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Vertical Profiles of HTO, HDO, and H_2O in the Troposphere

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PREFACE

This document presents vertical profiles of tritium, deuterium, and water vapor in the troposphere that were obtained by NCAR at various times from 1966 through 1973. These data enable development of more realistic models of the transport and rainout of tritium as well as a more realistic estimate of the tropospheric residence time of water vapor.

ACKNOWLEDGMENTS

I would like to thank the NCAR Aircraft Facility and especially the NCAR pilots who flew the missions. L. E. Heidt, G. J. Dolan, and W. H. Pollock operated the water-vapor sampler. Special thanks are due to L. Leiker, S. Gitlin, and N. Roper for careful and diligent work in recovering the water samples in the laboratory and carrying out the T analyses and to W. H. Pollock who prepared the data tabulations and figures for this publication.

CONTENTS

1. INTRODUCTION

Most of the tritium (T) present in the environment was produced by thermonuclear explosions and injected into the stratosphere; the largest such contribution came from the Soviet test series in 1961 and 1962. Natural T production by cosmic radiation plays only a minor role. Most of the bomb tritium reacts during cooling of the fireball to form tritiated water, HTO. HTO mixes down from the stratosphere into the troposphere and accumulates in surface waters, mainly the oceans, thereby entering all stages of the hydrological cycle. HTO is therefore a tracer particularly well suited to the study of the natural water cycle. At present its main applications are in hydrology where it is used to determine ground-water recharge as well as the recharge, age, and mixing of water bodies [cf. IAEA, 1967, 1970], and in oceanography where it is used in the study of vertical mixing and horizontal advection [IAEA, 1967; Roether et al., 1970]. Since the T content of the surface water depends on the T input by precipitation and by isotopic exchange with water vapor, these applications require that the variations in the T content of precipitation and water in space and time be known. However, such knowledge is limited. Often the T content of precipitation for past years has had to be extrapolated from present values at different locations. Such extrapolations suffer from the fact that the atmospheric transport of HTO is not completely understood. Until now the study of the tropospheric HTO distribution has been limited to surface air, and practically all such information comes from the measurement of rain samples. The distribution of HTO with height has been measured only for a few special situations like hurricanes [Östlund, 1968]. Thus, models of tropospheric transport of HTO and rainout of HTO have remained largely speculative

To remedy this lack of information, HTO profiles up to altitudes of 9 km were obtained regularly at two locations over continental United States in 1966 and 1967. Additional profiles were collected for the Pacific, 200 km west of San Louis Obispo, and Santa Barbara, California, during 1966 and 1967. After a three year pause, sampling flights were renewed

in 1971 aboard NCAR's Sabreliner, which allowed the maximum flight altitued to be extended to 13 km. Average values of the earlier data have been reported and interpreted [Ehhalt, 1971, 1973].

This note reports all the individual HTO-profiles obtained through 1973. In addition to profiles of the T-content, profiles of the deuterium content as well as of the water-vapor mixing ratio were measured and are reported here along with the meteorological data that were obtained for some of the Scottsbluff flights.

2. TECHNIQUE

Collection of water vapor. Aboard the NCAR Queen Air 80 (i.e., during the flights in 1966 and 1967), water vapor for T analysis was collected by passing air through U-tubes that were cooled in a mixture of dry ice and solvent. The air intake was mounted on the top forward section of the Queen Air fuselage to avoid contamination by engine exhaust and extended out 20 cm from the hull into the free airstream. It was connected to the U-tubes with a polyethylene tubing 2 cm in diameter. Suction was provided by a set of venturis at the side of the aircraft to maintain a flow of 35 ℓ/min at all altitudes. The U-tubes were made of stainless steel tubing 5 cm in diameter, and 1 m in length. Before and after collection each U-tube was closed by vacuum valves. A stainless steel fritte of 60-μm pore size and 40 cm^2 area was mounted at the exit of the U-tubes to retain any ice crystals that might form in the airstream during rapid cooling of moist air. Thus the loss of water vapor depended only on the temperature of the air leaving the U-tubes, which was 10°C above the dry-ice slush temperature. At the maximum altitude of 9 km (300 mb), where this loss becomes most important because of the dryness of air, the slush temperature was -90°C; the corresponding loss should be 1 mg H_2O/kg air. Since the average absolute humidity at an altitude of 9 km was about 50 mg H_2O/kg air, this loss amounts to only 2%, a value which does not influence the T concentration. It does however shift the D content by about 1‰ because of isotope fractionation during condensation. The efficiency of water-vapor

collection and the integrity of the isotopic content of the collected water also were checked experimentally by measuring the amount and D content of water vapor frozen out in the U-tubes at various flows and pressures and comparing these measurements with those obtained in a Horibe trap at a fixed flow of 1 ℓ/min. The agreement was excellent up to a flow of 40 ℓSTP/min.

The sampling time varied from 15 min at the lowest altitudes to 1 h at the four highest altitudes. At the two highest altitudes air was passed through two parallel U-tubes in order to double the total flow. The collected amounts of water varied from 50 mg to 10 g. In the laboratory the U-tubes were individually connected to a vacuum line and evacuated while cold. The U-tubes were then heated by a heat gun and the water vapor condensed directly into ampules in which the samples could be weighed and kept.

Absolute humidities were calculated from the flow rate, pressure, sampling time, and collected amount of water with a relative error of less than ±5%.

The Sabreliner flights in 1971-1973 were carried out to much higher altitudes and therefore encountered smaller water-vapor mixing ratios; thus liquid N_2 was used as a coolant to ensure quantitative collection. In addition, because the available flight time was much shorter, higher flow rates were needed to collect adequate amounts of water vapor. The system adopted consisted of eight stainless steel collection vessels mounted on one flange and submerged in a slightly pressurized liquid N_2 dewar. Each vessel was 80 cm long and 7.5 cm o.d. and consisted of three concentric tubes. The flow was forced downward along the gap between the outer and middle tubes where the lowest 10 cm consisted of a stainless steel fritte of 200 cm^2 surface; the flow then entered the gap between the inner and middle tubes where the air flowed upward. Both inner and outer tube walls were in contact with the liquid N_2. The tubes allowed flows up to 120 ℓSTP without loss of water vapor, as checked by a series of laboratory experiments at different flow rates and pressures. The tubes also collected CO_2

quantitatively when the dewar was full of liquid N_2 and showed a loss of about 10% CO_2 when the liquid N_2 level had dropped by about 20 cm. (The CO_2 was also collected and used as an additional check on the measured total flow.) The tubes were connected by vacuum valves to inlet and outlet manifolds which in turn were connected by stainless steel flexible tubes of 2.5 cm diameter to the intake and outlet on the fuselage. In flight the ram pressure was used to maintain the flow. Recovery of the water vapor was similar to that described for the U-tubes. As for the U-tubes, flow rate was measured by a "vol-o-flow" flow gauge and recorded during flight, air pressure of the flow was measured with a Wallace and Tiernan gauge (600 torr full scale) and temperature of the airflow was measured with a thermoelement. Absolute humidity was calculated the same way as for the U-tubes; its error is also ±5%.

T-measurement. For T analysis, 0.7 g of each water sample was reduced to hydrogen over uranium-238 at 600°C. The hydrogen was collected in a charcoal trap cooled with liquid N_2 and then transferred to a proportional counter of 2.5-ℓ sensitive volume at a partial pressure of 200 torr. If the amount of sample was smaller than 0.7 g, T-free hydrogen was added to obtain the normal operating pressure of 200 torr. Finally, 1000 torr of a mixture of 90% Ar and 10% T-free natural gas methane was added. This shifts the background spectrum to higher energy and thus lowers the background in the T channel between 1 and 16 keV.

The proportional counter was surrounded by an inner shield of mercury of 2.5-cm thickness, an anticoincidence ring in the form of an annular multi-wire Geiger flow counter and an outer shield of 20 cm of iron. An aluminum window of 20-μm thickness in the proportional counter allowed energy calibration by means of x rays from an external iron-55 source. The background in the T channel (1-16 keV) was 0.8 counts per minute. The sensitivity was 1 cpm/310 T.U. (tritium unit) at 200 torr hydrogen sample pressure. The T.U. is the unit of the T ratio of water: 1 T.U. = 1 T atom/10^{18} H atoms. The counting time was usually 1000 min to reduce the counting error to at least 3%, but

for samples from Sabreliner flights much longer and more variable counting times were used. The total errors for the T/H-measurements are given in the tables. Occasionally the errors are quite high due to the large errors introduced when reading the pressures for very small H_2 samples.

D-measurement. The D/H ratio, or D content, was measured by the usual analytic procedure [cf. Friedman, 1953] with an Atlas MS86 mass spectrometer. The D content is expressed as a δ value, which is defined as relative deviation of the D/H ratio, R, of the sample, SA, from the D/H ratio of standard mean ocean water, SMOW, in per mil [Craig, 1961]:

$$\delta_{SMOW} = [(R_{SA} - R_{SMOW})/R_{SMOW}] \times 1000$$

The standard deviation of the δ values is ±1 unit on this scale.

3. SAMPLING FLIGHTS

Aircraft sampling flights began in November 1965 over Scottsbluff, Nebraska. Situated at 41°50'N, 101°40'W in the western part of the great plains about 300 km east of the Rocky Mountains and 1.2 km above sea level, this is an area with relatively dry mid-continental climate. Sampling was done in clear air; no flights were made in completely overcast situations although on a few occasions, when flying between clouds, cloud water was collected. On the Queen Air flights the samples were collected at eight altitudes: 1.52 km (5000 ft), 1.83 km (6000 ft), 2.29 km (7500 ft), 3.05 km (10,000 ft), 4.57 km (15,000 ft), 6.1 km (20,000 ft), 7.62 km (25,000 ft), and 9.15 km (30,000 ft) above sea level. Each profile required two aircraft flights. From February to June 1966 about three profiles were collected each month. Later only one profile per month was obtained. Simultaneous radiosonde profiles were used to check the temperature measurements aboard the aircraft as well as the humidity estimates from the collected amount of water. The radiosondes also provided information on the speed and direction of winds. Once a month an ozone profile was also obtained.

The Scottsbluff flights were terminated in January 1967. In July 1966 a flight series was begun over the Pacific, about 34°N, 125°W, 200 km west of San Luis Obispo, California and over Death Valley, 36°N, 117°W, about 300 km inland. These flights were conducted on two consecutive days once a month. Initially eight altitude levels were sampled. However this number was reduced to seven because of the limited fuel capacity of the aircraft.

The flights on the Sabreliner started in March 1971 and ended in September 1973. Since available flight time on the Sabreliner was limited, the flight dates are irregular. In particular no flights during June and July could be obtained, so that even for the Scottsbluff location data for a full season are not available. Two oceanic flights, one each over the east and west coasts, were made for comparison. Other flights were obtained over east Texas when the Sabreliner was available to support NCAR's stratospheric balloon flights over Palestine, Texas.

Since the Sabreliner flights were undertaken to extend data from the earlier low-altitude Queen Air flights to higher altitudes, sampling was restricted to the upper troposphere. Seven sampling altitudes were selected for the Scottsbluff flights. These altitudes and their corresponding sampling times were at about 6.4 km (10 min), 7.6 km (15 min), 8.8 km (20 min), 10 km (20 min), 11.3 km (20 min), 11.9 km (30 min), and 13.1 km (30 min). Flights at other locations extended occasionally to the surface.

4. EXPLANATION OF TABLES AND FIGURES

The data tables and figures are ordered according to both location and time. The table headings give the date and location of the sampling flight as well as the local daytime when sampling was begun. Usually sampling was begun at the highest altitude after the plane had reached its designated geographical location. In the case of the Queen Air two flights were required and the sampling was spread over about eight hours; in the case of the Sabreliner over less than four hours. Correspondingly, samples between the highest and lowest altitudes may be

separated by as much as eight or four hours, respectively, a fact which should be borne in mind when detailed meteorological studies are undertaken. The height of the tropopause (measured by radiosonde or aboard the plane) is given on the bottom of each table. The columns in the tables are self-explanatory: altitude is given in meters; the Rosemount temperature is given (as measured on the airplane) in degrees Celsius; the water vapor mixing ratio is given in grams of water per kilogram of air; the deuterium content is given as a δ value in ‰ with respect to standard mean ocean water (SMOW); the T-content (i.e., the T/H ratio) is given in tritium units (T.U.); the tritium mixing ratio is given in HTO molecules per kilogram of air (which is identical with the number of T atoms per kilogram of air).

In the figures all these parameters (in the same units) are plotted versus altitude above sea level in kilometers on the ordinate. In addition where available, winds measured from radiosondes and O_3 as measured from a Mast ozonesonde are also given.

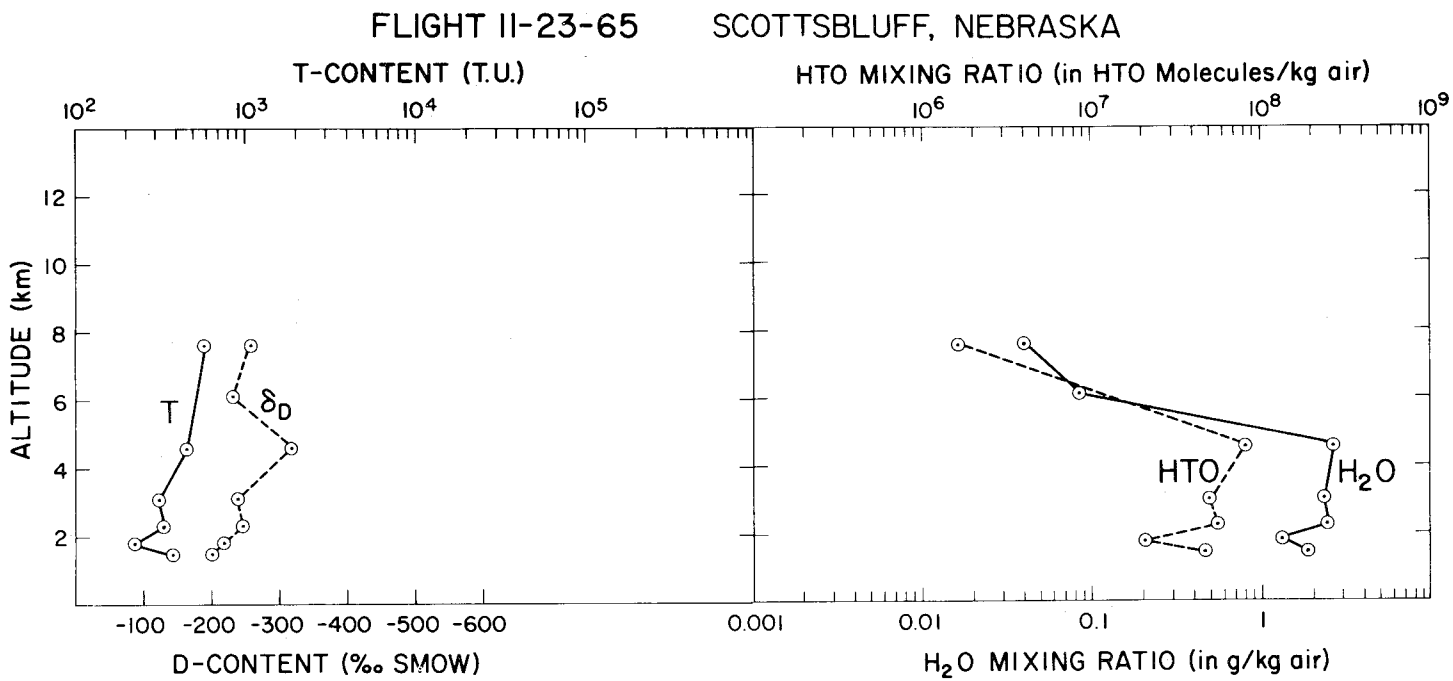
DATE: 23 November 1965

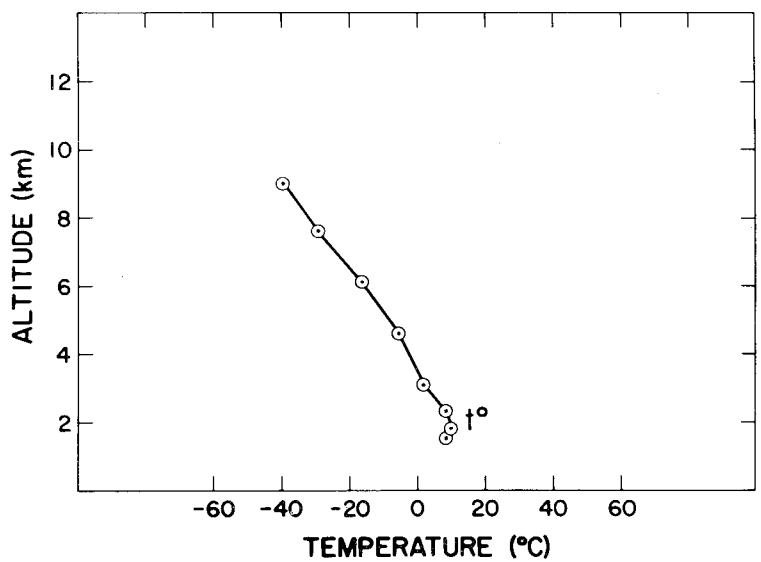
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:35

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+8.6	1.84	-204	380± 22	4.7×10^{7}
1830	+11.5	1.32	-218	230± 22	2.0×10^{7}
2280	+8.6	2.46	-246	340± 24	5.5×10^{7}
3050	+1.9	2.32	-239	320± 37	4.9×10^{7}
4580	-5.6	2.62	-319	460± 23	8.6×10^{7}
6100	-16.6	.086	-233	3260±230*	
7600	-29.6	.041	-259	580±130	1.6×10^{6}
9000	-39.8				

*Cyclotron on, erroneous tritium count.


FLIGHT II-23-65
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

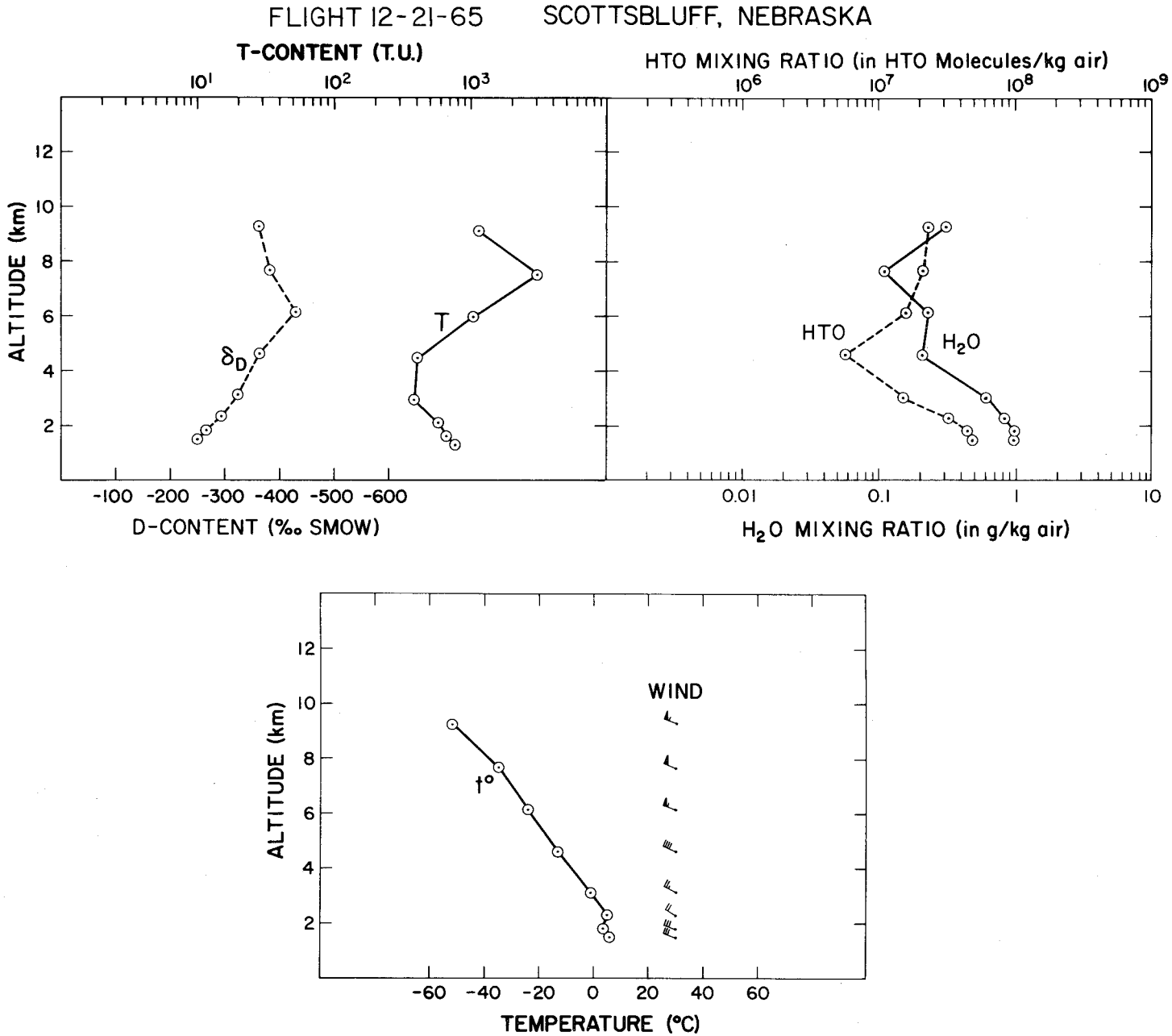
DATE: 21 December 1965

LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:00

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+6.1	.98	-251	740± 42	4.9×10^{7}
1830	+4	.98	-268	670± 36	4.4×10^{7}
2280	+5.1	.82	-295	590± 40	3.3×10^{7}
3050	-0.9	.61	-324	380± 65	1.5×10^{7}
4580	-12.9	.21	-360	410± 90	5.8×10^{6}
6100	-23.9	.23	-426	1040± 71	1.6×10^{7}
7600	-34.7	.11	-380	3000±200	2.1×10^{7}
9150	-51.1	.31	-359	1130±520	2.3×10^{7}

Tropopause: 07:07 11,250 m
14:32 10,640 m


FLIGHT 12-21-65 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)
WIND
t°
TEMPERATURE (°C)

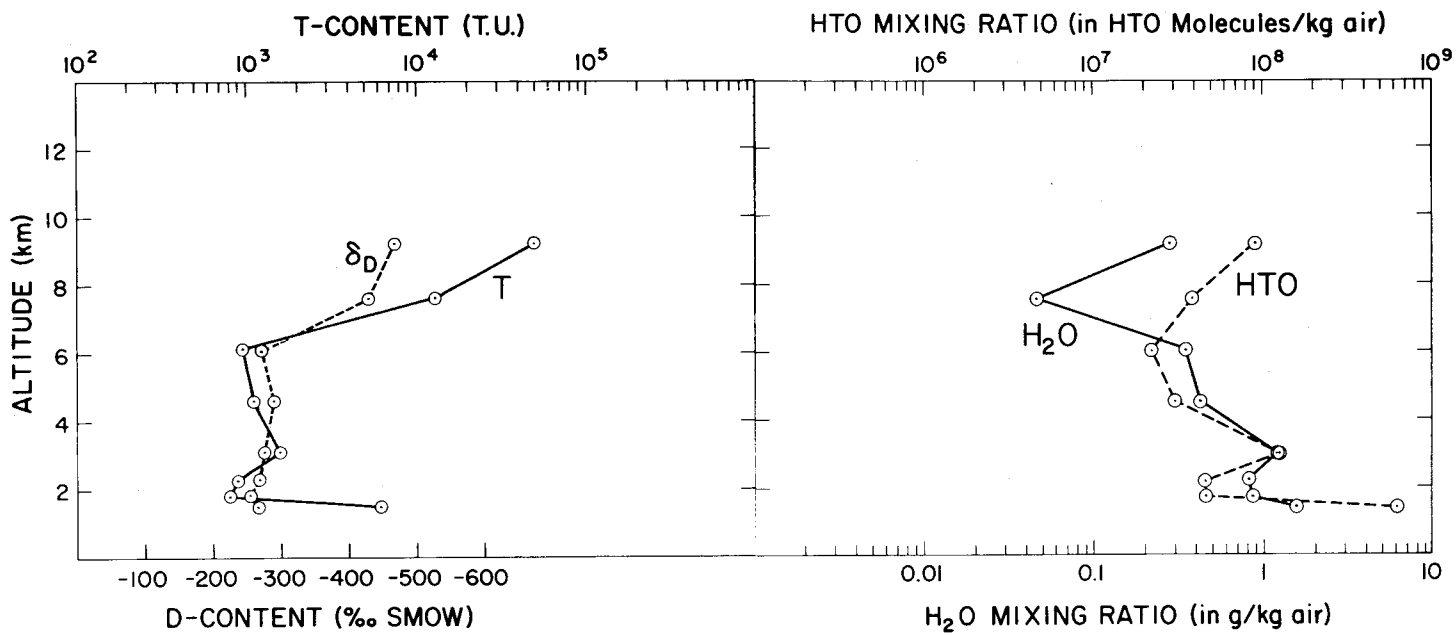
DATE: 26 January 1966

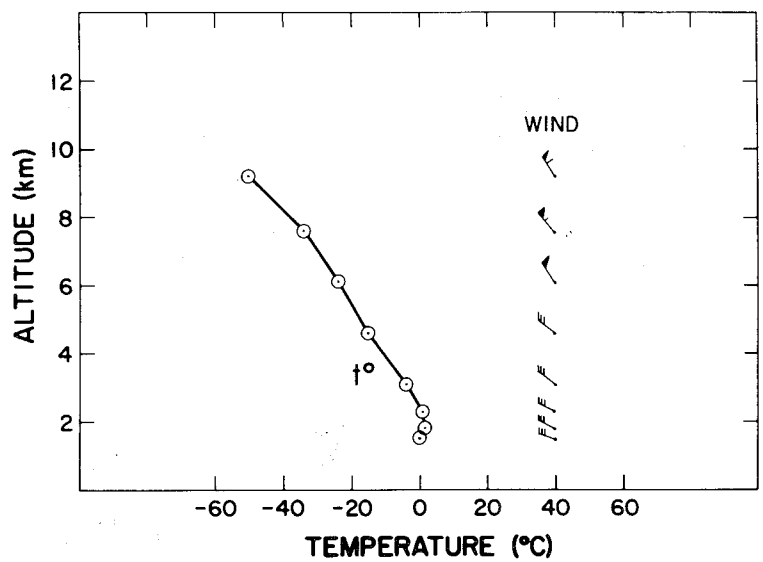
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:48

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	-0.1	1.54	-267	5980± 51	6.1×10^8
1830	+1.9	.87	-255	790± 25	4.6×10^7
2280	+0.9	.81	-269	870± 25	4.6×10^7
3050	-4.1	1.22	-275	1540± 29	1.3×10^8
4580	-15.1	.42	-289	1090± 30	3.1×10^7
6100	-24.1	.35	-271	930± 37	2.2×10^7
7600	-34.2	.046	-429	12,500±300	3.8×10^7
9150	-50.4	.28	-468	48,000±160	8.9×10^8

Tropopause: 07:47 10,500 m
14:20 11,100 m


FLIGHT I-26-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


WIND
ALTITUDE (km)
t°
TEMPERATURE (°C)

DATE: 10 February 1966

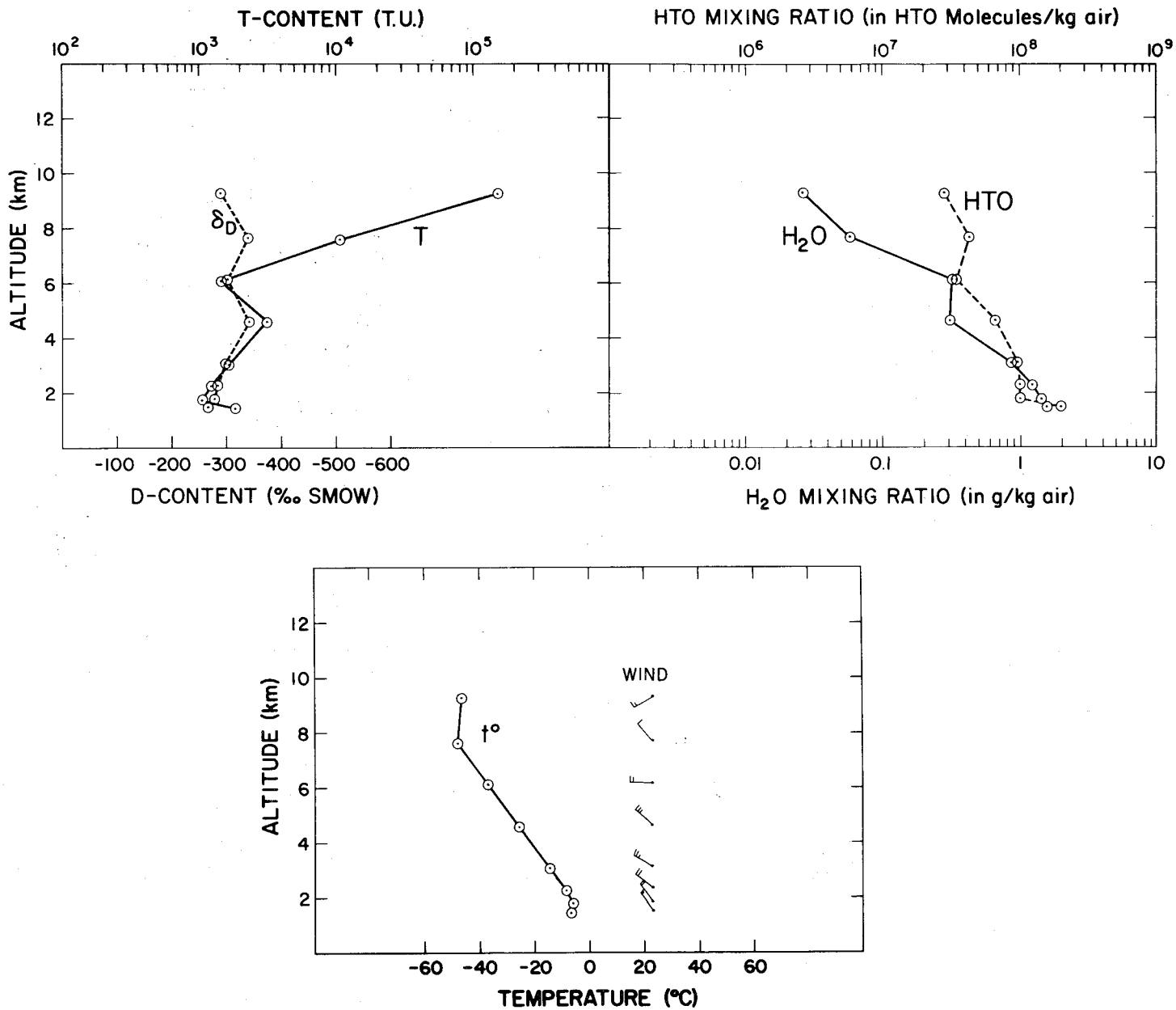
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:14

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	-6.9	1.61	-266	1830± 33	2.0×10^{8}
1830	-6.0	1.45	-276	1070± 28	1.0×10^{8}
2280	-8.9	1.23	-283	1210± 26	1.0×10^{8}
3050	-14.9	.87	-296	1640± 32	9.5×10^{7}
4580	-26.3	.32	-339	3110± 44	6.7×10^{7}
6100	-37	.35	-298	1480± 33	3.5×10^{7}
7600	-48.1	.059	-336	10,750±150	4.3×10^{7}
9150	-46.1	.027	-287	151,000±10,000*	2.8×10^{8}

*Large error due to manometer reading.

Tropopause: 15:35 7280 m


FLIGHT 2-10-66
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)
WIND
t°
TEMPERATURE (°C)

DATE: 24 February 1966

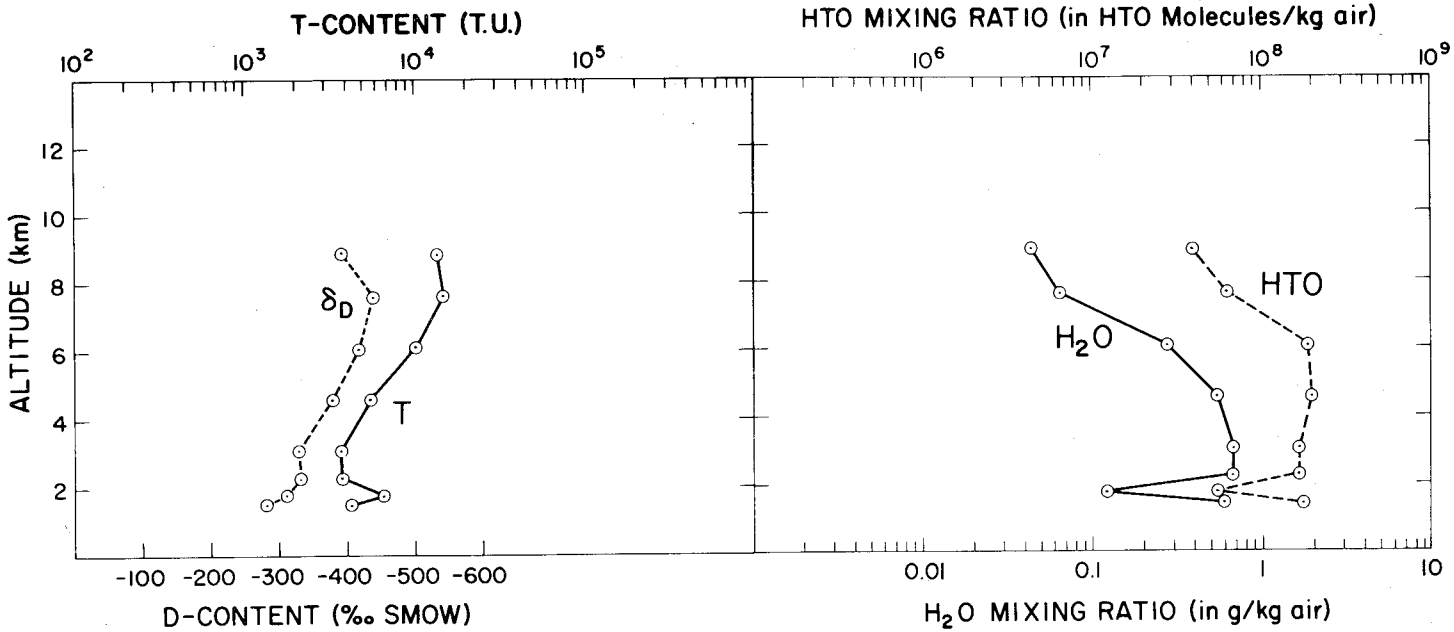
LOCATION: Scottsbluff, Nebraska

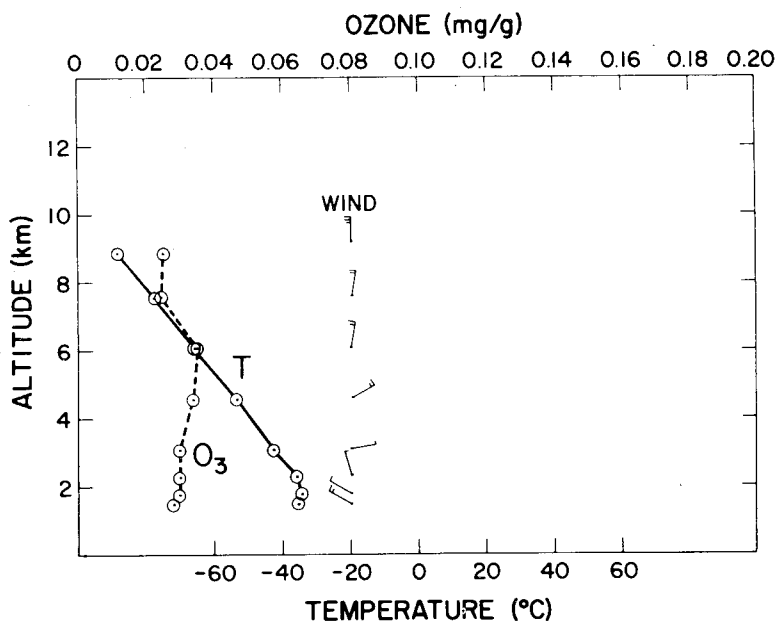
INITIAL SAMPLING TIME: 07:35

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+4.9	.58	-281	4380± 60	1.7×10^8
1830	+5.2	.12	-311	6400±200	5.3×10^7
2280	+4.2	.65	-333	3650± 40	1.6×10^8
3050	-2.8	.66	-329	3660± 40	1.6×10^8
4580	-13.9	.53	-378	5400± 50	1.9×10^8
6100	-25.1	.27	-419	9900±180	1.8×10^8
7600	-37.1	.063	-439	14,500±170	6.1×10^7
8850	-48.2	.043	-393	13,150±220	3.8×10^7

Tropopause: 06:47 11,570 m
15:59 11,400 m

FLIGHT 2-24-66 SCOTTSBLUFF, NEBRASKA





DATE: 10 March 1966

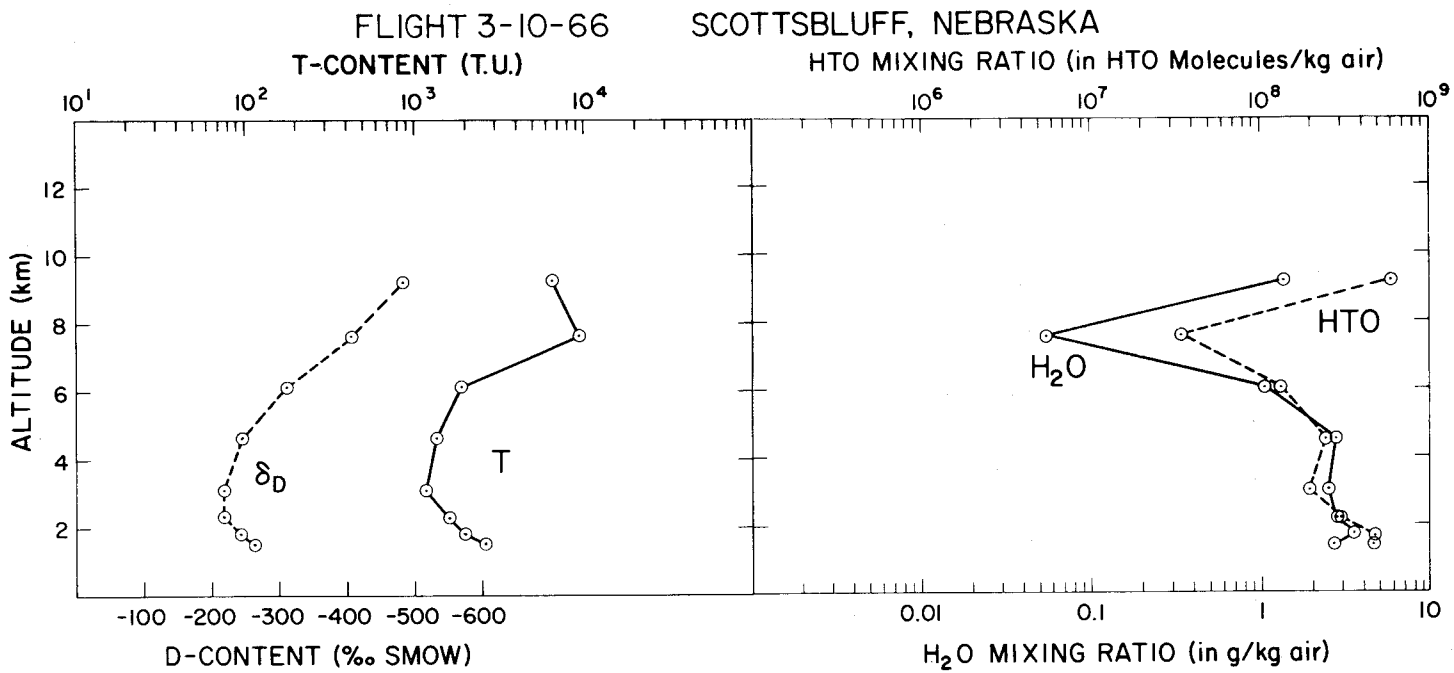
LOCATION: Scottsbluff, Nebraska

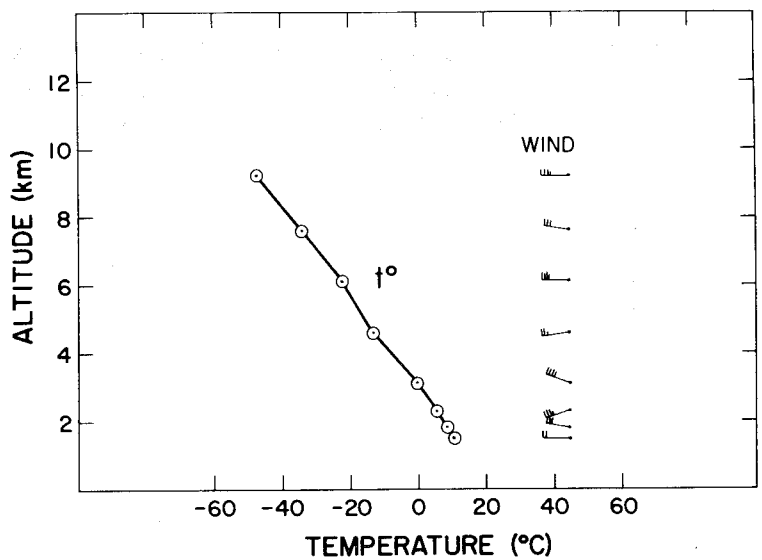
INITIAL SAMPLING TIME: 07:30

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+10.9	2.65	-263	2520± 40	4.5×10^{8}
1830	+8.9	3.50	-243	1960± 30	4.6×10^{8}
2280	+5.9	2.78	-218	1510± 30	2.8×10^{8}
3050	-0.1	2.47	-216	1130± 35	1.9×10^{8}
4580	-13.1	2.74	-243	1330± 30	2.4×10^{8}
6100	-22.1	1.06	-309	1860± 30	1.3×10^{8}
7600	-34.1	.055	-404	9100±2000	3.4×10^{7}
9150	-47.1	1.38	-480	6400± 60	5.9×10^{8}

*Plane flying in clouds.

Tropopause: 06:15 11,460 m
15:24 9,190 m


FLIGHT 3-10-66
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
WIND
TEMPERATURE (°C)

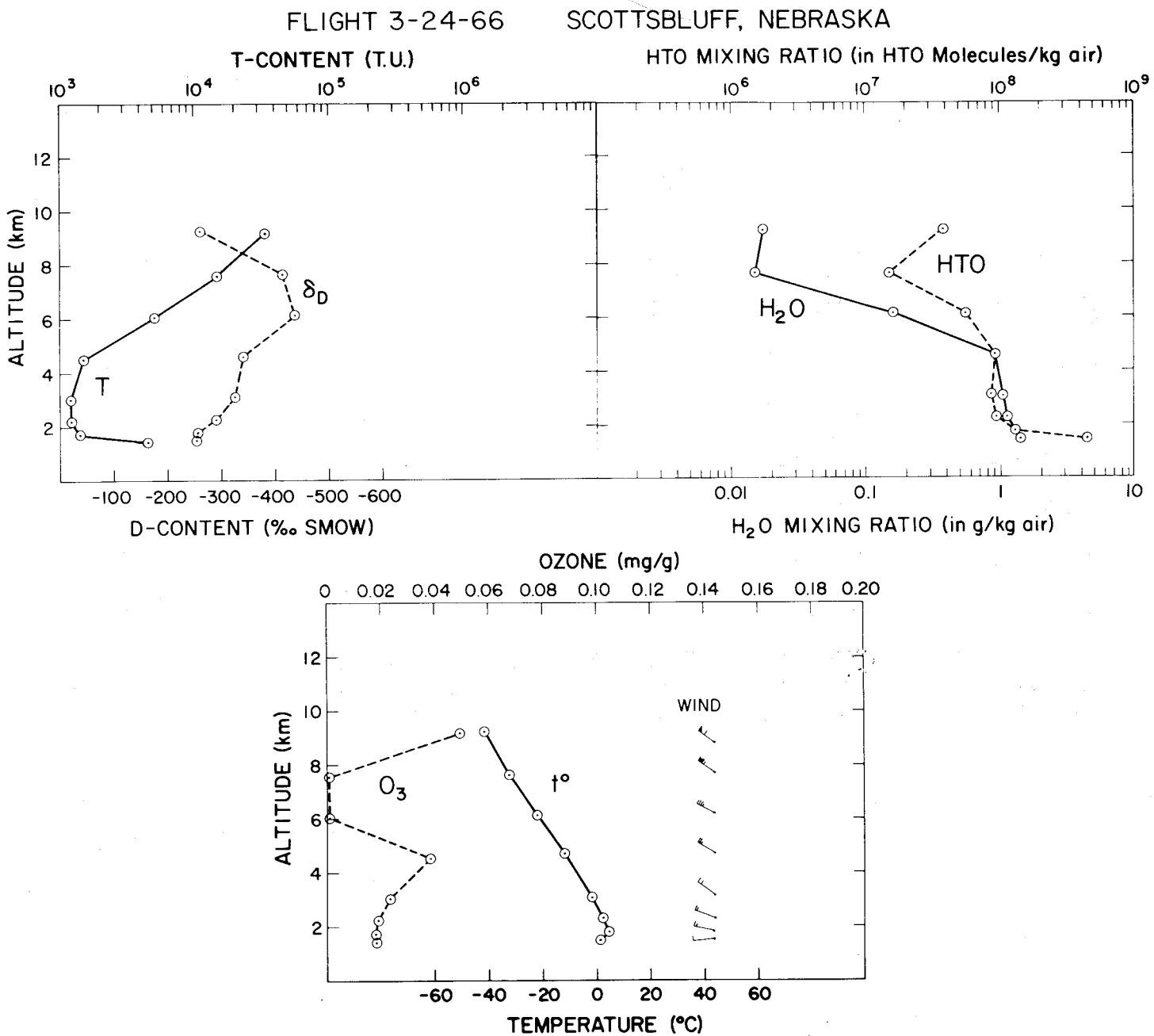
DATE: 24 March 1966

LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:20

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+1.2	1.42	-255	4510± 45	4.3×10^{8}
1830	+4.4	1.29	-258	1460± 30	1.3×10^{8}
2280	+2.2	1.12	-292	1240± 30	9.3×10^{7}
3050	-1.6	1.04	-326	1220± 30	8.5×10^{7}
4580	-11.7	.91	-343	1510± 30	9.2×10^{7}
6100	-21.8	.16	-437	5100±100	5.5×10^{7}
7600	-32.1	.015	-414	14,800±550	1.5×10^{7}
9150	-41.1	.017	-365	33,600±650	3.8×10^{7}

Tropopause: 07:15 11,880 m
14:00 11,720 m


FLIGHT 3-24-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)
OZONE (mg/g)
O3
t°
WIND
TEMPERATURE (°C)

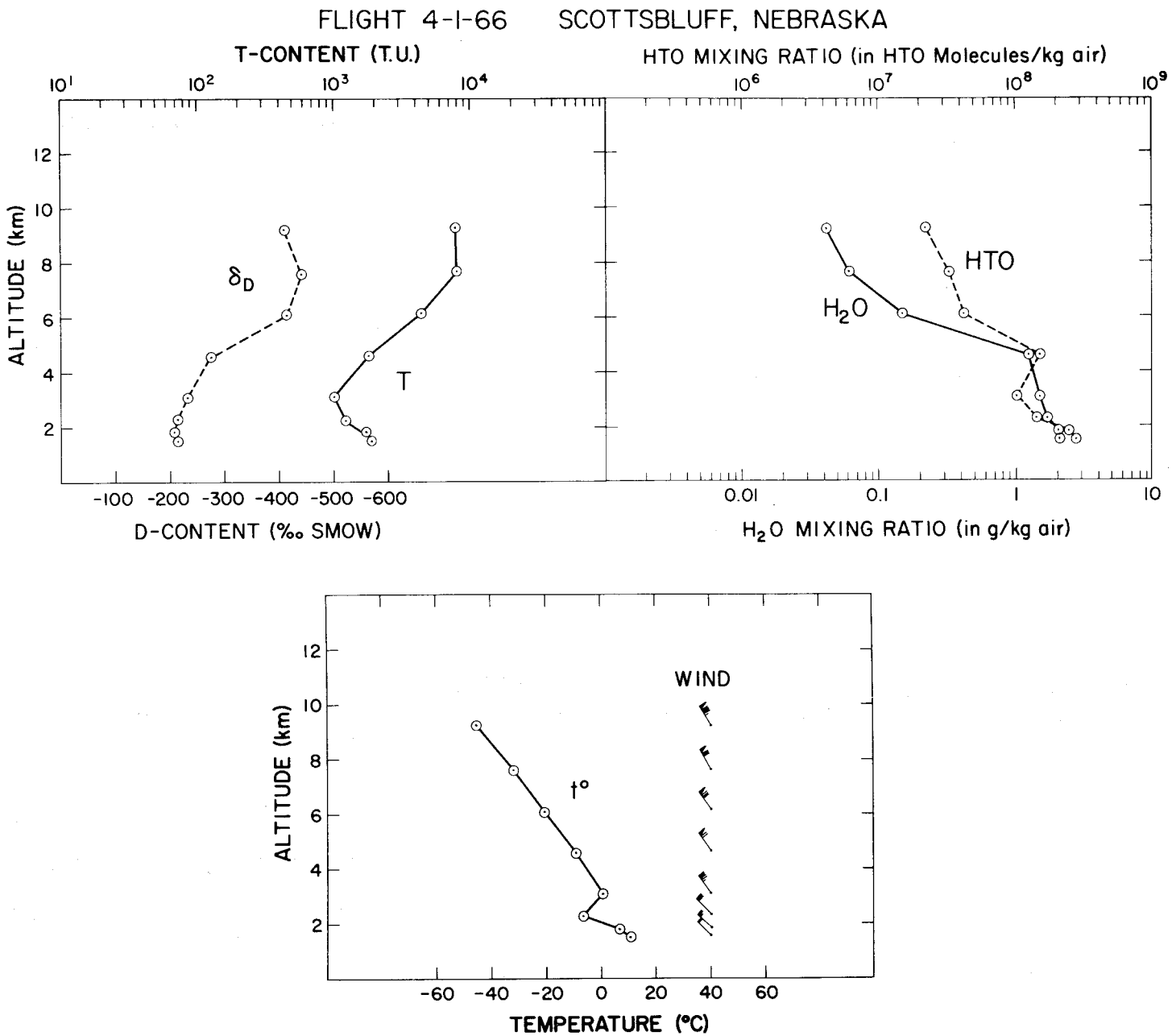
DATE: 1 April 1966

LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:05

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+10.9	2.12	-213	1900± 30	2.7×10^8
1830	+6.9	2.02	-207	1740± 30	2.4×10^8
2280	-6.1	1.67	-211	1210± 30	1.4×10^8
3050	+0.9	1.49	-230	1030± 25	1.0×10^8
4580	-9.1	1.22	-272	1820± 30	1.5×10^8
6100	-20.6	.15	-411	4300±143	4.2×10^7
7600	-31.8	.062	-443	7800±200	3.3×10^7
9150	-45.1	.042	-410	7700±250	2.2×10^7

Tropopause: 07:16 13,450 m
14:00 12,480 m


FLIGHT 4-1-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)
WIND
t°
TEMPERATURE (°C)

DATE: 12 April 1966

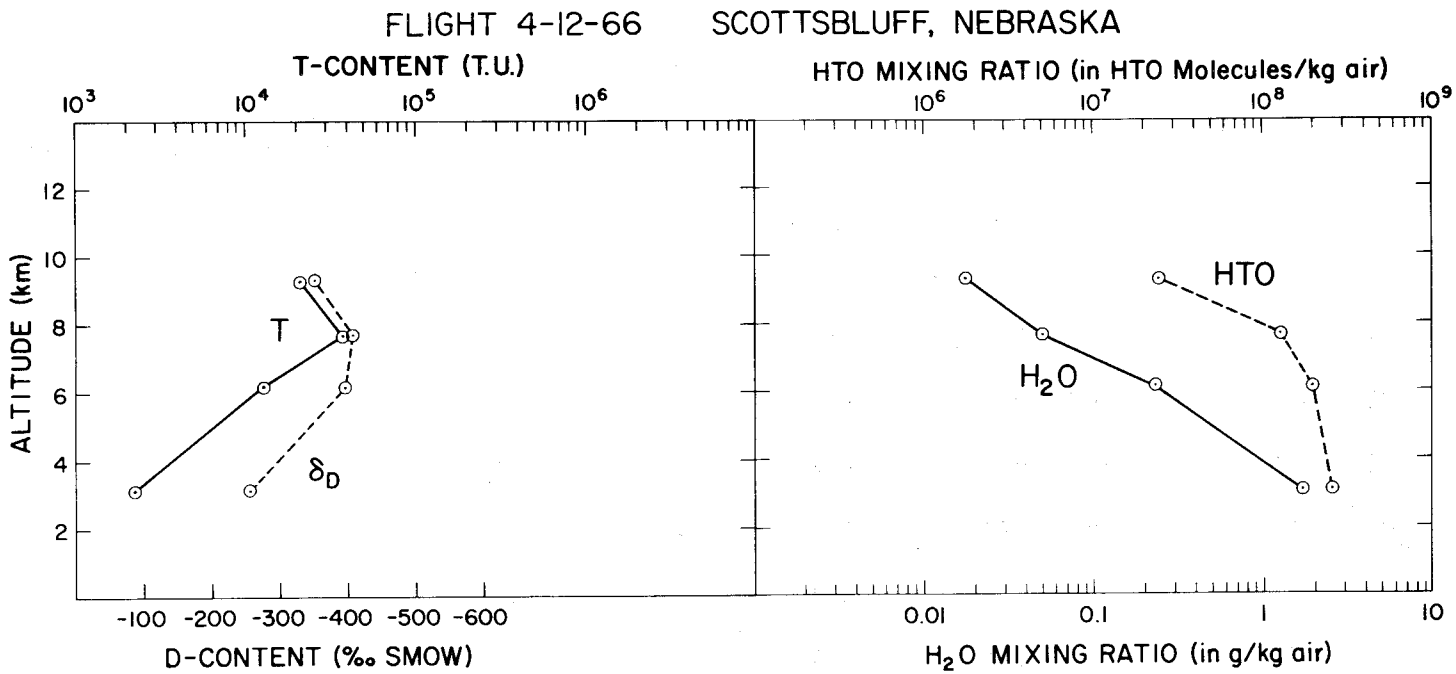
LOCATION: Scottsbluff, Nebraska

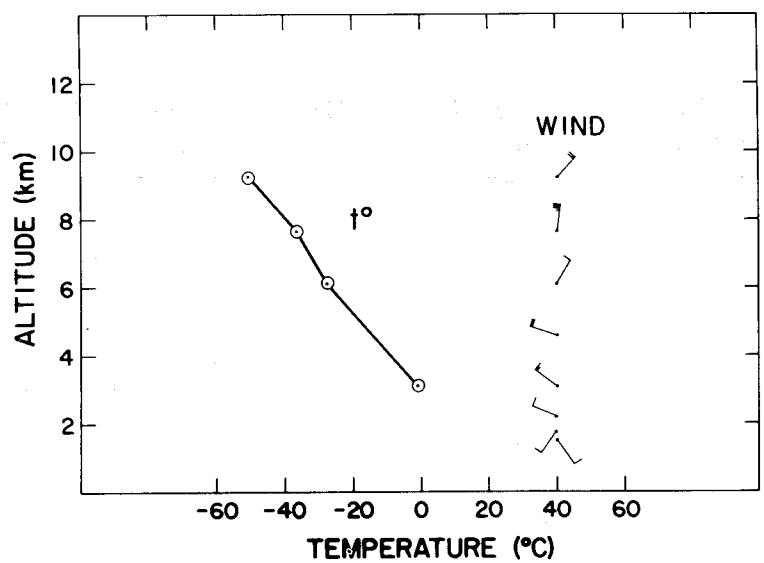
INITIAL SAMPLING TIME: 07:30

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520*					
1830*					
2280*					
3050	-1.1	1.78	-251	2200±100	2.6×10^8
4580*					
6100	-27.1	.24	-392	12,700±100	2.0×10^8
7600	-36.1	.051	-401	37,000±360	1.3×10^8
9150	-50.1	.018	-348	20,900±600	2.5×10^7

*Unable to sample due to cloud layer.

Tropopause: 08:40 10,230 m


FLIGHT 4-12-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δ_D
HTO
H_2O
D-CONTENT (‰ SMOW)
H_2O MIXING RATIO (in g/kg air)


WIND
t°
ALTITUDE (km)
TEMPERATURE (°C)

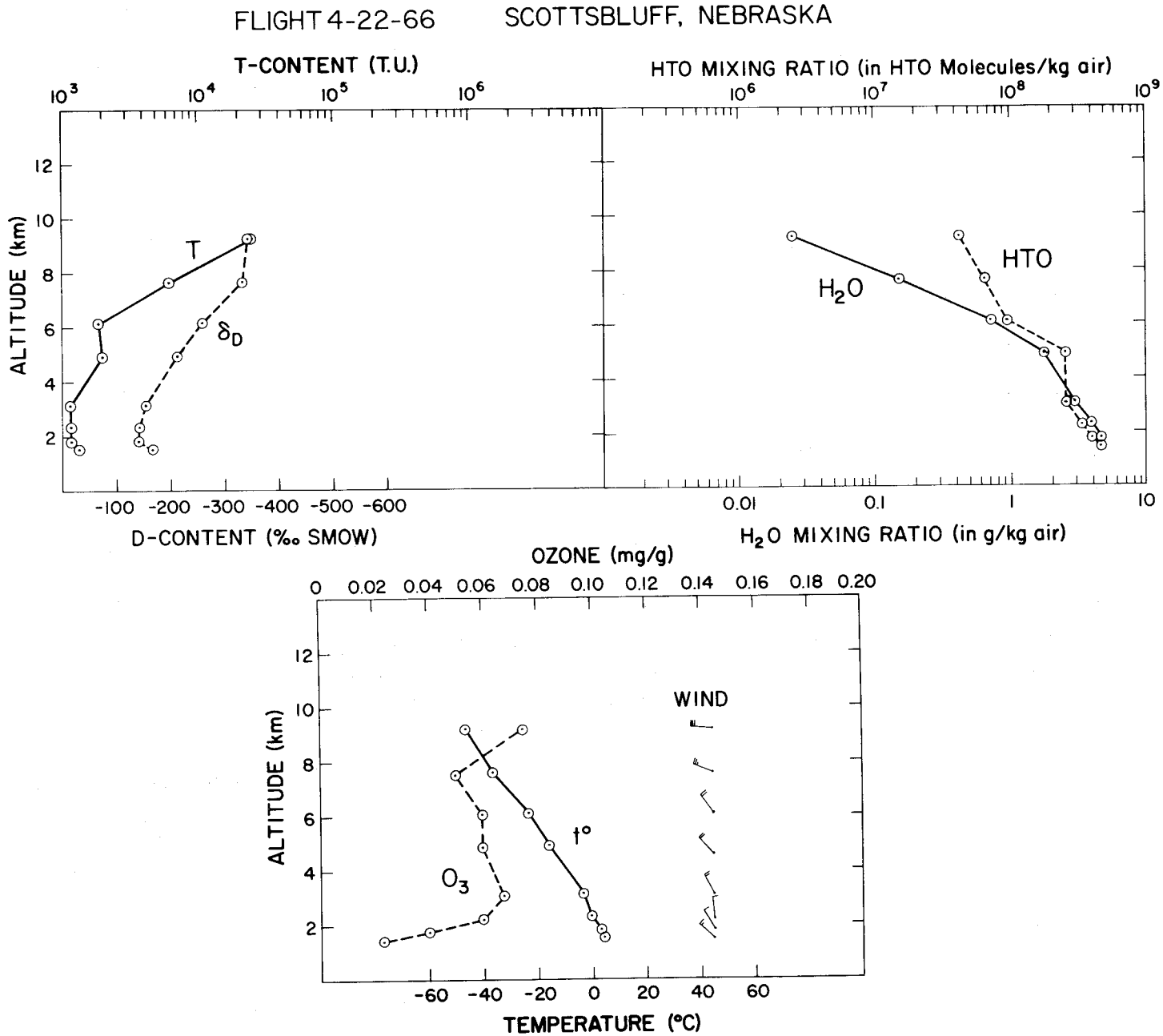
DATE: 22 April 1966

LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:00

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+4.2	4.58	-169	1480± 28	4.5×10^8
1830	+3.2	4.57	-142	1275± 26	3.9×10^8
2280	-0.8	3.85	-143	1280± 25	3.3×10^8
3050	-3.3	2.94	-155	1250± 27	2.5×10^8
4900	-15.9	1.76	-213	2160± 30	2.5×10^8
6100	-23.1	.71	-259	1980± 50	9.4×10^7
7600	-36.1	.15	-333	6400±200	6.5×10^7
9150	-46.5	.025	-342	25,000±400	4.2×10^7

Tropopause: 09:02 11,530 m
14:16 10,660 m


FLIGHT 4-22-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δ_D
HTO
H_2O
D-CONTENT (‰ SMOW)
H_2O MIXING RATIO (in g/kg air)
OZONE (mg/g)
WIND
O_3
t°
TEMPERATURE (°C)

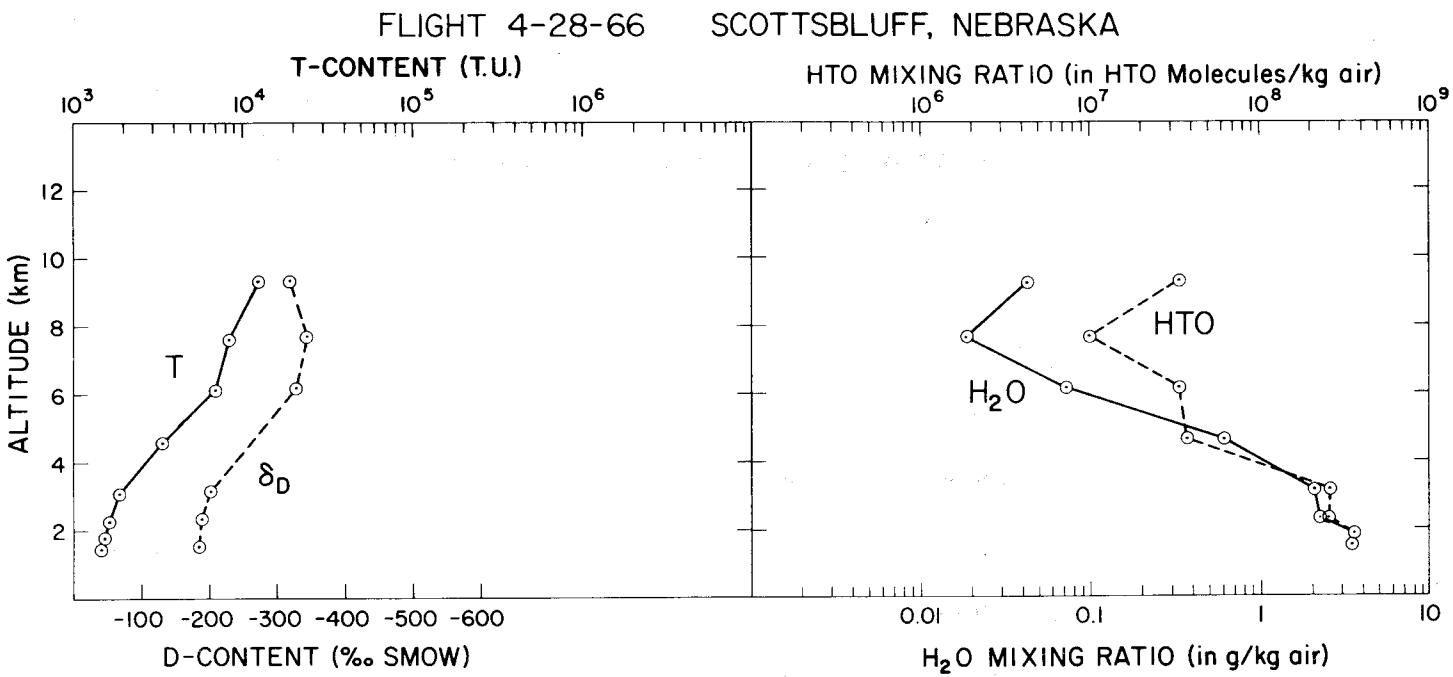
DATE: 28 April 1966

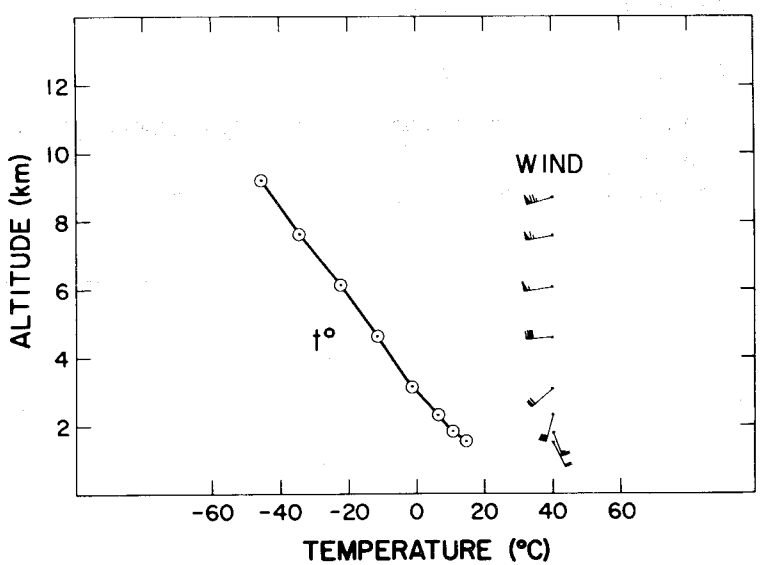
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:35

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+14.9	3.5	-186	1460± 28	3.4×10^8
1830	+10.9	3.5	-192	1530± 30	3.6×10^8
2280	+6.7	2.25	-190	1630± 30	2.5×10^8
3050	-1.3	2.06	-201	1850±100	2.6×10^8
4580	-11.3	.16		3380± 68	3.7×10^7
6100	-22.3	.073	-327	6880±160	3.4×10^7
7600	-34.3	.019	-343	8200±400	1.0×10^7
9150	-45.5	.043	-317	11,900±210	3.4×10^7

Tropopause: 09:00 11,670 m
14:10 12,010 m


FLIGHT 4-28-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δ_D
HTO
H_2O
D-CONTENT (‰ SMOW)
H_2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
WIND
t°
TEMPERATURE (°C)

DATE: 10 May 1966

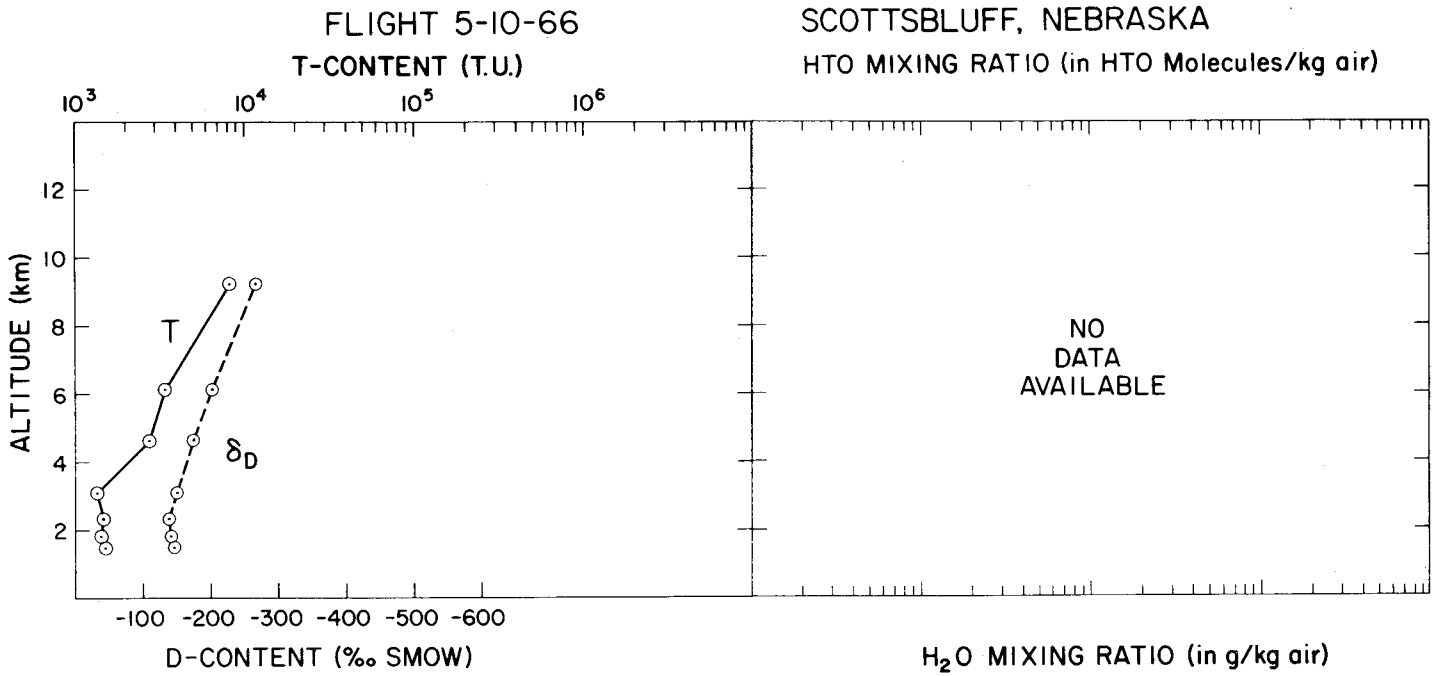
LOCATION: Scottsbluff, Nebraska

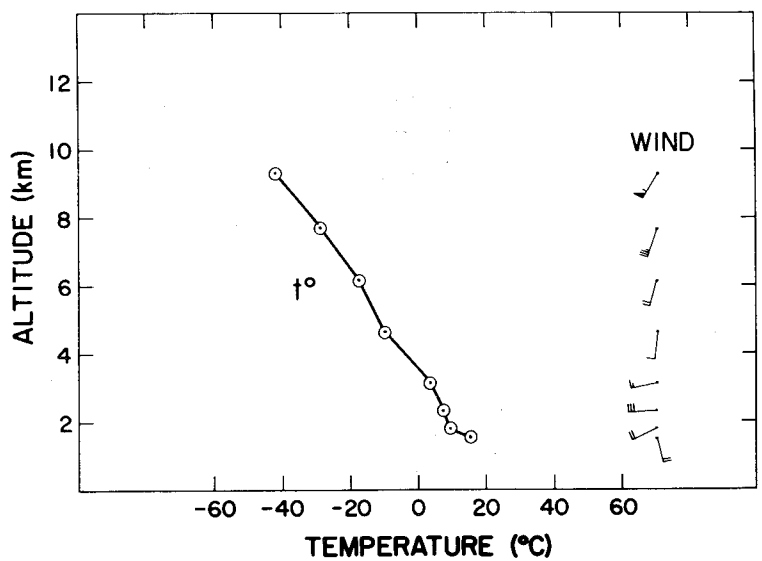
INITIAL SAMPLING TIME: 07:13

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+15.2	*	-145	1530± 29	
1830	+9.1		-140	1490± 29	
2280	+7.3		-137	1510± 29	
3050	+3.3		-148	1390± 26	
4580	-9.8		-171	2800± 30	
6100	-16.9		-200	3400± 61	
7600	-28.1				
9150	-41.2		-265	8380±280	

*Water vapor mixing ratio not evaluated becuase of failure of flow gauge.

Tropopause: 09:06 11,570 m


FLIGHT 5-10-66
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
10^3
10^4
10^5
10^6
ALTITUDE (km)
12
10
8
6
4
2
T
δ_D
NO
DATA
AVAILABLE
-100 -200 -300 -400 -500 -600
D-CONTENT (‰ SMOW)
H_2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
12
10
8
6
4
2
t°
WIND
-60 -40 -20 0 20 40 60
TEMPERATURE (°C)

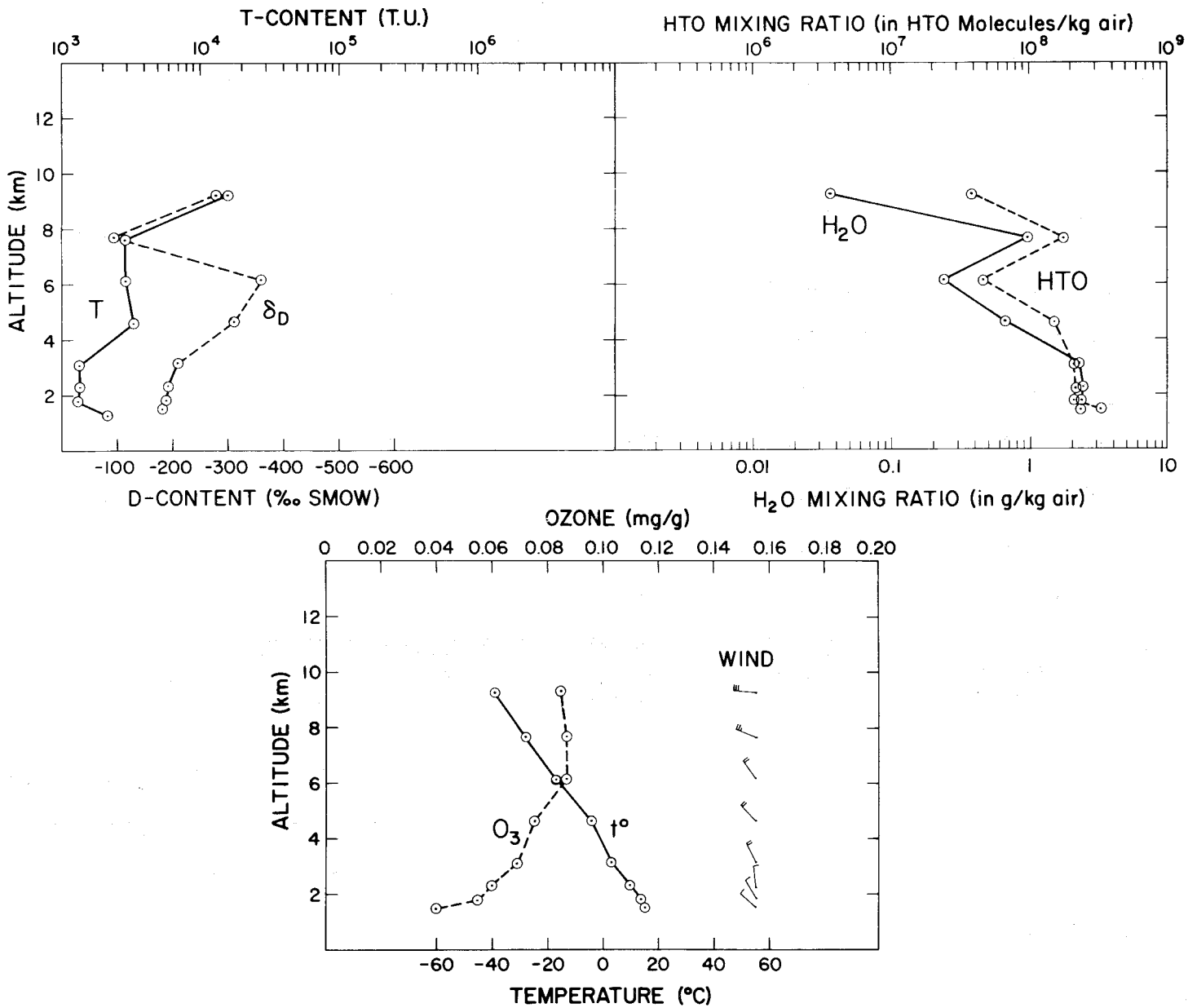
DATE: 24 May 1966

LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 06:55

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+15.1	2.34	-183	2120± 33	3.3×10^{8}
1830	+14.0	2.41	-190	1310± 28	2.1×10^{8}
2280	+10.1	2.45	-194	1350± 75	2.2×10^{8}
3050	+3.9	2.3	-211	1360± 28	2.1×10^{8}
4580	-3.1	.67	-308	3305± 40	1.5×10^{8}
6100	-15.1	.25	-359	2880±120	4.7×10^{7}
7600	-27.1	.98	-97	2820± 37	1.8×10^{8}
9150	-38.3	.037	-276	15,700±320	3.9×10^{7}

Tropopause: 08:33 12,170 m
14:45 12,370 m


FLIGHT 5-24-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)
OZONE (mg/g)
WIND
O3
t°
TEMPERATURE (°C)

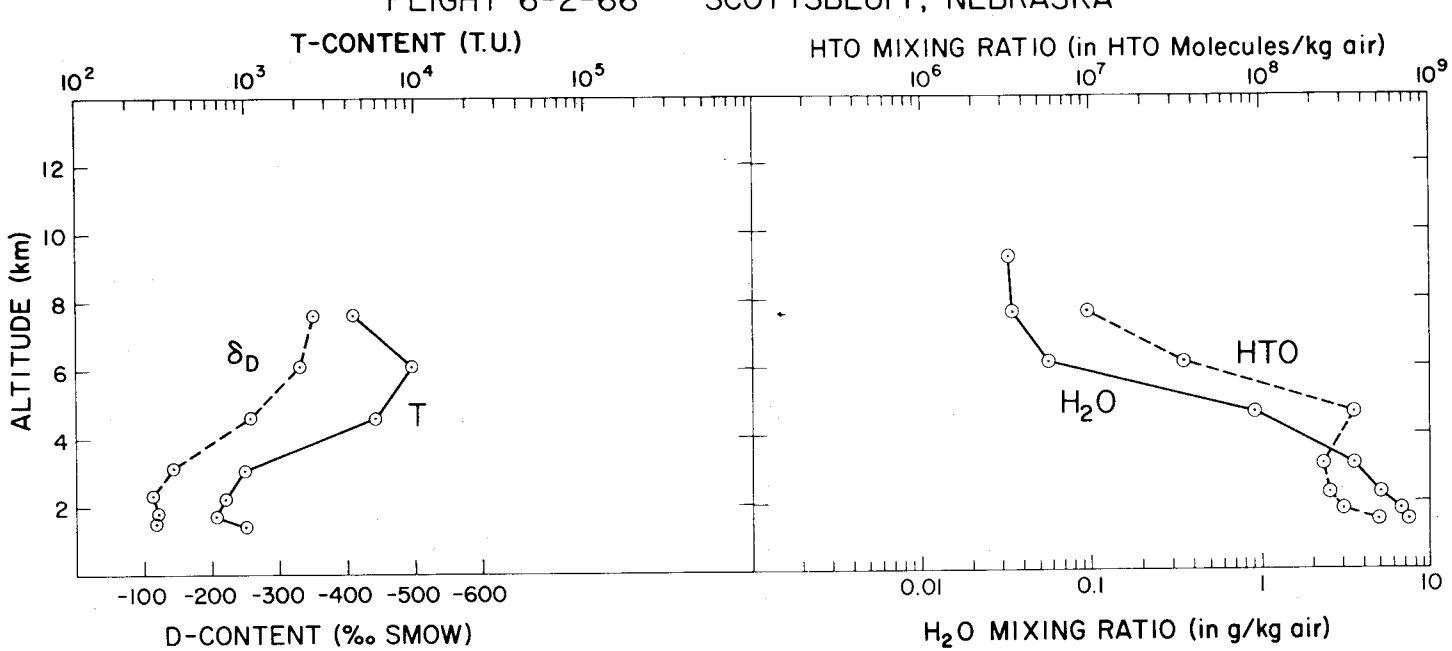
DATE: 2 June 1966

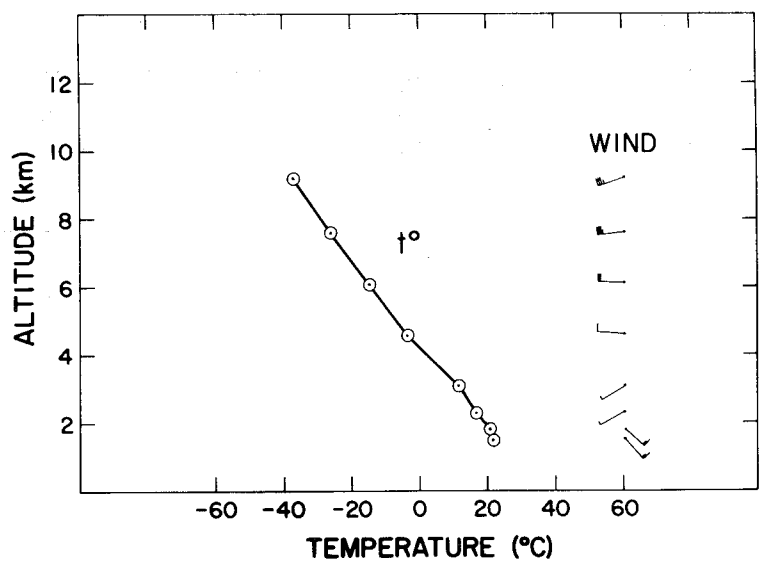
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:15

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+22	7.5	-118	1010± 25	5×10^{8}
1830	+21	6.78	-122	690± 23	3.1×10^{8}
2280	+17	5.15	-113	770± 23	2.6×10^{8}
3050	+12	3.58	-144	1000± 25	2.4×10^{8}
4580	-3.1	.95	-257	5700± 67	3.6×10^{8}
6100	-14.6	.058	-331	9260±360	3.6×10^{7}
7600	-26	.035	-350	4240±200	1.0×10^{7}
9150	-36.9	.034			

Tropopause: 07:31 11,880 m
13:08 12,140 m


FLIGHT 6-2-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


WIND
t°
ALTITUDE (km)
TEMPERATURE (°C)

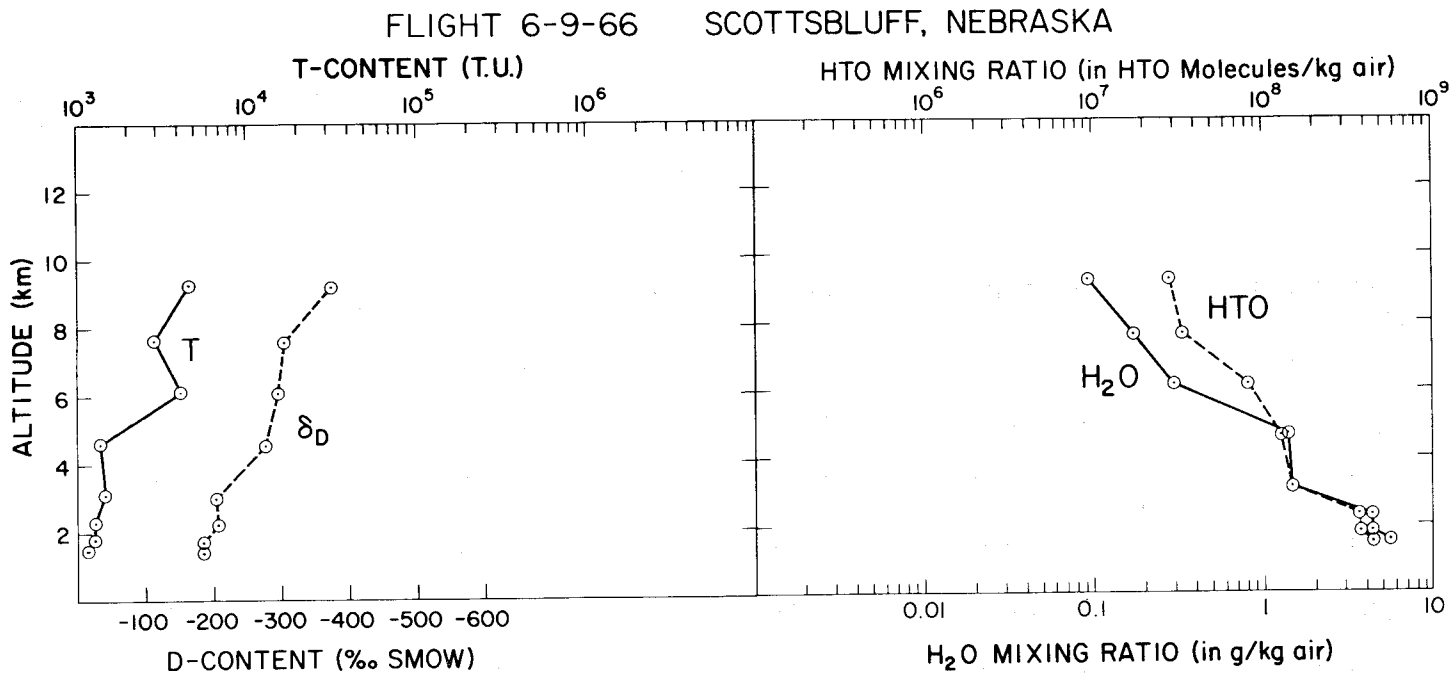
DATE: 9 June 1966

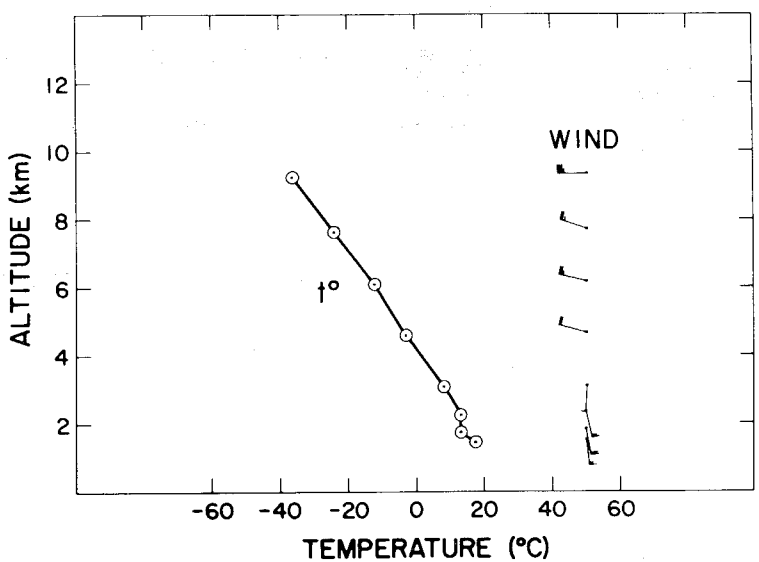
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:13

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+17.1	5.59	-185	1180± 26	4.4×10^{8}
1830	+13	4.35	-181	1290± 27	3.7×10^{8}
2280	+13	4.4	-207	1290± 27	3.7×10^{8}
3050	+8	1.48	-204	1460± 29	1.5×10^{8}
4580	-3.1	1.42	-275	1390± 28	1.3×10^{8}
6100	-12.1	.30	-293	4020± 65	8.2×10^{7}
7600	-24.2	.18	-301	2850± 67	3.4×10^{7}
9150	-36.3	.10	-372	4580±120	2.9×10^{7}

Tropopause: 06:54 12,475 m
14:24 12,300 m


FLIGHT 6-9-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δ_D
HTO
H_2O
D-CONTENT (‰ SMOW)
H_2O MIXING RATIO (in g/kg air)


WIND
t°
ALTITUDE (km)
TEMPERATURE (°C)

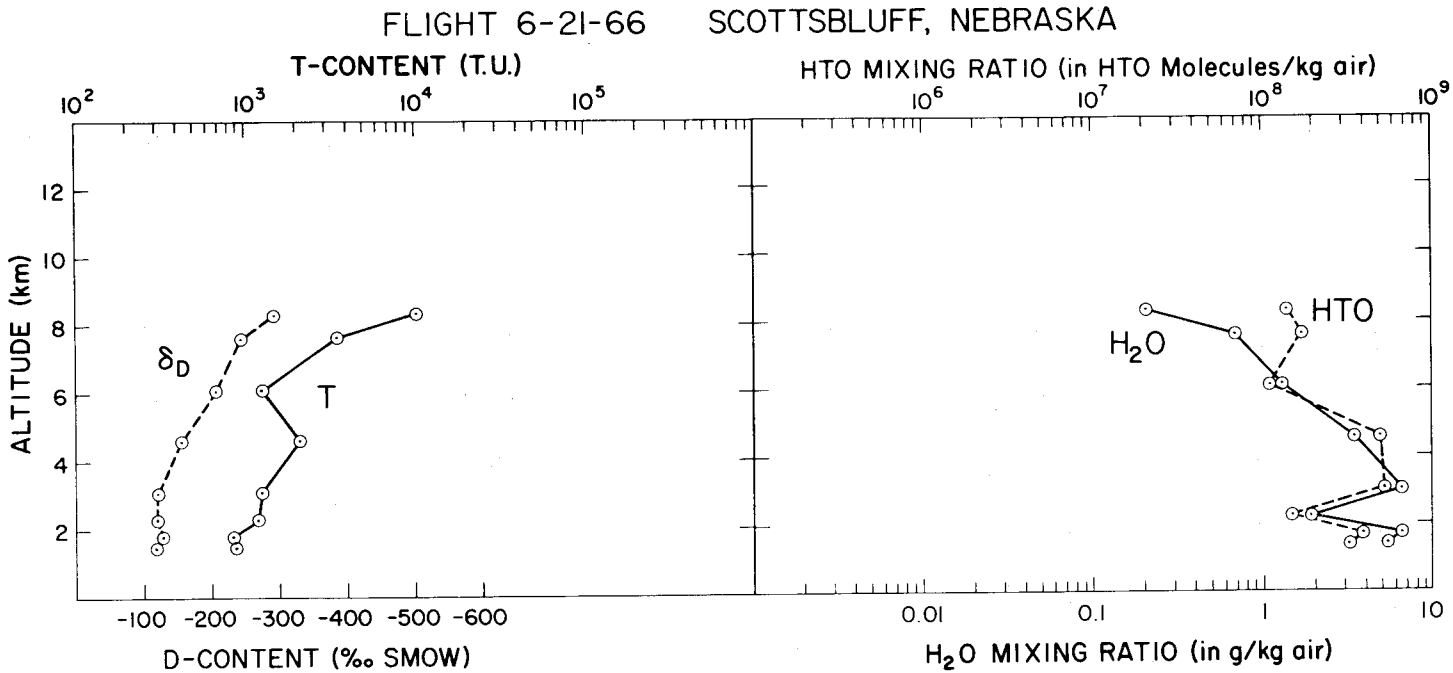
DATE: 21 June 1966

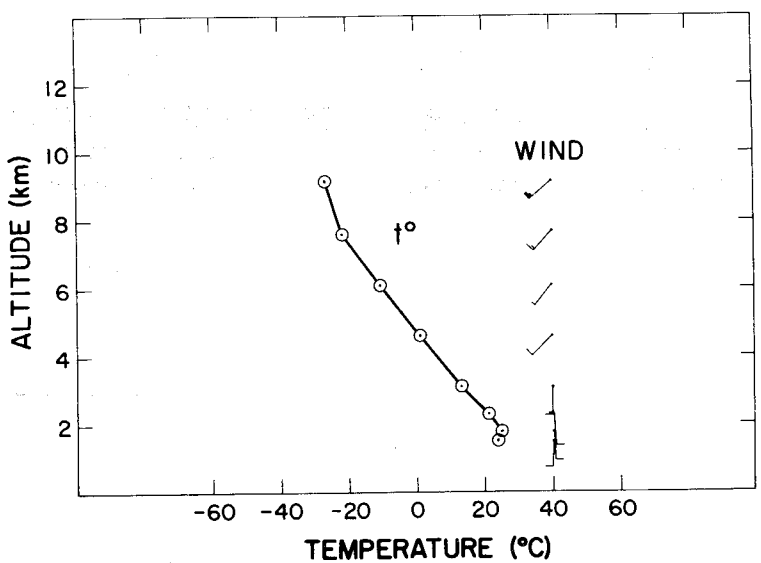
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:30

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+23.8	5.42	-119	870± 24	3.2×10^{8}
1830	+25.1	6.46	-127	850± 24	3.8×10^{8}
2280	+21.1	1.91	-122	1180± 27	1.5×10^{8}
3050	+13	6.46	-122	1230± 27	5.2×10^{8}
4580	+1	3.48	-157	2080± 33	4.8×10^{8}
6100	-10.6	1.3	-207	1250± 27	1.1×10^{8}
7600	-21.7	0.7	-245	3490±130	1.7×10^{8}
8250	-26.7	0.21	-293	10,060± 98	1.4×10^{8}

Tropopause: 13:25 12,990 m


FLIGHT 6-21-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


WIND
t°
ALTITUDE (km)
TEMPERATURE (°C)

DATE: 30 June 1966

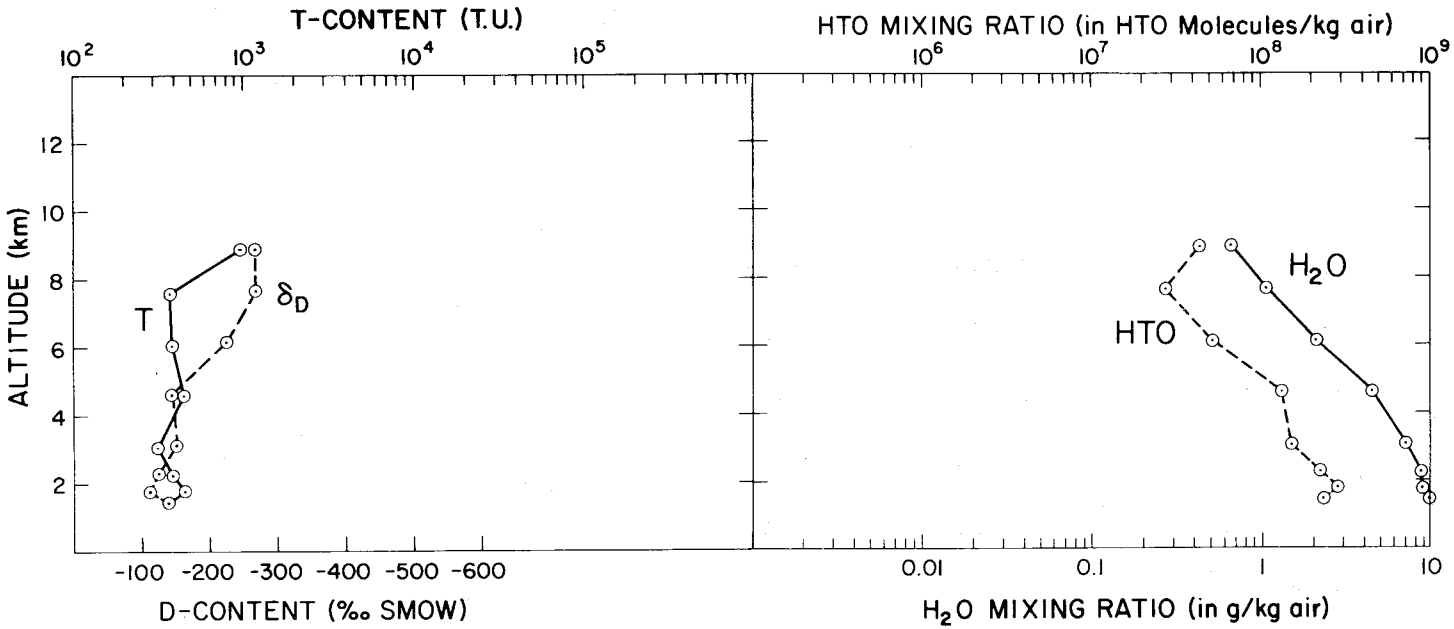
LOCATION: Scottsbluff, Nebraska

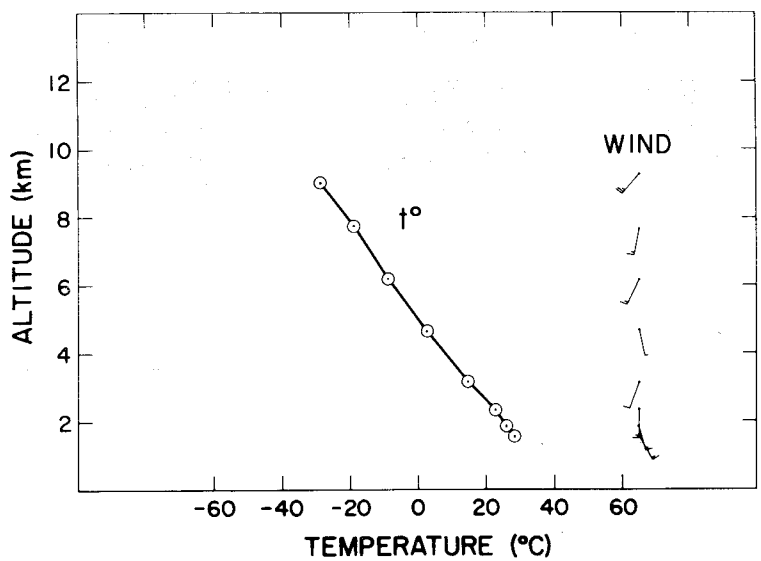
INITIAL SAMPLING TIME: 07:45

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+28	9.68	-142	360±19	2.3×10^{8}
1830	+25.5	8.84	-114	450±20	2.8×10^{8}
2280	+22.5	8.59	-127	380±32	2.2×10^{8}
3050	+14.6	7.0	-154	310±20	1.5×10^{8}
4580	+2.8	4.48	-147	450±21	1.3×10^{8}
6100	-9	2.07	-227	370±21	5.1×10^{7}
7600	-19	1.07	-270	370±20	2.7×10^{7}
8850	-29	0.66	-271	970±25	4.3×10^{7}

Tropopause: 07:58 14,710 m
12:56 14,820 m

FLIGHT 6-30-66 SCOTTSBLUFF, NEBRASKA





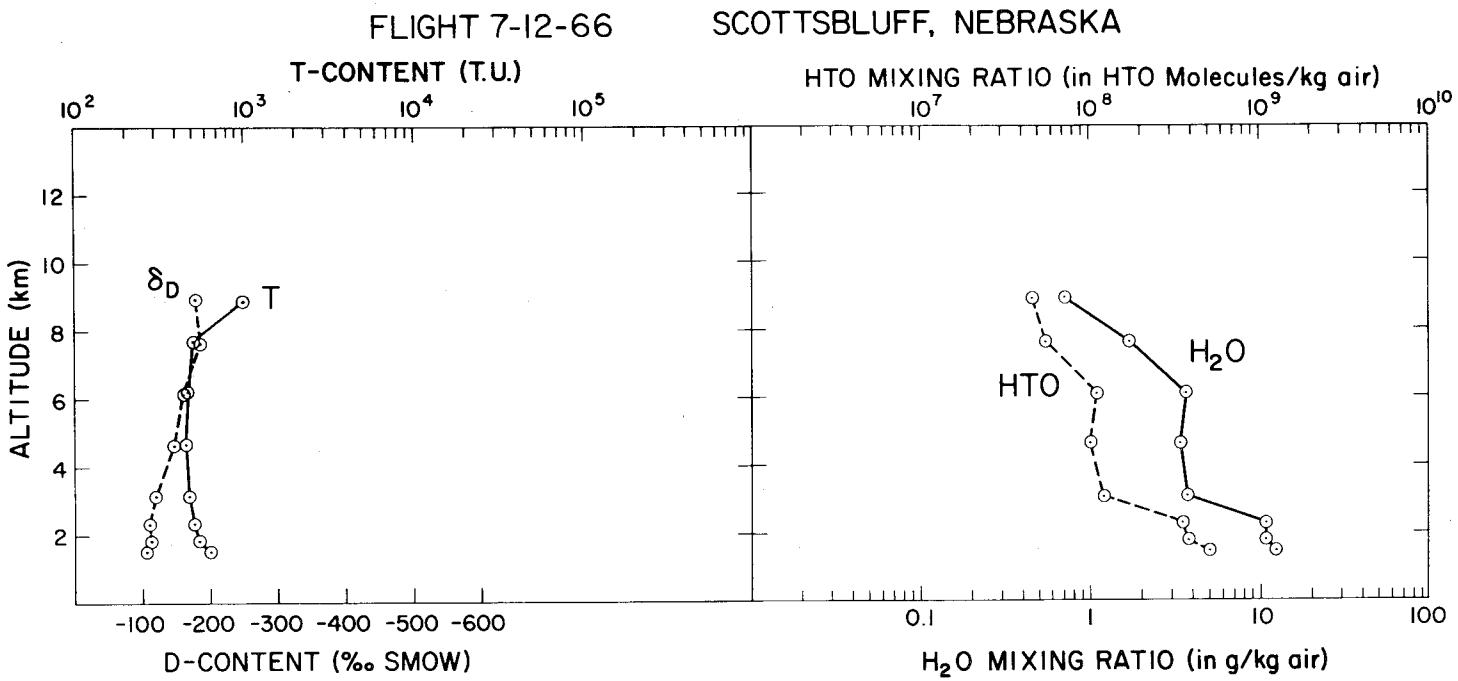
DATE: 12 July 1966

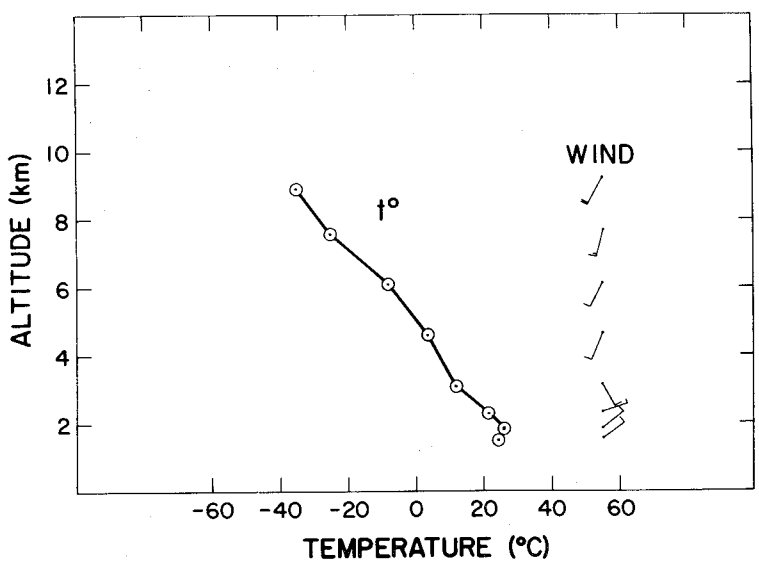
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:14

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+24.8	12.21	-107	610±22	5.0×10^8
1830	+26.2	10.57	-113	540±21	3.8×10^8
2280	+21.5	10.70	-111	490±20	3.5×10^8
3050	+12	3.76	-121	470±20	1.2×10^8
4580	+4	3.39	-148	440±18	1.0×10^8
6100	-8	3.72	-162	450±20	1.1×10^8
7600	-25	1.72	-187	480±20	5.5×10^7
8850	-35	0.71	-180	950±25	4.6×10^7

Tropopause: 06:32 15,170 m
12:38 15,990 m


FLIGHT 7-12-66
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
WIND
TEMPERATURE (°C)

DATE: 7 September 1966

LOCATION: Scottsbluff, Nebraska

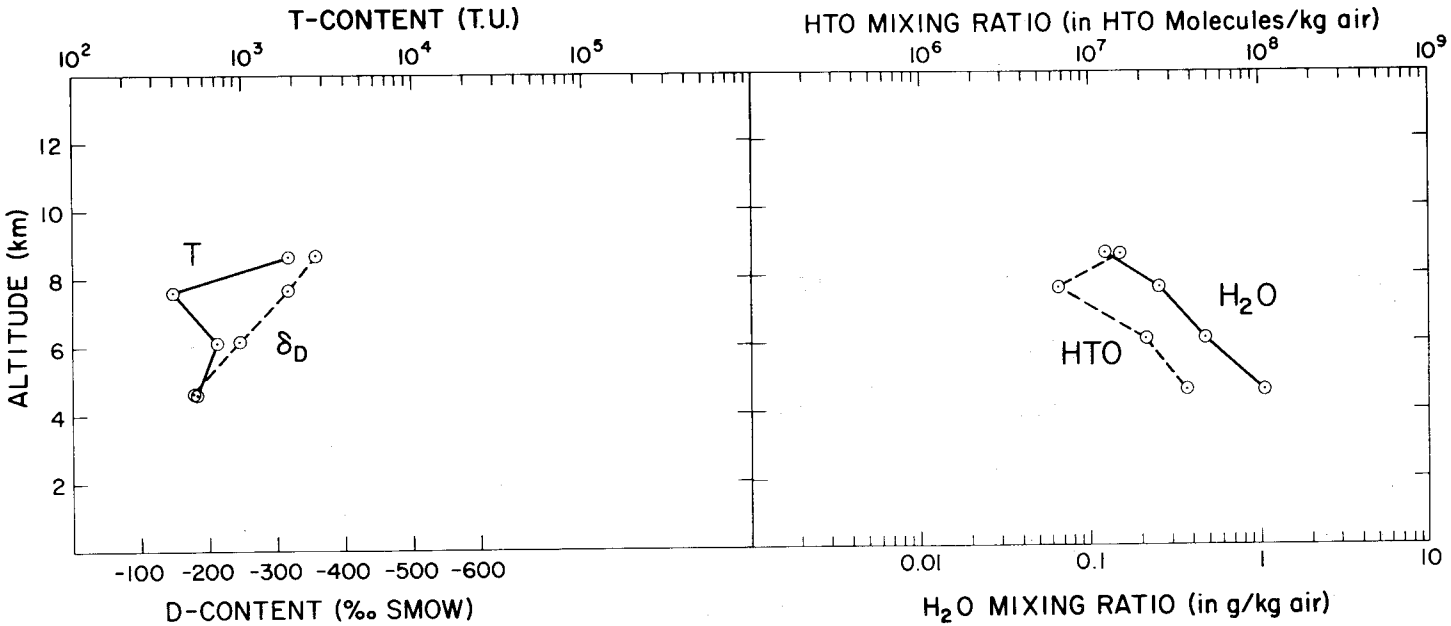
INITIAL SAMPLING TIME: 07:25

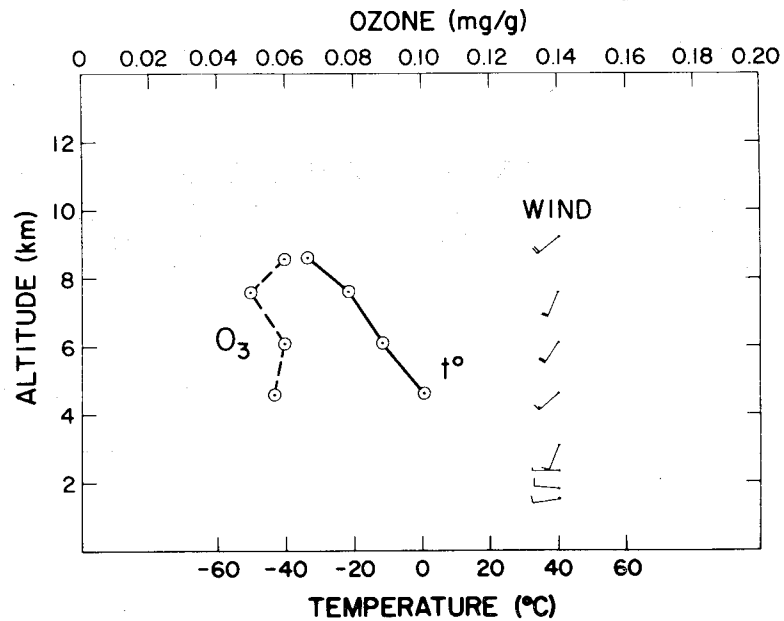
Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
*					
4580	+0.9	1.04	-177	530±18	3.7×10^7
6100	-11.1	.48	-245	700±21	2.1×10^7
7600	-21.1	.26	-314	380±19	6.6×10^6
8550	-33.3	.12	-353	1820±80	1.5×10^7

*Did not sample lower altitudes because of cloud cover.

Tropopause: 10:57 11,260 m
13:06 15,110 m

FLIGHT 9-7-66 SCOTTSBLUFF, NEBRASKA





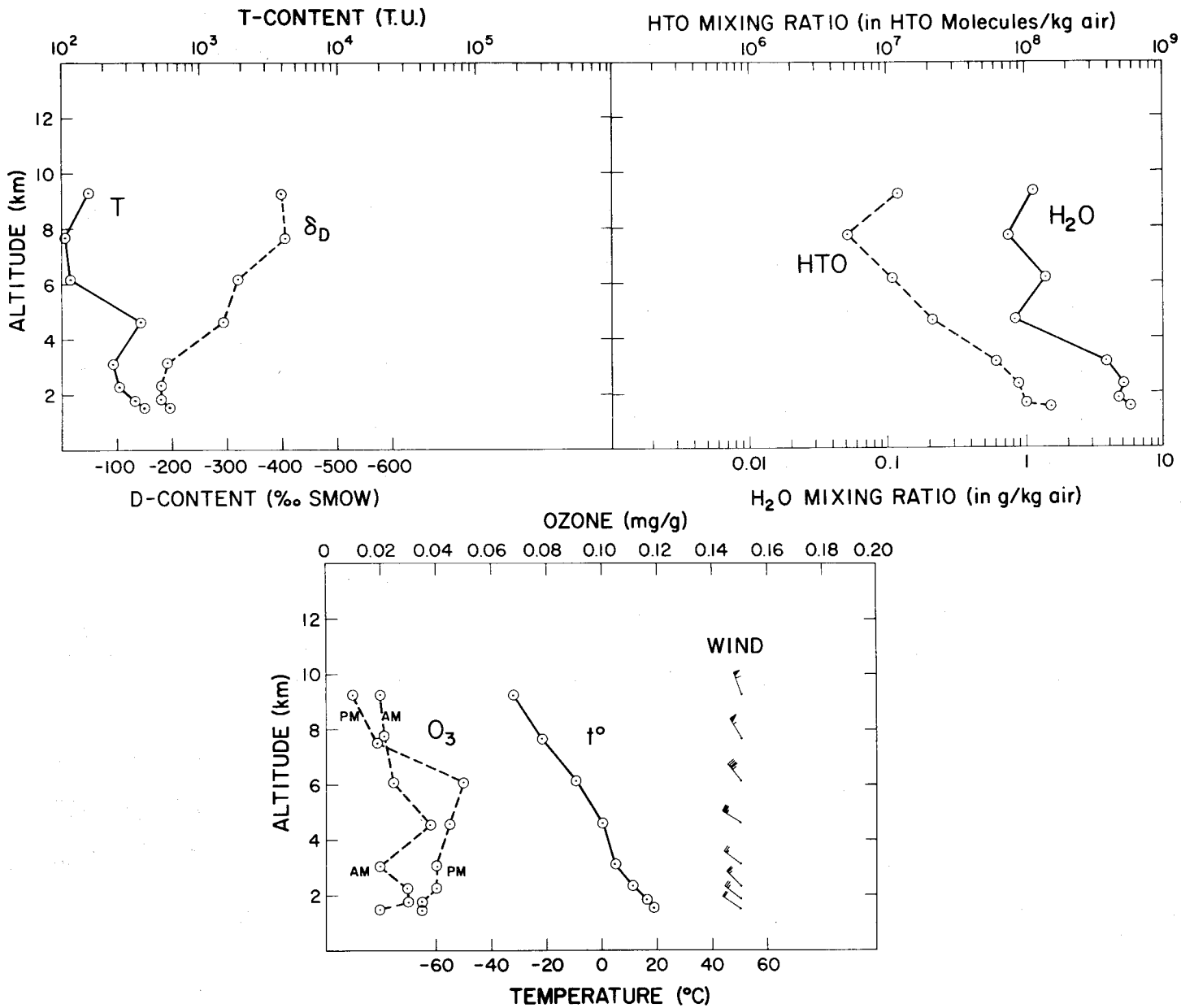
DATE: 28 September 1966

LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:08

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+18.2	5.73	-194	390±16	1.5×10^8
1830	+16.2	4.68	-179	330±15	1.0×10^8
2280	+11.2	5.04	-179	260±15	8.7×10^7
3050	+5	3.85	-191	230±14	6.0×10^7
4580	+0.2	.84	-293	360±16	2.1×10^7
6100	-9	1.38	-318	120±12	1.1×10^7
7600	-21.2	.72	-401	110±12	5.2×10^6
9150	-31.7	1.13	-396	160±13	1.2×10^7

Tropopause: 07:16 15,360 m
13:06 15,700 m


FLIGHT 9-28-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)
OZONE (mg/g)
WIND
PM
AM
O3
t°
TEMPERATURE (°C)

DATE: 25 October 1966

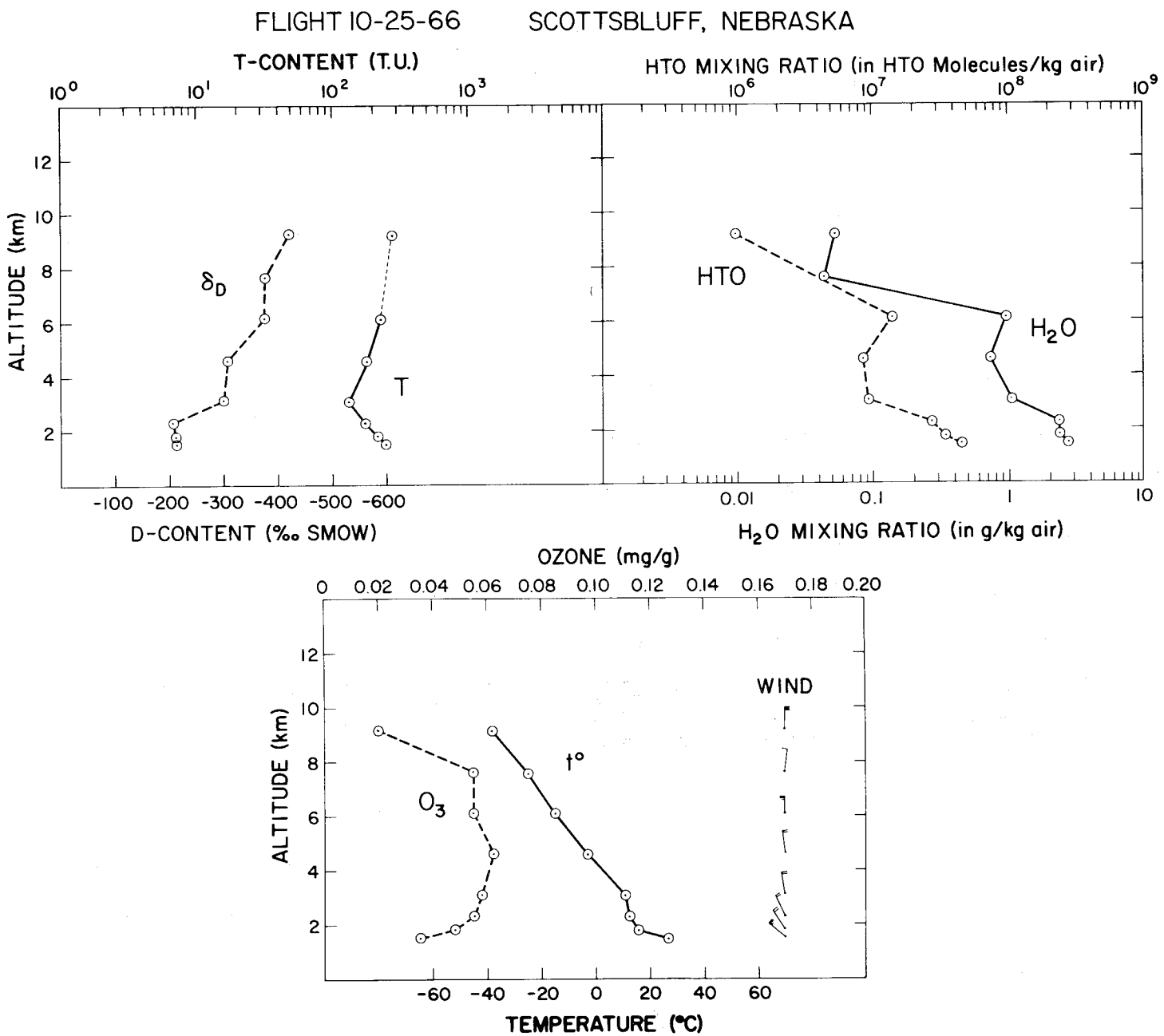
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 06:45

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+27	2.73	-211	250± 14	4.5×10^7
1830	+16	2.39	-212	210± 14	3.4×10^7
2280	+13	2.31	-206	170± 13	2.7×10^7
3050	+11	1.06	-298	130± 13	9.3×10^6
4580	-2.8	.734	-304	170± 13	8.5×10^6
6100	-15	.95	-373	230± 14	1.4×10^7
7600	-25	.044	-372	0.0±220*	
9150	-38	.054	-416	280± 60	9.9×10^5

*Large error due to small amount of water recovered.

Tropopause: 07:02 14,200 m
13:58 14,290 m


FLIGHT 10-25-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)
OZONE (mg/g)
WIND
O3
t°
TEMPERATURE (°C)

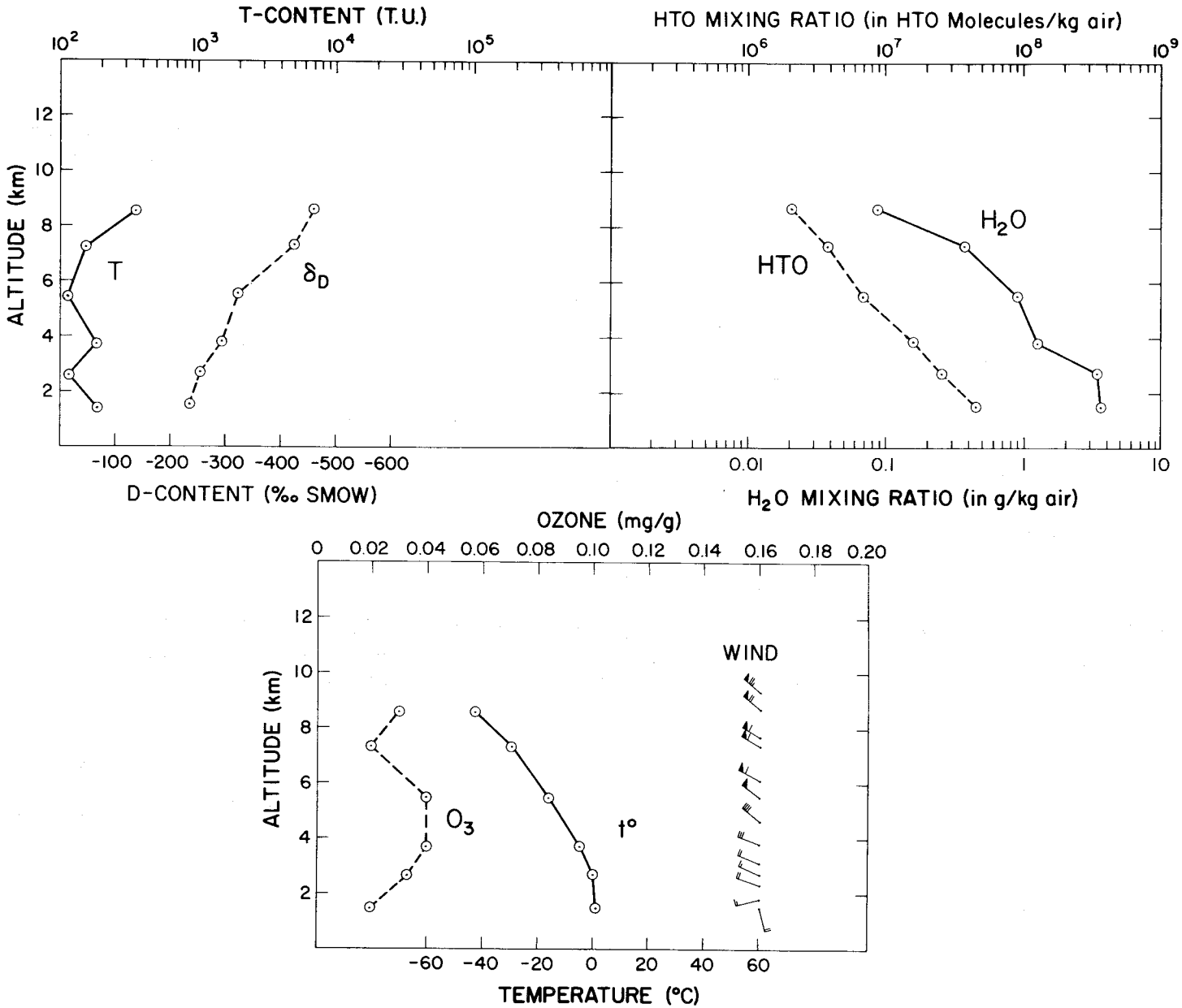
DATE: 30 November 1966

LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:05

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	+1.3	3.6	-237	190±13	4.5×10^{7}
2740	+0.3	3.39	-254	110±12	2.6×10^{7}
3750	-4.6	1.28	-294	180±14	1.6×10^{7}
5500	-16	.89	-324	120±13	6.9×10^{6}
7330	-29	.38	-425	150±13	3.9×10^{6}
8550	-42	.090	-459	350±47	2.1×10^{6}

Tropopause: 10:03 12,570 m
15:11 12,680 m


FLIGHT II-30-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δ_D
HTO
H_2O
D-CONTENT (‰ SMOW)
H_2O MIXING RATIO (in g/kg air)
OZONE (mg/g)
WIND
O_3
t°
TEMPERATURE (°C)

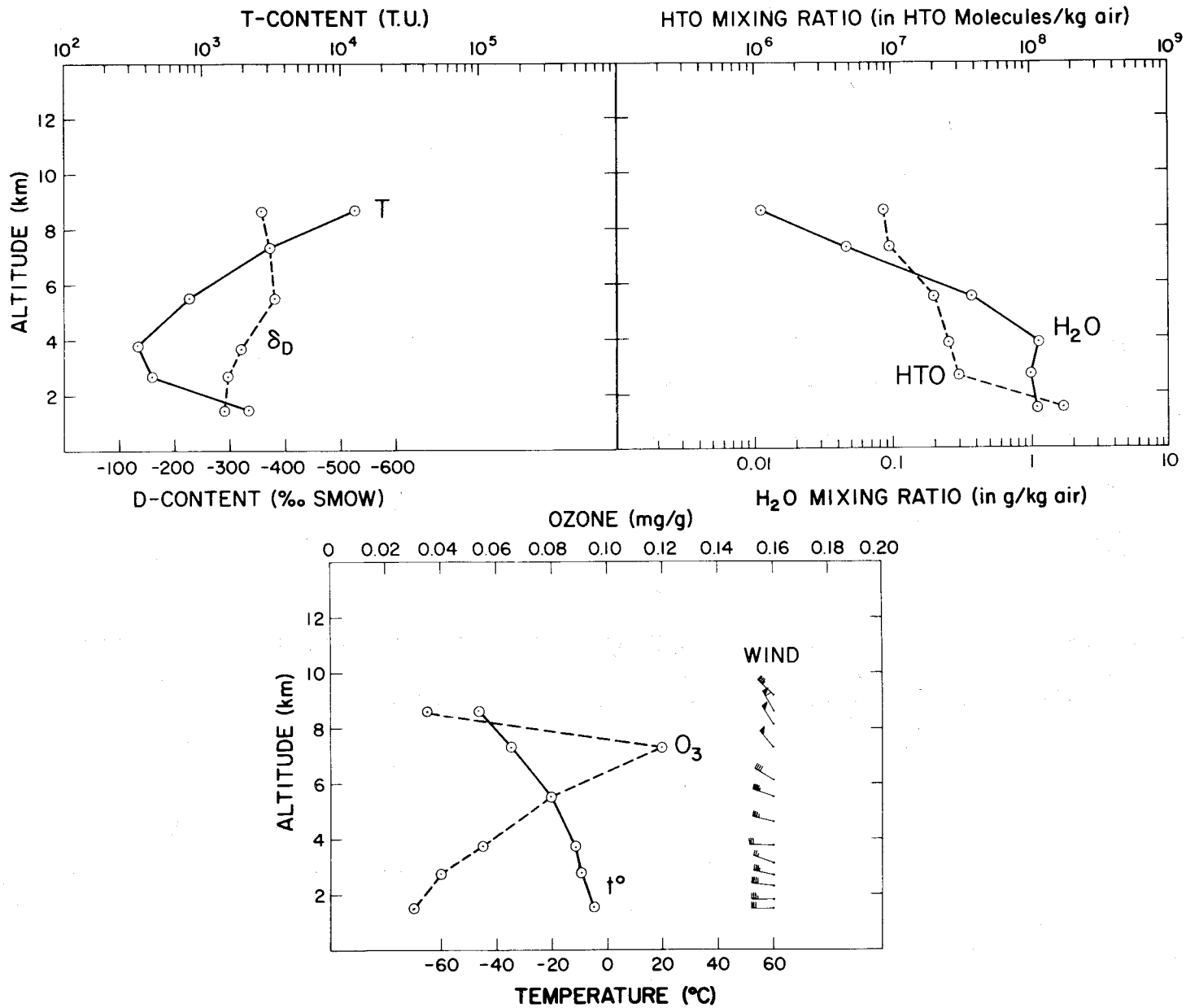
DATE: 29 December 1966

LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 07:00

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	-4	1.10	-290	2240± 31	1.7×10^{8}
2740	-9	1.00	-296	440± 16	3.0×10^{7}
3750	-11	1.12	-319	350± 16	2.6×10^{7}
5500	-20	.37	-379	810± 19	2.0×10^{7}
7330	-34	.046	-373	3070± 90	9.5×10^{6}
8850	-46	.011	-356	12,400±450	8.8×10^{6}

Tropopause: 09:27 10,540 m
13:58 10,530 m


FLIGHT 12-29-66 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)
OZONE (mg/g)
WIND
O3
t°
TEMPERATURE (°C)

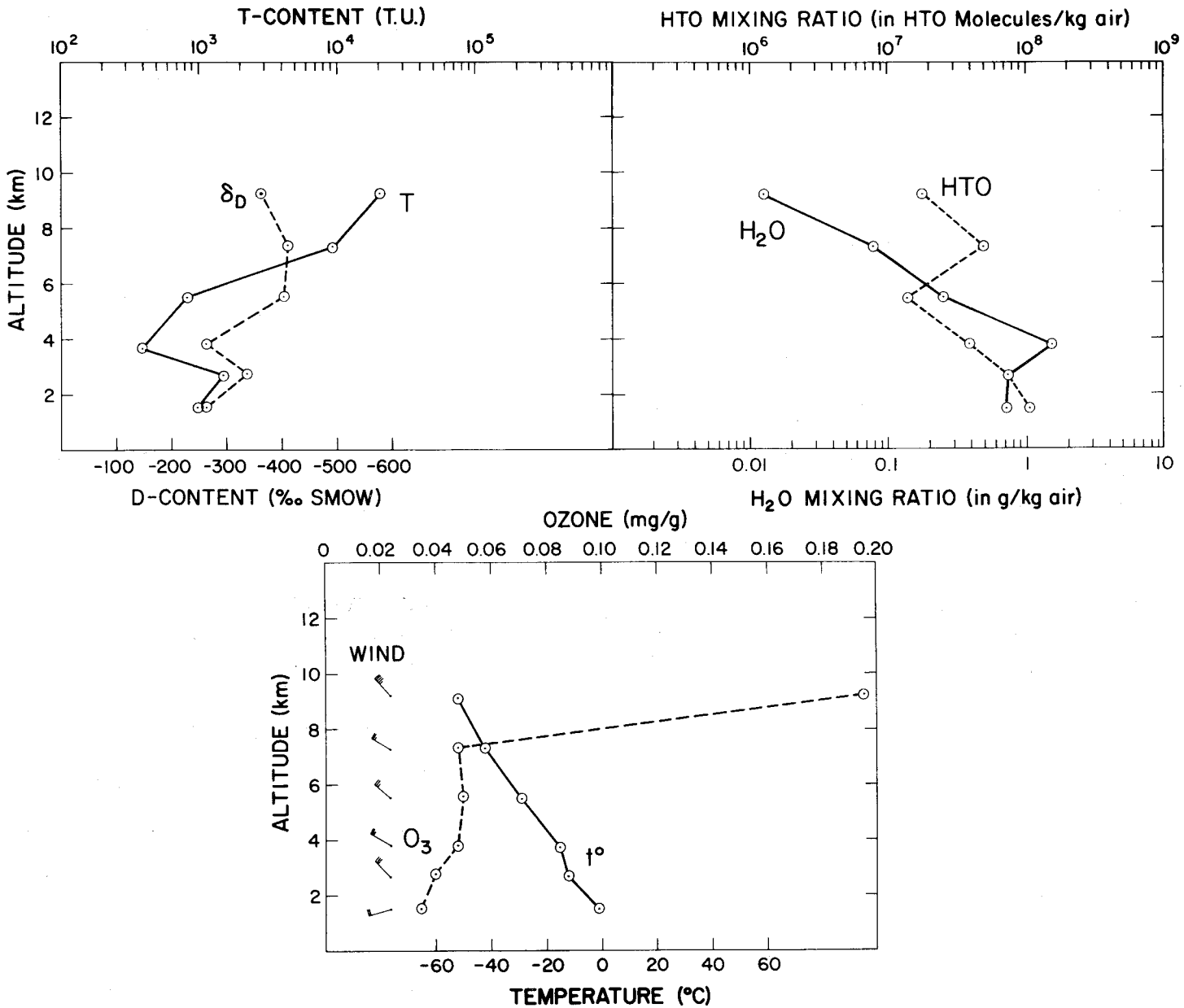
DATE: 18 January 1967

LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 06:55

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
1520	-1	1.08	-263	990± 21	7.1×10^{7}
2740	-12	.73	-337	1510± 25	7.5×10^{7}
3750	-15	1.53	-262	380± 16	3.9×10^{7}
5500	-29	.25	-402	840± 20	1.4×10^{7}
7330	-42	.079	-411	9340±100	5.0×10^{7}
9150	-52	.013	-361	20,600±580	1.8×10^{7}

Tropopause: 08:48 8740 m
13:44 9880 m


FLIGHT I-18-67
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)
OZONE (mg/g)
WIND
O3
t°
TEMPERATURE (°C)

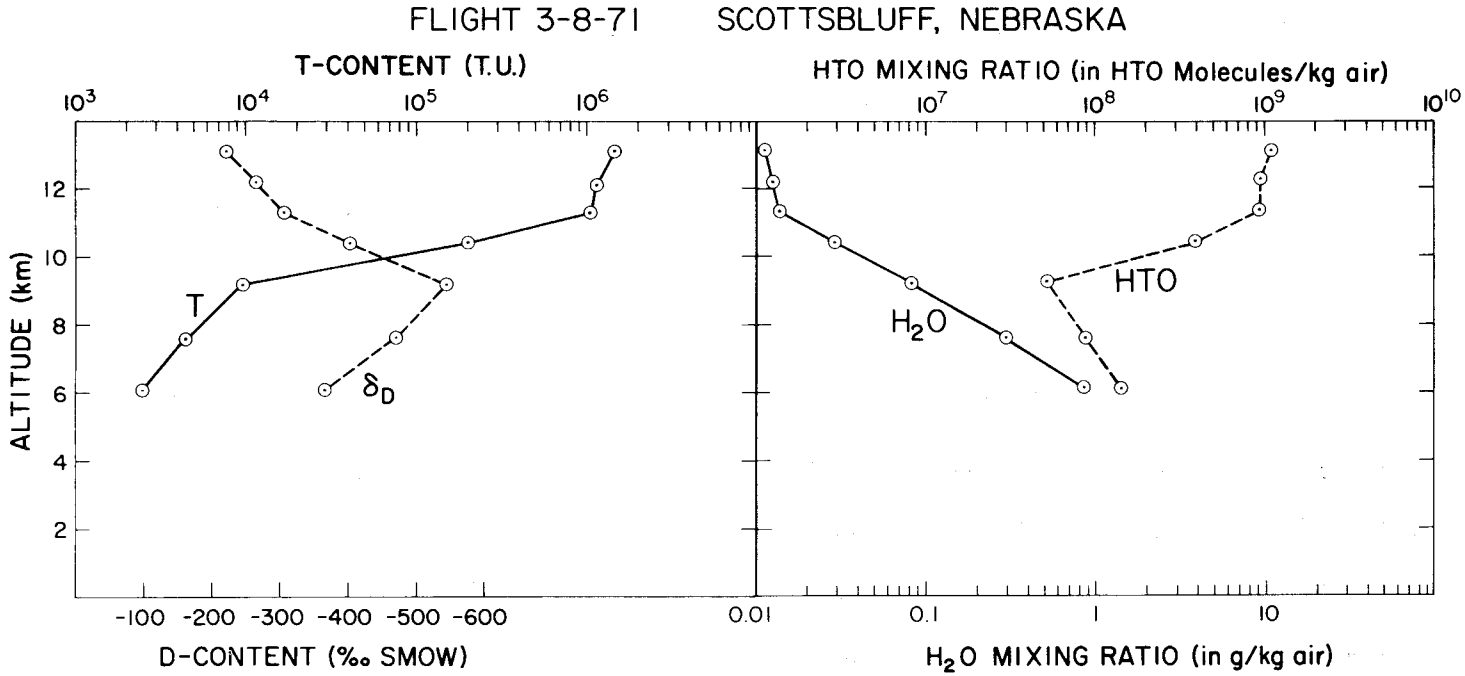
DATE: 8 March 1971

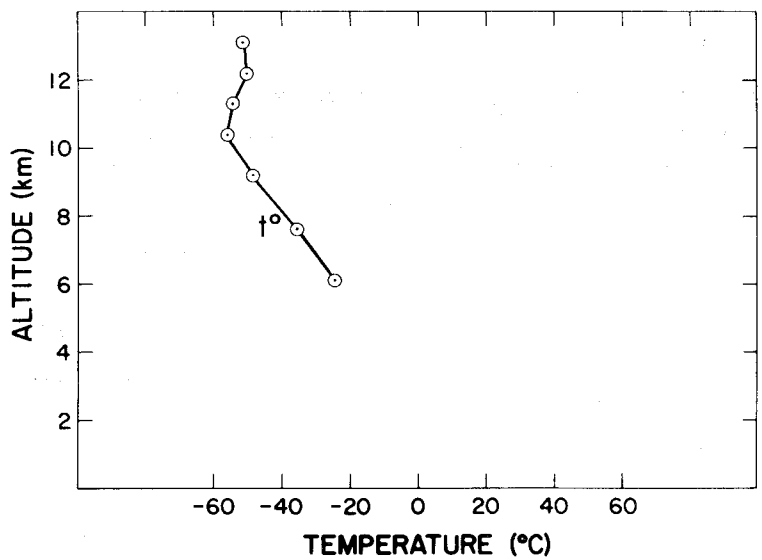
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 10:50

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
6,100	-24.8	0.86	-366	2490± 23	1.4×10^{8}
7,600	-35.7	0.3	-471	4420± 70	8.8×10^{7}
9,150	-48.8	0.082	-545	9640±294	5.2×10^{7}
10,300	-56.1	0.029	-403	$(2.0 \pm .09) \times 10^{5}$	3.9×10^{8}
11,300	-54.2	0.014	-307	$(1.03 \pm .03) \times 10^{6}$	9.3×10^{8}
12,200	-50.6	0.013	-266	$(1.14 \pm .03) \times 10^{6}$	9.4×10^{8}
13,100	-51.5	0.011	-221	$(1.47 \pm .05) \times 10^{6}$	1.1×10^{9}
13,100	-51.5	0.011	-220	$(1.68 \pm .06) \times 10^{6}$	1.2×10^{9}

Tropopause: 10,400 m


FLIGHT 3-8-71 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
10^3 10^4 10^5 10^6
HTO MIXING RATIO (in HTO Molecules/kg air)
10^7 10^8 10^9 10^{10}
ALTITUDE (km)
2 4 6 8 10 12
T
δ_D
HTO
H_2O
-100 -200 -300 -400 -500 -600
D-CONTENT (‰ SMOW)
0.01 0.1 1 10
H_2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
2 4 6 8 10 12
t°
-60 -40 -20 0 20 40 60
TEMPERATURE (°C)

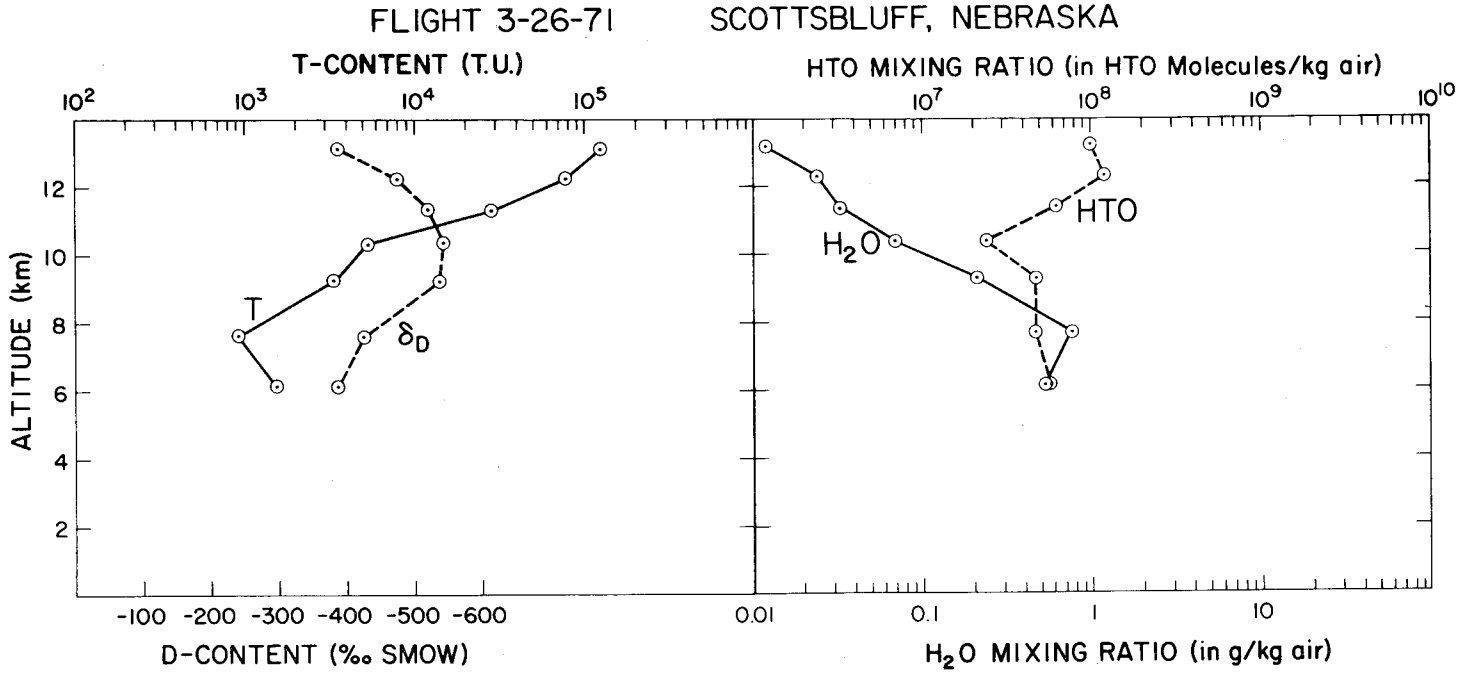
DATE: 26 March 1971

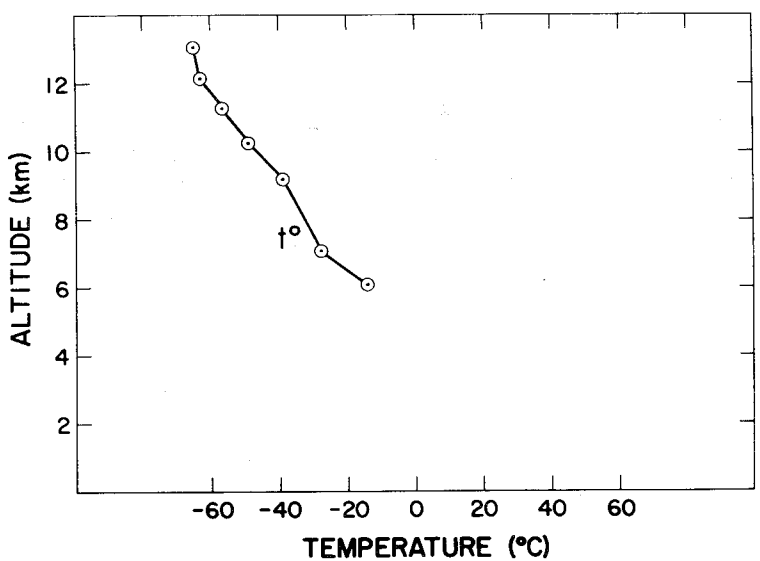
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 10:06

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
6,100	-14.8	0.53	-387	1550± 40	5.4×10^{7}
7,600	-28.4	0.76	-424	940± 8	4.7×10^{7}
9,150	-39.6	0.21	-535	3380± 80	4.7×10^{7}
10,300	-49.8	0.069	-542	5300±190	2.4×10^{7}
11,300	-57.4	0.033	-519	$(2.83\pm.05)\times10^{4}$	6.2×10^{7}
12,200	-64	0.024	-473	$(7.63\pm.04)\times10^{4}$	1.2×10^{8}
13,100	-66	0.012	-384	$(12.4\pm.13)\times10^{4}$	9.8×10^{7}

Tropopause: >13,100 m


FLIGHT 3-26-71
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

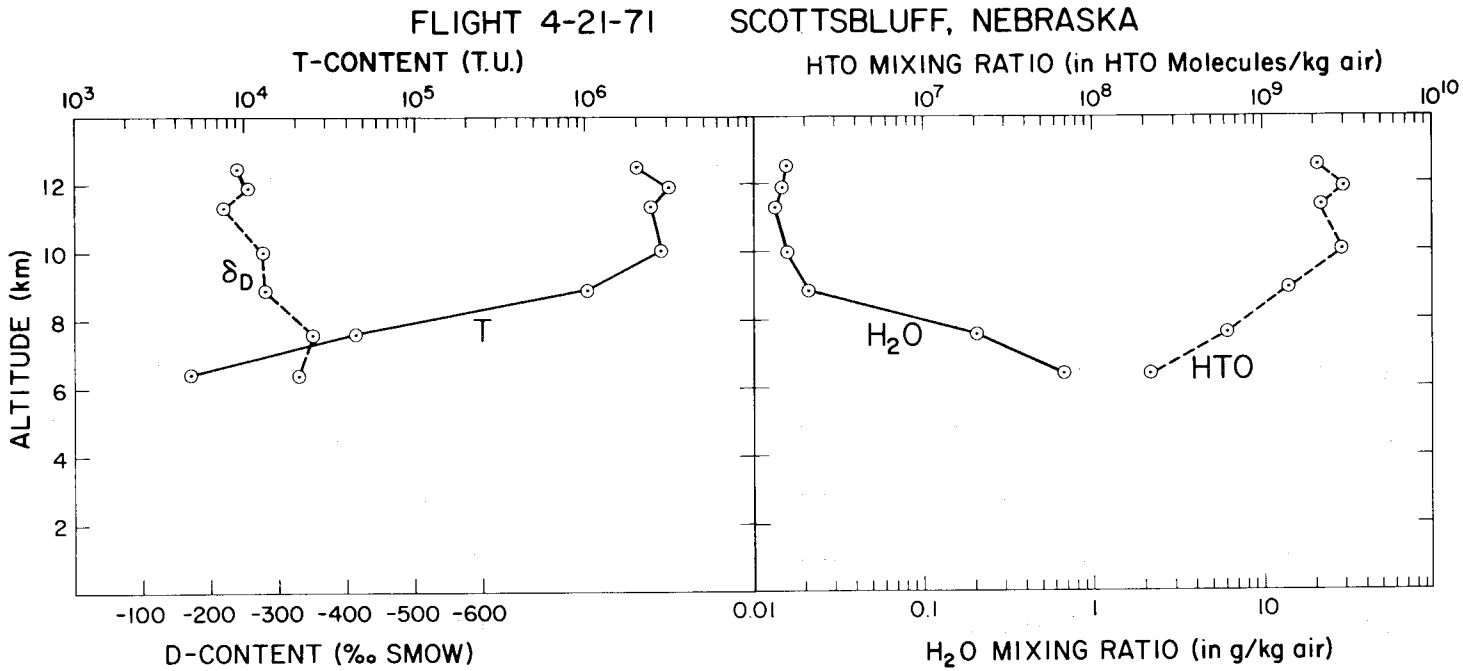
DATE: 21 April 1971

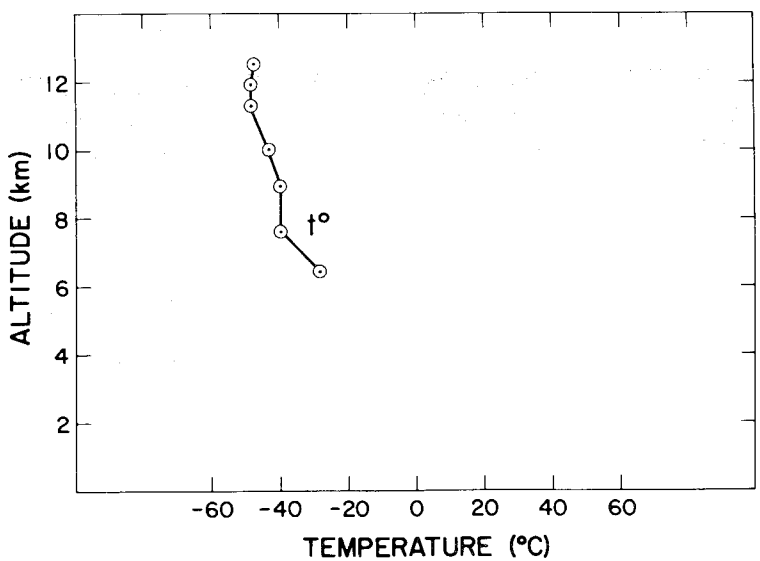
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 11:04

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
6,400	-28	0.68	-331	4860±50	2.2×10^{8}
7,600	-39.6	0.21	-351	$(4.51\pm.02)\times10^{4}$	6.1×10^{8}
8,850	-39.9	0.021	-280	$(1.03\pm.02)\times10^{6}$	1.4×10^{9}
10,000	-43	0.016	-278	$(2.8 \pm.3)\times10^{6}$	2.9×10^{9}
10,000	-43	0.009	-227		
11,300	-48.3	0.014	-221	$(2.46\pm.1)\times10^{6}$	2.2×10^{9}
11,900	-48.1	0.015	-258	$(3.12\pm.06)\times10^{6}$	3.0×10^{9}
12,500	-47.1	0.016	-240	$(2.02\pm.05)\times10^{6}$	2.1×10^{9}

Tropopause: 7,600 m


FLIGHT 4-21-71 SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

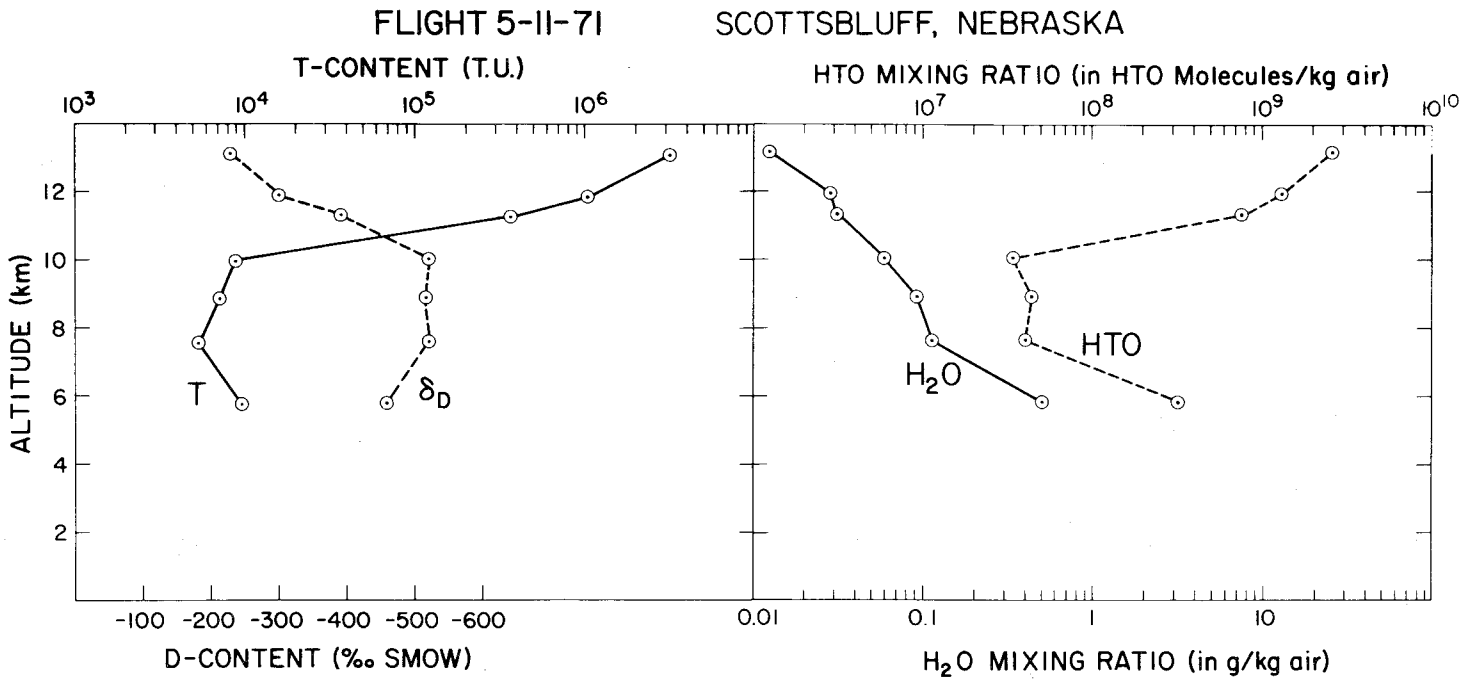
DATE: 11 May 1971

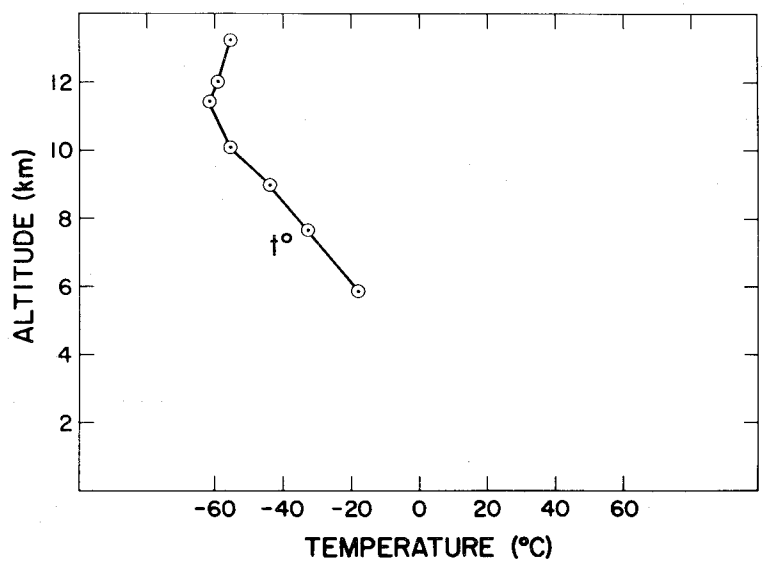
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 13:34

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
5,800	-17.9	0.502	-456	9600±800	3.2×10^{8}
7,600	-32.7	0.114	-518	5360± 30	4.0×10^{7}
8,850	-43.9	0.092	-515	7200± 30	4.4×10^{7}
10,000	-55.1	0.059	-520	8670± 45	3.4×10^{7}
11,300	-61.5	0.031	-388	$(3.7 \pm .04) \times 10^{5}$	7.6×10^{8}
11,900	-59.5	0.019	-297	$(1.04 \pm .02) \times 10^{6}$	1.3×10^{9}
13,100	-55.3	0.012	-227	$(3.15 \pm .03) \times 10^{6}$	2.6×10^{9}

Tropopause: 11,200 m


FLIGHT 5-11-71
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δ_D
H_2O
HTO
D-CONTENT (‰ SMOW)
H_2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

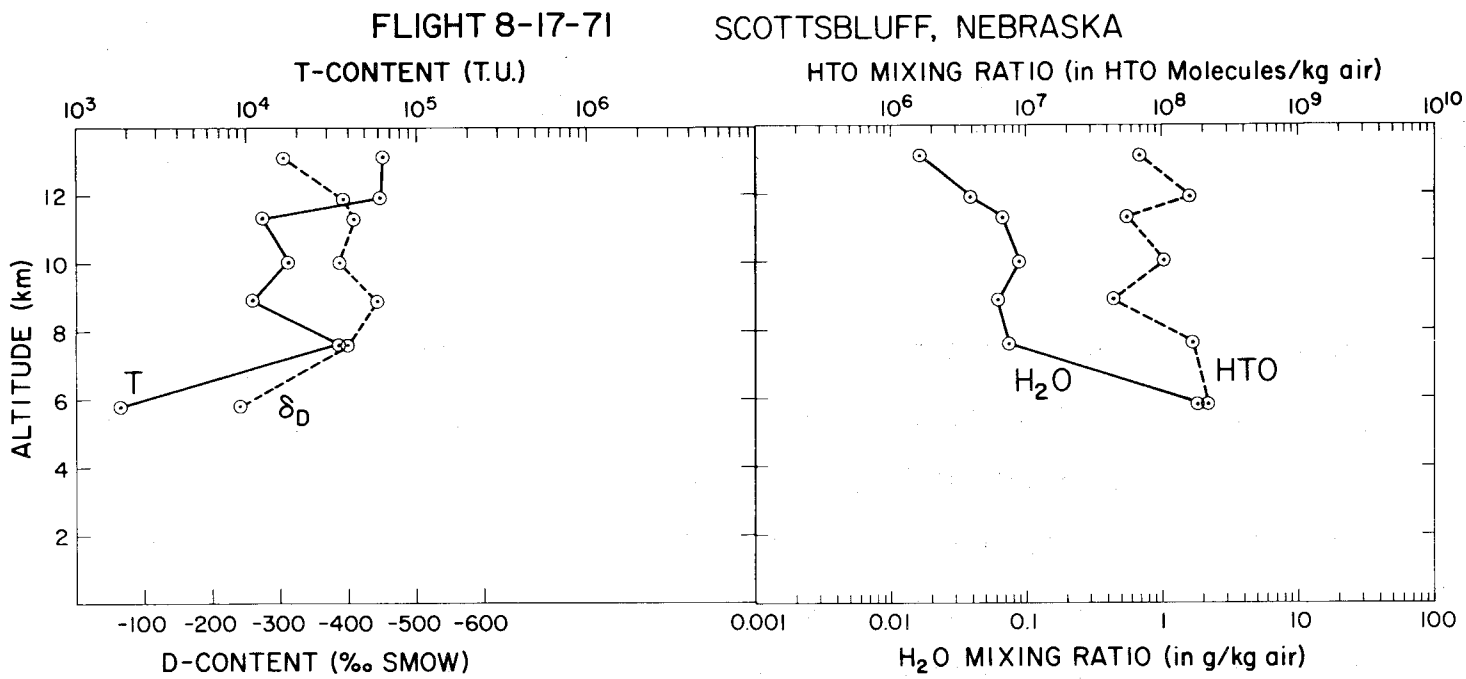
DATE: 17 August 1971

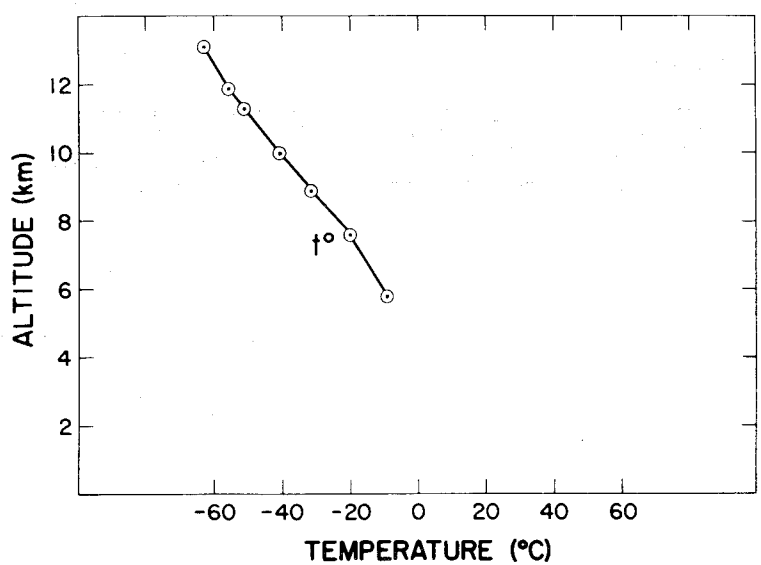
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 09:00

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
5,800	-9.3	1.89	-241	1830±30	2.2×10^{8}
7,600	-20	0.073	-397	$(3.5 \pm .01) \times 10^{4}$	1.7×10^{8}
8,850	-31.3	0.062	-442	$(1.09 \pm .03) \times 10^{4}$	$.44 \times 10^{8}$
10,000	-41	0.090	-387	$(1.77 \pm .02) \times 10^{4}$	1.1×10^{8}
11,300	-51	0.067	-408	$(1.26 \pm .01) \times 10^{4}$	$.56 \times 10^{8}$
11,900	-56	0.038	-391	$(6.1 \pm .05) \times 10^{4}$	1.6×10^{8}
13,100	-63	0.017	-304	$(6.3 \pm .06) \times 10^{4}$	$.69 \times 10^{8}$
13,100	-63	0.0055	-231	$(3.8 \pm .04) \times 10^{5}$	1.4×10^{8}

Tropopause: > 13,100 m


FLIGHT 8-17-71
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δ_D
H_2O
HTO
D-CONTENT (‰ SMOW)
H_2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

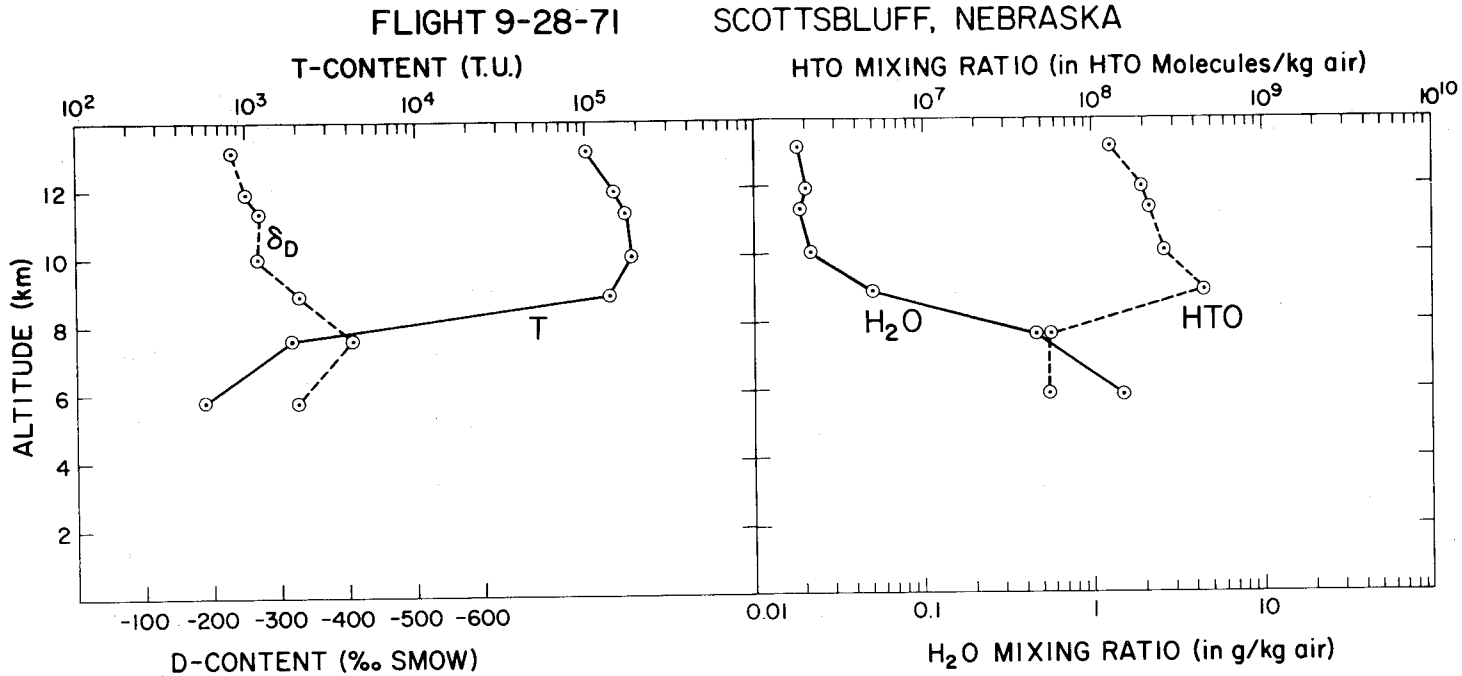
DATE: 28 September 1971

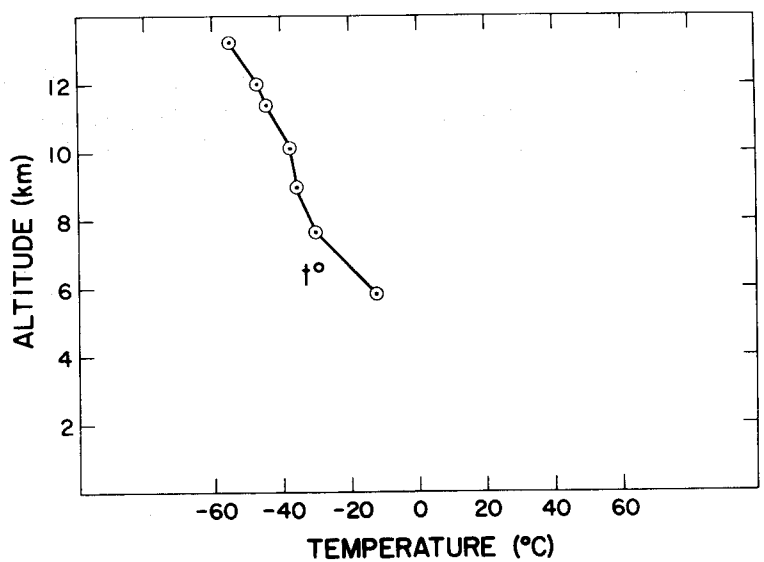
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 15:22

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
5,800	-12.5	1.51	-325	5.60±10	$.56 \times 10^{8}$
7,600	-30	0.47	-405	1850±40	$.58 \times 10^{8}$
8,850	-35.5	0.051	-327	$(1.38\pm.01)\times10^{5}$	4.6×10^{8}
10,000	-37.8	0.022	-265	$(1.84\pm.02)\times10^{5}$	2.7×10^{8}
11,300	-44.5	0.019	-268	$(1.72\pm.02)\times10^{5}$	2.2×10^{8}
11,900	-47	0.021	-250	$(1.49\pm.02)\times10^{5}$	2.0×10^{8}
13,100	-55	0.019	-229	$(1.03\pm.02)\times10^{5}$	1.3×10^{8}
13,100	-55	0.017	-255	$(1.91\pm.02)\times10^{5}$	2.1×10^{8}

Tropopause: > 13,100 m


FLIGHT 9-28-71
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

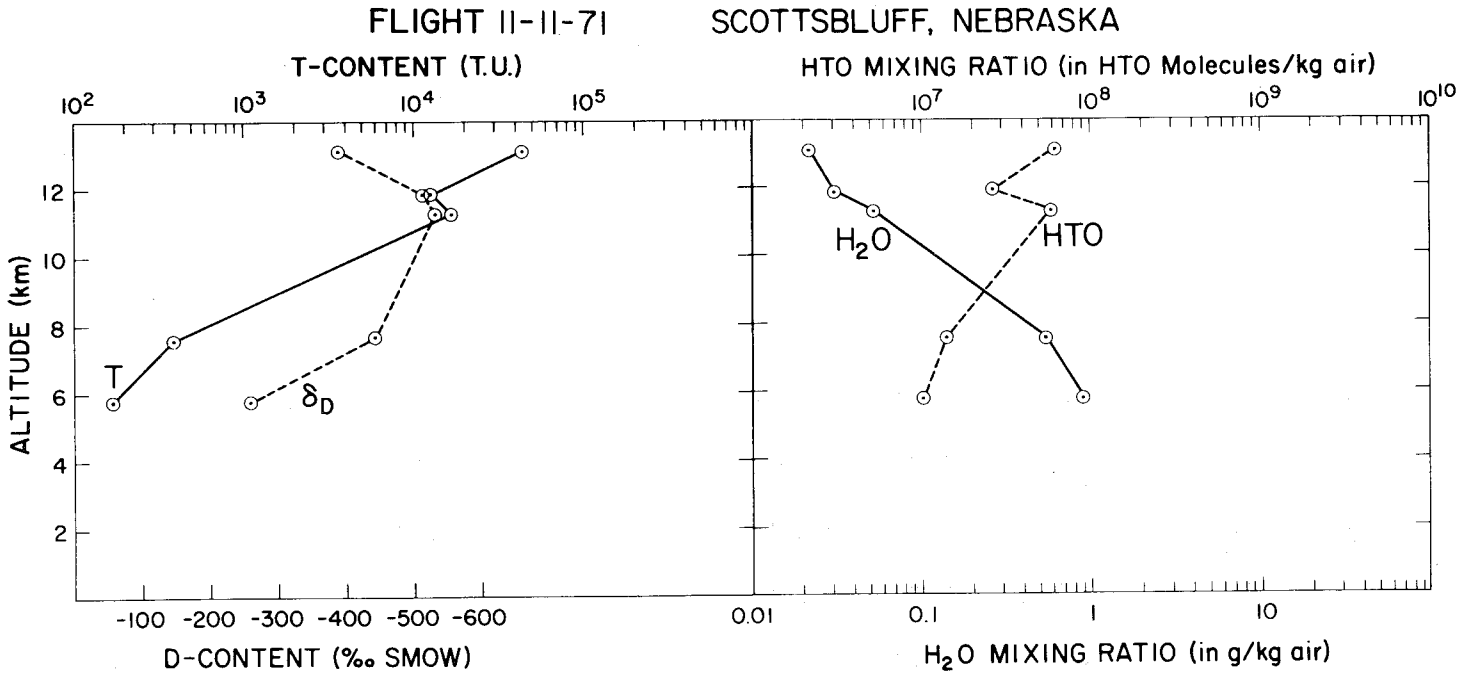
DATE: 11 November 1971

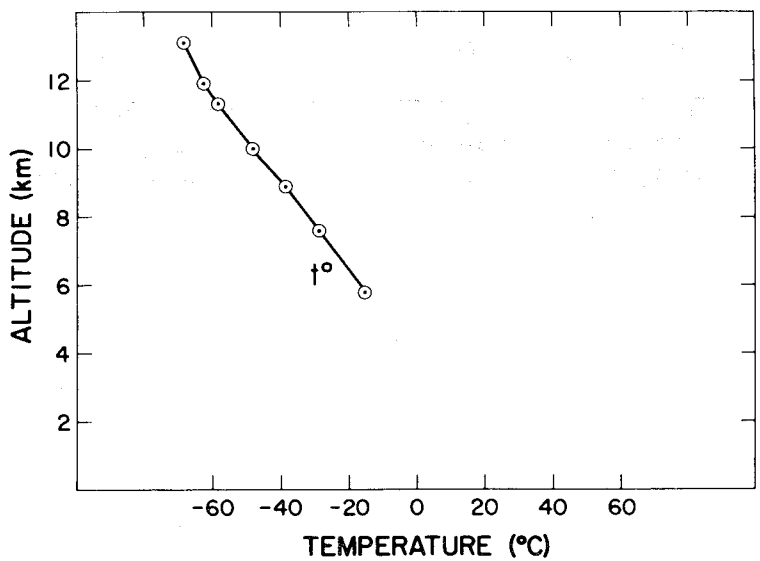
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 12:45

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
5,800	-15.1	0.90	-260	170±16	1.0×10^{7}
7,600	-28.5	0.54	-443	400±26	1.4×10^{7}
8,850	-38.5				
10,000	-48.2				
11,300	-58.0	0.052	-532	$(17.0\pm.2)\times10^{3}$	5.8×10^{7}
11,900	-62.7	0.031	-516	$(13\pm.3)\times10^{3}$	2.7×10^{7}
13,100	-68	0.024			
13,100	-68	0.022	-389	$(44\pm1.3)\times10^{3}$	6.4×10^{7}

Tropopause: > 13,100 m


FLIGHT 11-11-71
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

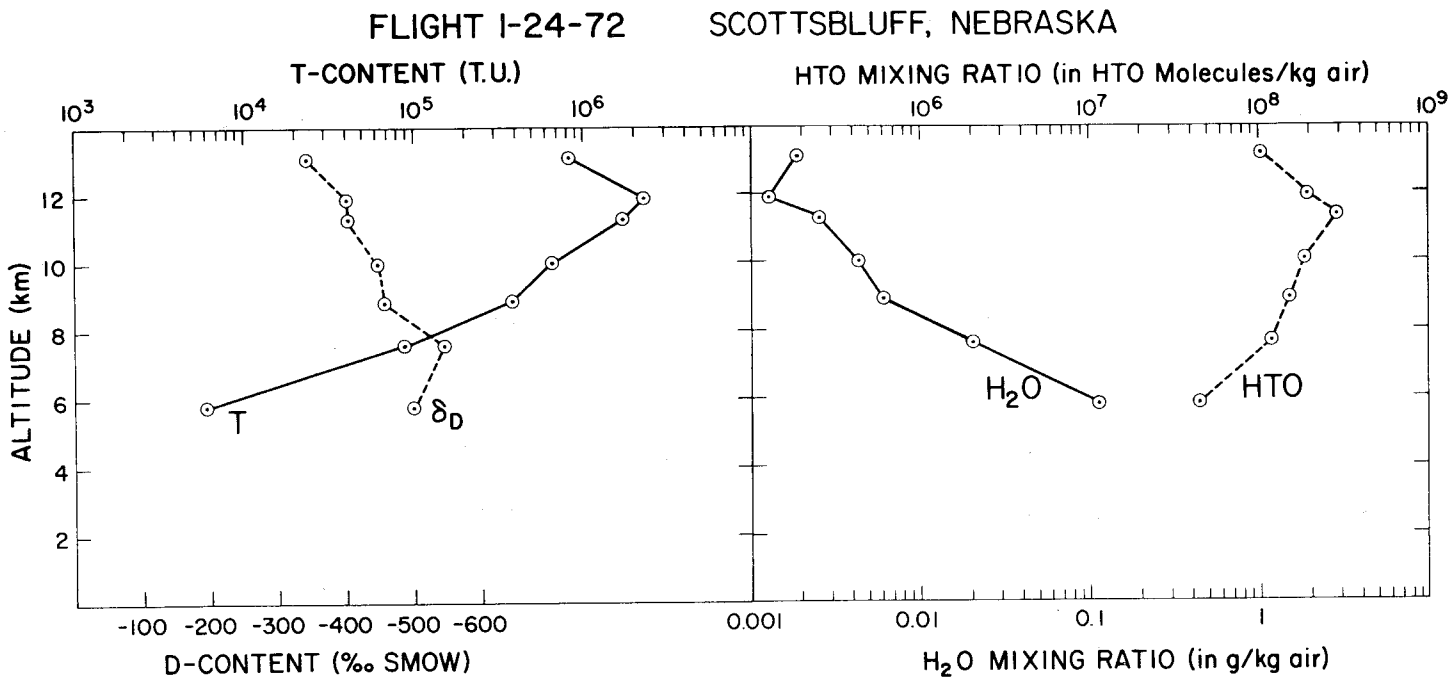
DATE: 24 January 1972

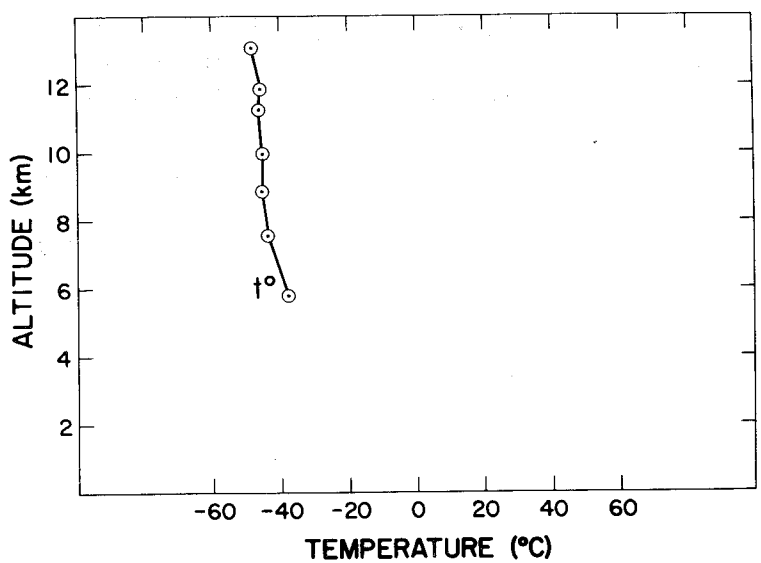
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 08:42

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
5,800	-37.5	0.11	-498	$(6.0\pm.06)\times10^{3}$	4.5×10^{7}
7,600	-43.5	0.021	-544	$(8.7\pm.1)\times10^{4}$	1.2×10^{8}
8,850	-45	0.0061	-456	$(3.8\pm.4)\times10^{5}$	1.5×10^{8}
10,000	-45	0.0044	-447	$(6.5\pm1.0)\times10^{5}$	1.9×10^{8}
11,300	-46	0.0026	-402	$(1.7\pm.1)\times10^{6}$	2.9×10^{8}
11,900	-45.5	0.0013	-401	$(2.3\pm.1)\times10^{6}$	2.0×10^{8}
13,100	-48	0.0019	-343	$(8.2\pm 1)\times10^{5}$	1.0×10^{8}
13,100	-48				

Tropopause: 7,600m


FLIGHT I-24-72
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

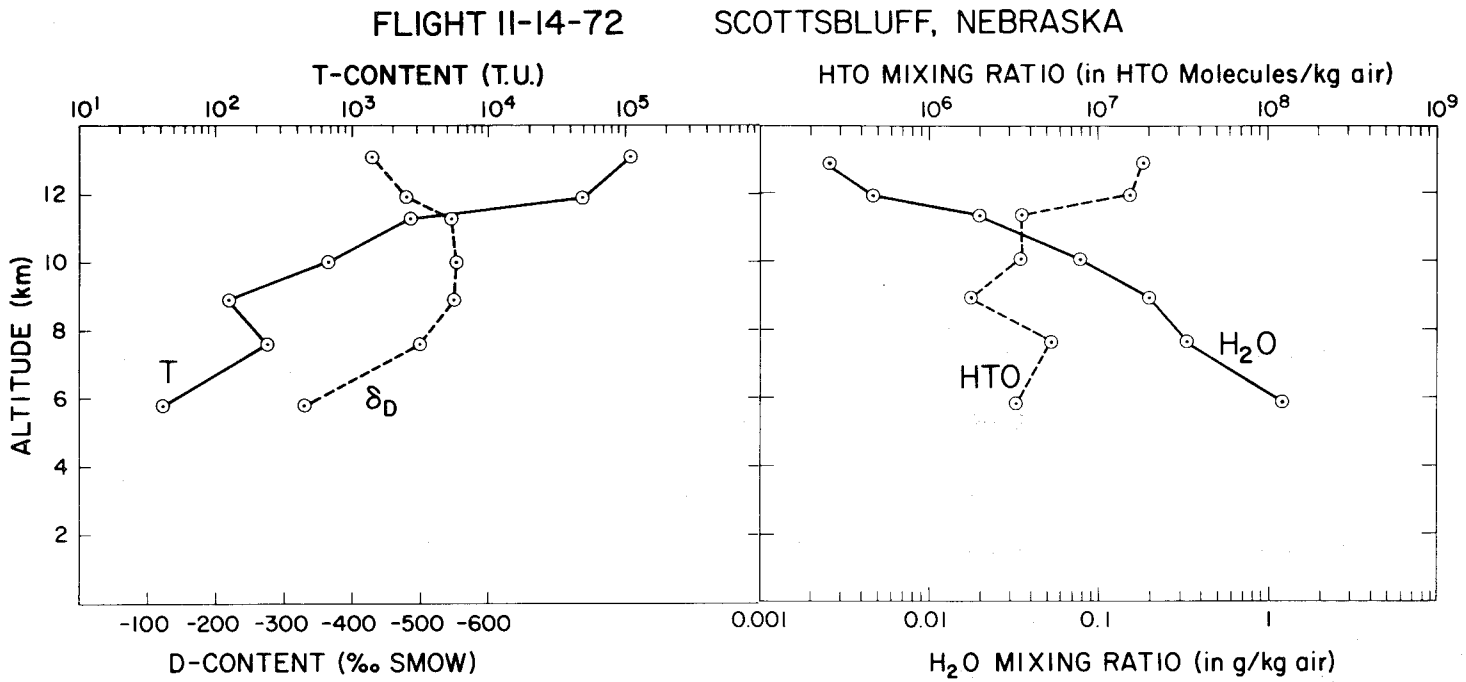
DATE: 14 November 1972

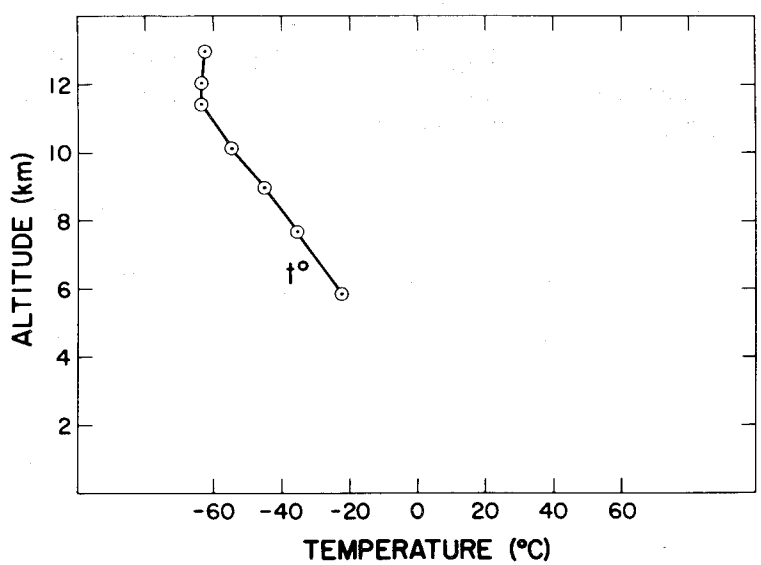
LOCATION: Scottsbluff, Nebraska

INITIAL SAMPLING TIME: 12:25

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
5,800	-22	1.23	-328	40± 4	0.33×10^{7}
7,600	-35	0.33	-498	240± 30	0.53×10^{7}
8,850	-44.5	0.20	-550	130± 40	0.17×10^{7}
10,000	-54	0.080	-554	660±150	0.35×10^{7}
11,300	-63	0.020	-547	2700±140	0.36×10^{7}
11,900	-63	0.0048	-479	$(4.95 \pm .2) \times 10^{4}$	1.6×10^{7}
12,800	-62	0.0026	-429	$(1.1 \pm .05) \times 10^{5}$	1.9×10^{7}

Tropopause: 11,200 m


FLIGHT II-14-72
SCOTTSBLUFF, NEBRASKA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

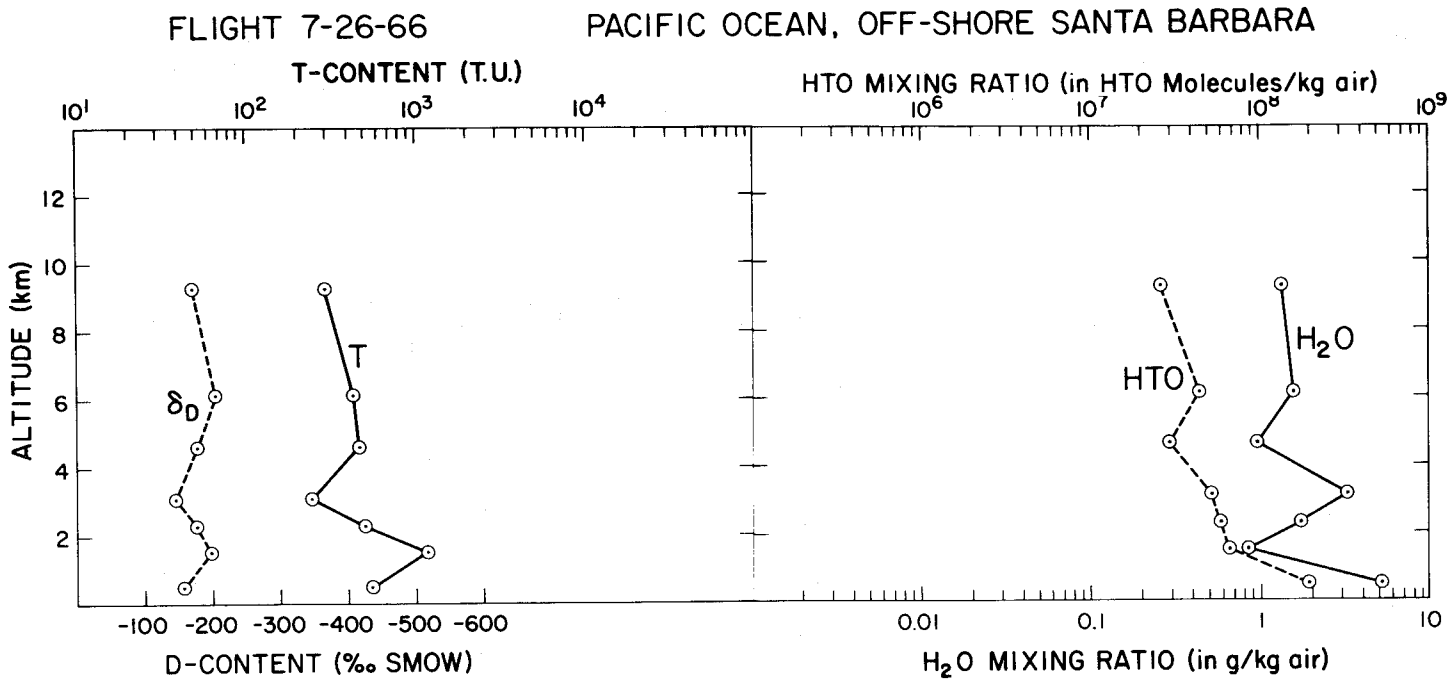

ALTITUDE (km)
t°
TEMPERATURE (°C)

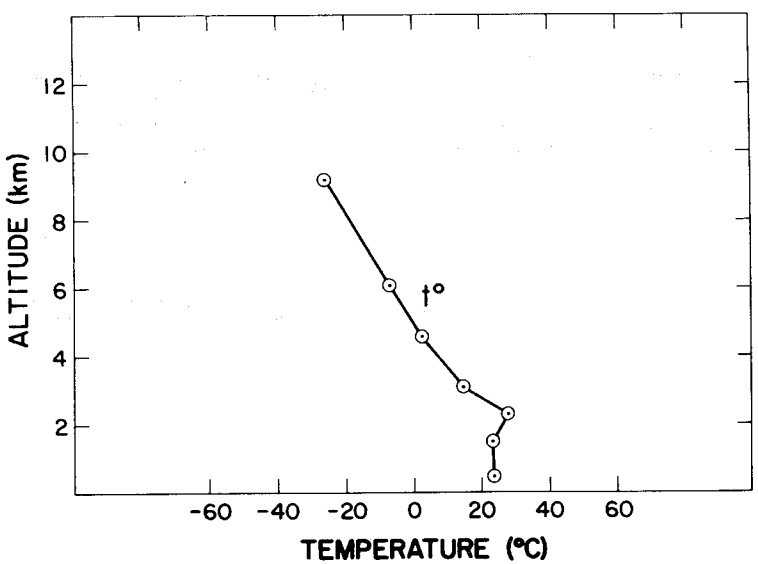
DATE: 26 July 1966

LOCATION: Pacific Ocean, off-shore Santa Barbara, Calif.

INITIAL SAMPLING TIME: 15:40

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
520	+24	5.18	-157	570±22	2.0×10^{8}
1520	+23.6	.85	-199	1170±28	6.6×10^{7}
2280	+28	1.75	-175	510±20	5.9×10^{7}
3050	+15	3.32	-146	240±18	5.3×10^{7}
4580	+2.5	.97	-177	470±20	3.0×10^{7}
6100	-7	1.59	-204	430±20	4.5×10^{7}
9150	-26	1.35	-172	300±20	2.7×10^{7}


FLIGHT 7-26-66
PACIFIC OCEAN, OFF-SHORE SANTA BARBARA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

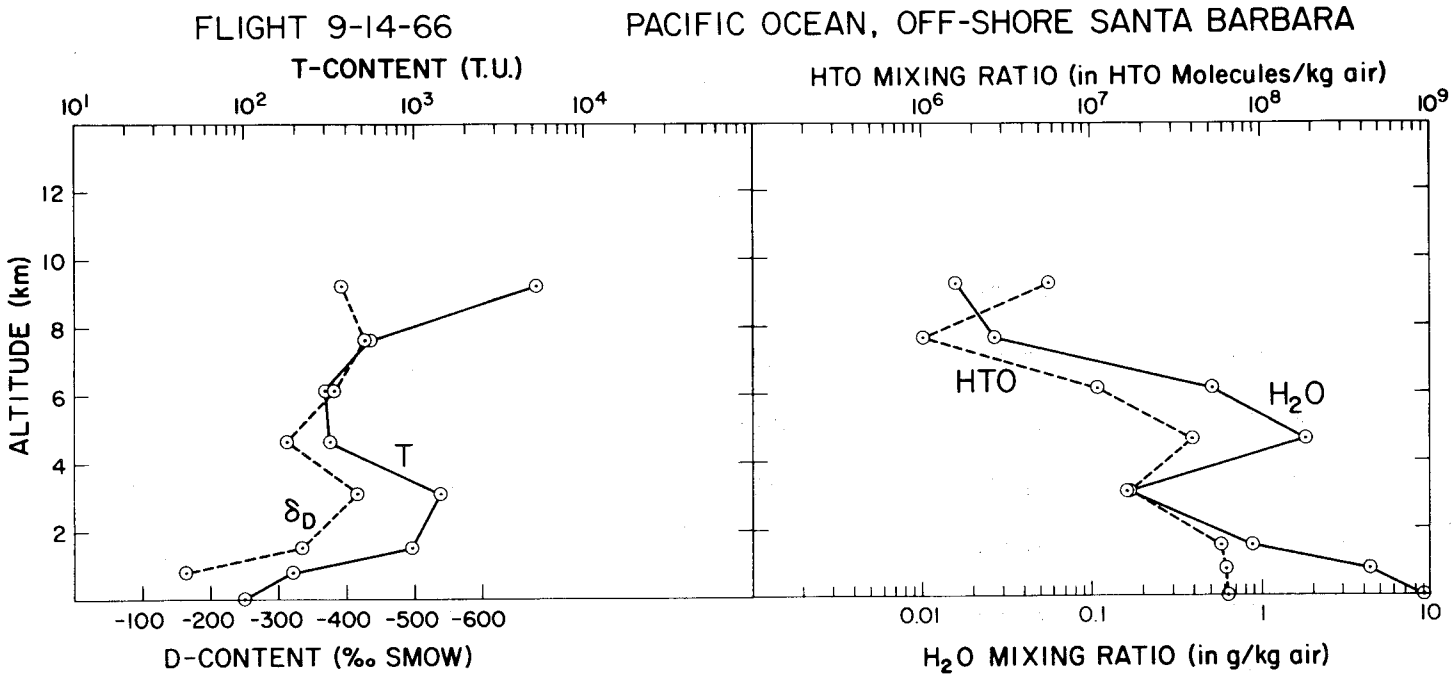

ALTITUDE (km)
t°
TEMPERATURE (°C)

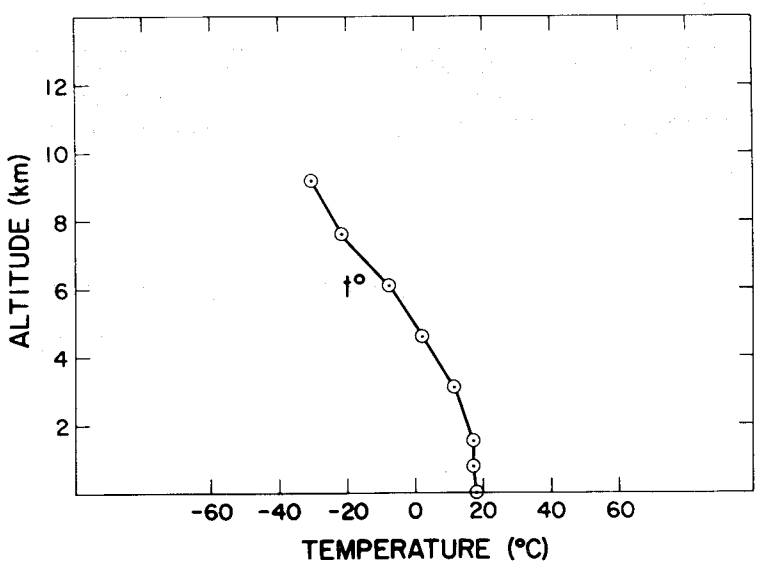
DATE: 14 September 1966

LOCATION: Pacific Ocean, off-shore Santa Barbara, Calif.

INITIAL SAMPLING TIME: 08:50

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+18	9.17		110± 12	6.4×10^{7}
760	+17	4.68	-164	200± 14	6.2×10^{7}
1520	+17.5	.89	-335	990± 22	5.8×10^{7}
3050	+11.5	.17	-415	1480± 65	1.7×10^{7}
4580	+2	1.84	-310	330± 15	4.0×10^{7}
6100	-7.6	.52	-380	310± 15	1.1×10^{7}
7600	-21.5	.027	-428	570±130	1.0×10^{6}
9150	-30.4	.017	-393	5350±360	5.7×10^{6}


FLIGHT 9-14-66
PACIFIC OCEAN, OFF-SHORE SANTA BARBARA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

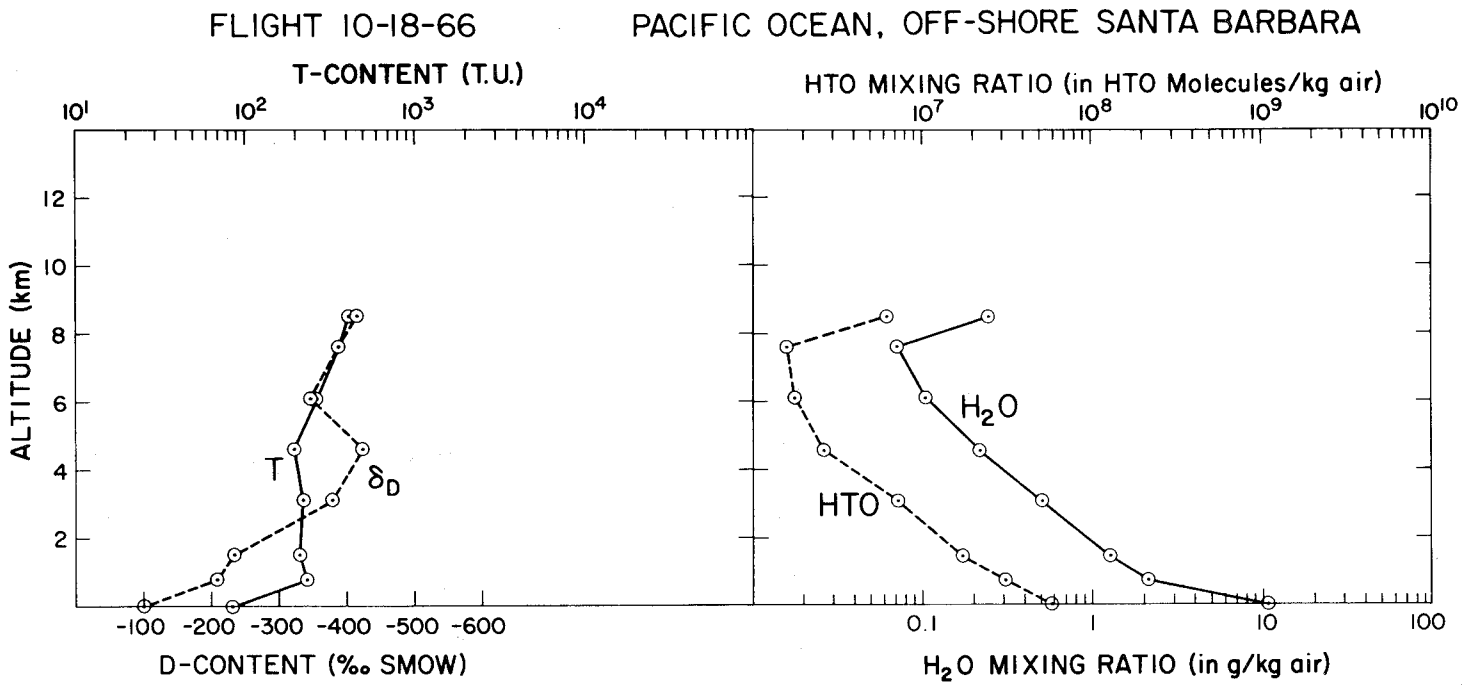

ALTITUDE (km)
t°
TEMPERATURE (°C)

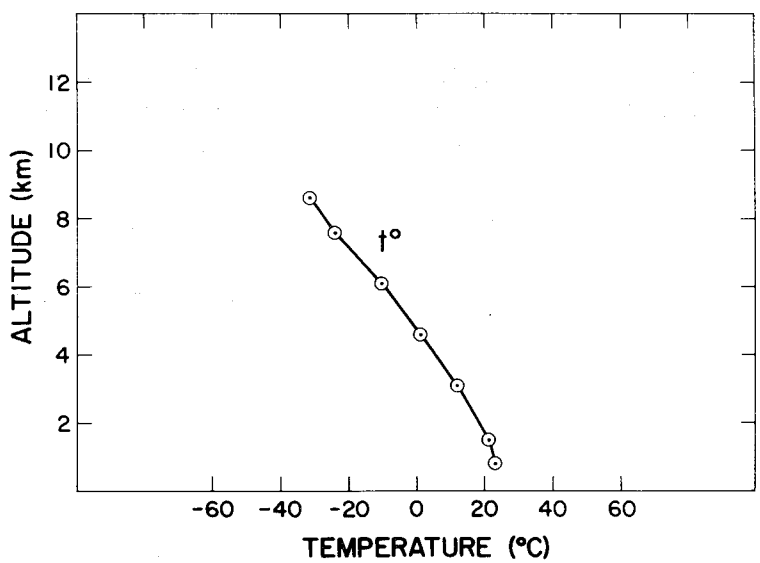
DATE: 18 October 1966

LOCATION: Pacific Ocean, off-shore Santa Barbara, Calif.

INITIAL SAMPLING TIME: 07:14

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
30.5	+18.3	10.8	-96	80±12	5.9×10^{7}
760	+23.3	2.15	-206	220±14	3.1×10^{7}
1520	+21.3	1.28	-234	210±14	1.8×10^{7}
3050	+12.1	.52	-377	210±14	7.3×10^{6}
4580	+1.0	.22	-423	190±50	2.7×10^{6}
6100	-10.0	.10	-343	260±63	1.8×10^{6}
7600	-24.0	.072	-386	340±45	1.6×10^{6}
8470	-31.2	.24	-414	390±22	6.3×10^{6}


FLIGHT 10-18-66
PACIFIC OCEAN, OFF-SHORE SANTA BARBARA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

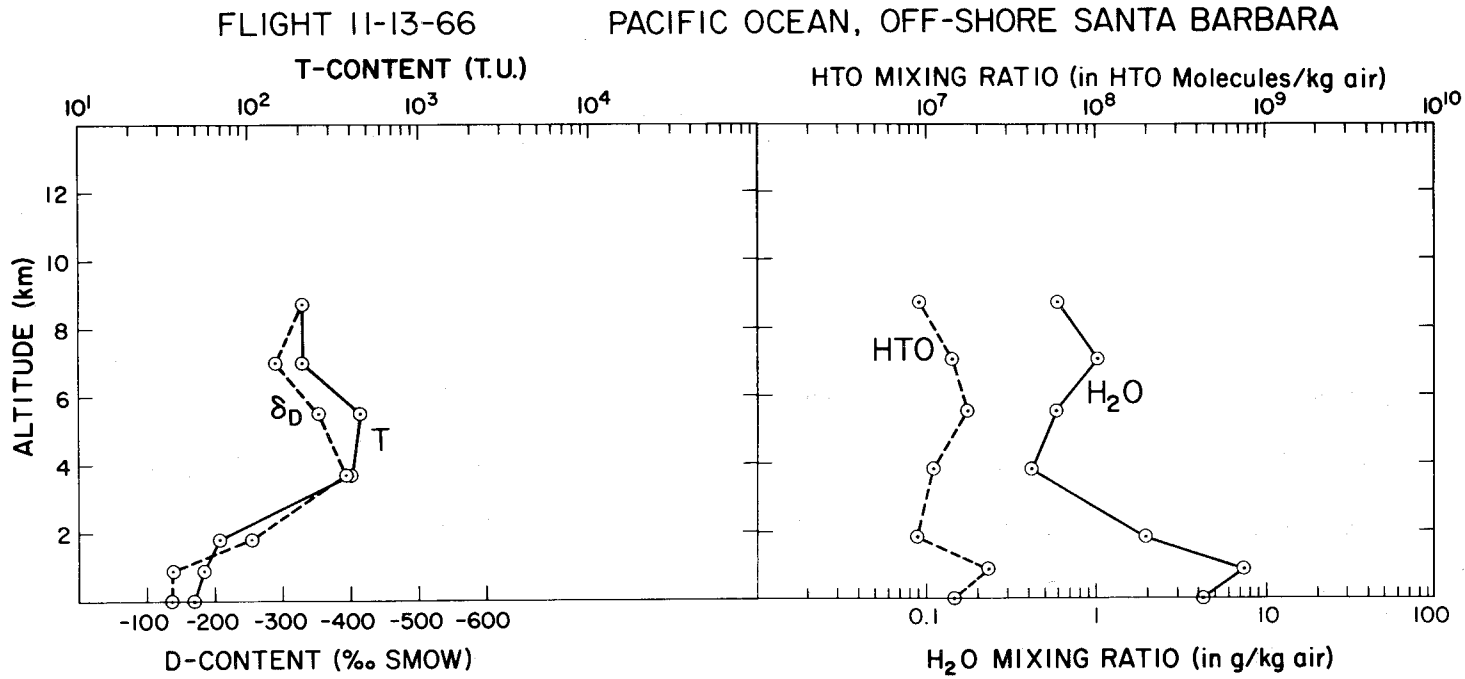

ALTITUDE (km)
t°
TEMPERATURE (°C)

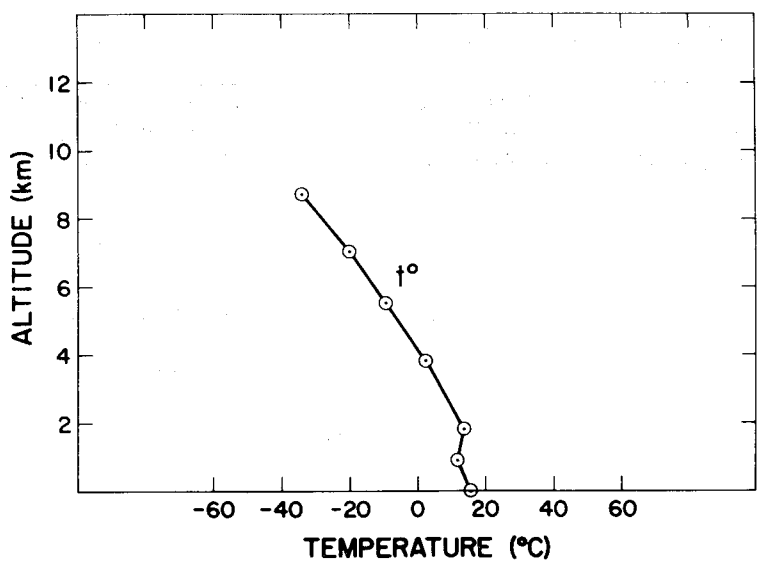
DATE: 13 November 1966

LOCATION: Pacific Ocean - off-shore Santa Barbara, Calif.

INITIAL SAMPLING TIME: 10:00

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+16	4.74	-136	50±12	1.5×10^7
915	+12	6.50	-140	60±15	2.4×10^7
1830	+14	1.99	-257	70±12	8.9×10^6
3750	+2.6	0.43	-394	400±20	1.1×10^7
5500	-9.2	0.59	-352	460±17	1.8×10^7
7000	-20	1.04	-289	210±14	1.4×10^7
8700	-34	0.61	-328	230±18	9.1×10^6


FLIGHT 11-13-66
PACIFIC OCEAN, OFF-SHORE SANTA BARBARA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

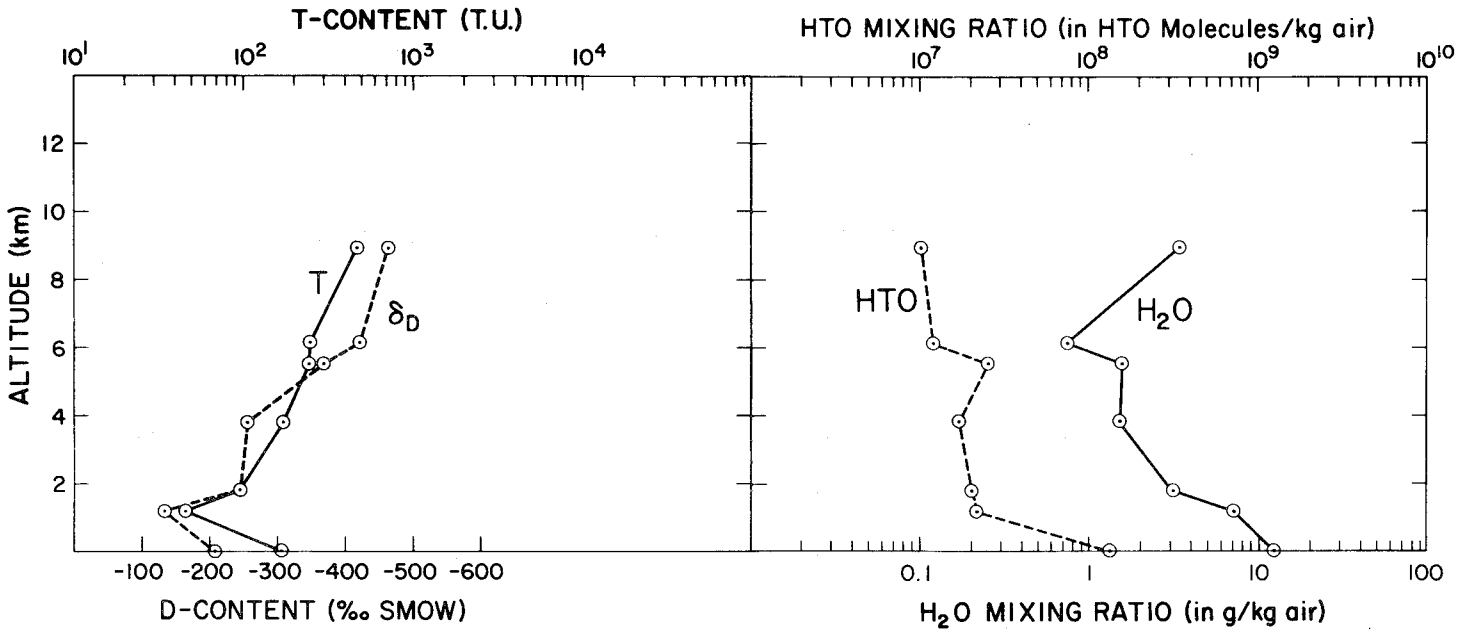

ALTITUDE (km)
t°
TEMPERATURE (°C)

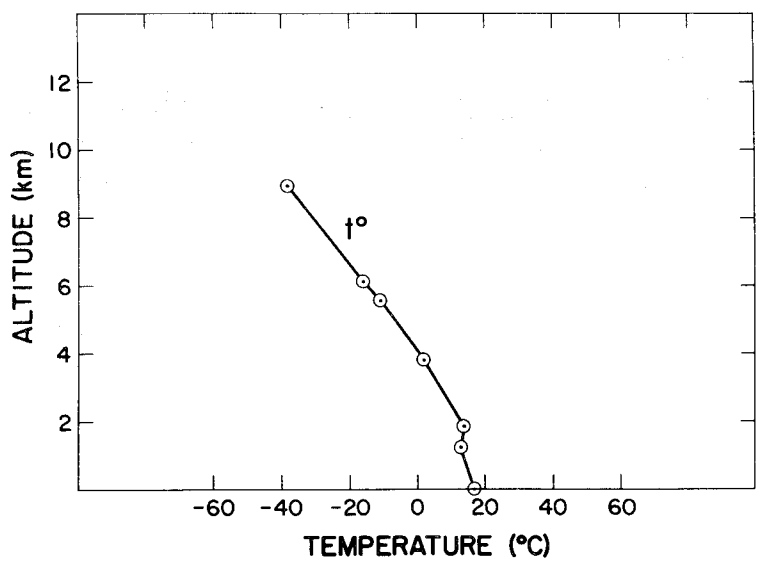
DATE: 13 December 1966

LOCATION: Pacific Ocean, off-shore Santa Barbara, Calif.

INITIAL SAMPLING TIME: 07:35

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+17	12.05	-207	170±14	1.3×10^{8}
1220	+13	7.34	-131	50±11	2.2×10^{7}
1830	+14	3.19	-244	100±11	2.1×10^{7}
3750	+2	1.53	-255	170±14	1.8×10^{7}
5500	-11	1.60	-367	250±13	2.6×10^{7}
6100	-16	0.76	-420	250±15	1.2×10^{7}
8850	-38	3.45	-462	470±17	1.0×10^{8}


FLIGHT 12-13-66
PACIFIC OCEAN, OFF-SHORE SANTA BARBARA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

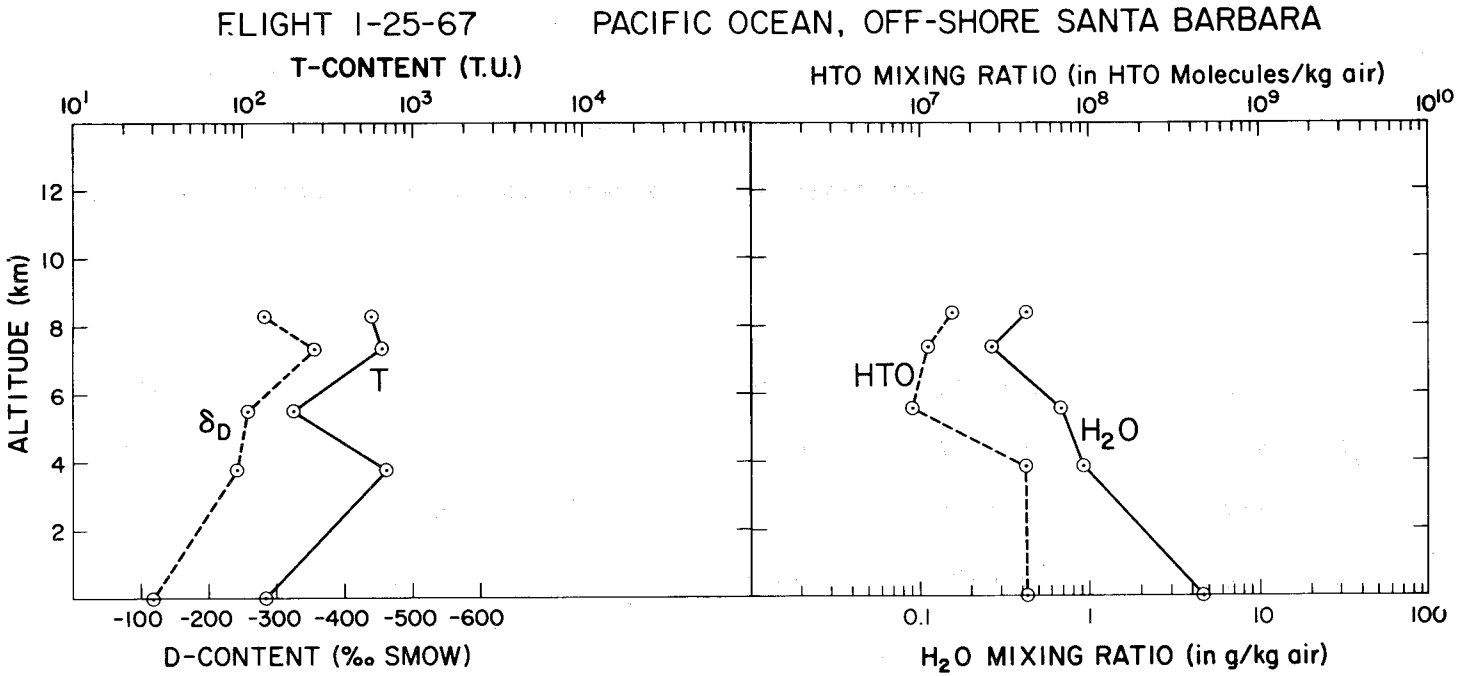
DATE: 25 January 1967

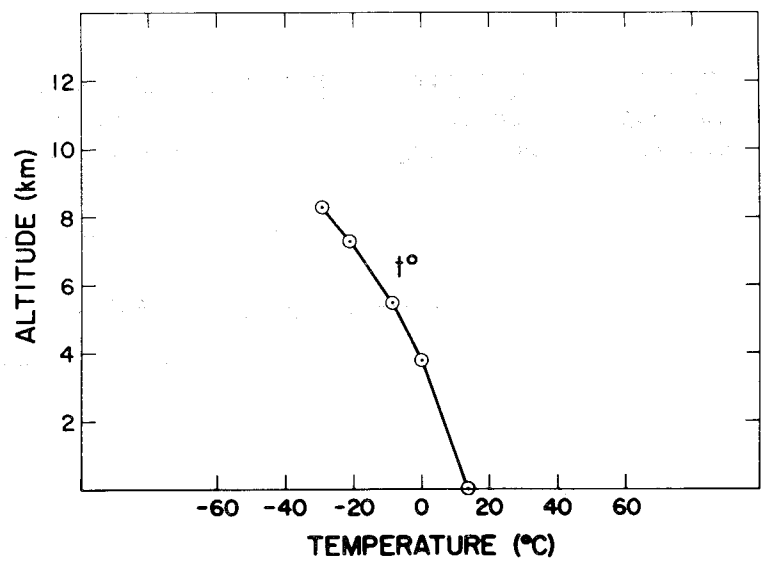
LOCATION: Pacific Ocean, off-shore Santa Barbara, Calif.

INITIAL SAMPLING TIME: 10:35

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+14	4.65	-116	140±12	4.3×10^7
*					
3750	+0.1	0.93	-240	690±19	4.2×10^7
5500	-8.4	0.67	-255	200±13	8.9×10^6
7330	-21	0.26	-353	650±17	1.1×10^7
8250	-29	0.42	-281	570±17	1.6×10^7

*Due to dense cloud cover, samples were not taken at these altitudes.


FLIGHT 1-25-67
PACIFIC OCEAN, OFF-SHORE SANTA BARBARA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

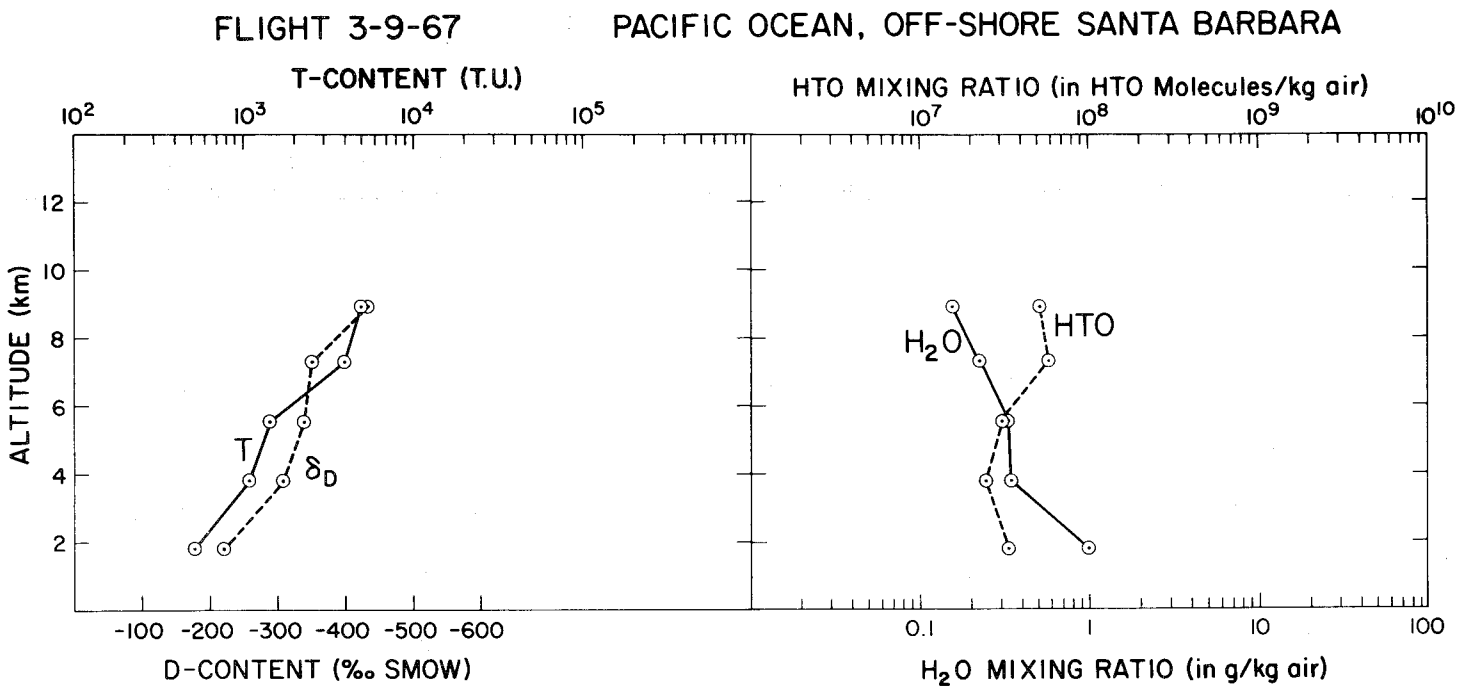
DATE: 9 March 1967

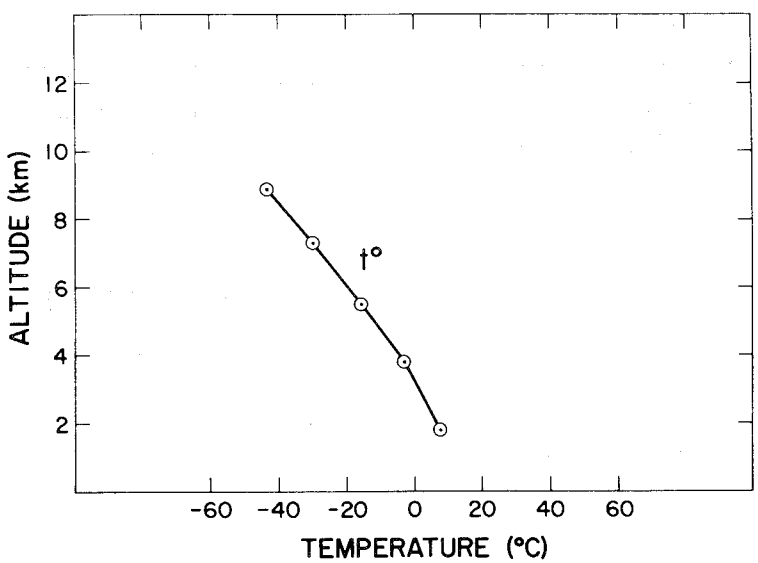
LOCATION: Pacific Ocean, off-shore Santa Barbara, Calif.

INITIAL SAMPLING TIME: 08:35

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
*					
1830	+8	1.0	-220	510±17	3.4×10^7
*					
3750	-2.9	0.35	-306	1080±31	2.5×10^7
5500	-15.4	0.33	-338	1430±33	3.1×10^7
7330	-29.9	0.22	-350	3920±60	5.8×10^7
8850	-43.0	0.16	-433	4970±95	5.2×10^7

*Due to dense cloud cover, samples were not taken at these altitudes.


FLIGHT 3-9-67
PACIFIC OCEAN, OFF-SHORE SANTA BARBARA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

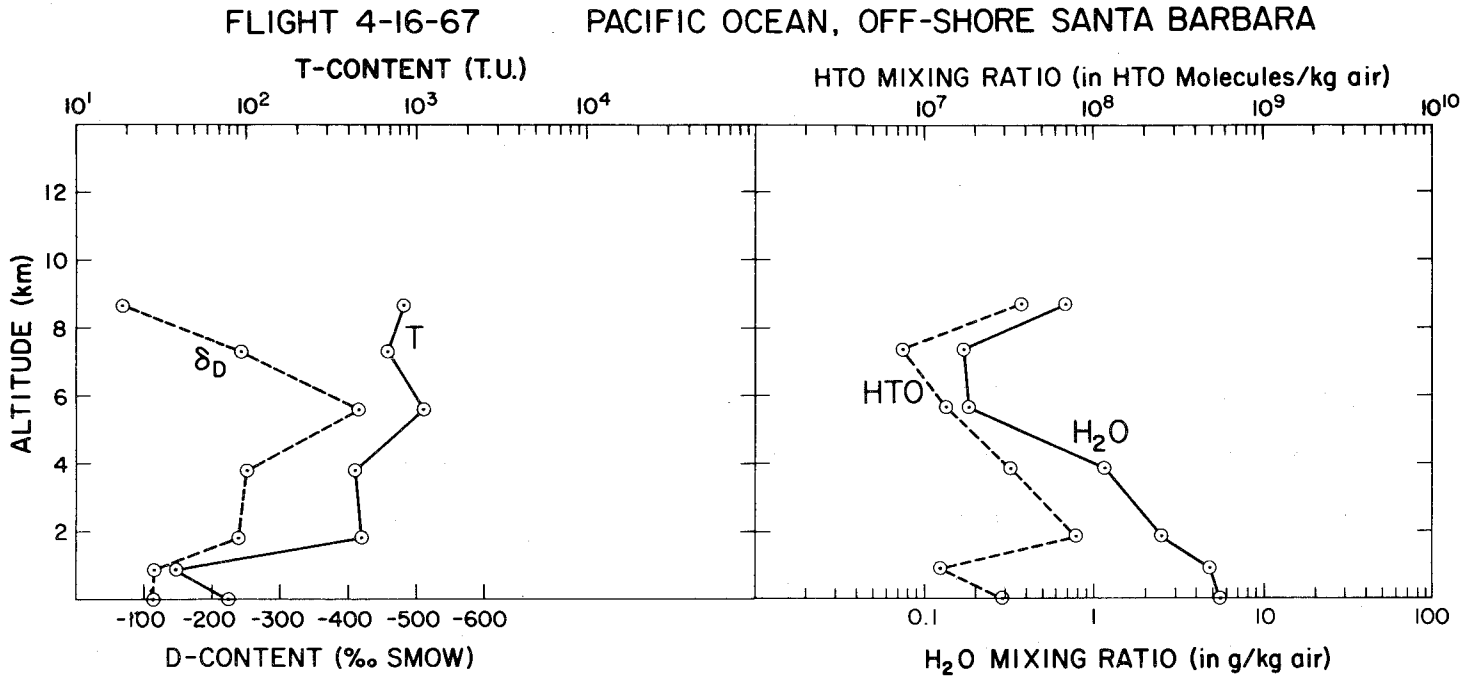
DATE: 16 April 1967

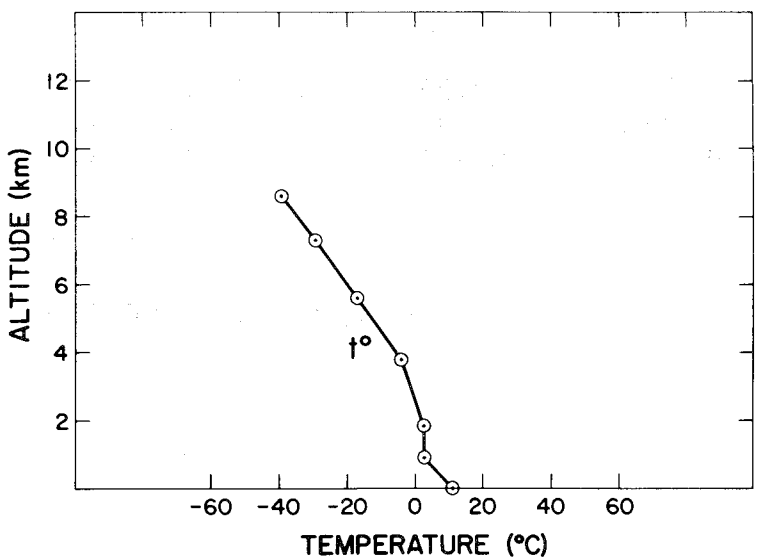
LOCATION: Pacific Ocean, off-shore Santa Barbara, Calif.

INITIAL SAMPLING TIME: 07:30

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+11.0	5.57	-109	80±11	2.9×10^{7}
915	+3.0	4.83	-108	40±11	1.2×10^{7}
1830	+3.0	2.53	-234	480±16	8.0×10^{7}
3750	-4.0	1.16	-245	430±16	3.3×10^{7}
5640	-17.0	0.19	-407	1100±50	1.4×10^{7}
7330	-29.5	0.17	-237	670±43	7.5×10^{6}
8550	-39.5	0.70	-61*	820±20	3.8×10^{7}

*There is no explanation for high water vapor and deuterium content; however, contamination unlikely in view of the high tritium content.


FLIGHT 4-16-67
PACIFIC OCEAN, OFF-SHORE SANTA BARBARA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

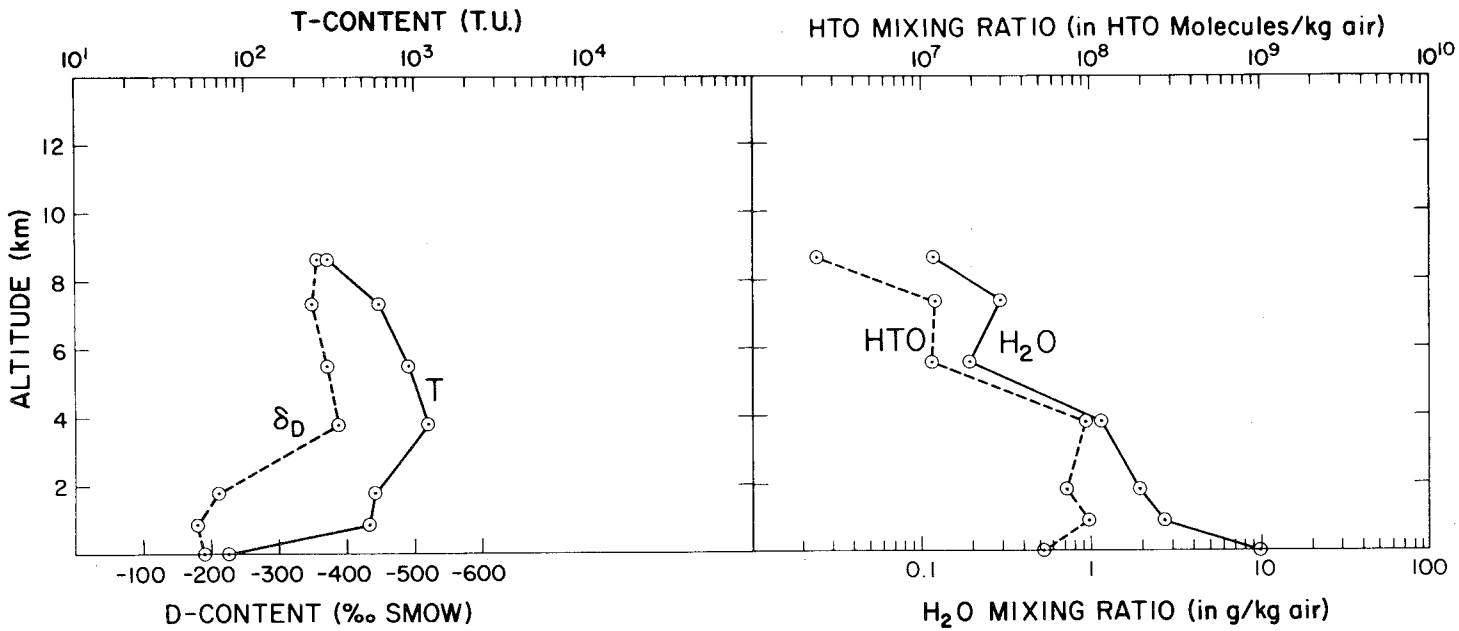

ALTITUDE (km)
t°
TEMPERATURE (°C)

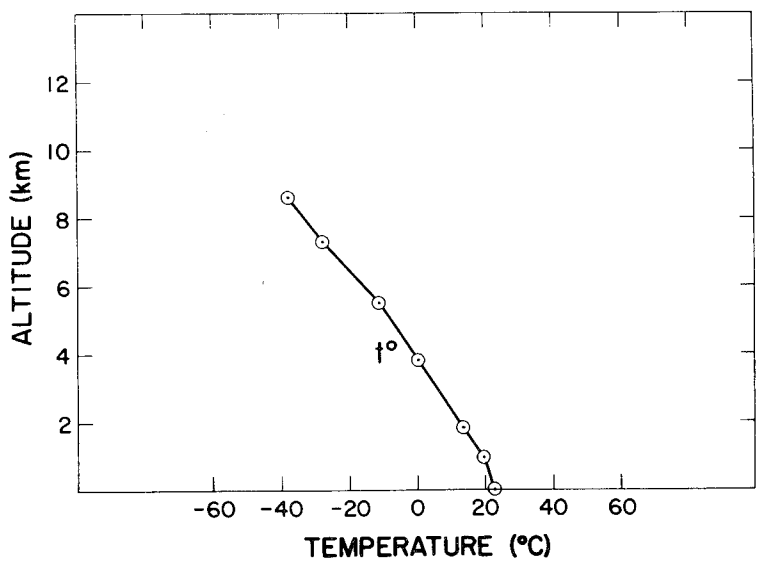
DATE: 16 May 1967

LOCATION: Pacific Ocean, off-shore Santa Barbara, Calif.

INITIAL SAMPLING TIME: 08:05

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+23	9.90	-192	80± 11	5.3×10^7
915	+20	2.72	-180	540± 16	9.6×10^7
1830	+14	1.95	-212	580± 11	7.1×10^7
3750	+0.5	1.16	-387	1200± 35	9.5×10^7
5500	-11	0.19	-372	920± 26	1.2×10^7
7330	-27.5	0.30	-350	610± 25	1.2×10^7
8550	-37.7	0.12	-358	310±220	2.4×10^6


FLIGHT 5-16-67
PACIFIC OCEAN, OFF-SHORE SANTA BARBARA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

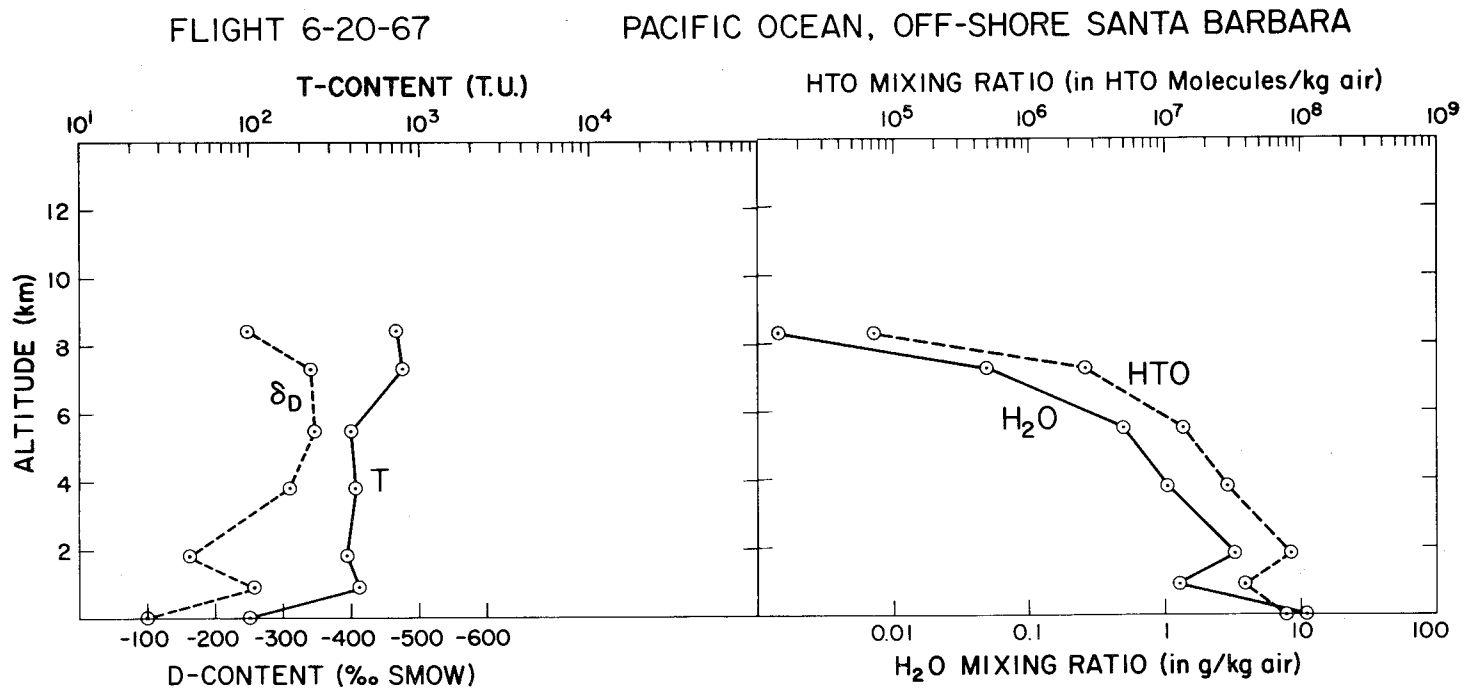

ALTITUDE (km)
t°
TEMPERATURE (°C)

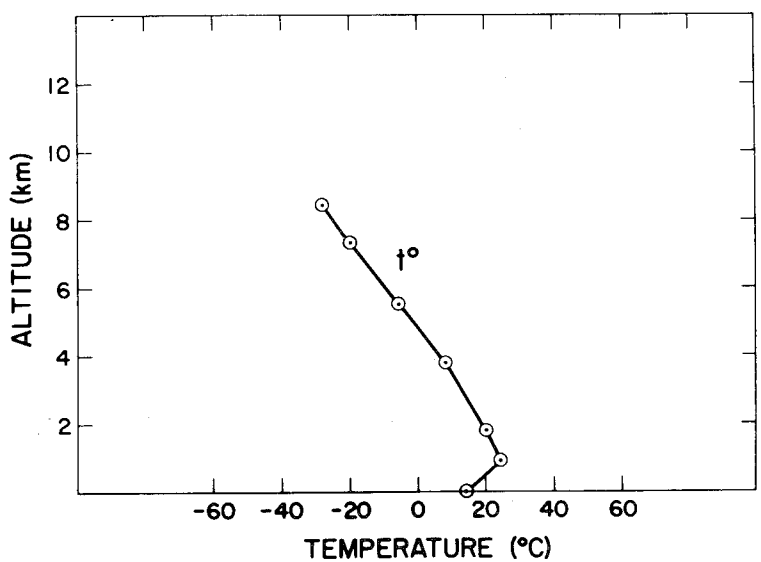
DATE: 20 June 1967

LOCATION: Pacific Ocean, off-shore Santa Barbara, Calif.

INITIAL SAMPLING TIME: 07:00

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+14.4	11.0	-100	100± 13	7.6×10^{7}
915	+24.5	1.29	-259	460± 16	3.9×10^{7}
1830	+20.5	3.28	-164	400± 16	8.6×10^{7}
3750	+8.4	1.02	-310	440± 17	2.9×10^{7}
5500	-5.5	0.50	-349	410± 16	1.4×10^{7}
7330	-20	0.048	-342	830± 82	2.6×10^{6}
8390	-28.2	0.0014	-250	760±670	7.0×10^{6}


FLIGHT 6-20-67
PACIFIC OCEAN, OFF-SHORE SANTA BARBARA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

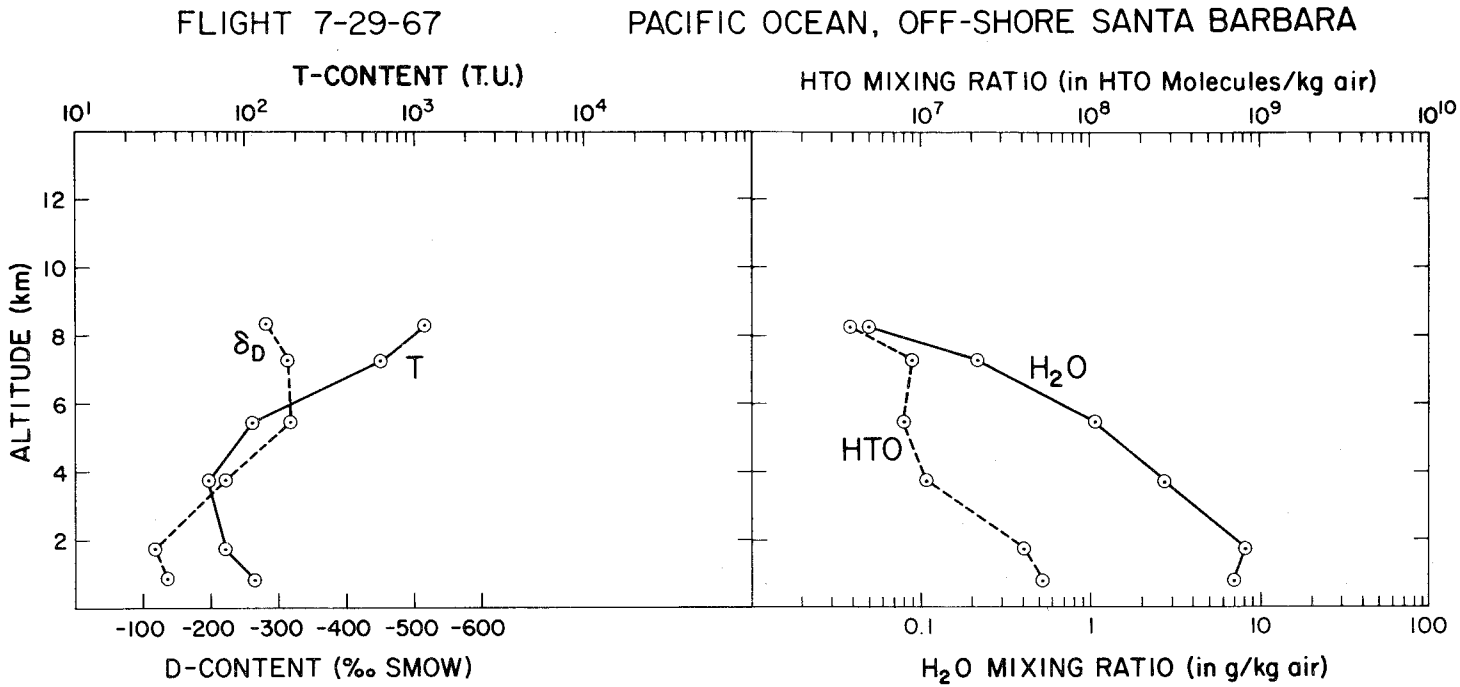
DATE: 29 July 1967

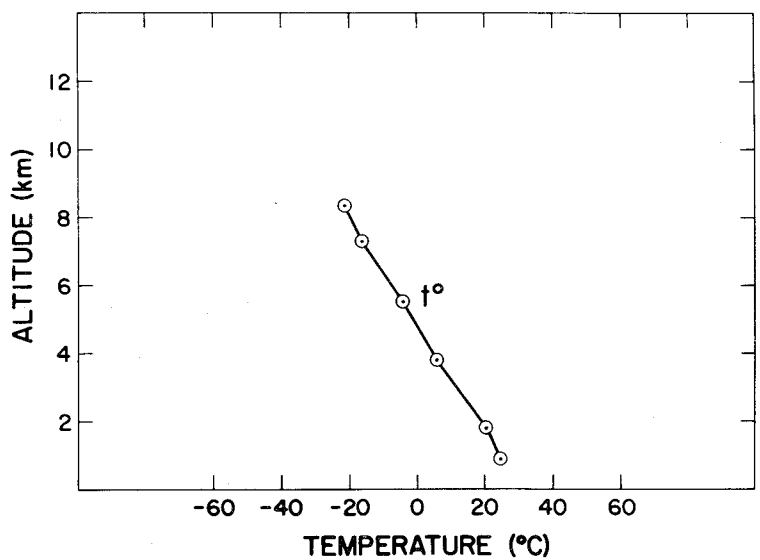
LOCATION: Pacific Ocean, off-shore Santa Barbara, Calif.

INITIAL SAMPLING TIME: 09:35

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2*					
915	+25.0	6.99	-134	110±12	5.3×10^7
1830	+20.5	8.04	-116	80±12	4.1×10^7
3750	+6.0	2.73	-222	60±10	1.1×10^7
5500	-4.2	1.08	-317	110±12	8.0×10^6
7330	-16.3	0.22	-312	640±12	9.1×10^6
8250	-21.5	0.051	-280	1160±83	3.9×10^6

*Not sampled because of surface fog.


FLIGHT 7-29-67
PACIFIC OCEAN, OFF-SHORE SANTA BARBARA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

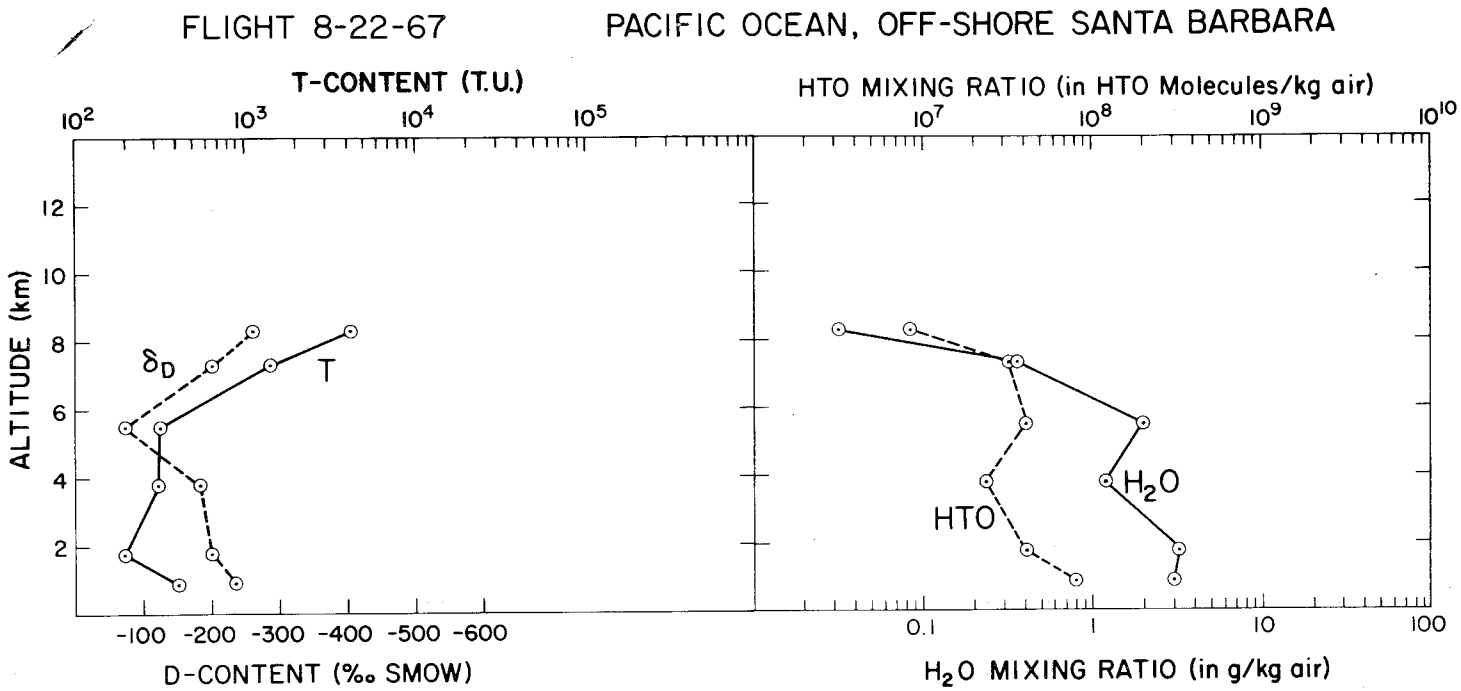
DATE: 22 August 1967

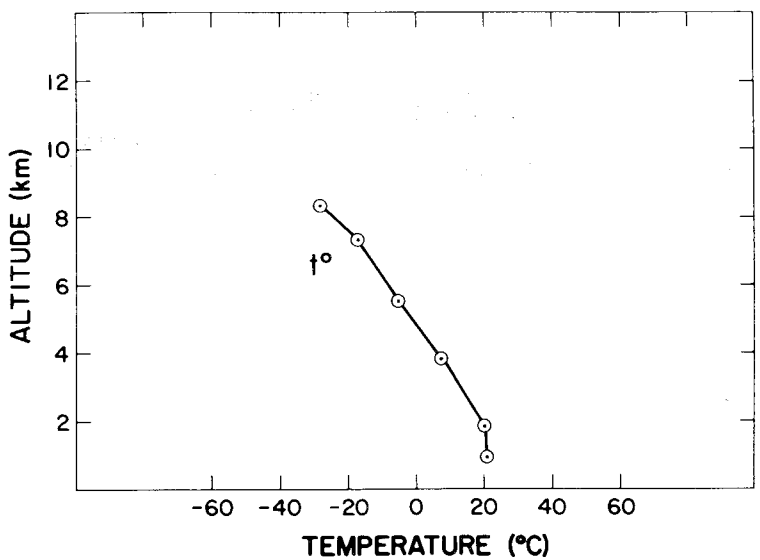
LOCATION: Pacific Ocean, off-shore Santa Barbara, Calif.

INITIAL SAMPLING TIME: 08:42

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2*					
915	+21.5	3.08	-235	400± 8	8.2×10^7
1830	+20.5	3.25	-199	190± 13	4.2×10^7
3750	+8.0	1.20	-182	310± 15	2.4×10^7
5500	-5.0	2.03	-71	310± 15	4.2×10^7
7330	-17.2	0.37	-199	1390± 25	3.3×10^7
8250	-28	0.032	-260	4070±169	8.6×10^6

*Not sampled because of surface fog.


FLIGHT 8-22-67
PACIFIC OCEAN, OFF-SHORE SANTA BARBARA
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

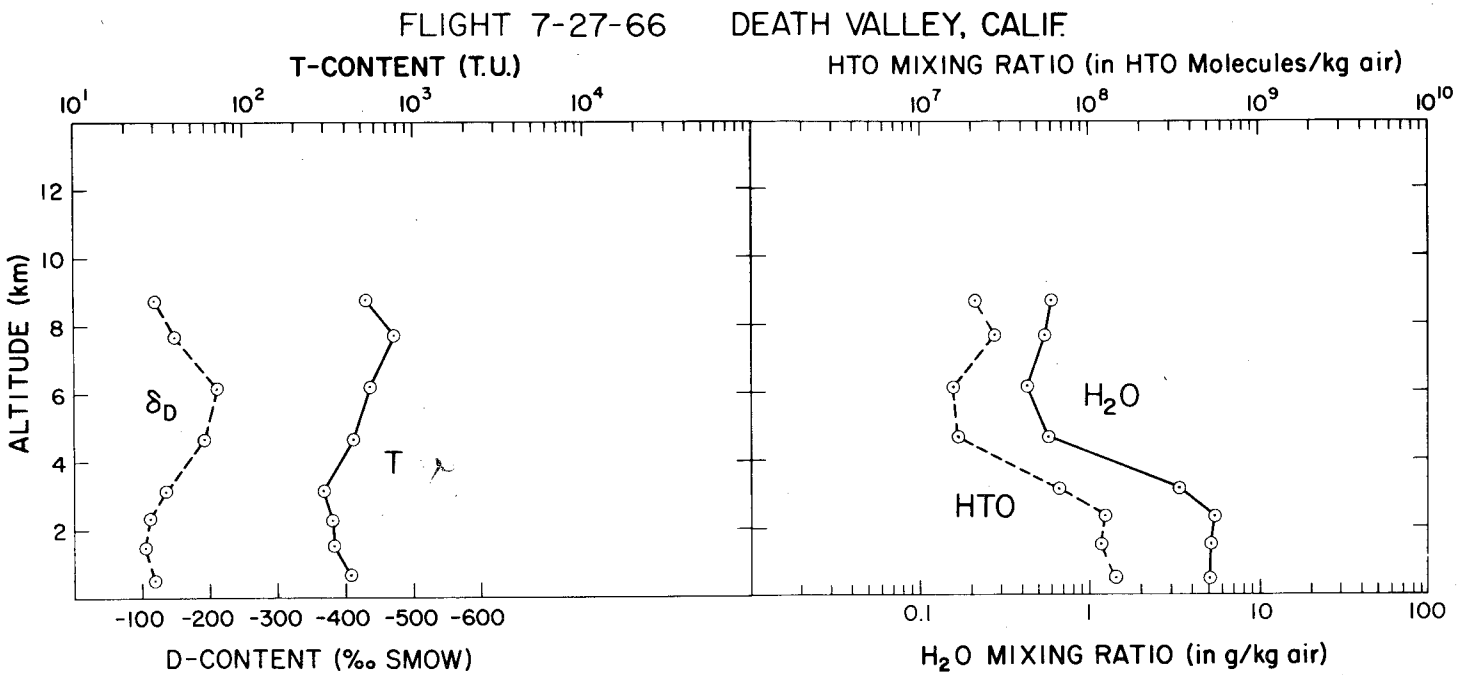

ALTITUDE (km)
t°
TEMPERATURE (°C)

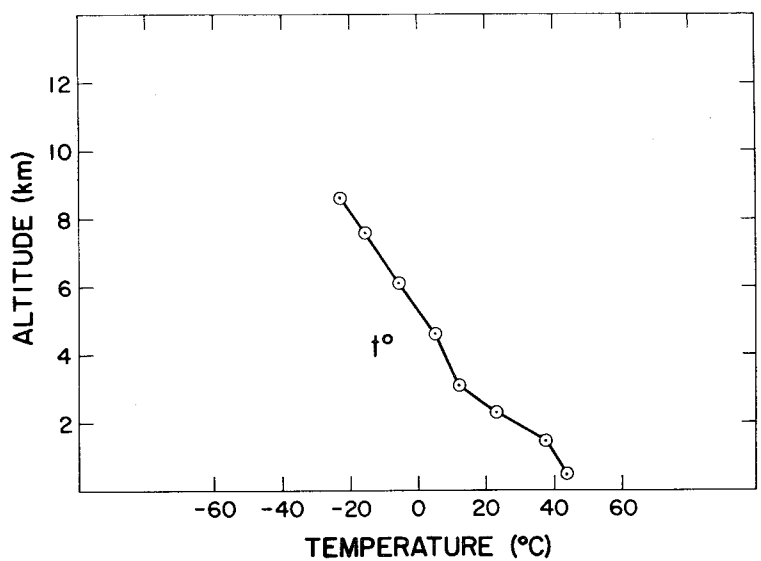
DATE: 27 July 1966

LOCATION: Death Valley, California

INITIAL SAMPLING TIME: 09:35

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
520	+43.5	5.10	-121	430±18	1.5×10^{8}
1520	+37.3	5.15	-108	340±19	1.2×10^{8}
2280	+23	5.57	-113	340±19	1.2×10^{8}
3050	+12	3.37	-137	300±18	6.7×10^{7}
4580	+5	.57	-192	450±20	1.7×10^{7}
6100	-6	.43	-210	560±26	1.6×10^{7}
7600	-16	.55	-148	770±22	2.8×10^{7}
8550	-23	.60	-120	530±23	2.1×10^{7}


FLIGHT 7-27-66 DEATH VALLEY, CALIF.
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

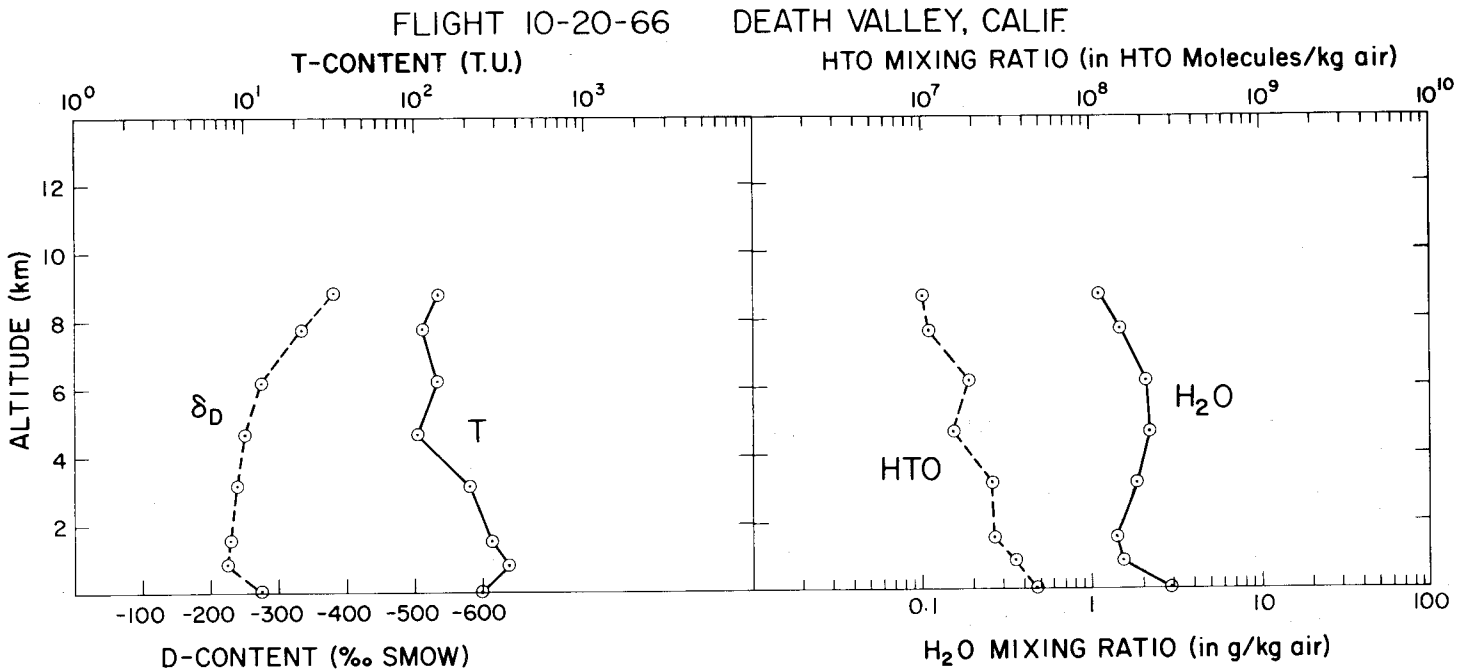

ALTITUDE (km)
t°
TEMPERATURE (°C)

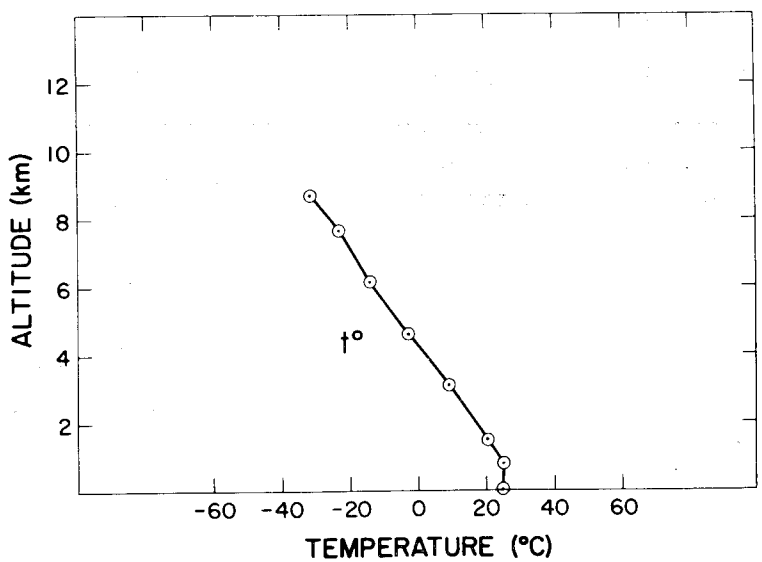
DATE: 20 October 1966

LOCATION: Death Valley, California

INITIAL SAMPLING TIME: 07:29

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+25.0	2.90	-277	250±13	4.8×10^7
760	+25.0	1.51	-226	360±35	3.6×10^7
1520	+20.2	1.41	-230	290±16	2.7×10^7
3050	+9.0	1.87	-243	210±14	2.6×10^7
4580	-3.0	2.20	-254	110±12	1.6×10^7
6100	-14.0	2.12	-278	140±13	1.9×10^7
7600	-23.2	1.49	-336	110±12	1.1×10^7
8550	-31.1	1.11	-383	140±13	1.0×10^7


FLIGHT 10-20-66 DEATH VALLEY, CALIF.
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

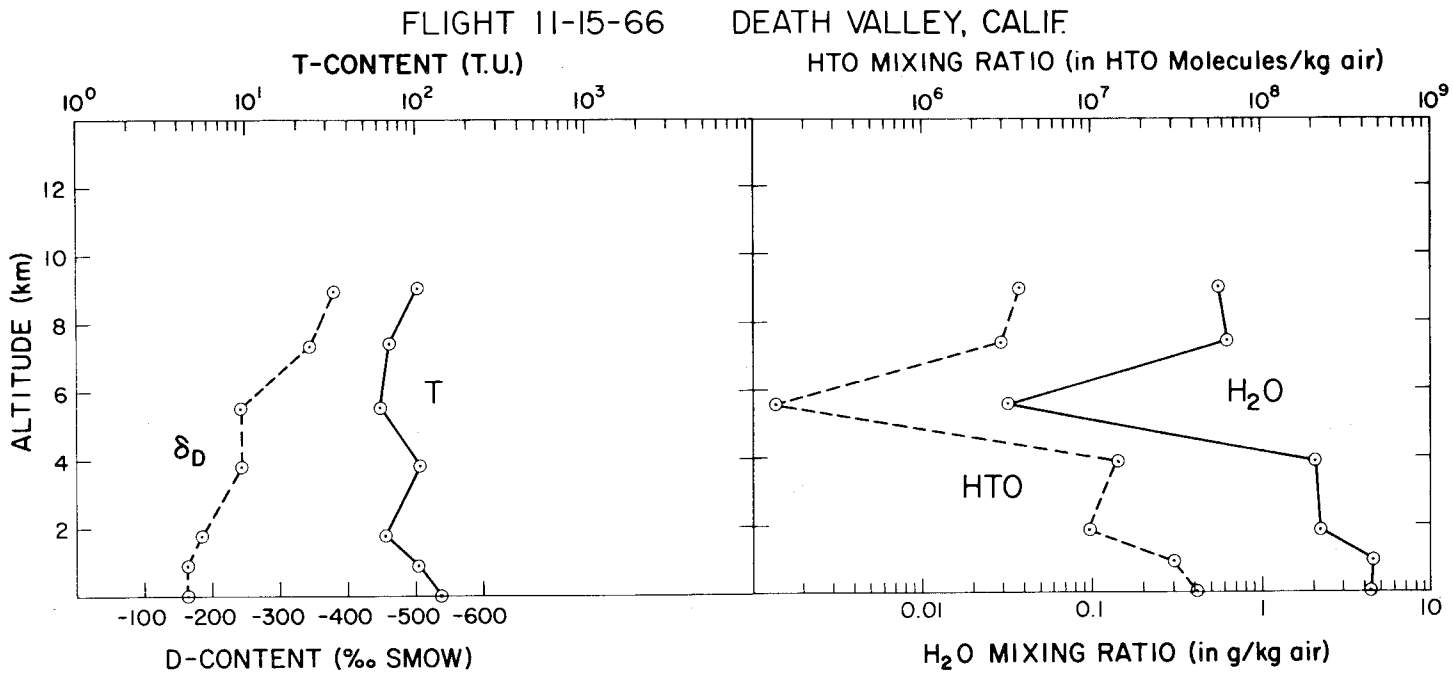

ALTITUDE (km)
t°
TEMPERATURE (°C)

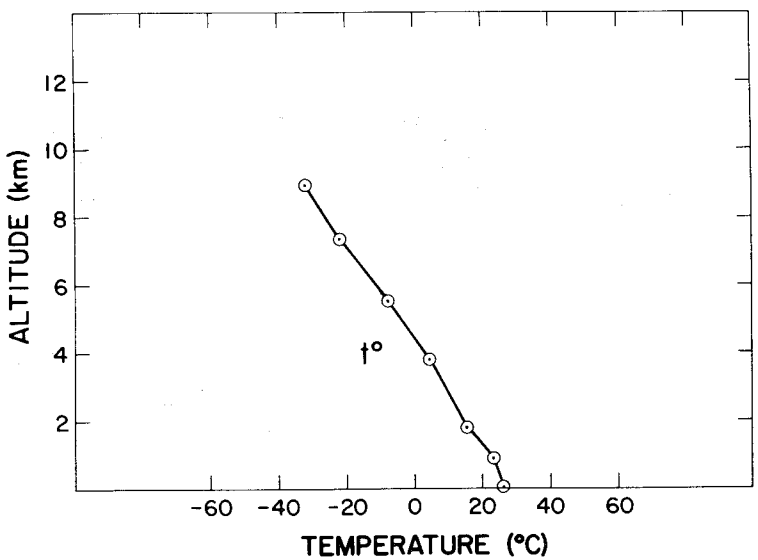
DATE: 15 November 1966

LOCATION: Death Valley, California

INITIAL SAMPLING TIME: 08:20

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+26	4.44	-167	140± 15	4.2×10^{7}
915	+23	4.53	-167	100± 12	3.1×10^{7}
1830	+15	2.23	-187	70± 12	9.9×10^{6}
3750	+4	2.07	-244	110± 13	1.5×10^{7}
5500	-8	0.033	-244	60±170	1.4×10^{5}
7330	-22	0.64	-345	70± 12	3.0×10^{6}
8850	-32	0.57	-378	100± 12	3.9×10^{6}


FLIGHT 11-15-66 DEATH VALLEY, CALIF.
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

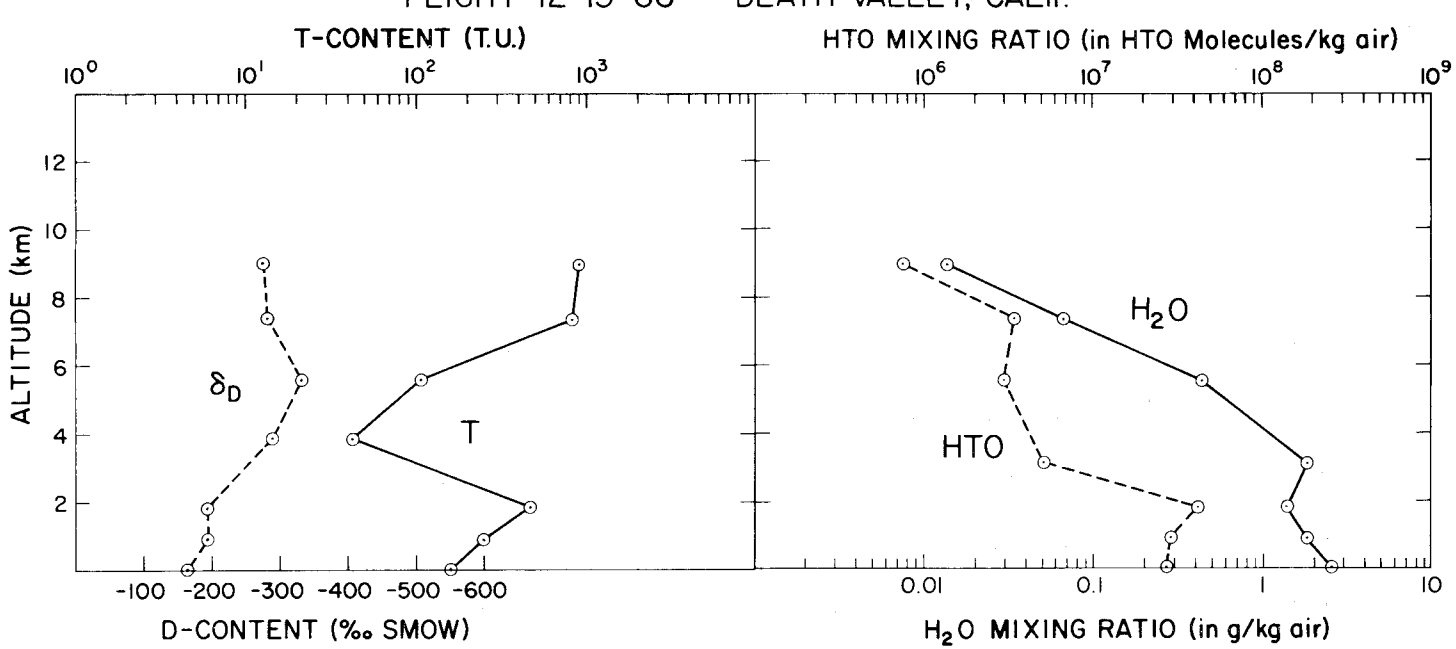

ALTITUDE (km)
t°
TEMPERATURE (°C)

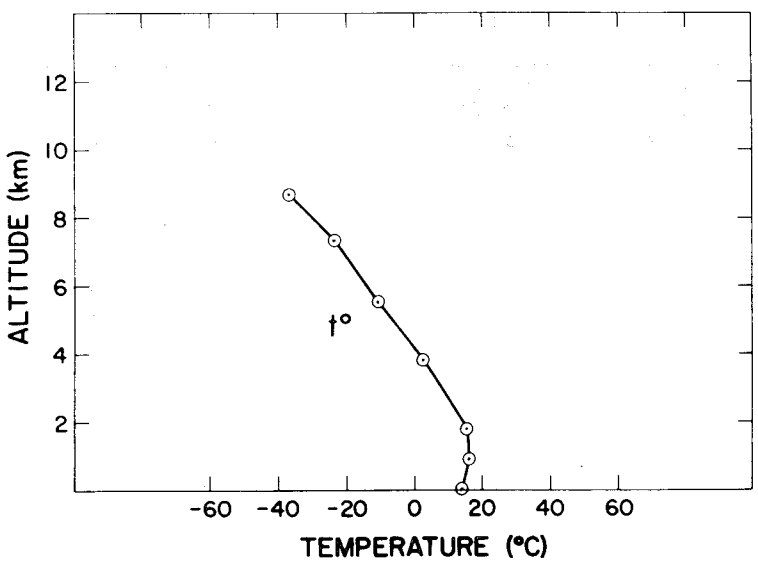
DATE: 15 December 1966

LOCATION: Death Valley, California

INITIAL SAMPLING TIME: 08:15

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+14	2.65	-164	160± 13	2.7×10^{7}
915	+16	1.83	-191	240± 15	2.9×10^{7}
1830	+15	1.40	-195	450± 17	4.2×10^{7}
3750	+2	1.83	-289	40± 12	5.1×10^{6}
5500	-11	0.43	-333	110± 11	3.0×10^{6}
7330	-24	0.067	-282	780± 56	3.4×10^{6}
8850	-37	0.014	-277	820±230	7.6×10^{5}


FLIGHT 12-15-66 DEATH VALLEY, CALIF.
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

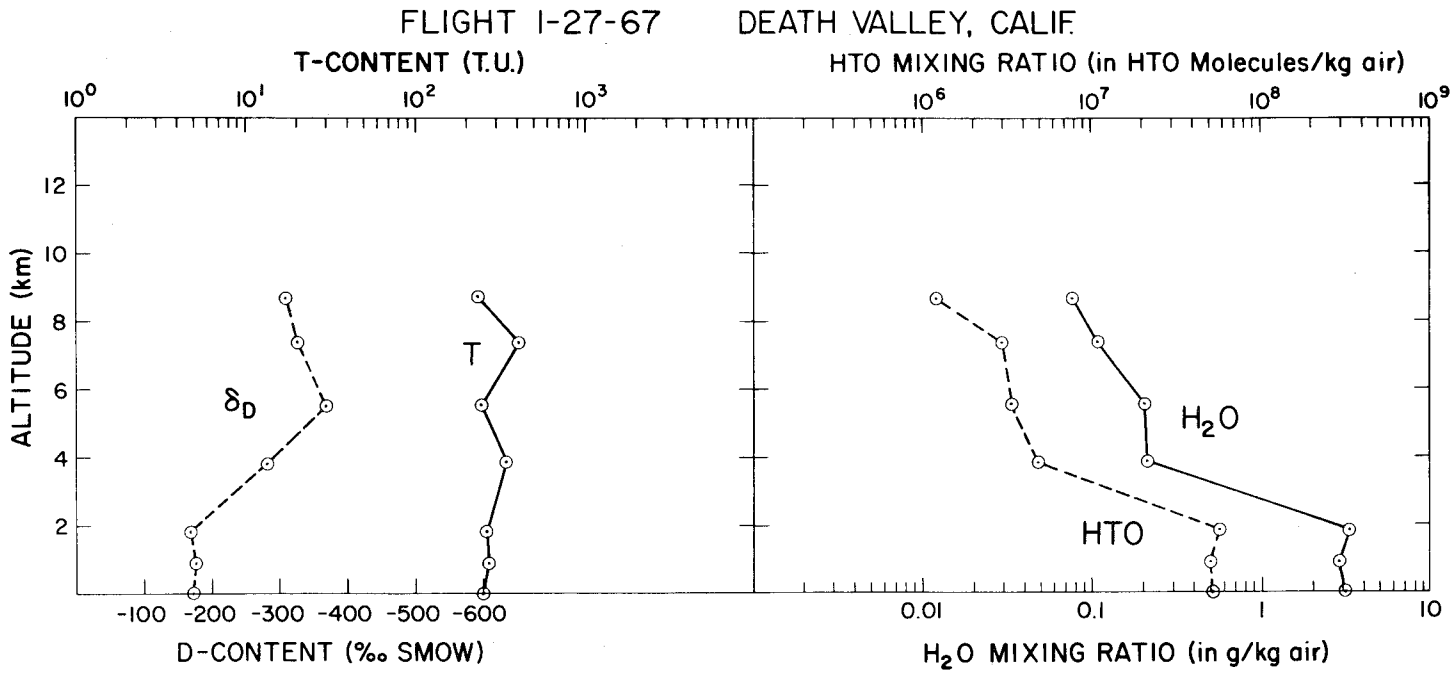

ALTITUDE (km)
t°
TEMPERATURE (°C)

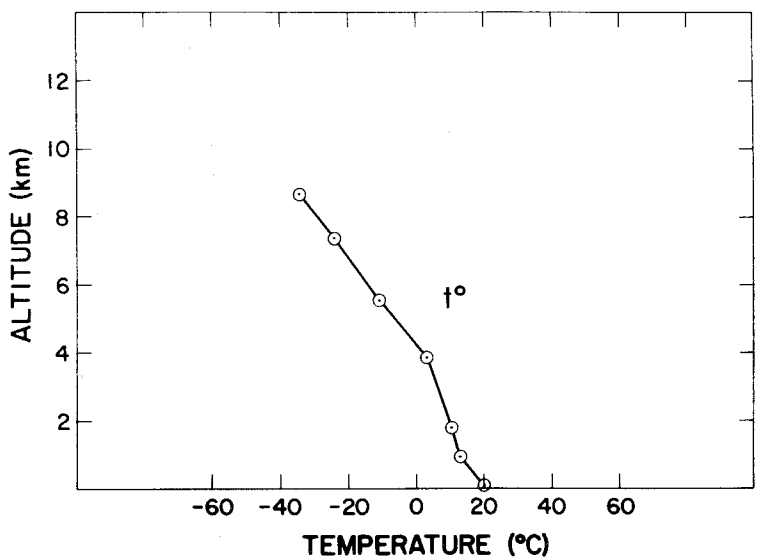
DATE: 27 January 1967

LOCATION: Death Valley, California

INITIAL SAMPLING TIME: 07:45

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+20	3.20	-172	250±15	5.3×10^7
915	+13	2.92	-176	270±14	5.2×10^7
1830	+10	3.34	-167	260±15	5.7×10^7
3750	+3	0.22	-282	340±36	4.9×10^6
5500	-11	0.21	-367	250±14	3.4×10^6
7330	-24	0.11	-325	400±36	3.0×10^6
8550	-34	0.079	-317	240±50	1.2×10^6


FLIGHT I-27-67 DEATH VALLEY, CALIF.
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

DATE: 11 March 1967

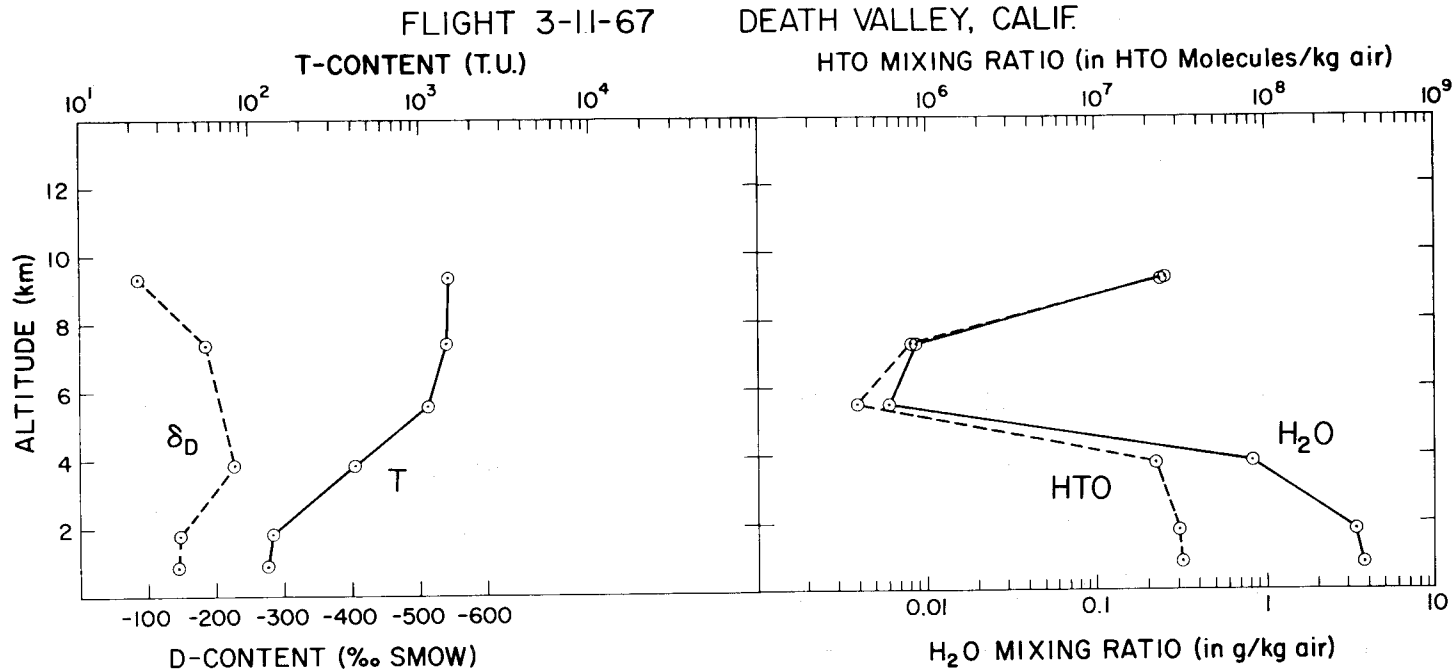
LOCATION: Death Valley, California

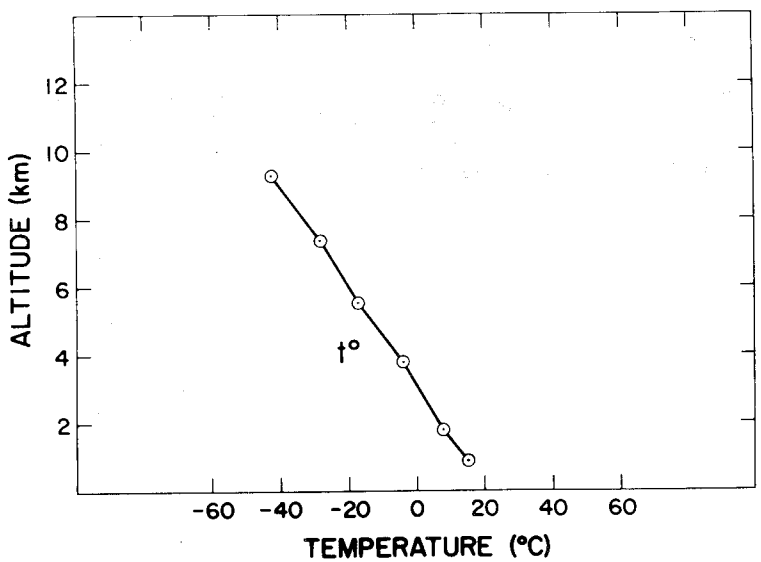
INITIAL SAMPLING TIME: 12:00

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2*					
915	+15.2	3.73	-147	130±15	3.2×10^7
1830	+7.5	3.34	-148	140±13	3.1×10^7
3750	-4	0.82	-228	420±16	2.3×10^7
5500	-17	0.006		1160±2200**	4.0×10^5
7330	-28	0.0086	-188	1450±1300**	8.2×10^5
9150	-42	0.25	-88	1470±42	2.4×10^7

*Not sampled because of surface fog.

**Large error due to extremely small amount of water.


FLIGHT 3-11-67 DEATH VALLEY, CALIF.
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

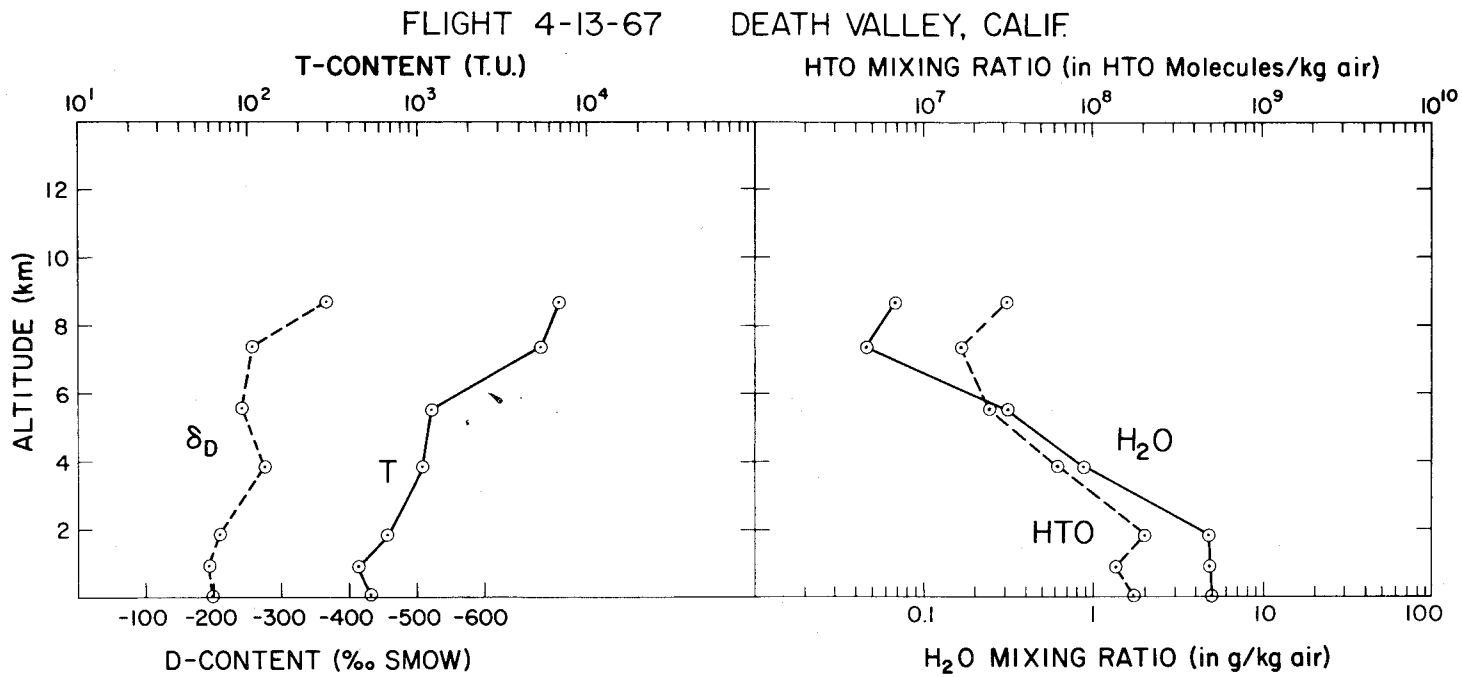

ALTITUDE (km)
t°
TEMPERATURE (°C)

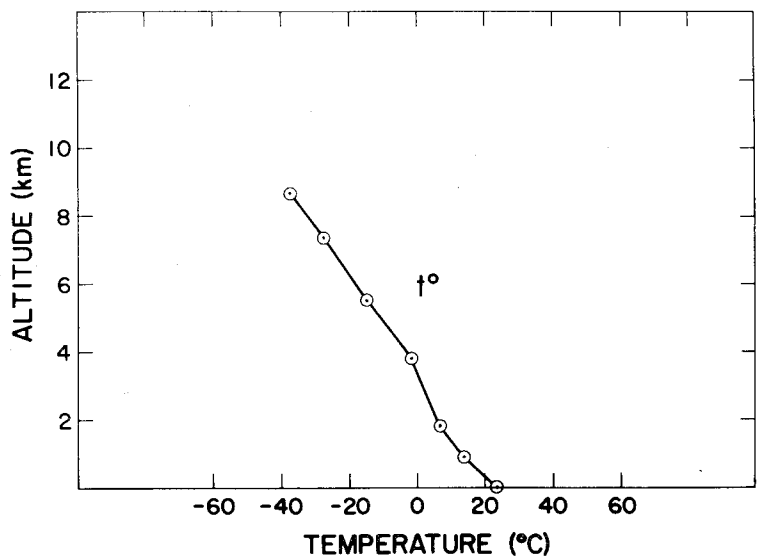
DATE: 13 April 1967

LOCATION: Death Valley, California

INITIAL SAMPLING TIME: 07:35

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+23.5	4.93	-201	530± 18	1.7×10^8
915	+13.5	4.60	-198	450± 17	1.4×10^8
1830	+6.0	4.53	-212	670± 12	2.0×10^8
3750	-2.0	0.87	-276	1070± 15	6.2×10^7
5500	-15	0.31	-243	1200± 31	2.5×10^7
7330	-28	0.046	-259	5430±220	1.7×10^7
8550	-37.5	0.068	-364	6910± 95	3.1×10^7


FLIGHT 4-13-67 DEATH VALLEY, CALIF.
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

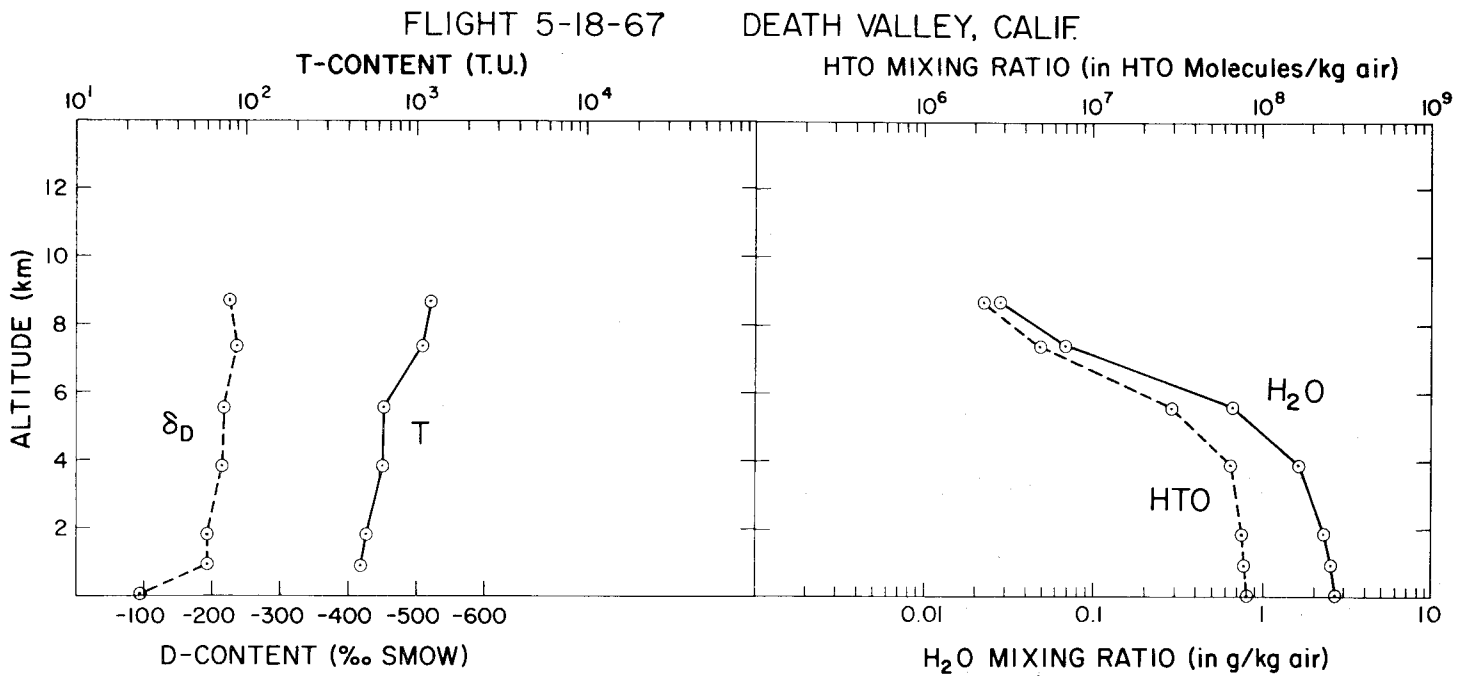

ALTITUDE (km)
t°
TEMPERATURE (°C)

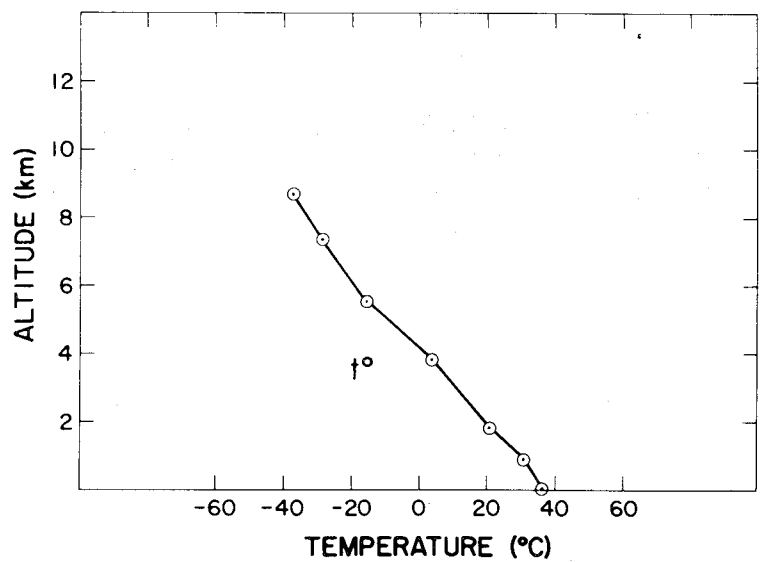
DATE: 18 May 1967

LOCATION: Death Valley, California

INITIAL SAMPLING TIME: 07:43

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+36	2.67	-97		8.0×10^7
915	+30.4	2.52	-192	460±16	7.7×10^7
1830	+20.3	2.30	-193	500±17	7.5×10^7
3750	+3.3	1.63	-214	610±18	6.6×10^7
5500	-16	0.67	-216	630±18	2.9×10^7
7330	-29	0.070	-234	1070±98	4.9×10^6
8550	-37.5	0.029	-224	1200±47	2.3×10^6


FLIGHT 5-18-67 DEATH VALLEY, CALIF.
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

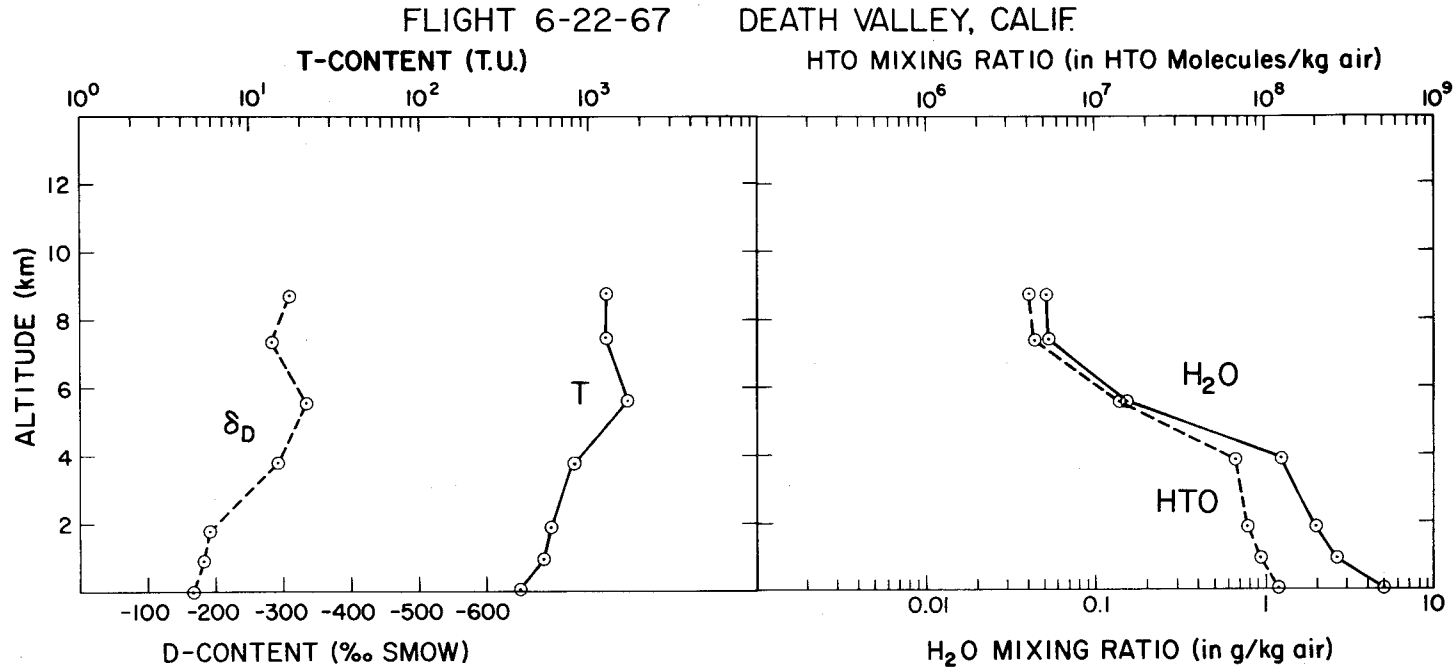

ALTITUDE (km)
t°
TEMPERATURE (°C)

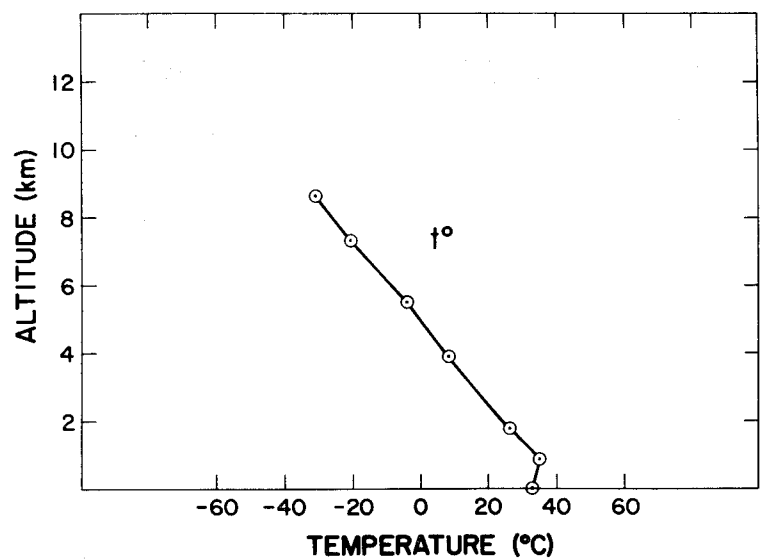
DATE: 22 June 1967

LOCATION: Death Valley, California

INITIAL SAMPLING TIME: 06:40

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
-30.5	+33	4.96	-166	390±16	1.2×10^{8}
915	+35	2.63	-182	540±18	9.4×10^{7}
1830	+26	1.98	-191	600±10	7.8×10^{7}
3750	+9	1.24	-292	810±20	6.6×10^{7}
5500	-4	0.14	-331	1650±58	1.5×10^{7}
7330	-21	0.053	-282	1240±83	4.3×10^{6}
8550	-31	0.051	-306	1240±42	4.2×10^{6}


FLIGHT 6-22-67 DEATH VALLEY, CALIF.
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

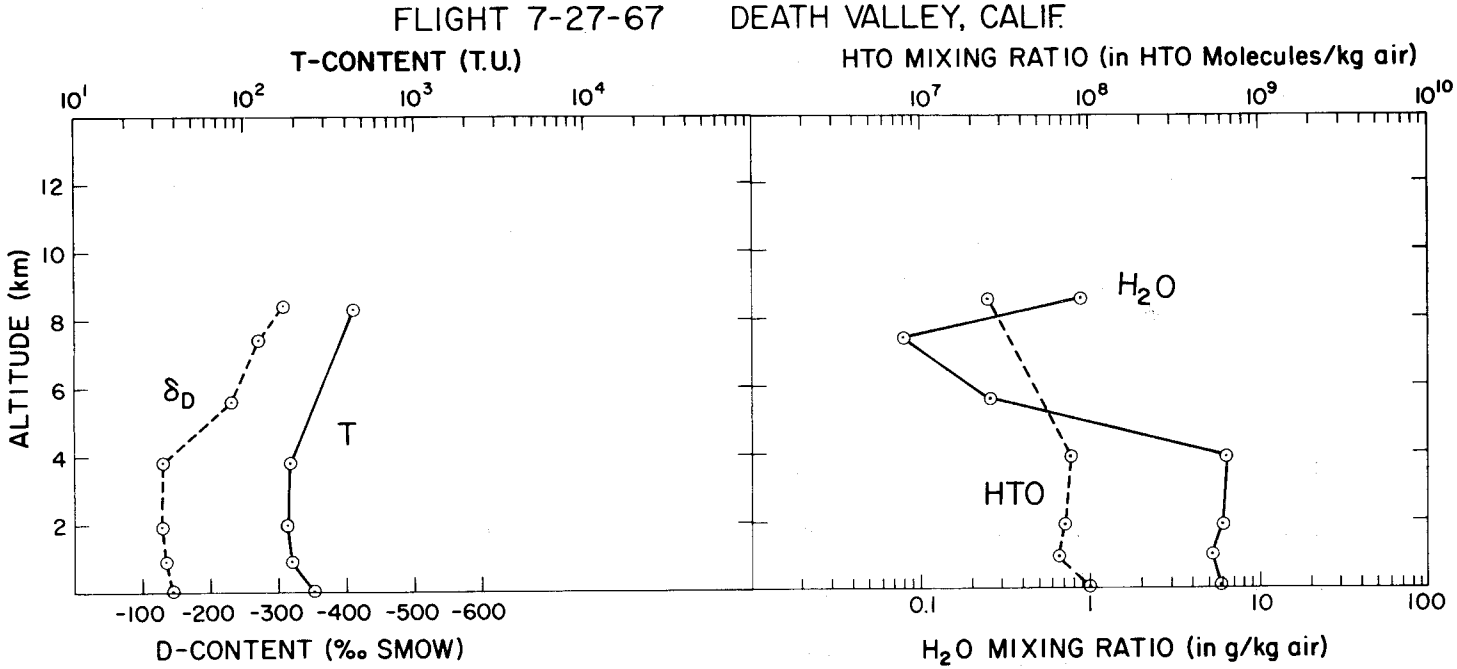

ALTITUDE (km)
t°
TEMPERATURE (°C)

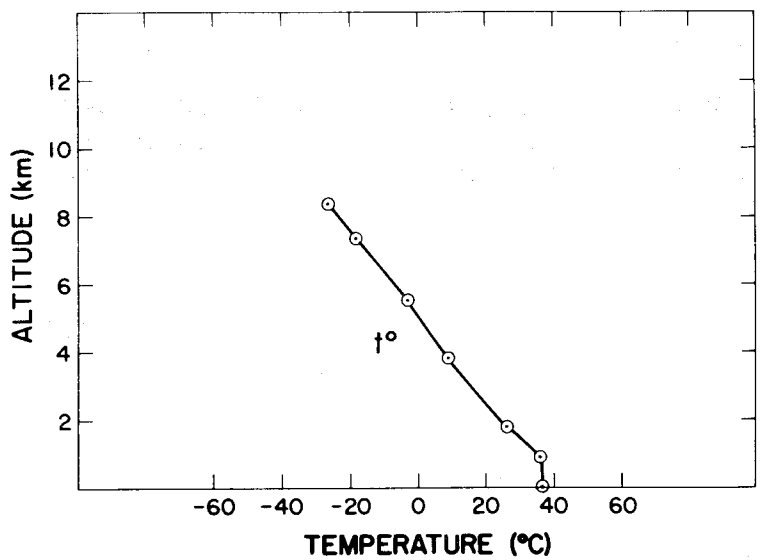
DATE: 27 July 1967

LOCATION: Death Valley, California

INITIAL SAMPLING TIME: 07:05

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+37	5.94	-147	260±13	1.0×10^{8}
915	+36	5.21	-136	190±13	6.6×10^{7}
1830	+26	6.00	-132	180±13	7.1×10^{7}
3750	+9	6.37	-131	190±13	7.8×10^{7}
5500	-3	0.26	-231		
7330	-18	0.076	-272		
8350	-26	0.89	-306	430±16	2.5×10^{7}


FLIGHT 7-27-67 DEATH VALLEY, CALIF.
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)

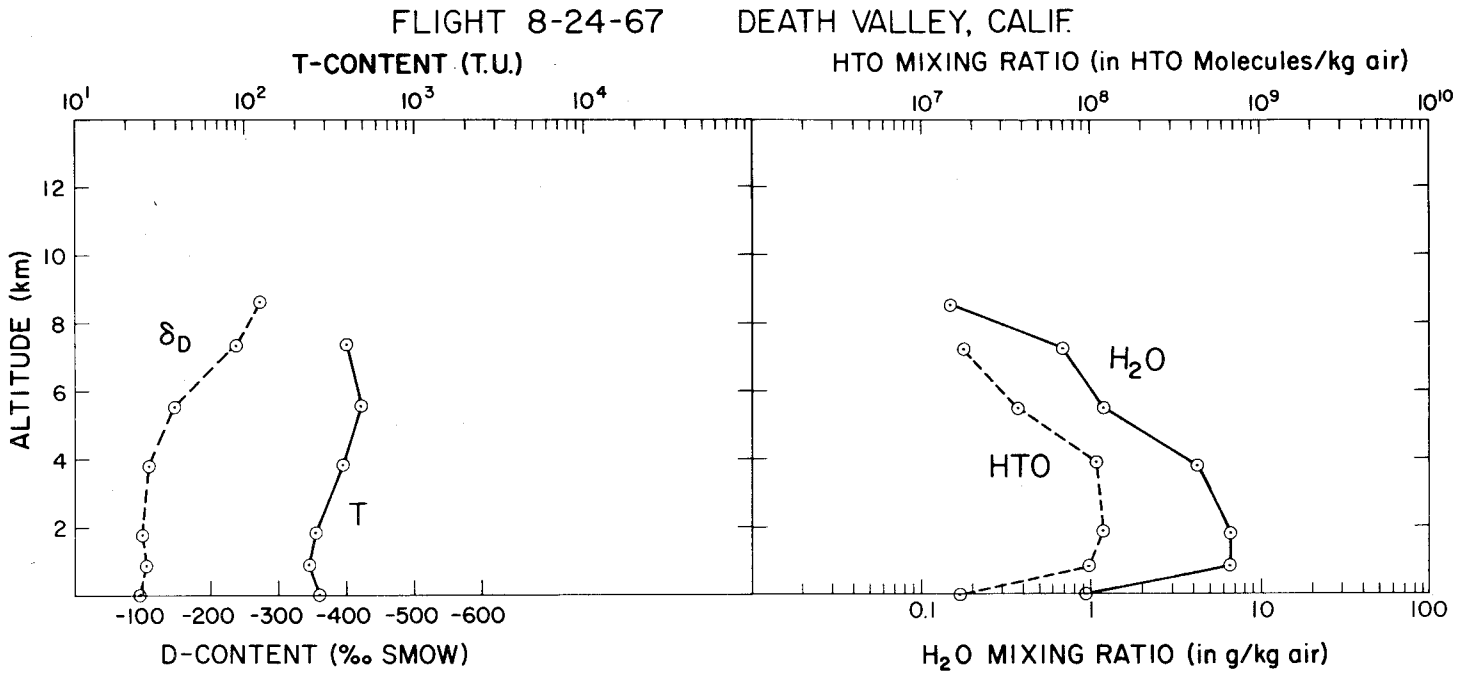

ALTITUDE (km)
t°
TEMPERATURE (°C)

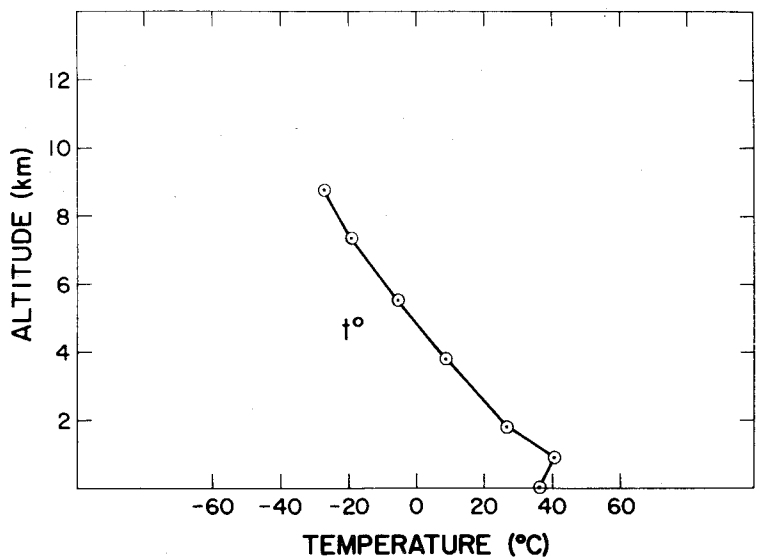
DATE: 24 August 1967

LOCATION: Death Valley, California

INITIAL SAMPLING TIME: 06:39

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
15.2	+36	0.95	-96	270±14	1.7×10^{7}
915	+40	6.61	-105	240±14	1.0×10^{8}
1830	+26	6.72	-98	260±14	1.2×10^{8}
3750	+8	4.24	-119	380±10	1.1×10^{8}
5500	-6	1.21	-146	480±16	3.8×10^{7}
7330	-20	0.69	-236	390±15	1.8×10^{7}
8550	-28	0.15	-271		


FLIGHT 8-24-67 DEATH VALLEY, CALIF.
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

DATE: 22 February 1972

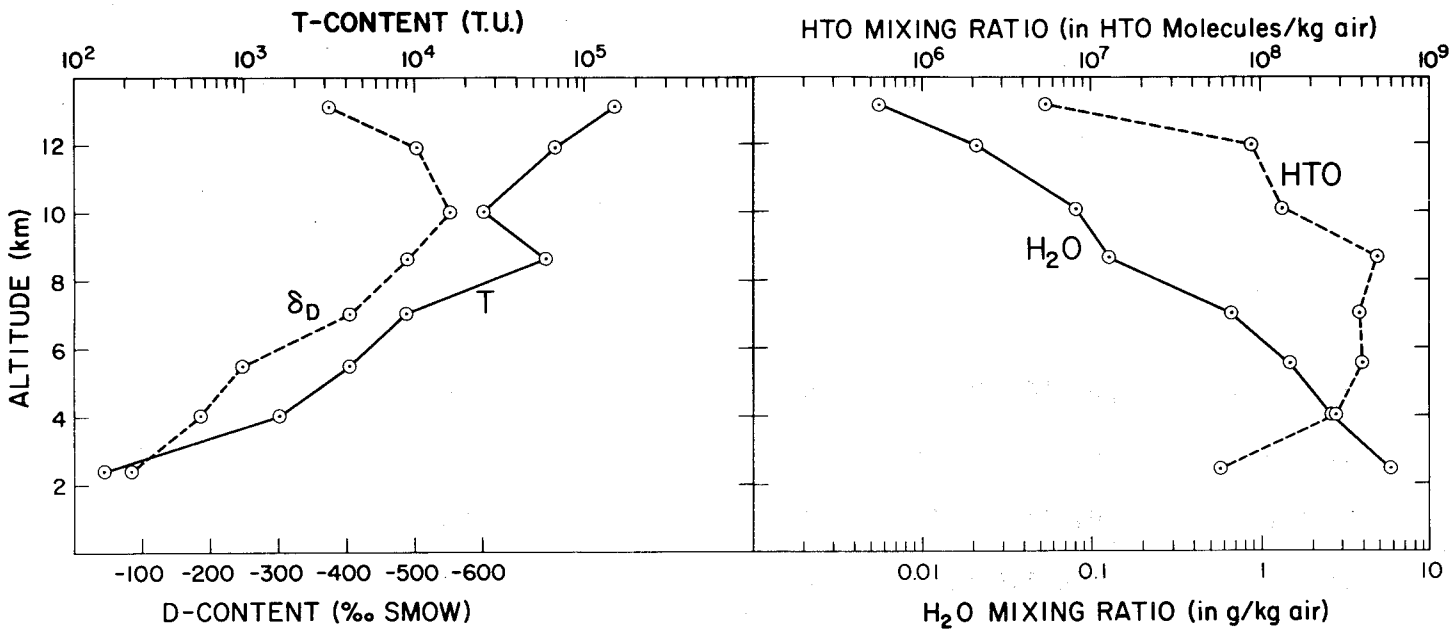
LOCATION: Palestine, Texas

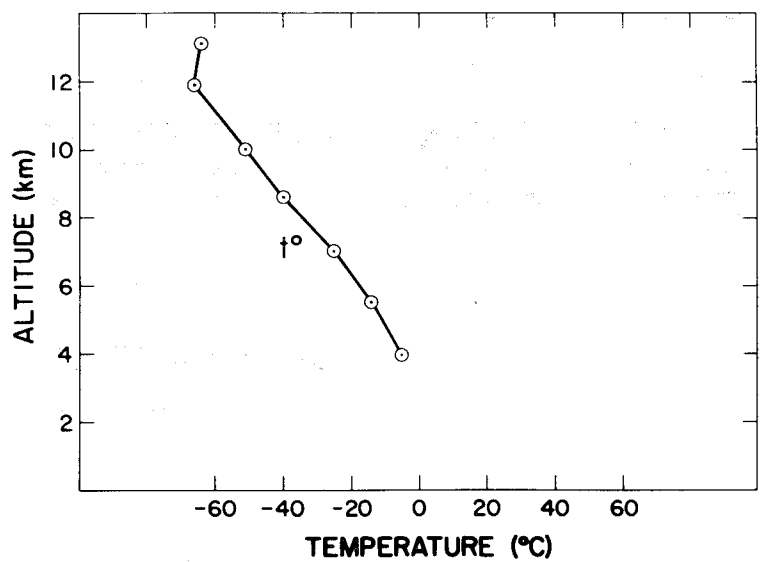
INITIAL SAMPLING TIME: 10:39

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
2,450		5.84	-85	150±5	5.8×10^{7}
3,960	-5	2.59	-185	$(1.6\pm.1)\times10^{3}$	2.7×10^{8}
5,500	-14	1.48	-247	4100±100	4.0×10^{8}
7,000	-25	0.67	-403	$(8.7\pm.1)\times10^{3}$	3.8×10^{8}
8,550	-40	0.13	-490	$(5.8\pm.1)\times10^{4}$	4.9×10^{8}
10,000	-51	0.082	-551	$(2.5\pm.1)\times10^{4}$	1.4×10^{8}
11,900	-66	0.021	-503	$(6.6\pm.1)\times10^{4}$	8.9×10^{7}
13,100	-64	0.0055	-373	$(1.5\pm.2)\times10^{5}$	5.5×10^{7}

Tropopause: 11,900 m

FLIGHT 2-22-72 PALESTINE, TEXAS





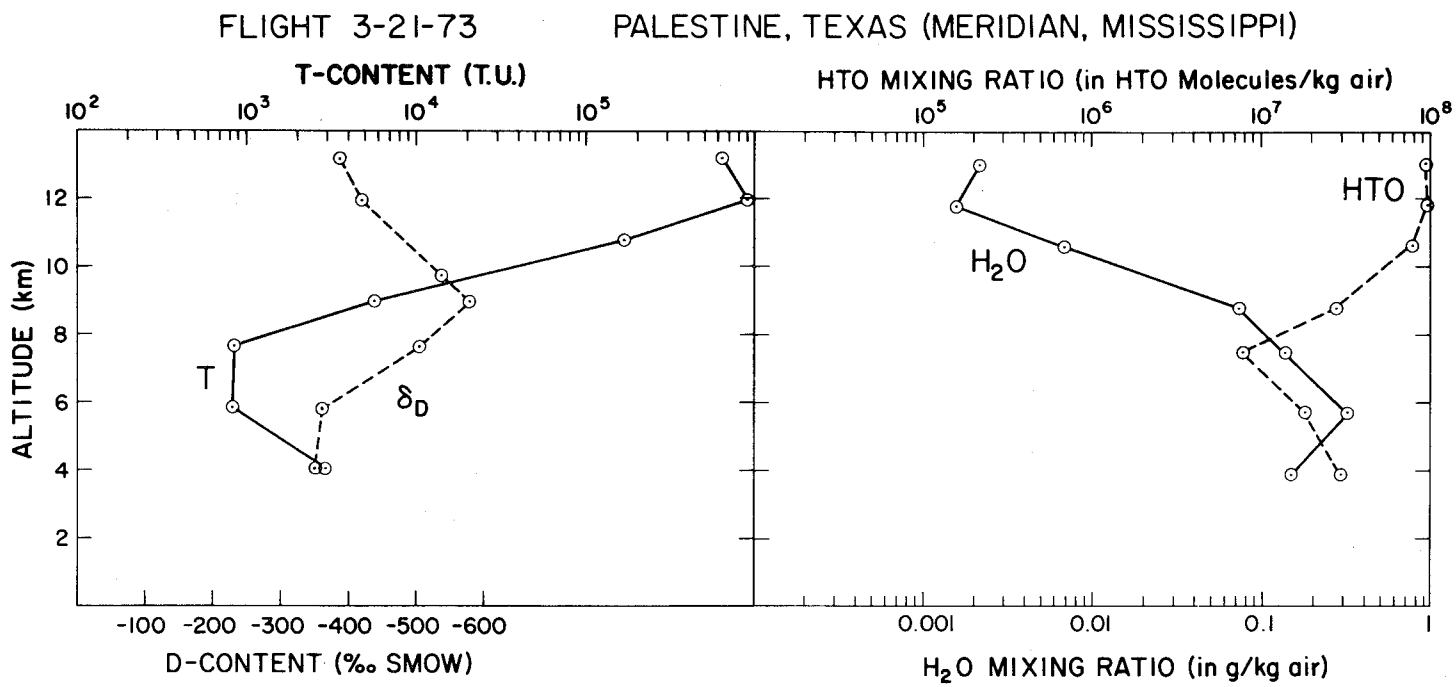
DATE: 21 March 1973

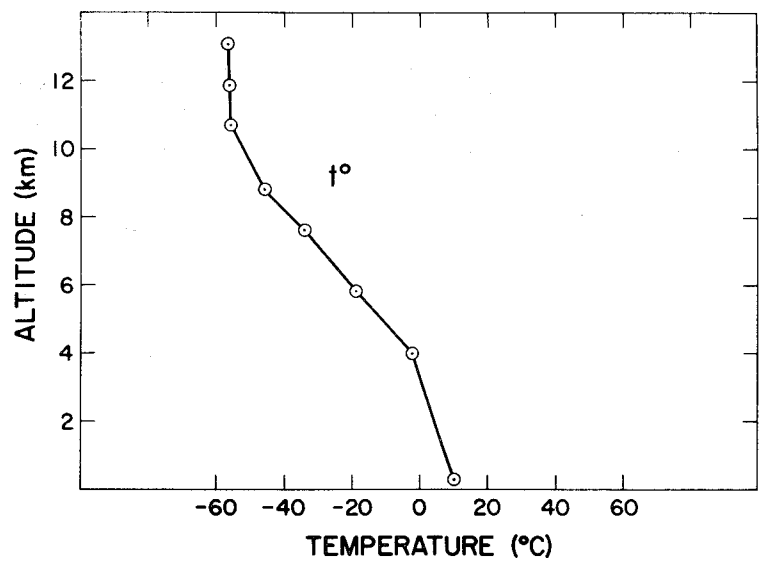
LOCATION: Palestine, Texas (Meridian, Mississippi)

INITIAL SAMPLING TIME: 11:11

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
3,960	-2.5	0.15	-351	2960± 40	2.9×10^7
5,800	-19	0.32	-360	840± 50	1.8×10^7
7,600	-34.4	0.14	-505	860± 40	0.78×10^7
8,850	-46	0.075	-578	5650±130	2.8×10^7
10,650	-56	0.0069	-537	$(1.7 \pm .01) \times 10^5$	7.7×10^7
11,900	-56.5	0.0016	-418	$(9.1 \pm .05) \times 10^5$	9.6×10^7
13,100	-57	0.0022	-385	$(6.5 \pm .09) \times 10^5$	9.4×10^7

Tropopause: 10,700 m


FLIGHT 3-21-73
PALESTINE, TEXAS (MERIDIAN, MISSISSIPPI)
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
T
δD
HTO
H2O
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

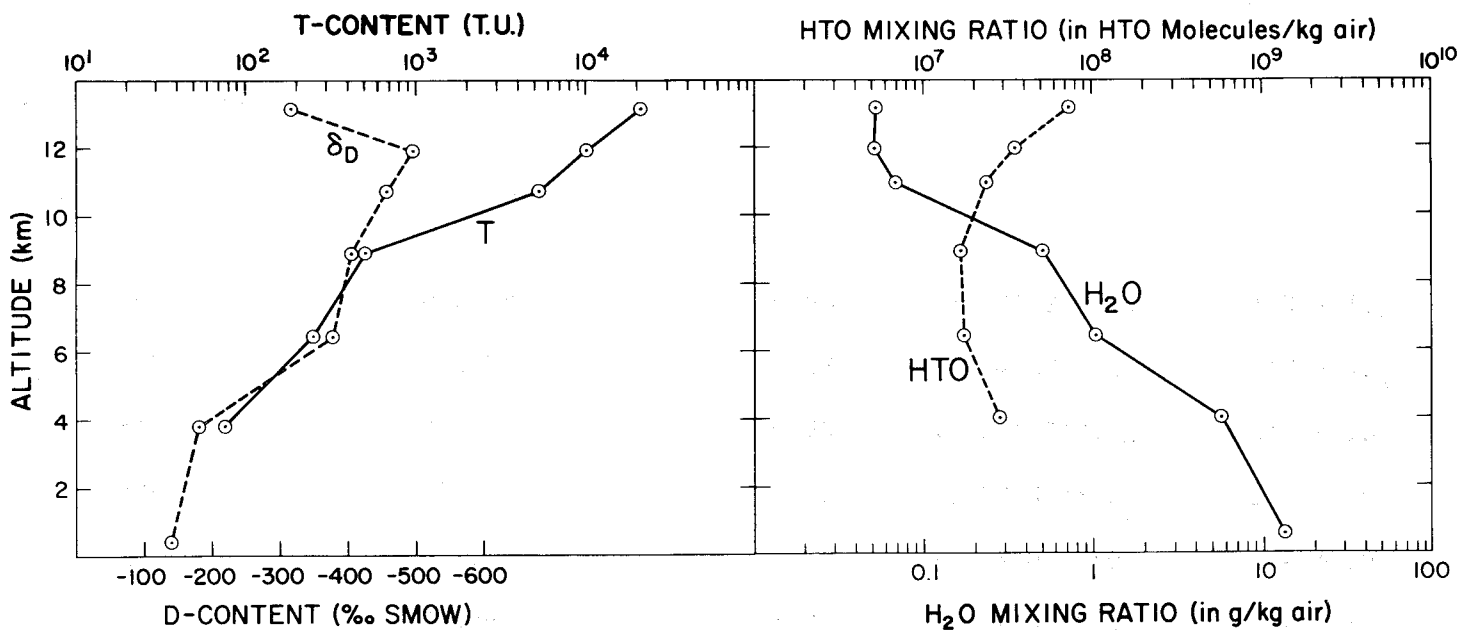
DATE: 10 September 1973

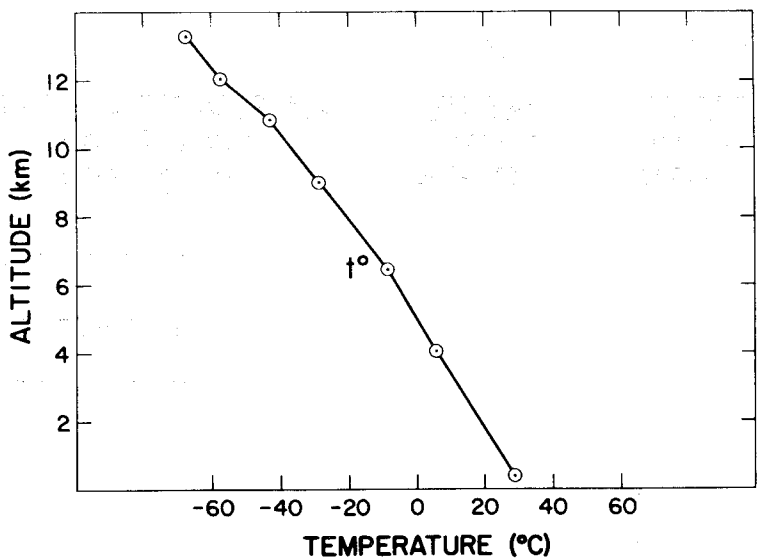
LOCATION: Palestine, Texas

INITIAL SAMPLING TIME: 10:24

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
366	28.5	13.6	-141	0.0± 40	0.0
3,960	5.5	5.76	-181	75± 15	2.9×10^{7}
6,400	-8.8	1.04	-377	250± 15	1.7×10^{7}
8,850	-28.5	0.51	-403	500± 10	1.7×10^{7}
10,650	-42.5	0.069	-456	5200±140	2.4×10^{7}
11,900	-57	0.052	-493	$(1\pm.02)\times10^{4}$	3.4×10^{7}
13,100	-67	0.053	-315	$(2.1\pm.03)\times10^{4}$	7.4×10^{7}

Tropopause: > 13,100 m


FLIGHT 9-10-73 PALESTINE, TEXAS
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

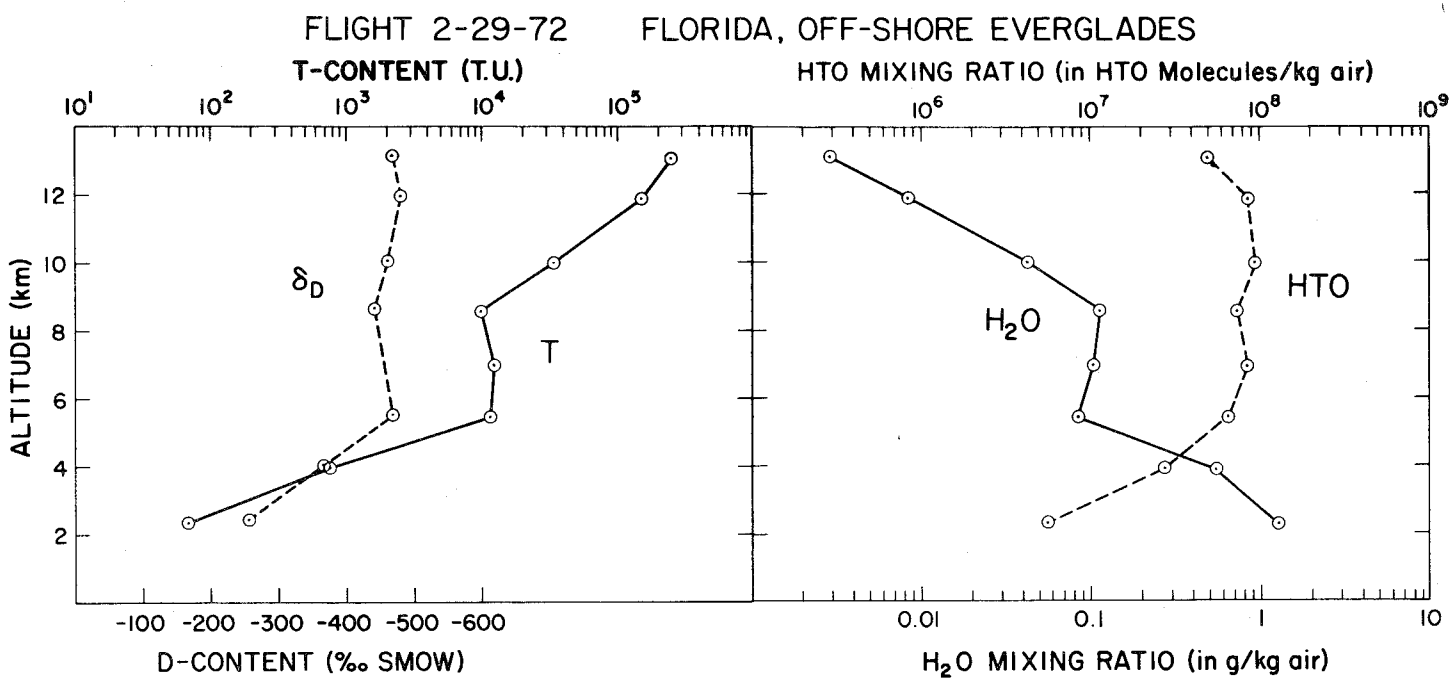
DATE: 29 February 1972

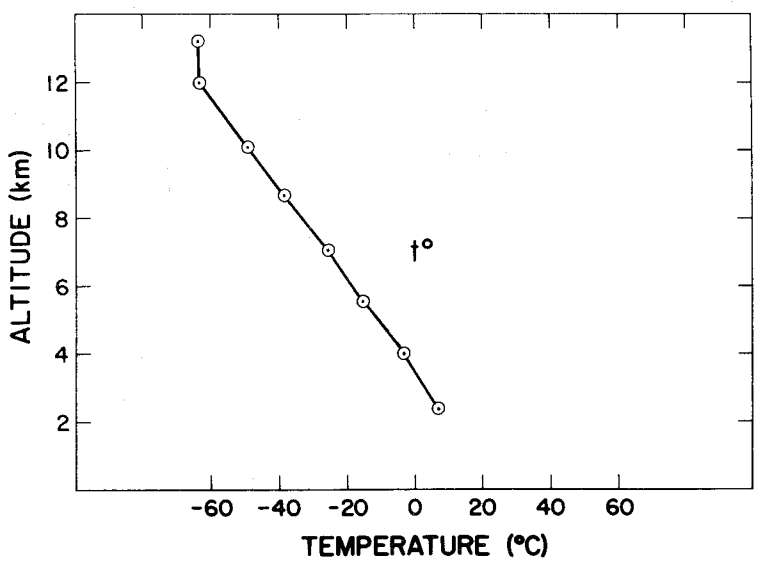
LOCATION: Florida, off-shore Everglades

INITIAL SAMPLING TIME: 11:41

Altitude (m)	Temperature (^{o}C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
2,450	+7	1.29	-256	68±10	5.8×10^{6}
3,960	-3	0.55	-356	$(7.6\pm.3)\times10^{2}$	2.8×10^{7}
5,500	-15	0.086	-468	$(1.2\pm.02)\times10^{4}$	6.5×10^{7}
7,000	-25	0.11		$(1.2\pm.03)\times10^{4}$	8.5×10^{7}
8,550	-38	0.11	-441	$(9.8\pm.2)\times10^{3}$	7.3×10^{7}
10,000	-48.5	0.043	-462	$(3.3\pm.06)\times10^{4}$	9.4×10^{7}
11,900	-62.5	0.0084	-482	$(1.5\pm.02)\times10^{5}$	8.3×10^{7}
13,100	-63	0.0029	-469	$(2.5\pm.03)\times10^{5}$	4.8×10^{7}

Tropopause: 11,900 m


FLIGHT 2-29-72 FLORIDA, OFF-SHORE EVERGLADES
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

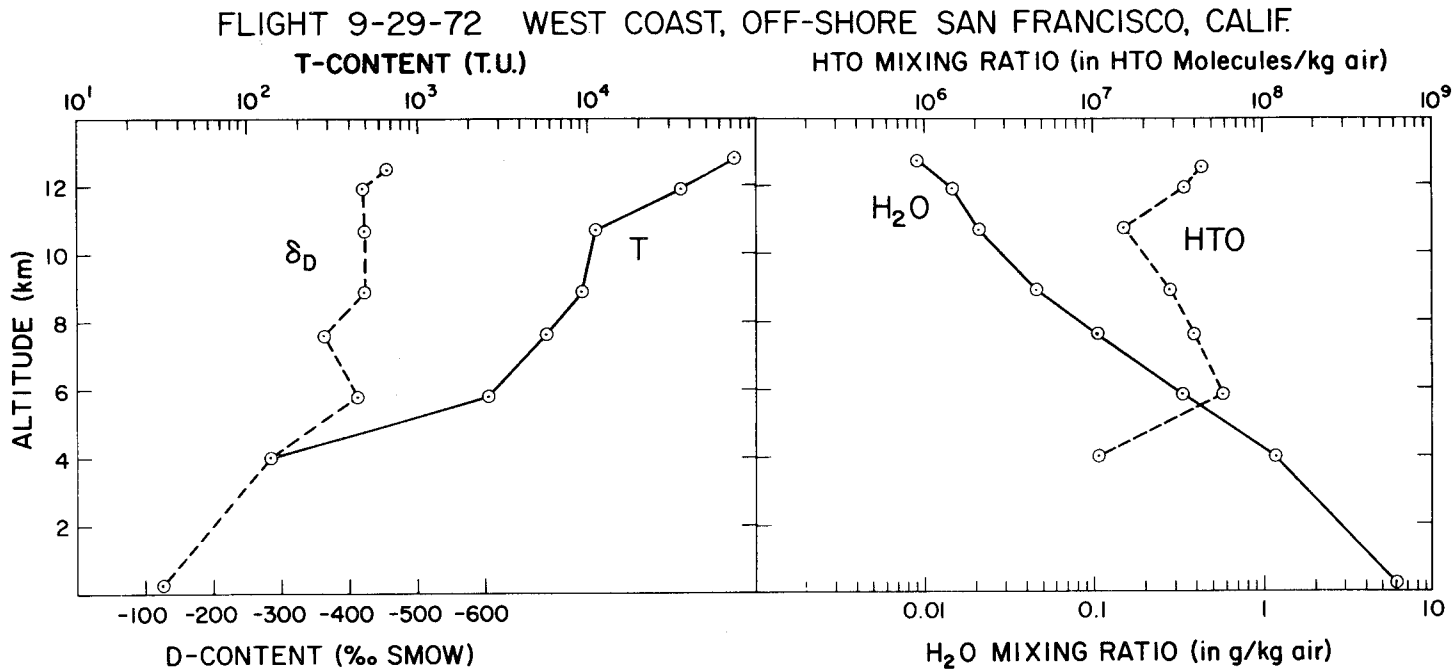
DATE: 29 September 1972

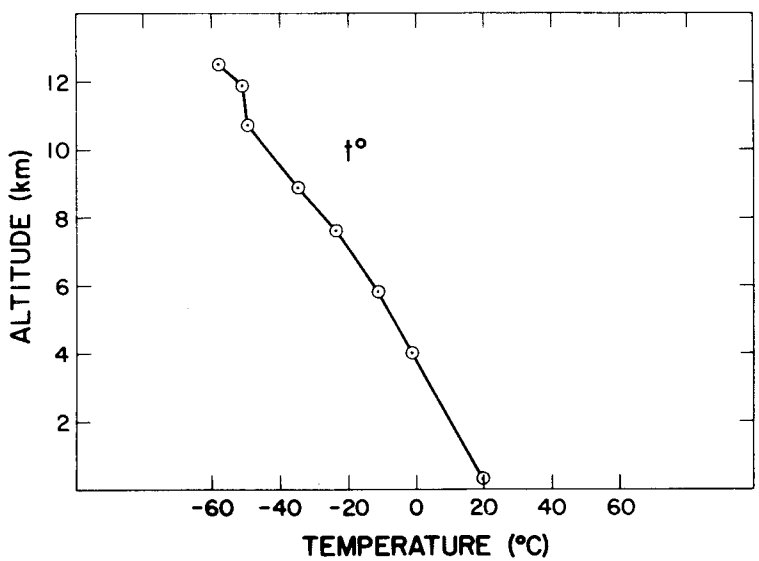
LOCATION: West Coast, off-shore San Francisco, Calif.

INITIAL SAMPLING TIME: 08:42

Altitude (m)	Temperature (°C)	Water Vapor Mixing Ratio (g water vapor/kg air)	Deuterium Content (‰ SMOW)	Tritium Content (T.U)	Tritium Mixing Ratio (Tritium Molecules/kg air)
305	+20	6.05	-128	0.0±30	$(0.0\pm1.2)\times10^{7}$
3,960	-1	1.18	-290	140±30	$(1.1\pm.25)\times10^{7}$
5,800	-11	0.33	-412	$(2.6\pm.1)\times10^{3}$	$(5.7\pm.2)\times10^{7}$
7,600	-23.5	0.11	-363	$(5.7\pm.2)\times10^{3}$	$(4.0\pm.2)\times10^{7}$
8,850	-34.0	0.046	-423	$(9.2\pm.3)\times10^{3}$	2.8×10^{7}
10,650	-49	0.021	-422	$(1.1\pm.1)\times10^{4}$	1.5×10^{7}
11,900	-51	0.015	-419	$(3.5\pm.1)\times10^{4}$	3.4×10^{7}
12,500	-58	0.009	-454	$(7.3\pm.3)\times10^{4}$	4.3×10^{7}

Tropopause: > 13,100 m


FLIGHT 9-29-72 WEST COAST, OFF-SHORE SAN FRANCISCO, CALIF.
T-CONTENT (T.U.)
HTO MIXING RATIO (in HTO Molecules/kg air)
ALTITUDE (km)
δD
T
H2O
HTO
D-CONTENT (‰ SMOW)
H2O MIXING RATIO (in g/kg air)


ALTITUDE (km)
t°
TEMPERATURE (°C)

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