EUFAR ESA Workshop on Atmospheric Correction of Remote Sensing Data

26 – 28 October 2016
Harnack Haus, Berlin, Germany

Hosted by

Freie Universität Berlin

Travel & Information Guide

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1. General Information

Workshop Venue: All participants will be housed at the Harnack Haus - the conference venue of the Max Planck Society, which will also be the workshop venue.

Address: Harnack-Haus., Ihnestr. 16-20 - 14195 Berlin
Website:

List of Participants

Participant	Organisation	Email
Organisers		
Thomas Ruhtz	FUB	Thomas.Ruhtz@fu-berlin.de
Invited Speakers		
Oleg Dubovik	CNRS	
Alex Kokhanovsky	VITROCISET	
Timothy Smyth	PML	
Carsten Brockmann	Brockmann Consult	Carsten.Brockmann@brockmann-consult.de
Scientists & Experts		
Saumitra Mukherjee	Jawaharlal Nehru University	
Dainis Jakovels	Institute for Environmental Solutions, Latvia	dainis.jakovels@videsinstituts.lv
Mark Warren	PML	mark1@pml.ac.uk
Lauri Markelin	PML / FGI	lma@pml.ac.uk
Cristiana Bassani	CNR	cristiana.bassani@iia.cnr.it
Mohcine Chakouri	Beni Mellal, Morocco	chakouri.mohcine@gmail.com
Christopher Ilori	Simon Fraser University, Canada	
Guido Bernini	University Roma	guido.bernini@uniroma1.it
Jean-Claude Thelen	UK MetOffice	jean-claude.thelen@metoffice.gov.uk
Trismono Candra Krisna	Uni Leipzig	trismono_candra.krisna@uni-leipzig.de
Elena Ruiz	Uni Leipzig	elena.ruiz_donoso@uni-leipzig.de
Jan Hanus	Global Change Research Institute CAS	
Sebastian Riedel	DLR	S.Riedel@dlr.de
Christina Karakizi	National Tech. University of Athens	chr.karakizi@gmail.com
Chloe Brown	University Nottingham	
Felix Ebojie	Uni Bremen	ebojfe@yahoo.com
Sindy Sterckx	VITO	sindy.sterckx@vito.be
Joan Christian Padro	Universitat Autònoma de Barcelona	
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Andre Hollstein	GFZ	Andre.Hollstein@gfz-potsdam.de
Max Brell	GFZ	brell@gfz-potsdam.de

Accommodation

The room requirements for the period 26 to 29 October are as follows (if there is any error, please contact Lilian Diarra ():

Participant	Organisation	Check In	Check Out	Room/Nights
Oleg Dubovik	CNRS	26/10/2016	28/10/2016	2
Alex Kokhanovsky	VITROCISET	26/10/2016	29/10/2016	3
Timothy Smyth	PML	26/10/2016	28/10/2016	2
Carsten Brockmann	Brockmann Consult	26/10/2016	28/10/2016	2
Saumitra Mukherjee	Jawaharlal Nehru University	26/10/2016	29/10/2016	3
Dainis Jakovels	Institute for Environmental Solutions, Latvia	26/10/2016	28/10/2016	2
Mark Warren	PML	26/10/2016	28/10/2016	2
Lauri Markelin	PML / FGI	26/10/2016	28/10/2016	2
Cristiana Bassani	CNR	26/10/2016	28/10/2016	2
Mohcine Chakouri	Beni Mellal, Morocco	26/10/2016	28/10/2016	2
Christopher Ilori	Simon Fraser University, Canada	26/10/2016	29/10/2016	3
Guido Bernini	University Roma	26/10/2016	28/10/2016	2
Jean-Claude Thelen	UK MetOffice	26/10/2016	28/10/2016	2
Trismono Candra Krisna	Uni Leipzig	26/10/2016	28/10/2016	2
Elena Ruiz	Uni Leipzig	26/10/2016	28/10/2016	2
Jan Hanus	Global Change Research Institute CAS	26/10/2016	28/10/2016	2
Sebastian Riedel	DLR	26/10/2016	28/10/2016	2
Christina Karakizi	NATIONAL TECHNICAL UNIVERSITY OF ATHENS	26/10/2016	28/10/2016	2
Chloe Brown	University Nottingham	26/10/2016	28/10/2016	2
Felix Ebojie	Uni Bremen	26/10/2016	28/10/2016	2
Sindy Sterckx	VITO	26/10/2016	28/10/2016	2
Joan Christian Padro	Universitat Autònoma de Barcelona	26/10/2016	28/10/2016	2
Dirk Schuettemeyer	ESA	26/10/2016	28/10/2016	2

Participants, arriving on the 25th of October, have been asked to arrange for their own accommodation for this night and will be reimbursed after the workshop on presentation of a justification (e.g. hotel invoice).

Meals

All meals and coffee breaks will be provided at the Harnack Haus during the meeting starting with lunch at 12:00 on 26 October.

For any meals not covered, participants can claim to be reimbursed for these meals after the meeting. See section 5 on Reimbursement of Travel and Subsistence expenses.

Directions: How to get to the Harnack Haus?

From Tegel Airport (18 km)
Take bus 109 towards Zoologischer Garten. Change at Jakob-Kaiser-Platz for underground line U7 towards Rudow to Fehrbelliner Platz. At this stop, change for underground line U3 towards Krumme Lanke to Thielplatz. Leave the underground station by walking in the direction of travel and by using the left exit. The Harnack House is 100 metres away on the right side.

From airport at Berlin Schoenefeld (25 km)
Take bus 171 to underground station Rudow. Once there, change for underground line U7 towards Rathaus Spandau to Fehrbelliner Platz. Then change for underground line U3 towards Krumme Lanke to Thielplatz. Leave the underground station by walking in the direction of travel and by using the left exit. The Harnack House is 100 metres away on the right side.

From Berlin´s Central Station Hauptbahnhof (15 km)
Take the S-Bahn city train S7 towards Potsdam Hauptbahnhof to Zoologischer Garten. There, change for underground line U9 towards Rathaus Steglitz to Spichernstraße. Then change for underground line U3 towards Krumme Lanke to Thielplatz. Leave the underground station by walking in the direction of travel and by using the left exit. The Harnack House is 100 metres away on the right side.

From train station Südkreuz (9 km)
Take the S-Bahn city train S41 Ringbahn (only selected trains) to Heidelberger Platz. There, change for underground line U3 towards Krumme Lanke to Thielplatz. Leave the underground station by walking in the direction of travel and by using the left exit. The Harnack House is 100 m away on the right side.

Arrival by car
If you arrive via highway A 115, take exit Hüttenweg number 2, turn right towards Dahlem until you reach the corner of Clayallee. Then turn right and at the next crossroads turn left to Saargemünder Straße. A short time afterwards, you will reach the Harnack House at the corner of Ihnestraße.

2. Workshop Agenda

Wednesday, 26 October 2016		
Time	**Session**	**Room/Hall**
12:00-13:00	Lunch at Harnack Haus	Einstein Lounge
13:00-15:00	Welcome – **Thomas Ruhtz (FUB)** Simultaneous retrieval of surface reflectance and aerosol properties using GRASP algorithm: Concept, perspectives, challenges – **Oleg Dubrovik (CNRS)** A semi-analytical technique for atmospheric correction of airborne and satellite remote sensing data – **Alexander Kokhanovsky (VITROCISET)**	Köhler
15:00-15:30	Coffee Break	Lynen
15:30-17:30	The special case of atmospheric correction over water **–** **Tim Smyth (PML)** Atmospheric Correction over Land for Sentinel 2 Data – **Grit Kirches/ Carsten Brockmann – TBD - (Brockmann Consult)**	Kohler
18:00-22:00	Dinner served at Harnack Haus	Einstein Lounge
Thursday, 27 October 2016		
07:30-08:30	Breakfast	Einstein Lounge
09:00-10:30	The importance of accurate definiton of the surface albedo on the Radiative Transfer Model (RTM) simulation – **Trismono Candra Krisna (University of Leipzig)** Pseudo Invariant Areas and their benefits for atmospheric corrections **- Joan-Cristian Padró Garcia (Universitat Autònoma de Barcelona)** HT-FRTC: A New, Fast Radiative Transfer Code For Atmospheric Correction **- Jean-Claude Thelen (Met Office)**	Kohler
10:30-11:00	Coffee Break	Lynen

11:00-13:00	Consistent Multi-Sensor Atmospheric Correction for Big Data Processing Methods - **Andre Hollstein (GFZ)** Atmospheric correction performance of hyperspectral airborne imagery over Loch Leven, UK, under changing cloud cover - **Laurin Markelin (PML/ FGI)** Fusion of HSI and ALS sensors: Towards a synergistic improvement of atmospheric correction – **Maximilian Brell (GFZ)** Hyperspectral data preprocessing for atmospheric correction - **Saumitra Mukherjee (Jawaharlal Nehru University)**	Kohler
13:00-14:00	Lunch at Harnack Haus	Einstein Lounge
14:00-16:00	Pre-processing chain for hyperspectral data established at CzechGlobe **– Jan Hanus (CzechGlobe)** Sentinel-2 L2A processor Sen2Cor – **Bringfried Pflug (DLR)** Initial assessment of atmospheric correction for Sentinel-2 data in coastal waters – **Mark Warren (PML)** Retrieval of Level-2 Water Data Products for the Gulf of Riga from Hyperspectral Airborne and Simulated Sentinel-3 OLCI Satellite Data - **Dainis Jakovels – Latvian Institute for Environmental Solutions**	Kohler
16:00-16:30	Coffee Break	Lynen
16:30-17:00	An improved atmospheric correction method for nearshore shallow water bathymetry - **Christopher Ilori (Simon Fraser University)** Comparision of EO1-Hyperion data and Landsat 8 OLI data atmospheric correction in order to obtain a good lithological mapping in centrals Jebilet, Morocco - **Mohcine Chakouri (Beni Mellal)** OPERA, an OPERational Atmospheric correction algorithm, for land and water scenes **Sindy Sterckx (VITO)**	Kohler
18:00-22:00	Dinner served at Harnack Haus	Einstein Lounge

Friday, 28 October 2016		
07:30-08:30	Breakfast	Einstein Lounge
09:00-10:30	Retrieval of Aerosol Parameters from Spectrometer Measurements **- Sebastian Riedel (DLR)** Aerosol modeling in the atmospheric correction of the remote sensing data. Selection effect of standard aerosol types and microphysical properties derived from AERONET on the surface reflectance **- Cristiana Bassani (CNR)** Presentation tbd…	Kohler
10:30-11:00	Coffee Break	Planck Lobby
11:00-13:00	Poster Session Comparing atmospherically corrected products from Sentinel-2, Landsat-8 and Modis - **Christina Karakizi (National Tech. University of Athens)** Retrieval of snow properties under overcast conditions – **Elena Ruiz (University of Leipzig)** Atmospheric correction effect on fire damage severity assessment - **Guido Bernini (University Roma)** Challenges in working with remote sensing data in tropics - **Chloe Brown (University of Nottingham)** Cloud screening on tropospheric ozone retrieval from SCIAMACHY - **Felix Ebojie (Bremen University)** Open Discussion	Kohler
13:00-14:00	Lunch at Harnack Haus	Einstein Lounge
14:00-15:00	Closing session	Kohler
15:00-15:30	Coffee Break	Planck Lobby

3. Contacts

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4. Useful links

Public transport journey planner:
Freie Universitat Berlin (FUB):
About Berlin:

5. Reimbursement of Travel & Subsistence Expenses

The EUFAR Office/Météo-France will be responsible for the reimbursement of any travel and subsistence (T&S) expenses incurred, unless differently agreed. The reimbursement of individual costs by the EUFAR Office will be based on real costs upon receipt of the proofs of payment (such as taxi, bus, etc.). This rule does not apply to meals (see below).

Meals:
Regarding the meals not organised by FUB/Harnack Haus, note that the reimbursement of the meals cannot exceed **€28.70 per meal** in accordance with Météo-France's T&S rate for Germany.

Accommodation:
Participants will not be reimbursed for accommodation as it has been organised at the Harnack-Haus, except for participants arriving on 25 October due to travel restrictions. The maximum per diem rate for Germany is €164. This amount includes about €106 for accommodation and €57.40 for meals and represents the maximum that an agent can be reimbursed per day for his/her subsistence expenses according to Météo-France/EUFAR's regulations. Please keep a proof of payment for accommodation (hotel invoice, Airbnb receipt) to claim for these expenses after the meeting.

Travel:
Your travel tickets, as proof of travel, will also be requested (boarding passes/train/metro tickets) even if paid by the EUFAR Office, thus please keep all your original tickets and receipts.

Use of a private car:
Reimbursement of use of private car is on the basis of about **€0.32 per kilometre** (depending on make of car, fiscal horse power etc.). Distances travelled can be calculated either on or , when claiming reimbursement. Fuel is included in the kilometre rate. Road tolls and parking fees may be paid extra, so please keep tickets/receipts as justification. When two or more participants travel together by car, only one person will be reimbursed for the associated travel costs.

Use of taxi:
Reimbursement of taxi fees requires prior approval from the EUFAR Office. As a general rule, participants with early or late flights are legible for reimbursement of taxi expenses.

To be reimbursed for travel and subsistence expenses, please fill in the form at the end of this document and send it, along with original invoices/receipts to the following postal address (unless agreed otherwise):

Attn: Lilian Diarra
Météo-France/CNRM/GMEI/ EUFAR Office
42, avenue Gaspard Coriolis
31057, Toulouse
France

Réalisation de la mission / *Travel Claim Form*

Nom (en majuscules) / *Name (Use capital letters)*

Adresse personnelle / *Home address*

Email

Objet du voyage / *Purpose of travel*

Lieu et date de la réunion / *Place and date of meeting*

Départ de / *Departure from* date time

Retour à / *Return to* date time

Please indicate if any of the above mission period was for personal reasons

Travel and Subsistence Expenses Declared:

Please indicate who paid for your flight/train ticket: yourself – your institute – EUFAR Office

In the case that your institute paid for your ticket, please provide us with an invoice and banking information of your institute.

N°	Item of expenditure (hotel, parking, flight tickets…)	Amount in local currency	Currency	Amount in euros	Checked by EUFAR Office/ MF-CNRM

Number of free meals : …………………..(covered by GFZ)

Number of free hotel room/ nights: …………………(covered by GFZ)

Please provide **original** receipts, tickets, boarding pass and invoices (including taxi receipts) and indicate the number of meals (lunches and dinners) you paid for yourself.

Je certifie que les dépenses déclarées ci-dessus ne seront pas remboursées par un autre organisme. / *I declare that the expenses claimed above are not being reimbursed from any other source.*

Date Signature

For official use

OMI N°:

Pour approbation

Le chef de service

6. Workshop abstracts

Invited Speaker:

Simultaneous retrieval of surface reflectance and aerosol properties using GRASP algorithm: Concept, perspectives, challenges

Oleg Dubovik

Laboratoire d'Optique Atmosphérique, UMR8518, CNRS – Université Lille 1, Villeneuve d'Ascq, France

Keywords: remote sensing, atmospheric aerosol, high performance computing

The GRASP (Generalized Retrieval of Aerosol and Surface Properties) algorithm has been developed for enhanced characterization of the properties of both aerosol and land surface from diverse remote sensing observations. The overall concept of the algorithm is described by Dubovik et al. (2014), while the detailed are given in the paper is by Dubovik et al. (2011). The algorithm is based on highly advanced statistically optimized fitting implemented as Multi-Term Least Square minimization and deduces nearly 50 unknowns for each observed site. The algorithm derives a set of aerosol parameters similar to that derived by AERONET including detailed particle size distribution, the spectral dependence on the complex index of refraction and the fraction of non-spherical particles. The algorithm uses detailed aerosol and surface models and fully accounts for all multiple interactions of scattered solar light with aerosol, gases and the underlying surface. All calculations are done on-line without using traditional look-up tables. In addition, the algorithm can use the new multi-pixel concept - a simultaneous fitting of a large group of pixels with additional constraints limiting the time variability of surface properties and spatial variability of aerosol properties. This principle provides a possibility to improve retrieval for multiple observations even if the observations are not exactly co-incident or co-located. Significant efforts have been spent for optimization and speedup of the GRASP computer routine and retrievals from satellite observations. For example, the routine has been adapted for running at GPGPUs accelerators. GRASP inherits many aspects used in AERONET retrieval. At first GRASP has been developed for POLDER/PARASOL multi-viewing imager and recently adapted to a number of other satellite sensors such as METEOSAT/MERIS, OLCI/Sentinel-3 at polar-orbiting platforms and COCI/GOMS and Sentinel-4 geostationary observations. It can be equally applied to ground-based AERONET and lidar observations. The results of numerical tests and results of aerosol and surface retrieval from different sensors will be presented and discussed.

References

1. Dubovik, O., T. Lapyonok, P. Litvinov, M. Herman, D. Fuertes, F. Ducos, A. Lopatin, A. Chaikovsky, B. Torres, Y. Derimian, X. Huang, M. Aspetsberger, and C. Federspiel "GRASP: a versatile algorithm for characterizing the atmosphere", SPIE: Newsroom, DOI:10.1117/2.1201408.005558, Published Online: September 19, 2014.

A semi-analytical technique for atmospheric correction of airborne and satellite remote sensing data

A. Kokhanovsky

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The physical and optical properties of various underlying surfaces are important for many applications such as monitoring human impacts on vegetation, snow fields (pollution), and climate change. The presence of the atmosphere always influences the radiation from the Sun to the ground and back from the ground to the sensor. Therefore, to retrieve correct atmospheric properties (say, in the visible region of the electromagnetic spectrum), one needs to correct detected signals for the presence of atmosphere. There are two approaches to this problem. The first one is the simultaneous retrieval of atmospheric characteristics and underlying surface properties (say, spectral bidirectional reflectance distribution function/matrix). This requires the use of complicated inversion schemes based on direct runs of raditiave transfer models. Alternatively, the look-up-table approach can be used. The second scheme is simpler. It is based on the possibility of retrieval of the atmospheric properties first and then use of radiative transfer models or simple analytical equations for the retrievals of underlying surface characteristics.

In this presentation, we show how the use of double-view/multi-view observations of the same target from the aircraft/satellite can be applied for the removal of underlying surface from the retrieval chain. Simple analytical equations are used in the retrievals. They are verified using the radiative transfer code runs. The derived atmospheric properties are used for the atmospheric correction of remote sensing data and determination of underlying surface characteristics in the framework of a semi-analytical approach.

The special case of atmospheric correction over water

Tim Smyth

Plymouth Marine Laboratory, Prospect Place, Plymouth, PL1 3DH, UK.

There are many applications of optical remote sensing from aircraft and satellites. These include detection of algal blooms, sediment outflow from rivers and estuaries as well as land-use applications. However, removing the effects of the atmosphere from the signal to determine geophysical quantities such as chlorophyll concentration and suspended particulate matter involves using a multi-stage modelling approach as well as programmes of vicarious calibration. In the case of satellite remote sensing of ocean colour, vicarious calibration involves taking surface radiometric measurements coincidentally with in situ measurements of chlorophyll concentration. Both require calibration and accuracies to within 5%. The particular problem for remote sensing of in-water geophysical quantities is that the water leaving radiances are typically very small (5 – 10%) of the total top of atmosphere radiances. This is compounded by the fact that the total atmospheric contribution to the signal is variable in time and space due to aerosol optical effects and coupled atmosphere-ocean effects. In this presentation I will concentrate on the special case of atmospheric correction over water, with particular focus on the "dark target (pixel)" approximation first adopted by Gordon and co-workers in the 1990s. This allows the atmospheric aerosol contribution to the path radiance to be quantified with the use of aerosol models. I will briefly discuss other approaches that have built on this, particularly for applications in highly scattering waters where the dark target assumption no-longer holds. Finally I will touch on validating the aerosol optical depth values, a by-product of the atmospheric correction schemes, using ground based and independent satellite sensors.

Atmospheric Correction over Land for Sentinel 2 Data

Grit Kirches and Carsten Brockmann

Brockmann Consult

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The purpose of atmospheric correction over land surfaces is the conversion of TOA-radiance to surface reflectance. A good estimation of the associated accuracy and consistency have to be evaluated and resulting uncertainties have to be quantified.

The atmospheric correction includes the correction for the absorbing and scattering effects of atmospheric gases, in particular ozone, oxygen and water vapour, of the scattering of air molecules (Rayleigh scattering) and the correction of absorption and scattering due to aerosol particles. All components except aerosols can be rather easily corrected because they can be taken from external sources or can be retrieved from the measurements itself. Aerosols are spatially and temporally highly variable and the aerosol correction is the largest error contributor of the atmospheric correction. The atmospheric correction particularly in case of high-resolution data like Sentinel 2 data has to take into account the effects of the adjacent topography or terrain in particular the radiance contributions from surrounding terrain such as reflected radiation from opposite slope and valleys as well as the effects of shadows due to blocking of the sunlight. Furthermore the final step of the atmospheric correction should be an approximate correction of the adjacency effect, which is caused by atmospheric scattering over adjacent areas of different surface reflectance, and is required for high spatial resolution satellite sensors.

Workshop participants:

The importance of accurate definiton of the surface albedo on the Radiative Transfer Model (RTM) simulation

Trismono Candra Krisna , Andre Ehrlich , Manfred Wendisch

Leipziger Institute of Meteorology, University of Leipzig, Germany

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Radiative Transfer Model (RTM) simulation needs high precision definition of the surface albedo as the input for the radiative properties simulation. According to Schaefer et al (2013), that the sensitivity of the cloud optical thickness (τ) retrieval is strongly in dependence of the surface albedo which an enhanced sensitivity of the retrieved τ found with respect to surface albedo is up to 30%, which is a huge impact compared to the other parameters therefore it can’t be underestimated. Consequently, using inappropriate surface albedo will lead high bias on the retrieval. Therefore the determination of the surface type or land cover to determine surface albedo is very important.

Airborne solar-radiation measurements are often used to measure solar-surface (e.g. clouds) radiation interaction applied for many application (e.g. cloud retrieval) using RTM simulation as the retrieval library. Nevertheless, it would be hard to determine the earth surface type from high altitude especially if there are cloud covers in between earth’s surface and aircraft. Satellite remote sensing is useful and can be used to define surface type or land cover e.g. using MODIS land collection 5 (Friedl et al., 2010) with 500 m resolution and improved algorithm, subsequently we can determine appropriate surface albedo on the RTM simulation. We propose to discuss and present the sensitivity of the surface albedo on the cloud retrieval, together with the impact of misleading definition of the surface type-albedo, and eventually an improvement by integrating MODIS land collection 5 on the RTM simulation.

Pseudo Invariant Areas and their benefits for atmospheric corrections

Joan-Cristian Padró Garcia
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Grumets uses an automatic radiometric (topographic + atmospheric) correction model for sensors in the solar spectrum, as ETM+, OLI and MSI imagery. The terrain effects are corrected taking into account the solar incidence angle, cast-shadows, etc. modeled on the basis of DSM of higher resolution than the imagery. Atmospheric effects are corrected using pseudoinvariant areas (PIA), automatically detected from the 12 year time-series Terra-MODIS MOD09 GA product, Sun-Earth distance, etc. A geostatistical criteria assures radiometric stability of these areas through all bands of the involved sensor (OLI, ETM+,…) during all the time-series, while the use of these PIA on a concrete image is submitted to statistical tests verifying a minimal variation between the PIA values and those pixels expected to be close to the reference reflectance (to prevent artifacts as cloud-shadows or abrupt/unexpected changes over the cover). This approach allows comparison of images from different dates as the radiometric reference is the same and quite robust; we consider this approach is especially useful when there is no available field data to model the atmospheric profile, for example when using imagery in the past. Details on this methodology can be found in:

Pons X. Pesquer L, Cristóbal J, González-Guerrero O (2014). Automatic and improved radiometric correction of Landsat imagery using reference values from MODIS surface reflectance images. International Journal of Applied Earth Observation and Geoinformation 33: 243-254- DOI: 10.1016/j.jag.2014.06.002

HT-FRTC: A New, Fast Radiative Transfer Code For Atmospheric Correction.

Jean-Claude Thelen and Stephan Havemann

UK MetOffice

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The Havemann-Taylor Fast Radiative Transfer Code (HT-FRTC) is a principal component based fast radiative transfer code that can be used across the whole electromagnetic spectrum to calculate transmittance, radiance and flux spectra. The principal components cover the spectrum at a very high spectral resolution, which allows very fast line-by-line, hyperspectral and broadband simulations for satellite-based, airborne and ground-based sensors. The principal components are derived during a code training phase from line-by-line simulations for a diverse set of atmosphere and surface conditions. The derived principal components are sensor independent, i.e. no extra training is required to include additional sensors. During the training phase we also derive the predictors which are required by the fast radiative transfer code to determine the principal component scores from the monochromatic radiances (or fluxes, transmittances). These predictors are calculated for each training profile at a small number of frequencies, which are selected by a k-means cluster algorithm during the training phase. The predictors are calculated using a kernel regression algorithm, which is more accurate than a linear regression algorithm.

The HT-FRTC was trained with a large variety of gases and surface properties. Rayleigh scattering, scattering by clouds, hydrometeors and aerosols have been included. The scattering phase function is fully accounted for by an integrated line-by-line version of the Edwards-Slingo spherical harmonics radiation code or approximated by a modification to the extinction (Chou scaling). Typically the simulation of a whole clear-sky radiance spectrum (3600000 monochromatic frequencies) takes less than one millisecond.

It will be demonstrated that the kernel regression increases the accuracy of the fast code when compared to a linear regression without a significant loss of speed. Moreover, we will present results from some of the applications of the HT-FRTC code.

In particular, we included the HT-FRTC code into an optimal estimation algorithm for the simultaneous retrieval of the atmospheric profiles (temperature, humidity, ozone and aerosol) and the surface reflectance from shortwave hyperspectral radiance measurements obtained from air/space-borne, hyperspectral imagers such as the 'Airborne Visible/Infrared Imager (AVIRIS) or Hyperion on board of the Earth Observatory 1, as well as IR measurements obtained from the Infrared Atmospheric Sounding Interferometer (IASI) and the Airborne Research Interferometer Evaluation System (ARIES).

Consistent Multi-Sensor Atmospheric Correction for Big Data Processing Methods

Andre Hollstein

Helmholtz Centre Potsdam–GFZ German Research Centre for Geosciences,

Section 1.4 Remote Sensing

14473 Potsdam, Germany;

Analysis of multi-sensor time series data is a powerful tool for many applications in optical remote sensing. Freely available data from the Sentinel-2 constellation and the Landsat series of imagers are widely used in many research oriented applications as well as operational services. A consistent processing of at-sensor radiances or reflectances to surface reflectance simplifies the analysis of dense time series. Such an approach is included in the GeoMultiSens () project and is presented in detail. The atmospheric correction is based on shared tables derived from radiative transfer simulations, and consistent sets of auxiliary data are used throughout all processing steps. If possible, similar strategies for the retrieval of water vapor and aerosol optical thickness are employed. In case that the retrieval of ozone, water vapor or aerosol optical thickness is not possible, reanalysis or forecasts products from ECMWF are used as a general fallback. Uncertainties of the obtained surface reflectance products are derived using a general method which takes the sensor uncertainty and the uncertainty of the derived parameters into account. Spatial shifts between different products are corrected using a highly accurate algorithm based on the Fourier Shift Theorem, which can detect and correct spatial shifts in the order of sup-pixels.

Atmospheric correction performance of hyperspectral airborne imagery over Loch Leven, UK, under changing cloud cover

Lauri Markelin

Plymouth Marine Laboratory (PML), Prospect Place, The Hoe, Plymouth, PL1 3DH, UK; lma@pml.ac.uk (until 28.9.2016).

Finnish Geospatial Research Institute (FGI), Geodeetinrinne 2,

FI-02430, Masala, Finland

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Water bodies have weak reflectance compared to land thus setting high radiometric requirements for passive optical sensors and for the accuracy of atmospheric correction. Even though some applications can work directly with the at-sensor radiance data recorded by the airborne sensor, producing water leaving reflectance spectra through accurate atmospheric correction is a crucial step for most of the water quality applications over optically complex case-2 waters, because in visible domain only about 5 % of the total radiance received by sensor comes from the water target. Moreover, translating airborne remote sensing techniques to satellite sensors will add to the requirement for accurate atmospheric correction. This remains as one of the biggest challenge for remote sensing, particularly over coastal and inland waters.

Several atmospheric correction models have been developed for satellite observations over coastal and inland waters. There currently exists no preferred approach to atmospherically correct airborne data collected over water. The general atmospheric correction methods do not embrace any assumptions on water spectra and can be either simple empirical/semi-empirical methods or more advanced physics based radiative transfer methods such as ATCOR4. The challenge with radiative transfer based methods is that they assume prior knowledge of key atmospheric parameters (aerosol type, horizontal visibility or aerosol optical thickness, water vapour) during the campaign. When the hyperspectral sensor has a sufficiently wide spectral range (VIS-NIR-SWIR), it can be possible to derive these parameters from the image data directly.

I will present atmospheric correction results of airborne hyperspectral imagery collected over Loch Leven, Scotland, UK, with AisaFENIX sensor. The campaign was performed under changing cloud cover, presenting challenging but common conditions for atmospheric correction. The atmospheric correction was performed with ATCOR4 software using fully image-driven atmospheric parameters, and the results were validated against boat based in situ hyperspectral measurements of water leaving reflectance collected with a set of TriOS RAMSES spectrometers. The campaign was carried out to collect in situ reference data for water quality algorithm development. The validation was based on both qualitative and quantitative comparisons using root-mean-square difference, spectral angle and chi-square metrics. Sensor signal-to-noise ratio (SNR) is evaluated using empirical image-based method.

ATCOR4 using image-derived atmospheric parameters produced a reflectance accuracy of ±0.002, i.e. lower than 15% difference to in situ reference. Amplitude and shape of the remotely sensed reflectance were in general accordance with the in situ reference. The spectral angle was better than 4.1° for the best cases and 10° or better for the most challenging cases in the spectral range of 450-750 nm. To conclude, the AisaFENIX sensor in combination with ATCOR4, which is not specifically designed for atmospheric correction over water, can be successfully used for inland water quality observations, and atmospheric correction can be performed in a fully image-driven way even under challenging atmospheric conditions.

Fusion of imaging hyperspectral and Lidar sensors: Towards a synergistic improvement of atmospheric correction

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The fusion of topographic and hyperspectral information is usually realized by using the distance measuring capabilities of ALS and the reflectance measuring capabilities of the HSI. Both data entities are generated in separated workflows, which results in discretization and substantial information loss. However, the main linkage between both sensors is the intensity information in the overlapping wavelength ranges. The passive/active dualism and their individual radiative transfer paths are inherent in their respective sensor responses. The synergistic combination of the intensity information can be used to investigate illumination and atmospheric effects. Cloud shadows, atmospheric transmissions and in general illumination effects can be compensated. In respect of multi spectral ALS, both contrasting sensor information should be used more intense to improve atmospheric correction of HSI data.

Hyperspectral data preprocessing for atmospheric correction

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Use of Hyperspectral data for resource evaluation requires preprocessing and atmospheric correction to infer the absolute information content. It is planned to use the Hyperspectral sensor data of Basaltic terrain of any parts of the world and correlate with the Lunar and Martian Hyperspectral data. Moon and Mars do not have similar atmospheric layers like the Earth it will be nice to have the relative evaluation of Hyperspectral sensor.

Pre-processing chain for hyperspectral data established at CzechGlobe

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CzechGlobe has been significantly extending its research infrastructure in the last years, which allows advanced monitoring of ecosystem changes at hierarchical levels spanning from molecules to entire ecosystems. One of the CzechGlobe components is a laboratory of imaging spectroscopy. The laboratory is now operating a new platform for advanced remote sensing observations called FLIS (Flying Laboratory of Imaging Systems). FLIS consists of an airborne carrier equipped with passive RS systems. The core instrument of FLIS is a hyperspectral imaging system provided by Itres Ltd. The hyperspectral system consists of three spectroradiometers (CASI 1500, SASI 600 and TASI 600) that cover the reflective spectral range from 380 to 2450 nm, as well as the thermal range from 8 to 11.5 μm. The airborne platform is prepared for mounting of full-waveform laser scanner as well, however laser scanner is not a permanent part of FLIS. In 2014 the installation of the hyperspectral scanners was completed and the first flights were carried out with all sensors.

The new hyperspectral imaging system required adaptations in the data pre-processing chain. The established pre-processing chain (radiometric, atmospheric and geometric corrections), which was tailored mainly to the AISA Eagle instrument operated at CzechGlobe since 2004, has been now modified to fit the new system and users' needs. The main effort was focused on development of the pre-processing of thermal data including emissivity estimation.

In this contribution, we will introduce data pre-processing chain in detail and show its outputs of multi-sensor hyperspectral images.

Sentinel-2 L2A processor Sen2Cor

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Sentinel-2 is a constellation of two polar orbiting satellite units each one equipped with an optical imaging sensor MSI (Multi-Spectral Instrument). Sentinel-2A was launched on June 23, 2015 and Sentinel-2B will follow in 2017.

The L2A processor Sen2Cor implemented for Sentinel-2 data provides a scene classification image, aerosol optical thickness (AOT) and water vapour (WV) maps and the Bottom-Of-Atmosphere (BOA) corrected reflectance product. The presentation gives an overview over the actual implementation of Sen2Cor and provides recent validation results.

Initial assessment of atmospheric correction for Sentinel-2 data in coastal waters

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Atmospheric correction is vital to retrieve information on water quality from water-leaving radiance acquired by ocean colour satellites. The percentage of the at-sensor radiance that is due to the water leaving signal is of the order of a few percent, meaning that there is a large unwanted atmospheric scattering signal (> 90 % of the signal).

Sentinel-2A is an ESA satellite in the land monitoring constellation that provides high resolution optical imagery through its multispectral imaging instrument. This high resolution also makes it ideal for monitoring coastal environments where the water optical properties change over very short scales. Radiometric sensitivity of the sensor is however a challenging issue.

In this study we analyse results from available atmospheric correction routines in coastal regions, including the Baltic Sea, comparing to in situ data acquired from research vessels and ships-of-opportunity operating in the region.

Retrieval of Level-2 Water Data Products for the Gulf of Riga from Hyperspectral Airborne and Simulated Sentinel-3 OLCI Satellite Data

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The Baltic Sea is one of the world's most threatened marine environments. Alarming rates of eutrophication caused by excessive input of nutrients such as nitrogen and phosphorus stimulates the growth of planktonic algae leading to imbalance in the marine ecosystem. Intense algal blooms and production of excess organic matter result in decreased water transparency as well as oxygen depletion which leads to the formation of dead zones at the sea bottom, as well as additional stress on biodiversity.

The Gulf of Riga accumulates a large amount of anthropogenic and natural cause's derived terrestrial nutrient influx. The Daugava River along with numerous smaller rivers brings a vast amount of dissolved and suspended material from the drainage basin to the coastal waters. The material is then transported across the wider Baltic Sea by the means of currents and wind activity. Riga agglomeration, recreational activities on the coast, coastal ecosystem transformation, and busy sea transport create additional stress on the marine ecosystem. Therefore, the Gulf of Riga serves both as a good model study reference area and a target for better management.

Remote sensing has proved to be an accurate and reliable tool in clear water environments like oceans or the Mediterranean Sea. However, the current algorithms and methods usually fail on optically complex waters like coastal and inland waters. The whole Baltic Sea can be considered as optically complex coastal waters.

In this study, simultaneous airborne and in situ data acquisition campaigns during summer algal bloom were organized in order to test remote sensing algorithms for calculation of level-2 water data products (eg., surface reflectance, chlorophyll-a concentration). Testing MERIS processors with historical in situ data showed poor overall correlation between field measurements and satellite chlorophyll-a data products. Simultaneous data acquisition improved the result. ATCOR-4 and FLAASH tools were tested for atmospheric correction of spectral data. Both performed well in shallow water, but failed to correct atmospheric path component in deep water, therefore alternative approaches were used for retrieval of surface reflectance.

An improved atmospheric correction method for nearshore shallow water bathymetry

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Shallow water environments present unique challenges for navigation and security, provide exceptionally valuable ecosystem services, and are heavily impacted by a range of anthropogenic activities. However, despite their importance our understanding of these environments is limited. Remote sensing provides global and frequently updated data coverage that can yield up-to-date information on shallow waters, and the long data record allows retrospective studies that can improve our understanding of their long-term and large-scale dynamics. Specifically, multispectral remote sensing has been established for many shallow water applications where information about water optical properties and bottom features are needed. With the advent of new sensors, applications that require bathymetry information can also now benefit from improved depth and accuracy made possible from the introduction of additional sensor bands. Despite this advantage, obtaining accurate information about water depths still relies heavily on a well proven atmospheric correction algorithm as water-leaving radiance is very difficult to determine accurately from the top of atmosphere signal. We use a radiative transfer based atmospheric correction procedure and apply it to a Landsat 8 image. We then use a radiative transfer model to obtain water depth and compare depth estimates with actual depth data from the field. Our result show that bathymetry estimates can be improved substantially with radiative transfer-based atmospheric correction methods.

Comparison of EO1-Hyperion data and Landsat 8 OLI data atmospheric correction in order to obtain a good lithological mapping in centrals Jebilet, Morocco

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Keywords: Atmospheric correction, FAASH, DOS, Lithological units, Hyperion, OLI, SVM, Centrals Jebilet, Morocco.

This study was made in the centrals Jebilet inlier in Moroccan anti atlas. This site is characterized by its geological diversity, its mining potential and an arid climate. Remote sensing data is more and more used for the regional geological mapping. The purpose of this study is to see the atmospheric correction effect and to evaluate the potential of hyperspectral Hyperion sensor of EO-1 and multispectral data of Operational Land Imager sensor (OLI) of Landsat-8 to discriminate lithological units of the study area.

After atmospheric correction of Hyperion and OLI data, FLAASH and DOS respectively, we have developed an iron index that allowed the discrimination of high iron concentrations in the central Jebilet. In addition, the Support Vector Machine classification algorithm (SVM) allowed a good mapping of lithological units in the study area. All in all this study demonstrated the performance of the two atmospheric corrections and that, the accuracy of hyperspectral data SVM classification is superior than SVM multispectral data, which was demonstrated by the confusion matrix and the Kappa coefficient.

Retrieval of Aerosol Parameters from Spectrometer Measurements

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We are developing a simple method, which enables the retrieval of aerosol optical thickness and Angstrom exponent from measurements with any spectrometer with suitable spectral range and resolution. Aerosol parameters, which can be used for validation of atmospheric correction of satellite or airborne multi-/hyperspectral data, are usually measured with handheld sun photometers. Also Aeronet stations provide aerosol data, with the problem of a fixed location of the station and limited spatial coverage. Spectrometer measurements can be acquired fast and reliable during a wide range of weather conditions and at almost any desired location. Spectrometers are commonly used for reflectance measurements in the water community, hence they are a much more common measurement equipment than sun photometers. This increases the number of potential users and occasions, during which aerosol parameters can be retrieved.

Aerosol modeling in the atmospheric correction of the remote sensing data. Selection effect of standard aerosol types and microphysical properties derived from AERONET on the surface reflectance

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The main research field was the radiative transfer in the atmosphere principally for the atmospheric correction of multi/hyperspectral airborne and satellite data in the visible and infrared spectral range. Currently, the research is focused on the development of algorithm for OLI (Landsat 8) and Sentinel 2 sensors. The developed and in going algorithms are based on the Second Simulation of a Satellite Signal in the Solar Spectrum (6S and 6SV) atmospheric radiative transfer model.

The last scientific and research activity is the analysis of the effects of the aerosol types (microphysical properties of the aerosol) on the surface reflectance obtained by the atmospheric correction. The last findings suggest that the aerosol type should be considered during the atmospheric correction processing to improve the accuracy of the retrieved surface reflectance and to study the energy exchange in the natural and anthropic ecosystems.

Recently, the research activity is also focused on the shortwave net radiation retrieval from these data. This key parameter for the energy exchange between the land and atmosphere is under investigation by exploiting the increased spatial resolution of the visible and near-infrared OLI and Sentinel 2 and 3 data.

Comparing atmospherically corrected products from Sentinel-2, Landsat-8 and Modis

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With the availability of Sentinel-2 imaging datasets the development of temporarily dense reflectance surfaces at high spatial resolution (10m/20m) is feasible. Along with the high resolution (15m/30m) multispectral Landsat-8 datasets, ‘virtual constellations’ or spatiotemporal reflectance surfaces can be contracted forming consistent time series reflectance archives for numerous environmental and geospatial applications. However, in order to do so, the inter- calibration of the reflectance products from Sentinel-2 and Landsat-8 is required. To this end, in this study atmospherically corrected products from different approaches are quantitatively compared over image acquisitions from the same day and as cloud-free as possible. The comparison is performed between the surface reflectance products of Landsat-8 and Sentinel-2 as well as among Landsat-8, Sentinel-2 and Modis.

OPERA, an OPERational Atmospheric correction algorithm, for land and water scenes

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The new generation of satellites (e.g. Landsat 8, Sentinel 2 and Sentinel 3 …) contain sensors that enable monitoring at increased spatial and/or spectral resolution. This opens a wide range of new opportunities, amongst others improved observation of coastal and inland waters. Algorithms for the pre-processing of these images and the derivation of Level 2 products need to take into account the specific nature of these environments, with adjacency effects of the nearby land and complex interactions of the optimally active substances with varying degrees of turbidity.

OPERA is an OPERational Atmospheric correction algorithm which is scene and sensor generic. OPERA can be used for water and land targets. Over water areas OPERA accounts for the contribution of adjacency effects through application of SIMEC (SIMilarity Environment Correction) (Sterckx et al., 2014).

At the workshop OPERA results will be presented for a variety of Landsat-8 and Sentinel-2 scenes.

Cloud screening on tropospheric ozone retrieval from SCIAMACHY

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Clouds play a major role in the atmosphere due to their influence on the Earth's radiative budget, on the hydrologic cycle and on the tropospheric chemical composition. In fact, one of the factors that affect the atmospheric radiative transfer at wavelengths important for tropospheric ozone retrieval is clouds. Clouds take part in reflection, absorption and transmission of solar radiation, thus affecting trace gas retrievals. In the nadir measurements for example, clouds have three major effects on the O3 retrievals. These are the albedo effect, an increase of the in-cloud absorption, and a shielding effect. The limb geometry is strongly affected by surface albedo and clouds, especially in the spectral ranges with small gaseous absorption. In the retrieval of tropospheric ozone from SCIAMACHY limb-nadir-matching observations, limb scenes that are contaminated with clouds are screened out while nadir scenes were investigated for different cloud fractions (cfs). To achieve this, Clouds are also detected in the limb viewing mode using the SCIAMACHY cloud detection algorithm (SCODA). SCODA uses vertical profiles of colour index ratios, calculated from different wavelength pairs, to determine the cloud top height and cloud thermodynamic phase (ice, liquid). In the case of nadir scenes, the retrieval was conducted first by setting the nadir cloud fraction threshold at ≤ 0 %. The retrieval process was then repeated for other cloud fraction thresholds (≤ 5 %, ≤ 10 %, ≤ 15 %, ≤ 30 %). From the analysis, it was found that cf ≤ 10 % is optimal for statistical analysis. The error value estimated from a global TOC mean using cf ≤ 0 % is higher than that of cf ≤ 10 % because of fewer measurements. For cf ≤ 30 %, questionable TOC values were derived at the high latitudes.