Universidad Nacional de Córdoba

FCEFyN
FACULTAD DE CIENCIAS EXACTAS, FÍSICAS y NATURALES

DOCTORADO EN CIENCIAS GEOLOGICAS

Curso de posgrado

LA GEOMORFOLOGÍA Y *CAMBIO CLIMATICO*

SEPTIEMBRE 2022

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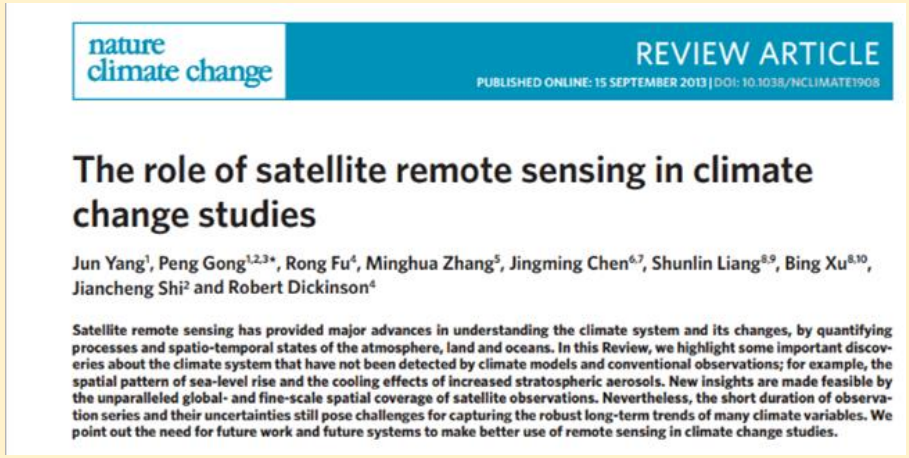
TEMA 5

TEMA 5

- Sensoramiento remoto y Sistema de Información Geográfica (SIG).

La teledetección por satélite ha proporcionado importantes avances en la comprensión del sistema climático y sus cambios, al cuantificar procesos y estados espacio-temporales de la atmósfera, la tierra y los océanos.



nature climate change

REVIEW ARTICLE

PUBLISHED ONLINE: 15 SEPTEMBER 2013 | DOI: 10.1038/NCLIMATE1908

The role of satellite remote sensing in climate change studies

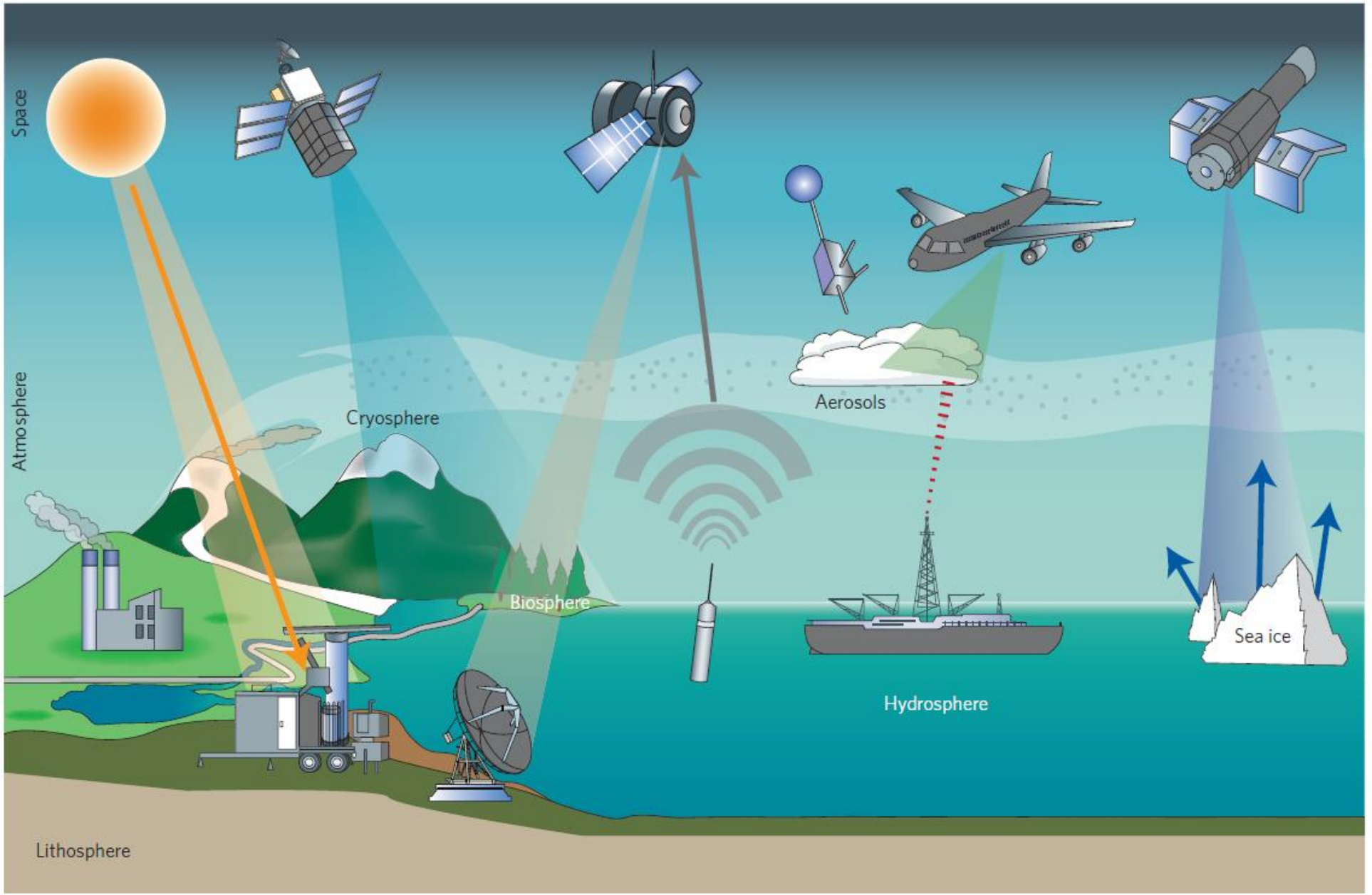
Jun Yang[1], Peng Gong[1,2,3*], Rong Fu[4], Minghua Zhang[5], Jingming Chen[6,7], Shunlin Liang[8,9], Bing Xu[8,10], Jiancheng Shi[2] and Robert Dickinson[4]

Satellite remote sensing has provided major advances in understanding the climate system and its changes, by quantifying processes and spatio-temporal states of the atmosphere, land and oceans. In this Review, we highlight some important discoveries about the climate system that have not been detected by climate models and conventional observations; for example, the spatial pattern of sea-level rise and the cooling effects of increased stratospheric aerosols. New insights are made feasible by the unparalleled global- and fine-scale spatial coverage of satellite observations. Nevertheless, the short duration of observation series and their uncertainties still pose challenges for capturing the robust long-term trends of many climate variables. We point out the need for future work and future systems to make better use of remote sensing in climate change studies.

En algunos descubrimientos importantes sobre el sistema climático que no han sido detectados por los modelos climáticos y las observaciones convencionales;

Por ejemplo, el patrón espacial de la subida del nivel del mar y los efectos de enfriamiento del aumento de los aerosoles estratosféricos. Los nuevos conocimientos son posibles gracias a la inigualable cobertura espacial a escala global de las observaciones por satélite.

Sin embargo, la corta duración de las series de observación y sus incertidumbres siguen planteando problemas para captar las tendencias sólidas a largo plazo de muchas variables climáticas. (Yang et a. 2019)


Space
Atmosphere
Cryosphere
Aerosols
Biosphere
Sea ice
Hydrosphere
Lithosphere

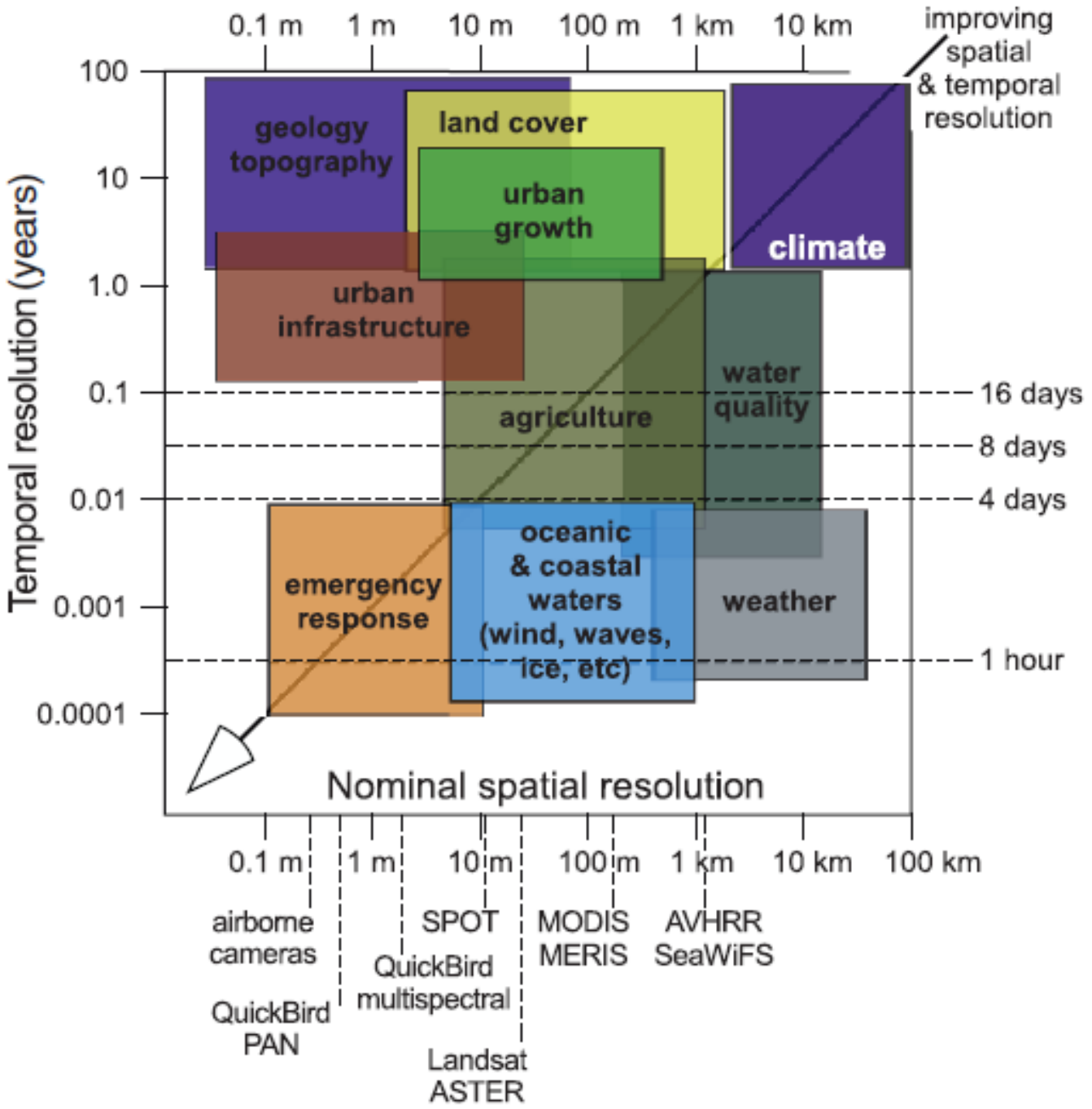

0.1 m
1 m
10 m
100 m
1 km
10 km
improving spatial & temporal resolution
100
10
1.0
0.1
0.01
0.001
0.0001
Temporal resolution (years)
geology topography
land cover
urban growth
climate
urban infrastructure
water quality
agriculture
16 days
8 days
4 days
emergency response
oceanic & coastal waters (wind, waves, ice, etc)
weather
1 hour
Nominal spatial resolution
0.1 m
1 m
10 m
100 m
1 km
10 km
100 km
airborne cameras
QuickBird PAN
QuickBird multispectral
SPOT
Landsat ASTER
MODIS MERIS
AVHRR SeaWiFS

Table 3.1 Classification of remote sensors.

Classification by application	Classification by wavelength	Classification by mode
Imagers (mappers) Photographic (film) Multispectral (array) Radar †Side-scan sonar	Visible (array or film) Near infrared (reflected) Thermal infrared (emitted) Microwave †Sound waves †Seismic waves	Active LiDAR Radar †Sonar Passive Visible Infrared Microwave
Radiometers		
Spectrometers		
Profilers (rangers) LiDAR, Radar		

† Not electromagnetic waves

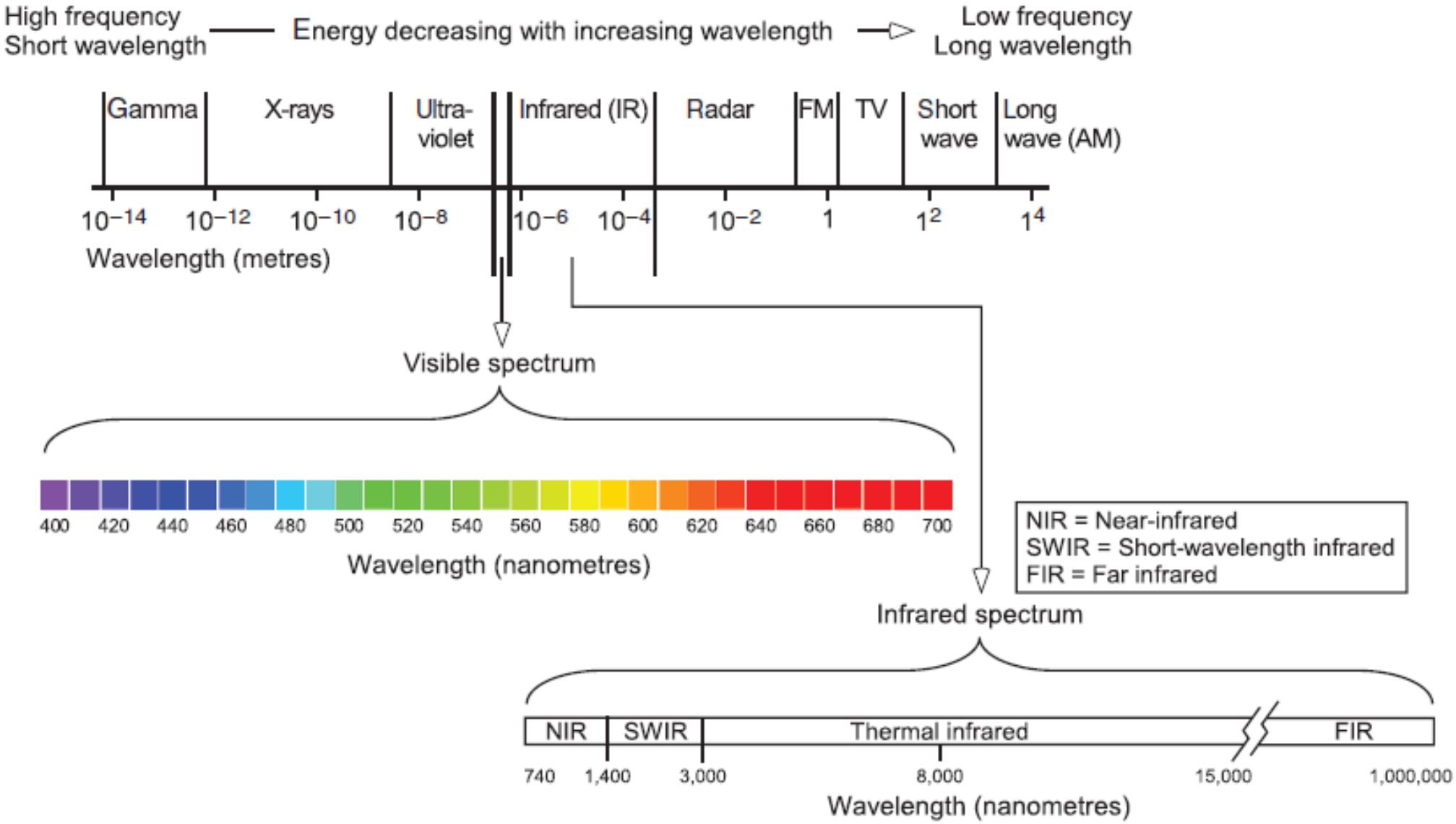
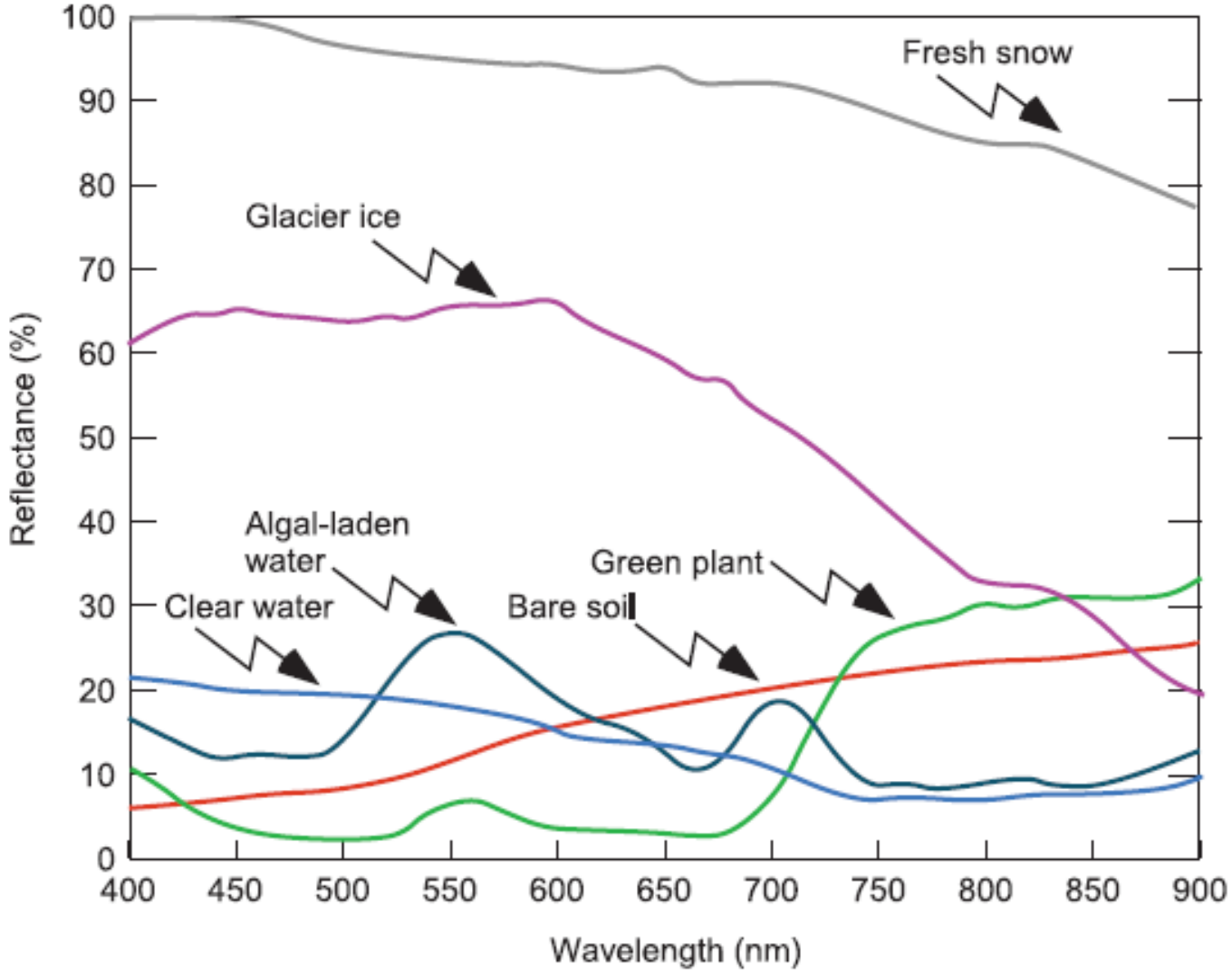
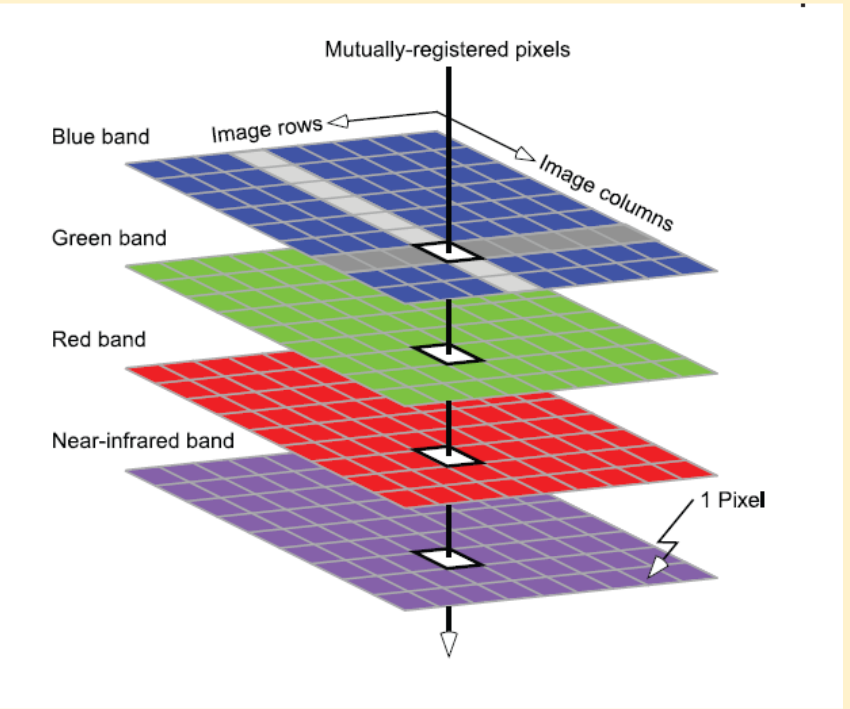


Figure 2.3 The electromagnetic spectrum.


Fresh snow
Glacier ice
Algal-laden water
Clear water
Bare soil
Green plant
Reflectance (%)
Wavelength (nm)
100
90
80
70
60
50
40
30
20
10
0
400
450
500
550
600
650
700
750
800
850
900


Mutually-registered pixels
Blue band
Image rows
Image columns
Green band
Red band
Near-infrared band
1 Pixel

Los satélites de observación de la Tierra de la NASA observan los cambios en todo el planeta, desde la atmósfera, la biosfera, la hidrosfera, la criosfera y la litosfera.
Proporcionan mediciones consistentes, oportunas, globales y precisas, desde los trópicos hasta las regiones polares.

La NASA lleva a cabo un programa de investigación de vanguardia sobre la ciencia del clima, mejorando la capacidad de la comunidad científica internacional para avanzar en la ciencia del sistema terrestre integrado a nivel mundial.

Hay varios tipos básicos de satélites artificiales que orbitan sobre la Tierra: satélites geoestacionarios y satélites polares.

Geoestacionarios: son aquellos que se mueven en dirección este-oeste por encima del Ecuador. Siguen la dirección y velocidad de la rotación de la Tierra

Los satélites geosincrónicos pueden tener cualquier inclinación, la diferencia clave con la órbita geoestacionaria es el hecho de que se encuentran en el mismo plano que el Ecuador.

Las órbitas geoestacionarias caen en la misma categoría que las órbitas geosincrónicas, pero están estacionadas sobre el Ecuador. Esta cualidad especial

Table 3.2 Characteristics of some current and scheduled remote sensing systems. SAV denotes Submerged Aquatic Vegetation. Modified from Donato & Klemas (2001).

Satellite/sensor	Spectral range	Bands	Spatial resolution	Revisit time	Swath-width	Applications
AVHRR NOAA 15/16	580–12,500 nm	6	1.1 km	< 12 h	2,400 km	SST, turbidity, circulation
SeaWiFS	402–885 nm	8	1.1 km	daily	2,800 km	Ocean colour, red products
MODIS Terra/Aqua	620–14,385 nm	16 VNIR	variable	daily	2,330 km	SST, turbidity, circulation
		4 SWIR	250 m			Ocean colour
		16 TIR	1 km	< 12 h		
MISR Terra (9 camera angles)	425–886 nm	4	275 m	9d	360 km	Ocean colour, circulation
ASTER Terra	520–11,650 nm	3 VNIR	15 m	16 d	60 km	Coral reef, SAV, vegetation
		6 SWIR	30 m			Land use, change detection
		5 TIR	90 m			Circulation, geomorphology
LANDSAT-7	450–20,80 nm	6 VNIR	30 m	16 d	180 km	Coral reef, SAV, vegetation
	10,420 nm	1 TIR	60 m			Land use, change detection
		1 Pan	15 m	16 d		Geomorphology, circulation
SPOT 1-2-4-5	500-890 nm	3 MS	20 m	26 d	60km	Coral reef, SAV, vegetation
		1 Pan	10 m	daily		Land use, change detection
						Geomorphology, circulation
IKONOS	450–750 nm	4 MS	4 m	1–3 d	13 km	Coral reef, SAV, vegetation
		1 Pan	1 m			Littoral processes, digital elevation models
QuickBird-2	450–900 nm	4 MS	2.4 m	1 d	16.4 km	Coral reef, SAV, vegetation
		1 Pan	0.61 m			Littoral processes, digital elevation models
WorldView-2	400–1,040 nm	8 MS	1.8 m	≈ 2 d	16.4 km	Coral reef, SAV, vegetation
		1 Pan	0.46 m			Littoral processes, digital elevation models
Orbview 3	450–900 nm	4 MS	4 m	< 3 d	8 km	Coral reef, SAV, vegetation
		1 Pan	1 m			Littoral processes, digital elevation models
Orbview 4	450–2,500 nm	200 HS	8 m	< 3 d	5 km	Coral reef, SAV, vegetation
	450–900 nm	4 MS	4 m		8 km	Littoral processes
		1 Pan	1 m			Digital elevation models
ALIEO-1	400–2,400 nm	9 MS	30 m	19 d	37 km	Coral reef, SAV, vegetation
		1 Pan	10 m			Land use, change detection, geomorphology, circulation
Hyperion EO-1	400–2,400 nm	220	30 m	16 d	8 km	Coral reef, SAV, vegetation, littoral processes
NEMO/COIS	400–2,500 nm	210	30 m			Coral reef, SAV, vegetation, littoral processes
MERIS ENVISAT-1	290–1,040 nm	15	300 m	< 3 d	1,150 km	Ocean colour, circulation
ASAR ENVISAT-1	C-band 4 pol	2	30 m	< 3 d	50–100 km	Circulation, waves
AMI ERS-2(SAR)	C-band V pol	1	25 m	28 d	100 km	Circulation, waves
RADARSAT-1(SAR)	C-band H pol	1	6–100 m	1–4 d	20–500 km	Circulation, waves
RADARSAT-2(SAR)	C-band HV pol	1	3–100 m	Quick	20–500 km	Circulation, waves

Table 3.4 Typical Remote sensing requirements.

	Open ocean	Coasts/estuaries	Land
Spatial resolution	1–10 km	20–200 m	1–30 m
Extent (coverage)	2,000 km	200 km	20–200 km
Frequency of coverage	1–6 days	0.5–6 hours	0.5–5 years
Dynamic range	Narrow	Wide	Wide
Radiometric resolution	10–12 bits	10–12 bits	8–10 bits
Spectral resolution	Multispectral	Hyperspectral	Multispectral (hyperspectral)

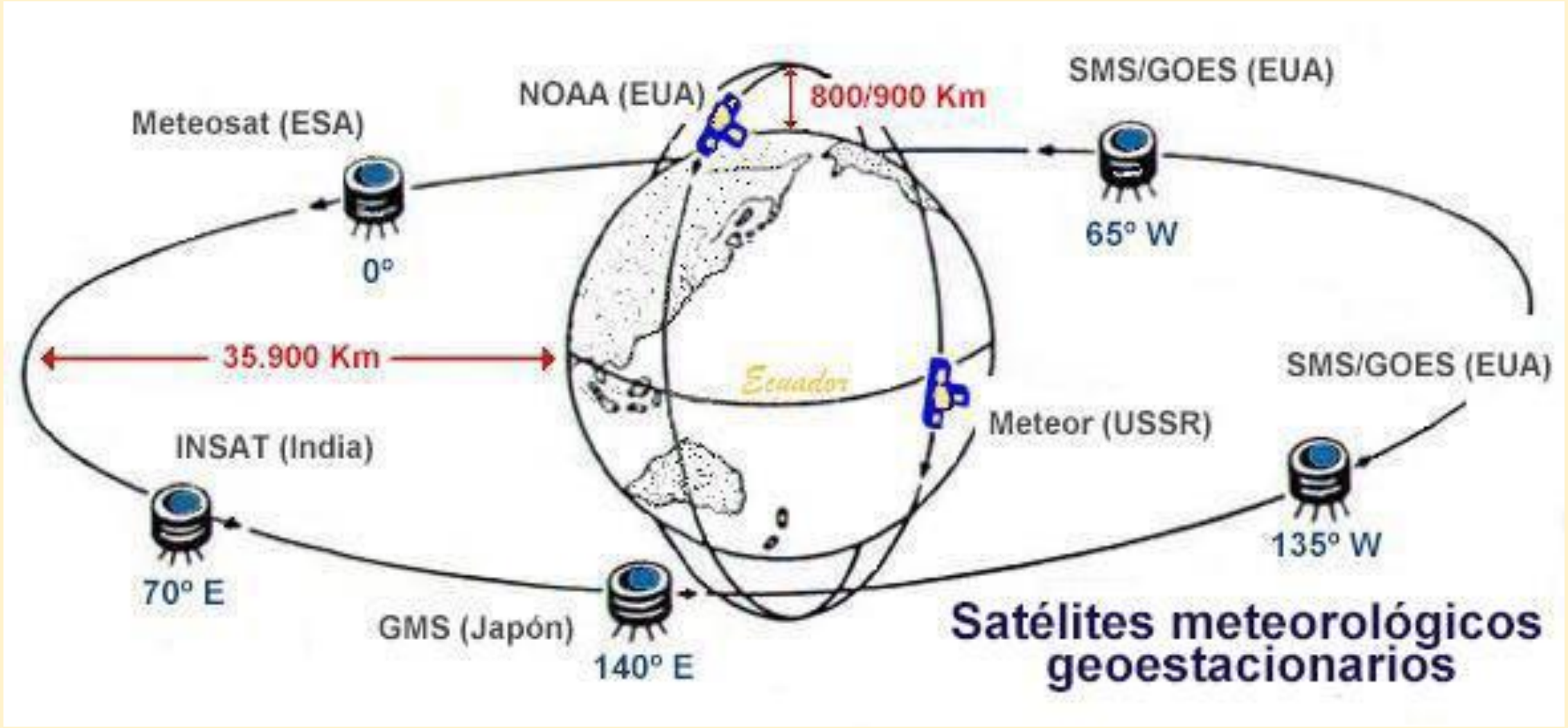
Table 3.6 High-resolution satellite parameters and spectral bands (Space Imaging, 2003; DigitalGlobe, 2003; Orbimage, 2003; Parkinson, 2003).

		IKONOS	QuickBird	OrbView-3	WorldView-1	GeoEye-1	WorldView-2
Sponsor		Space Imaging	DigitalGlobe	Orbimage	DigitalGlobe	GeoEye	DigitalGlobe
Launched		Sep 1999	Oct 2001	Jun 2003	Sep 2007	Sep 2008	Oct 2009
Spatial resolution (m)	Panchromatic	1.0	0.61	1.0	0.5	0.41	0.5
	Multispectral	4.0	2.44	4.0	n/a	1.65	2
Spectral range (nm)	Panchromatic	525–928	450–900	450–900	400–900	450–800	450–800
	Coastal blue	n/a	n/a	n/a	n/a	n/a	400–450
	Blue	450–520	450–520	450– 520	n/a	450–510	450–510
	Green	510–600	520–600	520–600	n/a	510–580	510–580
	Yellow	n/a	n/a	n/a	n/a	n/a	585–625
	Red	630–690	630–690	625–695	n/a	655–690	630–690
	Red edge	n/a	n/a	n/a	n/a	n/a	705–745
	Near-infrared	760–850	760–890	760–900	n/a	780–920	770–1,040
Swath width (km)		11.3	16.5	8	17.6	15.2	16.4
Off nadir pointing		±26°	±30°	±45°	±45°	±30°	±45°
Revisit time (days)		2.3–3.4	1.0–3.5	1.5–3	1.7–3.8	2.1–8.3	1.1–2.7
Orbital altitude (km)		681	450	470	496	681	770

Table 4.2 Landsat Thematic Mapper bands (Lachowski *et al.*, 1995).

Band	Wavelength (nm)	Application
1	450–520 Blue band	Coastal water mapping, bathymetric mapping of shallow water, soil/vegetation differentiation, deciduous/conifer difference, cultural feature identification
2	520–600 Green band	Green reflectance by healthy vegetation, vigour assessment and cultural feature identification; important for discriminating vegetation types
3	630–690 Red band	Chlorophyll absorption for plant species differentiation
4	760–900 Near infrared	Biomass surveys, water delineation, vegetation types, vigour, soil moisture
5	1,550–1,750 Mid-infrared	Vegetation moisture measurement, snow/cloud difference, soil moisture measurement
6	10,400–12,500 Thermal infrared	Vegetation heat stress analysis, soil moisture, urban heat island and water surface temperature mapping applications
7	2,080–2,350 Mid-infrared	Hydrothermal mapping, mineral and rock type, vegetation moisture content

Los satélites geoestacionarios están ubicados en un punto fijo de la "órbita geoestacionaria", situada a una distancia cercana a los 35800 Km. del ecuador terrestre. Permiten la observación continua de una área geográfica las 24 horas del día, ya que completan en este tiempo una órbita alrededor de la Tierra.

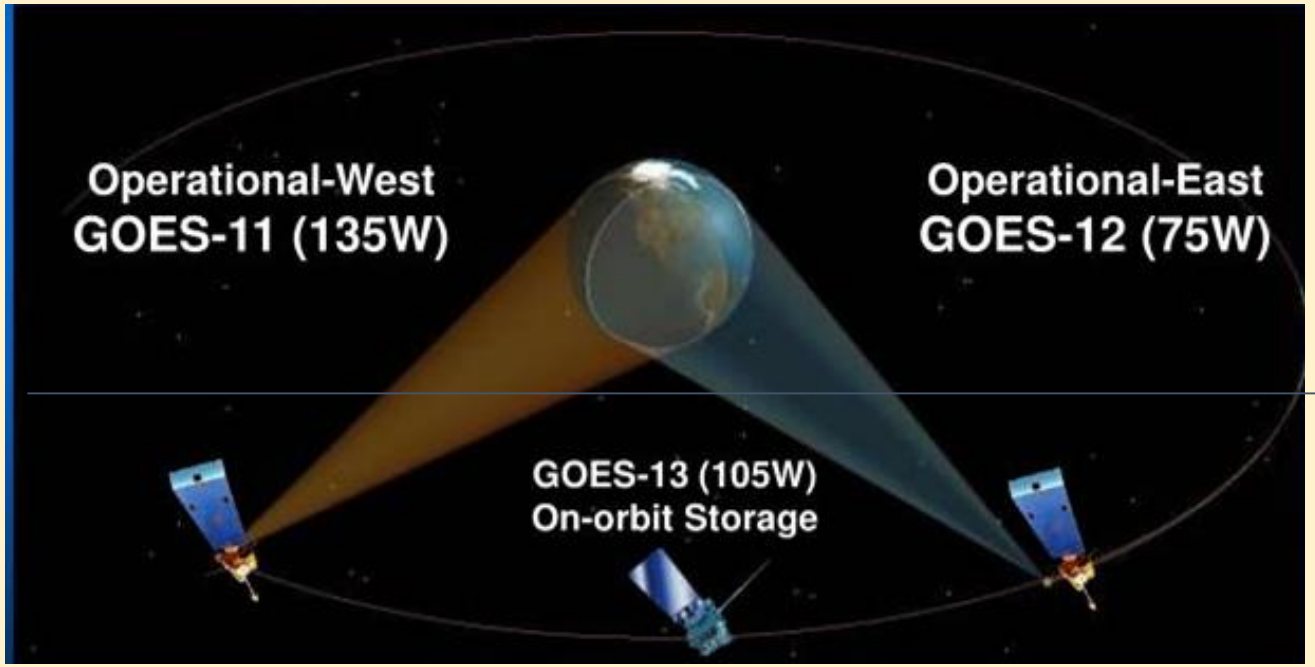


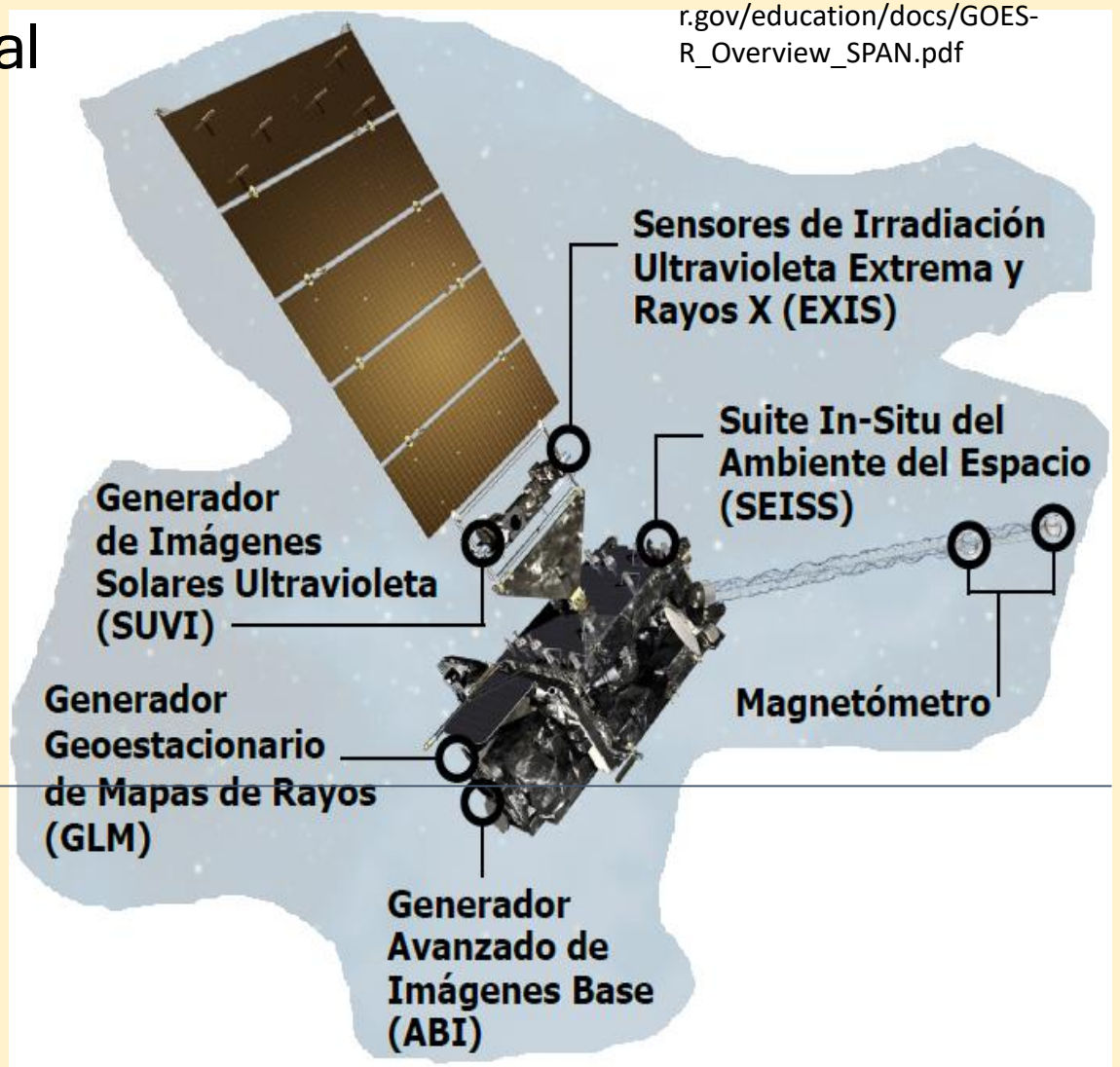
Geostationary Operational Environmental Satellite (GOES)

Satelite Operacional Geoestacionario Ambiental

https://www.goes-r.gov/education/docs/GOES-R_Overview_SPAN.pdf

GOES es una de las claves del programa estadounidense del National Weather Service "NWS" de la NOAA. Los datos de imágenes y de sonda del GOES son continuos y proveen una corriente de información ambiental para soportar el pronóstico del tiempo, el seguimiento de tormentas severas, y para investigación de meteorología.






2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028
Calendar Year
GOES 10 Backup
GOES 11 GOES West
GOES 12 GOES East
GOES 13 On-orbit Spare
GOES O
GOES P
GOES R
GOES S
Satellite is operational beyond design life
On-orbit GOES storage
Operational
As of January 5, 2009

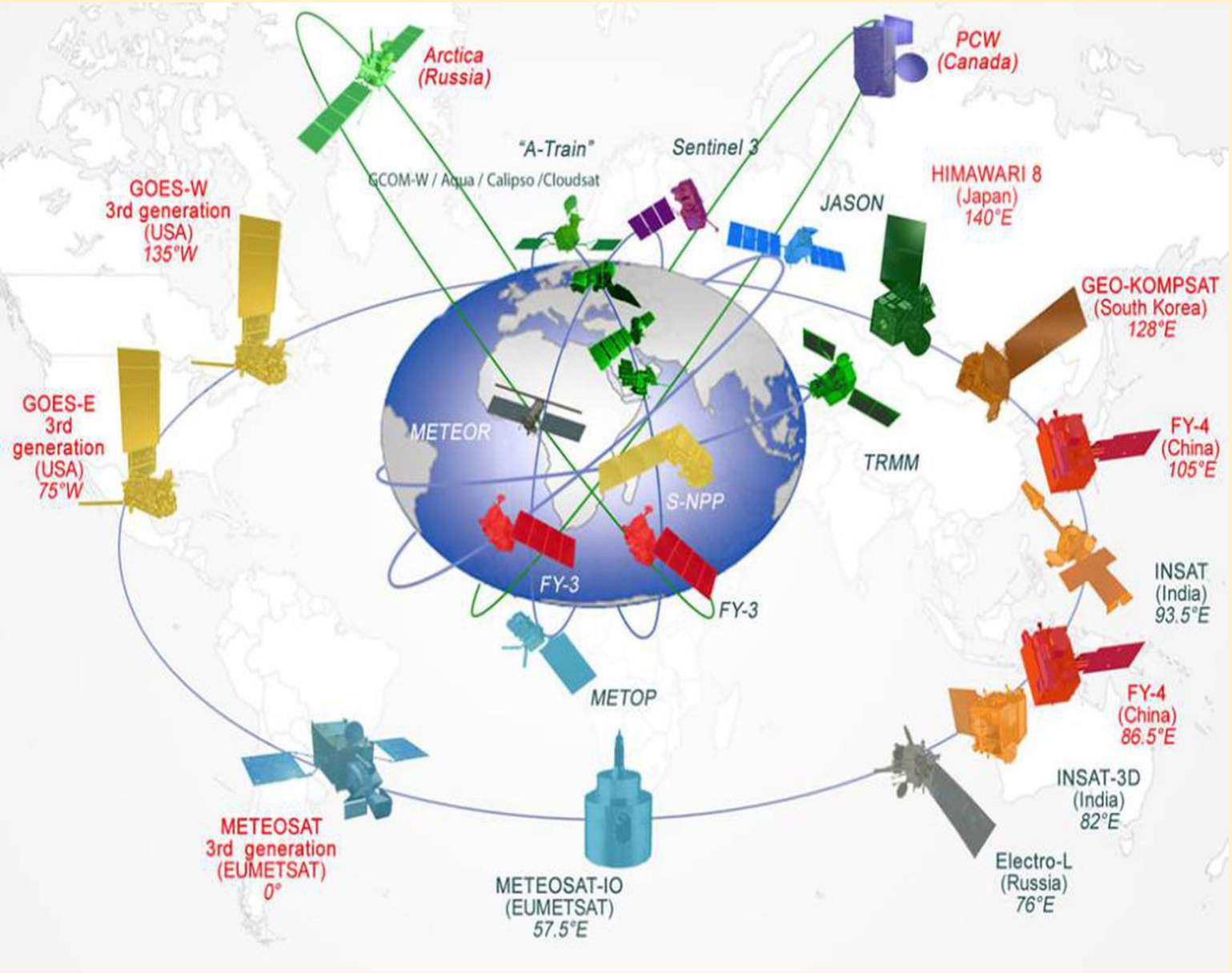
GOES-R ABI Bands and Bandwidths

GOES-R

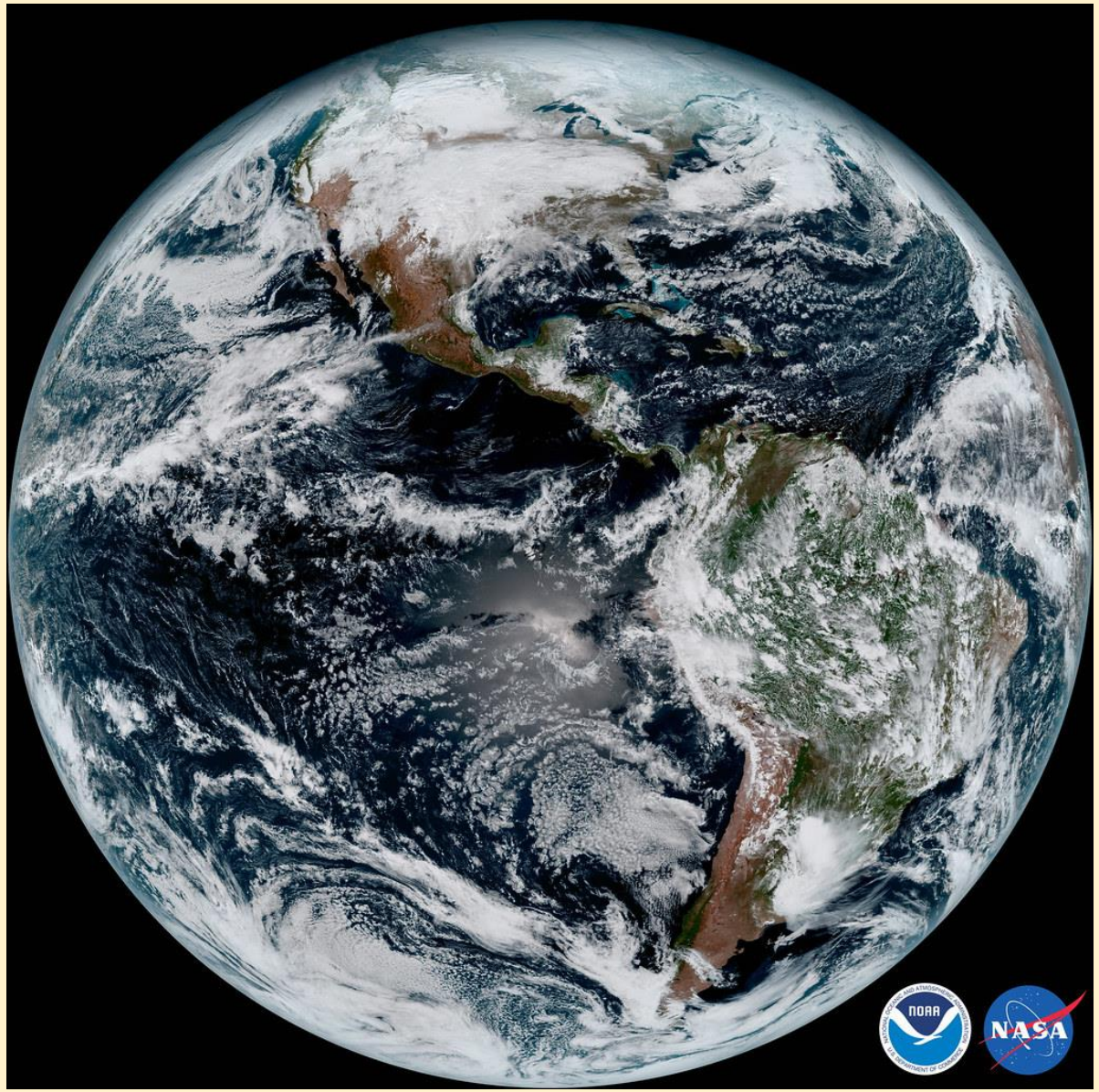
ADVANCED BASELINE IMAGER (ABI)

https://rammb.cira.colostate.edu/research/goes-r/goes-r_abi_bands_and_bandwidths.asp

ABI Band	Central Wavelength (μm)	Wavelength Range (μm)	Band Explanation	Spatial Resolution (km) @ nadir
1 (blue)	0.47	0.45 - 0.49	Visible/reflective	1
2 (red)	0.64	0.59 - 0.69	Visible/reflective	0.5
3	0.865	0.846 - 0.885	Reflective	1
4	1.378	1.371 - 1.386	Cirrus	2
5	1.61	1.58 - 1.64	Snow/ice	1
6	2.25	2.225 - 2.275	Particle size	2
7	3.9	3.80 - 4.00	Shortwave IR window	2
8	6.19	5.77 - 6.6	Water vapor	2
9	6.95	6.75 - 7.15	Water vapor	2
10	7.34	7.24 - 7.44	Water vapor	2
11	8.5	8.3 - 8.7	Water vapor, SO2	2
12	9.61	9.42 - 9.8	Ozone	2
13	10.35	10.1 - 10.6	Longwave IR window	2
14	11.2	10.8 - 11.6	Longwave IR window	2
15	12.3	11.8 - 12.8	Longwave IR	2
16	13.3	13.0 - 13.6	Longwave IR	2



En la actualidad hay activos cinco satélites meteorológicos situados en esta órbita geoestacionaria: el INSAT indio, los americanos GOES E y W (Geostationary Operational Meteorological Satellite), el GMS (Geostationary Environmental Satellite) japonés, el METEOSAT (European Geostationary Meteorological Satellite) y el GOMS (Geostationary Operational Environmental Satellite) de la URSS.



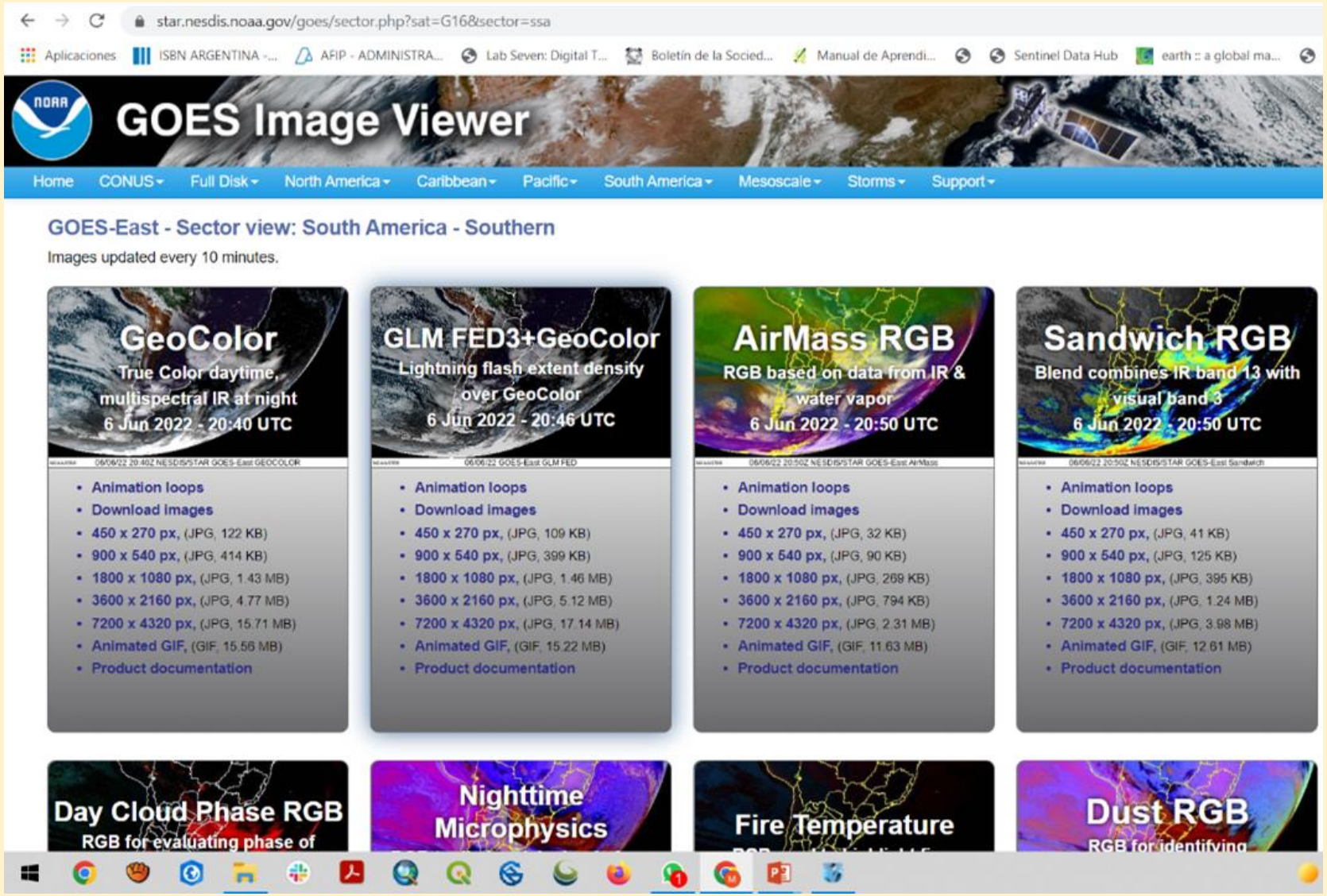
GOES R

- √ Pronósticos mejorados de trayectoria e intensidad de huracanes
- √ Más prontos avisos de tronadas y tornados
- √ Más prontos avisos de peligros de rayos
- √ Mejor detección de lluvia intensa y riesgos de inundaciones repentinas
- √ Mejoras en la seguridad en el transporte y planificación de rutas aéreas
- √ Mejoras en avisos de interrupciones en comunicación y navegación y apagones eléctricos
- √ Monitoreo más preciso de partículas energéticas responsables de peligros de radiación

Galería de imágenes ABI

GOES-16 Galería de datos e imágenes

GOES-17 Galería de datos e imágenes

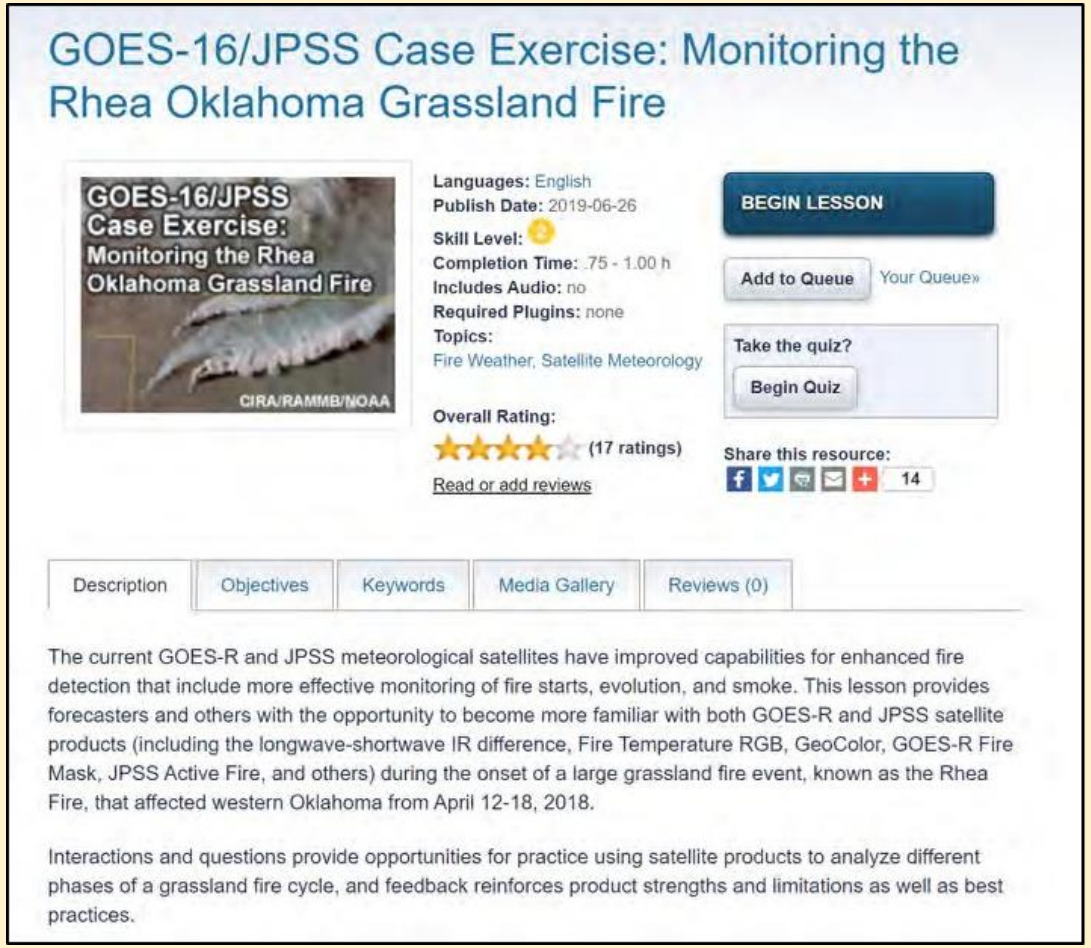


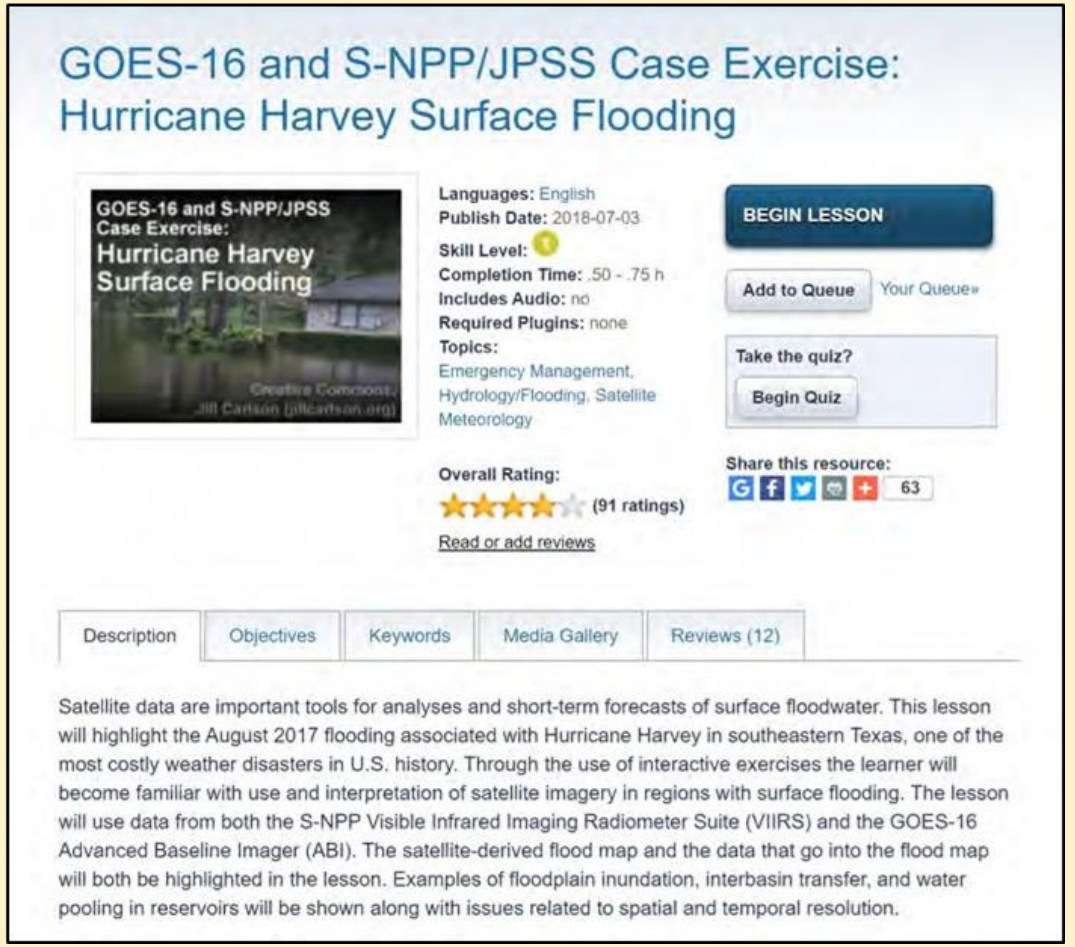
https://www.star.nesdis.noaa.gov/goes/sector.php?sat=G16&sector=ssa

El Advanced Baseline Imager es el instrumento principal de la serie GOES-R para obtener imágenes del clima, los océanos y el medio ambiente de la Tierra. ABI ve la Tierra con 16 bandas espectrales diferentes (en comparación con las cinco de la generación anterior de GOES), incluidos dos canales visibles, cuatro canales de infrarrojo cercano y diez canales de infrarrojo. Estos diferentes canales (longitudes de onda) son utilizados por modelos y herramientas para indicar varios elementos en la superficie de la Tierra o en la atmósfera, como árboles, agua, nubes, humedad o humo.

https://www.goes-r.gov/mission/ABI-bands-quick-info.html

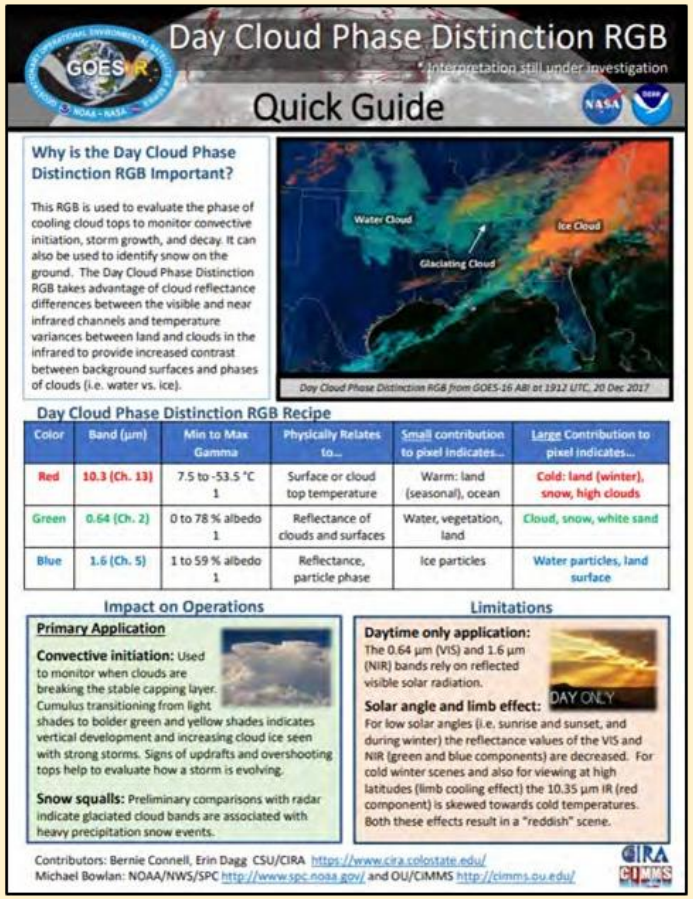
https://www.meted.ucar.edu/satmet/goes_resources/index_es.html





Rhea Oklahoma Grassland Fire: https://www.meted.ucar.edu/training_module.php?id=1418

Hurricane Harvey: https://www.meted.ucar.edu/training_module.php?id=1397



NOAA Users: https://vlab.ncep.noaa.gov/group/stor/goes2

Non-NOAA Users: http://rammb.cira.colostate.edu/training/visit/quick_guides/

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FDTD GOES Applications Webinars

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GOES-16 User Workshop at NWSTC, November 2017

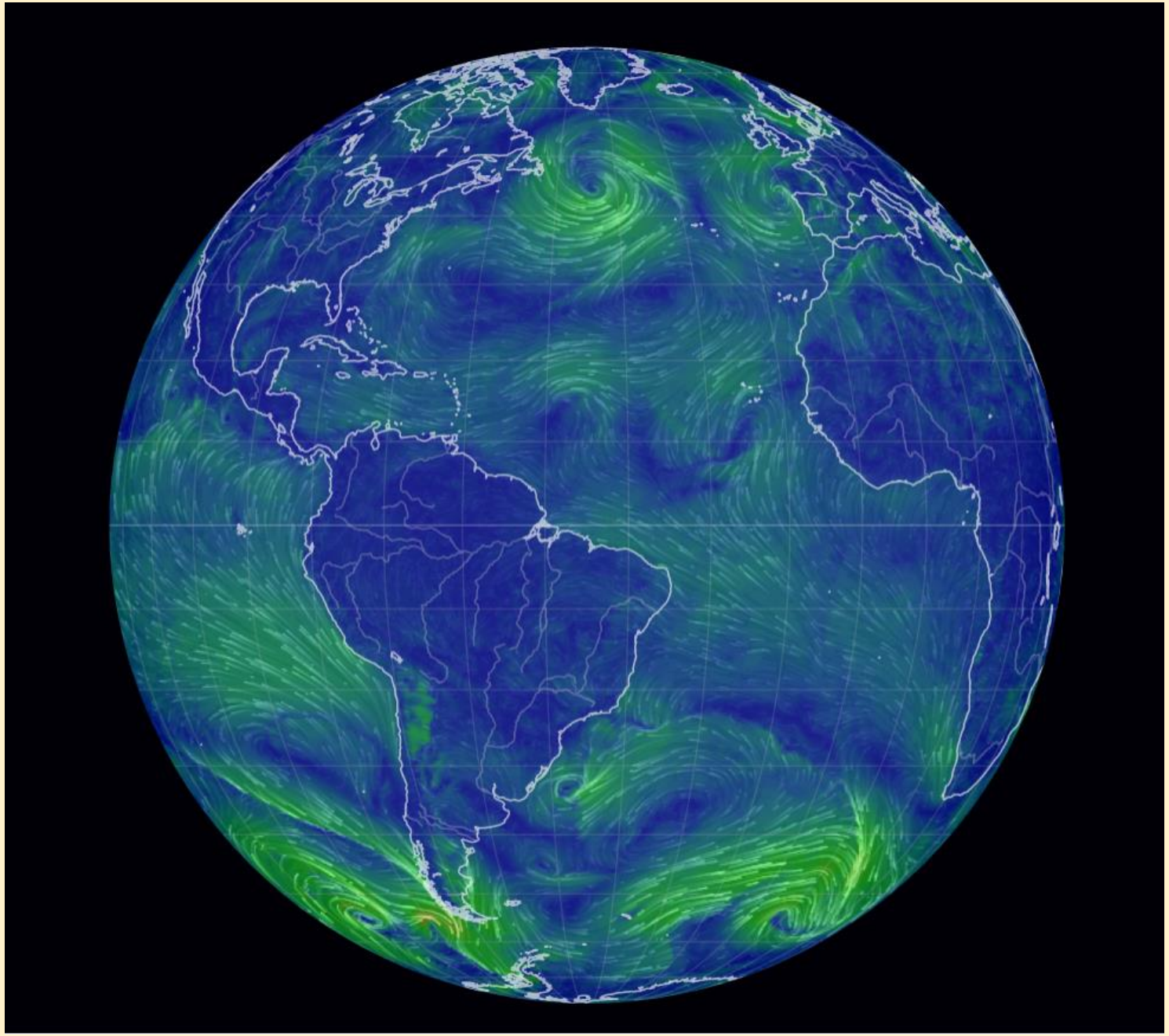
These webinars are peer-to-peer learning; staff from WFOs, National Centers, CWSUs, RFCs lead the presentations. The presentations are short (less than 30 minutes) and recorded for on-demand viewing. They are offered on a routine basis (typically bi-weekly) and offer recent in-season examples ready to apply operationally. The primary objective of these webinars are to share how to apply GOES imagery with other datasets for a specific operational application so that other WFO's learn how to do this.

Refer to the VISIT Training Calendar for the next scheduled FDTD GOES Application webinar.

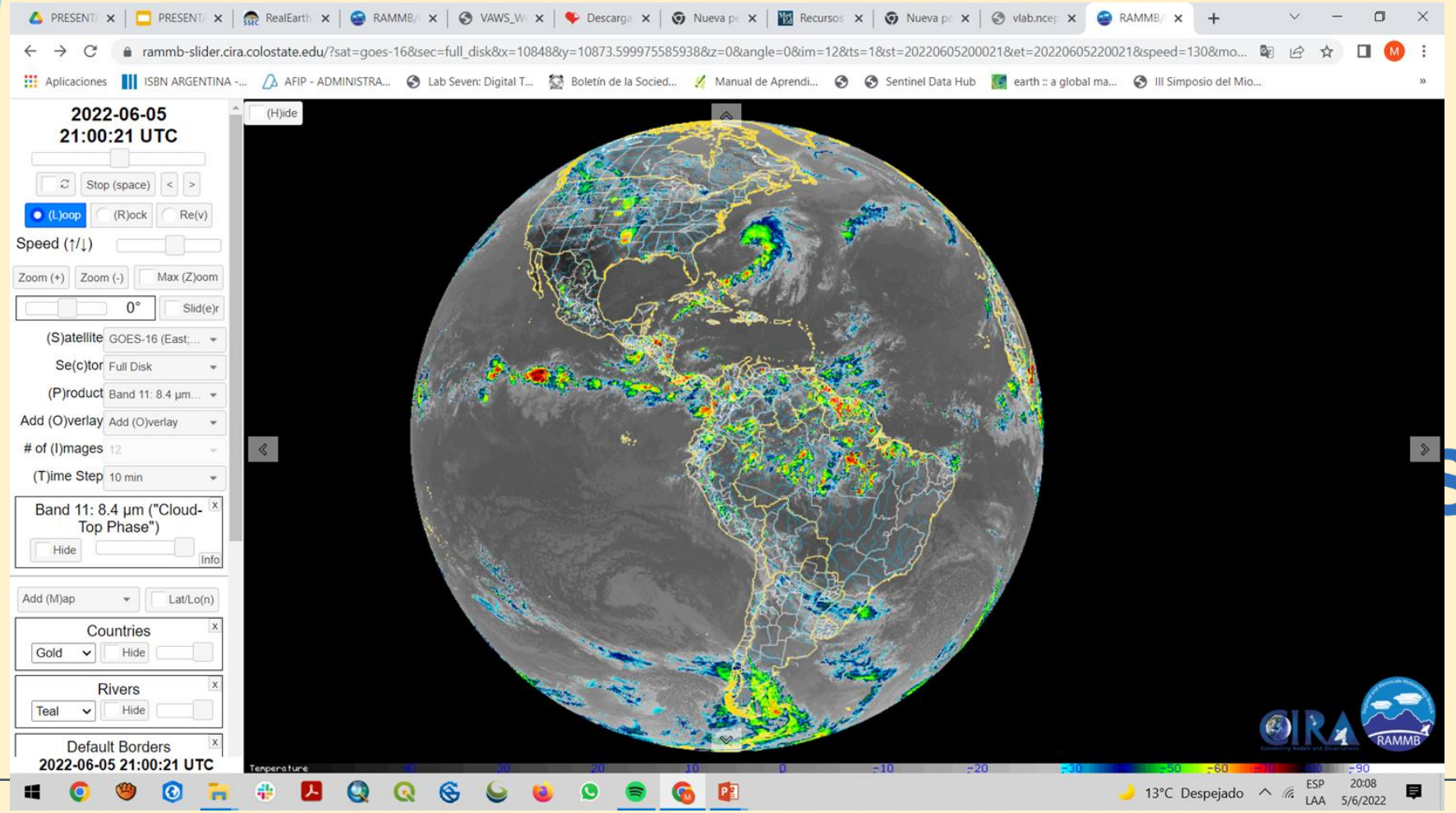
Below you'll find a list of FDTD GOES Applications Webinar recordings from the past (including links to powerpoint files), listed in reverse chronological order. Be sure to have your speakers on and the volume loud enough to hear the presentation. To sort them by a different column, click the column heading at the top to reorder them.

Title	Date	Brief Summary
Issuing Warnings with No Radar	2019-08-21	David Levin summarizes the 27 June 2019 event for southeast Alaska in which the Juneau WFO issued their first ever severe thunderstorm warning. Radar data was not available for this event due to beam blockage and distance from the radar site. This presentation shows the data and the thought process that went into the decision making.
Superior, WI Husky Refinery Explosion NWS Duluth Response	2019-07-17	Joe Moore summarizes the response by the NWS WFO in Duluth, MN to an explosion at a nearby refinery. Monitoring GOES-16 imagery played a role in monitoring the plume from the refinery. Lessons learned on the response for what went well and where improvements could be made are provided.
Nocturnal Wildfire Smoke Tracking using GOES-16	2019-06-12	Kevin Huyck investigates experimental GOES RGB products to assess nighttime detection of smoke from GOES. Smoke can be tracked at night, under clear conditions and also utilizing daytime imagery before nightfall. More development is needed with potential for new products.
The Above Anvil Cirrus Plume: An Important Indicator of a Severe Storm in Visible and IR Imagery	2019-06-05	Kris Bedka summarizes important findings from a recent Weather and Forecasting journal article on the Above Anvil Cirrus Plume (AACP) signature. AACP storms are much more intense than other storms, generating a higher fraction of reported severe weather and the vast majority of significant hail and tornadoes (2+ inch and EF2+ respectively).
New Applications of GOES-17 Imagery in Volcanic Plume Detection for the VAAC/Alaska Region	2019-04-24	Doug Wesley summarizes the use of new GOES-17 imagery to detect volcanic plumes. The primary case study is the Bezyimanny volcanic eruption of 16 March 2019. The Ash and SO2 RGB products from GOES-17 are highlighted, but also compared with GOES-15 to illustrate the major improvements since the inception of GOES-17.
Applications of GOES-17 Data in Fog Forecasting for Anchorage, AK	2019-03-20	Doug Wesley summarizes the use of new GOES-17 information to help define the coverage and evolution of a shallow fog event over and near the Anchorage/Cook Inlet area on 26 February 2019. This includes applications of derived product imagery in helping forecasters determine the formation, extent and dissipation of the shallow fog over a relatively data-sparse area.
GOES-16 Identification of Blowing Snow	2019-02-06	Carl Jones discusses using the Day Snow-Fog RGB from GOES-16 for identification of blowing snow. Several examples of blowing snow are shown along with possible explanations as to why it is being detected by GOES-16 and advantages and disadvantages of using this RGB to monitor blowing snow.
A GOES-16 Perspective on a Fatal Snow Squall Event	2018-12-17	Kristen Cassady and Ashley Novak discuss snow squall warnings and the event of 8 March 2018. GOES-16 Band 8 is useful in identifying and tracking PV anomalies / PV tropopause folds. GOES-16 band 13 and daytime cloud phase distinction RGB have utility in monitoring snow squalls.
Erie PA Lake-Effect Snow event	2018-12-12	Bob LaPlante and Zach Sefcovic discuss the 25-26 December 2017 lake-effect snow event that impacted the Erie, PA vicinity. GOES-16 imagery was particularly useful due to beam overshooting by the 2 nearest WSR-88Ds. A number of GOES-16 RGB products were helpful in identifying the lake-effect snow bands.

VISIT Webinar Link: http://rammb.cira.colostate.edu/training/visit/satellite_chat/

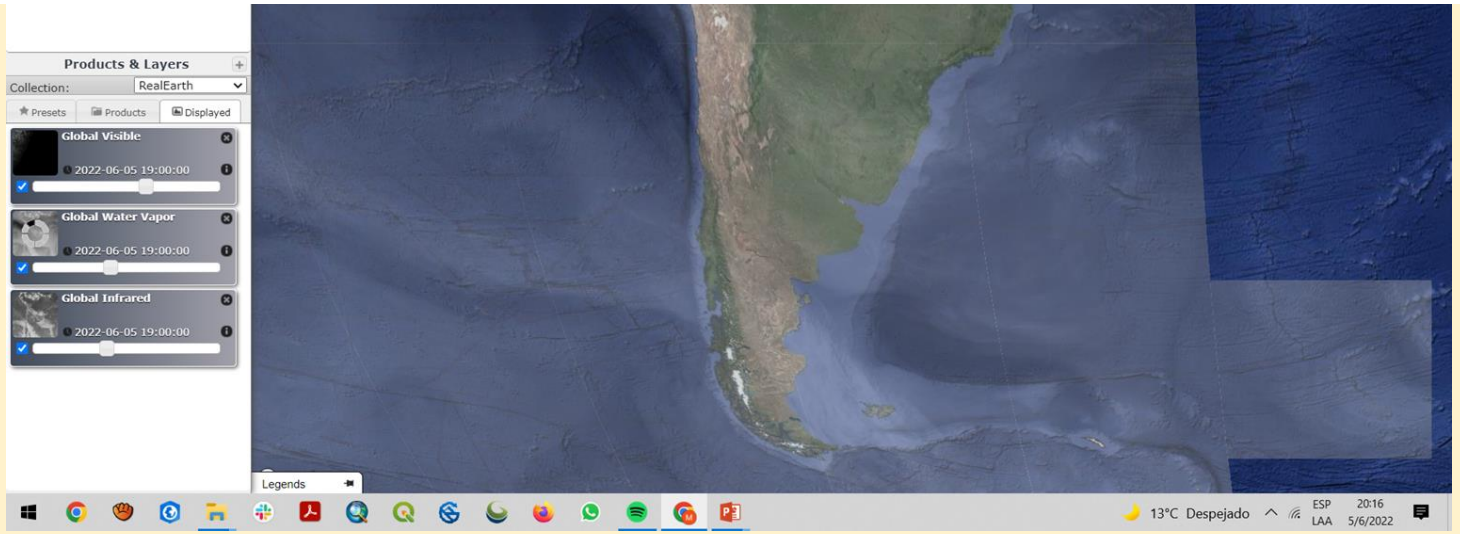


https://earth.nullschool.net/



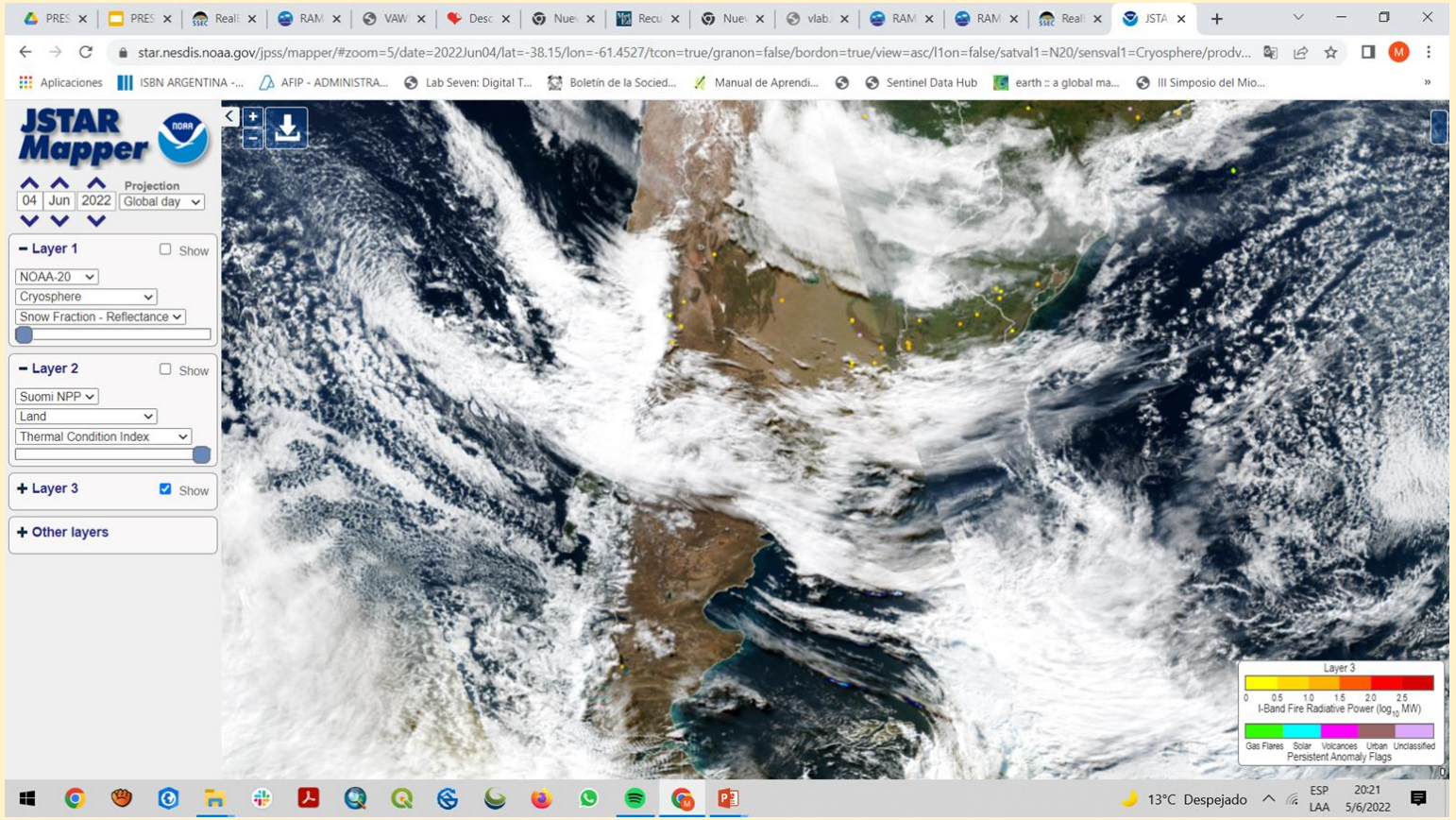
https://rammb-slider.cira.colostate.edu/

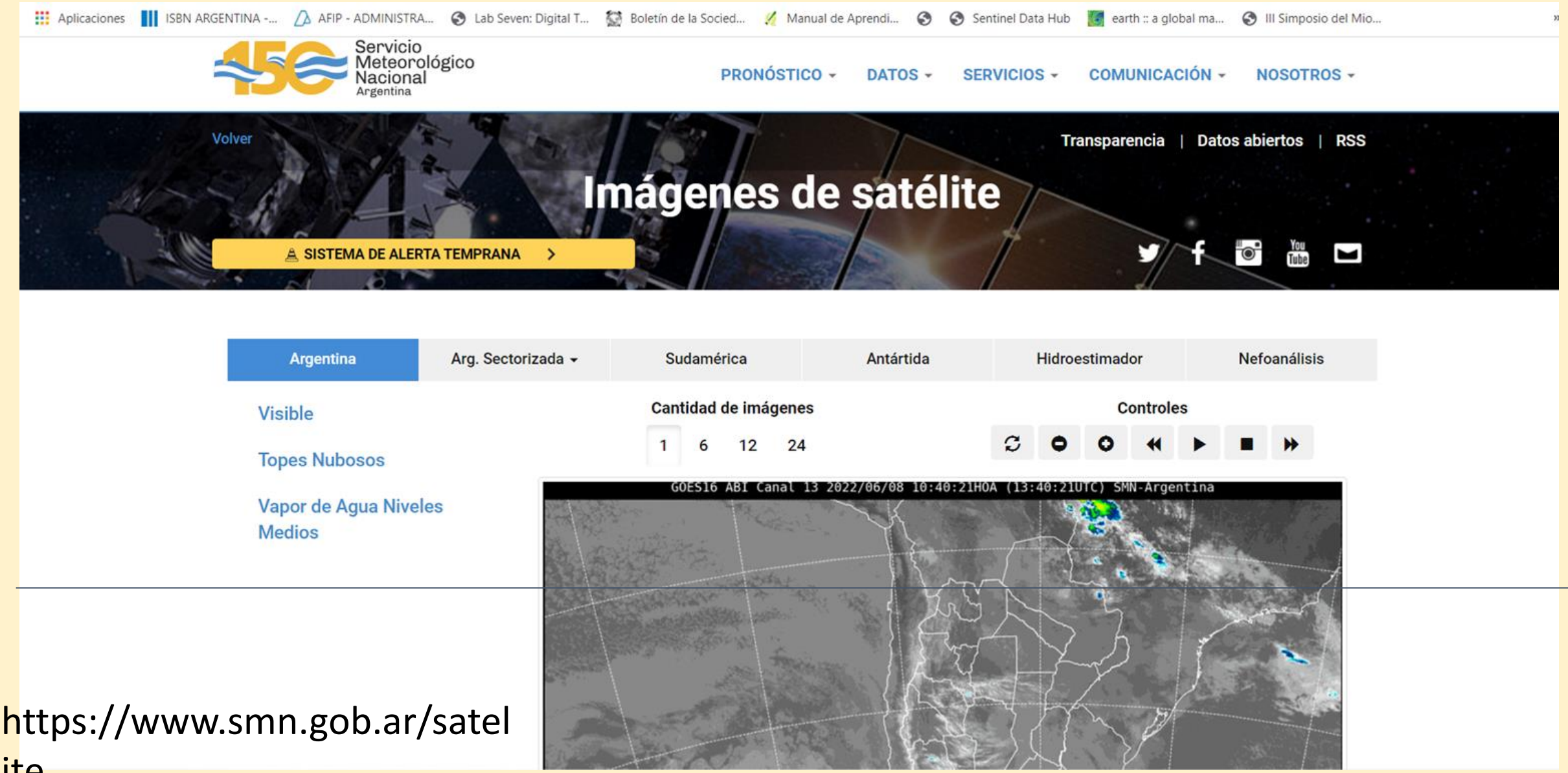
RealEarth https://realearth.ssec.wisc.edu/



JSTAR Mapper

https://www.star.nesdis.noaa.gov/jpss/mapper/





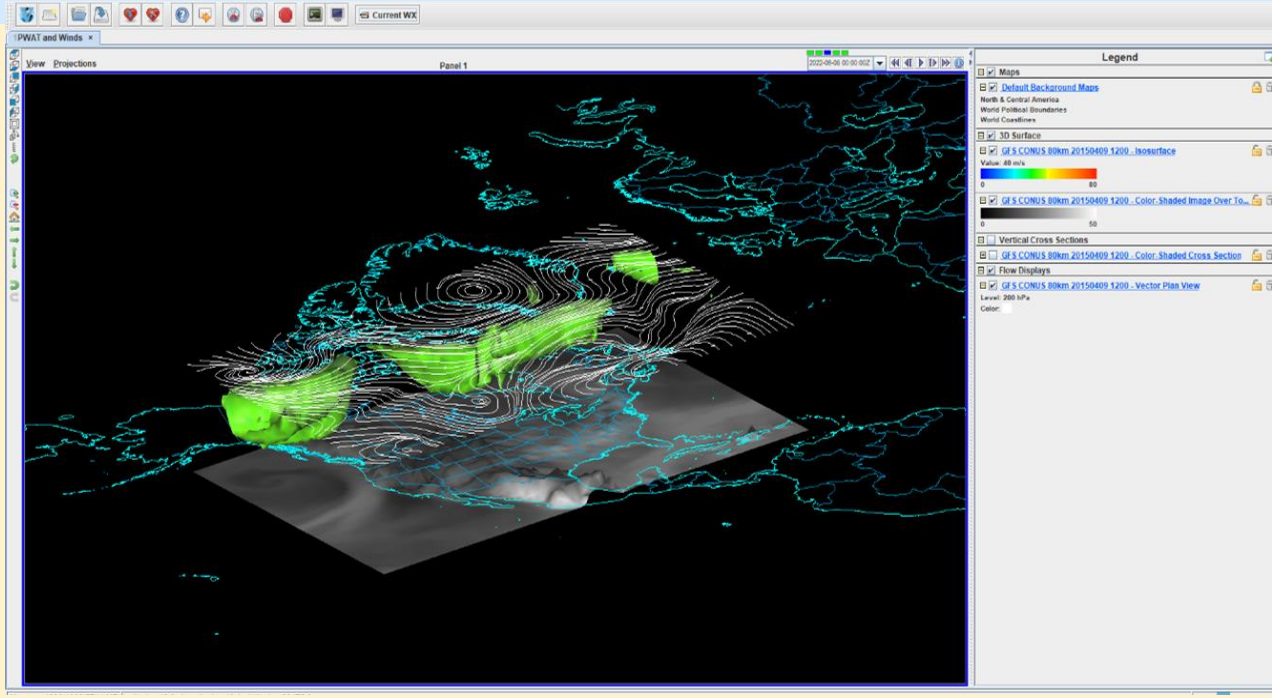
https://www.smn.gob.ar/satelite

Space Science and Engineering Center
University of Wisconsin-Madison

McIDAS para datos GOES-16 y -17

https://www.ssec.wisc.edu/mcidas/software/v/

McIDAS-V es un paquete de software **gratuito** , de código abierto, de visualización y análisis de datos que es la próxima generación en los 45 años de historia de SSEC, sofisticados paquetes de software McIDAS. McIDAS-V muestra el satélite meteorológico (incluido el hiperespectral) y otros datos geofísicos en 2 y 3 dimensiones. McIDAS-V también puede analizar y manipular los datos con sus potentes funciones matemáticas.



https://rammb.cira.colostate.edu/training/rmtc/video/McV_Tutorial_GOES16_Intro_Espanol/McV_Tutorial_GOES16_16Channels_20170419_Bundle_player.html

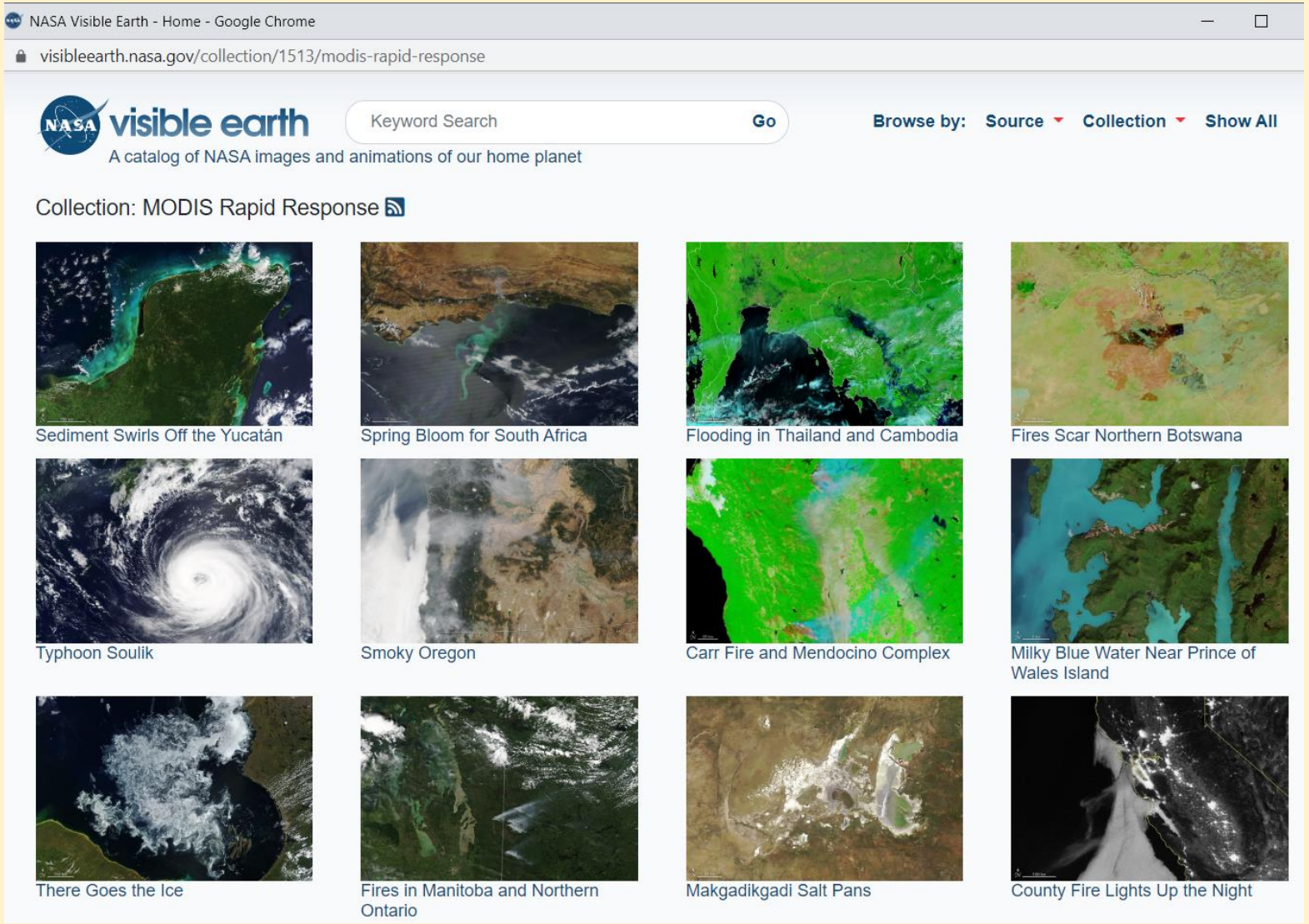
El instrumento MODIS está operando en las naves espaciales Terra y Aqua.

Tiene un ancho de banda de visualización de 2.330 km y ve la superficie completa de la Tierra cada uno o dos días.

Sus detectores miden 36 bandas espectrales entre 0,405 y 14,385 µm, y adquiere datos en tres resoluciones espaciales: 250 m, 500 m y 1000 m.
Los numerosos productos de datos derivados de las observaciones de MODIS describen características de la tierra, los océanos y la atmósfera que se pueden utilizar para estudios de procesos y tendencias a escala local y global.

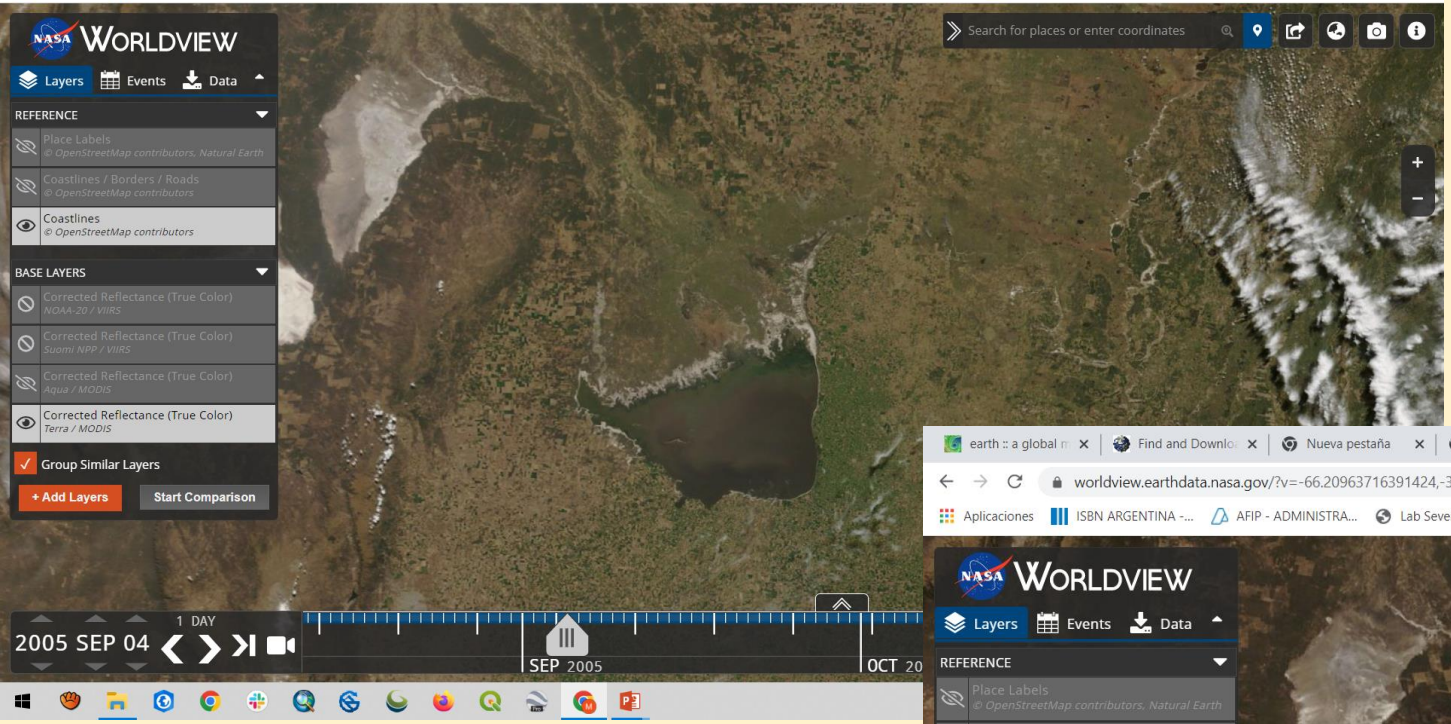
Datos MODIS nivel 1, geolocalización, máscara de nubes y productos atmosféricos:
http://ladsweb.nascom.nasa.gov/
Productos terrestres MODIS:
https://lpdaac.usgs.gov/
Productos de criosfera MODIS:
http://nsidc.org/daac/modis/index.html
Productos MODIS de color del océano y temperatura de la superficie del mar:
http://oceancolor.gsfc.nasa.gov/

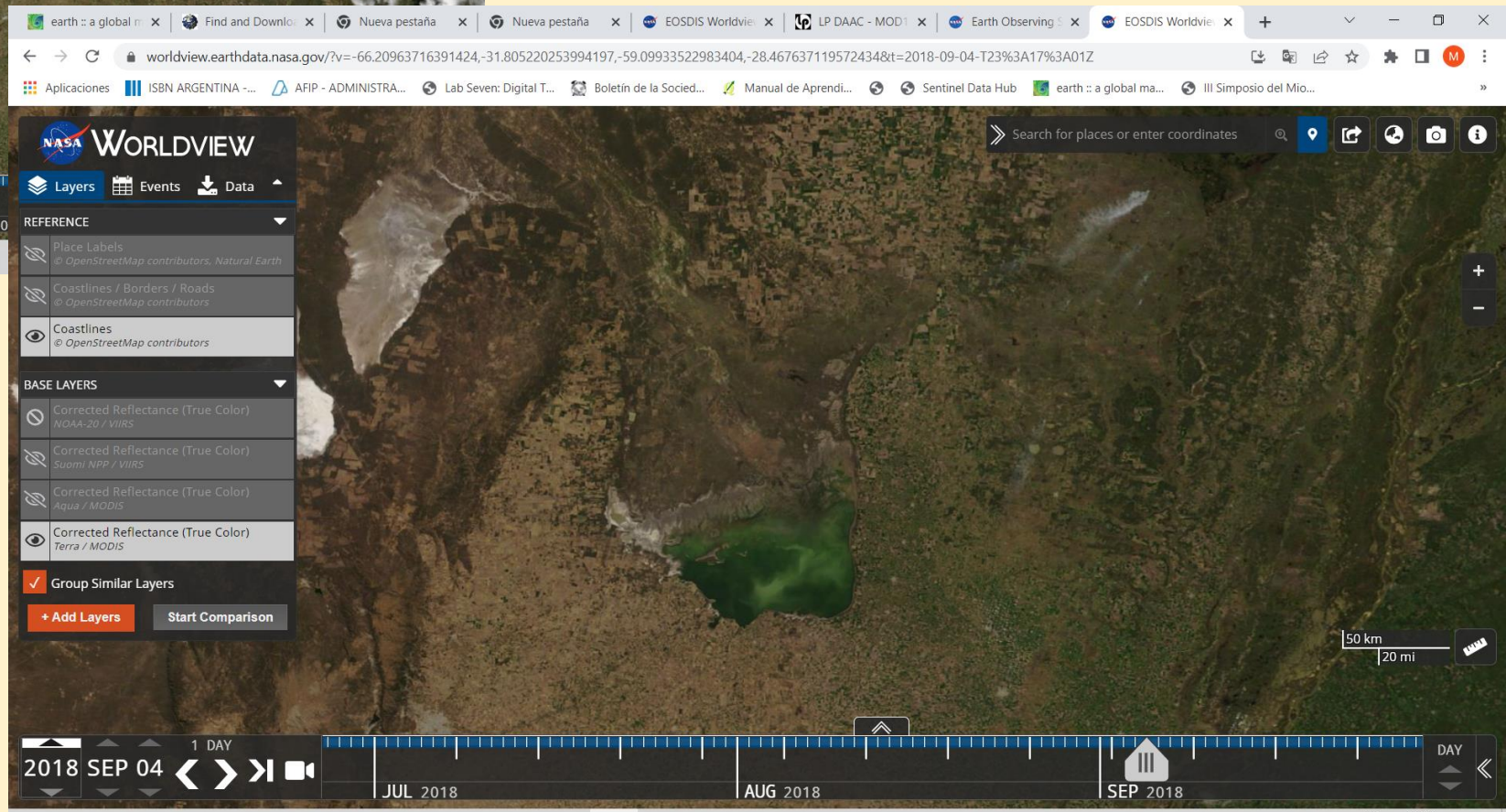
MODIS. https://visibleearth.nasa.gov/collection/1513/modis-rapid-response



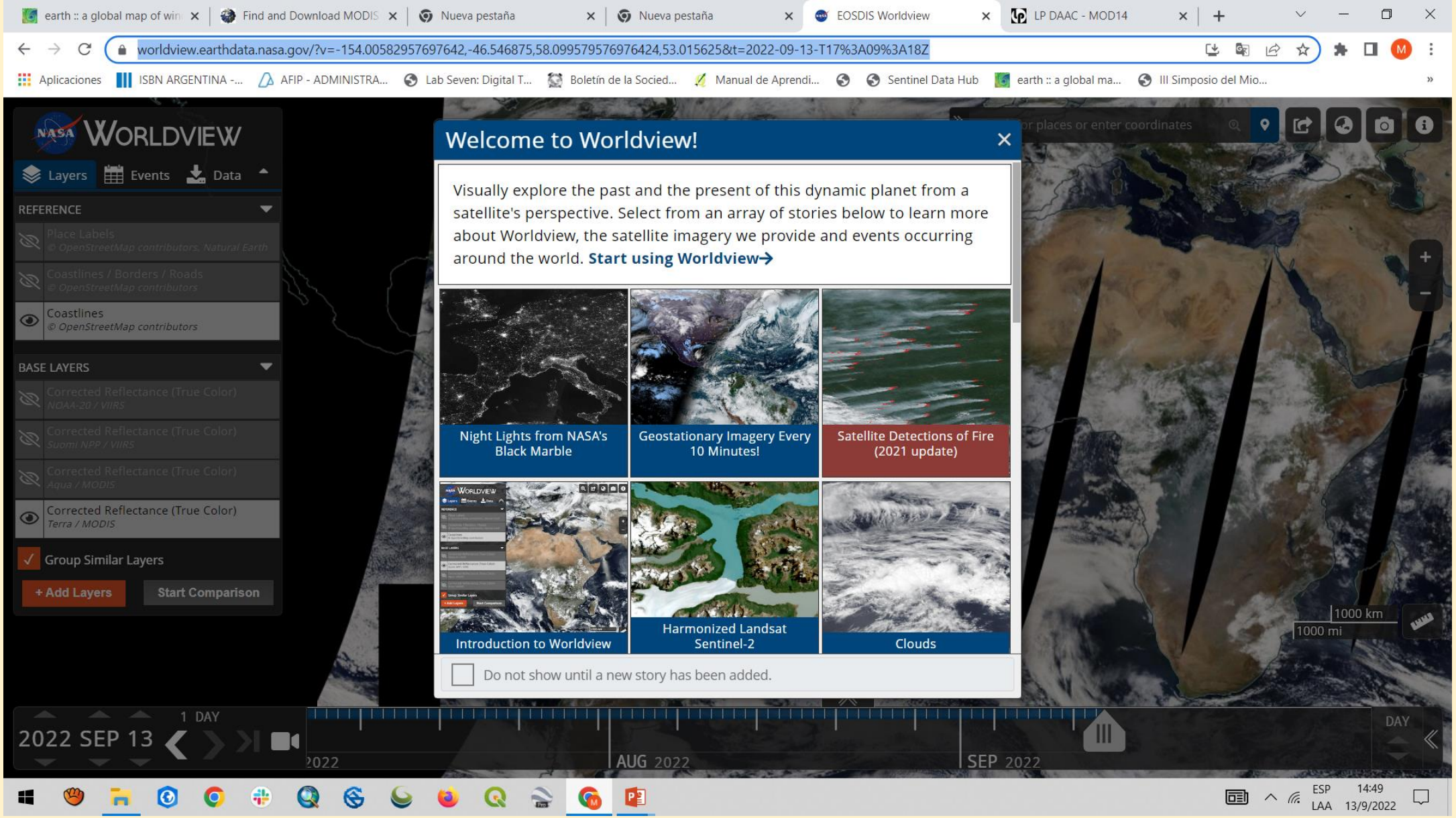
MODIS (color real)

2005 y 2018





https://climate.nasa.gov/news/2744/two-decades-of-earth-data/



https://worldview.earthdata.nasa.gov/?v=-154.00582957697642,-46.546875,58.099579576976424,53.015625&t=2022-09-13-T17%3A09%3A18Z

ESA-DEVELOPED EARTH OBSERVATION MISSIONS

2010

ERS-1
ERS-2
Envisat
Proba-1
GOCE
SMOS
CryoSat

2015

Meteosat-10 (MSG)
MetOp-B
Meteosat-11 (MSG)
Sentinel-1A
Sentinel-2A
Proba-V
Swarm
Sentinel-1B
Sentinel-2B
Sentinel-3A
Sentinel-5P
Sentinel-3B

2020

MetOp-C
Sentinel-6 Michael Freilich
Aeolus
Sentinel-2C
Sentinel-1C
SEOSAT-Ingenio
ALTIUS
Sentinel-3C
Biomass
EarthCARE
FLEX
Sentinel-1D
Sentinel-6B
Sentinel-2D
Sentinel-3D
FORUM
TRUTHS
Earth Explorer-10
CHIME
CRISTAL
LSTM
ROSE-L
CIMR
CO2M
Sentinel-5A MetOp-SG-A1
MTG-I1
Arctic Weather Satellite
Sentinel-4A MTG-S1
MTG-I2

2025

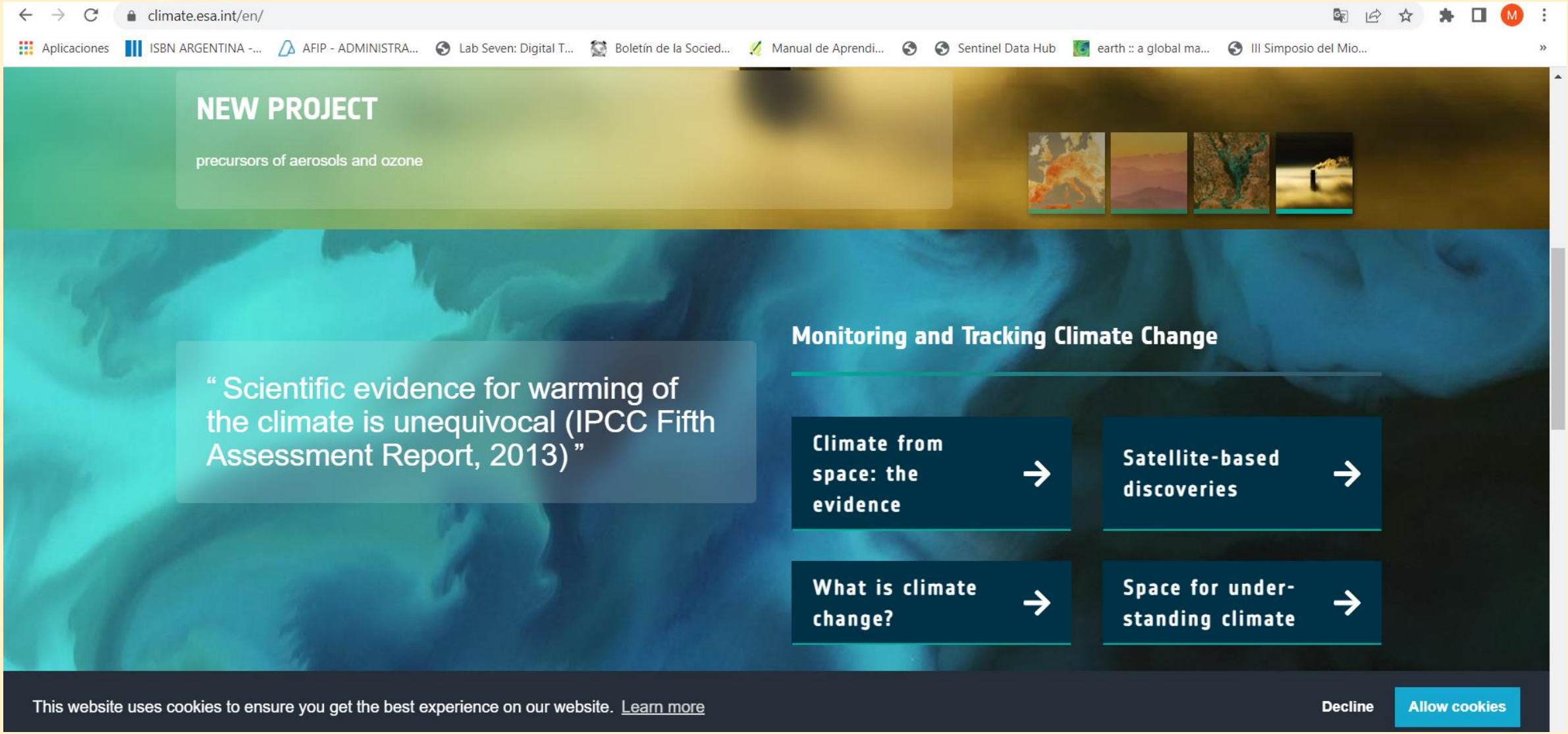
MetOp-SG-B1
Sentinel-5B MetOp-SG-A2
Sentinel-4B MTG-S2
MTG-I3
MetOp-SG-B2

2030

Science esa | Copernicus | Meteorology EUMETSAT

ESA Cambio climático

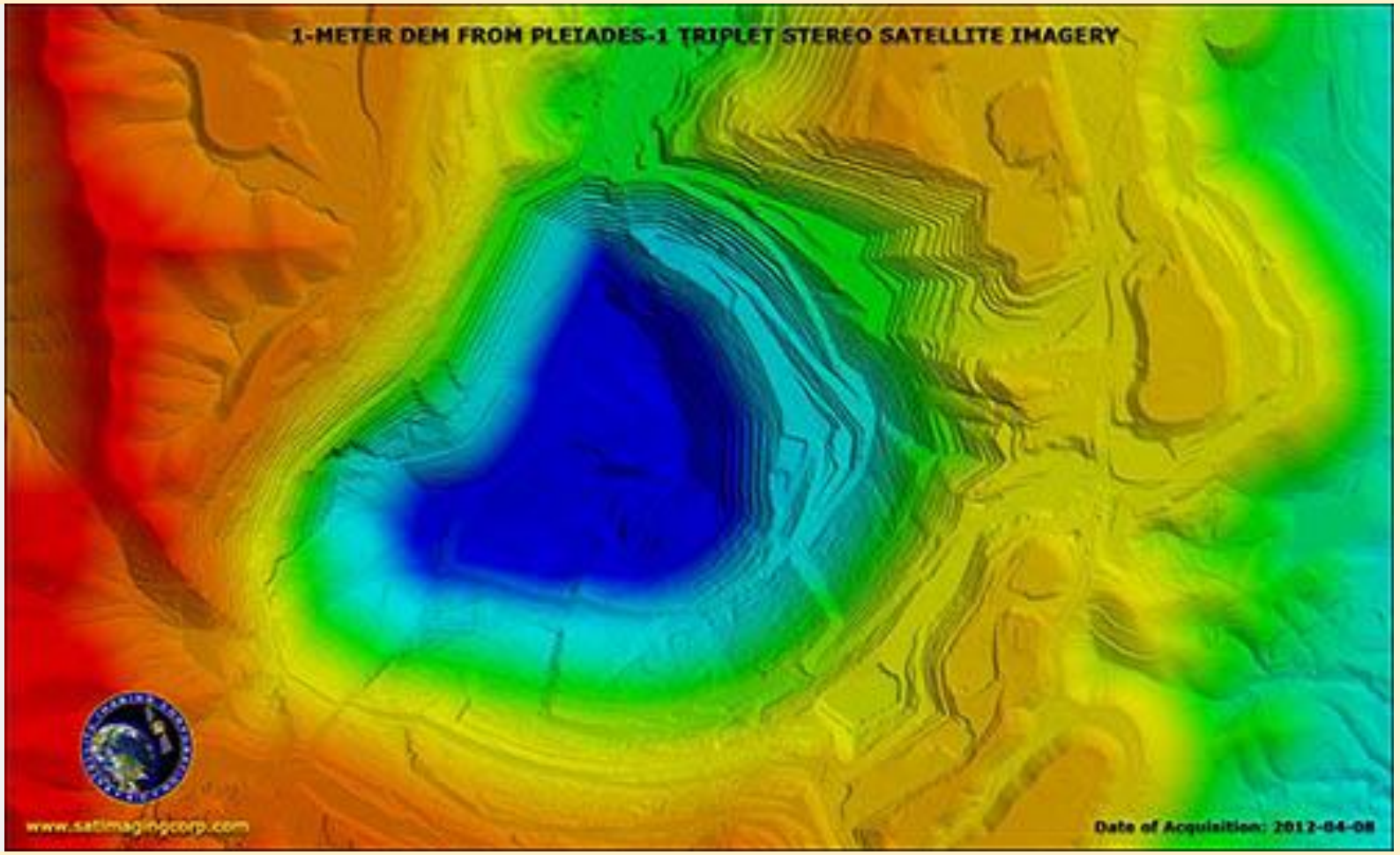
https://climate.esa.int/en/evidence/observations-change/



https://climate.esa.int/en/

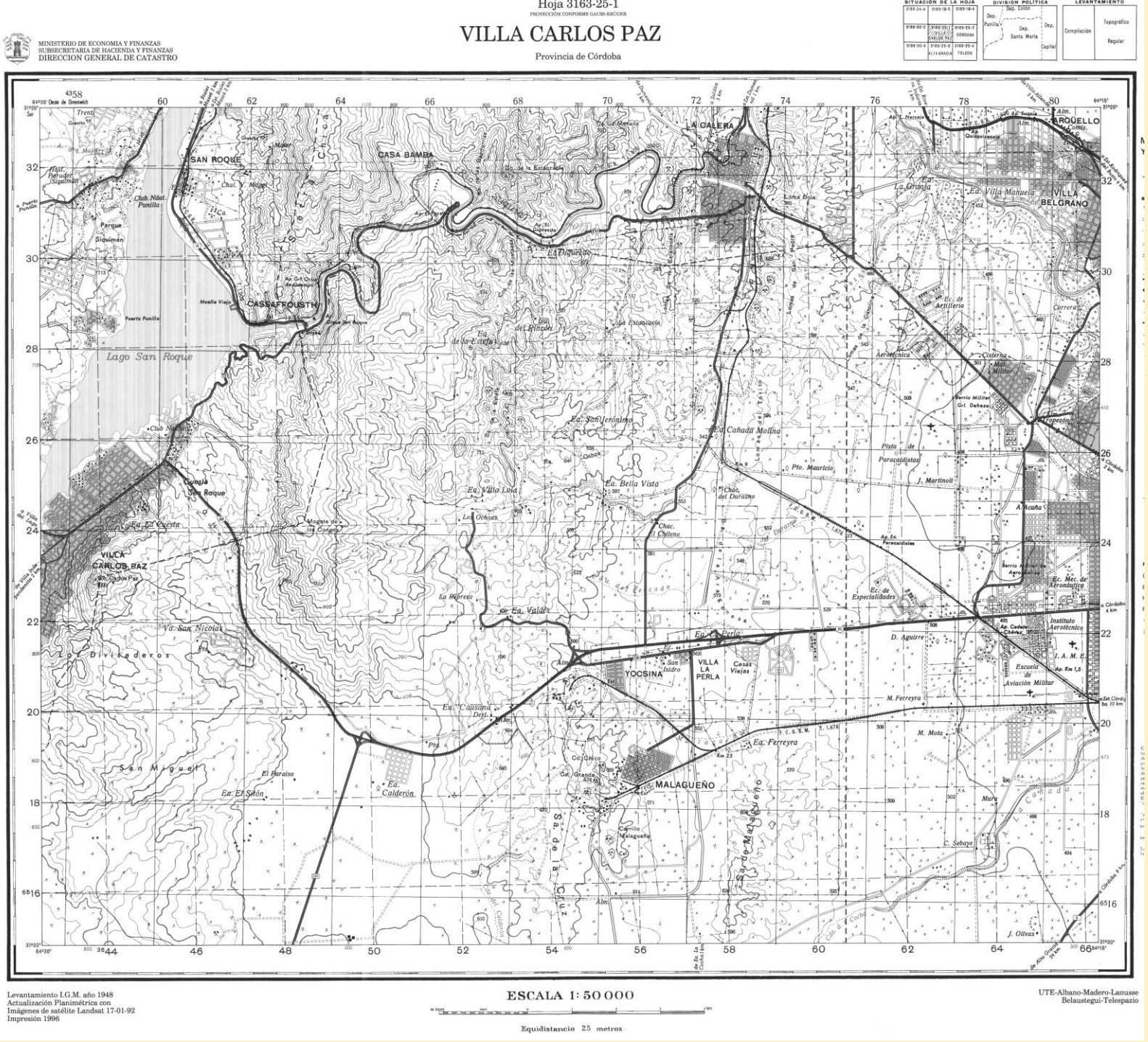
Fuente de datos MDE

- Cartas topográficas (analógicas)-Rasterización y georreferenciación
- Satelital: Radar y Optico
- Fotogrametría (aerotransportado)
- Lidar (aerotransportado)
- Combinaciones de MDEs



Hojas Topográficas

Los modelos de elevación pueden generarse a través de la medición directa de coordenadas de puntos o la extracción de valores x, y, z de otros conjuntos de datos. La recolección directa más común, por supuesto, es a través de un estudio de campo con receptores GPS, que puede ser muy preciso pero también extremadamente costoso y lento. Los DEM también se pueden extraer de los mapas de contorno topográficos, pero su precisión es tan buena como la de los mapas originales.



1980's DMA 90 m

10^2 cells/km^2

1990's USGS DEM 30 m

10^3 cells/km^2

2000's NED 10-30 m

10^4 cells/km^2

2010's LIDAR ~1 m

10^6 cells/km^2

MODELOS NUMERICOS DEL TERRENO

MNT de alta resolución mediante el tratamiento de imágenes por satélite:

Estereoscopía

GeoEye-1,1m - 5m HI-DEM
IKONOS 1m – 5m HI-DEM
ALOS PRISM -5 m DEM
Intermap 5m DEM/DTM/ORI
WorldView-1,1m - 5m HI-DEM
Cartosat 2,5m DEM
SPOT 20m DEM
ASTER - 15 y 30 m DEM

Interferometría radar

SRTM 90 m DEM
Harris SRTM-90 Gap Filled DEM
GTOPO30 1Km DEM
ETOPO2 2’ DEM

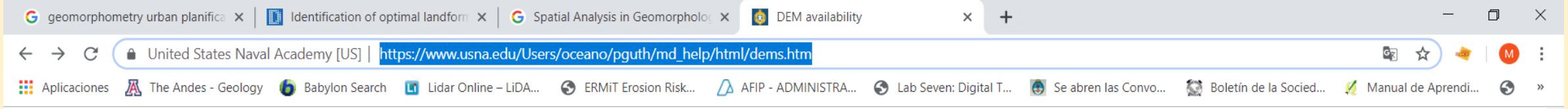
IMAGENES SATELITE RADAR

Satélite de media (100 metros) a muy alta resolución
(1 metro) :

ALOS PALSAR (libres12.5m, 30m)
ENVISAT
ERS
JERS
RADARSAT
TERRASAR-X

IMAGENES AEREAS LASER

LIDAR de alta (1 metro) a muy alta resolución (0,1 metro)



DEM Availability

Supported data formats. Bathymetery

Scale	Spacing	Data series	Coverage	Provider	Web Source	Notes
Global	5' (~10 km)	ETOPO5	Entire world, including ocean basins	NOAA		Get ETOPO1 and thin
	2'	ETOPO2				Get ETOPO1 and thin.
	2' long (lat has Mercator factor)	Smith & Sandwell Predicted topography	Entire world, including ocean basins	SIO/NOAA	Scripps	Ideal for regional base maps, especially for geologists
	1'	ETOPO1			NGDC	Entire data set, or custom grids
	30"	SRTM-15 Plus, SRTM-30_Plus: Merge of SRTM30, Smith & Sandwell, and IBCAO	Entire world, including ocean basins		Scripps	Get the SRTM version files, with a data file and an ERS header. Open with MICRODEM which will use GDAL. You will probably have to edit the header to get the correct SW corner.
	30" (~1 km)	GTOPO30	Entire world, land only	USGS	GTOPO30	Use GMTED2010 as better alternative.
		SRTM-30	Entire world, land only		SRTM-30	Use GMTED2010 as better alternative.
	30", 15", and 7.5"	Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010)	Entire world	USGS	GMTED	
Regional	3" (60-90 m)	SRTM-3		JPL	SRTM	Entire world except for polar regions (broadly defined) National Map Viewer directions.
	2" (40-60 m)	USGS 100K	United States	USGS		Must order from USGS ($)
	1" (20-30 m)	SRTM-1		JPL		National Map Viewer
	1" (20-30 m)	3DEP (formerly NED)	United States	USGS	• National Map Viewer	National Map Viewer
	1"	EU DEM	Europe, Turkey, parts of North Africa			
	1"	ALOS Global Digital Surface Model "ALOS World 3D - 30m" (AW3D30)			JAXA download or Home page	Free version of 5 m grid.

https://www.usna.edu/Users/oceano/pguth/md_help/html/dems.htm

Bathymetry Availability

Using NOAA point soundings | NOAA main bathymetry site | USGS Bathymetry Portal | DEMs on land

MICRODEM requires that depths have negative z values. You can quickly edit the DEM to multiply the depths by -1.

Spacing	Data series	Coverage	Provider	Web Source	Notes
5' (~10 km)	ETOPO5/1	Entire world, including ocean basins	NOAA	ETOPO1	Need header for MICRODEM. The original bathymetry came from the version of DBDBV available at the time ETOPO5 was created.
2' long (lat Mercator factor)	Smith & Sandwell Predicted topography	Entire world, including ocean basins	SIO/NOAA	Scripps	Ideal for geological base maps
2' long	ETOPO2		NOAA	NOAA download	GEODAS build a grid (use ASCII XYZ)
1' long	GEBCO One Minute Grid	Worldwide		http://www.gebco.net/data_and_products/gridded_bathymetry_data/ https://www.bodc.ac.uk/data/online_delivery/gebco/	Full data or subsets. netCDF, Geottff, or ESRI ASCII
1' long	ETOPO1			NOAA	
30"	GEBCO_2014 Grid			http://www.gebco.net/data_and_products/gridded_bathymetry_data/ https://www.bodc.ac.uk/data/online_delivery/gebco/	Full data or subsets. netCDF, Geottff, or ESRI ASCII
30"	Merge of SRTM30, Smith & Sandwell, and IBCAO	Entire world, including ocean basins		Scripps	Get the SRTM version files, with a data file and an ERS header. Open with MICRODEM which will use GDAL. You will probably have to edit the header to get the correct SW corner.
	Global Multi-Resolution Topography Data Portal (includes RIDGE data)			MGDS	
	Seamount database			Scripps	GMT format
	USGS Coastal mapping (includes lakes)		USGS	USGS 2	Crater Lake, Lake Tahoe, San Francisco, Los Angeles, San Diego, Hawaii, Gulf of Mexico--not all may be supported in MICRODEM
3" to 10'	NOAA Design a Grid			NOAA info NOAA download	US coastal and Great Lakes GEODAS build a grid (use ASCII XYZ for export). If you use the G98 format, expect to have to edit the coordinates of the SW corner.
	NOAA Multibeam Viewer and Data Downloader			NOAA	

https://www.usna.edu/Users/oceano/pguth/md_help/html/bathymetry.htm

1 meter Digital Elevation Models (DEMs) - USGS National Map 3DEP Downloadable Data Collection

View

Dates

Publication Date : 2017
Start Date : 2015-01

Citation

U.S. Geological Survey, 2017, 1 meter Digital Elevation Models (DEMs) - USGS National Map 3DEP Downloadable Data Collection: U.S. Geological Survey.

Summary

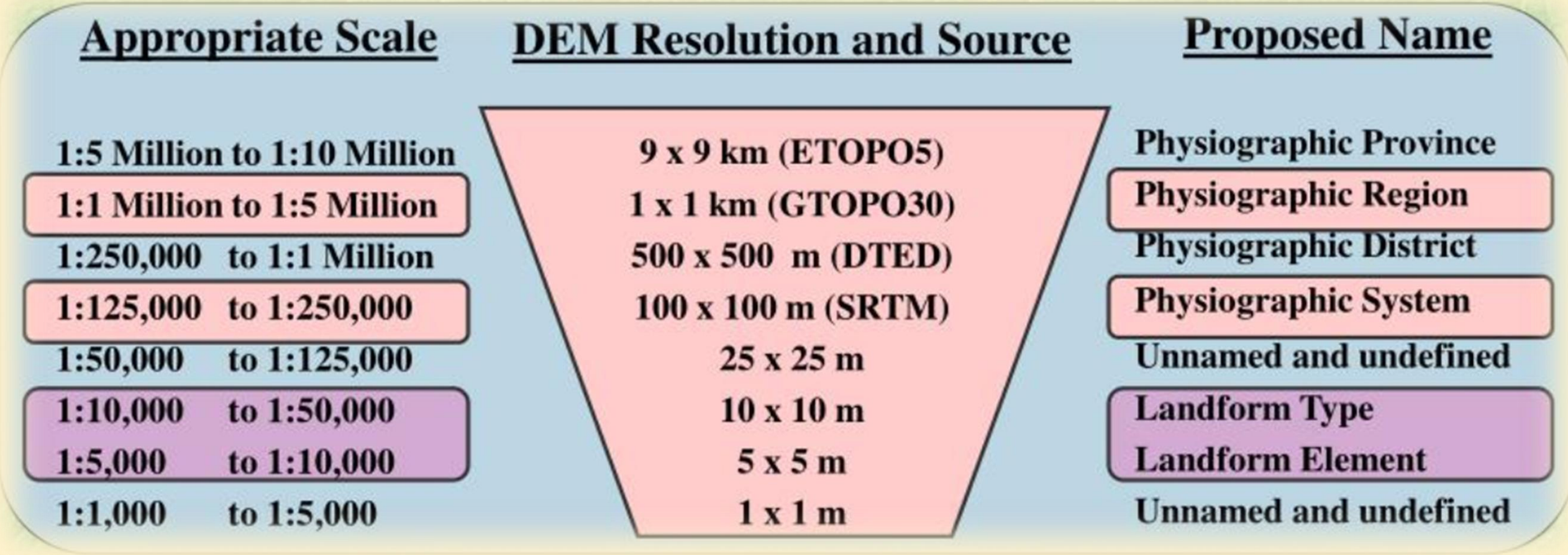
This is a tiled collection of the 3D Elevation Program (3DEP) and is one meter resolution.The 3DEP data holdings serve as the elevation layer of The National Map, and provide foundational elevation information for earth science studies and mapping applications in the United States. Scientists and resource managers use 3DEP data for hydrologic modeling, resource monitoring, mapping and visualization, and many other applications. The elevations in this DEM represent the topographic bare-earth surface. USGS standard one-meter DEMs are produced exclusively from high resolution light detection and ranging (lidar) source data of one-meter or higher resolution. One-meter DEM surfaces are seamless within collection projects, but, not necessarily seamless across projects. The spatial reference used for tiles of the one-meter DEM within the conterminous United States (CONUS) is Universal Transverse Mercator (UTM) in units of meters, and in conformance with the North American Datum of 1983 (NAD83). All bare earth elevation values are in meters and are referenced to the North American Vertical Datum of 1988 (NAVD88). Each tile is

Thumbnail JPG image

Map »

Dataset	Resolution	Coverage	Download Link
SRTM1	1 arcsec / 30 meter / 98 feet	United States	Download
SRTM3	3 arcsec / 90 meter / 295 feet	World except polar areas	Download
SRTM30	30 arcsec / 1 km / 0.5 NM	World except polar areas	Download
GTOPO30	30 arcsec / 1 km / 0.5 NM	World	Download
ETOPO5	5 min / 9.3 km / 5 NM	World	Download

Año	DEM	Cobertura	Metodología	Resolución Espacial	Desarrollado por	Disponibilidad	Error
1996	**GTOPO**	Global	Interpolación Curvas a Nivel	30 arc- seg. (1km)	USGS (U.S. Geological Survey´s)	Gratuito	
Febrero 2000	**SRTM**	80%	RADAR (trasbordador espacial Endeavour durante una misión de 14 días)	90- 30 m	NASA, USGS, NGA	Gratuito 90 m - Restringido 30 m	± 11 y 15 m
2000-2008	**ASTER (GDEM)**	Global	Estereoscopia Satelital	30 m	METI y NASA	Gratuito	± 20 y 25 m
1999	**STAR3I**	Areas Especificas	RADAR	10 m	Inter Map		± 3m
	LIDAR		Láser	alta resolución			± 1 m

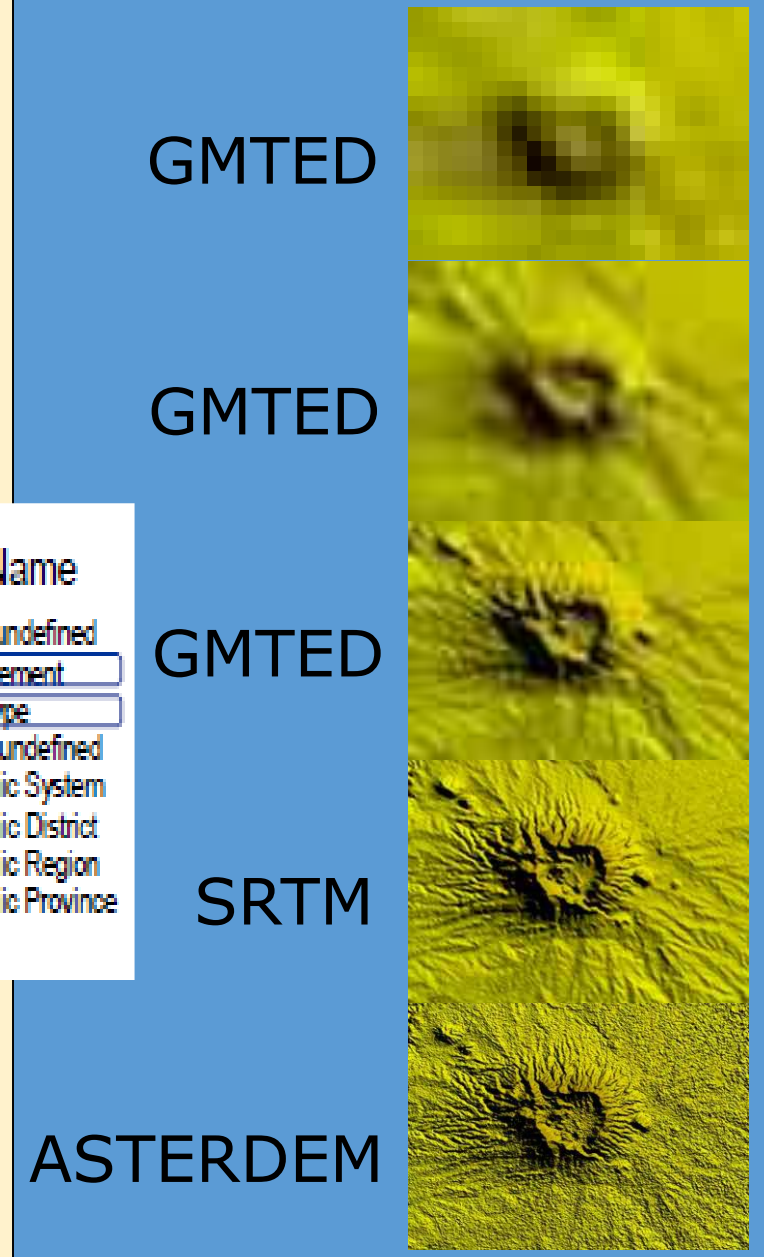


https://www.slideserve.com/shalin/automated-landform-classification-using-dems

Multiresolución con diferentes fuentes de datos

Ejemplo Cerro El Morro
San Luis

Appropriate scale	DEM resolution and source	Proposed Name
1:2000 to 1:5000	1x1 m	Unnamed - undefined
1:5000 to 1:10000	5x5 m	Landform Element
1:10000 to 1:50000	10x10 m	Landform Type
1:50000 to 1:125000	25x25 m	Unnamed – undefined
1:125000 to 1:250000	100x100 m SRTM	Physiographic System
1:250000 to 1:1 Million	500x500 m DTED	Physiographic District
1:1 Million to 1:5 Million	1x1 km GTOPO30	Physiographic Region
1:5 Million to 1:10 Million	9x9 km ETOPO5	Physiographic Province



Copernicus DEM: 30 meter dataset now publicly available

Copernicus DEM: 30 meter dataset now publicly available

1 Year Ago

ESA is pleased to announce that, in addition to the Copernicus Digital Elevation Model (DEM) GLO-90 released in December 2019, the access rights for the Copernicus DEM with global coverage at 30 meter resolution (GLO-30) have now been extended and the dataset is openly available to any registered user.

Explore More

- About CSCDA
- News Archive
- Operational News Archive
- Document Library
- PRISM
- COP-DEM FAQ
- CSCDA FAQ
- Site Map

Key Resources

- Data Access Portfolio (DAP)
- Copernicus DEM FAQ

TanDEM Science Service System

You are here : **Home**

For registered users only
Username:
Password:
Login

Registered User Access
- Investigator
- Evaluator
- Coordinator

Basic User Registration
- Investigators Registration

Documents (Download)
- Bandwidth Considerations
- Science Plan
- TanDEM-X Science Phase
- Manual Science Service System
- TanDEM-X Experimental Product Description
- TanDEM-X CoSSC Generati and Interferometric Considerations
- TanDEM-X DEM Product Specification
- TerraSAR-X Basic Products
- TerraSAR-X L1b Product Description
- User License Agreement
- COFUR Price List (Scientifi Use)

Home | Data access » | Mission » | Multimedia | FAQ

News

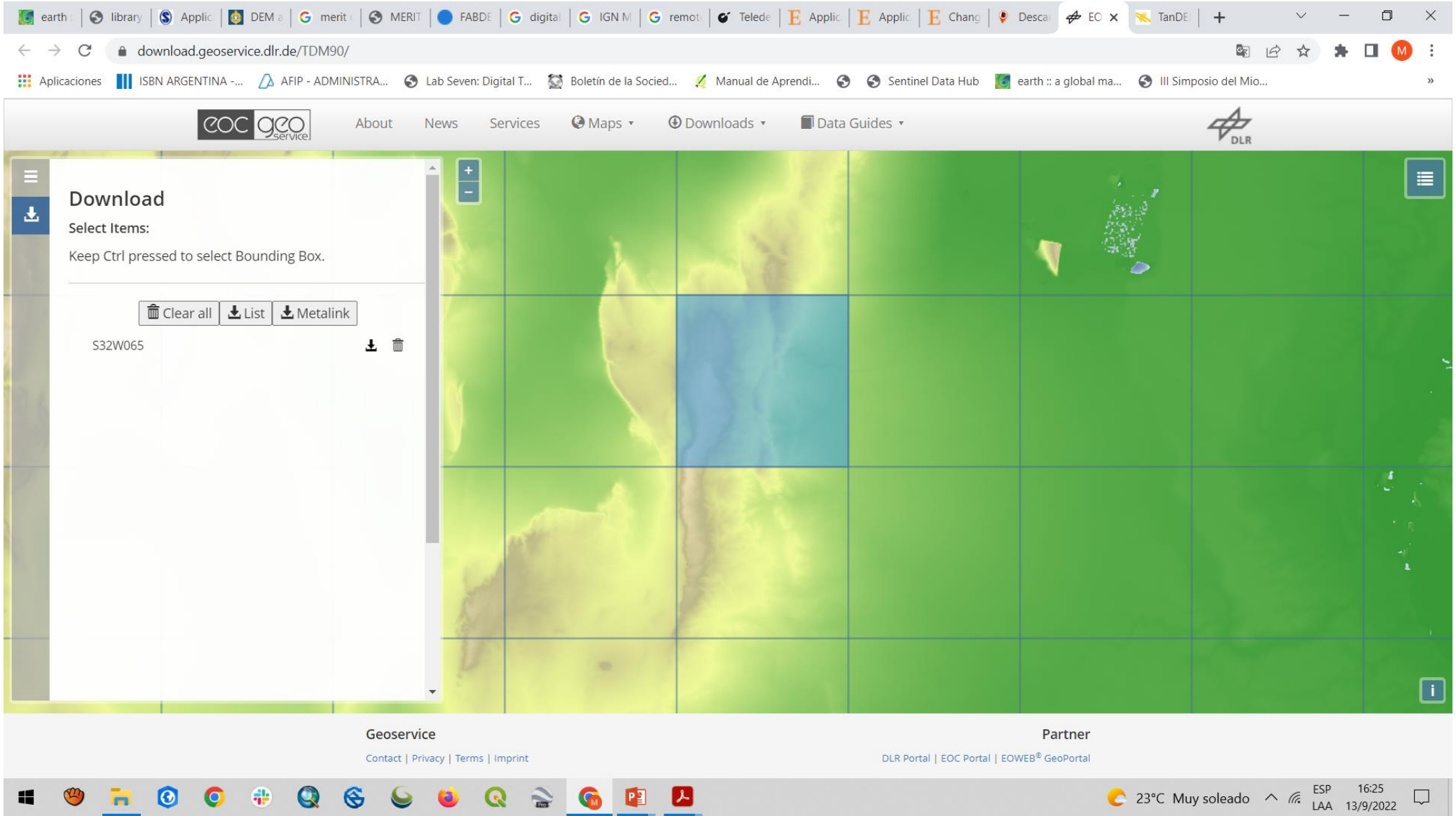
[February 24, 2022]

TanDEM-X Again In Operation

We would like to inform you that TanDEM-X is since 16.02.2022 again in nominal operation. Proposal for new data acquisitions are again accepted and welcome.

TANDEM 90M

https://download.geoservice.dlr.de/TDM90/



MERIT (Obtenido desde diversas fuentes)

MERIT DEM: Multi-Error-Removed Improved-Terrain DEM

Last Update: 15 Oct, 2018

Yamazaki Lab
Lab page
--
MainPage
Main
--
CV
(En)Publication
(En)Presentation
--
Japanese-CV
--
Old Posts
Model&Data
Developper Webpage
Dai Yamazaki
CaMa-Flood
Global Hydrodynamic Model
MERIT Hydro
Global hydrography map
MERIT DEM
Accurate DEM
GWD-LR
Global River Width
G3WBM
Global Water Map
OSM water layer

FrontPage

General Information

Product Info

The MERIT DEM was developed by removing multiple error components (absolute bias, stripe noise, speckle noise, and tree height bias) from the existing spaceborne DEMs (SRTM3 v2.1 and AW3D-30m v1). It represents the terrain elevations at a 3sec resolution (~90m at the equator), and covers land areas between 90N-60S, referenced to EGM96 geoid.
Hydrologically adjusted DEM is now available as a component of MERIT Hydro datasets.
Please visit MERIT Hydro webpage to get an access.

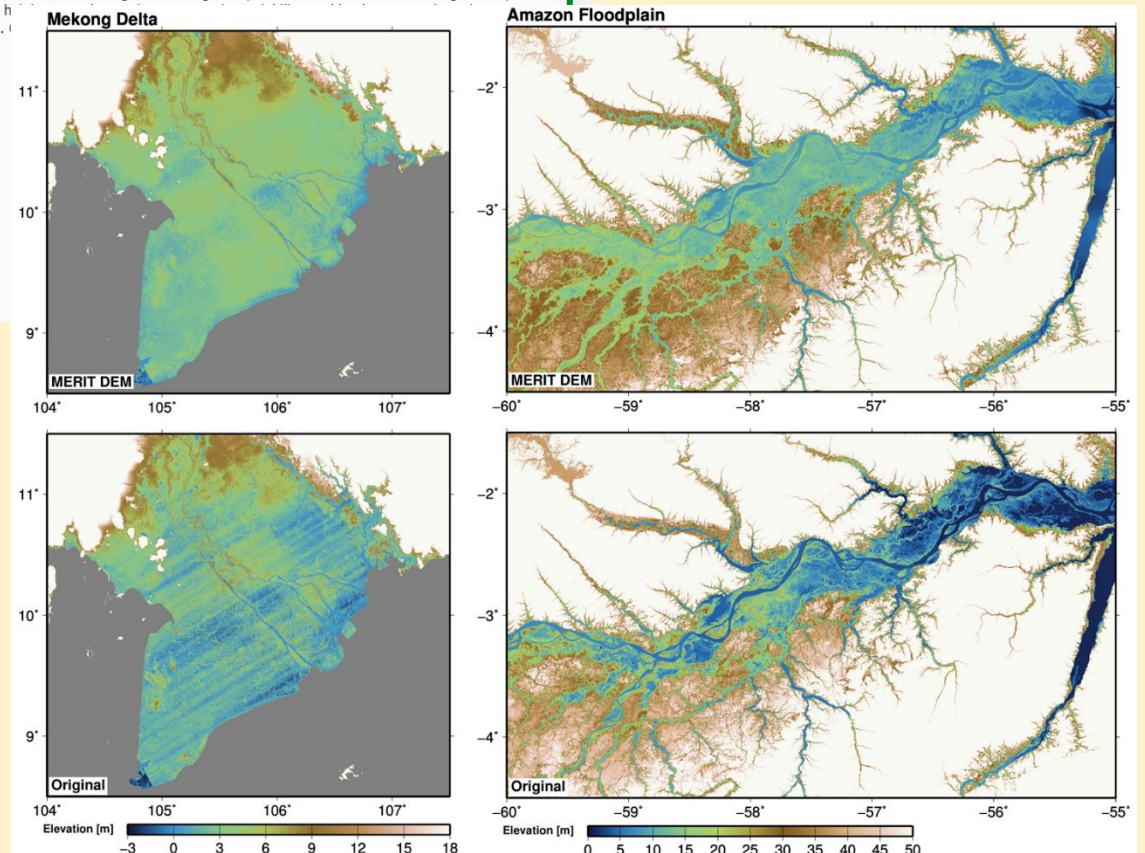
Data Summary

Spaceborne Digital Elevation Models (DEMs) are a fundamental input for many geoscience studies, but they still include non-negligible height errors. Here we introduce a high accuracy global DEM at 3 arcsecond resolution (~90 m at the equator) by eliminating major error components from existing DEMs (NASA SRTM3 DEM, JAXA AW3D DEM, Viewfinder Panoramas' DEM). We separated absolute bias, stripe noise, speckle noise and tree height bias using multiple satellite datasets and filtering techniques. After the error removal, land areas mapped with 2 m or better vertical accuracy were increased from 39% to 58%. Significant improvements were found in flat regions where h
networks and hill-valley structures became clearly represented. We found the topography slope of previous DEMs was largely distorted in most of world major floodplains (e.g.
The newly developed DEM will enhance many geoscience applications which are terrain-dependent.
-- Description Paper in GRL

Data Source

MERIT DEM was developed by processing the following products as baseline data (all are freely available from their web page).
- NASA SRTM3 DEM v2.1: link to the SRTM webpage
- JAXA AW3D-30m DEM v1: link to the AW3D-30m webpage
- Viewfinder Panoramas' DEM link to the ViewfinderPanoramas webpage

In addition to the above baseline DEMs, below products were used as supplementary data:
- NASA-NSIDC ICESat/GLAS GLA14 data link to the NSIDC webpage
- U-Maryland Landsat forest cover data link to the Global Forest Change webpage
- NASA Global Forest Height Data link to NASA webpage
- JAMSTEC/U-Tokyo G3WBM water body data link to G3WBM webpage



http://hydro.iis.u-tokyo.ac.jp/~yamadai/MERIT_DEM/

FABDEM

Followers

0

Organisation

Science

Some of the most significant discoveries of the last century are associated with research carried out in Bristol. We currently enjoy an outstanding international reputation as...
read more

Social

Dataset

FABDEM

As an experiment we also have a bittorrent download available at
https://academictorrents.com/details/a3ce54e3de8177011a3c6e1b9ed130e0467c3f4e

FABDEM (Forest And Buildings removed Copernicus DEM) is a global elevation map that removes building and tree height biases from the Copernicus GLO 30 Digital Elevation Model (DEM). The data is available at 1 arc second grid spacing (approximately 30m at the equator) for the globe. The FABDEM dataset is licensed under a Creative Commons "CC BY-NC-SA 4.0" license.

For commercial use queries, please contact fabdem@fathom.global

This dataset is published in support of the paper "A 30 m global map of elevation with forests and buildings removed" published by IOP in Environmental Research Letters at https://dx.doi.org/10.1088/1748-9326/ac4d4f.

UPDATE 14/03/2022 - Tile N00E011_FABDEM_V1-0.tif was corrupted and has now been replaced. This has been reflected in the geotiff tags with the following text "NOTE=This file is a replacement for originally corrupted file for tile N00E011" -mo "UPDATED=2022-02-23""

Complete download (zip, 462.3 GiB)

SIG

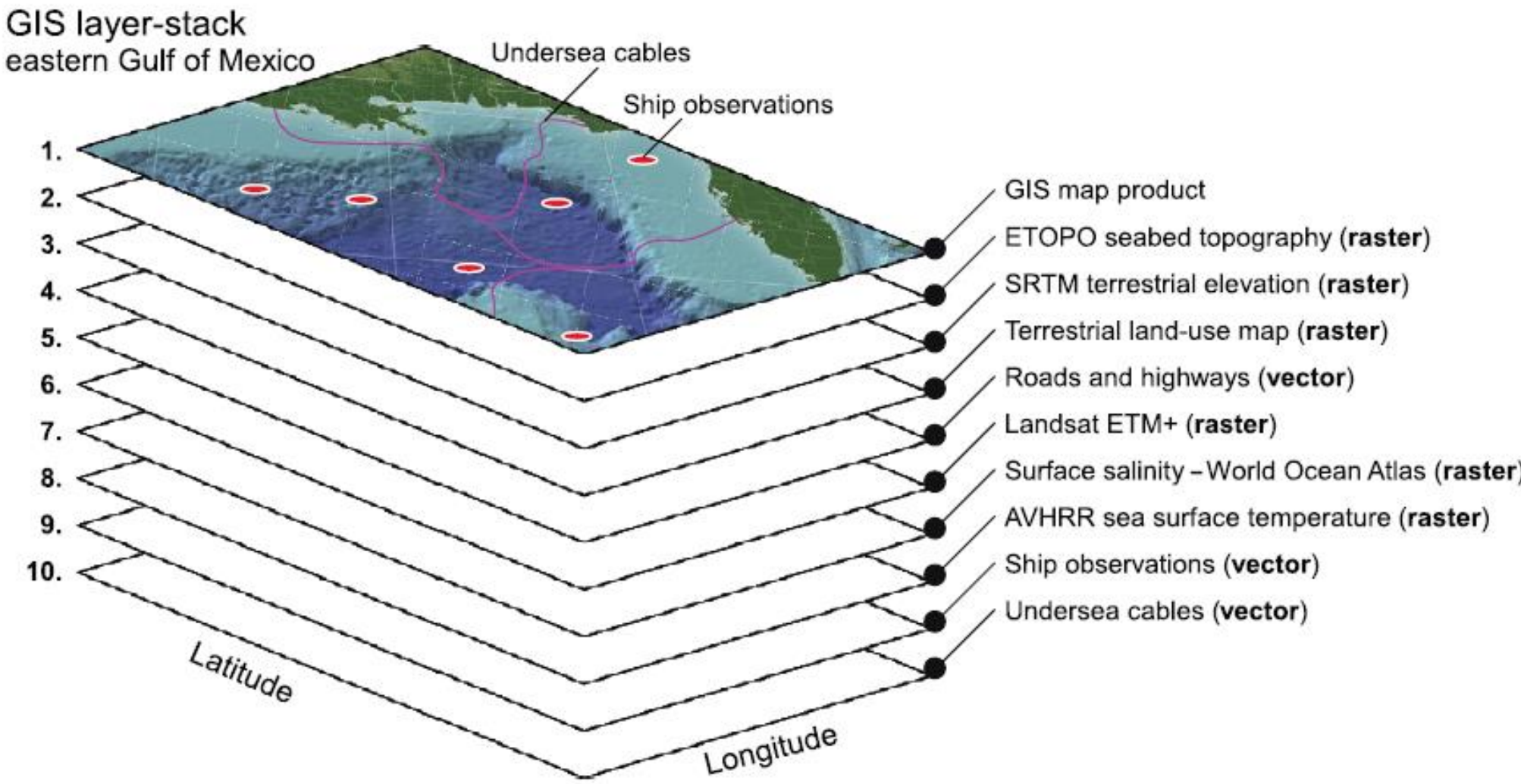


Figure 4.11 A Geographical Information System (GIS) layer-stack.

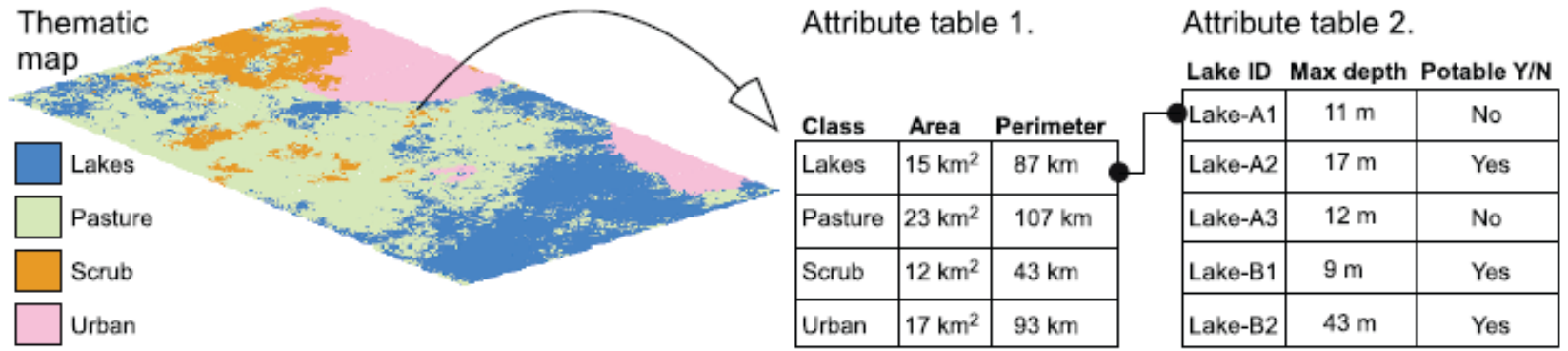


Figure 4.12 Storage of GIS attribute information in a relational database.

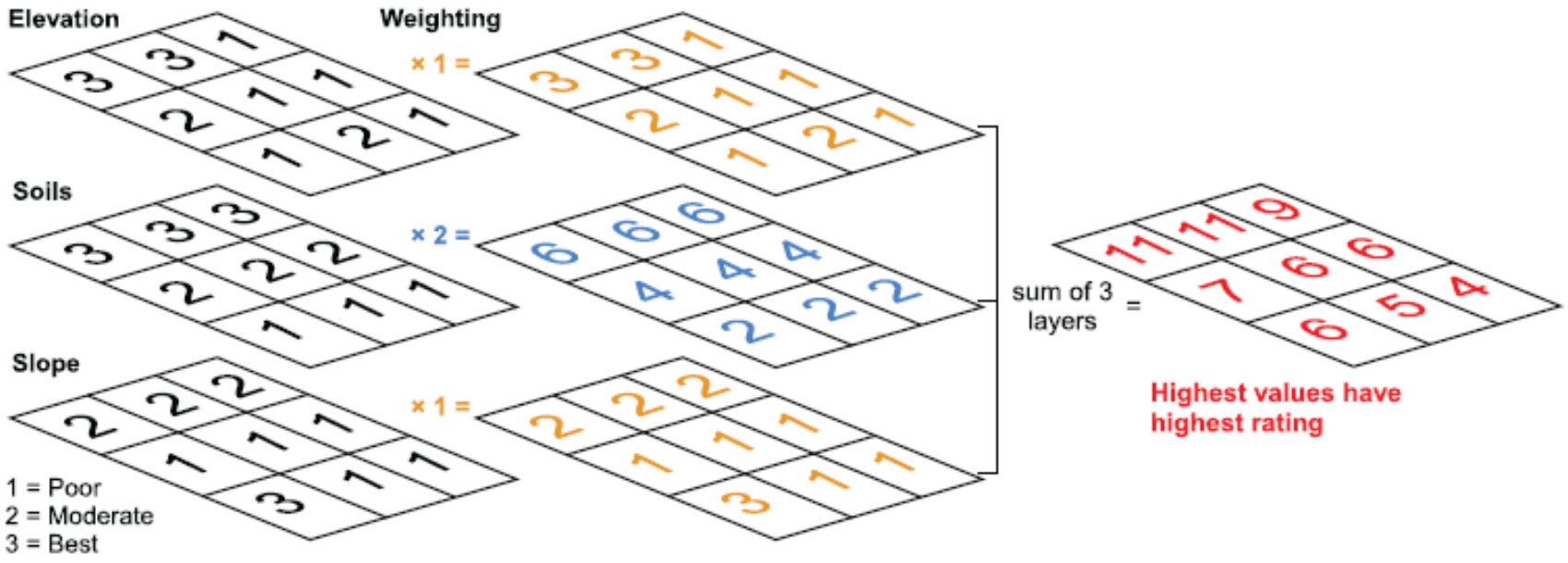


Figure 4.13 GIS overlay operation using different weights for data layers. Modified with permission from Davis (1996).

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- NASA ARSET : https://appliedsciences.nasa.gov/join-mission/training
- Panel Intergubernamental del Cambio Climático: https://ipcc.ch
- NASA GISS Temperaturas:https://data.giss.nasa.gov/gistemp/
- NASA Signos Vitales: https://climate.nasa.gov/

https://acolita.com/la-gran-lista-satelital-50-satelites-en-30-palabras-o-menos/

https://climate.esa.int/en/evidence/observations-change/

- IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [MassonDelmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

- Gaffney, O.; Steffen, W. (2017). "The Anthropocene equation," The Anthropocene Review (Volume 4, Issue 1, April 2017), 53-61.

- "Global Climate Change: Evidence." *NASA Global Climate Change and Global Warming: Vital Signs of the Planet*. Jet Propulsion Laboratory / National Aeronautics and Space Administration, 15 June 2008. Web. 14 Jan. 2015. http://climate.nasa.gov/evidence/.

- Levitus, S.; Antonov, J.; Boyer, T.; Baranova, O.; Garcia, H.; Locarnini, R.; Mishonov, A.; Reagan, J.; Seidov, D.; Yarosh, E.; Zweng,
  M. (2017). NCEI ocean heat content, temperature anomalies, salinity anomalies, thermosteric sea level anomalies, halosteric sea level anomalies, and total steric sea level anomalies from 1955 to present calculated from in situ oceanographic subsurface profile data (NCEI Accession 0164586). Version 4.4. NOAA National Centers for Environmental Information. Dataset. doi: 10.7289/V53F4MV