the problems that might be posed to yachting and the cruise liners operating in the Caribbean.

The government of Patrick Manning took part in the United Nations Framework Convention on Climate Change, signed in Rio de Janeiro in May 1992, and 2 years later, Trinidad and Tobago was represented at the Global Conference on the Sustainable Development of Small Island Developing States held in Barbados. On January 7, 1999, the Trinidad government of Basdeo Panday signed the Kyoto Protocol to the UN Framework Convention on Climate Change, with it being ratified exactly 3 weeks later, but only entering into force on February 16, 2005.

SEE ALSO: Climate Change, Effects; Floods; Tourism; Transportation.


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Tropopause

THE TROPOPAUSE IS the boundary region dividing the troposphere, the lowest layer of the atmosphere, from the overlying stratosphere. Since the tropospheric and stratospheric air masses have rather distinct features, in correspondence to each surface location, the tropopause height is the level in the vertical where abrupt changes in the physical and chemical properties of the atmosphere are observed.

Three different definitions are typically adopted. The thermal tropopause is related to the change of the sign of the vertical derivative of the temperature (lapse rate), which is negative in the troposphere and positive in the stratosphere.

The World Meteorological Organization defines the tropopause as the lowest level where the absolute value of the temperature lapse rate decreases to 2K/km. or less, with the average lapse rate between this level and all higher levels within 1.2 mi. (2 km.) not exceeding 2K/km. The dynamical tropopause is defined in terms of sharp changes in the potential vorticity (much higher in the stratosphere), which measures stratification and rotation of the air masses. An abrupt increase (decrease) with height of the ozone (water vapor) mixing ratio indicates the presence of the chemical tropopause. In spite of the necessity of choosing phenomenological thresholds, the three definitions of the tropopause are quite consistent.

TROPICAL TROPOPAUSE

Typically, the tropopause height decreases with latitude, being around 3.7 mi. (6 km.) near the poles and 11 mi. (18 km.) near the equator. Whereas radiative and convective processes with time scale of the order of one week to one month basically determine the properties of the tropical tropopause, in the midlatitudes a relevant role is played also by baroclinic-fuelled extra-tropical cyclones, having a typical time scale of a few days, in such a way that the tropopause readjusts its height in such a way as to act effectively as a stabilizing mechanism limiting the growth of the weather perturbations. The tropopause is not a hard boundary: exchanges of tropospheric and stratospheric air occur through various mechanisms, including vigorous thunderstorms and midlatitude perturbations.

The globally averaged tropopause height tends to increase if the troposphere warms up and/or the stratosphere cools down, and the height change is approximately proportional to the difference between the tropospheric and stratospheric temperature changes. Therefore, the mean tropopause height can act as a robust indicator of climate change. Recent climate simulations have shown that the estimated increase after 1979 of about 492 ft. (150 m.) may be primarily explained by anthropogenic causes, namely the stratospheric cooling driven by ozone depletion and the tropospheric warming driven by increases in the greenhouse gases concentration. Considering natural processes, episodic, short-lived strong reductions of the globally averaged mean tropopause height are caused by large explosive volcanic eruptions, which warm the troposphere and cool the stratosphere.
Troposphere

ON THE BASIS of thermal characteristics, the atmosphere is normally subdivided into four major vertical layers: the troposphere, stratosphere, mesosphere, and thermosphere. The troposphere makes up the lowest of these layers, extending from the surface to a global average height of 7.5 mi. (12 km.). Coined in 1908 by French scientist Leon Philippe Teisserenc de Bort, the name troposphere is derived from the Greek word tropos, meaning to turn, mix, or change. The term aptly describes the extensive vertical mixing and stability changes of this layer, which generates clouds, precipitation, and other meteorological events. For this reason, the troposphere is commonly referred to as the weather sphere.

The depth of the troposphere is relatively thin, yet it contains approximately 80 percent of the atmosphere's mass. Because the atmosphere is compressible, air molecules are more compact closer to the surface, thereby increasing the density and pressure of the air at lower altitudes. The relationship between density and pressure with altitude is nonlinear, decreasing at a decreasing rate with increasing altitude. In the lower troposphere, the rate of pressure decrease is about 10 mbars for every 330 ft. (100-m.) increase in elevation.

Temperature in the troposphere generally decreases with height, contrasting considerably between its lower and upper boundaries. Temperature in this layer is largely affected by the radiant energy exchanges from the underlying surface and insolation intensity. The global average temperature at the surface is 59 degrees F (15 degrees C) but decreases to around minus 82 degrees F (minus 63 degrees C) at the top of the troposphere. On the basis of mean tropospheric depth, the average rate of temperature decrease is 3.6 degrees F per 1,000 ft. (6.5 degrees C per km.), a measurement known as the normal lapse rate. This rate represents average global conditions, deviating substantially depending on latitude, time, and local modifications. The actual temperature change with height is the environmental lapse rate, which is measured remotely, using satellites, or directly, using Radiosondes (a balloon-borne instrument package). Eventually, temperature ceases to decline with height, transitioning into a zero lapse rate region (or isothermal layer), where temperature is neither increasing nor decreasing. This shift demarcates the boundary between the troposphere and the stratosphere, known as the tropopause.

The mean height of the tropopause can have considerable spatial and temporal variability. In the tropics, the depth of the troposphere is around 16 km. (10 mi.), but near the poles, the depth dwindles to about 8 km. (5 mi.) or less. The tropopause also varies seasonally, with higher heights occurring during the summer than the winter. Warm surface temperatures occurring at low latitudes and high sun periods encourage vertical thermal mixing, thereby extending the depth of the troposphere. Accordingly, the environmental lapse rate in these regions continues to remain positive (i.e., temperature decreases with height), and tropopause temperatures are typically lower in the tropics than for high latitudes. Occasionally the tropopause is difficult to discern because of extensive mixing between the upper troposphere and the lower stratosphere.

This situation is common in portions of the mid-latitudes, usually defining the location of jet streams (a narrow belt of high-velocity winds often in excess of 185 km. per hour (115 mi. per hour) that steer mid-latitude cyclones. Because the height of the tropopause is dependent on the average temperature of the troposphere, temperature changes in this layer can influence the location of extratropical storm tracks and cloud depth.

Embedded frequently within the troposphere are thin sublayers in which the temperature actually increases with height, known as temperature inversions. Radiation inversions result from nocturnal surface cooling. Under certain ambient conditions (e.g., cloudless nights), terrestrial radiation loss to space is enhanced and the ground (and air above) cool rapidly, thereby establishing a shallow inversion layer. Conversely,