A Web Application for Modeling Anti-Neutrino Emissions

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Introduction

Geoneutrinos, neutrinos originating from terrestrial sources, provide clues to the composition and distribution of radiogenic material within the Earth. However, the uncertainties of the current geoneutrino measurements are large enough such that no single earth model has been indicated[1]. Our web-based visualization allows quick comparisons between several models and even offers user defined inputs.

Going Forward

In future versions we hope to have a number of additional features:

- Update to CRUST 1.0
- Inclusion of tomographic mantle models
- Integration of reactor and earth model pages into a single page

Our goal is to implement a useful tool for education as well as the research community.

Acknowledgements & Source Code

This work was supported in part by Lawrence Livermore National Laboratory and National Science Foundation grants through the Cooperative Studies of the Earth's Deep Interior program (EAR 0855838 and EAR 1068097). The source code for the model and website are available on github:

`https://github.com/docotak/geoneutrinos.org`

Methods

The web-based **earth model** uses several data sources as inputs:

- CRUST 2.0 is used for basic crust parameters [2]
- PREM provides the basic physical mantle structure [3]
- A precomputed map of crustal neutrino fluxes [4]
- A precomputed map of neutrino fluxes from nuclear reactors
- A precomputed map of surface heat fluxes[6]

Data were converted to JSON using python scripting language.
Real time calculations are performed in the web browser using JavaScript (JS). The following JS libraries are used:

- D3 - Used to draw the map and colorbar
- jQuery - Used to handle user input events

The web-based **reactor model** uses the following sources of data as inputs:

- Reactor location, power (thermal), load factors from the IAEA
- Map tiles from OpenStreetMap[5]

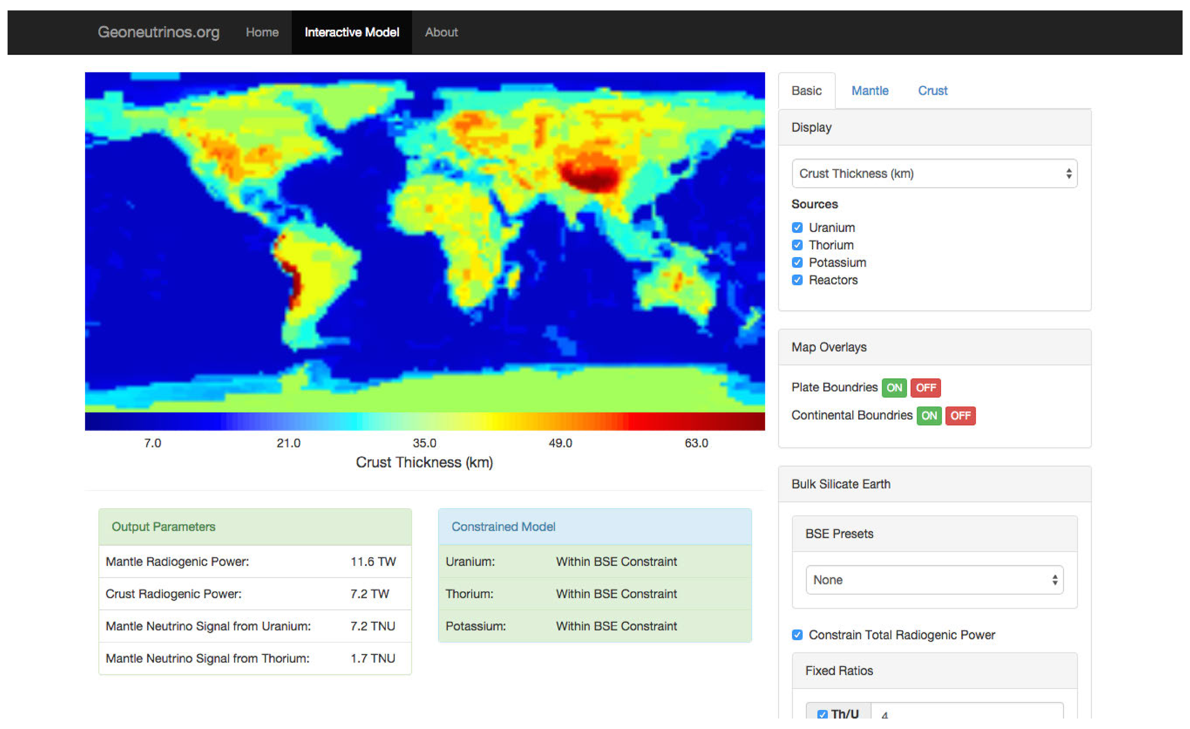
Data were converted to JSON using python scripting language.
Real time calculations are performed in the web browser using JavaScript (JS). The following JS libraries are used:

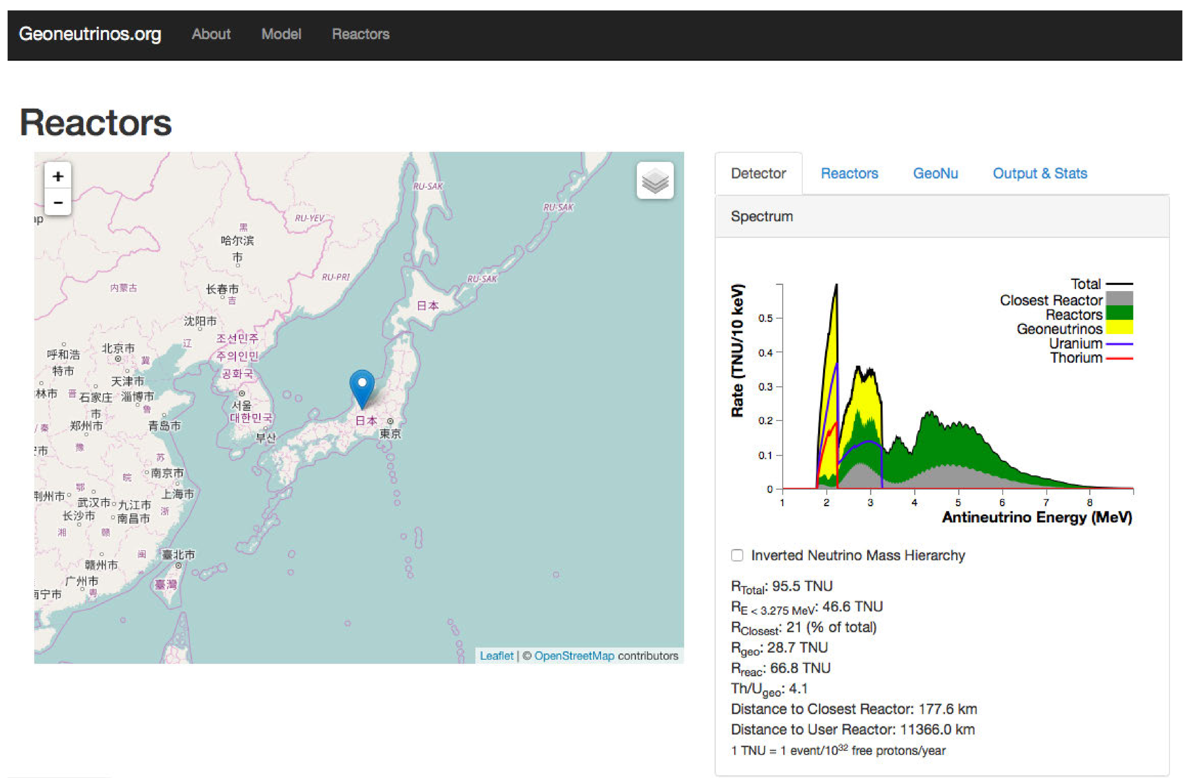
- D3 - Used to draw the spectrum plot
- React - UI Abstraction library for the general user interface
- Leaflet - Used to draw the map tiles

The webpage uses the Bootstrap library for quick user interface construction and tablet compatibility. Maps are drawn using HTML5 canvas, the overlays (land mass and plate boundaries) and colorbar are drawn using SVG.

Features

Overall Layout



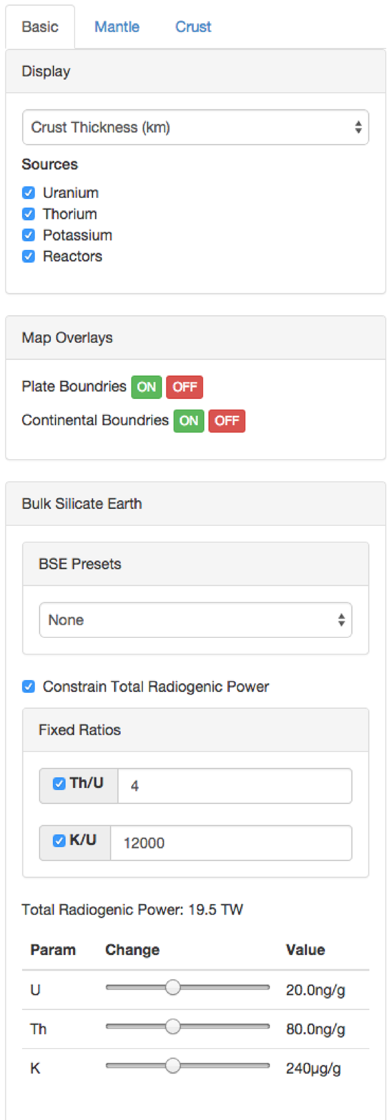


Both earth and reactor pages feature a two column design, with a map on the left and user input on the right. The earth page map displays the results from the selected output as a "heatmap" with a colorbar scale underneath. The reactor page map is zoomable and displays the detector location, and optionally the location of all IAEA registered reactors. Both pages have user controls are organized into categories accessible via labeled tabs. The pages will adjust their layout to best fit the screen size, including devices as small as smartphones.

User Controls

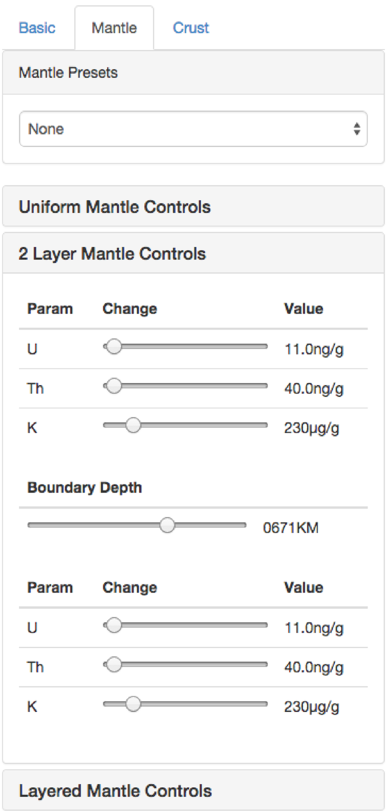
Basic:

- Change map display
- Change radiogenic sources
- Chose BSE preset
- Adjust BSE element ratios
- Toggle BSE constraint
- Adjust BSE element concentrations
- Toggle map overlays (continents, plate boundaries)



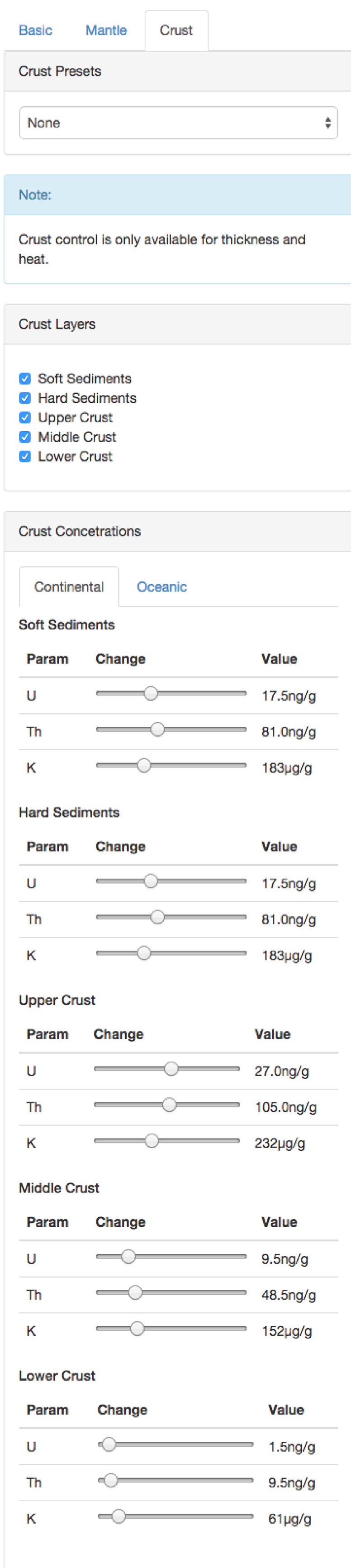
Mantle:

- Chose mantle layer concentration presets
- 3 modes of input: homogenous mantle, two layer with adjustable depth boundary, all discrete layers in PREM
- If BSE constrained, two layer mantle will solve for the layer not being adjusted



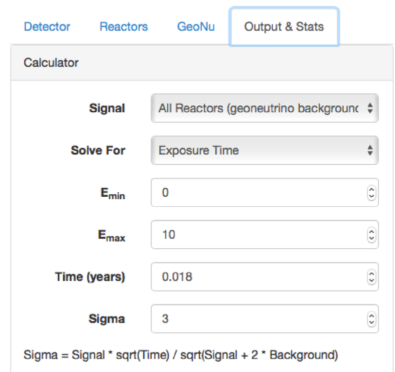
Crust:

- Ability to toggle crust layers
- Adjust the element concentrations in both continental and oceanic crust



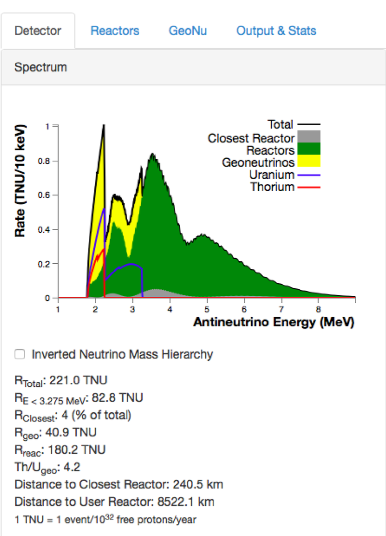
Output:

- Output for import into RAT-PAC
- Significance calculator

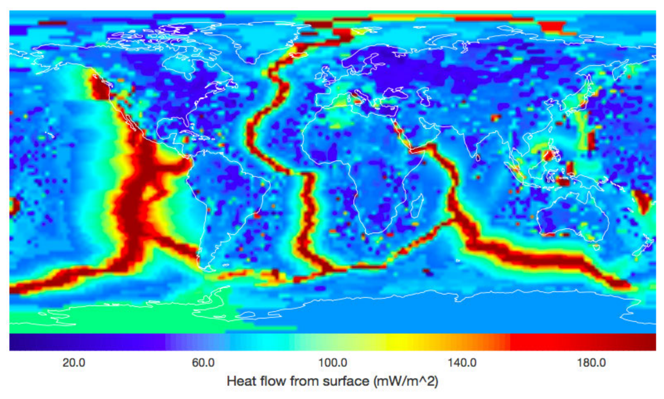


Detector:

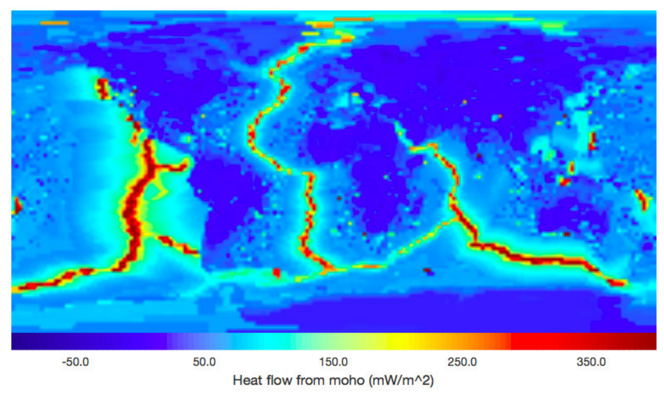
- Oscillated neutrino spectrum from reactor and natural sources
- Many preset detector locations including: Kamioka, Sudbury, Gran Sasso



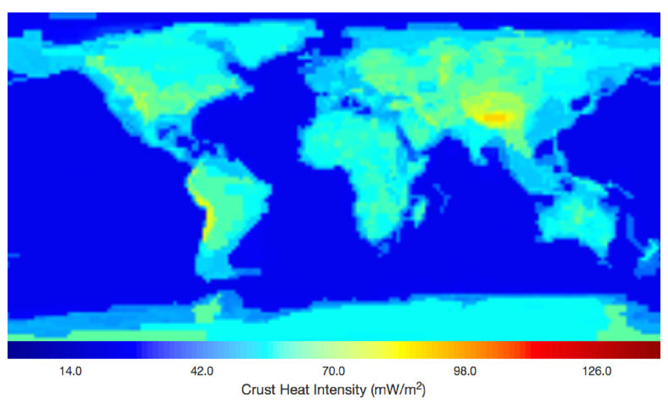
Output Displays



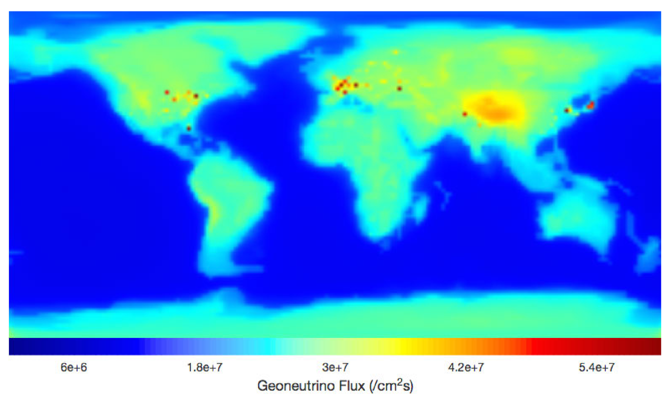
Surface heat flow.



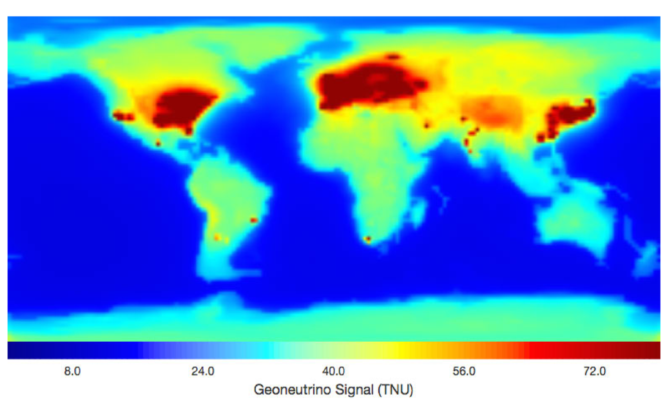
Heat flow across Moho.



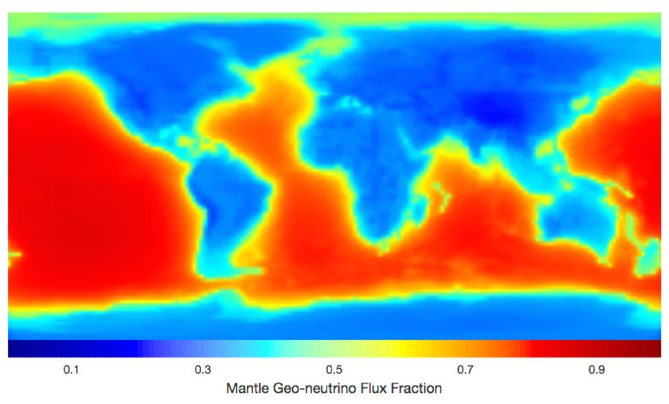
Radiogenic intensity of the crust (not the surface heat flux).



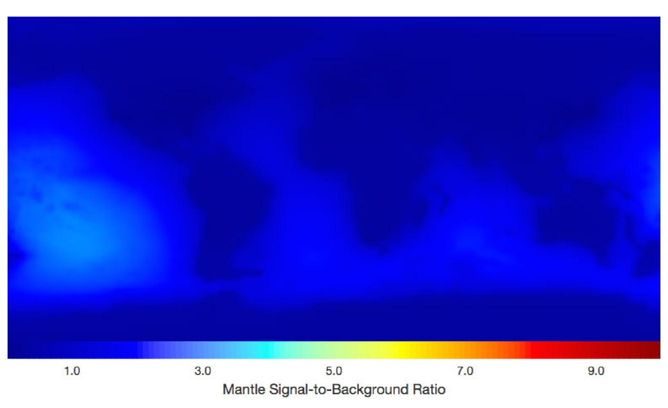
Flux of neutrinos from all user-selected sources.



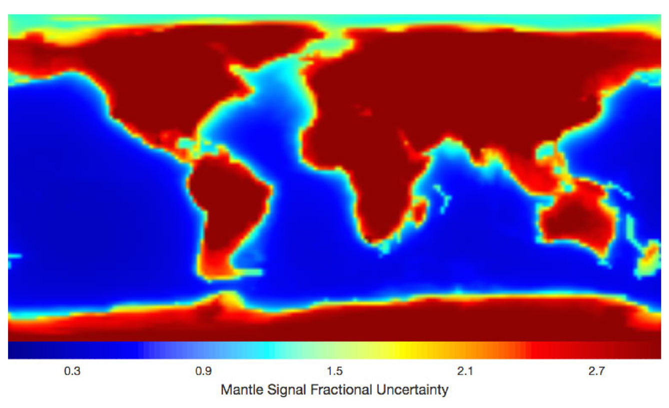
Neutrino signal from all user-selected sources.



Fraction of mantle neutrinos to total surface flux.



Signal ratio of the mantle vs all user-selected sources.



Fractional uncertainty of the mantle signal.

References

[1] S. T. Dye, Huang Y., Lekic V., McDonough W.F., & Sramek, O. (2014) Geo-neutrinos and Earth models. Physics Procedia (in press)
[2] Bassin, C., Laske, G. and Masters, G., The Current Limits of Resolution for Surface Wave Tomography in North America, EOS Trans AGU, 81, F897, 2000.
[3] Dziewonski, A.M. and Anderson, D.L., 1981. Preliminary reference Earth model. Phys. Earth Planet. Int., 25, 297-356.
[4] Huang, Y. et al. (2013), A reference Earth model for the heat-producing elements and associated geoneutrino flux, Geochem. Geophys. Geosyst., 14, 2003-2029.
[5] Map data copyrighted OpenStreetMap contributors and available from http://www.openstreetmap.org
[6] Davies, J. H. (2013), Global map of solid Earth surface heat flow, Geochem. Geophys. Geosyst., 14, doi:10.1002/ggge.20271.

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