August 31, 2013

Data Enhanced Investigations for Climate Change Education

Year 3 Annual Report (November 1, 2012 - October 31, 2013)

Year 3 Educational Activity Report (November 1, 2012 - October 31, 2013)

NNX10AT54A
SRI Project P19804

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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 second pilot study in the classrooms of participating teachers, and meet with the teachers concerning their implementation

In the 2012-13 academic year five teachers on the project implemented DICCE in their classrooms reaching approximately 145 students. This does not include teachers who may have implemented some use of DICCE in the Ventura County area schools, under the NICE-supported project at the California State University, Channel Islands called Promoting Educational Leadership in Climate Science (PEL). All of the implementing DICCE teachers developed their own curricular materials and instructional plans. Most of those appear as curriculum projects on the DICCE Learning Environment (LE) website with titles such as Heat and Temperature, Precipitation, Understanding DICCE Giovanni Data, Carbon Dioxide, The Most Polluted City in the U.S. versus Beijing, Net Shortwave Radiation, A Short Unit on Net Long wave (Infrared) Radiation, The Albedo Effect, Data Interpretation, CO2 Fraction, Compare and Contrast Climate Factors in San Diego and Greenland, The Issue of Global Warming, and Snow Depth. These are in addition to project staff-developed projects consisting of presentations, hands-on activities, and assessments.

Four were high school teachers and one was a middle school teacher. We anticipate a sixth high school teacher to implement before Nov 1, 2013 with 90 additional ninth grade Environmental Science students and perhaps some students in 10th and 11th grade chemistry. All of these teachers teach at schools serving diverse students (e.g., underserved students with Individualized Education Plans and "504" plans for addressing emotional challenges, students with varying academic levels of achievement, students with varying ethnicities, and students with varying amounts of English language proficiency. A 6^{th} high school teacher was planning on implementing in the spring but was in a car accident and put off implementation until the current academic year. Two middle school teachers also put off implementation the past academic year and will do so the current academic year. Each teacher has received professional development in the form of one-on-one or small group interaction with Zalles or Krumhansl, by phone and in person. Feedback surveys were offered for teachers and students to respond to during the 2012-13 academic year. Four teachers and 80 students responded so far.

During the months of October through December 2012, one of the DICCE teachers from New England implemented a DICCE lesson as the first in a series of lessons on climate change that she would administer to her 35 9th grade earth science students throughout much of the remainder of the school year. Her use of DICCE in her classroom confirmed several assumptions of the project. First, we assumed that teachers would find value in connections between the existing Foundations Earth Science curriculum and DICCE. As was the case with a San Diego teacher and a Maine teacher in Spring 2012, this teacher used DICCE as a resource for an activity that would follow up attention to a Foundations lesson in which students examine time series graphs on paper showing differences in temperature and precipitation between New Hampshire and Arizona. Then, for the DICCE activity, she projected for class discussion a project written by Zalles in DICCE LE that contains items about precipitation in the Indian subcontinent. Though these items were intended to serve as pre-post assessments for teachers who chose to develop curricular activities around local climate, this teacher chose to use the items for large group instruction. She situated these lessons in her climate education curriculum as an introduction to the topic and beginning in January did more formal instruction around the characteristics of climate and climate change. She planned to focus especially on carbon dioxide and use for instructional purposes already-developed DICCE LE projects about CO2 fraction.

As was the case in the other school implementation sites, her students had an easier time interpreting the data representations than looking across representations for different pieces of evidence and relating the evidence to scientific concepts. Furthermore, of the map and graph interpretation questions that the teacher posed to them, students had an easier time with those about the graphs because they have had less prior experience interpreting maps, especially color coded maps displaying data layers. The teacher attributed the students' greater challenge with the higher-order conceptual questions not only to lack of experience in critical thinking about data but also to the fact that she had not yet carried out any formal teaching about climate or climate change. In contrast, the comparison-contrast Foundations Science lesson was more of an exercise in simple data interpretation procedure than in conceptual learning about climate.

An interesting finding from this lesson's implementation was that the students appreciated the fact that each question was written as a multiple choice question with a correct answer because this questioning format helped them learn better and gave them immediate feedback about the correctness of their response. The teacher reported that the students were least enamored by open-ended constructed response questions. This confirmed our assumption that embedding many multiple choice items in the DICCE LE was an appropriate step which we would continue to do as we developed more DICCE LE projects for curricular and assessment purposes. Another project assumption supported by this teacher's implementation was that teachers would want to develop their own projects yet would also want to use curriculum projects that we developed, such as the one about precipitation on the Indian subcontinent that she decided to use.

Concerning the way she delivered the DICCE lesson, although she did it as a large group activity for which she had all students pay attention to a projection of the DICCE images and questions on a large screen, she said she would use a combination of modeling and practice in the future. The modeling part would come in large group fulfillment of the various DICCE data investigations and the practice part would come through small-group follow-up on similar yet different DICCE tasks.

The teacher reported to Zalles that she felt she had evolved with DICCE to the point where she was feeling more comfortable with the software and more capable of doing here own DICCE Giovanni (G) queries and developing her own DICCE LE projects. She also reported that the one-to-one help that she had received from Zalles on the phone and from Krumhansl in person had been “invaluable.” She also said however that it would be easier to learn and implement DICCE if other teachers at her school were also using it. It is worth noting that she was recruited as an individual for the project, as were all of the DICCE teachers (not including the different sets of PEL teachers). However, Zalles encouraged her to tell her colleagues at the school about DICCE and engage them in use of it. He also offered to provide DICCE LE authoring privileges for her colleagues if they were interested.

The other DICCE teachers planned to do classroom implementations after the first of the year. One for example planned to use DICCE in a problem-based unit concerning drought and water management in Colorado. Students would compare recent precipitation history in California and Colorado, both of which have similar topographies.
Another teacher who did DICCE in Spring 2012 in his environmental science course was reassigned to teach physics and had been discussing with Zalles some ways to integrate DICCE with physics content. Ideas they have pondered include focusing on the net longwave and that shortwave radiation and data parameters from DICCE G and ozone as well. Below is the text of an e-mail that Zalles sent him to get him thinking about the connections:

> This California standard about waves aligns to what you could have students study with the radiation data products in DICCE G: "Waves have characteristic properties that do not depend on the type of wave. As a basis for understanding this concept:
> - Students know waves carry energy from one place to another.
> - Students know radio waves, **light,** and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3 8 m/s (186,000 miles/second)." (source: http://www.cde.ca.gov/be/st/ss/documents/sciencestnd.pdf)
>
> In the monthly DICCE data we have the net long wave radiation and net shortwave radiation data. Those are good for reinforcing students/ understandings about how solar energy enters our atmosphere as short wave ultraviolet radiation and then gets emitted from the ground as long wave (infrared) radiation, some of which gets trapped in the atmosphere from water vapor and other greenhouse gases.. These "net" values can be difficult to understand so for greater understanding students could look at the trend guide about energy (http://dicce.sri.com/downloads/InterpretingDICCE_Giovanni_data/03_Energy_and_radiation_system_trend_guide.pdf) and also at a presentation in DICCE LE about the net longwave data (http://dicce-le.sri.com/?projects=new-longwave-radiation-presentation-draft). I'm planning on putting together a similar presentation about net shortwave radiation, but hopefully the trend guide explains that one enough for now. Basically, low values of net shortwave mean greater reflectivity on the surface (such as from snow or ice) and low values mean less reflectivity (which means more of the energy is being absorbed on the surface and then being emitted in all directions as the infrared radiation/heat.

Related to this, you could also focus on the heat and energy standards such as "Energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. As a basis for understanding this concept:
- Students know heat flow and work are two forms of energy transfer between systems.
- Students know the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as thermal energy. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object."

So, in addition to the net incoming and outgoing radiation data, your students could study air temperature data and draw conclusions about how some of these key science concepts concerning heat and energy are supported by the data over different geographical areas in different periods of time. For example you could ask them to explain why the nighttime temperatures in a part of the world with a wet climate are going to be closer to the daytime temperatures yet areas with dry climates are likely to see far greater difference between day and night temperatures. They could study maps of such regions and use what they observe in the maps to explain what happens to heat at night in a cloudy place compared to heat at night in a dry place. Check out the monthly DICCE G data for daytime and nighttime temperatures.

If you want to do lessons about ozone, we have both daily data and monthly data about it. We cover ozone in the atmospheric gases trend guide (http://dicce.sri.com/downloads/InterpretingDICCE_Giovanni_data/02_Atmospheric_gases_trend_guide.pdf). Please note that the ozone data are more likely to represent amounts in the troposphere when over hot urban areas because that ozone is generated from pollution. However, in rural areas, most of the ozone in the data is likely to be in the stratosphere. The trend guide explains what kind of conclusions you can draw from high values of tropospheric ozone vs. high values of stratospheric ozone.

There is not currently DICCE G data that measures electricity and magnetism but I suppose you could make connections with sunspots and their impacts on the Earth's climate. Sunspot activity tends to vary over decades and that gets manifest in global temperature trends, which you can examine in DICCE time series graphs.

Unfortunately, this teacher also experienced some severe health problems soon after this brainstorming and he was advised by his doctor to cut back on his extra responsibilities and commitments so he decided he had to stop participating in the project.

During the months of January through March 2013, we continued to focus much of our attention to working with DICCE teachers who were in the middle of planning and implementing DICCE activities in their classes. Two middle school teachers who teach eighth grade physical science at the same school were planning lessons about energy and radiation and planned to use DICCE data to teach about about net shortwave radiation. Specifically, they wanted their students to look at increased melting of ice and snow in the high latitudes, and how that corresponds to decreased albedo (which is manifest through increases in net shortwave radiation, as displayable on time series graphs). They were also considering using the net longwave radiation data parameter as well but because that was a harder variable to interpret they equivocated on that decision. Zalles met with them during the quarter to train them about how to use the DICCE software and acquaint them with choices of other data parameters they might be interested in.

Three high school teachers had already been implementing DICCE lessons in their classes during that semester. One decided to implement a curriculum project in DICCE LE (Learning Environment) that Dan Zalles developed called Reasoning about Local and Global Climate change in the Greater Ventura County California area. Another teacher took an assessment activity that Zalles devised about precipitation in India and decided to pose the questions instead as a class whole group instructional activity. This teacher then created instructional activities where students looked at maps of sea surface temperatures in the North Atlantic coast of New England in 2002 and 2011. One teacher decided to use images of DICCE maps and time series plots for lessons devoted as much to building data literacy as to reinforcing conceptual understanding of the characteristics of climate change. In whole class discussions, he projected time series plots and maps on a smart board and asked students questions designed to get them to understand concepts such as trends, anomalies and natural variation. For example, he put up two maps of monthly average temperatures about the same area but did one showing only one year's averages and the other showing ten year averages. He asked his students to compare and contrast the visualizations; the objective being for the students to understand that the individual year was not an anomaly but showed a very similar spatial distribution as was evident in the 10-year span.

Some teachers are devoting full class periods to DICCE then moving on to other topics. Others are introducing DICCE data investigation activities in small doses in the context of class periods with multiple activities. Another teacher decided to do DICCE activities every Friday over several months.

Teachers showed interest in place based lessons with the DICCE data concerning their own local regions yet they were also choosing to make instructional uses of data from other areas of the world if those other areas were telling interesting stories that help reinforce a particular learning objective around data literacy or understanding of climate change. For example, the high school teacher from San Jose had been interspersing maps and time series plots of California with maps of Greenland, the Antarctic, and the Amazon.

Most teachers continued to focus on CO2 and land surface temperature data though some attended to other data as well including precipitation, sea surface temperatures, ozone, nitrous oxide, and sulfur dioxide. Most continues to only use the monthly data but one teacher turned to daily data about various trace gases.

In some cases, teachers chose to use DICCE in large group activities where they led question and answer discussions about the data representations. For example, based on the flow of the class discussions, one teacher generated visualizations from DICCE G both before class and during class, sometimes making impromptu decisions about what place to look at, what variable, what time range, and what type of visualization. Other teachers implemented DICCE as hands-on individual or small group activities with the data. For example one teacher started a particular lesson as a large group activity where she asked a student to suggest which place in the world the student wanted the class to examine, what time range, and which variables. The teacher then generated images from DICCE G and asked students to pair up and share their predictions and analyses.

All teachers implementing in 2012-13 chose to go into DICCE G and select the data for the students to examine (or have the students tell them what to examine) rather than have their students generate their own data visualizations, which is what one San Diego teacher did the prior year. Regarding use of DICCE LE, most used DICCE LE to some extent to create their own curriculum projects but most implemented these activities through whole class discussions. One teacher who mainly implemented in in large-group discussions said that he will do upcoming DICCE lesson implementations as hands-on individual activities.

Teachers expressed different perspectives about the relative values of different types of data visualizations in DICCE. For example, one teacher assumed that the DICCE time series plots would be easier for his students to understand and hence more useful than the maps. However, Zalles, in a discussion with this teacher's students, asked them which they thought was more useful and all said the maps. They understood more than he thought they would about what the pallet colors mean on the maps and how the maps provide useful information about spatial distribution (compared to the time series plots, which they understood as displaying averages for the entire selected area). Nevertheless, Zalles perceived that neither the teacher nor the students had explicitly taken the time to compare and contrast the representational advantages and disadvantages of both. This was evident in the responses to some questions Zalles posed both to the teacher and the students. The teacher picked up on this omission of attention by following up on a recommendation by Zalles to have students compare a time series plot about temperatures in Greenland over 10 years to a map showing the Greenland averages in the first of the ten years and in the last of the 10 years. These maps and the plots proved compelling in showing how the warming trend evident in the graphs was more dramatic in the interior of Greenland than on its coastlines.

During the months of April through June 2013, three teachers decided to wait until 2013-14 to implement DICCE lessons. Two of these teachers felt they did not have enough time to prepare for spring implementation. They collaborated on curriculum planning and instruction at their middle school. Both teach eighth grade physical science. One of them needed more time because he had a new baby born during the spring months and that affected the readiness of his colleague too. The third, the high school teacher from

Colorado, had an automobile accident a few weeks before implementation and as a result decided to wait until the current academic year.

Also, we hired a summer fellowship teacher from the *Industry Initiatives for Science and Math Education program (IISME)* to work 10 weeks during the summer on DICCE, with the goal of developing adaptable curricula for the project that he would use himself with his students in the 2013-14 academic year. This teacher began by independently mastering all DICCE interfaces, then developed curricula on topics and themes determined in consultations with PI Zalles. He was teaching 9th grade Earth Science in 2012-13, shifting to 9th grade Environmental Science in 2013-14, and most of his students are currently but not irrevocably on a non-college preparatory track, which is good for DICCE because it keeps the project focused on needs of underrepresented students. We hired this teacher for two reasons. First, we wanted to see what professional development learning path is made possible through the independently-master-able, publicly available DICCE resources when a teacher has multiple weeks in the summer to devote to building mastery. The teacher's logs allowed us to track what technological pedagogical and content knowledge he is acquiring as he immersed himself in the DICCE resources. This added to our knowledge base about how accessible and useful the resources are. Second, we wanted to increase the quantity of teacher-developed curriculum materials available in DICCE LE because it became clear that some teachers were more likely to want to use existing curricula, then adapt the curricula to suit their needs, as opposed to developing their own DICCE curricula from scratch. The teacher had been taking project staff-produced curriculum projects and adapted them as needed for his grade 9 students, but also creating some curriculum projects from scratch. He then turned his attention to developing curriculum projects devoted primarily to show how well-aligned instruction with DICCE could be with Common Core and Next-Generation Science Standards. Zalles directed him to do this because it became clear during the Spring from interactions with different teachers that a big attraction of DICCE is in its making accessible to students real scientific data which they can utilize to build their understanding of scientific practices (e.g., hypothesis testing, investigation planning, evidence-based argumentation). For example, one PEL teacher who had been trained in the 2012 workshop said that at the time he wasn't interested in using DICCE but as the district put more and more emphasis on the Common Core Standards during the ensuing year, it became clear to him that DICCE had tremendous value as a skill building tool for meeting standards about building students' reading/language arts and math skills with authentic scientific data.

During the months of July and August 2013 we held lengthy meetings and training sessions with five participating teachers. For example, Zalles and Krumhansl met with the two New England teachers for a day of debriefing about their two years of piloting of DICCE and some of their comments and reactions are worth noting here because of the fact that both had done two rounds of classroom implementation of DICCE by this point (recounted above in the descriptions of project activities during prior quarters this year). The teachers varied greatly in their pedagogical approaches and the amount of readiness they displayed for implementing DICCE effectively in the classrooms. One of the teachers was an experienced teacher who incorporated DICCE into her discovery learning procedures. She taught a half-year course in Global Climate Change that provided full-year credit because it was taught in 90 minute blocks rather than the usual 45 minute blocks. It was offered to students in 10^{th} 11^{th}, and 12^{th} grade and counts as a course that can fulfill an Earth science requirement for graduation. The class had heterogeneous grouping, ranging from students who are on special-education individualized education plans (IEPs), which was the majority, to a smaller group composed of high academic performers. Every week the teacher had a “DICCE Friday” in which she and the students would take 30 to 40 minutes to pose research questions, predictions, hypotheses and questions together and then investigate data from the NASA missions to seek answers to. She asked them to decide what data (time range, geographical region, data parameter) to look at and why. “The students felt special,” she said, “because they were getting all these data and technology to use from real scientists and could appreciate how much work went into making the data available to them.” She would typically ask kids to make predictions about a certain area and a certain data parameter, they would make a prediction. Then she would produce in front of them, via DICC G, a time series to see if their prediction was correct. She primarily focused on seasonal rather than short-term changes.

A large part of the engagement, she reported, was in the “real-time aspect;" that students had so many choices of data to look at. They were intrigued by the range of output they could produce and examine about any part of the world they were interested in. For example, one student said he wanted to investigate DICCE data about Lithuania because that is where his grandmother is from. All the students would get turns deciding what places and data to investigate. In addition, making it a large group activity, the teacher made the students feel important and valued by having them come up to the screen and point out to their fellow students how to do a particular task that some of the others were struggling with, such as locating a particular country on the DICCE G base map. One Friday, when the assistant principal observed the class, the students “proudly” showed the principal what they could do with finding and analyzing DICCE data.

This teacher also made heavy use of the DICCE Enhanced Help for understanding the individual data parameters available to them on DICCE G. She would ask students to read sections of the enhanced help document themselves, pick data parameters they wanted to study, such as "cloud fraction". Then, they would investigate that data parameter through maps and time series plots. Her pedagogical method for probing students for meaning was to use simple language at first rather than scientific language. For example she asked the student interested in Lithuania “What do you know about Lithuania? The student said, “I want to know about the snow.” Then she said, “What you want to know about the snow? How deep? How much? Then, they discussed which data parameter would provide them the metrics they’d need to answer their questions. She would get them to understand that science is primarily about asking questions and that they should be reflective about “how much data we have,” and “what’s reasonable to conclude from that data?” At first, she tried as much as possible to use everyday language instead of scientific language for introducing concepts such as positive feedback loops, using analogies to their everyday lives, such the chain of events that occurs when one of their parents gets mad, leading them to get mad in reaction,, which only gets the parent more angry, etc. Then when they understood the concept, she challenged them to think about how they would teach this material to even younger students.

Later on, she would introduce the nomenclature of scientific concepts like feedback loops and dependent and independent variables, which by then would be valued by the students because she immersed them in the scientific thinking using everyday language first. This not only strategically limited the cognitive demand on them, but built their interest in learning the scientific language as a more useful and precise means for capturing what they were already noticing in the data but could not describe except with everyday language.

Similarly to the concept of feedback loops, she also tried to get students to understand the difference between independent and dependent variables by "teasing out" of them this understanding using everyday language; for example, the country they choose to investigate and the time span are the independent variables and the data parameters such as temperature are the dependent variables. She would get them to eventually realize that when they make a choice of where and when, they would be identifying the independent variables and when they chose what phenomena to investigate, the phenomenon would be the dependent variables. Then, to continue them in their inquiry and deepen their understandings about the data and the underlying scientific phenomena, she would invite them to think comparatively. Again using everyday language, after studying the data about that place and time, she would say, "What if we choose to go to a different place, such as a place by the ocean or near the equator? Would we see the same results?"

Another important component of her pedagogy with DICCE was to have them do frequent mental modeling through diagramming. For this purpose, she took advantage of some diagramming templates about climate change that are part of the EDC Earth Science Curriculum. She would describe these diagramming tasks to the students in everyday language, saying "(diagramming) is how your brain connects things." She told the students that by the end they would understand the relationships in the EDC diagram about climate change and will themselves be able to put together similar diagrams showing relationships. She showed them the diagram, said this is an example of how other people thought about climate change and now "you have an opportunity to put together your own version, showing how you think about climate change."

As for her professional development, she reported that DICCE makes it possible for both teachers and students to examine hard data knowing that we can draw different conclusions, all of which could be acceptable. "I'm a data-driven and systems thinker," she reported, drawn to thinking about how different parts of the system interact. "It's been a very empowering to have all the data to look at when we have theory questions, and analysis. So it has enhanced my ability to do that. My knowledge about climate change is growing all the time - the more I know the less I know. I want the students and me to think about what we can really impact and start working in those areas that we can really impact." Hence, she asks students to come up with 10 recommendations to the world for what to do in response to climate change and use supporting evidence from the DICCE data. “DICCE,” she added, “is an amazing support and tool which allows us to do more analysis and thinking and provide that support.”

Another component of the engagement was the teacher’s attitude of being a learner too who knew little more than her students did about what to expect the data about a particular region of the world. She communicated this attitude in the language she used with her students. Yet, she knew where she wanted to go with the inquiries. She described her overall utilization of DICCE this way: “I know where I want to take them and what I want them to discover but I give them crumbs so that they can taste it and be motivated for more.”

In contrast, this discovery-oriented pedagogical style was not natural to the other New England teacher, who nevertheless dedicated herself to implementing DICCE, but with more didactic approaches. Her lesser skill in being more student-centered was evident in a discourse that project senior researcher Krumhansl and external evaluator Haynie observed and wrote down (see Section A6 below).

This teacher used DICCE in her ninth grade Earth System class. In 2012-13, 40% of the students in the class had either special cognitive needs, as identified on IEPs, or special emotional needs (i.e., “504” students).[1] DICCE fit well into her scope and sequence, which addressed each of the 4 “spheres”: bio, cryo, litho, and hydro. “The last couple of years,” she reports, “have moved us (she and the other teachers at her school) from a teacher driven curriculum to a student driven curriculum. The labs were set up like following a recipe. Now, kids have to come up with their own questions and figure out how to set up an experiment and find an answer and the teacher is supposed to be a coach to see if they're going in a direction that might yield something. I'm still in the process of shifting over from a lecture in the front of the class to be more student-directed.”

She found usefulness in DICCE for meeting key learning objectives about the nature of science. “We’re trying to show kids how the process of science works but science doesn't work quickly and it doesn't go in a straight line. You have to put time in. You have to observe. It’s a process, and it's driven by what you don't know. What I tell my students is you need to have a question specific enough to be able to get an answer to. They have a tendency to pose big broad questions and they have to narrow them down to something more specific that they can actually get an answer to.” Hence, in her opinion, the primary

[1] Not all students who have disabilities require specialized instruction. For students with disabilities who do require specialized instruction, the Individuals with Disabilities Education Act (IDEA) controls the procedural requirements, and an IEP is developed. The IDEA process is more involved than that of Section Not all students who have disabilities require specialized instruction. For students with disabilities who do require specialized instruction, the Individuals with Disabilities Education Act (IDEA) controls the procedural requirements, and an IEP is developed. The IDEA process is more involved than that of Section 504 of the Rehabilitation Act and requires documentation of measurable growth. For students with disabilities who do not require specialized instruction but need the assurance that they will receive equal access to public education and services, a document is created to outline their specific accessibility requirements. Students with 504 Plans do not require specialized instruction, but, like the IEP, a 504 Plan should be updated annually to ensure that the student is receiving the most effective accommodations for his/her specific circumstances. (Source: http://www.washington.edu/doit/Stem/articles?52)

value of DICCE is not for "covering a topic" but of posing a question. This primary focus on questions rather than answers can be difficult for the students. "The data aren't always what you are going to expect," she says, "that's part of the scientific method. They get very upset if their hypothesis is not confirmed and I told them over and over again that they have to accept the results and try to figure out why the results are as they are, and maybe do some other research. That's par for the course in science."

As for her own professional development, this more didactic teacher said that DICCE helped build her skills in interpreting choropleth maps and being sensitive to options for how pallets can be altered to display different ranges of values. This was something she never thought of doing before when studying data on maps, but DICCE provides the opportunity to do so and there are tutorials in DICCE that explain these options and how to think through which are best for a given purpose.

Lastly, she felt that the very act of giving her a day to meet and share experiences with the more seasoned student-centered, constructivist teacher was itself a professional development opportunity because she always assumed that she should pre-select data visualizations for her students, determine what was significant about the findings in these visualizations, and pose questions designed to get the students to find the "correct answer." Now, for the future, she said she is more likely to do what the other teacher did, which was to be spontaneous in large group decision-making about what questions to ask and what data to look at to answer the questions.

Summer 2013 meetings with teachers provided opportunities to try out different methods of stimulating their professional growth with making optimal use of DICCE in their instruction. For example, with the New England teachers, Zalles took the time in the meeting to brainstorm with them researchable questions that they could pose to their students about the data. One teacher started the inquiry with "Is ocean acidification only happening in certain areas or is it happening worldwide?" This started a process of data investigation where Zalles, Krumhansl, and the two teachers made decisions about what data to look at, what conclusions to draw, and what questions to ask and refine along the way. Zalles will use this same method at a training workshop about DICCE at the upcoming conference of the North American Alliance for Environmental Education (NAAEE).

Zalles ended up spending two summer days with the two middle school teachers who passed on implementation during spring 2013. He asked the IISME teaching fellow we hired for a summer fellowship to join in. Having the IISME teacher there was motivating to the two teachers because seeing another teacher excited about DICCE and producing worthy DICCE-centered curricula set a good example. Furthermore, the two teachers saw much in common with this IISME teacher because they teach 8^{th} graders and he teaches 9^{th} graders. Especially helpful was the fact that he showed them lesson plans he wrote the align DICCE use to various Common Core standards. It became clear in the discussions that DICCE is a useful tool for teacher growth in content knowledge about climate change. This was most evident in the fact that the two teachers, as teachers of Physical Science, were very interested in the DICCE G radiation data parameters but did not understand some key principles of energy absorption and conversion that one needs to understand to make sense of the data's significance for climate change. Looking at DICCE data and presentations in DICCE LE that Zalles wrote about the net incoming and net outgoing radiation helped them get a fuller picture. The meetings then yielded rich brainstorming by them about what they might want to do with DICCE in the upcoming school year.

A2. Make revisions as needed to DICCE-G and DICCE-LE

Changes to DICCE G. On the DICCE G data portals, for the sake of greater consistency and user readability, Co-Investigator Jim Acker and PI Dan Zalles revised various data parameter names and links to the Enhanced Help resource, which explains in layman's language about the data parameters. They have also completed entries for data parameters that are distinctive to the daily data; specifically, those that explain what the various trace gases are that DICCE G provides data about, how the missions collect those data, and what are their significances for climate change.

Acker and Zalles frequently iterate together on content about the data parameters. Typically, Acker offers first drafts with the key content, then Zalles reorganizes and simplifies his text to make to easier to understand for the nonscientist teachers and students who are the primary DICCE users.

It became clear in work with teachers during the summer of 2013 that we needed to provide more explanations about fundamental data nomenclature in DICCE G. So, Zalles, with the help of one of the teachers, wrote the following definitions of key terms which will shortly be on both DICCE G and the main SRI DICCE entry site (dicce.sri.com).

- **Data parameter.** A data parameter is a single measured quantity (variable) obtained by observation of the Earth system. For example, the quantity "rainfall rate" is generated through an observation of how quickly rain is falling. Data parameters in the DICCE G monthly data sets are averages of these observations. Some in the daily data are also averages but others are single measurements taken once a day. Most of these data parameters in DICCE G are generated by remote sensing on satellites.
- **Data product** (i.e., data set): A data product (i.e., data set) is composed of one or more data parameters. Each mission decides how to group them. For example, there is a data product called MODIS Terra Version 5.1. MODIS is an instrument on a particular satellite named Terra Version and 5.1 is the current publically available version of this data product. MODIS Terra and Version 5.1 contains numerous data parameters, several of which are available in DICCE G, including AOD and Deep Blue AOD. If you go to the main Giovanni web site you can see a list of all the actual data products. In the case of the MODIS Terra Version 5.1 data product, all the data parameters are about various atmospheric phenomena. Frequently, some of the data parameters in a data product/data set are used to calculate other data parameters in the same product/set.

This need for definitions became clear when a DICCE teacher started an exchange about the data. He wrote to Zalles, “I have a question that I know my students will ask. What determines the time periods of a particular data product? Why are some smaller (or greater) than others?” Zalles translated this question into more precise questions that Acker would be able to answer: “What terminates the production of a particular data product that results from observations of instruments on satellites? Does an instrument like MODIS have a finite life? Does a satellite, like Terra, have a finite life? Or, are they set up to go as long as they can without anybody really knowing how long that might be? Acker responded with “There are a lot of different factors that determine the length of a satellite data set. One obvious one is the length of the mission – if the satellite instrument quits working, that’s the end of that data set! However, it can be more subtle – the instrument might still be working, but a particular wavelength band might lose too much sensitivity to be used, and that can affect other data products. This is what happened to the Terra Deep Blue, for example (I think). Another factor is the satellite. TRMM’s orbit was spiraling in due to atmospheric drag, so they raised the orbit. This changed the ground resolution a bit, so they have different periods in the data with different spatial resolutions (this isn’t as noticeable in the global data that’s averaged to a bigger grid than the satellite’s highest spatial resolution). In general, the main factor is scientific quality. A scientific agency like NASA or NOAA or the European Space Agency doesn’t want to release data that isn’t scientifically useful, so they’ll terminate the data set if it’s not good data anymore.” This exchange prompted Zalles to conclude that the explanations about data parameter and data product were needed.

For the sake of helping teachers and students choose which data parameter to investigate when there are two or three that sound by name to be almost the same (the names are fixed and imposed by the missions that feed data into the Giovanni portal), Zalles asked Acker to put together tables for the DICCE G Resource Page that would explain differences and thus help decision-making. Appendix A of this report contains the two posted tables. Then Zalles noticed how some of the data parameters are labeled as ascending or descending and pointed out to Acker that these terms were not intuitive and needed explanation. Hence, Acker produced an additional explanatory resource about orbital characteristics of the satellites that appears in Appendix B.

Inducing nonscientists like teachers and students to feel comfortable exploring real mission data can be taxing when particular data parameters have special idiosyncrasies that mission scientists may be able to understand easily but that others would not. For example, a teacher discovered over the summer that there seemed to be a problem with a particular data parameter from MODIS for measuring aerosol optical depth. The teacher wrote an e-mail to Acker. “This morning I tried to create visualizations in the daily and monthly Giovanni portals showing Deep Blue AOD at 550 nm (QA-w, Land only) for all of 2010 over Northern California. On these occasions, I received the message ‘all data values are fill values and invalid!’ I attempted different years and got the same message. Am I doing something wrong or is this a glitch in the system?” This error message was the result of the fact that the time ranges of data on the query page reflect data products and not the data parameters so there are occasionally cases where a particular data parameter in a particular data product had to be discontinued. The design of Giovanni only permits identification of time range by product, not by parameter, so the discontinuation of the data collection for this particular parameter is not identifiable in the regular interface.

This discovery by the teacher prompted Zalles and Acker to think of a way to explain to the nonscientist users of DICCE G that there was in effect a complication with the gathering of the MODIS deep blue aerosol optical depth parameter, though the MODIS product continued gathering data. This need for clarification led them to iterate on an appropriate explanation that users can understand. Yet, it also needed to be made clear to users that in the DICCE G interface, the time range identified for a particular data parameter was in fact representative of the entire data product. This required several explanations. In addition, Zalles and Acker were faced with the challenge of figuring out where these explanations should best go within the constraints of the overall Giovanni portal design that Goddard imposes.

Below are three bullets of texts that Zalles and Acker decided needed to be available to the user. They decided that that the text in the first bullet should appear as a banner in the DICCE G query page for this particular data parameter and the text of the second bullet below can appear on the DICCE G Resource Page. The first bullet text notifies the user selecting a range of data to query that there is a complication in the data after 2007. The text in the second bullet explains the fact that the time ranges represent the data products and not the data parameters, even though the time range information is presented by data parameter, not product. The text in the third bullet provides background information about mission data calibration and quality assurance, which was necessary to explain so non-scientist users can understand that there was a reason why the collection of particular MODIS data had to be interrupted in 2007 and that the error message was not simply caused by a computer bug.

- *Appears in the banner:* "The data parameter known as "**Deep Blue AOD at 550 nm (QA-w, Land only**), which comes from the MODIS-Terra Ver. 5.1 data product/data set is not available after December 2007, because additional data needed to correctly calculate this data parameter were not available after that date. For measurements of Deep Blue AOD that are more recent than 2007, go to the MODIS-Aqua Deep Blue AOD" data parameter in (Giovanni's) MODIS-Aqua data product/data set" (a link is provided).
- *Appears on the Resource Page about what the time ranges on the query pages signify:* "In DICCE G, the start and end dates that appear to the right of each data parameter selection option are in fact the start and end dates of the data product that the parameter belongs to. In most cases, all the data parameters that belong to a particular data product will have the same start and end dates. There is however one exception. All of the MODIS Terra Version 5.1 data parameters in DICCE G have observations that began in March 1, 2000 and continued today except for the data parameter known as "Deep Blue AOD at 550 nm (QA-w, Land only)", which ended in 2007 for reasons having to do with data quality. (For more about this particular data parameter and why it ended in 2007, see its description in the DICCE enhanced help."

- *Appears on the DICCE G Resource Page about what characterizes the quality assurance testing process, for all DICCE MODIS data products:* "MODIS mission scientists determine the quality of their data and filter out data that have poor quality. There are several reasons why the data may have poor quality; for example, thin cirrus clouds can interfere with the abilities of the instruments on the satellites to remotely sense the Earth's surface. This is why for the aerosol data from the MODIS instrument, scientists and technicians have instituted a *quality assurance (QA)* process, as explained in this paraphrased text from a published description of algorithms used to produce the MODIS aerosol data products. "The MODIS products are assigned a QA "confidence' flag" (QAC) that represents an overall assessment of the quality of the data based on the individual QA flags. Each QA flag indicates whether or not a certain condition affected its quality. A QAC value can be 3, 2, 1, or 0. A value of 3 represents the best quality and 0 represents the worst. The QA confidence (QAC) flag serves another purpose as well. All MODIS-atmosphere products are averaged globally, on a 1° x 1° degree grid, on daily, weekly, and monthly time scales. These gridded products are known as the Level 3 (L3) products. The QAC flag is used for weighting data products at a spatial resolution of 10 km onto the 1° grid. Those retrievals with QAC = 3 are assigned higher weights than those with QAC = 2 or QAC = 1. Retrievals that receive a rating of 0 are not included in the 1° averages. A higher weight means greater confidence that the data are accurate. Note that DICCE-G uses only Level 3 data products from MODIS."

In the coming months, Zalles has directed Acker to seek more information about (1) significant signal for different measured phenomena in DICCE G and (2) significance of the stratospheric cooling in the temperature vertical column data. #1 is in response to feedback that Zalles obtained from teachers about how they do not know how to judge whether the magnitudes of trends exhibited in the short ranges of data from the NASA missions are noteworthy in the longer context of climate change. For example, this comes out comparing global or regional temperature changes, which in DICCE cover only several decades, to full historical climate records from Mauna Loa that show the "hockey stick" of recent temperature increases on time series plots covering much longer periods of time than covered in the NASA satellite mission data against historical data that go back much further in time than do the DICCE G mission data.

Changes to DICCE LE. Work with teachers over the summer yielded additional insight as to how DICCE LE needed to be enhanced as well as DICCE G. First, it became clear that some teachers like to create lesson plans, which are primarily meant for teacher audiences. At the time however, Zalles and his SRI staff only anticipated that they would be interested in creating activities for their students or making presentations. The activities object in the system was designed to be a template for teachers to develop hands-on instructional activities or assessments. The concept of the template was to have fields for overview, directions, images, image captions, questions, and answer keys that only registered teachers could see. Concept of the presentation template in contrast was to have fields for introducing the topic of the presentation, presenting images with captions, and noting conclusions at the end. In contrast, lesson plans typically include fields for stipulating measurable learning objectives, time duration of the lesson, primary and secondary alignments of the lesson to standards, the instructional sequence, materials needed to carry out the lesson, and information about how student progress should be assessed. So, the DICCE team created a new lesson plan object that, along with presentations, activities, and trend tables, could be put by an author into a DICCE LE curriculum project.

Another need became clear concerning flexibility of how the various objects could appear in DICCE LE projects. It was initially designed so that in DICCE LE curriculum projects, objects by type would appear in groups: presentations first, followed by activities, then trend tables. Zalles asked the SRI programmers to reconfigure this so that curriculum project authors could sequence the objects in any order so that for example, it would be possible for a teacher to start a project with a particular lesson plan followed by a particular presentation, then activity, then another lesson plan etc. With the constraints of the Wordpress tool that SRI used to create DICCE LE, the team decided that the best interface for determining order would be to allow the author to type in to a sorting field a number for where the particular object should belong in the curriculum project sequence. The team also determined that if the author does assign a number for where the object should appear in the sequence, the objects would default to appearing in alphabetical order. Then, the team determined that the author should always have capability of changing the order, even after publishing the project for other users to access. In August these features were rendered operational.

A3. Make changes to the Foundations Science climate curriculum to integrate it with the DICCE local climate change investigation capabilities

Integration of DICCE with the Foundations Science curriculum will be fulfilled in the upcoming year. The process of making these decisions about integration was set in motion in discussions with teachers during the summer of 2013 who have now used both the EDC curriculum and DICCE in their classrooms. It was discussed that students and teachers can focus on the data and images that are already in the curriculum (which is being developed into a published textbook) then turn to DICCE for suggestions of new related data to examine (e.g., data about the local area or more recent data or data about related phenomena such as snow cover, snow depth, radiation, surface greenness). In the curriculum, they look at different images of the Earth and rank them. This ranking exercise could be embellished through examining trends over time on the related phenomena. At a more practical level, and concerning engagement and usability, a teacher recommended that DICCE should ideally show up in small yet different ways in each chapter of the curriculum so that the teachers and students get in the habit of using it, which then would build their mastery. She recommends the practice of looking at data from the curriculum, then selecting new related data from DICCE to investigate the phenomenon further, yet varying the verbiage of the investigations slightly from activity to activity. She suggested that the use cannot feel like an add-on to the teacher that is reading about these activities because if so they will be less inclined to use it. Yet, since the Foundations Science curriculum has already been written and textbooks in the course of being assembled, the best existing way to pursue this integration would be in web-based resource guides where the teachers are introduced to DICCE early in the curriculum and reconnected to it later in the curriculum knowing that DICCE would be a vehicle for them to supplement the curriculum with additional real-time data and thus make their instruction with the textbook feel more immediate.

A4. Execute dissemination strategies

During October 2012, Zalles presented to 15 high school science teachers about DICCE at second workshop of the PEL project. In this presentation, Zalles asked the participants to compare and contrast what they might do instructionally with DICCE resources compared to what they would do with various lab activities suggested by PI Steve Getty of the Carbon Connections project, also funded by NICE. The group compared and contrasted the characteristics of the argumentation elicited in the "pair and share" activities that Getty had them do to the characteristics of argumentation that they can elicit from their students in the DICCE data. The brainstorming focused on how the Carbon Connections-related lab activities isolate specific variables to explore relationships between variables in closed systems whereas the Giovanni data sets available through DICCE display real readings of data in real settings where many phenomena interact at once. Zalles asked the teachers to think of examples of how they could have students practice evidence-based argumentation with DICCE data. An example would be looking at topographical influences on an area's temperature that mediate the otherwise more predictable influences of Earth tilt, orbital path, and seasonality that Getty's lab activities prompt investigation of. Zalles also introduced the new DICCE master site and showcased how all the DICCE resources could be accessed from there.

On October 12th and 13th, 2012, PI Zalles and assistant Amy Hafter from SRI International attended the 41st annual meeting of the North American Association for Environmental Education (NAAEE). Zalles and Hafter ran a booth to showcase to potential users DICCE and three other recent and current Zalles-led climate change education projects. The attendees who visited the booth represented a broad range of interests and professions.

1. Teachers working with students as high school and middle school teachers.
2. Providers of professional development via county offices of Education and community action groups working with teens and adults on environmental issues)
3. Directors of non-profits seeking more information about resources to use with their clients and target audience
4. Artists who work build community environmental awareness through video and art production and dissemination
5. Curious home-educators seeking useful information for enhancing their curricula
6. Other miscellaneous participants

Zalles and Hafter engaged in multiple conversations throughout both days related to possible uses of DICCE for enriching climate change curricula and project based learning opportunities with real, authentic data. Different attendees came up with different ideas for how DICCE could be expanded to be even more useful and for how they might use it in the course of their work. For example,

1. Creating real time data tracking projects linked to other interests in Environmental education (e.g., adopting a local nature preserve and tracking the progress of preservation efforts).
2. Building opportunities to do cross-disciplinary projects including spanning math, language arts, social sciences, and other scientific disciplines such as physics and biological sciences.
3. Developing lesson plans that utilize DICCE for math and science teachers, and including formulas for working with real time and historical data.
4. Creating videos with the application Educreations to guide students on how to access and use the data for multiple purposes.
5. Adding tool-kits that bring virtual tools, such as 3-D mapping techniques and modeling based on the projection features that both teachers and students can use.
5. Creating a compendium curriculum resource that helps teachers relate the concepts from DICCE across their various scopes and sequences.
6. Mapping the standards of new district core curricula to the different SESIS project curricular and assessment components.

Zalles and Hafter also had the opportunity to speak to several university professors and graduate students about possible use of DICCE and the other resources in their courses or with their teachers-in-training. Some expressed that new-to- the-field teachers tend to be more tech-savvy than their more seasoned counterparts might be, and that the resources available would appeal to their sense of modern teaching style and engagement. In all, Zalles and Hafter spoke to approximately 80 people throughout the two days. For follow-up, one county administrator requested 50 brochures describing DICCE that he would circulate to teachers at an event in February and Zalles agreed to create student flyer for him as well. In addition, Zalles was invited to speak about DICCE at a Microsoft-supported Bay Area environmental education conference in June, to be confirmed after the first of the year.

At the *December 2012* Annual Meeting of the American Geophysical Union, DICCE was featured on four posters: two developed by Zalles, one developed by Jim Acker, and one developed by Ruth Krumhansl:

1. Alternative Evaluation Designs for Data-Centered Technology-Based Geoscience Education Projects
2. Assessing Student Learning about Climate Change with Earth System Place-Based Geospatial Data
3. Supporting teachers in the use of authentic, near-real time climate data from the NASA Giovanni data portal in the pre-college classroom.
4. Giovanni Data Portals and Resources Support Student Problem-Based Learning for Climate Change Education

These posters attracted interest among academics, PIs of related projects, and program managers at various agencies. Four individuals at the meeting, including a manager at the British Geological Survey, saw strong potential use of DICCE in online undergraduate programs. For example, one focused on how the types of assessment items that we have been creating for the different DICCE G data parameters could be used as a way to formatively diagnose levels of student understanding of geoscience topics and individualize learning paths accordingly.

In June 2013, Zalles presented an exhibit about DICCE at an annual Greenkids conference (http://greenkidsconference.org/). To develop the exhibit, which was aimed at attracting the interest of young children, Zalles developed a set of “brain teasers” about various data visualizations. He turned this into a game. Students who came to the exhibit would have to guess what places in the world are represented by various time series plots and maps showing different data parameters. The questions are in a multiple choice format. Students would guess the answer and then be told if they were correct or not. Also, Zalles set up a computer for students to do queries in DICCE G. it was heartening to see children as young as seven years old figure out how to query DICCE G with very little input from Zalles, and play the brainteaser game as well. What was especially interesting about observing these children using DICCE was their quick independent perseverance in making decisions about what types of visualizations they wanted to study, what regions (some students wanted to compare data about a section of China with data about California), and how to use the DICCE G query interface to generate the visualizations. This is in marked contrast to some of the older teachers who took longer to get comfortable with the software.

In June 2013, Zalles also presented about DICCE at a second workshop of Ventura County teachers as part of the CSU Channel Islands PEL grant. To prepare for this workshop, Zalles authored a new resource that will be put on the main DICCE website. The resource consists of a set of slides about interesting phenomena that one can observe in different regions of the world from the DICCE G (DICCE G) data that support what is commonly known about the characteristics of climate change. The slides focus on detecting clear signs of climate change in northwestern Alaska in the data about land cover, net shortwave radiation, near surface air temperatures and snow cover, (2) CO2 fraction data from Ontario, Canada and Colombia, South America, and (3) contrasting trends in precipitation in regions of the greater Indian subcontinent. The slides also contain examples of how teachers can use DICCE data to support greater understanding of certain climate feedback loops and schematic models. In the workshop, a teacher from the prior year met with Zalles for a special afternoon session in which Zalles helped her think through curricular possibilities for using DICCE data about Central America to build greater understanding among students in Belize about the impacts of climate change on pollution and coral destruction off the Belizean coast. She had conversations with informal environmental educators in Belize who expressed interest in using DICCE to educate students and the public about these threats and she promised to train them in how to use it. Zalles helped her with the software but the main topic of their discussion was studying the South American data in DICCE G and thinking about what kinds of curricular activities would help Belizean educators build understanding among the students about the threats. An important component of her professional development was to have her come up with research questions before running data queries. This has proven to be an important facet of DICCE teacher professional development. It is too often the case that teachers make instructional choices around topics (e.g., sea surface temperatures, euphotic depth) rather than research questions (e.g., could climate change be affecting the Belizean barrier reef?).

A5. Analyze student outcomes of the piloting

Analysis of student outcomes from the piloting is proceeding. Students have been doing assignments and filling out questionnaires at the end of their experience with DICCE. We have analyzed survey results from 80 students so far and will be coding the student assignment products for the purpose of assessing their learning outcomes. For now, Table 1 below shows results from scaled items on the survey. The results are expressed in means and frequencies.

Item	**Scale**	**Frequencies**	**Mean**
1. How much experience have you had studying maps and graphs in science classes before, including in this class and in previous science classes?	1= none	1	3.8625
	2= once or twice	13	
	3=3 to 5 times	28	
	4=6 to 8 times	8	
	5= more than 8 times	38	
2. How much do you like studying maps and graphs in science class now that you've done DICCE activities?	1= none at all	13	2.375
	2=just a little bit;	27	
	3=somewhat	37	
	4= a lot	3	
3. DICCE activities are about data concerning regions of the world, such as your own region. How much does studying your local region make your studies more interesting?	1= none at all	10	2.6625
	2=just a little bit	21	
	3=somewhat	35	
	4= a lot	14	

Table 1. Results of Student Survey administered in implementing DICCE classes during the 2012-13 academic year.

Item 1 results show a big divergence between numbers of times the students across the different classes have had prior exposure to maps and graphs in science class. This is important because the more exposure they might have had, the easier it would have been for them to analyzing the data in DICCE without taking class time to build prerequisite interpretation skills first. There were large groups of students who had 3 to 5 exposures (N=28) and even more had more than 8 exposures (N=38). The results of Question 2 show that DICCE has had a positive impact on how much the students like studying maps and graphs in science class, with only 13 out of 80 (16%) saying it has not had a positive impact, though the degree of impact varies from "just a little bit" to "a lot." The results of Item 3 suggest that students welcome the emphasis in DICCE on studying regional climate change. 70 out of 80 (88%) said that studying their local region makes their studies more interesting.

We have also gathered data from observations of various implementing classrooms. The results of these observations yield rich information about how teachers and students interact about the DICCE data. For example, one exchange between a teacher and students (see Figure 1) concerning maps she produced about amounts of net outgoing long wave radiation over Greenland in 1979 (first full year of data collection by the mission) and 2012 (the most recent full year of data collection) exemplify the challenges faced by teachers trying to carry out an effective discourse with students. It should be noted that the particular teacher in question received additional professional development after implementation and confessed to being more comfortable doing direct instruction than student-centered instruction but was motivated to improve her skills.

Teacher-student dialog	**Commentary**
T: What is your interpretation of these two maps? As far as the amount of energy that is leaving the earth? Is there more of it leaving the earth in '79 or 2012?	The teacher asks the students to pay attention to the two maps. By this time she has explained that the legend indicates what the colors mean concerning the amounts of outgoing net long wave radiation.
S: 2012?	The student comes up with the wrong answer. The changing ranges of values (from approximately -131 to -12 watts per meter squared in July 1979 to -113 to -41 watts per meter squared in July 2012) show decreased net long wave radiation, which provide evidence of greater retention of long wave infrared radiation in the atmosphere as heat, yet due to the fact that each map only shows one month of data, there could be other mediating factors such as amount of cloudiness or other naturally varying weather or climate conditions. In fact, the most interesting pattern in the data is greater retention in-

	land in 2012 but less retention along the coasts, which could be more a product of greater cloudiness along the coasts that blocks the amount of radiation hitting the ground compared to more of it hitting the ground under possibly different weather conditions in the interior. A good follow up task would have been for the teacher and students to study Greenland maps for the same month showing amounts of cloudiness and precipitation.
T: In ’79 you’ve got more of it that is leaving, because the blue means that it is staying and being absorbed. Okay. So, for this one, 2012, now there is a difference in the middle of the continent versus the edges. But, the more dramatic change seems to be around the edges of the continent. Why do you suppose that might be the case?	Instead of probing to see what the student was thinking, the teacher offers an explanation but does not check for understanding and instead moves on to a question calling for an explanation about what might be causing differences between what is happening at the coasts compared to inland.
S: Because of the population on the coast makes it warmer.	The student is on the right track in identifying that a good case could be made that the net long wave radiation differences are connected to greater warmth along the coasts, but may or may not be on the wrong track when making a conceptual connection between increased warmth and greater population.
T: Well, there aren’t a whole lot of people who live there. But, that would be something. Could be. Where do you think the ice is thinner?	Instead of probing to see what conceptual connection the student thinks exists between population and greater warming, the teacher simply states that there probably is not a connection because there are not many people along the Greenland coast. She then turns the students’ attention to the thinning of the ice, which would be a reasonable connection to make with the trend of less reflectivity along the coasts. She prompts the students to notice on the map places where this connection may exist. The students need to look at the colors against the map legend to notice what she wants them to notice.
S1: Right there.	
S2: Edges.	

S3: Probably in the middle.	
T: So, this doesn't really tell us how thick the ice is, just how reflective it is. But, chances are it is melting faster on the edges than it is in the middle.	The third student is on the wrong track if he is referring to the middle of Greenland, but the teacher ignores the comment and explains that the net long wave statistic may be correlated with the amount of ice cover, yet it may also be correlated with other naturally varying factors.

Figure 1. Example of dialog between teacher and students comparing two maps about net longwave radiation in Greenland

We will in the coming months conduct more analyses of student responses to DICCE in questionnaires, assignment products, and discourses. The observations and interactions with the teachers provide important context by which to build meaning about to what extent the DICCE resources impact the student outcomes compared to the characteristics in relation to how the teachers use the resource.

A6. Put structures in place for public access to DICCE-G and DICCE-LE and to long-term hosting of the two websites at GES DISC and SRI, respectively

Both DICCE G and DICCE LE have been publicly available since Year 1 of the project and we created in addition a primary-access public website that connects to all the DICCE G and DICCE LE sites as well to supporting additional resources and information, including YouTube videos about how to use DICCE. This primary site is at http://dicce.sri.com. At SRI, Zalles instituted structures for long-term maintenance of the public DICCE sites on the SRI server (i.e., the main DICCE site and the DICCE LE site) plus means for updating the LE site when new versions of the core technology program Wordpress are released. SRI hosts a test site for trying out new software features in DICCE LE and has a mechanism for maintaining the content so that if any problem arises with an update that requires a change in design, user content is not impacted.

Zalles and Acker have begun discussions about how to port DICCE G, which is part of Giovanni Version 3, to Version 4, which will be released in 2014.

B. PROJECT ACCOMPLISHMENTS MEASURED AGAINST THE PROPOSED GOALS AND OBJECTIVES

In the DICCE proposal we 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."

Since November 1, 2012, five teachers implemented DICCE with their students and four others are expecting to do so in the 2013-14 academic year. Each developed their own curricula and instructional plans and received some personalized instruction in DICCE. At conferences plus at training workshops put on by a different grantee in Southern California, we have also introduced DICCE to teachers and other educators as well as directly to young students in a summer camp. Hence, there is most likely much wider use of DICCE occurring than we are monitoring in the project. Previous reports have described in detail our interactions with wider audiences and we will continue to report them in the upcoming year.

We have been administering surveys to teachers as well as to the students. Also, we have conducted observations and interviews with the teachers and observed them as they respond to the DICCE resources in their training. It is noteworthy in this report to contrast input about DICCE from the two types of users. Student survey results and observations of children setting up queries and studying DICCE data suggest that it can be a compelling and welcome learning resource for students as young as elementary school. Yet, a challenge remains as to how to build the teachers capacity is to implement effectively, to be motivated to implement, and to be interested in taking the time it takes to build enough understanding of the DICCE software and data to appreciate its educational value for their students. Prior results from research about teacher professional development align well with what we have been finding in this regard:

- Teachers need to feel comfortable with technology to implement technology-based innovations, especially those with interface constraints such as DICCE G. Ideally, an interface should be so easy and intuitive to use that any user can jump right in and master it quickly, as easily as a user can master how to navigate a Web browser, do a Google search, or send an email message. Unfortunately, there remains a generational divide in teacher capacity building with technology. Young teachers, who have grown up with technology, are more likely to react to technology challenges more like their digital native students would than older teachers, who are more anxious about technology because they did not grow up with it and hence may be less skilled at figuring out for themselves (i.e., what to click for example on a particular page to perform particular function). Despite these challenges, we are happy to report that the enthusiastic teacher who did "DICCE Fridays" (reported in Section A1) is an older teacher who was initially frustrated with the DICCE technology. Fortunately, an hour–long phone call with Zalles through how to do basic functions changed her attitude, at which point she put much dedication into the project. More one on one or small group coaching and troubleshooting has been effective with other teachers as well.
- As a portal of data with many possibilities for inquiry, users are challenged about what to look at and why. The teacher needs to figure out what would be an

interesting line of inquiry for their students to pursue. But first, the teachers need to have a good sense of how to study the data themselves, posing questions or hypotheses, checking data, drawing conclusions, and choosing what other data to look at to validate their hypotheses. The data choices in DICCE, while powerful and rich, can also be daunting without sufficient capacity in scientific practices and broad mental models of how the variables relate to each other. When teachers are presented with data that they can then use in their instruction, the data usually come in articles or textbooks, are preselected, and are displayed on fixed visualizations that were created by the author to make a specific point.

- We are finding that teachers who are looking for quick resources to use in short units about climate change are less likely to be enamored of DICCE than are teachers who either have more time to spend digging deeply into this complex topic or need to focus on skill building outcomes aligned to the Common Core and other standards. Some want to simply show students time series graphs with visually dramatic trend slopes that motivate their students to believe in climate change. Certainly, the CO2 data in DICCE show such dramatic trends yet other trends are less obvious and more regionally varying.
- Even when teachers are motivated, there is the challenge of figuring out how best to train them. Teachers like to say that they want opportunities for interaction but when these opportunities are presented to them, scheduling conflicts get in the way and they may not even take advantage of them when they the scheduling fits. What has been most effective with the DICCE teachers is Zalles and Krumhansl meeting with them one on one or in small groups. Summers work best for these sessions because that is when they have the most time and they usually need reinforcement sessions as well, scheduled at their convenience.

These challenges for determining what it takes to get teachers trained and committed to DICCE motivated Zalles to hire the IISME teacher for a summer fellowship. This teacher, a 55-year-old man who has been teaching science for 5 years and had formerly spent many years in a non-technology career as a chiropractor, served as a test case for how usable are the DICCE resources, how much of a learning curve there is in an ideal situation where a the teacher has unlimited time to use the posted tutorials and videos to build independent mastery of the technology, followed by unlimited time to develop DICCE-centered lesson plans for his students. Zalles asked the teacher to figure out how to use DICCE on his own and keep a journal to record his thoughts and conclusions. The journal is in the course of being analyzed and will be reported in more detail in later reports. For now it is useful to study what he wrote in his concluding reflections at the end of his fellowship (see Appendix C). Broadly speaking, he was able to master the interfaces relatively quickly and once he did that, he had many brainstorming thoughts about how to use DICCE with his students. In the process, he also learned a lot more about complexities of climate change and how the different DICCE data parameters inter-relate.

C. EVIDENCE OF HOW PROJECT ACTIVITIES HAVE FURTHERED STAKEHOLDER PRIORITIES

We mentioned in our proposal that DICCE 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 3 impacted teachers and diverse students. Through the more user-friendly public access to NASA data afforded by DICCE G, and through the growing bank hands-on data-centered presentations, lesson plans, assessments, and hands-on activities available to the public via DICCE LE, we are furthering the goal of bringing NASA data to different types of stakeholders.

It became clear in various conversations with teachers that the current attention at the district level to implementing the Common Core Standards and, to a lesser but still important agree, to the Next-Generation Science Standards, is making teachers view DICCE as a more compelling and useful resource because they come to appreciate how the authentic, real-time scientific data it provides brings many opportunities for exercising scientific practices and giving students opportunities to build their reading and language arts literacy is with scientific information in its various modalities (text-based, graphical based, map-based, table-based, diagram based). This is why Zalles asked the IISME teacher during the summer to purposely focus his curriculum development work on finding opportunities within the DICCE data to develop lesson plans aligned to the standards. He differentiated primary and secondary alignments. He developed one lesson focused primarily on having students follow multistep directions, two lessons devoted primarily to getting the students to be able to compare real data from DICCE to real cutting-edge research findings reported in scientific journals, and one lesson to building students' abilities to construct time series graphs from real table-based data provided by DICCE and practice depicting trend lines. These lessons, though still in review, can be accessed at the following individual web addresses within DICCE LE.

- Lesson Plan and Data about Greenland's Decreasing Albedo (http://dicce-le.sri.com/?projects=lesson-plan-and-data-about-greenlands-decreasing-albedo)
- Lesson Plan about the "Greening" of Australia's Deserts (http://dicce-le.sri.com/?projects=the-greening-of-australias-deserts)
- Lesson Plan about California's Changing Atmospheric Carbon Dioxide Levels (http://dicce-le.sri.com/?projects=lesson-plan-californias-changing-atmospheric-carbon-dioxide-levels)
- Lesson Plan about Decreasing Snow Amounts in the Swiss Alps (http://dicce-le.sri.com/?projects=lesson-plan-decreased-snow-in-the-swiss-alps)

Each lesson is targeted to be useful for teachers from grades 6 to 12, and DICCE LE makes it possible for any teacher to adapt the lessons to be more age appropriate for their students.

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

The new pressure among California teachers this year to start to teach to the Common Core standards has provided additional impetus for DICCE classroom use. Teachers in three California districts (Ventura, Livermore, Mount Diablo) have explicitly stated this to Zalles. This is why we have increased our interest aligning the materials to the Common Core and Next Generation Science Standards.

We wrote a proposal in the winter for a NOAA Environmental Literacy Grant with a partner that we began a relationship with after Zalles presented at a conference of theirs last year. The group is the North American Alliance for Environmental Education. The project, if funded, will provide an opportunity for us to apply design, professional development, and implementation principles and lessons learned from DICCE to educator use of a NOAA portal of environmental science data. The proposal was highly rated and we have been told that the project may be funded in fiscal year 2014.

In the past month, we began exploring the possibility of writing a grant proposal for a research project with a particular large diverse California school district to study the impact of the use of DICCE in elementary and middle schools. The study would serve as a vehicle for integrating science with math and reading language arts in ways that bring about greater gains in Common Core Standards compared to comparison group classrooms where the integration is not occurring.

E. PLAN OF ACTIVITIES FOR THE NEXT YEAR

There will be additional tracked teacher implementation of DICCE in the 2013-14 academic year. An 8th grade teacher has promised to do DICCE in the fall in her 12 week long environmental science course. Another 8th grade middle school teacher has promised to implement DICCE during his climate unit in his physical science course in the spring, which will follow units on chemistry and astronomy. A high school Earth science teacher said she will be using DICCE in her Atmospheric Science unit between January and March, which will follow Fall units on Geology and Natural Resources. This was the teacher who planned to implement DICCE lessons in late April but got in a car accident. She intends for her students to examine mission data about temperatures, snow cover, and precipitation in the Sierra Nevada Mountains compared to the Rocky Mountains. She wants her students to understand basic orographic water principles and how climate change has been manifesting itself more drastically in the Rockies than in the Sierras with its lengthier drought. Lastly, the IISME teacher plans to teach his students data skills with DICCE in the fall, incorporate DICCE use in his Spring climate unit and is thinking of using DICCE in chemistry class as well. This teacher will this year be teaching a new grade 9 environmental science course as well as and 10th and 11th grade chemistry,

In the coming months we will do more analyses of student outcomes, teacher outcomes, teacher-student interactions and pedagogical practices, plus carry out further refinements and enhancements to DICCE G, LE, and the master site as needed. We will also determine sustainability structures for DICCE G in face of the public release of Giovanni Version 4, which is slated to occur sometime within the next year. WE will also carry out more dissemination in the form of a session at AGU, a session at NAAEE, and a pending session at AERA. Lastly, we plan to write articles for peer-reviewed journals about DICCE. Finally, we are exploring what opportunities there are for connecting with other funders for additional sources of revenue in ways that would allow for continued enhancement and expanded use of DICCE among more teachers and classrooms.

Appendix A
Guides to differences between similar data products

Monthly data

Data Product 1	**Data Product 2**	**Data Product 3**	**Attributes of DP1**	**Attributes of DP 2**	**Attributes of DP 3**
MODIS-Aqua chlorophyll *a*	SeaWiFS chlorophyll *a*		MODIS chlorophyll *a* is slightly more accurate in turbid waters; the MODIS chlorophyll data is current to the present day	The SeaWiFS chlorophyll *a* data extend back to September 1997, and include the large El Nino event of 1997-1998.	
Aerosol optical depth at 550 nm	Deep Blue AOD at 550 nm		Aerosol optical depth at 550 nm is calculated by the standard MODIS algorithm. This algorithm does not work over bright Earth surface areas.	Deep Blue AOD is calculated using the MODIS blue wavelength band, and does allow estimation over bright surface areas, primarily desert regions.	
Mass concentration (Land)	Mass concentration (Ocean)		The aerosol mass concentration algorithm has two parallel data products, calculated over land and ocean. Mass concentration for land can be used with either AOD data product.	The aerosol mass concentration algorithm has two parallel data products, calculated over land and ocean. Mass concentration for ocean can be used with either AOD data product.	
GPCP Precipitation	Observed ground station precipitation	Rainfall rate	GPCP precipitation is calculated by combining data from several data sources (satellites	Observed ground station data is only derived from rain gauges on	Rainfall rate is a model-derived quantity. It gives rainfall data in terms of mass,

			and ground stations), providing accurate comprehensive coverage. GPCP precipitation and rainfall rate cover the same time period.	weather stations. The data does extend back to 1950, allowing trend analysis, but ends in 1999.	rather than accumulation (i.e. inches or centimeters). The model can fill areas where actual data coverage was sparse.
Land surface temperature (day)	Land surface temperature (night)	Land surface temperature (day and night) 5.6 km	Land surface temperature (day) is affected by solar heating and cloud cover, and thus may be more variable than nighttime temperatures.	Land surface temperature (night) is less affected by solar heating and cloud cover, which can be considered to give a truer indication of surface temperature and trends.	The 5.6 km data products are at higher spatial resolution, improving ability to distinguish surface features and boundaries (such as between urban and rural areas).
Near surface air temperature			Near surface air temperature is a model-derived data product based on surface and satellite data inputs. It extends back to 1979, unlike the land surface temperature data products, which are from satellites and begin the year 2000.		
Snow depth	Snow mass	Snowfall rate	Snow depth is the most familiar snow variable, expressing the amount of snow in terms of depth (inches or centimeters). Snow depth can vary depending on the type of snow crystals present and	Snow mass expresses the amount of snow in terms of mass (grams or kilograms), which is more indicative of actual water content than snow depth.	Snowfall rate expresses the amount of snow falling as precipitation, and does not indicate how much snow is actually present on the ground.

			the water content of the snow pack.		
Enhanced Vegetation Index (EVI)	Normalized Difference Vegetation Index (NDVI)		EVI seeks to be an improved variable over NDVI by reducing the influence of the atmosphere on the satellite data, and providing a better way to assess variability in high biomass regions (i.e. dense forests and grasslands).	NDVI has been a standard way to assess the greenness of the land surface, i.e. the presence and health of plants, since it was first used for satellite observations.	

Appendix A (continued)
Guides to differences between similar data products

Daily data

Data Product 1	Data Product 2	Attributes of DP 1	Attributes of DP2
MODIS-Aqua Aerosol Optical Depth (AOD)	MODIS-Terra Aerosol Optical Depth (AOD)	MODIS-Aqua crosses the equator on the lighted side of the Earth at approximately 1:30 PM local time. The MODIS-Aqua mission began in 2002, so the data record is shorter than for MODIS-Terra.	MODIS-Terra crosses the equator on the lighted side of the Earth at approximately 10:30 AM local time. Because the MODIS-Terra mission began in 2000, this data record is longer than for MODIS-Aqua.
MODIS-Aqua Deep Blue AOD	MODIS-Terra Deep Blue AOD	The MODIS-Aqua Deep Blue AOD data record covers the period 2002-present.	The MODIS-Terra Deep Blue AOD data record covers the period 2000-2007. MODIS-Terra Deep Blue AOD data is not available after 2007 due to the loss of polarization correction.
Mass Concentration (Land)	Mass Concentration (Ocean)	The aerosol mass concentration algorithm has two parallel data products, calculated over land and ocean. Mass concentration for land can be used with either AOD data product.	The aerosol mass concentration algorithm has two parallel data products, calculated over land and ocean. Mass concentration for ocean can be used with either AOD data product.
CH4 Volume Mixing Ratio (ascending)	CH4 Volume Mixing Ratio (descending)	The ascending data product is collected on the night (unlit) side of the Earth, and may be less influenced by daytime solar radiation and heating effects.	The descending data product is collected on the day (illuminated) side of the Earth, and may thus be affected by solar radiation and diurnal atmospheric heating. CH4 may be released from the Earth's surface as it is warmed by sunlight. CH4 can also be broken down by sunlight to produce CO2.
CO Volume Mixing Ratio (ascending)	CO Volume Mixing Ratio (descending)	The ascending data product is collected on the night (unlit) side of the Earth, and may be less influenced by daytime solar radiation and heating effects.	The descending data product is collected on the day (illuminated) side of the Earth, and may thus be affected by solar radiation and diurnal atmospheric heating. CO can be produced by photochemical reaction of sunlight with organic matter in surface waters.
Total Column	Total Column	The ascending data product	The descending data product is

Ozone (ascending)	Ozone (descending)	is collected on the night (unlit) side of the Earth, and may be less influenced by daytime solar radiation and heating effects.	collected on the day (illuminated) side of the Earth, and may thus be affected by solar radiation and diurnal atmospheric heating.
Outgoing longwave radiation flux (ascending)	Outgoing longwave radiation flux (descending)	The ascending data product is collected on the night (unlit) side of the Earth, and may be less influenced by daytime solar radiation and heating effects.	The descending data product is collected on the day (illuminated) side of the Earth, and may thus be affected by solar radiation and diurnal atmospheric heating.
Relative humidity (ascending)	Relative humidity (descending)	The ascending data product is collected on the night (unlit) side of the Earth, and may be less influenced by daytime solar radiation and heating effects.	The descending data product is collected on the day (illuminated) side of the Earth, and may thus be affected by solar radiation and diurnal atmospheric heating. Relative humidity varies with temperature.
Surface air temperature (ascending)	Surface air temperature (descending)	The ascending data product is collected on the night (unlit) side of the Earth, and may be less influenced by daytime solar radiation and heating effects.	The descending data product is collected on the day (illuminated) side of the Earth, and may thus be affected by solar radiation and diurnal atmospheric heating. Surface air temperature usually increases due to solar heating of the ground surface.
Temperature profile (ascending)	Temperature profile (descending)	The ascending data product is collected on the night (unlit) side of the Earth, and may be less influenced by daytime solar radiation and heating effects.	The descending data product is collected on the day (illuminated) side of the Earth, and may thus be affected by solar radiation and diurnal atmospheric heating. Surface air temperatures are usually warmer during the day due to solar heating of the ground surface.
NO2 Column	NO2 Tropospheric Column	The NO2 column amount data product indicates the total amount of NO2 from the surface to the top of the atmosphere.	The NO2 tropospheric column data product indicates near-surface NO2 concentrations. This is the estimated tropospheric contribution to total NO2 column amount.

Appendix B
Additional Information about Ascending and Descending Nodes
(Appears on the DICCE G Resource Page)

Many satellites that orbit the Earth are in orbits that are called *polar* orbits - that means that they go over both of Earth's polar regions, the Arctic and Antarctic. Satellites with this kind of orbit have an *ascending node* and a *descending node* of the orbit. The ascending node is when the satellite is traveling south to north over the Earth's surface. The descending node is when the satellite is traveling from north to south over the Earth's surface.

The AIRS instrument that provides relative humidity and temperature data is on the NASA Aqua satellite, which has its descending node on the sunlit (day) side of the Earth, and its ascending node on the dark (night) side of the Earth.

Below is a table that shows for parameters that have ascending and descending node data, which of these is on the day side and which of these is on the night side of the Earth. For the data in the DICCE Daily portal, both the Aqua and Aura satellites are in ascending node orbits, so all the ascending node data products are acquired on the daylight side, and the descending node data products are acquired on the nighttime side.

Parameter	**Node**	**Day Side/Night Side**
CH4 (methane)	Ascending	Day
CH4 (methane)	Descending	Night
CO (carbon monoxide)	Ascending	Day
CO (carbon monoxide)	Descending	Night
Outgoing longwave radiation flux	Ascending	Day
Outgoing longwave radiation flux	Descending	Night
Relative humidity	Ascending	Day
Relative humidity	Descending	Night
Surface air temperature	Ascending	Day
Surface air temperature	Descending	Night
Temperature profile	Ascending	Day
Temperature profile	Descending	Night
Total column ozone	Ascending	Day
Total column ozone	Descending	Night

Appendix C

Closing reflections of the IISME teacher about his experiences over the summer with DICCE

At first, I saw the website as a little intimidating with so many boxes, unfamiliar terms and dates. For the most part, I taught myself with the help of some of the video tutorials. While I think that this is fine for me, as a summer teaching fellow with enough time and energy, I don't think it would work well with a teacher during the school year or even during summer, if alone. On the other hand, because I did this mostly by myself, I do feel that I am more competent with the interface than I might otherwise be.

Despite this, I still have not explored many of the data parameters beyond temperature, CO2 fraction, snow fraction, precipitation, radiation, mass concentration and vegetative index. At some point in the future, I would like to examine the others. These limitations are probably a good idea in the classroom.

Once I became familiar with the interface's layout and the process of creating visualizations, I found it to be very easy and when a question came up, I could quickly produce a map or graph that gave me the answer. I think that this will be great for students who have access to the site.

Content

I believe that the content aligns well with many of the science standards and directly relates to a number of concepts in the classroom. While climate change appears to be the main focus of DICCE G, I can see using it for more than that. Climate, weather, photosynthesis, oceanography, radiation and pollution are all related to the data provided here. The biggest drawback is the limited temporal range. I understand that we can only use what's provided but, in an ideal world, my students would like to look back farther than 20 or so years. If climate change is the topic, I really need to show students data from 50 or more years ago. Links to other sites with expanded time frames would be helpful.

Beyond the specific science content, I feel that the real value of DICCE G is as a vehicle for introducing and practicing science skills. NGSS and common core refer to skills and practices involving gathering, examining and interpreting data. This is exactly what is involved with using DICCE.

Instruction

I think that it would not be difficult to weave in DICCE as an instructional tool for class – either online access for individual students, online projected to the class as a whole or as preprinted handouts using DICCE data. The DICCE LE projects are already set up to use easily offline. I do believe that I will have to use a step-by-step set of instructional activities to fully exploit the value of this resource. First, I will introduce the DICCE LE project "Understanding DICCE G Data". This will allow my students to understand how

to navigate and create visualizations. We would then follow with the lesson: "California's Changing Atmospheric Carbon Dioxide Levels" to reinforce the DICCE procedures and begin an examination of content.
Ultimately, I think that the data and visualizations from DICCE should be used in a sequential order with each new lesson or activity building on the one before.
Example: 1) how to use DICCE -> 2) CO2 -> Temperature -> CO2 and Temperature together -> snow Fraction -> temperature and snow fraction -> Temperature/snow fraction/albedo -> net shortwave and net longwave radiation. This is how I plan to use DICCE.

Technology
While I'm impressed with the results of this resource, I do worry about the access in the classroom. We always have to be concerned about the availability of computers and internet connection in the classroom. Fortunately, DICCE LE and lesson plans using data and visualizations from DICCE G will allow for access to non-computer classrooms. I probably will create some sort of back-up plan so that we will still be able use the activity for the period.

Using this technology will allow my students to interact and not simply be a "passive" learner so I hope that connection directly to these resources will be available.