Total Eclipse Aircraft Mission (TEAM)

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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.

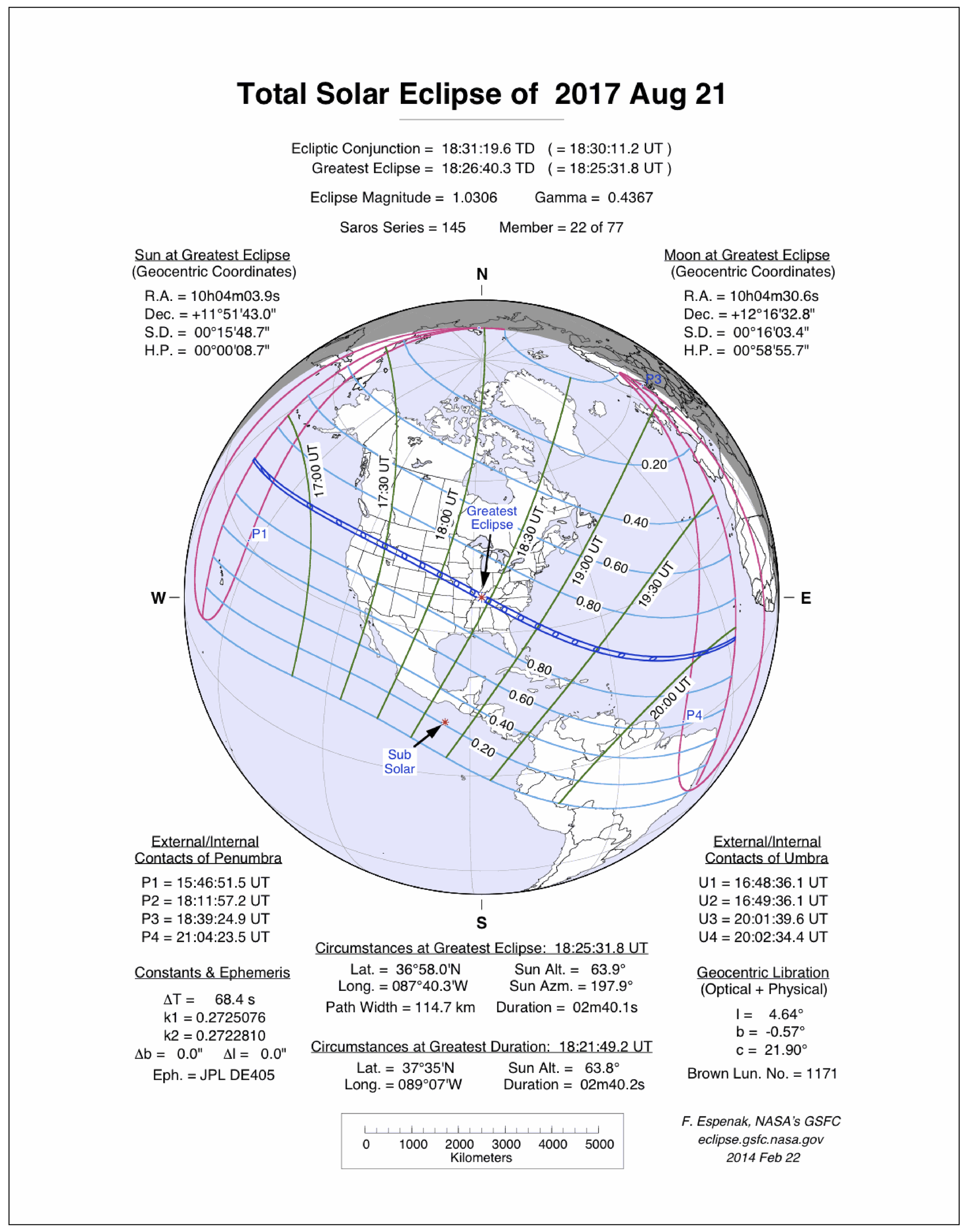


Figure 1 – Eclipse conditions during the August 21st, 2017 total solar eclipse. The shadow path traverses the United States from the northwestern Pacific coastal region to the southeastern Atlantic coastal region. Eclipse figure courtesy of Fred Espenak, NASA/Goddard Space Flight Center.

Mission Overview

The Total Eclipse Aircraft Mission (TEAM) is a high altitude aircraft mission concept that is intended to acquire complementary measurements to those taken from a high-altitude 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].

Mission Overview (cont.)

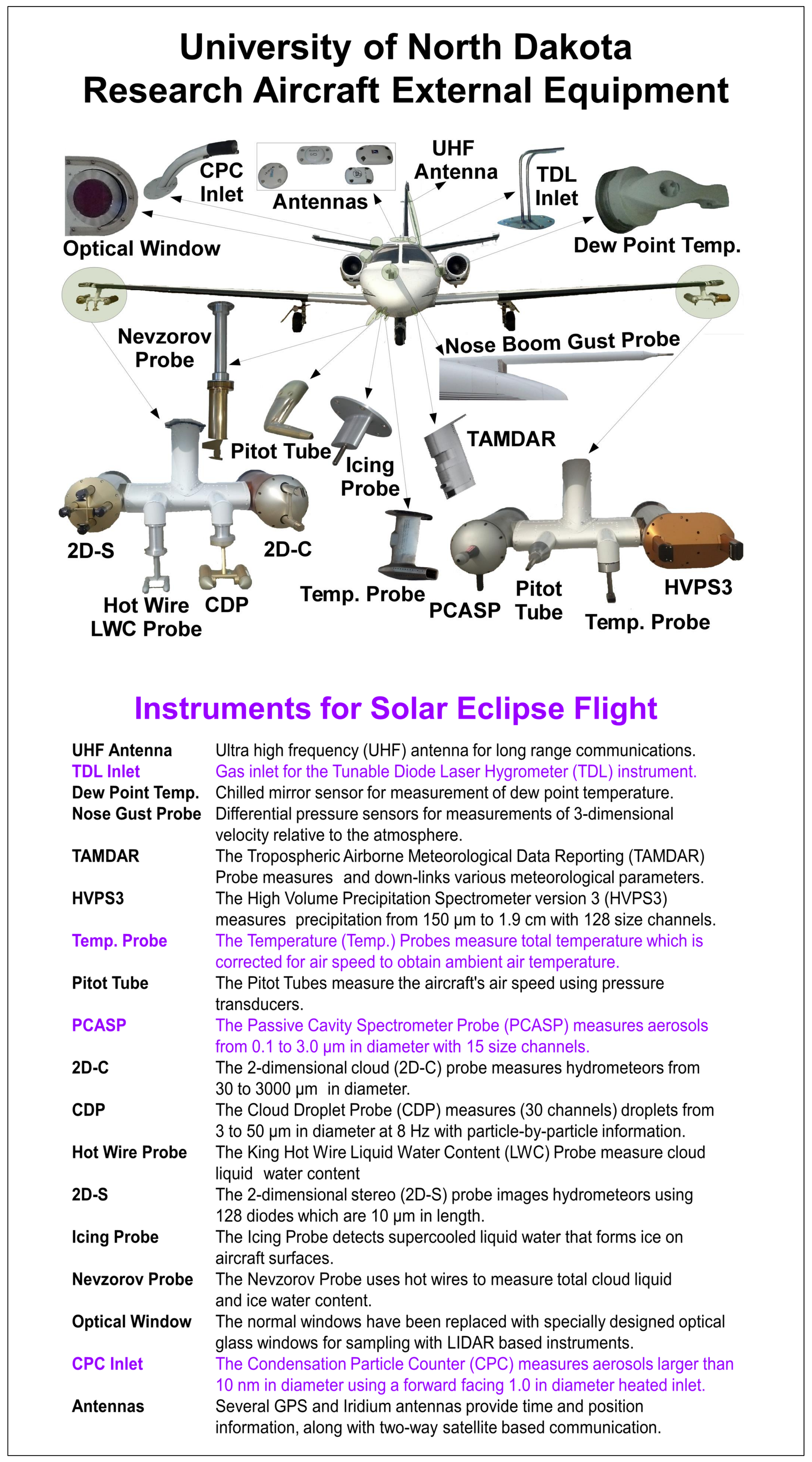


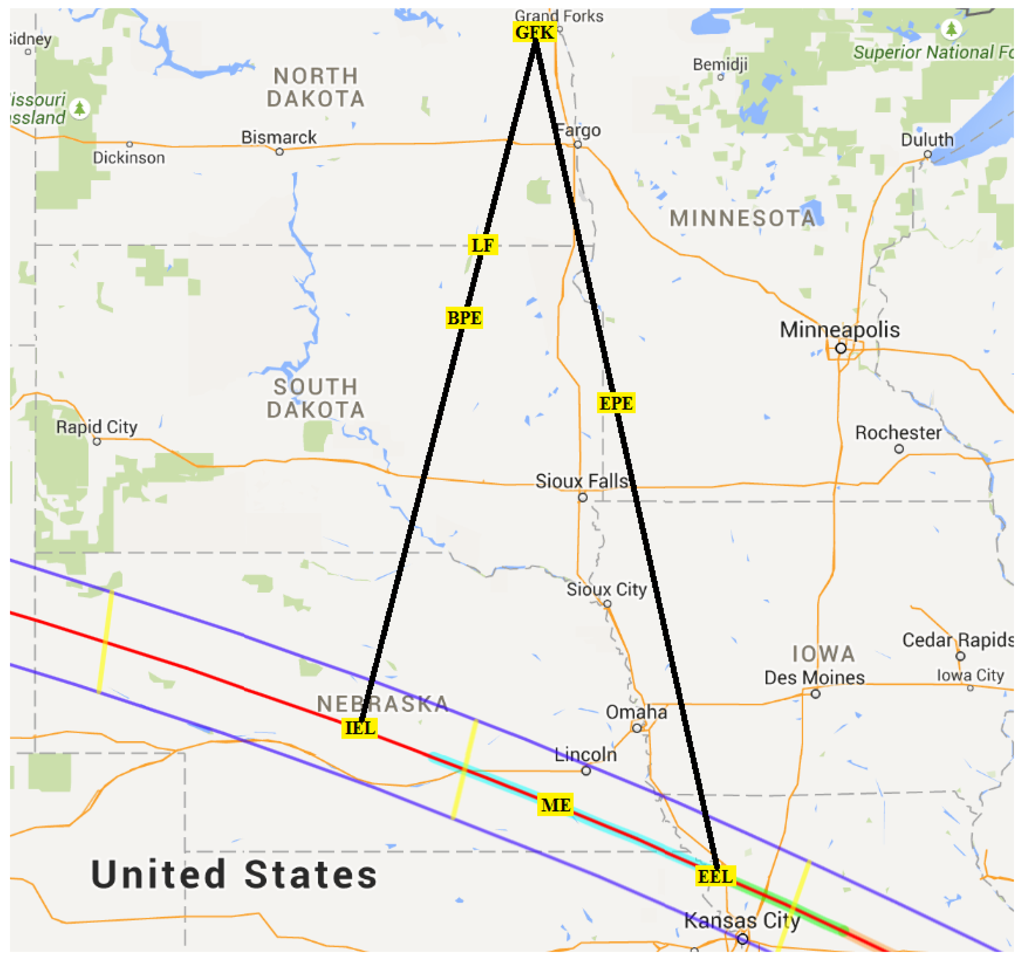
Figure 2 – University of North Dakota's Citation Research Aircraft along with the suite of instruments which can be flown on this research jet. Instruments with purple lettering are likely candidates for the TEAM mission.

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.

Mission Operations

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.



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.

Mission Science

Initial plans are to accurately measure temperature, O_3, OH^-, 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.

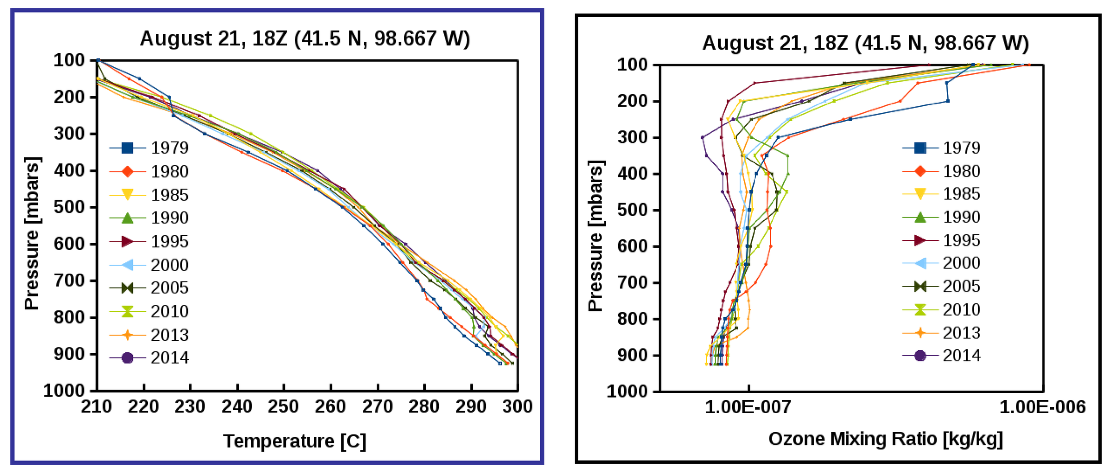


Figure 3 – An example of modeled temperature and O_3 data for the 35 years spanning 1979-2014. Measurements of atmospheric gases and physical parameters during the total solar eclipse can be used to validate such models. Note that the University of North Dakota's Citation Research Aircraft can ascend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

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 alternate mission architectures are being considered. High-level functional and operational performance requirements that flow from science and mission objectives are in development.

References

[1] Delene, D. (2014). Comparison between Research Aircraft and Balloon-borne 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*.

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