ANALYSIS OF TRANSIENT FOG FEATURES ON TITAN. E.A. Romashkova[1], P. Corlies[1], J. Tan[2], J. Kelland[2], J.M. Soderblom[1], [1]Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology (elenarom@mit.edu), [2]Department of Astronomy, Cornell University

Introduction: Saturn's moon Titan is the only known solar system body other than Earth with an active hydrological cycle, based on methane and ethane instead of water. Evidence of this hydrological cycle is provided by observations of surface bodies of methane [1, 2], tropospheric clouds [3, 4, 5], and fluvial features [1, 6]. To better characterize this environment, we examine transient low-altitude methane clouds that have been observed near Titan's surface in data from the Visual and Infrared Mapping Spectrometer (VIMS) aboard the Cassini mission [7]. Note that we refer to these features as fogs for simplicity, but as it is impossible to fully confirm that they are in contact with the surface, they are more accurately called low-altitude clouds.

Previous work has proposed that fog can result from evaporation of liquid surface methane that acts to both cool the air and increase humidity [8]. Using an expanded data set, we investigate this potential mechanism by analyzing the fogs' proximity to lakes. We then analyze a range of other factors that could also influence fog formation, providing insight into Titan's hydrological cycle.

Data and Methods: We analyze a set of Titan fog observations identified in VIMS multispectral images. These observations were identified by examining more than ten years of VIMS data to find transient fog features. Fogs were identified as areas that are bright in the 5.0 μm region of the spectrum and not in other spectral regions that are associated with higher-altitude clouds [5]. They must also be transient, distinguishing them similar 5.0-μm bright features on Titan's surface, such as Tui and Hotei Regiones [9, 10].

Several analyses were performed to investigate factors that may influence the formation of these fogs. The latitudes of the fogs were compared to climate and precipitation models [11]. The locations of observed fogs were compared to known locations of lakes and empty lake basins on Titan's surface [2]. The duration and surface area of the fogs were examined. Fog locations were compared to a digital elevation model (DEM) to investigate whether local topography influences the location of fogs [12]. Finally, the timing of fog features was analyzed to determine if season and time of day have an impact on fog formation. Radiative transfer modeling will be used to confirm the fog features' near-surface altitudes.

Results and Discussion: A set of ~20 sequences of multispectral images, each representing one fog occurrence, was analyzed. A map of these observations is given in Figure 1. Several preliminary results can be derived from the analysis, though work is ongoing. Fogs were primarily observed at high latitudes above ~60°, with most, though not all, occurring in the northern hemisphere. The observation of fogs at high, particularly northern, latitudes could be attributed to several different factors. Many methane lakes are found at high latitudes, particularly in the north; these lakes could either directly contribute to fog formation or serve as a reservoir to increase humidity at these latitudes and make fog formation more likely. Climate models of Titan have also found increased precipitation at these latitudes [11]. Some number of these factors likely contributes to preferential fog formation at these latitudes. This result is also notable given that higher-altitude clouds have been observed in mid-latitude regions; this is consistent with the observed meridional gradient in methane surface humidity [13].

The mean duration of a fog observation is 3.7 hours, and the mean area encompassed by a fog feature, averaged over each sequence, is 214,000 km^2, or roughly 4% of Titan's polar area However, few conclusions can be made from this information due to the limitations of this data set. Observations are limited by timing of flybys, resolution, and viewing geometry, and the full temporal and spatial extent of fogs are often not captured. Because of this, these estimates likely underpredict the true values.

A topographic analysis was performed to determine whether fogs form preferentially in topographic lows. Many fogs form near lake basins, which are generally found in local topographic lows near the north pole. One fog is found to trace a valley at the south pole [14]. However, it is difficult to discern the relative influence of topography from the presence of filled lakes.

Fog features were generally observed during seasons with higher solar insolation. Fogs near the north pole began to be observed only after the northern spring equinox, and fogs near the south pole were only observed in southern summer. This indicates that fog formation may be correlated to seasonality. This effect is consistent with observations of other hydrologic activity, such as clouds and storms [4, 11, 15, 16].

Most fogs were observed in the morning or evening, based on an analysis of the solar zenith angle on Titan. This result indicates a potential connection to diurnal forcing. This is particularly notable since many fogs occur at polar latitudes during late spring or

summer when the Sun remains above the horizon throughout the day. Previous analyses have neglected this factor due to the small magnitude of diurnal surface temperature variations on Titan [17]. This result indicates that diurnal forcing may have a measurable impact on Titan's weather. Further observation and modeling are necessary to determine how diurnal forcing influences fog formation.

Conclusion: Most fogs were observed at high latitudes and in the north, indicating a potential correlation with global climate and proximity to lakes. A correlation was found with seasonality, with fogs preferentially observed in seasons with more solar insolation. The majority of fogs were observed in the morning or evening, indicating a possible correlation with diurnal forcing. These results are preliminary and limited by the data quality and timing of observations; however, they reveal a variety of factors that could influence fog formation. Further data and modeling are necessary in order to determine possible causation mechanisms for these fog features.

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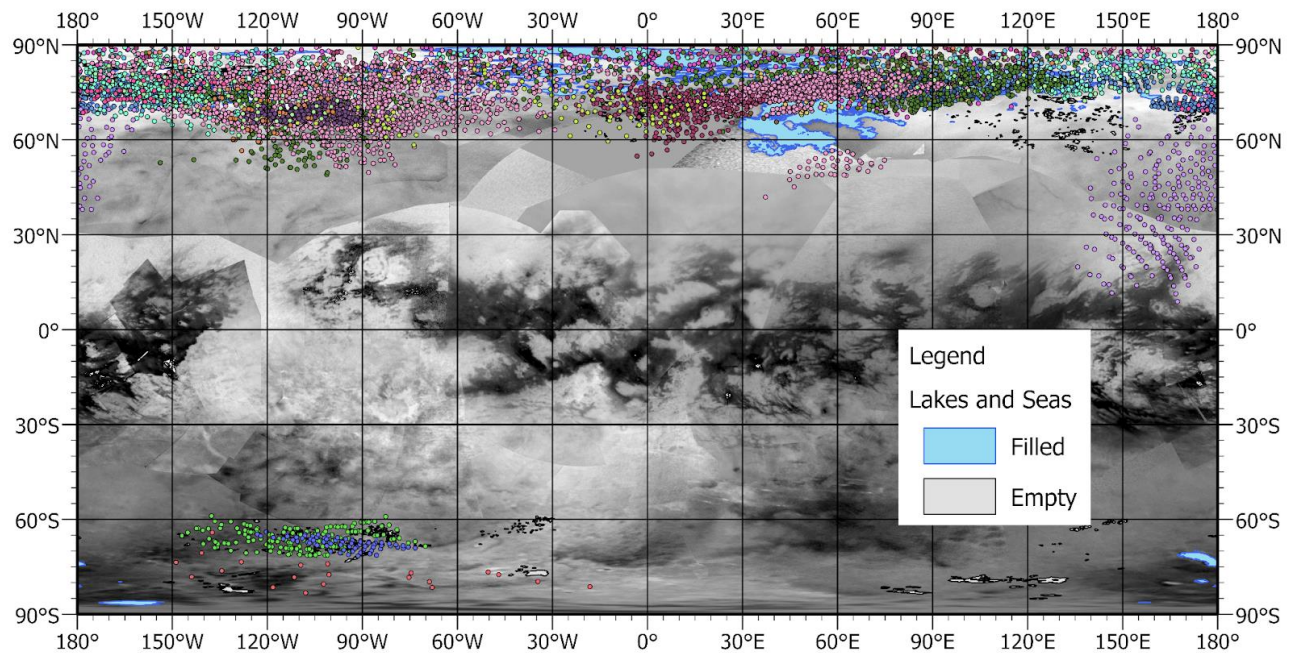

Figure 1. A map of fog observations identified for this analysis. Each fog observation is displayed as a collection of points and each sequence of observations is shown in a unique color. The basemap is a mosaic of Cassini ISS images of Titan's surface (image courtesy of USGS). Filled lakes and empty lake basins are also shown [2].