Accessing and working with Copernicus Marine data

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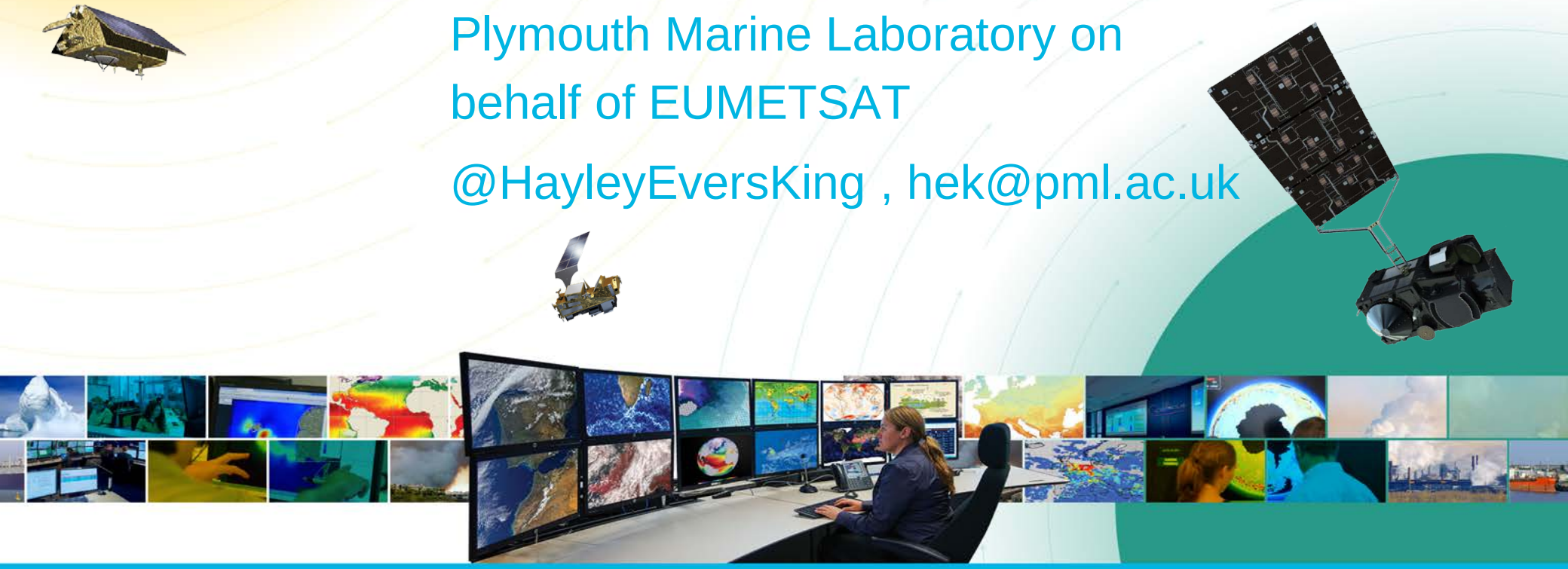
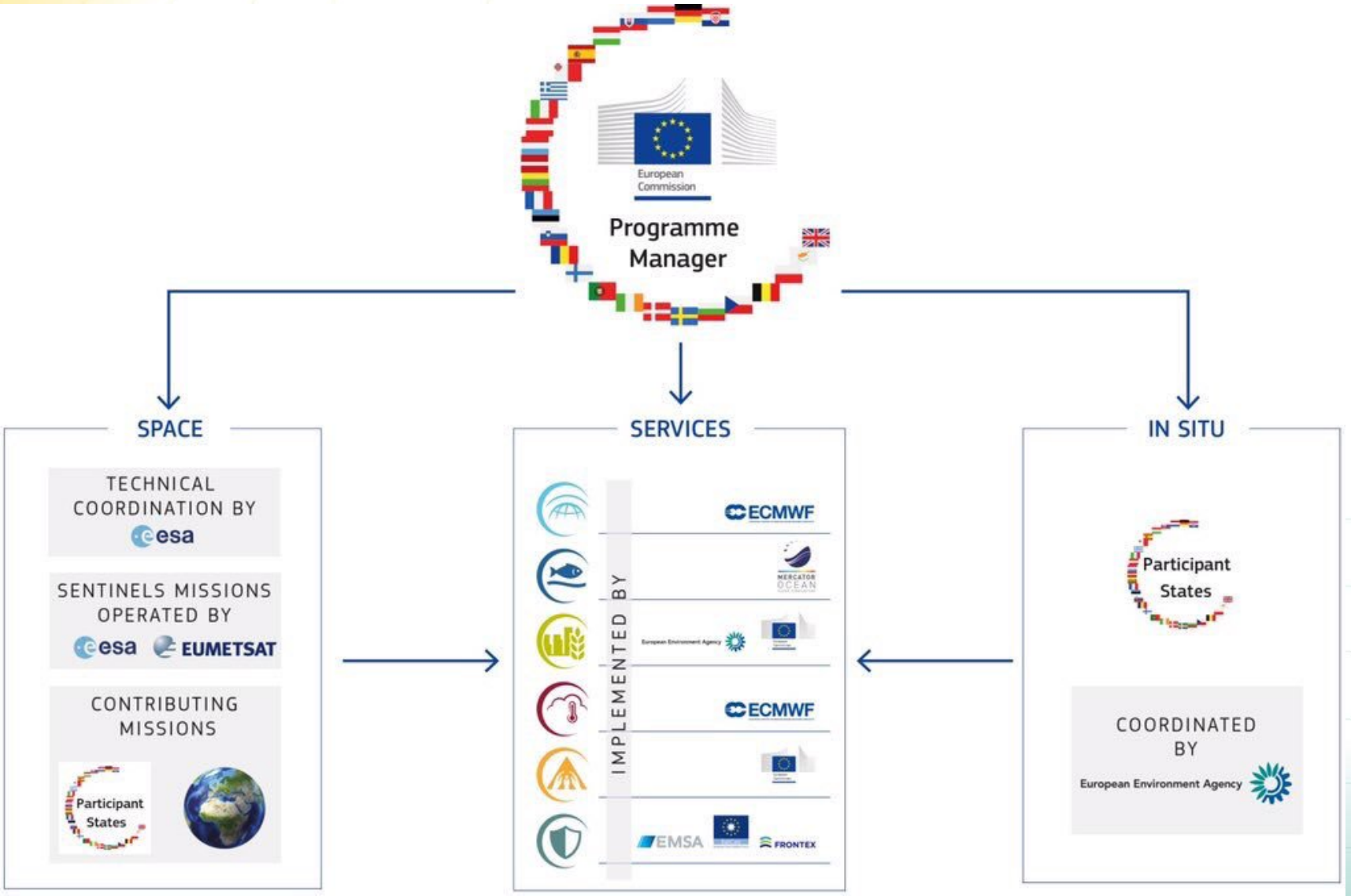


Overview

- Copernicus programme structure
- Sentinel 3:
  - Altimetry (SRAL)
  - SST (SLSTR)
  - Ocean Colour (OLCI)
- Data levels and selecting the right data for your work
- Practical

Copernicus Programme: free and open data!



European Commission
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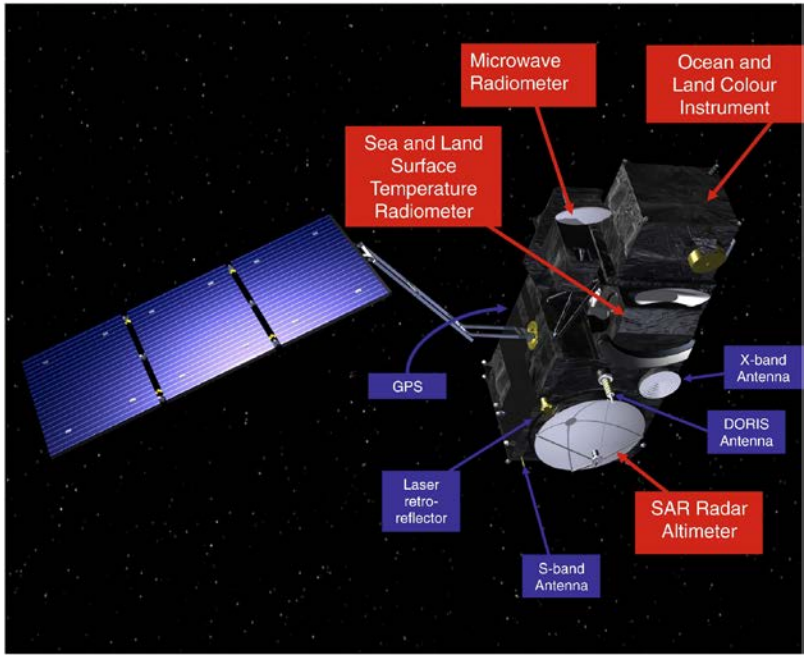
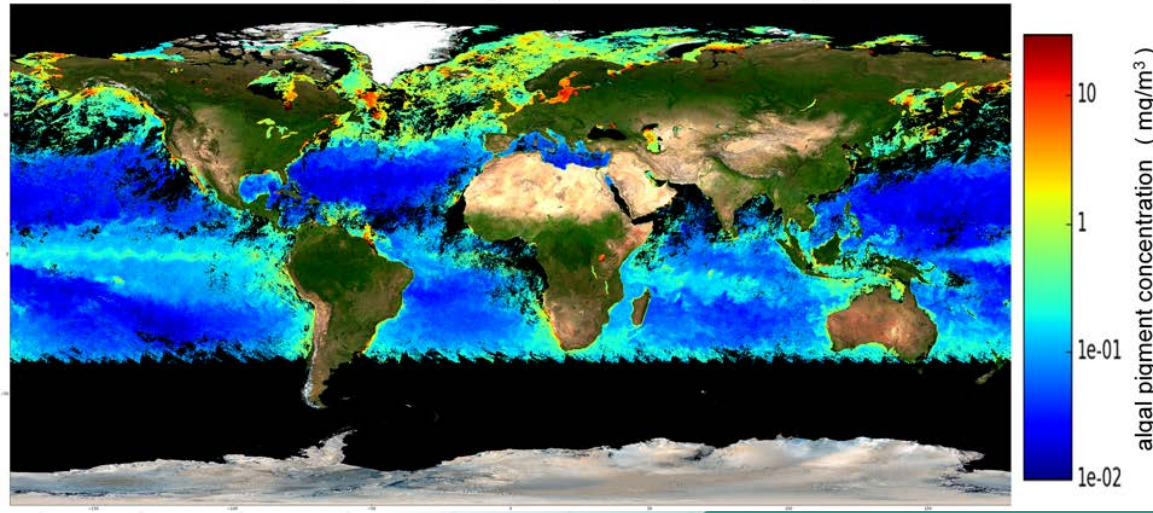
Copernicus – Sentinel 3 marine data

- Sentinel 3
  - SRAL (Altimetry)
  - OLCI (Ocean Colour)
  - SLSTR (SST)
- Builds on heritage but with improved resolution and sensors.
- 3a (since Feb 2016), 3b (launched 25th April)
  - Currently in ESA managed tandem phase
- Operated and marine data processed by EUMETSAT
- Many applications for ocean research and commercial operations.



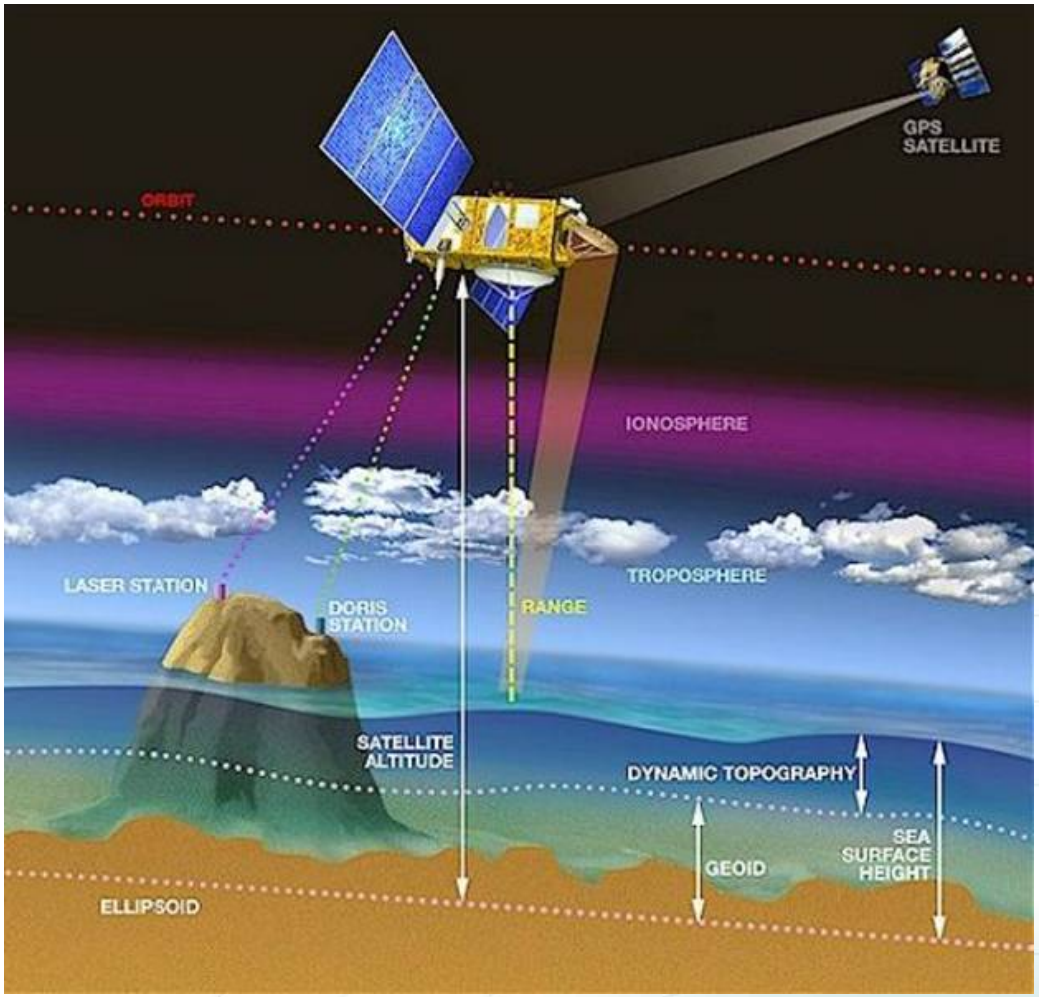
Sentinel-3A OLCI algal pigment concentration

14-27 June 2017, 14-day composite, OC4ME clear water algorithm



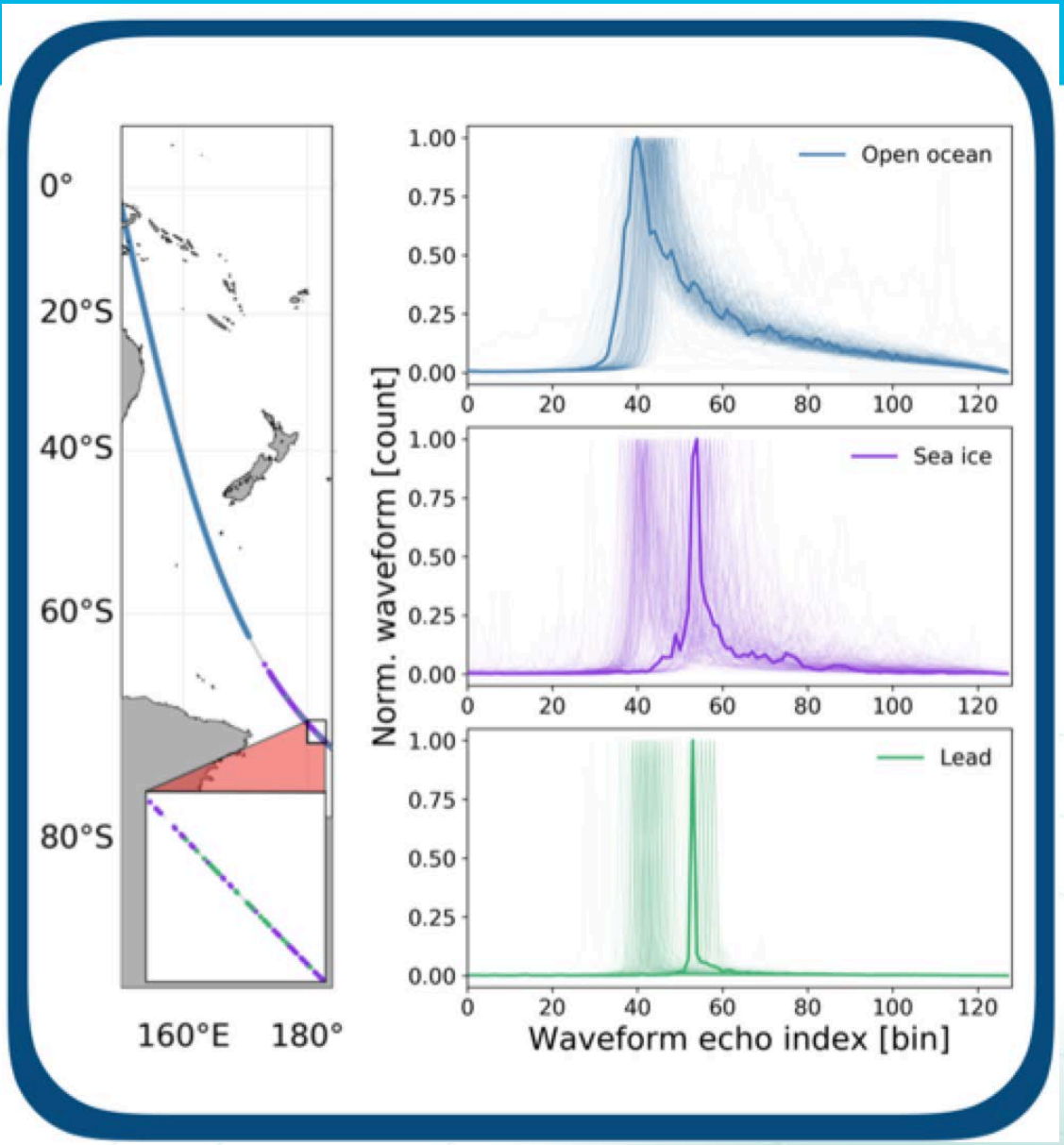
Theory - altimetry

- Altimeters measure sea surface height
- Time it takes for a radar pulse emitted from sensor to travel to surface, reflect, and be received by satellite.
- Low Resolution Mode (LRM) or delayed doppler (SAR) mode.
- Corrections for wet troposphere, dry troposhere, and ionosphere.
- Errors due to retracking, tides (esp on shelf) and fallible geoid characterisation



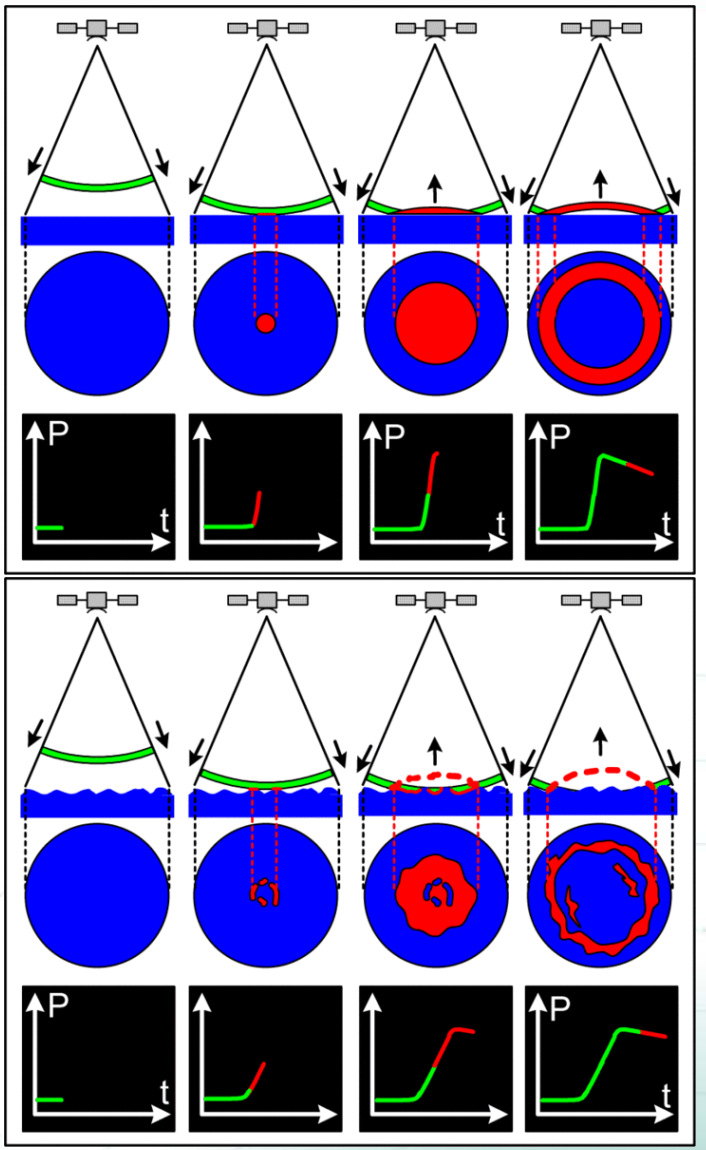
Altimetry products

- Products derived from the altimetry waveform:
  - Sea-surface height is the difference in distance between the range (R) and the satellite altitude (S), relative to a terrestrial reference frame.
    - Need satellite location with precision, plus reference ellipsoid.
    - Retracking to get accurate R based on multiple waveforms. Tracking varies for ocean, coast, sea ice.



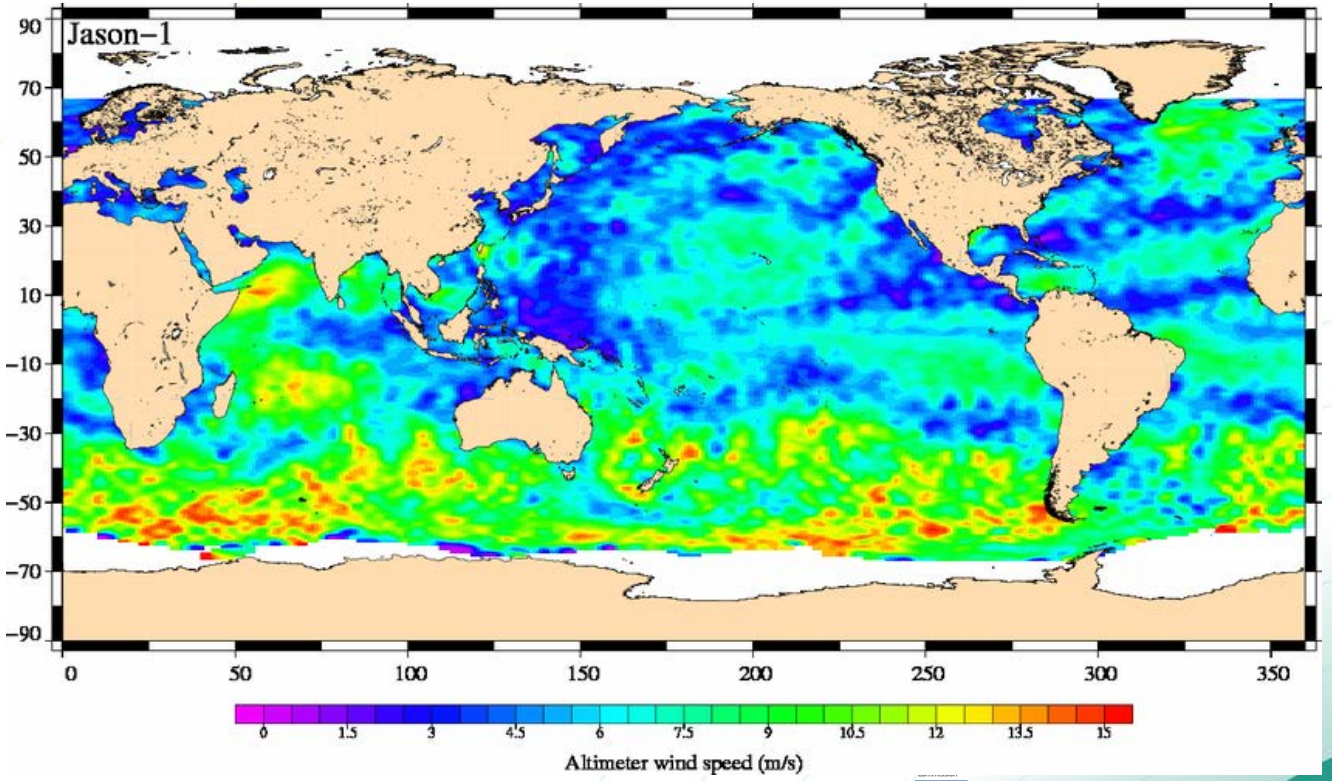
Altimetry products

- Products derived from the altimetry waveform:
  - Significant wave height: derived from the slope of the leading edge of the altimetry waveform
  - SWH = mean value of highest third of waves



Altimetry products

- Products derived from the altimetry waveform:
  - Wind speed (not direction) – wind affects the roughness which affects the backscatter of the radar pulse and the amplitude of the waveform.

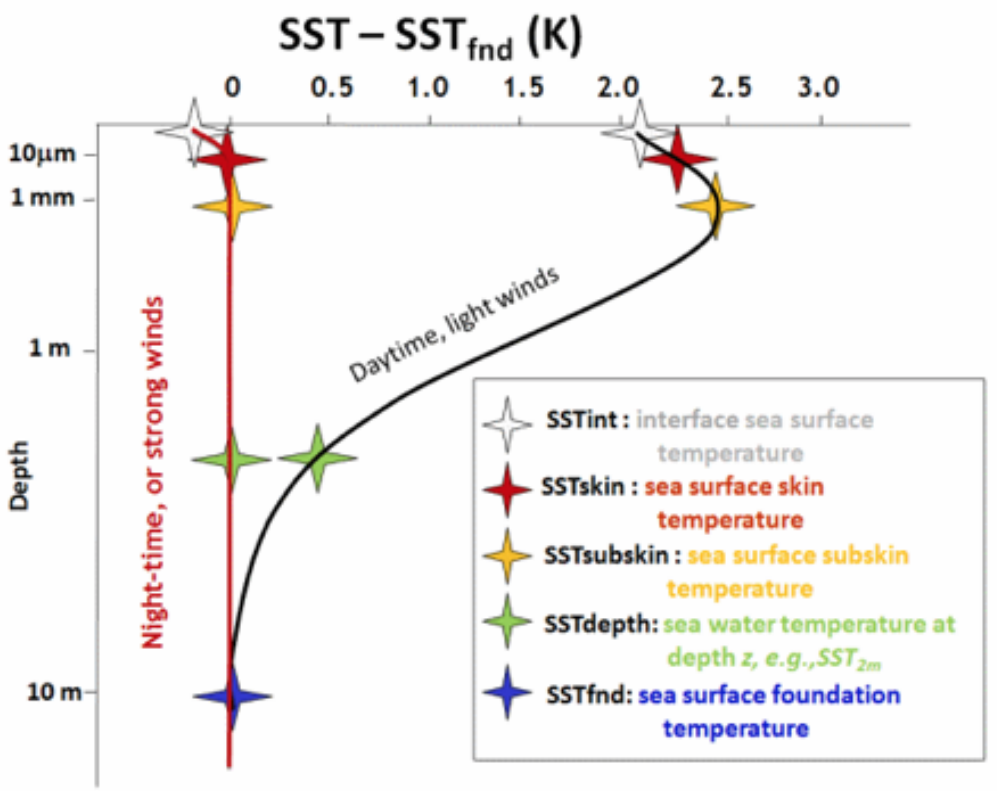


Sentinel 3 instruments: SRAL

- Synthetic aperture Radar ALtimeter (SRAL) on
  - Operates in SAR mode following Cryosat 2 legacy.
  - Improved resolution.
- Relies on highly accurate positioning (GNSS laser reflectors and DORIS)
- Improved retracking for coastal applications.
- More appropriate for ice measurements.

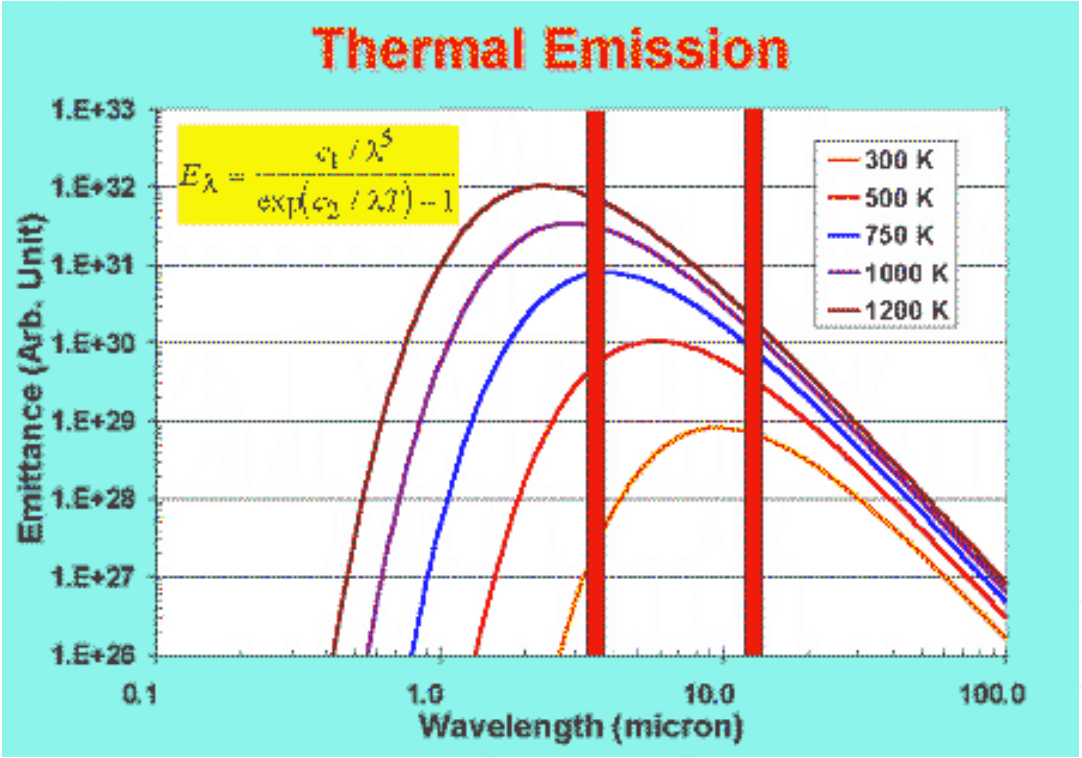
Theory - SST

- Measured by radiometers, as with ocean colour, but using infrared or microwave part of the spectrum.
- SST is a little tricky to define, and measured differently by different satellite and in situ sensors.
  - IR and microwave measure different SST.
- GHRSST for best community resources on SST: www.ghrsst.org



Theory - SST

- Microwave – can see through cloud but lower resolution (convergence of black body curves).
- Signal at sensor (once calibrated) = top of atmosphere brightness temperature.
- Must correct for atmosphere: newest approaches (e.g. SLSTR) use dual view.



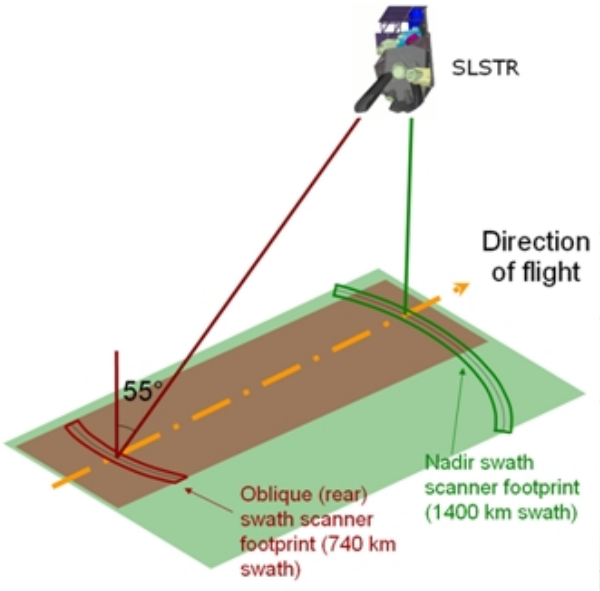
SST products

- Excellent intercomparison of two types of SST here: http://www2.hawaii.edu/~jmaurer/sst/

- Merged SST products also exist. E.g.
  - GHRSST-PP
  - NASA MUR
  - Seek to get benefit of coverage/resolution/accuracy from combining both TIR and microwave

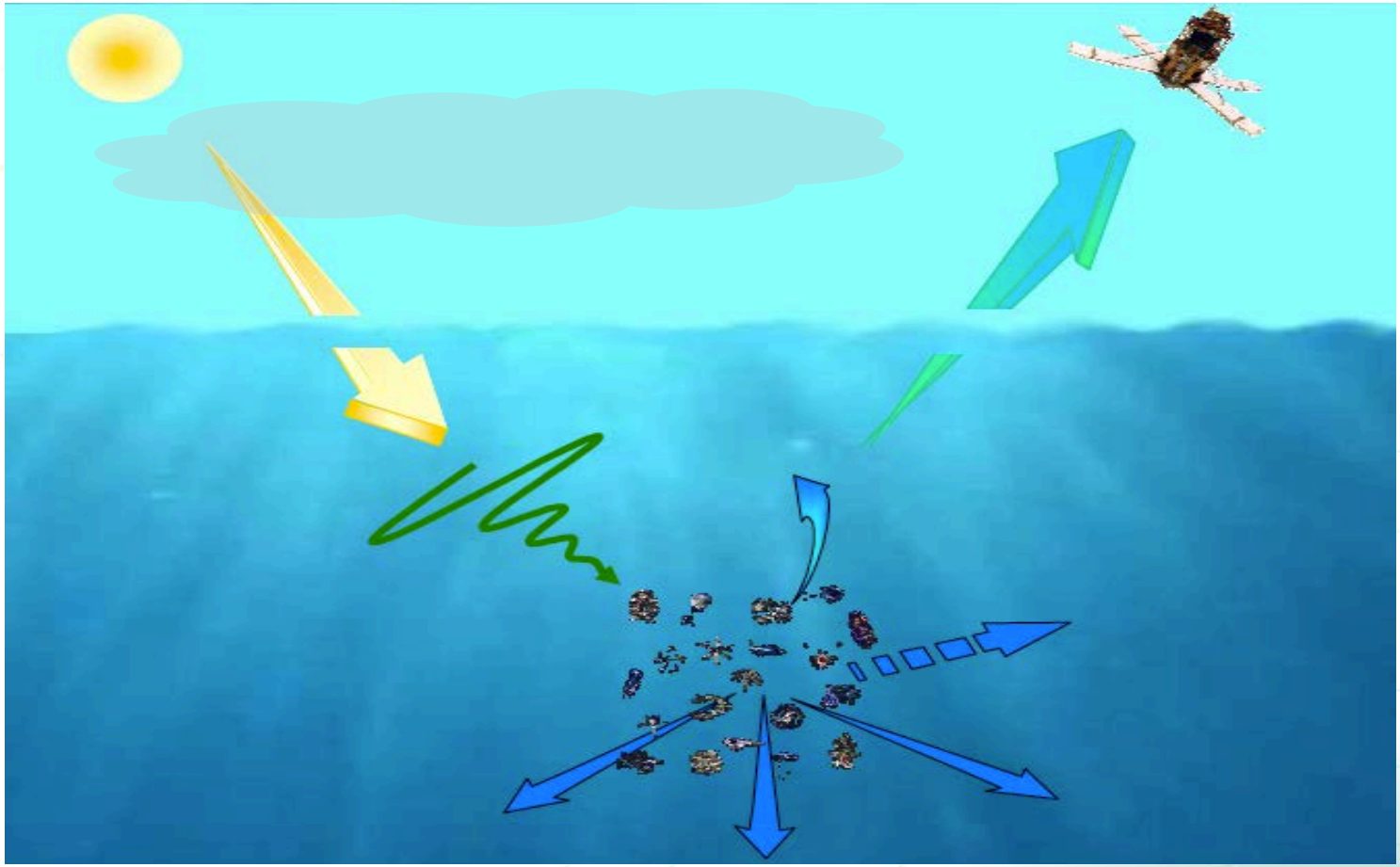
Sentinel-3 instruments: SLSTR

- Sea and Land Surface Temperature Radiometer
  - Dual view (better atmospheric correction)
  - 1km resolution
  - Two on board black bodies for calibration.
    - Accurate for each measurement
  - Highly stable cooled detectors
    - Use as a reference sensor for climate studies

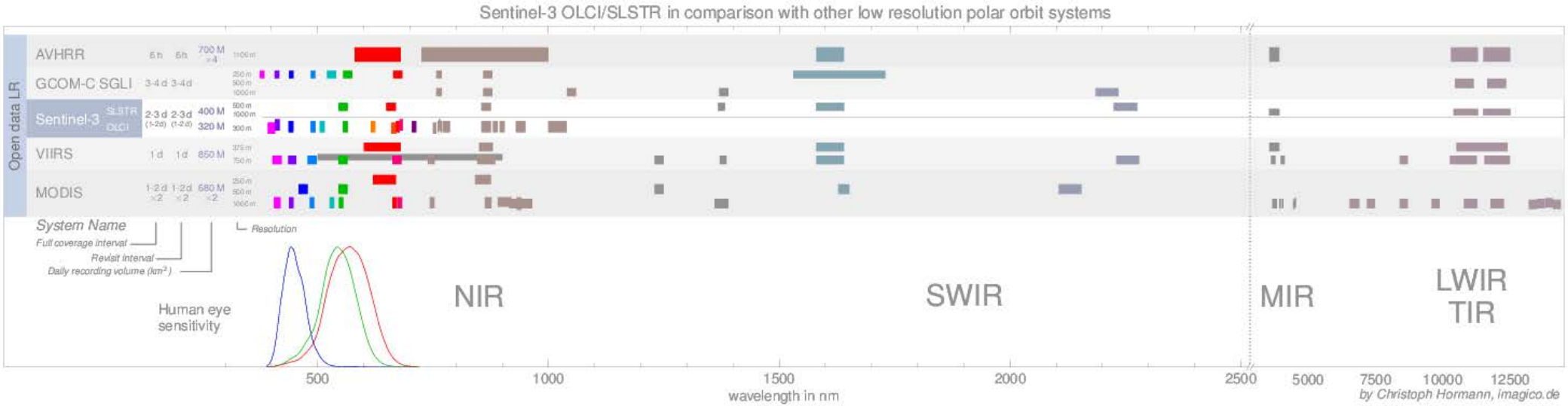


Theory – Ocean Colour

- Covered earlier this week!



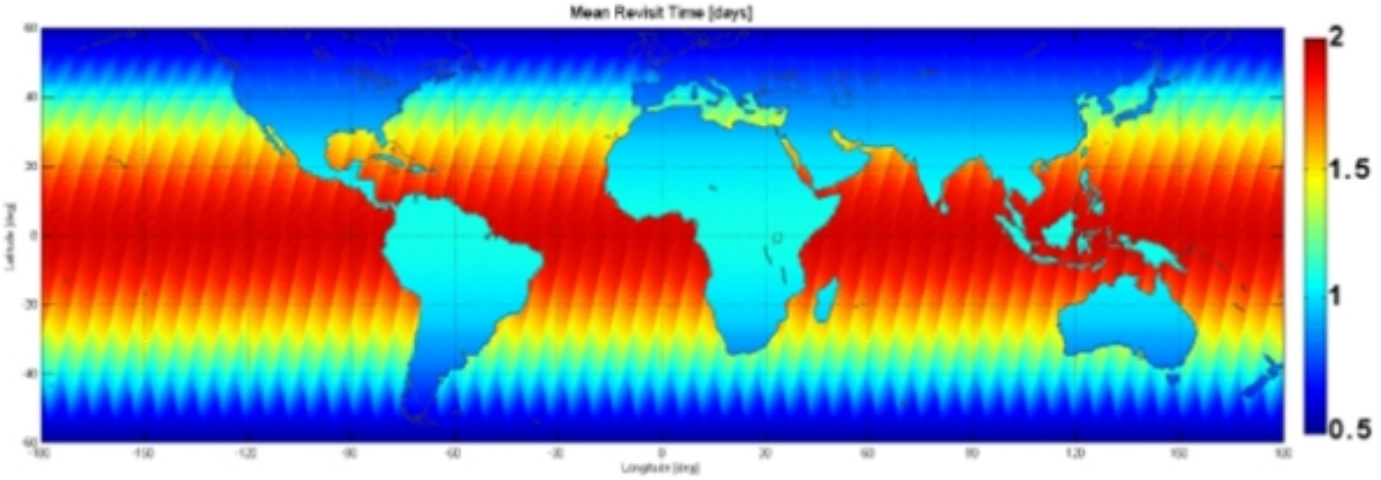
Sentinel-3 instruments: OLCI



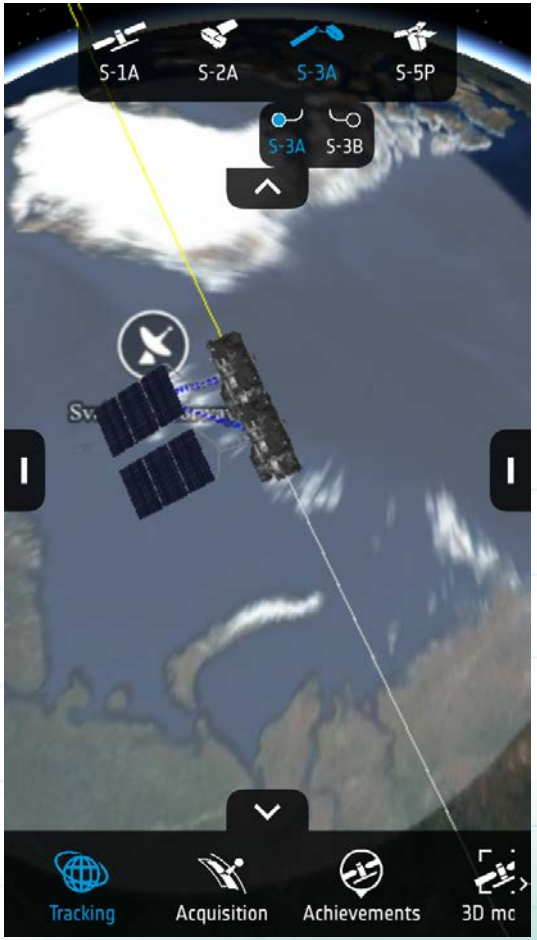
- OLCI global FR at 300m
- 21 spectral bands

Sentinel 3a and 3b

- Double the data – better revisit time.
- Redundancy
- Opportunities for intercalibration
  - Currently in tandem phase
  - Test data available through S3VT



Copernicus Sentinel app



Processing Levels

Processing Level	Description
Level 0	*Reconstructed, unprocessed instrument and payload data at full resolution, with communications artefacts removed.*
Level 1 (a not always available)*	*Reconstructed, unprocessed instrument data at full resolution, time-referenced, and annotated with ancillary information.*
Level 2	Derived geophysical variables at the same resolution and location as Level 1 source data.
Level 3	Variables mapped on uniform space-time grid scales, usually with some completeness and consistency.
Level 4	Model output or results from analyses of lower-level data (e.g., variables derived from multiple measurements/gap filled).

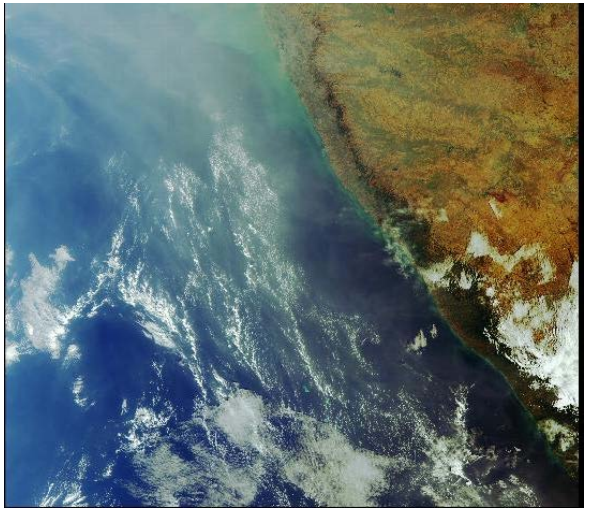
General notes on formats/timeliness

- SAFE format
  - Folder containing NetCDF files.
  - Also manifest file (.xml)
  - Can download individual files or all
- Timeliness:
  - NRT – Near Real Time
  - STC – Short Time Critical
  - NTC – Non Time Critical

Which data are best for me?

Level 1

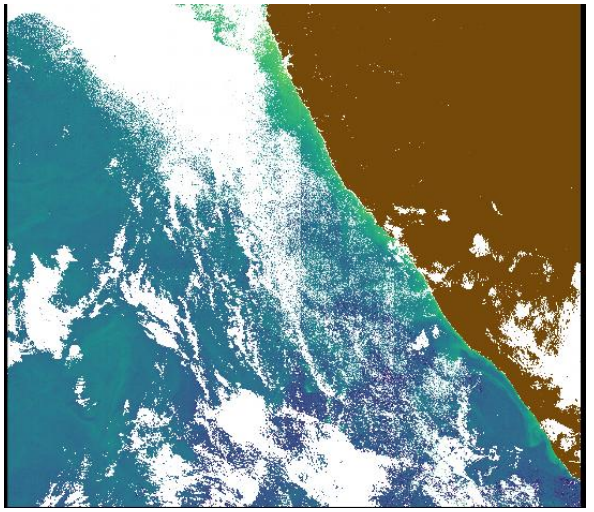
- **Advantages**
  - Gives you the most control over processing (regionalisation)
  - Makes visually pleasing ‘real’ pictures
- **Disadvantages**
  - Not the ‘water leaving’ signal
  - Need advanced knowledge of satellite processing to get usable data/products
  - Processing to level 2 is computationally expensive and requires a fair amount of programming skill (more tools becoming available).



Level 1 OLCI image of the West Coast of India from EUMETSAT CMDS

Level 2

- **Advantages**
  - Atmospheric correction already applied - actual ocean signal
  - Land pixels removed (for ocean data)
  - Still at the same high resolution offered by L1 data
  - Geophysical products – e.g. Chlorophyll, SST, SSH, SWH, WS.

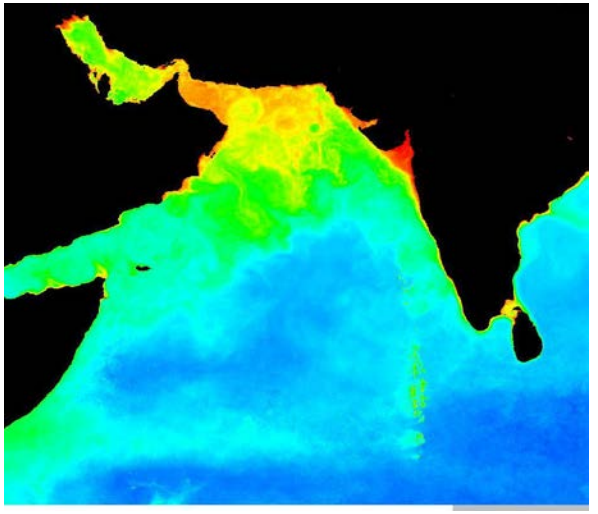


Level 2 OLCI image of the same granule from EUMETSAT CMDS

- **Disadvantages**
  - Large file sizes
  - Non-uniform grid makes visual comparisons difficult
  - A.corr etc not always regionally appropriate
  - Can remove data you might want!

Level 3

- **Advantages**
  - Mapped onto a predefined spatiotemporal grid
  - Easily make comparisons between different points in time
  - Some merged products – easier to use/more consistent

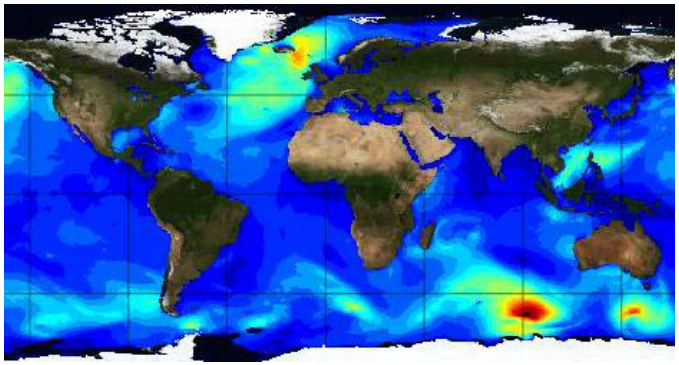


ESA OC-CCI level 3 monthly chlor-a composite (also in CMEMS)

- **Disadvantages**
  - Usually lower spatial resolution than L1/L2 data - some detail lost
  - Projected maps are inherently inaccurate
  - Not everyone uses the same grid
  - Products more generic, hard to create your own.

Level 4

- **Advantages**
  - Very few/no gaps in the data
  - Useful for some statistical analysis methods that don't cope well with gaps
  - Broad definition includes forecasting - safety implications



CMEMS Level 4 wave field forecast data

- **Disadvantages**
  - Data output from models generally has higher uncertainty
  - Gap filled data may look convincing but sometimes tells the wrong story

Some places to access these data

- **Level 1 and 2**
  - Recent data (last 12 months)
    - CODA (EUMETSAT): https://coda.eumetsat.int/ (requires registration)
    - CODA rep for reprocessing
  - Older data
    - EUMETSAT Data Centre: https://www.eumetsat.int/website/home/Data/DataDelivery/EUMETSATDataCentre/index.html
- **Level 3**
  - Ocean Colour CCI (ESA): https://oceancolour.org
- **Level 3 and 4**

  Copernicus Marine Ecosystem Monitoring Service: http://marine.copernicus.eu/ (also requires registration)

NOTE: Sentinel 2 data comes from a different hub as the data is processed and distributed by ESA ☺

Advanced ways to get the S3 marine L1/L2 data

- **CODA batch download**
  - Currently only supports Linux systems
  - Allows automated downloading of multiple files
  - Specific instructions can be found in the CODA User Manual (Pg. 35)
    - https://coda.eumetsat.int/manual/CODA-user-manual.pdf
- **EUMETCAST Satellite Link**
  - Secure delivery of data via encrypted satellite link
  - Extremely useful in areas with difficulties accessing the internet
  - Not as expensive as it sounds
  - https://www.eumetsat.int/website/home/Data/DataDelivery/EUMETCast/index.html

Where to get help/get involved

- Help desk: contact ops@eumetsat.int
- Forum: http://forums.eumetsat.int/forums/forum/copernicus-marine-calval/
- Product handbooks/notices (see links in practical)
- Sentinel 3 validation team: https://earth.esa.int/web/guest/pi-community/apply-for-data/ao-s?IFRAME_SRC=%2Fpi%2Fesa%3Fcmd%3Daodetail%26aoname%3DS3VT%26displayMode%3Dcenter%26targetIFramePage%3D%252Fweb%252Fguest%252Fpi-community%252Fapply-for-data%252Fao-s

Opportunities through CMDS@EUMETSAT

- Further training opportunities: https://training.eumetsat.int/
- Funding for collaborative exchanges: https://www.eumetsat.int/website/home/TechnicalBulletins/Training/index.html
- Present your use of Copernicus data (support funding attached to conferences).

- Please feel free to reuse/share code etc provided here. We welcome suggestions and contributions to build sets of open source tutorials!

Practical session

- Main aims:
  - Look at how to download data from CODA: https://coda.eumetsat.int/
  - Work with data in SNAP/Python
  - Ask any questions!
- Documentation, code and test data here: http://bit.ly/COPIOCCG