Open Data Sources for Water Resources
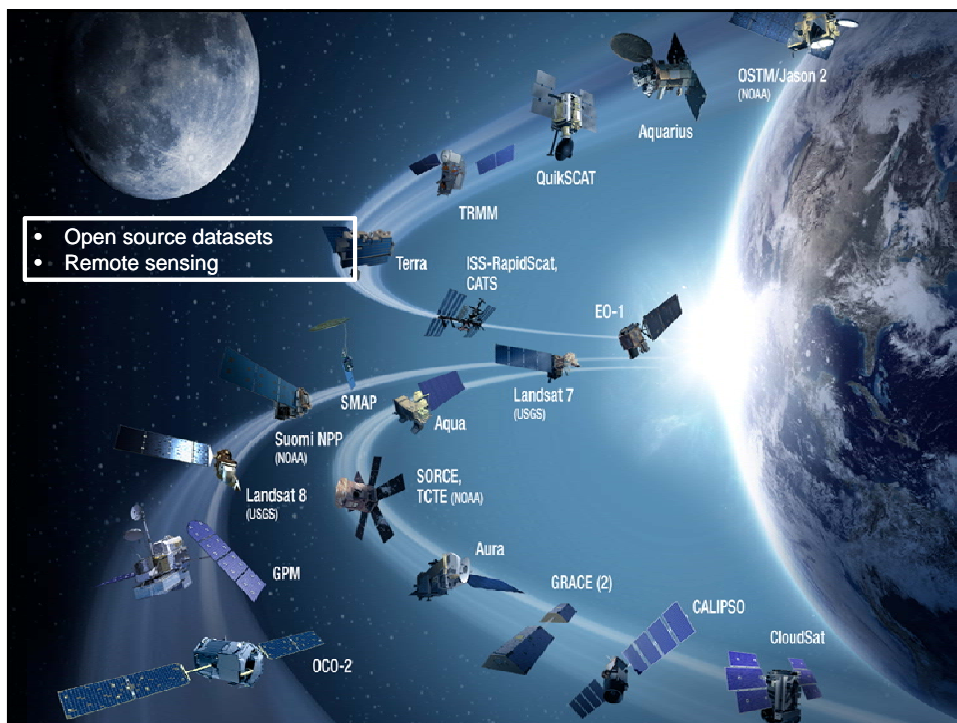
One Week Customized Course on Remote Sensing & GIS Technology

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National Remote Sensing Centre
Hyderabad - 500037, India
anurag_joshi@nrsc.gov.in
040-23884547

इसरो ISRO

nrsc

- Open source datasets
- Remote sensing

Global Datasets

Global Datasets

Precipitation

- TRMM
- CHIRPS
- GPM
- CMORPH
- PERSIANN
- CPC
- ARC
- GPCC

Evapotranspiration

- MOD16
- GLEAM
- ET-Monitor
- LANDSAF
- METRIC/EEFLUX
- ALEXI
- CMRSET
- SEBS
- SSEBop

Land Use Land Cover

- NRC-250k LULC
- GLOBCOVER
- IWMI
- GMIA
- MICRA
- WDPA
- JRC
- GRAND
- MODIS
- WORLD POP
- GLOBAL SURFACE WATER

Soil Moisture

- GLDAS
- ASCAT
- SMAP

MODIS

- LAI – MOD15
- GPP – MOD17
- NPP – MOD17

Others

- Grey Water Footprint
- Environmental Water Flow
- Elevation – HydroSHEDS
- GRACE

Global Datasets

Glacier & Snow Monitoring

- Mountain Geoportal (ICIMOD)
- Mountain Geoportal (ICIMOD)
- GLIMS Glacier Viewer (NSIDC)
- Swiss GMN
- Arctic SDI Geoportal

DEM

- SRTM
- ASTER
- CARTOsat
- GTOPO

Irrigation Informatics

- Water Watch
- CIMIS
- WaterNSW
- IWMI
- DEWS
- Global surface water explorer

Others

- National water information system :Web Interface
- AQUASTAT
- Giovanni
- Environmental Data Explorer
- Joint Research Centre
- Water Portal
- LAADS DAAC
- DIVA-GIS

Global Datasets

Precipitation

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- ASCAT
- SMAP

Precipitation: TRMM

- Tropical Rainfall Measuring Mission (TRMM)
- NASA & JAXA mission
- Spatial resolution: 0.25° ~27 km
- Temporal resolution: 3-hourly, daily, monthly
- From 1998 to April 2015

- Instruments
  - Precipitation radar
  - Microwave imager
  - Visible and Infrared Scanner (VIRS)
  - Lightning Image Sensor (LIS)

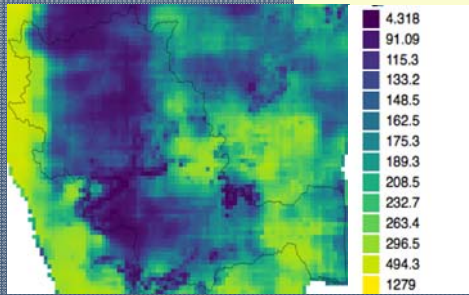- Elevation – HydroSHEDS
- GRACE

Source: http://trmm.gsfc.nasa.gov/

Global Datasets

Precipitation

- TRMM
- CHIRPS
- GPM
- CMORPH
- PERSIANN
- CPC
- ARC
- GPCC

Precipitation: CHIRPS

- Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)
- Funded by USGS and USAID
- Spatial Extent: -180, 180, -50, 50°
- Temporal resolution: daily, monthly
- Initial date: 1981
- Spatial Resolution: 0.25°

4.318
91.09
115.3
133.2
148.5
162.5
175.3
189.3
208.5
232.7
263.4
296.5
494.3
1279

- Environmental Water Flow
- Elevation – HydroSHEDS
- GRACE

Source: http://chg.geog.ucsb.edu/data/chirps/
http://www.nature.com/articles/sdata201566

Global Datasets

Precipitation

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- CMORPH
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- ARC
- GPCC

Soil Moisture

- GLDAS
- ASCAT
- SMAP

Precipitation: GPM

- Global Precipitation Measurement (GPM)
- NASA & JAXA Mission
- Spatial resolution: 0.1° ~11 km
- Temporal resolution: 30min
- Initial date: March 2015

- Instruments
  - Dual - Frequency Precipitation radar (DPR) x2
  - Microwave imager

- NPP – MOD17

- Environmental Water Flow
- Elevation – HydroSHEDS
- GRACE

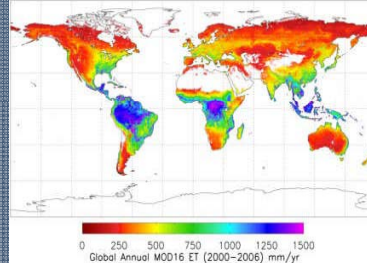Source: http://www.nasa.gov/mission_pages/GPM/main/index.html

Slide 1

Global Datasets

Precipitation

- TRMM
- CHIRPS
- GPM
- CMORPH
- PERSIANN
- CPC
- ARC
- GPCC

Evapotranspiration

- MOD16
- GLEAM
- ET-Monitor
- LANDSAF
- METRIC/EEFLUX
- ALEXI
- CMRSET
- SEBS
- SSEBop

Global Annual MOD16 ET (2000–2006) mm/yr
0   250   500   750   1000   1250   1500

- MODIS
- WORLD POP
- GLOBAL SURFACE WATER

Others

- Grey Water Footprint
- Environmental Water Flow
- Elevation – HydroSHEDS
- GRACE

Evapotranspiration: MOD16

- Moderate Resolution Imaging Spectroradiometer (MODIS)
- Two satellites / 36 bands
- Spatial Resolution: 1km
- Temporal resolution: 8-day, monthly
- Initial date: 2000

Source: http://www.ntsg.umt.edu/project/mod16
http://modis.gsfc.nasa.gov/data/dataprod/

Slide 2

Global Datasets
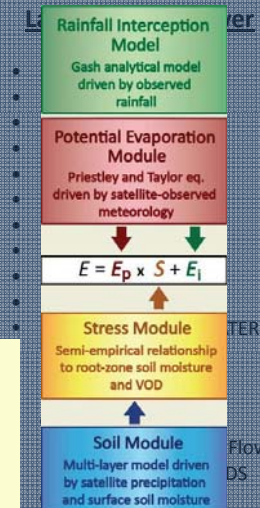
Precipitation

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- GPM
- CMORPH
- PERSIANN
- CPC
- ARC
- GPCC

Evapotranspiration

- MOD16
- GLEAM
- ET-Monitor
- LANDSAF
- METRIC/EEFLUX
- ALEXI
- CMRSET
- SEBS
- SSEBop

Rainfall Interception Model
Gash analytical model driven by observed rainfall

Potential Evaporation Module
Priestley and Taylor eq. driven by satellite-observed meteorology

$E = E_p \times S + E_i$

Stress Module
Semi-empirical relationship to root-zone soil moisture and VOD

Soil Module
Multi-layer model driven by satellite precipitation and surface soil moisture

Evapotranspiration: GLEAM

- Global Land Evaporation Amsterdam Model (GLEAM)
- VU - ESA
- Global, 0.25° ~27km
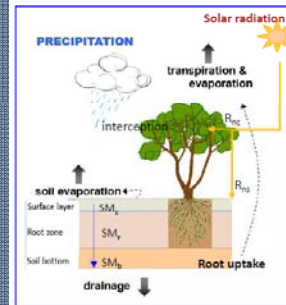- Temporal resolution: daily, monthly
- From 2003 to 2012

Source: http://www.gleam.eu/

Global Datasets

Precipitation

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- GPM
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- PERSIANN
- CPC
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- GPCC

Evapotranspiration

- MOD16
- GLEAM
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- SEBS
- SSEBop

- GLOBAL SURFACE WATER

Evapotranspiration: ET - Monitor

- A process based model implementing processess of energy balance, plant physiology and soil water balance developed by EOWater Lab at RADI.

Others

Grey Water Footprint
Environmental Water Flow
Elevation – HydroSHEDS
GRACE

Global Datasets

Precipitation

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Land Use Land Cover

- NRC-250k LULC
- GLOBCOVER
- IWMI
- GMIA
- MICRA
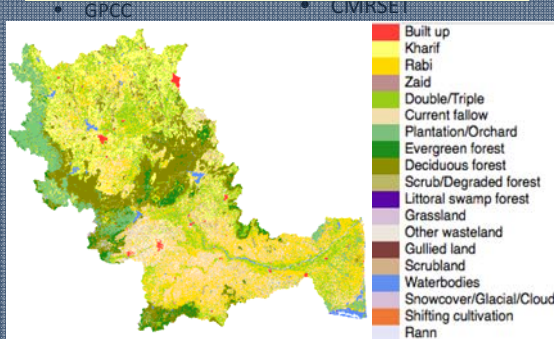- WDPA
- JRC
- GRAND
- MODIS
- WORLD POP
- GLOBAL SURFACE WATER

Evapotranspiration: ALEXI

- Atmosphere Land Exchange Inverse (ALEXI)
- EF = Latent Heat Flux / (Rn – G)
- Spatial Resolution – 0.027 degree ~ (3 km)
- Daily
- Data availability - 2007-2012

Others

Grey Water Footprint
Environmental Water Flow
Elevation – HydroSHEDS
GRACE

Global Datasets

Land Use Land Cover: NRC – 250k

- NRC – land cover
- Spatial resolution - 56 m
- Data Availability   - 2004-05 to 2015-16
- ResourceSAT 2 – Advanced Wide Field Scanner (AWiFS)

- GPCC   • CMRSET

■	Built up
■	Kharif
■	Rabi
■	Zaid
■	Double/Triple
■	Current fallow
■	Plantation/Orchard
■	Evergreen forest
■	Deciduous forest
■	Scrub/Degraded forest
■	Littoral swamp forest
■	Grassland
■	Other wasteland
■	Gullied land
■	Scrubland
■	Waterbodies
■	Snowcover/Glacial/Cloud
■	Shifting cultivation
■	Rann

Land Use Land Cover

- NRC-250k LULC
- GLOBCOVER
- IWMI
- GMIA
- MIRCA
- WDPA
- JRC
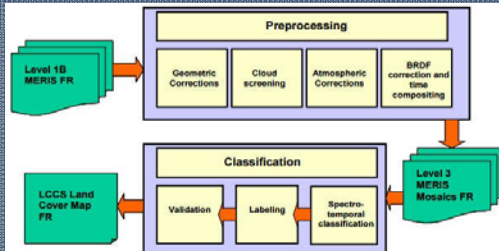- GRAND
- MODIS
- WORLD POP
- GLOBAL SURFACE WATER

Others

- Grey Water Footprint
- Environmental Water Flow
- Elevation – HydroSHEDS
- GRACE

Source: http://bhuvan.nrsc.gov.in/

Global Datasets

Land Use Land Cover: GLOBCOVER

- ESA – land cover
- Spatial resolution -- 300m
- Two periods   -- December 2004 – June 2006
                     -- January – December 2009
- Meris mission
  - Land surface reflectance
  - Classification

Land Use Land Cover

- NRC-250k LULC
- GLOBCOVER
- IWMI
- GMIA
- MIRCA
- WDPA
- JRC
- GRAND
- MODIS
- WORLD POP
- GLOBAL SURFACE WATER

Others

- Grey Water Footprint
- Environmental Water Flow
- Elevation – HydroSHEDS
- GRACE

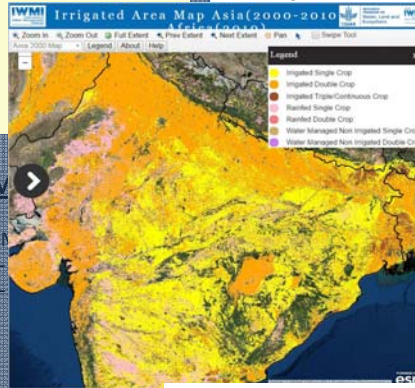Source: http://due.esrin.esa.int/page_globcover.php

Slide 1

Global Datasets

Land Use Land Cover: IWMI

- International Water Management Institute (IWMI)
- Agricultural Areas
  – Irrigated
  – Rainfed
- Spatial extent: Africa and Asia
- Period: 2000
- Spatial resolution: 250m
- Based on MODIS NDVI data

Land Use Land Cover

- NRC-250k LULC
- GLOBCOVER
- IWMI
- GMIA
- MIRCA

...ATER

Soil Moisture

- GLDAS
- ASCAT
- SMAP

M...

- LAI – ...
- GPP – ...
- NPP – ...

...Flow
...EDS

Source: http://waterdata.iwmi.org/applications/irri_area/

Slide 2

Global Datasets

Land Use Land Cover: GMIA

- Global Map of Irrigated Areas

  - area equipped for irrigation with surface water
  - area equipped for irrigation with groundwater
  - area equipped for total irrigation

- It is based on statistical data from various sources.

Land Use Land Cover

- NRC-250k LULC
- GLOBCOVER
- IWMI
- GMIA
- MIRCA
- WDPA
- JRC
- GRAND
- MODIS
- WORLD POP
- GLOBAL SURFACE WATER

Others

- GLDAS
- ASCAT
- SMAP

- LAI – MOD15
- GPP – MOD17
- NPP – MOD17

- Grey Water Footprint
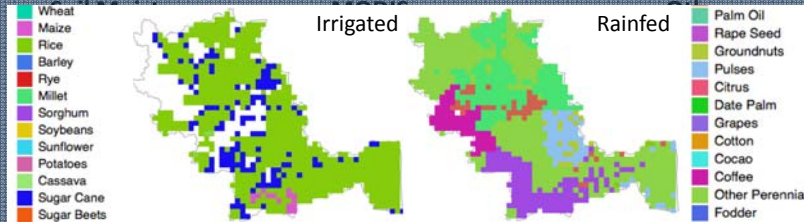- Environmental Water Flow
- Elevation – HydroSHEDS
- GRACE

Slide 1

Global Datasets

Land Use Land Cover: MIRCA

- Monthly growing area grids for 26 Dominant crop classes
  - Irrigated
  - Rainfed

- Spatial resolution - 10 km

SEBS
SSEBop

Land Use Land Cover

- NRC-250k LULC
- GLOBCOVER
- IWMI
- GMIA
- MIRCA
- WDPA
- JRC
- GRAND
- MODIS
- WORLD POP
- GLOBAL SURFACE WATER

Legend (left): Wheat, Maize, Rice, Barley, Rye, Millet, Sorghum, Soybeans, Sunflower, Potatoes, Cassava, Sugar Cane, Sugar Beets

Labels: Irrigated, Rainfed

Legend (right): Palm Oil, Rape Seed, Groundnuts, Pulses, Citrus, Date Palm, Grapes, Cotton, Cocao, Coffee, Other Perennial, Fodder
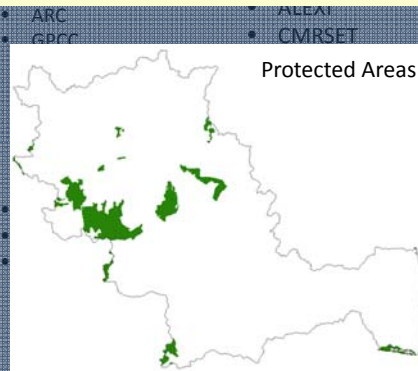
Slide 2

Global Datasets

Land Use Land Cover: WDPA

- World Database on Protected Areas
- Terrestrial and Marine protected areas
- Recognised as major tools in conserving species and ecosystem.

ARC
GPCC

ALEXI
CMRSET

Protected Areas

Land Use Land Cover

- NRC-250k LULC
- GLOBCOVER
- IWMI
- GMIA
- MICRA
- WDPA
- JRC
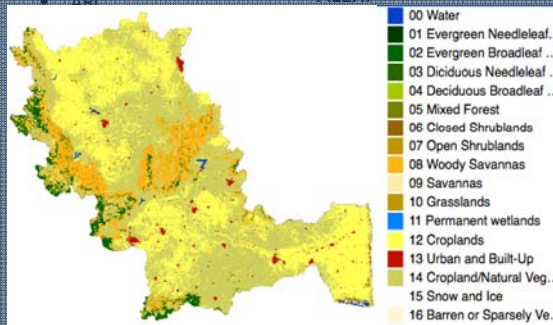- GRAND
- MODIS
- WORLD POP
- GLOBAL SURFACE WATER

Others

- Grey Water Footprint
- Environmental Water Flow
- Elevation – HydroSHEDS
- GRACE

Source: https://www.iucn.org/theme/protected-areas

Global Datasets

Land Use Land Cover: MODIS

- MCD12Q1
- Spatial resolution – 500 mtrs
- Temporal Coverage – 2001 -2013
- Total Classes – 17

00	Water
01	Evergreen Needleleaf…
02	Evergreen Broadleaf …
03	Diciduous Needleleaf …
04	Deciduous Broadleaf …
05	Mixed Forest
06	Closed Shrublands
07	Open Shrublands
08	Woody Savannas
09	Savannas
10	Grasslands
11	Permanent wetlands
12	Croplands
13	Urban and Built-Up
14	Cropland/Natural Veg…
15	Snow and Ice
16	Barren or Sparsely Ve…

Land Use Land Cover

- NRC-250k LULC
- GLOBCOVER
- IWMI
- GMIA
- MICRA
- WDPA
- JRC
- GRAND
- MODIS
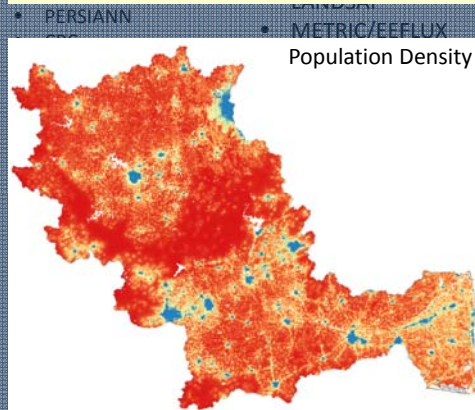- WORLD POP
- GLOBAL SURFACE WATER

Others

- Grey Water Footprint
- Environmental Water Flow
- Elevation – HydroSHEDS
- GRACE

Source : https://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table/mcd12q1

Global Datasets

Land Use Land Cover: World Population

- Random Forest Model
  - Stevens, et al. (2015)
- Population density per Ha

Population Density

Land Use Land Cover

- NRC-250k LULC
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- IWMI
- GMIA
- MICRA
- WDPA
- JRC
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- MODIS
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- GLOBAL SURFACE WATER

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- Environmental Water Flow
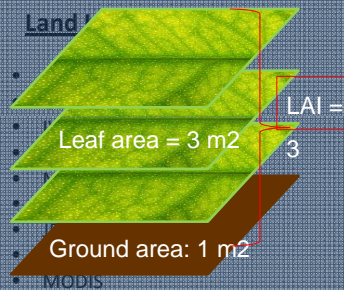- Elevation – HydroSHEDS
- GRACE

Source : **Stevens, F. R., Disaggregating Census Data for Population Mapping Using Random Forests with Remotely-Sensed and Ancillary Data. doi:10.1371/journal.pone.0107042**

Global Datasets

Soil Moisture: ASCAT

- Advanced SCATterometer (ASCAT)
- EUMETSAT
- Spatial resolution: 12.5km
- Temporal resolution: daily
- Initial date: 2007
- SWI (Soil Water Index) at different depths

Land Use Land Cover

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- IWMI
- GMIA
- MICRA
- WDPA
- JRC
- GRAND
- MODIS
- WORLD POP
- GLOBAL SURFACE WATER

- SSEBop

Soil Moisture

- GLDAS
- ASCAT
- SMAP

MODIS

- LAI – MOD15
- GPP – MOD17
- NPP – MOD17

Others

- Grey Water Footprint
- Environmental Water Flow
- Elevation – HydroSHEDS
- GRACE

Source: http://www.eumetsat.int/website/home/News/DAT_2633340.html
http://land.copernicus.vgt.vito.be/PDF/portal/Application.html#Home

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Global Datasets

MODIS: LAI

- Leaf Area Index
- Dimensionless values to characterize canopy coverage [m2/m2]
- Application -
    - assess the growth of vegetation
    - parameterization of climate models
    - photosynthesis, respiration, transpiration, and interception

Land

LAI =

Leaf area = 3 m2

3
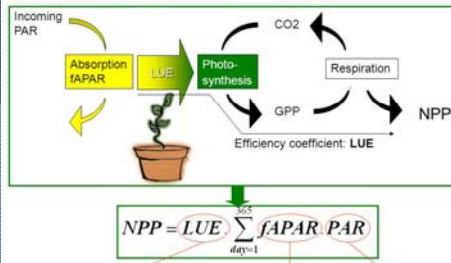
Ground area: 1 m2

MODIS

Soil Moisture

- GLDAS
- ASCAT
- SMAP

MODIS

- LAI – MOD15
- GPP – MOD17
- NPP – MOD17

Slide 1

Global Datasets

Light Use Efficiency models

Incoming PAR

Absorption fAPAR → LUE → Photo-synthesis → CO2 / Respiration

GPP → NPP

Efficiency coefficient: **LUE**

$$NPP = LUE \sum_{day=1}^{365} fAPAR\ PAR$$

The LUE may depend on biome, soil moisture, temperature, nutrients, age,

Measured by satellites

Modeled or measured by satellites

MODIS: NPP/GPP
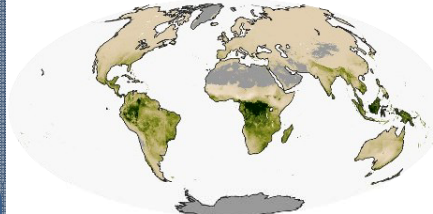
- Net Primary Production (NPP)
- Gross Primary Production (GPP)

Net Primary Productivity
gC/m²/day
-1.0   0   6.5
February 2000

Soil Moisture

- GLDAS
- ASCAT
- SMAP

MODIS

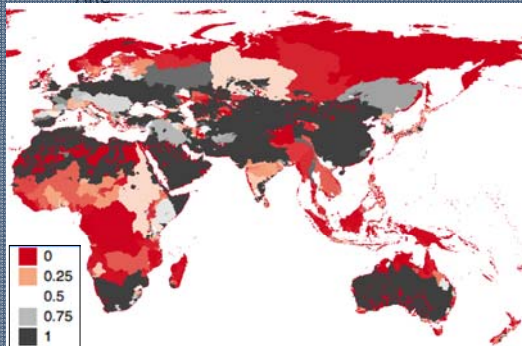- LAI – MOD15
- GPP – MOD17
- NPP – MOD17

- Elevation – HydroSHEDS
- GRACE

Slide 2

Global Datasets

Others: Grey Water Footprint

- *Global anthropogenic phosphorous loads to fresh water*
- *5 * 5 min*
- *2002-2010*

0
0.25
0.5
0.75
1

Land Use Land Cover

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- JRC
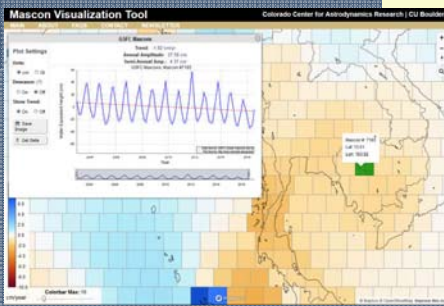- GRAND
- MODIS
- WORLD POP
- GLOBAL SURFACE WATER

Others

- Grey Water Footprint
- Environmental Water Flow
- Elevation – HydroSHEDS
- GRACE

Global Datasets

GRACE

- Gravity Recovery and Climate Experiment (GRACE) - NASA- JPL
- Measures changes in gravity
- Temporal resolution: ~ monthly
- Spatial resolution: ~3° (~300km)
- Initial date: April 2002
- Equivalent water depth – Groundwater, Root zone, Surface

GLOBAL SURFACE WATER

Others

- Grey Water Footprint
- Environmental Water Flow
- Elevation – HydroSHEDS
- GRACE

Source: http://ccar.colorado.edu/grace/gsfc.html

Global Datasets

Glacier & Snow Monitoring

- Mountain Geoportal (ICIMOD)
- Mountain Geoportal (ICIMOD)
- GLIMS Glacier Viewer (NSIDC)
- Swiss GMN
- Arctic SDI Geoportal

Irrigation Informatics

- Water Watch
- CIMIS
- WaterNSW
- IWMI
- DEWS
- Global surface water explorer

Others

- National water information system :Web Interface
- AQUASTAT
- Giovanni
- Environmental Data Explorer
- Joint Research Centre
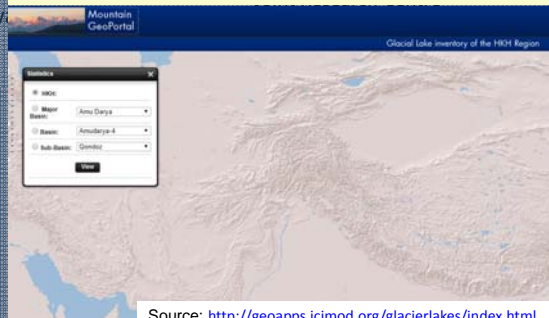- Water Portal
- LAADS DAAC
- DIVA-GIS

Slide 1

Glacier & Snow Monitoring

- Mountain Geoportal (ICIMOD)
- Mountain Geoportal (ICIMOD)
- GLIMS Glacier Viewer (NSIDC)
- Swiss GMN
- Arctic SDI Geoportal

Glacial lake

- ICIMOD
- HKH Region
- Classification of Types of Glacial Lakes
- Contains Hydrological, Geometric, Lake, and Other Information
- Basin, Sub-basin, and Elevation wise Glacial Lake distribution, along with lake types

Source: http://geoapps.icimod.org/glacierlakes/index.html

Slide 2

Glacier & Snow Monitoring

- Mountain Geoportal (ICIMOD)
- Mountain Geoportal (ICIMOD)
- GLIMS Glacier Viewer (NSIDC)
- Swiss GMN
- Arctic SDI Geoportal

Glacial

- ICIMOD
- HKH Region
- Categorized majorly based on its Primary Classification, Form, Frontal Characteristics, and Longitudinal Profile
- Areal distribution as per Basin, Sub-basin, and Elevation Range wise

Source: http://geoapps.icimod.org/glacier/hkhglacier/

Global Datasets

Glacier & Snow Monitoring

- Mountain Geoportal (ICIMOD)
- Mountain Geoportal (ICIMOD)
- GLIMS Glacier Viewer (NSIDC)
- Swiss GMN
- Arctic SDI Geoportal

Glacial View

- HKH Region
- Includes glacier outline of RGI and WGI
- Glacier class defined by RGI
- Contains areal, hydrological and other information of Glacier

Source: http://www.glims.org/maps/glims

Global Datasets

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- GLIMS Glacier Viewer (NSIDC)
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Irrigation Informatics

- Water Watch
- CIMIS
- WaterNSW
- IWMI
- DEWS
- Global surface water explorer

Water for US

- Water Alert,
- Real-time stream flow
- Real-time flood data
- Real-time drought data
- Real-time groundwater levels

Source: http://waterwatch.usgs.gov

Global Datasets

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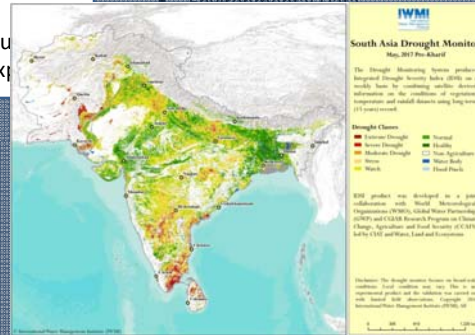- Swiss GMN
- Arctic SDI Geoportal

Irrigation Informatics

- Water Watch
- CIMIS
- WaterNSW
- IWMI
- DEWS
- Global surface water exp

Others

- National water information system :Web Interface
- AQUASTAT
- Giovanni
- Environmental Data

IWMI

- Water accounting
- Water data portal
- Mapping drought pattern and impacts
- Irrigated area mapping
- Drought Monitor

Source: http://www.iwmi.cgiar.org/

Global Datasets

Glacier & Snow Monitoring

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- Mountain Geoportal (ICIMOD)
- GLIMS Glacier Viewer (NSIDC)
- Swiss GMN
- Arctic SDI Geoportal
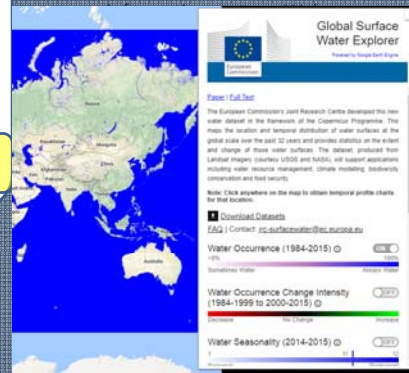
Irrigation Informatics

- Water Watch
- CIMIS
- WaterNSW
- IWMI
- DEWS
- Global surface water explorer

Others

- National water

Global Surface Water Explorer

- Landsat Imagery
- Temporal Distribution of Water Surface over past 32 years

Source: https://global-surface-water.appspot.com/

Slide 1

Global Datasets

...rrigation ...formatics

...ter Watch
...IS
...terNSW
...MI
...WS
...bal surface
...ter explorer

Others

- National water information system :Web Interface
- AQUASTAT
- Giovanni
- Environmental Data Explorer
- Joint Research Centre
- Water Portal
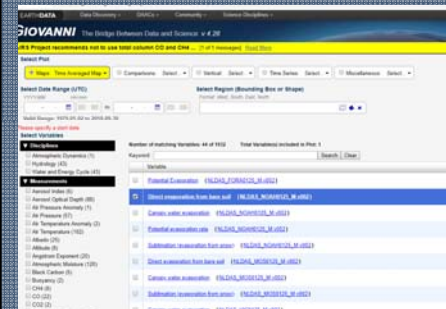- LAADS DAAC
- DIVA-GIS

AQUASTAT

- Food and agricultural organization of the united nations
- Water resources
- Water uses
- Waste water
- Irrigation and drainage
- Global
- 1960 onwards

Source: http://www.fao.org/nr/water/aquastat/main/index.stm

Slide 2

Global Datasets

...tion ...natics

...atch
...SW
...surface
...xplorer

Others

- National water information system :Web Interface
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GIOVANNI

- Geospatial Interactive Online Visualization ANd aNalysis Infrastructure
- Precipitation
- Evapotranspiration
- Soil moisture content layer
- Surface Runoff
- Global
- 1948-2018

Source: https://giovanni.gsfc.nasa.gov/giovanni/

Slide 1:

Global Datasets

Glacier & Snow Monitoring

Irrigation Informatics

Others
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UNEP DEWA GEO

United Nations Environment Programme
environment for development
UNEP

Environmental Data Explorer

The Environmental Data Explorer is the authoritative source for **data sets** used by UNEP and its partners in the Global Environment Outlook (GEO) report and other integrated environment assessments. Its **online database** holds more than **500 different variables**, as national, subregional, regional and global statistics or as geospatial data sets (maps), covering themes like Freshwater, Population, Forests, Emissions, Climate, Disasters, Health and GDP. Display them on-the-fly as **maps, graphs, data tables** or download the data in different formats.

- Viewer (NSIDC)
- Swiss GMN
- Arctic SDI Geoportal
- DEWS
- Global surface water explorer

Data Explorer
- United Nation Environment programme **Environmental Data Explorer**
- Precipitation
- Temperature
- DEM
- River Networks
- Watershed Boundaries
- Irrigated areas
- Global
- 1970-2002

Source: http://geodata.grid.unep.ch/

Slide 2:

Global Datasets

EARTHDATA   Other DAACs
LAADS DAAC
Search   About LAADS   Find Data

ABOUT LAADS — What we do
DATA DISCOVERY — Information, products, and services
QUALITY — Evaluation and validation

Others
- National water information system :Web Interface
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- Water Portal
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Data Explorer
The Level-1 and Atmosphere Archive & Distribution System (LAADS) Distributed Active Archive Center (DAAC)
- Level 0, Level 1 radiance data, reflectance data, albedo
- Atmospheric products
- (Aerosol, Water vapour, cloud mask)
- Annual water abstraction
- Global
- Since 1999

Source: https://ladsweb.modaps.eosdis.nasa.gov/

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Slide 1

Global Datasets: DEM

ASTER GLOBAL Digital Elevation Model

Pixel Size	1 arc-second (30 m)
Geographic coordinates	Geographic latitude and longitude
DEM output format	GeoTIFF, signed 16 bits in units of vertical meters
Geoid reference	WGS84/EGM96
Special DN values	-9999 for void pixels, and 0 for sea water body
Tile volume	25 MB uncompressed, 4–5 MB compressed
Coverage	North 83 degrees to south 83 degrees, 22,702 tiles

CARTOSAT 1 Digital Elevation Model

Projection	Geographic
Horizontal Datum	WGS84
Vertical Units	Meters
Spatial Resolution	1 arc-second for global coverage (~30 meters)
Download	Bhuvan portal

Shuttle Radar Topography Mission (SRTM)

Projection	Geographic
Horizontal Datum	WGS84
Vertical Datum	EGM96 (Earth Gravitational Model 1996)
Vertical Units	Meters
Spatial Resolution	1 arc-second for global coverage (~30 meters) 3 arc-seconds for global coverage (~90 meters)
Raster Size	1 degree tiles
C-band Wavelength	5.6 cm

- Global 30 Arc-Second Elevation (GTOPO30)
- Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010)

Source: https://earthexplorer.usgs.gov/

Slide 2

Open Sources Software for Water Resources

GIS Software
1. QGIS - https://www.qgis.org/en/site/

Image Processing
1. ORFEO Toolbox - https://www.orfeo-toolbox.org/
2. SNAP - https://step.esa.int/main/toolboxes/snap/
3. GRASS - https://docs.qgis.org/2.8/en/docs/user_manual/grass_integration/grass_integration.html

Data Visualization
1. Panoply - https://www.giss.nasa.gov/tools/panoply/
2. HDFview - https://www.hdfgroup.org/downloads/hdfview/

Hydrological Models
1. HEC-HMS - https://www.hec.usace.army.mil/software/hec-hms/
2. SWAT - https://swat.tamu.edu/
3. VIC - https://vic.readthedocs.io/en/vic.4.2.c/Documentation/TechnicalNotes/Modes/
4. sphy - https://www.sphy.nl/
5. CROPWAT - http://www.fao.org/land-water/databases-and-software/cropwat/en/
6. MODFLOW - https://www.usgs.gov/mission-areas/water-resources/science/modflow-and-related-programs?qt-science_center_objects=0#qt-science_center_objects

Thank you