Building Capacity in Utilizing NASA Remote Sensing Observations in SWAT for Water Resources and Agricultural Management Applications

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Impacts Assessment of Decadal Climate Variability on Water and Crop Yields in the Missouri River Basin (MRB)

A multi-institution project (CRCES, Texas A&M, UMBC-JCET, NDMC)

- **Climate Model Predictions**
  - Multidecades, daily, 100x100 km² grids

- **High Resolution Observations** + Statistical Downscaling

- **Climate Model Predictions**
  - Multidecades, daily, ~10x10 km² grids

- **Soil and Water Assessment Tool (SWAT)**

**Water and Agricultural Yields Analysis**

**Economic Impact assessment over MRB**

**Development of management strategy over MRB**

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SWAT Meeting, June 24-26, 2015
Objectives

- Provide an overview of weather, climate, and land parameters based on NASA remote sensing observations relevant for SWAT inputs and useful for verification for SWAT simulations.

- Engage the SWAT users community in discussing possibilities of developing joint capacity building trainings in using NASA remote sensing data in SWAT for regional decision support activities.
Overview of:

- Applied Remote Sensing Training (ARSET) Program
- Data products from NASA satellites and atmosphere-land models
- How to request on-line and/or on-site trainings for data information and access
GOAL: Increase utilization of NASA observational and model data for decision-support through training activities for environmental professionals.

Application Areas: water resources, disasters, health/air quality, wildfires, and land management.

Online Trainings: Live and recorded, 4-6 weeks in length. Include demos on data access

In person Trainings: In a computer lab, 2-4 days. Major focus on data access

Train the Trainers: Courses and training manuals for those interested in conducting their own remote sensing training.

http://arset.gsfc.nasa.gov

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SWAT Meeting, June 24-26, 2015
Online and Hands-on Trainings

• **Who**: policy makers, environmental managers, modelers and other professionals in the public and private sectors.

• **Where**: U.S and internationally

• **When**: throughout the year. Check websites

• **Do NOT require prior remote-sensing background.**

• Presentations and hands-on guided computer exercises on how to access, interpret and use NASA satellite images data for various applications
Number of participating organizations per country (above) and U.S State (right) : Air Quality, Water, Flood, and Land management

52 Trainings
3000+ End-users
800+ Organizations
ARSET Website

http://arset.gsfc.nasa.gov/

Applied Remote Sensing Training

The goal of the NASA Applied Remote Sensing Training (ARSET) is to increase the utility of NASA earth science and model data for policy makers, regulatory agencies, and other applied science professionals in the areas of Health and Air Quality, Water Resources, Eco Forecasting, and Disaster Management.

The two primary activities of this project are webinars and in-person courses.

Webinars (Free)

Webinars are offered throughout the year in all four application areas, generally 4-5 weeks in duration, 1 hour per week. They are intended for those new to remote sensing. For more information and to register please go to the webinars section of the website.

In-Person Courses

ARSET in-person courses are a combination of lectures and computer hands-on activities that teach professionals how to access, interpret, and apply NASA data at regional and global scales with an emphasis on case studies. ARSET works with organizations who will host the training for groups within their geographical region, tailoring the curriculum to the needs of the project participants. NASA does not charge an attendance fee, but attendees must make their own arrangements to travel to the course meeting location.

Skills Taught:

- Search, access, and download of NASA data products and imagery
- Appropriate use and interpretation of satellite imagery.
- Visualization and analysis of NASA imagery using NASA, EPA, and NOAA webtools and other resources such as GIS, Google Earth, Panospy, RS80, and HDFLook.

ARSET is sponsored by the Applied Sciences Program within NASA's Earth Science Division. We would like to thank Nancy Searby, Applied Sciences' Capacity Building Program Manager for her support of this project.
Data Products from NASA Satellites and Atmosphere-Land Models Relevant to SWAT Inputs and Validation
NASA Earth Observing Satellites for Weather, Climate, and Land Surface Parameters

Landsat (07/1972-present)
TRMM (11/1997-4/2015)
GPM (2/27/2014-present)
Terra (12/1999-present)
Aqua (5/2002-present)
SMAP (1/31/2015-present)

TRMM: Tropical Rainfall Measuring Mission
GRACE: Gravity Recovery and Climate Experiment
GPM: Global Precipitation Measurements
SMAP: Soil Moisture Active Passive

TOPEX/Poseidon, Jason 1-2-3 (1992-present)
Advantages of Remote Sensing Observations

- Provide information where surface-based measurements are not available and augment existing measurements.
- Provide global/near-global coverage with consistent, continuous, large-scale coverage compared to point measurements.
- Enhance and improve model performance when assimilated in weather and climate models.

Continuous Coverage From TRMM Multi-satellite Precipitation
NASA Models Provide Value-added Information For Weather, Climate, and Land Parameters

Remote Sensing + Surface Observations + Numerical Models

Satellite Data

Surface Measurements and In-Situ Data

Numerical Models
NASA Models for Monitoring Weather and Climate

(Atmosphere-Ocean-Land Models)

➢ **GEOS-5**: The Goddard Earth Observing System Version 5

➢ **MERRA**: Modern Era Retrospective-analysis for Research and Application

➢ **GLDAS**: Global Land Data Assimilation System

➢ **NLDAS**: North American Land Data Assimilation System
Blends the vast quantities of observational data with output data of the Goddard Earth Observing System (GEOS) model [1979-present]

Current satellite coverage assimilated in MERRA

MERRA
http://gmao.gsfc.nasa.gov/merra/
Global Land Data Assimilation System (GLDAS)

**GOAL:** Integrate ground and satellite observations within sophisticated numerical models to produce physically consistent, high resolution fields of land surface states (e.g., snow) and fluxes (e.g., evaporation)

**USES:** Weather and climate forecast initialization studies, water resources applications, hydrometeorological investigations

**AVAILABILITY:** Output from 1979-present simulations of Noah (1/4°; 1°), CLM (1°), and Mosaic (1°), and VIC (1°), are available at [http://disc.gsfc.nasa.gov/hydrology/index.shtml](http://disc.gsfc.nasa.gov/hydrology/index.shtml)

**Parameter Inputs**
- Soil Texture
- Land Cover
- Slope
- SW Radiation
- Precipitation

**Integrated Output**
- Soil Moisture
- Evapotranspiration
- Runoff
- Snow Water Equivalent

**Assimilated Observations**

*Courtesy Matt Rodell, NASA-GSFC*

Primary SWAT Input Parameters

http://swat.tamu.edu/media/69302/ch01_overview.pdf

Watershed Level Input Data (Daily):

Precipitation
(Rainfall, Snow Fraction and Snow Water Equivalent)

Maximum and Minimum Temperatures

Solar Radiation

Winds

Relative Humidity

Climate Data
# Additional SWAT Data Parameters

- Land Cover
- Leaf Area Index
- Terrain
- Soil Moisture
- Ground Water
- Lake Level Height
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Temperature, Humidity</td>
<td>(Aqua/AIRS, MERRA)</td>
</tr>
<tr>
<td>Rain</td>
<td>(TRMM, GPM)</td>
</tr>
<tr>
<td>Winds</td>
<td>(MERRA)</td>
</tr>
<tr>
<td>Solar Radiation</td>
<td>(Terra, Aqua, NPP – CERES)</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>(GLDAS, SMAP)</td>
</tr>
<tr>
<td>Snow Cover</td>
<td>(Terra and Aqua MODIS)</td>
</tr>
<tr>
<td>Snow Water Equivalent</td>
<td>(GLDAS)</td>
</tr>
<tr>
<td>Terrain</td>
<td>(Shuttle Radar Topography Mission, Terra/ASTER)</td>
</tr>
<tr>
<td>Ground Water</td>
<td>(GRACE, GLDAS)</td>
</tr>
<tr>
<td>Land Cover</td>
<td>(Landsat, Terra and Aqua/MODIS)</td>
</tr>
<tr>
<td>Leaf Area Index</td>
<td>(Terra and Aqua MODIS)</td>
</tr>
<tr>
<td>Run Off, ET</td>
<td>(GLDAS)</td>
</tr>
<tr>
<td>Lake Levels</td>
<td>(TOPEX/Poseidon, Jason-Altimeters)</td>
</tr>
</tbody>
</table>
# Temperature and Rainfall Data Required for SWAT Input

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Source</th>
<th>Spatial Resolution and Coverage</th>
<th>Temporal Resolution and Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall (uniformly gridded by space/time averages of multiple satellites and sensors)</td>
<td>TRMM</td>
<td>0.25°x0.25°, Global 50°S-50°N</td>
<td>3-hourly, Daily, 11/1997-4/2015</td>
</tr>
<tr>
<td></td>
<td>GPM</td>
<td>0.1°x0.1°, Global 65°S-65°N</td>
<td>Half-hourly, Daily, 2/2015-Present</td>
</tr>
<tr>
<td>Temperature</td>
<td>MERRA</td>
<td>1.25°x1.25°, Global</td>
<td>Hourly, 1979-Present</td>
</tr>
<tr>
<td></td>
<td>Aqua/AI RS</td>
<td>1.0°x1.0°, Global</td>
<td>Twice-daily, 5/2002-Present</td>
</tr>
</tbody>
</table>

Note: Most Data Products can be Imported into ArcMap
## Multiple Data Access Tools are Available

<table>
<thead>
<tr>
<th>Tools</th>
<th>Data Formats</th>
<th>Analysis and/or Visualization</th>
<th>Data Download</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mirador</td>
<td>HDF5, OPenDAP (can be converted to ASCII, Binary, NetCDF)</td>
<td>N/A</td>
<td>Batch Download</td>
</tr>
<tr>
<td>Giovanni</td>
<td>NetCDF, GeoTIFF, PNG</td>
<td>Visualization: Map, Time Series, Scatter Plot, Histogram</td>
<td>Download by Select and Click on Data Files</td>
</tr>
<tr>
<td>PPS/STORM</td>
<td>HDF5, PNG</td>
<td>Analysis: Time-averaged Maps, Time Series, Scatter Plot, Map Correlations, Vertical Profiles, Time-averaged Differences</td>
<td>FTP</td>
</tr>
</tbody>
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[https://storm.pps.eosdis.nasa.gov/storm](https://storm.pps.eosdis.nasa.gov/storm)
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<td>HDF, Image</td>
<td>Map Visualization</td>
<td>Batch Download Possible</td>
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How to Request On-line and/or On-site Trainings for Data Information and Access

http://arset.gsfc.nasa.gov/

ARSET can design trainings according to your interests/needs, application areas, and geographic regions

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ARSET ListServ

For information on upcoming courses and program updates sign up to the listserv

https://lists.nasa.gov/mailman/listinfo/arset
Summary

Many of the input parameters used by SWAT are **freely** available from NASA remote sensing and modeling activities.

There are multiple sources of data with different spatial/temporal resolutions and coverage (Landsat: 30 m/16 days, GPM: 5 to 10 km/half-hourly, GLDAS and MERRA: 12 km to 125 km/hourly to daily, GRACE - 150000 km²/monthly).

*Multiple data access tools are available*

Data pre-processing may be required for using them in SWAT.

ARSET can provide introductory and advanced trainings to SWAT user-groups to build capacity in using NASA earth science data for SWAT simulations and validation.

ARSET seeks opportunities for conducting workshops and trainings for SWAT end-users.
Thank You!