

Report on NASA MAIRS Data Center Project

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Summary

The NASA Land Cover/Land Use Change (LCLUC), [NASA Data and Services Supporting Monsoon Asia Integrated Regional Study in Eastern Asia \(MAIRS\)](#) data center project at Goddard Earth Sciences Data and Information Services Center (GES DISC), started in late spring 2009, focuses on leveraging existing infrastructure, data, and tools to bring heterogeneous multi-sensor geophysical measurements together so that they can be co-registered and viewed together to provide a more meaningful view of the region's environment. The MAIRS project adapts much functionality and services provided for the successful NASA Northern Eurasian Earth Science Partnership Initiative (NEESPI) data center project, providing NASA Earth science remote sensing and model data at global and regional scale resolutions, tools, and information in supporting the MAIRS program, and providing scientific and technical expertise in data management and interoperability to MAIRS regional partners for setting up a data sharing infrastructure. A number of Giovanni MAIRS portals have been created containing grouped products in 8-day, monthly, and yearly temporal resolutions.

The MAIRS project focuses on integrating higher resolution data (1km over MAIRS region and 5.6km global) into the Giovanni system. More than 30 products have been integrated into the system, with total compressed data file volumes of about 1.7 TB. The total numbers of views of Giovanni MAIRS result page have exceeded 29K from May 2009 to April 2012.

Project portal: <http://disc.sci.gsfc.nasa.gov/mairs>

1. Background

Monsoon Asia Integrated Regional Study in Eastern Asia (MAIRS) is an international research program focused on human-monsoon system interaction. The program attempts to understand to what extent human activities may modulate the Asia monsoon climate and how a changed monsoon climate will impact further social and economic development of Asia.

This project collects and provides Earth science data, tools, and information to support studies on Asian Monsoon regional climate impacts and adaptation, by highly leveraging the already developed data management system components and data from the successful NASA Northern Eurasian Earth Science Partnership Initiative (NEESPI) Data Center at GES DISC. The collection of data products include atmosphere, land surface, and ocean parameters, such as precipitation, temperature, wind, vegetation index, fire, soil moisture, aerosol optical depth, and chlorophyll, etc., from multiple satellites and models at different spatial and temporal resolution. Combined with models and these multidiscipline data, researchers could conduct studies, such as, how climate variability and change affect land use and land cover, and what are the potential feedbacks of changes in land use and land cover to climate. Such studies will help to enhance

the “state of knowledge” of changes in the atmospheric, terrestrial and marine components, of the Asian monsoon systems.

The GES DISC MAIRS data center project activities include:

- Providing NASA satellite remotely-sensed and modeled land, atmospheric, and oceanic data (and their subsets) over the Asian monsoon region, using data from archives at the NASA NEESPI project and other public data sources, such as NASA LP DAAC, and NOAA NGDC, etc. ;
- Providing an innovative Web-based visualization tool to allow data exploration and preliminary studies of correlations and interactions between various atmospheric, land, and socioeconomic variables to assess mutual relationships;
- Providing a data information (metadata) portal which contains satellite remotely-sensed data, global and region model products, as well as ground measurements;
- Providing technical expertise in data management and interoperability to our MAIRS program regional partner for the creation of a data sharing framework.

This project focuses on making data, **especially the large size data**, easily accessible and usable. With established data management infrastructure at GES DISC, regional high resolution data is collected for the MAIRS study region, such as 1-km land surface temperature, vegetation index, and land cover type, etc. Due to large data volume, the higher resolution land data are normally stored in tiles, thus reducing the effort to extract the data of an interested region. Data preprocessed for the entire MAIRS study region (60°E – 150°E, 10°S – 60°N) makes it easy to be accessed and analyzed online, reducing the data preparation time for each individual scientist.

Most collected data are integrated into the GES DISC developed online visualization and analysis system, Giovanni. Giovanni portals are created and customized for MAIRS project, with selected parameters from satellite observation and models that allow users to explore data through basic statistical analysis functions.

The project also works with MAIRS partners to improve their ability to share their data more effectively.

2. Accomplishments

2.1 MAIRS Data Center Project Portal

The NASA GES DISC MAIRS data center project portal web page was initially set up in early November 2009 (<http://disc.sci.gsfc.nasa.gov/mairs>) and is updated regularly. The page includes the following parts:

- Overview – describes project and goals.

- Data Holding – lists products archived at the NASA GES DISC through NEESPI and MAIRS data support projects, and product metadata of selected products archived at other data centers.
- Visualization – leads a user to online visualization and analysis tools, Giovanni, WMS portal, and Google Earth portal. (Detailed summary of these tools are given below)
- News – documents project related activities and progress.
- Science Focus – documents related research, including papers.
- Partners – lists PI, Co-PI, and collaborators of this project;
- Links – lists important web sites that are related to this project, cataloged into three groups: general, data sources, and visualization services

2.2 Giovanni MAIRS

Giovanni is an online web-based application developed by the NASA GES DISC. It provides a simple and intuitive way to visualize, analyze, and access vast amounts of Earth science data without having to download the data (Acker and Leptoukh, 2007; Berrick, et al 2008). The system consists of the following components: Easy use Web interfaces; Back-end data processing software; Image renders, and; An instance generator. Giovanni’s visualization functions include latitude-longitude area maps, animations, time-series, and cross-sections (Latitude/Longitude–Time and Height-Latitude/Longitude), etc. The system enables comparisons or relationship studies between parameters through functions, such as scatter plots, correlation coefficient maps, difference, and overlays, etc. Other features of Giovanni include: Downloading original or subsetted data in different formats, such as ASCII, hdf, or netCDF; Providing product lineage which presents brief descriptions of how images and data were created, and; Providing images in formats: gif, png, or KMZ for Google Earth. In addition, Giovanni can be accessed in a machine-to-machine way via WMS and WCS protocols.

Giovanni has been used widely to explore data and conduct initial studies, for example, dust and aerosol (Ramachandran & Cherian 2008), ocean color (Shen et al., 2008), and precipitation (Huffman, et al., 2007).

2.2.1 Products in Giovanni MAIRS

The following two tables list parameters available in MAIRS Giovanni portals:

Table 1: Land and Social Products:

| Parameters | Product Name | Sensor/model | Temporal Coverage | Temporal Resolution | Spatial Resolution, Coverage |
|--------------------|--|--------------|-------------------|---------------------|---|
| Vegetation Indices | MODVI.005 MYDVI.005 MOD13A3_MAIRS.005 MYD13A3_MAIRS.005 | MODIS | 2000.03 - present | Monthly, 16day | 1° Global 5.6 km, Global 1km, MAIRS |

| | | | | | |
|---|--|------------|-------------------|---------------|--|
| Land Surface Temperature | MOD11CM1.005 MYD11CM1.005 MOD11A2_MAIRS.005 MYD11A2_MAIRS.005 | MODIS | 2000.03 - present | Monthly 8-Day | 1° Global 5.6 km, Global 1km, MAIRS |
| Active Fire | MOD14CM1.005 MYD14CM1.005 MOD14A2_MAIRS.005 MYD14A2_MAIRS.005 | MODIS | 2000.03 - present | Monthly 8-Day | 1°, Global 1km, MAIRS |
| Land Cover Types | MCD12C1.005 MCD12Q1_MAIRS.005 | MODIS | 2001-present | Yearly | 5.6 km, Global 0.5 km, MAIRS |
| Land Cover Dynamics | MCD12Q2_MAIRS.005 | MODIS | 2001-present | Yearly | 1km, MAIRS |
| Snow/Ice | NHSNOWM.001 | NESDIS/IMS | 2000.01-present | Monthly | 1°, northern Hemisphere |
| Soil moisture | AMSRE_AVRMO.005 | AMSRE-E | 2002.10 - present | Monthly | 1°, Global |
| Evapotranspiration, snow-water equivalent, surface runoff | GLDAS_NOAH10_M.001 | GLDAS | 1979.01 - present | Monthly | 1°, Global |
| Nighttime Lights | FnnNLGT_5km.004 FnnNLGT_MAIRS.004 | DMSP-OLS | 1992-2010 | Yearly | 5.6km, Global 1km, MAIRS |

Table 2: Atmospheric and Ocean Products:

| Parameters | Product Name | Sensor/Model | Temporal Coverage | Temporal Resolution | Spatial Resolution, Coverage |
|---|----------------|--------------|-------------------|---------------------|------------------------------|
| Aerosols, cloud fraction, water vapor | MOD08_M3.051 | MODIS | 2000.02 - present | Monthly | 1°, Global |
| Trace gases (CH ₄ , CO, CO ₂ , O ₃) | AIRX3STM.005 | AIRS | 2002.09 - present | Monthly | 1°, Global |
| OLR, surface air temp, column water | AIRX3STM.005 | AIRS | 2002.09 - present | Monthly | 1°, Global |
| Precipitation | GPCP_1DMO.2.1 | GPCP | 1979.01-2009.09 | Monthly | 1°, Global |
| | TRMM_3B43.006 | TRMM | 1998.01-2011.06 | | |
| Temperature, Wind, Pressure, Humidity | MATMNXLV.5.2.0 | MERRA | 1979.01-present | Monthly | 0.667°x0.5°, Global |
| Chlorophyll-a, | SWFMO_CHLO.CR | SeaWiFS | 1997.09 – 2010.12 | Monthly | 9km, Global |
| Sea Surface Temperature | MTMONSST.001 | MODIS | 2000.02-present | Monthly | 9km, Global |

2.2.2 Giovanni MAIRS Portals

Integrating the collected data into Giovanni system was a major effort of the project. Four Giovanni Web portals have been created for MAIRS and are summarized as followings:

- Monthly products of coarse resolution (0.5 – 1.0 degree):

http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=mairs_monthly

This is a collection of global monthly atmosphere, land surface, and ocean products from satellite measurements and model outputs, including air temperature, wind, precipitation, aerosols, land surface temperature, vegetation index, active fire, soil moisture, and snow/ice etc. The spatial resolution of most products in this collection is 1x1 degree for global scale analysis.

Monthly climatology of several atmospheric and land products have been created and integrated into this portal, for displaying climatology images and exploring interannual variations.

- Monthly products of higher resolution (1km – 5.6km):

http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=mairs_monthly_hres

This is a collection of MODIS monthly land and ocean data at spatial resolution of 5.6 km (0.05 degree) or higher (1km), including land surface temperature, vegetation index (NDVI and EVI), sea surface temperature, and ocean color. This Giovanni portal allows one to conduct time series analysis at regional-scale easily.

- 8day and 16day products of higher resolution (1km – 5.6km):

http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=mairs_8day

The MODIS land data of 8day or 16day temporal resolution are available in mairs_8day Giovanni portal. The spatial resolution of the data is 5.6km for global and 1km for the MAIRS region. Parameters include land surface temperature, NDVI, EVI, surface albedo, and fire mask.

- Yearly products of higher resolution (0.5 – 5.6km):

http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=mairs_yearly

The yearly MODIS land cover types and land cover dynamics at 0.5 km and 5.6km, are integrated to Giovanni. The DMSP-OLS nighttime lights from NOAA NGDC were added as well for supporting urbanization studies.

In addition to MAIRS Giovanni portals, two existing Giovanni portals designed for NEESPI project are supporting MAIRS project due to the overlapped geographical regions and similar research interests. One portal is for monthly products grouped as: atmosphere, land surface, cryosphere, and model (http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=neespi). The other portal contains daily products for atmospheric parameters from MODIS Terra, MODIS Aqua, and selected land surface parameters from AIRS (http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=neespi_daily). Products in NEESPI Giovanni portals are at coarse resolution: $1^{\circ} \times 1^{\circ}$ for observation and $2.5^{\circ} \times 2.5^{\circ}$ for model data.

2.2.3 Sample Plots from Giovanni MAIRS

Example 1: MODIS Land Surface Temperature at 1km resolution

Daytime Land Surface Temperature (LST) at 1km resolution from MODIS Terra 8day product (MOD11A2_MAIRS.005) were averaged for the summer (Jun, Jul, Aug) 2001 and 2009 over Shanghai, China by using Giovanni. Images in Figure 1 were saved in KMZ format and displayed in GoogleEarth with the layer “Road” (orange lines) turned on. The observed significant local warming from 2001 to 2009 is associated mostly with the conversion of croplands to urban land during this period. Interestingly, the warmer area is expended outward from the city and is significant along the major intercity roads.

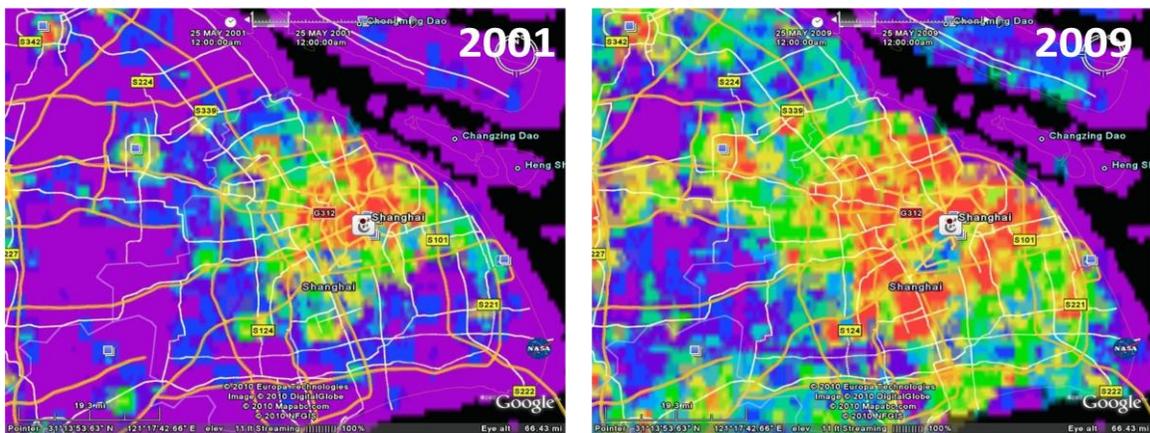


Figure 1: Averaged summer LST from MODIS 1km 8-day product for 2001 and 2009, respectively. Images are generated from Giovanni.

Example 2: MODIS Land Cover Types and Seasonal Variation of Vegetation Index

MODIS Land Cover Type (LCT) of five different classification methods is available in Giovanni. Figure 2 is the 5.6 km resolution LCT that utilizes the “International Geosphere Biosphere Programme (IGBP)” classification method, over Asia region for year 2009.

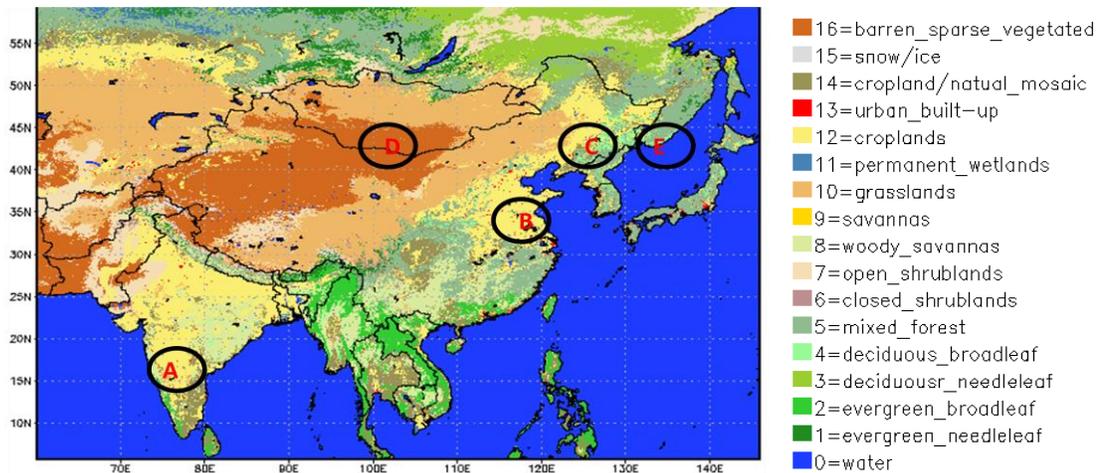


Figure 2: MODIS 5.6km Land Cover Types (IGBP) for year 2009. Image was generated from Giovanni

Vegetation growth relies largely on local climate. The seasonal variations of vegetation index are very different over different land cover types or over the same land cover type at different region. Figure 3 shows the time series of monthly NDVI over croplands at lower, middle, and higher latitudes, respectively; and over cropland, desert, and forest at similar latitude. The Giovanni generated monthly time series at selected locations were imported into Excel for plotting multiple lines.

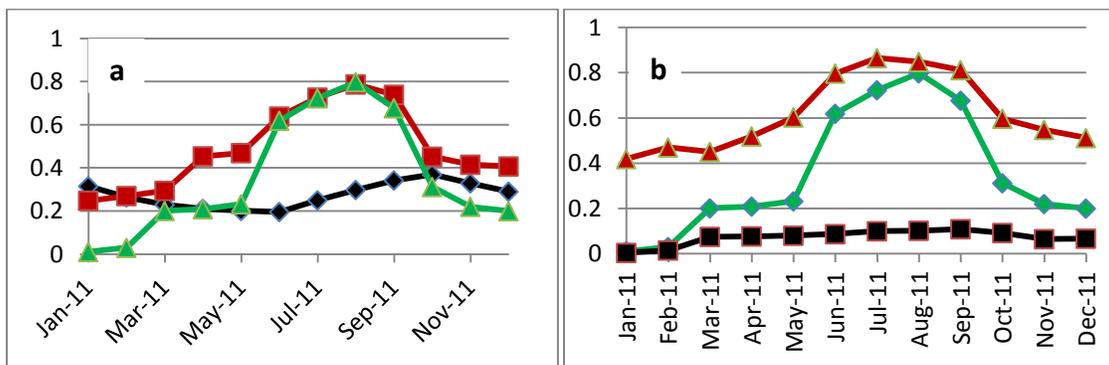


Figure 3: Time series of monthly NDVI: (a) over croplands at lower (**A=black**), middle (**B=red**), and higher (**C=green**) latitudes; and (b) over similar latitude for cropland (**C=green**), desert (**D=black**), and forest (**E=red**). The locations A, B, C, D, and E, associated with each time series is indicated on Figure 2.

2.2.4 Giovanni MAIRS Access Statistics

Access statistics of Giovanni portals are collected by NASA ESDIS Metrics System (EMS).

Figure 4 is the cumulated user views of Giovanni MAIRS and NEESPI from May 2009 to Apr

2012. One view denotes one user visit of the Giovanni result page, indicating one or more images are created through Giovanni system. Giovanni NEESPI portals were created in 2007-2008. More than 29,000 views are recorded in three years since May 2009 from both Giovanni NEESPI and MAIRS portals.

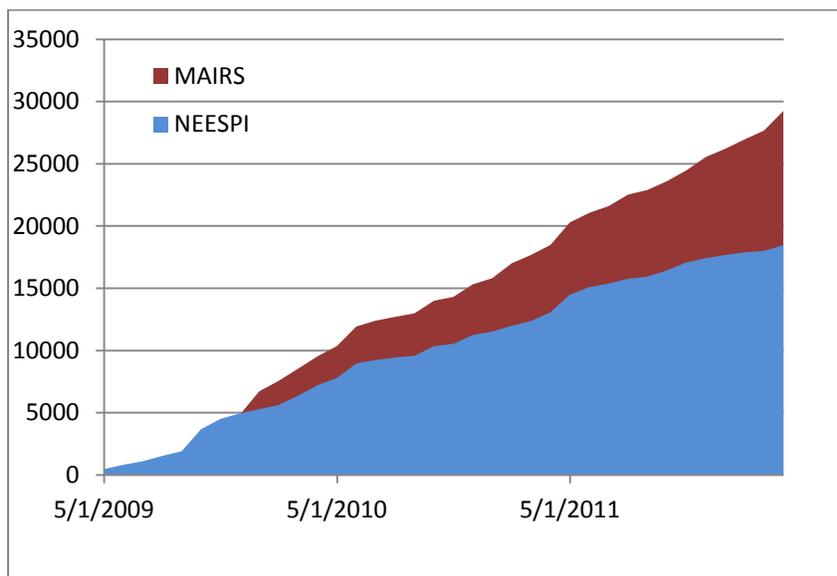


Figure 4: Cumulated views of Giovanni MAIRS and NEESPI portals

2.3 Products Processed and Archived at GES DISC

Total of 1.7 TB data (compressed) have been archived for this project. An automated system has been developed using the Simple, Scalable, Script-Based, Science Processing Archive (S4PA) at GES DISC to monitor remote data source, ingest and archive data routinely. The system populates the ftp directory, Mirador database, and Giovanni database automatically right after data are archived, enabling users to access and visualize data as soon as the data are available.

The following products are ingested and archived at GES DISC through S4PA by the NASA MAIRS project:

- **Land surface temperature from MODIS:** global monthly at 0.05° (5.6 km at Equator), global 8-day at 0.05° resolution, Monsoon Asia region 8-day at 1 km resolution;
- **Vegetation indices (NDVI and EVI) from MODIS:** global monthly at 0.05° resolution, global 16-day at 0.05° resolution, Monsoon Asia region monthly at 1 km resolution;
- **Land cover types from MODIS:** global yearly at 0.05° resolution, Monsoon Asia region yearly at 500 m resolution;
- **Land cover dynamic:** Monsoon Asia region yearly at 1 km resolution;

- *Surface albedo from MODIS*: global 8-day at 0.05° resolution;
- *Active fire from MODIS*: Monsoon Asia region 8-day at 1 km resolution;
- *Nighttime Lights from DMSP-OLS*: global yearly at 0.05° resolution; Monsoon Asia region yearly at 1 km resolution

The MODIS land products of 500m and 1km resolution downloaded from LP DAAC are 10 x10 degree tiled of sinusoidal projecteions data. In order to integrate the data into Giovanni, datasets are processed by using MODIS Reprojection Tool (MRT) release 4.0 from LP DAAC. First, the original data tiles (~50 tiles over the Asian monsoon region) at each time step were downloaded. Then, programs **mrtmosaic** and **resample** were run under batch mode with the following setting:

```

SPATIAL_SUBSET_TYPE = INPUT_LAT_LONG
SPATIAL_SUBSET_UL_CORNER = ( 60.0 60.0 )
SPATIAL_SUBSET_LR_CORNER = ( 0.0 150.0 )
RESAMPLING_TYPE = NN (nearest point)
OUTPUT_PROJECTION_TYPE = ER (equi-rectangular projection)
OUTPUT_PROJECTION_PARAMETERS = ( 6371007.181 0.0 0.0 0.0 0.0 0.0 0.0 0.0 )
0.0 0.0 0.0 0.0 0.0 0.0 0.0 )
DATUM = NoDatum
OUTPUT_PIXEL_SIZE = 1000

```

The above procedure mosaics and maps the data onto an equidistant cylindrical projection (or equirectangular projection) with nearest point sampling method. The output data file covers entire Asian Monsoon region (0° – 60°N, 60°E – 150°E).

The data quality of each grid point is retained with the input data. No quality filtering was performed in the data processing. **Readme documents** have been created for each processed products.

2.4 Data Search and Order through Mirador

A number of datasets are accessible through GES DISC Mirador system (<http://mirador.gsfc.nasa.gov/>). Mirador is a search and order Web tool developed by the GES DISC (Lynnes, et al, 2009). Mirador employs the Google mini appliance for metadata keyword searches to drastically simplify the user interface for acquiring data. Mirador supports search by keyword, time span, and location. Keywords can be parameter names; science discipline areas (such as Land Biosphere, and Land Temperature); instrument, sensor, or model names; or data product short names (such as *MOD14CM1*). Time spans can be specified in any unambiguous way (e.g. *Sep 1, 2005* or *9/1/05*). Location can be specified by area name (e.g. Asia) or by geographic coordinates. Event search allows a user to search by an event name including hurricanes named storms, cyclones, and typhoons; as well as volcanoes, and air pollution events (dust storms). Other features include quick response, data file hit estimator, and an interactive shopping cart.

In addition, products searchable in Mirador system have been added into NASA global change master directory (GCMD) system for general searching purpose.

2.5 Items Differ from Original Proposed

Based on interactions with MAIRS and NEESPI researchers, we have dropped two proposed products: yearly Vegetation Conversion- Continuous Fields (MOD44B), and monthly Burned Area (MCD45A1), but integrated the following products not on the initial list:

- Global land product at 5.6km resolution: monthly and 16day mean of NDVI and EVI from MODIS-Terra (MOD13C2.005, MOD13C1.005); monthly and 8day mean of Land surface temperature (MOD11C3.005, MOD11C2.005), 16day composite of surface albedo (MCD43C3.005); land cover types (MCD12C1.005).
- Generated global monthly climatology at 1x1 degree resolution: NDVI, EVI, land surface temperature. They are integrated into Giovanni system for climatology and anomaly study.
- Ocean data: monthly chlorophyll-a concentration, sea surface temperature, Colored Dissolved Organic Matter (CDOM), and Euphotic depth from MODIS-Aqua are integrated into MAIRS Giovanni for supporting coastal Mega-city studies.
- GPCP precipitation: in addition to monthly TRMM precipitation data, the monthly GPCP and GPCP climatology data have been integrated into MAIRS Giovanni for its high quality, long temporal and larger spatial coverage. The GPCP data begins from Jan 1979 with global coverage.

We did not create a MAIRS Giovanni portal for daily products. Instead, we have created a link from the MAIRS visualization portal to the existing Giovanni portals that contains proposed data, such as meteorology data from MERRA, trace gases from OMI, and precipitation from TRMM.

2.6 Support Partner to Create Data Sharing Infrastructure

- Google Earth visualization portal: Developed an online portal prototype to access climate data and images from multiple data sources by using Google Earth and online data sharing technologies, such as WMS, GDS, and OPeNDAP. The portal is installed on MAIRS regional partner's system at Nanjing University of Information Science & Technology (NUIST), China (<http://nadsc.nuist.edu.cn/mairsprogram/data/mairs.kml>), which is a result of collaboration between the NASA GES DISC MAIRS project and NUIST. A user can access simultaneously the station data archived on the local server (NUIST) and the remote sensing and model data from NASA along with Google Earth geographic information to conduct climate studies (Sun, et al. 2011).
- Mirror data site: Transferring data directly from GES DISC is slow from many cities in Asia, due to the narrow bandwidth of the local network. NUIST has downloaded selected products

from GES DISC and created a mirror data site for MAIRS scientists. The data are stored offline and has been distributed as requested since summer 2011. The data product list and request form is available online (<http://nadsc.nuist.edu.cn/Eindex.php>). Within the first six months, data were requested by students and professors of more than ten projects and downloaded more than 180 GB data from this mirror site.

3 Milestones

- 10/2009 Released Giovanni MAIRS for coarse resolution global monthly products (mairs_monthly)
- 11/2009 MAIRS project portal released
- 02/19/2010 Added more chemistry products into Giovanni (mairs_monthly)
- 07/2010 Processed 8-day 1km resolution LST
- 11/2010 Release Giovanni portal mairs_8day, containing MODIS LST
- 12/2010 Added GPCP climatology to Giovanni mairs_monthly
- 03/2011 Release Giovanni portal mairs_monthly_hres for 1km NDVI/EVI
- 01/2012 Released Giovanni portal mairs_yearly for land cover types
- 01/2012 Added 1km 8-day active fire mask into mairs_8day
- 02/2012 Process and archived five global 5.6km MODIS data(MOD13C1.005, MOD13C2.005, MOD11C2.005, MOD11C3.005, MCD43C3.005)
- 02/2012 Added five MODIS global 5.6km products into Giovanni
- 03/2012 Generated monthly climatology for LST and NDVI/EVI at 1x1 degree resolution and added into Giovanni
- 03/2012 Processed DMSP/OLS nightlight data and integrated into Giovanni
- 04/2012 Added MODIS land cover dynamics to Giovanni

4 Activities (visiting/conference/workshop/publication)

4.1 Collaboration Activity

We have been interacting with the following Science teams/members of the MAIRS program:

- Prof. Jiang, Zhihong at NUIST, China, to study urbanization and climate by using MODIS data, results submitted to journal;
- Prof. Guo, Weidong at Nanjing University, provided customized MODIS land data at experiment sites over semi-arid region northern China remote sensing data;
- Prof. Pasha Groisman at NCDC/NOAA, to evaluate potential use of data for drought monitoring, submitted a NASA proposal;
- Prof. Katherine Morton at Australian National University, for applying NASA remote sensing data to develop a climate change adaptation framework to guide livelihood improvement and regional cooperative efforts across the Himalaya-Tibetan Plateau (HTP), submitted a APN proposal;
- Prof. Irina Sokolik at Georgia Institute of Technology, initiated potential collaboration of using NASA remote sensing data to conduct LCLUC synthesis study over Central Asia, submitted a NASA proposal;

- Visited NUIST in Oct 2009, introduced NASA remote sensing data to MAIRS project scientists, students, and discuss details about collaboration with partner;
- Participated summer training program, July 2010 Beijing, on Land surface observation, modeling, and data assimilation.

4.2 Funded Students/Researchers

GES DISC MAIRS project hosted a visiting graduate student from NUIST, Xiaojuan Sun, for three months from September to December 2010. During the period, Xiaojuan learned about techniques for online data sharing. Under the supervise of Dr. Suhung Shen, she created a prototype to access remote sensing and ground station measured climate data and images from multiple data sources by using Google Earth and online data sharing technologies, such as WMS, GDS, and OPeNDAP.

4.3 Project Papers Published and Presented on Conferences

4.3.1 Published Papers

1. 2009, Shen, S., G. Leptoukh, T. Loboda, I. Csiszar, P. Romanov, I. Gerasimov: The NASA NEESPI Data Portal to Support Studies of Climate and Environmental Changes in Non-boreal Europe, Chapter of book “Regional aspect of climate-terrestrial-hydrologic interactions in non-boreal Eastern Europe”, 7-14, pp252.
2. 2011, Sun, x. S. Shen, G. Leptoukh, P. Wang, L. Di., M. Lu, Development of a Web-based Visualization Platform for Climate Research Using Google, Computers and Geosciences, 10.1016/j.cageo.2011.09.010
3. 2011, Shen S., G. Leptoukh, Estimation of surface air temperature over central and eastern Eurasia from MODIS land surface temperature, Environ. Res. Lett., **6** (2011) 045206, doi:10.1088/1748-9326/6/4/045206
4. 2011, Suhung Shen, Gregory Leptoukh, Hongliang Fang, NASA Satellite and Model Land Data Services: Data Access Tutorial, Chapter 5 in book: Land Surface Observation, Modeling and Data Assimilation, accepted.
5. 2011, Suhung Shen, Gregory Leptoukh, Hualan Rui, Jianfu Pan, Keith Bryant, Irina Gerasimov, Ivan Csiszar, Peter Romanov, Tatiana Loboda, GIOVANNI Data and Information System for the NEESPI Domain, Chapter 8.2 in book: Environmental Changes in Siberia: Regional Changes and their Global Consequences, accepted.

4.3.2 Presentations on Conferences

1. 2009, Shen, S. Leptoukh, G., Gerasimov, I. (2009). NASA Data and Services to Support MAIRS, 2nd MAIRS International Workshop on Asian Dryland Study, Changchun, China, July 23-25 2009
2. 2009, Shen, S. Leptoukh, G. (2009). Introduction of NASA Data and Services, Invited talk at Nanjing University of Information Science & Technology, Nanjing, China, Oct. 27, 2009
3. 2009, Leptoukh, G., Shen, S., Gerasimov, I. (2009). NASA Data and Services Supporting Monsoon Asia Integrated Regional Study in Eastern Asia . *Joint NASA LCLUC Science*

Team Meeting and GOF-C-GOLD/NERIN, NEESPI, MAIRS Workshop , Sep 15-19, 2009, Almaty, Kazakhstan

4. 2009, Shen, S. Leptoukh, G., Gerasimov, I. (2009). NASA Satellite and Model Data and Services to Support NEESPI and MAIRS Projects, AGU 2009 Fall San Francisco, CA December 14-19 2009
5. 2009, Leptoukh G. G; C. Lynnes, P. A. Fox, A. I. Prados, S. Shen, S. Zednik, P. West, D. J. Lary, Multi-Sensor Data Synergy Advisor, AGU 2009 Fall San Francisco, CA December 14-19 2009
6. 2010, Shen, S. G. Leptoukh: Utilizing Higher Resolution Land Surface Remote Sensing Data for Assessing Trends over Asia Monsoon Region, MAIRS DRYLAND WORKING GROUP ON COUPLED HUMAN-ENVIRONMENT SYSTEMS, Mar 22-25 2010, Kunming, China
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5 Conclusion

We have achieved our proposed goal that integrates NASA higher resolution (1km over MAIRS region, and 5.6km global) land products from MODIS into Giovanni system for MAIRS and other scientists. Additional Giovanni features were developed outside of the MAIRS project to enrich the current portal. New version of data might be added to the system when they become available.

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