

# NOAA Satellite Data Visualizations Project Summative Evaluation



Prepared by Ellen Giusti  
August 2009

# Table of Contents

<u>Summary of Major Findings</u> .....	4
Professional Development.....	4
Assembly/Field Trip for ELL Students.....	4
NOAA Program’s Support for Teachers’ Work.....	5
General Audience.....	5
Conclusions and Implications.....	5
<u>Detailed Findings</u> .....	6
Purpose and Background.....	6
Methodology.....	7
Professional Development.....	8
Findings: Climate Change Institute.....	9
Learning.....	11
Teachers’ Personal Feedback on the Institute.....	12
Institute ELL Teachers’ Characteristics .....	12
Findings: Visualizing Climate Change Course.....	14
Teacher characteristics: .....	15
NOAA Teachers Reflect on the Program.....	16
Assembly/Field Trip for ELL Students.....	19
Professional Development’s Influence on Field Trips.....	21
NOAA Program’s Support for Teachers’ Work.....	23
Science Bulletins in Schools.....	28
Concerns .....	29
Anything Else We Should Know? .....	29
Website Material.....	30

General Audience Response .....	34
Method.....	34
Findings .....	35
Visitors’ Characteristics .....	35
Table 10. Participant Groups .....	35
Prior Interest and Knowledge .....	36
The Main Idea .....	37
Preference for Up-to-date Data.....	39
Learning.....	40
Visitors want more information .....	41
Conclusions and Implications.....	44
The National Research Council Report: School Groups.....	44
AMNH General Audience .....	46
Source.....	47

# Satellite Data Visualizations Project

## Summative Evaluation

### Summary of Major Findings

#### ***Professional Development***

NOAA teachers participated in professional development programs in February and March 2009, which provided them with extensive take-home materials.

Three in 4 teachers said they hoped to gain ideas from PD for teaching about weather and climate; 2 in 3 teachers said that they needed to know more about the topic, wanted to receive materials and meet scientists; and about half hoped to learn to use visualizations with students and network with other educators.

The top 3 topics teachers planned to focus on were 1) linkages between oceans, land and atmosphere (94%); 2) how scientists use cloud visualizations to study climate and weather (72%) and 3) topics related to the scope and sequence for science standards (72%). The 2 topics that drew the least interest turned out to be the most important after they had used the visualizations: time series data about weather and climate and diurnal patterns of cloud flow.

After PD, all but one participant said they felt better informed about using visualizations (95%) and the majority (58%) said they learned about using the visualizations for inquiry-based lessons. Only 2 participants (11%) said they felt confused about some of the ideas presented. Most participants (79%) said they plan to use the visualizations for teaching the science standards for weather and climate literacy goals.

At the end of the school year, all the NOAA teachers said they had used the visualizations data with their students. They felt that the visualizations addressed the special challenges of ELL teaching by turning complex concepts into comprehensible images and building vocabulary.

#### ***Assembly/Field Trip for ELL Students***

The experience was designed to convey to students that they could actually understand science and even become scientists. A bilingual Museum scientist/educator gave a slide-illustrated talk about her background and field of study.

Following the assembly, classes visited the Museum’s Climate Change exhibition and the Hall of North American Mammals where the background paintings accurately depict the various types of clouds they had learned about. Observation of students in the Museum indicated that they were all deeply engaged by the exhibits.

Teachers deemed the Museum visit a valuable experience for their students: it inspired and motivated students; combined with pre- and post-visit activities, it was a true learning experience; many learning modalities; students learn that science has its own language.

### ***NOAA Program’s Support for Teachers’ Work***

The program has encouraged interdisciplinary planning, facilitating communication across schools and departments, providing techniques to use in all subjects. Teachers said that visualizations help them differentiate between “understanding a concept and knowing vocabulary.” Teachers affirmed that visual learning works for all students.

### ***General Audience***

Museum visitors appear to have little prior knowledge about climate and weather topics. After viewing the video Bulletin, the majority of participants understood the main idea of the visualizations: how to read cloud patterns. Many of them recognized that reading weather patterns occurs over time and that weather patterns are global phenomena.

The most frequently mentioned new information these visitors took away was wind direction—citing the “Easterlies” and “Westerlies” that circle the planet. A number of respondents wanted more information, particularly about how scientists interpret cloud images and patterns and about how the cloud patterns could be used to make predictions.

## **Conclusions and Implications**

All aspects of the project promote and encourage NOAA’s educational goal. While the visualizations were highly effective for students, particularly ELLs, the Clouds portion of the Weather and Climate Science Bulletin had limited impact on the Museum’s general public. The Weather and Climate via Satellite images work well with school classes because teachers prepare students to use the visualizations as a tool to understand the larger concepts in climate and weather. Visitors to HoPE seem to need orientation to better understand the images.

## **Detailed Findings**

### **Purpose and Background**

The American Museum of Natural History (AMNH) received funding from the National Oceanic and Atmospheric Administration (NOAA) to deepen understanding of weather and climate patterns utilizing existing NOAA satellite data. The Museum's National Center for Science Literacy and Technology (NCSLT) produced biweekly interpretations of the data for a Science Bulletin on weather and climate. The Bulletin uses graphics to identify cloud patterns that influence specific weather events.

AMNH partnered with schools in a program known as *Science Literacy Initiative for Grade 6 English Language Learners*. This program defined three principal goals:

- To enhance climate and weather literacy among teachers and students through the use of visualizations produced by AMNH from NOAA data.
- To enhance climate and weather literacy for new English Language Learner (ELL) students and their teachers through visual treatment of scientific concepts.
- To provide teachers with strategies for English language instruction and scientific inquiry.

The program consists of three major components:

- Professional development for teachers and distribution of extensive resources for use in the classroom.
- A field trip to the Museum with an assembly for students and teachers featuring bilingual scientists and educators and guided visits to Museum halls and exhibitions.
- Vouchers for students to return to AMNH with their families.

The secondary objective of the project was to enhance and deepen the general public's understanding of weather and climate through visualizations of cloud patterns. To this end, the satellite data is included in the Earth Bulletin displayed in the Museum's Hall of Planet Earth (HoPE).

This summative evaluation, conducted by an independent evaluator, assesses the project's effectiveness with respect to its goals and objectives. The report is divided into the following five sections: Professional Development; Field Trip/Assemblies; Support for Teaching; General Public; and Conclusions and Implications.

## Methodology

To assess the program, the evaluator conducted various activities from February through July 2009.

- Administered 2-page evaluative surveys to teachers who participated in professional development programs during February and March 2009. The surveys were designed to assess the PD programs' value relative to the NOAA project's goals.
- Administered a follow-up survey in June 2009, to assess the NOAA program's value to teachers' practice during the 2008-09 school year.
- Observed and recorded informal discussions between participating teachers, school administrators and Museum educators and scientists during a Leadership Breakfast.
- Observed and recorded informal discussions between participating teachers, school administrators and Museum educators and scientists during a Celebratory Dinner.
- Observed and photographed students' work that teachers presented to the group for peer review.
- Assessed teachers' written reflections on the project (recommendations and lesson plans on the AMNH website).
- Observed student and teacher interaction with AMNH scientists and educators during assemblies and visits to Museum exhibitions. Reviewed lessons and worksheets.
- Observed Museum visitors—members of the general public—in the Hall of Planet Earth to assess their viewing behavior related to the Science Bulletin.
- Conducted focus groups with members of the general public about the Clouds visualizations in the HoPE Science Bulletin.

## **Professional Development**

The Museum offered participating NOAA teachers a 3-day professional development program—Climate Change Institute—during the midwinter school break, February 17 through 19, 2009, from 10am to 5pm. Participating ELL teachers could choose instead to attend a course, Visualizing Climate Change, that took place on 3 evenings—February 19, 26 and March 5, 2009. This section of the report analyzes teachers’ response to those programs.

AMNH’s Gottesman Center for Science Teaching and Learning planned and conducted the Institute. The first day covered the N. Y. State Standards for teaching weather and climate, taught by two scientists from the American Association for the Advancement of Science. The second day featured talks and discussions with AMNH curator (and curator of the Climate Change exhibition), Ed Mathez, Department of Earth and Planetary Sciences. The third day focused on working with AMNH Education Department staff to learn how to use Museum exhibits for teaching. There was also a special session for NOAA ELL teachers with Dr. Maritza Macdonald to discuss strategies for teaching this population. Nineteen teachers attended the Institute.

The second professional development option for NOAA program teachers, Visualizing Climate Change, a course taught by NOAA scientists, was open to the public. During the 3 sessions, participants learned about “observations, models and visualization techniques that are essential for understanding Earth’s climate.” Five teachers chose this option.

Both programs provided extensive take-home materials.

### ***Findings: Climate Change Institute***

Three in 4 teachers (74%) had a Master's degree. Half the teachers said they were certified to teach (53%) and only 1 said she was certified to teach Earth Science. Half the teachers taught General Science, 8 taught Living Environment and 5 taught Earth Science. (See pages 10 and 11 for more complete data.)

**Table 1. Main Benefits Teachers Hoped to Gain from the Climate Change Institute**

<b>Benefits</b>	<b>Frequency N=19</b>	<b>Percent of teachers*</b>
Get ideas for teaching about weather and climate	14	74%
I personally need to know more about weather and climate	13	68%
Receive materials	13	68%
Meet scientists	13	68%
Learn to use visualizations with students	10	53%
Network with other educators	10	53%
Plan a field trip	8	42%
Learn how to use secondary research for teaching	7	37%
Other	1	5%

\*Percents add up to >100 due to multiple responses

Each teacher hoped to gain multiple benefits from the Institute. Primarily, teachers hoped the Institute would help them with ideas for teaching about weather and climate. This could be achieved by gaining a better understanding of the topics themselves, receiving materials for the classroom and meeting scientists. More than half hoped to learn how to use visualizations with students and networking with other educators.

Three in 4 participants (74%) said they planned to bring their students to the Museum, the majority during the spring of 2009. The topics they planned to focus their teaching on are illustrated in table 2 in order of most to least frequently cited.

**Table 2. Topics to Focus on for Teaching**

<b>Topics</b>	<b>Frequency N=19</b>	<b>Percent of teachers</b>
Linkages between oceans, land and atmosphere	17	89%
How scientists use cloud visualizations to study climate and weather	13	68%
Topics related to scope and sequence for science standards	13	68%
The difference between weather and climate	12	63%
The interactions between Earth's heating by the sun, Earth's rotation and the hydrologic cycle	12	63%
Tools scientists use to gather data	12	63%
How winds affect weather	11	58%
What is climate?	10	53%
How to conduct investigations using secondary research	9	47%
Seasonal patterns in cloud flow	6	32%
What time series data tell us about weather and climate.	5	26%
Diurnal patterns in cloud flow	1	5%

Percents add up to >100 due to multiple responses

The number 1 topic teachers planned to focus their teaching on was linkages between oceans, land and atmosphere (94%). This topic was not covered specifically in the cloud visualizations, requiring teachers to augment the data with other material. The satellite data provide ample entry to the second most frequently mentioned topic, how scientists use cloud visualizations to study climate and weather.

## Learning

To what extent did the Institute contribute to participants' own learning about weather topics?

Table 3 illustrates the percentage of teachers who said they already knew about a topic, the percentage who learned nothing, learned a little, learned some and learned a lot. Figure 1 illustrates the amount teachers learned about each topic.

**Table 3. Percent of Participants Who Learned about Relevant Topics (N=19)**

	Already knew	Learned nothing	Learned a little, some or a lot
Monitoring weather features	5%	11%	84%
Cyclone identification & monitoring	-	32%	68%
Diurnal precipitation cycles	-	22%	78%
Effects of climate patterns	5%	5%	90%
Monsoon onsets and retreats	5%	37%	58%

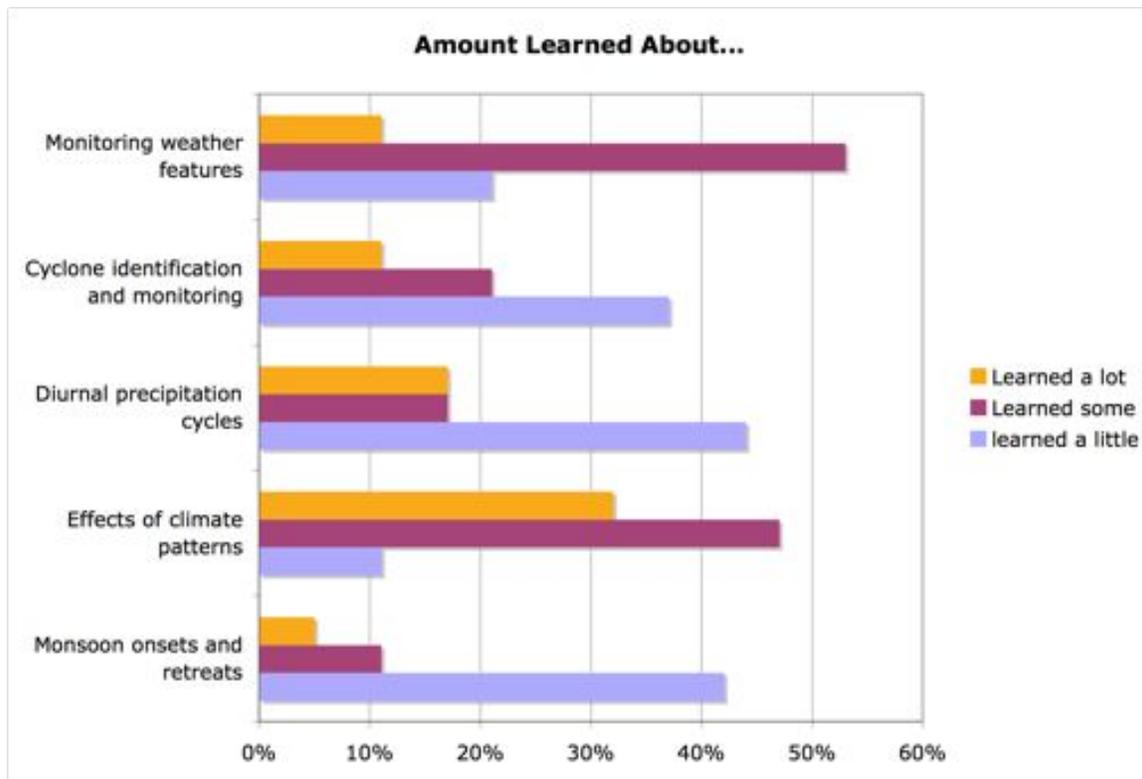


Figure 1. Percent of Participants and How Much They Learned (N=19)

## **Teachers' Personal Feedback on the Institute**

Teachers selected from a predetermined list of responses.

- All but 1 participant said they felt better informed about using visualizations (95%).
- Only 2 participants (11%) said they felt confused about some of the ideas presented.
- Most participants (79%) said they plan to use the visualizations for teaching the science standards for weather and climate literacy goals.
- The majority of participants (58%) said they learned about using the visualizations for inquiry-based lessons (some teachers may not have selected this option because they already knew about using visualizations for inquiry-based learning).
- The vast majority of teachers (84%) agreed that a Museum visit would enhance a unit on climate and weather.

## **Institute ELL Teachers' Characteristics**

- Participating teachers had from 2 to 18 years of teaching experience, averaging more than 8 years.
- Each participant taught from 34 to 150 students. The average number of students was 110, but the median number was 125. Some 40% taught 90 students or less; 60% taught upwards of 90 to 150 students.
- 13 participants said they had been teaching middle school for 1 to 15 years. The average was 6 years and the median was 5 years.
- 14 participants said they had been teaching ELL students for 0 to 15 years. The average number of years teaching ELL students was 4 years and the median 2 years.
- Participating teachers taught from 1 to 6 sections. The average and median were 4 sections.
- The teachers said their students had from 1 to 10 periods of science per week, the average and median number being 5. The number of periods taught in English ranged from 1 to 5, averaging 2. The number of periods taught in students' native language ranged from 1 to 6 and averaged 2.5.

**Table 4. Teachers' Education**

	<b>Frequency</b>	<b>Percent</b>
PhD	1	5%
BA	3	16%
Masters	14	74%
Total	18	95%
System	1	5%
Total	19	100%

- 10 of 19 participants said they were certified to teach
- 1 participant said she was certified to teach Earth Science
- The majority taught in Queens

**Table 5. Location of Participants' Schools**

	<b>Frequency</b>	<b>Percent</b>
Queens	13	68%
Manhattan	2	11%
Brooklyn	2	11%
Bronx	1	5%
Other	1	5%
Total	19	100%

## ***Findings: Visualizing Climate Change Course***

The 5 NOAA teachers completed a 2-page evaluation—the same as the one the Institute teachers completed, with the addition of 2 questions that referred specifically to the course. Their backgrounds and teaching experience were similar to the Institute participants’ (see page 13 for characteristics). Four of them taught science and 1 taught ESL in all content areas. One of the 5 teachers did not respond to any of the open questions.

Two teachers said that visualizations would help them teach units on weather and climate, but responses highlighted the difference between high- and low-functioning ELLs:

The visualizations will help me teach the units on weather and climate to show students on the smart board in the classroom the different statistics, visuals and trends in how weather changes during the short term and how climate changes during the long term.

Visualizations are a requirement when teaching ELLs , especially low level students. I would have to pre-prepare the visualizations for the students.

All respondents said that visualizations are a valuable tool for teaching ELLs science and other skills, citing specific ways they would use them:

Visualization is an important skill for ELLs to access. It is also a great tool for writing and understanding concepts.

The diagrams are a way to compare and demonstrate change without too much vocabulary.

The visualizations should be very helpful, because if students see a picture of something they would be able to associate a word or words with the picture.

The graphs and charts [make it] easy for the ELL students to visualize the sophisticated data in the graphs and charts and yet understand the data represented visually.

One teacher noted the advanced level of the course material:

Some of the material was interesting and informative; however, the content was at times more appropriate for high school students rather than middle school students I teach.

When asked to cite something in the three classes that was particularly interesting to them personally, only 1 of the teachers was able to separate her *personal* from her *professional* persona.

Session 3: GCM model was helpful seeing how the atmosphere, oceans, vegetation, etc. are connected and work together. Learning how the changing climate affects all.

What was most valuable to participants as teachers was easier to pinpoint:

Learning that programs like those shown exist! I struggle finding appropriate material that demonstrates and explains concepts for students.

Receiving resources for my students, like the GCM model program and what it would enable my students to do.

The first class was most valuable for me as a teacher because the content was something my students could relate to easily, both the content and the visuals.

All 5 teachers planned to bring students to the museum in the spring of 2009.

**Teacher characteristics:**

- All 5 teachers had Master's degrees, 2 were certified to teach and 1 was certified to teach science.
- The 5 teachers had between 2 and 30 years experience teaching: 2 had 3 or fewer years experience, 3 had more than 10 years.
- Two of the 5 were experienced ELL teachers, the others had 3 or fewer years experience with ELLs. All but 1 taught science.
- Their teaching load ranged from 1 to 10 periods per week (3 teachers had 5 periods) and 27, 75, 81, 145 and 150 students. All 5 taught in English and 3 taught in students' native language as well.

### **NOAA Teachers Reflect on the Program**

NOAA teachers and administrators who attended a celebratory dinner on June 22, 2009, were asked to complete one final survey about the program. Six teachers and 1 administrator responded (the administrator was not counted in analyses below). Many of the questions were identical to those on the February Institute instrument. Table 6 compares the main benefits June respondents said they *gained* from the program with those that February respondents *hoped to gain*.

**Table 6. Hoped For Benefit Gains Before and Actual Gains After Professional Development**

<b>Benefits</b>	<b>June Data N=6</b>		<b>February Data N=19</b>	
	<b>Frequency</b>	<b>Percent of teachers</b>	<b>Frequency</b>	<b>Percent of Teachers</b>
Get ideas for teaching about weather and climate	6	100%	14	74%
Receive materials	6	100%	13	68%
Meet scientists	6	100%	13	68%
Network with other educators	5	83%	10	53%
I personally need to know more about weather and climate	4	67%	13	68%
Learn to use visualizations with students	4	67%	10	53%
Plan a field trip	2	33%	8	42%
Learn how to use secondary research for teaching	1	17%	7	37%
Other	-	-	1	5%

The benefits that teachers hoped to gain from the training and those they said that they actually did gain were ranked consistently. Networking with other teachers was deemed more important for the NOAA teachers in June (completing the program), while learning about weather and climate was more important for those who had just completed the Institute. Planning a field trip was more important for Institute teachers and less important in June when most teachers had already taken their field trips.

Teachers were asked to check the topics for which they used visualizations in their teaching from a list on the survey instrument. Table 7 illustrates responses and compares the June responses with those from February participants' estimates of which topics they would use.

**Table 7. Topics Using Visualizations in Teaching**

Topics	June Data N=6		February Data N=19	
	Frequency	Percent	Frequency	Percent
What time series data tell us about weather and climate	6	100%	5	26%
What is climate?	5	83%	10	53%
The difference between weather and climate	5	83%	12	63%
Tools scientists use to gather data	5	83%	12	63%
How winds affect weather	4	67%	11	58%
The interactions between Earth's heating by the sun, Earth's rotation and the hydrologic cycle	2	33%	12	63%
Linkages between oceans, land and atmosphere	2	33%	17	89%
Seasonal patterns in cloud flow	2	33%	6	32%
Diurnal patterns in cloud flow	2	33%	1	5%
How scientists use cloud visualizations to study climate and weather	2	33%	13	68%
How to conduct investigations using secondary research	2	33%	9	47%
Topics related to scope and sequence for science standards	2	33%	13	68%

By June, NOAA teachers had used the visualizations for teaching, hence their responses varied from those of the February respondents. However the June sample is too small to look for statistical significance between the two. The greatest variation between responses can be seen in “What time series data tell us about weather and climate”: all June respondents said they used this in teaching, while only 1 in 4 Institute participants estimated they would use it. The Institute participants (February data) were more interested in “Linkages between oceans, land

and atmosphere” and “The interactions between Earth’s heating by the sun, Earth’s rotation and the hydrologic cycle,” topics not addressed in the cloud visualizations. Institute participants were more likely than June respondents to say they would use visualizations to teach “Topics related to scope and sequence for science standards.”

Visualizations were intended to engage students who did not yet have English language skills. Table 8 suggests that “Scientists at work” and “Monitoring weather features” (hurricanes and such) were the most engaging parts, followed by the technology of satellite images. Daily and seasonal patterns were deemed somewhat less engaging to students.

**Table 8. Parts of the Visualizations that Engaged Students (N=7 includes administrator)**

	Extremely engaging	Somewhat engaging	Not very engaging	N/A
Scientists at work	5	2	-	-
Technology of satellite images	4	2	1	-
Daily cycles	3	3	1	-
Seasonal climate patterns	3	3	-	-
Monitoring weather features	5	2	-	-
Sea surface temperature data	2	2	1	-

All of the June teacher respondents said they used the visualization data with their students.

By having the materials I was given paired with increasing content knowledge, I was able to differentiate many lessons pertaining to weather and climate to meet ALL of my students’ needs.

We used them to analyze weather fronts and temperature.

It supplemented the 6<sup>th</sup> grade weather and climate unit—clouds, transfer of energy, atmosphere.

I used the visualizations to introduce them to climate change and how scientists go about studying the changing climate and how fast it’s changing.

How did teachers think visualizations addressed the special challenges of ELL teaching?

Visualizations were great to build vocabulary and make content connections.

... provide time for students to process information and go back multiple times.

... help turn complex and abstract concepts into comprehensible images.

They allow students to grasp the important concepts despite a lack of language skills. They have become essential to my teaching of ELLs now.

I used the clips to introduce students to the language of science and how to talk about science.

Two teachers' responses were more specific:

Visualizations address the limits of learning in a language that is still developing by depicting concepts and allowing students to start with pictures and add language to them at whatever level they can.

1) I'd like to have visualizations with Spanish translations. 2) The visualizations use language that is highly technical and will probably be broken down for my ELL students.

### ***Assembly/Field Trip for ELL Students***

A visit to AMNH for ELL students and their teachers was a major component of the NOAA program. The experience was designed to convey to students that they could actually

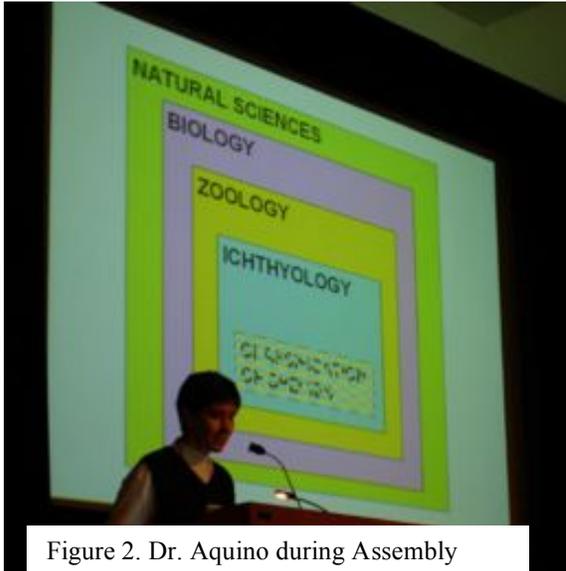


Figure 2. Dr. Aquino during Assembly

understand science and even become scientists. During the assembly science was presented as an enjoyable, accessible pursuit. A bilingual Museum scientist/educator, Dr. Adriana Aquino, gave a slide-illustrated talk about her background and her field of study. She drew the students into the conversation, asking and answering questions and modeling inquiry method techniques. One of her slides illustrated increasing specializations, from natural science to biology, to zoology and finally ichthyology,

her specialty. She showed students how to decode scientific words, breaking them down, for example, to “bio” and “logy”—bio=life and logy=study. Dr. Aquino, whose first language is Spanish, modeled the advantage of knowing more than one language.

The interactive “lecture” ended with images of cloud formations—cumulus, stratus and cirrus—reminding the 6<sup>th</sup> grade students of previous classroom work. Following the assembly, classes visited the Museum’s Climate Change exhibition (not available to classes who visited during fall 2009), complementing their science curriculum unit on weather and climate. Classes supplemented their study of clouds with a visit to the Hall of North American Mammals, where diorama background paintings accurately depict the types of clouds studied.

The dioramas also support the non-native-born American students’ learning about North American geography. An activity prepared by Museum scientist/educator Jay Holmes focused on the cloud formations and locating diorama sites on a map of North America using longitude and latitude. Some teachers provided worksheets for their classes to focus attention on particular exhibits.

Observation of students in the Museum indicated that they were all deeply engaged by the exhibits, particularly the ones that offered interactive participation. Teachers deemed the Museum visit a valuable experience for their students. Table 9 illustrates the aspects of the visit they found most valuable.

**Table 9. Teachers’ Feedback on the Assembly and Visit (N=7)**

	Very valuable	Somewhat valuable	Not very valuable	N/A
Meeting with scientist	7	-	-	-
Visit to Climate Change exhibit	7	-	-	-
Visit to N. American Mammals	4	2	-	1
Visit to other AMNH exhibits	6	-	-	-
Materials we were given	7	-	-	-
Introducing students to Museum	5	1	-	-

Selected comments follow:

Contact with scientists [was valuable]. Some kids have never been to a museum before. [The visit] inspires and motivates kids. Our school is based on expeditionary learning. [In our study] about climate change, it teaches them to ask, “What do I know?” “What can I do?” The most important parts of the NOAA [program] are PD and field trips.

The field trip should not be “a day away from school.” It needs a systematic approach with pre- and post-visit activities, which are on the AMNH website.

The field trip is a big deal. It’s contagious to other classes. Teachers learn they don’t have to wait for NOAA to bring a class to the Museum. From NOAA teachers learn the value of the Museum visit. Science has fewest periods and they can be cut [for other things deemed more important]. (An administrator)

Teachers commented on the Museum visit’s ability to motivate students to learn:

Kids see things in the Museum and want to know the English vocabulary. That’s a great strategy for all students.

[One of my students] went from a 45 average to 85 after the visit.

There are many learning modalities in exhibits—visuals, interactives, films, etc.

[The program] has worked as PD for all [teachers in my school]. The school backplans from 12<sup>th</sup> to 6<sup>th</sup> grades. Teachers learn to use field trips as an integral part of teaching with pre- and post-visit activities. [They convey to kids that it is] not a free day when kids think they don't have to show up. The Educators Guide is extremely important, a scaffolding resource.

An administrator commented that the program brought science to “another level” in her school, specifically, meeting scientists and coming to the Museum. “[Students] learned how to use the Museum in their language and the language of science.” A teacher added, “Great to see students pursue science projects even though they have no English. Science is its own language.”

### **Professional Development's Influence on Field Trips**

The teachers found the workshops helpful in planning their field trip to the Museum.

[Students will gain] a greater understanding of climate change and how it is measured. ... weather and how it's changing due to global warming.

The focus of my visit will be the Climate Change exhibit as well as looking ahead to my next unit on animals and their ecosystems [the Hall of North American Mammals].

A teacher praised the Museum for its PD programs because they focus on showing teachers how to provide educational value before, during and after a Museum visit.

Programs and PD such as this are absolutely necessary and very beneficial to all involved, students and teachers. It helps the students develop pre-, during- and post-visit knowledge for the field trip. Then (because of the PDs) the trip's educational value is multiplied and it's not just a “day out of the classroom.”

One of the teachers wrote in her website account:

In their visit to the Museum, my students had an opportunity to apply the English language skills and knowledge they had gained to read, write, listen and speak both formally (during an assembly) and informally (in the exhibit halls) with the scientists at AMNH. The students met scientists Dr. Jay Holmes and Dr. Adriana Aquino, with whom they observed the clouds in the dioramas and made real-life connections to their learning and personal lives.

One of the visiting 6<sup>th</sup> grades consisted of Chinese students with very limited English. Their letters thanking the Museum and Dr. Aquino reflect their interests and what they learned,. Their teacher commented that her students were “super impressed with Dr. Aquino and her catfish.” She added, “Chinese kids copy words carefully. [For them, even] the alphabet is new. ... The kids can understand and draw concepts. That is why visualizations are so important for them.”

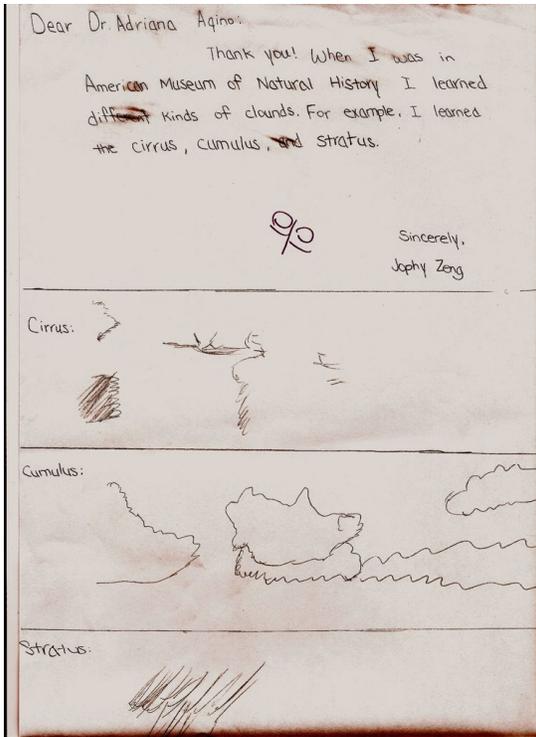


Figure 3. Thank you letter, IS 131

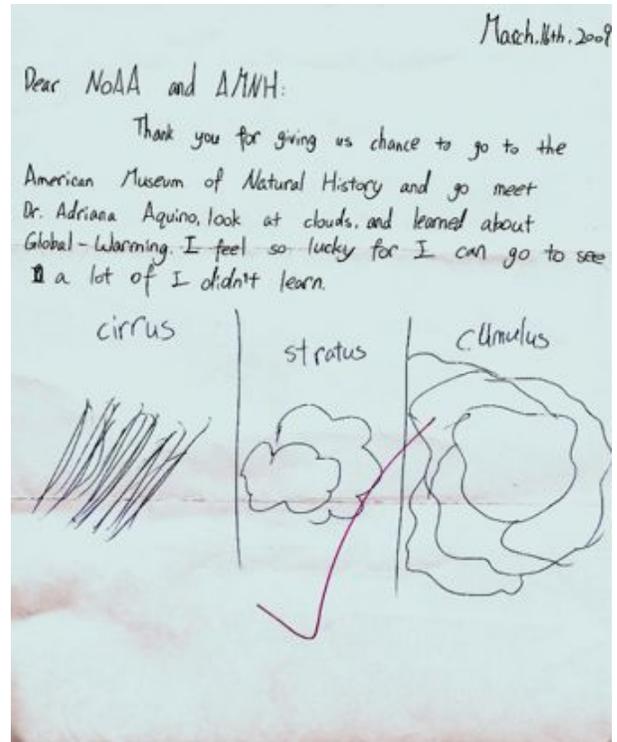


Figure 4. Thank you letter IS 131

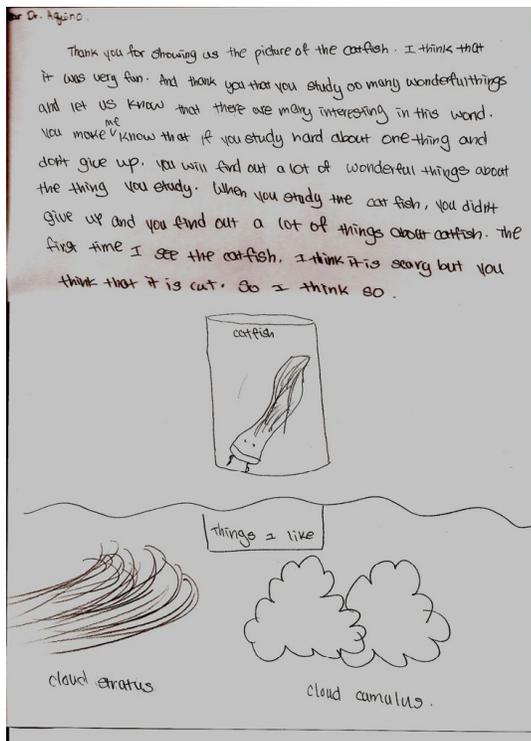


Figure 5. Thank you letter with catfish, IS 131

## ***NOAA Program's Support for Teachers' Work***

On the last day of the Climate Change Institute, Dr. Maritza Macdonald conducted a special session with 5 ELL teachers about topics ranging from using globes to identify students' home countries to teaching "the language of science"—using science to expand English literacy. NOAA participants had numerous opportunities to respond to questions regarding how the NOAA program supported their teaching. Selected responses follow.

Teachers said that the visualizations would help their teaching units on weather and climate.

Yes. The DVDs will be eye-openers.

It makes them more concrete. Students will grasp the meaning of a topic when they're exposed [to it].

Two teachers responded positively with specific lesson plans utilizing visualizations:

It will help me make connections about weather clear to students (regarding the Earth's systems: atmosphere, hydrosphere, biosphere, geosphere).

1) To see how and where storms mostly form. 2) I can use the visualizations to teach my students about maps and longitude and latitude lines.

One of the teachers was slightly more skeptical about how useful the visualizations would be:

I think that the visualizations would help me somewhat. Cloud interpretation might be difficult for students' understanding, but using it for Earth's season and Earth's daily cycle might be helpful.

Teachers explained how visualizations helped them address the challenges of ELL teaching. Program educators wondered whether they provided content that is understandable without language. A few teachers gave positive but nonspecific responses, for example, "When students see something, they usually understand content better."

According to teachers and administrators, the program has encouraged interdisciplinary planning, facilitating communication across schools and departments and helping to develop collaborations among teachers in a variety of disciplines. A teacher cited an example that combined science and art projects. In one of the participating schools the principal has institutionalized "structured common planning." The program has facilitated communication among ELL teachers around the city.

More than one teacher said that the program is changing the meaning of "making science accessible," providing teachers with techniques to use in all subjects. A teacher said she had "learned to give students time to process, using minilessons instead of long ones. Students can be passionate about learning."

NOAA “brings ELLs and science together: school administrations support the program and there is state support for ELL.” A teacher remarked, “ELLs are neglected usually. Also science is neglected. The NOAA program addresses [both those neglected areas]. The program represents community partnership with schools; Urban Advantage picks up in the 8<sup>th</sup> grade.”

In discussion about testing, specifically science assessments, a teacher noted: “For kids to do well in 4<sup>th</sup> and 8<sup>th</sup> grade tests, they need to do well in other grades. The Board of Education gives a quality review focusing on how we move kids up. If we want kids to become scientists we have to motivate them to take courses [and do well] early on or they cannot catch up.”

Another teacher commented, “[One of my students] never knew he could be a scientist. Didn’t know it could be a real job. [The program helps us] tell the kids they can do that.”

Teachers said that visualizations help them differentiate between “understanding a concept and knowing vocabulary.” Once students understand the concept, the vocabulary connected to it can follow. “Visualizations are good for everyone, not just the ELL connection. Visual learning works for all students.” “Visualizations are so important: you cannot understand a tiger from a picture in a book that is the same size as a squirrel.”

“[We have to] get kids out of their neighborhoods into a low comfort zone, then scaffold.” The theme of “getting kids out of their neighborhoods” was repeated frequently. It is difficult for all elementary and middle school students to leave their immediate surroundings, but it is exponentially difficult for ELL students whose parents are not comfortable in English or in unfamiliar areas of the city.



Figure 6. AMNH resources help with longitude and latitude



Figure 7. Cloud Mural

One of the teachers' weather and climate unit was 2 months long with 1 week for clouds. Her class created a cloud mural to wrap up the unit: "The final project for was a class-wide project designed to demonstrate students' learning about different kinds of clouds. The project was scaffolded to meet the learning needs of each level of English Language Learners in the class, giving students the opportunity to use visualizations, as well as written work to demonstrate their understanding. The beginning level students used cotton balls to make models of each type of cloud; the advanced level students wrote reports;

and the intermediate level students answered open-ended, critical thinking questions.

The students glued their work onto a double tri-fold board, placing their cotton ball models and writing pieces on the board in the position of each cloud type in the sky (low, middle, high). Everyone in the class contributed toward its creation.



Visualizations were useful when comparing temperature in different climate zones: Chinese ELL students graphed weather, precipitation and temperature.

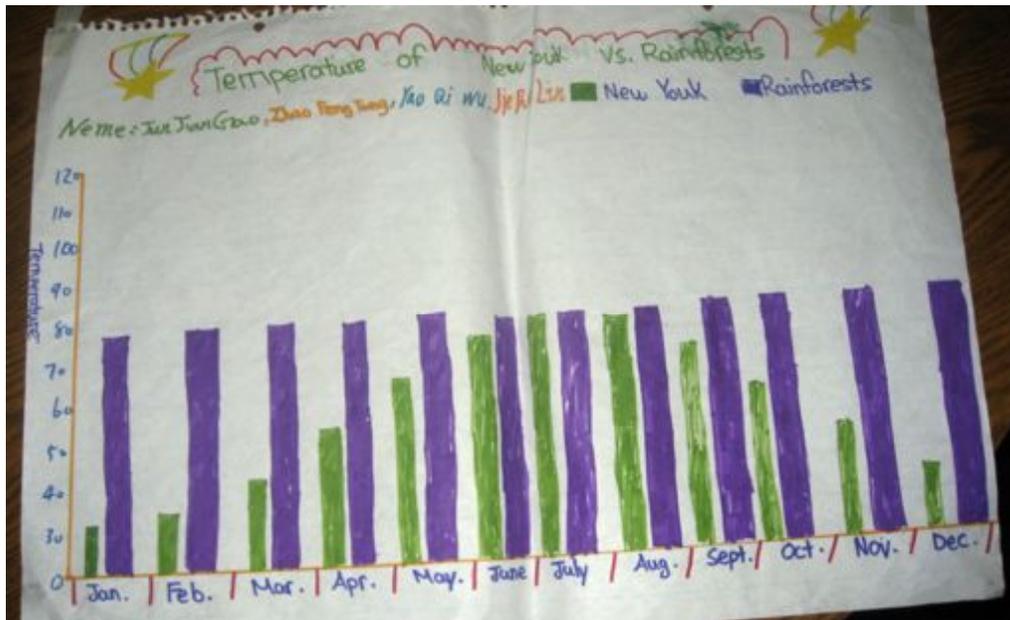


Figure 11. Comparison of temperatures in NYC and Rainforests

Their teacher created a book to reinforce her goal of conveying to students that they are part of the living environment.

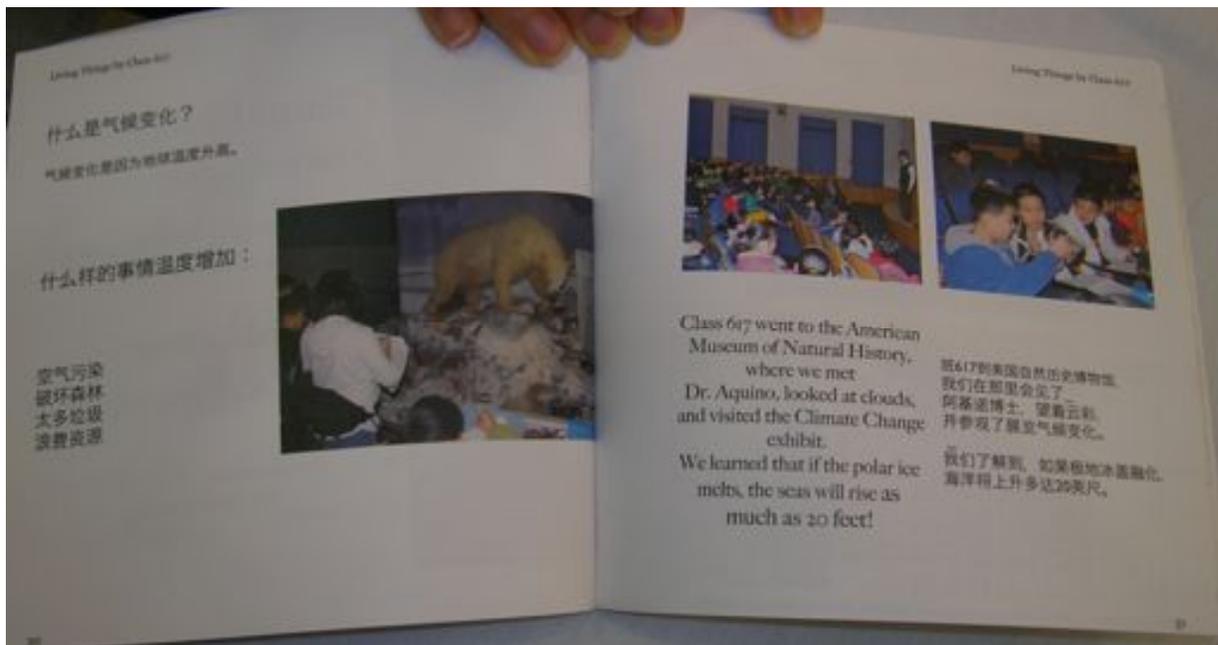


Figure 12. Living Things book

## ***Science Bulletins in Schools***

NOAA teachers received DVDs containing the Museum’s Science Bulletins. Teachers spoke about the importance of seeing scientists at work on the films—real people, including women. The Bulletins promote hands-on learning, suggesting that kids look for fossils in the parks or in their yards. The films show how scientists observe cloud patterns, form a hypothesis and then test it. They answer students’ question, “How do you know?” Scientists collect evidence and test it. “It’s like a lab, only outdoors.” Studying climate change “shows how the past can explain the present, like history. You make predictions; you can see a link between animals and climate.” It “shows that science is a living subject, not just something in a textbook. We need to tell kids what they have to study to be a scientist.”

ELL teachers say reading should be assigned to ELL students *after* watching a film: teachers in regular classrooms assign background reading *before* showing a film in class, but ELL students need vocabulary that the film introduces so they can go on to reading about the topic. ELL teachers need to focus students on 1 to 3 things. Other teachers commented that this is no different from good teaching in general: all kids need scaffolding, whether for language or science content or both.

Teachers reported that students were fascinated by the diurnal and seasonal cloud and weather patterns, asking to see what happened on a particular day such as their birthday. They wondered about the technology, asking if it was real and how scientists can interpret the cloud patterns. The Bulletins helped with study of major biomes and climate zones, showing correlation with cloud formations and precipitation. Connections were made to students’ experience of weather in their home countries. The films helped students understand how cloud formations indicate where hurricanes and cyclones occur; they observed long-term climate and short-term weather events (dry spell, monsoon, etc).

## **Concerns**

NOAA teachers brought up a number of issues that concerned them. First, the achievement gap between ELL and native English speakers in schools: they believe that the State Board of Education should aim to correct this with targeted funded initiatives, such as the visualization program at AMNH supported by NOAA.

Teachers believe it is unrealistic and unfair to expect kids to learn both a new language and content so fast: “After the first year in school, ELL kids’ [negative] assessment counts against the school; after 3 years it counts against the kid,” which seems to pigeonhole the ones who do not progress fast, shutting them out forever from advanced content work.

Another concern involved teachers’ lack of preparation. Teaching in an urban setting requires sensitivity to linguistic and cultural variation and sensitivity to the link between language acquisition and subject-matter content. Bilingual certification does not require training in ESL strategies; there is a need for mentoring in this area. AMNH could mentor teachers, instructing them how to use the Museum in order to give students a view of what is available outside their neighborhoods.

Dr. Macdonald pointed out, “Teachers need to be plugged in to what is available: Program administrators and teachers will receive free membership in NSTA.”

## **Anything Else We Should Know?**

Teachers were asked to think back on their NOAA ELL experience and suggest things to add or change to support their teaching. Virtually all the teachers could think of nothing substantive to add or change:

The professional development was outstanding.

Less lecturing and more on-hands (*sic*) activities that we can use with our students would help.

More PD specifically for ELL on weather/climate

Some teachers suggested offering PD days during the summer instead of on Saturdays.

### **Website Material**

NOAA Project participating teachers came together for a final intensive week during July 2009 to document their individual experiences in the project. The AMNH website will feature these experiences along with lessons developed by the NOAA-funded ELL visualization program so that K-12 teachers everywhere can take advantage of them. This documentation will extend the program beyond the life of its 3-year funding. The Website will include personal reflections (stories), photographs, lesson plans with specific hands-on lessons and lessons learned about using the Museum as a resource for both ELL and science teaching. Teachers focused principally on what they had learned about using visualizations and its value for language and vocabulary acquisition as well as science content. Dr. Macdonald created a flow chart to illustrate how parts of the project fit together:

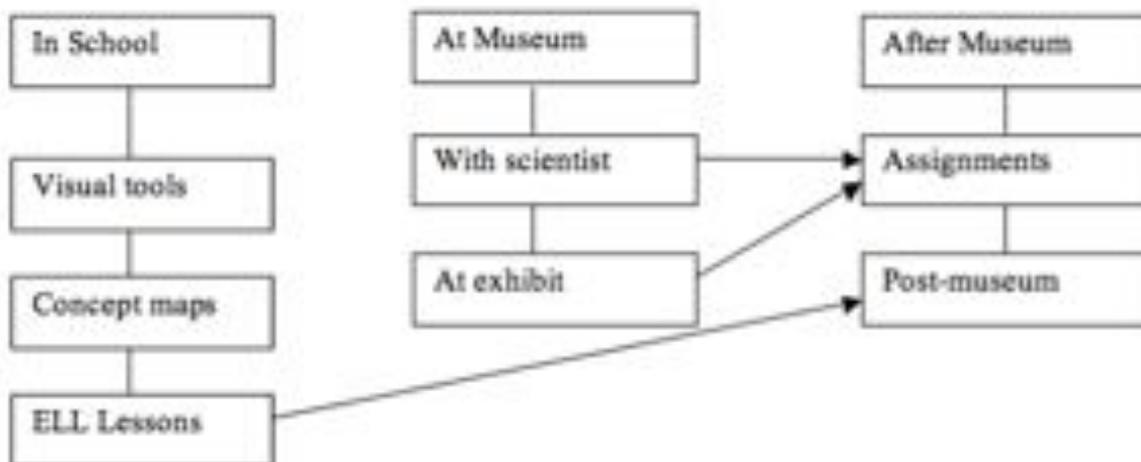


Figure 13. ELL Student Pre-visit, Visit and Post-visit Experiences

Examples of NOAA teachers' stories illustrate what the program meant to them. A native Spanish-speaking teacher who teaches in a bilingual program wrote:

Thanks to the NOAA *Science Literacy for Grade 6 English Language Learners Project*, I used the AMNH to teach my students a curriculum unit on clouds, which is part of a larger unit on weather in the New York City 6<sup>th</sup> grade scope and sequence. The program truly helped me reach a higher level of excellence by giving me the space and time to reflect on my bilingual teaching practices and the opportunity to catch up on the latest research on ESL instructional strategies related to science.

In the lesson [to prepare them for their trip to AMNH], students identified different cloud names and prefixes, which helped students categorize different cloud types according to their position in the sky (low, middle, high).

I collaborated with the Social Studies teacher to review the topic of latitude and longitude so that students would be prepared to locate and mark the geographical location of each diorama [in the Hall of North American Mammals] and the distribution of the dioramas' animals throughout North America.

In their visit to the Museum, my students had an opportunity to apply the English language skills and knowledge they had gained to read, write, listen and speak both formally (during an assembly) and informally (in the exhibit halls) with the scientists at AMNH. The students met scientists Dr. Jay Holmes and Dr. Adriana Aquino, with whom they...made real-life connections to their learning and personal lives.

Another participant teaches special needs ELLs, as she wrote:

Fortunately for me, there are a lot of overlaps in teaching techniques and strategies for special education and English Language Learners. In my class I had the challenge of introducing language and science to students whose academic deficit was language, either because English was not their native language and/or their cognitive/academic impairment made learning such concepts difficult.

I participated in the *NOAA Science Literacy for Grade 6 English Language Learners Project* AMNH. The program supplied many materials, as well as opportunities for me to teach my ELL Special Education students about weather and climate change using the Museum's visualizations and differentiated teaching strategies. Students were able to use what they learned at the Climate Change exhibit and the lessons as the inspiration to conduct a scientific investigation as a class....

The quality of the students' projects and the intensity of their engagement in the work demonstrates that even with their varying deficits, all of my students use science as a means to feel empowered and to communicate to their peers and teachers that they do want to learn and are certainly capable of it. As a result of this experience in the NOAA program, the students' level of undesirable behaviors has declined and their academic performance has improved in all subject areas.

For all of my students, field trips to the Museum have inspired and motivated them to think like a scientist in and out of my classroom....

While most ELLs in the NOAA Project were Spanish speakers, one school's ELLs were

Chinese speakers. The participating teacher recounts her story and experience in the program:

Most of my students have only recently come to the United States from Mainland China. Many have never had exposure to the English language until they come to my school. They are unable to write the letters of the alphabet or recognize their own name when pronounced by a native English speaker.

The materials and experiences provided by NOAA and AMNH were invaluable for my students' learning. After their experience in the program, my students were burning with questions and concerns (expressed in English) about the environment.

The NOAA program provided me with a globe, map and books with strategies for teaching English language learners in science. These were visualization tools that facilitated the visual learning techniques I use in my classroom to bridge the language gap.

In addition to supplying our classroom with supplies, the program provided an opportunity

for my students and me to visit AMNH and meet one of the Museum’s scientists, Dr. Adriana Aquino. After almost six months my students still talk to me about the experience of meeting Dr. Aquino. With the help of an interpreter my students were able to interact with Dr. Aquino and ask her questions about her work as an ichthyologist... and her research work with the South American armored catfish.... Dr. Aquino gave many of my female students the opportunity to see that there are female scientists.

Getting my students excited about learning is a big feat, and with the support of NOAA and AMNH, we were able to learn about what we as individuals can do to help stop climate change through the weather visualizations and other activities.

In our field trip to the AMNH we visited the Hall of North American Mammals to observe and record our observations of cloud types. Observing the dioramas allowed my students to practice their English-speaking skills with docents and Museum staff.

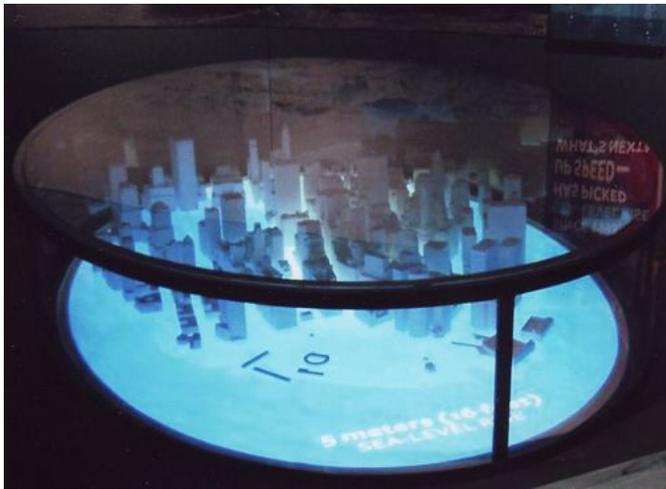


Figure 14. Manhattan under water

We also visited the Climate Change exhibit at the Museum. We were able to dive into aspects and concerns about climate change because of the things we were able to touch and see at the Museum. My students wanted to learn more about alternative sources of energy, the polar ice caps melting, and what is happening to the polar bears as a result of global warming.

Students were particularly concerned when they saw a model of what would happen to New York City when the polar ice caps melt. Their neighborhood – Chinatown – would be underwater. Six months later my students were still talking about this. This visualization allowed us to transition directly into an exploration about adaptations and why and how living things adapt to their environment.

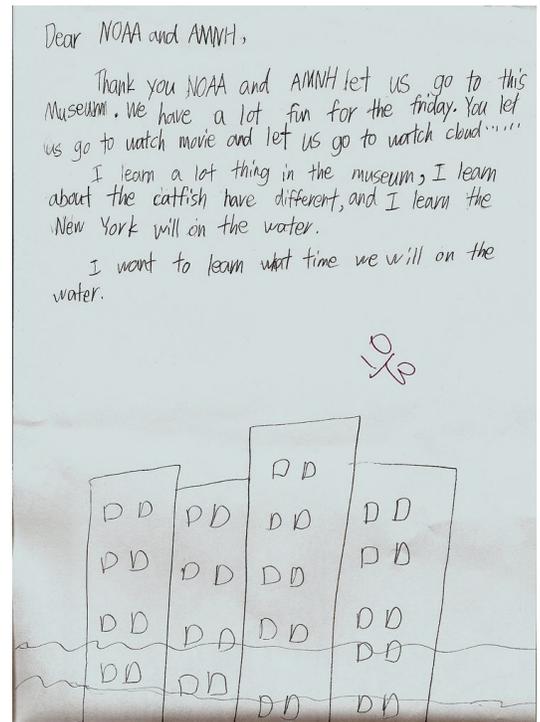


Figure 15. Thank you letter IS 131

The assistant principal from the Chinatown school wrote:

In my school, 80 percent of the students are English Language Learners. At the Leadership Breakfast we viewed a DVD produced as an AMNH Science Bulletin titled Weather and Climate via Satellite, a time-lapsed view of the Earth's ever-changing atmosphere showing weather patterns and storms around the world over the period of a year. I used this DVD in a workshop with my grade 6 and 7 teachers to deepen their conceptual understanding of weather phenomena, focusing specifically on hurricanes because they are easy to trace visually. Then we concentrated on watching the movement of clouds through the seasons in the New York area, the Caribbean, and in China, our students' homelands.

NOAA provided several excellent resources that support content area teachers use in developing strategies to support English language acquisition. The NOAA program has been an extremely high-quality, interactive experience. It assisted me in supporting teacher excellence through professional development, materials and field trips to AMNH to learn from multilingual scientists.

Another teacher wrote:

Visiting the Climate Change exhibit at the American Museum of Natural History and showing my students the AMNH Science Bulletins helped answer my students' questions about climate change. Using the visualization materials that the NOAA program provided helped my students understand the science of weather and climate and helped increase their English vocabulary, enabling them to use some, if not most, of the terminology they learned.

The resources provided by the NOAA program were very helpful in teaching the weather unit to my ELL students. The globe was useful in helping students learn about latitude and longitude, the seasons, climate zones. It helped them visualize what they were learning. By the end of the unit, my ELL students were able to locate the longitude and latitude of various cities on the globe, and particularly, the longitude and latitude of where they live now, as well as the cities or countries they came from.

## **General Audience Response**

The secondary goal of the NOAA project was to enhance climate and weather literacy for general public audiences at informal science institutions. Real NOAA satellite data were used in a Science Bulletin displayed in HoPE to convey fundamental weather and climate principles to the Museum's general public. To evaluate the product's effectiveness, the external evaluator conducted a series of focus groups at the AMNH.

### ***Method***

Groups of Museum visitors consisting of 3 to 7 adults and children were intercepted on the Museum floor and asked to view a short video and respond to some questions about it. In return, we offered each participant two complimentary admissions to return to the Museum. Visitors were selected at random; however, the evaluator aimed to achieve a diverse sample in terms of gender, age and ethnicity. All participants were English speakers.

Group discussions were conducted in the People Center classroom: the evaluator introduced the topic and the purpose of the discussion, namely, to collect visitors' feedback about a video that dealt with weather. Before watching the video, participants completed a 1-page questionnaire designed to gauge their prior interest and knowledge about aspects of weather and climate addressed in the video, as well as limited demographic data.

A computer projected a Science Bulletins DVD, *Weather and Climate Via Satellite*, on a large screen similar to the one in the Hall of Planet Earth (HoPE). Visitors saw *Clouds Interpretation Guide* (2:02 minutes) to provide context, followed by 2-3 *Monthly Interpretations* showing diurnal cloud formations during a specific month in 2007.

After watching the video, visitors turned over their questionnaire and answered several questions about their impressions of the video. When all members of the group had finished writing, the evaluator led the group in focused discussion.

## ***Findings***

### **Visitors' Characteristics**

Half the participants were visiting AMNH for the first time and half were repeat visitors. Nineteen had visited the HoPE that day and eight said they had seen it on a previous visit, indicating that at least half the respondents had experienced the Museum context for learning about weather and climate.

**Table 10. Participant Groups**

<b>Group</b>	<b>No. in Group</b>
New Jersey Family	4
Texas Family	4
Bronx Girls Day Camp	7
Vancouver Boys (entering college)	4
AMNH Interns	4
New Jersey Couples	4
Indianapolis Family	4
Atlanta Family	4
Lexington KY Family	3
New York College Students	5
Barbados/New York Adults	6
Total	49

Participants were evenly divided between male (24) and female (25). One in 4 participants were between 10 and 16 years old, 2 in 5 between 17 and 25 years and 1 in 3 were adults 26 years and older, as illustrated in figure 17 below.

The youngsters and teens were still in school or college and the vast majority of adult participants had at least an undergraduate college degree. Some 40% were from the Greater New York area, 42% from other parts of the USA and the rest (16%) were international visitors. Only 4 participants said they had special knowledge or training in science.

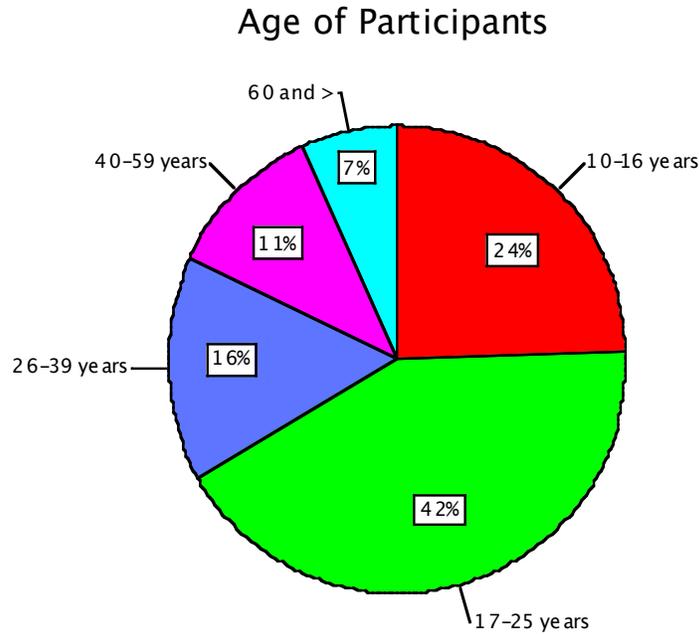


Figure 16. Participants' Ages (N=49)

### Prior Interest and Knowledge

Motivation is a primary driver for learning, thus we wanted to know how interested AMNH visitors were in topics covered in the Climate and Weather satellite data. We asked visitors to record their level of interest in finding out the answers to 4 questions as well as their prior knowledge about the topics. The results are illustrated in tables 11 and 12 below.

**Table 11. Visitors' Interest Levels in Learning the Answer to Questions about Climate And Weather Topics (N=45)**

	Not at all interested	Not particularly interested	Somewhat interested	Very interested
How do scientists study climate and weather?	-	9%	62%	29%
How do land, oceans and atmosphere interact?	-	24%	40%	36%
What can we learn from cloud patterns?	4%	18%	51%	27%
How can we predict events like snowstorms, droughts & cyclones?		4%	31%	64%

The last question drew the most interest, supporting what was found in earlier formative evaluations of student interest: while the public is at least “somewhat interested” in answers to all the questions, they are most interested in learning about significant climate and weather events, such as snowstorms, droughts and cyclones.

There was no significant variation in responses based on age. Education or self-assessed special knowledge or training in science.

**Table 12. Visitors’ Prior Knowledge about Climate and Weather Topics (N=45)**

	<b>Know Nothing</b>	<b>Know a Little</b>	<b>Know Some</b>	<b>Know a Lot</b>
How do scientists study climate and weather?	11%	49%	40%	-
How do land, oceans and atmosphere interact?	22%	28%	40%	-
What can we learn from cloud patterns?	33%	40%	22%	4%
How can we predict events like snowstorms, droughts & cyclones?	18%	61%	16%	4%

Percents do not add up to 100 due to rounding.

The majority of participants had little or no prior knowledge of the topics. The topics they knew least about are the ones most directly impacted by the satellite data: what can be learned from cloud patterns and how to predict weather events from the data.

### **The Main Idea**

Responses to an open-ended question about the video’s main purpose were coded for analysis. Seven participants included more than one “main purpose.” There was no significant variation among responses based on age or education.

**Table 13. The video's Main Purpose**

<b>Purpose</b>	<b>Frequency N=45</b>	<b>Percent</b>
How to read cloud patterns	26	58%
To understand weather over time	9	20%
Global effects	5	11%
See/understand dramatic weather events	4	9%
How scientists study weather/climate	4	9%
To make predictions	3	7%

Clearly visitors understand that the video's main purpose was to show people how to read the satellite data on cloud images to interpret weather patterns, as the following quotes illustrate.

How clouds work in relation to weather patterns. F 19

How cloud patterns and the jet stream affect weather events. F 43

The video's main purpose was to show how weather patterns are created by the measurement and investigation of clouds and different winds and also by instruments used, such as satellite imaging. F 21

Although there is little about predictions in the cloud visualizations, 3 participants intuitively understood that predictions could and should be the ultimate goal of the satellite data. These people noted that, in addition to observations, the data could help meteorologists predict weather events, for example:

[What is] the distinction between predictions and observations? They're looking at weather patterns that are happening right now; what's the difference between that and actually predicting what's going to happen? M 18

How can the movement of clouds and wind patterns be used to predict and observe weather events in different regions? M 18

How weather satellites work and the patterns that emerge affect weather forecasts and how we can (roughly, probably not with total, or even near-total accuracy) have a heads-up on potential disasters. M 22

Participants recognized that reading the weather patterns occurred over time:

How the climate patterns evolve with time. M 48

Changes and patterns in weather and how we can learn from them. F 68

A timeline of weather patterns and basic explanation on how meteorological data is obtained. M 22

Several participants noted that weather patterns are global phenomena:

The global pattern of cloud movement and weather phenomena related to it. M 18

[The point was to show] weather patterns across our planet and their interconnectedness. F 38

How wind and cloud patterns work across the globe and with it weather changes. M 22

A few participants cited scientists' work in studying weather and cloud patterns:

How weather is tracked and how scientists study climate and cloud pattern. M 13

How scientists watch the climate through clouds. M 21

As was noted in formative evaluation of the visualizations, youngsters were drawn to the dramatic weather events called out in the film, such as cyclones and hurricanes. One boy

remarked, “[It would be more interesting if it] actually showed the weather, like hurricanes and tornadoes and stuff. Teenagers are attracted to violence!”

Some participants felt that the main idea was not made clear enough:

I think the images are really cool. But don't think they explain the purpose or what they're used for. (M 40s)

The main idea is showing a timeline and visitors [should] draw their own conclusions. Some people may need more background information to figure that out. (M 20s)

### **Preference for Up-to-date Data**

We explained to visitors at the outset that the “real” visualizations in the Hall of Planet Earth portrayed data about weather that took place within the past month, while the one we showed them covered data from 2007. After watching the video, did participants think it would be much more interesting, somewhat more interesting or about the same to see weather data from the past month in 2009? The vast majority (84%) said it would be more interesting to see up-to-date data, and half said it would be “much more interesting.”

The principal reasons they said more recent events would be more interesting were 1) because it would help them interpret recent weather, e.g., the enormous amount of rain in the Northeast; 2) it was more relevant than past weather; 3) they could remember recent weather events and could compare them with the cloud data. A few participants said they would prefer to see a month with a major event such as Hurricane Katrina. There was no significant variation among responses based on age or education.

### **Help people interpret recent weather**

Over the past month there have been irregularities with the weather. The amount of rain is greater than I ever remember. I want to know how it can be predicted from clouds. F 18

Because of the unusual cool temperatures we are having considering it is summer season. F 51

During 2008 - 2009 the weather patterns have changed drastically in all regions, and systems seem to be more severe. It would be interesting to track them. F 35

### **More relevant**

People will find the exhibit more relevant to their lives. M 18

I'd probably be paying closer attention to the pattern and certainly more attention to one or two specific locations that are relevant to me. It would be more interesting, I guess, because it would feel like it's been processed less and I'd be some sort of insider. M 22

### Visitors remember recent weather

Even though 2007 is only 2 years ago, I find it much easier to remember important weather events that occurred more recently, and it would be quite a bit more interesting to see an analysis of events I remember well. M 18

I remember last month's weather better than I remember 2007's and it would be better to compare the weather as I remember it with the video screen. M 22

### Learning

Table 14 illustrates the categories of participants' responses when asked to cite one new thing they had learned in the video (1 person mentioned more than 1 learning outcome). There was no significant variation among responses based on age or education.

**Table 14. What Participants Learned**

Learning outcomes	Frequency N=45	Percent
Easterlies/westerlies/trade winds, wind directions move clouds	17	38%
Effect of wind and clouds on weather	7	16%
Dynamic cloud movements over time	5	11%
Make predictions	3	7%
Scientists' methods, role of satellite images to study weather	2	4%
Other	2	4%
What events look like (from satellite)	1	2%
Nothing	9	20%

Interestingly, the most frequently mentioned new information participants said they took away was about wind direction—the “Easterlies” and “Westerlies” that circle the planet. A few people added “Trade Winds.”

Top and bottom clouds move west and middle move east. M 10

What "Trade Winds" actually means. M 21

Winds that go east to west are Easterlies. Winds that go west to east are Westerlies. M 22

That there are both westerly and easterly winds occurring simultaneously and systematically. M 22

The next most frequently cited new learning was about dynamic cloud movements over time and the effects of wind and clouds on weather.

How the wind pushes the clouds. F 17

I learned that as time goes by, on ... moving maps you see that clouds move. F 12

The difference wind patterns make on storm development. M 27

Africa has dry seasons, because winds are moving storms away from it. M 13

Three people said they learned about scientists and the role of satellites in weather study, and 3 people mentioned the ability to make predictions about weather.

I learned that scientists use special devices that can predict the weather. F 11

I learned that images play a very important role in past, current and future weather patterns.  
F 19

...what each type of storm system looked like from a satellite image. M 17

Although *observation* and not *prediction* was the focus of the video, 3 people said they learned that the clouds enable scientists to predict weather:

That you can predict what the weather will be like due to the clouds. (F 11)

That cloud patterns can predict severe weather systems, i.e., tornadoes, cyclones, etc. F 35

One in 5 respondents said that they learned nothing new (A woman said, “[I didn’t learn] much because I love the weather channel and watch it a lot.”)

### Visitors want more information

Was there anything in the video that visitors did not understand or wanted to know more about? Table 15 illustrates the suggestions by category. Thirteen people said they had no questions and could think of nothing they wanted to learn more about.

**Table 15. Topics Participants Did Not Understand or Would Like to Know More About**

Topics	Frequency N=45	Percent
How scientists interpret patterns	5	11%
How events (e.g., hurricanes) start	4	9%
Relationship of pressure, fronts to clouds and wind and effects	4	9%
Narration instead of or over music	3	7%
See closer, zoom in	3	7%
Predictions	3	7%
Effects of weather on the ground	1	2%
Other	9	20%
Nothing	13	29%

A number of respondents wanted more information, particularly they wanted to know more about how scientists interpret the images and patterns and more about how the cloud patterns could be used to make predictions.

More on the techniques used to gather the data and how it is used to draw conclusions concerning weather patterns. M 22

How scientists make predictions for weather events such as hurricanes, specifically how they use data to come to those conclusions. M 18

The video had great images but did not explain the purpose or methods of how you learn from those images. M 29

How does a scientist see that a hurricane [like this is] definitely a stage 5? F 38

A few people suggested adding narration or captions to explain the visuals.

Was pretty easy to understand, but I think having the information spoken over the music would be a nice addition. M 29

A narrator that would explain it [better]. This is what Easterlies are, etc. and this is what happens when you have trade winds. It's mostly scientific what you're looking at. F 48

We're not trained anymore to be reading on the screen and going back and forth. We need narration. M 22

I feel if there was narration [it would be easier to understand]. There is way too much to look at—Easterlies, Westerlies, cyclones, hurricanes—like coming out of nowhere. F 18

I think it needs more words for us to comprehend what's going on. Just looking at pictures, I could barely understand it. Maybe words in captions. F 11

A number of participants said that the call-outs highlighting weather events were too small.

Several mentioned “zooming in” on the call-outs.

You can't really see what's happening. You can see generally, but not enough. You should zoom in. It's hard to know what I'm looking at. M 22

It is very small, so many things happening at once; [it would be clearer] if it zoomed in on it a little more. F 29

In addition to zooming in on the call-outs, some participants wanted to see what a hurricane or cyclone looked like on the ground.

I think it's a little too distant. When they showed there's a hurricane here [on the video] they should show it where it is on Earth. They should show what it was like on the ground; place it in context [so people can] experience what that would be like. M 18

Take it down a few scales and show what's happening on, on the ground. To bring it home to what this really means to you. Experience it from street level. M 33

I think it has potential to be an interesting exhibit but needs to be looked at from a more relevant perspective, more from what we experience on the ground. M 18

A number of participants (not just the youngsters) said they would like more information about how dramatic weather events start. Participants originally from the Caribbean were particularly interested in seeing what the cloud patterns looked like leading up to a major storm.

I would like to know more about how storms and cyclones start. F 11

More about how weather patterns are formed, for example, tornadoes. M 29

You should see the steps of a cyclone or hurricane being created. M 13

A few participants complained that the video moved too slowly, particularly when several days went by with no call-outs. One person suggested having the timeline move faster when there were no call-outs and slow up when an event was highlighted.

A notation on the images of “pressure front” inspired several people to ask what this meant.

#### **Other comments**

I would be more interested in the concepts [which any relevant example could help explain] rather than any specific recent weather event. M 17

The film seems to make observations about weather rather than showing the implications of such facts. M 22

## Conclusions and Implications

### ***The National Research Council Report: School Groups***

The National Research Council's (NRC) *Learning in Informal Environments: People, Places and Pursuits* (2009) notes the pervasiveness of science media today: "Science media are qualitatively shaping people's relationship with science and are new means of supporting science learning." It goes on to note that while educational television has proven its value in science learning, "substantially less evidence exists on the impact of other media"—and cites "digital media" specifically.

The NOAA visualizations project uses digital media for instructional purposes and the evidence presented herein suggests that it can be highly effective. This project represents collaboration between formal and informal education and a scientific organization whereby scientific data are reformatted to enable teachers, students and the general public to understand complex conceptual content.

Furthermore, the project embodies the 3 NRC Recommendations for Exhibit and Program Designers:

1. Programs should be designed with specific learning goals; provide multiple ways for learners to engage with concepts and build on learners' prior knowledge.
2. Programs should be developed through community-educator partnerships.
3. Educational tools should be developed using an iterative process involving learners, educators, designers and experts in science.

And finally with respect to the NRC document, the program adheres broadly to the proposed "strands of science learning" framework, "building on the framework developed for K-12 science learning in *Taking Science to School* (National Research Council, 2007)." The 6 strands aim to help schools and informal environments "pursue complementary goals." The purpose of the strands is to "serve as a conceptual tool for organizing and assessing science learning."

Let us examine the 6 strands to see how they might function as an assessment tool in relation to the NOAA-funded program.

*Strand 1: Experience excitement, interest and motivation to learn about phenomena in the natural and physical world.*

Participating teachers' feedback, along with examples of student work included in this report, indicates a positive outcome regarding this strand. Students, perhaps for the first time, ventured outside their communities, hopefully finding inspiration as well as a comfort zone that would draw them to return to the museum on their own.

*Strand 2: Come to generate, understand, remember and use concepts, explanations, arguments, models and facts related to science.*

This strand relates to all students but is particularly important for ELLs; teachers' descriptions of their strategies for students to report orally and in writing about weather-related concepts underscores this strand's relevance to digital media/visualizations in teaching.

*Strand 3. Manipulate, test, explore, predict, question, observe and make sense of the natural and physical world.*

Student work and experiences during field trips cited in this report indicate this strand's relevance to the NOAA visualizations, for example, in the way inquiry-based methods of teaching were modeled by Museum educators.

*Strand 4: Reflect on science as a way of knowing; on processes, concepts and institutions of science; and in their own process of learning about phenomena.*

This strand is reflected in the NOAA program's goals and objectives.

*Strand 5: Participate in scientific activities and learning practices with others, using scientific language and tools.*

This strand was a powerful aspect of the program, revealed in student projects and teachers' reflections. The ELL students were learning the language of science as well as English, according to their teachers. ELLs learned that science has a language all its own and were able to use it to describe concepts related to climate and weather.

*Strand 6: Think about themselves as science learners and develop an identity as someone who knows about, uses and sometimes contributes to science.*

this was the project's major goal, as it is for all STEM programs. Teachers emphasized their hope that students would see science as a possible career, something heretofore unimaginable. For example, the field trip assemblies featured a bilingual female scientist to model the science career future that ELL students may not have thought of.

All aspects of the project promote and encourage NOAA's 3 educational goals:

1. "To promote environmental literacy by increasing understanding and use of NOAA data, information and programs";
2. "Build on NOAA's capability to engage audiences and enable informed decision making;"
3. "Increase the number of people, particularly in underrepresented groups, who choose education and careers supporting NOAA's mission."

### ***AMNH General Audience***

The Clouds portion of the Weather and Climate Science Bulletin had limited impact on the general public. The images increased visitors' awareness of the effect that cloud patterns have on weather. They recognized that clouds move around the globe propelled by the Easterly and Westerly winds in a systematic fashion. They understood that scientists study these cloud patterns to learn about weather and climate. However, these positive responses came about in a controlled environment. A number of responses in this study confirmed what was observed in the HoPE where the Earth Bulletin with the clouds segment is on view:

I don't think it would keep anyone standing there, wondering, wanting to know more.  
F 43

The satellite images of cloud patterns and the weather associated with them are not particularly compelling to the general audience passing by in the Hall. When seating is available, as it is in the Halls of Biodiversity, Ocean Life and Human Origins, visitors tend to stop and watch; without a place to perch in HoPE, visitors tend to keep moving. If she doesn't happen to look up at precisely the right moment during the 2-minute cloud visualizations, a visitor will miss the call-outs for important weather events. We have learned that visitors are interested in the events themselves—hurricanes, cyclones, tornadoes and even the unusually cold and wet summer of 2009—and would like to learn about them. Our focus group participants suggested zooming in for a closer look at the graphics or images of a storm as it appears to people on the ground. Cloud visualizations in the Earth Bulletin do not pass the test of Strand 1 in the NRC document—visitors should "experience excitement, interest and motivation to learn." Focus group participants' comments illustrate the deficiency:

What's the weather like right *there*? (points to map)? Is it a huge storm or a nor'easter?  
...what is it doing to the land? (F 11)

I don't know if this could keep my attention. I want to know what's going on on the ground. M 45

The Cloud images are conceptually quite abstract. The human element appears to be lacking for visitors. Unlike some of the other Bulletin segments, there is no scientist to say how he or she uses the data. Focus group participants suggested narration—a human voice telling them what they are looking at and what it means. They asked for indications of human impact: what does the weather mean to people on the ground? They asked for more interactivity—perhaps a related site on the kiosk computer. Visitors seemed to be searching for context with which to understand the images: several mentioned wanting to know more about “interconnectedness.”

One might argue that Strand 2 is involved in the cloud and weather visualizations: visitors who were shown the video under controlled conditions did “come to understand, remember and use concepts and explanations related to science.” These participants did find the satellite images interesting and understood that certain cloud patterns pertained to certain weather events. And they wanted to understand how scientists could identify and/or predict extreme weather events from cloud patterns (possibly Strand 3).

The Weather and Climate via Satellite images work well with school classes because teachers provide the missing context. They prepare their students with lessons and projects that lead them to see the visualizations as a tool to understand the larger concepts in climate and weather study. The images supplement and enhance curriculum, a touchstone for acquiring English language vocabulary as well as scientific content. When teachers refer to global systems, the satellite images illustrate clearly how winds move clouds and weather around the Earth in recognizable patterns. To personalize and humanize the data, students can focus on their home countries’ weather and climate. They can even find out what weather was like on their birthdays.

Visitors to HoPE have the opportunity to learn about weather and climate context, but unlike a classroom, a museum visit is not typically a linear experience. Museums cannot dictate the order in which visitors see information or even that that they see it at all.

## **Source**

Bell, P., Lewenstein, B., Shouse, A., Feder, M., Ed. Learning Science in Informal Environments: People, Places and Pursuits. National Research Council. 2009