**Introduction**

Non-sorted circles are an abundant form of patterned ground with limited vegetation located in the arctic tundra. These features can be found in fine-grained, frost-susceptible, and mineral soils with permafrost. The age of these patterns is estimated to be thousands of years during which the shape and size are maintained. Biological and physical interactions in the non-sorted circle system are balanced. Plant succession drives vegetation toward the center of the circle, where frost heave prevents vegetation development. Accumulation due to vegetation and snow creates a temperature gradient in the soil during freezing. This gradient leads to ice sorting (frost heave) which prevents plant roots from developing. Over many years, vegetation is successful in areas with minimal heave, resulting in an accumulation of organic matter, which further stabilizes soils without circles to vegetated with circles. We discuss two theories for the initial development of the system: (1) instability of the frost heave process, and (2) initial establishment of random vegetation with redistribution of liquid water.

**Differential Frost Heave model**
- Governing Equations as proposed by Fowler and Krantz (2006)
- Linear stability analysis
- Small perturbations grow if conditions are optimal
- The growth depends on the wavelength of the perturbation

**Arctic Vegetation**
- Nitrogen limited vegetation development (Epstein 2001)
- Climate influence is determined stochastically
- Frost heave controls plant growth
- Provides insulation to WIT through plant biomass

**Water Ice Temperature**
- (Daanen and Misra 2006)
- Phase change according to the general Clapeyron equation to account for ice melting in liquid water and the freezing characteristic curve to determine ice formation
- Insulation at the soil surface drives soil temperature gradients, that leads to preferential ice accumulation

**Coupled WIT-ArcVeg**
- Ice accretion as a proxy for the heave parameter in ArcVeg
- Neighboring node heave is tied to current node
- Biomass is used to estimate the insulation value for each node
- Soil organic nitrogen is used to adjust the freezing characteristic curve
- Virtual reality tool developed (Daanen et al. 2006)

**Results**

The Differential Frost Heave model (DFH) was applied to simulate the initiation of non-sorted circles from bare soil. The WIT-ArcVeg model was applied to simulate pattern formation and identify the stability between heave and growth of the regular pattern predicted by the DFH model. The results show that:
- Number density of non-sorted circles is maintained.
- Initial pattern is not maintained in the tundra/nontundra vegetation case and (3) WIT-ArcVeg pattern is very dynamic.

**Discussion**

The WIT-ArcVeg model may need more pattern stabilizing mechanism. This can be achieved through:
- (1) Thawing of the soil, (2) Vegetation expansion from the vegetated areas through rhizomes and (3) organic layer root mat on top of thawing mineral soil.

**References**


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