Hydrological Modeling of the Black Sea Catchment using SWAT

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Content:

Part 1: Black Sea General Information
Part 2: enviroGRIDS Project Objectives
Part 3: Black Sea Catchment SWAT Project_ Results
Part 1: Black Sea

Black Sea General Information
Where is Black Sea

Black Sea Catchment

Sources: ESRI, HydroSHEDS, GeoNames

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Black sea has a really badly managed and unsustainable ecosystem and environment.

With the large population growth and increasing food requirements and the existing fresh water availability and the existing water quality, we have a severe water problem in Black sea region.

Because of large existing problems in the region, lots of projects was funded in black sea region.

- Growing population
- Water use and water scarcity
- Nitrate, Phosphate and DDT
- Oil Spills
- Endangered species
Part 2: enviroGRIDS

Building Capacity for a Black Sea Catchment Observation and Assessment System supporting Sustainable Development

Content:
Introduction to enviroGRIDS
enviroGRIDS Objectives
enviroGRIDS Work packages
3 main Steps in enviroGRIDS project
Analyses Pipeline
enviroGRIDS information dissemination
Coordination team: UNIGE and UNEP/GRID
Coordinator: Dr. Anthony Lehmann
Duration: April 2009 - March 2013
Consortium: 27 partners, 15 countries
Total budget: 7.9M€
Introduction to enviroGRIDS

A team work by the enviroGRIDS consortium...
What is enviroGRIDS about?

...exploring the past, present and future (hydrology) of the Black Sea catchment

...build the capacity of scientists to observe the environment, the capacity of decision-makers to use it, and the capacity of the public to understand the issues at stake
## enviroGRIDS Objectives

### Global average annual temperature change relative to 1980-1999 (°C)

<table>
<thead>
<tr>
<th>Water</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increased water availability in moist tropics and high latitudes</td>
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<tr>
<td></td>
<td>Decreasing water availability and increasing drought in mid-latitudes</td>
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<tr>
<td></td>
<td>and semi-arid low latitudes</td>
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<tr>
<td></td>
<td>Hundreds of millions of people exposed to increased water stress</td>
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<table>
<thead>
<tr>
<th>Ecosystems</th>
<th>Impact</th>
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<tbody>
<tr>
<td></td>
<td>Up to 30% of species at increasing risk of extinction</td>
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<tr>
<td></td>
<td>Significant extinctions around the globe</td>
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<tr>
<td></td>
<td>Increased coral bleaching</td>
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<tr>
<td></td>
<td>Most corals bleached</td>
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<tr>
<td></td>
<td>Widespread coral mortality</td>
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<td></td>
<td>Terrestrial biosphere tends toward a net carbon source as:</td>
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<tr>
<td></td>
<td>~15%</td>
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<tr>
<td></td>
<td>~40% of ecosystems affected</td>
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<td></td>
<td>Increasing species range shifts and wildfire risk</td>
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<td></td>
<td>Ecosystem changes due to weakening of the meridional overturning</td>
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<tr>
<td></td>
<td>circulation</td>
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<table>
<thead>
<tr>
<th>Food</th>
<th>Impact</th>
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<tbody>
<tr>
<td></td>
<td>Tendencies for cereal productivity to decrease in low latitudes</td>
</tr>
<tr>
<td></td>
<td>Productivity of all cereals decreases in low latitudes</td>
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<tr>
<td></td>
<td>Tendencies for some cereal productivity to increase at mid- to high</td>
</tr>
<tr>
<td></td>
<td>latitudes</td>
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<tr>
<td></td>
<td>Cereal productivity to decrease in some regions</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Coasts</th>
<th>Impact</th>
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<tbody>
<tr>
<td></td>
<td>Increased damage from floods and storms</td>
</tr>
<tr>
<td></td>
<td>About 30% of global coastal wetlands lost</td>
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<tr>
<td></td>
<td>Millions more people could experience coastal flooding each year</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Health</th>
<th>Impact</th>
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<tbody>
<tr>
<td></td>
<td>Increasing burden from malnutrition, diarrhoeal, cardio-respiratory</td>
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<tr>
<td></td>
<td>and infectious diseases</td>
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<tr>
<td></td>
<td>Increased morbidity and mortality from heat waves, floods and droughts</td>
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<tr>
<td></td>
<td>Changed distribution of some disease vectors</td>
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<tr>
<td></td>
<td>Substantial burden on health services</td>
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</tbody>
</table>

* Significant is defined here as more than 40%.
* Based on average rate of sea level rise of 4.2mm/year from 2000 to 2080.
3 main Steps in enviroGRIDS project

Carrying out the project

1. Model the hydrology
2. Store and process large amount of data
3. Share spatially explicit data
Step 1: Soil and Water Assessment Tool

How can we model the hydrology?
How can we store and process large amount of data?
CERN super computer center
Step 3: Spatial Data Infrastructure (SDI) & Group on Earth Observation System of Systems (GEOSS)

How can we share spatially explicit data?
GEOSS: A Global, Coordinated, Comprehensive and Sustained System of Observing Systems

THE GLOBAL EARTH OBSERVATION SYSTEM OF SYSTEMS

INFORMATION FOR THE BENEFIT OF SOCIETY
Step 3: SDI & GEOSS

www.earthobservations.org
Pipeline of analyses

1. Scenarios
2. SWAT
3. Pilote studies
4. Assessment System

WEB SERVICES: INSPIRE, GEOSS, UNSDI, ...

Group on Earth Observation Societal Benefit Areas

Dissemination
Content:
Project Deliverables and Objectives
BSC SWAT Project
Preliminary Results
Future Plans

Building a Hydrologic Model of the Black Sea Catchment
**Project Deliverables and Objectives**

Data collection for SWAT to model spatial distribution of water resources in the BSC

Build, calibrate and validate a hydrologic model of BSC with uncertainty analysis using EGEE

Quantify the impact of land use and climate change on water quantity and water quality

Provide calibration scheme for the grid

Provide output visualization on Google Earth

Investigation of some issues with large-scale calibration of hydrologic models

- Model uncertainties
- Parameterization
- Input data resolution
- Impact of deriving input data (i.e., rainfall, temperature)
Database for BSC
SWAT Data Needs

**Basic SWAT data requirement:**

- Dem
- Soil
- Landuse
- Climate
- Discharge

**More data requirement:**

- Reservoir operation
- Inlet stations
- Agricultural management
- Water management
- Crop yield data
- Water quality at hydrometric stns
- Point sources
Spatial Resolution 1 km
Global DEM GOTOPO 30, USGS

Spatial Resolution 90 m (SRTM)
Soil

Spatial resolution 10 k

Global Soil Map (FAO 1995)

Landuse

Spatial resolution 100m – 1000m

CORINE + Global USGS
SWAT Database

River Map

Hydro 1K
USGS

50 m spatial resolution
SWAT Database

Temperature, Precipitation, River Discharge
Build up a SWAT model for BSC
SWAT project _ BSC Catchment

Model setup

- 2,000,000 km² Area
- 1629 sub-basins
- Dominant soil and land use
- ET Calculation based on Hargreav's Method
- Daily Steps SWAT Run and Monthly Outputs
- 39 yr simulation period, 3 yr warm up
Calibration and Gridification
Department System Analysis, Integrated Assessment and Modelling

**SWAT-CUP**

SWAT-CUP is a computer program for calibration of SWAT models. SWAT-CUP is a public domain program, and as such may be used and copied freely. The program links GLUE, ParaSol, SUFI2, and MCMC procedures to SWAT. It enables sensitivity analysis, calibration and uncertainty analysis of a SWAT model. The overall program structure is as shown in the Figure below.

![Diagram of SWAT-CUP process](https://www.eawag.ch/organisation/abteilungen/siam/software/swat/index_EN)

**Publications**

Abbaspour et al. 2007 (Application of SUFI2 to Thur Watershed in Switzerland) (pdf, 465 KB)

Abbaspour et al. 2004 (Application of SUFI2 to two landfills in Switzerland) (pdf, 1.9 MB)

Schuel et al. 2008 (Application of SWAT in Western Africa) (pdf, 4.6 MB)

Yang et al. 2008 (Comparison of five optimization programs) (pdf, 1.6 MB)

Schuel et al. 2008 (Application of SWAT to Continent of Africa) (pdf, 2.1 MB)

Faramarzi et al. 2009 (Application of SWAT in Iran) (pdf, 1.2 MB)

**Contact**

Karim C. Abbaspour (abbaspour@eawag.ch)

**Downloads**

- Program manual: Usermanual_Swat_Cup.pdf (pdf, 2.4 MB)
- Programme Version 2.1.5 (zip, 68.4 MB) (… New setup, plus pesticide parameters)
Calibration, Evaluation & Uncertainty

Parameterisation → 500x simulation → Evaluation → Parameter updating
Gridification on CERN Grids

1st Parameter Set

2nd Parameter Set

3rd Parameter Set

nth Parameter Set

Output Collection
First run results
**NS Coefficient and 95PPU**

**LUNGOCI Station, SIRET River, Romania**

- P-factor = 0.74
- R factor = 1.58
- R^2 = 0.21
- Nash_Sutcliffe = -0.65

**SENTA Station, Tisza River, Serbia**

- P-factor = 0.72
- R factor = 3.43
- R^2 = 0.29
- Nash_Sutcliffe = -2.94

**DRAGESTI Station, SIRET River, Romania**

- P-factor = 0.81
- R factor = 1.24
- R^2 = 0.34
- Nash_Sutcliffe = 0.18

**Nash_Sutcliffe Coefficient (NS)**

- NS < -5
- -5 < NS < -1
- -1 < NS < 0
- 0 < NS < 0.5
Preliminary Results (longterm average)
Preliminary Results (longterm average)
Future Plans

Building a finer resolution BSC SWAT model

- 90-m dem,
- 50-m River,
- More Climate stations
- More Discharge stations (Danube)

Collaborate with building the Grid application

Calibrate, Validate, and perform uncertainty analysis

Build a Danube River Basin hydrologic model

Compare SWAT and MONERIS

Evaluate the impact of landuse and climate change on water resources

Help build local SWAT models in Black Sea basin
Thanks for your attention
Results on Google Earth