Ocean Colour as a Climate data record: The cycle of research dataset development into climate service data

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Overview of Ocean Colour Climate Change Initiative

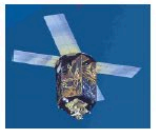
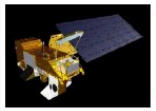
The OC-CCI dataset:

- Largest dataset of the ESA ECV catalogue (>90%)
- Contains over 90 variables
- Global coverage from 1997-near present
- 4km resolution with 1km resolution subsets available for testing purposes.

Processing chains developed in a research phase under OC-CCI now used for operational data processing for services such as CMEMS and Copernicus Climate Change Service (C3S).

CCI	Catalogue size (TB)
Aerosol	0.459
Cloud	0.212
GHG	0.103
Ozone	0.001
Ocean colour	209.2
Sea Ice	0.157
Sea Level	0.262
Sea State	0.545
SSS	0.046
SST	14.8
Ant IS	0.094
Biomass	0.289
Fire	0.239
Glaciers	0.00009
Green IS	0.006
Lakes	2.4
Land cover	0.068
PermaF	0.043
Snow	0.448
Soil Moist	0.124

Overview of Ocean Colour Climate Change Initiative

MERIS

SeaWiFS

MODIS

VIIRS 2012-present

Sentinel 3 2016-present

OC-CCI data processing

Atmospheric Correction using best algorithms for each sensor from round-robin comparison

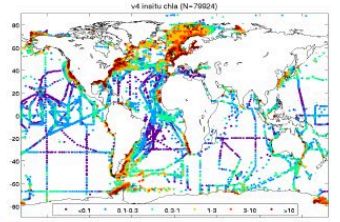
Band shifting, Merging, Bias Correction

Ocean products using best algorithms from round-robin comparisons

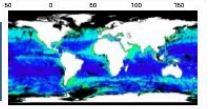
Unified multi-sensor Products

Quality Control and Scientific Analysis

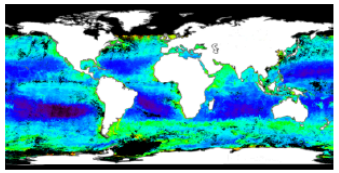
Global In-situ database



Uncertainty characterisation



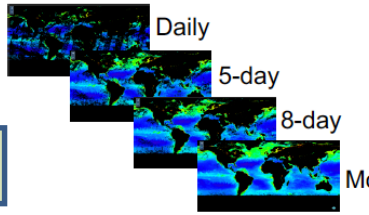
User Community



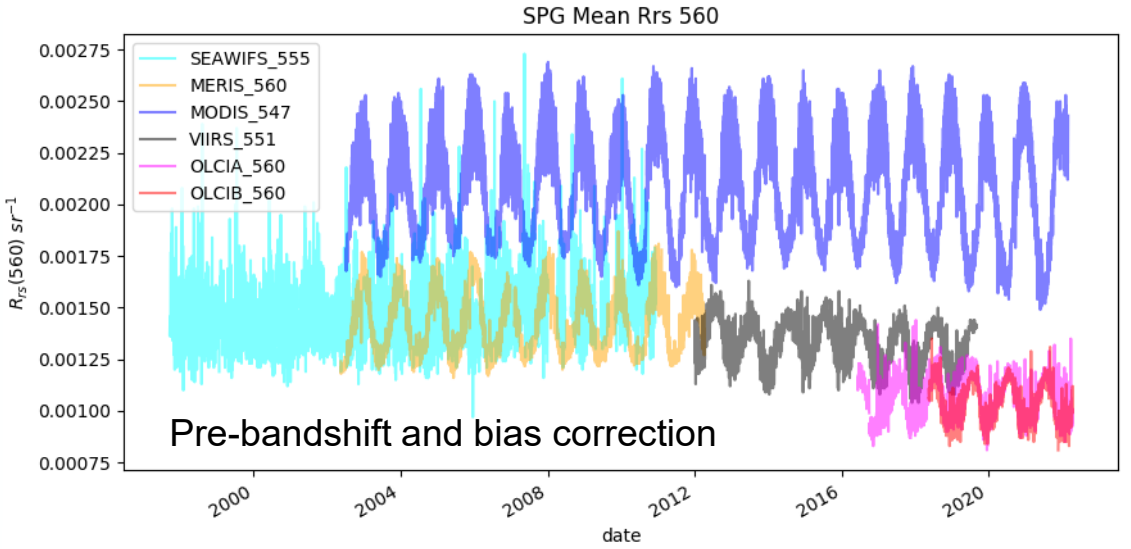
Modellers

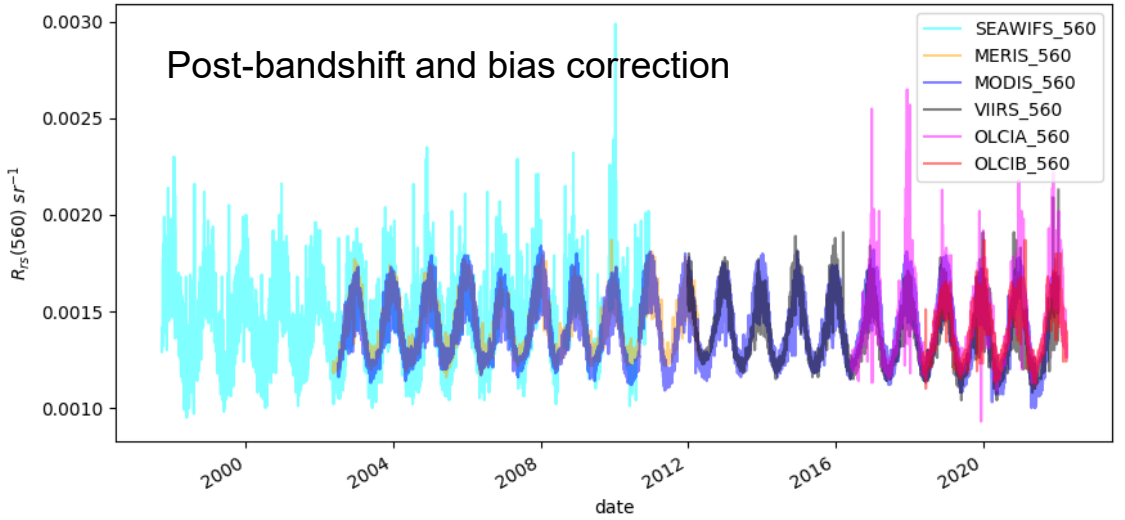
Oceanographic Scientists

Earth Observation Scientists



http://www.oceancolour.org/





Overview of Ocean Colour Climate Change Initiative

The OC-CCI project has spent ≅ decade working to create the highest quality climate data record (CDR) of the ocean colour Essential Climate Variable (ECV).

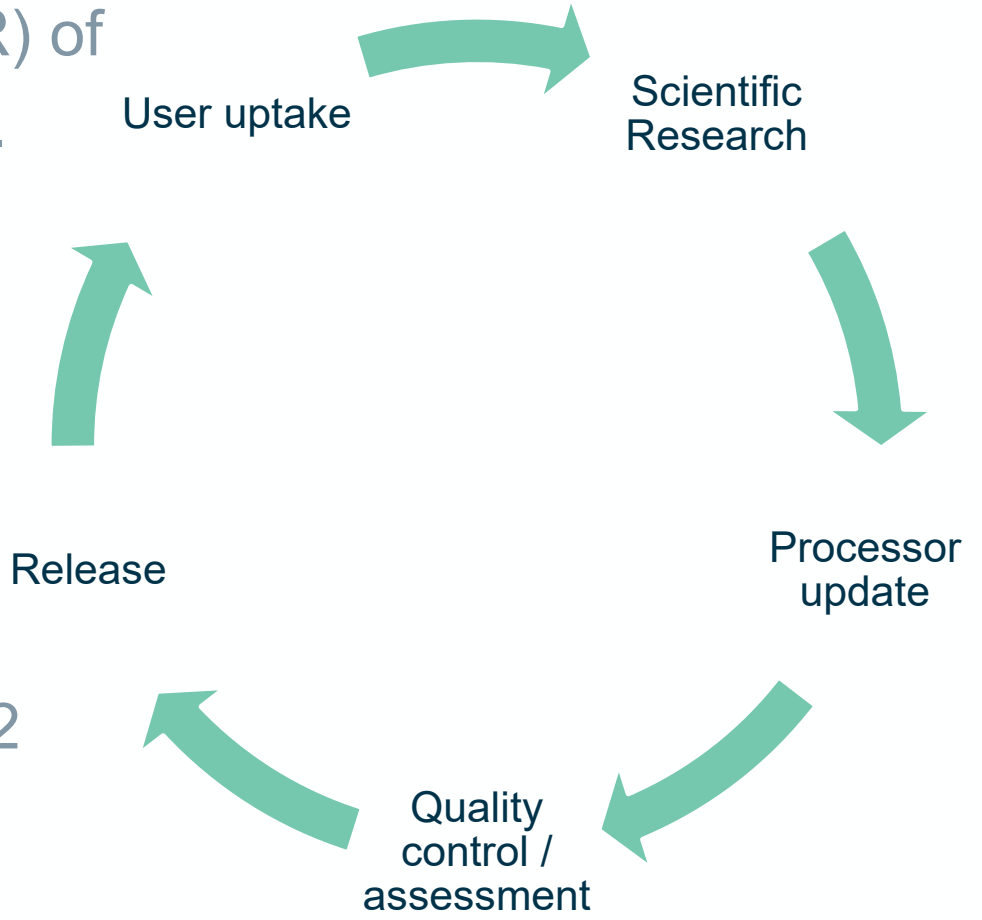
Cyclical process of improvement, release and feedback.

Six versions of the dataset created to-date

OC-CCI data used in > 180 publications

Impact through work such as IPCC working group 2

But the cycle continues!



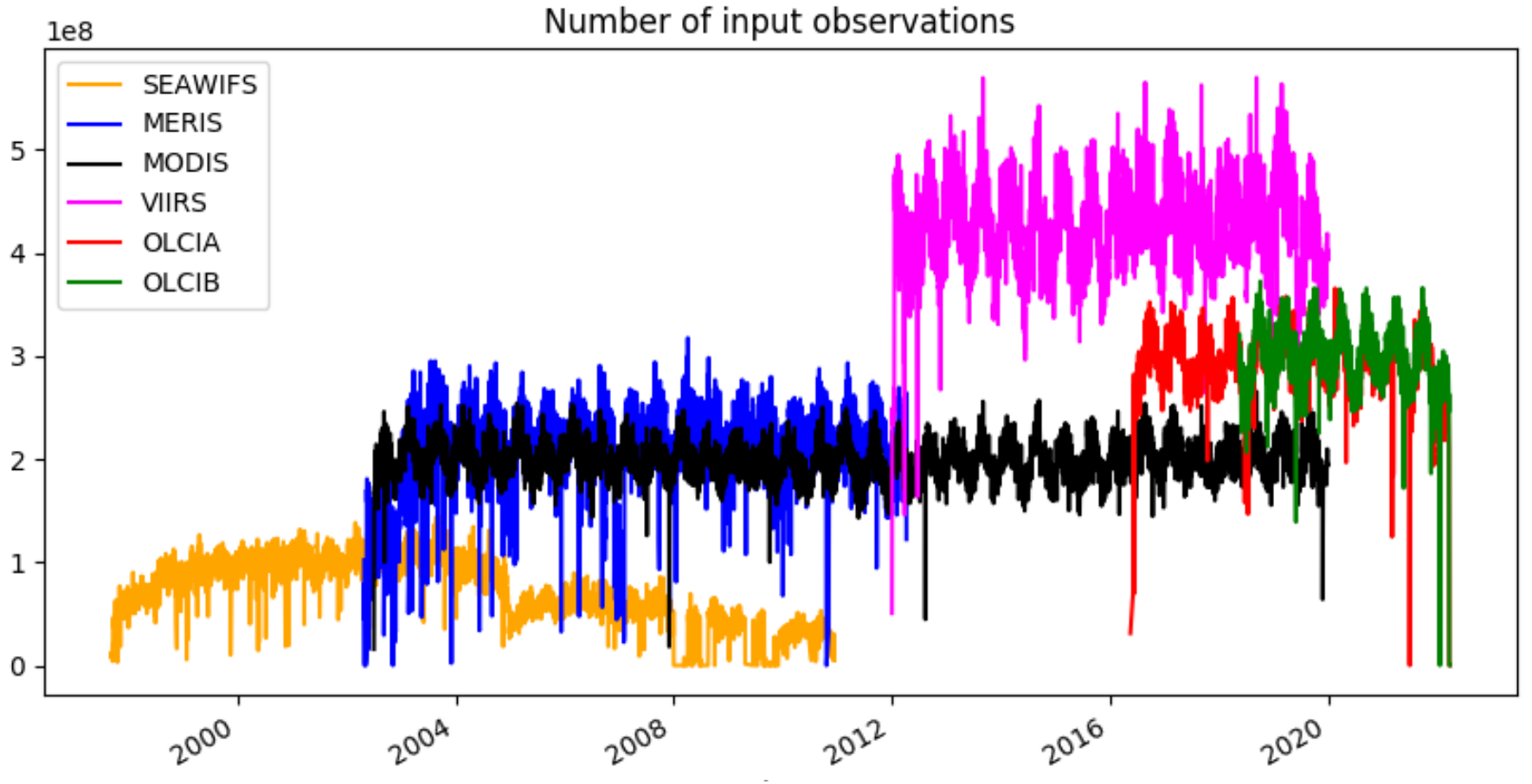
Transforming research into operational products

Required property/step	Approaches to help
1. Operationalization of research Algorithms	1. Open + clear communication between researchers and processing experts
2. Products/outputs tested exhaustively (and tests are ongoing with production)	2. Well designed (automated) mass data quality assessments plus tactical human checks.
3. Sufficient metadata and product/file standards	3. Early discussion with data-standards experts and review of user community needs and conventions.

Transforming research into operational products

If you think you have enough QC then you could probably do with more QC.

With datasets this large, “1-in-a-million” means that you (or a user) are going to run into “it” and “it” may be a significant problem.



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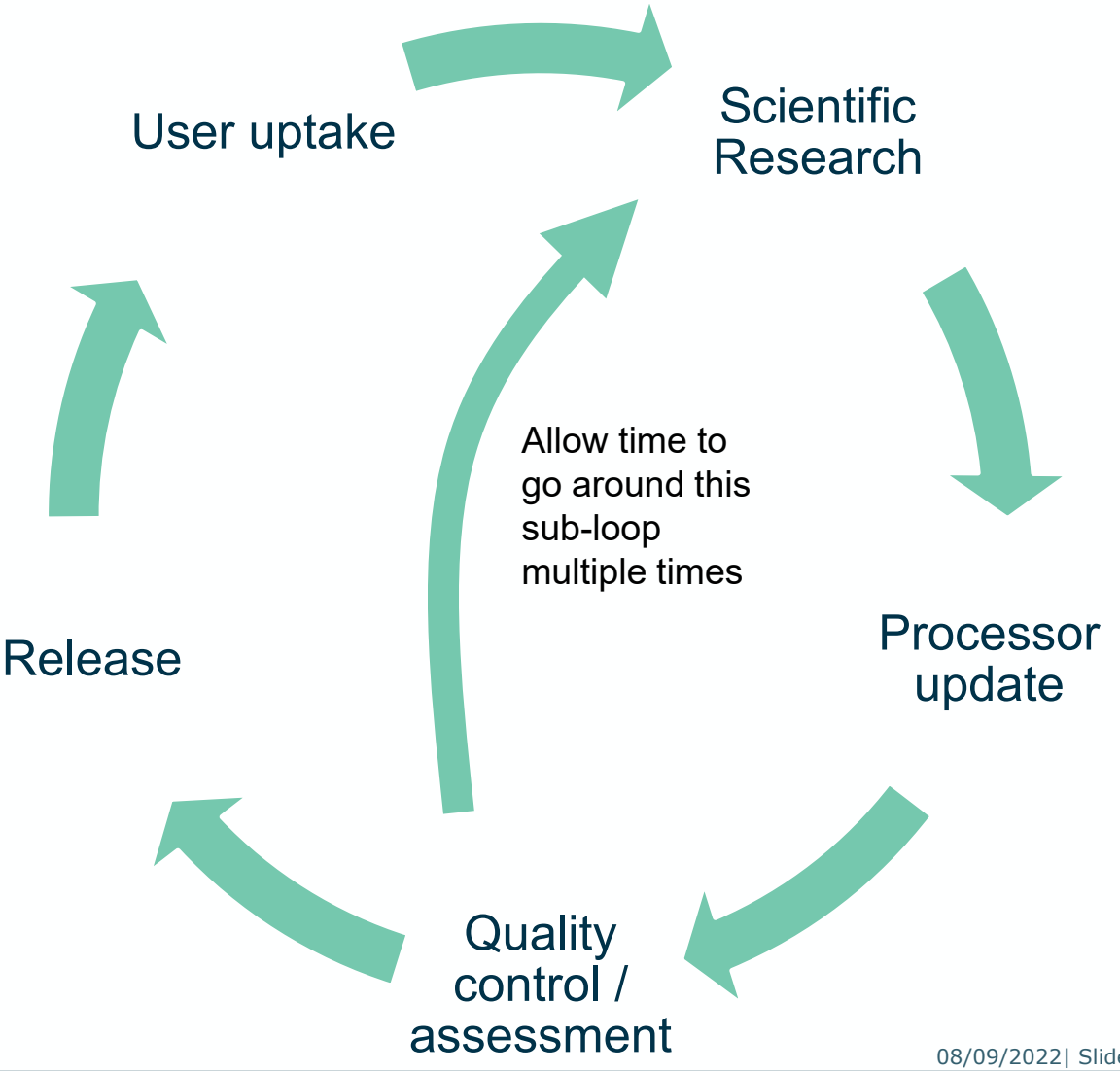
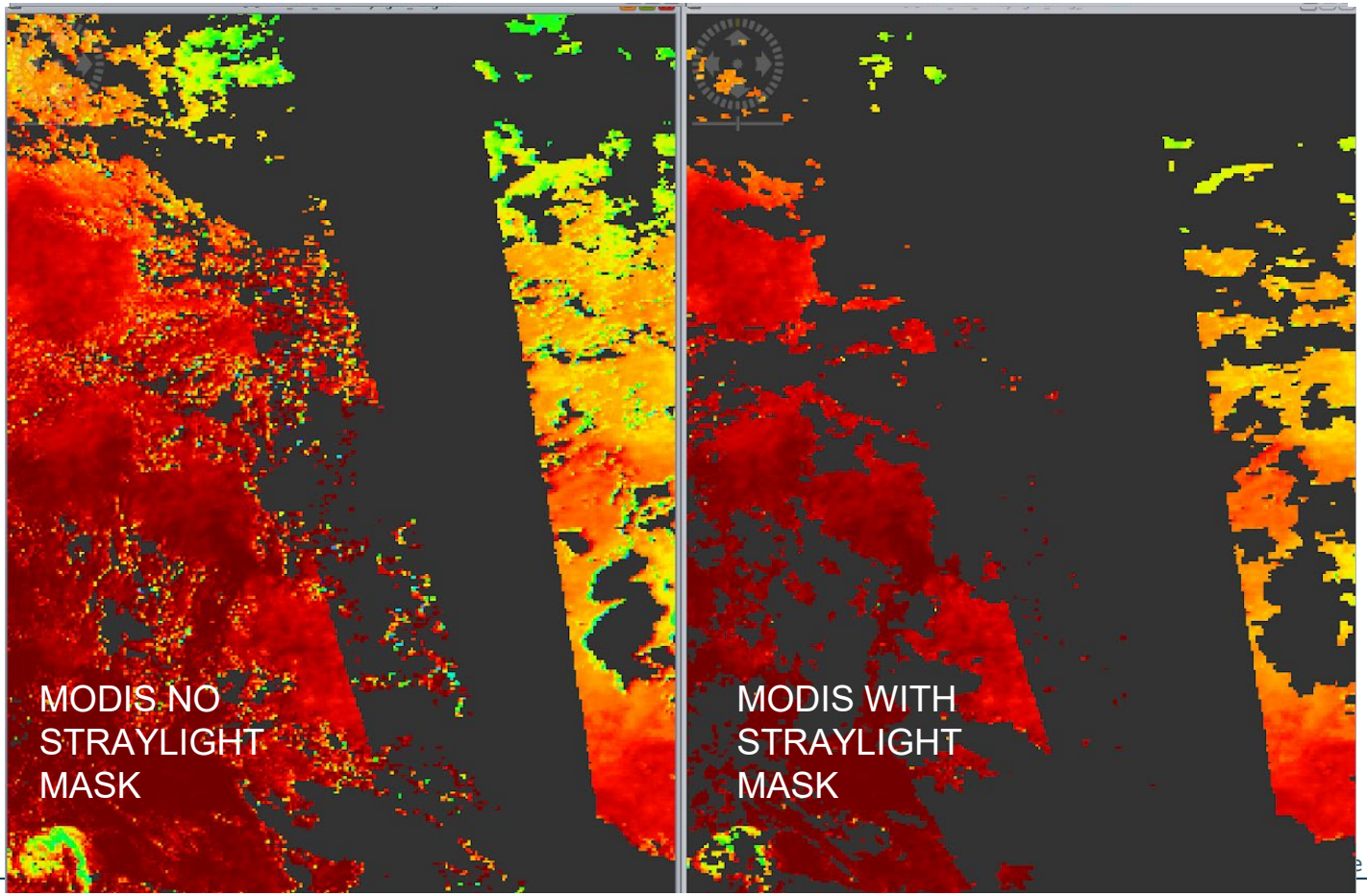


Don’t lose sight of mission as you push forward

Always keep the core objectives in mind. There is always a desire for ‘more coverage’ and we have seen some data providers (not OC-CCI) make questionable choices.

e.g. considering a flag such as STRAYLIGHT to be overzealous and ignoring it.

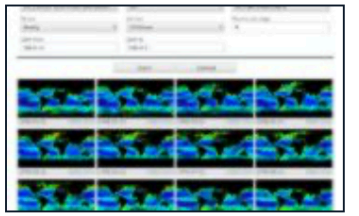
For climate research quality data, you must make choices that maximise data quality/reliability.



Data accessibility and interface with toolboxes

Make access easy!

1. Provide multiple options at different levels of user expertise.
2. Give worked examples of using access options.
3. File formats and metadata are of vital importance for data visualization tools.
4. Provide ongoing assistance /response for user queries.



Composite Browser

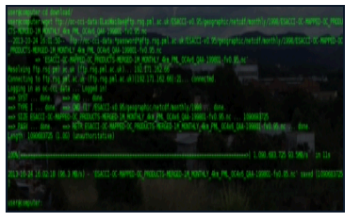
Access a range of products composited in different periods. Data can be searched by time ranges, periods, products & wavelengths.

Web GIS Portal

View, manipulate & analyse data.

OPeNDAP

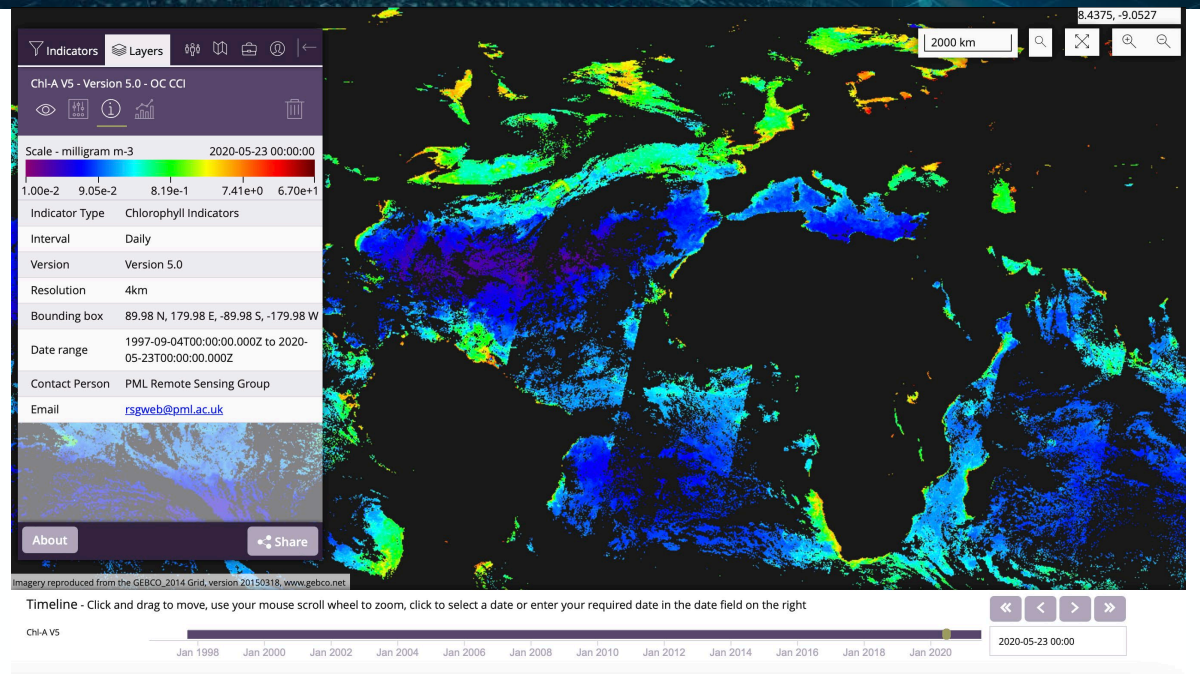
A freely available framework that simplifies all aspects of scientific data networking, making local data available to remote locations regardless of storage format.



FTP

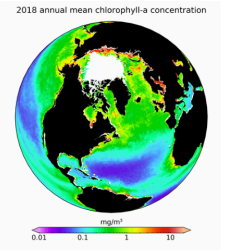
Download large sets of data easily. Version 5.0 datasets available now.

Data accessibility and interface with toolboxes



Project level e.g.
https://www.oceancolour.org/portal/

Overview | Download data | Quality assessment | Documentation



This dataset provides global daily estimates of ocean surface chlorophyll-a concentration and remote sensing reflectance derived from multiple satellite sensors. These two products are part of the broader discipline of ocean colour remote sensing, which analyses ocean surface radiances measured from space to derive information about the optical properties and constituents of the upper ocean. This information plays an essential role in our ability to monitor the health and productivity of marine ecosystems, assess the role of the oceans in the global carbon cycle, and quantify the impacts of climate change. Satellite remote sensing is the only method for regular monitoring of ocean biology on a global scale.

Remote-sensing reflectance (or Rrs) is defined as the ratio of water-leaving radiance to downwelling irradiance and serves as the main input to algorithms used to derive other ocean colour products. Chlorophyll-a (Chl-a) is the main photosynthetic pigment found in phytoplankton, which form the base of the marine food-web and are responsible for approximately half of global photosynthesis. Chl-a can be estimated from Rrs data using different algorithms (see details in the Documentation). Here, we provide a blended Chl-a estimate from multiple algorithms, where blending is based on the suitability of each candidate algorithm to the optical typology of a given pixel. This approach provides the best estimates of global Chl-a across a range of water types.

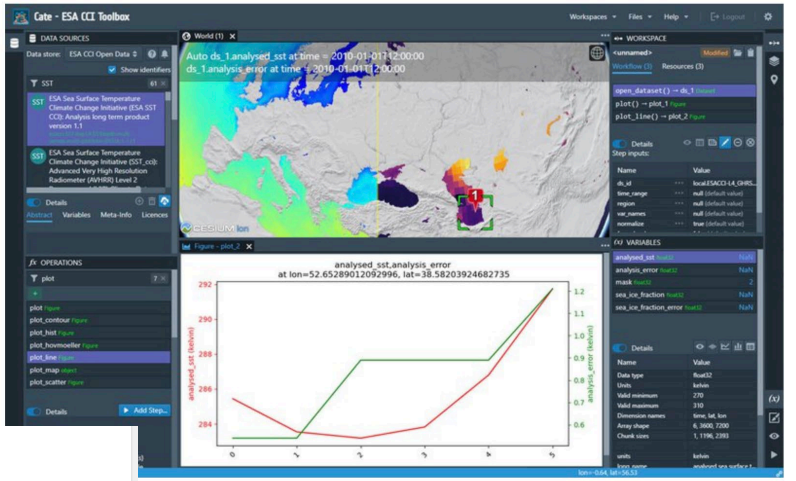
The files from this dataset contain global daily composites of merged sensor products: SeaWiFS, MERIS, MODIS Aqua, VIIRS, and (from version 5.0 onward) OLCI. Note that Rrs and Chl-a data are only available over cloud- and ice-free areas. As a result, more complete spatial coverage (as shown in the map in the upper-right corner) can be achieved by aggregating data over longer time periods.

Software

Program level e.g.
https://climate.esa.int/en/explore/analyse-climate-data/

Cate comprises various user interfaces:

- App – graphical user interface (GUI) that runs in all modern internet browsers.
- Command-line tool – used to access and process ESA climate data through a command shell. Use it to write your own batch scripts.
- Python API – allows you to use Cate in your own Python programmes and make up new functions for Cate.



Toolbox.jpg

Downstream/operational service level
https://cds.climate.copernicus.eu/#!/home

Percolation of the data into decision-making spheres

OC-CCI dataset has been used in > 180 publications, including:

Prominent climate related studies e.g upcoming IPCC working group 2 report

Publications in eminent journals e.g Nature (Tang et al. 2021, Dutkiewicz et al. 2019)

Impacts of climate from the local (Okamoto et al. 2019) to global (Kulk et al. 2020)

European State of the Climate Report

Cross-disciplinary research areas include:

Connections between ocean physics and biology (Balaguru et al. 2018)

Synergy between ocean models and remote-sensing observations (Baird et al. 2020)

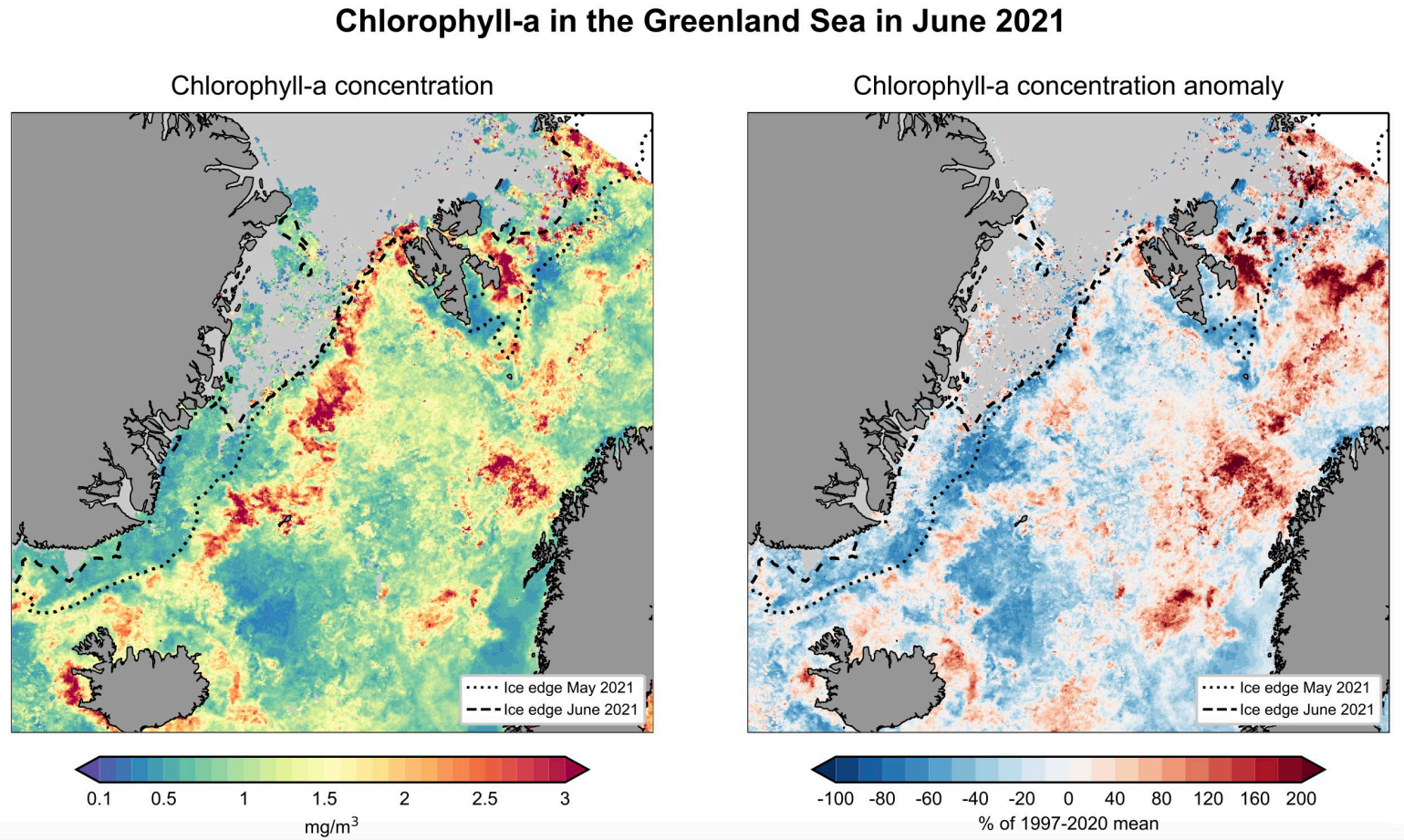
Linking ocean and human health (Sathyendranath et al. 2020, Anas et al. 2021).

Percolation of the data into decision-making spheres

After data creation there is an ongoing requirement for input to data assessment and use.

Especially true for summary / condensed key information for policy makers (e.g multiple dataset summaries, KPIs, etc).

Example: European State of the Climate Report 2021 (thematic area Arctic).



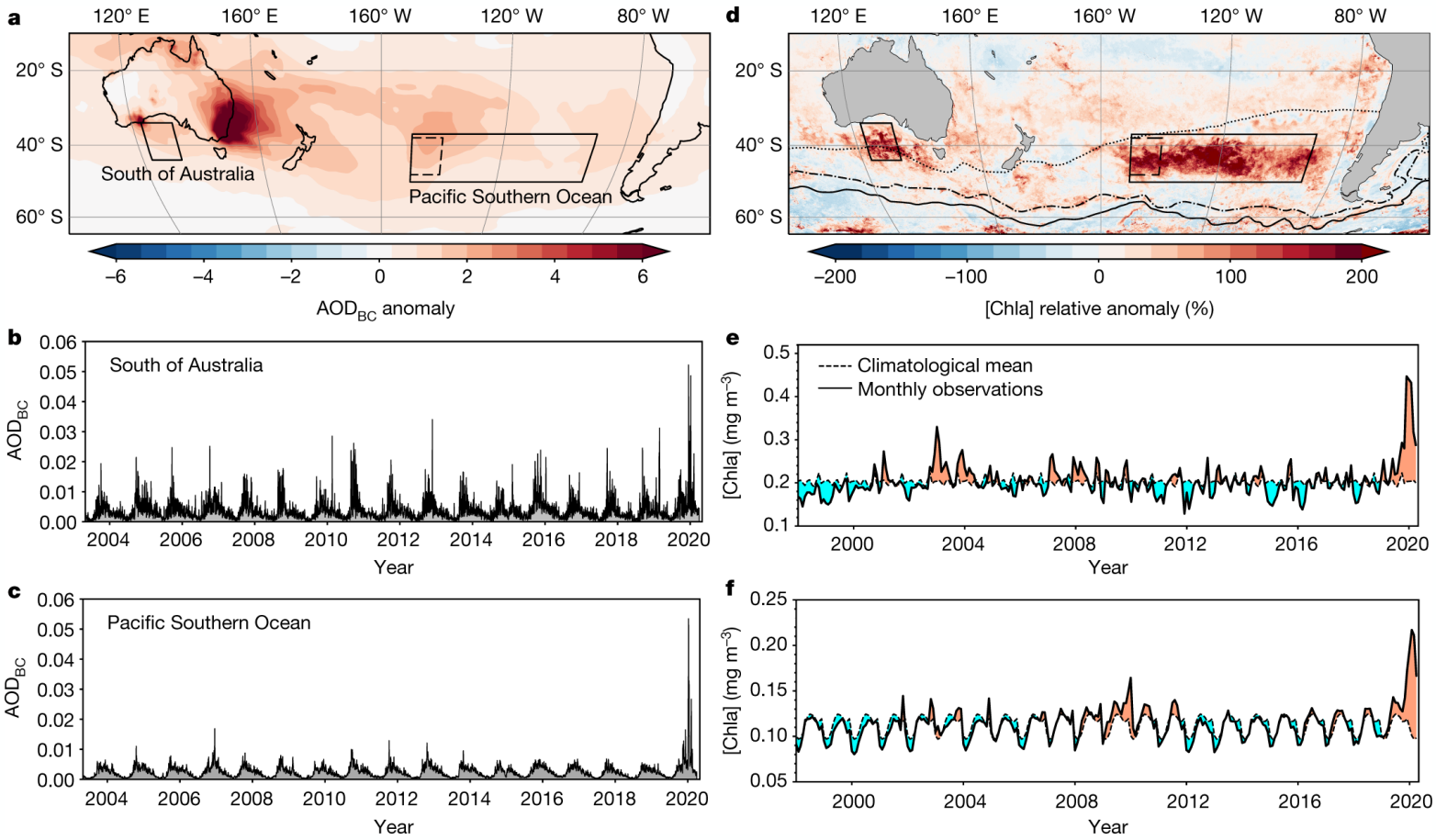
https://climate.copernicus.eu/esotc/2021

Cross disciplinary research

Communication and detailed discussion is essential. After data release, remain open to enquires for expert input.

Recent example studied massive phytoplankton blooms triggered by wildfires.

OC-CCI data record used alongside re-analysis products and in-situ argo-float data.



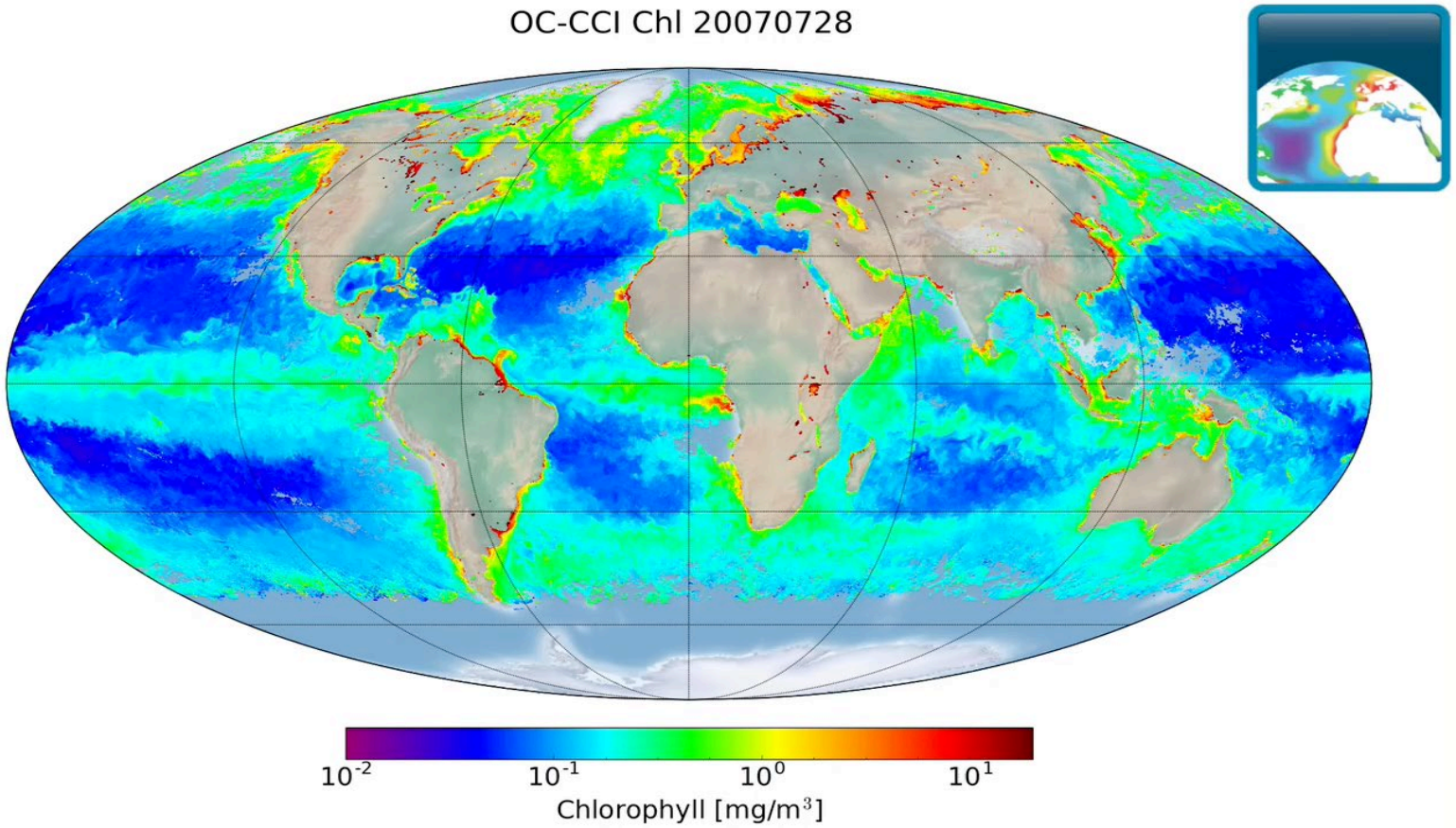
Tang, W., Llort, J., Weis, J. *et al.* Widespread phytoplankton blooms triggered by 2019–2020 Australian wildfires. *Nature* **597,** 370–375 (2021). https://doi.org/10.1038/s41586-021-03805-8

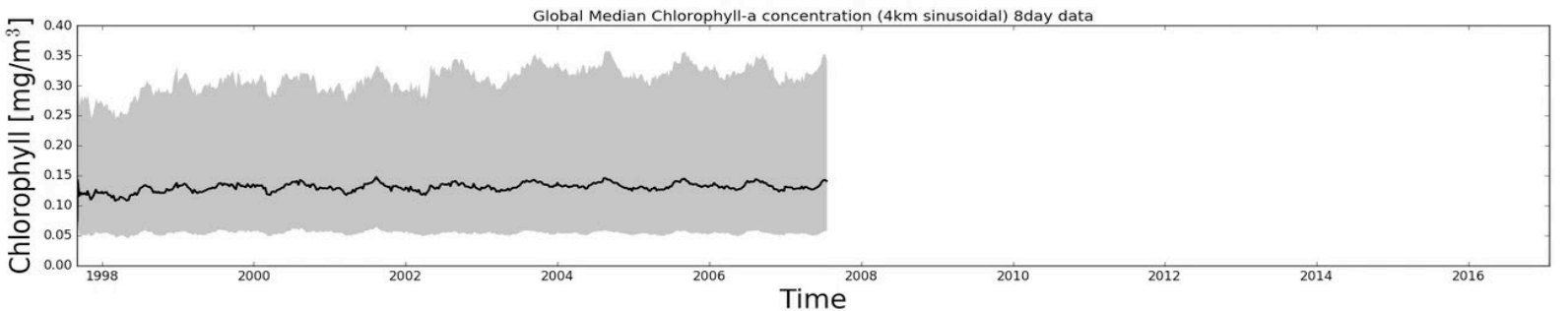
https://www.nature.com/articles/s41586-021-03805-8

Summary

With each version OC-CCI has improved based on new research with increases in product performance, dataset volume and science impact.

This has been possible due to a huge amount of effort from a very talented team.





Summary

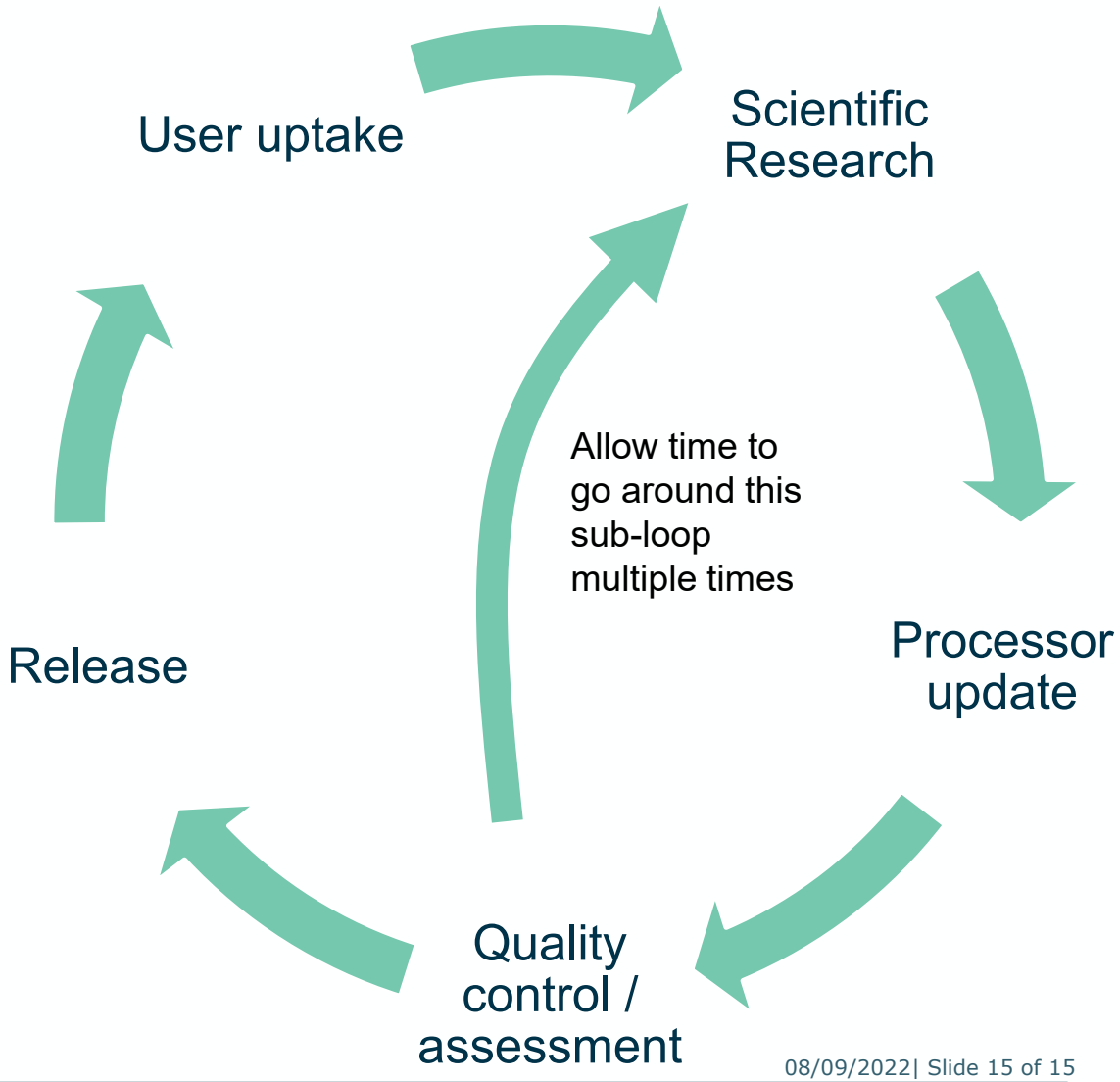
So, when setting out to make (or fund) climate service data:

1) Ensure clear and open communication at all times

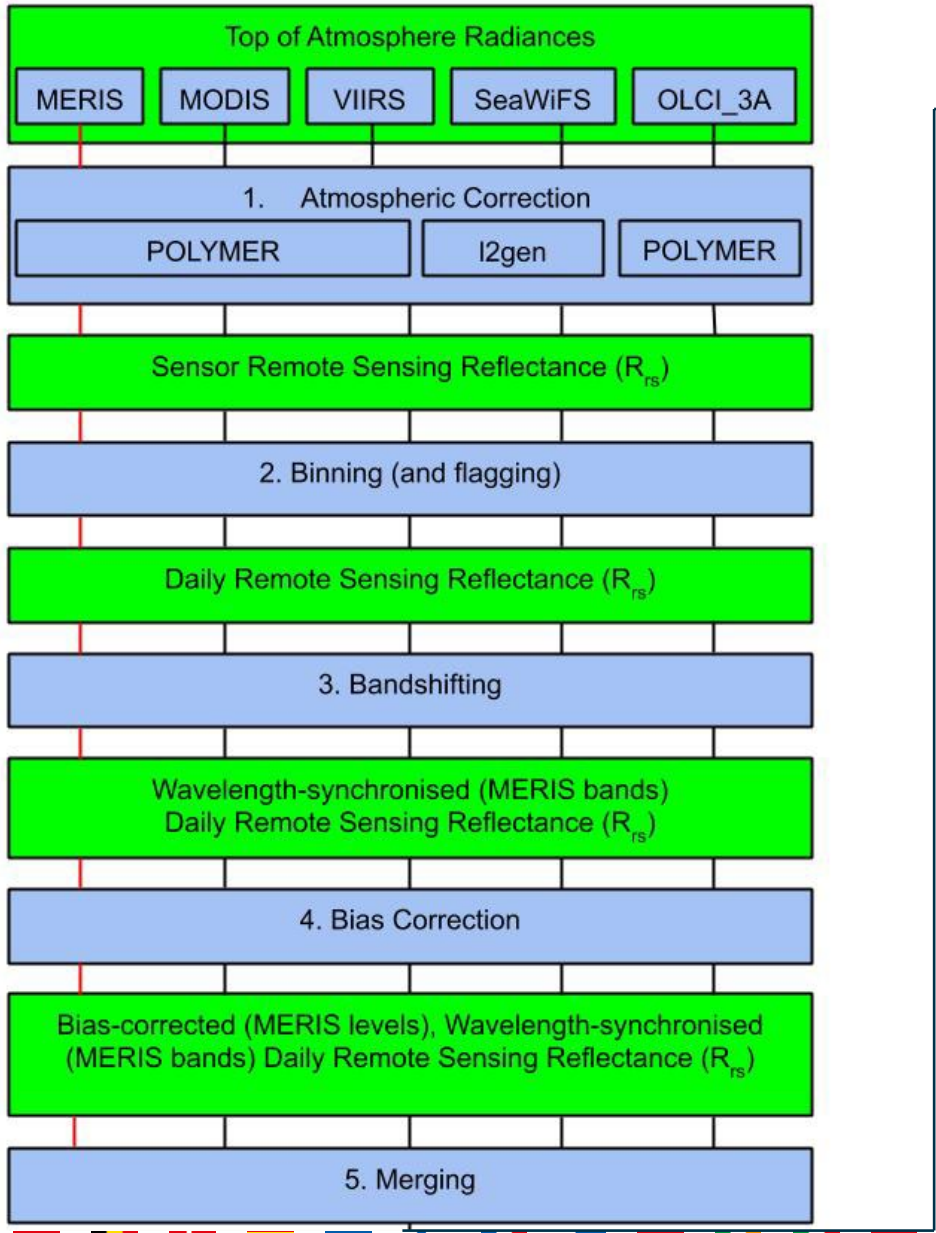
2) Budget (time and money) for the research required during QC and 'additional algorithm development'.

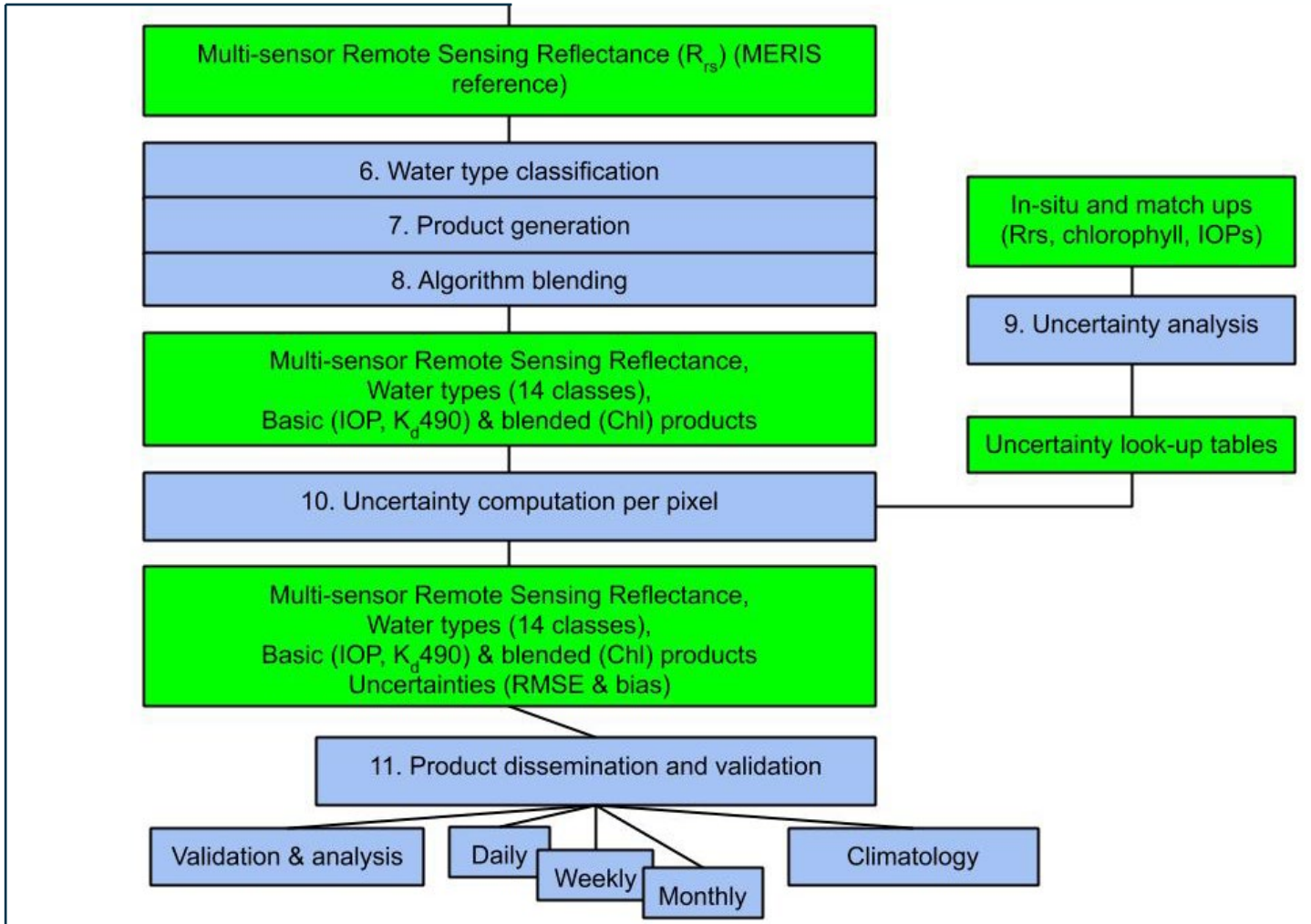
3) Spend time considering how data will be served to different user communities

4) Provide ongoing support to users to help investigate the data.

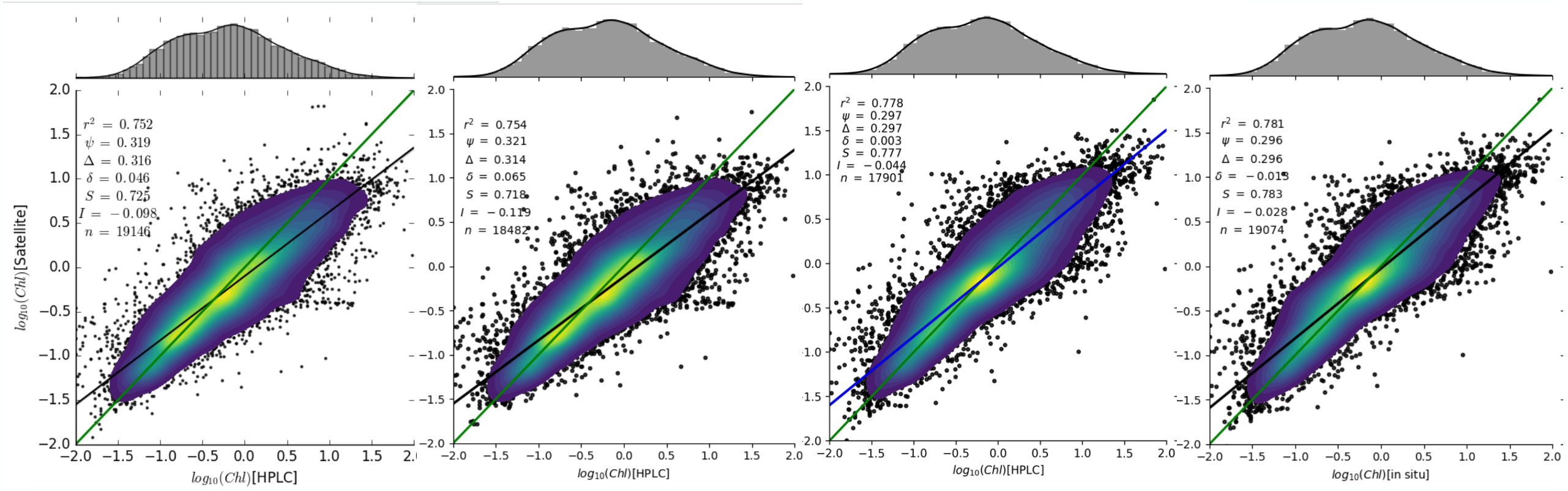


Extras


Top of Atmosphere Radiances
MERIS
MODIS
VIIRS
SeaWiFS
OLCI_3A
1. Atmospheric Correction
POLYMER
l2gen
POLYMER
Sensor Remote Sensing Reflectance (Rrs)
2. Binning (and flagging)
Daily Remote Sensing Reflectance (Rrs)
3. Bandshifting
Wavelength-synchronised (MERIS bands) Daily Remote Sensing Reflectance (Rrs)
4. Bias Correction
Bias-corrected (MERIS levels), Wavelength-synchronised (MERIS bands) Daily Remote Sensing Reflectance (Rrs)
5. Merging


Multi-sensor Remote Sensing Reflectance (Rrs) (MERIS reference)
6. Water type classification
7. Product generation
8. Algorithm blending
Multi-sensor Remote Sensing Reflectance, Water types (14 classes), Basic (IOP, Kd490) & blended (Chl) products
10. Uncertainty computation per pixel
Multi-sensor Remote Sensing Reflectance, Water types (14 classes), Basic (IOP, Kd490) & blended (Chl) products Uncertainties (RMSE & bias)
11. Product dissemination and validation
Validation & analysis
Daily
Weekly
Monthly
Climatology
In-situ and match ups (Rrs, chlorophyll, IOPs)
9. Uncertainty analysis
Uncertainty look-up tables

Extras



V3 V4 V5 V6