The strength of contributions from topography mismatch and measurement filtering on simulated net ecosystem exchange in complex terrain

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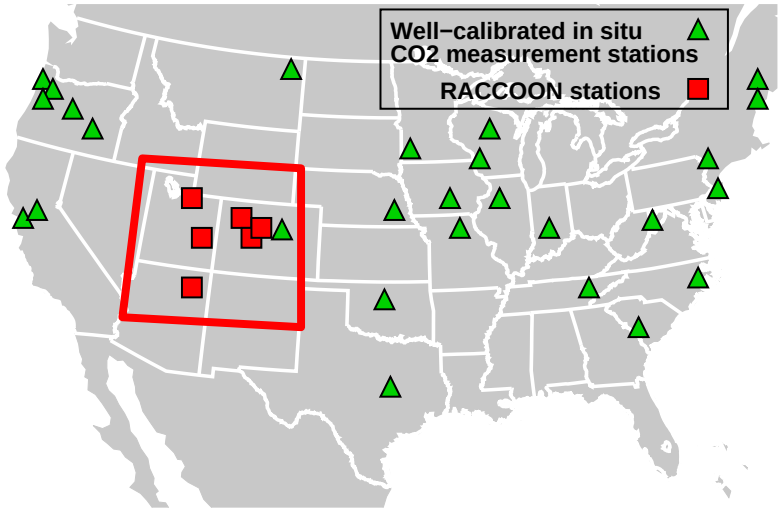
Global scale carbon cycle inversion models

Image taken from USGS Map Maker nationalatlas.gov

- North America is suspected to have significant but highly variable carbon sources and sinks
- These regional sources/sinks are not spatially well-resolved
  - Retrieved NEE over complex terrain is not as well represented due to reduced data assimilation or statistical weighting
  - Coarse-gridded schemes work well for homogeneous terrain/land cover cover (cf. Wu et al., 2011, JGR)

Improving Rocky Mountain representation in a global inversion model

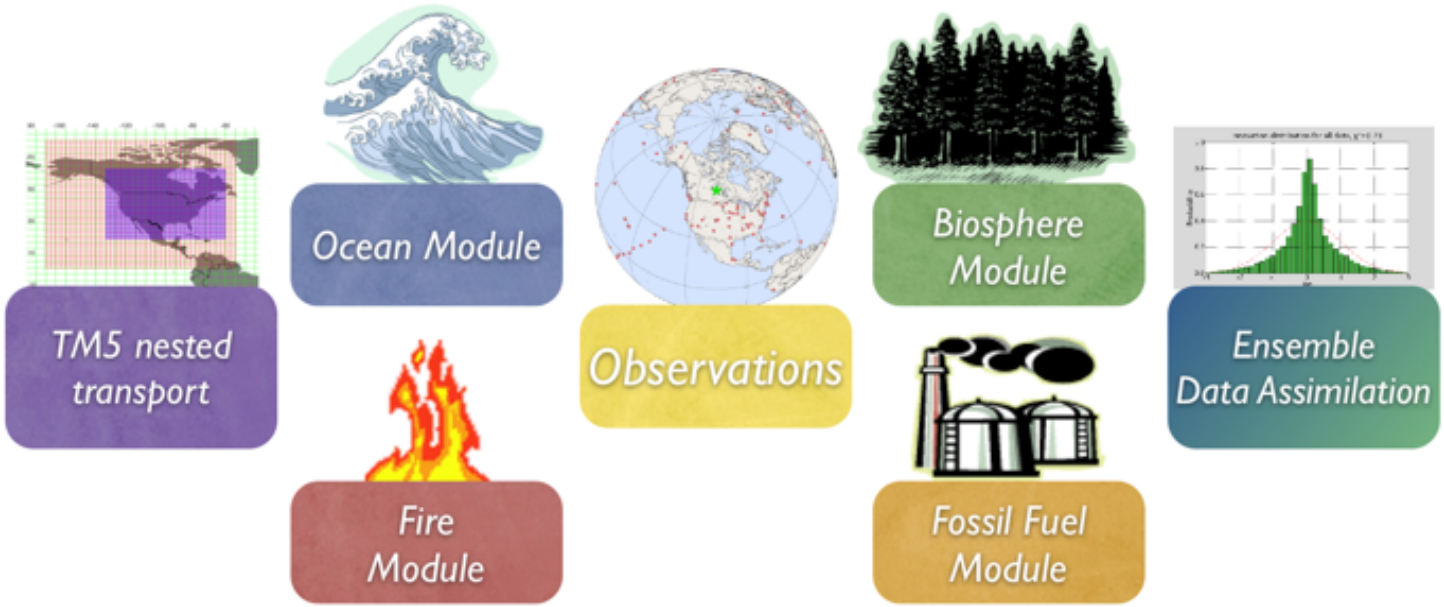
- Regional Atmospheric Continuous CO2 Network RACCOON consists of 6 stations measuring CO_2 mole fractions spanning the past 5 years
- 4 stations have been used for comparison with CarbonTracker (CT) model output



- CO_2 measurements from 2 stations, Niwot Ridge and Storm Peak (NWR, SPL), are included in CT inversions, but these are only nocturnal (0:00–4:00 LT)

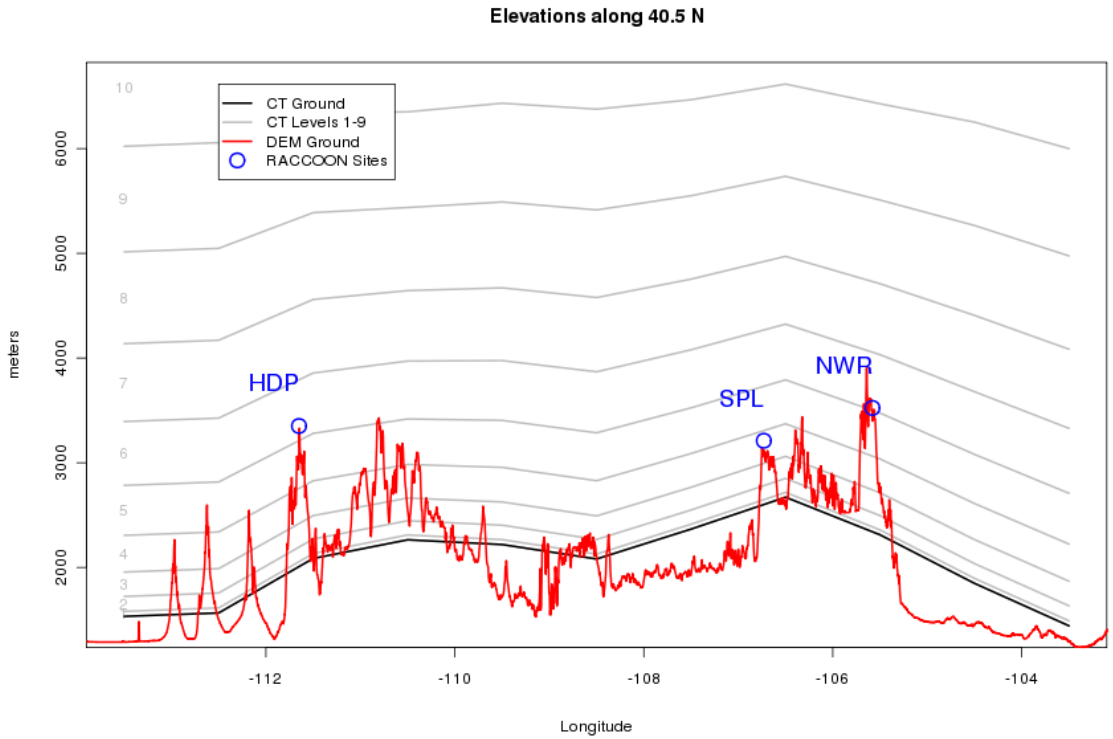
CarbonTracker framework

- Global inverse models provide empirically based estimates of CO_2 exchange useful for estimating regional precedence of carbon sources/sinks
- CarbonTracker's global inversion system uses multiple modules to do tracer-transport inversions that derive flux estimates at a $1^\circ \times 1^\circ$ resolution over North America



Discrepancies between the model and measurement site in complex terrain

Figure: East-West terrain cross-section shows mismatch between CT model surface and 3 RACCOON sites Hidden Peak (Utah), Storm Peak and Niwot Ridge (Colorado), located 40–41N. Elevation data taken from gpsvisualizer.com/profile_input.

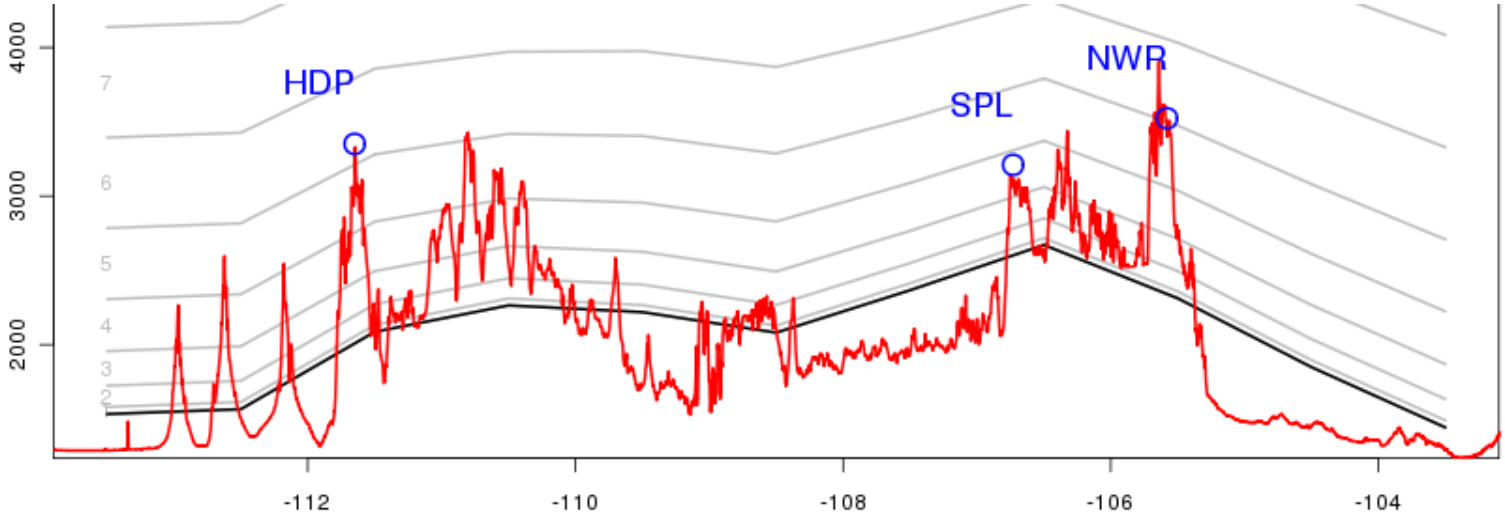


Regional scale carbon cycle inversions

- Regional inversions (de Wekker et al. 2009; Göckede et al. 2010; Desai et al. 2011) have been used to redress two barriers to accurate inversions in complex terrain
  1. Transport wind fields over smoothed model representations of mountain regions are not always sufficiently resolved to inform the model about the source region for assimilated measurements
  2. Coarse gridding of model topography leads the model to sample observations at elevations far above the model surface

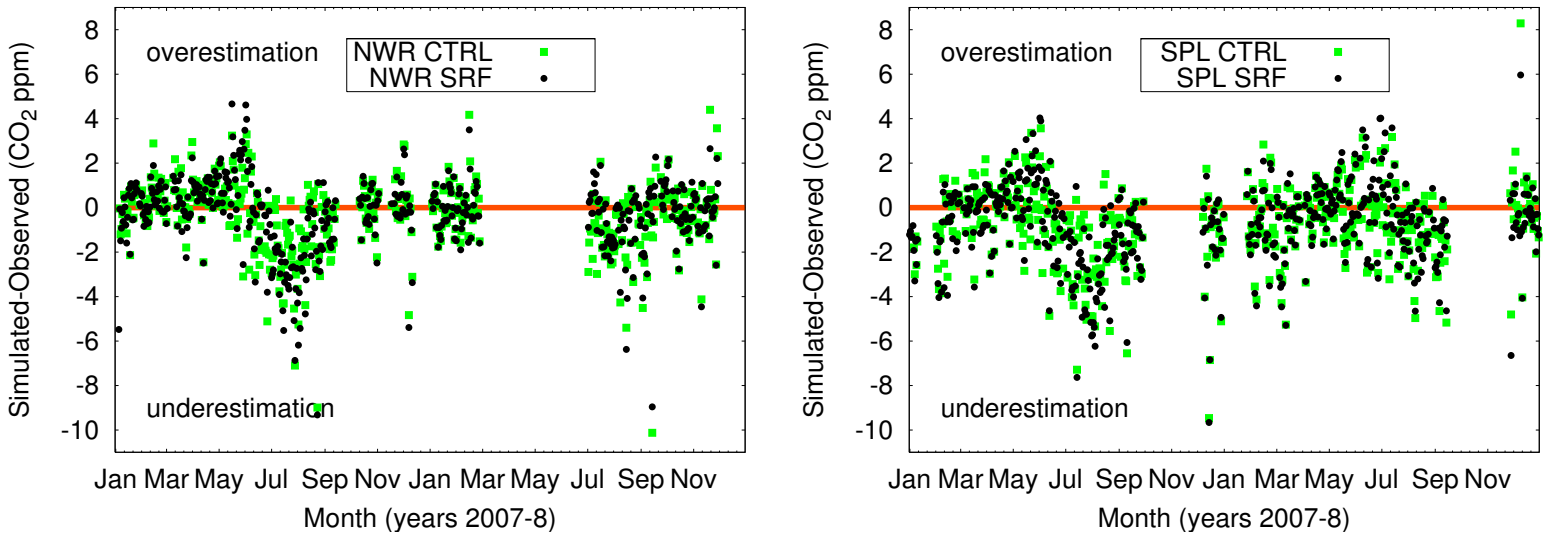
Options for coarse models in complex terrain

- There are several options for coarsely gridded inversions that assimilate observations in terrain
  1. Filter observations to be representative of model's spatial grid or vertical transport capabilities
     - Time of day filtering (nocturnal)
     - Local gradient or lapse rate filtering
  2. Adjust the assimilation protocol to a relative height (to model surface) for assimilated observations



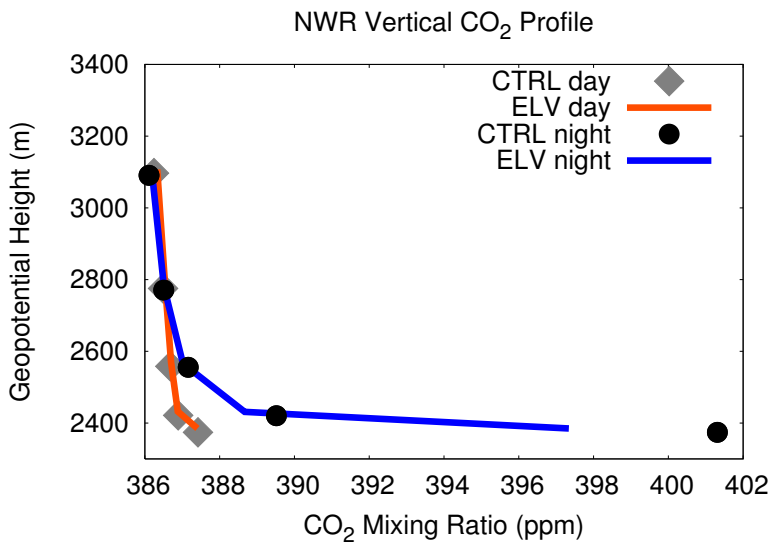
Model-data mismatch: Niwot Ridge & Storm Peak stations

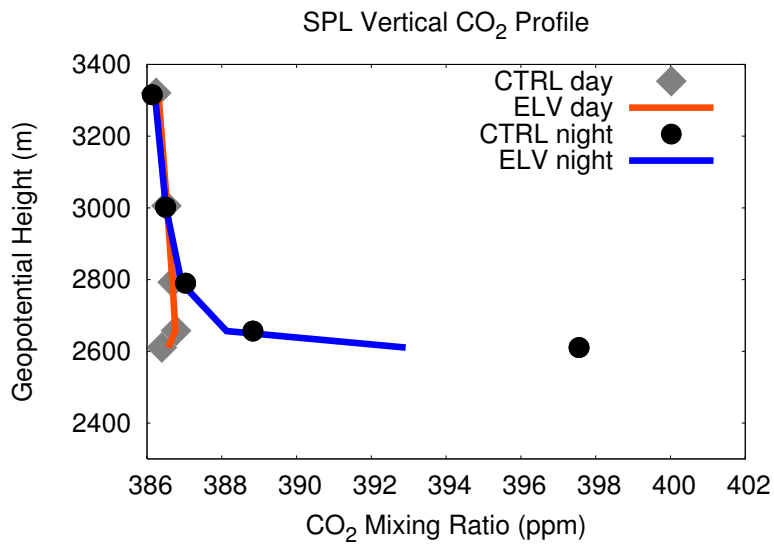
Figure: CT Model skill for simulating CO_2 variability at NWR (left) and SNP (right).



Vertical CO_2 profiles

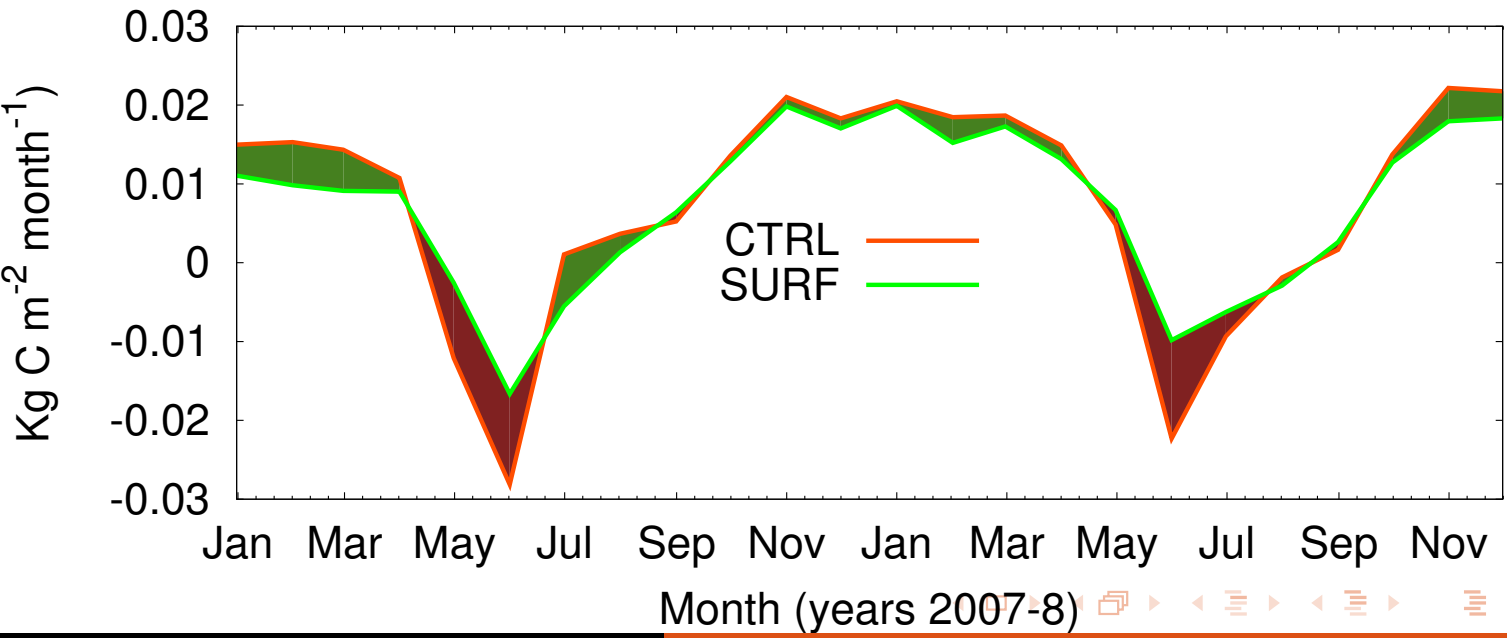
Figure: Gross overestimation of near surface CO_2 is a known issue with CT in complex terrain. Mean vertical CO_2 profiles from CT-2010 at NWR and SPL averaged over years 2007, 2008 show that near surface CO_2 gradients are reduced by model surface assimilation.





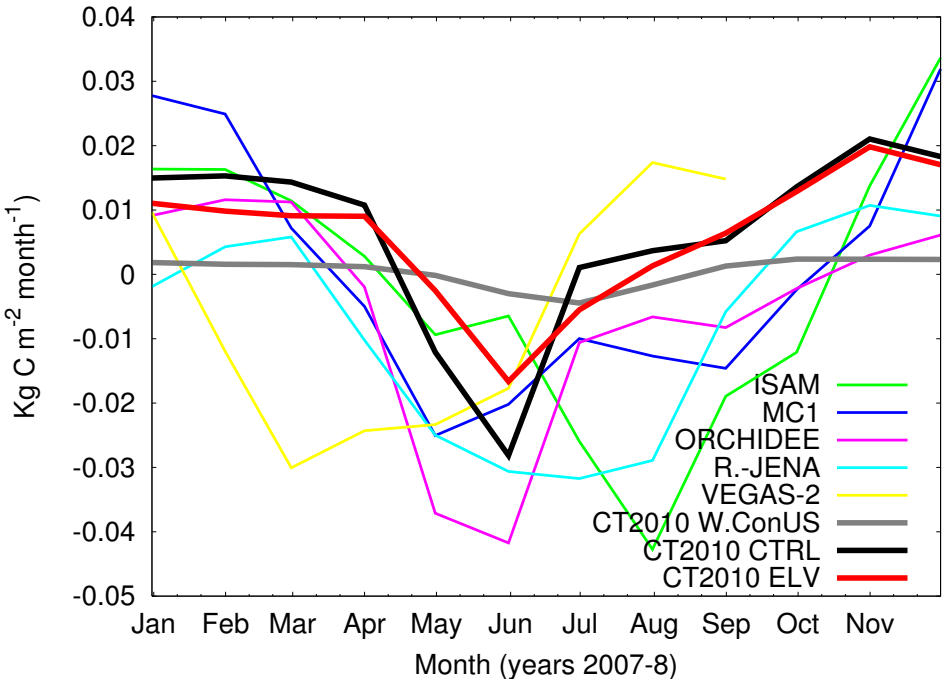
Effect on net ecosystem exchange

Figure: Difference in simulated carbon uptake by biosphere (negative) and release to atmosphere (positive) over two years for the RACCOON domain ($\sim 10^\circ \times 10^\circ$). Assimilating NWR, SPL observations has the effect of diminishing C-release to the atmosphere (green) during the winter and diminishing C-uptake from the atmosphere (red) during the summer.



Comparisons to other carbon-cycle models

Figure: Preliminary results comparing carbon uptake from CT-2010 to NACP forward and inverse models.



Summary of regional inversions

Table: Preliminary results from CT-2010 inversion for 2007–2008 for model-data mismatch (ppm CO_2), difference in near surface CO_2, and net carbon exchange (kg C m^2 month).

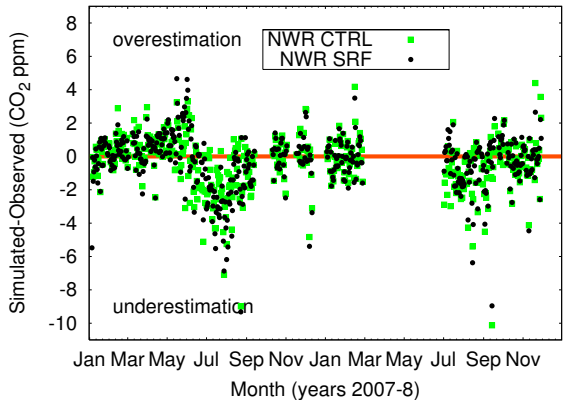
Test	Control	Surface Assim.	Diff.
MDM NWR (ppm)	1.14	1.20	+0.06
MDM SPL (ppm)	1.42	1.48	+0.06
Δ NWR near surf. CO_2			−4.0 ppm
Δ SPL near surf. CO_2			−4.6 ppm
RACCOON domain NEE	0.0076	0.0074	−3.0%
ConUS NEE	0.0004	0.0004	−0.1%

Summary

- In areas of large terrain mismatches assimilating observations relative to model surface (rather than 10^3 m aloft) has little effect (0.06 ppm) on total MDM (aloft) at NWR and SPL stations during 2007 and 2008
- However, near surface CO_2 changes markedly and (nocturnal) gradients become more gradual
- Assimilation relative to the model surface reduces simulated summer carbon uptake by the biosphere in the RACCOON domain (Colorado, Utah, Arizona, New Mexico) and reduces carbon release to the atmosphere during the winter resulting in smaller seasonal amplitude

Future work

- Incorporate nearby climate station data for a factor analysis of MDM
- Clustering analysis to associate model-data mismatch anomalies with time of day, hourly variance, local meteorological states



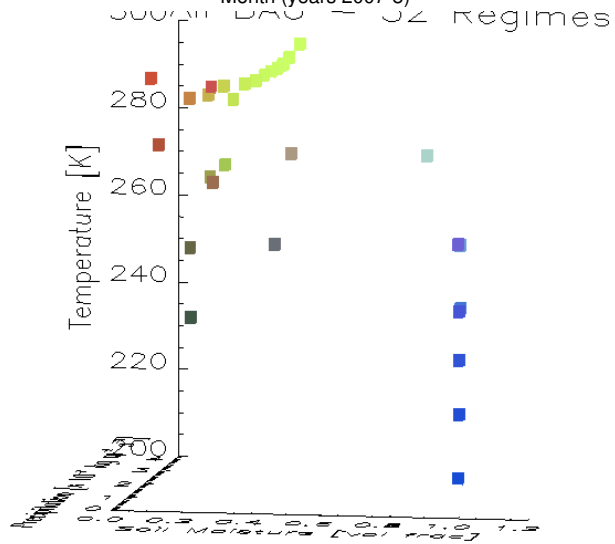


fig. taken from Hoffman et al. 2005, Earth Interact.

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RACCOON homepage: http://raccoon.ucar.edu
CarbonTracker: carbontracker.noaa.gov