A Climate Change Journal

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Fig. 1: View of Pacific from central Peruvian coast

The oceans reach their greatest expanse in the tropics. Ten thousand miles of Pacific straddles the equator, an endless vista of deep blue water through which anything rising from the depths can be seen as a ghostly silvery form, even far below the surface.

That tropical ocean draws light from a wide pale sky and feeds a vast heat engine rising from the sea and high into the atmosphere. The feelers of this engine reach even to high latitudes as they spread energy and water everywhere. Ultimately, this diffusing energy makes the world that we have.

The beating heart of the tropical heat pump is the ENSO-El Nino and linked monsoon phenomena. The pump fluctuates, especially in the eastern tropical Pacific. There, an irregular rhythm drives great oscillations in climate conditions as normally dry deserts in Peru are flooded and tropical rainforest in Borneo burns. Ocean life swings from dense abundance off the coast of South America, to near absence and large scale migration (of those that can) to distant locales.

That beat rises from the tropics on the wings of atmospheric circulation and spreads to the ends of the earth, bringing water or drought and often heat in unusual measure to distant Canada and Africa. Nearly all life is impacted by ENSO's samba.

The earth captures heat in the tropics and the pulsations of the ocean and atmosphere spread it to higher latitude; and at the poles delicate climate balances respond. Stately tropical process becomes magnified and one response builds on another bringing swift, even abrupt, change. Within the lifetime of ordinary people, the northern world shifts its face. Once mountains draped in ice become free and green-grey with moss and lichen. A solid ocean becomes liquid and blue. Solar energy once reflected back to space is greedily absorbed, concentrating even more warmth and change.

Over time, the dance of energy over the earth's surface changes. Flows have been different in the past. Now, as we feed ever more greenhouse warming into the atmosphere, they are shifting again. We want to know what the change will be like?

Humans rely on the flows of energy in so many ways, and assume a constancy that our very actions challenge.

What will the changes be? Where and how big? The answers lie in knowing the rhythms and the interconnections from equator to poles. They lie in having a sense of those rhythms through time.

We capture a view of the heat engine, and its distant consequences, by investigation in Peru and in Svalbard, land's northernmost edge on the Arctic sea. Peru brings us to the heart of ENSO, Svalbard gives us a planetary response to our CO_2 push.

Peru, in all its natural aspects, reflects the ocean-atmosphere coupling which is ENSO. Desert banks along a cold ocean filled with marine life fed by the nutrients rising from the deeps (and ultimately the subantarctic) in response to tradewinds blowing surface waters ever westward. Waters even 1000 years old rise to the sunlit shallows here. Then, all that stops. The ocean warms, life dwindles and the skies pour rain on the dry, cracked, land. El Nino briefly washes the dusty face of western South America. The cold ocean returns again.

Fig. 2: Peruvian coastal ruin

There is a pattern to this, but the pattern changes in time. ENSO responds to the global climate even as it drives it. The 'background state' of the world sends messages back to Peru, then ENSO shifts. But in what way? What has it done during other 'background states'? We need the view of the immortals to know.

We can't do much about how long we live, or how long anyone has been around making measurements along the coast of Peru. But, we can acquire the long view sifting through the rubble of times past. A fascinating opportunity for that is afforded to us through work with NIU archeologist Winifred Creamer and Field Museum director, Jonathan Haas. They have translated great mounds of scatter rock and dirt into the skeletons of mighty citadels built by a shadowy people who traversed the barrens at the foot of the Andes and settled isolated river valleys on the coast of central Peru. There, these Indians made cities of stone, farmed narrow fields with seasonal flow of water from the mountain snowfields, and thrived on the bounty of the ENSO governed sea. They left us piles of clam shells in their trash heaps; their food and

Fig. 3: Grad. student Jennifer Cumpston and undergrad. Neil Rowe sample the Peruvian coastal ocean

our window to their world.

The clams captured month by month the conditions of the ocean in which they lived, preserving that for us to examine. They caught ENSO under different ‘background states’ so that we might see how it behaves. Jennifer Cumpston, graduate student in Environmental Geosciences at NIU is unraveling the story of the clams. She will test ideas on ENSO behavior and global climate change through careful measurement of the year by year record of the clams at key times in human pre-history. Doing this will teach us about our climate system, and it will also let us see how human destiny couples with climate as change forced response and adaptation from the South American natives.

Fig. 4: 'Macha' the surf clam

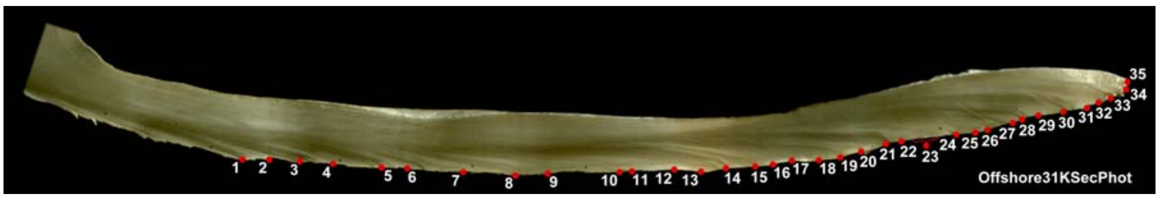

Fig. 5: Macha in cross section showing its growth layers which can be sampled for paleoclimate research and providing a seasonal view of ocean conditions.

In the meantime, El Nino has ruled the eastern tropical Pacific through the last two decades. Earlier this century, and in the last, this was not so. Cool conditions dominated and each El Nino was followed by several years of La Nina cold extremes. We had La Nina last year, but already it is giving way to the warmth. Again, the waters are warm along the coast.

At the other end of the world, ocean swells the color of gun metal, sky pewter grey, sandwich peaked mountains black, serrated, against a narrow horizon. Fjord walls rise from an oily sea in contorted beds of black and ochre. Cloud mists undulate slowly from ridge to crag. Languid tongues of pale blue ice, draped on the edges with black rubble, wind sinuously to the water where they drop great shards into the water. These bob and roll ponderously away from the shore, creaking and popping as they go.

Svalbard is a long way from Peru, but both are deserts. One in dry heat, the other in cold diffuse silver light. On Svalbard during the summer that light is continuous; but winter is relentlessly dark. Then, life waits. Summer is when all can burst out and the sun’s energy provides for ceaseless activity. This is a fiercely seasonal world.

The sun, however, is not the only

Fig. 6: Svalbard fjord in night sunlight

source of energy to the Arctic. The tropics speak hear also. The Gulf Stream has its roots in the equatorial Atlantic close to western Africa. From there it trails across the ocean, drawing tropical solar power as it goes. This it transports all along the eastern seaboard until it turns to the polar ocean. Streaming towards the British Isles, the tropical flow turns past Iceland and reaches to the Arctic. South of Svalbard it slips beneath colder but fresher (so less dense) Arctic water and feels its way along the margin of the islands into the polar basin. In the Arctic, heat comes from beneath.

That Atlantic water also creeps into Svalbard's fjords bringing them nutrients for life and warmth to melt marine ending glaciers. This is a fingerprint of the tropical heat flow that the oceans are feeding to the North Pole.

Fig. 8: Norwegian Polar Institute Research vessel 'Lance' in the Svalbard fjords

The polar ice cap is a mighty reflector of solar energy sitting atop the world. Its existence dominates the climate of the northern world, and is self perpetuating as it rejects the sunlight that would melt it. But, warm water underneath eats at it. The ice cover's continued existence depends on a balance of cold above, water supply from land and warmth and salt from below. The sea ice, and its annual migrations back and forth in the North Atlantic from summer to winter, dictate the rhythm and distribution of life in the Nordic seas. Humans around the North Atlantic have always depended on these rhythms to draw life from the ocean. Those patterns are changing in response to Global Warming. The natives know this and frequently comment on it when we visit for scientific research. How much will it change? How sensitive is the Arctic to altering the global system? Can all that ice really disappear? Again, we need to know the interconnections of the climate parts, and we need perspective in time of how change happens. In this case, the view of the immortals is provided by sediments that accumulate rapidly in the fjords and margins of the Svalbard islands. These are uniquely placed to capture the Arctic scene. The key here is to know how to read the sediments and their contents for the signals we are most interested in. That is our work currently, examining the process of sediment record formation and learning to better draw the past world from this record. NIU graduate student Brittani Duhamel took her first trip to the Arctic this summer and helped an international team of scientists explore the Nordic sediments as part of International Polar Year (IPY) sponsored

Fig. 7: Fjord marine ending glacier, calving ice to the sea

research. There are direct field measurements to be made, and samples that came home for laboratory analysis. The mass spectrometer facilities in the Department of Geology and Environmental Geosciences will play a part here.

Observations in the fjords shows that warm Atlantic water is penetrating further and with more intensity than it has in the past. Ice has responded to this so that it is less well developed in the open water from year to year. On the broader scene, we will once again see a summer with unusually reduced Arctic sea ice cover. It's going quickly. The warmth of the Atlantic continues to harry it.

Fig. 9: Mathieu Richaud, NIU alumnus, WarmPast project researcher

Fig. 10: Brittani Duhamel, NIU grad. student, in the ship's lab space and dressed for deck work

Fig. 11: Co-chief scientist Paul Loubere with NIU crew member Mathieu Richaud retrieving fjord sediments in a multicore