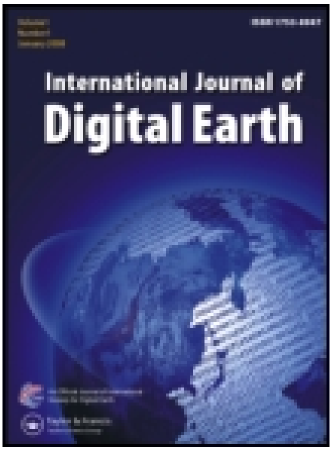

International Journal of Digital Earth
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tjde20

Recent progress in land remote sensing: algorithms and products

Shunlin Liang[ab], Ainong Li[c] & Jianchang Shi[d]

[a] State Key Laboratory of Remote Sensing Science, College of Global Change and Earth System Science, Beijing Normal University, Beijing 100875, China

[b] Department of Geographical Science, University of Maryland, College Park 20742, MD, USA

[c] Institute of Mountain Hazards and Environment, Chinese academy of Sciences, Chengdu 610041, China

[d] State Key Laboratory of Remote Sensing Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing 100094, China

Published online: 13 Dec 2013.

To cite this article: Shunlin Liang, Ainong Li & Jianchang Shi (2013) Recent progress in land remote sensing: algorithms and products, International Journal of Digital Earth, 6:sup1, 1-4, DOI: 10.1080/17538947.2013.846995

To link to this article: http://dx.doi.org/10.1080/17538947.2013.846995

International Journal of Digital Earth, 2013
Vol. 6, Supplement 1, 1–4, http://dx.doi.org/10.1080/17538947.2013.846995

EDITORIAL

Recent progress in land remote sensing: algorithms and products

During the past half century, since the launch of the first meteorological satellite in April 1960, satellite remote sensing technologies for observing the Earth have made great advances. Today, more than 200 Earth observing satellites are in obit and substantial progress has been achieved in extracting land surface information from many of their observations.

The National Aeronautics and Space Administration (NASA)'s Earth Observing System marks a new era of land remote sensing. One of its distinguishing features is the ability to generate high-level land products from most satellite missions. Thus, users can obtain not only satellite imagery with appropriate geometric and radiometric calibration and correction, but also many biogeophysical parameters that characterize land surface conditions. Generating high-level biogeophysical products has been driven by several factors. First, although huge quantities of satellite observation data from different missions have been generated, many ordinary users are unable to process them effectively. Second, different types of satellite data require sophisticated radiative transfer models and inversion algorithms to extract accurate land surface information. Third, many applications require a set of common preprocessing and analysis that should not be repeatedly done by individual users. Therefore, researchers with special skills and knowledge and a central processing facility have produced different high-level land products.

The user communities have expressed their need for high-level land products. For example, the Global Climate Observing System (GCOS) identified 50 Essential Climate Variables (ECVs) to support the work of the United Nations Framework Convention on Climate Change and the Intergovernmental Panel on Climate Change (GCOS 2010). All ECVs are technically and economically feasible for systematic observation, but many land surface-related ECVs can be monitored at different spatial scales by satellite remote sensing. These include surface radiation budget, snow cover, glaciers and ice caps, ice sheets, albedo, land cover (including vegetation type), fraction of absorbed photosynthetically active radiation, leaf area index (LAI), above-ground biomass, and soil moisture.

The instantaneous estimates of geophysical variables retrieved in near real-time using only information from the past satellite observations are called Environmental Data Records (EDR). Many EDRs are being generated by the operational agencies, such as National Oceanic and Atmospheric Administration (NOAA). For scientific research, science-quality time series data records are known as Earth System Data Records.

Most land products are generated from specific mission-oriented satellite data. Since each satellite has a limited life span, many biogeophysical parameters cover only limited periods of time. However, long-term products are needed for climate change and environmental change studies. A Climate Data Record (CDR) is defined by the National Research Council as a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change (NRC 2004). Efforts are currently under way to generate CDRs, such as NOAA's National Climatic Data Center satellite CDR program (http://www.ncdc.noaa.gov/cdr/operationalcdrs.html).

To assess the progress and identify the future research directions of land remote sensing, the *First International Conference on Land Remote Sensing: Algorithm and Product* was held in Chengdu, China, 30 May through 1 June 2012. More than 150 people attended this conference which featured eight sessions: land surface albedo, skin temperature and emissivity, LAI, biomass, incident solar radiation, soil moisture, and energy budget and phenology. Selected papers will be published in three special issues: *The International Journal of Digital Earth*, *The Journal of Mountain Science*, and *The Journal of Remote Sensing*.

The eight papers selected for this special issue are outlined below.

Liang et al. (2013) describe an effort for producing long-term land products from multiple satellite data in China. They have released five Global LAnd Surface Satellite (GLASS) products, including LAI, shortwave broadband albedo, longwave broadband emissivity, incident short radiation and photosynthetically active radiation (PAR). The first three products cover from 1981 to at present (was from 1981–2010) at 1–5 km and 8-day resolutions, longest similar products in the world. This paper also demonstrates the high quality and accuracy of the GLASS products through validation and also identifies potential applications and some analysis examples of these products.

Liu et al. (2013) present further details of the GLASS albedo product, which originally covered 1981–2010 but has now been extended to present. The paper introduces the algorithms and then analyzes the quality of the GLASS albedo product. It further demonstrates that the GLASS albedo product is spatially and temporally continuous and self-consistent with a comparable accuracy with the Moderate Resolution Imaging Spectroadiometer (MODIS) albedo product.

Huang et al. (2013) provide the validation results of the GLASS shortwave radiation product using surface measurements in arid and semi-arid regions of China. A more sophisticated validation scheme has been developed to reduce the impact of many other factors. Results indicate that the GLASS shortwave radiation products are considerably accurate over most parts of arid and semi-arid regions in China, but in complex terrain areas the products may need further refinements.

Cheng and Liang (2013) describe the algorithms and validation results of the GLASS longwave emissivity product from the Advanced Very High Resolution Radiometer visible and near infrared data during 1985–1999. The retrieved emissivity values were first compared with values derived from the MODIS data, then with those derived by the normalized difference vegetation index (NDVI)-threshold method. The results indicate the GLASS longwave emissivity product is highly consistent for the entire period.

Dong et al. (2013) validate the GLASS longwave emissivity product with multi-point field measurement data using infrared radiometry in China. Very few ground measurements of surface longwave emissivity were available in the remote sensing community. The GLASS longwave emissivity product was validated over bare surfaces with field measurement data from sand samples collected at many pseudo-invariant sand dune sites in western/northwestern China. These results indicate that the GLASS emissivity product is very accurate over arid and semi-arid regions, and for most deserts such as the Taklimakan Desert.

The GLASS products have been demonstrated to be more accurate than the MODIS corresponding products. Besides the new inversion algorithms compared to the MODIS algorithms typically developed before 2000 with constant refinements, further preprocessing of the MODIS surface reflectance product was the key. Tang et al. (2013) introduce a new cloud detection algorithm based on the relative stability of ground reflectance and the quick variations of reflectance result from cloud cover. It shows the improvements over the MODIS algorithm.

Land surface temperature (LST) is another key variable in radiation and energy budgets. Wu et al. (2013) present a new spatial-temporal fusion method for retrieving LST at high spatial and temporal resolutions. The method was tested and assessed quantitatively using Landsat TM/ETM+, MODIS, and the GOES Imager data. The validation results indicate that the proposed multi-sensor fusion method performs well.

A paper by Sun et al. (2013) presents an improved Penman–Monteith method for estimating evapotranspiration (ET) of land surfaces. It incorporates a soil moisture index, derived from the improved surface temperature–vegetation cover feature space. Validation results indicate that it improves the most over sparse vegetation covers.

The land remote sensing community is faced with continuing challenges. Immense amounts of data available from satellite observations offer promise yet also require efficient and effective inversion algorithms. Considerable investments were put into developing physical models to understand surface radiation regimes in early years, but few people now are developing realistic and computationally simplified surface radiative transfer models mostly suitable for inversion of land surface variables from satellite data. Such models are urgently needed. State-of-the-art remote sensing inversion is well advanced, but the use of regularization methods by incorporating a-priori knowledge and integrating multiple-source data from different spectra and instruments deserves further research. More efforts are needed to develop various land CDRs. The good news is that the second phase of the GLASS project, which aims to produce a total of 12 GLASS products including evapotranspiration, and gross primary productivity, has begun. Validating, intercomparing and eventually integrating multiple products of the same biogeophysical variable are also needed.

Acknowledgments

We are very grateful for our sponsors: State Key Laboratory of Remote Sensing Science, Beijing Normal University, Institute of Mountain Hazards and Environment of Chinese Academy of Sciences, and University of Maryland for their sponsorship for the first International Symposium on Land Remote Sensing: Algorithm and Products. We are indebted to many colleagues for their assistance in organizing this meeting, especially Ms. Hongmin Zhou, Ms. Liya Ma, Ms. Yuzheng Wang, and Ms. Bo Kong. We would like to thank Prof. Changlin Wang, Executive Editor of *the International Journal of Digital Earth* (IJDE), for his encouragement and advice, and Ms. Zhen Liu of the IJDE Editorial Office for her assistance. All authors and editors would also like to thank anonymous reviewers for their constructive comments on the papers.

Funding

This work was partially supported by the 'Generation and Application of Global Products of Essential Land Variables' project funded and managed by the National Remote Sensing Center of China, Ministry of Science and Technology of China [grant number 2009AA122100].

References

Cheng, J., and S. Liang. 2013. "Estimating Global Land Surface Broadband Thermal-infrared Emissivity from the Advanced Very High Resolution Radiometer optical data." *International Journal of Digital Earth*. 6 (S1): 34–49. doi:10.1080/17538947.2013.783129.

Dong, L., J. Hu, S. Tang, and M. Min. 2013. “Field Validation of GLASS Land Surface Broadband Emissivity (LSBE) Database Using Pseudo-invariant Sand Dune Sites in North of China.” *International Journal of Digital Earth*. 6 (S1): 96–112. doi:10.1080/17538947.2013.822573.

GCOS. 2010. *Update of the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC*. Geneva, Switzerland: World Meteorological Organization.

Huang, G., W. Wang, X. Zhang, S. Liang, S. Liu, T. Zhao, J. Feng, and Z. Ma. 2013. “Preliminary Validation of GLASS-DSSR Products Using Surface Measurements Collected in Arid and Semi-arid Region of China.” *International Journal of Digital Earth*. 6 (S1): 50–68. doi:10.1080/17538947.2013.825655.

Liang, S., X. Zhao, W. Yuan, S. Liu, X. Cheng, Z. Xiao, X. Zhang, et al. 2013. “A Long-term Global LAnd Surface Satellite (GLASS) Dataset for Environmental Studies.” *International Journal of Digital Earth*. 6 (S1): 5–33. doi:10.1080/17538947.2013.805262.

Liu, Q., L. Wang, Y. Qu, N. Liu, S. Liu, H. Tang, and S. Liang. 2013. “Preliminary Evaluation of the Long-Term GLASS Albedo Product.” *International Journal of Digital Earth*. 6 (S1): 69–95. doi:10.1080/17538947.2013.804601.

NRC. 2004. *Climate Data Records from Environmental Satellites: Interim Report*. Washington, DC: The National Academies Press.

Sun, L., S. Liang, W. Yuan, and Z. Chen. 2013. “Improving a Penman–Monteith Evapotranspiration Model by Incorporating Soil Moisture Control on Soil Evaporation in Semiarid Areas.” *International Journal of Digital Earth*. 6 (S1): 134–156. doi:10.1080/17538947.2013.783635.

Tang, H., K. Yu, O. Hagolle, K. Jiang, X. Geng, and Y. Zhao. 2013. “A Cloud Detection Method Based on Time Series of MODIS Surface Reflectance Images.” *International Journal of Digital Earth*. 6 (S1): 157–171. doi:10.1080/17538947.2013.833313.

Wu, P., H. Shen, T. Ai, and Y. Liu. 2013. “Land-surface Temperature Retrieval at High Spatial and Temporal Resolutions based on Multi-sensor Fusion.” *International Journal of Digital Earth*. 6 (S1): 113–133. doi:10.1080/17538947.2013.783131.

Shunlin Liang
State Key Laboratory of Remote Sensing Science, College of Global Change and Earth System Science, Beijing Normal University, Beijing 100875, China
Department of Geographical Science, University of Maryland, College Park 20742, MD, USA
Ainong Li
Institute of Mountain Hazards and Environment, Chinese academy of Sciences, Chengdu 610041, China
Jianchang Shi
State Key Laboratory of Remote Sensing Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing 100094, China