SEMI-ANNUAL REPORT

NASA CONTRACT NAS 5-31368

For
MODIS Team Member: Steven W. Running
Assoc. Team Member: Ramakrishna R. Nemani
Software Engineer: Petr Votava

6 January 2003

OBJECTIVES:

We have defined the following near-term objectives for our MODIS contract:

- Test software for our MODIS products, #15 Leaf Area Index and Fraction Absorbed Photosynthetically Active Radiation, #16 Evapotranspiration from land surface, and #17 Daily Photosynthesis Annual Net Primary Production as MODAPS processing delivers global datasets.

- Deliver software for the Aqua MODIS sensor, for MOD 15, MOD 17 and the new MOD 16, Surface Evaporation Index

- Develop MODIS applications products for national natural resource management.

- Organization of a validation effort using AMERIFLUX fluxnet sites to correlate and test the MODIS derived LAI and Net Primary Production.

The NTSG lab currently employs:

Dr. Steven Running, Director and Professor,
Dr. Ramakrishna Nemani, Research Assoc. Professor
Dr. John Kimball, Research Assistant Professor
Dr. Sinkyu Kang, Postdoctoral Research Associate
Dr. Maosheng Zhao, Postdoctoral Research Associate
Dr. Faith Ann Heinsch, Postdoctoral Research Associate
Dr. Swarna Reddy, Research Associate
Mr. Petr Votava, Software Engineer
Mr. Chad Bowker, Programmer
Mr. Andrew Neuschwander, Programmer/Sys Admin
Mr. Saxon Holbrook, Computer Systems Engineer
Mr. Matt Reeves, PhD student
Mr. W. Matt Jolly, PhD student
Ms. Pat Andrews, PhD student
Ms. Rachel Loehman, PhD student
Ms. Cristina Milesi, PhD student

Ms. Ann Radil, PhD student
Ms. Divya Tipparaju, MS Student
Ms. Alana Oakins, MS Student
Mr. David Mildrexler, MS Student
Ms. Youngee Cho, Office Manager
Mr. Andy Michealis (Student Programmer)
Mr. Douglas Wissenbach (Student Programmer)

All of these members contribute to certain aspects of our MODIS work.

EOS-IWG

I participated in a number of projects to develop both MODLAND, and more generally EOS Land product validation. These projects are in many ways interrelated, and their efficiency is maximized by regular coordination. Following are brief summaries of current activity for:

BIGFOOT = a field ecological measurement program in the US
FLUXNET = a global array of CO_2 and H_2O flux towers
GTOS-NPP = a global program related to BIGFOOT for GTOS

BIGFOOT

The BigFoot project grew from a workshop held in 1996, which was attended by ecologists and scientists of related disciplines, primarily from the Long Term Ecological Research (LTER) Network. The purpose was to explore validation protocols and scaling issues that would lead to an improved understanding of several MODLand products. The BigFoot field sites are also EOS Land Validation Core Sites and are part of the FLUXNET program. The sites have active science programs concentrating on CO2, water vapor, and energy exchange using flux tower measurements. The "footprint" over which gas flux data are collected varies, but is roughly 1 km or less. For the BigFoot analysis, this footprint will be extended to 25 km2 to include multiple 1 km MODIS cells, hence the project name. BigFoot investigators will focus on validation of the MODLand land cover, LAI, FPAR, and NPP products. We will develop fine grain (25 m resolution) surfaces of land cover, LAI, FPAR, and NPP, aggregate these to 1 km resolution, then assess the similarities and differences between these surfaces and the MODLand products.

http://www.fsl.orst.edu/larse/bigfoot/overview.html

I attended the BIGFOOT annual project meeting at Sevilleta LTER in March 2002.
See the AGU posters, below for summaries of Bigfoot work for this year.

FLUXNET

The FLUXNET program is maturing rapidly as the cornerstone of EOS Land validation, website at:

http://daacl.ESD.ORNL.Gov/FLUXNET/.

There are now 120 sites globally, and substantial international coordination. We inaugurated the RealTime flux validation activity with the active participation of ORNL. The following text from the Ameriflux website explains the project, found at:

http://cdiac.esd.ornl.gov/programs/ameriflux/Model_Evaluation/index.html

See the AGU Posters below for summaries of our Fluxnet work

MEETINGS ATTENDED S.W.RUNNING (the meetings listed in bold I was an invited speaker)

US Climate Change Science Meeting, Washington DC, December 2002
U.S. Interagency Carbon Cycle Science Steering Group, Dec 2002
AGU Fall Meeting, San Francisco, December 2002
NASA/EOS Investigator Working Group Meeting, Washington DC, November 2002
Amer Meteorological Society Biometeorology Mtg, Kansas City, MO Oct 2002
NASA Ames Center Seminar, October 2002
Ameriflux meeting, October 2002
IPCC Expert Group Meeting, September 2002
AGU Chapman Conference, September 2002
ISSAOS Remote Sensing of the Earth's Environment from Terra, Rome, Italy August 2002
IGBP GCTE CO2 Workshop Basel Switzerland August 2002
MODIS Vegetation workshop , HOST July 15 – 18 2002
The Fifth Mansfield Pacific Retreat, CO-HOST Bigfork, MT, June 2002
U.S. Drought: Prediction, Impacts, Mitigation and Policy, Congressional Lunch briefing Washington DC, June 2002

NTSG presented five posters of research results at Fall 2002 American Geophysical Union Meeting in San Francisco. These 5 posters are attached as a Powerpoint file and are the best collective summary of our research over the last 6 months.

ACTIVITIES of Ramakrishna Nemani (Associate Team Member)

Recent Trends in hydrologic balance have enhanced the terrestrial carbon sink in the United States (printed in Geophysical Research Letters, May 2002)

The continental U.S hydrologic cycle has undergone significant changes since 1900 including increases in precipitation, atmospheric humidity and stream flows. As a consequence, plant growth, which is often limited by water, increased absorbing greater amounts of atmospheric CO_2. Two thirds of the increase in observed forest growth rates could be accounted for by observed climatic changes, including the confluence of earlier springs and wetter autumns leading to a lengthening of the vegetation carbon uptake period. However, regional differences in precipitation trends produced differing regional carbon sink responses. The changes in the hydrologic cycle are one of the mechanisms that are often overlooked in the recent debate over carbon sequestration in the United States. Since the latter part of the 20^{th} Century, scientists have found evidence of an increased United States carbon sink. Currently, between 15 and 30 percent of the nearly 1.5 billion tons of carbon dioxide that the U.S. coughs out into atmosphere each year is being absorbed back into the land, and this sink appears to be draining more carbon as time goes by. Researchers have proposed a number of theories as to why the land is pulling carbon dioxide (CO_2) from the air at greater rates. The most talked about theories revolve around an observed greening of North America. Viable causes for why plants have done so well include a revival of forests from agricultural and urban clear-cutting in the 1800s, greater concentrations of atmospheric CO_2 from fossil fuel burning, and warmer global temperatures in the 1900s. But a new study points to another factor vital to plant growth that may be at the root of the matter—more water. The continental U.S carbon fluxes were estimated using a prognostic terrestrial ecosystem model, and the results show that increased growth by natural vegetation was associated with increased precipitation and humidity, especially during the 1950-1993 period. CO_2 trends and warmer temperatures had a lesser effect. The strong coupling between carbon and hydrologic cycles implies that global carbon budget studies, currently dominated by temperature analyses, should consider changes in the hydrologic cycle.

Biospheric Monitoring and Ecological Forecasting (to appear in EOM, special NASA/ESE ISSUE)

The latest generation of NASA Earth Observing System satellites has brought a new dimension to continuous monitoring of the living part of the Earth System, the Biosphere. EOS data can now provide weekly global measures of vegetation productivity and ocean chlorophyll, and many related biophysical factors such as land cover changes or snowmelt rates. However, information with the highest economic value would be forecasting impending conditions of the biosphere that would allow advanced decision-making to mitigate dangers, or exploit positive trends. NASAs strategic plan for the Earth Science Enterprise identifies ecological forecasting as a focus for future research. Ecological forecasting ***predicts*** the effects of changes in the physical, chemical and biological, environment on ecosystem activity. Imagine if we could accurately predict shortfalls or bumper crops of agricultural production, or West Nile virus epidemics or wildfire danger 3-6 months in advance, allowing improved preparation and logistical efficiency.

Early warnings of potential changes in key biospheric processes (such as soil moisture, snow pack, stream flow or vegetation production) could enhance our ability to make better socio-economic natural resource management decisions. Whether we prepare for the summer fire season or spring floods, knowledge of the magnitude and direction of future conditions can save time, money and valuable resources. A combination of space- and ground-based observations have significantly improved our ability to monitor natural resources and identify potential changes. However, these observations can only provide information about current conditions. While this information is useful, many resource managers have to make decisions for the coming season, often 3-6 months in advance. Recent advances in climate forecasting have elicited strong interest in the energy and agricultural sectors. The climate forecasting skills of many coupled Ocean-Atmosphere general circulation models (GCM) have steadily improved over the past decade. Given observed anomalies in sea-surface temperatures from satellite data, GCMs are able to forecast general climatic conditions 6-12 months into the future, trends of hotter/colder temperatures and wetter/drier precipitation than normal, with reasonable accuracy. While such climatic forecasts are useful alone, these advances in ecosystem modeling allow us to explore specifically the impacts of these future climate trends on the ecosystem directly. In March, we may be able to predict whether the winter wheat production in Montana will be higher or lower than normal when harvested in July, and whether the growing season will be early or late.

One of the key problems in adapting climate forecasts to natural ecosystems is the "memory" that these systems carry from one season to the next (e.g. soil moisture, plant seed banks, fire fuel accumulation etc.). Simulation models are often the best tools to carry forward the spatio-temporal ‘memory’ information. The power of models that can describe and predict ecosystem behavior has advanced dramatically over the last two decades, driven by major improvements in process-level understanding, computing technology, and the availability of a wide-range of satellite- and ground-based sensors.

Terrestrial Observation and Prediction System

In order to estimate possible future states of the biosphere, we are building a system that integrates ecosystem models with frequent satellite observations, that can be forced by weather or climate forecasts, and downscaled to resolutions appropriate to resolve surface processes. Such a system will allow us to determine the vulnerabilities of different socio-economic and resource systems to fluctuations within our biosphere, and would help in mitigating potential negative impacts. Agriculture, a $200 billion sector of the U.S. economy, as well as many other businesses such as the recreation and tourism industries, are vulnerable to changes in Earth’s biosphere.

Funded by NASA’s Earth Science Enterprise and its Aerospace Enterprise’s Computing, Information, and Communications Technology Program, researchers at the University of Montana, in collaboration with scientists at the Utah State University and California State University at Monterey Bay, have developed a system called the Terrestrial Observation & Prediction System (TOPS, Figure 1) to rapidly and accurately interpret data from NASA's Earth Observing System (EOS). TOPS is a modeling software system that automatically integrates and pre-processes EOS data fields so that land surface models can be run in near-realtime with minimal intervention. To further speed the conversion of EOS data into a value-added products, TOPS automatically proceses output from the models, using data-mining and feature extraction tools. TOPS brings together state-of-the-art technologies in information technology, weather/climate forecasting, ecosystem modeling, and satellite remote sensing to enhance the management of floods, droughts, forest fires, crop/range/forest production, and human health.

Ecosystem models

Spatial simulation models in ecology and hydrology estimate various water (evaporation, transpiration, stream flow, and soil water), carbon (net photosynthesis, plant growth) and nutrient flux (uptake and mineralization) processes at the landscape level. The models have been adapted for all major biomes (based on each biome's unique ecophysiological adaptations to climate and soil characteristics) exploiting biome-specific eco-physiological principles such as drought resistance, cold tolerance etc. They are initialized with soil physical properties and satellite based vegetation information (type and density of plants). In combination with daily weather data (max/min temperatures, solar radiation, humidity and rainfall), these input data fields are used to simulate various ecosystem processes (e.g. transpiration, evaporation, photosynthesis and snowmelt etc.), conditioned by variations in soils, terrain and canopy cover, that can be translated into information on drought, crop yields, net primary production, and water yield estimates.

A number of key developments in recent years now allow us to run models in nowcast and forecast modes. These developments include widespread availability of up-to-date weather conditions on the internet, sophisticated algorithms that convert raw satellite data into various biophysical products that can be directly used in models, and operational availability of climate/weather forecasts in formats that can be used in ecosystem models.

An Ecological Forecasting example: TOPS helping California wine industry

The impetus for developing TOPS came from our work in the Napa Valley, California on the impacts of climate variability on wine quality and the application of remote sensing and modeling in vineyard management. Analysis of long-term climate records and wine ratings showed that inter-annual variability in climate has a strong impact on the $30 billion per year California wine industry. Warmer sea surface temperatures along the California coast were found to help wine quality by modulating humidity, reducing frost frequency and increasing growing season length. Because changes in regional SSTs persist for 6-12 months, predicting vintage quantity and quality from previous winter conditions appears possible. Given the probability of an upcoming growing season to be worse or better than average, growers can use the information to make a number of key decisions concerning crop management.

TOPS can also help vintners during the growing season in a variety of vineyard anagement decisions. For example, satellite remote sensing data during the early growing season helps to locate areas for pruning so that an optimum canopy density is maintained. Similarly, leaf area index (area of leaves per unit ground area) derived from satellite data is used in process models to compute water use and irrigation requirements to maintain vines at a given water stress level. Research suggests that vines need to be maintained at moderate water stress to maximize fruit quality. TOPS, by integrating leaf area, soils data, and daily weather, can estimate spatially-varying water requirements within the vineyard so that managers can adjust water delivery from irrigation systems. Finally, satellite imagery from the end of the growing season helps in delineating regions of similar grape maturity and quality so that differential harvesting can be employed to optimize wine blending and quality.

Figure Captions:

Figure 1: The Terrestrial Observation & Prediction System (TOPS) integrates a wide variety of data sources at various space and time resolutions to produce spatially and temporally consistent input data fields, upon which ecosystem models operate to produce ecological *forecasts* needed by natural resource managers.

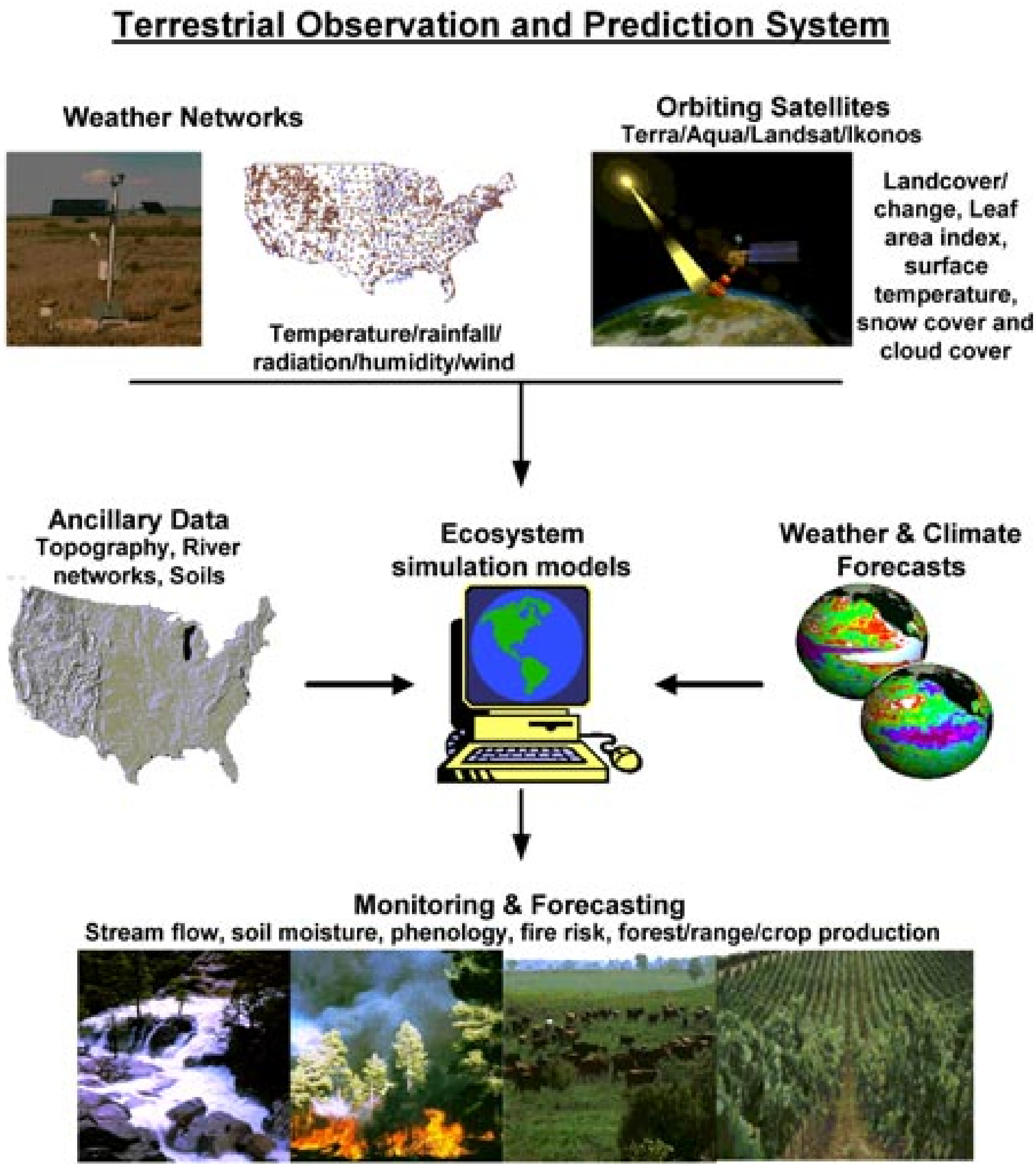


Figure 2: Maps of leaf area index, derived from 2000 IKONOS satellite data over vineyards in the Napa Valley, California, are important for quantifying spatial variation in canopy conditions, and as inputs to ecosystem models for estimating water requirements and crop yields.

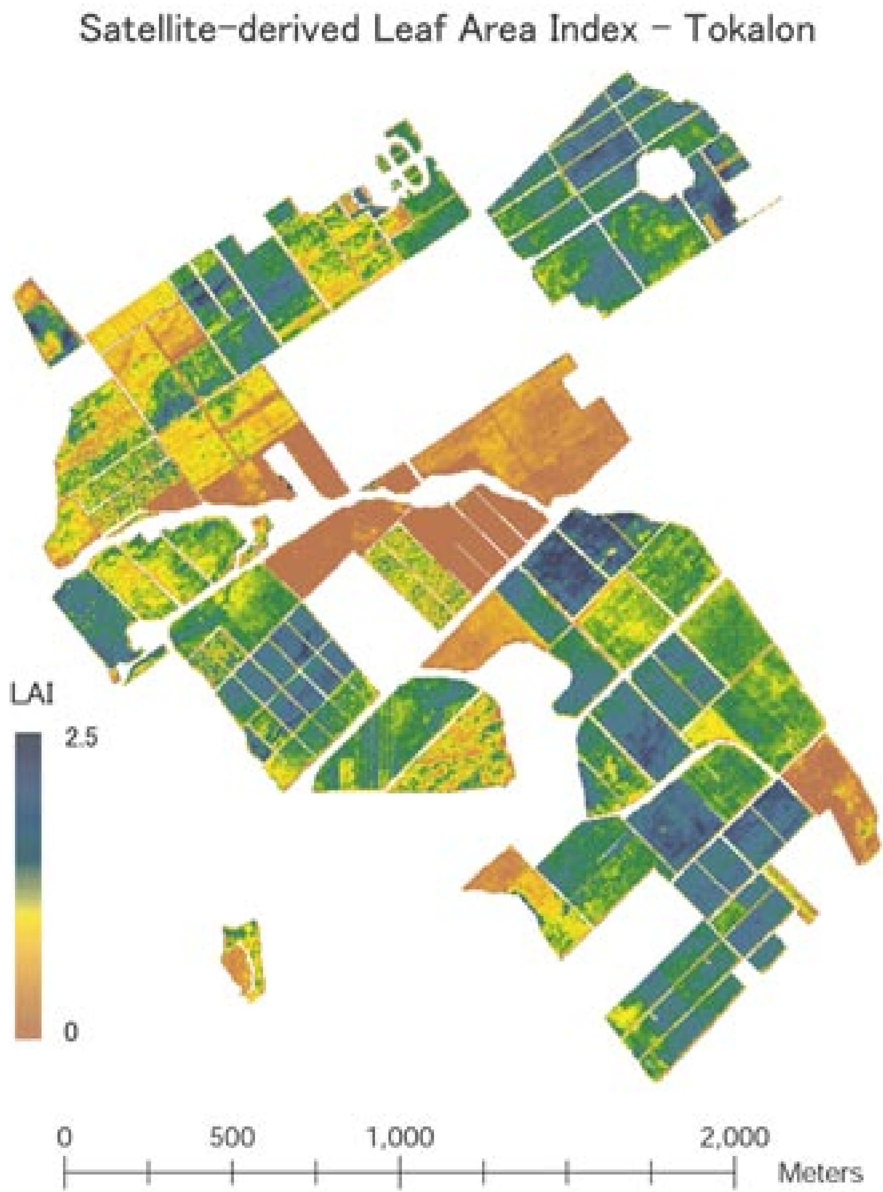
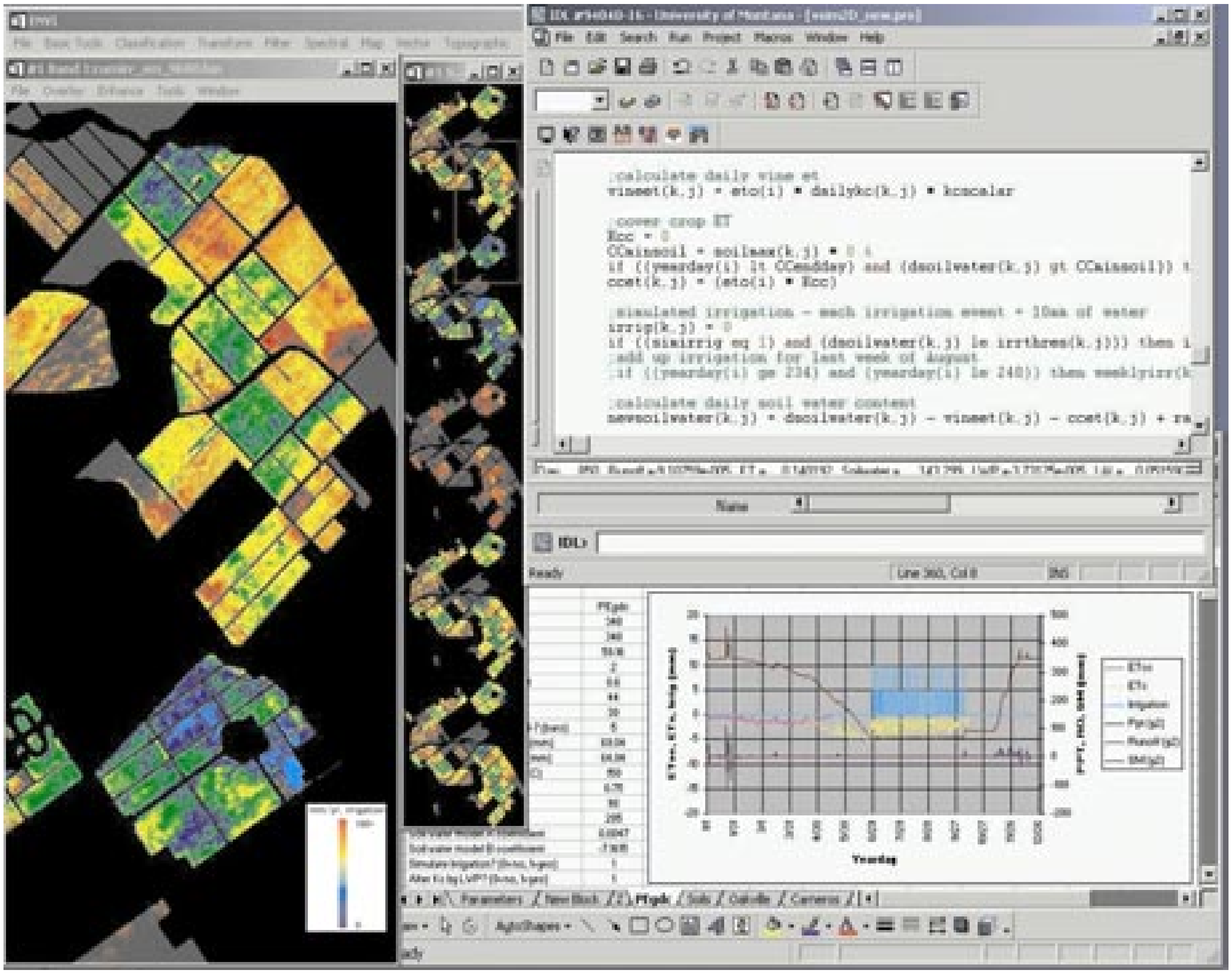


Figure 3: TOPS combines the vineyard leaf area index maps with soils and weather data to compute a seasonal water balance that can be used to estimate the amount of irrigation required to maintain the vines at an optimal water stress level chosen to maximize crop yield and fruit quality.



Tropical ecosystems dominate climate driven increases in global terrestrial net primary production from 1982 to 1999. (Submitted to Journal of Geophysical Research)

Studies of global carbon cycling indicate increased global vegetation activity during the 1990s relative to 1980s, though the location and the purported mechanisms behind the increased vegetation activity vary widely. In order to assess climate variability as a possible mechanism, we estimated the spatio-temporal dynamics of global net primary production (NPP) from 1982-1999 by combining satellite derived monthly photosynthetic capacity observations with daily climate data. A moderate increasing trend in global NPP was observed with a strong inter-annual variability associated with ENSO phenomenon. Global climatic changes between 1982 and 1999, in general, were found to relieve climatic constraints to plant growth over large regions of the Earth. In the temperature limited regions of high- and mid- latitudes, warmer spring temperatures advanced growing season. However, during the growing season increases in rainfall over water limited regions of North America and declines in cloud cover over radiation limited ecosystems of Eurasia further contributed to increases in NPP. Water limited tropical ecosystems showed the least amount of increase in NPP, except over the Indian sub-continent where changes in monsoon intensity and seasonality enhanced plant growth. Evergreen broadleaf forests of tropical regions, predominantly limited by cloud cover, showed the largest increase in NPP in response to changes in tropical circulation patterns leading to reduced cloud cover. Global photosynthetic activity increased more during the northern boreal winter months than summer months. Whether the observed climatic changes are a part of decadal climatic variability or of anthropogenic origin is unknown; nevertheless, our analysis showed global climatic changes, particularly in tropical regions, during the 1990s have contributed substantially to increases in global NPP from 1982 to 1999.

ACTIVITIES OF Maosheng Zhao (Postdoctoral Researcher)

Now we have an entire 2001 MODIS data and this allow us to validate MODIS products and study the sensitivity of MODIS algorithm to the variability of different inputs. The follows are the preliminary results from the works being done now.

DAO validation

DAO is one kind of assimilation data and original data are 1 degree with 3-hour interval. MODIS17 algorithm uses daily DAO data as input, and hence PSN and NPP values are largely dependent on the quality of DAO. We have found that over large part of Amazon region, NPP for 2001 is very low, and even some negative NPP appear in this region. But using NCEP data as input to run the algorithm for this region, NPP values are reasonable. Therefore, there is need to validate DAO. The problem for the validation is that common meteorological stations have no daily radiation observation; in addition, even most eddy flux towers have radiation observation, it is still hard to get them because 2001 is so latest.

Currently, we have just got 163 agricultural stations with observed radiation for 2001 over 4 states (Fig. 1). To some extend, these four states (California, Arizona, North Dakota and North Carolina) cover most of climatic zones of USA. For easier comparison, we just show seasonal mean value of each variable against the observed using one by one line. Further, in order to investigate how much error will be introduced to PSN and NPP by error from DAO, we run MODIS17 algorithm for each station's cutout by inputting DAO and observed, respectively. The results (fig. 2) suggest that, first, DAO can capture the seasonality of meteorological variables and its magnitude is fairly good. Secondly, DAO introduced more errors in summer than other seasons, and this leads to some errors of PSN in summer. For annual NPP, DAO running results are fairly agree with that run by observed.

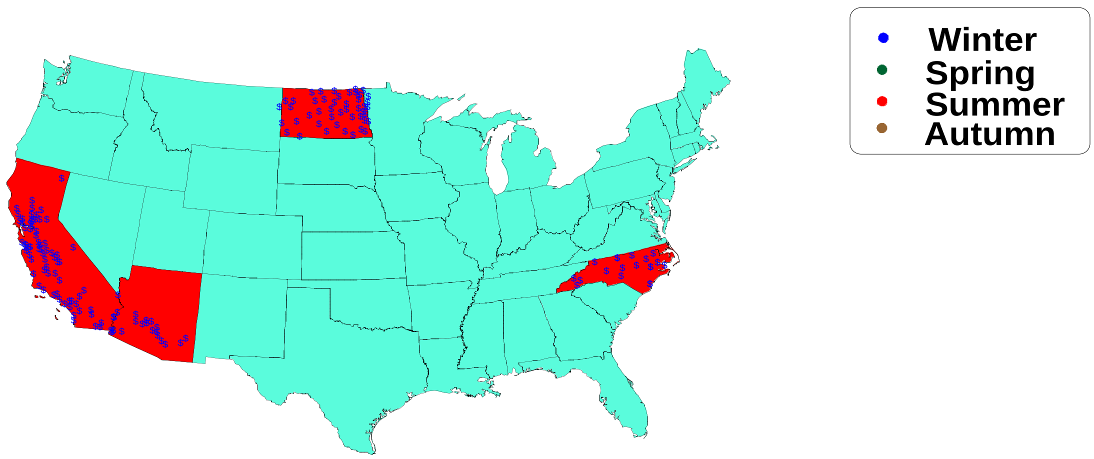


Fig.1 meteorological stations with observed radiation

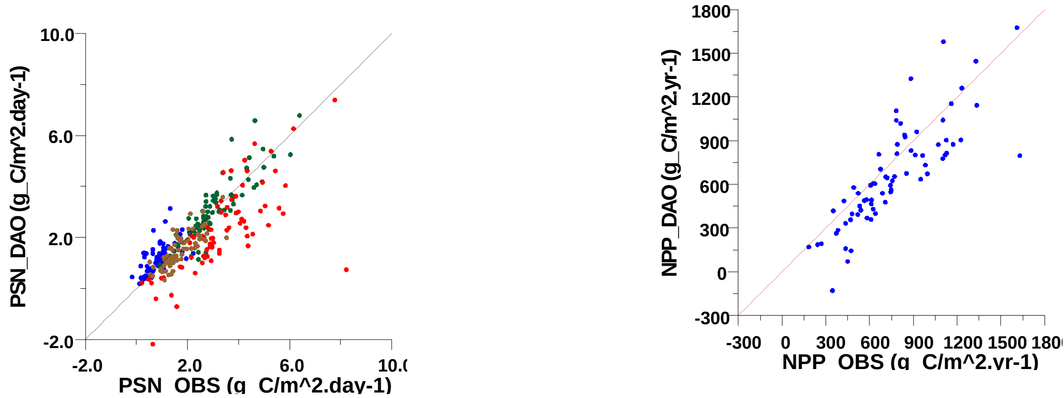


Fig.2 The DAO run MOD17 vs. observed meteorological run for stations cutout in California

Now we still try to contact some people who may have 2001 LBA data so that we can see DAO quality in Amazon region.

Validation of PSN and NPP

Validation of PSN and NPP is by using eddy flux towers observed GPP. Currently, for each tower, we got 5km by 5km cutout with ISIN projection using its latitude and longitude as the central pixel. For each cutout, we use land cover of central pixel as cutout vegetation type, and average the Fpar and Lai of pixels with the same land cover as central pixels. Using these mean Fpar and Lai run MOD17 algorithm to get cutout's PSN and NPP and then send the results to each towers' PI, this will enable us to find the way to improve our algorithm.

Now we have finished some programs that will automatically cut any pixel on land if accurate latitude and longitude provided. Also an IDL program has been finished to automatically plot all cutouts Fpar, Lai, EVI and PSN at once.

For validation of annual NPP, we have got EMDI observed NPP. Because currently we have validated DAO data for some regions over USA and have confidence in DAO data over USA, we just compare MODIS NPP and EMDI NPP for North American. Fig.3 shows that MODIS NPP are acceptable compared with EMDI NPP, and the difference between two data sets are mainly from two factors, one is uncertainty of MOD17 daily radiation and humidity inputs from the NASA Data Assimilation Office (DAO) weather forecast model; another factor may be due to uncertainty in direct comparison between field data and coarse resolution MODIS data.

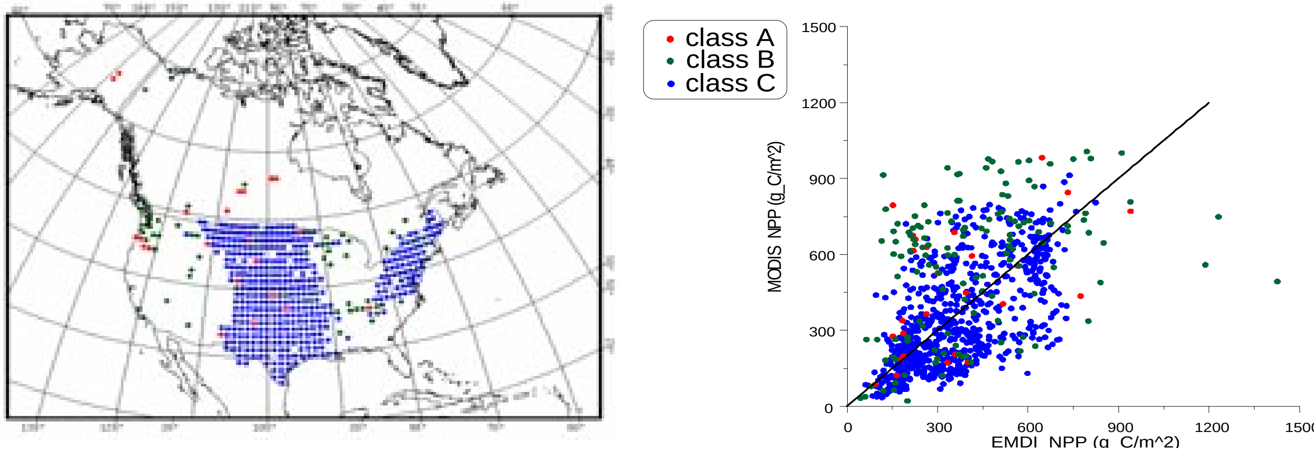


Fig.3 the EMDI sites distribution (left) and MODIS NPP vs. EMDI NPP (right)

Sensitivity of MODIS17 to the variability of inputs

(1) Sensitivity to meteorological input

DAO is assimilation data, and NCEP is assimilated data, too, which is widely used. Now we have known there are big differences in tropical region between DAO and NCEP run MOD17. By validation of DAO, it reveals that DAO agrees well with the observed for USA. Because DAO spatial resolution is 1 degree, while NCEP is about 1.9 degree. Then we run MODIS algorithm forced by NCEP to see the sensitivity of MODIS17 to different meteorological inputs.

Results reveal that over large part of USA, the NCEP run overestimate PSN and NPP compared DAO run and observed run (Fig. 4). Therefore, the problem now is over USA, DAO quality is better than NCEP, while DAO has very big problem over much of tropic region, especially over Amazon region.

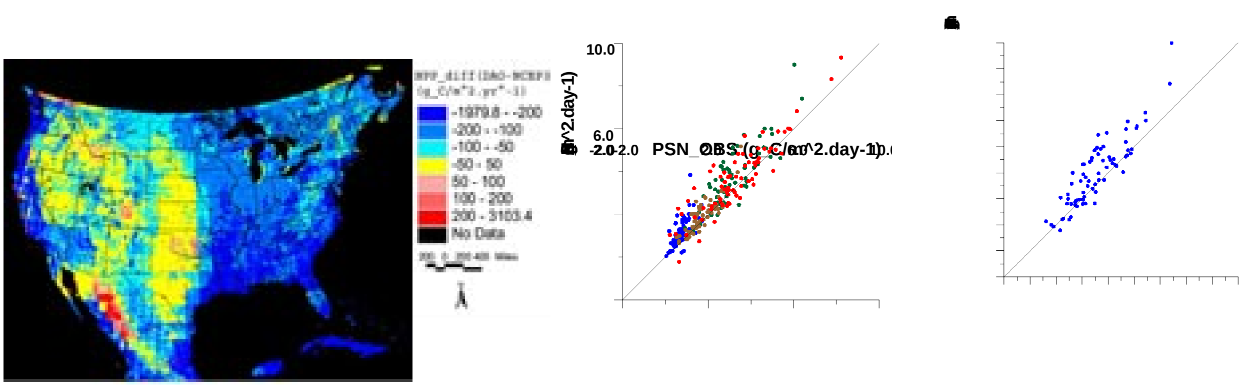


Fig.4 The difference of NPP between DAO and NCEP run The DAO run (left). NCEP run PSN and NPP vs. observed meteorological run for stations cutout in California (right)

(2) Sensitivity to MOD15A2 errors

To study the sensitivity of MOD17 algorithm to the error from upstream input MOD15A2, we just set Fpar and Lai to change from –20% to 20% by 5% interval to run MODIS17 algorithm 81 time. Results (Fig. 5) demonstrate that, first, MOD17 is more sensitive to Fpar than Lai, and sensitive level is different for difference biomes, Secondly, if Fpar changes with a given proportional Lai as the graphics show below for difference biomes. NPP will be no change.

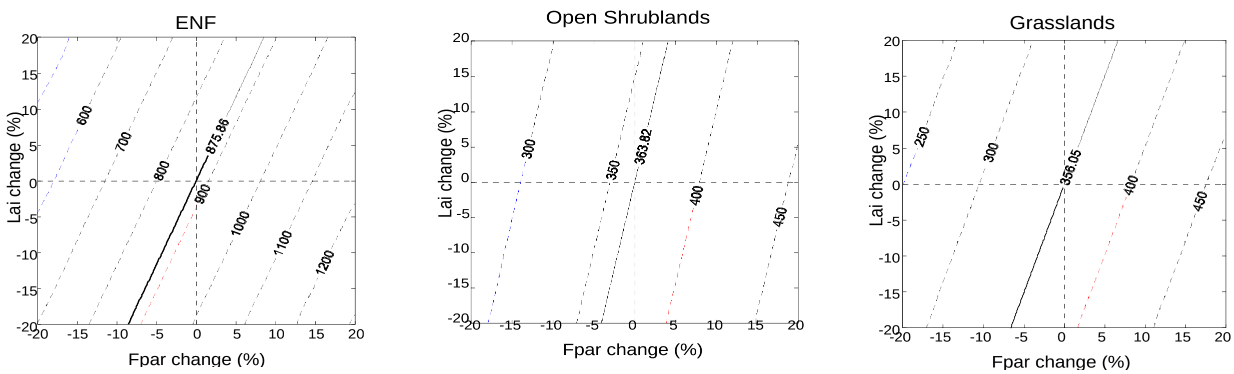


Fig.5 Some biomes' NPP contour lines to the change of Fpar and Lai

(3) Sensitivity to MOD15 QC

MOD15 is 8-day composite data, and sometimes due to cloud contamination, LAI and Fpar are retrieved under different cloudy conditions, which is described by QC value. For annual NPP, we don't know how much error could be introduced to MOD17 NPP by MOD15 pixels with bad QC. To study this, we run the MOD17 in 5km by 5km moving window, we just average Fpar and Lai for these pixels with the same land cover as central pixel and best QC (Qc < = 4) to recalculate NPP. The results (fig. 6) suggest that, on the whole, the difference between quality-controlled MOD15 and no controlled is small. These pixels with large difference are scattered distributed. Also NPP histogram for difference biomes reveals that there is nearly no difference, too.

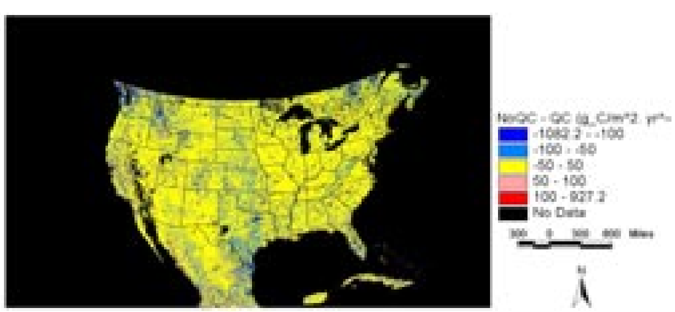


Fig.6 The difference of MOD17 NPP between no quality-controlled MOD15 forced NPP and quality-controlled run

Evaluate linkage between land surface LAI seasonality and Ku-band radar backscatter data from Seawind (with John Kimbal and Steve Frolking et al at UNH)

Because Seawinds has a coarse (~25km) spatial resolution so we need find a series of 50kmX50km homogeneous cover. This is first step for the study. Fig. 7 is the 50km window homogeneous cover over the world under the condition that over 80% pixels of 1km MODIS land cover are same.

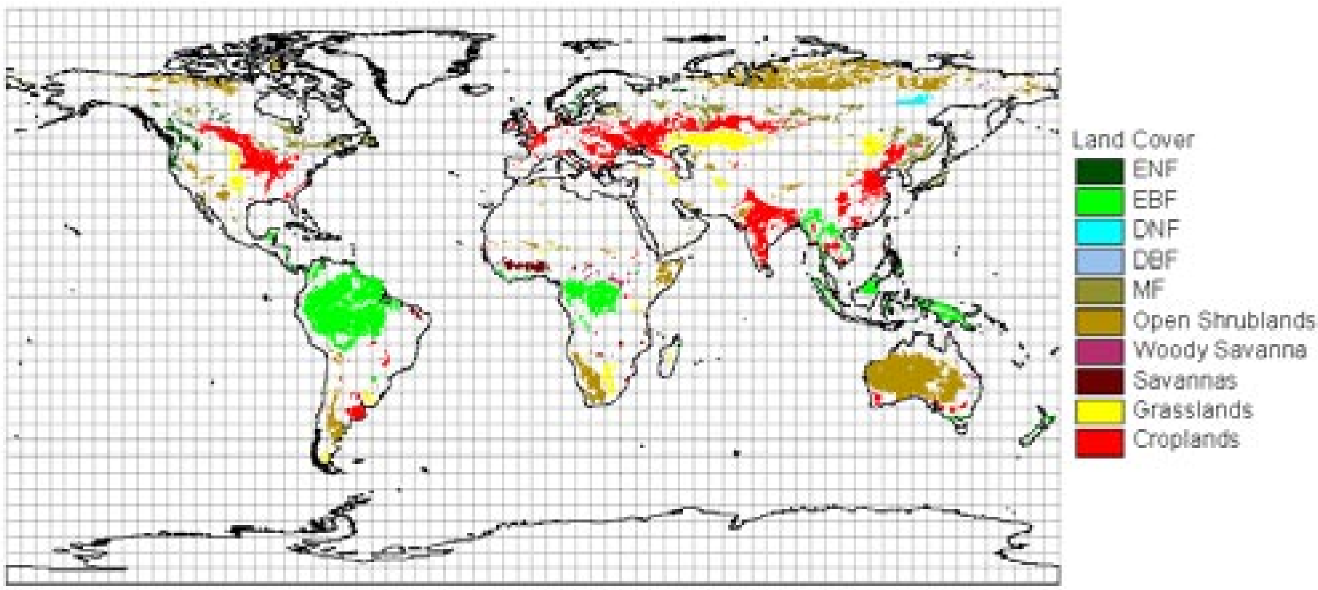


Fig.7. 50km homogeneous MODIS land cover over the world

Presentation:

1. "DAO validation", Zhao M., presented at the MODIS Vegetation workshop, Missoula, MT, July 15,2002
2, "Sensitivity analysis of MOD17 to MOD15 input " , Zhao M., R. Nemani, S. W. Running, S. Kang , poster at the MODIS Vegetation workshop, Missoula, MT, July 15,2002
3, "Sensitivity of MODIS derived photosynthesis and net primary productivity to relative accuracy of meteorological inputs", Zhao M., W. M. Jolly, J. S. Kimball, R. Nemani, S. W. Running, S. Kang, presented at ESA meeting, Tucson, AZ, August 4, 2002
4, "MODIS 17 NPP sensitivity analysis and validation", Zhao M., R. R. Nemani, S.W. Running, J.S. Kimball, S. Kang, IARC meeting, Honolulu, HI, Oct 15-17, 2002
5, "Validation of the MODIS MOD17 Algorithms for Estimating global Net Primary Production", Zhao M., S. W. Running, R. R. Nemani, J. S. Kimball, S. Kang, AGU fall meeting, San Francisco, CA, Dec 6-10, 2002

ACTIVITIES OF Sinkyu KANG (Postdoctoral Researcher)

Research Activities

1. Cloud Filling of MOD17A2 PSN product

Cloud effect on MODIS GPP product was examined using three alternative cloud-filling algorithm in Pacific Northwest (PNW). Our tentative conclusions are described as followings: in PNW, the cloud-filling produced higher PSN than Coll4P MOD17A2 (~10% in regional mean and up to +60% in point-wise comparison); the sensitivity to the cloud-filling increased in order of Grass (+11gC/m^2/y), Crop (+21), DBF (+47), and ENF(+113); in weekly comparisons, two post-processing algorithms produced distinctly different patterns from the in-processing algorithm; in annual comparisons, three algorithm produced quite similar values and patterns; the cloud-filling is selectively recommended depending on local topography and meteorology.

2. A regional phenology model based on MOD15A2 LAI product

A regional phenology model for detecting onset of vegetation greenness was developed using MODIS land products in temperate mixed forests in Korea. The model incorporates a digital elevation model (DEM), Moderate Resolution Imaging Spectroradiometer (MODIS) Landcover and Leaf Area Index (LAI) products, and climatological and meteorological data from weather stations. Air temperature was identified as a primary climatological variable significantly correlated with the MODIS-based onset dates ($r = -0.70$, $p<0.001$). Our method is to relate site-specific thermal summation based on the onset date with the 30-year mean air temperature, which predicts site-specific critical thermal summation. Two unknown parameters and the best regression were determined by iterative cross-validation. Minimal errors between the predicted and satellite-based onset dates were found at a mean absolute error (MAE) (3.0 days) and bias (+1.6 days). The predicted onset dates show good agreements with field observations (MAE = 2.5 and bias = +2.5 days). This study provides an objective method to develop and parameterize a regional phenology model using MODIS land products which is easily applicable to different regions.

3. Comparison of MODIS Productivity and Potential Productivity

MODIS annual productivity (GPP & NPP) in 2001 was compared with the potential productivity predicted by BIOME-BGC in Pacific Northwest (PNW). BIOME-BGC was calibrated with field measurements of LAI. A gridded BIOME-BGC simulation was conducted using Daymet daily meteorological data (1km-by-1km spatial resolution). Spatial patterns of MODIS productivity in 2001 and 18-year mean potential productivity were compared with each other.

The potential forest is similar to the old forest in terms of maximum LAI and seasonal NEE and ET. ENF and DBF showed higher productivity than Shrub and Grass biomes in both potential and MODIS productivity. MODIS NPP is spatially more variable than potential NPP. Landcover explains the distinct spatial variation of productivity across different biomes but local topography seems to produce spatially variable productivity within a homogeneous landcover. In general, MODIS NPP is lower than potential NPP at higher elevations but higher or equivalent at lower elevations. It is uncertain whether the lower MODIS NPP at higher elevation is artifact of, for example, snow/cloud contamination.

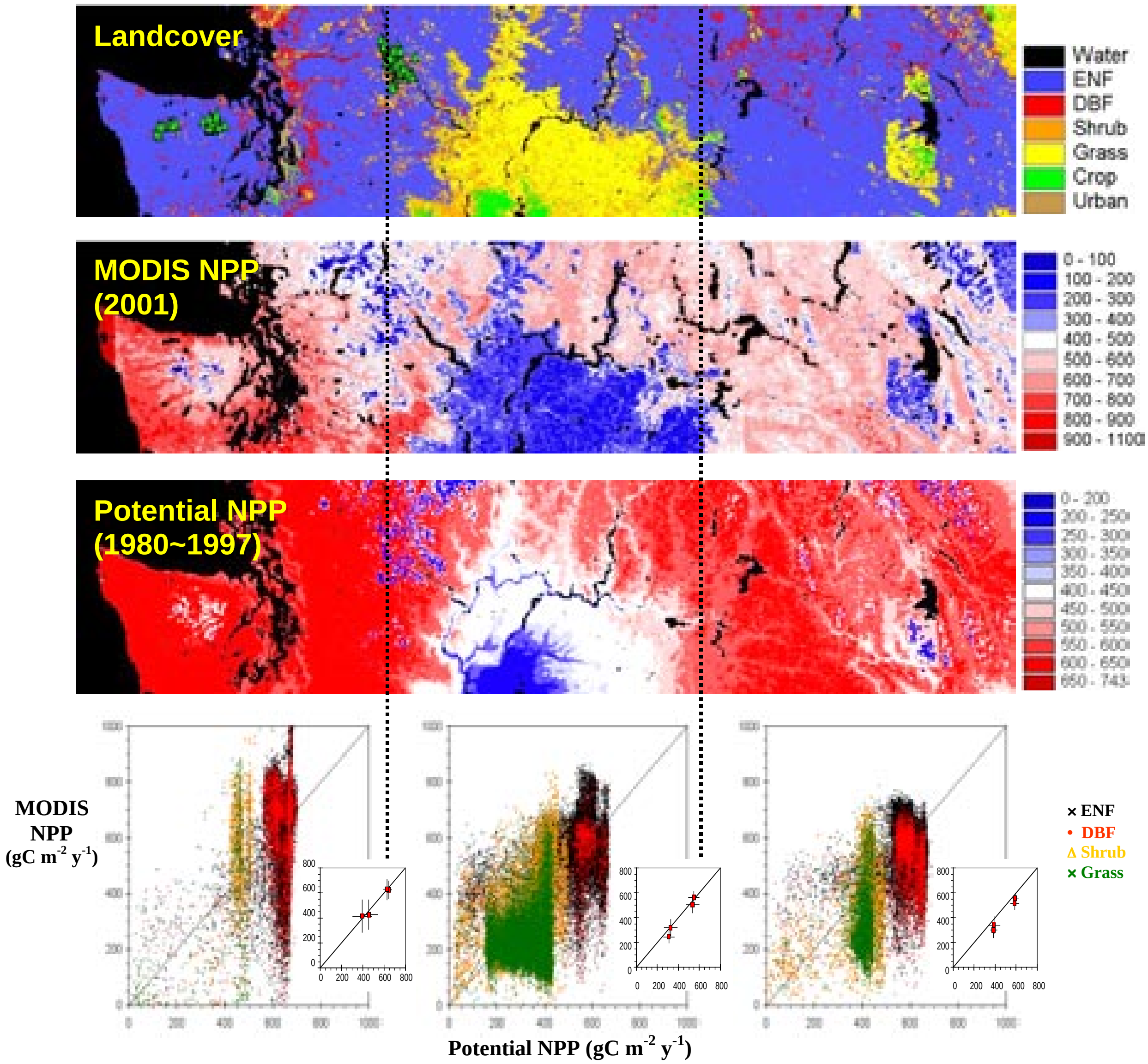


Fig.1 MODIS landcover, NPP in 2001, and simulated potential NPP for 1980-1997. The bottom scatter graphs show cell-by-cell comparison of MODIS and potential NPP in three adjacent areas with different climate: humid and warm; dry and warm; dry and cold from left to right. Small scatter diagrams compare averages of each biome types of MODIS and potential NPP.

Publications

Sinkyu Kang**, Dowon Lee, Jangho Lee, Steve W. Running (200?) Topographic and Climatic Controls of Forest Hydro-Ecological Processes in a Rugged Temperate Hardwood Forest in Korea. Agricultural and Forest Meteorology (in review).**

Sinkyu Kang**, Dowon Lee, John Kimball (200?) The effects of spatial aggregation of complex topogrqphy on hydro-ecological process similations within a rugged forest landscape: Development and application of a satellite-based topoclimatic model. Can. J. For. Res. (in review)**

Sinkyu Kang**, Sueyoung Doh, Dongsun Lee, Dowon Lee, Virginia L. Jin (200?) Topographic and Climatic Controls on Soil Respiration in Six Temperate Mixed-Hardwood Forest Slopes, Korea. Global Change Biology (in review)**

Sinkyu Kang**, Steve W. Running, Jong-Hwan Lim, Maosheng Zhao, Chan-Ryul Park, Rachel Loehman (200?) A Regional Phenology Model for Detecting Onset of Greenness in Temperate Mixed Forests, Korea: An Application of MODIS Leaf Area Index (LAI). Remote Sensing of Environment (Accepted).**

Dowon Lee, Sinkyu Kang**, Sun-Jin Yun (200?) Ecological knowledge and practices embedded in old Korean cultural landscapes. Human Ecology (Accepted)**

Lee, D., Yook, K.H., Lee, D., Kang, S.**, Kang, H., Lim, J.H., Lee, K.H. (2002) Changes in annual CO_2 fluxes estimated from inventory data in South Korea. Science in China 45 (Supp.), 87-96.**

Sinkyu Kang**, Hojeong Kang, Dongwook Ko, Dowon Lee (2002) Nitrogen removal from a riverine wetland: a field survey and simulation study of *Phragmites japonica*. Ecological Engineering 18, 467-475.**

Sinkyu Kang**, Sungwoo Kim, Dowon Lee (2002) Spatial and temporal patterns of solar radiation based on topography and air temperature. Can. J. For. Res. 32, 487-497.**

Presentations (senior authorship only)

Sinkyu Kang**, Steve W. Running, Jong-Hwan Lim, Maosheng Zhao, Chandra Park. A Regional Phenology Model for Detecting Onset of Greenness in Temperate Mixed Forests, Korea: An Application of MODIS Leaf Area Index (LAI). A paper presented at MODIS Vegetation Workshop held in Missoula, MT, USA in July 16-18, 2002.**

Sinkyu Kang**, Steve W. Running, Rama Nemani, Maosheng Zhao. A Comparison Study between MOD17A2 PSN and Biome-BGC Prediction. A paper presented at MODIS Vegetation Workshop held in Missoula, MT, USA in July 16-18, 2002.**

Sinkyu Kang**, Maosheng Zhao, Steve W. Running. Cloud Filing of Mod17A2 Photosynthetic Product (PSN). A paper presented at VIII INTECOL Meeting held in Seoul, Korea in August 11-18, 2002.**

Sinkyu Kang**, Dowon Lee, Steve W. Running. Prospectiveness of modeling and MODIS data to predict effects of climatic variability on long-term carbon sequestration in a mixed hardwood forest. A paper presented at VIII INTECOL Meeting held in Seoul, Korea in August 11-18, 2002.**

Sinkyu Kang **and NTSG members. Global terrestrial net primary production from MODIS. A paper presented at IARC Meeting held in Honolulu, Hawaii in October 14-17, 2002.**

Sinkyu Kang**, John Kimball, Steve W. Running, Andrew Michaelis, Maosheng Zhao. Comparisons of MODIS Productivity and Potential Productivity in Pacific Northwest and BOREAS Areas. A paper presented at AGU Meeting held in San Francisco, CA in December 5-10, 2002.**

Meetings Attended

MODIS Vegetation workshop, Missoula, MT, USA for July 14-18, 2002
VIII INTECOL Meeting, Seoul, Korea for August 11-18, 2002
IARC Meeting, Honolulu, Hawaii for October 14-17, 2002
AGU Meeting, San Francisco for December 5-10, 2002

ACTIVITIES OF M. Reeves (Ph.D. Student)

Activities for the last six months can be divided into two categories: Part 1 focuses on work related to the grassland biomass project while part two aims to construct a vegetation monitor capable of computing wheat yield in Montana.

Part 1

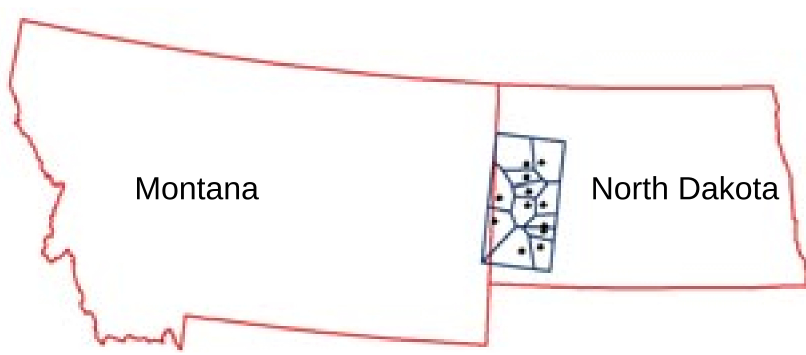
The purpose of this research is to characterize the relation between MODIS, LAI, NDVI, and EVI and above ground biomass on western rangelands. I have compiled two ground-based data sets of observed biomass. These data sets include over 4000 clipped plots (0.5 m^2) for the 2001 and 2002 growing seasons combined. I have prepared a paper that will be submitted to the International Journal of Remote Sensing by 20, December 2002. This paper characterizes the response of MODIS LAI, EVI, and NDVI over grassland in western North Dakota

Collecting Biomass Observations

In 2001 Biomass was measured within a 0.5 m^2 quadrat at a total of 473 transects (2200 plots) divided over four sampling periods during the growing season. A similar sampling scheme was employed during 2002. This series of sampling periods permits broad characterization of growing season dynamics ranging from greenup, maximum productivity and finally ontogenetic decline. Two years of plot level biomass data will provide an appropriate test-bed to characterize the response of MODIS land products to inter-annual grassland vegetation dynamics.

Estimating Biomass for the Entire Grasslands

Despite the vast number of observations recorded during the 2001 and 2002 growing season, they are spatially disjunct. This means that biomass must be interpolated between sampling plots or areas for which there are no observations. To accomplish this task observed biomass was modeled as a simple function of Landsat Enhanced Thematic Mapper (ETM) NDVI, thermal time, and precipitation. These variables were used to estimate biomass within Thiesson polygons around each of 12 weather stations within and adjacent to the LMNG (Fig 1.) Cross validation of the biomass prediction model was satisfactory for computing landscape level above ground biomass that can be compared to MODIS products (Fig. 2). Results of this analysis were presented at the 2002 Ecological Society of America (ESA) annual meeting in Tucson.



ecological units to compute
National Grasslands.

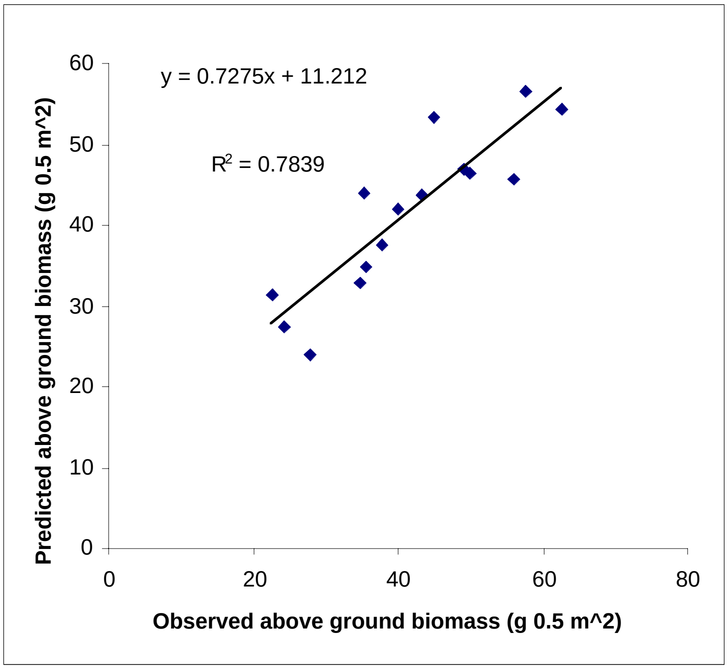


Fig. 2. Cross validation results for predicting above ground biomass at the Little Missouri National Grasslands.

Results. The results indicate that there is significant promise for use of MODIS land products to estimate above ground biomass in grassland ecosystems at regional scales (Table 1.). Table 1 reveals that when the spectral response of MODIS land products to agricultural land use is accounted for (Table 1b) there is a high level of agreement with above ground green biomass. It is also clear that the relations established during this research are time dependent (Figure 1) and should be re-evaluated and modified several times during the growing season if the intended use of MODIS land products is predicting biomass.

Table 1. Relationship (r^2) between MODIS products with modeled above ground green biomass for all zones (A) and with the agricultural zones removed (B). Dates for above ground green biomass are 28, May, 15, June, 15 July, 9 August 2001.

A					B				
Relation with all zones					Relation with agricultural zones removed				
MODIS Product	Composite period				MODIS Product	Composite period			
	145	161	193	217		145	161	193	217
LAI	0.46	0.72	0.34	0.368	LAI	0.73	0.79	0.80	0.72
EVI	0.82	0.78	0.56	0.75	EVI	0.87	0.79	0.83	0.75
NDVI	0.72	0.687	0.48	0.64	NDVI	0.82	0.72	0.75	0.87

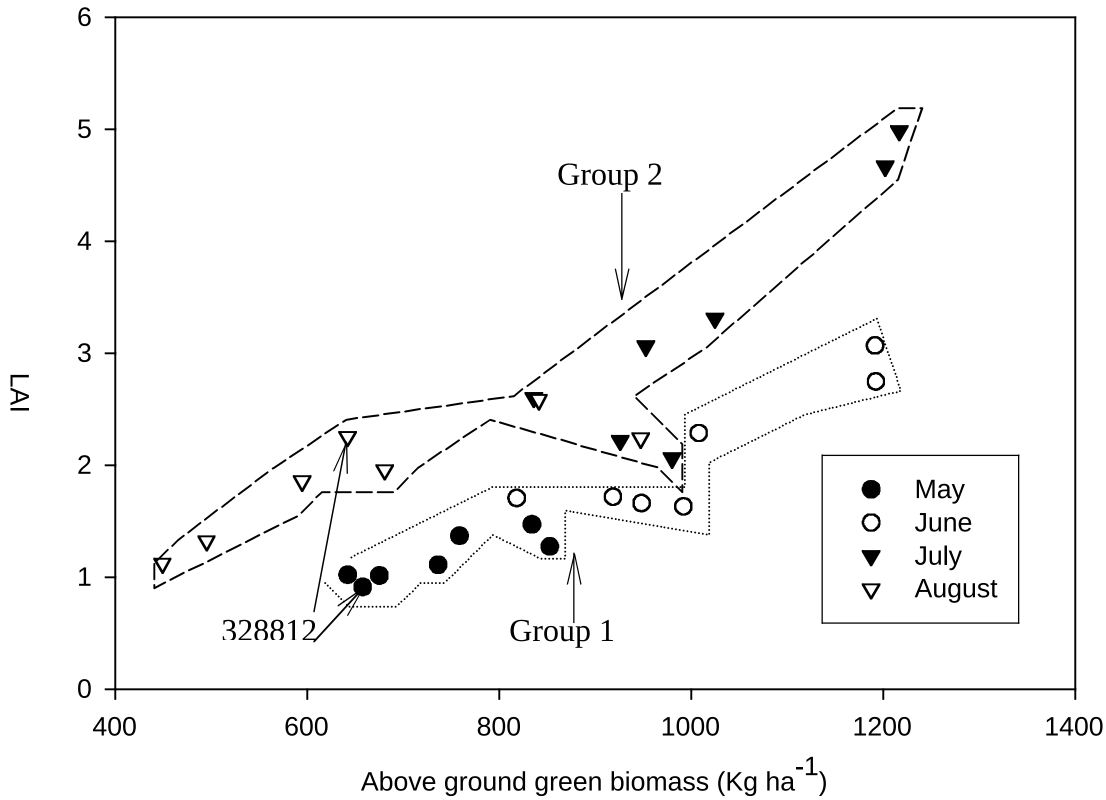


Figure 3. Spatial relation between MODIS LAI and above ground green biomass during all time periods in Group 1 (May and June , r = 0.94) and group 2 (July and August, r = 0.87). Note the change in relationship at different phenological states for National Climate Data Center Cooperative-id 328812.

Another paper has been started which uses both the 2001 and 2002 data to compare inter-annual productivity in the LMNG to MODIS land products. This paper should be completed in March 2003.

PART 2

Collecting Wheat Field Locations and Monitoring Crop Conditions

The locations of more than 500 wheat fields in Montana and North Dakota have been collected using a Global Positioning System. These data will be used as training areas to construct an algorithm using MODIS surface reflectance data that will be capable of automatically classifying wheat fields throughout the region. Once most of the wheat fields have been correctly identified, a wheat yield algorithm will be applied that aims to monitor crop yield conditions retrospectively throughout the 2002-growing season. We are hoping the algorithm will be useful for near-real time large area operation. To this end we have been consorting with MSE technologies Butte, Montana in some aspects of the project.

Recent Research Highlights

1. Speaker at Ecological Society of America conference at Tucson Arizona: Title: *“Scaling Biomass Measurements for Examining MODIS Derived Vegetation Products“*
2. Completed two year field sampling campaign in the Little Missouri National Grasslands
3. Constructed empirical models to compute productivity at a regional level appropriate for characterizing MODIS data
4. Assisted a private company in their use of some MODIS data
5. Prepared a manuscript for submission to International Journal of Remote Sensing
6. Intended speaker at Environmental Protection Agency “Spectral Remote Sensing of 7. Vegetation” (March, 2003). During this presentation I will provide an overview of MODIS land products and their utility as vegetation monitors.
7. Mapped approximately 500 wheat fields in Eastern Montana and Western North Dakota for use as training data to develop a map of wheat distribution in Montana during 2002.

<u>Activities of Cristina Milesi (PhD candidate) for June 2002-December 2002</u>

During the past six months we have developed a methodology for assessing the impacts of urbanization on regional net primary productivity. The efforts have produced a journal article that has been accepted for publication in *Remote Sensing of Environment*.

The research addresses the lack of quantitative information on the impact of urban development on the photosynthetic capacity of the land. The study focused on the southeastern United States, which has undergone one of the highest rates of landscape change and urban sprawl in the country, with urbanization rates much higher than the national average. We used a combination of MODIS and nighttime Defense Meteorological Satellite Program / Operational Linescan System (DMSP/OLS) data to estimate the extent of recent urban sprawl and its impact on regional NPP in the southeastern United States. Since urban areas are masked out in the standard MOD15 (LAI/FPAR) and MOD17 (NPP) products, we estimated NPP from MOD13 (NDVI, Figure 1) using the backup algorithms, considering urban areas as savannas.

The analysis based on the nighttime data (Figure 2) indicated that in 1992/93 urban areas amounted to 4.5% of the total surface in the region. In the year 2000, the nighttime data revealed an increase in urban developed land by 1.9%. Estimates derived from the MODIS data (Table 1) indicated that land cover changes due to urban development that took place during the analyzed period reduced annual NPP of the southeastern United States by 0.4%, with an average loss of 180 g of carbon per square meter per year. In spite of this loss, urban land retained relatively high values of vegetation productivity, which can be attributed to high urban tree cover and numerous golf courses in the regions. Results from this study indicated that the combination of MODIS products such as NPP with nighttime data could provide rapid assessment of urban land cover changes and thei

Figure 1. MODIS NDVI data for the year 2001 for the southeastern US.

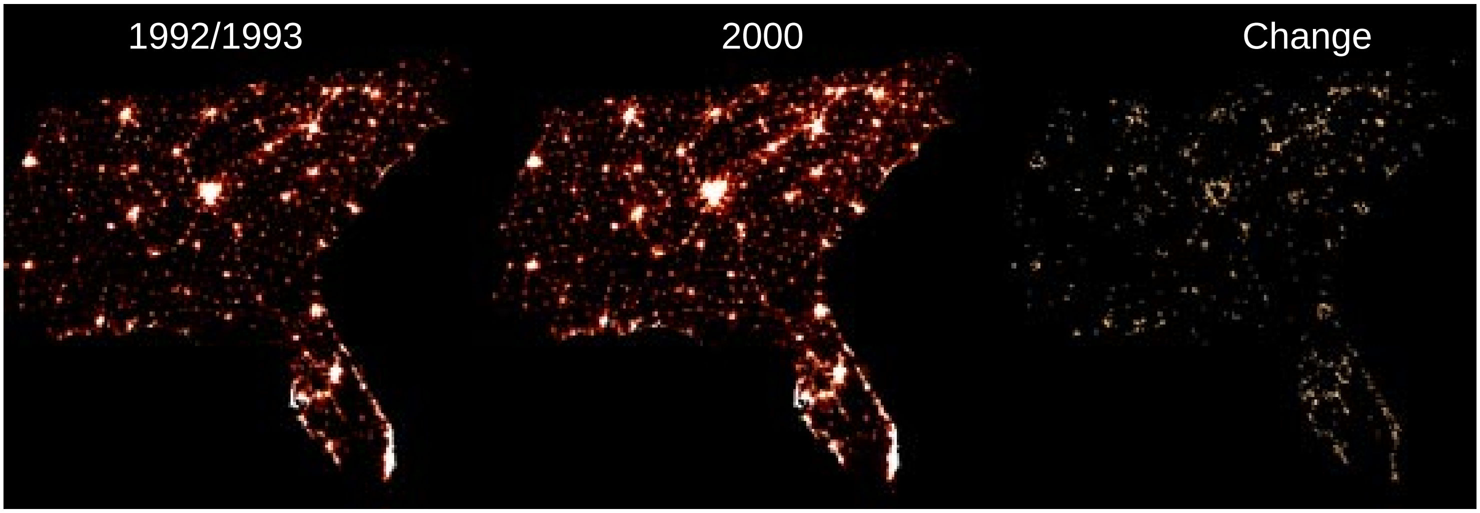


Figure 2. Nighttime data from the DMSP/OLS data set. Urban areas increased by almost 2% during the 1992/93-2000 period.

		Loss in NPP due to urban land development	
	Average NPP ($g\ C\ m^{-2}\ y^{-1}$)	*Unit loss ($g\ C\ m^{-2}\ y^{-1}$)*	*Total loss ($Tg\ C\ y^{-1}$)*
Alabama	800	221	0.38
Florida	749	153	0.55
Georgia	848	204	0.63
Mississippi	765	196	0.26
N. Carolina	798	178	0.54
S. Carolina	789	194	0.37
Tennessee	759	163	0.30
SE-US	786	183	3.04

Table 1. Summary statistics on NPP for the southeastern states

Publications

C.Milesi , C.D. Elvidge, R.R. Nemani and S.W. Running (2002) Impact of urban sprawl on net primary productivity in the Southeastern United States. *Remote Sensing of Environment*. (Accepted)

C.Milesi , C.D. Elvidge, R.R. Nemani and S.W. Running (2002) Impact of urban sprawl on net primary productivity in the southeastern United States, *2002 International Geoscience and Remote Sensing Symposium and 24th Canadian Symposium on Remote Sensing*, V:2971-2973

Meetings attended

IGARSS 2002, Toronto, Ontario, Canada, June 24-28, 2002
MODIS Vegetation workshop, Missoula, MT, USA, July 14-18, 2002
AGU Meeting, San Francisco, CA, USA, December 5-10, 2002

Presentations

- Java Distributed Application Framework (JDAF) at MST, 2002
- Distributed Application Framework for Earth-Science Data Processing at IGARSS'02
- Parallelization of Earth Science Applications at NASA IDU Workshop 2002

POSTERS

- Biospheric Forecasting Nemani, R, White, M, Votava, P. IGARSS'02
- Forcing of 1982-1997 Ecosystem Water and Carbon Fluxes in the Conterminous United States: Relative Influence of Vegetation Structure and Phenology Versus Climate, White, M A, Nemani, R R, Votava, P. AGU 2002.
- Terrestrial Observation and Prediction System: Integration of satellite and surface weather observations with ecosystem models, Nemani, R R, Votava, P, Roads, J, White, M, Thornton, P, Coughlan, J. AGU 2002.
- Distributed Application Framework for Earth Science Data Processing. Votava, P, Nemani, R, Michaelis, A, Neuschwander, A, Coughlan, J, Bowker, C. AGU 2002.

PAPERS

P. Votava et al, 2002. *Distributed Application Framework for Earth-Science Data Processing*. In proceedings of IGARSS 2002. June 2002. Toronto, Canada.

Myneni et al., "*Global products of vegetation leaf area and fraction absorbed PAR from year one of MODIS data*." Remote Sensing Environment, 83: 214 –231, 2002

<u>ACTIVITIES OF P. Votava, Lead Software Engineer</u>

OBJECTIVES

The objectives during the time period January 2001 to January 2002 are summarized here, with details on each of the indicated activity areas following.

- Patch our existing production code for Collection 3 reprocessing
- Prepare all our production code for Collection 4 reprocessing
- Oversee and troubleshoot MODAPS production of our biophysical land product suite.
- Perform ad-hoc Quality Assurance/Quality Control activities on our set of MODIS data products.
- Refine our SCF procedures and architecture using early MODIS product experience.
- Augment the MODAPS production team efforts by implementing selected SCF production scenarios required to supply NASA collaborators with early PR materials
- Continue to develop our MODIS/Aqua production code
- Continue development on the TOPS project

WORK ACCOMPLISHED

On the MODIS front, we have focused our efforts mainly at troubleshooting of our at launch algorithms, and at monitoring of the production of our products in the MODIS Adaptive Processing System (MODAPS). As a part of the troubleshooting, we have implemented number of Quality Control and Quality Assurance procedures. Additionally, we have introduced significant changes to all our algorithms that will produce much better results during the Collection 4 reprocessing that will start in December 2002.

Key accomplishments internal to the SCF for this period are further automation of procedures for PR image production, including reprojection, tiling, and sub-sampling. Additionally, we have improved our in-house software for our internal QA procedures with capabilities missing in all externally available tools. Most of this process is now database driven and the overall design uses a set of plug-in filters. Finally, we have produced global, local, and regional images of our MODIS PSN data for all the periods of 2001 and available periods of 2002 – this was done at 3 different resolutions. We have significantly upgraded our MODIS image Web site where all of these images are posted, and added database back end to this web site.

In TOPS we have significantly improved our prototype by improving the database design and started integration with the Automated Planner from Dr. Golden at NASA Ames.

ALGORITHM DEVELOPMENT

FPAR, LAI Daily and 8-day Composite (PGE33, PGE34)

The main science logic in the daily and 8-day FPAR, LAI has been stable for quite some time, with the changes in Collection 3 algorithm during this period mostly applying to minor engineering issues pertaining to QA handling and ECS metadata interpretation. Additionally, new version of PGE34 (v3.0.8) has been delivered. Last, two more patch deliveries has been made – both of them deal with metadata issues.

I have implemented major changes that are required for Collection 4 reprocessing – this includes changing the SCF QA in our of our algorithms, changing the landcover used in daily FPAR/LAI (PGE33) from static IGBP at-launch landcover to a new MODIS-derived landcover, changing the strategy for compositing of our 8-day FPAR/LAI (PGE34) and implementing scientific changes related to high LAI values during saturation for biomes 1 through 4. Finally, we have changed the projection of the output data from integerized sinusoidal (ISIN) to sinusoidal (SIN).

I have also started working on a prototype of a combined Terra/Aqua product that should go into production in second half of 2003, and on global Climate Modeling Grid (CMG) that should be in production in the second quarter of 2003.

The daily FPAR, LAI algorithm (PGE33) is currently at version v3.0.8, for Collection 3 and is built using the SDPTK v5.2, HDFEOS 3.2, HDF 4.1r3, and MUM v.2.5.5 libraries. This algorithm is now at 18,723 LOC (77,095 LOC total includes the MUM API). The Collection 4 algorithm went through 4 science tests and is at version 4.0.5. This algorithm will be used for both forward and backward processing staring on 12/20/2002.

The 8-day FPAR, LAI algorithm (PGE34) is currently at version v3.0.7 for Collection 3, and is built using the SDPTK v5.2, HDFEOS 3.2, HDF 4.1r3, and MUM v.2.5.5 libraries. This algorithm is now at 10,198 LOC (70,043 LOC total includes the MUM API). Collection 4 algorithm is at version 4.0.3 and will be used in both forward and backward processing starting on 12/20/02.

PSN, NPP (PGE36, PGE37, PGE38) Algorithm

The PSN, NPP biophysical algorithm (ESDT: MOD17A1, A2, A3) is unique among the other MODIS Land algorithms in the degree to which it is a model oriented rather than instrument radiometry oriented process. It requires daily availability of the new DAO DAS subset of global surface climatology variables, as well as the FPAR, LAI 8-day composite tiles from the most recent period relative to the day, the MOD12Q1 landcover definition, and its static ancillary data. The single most critical factor that sets the PSN, NPP algorithm apart from the others its temporal sensitivity, driven by the way that cumulative (additive) state variables for GPP, GPP minus maintenance respiration, maximum leaf mass and annual sum of maintenance respiration are carried forward throughout the year. From a production standpoint, delivering a temporally reliable stream of FPAR, LAI data to the daily PSN, NPP algorithm has become one of the most challenging, quality limiting aspects of the MODAPS. In the larger MODIS Land processing stream, persistent production gap problems arising in the EDOS portion of the ground system have propagated tile and time drop-outs of the MODAGAGG to the daily FPAR, LAI processing. These in turn are reflected in drop-outs of 8-day MOD15A2 to the daily PSN algorithm. While corrections to EDOS problems are reportedly on their way, to run our PSN, NPP algorithm reliably, our SCF has had to locally stage up the required inputs, to implement limited processing here. We were able to implement a distributed production system and we were able to produce global annual products in a matter of a single day. The architecture uses Perl with thread support and distributes the processing across a 16-node Linux cluster. The runtime for global annual products (365 days x 288 tiles = over 100,000 tiles of data) is 22 hours.

There have been several major changes in the Collection 4 code to improve it from the current version. First, we have changed the QA to reflect the changes in the upstream FPAR/LAI product, additionally the QA of the yearly NPP has been simplified and corrected. Next we have fixed several bugs in the metadata and the science dealing with the DAO unit conversion. We have also added a new SDS to our 8-day product so that both GPP and PSN are generated every 8 days. Finally, there is a new lookup table (BPLUT) that significantly improves the quality of both PSN and NPP data. An external change introduced into the Collection 4 processing is the change of the climate data from DAO that transitions from GEOS3 to GEOS4 – the impact of this change will be analyzed as the Collection 4 data become available in 2003.

The PSN, NPP algorithm (PGE36, 37, 38) are currently at version v3.1.0 for Collection 3, built using the SDPTK v5.2, HDFEOS 3.2, HDF 4.1r3, and MUM v.2.5.8 libraries. The PSN, NPP algorithm is now at 18037 LOC (78,093 LOC total includes the MUM API).
The Collection 4 version is 4.2.0 and it will be used in the production from 12/20/02.

TOPS

There are ongoing improvements of our framework prototype involving addition the Automated Reasoning Front End with Dr. Golden at NASA Ames. Other improvements include implementation of about 10 different modules including all the TOPS required modules, several visualization packages, and a MODIS PSN/NPP prototype. The prototype of the entire TOPS system should be ready in January 2003 and we will be ready to start daily-automated forecasts.

SCF DEVELOPMENT

Incremental additions to the Montana SCF were made during this period to increase our ability to perform high volume QA, test, and limited production in support of our global validation program.

Linux Cluster Development and Implementation

In last several months we have geared up to do several processing campaigns that involved our Linux clusters. The development of the cluster and automation software has spanned several versions. We have now completed the move from collection of Perl and shell scripts towards an integrated Java environment that gives us more control in the distributed environment. We have refined our Java client/server model to implement the distribution of tasks among the hosts in the cluster. One of the advantages of this approach is that we have removed the limitation of running the distributed environment only on Linux hosts – the Java portability should allow us to operate in truly heterogeneous environment.

UM SCF Cluster and Processing Development

We have currently implemented distributed cluster servers to run both the FPAR, LAI 8-day (PGE34) and PSN daily, 8-day, and annual (PGE36, 37, 38). On the client side we have a new version of PGE34 client and scheduler that implements a simple load balancing scheme. Additionally, we have added our global PR (reprojection, mosaicing, subsampling, and imaging) system to run on our distributed environment as well. This system has been used in runs that produced our latest PSN composites. A similar system was used to produce our global 8-day PSN composite, which is quite bit more complicated. In the latter case, we needed to perform around 5,000 tile executions using the PGE. On current Linux cluster this required ca 4 hours to complete. In the next version, we plan on implementing a better graphical user interface for our system and to unify the Java/RMI environment. The initial step of each processing campaign starts with a PCF (runtime input command set) generation step is now part of the distributed environment and is done in Java. Finally, we have integrated our production algorithms with the Java distributed system, which helps us to maintain unified API across many different algorithms, and thus enables us to do much faster integration and more efficient scheduling.

COLLABORATIONS: SCIENCE AND DATA SYSTEMS

During this period the following collaborations were pursued for MODIS and TOPS related activities:

- Continued to closely collaborate with the Boston University staff on the refinements to QA procedures and interpretation of MOD15A1 and MOD15A2.
- We initiated an interim scheme to locally archive data products (MOD15A2 and MOD17A2), in support of our on-going Quality Assurance program, via periodic downloads from the MODAPS production environment. We are also archiving the following products: MOD09, MOD11A2, MOD43B3, MOD12Q1, MOD13A2
- Collaboration with Dr. Keith Golden at NASA Ames on the Automated reasoning front end of the tops project
- Collaboration with Dr. Steve Minton at Fetch/UCS on the execution environment of the TOPS project

CONFERENCES/MEETINGS

- IGARSS 2002, June 2002
- NASA Modis Science Team Meeting, July 2002
- NASA IDU Workshop, September 2002
- AGU Fall Meeting, December 2002

Compute Services Team (CST) Progress Report 2002

The CST as a team, and as individual members, has made great progress this year. We have closed the gap between the Science and Computing teams with the internal documentation website (http://docs.ntsg.umt.edu) and by holding seminars and working closely with members of the science team on their projects.

The team has handed the current data distribution website (http://images.ntsg.umt.edu) and they prototype replacement we developed over the summer to Lupine Logic. We have met with them and are working on integrating their work into the new production and distribution system plan. (see figure)

The CST is providing a stable hardware and software environment, which quite frankly, are unrivaled at most ESIPs and University research labs nation wide.

Current Status of the NTSG data warehouse:

NTSG is pulling in Several MODIS datasets through subscription services with the National Snow and Ice Data Center and the LP DAAC. These datasets include: MOD09A1, MOD10A2, MOD11A2, MOD12Q1, MOD13A2, MOD13Q1, MOD15A2, MOD17A2, MOD17A3, MOD43B3. This will enable us to automate the process of production of value added products as well as receive the latest version of EOS data. We currently have three Terabytes of disk available for our data warehouse, with an aggressive hardware upgrade plan for the future. We are currently working on a database driven distribution and browse interface to our data holdings, which will enable both internal and external users to get fast access to our public data.

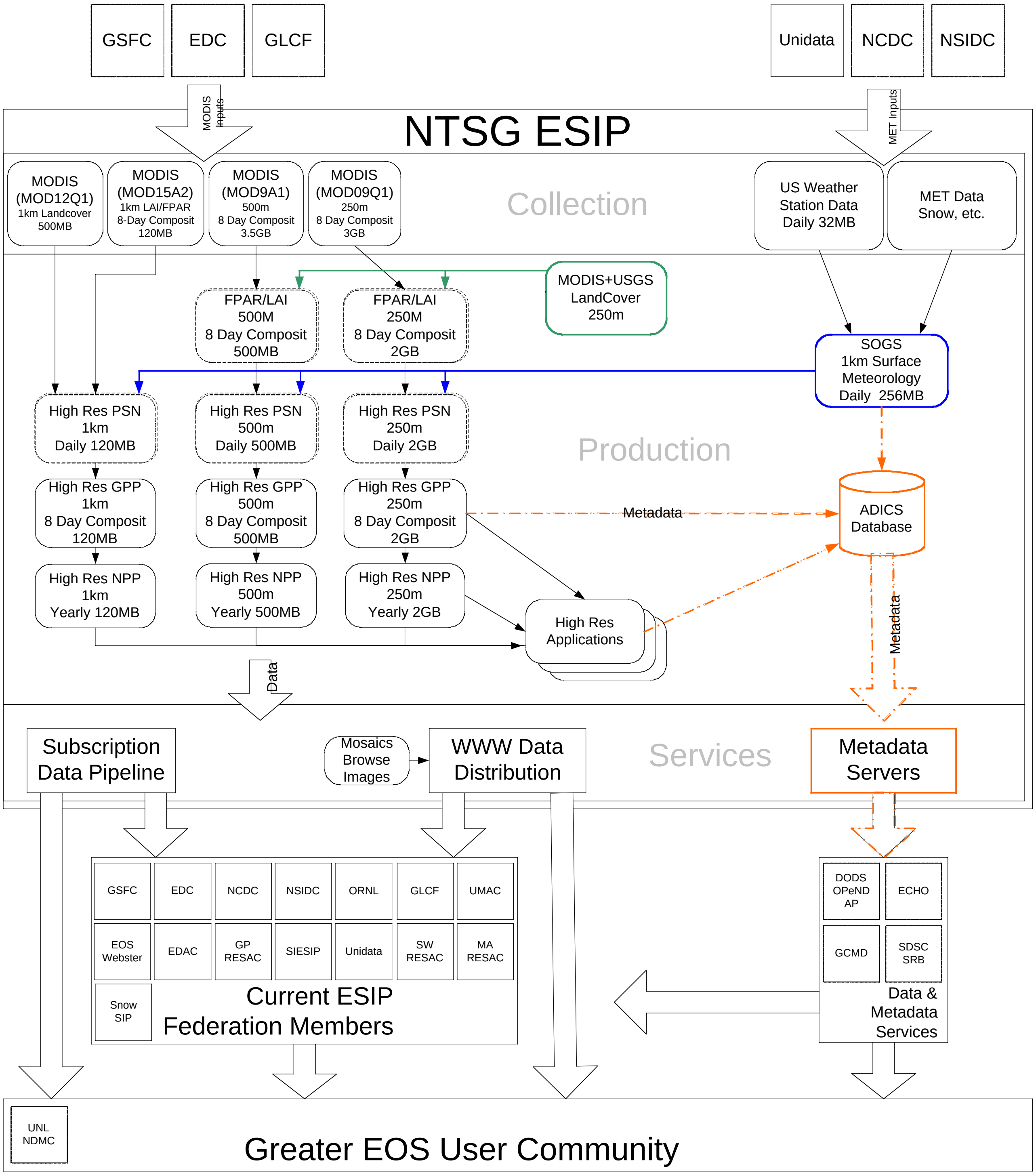


Figure: Latest revisions of the production system plan for High Res Npp and related products.

Individual CST member reports:

Saxon Holbrook (CST Manager, Network & System Administrator, NTSG's ESIP Federation Representative)

Tasks & Accomplishments:

- CST Team Management
- ESIP Federation Participation including the Constitution and Bylaws Committee, Peer Review working group and multiple clusters.
- Replaced all workstations in the lab
- Installed Catalyst 4006 for Gigabit Ethernet Support
- Maintained network and system services
- Maintained software licenses and contracts

Meetings & Workshops:

- AIST Projections Workshop – January 9-10, 2002; Greenbelt, Maryland. I was NTSG's chosen representative for this invitation only workshop. The agenda was to review, modify and update the technology needs database and investment themes and to explore and develop a more detailed 10-year technology roadmap.

- ESIP Federation Meeting – January 23-25,2002; Aleyska, Alaska. I represented NTSG during the business meeting and was the NTSG voting proxy. Although the attendance at this meeting was a bit lacking, it provided a great opportunity for me to interact with more members of the federation. I spent a considerable amount of time with Jim Simpson and George Seilestad discussing the current operation and future of federation and potential collaborative projects. During this meeting, Jim Simpson and I formed the working group for Peer Review.

- ESIP Federation Meeting – May 15-17, 2002; College Park, Maryland. I represented NTSG during the business meeting and was the NTSG voting proxy. There were presentations from Karen Moe on SEEDS Capability Vision Development, Ed Sheffner on the ESE and Vanessa Griffin on the SEEDS Formulation.

  During the meeting I participated in a 4-hour workshop on the MN MapServer and a two-hour ArcIMS workshop. The MapServer technology will be extremely useful in providing access to our data holdings to both the outside world and our own users. http://terrasip.gis.umn.edu The ArcIMS workshop didn't really lend any valuable information except the contact of gyetman@ciesin.columbia.edu (Greg Yetman) who's an ArcIMS wizard and seemed interested in helping anyone with questions.

  Spoke with Peter Cornillion about the OPeNDAP (formerly DODS) Open Source Project for Network data - discipline neutral. Could definitely serve our MODIS HFD-EOS data and other data. Current solutions include IDL clients, aggregation servers, etc.

  Spoke to Gene Major about registering our data with the GCMD.

http://gcmd.nasa.gov I've already set Chad to this task. (NOTE: The standard MODIS product stream is already included via EDC but DAYMET is not.

- MODIS Vegetation Workshop, July 16-18, 2002; Missoula, MT. As on of the hosts of this workshop, I was responsible for insuring all hardware for presentations and technical workshop sessions was installed and operational. It was also a great opportunity to interact with members of the greater EOS community.

Chad Bowker (Data Manager, Programmer)

Tasks Accomplished:

Prototype of the web interface to NTSG Data Warehouse.
Data filters for meteorological data.
Data download automation for meteorological data.
Work on aspects of the JDAF framework.
Retrieval and processing of MODIS data for EOS Ed website.
Automation of processing of MODIS data for EOS Ed website.
Negotiation of data subscription with the Snow and Ice Data Center.
Negotiation of data subscription with the Land Processes Data Center.

Current and Ongoing tasks:

Acquisition and management of MODIS and other EOS datasets.
Monitoring of NTSG Data Warehouse to ensure data integrity and compliance of metadata to NTSG, ESIP Federation and NASA guidelines/standards.
Participation in automation of data retrieval and dissemination system.
SEEDS liaison.
Maintaining the MODIS Vegetation Workshop website help desk.

Recently attended Conferences:

HDF EOS Conference, Greenbelt Maryland.
MODIS Vegetation Workshop, Missoula Montana.
SEEDS Second Workshop, San Diego California.
ECHO Training Session, Greenbelt Maryland.

HDF-EOS Conference highlights:

At the HDF-EOS conference we were exposed to several budding new technologies as well as new ideas about old ones. We were able to glean a better understanding through hands on tutorials of the HDF-EOS data format. We also met some collegues who were interested in our activities.   This conference also gave us an avenue to get some feed back from the broader user community on what needs are not being met in data availability and data services.

SEEDS Second Workshop:

The SEEDS group promises to be the new standards entity for NASA's Earth Science Enterprise. By attending the workshop we have a good idea of where NTSG will fit in and where we can be of the most use to the SEEDS group. While at the workshop I was able to participate in some of the breakout groups, giving me a good understanding of where the community is, and where it is headed in the future. Of paramount concern at the Conference was the lack of representation by the scientific user community. NTSG would be able to be a key voice for the science community at SEEDS.

ECHO training Session:

The ECHO training session helped to enlighten NTSG as to this new service. NTSG is eager to participate in this developing technology in order to better facilitate our data services to our users. Using ECHO we will be able to reach an even broader user base than we currently have, and with ECHO's close ties with SEEDS we will be able to grow into the future together. We have decided to write a data provider interface to ECHO to make our metadata available, with the possibility of writing a client interface in the future.

Co Authored Papers:

Votava, P., R. Nemani, C. Bowker, A. Michaelis, A. Neuschwander, J. Coughlan. 2002. "Distributed Application Framework for Earth-Science Data Processing". In Proceedings of IEEE IGARSS 2002, Toronto, Canada

Andrew Neuschwander (LINUX System Administrator)

Primary tasks include managing the LINUX compute environment and designing and implementing the ADICS data tracking database.

- System maintenance. I continued to be vigilant in maintaining and developing the integrity and security of our Linux compute infrastructure.
- Continued infrastructure upgrades. I acquired new high performance database server in anticipation of both ADICS & SOGS. I acquired a new 4 node linux server cluster which will provide 4TB of additional storage capacity as well as tape back-up services, and redundant core network services (Web, FTP, Mail).
- I brought our second cluster online (Romulus) and configured it to be used in conjunction with the Remus cluster. This allowed Andy to do a massive gridded BGC run for Sinkyu.
- Most significantly I continued to develop the design and tools needed for an end-to-end data management system. Significant work is being done on ADICS. The database design has undergone a major revision and is now in place on the new database server.

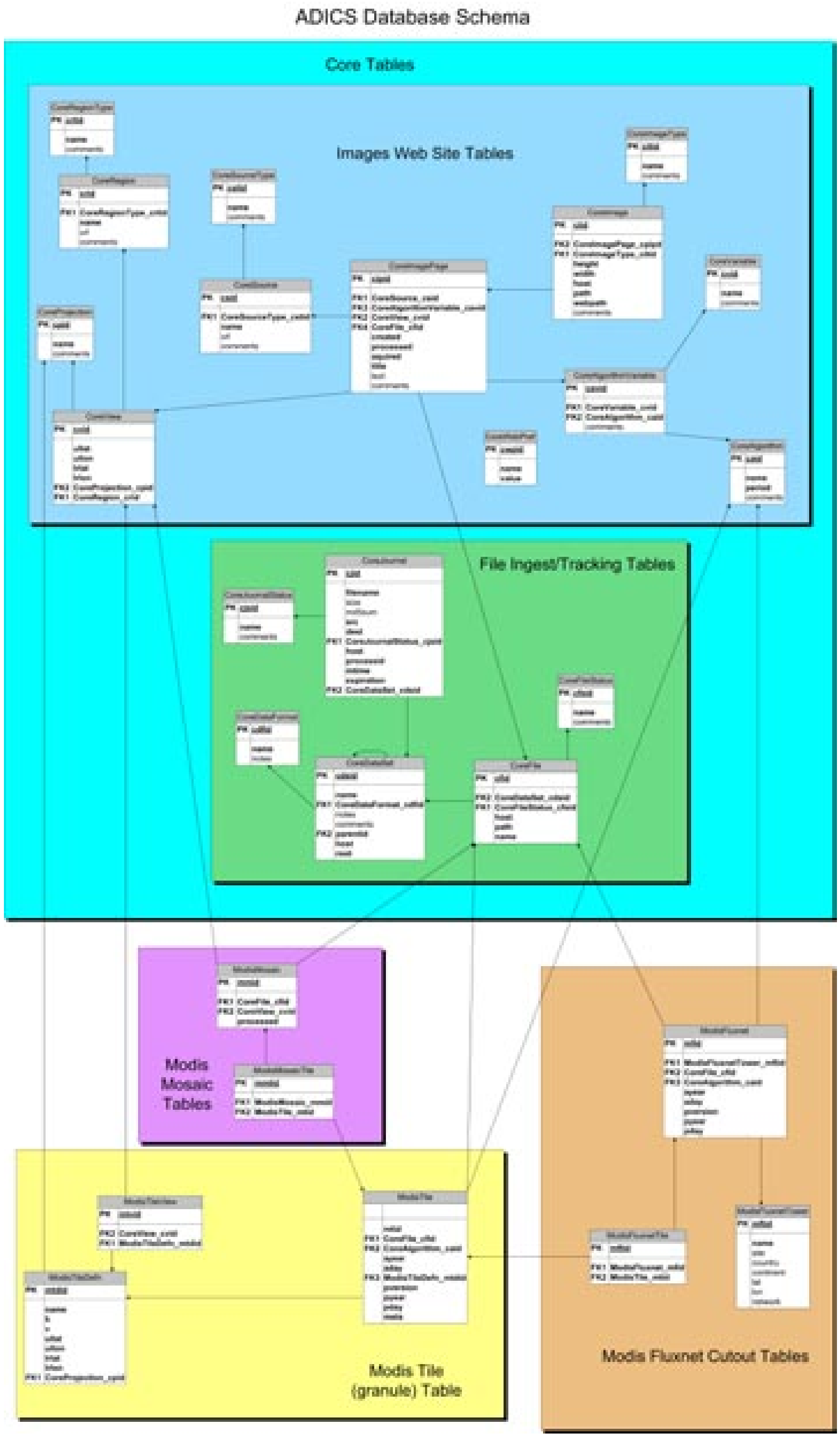


Figure: ADICS Database Schema

Andy Michealis (Student Programmer)

Primary Task: Design and implementation of Newmet prototype meteorological interpolation program. This program will be incorporated into the SOGS (Surface Observation Gridding System) prototype system. The current status of the of the SOGS system as a whole is still in the Analysis/design phases. Limited prototypes* of the three subsystems exist but the initial system as a whole is not currently ready for production.

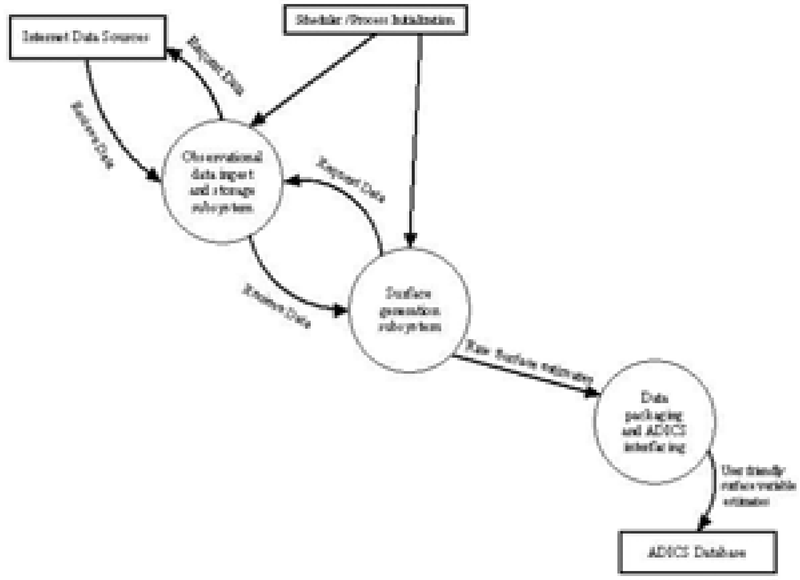


Figure: SOGS Operational Diagram

Python/sh distributed computing framework for the NTSG computing platforms. This successful system has been utilized with many in-house, large-scale model runs such as: Mod17 processing runs, Newmet processing runs, large-scale **biomebgc** runs. This small but indispensable framework has proven successful and "needs" no further work. However, fine-tuning this framework to better utilize computing resources and limit resource idle times would be worth the effort.

General MODIS data visualizations work: The production of MODIS imagery for lab personnel.

Coauthored papers:
1. Votava, P., R. Nemani, A. Michaelis, K. Golden. 2002. "Distributed Application Framework for Earth-Science Data Processing Terrestrial Observation and Prediction System Case Study". American Geophysical Union (AGU) Fall 2002 Meeting. San Francisco, CA.

2. Votava, P., R. Nemani, C. Bowker, A. Michaelis, A. Neuschwander, J. Coughlan. 2002. "Distributed Application Framework for Earth-Science Data Processing". In Proceedings of IEEE IGARSS 2002, Toronto, Canada

Douglas Wissenbach (Student Programmer)
Joined the team in late summer and was quickly getting his feet wet with the DAO data feed. He completed an exhaustive comparison of the GEOS3 vs. GEOS 4 DAO for the available time periods. He is currently working on the script interfaces to the ADICS database.

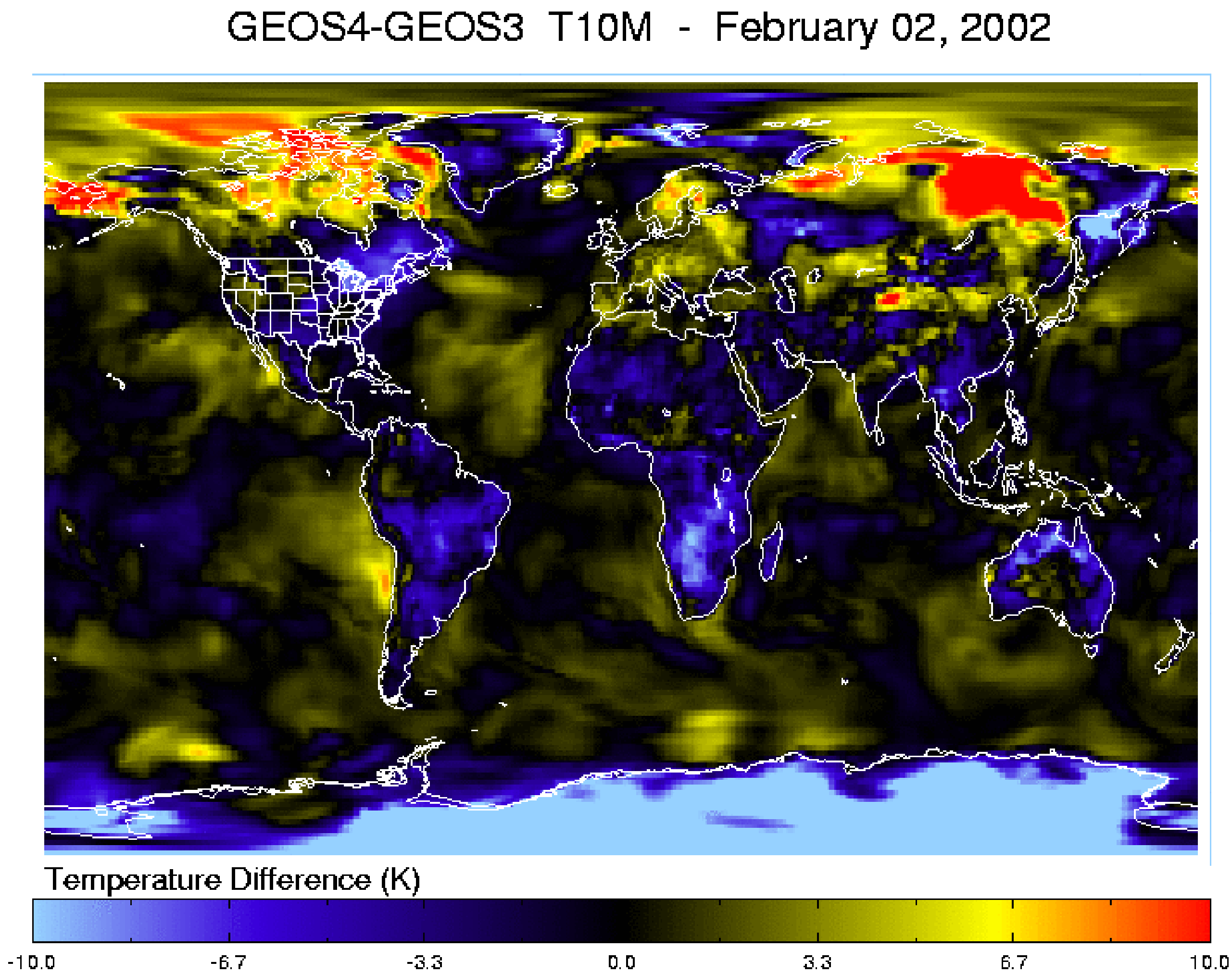


Figure: GEOS4 – GEOS3 DAO Global Difference Map

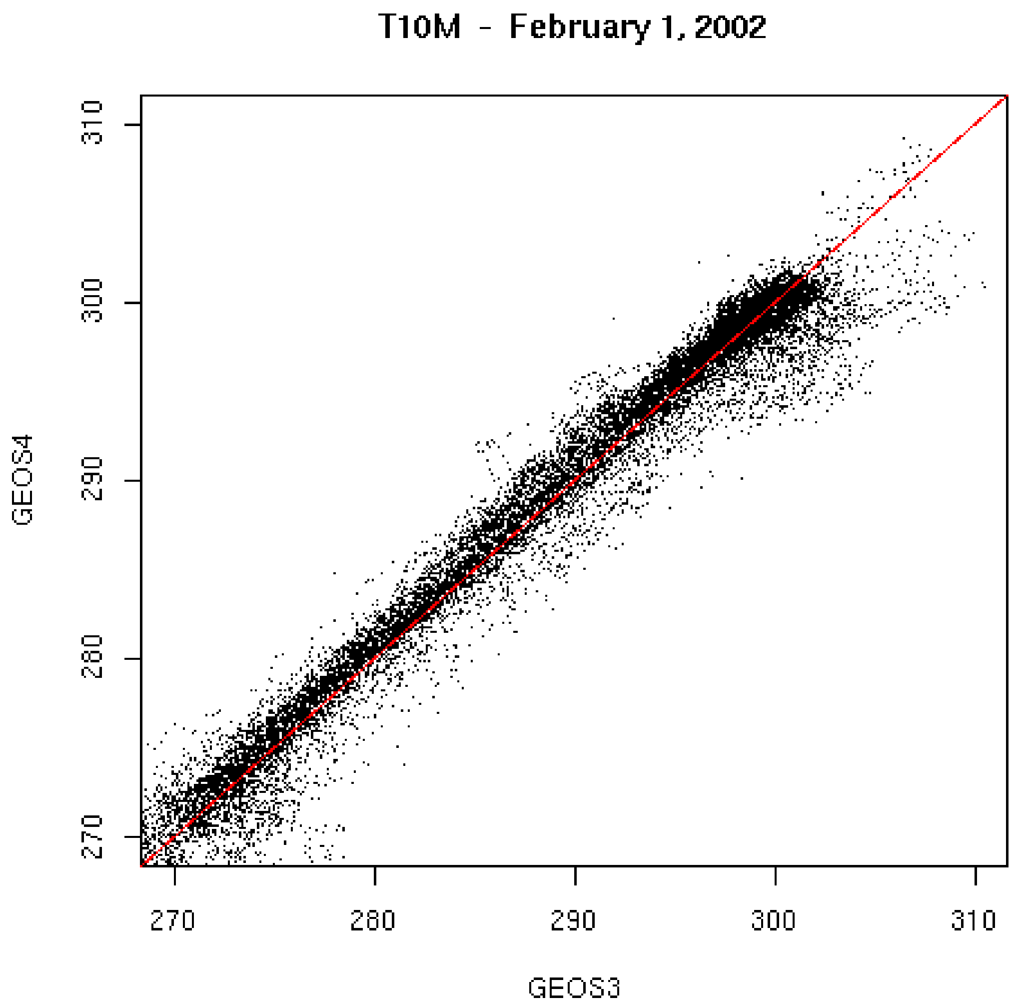


Figure: GEOS4 vs GEOS3 DAO Scatter Plot