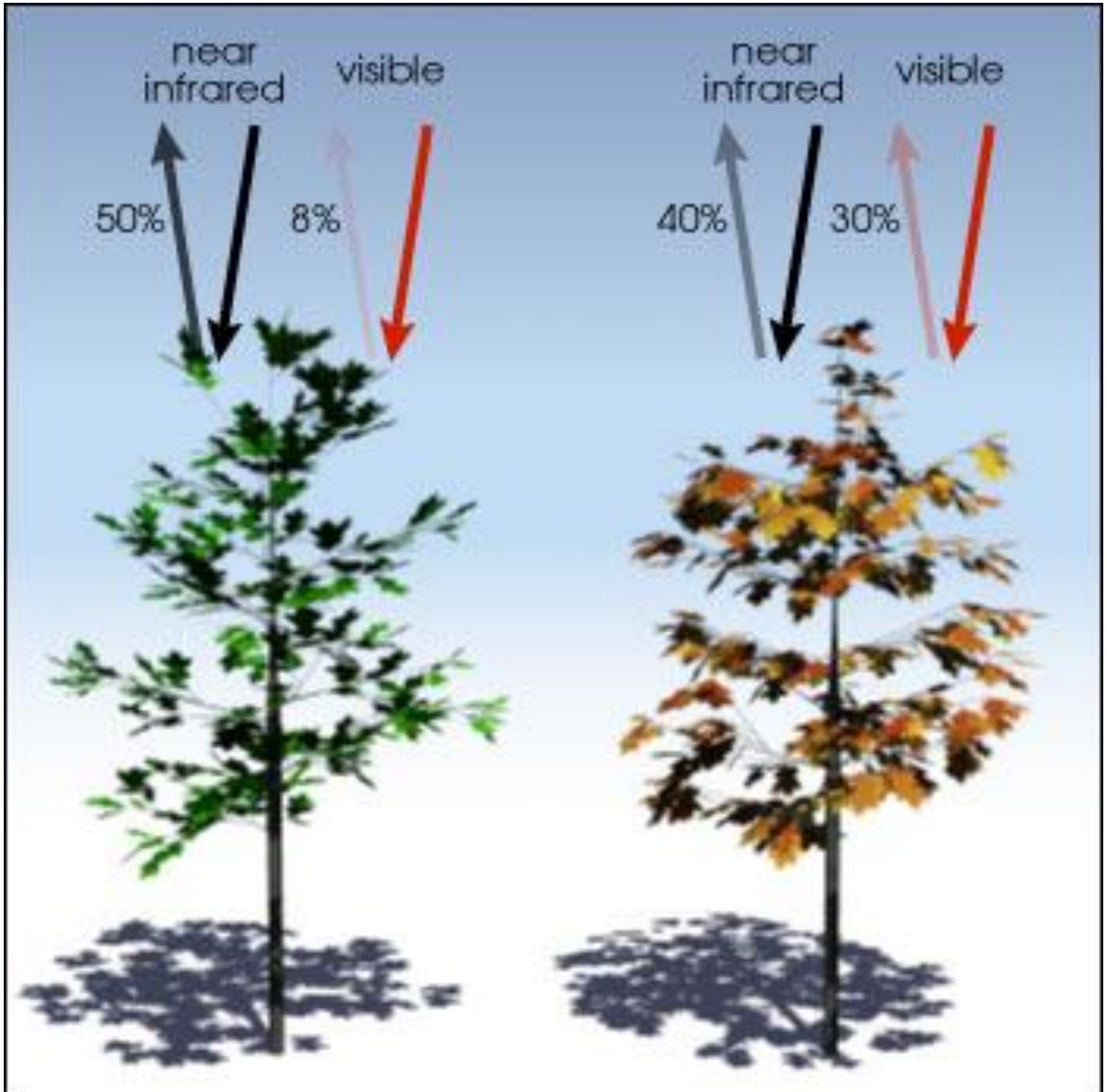
Highest NDVI values in different environments

Ecosystem	Typical NDVI values	Location	References
Boreal forest	0.6-0.8	Alaska	Parent and Verbyla, 2010
Temperate forest	0.3-0.7	France	Pettorelli et al., 2006
Coastal rainforest	0.88-0.92	Solomon Islands	Garonna et al., 2009
Alpine pastures	0-0.35	Italy	Pettorelli et al., 2007
Annual grassland	0.15-0.45	California	Gamon et al., 1995
Desert	0.06-0.12	Sinai, Egypt	Dall'Olmo and Karnieli, 2002

Table 1 - Typical NDVI values for different ecosystems (Pettorelli, 2013)

https://medium.com/regen-network/remote-sensing-indices-389153e3d947

Annual and interannual changes in NDVI



$$\frac{(0.50 - 0.08)}{(0.50 + 0.08)} = 0.72 \qquad \frac{(0.4 - 0.30)}{(0.4 + 0.30)} = 0.14$$

Canada

NDVI values increase with 'green-up' in spring

Peak in mid-late July ..

start to drop in August, and into the fall

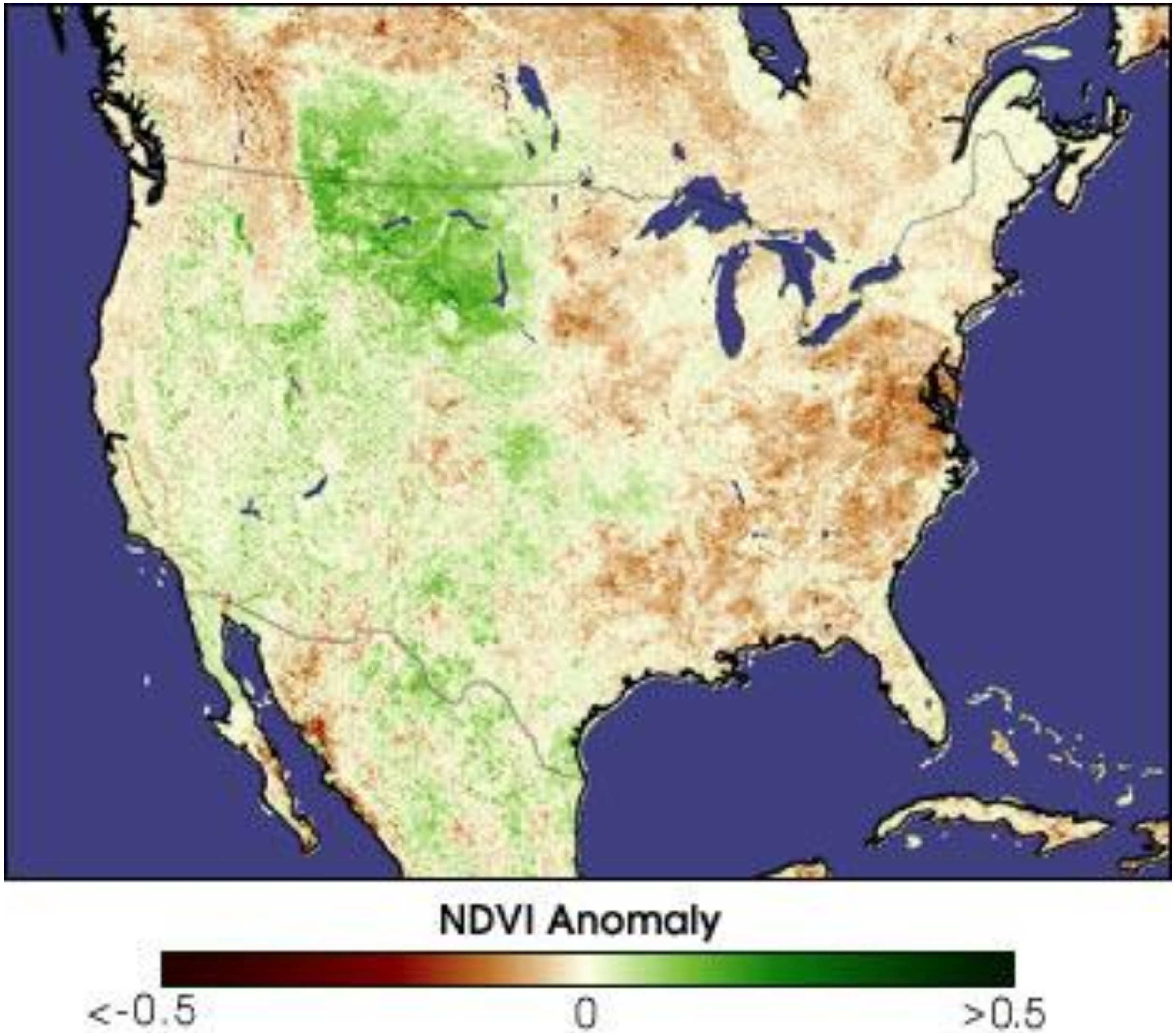
From mid-summer

-> Near-IR decreases

-> Red increases

(until leaf fall)

->Implications for wildlife habitat and movement



Monitoring monthly and yearly changes and anomalies in NDVI

Long term changes: may represent global impacts e.g. large scale forest change - clearance / regrowth

The difference between the average NDVI for a particular month of a given year (such as August 1993, above) and the average NDVI for the same month over the last 20 years is the NDVI anomaly. In 1993, heavy rain in the Northern Great Plains led to flooding in the Missouri River. The resulting exceptionally lush vegetation appears as a positive anomaly (green).

Many satellite sensors have red and Near IR bands to assess global vegetation

Table 1. Low or no-cost satellite sensors and data streams utilized for land surface phenology studies[1]

Sensor	Satellite	Overpass/ Orbit Frequency	Data Source (terrestrial data)	Data Record (years)	Spatial Resolution(s)	Processed Time Step	Latency
AVHRR	NOAA series	Daily	USGS/EROS[2]	1989-present	1 km	1-week, 2-week	~24 hours
AVHRR	NOAA series	Daily	NASA Ecocast[3]	1982-2013	8 km	Twice monthly	N/A
MSS	Landsat 1-5	18 days	USGS/EROS[2]	1972-1992	79 m	Distributed by scene	N/A
TM	Landsat 4-5	16 days	USGS/EROS[2]	1982-2011	30 m	Distributed by scene	N/A
ETM+	Landsat 7	16 days	USGS/EROS[2]	1999-present	30 m	Distributed by scene	~1-3 days
Vegetation	SPOT	1-2 days	VITO[4]	1999-present	1.15 km	10-day	~3 months
MODIS	Terra	1-2 days	LPDAAC[5]	2000-present	250 m, 500 m, 1 km	8-day, 16-day	~7-30 days
MODIS	Aqua	1-2 days	LPDAAC[5]	2002-present	250 m, 500 m, 1 km	8-day, 16-day	~7-30 days

MODIS (Moderate-resolution Imaging Spectroradiometer)

EarthExplorer datasets

MODIS SPECIAL THEMES

MODIS Team Member	MODIS Product
E. Vermote	Surface Reflectance
Z. Wan	Land Surface Temperature
A. Strahler/J.-P. Muller	BRDF/Albedo
A. R. Huete/C. O. Justice	Vegetation Indexes
R. B. Myneni/S. W. Running	LAI/FPAR
C. O. Justice/Y. J. Kaufman	Fires/Burned Area
D. Hall	Snow/Ice/Sea Ice
J. R. G. Townshend/A. Strahler	Land Cover/Land Cover Change
S. W. Running	PSN/NPP

Launched by NASA in 1999 on the Terra (EOS AM) satellite, and in 2002 on the Aqua (EOS PM) satellite.

Terra: 10.30am descending

Aqua: 1.30pm ascending

MODIS: MODerate-resolution Imaging Spectroradiometer

36 spectral bands ranging in wavelength 0.4 µm to 14.4 µm and at spatial resolutions 250m to 1km. Swath: 2330 km Earth covered 1-2 days

Designed to combine some of the characteristics of AVHRR and Landsat TM

'Superspectral' (vs Multispectral)

MODIS is THE main medium resolution EO satellite sensor, but nearing end of life – gradually replaced by the Visible Infrared Imaging Radiometer Suite (VIIRS) onboard Suomi (Finland)

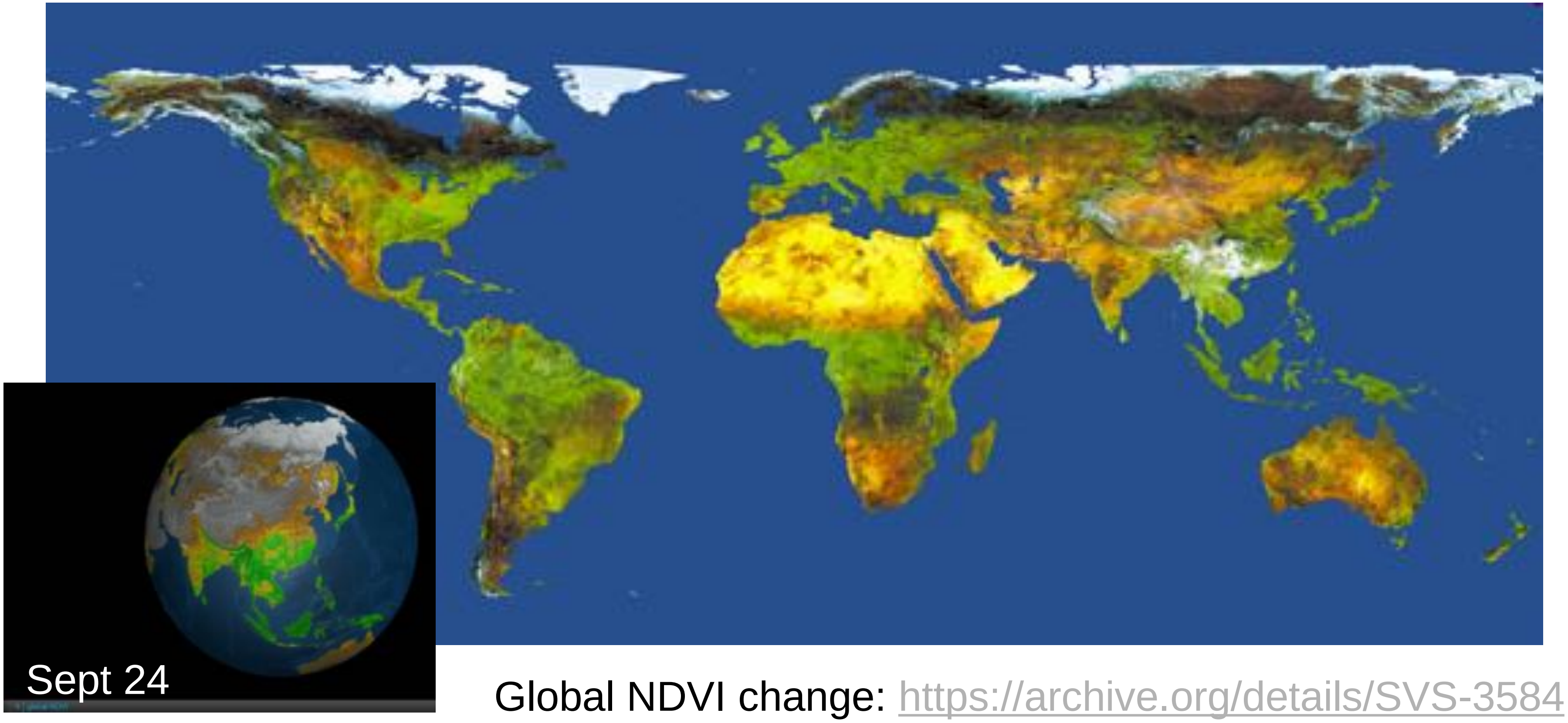
Reflected Solar Bands			Emissive Bands
Aggregrated 250 m	*Aggregrated 500 m*	*1 km*	*1 km*
Band 1 (620-670 nm)	Band 3 (459-479 nm)	Band 8 (405-420 nm)	Band 20 (3.660-3.840 µm)
Band 2 (841-876 nm)	Band 4 (545-565 nm)	Band 9 (438-448 nm)	Band 21 (3.929-3.989 µm)
	Band 5 (1230-1250 nm)	Band 10 (483-493 nm)	Band 22 (3.939-3.989 µm)
	Band 6 (1628-1652 nm)	Band 11 (526-536 nm)	Band 23 (4.020-4.080 µm)
	Band 7 (2105-2155 nm)	Band 12 (546-556 nm)	Band 24 (4.433-4.498 µm)
		Band 13L (662-672 nm)	Band 25 (4.482-4.549 µm)
		Band 13H (662-672 nm)	Band 27 (6.535-6.895 µm)
		Band 14L (673-683 nm)	Band 28 (7.175-7.475 µm)
		Band 14H (673-683 nm)	Band 29 (8.400-8.700 µm)
		Band 15 (743-753 nm)	Band 30 (9.580-9.880 µm)
		Band 16 (862-877 nm)	Band 31 (10.780-11.280 µm)
		Band 17 (890-920 nm)	Band 32 (11.770-12.270 µm)
		Band 18 (931-941 nm)	Band 33 (13.185-13.485 µm)
		Band 19 (915-965 nm)	Band 34 (13.485-13.785 µm)
		Band 26 (1.360-1.390 µm)	Band 35 (13.785-14.085 µm)
			Band 36 (14.085-14.385 µm)

Special sensors for NDVI

SPOT 5 has extra bands / wide sensor in visible/NIR with 1 km resolution to capture a repeat 2400 km swath for global coverage

MODIS and NOAA-AVHRR have 250m/1000m red /near-IR bands for NDVI

NDVI is used to measure vegetation amount or biomass, in regional and global estimates.
NDVI is directly related to photosynthesis and thus energy absorption of plant canopies



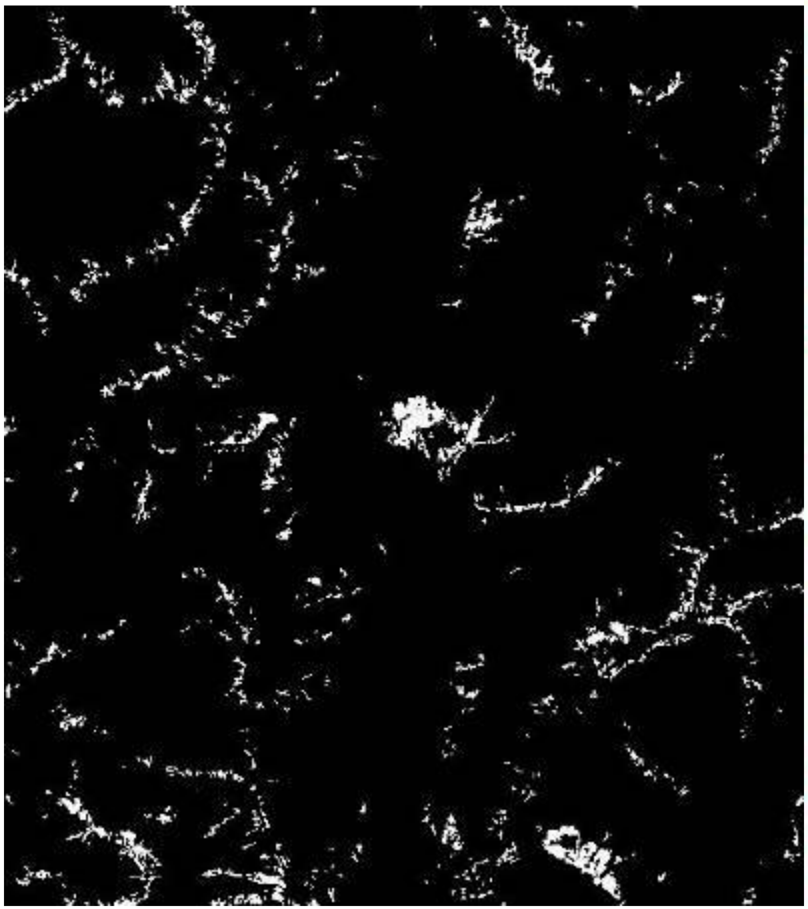
Global NDVI change: https://archive.org/details/SVS-3584

Delineation of Grizzly Bear Habitat in Bute Inlet

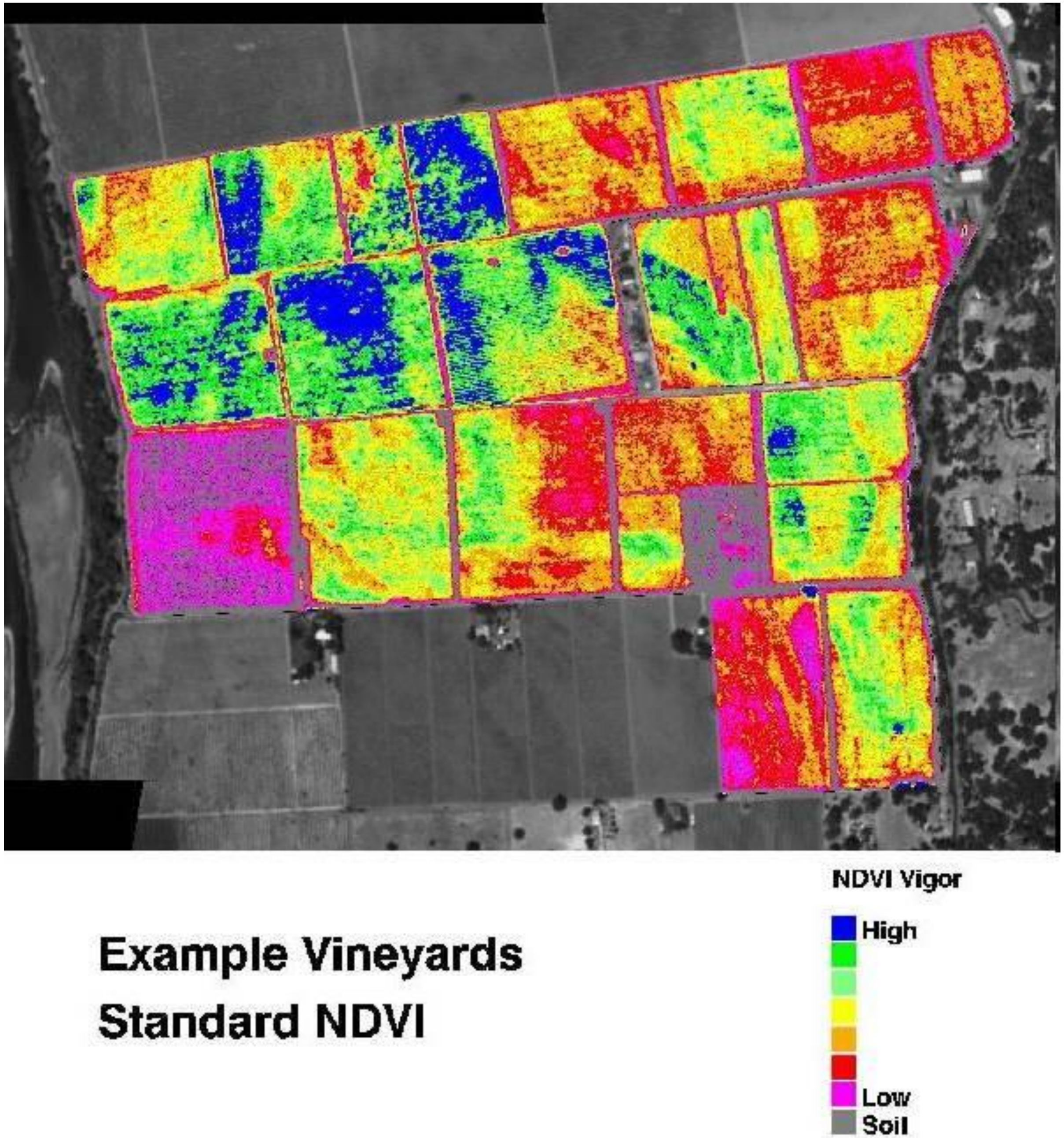
GEOG357 project

- Assumes bears are attracted to highest biomass areas e.g. avalanche slopes

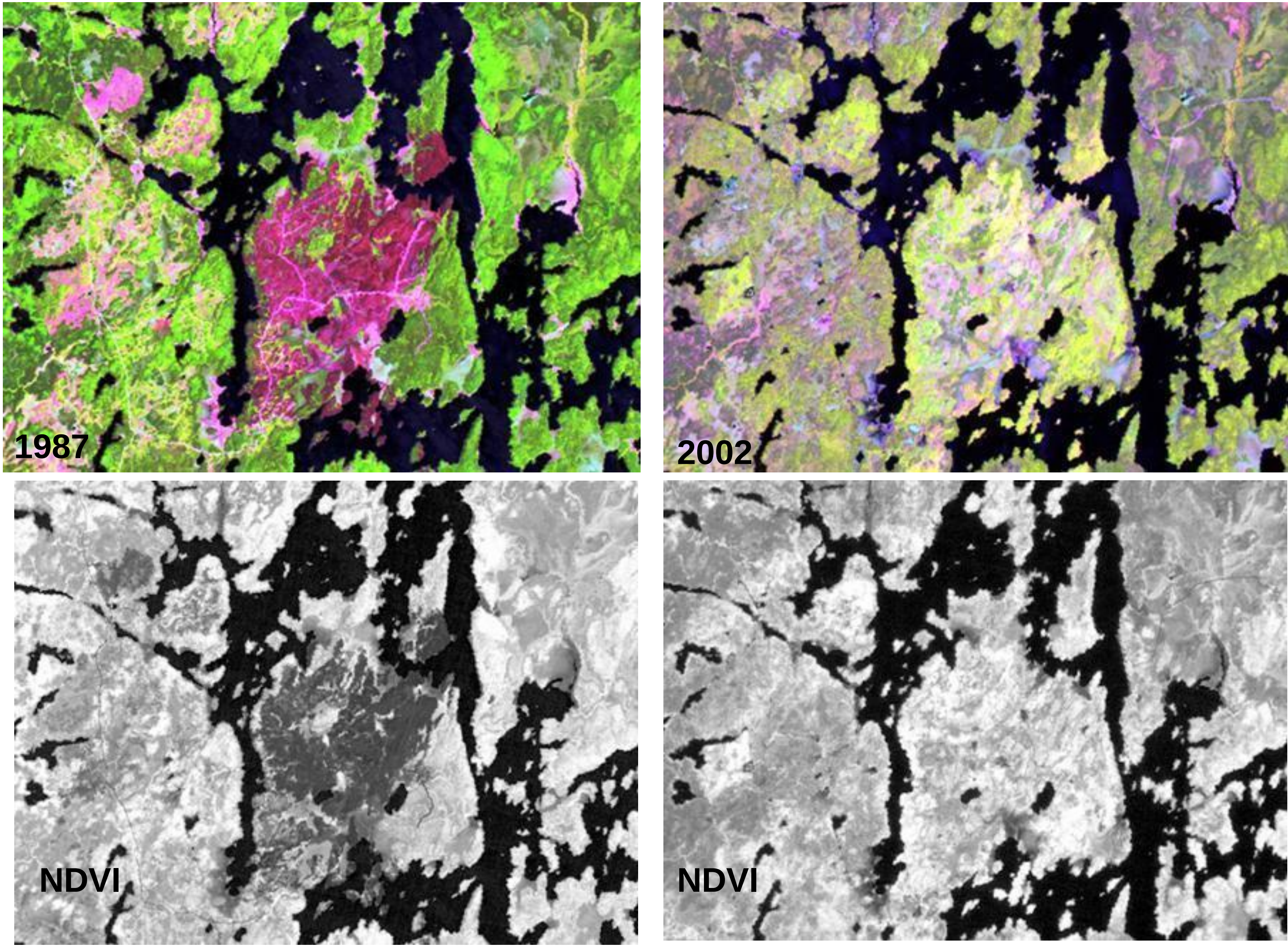
Sieved maximum NDVI result



http://grayhawk-imaging.com/use-of-ndvi/



The use of NDVI to determine vegetative green-up after a forest fire Geog357



GNDVI (NDGI) Green: = (NIR-G) / (NIR+G)

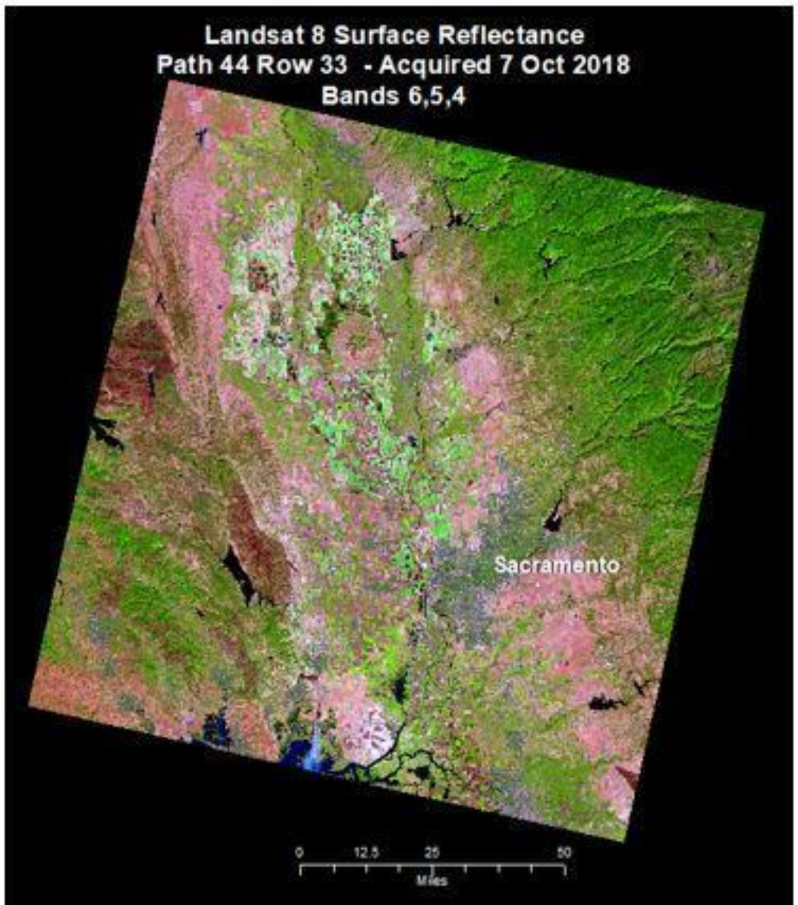
GNDVI is more sensitive to chlorophyll variation in the crop than NDVI. It can be used in crops with dense canopies or in more advanced stages of development while NDVI is suitable for estimating crop vigor during the early stages.

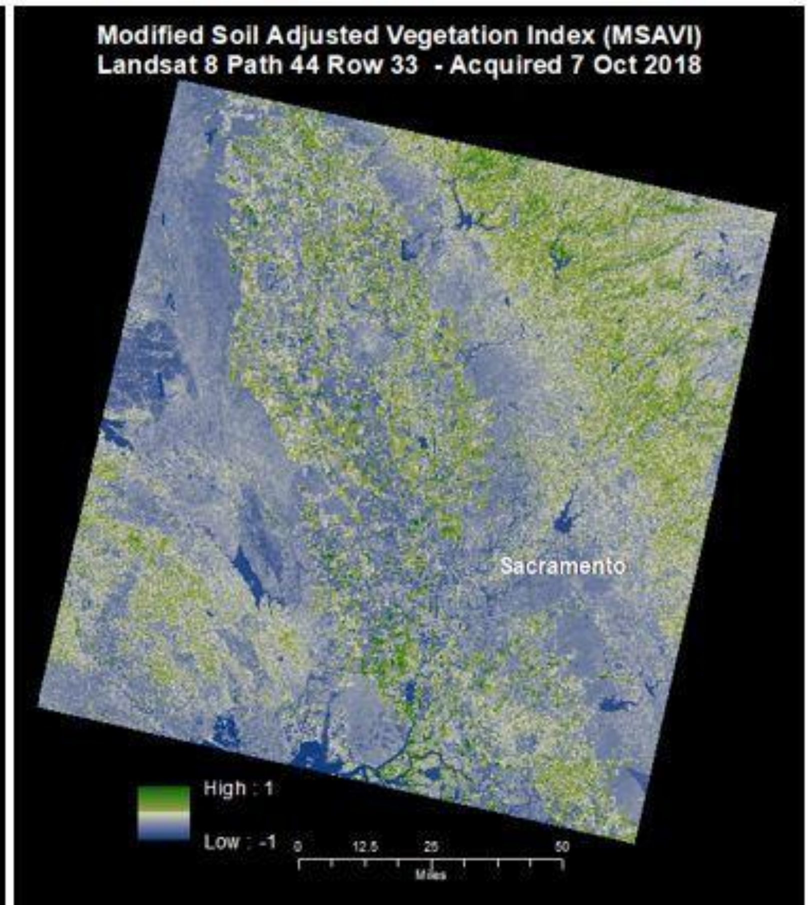
Soil-adjusted Vegetation Index **(SAVI)** = 1.5 * (NIR - R) / (NIR + R + 0.5)

Optimised Soil-adjusted Vegetation Index **(OSAVI)** = (NIR - R) / (NIR + R + 0.16)

MSAVI: Modified Soil Adjusted Vegetation Index (MSAVI) minimizes the effect of bare soil on the Soil Adjusted Vegetation Index (SAVI)

$$MSAVI2 = \frac{(2 * NIR + 1 - 1\sqrt{(2 * NIR + 1) - 8 * (NIR - RED))}}{2}$$



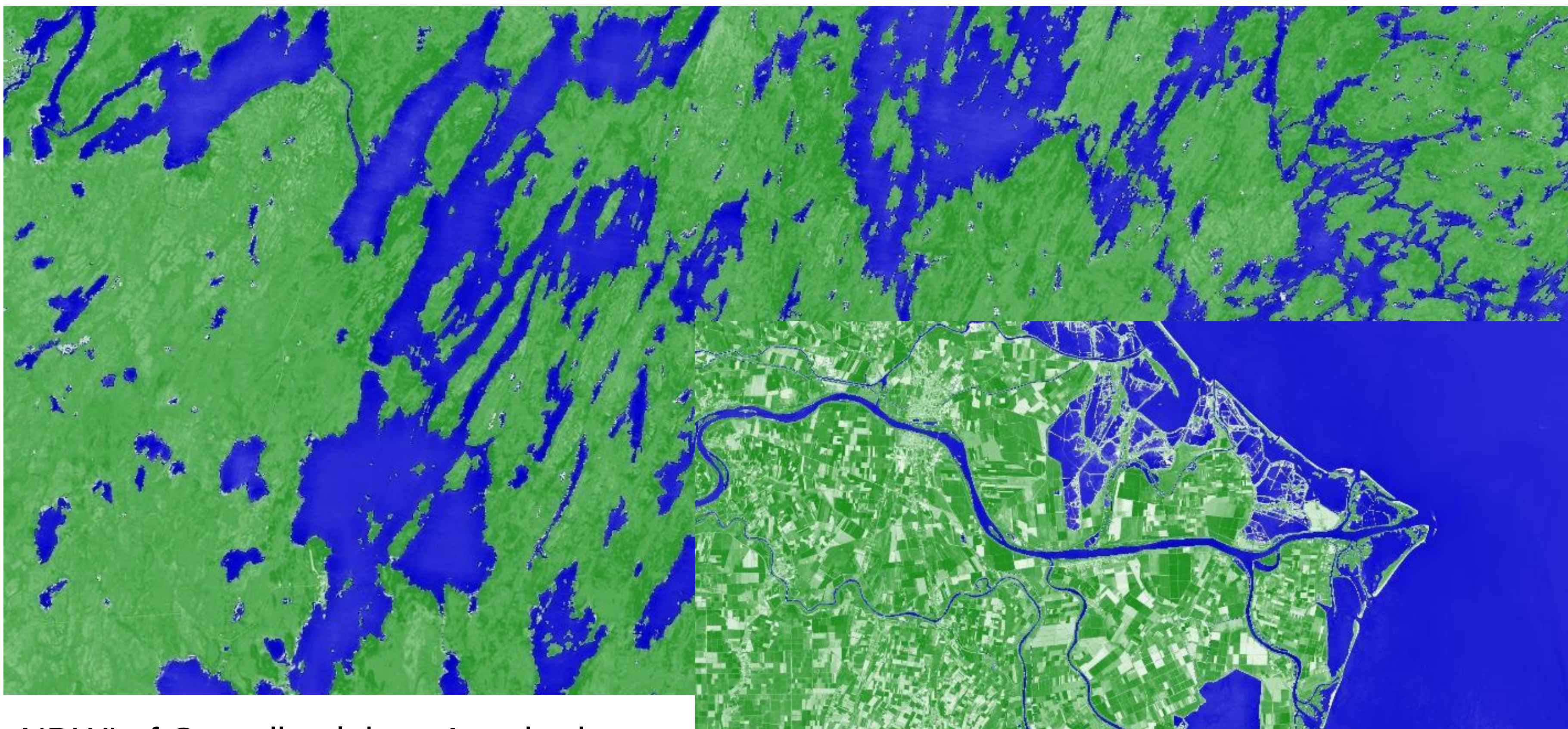


NDWI (Water): (Green - NIR)/ (Green + NIR) 1996

- Mapping water – lakes, floods etc.. > 0.2 = water

Also **NDWI** = (NIR – SWIR1)/ (NIR + SWIR1)

Water content in leaves



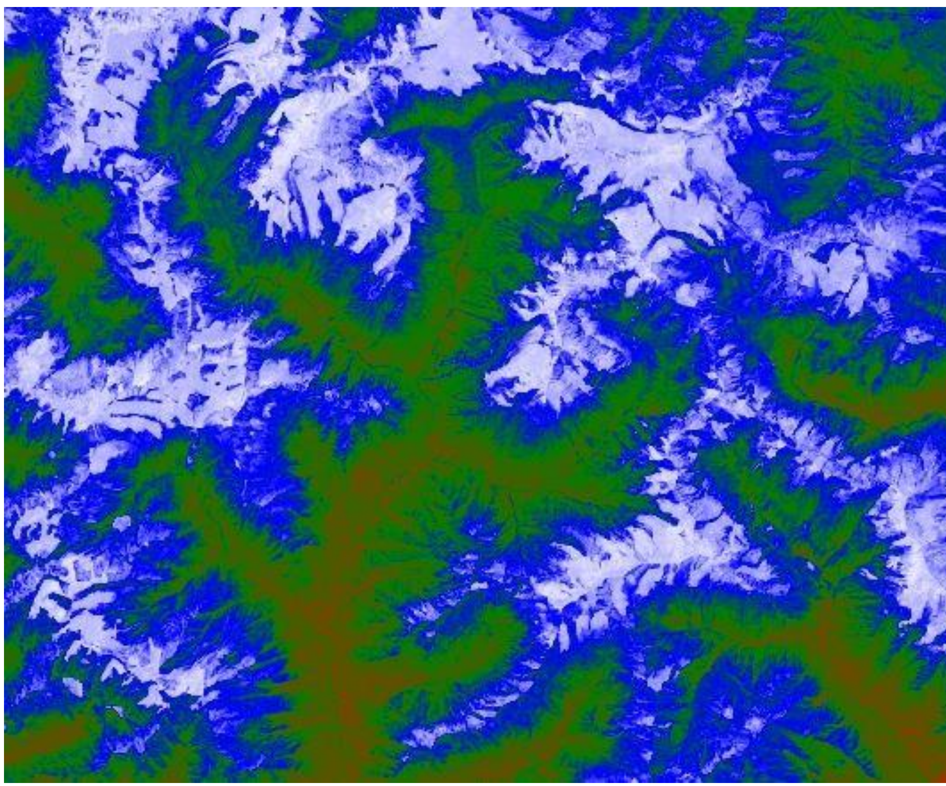
NDWI of Canadian lakes. Acquired on 2020-08-05, Sentinel-hub

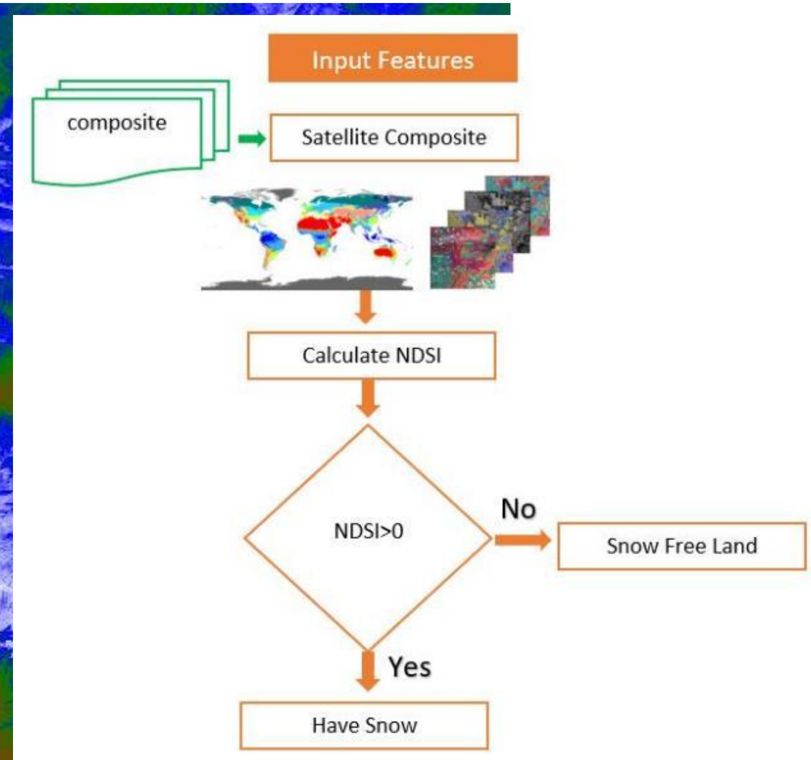
NDWI of Italy. Acquired on 2020-08-01

Snow: NDSI = (Green-SWIR) / (Green+SWIR)

NDSI has mostly been used for assessments of

1. Snow cover detection and mapping
2. Discriminate snow and clouds
3. Detect glacier ice in shadowed terrain
4. Detect frozen lakes
5. Glacier mapping





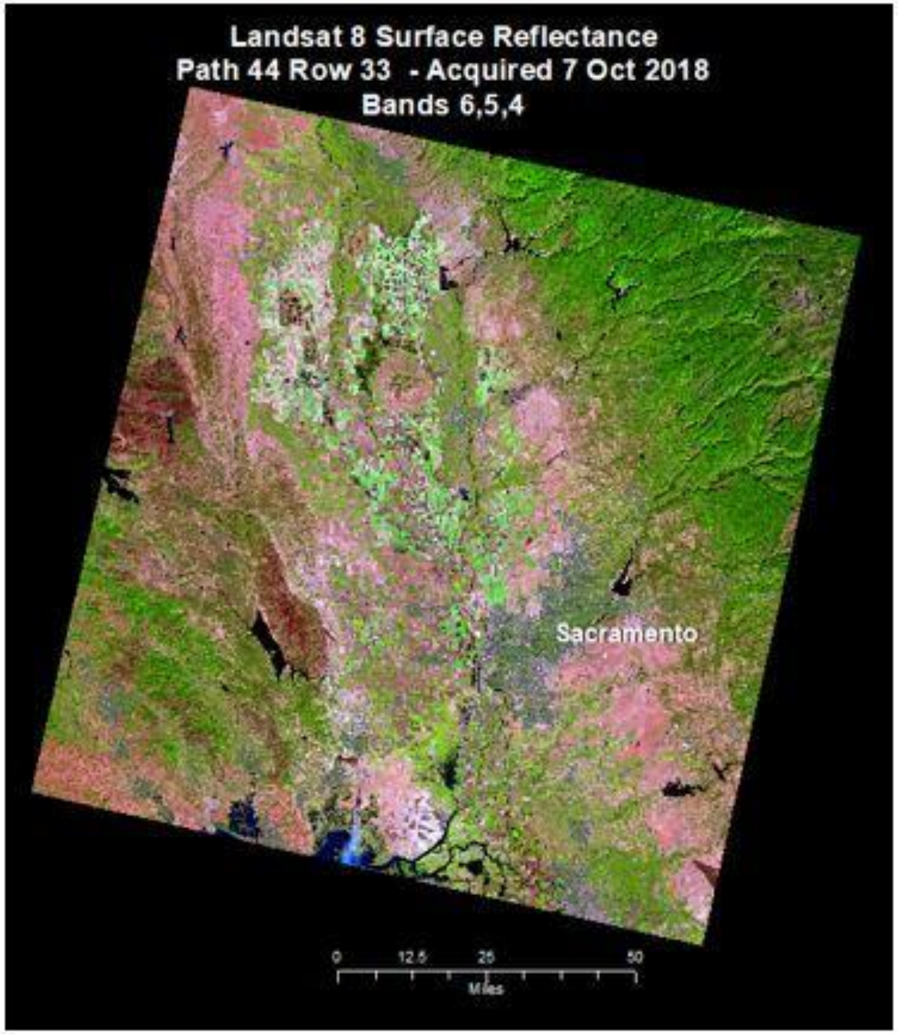
Red Edge índices – Sentinel 2 and Worldview

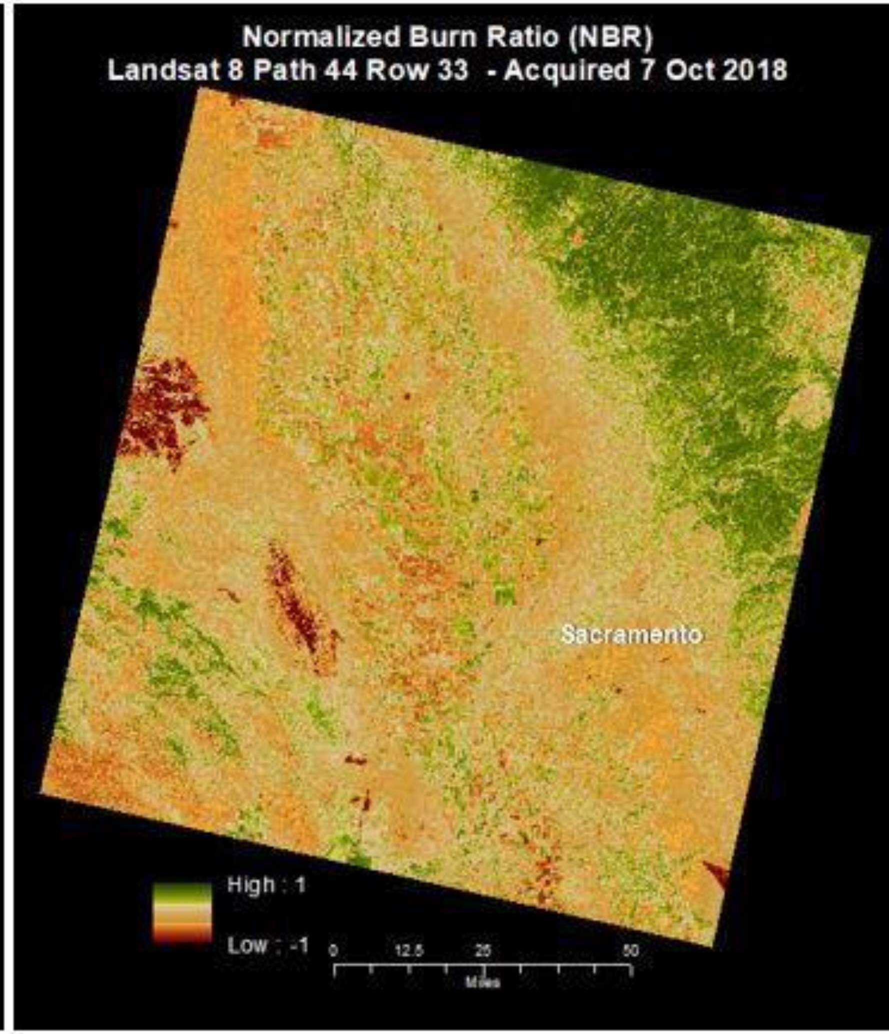
NDRE = (NIR – RED EDGE) / (NIR + RED EDGE) (Normalized Difference Red Edge): It is closely related to NDVI; however, it enables to identify vigor decreases earlier.

How NDRE map looks on EOSDA Crop Monitoring.

Similar indices: **Normalised** Difference **Burn Ratio (Index)**

(NIR – SWIR2) / (NIR + SWIR2) Landsat TM: NBR = (4-7)/(4+ 7)



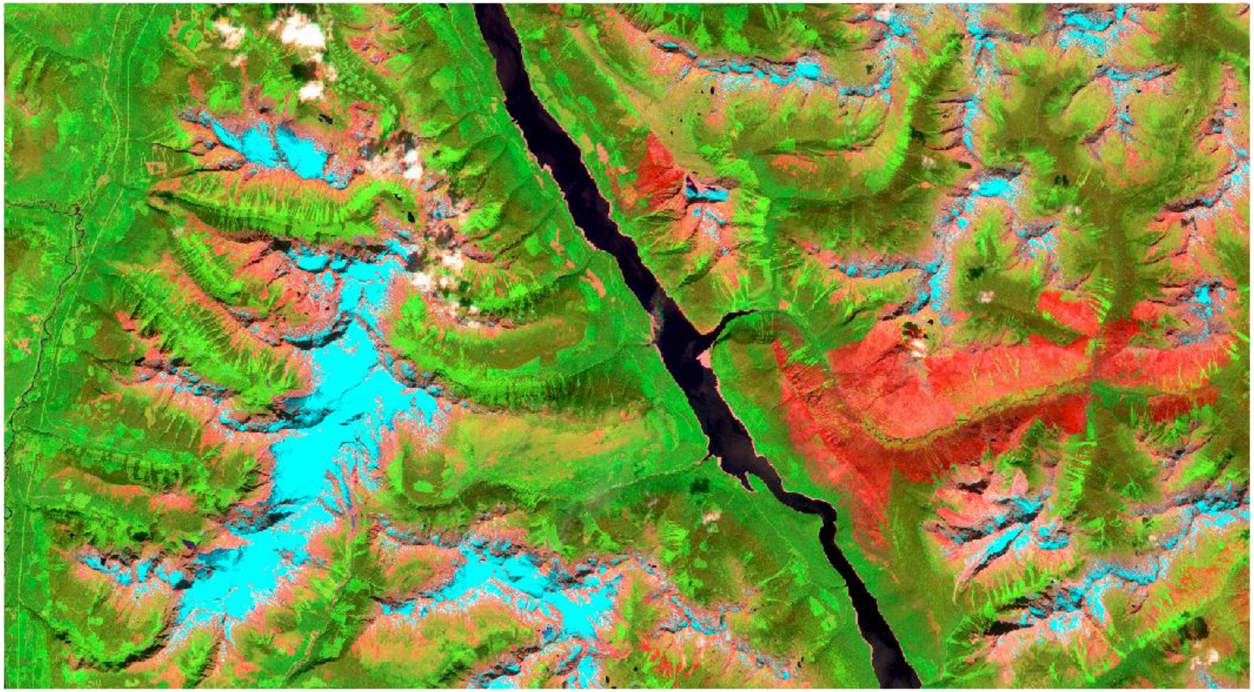


https://www.usgs.gov/landsat-missions/landsat-normalized-burn-ratio

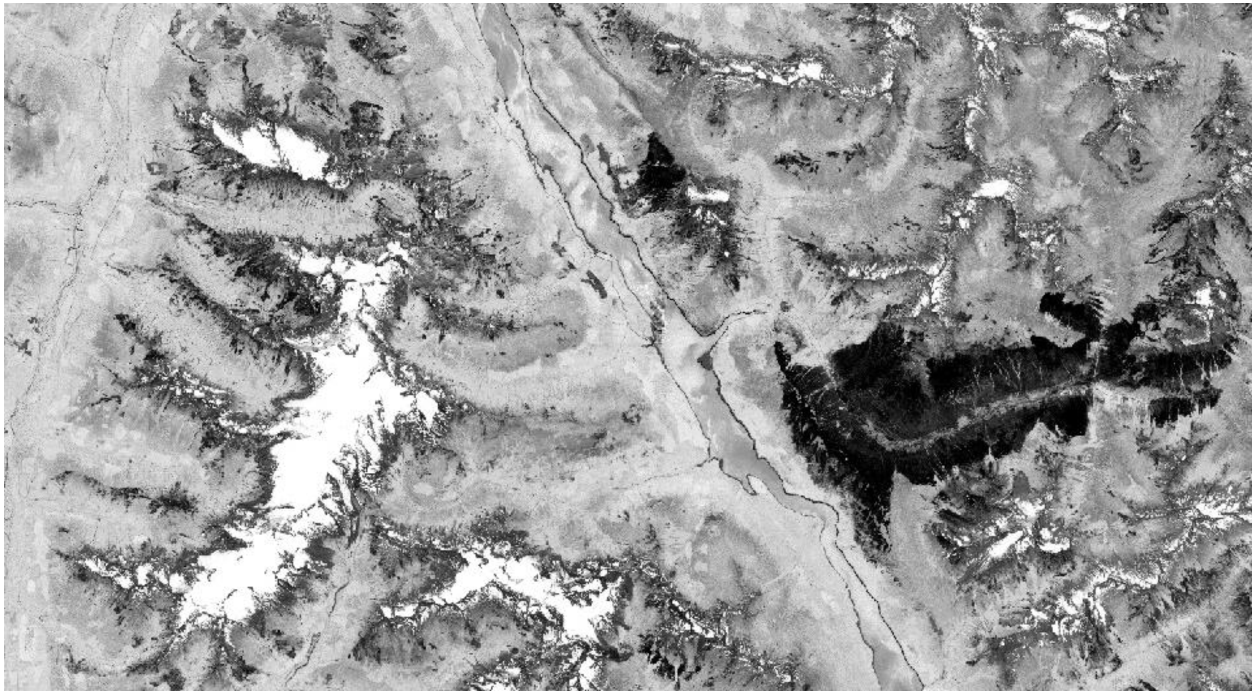
GEOG 357 projects 2020

Kinbasket Lake
August 2018

Sentinel 2 MSI
Bands: SWIR2, NIR, Red



NDBR:
(NIR-SWIR2)
/ (NIR+SWIR2)



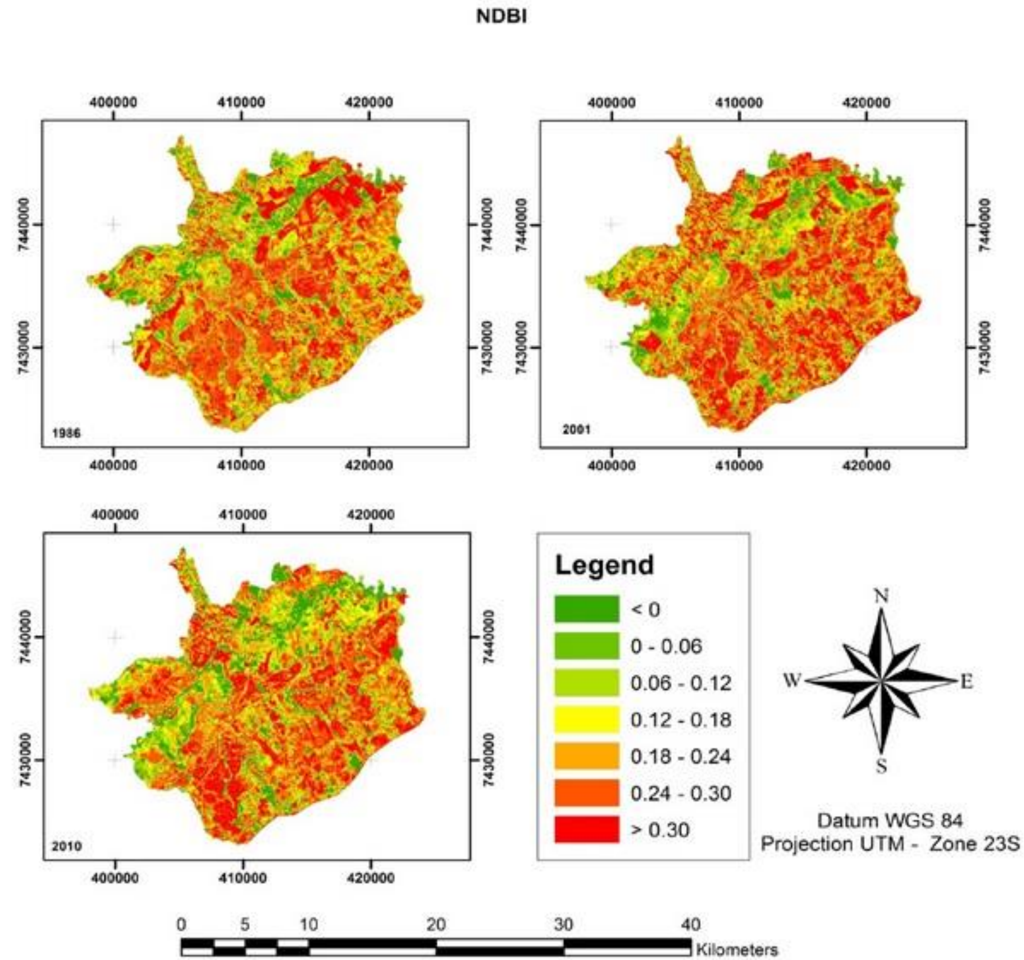
Normalized Difference Built-up Index

NDBI = (SWIR - NIR) / (SWIR + NIR)

uses the NIR and SWIR bands to emphasize built-up areas.

São José dos Campos, Brazil

Figure 10. NDBI calculated from the image of TM/Landsat 5 for 1986, 2001, and 2010.



https://www.researchgate.net/publication/233629918_A_Quantitative_Approach_for_Analyzing_the_Relationship_between_Urban_Heat_Islands_and_Land_Cover

Summary of Indices

Vegetation and soil: NDVI most common
with many variants e.g. NDGI, DVI, SAVI, NRDE

Water: NDWI

Snow: NDSI

Burn (fires): NDBR

All have values = -1.0 to +1.0 – store in 32 bit real channel
This standardization enables direct comparison for change detection

Many more… latest count > 150 ?

https://medium.com/regen-network/remote-sensing-indices-389153e3d947

https://pro.arcgis.com/en/pro-app/latest/help/data/imagery/indices-gallery.htm