WATCHING OVER TEXAS FROM SPACE

An Earth Observations education resource for grades 4 -12 in support of TEKS covering
Earth Science and Environmental Science Standards

Section 1. Introduction for Teachers

Watching over Texas from Space has been growing over the past six years, as TexasView has expanded its outreach effort through teacher-training workshops. It is modeled after an online publication from the Canada Centre from Remote Sensing ***"Watching Over Our Planet from Space"*** (Microsoft Word - watching_part1.doc (nrcan.gc.ca). The initial lessons were developed specifically to address the Eighth-grade requirement for Texas' Earth and Space Science course that states ***"the student is expected to interpret topographic maps and satellite views to identify land and erosional features and predict how these features may be reshaped*** **by weathering".** Teachers from other grade levels always attend these workshops and found the lessons applicable for diverse requirements. Lessons that provide imagery for teachers to use at multiple grade levels have been integrated with lectures and games, to enable teachers to easily find and use imagery in the classroom and in laboratory activities to address knowledge and skills defined within the Texas Essential Knowledge and Skills (TEKS) standards. The imagery used in the lessons is predominantly over the State of Texas, but the topics that are covered also fit very well with national-level standards defined in the Next Generation Science Standards (NGSS).

1.1. Insertion points

My approach to helping teachers integrate satellite imagery into their curriculum uses a concept that I call "insertion points". It is based on the idea that imagery is a tool that teachers can learn to use for many applications, e.g.:

- To address specific scientific process and content knowledge and disciplinary core ideas required by Texas Essential Knowledge and Skills and standards and Next Generation Science Standards Disciplinary Core Ideas
- To introduce specific skills required by standards
- To capture students' attention with visually appealing views of Earth's surface from their own geographic region

To enable teachers to insert imagery into a lecture, an assignment, or an activity, my approach identifies targeted knowledge and skills where imagery can meet teachers' needs and then provides examples that are ready to use and easily accessible and replicable. Within this teachers' guide I have focused on a limited number of insertion points, which are common between the Texas

Essential Knowledge and Skills (TEKS) standards for Earth and Space Science and the Next Generation Science Standards (NGSS) for Earth's Systems. This section provides examples of the *insertion points* at multiple grade levels in the form of tables. Table 1 groups key words and phrases identified in common between the standards and shows which of the lessons and activities address those phrases and words. If you are looking for a specific topic area such as "changes to Earth's surface features' (e.g. weathering, erosion; deformation) or "impact of humans on Earth's subsystems" (e.g. development; energy production; use of fresh water), Table 1 is the place to start.

Tables 2 and 3 show the specific standards for which insertion points have been identified and incorporated into the lessons and activities in this document. If you need an overview of specific TEKS or NGSS standards identified as insertion points, Tables 2 and 3 provide details.

1.1.1 Insertion Point Key Words and Phrases

Table 3 combines key words and phrases common between the TEKS and NGSS, across multiple grade levels ranging from Elementary through Middle and High School. These will be highlighted for each of the lessons and activities in the following sections. Teachers should be able to search for lessons and activities by key phrases and key words in Table 3, extracted from Tables 1 and 2. Some landforms or human impacts are not explicitly mentioned in the standards, but are included in the table*.

Key Phrase	Key Word(s)	TEKS	NGSS	Lesson/activities
Identify changes to Earth's surface features		X		Which is Which?; How is Texas Changing?;
	Weathering	X	X	
	Mass wasting		X	
	Erosion	X	X	
	Deposition	X	X	
	Deformation		X	
	Wind	X	X	
Recognize landforms/ land features				Which is Which; How is Texas Changing?; Find It; Measure It; Monahans Sandhills; Texas as Art
	Deltas	X	X	
	Dunes	X		
	Canyons	X		
	Mountains		X	
	Valleys	*	*	
	Rivers	*	X	
	Lakes	*	*	
	Plateaus		X	
	Bays	*	*	
	Barrier Islands	*	*	

Key Phrase	Key Words	TEKS	NGSS	Sections that cover
	Channels	*	*	
	Wetlands		X	
	Islands	*	*	
	Beaches			
Interpret Earth's surface features using a variety of methods				Which is Which; How is Texas Changing?; Find It; Measure It; Monahans Sandhills; Texas as Art
	Satellite imagery	X	X	
	Aerial photography	X		
Impact of changes in Earth's subsystems and natural hazards				Which is Which; How is Texas Changing?; Texas as Art
	Snow storm	*	*	
	Dust storm	*	*	
	Volcanic eruption	X	X	
	Hurricane	X	X	
	Flooding	X	X	
	Storm surges	X		
	Fires (wildfire)	X		
	Drought	X		
Impact of humans on Earth's subsystems				Which is Which; How is Texas Changing?; Find It; Measure It; Monahans Sandhills; Texas as Art
	Population growth	X	X	
	Development	*	*	
	Use of fresh water	X	X	
	Fossil fuel burning	X		
	Dams		X	
	Energy production	X	X	
	Agriculture	*	*	
Use of resources: impacts Earth's subsystems				Which is Which; How is Texas Changing?;
	Environmental impacts	X	X	
Earth's systems continuously change over a range of time scales		X	X	Which is Which; How is Texas Changing?;
	Rate of (change)	X	X	
	Water movement/runoff	X	X	

Table 1. Key words and phrases common between TEKS and NGSS and the lessons and activities that address these insertion points.

1.1.2 Texas Essential Knowledge and Skills (TEKS) Standards Insertion Points

Table 1 shows Elementary, Middle, and High School TEKS standards by grade level, topic or course, content knowledge, and expected skills that have been identified as insertion point targets for the use of satellite imagery in classroom and laboratory activities. Key words and phrases are highlighted that associate with different activities and lessons in ***Watching over Texas from Space***.

TEXAS ESSENTIAL KNOWLEDGE AND SKILLS (TEKS)			
GRADE LEVEL	**TOPIC or COURSE**	**KNOWLEDGE**	**SKILLS**
Grade 4 Science	Earth and Space	(7) Earth and space. The students know that Earth consists of useful resources and its ***surface is constantly changing***. The student is expected to:	(B) observe and identify slow changes to Earth's surface caused by ***weathering, erosion, and deposition from water, wind, and ice***
Grade 5 Science	Earth and Space	(7) Earth and space. The student knows Earth's ***surface is constantly changing*** and consists of useful resources. The student is expected to:	***(B) recognize how landforms such as deltas, canyons, and sand dunes*** are the result of ***changes to Earth's surface by wind, water, and ice***
Grade 7 Science	Earth and Space	(8) Earth and space. The student knows that ***natural events and human activity can impact Earth systems.*** The student is expected to:	(B) analyze the effects of ***weathering, erosion, and deposition*** on the environment in ecoregions of Texas
Grade 8 Science	Earth and Space	(9) Earth and space. The student knows that ***natural events can impact Earth systems.*** The student is expected to:	(C) interpret topographic maps and satellite views to identify ***land and erosional features*** **and predict *how these features may be reshaped* by weathering**

High School	Earth and Space	(11) Solid Earth. The student knows that the ***geosphere continuously changes over a range of time scales*** involving dynamic and complex ***interactions among Earth's subsystems.*** The student is expected to:	(A) compare the roles of ***erosion and deposition*** through the actions of ***water, wind, ice, gravity, and igneous activity*** by lava in constantly reshaping Earth's surface
High School	Earth Science	(11) Solid Earth. The student knows that the ***geosphere continuously changes over a range of time*** scales involving dynamic and complex ***interactions among Earth's subsystems***. The student is expected to:	(D) ***interpret Earth's surface features using a variety of methods such as satellite imagery, aerial photography, and topographic and geologic maps*** using appropriate technologies
High School	Earth Science	(11) Solid Earth. The student knows that ***the geosphere continuously changes over a range of time*** scales involving dynamic and complex ***interactions among Earth's subsystems. The student is expected to:***	(E) evaluate the ***impact of changes in Earth's subsystems on humans*** such as ***earthquakes, tsunamis, volcanic eruptions, hurricanes, flooding, and storm surges*** and the ***impact of humans on Earth's subsystems*** such as ***population growth, fossil fuel burning, and use of fresh water.***
High School	Earth Science	(12) Solid Earth. The student knows that ***Earth contains energy, water, mineral, and rock resources and that use of these resources impacts Earth's subsystems.*** The student is expected to:	***(D) analyze the economics of resources from discovery to disposal, including*** technological advances, ***resource type, concentration and location,*** waste disposal and recycling, and ***environmental costs***

Table 2. Texas Essential Knowledge and Skill Standards (TEKS) insertion point targets for the use of satellite imagery in classroom and laboratory activities.

1.1.3 Next Generation Science Standards Correlations

Table 2 shows Elementary, Middle, and High School NGSS standards by grade level, topic or course, disciplinary core idea, and expected skills that have been identified as insertion point targets for the use of satellite imagery in classroom and laboratory activities. Key words and phrases are highlighted that associate with different activities and lesson in ***Watching over Texas from Space***.

NEXT GENERATION SCIENCE STANDARDS			
GRADE LEVEL	**COURSE**	**DISCIPLINARY CORE IDEA**	**SKILLS**
Grade 4 Science	Earth's Systems	**4-ESS2-1:** Rainfall helps to shape the land and affects the types of living things found in a region. ***Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.*** *Students who demonstrate understanding can:*	Make observations and/or measurements to provide evidence of the ***effects of weathering or the rate of erosion by water, ice, wind, or vegetation.*** [Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, ***relative rate of deposition,*** cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.]
Grade 4 Science	Earth's Systems	**4-ESS2-2:** The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. ***Maps can help locate the different land and water features areas of Earth.*** *Students who demonstrate understanding can:*	***Analyze and interpret data from maps to describe patterns of Earth's features.*** [Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes]

Middle School	Earth's Systems	**MS-ESS2-1:** All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. ***The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials*** and living organisms. *Students who demonstrate understanding can:*	Develop a model to ***describe the cycling of Earth's materials*** and the flow of energy that drives this process. [Emphasis is on the processes of melting, crystallization, ***weathering, deformation, and sedimentation***, which act together to form minerals and rocks through the cycling of Earth's materials.]
Middle School	Earth's Systems	**MS-ESS2.2:** Water's movements—both on the land and underground—cause ***weathering and erosion, which change the land's surface features*** and create underground formations. *Students who demonstrate understanding can:*	Construct an explanation based on evidence for how ***geoscience processes have changed Earth's surface at varying time and spatial scales.*** [Examples of geoscience processes include ***surface weathering and deposition by the movements of water, ice, and wind.***]
Middle School	Earth's Systems	**MS-ESS3-2:** ***Mapping the history of natural hazards in a region***, combined with an understanding of related geologic forces ***can help forecast the locations and likelihoods of future events.*** *Students who demonstrate understanding can:*	***Analyze and interpret data on natural hazards to forecast future catastrophic events*** and inform the development of technologies to mitigate their effects. [Examples of ***natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as***

			hurricanes, tornadoes, and floods*)*. Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. ***Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires****)* or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]
Middle School	Earth's Systems	**MS-ESS3-3:** Human activities have significantly altered the biosphere, sometimes ***damaging or destroying natural habitats*** and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. *Students who demonstrate understanding can:*	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Examples of the design process include ***examining human environmental impacts,*** assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. ***Examples of human impacts can include water usage*** (such as the withdrawal of water from streams and aquifers or the ***construction of dams*** and levees), land usage (such as ***urban development, agriculture, or the removal of wetlands***), and pollution (such as of the air, water, or land)].

Middle School	Earth's Systems	**MS-ESS3-4:** Typically, as ***human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth*** unless the activities and technologies involved are engineered otherwise. *Students who demonstrate understanding can:*	Construct an argument supported by evidence for how ***increases in human population and per-capita consumption of natural resources impact Earth's systems.*** [***Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change.***
High School	Earth's Systems	**HS-ESS2-1:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *Students who demonstrate understanding can:*	Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. [***Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus****)* and sea-floor features (such as trenches, ridges, and seamounts) ***are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).***
High School	Earth's Systems	**HS-ESS2-2:** ***Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.*** *Students who demonstrate understanding can:*	Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth

			systems. [Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in ***water runoff and soil erosion***; how dammed rivers increase groundwater recharge, decrease ***sediment transport, and increase coastal erosion***; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]
High School	Earth and Human Activity.	**HS-ESS3-1:** Resource availability has guided the development of human society. ***Natural hazards and other geologic events*** have shaped the course of human history; they have significantly altered the sizes of human populations and have driven human migrations. *Students who demonstrate understanding can:*	Construct an explanation based on evidence for how **the *availability of natural resources, occurrence of natural hazards***, and changes in climate ***have influenced human activity.*** [Examples of key natural resources include access to ***fresh water (such as rivers, lakes, and groundwater),*** regions of fertile soils such as river deltas, and high ***concentrations of minerals and fossil fuels***. [Examples of ***natural hazards can be from*** interior processes (such as volcanic eruptions and earthquakes), ***surface processes (such as tsunamis, mass wasting and soil erosion), and***

			severe weather (such as hurricanes, floods, and droughts).]
High School	Earth and Human Activity.	**HS-ESS3-2:** All forms of *energy production* and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and ***environmental impacts.*** *Students who demonstrate understanding can:*	Evaluate competing design solutions for developing, managing, and utilizing *energy and mineral resources* based on cost-benefit ratios. [Examples include developing best practices for ***agricultural soil use***, mining (for coal, tar sands, and oil shales), and pumping (for ***petroleum and natural gas***).]
High School	Earth and Human Activity.	**HS-ESS3-4:** Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ***ecosystem degradation.*** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and ***environmental impacts***. *Students who demonstrate understanding can:*	Evaluate or refine a technological solution that reduces ***impacts of human activities on natural systems.*** [Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or ***areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining.***]

Table 3. Next Generation Science Standards (NGSS) insertion point targets for the use of satellite imagery in classroom and laboratory activities.