**Pan-Tropical Cascade of Fire Activity from El Niño**

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**Fire emissions**

- EQAS
- NHAF
- NHSA
- SEAS
- CEAM
- SHAF
- SHSA
- AUST

![Map showing fire emissions across different regions.](image)

- **El Niño** redistributes rainfall across the tropics, leading to a predictable cascade in fire emissions over an 18-month period.
- Emissions peak first in Equatorial Asia (EQAS), followed by northern hemisphere regions that border the Pacific Ocean (NHSA, SEAS, CEAM), and finally southern Hemisphere South America (SHSA).
- In Australia, El Niño reduces rainfall and fuel accumulation, with negative fire emissions anomalies in Year 2—nearly a full year after Pacific Ocean temperatures peak.
- The cascade of fire responses to El Niño illustrates an important time delay in the Earth System response to climate and provides information necessary for the design of fire forecasts and effective decision-support systems for land use and landscape management.

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References:

Data Sources: A wide range of satellite data were used to assess the pantropical fire activity in response to El Niño Southern Oscillation (ENSO), including burned area and fire emissions from the Global Fire Emissions Database (Version 4s, www.globalfiredatal.org), MISR Aerosol Optical Depth (AOD), MOPITT column carbon monoxide (CO), GRACE Terrestrial Water Storage (TWS), and precipitation from the Global Precipitation Climatology Centre (GPCC, version 7).

Technical Description of Figures:
Graphic 1: Tropical land regions are strongly influenced by ENSO, primarily through shifts in rainfall. The timing and magnitude of shifts in tropical rainfall have a pronounced impact on pantropical fire activity. This plot shows the relative difference in fire emissions between 6 El Niño and 6 La Niña periods during 1997-2016, defined as an 18-month window from June (year 1) through September (year 2). Fire emissions were normalized by the all-year mean to show positive and negative anomalies (a value of 2 indicates that monthly fire emissions during El Niño were higher than during La Niña by twice the mean monthly emissions during an average year). The spatial and temporal progression of fire anomalies highlights the cascade of ENSO impacts in the Earth system—extending for nearly a full year after sea surface temperature anomalies in the tropical Pacific Ocean subside.

Scientific significance, societal relevance, and relationships to future missions: The predictable pattern of pantropical fire activity to ENSO aids the development of early warning forecast efforts to mitigate fire effects on human health and ecosystems. The long tail of ENSO—as fire responses extend up to a year after peak ocean temperatures—illustrates an important delay in the Earth system response to drought.
Landsat 8 Operational Land Imager (OLI) scenes from late 2015 to early 2016 were used to create a mosaic of the Antarctic Peninsula’s ~40,000 km² Larsen C Ice Shelf (left). Additional OLI scenes from September 16, 2017 (right) show the ~5800 km² A-68 iceberg after it calved and broke into major (A-68A) and minor (A-68B) pieces.
References:
Project MIDAS - Impact of Melt on Ice Shelf Dynamics And Stability. http://www.projectmidas.org

Data Sources: Landsat 8 Operational Land Imager (OLI) panchromatic imagery (Band 8) and Landsat 4 and 5 Thematic Mapper imagery (multispectral) and image interpretation were used to create this time series of major Larsen C iceberg calvings (since 1984) using ice shelf front positions. At GSFC, the support of Compton Tucker and Katherine Melock were important to the creation of the visualization.

Technical Description of Figures:
Figures 1-2: The figures are composites of Landsat Operational Land Imager (OLI) imagery over the Larsen C Ice Shelf. A red arrow indicates the position of the rift tip in early 2016 that finally broke through and released Iceberg A-68 on July 11, 2017. The September 2017 image shows Iceberg A-68A, estimated by Project Midas to weigh >1 trillion tonnes (~1.2 trillion tons), after the smaller, rectangular A-68B iceberg broke free at its north end on 13-14 July. The panchromatic images are presented with some enhancements of the grey-scale data but generally the Larsen Ice Shelf is in lighter, brighter tones relative to the adjacent Weddell Sea’s sea ice floating on darker water. The rougher texture of the mountainous Antarctic Peninsula and the Jason and Hollick-Kenyon peninsulas that bound the Larsen C ice shelf is enhanced partly by the shadows cast from their terrain. The Larsen C ends at a line between Cape Agassiz at the end of the Hollick-Kenyon Peninsula and Gipps Ice Rise (Vaughan and Doake, 1996) and the Larsen D’s ice area is south of that line. A previous calving from the Larsen C in 1986 released the even larger ~7300 km$^2$ Iceberg A-20. Image processing was done with PCI-Geomatica and Adobe Photoshop with final annotations added in Powerpoint.

Scientific significance, societal relevance, and relationships to future missions: The continuing observations from the Landsat series of sensors in areas of dramatic cryospheric change provides compelling visuals for the public, scientific colleagues, and policymakers. The ability of Landsat 8’s sensors to detail glaciologic features is very well known including capturing the opening rift using Landsat 8’s Thermal Infrared Sensor during the austral winter’s polar darkness. However, it is also worth noting that Landsat 8 is acquiring imagery frequently enough to catch details not captured by earlier Landsat missions including enabling the creation of this large area mosaic on the Antarctic Peninsula with almost no cloud cover between November 2015 and February 2016. This allows an iceberg larger than the State of Delaware’s land area to be placed in context with the remaining Larsen C Ice Shelf’s area still held in place with the help of the Bawden and Gipps ice rises, bedrock knobs that help to stabilize the deeply embayed new ice shelf front.
The electrical conductivity of the ocean is a fundamental parameter in the electrodynamics of the Earth System. This parameter is involved in a number of applications ranging from the calibration of in situ ocean flow meters, through extensions of traditional induction studies, and into quite new opportunities in remote sensing Earth’s properties from space-borne magnetometers, such as carried aboard the three satellites of the Swarm mission launched in 2013. Here, the first ocean conductivity data set calculated directly from the large historical data set of observed temperature and salinity measurements is provided. These data describe the globally gridded, three-dimensional mean conductivity as well as seasonal variations. This “climatology” data set of ocean conductivity is offered as a standard reference similar to the ocean temperature and salinity climatologies that have long been available. This conductivity data collocated with the temperature and salinity data is also an essential first step in formulating methods for inferring ocean temperature/salinity from remotely inferred conductivity. The sea surface values shown in the figure provide an example of the dependence of conductivity on salinity and temperature.
References:


**Data Sources:** Data used for calculating conductivity (version woa13) is the same temperature, salinity, and pressure observed data sets used to objectively map the climatological temperature and salinity data sets. All data is available at https://www.nodc.noaa.gov/OC5/woa13/

**Technical Description of Figures:** This example of the 3D data set shows the ocean electrical conductivity at the sea surface (top frame). Similar surface data for temperature and salinity are shown in the two panels below this. One can see that conductivity tracks sea surface temperature on the large scale but can be mostly controlled by salinity in some regions such as the Arctic where there is large river runoff.

**Scientific significance, societal relevance, and relationships to future missions:** The primary electrical conductor near the Earth’s surface is the ocean and so it’s accurate description has immediate and high significance to a number of fields ranging from in-situ studies to remote sensing methods that involve electromagnetic variables. This is the first climatological conductivity data set to compliment similar climatological data sets for temperature and salinity that have long been provided by NOAA. The data is immediately being used in studies related to the ESA Swarm mission, and it is expected that this data (together with updated versions using updated observations) will be a fundamental data set used in studies of future missions involving surveys of the Earth’s magnetic field.