Remote Sensing Systems

An Overview Focussing on Environmental Applications

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Trends of recent years

- increasing resolution (geometric, spectral, temporal)

ultra high	very high	high	medium	low	very low
< 1 m	1 – 4 m	4 – 10 m	10 – 50 m	50 – 250 m	> 250 m

	panchromatic	multispectral	hyperspectral	ultra spectral
number of bands	1	2 – 20	20 – 250	> 250
bandwidth	broad	broad	narrow	narrow

- large satellite systems vs. micro satellites
- increasing number of nations with satellite programmes
- commercial satellites

	Airborne systems	Spaceborne systems

	DAEDALUS	LANDSAT (ETM+)	ASTER	SPOT4
pan		520 – 900 nm		510 – 730 nm
blue	420 – 450 nm 450 – 520 nm	450 – 520 nm		
green	520 – 600 nm 605 – 625 nm	520 – 600 nm	520 – 600 nm	500 – 590 nm
red	630 – 690 nm	630 – 690 nm	630 – 690 nm	610 – 690 nm
NIR	695 – 750 nm 760 – 900 nm 910 – 1050 nm	760 – 900 nm	760 – 860 nm	
SWIR	1550 – 1750 nm 2080 – 2350 nm	1550 – 1750 nm 2080 – 2350 nm	1600 – 1700 nm 2145 – 2185 nm 2235 – 2285 nm 2295 – 2365 nm 2360 – 2430 nm	1580 – 1750 nm
THIR	8500 – 13000 nm	10400 – 12400 nm	8125 – 8475 nm 8475 – 8825 nm 8925 – 9275 nm 10250 – 10950 nm 10950 – 11650 nm	

Multispectral Systems

	Airborne systems	Spaceborne systems		

	DAEDALUS	LANDSAT (ETM+)	ASTER	SPOT4
GSD pan	depending on ve-	15 m		10 m
GSD VNIR	locity and flying	30 m	15 m	20 m
GSD SWIR	height above	30 m	30 m	20 m
GSD THIR	ground	60 m	90 m	
stereo	–	–	+	+

Multispectral Systems

LANDSAT TM5

1. August 1993
multispectral
channels 7 4 3
30m x 30m

Karlsruhe

SPOT 4

21. July 1998
multispectral
channels 3 2 1
20m x 20m

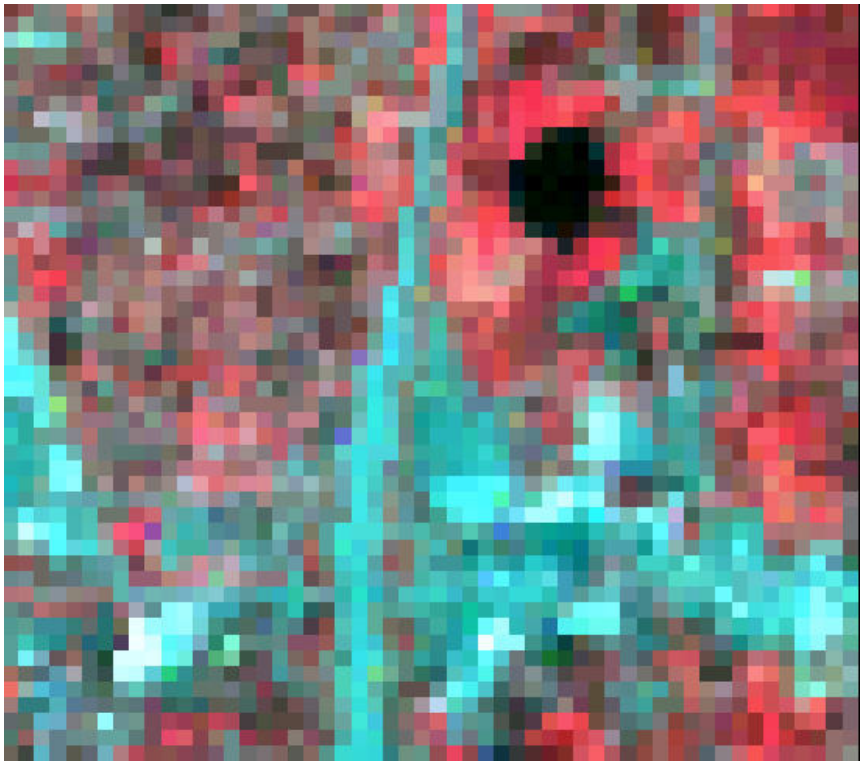
Strasbourg

system	launch	GSD [m] pan / MS	swath [km]	remarks
SPOT 1 France	1986	10 / 20	60	+/-27° across orbit
SPOT 2 France	1990	10 / 20	60	+/-27°
SPOT 3 France	1993	10 / 20	60	failed
SPOT 4 France	1998	10 / 20	60	+/-27°
SPOT 5 France	2002	5 / 10 2.5 HRS 5*10	60 120	+/-27° staggered 23° fore 23° after
JERS-1 Japan	1992	OPS 18	75	+ SAR
MOMS 02 Germany	1993	4.5 / 13.5	37 / 78	nadir + 21.5° fore + 21.5° aft
MOMS-2P Germany	1996	6 / 18	48 / 100	like MOMS 02
IRS-1C India	1995	5.7 / 23	70 / 142	+/-26° across orbit
IRS-1D India	1997	5.7 / 23	like IRS-1C	
IRS P6 India Resourcesat	2003	5.7 MS	24 / 70	+/-26° across orbit
KOMPSAT-1 South Korea	1999	6.6 pan	17	+/-45° across orbit
CBERS-1 China + Brazil	1999	20	113	+/-31° across orbit
CBERS-2	2003	like CBERS-1		
Terra USA / ASTER Japan	1999	15, 30, 90 all MS	60	nadir + 24° aft
IKONOS-2 USA SpaceImage	1999	0.82 / 3.24	11	free view direction, TDI
EROS A1 Israel Imagesat	2000	1.8 pan	12.6	free view direction
TES India	2001	1 pan	15	free view direction
QuickBird-2 USA DigitalGlobe	2002	0.62 / 2.48	17	free view direction, TDI
OrbView-2 USA OrbImage	2003	1 / 4	8	free view direction, TDI
FORMOSAT-2 (ROCSAT-2) Taiwan	2004	2 / 8	24	free view direction, TDI

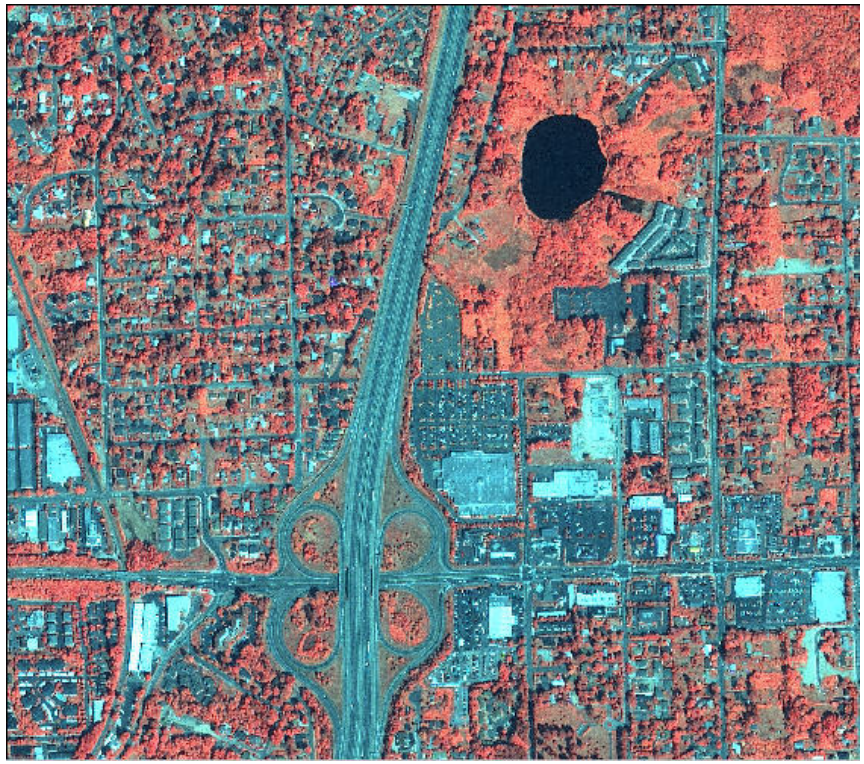
Optical sensors

Source: Jacobsen (2005)

	IKONOS	QuickBird	OrbView	SPOT5
pan	450 – 900 nm	450 – 900 nm	450 – 900 nm	480 – 710 nm
blue	455 – 516 nm	450 – 520 nm	450 – 520 nm	
green	506 – 595 nm	520 – 600 nm	520 – 600 nm	500 – 590 nm
red	632 – 698 nm	630 – 690 nm	625 – 695 nm	610 – 680 nm
NIR	757 – 835 nm	760 – 900 nm	760 – 900 nm	780 – 890 nm
SWIR				1580 – 1750 nm
GSD pan	1.0 m	0.6 m	1.0 m	(2.5) / 5.0 m
GSD VNIR	4.0 m	2.4 m	4.0 m	10.0 m
GSD SWIR				20.0 m
stereo	+	+	+	+



LANDSAT 7



IKONOS

system	launch	GSD [m] pan / MS	swath [km]	remarks
IRS-P5 Cartosat-1 India	2005	2.5 pan	30	-5°, +26° 2 cameras in orbit
IRS Cartosat-2, India	2005	1 pan	10	free view direction
ALOS, Japan	2005	2.5 / 10	35 / 70	-24°, nadir, +24°, 3 cameras in orbit
KOMPSAT-2 South Korea	2005	1 / 4	15	free view direction
Resurs DK1 Russia	2005	1 / 2.5-3.5	28	free view direction
Monitor-E Russia	2005	8 / 20	94 / 160	free view direction
EROS B Israel	2005	0.7 pan	14	free view dir., TDI
EROS C Israel	2009	0.7 / 2.8	11	free view dir., TDI
RazakSat Malaysia	2005	2.5 / 5	20	free view direction, inclination 7°
CBERS 2B China, Brazil	2005/ 2006	2.5 / 20		+/-32° across
CBERS-3 China, Brazil	2008	5 / 20	60/ 120	"
CBERS-4 China, Brazil	2008	5 / 20	60/ 120	"
WorldView 1 DigitalGlobe	2006	0.5 / 2		free view direction TDI
OrbView 5 OrbImage	2006	0.41 / 1.64	15	free view direction TDI
THEOS Thailand	2007	2 / 15		free view direction TDI
Pleiades 1 France	2008	0.7 / 2.8	20	free view direction TDI
Pleiades 2 France	2009	like Pleiades 1		

Optical sensors (announced)

Source: Jacobsen (2005)

stereo	+
panchromatic	-
blue [nm]	440 – 510
green [nm]	520 – 590
red [nm]	630 – 685
red2 [nm]	690 – 730
NIR [nm]	760 – 850
SWIR [nm]	-
GSD (multispec.)	5 -7 m
swathwidth	80 km
GSD (panchrom.)	-
swathwidth	-

system	launch	GSD [m] pan / MS	swath [km]	remarks
DMC China	2005	4 / 32	600	DMC
VinSat-1 Vietnam	2005	32 MS	600	DMC
ThaiPhat Thailand		36 MS	600	DMC
TopSat UK BNSC	2005	2.5 / 5	10 / 15	free view direction, TDI
X-Sat Singapore	2006	10 MS	50	
RapidEye Germany commercial	2007	6.5 MS	78	free view direction, 5 satellites

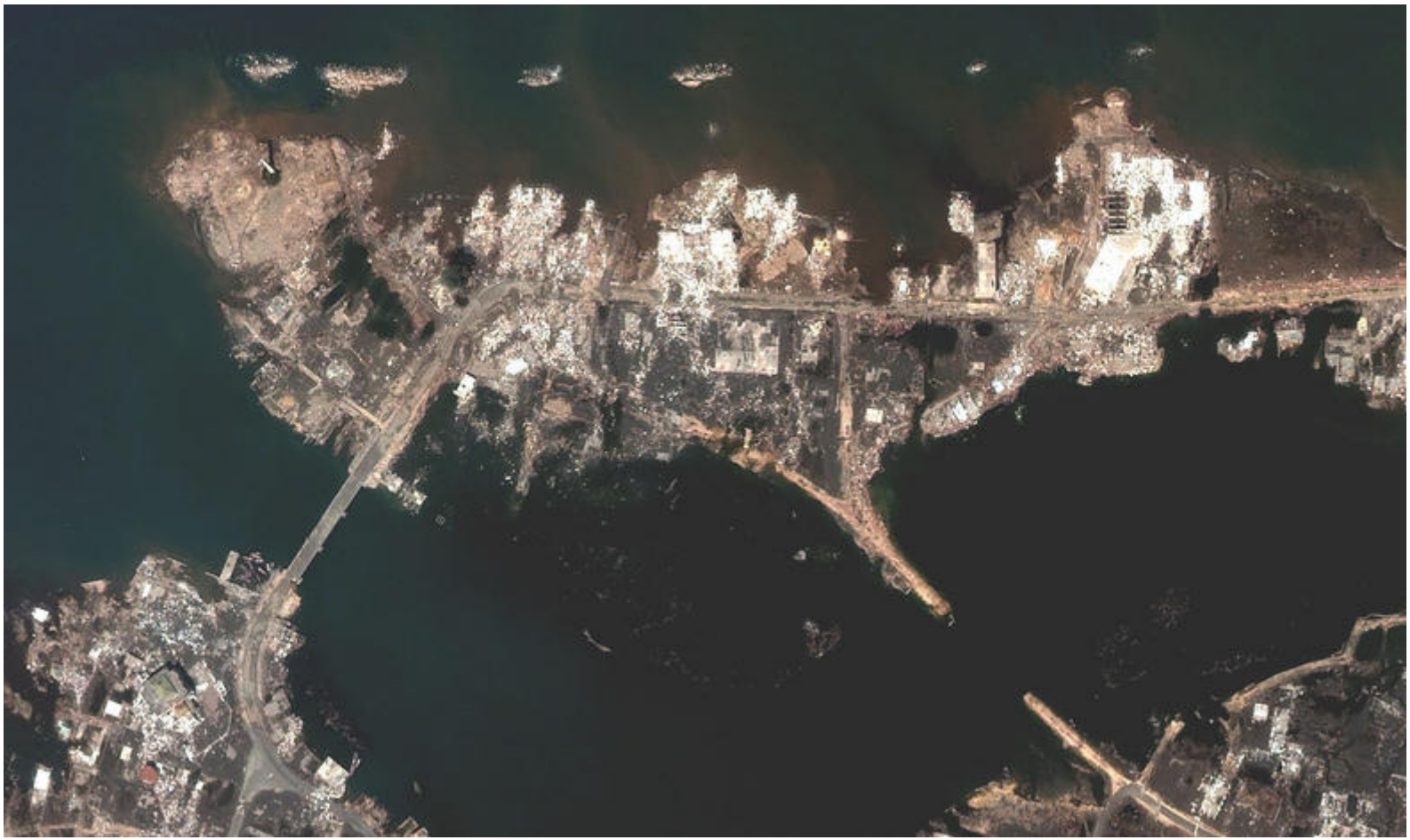
Table 6: announced small optical space sensors

Micro satellites

Source: Jacobsen (2005)

Banda Aceh: Coast line (23.06.2004, QuickBird)

Source: DigitalGlobe (2005)



Banda Aceh: Coast line (28.12.2004, QuickBird)

Source: DigitalGlobe (2005)

Punta Gorda (pre-Charley, 28.07.2002, IKONOS)

Punta Gorda (post-Charley, 15.08.2004, IKONOS)

system	launch	GSD [m]	swath [km]	remarks
ERS-1 ESA	1991	10-30	100	C-band 5.6cm
ERS-2 ESA	1995	like ERS-1 1995 – 96 used in Tandem configuration		
JERS-1 Japan	1992	18	75	
RADARSAT -1, Canada	1995	9-100	50-500	C-band 5.6cm
SRTM USA , Germany, Italy	2000	30 30	225 45	C-band 5.6cm X-band 3cm IfSAR
ENVISAT ESA	2002	30-1000	100-405	C-band 5.6cm full polarisation

Table 4: SAR space sensors

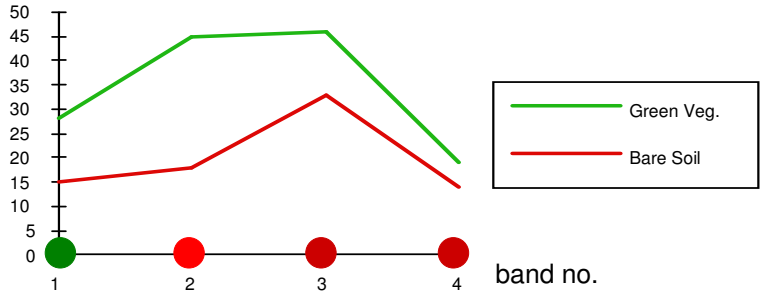
system	launch	GSD [m]	swath [km]	remarks
SAR-X Cosmo-Skymed-1 Italy	2006	1-several 10th	10-few hundreds	X-band 3.1cm
RADARSAT-2, Canada	2006	3 – 100	20-500	C-band 5.6cm, full polarisation
TerraSAR-X Germany ppp	2006	1/3/16	10/30/100	X-band 3.1cm
RISAT India	2006	3 – 50	10 – 240	C-band
Surveyor SAR, China	2007	10 / 25	100 / 250	C-band 5 satellites

Table 7: announced SAR space sensors
ppp = private public partnership

Radar sensors

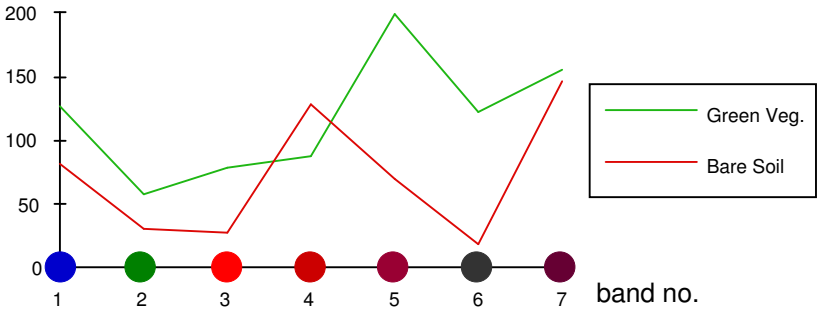
Source: Jacobsen (2005)

1968: MSS



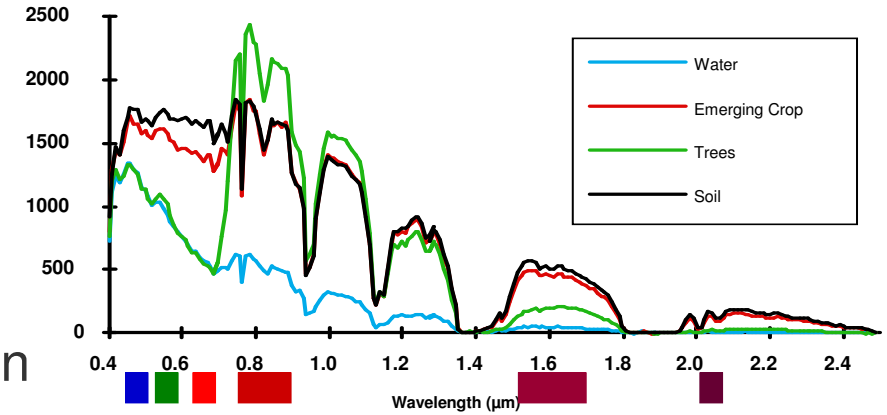
6-bit data

1975: TM



8-bit data

1986: Hyperspectral



10-bit data

HyMap next generation

+ THIR

Airborne Systems	Spectral range [nm]	Number of bands	Bandwidths [nm]	Year
AVIRIS	380 – 2500	224	10.0	1987
CASI	400 – 1000	288	2.2	1989
HyMap	400 – 2500	128	10.0 … 20.0	1997
DAIS 7915	498 – 1010	32	16.0	1994
	1500 – 1800	8	100.0	
	1970 – 2450	32	15.0	
	3000 – 5000	1	2000.0	
	8700 – 12300	6	600.0	
MIVIS	400 – 800	20	20.0	1994
	1100 – 1500	8	50.0	
	1900 – 2500	64	9.0	
	8200 – 12700	10	35.0 … 45.0	
HYDICE	400 – 2500	210	10.0	1995

Spaceborne Systems	Spectral range [nm]	Number of bands	Bandwidths [nm]	Year
MOS	400 – 1000	17	2.0 … 5.0	1996
MODIS	400 – 14400	36	15.0 … 300.0	1999
Hyperion	400 – 2500	220	10.0	2000
CHRIS	415 – 1050	63	2.0 … 12.0	2001
MERIS	400 – 1035	15	4.0 … 20.0	2002

MERIS (MEdium Resolution Imaging Spectrometer)

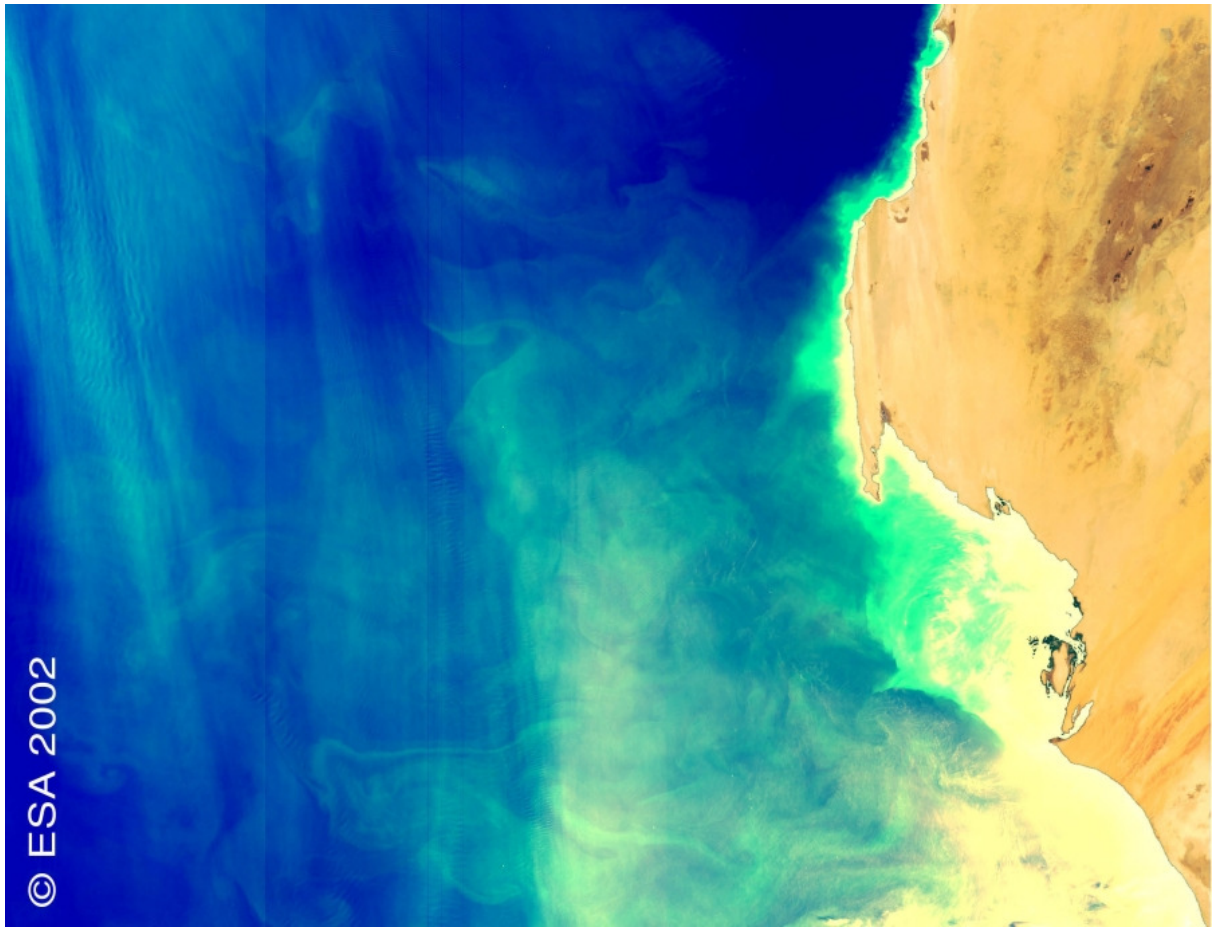
#bands	15
spectral range	400 – 1035 nm
bandwidths	4 – 20 nm
GSD	300 m / 1200 m
swath width	1150 km

Source: www.envisat.esa.int/instruments/meris/

MERIS

Chlorophyll

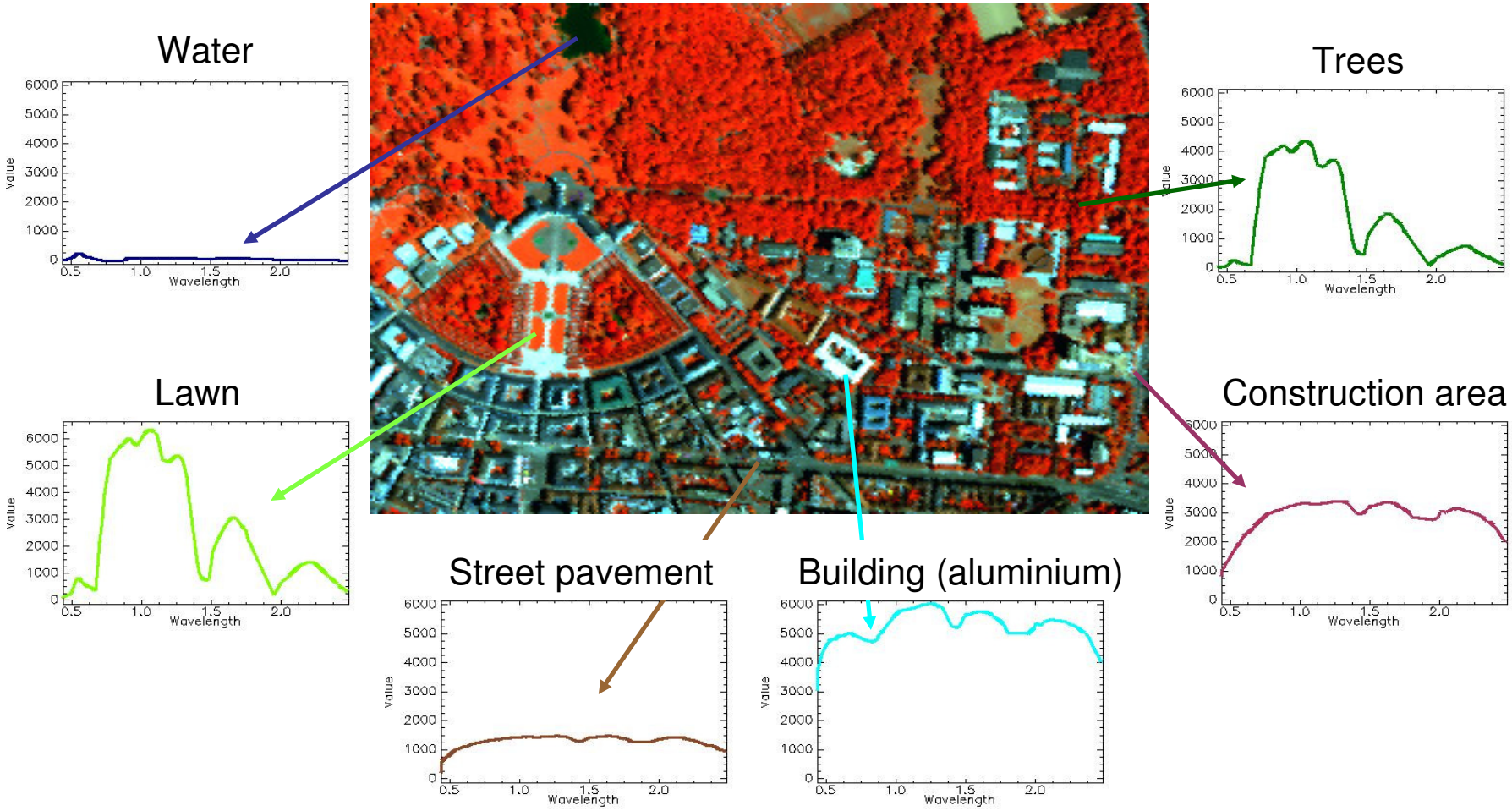
concentration



HyMap

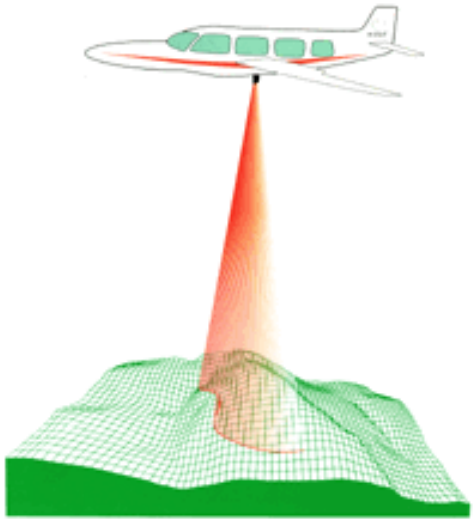
#bands	126
spectral range	400 – 2500 nm
bandwidths	15 – 20 nm
GSD	3 – 10 m
airborne	

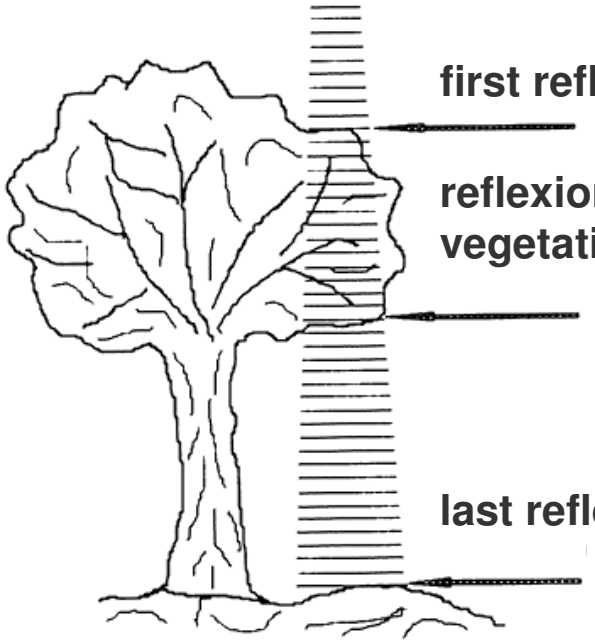
Source: http://www.hyvista.com



HyMap Karlsruhe (RGB = 25 / 10 / 2; 0.79 / 0.57 / 0.45 µm)

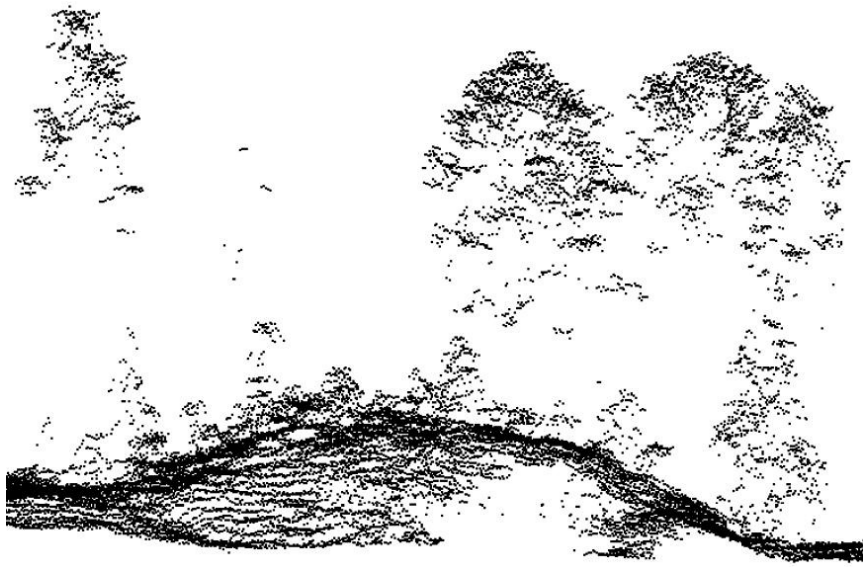
Laserscanner



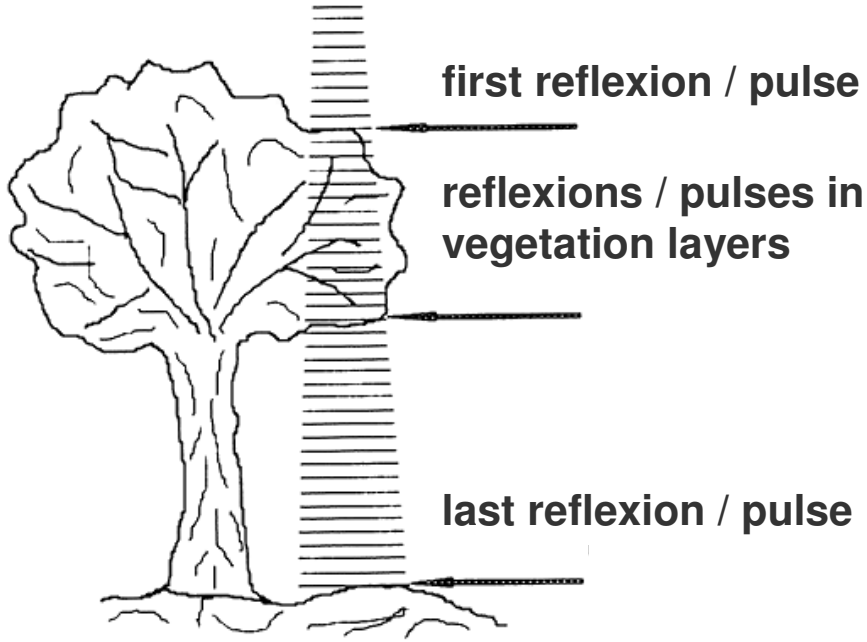


Source: Lindenberger (1993)

Laserscanner

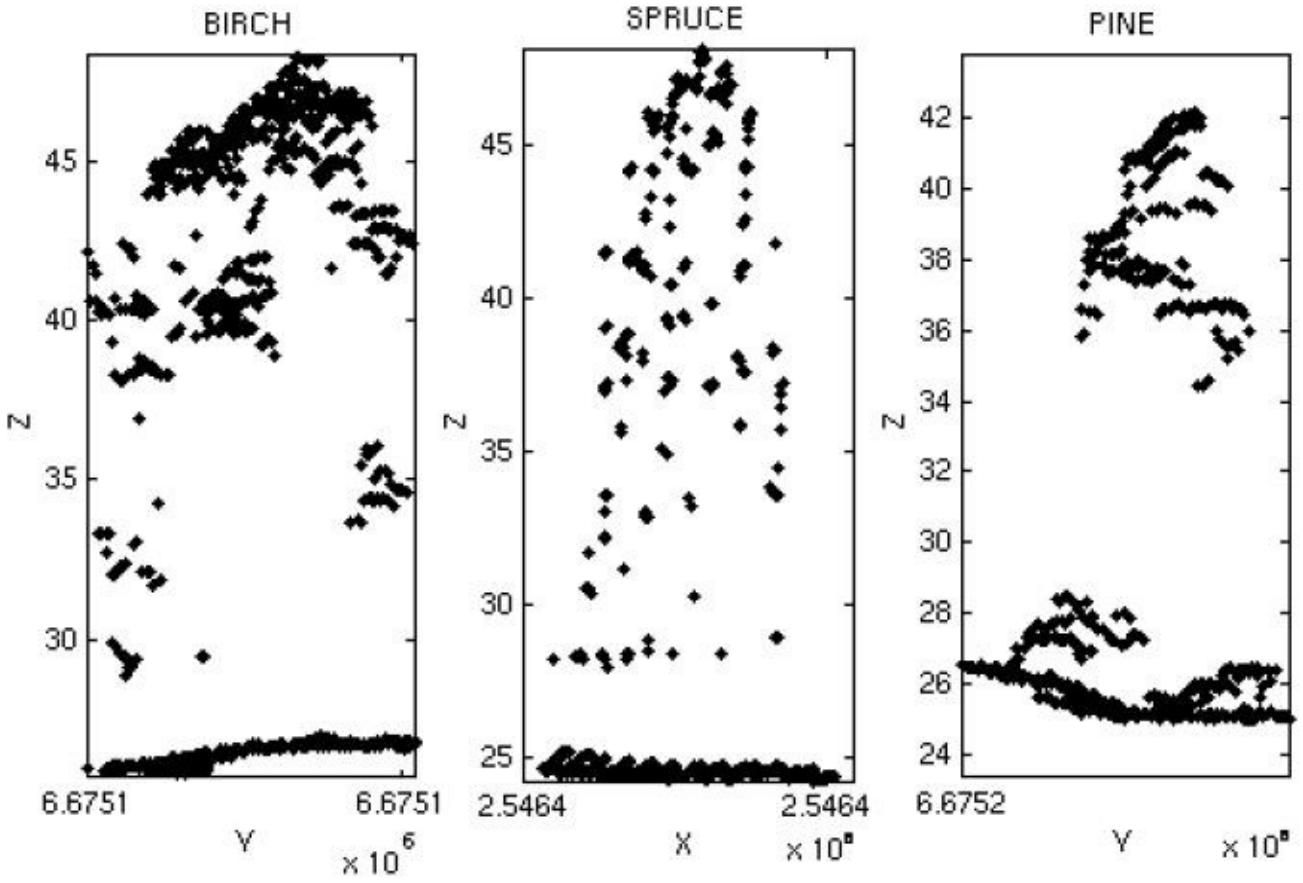


Source: Törmä (2000)



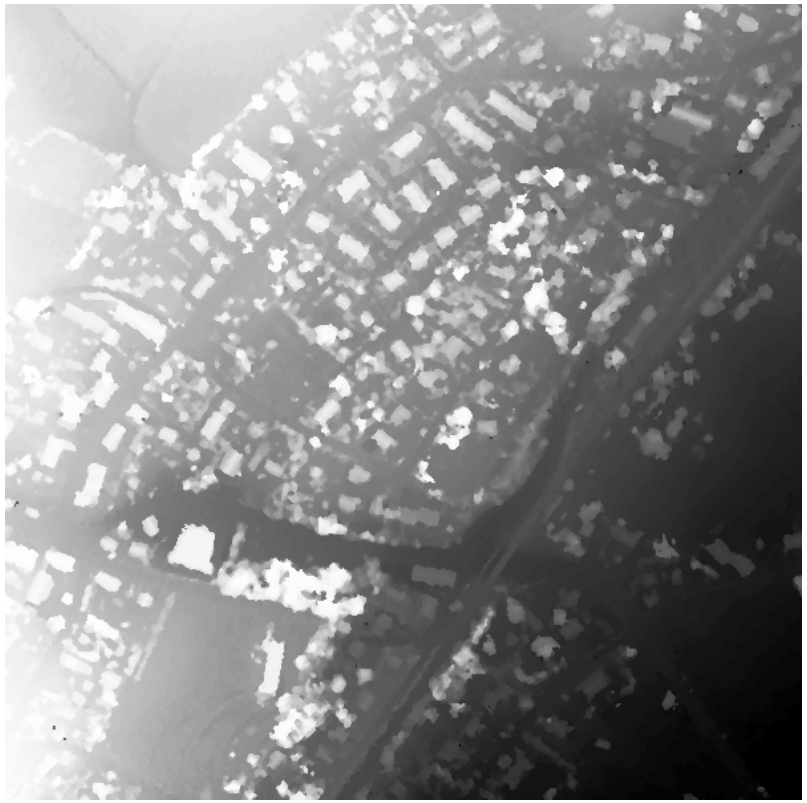
Source: Lindenberger (1993)

Laserscanner



Source: Pyysalo/Hyyppa (2002)

Laserscanner



Digital Surface Model

Reflexion rate

Source: Institut für Navigation, Stuttgart

Real Changes by Analysis of LIDAR Data

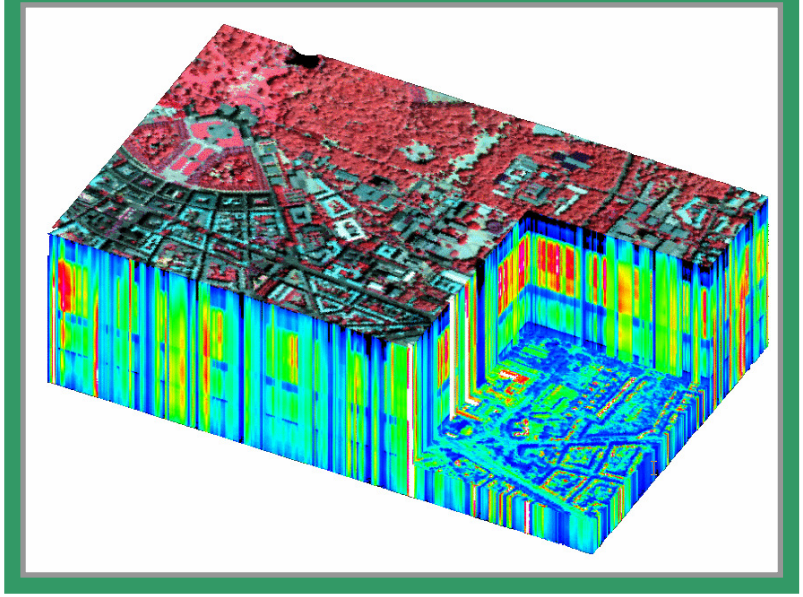
Buildings 1997

Buildings 2002

Automatic change detection based on height differences of objects

Source: Steinle/Bähr (2002)

HyMap



Laser

Surface material

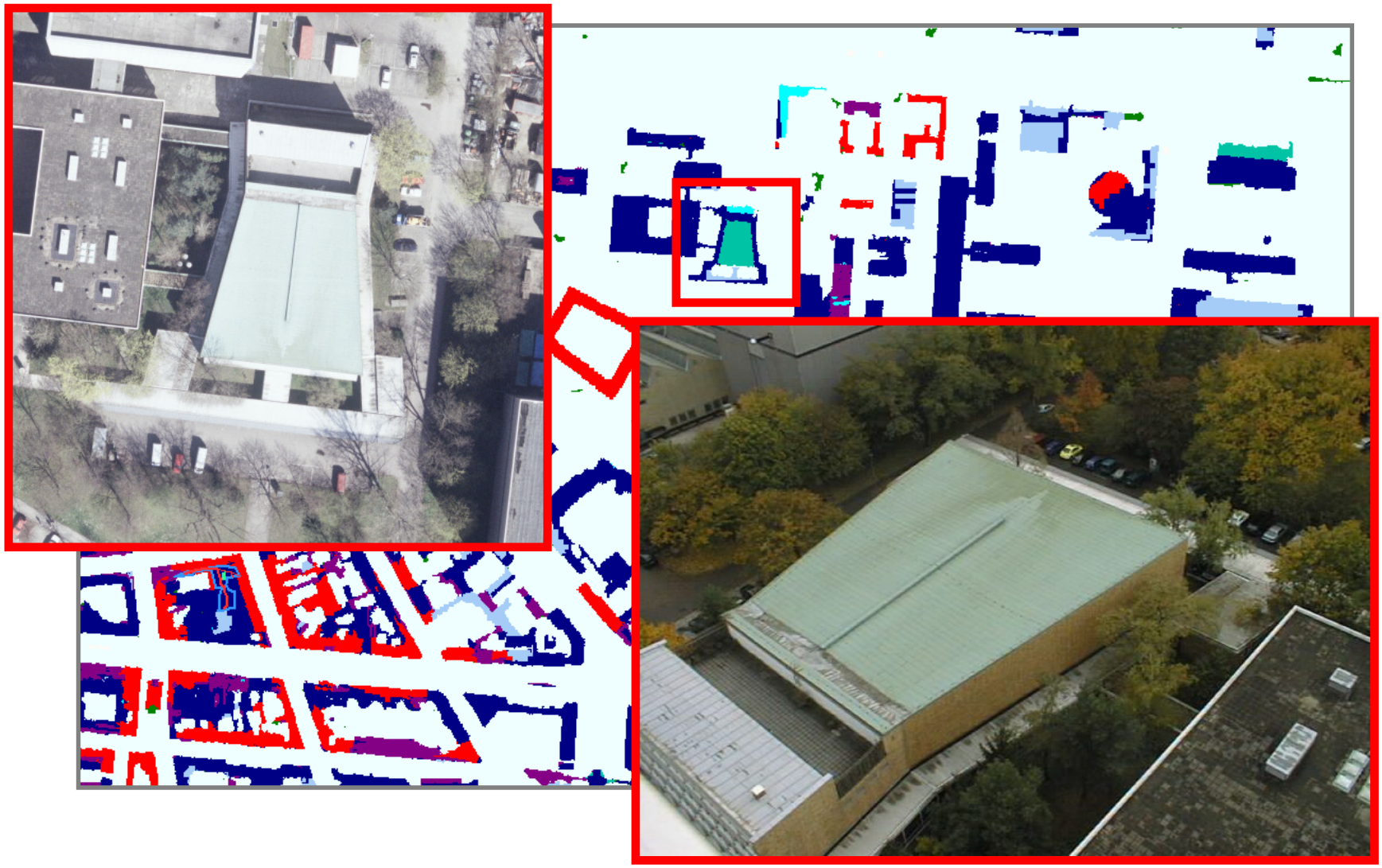
- sealed surface ?
- material ?

Surface geometry

- slope ?
- exposition ?
- surface area ?

Comparision with reference data (hyperspectral & Laser scanning data)

correct classification	92.8 %	zink/alu	21.8 %	yellow
		other	71.6 %	green
misclassification	7.2 %	zink/alu	2.8 %	red
		other	4.4 %	red



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