Draft

2020-2022 GEO Work Programme Activities
(Community Activities)

GEO Multi-source Synergized Quantitative Remote Sensing Products
and Services (GEO MUSYQ)

Contents

1. Executive Summary

● Full title of the Community Activity: **GEO Multi-source Synergized Quantitative Remote Sensing Products and Services.**

● Short title or acronym: **GEOMUSYQ.**

● Proposed or existing category: **Community Activity.**

● **Overview**

    GEO Multi-source Synergized Remote Sensing Products and Services has been included in 2017-2019 GEO Work Programme as a Community Activity. Since 2016, it has delivered more than 10 kinds of long time series global biophysical parameter products by synergizing multi-sensor datasets, including MODIS-Terra/Aqua, MERSI-FY3A/B/C, and VIRR- FY3A/B/C. Building on previous achievements, **GEO MU**lti-source **SY**nergized **Q**uantitative Remote Sensing Products and Services (GEOMUSYQ) will enhance data sharing and collaboration to provide analysis ready data in 2020-2022.

● **Planned activities include:**

    1) **Continue** the normalization or standardization of multi-source remote sensing data, especially for Chinese satellite data.

    2) Improve the inversion algorithms for Multi-source Synergized Quantitative Remote Sensing Products.

    3) Develop the global quantitative remote sensing product validation network

    4) Promote the sharing of quantitative remote sensing data products, user service and training courses.

● **Points of Contact:**

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2. Purpose

    As more and more Earth Observation (EO) data accumulated, many countries have developed kinds of remote sensing product generation system based on different satellite series. However, the different remote sensing products are inconsistent and cannot satisfy the application requirements, which become one key bottleneck to restrict the high-level application of EO data. GEOMUSYQ is to promote not only the access to the data, but the technology and standards to support the Multi-source Synergized Remote Sensing Data Processing, Common Product Generation, Global Product Evaluation and Validation.

    GEOMUSYQ is following the existing Community Activities in the GEO 2017-2019 Work Programme, which has formed the standardized processing ability of 24 kinds of sensors data. As the rapid development of Chinese remote sensing satellites, there are more and more application potential to support the three GEO priorities areas due to the constantly improved spatial and temporal resolution. GEO MUSYQ will focus on:

    - Multi-source remote sensing satellites data normalization or standardization, especially for Chinese satellites data;

    - improve the accuracy and consistency of quantitative remote sensing product synergizing multi-source remote sensing data;

    - Establish an operational common quantitative remote sensing product validation network;

    - Promote collaboration for the data sharing and application of quantitative remote sensing products;

3. Background and Previous Achievements

"Multi-source Synergized Remote Sensing Products and Services" has been included in 2017-2019 GEO Work Programme Since 2016, which has delivered more than 10 kinds of long time series of global biophysical parameter products by synergizing multi-sensor datasets include MODIS-Terra/Aqua, MERSI-FY3A/B/C, and VIRR- FY3A/B/C. The global biophysical parameter products include Aerosol Optical Thickness, Vegetation Index, Leaf Area Index, Fractional Vegetation Coverage, Land Surface Reflectance, Fraction of Photosynthetic Active Radiation, Photosynthetic Active Radiation /Downward Shortwave Radiation and Net Primary Productivity from 2010-2015. The multi-source remote sensing data normalization or standardization, terrestrial parameter retrieval algorithms development and product validation have been conducted by the partners. The financial support comes from several related projects of the Ministry of Science and Technology of China, Natural Science Foundation of China, Chinese Academy of Sciences et al.

We have published LAI, NDVI, FVC, Land Surface Reflectance, NPP, PAR, DSR datasets over China and the Association of Southeast Asian Nations and in the Belt and Road and Surround Region on the Global Change Research Data Publishing & Repository (http://www.geodoi.ac.cn/WebEn/Default.aspx). The datasets also have been shared on ChinaGEOSS Data Sharing Network(http://www.chinageoss.org/geoarc/en/news/DataSet.html). Sharing of all datasets will be completed in 2019.

The global common quantitative remote sensing product list

Products	Temporal resolution	Data source	Spatial Resolution/Coverage	Status
EVI	5 days	MODIS,MERSI,VIRR	1km/China and the Association of Southeast Asian Nations/2013	Published
			1km/global/2010-2015	To be published
LAI	5 days	MODIS,MERSI,VIRR	1km/China and the Association of Southeast Asian Nations/2013	Published
			1km/the Belt and Road and Surround Region/2010-2015	Published
			1km/global/2010-2015	To be published
FVC	5 days	MODIS MERSI VIRR	1km/China and the Association of Southeast Asian Nations/2013	Published
			1km/the Belt and Road and Surround Region/2010-2015	Published
			1km/global/2010-2015	To be published
NPP	5 days	GEOS, MTSAT, MSG, FY2E	1km/China and the Association of Southeast Asian Nations/2013	Published
			5km/global without polar region /2010-2015	To be published
LSR	5 days	MODIS MERSI VIRR	1km/China and the Association of Southeast Asian Nations/2013	Published
			1km/global/2010-2015	To be published
PAR	3hours/ daily	GEOS, MTSAT, MSG, FY2E	5km/China and the Association of Southeast Asian Nations/2013	Published
			5km/global/2010-2015	To be published
DSR	3hours/ daily	GEOS, MTSAT, MSG, FY2E	5km/China and the Association of Southeast Asian Nations/2013	Published
			5km/the Belt and Road and Surround Region/2015	Published
			1km/global/2010-2015	To be published
DLR	3hours/ daily	GEOS, MTSAT, MSG, FY2E	1km/global/2010-2015	To be published
AOT	---	MODIS,MERSI,VIRR	1km/global/2010-2015	To be published
BRDF/Albedo	5days	MODIS,MERSI,VIRR	1km/global/2010-2015	To be published
FPAR	5days	MODIS,MERSI,VIRR	1km/global/2010-2015	To be published

The key philosophy of GEOMUSYQ is to integrate multi-sensor data to achieve high accuracy and good spatial-and-temporal continuous common remote sensing products. All the dataset has been shared by GEO portal to support different applications. For example, GEO MUSYQ have supported GEOARC and AOGEOSS for the global ecosystem environment monitoring and analyzing, which include several typical ecological environment elements and hot environment issues. GEOMUSYQ products have been directly used to support the TG 7 'Environment Monitoring and Protection' in AOGEOSS to evaluate the environmental status of Asia and Oceania region. The products have also been utilized to serve for the annual GEOARC (Global Ecosystems and Environment Observation Analysis Report Cooperation) report as the major data source.

Furthermore, we have organized several international conferences and training workshop to promote the GEOMUSYQ and the leader and partners have been invited by different organizations and universities to present the related work. With such exchanges and communications, the MUSYQ has engaged the users, attracted potential users and meanwhile enquiry the users' demands for further improvements.

4. Key Activities

GEOMUSYQ collaboratively uses multi-source data to produce multi-scale global common remote sensing products and provide application services. It is to improve the Multi-source Synergized Quantitative Remote Sensing Production System (MuSyQ), to generate a long time series of common quantitative remote sensing products, to promote the remote sensing product validation network. GEOMUSYQ is open for public and provides service for all kinds of users.

16 categories of global products at 1km spatial resolution and 7 categories for Chinese area at 30 m resolution of 12 years (2009-2020) is planned to be produced and released before 2022. A new product releasing platform will be provided. The platform will have a variety of service functions, such as dynamic display of product thematic maps, product time series change analysis and data download services. The platform will also develop online computing function to support system and user provided algorithms.

Intended users of global quantitative remote sensing products are agricultural, forestry, ecological and other application domain users. Intended users of consultation reports on monitoring ecological environment and energy balance are the public and government decision-making departments. Intended users of product releasing platform for multi-source fusion remote sensing data and remote sensing products are scientific researchers and application departments.

The schedule activities in 2020-2022 will include:

(1)　Algorithms of Multi-source Synergized Quantitative Remote Sensing Products

▢ 23 categories Algorithms including Land Cover, Vegetation Index (VI), Fraction of Vegetation Cover (FVC), Leaf Area Index (LAI), Fraction of Photosynthetically Active Radiation (FPAR), Gross Primary Productivity (GPP), Net Primary Productivity (NPP), Surface roughness, Land Surface Albedo (LSA), Land Surface Temperature (LST), Upward Longwave Radiation, Aerosol Optical Depth (AOD), Atmospheric water vapor content, Downward Shortwave Radiation (DSR), Downward Longwave Radiation (DLR), Photosynthetically Active Radiation (PAR).

▢ Algorithms design, programme and validation.

▢ Conference for Quantitative Remote Sensing Products algorithms in 2020.

(2)　Normalization or Standardization of multi-source remote sensing data and Products

▢ Standardize coarse, moderate and high-resolution images, including GF1, GF6, HJ1A/1B, Sentinel-2, FY4A, MSG3/4, Himawari 8 AHI, NPP, Sentinel-3 etc.

⦿ Integrate pre-processing and products algorithms into Multi-source Synergized Quantiative Remote Sensing Production System.

⦿ Improve system performance. Change the cluster management and production to cloud computing; Support system and user provided algorithms online computation.

⦿ Produce 16 categories of global products at 1km spatial resolution and 7 categories for Chinese area at 30 m resolution of 12 years (2009-2020).

(3)   Develop the global Product Evaluation and Validation Network

⦿ Develop reliable validation techniques to infer ground truth data at pixel level over heterogeneous land surfaces.

⦿ Design and coordinate a worldwide validation network composed of a certain amount of well characterized reference sites in China and other countries.

⦿ Establish a platform and system to realize operational validation activities.

⦿ The validation system and network will join in Land Product Validation (LPV)

(4)   Products releasing platform, user service and training courses

⦿ Advance products sharing through China GEO data center. Provide download services, dynamic display of thematic products and temporal change analysis service.

⦿ Promote the data publishing of the quantitative remote sensing products

⦿ Develop application demonstration and services for radiation budget, ecosystem services, agriculture, forests, climate change and carbon etc.

⦿ Host the international workshop on Quantitative Remote Sensing Modeling and inversion for Heterogeneous Land Surface.

⦿ Participate in The International Conference of Asia-Oceania GEO (AOGEO) &The International Training Workshop.

5. Relationship to GEO Engagement Priorities and to other Work Programme Activities

As the only macroscopic observation method, remote sensing has been widely used in the study of global change, and many research results have been achieved. However, the existing remote sensing products of global change parameters are not precise enough to meet the needs of the analysis and attribution of global change characteristics, radiation forcing, ecological environment and surface response of global climate change. GEOMUSYQ will make full use of the advantages of Chinese and others' satellites data, and form long time series, high spatial-temporal resolution global change products which can provide status and change monitoring data on land surface temperature, land cover, Fraction of Vegetation Cover etc. for service to SDG3,11,13, 15.

SDG 7 requires to ensure access to affordable, reliable, sustainable and modern energy for all. And solar energy is the cleanest and an inexhaustible source of energy. GEOMUSYQ can provide downward shortwave radiation products for the calculation of solar power generation potential. In fact, this product has been applied in the GEOARC to analyze the potential of solar energy of the 'Belt and Road' region. GEOMUSYQ serves SDG7 by providing long time series and global distribution data of solar energy resources.

Parties need to regularly provide a national inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases in the Paris Agreement. GEOMUSYQ is dedicated to answering the carbon sinks issues through remote sensing products such as Gross Primary Productivity and Net Primary Productivity products.

GEOMUSYQ will also continue to work with other GEO work programmes to expand the application of remote sensing products and enhance response to GEO engagement priorities. GEOMUSYQ will provide data support for the remote sensing monitoring of ecosystem and environment and radiation budgets in the GEOARC Community Activities. GEOMUSYQ also provides global and Asia-Oceania area remote sensing products for AOGEO.

6. Governance

GEO MUSYQ consists of leader and four working groups. The four GEO MUSYQ working groups address topics such as multi-source synergized remote sensing products algorithms, standardization and coordination of remote sensing data, validation, data portals, application service and training.

1) The GEO MUSYQ Leader

GEO MUSYQ leader is the primary interface for all external coordination. The leader reports to GEO annually and ensures that the guidance and direction are appropriately. The leader presides over the three working group and the GEO MUSYQ Secretariat.

2) The Working Group on Products Algorithms

This group coordinates and encourages collaborative activities on Inversion Algorithms research of Quantitative Remote Sensing Products with the overarching goal to improve the accuracy of products algorithms and enhance the utilization of multi-source remote sensing data.

3) The Working Group on data Standardization and Product Generation
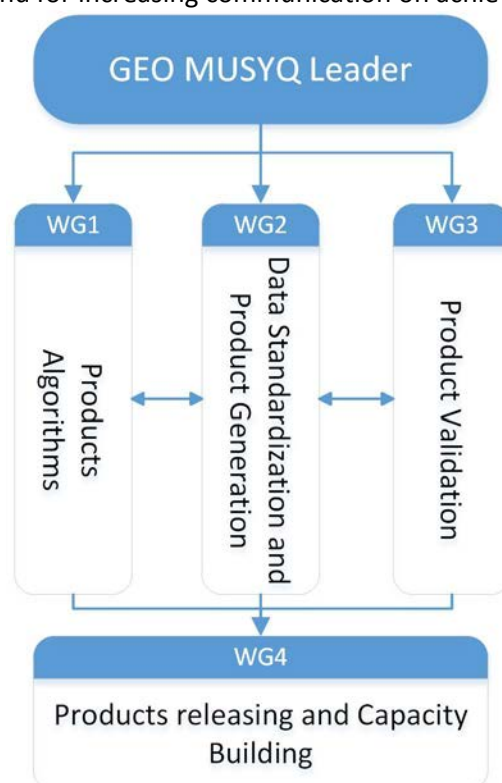
The working group promotes collaboration in the management the multi-source remote sensing data and aims to standardize these data. The group also addresses the delivery of products.

4) The Working Group on Product Validation

The mission of this working group is to ensure long-term confidence in the accuracy and quality of GEO MUSYQ products and to provide a system platform to share validation data. Organize related activities to attract teams in the research of validation data acquisition and validation methods to participate.

5) The Working Group on Products releasing and Capacity Building

The working group aims to provide easier access and download to GEO MUSYQ products data, increase dynamic display and temporal change analysis of product results, provide application demonstration and training for enabling end users to gather the information they need and for increasing communication on achieved results.

GEO MUSYQ organizational structure

7. Data Policy

As an effective means of global change monitoring, multi-source remote sensing data has been paid more and more attention. GEOMUSYQ standardizes the remote sensing data of many sensors, especially Chinese sensors, and transforms the data into knowledge for sharing. The products releasing platform will be developed. Then the quantitative remote sensing products based on standardized raw data should be download for free. The product data will be stored in the international common format HDF5 format and data reading tools will be provided at the same time. The platform will use visual interface to provide online computing services for users' individualization requirements.

The outputs of GEOMUSYQ in 2020-2022 will include:

⬚ A product generation system using GF1, GF6, HJ1A/1B, Landsat/TM, Sentinel-2, FY4A, MSG3/4, Himawari 8 AHI, NPP, Sentinel-3 MODIS, FY3/MERSI & VIRR, AVHRR, to produce 23 categories of remote sensing products.

⬚ 16 categories of global products at 1km spatial resolution and 7 categories for Chinese area at 30 m resolution of 12 years (2009-2020).

⬚ A Global validation network where the core observation sites are the Huailai Station, the Hulunber Station, the Heihe Station and the Jingyuetan Station.

⬚ A product releasing platform for products downloading and online computing.

Tables
A. Individual Participants

Name	Organization	Email	Nationality	Contribution
The GEO MUSYQ Leader				
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The Working Group on Products Algorithms				
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Thomas.Painter	NASA	Thomas.Painter@jpl.nasa.gov	USA	Data processing
Sun Genyun	UPC	genyunsun@163.com	China	Data processing
The Working Group on Product Validation				

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Fang Hongliang				
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B. Confirmed Contributions

GEOMUSYQ will receive financial support from related projects from the Ministry of Science and Technology of China. These sources have well-supported the operation and further development of GEO MUSYQ.

1) The project in National Key R&D Plan from the Ministry of Science and Technology named 'Study on the key data in the global change based on domestic satellites observations' with a financial support of 9.58 million RMB from 2018 to 2021.

2) The project in National Key R&D Plan from the Ministry of Science and Technology named 'Stereoscopic observation and inversion of key parameters of global ecosystem carbon cycle' with a financial support of 3.80 million RMB from 2018 to 2021.

Annexes

I. Acronyms and abbreviations

Chinese Academy of Sciences (CAS, China)
National Oceanic and Atmospheric Administration (NOAA, USA)
Peking University (PKU)
Boston University (BU, USA)
French National Institute for Agricultural Research (INRA)
University of Technology Sydney (UTS, Australia)
US Department of Agriculture (USDA, USA)
Wuhan University (WHU)
South Dakota State University (SDSU, USA)
National Satellite Meteorological Centre (NSMC)
George Mason University (GMU, USA)
Instituto Português do Mar e da Atmosfera (IPMA, Portugal)
Solar Consulting Services (SCS, USA)
Science Systems and Applications, Inc. (SSAI, USA)
MINES ParisTech (France)
Geoscience Australia (GA, Australia)
China Centre for Resources Satellite Data and Application (CCRSDA, China)
National Research Council, Rome (NRC, Italy)
University College London (UCL, UK)
National Aeronautics and Space Administration (NASA)
China University of Petroleum (UPC)
University of Maryland (UMD)
Research Institute of Forest Resource and Information Techniques (IFRIT/CAF/China)
Goddard Space Flight Center (GSFC)
Beijing Normal University (BNU)
Chinese Academy of Agricultural Sciences (CAAS, China)
Beihang University (BUAA)

II. Brief CV of Project Leader(s)

Qinhuo Liu, received the B. Sc. degree in Hydrogeology and Engineering Geology in 1988 from Southwest Jiaotong University, the M. Sc. degree in Cartography and Remote Sensing in 1994 and the Ph. D. degree in Atmospheric Physics in 1997 from Peking University. He had been worked with the Institute of Remote Sensing Applications, Chinese Academy of Sciences from 1997 to 2012. He worked as visiting scholar with INRA of France in 1998, with Boston University in 1999, with University of Maryland in 2004, with George Mason University in 2010 and University of Technology, Sydney in 2014.

He is a Professor, Executive Deputy Director of the State Key Laboratory of Remote Sensing Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences. He is also with the University of Chinese Academy of Sciences. His research interest focuses on radiation transfer modeling for optical remote sensing, terrestrial parameter inversion from multi-source remote sensing data, and quantitative remote sensing applications for land surface energy balance and ecosystem. He has published more than 250 SCI papers. He is a senior member of the IEEE Geoscience and Remote Sensing Society (IEEE GRSS).

He is currently the leader of the existing Community Activities (Multi-source Synergized Remote Sensing Products and Services), and the task group leader of TG 7 (Environment Monitoring and Protection) of AOGEOSS.