COMPARATIVE STUDY OF HIGHER-ORDER NEIGHBOUR STATISTICS AND DUNE FIELD SELF ORGANIZATION FOR THE HYPERBOREAE UNDAE AND OLYMPIA UNDAE ERGS, MARS. A. J. Wheeler[1] and M. A. Bishop[1,2], [1]School of Natural and Built Environments, University of South Australia, SA 5095, Australia (andrew.wheeler@postgrads.unisa.edu.au), [2]Planetary Science Institute, 1700 East Fort Lowell Road, Tucson, AZ 85719, USA (bishop@psi.edu).

Introduction: Ordered neighbor analysis has shown that dune geography for high-latitude dune fields on Mars is not a random process, but one that identifies with a geomorphic system that has evolved towards a pattern of uniformity across a variety of spatial scales [1]. Wilkins and Ford [2] have suggested also that eolian systems reflect, within different spatial regions of the field, the sum of changes that result in the spatially variable states of dune field organization. Therefore, if barchanoid form of Martian circumpolar dunes, represents a geomorphic system approaching a high degree of self-organization, as exemplified from Hyperboreae Undae, then such a state may be considered to have been numerically characterized by a nearest neighbor index that approaches a dimensionless value of $R \sim 1.42$, and by higher order neighbors that show a tendency towards randomness. Such dimensionless values may be regarded as geographical signatures of crescentic dune self-organization.

HiRISE imagery of portions of dunefields between Olympia Undae and Siton Undae (~ 120° of longitude east from Hyperboreae Undae) presents an opportunity to compare ordered neighbor analyses between north polar ergs and refine the geographical signatures of circumpolar crescentic dune self-organization.

Methodology: Nearest neighbor (NN) or 1st-order statistics identify a particular pattern (clustered, random, dispersed) at the local scale, while higher order statistics are capable of detecting heterogeneous processes at regional or global scales [3]. It has been shown that spatial statistical analysis using Mars Orbiter Camera (MOC) data within a GIS offers quantitative methods from which an understanding of Martian dune geography can be surmised [1].

Some 2800 data points, selected from nine MOC images of Hyperboreae Undae dunefields, were reduced to a set of six-index values, the dimensionless statistic *R*. From these, several major findings were determined for the spatial characterization of dunes associated with the Hyperboreae Undae erg at the Martian north pole and served as benchmarks for understanding the techniques, results and interpretations of point pattern analysis and the distribution of simple and compound crescentic dunes for an extra-terrestrial landscape.

A portion of a dunefield marginal to Olympia Undae, is seen in HiRISE image PSP_001660_2570 (Figure 1). From this, 1216 data points consisting of dome, barchan and barchanoid dunes in simple, compound and complex morphologies, were reduced to a set of six *R* values. Further intra-field analyses were performed on discrete dune forms (barchanoid, barchans and dome).

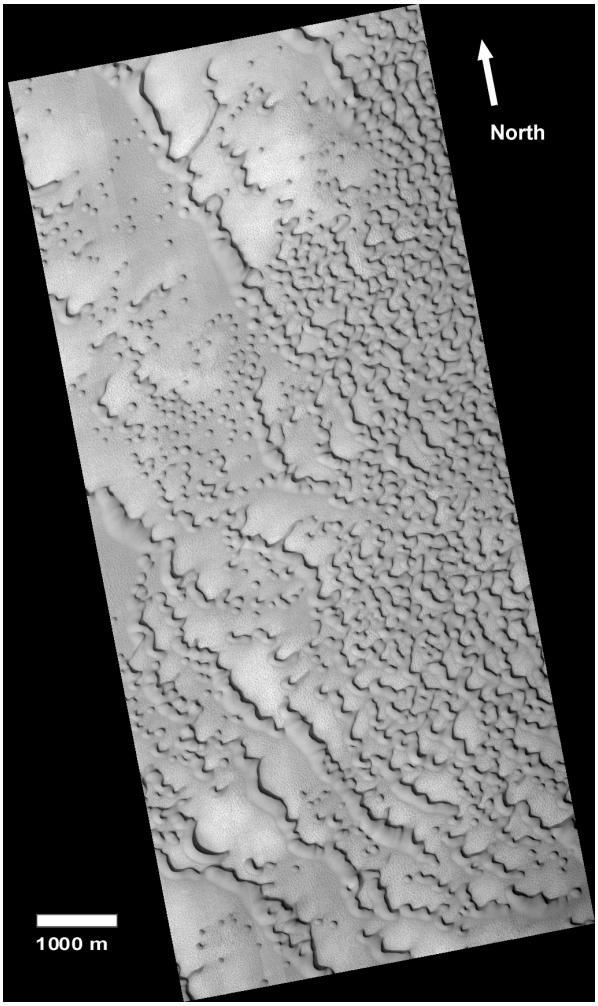

Figure1: Crescentic dunes of the North Polar region, Mars. HiRISE image PSP_001660_2570 centered at 109.6°E 76.7°N.

(The authors acknowledge the use of the HiRISE image processed by HiRISE Operations Centre and available at http://hiroc.lpl.arizona.edu/images/PSP/index.html).

Results and Discussion: The NN statistics show that the pattern for crescentic dunes is one of statistically significant dispersion, R = 1.12, with higher order neighbors successively tending towards spatial randomness (Table 1).

Ordered Neighbor	*R-statistic*	Z_R	*Pattern*
1st	1.12	6.64	Dispersed
2nd	1.06	5.44	Dispersed
3rd	1.04	5.13	Dispersed
4th	1.04	5.34	Dispersed
5th	1.03	5.02	Dispersed
6th	1.03	5.28	Dispersed

Table 1: Ordered neighbor statistics for 1216 crescentic dunes, Olympia Undae (Area of dune sample = 88.32 km²; spatial resolution of PSP_001660_2570 = 0.50m/pixel)

This is consistant also with results obtained from the Hyperboreae Undae (Figure 2). The values for the pattern of dispersion are among the lowest recorded for dunefields on the northern plains at this time. This is particularly true for the nearest neighbor (Figure 2). For Hyperboreae Undae, Bishop [1] has implied that locations exhibiting intermingled duneforms have demonstrated lower R-indices. Domes, barchans, barchan-seif, short barchanoid 'chains' and barchanoid ridges are all identified in relatively large numbers in this dunefield. This suggests that morphological diversity correlates with self-organization and maturity of the eolian system. Image PSP_001660_2570 is located marginal to the Olympia Undae erg where nascent barchans (transitional domes) and barchans are in the process of organizing into barchanoid 'chains' and ridges.

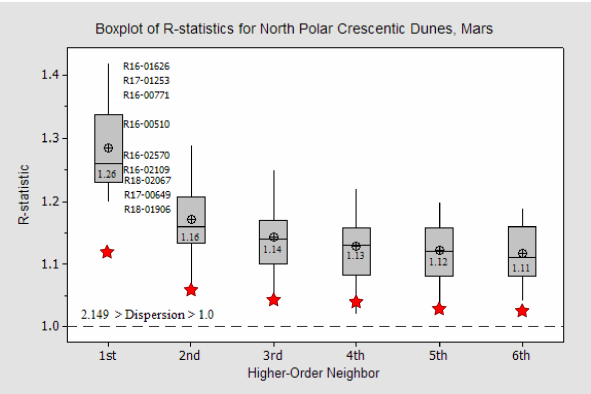

Figure 2: A boxplot of the distribution of the R-statistic for the nearest neighbor and higher order neighbors for crescentic dunes of Hyperboreae Undae. 'Star' symbols represent the R-statistic for crescentic dunes marginal to Olympia Undae.

Summary: Spatial statistical analysis, as a means to investigate Martian dune geography, has determined a number of major findings for the spatial characterization of dunes associated with Hyperboreae Undae on the Martian north polar plains. A comparative study at a dunefield marginal to Olympia Undae, was undertaken to test these findings.

Firstly, the nearest neighbor R-statistic, regardless of crescentic dune morphology, expresses the most significant degree of dispersion relative to the R-statistic of all other higher ordered neighbors and is consistent between ergs. Secondly, crescentic dunes, regardless of morphology, have a tendency towards increasing spatial randomness as the distance between neighbors increases (i.e. at higher order neighbors). Thirdly, crescentic dune fields comprising barchanoid morphology exhibit the highest R-statistics relative to fields comprised of interspersed domes, barchan, barchanseif, and short barchanoid 'chains' and is consistent between ergs. Dunefields marginal to the ergs, where morphological diversity is greatest, exhibit the lowest R-statisitcs relative to dispersion and tend towards random organization.

Further comparative studies at both the margins and interior of other regions (for example; Siton Undae, Nili Patera and southern intracrater and intercrater dunefields) alongside terrestrial sites will better clarify the relationship between spatial patterns, self-organization and the state of geographical maturity of dunescapes.

References: [1] Bishop M.A. (2007) *Icarus 191* 151-157. [2] Wilkins D.E. and Ford R.L. (2007) *Geomorphology 83* 48-57. [3] Wong W. S. and Lee J. *Statistical Analysis of Geographic Information with ArcView GIS® and ArcGIS® (2005)* John Wiley & Sons, Inc., New Jersey. pp 246-248.