



Goddard Institute for Space Studies



## Abstract

One of the fundamental questions about Venus is whether it ever had a habitable period in its distant past. If it did have such a period how did Venus get from a temperate state to its present day hot-house?

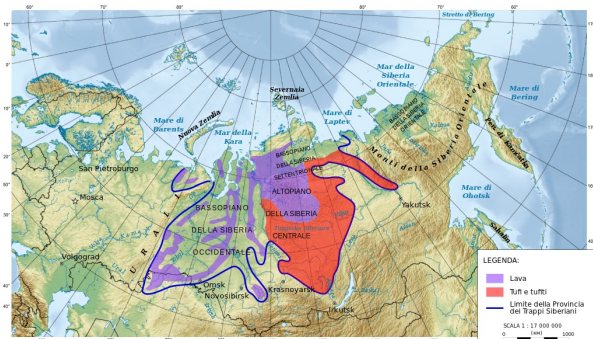
Recent studies have demonstrated that increasing solar luminosity through time is an unlikely pathway [1] For Venus even if that is one way for Earth to end up in a runaway greenhouse state.

Large Igneous Provinces (LIPs; like that of the Siberian Traps – Fig 1) have been responsible for the End Permian mass extinction and other dramatic climate change events throughout Earth's history [2,3]

We investigate the hypothesis that **overlapping Large Igneous Provinces could have driven Venus from a temperate to a runaway greenhouse state.** We look at the LIP record in Earth history and the probability for overlapping LIP events as a proxy.

- [1] Way & Del Genio 2021 JGRP, 125 e2019JE006276
- [2] Wignall 2011, Nature 477, 285
- [3] Ernst & Youbi 2017, PPP, 478, 30-52

Siberian Traps Large Igenous Province



Extent of Siberian Traps in Russia  
<https://creativecommons.org/licenses/by-sa/3.0/deed.en>  
 Author: Kaidor,  
[https://commons.wikimedia.org/wiki/File:Extent\\_of\\_Siberian\\_traps-ru.svg](https://commons.wikimedia.org/wiki/File:Extent_of_Siberian_traps-ru.svg)

# Can Large Scale Volcanism Explain the Heat-Death of Venus (and Venus-like worlds?)

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## Data Sources

**Database of LIPs:** Ernst et al. 2021 “Large Igneous Province Record Through Time and Implications for Secular Environmental Changes and Geological Time-Scale Boundaries

- **280 Continental LIPs identified over past 2800Myr**
- **In past ~200Myr we see ~1 Oceanic LIP per Continental LIP**
- **We then double the rate to 560 LIP events over past 2800Myr**



## Results (Preliminary)

	(1) N(k=1)	(2) close pair rate relative to LIP rate	(3) Waiting time (Myr)	(4) Prob of at least one
<b>pair</b> $\Delta t = 0.1$	11	2.0%	252	0.9999...
$\Delta t = 1$	101.5	18.1%	28	0.9999...
<b>triple</b> $\Delta t = 0.1$	0.11	.02%	25,345	0.1046
$\Delta t = 1$	9.8	1.7%	285	0.9999
<b>quad</b> $\Delta t = 0.1$	.0007	.0001%	3,800,660	0.0007
$\Delta t = 1$	0.64	0.11%	4354	0.4746

Summary statistics of LIP k-clusters (k=1, or pairs) for the fiducial Earth record over T=2800 Myr.

The first entry is  $\Delta t = 100000$  years.

The second entry is for  $\Delta t = 1$  Myr

Latter yields more coincidences than  $\Delta t = 100000$  because of the wider window of overlap opportunity.

Col. (1) Expected number of 1-clusters, or pairs;

Col. (2) pair rate as a fraction of LIP rate;

Col. (3) Expected time between pairs, the so-called "waiting time";

Col. (4) Probability of at least one pair.

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