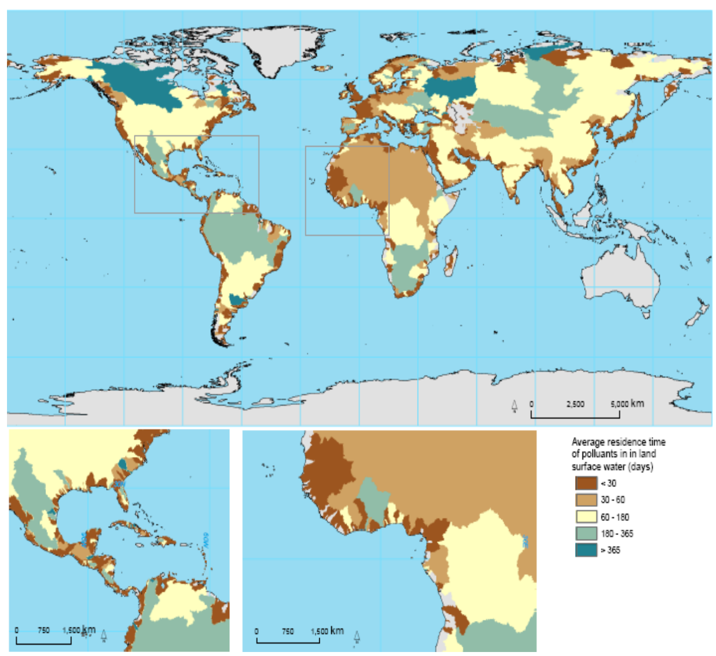
JRC Scientific and Technical Reports

Global Atlas of environmental parameters for chemical fate and transport assessment

Grazia Zulian, Paolo Isoardi, Alberto Pistocchi



EUR 24255 EN - 2010

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European Commission
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Institute for Environment and Sustainability

Contact information
Address: Grazia Zulian, JRC, TP 460, Via Enrico Fermi 2749, 21027 Ispra (VA), Italy
E-mail: grazia.zulian@ext.jrc.ec.europa.eu
Tel.: +390332783099
Fax: +390332785601

http://ies.jrc.ec.europa.eu/
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JRC 59846

EUR 24255 EN
ISBN 978-92-79-15025-8
ISSN 1018-5593
doi:10.2788/63436

Luxembourg: Publications Office of the European Union

Printed in Italy

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1. Introduction

This report describes the construction, formatting and analysis of global data retrieved with the purpose to parameterize the global spatial model of chemical fate and transportation. Such model is described in a companion report (Pistocchi e al. 2010).
The data collection concerns the atmosphere, soils, the strean network and lakes, and the ocean; besides environmental media, factors representing anthropic activity are also included, which are an indicator of both potential chemical emissions, and potential exposure. Most of the data were readily available and needed simple reformatting and organization in the database. Some datasets were generated by models run in different contexts, such as the ones about atmospheric aerosol and deposition. Most of the datasets were originally in time series and required averaging monthly and annual values.
A few datasets were generated specifically for the present atlas: notably the residence time of inland surface waters, sediment yields from catchments, and ocean particulate organic matter and sinking fluxes, which were derived using specific regression equations.
In the report, all details concerning each dataset are presented along with discussion on the methods used for original datasets. The need to provide also rather technical metadata justifiesthe schematic organization of the text in most sections of the report. References given for each data set provide additional information. The data set is available in a collection of GIS files organized as indicated for each theme hereafter; the datasets are available upon request, subject to conditions of use to be established by the JRC.
Data can be downloaded from the JRC FATE Web sites http://fate.jrc.ec.europa.eu/rational/home

2. Data catalog: Soil

2.1 OC content and bulk density

DATA SOURCE
ISRIC - World Soil Information

ORIGINAL DATA DESCRIPTION
ISRIC-WISE derived soil properties on a 5 by 5 arc-minutes global grid (ver. 1.1). This harmonized, global data set was prepared using: spatial data from the 1:5 million scale FAO-Unesco Soil Map of the Word and soil parameter estimates derived from ISRIC's WISE database.

The data set includes derived soil properties for the 106 soil units shown on the Soil Map of the World, for fixed depth intervals of 20 cm up to 100 cm depth.

The soil variables under consideration are: drainage class, **organic carbon content** (g kg^{-1}), total nitrogen, C/N ratio, pH(H2O), CECsoil, CECclay, effective CEC, base saturation, aluminum saturation, calcium carbonate content, gypsum content, exchangeable sodium percentage (ESP), electrical conductivity, particle size distribution (i.e. content of sand, silt and clay), content of coarse fragments, **bulk density** (kg dm^{-3}), and available water capacity (-33 to -1500 kPa).

Modal values shown for the derived soil properties should be seen as 'best' estimates; possible types and sources of uncertainty are discussed in the documentation.

The GIS project file includes selected binned data sets, as examples of possible output; these classified data consider the full map unit composition. The data set also includes several other tables, listing derived soil parameters by soil unit and depth layer, which can be joined to the raster data using GIS. These include both binned and un-binned data.

SOURCE CITATION

Batjes NH 2006. ISRIC-WISE derived soil properties on a 5 by 5 arc-minutes global grid. Report 2006/02 (available through http://www.isric.org), ISRIC – World Soil Information, Wageningen (with data set)

DOWNLOAD LINK

http://www.isric.org/UK/About+Soils/Soil+data/Geographic+data/Global/WISE5by5minutes.htm

ACCESSED

18/07/2008

SPATIAL RESOLUTION

5’x5’, 1°x1°

PRIMARY DATA FORMAT

GRID file *smw5by5min*

PROCESSING

Import of original GRID file *smw5by5min* into “File GeoDatabase Raster Dataset” format; resample to 1 by1sec resolution.

Reclass using the central values of classes.

STORED IN

\\globaldata\soil\Bulk

\\globaldata\soil\OC

Figure 1: Bulk density

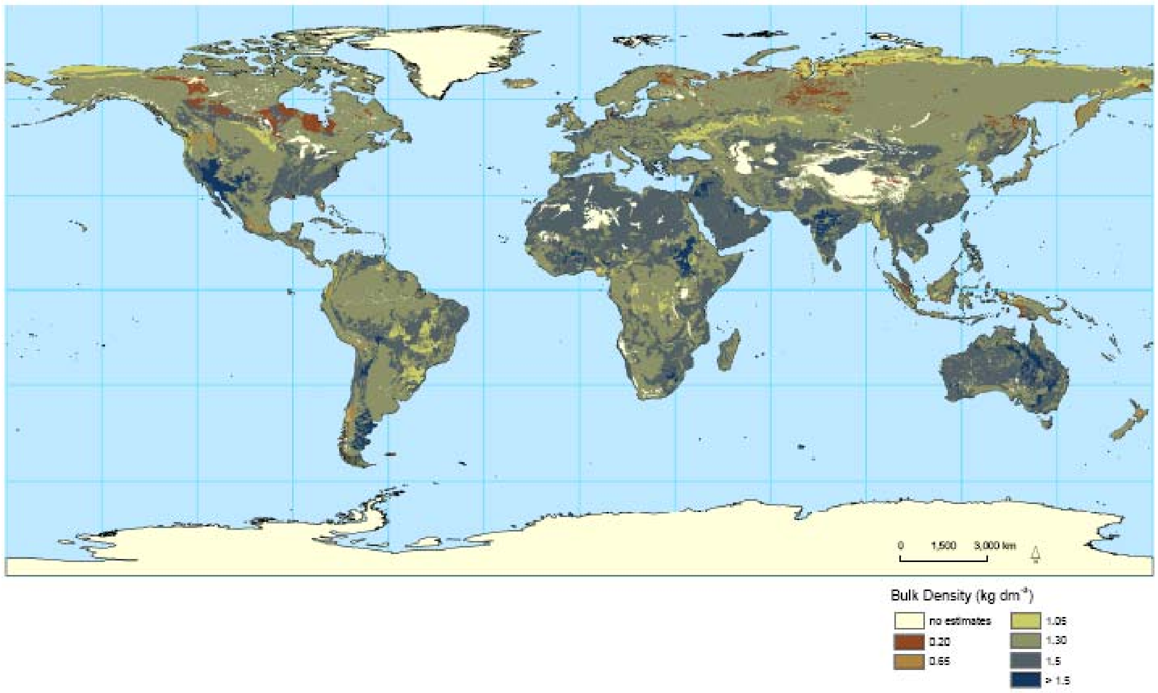
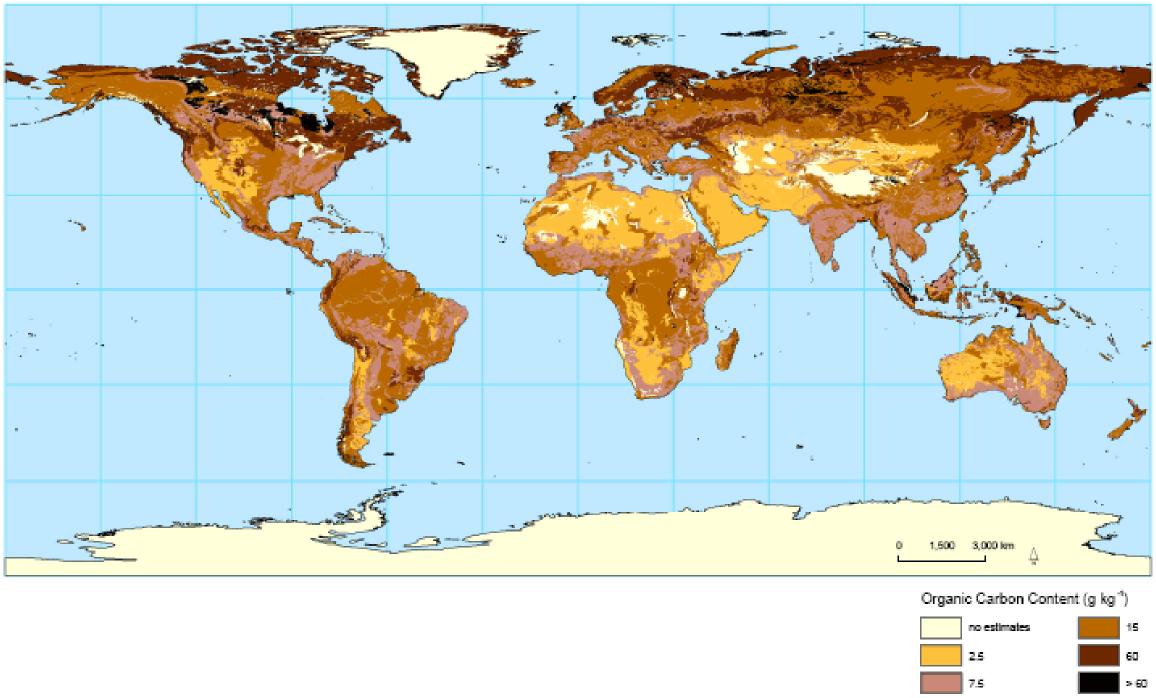


Figure 2: Organic Carbon Content.



2.2 Soil Texture

DATA SOURCE

Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC)

ORIGINAL DATA DESCRIPTION

A standardized global data set of soil horizon thicknesses and textures (particle size distributions) was compiled by Webb et al. This data set will be used for the improved ground hydrology parameterization design for the Goddard Institute for Space Studies General Circulation Model (GISS GCM) Model III. The data set specifies the top and bottom depths and the percent abundance of sand, silt, and clay of individual soil horizons in each of the 106 soil types cataloged for nine continental divisions. When combined with the World Soil Data File (Zobler, 1986), the result is a global data set of variations in physical properties throughout the soil profile. These properties are important in the determination of water storage in individual soil horizons and exchange of water with the lower atmosphere. The incorporation of this data set into the GISS GCM should improve model performance by including more realistic variability in land-surface properties.

All data are global at a 1 degree resolution and are provided in ASCII format. The profile data are also offered in ESRI export file format. The primary data consist of depth and particle size (percent sand, silt, and clay) information for each major continent, soil type, and soil horizon. Ocean/continental coding (corresponding to FAO/UNESCO Soil

Map of the World) (FAO/UNESCO, 1971-1981) and Zobler soil type classifications (Zobler, 1986) are also included. In addition to the primary data files, there are also four derived data sets available for download: (1) data on potential storage of water in the soil profile, (2) data on potential storage of water in the root zone, (3) data on potential storage of water derived from soil texture, and (4) a data set used to prescribe water-holding capacity in the GISS GCM (Model II).

There are 15 global grids included in this data set. Each grid represents a soil horizon (named profile*m), with profile1m representing the horizon closest to the soil surface and profile15m representing the deepest horizon possible. No soil type within this data set contained more than 14 horizons. However, empty records were retained and flagged with a value of -1. For example, if a given soil type contained 13 soil horizons, the first grid (profile1m) would record a depth of 0 and the corresponding sand, silt, and clay proportions for the first horizon, the second grid (profile2m) would record the contact depth of the second horizon as well as the proportion sand, silt, and clay for the second horizon, and so on. The thirteenth grid (profile13m) would record the contact depth of the thirteenth horizon and the proportion sand, silt, and clay for the thirteenth (and final) horizon, and the fourteenth grid (profile14m) would record the depth of the BOTTOM of the thirteenth horizon and carry the flagged value of -1 for the values of sand, silt, and clay. The fifteenth grid (profile15m) would carry the flagged value of -1 for the depth, sand, silt, and clay attributes.

Table 1: Soil Texture attributes.

Code	Soil Moisture Capacity
VALUE	an arbitrary but unique identifier assigned during the creation of the grid
COUNT	the number of cells within the grid assigned to a given VALUE
CONTNGDC	continent code (1-10)
ZOBLER_106	Zobler soil type
UNIQUE_ID	a key-id created by combining the CONTNGDC_ZOBLER_106
DEPTH*	soil depth (meters); the first value is 0 for a given soil type
SAND*	percent sand for a given horizon
SILT*	percent silt for a given horizon
CLAY*	percent clay for a given horizon

SOURCE CITATION

Webb, R. W., C. E. Rosenzweig, and E. R. Levine. 2000. Global Soil Texture and Derived Water-Holding Capacities (Webb et al.). Data set. Available on-line (http://www.daac.ornl.gov) from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/548.

LINK

http://daac.ornl.gov/SOILS/guides/Webb.html

ACCESSED

21/07/2008

Spatial resolution
1°x1°

Temporal resolution

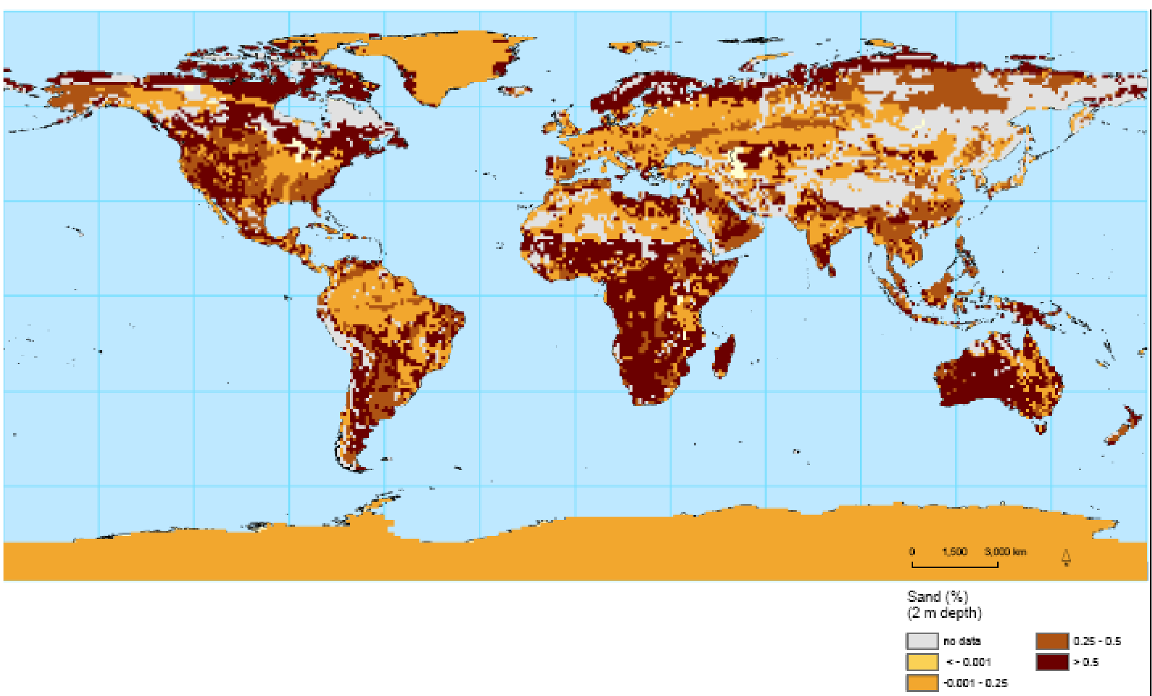
Primary Data Format

*.e00 file

Processing
Import of original e00 files into "File GeoDatabase Raster Dataset" format

Stored in
\\globaldata\soil\Texture

Figure 3: example map from the soil texture data set: percentage of sand at 2 m depth



2.3 Soil moisture storage capacity

DATA SOURCE

FAO-UNESCO Soil Map of the World

ORIGINAL DATA DESCRIPTION

The raster dataset of soil moisture storage capacity has a spatial resolution of 5 * 5 arc minutes and is in geographic projection. Information with regard to soil moisture was obtained from the "Derived Soil Properties" of the FAO-UNESCO Soil Map of the World which contains raster information on soil properties.

This parameter indicates the amount of soil moisture that can be stored between field capacity and wilting point and is presumed to be available to plants. **It is calculated on the basis of soil depth and textural class.** The dataset is available for download (below) in both ASCII and ESRI GRID formats. A layer (.lyr) legend (.avl) and excel file are provided in the downloads.

Structure of the attributes:

The first digit indicates the dominant Smax class (60% of the cell). The second digit indicates the associated (40% of the cell) class. When the second number is 0, this indicates that the whole cell is made up by the Smax class indicated by the first number. Soil Moisture Capacity -- The classes are: 1: Wetlands 2: > 200 mm/m 3: 150 - 200 mm/m 4: 100 - 150 mm/m 5: 60 - 100 mm/m 6: 20 - 60 mm/m 7: < 20 mm/m 97:Water 99:Glaciers, Rock, Shifting sand, Missing data

SOURCE CITATION

FAO/UNESCO. Digital Soil Map of the World and Derived Soil Properties. Rev. 1. (CD Rom), 2003. Available from http://www.fao.org/catalog/what_new-e.htm (interactive catalogue).

LINK

http://www.fao.org/geonetwork/srv/en/resources.get?id=30576&fname=smax.zip&access=private

http://www.fao.org/geonetwork/srv/en/metadata.show?id=30576

ACCESSED

21/07/2008

SPATIAL RESOLUTION

5’x5’, 1°x1°

TEMPORAL RESOLUTION

PRIMARY DATA FORMAT

*.mdb

PROCESSING

Import of original files into “File GeoDatabase Raster Dataset” format; resample to 1by1sec resolution.

Reclass following the structure of the attribute table.

The first digit indicates the dominant Smax class (60% of the cell). The second digit indicates the associated (40% of the cell) class. When the second number is 0, this indicates that the whole cell is made up by the Smax class indicated by the first number.

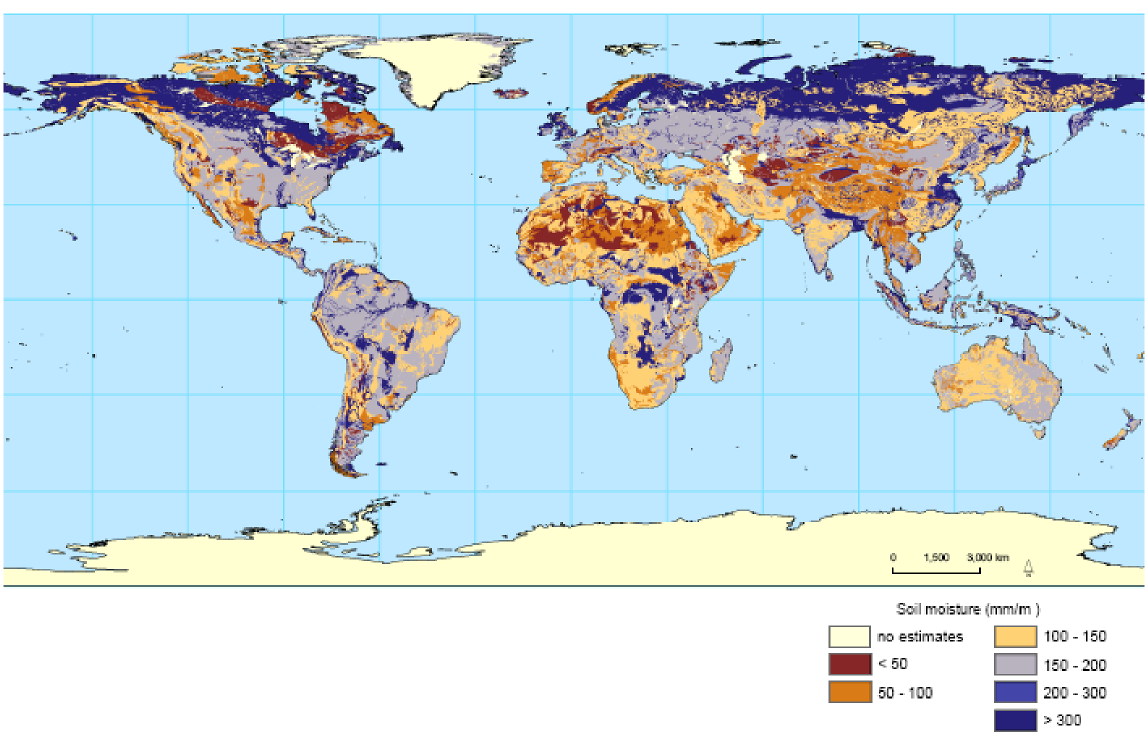
Table 2: structure of the attribute table

Code	Soil Moisture Capacity
1	Wetlands
2	> 200 mm/m
3	150 - 200 mm/m
4	100 - 150 mm/m
5	60 - 100 mm/m
6	20 - 60 mm/m
7	< 20 mm/m
8	Water
9	Glaciers, Rock, Shifting sand, Missing data
10	Wetlands

STORED IN

\\globaldata\soilmoisture\soilmoisture

Figure 4: Soil Moisture storage capacity.



2.4 Runoff

DATA SOURCE
UNH-GRDC Global Composite Runoff Fields

ORIGINAL DATA DESCRIPTION
The present data set demonstrates the potential of combining observed river discharge information with a climate-driven Water Balance Model in order to develop composite runoff fields which are consistent with observed discharges. Such combined runoff fields preserve the accuracy of the discharge measurements as well as the spatial and temporal distribution of simulated runoff, thereby providing the "best estimate" of terrestrial runoff over large domains.

Runoff Field Data Structures

Three sets of annual and monthly climatological (1+12 layers per set) runoff fields are included on the accompanying CD-ROM. The sets are observed, WBM-simulated, and composite monthly runoff fields in the ./arc/w_runoff ARC/INFO workspace and ./ascii/runoff directory. The grid coverage names are g_obs_ro01, g_obs_ro02, ..., g_obs_ro12 and g_obs_ro, where the numbered coverages are the monthly values and g_obs_ro contains the annual sum of the observed runoffs. The WBM simulated and the composite fields are organized similarly in g_wbm_ro## and g_cmp_ro## coverages. The same grid coverages are given as ARC/INFO ASCII grids as well in the ./ascii/runoff directory using the same naming convention (obs_ro##.grd, wmb_ro##.grd and cmp_ro##.grd). The monthly runoff values are given in mm/mo at 30-minute (0.5 degree) spatial resolution. The annual values are given in mm/yr.

SOURCE CITATION
Fekete, B.M., Vo¨ro¨smarty, C.J., Grabs, W., 1999. Global composite runoff fields of observed river discharge and simulated water balances. Report No. 22, Global Runoff Data Centre, Koblenz, Germany.

LINK
http://www.grdc.sr.unh.edu/

ACCESSED
15/07/2008

SPATIAL RESOLUTION
0.5°x 0.5°

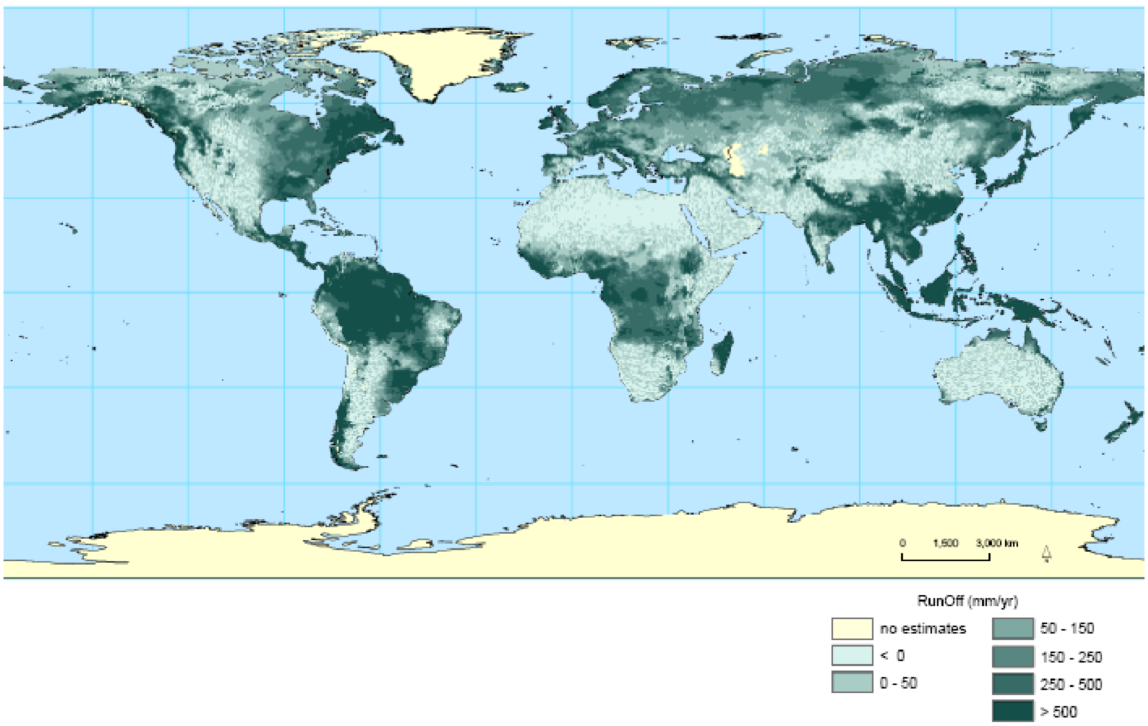
UNIT
mm/yr

PROCESSING
Import of original *cmp_ro.asc* file into “File GeoDatabase Raster Dataset” format.

STORED IN

\\globaldata\soil\Run_Off\run_off

Figure 5: Runoff



2.5 Sediments removal rate for basin

DATA SOURCE
Inputs:

- Basins: H1K (for each Continent)
- Elevation: H1K (global)
- Run Off: (global)
- Temperature : global monthly means

SPATIAL RESOLUTION
1km x 1km (0.008333° x 0.008333°)

PROCESSING
Modified Syvitski model

$kg/s/m^2$

BRIEF DESCRIPTION OF THE MODEL ADOPTED TOGENERATE THE DATASET

the total sediment yield from a catchment's unit area in kg $s^{-1}m^{-2}$ is computed according to the model proposed by Syvitski et al., 2000 (see also Pistocchi, 2008):

$$Q_s = \alpha\varphi\Delta^{1.5}A^{-0.5}$$

where A is the catchment area in km^2, and H is the basin relief (defined as the maximum elevation above catchment outlet) in m, α is a coefficientaccounting for the catchment climate, and φ is a parameter, not included in the original model, which is added here to account for the actual capacity of the catchment hydrology to deliver sediments.

The parameter α is suggested to be equal to 2 x 10^{-5} for temperate climates, and 10^{-6} for cold catchments (Syvitski et al., 2000). We represented this parameter through a fuzzy membership function in the form shown in Figure 6.

The function is a simple transformation of the map of mean annual temperature [temp_avg], which is obtained through the following map algebra statement (ESRI ArcGIS ® syntax):

[alfa]= Con([temp_avg] >= 278, 0.00002, Con([temp_avg] <= 273, 0.000001, 0.000001 + ([temp_avg] - 273) / (278 - 273) * (0.00002 - 0.000001))

The capacity of a catchment to actually deliver sediments depends on its average runoff generation. We assume that φ is valued 1 whenever runoff [runoff_composite_annual] exceeds 100 mm, and 0 when it is below 25 mm. In between, a linear variation is assumed (Figure 7).

This can be obtained through a map algebra statement as follows:

[phi]=Con([runoff_composite_annual] >= 100,1, Con([runoff_composite_annual] <= 25, 0, [runoff_composite_annual] / 100))

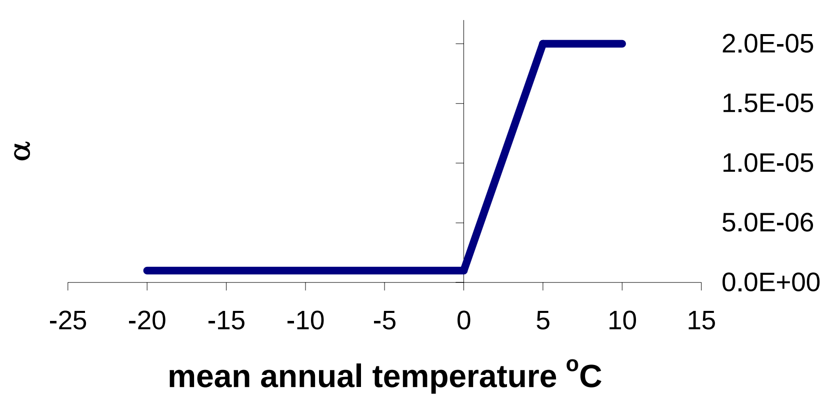


Figure 6 – α as a function of mean annual temperature of the catchment.

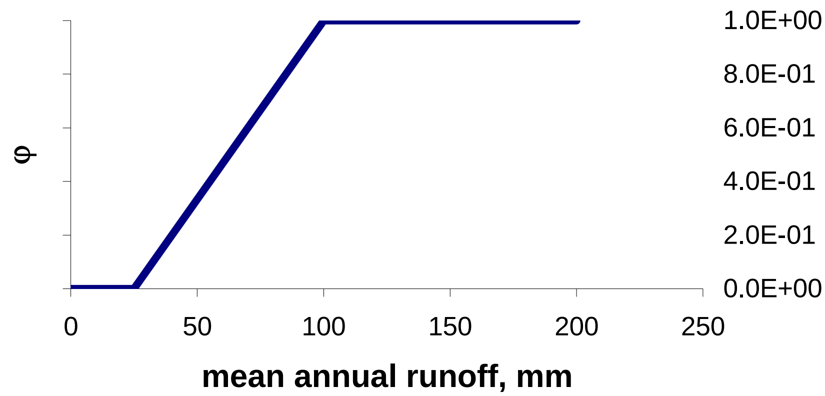
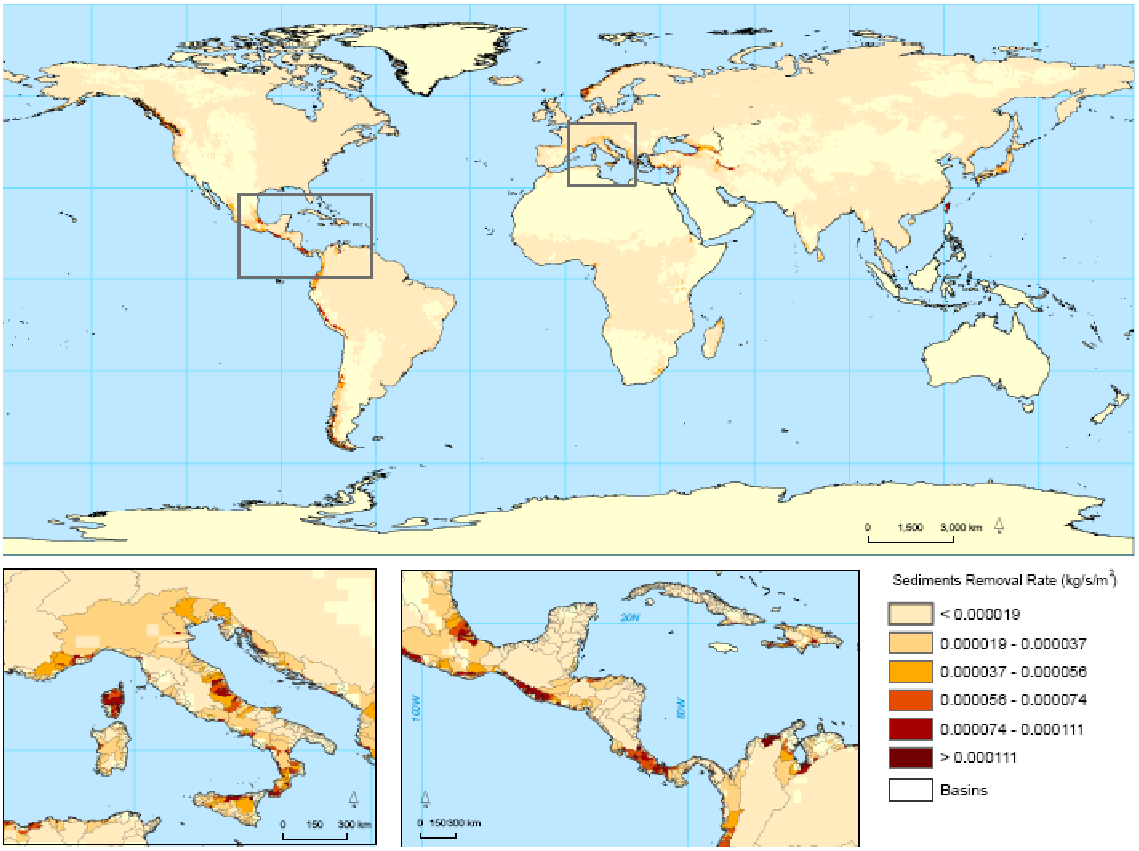


Figure 7 – φ as a function of mean annual temperature of the catchment.

STORED IN

\\globaldata\sediments_yield

Figure 8: Sediments removal rates for basins



REFERENCES

Syvitski, J.P., Morehead, M.D., Bahr, D.B., Mulder, T. (2000) Estimating fluvial sediment transport: the rating parameters, Wat. Res. Research, 36 (9): 2747-2760.

Pistocchi, A. (2008) An assessment of soil erosion and freshwater suspended solid estimates for continental-scale environmental modeling. Hydrological Processes, Volume 22, Issue 13, Pages: 2292-2314.

3. Data catalog: atmosphere

3.1 ABL mixing height

DATA SOURCE
ECMWF 40 Years Re-Analysis monthly means

ORIGINAL DATA DESCRIPTION
Atmospheric boundary layer mixing height (BLH).

FILENAME:
1957-09 ... 2002-08, Surface, mnth, Boundary layer height , 40 years reanalysis

SOURCE CITATION
ECMWF ERA-40 data used in this project have been obtained from the ECMWF Data Server

LINK

http://data-portal.ecmwf.int/data/d/era40_mnth/

ACCESSED
16/04/2009

SPATIAL RESOLUTION
2.5°x2.5°

Temporal resolution

- Monthly data
- 1957-09 ... 2002-08
  - diurnal (12:00)
  - nightly (00:00)

UNIT
m

PRIMARY DATA FORMAT

NetCDF format

PROCESSING AND DATA PREPARATION

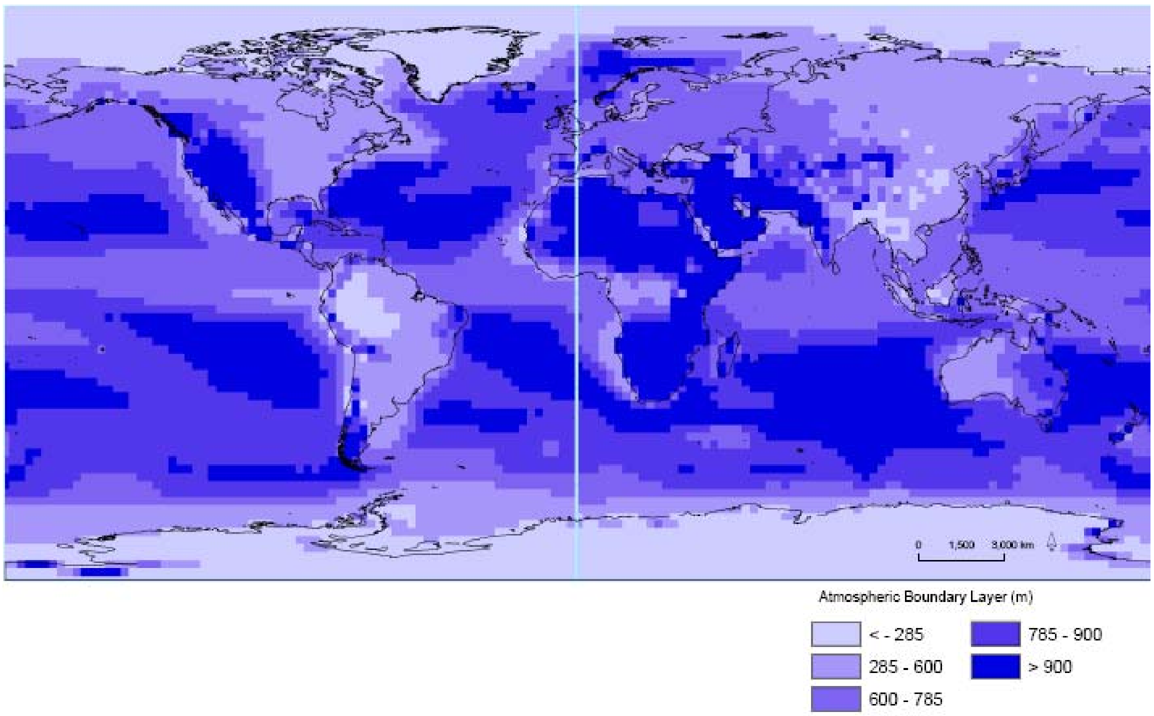
Mean on diurnal and nightly data

Total monthly mean
Converted to raster GRIDD

STORED IN

\\globaldata\Atmosphere\ABL_mh

Figure 9: Atmospheric boundary layer mixing height (BLH)



3.2 Temperature

DATA SOURCE
ECMWF 40 Years Re-Analysis monthly means

ORIGINAL DATA DESCRIPTION
Temperature.

SOURCE CITATION
ECMWF ERA-40 data used in this project have been obtained from the ECMWF Data Server

LINK

http://data-portal.ecmwf.int/data/d/era40_mnth/

ACCESSED

16/04/2009

Spatial resolution
2.5°x2.5°

Temporal resolution

Monthly data from 1957-09 to 2002-08, diurnal (12:00)

Unit
kelvin

Primary Data Format

NetCDF format

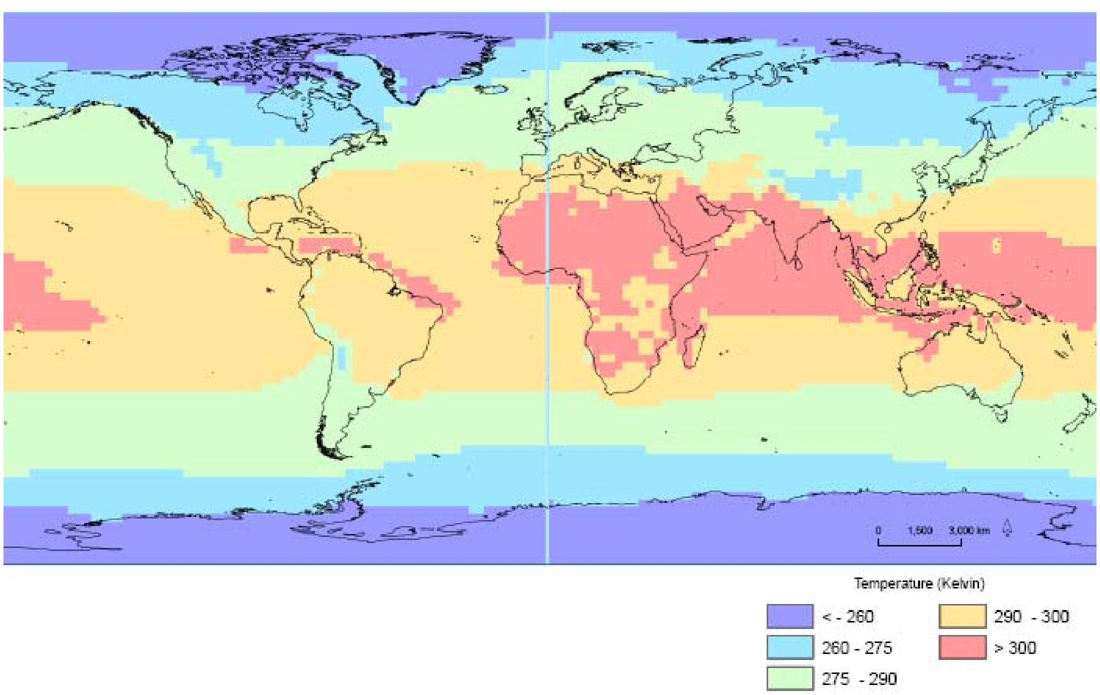
Processing and data preparation

Importing NetCDF data in GeoDataBase Tables
Total monthly mean

Stored in

\\globaldata\Atmosphere\Temperature

Figure 10: Temperature



3.3 Wind Speed

DATA SOURCE
ECMWF 40 Years Re-Analysis monthly means

SOURCE CITATION
ECMWF ERA-40 data used in this project have been obtained from the ECMWF Data Server

LINK
http://data-portal.ecmwf.int/data/d/era40_mnth/
ACCESSED
17/04/2009

SPATIAL RESOLUTION
2.5°x2.5°

TEMPORAL RESOLUTION
Monthly data from 1957-09 to 2002-08, diurnal (12:00)

UNIT
$m\ s^{-1}$

PRIMARY DATA FORMAT

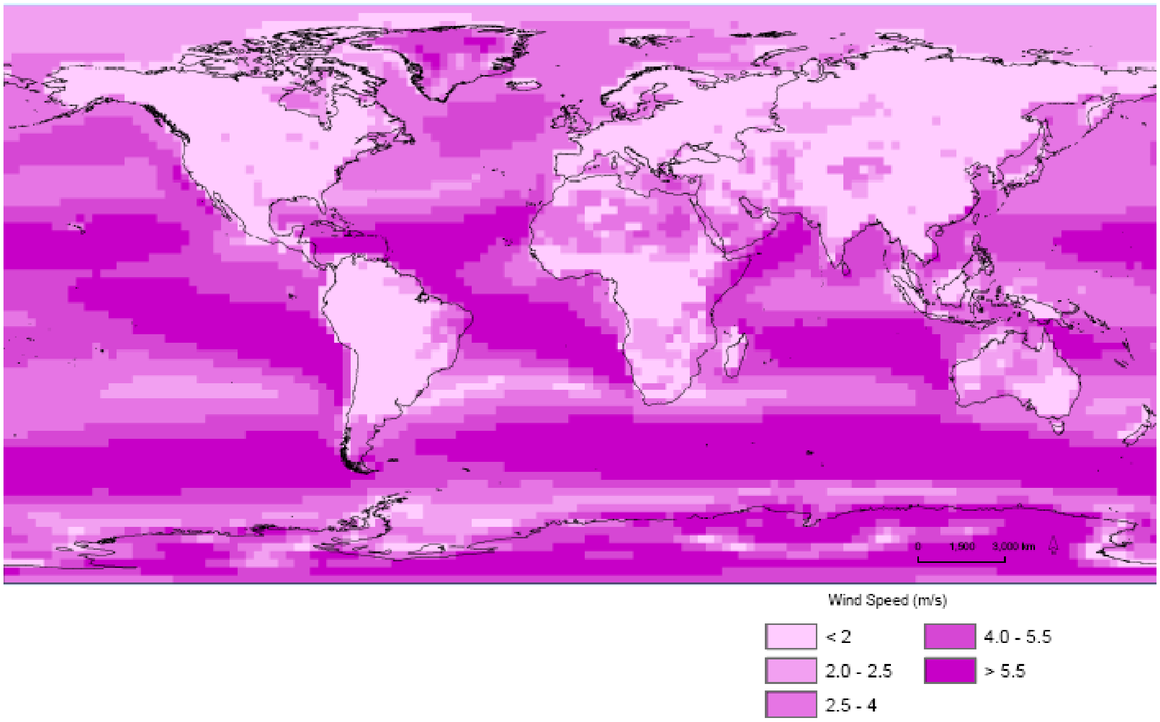
NetCDF format

PROCESSING
Importing NetCDF data in GeoDataBase Tables
Total monthly mean for the X- and Y- values of wind speed (u , v)
Computation of the wind speed = $\sqrt{(v * v) + (u * u)}$

STORED IN

\\globaldata\Atmosphere\WindSpeed

Figure 11: Wind Speed



3.4 Precipitation

DATA SOURCE
ECMWF 40 Years Re-Analysis daily

ORIGINAL DATA DESCRIPTION
Total Precipitation

SOURCE CITATION
ECMWF ERA-40 data used in this project have been obtained from the ECMWF Data Server

LINK
http://data-portal.ecmwf.int/data/d/era40_daily/

ACCESSED
16/04/2009

SPATIAL RESOLUTION
2.5°x2.5°

TEMPORAL RESOLUTION
Monthly data from 1957-09 to 2002-08, diurnal (12:00)

Unit
mm/month

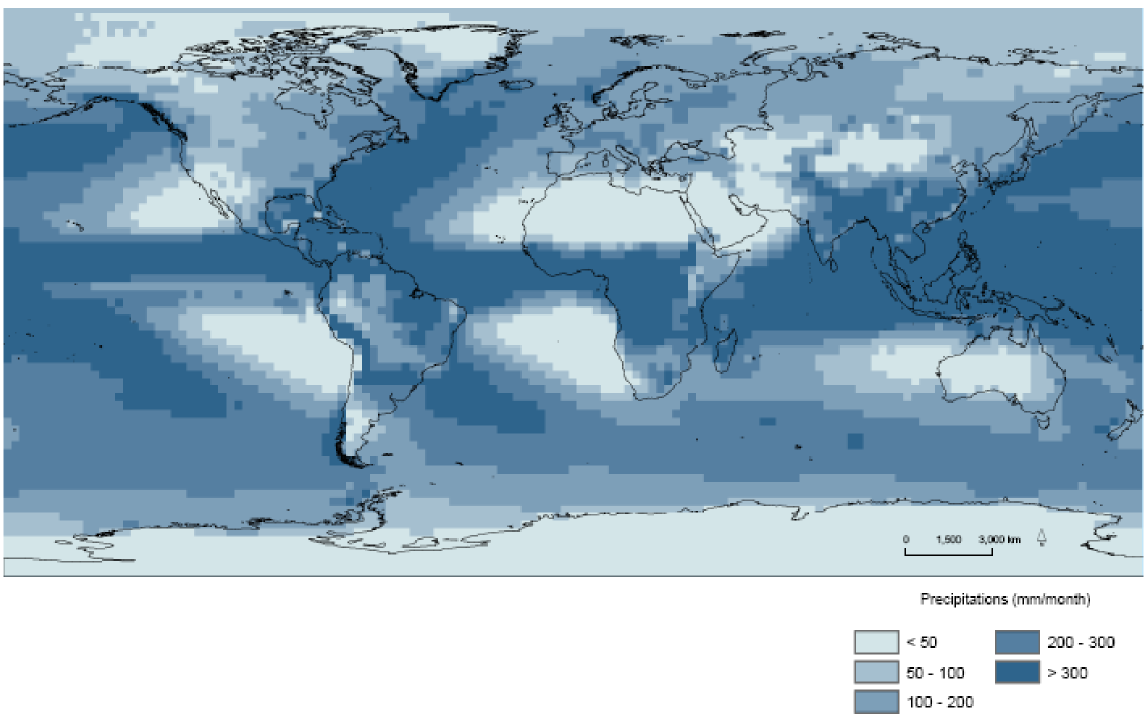
Primary Data Format

NetCDF format

Processing
Importing NetCDF data in GeoDataBase Tables
Total monthly mean
Stored in

\\globaldata\Atmosphere\Precipitation

Figure 12: Precipitation



3.5 SnowFall

DATA SOURCE
ECMWF 40 Years Re-Analysis daily

ORIGINAL DATA DESCRIPTION
SOURCE CITATION
ECMWF ERA-40 data used in this project have been obtained from the ECMWF Data Server

LINK
http://data-portal.ecmwf.int/data/d/era40_daily/

ACCESSED
16/04/2009

SPATIAL RESOLUTION
2.5°x2.5°

TEMPORAL RESOLUTION
Monthly data from 1957-09 to 2002-08, diurnal (12:00)

UNIT
m of water equivalent per day

PRIMARY DATA FORMAT

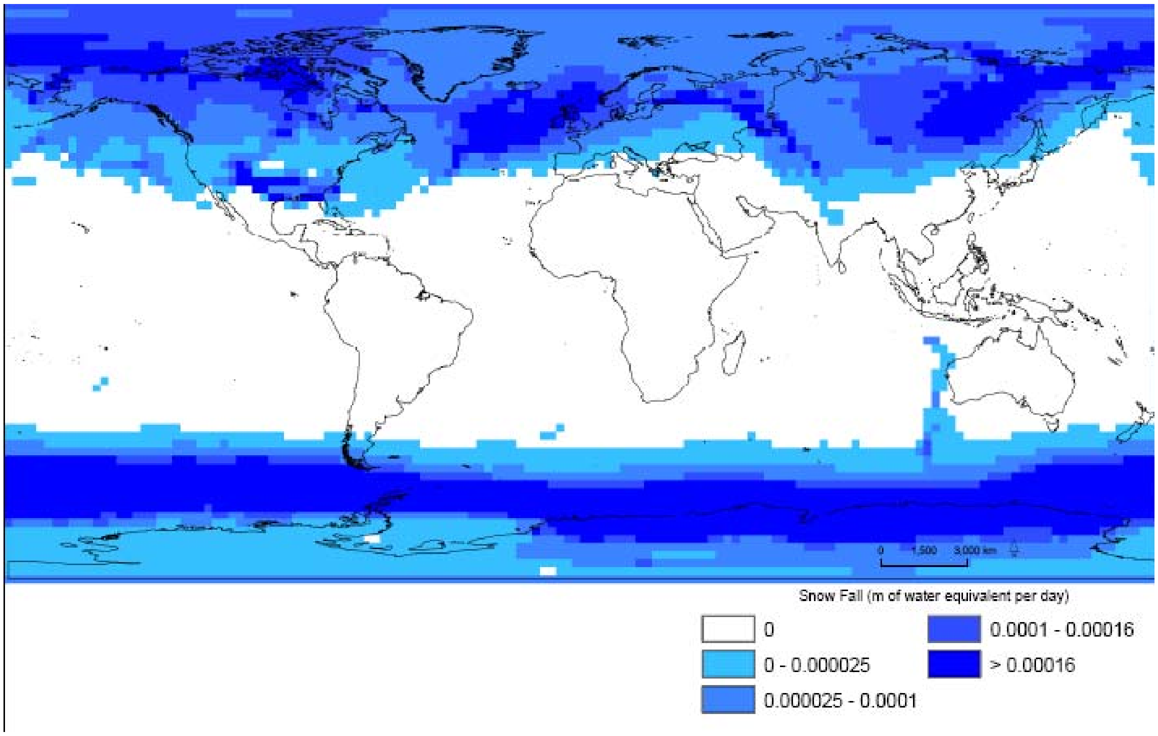
NetCDF format

PROCESSING
Importing NetCDF data in GeoDataBase Tables
Average of Montly data

STORED IN

\\globaldata\Atmosphere\Snowfall

Figure 13: Snow fall



3.6 Aerosol

DATA SOURCE

Aerosol data were provided by colleagues at the Joint Research Centre - Institute for Environment and Sustainability, Climate Change Unit,and derive from simulations sun with the TM5 model. The data (summarized in Table 3) were in NetCDF format and were imported an processed as grids of monthly values. Data come referred to months of year 2001 and to a number of vertical atmospheric layers (levels) of which the pressure and indicative elevation is given in Table 4.

FILENAMES

TM5-JRC-cy2-ipcc-v1_SR1_aerosolm_2001.nc
TM5-JRC-cy2-ipcc-v1_SR1_depm_2001.nc
TM5-JRC-cy2-ipcc-v1_SR1_tracerm_2001.nc

SOURCE CITATION

Gregory Carmichael, Frank Dentener, Richard Derwent, Arlene Fiore, Michael Prather, Michael Schulz, Oliver Wild, Chapter 5: Global and Regional modeling, in Hemispheric Transport of Air pollution 2007, Air pollution studies, 16, United Nations Economic Commission for Europe, ISBN, 1014-4625, Geneva, 2007

Krol, M., Houweling, S., Bregman, B., van den Broek, M., Segers, A., van Velthoven, P., Peters, W., Dentener F., Bergamaschi P., The two-way nested global

chemistry-transport zoom model TM5: algorithm and application. Atmos. Chem. Phys. 4, 3975-4018 – 2005.

De Meij, A., M. Krol, F. Dentener, V. E., E. Cuvelier, and P. Thunis, The sensitivity of aerosol in Europe to two different emission inventories and temporal distribution of emissions, Atmospheric Chemistry and Physics, Vol. 6, pp 4287-4309, 25-9-2006.

LINK

None

ACCESSED

26/10/2009

SPATIAL RESOLUTION

1° x 1°

COVERAGE

Global

TEMPORAL RESOLUTION

2001

PRIMARY DATA FORMAT

NetCDF

PROCESSING

Extracting tables from NETCDF
Average of levels 0 to 6 for each month
Montly data average

STORED IN

\\globaldata\Atmosphere\Aereosol\

Table 3: Aereosol data

	Variables standard_name	Units	Processing
OC	"mass_fraction_of_organic_carbon_as_particulate_organic_carbon_dry_aerosol_in_air" "POM" mmr_pom	kg kg-1	Level 0 to level 6 average for each month Montly data average
BC	"mass_fraction_of_black_carbon_dry_aerosol_in_air" mmr_bc	kg kg-1	Data only in level 0 Montly data average
BC_flux	"surface_dry_deposition_mass_flux_of_black_carbon_dry_aerosol" "dry deposition of BC" dry_bc	kg m-2 s-1	Montly data average
OC_flux	"surface_dry_deposition_mass_flux_of_organic_carbon_as_particulate_organic_carbon_dry_aerosol" "dry deposition of POM" dry_pom	kg m-2 s-1	Montly data average
OH	"mole_fraction_of_hydroxyl_radical_in_air" "OH" vmr_oh	mole mole-1	Level 0 to level 6 average for each month Montly data average

Table 4: level, pressure and meters for aereosol data

Level#	Indicative pressure(Pa)	Indicative elevation of the level (m)
0	100000.00	0.00000000
1	98822.158	50.357291
2	96390.413	156.41375
3	92265.932	343.66616
4	86362.766	630.37319
5	78918.506	1029.9382
6	70421.380	1552.7282
7	61502.330	2207.3482
8	52810.855	3001.4824
9	44897.576	3942.3878
10	38124.360	5037.1164
11	32616.903	6292.5561
12	28266.291	7715.4747
13	24776.791	9313.0526

14	21748.501	11095.247
15	18777.332	13082.395
16	15563.598	15318.425
17	12099.698	17840.760
18	8765.7189	20685.030
19	6018.0195	23888.502
20	3960.2915	27445.247
21	1680.6403	34730.961
22	713.21808	42016.675
23	298.49579	49420.442
24	95.636963	59095.112
25	0.00000000	Infinity

Figure 14: Mass fraction of organic carbon

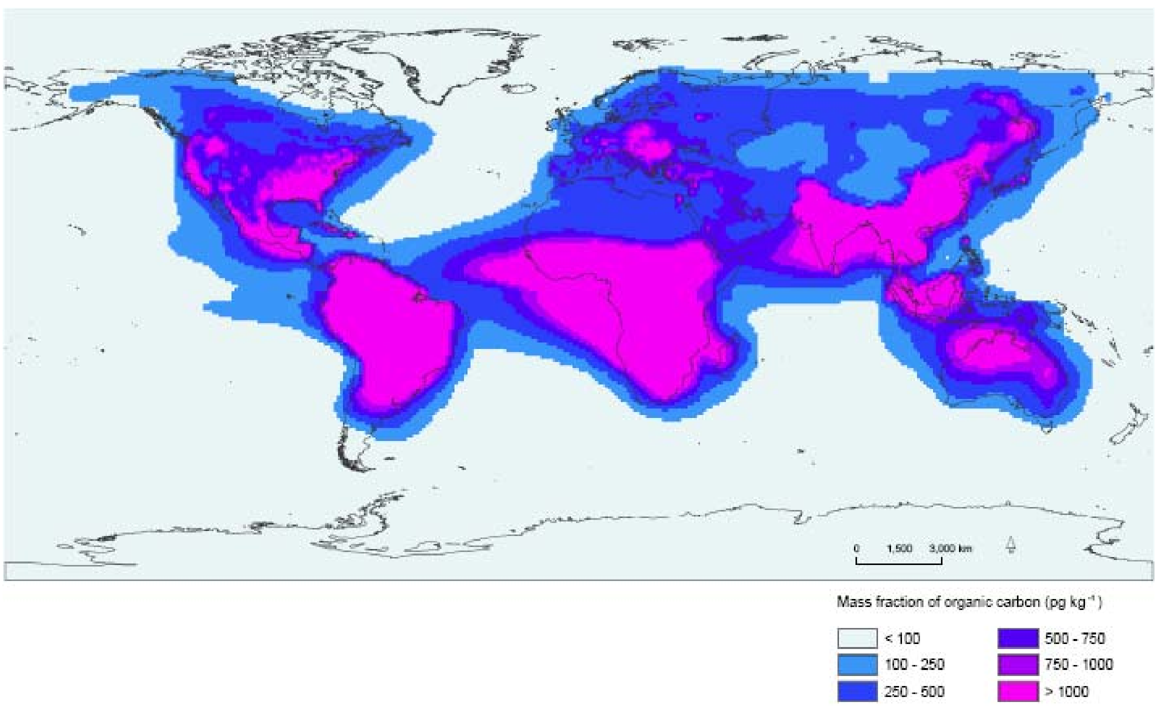


Figure 15: flux of black carbon dry aerosol

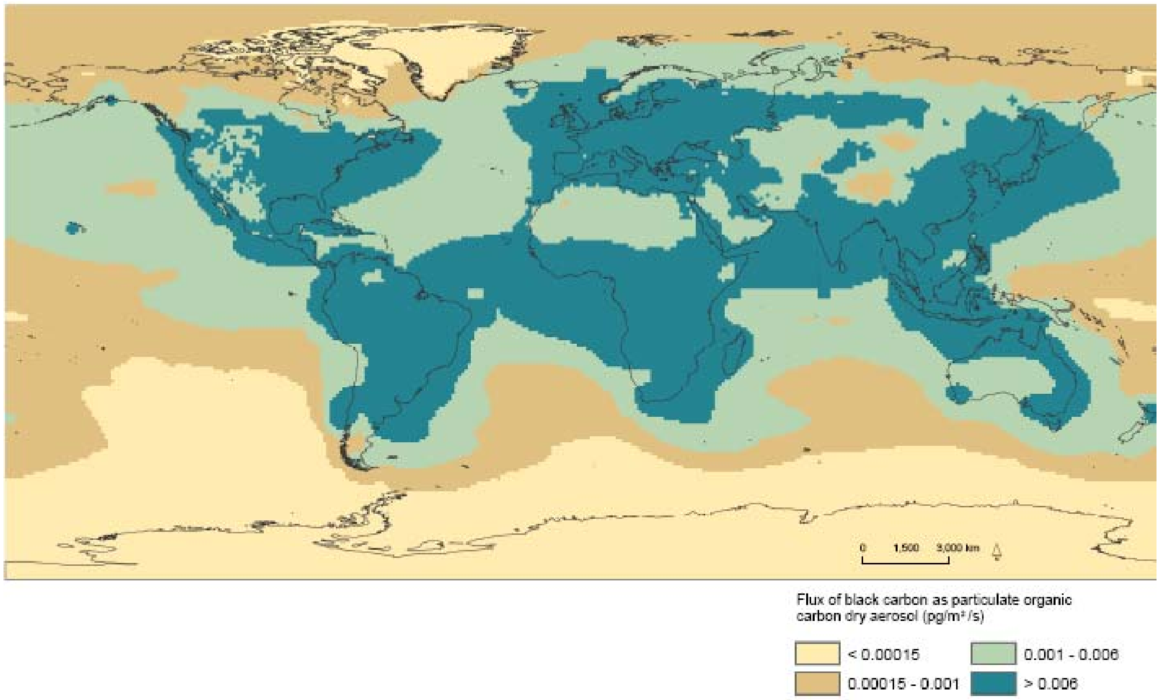
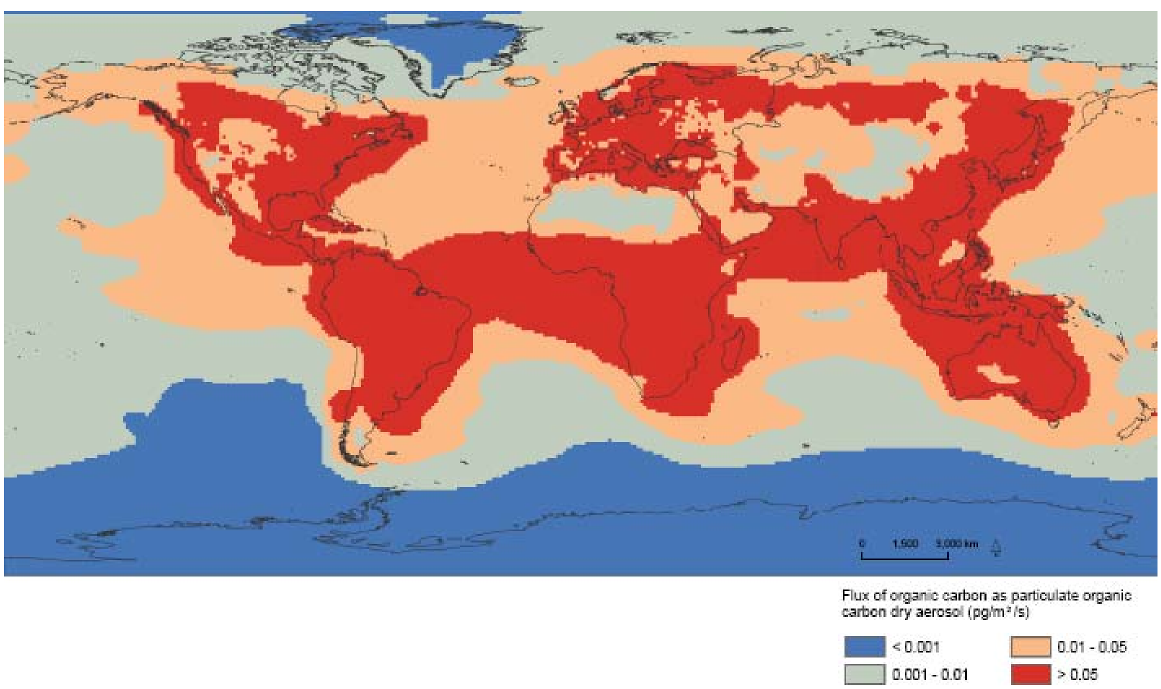


Figure 16: flux of organic carbon dry aerosol



NOTES

Modeled aerosol concentrations and fluxes werepreferred here to alternatives such as satellite products from MODIS (http://modis.gsfc.nasa.gov/about/ ; ftp://ladsweb.nascom.nasa.gov/allData/4/MYD08_M3/).

4. Data Catalog: Stream Network

4.1 Networks

DATA SOURCE
HYDRO1k

ORIGINAL DATA DESCRIPTION
HYDRO1k is a geographic database developed to provide comprehensive and consistent global coverage of topographically derived data sets, including streams, drainage basins and ancillary layers derived from the USGS' 30 arc-second digital elevation model of the world (GTOPO30). HYDRO1k provides a suite of geo-referenced data sets, both raster and vector, which will be of value for all users who need to organize, evaluate, or process hydrologic information on a continental scale.

Developed at the U.S. Geological Survey's Center for Earth Resources Observation and Science (EROS), the HYDRO1k project's goal is to provide to users, on a continent by continent basis, hydrologically correct DEMs along with ancillary data sets for use in continental and regional scale modeling and analyses. Detailed descriptions of the processing steps involved in development of the HYDRO1k data sets can be found in the Readme file.

This work was conducted by the U.S. Geological Survey in cooperation with UNEP/GRID Sioux Falls. Additional funding was provided by the Brazilian Water Resources Secretariat and the Food and Agriculture Organization/Inland Water Resources and Aquaculture Service.

Each data set is made up of six raster and two vector layers.

Projection and georeferencing information:

Africa:

Number of rows = 9194
Number of columns = 8736
XY corner coordinates (center of pixel):
Lower left: -4368500.000, -5044500.000
Upper left: -4368500.000, 4149500.000
Upper right: 4367500.000, 4149500.000
Lower right: 4367500.000, -5044500.000
Projection used: Lambert Azimuthal Equal Area
Units = meters
Pixel Size = 1000 meters

Radius of Sphere of Influence = 6,370,997 meters
Longitude of Origin = 20 00 00E
Latitude of Origin = 5 00 00N
False Easting = 0.0
False Northing = 0.0

Asia
Number of rows = 11882
Number of columns = 9341
XY corner coordinates (edge of pixel):
Lower left: -4355500.000, -5438500.000
Upper left: -4355500.000, 6443500.000
Upper right: 4985500.000, 6443500.000
Lower right: 4985500.000, -5438500.000
Projection used: Lambert Azimuthal Equal Area
Units = meters
Pixel Size = 1000 meters
Radius of Sphere of Influence = 6,370,997 meters
Longitude of Origin = 100 00 00E
Latitude of Origin = 45 00 00N
False Easting = 0.0
False Northing = 0.0

Europe

Number of rows = 7638
Number of columns = 8319
Lower left: -4091500.000, -4344500.000
Upper left: -4091500.000, 3293500.000
Upper right: 4227500.000, 3293500.000
Lower right: 4227500.000, -4344500.000
Projection used: Lambert Azimuthal Equal Area
Units = meters
Pixel Size = 1000 meters
Radius of Sphere of Influence = 6,370,997 meters
Longitude of Origin = 20 00 00E
Latitude of Origin = 55 00 00N
False Easting = 0.0
False Northing = 0.0

North America

Number of rows = 8384
Number of columns = 9102
Lower left: -4462500.000, -3999500.000
Upper left: -4462500.000, 4384500.000

Upper right: 4639500.000, 4384500.000
Lower right: 4639500.000, -3999500.000
Projection used: Lambert Azimuthal Equal Area
Units = meters
Pixel Size = 1000 meters
Radius of Sphere of Influence = 6,370,997 meters
Longitude of Origin = 100 00 00W
Latitude of Origin = 45 00 00N
False Easting = 0.0
False Northing = 0.0

South America
Number of rows = 9094
Number of columns = 7736
Lower left: -3776500.000, -5258500.000
Upper left: -3776500.000, 3835500.000
Upper right: 3959500.000, 3835500.000
Lower right: 3959500.000, -5258500.000
Projection used: Lambert Azimuthal Equal Area
Units = meters
Pixel Size = 1000 meters
Radius of Sphere of Influence = 6,370,997 meters
Longitude of Origin = 60 00 00W
Latitude of Origin = 15 00 00S
False Easting = 0.0
False Northing = 0.0

SOURCE CITATION

USGS EROS Data Center, HYDRO1k Elevation Derivative Database. Sioux Falls, South Dakota, LP DAAC.

LINK

http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/gtopo30/hydro

ACCESSED

01/10/2009

SPATIAL RESOLUTION

1km x 1km (0.008333°x0.008333°)

Processing

- GlobalNet.mdb:
  - Vector data (stream network, lakes and basins) for each continent

- Mosaic to global extent (except for the Australia dataset); reprojection to wgs84 (filed Shape_area has the polygons' surface in m^2)

Stored in
\\globaldata\Stream_Network\StreamNet

4.2 Potential Simulated Topological Networks

DATA SOURCE
STN-30p
ORIGINAL DATA DESCRIPTION
The global Simulated Topological Network at 30-minute spatial resolution (STN--30p) represents rivers as a set of spatial and tabular data layers derived from a 30-minute flow-direction grid. Simulated Topological Networks are used to represent the linkage of continental land mass and river networks in the Global Hydrologic Archive and Analysis System (GHAAS). STN networks are generated at various resolutions. The 30-minute STN for the world (shown above) is suitable for monthly flow simulations, such as used in the GHAAS Water Transport Model (WTM). Other uses of the STN include the derivation of basin-wide or subbasin characteristics such as stream order, mainstem length and catchment area.

Table 5: STN 30p data structure

File	Data
g_basin	Basin grid with basin attributes
g_celllength	Grid cell length [km] grid
g_cumularea	Upstream catchment area [km^2] grid
g_distmouth	Distance [km] to mouth of river defined as the confluence with equal or higher order stream
g_distocean	Distance [km] to the outlet of river basins
g_network	Flow-direction grid
g_order	Strahler stream order grid
c_basin	Basin polygon coverage with the same basin attributes as the basin grid
c_network	Arc/point coverage representing river segments and basin mouths

SOURCE CITATION
Simulated Topological Networks (STN-30p) Version 6.01

Link
http://www.wsag.unh.edu/Stn-30/stn-30.html

ACCESSED

25/09/2009

SPATIAL RESOLUTION
30'
cellsize 0.5

PRIMARY DATA FORMAT

ARC/INFO coverages and ASCII interchange files

STORED IN

\\globaldata\Stream_Network\Topo_Net\stn30

4.3 Global Lakes

DATA SOURCE
World lakes database –

See annex A
Framework Contract JRC.REF ESP DESIS DI/05712 (LOT 1 B)

Link

http://www.ilec.or.jp/database/database.html

STORED IN
\\globaldata\Stream_Network\lakes

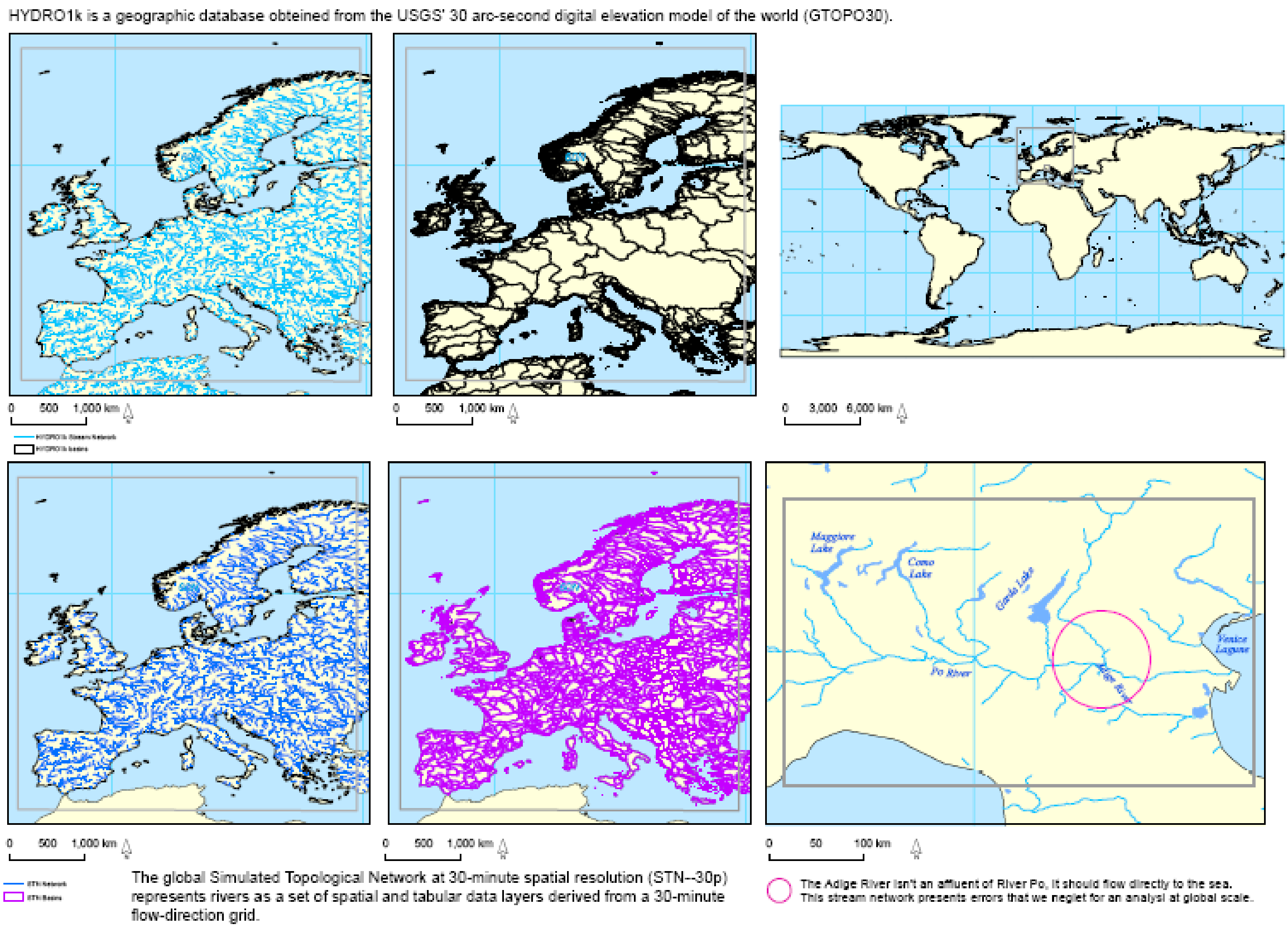


Figure 17: Stream Networks data type

4.4 Average Residence Time (ART) of Pollutants in Inland Surface Water

DATA :
Hydro 1K (by Continent)
Global Runoff (global)
Global Lakes (global)
Nighttime Lights of the World (global)

SPATIAL RESOLUTION
1km x 1km (0.008333°x 0.008333°)

PROCESSING SCHEME
The average residence time of a contaminant in a catchment may be defined as:

$$ART = \frac{1}{k}\ln\left(\frac{\sum_{i=1}^{n} E_i}{\sum_{i=1}^{n} E_i \exp(-kt_i)}\right)$$

Where n is the number of contaminant emissions existing in the catchments, E_i is the intensity (mass discharge) of the i-th emission, and t_i is the timeof travel of water from the i-th emission to the catchment outlet, while k is the contaminant decay rate. From the definition, it is clear that ART can be only defined with reference to a given decay rate. However, by assigning a generic value of k the ART provides an idea of the time required for a contaminant to be washed off from a catchment. We computed the ART with reference to a persistent water pollutant with half life of 60 days, according to the procedure detailed below. Emissions are represented through the proxy given by the worldstablelights atnight from satellite images, described below.

The time of travel of water in catchments is computed considering an average water velocity of 0.2 m s^{-1} in rivers, and a velocity in lakes given by:

$$V_L = \frac{\sqrt{\frac{4A_L}{\pi}}}{T_L}$$

where A_L is the lake surface area and T_L its hydraulic retention time.

Examples of steps in the processing chain are shown in

Figure 18.

Procedure	***input***	***output***	***Results description measure units***
Compute annual average discharge	Flow direction, annual average runoff (mm)	[Q]	The water discharge map computed from runoff in mm using a resolution of 1 km^2 $=10^6$ m^2 is multiplied by the conversion factor 0.0000317=0.001*1000000/ 86400/365 to have m^3s^{-1}.
Compute each lake's discharge	Zonal statistics (max) of grid [Q] over each lake's polygon	An attribute of discharge for each lake polygon	M^3 s^{-1}
Compute lake volume	Lakes.shp,	An attribute of volume for each lake polygon	$V_i = hmean_i A_i * 1000000$ Vi=Volume in m^3 Ai=Surface in km2 hmean i = lake mean deph computed as described in Annex B
Compute average Time of residence in Lakes	Lakes.shp,	An attribute of residence time for each lake polygon	T=V/Q/86400 (days)
Compute equivalent flow velocity in lakes	Lakes.shp,	An attribute of velocity for each lake polygon	$VL_i = \frac{\sqrt{\frac{4A_i}{\pi}}}{T_i}$ VLi = speed in m/day for each lake Ai= surface area of each lake Ti= Average Time of residence in Lakes in days Appropriate conversion of units yields m day^{-1}.
Rasterize Lakes.shp, (using previous velocity as attribute)	Lakes.shp,	[Vellake], grid	
Define a weight representing the average crossing time of in Lakes and the stream network (days per meter)	[Vellake], [mask] (a mask grid representing only rivers above 500 km2 of catchment)	[F_W]	ESRI ArcGIS syntax: [F_W]= Con (IsNull([Vellake]), 1 / 0.2 / 86400, 1 / [Vellake]) * [Mask]
Compute time to reach the sea foreach point, through a weighted downstream flowlength using weight F_W	Fdirection, F_W	[tau]	Map of the time to reach the sea (days)

Procedure	***input***	***output***	***Results description measure units***
Define the product of emission and exp(-kt): $Ls\_weigh = E * e^{-kt}$ E=emission T=time to the sea Assuming halflife of 60 days K = 0.011552 (= ln2/60)	[tau], [world_lights]	[Ls_weigh]	We assume here world stable lights [world_lights] as a proxy for chemical emissions: [Ls_weigh]=Exp(-0.011552453 * [tau]) * [world_lights]
Denominator of the logarithm argument in: $ART = \frac{1}{k}\ln\left(\frac{\sum_{i=1}^{n} E_i}{\sum_{i=1}^{n} E_i \exp(-kt_i)}\right)$	Fdirection, Ls_weigh	[Fl_Acc_W_1]	--
Numerator of the logarithm argument in: $ART = \frac{1}{k}\ln\left(\frac{\sum_{i=1}^{n} E_i}{\sum_{i=1}^{n} E_i \exp(-kt_i)}\right)$	[Fdirection], [world_lights]	[Fl_Acc_W_2]	--
Identification of the catchments discharging to the sea	[Fdirection]	[Basins]	We use an ArcGIS spatial analyst "basin" operation.
Extraction of the denominator of the logarithm argument by basin	[Fl_Acc_W_1] , [basins]	[zonal1]	zonal statistics di [Fl_Acc_W_1] on [basins] (max value)
Extraction of the numerator of the logarithm argument by basin	[Fl_Acc_W_2], [basins]	[zonal2]	zonal statistics di [Fl_Acc_W_1] on [basins] (max value)
Compute the logarithm argument	[zonal1], [zonal2]	[TT]	zonal1/zonal2
Average Residence Time of Pollutants in Island Surface Water in days	[TT]	[LogTT]	[LogTT]=Log(1/[TT])/k

STORED IN

\\globaldata\Stream_Network\ART

Figure 18: main phases of the analysis procedure.

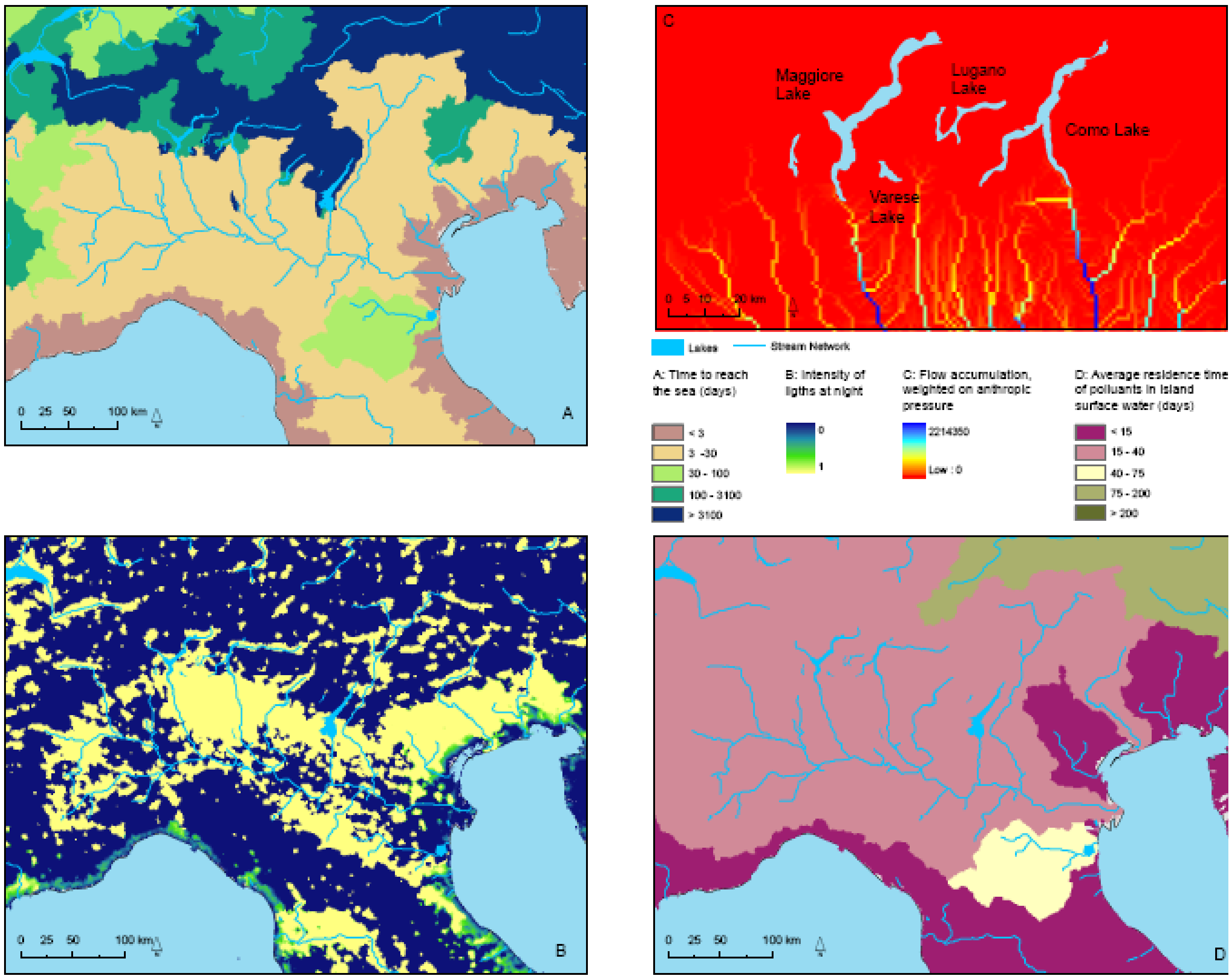
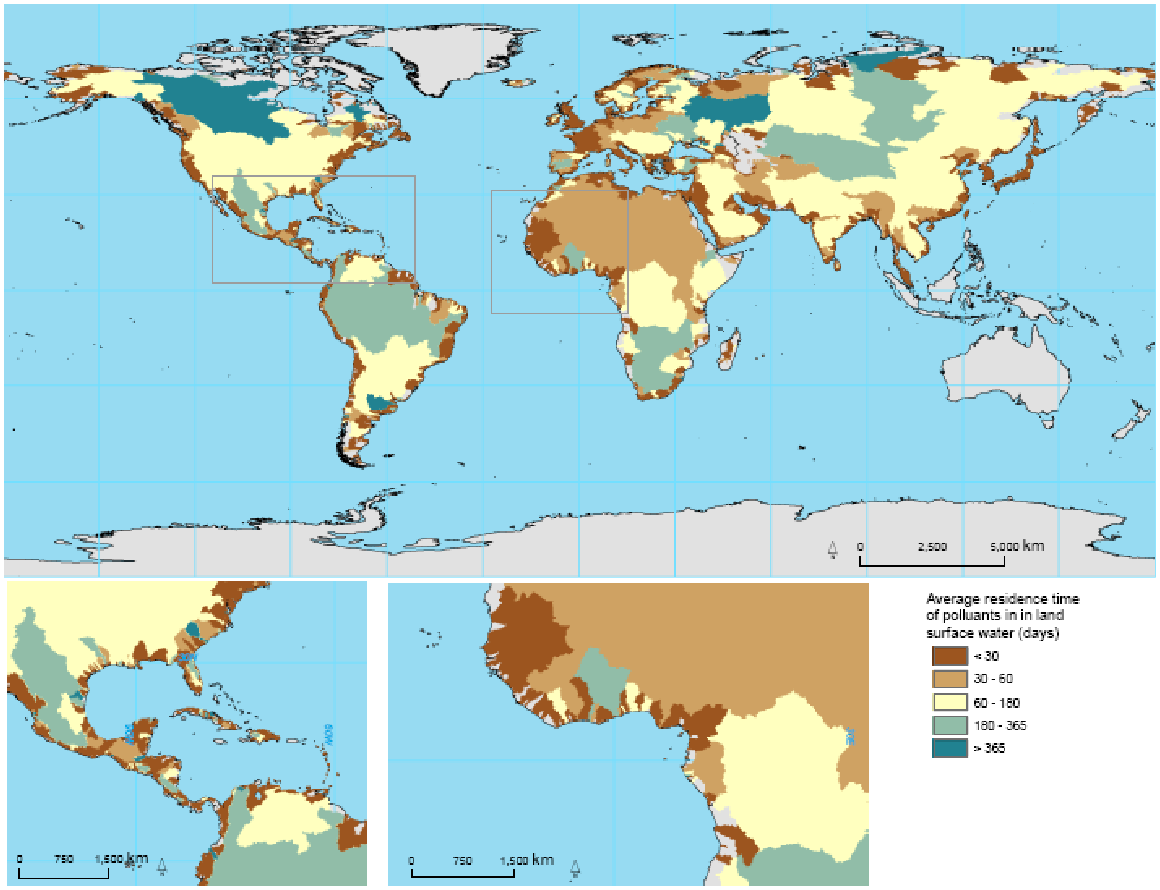


Figure 19 : Average residence time of pollutants in surface water



5. Data Catalog: Oceans

5.1 Temperature

DATA SOURCE
World Ocean Atlas 2005 (NOAA)

ORIGINAL DATA DESCRIPTION
Annual climatological mean of oceanographic temperature at 0-5500 meters (33 levels)

SOURCE CITATION
Locarnini, R. A., A. V. Mishonov, J. I. Antonov, T. P. Boyer, and H. E. Garcia, 2006. World Ocean Atlas 2005, Volume 1: Temperature. S. Levitus, Ed. NOAA Atlas NESDIS 61, U.S. Government Printing Office, Washington, D.C., 182 pp.

LINK
http://www.nodc.noaa.gov/cgi-bin/OC5/SELECT/woaselect.pl?parameter=1

ACCESSED
07/10/2008

SPATIAL RESOLUTION
1°x1°

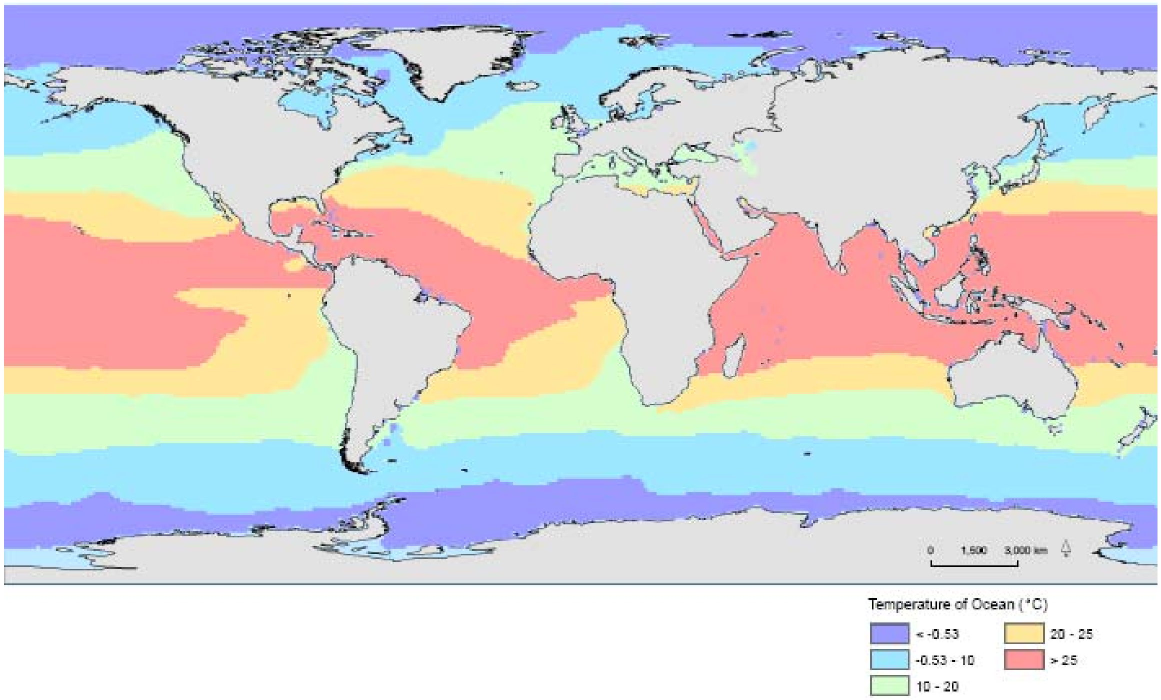
TEMPORAL RESOLUTION
2005

PROCESSING
Data are stored in "File GeoDatabase Feature Class" format
Average of first 30 meters

STORED IN

\\globaldata\Ocean\OceanTemp

Figure 20: Ocean temperature



5.2 Salinity

DATA SOURCE
World Ocean Atlas 2005 (NOAA)

ORIGINAL DATA DESCRIPTION
Annual climatological mean of oceanographic salinity at 0-5500 meters (33 levels)

SOURCE CITATION
Antonov, J. I., R. A. Locarnini, T. P. Boyer, A. V. Mishonov, and H. E. Garcia, 2006. World Ocean Atlas 2005, Volume 2: Salinity. S. Levitus, Ed. NOAA Atlas NESDIS 62, U.S. Government Printing Office, Washington, D.C., 182 pp.

LINK
http://www.nodc.noaa.gov/cgi-bin/OC5/SELECT/woaselect.pl?parameter=2

ACCESSED
07/10/2008

SPATIAL RESOLUTION
1°x 1°

TEMPORAL RESOLUTION

PROCESSING
Data are stored in "File GeoDatabase Feature Class" format.

STORED IN
\\globaldata\Ocean\GDB\Ocean.gdb

5.3 Mixed layer depth

DATA SOURCE
World Ocean Atlas 1994 (NOAA)

ORIGINAL DATA DESCRIPTION
"The MLD fields available are computed from climatological monthly mean profiles of potential temperature and potential density based on three different criteria: a temperature change from the ocean surface of 0.5 degree Celsius, a density change from the ocean surface of 0.125 (sigma units), and a variable density change from the ocean surface corresponding to a temperature change of 0.5 degree Celsius. The MLD based on the variable density criterion is designed to account for the large variability of the coefficient of thermal expansion that characterizes seawater." (documentation from the source - MLD is in meters)

Source citation
Monterey, G. and Levitus, S., 1997: Seasonal Variability of Mixed Layer Depth for the World Ocean. NOAA Atlas NESDIS 14, U.S. Gov. Printing Office, Wash., D.C., 96 pp. 87 figs.

Link
http://www.nodc.noaa.gov/OC5/WOA94/mix.html

ACCESSED
11/07/2008

SPATIAL RESOLUTION
1°x1°

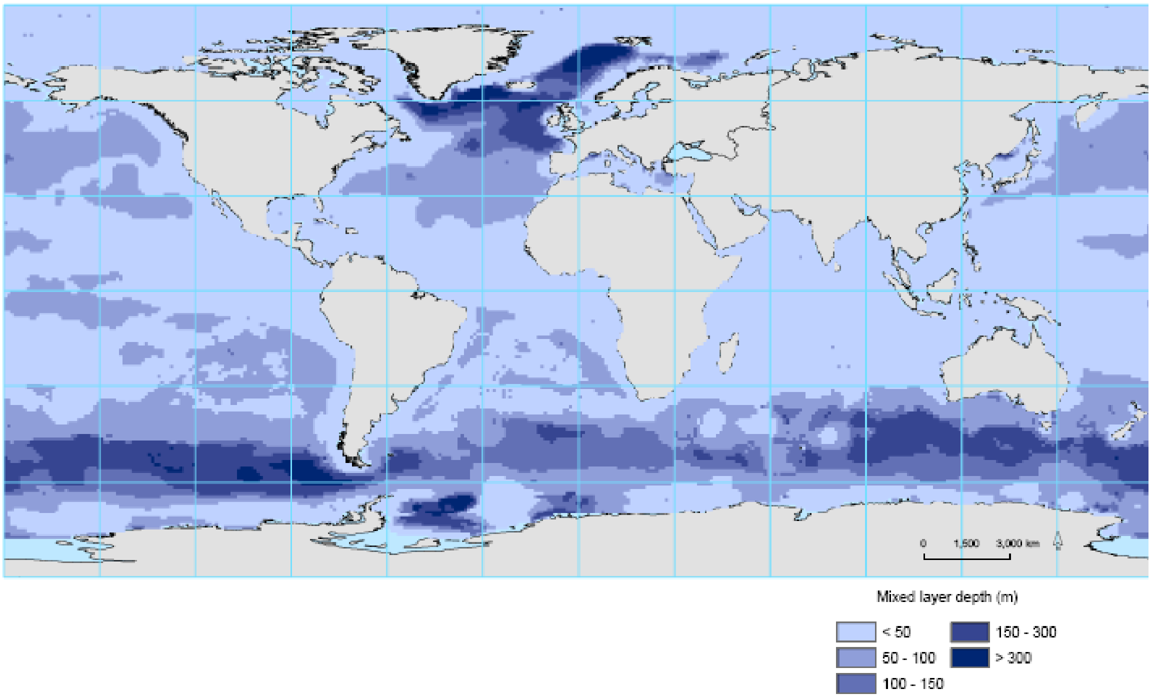
TEMPORAL RESOLUTION
Monthly

PROCESSING
Conversion of original monthly data files to GRID format.

STORED IN

\\globaldata\Ocean\MLD

Figure 21: Mixed Layer Deph



5.4 Chlorophyll

DATA SOURCE
World Ocean Atlas 2001 (NOAA)

ORIGINAL DATA DESCRIPTION
1. Annual mean chlorophyll (µg/l) at the surface.
2. Annual mean chlorophyll (µg/l) at 10 m depth.
3. Annual mean chlorophyll (µg/l) at 20 m depth.
4. Annual mean chlorophyll (µg/l) at 30 m depth.
5. Annual mean chlorophyll (µg/l) at 50 m depth.
6. Annual mean chlorophyll (µg/l) at 75 m depth.
7. Annual mean chlorophyll (µg/l) at 100 m depth.

Analyzed fields (an) - One-degree all-data objectively analyzed mean. For all variables, the annual analyzed field is the average of the twelve monthly fields for each standard level for which monthly fields exist

SOURCE CITATION

Conkright, M.E., T.D. O'Brien, C. Stephens, R.A. Locarnini, H.E. Garcia, T.P. Boyer, J.I. Antonov , 2002: World Ocean Atlas 2001, Volume 6: Chlorophyll. Ed. S. Levitus, NOAA Atlas NESDIS 54, U.S. Government Printing Office, Wash., D.C., 46 pp.

LINK
http://www.nodc.noaa.gov/OC5/WOA01/1d_woa01.html

ACCESSED
11/07/2008

SPATIAL RESOLUTION
1°x1°

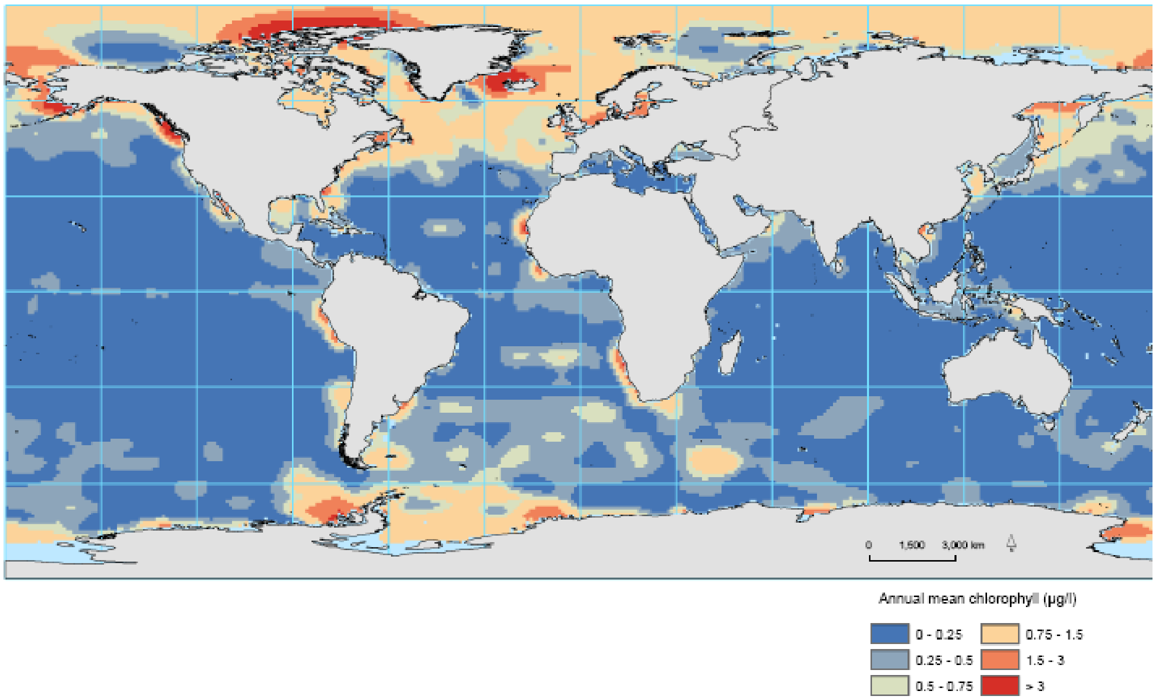
TEMPORAL RESOLUTION

PROCESSING
Conversion of original files to "File GeoDatabase Raster Dataset" format.
Average of first 30 meters

STORED IN

\\globaldata\Ocean\Chlorophyll

Figure 22: Chlorophyll



5.5 Surface velocity

DATA SOURCE

Mariano Global Surface Velocity analysis

ORIGINAL DATA DESCRIPTION

The initial input data set is the Maury Ship Drift database from 1900 to 1945. Each velocity component, u and v, were estimated using the scalar Parameter Matrix Objective Analysis algorithm (PMOA) routine described in Mariano and Brown (1992) after a median filter was applied to the data to remove gross outliers. This data was mapped monthly and has a horizontal resolution of 100 km (Mariano et al, 1995).

Each velocity component, u and v, were estimated using the scalar OA routine described in Mariano and Brown (1992) after a median filter was applied to the data to remove gross outliers. The velocity estimates are poor in the southern ocean due to the lack of data, especially south of 50 S.

SOURCE CITATION

Mariano, A.J., E.H. Ryan, B.D. Perkins, S. Smithers. The Mariano Global Surface Velocity analysis 1.0, U.S. Coast Guard Technical Report, CG-D-34-95, 1995.

Mariano, A.J. and O.B. Brown. Efficient objective analysis of dynamically heterogeneous and nonstationary fields via the parameter matrix. Deep-Sea Res., 39 (7/8), 1992, 1255-1271.

LINK
http://www.rsmas.miami.edu/personal/eryan/mgsva/

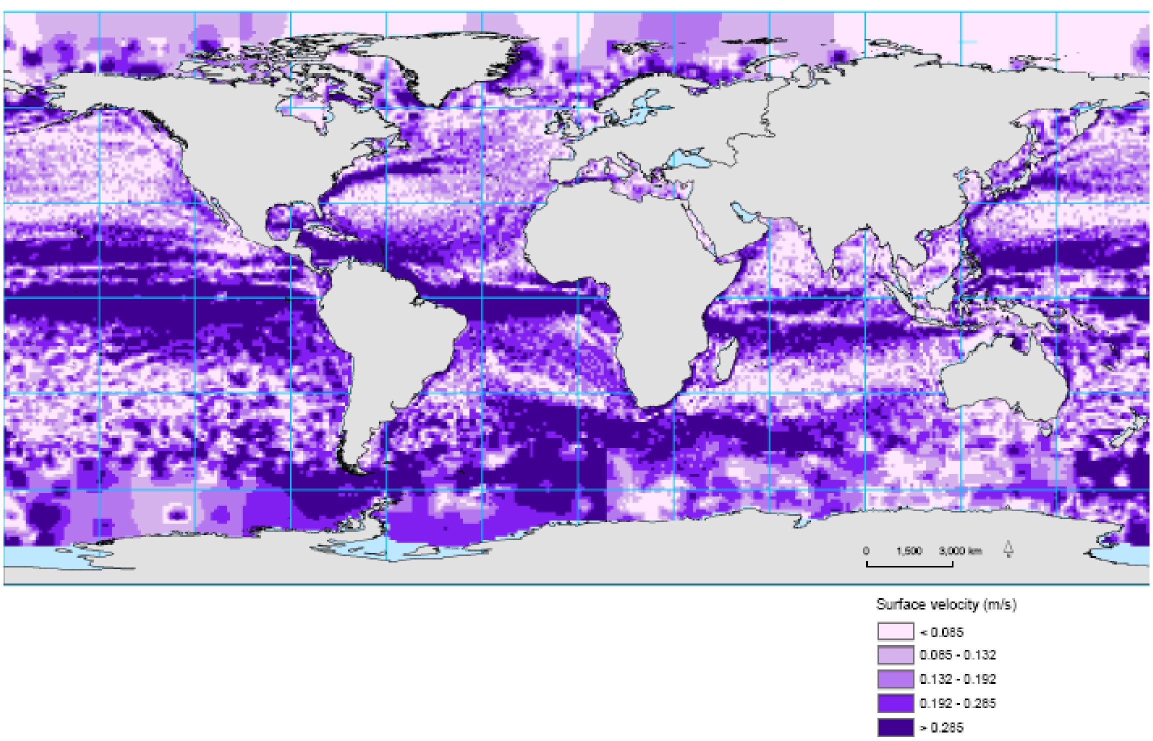
ACCESSED
11/07/2008

SPATIAL RESOLUTION
1°x1°
UNIT
m/s
TEMPORAL RESOLUTION
1900-1945

PROCESSING
Conversion of original csv files to "File GeoDatabase Feature Class" format.
Calculation of velocity:
$$\sqrt{(v*v)+(u*u)}$$

STORED IN
\\globaldata\water\Ocean\Velocity

Figure 23: Surface velocity



5.6 Water surfaces

DATA SOURCE

Inputs:

- Lakes: Vector Lakes from the World lake database
- Continents shape file from the ESRI digital chart of the world
- Mask of ocean/land surface created from the Continents shape file

SPATIAL RESOLUTION

0.25 x 0.25

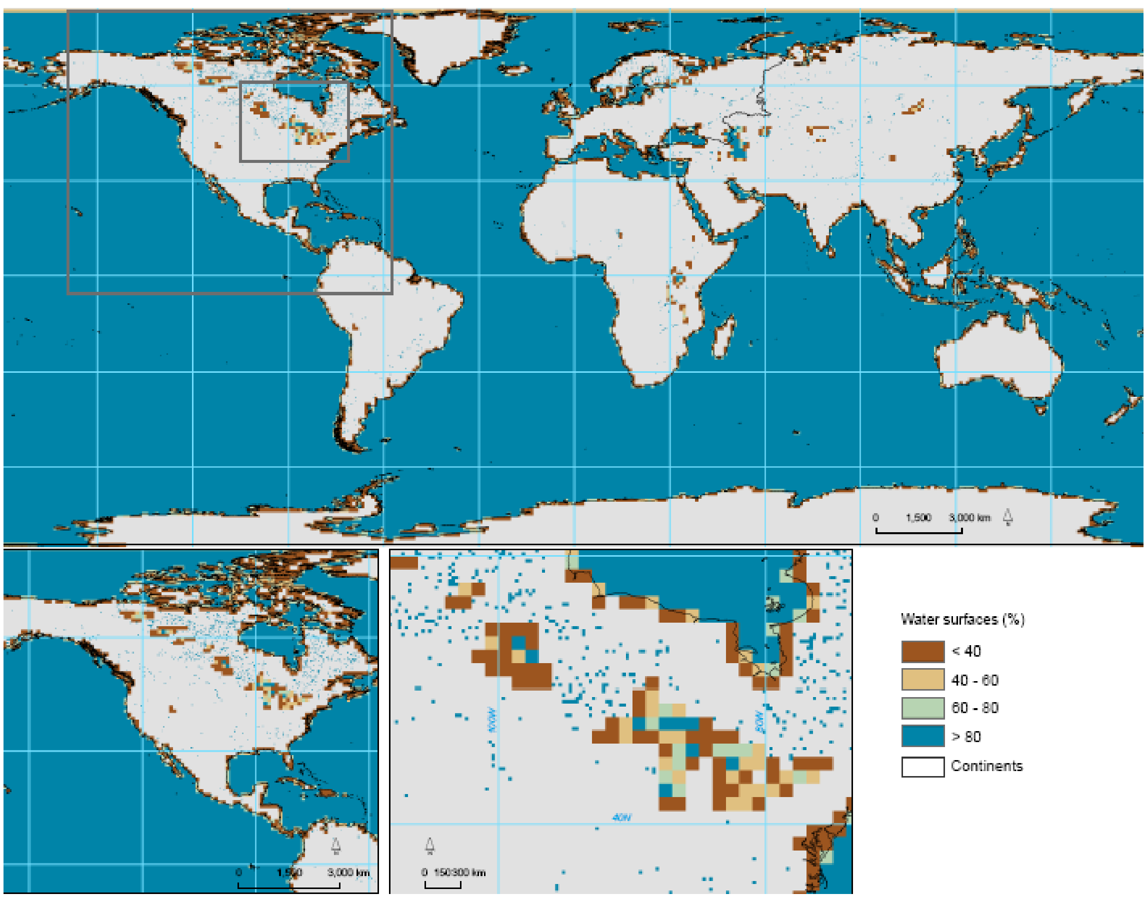
UNITS

% of water surface

STORED IN

\\globaldata\water\water025_b

Figure 24: percentage of water surface



6. Data Catalog: Vegetation

6.1 Vegetation

Data source
Continuous Fields of Vegetation Cover

Original data description
"*The objective of this study was to derive continuous fields of vegetation cover from multi-temporal Advanced Very High Resolution Radiometer (AVHRR) data using all available bands and derived Normalized Difference Vegetation Index (NDVI). The continuous fields describe sub-pixel proportions of cover for tree, herbaceous, bare ground and water cover types. For tree cover, additional fields describing leaf longevity (evergreen and deciduous) and leaf morphology (broadleaf and needleleaf) were also generated. The modeling of carbon dynamics and climate require knowing tree characteristics such as these. These products were resampled and aggregated to 0.25, 0.5 and 1.0 degree grids for the International Satellite Land Surface Climatology Project (ISLSCP) data initiative II. The data set describes the geographic distributions of three fundamental vegetation characteristics: tree, herbaceous and bare ground cover, plus a water layer. For tree cover, leaf longevity and morphology layers were produced.*" (data set description from the source)

The data sets are provided at three spatial resolutions of 0.25, 0.5 and 1 degrees lat./long. For each spatial resolution there are eight files describing the percentage, from 0 to 100, of the following global continuous fields:

Table 6: Vegetation Type

Value	Description
1	Bare Cover
2	Herbaceous cover
3	Tree cover
4	Water
5	Deciduous tree cover
6	Evergreen tree cover
7	Needleleaf tree cover

The files for 1) are called bare_percent_xx.asc, where xx is qd, hd, or 1d, denoting a spatial resolution of 1/4, 1/2 or 1degree, respectively. The files for 2) are called herb_percent_xx.asc, with xx as above, and so on for the different continuous fields. Missing data points are listed as -999.

SOURCE CITATION

DeFries, R. S., Townshend, J. R. G., and Hansen, M. C., 1999, Continuous fields of vegetation characteristics at the global scale at 1km resolution, Journal of Geophysical Research, 104, 16 911-16 925.

DeFries, R. S., Hansen, M. C., Townshend, J. R. G., Janetos, A. C., and Loveland, T. R., 2000, A new global 1-km dataset of percentage tree cover derived from remote sensing. Global Change Biology, 6, 247-254.

LINK
http://islscp2.sesda.com/ISLSCP2_1/html_pages/groups/veg/veg_continuous_fields_xdeg.html

ACCESSED
16/07/2008

SPATIAL RESOLUTION
1°x1°, 0.5°x0.5°, 0.25°x0.25°

TEMPORAL RESOLUTION
1992-1993

PROCESSING
Import of 0.25°x0.25° files into "File GeoDatabase Raster Dataset" format.

STORED IN
\\globaldata\Others\GDB\Others.gdb
\\globaldata\Others\Vegetation (grid format)

Figure 25: percentage of deciduous tree cover

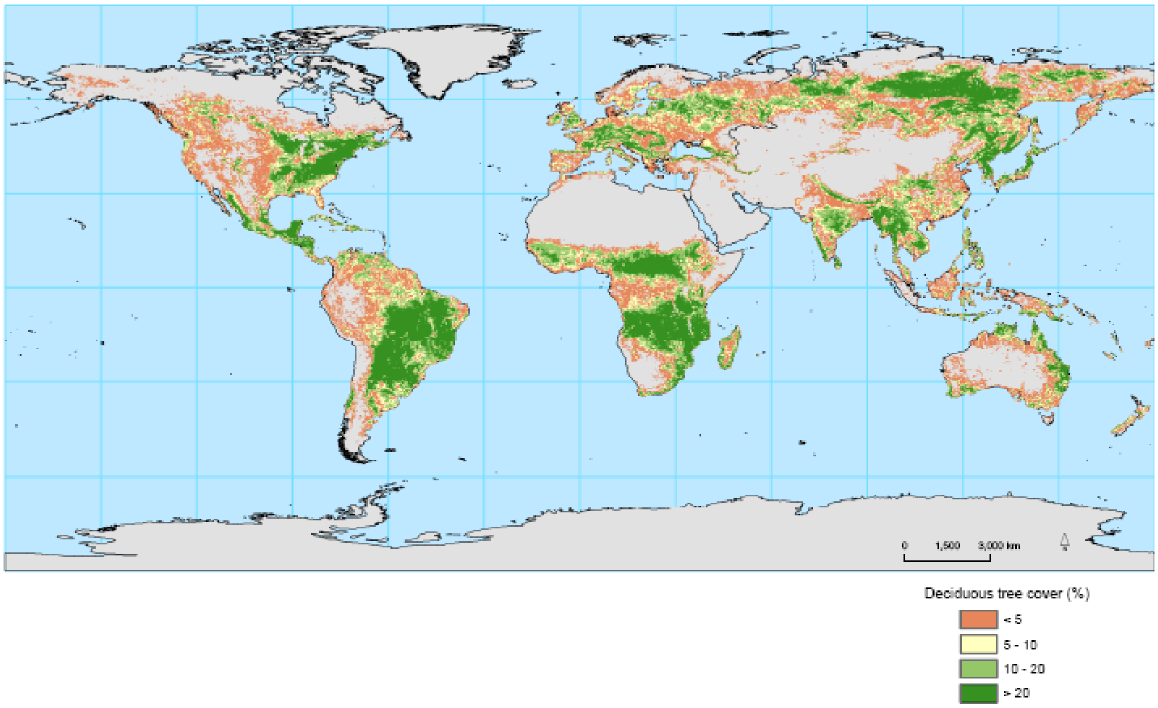
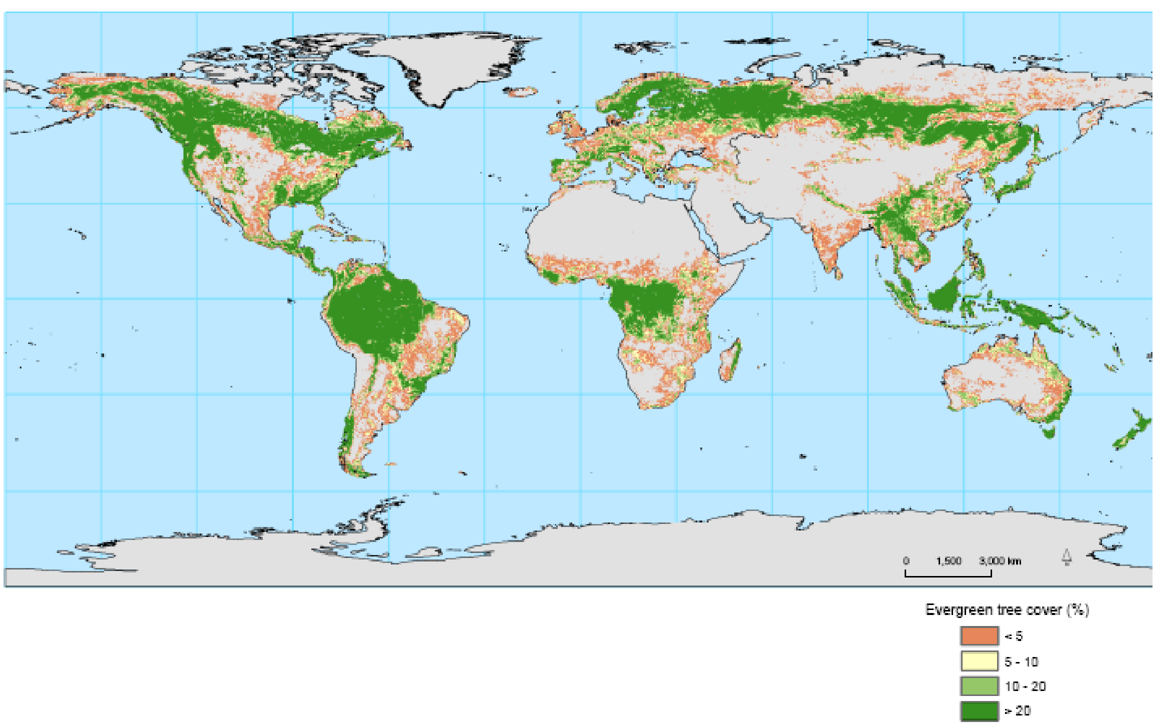


Figure 26: evergreen tree cover



7. Data Catalog: Antrophic Factors

7.1 World stable lights

DATA SOURCE
world_stable_lights - World stable lights percent frequency file.

ORIGINAL DATA DESCRIPTION
"The Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS) has a unique low-light imaging capability developed for the detection of clouds using moonlight. In addition to moonlit clouds, the OLS also detects lights from human settlements, fires, gas flares, heavily lit fishing boats, lightning and the aurora. By analyzing the location, frequency, and appearance of lights observed in an image times series, it is possible to distinguish four primary types of lights present at the earth's surface: human settlements, fires, gas flares, and fishing boats. We have produced a global map of the four types of light sources as observed during a 6-month period in 1994 - 1995." (documentation from the source)
This file is the cities and flares combined.

SOURCE CITATION

LINK
http://www.ngdc.noaa.gov/dmsp/download_Night_time_lights_94-95.html

ACCESSED
16/10/2008

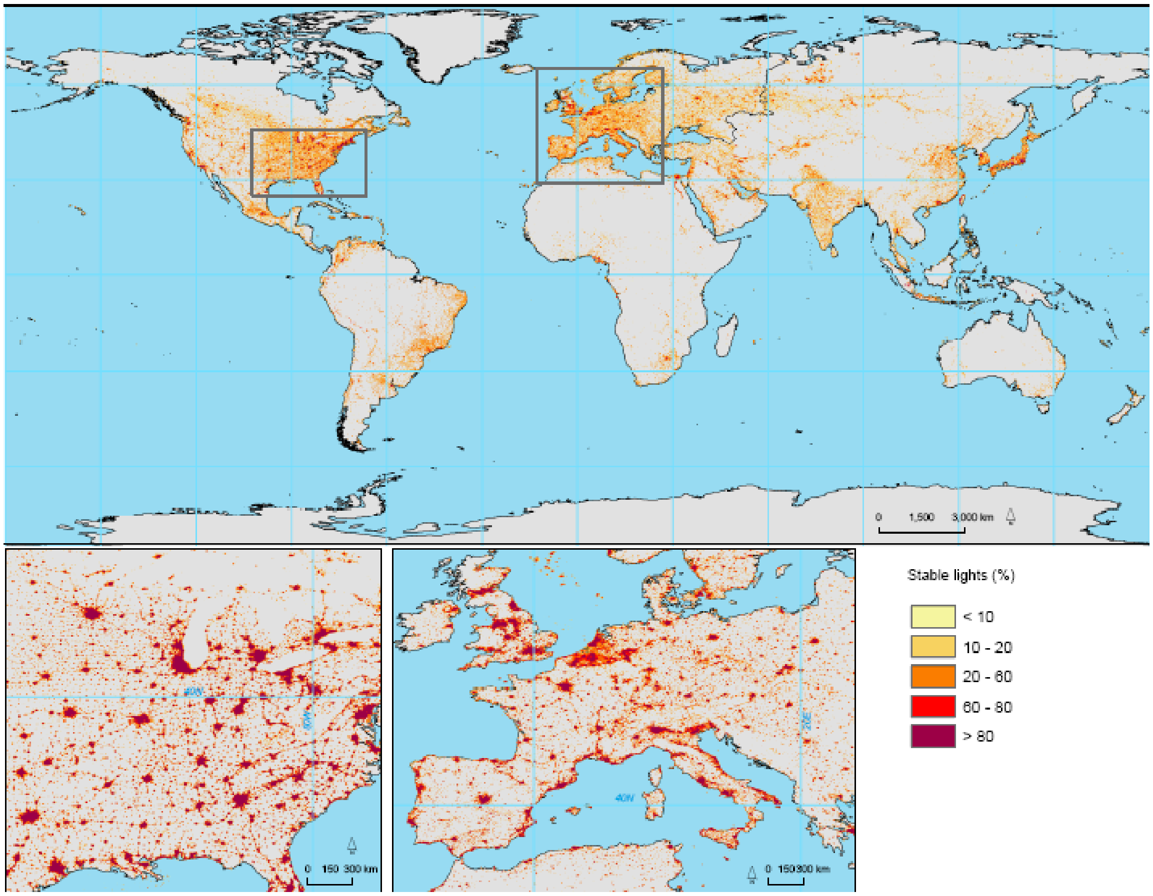
SPATIAL RESOLUTION
30"x30", 1"x1"

TEMPORAL RESOLUTION
1994-1995

PROCESSING
Import of original tiff files into "File GeoDatabase Raster Dataset" format.

STORED IN
\\globaldata\Others\GDB\Others.gdb
\\globaldata\Others\W_lights (GRID format)

Figure 27: Percent frequency of World Stable Lights



7.2 Population counts, population density

DATA SOURCE

Gridded Population of the World Version 3 (GPWv3)

ORIGINAL DATA DESCRIPTION

This archive contains population counts and population densities, both UN-adjusted and unadjusted, in ArcInfo GRID format. The raster data are at 2.5 arc-minutes resolution and contain the following data:

p00g population counts in 2000, unadjusted
p00ag population counts in 2000, adjusted to match UN totals
ds00g population densities in 2000, unadjusted, persons per square km
ds00ag population densities in 2000, adjusted to match UN totals, persons per square km

The data are stored in geographic coordinates of decimal degrees based on the World Geodetic System spheroid of 1984 (WGS84).

SOURCE CITATION

Center for International Earth Science Information Network (CIESIN), Columbia University; and Centro Internacional de Agricultura Tropical (CIAT). 2005. Gridded Population of the World Version 3 (GPWv3): Population Grids. Palisades, NY: Socioeconomic Data and Applications Center (SEDAC), Columbia University. Available at http://sedac.ciesin.columbia.edu/gpw.

LINK

http://sedac.ciesin.columbia.edu/gpw/index.jsp

ACCESSED

27/11/2008

SPATIAL RESOLUTION

2.5’x2.5’

TEMPORAL RESOLUTION

2000

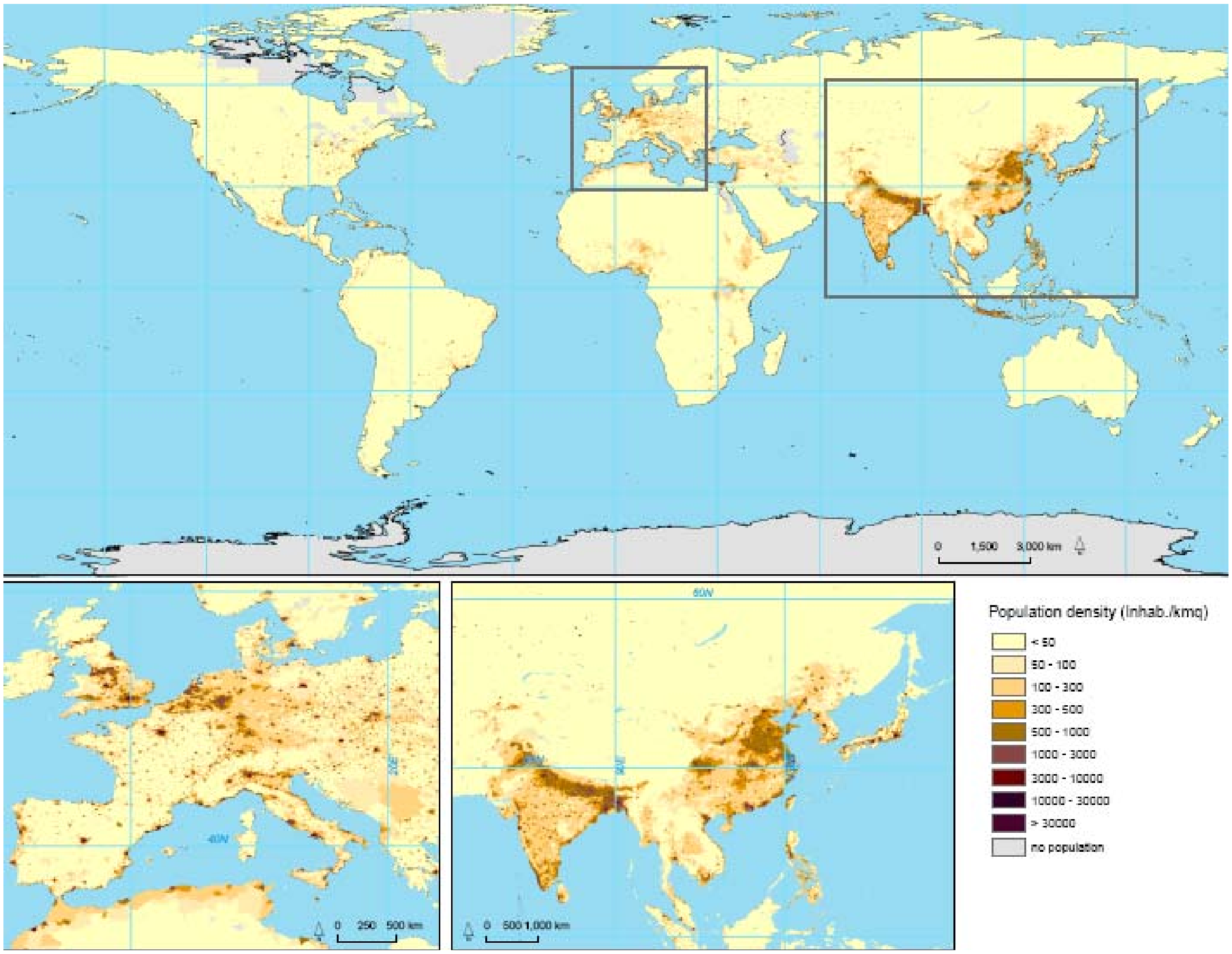
PROCESSING

Import of files into “File GeoDatabase Raster Dataset” format.

STORED IN

\\globaldata\Others\GDB\Others.gdb

Figure 28: population density



7.1 Impervious Surface Area

DATA SOURCE

Global Distribution and Density of Constructed Impervious Surfaces (NOAA-NESDIS-NGDC-DMSP)

ORIGINAL DATA DESCRIPTION

"*We present the first global inventory of the spatial distribution and density of constructed impervious surface area (ISA). Examples of ISA include roads, parking lots, buildings, driveways, sidewalks and other manmade surfaces. While high spatial resolution is required to observe these features, the product we made is at one km^2 resolution and is based on two coarse resolution indicators of ISA. Inputs into the product include the brightness of satellite observed nighttime lights and population count. The reference data used in the calibration were derived from 30 meter resolution ISA estimates of the USA from the U.S. Geological Survey. Nominally the product is for the years 2000-01 since both the nighttime lights and reference data are from those two years. We found that 1.05% of the United States land area is impervious surface (83,337 km^2) and 0.43% of the world's land surface (579,703 km^2) is constructed impervious surface. China has more ISA than any other country (87,182 km^2), but has only 67 m^2 of ISA per person, compared to 297 m^2 per person in the USA. Hydrologic and environmental impacts of ISA begin to be exhibited when the density of ISA reaches 10% of the land surface. An examination of the areas with 10% or more ISA in watersheds finds that with the exception of Europe, the majority of watershed areas have less than 0.4% of their area at or above the 10% ISA threshold. The authors believe the next step for improving the product is to include reference ISA data from many more areas around the world.*" (documentation from the source)

SOURCE CITATION

Elvidge, C.D., Tuttle, B.T., Sutton, P.C., Baugh, K.E., Howard, A.T., Milesi, C., Bhaduri, B.L., and Nemani, R. 2007. Global distribution and density of constructed impervious surfaces. Sensors 7: 1962-1979.

LINK

http://www.ngdc.noaa.gov/dmsp/download_global_isa.html

ACCESSED

14/10/2008

SPATIAL RESOLUTION

30" (~1km)

TEMPORAL RESOLUTION

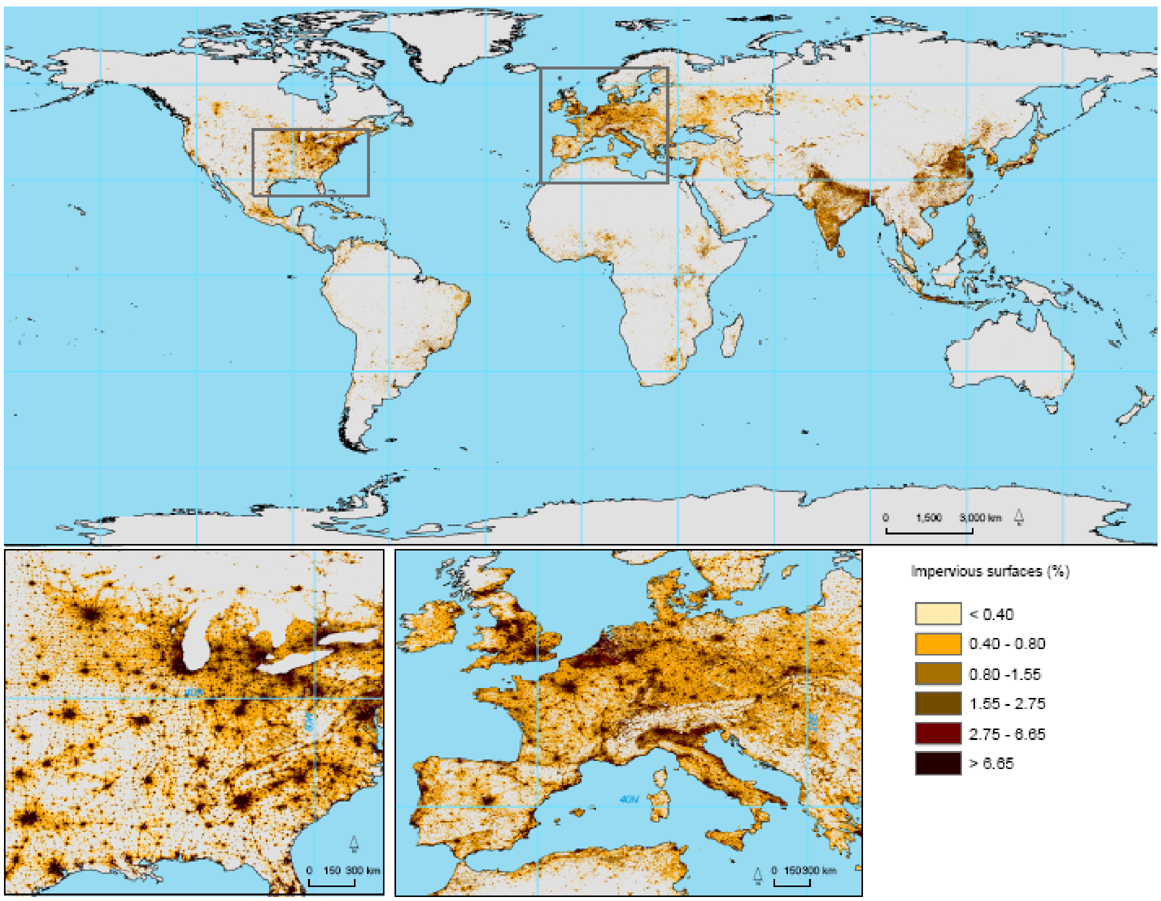
2000-2001

PROCESSING

Import of original geotiff file into "File GeoDatabase Raster Dataset" format.

STORED IN
\\globaldata\AntrophicF\Impervious

Figure 29: percentage of impervious surface



	Value	data	source	temporal res	spatial res
Soil	FAO soil map	OC content Bulk density	www.isric.org	//	5’
Soil	Global soil texture and derived water-holding capacities (webb et al.)	Texture	daac.ornl.gov	//	
Soil	Soil Moisture Storage Capacity (mm/m) [Maximum available soil moisture]	Soil Moisture	www.fao.org	//	5’
Soil	UNH-GRDC Global Composite Runoff Fields	Runoff	grdc.bafg.de	//	0.5°
Soil	Sediment Removal Rate for basins	Sediments Yeld	JRC original model	//	
Atmosphere	Surface, Boundary layer height , 40 years reanalysis	ABL mixing height	http://data-portal.ecmwf.int/data/d/era40_mnth/	1957/09-2002/08	2.5°
Atmosphere	mnth, Surface, 2 metre temperature, 40 years reanalysis	Temperature	http://data-portal.ecmwf.int/data/d/era40_mnth/	1957/09-2002/08	2.5°
Atmosphere	Surface, mnth, 10 metre U wind and V wind component , 40 years reanalysis	Wind Speed	http://data-portal.ecmwf.int/data/d/era40_mnth/	1957/09-2002/08	2.5°
Atmosphere	Total Precipitation, 40 years reanalysis	Total Precipitation	http://data-portal.ecmwf.int/data/d/era40_mnth/	1957/09-2002/08	2.5°
Atmosphere	Snow Fall, 40 years reanalysis	Snow Fall	http://data-portal.ecmwf.int/data/d/era40_mnth/	1957/09-2002/08	2.5°
Atmosphere	Aerosol Indexes	OC BC_flux OC_flux OH	JRC	//	1°
Ocean	World Ocean Atlas 2005 (WOA05)	temperature, salinity	www.nodc.noaa.gov	//	1°
Ocean	World Ocean Atlas 1994 (WOA94)	mixed layer depth	www.nodc.noaa.gov	//	1°
Ocean	World Ocean Atlas 2001(WOA01)	chlorophyll	www.nodc.noaa.gov	//	1°
Ocean	The Mariano Global Surface Velocity Analysis 1.0 (MGSVA)	surface velocity	www.rsmas.miami.edu	yearly	1°

Stream Network	Networks	Hydro 1k	edc.usgs.gov	//	30'' (~1km)
	Potential Simulated Topological Network	stn30	http://www.wsag.unh.edu/Stn-30/stn-30.html	//	30' cellsize 0.5
	Global Lakes		wwf		
	Average Residence Time of Pollutants in Island Surface Water	Hydro 1k, runoff, global lakes, lights at night	Derived model	//	30'' (~1km)
Other	Continuous Fields of Vegetation Cover	vegetation	islscp2.sesda.com	1992-1993	1°, 0.5°, 0.25°
	FASIR NDVI Monthly	vegetation	islscp2.sesda.com	1982-1998	1°, 0.5°, 0.25°
	World stable lights	lights at night	www.ngdc.noaa.gov	1994-1995	30”, 1”
	Global Population of the World	population counts, population density	http://sedac.ciesin.columbia.edu	2000	1°, 2.5'
	Impervious Surface Area	ISA	http://www.ngdc.noaa.gov/dmsp/download_global_isa.html	2000-2001	30'' (~1km)

8. Softwares

8.1.1 Arcgis 9.x

Proprietary software
http://www.esri.com/
Principal platform for data preparation, visualization, analysis, cartography
ArcHydro extension

8.1.2 Panoply

Netcdf viewer
http://www.giss.nasa.gov/tools/panoply/

8.1.3 NCO operators

The netCDF Operators, or NCO, are a suite of programs known as **operators**. Each operator is a standalone, command line program which is executed at the UNIX shell-level. The operators are primarily designed to aid manipulation and analysis of gridded scientific data.

http://nco.sourceforge.net/

8.1.4 Ilwis 3.3

The Integrated Land and Water Information System (ILWIS) is a PC-based GIS & Remote Sensing software, developed by ITC up to its last release (version 3.3) in 2005. ILWIS comprises a complete package of image processing, spatial analysis and digital mapping.

http://www.itc.nl/ilwis/downloads/ilwis33.asp

8.1.5 HDF

http://gis-lab.info/programs-eng.html#libraries

9. Annex A - Data mining from the online World Lake Database

(http://www.ilec.or.jp/database/database.html)

The scraping of data is performed using the software Web-Harvest (http://web-harvest.sourceforge.net/):

"Web-Harvest is *Open Source Web Data Extraction tool* written in Java. It offers a way to collect desired Web pages and extract useful data from them. In order to do that, it leverages well established techniques and technologies for text/xml manipulation such as *XSLT*, *XQuery* and *Regular Expressions*."

The following script has been used to extract data from the ILEC web site:

```
<?xml version="1.0" encoding="UTF-8"?>

<config charset="ISO-8859-1">

    <!-- start page url -->
    <var-def              name="startUrl">http://www.ilec.or.jp/database/index/idx-
lakes.html</var-def>
    <file       action="write"       path="D:/LakesDB/webharvest/output_lakes.xml"
charset="UTF-8">
        <template>
            <![CDATA[ <lakes> ]]>
        </template>
        <loop item="lakeUrl" index="i">
            <!-- collects URLs of all lakes from the start page -->
            <list>
                <xpath          expression="//div[@id='main']//a[starts-with(@href,
'../')]/@href">
                    <html-to-xml>
                        <http url="${startUrl}"/>
                    </html-to-xml>
                </xpath>
            </list>
            <!-- downloads each lake page and extract data from it -->
            <body>
                <xquery>
                    <xq-param name="doc">
                        <html-to-xml>
                            <http url="${sys.fullUrl(startUrl, lakeUrl)}"/>
                        </html-to-xml>
                    </xq-param>
                    <xq-expression><![CDATA[
declare variable $doc as node() external;

let $sitename                  :=
data($doc//div[@id='main']/table[1]/tbody/tr[1]/td[1])
let $lakename                  :=
data($doc//div[@id='main']/table[1]/tbody/tr[2]/td[1])
let $state                     :=
data($doc//div[@id='main']/table[1]/tbody/tr[3]/td[1])
let $country                   :=
data($doc//div[@id='main']/table[1]/tbody/tr[4]/td[1])
let $latitude                  :=
data($doc//div[@id='main']/table[1]/tbody/tr[5]/td[1])
let $longitude                 :=
data($doc//div[@id='main']/table[1]/tbody/tr[6]/td[1])
let $altitude                  :=
data($doc//div[@id='main']/table[1]/tbody/tr[7]/td[1])
let $surfacearea               :=
```

```
data($doc//div[@id='main']/table[2]/tbody/tr[1]/td[1])
        let $volume                   :=
data($doc//div[@id='main']/table[2]/tbody/tr[1]/td[2])
        let $maxdepth                 :=
data($doc//div[@id='main']/table[2]/tbody/tr[2]/td[1])
        let $meandepth                :=
data($doc//div[@id='main']/table[2]/tbody/tr[2]/td[2])
        let $waterlevelcontrol        :=
data($doc//div[@id='main']/table[2]/tbody/tr[3]/td[1])
        let $waterlevelfluctuation    :=
data($doc//div[@id='main']/table[2]/tbody/tr[3]/td[2])
        let $lengthofshoreline        :=
data($doc//div[@id='main']/table[2]/tbody/tr[4]/td[1])
        let $residencetime            :=
data($doc//div[@id='main']/table[2]/tbody/tr[4]/td[2])
        let $catchmentarea            :=
data($doc//div[@id='main']/table[2]/tbody/tr[5]/td[1])
        let $hoursofbrightsunshine    :=
data($doc//div[@id='main']/table[2]/tbody/tr[5]/td[2])
        let $solarradiation           :=
data($doc//div[@id='main']/table[2]/tbody/tr[6]/td[1])
        let $freezingperiod           :=
data($doc//div[@id='main']/table[2]/tbody/tr[6]/td[2])
        let $mixingtype               :=
data($doc//div[@id='main']/table[2]/tbody/tr[7]/td[1])
        let $annualfishcatch          :=
data($doc//div[@id='main']/table[2]/tbody/tr[7]/td[2])
        let $totalnloading            :=
data($doc//div[@id='main']/table[2]/tbody/tr[8]/td[1])
        let $totalploading            :=
data($doc//div[@id='main']/table[2]/tbody/tr[8]/td[2])
        let $population               :=
data($doc//div[@id='main']/table[2]/tbody/tr[9]/td[1])
        let $popdensofcatchmentarea   :=
data($doc//div[@id='main']/table[2]/tbody/tr[9]/td[2])
        let $domesticwaterusage       :=
data($doc//div[@id='main']/table[3]/tbody/tr[1]/td[1])
        let $irrigationwaterusage     :=
data($doc//div[@id='main']/table[3]/tbody/tr[1]/td[2])
        let $industrialwaterusage     :=
data($doc//div[@id='main']/table[3]/tbody/tr[2]/td[1])
        let $powergenerationusage     :=
data($doc//div[@id='main']/table[3]/tbody/tr[2]/td[2])
        let $lunaturallandscape       :=
data($doc//div[@id='main']/table[4]/tbody/tr[1]/td[1])
        let $luagriculturalland       :=
data($doc//div[@id='main']/table[4]/tbody/tr[1]/td[2])
        let $luothers                 :=
data($doc//div[@id='main']/table[4]/tbody/tr[1]/td[3])
        let $siltation                :=
data($doc//div[@id='main']/table[5]/tbody/tr[1]/td[1])
        let $toxiccontamination       :=
data($doc//div[@id='main']/table[5]/tbody/tr[1]/td[2])
        let $eutrophication           :=
data($doc//div[@id='main']/table[5]/tbody/tr[2]/td[1])
        let $acidification            :=
data($doc//div[@id='main']/table[5]/tbody/tr[2]/td[2])

        return
        <lake>
        <site_name>{data($sitename)}</site_name>
        <lake_name>{data($lakename)}</lake_name>
        <state>{data($state)}</state>
        <country>{data($country)}</country>
        <latitude>{data($latitude)}</latitude>
        <longitude>{data($longitude)}</longitude>
        <altitude>{data($altitude)}</altitude>
        <surface_area>{data($surfacearea)}</surface_area>
        <volume>{data($volume)}</volume>
        <maximum_depth>{data($maxdepth)}</maximum_depth>
        <mean_depth>{data($meandepth)}</mean_depth>
```

```
        <water_level_control>{data($waterlevelcontrol)}</water_level_control>
        <water_level_fluctuation>{data($waterlevelfluctuation)}</water_level_fluctuation>
        <length_of_shoreline>{data($lengthofshoreline)}</length_of_shoreline>
        <residence_time>{data($residencetime)}</residence_time>
        <catchment_area>{data($catchmentarea)}</catchment_area>
        <hours_of_bright_sunshine>{data($hoursofbrightsunshine)}</hours_of_bright_sunshine
>
        <solar_radiation>{data($solarradiation)}</solar_radiation>
        <freezing_period>{data($freezingperiod)}</freezing_period>
        <mixing_type>{data($mixingtype)}</mixing_type>
        <annual_fish_catch>{data($annualfishcatch)}</annual_fish_catch>
        <total_n_loading>{data($totalnloading)}</total_n_loading>
        <total_p_loading>{data($totalploading)}</total_p_loading>
        <population>{data($population)}</population>
        <population_density_of_catchment_area>{data($popdensofcatchmentarea)}</population_
density_of_catchment_area>
        <domestic_water_usage>{data($domesticwaterusage)}</domestic_water_usage>
        <irrigation_water_usage>{data($irrigationwaterusage)}</irrigation_water_usage>
        <industrial_water_usage>{data($industrialwaterusage)}</industrial_water_usage>
        <power_generation_usage>{data($powergenerationusage)}</power_generation_usage>
        <land_use_natural_landscape>{data($lunaturallandscape)}</land_use_natural_landscap
e>
        <land_use_agricultural_land>{data($luagriculturalland)}</land_use_agricultural_lan
d>
        <land_use_others>{data($luothers)}</land_use_others>
        <siltation>{data($siltation)}</siltation>
        <toxic_contamination>{data($toxiccontamination)}</toxic_contamination>
        <eutrophication>{data($eutrophication)}</eutrophication>
        <acidification>{data($acidification)}</acidification>
        </lake>
                    ]]></xq-expression>
                </xquery>
            </body>
        </loop>

        <![CDATA[ </lakes> ]]>
    </file>

</config>
```

(North America lake tabs are encoded differently; therefore a slightly modified code has been used to extract those data)

The output file, in XML format, looks like:


```
        <lakes>
                <lake>
                        <site_name>AFR-11</site_name>
                        <lake_name>Lake Albert</lake_name>
                        <state>Haut-Zaire, Zaire; and Western, Uganda</state>
                        <country>Zaire and Uganda</country>
                        <latitude>1:4N</latitude>
                        <longitude>30:5E</longitude>
                        <altitude>615</altitude>
                        <surface_area>5,300,000,000</surface_area>
                        <volume>280,000,000,000</volume>
                        <maximum_depth>58</maximum_depth>
                        <mean_depth>25</mean_depth>
                        <water_level_control>Unregulated</water_level_control>
                        <water_level_fluctuation>0.45</water_level_fluctuation>
                        <length_of_shoreline>-</length_of_shoreline>
                        <residence_time>-</residence_time>
                        <catchment_area>-</catchment_area>
                        <hours_of_bright_sunshine>2,190</hours_of_bright_sunshine>
                        <solar_radiation>-</solar_radiation>
                        <freezing_period>None</freezing_period>
                        <mixing_type>Monomictic</mixing_type>
                        <annual_fish_catch>10,000</annual_fish_catch>
                        <total_n_loading>-</total_n_loading>
```

```
                        <total_p_loading>-</total_p_loading>
                        <population>-</population>
                        <population_density_of_catchment_area>-
</population_density_of_catchment_area>
                        <domestic_water_usage>-</domestic_water_usage>
                        <irrigation_water_usage>-</irrigation_water_usage>
                        <industrial_water_usage>-</industrial_water_usage>
                        <power_generation_usage>-</power_generation_usage>
                        <land_use_natural_landscape>-</land_use_natural_landscape>
                        <land_use_agricultural_land>-</land_use_agricultural_land>
                        <land_use_others>-</land_use_others>
                        <siltation>-</siltation>
                        <toxic_contamination>-</toxic_contamination>
                        <eutrophication>Serious</eutrophication>
                        <acidification>-</acidification>
                </lake>
                <lake>
                        <site_name>AFR-19</site_name>
                        <lake_name>Aswan High Dam Reservoir</lake_name>
                        <state>Aswan, Egypt; and Northern, Sudan</state>
                        <country>Egypt and Sudan</country>
                        <latitude>22:1N</latitude>
                        <longitude>31:4E</longitude>
                        <altitude>183</altitude>
                        <surface_area>6,000,000,000</surface_area>
                        <volume>162,000,000,000</volume>
                        <maximum_depth>110</maximum_depth>
                        <mean_depth>70</mean_depth>
                        <water_level_control>Regulated</water_level_control>
                        <water_level_fluctuation>25</water_level_fluctuation>
                        <length_of_shoreline>9,000,000</length_of_shoreline>
                        <residence_time>-</residence_time>
                        <catchment_area>2,849,000,000,000</catchment_area>
                        <hours_of_bright_sunshine>3,866.6</hours_of_bright_sunshine>
                        <solar_radiation>-</solar_radiation>
                        <freezing_period>None</freezing_period>
                        <mixing_type>Monomictic</mixing_type>
                        <annual_fish_catch>18,000</annual_fish_catch>
                        <total_n_loading>-</total_n_loading>
                        <total_p_loading>-</total_p_loading>
                        <population>-</population>
                        <population_density_of_catchment_area>-
</population_density_of_catchment_area>
                        <domestic_water_usage>-</domestic_water_usage>
                        <irrigation_water_usage>-</irrigation_water_usage>
                        <industrial_water_usage>-</industrial_water_usage>
                        <power_generation_usage>-</power_generation_usage>
                        <land_use_natural_landscape>-</land_use_natural_landscape>
                        <land_use_agricultural_land>-</land_use_agricultural_land>
                        <land_use_others>-</land_use_others>
                        <siltation>Serious</siltation>
                        <toxic_contamination>-</toxic_contamination>
                        <eutrophication>-</eutrophication>
                        <acidification>None</acidification>
                </lake>
                ...
                ...
                ...
                ...
        </lakes>
```


The xml file is then imported into Excel for further processing. In particular, latitude and longitude values must be formatted into standard *Degree Minutes Seconds* format DDD°MM’SS”d (where d=N or S or W or E). For instance:

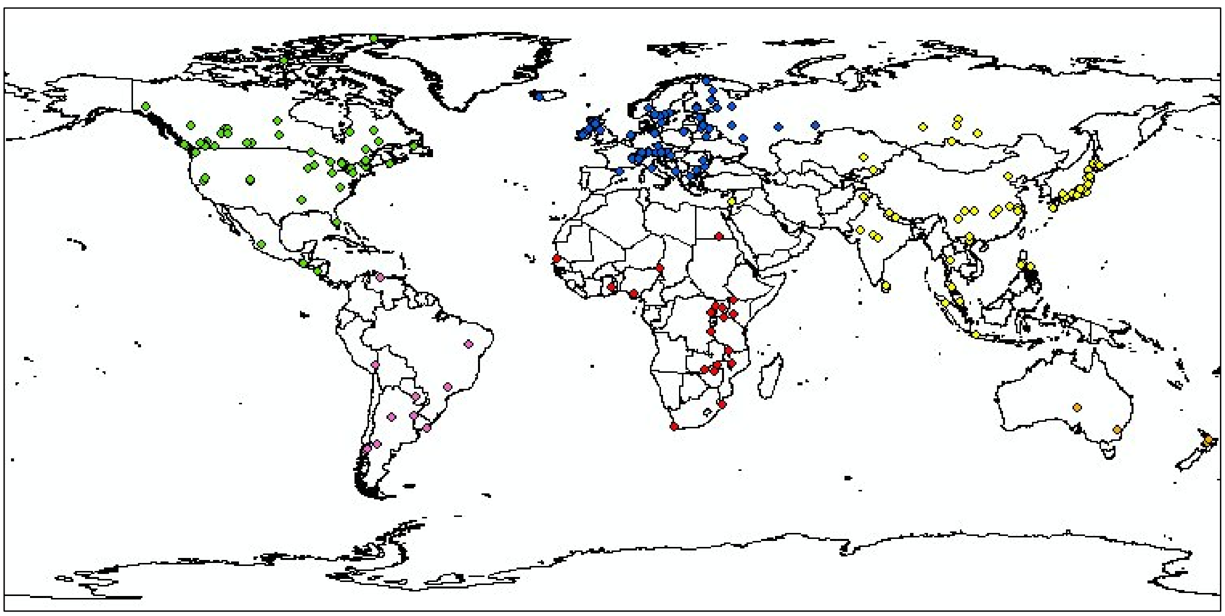
14:4N, 30:5E → 14°40’N, 30°50’E

Afterward the Excel table is imported as .dbf table into ArcGIS, where latitude and longitude values are converted to *Decimal Degrees* (creation of 2 new fields, lat_deg and lon_deg) with the field calculator, using the following script:

```
'=========================
'field_DMS2DD.cal
'Author: Ianko Tchoukanski
'http://www.ian-ko.com
'=========================
…
```

Data are now ready to be imported into ArcGIS as a geographic layer. This step is achieved using the "Add XY data" tool. The result of this operation is then exported as point shapefile (ILEC_lakes) as shown in Figure 30.

Figure 30: spatial distribution of the world lakes from the ILEC database



9.1 Mean depth

Values for the mean depth ($\bar{h}$) parameter are missing for all lakes in the North America (NAM) section, therefore it has been calculated by dividing the lake's volume by its surface area.

Mean depth values were retrieved from wikipedia for five other lakes missing mean depth values. Note that values of $\bar{h}$ for lakes Kyoga and Hazen have the same values of their max depth and thus are probably incorrect. However, for the purposes of the analysis they were considered to be representative as well.

Table 7 **: Source: wikipedia.**

Name	Mean deph (m)
Lake Kyoga	5.7
Danau Toba (Lake Toba)	212
Lake Okeechobee	2.7
Hazen Lake	280
Lake Nahuel Huapi	157

9.2 GLWD integration

The point shapefile is next spatially joined with the global lakes and wetlands database GLWD.

The point shapefile is somehow inaccurate in regard to latitude and longitude values, because the values in the original ILEC database are rounded to 1 minute of degree.

Because of this limitation, the spatial join with the global lakes and wetlands database GLWD produces inaccurate results.

Therefore the next step of the procedure consists in the manual editing of the point shapefile to correct the points falling outside the GLWD polygons.

As a final point, latitude and longitude values are re-calculated for all lakes.

10. Annex B - Estimation of parameters to predict mean lake depth on a global scale.

10.1.1 Conversion of Hydro1k dataset to GRID format

HYDRO1k, developed at the U.S. Geological Survey's (USGS) EROS Data Center, is a geographic database providing comprehensive and consistent global coverage of topographically derived data sets. Developed from the USGS' 30 arc-second digital elevation model (DEM) of the world (GTOPO30), HYDRO1k provides a standard suite of geo-referenced data sets (at a resolution of 1 km) developed on a continent by continent basis, for all landmasses of the globe with the exception of Antarctica and Greenland. The HYDRO1k package provides, for each continent, a suite of six raster and two vector data sets. These data sets cover many of the common derivative products used in hydrologic analysis. The raster data sets are the hydrologically correct DEM, derived flow directions, flow accumulations, slope, aspect, and a compound topographic (wetness) index. The derived streamlines and basins are distributed as vector data sets.

(Hydro1k Documentation)

The following procedure prepares the Hydro1k files (dem) for further use in ArcGIS.

- Load Hydro1k dem file into ArcGIS (xx_dem.bil)
- Export data to GRID format (xx_dem)
- Set Spatial Analyst options Extent and Cell Size both to "Same as Layer xx_dem"
- Open the Raster Calculator tool
- Evaluate the following expression:
  `CON([xx_dem] >= 32768, [xx_dem] - 65536, [xx_dem])`
  (cell values greater than or equal to 32768 are an artifact of the original conversion, where the 16th bit was interpreted as an integer rather than a negative sign)
- Evaluate the following expression:
  `SETNULL([Calculation] == -9999, [Calculation])`
  (This statement converts all raster values equal to -9999 (oceans) to 'no data')
- Make permanent Calculation2 (i.e. as xx_dem_grid)
- Apply the correct spatial reference
- Reproject dataset to wgs84

10.1.2 Calculation of parameters

Statistics have been calculated in ArcGIS for the following parameters, ΔZ_{max}, slope, CTI and TPI indexes and curvature, in order to find out significant correlations with the measured mean depths extracted from the ILEC database.

Only natural lakes have been selected for the analysis, thus all lakes with dams have been removed from the data sample.

10.1.2.1 Landscape roughness index ΔZ_{max}

ΔZ_{max} is the local elevation range, calculated on the Hydro1k dem using a kernel value of 10km*10km (Pistocchi and Pennington, 2006).

Procedure:

- Open the Neighborhood Statistics tool and execute it with the following parameters:
  Statistic type: range
  Neighborhood: rectangle
  Height: 10 km
  Width: 10 km
- Save the output raster as xx_dem_dz

- Evaluate the following expression:
  merge([af_dem_dz], [as_dem_dz], [au_dem_dz], [eu_dem_dz], [na_dem_dz], [sa_dem_dz])
- Make permanent "Calculation" as global_dem_dz
- Execute Zonal statistics of global_dem_dz with ILEC db lake polygons
- Join statistics with lakes layer and export the table to Excel for further analysis

10.1.2.2 Slope

The Hydro1k slope dataset describes the maximum change in the elevations between each cell and its eight neighbors (Hydro1k Documentation).

The zonal statistic tool has been used to calculate statistics for different values of buffer rings around 178 lakes of the ILEC database (buffer size of 1, 2, 5, 10, 15, 18, 20, 25, 30 and 50 km).

Procedure:

- Create different size of rings around lakes (using buffer and erase tools)
- Create global_slope grid using the following expression:
  merge([af_slope], [as_slope], [au_slope], [eu_slope], [na_slope], [sa_slope])
- Execute Zonal statistics of global_slope with ring polygons
- Join statistics with lakes layer and export the table to Excel for further analysis

10.1.2.3 Wetness Index (CTI)

The Compound Topographic Index (CTI), commonly referred to as the Wetness Index, is a function of the upstream contributing area and the slope of the landscape. The CTI is calculated using the flow accumulation (FA) layer along with the slope as $CTI = \ln (FA / \tan (slope))$ (Hydro1k Documentation).

Procedure:

- Create global_cti grid using the following expression:
  merge([af_cti], [as_cti], [au_cti], [eu_cti], [na_cti], [sa_cti])
- Execute Zonal statistics of global_cti with lake polygons
- Join statistics with lakes layer and export the table to Excel for further analysis

10.1.2.4 Topographic Position Index (TPI)

The Topographic Position Index (TPI) is the difference between a cell elevation value and the average elevation of the neighborhood around that cell. Positive values mean the cell is higher than its surroundings while negative values mean it is lower (Weiss, 2001).

Procedure:

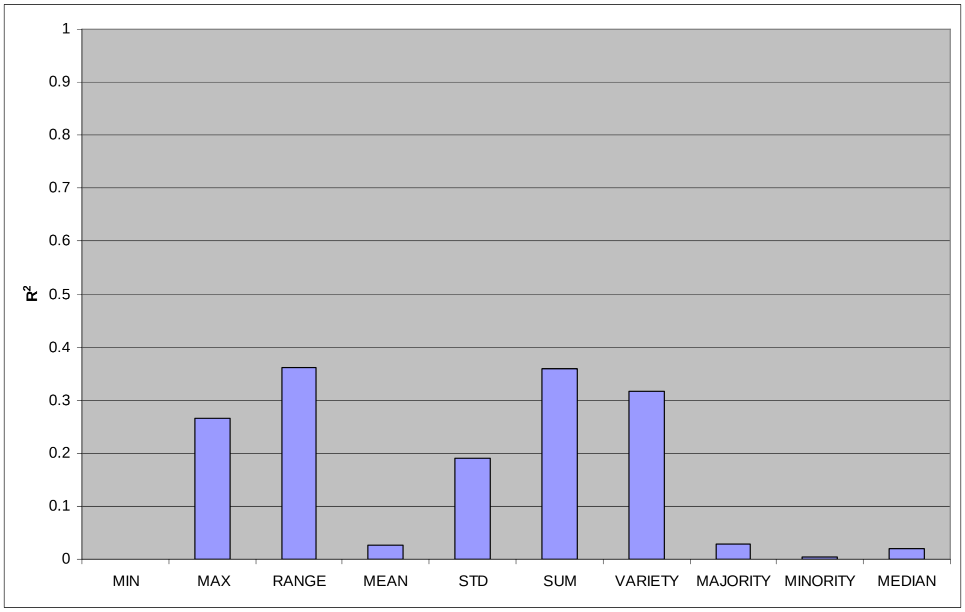
- Create af,as,au,eu,na,sa TPI grids using the CorridorDesigner tool (www.corridordesign.org)
- Create global_tpi grid using the following expression:
  merge([af_tpi], [as_tpi], [au_tpi], [eu_tpi], [na_tpi], [sa_tpi])
- Execute Zonal statistics of global_tpi with lake polygons
- Join statistics with lakes layer and export the table to Excel for further analysis

10.1.3 Analysis of parameters

The analysis of parameters potentially explaining mean lake depth was conducted as explained below. Only lakes having a natural morphology, i.e. for which no existing dam was reported, were considered.

10.1.3.1 Landscape roughness index ΔZ_{max}

Evaluating R^2 for each statistic, the SUM of ΔZ_{max} shows the second-best correlation with the measured mean depth (after RANGE); however, the distribution of errors for SUM is more even than for RANGE, where a larger scatter of the data appears at lower depths. Therefore, the SUM has been retained for further analyses (Figure 31).



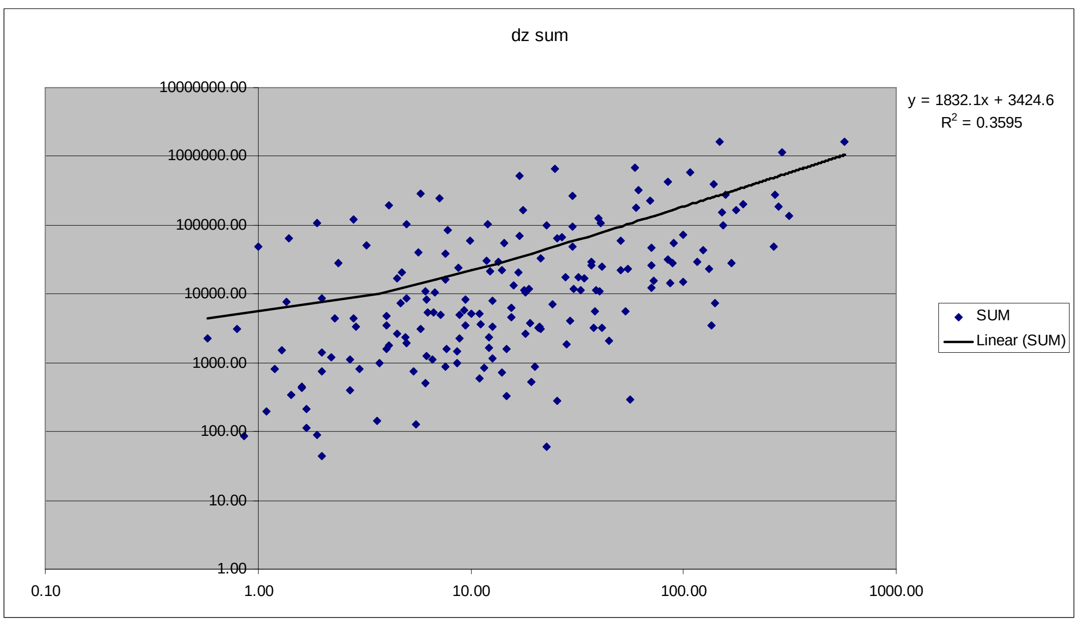
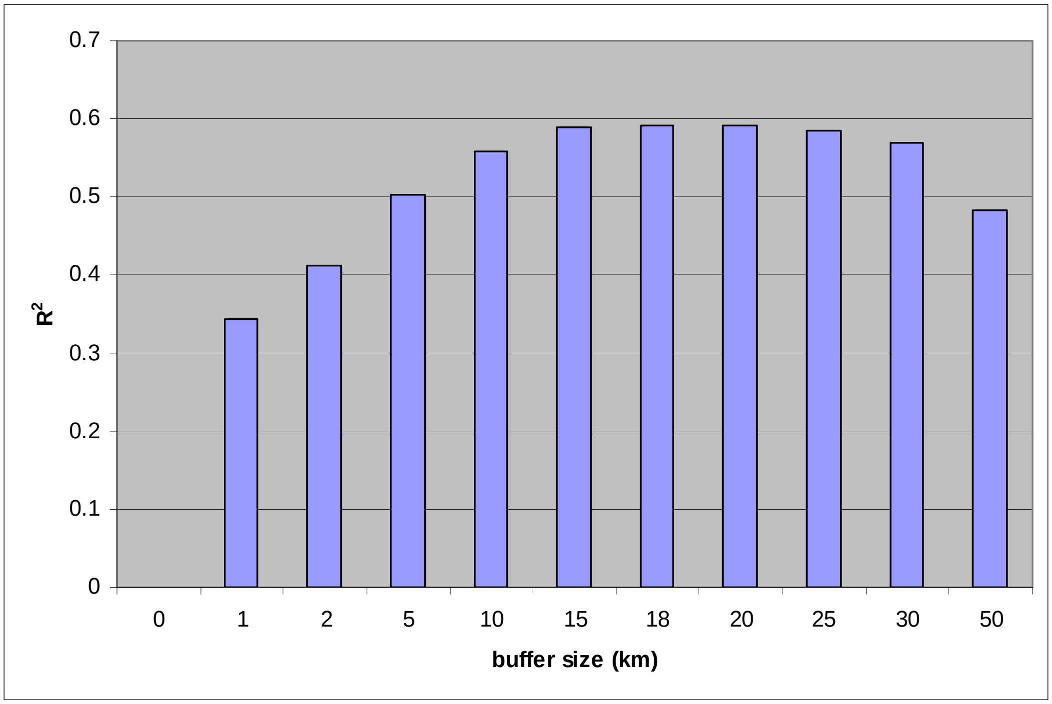


Figure 31 – above: R^2 values for different zonal statistics of the landscape roughness parameter; below: scatter plot for the chosen predictor (sum)

10.1.3.2 Slope

The best correlation with measured mean heights is found for the 18 km distance ring (R^2=0.592), using the SUM statistic.



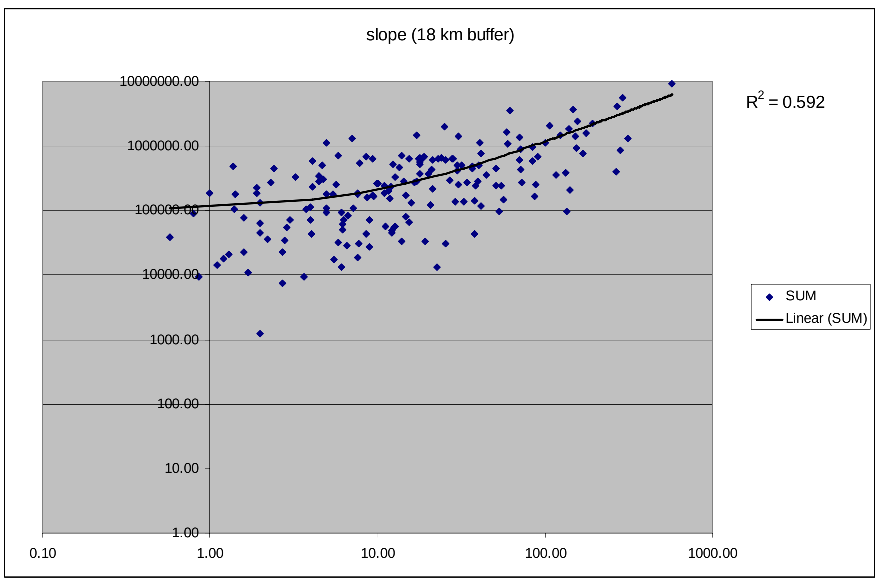


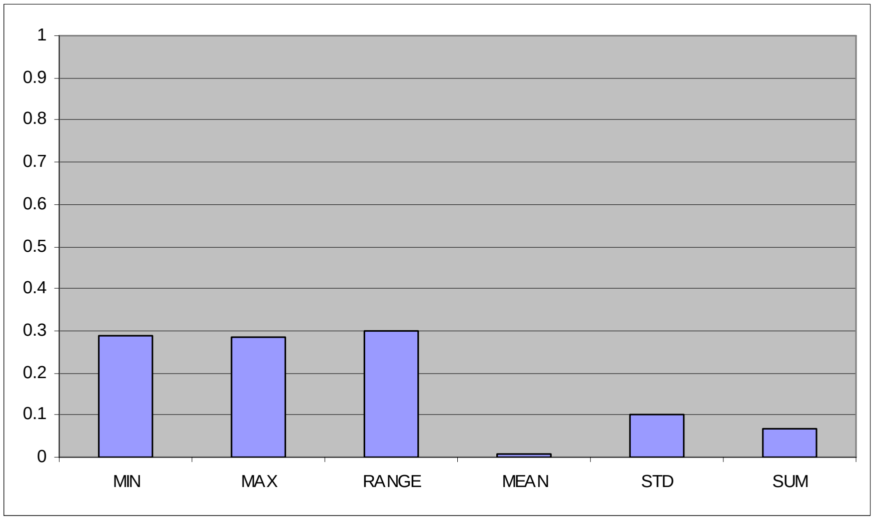
Figure 32 - above: R^2 values for different buffer distances; below: scatter plot for the chosen predictor (18 km buffer)

10.1.3.3 Wetness Index (CTI)

CTI index shows no relevant correlation with measured mean depth. Results are not shown here for simplicity.

10.1.3.4 Topographic Position Index (TPI)

The best correlation with measured mean heights is found using the RANGE statistic (R^2=0.3):



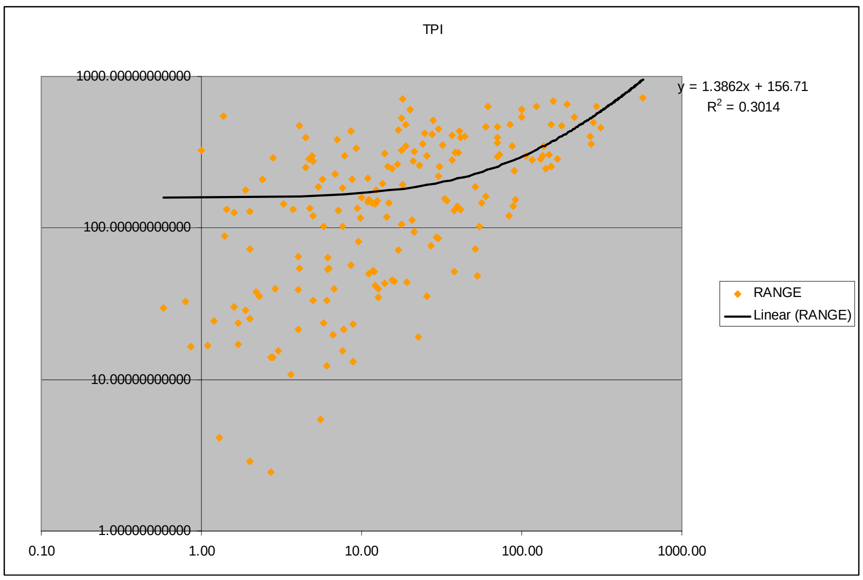


Figure 33 - above: R^2 values for different zonal statistics of the TPI; below: scatter plot for the chosen predictor (range)

10.1.3.5 Surface Area /Catchment area ratio ("Area" parameter)

The ratio between lake surface area and its catchment area has a correlation with the measured mean depth of R^2=0.09:

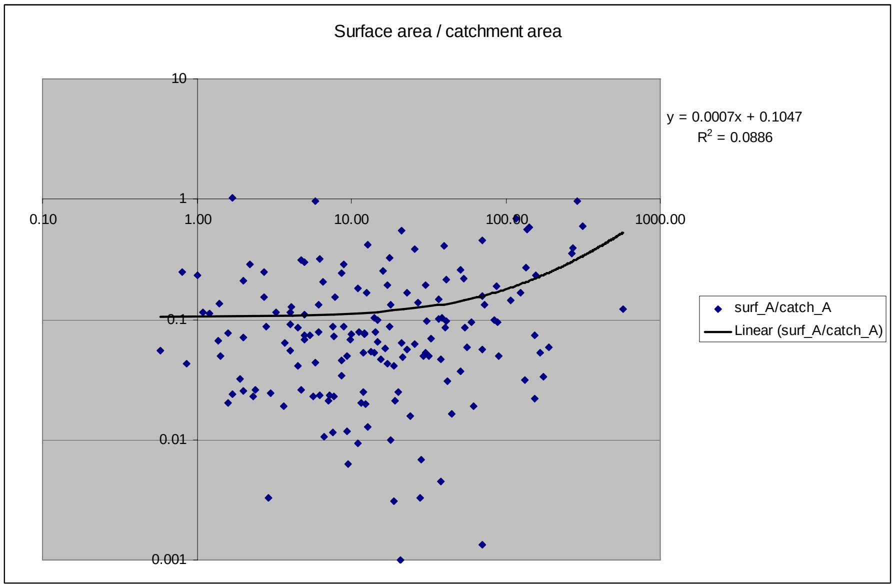


Figure 34 – scatter plot of "area" and mean lake depth.

10.1.4 Regression analysis

Values of R^2 for each investigated parameter are summarized hereafter:

dz (SUM)	slope 18km (SUM)	TPI (RANGE)	surf_A/catch_A	CTI (MIN)
0.505354324	0.633504556	0.282630341	0.088565494	negligible

Table 8

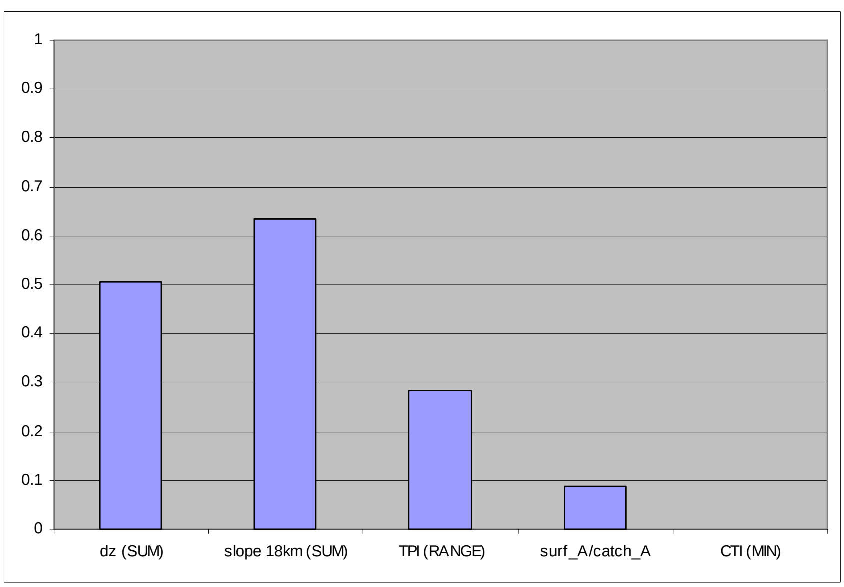


Figure 35

Slope and dZ seems to be correlated together, therefore dZ is discarded as the slope parameter shows a better R^2 value:

	slope (SUM)	dz (SUM)
slope (SUM)	1	
dz (SUM)	0.943943768	1

Table 9

CTI parameter is discarded too, as its R^2 value is not significant enough.

The model is subsequently tested with slope, TPI and surf_A/catch_A parameters for R^2, both with normal and logarithmic values.

10.1.4.1 Slope regression analysis

10.1.4.1.1 Normal

Regression Statistics	
Multiple R	0.795929994
R Square	0.633504556
Adjusted R Square	0.631213959
Standard Error	42.79118334
Observations	162

	Coefficients
Intercept	10.13893941
slope 18km (SUM)	5.65646E-05

Table 10

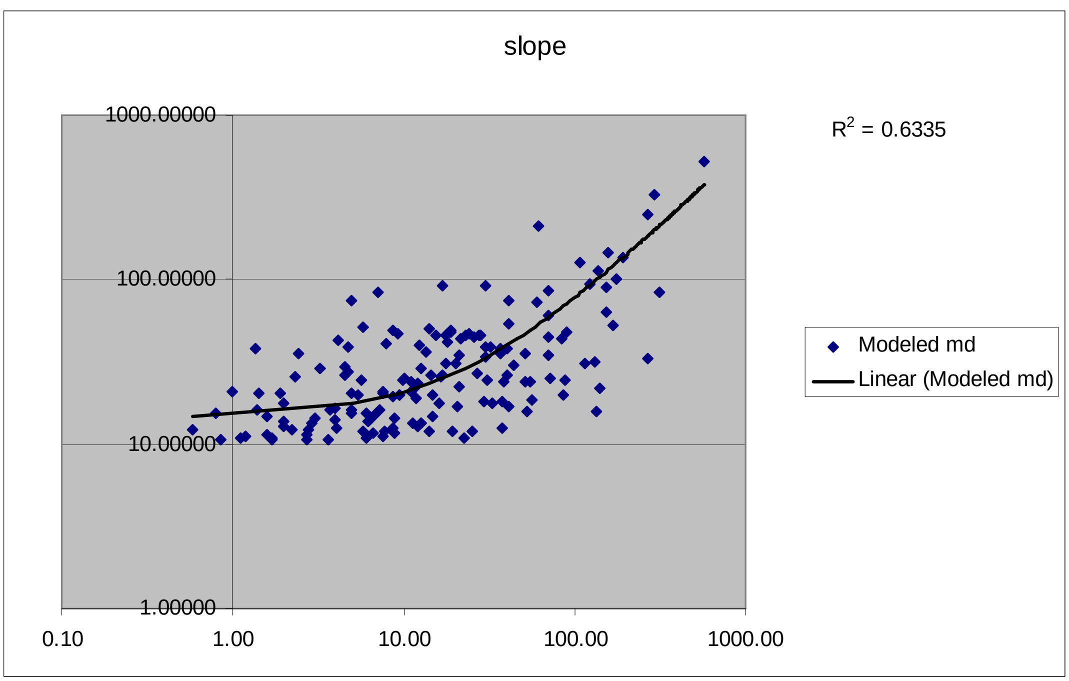


Figure 36

10.1.4.1.2 Logarithmic

Regression Statistics	
Multiple R	0.625410478

R Square	0.391138266
Adjusted R Square	0.38733288
Standard Error	0.487970997
Observations	162
	Coefficients
Intercept	-2.260368352
slope 18km (SUM)	0.643134427

Table 11

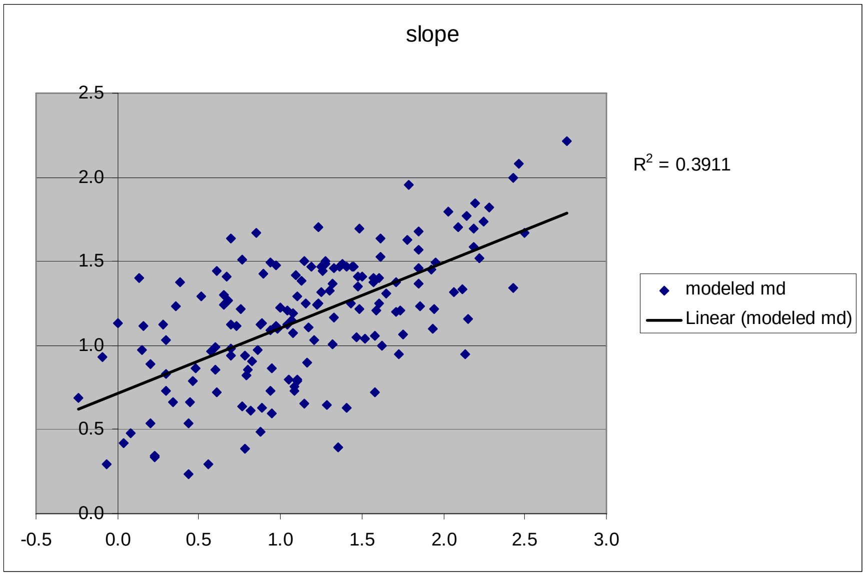


Figure 37

10.1.4.2 Slope-area regression analysis

10.1.4.2.1 Linear

Regression Statistics	
Multiple R	0.811487745
R Square	0.65851236
Adjusted R Square	0.654216918
Standard Error	41.4351514
Observations	162
	Coefficients
Intercept	2.507264226
slope 18km (SUM)	5.45269E-05
surf_A/catch_A	64.94439138

Table 12

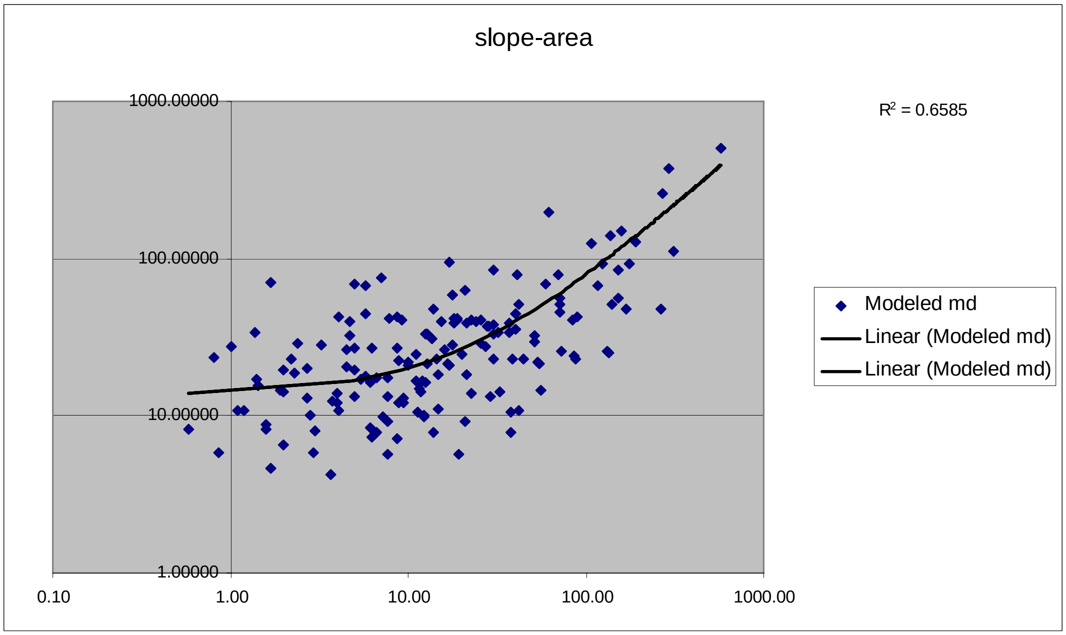


Figure 38

10.1.4.2.2 Logarithmic

Regression Statistics	
Multiple R	0.64219769
R Square	0.412417873
Adjusted R Square	0.405026902
Standard Error	0.480872994
Observations	162
	Coefficients
Intercept	-2.089126616
slope 18km (SUM)	0.647733323
surf_A/catch_A	0.169440781

Table 13

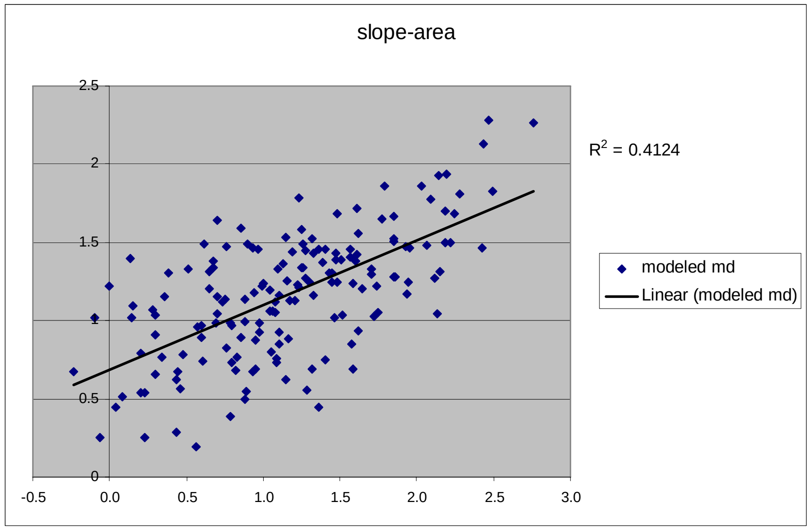


Figure 39

10.1.4.3 Slope-TPI-area regression analysis

10.1.4.3.1 Linear

Regression Statistics	
Multiple R	0.815059953
R Square	0.664322726
Adjusted R Square	0.657949107
Standard Error	41.2109308
Observations	162
	Coefficients
Intercept	-3.844276963
slope 18km (SUM)	5.0213E-05
TPI (RANGE)	0.038209166
surf_A/catch_A	68.51706482

Table 14

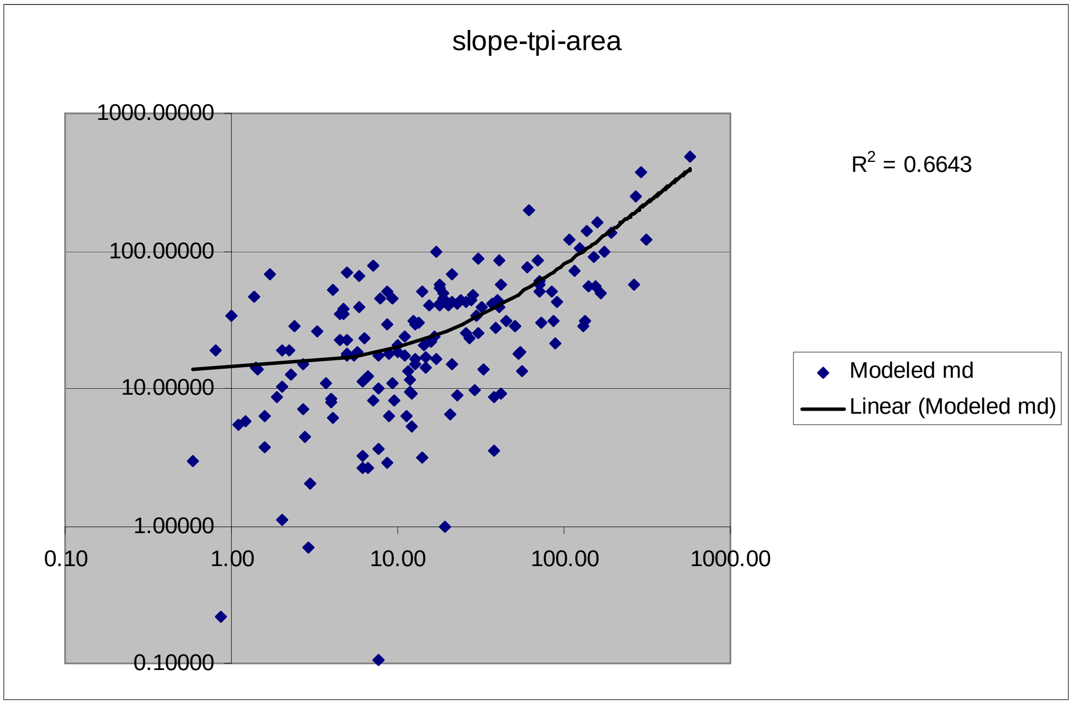


Figure 40

10.1.4.3.2 Logarithmic

	Regression Statistics
Multiple R	0.650319584
R Square	0.422915561
Adjusted R Square	0.411958262
Standard Error	0.478063734
Observations	162
	Coefficients
Intercept	-1.672629969
slope 18km (SUM)	0.47287997
surf_A/catch_A	0.174982795
TPI (RANGE)	0.247166614

Table 15

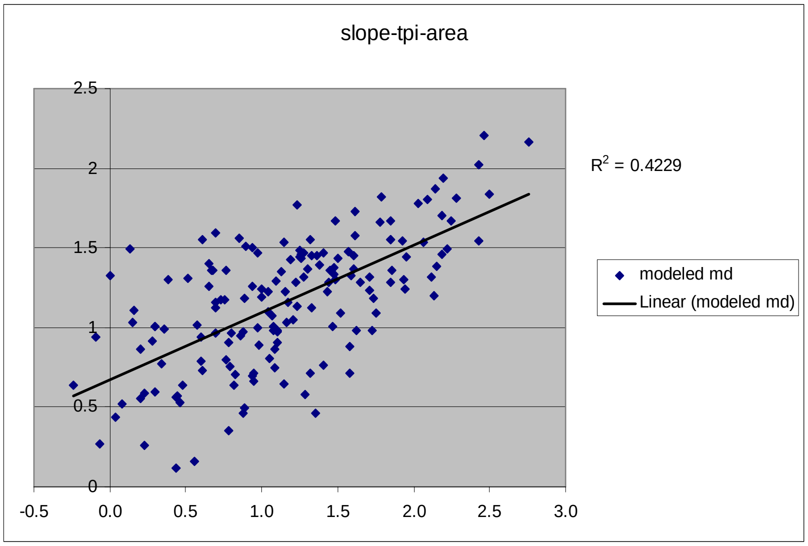


Figure 41

10.1.5 Conclusions

The model based on *slope-TPI-area* parameters shows the best correlation R^2 for both logarithmic and normal regression analysis. Logarithmic models show worse performance than linear models.

	Slope	*Slope-area*	*Slope-TPI-area*
Normal	0.633	0.658	0.664
Logarithmic	0.391	0.412	0.423

Table 16

10.2 Application of the Slope-area model on global scale.

The model equation selected for analysis was the one dependent on slope and area, as the improvement given by introducing TPI was deemed negligible. The equation for mean lake depth is:

$y = 2.5072642258973 + 0.0000545269266431377x_1 + 64.9443913808055x_2$

where:

y = mean lake depth (h)

x_1 = statistical SUM of slope values around lake (18km buffer) – (SL_{sum})

x_2 = lake area / statistical MAX of lake Flow Accumulation (FA_{max})

SL_{sum} and FA_{max} have been calculated for world lakes obtained from the GLWD database, following the processing chain explained above. With the regression equation, only lakes not having information on depth from the original database were assigned a computed lake depth.

It is apparent that, although the variance explained by the model is relatively high (>60%), the scatter of the data is very broad and the model aims at introducing some form of reasonable variation in lake depths rather than at point-wise accurate estimates of this parameter. Therefore, predicted lake depth should be used with care in model applications, keeping well in mind current limitations.

Due to hardware and software limitations, only lakes having an area bigger or equal than 10 km^2 have been taken into account.

10.3 References

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Weiss, A. 2001. Topographic Position and Landforms Analysis. Poster presentation, ESRI User Conference, San Diego, CA.

11. Acknowledgements

Data were collected by Paolo Isoardi during 2008, under a framework contract of Reggiani spa, Italy, with the European Commission JRC, and by Grazia Zulian during 2009, under a framework contract of Reggiani spa, Italy, with the European Commission JRC. Grazia designed the final database and cartographic layout, besides carrying out the analysis on the inland residence time and most of the soil, ocean and atmospheric data processing. Paolo developed the data mining and regression analysis on world lakes as described in annexes A and B, besides preparing an initial version of the whole data catalog. Alberto Pistocchi ideated and designed the research and the analyses and supervised the activities as the technical responsible and project manager of the contracts with Reggiani spa, Italy.

European Commission

EUR 24255 EN – Joint Research Centre – Institute for Environment and Sustainability
Title: Global atlas of environmental parameters for chemical fate and transport assessment
Authors: Grazia Zulian, Paolo Isoardi, Alberto Pistocchi
Luxembourg: Publications Office of the European Union
2010 – 80 pp. – 21 x 29.7 cm
EUR – Scientific and Technical Research series – ISSN 1018-5593
ISBN 978-92-79-15025-8
doi:10.2788/63436

Abstract
This report describes datasets forming an atlas of global landscape and climate parameters which were collected, homogenized and processed in order to provide input to a global model of chemical fate. The datasets can be used to parameterize the main land and ocean compartments usually considered in fate and transport models, and provide meaningful geographic patterns of the drivers of the environmental fate of contaminants. The maps were specifically designed to be used for a multimedia assessment of pollutant pathways in the environment (MAPPE Global), described in a companion report.
The data can be downloaded from the JRC FATE Web sites http://fate.jrc.ec.europa.eu/

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LB-NA-24255-EN-C

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ISBN 978-92-79-15025-8