PI-SWIRL: A New Technique for Measuring Wind Blown Dust Emission Potential

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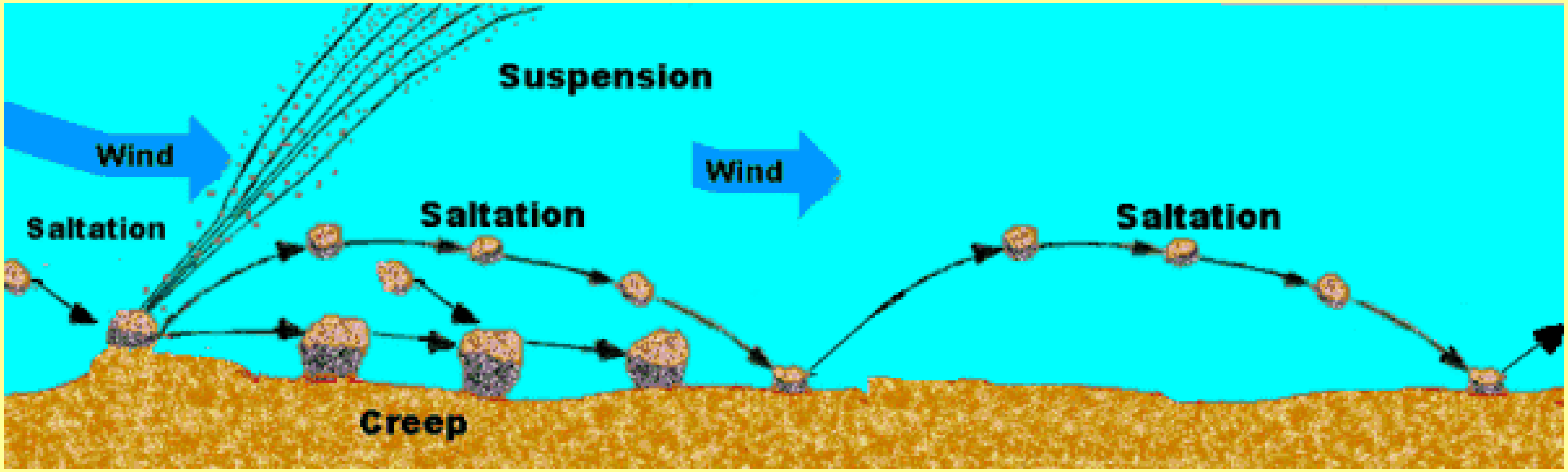
Sources of Windblown Dust

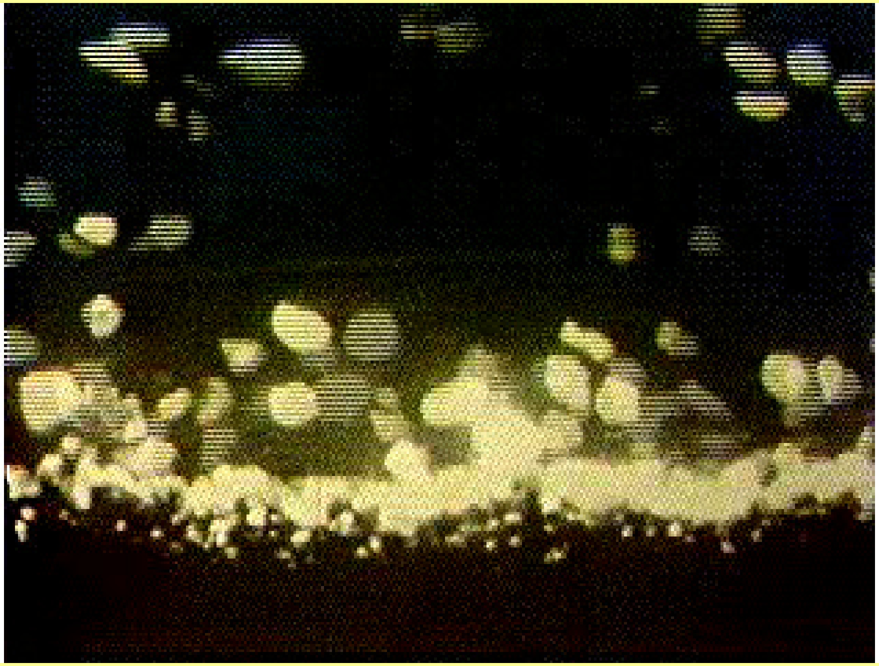
- Windblown dust
  - Vacant lands: Human disturbance makes it worse
  - Storage Piles
  - Construction sites
- Windblown Dust Requires wind
  - Emission Factor = $k\sum_{i=1}^{N} P_i$ where N is # disturbances/yr
  - $P = 58(u^* - u_t^*)^2 + 25(u^* - u_t^*)$ e.g. AP-42

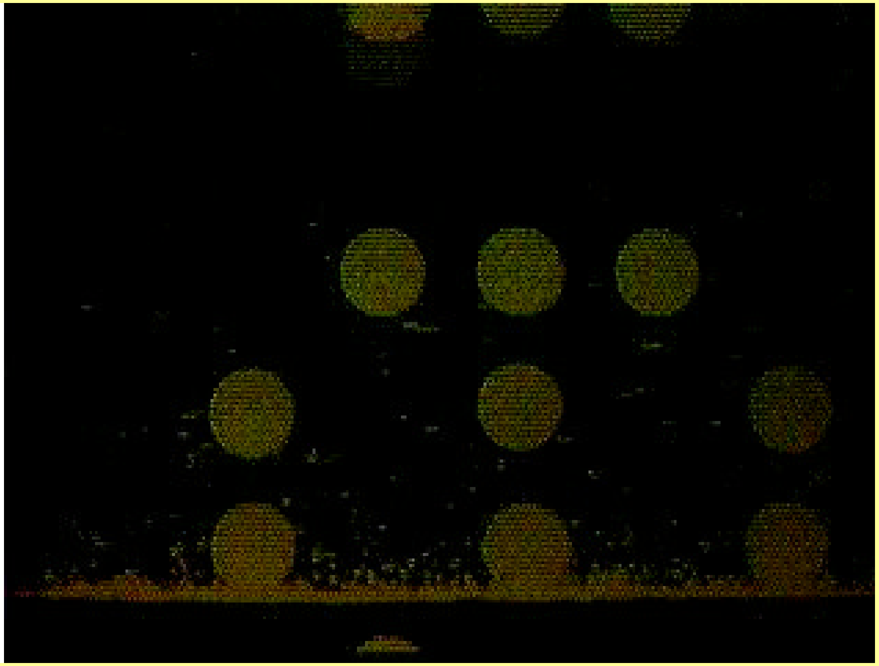
Mechanisms of Windblown Dust Suspension

- "Creep"
  - ❖0.5 - 2 mm particles roll due to pressure differential
- "Saltation"
  - ❖0.1 - 0.5 mm particles suspended, travel parallel to ground 1-5 m, re-impact
  - ❖Cause release of additional particles
- "Emission"
  - ❖0.001 - 0.1 mm particles suspended and transported between 10 – 10,000 m

USDA-ARS Wind Erosion Research Unit
http://www.weru.ksu.edu/vids







Measurement of Wind Erosion

- Measure What/Why:
  - – Threshold friction velocity
  - – Emissions at given friction velocity
  - – Emissions dependence on
    - Surface parameters (texture, moisture, vegetative cover), location, time of year
  - – Substantial heterogeneities make exhaustive test matrix difficult
  - – Information necessary for accurate modeling

In-Situ Surface Stability Tests

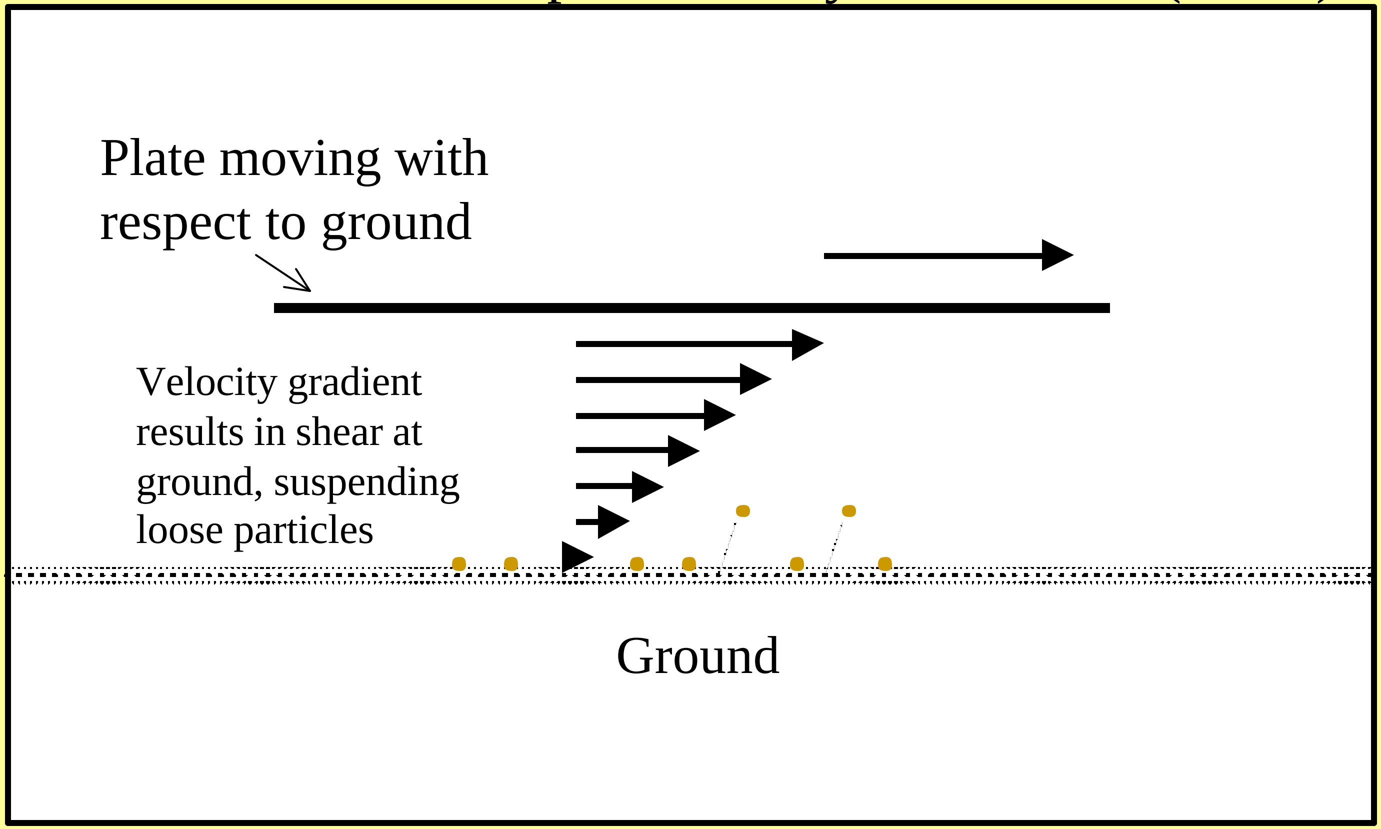
- Several Alternatives
  - Large Wind Tunnel (LWT): Probably best method, but requires ~10-30 man hours per sample location
  - Small Wind Tunnel (SWT): Less accurate than LWT, but requires less time
  - PI-SWIRL: Comparable to Small Wind Tunnel; requires ~10 minutes per sample; potentially man-portable

LWT at Ft. Bliss, TX

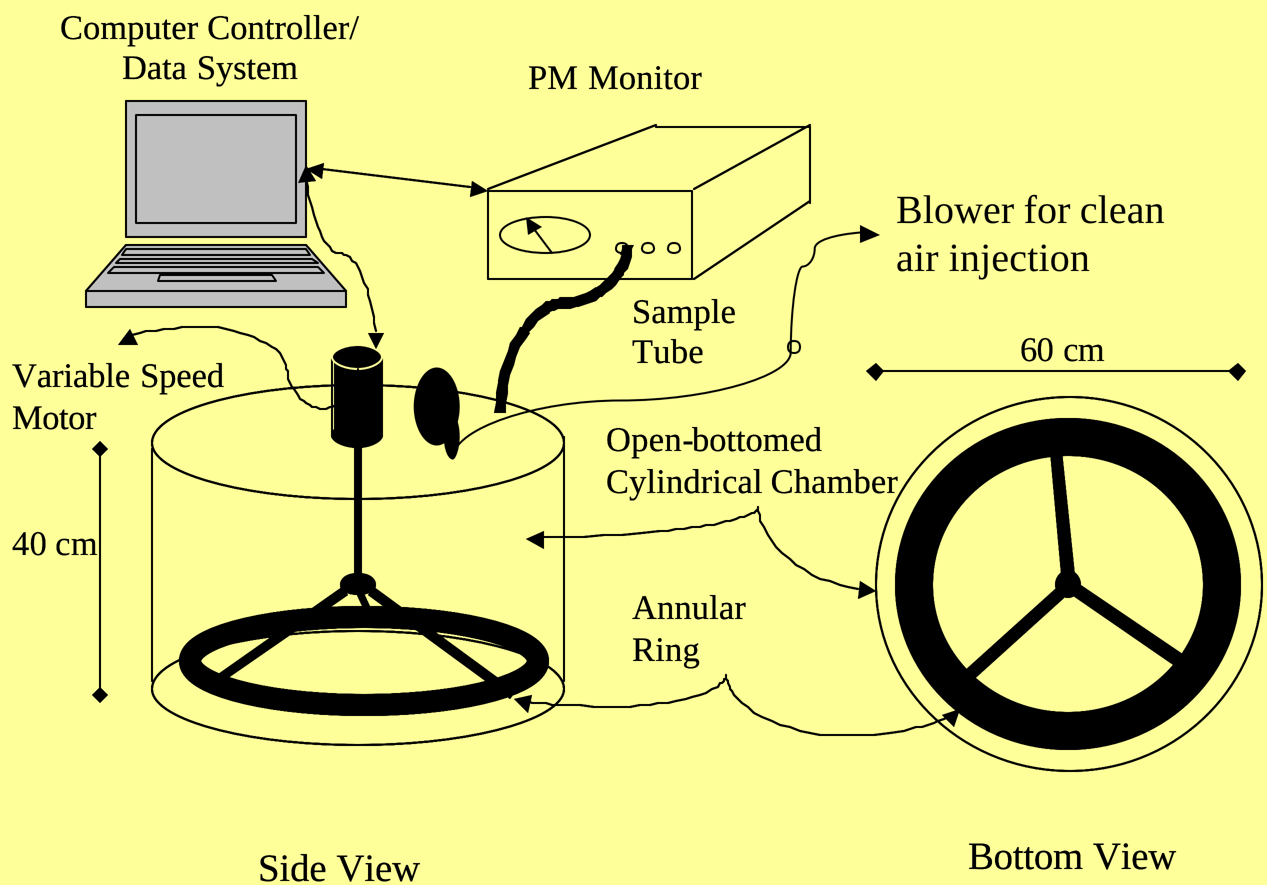
- J. Gillies and B. Nickling testing emission flux potential
- LWT is closest measurement to a “standard”
- SWT - e.g. D. James (UNLV), D. Gillette (NOAA)
  - Concerns with boundary layer development, maximum wind speeds, and accounting for saltation

Portable In-Situ Wind Erosion Laboratory: The PI-SWIRL concept

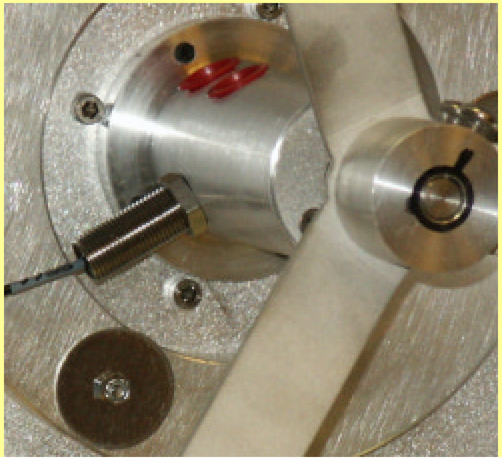
Philosophy: Don’t try to simulate atmospheric flow, instead simulate shear stress experienced by soil surface (i.e. u^*)



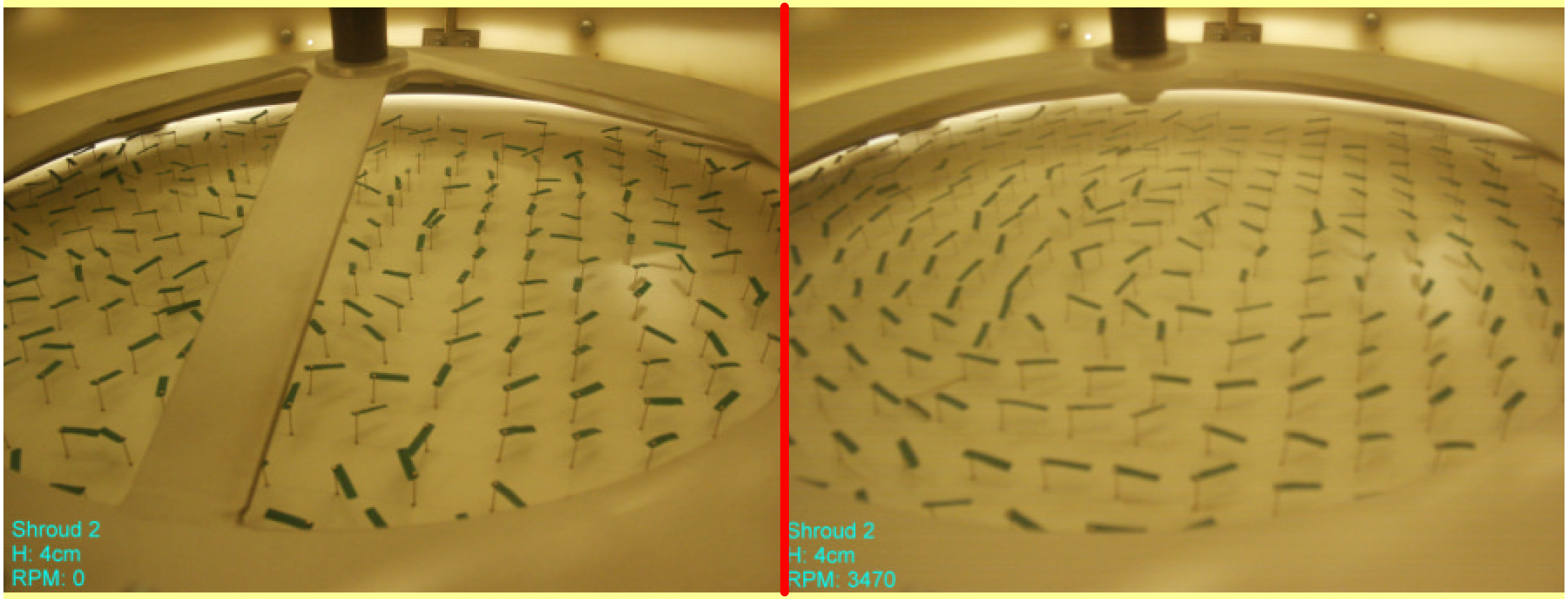
PI-SWIRL Schematic



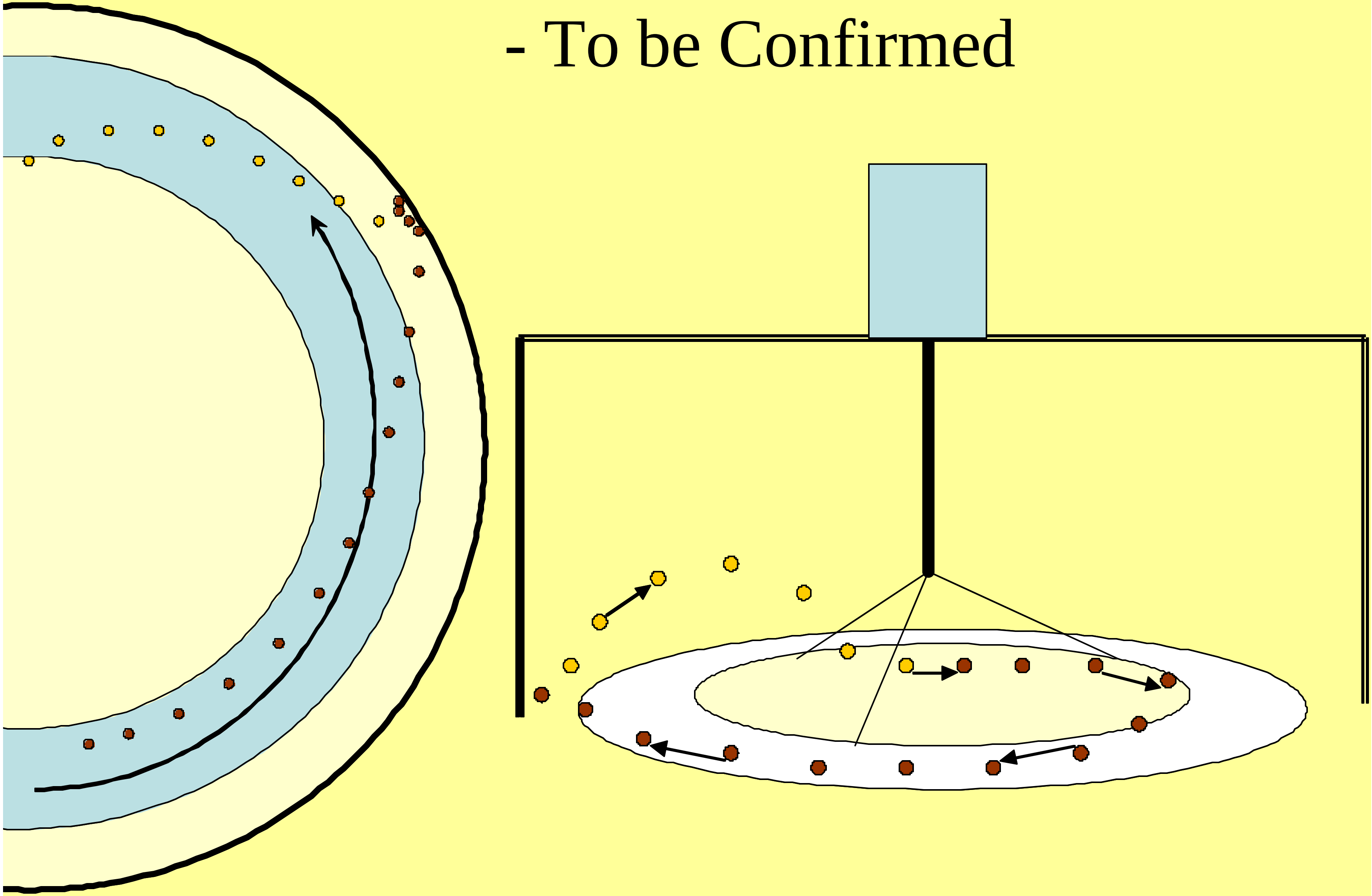
PI-SWIRL v.2



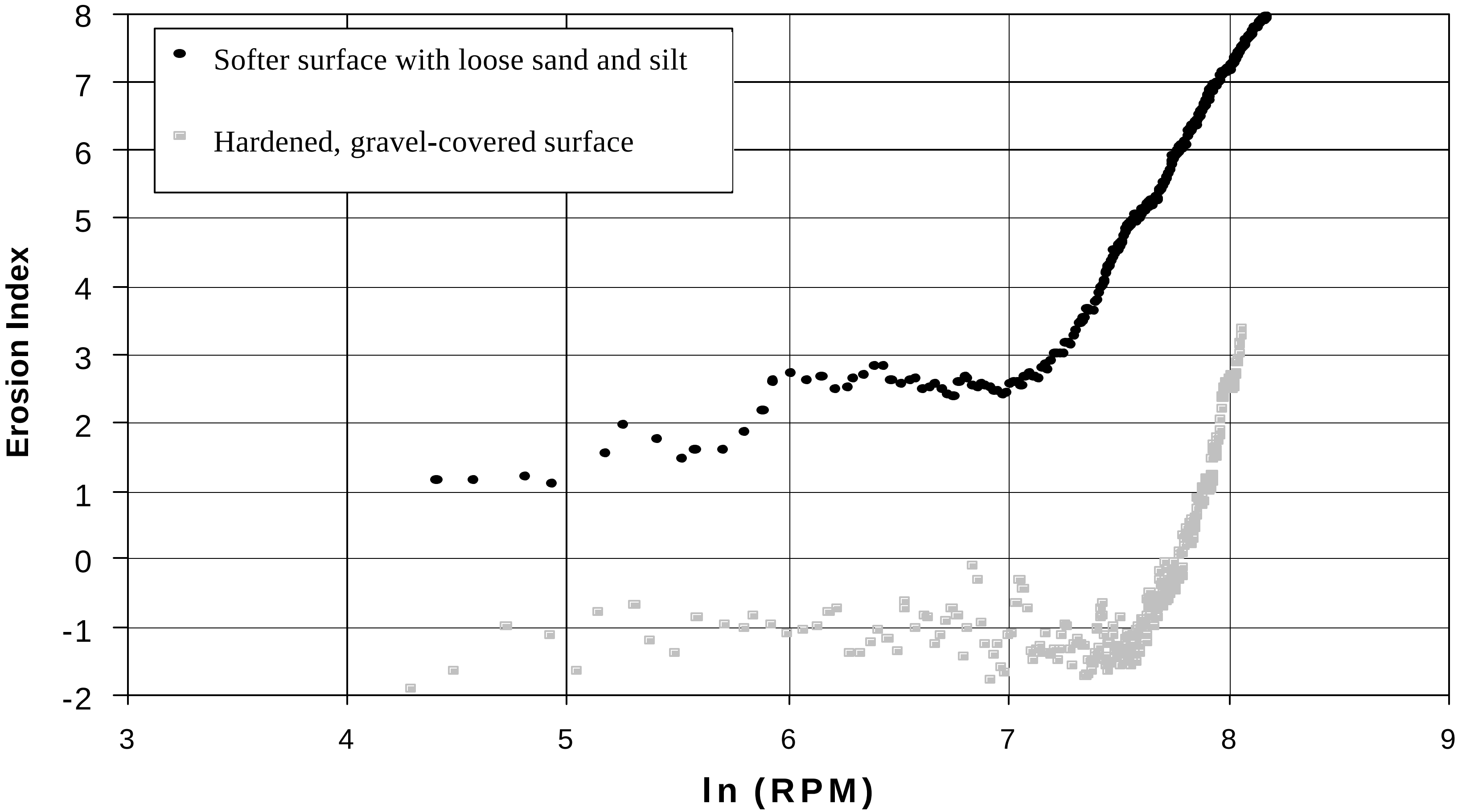
Wind Vectors in PI-SWIRL



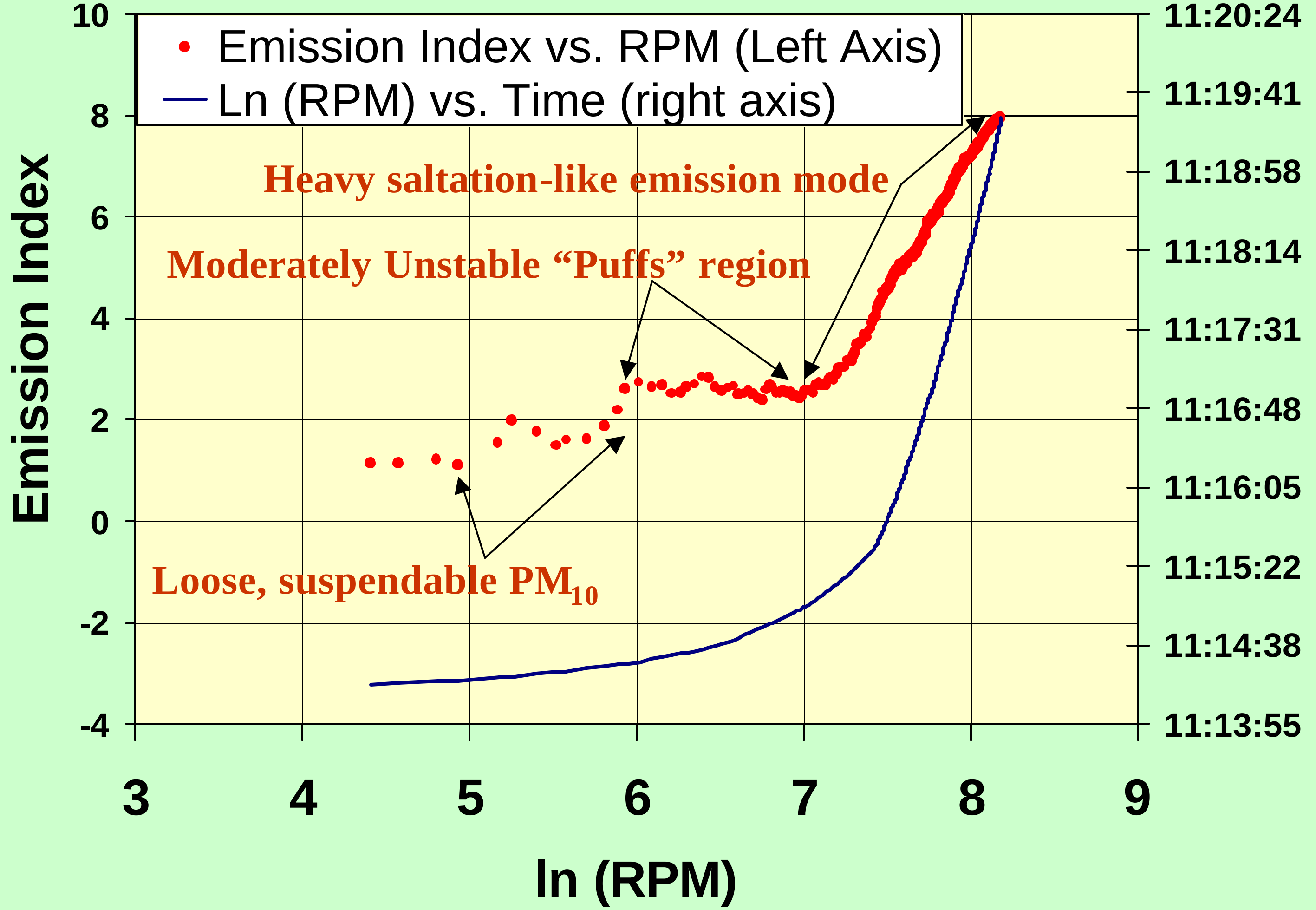
Sand grain motion in PI-SWIRL Cavity - To be Confirmed



The PI-SWIRL-ogram



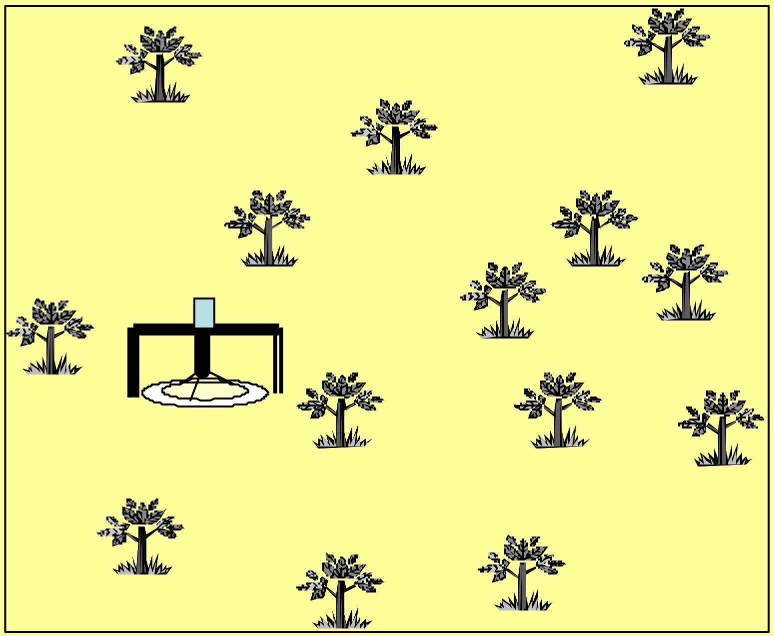
PI-SWIRL-ogram Parts

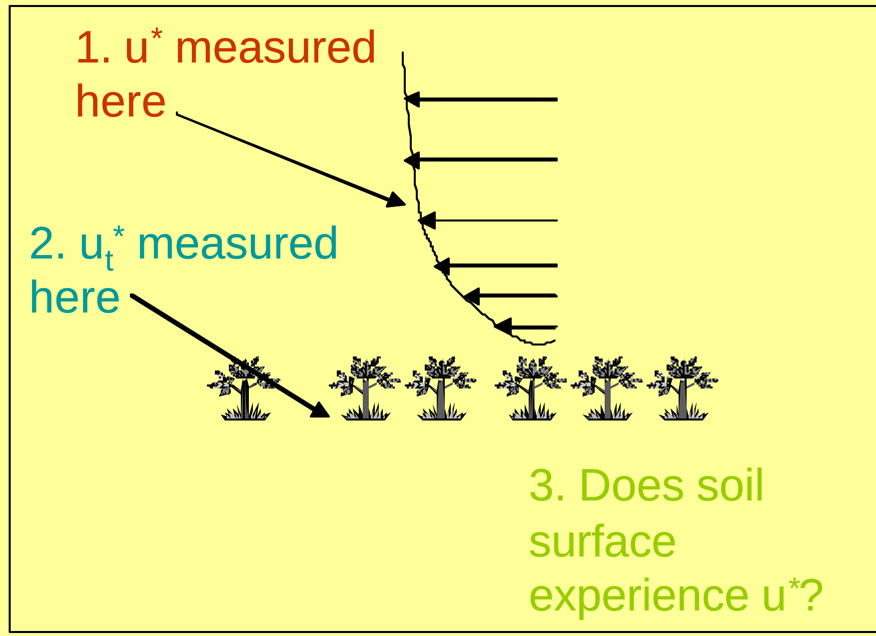


PI-SWIRL: Advantages/Disadvantages

- Advantages:
  - Fast, semi-portable, measures index based on shear stress
  - Symmetry bypasses boundary layer issue
  - Geometry allows simulation of “saltation-like” emissions
- Disadvantage: At present – relative standard
  - calibrate against LWT?
  - characterize shear stresses distribution with
    - Internal sensors?
    - Modeling?

Interpreting In-Canopy Data





SWIRLER: Future priorities

1. Characterize shear stresses/flow as *f (RPM)*
2. Establish equivalent emission factors
3. Investigate importance of dimensions
    a. Does height have effect on measurement?
    b. Should rotor blade be wider/narrower?
    c. How small can you go without losing physics?
4. Establish equivalent u^*_t for in-canopy work
5. Replace DustTrak with rugged light-based measure

Thank you

- DRI
- Encapco Inc – NTS Soil Stabilization