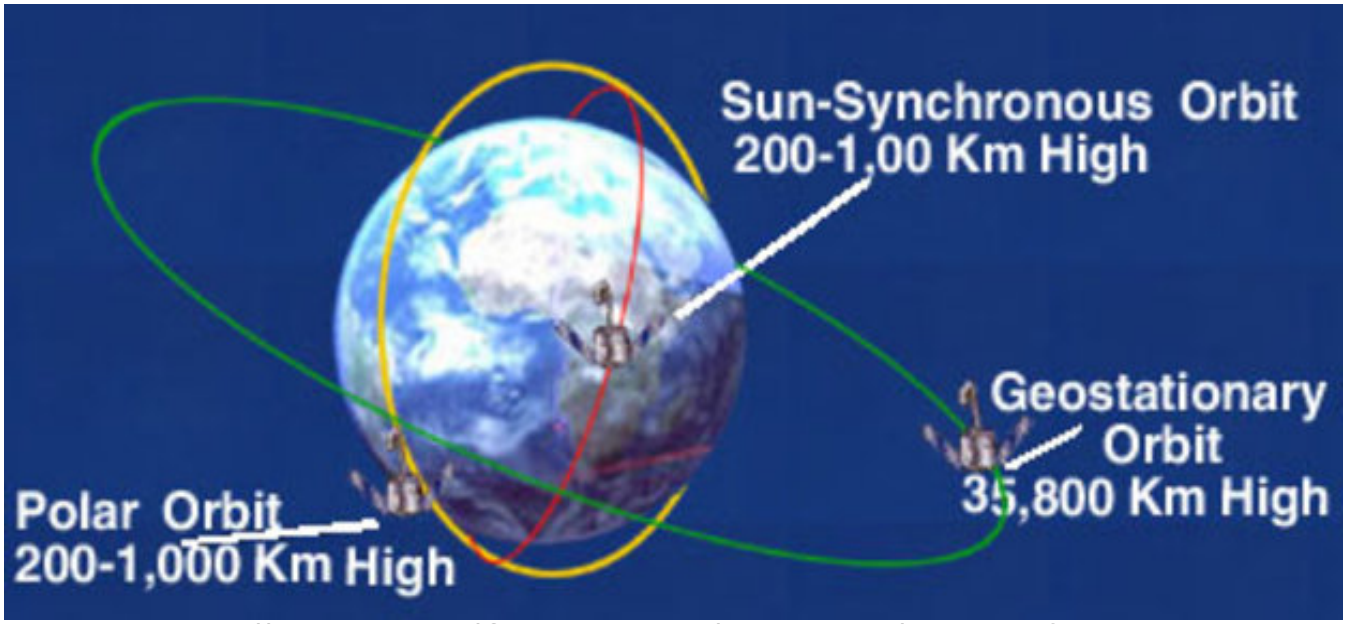
Environmental Remote Sensing
GEOG 0027

Lecture 8

Orbits, scale and trade-offs

Orbits revisit

- Orbits
  - geostationary (35 800 km altitude)
  - polar orbiting (200-1000 km altitude)



http://www.esa.int/Our_Activities/Launchers/Types_of_orbits

Orbits: trade-offs / pros and cons

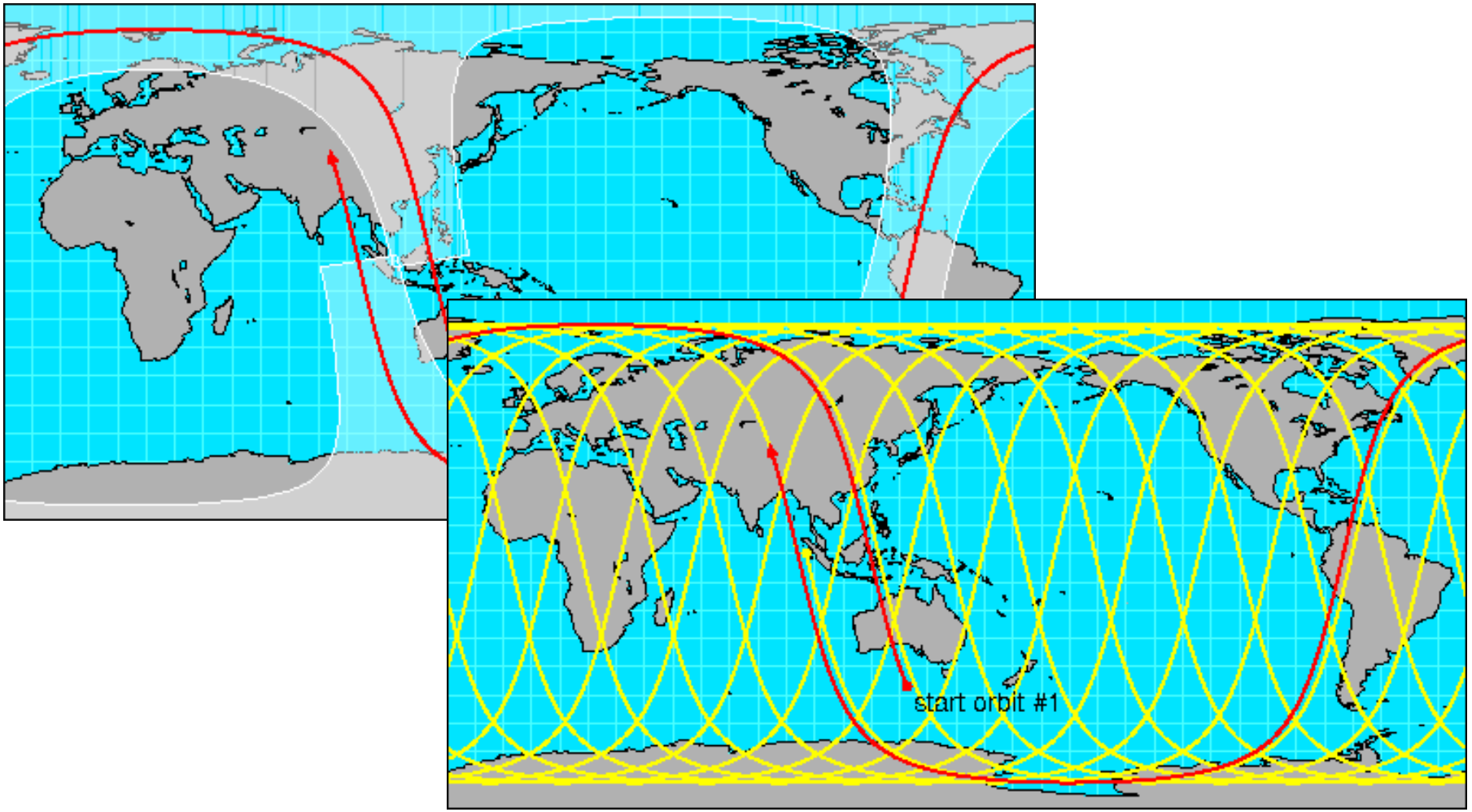
- Polar orbiting
  - Polar (or near-polar) orbit – inclined 85-90° to equator
  - Typical altitude 600-700km, orbital period ~100 mins so multiple (15-20) orbits per day
  - Majority of RS instruments

    e.g. MODIS, AVHRR,

    Landsat, SPOT,

    Ikonos, Sentinels, etc.

Orbits and trade-offs: polar

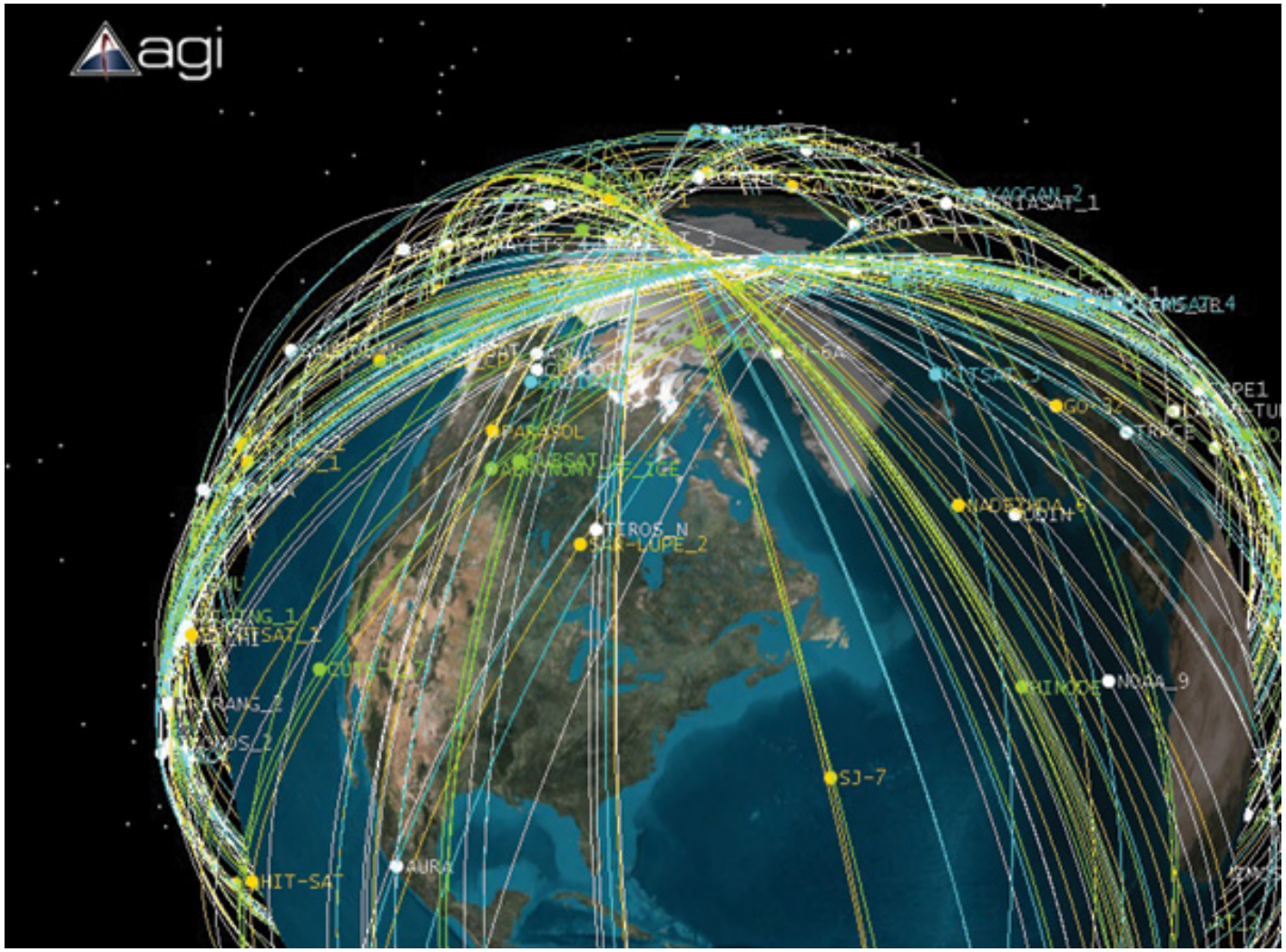


http://www.rap.ucar.edu/~djohnson/satellite/coverage.html

Orbits and trade-offs: polar

- Advantages
  - Higher spatial resolution (<m to few km), depending on instrument and swath width
  - Global coverage due to combination of orbit path and rotation of Earth
- Disadvantages
  - Takes time to come back to point on surface
    - e.g. 1 or 2 days for MODIS, 16 days for Landsat , 5 or 10 days for Sentinel-2

Orbits and trade-offs: polar



Orbits and trade-offs: polar

Ortib Track (e.g. Terra)

Live: http://www.n2yo.com/?s=25994

Static: http://www.ssec.wisc.edu/datacenter/terra/

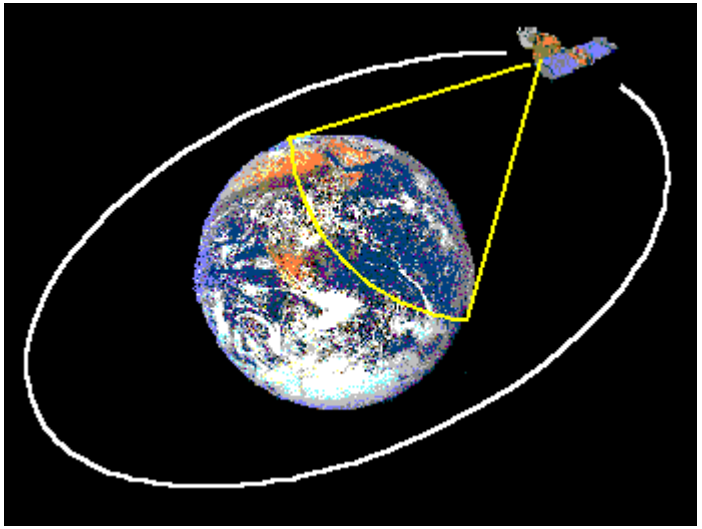
EarthNow! Landsat Image Viewer

http://earthnow.usgs.gov/

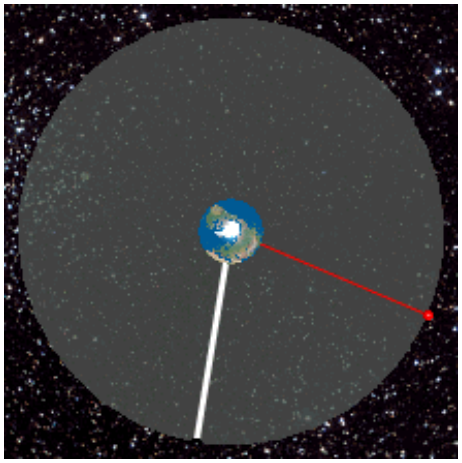
Orbits: trade-offs / pros and cons

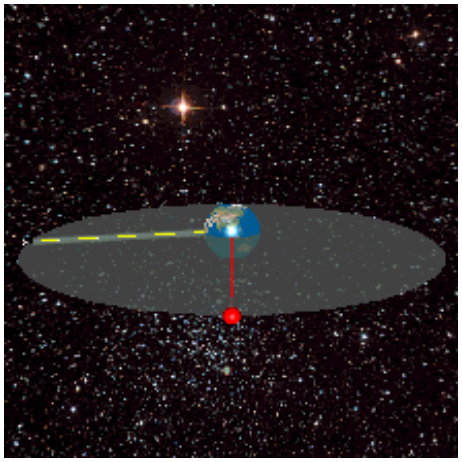
- Geostationary
  - Orbit over equator, with orbit period (by definition) of 24 hours
  - Always in same place over surface
  - MUCH further away then polar

    ~36,000km altitude



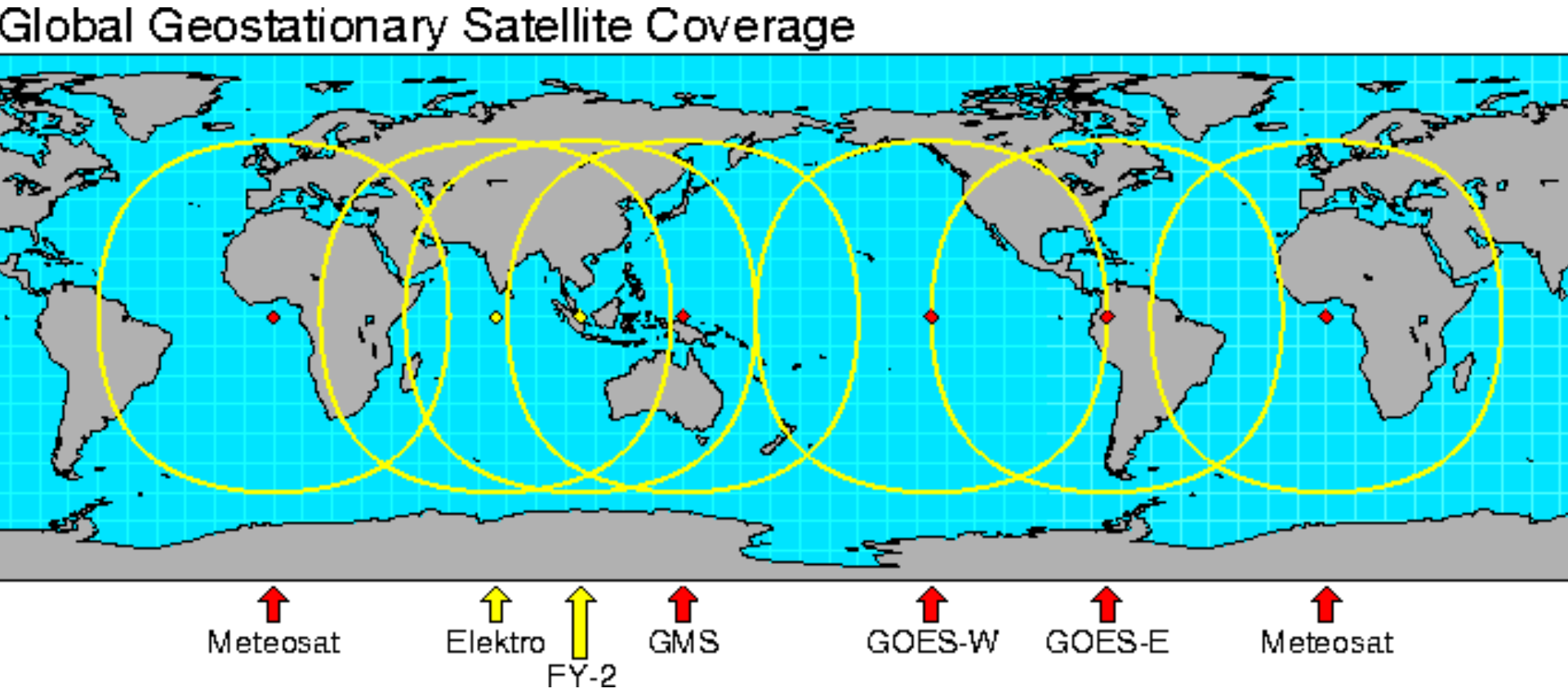
Orbits and trade-offs: Geostationary





http://www.meted.ucar.edu/satmet/climate_monitoring/navmenu.php

Orbits and trade-offs: Geostationary



Orbits and trade-offs: Geostationary

- Advantages
  - Always look at same part of Earth
  - Rapid repeat time (as fast as you like) e.g. Meteosat every 15 minutes - ideal for weather monitoring/forecasting
- Disadvantages
  - Much higher (36000km) altitude means lower resolution
  - Not global coverage
    - See same side of Earth
    - High-latitude

Orbits and trade-offs: Geostationary

METEOSAT 2nd Gen (MSG) (geostationary orbit)

- 1km (equator) to 3km (worse with latitude)
- Views of whole Earth disk every 15 mins
- 30+ years METEOSAT data

MSG-2 image of Northern Europe

- "Mostly cloud free"

Remember, we always have trade-offs in *space*, *time*, *wavelength* etc. – determined by application

- Global coverage means broad swaths, moderate-to-low resolution
  - Accept low spatial detail for global coverage & rapid revisit times
  - Land cover change, deforestation, vegetation dynamics, surface reflectance, ocean and atmospheric circulation, global carbon & hydrological cycle
  - E.g. MODIS, MERIS

Remember, we always have trade-offs in *space*, *time*, *wavelength* etc. – determined by application

- Global coverage means broad swaths, moderate-to-low resolution
  - MODIS (Terra, Aqua) (near-polar orbit)
    - 250m to 1km, 7 bands across visible + NIR, swath width ~2400 km, repeat 1-2 days
  - MERIS (near-polar orbit)
    - ~300m, 15 bands across visible + NIR, swath width ~1100 km, repeat time hours to days
  - SeaWiFS (Sea-Viewing Wide Field-of-View Sensor)
    - 1km resolution, 2800km swath, 16 day repeat
    - Designed for **ocean colour** studies

Remember trade-offs in *space*, *time*, *wavelength* etc.

- **SeaWiFS** (Sea-Viewing Wide Field-of-View Sensor)
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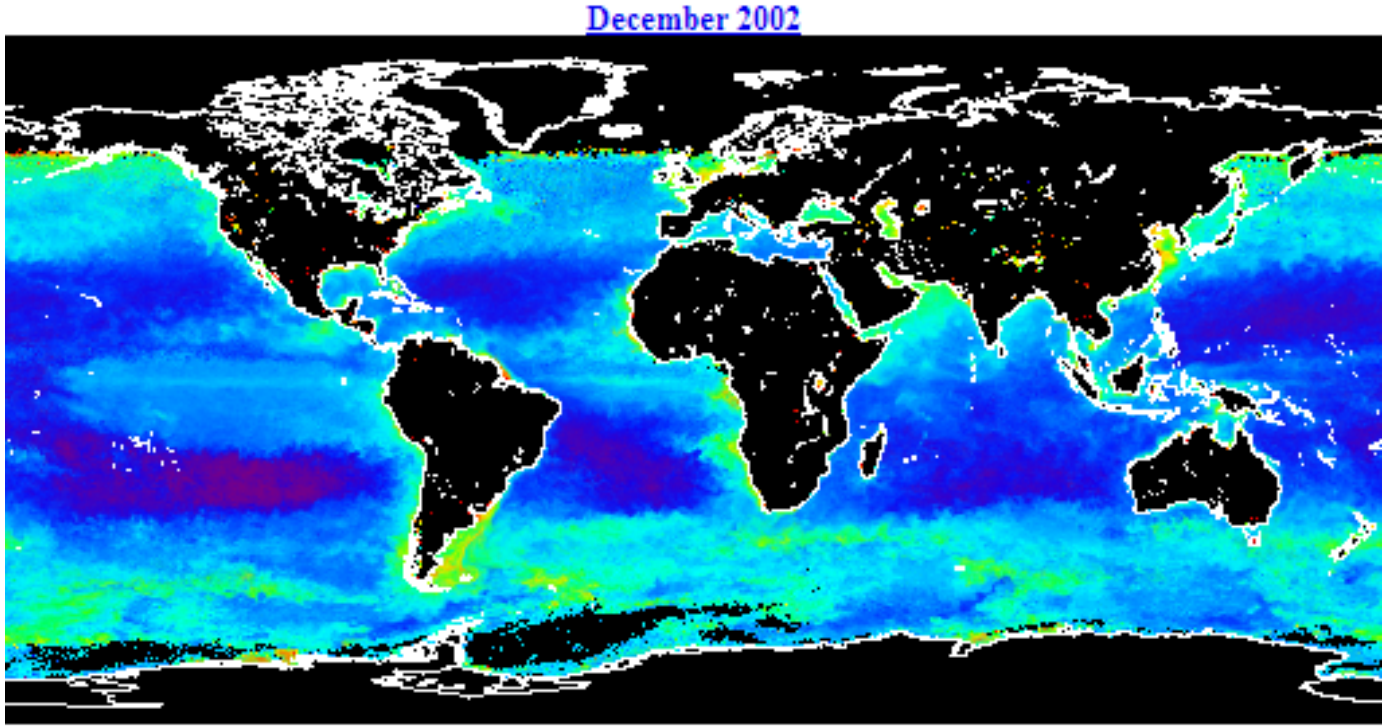
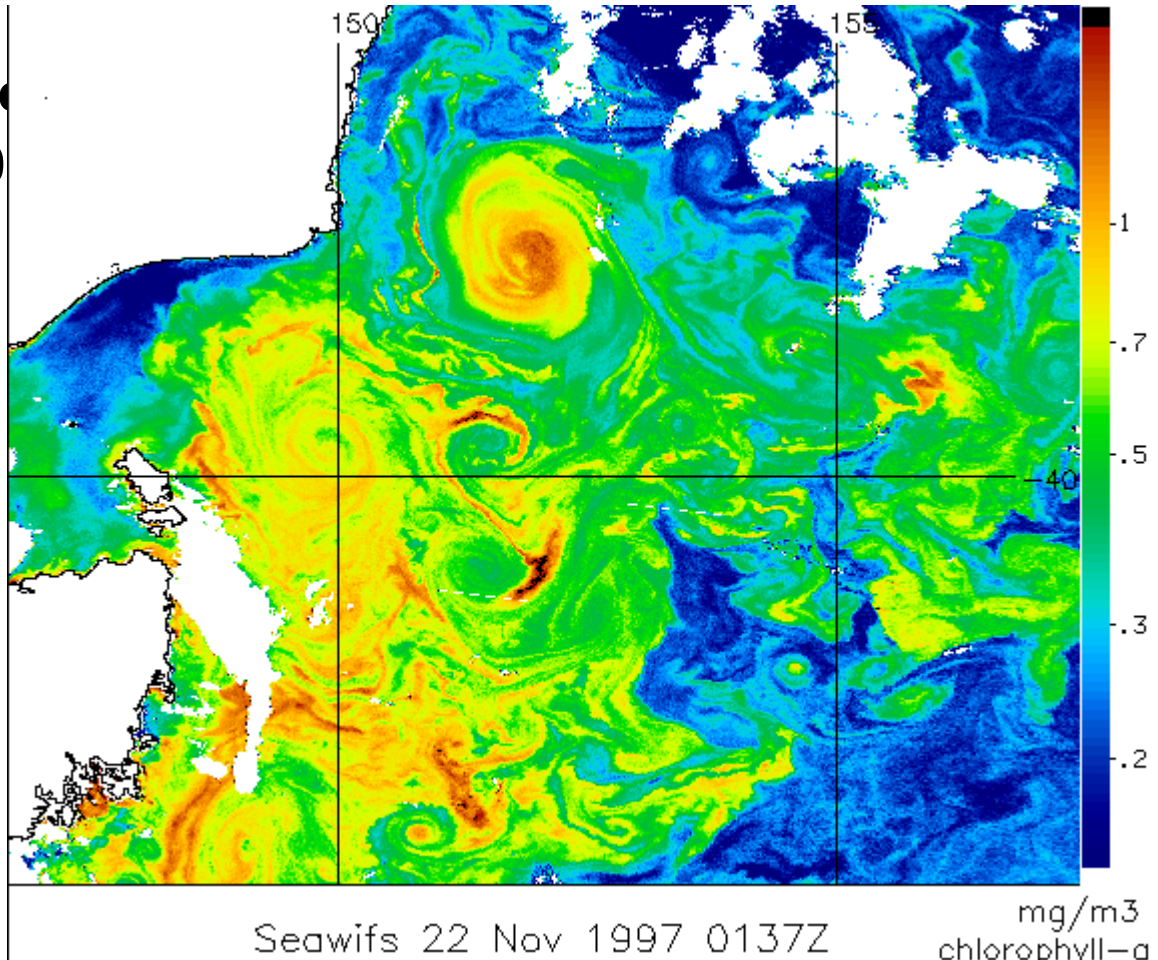


Remember trade-offs in *space*, *time*, *wavelength* etc.

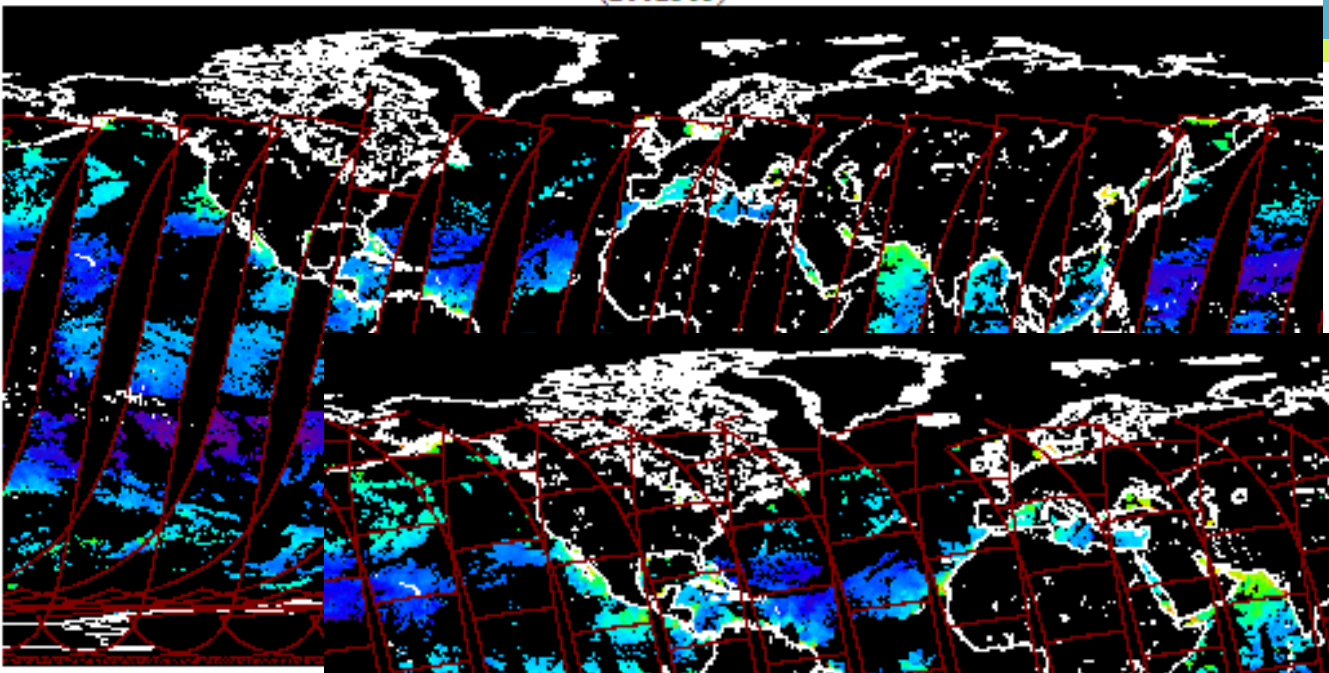
- **SeaWiFS** (Sea-Viewing Wide Field-of-View Sensor)
  - Designed for **ocean**
  - 1km resolution, 2800



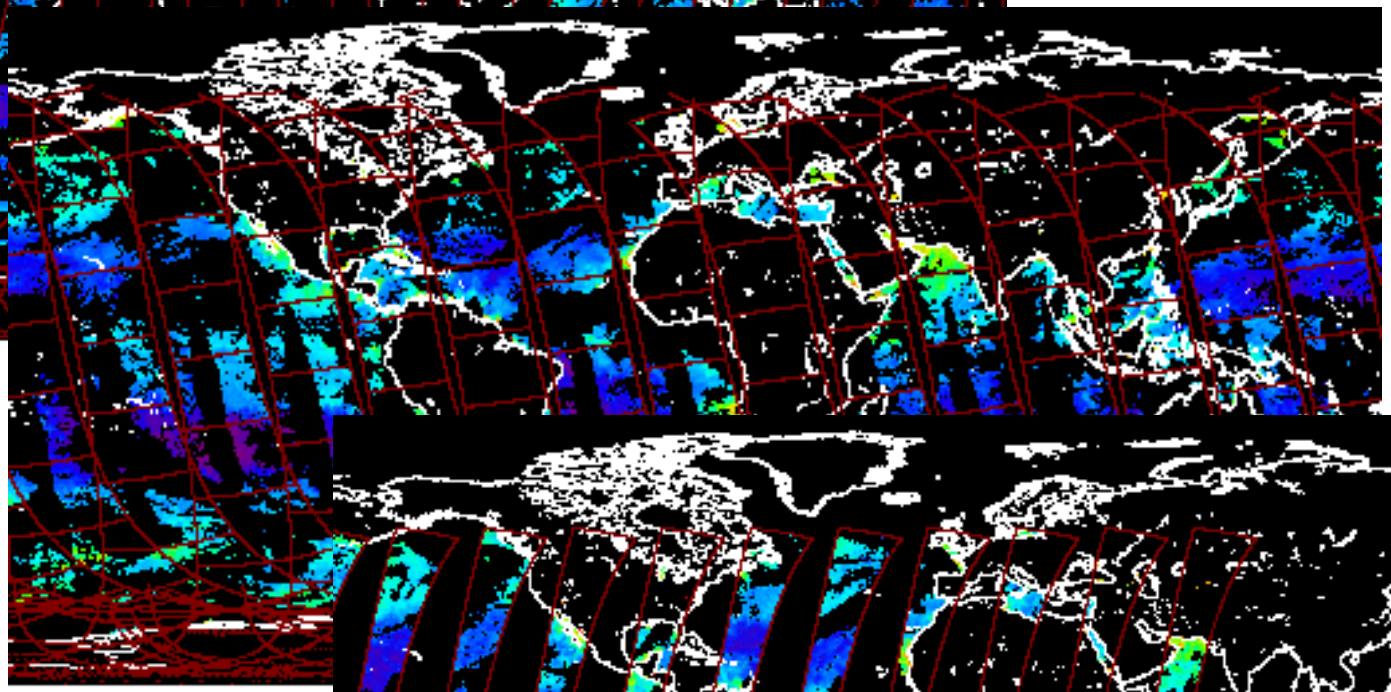
Tuesday, 31 December 2002
(2002365)

UCL

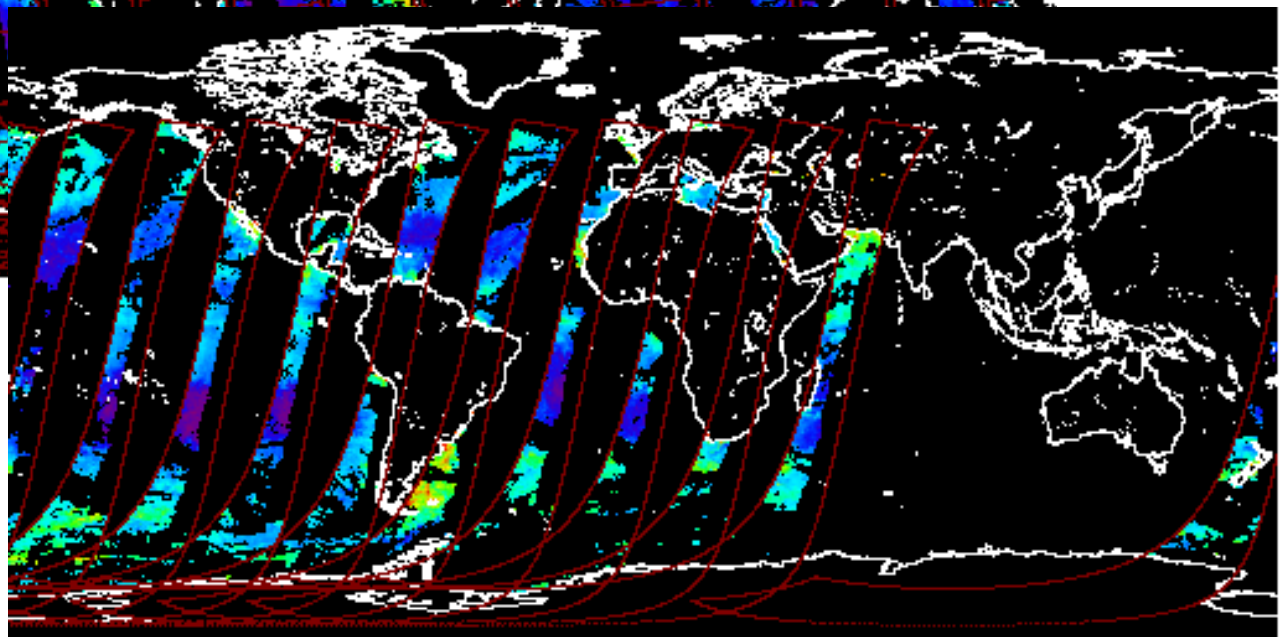
http://oceancolor.gsfc.nasa.gov/cgi/browse.pl



SeaWiFS



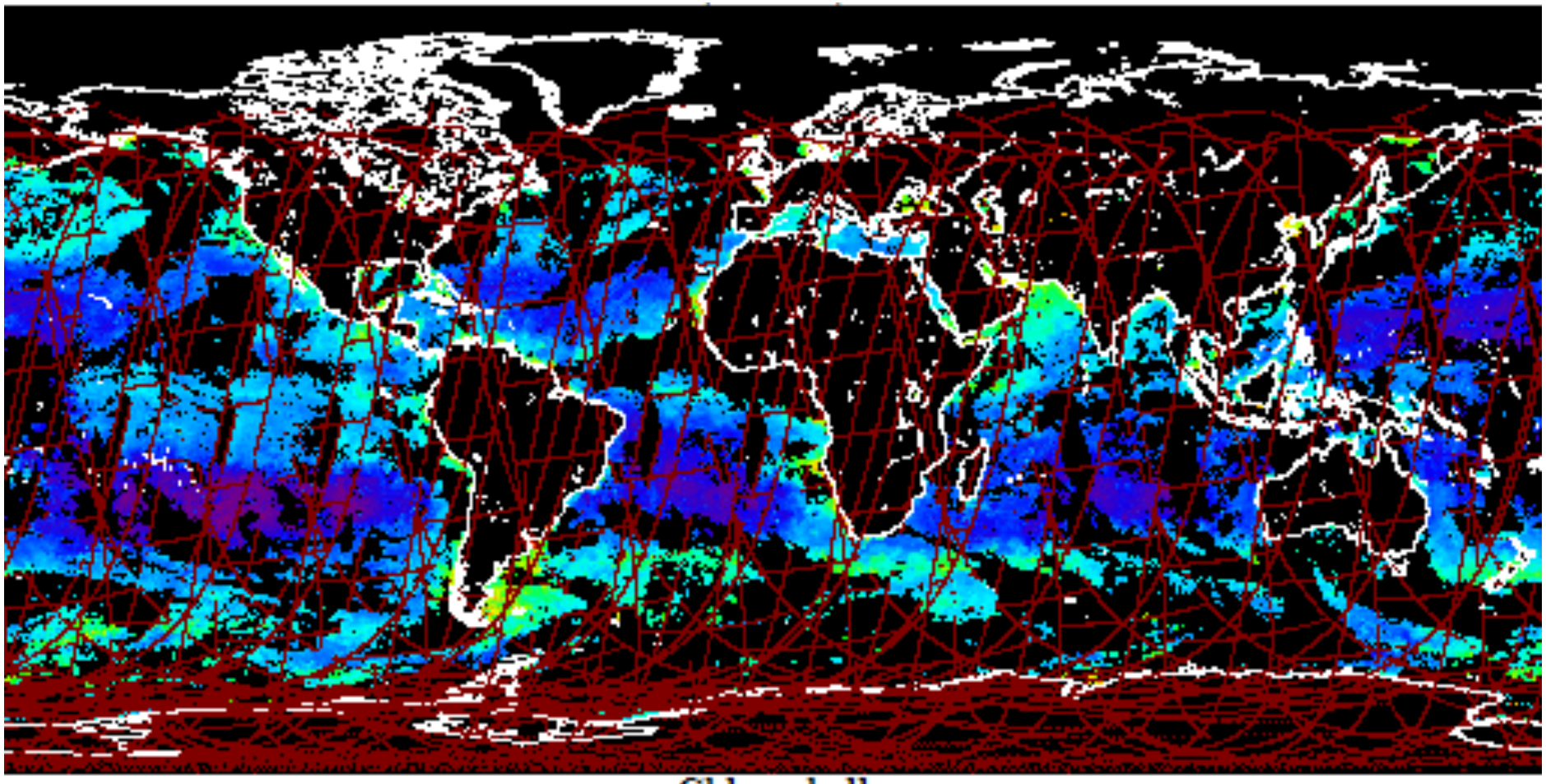
MODIS



MERIS

Combined Chlorophyll (Ocean Colour)

Combined SeaWiFS, MODIS, MERIS Dec 31, 2002



Remember trade-offs in *space*, *time*, *wavelength* etc.

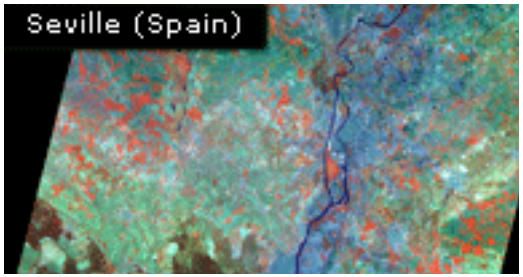
MERIS image of Californian fires, October 2007

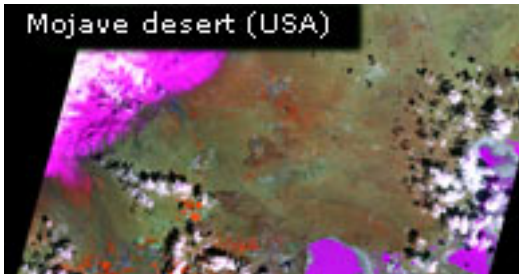
Remember trade-offs in space, time, wavelength etc.

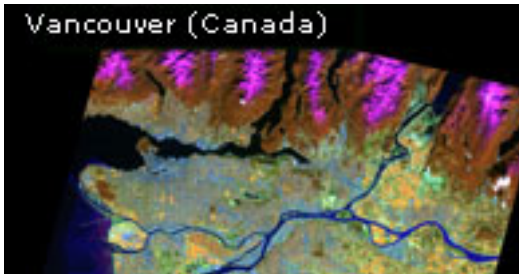
- Local to regional
  - Requires much higher spatial resolution (< 100m)
  - So typically, narrower swaths (10s to 100s km) and longer repeat times (weeks to months)
  - E.g. LandSat (polar orbit)
    - 28m spatial, 7 bands, swath ~185km, repeat time nominally 16 days BUT optical, so clouds can be big problem
  - E.g. IKONOS (polar orbit)
    - 0.5m spatial, 4 bands, swath only 11 km, so requires dedicated targeting

Remember trade-offs in space, time, wavelength etc.

- SPOT 1-4
  - Relatively high resolution instrument, like Landsat
  - 20m spatial, 60km swath, 26 day repeat



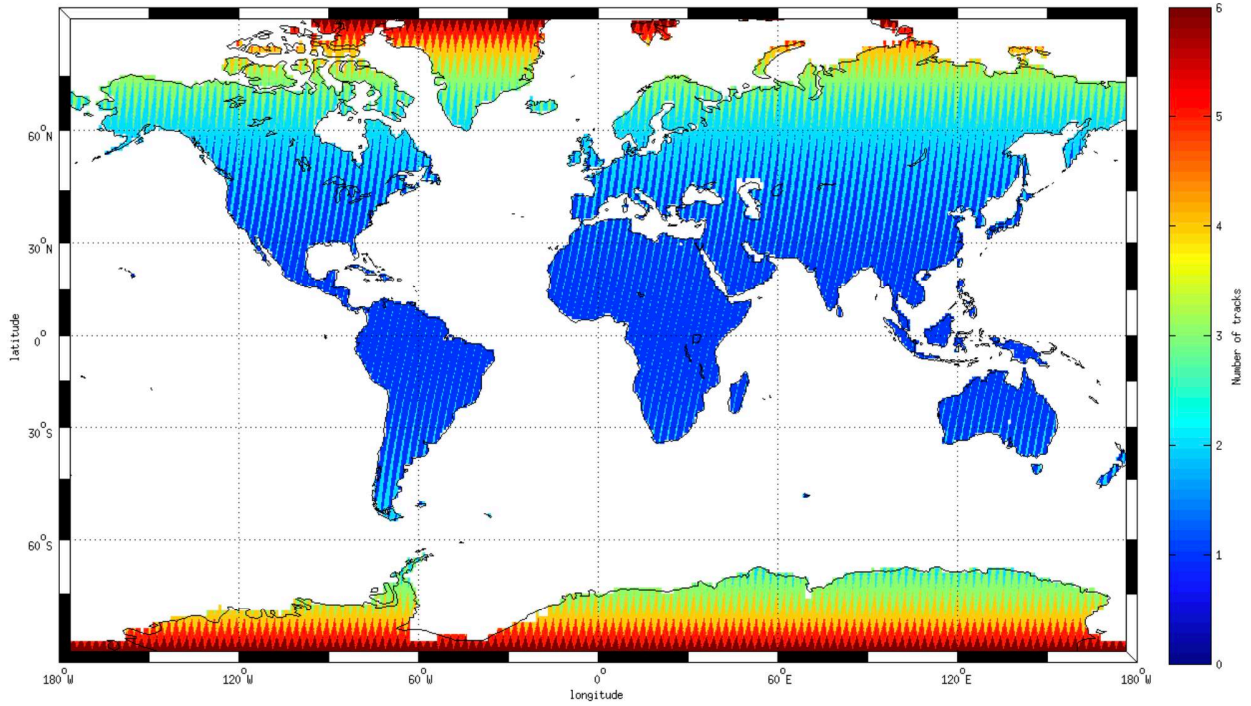




- IKONOS, QuickBird
  - Very high resolution (<1m), narrow swath (10-15km)
  - Limited bands, on-demand acquisition

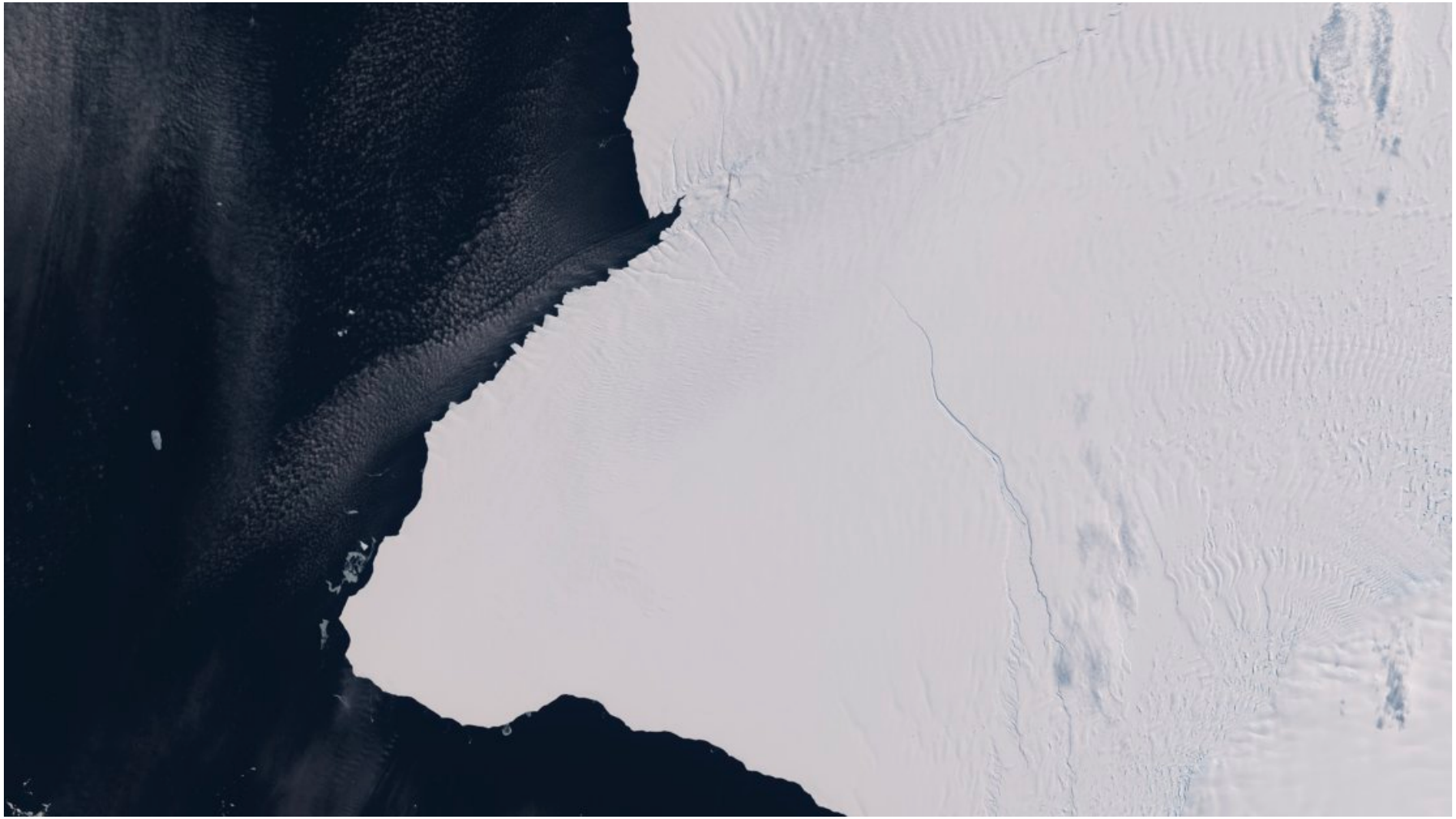
Remember trade-offs in space, time, wavelength etc.

Sentinel-2 *(5 day revisit, 290 km swath, 10, 20 & 60 m resolution)*



Geometric revisit frequency due to the overlap between adjacent orbits (Credits: Pascal Lacroix)

Antarctica’s Brunt ice shelf



RADAR revisit

- What does RADAR backscatter measure?
  - Why speckles?
- E.g. ERS-SAR
  - operates in C band, detects changes in surface heights
  - near-polar, orbit100 min, repeat 35 days, swath 100km

RADAR

- Parameters affecting radar backscatter?
  - Influence of frequency, polarization, roughness, incidence angle, and moistures
- Advantages
  - All-weather
  - Day and night
- Readings:
  - http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9371
  - http://earth.esa.int/applications/data_util/SARDOCS/spaceborne/Radar_Courses/Radar_Course_III/parameters_affecting.htm

Summary

- Instrument characteristics determined by application
  - How often do we need data, at what spatial and spectral resolution?
  - Can we combine observations??
  - E.g. optical AND microwave? LIDAR? Polar and geostationary orbits? Constellations?

Live tracking of satellites

- Live LandSat image over N. America:
- http://earthnow.usgs.gov/