

Introduction

A unique opportunity exists during the 2017 total solar eclipse that traverses the United States to study atmospheric chemistry by obtaining high altitude aircraft and balloon based measurements during this once-in-a-lifetime event. Figure 1 shows eclipse conditions for this event.

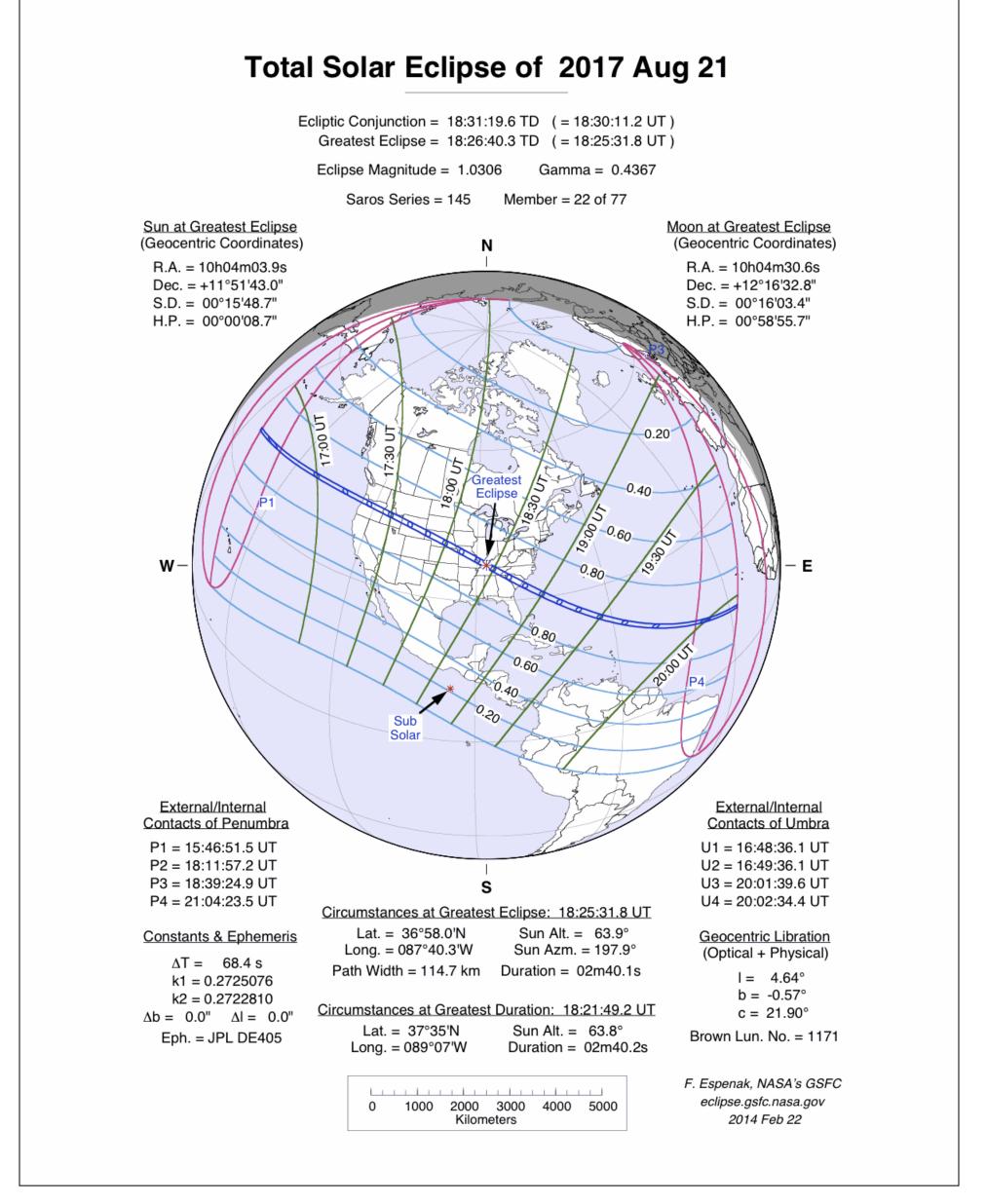


Figure 1 – Eclipse conditions during the August 21st, 2017 total solar eclipse. The shadow path traverses the United States from the northwestern Pacific coastal region to the southeastern Atlantic coastal region. Eclipse figure courtesy of Fred Espenak, NASA/Goddard Space Flight Center.

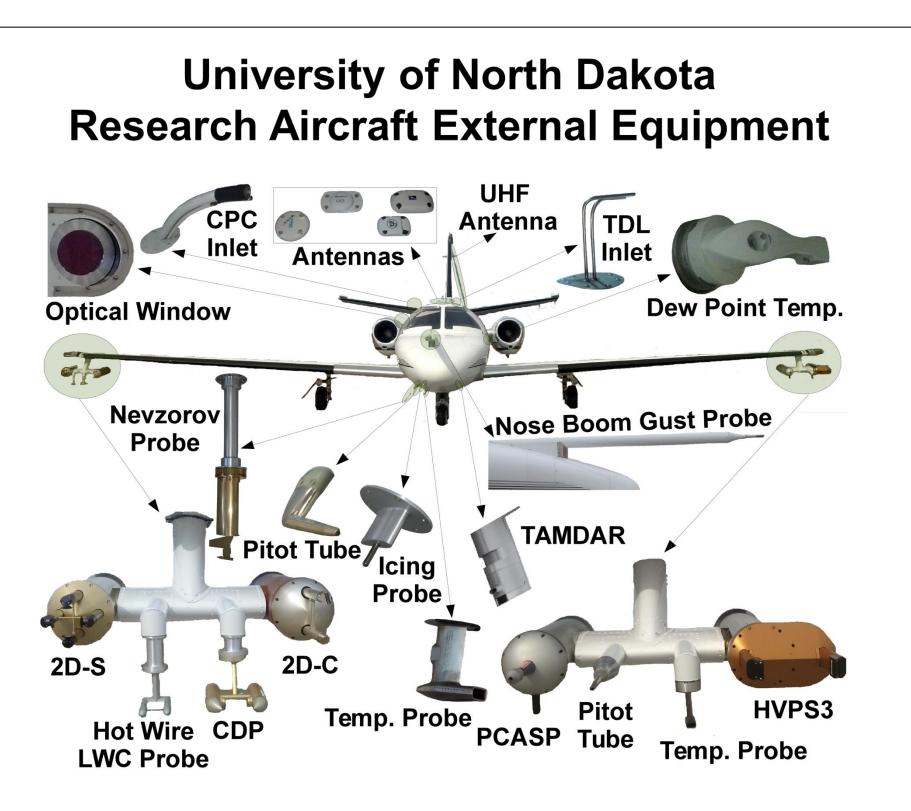
Mission Overview

The Total Eclipse Aircraft Mission (TEAM) is a high altitude aircraft mission concept that is intended complementary to acquire measurements to those taken from a highaltitude balloon platform along the eclipse path using the University of North Dakota's Citation Research Aircraft. Figure 2 shows this aircraft, along with the suite of instruments currently available [1].

The North Dakota Space Grant Consortium (ND SGC) is planning to participate in the NASA National Space Grant College and Fellowship Program (NSGCFP) nationwide network of total solar eclipse high altitude balloon flights [2]. The mission objectives for the TEAM are closely aligned with this ND SGC total solar eclipse high altitude balloon mission: • Primary Objective – Obtain complementary atmospheric chemistry measurements in the tropopause to those made in the stratosphere. • Secondary Objective – Obtain these same measurements at a constant altitude as a function of eclipse obscuration. • Tertiary Objective – Stream live video of the eclipse to the ground as part of the NASA NSGCFP total solar eclipse high altitude balloon campaign.

Total Eclipse Aircraft Mission (TEAM) R. Fevig* and D. Delene** *Department of Space Studies, University of North Dakota, Grand Forks, ND **Department of Atmospheric Sciences, University of North Dakota, Grand Forks, ND

Mission Overview (cont.)

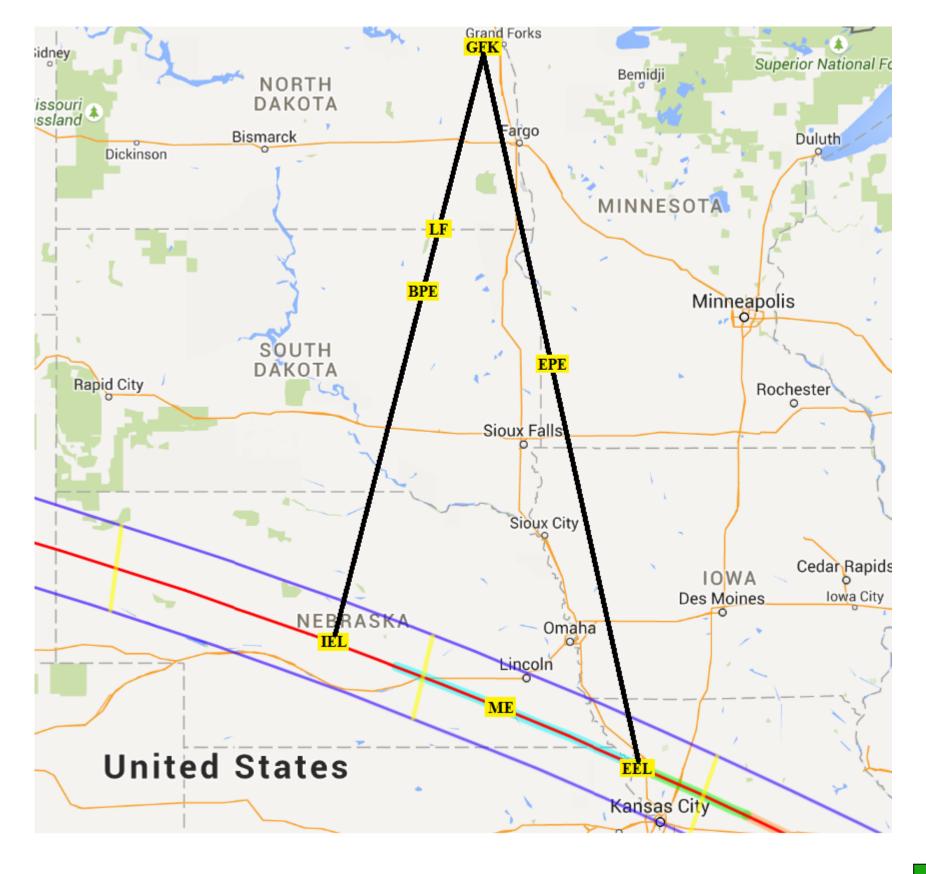


Instruments for Solar Eclipse Flight

	• •		
UHF Antenna	Ultra high frequency (UHF) antenna for long range communications.		
TDL Inlet	Gas inlet for the Tunable Diode Laser Hygrometer (TDL) instrument.		
Dew Point Temp.	Chilled mirror sensor for measurement of dew point temperature.		
Nose Gust Probe	Differential pressure sensors for measurements of 3-dimensional		
	velocity relative to the atmosphere.		
TAMDAR	The Tropospheric Airborne Meteorological Data Reporting (TAMDAR)		
	Probe measures and down-links various meteorological parameters.		
HVPS3	The High Volume Precipitation Spectrometer version 3 (HVPS3)		
	measures precipitation from 150 μ m to 1.9 cm with 128 size channels.		
Temp. Probe	The Temperature (Temp.) Probes measure total temperature which is		
	corrected for air speed to obtain ambient air temperature.		
Pitot Tube	The Pitot Tubes measure the aircraft's air speed using pressure		
	transducers.		
PCASP	The Passive Cavity Spectrometer Probe (PCASP) measures aerosols		
I OAOI	from 0.1 to 3.0 μ m in diameter with 15 size channels.		
2D-C	The 2-dimensional cloud (2D-C) probe measures hydrometeors from		
20-0	$30 \text{ to } 3000 \ \mu\text{m}$ in diameter.		
CDP	The Cloud Droplet Probe (CDP) measures (30 channels) droplets from		
	3 to 50 μ m in diameter at 8 Hz with particle-by-particle information.		
Hot Wire Probe	The King Hot Wire Liquid Water Content (LWC) Probe measure cloud		
	liquid water content		
2D-S	The 2-dimensional stereo (2D-S) probe images hydrometeors using		
20-0	128 diodes which are 10 μ m in length.		
Icing Probe	The Icing Probe detects supercooled liquid water that forms ice on		
ionig i robe	aircraft surfaces.		
Nevzorov Probe	The Nevzorov Probe uses hot wires to measure total cloud liquid		
11072010711000	and ice water content.		
Optical Window	The normal windows have been replaced with specially designed optical		
	glass windows for sampling with LIDAR based instruments.		
CPC Inlet	The Condensation Particle Counter (CPC) measures aerosols larger than		
or o mict	10 nm in diameter using a forward facing 1.0 in diameter heated inlet.		
Antennas	Several GPS and Iridium antennas provide time and position		
/	information, along with two-way satellite based communication.		
	internation, along with two way bateline babea communication.		

Figure 2 – University of North Dakota's Citation Research Aircraft along with the suite of instruments which can be flown on this research jet. Instruments with purple lettering are likely candidates for the TEAM mission.

One of the mission architectures under consideration includes a flight that begins and ends in Grand Forks, North Dakota. The research jet would ascend to its mission altitude in the tropopause, very near the boundary of the lower stratosphere, at an altitude of approximately 13 km. It would begin gathering data while total eclipse is still over the Pacific Ocean, and the local eclipse obscuration is 0%. The aircraft would enter partial eclipse over South Dakota, intercept the eclipse line over Nebraska before totality in that region, and be overtaken by the eclipse. The jet would return to its base in Grand Forks as total eclipse proceeds toward the southeastern portion of the United States, all the while collecting atmospheric data within the tropopause. Figure 4, a map along with the associated table, outline the flight plan associated with one of the mission architectures that is being considered.



Initial plans are to accurately measure temperature, O_3 , OH^2 , and NO_x as a function of eclipse obscuration. These measurements would be used to validate atmospheric chemistry models, given the unique solar irradiance conditions that will exist during the total solar eclipse. Figure 3 shows an example of modeled temperature and O_3 data.

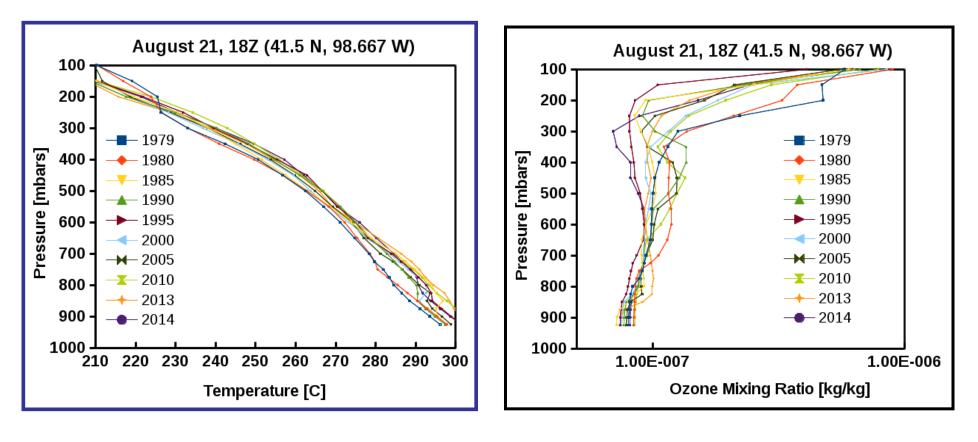


Figure 3 – An example of modeled temperature and O_3 data for the 35 years spanning 1979-2014. Measurements of atmospheric gases and physical parameters during the total solar eclipse can be used to validate such models. Note that the University of North Dakota's Citation Research Aircraft can ascend to 40,000 ft (~ 13 km) which corresponds to an atmospheric pressure of approximately 277 mbars.

Mission Operations

Mission Science

Waypoint	Event	Time (UT)	Distance (km)
GFK	Takeoff	15:57	0
LF	Level Flight at 13 km	16:27	240
BPE	Partial Eclipse Begins	16:36	330
IEL	Intercept Eclipse Line	17:27	770
	Total Eclipse Begins	18:01:15	980
ME	Maximum Eclipse	18:02:50	995
	Total Eclipse Ends	18:04:25	1010
EEL	Exit Eclipse Line	18:22	1210
EPE	Partial Eclipse Ends	19:25	1720
GFK	Landing	20:12	2120

Figure 4 – Map and associated table showing a proposed flight path and significant waypoints for the TEAM. The flight begins and ends in Grand Forks, ND (GFK), and follows a counterclockwise path. Significant waypoints corresponding to eclipse conditions, along with the cumulative distance traveled are shown in this figure. Eclipse map and predictions courtesy of Fred Espenak, NASA/Goddard Space Flight Center.

Conclusion

This presentation gives an overview of the TEAM science and mission objectives, architecture, and concept of operations. The schedule, cost, and risk associated with this mission, along with mission architectures are being alternate considered. High-level functional and operational performance requirements that flow from science and mission objectives are in development.

[1] Delene, D. (2014). Comparison between Research Aircraft and Balloonborne Radiosonde Observations. Poster presentation at the 5th Annual Academic High-Altitude Conference. [2] Des Jardins, A. (2014). National Network of Total Solar Eclipse High-Altitude Balloon Flights. Presentation at the 5th Annual Academic High-Altitude Conference.

Acknowledgements

We thank and acknowledge the following for their help in making this presentation possible: • UND - SSAC Faculty Travel Grant

References

Eclipse map/figure/table/predictions courtesy of Fred Espenak, NASA/Goddard Space Flight Center