Placing Urban Schools at the Forefront of the Revolution in Earth Science Education

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ABSTRACT

Space-age technologies have revolutionized Earth science, but this revolution has yet to extend to Earth science education. Urban schools, however, can be at the forefront of reform because cities offer a wealth of opportunities and resources for study. By relying on publicly-available aerial and satellite perspectives of urban areas and tapping into ground and historical data and easily used visualization tools, students can understand their cities as dynamic, interconnected systems of human and environmental forces. Using the powerful views of astronaut and satellite imagery to study Los Angeles, for example, students can acquire skills of inquiry, analysis and problem solving as they learn how the city is shaped by its environment, climate and geography. Themes for urban Earth science studies include regional ecology, climate, water resources and transportation. In engaging students in Earth science studies of their metropolitan areas, schools can meet critical goals of state frameworks as well as of the National Science Education Standards and the National Geography Education Standards. Educators can present Earth science in a way that is relevant and accessible to students, helping to forge a science-literate public and placing urban school districts in the vanguard of Earth science education.

INTRODUCTION

Earth science education is in the midst of a revolution (National Conference on the Revolution in Earth and Space Science Education) and the reasons are twofold. First, Earth science itself is emerging as an increasingly vital discipline that informs critical endeavors ranging from urban planning and weather forecasting to energy procurement and resource management. As a result, citizens will need to grasp basic Earth science concepts to make decisions of economic, political, social and environmental consequences. The National Science Education Standards recognizes this need by focusing on "Earth and Space Science" as a core domain of science education at all grade levels. The Standards recommend that students experience Earth and space science as a process of inquiry, exploration and discovery.

Secondly, new generations of technology have endowed Earth scientists with powerful tools that reveal with convincing clarity the planet's systemic components and their complex interactions. Resources like telecommunications, data visualizations, analysis tools, remotely sensed imaging and a rich array of satellite sensors enable us to understand our world as never before. Many of these resources are widely available to classrooms, which fuels momentum for Earth science education reform. NASA, USGS, NOAA and other organizations post a wealth of satellite imagery, animations, interactive maps and other visualizations posted on the Internet. These resources empower learners to see how Earth's forces affect their daily lives and to understand the planet as a dynamic system.

Attempts to reform Earth science education in urban schools, however, have had frustratingly little impact (AGI, National Status Report on K-12 Earth Science Education, 2001). Even with major initiatives to install computers and telecommunication technology in urban schools, there is disproportionately little effort to develop educational activities that use these resources to truly engage and challenge students.

Ironically, urban areas are rich with opportunity for learning and exploration in Earth science. Urban schools should be at the cutting edge of reform, not only due to the great need, but also because of the opportunities and resources inherent in cities, such as natural parks to explore, water and other resource agencies with experts and data to share, and a wealth of remotely-sensed image and GIS maps showing cities and their physical and human infrastructure in impressive detail. Viewing cities as resources and the focal point of study helps students understand key aspects of the National Science Education Standards, such as the "unifying concepts and processes" of science like "systems"—how components and processes interact. Cities offer a strong context for learning and exploring systems. Water supplies, waste processing, electric grids, food distribution and transportation all interact to make a city work. Cities also interact with the physical environment—most are near rivers, tall buildings are built where bedrock is close to the surface, growth follows the natural landscape, and so on.

LEARNING THE EARTH SCIENCE OF CITIES

By focusing on Earth science topics of relevance to urban students and by integrating satellite data sources, orbital and aerial photography, and visualization tools into their science curricula, urban schools can support a wonderful and engaging array of student explorations of urban environments. Students can study their cities from the unique perspective of space using images of metropolitan areas that range from decades of archived imagery to the high-resolution, multi-spectral imagery from newer sensors. They can use interactive maps to overlay and analyze regional data and use annotations to share their investigations with others.

These resources strongly complement ground-based and historical data. Students can cross-reference remotely-sensed images with a progression of historical maps to study the development of their cities. They can link detailed satellite images of rivers and waterways with data about water processing and distribution from the regional water commission. They can link satellite-based data on surface geology with borehole data collected for new building construction. These experiences empower students to see their cities (and others worldwide) with new eyes.

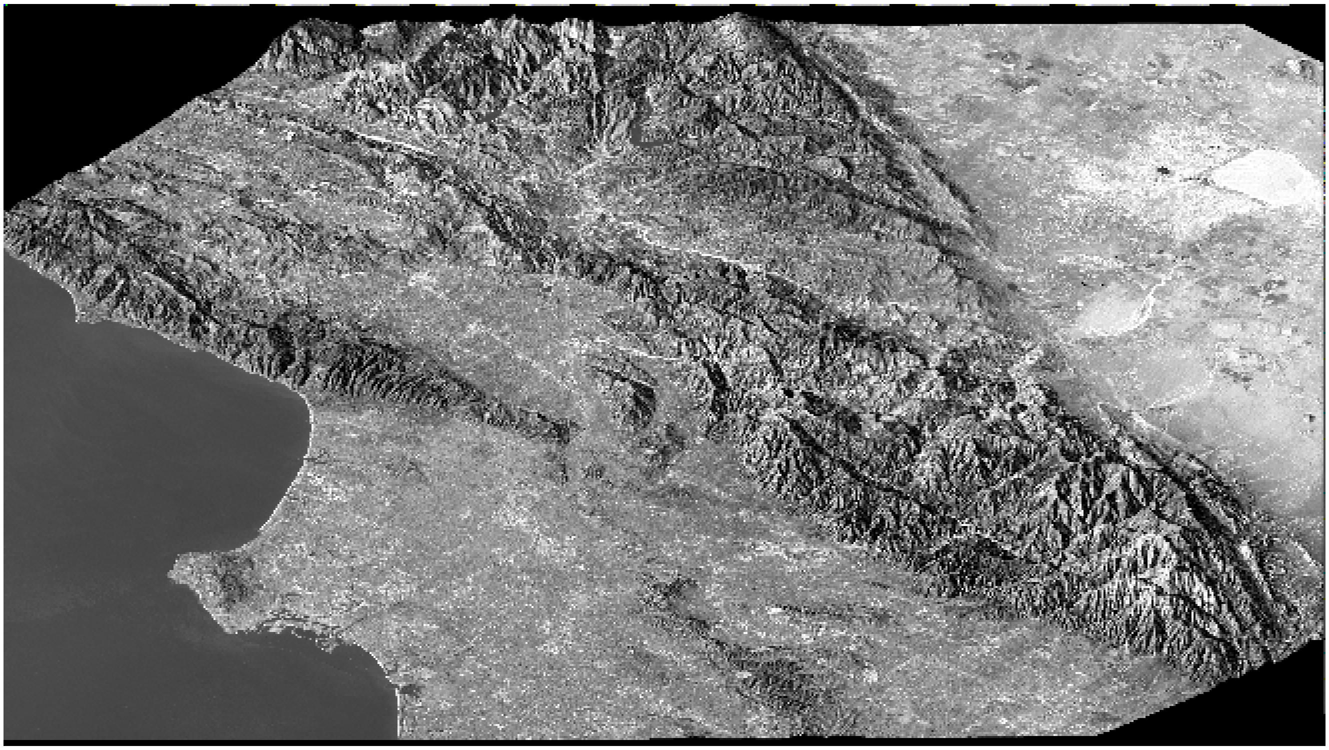

Figure 1. The Los Angeles Basin. This image was created from digital elevation data, seismic data, Landsat images, and shuttle astronaut photos (Dr. Robert Crippen, NASA JPL).

Using remotely-sensed data and easy-to-use visualization tools, minority and under-represented urban students can view their own environments with new eyes, and better understand how Earth science and human geography relate to their own lives. They can understand their urban areas as marvelously dynamic, interconnected systems, full of data resources, and ripe with opportunities for inquiry and exploration using direct observation, satellite technology and computer-supported analysis. This powerful strategy can help urban students learn essential concepts in Earth science and human geography, as well as skills of inquiry, analysis and problem solving.

LOS ANGELES: A SAMPLE URBAN INVESTIGATION

Los Angeles is a city shaped by its physical environment. In figure 1, students can see the mountains surrounding the Los Angeles region and fault lines caused by plate tectonics. The threat of earthquakes is an underlying presence. Students can identify the fault lines and use data on recent seismic activity to compare seismic values and corresponding risk in different parts of the city.

Los Angeles is a thirsty city. Los Angeles is located in one of the most arid regions of the U.S. Urban growth now spills onto the Mojave Desert. The regional climate, evidenced by the greenness of local vegetation and the distribution of aqueducts and reservoirs, can be seen in satellite color imagery. Satisfying Los Angeles water demands has helped shape regional politics in California and the southwest. Students can map L.A.'s aqueducts and canals, and trace others throughout southern California, monitor cumulative rainfall, collect data on water usage throughout the city, and tap into data and discussions about proposed solutions to water-related issues.

Los Angeles is a city on wheels. Looking at images of Los Angeles from space, one is struck by the grid of highways and roads throughout the entire basin (see figure 2). Large-scale transportation of goods and people is a defining element of the region, and leads to several potential investigations about regional transportation. How are the various transport systems integrated and how do they impact the physical environment? Traffic flow patterns can be overlaid and analyzed. Such analysis provides new insight on changes in development and settlement patterns.

Putting these pieces into a larger context, students can see Los Angeles as a large metropolitan region, shaped by and reshaping its physical environment, that has evolved over time into a complex multi-faceted region, linked by ubiquitous transportation routes moving people and goods throughout the region. Students begin to perceive how they and their neighborhoods fit into this larger context, how such knowledge might help them take better advantage of what the city offers, and possibly find new answers to problems affecting their neighborhoods. They also project into the future to think about how the city might change in the next few decades based on projected population growth and limiting resources.

While this example focuses on the new insights and perspectives on urban areas afforded by satellites, on-the-ground field experiences are certainly an essential and equally important component of urban geoscience education. Whether students simply explore the areas around their school and neighborhood, or extend their field work to sites of unique interest (such as urban parks, water systems, exposed building sites, water processing plants, or weather forecasting centers), they see that Earth science is something that happens all around them.

LEARNING GOALS

Such an approach to urban Earth science education strongly supports state frameworks as well as the

Figure 2. Los Angeles at Night. An image of Los Angeles taken from the International Space Station.

National Science Education Standards and National Geography Education Standards. It enables teachers to address some of the following topics commonly found in state and national standards:

Science as Inquiry – Students ask questions about urban environments, and pursue answers using satellite images, visualizations and other primary data sources.

Earth Science – Students learn about cities as dynamic systems and learn about Earth science in the context of their local environments.

Science and Technology – Students experience technology through visualizations, telecommunications and remote sensing as an integral part of their science inquiry, exploration and discovery.

Science in Personal and Social Perspectives – Cities feature the interconnections among populations, resources and environments.

Unifying Concepts and Processes – Students will learn about cities as systems, use images as evidence, explore how cities have both constancy and change, infer how cities evolve over time, and investigate the form and function of each city's elements.

The World in Spatial Terms – Students will use images, maps and visualization technologies.

Places and Regions – Students can learn about the physical environment and the human characteristics of cities, exploring how they affect each other.

Physical Systems – Students can explore cities as ecosystems (with natural and human elements) and investigate the differences in these ecologies around the world.

Human Systems – Students can investigate human settlement patterns in their own city and in others around the world, looking for similarities and differences in the patterns and functions of human settlement in urban areas.

Interpreting the Past – Students can develop skills of geographic inference to find and interpret evidence of past development based on recent images. Students can use historic maps as data and as a contrast with current remotely-sensed images.

Plan for the Future – Students can develop and apply a range of geographic skills to interpret the present nature of the cities. Students also can use this knowledge and these skills to better understand current social and environmental problems.

SAMPLE THEMES FOR URBAN INVESTIGATIONS

In studying their urban environments, students can rely on the many perspectives offered by multiple data sources with a range of spatial scales and spectral representations, like interactive animations, overlay options and 3-D perspectives. The images (and student experiences) spark questions and focus attention on core themes. How have the mountains and coastline defined the development of the city? What other environmental factors (e.g. water resources, petroleum resources and the distribution of green belts, parks and nature preserves) have influenced, or been impacted by, urban growth? How do students' homes, schools and neighborhoods relate to the physical geography of the city?

Sample themes for student investigations could include:

1. Regional Ecology (the "big picture"): Students can combine imagery from NASA and others with local data to explore the regional ecology of cities. This could include describing (both qualitatively and quantitatively) topography, hydrology, soil types, agricultural production patterns, and so on. Students can analyze these variables from the inner city to the outlying areas, and look for similarities and differences among cities.

2. Natural Hazards and Disasters: Floods, volcanoes, blizzards, earthquakes, hurricanes, tsunamis and other natural phenomena can seriously impact cities where population density and dependence on the surrounding environment are high. Students can explore the effect of potential volcanoes in Tokyo, with it population of more than 12 million people, and Seattle, a much smaller city with suburbs that spread up the slopes of solidified mudflows from Mount Rainier.

3. Climate: The continental climate of Moscow includes sweltering summers and six-month periods when snow is common. Minneapolis has somewhat cooler summers and cold but dry winters with little snow accumulation. In contrast, Phoenix enjoys a warm, sunny, and snow-free climate but receives less than 8 inches of precipitation annually. Students could explore the factors that account for both the similarities and differences in climate for these three cities.

4. Water Resources: As cities grow, some exceed their water supplies and need new and sometimes distant sources. Los Angeles pipes water from the central and northern parts of the state as well as from the Colorado River. In contrast, Riyadh, Saudi Arabia desalinates seawater, taps subterranean reservoirs and purifies and recycles 200,000 cubic meters of water each day. Students could explore the hydrology and the water supplies for both cities.

5. Transportation: While students may appreciate a city's transportation systems, they are less likely to understand that transportation lines have always been the lifelines of cities. New York City's position at the mouth of the Hudson River and Manhattan's long shoreline and deep water all contributed to that city's emergence as a major trade center. Stockholm, Sweden sits at a strategic point where shipping can pass from the Baltic Sea to inland waterways.

SAMPLE WEB RESOURCES

There are many data sets available for students on the World Wide Web. Many feature search engines or other mechanisms that allow learners to access images of specific urban areas. As starting points, here are two outstanding examples:

NASA Earth Observatory – a wonderful site with weekly updates on Earth science in the news, featured images and links to NASA satellite data sources. Often the images and stories feature urban areas. (earthobservatory.nasa.gov)

Astronaut photos of cities – NASA astronauts have taken over 400,000 photos of Earth from space – many of these photos show cities around the world. These will help students compare cities globally and see the changes over the few decades of human flight. (eol.jsc.nasa.gov/cities)

CONCLUSIONS

The revolution in Earth science research enabled by the space-age perspective and visualization technologies have radically transformed the practice of Earth science—especially in providing new and deeper insights into Earth as a system. As the movement grows to infuse this revolution into the classroom, urban schools have the opportunity to be at the cutting-edge of reform.

Student investigations of cities, such as the examples above, offer urban schools an opportunity to advance to the forefront of Earth science education. Educators can present Earth science in ways that are relevant and accessible to their students. Students, after all, will study the environment they know best and care most about.

Moreover, urban investigations offer teachers a powerful strategy for meeting state and national science standards. They can bring true inquiry into classrooms and introduce students to visualization technologies. In studying their urban environments, students can learn vital Earth science concepts, such as every environment, from global to local levels, is comprised of dynamic and interacting systems. They can learn to access, compare and analyze a variety of sources, from orbital photography and remotely-sensed satellite imagery to ground data and historical records.

Perhaps most importantly, viewing cities through the illuminating lens of Earth science can help produce a science-literate public. It can motivate minority and under-represented urban students to pursue careers in science, mathematics, engineering and technology. It might even inspire the next generation of explorers from the ranks of our urban students.

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