The DEVELOP National Internship Program at NASA Ames Research Center

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Abstract

DEVELOP is a NASA-sponsored student intern program with activities at five NASA centers: Langley Research Center in Virginia, Stennis Space Center in Mississippi, Ames Research Center in California, Goddard Space Flight Center in Maryland, and Marshall Space Flight Center in Alabama. The DEVELOP National Program Office is located at Langley Research Center and funded by the Applied Science Program under NASA's Earth Science Division within the Science Mission Directorate at NASA Headquarters. DEVELOP uses geospatial technology to demonstrate to federal, state, local and tribal governments how NASA earth science technology and data can be used to assist federal, state and tribal agencies as they seek solutions for resource management problems. DEVELOP is a unique program because it is student-run and student-led, with science advisors and mentors from the public and private sector.

DEVELOP began at NASA Langley in 1998 and expanded to include NASA Ames as the Western Regional DEVELOP center in 2003. Since then, the Ames DEVELOP program has had a total of 57 students and completed 10 projects. These ten projects address problems in four application areas: invasive species, carbon management, ecological forecasting and public health. As in all DEVELOP projects, the students developed the methodologies, field work protocols and final papers for each of the projects, enabling students to learn about geospatial technology, advanced visualization tools, project management skills and team building in the context of addressing a national resource management problem.

Internships at NASA

One of NASA's three strategic education goals is to "Strengthen NASA and the Nation's future workforce" (NASA, 2006) through a variety of education initiatives, including providing hands-on training through internship programs. In order to implement this goal, NASA has developed the NASA Education Strategic Coordination Framework. Within this Framework are four categories of involvement: Inspire, Engage, Educate and Employ. Within the Employ category, NASA will focus on :

> Targeted development of individuals who prepare for employment in disciplines needed to achieve NASA's mission and strategic goals. Through internships, fellowships, and other professional training, individuals become participants in the Vision for Space Exploration and NASA science and aeronautical research. At the apex, they have acquired sufficient mastery of knowledge for employment with NASA, academia, industry or within STEM (Science, Technology, Engineering and Mathematics) fields of teaching. (NASA[1], 2007)

NASA is organized into four Mission Directorates, Aeronautics Research, Exploration Systems, Science and Space Exploration. Through these Directorates, NASA offers students opportunities to work at world-class laboratories and facilities and to work with a talented and dedicated workforce at 10 NASA Centers and NASA Headquarters located nationwide (Figure 1).

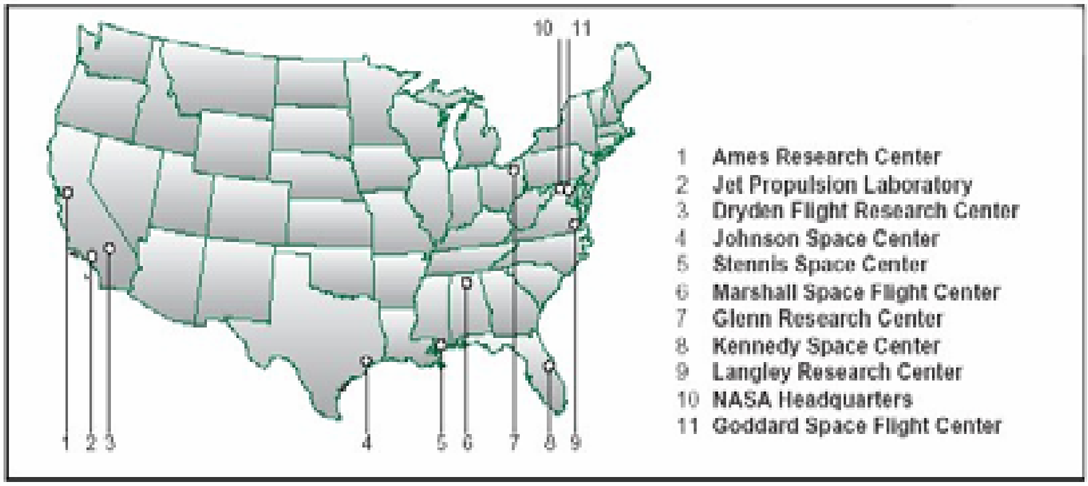

Fig 1. NASA Field Center Locations

The DEVELOP internship program is funded by the Earth Science Division within the Science Mission Directorate. The Earth Science Division follows NASA's central mission "to improve life here" by studying Earth from space. The division deploys and operates a comprehensive constellation of Earth-observing research satellites designed to observe and monitor interactions between the land, oceans, atmosphere and human life. Data and information from the satellites enable researchers to understand the causes and consequences of global change and to provide governments, businesses, and citizens with the information to make decisions and improve our quality of life (NASA[2], 2007).

Within the Earth Science Division, the Applied Science Program identifies and promotes practical uses of NASA earth science data, technology and models through partnerships with other federal agencies and universities. These partnerships focus on innovative approaches for using Earth science information to provide decision support that can be adapted to applications worldwide. The Earth Science Division focuses on twelve applications of national priority to expand and accelerate the use of knowledge, science, and technologies resulting from NASA research and development (Table 1). The approach is to enable the assimilation of Earth Science model and remote sensing mission outputs to serve as inputs to decision support tools in integrated system solutions.

Table 1. Twelve Applications of National Priority

Carbon Management	Coastal Management
Public Health	Disaster Management
Energy Management	Agricultural Efficiency
Aviation	Invasive Species
Water Management	Ecological Forecasting
Homeland Security	Air Quality

The DEVELOP Internship Program

The DEVELOP program began in 1998 at NASA's Langley Research Center in Virginia with the goal of using students to demonstrate the practical benefits of NASA's Earth science data and technology. Three students originally participated in the program and by summer 2002, 46 students from throughout the eastern United States were participating in the program at Langley. In 2003, Langley expanded the program to the West Coast and started DEVELOP at the Ames Research Center in California. Other DEVELOP sites include, NASA Stennis Space Center in Mississippi, Marshall Space Flight Center in Alabama, Goddard Space Flight Center in Maryland, as well as the Mobile County Health Department in Alabama, Georgia Tech in Georgia, the University of Northern Iowa, and the University of Connecticut. More than 300 students have actively participated in the program since its inception.

DEVELOP focuses on the community benefits of NASA earth science data and technology by using satellite imagery, models and other Earth science information to help solve national, state, local and tribal environmental issues within the 12 applications of national priority. Student teams work closely with their federal, state, local or tribal collaborators to assess their needs and develop a project plan. In addition to working on specific projects, DEVELOP students are required to present results of their projects to a variety of audiences. Students have presented to high-ranking political officials, such as state governors, top NASA officials and scientists, and have presented at several scientific conferences such as the American Society for Photogrammetry and Remote Sensing (ASPRS), and the American Geophysical Union (AGU) and conducted several media interviews.

DEVELOP is a student led, student run program meaning that at each DEVELOP center, there is an overall student leader who oversees all projects and mentors less experienced students. There are also student leaders for each project. The students also have mentors and advisors from the NASA science community to assist in teaching the science and technology skills needed to complete a project, and to provide guidance during the project. Students from high school (rising juniors and graduating seniors) through graduate level participate in this program.

The Ames DEVELOP Program

To date, the DEVELOP program has run four consecutive summers, beginning in 2003. A total of 57 students have worked on ten projects addressing four areas of national priority: Invasive Species, Carbon Management, Ecological Forecasting and Public Health (Table 2). The summer projects evolve during the Fall, Winter and Spring terms prior to the summer. Although the majority of the students participate in DEVELOP during the summer, a few students remain during the school year.

The students arrive with varying levels of expertise and their duties are divided accordingly. The students are roughly divided into those that have remote sensing experience, those that have GIS experience and those that have no GIS or remote sensing (RS) experience. The students are allowed to choose the project they wish to work on, with the condition that the skills are reasonably balanced between each team. The students with GIS experience typically outnumber the students with remote sensing experience so each team is usually comprised of at least one student with remote sensing experience to ensure success of the project. Those with no GIS or remote sensing experience (typically the high school students) are also divided evenly between the teams. Those students are able to learn the basics of the technology as the projects progress. In addition to learning RS and GIS technology, the students also acquire experience in working with three-dimensional visualization software.

Table 2. Ames Research Center DEVELOP Projects to Date

Year	State	Subject	Application Area	Description
2003	NV	Tall Whitetop Infestation	Invasive Species	Mapped and predicted spread of Tall Whitetop on the Pyramid Lake Paiute Indian Reservation
2003	CA	West Nile Virus	Public Health	Identified larval and adult habitat for mosquitoes in Monterey County
2004	NV	Tamarisk Infestation	Invasive Species	Mapped and predicted spread of Tamarisk in Nevada
2004	OR	Forest Carbon Sequestration	Carbon Management	Identified tree species and modeled the effect of tree harvesting on carbon sequestration
2005	CA	Vegetation Recovery in Fire Scars	Ecological Forecasting	Determined the type and extent of vegetation re-growth after wildfires in Yosemite National Park
2005	UT	Cheatgrass Infestation	Invasive Species	Mapped and predicted spread of cheatgrass in northern Utah
2005	CA	Waste Tire Detection	Ecological Forecasting	Located waste tire piles using high resolution satellite imagery
2006	CA	Identifying Vegetation Anomalies	Ecological Forecasting	Identified location of known and unknown vegetation anomalies in Yosemite National Park
2006	NV	Red Brome Infestation	Invasive Species	Determined extent of Red Brome infestation in an existing fire scar in Southern Nevada
2006	AK	Sea Ice Characterization	Ecological Forecasting	Characterized sea ice to determine preferred walrus habitat off the western coast of Alaska

The Projects

Projects are typically chosen during the winter and spring terms and then implemented in the summer term. Candidate projects are required to meet several criteria:

- They must incorporate the use of NASA Earth observing satellite imagery
- They must meet some need(s) of another federal, state or local or tribal government organization
- There must be a scientist that is willing to provide guidance during the project.
- There must be a fieldwork component to the project

Upon completion of the projects the students must complete the following:

- A technical paper to be submitted to a national conference (ASPRS, AGU, etc.)
- A presentation to NASA Earth Science program managers at NASA Headquarters in Washington D.C.
- A presentation to the NASA Ames science community

Brief descriptions of the ten projects follow:

Tall Whitetop Invasion, Pyramid Lake Paiute Indian Reservation, Nevada (2003)
Tall Whitetop is a highly competitive invasive plant species, and a halophyte (salt-loving plant), thriving in the alkaline soils of the Great Basin. Ecological impacts of Tall Whitetop include aggressive competition with native communities, destabilization of riverbanks, and increasing salinization of infested

soils. DEVELOP students utilized Landsat Thematic Mapper (TM) satellite imagery to map the spread of Tall Whitetop over time along the Truckee River. They also incorporated vector files representing roads, waterways, irrigation ditches, marsh lands, and irrigated fields to create a model to predict the future spread of the invasive weed. This model predicted the spread under two scenarios: treated and untreated. As expected, the untreated scenario resulted in the continued drastic spread of the weed over a five year period. Alternatively, the treated scenario demonstrated that the weed could be virtually eliminated over a fairly short period of time, but only if done on a comprehensive basis. These short term predictions along with accurate maps of real distribution are very useful in determining the effectiveness of particular management methods, and for helping to coordinate local and regional interest groups policy and management strategies.

West Nile Virus (WNV), Monterey County, California (2003)
The goal of this project was to create a map of potential mosquito habitat using Landsat TM satellite imagery and to correlate potential habitat to at-risk human communities in Monterey County (Fig.2). For the purpose of this project, the population over 55 years of age was considered the major concern because Monterey County has a very high percentage of adults in this age group. In addition to the potential mosquito habitat map, the students created a surveillance map to indicate where the virus might enter the county and where additional mosquito surveillance should be placed. This map has been used by the Northern Salinas Mosquito Abatement District with Monterey County Health Department to place new surveillance (one additional sentinel chicken flock and additional light traps) in the recommended locations. This project was completed prior to the emergence of WNV in California. In 2004, Monterey County confirmed the first cases of WNV in dead birds. The student maps accurately predicted virus activity in locations that local mosquito abatement officials never expected.

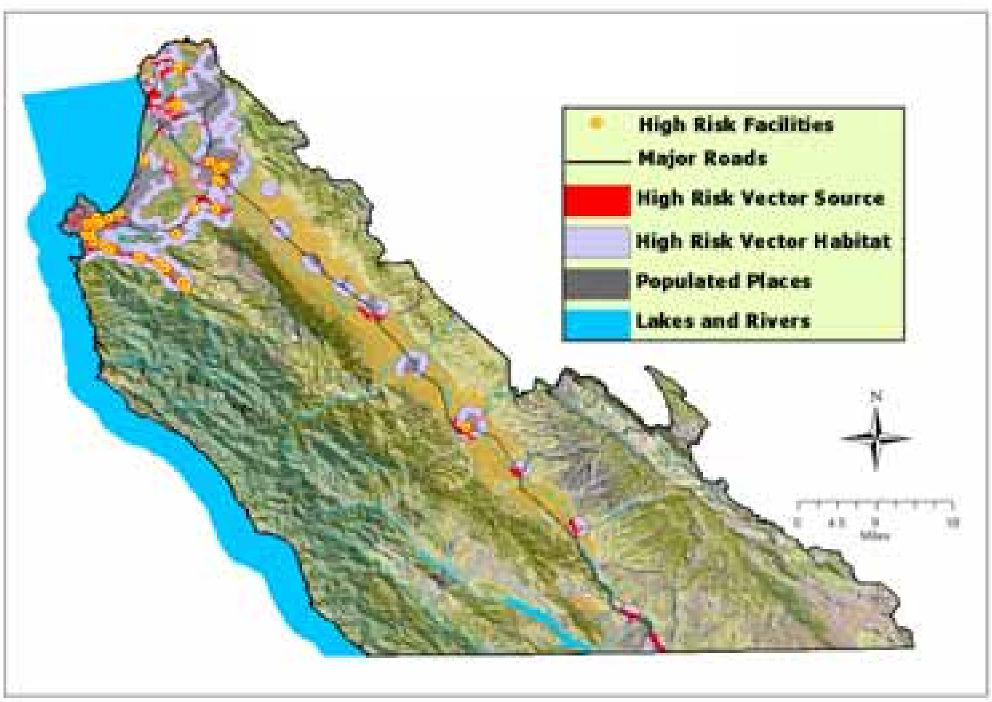

Fig. 2 High risk locations in Monterey County

Tamarisk Infestation, Nevada (2004)
Tamarisk (*Tamarix* sp.), or salt cedar as it is commonly known, is a prevalent invasive species that infests the riparian zones in the western United States. Mature salt cedar plants are resistant to high stress environments and drought conditions mainly due to their extensive root systems. This has altered hydrology patterns, decreased recreational water use, and changed regional plant diversity in some areas. Many federal and state agencies have implemented programs for monitoring and controlling the spread of salt cedar, however, a scientifically based invasive species data collection protocol that combines field data with remote sensing and GIS methods is conspicuously absent from many land management plans; many less accessible areas are ignored during standard mapping studies. DEVELOP students designed and implemented an invasive species sampling protocol that integrates field data collected in the state of Nevada, environmental variables including elevation, groundwater and percent coverage of salt cedar , water areas, and Landsat TM imagery in a GIS. The project resulted in a map summarizing an estimate of salt cedar presence throughout the study area, as well as a map predicting which regions might be more susceptible to the spread of salt cedar. (Sengupta et al. 2005)

Forest Carbon Sequestration, Fremont-Winema National Forest, Oregon (2004)
Carbon management has become a significant component in long-term forest planning. Fremont-Winema National Forest management in southern Oregon was interested in investigating how selective cutting or fuel load reduction treatments affect fire risk and forest carbon sinks. Fremont-Winema forest resource managers harvest a fixed amount of timber yearly for monetary return and to remove fuel loads. Students collected ground data for model and vegetation map validation. To address fire risk, a dominant vegetation species map of the study area was generated from Landsat 5 imagery and used with a mosaic of digital elevation models (DEMs). The vegetation map was used to estimate fuel load based on biomass. The fire behavior simulator FlamMap was employed to generate numerous fire scenarios. To study carbon dynamics, fraction photosynthetically active radiation (FPAR) maps from MODIS and regional climate data were combined with a GIS generated land cover map and used as inputs to the Carnegie-Ames-Stanford-Approach (CASA) model. The resulting model output was current net ecosystem productivity (NEP) values. Predicted NEP values were then obtained by additionally incorporating fuel-load reduction scenarios into the NASA-CASA model. For the first time, Fremont-Winema Forest resource managers considered the value of carbon as a resource in their decision making process for the 2005 Fremont-Winema Forest management plan. (Cleve et al. 2005)

Vegetation Recovery in Fire Scars, Yosemite National Park (2005)
Assessing ecological change is increasingly important to Yosemite National Park managers. The park experienced some of its largest fires in recent history that significantly changed its ecosystems and landscapes. Change detection techniques were utilized in assessing post-fire regeneration in Yosemite for fires that occurred in 1988, 1990, and 1996. Change patterns were detected with a time-series of Normalized Difference Vegetation Index (NDVI) and Normalized Difference Moisture Index (NDMI) images derived from Landsat TM and ETM+ imagery. Two-year interval change maps were created categorized by classes of increasing and decreasing standard deviations to distinguish significant changes. Fieldwork was conducted at three study areas to document present forest stand characteristics. Remote sensing techniques in conjunction with fieldwork identified distinct patterns of regeneration in the post-fire areas. Some of the most distinctive patterns were primarily linked with *Ceanothus* sp., an early successional shrub species. This study provides natural resource managers at Yosemite with data to aid in long-term fire management plans. (Syfert et al., 2006)

Cheatgrass Infestation, Utah (2005)
Cheatgrass (*Bromus tectorum)* is well suited for the low elevation arid regions of the Great Basin. Quick maturation gives it the ability to drain the soil of nitrogen first, leaving little of the nutrient for other plants. Cheatgrass is more likely to burn compared to native bunchgrasses, increasing the risk of fire,

while also wiping out its competitors. Students, in collaboration with Utah State University (USU), used field measurements with Moderate Resolution Spectroradiometer (MODIS) satellite imagery Normalized Difference Vegetation Index (NDVI) change images to model cheatgrass cover over time. Using a customized regression model (CART), a percent coverage map for cheatgrass was derived from presence and absence points from the Southwest ReGAP data set. The DEVELOP team developed a method of field validation for the percent coverage map, as well as a means of estimating invasive species density using MODIS data sets. The team conducted and analyzed a three-part accuracy assessment on the predictive coverage maps created by the model to evaluate the iterative regression tree model process used by researchers at USU, and recommended improvements to the modeling process. (Quarm et al. 2006)

Waste Tire Detection, California (2005)
Students worked with the California Integrated Waste Management Board's (CIWMB) Special Waste Division to create a proof of concept project investigating the use of high-resolution satellite imagery for locating and mapping waste tire disposal sites in the Sonoma and San Bernardino Counties of California. Previous methods for locating waste tire disposal sites in California included contracting with the California Highway Patrol to fly over suspected sites and take photographs, which were georeferenced with a GPS in post processing. The outputs generated from this project reduce time and capital necessary to manage illegal waste tire disposal sites, which pose fire and disease vector risks if left unmanaged. The students successfully identified all waste tire sites undisclosed to the team for testing purposes, and identified waste tire sites not previously known to CIWMB. (Huybrechts et al, 2006)

Identifying Vegetation Anomalies, Yosemite National Park (2006)
Monitoring ecological disturbances such as fire and insect infestation within Yosemite National Park's 1,158 square miles is a challenging endeavor for the National Park Service. Students examined vegetation disturbances in Yosemite National Park. This project used Moderate Resolution Spectroradiometer (MODIS) Leaf Area Index (LAI) data processed by the Terrestrial Observation and Prediction System (TOPS) (Fig. 3). Monthly LAI was averaged over a four-year period from 2001 – 2005 and then compared with the monthly averages for summer, 2005 to produce a map of LAI anomalies. This map was then overlaid with known areas of insect infestations, snow cover, and recent wild fires to identify possible causes of low LAI. Field work was conducted to confirm the explained causes and ascertain the causes of unexplained anomalies. Thus far, the ecological disturbances for over a quarter of anomalous area have been identified and verified, and further fieldwork is currently underway to investigate the remaining unexplained regions. Continuation of the project will result in the creation of an automated change detection model, which will not only output the coordinates of sites for further investigation, but also help reveal the cause and severity of future disturbances. This methodology is of interest to managers of national parks and forests due to the accessibility of MODIS data, its high temporal resolution, and the speed with which large areas of land can be analyzed. (Voss et al., 2007)

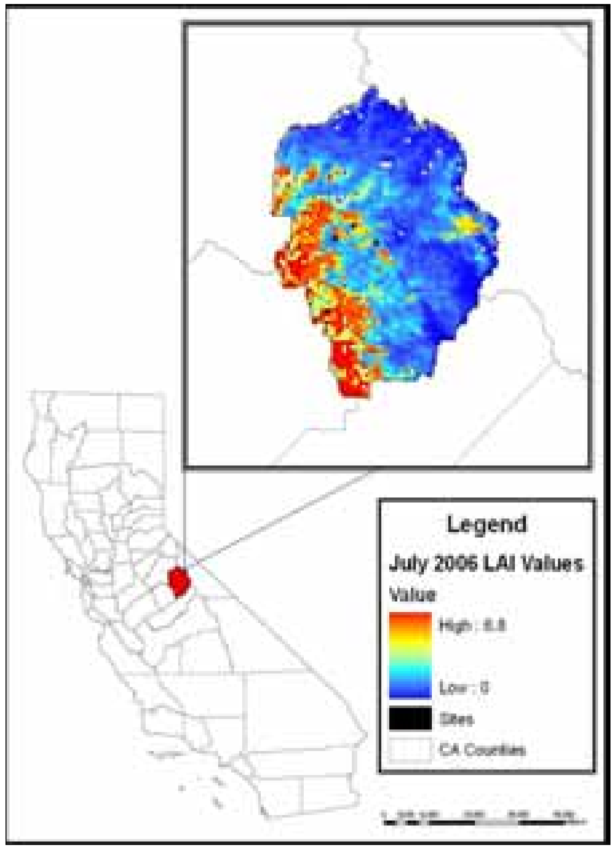

Fig. 3 Leaf Area Index values for Yosemite National Park

Red Brome Infestation, Nevada (2006)
Red Brome (*Bromus rubens)* a grass native to the arid deserts of the Mediterranean, was first identified in the southwestern United States in the mid-1800s. Due to its quick proliferation after fires, this annual is regarded as a severe ecological threat. By the depletion of soil moisture, red brome suppresses the growth of native plant species which provide food and shelter for animals living in the area. One such affected animal is the nationally threatened Desert Tortoise (*Gopherus agassizii*). The purpose of this project was to assess the utility of using satellite imagery to detect Red Brome. Students worked with the Bureau of Land Management (BLM) and the National Park Service (NPS) to map Red Brome's areal extent and predict its density within the 2005 Goodsprings fire-scar located southwest of Las Vegas, Nevada. MODIS Enhanced Vegetation Index (EVI) was used to identify optimal Landsat and ASTER scenes, which were then used to evaluate the density of Red Brome. Additionally, statistical analysis was used to confirm that average EVI values in seeded areas were higher than in unseeded areas within the fire-scar, thereby suggesting the likely success of restoration efforts. Such information will be extremely valuable to the Bureau of Land Management (BLM), the National Park Service (NPS) and other land managers as they make decisions on how to control this invasive plant.

Sea Ice Characterization, Alaska (2006)
Long-term alterations in climate are causing changes in sea ice formation resulting in a potentially degraded habitat for Pacific walrus (*Odobenus rosmarus divergens*). Students worked with the U.S. Fish and Wildlife Service in Alaska to determine the usefulness of satellite imagery for studying walrus habitat on sea ice. The dynamic nature of sea ice poses a challenge to remote sensing studies and matters are further complicated when additional data are incorporated. Passive multispectral sensors cannot penetrate

the cloud base without information loss. In cases where heavy cloud cover exists, such as in the Alaskan Yukon-Kuskokwim Delta, radar sensors are preferred because they are relatively unaffected by clouds, have high temporal resolution, and operate day or night. This study presented a method for sea ice image analysis using remote sensing segmentation and classification techniques with RADARSAT1 Synthetic Aperture Radar. Image processing results were associated with ground point data to determine the relationships of sea ice features to walrus' preferred habitat. The challenge and goal was to capture, display, and relate geophysical information from radar images that correlate with georeferenced species data points for the same time period. (Brigham et al., 2007)

Conclusion

The DEVELOP internship program has been an extremely successful program for the students, the collaborators and NASA. The students plan and implement their projects through direct communication with their state, tribal and federal collaborators. The communication with the collaborators, which begins early in the project formulation, gives the students an understanding of how other agencies operate and how challenging it is to incorporate new technology into other agencies operations. Students also benefit by learning science using geospatial technology, learning to work in teams, learning project management skills, and learning how to communicate with members of the public, political officials, scientists and news media. The state, tribal and federal collaborators benefit from learning how NASA Earth science data and technology can be incorporated into existing decision making tools. The projects are intended to be used by the collaborators to enhance their Decision Support Systems; however the adoption of new technologies is challenging for many reasons. (Skiles and Schmidt, 2006) One is because of shrinking budgets and overloaded personnel, incorporating a new technology can prove difficult. Second, the agency may not have the budget to invest in new software, hardware or data, if required. Third, the collaborator may ultimately need higher spatial resolution imagery than the DEVELOP program has provided. NASA DEVELOP students are required to work with NASA data which is typically medium to low resolution (30 meters to more that 1km pixels). Ideally, however, federal, state and tribal government users have been provided with tools and products that will help them in their decision making processes. NASA benefits from this program for two reasons. One, the program develops a workforce, knowledgeable in NASA's Earth science technology, and one that is enthusiastic about the Agency's mission. Two, the program helps to demonstrate the direct benefits of NASA's Earth Science data, technology and models to society.

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