RESPONDING TO PSEUDOSCIENCE, CONSPIRACIES, AND HOAXES

The best practices and strategies identified in this document were informed by a literature review across science communications, education, and social sciences. Special thanks to the National Informal Science Education Network (NISE Net), NASA Solar System Ambassador Program, and the Astronomical Society of the Pacific for their input.

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The scientific case has been closed for thousands of years that the Earth is round, from the ancient Greeks observing lunar eclipses, to Magellan's crew sailing around the world, to modern astronauts orbiting the Earth, Apollo's iconic EarthRise image, and thousands of images of Earth from space that show the Earth is a sphere.

Yet, there are indications that there has recently been a rise in interest in the Flat Earth movement in the U.S. (Burdick, 2018; Dyer, 2018; Economist, 2017; Pappas, 2017).[1] There are also some recent reports from NASA Science Activation (SciAct) education projects of confrontations with science deniers and conspiracy theorists at NASA-related public events.

There are numerous publications, from scholarly, peer-reviewed journals to popular magazines, that span disciplines including psychology, social sciences, science education, and science communications research[2] that are related to science misconceptions and naïve understandings, pseudoscience beliefs, and anti-science extremists (science deniers and conspiracists). Following are initial recommendations and curated resources based on best practices and research that are aimed at supporting those who are working with the public. These provide practical approaches for A) explanations, demonstrations, and observations and B) strategies for defusing contentious situations. An extended reference list is provided of references consulted and related references and resources related to the resurgence of flat-Earthers and increasing anti-science attitudes in the public.

A. Recommended Approaches: Explanations, Demonstrations, and Observations

Overcoming and avoiding misconceptions and non-science beliefs requires more than providing the correct scientific explanation or simply dismissing questions. (Alters and Alters, 2001; Fraknoi, 2003; Pierce, 1957; Sinatra, 2014 and 2016). Effective educational approaches build on previous knowledge or experience of the learner, remain positive, and provide hands-on, experiential learning or observations that demonstrate evidence, and support a new way of thinking about the topic (NISE Net, 2017; Lightman, 1998). When refuting information, it is suggested that less is more: information that is easy to process is more likely to be accepted as true; a simple myth is cognitively more attractive than an over-complicated correction (Cook, 2011). This is consistent with best practices for science communicators that messaging should be easily understood and emphasize concrete experiences that audience members can relate to. (Roser-Renouf, 2018). However, science literacy is just one factor. There are also

[1] It's difficult to pinpoint the number of Americans that either believe the Earth is flat or are unsure, but it does still appear to be on the fringes. A 2018 U.S. poll by YouGov reported that a third of millennials believed the Earth is flat, but critics identified flaws in their methods (Pappas, 2018, and Foster, 2018) with a closer examination of the data showing 4% (not 33%) of 18-24 year old responding "I have always believed the Earth is flat." A 2017 poll of 941 registered U.S. voters by Public Policy Polling found that 1% think the Earth is flat and 6% were not sure. Google Trends suggest that interest in the concept "flat Earth," while not necessarily equaling belief, has risen somewhat over the past few years, with increases tied to events like eclipses and celebrity reports (Jones, 2018; Gartland, 2018). The first Flat Earth Conference in Raleigh, November 2017 drew 500 participants and a second conference held in Denver, November 2018 drew 650 participants.

[2] Searches of Google Scholar and the Dept. of Education ERIC Database for articles related to topics including "flat Earth" "creationists," "conspiracy theories," "science deniers," "anti science," and "science hoaxes" returned numerous articles in scholarly and peer-reviewed publications. A small sample of these peer-reviewed articles is included in the extended reference list attached. Note that these articles also each include additional references (e.g., the article by Douglas (2017) is a review of research related to the psychology of conspiracy theories and includes 39 references).

indications that when faced with information that conflicts with their own values, flat Earthers resolve these conflicts not by changing their world view, but by rejecting the conflicting information (Landrum, 2018). [3] More broadly, research also suggests that in addition to increased scientific literacy (knowledge), addressing challenges to public understanding of science includes teaching scientific processes, emphasizing a deeper understanding and how to think over what to think, and avoiding "balanced perspectives" when there is scientific consensus (Sinatra, 2016).

Following are examples of approaches for audiences related to the notion that the Earth is flat.

- **Listen to the participant and respond to what they are saying**. Try the "Yes, and…" approach, borrowed from improvisational theater. YES, I acknowledge something you said that is helpful to understanding this concept, AND I would like you to consider some new evidence that will help deepen your understanding. For example, respond to the statement, "The Earth is Flat" with "YES, Earth does look flat to us, AND that's because it's so big that we can't tell that it's actually shaped like a ball. Let's examine this scale model Earth experiment." (NISE Net, 2017)
- **Observe the Appearance of Objects on the Horizon:** Go to a lake or the coast, and with a pair of binoculars look at boats far away. The farther away a boat is, the more the bottom of the boat will disappear until the last thing you see is the very top mast of the boat. This is because the boat is going over the horizon that's curved. This would not happen if the Earth was flat - the boats would simply look smaller and smaller the farther away, but you would still see the whole thing (the boat) with the same proportions (Thaller, 2018). *Science and Children* magazine includes a related demonstration utilizing a large balloon and model ship as a hands-on experience demonstrating this concept and the need to address childrens' naïve conceptions that the Earth is flat (Lightman, 1998).
- **Sunrise and sunset happen at different times depending on your latitude.** If the Earth were flat, then someone in New York and someone in Los Angeles would see the sun rise and set at exactly the same time as one another. But in practice, the difference is approximately three hours. Not only that, but at every point in between, the Sun rises/sets at a different time, something that could not happen if the Earth were flat. (Siegel, 2017)
- When it is winter in the U.S., it is summer in Australia. This is because **different locations on Earth experience seasons at different times** because the Sun's rays strike the Earth at different angles throughout the year. If the Earth were flat the Sun's rays would always come in at the same angle, and

[3] A. Landrum, Texas Tech University, interviewed attendees at flat Earth conferences in 2017 and 2018 and presented her results at the 2018 and 2019 AAAS annual conferences. In 2018, she suggested that "Though many intuit that the real problem is one of knowledge: 'if we just improved science literacy, then more people would accept what science knows'; this is only part of the equation. When people are motivated to resolve cognitive dissonance that they face when information conflicts with their own values, they do this not by adjusting their deeply held worldviews, but by rejecting the conflicting information. The so-called 'Flat Earthers' are doing just that." She also noted in 2019 that when the US astrophysicist Neil deGrasse Tyson explained how small sections of large curved surfaces will always appear flat to the little creatures that crawl upon it, his message was seen by some Flat Earthers as patronizing and dismissive. She noted that "There's always going to be a small percentage of people who will reject anything that scientists put out there but maybe there's a group in the middle that won't," she added. "The only tool we have to battle misinformation is to try and overwhelm it with better information." (Sample, 2019)

all parts of Earth would experience seasons exactly the same. A simple demonstration is to observe the length of shadows of sticks placed in the ground. If the Earth were flat the length of the shadow would be the same no matter how far apart the sticks are placed. (Schottlender, 2016)

- **Observe what happens during a lunar eclipse.** A lunar eclipse happens when the Earth casts a shadow on the moon. The Sun is one side of the Earth, the moon on the other. As the Earth's shadow moves across the moon you can see the shape of the Earth, which is a sphere.

  If the Earth were shaped like a disc (and not a sphere) couldn't it also do that? Lunar eclipses occur at many different angles. Sometimes the shadow goes straight across the moon, sometimes it glances across the moon and just a little of the moon is in the shadow. From every different angle the sun is casting a shadow of the Earth onto the moon, you always see a perfectly curved shadow. The only shape that can cast a shadow in any direction is a sphere. This can be demonstrated with a flashlight and shadows cast by different shapes. (Thaller, 2018)

- **Seeing Farther from Higher Up.** Compare how far you can see from different elevations with a clear view: the higher the elevation, the further you can see. On a rounded Earth, elevation makes a difference in how far you can see, due to the curvature of the Earth. (Schottlender, 2016)

- **Different Stars are Visible at Different Latitudes.** The stars and constellations that are visible in the far north hemisphere are different from those visible in the southern hemisphere. If the Earth were flat, everyone on the night side of the Earth would see the same sky. (Siegel, 2017)

- **Views of Earth from Space.** There are thousands of images and video of Earth from space, updated daily and freely available online (However, for those who believe NASA is part of a conspiracy, these will not be effective). International Space Station HD video of Earth is available to stream on UStream or NASA Live Earth Views from Space Station on YouTube at https://www.nasa.gov/multimedia/nasatv/iss_ustream.html. Also check the Earth Observatory at https://earthobservatory.nasa.gov/ for feature stories and satellite images of Earth.

B. Recommended Approaches: Defusing Contentious Situations

Strategies are provided for dealing with the small number of people at public events who are there to disrupt or be confrontational. There is little chance of changing the minds of these extremists (Landrum, 2018; Lewandowsky et al., 2015; Roser-Renouf, 2018). General advice is to be respectful and don't argue or debate the science, while getting back on topic (if giving a presentation) or acknowledging that there is not agreement and moving on. Following are resources with specific, practical recommendations for defusing these situations

1. ***Astronomical Society of the Pacific: Handling Difficult Questions (and Difficult People)***
   https://www.youtube.com/watch?v=V7IoSxTeOPU&feature=BFa&list=PL6E25C335227A1768
   Developed under an NSF grant (Sharing the Universe project), these tips and role-playing exercises provide practical and proven strategies for handling difficult questions and difficult people at public events. An 8-minute video models the strategies on action. Intended for amateur astronomers giving presentations, the practical strategies easy-to-use and applicable across a range of science topics.

   Main Ideas: Avoid difficult questions and get back on topic. Don't be afraid to seize control as

needed. How to deal with difficult questions: 1) Seize control, 2) Be pleasant, 3) Respond neutrally, and 4) Get back on topic.

2) ***NISE Net Explore Science Toolkits: Tips for leading hands-on activities and contentious topics***
http://www.nisenet.org/catalog/explore-science-tips-leading-hands-activities
Each activity in the toolkits also include a facilitators guide, with a section on related difficult concepts (misconceptions as well as responses to potentially contentious topics). For example, the 2017 toolkit activity "Investigating Clouds," notes: "Some participants might dispute climate change. You can respectfully respond, "Yes, not everyone is in complete agreement about climate change. The great majority of scientists agree it is occurring, and we have a lot of supporting evidence. We are presenting the scientific perspective on the importance of studying clouds in this activity."

3) **JPL Safety Training for Solar System Ambassadors**
Following are suggestions by JPL safety experts for avoiding confrontations with audience members. These are provided as part of ethics training for Solar System Ambassadors. (Source: Kay Ferrari, JPL)
- Don't make debunking myths the topic of your presentation.
- With the Apollo anniversaries going on, there's a possibility of Moon landing hoaxers.
- Mention the possibility of confrontations when discussing safety awareness with a host/venue.
- If confronted, offer to speak with the person privately after your program ends and resume the program.
- Don't argue. If a person's mind is made up on a particular idea, arguing won't change it.
- If the person is intent on communicating with someone about his/her beliefs, get that person's contact info.
- NASA does not respond to conspiracy theories but refers to others who will.

Extended References (*****Peer reviewed publications)

*****Alters, B. J., & Alters, S. 2001, **Defending Evolution: A Guide to the Evolution/Creation Controversy,** Boston: Jones and Bartlett.

American Astronomical Society. (2004) ***An Ancient Universe How Astronomers Know the Vast Scale of Cosmic Time: A Guide for Teachers, Students, and the Public***.
https://aas.org/education/ancientuniverse

Behind the Curve. Directed by Daniel J. Clark, Delta-v Productions, 15 Nov. 2018.
https://www.imdb.com/title/tt8132700/
This documentary follows leaders of the Flat Earth Society. The movie also includes interviews with scientists and psychologists, and delves into the mindset that propagates dogmatic, unscientific propositions like Flat Earth and offers reasons why empirical evidence rarely turns people away from their conspiracy theory beliefs. An article about the movie includes an overview of the two experiments conducted in the documentary that provide evidence that the Earth is round, and yet doesn't turn flat Earth believers away from their conspiracy theory. https://www.newsweek.com/behind-curve-netflix-ending-light-experiment-mark-sargent-documentary-movie-1343362.

*****Brízová, Leontýna; Gerbec, Kelsey; Šauer, Jirí; Šlégr, Jan. (2018). **Flat Earth Theory: An Exercise in Critical Thinking.** *Physics Education*, v53 (4).
https://doi.org/10.1088/1361-6552/aac053
This paper presents a critical analysis of some of the arguments of flat Earth theory, and also attempts to show that this analysis and refutation of these false claims can be a useful exercise in critical thinking.

This article is also intended to make it easier for teachers who are exposed to some of the arguments of flat Earth theory by their students.

Burdick, A. (2018) **Looking for Life on a Flat Earth: What a burgeoning movement says about science, solace, and how a theory becomes truth**, in the New Yorker, May 30, 2018. Retrieved from: https://www.newyorker.com/science/elements/looking-for-life-on-a-flat-earth
Article about modern Flat Earth movement and history, including reporting from the first Flat Earth International Conference (2017 in Raleigh, NC) included 500 participants.

*****Carbon, C.-C. (2010). **The Earth is flat when personally significant experiences with the sphericity of the Earth are absent**. *Cognition*, 116 (1), 130–135.
https://doi.org/10.1016/j.cognition.2010.03.009
Participants with personal and without personal experiences with the Earth as a sphere estimated large-scale distances between six cities located on different continents. Cognitive distances were submitted to a specific multidimensional scaling algorithm in the 3D Euclidean space with the constraint that all cities had to lie on the same sphere. A simulation was run that calculated respective 3D configurations of the city positions for a wide range of radii of the proposed sphere. People who had personally experienced the Earth as a sphere, at least once in their lifetime, showed a clear optimal solution of the multidimensional scaling (MDS) routine with a mean radius deviating only 8% from the actual radius of the Earth. In contrast, the calculated configurations for people without any personal experience with the Earth as a sphere were compatible with a cognitive concept of a flat Earth.

Cook, J. and Lewandowsky, S. (2011), **The Debunking Handbook.** St. Lucia, Australia: University of Queensland. November 5. ISBN 978-0-646-56812-6. [http://sks.to/debunk]
This concise guide (7 pages) to debunking misinformation is freely available to download. “Although there is a great deal of psychological research on misinformation, there's no summary of the literature that offers practical guidelines on the most effective ways of reducing the influence of myths. The Debunking Handbook boils the research down into a short, simple summary, intended as a guide for communicators in all areas (not just climate) who encounter misinformation.”

*****Douglas, K.M., Sutton, R.M., and Cichocka, A. (2017). **The Psychology of Conspiracy Theories**. *Current Directions in Psychological Science:* Vol. 26(6) 538 –542
DOI: 10.1177/0963721417718261
https://doi.org/10.1177/0963721417718261
This paper provides a review of current research of what psychological factors drive the popularity of conspiracy theories and the psychological consequences of adopting these theories. Research suggests that belief in conspiracy theories appears to be driven by motives that can be characterized as epistemic (understanding one’s environment), existential (being safe and in control of one’s environment), and social (maintaining a positive image of the self and the social group). However, little research has investigated the consequences of conspiracy belief, and to date, this research does not indicate that conspiracy belief fulfills people’s motivations. Instead, for many people, conspiracy belief may be more appealing than satisfying. Further research is needed to determine for whom, and under what conditions, conspiracy theories may satisfy key psychological motives.

Dyer, H. (2018). **I watched an entire Flat Earth Convention for my research—here’s what I learned** Retrieved from: https://arstechnica.com/science/2018/05/i-watched-an-entire-flat-earth-convention-for-my-research-heres-what-i-learned/. Discusses how shifts in who has power to spread information have led to a resurgence in fringe ideas, specifically flat-Earthers. Dyer attended a flat-Earther

conference in the UK and reflects on that experience. He posits that in the 21st century, we are witnessing an important shift in both power and knowledge due to factors that include the increased public platforms afforded by social media that give anyone the ability to create and share content. He notes that at the same time there has been a rise in populist politics that are increasingly skeptical and distrustful of scientific institutions and knowledge. (Ars Technica is one of the oldest and largest tech focused websites that Columbia Journalism Review describes, "Since its founding in 1998, Ars Technica has grown to become a trusted, go-to source for news, reviews, and information about scientific advancements, technological breakthroughs, video gaming, tech policy, gadgetry, software, hardware, and everything in between."

Foster, C.A. and Branch, G. (2018) **Do People Really Think Earth Might Be Flat?** Retrieved from: https://blogs.scientificamerican.com/observations/do-people-really-think-earth-might-be-flat/?redirect=1
The authors found discrepancies between the original YouGov report on U.S. public views of the Earth's shape and data provided by YouGov. They found the data showed the number of millennials that believe the Earth is round is larger than what was in the original report (82.5% rather than 66%).

*****Fraknoi, A. (2003). **Dealing with Astrology, UFOs, and Faces on Other Worlds: A Guide to Addressing Astronomical Pseudoscience in the Classroom.** *Astronomy Education Review* v. 2, n. 2: 150-160. DOI: 10.3847/AER2003022
To assist instructors (Astro 101) who want to help their students develop better critical thinking skills related to astronomical pseudoscience, a range of ideas and resources is listed in this guide (many older links, but still a good reference).

Fraknoi, A. (2009). **Astronomical Pseudo-Science: A Skeptic's Resource List**, Foothill College & Astronomical Society of the Pacific. Retrieved May 31, 2019 from https://www.astrosociety.org/education/astronomy-resource-guides/astronomical-pseudo-science-a-skeptics-resource-list/

Gartland, G. (2018) ***Kyrie Irving Says Instagram Taught Him That Earth Is Flat***, Sports Illustrated. Retrieved from https://www.si.com/nba/2018/01/12/kyrie-irving-celtics-flat-earth-instagram

*****Gauchat, G.W. (2012). **A Test of Three Theories of Anti-Science Attitudes.** *Journal of Sociological Focus.* 41:4, pages 337-357.
Using the 1993 General Social Survey (GSS), this study compares three different explanations of anti-science (i.e., negative attitudes toward science). The first theory suggests that a lack of scientific knowledge engenders anti-science attitudes. The second perspective points toward strong religious faith or evangelical beliefs as the primary impetus of anti-science attitudes. A third approach suggests anti-science attitudes are a result of the social context of individuals. All three explanatory factors contribute to our understanding of anti-science.

*****Gauchat, G. (2015) **The Political Context of Science in the United States: Public Acceptance of Evidence-Based Policy and Science Funding.** *Social Forces* 94:2, pages 723-746.

Google Trends, Google searches for "flat earth" for past 5 years, with related topics, retrieved from: https://trends.google.com/trends/explore?date=today%205-y&geo=US&q=flat%20earth

*Hartman, R.O., Dieckmann, N.F., Sprenger, A.M., Stastny, B.J., and DeMarree, K.G. (2017) **Modeling Attitudes Toward Science: Development and Validation of the Credibility of Science Scale.** *Basic and Applied Social Psychology* 39:6, pages 358-371.

Ingold, J. (2018). **We went to a flat-Earth convention and found a lesson about the future of post-truth life.** Retrieved from: https://coloradosun.com/2018/11/20/flat-earth-convention-denver-post-truth/

Jones, K. (2018) **Kyrie Irving Apologizes for Saying the Earth Is Flat**. Sports Illustrated. Retrieved from https://www.si.com/nba/2018/10/01/kyrie-irving-earth-flat-apologizes.

*Klinger, Art. (1998). **The Earth is Flat, and I Can Prove It!** *Science Scope*, v21 n4 p35-36.
Describes an educational program that asks students to attempt to prove that the Earth is spherical and that it rotates. Presents tips to pique student interest and charts related to sensing the spin, nonrotation notions, flat Earth fallacies, evidence that the Earth is spherical and rotates, and the role of watersheds in proving that the Earth rotates.

Landrum, A.R. (2018). **Believing in A Flat Earth**. Presentation at AAAS Annual conference, February 17, 2018. Abstract retrieved from: https://aaas.confex.com/aaas/2018/meetingapp.cgi/Paper/21432

Landrum, A.R. (2019). **YouTube as the Primary Propagator of Flat Earth.** Symposium at the American Association for the Advancement of Science (AAAS) Washington, D.C.
Retrieved from:
http://www.asheleylandrum.com/uploads/4/7/8/3/47833717/landrum_2019_02.18_aaas_online.pdf

*Lewandowsky, S., Oberauer, K., & Gignac, G. E. (2013). **NASA faked the moon landing—Therefore, (climate) science is a hoax: An anatomy of the motivated rejection of science.** *Psychological Science, 24*, 622–633.

*Lewandowsky, S., Cook, J., Oberauer, K., Brophy, S., Lloyd, E. A., & Marriott, M. (2015). **Recurrent fury: Conspiratorial discourse in the blogosphere triggered by research on the role of conspiracist ideation in climate denial.** Journal of Social and Political Psychology, 3, 142–178.

*Lightman, Alan and Sadler, Philip. (1998). **The Earth Is Round? Who Are You Kidding?** *Science and Children*, p24-26.
Describes an activity using a large balloon to help children understand that, even though the horizon appears to be flat, the Earth is, indeed, round. Uses a toy ship to reinforce evidence from the first part of the activity. Stresses the importance of confronting naive theories at an early age.

McIntyre, L. (2019). **The Scientific Attitude: Defending Science from Denial, Fraud, and Pseudoscience,** The MIT Press.
This new book by the author of *Post-Truth* is getting very good reviews, including the following by Michael Shermer, publisher of Skeptic Magazine and columnist for Scientific American; Presidential Fellow at Chapman University; author of Why People Believe Weird Things, The Believing Brain, The Moral Arc, and Heavens on Earth: “After a three-decade career devoted to studying (and often debunking) pseudoscience and science denial, I am emboldened by Lee McIntyre's deeply insightful examination and clarification of what, exactly, science is and how it differs from pseudoscience. In this age of fake news and alternative facts, when creationists, climate deniers, and anti-vaxxers are taken

seriously by media and voters, this important book could not come at a more crucial time. Now, more than ever, evidence matters, and the evaluation of evidence is what science does best."

*****Morgan, M., Collins, W., Sparks, G., and Welch, J. (2018) **Identifying Relevant Anti-Science Perceptions to Improve Science-Based Communication: The Negative Perceptions of Science Scale.** *Social Sciences* 7:4, pages 64.

*****Motta, M. (2018). **The Polarizing Effect of the March for Science on Attitudes toward Scientists.** *PS: Political Science & Politics* 51:4, pages 782-788.
Americans' attitudes toward scientists have become more negative in recent years. Although researchers have considered several individual-level factors that might explain this change, little attention has been given to the political actions of scientists themselves. This article considers how March for Science rallies that took place across the United States in late April 2017 influenced Americans' attitudes toward scientists and the research they produce. An online panel study surveying respondents three days before and two days after the March found that liberals' and conservatives' attitudes toward scientists polarized following the March. Liberals' attitudes toward scientists became more positive whereas conservatives' attitudes became more negative. However, the March appears to have had little effect on the public's attitudes about scientific research. In addition to answering questions about the March's political impact, this research calls attention to the possibility that the political actions of scientists can shape public opinion about them.

*****Motta, M., Callaghan, T., and Sylvester, S. (2018) **Knowing less but presuming more: Dunning-Kruger effects and the endorsement of anti-vaccine policy attitudes.** *Social Science & Medicine* 211, pages 274-281.

*****Motta, M. (2018) **The Dynamics and Political Implications of Anti-Intellectualism in the United States.** *American Politics Research* 46:3, pages 465-498.

*****Michaluk, M. Stoiko, R., Stewart, G., and Stewart, J. (2018) **Beliefs and Attitudes about Science and Mathematics in Pre-Service Elementary Teachers, STEM, and Non-STEM Majors in Undergraduate Physics Courses.** *Journal of Science Education and Technology* 27:2, pages 99-113.

National Center for Science Education (NCSE)
Dealing with Denial: https://ncse.com/dealingwithdenial
God and Evolution: https://ncse.ngo/god-and-evolution

Since 1981 NCSE has "worked to ensure that what is taught in science classrooms and beyond is accurate and consistent with the best current understanding of the scientific community." NCSE is a non-profit, 501(c)(3) organization that was initially established to coordinate grass roots science organizations working to counter the teaching of creationism alongside or instead of evolution. The NCSE website includes several resources and links to additional resources related to dealing with science denial, particularly related to climate change and evolution. NCSE helps train teachers and community volunteers in approaches that have been proven to reduce conflict and help learners overcome even deeply held misconceptions.

Nguyen, H. (2018) **Most Flat Earthers Consider Themselves Very Religious.** Retrieved from https://today.yougov.com/topics/philosophy/articles-reports/2018/04/02/most-flat-earthers-consider-themselves-religious

Provides an overview of the YouGov poll of the U.S. public's views of the Earth's shape. (However, note there were some issues identified with the poll results – see Scientific American blog post by Foster).

NISE Net Explore Earth and Space Toolkits: Tips for leading hands-on activities and contentious topics
http://www.nisenet.org/catalog/explore-science-tips-leading-hands-activities
This simple reference sheet offers basic tips for leading the hands-on activities in the Earth and Space Science Toolkits. It includes suggestions for engaging and encouraging visitors, as well as for handling difficult concepts and misconceptions.

Oliver, J.E. and Wood, T.J. (2014) **Conspiracy Theories and the Paranoid Style(s) of Mass Opinion.** In *American Journal of Political Science.* https://onlinelibrary.wiley.com/doi/full/10.1111/ajps.12084
Although conspiracy theories have long been a staple of American political culture, no research has systematically examined the nature of their support in the mass public. Using four nationally representative surveys, sampled between 2006 and 2011, we find that half of the American public consistently endorses at least one conspiracy theory and that many popular conspiracy theories are differentiated along ideological and anomic dimensions. In contrast with many theoretical speculations, we do not find conspiracism to be a product of greater authoritarianism, ignorance, or political conservatism. Rather, the likelihood of supporting conspiracy theories is strongly predicted by a willingness to believe in other unseen, intentional forces and an attraction to Manichean narratives. These findings both demonstrate the widespread allure of conspiracy theories as political explanations and offer new perspectives on the forces that shape mass opinion and American political culture.

Pappas, S. (2018) **A Third of Young Millennials Are Confused About This Incontrovertible Fact.** Retrieved from Live Science at: https://www.livescience.com/62220-millennials-flat-earth-belief.html

Public Policy Polling (2017). **National Survey** Retrieved from https://www.publicpolicypolling.com/wp-content/uploads/2017/09/PPP_Release_National_22417.pdf

*****Roser-Renouf, C. and Maibach, E.W. (2018) **Strategic Communication Research to Illuminate and Promote Public Engagement with Climate Change**. In: Hope D., Bevins R. (eds) *Change and Maintaining Change*. Nebraska Symposium on Motivation, vol 65. Springer, Cham.
DOI: 10.1007/978-3-319-96920-6_6
In this chapter, we describe Global Warming's Six Americas – six unique audience segments that view and respond to the issue in distinct ways. We describe the beliefs and characteristics of each group and discuss methods of effectively communicating with them in light of: (1) the pro- or counter-attitudinal nature of messages on the issue for each group; (2) their willingness to exert the cognitive effort necessary to process information on the issue; (3) their propensity for counter-arguing, motivated reasoning and message distortion; and (4) the communication content they say they most desire and, hence, would be most likely to process and accept.

Sample, I. (2019) **Study blames YouTube for Rise in Number of Flat Earthers**. Retrieved from: https://www.theguardian.com/science/2019/feb/17/study-blames-youtube-for-rise-in-number-of-flat-earthers

Siegel, E. (2017) **Five Impossible Facts That Would Have to be True if the Earth Were Flat**: Simple observations that you can make from the ground to demonstrate the Earth is round.
Retrieved from https://medium.com/starts-with-a-bang/five-impossible-facts-that-would-have-to-be-true-if-the-earth-were-flat-7d72c69f73ec

Schottlender, M. (2016). **10 easy ways you can tell for yourself that the Earth is not flat.** https://www.popsci.com/10-ways-you-can-prove-earth-is-round

*****Sinatra, G.M., Kienhues, D., and Hofer, K.H. (2014) **Addressing Challenges to Public Understanding of Science: Epistemic Cognition, Motivated Reasoning, and Conceptual Change.** *Journal of Educational Psychologist*. 49:2, pages 123-138.
As scientific problems increase in their number and complexity, so do the challenges facing the public in understanding these issues. This paper focuses on three of those challenges: the challenge of reasoning about knowledge and the processes of knowing, the challenge of overcoming biases in that reasoning, and the challenge of overcoming misconceptions. The authors propose that research in epistemic cognition, motivated reasoning, and conceptual change can help to identify, understand, and address these obstacles for public understanding of science. They explain the contributions of each of these areas in providing insights into the public's understandings and misunderstandings about knowledge, the nature of science, and the content of science. The article closes with educational recommendations for promoting scientific literacy.

*****Sinatra, G.M., Kienhues, D., and Hofer, K.H. (2014) **Public Understanding of Science: Policy and Educational Implications.** In *Policy Insights from the Behavioral and Brain Insights.* 3:2, pages 245-253. https://journals.sagepub.com/doi/10.1177/2372732216656870
The need for public understanding of science is especially critical in today's society when citizens frequently confront complex, conflicting information on challenging topics. This article presents research on challenges for public understanding of science: In addition to increased scientific literacy (knowledge), people may need to shift epistemic cognition (beliefs about the nature of knowledge) and epistemic trust (beliefs about source credibility) to accept scientific perspectives. The article suggests how educators, media specialists, and scientists who communicate about their work might help address these challenges. Educational implications include (a) teach scientific processes, (b) teach for deeper understanding, (c) promote epistemic cognition, and (d) use instructional scaffolds. Policy recommendations include (a) fund educational research on thinking, (b) emphasize how to think over what to think, (c) support malleable psychological skills and dispositions, (d) avoid presenting "balanced perspectives" when there is scientific consensus, and (e) demand more rigorous teacher preparation standards. All these develop an informed citizenry.

*****Stewart, C.O., McConnell, J.R., and Dickerson III, D.L. (2017). **Socioscientific and epistemic dimensions of support for science: associations with science education and religiosity**. *International Journal of Science Education, Part B* 7:1, pages 1-13.

Thaller, M. (2018) **Big Think Top Ten - Ask an Astronomer: Is There Proof the Earth is Round?** NASA astronomer, Dr. Michelle Thaller, explains three proofs that debunk the belief that the Earth is flat. https://www.youtube.com/watch?v=550q8rkh7ns.

*****Torres, J.R. (2008). **How Do Preservice Teachers' Religious Beliefs Affect Their Understanding of Astronomy?** *Astronomy Education Review,* 7 (2), 25-39.
http://dx.doi.org/10.3847/AER2008018
This article describes research on conceptions of preservice science teachers (fourth year undergraduates) relating to: whether Earth is the center of the Universe; whether the sky is a literal vault or dome; whether Earth is flat or round; the timeline of the formation of the Universe; and the age of the Earth. The results, which indicate that religion has a strong influence on teachers' astronomical

beliefs, are potentially helpful to professors of astronomy who have an opportunity to correct preservice teachers' misconceptions.