Sharing input and output data for large scale applications of SWAT with OGC web services

A. Lehmann, M. Fasel, P. Lacroix, Y. Guigoz, & G. Giuliani

SWAT conference—Warsow—June 30, 2017

Anthony.Lehmann@unige.ch
Lifting the Information Barriers to Address Sustainability Challenges with Data from Physical Geography and Earth Observation

Anthony Lehmann, Rebecca Chaplin-Kramer, Martin Lacayo, Grégory Giuliani, David Thau, Kevin Koy, Grace Goldberg and Richard Sharp Jr.
General modeling workflows with Open Geospatial Consortium (OGC) standards
Reviewing innovative Earth observation solutions for filling science-policy gaps in hydrology

Anthony Lehmann, Gregory Giuliani, Nicolas Ray, Kazi Rahman, Karim C. Abbaspour, Stefano Nativi, Massimo Craglia, Douglas Cripe, Philippe Quevauviller, Martin Beniston
The Black Sea project
Filling the gap between Earth observation and policy making in the Black Sea catchment with enviroGRIDS

A. Lehmann\textsuperscript{a,*}, G. Giuliani\textsuperscript{a,b}, E. Mancosu\textsuperscript{c}, K.C. Abbaspour\textsuperscript{d}, S. Sözen\textsuperscript{e}, D. Gorgan\textsuperscript{f}, A. Beel\textsuperscript{g}, N. Ray\textsuperscript{a,b}
Black Sea Catchment Observation System as a Portal for GEOOSS Community

Dorian Gorgan, Gregory Giuliani, Nicolas Ray, Anthony Lehmann, Pierluigi Cau, Karim Abbaspour, Karel Charvat, Andreja Jonoski

>>> gSWATCloud

(IACSA) International Journal of Advanced Computer Science and Applications, EnviroGRIDS Special Issue on "Building a Regional Observation System in the Black Sea Catchment"
Water resources of the Black Sea Basin at high spatial and temporal resolution

Elham Rouholahnejad\textsuperscript{1,2}, Karim C. Abbaspour\textsuperscript{1}, Raghvan Srinivasan\textsuperscript{3}, Victor Bacu\textsuperscript{4}, and Anthony Lehmann\textsuperscript{5}

Data Descriptor: A web platform for landuse, climate, demography, hydrology and beach erosion in the Black Sea catchment

Anthony Lehmann\textsuperscript{1,2}, Yarlen Salgado, Nicolas Rebol\textsuperscript{3}, Emanuel Marcone\textsuperscript{1}, Karim C. Abbaspour\textsuperscript{1}, Elham Rouholahnejad Freudent\textsuperscript{1}, Karim Abbaspour\textsuperscript{1}, Andrea De Bon\textsuperscript{4}, Marc Faust\textsuperscript{5}, Ana Gaspard\textsuperscript{5}, Roger Barl\textsuperscript{5}, Pierre Lecroix\textsuperscript{5} & Gregory Giuliani\textsuperscript{1,3}
Contributions of enviroGRIDS to GEOSS

ENVIROGRIDS - CORE DATASETS
Search, discover, and access enviroGRIDS core datasets.

More project datasets available on the EnviroGRIDS portal

LATEST LAYERS
Total: 228

- Monthly mean precipitation (HB1 scenario) 2033-2036 [mm]
  Layer from geonodeadm, 7 mois ago
  The data consist in a vector map representing the HB1 monthly mean value for precipitation, from 2033 to 2036

- Monthly mean value for maximum temperature (HB1 scenario) 2069-2072 [°C]
  Layer from geonodeadm, 7 mois ago

LATEST MAPS

http://blacksea.grid.unep.ch
SWAT Input and output data
Breaking Walls Towards Fully Open Source Hydrological Modeling

Kazi Rahman, Nicolas Ray, Grégory Giuliani, Chetan Maringanti, and Anthony Lehmann

Fig. 1. Flow chart of data and software requirement for SWAT model preparation, calibration and validation.

Table 1. Data used for the Mendoza catchment in Argentina

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Sources</th>
<th>Scale/Resolution</th>
<th>Description/Web site</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEM</td>
<td>SRTM</td>
<td>90 m</td>
<td>Elevation [<a href="http://srtm.csi.cgiar.org">http://srtm.csi.cgiar.org</a>]</td>
</tr>
<tr>
<td>Land use</td>
<td>GlobCover</td>
<td>1000 m</td>
<td>Classified land use such as crop, urban forest etc. [<a href="http://jonia.lesrin.esa.int">http://jonia.lesrin.esa.int</a>]</td>
</tr>
<tr>
<td>Soil</td>
<td>FAO</td>
<td>1:500000</td>
<td>Classified soil and physical properties such as sand, silt, clay density [<a href="http://www.fao.org/climatechange/54273/en">http://www.fao.org/climatechange/54273/en</a>]</td>
</tr>
<tr>
<td>River flow</td>
<td>GRDC</td>
<td>–</td>
<td>River discharge [<a href="http://grdc.bafg.de">http://grdc.bafg.de</a>]</td>
</tr>
</tbody>
</table>
OWS4SWAT: Publishing and Sharing SWAT Outputs with OGC standards

Gregory Giuliani¹,², Kazi Rahman¹, Nicolas Ray¹,², Anthony Lehmann¹

¹Institute for Environmental Sciences, enviroSPACE University of Geneva 1227 Carouge, Switzerland
²United Nations Environment Programme Global Resource Information Database, 1211 Châtelaine, Switzerland
gregory.giuliani@unige.ch
SCOPED-W: SCalable Online Platform for extracting Environmental Data and Water-related model outputs

1. Web-based GUI

SWAT-related data extractor

This platform provides tools and useful information for extracting SWAT input data and SWAT outputs, for a catchment. You can extract three types of data (SWAT input data, hydrological projections and Land Use by rectangle).

Make up your choice:
- Extract by basin
- Extract by country
- Extract by rectangle
- Access other useful SWAT-related data & tools

Examples of data that can be extracted:

2. Data server

WMS
WFS
WCS

3. Data processing

WPS

4. Scripts

Parameters

HTML + OpenLayers

5. Web client

shp, tiff, zip

Yaniss Guigoz1,2,* | Pierre Lacroix1,2,* | Elham Rouholahnejad4
Nicolas Ray1,2 | Grégory Giuliani1,2,3
New projects
Figure 3 Organization of the workflow in six main tasks
1. SWATCH21: ES supplies and demands

**Provisioning services**
- Agriculture: crop yield will be directly derived from SWAT outputs
- Drinking water: the amount of blue water used for drinking will be assessed from the population distribution and needs
- Hydropower: blue water transformed in energy by hydropower will be estimated using the distribution and size of existing dams
- Water for livestock: blue water available for livestock will be estimated from the distribution of different types of livestocks

**Regulating and maintenance services**
- Biodiversity: the ecosystem diversity will be assessed by downscaling existing land use information from 100m (geostat) resolution to 25m (Lehmann et al. unpublished).
- Flood protection: The Critical Consecutive Days Analyzer (CCDA) has been developed at EAWAG (Vaghefi et al. in prep.).
- Nutrient and sediment retention will be directly derived from SWAT outputs
- Carbon sequestration will be calculated with the InVEST package
- Avalanche protection: this services will be assessed by GIS analyses as in Grêt-Regamey et al. (2008)97

**Cultural services**
- Fishing for recreation: this service will be assessed by modelling the species distribution of emblematic fishes species such as trouts using species distribution models (e.g. GRASP160,161 or MARS162)
- Recreation: the recreational value of river beds will be assessed by a combination of GIS analyses of accessibility from roads and walking tracks, and the density of photos made available on Flickr.
2. neXswiss
Blue water scarcity in the Black Sea catchment: Identifying key actors in the water-ecosystem-energy-food nexus

M. Fasel, C. Bréhaut, E. Rouholahnejad, M.A. Lacayo-Emery, A. Lehmann

* University of Geneva, Institute for Environmental Sciences, Bâtiment Vaudois, 6903, CH - 1211 Geneva, Switzerland
* Department of Environmental Systems Science, ETH Zurich, Universitätstrasse 16, 8092, Zurich, Switzerland

3. GEOessential: Essential X Variables

Sustainable development goals and targets

Knowledge base

SDGs indicators

Global policy
European policy
Extractives
Raw materials
WB
Soils
Agriculture policy
Energy
Water
Climate
Biodiversity

Data sharing (e.g. GEOSS, Copernicus)

National statistics (e.g. EDE)

Other data sources ...

Scientific evidences

Horizon 2020
Call: H2020-SISE-2015 one-stage
Topic: SDG15-2015
Type of action: ERA-NET-Cofund
Grant agreement no: 685564
Proposal: 1/2017/ERA-PLANET

ERA-PLANET
The European network for ensuring our changing planet

UNIVERSITÉ DE GENEVE

GEOSS
ESSENTIAL
# 3. Essential Water Variables

## Primary Essential Water Variables

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Evaporation and evapotranspiration</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Snow cover (SWE, depth, freeze thaw margins)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Soil moisture/temperature</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Groundwater</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Runoff/streamflow/river discharge</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Lakes/reservoir levels and aquifer volumetric change</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Water quality</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Water use/demand</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Glaciers/ice sheets</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

## Supplementary Essential Water Variables

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface meteorology</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Surface and atmospheric radiation budget</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cloud and aerosols</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Land Cover and vegetation/land use</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Permafrost</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Elevation/topography and geological stratification</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

## Areas of application

- **SWAT inputs**
- **SWAT outputs**
- **???
- **Cross Reference**
More on OGC web services...
More on OGC web services...

The story of data on the environment (long)

https://www.youtube.com/watch?v=9SKOwQDFhYI
OGC working and standards groups

Hydrology DWG
Chair(s):
Zaslavsky, Ilya (University of California, San Diego Supercomputer Center)
Boston, Tony (National Computational Infrastructure)
Pecora, Silvano (World Meteorological Organization (WMO))

Group Description:
The Hydrology Domain Working Group is a Joint Working Group of the World Meteorological Organisation (WMO) and the OGC.

WaterML 2.0 SWG
Chair(s):
Sheahan, Paul (Australian Bureau of Meteorology)

Group Charter:
Download Charter document

Group Description:
WaterML 2.0 Standards Working Group
WaterML 2.0 Part 1 is an Open Geospatial Consortium encoding standard (opengeospatial.org/standards/waterml) for the representation of hydrological observations data, with a focus on time-series. This work activities defined in this charter extends WaterML 2.0 with the inclusion of WaterML2 Part 2 - Ratings, Gaugings and Sections.

OGC WaterML 2: Part 4 – GroundWaterML 2 (GWML2)
1) Overview
2) Downloads
3) Official Schemas
4) Related News

1) Overview
This standard describes a conceptual and logical model for the exchange of groundwater data, as well as a GML/XML encoding with examples.

OGC network Common Data Form (netCDF) standards suite
1) Overview
2) Downloads
3) Related News

1) Overview
netCDF is a set of software libraries and self-describing, machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data. The conventions for climate and forecast (CF) metadata are designed to promote the processing and sharing of netCDF files. The conventions define metadata that provide a definitive description of what the data represents, and the spatial and temporal properties of the data.

Sensor Observation Service
1) Overview
2) Downloads
3) Official Schemas
4) Related News

1) Overview
The SOS standard is applicable to use cases in which sensor data needs to be managed in an interoperable way. This standard defines a Web service interface which allows querying observations, sensor metadata, as well as representations of observed features. Further, this standard defines means to register new sensors and to remove existing ones. Also, it defines operations to insert new sensor observations. This standard defines this functionality in a binding independent way, two bindings are specified in this document: a KVP binding and a SOAP binding.

OGC® Open Modelling Interface (OpenMI) Interface Standard
1) Overview
2) Downloads
3) Related News

1) Overview
The purpose of the Open Modelling Interface (OpenMI) is to enable the runtime exchange of data between process simulation models and also between models and other modelling tools such as databases and analytical and visualization applications. Its creation has been driven by the need to understand how processes interact and to predict the likely outcomes of those interactions under given conditions. A key design aim has been to bring about interoperability between independently developed modeling components, where those components may originate from any discipline or supplier. The ultimate aim is to transform integrated modelling into an operational tool accessible to all and so open up the potential opportunities created by integrated modelling for innovation and wealth creation.

http://www.opengeospatial.org/docs/is
Bringing GEOSS Services into Practice: A Capacity Building Resource on Spatial Data Infrastructures (SDI)

Gregory Giuliani, Pierre Lacroix, Yaniss Guigoz, Roberto Roncella, Lorenzo Bigagli, Mattia Santoro, Paolo Mazzetti, Stefano Nativi, Nicolas Ray and Anthony Lehmann

Programme of the workshop "Bringing GEOSS services into practice"

Ch. 1: Concepts on spatial data infrastructures
Ch. 2: How to store geospatial data?
Ch. 3: How to publish geospatial data?
Ch. 4: How to document and search geospatial data?
Ch. 5: How to process geospatial data?
Ch. 6: How to view geospatial data?
Ch. 7: How to download geospatial data?
Ch. 8: How to share geospatial data?
Ch. 9: Discovery & Access Broker
Ch. 10: GME, UNOSID, SDI, INSPIRE

OGC & ISO standards

Application layer

Service layer

Data & metadata layer
New Summer School: 4-15 September 2017

Geomatics for a Sustainable Environment
July to December 2017

Module 1 | MOOC on Ecosystem Services
July-August 2017
Dr Martin Schlaepfer, Prof. Julietta Full, Prof. Lehmann
- Basics of Ecosystem Services
- Understanding of the key services associated with any resource
- Mapping of the ecosystem services with GIS tools
MOOC available at: coursera.org/learn/ecosystem-services

Module 2A | Summer School in Presence at University of Geneva
GIS Introduction | 4 September 2017
Prof. Lehmann, Dr Yaniss Guigez, Dr Pierre Lacroix
General Introduction + Basics of GIS + Quantum GIS (QGIS) Software
Remote Sensing | 5 September 2017
Ms Karin Allenbach, Mr Bruno Chatenoux
SDI – Metadata | 6 September 2017
Dr Andrea de Bono, Dr Grégory Giuliani, Dr Yaniss Guigez
Spatial Data Infrastructure (SDI) General Introduction + Basics of Metadata + GeoNode software
SDI – Data | 7 September 2017
Dr Yaniss Guigez, Dr Pierre Lacroix
Geoserver Software + GeoNode Software
Geoprocessing | 8 September 2017
Dr Grégory Giuliani, Dr Pierre Lacroix
Overview of Geoprocessing Concepts + Python Language

Module 2B | Integrative Work
September-November 2017
- Personal project based on the theme defined during the enrollment and validated during the summer school, using the knowledge and tools acquired during the training
- The personal project should include some concepts learnt during the modules 1 and/or 2A
- The professional or research topic will be discussed individually during the summer school

Statistics and Geostatistics | 11 September 2017
Prof. Anthony Lehmann
Overview of Statistics and Geostatistics Concepts + Programming Statistics in R
Species Distribution Modeling | 12-13 September 2017
Prof. Anthony Lehmann, Prof. Antoine Guisan
Introduction to Species Distribution Modeling and Biodiversity Assessment + Modeling in R
Soil and Water Assessment | 12-13 September 2017
Dr Karim Abbaspour, Mr Marc Fasel
Introduction to Hydrological Modeling + Preparing a SWAT Model with QGIS + Calibrating a SWAT Model with SWAT-CUP
Ecosystem Services Assessment | 14-15 September 2017
Prof. Anthony Lehmann, Mr Martin Lacayo
Introduction to Ecosystem Services + Assessing Ecosystem Services with InVEST + Assessing Ecosystem Services with Python
Field trip (optional) | 19 September 2017
Conclusions

- Data sharing through **Spatial Data Infrastructures** (SDI) is needed to access faster the necessary data for hydrological modeling and publish the outputs.

- Integrated hydrological models such as **SWAT and Ecosystem services** assessment can serve as a central concept for the **Nexus** approach to allow for tradeoffs and synergies analyses.

- **Essential Water Variables** need to be clarified for policy purposes and SWAT can benefit from them as inputs and contribute to model them as outputs.

The combination of these elements can significantly improve the connection between: **Data > Model > Decision making**

*It would help if data web services included metadata (like NetCDF) and were searchable on the Internet as regular web pages.*


More at: http://unige.ch/envirospace/publications/
THX for your attention

anthony.lehmann@unige.ch

Institute for Environmental Sciences
Dpt Forel for Aquatic and Environmental Sciences