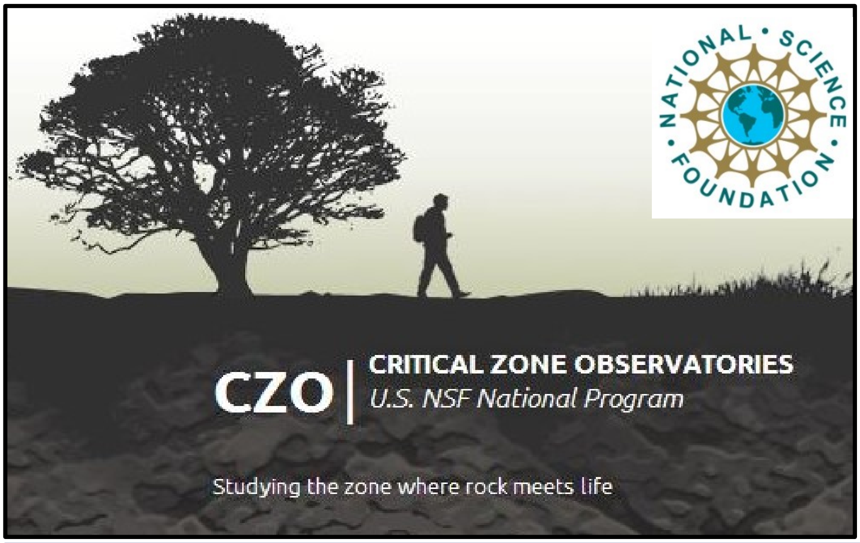

Connectivity of Global Ecosystems: The Influence of Dry Deserts on Tropical Rain Forests

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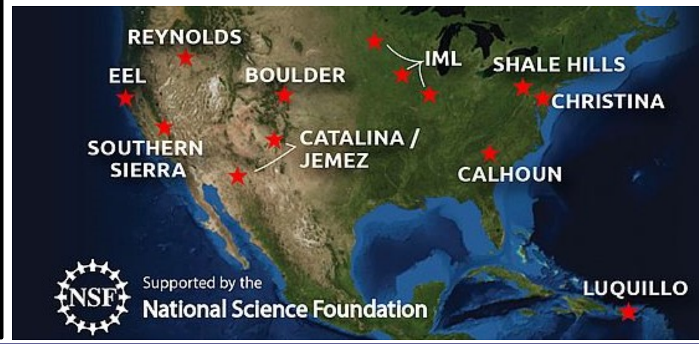
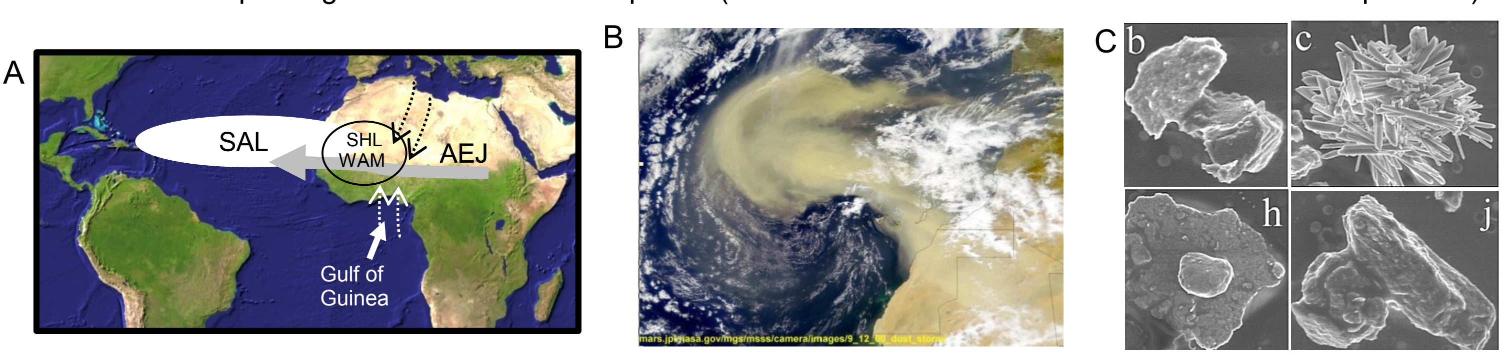


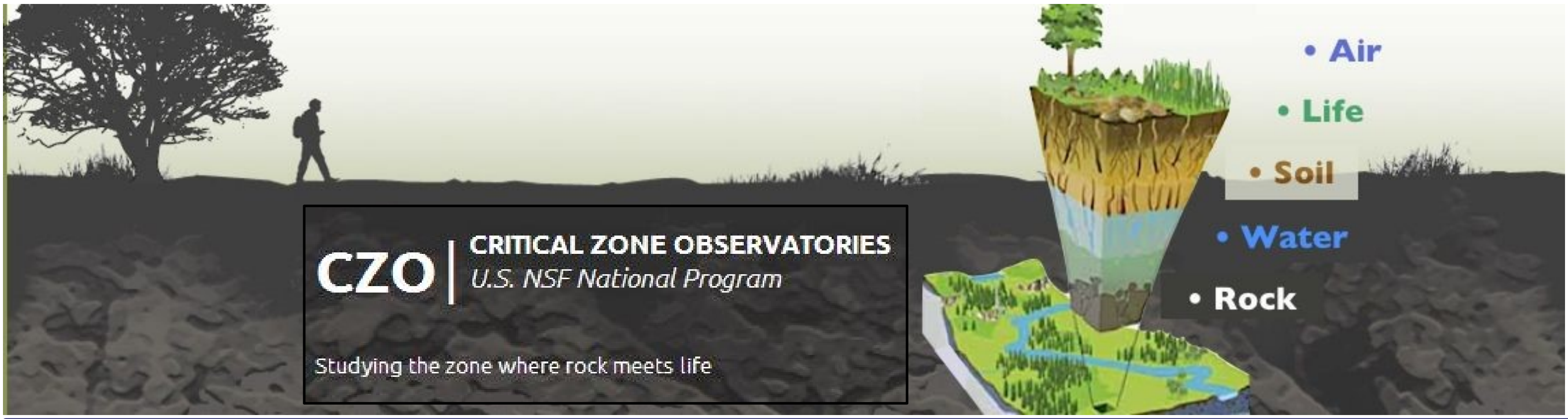
The Critical Zone: The Earth's Critical Zone (CZ) is defined as the surface of Earth extending from the boundary between the vegetation and atmosphere, down through the soil, and to belowground depths where groundwater and bedrock interact. The CZ is where terrestrial life, including humanity, resides. The CZ provides many of the resources organisms need including fresh water, sustainable soils and a balanced atmosphere. Critical Zone science is an emerging field of Earth Science seeking to integrate across multiple scientific disciplines to study how the CZ supports life and how the CZ responds to change. Ten Critical Zone Observatories (CZOs) have been established to support integrative research of CZ processes (criticalzone.org). CZ science requires large-scale systems thinking to understand all of the factors that influence the CZ. One such example of the connectivity of Earth's Critical Zone is dust and nutrient inputs that originate from the Saharan and Sahel Deserts on the African continent and are deposited in neotropical rain forests via precipitation events in the Luquillo Mountains of Puerto Rico and the Luquillo CZO.

National Science Standards & Objectives: This activity meets National Science Standard ***HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.*** Use this activity as part of the Life Science unit on Interdependent Relationships in Ecosystems or the Earth and Space Science unit on Weather and Climate. Students should be familiar with concepts of convective systems, trade winds, nutrient cycling and ecosystems. ***The objectives*** of this activity are to demonstrate that **(1)** Earth's ecosystems and Critical Zones are inextricably linked via feedback processes and **(2)** nutrients that feed ecosystems can be derived from outside the system. We encourage instructors to use their creativity to modify and adapt this activity to meet their needs. **Timing**: Parts I-II: 60-90 min.

Part I: African Dust Storms (A): The Saharan and Sahel regions of North and West Africa have an arid climate with little plant growth. The desert heat creates rising air motions, leading to a large, strong surface low pressure system (Saharan Heat Low; SHL). As boreal spring transitions to summer at northern latitudes, moisture from the Gulf of Guinea penetrates into the Sahel, driving the formation of the West African Monsoon (WAM). Typically, temperatures decrease from the tropics pole-ward; however, during this time there is a reversal in this archetype leading to easterly winds through much of the atmosphere (African Easterly Jet; AEJ). The dry (northern; black dashed lines) and moist (southern; white dashed lines) air masses form a strong atmospheric frontal boundary across the Sahel which spur large thunderstorm development (~80% of Sahelian annual rainfall occurs June-September).



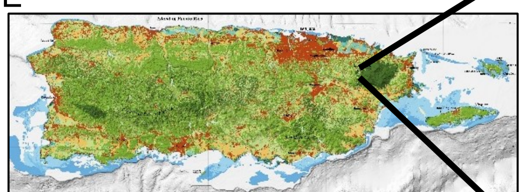
Dust storms are common during the WAM. These dust storms are produced by large near-surface winds generated by low level jets associated with the SHL, local orography, large scale weather systems intruding from the north and regional thunderstorms. Each phenomenon lofts dust particles high in the atmosphere for efficient long range transport via the AEJ. This dust-laden air mass is known as the Saharan Air Layer (SAL) **(B)**. Airborne dust particles **(C)** contain essential elements (e.g. calcium) derived from the Earth's crust which fertilize neotropical rain forests.
Visit: http://criticalzone.org/national/education-outreach/k-12-education-1national/ for larger versions of figures, supplemental resources including video of African dust storms (Link: *African_Dust_Supplementary*).



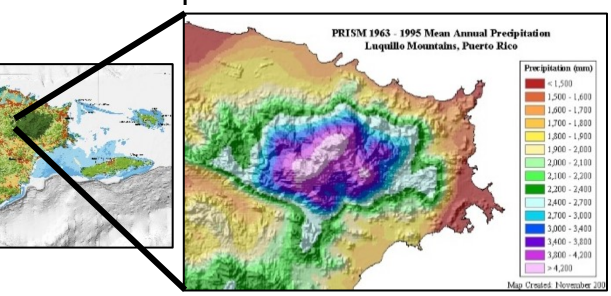
Part II: Dust and nutrient inputs into tropical rain forests. As the SAL moves across the Atlantic and into the Caribbean, elements derived from dust storms in North and West Africa are deposited into tropical island ecosystems. One major site of deposition is the Luquillo Mountains of Puerto Rico. The Luquillo Mountains are home to one of the ten CZOs (**D**). The Luquillo CZO in particular provides a unique setting to quantify the dust and nutrients that arrive in the neotropics due to the SAL. The Luquillo Mountains extend upwards on the NE corner of Puerto Rico (**E**) with peak elevations of approximately 1050 meters. This creates a precipitation gradient which increases with elevation (**F**). Precipitation events promote the deposition of Saharan and Sahelian dust and crustal elements including calcium which is essential for soil fertility.

D

E



F



In the below portion of the activity, students will download rainwater chemistry data and look for seasonal patterns of calcium inputs. Students will then interpret how precipitation-derived calcium compares with seasonal patterns of the SAL and seasonal dust inputs. Students should work to interpret the data to show the connectivity of meteorological process in North and West Africa and nutrient inputs into tropical rainforest.

Materials needed:

Computer with internet access

Overhead projector for viewing slides contained within supplementary information

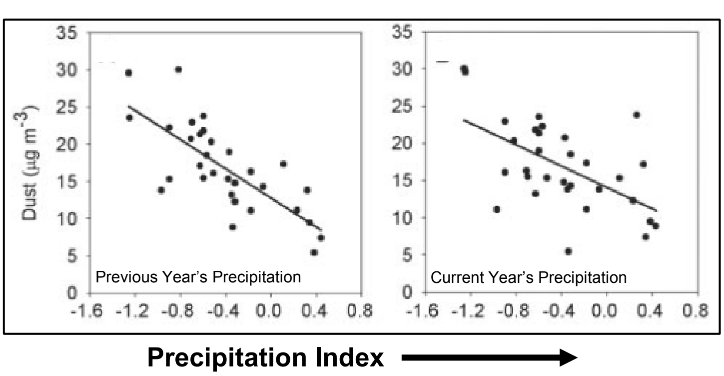
Working knowledge of Excel

Directions for activity:

1. Go to: http://criticalzone.org/national/education-outreach/k-12-education-1national/, and download the excel worksheet: *Rain_chemistry_data_AGI.*
2. Read information on "Instructions" tab
3. Have students determine monthly averages for rainwater chemistry
4. Have students build graphs to compare the different sites and depositional processes

Part III. Activity extension: **1)** Students generate hypotheses for how changes in Saharan and Sahelian precipitation influence dust export to the Caribbean (**G:** See Supplementary Material) **2)** Students research examples of global transport (**H:** See Supplementary Material) **3)** Students research local examples from their community that receive external inputs (e.g. air quality). **Timing**: Various length depending on scope of projects.

G



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