MATERIAL FLUX ON TITAN: THE FATE OF DUNE MATERIALS. Michael J. Malaska[1], Rosaly M. Lopes[1], Alex G. Hayes[2], Jani Radebaugh[3], Ralph Lorenz[4], Jason Barnes[5], Elizabeth Turtle[4]. [1]Jet Propulsion Laboratory / California Institute of Technology, Pasadena, CA. [2]Cornell University, Ithaca, NY. [3]Brigham Young University, Provo, UT. [4]John Hopkins University Applied Physics Laboratory, Laurel, MD. [5]University of Idaho, Moscow, ID. (Michael.J.Malaska@jpl.nasa.gov)

Introduction: The Cassini mission instruments have revealed Titan to be a complex world with both fluvial and eolian surface processes [1,2]. Organic photochemical products are created in the atmosphere and then deposited onto Titan's surface [2,3]. Extensive dune seas in the equatorial region suggest that wind is a major force in those locations on Titan [4,5]. The equatorial dune materials are thought to be transported predominantly by storm-driven winds [6]. However, the upwind sources, and the downwind sinks (if any) of the dune materials, has not been determined.

Previous work by Lorenz and Radebaugh [7] analyzed the orientation of the long axes of the linear dunes within the equatorial sand seas using Cassini SAR images and revealed a parallel alignment of the dune axes. Further analysis by Lucas et al. [6] suggested that dune sands are carried to the east by storm-driven winds based on analysis of the effects of topographic obstacles on dune patterns. Other terrain units have morphologies, gradations, and regional parallel orientations that also indicate aligned flow on the surface of Titan. These include streak-like plains, bright lineated plains, and dark sand streaks. Many of these features are also aligned with the orientations of linear dunes, consistent with aeolian transport affecting the morphologies of these terrain units. We extended the study of Lorenz and Radebaugh [7] to include these terrain units in order to determine the global pattern of wind-driven of material transport on Titan.

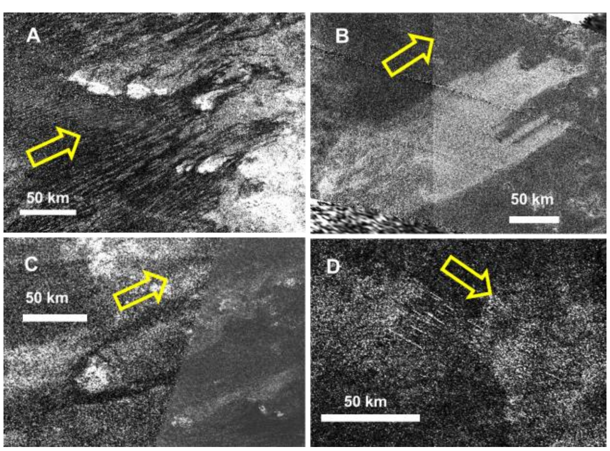

Figure 1. A) Linear dunes. B) Streak-like plains. C) Dune streak, D) Bright lineated plains. Yellow arrow indicates inferred flux direction.

Materials and Methods: We used SAR images acquired by the Cassini spacecraft on Titan through T104 (August 21, 2014) to identify diagnostic features such as streak-like plains, linear dunes, dune streaks, and bright lineated plains (Figure 1). The orientations of these features were mapped to determine wind directions. Using ArcGIS (ESRI) tools such as Create Fishnet, a grid of 100 km x 100 km squares was created over mosaicked SAR images. The overall feature orientation was recorded for each square to build up a map of material flux direction.

Results: We used alignments between 70 N and 70 S. Our preliminary results show that the material flux and inferred wind direction on Titan is hemispherically symmetrical and predominantly eastward. We find good agreement with patterns observed in ISS images.

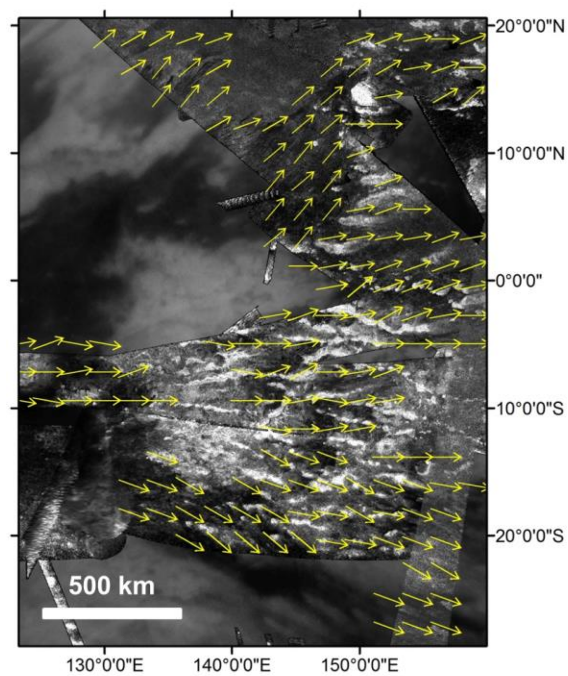

Figure 2. Material flux divergence near E Belet-Adiri-Shangri-La with the SAR and ISS mosaic as basemap. ample. Yellow arrow indicates inferred flux direction.

At the equator, the surface indicators suggest material flux along the equator, with regional perturbations due to topographic obstacles (Figure 2). Our results are also in agreement with the equatorial dune patterns presented in Lorenz and Radebaugh, 2009 [7]. From the equator poleward, the material vectors suggest eastward transport, but with an increasing poleward component that reaches a maximum inclination around latitude 20 degrees N or S. From latitude 20 poleward, the vectors becomes increasingly eastward, until latitude 35, where they are directly eastward.

Above 35 degrees latitude, the material flow is still eastward but with an equatorward component that increases at higher latitudes. Figure 3 shows a region near Afekan Planitia where materials flow southeastward from the poles and northeastward from the equator to converge at roughly latitude 35. In the area right at 35 N in Caladan Planitia there are few indicators of wind direction.

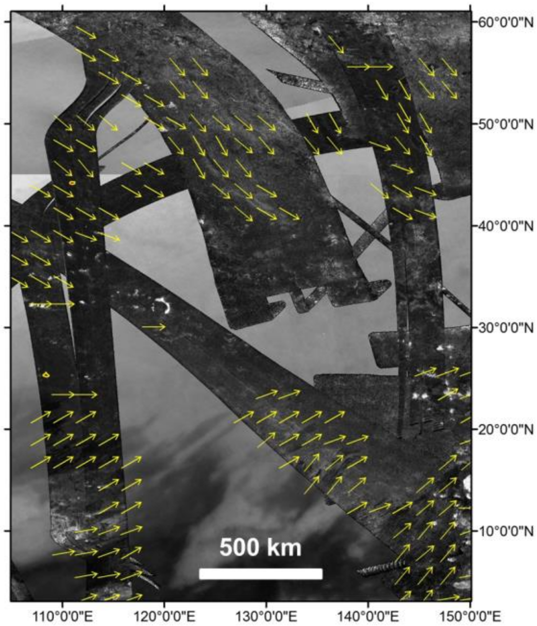

Figure 3. Material flux in the Caladan Planitia region. Yellow arrows indicate material fluxes in this northern hemisphere region converging in a zone centered near 35 N latitude.

However, at southern mid-latitudes near longitude 160 W, several impressively long eastward streaks can be observed in both radar (SAR) and infrared (ISS) images (Figure 4). The material flux vectors (yellow arrows) can be seen to converge to an easterly direction at latitude 35 S. Hobal Virgae is a windstreak that extends over 1000 km directly eastward with a maximum width of 80 km. It lies at latitude 35 S. The wind flux pattern suggests that these streaks were formed by eolian deposition and that materials are effectively confined to narrow lanes. The material fluxes converge in Titan's mid-latidutes and diverge at the equator.

Implications: The overall pattern suggests that regions at latitude 35 are major sinks for Titan surface materials migrating from the high mid-latitudes and from the equator. This suggests that Titan's equatorial sand seas are metastable. The material contained in the dunes will eventually migrate to the mid-latitudes. The relative lack of features in Titan's mid-latidudes is consistent with burial by transported materials. However, it should be noted that dune structures are not observed in the mid-latitude plains terrains. Either dune structure are present in this region and below Cassini radar resolution (300 m) or dune are not being formed.

Since any dune materials will eventually be transported to the mid-latitude plains regions, our results suggest that dune materials are one of the precursors to mid-latitude plains materials.

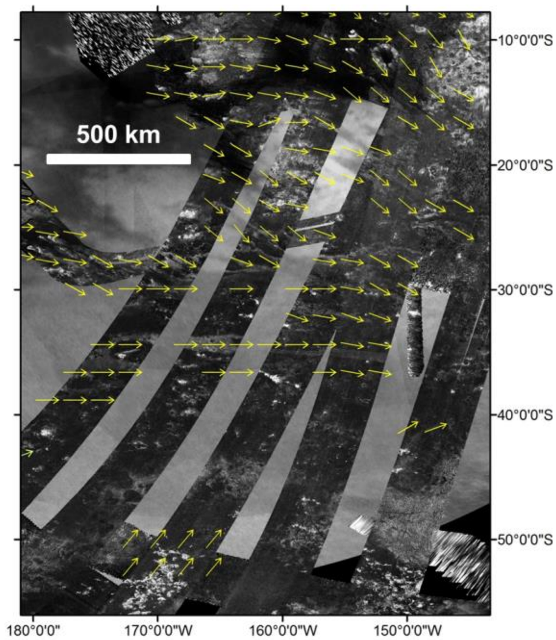

Figure 4. Material flux (yellow arrows) around Hobal Virga shown on an SAR mosaic over an ISS basemap. Hobal is the large streak-like feature at latitude 35 S.

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References: [1] Lopes et al. *Icarus* 205 (2010), 540–558. [2] Lorenz et al., *Science* 312 (2006), 724-727. [3] Soderblom et al., *Planetary and Space Sci.*, 55 (2007), 2025-2036. [4] Lorenz et al., *GRL* 35 (2008), L02206. [5] Radebaugh et al., *Icarus* 194 (2008), 690-703. [6] Lucas et al., *GRL* 41 (2014), 6093-6100. [7] Lorenz and Radebaugh *GRL* 36 (2009), L03202.