# Geothermal heat: an episodic heat source in oceans

Plate climatology (www.plateclimatology.com) is a theory introduced in 2014 by James Kamis. Unlike the Sun which is the first order driver of earth's climate, it is an underestimated second order driver which can contribute significantly to regional natural variations. The overall theory contends that periods of active earth tectonics and volcanism can be correlated to periods of active climate change and/or climate related events.

According to the National Atmospheric and Oceanographic Administration (NOAA), 2015 was the hottest year since record began in 1880 from globally averaged temperatures over land and ocean surfaces following the 17-year pause since 1998. A popular explanation is an immense amount of heat released from the Pacific Ocean caused by the strongest and longest El Niño year this century during 2015 but what triggered such a condition is unresolved. Proponents of anthropogenic global warming including the United Nations have used the temperature rise as signaling a return to global warming.

In this article, two initially submarine volcanic eruptions and one subaerial volcanic eruption all contributing to the regional warming of the Pacific Ocean are investigated using available information including satellite records of sea-surface temperature anomalies and ocean surface topography. In conclusion, geothermal heat is a reminder of a dynamic earth in spite of overpopulation and resource usage on planet earth.

The Pacific Ocean and the Atlantic Ocean are the two oceans with connections to the two poles. Because an estimated three quarters of the world's active volcanoes are located within the Ring of Fire, the release of geothermal heat through volcanism in the Pacific Ocean is the highest and may provide a heat source additional to the sun for triggering El Niño years. This is supported by 'Explanation for the northern Pacific Blob' featured in the Autumn 2016 issue of *Imperial ENGINEER*. Currently such geological forcing by plate tectonics on climate is not well appreciated by climate scientists probably because of their atmospheric bias.

Three volcanic eruptions generating positive sea-surface water anomalies in different parts of the Pacific Ocean from before November 2013 until November 2015 based on reported information are analysed. Two of the eruptions were initially submarine followed by subaerial eruptions after new islands were created while the third eruption is entirely subaerial with basaltic lava flows at ~1000°C entering the ocean. All three eruptions contributed geothermal heat to the longest-lasting El Niño this century in 2015 perhaps even stronger than the 1997 to 1998 event. Important environmental impacts included the suppression of heat loss from the ocean during winter, record high summer temperatures over parts of land in the Pacific northwest, record sea-surface temperatures in the Pacific northeast for February since the 1980s, record high sea-surface pressure for the years 1949 to 2014, acceleration in the contraction of Arctic sea ice during the summers of 2014 and 2015, catastrophic ecological damage such as coastal algal blooms and coral bleaching, and, the return to La Niña conditions after sea-surface temperature returned to equilibrium during 2016.

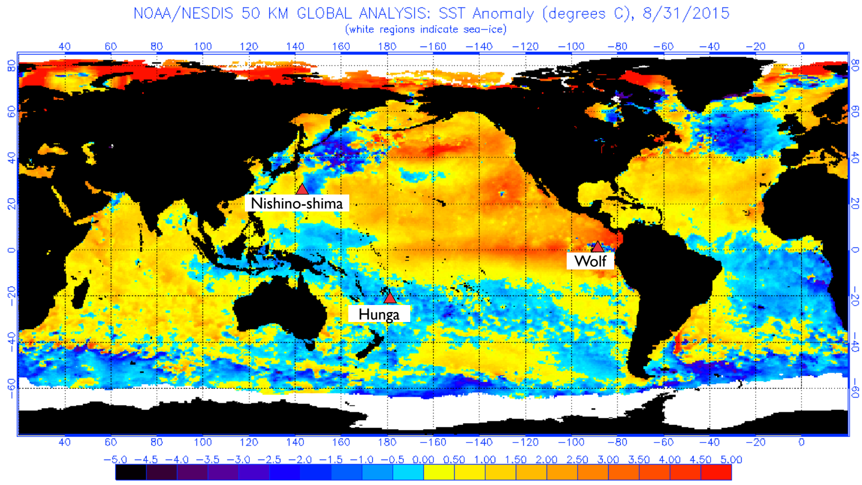



Image: NOAA / NESDIS / OSPO

***Global map of sea-surface temperature anomalies showing the El Niño conditions on August 31, 2015 under the influence of the northern Pacific blob and further exacerbated by the May 25, 2015 Wolf eruption with lava flows into the sea. The locations of the Nishino-shima, Hunga and Wolf volcanoes are also shown. The severe contraction of Arctic sea ice in the north Pacific compared to the north Atlantic and the cold water upwelling in the northwest Pacific can also be explained by the sea-surface temperature distribution.***

Events related to the three volcanic eruptions which contributed to the development of the abnormally strong El Niño conditions in 2015 are shown in the summary table opposite.

Out of the three eruptions, the longest lasting and the most powerful in terms of the quantity of geothermal heat released was from the Nishino-shima volcano located 940 km south of Tokyo. The Volcanic Explosivity Index (VEI) based on the volume of subaerially erupted materials from November 20, 2013 to November 17, 2015 was rated 2 but this is not reflective of the severity of the submarine eruption because such a measurement scale is not currently available. On November 20, 2013, the beginning of the northern hemisphere winter, the appearance of a new island adjacent to Nishino-shima was reported. An examination of NOAA satellite sea-surface anomalies map archives has revealed that hot sea-surface water was already in existence at the site during the end of March 2013 six months earlier when the submarine eruption started. In late 2013, the patch of warm surficial water spread into the Gulf of Alaska to form the northern Pacific blob. The interaction between the warm ocean's surfaces with the atmosphere generated a long-lasting high-pressure condition referred to as the 'Ridiculously Resilient Ridge' which resulted in weird weather conditions in the Pacific northeast. Surveys by the Japan Coast Guard show the new land area of the volcanic island increased from a total area of 0.01 $km^2$ on November 20, 2013 to an area of 1.08 $km^2$ on July 7, 2014, and, to a maximum area of 2.71 $km^2$ on August 18, 2015. The continuous expansion of the volcanic island through episodic lava flows means geothermal heat was available to sustain blob through ocean circulation changes until early 2016 since seawater is a poor conductor of heat. During the peak stage, the warm water covered a total area exceeding 9M $km^2$ from Mexico to Alaska, an area larger than the contiguous US.

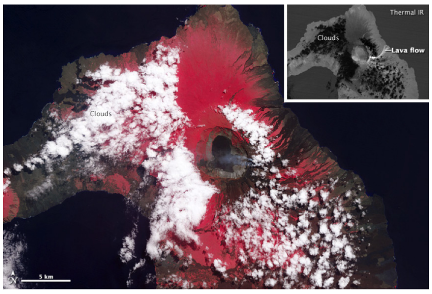
The existence of the north Pacific blob in the Gulf of Alaska which is connected to the Arctic Ocean through the Bering Strait is consistent with the record of sea ice contraction observed during the summers of 2014 and 2015. Based on monthly maps of the National Snow and Ice Data Centre during the northern hemisphere summer and early autumn, Arctic sea ice contraction was much more rapid and extensive in the Arctic Ocean portion adjacent to the northern Pacific Ocean compared to the northern Atlantic Ocean.

The second eruption, Hunga volcano, from November 2014 to January 23, 2015 during the peak of the southern hemisphere summer is also the second long lasting. The VEI based on the volume of erupted materials with a reported plume height ranging from 7-10 km was rated 2. There is again an underestimation of the severity of the submarine eruption because of the absence of a measurement scale.

On December 19, 2014, local fishermen reported a tall white steam plume rising from the ocean over the submarine volcano. On December 29, satellite images taken showed the eruption continuing, with discoloured seawater possibly caused by smoke and ash released below the surface, or by disturbance of the seabed. The eruption entered a new stage on January 11, 2015, when the volcano began sending ash plumes as high as 9 km. On January 13, the large amounts of nitrogen and phosphorous released underwater caused an explosion in the growth of algae and causing a red tide. At the end of the eruption, a new island 1 km wide, 2 km long and 120 m high was created. Subsequent environmental impacts of the warm sea-surface water included coral bleaching of the Great Barrier Reef from January 2015 and the development of severe tropical cyclone Pam which devastated Vanuatu in mid-March 2015.

The third eruption, the Wolf volcano from May 25 to June 2, 2015 is the shortest in duration. The high VEI 4 rating is in response to the much larger volume of subaerially erupted materials. Lava flows were reported to first reach the sea on May 28 (see satellite image) exacerbating the already strong El Niño conditions.

NASA Earth Observatory image by Jesse Allen, using data from NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team




***Thermal infrared image of the Wolf volcano, Galapagos acquired on June 11, 2015 after the May 25 to July 2, 2015 eruption, showing lava flows reaching the sea to the east.***

The NOAA sea-surface temperature anomalies map of August 31, 2015 (opposite) highlights the pattern characterised by the longest-lasting event this century is distinctly different from El Niño events in the past covered by satellite observation records. The causation factors for each event must therefore differ.

A comparison of ocean surface topography during the two strongest and longest El Niño years this century, 1997 to 1999 and 2015 to 2017, is shown (right). The hot sea-surface water generated by the three volcanic eruptions during 2013 to 2015 described in this study provides the best explanation to both the pattern and the timing of the ocean surface topographical changes observed.

The three volcanic eruptions causing regional warming in different parts of the Pacific Ocean over the three-year period from 2013 to 2015 is supported by the satellite sea-surface temperature anomalies records and ocean surface topography records. The warm sea-surface water was responsible for oceanic and atmospheric circulation changes regionally which cannot be accounted for by carbon dioxide variations.

For future work, Smithsonian's Global Volcanism Program (GVP) should be extended to include coverage of submarine volcanic eruptions. A severity scale based on the amount of geothermal heat released from such eruptions taking into account the eruption history should be devised assisted by an expanded ARGO monitoring data buoy network.

| Date | Event(s) | Observation(s) |
|---|---|---|
| Mar 2013 | Submarine eruption of Nishino-shima | Warming first detectable in sea-surface temperature anomalies maps (start of submarine eruption). |
| Nov 2013 | Submarine and subaerial eruption of Nishino-shima | Source: en.wikipedia.org/wiki/Nishinoshima_(Ogasawara); during northern hemisphere winter. |
| Feb 2014 | Temperature measurement | Sea-surface temperature ~2.5°C above normal was reported. |
| Jun 2014 | Island ~2.3 km in diameter; ~110 m above sea level | Name Blob was coined by Nicholas Bond; size reached 1600 km by 1600 km and 91 m deep; spread to the coast of North America with patches off Alaska, Victoria/California and Mexico. |
| Jul-Sep 2014 | Mass coral bleaching in Hawaii | Reported by the University of Queensland; area of warm water exceeded 9 million km$^2$ during peak stage; rapid contraction of Arctic sea ice during summer and early autumn. |
| Jan-Aug 2014 | Episodic eruption of Nishino-shima with lava flows | Japanese Coast Guard reported increase in area of the island through lava flows; onset of El Niño conditions; abnormally hot summer in Pacific northeast. |
| Dec 2014 | Submarine and subaerial eruption of Hunga, Tonga | Source: en.wikipedia.org/wiki/Hunga_Tonga; occurred during southern hemisphere summer; year without winter in Pacific northeast. |
| Jan 2015 | Eruption of Hunga ended | Strong El Niño conditions forecast; coral bleaching in the northern parts of the Great Barrier Reef. |
| Mar 2015 | Severe tropical cyclone Pam | Most intense tropical cyclone of the South Pacific in terms of sustained wind; Vanuatu's worst natural disaster. |
| May-Jun 2015 | Eruption of Wolf, Galapagos | Lava flows entered the ocean exacerbating the already strong El Niño conditions; rapid contraction of Arctic sea ice during summer and early autumn. |
| Early 2016 | Blob dissipation | Change to La Niña conditions. |

Summary table of events attributable to three volcanic eruptions releasing geothermal heat in different parts of the Pacific Ocean, contributing to the development of the strongest and longest-lasting El Niño this century. For further details on the environmental and ecological damage see 'The Heat Wave' featured in the September 2016 issue of *National Geographic*.

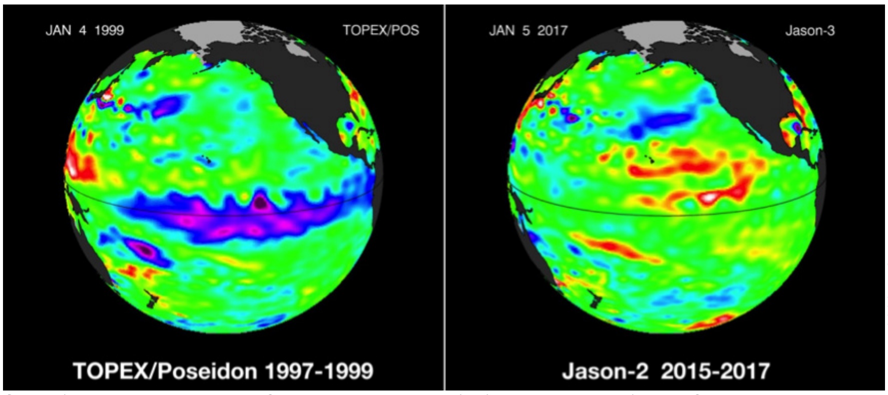



Photo: NASA/JPL-Caltech

***Satellite-based ocean surface topography still image comparison of the two strongest El Niño years this century***

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Professor Wyss Yim DSc PhD DIC FGS was at Imperial College in the Department of Geology from 1971-1974. After that he spent 35 years until retirement at the University of Hong Kong where he taught civil engineering, geosciences and environmental management students, and, helped found the Department of Earth Sciences. He was awarded the DSc by the University of London in 1997. Wyss served as the Deputy Chairman of the Climate Change Science Implementation Team of UNESCO's International Year of Planet Earth 2007-2009.