Automated processing & distribution of MODIS and AVHRR data through UAF-GINA: Current MODIS products & monitoring applications for growing season metrics

J. Zhu[1], D. Broderson,[1] T. Heinrichs[1], P. Martyn[2], and A.E. Miller[2]

[1]University of Alaska Fairbanks - Geographic Information Network of Alaska (GINA); [2]National Park Service, Inventory & Monitoring Program

Introduction

Moderate Resolution Imaging Spectroradiometer (MODIS) and Advanced Very High Resolution Radiometer (AVHRR) data are being used by the National Park Service (NPS), Alaska Region Inventory & Monitoring (I&M) Program and the University of Alaska-Geographic Information Network of Alaska (GINA) to estimate interannual variation in a suite of seasonal metrics. MODIS-derived true color imagery, Normalized Difference Vegetation Index (NDVI) and snow products (2000-present), and AVHRR-derived NDVI (1990-present) are now being acquired, processed, and distributed by GINA. Standardized AVHRR and MODIS products are being obtained from existing archives at the USGS-EROS Data Center, NASA/GSFC, and the NSIDC. MODIS true color imagery is generated by GINA using the corrected reflectance algorithm. Sun angle, azimuthal, and generalized Rayleigh corrections are applied. For the true color data the red, green and the blue color bands are scaled to 8 bit and combined to form a 24 bit color image. Once acquired and/or generated, each data set is distributed using web coverage (WCS) and mapping (WMS) services. The data products are being used by NPS to monitor interannual variability in growing season length, lake ice formation and breakup, and snow season across Alaska. This poster presents the NDVI metrics algorithm in detail and gives the initial results.

Data acquisition & delivery

NDVI Datasets

NDVI products from MODIS and AVHRR satellite sensors are being made available by GINA via a Web Coverage Service (WCS). eMODIS Alaska data is available from 2000 onwards and covers the majority of Alaska. GINA is also providing AVHRR NDVI data products produced by EROS. The AVHRR derived data is available from 1990 to today. GINA worked with EROS to expand the coverage of the products to include the entire Alaska Peninsula from late 2010 onward. The historical data archive will be reprocessed to the expanded coverage area, ingested by GINA, and will also be made available in the WCS feeds. Figure 1 describes data acquisition, process, and delivery processes. The delivery data are very easy to use in an desktop mapping and GIS environment. For more information including instructions on how to use the services please see http://docs.gina.alaska.edu/ndvi.

Natural Color MODIS Imagery

GINA is providing MODIS imagery captured at GINA's receiving station (Fig. 2) processed to provide a natural color presentation. The final product includes atmospheric corrections and image enhancement techniques to provide the best possible quality. In addition to the data acquired by GINA, a limited subset of data collected by the MODIS Rapid Response System is also being made available. The MODIS natural color imagery is published as Web Mapping Services (WMS) and as GeoTIFF files. The WMS includes data from 2009 onward.

NDVI Metrics Calculation

Work has recently begun to generate a set standardized metrics calculations for the NDVI products. The NDVI metrics calculation is based on eMODIS Alaska data sets. One year of 7-day 250 meter NDVI composites are filtered and stacked together into a one-year NDVI composite. A smoothing algorithm is applied along the time series to clean up the final data using a nonlinear running median line-smoother. Twelve seasonal metrics are derived from the smoothed NDVI data. The NDVI time-series values of every pixel, their backward/forward moving average, and the differentiation are compared to get the sudden increase and decrease that signals the onset of greenness and the end of greenness. The smoothed one-year composites and derived metrics will then be made available as an additional WCS feed.

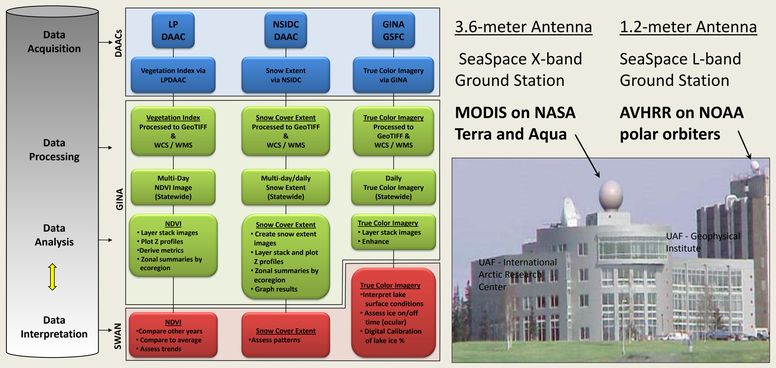


Fig. 1. Process flow used by GINA and NPS to acquire, process, distribute, and use NDVI and Snow products.

Fig. 2. Satellite receiving antennas used by GINA to downlink MODIS and AVHRR satellite data.

Algorithms

11 seasonal metrics are derived from MODIS 250m, 7-day NDVI data.

- time (Day of year) of start of greenness season (SOS)
- value of onset of greenness
- time of end of greenness season (EOS)
- value of end of greenness
- duration of greenness
- time of maximum NDVI
- value of maximum NDVI
- range of NDVI
- rate of green up
- rate of senescence
- time-integrated NDVI

The forty two 7-day composite NDVI data files of a year are stacked into a 42-band data file (for example, Jan-29-2008 to Nov-17-2008). The NDVI metrics are calculated pixel-by-pixel. The metrics algorithm includes three steps: interpolation, smoothing, and the metrics calculation. Figure 3 describes the procedures of the algorithm in detail. Figure 4 shows an example of how the processed results varies in four steps.

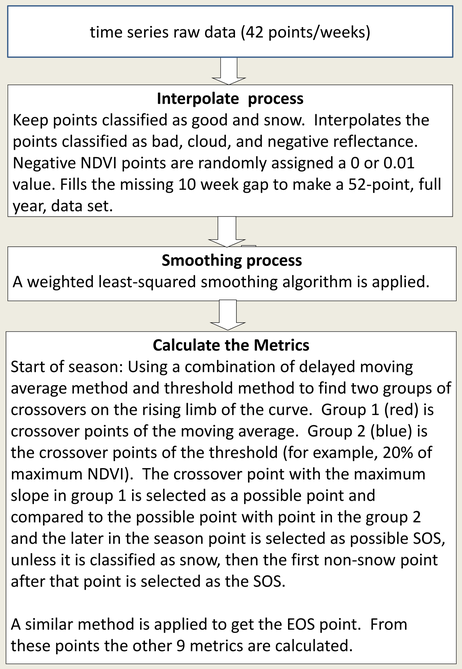
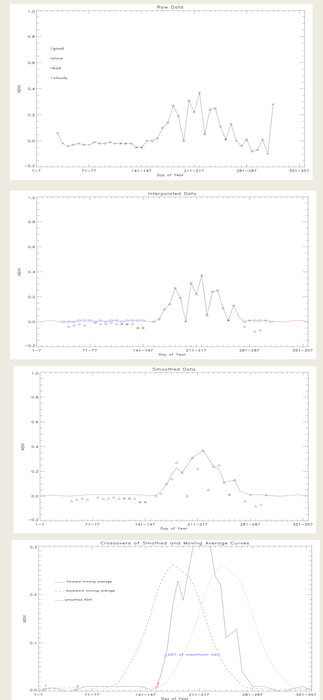


Fig.3. NDVI Algorithm Flowchart



A time series of raw data for a pixel include 42 weekly composite data points, starting with the 5th week of the year. The raw data are classified into 6 types: good, cloud, bad, negative reflectance, snow, and fill.

Only good and snow data points are kept, other points are interpolated linearly; Negative NDVI points are randomly assigned a 0 or 0.01 value to avoid false crossovers for start of season and end of season detection; finally to fill out the full year the 10 week winter gap, 4 points at beginning and 6 points at end, are randomly assigned values of 0 or 0.01.

The smoothing process eliminates points with anomalously low NDVI values (for example, 28th and 32th points), and makes the time series be smooth using a weighted least-square approach.

Three crossover points (1.1, 7.0, and 22.1) in group 1, are marked in red, and their heights in y direction reflect their slopes. The crossover point with the maximum slope is possible SOS (22.1); because possible SOS point is earlier than the crossover point (23.7) in group 2; uses 23.7 as the possible SOS point; check points 23 and 24, they are both not snow points, so point 23.7 is the SOS point.

Fig.4. A example of the variation of the time series in different processes

NDVI Metrics Results

Figures 5, 6, and 7 show three main metrics: SOS, duration of growing season, and EOS, respectively. Growing season varies by location and elevation. The metrics calculations indicate that the Alaska Peninsula region has an earlier start of growing season (about Apr. 1-15), and later end of growing season than many other areas of Alaska. The estimated growing season length is about 200 days as interpreted from the MODIS NDVI time-series. The Interior region has a moderately long growing season. The average growing season is about 160 days. The North Slope region has the shortest growing season with an average of 120 days. These start and end of season dates have not been validated, but seem plausible based on a review of year-round time-lapse photography from the field, as well as a review of snow-on and snow-off dates interpreted from 250-m eMODIS images.

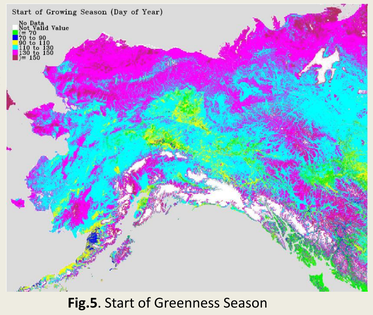


Fig.5. Start of Greenness Season

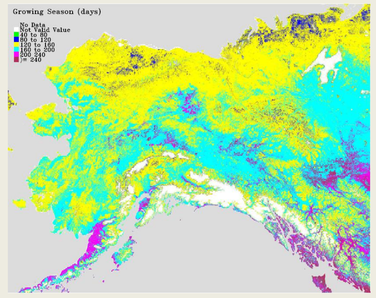


Fig.6. Duration of Growing Season

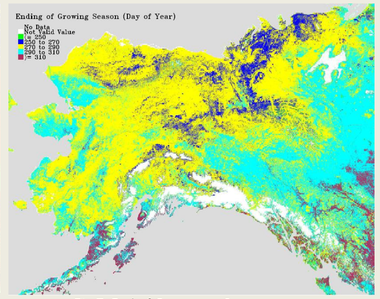


Fig.7. End of Greenness Season

Acknowledgement

We appreciate the USGS Land Remote Sensing Program for providing eMODIS Alaska data. https://lpdaac.usgs.gov/

Literature cited:

Reed, B. C., Budde, M., Spencer, P., & Miller, A. (2006). *Satellite-derived measures of landscape processes: Monitoring protocol for the Southwest Alaska I&M Network.* National Park Service, Inventory & Monitoring Program, Southwest Alaska Network, Anchorage, Alaska 30 pp.

Swets, D. L., Reed, B. C., Rowland, J. D., Marko, S. E. (1999). *A weighted least-squares approach to temporal NDVI smoothing*, Proceedings of the 1999 ASPRS Annual Conference, Portland, Oregon, pp. 526-536.