COMPARING TERRESTRIAL SEAFLOOR DUNES TO VENUSIAN DUNES. L.D.V. Neakrase[1], M. Klose[2], [1]Department of Astronomy, New Mexico State University, P.O.Box 30001 MSC 4500, Las Cruces, NM 88003-3001. [2]USDA-ARS Jornada Experimental Range, New Mexico State University, P.O.Box 30003 MSC 3 JER, Las Cruces, NM 88003. lneakras@nmsu.edu

Introduction: Dunes on Venus have been long debated since their discovery in radar data from Magellan in the early 1990s[1]. Due to the thick atmosphere on Venus many have suggested that the surface boundary layer on Venus may behave much like the subaqueous environment at the bottom of the ocean on Earth [2,3]. We aim to compare seafloor dunes with what is known about dunes on Venus, examining morphologies and potential similarities in particle entrainment capabilities. The goal of this work is to understand morphologic parameters of dunes formed in more viscous flow environments in the hopes of using the more diverse marine literature for comparison to Venus.

Venusian Dunes: There are only two identified dune fields on Venus, referred to as Al-Uzza Undae (centered at 67°N, 91°E) and Menat Undae (centered at 25°S, 340°E). Both dune fields consist of topographically constrained low lying areas with north-south trending transverse dunes [1,4]. These have been reported to be on the order of 20-60 m in height (Al-Uzza) and 0.5-5 km in length, ~0.2-0.5 km in width and spaced ~0.5 km [5,4]. The Al-Uzza Undae and Menat Undae encompass areas of 17,120 and 1290 km^2, respectively [4].

In the absence of further surface data from Venus, exact flow conditions can only be hinted at from the few measurements from the Soviet Venera 9, 10, 13, and 14 landers. Wind data from ~1 m above the surface suggest that wind speeds are on the order of 0.2-1.3 ms^{-1}[6]. Some particulate material was seen to have moved in Venera 13 images suggesting wind speeds can be above particle entrainment threshold.

Terrestrial Seafloor Dunes: Terrestrial seafloor dunes have been known since the 1960s once side-scanning sonar systems became available and the bottom of the ocean became a target for mapping (e.g., [8]). Isolated barchan dunes to transverse dune forms are common in seafloor environments with responsible currents (flow velocities) of 0.3-2 m s^{-1} as reviewed in [3]. Typical areas where seafloor dunes are found include topographically constrained valleys and local topographic lows where sediment can accumulate. Sizes of seafloor dunes can be 10-100+ m in length with heights ranging from 10s of centimeters to a few meters in height. Dune spacings are typically on the order of tens of meters.

Similarity of Environments: Similarity of the two environments depends on many aspects including basic parameters for flow velocity, fluid viscosity, the ability to entrain particles in order to build dune forms, and not least the resulting bedform geomorphology. For subaqueous environments, marine communities tend to use the observed bedforms to constrain the flow velocity [9]. In many ways our current knowledge about the Venusian surface resembles aspects of the subaqueous seafloor environment with regard to particle movement and dune formation.

Estimates of the threshold friction velocity for particle entrainment suggest very low values for both Venusian (< 2.7 cm s^{-1}) and for subaqueous (< 1 cm s^{-1}) environments for sand-sized particles as reviewed in [3] (Fig. 1). Higher-viscosity fluid environments such as Venus or the seafloor also mute the ability for cascades in saltation or splash-driven continuation of particle entrainment. The higher-viscosity environment reduces particle momentum, leading to shallower particle trajectories and slower particle speed [11]. In both cases (Venus and seafloor) this could lead to smaller dunes, shorter wavelengths and closer spacings.

Conclusions: Many similarities between the Venusian atmosphere and subaqueous seafloor dune environments suggest that these are analogous to some extent. The morphological differences between seafloor and Venusian dunes and and the lower subaqueous threshold friction speeds suggest that seafloor conditions are somewhat more extreme than the Venusian environment in terms of particle entrainment. However, seafloor dune processes may provide a closer representation of what may be happening in Venusian dunes. Together with knowledge about dunes on Earth and Mars, dune morphologies could possibly be represented as a continuum of conditions from the seafloor aqueous environments through Venus, terrestrial aeolian dunes, and ending with Martian dunes, relating primarily to the viscosity of those environments and how the viscosity effects the threshold conditions for particle entrainment, saltation trajectories, and impact-driven saltation.

Terrestrial subaqueous seafloor dunes can help understanding how different parameters affect the bulk morphology of dunes as well as put constraints on the movement of grains on Venus, including sediment availability. The seafloor is clearly not a sediment starved environment, yet has fluid-driven controls on dune formation.

Several other uncertainties about how deep sea 'storm' events affect the longevity and movement of dunes in a seafloor environment could be good predictors of what to expect on the surface of Venus, until more data from the Venusian surface is available.

References: [1] Greeley et al., *JGR*, 97 (E8), 1992; [2] Sagan, *J.Atmos.Sci*, 32, 1975; [3] Neakrase et al., *Aeol. Res.*, *in review*; [4] Weitz et al., *Icarus*, 112, 1994; [5] Lorenz, *4th Int.Planet.Dunes Wkshp.*, 2015; [6] Keldysh, *Icarus*, 30, 1977; [7] Kreslavsky & Bondarenko, *Aeol.Res.*, 2016; [8] Lonsdale & Malfait, *Geol.Soc.Am.Bull.*, 85, 1974; [9] Stow et al., *Geology*, 37, 2009; [10] Lancaster, *Geomorphology of Desert Dunes*, 1995; [11] Kok et al., *Rep. Prog. Phys.*, 2012; [12] Shao and Lu, *JGR*, 2000.

Figure 1. Comparison of particle threshold friction speed, u_{*t}, as a function of particle size, D_p, [12] for Mars, Earth (air), Venus, and Earth (water) showing approximate optimal particle size at local minima (left) [3]. Cartoon of comparison of idealized dunes in each environment with rough estimates of height and widths [2,4,5,10].