ANALYSIS OF VEGETATION INDEX NDVI ANISOTROPY TO IMPROVE THE ACCURACY OF THE GOES-R GREEN VEGETATION FRACTION PRODUCT

Yuhong Tian[1], Peter Romanov[2], Yunyue Yu[3], Hui Xu[1], Dan Tarpley[4]

[1]I.M. Systems Group at NOAA-NESDIS-STAR, 5200 Auth Rd, Camp Springs, MD USA 20746

[2]CICS, University of Maryland, College Park, MD, USA 20742

[3]NOAA-NESDIS-STAR, 5200 Auth Rd, Camp Springs, MD USA 20746

[4]Short and Associates, 5200 Auth Rd, Camp Springs, MD USA 20746

1. INTRODUCTION

The normalized difference vegetation index (NDVI) at the top of atmosphere (TOA), such as NDVI from AVHRR datasets, has been widely applied in optical remote sensing for estimating vegetation parameters such as green vegetation fraction (GVF), agricultural production, net primary production and soil moisture [1, 2]. It has also been applied for monitoring phonology, land degradation, deforestation and desertification, detecting land cover/land change and climate change [3, 4]. Many such applications simply assume that the angular effects on NDVI are neglectable (e.g., the maximum NDVI value composite method). However, it has been demonstrated that TOA NDVI is still partially affected by atmospheric path scattering and bidirectional (illumination and viewing geometry) effects [5].

2. DATA AND RESULTS

To develop GOES-R land products of GVF, we designed a prototype GVF algorithm that used a proxy dataset from the Spinning Enhanced Visible and Infrared Imager (SEVIRI) sensor onboard the European Meteosat Second Generation (MSG) geostationary satellite. Two years of SEVIRI full disk data measured at half-hour intervals was collected and used. Fifty-six pixels (stations) were selected from the SEVIRI full disk. These pixels belong to different IGBP types at different locations. Their NDVI daily data under clear-sky conditions were extracted from the full disk data in summer and winter. The directionality of NDVI was examined. It is found that there is a change of up to 0.4 in NDVI due to the change in solar zenith angle, and NDVI angular anisotropy is the strongest for pixels with high NDVI values. Changes in relative azimuth has a minor effect on NDVI compared to those in solar zenith angle, but may still cause a change of about 0.1 in NDVI. The NDVI dependence on relative azimuth may result in an asymmetry in the NDVI daily change.

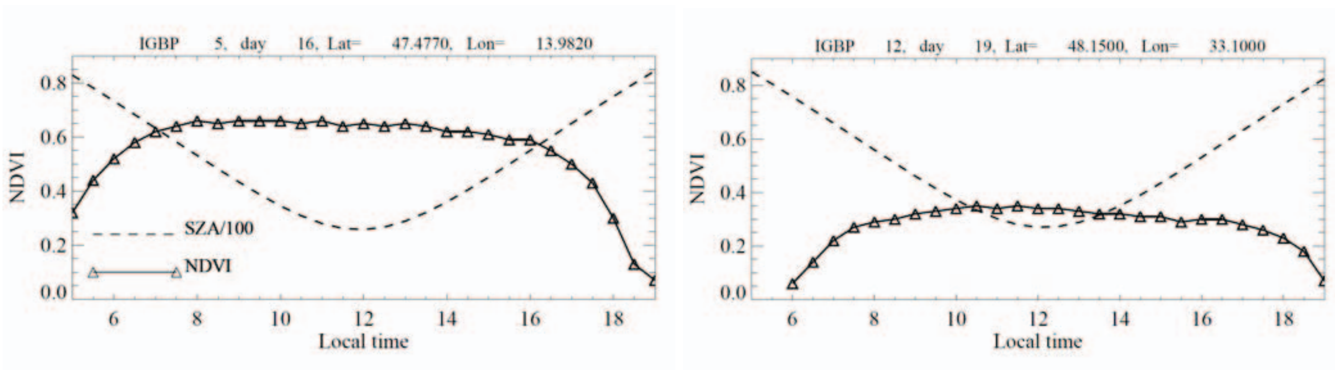

Figure 1. Examples of NDVI daily change (as function of solar zenith angle/local time) from July 2008 MSG-SEVIRI cloud-clear data. The vegetation types are mixed forest (left panel) and cropland (right panel).

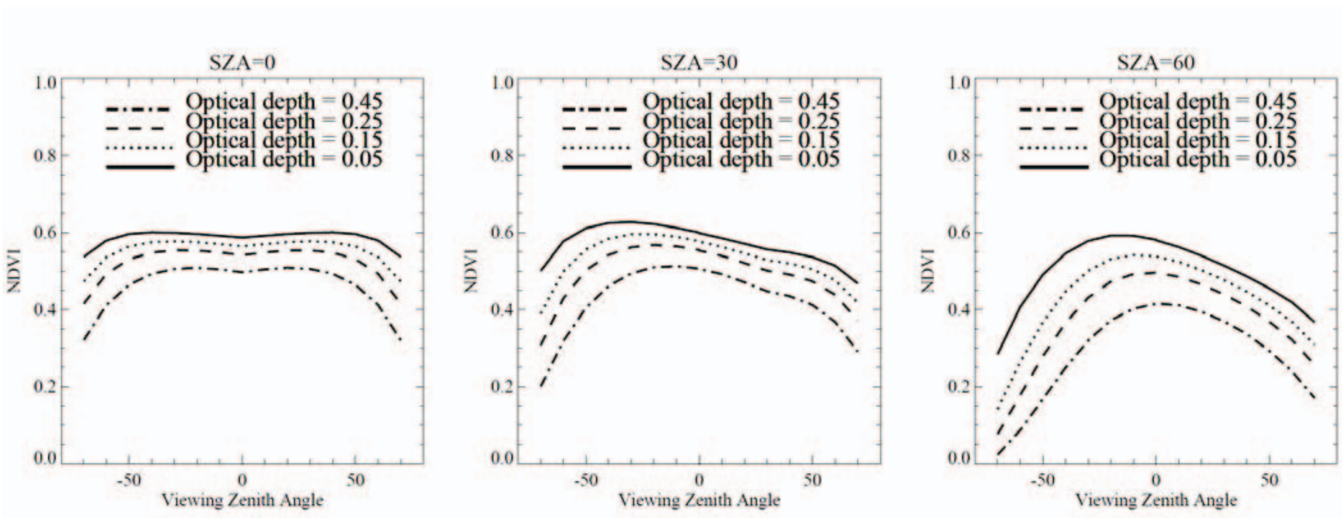

Figure 2. Simulated TOA NDVI as function of view zenith angle, with the aerosol optical depth of 0.05, 0.15, 0.25, and 0.45. The vegetation type used in this simulation is dense needleleaf trees-shrubs.

In order to understand how atmospheric effects influence the NDVI anisotropy seen by satellites, the "second simulation of a satellite signal in the solar spectrum" (6S) code and Boston University's BRDF model were used to simulate the TOA and top of canopy (TOC) reflectance and NDVI with aerosol optical depth (AOD) of 0.05, 0.15, 0.25 and 0.45, respectively. Three different vegetation types (dense broadleaf tree-shrubs, dense needle leaf trees-shrubs, and dense grass like vegetation - crops) and three different soil types (smooth dark soil, smooth bright soil, rough bright) were used in this work. These results show that the magnitude of NDVIs generally decreases with the increase of AOD. Bidirectional NDVI at TOA features with an overall dome shape when canopy was measured from the near-nadir view to larger view angles. As the viewing or solar zenith angle increases, the atmospheric contribution to TOA reflectance increases and thus causes a TOA bidirectional NDVI decrease. In addition, the change from a bowl shape of NDVI at TOC to mostly a dome shape at TOA indicates that the decrease of NDVI resulting from atmospheric scattering is larger than the increase of surface NDVI as the viewing zenith angle increases.

3. DISCUSSION

These results show that although geostationary satellites making repeat observation over a given region can provide high temporal resolution data, the different satellite viewing zenith angles for different locations on Earth may bring large uncertainties to NDVI related products (e.g., GVF). The NDVI measured from larger viewing zenith angles will be underestimated even at the overhead sun condition. Therefore, it is reasonable that all TOA NDVI measurements should be brought to a reference geometry before any other NDVI related parameters are derived or any other NDVI related trend analysis is performed. A simple analytical model that is used to describe the NDVI angular anisotropy (i.e., NDVI as a function of viewing, solar and azimuth angles) will be developed. The model assumes reciprocity of viewing and illumination angles. The angular anisotropy decreases with the decrease of NDVI. The NDVI anisotropy model will be first developed using modeled NDVIs from 6S code which will be modified to simulate the real SEVIRI data. The geometry information of the selected 56 pixels will be the input to the 6s code to simulate NDVI with AOD of 0.05, 0.15, 0.25 and 0.45, respectively. Later, this model will be applied to the real SEVIRI data. Preliminary results of this study will be presented at the meeting.

4. REFERENCES

[1] Gutman, G., and A. Ignatov, “The derivation of the green vegetation fraction from NOAA/AVHRR data for use in numerical weather prediction models”, *Int. J. Remote Sens.*, 19 (8), 1533–1543, 1998.

[2] Jackson, T. J., “Measuring surface soil moisture using passive microwave remote sensing”, *Hydrol. Process*, vol. 7, pp.139-152, 1993.

[3] SchwartZ, M.D., Reed, B.C. and White, M.A., “Assessing satellite-derived start-of-season measures in the conterminous USA”,. International Journal of Climatology, 22, pp. 1793–1805, 2002.

[4] Zhou, L., Tucker, C.J., Kaufmann, R.K., Slayback, D., Shabanov, N.V, and Myneni, R.B., “Variations in northern vegetation activity inferred from satellite data of vegetation index during 1981 to 1999”, *J. Geophys. Res*., 106, 20069-20083, 2001.

[5] Gao, F., Y. Jin, X. Li, C. Schaaf, and A. H. Strahler, Bidirectional NDVI and Atmospherically Resistant BRDF Inversion for Vegetation Canopy, IEEE Trans. Geosci. Remote Sens., 40, 1269-1278, 2002.