# Manabe and Weatherald 1967

The 1967 paper by Manabe and Wetherald, published in the Journal of Atmospheric Sciences, revolutionized climate modeling by quantifying the global-warming effects of carbon dioxide. They demonstrated that doubling CO2 led to a marked cooling of the stratosphere, a key indicator of increasing CO2 levels. Their model included various physical processes crucial to understanding climate change, such as changes in radiation and cloud cover. This foundational work provided insights into the warming potential of greenhouse gases and highlighted the importance of feedback mechanisms in climate systems. Overall, their research significantly influenced the trajectory of climate change science.

Focused on computing the radiative-convective equilibrium of the atmosphere with specific humidity distributions. They found that it took nearly twice as long for an atmosphere with a given relative humidity distribution to reach equilibrium compared to one with a fixed absolute humidity distribution. Additionally, they observed that the surface temperature equilibrium of the former was about twice as sensitive to changes in factors like solar radiation, CO2 levels, ozone content, and cloud cover. Their model estimated that doubling CO2 levels would increase atmospheric temperature by approximately 2°C under fixed relative humidity conditions

# Norman Philips 1956

Introduced the first successful general circulation model of climate, depicting monthly and seasonal atmospheric patterns realistically. This mathematical model, a breakthrough in geophysical fluid dynamics, accurately represented tropospheric behaviors. Phillips's work laid the foundation for understanding global air movements and climate dynamics. By developing a model that captured the general circulation of the atmosphere, he significantly advanced meteorological science. His contributions were pivotal in shaping subsequent climate modeling efforts and establishing the basis for modern atmospheric research.

Norman Phillips's global circulation model, developed in 1956, had several key features that set it apart as the first successful general circulation model of climate:

1. Realistic depiction of monthly and seasonal patterns in the troposphere.
2. Representation of global air movements and atmospheric circulation.
3. Utilization of a mathematical model to simulate atmospheric behaviors accurately.
4. Foundation for understanding the general circulation of the atmosphere.
5. Pioneering work in geophysical fluid dynamics and climate modeling.
6. Influence on subsequent climate modeling efforts and advancements in atmospheric research

"The general circulation of the atmosphere: a numerical experiment," did not include extensive equations within its text itself; instead, it presented the conceptual framework and methodologies behind his groundbreaking model. However, some details regarding the underlying mathematics can be gathered from other sources:

* Phillips employed finite difference approximations to solve the governing equations of motion for the atmosphere.
* These equations consisted primarily of the hydrostatic equation, continuity equation, momentum equations, and thermodynamic equation.
* To account for the Earth's rotation, Coriolis forces were incorporated into the momentum equations.
* The model utilized a horizontal grid system, dividing the globe into latitude bands and longitudinal zones.
* Vertically, the model divided the atmosphere into pressure layers or isobaric surfaces.
* The model solved these equations iteratively, adjusting variables until the calculated values converged upon those specified in initial boundary conditions

# Parmesan and Yohe (2003)

Investigated the relationship between climate change and shifts in species ranges. They analyzed over 1,700 species across North America and Europe, revealing significant correlations between rising temperatures and alterations in species distributions. Their research provided empirical evidence supporting the idea that climate change leads to ecological consequences, including range contractions and expansions.

.Key Findings:

* Documented widespread shifts in species ranges due to climate change.
* Identified trends indicating that northern species shifted poleward while southern species experienced limited expansion.
* Provided strong support for the hypothesis that climate change affects ecosystem composition and function through altered species interactions.

This seminal work has been instrumental in informing conservation strategies and policy decisions related to biodiversity preservation in response to ongoing climate change.

## Methods

Camille Parmesan and Gary Yohe's 2003 research examined the correlation between climate change and shifting species ranges. They achieved this goal utilizing the following methods:

1. Data collection: Gathered data sets containing records of species occurrences throughout North America and Europe.
2. Statistical analysis: Applied various statistical methods to analyze the collected data, identifying relationships between changing climates and species distributions.
3. Temporal comparisons: Compared historical species observations with more recent ones, accounting for temporal variations in environmental conditions.
4. Spatial analyses: Analyzed spatial patterns of species distributions, focusing on shifts in species ranges.
5. Climate data integration: Integrated climate data from General Circulation Models (GCMs), allowing them to assess the influence of climate change on species distributions.

By employing diverse analytical tools and integrating climate data, Parmesan and Yohe produced robust evidence demonstrating the linkage between climate change and species redistribution.