

Possibilities of Remote Sensing and Copernicus in the Area of Inland Waters and WRM

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1. Introduction

German Federal Institute of Hydrology (BfG)

In Koblenz, on the banks of the rivers Rhine and Moselle







Network of federal German waterways

BfG is located at Koblenz, where the Mosel joins the Rhine (Deutsches Eck).



Deutsches Eck ('German Corner') in Koblenz

Key facts on the BfG

- Federal scientific institute for research, assessments, and scientific consulting in the fields of
 - hydrology
 - water resources management
 - ecology
 - water conservation
- Higher authority of the Federal Republic of Germany in the jurisdiction of the Federal Ministry of Transport and Digital Infrastructure (BMVI)
- Provides consulting services to different federal ministries (of transport, environment, research, foreign affairs/international development)
- Provides highly specialised consulting services to the Federal Waterways and Shipping Administration regarding the planning, development and new construction of federal waterways
- Has over 400 employees







Main tasks BfG

- Identifying and balancing conflicting interests regarding federal waterways in terms of
 - transportation
 - water resources management (quantity and quality)
 - ecology
- Studying flood flow and low-flow conditions
- Hydrological and ecological **forecasting**
- **Computing** water balances
- Setting up **methodologies** for environmental impact studies
- Impact assessment of anthropogenic activities on water quality, their risks for humans and environment
- Monitoring water quality in federal waterways
 - radiological
- ➔ alarm system
 - chemical
- water, suspended solids and sediments
 water, habitats, impacts
 - biological
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The federal waterways in Germany



The federal waterways in Germany have a **total length** of **7,290km** and sea waterways with an area of approx. **17,800km**².

Annual **freight** on inland waterways is currently **227 million tonnes** (2013).



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Tasks BfG-Remote Sensing







Oil spill surveillance





Inland- and coastal waters

- 20+ years active in remote sensing
- Remote sensing interface and consultant for WSV and CCME
- Network: inland water an oil spill remote sensing communities

© Sat: ESA; LfZ: HK; Ship: WSV Gyrocopter: HS Koblenz

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Examples for Remote Sensing applications





Remote sensing can provide valuable data on inland waters - not only on the watercourse itself, but also on the foreland and the entire catchment area.





2. RS-Data: Aspects of Use

Aspects of Use -Evaluation of new applications





Opportunities	Parameter	Parameters visible by remote sensing? In the relevant depth?		
fit ? My Requirements		Which sensor? Which products are available?		
		Combine several data types effectively? How to integ workflows and reporting?	grate data into	
and Needs				
New approaches!	Attainable Accuracy	Qualitative? Classes? Quantitative? Indicative? Change detection?		
		Spatial resolution and coverage	Validation?	
		Temporal resolution & cloud cover dependency		
Added value!				





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Aspects of Use Contribution of remote sensing of inland waters





- Often a combination of methods/sources leads to the goal
- Check benefits and contribution of remote sensing for each application: VALIDATION!



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3. Hands-on: An operational Product-Workflow:

Turbidity

...and other products

In-situ Monitoring Network Suspended Matters and Turbidity

Why to monitor suspended matter?

- part of the sediment balance of a river.
- are carriers for sediment bound pollutants.
- can cause maintenance dredging in waterways or may lead to silting up of reservoirs
- influence water quality.
- are integrated into sediment management concepts.

Continuous in-situ-monitoring of turbidity

- Turbidity is used as proxy for suspended matter concentration.
- More than 100 active measuring stations.
- All stations are equipped with optical sensors.



Status Quo: Restrictions What happens between measuring stations?



RS-data brings added value of a longitudinal profile linking both stations.

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Sentinel-2 TOA © ESA, 7.6.2016

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Zoom on "German Corner," in Koblenz



Sentinel-2 TOA © ESA, 7.6.2016

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Processing Workflow (Method)



"Calvalus" workflow (developer & provider: Brockmann Consult) Web-based portal: setup processing requests and parameters





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Processing Workflow (Method)



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Turbidity – Rhine





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Turbidity – Rhine





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Twodimensional, locally calibrated turbidity data

Product example - longitudinal turbidity profile Rhine







Transferability – Elbe Estuary





Transferability – Elbe Estuary

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26 Tideelbe_S2 Extrem 2015-16

Elbe Estuary: Shift of the turbidity zone





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Remote Sensing Turbidity Monitoring

Sentinel-2 / Landsat8 are suitable sensors

- Sufficiently high spatial resolution of the data (20-30 m; e.g. large rivers, lakes).
- Secured continuity of data.
- Theoretically up to about 14 images per month (Sentinel-2 and Landsat8 combined).
- Reduced to an average of roughly 30 % (Germany) depending on cloud cover, season and region, filtering.

Accuracy of turbidity data

- Depending on river catchment and satellite.
- Can be improved by validation/calibration based on in-situ data.
- Research on uncertainties & scopes
- Better less data, but higher quality
 - \rightarrow Flags for filtering \rightarrow turbidity raster data products

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→ Application

- Overview,
 two-diemnsional data
- ➔ Reference conditions
- Differentiation of water bodies
- → Representativity of measuring stations
- System understanding, management

Chlorophyll-a in Rivers

not calibrated

Moselle & Rhine 25.9.2018

Temp

Temperature of Rivers

Koblenz

Lahn

Lahnstein

a of

Satellite

- spatial resolution: 60 m (not Sentinel)
- Comparison in-situ / remote sensing Landsat-7 scene Rhine $\mu = 0.5^{\circ}C$ $\sigma = 0.7^{\circ}C$
- low number of in-situ measurements
- Atmosphere

Aircraft

spatial resolution: : ~4 m (depending on sensor / flight altitude) Comparison in-situ / remote sensing; Rhine with in-situ calibration: $\mu = 0 \ ^{\circ}C, \ \sigma = 0.2 \ ^{\circ}C$ (without: $\mu = 0,2 \ ^{\circ}C, \ \sigma = 0,4 \ ^{\circ}C$) 3.9°C 11,7°C

12,2°C

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UAV: GEOCOPTIX River bank: BfG

igitale Infrastrukti

mFUND-Project "mDRONES4rivers"

mDRONES4rivers

Modern sensor technology and airborne remote sensing for vegetation and hydromorphological applications along waterways

Contributed by Dr. Björn Baschek, BfG

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4. Copernicus Data and Products for Inland Water Bodies

What is Copernicus?

- European Union's Earth Observation Programme, est. 2014
- Copernicus program with a budget of 4,3 bn € until 2020
- Coordinated & managed by EU-COM, implemented in partnership with the Member States
- Open and free access to Copernicus data and services for any and all types of use

In cooperation with:

The Copernicus Sentinel Satellites

- Six Sentinel missions plus circa 30 contributing missions
 - o **S1:** Radar; all-weather, day and night (since 2013)
 - **S2:** Optical imagery ; high resolution (since 2015)
 - S3: Optical (medium resolution), radar and altimetry data for marine & land services (since 2016)
 - S4/5/5P: Atmospheric composition
 - **S6:** Altimetry, global sea surface height

Figures : <u>www.copernicus.eu</u>

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The Copernicus Services

- Data and products are streamlined through six thematic core services
- More than satellite data & services: models, community, in-situ, (drones)
- Value-added information, free and open
- Products about inland waters distributed over several Copernicus services
- Basis for further, tailor-made "downstream"-products

Figures: <u>www.copernicus.eu</u>; <u>www.d-copernicus.de</u>

- services and inland waters

Emergency Management

 Global Flood Awareness System: flood monitoring

https://www.globalfloods.eu/

 Global Drought Observatory: drought monitoring

https://edo.jrc.ec.europa.eu/gdo/p hp/index.php?id=2000

ernicus - services and inland waters

Soil moisture

- Generated from data from microwave sensors (active and passive)
- Spatial resolution: 25km
- Soil moisture in %
- Volumetric soil moisture in m³
- Daily/ 10-day/ monthly products
- Data since 1978
- <u>https://cds.climate.copernicus.eu/cdsapp#!/</u> <u>dataset/satellite-soil-</u> <u>moisture?tab=overview</u>

Quelle: https://climate.copernicus.eu/land-hydrology-cryosphere

Satelites:

(SMMR, SSM/I, TMI, AMSR-E, WindSat, AMSR2, SMOS, AMI-WS, Metop-A, Metop-B)

figure: https://www.d-copernicus.de/daten/daten-eu-kerndienste/

opernicus - services and inland waters

RS and Modelling

Portfolio: global products

- Temperature
- Salinity
- Sea surface height
- Current Velocity
- Mixed layer thickness
- Sea Ice
- Wind
- Plankton

Ocean CHL - 15.02.2020 Figure: http://marine.copernicus.eu/services-portfolio/access-to-products/

Lakes products in Copernicus Global Land Service

Selected lakes worldwide, 10 days average

- Water quality (since 01.07.2017) 300m/1km spatial resolution MERIS and Sentinel-3 data trophic_state_mean & turbidity_mean
- Surface temperature (since 01.04.2018)
 1km spatial resolution
 ENVISAT (Archive) and Sentinel-3 data
- Water bodies (since 01.01.1999) 300m/1km spatial resolution PROBA-V and SPOT data
- Water level (partially since 1992) 300m/1km spatial resolution Jason-3 and Sentinel-3 Altimeter measurements

Lakes products in Copernicus Global Land Service

figures: Brockmann Consult

Lakes products in Copernicus Global Land Service

Asian countries with lakes served by CGLS

Processed Lakes in Iran and Iraq

Urmia Hawizeh marshes Aras dam Therthar Razazza Hammar Hadithah dam Habbaniyah Dukan Hamrin Nn-lake ?? Mosul Afghanistan Bangladesh Burma Cambodia China India Indonesia Iran Iraq Israel Japan Jordan Kazakhstan

Kyrgyzstan Laos Malaysia Mongolia Philippines Russia Sri Lanka Syria Tajikistan Thailand Turkey Turkmenistan Uzbekistan

ca. 1000 lakes worldwide

+ additional 2000 lakes in 2020

+ new planned 100m product

Lakes products in Copernicus Global Land Service – 100m product planning

100 x 100m Based on S2 data

Wasserreflektanzen bei 665nm

Quelle: Brockmann Consult

Land Monitoring

Lakes products in Copernicus Global Land Service - Data access

Lake Water Quality

Monitoring water quality in lakes and reservoirs is key in maintaining safe water for drinking, bathing, fishing and agriculture and aquarulture activities. Long-term trends and short-term changes are indicators of environmental health and changes in the water catchment area. Directives such as the EU's Water Framework Directive or the US EPA Clean Water Act request information about the ecological status of all lakes larger than 50 ha. Satellite monitoring helps to systematically cover a large number of lakes and reservoirs, reducing needs for monitoring infrastructure (e.g. vessels) and efforts.

The Lake Water Products (lake water quality, lake surface water temperature) provide a semi-continuous observation record for a large number (nominally 1,000) of medium and large-sized lakes, according to the Global Lakes and Wetlands Database (GLWD) or otherwise of specific environmental monitoring interest. Next to the lake surface water temperature that is provided separately, this record consists of three water quality narameters:

LWQ product updates

New 100m Lake Water Quality based on Sentinel-2 *Tue, 16 Jul 2019* First Lake Water Quality products *Fri, 25 May 2018* Read more or Subscribe

https://land.copernicus.eu/global/products/lwq

Lake Water Quality characteristics							
LWQ 100m LWQ 300m LWQ 1km							
Access Algorithm Quality Application Technical Documents Gallery							
File(s)	Size	Available since					
Algorithm Theoretical Basis Document	2.55 MB	2018-11-19					
List of processed lakes	114.74 KB	2019-02-26					
Product User Manual	1.06 MB	2018-11-16					
d Validation Report	4.87 MB	2018-11-16					
	Application Technical Documents Gallery File(s) Algorithm Theoretical Basis Document List of processed lakes Product User Manual Validation Report	Application Technical Pocuments Gallery File(s) Size Algorithm Theoretical Basis Document Algorithm 2.55 MB List of processed lakes 114.74 KB Product User Manual 1.06 MB Validation Report 4.87 MB					

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- services and inland waters

Existing products :

Cryosphere

- (Europe) Lake Ice Extent 250m
- (Europe) Snow Cover Extent (Land) 500m/1km
- (Northern Hemisphere) Snow Water Equivalent (Land) – 5km
- <u>https://land.copernicus.eu/global/themes/</u> <u>cryosphere</u>

Lake Ice Extent 250m

Quelle: https://land.copernicus.eu/global/products/lie

Land Monitoring Service

Bildquellen: https://www.d-copernicus.de/daten/daten-eu-kerndienste/

ernicus – Source of information

Services

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Copernicus Open Access Hub

Accessing Data

https://scihub.copernicus.eu/dhus/#/home

Copernicus Global Land Service https://land.copernicus.eu/global/products/

Marine environment monitoring service <u>http://marine.copernicus.eu/services-portfolio/access-to-products/</u>

Accessing and Processing Data Data and Information Access Services

- Access to Copernicus Sentinel data
- Products from Copernicus' six operational services
- Additional commercial satellite or nonspace data sets
- Cloud-based tools
- Develop and host new applications in the cloud

No need to download bulky files from several access points and process them locally

https://www.copernicus.eu/en/access-data/dias

5. The Copernicus Emergency **Management Service**

Slides by Dr. Fabian Löw, Federal Office of Civil Protection and Disaster Assistance (BBK)

Federal Office of Civil Protection and Disaster Assistance

What is the scope of CEMS?

- Est. 2012, implemented by DG-JRC
- Support all phases of the emergency management cycle, 24/7/365
- Timely & accurate geo-spatial information, i.e. maps using satellite EO
- Serve severe and large scale national or cross-border disasters worldwide
- Free and open but activated by authorized users (AU) only!

Slide: European Commission

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Reference Maps | Delineation Maps | Grading Maps

Activation Time (UTC): 2019-04-09 15:20 Production Time (UTC): 2019-04-10 05:10

Delivery Time ca 36-72h, here: 14h

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Europe's eyes on Earth

Reference Maps | Delineation Maps | Grading Maps

https://emergency.copernicus.eu/mapping/list-of-components/EMSR419

Reference Maps | Delineation Maps | Grading Maps

Consequences within t	he AOI						
		Unit of measurement	Destroyed	Damaged	Possibly damaged	Total affected	Total i AOI
Flooded area		1			1883.1		
Flood traces					149	96.1	
Estimated population	Number of inhabitants					N/A	37532
Settlements	Residential	No.	1	24	179	204	N/A
	Industrial building and warehouse	No.	0	3	14	17	N/A
	Other non-residential	No.	0	86	142	228	N/A
Transportation	Airfield runway	km	0.0	0.0	0.0	0.0	23.8
	Bridge and elevated highway	No.	0	0	0	0	1
	Primary Road	km	0.0	0.9	2.4	3.3	33.5
	Secondary Road	km	0.0	0.0	0.1	0.1	7.4
	Local Road	km	0.0	0.0	7.9	7.9	106.9
	Cart Track	km	0.1	1.1	0.6	1.8	29.4
Facilities	Harbour	ha	0.0	0.0	0.0	0.0	8.8
	Complex Constructions on Industrial Sites	ha	0.0	6.5	3.4	9.8	116.8

Slide: European Commission

- Hazard exposure
- Vulnerability & resilience of buildings, people, assets
- Risk status for population and assets
- Evacuation plans, contingency scenarios
- Civil protection exercises

Reference Maps | Pre-disaster situation | Post-disaster situation propers eyes on Earth Risk and recovery mapping for risk analysis

Civil Protection and satter Assistance

EMSN035; Economic impact of floods on agriculture sector in Centre-Val de Loire region, France

- Only authorized users can trigger the CEMS:
 - NFPs of EU Civil Protection Mechanism in EU Member States & Copernicus Participating States (Iceland, Norway)
 - o EU Service (e.g. DG-ECHO, DG-JRC).
 - o ERCC is focal point for UN, World Bank, international NGOs

 If products needed: either ask ERCC via national situation center or activate via GIZ via BBK/GMLZ

Activation of the Risk & Recovery Mapping

Naaster Assistance

- Sentinel data for creating maps of land use (e.g. rice) and/or land cover (e.g. mangroves) in different years, assess land use / land cover change
- Activate CEMS in <u>Rapid Mode</u> when an event (e.g. flood) actually strikes
 ✓ Flood Hazard Maps
- Activate CEMS in <u>Risk & Recovery Mode</u>
 - ✓ E.g. to frame your research / project activities
- Activation via BBK/GMLZ

ECMWF VT:Friday 31 October 2014 00UTC Surface: H14 Layer 4 (100-289cm) H-SAF CDOP - Copyright © Eumetsat

6. Soil-Moisture, Precipitation, Snow: H-SAF Products Slides by Peter Krahe, EUMETSAT H-SAF / BfG

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H-SAF Structure and Organization

opernicusⁱ Relays

to provide satellite-derived products from existing and future satellites with sufficient time and space resolution to satisfy the needs of operational hydrology. Identified products:

H-SAF Objectives

- precipitation (liquid, solid, rate, accumulated);
- soil moisture (at large-scale, at local-scale, at surface, in the roots region);
- snow parameters (detection, cover, melting conditions, water equivalent);
- to perform continuous quality assessment and independent validation of the usefulness of the products for facing floods, landslides, avalanches, and managing water resources

- Products are provided in NRT
- Their timeliness is compliant with the needs of operational users: some products are provided within 15 minutes from last received image
- Operational provision:
 - > 24/7 service
 - Full operational support
- Long term perspective (up to 2032)
- High accessibility: EUMETCast dissemination, ftp direct download, orders

H-SAF Operational Products

Precipitation Products Soil Moisture Products Snow Products

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Example Extension of Precipitation products from European continent → MSG Full Disk → Globe (on going developments)

EUMETSAT H-SAF PR-OBS-3

Instantaneous Rain Rate retrieved from IR-MW blending data Blending of: SEVIRI IR + SSMI-SSMIS MW + AMSU MW: 20190205 1145

EUMETSAT H-SAF P-DM-RME-PMW

Gridded daily mean precipitation

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 Copernicus as a source of versatile data and products

- for inland water bodies
- and more...

Usage - what do I have to consider?!

Questions?

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