Welcome to the CFA society of New York's 2nd Annual Climate and ESG Owners Summit. I want to thank Tom Brigandi and CFA society of New York for organizing this event and the Climate Group for sponsoring Climate Week. And for inviting me to speak with you here today.

I am here to talk about the intersecting roles of Climate Science and Capital analysis. But before I do, I want to share with you a brief personal story.

I graduated from College in 1998 and like many people in this room, I headed straight to Wall Street. I was interested in corporate debt and went to work in the distressed debt research group at a leading investment bank. After a few years, I moved over to the trading desk, where I was advised by my boss to focus on Credit Derivative Swaps, because as he said, they were a growth area and it would be good for my career.

I soon went from trading 10's of millions of risk to 100's of millions of risk every day. My colleagues also found that due to the low margin requirements of derivatives that our clients took on much more risk leading our desk to trade significantly greater volumes. Since we were paid based, in part, on the notional amounts of risk traded this was welcomed by all.

Within a few years, in my late 20's I transacted in billions of dollars of risk a week. And while I couldn't possibly grasp the different permutations of that risk, I slept well at night, knowing that there was a system in place, risk managers above me, equity holders checking the firm's balance sheet and federal regulators all designed to insure the system remained stable. But that system, like all risk systems was based on backward looking assumptions. In this case, that the U.S. housing markets could not all decline simultaneously.

We now know the impact to the system when one of the core tenets, shifts. The firm I worked for was Lehman Brothers and while our desks activities did not lead

to its demise, my experience there taught me that the capital markets are predicated on assumptions based on past paradigms. If those paradigms shift, institutions thought to be stable can collapse.

Today, the financial markets continue to rely on retrospective data to make forecasts. But that retrospective data does not, and cannot, forecast changing paradigms, and we live in a time, due to climate change where the future will not look like the past.

Let's talk about where the planet is today.

The second quarter of this year saw the second hottest April and the hottest June in the history of recorded temperatures (May was the 4th warmest). Globally the month of June was 2 degrees Celsius warmer than historic norms and 6-10 degrees Celsius (18 degrees Fahrenheit) warmer throughout Europe. Greenland's ice sheet recorded record melting as temperatures peaked at 40 degrees F above average.

Taking a step back from specific geographical regions, it's worth noting that each of the five warmest years on record have occurred in the past five years. 19 of the 20 warmest years have happened since 2001. The only exception was 1998 when there was a record El Nino event. As an additional point of perspective, the warmest year on record 2016 was +.94 C above historical averages. The coldest year on record was less than half that deviation at -.44 C. The last below average year for the globe happened in 1976. And the last month to record a below average temperature was in December of 1984. We are currently on a 413 month streak of above average temperatures.

Warmer temperatures have economic consequences. The insurance company Aon recently published the results of a multiyear reanalysis project that produced a significant expansion of their natural disaster database. This has enabled them to conduct annual analyses for years "earlier and deeper" into the 20th century. They did this to be able to better identify the climate change signal, while acknowledging that it is already well established that nominal and inflation adjusted catastrophes losses are increasing at a statistically significant level. Their research found that the number of events has also grown steadily throughout the century.

In April this year, the Congressional Budget Office released a report titled "Expected Costs of Damage From Hurricane Winds And Storm Related Flooding."

The CBO is known as the non-partisan analyst and forecaster of government spending. In their April report they said total expected annual losses for just hurricane winds and storm-related flooding, will be about $54 billion or the equivalent of .3 percent of the Gross Domestic Product. Given the United States GDP grew at 2.9% in 2018 and likely less in 2019, .3% is a meaningful percentage of GDP's annual growth. The CBO concluded that the costs are going to increase and the only way to slow these increasing costs is to reduce Greenhouse Gas Emissions (GHG).

Storm damage is just ONE example of the economic consequences of climate change, and despite a clear, economically meaningful, multi-decadal trend, climate change is not considered in most traditional investment analysis. I believe that this is due to three main misconceptions.

Misconception one: We don't have a good enough forecast to incorporate climate change into investment models.

Misconception two: The costs of climate change will unfold in a linear way and are decades away

Misconception three: Climate's investment risks and opportunities are limited to Exploration and Production and Renewable energy.

Let's start with climate science's forecasting ability. If one were to review 1980's scientific journals, as Woods Hole Research Center Senior Fellow Spencer Glendon has, one would discover that scientists and their climate models offered eight predictions about what we would see in the world today:

1) Rising average temperature

2) More rapid rise in temperature at the poles

3) More record high nights than days

4) Increasingly intense rainfall

5) Higher ocean levels

6) Decreasing Artic sea ice

7) Hurricanes and typhoons at higher latitudes

8) Later winter and earlier spring

The models were right on all eight. These predictions were made on computers that have about a third of the computing power as the phone in your pocket. The forecasting ability of the scientific community has only improved since the 1980's. Private and public organizations like Jupiter Intel, 427 and Woods Hole Research Center are using the latest in Artificial Intelligence, big data computing and climate science to accurately identify climate costs to corporate assets and supply chain. The CFA is an organization in an industry that celebrates people who can get investments predictions right 55% of the time. Yet climate science, supported by the laws of thermodynamics and its forecasts remain outside the scope of traditional economic analysis.

Now to the linear nature and timing of costs.

Let's look at one such climate forecast, wildfires in the American west. Climate science has long forecasted that for every degree warming in the American west, we'll see a doubling of acreage burned by wildfires per year. In 1990, about 3 million acres burned in American West annually. By 2015 that number has grown to 23 million acres, and according to recent report by Munich Re about half of those wildfires are attributable to warmer temperatures.

As acres burned by wildfires increased, the potential for catastrophic losses for utilities throughout California in a given year also increased. California utilities reported 2,009 fires caused by their wirelines over the past four years. PG&E alone reported over half the total incidents. With approximately 500 catalysts a year, the prospect for more severe fires increased as the wildfire season lengthened, and drought create more flammable conditions.

In 2017 and 2018 PG&E caused two fires that created between $15- $30 billion of liabilities and forced PG&E into bankruptcy. In addition, the utility claimed that in order to meet US District court Judge Alsup's request that they limit the potential for future fires, it would cost the company $150 billion. So, with $15-30 billion of known costs and $150 billion of preventative costs, the costs to PG&E to manage their climate risk is somewhere between those albeit wide, goal posts of $15 to $180 bln. What I want to focus on is that the cost did not go from zero to $180 billion between 2016 - 2018. <u>It has been an off-balance sheet risk, forecast by climate science, that has been growing for two decades.</u>

But just as their risks are being forecast by climate change there are opportunities as well. There must be innovation to mitigate and adapt to climate change.

One of the greatest potential areas to reduce GHG emissions is urban design. Today 55% of the world's population, 4.3 billion people live in cities. By 2050, it is expected to be 68% of the world's growing population or approximately 6.8 billion people. Cities have a voracious appetite for energy, consuming about 66% of the world's annual energy, and emitting 70% of its emissions. Making cities more efficient is so important that "Sustainable Cities" is the title of one of the United Nation's four Sustainable Development Goals focused specifically on climate.

Not only do cities house most of the world's population and emit the bulk of its GHG emissions, they are disproportionately exposed to the physical impact of climate change. 90% of cities are in coastal regions, with 70% already dealing with the effects of climate change. A July research report from Crowther Lab and ETH Zurich, used state of the art climate models of existing data in a way that they hoped would be more meaningful to urban planners. They used existing science to predict the weather and climate for 520 of the world's largest cities.

If you moved to San Francisco because you liked its temperate climate, you'll find that same climate in Seattle in 2050. Sacramento, the capital of California, will have climate more like Irbil, Iran with an average August temperature 10 degrees Fahrenheit warmer than today's temperatures. Los Angeles' climate in 2050 can be found today in Hargeisa, Somalia. London's 2050 climate will look like Barcelona But these are the lucky cities. 115 of the 520 cities will experience weather conditions whereby temperatures, seasonality and precipitation are so variable, there is no current climate like it. This will happen for 16 American cities, including our nation's capital, Washington D.C..

This is where opportunity exists. Cities' density, and exposure to damage create the opportunity and motivation for efficient planning to reduce emissions and build for adaptive strategies. Preparing these cities for more variable temperature and new climates will require significant new infrastructure and a smarter use of resources. The Internet of Things (IoT) future holds promise for many of those things. Companies like Qualcomm (with its 5G Patents), Acuity Brands (in smart lighting), and Johnson Controls (in smart buildings) are all well positioned to benefit from an accelerated growth trend driven by more efficient and smarter cities.

Just last month, passively invested funds passed 4.27 trillion and for the first time they invest more assets than actively managed funds. If you are allocating capital as a fiduciary today, beware of being too heavily reliant on passive investing or divestment strategies. Not unlike the unexpected decline in housing prices in 2008, a paradigm shift that affects all parts of the economy is occurring today. But unlike the housing crisis, there is an accurate forecast provided by some of the world's best scientists and supercomputing. Investing as normal, is to bet against the laws of thermodynamics.

Incorporating climate science into an investment model can help investors, not just drive capital to much needed mitigation solutions, but also capture what I believe to be the last major market inefficiency and active alpha opportunity. Put simply, you can help the planet and your investment returns.