hockeystick
Visualizing Global Heating With R

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R in Finance Conference

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hockeystick

hockeystick R Package

- The impact of global heating on markets is an active research topic
- Central Banks and regulators: ECB, FRB, BIS are studying policy and regulation
- The EU has specific regulation on Paris-Aligned Benchmarks and funds
- There are multitudes of climate-oriented active and passive funds

- **The Challenge**: most finance practitioners are not climate experts
- However, we like to look at data -- but which climate data?
- The volume of climate research and data on the web is vast and complex

- `hockeystick` makes essential climate data easily available in R to non-climate experts

Opinions are my own and may not reflect those of my employer.

Install hockeystick

Install the **hockeystick** package from CRAN or Github:

```
install.packages("hockeystick")
```

```
remotes::install_github("cortinah/hockeystick")
```

```
library(hockeystick)
```

Features:

- Simple API to curated climate data
- Fetches latest data from original source
- Pre-defined plots
- Optional caching
- Very easy to use

A Brief and Incomplete History of Climate Science

- 1856: Eunice Foote published a scientific paper demonstrating the absorption of heat by CO_2.
- 1896: Svante Arrhenius predicted that more carbon in the atmosphere would lead to global warming.
- 1960: Charles Keeling demonstrated that the level of CO_2 in the atmosphere was rising.
- 1979 World Climate Conference: plausible that increased carbon dioxide in the atmosphere can contribute to a gradual warming.
- 1988: Jim Hansen assessed human-caused warming had already measurably affected the climate.
- 2020: `hockeystick` published on CRAN. 😄

ART. XXXI.—*Circumstances affecting the Heat of the Sun's Rays;* by EUNICE FOOTE.

(Read before the American Association, August 23d, 1856.)

MY investigations have had for their object to determine the different circumstances that affect the thermal action of the rays of light that proceed from the sun.

Several results have been obtained.

First. The action increases with the density of the air, and is diminished as it becomes more rarified.

The experiments were made with an air-pump and two cylindrical receivers of the same size, about four inches in diameter and thirty in length. In each were placed two thermometers, and the air was exhausted from one and condensed in the other. After both had acquired the same temperature they were placed in the sun, side by side, and while the action of the sun's rays rose to 110° in the condensed tube, it attained only 88° in the other. I had no means at hand of measuring the degree of condensation or rarefaction.

The observations taken once in two or three minutes, were as follows:

Exhausted Tube		Condensed Tube.	
In shade.	In sun.	In shade.	In sun.
75	80	75	80
76	82	78	95
80	82	80	100
83	86	82	105
84	88	85	110

This circumstance must affect the power of the sun's rays in different places, and contribute to produce their feeble action on the summits of lofty mountains.

Secondly. The action of the sun's rays was found to be greater in moist than in dry air.

In one of the receivers the air was saturated with moisture—in the other it was dried by the use of chlorid of calcium.

Both were placed in the sun as before and the result was as follows:

Dry Air.		Damp Air.	
In shade.	In sun.	In shade.	In sun.
75	75	75	75
78	88	78	90
82	102	82	106
82	104	82	110
82	105	82	114
88	108	92	120

The high temperature of moist air has frequently been observed. Who has not experienced the burning heat of the sun that precedes a summer's shower? The isothermal lines will, I think, be found to be much affected by the different degrees of moisture in different places.

Thirdly. The highest effect of the sun's rays I have found to be in carbonic acid gas.

One of the receivers was filled with it, the other with common air, and the result was as follows:

In Common Air.		In Carbonic Acid Gas.	
In shade.	In sun.	In shade.	In sun.
80	90	80	90
81	94	84	100
80	99	84	110
81	100	85	120

The receiver containing the gas became itself much heated—very sensibly more so than the other—and on being removed, it was many times as long in cooling.

An atmosphere of that gas would give to our earth a high temperature; and if as some suppose, at one period of its history the air had mixed with it a larger proportion than at present, an increased temperature from its own action as well as from increased weight must have necessarily resulted.

On comparing the sun's heat in different gases, I found it to be in hydrogen gas, 104°; in common air, 106°; in oxygen gas, 108°; and in carbonic acid gas, 125°.

ART. XXXII.—*Review of a portion of the Geological Map of the United States and British Provinces by Jules Marcou;** by WILLIAM P. BLAKE.

GEOLOGICAL maps of the United States published in Europe and widely circulated among European geologists, are necessarily regarded by us with no small degree of attention and curiosity. This is more especially true, when such maps embrace regions of which the geography has only recently been made known and the geology has never before been laid down on a map with any approach to accuracy.

The recent geological map and profile by M. J. Marcou, which has appeared in the Annales des Mines and in the Bulletin of

* Carte Géologique des Etats-Unis et des Provinces Anglaises de l'Amérique du Nord par Jules Marcou. *Annales des Mines*, 5e Série, T. vii, p. 329. Published also with the following:

Résumé explicatif d'une carte géologique des Etats-Unis et des provinces anglaises de l'Amérique du Nord, avec un profil géologique allant de la vallée du Mississippi aux côtes du Pacifique, et une planche de fossiles, par M. Jules Marcou *Bulletin de la Société Géologique de France.* Mai, 1855, p. 813.

"Circumstances Affecting the Heat of the Sun's Rays" by Eunice Foote

Svante Arrhenius

The Selma Morning Times.

SELMA, ALA., WEDNESDAY, OCTOBER 15, 1902

Hint to Coal Consumers.

A Swedish professor, Svend Arrhenius, has evolved a new theory of the extinction of the human race. He holds that the combustion of coal by civilized man is gradually warming the atmosphere so that in the course of a few cycles of 10,000 years the earth will be baked in a temperature close to the boiling point. He bases his theory on the accumulation of carbonic acid in the atmosphere, which acts as a glass in concentrating and refracting the heat of the sun.

Early Warning on Climate Change, 1902

THE RODNEY AND OTAMATEA TIMES,
WEDNESDAY, AUGUST 14 1912.

Science Notes and News.

COAL CONSUMPTION AFFECTING CLIMATE.

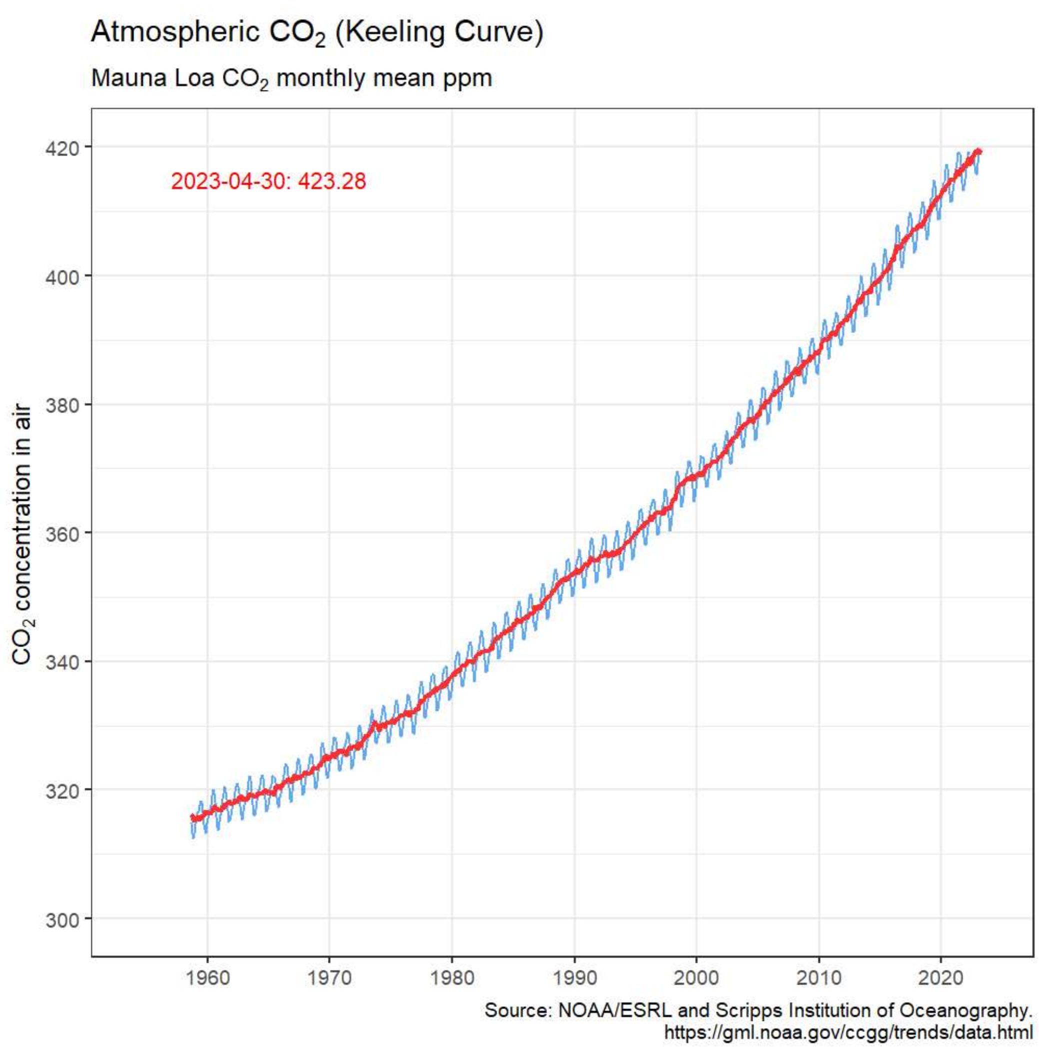
The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.

Prescient Warning from 1912, Based on Popular Mechanics article

Let's Get to the Code!

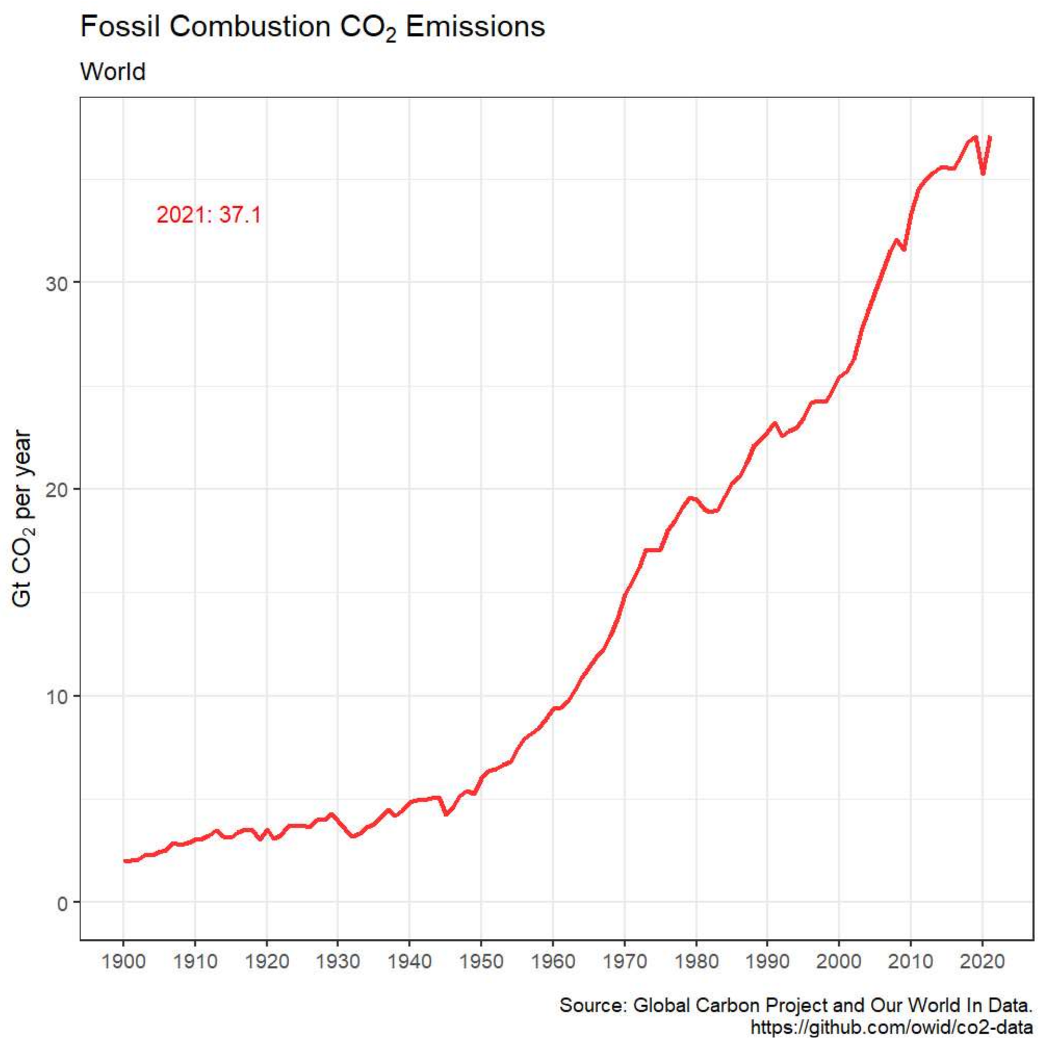
Carbon Concentration in the Atmosphere, Mauna Loa, Since 1958

```
co2 <- get_carbon()
plot_carbon(co2)
```



Global Annual CO_2 Emissions:

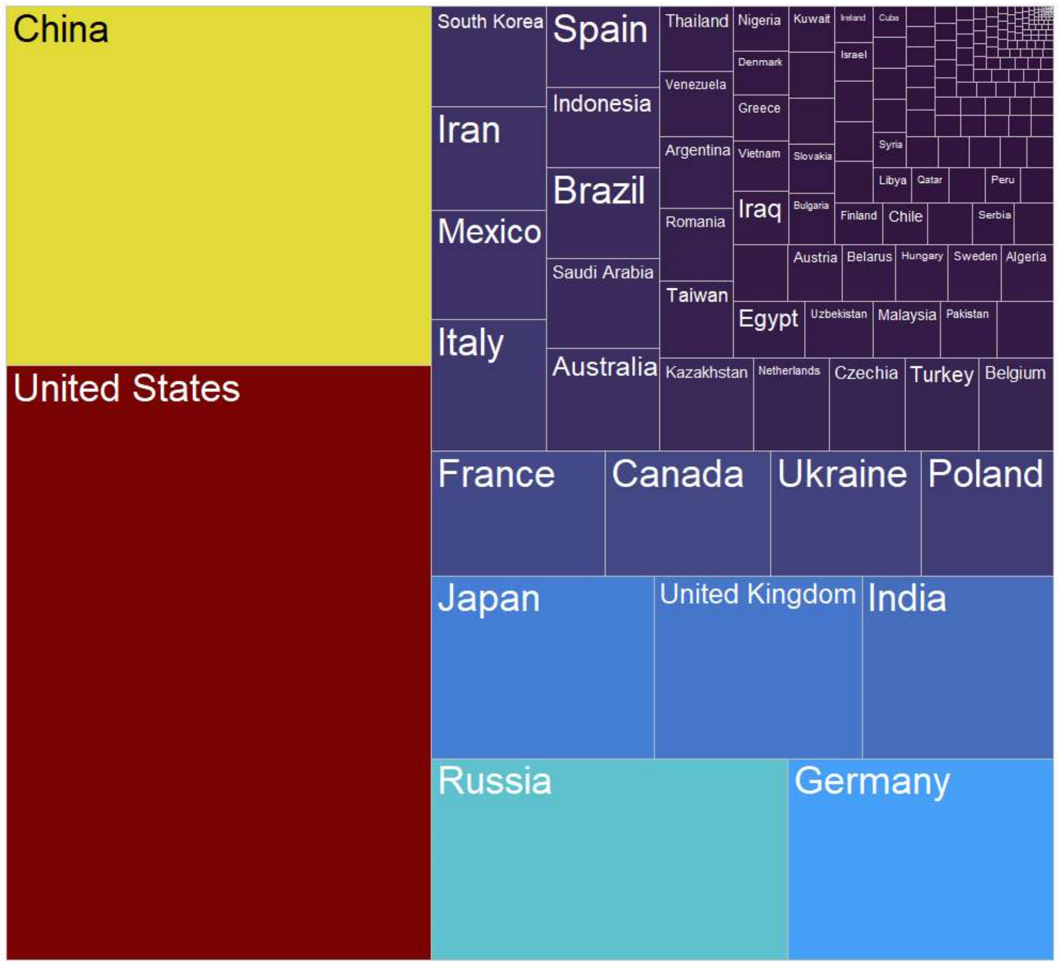
```
emissions <- get_emissions()
plot_emissions(emissions)
```



Visualize Cumulative Emissions by Country:

```
emissions_map(emissions)
```

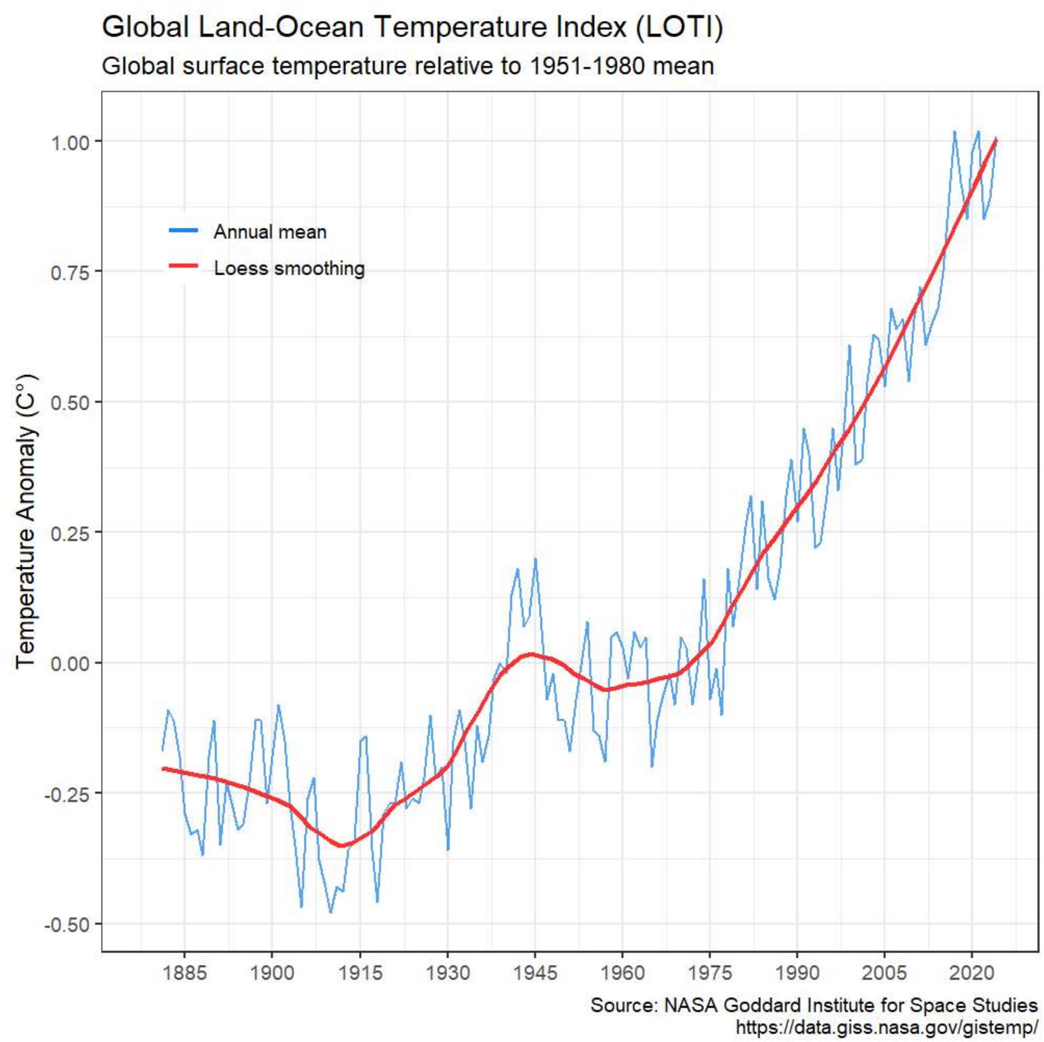
1900-2021 Cumulative CO_2 Emissions by Country



Source: Global Carbon Project and Our World In Data

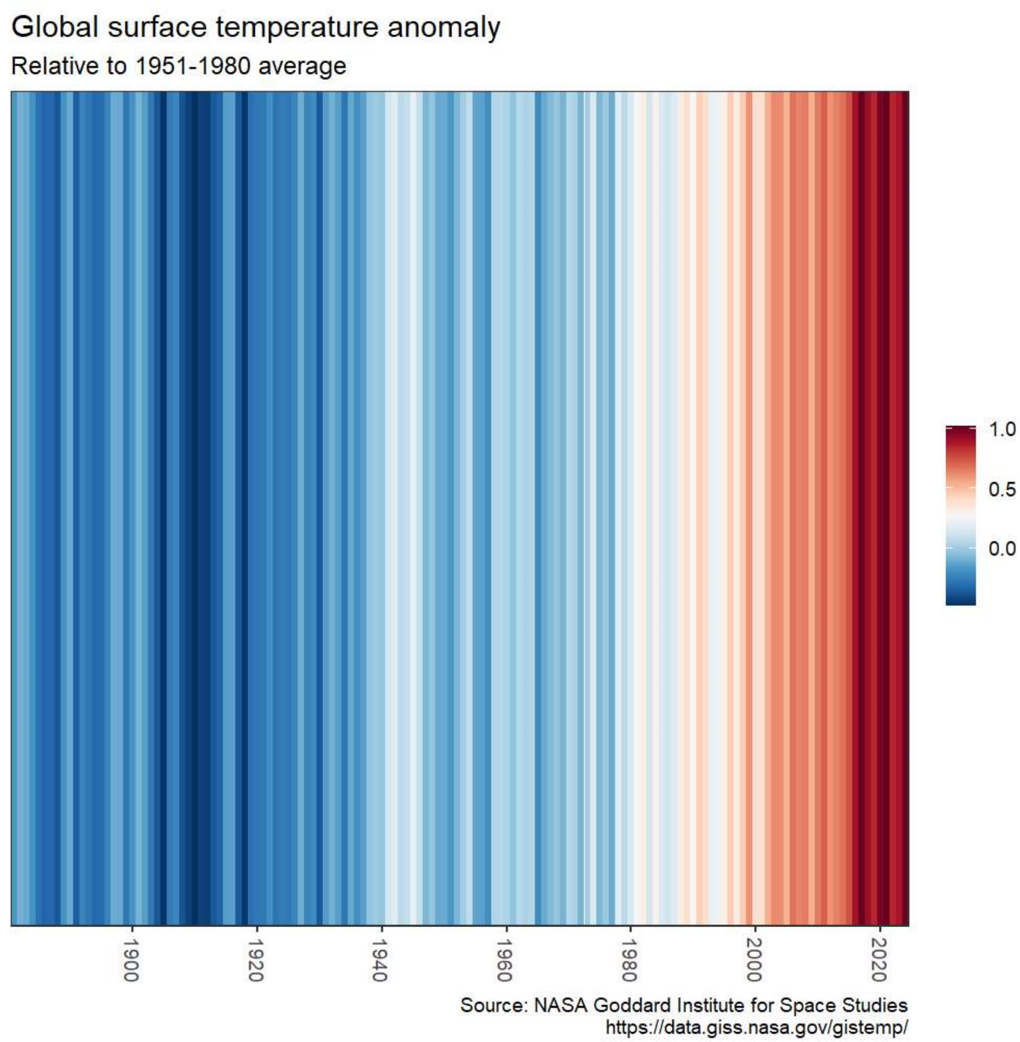
Global Temperature Anomaly

```
anomaly <- get_temp()
plot_temp(anomaly)
```



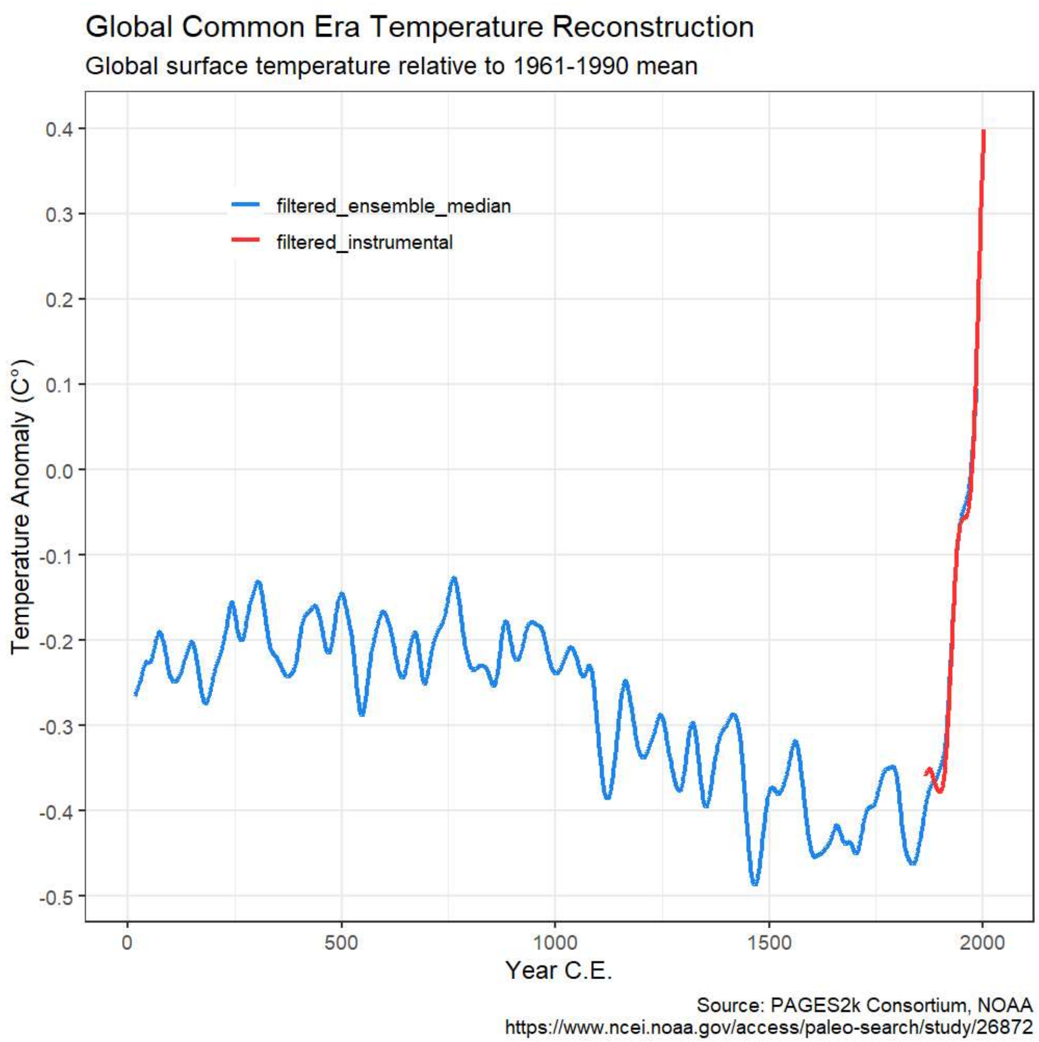
Warming Stripes Visualization

```
warming_stripes()
```



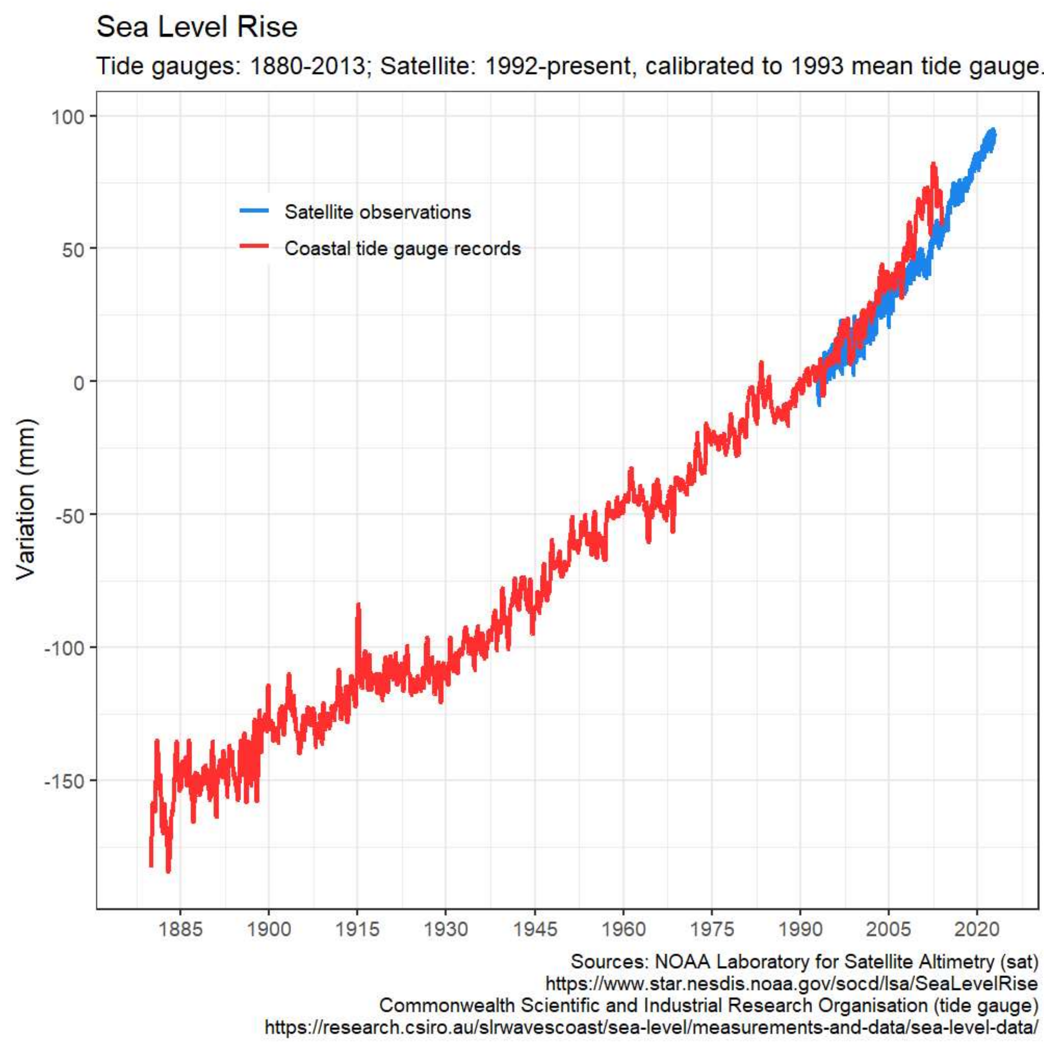
Common Era Temperatures

```
anomaly2k <- get_temp2k()
plot_temp2k(anomaly2k)
```



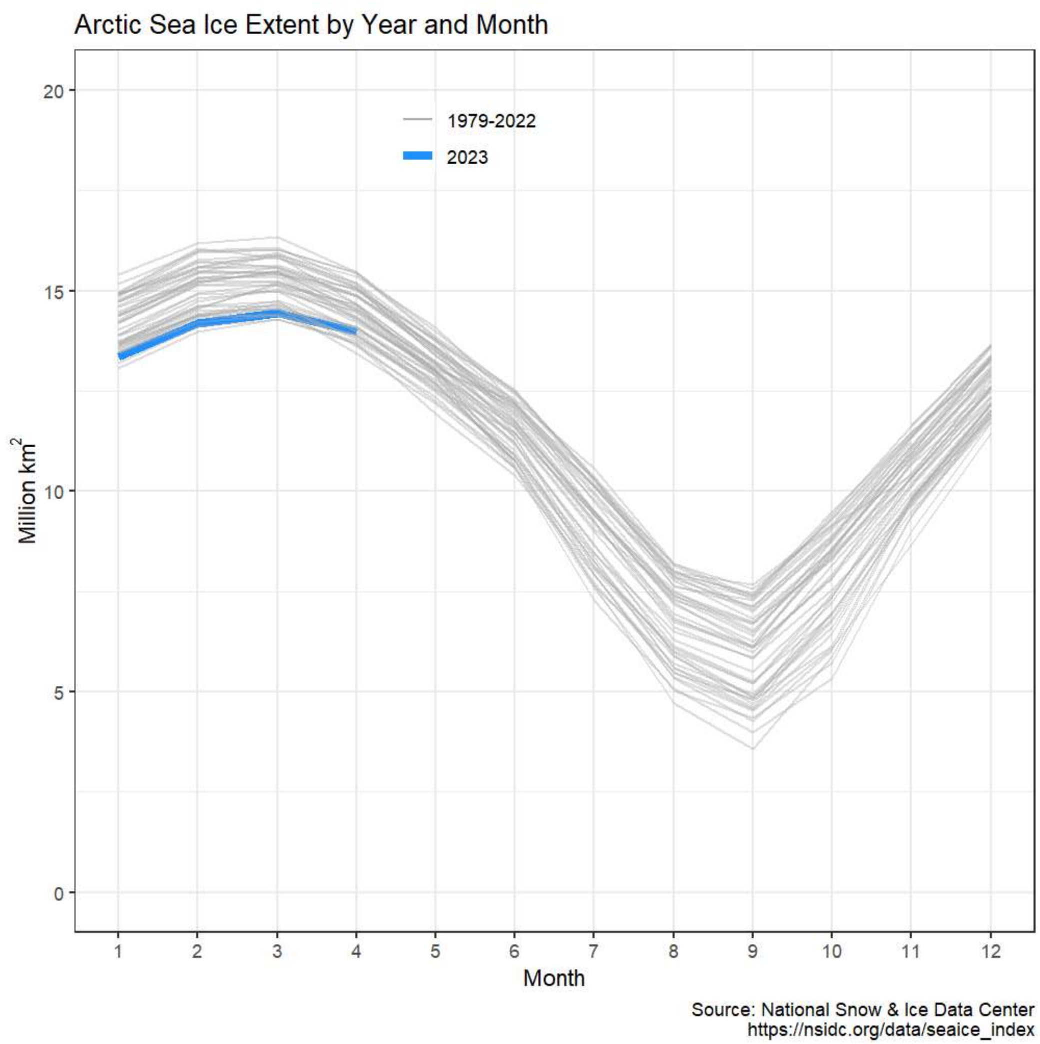
Sea Level Rising

```
gmsl <- get_sealevel()
plot_sealevel(gmsl)
```



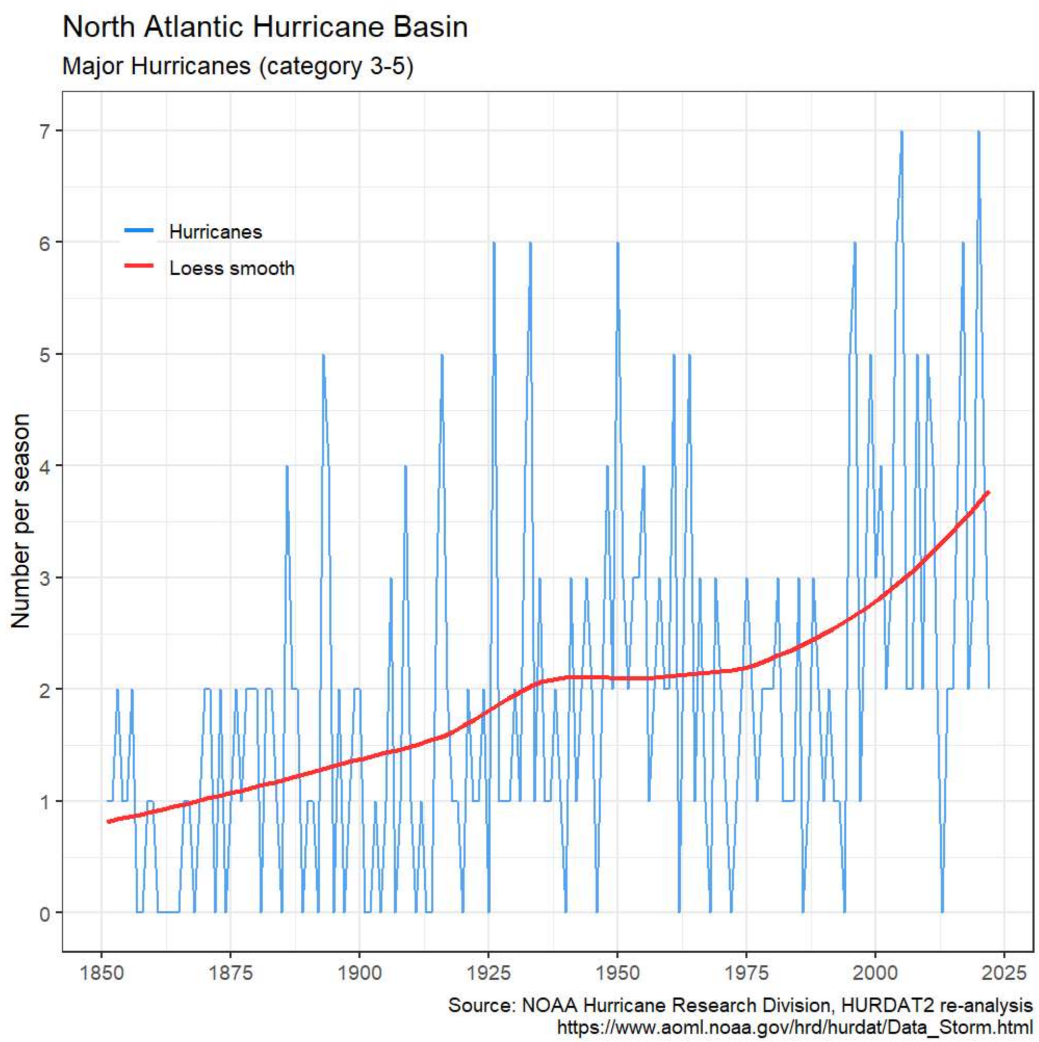
Shrinking Arctic Ice

```
arcticice <- get_icecurves()
plot_icecurves(arcticice)
```



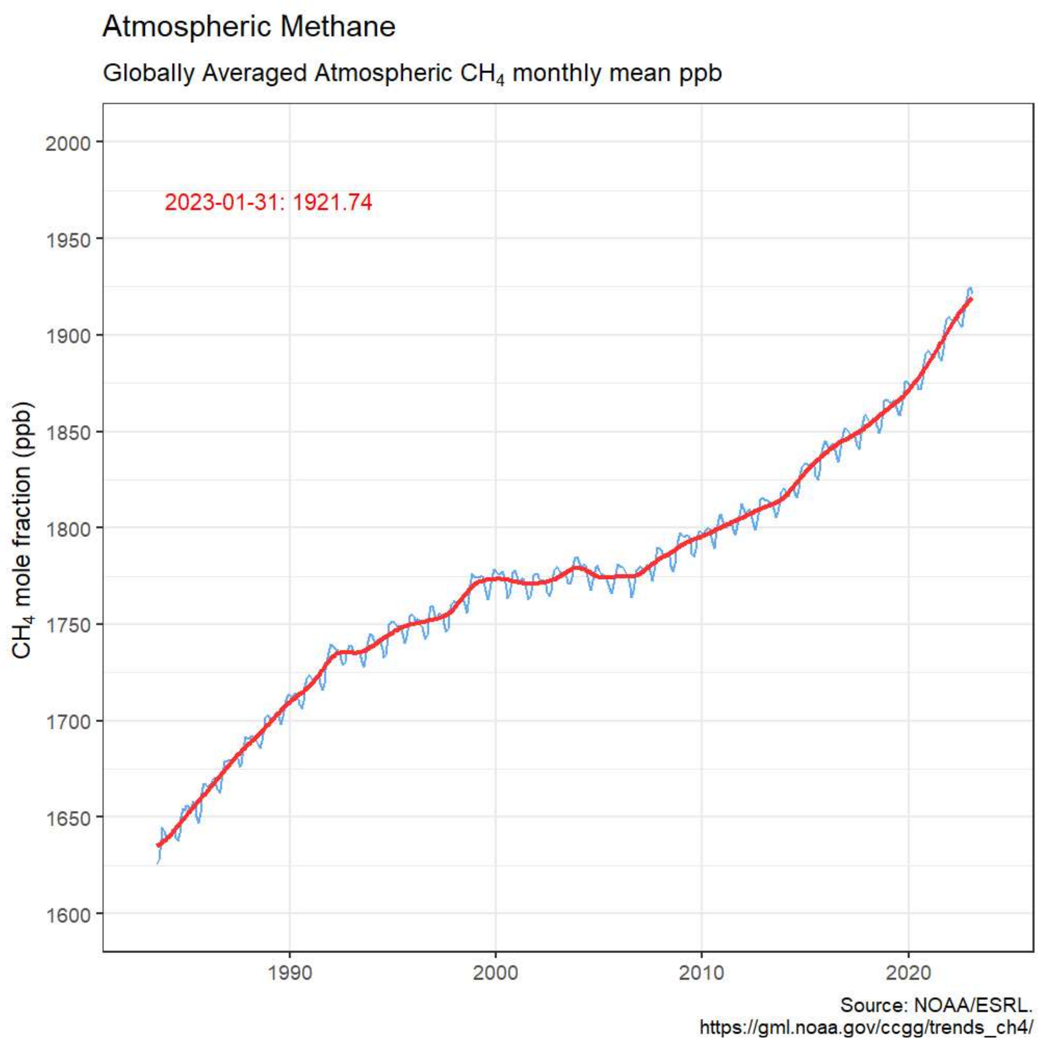
Increasing Hurricane Activity

```
hurricanes <- get_hurricanes()
plot_hurricanes(hurricanes)
```



Methane Traps 80x As Much Heat as CO_2 Over 20 Years

```
ch4 <- get_methane()
plot_methane(ch4)
```



hockeystick Summary

- Easy to use access to peer-reviewed climate data
- Returns data frames or pre-defined plots
- Plenty of customization options
- Please open issues or submit PRs via github
- Collaborators very welcome

https://github.com/cortinah/hockeystick

Thank you!