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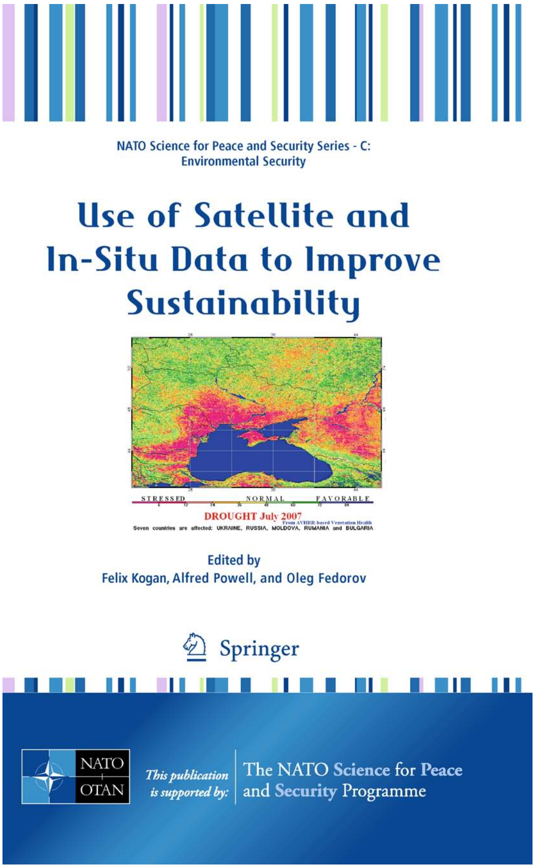

# Comparison of AVHRR-Based Global Data Records

**Felix Kogan, Marco Vargas, and Wei Guo**

**Abstract** Several global data sets have been developed from the AVHRR instrument measuring reflectance/emission of the Earth since the early 1980s. The longest datasets currently available for users are NOAA's Global Vegetation Health (GVH), NASA's Global Inventory Modeling and Mapping Studies (GIMMS) and Land Long Term data Records (LTDR). The GVH has 30-year records (1981–2010), GIMMS – 26 (1981–2006) and LTDR – 19 (1981–1999). These datasets have different spatial and temporal resolutions, processing methods (sampling, calibration, noise removal, mapping, gap treatment etc.), applicability, availability, distribution etc. They have been used frequently for monitoring earth surface, atmosphere near the ground and analysis of climate related land surface trends. Since one of the common features of these datasets is the Normalized Difference Vegetation Index (NDVI) this paper is focusing on comparison of NDVI time series, specifically comparing time series dynamics and trends. It is shown that GIMMS NDVI is two to three times higher and has steeper long-term trend compared to GVH and LTDR.

**Keywords** Vegetation health • 30-year 4-km data records • Vegetation condition index (VCI) • Temperature (TCI) and Vegetation health (VHI) indices • NDVI and BT

## Introduction

The Advanced Very High Resolution Radiometer (AVHRR) has been in space on NOAA operational polar-orbiting satellites for the past 30 years observing earth surface and atmosphere and will continue this endeavor in the future. The AVHRR

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data are extremely useful for monitoring weather and weather-related disasters, land ecosystems, agriculture, forestry, human health, invasive species, climate forcing and other human activities. In the recent 20 years, following such a wide spectrum of applications, AVHRR-based Normalized difference Vegetation Index (NDVI) was used for the analysis of climate trend and land surface changes (Zhou et al. 2001; Myneni et al. 1997; Nemani et al. 2003). That stimulated development of AVHRR-based historical records.

Several global data sets were developed from AVHRR measurementss since the early 1980s. The most popular were NOAA's Global Vegetation Index (GVI, since 1985 and GVI-2 since the early 1990s) and Global Vegetation Health (GVH since 2000), NASA's Pathfinder (since the early 1990s), Global Inventory Modeling and Mapping Studies (GIMMS, from the late 1990s) and currently under development the Land Long Term data Records, LTDR (Tarpley et al. 1984; James and Kalluri 1994; Kidwell 1995; Tucker et al. 2005; LTDR 2010; GIMMS 2010; GVH 2010; Kogan et al. 2010). These data were focused (except GVI-2 and LTDR) on NDVI, ignoring infrared measurements, which are very useful for monitoring land, climate and socioeconomics (Kogan 1995).

The available data have different spatial and temporal resolutions and processing methods (sampling, calibration, noise removal, mapping, gap treatment etc.), applicability, availability, distribution and others. Although the data were produced from the same original source they are often mismatch characterizing the same phenomena. However, NDVI from each dataset was available for the global community (GVH 2010; LTDR 2010; GIMMS 2010) and was used frequently, especially for analysis of climate related land surface trends (Zhou et al. 2001; Nemani et al. 2003; Myneni et al. 1997). Therefore, this paper is focused on comparison of NDVI time series and specifically comparing time series dynamics and trends.

## Data Sets Description

Global AVHRR data of the Global Area Coverage (GAC) format at 4 km special and daily temporal resolution have been archived from 1981 through present for all NOAA series polar-orbiting operational satellites (Kidwell 1995; Cracknell 1997). The observations for the entire period are available for four channels (Ch): visible (VIS, 0.58–0.68 μm, Ch1), near infrared (NIR, 0.725–1.1 μm, Ch2) and two infrared (IR, 10.3–11.3 μm, Ch4 and 11.5–12.5 μm, Ch5). The data are presented in 10-bit digital count values for each 4-km pixel between latitudes 75.024° N and 55.152° S and longitudes 180°W and 180° E. The GAC data were used in the development of all datasets. Three data sets GIMMS, LTDR and GVH were selected for further analysis. Below is a brief description of the data.

*GIMMS* dataset provides NDVI only calculated from the VIS and NIR; satellites – NOAA-7, 9, 11, 14, 16 and 17; period – 1981–2006; resolution: 8 km (0.072°) special and 15-day maximum value composites (MVC) temporal; calibration – vicarious from Vermote and Kaufman (1995); corrections – volcanic stratospheric aerosol during 1982–1984 and 1991–1994, and satellite orbital drift using empirical mode decomposition/reconstruction (EMD) method; projection – Albers; web http://glcf.umiacs.umd.edu/data/gimms/.

*LTDR* dataset: provides daily NDVI, daily surface reflectance (five channels), three angles and quality flag; satellites – NOAA-7, 9, 11 and 14; period – 1981–1999; resolution – 5.5 km (0.05°), daily temporal; calibration – Vermote and Kaufman (1995); satellites NDVI product available from 1981 to 1999. web – http://ltdr.nascom.nasa.gov/ltdr/products2007.html.

*GVH* dataset: provides – original measurements (VIS, NIR, IR4, IR5, NDVI, Brightness temperature (BT), three angles); no noise NDVI and BT, climatology of NDVI and BT, products (Vegetation (VCI), Temperature (TCI) condition indices and Vegetation health index (VHI), Fire risk index, Drought index; satellites – NOAA-7, 9, 11, 14, 16, 17, 18 and 19; period – 1981–2010; resolution – 4-km (0.036º) and 7-day MVC; calibration – vicarious from Rao and Chen (1999); corrections – volcanic stratospheric aerosol during 1982–1984 and 1991–1994, satellite orbital drift, difference between AVHRR-2 and AVHRR-3 instruments; difference in equator crossing time, high frequency noise; projection – Plate Carree (latitude–longitude); validation – in 27 countries; focus: – globe; web – http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/index.php.

## Results and Discussion

The currently available three datasets have the same start year (1981) for the time series but different end year (for GVH 2010; GIMMS 2006; and LTDR 1999). The comparison was done for the period 1982–1999, considering the earliest year (1999) of LTDR data end and that the 1981 data covered only the last 3 months of the year. Since the description of GIMMS and LTDR data processing is quite sketchy the comparison analysis does not explanation causes of the differences. Three regions in Asia, Africa and South America were selected (Table 1) to characterize all major ecosystems.

Figure 1 shows 19-year average NDVI time series for the major areas indicated in Table 1 for the three continents Asia, South America and Africa. As seen, the GVH and LTDR time series are quite similar while the GIMMS data are very different having two to three times higher NDVI. Moreover, the amplitude of NDVI variation inside a year is also two times larger for GIMMS compared to two other data sets. These differences are consistent for the three continents. Although LTDR data are daily and GVH – weekly they match quite well though LTDR has slightly smaller NDVI and larger variation over time, which can be explained by GVH's

**Table 1** Regions selected to average NDVI

| | Coordinates (º) | |
|---|---|---|
| Region | Latitude | Longitude |
| Asia | 40°N–60°N | 15°W–30°E |
| Africa | 15°N–30°S | 15°W–40°E |
| South America | 15°N–25°S | 80°W–35°W |

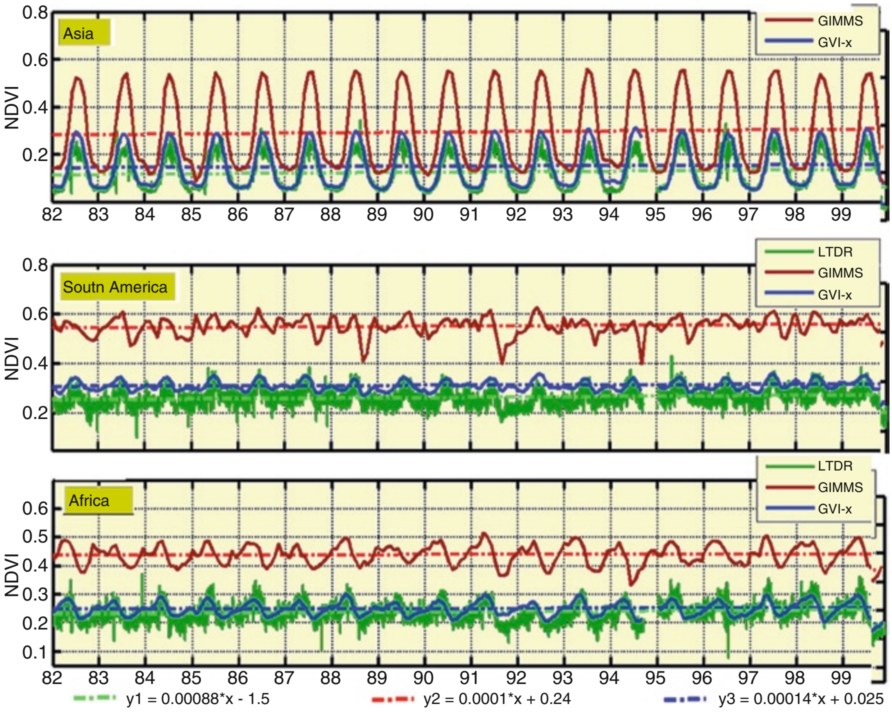


**Fig. 1** 1982–1999 NDVI time series for GIMMS, LTDR and GVH

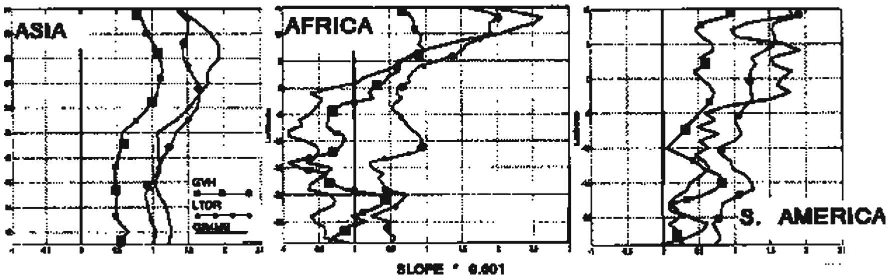


**Fig. 2** 1982–1999 slope trend (*$10^{-3}$) for GIMMS, LTDR and GVH datasets

temporal data sampling with MVC procedure which gives preference to a larger NDVI compared to no sampling (daily values) for LTDR. Also, more pronounced seasonal cycle is observed in LTDR and GVH compared to GIMMS in South America.

Evaluation of the three datasets for the trend existence during 1982–1999 indicates that all three have small mostly upward trend since the slope is positive, Fig. 2 shows slope change for the NDVI averaged for each degree latitude. As seen, the trend is changing for both latitude and for the area. The northern regions have slightly larger trend. Moreover, in sub Sahara Africa the trend for GIMMS and GVH is changing from positive above equator to slightly negative below the equator. From the three datasets, GVH shows the smallest trend since it is closer to zero line compared to the other two datasets.

## Conclusion

The three datasets produced from the same GAC data showed different NDVI values since they have different sampling, calibration and processing. GVH dataset is the longest, has the highest special resolution, also has all original measurements (VIS, NIR, IR4, IR5, NDVI, Brightness temperature (BT), three angles); no noise, climatology and what is the most important products (Vegetation (VCI), Temperature (TCI) condition indices and Vegetation health index (VHI)). All three datasets have small mostly upward trend; the GVH has the smallest slop. In Africa, the GVH and GIMMS data change slope from positive to negative while crossing the equator.

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