RADAR IMAGING OF GIANT LONGITUDINAL DUNES : NAMIB DESERT (EARTH) AND THE BELET SAND SEA (TITAN). R.D. Lorenz[1], S. D. Wall[2], E. Reffet[1], G. Boubin[1], J. Radebaugh[1], C. Elachi[2,8], M. D. Allison[3], Y.Anderson[2], R. Boehmer[2], P. Callahan[2], P. Encrenaz[4], E. Flamini[5], G. Francescetti[6], Y. Gim[2], G. Hamilton[2], S.Hensley[2], M. A. Janssen[2], W. T. K. Johnson[2], K. Kelleher[2], R. L. Kirk[7], R. M. Lopes[2], J. I. Lunine[1,15], K. Mitchell[1], D. O. Muhleman[9], G. Ori[16], R. Orosei[17], S. J. Ostro[2], F. Paganelli[2], G. Picardi[10], F. Posa[11], L. E. Roth[2], R. Seu[10], S. Shaffer[2], L. A. Soderblom[7], B. Stiles[2], E. R. Stofan[12], S. Vetrella[6], R. West[2], C. A. Wood[13], L. Wye[14], and H. A. Zebker[14], [1]Lunar and Planetary Lab, U. Arizona, Tucson, AZ 85721, U.S.A. (rlorenz@lpl.arizona.edu), [2] Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109. U.S.A., [3] NASA Goddard Institute for Space Studies, New York, NY 10025, U.S.A., [4]Observatoire de Paris, 92195 Meudon, France, [5]Agenzia Spaziale Italiana, 00131 Rome, Italy,[6] Facoltá di Ingegneria, 80125 Naples, Italy, [7] USGS Flagstaff, AZ 86001, U.S.A. [8] RADAR Team Leader, [9] GPS, Caltech, Pasadena, CA 91125, U.S.A.,[10] Universitá La Sapienza, 00184 Rome, Italy,[11] INFM and Dip. Interateneo di Fisica, Politecnico di Bari, 70126 Bari, Italy, [12] Proxemy Research, Bowie, MD 20715, U.S.A., [13] Planetary Science Institute, Tucson, AZ 85719, U.S.A., [14] Stanford University, Stanford, CA 94305, USA, [15]INAF-IFSI, 00133, Rome, Italy. [16]IRSPS, Pescara, Italy, [17]CNR-IASF, 00133, Rome.).

Introduction: Sand dunes cover about 5% of the land surface on Earth, and longitudinal ('seif') dunes, where the material accumulates in lanes oriented along the mean transport direction, are among the most common type of dune[1,2], covering half to two-thirds of sand seas. In contrast, they are among the least common dune-type on Mars [3]. The Cassini RADAR instrument [4,5] has observed [6] apparently aeolian landforms during the T3 flyby, nicknamed 'cat scratches' that we interpreted as aeolian. Large regions of similar features have been observed [7] near Titan's equator during the T8 flyby, and favourable viewing geometry, higher resolution and possibly larger features now show these clearly to be longitudinal dunes (fig.1). Here we show some example Titan image sections acquired with the Cassini Ku-band (2-cm) SAR with typical resolutions of ~500m, and Shuttle-borne radar from the SIR-C/X-SAR mission (at C- and L-band, 24 and 6 cm)

Discussion: The morphologies of the terrestrial and Titanian dunes are remarkably similar (figs. 1-6), despite the known environmental differences (factor of

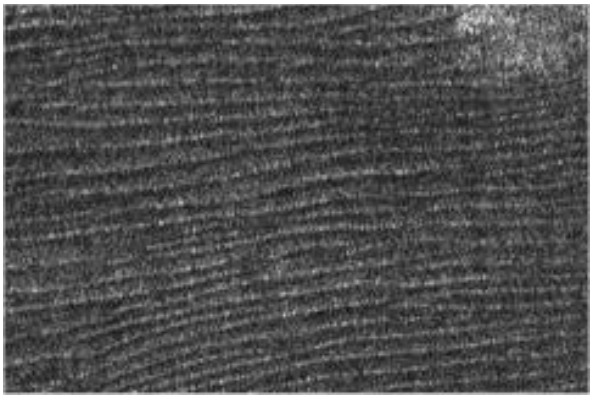

Figure 1. 75x50 km segment of Cassini Ku-band SAR acquired October 2005 during T8 flyby over Belet

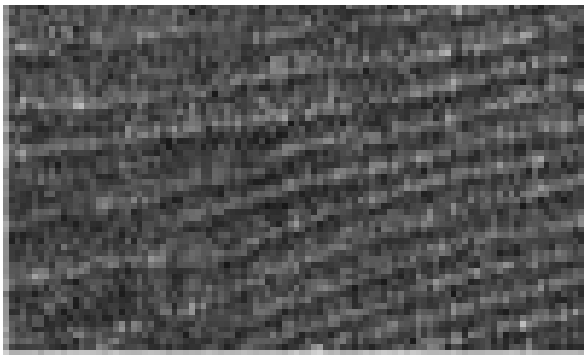

Figure 1b – as above but a 30x20km blowup for comparison with the terrestrial analogs imaged at higher resolution

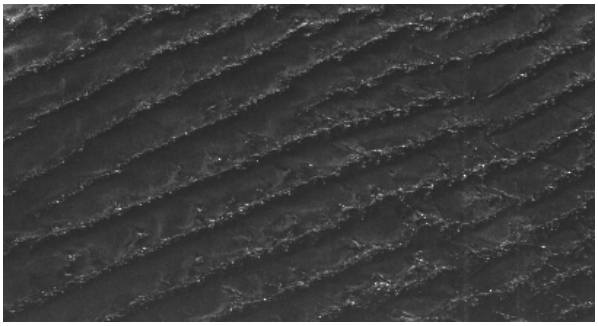

Figure 2. 30x20km segment of SIR-C L-band image of Namib desert acquired in 1994. Data Take 58.40 Processing ID 44419

1/7 difference in gravity and 4 in air density Titan vs. Earth) and presumed differences in windblown materials. Terrestrial dunes, the best examples being in the Namib (fig.2) and Australian deserts, are typically half as wide as the gaps between them, a geometry we also observe on Titan. This ratio indicates an ample sand supply in the Belet dark region where we observe most of the Titan dunes on T8. As with terrestrial dunes, the Titan features are sub-parallel, with length/width ratios of order 100, and occasional tuning-fork junctions. The longitudinal character of the

dunes on Titan is very clear in their often complex interaction with preexisting topographic features, where the dunes part and rejoin beyond. This permits a determination of the characteristic wind direction near the surface [7].

Figure 3. 75x50 km segment of Cassini Ku-band SAR acquired October 2005 during T8 flyby over Belet

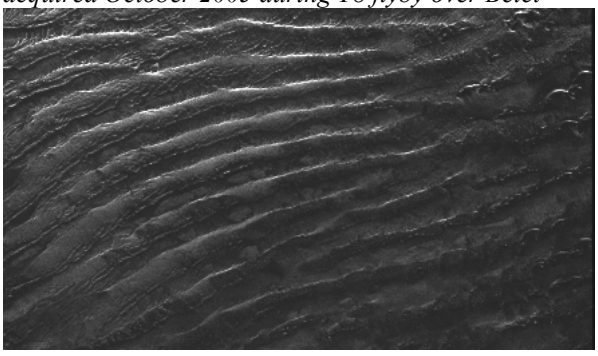

Figure 4. 30x20km segment of SIR-C C-band image of Namib desert acquired in 1994. Data Take 58.40 Processing ID 44422

Contrary to the Belet region where the features have evident topographic expression (with uprange glints as observed on terrestrial dunes) the cat-scratch features observed in T3 around 30 degrees latitude (fig.5) are simply dark streaks. These often have a tapered shape, perhaps indicating less abundant sand. Again, similar features are observed in the Namib desert (fig.6).

Implications: The detection of dunes requires winds strong enough to saltate particles : longitudinal dunes are associated specifically with a fluctuating wind regime. Detection of dunes also requires sand-generating processes to have been active on Titan, and that sand sinks (such as standing bodies of liquid) are absent in the regions in which dunes are so far observed. The dunes reported here have been observed in optically-dark regions, but not all optically-dark regions have dunes. Only the Cassini RADAR instrument has been able to identify the dunes from orbit, so further study of the global-scale distribution of dunes and the implications for hydrology and meteorology awaits additional radar imaging coverage. The next SAR pass presently planned is T13 in April 2006.

Unlike Mars, where Aeolian processes appear to dominate the present epoch, Titan appears to exhibit both recent fluvial and Aeolian features. The striking similarity of the Namib dunes with those on Titan reinforces the growing perception of Titan as an Earth-like world, with ongoing geological processes similar to, but circumstances very different from, those here.

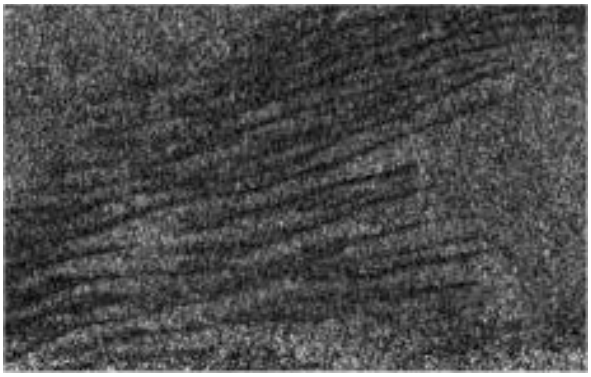

Figure 5. 75x50 km segment of Cassini Ku-band SAR acquired Feburary 2005 during T3 flyby north of Xanadu.

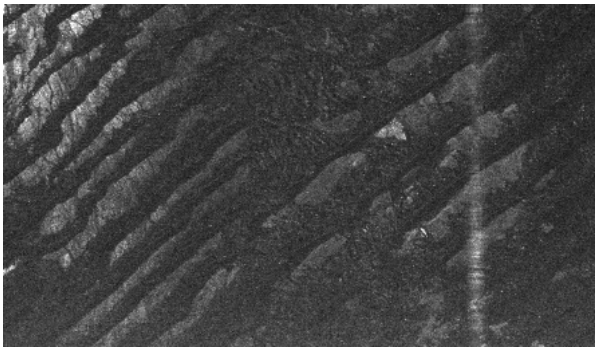

Figure 6. 30x20km segment of SIR-C C-band image of Namib desert acquired in 1994. Data Take 58.40 Processing ID 11859.

References: [1] Lancaster, N. The Geomorphology of Desert Dunes, Routeledge, 1996 [2] Bagnold, R., Physics of Wind-Blown Sand and Desert Dunes, Methuen, 1941 [3]. P. Lee and P. C. Thomas, *Journal of Geophysical Research*, 100, 5381-5395, 1995 [4] Elachi, C. et al., *Space Science Reviews*,115, 71-110, 2004 [5] Elachi, C. et al., *Science*, 308, 970-974, 2005. [6] Elachi, C. et al., *Nature*, submitted [7] Lorenz, R. D. et al., The Sand Seas of Titan : Cassini RADAR observations of Equatorial Fields of Longitudinal Dunes, *Science*, submitted.