SRI International

August 31, 2012

Data Enhanced Investigations for Climate Change Education

Year 2 Annual Report (November 1, 2011 - October 31, 2012)

NNX10AT54A
SRI Project P19804

Submitted to:

Andi Geyer
Virginia Space Grant Consortium
600 Butler Farm Road
Hampton, Virginia 23666
757.766.5210
757.766.5205 FAX
ajgeyer@odu.edu

Prepared by:

Daniel R. Zalles, Principal Investigator
SRI International
333 Ravenswood Ave., Menlo Park CA, 94025

Table of Contents

Appendices

A. PROJECT ACTIVITIES OVER THE PERIOD OF PERFORMANCE OF THE COOPERATIVE AGREEMENT

We have carried out the following activities aligned to our project timeline:

A1. Conduct first pilot study in the classrooms of the six participating teachers (Nov 2011 - April 30, 2012)

In the first quarter (Oct 1 through Dec 31, 2011), the core project team completed training of six DICCE-participating teachers, as promised in the proposal. Each teacher received face-to-face one-on-one training from either PI Dan Zalles or senior project researcher Ruth Krumhansl. Training consisted of the teachers examining printouts of data visualizations that the researchers created of their local areas in conjunction with the climate change schema and trend guide documents. This procedure was carried out as the first step in the training agenda because the researchers concluded that it would be most useful for the teachers to first think conceptually about the data before getting immersed in how to use the software. Hence, the researchers acquainted the teachers with data output and asked them to (1) brainstorm about what patterns they noticed, (2) ponder what potential student learning opportunities existed if the students were also to study the output, and (3) ponder what activities and questions they could devise to prompt these student learnings. Teachers varied on what types of regional data they took note of. For example, a teacher from New Mexico focused on trends in air temperature and forms of precipitation, a teacher from San Jose California focused on western Pacific sea surface temperatures, and a teacher from San Diego California focused on atmospheric data parameters signifying human influences on the troposphere over the region (ozone, CO2 fraction, and aerosol optical depth). A critical part of the training was to get the teachers to think about what types of questions about their regions are best addressed by examining map output as opposed to output from time series plots and vertical profiles.

Several weeks after the training, the external evaluator conducted interviews with participating teachers to gauge their reaction to the training and ask them their current thinking about how they will use DICCE with their students. Examples of thoughts that the teachers expressed to the evaluator include using DICCE...

- to teach about other science topics in addition to climate change; for example, studying variables about motion or air density in physics, water density in chemistry plus other environmental science topics such as biome diversity and whether the vegetation is changing in the region
- to study the characteristics and effects of sea surface temperature changes during the El Nino years and have students measure the breadth of those changes
- to teach students how to interpret graphs in conjunction with having the students graph counts of familiar objects themselves, such as different types of cars in the parking lot, and in the process think about what should go on the axes and what are the dependent and independent variables.
- to make connections to the carbon and water cycles and to how these cycles affect the students and the local environment

- to connect the data to the Farmer's Almanac and to the students' everyday lives, since many of the students live on ranches, hence very dependent on the weather and climate
- in a culminating activity that would bring in what the students have been learning about increasing CO2 in the atmosphere and its effects
- to teach about how the climate affects the biomes and their biodiversities and how global warming may not mean that every local area is getting warmer
- to reinforce learnings from the curriculum about the oceans, weather and climate, factors affecting climate change, albedo, the Earth system, water cycle, carbon cycle, air currents, and water currents

See Appendix A for the evaluator's anonymized notes of the interviews.

In the second quarter, four participating teachers piloted DICCE lessons, each of which they authored, with assistance from PI Dan Zalles and Senior Researcher Ruth Krumhansl. A fifth developed lesson drafts in DICCE LE but requested withholding her first piloting until Fall 2012. The sixth teacher, after training, also requested to withhold further work until Fall 2012, then he left the project because he resigned his teaching position to start graduate school. He has since been replaced by a new teacher from San Francisco.

Three of the four piloting teachers developed their own projects in the DICCE Learning Environment (LE). The fourth used DICCE materials (e.g. the climate change schema, DICCE G-queried data images, and the "Extended Help" about the different types of data) but did enter the learning activities into DICCE LE. One of the teachers decided to give the students in his Environmental Science and Society class direct access to DICCE Giovanni (G) and use the DICCE LE curriculum authoring tool to create presentations comparing an area of their choice to the greater San Diego area, (an stretching from the ocean west of San Diego through the southeastern California desert) Places the students selected to compare to greater San Diego included Spain, South Africa, Greenland, Laos, the Philippines, and a section of central-western United States. Some of the students posted their projects on the DICCE LE website for public view. The 5-day DICCE unit that this San Diego teacher conducted with these students provided an important proof of concept for the project: that students in an ethnically and socioeconomically diverse large urban public school could, with a short learning curve, master the user interfaces for DICCE G and DICCE LE sufficiently to compare Giovanni data across different geographical regions. The strategy that the teacher employed, with input from Dr. Zalles, was to give the students all the San Diego images they needed in order to compare San Diego temperature, precipitation, and carbon dioxide levels to another region of their choice. They were taught how to generate parallel images of their chosen regions in DICCE-G and import them into DICCE LE.

Other teachers carried out different strategies. A New Mexico teacher developed an activity for students about recent changes in snow depth. She gave her students a time series plot that she created from DICCE G showing average snow depth for the high desert region of her area of New Mexico and directed her 9th grade students to "calculate the average snow depth for each year in the time series graph for the winter months

(November - March)." Then she had them "average across the four years and compare each year's average to the four year average."

A participating New Hampshire teacher decided to create a 5 day DICCE curriculum project around a climate change schema that Dr. Zalles produced about what we know and do not know about climate change. She directed her students to create images in DICCE G that concern the different Giovanni data parameters mentioned in the schema, then discuss answers to essential questions from the curriculum, plus open-ended questions that individual students posed. For each data parameter, the students were asked to create a poster with a definition of the parameter, how it is measured, the units involved, and what the parameter indicates about climate change. Students were assessed on the quality of their posters, explanations of graphs they created about data parameters, open ended questions, and discussion participation.

A2. Conduct group sessions with the teachers to discuss progress before, during, and after the piloting (Nov 2011, Feb 2012, May 2012 respectively)

There were three meetings with the core teachers this year. These meetings ended up being devoted as much to the project team introducing new features as to the teachers expressing what was on their minds about DICCE. The teachers also listened to each other and provided helpful feedback. The first meeting was held on March 2nd. The purpose of that meeting was to update the teachers about the fact that DICCE G and DICCE LE were now operational and they could begin to pilot these resources in their classes. The second meeting was held after the spring semester, on July 10, 2012. The purpose was to get teachers to give feedback about how their piloting went and share their feedback with each other. Topics discussed were that teachers wanted to do assessment items about areas that contain both ocean and land, mountain areas, and flat areas. They particularly preferred an area stretching from Ireland into Northern Africa on the West and stretching from Sweden to Italy on the east. We have created items about CO2 for this area. However, we have revised our thinking about always committing to a that area and have instead decided to select on the basis of how well the particular area tells a discernible story about spatial and temporal distribution for the focal data product. that a student would be able to detect.

Other topics about assessment were discussed at the meeting as well. The following were points raised by the teachers in the discussion.

- having simple data interpretation questions in each item set for each data parameter would be preferable to having such items in a separate item bank.
- students have more prior knowledge with time series plots (due to prior exposure for their math curriculum) yet much less with maps, so checking students basic map interpretation capabilities with simple interpretation questions was important to do before posing more challenging questions that required both map interpretation and application of content knowledge.
- some assessment items should require students to jointly cite information from time series plots and maps about the same geographical area and range of data to show they understand what both types are useful for.

- that assessment items Zalles developed about air temperature in a section of California include Google Earth images of the Giovanni data so that additional geo-referencing could be superimposed for context-setting

Senior Researcher Krumhansl made a suggestion as well, that we focus on helping students better understand and recognize the forms of coordinate representation on technology-delivered map output so that students become capable of recognizing whether for example the appearance of one object straight above another object on the map means it is directly north of that object. This cannot be assumed with electronic maps. For example, the manipulable compass roses on Google Earth and ARC GIS Explorer maps provide continuous shiftability in directionality yet map output from Giovanni has fixed directionality, unless it is imported, as kmz-formatted query output, into one of these other tools. So, we discussed how students should compare and contrast a Google Earth map representation with a parallel Giovanni map representation and demonstrate that they can differentiate the directionalities.

A 3rd meeting was held on Aug 15th to update the teachers on development work that the project team carried out during the summer and ask them what they were planning on doing during the 2012-13 academic year. The teachers shared with each other what they had been doing and what they are planning on doing with DICCE in the 2012-13 school year. They also expressed satisfaction about the new DICCE LE functionality for copying and adapting projects and for switching between published and unpublished status. What they are becoming more familiar with through these meetings is how the DICCE LE features can support their workflows. For example, they can make their assessments visible to students when administering the assessments, then "unpublished" them to make them not viewable during instructional time.

A3. Analyze student outcomes of the piloting (May - July 2012)

We aim to have a comprehensive set of assessments available for the teachers in Year 3, with items that the project team will provide for teachers to use on data products that they choose for instruction. In Year 2, the work of three of the DICCE teachers in the area of assessment has permitted us to do some useful analyses that inform student learning needs.

San Diego students' projects. High school students in the San Diego teacher's class created projects comparing and contrasting data about the San Diego area with data about another area of the world of their choice. The teacher asked them to answer these questions about the data from the two regions:

1. Describe and compare the temperature and precipitation trends for the two regions.
2. Discuss qualitatively the effect that increases of CO2 level might have on the environment.
3. Discuss how climate change is leading or not to a change in the ecological footprint of the area under study.

Students had already read textbook chapters about climate change and heard teacher presentations about the topic but this was their first foray into examining related Giovanni data. Each student wrote projects which are published on the DICCE LE site

and the teacher put his directions in a project he titled "The Issue of Global Warming." The responses provide evidence of relative student abilities to make meaning of the data.

There are student responses showing emerging but incomplete understanding. For example, a student comparing Spain and San Diego noted correctly from parallel time series plots that the air temperature in Spain shows no trend of increase but the San Diego area time series does show such a trend. This answer requires little more than basic data interpretation of a time series plot. The student then tries to provide a scientific explanation, which provides some evidence of emerging, yet incomplete understanding. The student uses proper scientific terminology about how air temperatures could be producing "negative feedbacks" through effects on ocean and wind characteristics. However the connection is never explained, so the point is confusing, rendering unclear if the student truly understands what a negative feedback mechanism is. Specifically, the student writes that "A negative feedback mechanism would be associated in both locations if global temperature causing changes in ocean and wind trends (are) leading to climate changes."

In addition, some students demonstrated understanding via inferences they drew from the data. For example,

- A student comparing CO2 trends in the greater San Diego area to the Philippines drew the following reasonable conclusion, "The potential effects of increased temperature in San Diego could lead to a spike in electricity due to increased air conditioning and fan use. This leads to more CO2 emissions from power plants, and contribution to greenhouse gases, further heating the Earth. In the Philippines, an increase in temperature may not affect the locals too much, due to the lack of air conditioning (*by this the student likely means that the Filipinos do not use air conditioners much and are unlikely to start using them more in the future even if the temperatures increase*). However, crop growth may be affected due to the heat which would drastically affect the locals."
- This same student was able to interpret variances in the seasonal fluctuations on time series plots. The student correctly noted that "San Diego has more fluctuation in CO2 than the Philippines, however both trends are increasing. The CO2 levels rise and fall around the same time during the years."
- A student wrote that relatively low levels of atmospheric CO2 do not necessarily "...mean that that there are low carbon emissions in the location." This answer suggests that the student recognizes that carbon sinks and weather patterns impact the presence of CO2.

Since DICCE teachers have noted that students and their schools are exposed to time series graphs far more than data-embedded maps, it has been useful to examine how students interpreted their the maps comparing San Diego to their selected regions. In some instances, students used appropriate language to clearly explain what they observed on their maps. For example, a student comparing Spain to the greater San Diego area wrote that "Spain's CO2 map shows a range of variation on the CO2 levels and distribution.

Other responses suggest that some students need help explaining what they observe better and using the data nomenclature correctly, whether for maps or time series plots. For example,

- A student noticed a trend of diminishing precipitation in the greater San Diego area but was unable to use the nomenclature to describe that trend appropriately. The student wrote, "The trend in precipitation for San Diego is already low and the trend is decreasing slightly." What he likely meant to write was that San Diego has had relatively low precipitation and there is a trend of it decreasing to even lower levels. Then, in comparing the San Diego area to the Philippines, the student's thinking is unclear in his next conclusion, that "There are no real relationships between the two trends. The different areas have different precipitation levels."
- A student wrote that "The San Diego temperature map shows that San Diego's temperature becomes warmer in temperature within latitude." The phrase "within latitude" is not explained. Without probing, it is difficult to determine what the student was thinking when he chose this phrase. Does he understand that the San Diego area's temperatures typically increase from west to east, and is that what he meant when he said "within latitude"? If so, why would the student use that phrase? Does he understand the concept of latitude?
- A student comparing Greenland and the San Diego area made a curious observation about her Greenland temperature time series plot that revealed some emerging understanding. She noticed how there are large "drastic" variances in temperatures, but it is unclear if she was referring to typical seasonal variances or to some broad cross-year evidence of climate change.
- In interpreting a map of CO2 levels in the greater San Diego area, a student wrote that "The San Diego CO2 Levels map shows that there is less than 3.9 amount of CO2 in the San Diego atmosphere". Unfortunately, the student did not specify if this measurement applies just to the city area (which would be correct) or to the whole mapped area (which would be incorrect). Furthermore, the student did not state the characteristics of the measurement well. A clearer statement would have expressed the amount as "parts per million." The form of measurement of the CO2 fraction data parameter was available for students to learn about on the DICCE G resource page (http://disc.sci.gsfc.nasa.gov/giovanni/additional/users-manual/dicce_resources_page/)

Other learning challenges evident in the student responses concern comparing and contrasting maps and time series plots of different regions when those representations (1) neither account for nor control for different range intervals and (2) are not queried from the same data products. For example, one student made erroneous conclusions about precipitation based on the fact that for one region he looked at precipitation amounts and for the other region he looked at rainfall rate.

We will be using these and other results to encourage our teachers to probe their students with clarification questions that better reveal what ideas they are trying to express in their written responses, and to what extent those ideas demonstrate understanding or confusion. .

New Hampshire students' comments during a DICCE unit. The New Hampshire teacher mentioned in Section A1 kept careful records of comments her students made while doing the activities in her five-day DICCE unit. Unlike the San Diego teacher, this

teacher implemented most of her DICCE instruction as whole-class interactions and the comments are what the students said during these interactions. Appendix B presents her notes with color coding of noteworthy student and teacher comments. All in all, the students responded well to looking at different data parameters when given DICCE resources that explain what each data parameter means and how the data parameters are connected within the broad scheme of current climate change. There are many comments that attest to the students building up of greater confidence with the material, curiosity about the systemic connections between the data parameters, critical thinking about what conclusions to draw from the data, and how to influence future environmental outcomes for the better.

New Mexico student outcomes from implementation of the New Mexico snowpack curriculum project. The teacher who implemented the northern New Mexico snowpack activity gathered assessment information through tracking what types of comments students were making in a class discussion about the data. There were 25 students in this Integrated Science class. They were studying the Earth science topic of "Earth's Changing Surface" which according to the teacher was well-connected to the DICCE activity because it fit into a discussion about how climate change affects precipitation and how precipitation influences the shape of the landscape. Following the discussion, students worked alone to answer the questions in the DICCE snowpack project. Her questions included:

1. "What does this time series graph represent?
2. What is represented on the Y axis? X axis?
3. What was the average snow depth for each year in cm? m? (Hint: .01 m = 1 cm)
4. How does the average snow depth for each year compare to the average snow depth for the four years?
5. What conclusion about snow depth can you derive from these data?
6. Do these data show evidence of climate change?
7. What other snow depth data would be needed to determine if climate change is occurring in New Mexico?"

The teacher checked the students' answers to the seven questions. She found that students had an easy time with questions 1-5 because at the beginning of the school year they studied different forms of graphs and did a lot of graphing themselves. Questions 6-7 however were more difficult because students were uncertain about the type of evidence needed to determine if climate change was occurring in New Mexico. The teacher and students discussed how additional information would be helpful such as more than just four consecutive years of data, and more New Mexico regions to compare to each other.

A4. Conduct second project face-to-face meeting (Aug 2012)

There have been numerous meetings between PI Zalles, co-Investigator Acker, and Senior Researcher Krumhansl in Year 2. Most have been by phone using Web Ex software for desktop sharing, but some have been face-to-face. Zalles and Acker met at the Tri-Agency Climate Change Education meeting in the spring, then they met again at the ESSEA conference in the middle of the summer. Krumhansl and Zalles met face-to-face at the NSF DRK12 PI Meeting and at the Annual Conference of the National

Association for Research in Science Teaching Conference. Both of these events were in the spring.

A5. Revise DICCE as needed based on the results of the piloting (Aug 2012 - Oct 2012)

We have drawn several conclusions from our Year 2 training and piloting experiences with teachers. *First, we've concluded that DICCE can be mastered independently with the how-to-use videos and other tutorials we provide, but the experience is enhanced through formal training*. Our teachers say we providing a fairly exhaustive set of resources to both learn about how to use the DICCE technology applications but also to build up their knowledge concerning the usefulness of the Giovanni data for studying climate change and other topics. Nevertheless, as with many educational programs, there are alternatives strategies for building teacher capacity, each with its advantages and disadvantages. For example, scheduled facilitated time can be an excellent training vehicle because trainees stay focused on the tasks at hand. However, such times can be very hard to schedule with busy full-time teachers, especially when group interaction is needed and even more so if the interaction requires face-to-face contact. Conversely, training through independent study does not carry these scheduling challenges yet is more likely to be threatened when trainees get distracted by other priorities.

We recognize the trade-offs of different training strategies and believe that it behooves us to examine outcomes of a variety of them. We are in the middle of that process and will continue doing more of it in Year 3.

- *Group training*. To explore the usefulness of real-time group-oriented DICCE training, we have had the opportunity through PEL[1] and ESSEA[2] (see Section D), to develop and pilot a workshop agenda that can be applied in group forums. The agenda involves overviewing the features of DICCE G and DICCE LE, then giving users time to (1) do queries in DICCE G, (2) preview existing DICCE LE project exemplars, and (3) start creating their own projects with the Giovanni images or Google Earth layers they save from their queries.
- *Independent study training*. To explore the usefulness of independent study-oriented training, we have created a host of supports on the DICCE LE and DICCE G sites, plus a YouTube channel with videos about how to use DICCE G. We have also created a PowerPoint presentation about how to use DICCE LE and will soon also be making DICCE LE how-to-use videos. We have evidence that novices can learn how to use the DICCE G and DICCE LE software without any formal supervision from a trainer. We tested this with an individual from the Oxnard School District who will eventually provide support to the implementing PEL teachers. Zalles asked this person, who had no experience with DICCE, to on her own do one DICCE G query and construct one short DICCE LE project with data visualizations from that query. The only resources she had were the DICCE

[1] PEL stands for the NICE project "Promoting Educational Leadership in Climate Science". SRI has a NICE sub-grant to the California State University Channel Islands project to help train and support Oxnard CA school district teachers to use DICCE.

[2] ESSEA stands for the Earth System Science Education Alliance. It also is supported with funding from NICE.

G how-to videos on YouTube and the PowerPoint tutorial for how to use DICCE LE. She reported that it only took her 10 minutes to figure out how to do these tasks on her own.

- *One-on-one training.* This is the form of training we have used for the core DICCE teachers, who happen to live and work in three different states. Each individual teacher met one-on-one with a trainer to examine printouts of Giovanni data about their local region, then think aloud about what the data reveal and how the data can help them in classroom instruction about focal topics in their curricula. The strategy culminates in the trainer working hands-on with the trainee to query Giovanni for data of their choice and do a draft of a curriculum project in DICCE LE. Our teachers have responded positively to this training, but it has been necessary to follow up with them in group meetings and in traditional one-on-one conversations to support them as they move ahead with implementation. We believe that implementation is likely to be easier when they interact face-to-face with other implementers at their school or district because they would have a more readily available support system for implementation, which is what is happening with the Oxnard teachers in the PEL project.

Second, the teachers' responses and Zalles's experiences on PEL and on an NSF project with similar professional development objectives led us to the conclusion that we needed to provide more pre-developed curriculum projects and then tweak the DICCE LE software to allow teachers to copy and adapt them, yet continue to also permit them to develop their own curriculum projects from scratch. This strategy provides the greatest implementation flexibility because it gets the Giovanni data in the classroom, yet accommodates different teachers' preferences. The pre-developed projects are targeted for teachers who do not have the time or sufficient comfort with the technology to author their own materials. Doing so requires both understanding of how to a DICCE G data query and import the data visualizations into the DICCE LE authoring tool.

The copy-and-adapt feature became operative in August. The current list of published projects includes these 5 developed by PI Zalles:

- Reasoning about local and global climate change: the Greater Ventura County area, California
- Examining night-time temperatures in a section of Southern California
- Northwestern Alaska climate and data
- Investigating global climate change
- Investigating climate change in central and northern New Mexico

Plus there is a published project developed by a team of Oxnard teachers (Compare and contrast climate factors in San Diego and Greenland), one by a teacher in San Diego (The issue of global warming), and one by a teacher in New Mexico (Snowdepth). There are several curriculum projects by other participating teachers who have opted not to publish them yet. These include one by San Jose teacher about Eastern Pacific sea surface temperatures during a recent El Niño year and two by a New England teacher CO2 over the United States and sea surface temperatures in the Atlantic Ocean off the New England coast. There are in addition five projects described in Section A3 that were developed by San Diego high school students.

Development of the exemplar curriculum projects began in the Spring. Zalles authored the project around investigating global data and he collaborated with Krumhansl and Acker to produce the one about a region of northwestern Alaska with strong data-backed evidence of climate change. Drafts of additional units about New Mexico and San Diego were published on DICCE LE for the teachers' consideration. Dr. Zalles over the summer revised those projects, primarily to permit more parallel sets of comparisons between regional and global averages and more precise trend identification.

Further development work has taken place to support access of more key Giovanni data through DICCE. Co-Investigator Jim Acker has created a parallel DICCE-G portal for querying Giovanni data parameters that yield daily output. The parameters include aerosols from MODIS; gases, temperature, pressure and humidity from AIRS; and gases from OMI. They are listed as follows on the daily data query page. [3]

A. From Moderate Resolution Imaging Spectro-radiometer (MODIS):
    1. Aerosols
        a. Aerosol optical depth
        b. Deep blue aerosol optical depth
        c. Mass concentration
B. From Atmospheric Infrared Sounder (AIRS)
    1. Gases
        a. CH4 volume mixing ratio ascending
        b. CH4 volume mixing ratio descending
        c. CO volume mixing ratio ascending
        d. CO volume mixing ratio descending
    2. Temperature, Pressure, and Humidity
        a. Outgoing longwave radiation flux ascending
        b. Outgoing longwave radiation flux descending
        c. Relative humidity ascending
        d. Relative humidity descending
        e. Surface air temperature ascending
        f. Surface air temperature descending
        g. Temperature profile ascending
        h. Temperature profile descending
C. From Ozone Measuring Instrument (OMI)
    1. Gases
        a. Ozone Measuring Instrument
        b. Aerosol optical thickness
        c. Column amount ozone
        d. NO2 column
        e. NO2 tropospheric column
        f. SO2 column amount (lower, middle and upper troposphere)
D. From Tropical Rainfall Measuring Mission (TRMM)
    1. Precipitation

[3] http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=DICCE-G_Daily

Using these data, students will be able to study event-derived greenhouse influences and additional anthropogenic factors.

B. PROJECT ACCOMPLISHMENTS MEASURED AGAINST THE PROPOSED GOALS AND OBJECTIVES

Our proposal stated our goals and objectives as follows:

> Our aim has been to meet Goals 2 and 1of the CAN, to "increase the number of people, particularly high school students, using NASA Earth observation data, Earth system models, and/or simulations to investigate and analyze global climate change issues" and to "improve teaching and learning about global climate change." We are doing this do this by developing, piloting, and disseminating a new interactive pathway and online learning environment that support teachers in selecting NASA satellite mission data for students' climate change investigations, developing curricula for student data use, and using these resources to increase their students' learning about climate change. We are piloting professional development resources and processes to help teachers use these resources with their students. Our project aligns primarily with CAN Objective 2.3 in its focus on creating new classroom resources and also with Objective 2.1 in its focus on 3 years of partnering with six high school teachers.

We pursued the Year 2 activities described in Section A to meet our eventual goals of improving teaching and learning about global climate change. The extent to which we are making progress comes partly from positive feedback we have received about the usefulness and understandability of DICCE G and DICCE LE from our core teachers as well as from additional stakeholders who have been introduced to DICCE. For example, as described in Section D below, Zalles and Acker presented to workshop sessions at an ESSEA Meeting during the summer. Some participants had attended prior Giovanni workshops several years before DICCE began. Feedback we received was that DICCE was making Giovanni much easier to use and hence becoming a more appealing educational resource. For example, we received this email from one of these participants.

> "The first time I was introduced to Giovanni was during an "On the Cutting Edge" workshop offered at the University of Washington, School of Oceanography, in Seattle during July of 2005. Jim Acker made the presentation. At the time, I was excited about the idea behind using Giovanni and being able to have real data in my classes. However, the interface was not very user-friendly and I felt you had to have a more in-depth understanding of the data than my Geology background provided just to be able to retrieve the data. I remember trying to work with the system after I got back from the workshop and having basically zero success in pulling up items that were useful to me. It seems that the newer version (through DICCE) is MUCH easier to use, just from my brief introduction to it at ESSEA. I have not yet attempted to access data from my office, but based on what I saw while in Monterey, the new interface appears to be pretty self-explanatory and soooooo much simpler to understand. I believe I should be able to access data and use this for classes starting this semester. I look forward to it!"

As for our core teachers, we are happy to report that that our two most technology-shy ones have taken to DICCE. One of them is heartened by the availability now of the pre-developed curriculum projects because she has had challenges authoring her own materials. The other teacher expressed only two weeks ago in a project meeting how happy she and her students were with the DICCE G expanded help guides, which describe in sufficiently simple terms the characteristics of each data parameter. We also have the positive student outcomes reported in Section A3.

Broadly speaking then, our outcomes suggest that we have gone a long way toward accomplishing our goal of providing more educative user-friendly access to Giovanni data, yet we are also aware that it is a continuous challenge to devise the best strategies for stimulating the most optimal teacher and student utilizations of our resources that would result in greater understanding of climate change. We have tried to come up with effective supports for understanding climate change and for building greater data literacy around examining climate change-related phenomena with the Giovanni data, yet we understand that many teachers have a sizable learning curve in their understanding of this topic and in their capacities with geospatial data. Furthermore, we understand that any limitations they have can negatively impact their teaching capabilities with this material. Though we believe that we are making progress in meeting this challenge, we understand that the onus is on the teachers to take the time to build their capacities and remain committed to using the DICCE resources effectively in their classrooms.

C. EVIDENCE OF HOW PROJECT ACTIVITIES HAVE FURTHERED STAKEHOLDER PRIORITIES

We mentioned in our proposal that our project was going to address this NASA K-12 STEM priority, as expressed in documents referred to on p. 5 of the CAN: "Through hands-on interactive educational activities, NASA will engage students, educators, families, the general public, and all Agency stakeholders to increase Americans' science and technology literacy (NASA Strategic Management Council 2006, p. 6)." As the various sections of this report indicate, we have in Year 2 impacted teachers, environmental science curriculum developers, and members of the professional STEM research community. We have also acquainted district administrators with the project, most notably the superintendent of the Oxnard California School District, a strong supporter and collaborator on the PEL project. Furthermore, our teacher group now contains a middle school teacher from San Francisco who has replaced the one who left the teaching profession to attend graduate school. Through these relationships, through the more user-friendly public access to NASA data afforded by DICCE G, and through the hands-on data-centered activities available to the public via DICCE LE, we are furthering the goal of bringing NASA data to many different types of stakeholders.

D. EXTENT TO WHICH COLLABORATIONS AND/OR PARTNERSHIPS HAVE EVOLVED

During the first quarter, PI Zalles made three presentations about DICCE at conferences. At the Society for Information Technology and Teacher Education (SITE) International Conference in Austin Texas from March 5-9, Dr. Zalles gave two oral session presentations describing DICCE. One of his SITE presentations, "A framework for beginning to think about differentiating options for age-appropriate geospatial instruction," was in the panel session called "Developing a Curricular Sequence for K-16 Geospatial Integration." The other was a paper session titled Building teacher capacity for teaching about climate change with geospatial data and visualization technology." Then, on March 28, at the Annual International Conference for the National Association for Research in Science Teaching, he presented at a poster symposium of NICE projects called "Climate Change Education for the 21st Century." Dr. Zalles and his team also authored a paper about DICCE which he handed out at the conference.

Several opportunities arose during summer 2012 to disseminate DICCE among a wider group of users than the core six to whom we promised to work with in the proposal. First, through the PEL project, Dr. Zalles trained 15 high school science teachers from the Oxnard, CA school district about DICCE during the week of June 18-22. To support the summer training and subsequent classroom implementation during the 2012-13 academic year, Dr. Zalles authored a nine-activity curriculum project in DICCE LE that prompts students to compare and contrast Giovanni temperature, precipitation, and carbon dioxide data about the local region to parallel map and time series images showing global averages. He embedded these data investigation activities within a broader focus on argumentation about what evidence exists for climate change and what challenges exist for developing and evaluating solution policies. In the training, Dr. Zalles asked the teachers to try to answer the questions in the three climate change investigation activities within the project, just as their students would, then discuss their answers. After this, they completed a short feedback questionnaire about the design of the curriculum project and in addition provided informal oral feedback. Some teachers were concerned that the comparative map and time series images were not parallel enough, so Zalles inputted some new global images and revised various related student directions, questions and image captions.

The PEL training was structured to coincide with a summer camp for 42 students the following week. During the summer camp, the teachers were to provide to the students learning activities pertaining to climate change. The teachers chose to develop a 40-45 minute DICCE activity in DICCE LE that the camp students would be rotated through in four sections. The teachers browsed the existing DICCE LE projects and decided to adapt one comparing greater San Diego to Greenland, which was created by a San Diego student. This is an example of the type of resource sharing and leveraging that we have designed DICCE LE to facilitate. The students took the survey. 93% reported that they learn something new about science from the DICCE activity, 60% said that the activity was fun, and 63% said it made them more interested in science.

Then, on July 31, we got the opportunity to present about DICCE to the ESSEA. Five teachers and 26 teacher educators and curriculum developers attended two sessions about how they could use DICCE to develop problem-based learning units about

environmental sustainability topics. Three attendees asked if they could use DICCE LE to author their own curricula, which we granted to them. In return, they have promised to give us feedback about how useful DICCE is for them. These individuals are Laurie Ruberg, another NICE PI and Associate Director and Adjunct Faculty Center for Educational Technologies at Wheeling Jesuit University (WJU), David Slavsky, a Physicist and Science Professor at Loyola University, and Cheryl Manning, a Boulder Colorado high school teacher. Section B contains a testimonial about DICCE from one of the ESSEA participants.

During the week of Aug 20, Senior DICCE Researcher Ruth Krumhansl shared portions of the DICCE-G interface at the advisory meeting for her Oceans of Data project, an NSF-funded exploratory project that has developed guidelines for how to design interfaces to large scientific databases for high school use. She reports that the advisors recognized how the supports and pedagogical tools built into the DICCE-G interface document how data interfaces designed for expert scientists are challenging for novice students and teachers. They identified the hurdles to broad use of scientific data among students teachers and the general public, including (1) unexplained expert terminology, (2) data parameters difficult for novices to differentiate, and (3) lack of guidelines that would help them make the right decisions (e.g., about which data to display, how to display the data, and what display aspects require explanation). The advisers agreed that what is learned from the DICCE project about how to build an education interface on top of a professional science expert interface is very leverageable for other cyber-infrastructure projects aimed at bringing scientific data to learners.

E. PLAN OF ACTIVITIES FOR THE NEXT YEAR

Over the summer, after the first round of teacher training and piloting, we brainstormed what types of additional learning supports would be most appropriate for teacher and student use of DICCE G. For the daily data products, our resource guide will yield information about whether each is a contributor to or mitigator of greenhouse gas increases. For both the monthly and daily data, we are in the process of adding a table on the DICCE G Resource Page[4] that focuses exclusively on data products that seem redundant yet have distinctive characteristics. This will support learning because it will provide learners with the information they need to figure out under what circumstances and in response to what research questions would it be better to query one seemingly redundant data product vs. another. Factors to consider for example include spans of data collection years, region being investigated, and data resolution. In addition, we are developing a table showing the spans of years for each data product.

We are also responding to different outcomes in Year 2 about DICCE LE and building some additional features.

1. Due to the fact that it is clear now that some teachers want to use DICCE LE to have students author presentations around DICCE G images, we decided to create a new presentation object in the project object. In other words, when making projects, registered teacher or student users will be able to embed presentations in addition to or instead of instructional activities.

[4] http://disc.sci.gsfc.nasa.gov/giovanni/additional/users-manual/dicce_resources_page/

2. We are also making paper printouts of DICCE projects more useful by enabling larger size printing of the data images (i.e., the maps, time series plots, and vertical profiles captured in DICCE G).
3. We are making it possible for registered users to create "teacher versions" of assessments and instructional activities that contain answers and explanations. The teacher versions will be available to the community of registered users but not available to non-registered users, which would in most cases include students. (That said, a DICCE teacher can request that his or her students get registered user privileges to create presentations for example, but this is not a requirement for DICCE classroom use.)
4. We have created a review status field at the project level that sets the stage for quality review by the project team of teacher or student submitted materials. The status options are "Not reviewed by project staff," "Reviewed by project staff," and "Created by a student or students."

For the sake of examining outcomes, the assessment component of DICCE is going to receive major focus for content development. We have already built draft assessments around air temperature and carbon dioxide and will be creating assessment item sets about other of our basic data parameters in the months ahead. Furthermore we are asking all teachers to administer assessments before and after their implementations of DICCE instructional activities.

We also intend to initiate with colleagues at the New Mexico Highlands University Gear Up program a campaign for greater DICCE teacher use in northeastern New Mexico. This will give us an opportunity to test a train-the-trainer model that we have been doing somewhat with PEL. We want to do this because our experience so far with PEL program suggests that a training and implementation model structured around small groups of university-connected geographically-adjacent teacher networks could be an effective way to initiate and sustain greater interest and commitment. Both the PEL and New Mexico Highlands efforts will impact networks of teachers teaching large populations of Hispanic and other underrepresented student groups.

We continue in addition to search for other ways to encourage interest and use by other teachers, schools, and STEM stakeholder groups. The team is waiting to hear about the fate of several proposals for sessions at upcoming AGU and NARST meetings, and Dr. Zalles is already slotted to present about DICCE in an invited AGU talk. Zalles also plans to build interest in DICCE at a booth at the NAAEE conference in October.

Lastly, we will be constructing a website that links to both DICCE G and DICCE LE but also provides overview information about the project and access to project-related presentations and papers.

Appendix A
External Evaluator interviews with participating DICCE teachers

The following our anonymized notes of interviews with five DICCE teachers conducted by external evaluator Kathleen Haynie during February and March 2012. These interviews were conducted soon after the teachers received their first DICCE training and before any of them had done classroom implementation. Feedback from these interviews has informed further development work described in the report, such as the development of how-to-use DICCE GE videos, expanded resources on the DICCE G Resource Page, and an expanded set of pre-developed adaptable curricula on DICCE LE.

1. *What is your assessment of the training, in terms of what you did and in what order you did them*?

T1: Trained with Ruth. We covered the information on DICCE-G, learned to bookmark it, went through several examples of making maps and graphs, tried a couple of different ones, learned how to upload those onto a site to share with everybody. We did not get to the wiki site. The other stuff was pretty good.

T4: It was good. Trying to make sure that we got different things down – downloading off Giovanni, correct websites, and logon to them. At first I couldn't get on to them, but they fixed that. I'm trying it on a new computer. I trained with both Dan and Ruth on Friday February 3. I came on Saturday as well, till 12:00. It was a lot of information. They showed me how to access Giovanni, all the different graphs I could download, how I can make lesson plans. Saturday that's what I did – made a lesson on snow depth. On Friday we were comparing graphs, trying to make sure that the measurements were the same on each graph to be sure graphs were comparable. Also, how to print out, access, etc. There was stuff that was hard to get into. Getting into DICCE was hard at first.

T2: Trained with Dan on February 11. The training was great. It's a great opportunity for students to manage large amounts of information. I'm applying this to my senior IB class, environmental systems and society. Right now we are studying global warming. Using for comparing climate condition – temperature and precipitation – from San Diego and around the world for over 30 years or more. Students manipulate a lot of data to make their interpretation. Climate change from different cities – I applied the curriculum from Ruth (Foundation Science) and I like the lessons. A great idea. Lessons with this new, fresh satellite information. The training went through the basic stuff – where to find information, how to utilize DICCE-G to create maps, how to import into Google Earth.

T5: Training with Ruth. She recruited me a couple of years ago while writing the grant. I'm excited to help this project! I had some training last summer (a full day), and we worked a couple of weeks ago at my school (half a day). This time, we got on to a place where you get the real-time data. Earlier, at her house during the summer, we had created maps and graphs; at the school we created maps and graphs. After that, we went to lesson planner, pulled in map/graph, and talked about questions to engage students

with particular map/graph we had made. We also looked at resources on the wiki site – flowcharts, definitions for students to use. We had some in the summer, though less formally. This time, it was a beautiful introduction and I got to pull everything together, put on a lesson plan. First, create the graphs – not all of that works all the time, and there are some glitches that have to be worked out; we just figured out which ones we could make. There were enough things that worked that I was able to make different graphs of temperature, radiation on land / water. Student questions are easy for me.

T3: I trained with Dan at SRI. Tried to work with program – we spent a whole day going through the program at SRI, and I really enjoyed what we did. We found a couple of little glitches, and I gave Dan some ideas and got some things worked out with Jim Acker as well. I offered several suggestions from the educational viewpoint on implementation and application. I'm going to be meeting with Dan again in the next few weeks to do some more work on the program itself. I did start to develop a class lesson using sea surface temperatures during the El Nino years. Showing that, and the effects, and having students measure the breadth of that development. Good, basic tool to start with. In the training, we started at the beginning – Dan loaded DICCE formats and files onto my computer. Went through those step by step, then went through the instruction of the DICCE program step by step. He took me through everything. There were a few glitches here and there. He took me through how to access data, graphics, and to apply it and to use Google Earth in combination with that.

2. *What is your assessment of how well Ruth or Dan conducted the training? Do you have any suggestions for how they could improve the training process for other teachers?*

T1: Ruth did a great job. Sometimes I need more than one session with someone. There's so much information, and just so much that you can grasp in one sitting.

T4: Good, good. Trial and error, you know. Dan made notes about how to simplify this, gaining access to different stuff. How to improve training – I downloaded stuff from earthscience.org (salinity experiments) so kids can do those activities.

T2: Dan went step by step through everything – very patient with me.

T5: Ruth is an intuitive and brilliant instructor. She was able to meet me where I was, rather than a pre-determined sequence. She was able to give me what I needed in the order I needed it in. Ruth gave me a lot to bring to the table (candy store of things I hadn't tried before). She offered me the chance to be stretched. More to add to what I do with this resource she introduced. I would think that the training should begin with a one-on-one, getting at the teacher's prior knowledge before you begin the session. If there were a large number of teachers, categorize different types of needs – technology, curricular training, etc. It would have to be an intensive full day or two half days. Would need to assess what people's training needs would be. It's a sales process to get a teacher to try something new. Need to meet them where they are to get them motivated.

T3: Dan was great. It was like having a one-on-one teacher. He was really precise, but he's got an educational background as well as a brilliant doctoral mind. It's great to work with someone like that, to understand the educational side of it as well. I came up with some ideas, and he was very enthusiastic and supportive of the ideas. I couldn't ask for anyone better! The training process could be improved by having a print book, rather than just going screen after screen. Having it printed out and being able to follow it would be useful. I would have thought having that available for teachers to refer to would have been helpful. Easier than scrolling back and forth on the screen.

3. *Do you think you would benefit from additional training time either in person or in conference calls with Dan and Ruth? About how much? Covering what topics?*

T1: More training on making a map of ice coverage. Additional training would be very good. To be able to digest it, try it out, and have another session to try it out more. I would need the wiki part, and want to know if I am missing any steps with the DICCE-G. Maybe there is a little training video on that. For example, you have to part the last letters on at the end to be sure it uploads[5]. The tech person at our school gives us a lesson, then has an on-line tutorial you can use to continue to learn. Right now, I could use a lot of temperature, precipitation, amount of ice cover. Editing activities once up on DICCE-LE.

T4: Probably in person, because a conference call is different. Maybe one more session? In actuality, this is the first time I've really looked at it, because last year it wasn't really much. A lot of stuff is just using graphs, etc. But with kids, if they can come up with different graphs, pertaining to this stuff, they'd like it a lot better. What's useful is taking the time to create hands-on activities with the kids. How can I apply this to everyday? I try to explain to kids how this pertains to everyday life, more relevant. Kids always ask why they have to learn something. I tell kids about the river by our high school. We could incorporate that stuff. For our many kids who live on ranches, it's important for them to understand how climate change affects them. They have farms, animals, plants, etc. A lot of people have a system for determining when to plant (farmer's almanac, etc.). We need to bring that into this, to make it relevant to them. Kids hear on TV that climate control is from scientists, but there's other things causing it. That is confusing to kids. Have to see that the scientists are right. Look at history. Drill into arctic ice to view CO2 across time. Elders are living history – greener, richer soil, more snow and rain. Like in the movie "2012" kids need to know it's a real possibility. Students see the tsunami and think, "that's on the other side of the globe, won't affect me." They heed to know it will. Science is important because you also need to be able to predict stuff, and warn people. There were 30 tornadoes yesterday – how do we predict them (where, when) and warn people? What part does climate change play in this? Ocean salinity is changing, and it affects ocean currents. They need to understand that.

T2: So far, I'm comfortable. Dan asked me to call him anytime I need help. I'm very comfortable with that. I'm not sure another training is necessary – just phoning or emailing for assistance.

[5] The teacher is referring to the image format, such as .jpg or .gif.

T5: I know that Ruth is 10 minutes from my school – a big gift. I have no fear that when I start putting together a lesson, if I get stuck, she will help. She has provided me with the confidence that she is there, and she knows me so well. If I need anything, it's going to be in the technology piece. As far as curriculum-related, that's not what I'm going to need.

T3: Absolutely. I need to practice this stuff a couple or few more times. I'm going to go back and visit Dan a couple of times in the next few weeks, and maybe a third time. I did develop one activity, but would like to try something a little more complex and far-reaching. More practice on map/graph creation.

4. *What is your assessment of the DICCE resources available to you, including DICCE G, DICCE LE, and the resources on the DICCE wiki (for example, in terms of quality, relevance, and usability)? What might improve these resources?*

T1: I would like more background information on albedo effect and ice cover. DICCE-G: the quality is really good. There was an issue with zooming in. I still haven't been able to get really close. If come up with a really good map, there is not a lot that is really useful except information with CO2, sea surface temperatures. There is a lot of information there that I'm not really using. Right now, I could use a lot about temperature, precipitation, and amount of ice cover. The atmospheric stuff (in DICCE G) is very specific. What we do is a lot more general. I would like students to be able to view my maps/graphs on their own computers.

DICCE-LE: That's not too bad. I'm having problems going back and editing stuff (adding or modifying). It takes you back to this one edit page that is very specific. I'm having a hard time going back and changing things that are specifically listed there. Not sure how to change existing activity.

T4: DICCE-G – that's something I still have to play with more. How to make certain graphs, how to change them. I'm trying to get used to the stuff. I need the stuff on how to make a map bigger or smaller or different. Would like it to be more usable.

DICCE-LE is easy to access. It's not bad. Wasn't difficult. Just a matter of getting the graph that you need.

T2: DICCE-G is a LOT of work – lots of information to handle. Such a variety of variables – fantastic job, must have taken years to put together. Quality is very good. Trustful information. I think I can use it beyond climate change – maybe apply to my physics classes as well, using variables about motion or density or air density. Maybe I can apply it in earth science, environmental systems, and probably physics as well. Maybe not just apply to global warming, but also biome diversity and vegetation. Is it changing? Same? Replaced by other species? Very reliable information, applied in many ways. Maybe even applied to chemistry (water density). I was asking Dan if we can apply it to natural research, and Dan thought it might be too narrow (a specific point),

but cover an area, e.g., northern and southern California. We will be exploring many applications. It's a great tool for measuring global warming, climate, CO2 concentration, etc. According to what I learned that particular day, it's very user-friendly. Not hard to understand the procedure and create the graphs. I may get a little stuck here and there, but I'm sure I can get the support from Dan. It's a matter of practicing and using it. I need to play with it a little bit more. I like what I saw.

DICCE-LE: For that one, creating your lesson and posting it, we covered the last two hours of that, and we think it's pretty simple way to use it to see everyone else's lessons. People can comment on your lessons or you can modify them. I think it is very important to see other teachers' lessons – a way of growing by positive comments.

T5: DICCE-G – that thing is like a rocket ship with a million buttons and whistles. If it wasn't me, I would be overwhelmed with the choices. It's easy to choose something with the range of data not there, or doesn't show up as it should. I have to really sift through that to find what I need. Remember the huge computer rooms of the 70's with cards? That's the feeling I have when I'm in that. At the same time, I feel like I can get what I need, it just takes me time to figure out where to go to get it. I find it hard to use, and I know I'm going to need time to – an hour wouldn't be enough time to hone in on what I want to do. It's not user-friendly enough to figure out in that timeframe. Once I've devoted a couple of hours, I think I will be able to figure it out. You have to just get in there and do it. It's very front-loaded, timewise.

As much as I've used the DICCE-LE, it's very, very intuitive. I've not saved and printed yet. I've put the image in there, and written questions for students. You give me a template and I'll do it. Whether it will print and be usable with my kids is an unknown still. I'm sure Ruth will help me with anything I can't do. What I've used so far is really good. Ruth has asked me to keep a journal as I use DICCE-G and DICCE-LE – I'll write down what I'm feeling and seeing and thinking. Just keep a running log of that (action research) to be useful to the project.

About the wiki, I know the resources are very comprehensive and technically correct. What I'll be doing as I go through there I'll have an eye towards the work needed to make the language, metaphors, examples, diagrams really, really useful to kids. Have levels from the technical to sciencey, to application user-friendly. We'll need three levels, so the student can look at all three at the same time. [6] My strength is making it accessible to kids. Teaching is a sales process, and if kids don't see that they need what I have, they don't want it. Would like to add two other levels to the wiki – to go from the real technical to science level (so the kids feel there is credibility), to application that includes diagrams that are very concrete for kids. Most of what's there is abstract. Use diagrams that kids can really wrap their brains around. For example, when we talk about salinity, we have pictures that show it. When we talk about concentration, have some common icon or diagram that represents that. Diagrams for the effects of different climate change phenomenon. For example, albedo might be a circle for globe, circle for

[6] The additional learning resources on the DICCE wiki will in Year 3 be transferred to a master DICCE web site that also opens DICCE G and DICCE LE.

atmosphere, arrows for absorption and reflection and light and dark. Unifying themes within these things that seem so disparate. Kids have schema in their brain, and if there is something that makes a smaller number of categories for them, it makes it easier for them. I'm thinking about hyperlinks that might bring students to a picture so they can, for example, link color to vegetation to absorption to de-forestation. Thinking systemically. Students list all things impacted by one thing. Help systematize what is connected to what.

T3: I like the quality of the DICCE-G – the clarity to be able to implement things. I don't see any problems with it. Relevance - I'm teaching in earth science in an alternative program – doing earth science in September. I'm going to be teaching all the other teachers in our program. I'm also a member of the Bay Area Earth Science Institute, and I'm going to be introducing DICCE to other teachers in Northern California. Usability – at first a little bit awkward; after edits, I found it a little bit more flowing.

DICCE-LE: I liked the quality. It's straightforward to work with. I'm a strong believer in teachers sharing information. I try to bring the newest stuff to my students. I like the idea of teachers sharing those questions. The only slight glitch was moving the diagrams and pictures from one site to the actual lesson plan. If there was an easier way to do that, it would have helped.

I was on the DICCE wiki a few weeks ago. It's a great resource, containing all the DICCE resources. I like that you can go from basic information to upper level doctoral data. It works across the spectrum of the levels of skills for students and teachers.

5. *Have you created a DICCE-LE activity? How did that go? If not, are there barriers to creating an activity that we should know about?*

T1: I'm working on having students look at a map or graph and interpret what they are seeing. One topic is CO2 in a map – higher and lower levels – asking students to explain why there are differences. The other one is a graph, and students answer questions on interpreting what the graph is saying. I currently have a couple of drafts (two I did with Ruth, one I did by myself a day or two later), they're just not ready to be published yet. I'm comfortable with getting to data, manipulating it, and getting what I need. It took me a little trial and error after Ruth left to do it on my own and remember everything I needed, but I was able to get back to it. I put a couple of things together, but not full lessons yet, so I'm not ready to publish yet. With the data – I was trying to make something today for a quiz, and the DICCE-G came up saying I didn't have the parameters for doing it in a graph form. I was trying to use a graph as opposed to a map, since I haven't gone over a map yet (trend lines, etc.). I was trying to do it with land surface temperature, and wasn't able to make it.

T4: I started to create an activity after the training, but I couldn't get what I needed from the wiki.

T2: I created a first draft of a lesson with Dan during the training, and loaded into the website. Most challenges were to understand myself what I wanted to put in it, narrowing down what I wanted my students to do and to learn. I haven't done my homework yet, to create a lesson (I've been extremely busy). I will start working on it next week.

T5: I will write a student activity and use it between now and April vacation. Hopefully more than one.

T3: I created a student activity as part of the training with Dan. It's very simplistic. A good basic lesson to start with. It wasn't difficult to create that activity. Dan was there to help guide me – I just went step by step for the most part. Bandwidth prohibits running any videos, etc., for students. But they can go to the lessons. I will let them use my computer to do the graphs, maps, etc.

6. *Would you prefer to develop your own activities or use already created activities?*

T1: I would certainly not mind using something that is already there. But the ability to make your own is nice. The ability to input data for students and make their own is nice. A combination of the two (make own, use already made) would be good.

T4: It could be both. Could be given one, but might tweak it or do something in addition to it. Could take something from Giovanni and then do a lab with that. One on the ocean – have temperature, chlorophyl concentration, but there was no salinity (data). Something with a lab would be good. Rainfall rates, snow mass, different stuff like that.

T2: A combination of both would be more helpful to me as a teacher. I like to hear what other teachers are thinking. I can get an idea from another teacher, and adjust it to my students.

T3: Definitely a combination of the two – one combo plate!

7. *Now that some time has passed since the training, please explain your current thinking about how you will use DICCE with your students. Has your thinking changed since the training? If so, how? Learning goals? Are there any barriers to implementing DICCE that you would like to tell me about?*

T1: My hope was to be able to use it during – we're going into albedo effect, feedback loops – I was hoping students would be able to look at polar ice cover over the last hundred years. I use a projector (images for students to interpret and make predictions based on past). I was wondering if I could create things and then put them on a website that students could get onto and have on their computer. I was wondering if my map/graphs would be viewable on students' computers. I'd like them to be able to look at data and get information out of it. Students have to practice looking at these things, reading the map legend, axis labels, etc. and figuring out what this image is telling them.

T4: Well, I'll give them (ecosystem) stuff I've collected over the years. See it, learn how to read graphs, answer questions based on what you see there. This is still that affects us all. It's real, it does occur. If you occur years or different areas of the country… don't just look at it by itself. Less snow in NJ, and out of season. Snow on the west coast (people aren't used to it). Unseasonably cold in Alaska. I want this to pique the interest of my students, and to connect it with their own experiences (e.g., early seasons on their ranch). Motivate them to look on-line for more information, paying attention to the news, etc. I think the majority of the kids will do this and be engaged. More sickness spread due to lack of moisture. Not concerned about problems.

T2: Students use different maps and graphs, and make interpretations. I ask the students to get the information from the satellite to create their own interpretation – their own point of view. They compare among themselves the similarities and differences. Dan wants to observe my classes sometime soon. I'll be working on the project the next few weeks. I talked with Dan about how to use it with my students. Initially, I thought students would be gathering information. My students actually create their own research questions, so that is the only thing I may be changing. DICCE is more for me to create the lessons, and me to apply it. I'm curious – can they create their own research? Dan said I could give them access to DICCE-G. It would take longer time – they could think of a research question, and apply DICCE-G to create datasets that inform their lessons. My perspective was instead of giving students topics, they would create them. But with DICCE, the teacher creates the lesson for the students to just perform it. My learning goals now would be to create a planning section (students state aims, goals, materials to use), but that it going to be general for everybody. They may be choosing the places, to end up with different results. Students may choose other things to study – CO2, precipitation, temperature, water vapor, methane, ozone, etc. at two different places (or same places, seen from different perspectives). Start seeing the same problem from different perspectives. Problems could be not finding the right information or computer problems.

T5: Students working in groups. I try to use what they are comfortable with as a portal to their brain. As I implement the lesson, I will explain that I'm part of the research grant. I will ask them to tell me what is easy and hard – feedback in real time. I expect that I will get amazing feedback during and after implementation. We might even go on-line together and critique different things. Students may need different things, like a spreadsheet in addition to a graph. We'll do it as we go. I want students to be literate in reading graphs, tables, and maps. Entry level will be to ask them to tell me what they can with the picture itself. Then for them to start making inferences (given date range, axes, key) and tell me everything they are seeing.

T3: I think the main issue is there has been so much chatter and misinformation about climate change. There is a strong force out there that denies climate change. The idea of trying to dispel a lot of that static/white noise is important. How students understand that truth. They are pushing their agenda – typically based on profit. Need to get them to profit educationally. Student learning goals – to get a better grip on what climate change

is. I love that students can get information about San Jose – their own local area – rather than something far and distant. Sometimes students think science information is so distant; this is applicable to right here. I have no concerns that any major issues will arise during implementation.

8. Has your thinking changed since the training in any way? If so, how?

T1: I want to be able to incorporate more real-time data. When I look for things on-line, a lot of things are really dated. Students want to know what this has to do with them now. The more current the data is, the more buy-in from the students.

T4: Not really. I'll just come across something on the internet, or on TV that connects with this. So, I'm thinking about it more. [Various scenarios portrayed] how do you prepare for it? Need to inform people – we are contaminating the earth. Have rights until we infringe on someone else. Look at the bigger picture.

T3: In come respects intense data can be put-off to a lot of teachers. Taking these data and starting at a more basic level helps us to see how these applications can grow without feeling buried in it.

9. Approximately when are you planning on implementing DICCE activities with your students this semester? How many class periods do you estimate you will devote to DICCE?

T1: I'm putting that together now. I'm hoping to get it done before our break in April. I teach four classes. We'll probably just try it in just one class period.

T4: Giving them the stuff next week. Trying to work out some stuff. I'll give the activity I made, then a lab related to it. I like to do different labs with the kids. I couldn't tell you how many class periods. I'll see what their interest is. I have my kids doing labs all the time, at least once or twice a week.

T2: I'm planning to start within the next couple of weeks. I just have to plan out the goals – what are the end goals? After that, I'll get a computer lab to go every day to give them the time to do the research and make their own interpretation. I was thinking of 5-10 days, or two weeks. It will partly depend on the students. Some are very computer-wise, others need more time.

T5: My goal is to have it done within the next 6 weeks (one, maybe two). Once I start, I'd like to do it once a week, easily. Have a DICCE day. Once I get it, I want to do it every week for the rest of the year. I value this type of literacy as much as reading. The grammar of the future. Knowledge base is so large, that kids need to be able to analyze quickly what we are presenting them. I want to do it once a week because of the value I place on it.

T3: Some this semester, but then next year I'll be doing a whole unit on it. Since we are in lifetime biology mode, basically how it affects flora and fauna. Within the next several months. Not yet sure how many class periods I will use DICCE in.

10. Are your DICCE activities connected to other topics and activities you are covering in your class? Is so, please describe the connections.

T1: It's going to be – sort of like what we are already doing. I'm seeing it as a culminating activity that would bring in things we have been learning about trend lines, CO2 in the atmosphere and its effects. They love to see data that has already been created, but one of the things that is important in the curriculum is to get them to look at new information that they haven't already seen, and to make connections with what they've already been taught. If I can give them new maps and data, and ask them to read, understand, and make connections to what they've already learned from this unit to show that they understand the material.

T4: Yes. I have my kids graph stuff – a simple graph. Number of cars in the parking lot, number of SUVs, number of girls and boys in different classes. Learn to make graphs, interpret graphs, etc. Tables - how are you going to graph this stuff? X-axis, Y-axis, dependent and independent variables. Give them a table – now make a bar graph. Hard to interpret – that's how you look at a lot of stuff, by using graphs. In Biology, carbon cycles and water cycles. It actually affects us! Kids are curious about weather, temperature, precipitation because these are connected with their experience.

T2: Since we are covering global warming, definitely the climate affects the biomes – biodiversity. As humans, we can apply it to our environment. Maybe we can see the changes. In San Diego, for the last 30 years, the climate is getting colder. Global warming doesn't mean every area is getting warmer. Some may get colder, wetter, dryer, etc. It affects migration, evolution, and other things.

T5: Easily fit into the curriculum. I'm using chapters 6-9 from the EDC Earth Science curriculum. This is a natural connection to the topic. Chapters: 6 = ocean, 7 = atmosphere, 8 = how past influences the future (ice ages, global warming, etc. what mean in terms of future), 9= back to the future (using the past to predict the future, what's going on with the world today – mini ice age + global warming). There's also a unit in between where they look up all the political stuff going on, analyze the background of people such as Al Gore, Greenpeace, etc. Different agendas. The final unit is about what is a good way to present research and findings, what are 10 recommendations and why?

T3: Climate change is affecting everyone in northern California. Part of an ecology unit.

11. What's your level of comfort with teaching about climate change, from 1 to 5, where 1 is not comfortable at all and 5 is very comfortable? Please explain your rating.

T1: Probably around a 4. I can't always answer all student questions. How do we know what's going on? We teach about proxies and the information we get, but it's hard to explain that even though we have an idea, we don't really know. That kind of uncertainty is hard – no one really knows. We can make educated guesses about things. I think I'm fairly well versed in the stuff we have known for a while, I don't feel as though I know the latest information that is out there. That's an area that I need a little more… why I'm doing this is to find out the latest information.

T4: A 4. I wish I knew more information. I think it's important to take care of our earth, because it is taking care of us. We have a carbon footprint, and have to care about how big a footprint we leave here for other generations.

T2: Between 4 and 5. I'm a geologist. Evolution of planet is part of our curriculum. I have a Masters in science. I saw lots of this information before I became a teacher. I love that curriculum, actually. I'm sad I'm not teaching earth science any more. I feel pretty comfortable.

T5: It's a 5. I was hungry to do it. I think it's necessary. This is my 8th time teaching it. I wrote the curriculum. Kids need to think critically and be taught like adults. They need to learn how to interact as adults on the team. This course connects 150% to what I believe kids, value-wise, should be getting. It can't be a more perfect fit (in terms of content, teaching style).

T3: I'm comfortable with teaching it, a 4 as far as teaching all the aspects of the DICCE program.

12. On the same five-point scale, what's your level of comfort with using technology personally?

T1: [laughs] probably lower. Probably about a 2 or a 3. I've only been doing this the last couple of years. Before that, I was old school. I'm only doing the new tech because it is mandated at the school. I taught out of books forever. Now it's all changing – luckily there is very good support at my school. I've really improved in the last year or two with this stuff.

T4: A 3-4. I wish I could use it more. Sometimes I think I know what I'm doing, and it doesn't work. I have my son do it sometimes!

T2: Maybe 3-4. I'm not computer-wise, but I'm not illiterate either.

T5: I'm older, and I have a love-hate affair with technology. I love what it can do, but have to overcome my own inertia. There's always something that goes wrong. I hate working with new technology. In my adult ed math course, problems with technology (lost whole lab the other day, because Java stopped working about an hour before I went in). I was very anxious. I had to gain permission to cancel the class. I'd rather have a chalkboard and chalk! Technology is very hard for me. It's love-hate.

T3: I'm not extremely proficient. I'd give it a 3.5.

13. On the same five-point scale, what's your level of comfort with using technology with your students?

T1: I don't mind using tech with my students – they are really good with it. Lots of times, if I can't help them, they can help each other. It doesn't bother them to help out with the older teachers [laughs].

T4: Probably a 3. I ask them to help me. I allow them to argue for why they should deserve credit!

T2: With my students, 4-5. Sometimes they know more than me, which is okay. They help me sometimes.

T5: After vacation, I would like to have students create a map and a system around the map telling what the map would explain, and what it illustrates on the globe, why the color scheme? Why that area? I like for them to create using technology. Their comfort level with technology is much different from mine, and I think I will learn from watching them!

T3: 4 or 5.

14. Last comments?

T1: I will let Dan know that another session, even telephone session, would be helpful. I'll have my stuff in front of me and have specific questions.

T2: I just need to play more with those sites. I feel pretty comfortable with Dan explaining it to me. I didn't feel any doubts when he explained it to me. Right now, I'm okay.

T3: For something that just came out of the blue, and being asked to participate, I feel humbled and gratified to be part of the program.

Appendix B
DICCE Teacher implementation log

The following is a DICCE teacher's daily log of implementation of her DICCE unit , plus her own reflective feedback about it and responses of her students. In the unit, students did research and presentations on data parameters diagrammed in the DICCE climate change schema diagram (http://disc.sci.gsfc.nasa.gov/giovanni/additional/users-manual/climate_change_schema). The schema is accessible to all on the DICCE G monthly data resource page and a DICCE LE-using teacher or curriculum author can make it accessible to students through the DICCE LE project template. (Note: the student names have been anonymized as S1, S2, etc. and the teacher has been assigned a fictitious name: "Ms. Stanley").

Noteworthy comments are shaded in these colors:

- In blue are expressions of learning and reasoning with the content
- In green are comments about level of confidence or engagement with the content
- In yellow are comments about broad issues pertaining to climate change
- In pink are noteworthy comments from the teacher about the student outcomes

Global Climate Culminating Activity: Putting it all together
June 2012
Ms. Stanley

Goals

To review parameters related to climate change, for students to demonstrate what they know about a particular parameter by

- creating a poster with
    - a definition,
    - how it is measured and
    - the units involved, and
    - what the parameter indicates
- Creating a group system model parallel construction to the one in the power point by Dan Zalles "Global climate change schema: "What we know and what we don't know"
- Choosing (Giovanni) data (visualizations) for each parameter and looking at it as a class on a projected image
- Having a Socratic discussion to discuss essential questions from the curriculum and student-generated open ended questions.

Time – 5 days, each class is 90 minutes, 5 days of 90 minute blocks.

Assessment

- Posters
- Participation in group system model and explanation of the connections between the parameter correctly explained
- Participation and explanation of graphs created for each parameter chosen
- Generation of open ended questions
- Participation in Socratic discussion

Student Comments

June 11-Choose a measurement and create a poster

Class – Students 1 - 6 (S1, S2, S3, S4, S5, S6)

- Talked to students about the closing week using the tools from DICCE and Giovanni.
- Gave students a print out of the definitions for measurements used from the Giovanni site including what they measure and how they are connected to Global Climate.
- Each student chose a topic and made a post to visually explain the measurement.

Comments

- S3 (i.e., Student 3) -These definitions are really easy to understand
- S5 -I like the three parts, it makes is easy to see how the measurement influences the whole picture
- S5 -He (the researcher who authored the resource) really gets what we need to know.
- S1 - Will they see our posters? I think they would like them
- S2 - The more we go over these things (the parameters) the more I see how complicated the system is. It really is hard to determine what has the most influence in the whole system and we are only looking at 7 factors here.

Ms. Stanley's notes - The students were engaged and talked freely as they created really comprehensive posters. The posters included a diagram, a reworked definition using the resource form Giovanni and notes and prior knowledge, and how the parameter might influence Global Climate. The comments were directed to (the DICCE team) as I explained we were part of a research project and their input would help the researchers develop these tools further for use in high school classes. They took their roles seriously as they thoughtfully produced comments.
I found the resource very comprehensive and fit is well as a review tool at the end of the year.

June 12
Finish Posters and begin creating a group system model parallel construction to the one in the power point by Dan Zalles "Global climate change schema: "What we know and what we don't know"
We took half of the 90 minute block to complete the posters and share them with each other.
Student comments

- S4 – I never understood how this all worked before I heard the definitions today, it is starting to make sense.
- S3 – I thought this was too hard for me to learn, I guess it really isn't that hard, I understand how all of these measurements can change all the other ones. The whole thing is pretty complicated, how can we influence the model on earth?
- S2 – I agree with S3, I really did NOT think I could learn all of this, I guess I did somewhere. That guy Dan did a lot of work for us, we are pretty lucky.
- S6 – The more I look at these ideas and the more I hear what all of these things (parameters, measurements) do on the planet, the more I think we just really need to be

good stewards of the earth. We should not try to make big changes; all of these things are linked.

We took the second half of the 90 minute block to Study the PowerPoint and our understandings and analysis of it.

- S1 – I wish I had seen this in the beginning, it would have shown me a good way to make a model. I was really confused by the big complicated map you showed with all of the factors (from the EDC text-climate change factors all mapped). This shows me how simple the map can be, but it really isn't simple, because when one thing changes all the others can too!
- S2 – Wow, I never realized there were so many uncertain factors, how can we possible predict the climate change in the future? That Dude really gave me a lot to think about.
- S6 – Is that the kind of models you wanted? That takes a lot of knowledge; can you teach Climate change part 2 next year so we can study this more?

June 13

Finish creating a group system model parallel construction to the one in the power point by Dan Zalles "Global climate change schema: "What we know and what we don't know"

This took the whole 90 minutes and a lot of bargaining and looking up details related to the parameters the students chose: energy, cloud fraction, carbon dioxide fraction, snow mass, rainfall rate, and snow fall rate.

We revisited:

What is the definition?

What is the measurement, units etc, How can we explain with examples form our daily life?

Why is this parameter important?

What do trends mean?

We placed the posters on tables and tried to make a system model parallel to the ones depicted in the PowerPoint on the DICCE Giovanni web site.

- S6-The snow mass and snow fall should be related, I wonder if they are. Maybe we should add the temperature of the atmosphere here?
- S3-What about the ocean temperature and albedo, wouldn't that make a difference?
- S2-The more I look at this the more I think I need to add to make this complete, the climate change system is big!
- S1-lets try to just use what we have here. Then we can get this done before we are old. I just wonder how long it took Dan to get his model. I think we should know enough to be able to do this.

The students worked hard and got a working model. It took the whole time!

June 14

The plan was to use computers to observe data from the site. The plan was overridden by rescheduling for assemblies…"

The students were looking forward to this part, but I have a good paradigm here, the kids really are ready to take time with graph analysis. That was a major goal, to prepare them to want to take time to study the graphics.

MY BACKUP PLAN thanks to Dan

In an effort to show them graphs in the 30 minute time (instead of the 90 minutes planeed) we had I used the lesson (I was concerned about the internet connection and the time I might waste trying to get the images)

Global climate investigation

Posted By dan On January 27, 2012 @ 10:01 am

I asked them to look at any graph or map and make one comment each

- S6-Answered the first set of questions and stated "the line graph was easiest because that is what we usually see in math. I think the other ones are really interesting, I think I would like time to study the colors and try to make sense of them, and they are not intuitive to me."
- S3-On the same set of questions in the first section of the lesson, "I like the third picture, the colors kind of make sense, the blue is cold and the tan is warm like a desert. I think that one make a lot of sense because I can FEEL the average temperature."
- S2-Overall "the maps are really nice to look at but they make no sense to me. I get it that the colors mean things but I need to see a real graph. Maybe if we had time I would get used to the maps. I would like to, they probably tell more."
- S1- Average monthly global CO2 levels in the atmosphere in 2008-That coloring is clearly different around the equator and then matches above and below. I wonder how temperate is related? This is cool, it makes me think of questions I have. I thought that cites vs. rural would be a clear difference if carbon dioxide is give off by people, cars, and industry. Why is that not clear on that graph? Or is my idea all wrong?

S4 and S5 were absent.

I can clearly see the value of the visuals for class, and the manner in which this was developed surely invested the students because we created a set of questions as the system model and definitions were reviewed.

June 15

Having a Socratic discussion to discuss essential questions from the curriculum and student generated open ended questions.

(The essential questions and other documents referred to are attached in the email.)
The students had 90 minutes and the task was to discuss the essential questions and to come with a few of their own questions as well.
The question is posed (by a volunteer) and any person answers with an idea and an explanation based on evidence as to why their answer or comment is valid.
Each person is required to make 3 valid supported comments in order to receive a C, 4 for a B, 5 for an A.
All students received A
The students commented that the use of data at the end reminded them how important support is and data is the best support. They noted how many politicians and others make data mean what they want and they will be sure to learn more how to analyze data. The comments were consistent in this vein by all 6 students.