FRONTIERS in GLOBAL CHANGE EDUCATION

Past, Present, Future

Cherilynn Morrow, PhD
Senior Research Fellow – Science Education, AGCI

Frontiers of Global Change Science
Aspen Global Change Institute Workshop
Aspen, Colorado
19 August 2014

Career Trajectory

1981-1990: Research scientist in solar physics - NCAR/HAO/U. Colorado, Cambridge U.

1990 – First Contact with AGCI – cross disciplinary communication

1990-1992: Math & science educator, U. Colorado – ***math education as human development***

1992-1994: Strategic planner, policy developer, program officer at NASA HQ – ***power of integrating education programs in scientific research environments***

Fall 1994: around-the-world voyage with Semester at Sea as instructor in physics, astronomy, and environmental science – ***power of "felt experience" in developing global perspectives***

1995-2007: Director of Education and Public Outreach at the Space Science Institute

- NASA Broker-Facilitator – matching resources of space science research community with educational needs in a 9-state region of the American West
- Reaching out to indigenous students and educators on Navajo & Sioux reservations & Chaco ***[seeing opportunity to create a new synthesis of traditional and modern perspectives]***
- Strengthening capacity of educators in space and earth science
- Developing capacity of scientists to become more effective partners in education ***(AGU)***

1998-1999 – Second Contact with AGCI – broadening roles for scientists, PESTO

2008-2012: Professor of Physics and Astronomy, Georgia State University, Atlanta

- Physics education innovation – ***developing students' values from dogma to inquiry***
- Discipline-based education researcher in climate science – ***awakening to epistemology***
- Integration of art, music, and science in service to education – ***combining heart and mind***

2012-present: Research Fellow in Science Education, ***AGCI*** – ***communication vs. education***

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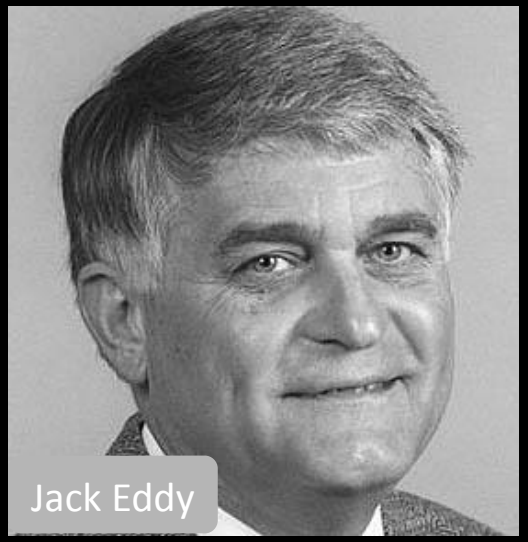
- Physics education innovation ***– inquiry vs. dogma, communication vs. education in science***
- Discipline-based education researcher in climate science ***–qualitative inquiry, epistemology***
- Integration of art, music, and science in service to education ***– dialogue-generating products***

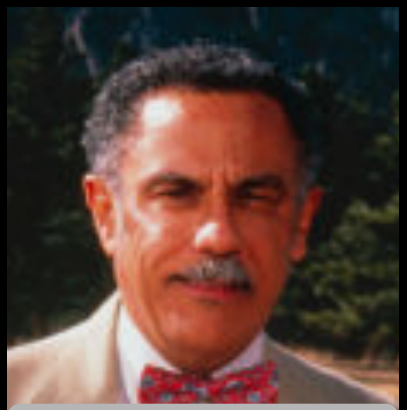
2012-present: Research Fellow in Science Education, ***AGCI – activating archive, all of above***



Jack Eddy

Steve Schneider

Walter Orr Roberts

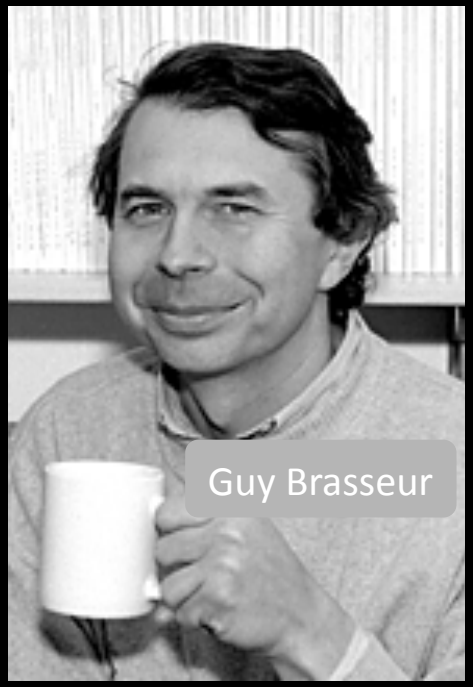


Warren Washington

Susan Solomon

Ralph Cicerone

Mickey Glantz



Guy Brasseur

Graduate days at NCAR
Note overlap with Jeff Kiehl

Interdisciplinary Teaching Assistants in Math – 1990

Math Education as a Context for Human Development

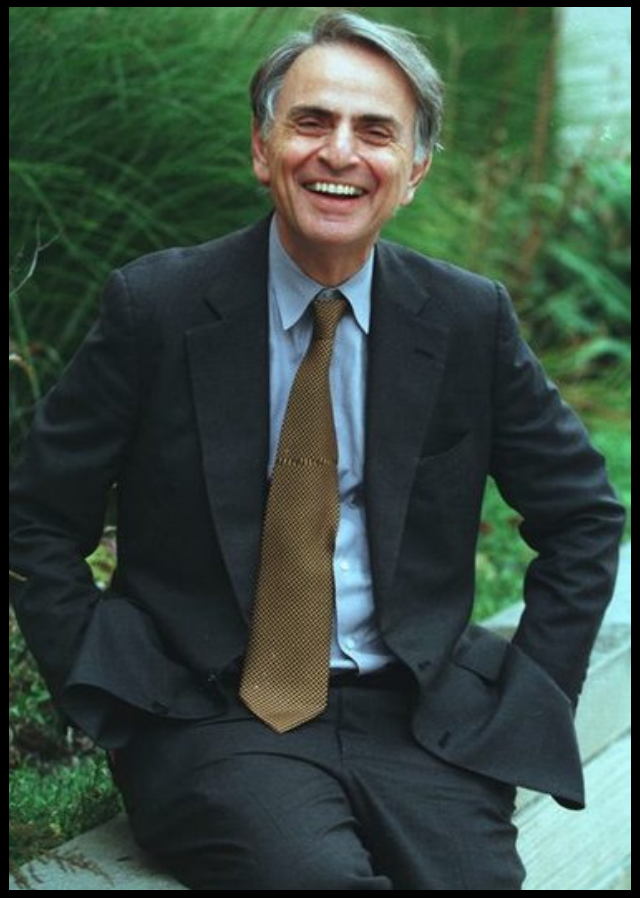
Quantitative Reasoning & Mathematical Skills (QRMS) Teaching Assistants, U. Colorado, early 90's

Heady Days at NASA Headquarters – early 1990's

NASA Administrator, me, Space Policy pundit John Logsdon, Hubble Repair astronaut Jeff Hoffman

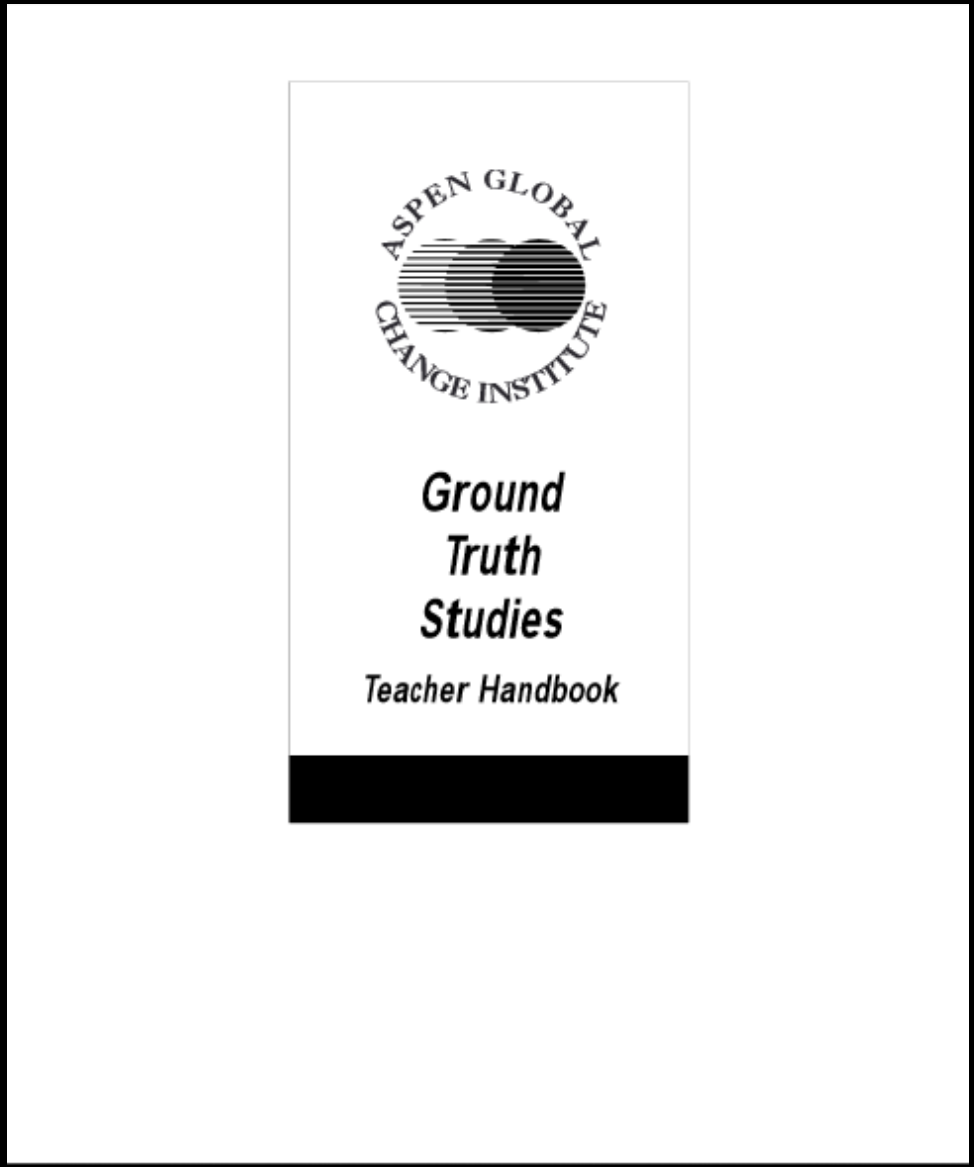
Challenged by Stephen Hawking and Carl Sagan

Later epistemologically and ethically broadened by the Dalai Lama

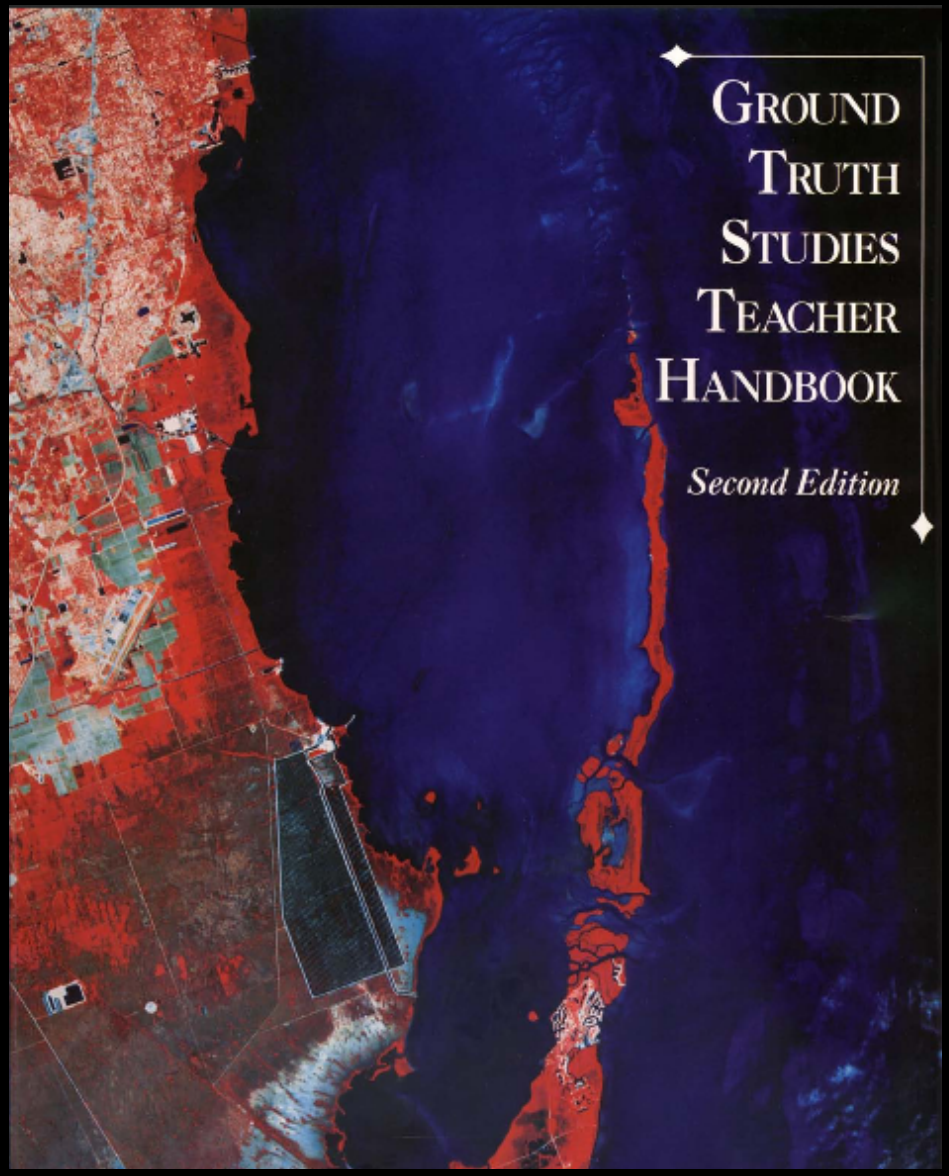


NASA Mission Education & Public Outreach
Exploring space-based perspectives in Earth science Education

First Contact with AGCI



Sampling the Kindredness of mission with AGCI



- This pioneering AGCI educational product of the early 1990's was rooted in close partnership among research scientists and educators.
- It helped lay a foundation for the GLOBE program wherein students are involved in scientific observing protocols that feed data into authentic research projects.
- Writing for this document was among Susan Hassol's first tasks at AGCI.

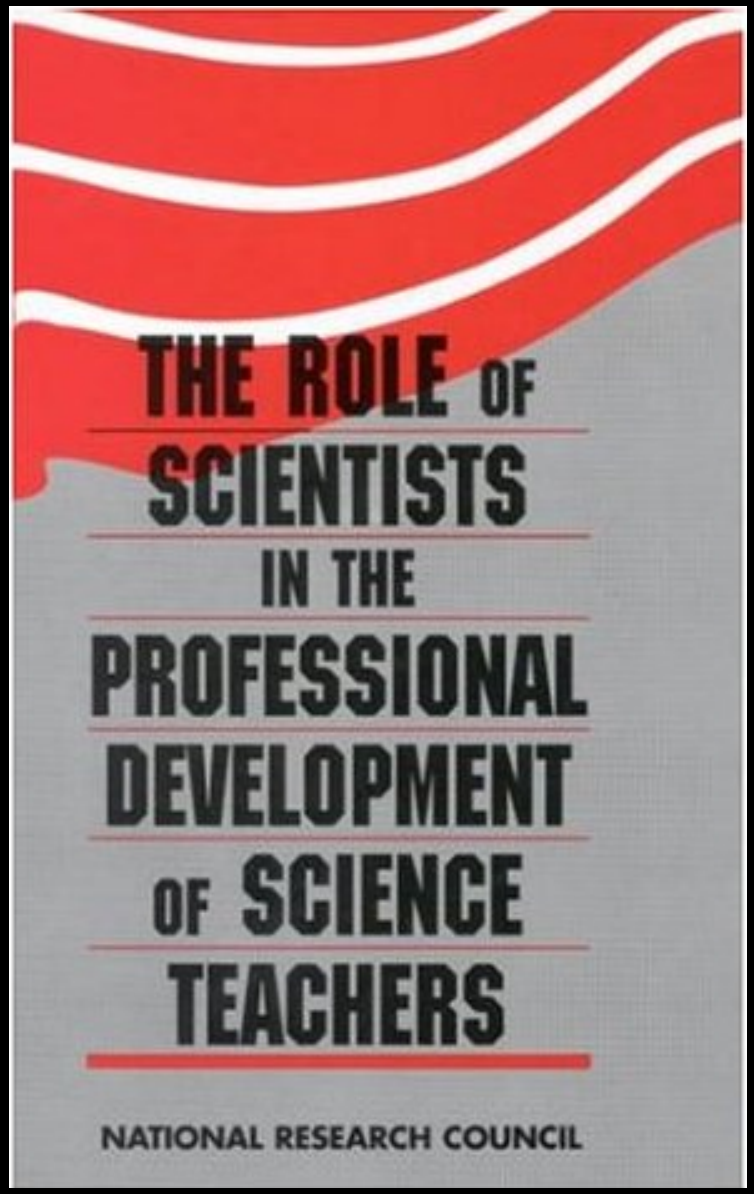
Space Science Institute's
Ninth Annual

K-12 Education Workshop for Scientists, Engineers, & E/PO Professionals

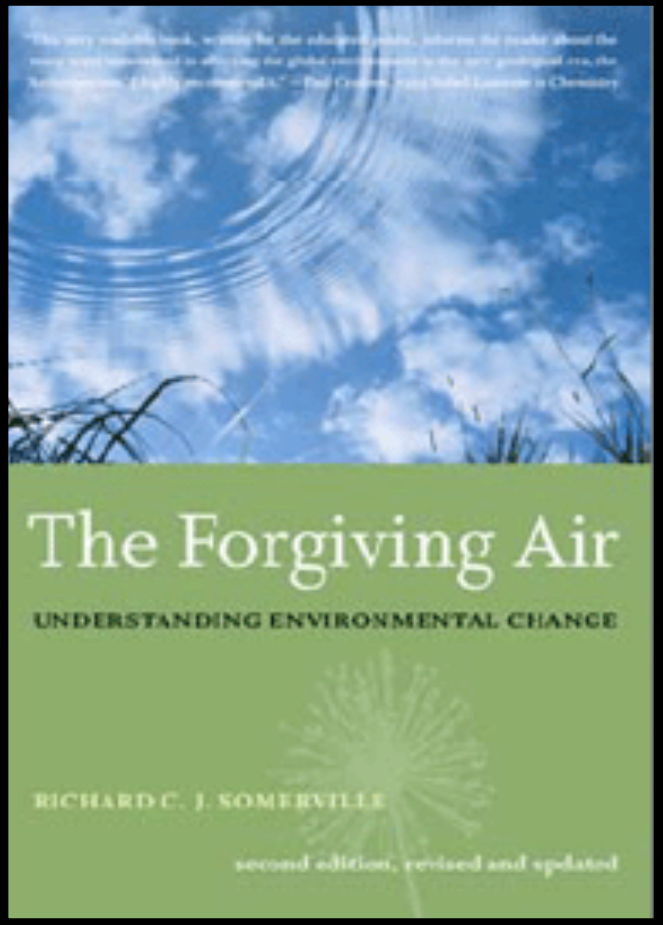
Program

4-7 May 2003
Boulder Broker Inn
Boulder, CO

NSF
SPACE SCIENCE INSTITUTE
NASA


THE ROLE OF SCIENTISTS IN THE PROFESSIONAL DEVELOPMENT OF SCIENCE TEACHERS
NATIONAL RESEARCH COUNCIL

1996


The Forgiving Air
UNDERSTANDING ENVIRONMENTAL CHANGE
RICHARD C. J. SOMERVILLE
second edition, revised and updated

Second Contact with AGCI

Improving Science Education: The Role of Scientists

Rodger W. Bybee and Cherilynn A. Morrow

FORUM ON EDUCATION

of The American Physical Society
Fall 1998

Planning Workshops within Workshops for AGCI

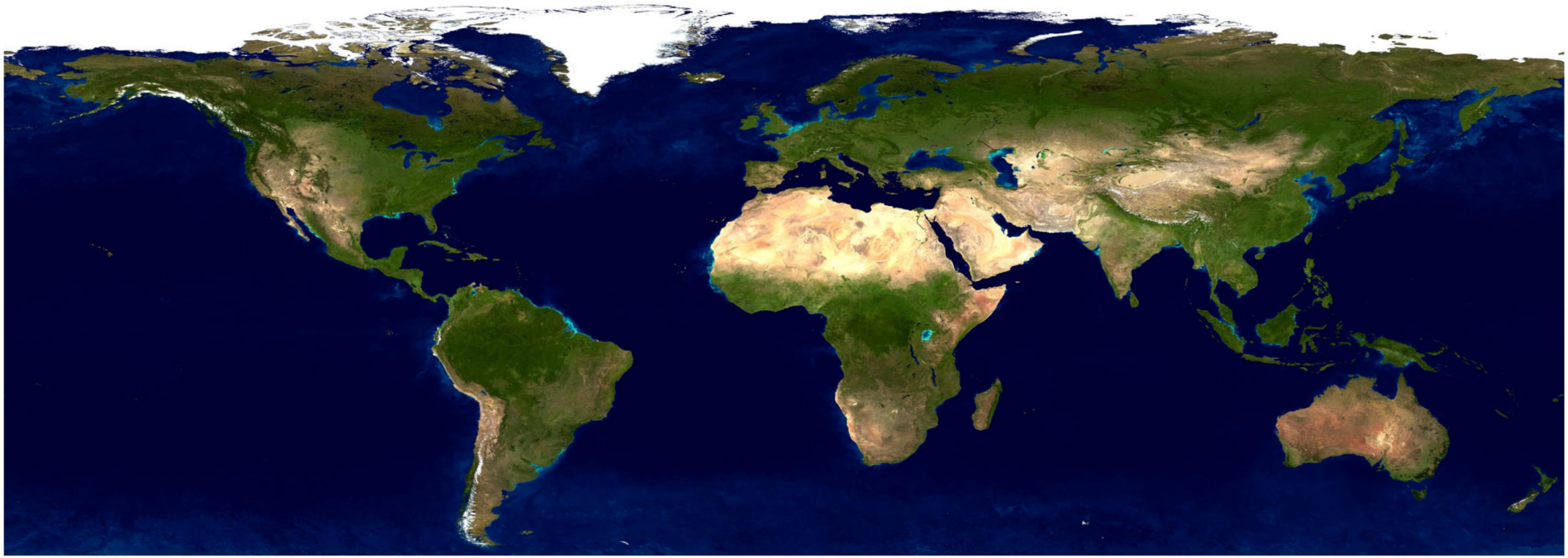
*Figure 1. A Sampling of Roles for Scientists in Education

LEVEL OF INVOLVEMENT=>	ADVOCATE	RESOURCE	PARTNER
K-12 STUDENTS	• Participate in PTA. • Talk to school board about importance of science education.	• Judge a science fair. • Answer student e-mail. • Give tour of research facility.	• Mentor a student in your laboratory. • Partner with students in a research project.
IN-SERVICE K-12 TEACHERS	• Speak out in support of appropriate professional development opportunities for teachers.	• Answer teacher e-mail about science content questions. • Present in teacher workshop or some aspect of science.	• Work with a teacher to implement curriculum. • Hire a teacher intern.
SCHOOLS OF EDUCATION (Pre-Service Teachers, Graduate Students, Faculty Members)	• Speak out in your department or organization in favor of closer ties with Colleges of Education. • Speak favorably of teachers and the teaching profession in your undergraduate classes.	• Teach a science course or workshop segment for pre-service teachers. • Collaborate with education faculty to improve courses on teaching science.	• Hire a graduate in education to work as evaluator or co-developer of education project. • Develop a science course or curriculum for teachers-to-be.
SYSTEMIC CHANGE (District, State, National)	• Speak out at professional meetings about the importance and value of scientist involvement in systemic change.	• Review science standards for science accuracy. • Review the state framework for science education.	• Collaborate on writing or adapting science standards. • Participate on state boards for adoption of standards, instructional materials, or teacher certification.
EDUCATIONAL MATERIALS DEVELOPMENT (NSRC, EDC, Lawrence Hall)	• Speak out at a school board meeting for adopting exemplary educational materials.	• Agree to serve on an advisory board for a science education project. • Review science educational materials for science accuracy.	• Collaborate to create exemplary science education materials.
INFORMAL EDUCATION (Science Centers, Scouts, Planetaria)	• Participate on the board of a science center, planetarium, environmental center, or museum.	• Review science content of scripts for science exhibits, planetarium shows, or environmental programs. • Give talk at a science center.	• Collaborate in creation of a museum science exhibit or planetarium show. • Serve as science coordinator for a scout troop.

Workshop on Education

for NASA Earth Science Senior Managers

Friday, November 15, 2002 . NASA Headquarters



Modern Science Education Reform in a nutshell

- Students as "scientists" with teachers as facilitators of learning
  - Teacher as "a guide on the side" rather than a "sage on the stage".
- "Inquiry-based" process of teaching & learning
  - "The way scientists *do* science rather than the way they were *taught* science."

The Monotillation of Traxoline

It is very important that you learn about traxoline. Traxoline is a new form of zionter. It is monotilled in Ceristanna. The Ceristannians gristerlate large amounts of fevon and then bracter it to quasel traxoline. Traxoline may well be one of our most lukized snezlaus in the future because of our zionter lescelidge.

Directions: Answer the following questions in complete sentences.

1. What is traxoline?
2. Where is traxoline monotilled?
3. How is traxoline quaselled?
4. Why is it important to know about traxoline?

Attributed to Judy Lanier

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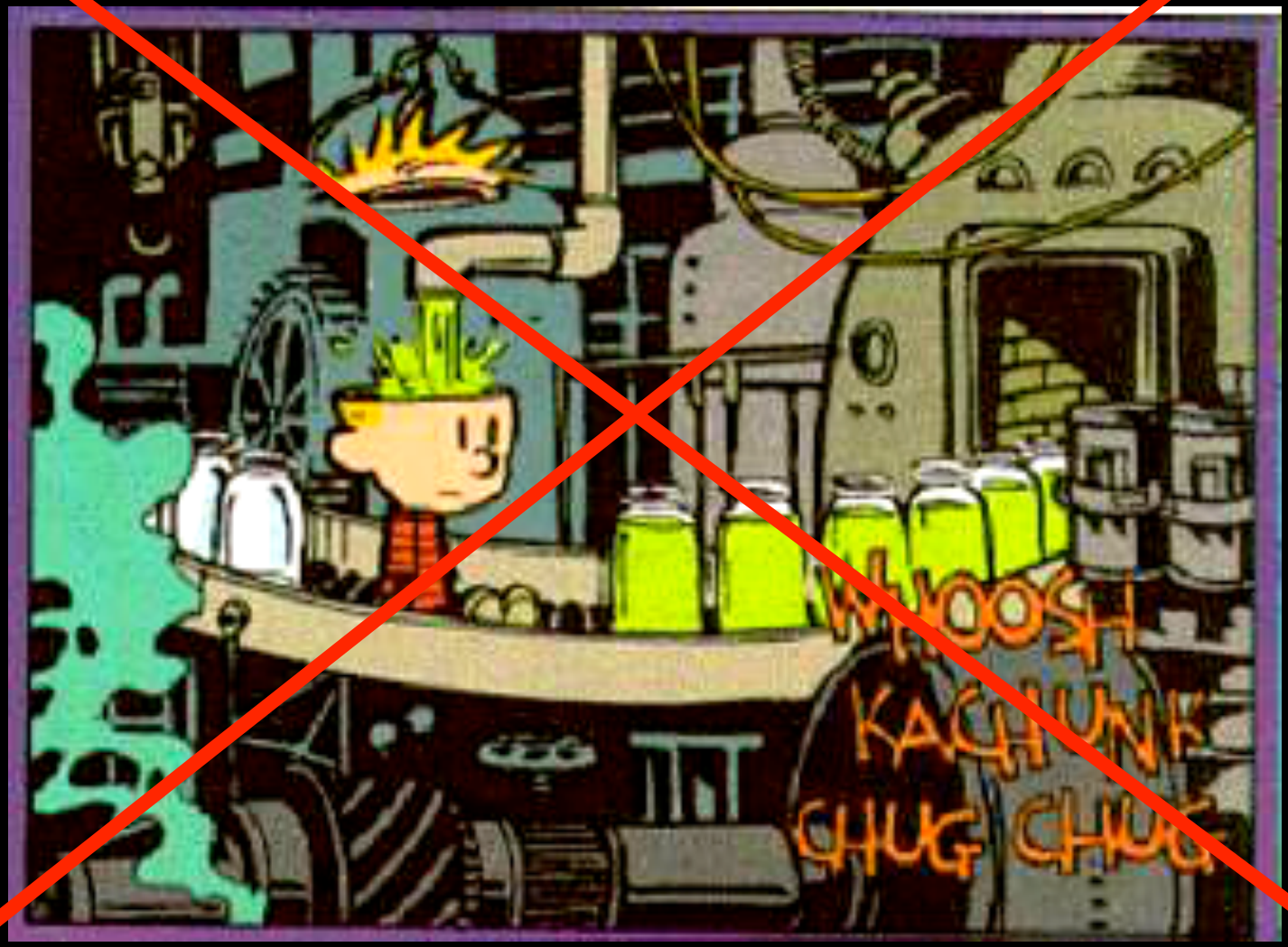
People are NOT blank slates, they come with pre-conceived ideas



Same Research Foundation for Science Education and Science Communication

Insights into How College-Age Students at a Southeastern Research University Think about Climate Change Concepts

Cherilynn A. Morrow, John Katzenberger, Comfort Afolabi,
Judith Monsaas, Richard Somerville, W. Crawford Elliott

Presentation for
AGU Chapman Conference
Communicating Climate Science
11 June 2013

Comparing Best Practice Communication and Education in Science

DOMAIN	Best Practice Communication	Best Practice Education
TIME FRAME	Generally shorter	Generally longer
CONTEXT of PRACTICE	Mass media, Public Talks…	Classroom, Science Center…
NATURE of MESSAGE	Well-framed 3-pt messages. Sound bytes Avoid use of math and jargon	Age-appropriate lessons. Cultivate appropriate use of math and jargon
INTENDED OUTCOME	Influencing opinion or behavior	Conceptual understanding; Developing skepticism and capacity to discern dogma vs. evidenced-based inquiry
PRACTITIONERS	Scientists and science communicators	Scientists and science educators

Considering Research-based Communication and Scientific Accuracy

	Making a Scientifically Accurate Statement?	Offering a Science-based Idea about How Society Needs to Respond to Excess CO2 in the Atmosphere due to the Combustion of Fossil Fuels?
CO2 is Pollution ["CO2 is toxic"]	**NOT REALLY**	**YES**
CO2 is Plant Food ["CO2 is good"]	**YES**	**NO**

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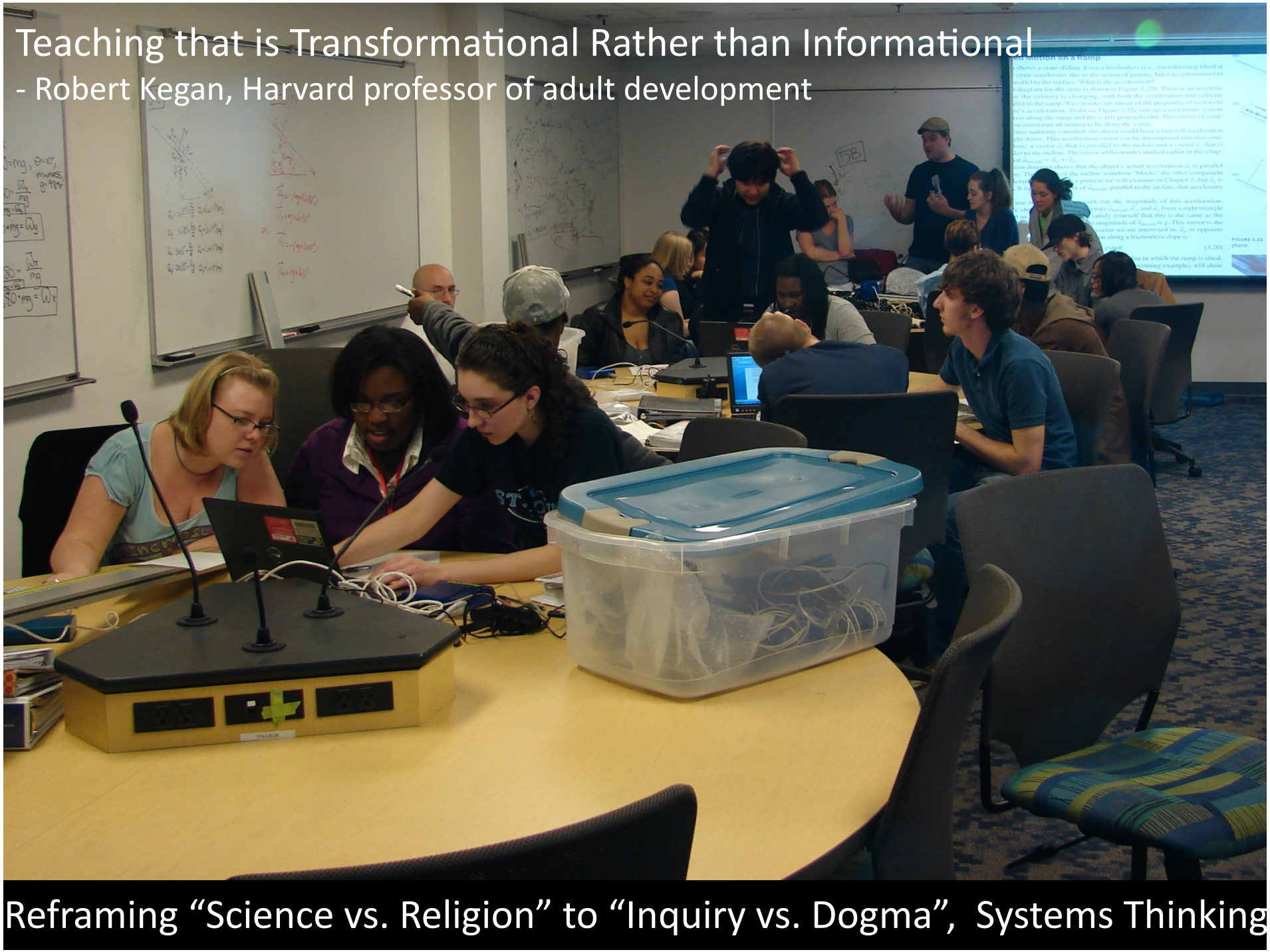
Studio Physics Classroom – Georgia State University

Studio Physics Classroom – Georgia State University


Teaching that is Transformational Rather than Informational
- Robert Kegan, Harvard professor of adult development
Reframing “Science vs. Religion” to “Inquiry vs. Dogma”, Systems Thinking

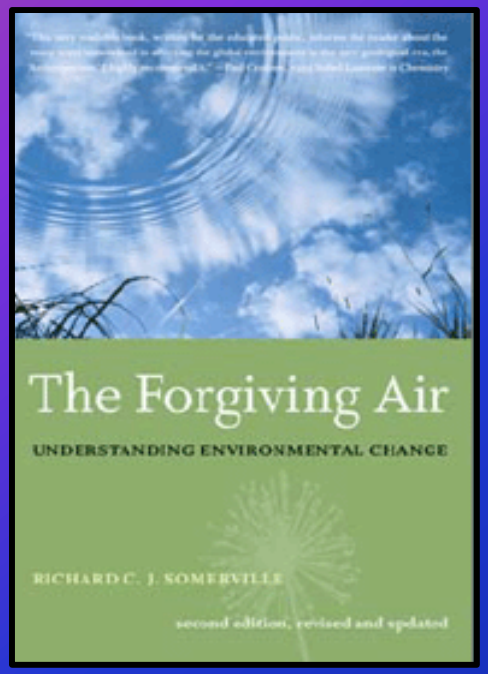
Learning Theory and Practical Lessons from Experiences in Science Education Reform

Cherilynn A. Morrow
Professor of Physics & Astronomy
(education focus)
STEM Director
Georgia State University

Aspen Global Change Institute Workshop:

Global Change and the Solar-Terrestrial Environment
Session H: Education and Public Outreach
Aspen, CO
15 June 2010

Dr. Richard Somerville Talk at GSU



Data we collected at Richard's emphatically "straight science" talk at Georgia State suggested shifting attitudes toward more willing consideration of scientific perspectives. NOT an example of a failing "deficit" model here.

Undergraduates - a powerful time in life to challenge conditioned ideas …..

IT MOVES BECAUSE THE SUN SHINES

Adapted from physicist Richard Feynman's 1966 speech to the National Science Teachers Association, titled "What is Science?"

The Toy Dog Dialogue

Child: Why does the toy dog move?

Adult: It moves because the sun is shining.

Child: No it doesn't. What does that have to do with the Sun shining? The toy dog moves because I wind up the spring.

Adult: Yes, but why are you able to move to wind up the spring?

Child: Because I eat.

Adult: Okay…what do you eat?

Child: I eat food.

Adult: Where does that food come from?

Child: Plants and trees…

Adult: And how do plants and trees grow?

Child: Aha! They grow because the Sun is shining….

Adult: Right! So both you and the toy dog move because the Sun is shining.

The Concept Inventory on Climate Change

The **CICC** has been developed in the context of a popular introductory weather and climate lab/lecture course at a southeastern research university (N~400-500 per semester).

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The Concept Inventory on Climate Change

The Concept Inventory on Climate Change **[CICC]** is a research-based multiple-choice "test" that provides a valuable new assessment tool on science concepts related to climate change for…

1. Undergraduate instructors of climate-related courses
2. Teacher educators or professional developers
3. Education researchers
4. Project evaluators
5. **Others? Climate Service Providers?**

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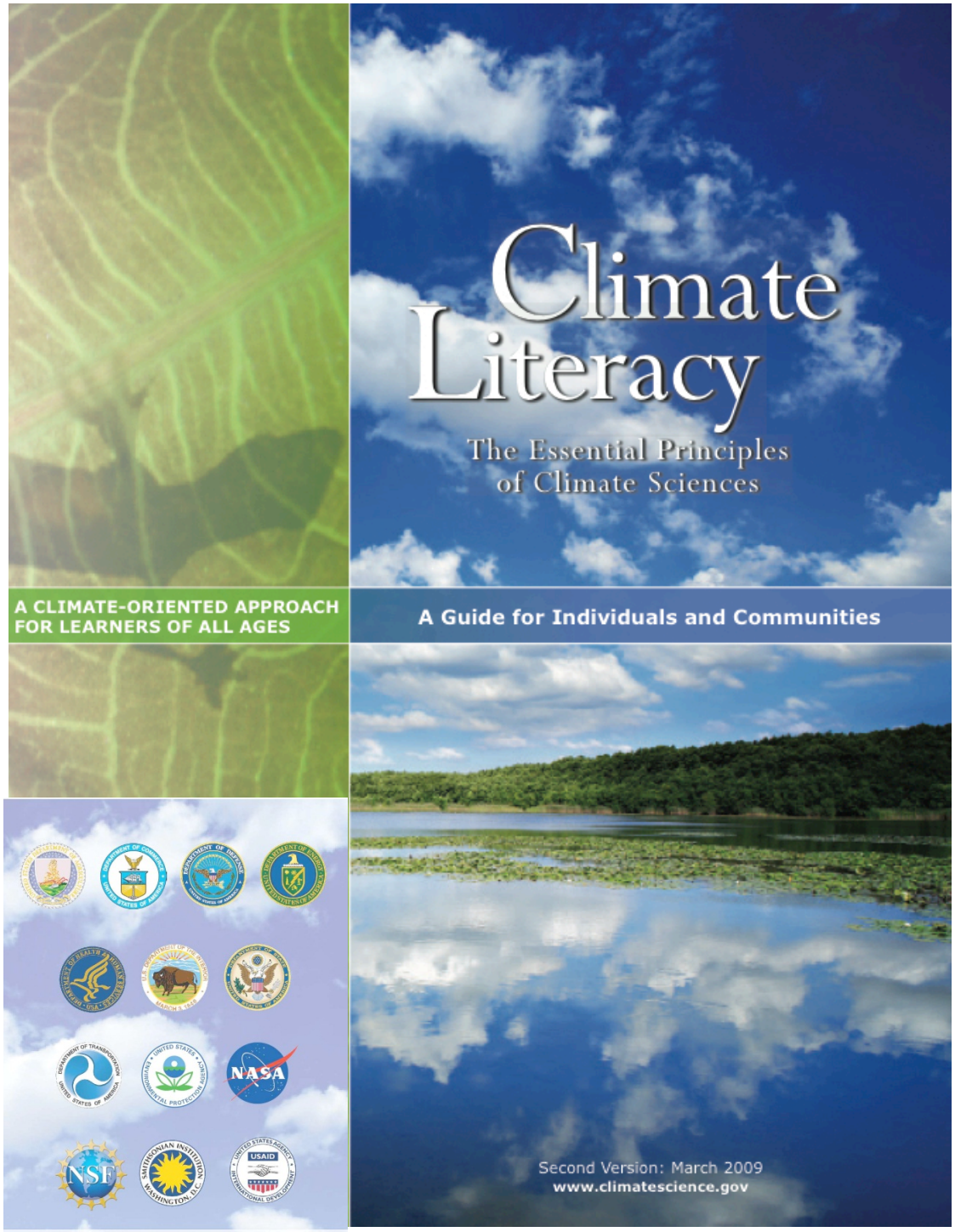


CONTENT VALIDITY

Our content validity derives predominantly from the national consensus document entitled:

Climate Literacy: The Essential Principles of Climate Science.

C. Morrow - cmorrow@agci.org

Core Development Team

Dr. Cherilynn Morrow

Science Education Research – Interviewing students about their ideas on climate change.

Dr. Judy Monsaas
Psychometrics

Executive Director of
Assessment and Evaluation
University System of Georgia

Senior Research Fellow
Aspen Global Change Institute

Research Specialist, USG

Dr. Comfort Afolabi
Data Collection & Analysis

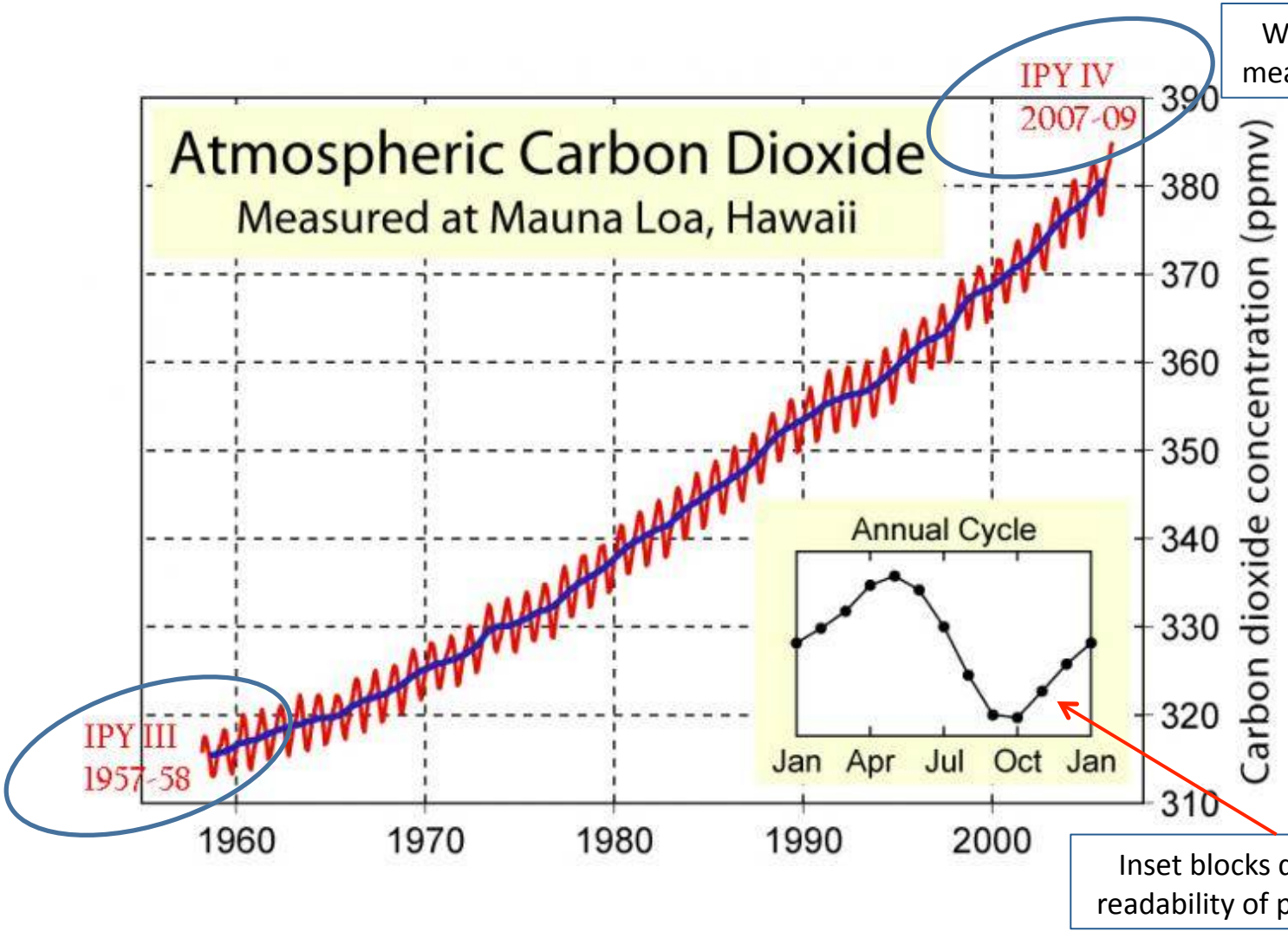
John Katzenberger
Science Expertise

Executive Director
Aspen Global Change Institute

C. Morrow - cmorrow@agci.org

The Effect of Interviews on **Graphics**

Example #1 – Keeling Graph of Atmospheric CO_2 Concentration



What does this mean? Distracting

Inset blocks quantitative readability of primary curve

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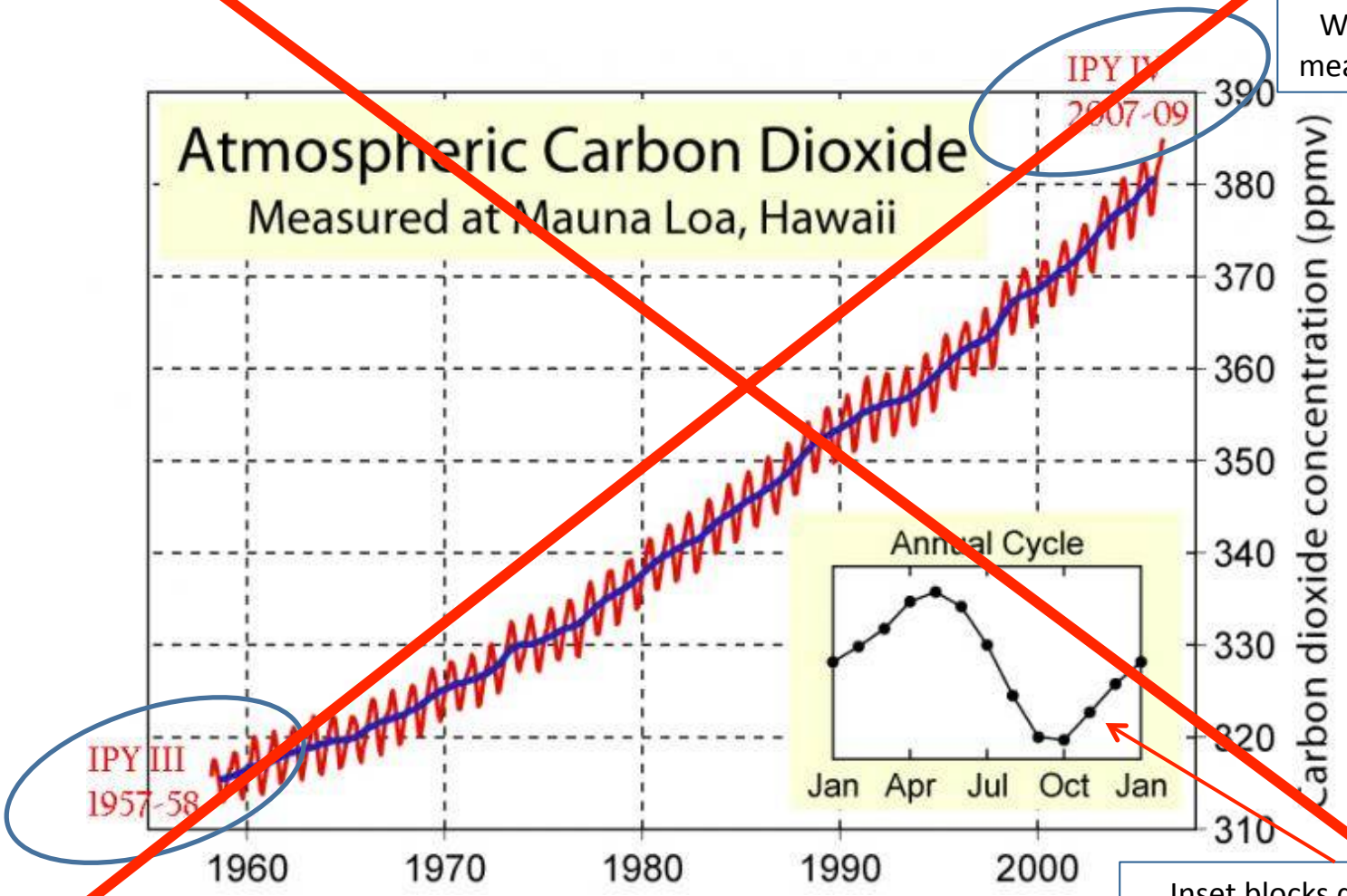

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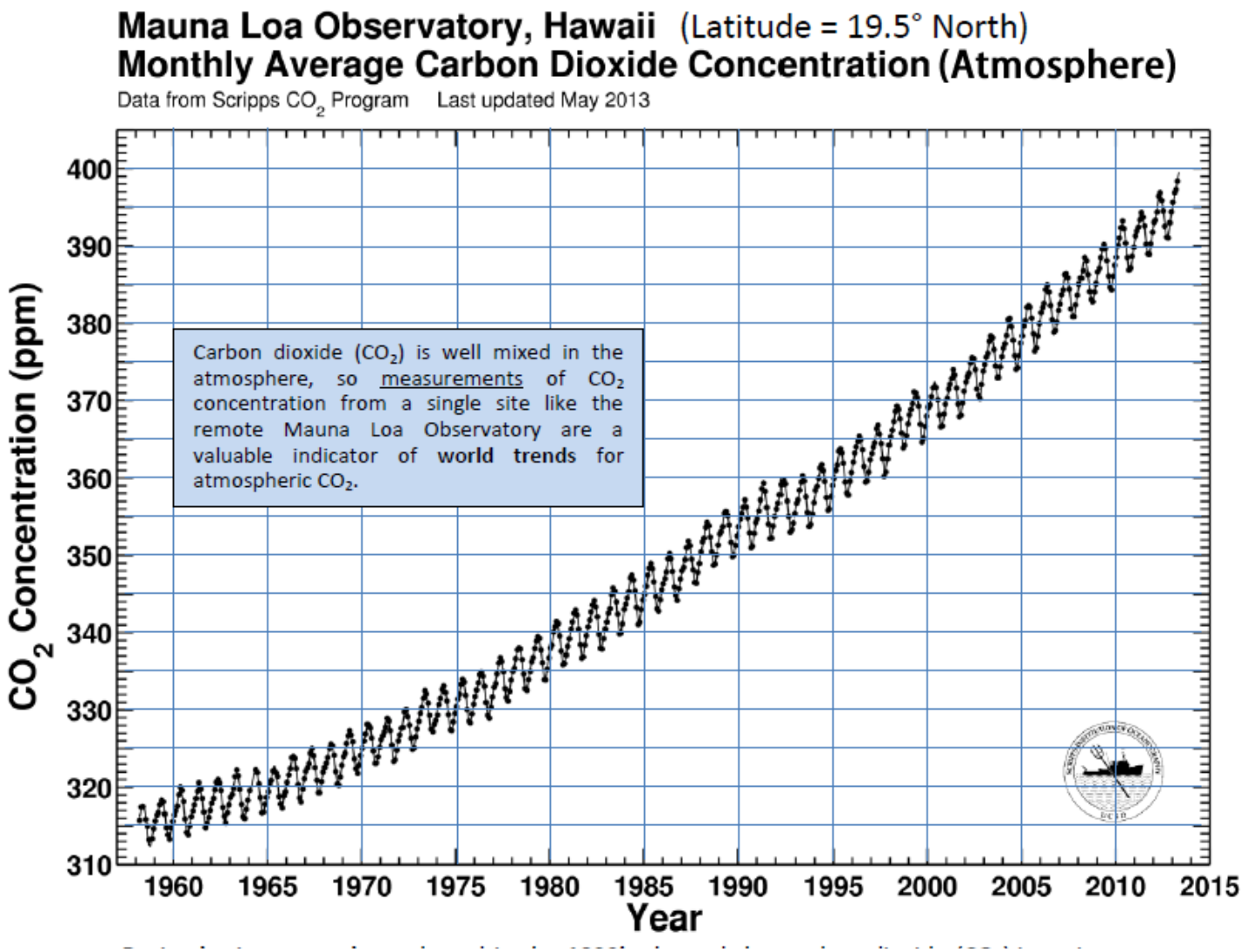

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Concept Inventory for Climate Change

Potential as Tool for Change

In higher education (e.g. introductory physics), The Force Concept Inventory (FCI) has been used to provide curriculum developers, education researchers, and instructors with valuable feedback on the effectiveness of teaching strategies.

Properly used, a well-designed Concept Inventory can play a vital role in transforming teaching practices among faculty toward becoming more evidence-based.

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Intended Use of Concept Inventory

The CICC is NOT a test for a grade!!

A *multiple-choice* test cannot purport to assess deep conceptual understanding but if well developed, a multiple choice concept inventory can…

1. ***flag*** conceptual issues (PRE-instruction).
2. ***detect*** conceptual change (POST-instruction).
3. ***inform*** decisions about teaching strategies.
4. ***all of the above***.* ☺

☺ This is NOT a *best-practice* structure for an item, but it serves the intended purpose here.

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THE ROLE OF A NEW RESEARCH-BASED ASSESSMENT TOOL IN IDENTIFYING MISCONCEPTIONS AND DETECTING CONCEPTUAL CHANGE IN UNDERGRADUATE LEARNERS

NASA Innovations in Climate Change Education (NICE)

Concept Inventory on Climate Change [CICC]

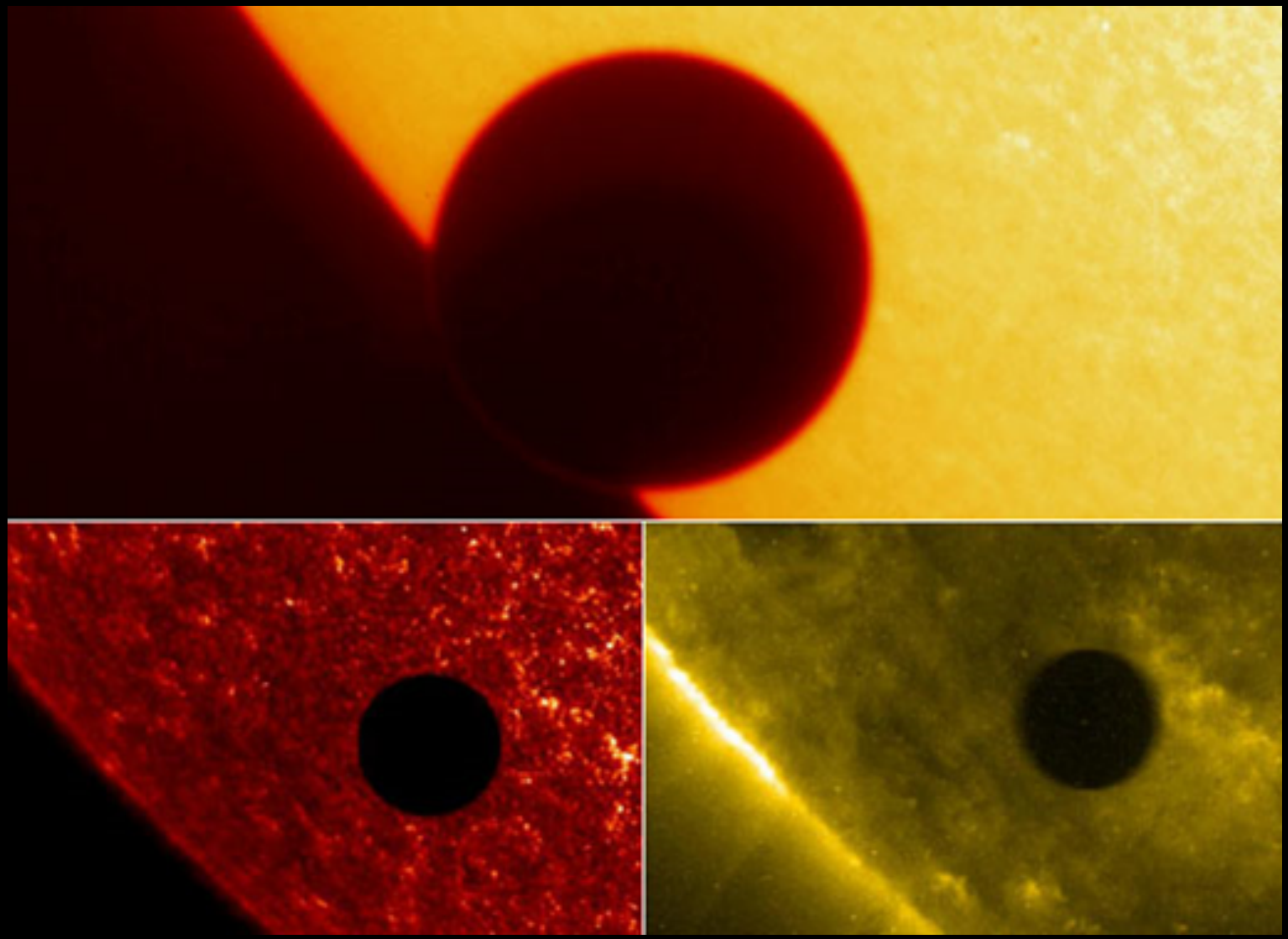
Cherilynn A. Morrow
John Katzenberger
Judith Monsaas
Comfort Afolabi
and also
W. Crawford Elliott

Geological Society of America
30 Oct 2013 - Session No. 317
T116. Climate Literacy: Research and Evaluation Results from Informal and Formal Climate Education Efforts

Venus Transit as Context for Art & Science Education

Workshop for Arts, Music, and Science Teachers together

Importance of Products to provide opportunity to collaborate



Venus Transit Atop Mauna Kea – June 2012

Context for Art & Music & Spirit & Felt Experience in Service to Science Education

From the Horse's Mouth:

A Unique Resource for Bringing NGSS Standards on the Nature and Process of Science to Life via Educational Access to Videos of Scientists Communicating with Each Other

FROM THE
HORSE'S MOUTH

SCIENTISTS ON THE SCIENCE OF GLOBAL CHANGE

This work was supported by NSF grant GEO-1035125.

Cherilynn A. Morrow
John Katzenberger
Elise C. Osenga
James C. Arnott

American Geophysical Union
11 Dec 2013 –ED Session on NGSS
ED005: Climate Literacy and the Next Generation Science Standards for K-12 Education

Ideas for Future of AGCI

- *Selected* AGCI meetings as contexts for appropriately non-intrusive research on the ingredients for successful cross-disciplinary communication (e.g. NOAA REESE efforts)
- Workshop that explores the interface between science communication and science education in both research and practice (including relevant psychology for scientists regarding more effective education and communication).
- Developing developing assessment instruments on global change content akin to the Concept Inventory on Climate Change – explore link to Kahan research (quoted by Marty).
- Persistence with activating the AGCI archive for use with Next Generation Science Education Standards (NGSS)
- Enhancing the integration of the Arts with STEM education

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Lessons of Career Trajectory

- ***Joys and challenges of cross-disciplinary communication***
- ***Education as development of human potential insights on math and science illiteracy, inquiry vs. dogma, systems thinking, Teaching for Transformation rather than Information….***
- ***Exceptional Value of integrating education programs within scientific research environments.***
- ***The power of "felt experience" in developing global perspectives***
- ***Seeing opportunity for needed solutions to derive from a new synthesis of traditional and modern values***
- ***Roles for scientists in education – re-examine in light of climate change***
- ***Inquiry vs. dogma (Dalai Lama)***
- ***Comparing Communication and Education Research***
- ***Joys of qualitative inquiry***
- ***Dialogue-generating products across knowledge domains***
- ***Activating archive, all of above***

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AGU - FTHM ABSTRACT

- ABSTRACT BODY: "From the Horse's Mouth" (FTHM) is a standards-aligned educational website that is being developed by the Aspen Global Change Institute (AGCI) with NSF support for purposes of both formal and informal education. The project allows students, teachers, and the public to become "(horse) flies on the wall" as science communication on key global change issues is practiced by leading scientists from around the world. The website will offer a uniquely valuable resource for explicitly addressing educational standards about science as human endeavor, the nature of science, the process of science, and cross cutting themes such as systems and cycles.

The source material for the FTHM website is more than 1200 hours of video documentation of scientists communicating with each other about both foundational and emerging global change topics at 50 AGCI interdisciplinary workshops (N~25-30 participants/workshop) over the past 24 years. Scientists from more than 35 countries have presented in AGCI workshops on a broad array of topics in Earth system science.

The FTHM project team has been scouring the AGCI archive for excerpts (2-8 min) with exceptional educational potential that well illustrate the values, nature, and process of the scientific endeavor in the context of engaging multi-disciplinary topics and concepts. The website surrounds these clips with supporting materials that help the viewer comprehend the communication of scientific concepts and, most importantly, identify key elements of the scientific process. The FTHM website will provide a unique resource for teachers and teacher educators to bring to life the nature of scientific discourse and the process of science that is so important to fulfilling the Next Generation Science Standards (NGSS).

This work was supported by NSF grant GEO-1035125.

6/1/15 C. Morrow - cmorrow@agci.org

CURRENT CICC Characteristics

- 34 multiple choice items with 4 answer choices
- Distribution of content by *Climate Literacy Principle* – Each item keyed to relevant Principles
- Item structure in accordance with standard best practices (e.g., Burton et al.)
- Cognitive sophistication: about 1/3 each:
  Knowledge, Comprehension, Application
- Distribution of item difficulties
- The CICC does not cross the line into assessing opinions or beliefs, but may serve as a complement to other instruments that do so.

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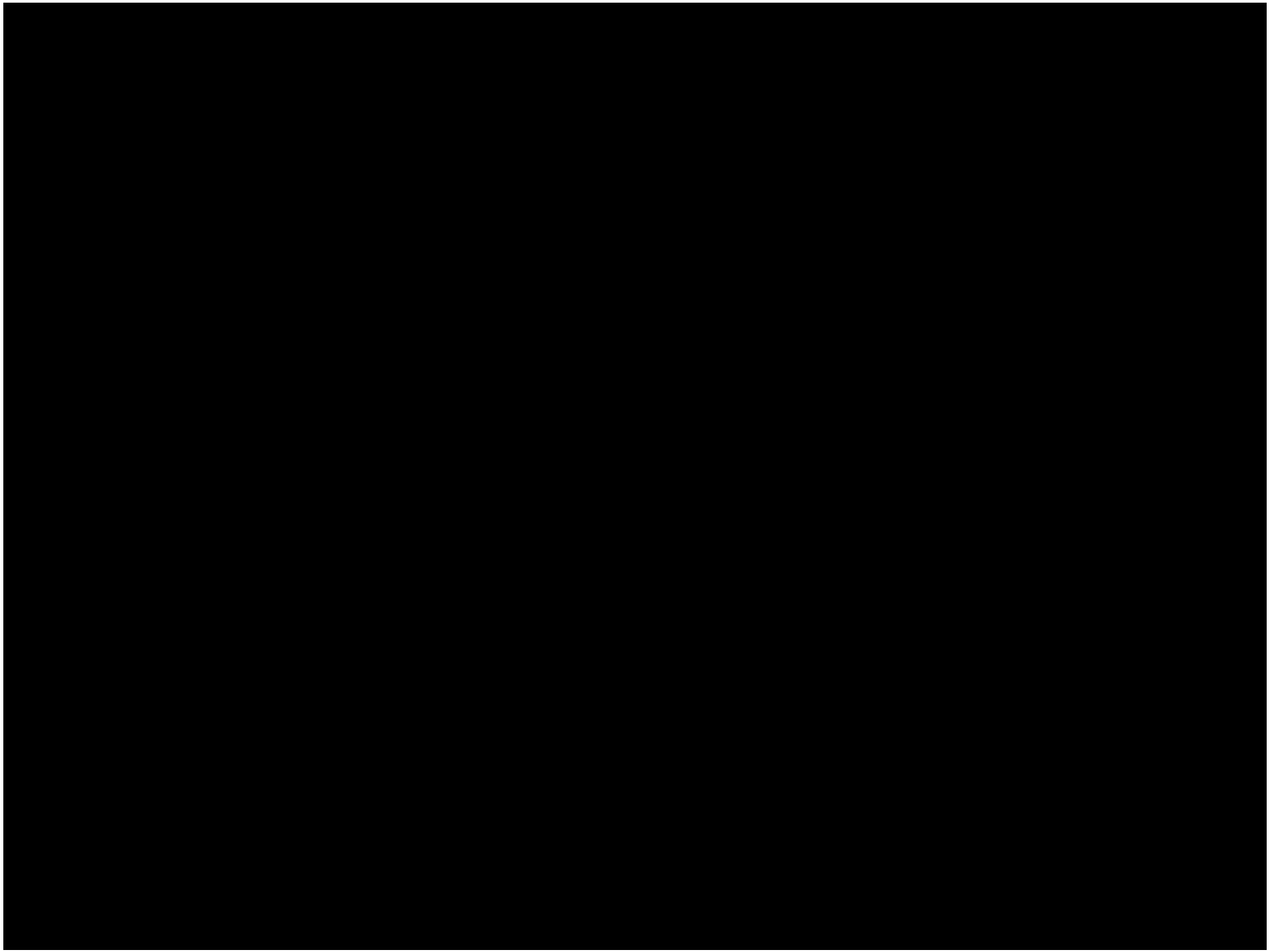

Communications Research

question: what instruments were used to measure science literacy and numeracy? Heard a talk about this…

- The polarizing impact of science literacy and numeracy on perceived cl imate change risks….Dan M. Kahan…Nature climate change…..deficit in comprehension…eficit omcrhesnion… We conducted a study to test this account and found no support for it….27 Mat 2012….Ellen Peters, Maggie Wittlin, Paul SLovice….Abstract…
- Evolutionary psychology…

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Career Trajectory

- My own expertise has evolved with time from solar physics research, to earth and space science education, to physics and climate education research. The latter has involved conducting group interviews with undergraduate students in an introductory weather and climate course to understand how they think and reason about the science of climate change, and to detect any commonly held misunderstandings about the science. This is kindred with an important research method in communications that involves convening focus groups to learn about the mental frameworks people use to respond to information about climate change. By this means researchers can also test the most effective ways of communicating the realities of climate change to people with diverse values and perspectives.
-
- As a research scientist in solar physics, turned into a NASA program officer, then into a cross-cultural astronomy educator, then into a professor of physics education, and now into a discipline-based education researcher in climate science, the scientifically inaccurate ideas conjured by “carbon pollution” are annoying. ***Graduate student in***

Career Pathway and Influences

- Your career:
- How have the research
- questions and scientific priorities
- in your work/specific
- field
- evolved since you began as a scientist, and how has that evolution of the science brought
- you to where you are now in terms of what you are currently studying?
- What are the key factors
- (e.g. d
- iscoveries, publications, workshops, research projects, assessments, or mentors) that have
- influenced your career and topics of your research?

Evolution of Global Change Research

- 2.
- Global change research more broadly
- : Looking back, what have been the major ways in which
- global change
- research
- has evolved for the better and for the worse? What has enabled progress,
- and what has slowed it? What lessons do you draw for the future? You can focus on anything,
- e.g., research topics, data, infrastructure, political
- conditions, societal relevance

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Societal Needs vis-à-vis Science

3.

- Societal needs:
- How is society's need for information about global change evolving? What do
- you see as the critical role for science moving forward? Are there tradeoffs between fundamental
- science and its application, and if so, how should they be managed effectively?

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Future – Opportunities and Challenges

4.

The future:

- Where do you see global change science going over the next 10- 20 years, and what
- new research priorities are emerging? What are the impediments and opportunities that will need
- to be managed? You could answer for your specific field, more generally, or both.

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AGCI's Influence and Future Role

5.

- AGCI's role:
- This year marks the 25th anniversary of the Aspen Global Change Institute.
- If you have been an attendee or a co-chair of a previous AGCI session, how did those sessions you
- participated in help steer or influence global change science? And, how do you see AGCI's role
- evolving into the next 25 years.
-

EXAMPLE ITEMS

Our Greenhouse Item - Thank you Researchers!

14. Which statement best describes how Earth's *natural* "greenhouse" effect works?

The "greenhouse" effect is a basic physical process by which…

A. *infrared* (longwave) energy from Earth's heated surface is absorbed and re-emitted by certain atmospheric gases, leading to a warming of Earth's lower atmosphere.

B. *visible light* (shortwave) energy from the Sun is absorbed and re-emitted by certain atmospheric gases, leading to a warming of Earth's lower atmosphere.

C. *heat energy* given off by factories and industrial activities is trapped in Earth's lower atmosphere, leading to a *global warming*.

D. *ultraviolet* (shortwave) energy from the Sun interacts with greenhouse gases causing *ozone depletion* and leading to a *global warming* of Earth's upper atmosphere.

Item Frequencies: Fall 2013 [19, 12, 30, 39]
N~500

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EXAMPLE ITEM

Cognitive Sophistication

1. Climate scientists and research meteorologists distinguish between "weather" and "climate". According to this distinction, which statement is more about the climate of a town?

A. The average of the high and low temperatures measured yesterday was 19°C (66°F).

B. One centimeter (0.4 inches) of rain fell on 18 September 2010.

C. The high humidity this past week has been very unpleasant for working outside.

D. The average yearly snowfall is 122 centimeters (48 inches).

POLL: Which TYPE of item would you say this is?

K K/C A/A

[K] = Knowledge - asks for knowledge of a fact or definition

[K/C] = Knowledge/Comprehension - requires more conceptual understanding to answer correctly.

[A/A] = Application/Analysis - asks for application of underlying concept to answer correctly.

EXAMPLE ITEMS
Cognitive Sophistication

26. Which of these observations would provide the *strongest* scientific evidence of a major change in Earth's climate?

A. Record snowstorms this past winter in the eastern United States

B. Increasing frequency and intensity of hurricanes in the Gulf of Mexico in the past few years

C. Intense heat waves during the past two summers in Europe

D. Continuing retreat of almost all glaciers in the world during the last several decades.

POLL: Which TYPE of item would you say this is?

K K/C A/A

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Example Sources of Stimulation for Item Generation

Our item generation has been stimulated by other key sources in addition to the *Climate Literacy Principles,* but all items are grounded in those *Principles*:

1. AAAS Atlas for Weather and Climate – linked to *Climate Literacy Principles;*
2. Intergovernmental Panel on Climate Change (IPCC) Physical Science FAQ;
3. Somerville & Hassol – Physics Today article on Climate Communication;**
4. NAEP – released items 2009 and 2012 , Physical, Earth & Space Science;**
5. Questionnaires whose analysis resulted in the *Six Americas* Report; and
6. Research papers on misconceptions (e.g. Buhr & McCaffery 2008 in *Physical Geography*, Shepardson et al. 2010 in *Climatic Change).*

** = focus of commentary in oral presentation

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Item Categories

Possible Sub-scoring Validation

To be explored further via factor analysis

1. Basic Weather & Climate (BWC)
2. Systems, Cycles, Feedbacks (SYS-CYC)
3. GH Effect & CO2 Literacy (GH-CO2)
4. Consequences of Climate Change (CONSQ)
5. Scientists on Climate Change (SoCC)

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The Concept Inventory on Climate Change

The **CICC** has been developed in the context of a popular introductory weather and climate lab/lecture course at a southeastern research university (N~400-500 per semester).

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Sample GEOG 1112 Demographics

Fall 2013 Semester N ~ 500

- ~66 % Freshmen or Sophomores
- ~49 % < 20 years of age

- ~08 % STEM majors
- ~12 % Education or Communication majors

- ~51 % Female
- ~28% White; 53% Black; 9% Asian; 9% Hispanic

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Concept Inventory for Climate Change

Development Process

The **CICC** development process has involved data-driven changes to successive versions. Data sources have included:

- item statistics from the administration of progressively evolved versions of the **CICC** in the weather and climate course;
- student group interviews (conceptual "think aloud" conversations, vocabulary, and graphics reviews immediately after taking the **CICC**;
- expert review by climate scientists, educators, and project evaluators based primarily in the US and Canada.

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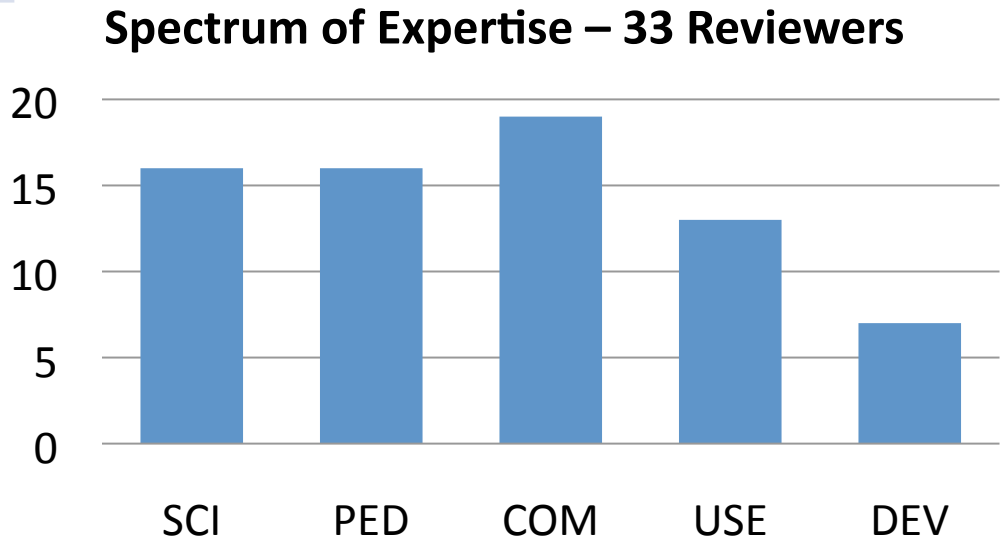
Spectrum of Reviewer Expertise

For purposes of this review, the primary expertise you bring is…
SCI: Climate Science
PED: Pedagogy of Climate Science
COM: Communication of Climate Science
USE: Use of Assessment Tools
DEV: Development of Assessment Tools

Each reviewer could choose up to **three** types of expertise



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FINAL ROUND of EXPERT REVIEWERS

Team A

Alley, Richard	Pennsylvania State University
Arnott, James	Aspen Global Change Institute
Bennett, Jeff	Big Kid Science, Boulder, CO
Bernacchi, Leigh	University of Idaho
Donner, Simon	University of British Columbia
Hammerman, James	TERC
Kelly, Kim	University of Southern California
Ledley, Tamara	TERC
Lynds, Susan	University of Colorado, CIRES
Nave, Bill	Bill Nave Consulting
Rebich Hespanha, Stacy	UC Santa Barbara
Somerville, Richard	University of California, San Diego
Steinberg, Daniel	Princeton University
Zawaski, Mike	Front Range Community College, CO
Martin, Ann M.	NASA Langley

Team B

Beach, Sheryl L	George Mason University
Brey, James	American Meteorological Society Education
Campbell, SueEllen	Colorado State University
Criswell, Brett	University of Kentucky
DeWaters, Jan	Clarkson University
Gold, Anne	University of Colorado, CIRES
Wuebbles, Donald	University of Illinois

Team C

Bagenal, Fran	University of Colorado
Bleicher, Robert	California State University, Channel Islands
Brasseur Guy	Climate Service Center
Buhr, Susan	University of Colorado, CIRES
Holthius, Nicole	Holthius Research & Consulting
Mark McCaffrey	National Center for Science Education
Stoll, Will	Georgia State University
Tu, Jun	Kennesaw State University
Weston, Tim	University of Colorado
Yan, Fei	North Carolina Central University

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The Mantra of Good Item Development

The mantra of good item development is:

** The student who understands, gets it right:*

*** The student who doesn't understand, gets it wrong.*

NOT as easy as it may sound…

THE STUDENT…	Gets Item RIGHT	Gets Item WRONG
KNOWS	☑ ***YES!** (Accuracy. No ambiguity)	☒ NO (Student is fooled.)
DOES NOT KNOW	☒ NO (Student guesses right.)	☑ ****YES!** (Use misconceptions as distractors)

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CICC SAMPLE ITEM

Benefit of Expert Review

Avoid making it too easy to guess

1. Climate scientists and research meteorologists distinguish between "weather" and "climate". Which statement is more about the *climate* of a town?

A. The high temperature today was 30°C (86°F).
B. Ten centimeters (Four inches) of rain fell on 18 September 2010.
C. The high humidity this past week has been very unpleasant for working outside.
D. The average yearly snowfall is 218 centimeters (86 inches).

1. Climate scientists and research meteorologists distinguish between "weather" and "climate". According to this distinction, which statement is more about the climate of a town?

A. The average of the high and low temperatures measured yesterday was 19°C (66°F).
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NEW CONCEPTUAL ISSUES?

1. Climate scientists and research meteorologists distinguish between "weather" and "climate". According to this distinction, which statement is more about the climate of a town?

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SPRING 2013 **PRE** [17, 3, 33, 47]

FALL 2013 **PRE** [24, 3, 29, 44]

Using the item prior to Expert Review

Using the item **above** after modified by Expert Review

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CICC SAMPLE ITEM

Benefit of Expert Review

Avoid confounding the knowledgeable student

1. Climate scientists and research meteorologists distinguish between "weather" and "climate". Which statement is more about the *climate* of a town?

A. The high temperature today was 30°C (86°F).

B. Ten centimeters (Four inches) of rain fell on 18 September 2010.

C. The high humidity this past week has been very unpleasant for working outside.

D. The average yearly snowfall is 218 centimeters (86 inches).

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Concept Inventory for Climate Change

Frequent Reference to Sources of Data

5. According to measurements made around the world by weather stations, ocean instruments, weather balloons, and satellites during the past several decades, average surface temperatures on Earth have…

A. remained about the same in all areas of the planet.

B. increased by about the same amount at every location on the planet.

C. increased in most areas, with the strongest increase in the Arctic.

D. increased in most areas, with the strongest increase in the Tropics.

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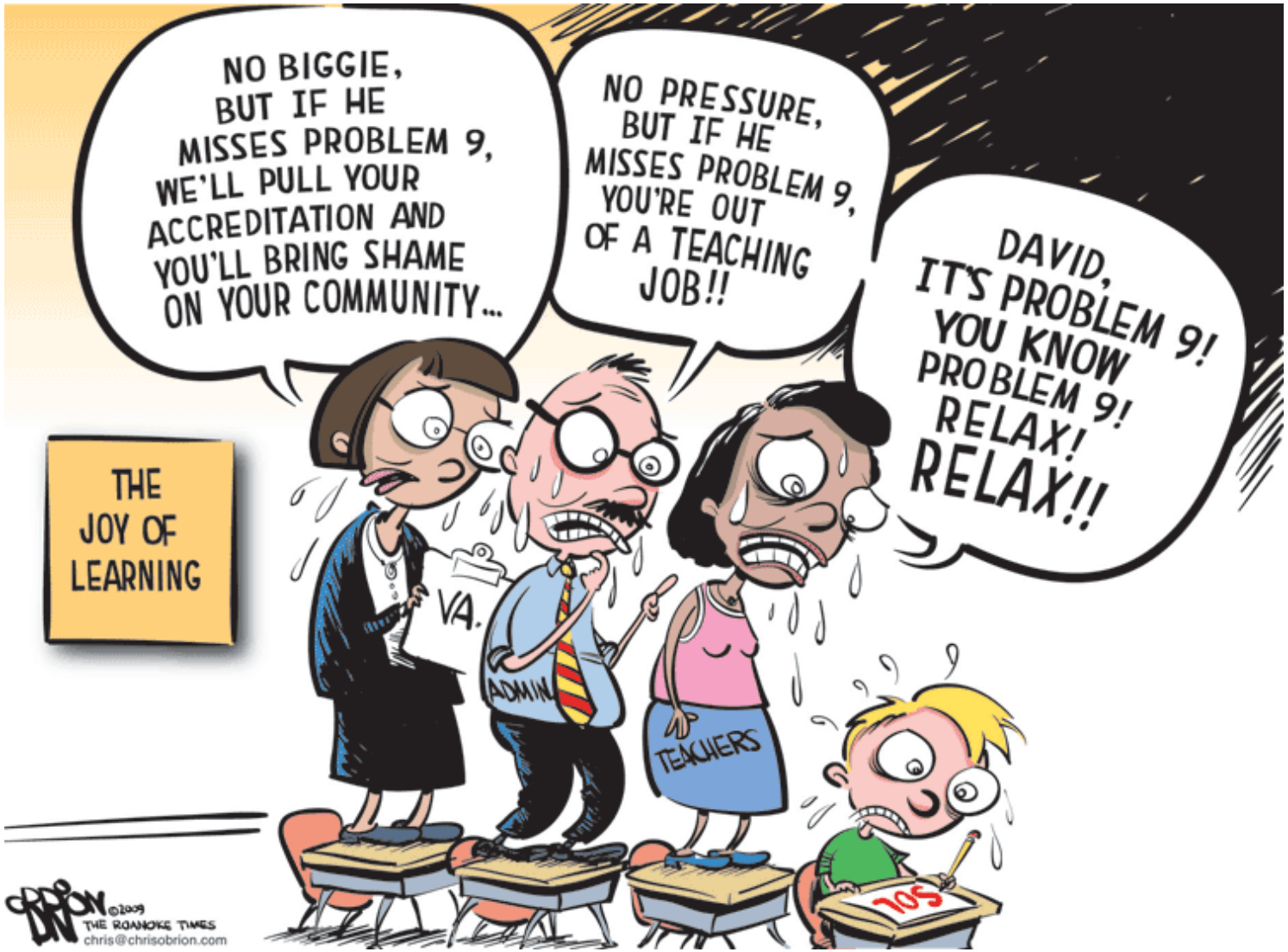

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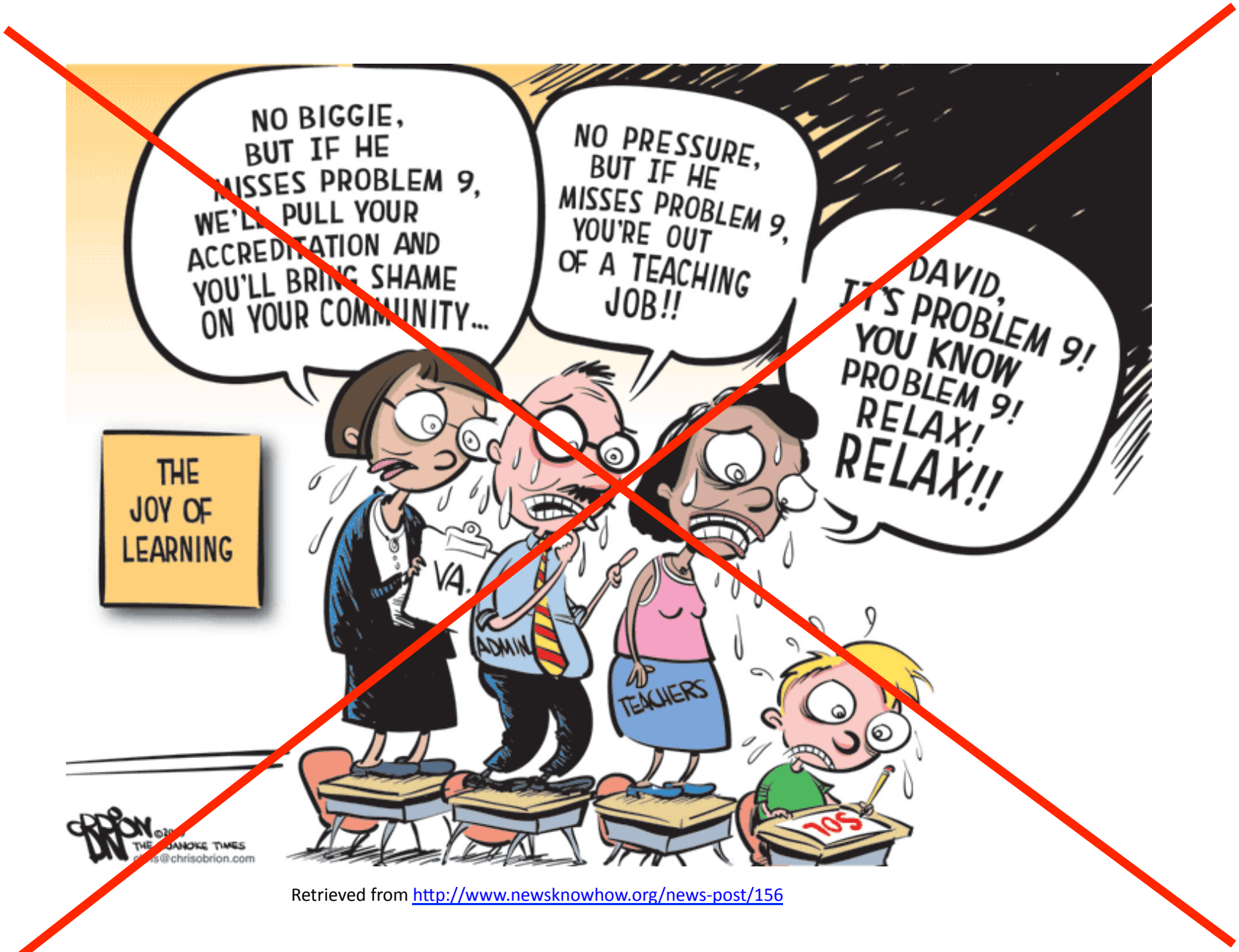

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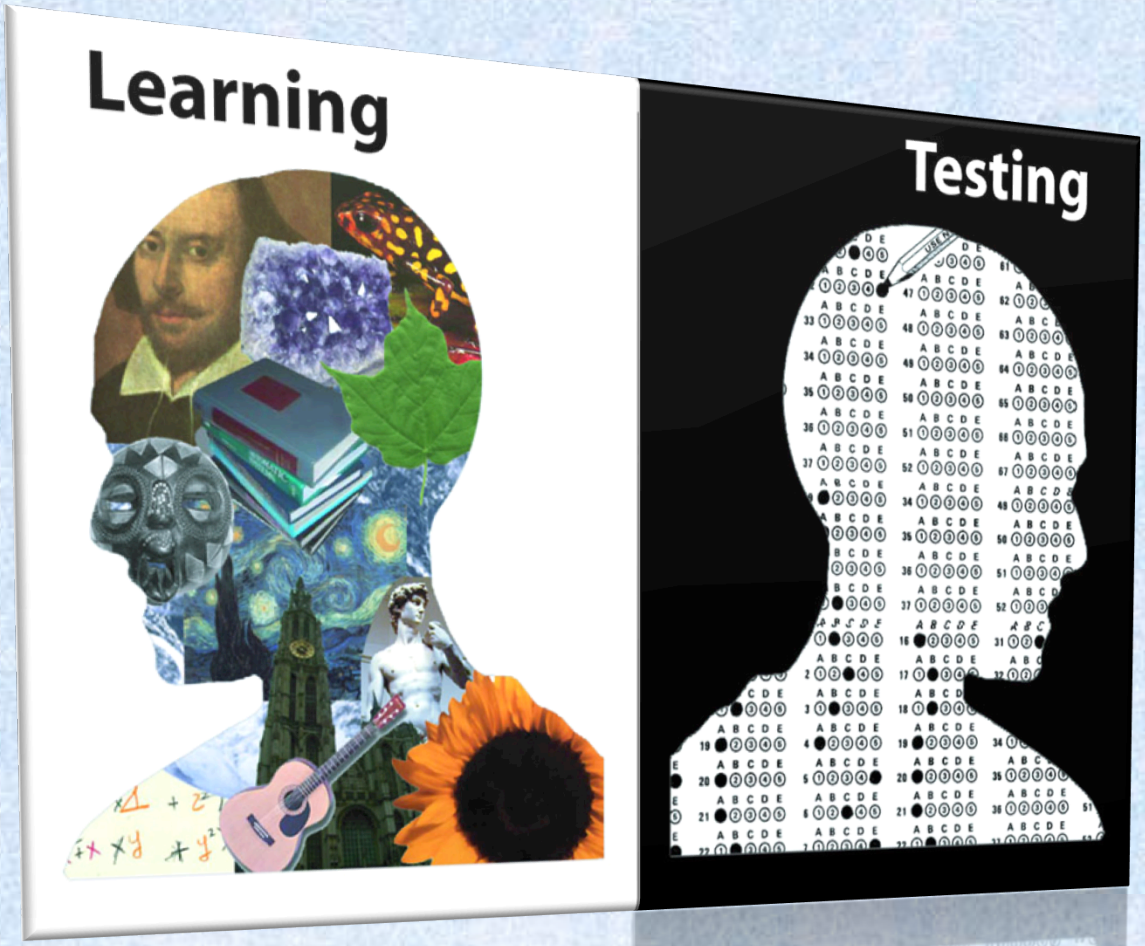
Recruiting additional Pilot Test Sites

outside of the developmental context for Spring 2014 semester. Please contact cmorrow@agci.org



If you are interested to be a CICC pilot test site in the Spring 2014 Semester, or if you have questions or ideas, related to the CICC, please contact...

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Aspen Global Change Institute
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