Ocean Colour Remote Sensing of Coastal Waters

Coastcolour Products & Algorithms

C. Brockmann, R. Doerffer, S. Sathyendranath, K. Ruddick, V. Brotas, R. Santer

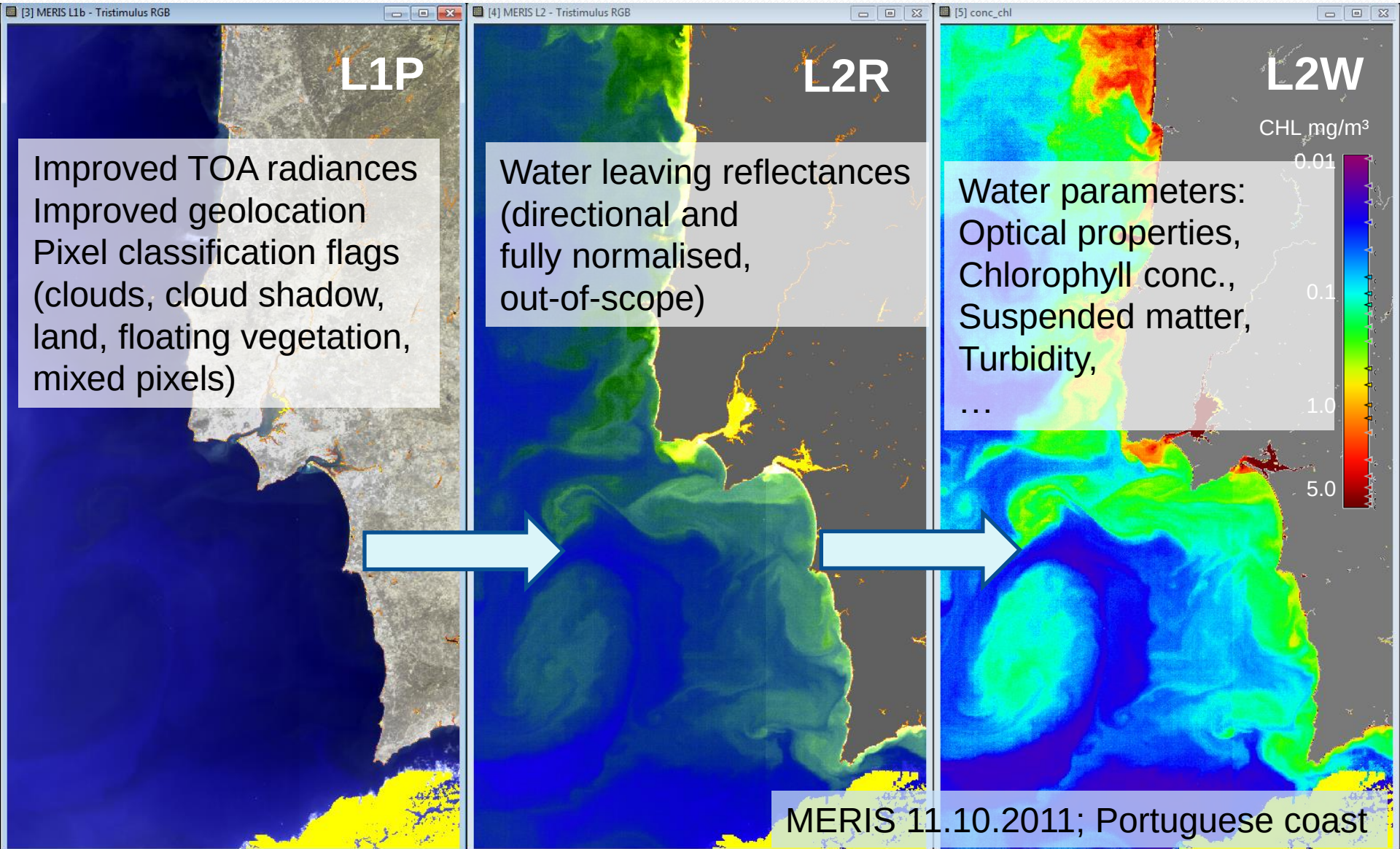
CoastColour

- Exploitation of MERIS Full Resolution for coastal waters
- Development of regional algorithms
- Algorithm Round Robin intercomparison
- Production & dissemination of MERIS derived products (2005 – 2012)
- Case 2 water algorithm development consensus protocol

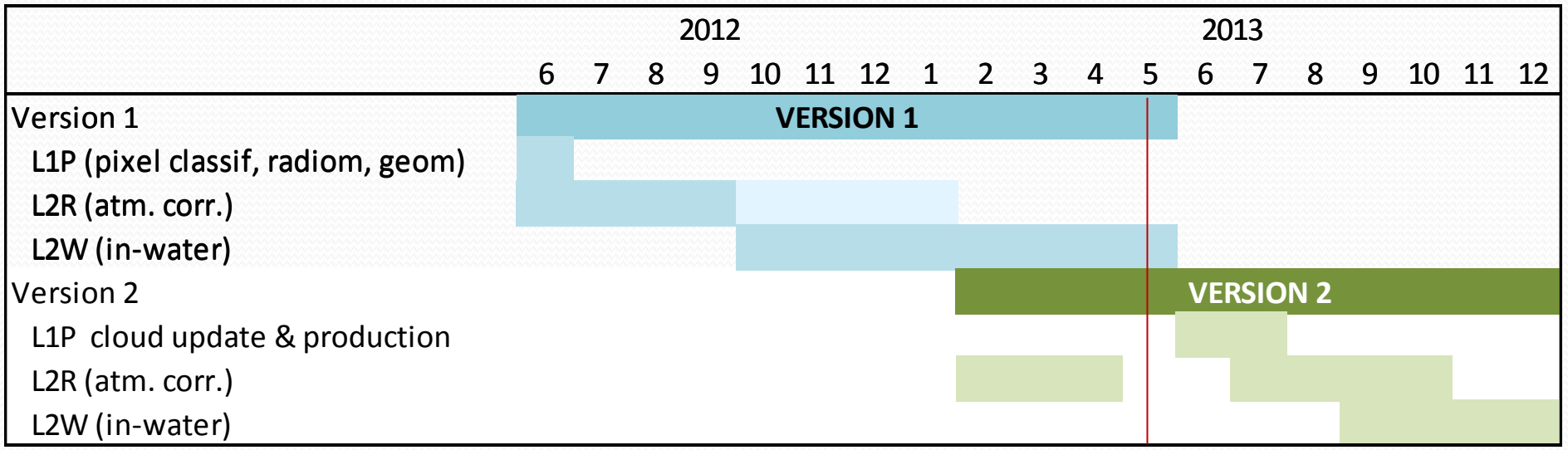
Initiated and funded by the **European Space Agency, DUE Programme**
Carried out by:

- Brockmann Consult, Germany
- HZG Research Centre, Germany
- MUMM, Belgium
- PML, UK
- LISE/Adrinord, France
- Univ. Lisbon, Portugal
- Consultants

CoastColour Products



Timeline



- **Version 1**
  - Geographical coverage: 27 sites
  - Temporal coverage: 2005 - 2012
  - Algorithms: NN covering full concentration range, QAA
  - MEGS8 processing (on disk only)
- **Version 2**
  - Geographical coverage: globally all coastal areas
  - Temporal coverage: full mission, 2002 - 2012
  - Algorithms: 2 NNs covering (normal range, extreme waters) + classification, QAA

Product Availability

coastcolour

| Project info | Users & Sites | Products | Publications | Round Robin | Internal | Contact |

Contents

NRT Service
Data Archive
Product Description

Products

NRT Service

The demise of ENVISAT in April 2012 determined the end of the NRT service within CoastColour. However, all MERIS Archive products that have been processed are available via the CoastColour archive.

Data Archive

The CoastColour data archive contains, for all 27 sites and for the years 2005 to 2012, L1P, L2R and L2W data products.

Data Access

The access to the data archive and NRT data is free and open. You can use the direct web access, which is good for downloading only a few data products. If you like to download more than just a couple of products, we kindly ask you to register for getting access to the FTP server. After registration, which is free of charge, a username and password will be sent to you.

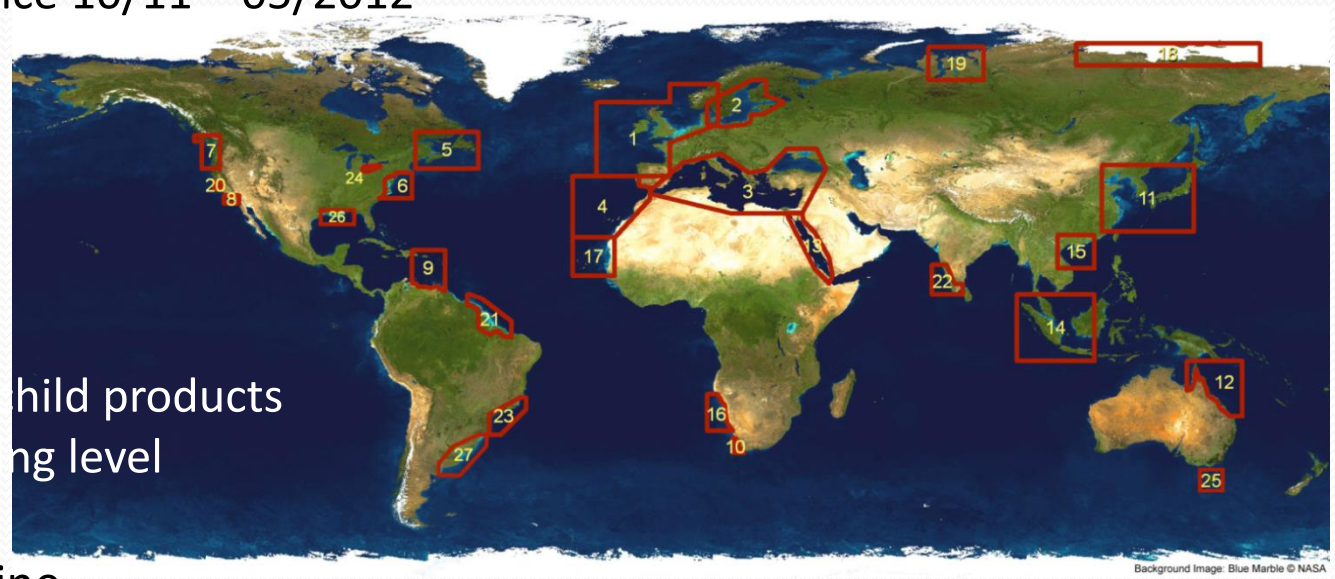
- Direct web access to the Data Archive
- Register for FTP access
- MERCI interactive product search and download

1	Quicklook	MER_FSG_CCL1P_20100101_092619_000002502085_00351_40986_0001	
2	Quicklook	MER_FSG_CCL2R_20100101_092619_000002502085_00351_40986_0001	
3	Quicklook	MER_FSG_CCL2W_20100101_092619_000002502085_00351_40986_0001	
4	Quicklook	MER_FSG_CCL1P_20100102_085341_000003402085_00365_41000_0001	

southerncalifornia/	11-Sep-2012 16:27	-
southindia/	06-Sep-2012 01:56	-
tasmania/	11-Sep-2012 16:31	-

Coastcolour Processing

- Temporal coverage
  - 7 years of data 2005 – 2012
  - Input data volume ~ 7.7TB/year = 54TB
  - Near real time service 10/11 – 05/2012
- Spatial coverage
  - 27 sites
- Data Volume
  - 75 000 meris FRS hild products
  - 33 Tbytes /process ng level
- Complex production line
  - All processors implemented in BEAM
  - Execution on Calvalus Cluster at BC; 1 year of data in 3 days

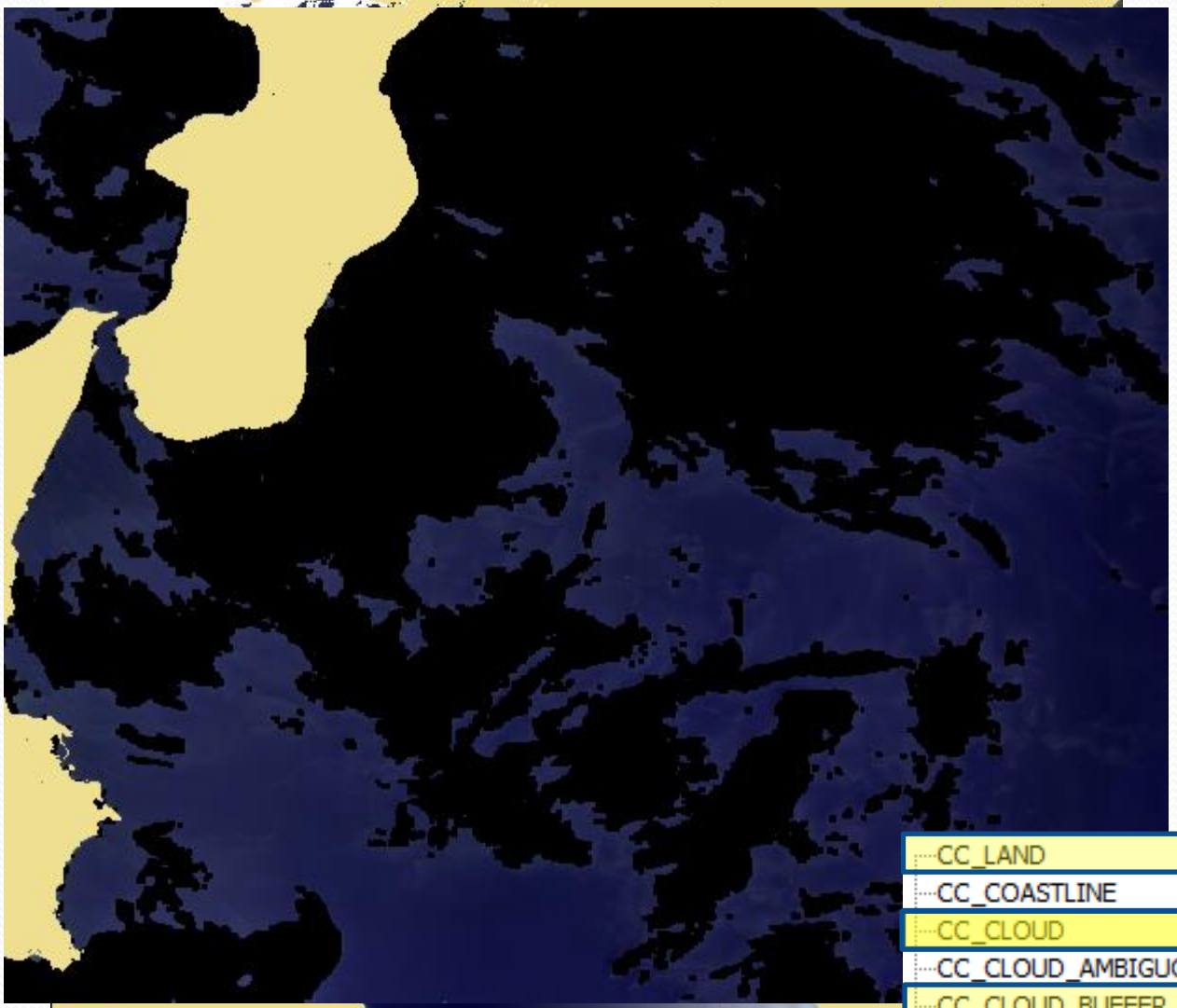


Level 1P

- Precise ortho-rectification (AMORGOS)
- Precise land-water mask and coastline
- Radiometric improvements
  - Calibration harmonisation to 3rd reprocessing
  - Smile correction
  - Coherent noise equalisation
- Pixel flagging

CC_LAND	Pixel masked as land
CC_COASTLINE	Pixel masked as coastline
CC_CLOUD	Pixel masked as cloud
CC_CLOUD_AMBIGUOUS	Pixel masked as ambiguous cloud
CC_CLOUD_BUFFER	Pixel masked as cloud buffer
CC_CLOUD_SHADOW	Pixel masked as cloud shadow
CC_SNOW_ICE	Pixel masked as snow/ice
CC_MIXEDPIXEL	Potential land pixel
CC_GLINTRISK	Risk that pixel is under glint

Land Water Mask

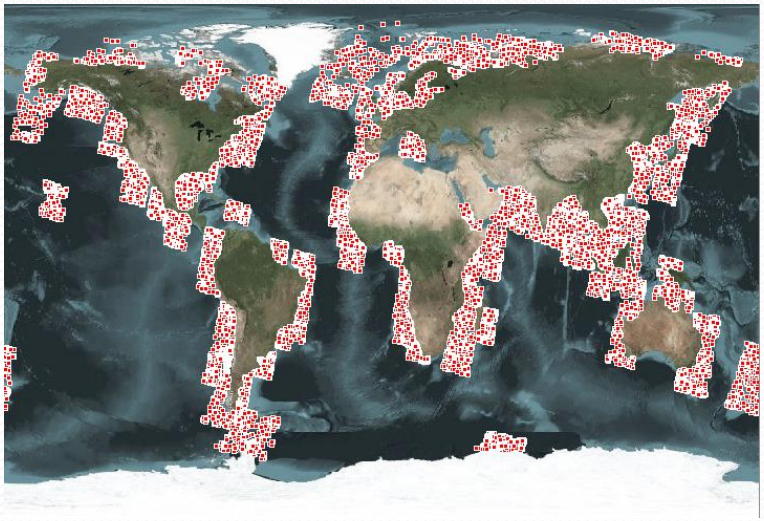


CC_LAND	Pixel masked as land
CC_COASTLINE	Pixel masked as coastline
CC_CLOUD	Pixel masked as cloud
CC_CLOUD_AMBIGUOUS	Pixel masked as ambiguous cloud
CC_CLOUD_BUFFER	Pixel masked as cloud buffer
CC_CLOUD_SHADOW	Pixel masked as cloud shadow
CC_SNOW_ICE	Pixel masked as snow/ice
CC_MIXEDPIXEL	Potential land pixel
CC_GLINTRISK	Risk that pixel is under glint

L1P Validation

- PixBox dataset of MERIS FR data over coastal areas
  - 25 000 pixels

Spatial distribution:



Pixel type distribution:

Totally Cloudy (5580)	30%
Clear sky water (5497)	30%
Clear sky land (0)	
Clear sky snow_ice (83)	
Non-clear sky water (3720)	
Non-clear sky land (0)	
Non-clear sky snow_ice (0)	40%
Spatially mixed cloud/land (0)	
Spatially mixed cloud/water (3720)	
Spatially mixed cloud/snow_ice (0)	
Spatially mixed snow_ice/land (0)	
Spatially mixed snow_ice/water (0)	
Spatially mixed land/water (0)	

Seasonal distribution:

Spring (4496)	
Summer (4667)	
Autumn (4891)	
Winter (4546)	

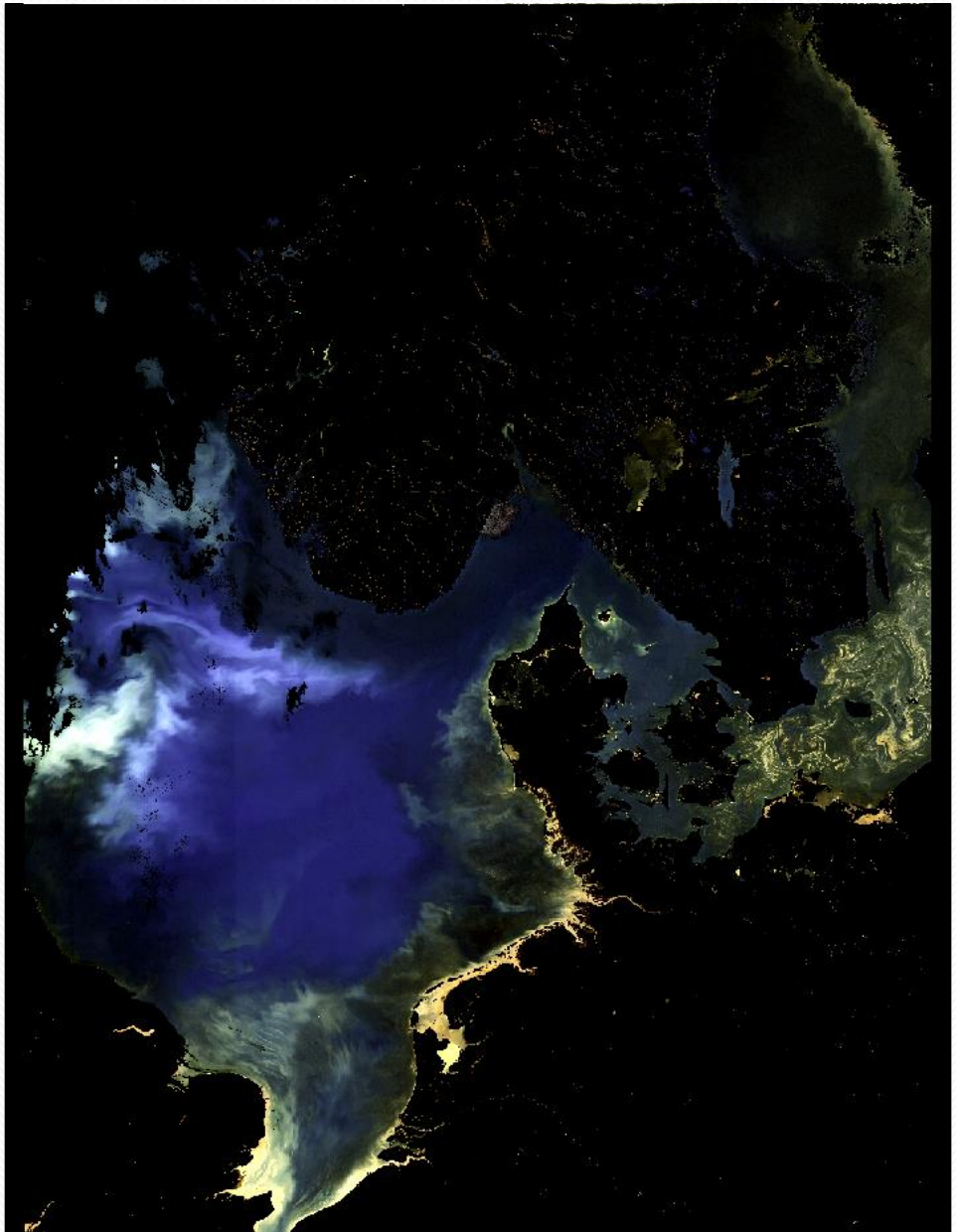
Confusion Matrix (CLOUD flag)

IdePix \ In-Situ Database	water	cloud	Snow/ice	Σ	
WATER	5433	23	2	5458	99%
CLOUD	1033	15068	2746	18847	80%
SNOW_ICE	2	66	1124	1192	94%
Σ	6468	15157	3872	25497	
CC UCM4	84%	99%	29%		

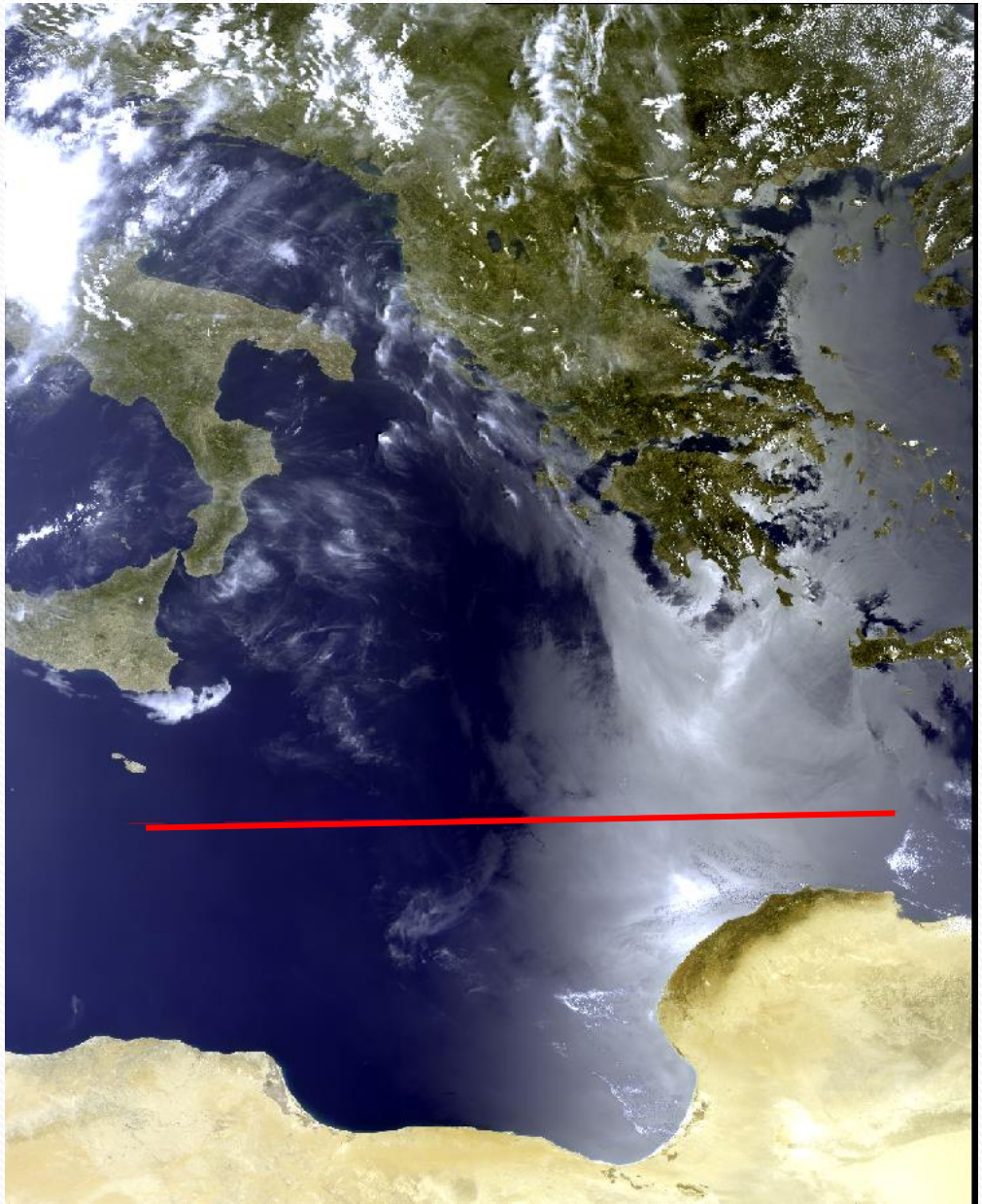
Level 2R

- Result of the atmospheric correction
  - Algorithm -> Talk by Roland Doerffer
- Product content
  - Water leaving reflectances in 13 bands
  - Normalised water leaving reflectances in 13 bands
  - Aerosol optical depth@550nm
  - Angstrom coefficient 443/865
  - Quality indicator / error
  - Flags

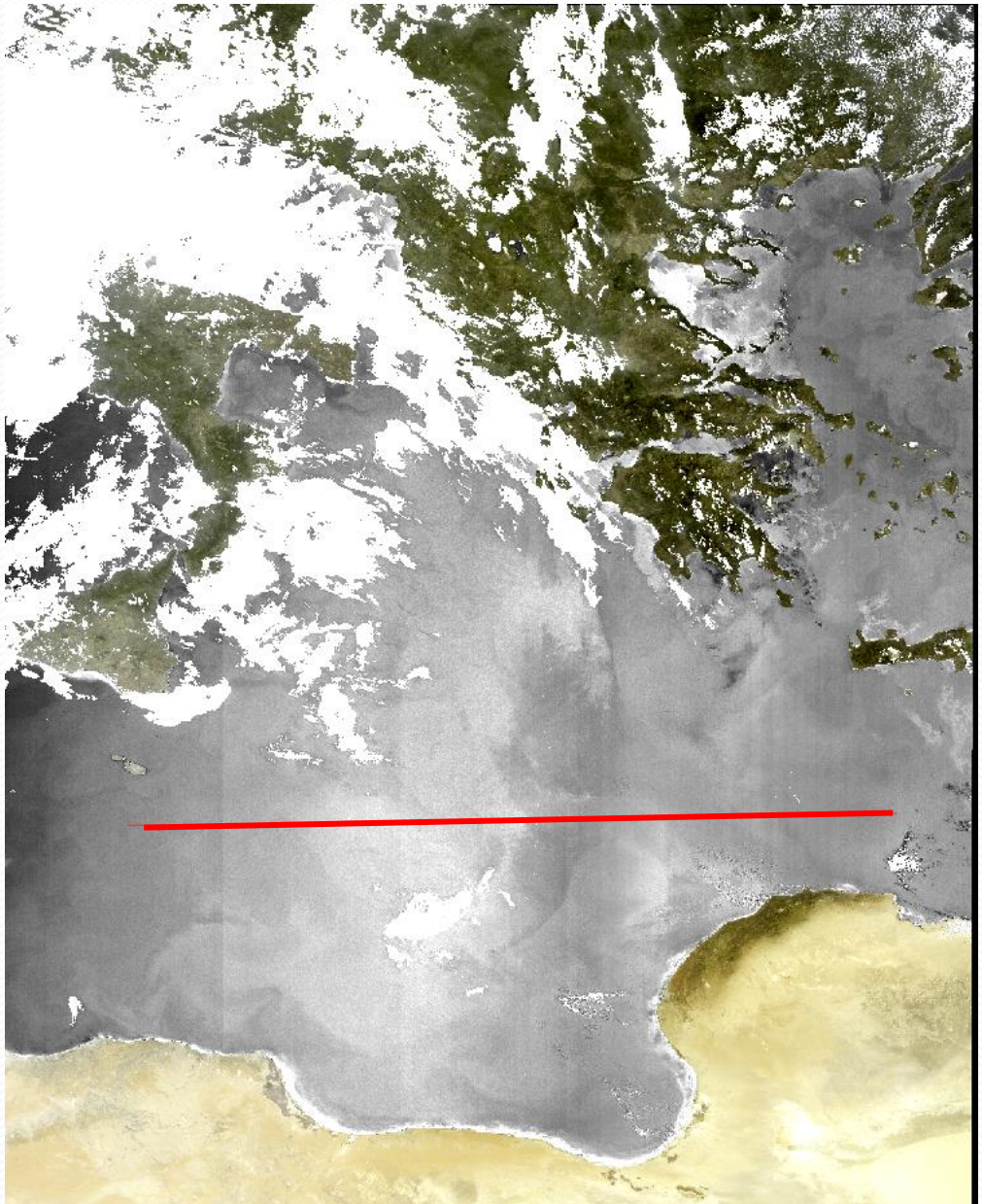
Example north sea RGB L1 + L2R

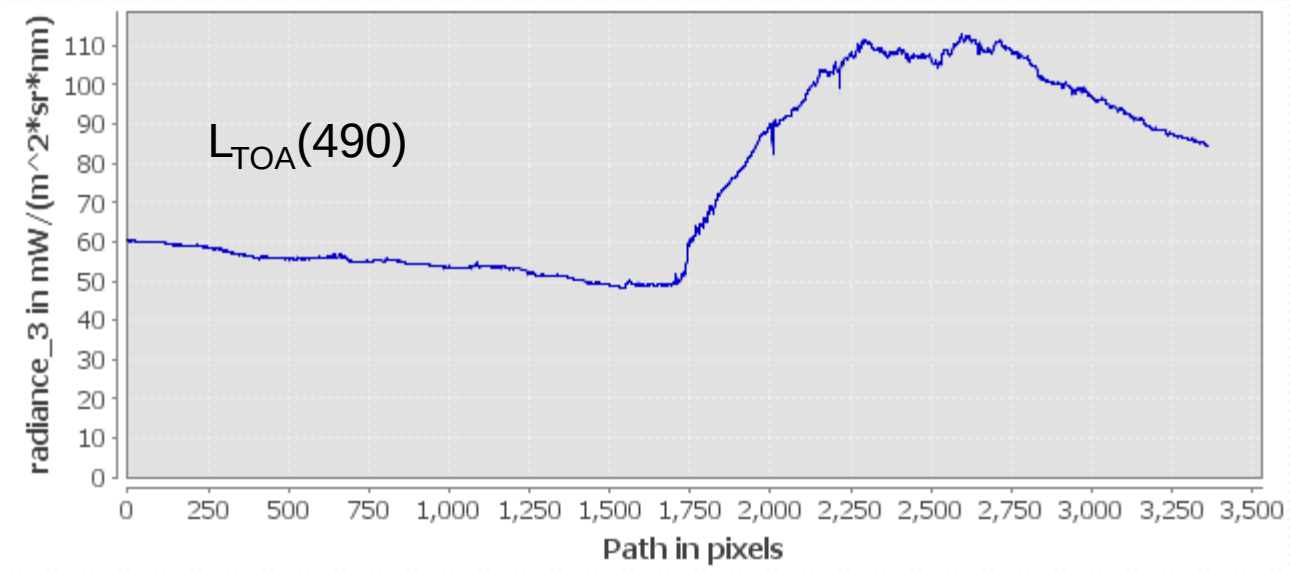


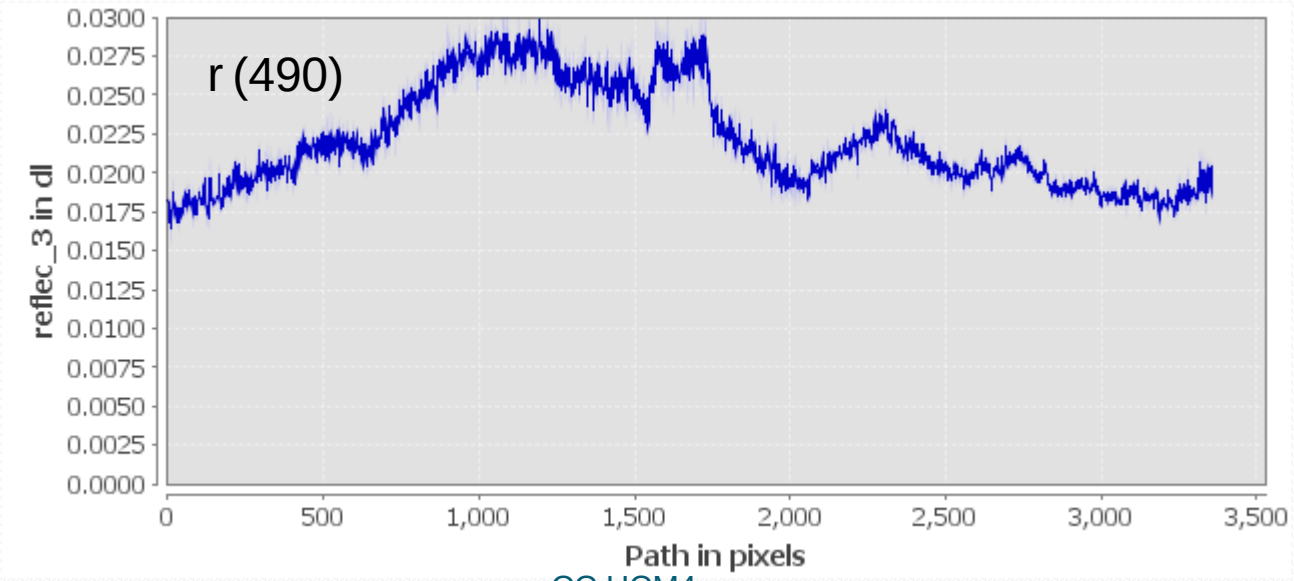
TOA RGB, 19.05.2006



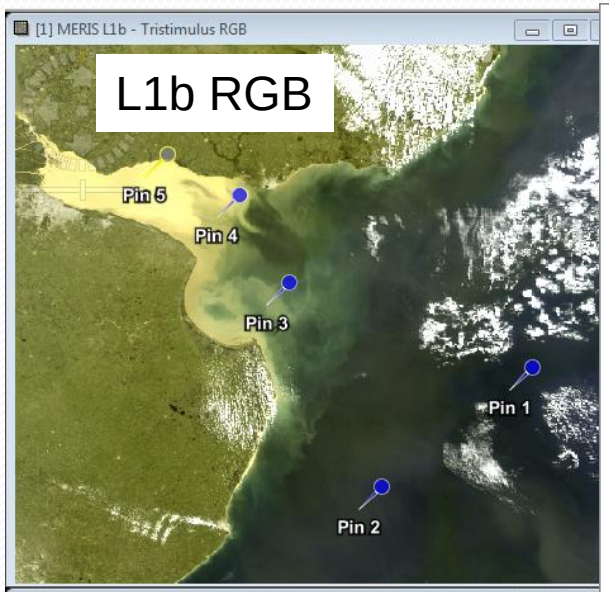
r(490)

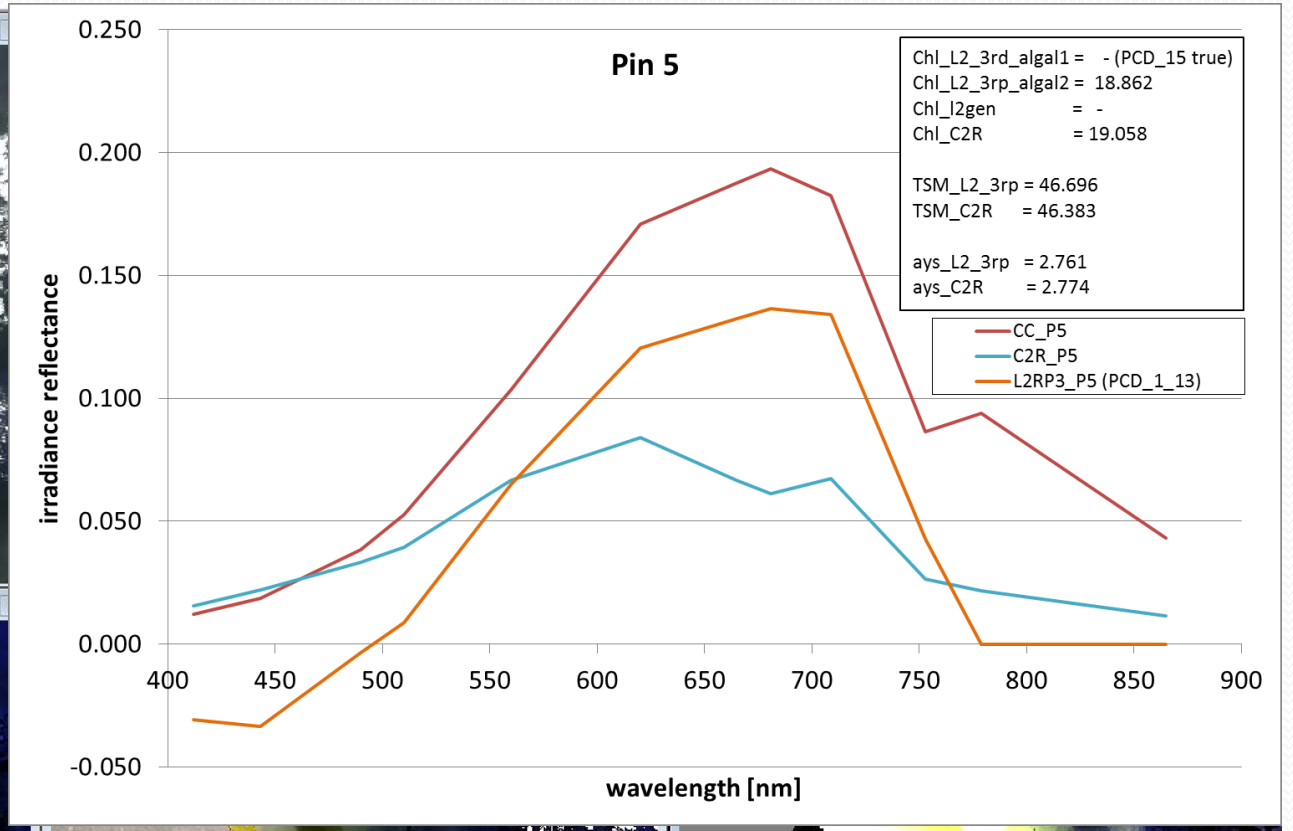


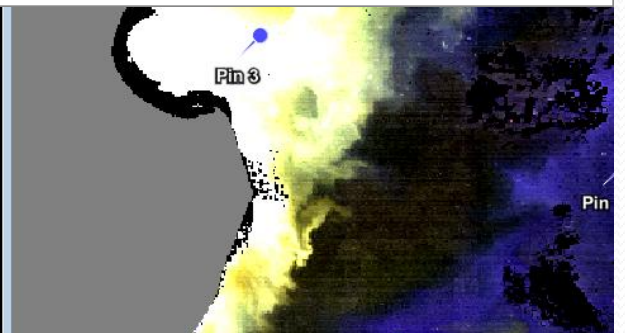

L_{TOA}(490)
radiance_3 in mW/(m^2*sr*nm)
110
100
90
80
70
60
50
40
30
20
10
0
0
250
500
750
1,000
1,250
1,500
1,750
2,000
2,250
2,500
2,750
3,000
3,250
3,500
Path in pixels


r (490)
reflec_3 in dl
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0
500
1,000
1,500
2,000
2,500
3,000
3,500
Path in pixels

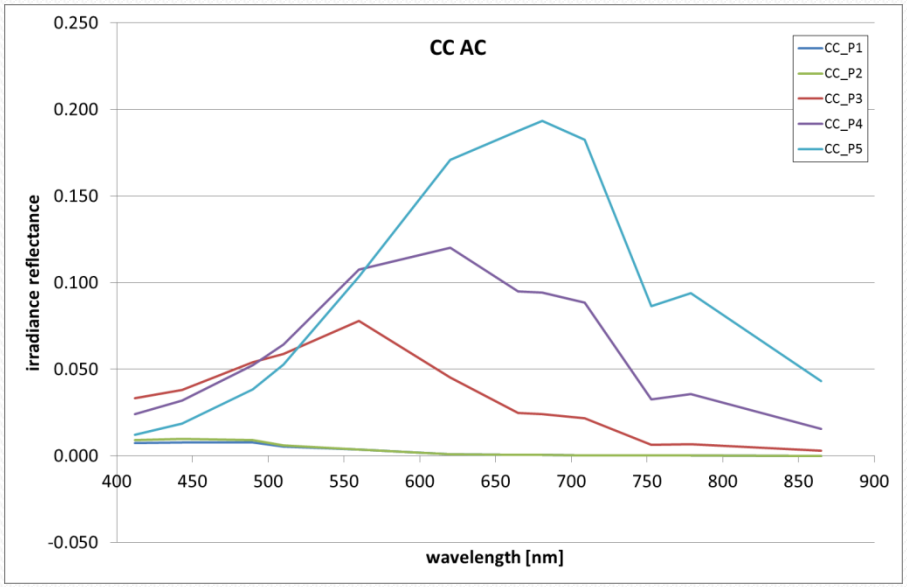
Rio de la Plata

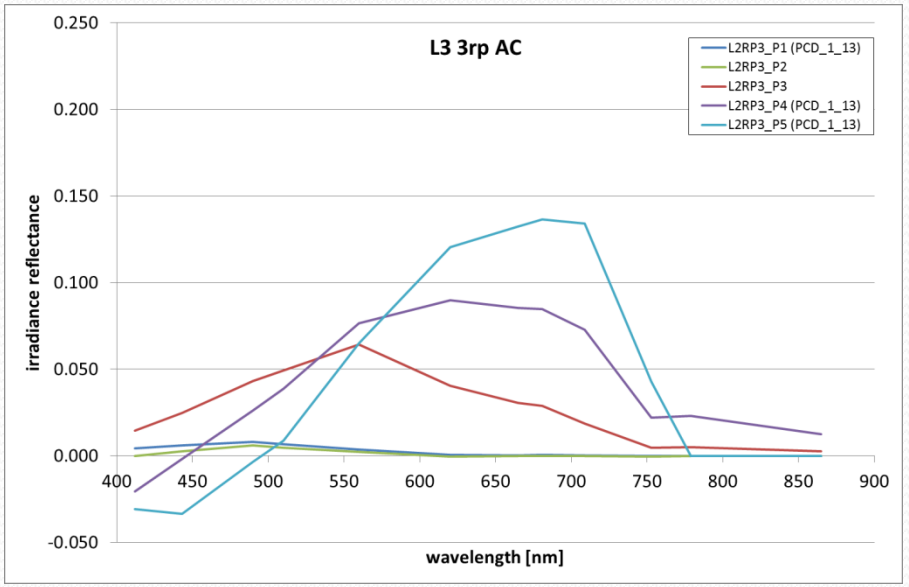






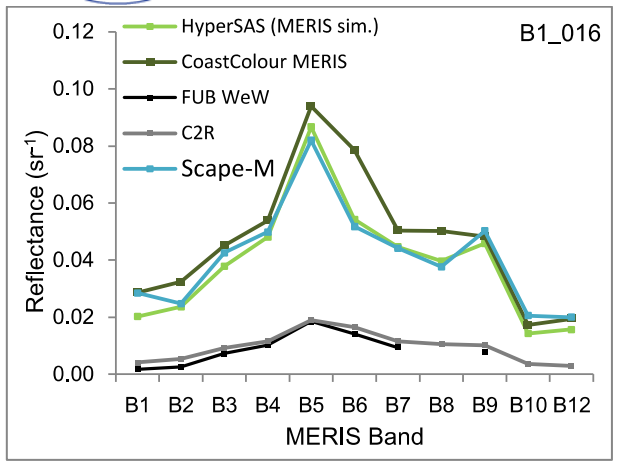
Rio de la Plata
Comparison CC – standard 3rp

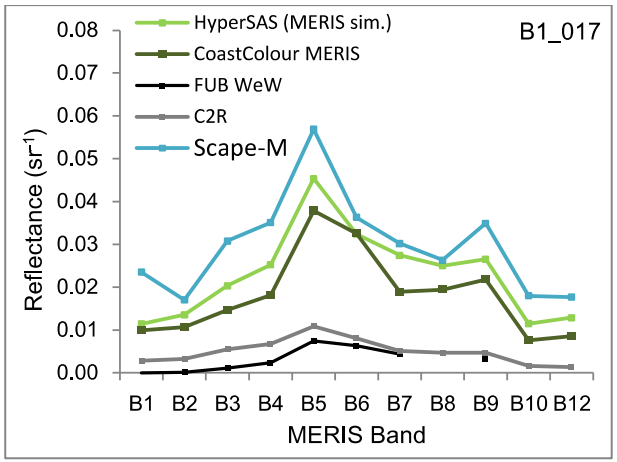


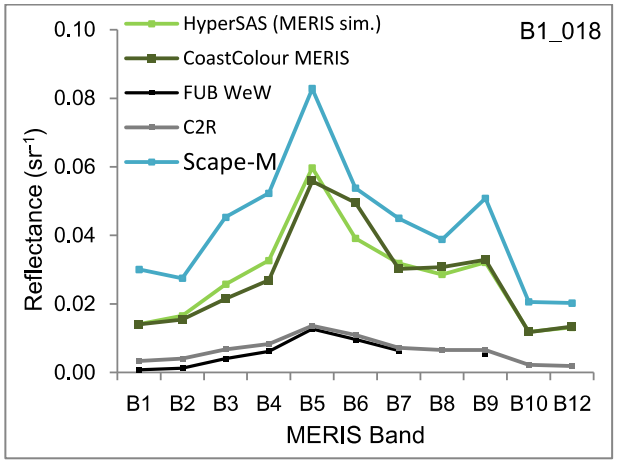


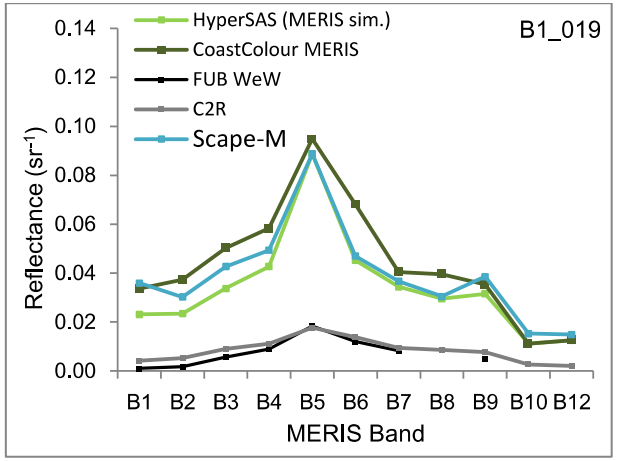
Atmospheric Correction

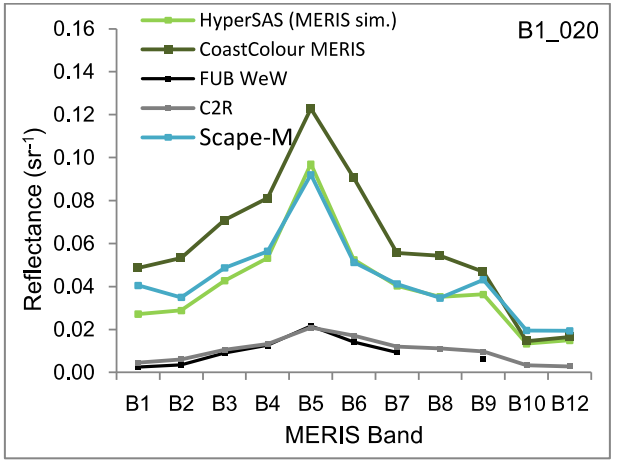
Global Observatory of Lake Responses to Environmental Change

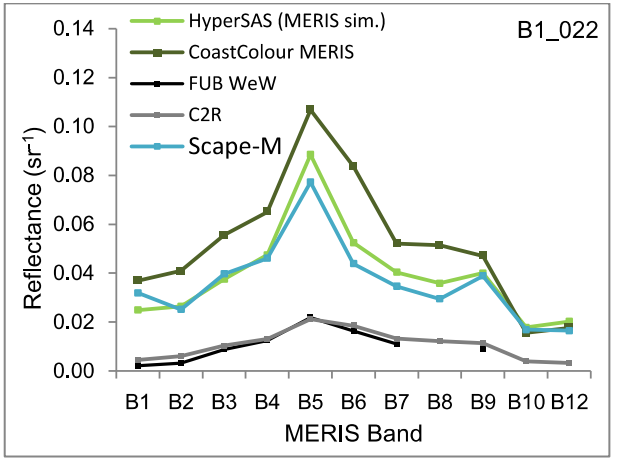






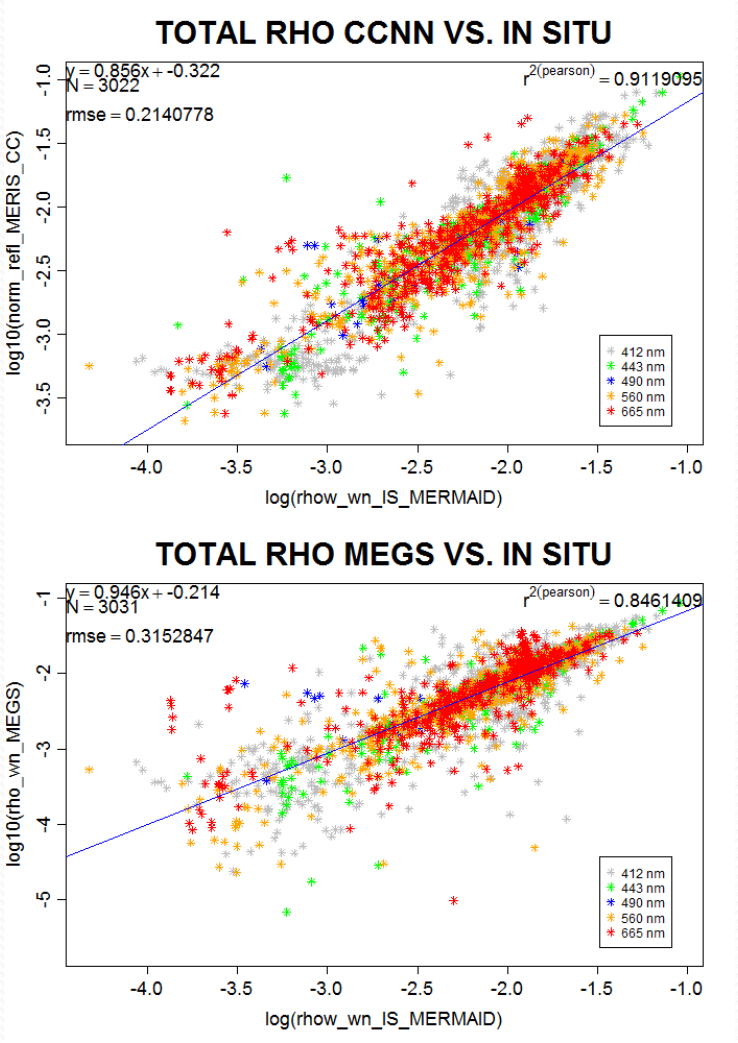


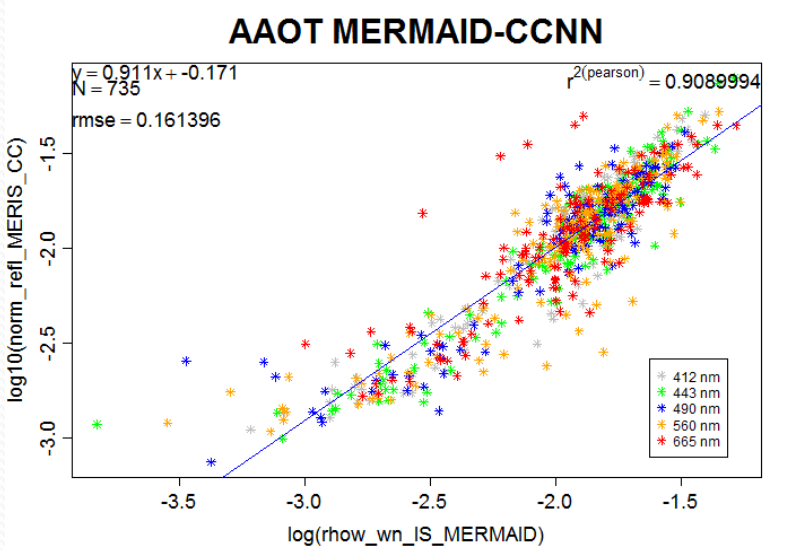


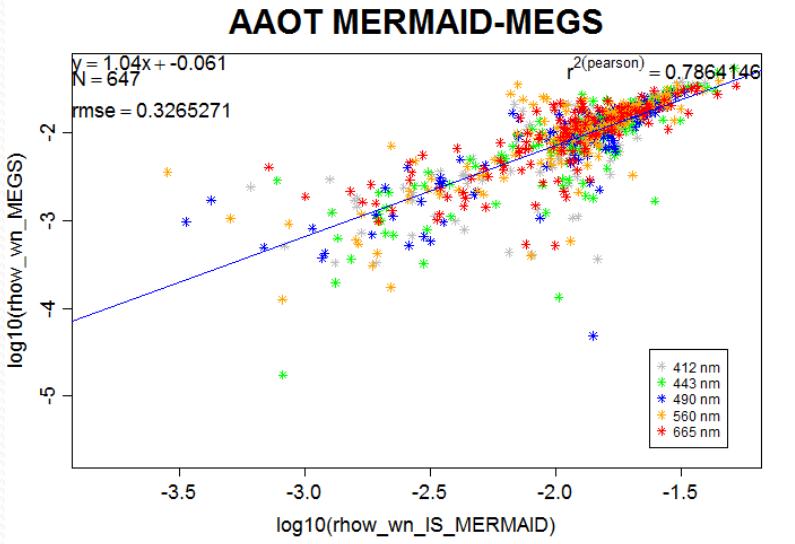


Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL
University of Dundee
The University of Edinburgh
University of Glasgow
PML Plymouth Marine Laboratory
University of Stirling

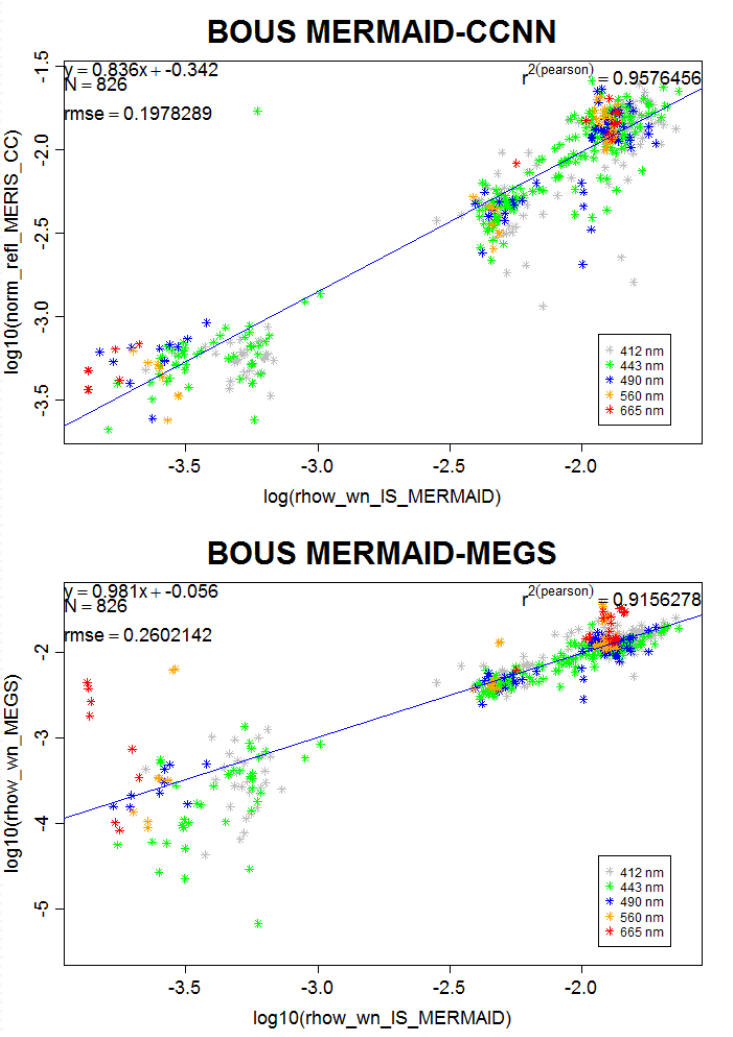
Validation against MERMAID





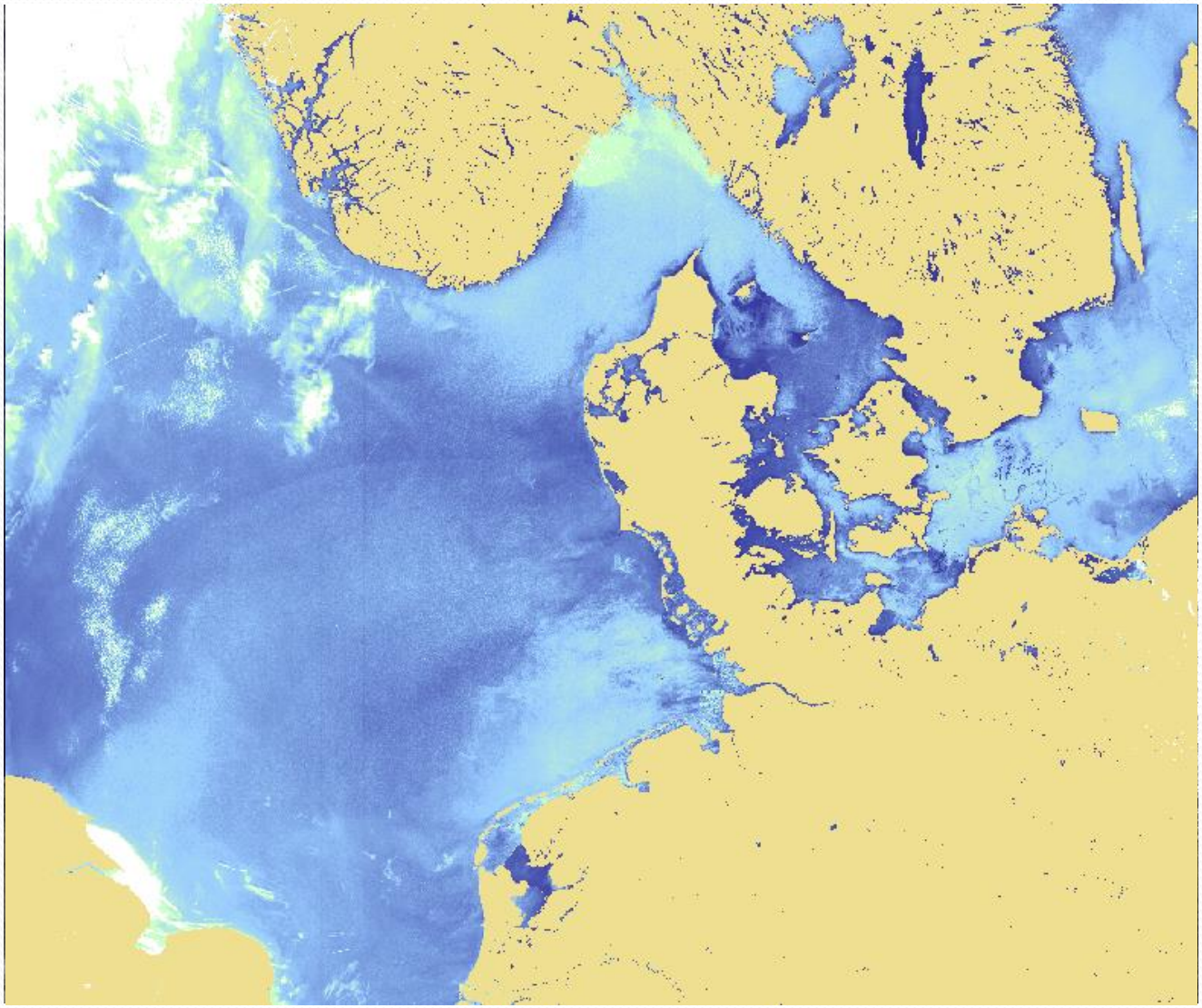


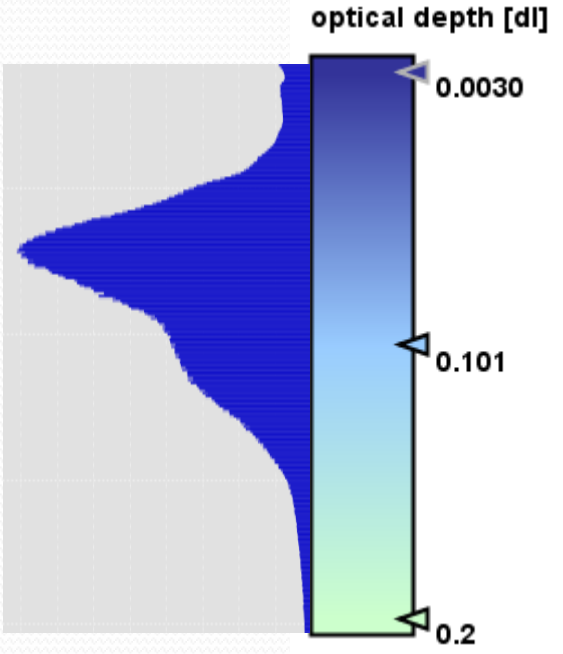
Clear Water



CC UCM4

Aerosol Optical Depth





CC UCM4

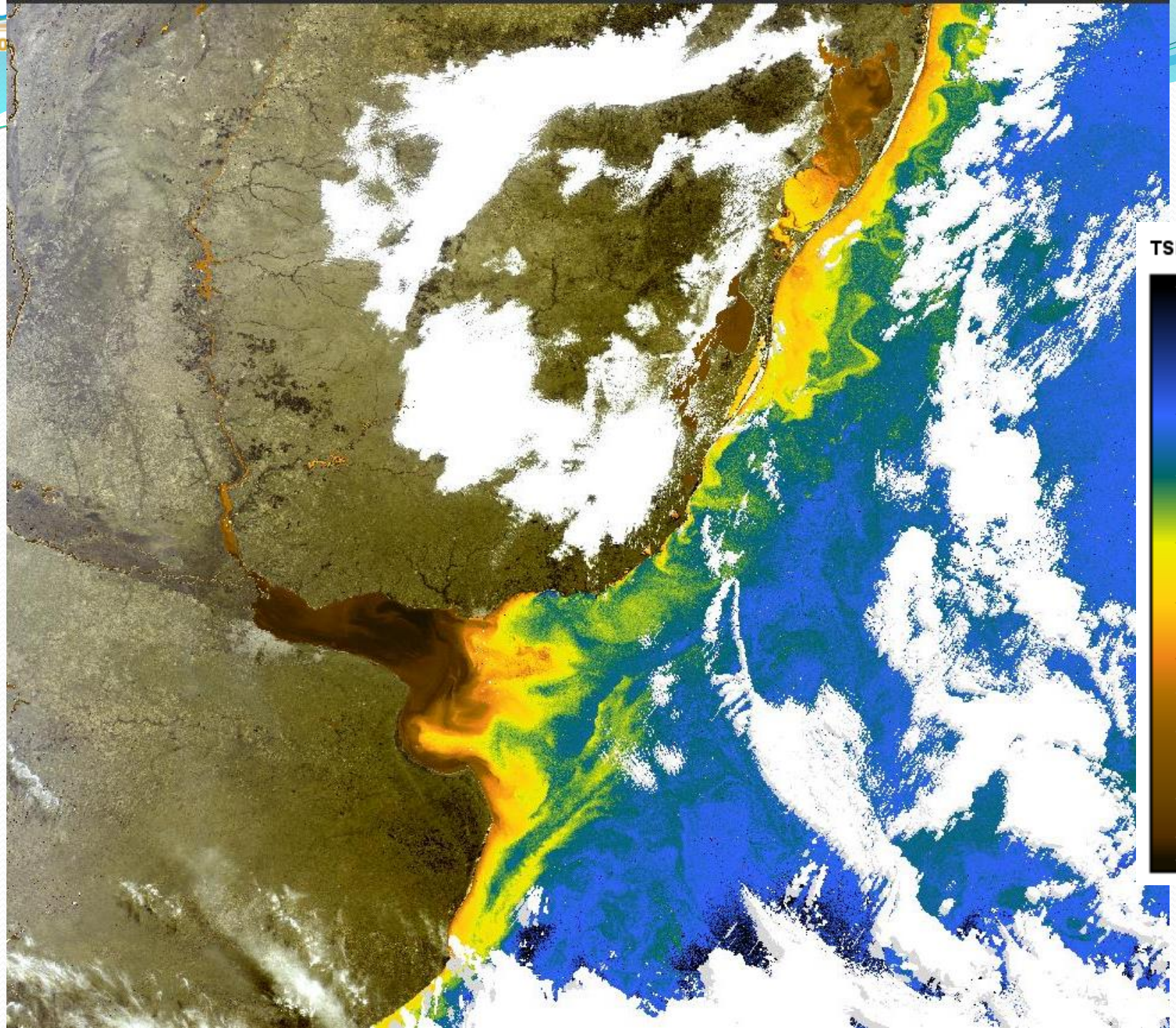
Level2 W

- Result of inversion of the water leaving reflectance
  - Talk by Roland Doerffer

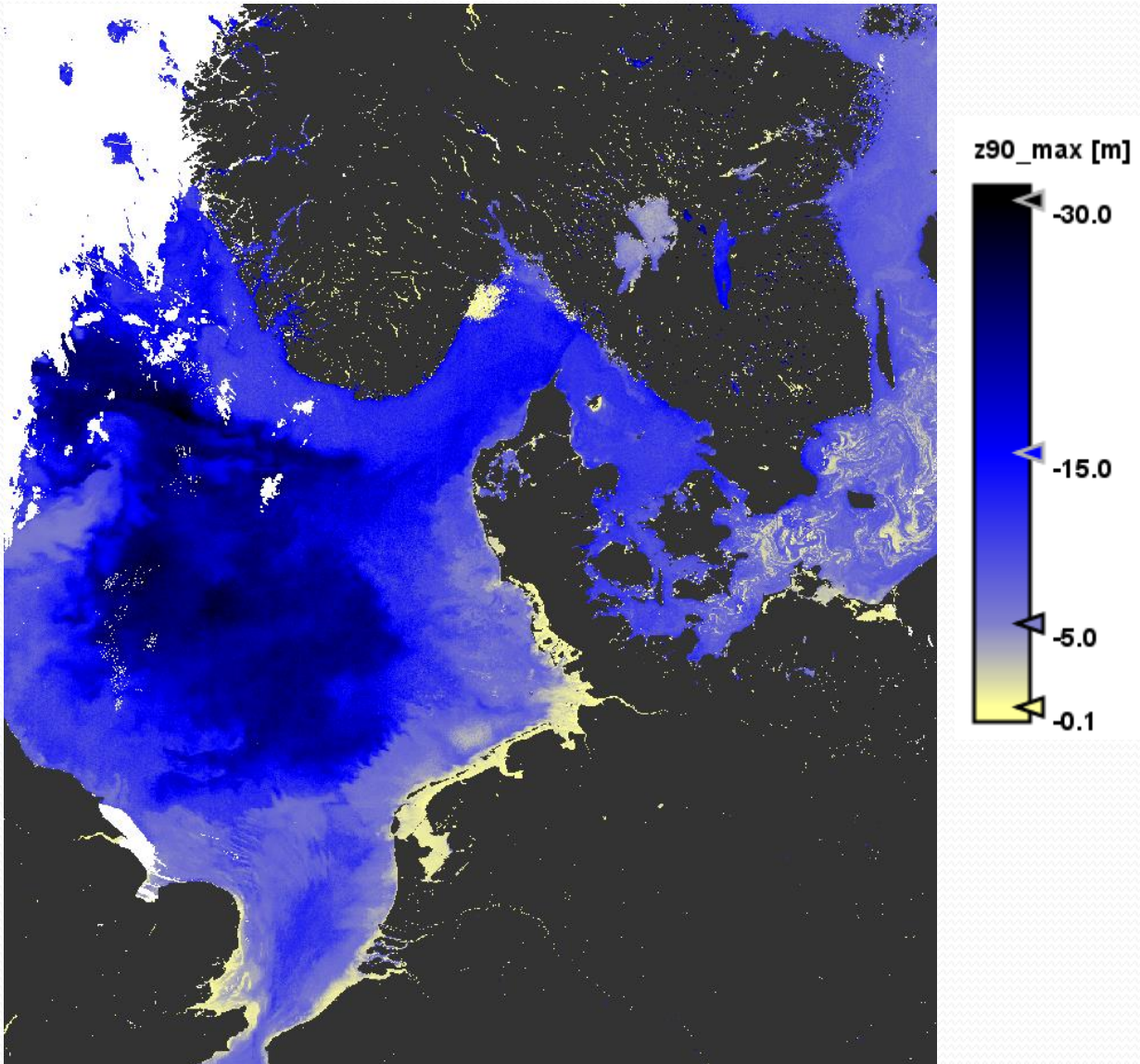
- Product Content
  - IOPs (neural net)
    - a_total, a_pig, a_dg, (a_ys, a_det)
    - bb_spm, b_tsm, b_whit
    - quality indicator (error)
  - IOPs (QAA)
    - a_total, a_pig, a_ys
    - bb_tsm

from neural net:

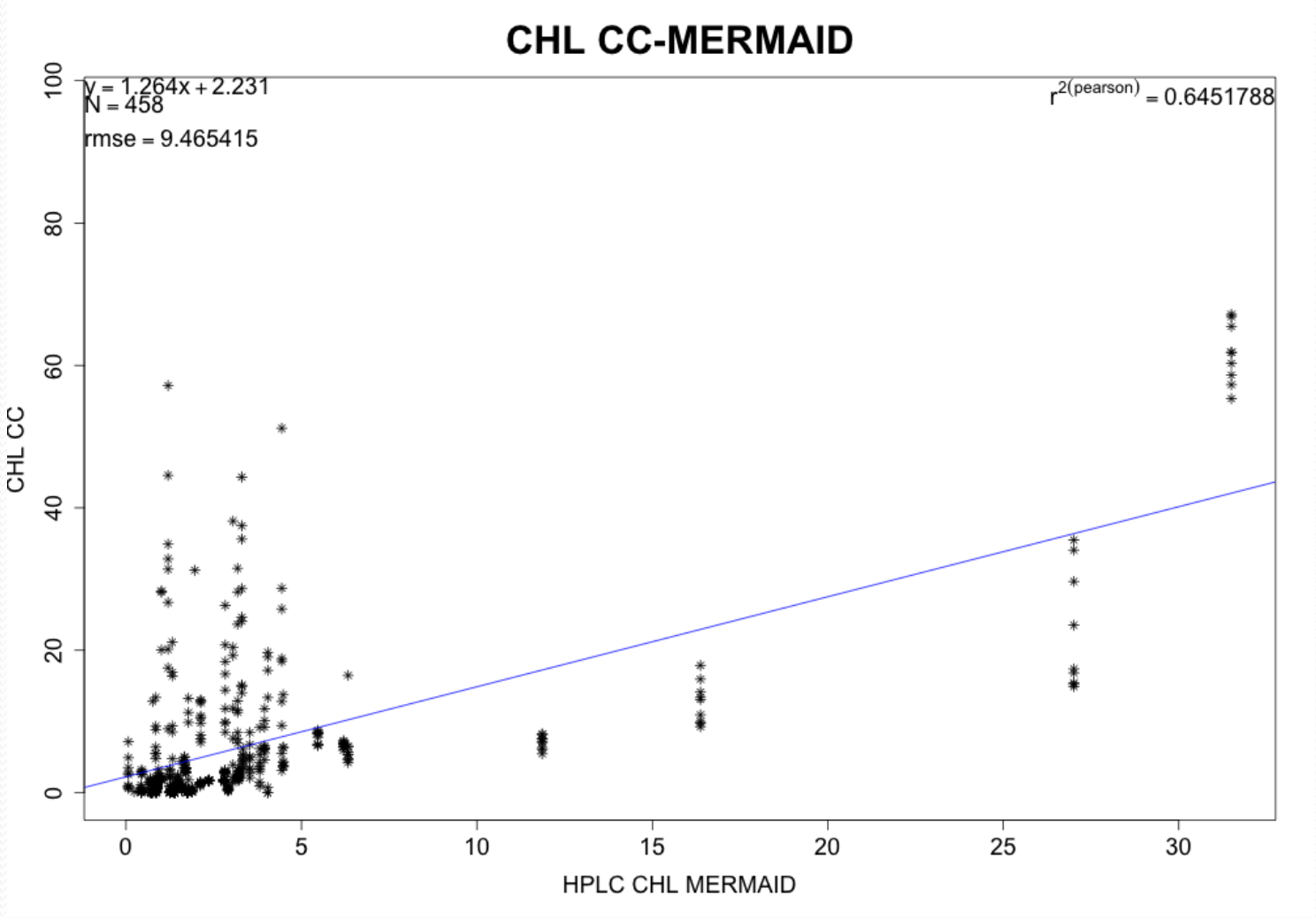
- Concentrations
  - chl, tsm
- Spectral k_d
- $Z90_{max}$
- Turbidity
- flags


TSM [g m^-3]
0.01
0.1
0.3
1.0
3.0
8.0
15.0
30.0
100.0
200.0
300.0

Z90 max

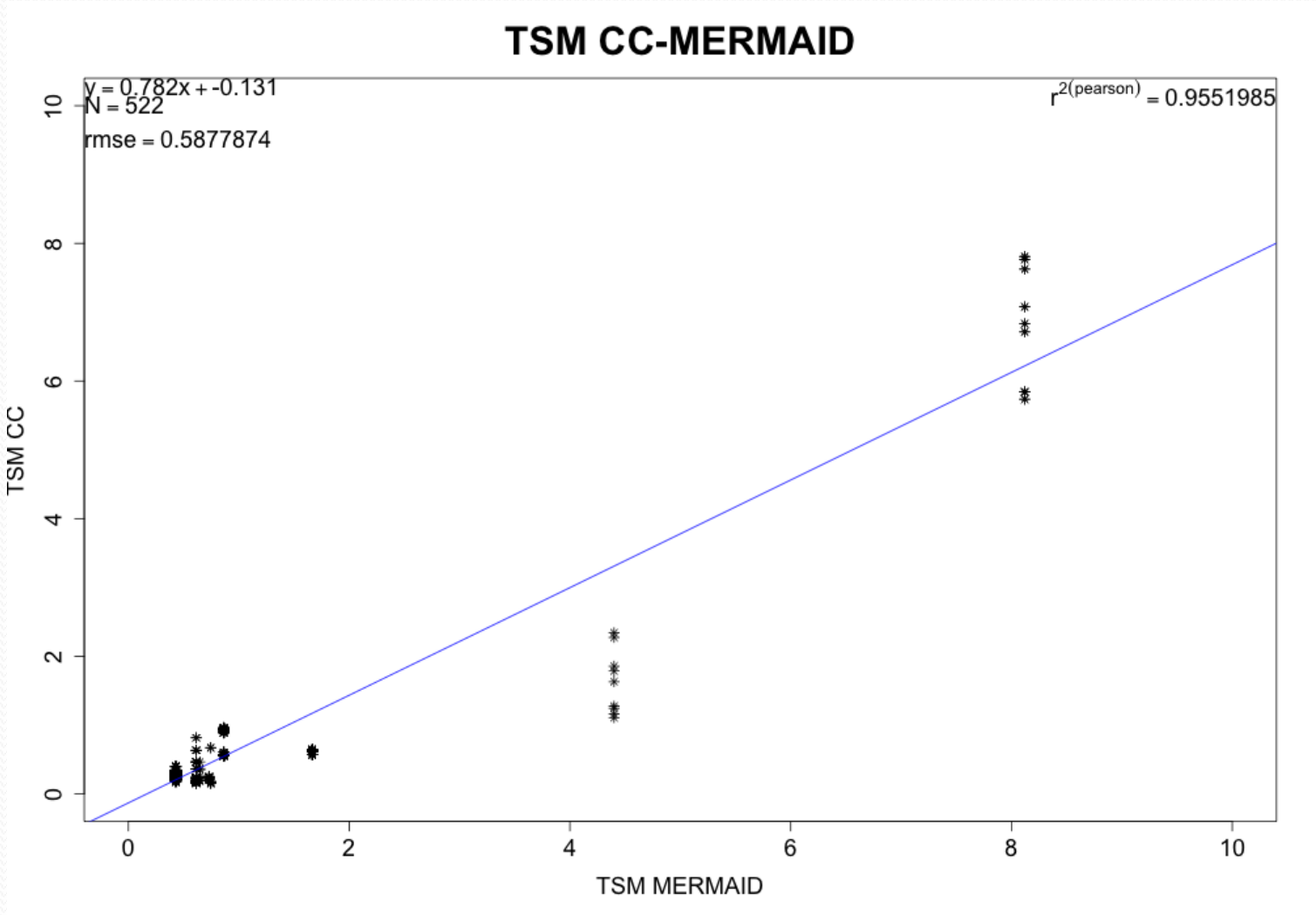


Validation with MERMAID - Chl



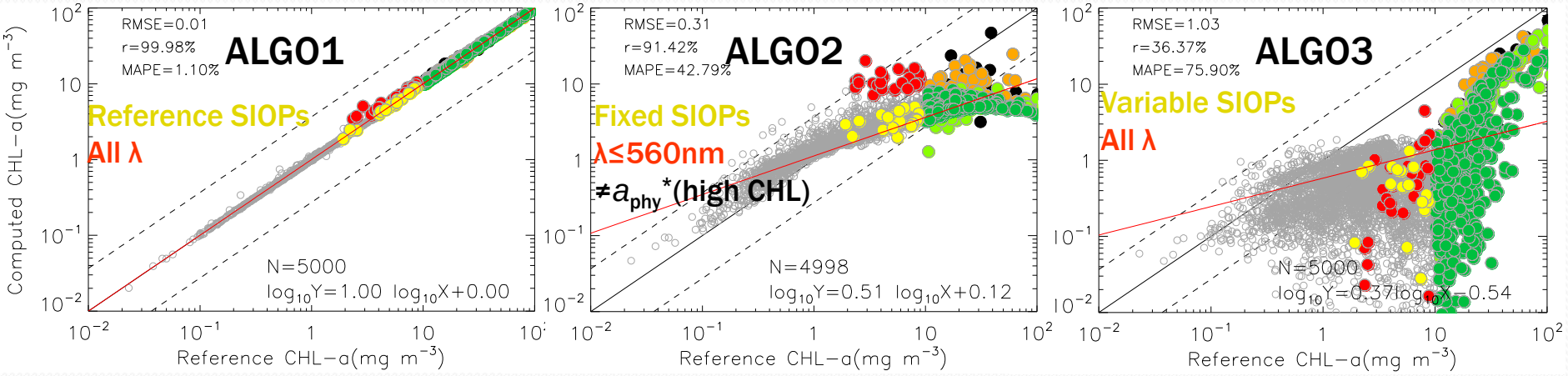
CC UCM4

Validation with MERMAID - TSM



Algorithm Round Robin Intercomparison

- Learning exercise, 14 algorithms
- Assessing strengths and weaknesses of different techniques
  - SIOPs, bio-optical model, radiative transfer, inversion, regionalisation, …
- Transfer into an IOCCG working group



Reference SIOPs (fixed) vs real SIOPs (natural variability)

Consensus Case 2 Regional Protocol

- Best practice protocols for defining regional algorithms for a specific area
- An overview of the individual steps required colour algorithm and documenting existing used to undertake such a task.
- In more depth addressing the following:
  - Minimum requirements for in-situ data for d
  - Methods for the definition and parameterisa (forward model) for a specific regional of int atmospheric correction and modelling marin
  - Approaches to solving the inverse problem, methods.

Content

- Approaches and existing algorithms
- Characterisation of the Area
- Step-by-step definition of the algorithm
- Bio-optical Model
- Atmospheric Correction
- Scope of the algorithm
- Uncertainties
- Testing
- Validation Requirements

Spatial high resolution study

- Investigating the advantages of spatial high resolution data
  - Preparation of Sentinel 2 → ~ 10 – 30m data resolution
- Landsat 8 would be best sensor; not yet available
- SPOT 4 during de-orbiting
  - Chesapeka Bay
  - Korean Coast
- Rapid Eye
- Non of these instruments has comparable spectral characteristics
  - Looking into structures and high contrast pattern
  - Testing neural network approach


2013-04-02_RE4_3A_159422

Results

- … CoastColour at ESA Living Planet Symposium, 09.-13.09.2013, Edinburgh

Acknowldements

- All CoastColour Champion users for requirements, in-situ data and feedback

- All MERMAID PIs for their experimental data and ESA, ACRI and ARGANS for access to the MERMAID database


Thank you for your attention
office@coastcolour.org
www.coastcolour.org
MERIS RGB, Lena Delta, 09. September 2005, orbit: 18438
CC UCM4

Atmospheric Correction & IOP Retrieval

- Key to success: Atmospheric Correction
  - For Case2 water processing we need an AC which performs over clear, turbid as well as absorbing waters
  - CC-AC emphasis is on turbid waters, even over extreme waters (high reflective as well as highly absorbing) the AC shall not fail
  - Coupled ocean-atmosphere Radiative transfer modelling for AC and IOP retrieval

- Regional IOP retrieval
  - Neural network methodology
    - Global NN & Optical Water Type classification related NNs
      - Will be addressed by presentation of R. Doerffer
    - Strength in turbid waters
  - Quasi Analytical Approach (QAA)
    - Strength in clear waters

Atmosphere

- Atmosphere
  - Radiative Transfer Model of R. Santer, using Aerosol models based on coastal AERONET measurements
  - Parameters for simulation: AOT 550, angstrom, wind
- All simulations for different sun and viewing angles
- 7 Mio cases with water model simulated

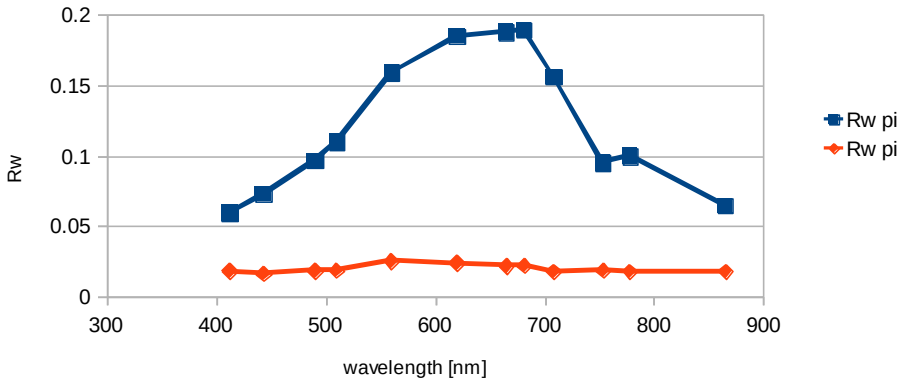
Water

- Analysis of reflectance spectra of extreme cases
- Chlorophyll range 0.01 – 100 mg m^3
- TSM range 0.01 – 1000 mg/l
- Bio-optical model 5 IOP components:
  - a_pig
  - a_detritus (slope 0.01)
  - a_gelbstoff (slope 0.02)
  - b_particle (slope 0.8)
  - b_white (slope 0.0)
- Frequency distribution
- Temperature: 0 – 36 deg C, salinity: 0 – 42

Max reflexion spectra in turbid estuaries

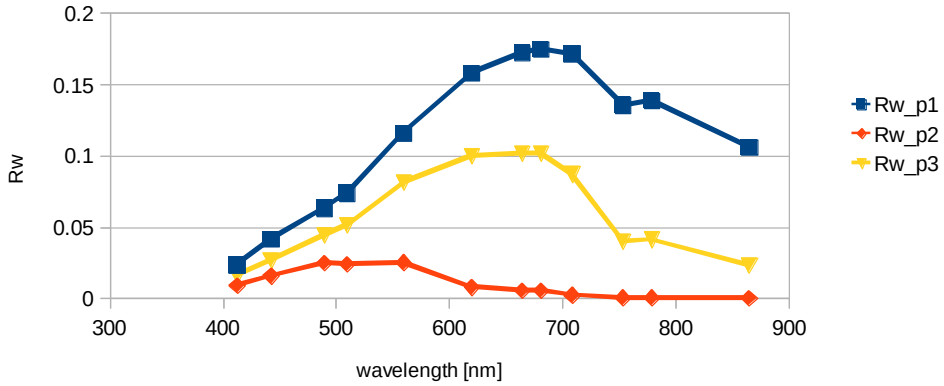
Amazone 20050803

Rw pin1, 2 compute from RLtosa



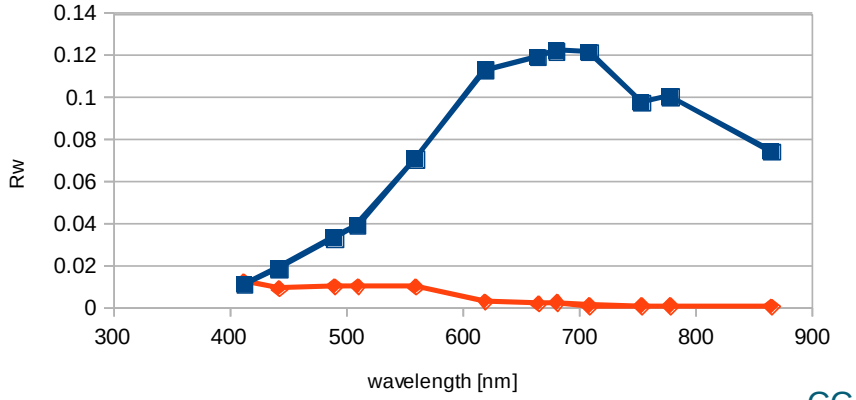
Rio de la Plata 20080613

Rw computed from RLpath



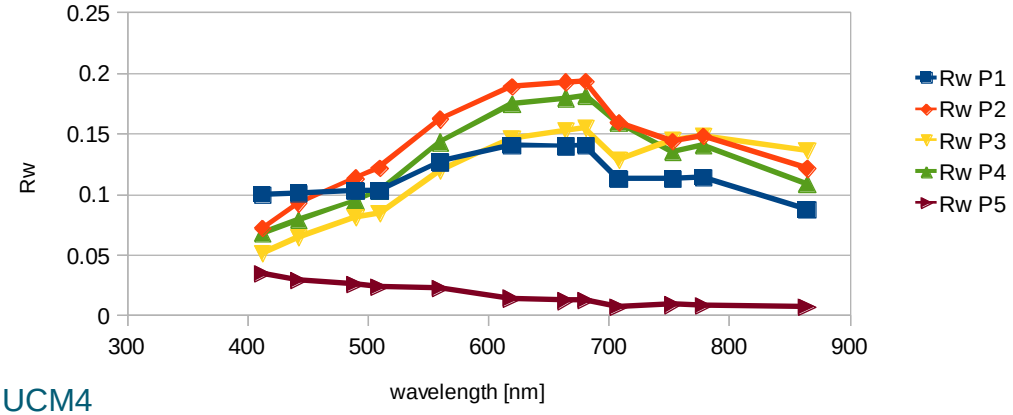
Bay of Fundy 20050905

Rw

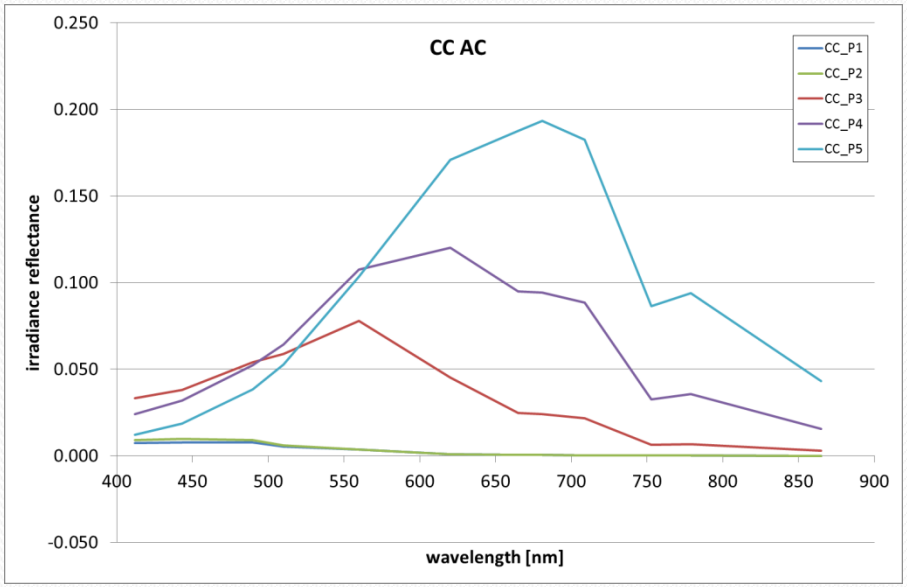


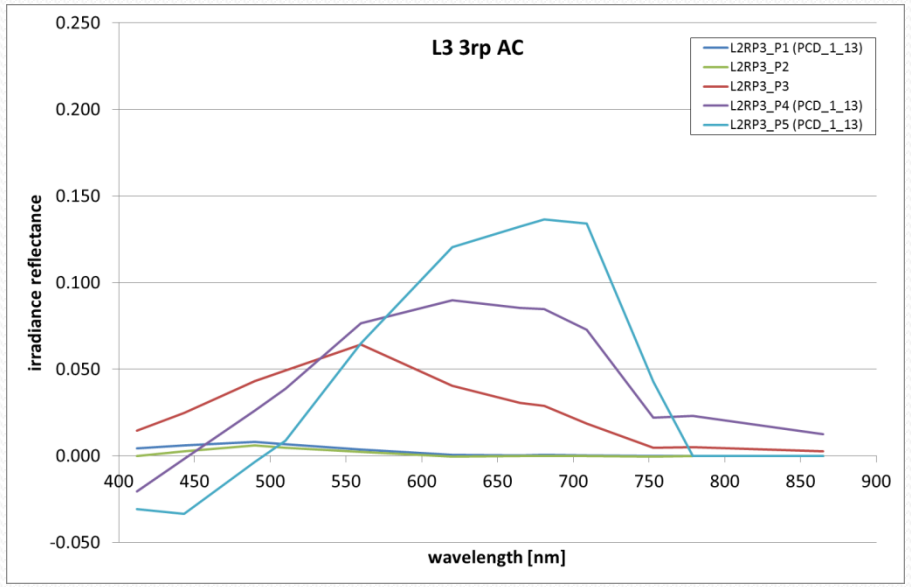
Yangtse 20050809

Rw computed from RL_toa

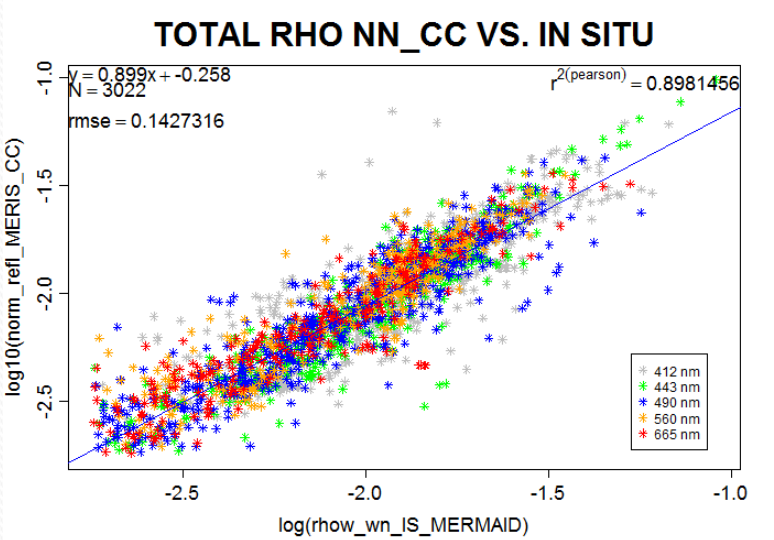


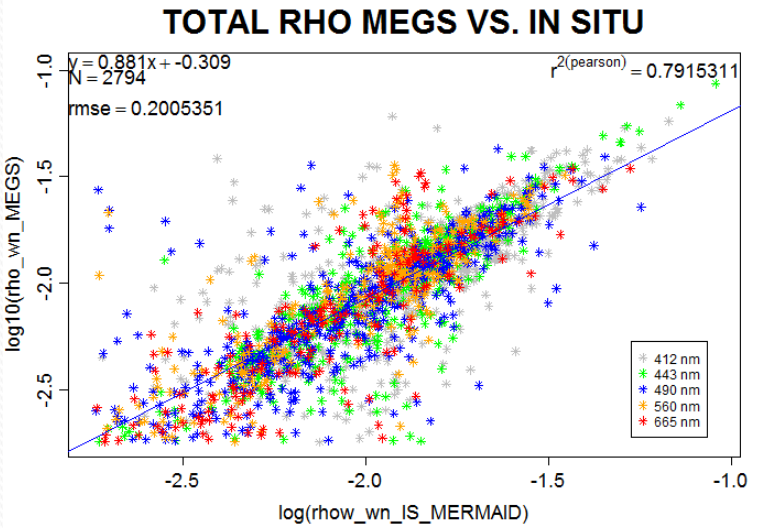
Rio de la Plata
Comparison CC – standard 3rp



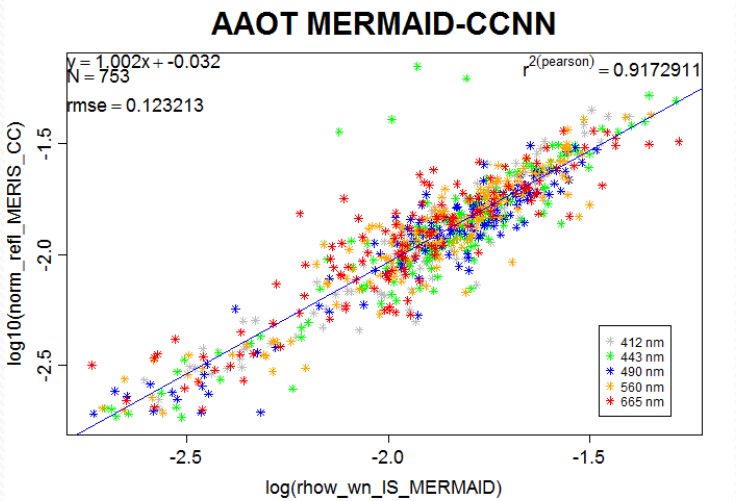


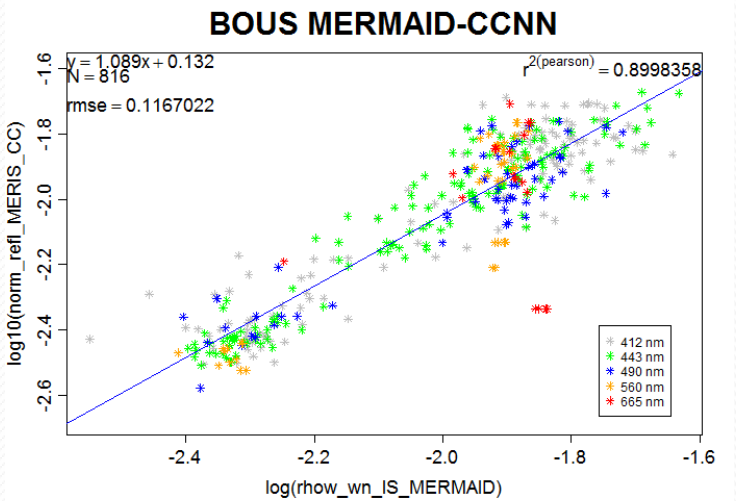
Validation on MERMAID data

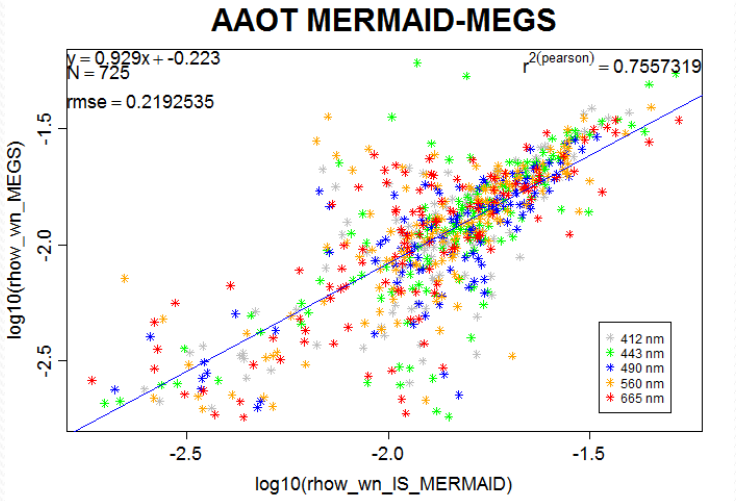


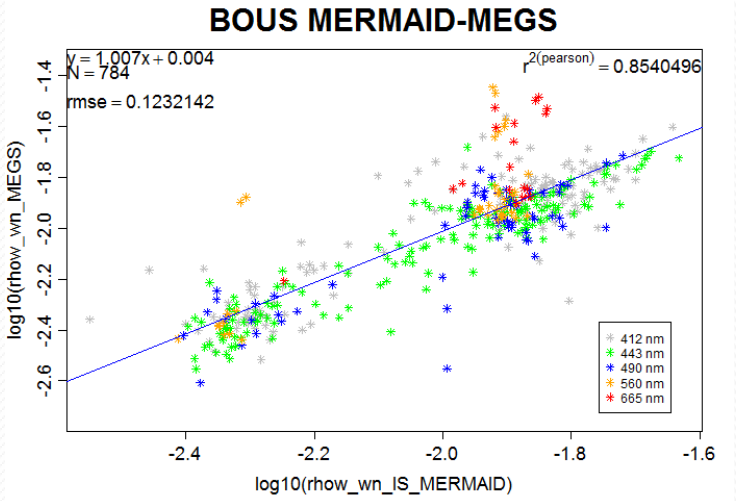


AAOT and Boussole





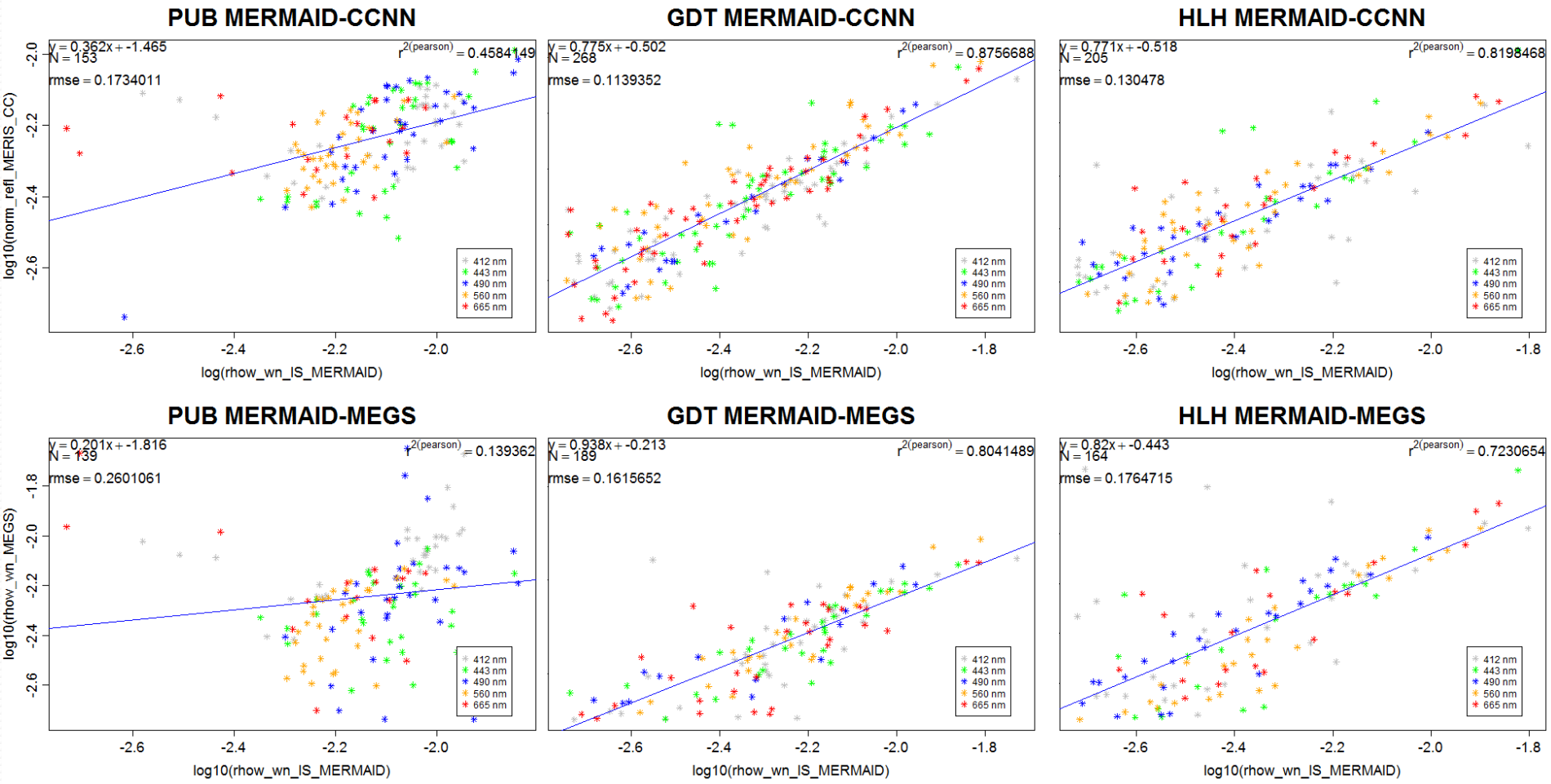




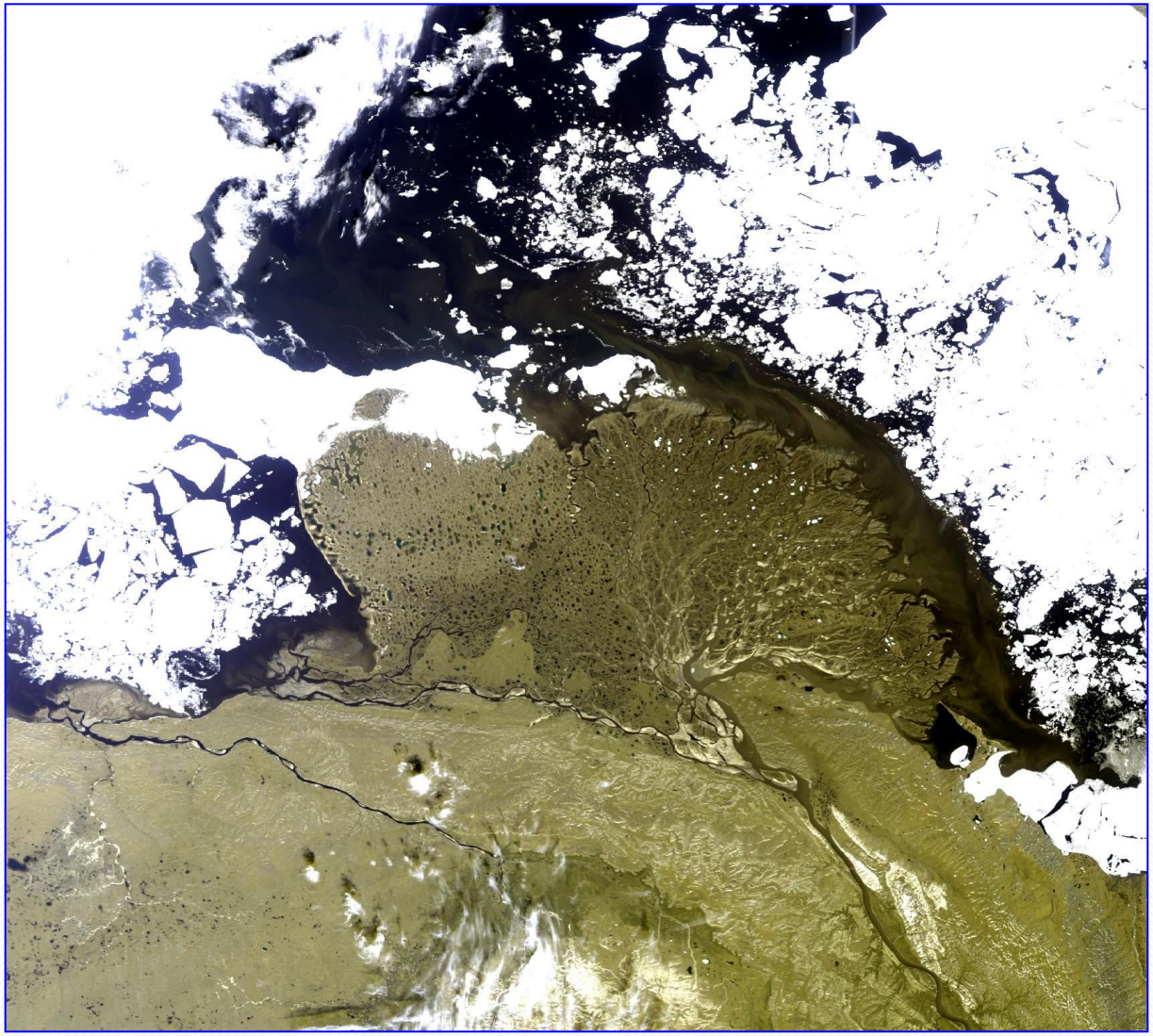
Turbid Waters & Absorbing Water

US West Coast, turbid

2 stations in the Baltic Sea, absorbing water



Validation Water Constituents



Lena Delta, site 18

MERIS FR 20110704

Lena Delta 73 N
Lena > 500 km^3 fresh water, 2nd after Yenesei in the Arctic

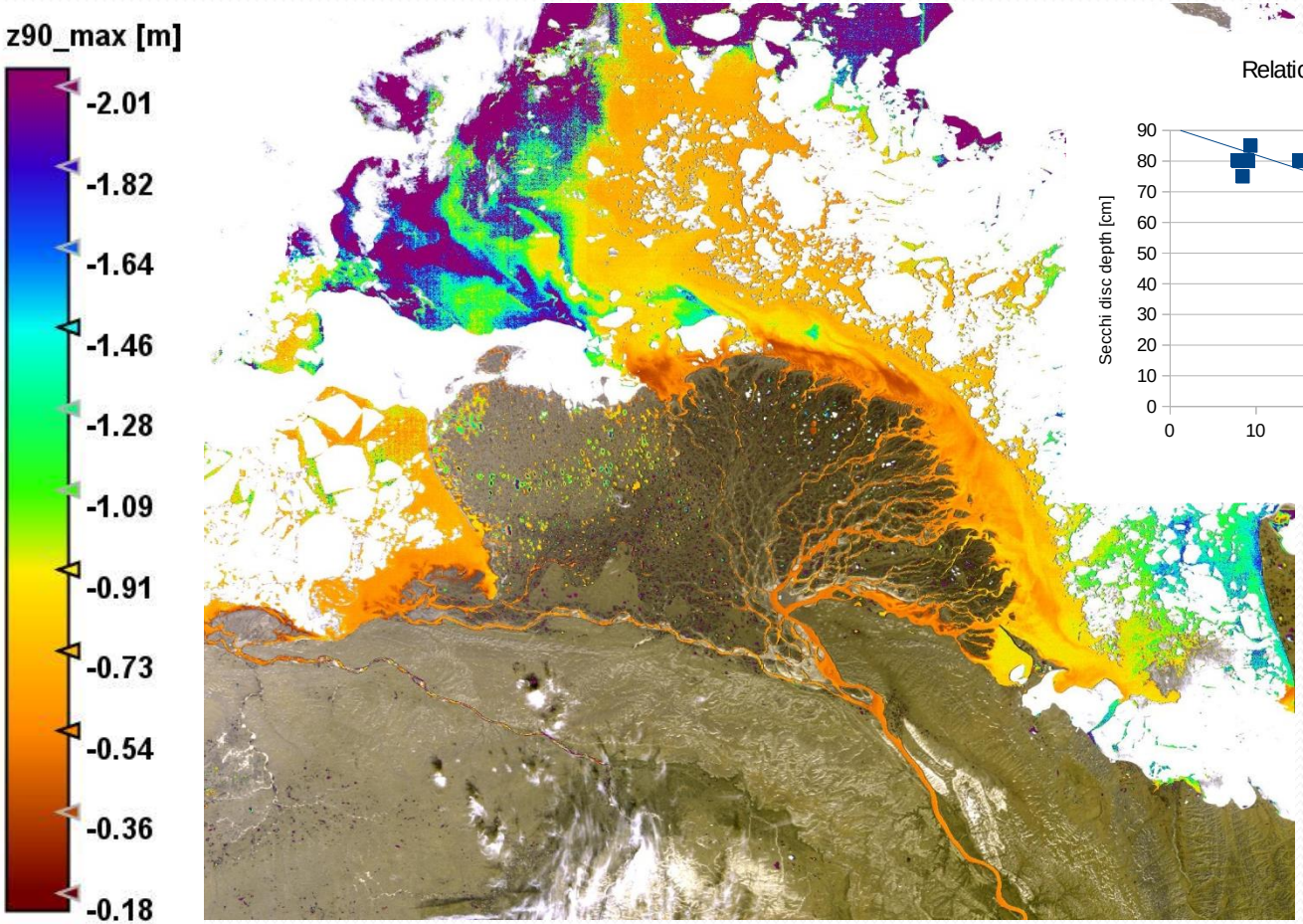
Very high concentration of absorbing substances (Carbon)

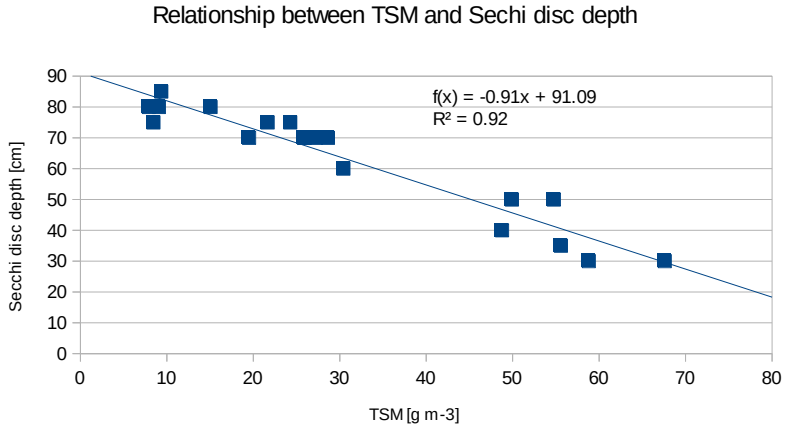
a443 5-8 m^{-1}

Partly very turbid

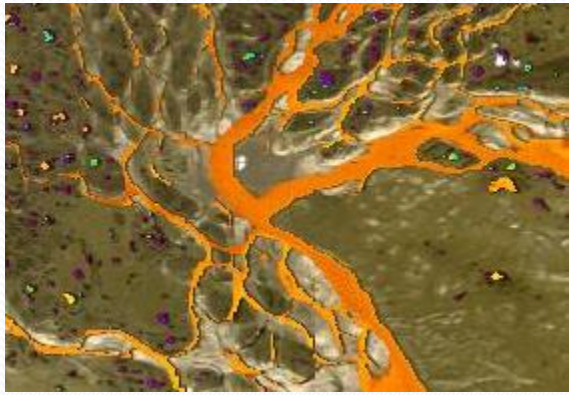
Bio-optics campaign
June 26 – July 5th 2011

Z90_max

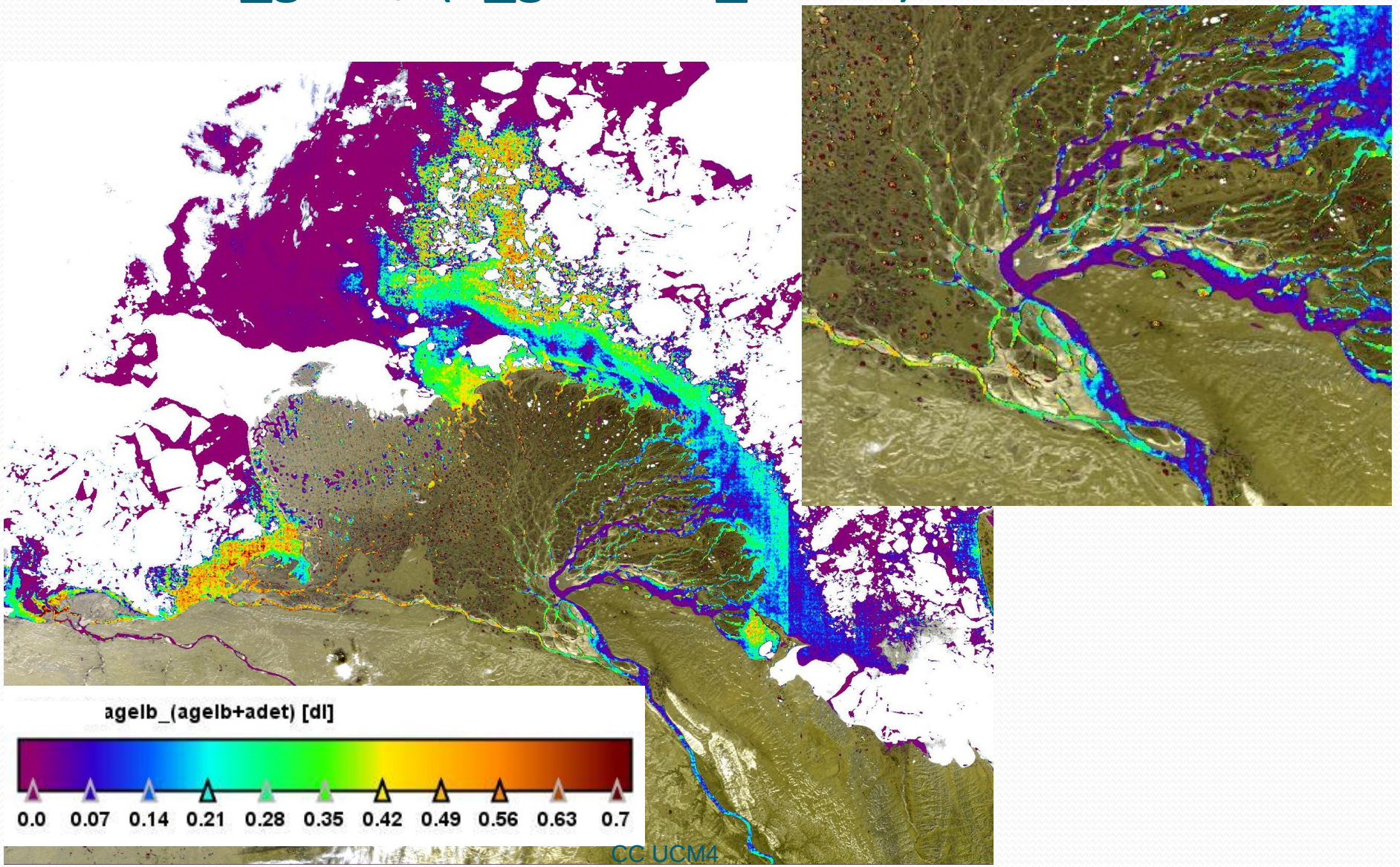




Secchi: 30 – 85 cm

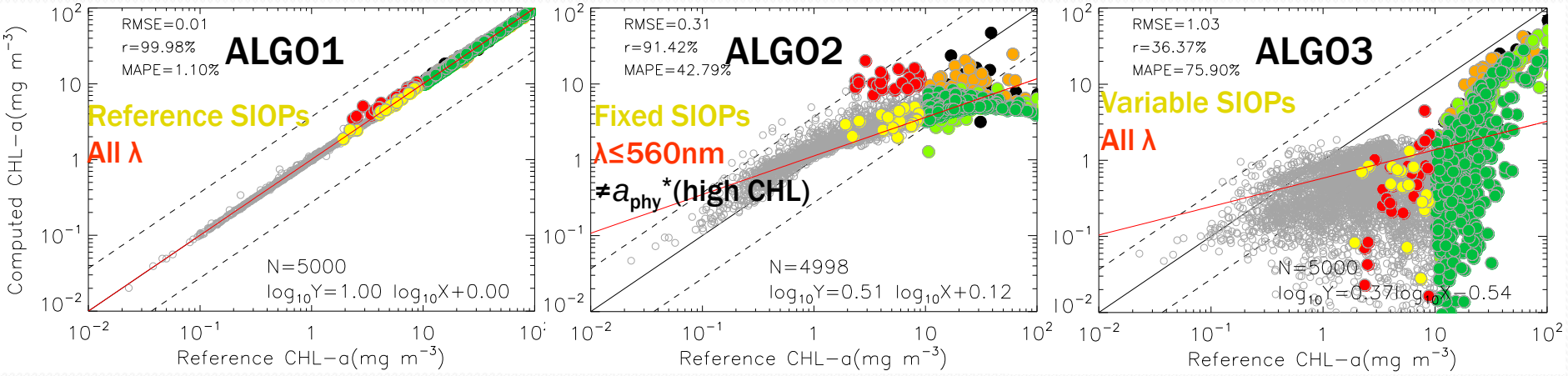


a_gelb / (a_gelb + a_dritus) at 443 nm



Algorithm Round Robin Intercomparison

- Learning exercise, 14 algorithms
- Assessing strengths and weaknesses of different techniques
  - SIOPs, bio-optical model, radiative transfer, inversion, regionalisation, …
- Transfer into an IOCCG working group



Reference SIOPs (fixed) vs real SIOPs (natural variability)

Consensus Case 2 Regional Protocol

- Best practice protocols for defining regional algorithms for a specific area
- An overview of the individual steps required colour algorithm and documenting existing used to undertake such a task.
- In more depth addressing the following:
  - Minimum requirements for in-situ data for d
  - Methods for the definition and parameterisa (forward model) for a specific regional of int atmospheric correction and modelling marin
  - Approaches to solving the inverse problem, methods.

Content

- Approaches and existing algorithms
- Characterisation of the Area
- Step-by-step definition of the algorithm
- Bio-optical Model
- Atmospheric Correction
- Scope of the algorithm
- Uncertainties
- Testing
- Validation Requirements

Future

- 2013
  - User Consultation Meeting 4
    - Under discussion: back-to-back with IOCCG
  - Reprocessing
  - All years
  - Globally all coastal zones
- 2014 and beyond
  - Coastal component in Ocean Colour CCI