Algorithms for the Atmospheric correction and the retrieval of constituents in Case 2 waters with MERIS - BEAM

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The Challenge of Case 2 Water Remote Sensing

- Different types of aerosols
- Contrails
- Different constituents with varying optical properties
- Foam and sun glint
- Shallow water with bottom reflection effects
- High concentrations of suspended matter, which masks other constituents

MERIS RR 16.4.2003 full swath

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Regional Case 2 water processor in BEAM
Regional Case 2 water processor - feature

- Atmospheric correction based on neural network
  - Aerosols
  - Thin cirrus clouds
  - Turbid water
  - Sunglint
  - Smile correction
- Retrieval of water constituents based on neural network
  - Optional with optimization
  - Out of training range index
- Further development
  - Confidence range index
  - Improved fluorescence index
  - Retrieval of extreme TSM concentrations
  - Exceptional Spectra indicator
Products

- Present
  - Path radiance reflectance (9 bands)
  - Transmittance (9 bands)
  - Water leaving radiance reflectance (9 bands)
  - B_tsm
  - A_pig
  - A_gelb
  - Chlorophyll
  - Tsm
  - Chi_square
- Future
  - Confidence intervall for a_pig, a_gelb, b_tsm
  - Tsm for extreme cases
  - Exceptional spectra index
  - Fluorescence based on neural network
Bands for atmospheric correction

Ltoa over water with high SPM and gelbstoff concentration

MERIS FR 20030416, x=589, y=194, Elbe/Oste

Radiance $L$ [W m$^{-2}$ sr$^{-1}$ µm$^{-1}$] vs. Wavelength [nm]
NN for atmospheric correction

Input
- RLtosa
- sun zenith
- view zenith
- azimuth diff
- Opt. wind

Output
- MERIS band 1-9
- Trans tosa-surface
- Path radiance
- errcode

\[ RLw(\theta,\phi) = \frac{Lw(\theta,\phi)}{Ed} \]
Model Atmosphere for MC simulations

Correction layer

50 layers
Constant pressure profile
Constant ozone profile
Variable:
All aerosols and cirrus, but relative profile fixed per aerosol type

Rough surface, wind variable, sunglint separately counted

Scattering particles for MERIS bands 708.1, 753.1, 778.2, 864.6
### Range of atmospheric properties

- **Maritime aerosol** $\tau_{550}$: 0 - 0.2
- **Urban aerosol** $\tau_{550}$: 0 - 0.2
- **Continental background aerosol** $\tau_{550}$: 0 – 0.025
- **Cirrus cloud** $\tau_{550}$: 0 – 0.3
- **Stratospheric aerosol** $\tau_{550}$: 0 - 0.003
- **Total** $\tau_{550}$: 0 – 0.528
- **Scattering particles in water** $b_s550$ m$^{-1}$: 0 – 6.25
- **Wind** m/s: 0 – 8
- **Sun zenith angle degree**: 1 - 80

### Correction layer
- **Surface pressure**, taken from MERIS aux data
- **Ozone concentration**, taken from MERIS aux data
Radiance reflectances

![Graph showing radiance reflectances for MERIS RR Helgoland 20020729 pixel 8 with various labels: RL_toa, RL_tosa, RL_path, RLw_bread.](image-url)
Path radiance, MERIS band 1
Path radiance MERIS band 9
Red Tide Myrionecta rubra German Bight 3.8.2004
Smile Correction in Beam C2R Processor

With Beam C2R smile correction

Without Beam C2R smile correction

Chlorophyll

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Beam C2R L2 RGB (after atmospheric correction)
Path radiance band 5
Transmittance band 5
Water leaving radiance reflectance RLw band 5
Atmospheric correction separation test

Path radiance, water leaving radiance reflectance, transmittance MERIS band 5
Transect German Bight ("Wappen"), 3.8.2004
Helgoland transect Beam C2R Concentrations

wappentranssect 3.8.2004 beamc2r

- concent. mg m$^{-3}$, g m$^{-3}$
- suspended
- pigment
- Sample chlor
- sample tsm

Longitude: 7.9 to 8.7

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Test of Separation with BEAM breadboard

Radiance reflectance, test transect 29.7.2002, band8, breadboard

RL [sr\(^{-1}\)]

RL\(_{\text{toa}}\)
RL\(_{\text{path}}\)
RL\(_{\text{w_bread}}\)
Sun glint
Sun glint transect

Radiance reflectance, band8, breadboard nowind

RL [sr⁻¹]

index no. along transect Med Sea 20020730 line 145
Pixel 300 of transect (outside glint)
Pixel 700 of transect (middle of glint)

MERIS RR MedSea 20020730 line 145 pixel 700

- RL_toa
- RL_tosa
- RL_path
- RLw_bread

Graph showing spectral reflectance (RL) versus wavelength (nm) for MERIS RR MedSea 20020730 line 145 pixel 700.
Pixel 900 of transect (maximum of glint)

![Graph showing MERIS RR MedSea 20020730 line 145 pixel 900 RL vs wavelength in nm]
River discharge
Yangtze mouth (China)
March 2003

Shanghai
Suspended Matter Concentration Yellow Sea, May 25, 2005
Simulated relationship between TSM and MERIS TOA Red - NIR bands
Difference TOA radiance reflectances

![Graph showing the difference in TOA radiance reflectances for different TSM concentrations. The x-axis represents TSM concentration in mg m\(^{-3}\), and the y-axis represents the difference in RLw m\(^{-1}\). The graph includes four curves for different pairs of sensors: M9-M6, M10-M9, M11-M10, and M12-M11. The points on each curve represent the data points for each TSM concentration.]
Result of NN test

NN test for 3 toa reflectance differences MERIS band 9,10,12,13

Neuroet
2 hidden
Log_tsm
Lin_outtransfer
Log-Sigmoid
bias
LM training

Input:
RLtoa(10-9)
RLtoa(12-10)
RLtoa(13-12)
Out: log TSM

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Summary & Conclusions

• A case 2 water regional processor will be implemented in BEAM
• Includes atmospheric correction and products path radiance, transmittance, water leaving radiance reflectance
• Retrieval of IOPs and concentrations
• A special smile correction for water has been implemented
• Validation shows in some cases strange behaviour of NN -> has to be investigated
• Atmospheric correction including sun glint shows good results
• But a new aerosol model will be implemented (blue problem)

• Next step is the validation for different sites
• Further improvement by
  – new bio-optical model
  – Optional optimization procedure
• Further extensions such as fluorescence will be investigated
RLw for MERIS bands 1 (412 nm), 6 (560 nm), 10 (708 nm)

SPM [g m\(^{-3}\)]
RLw [sr\(^{-1}\)]

- band 1 = 412 nm
- band 5 = 560 nm
- band 9 = 708 nm

a_gelb_440: 0.2, a_part_440: SPM/25, pig: 2 mg m\(^{-3}\)
Helgoland transect Beam C2R Concentrations with Chi2 values

beamc2r wappen transect 20040803

longitude: 7.9 - 8.7
conc mg m⁻³, g m⁻³

- suspended
- pigment
- Sample chlor
- sample tsm
- chiSquare

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