



# ÇEV 361

## Coğrafi Bilgi Sistemleri ve Uzaktan Algılama

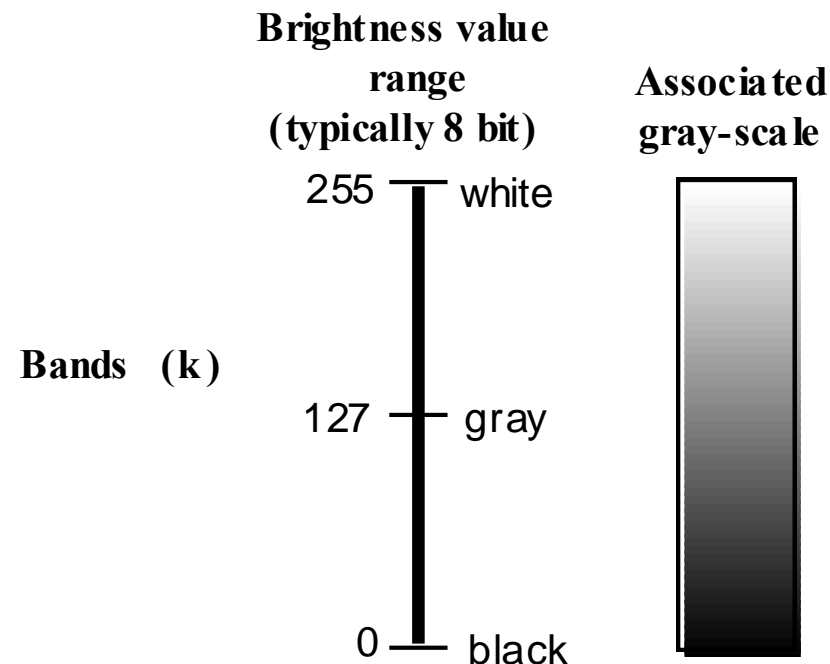
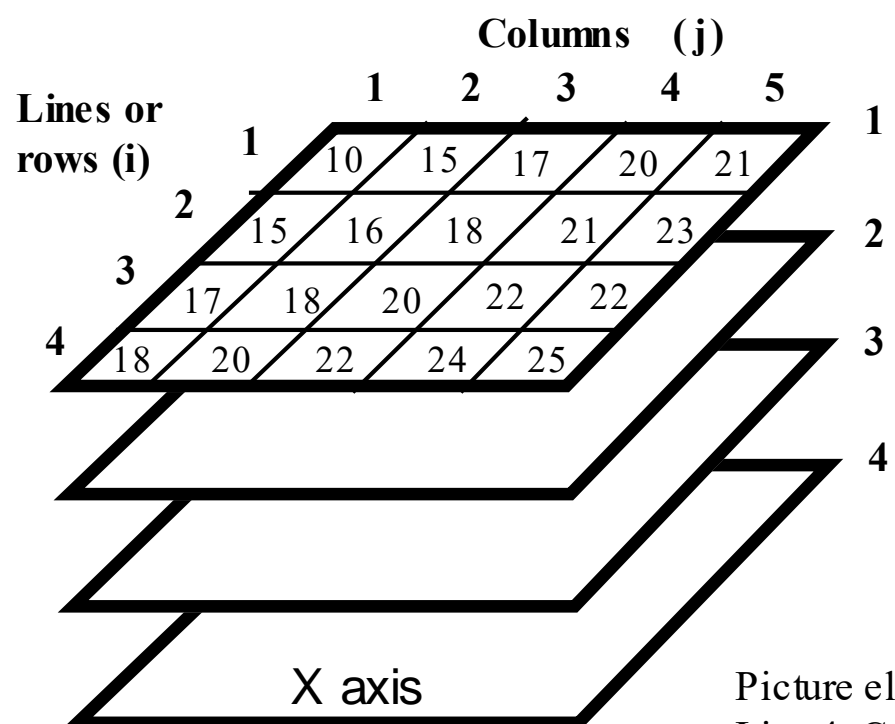
### Uzaktan Algılamada Çözünürlük Kavramı

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<https://ozgurzeydan.com.tr/>



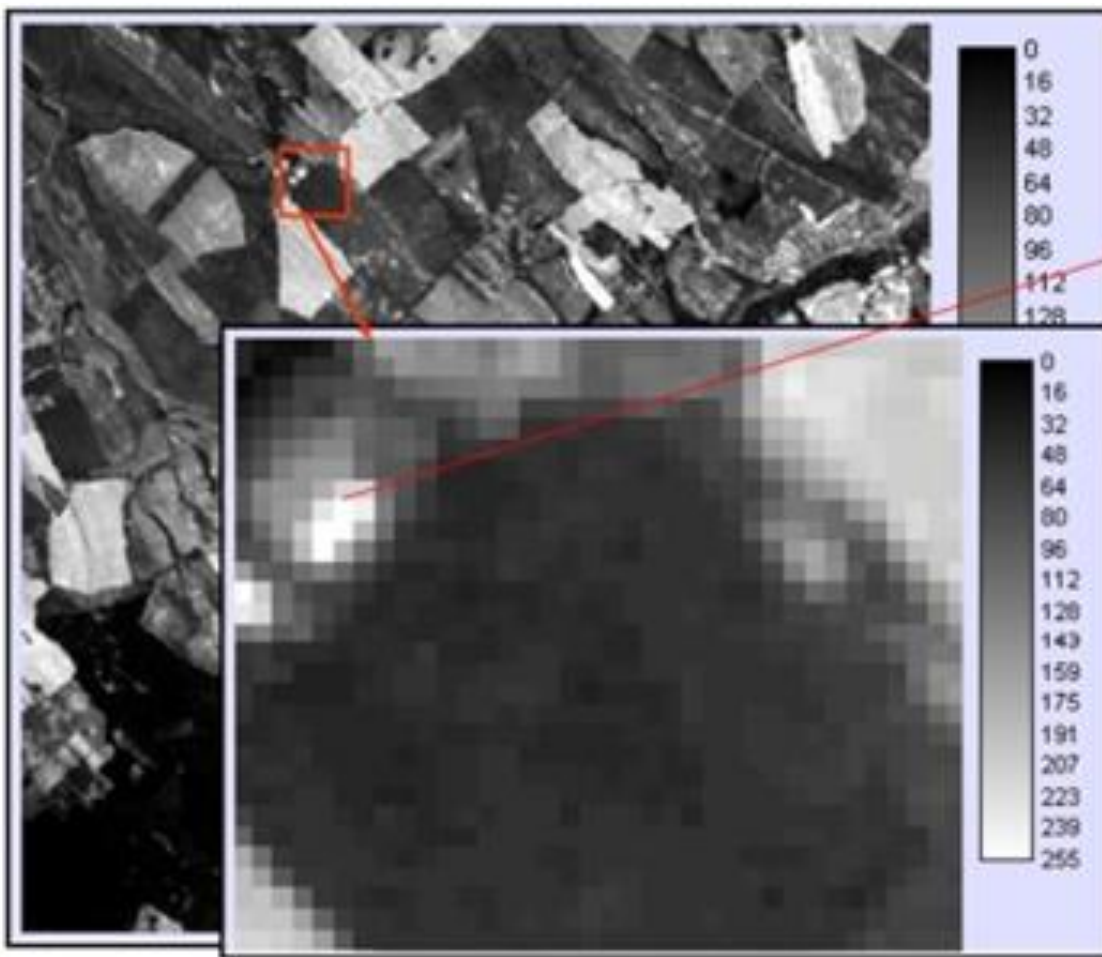
# Uzaktan Algılama Verisi

## Raster Veri Formatı



Picture element (pixel) at location  
Line 4, Column 4, in Band 1 has a  
Brightness Value of 24, i.e.,  $BV_{4,4,1} = 24$ .

# Uzaktan Algılama Verisi

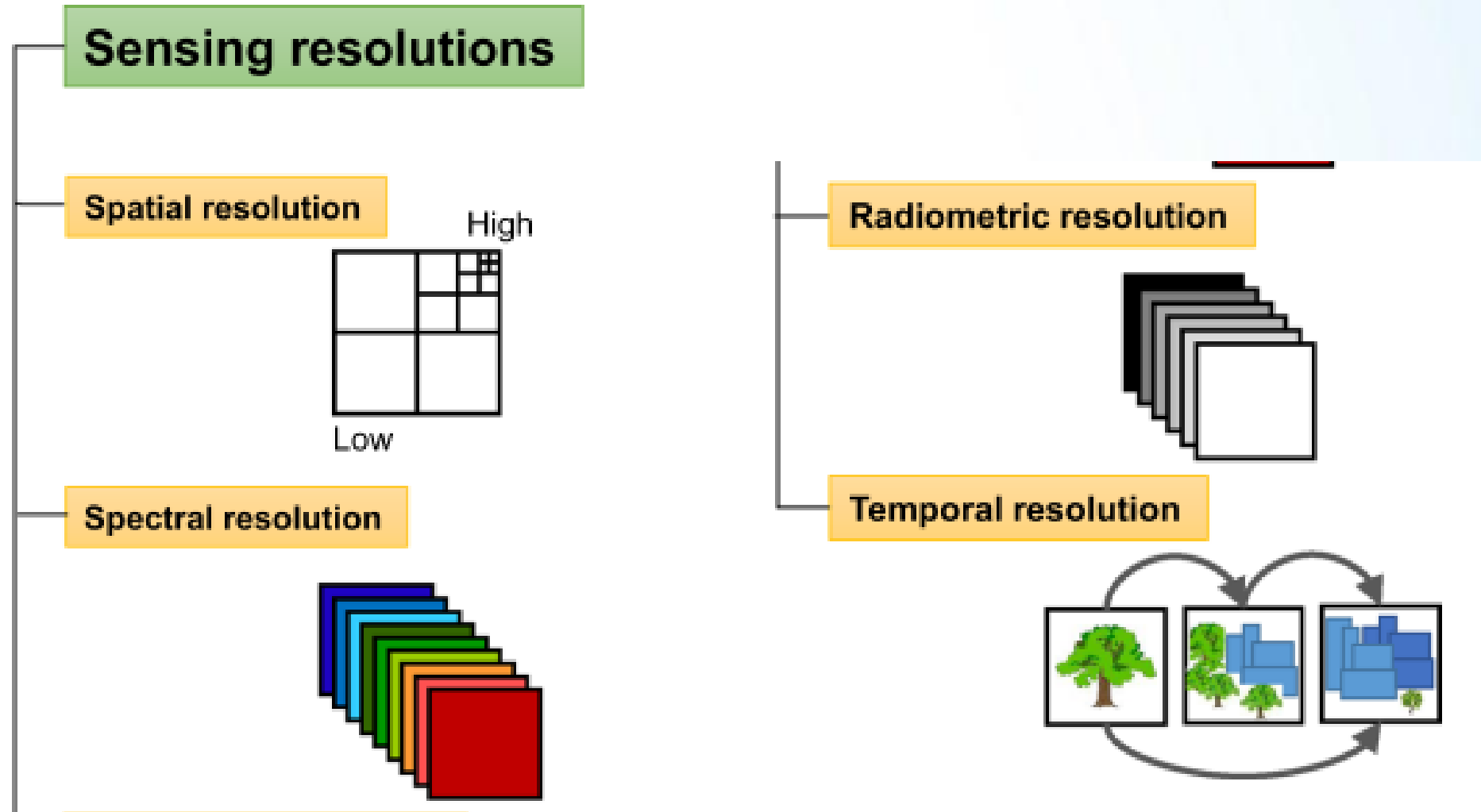


174	212	212	114	81	
228	225	239	125	43	
255	255	185	108		
255	179				

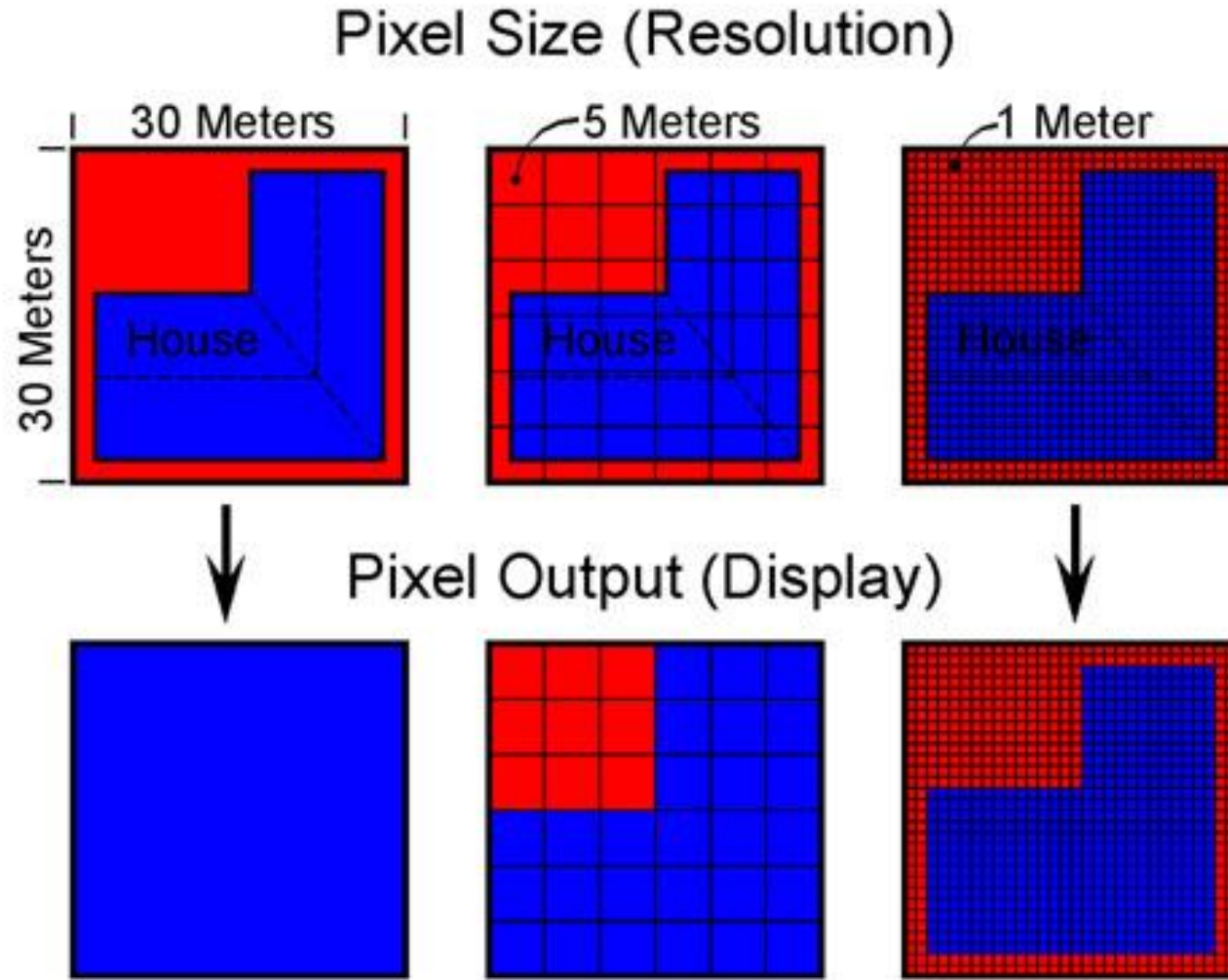
# Uzaktan Algılama Verilerinde Çözünürlük

1. **Mekansal** (Spatial) Çözünürlük
  - Objelerin ayırt edilebilirliği
2. **Spektral** (Spectral) Çözünürlük
  - Spektral bant sayısı
3. **Radyometrik** (Radiometric) Çözünürlük
  - Verinin parlaklık değerindeki ayrıntı
4. **Zamansal** (Temporal) Çözünürlük
  - Verinin kaç günde bir toplandığı

# Uzaktan Algılama Verilerinde Çözünürlük

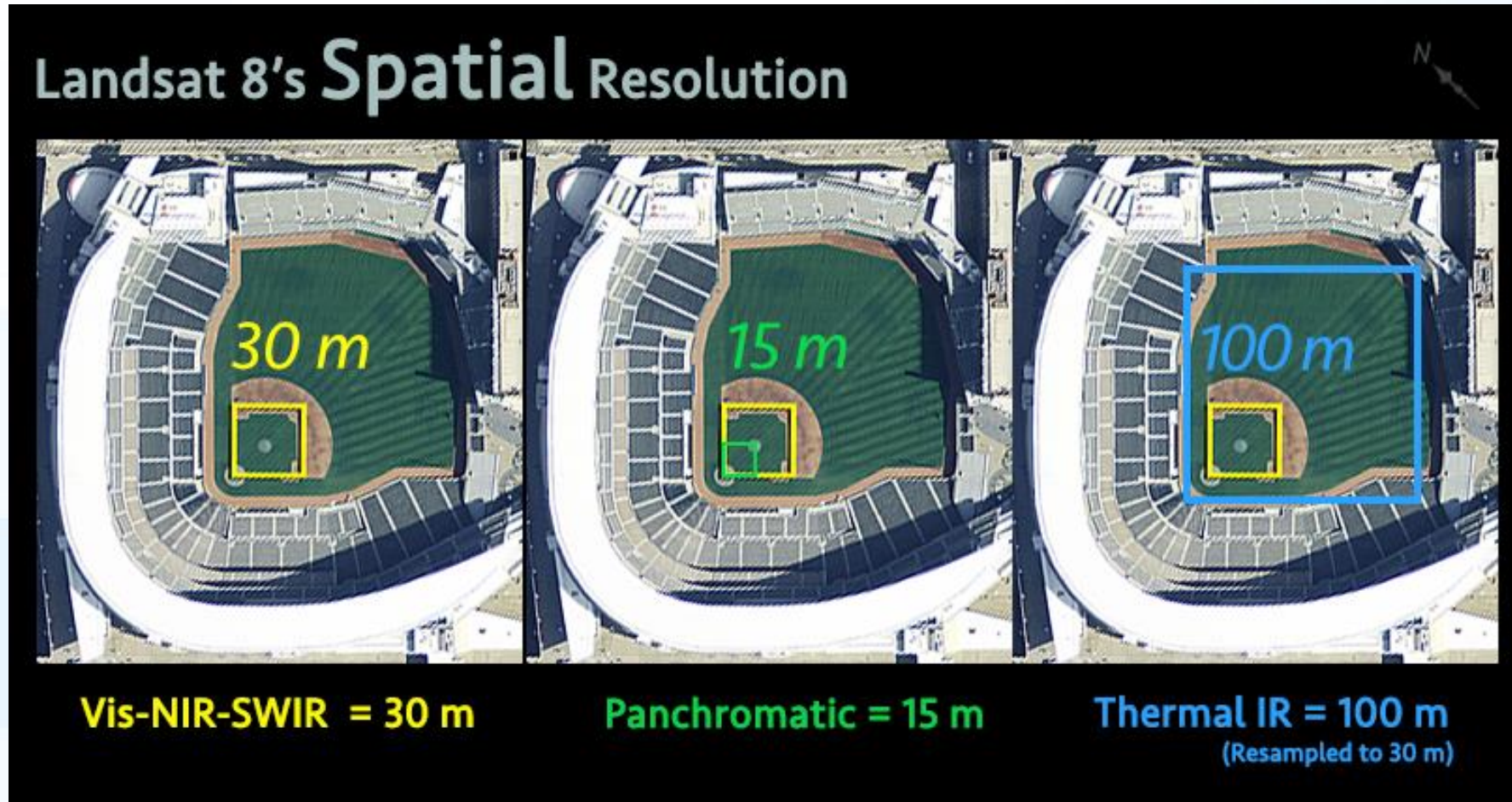


# Mekansal Çözünürlük

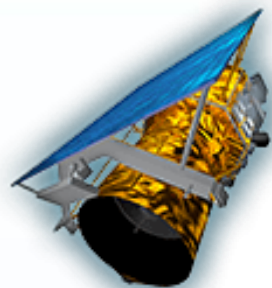




# Mekansal Çözünürlük



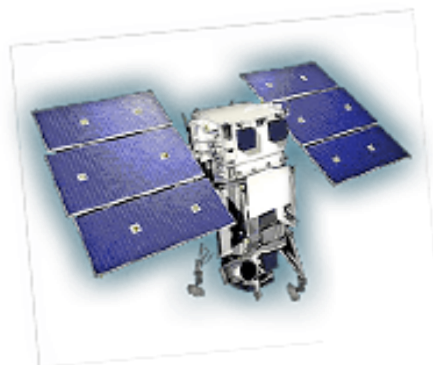
<https://landsat.gsfc.nasa.gov/satellites/landsat-8/>



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**GEOEYE-1** SMD  
(0.41m)

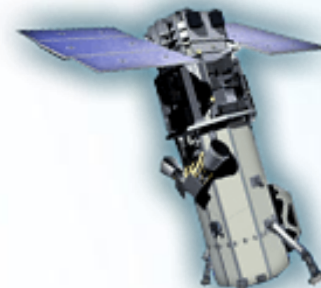
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**WORLDVIEW-1** SMD  
(0.46m)

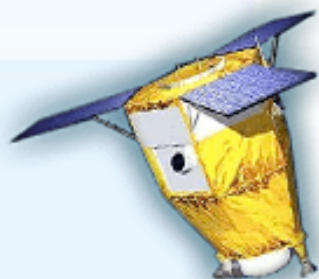
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**WORLDVIEW-2** SMD  
(0.46m)

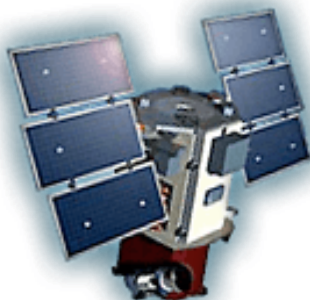
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**PLEIADES-1A** SMD  
(0.5m)

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**QUICKBIRD** SMD  
(0.61m)

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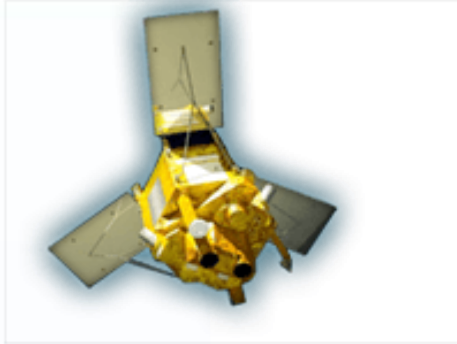


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**IKONOS** SMD  
(0.82m)

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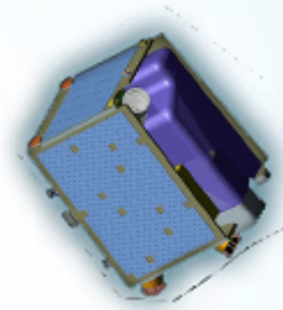




**SPOT-6** HD  
(1.5m)



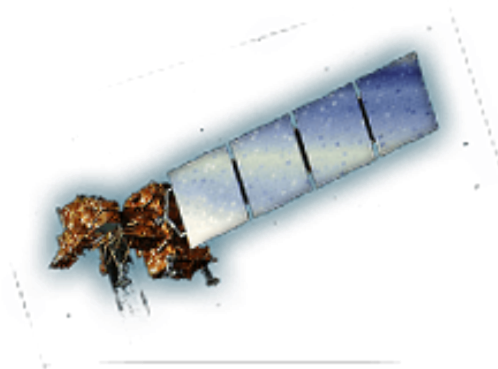
**SPOT-5** HD  
(2.5m/5m)



**RAPIDEYE** HD  
(5m)



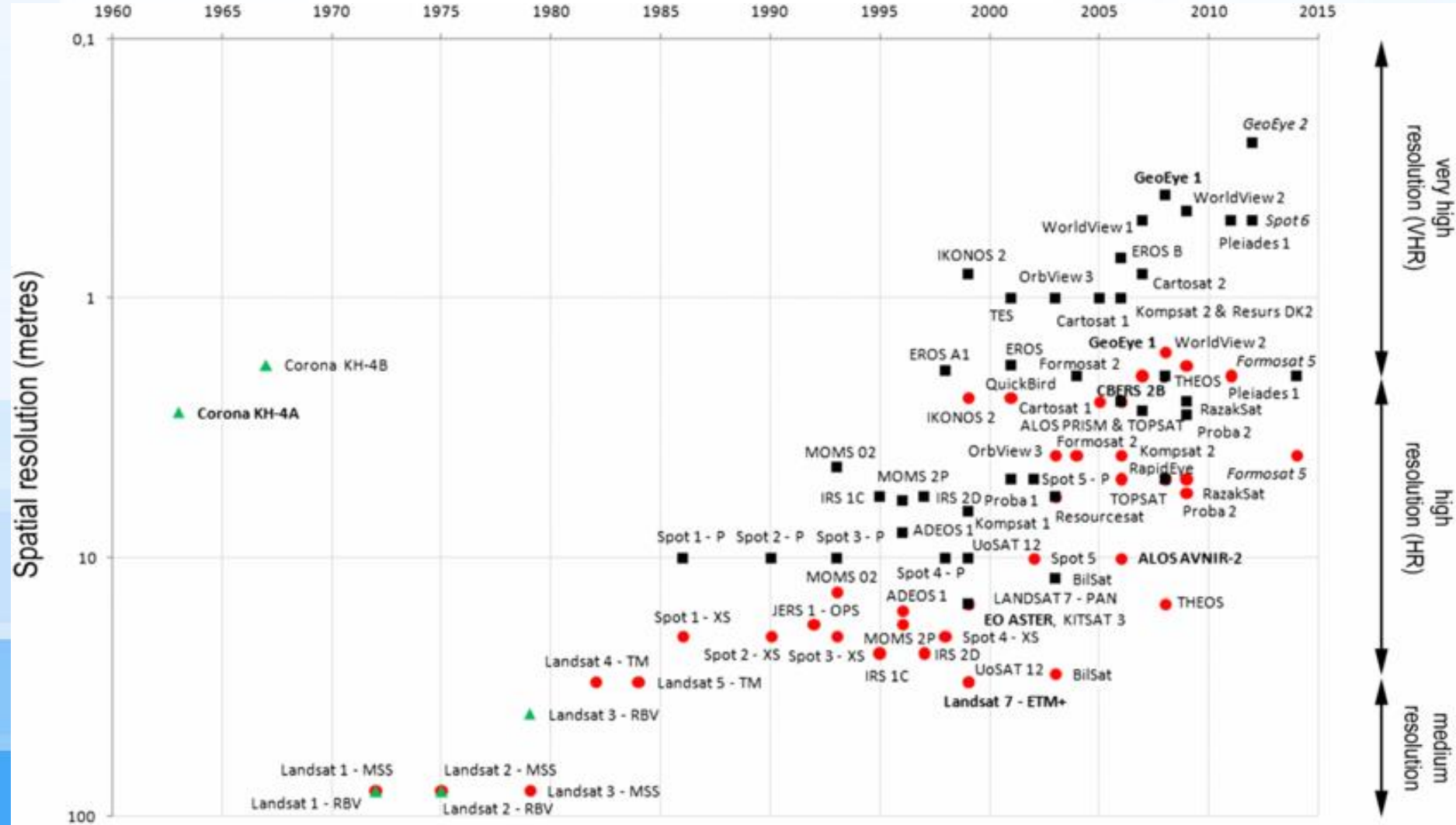
**ASTER** MED  
(15m)

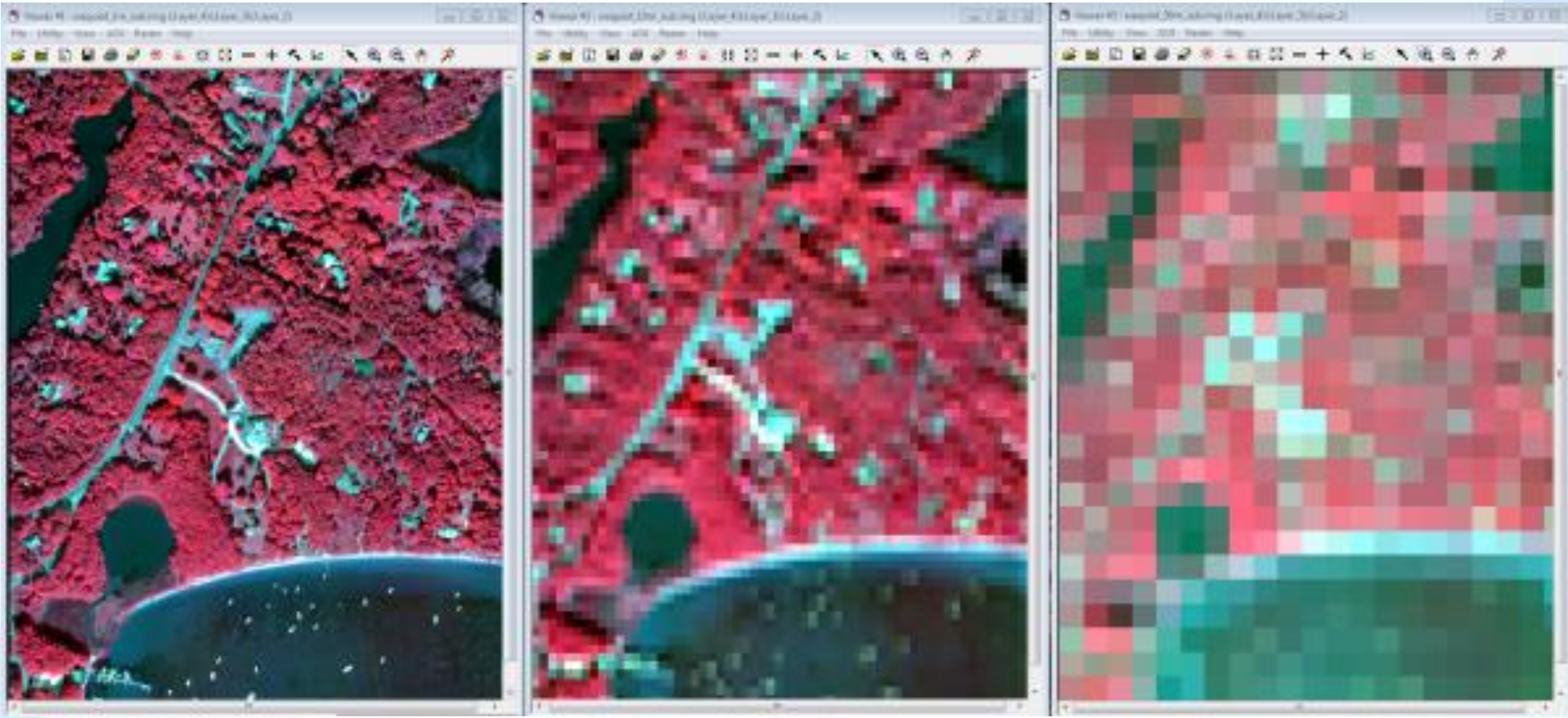


**LANDSAT 7 + ETM** MED  
(30m)

<http://www.satimagingcorp.com/services/resources/characterization-of-satellite-remote-sensing-systems/>

# Uydular ve Mekansal Çözünürlükleri





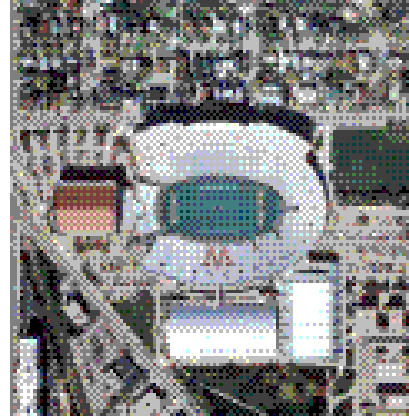
NAIP aerial imagery in its native 1m format (left) compared to a 10m (middle) and 30m (right) version of the same data. While visual differences are easy to see, the file sizes also change from 2.5MB to 39kB to 23kB.

<http://coast.noaa.gov/geozone/you-say-you-want-high-resolution/#.VH3LvnvIDhA>

# Çözünürlük



1 m çözünürlük



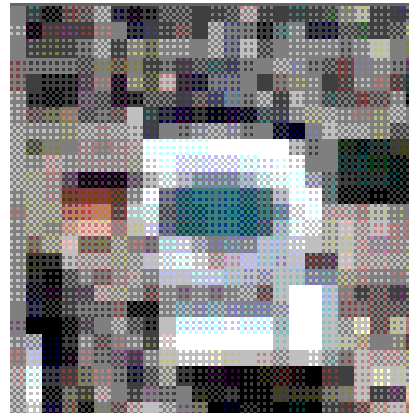
2 m çözünürlük



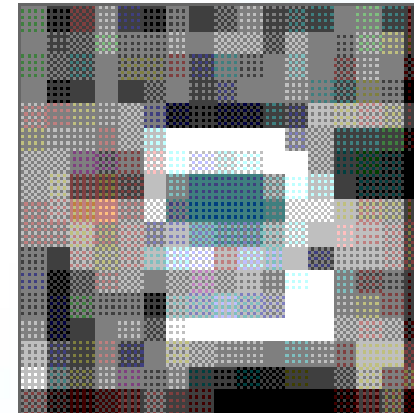
5 m çözünürlük



10 m çözünürlük



20 m çözünürlük

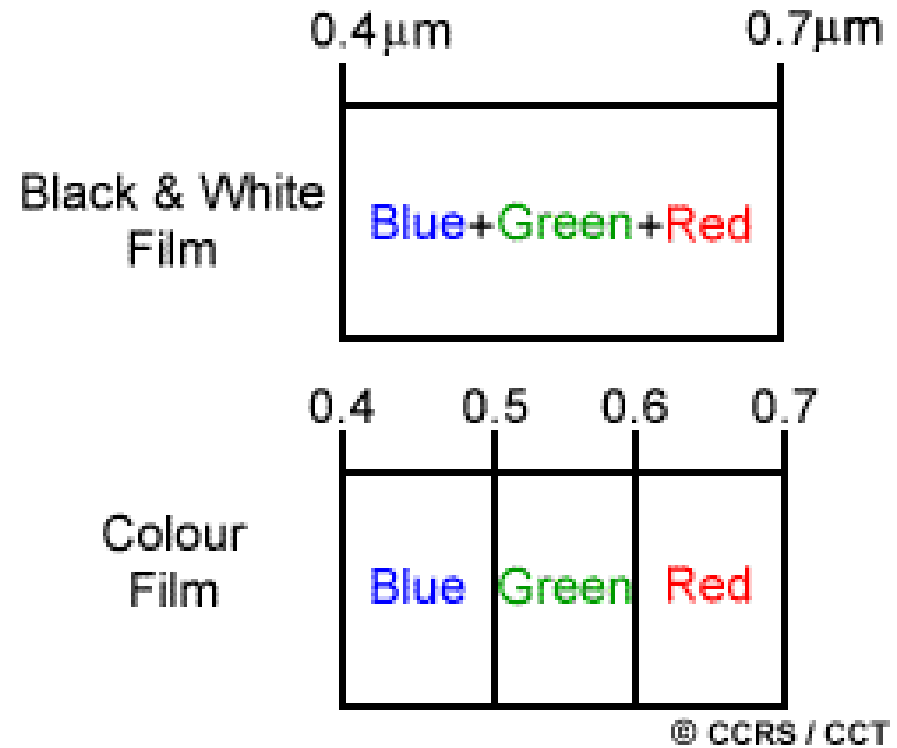


30 m çözünürlük



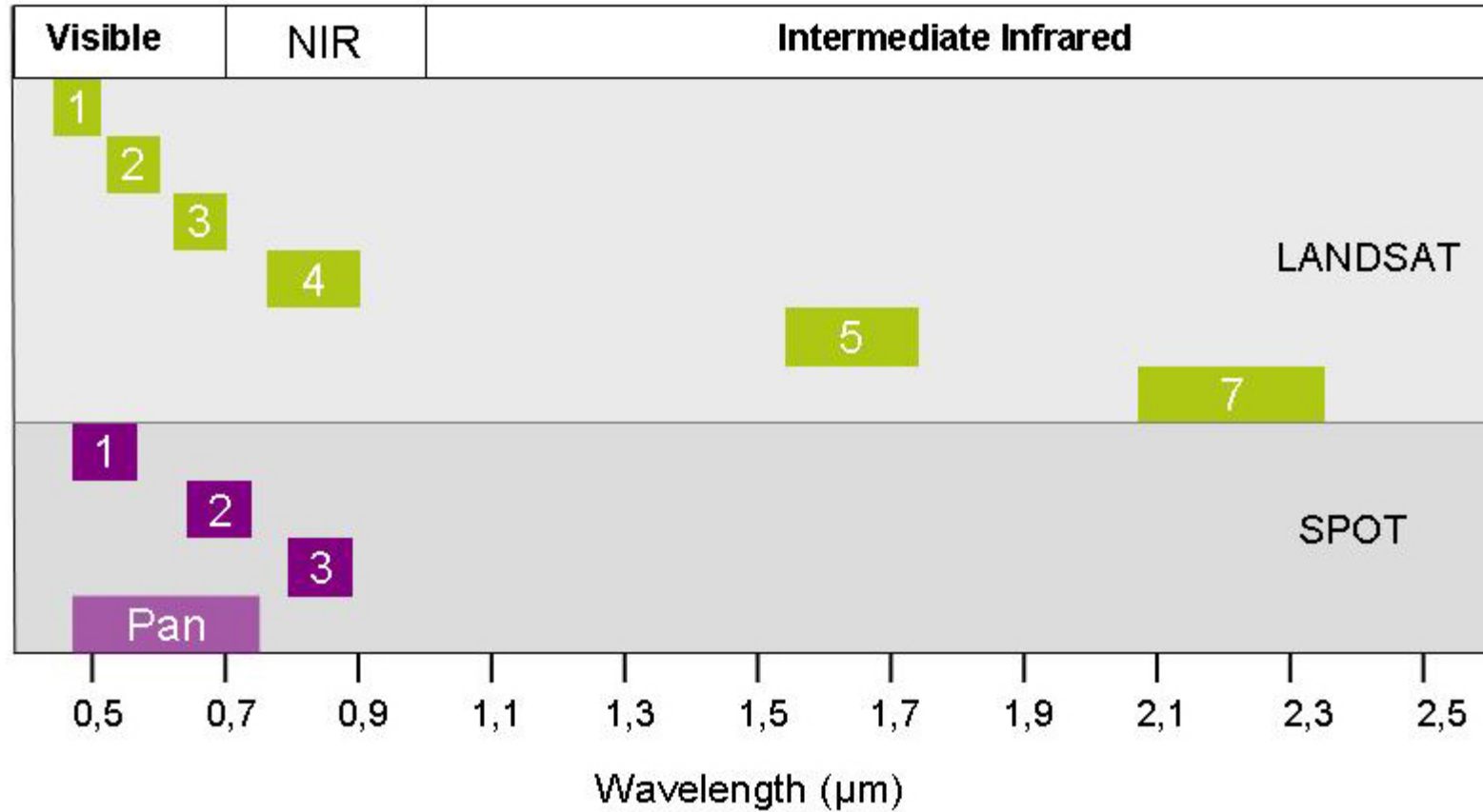
# Spektral Çözünürlük

- Sensörün farklı dalga boylarında görüntü alabilme yeteneğidir.
- Spektral çözünürlüğün yüksek olması, belirli bir banttaki dalga boyunun daha dar olarak görüntülenmesi ile ilişkilidir.



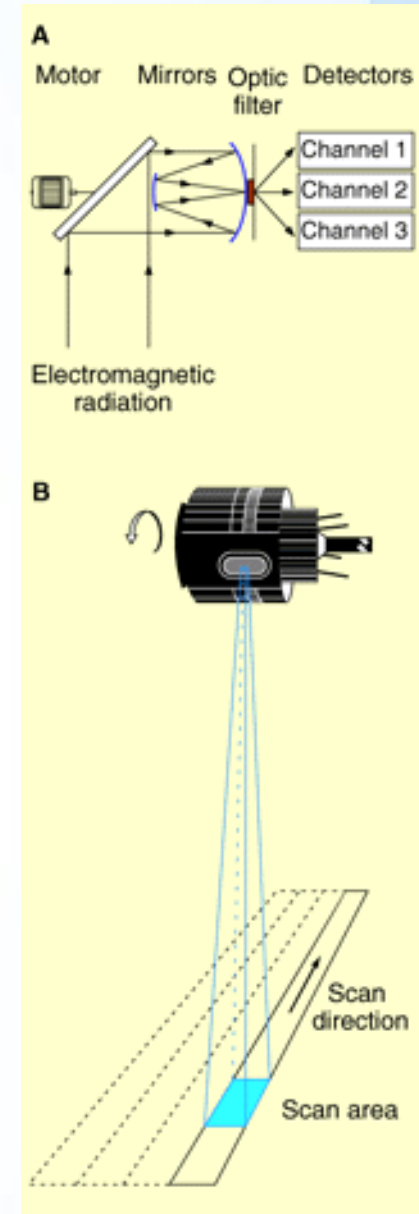
<http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9393>

# Spektral Çözünürlük



# Spektral Çözünürlük

- Yüksek:  $\sim 220$  bant
- Orta: 3 - 15 bant
- Düşük:  $\sim 3$  bant



# Radyometrik Çözünürlük

- EMR'deki enerji farklılıklarını ortaya çıkarabilmenin ölçüsüdür.
- Yüksek radyometrik çözünürlükte EMR'deki enerji değişimleri daha iyi algılanır.



2-bit



8-bit



# Radyometrik Çözünürlük

- 1-bit ( $2^1$ ): 0 → 1
- 4-bit ( $2^4$ ): 0 → 15
- 8-bit ( $2^8$ ): 0 → 255

Bits	Werteumfang	Grauwerte
1Bit	$2^1 = 2$ (0-1)	0  1
4Bit	$2^4 = 16$ (0-15)	0  15
8Bit	$2^8 = 256$ (0-255)	0  255

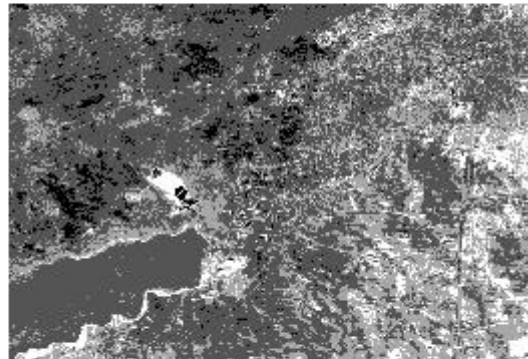
# Radyometrik Çözünürlük



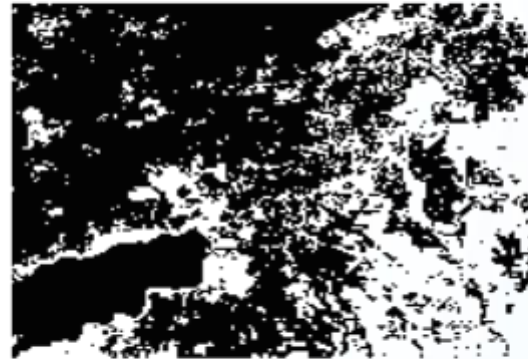
16 Values (4 bit)



8 Values (3 bit)



4 Values (2 bit)



2 Values (1 bit)

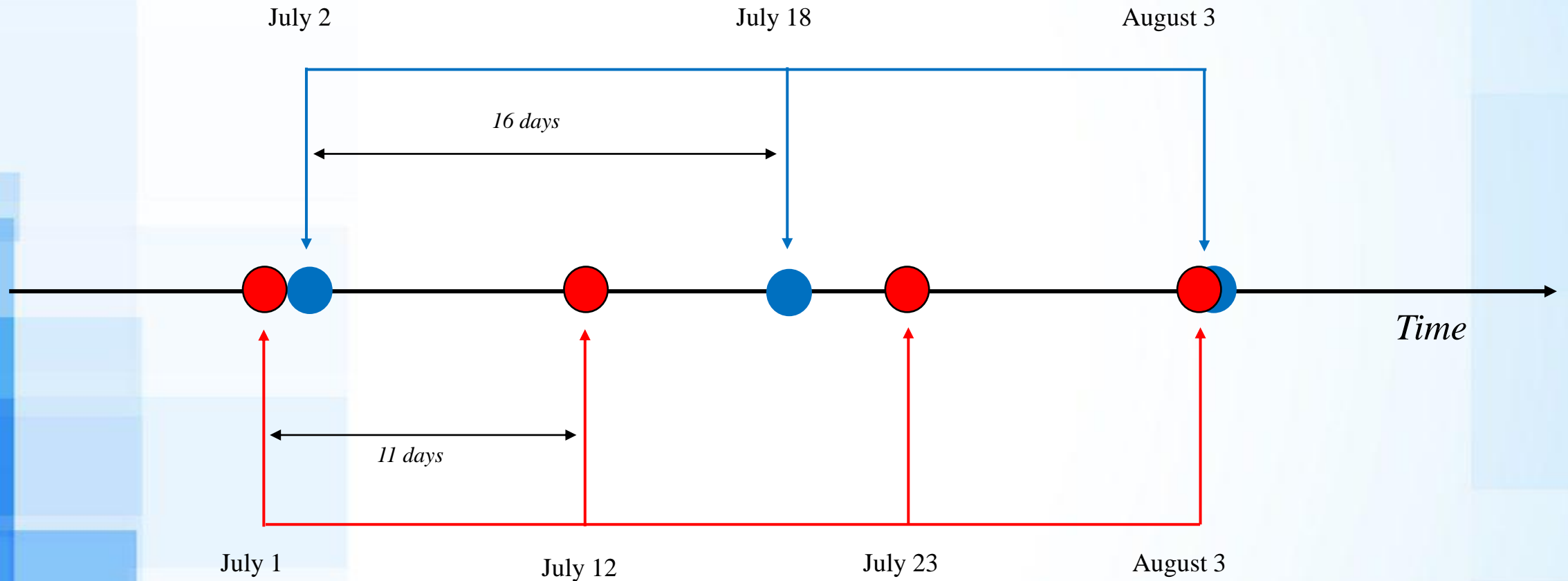


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Author: <http://commons.wikimedia.org/wiki/User:Arbeck>

# Zamansal Çözünürlük

- Sensörün aynı bölgeden kaç günde bir görüntü aldığıнын ölçüsüdür.
- Daha sık görüntü alınması yüksek zamansal çözünürlüğün göstergesidir.
- Yüksek :  $< 24$  saat - 3 gün
- Orta : 4 - 16 gün
- Düşük:  $> 16$  gün

# Zamansal Çözünürlük





# TÜBİTAK UZAY

## ➤ Yer Gözlem Uyduları:

- Bilsat
- Rasat
- Göktürk-2
- İMECE

■ <https://uzay.tubitak.gov.tr/uydu-platformlari/>



# RASAT Araştırma Uydusu

## TEKNİK ÖZELLİKLER

Türk Yer Gözlem Uyduları	RASAT
Ağırlık	93 kg
Yörünge	689 km'de dairesel, güneşe eşzamanlı
Yönelim kontrolü	3 eksen kontrollü
Yörünge süresi	98.8 dakika
Ekvator geçişi yerel zamanı	10:30
Uzamsal çözünürlük	Pankromatik: 7.5 m Çok bantlı: 15 m
Tahmini ömür	3 yıl
Tayfsal çözünürlük (µm)	0.42 – 0.73 (Pankromatik) 1. Bant: 0.42 – 0.55 (Mavi) 2. Bant: 0.55 – 0.58 (Yeşil) 3. Bant: 0.58 – 0.73 (Kırmızı)
Radyometrik çözünürlük	8 bit
Zamansal çözünürlük	4 gün
Şerit genişliği	30 km
Faydalı yükler	<ul style="list-style-type: none"><li>• Optik faydalı yük: Stereoskopik görme özelliğine sahip Pushbroom görüntüleyiciden oluşmaktadır.</li><li>• BiLGE: Spacewire veriyolu kullanabilen uçuş bilgisayarı.</li><li>• GEZGIN-2: JPEG2000 algoritmaları ile yüksek hızda çok bantlı görüntü sıkıştırma ve şifreleme yapabilen yeni nesil görüntü işleme kartı.</li><li>• X-Bant Verici Modülü: 100 Mb/s iletim hattına ve 7W çıkışa sahip iletişim sistemi.</li></ul>

<http://uzay.tubitak.gov.tr/tr/uydu-uzay/rasat>

# Band specifications for Landsat sensors

Spectral Channel	Landsat-8 OLI		Landsat-7/ETM+		Landsat-5/TM	
	Bands	Wavelength ( $\mu\text{m}$ )	Bands	Wavelength ( $\mu\text{m}$ )	Bands	Wavelength ( $\mu\text{m}$ )
Band 1	Coastal	0.43–0.45	Blue	0.45–0.52	Blue	0.45–0.52
Band 2	Blue	0.45–0.51	Green	0.52–0.60	Green	0.52–0.60
Band 3	Green	0.53–0.59	Red	0.63–0.69	Red	0.63–0.69
Band 4	Red	0.64–0.67	Near-Infrared	0.77–0.90	Near-Infrared	0.76–0.90
Band 5	Near-Infrared	0.85–0.88	Near-Infrared	1.55–1.75	Near-Infrared	1.55–1.75
Band 6	SWIR 1	1.57–1.65	Thermal	10.40–12.50	Thermal	10.40–12.50
Band 7	SWIR 2	2.11–2.29	Mid-Infrared	2.08–2.35	Mid-Infrared	2.08–2.35
Band 8	Panchromatic	0.50–0.68	Panchromatic	0.52–0.90		
Band 9	Cirrus	1.36–1.38				
Band 10	TIRS 1	10.60–11.19				
Band 11	TIRS 2	11.50–12.51				

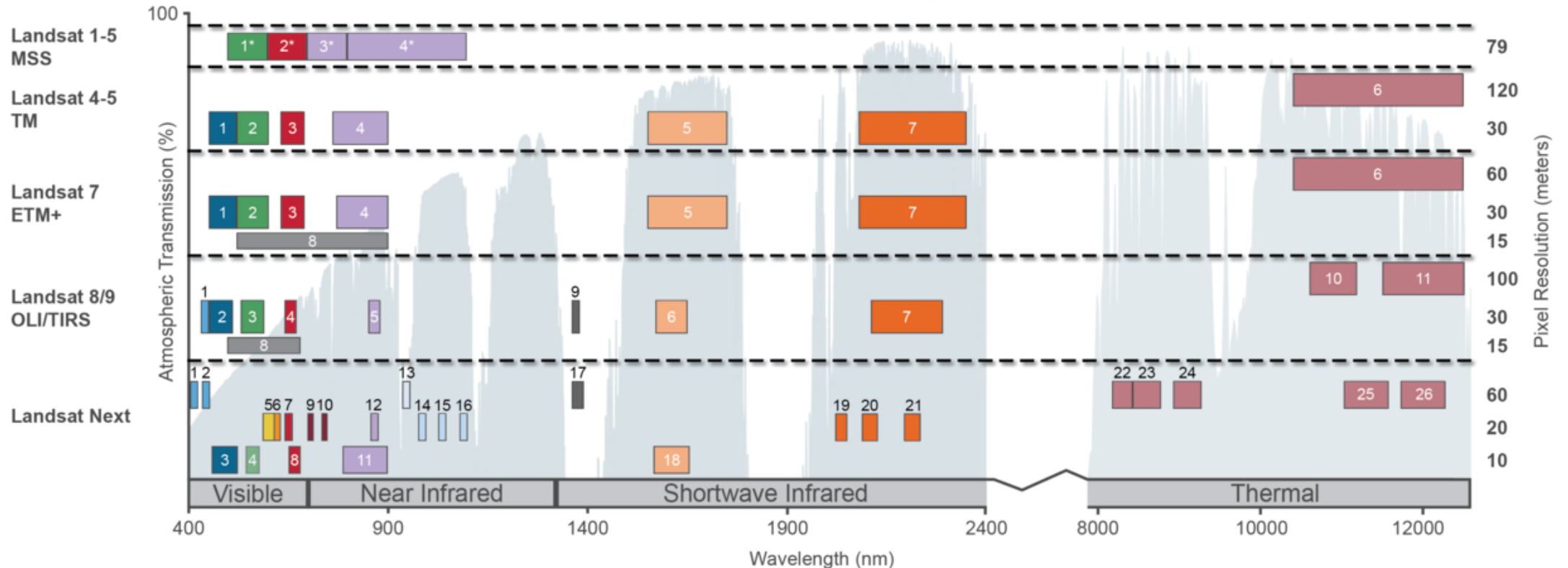
# Landsat 8

Landsat-7 ETM+ Bands ( $\mu\text{m}$ )			Landsat-8 OLI and TIRS Bands ( $\mu\text{m}$ )		
			30 m Coastal/Aerosol	0.435 - 0.451	Band 1
Band 1	30 m Blue	0.441 - 0.514	30 m Blue	0.452 - 0.512	Band 2
Band 2	30 m Green	0.519 - 0.601	30 m Green	0.533 - 0.590	Band 3
Band 3	30 m Red	0.631 - 0.692	30 m Red	0.636 - 0.673	Band 4
Band 4	30 m NIR	0.772 - 0.898	30 m NIR	0.851 - 0.879	Band 5
Band 5	30 m SWIR-1	1.547 - 1.749	30 m SWIR-1	1.566 - 1.651	Band 6
Band 6	60 m TIR	10.31 - 12.36	100 m TIR-1	10.60 - 11.19	Band 10
			100 m TIR-2	11.50 - 12.51	Band 11
Band 7	30 m SWIR-2	2.064 - 2.345	30 m SWIR-2	2.107 - 2.294	Band 7
Band 8	15 m Pan	0.515 - 0.896	15 m Pan	0.503 - 0.676	Band 8
			30 m Cirrus	1.363 - 1.384	Band 9



# Landsat Bantları

## Comparison of Landsat Spectral Bands



\* MSS bands 1-4 were known as bands 4-7, respectively, on Landsats 1-3

USGS, March 2024

<https://www.usgs.gov/media/images/spectral-bandpasses-all-landsat-sensors>

# GeoEye-1

Altitude 681 km	
Orbit	Type: Sun-synchronous, 10:30 am descending node Period: 98 min
Sensor Resolution and Spectral Bandwidth	Panchromatic: 41 cm GSD at nadir Black & White: 450 - 800 nm  Multispectral: 1.65 m GSD at nadir Blue: 450 - 510 nm Green: 510 - 580 nm Red: 655 - 690 nm Near-IR: 780 - 920 nm
Dynamic Range	11-bits per pixel
Swath Width	Nominal Swath Width: 15.3 km at nadir
Attitude Determination and Control	Type: 3-axis Stabilized Star tracker/IRU/reaction wheels, GPS
Retargeting Agility	Time to slew 200 km: 20 sec
Onboard Storage	1 Tbit capacity
Communications	Payload Data: X-band 740/150 Mbps AES/DES encryption Housekeeping: X-band 64 kbps AES encryption
Revisit Frequency (at 40°N Latitude)	2.6 days at 30° off-nadir
Metric Accuracy	5 m CE90, 3 m CE90 (measured)
Capacity	350,000 km <sup>2</sup> /day Multi-spectral

# IKONOS

<b>Spatial resolution</b>	Panchromatic: 0.82 m Multispectral: 3.2 m
<b>Positional accuracy</b>	15 meter CE90 (specification) 9 meter CE90 (measured)
<b>Swath width</b>	11.3 km
<b>Off-nadir imaging</b>	Up to 60 degrees
<b>Dynamic range</b>	11 bits per pixel
<b>Revisit time</b>	Approximately 3 days
<b>Orbital altitude</b>	681 km
<b>Nodal crossing</b>	10:30 am
<b>Collection capacity</b>	240,000 km <sup>2</sup> /day (Pan + MSI)

# QuickBird

	Altitude 400 km	Altitude 450 km
<b>Orbit</b>	Type: Sun synchronous, 10:00 am descending node Period: 92.4 min.	10:25 am descending node Period: 93.6 min
<b>Sensor resolution and spectral bandwidth</b>	Panchromatic: 55 cm GSD at nadir Black & White: 405 - 1053 nm  Multispectral: 2.16 m GSD at nadir Blue: 430 - 545 nm Green: 466 - 620 nm Red: 590 - 710 nm Near-IR: 715 - 918 nm	Panchromatic 61 cm GSD at nadir  Multispectral 2.44 m GSD at nadir
<b>Dynamic range</b>	11-bits per pixel	
<b>Swath width</b>	Nominal Swath Width: 14.9 km at nadir	Nominal swath width: 16.8 km at nadir
<b>Attitude determination and control</b>	Type: 3-axis Stabilized Star tracker/IRU/reaction wheels, GPS	
<b>Retargeting agility</b>	Time to slew 200 km: 37 sec	38 sec
<b>Onboard storage</b>	128 Gb capacity	
<b>Communications</b>	Payload Data: 320 Mbps X-band Housekeeping: X-band from 4,16 and 256 Kbps, 2 Kbps S-band uplink	
<b>Revisit frequency (at 40°N Latitude)</b>	Revisit time may vary from 2 to 12 days depending on target location as the orbit decays.	
<b>Metric accuracy</b>	23 m CE90, 17 m LE90 (without ground control)	
<b>Capacity</b>	200,000 sq km per day	

# SPOT

Sensor-system	Spectral resolution (µm)	Spatial resolution (m)	Scan-width (km)	Revisit period	Orbital altitude	Operation periode
HRV	channel 1: 0,50 - 0,59	20×20	60	26 days / variable	832 km, near polar, sun-synchronous	21/02/1986 -
	channel 2: 0,61 - 0,68					
	channel 3: 0,79 - 0,89					
	Panchromatic: 0,51 - 0,73	10×10	117			



# Uydular İçin Web Kaynakları:

- [http://www.nik.com.tr/content\\_sistem\\_uydu\\_goruntuleri.asp](http://www.nik.com.tr/content_sistem_uydu_goruntuleri.asp)
- <http://www.satimagingcorp.com/satellite-sensors/>
- [http://www.esa.int/SPECIALS/Eduspace\\_EN/SEM7YN6SXIG\\_0.html](http://www.esa.int/SPECIALS/Eduspace_EN/SEM7YN6SXIG_0.html)
- <https://eosps.nasa.gov/>