



Climate Change in the Back of the Envelope

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The first step in solving a problem is understanding what that problem is about.



And a big part of understanding goes on visualizing.

Because only by visualizing, in the gut feeling sense, makes us truly aware.

Visualizing \neq Simple Data Checking/Reading.



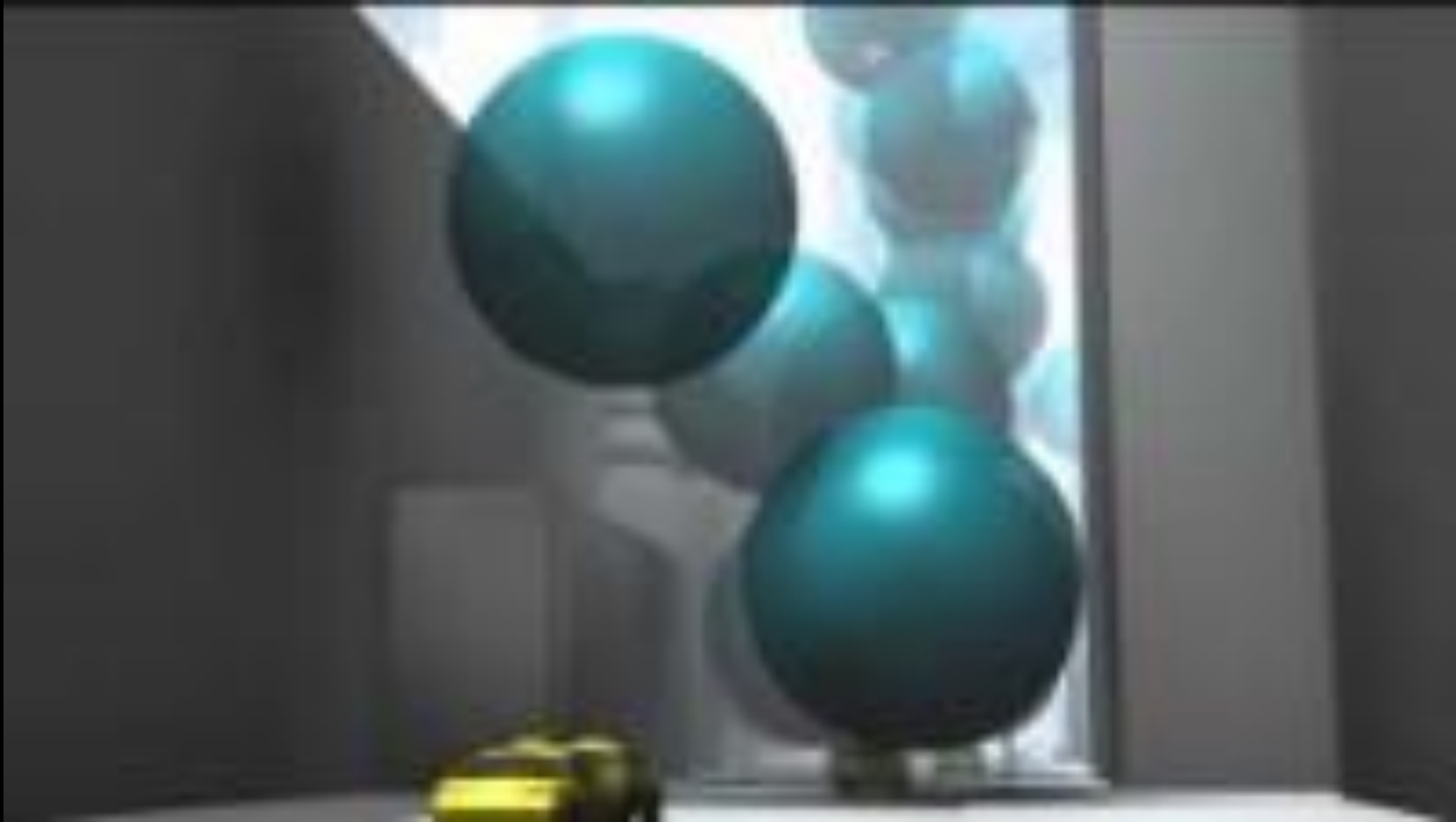
Visualizing: A Physicist's Approach

| <u>Volume of all beaches on Earth</u> | <u>Volume of a grain of sand</u> |
|---|---|
| length $\sim 10^5$ km avg. width $\sim 10^2$ m avg. depth ~ 10 m | $l \sim 0.5$ mm $w \sim 0.5$ mm $h \sim 0.5$ mm |
| "beaches" $\sim 10^{11} \text{ m}^3$ | "sand" $\sim 10^{-10} \text{ m}^3$ |

\Rightarrow to fill all beaches requires about 10^{21} grains of sand

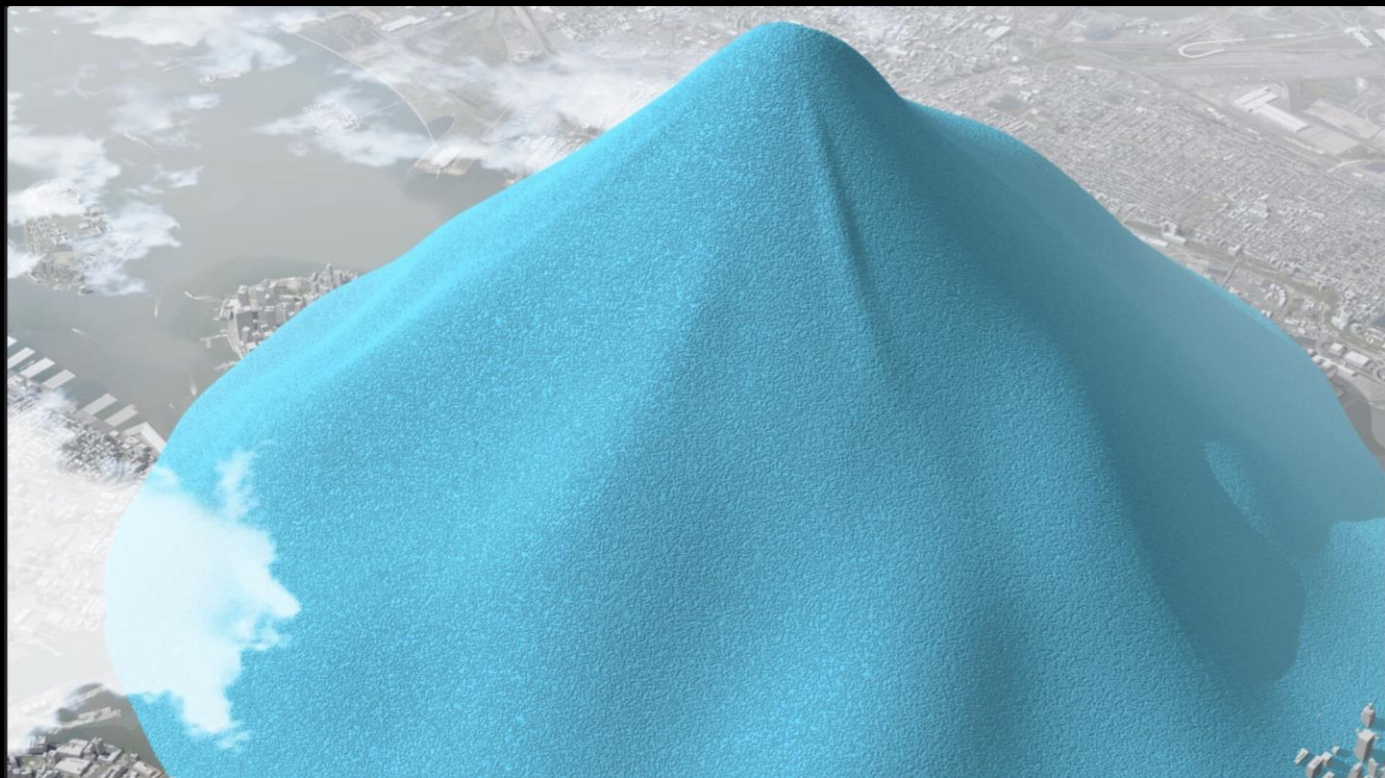
Back of the Envelope
Estimations

What if I tell you that the city of New York emits 54 million tons of CO₂ a year?



How about seeing it this way?

Let us focus on two examples producing A LOT of CO₂ footprint...
...more than 100 Million tons CO₂ equivalents/year



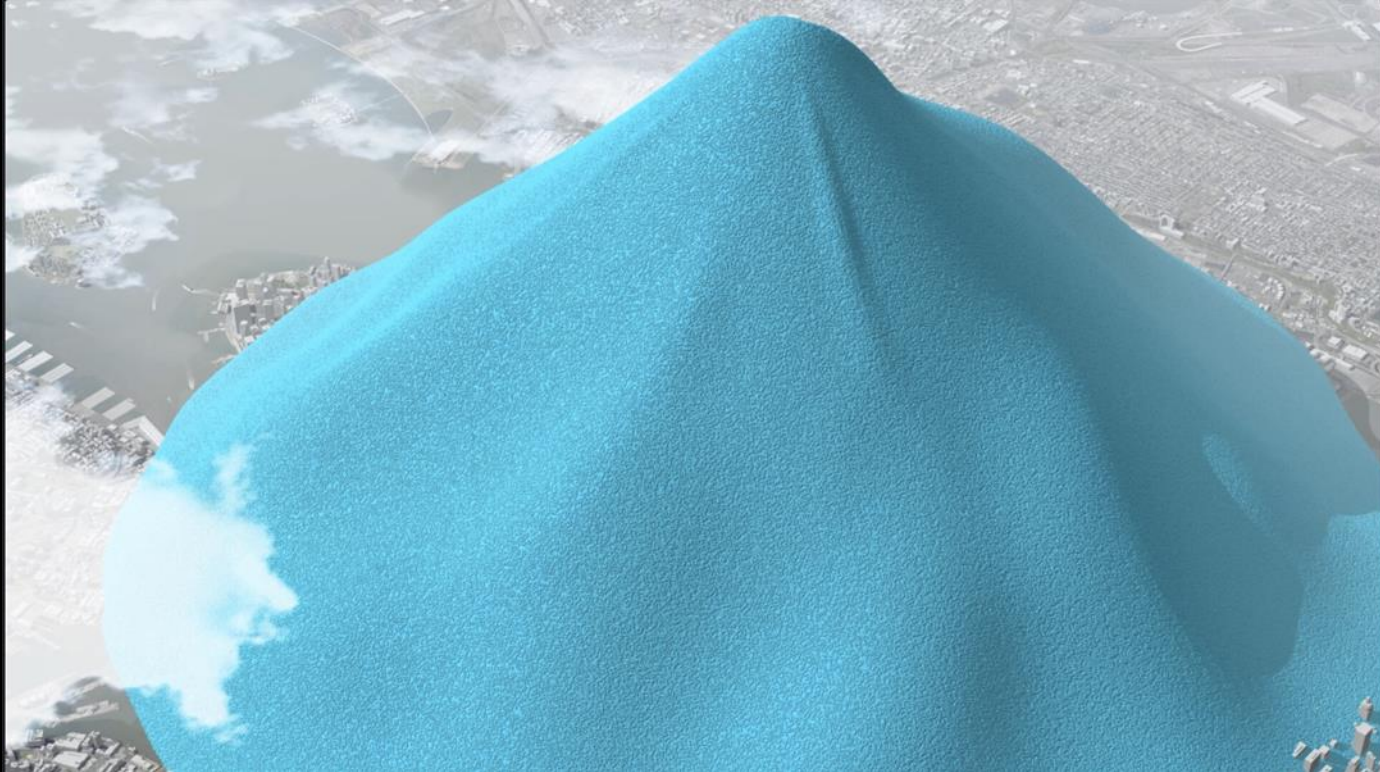
We are talking
about 2 of these
minimum!

<http://www.carbonvisuals.com/resources>



Yes, Data Centers...for example.

Data centers accounted for 340 million tons of CO₂e in 2020 (<https://www.unep.org/>).



We are talking about ~ 6 of these!

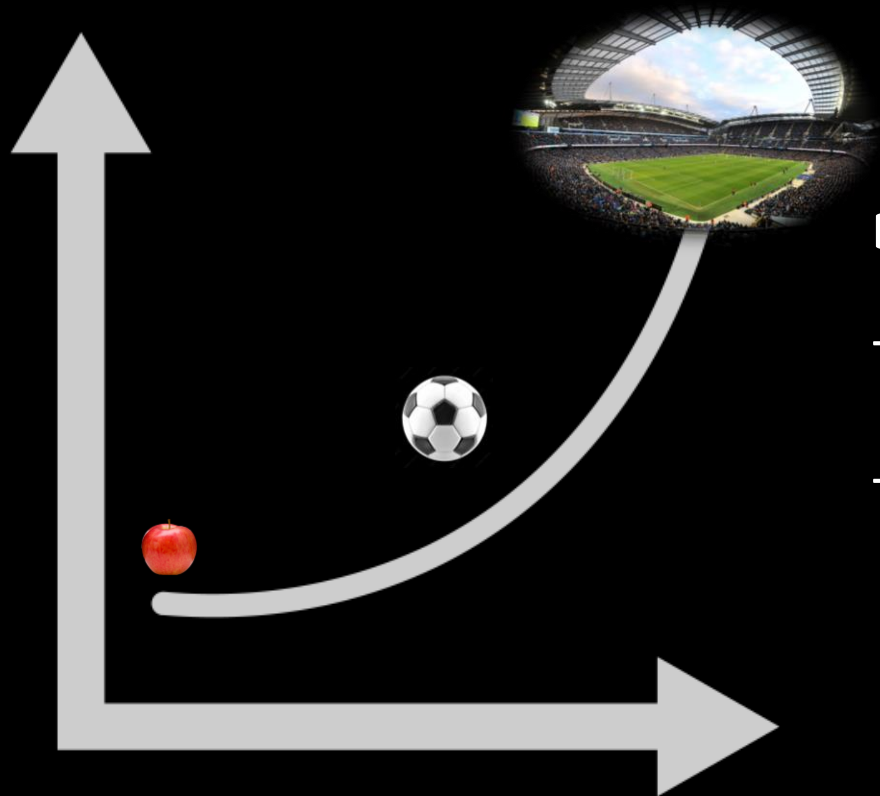
Today we generate $\sim 10^{22}$ bytes of info used and stored.

There are 10^4 data centers.

It means 10^{18} bytes/data center.

If you imagine the amount of data available to us as an apple, by 2030, this apple has turned into a soccer ball.

By 2050, it's going to be the size of an entire soccer field!



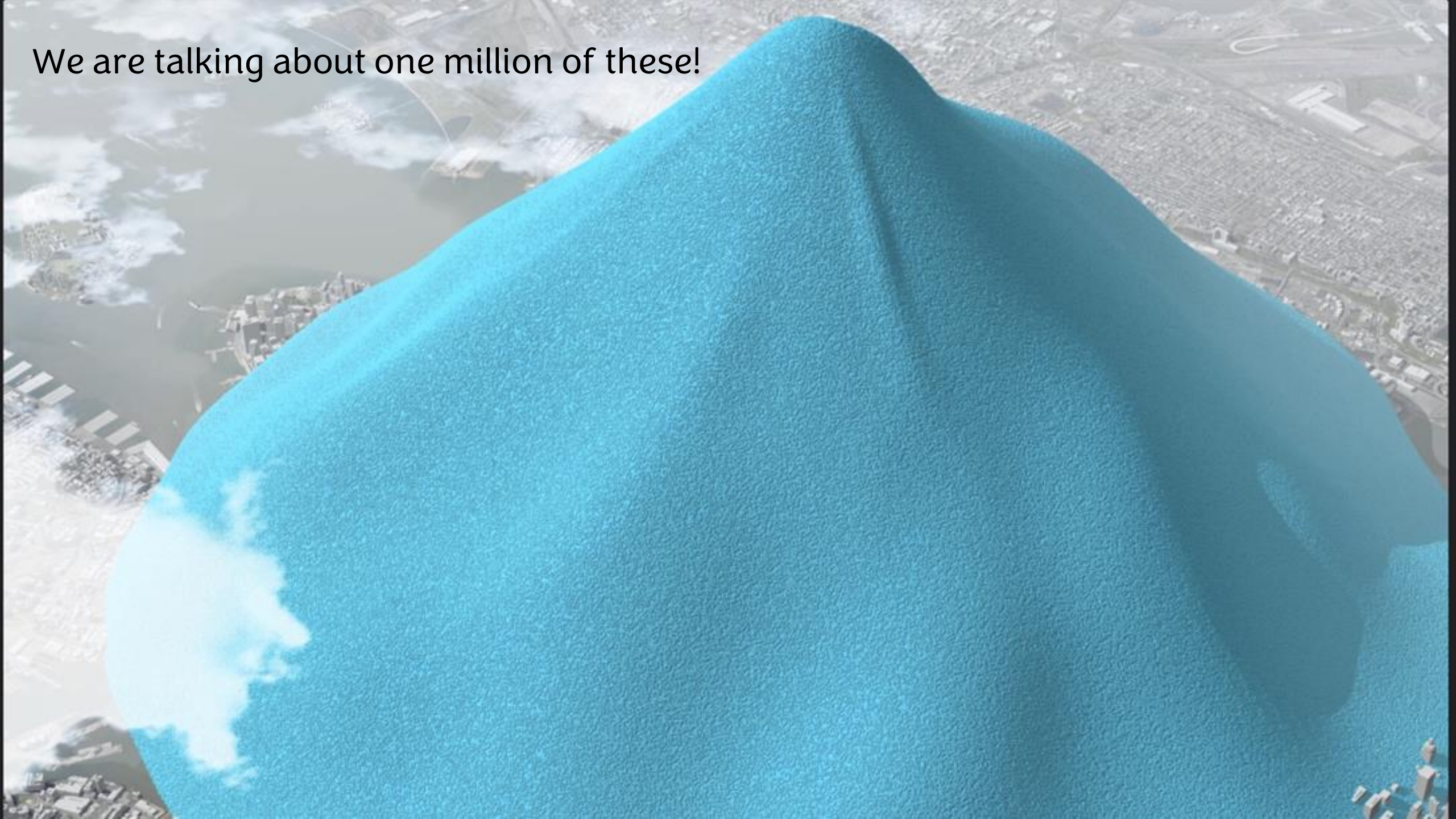
By 2050 we will have 500,000 Zettabytes ($\sim 10^{26}$ bytes).

They will need 10^8 data centers.

They will emit $\sim 10^6$ millions of CO_2e .

<https://towardsdatascience.com/>

We are talking about one million of these!



Let's talk about plastic



What if I tell you that ~7 billion of the 9.2 billion tonnes of plastic produced from 1950–2017 became plastic waste, ending up in landfills or dumped?

What is the weight of all the plastic cups of coffee used per day in the World?

A physicist may come up with this strategy for figuring out the answer

| Data I need | Assumptions I need to make and justify |
|----------------------|---|
| The world population | How many of it drinks coffee? |
| | How many coffee cups they drink per day? |
| | How many of those cups are made of plastic? |
| | The average weight of a coffee cup? |

Working out the answer

World population: 8 billion humans = 8×10^9 humans

| Assumption needed | Assumption translated into numbers | Justification |
|---|------------------------------------|--|
| How many humans out the total world population drink coffee in a given day. | 1/3 humans | The coffee market is huge and a cup of coffee is relatively cheap around the world for anybody to buy. Also, although in many countries the population is young, let's say that one becomes a coffee drinker at 18 y/o. So, it is reasonably plausible that 1/3 of the world population drinks coffee per day. |
| How many coffee cups they drink per day | 4 cups | Let's balance heavy coffee drinkers with light drinkers and assume that a minimum of 4 coffees are drank per day. |
| How many of those cups are made of plastic | 3 cups | Let's assume that at least 3 of these cups per day is a plastic cup. |
| The average weight of a coffee cup | 170 grams | Let's average between the weight of a plastic mug (~300 grams) and the weight of a coffee cup from a vending machine (~40 grams) |

Estimating the answer

$(8 \times 10^9 \text{ humans}) \times (1/3 \text{ coffee drinkers}) \sim 3 \times 10^9 \text{ humans}$

$(3 \times 10^9 \text{ humans}) \times (4 \text{ cups/day human}) \sim 12 \times 10^9 \text{ cups/day} = 10^{10} \text{ cups/day}$

$(10^{10} \text{ cups/day}) \times (2/3 \text{ cups made of plastic}) \sim 10^{10} \text{ plastic cups/day}$

$(10^{10} \text{ plastic cups/day}) \times (170 \text{ grams/cup day}) = \mathbf{2 \times 10^{12} \text{ grams}}$

Is this a large number?

Is this a small number?

We physicists like to visualize things!

Only visualizing, the meaning of numbers can be grasped!

Visualizing the answer

First, let's talk about Kg since it is more intuitive than grams...

$$2 \times 10^{12} \text{ grams} = (2 \times 10^{12} \text{ grams}) \times (10^{-3} \text{ Kg/gram}) = 2 \times 10^9 \text{ Kg}$$

| Comparisons | Our estimated answer |
|---|---|
| A Blue Whale weights $\sim 2 \times 10^5$ Kg | The weight of all the plastic cups of coffee used per day in the World would be approximately the equivalent of the weight of 10,000 Blue Whales. |
| The Great Pyramid weights $\sim 2 \times 10^9$ Kg | The weight of all the plastic cups of coffee used per day in the World would be approximately the equivalent of the weight of The Great Pyramid in Egypt. |

How good we did?

It is interesting to check if somehow you can figure out whether you did good or way off.

In our case we figured along the way that we consume $\sim 10^{10}$ plastic cups/day.

The Earth Day * organization estimates that 16 billion disposable coffee cups are used each year ($\sim 10^{11}$ disposable cups/year) . This will be ($\sim 10^9$ disposable cups/day).

Considering our habits and where and how we consume coffee we can plausibly argue that most of the plastic cups we use are disposable, so we did not do bad with $\sim 10^{10}$ plastic cups/day!!!

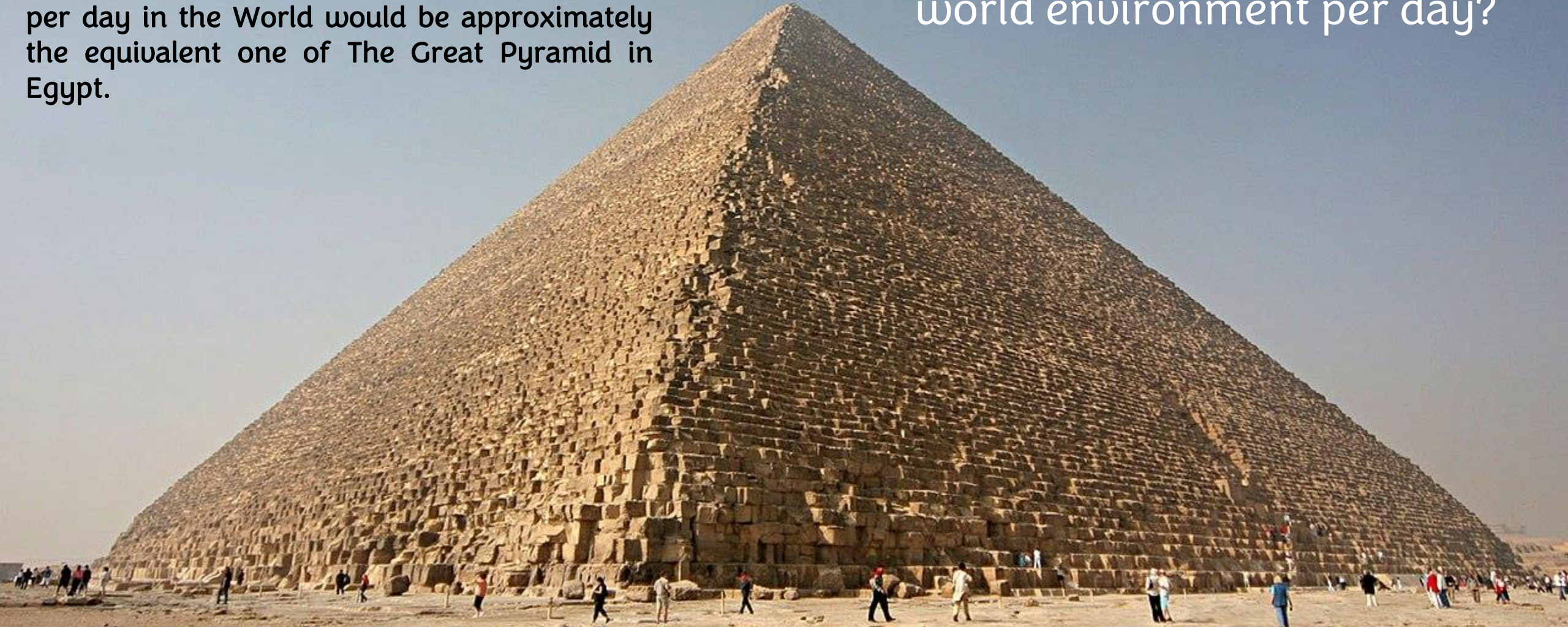
* <https://www.earthday.org/fact-sheet-how-much-disposable-plastic-we-use/>

Solution needed!!!

So now that you figured out that:

The weight of all the plastic cups of coffee used per day in the World would be approximately the equivalent one of The Great Pyramid in Egypt.

How would you propose a solution, so we don't throw a pyramid of plastic to our world environment per day?



Thanks and Questions