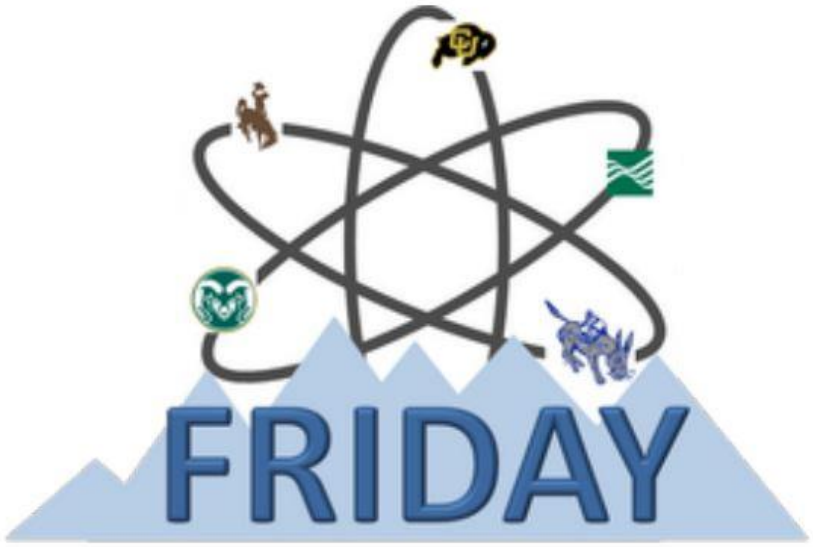
Front Range Isotope Day 2015



Friday, August 7th 2015

U.S. Geological Survey, Denver Federal Center

Program and Abstracts

8:00am **Breakfast**
(courtesy of the Dolan Integration Group)

An opportunity to chat with other guests while enjoying a delicious breakfast buffet. Bagels, assorted breads, cinnamon rolls, Danish, muffins, scones and seasonal fruit. Beverages include coffee, decaf, tea and water.

8:45am **Welcome and Introductions**

A welcome speech by Trude King, the director of the Crustal Geophysics and Geochemistry Science Center.

9:00am **Oral Presentations I**

Nitika Dewan

Tracing dust sources using stable lead and strontium isotopes in Central Asia

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From 1960 to 2014, the Aral Sea's surface area has receded about 90% in size from 68,000 km^2 to 8,444 km^2. Consequently, newly exposed sediments are resuspended by the wind and are now a source of atmospheric particulate matter in Central Asia, which may have an impact on human health and climate. In this study, strontium (Sr) and lead (Pb) stable isotopic ratios, along with other elemental compositions, are used to explore the extent to which Aral Sea sediments are an important source of air pollution to Central Asia. PM_{10} ambient samples were collected at the Bishkek and LIDAR (in Teploklyuchenka) sites from mid-July 2008 to mid-July 2009. These air quality sites are located ~1,200 km and ~1,500 km east-southeast of the Aral Sea. The PM_{10} samples were collected for detailed chemical analysis every other day and included dust and non-dust events. Soil samples also were collected during the study at the Aral Sea and near the Bishkek and LIDAR sites, resuspended, and collected as PM_{10} for chemical analysis. The average $^{87}Sr/^{86}Sr$ ratio for the Aral

Sea sediments was 0.70992 (range, 0.70951 - 0.71064). The Sr isotope ratio in the surface soils in Kyrgyzstan averaged 0.71579 (range, 0.71448 - 0.71739), which is significantly different from the Aral Sea sediments (t-test, $p < 0.05$). In contrast, the airborne PM_{10} collected in Kyrgyzstan had an average $^{87}Sr/^{86}Sr$ ratio of 0.71177 (range, 0.70946 - 0.71335), which is between the two ratios, indicating a possible mixture of sources. However, since no differences in Sr ratios were observed between dust and non-dust events, this imply that the impact of Aral Sea sediments on the sampling sites is minimal. The elemental composition and stable Pb isotope ratios are employed to further understand the source of PM_{10}. Both indicate an anthropogenic source of airborne Pb in Kyrgyzstan.

James Paces

Use of Sr and U isotopes to evaluate water sources and mixing in freshwater and estuarine wetlands

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Understanding wetland water supplies is important for managing resources and determining habitat impacts due to climate change or anthropogenic activity. However, identifying multiple sources and contributions is often difficult due to complex hydrologic, biologic, and chemical processes operating in near-surface environments. Fortunately, heavy radiogenic isotopes (in particular, $^{87}Sr/^{86}Sr$ and $^{234}U/^{238}U$) remain largely unaffected by these processes and can be used to help identify unique signatures from different sources. Combined Sr- and U-isotope data from wetlands in Nevada and California allowed identification of 3-component mixing patterns that were not easily recognized using other chemical approaches. Isotopes of Sr and U are particularly useful because they are relatively abundant in many aqueous solutions, can be analyzed with high precision, may have large differences between sources, and are not fractionated by most near-surface processes. At both sites, mixtures of 3 dominant end members form distorted triangular nets that bound the data and allow contributions from each source to be estimated.

Sources of water in wetlands on the Pahranagat National Wildlife Refuge (PNWR) in southern Nevada consist of discharge from high-volume springs associated with the regional carbonate aquifer and from local volcanic aquifers. Dissolved ions and H-O-S isotopes are strongly affected by evapotranspiration, mineral precipitation, and sulfate reduction in heavily vegetated areas. Unlike other components, $^{87}Sr/^{86}Sr$ and $^{234}U/^{238}U$ do not show seasonal variation at individual sites and define mixtures between surface flow entering the PNWR and diffuse discharge from the shallow volcanic aquifer. Variations depend on location within the wetland and water management practices.

Variations in fluvial and tidal influence in the Sacramento-San Joaquin Delta, CA, have been evaluated over the last 6,000 years using $^{87}Sr/^{86}Sr$ and $^{234}U/^{238}U$ preserved in peat cores. Plants take up substantial amounts of dissolved Sr during growth, whereas redox reactions at the peat-water interface cause immobilization of U dissolved in the water column. Analyses of peat cores show coherent variations in space and time, reflecting substantial changes in proportions of fluvial and seawater components in the estuarine environment. Isotope data show that the largest effects on hydrologic balances in the Delta resulted from resource exploitation and land-use change caused by large-scale development starting in the mid 19th century. More recent water-management practices have started to reverse those trends.

Andrew Doll

Sea lion vibrissae indicate seasonal patterns in trophic consumption

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The vibrissae of Steller sea lions grow continuously without regular shedding. Once grown, these keratinaceous tissues become fixed and thus can represent a multiyear record of dietary consumption. We measured stable isotopes of carbon and nitrogen in segments along the length of vibrissae collected from 12 adult sea lions in the central and western Aleutian Islands; both $\delta^{13}C$ and $\delta^{15}N$ exhibited an oscillating pattern. We paired this data with isotope data from groundfish species collected in the same region to estimate the proportional contribution of these potential prey items. Due to the number of potential prey species, the level of overlap in prey isotopes and the temporal (vs. population) nature of our sea lion data, traditional mixing models were not appropriate for this analysis. Therefore, we used a kernel density approach to describe the isotopic space occupied by each prey species and used these 'utilization distributions' to estimate a probability of each prey's contribution to every vibrissae segment. While the level of overlap in prey isotope values remained too high to make species-level assessments of proportional contribution, we did identify a positive correlation between species of similar trophic levels. Assuming the oscillations in vibrissae isotope values represents an annual signal; our results suggest that Steller sea lions alternate between high trophic level prey in the winter months and low trophic level prey in the summer months. These findings suggest a system level pattern in prey availability which could aid fisheries managers seeking to reduce the role human-competition may play in current sea lion population declines.

Michelle Haddix

Using dual differential isotopic labeling of plant litter to track the contribution of labile and recalcitrant components to soil organic matter formation.

Michelle L. Haddix, Eldor A. Paul, and M. Francesca Cotrufo

The classical view of soil organic matter (SOM) formation is that lignin-like compounds in plant material that resist decomposition are complexed or "humified" and eventually form stable SOM. The application of new techniques has revealed that SOM is mostly made of simple molecules, comprising microbial products and plant material in various stages of decomposition and lignin is not selectively preserved in soil. New plant stabilization frameworks have emerged proposing that mineral stable SOM is formed from the microbial processing of labile plant inputs and subsequent stabilization of those inputs onto mineral surfaces. We set out to test this new stabilization framework using a novel approach of dual ^{13}C and ^{15}N differentially labeled plant material where we are able to isotopically distinguish the metabolic and structural components within a single plant material. We were able to differentially label Big Bluestem (Andropogon gerardii) by growing

seedlings in a dua l isotopic labeling chamber until maturity and, 21 days prior to harvest, removing the plants from the chamber to allow them to incorporate natural abundance ^{13}C-CO2 and natural abundance ^{15}N fertilizer into the metabolic plant components. Using this method we were able to achieve a greater than one atom % difference in ^{13}C between the metabolic and structural components within the litter, but the ^{15}N difference between these two plant components was not as strong. We then incubated this differentially labeled litter with soil at 35°C, for 386 days with destructive harvests at 14, 28, 147, and 386 days. CO2 was measured throughout the incubation and at each harvest the soil was fractionated into light fraction, sand, silt, and clay. We did not see a significant difference in the amount of litter biomass stabilized or the proportion of litter stabilized versus respired over time. We found isotopically labeled plant material already in the mineral fraction after 14 days of incubation. Only the metabolic litter component was found! in the sand, silt, or clay fraction with the structural component only being found in the light fraction. These results support the stabilization framework that mostly labile plant components are being stabilized onto mineral surfaces.

10:30am **Coffee Break and Poster Session I**
(all-day beverages courtesy of Elementar)

Enjoy your choice of beverages and snacks while reading the posters on display at the back of the conference room.

11:00am **Oral Presentations II**

Shannon Murphy

Impacts of nutrient subsidies on salt marsh food webs

Shannon Murphy, University of Denver, Gina Wimp and Danny Lewis, Georgetown University

Anthropogenic nutrient inputs into native ecosystems cause fluctuations in resources that normally limit plant growth, which has important consequences for associated foodwebs. Such inputs from agricultural and urban habitats into nearby natural systems are increasing globally and can be highly variable, spanning the range from sporadic to continuous. Despite the global increase in anthropogenically-derived nutrient inputs into native ecosystems, the consequences of variation in subsidy duration on native plants and their associated foodwebs are poorly known. Specifically, while some studies have examined the effects of nutrient subsidies on native ecosystems for a single year (a nutrient pulse), repeated introductions of nutrients across multiple years (a nutrient press) better reflect the persistent nature of anthropogenic nutrient enrichment. Using stable isotopes of nitrogen and carbon, we tested the effects of a one-year nutrient pulse with a four-year nutrient press on arthropod consumers in two salt marshes. We found that plant biomass and %N as well as arthropod density fell after the nutrient pulse ended but remained elevated throughout the nutrient press. Notably, higher trophic levels responded more strongly than lower trophic levels to fertilization, and the predator/prey ratio increased each year of the nutrient press, demonstrating that foodweb responses to anthropogenic nutrient enrichment can take years to fully manifest themselves.

Christopher Laughrey

The Stable Isotope and Noble Gas Geochemistry of a Natural N_2 Gas Reservoir, Northwestern Denver-Julesburg Basin, Goshen County, Wyoming

Natural gas produced from the Permian Hartville sandstone in the Samson Oil and Gas Bluff #1-11 well in Goshen County, Wyoming is composed of 97.58% N_2, 2.05% CH_4, 0.17% CO_2, 0.151 to 0.152% He, and trace amounts of C_2H_6 through C_6+ hydrocarbons and argon. The N_2/Ar ratio is 7,933.3, a value that eliminates air contamination as a possible source of the N_2. The $\delta^{15}N$ of the produced nitrogen gas is +20.4‰, a value compatible with a crustal or magmatic source. The 3He/4He ratio of the Bluff #1-11 gas is 4.5 x 10-8 (R/Ra = 0.032), a value which eliminates a magmatic source from consideration and indicates a crustal origin for the N_2. There are three possible crustal sources for the nitrogen: 1) N2 fixed as NH4+ in potassium-rich sediments; 2) N_2 fixed in biotite and K-feldspar in crystalline rocks; and 3) denitrification of organic matter in hydrocarbon source rocks. The N_2 concentration, $\delta^{15}N$ of the gas, $4He/N_2$ and $N_2/^{20}Ne$ ratios support an interpretation that the N_2 produce d from the Bluff #1-11 well was generated by denitrification of post mature organic matter. The methane $\delta^{13}C$ of the Bluff #1-11 gas is -32.87‰ and the $\delta^{2}H$ of the methane is -173.7‰. These carbon and hydrogen isotopic values, in combination with the chemical composition of the Bluff gas, indicate that the CH_4 is a thermogenic, post-mature gas. The respective C_2H_6 and C_3H_8 $\delta^{13}C$ of the hydrocarbons are -27.9 and -32.3‰. The hydrocarbon gases exhibit a partial isotope reversal with respect to carbon number, i.e., $\delta^{13}C_1 < \delta^{13}C_2 > \delta^{13}C_3$ which suggests mixing of wet and dry thermogenic gases in the Hartville sandstone and/or its source rocks (Pennsylvanian-age Desmoinesian black shales and marlstones) during progressive burial in the Paleogene. The CH_4 and C_2H_6 in the Bluff well gas are co-genetic and were generated through moderate to extensive cracking of oil. The C_3H_8 is residual and was generated earlier from labile (oil-prone) kerogen within the late oil window. The $\delta^{13}C$ of the CO_2 in the gas is -1.6‰. The relative magnitude of isotopic offset between the CO_2 and CH_4 in the gas (αCO_2-CH_4) is 1.03215, a value consistent with a thermogenic origin. Thermal degradation of carbonate minerals in the source rocks is the likely source of CO_2 in the gas. The $^{20}Ne/^{22}Ne$ ratio of 9.461 in the Bluff #1-11 well gas approximates the air ratio of 9.80. Respective $^{38}Ar/^{36}Ar$ and $^{21}Ne/^{22}Ne$ ratios of 0.190 and 0.0365 constrain an atmospheric source for the ^{20}Ne and ^{36}Ar components in the produced gas. R/Ra and $^{20}Ne/^{4}He$ ratios suggest mixing of radiogenic crustal-produced He and Ne with groundwater-transported radiogenic He and atmospheric Ne components. Regional groundwater degassing of ^{20}Ne, ^{36}Ar, and ^{84}Kr is the source of the atmospheric noble gas components in the Bluff well gas.

Leah Morgan

Potassium Isotope ratio measurements elucidate physical, chemical, and biological processes.

Potassium is the last major rock-forming element to be isotopically characterized, due to difficulties with existing analytical techniques. Here we use high-resolution cold plasma mass spectrometry to measure potassium isotopic ratios with precisions improved by a factor of three over previous work. We show that a diverse group of geological and biological samples, including silicate and evaporite minerals, seawater, plant and animal tissues exhibit variability in $^{41}K/^{39}K$ ratios with a total range of ca. 2.6‰. Seawater and seawater-derived evaporite minerals are systematically

enriched in $d^{41}K$ compared to silicate minerals by ca. 0.4 ‰. Igneous, metamorphic, and sedimentary silicates span a range of 2.6‰, and biological samples span a 1.25‰ range. This work suggests that measurements of stable K isotopes will provide unique insights into potassium-based earth and life processes.

12:00pm **Lunch and Poster Session II**
(courtesy of Thermo and Elementar)

Socialize and peruse the posters while enjoying an assortment of sandwiches and wraps (including vegetarian and gluten-free options), salad, cakes and brownies. Coffee, decaf, tea and water are also on-hand.

1:00pm **Oral Presentations III**

Hongyan Luo

NEON stable isotopic measurements

National Ecological Observatory Network (NEON) is a large facility to provide physical infrastructure and information infrastructure to science community to enable understanding and forecasting of climate change, land use change, and invasive species on continental-scale ecology. Stable isotopic measurement as one of the importance ecological research tools has been included in NEON design. An example of the biogeochemical cycle will be given in the presentation to show the stable isotopic measurements at NEON cross atmospheric, terrestrial and aquatic systems. Some technical details such as instrumentation, sampling frequency, system design will be briefly discussed. Some updates about NEON construction status, data availability, and time frame will also be provided.

Craig Stricker

Isotopic incorporation and the effects of fasting and dietary lipid content on isotopic discrimination in large, carnivorous mammals

C. A. Sricker, K.D. Rode, J. Erlenbach, C.T. Robbins, A. Cutting, S. Jensen, S. D. Newsome, S. G. Cherry, G. Stenhouse, M. Brooks, A. Hash, and N. Nicasso

Stable isotope analysis has become a ubiquitous method to assess wildlife diets. However, the utility of this method relies on understanding the relationship between isotopes in animal tissues and diets, and the temporal window that tissues represent. There has been considerable emphasis on understanding isotopic discrimination in omnivores, but discrimination may differ for carnivores, particularly those consuming lipid-rich diets. Here, we examined the effects of several factors important to applying stable isotopes for quantifying high-lipid diets of bears, including dietary lipid

content and fasting behavior. We conducted feeding trials with captive grizzly bears (Ursus arctos) and polar bears (U. maritimus). We observed increasing Δ13C and decreasing Δ15N in plasma with increasing dietary lipid content up to 92% lipid for non-lipid extracted diets. We found that plasma δ15N values changed by 1.6-1.8‰ but δ13C exhibited no trend during fasts for four adult and four yearling grizzly bears. Our estimates for discrimination in blood, hair, and adipose tissue were most similar to other non-marine carnivores, such as mink (Neovison vison) and Arctic fox (Vulpes lagopus), fed fish-based diets, but differed from estimates for omnivores and some of the previous values applied to polar bears. Incorporation in red blood cells and whole blood was ≥ 6 months in larger subadult and adult bears which is considerably longer than previously measured in younger, smaller bears. Our results support the importance of considering the effects of variability in dietary lipid content and body size when estimating diets of carnivores.

Sylvia Michel

Twenty-five years and counting: stable isotopes of greenhouse gases measured by the NOAA-CU INSTAAR cooperative program

Sylvia Michel[1], James White[1], Bruce Vaughn[1], Owen Sherwood[1], Andrea Sack[1], Isaac Vimont[1], Amy Steiker[1], John Miller[1,2], Caroline Alden[1], Edward Dlugokencky[2], Kenneth Masarie[2]

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In 2015 we marked the 25th anniversary of stable isotope measurements in the NOAA Global Greenhouse Gases Reference Network. Our records of $\delta^{13}C$ and $\delta^{18}O$ of CO_2 (since 1990), $\delta^{13}C$ of CH_4 (since 1998), and our up-and -coming measurement systems for δD of CH_4, isotopomers of N_2O, and $\delta^{13}C$ of CO are important tools for understanding sources and sinks of greenhouse gases in this era of global change. However, in order to be useful, isotopic measurements of atmospheric trace gases require a high level of precision and accuracy, and we will discuss some of the challenges of our instrumentation, calibration, and ties to primary standards. We will also explain some of our quality assurance procedures, and how we ensure that we are providing the highest quality data to users (as the data is publicly available). Finally we will discuss some of our scientific findings, highlighting recent changes in $\delta^{13}C$ of CH_4. Whereas previous increases in concentration had only subtle changes in the carbon isotope ratio, the recent rise in CH_4 is concurrent with a significant decrease in $\delta^{13}C$ of CH_4. Our data and simple models suggest an increase in tropical, biogenic sources of methane with only a small contribution from extraction of natural gas and oil or from thawing Arctic permafrost. For $\delta^{13}C$ of CO_2, our long record of atmospheric measurements continues to show the remarkable anti-correlation with CO_2 concentrations at both seasonal and inter-annual timescales, demonstrating the strong role of the terrestrial biosphere in modulating atmospheric CO_2. These analyses underscore the value in measuring stable isotopes of greenhouse gases across a wide global network.

Michael Wunder

Continental-scale, seasonal movements of a heterothermic migratory tree bat

M.B. Wunder (UC Denver), P.M. Cryan (USGS), C.A. Stricker (USGS)

Our aim was to infer seasonal movements of individual hoary bats to better understand their migration and seasonal distribution in North America. We analyzed the stable isotope values of non-exchangeable hydrogen in the keratin of bat hair of animals killed at wind turbine facilities from across North America. We combined isotope data with museum-based distributional information to derive relative probability density surfaces for the geographic origins of individuals. We then mapped directions and distances of seasonal movements. Results indicate that hoary bats summer across broad areas. In addition to previously suspected patterns of latitudinal migration, we uncovered evidence of regular longitudinal movement by hoary bats from inland summering grounds to more thermally stable coastal regions during autumn and winter. Hoary bats migrating through any particular area, such as a wind turbine facility in autumn, are likely to have originated from a geographically expansive summering range. Heavily used migratory routes were not readily apparent and hoary bat migration may be more facultative than previously believed. Better characterization of hoary bat migration patterns and wintering behaviors illuminates our understanding of the evolution of migration and provides context for conserving these migrants.

2:30pm Coffee Break and Poster Session III

(Poster Prize courtesy of Elementar)

The last chance to view the posters and cast your vote for the best one. The poster with the most votes will win the Elementar poster prize.

3:00pm Lab Tour and Demos

Buildings 21, 20 and 15 house a total of 21 mass spectrometers almost all dedicated to isotope ratio analyses.

The isotope ratio mass spectrometry facility tour (building 21)
Sixteen mass spectrometers are housed in building 21 – it's practically a mass spec. museum!

Demonstration of the Nu Instruments AttoM high resolution ICPMS by Aaron Pietruszka
Aaron will be demonstrating the capabilities of one of the facility's newest mass spectrometers.

Demonstration and discussion of the techniques and equipment used in homemade sample preparation systems by Matt Emmons
Intended to be an opportunity to exchange methods and ideas for the construction of mass spec. peripheral systems and modifications.

Tour of the Argon lab in building 15 by Leah Morgan and Mike Cosca
Groups of five-to-ten guests can go across the road to building 15 to tour the cutting-edge Argon lab.

Tour of the Energy Science Center's stable isotope lab in building 20 by Mark Dreier
Groups of five-to-ten guests can go across the road to building 20 to tour the Energy Science Center's stable isotope lab.

Tour and demonstration of the TRIGA reactor by Tim Debey
A groups of approximately fifteen guests can tour the TRIGA reactor. Tim Debey and Brycen Roy will explain what the reactor is used for and how it operates. They will then fire the reactor up and demonstrate its operation (see that Cherenkov glow!)

4:30pm Ice Cream Social

Please stick around after the lab tours and participate in a brief social gathering and sample more than twenty different flavors of ice cream. Other refreshments and snacks will also be available. (Unfortunately, we are prohibited from providing alcoholic beverages on the DFC)
If the weather is conducive, we can sit in the shade of the trees on the lawn outside building 21.