National Aeronautics and Space Administration

NASAFacts

TC4

The NASA Tropical Composition, Cloud and Climate Coupling Mission

What will NASA study during the TC4 mission?

TC4 is probing a region high in the atmosphere over the tropics that has rarely been studied but has a major impact on the climate of the whole planet. This layer between approximately 46,000 ft and 59,000 ft (14-18 km) is where the lower part of the atmosphere (the troposphere) meets the upper part (the stratosphere). There are many unique but poorly understood processes taking place in this *tropical tropopause transition layer* related to the formation of icy cirrus clouds and the flow of air, water vapor and chemicals.

Why is it important to study this part of the atmosphere?

Increased knowledge of the many processes occurring in this layer is essential to improving our understanding of global climate change and the health of Earth's protective ozone layer. The tropics and subtropics compose half of our planet, and the meteorological processes and deep convective cloud systems created here have a profound effect on Earth's climate. The significant upward movement of air in this region carries water vapor and other chemicals from sources at or near Earth's surface up as high as the stratosphere. Reactions involving these chemicals play an important role in the evolution of the ozone layer. Water vapor affects the formation of various types of cloud systems, which in turn play very important roles in climate change. TC4 will investigate the composition of this layer and analyze the impact of the deep clouds that penetrate the lower atmosphere into this region.

Why is the TC4 mission based in Costa Rica?

Tropical weather systems have a dramatic effect on the overall amount of radiation and heat the Earth's atmosphere contains. These systems also produce lots of rainfall, which releases heat into the atmosphere and plays a key role in driving the general circulation of the atmosphere.

The cloud systems that form just off the Pacific coast of Costa Rica in the Gulf of Panama are remarkably intense for tropical maritime systems due to a number of unique factors there. During the peak of the summer, these strong systems form almost daily, so there are many opportunities to observe them during a time-limited field campaign. Mission scientists will be able to sample the air flowing out of typical weak maritime convection systems and strong maritime convection systems. They will also be able to study cloud systems associated with clean air flowing into them versus inflow that has much higher concentrations of small particles called aerosols, which can change the properties of the cloud systems.

How fast can air rise into the upper atmosphere in this region?

Heat-driven convection brings air aloft in the rain-filled column of these deep convection cloud systems. It may only take 20 minutes for the air to move from the surface to the tropopause, which is faster than a commercial airliner can climb. Some of this air may rise as high as the stratosphere, possibly bringing very reactive, short-lived chemicals from the ground.

How are NASA satellites involved in the TC4 campaign?

NASA is using a suite of seven satellites during TC4, five of which are flying in a close formation called the "A-Train." Each instrument on the A-Train satellites uses a different technique and sees a different part of the complex structures of the Earth-atmosphere system. *Aura,* launched in 2004, will focus on the chemical composition of the tropopause transitional layer, measuring ozone, water vapor, carbon monoxide and particles. *Aqua*, launched in 2002, will map clouds in the upper troposphere, including thin cirrus, thick cirrus and deep convective cloud systems.

The two newest members of the A-Train, *CALIPSO* and *CloudSat,* launched together in 2006, will pierce the atmosphere to provide vertical profiles of clouds and of aerosols that can change how clouds form. The combination of data from all these satellites gives scientists a three-dimensional view of the atmosphere.

How will NASA aircraft study this complex region of the atmosphere?

While our latest suite of satellite instruments provide crucial information on the overall processes occurring in the region, they do not always capture the small-scale details and processes that change over time that are necessary to fully understand this complex region. By using coordinated flights of instrumented aircraft along with ground-based measurements and satellite observations, TC4 will be able to obtain a detailed multi-dimensional picture of this atmospheric region.

Three NASA aircraft -- ER-2, WB-57, and DC-8 -- are involved in the TC4 campaign, carrying a total of over 60 specialized instruments. The ER-2 looks down from the highest altitudes to see the tropical tropopause transition layer. The WB-57 flies through the transition layer, and the DC-8 looks up into the layer and measures what is being transported upward into the layer.

The ER-2, which flies up to altitudes of 70,000 feet, carries instruments similar to those on NASA satellites to look down on the atmosphere and cloud systems. The WB-57 flies at an altitude range of 35,000-65,000 feet and carries instruments that directly sample trace gas, clouds, and aerosols in the air the plane flies through (in-situ measurements). The DC-8 flies from near Earth's surface up to 40,000 feet making a wide range of both upward- and downward-looking remote-sensing measurements as well as in-situ measurements.

Are scientific instruments on the ground also involved in TC4?

Yes. A radar is located at the San Jose airport to provide local weather data. A large S-Band polarimetric radar and an atmospheric research trailer are based in Las Tablas, Panama. Helium-filled balloons called balloon-sondes will carry small, light instrument packages for measuring winds, temperature, humidity and ozone. The Ticosonde balloon program in Costa Rica will employ local meteorology students from the Instituto Meteorológico Nacional and the Universidad de Costa Rica.

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