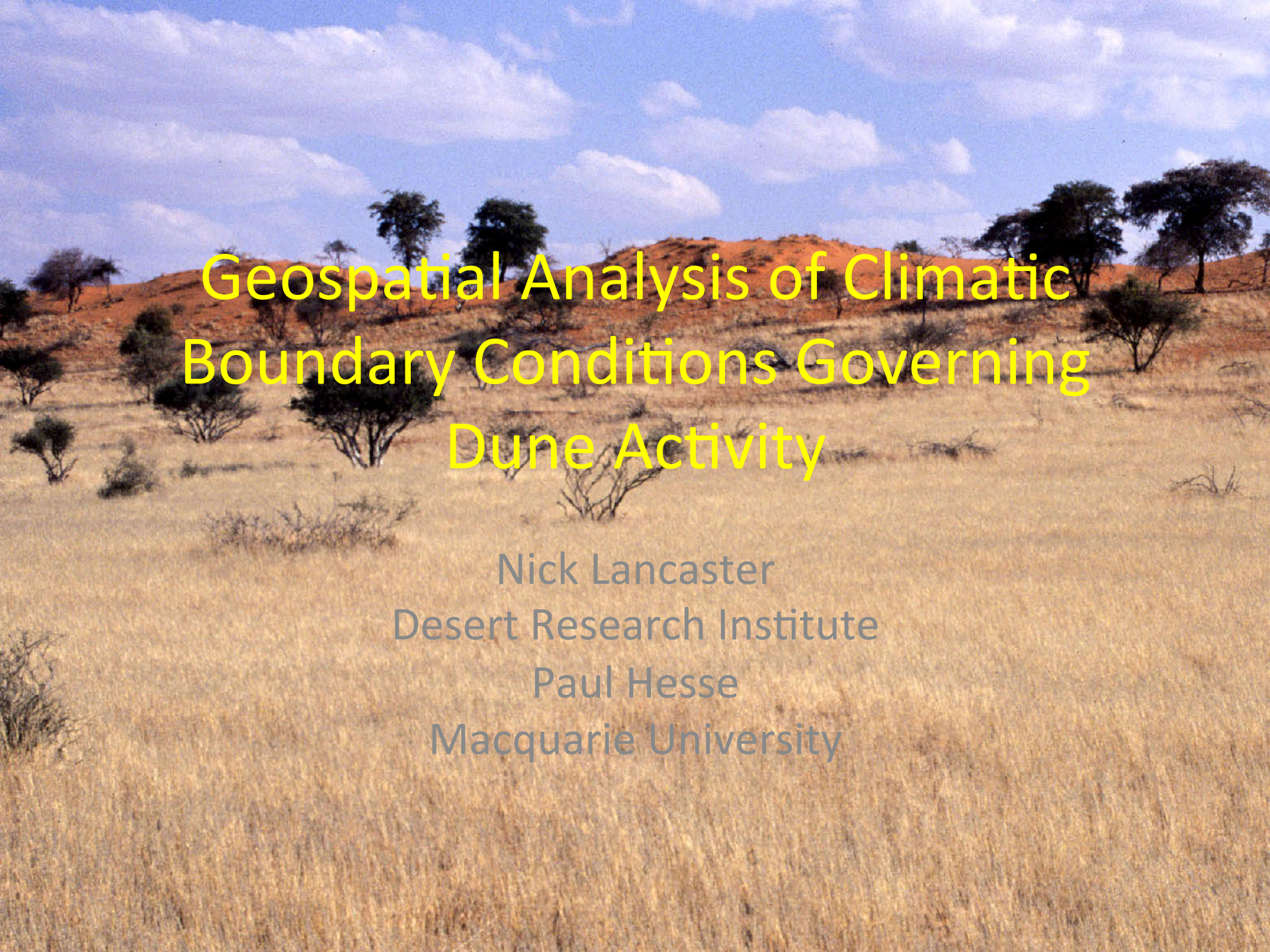

Geospatial Analysis of Climatic Boundary Conditions Governing Dune Activity

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Dune activity

Wide spectrum of states

"Active" → "Inactive"

Increasing vegetation cover

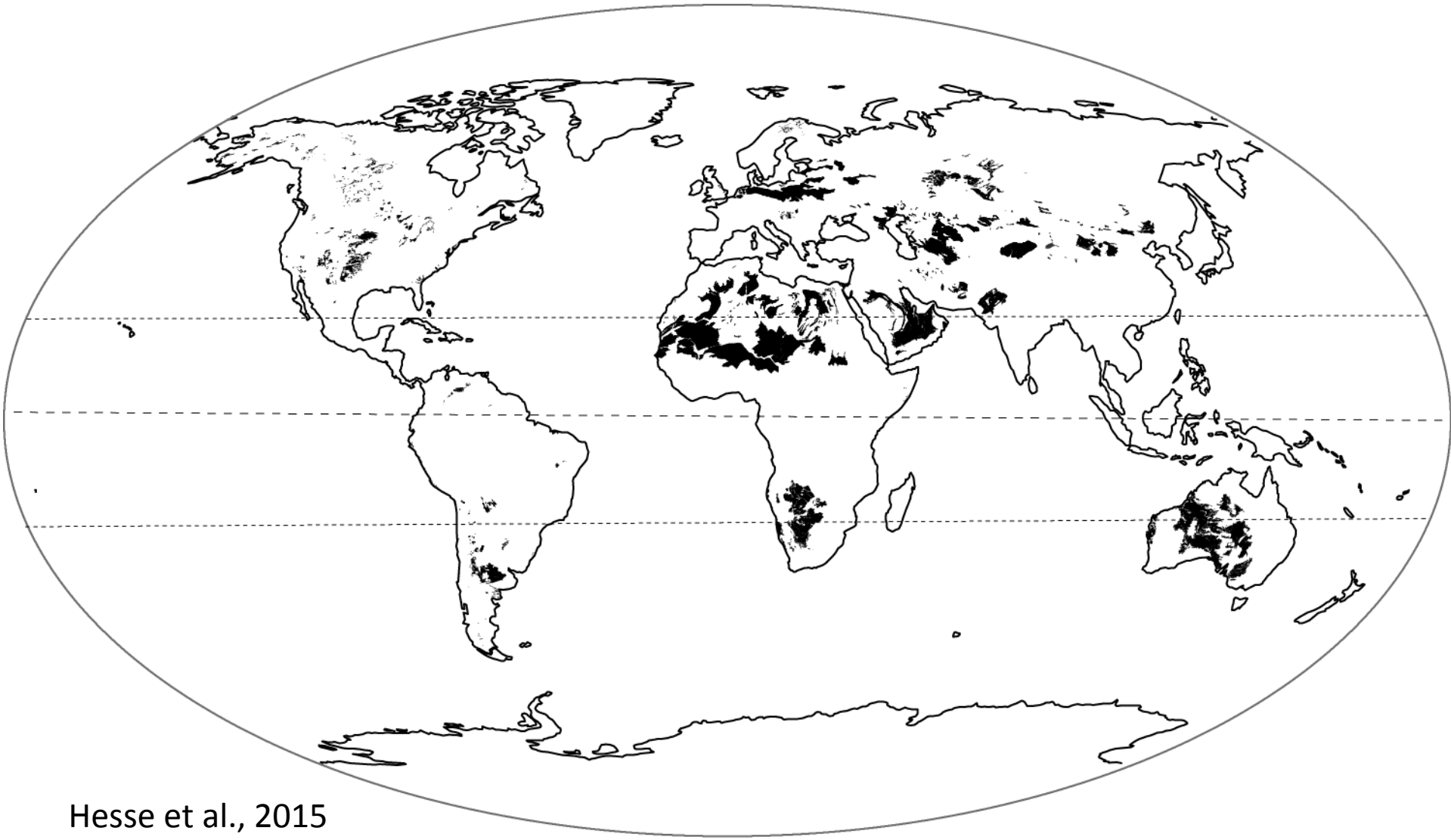
Controls on dune activity (boundary conditions)

- Sediment supply
- Sediment availability
  - Vegetation cover
  - Soil moisture
  - Crusts
- Sediment mobility
  - Wind energy
  - (sand) Drift Potential (DP)

Quantifying boundary conditions

- Sparse information from observations
- Global gridded datasets faciliate new approach
  - Precipitation, temperature, aridity index (P/PET) (1 km resolution)
    - Trabucco and Zomer, 2009
  - Sand drift potential (DP) (2.5 km resolution)
    - Ashkenazy et al., 2011
  - Satellite-derived vegetation cover (1 km resolution)
    - Broxton et al., 2014
- Combined with digital dune mapping in GIS framework

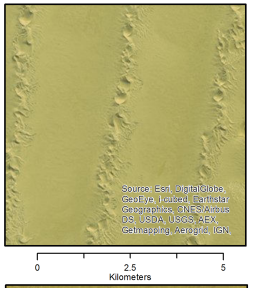
Global digital dune map

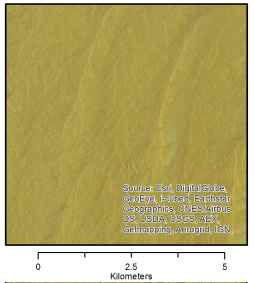


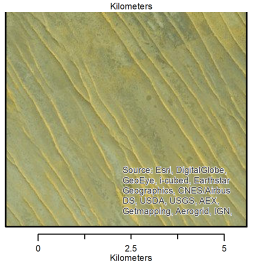
Hesse et al., 2015

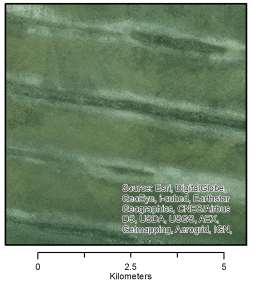
Dune activity classes

Class	Dune Morphology	Vegetation
1 (active)	continuous sharp crests with slip faces	little or no perennial vegetation present (<5%)
2 (partly active)	discontinuous segments of sharp crests with slip faces	sparse cover of perennial vegetation except on slip faces and crests (10-15%)
3 (Inactive)	distinct crests but only rare patches of bare crest or slip faces	Discontinuous perennial vegetation present on crests, flanks and interdunes (>15%)
4 (degraded)	indistinct crests with very rare or no bare areas	continuous cover of perennial grasses, shrubs, and trees (>20%)



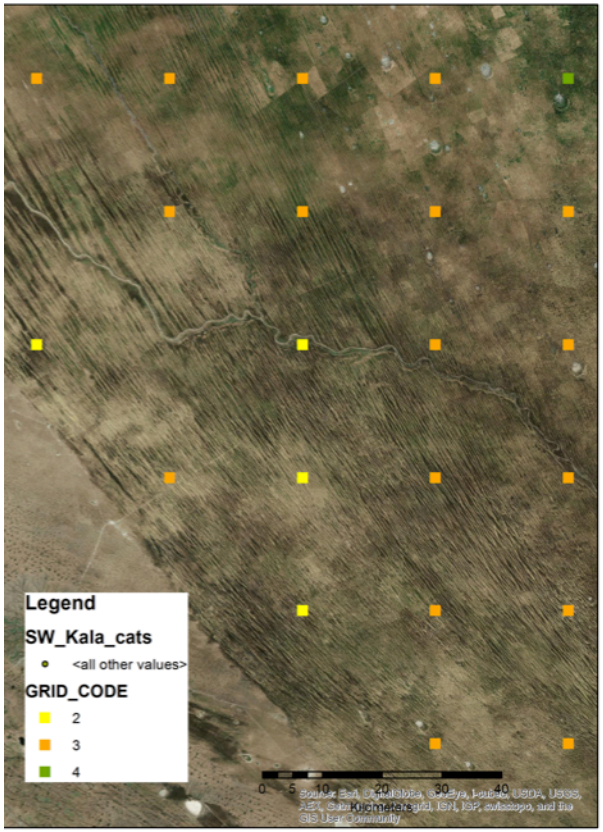


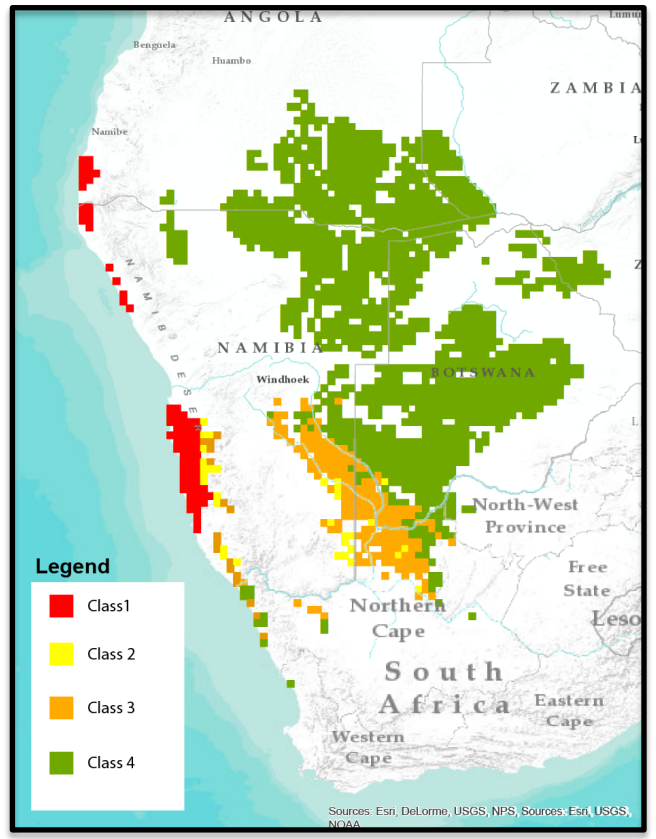




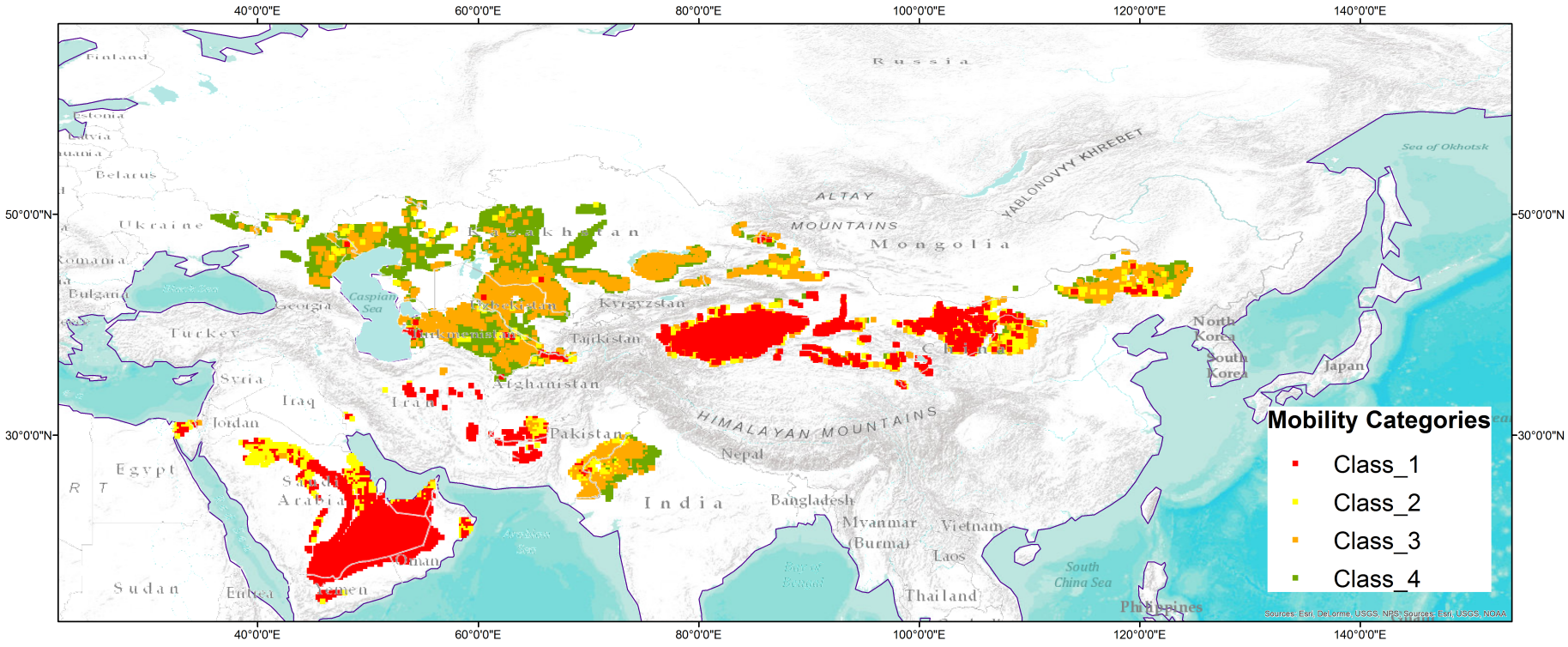
Mapping dune activity

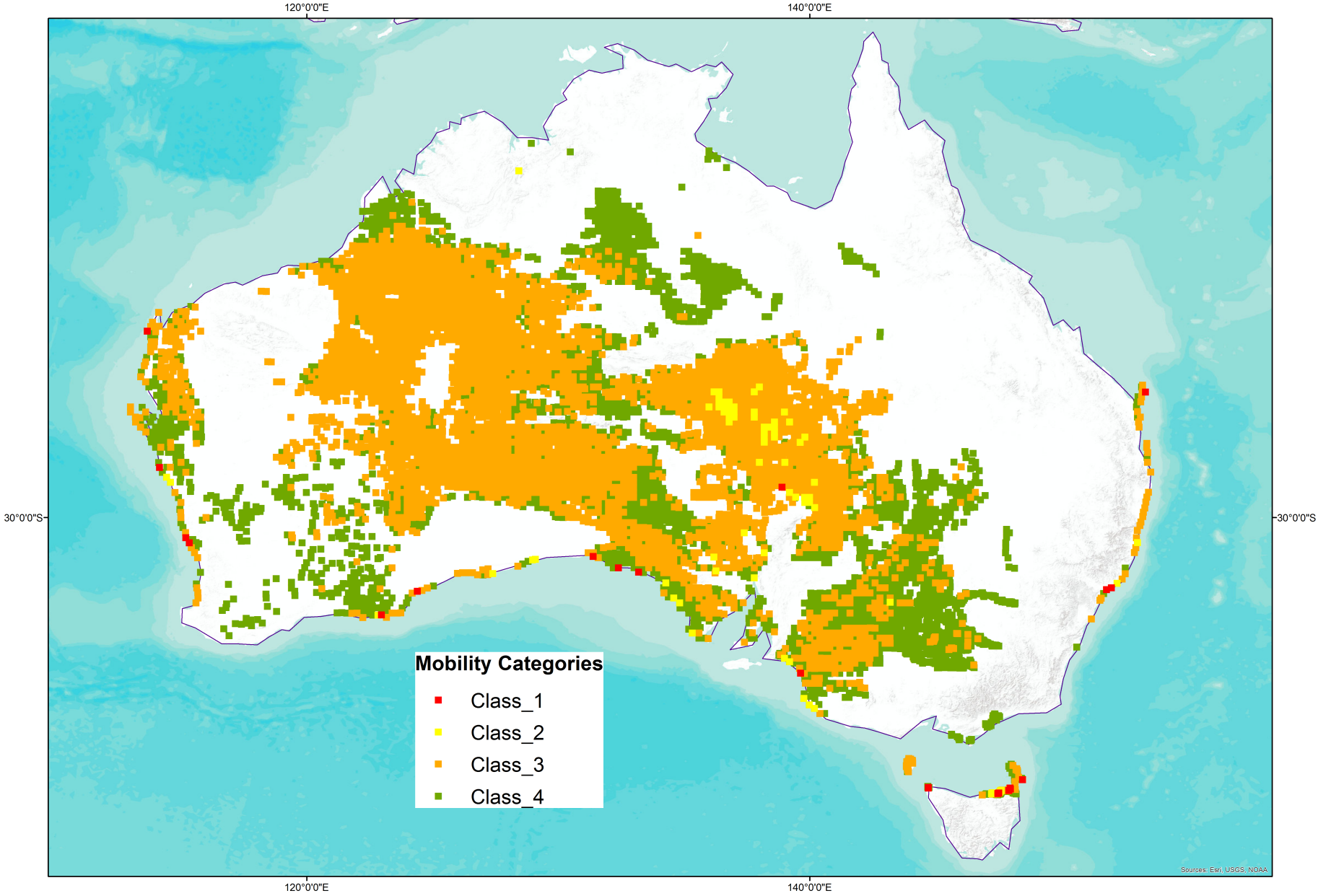
- 0.2 degree grid superimposed on image layer
- Activity classified at grid nodes using Hesse et al. (2016) criteria
- Data extracted for each dune field polygon



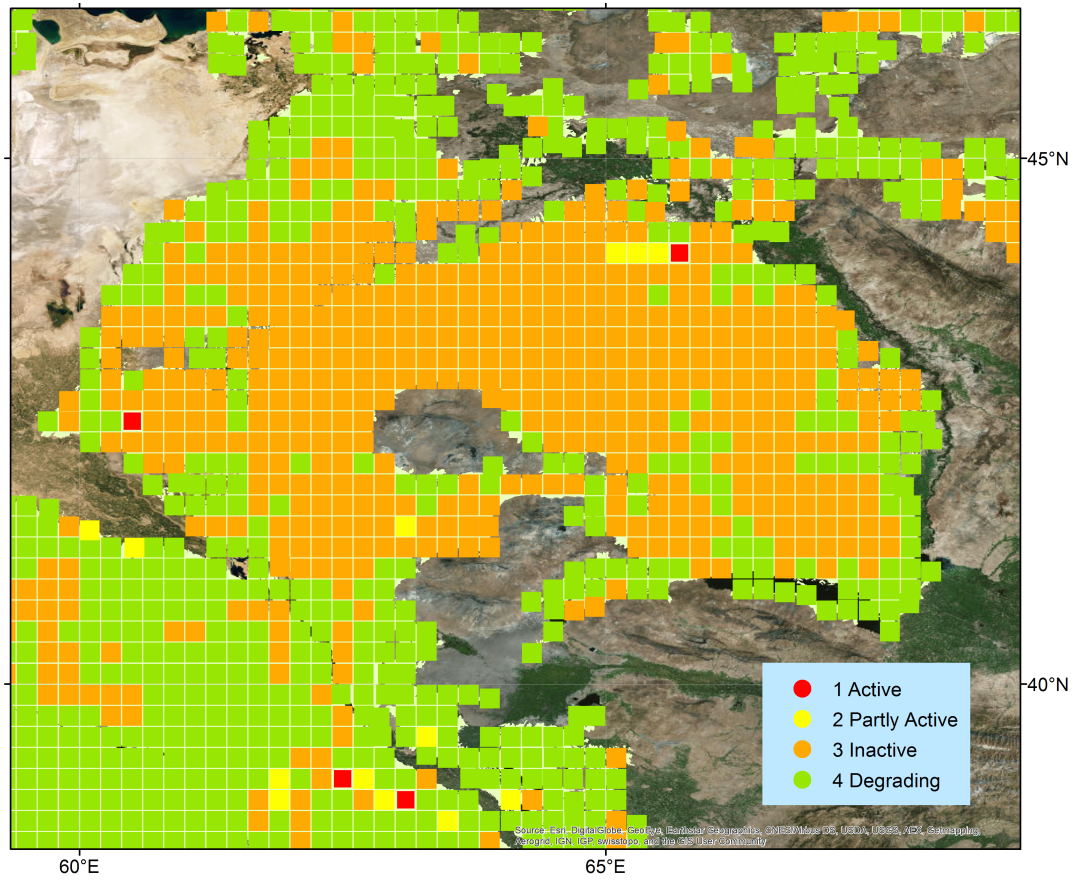


Dune activity map examples



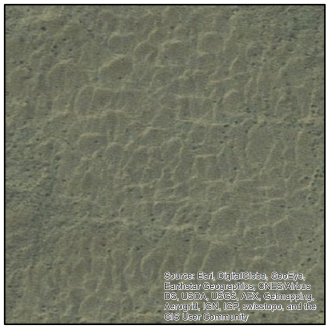

120°0'0"E
140°0'0"E
30°0'0"S
Mobility Categories
Class_1
Class_2
Class_3
Class_4
Sources: Esri, USGS, NOAA

Intra-dunefield patterns



Concentric activity pattern: Kyzyl Kum

Degrading – dunefield margins



Inactive - dunefield interior

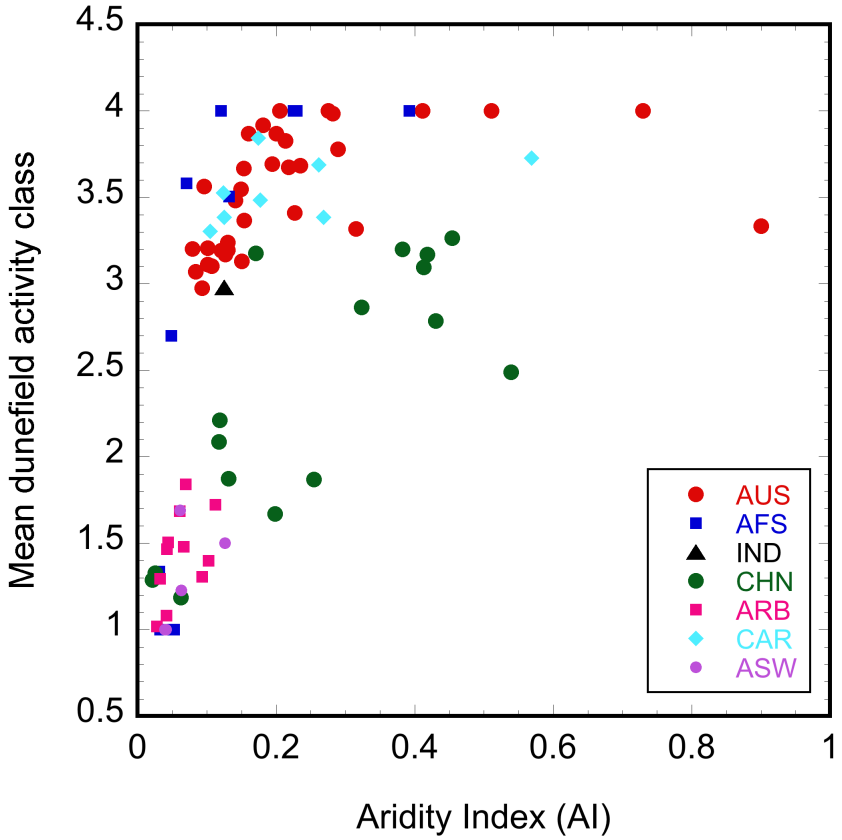
Active – tallest dunes

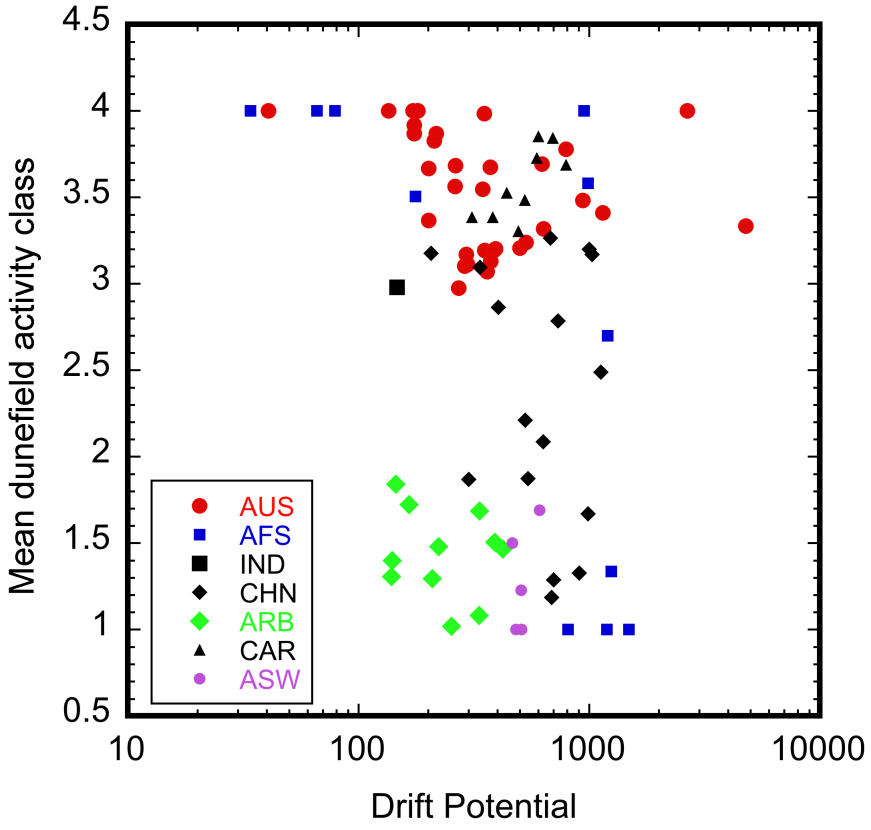
Integrating datasets

- Global datasets for DP, AI, and Vegetation cover sampled at 0.2 degree grid points for each dune field
- Calculation of modified sand mobility index

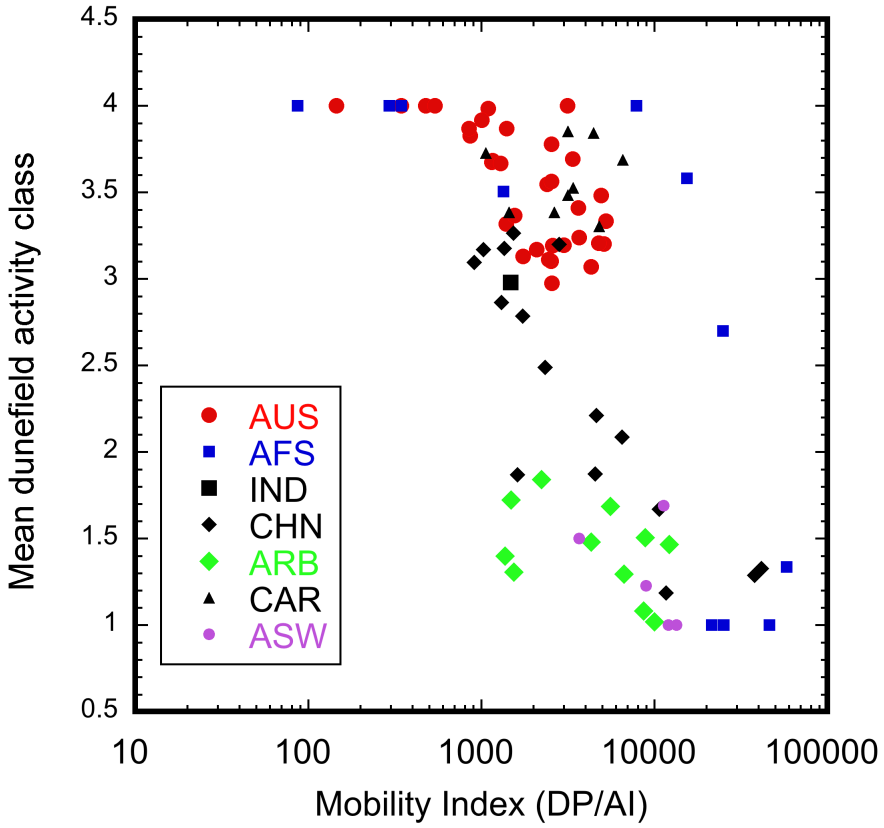
  SMI = Drift Potential/Aridity Index
- Comparison of activity classes with AI, DP, SMI

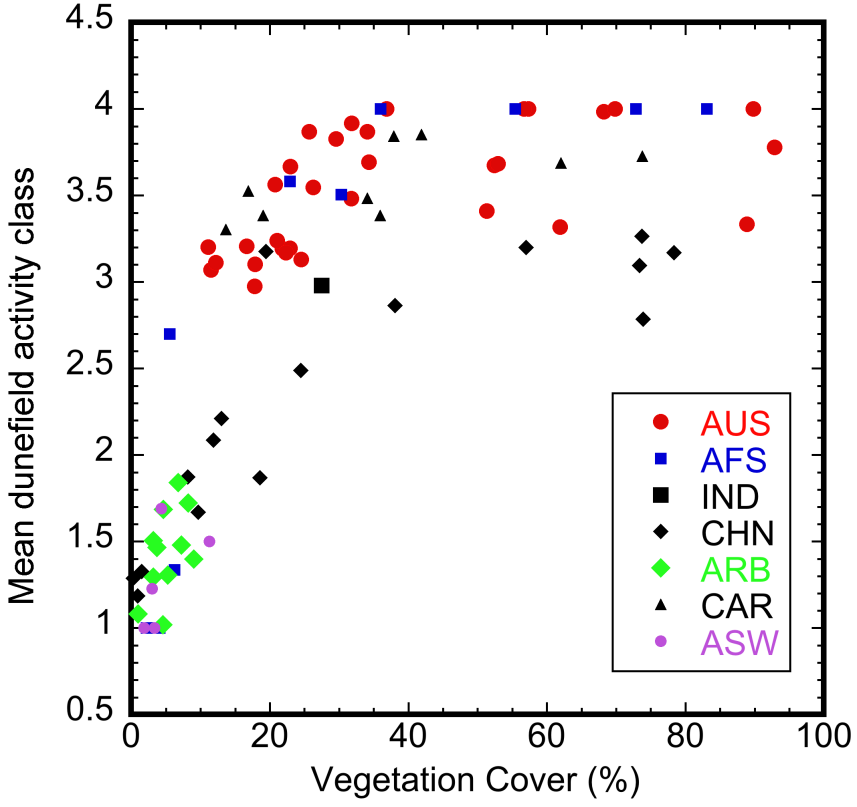
Aridity Index and Sand Drift Potential



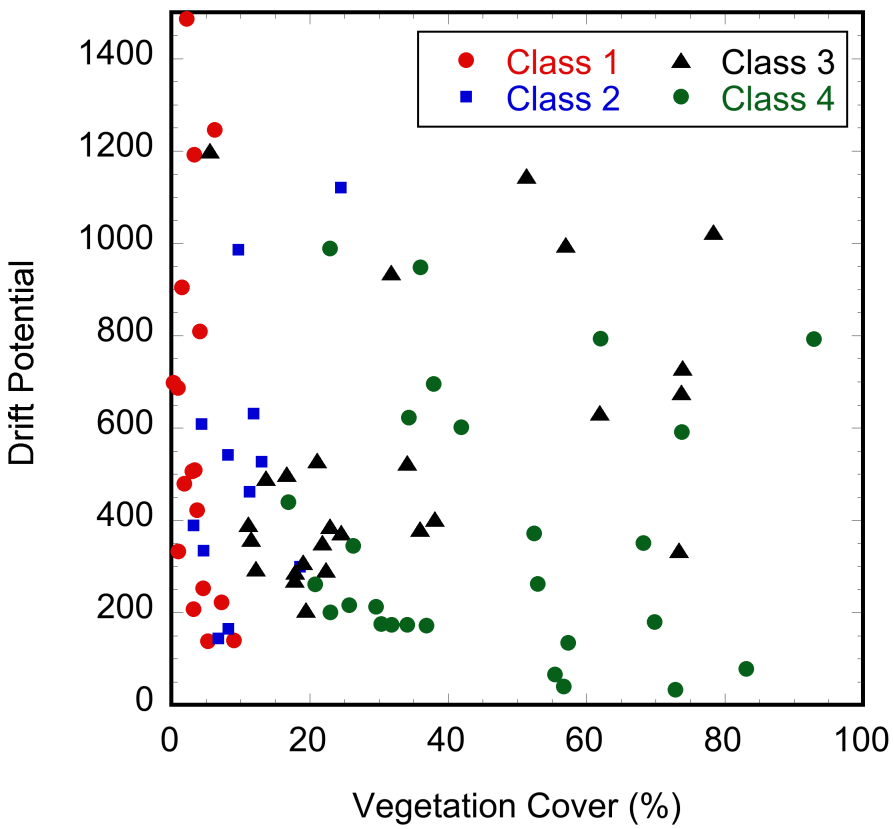


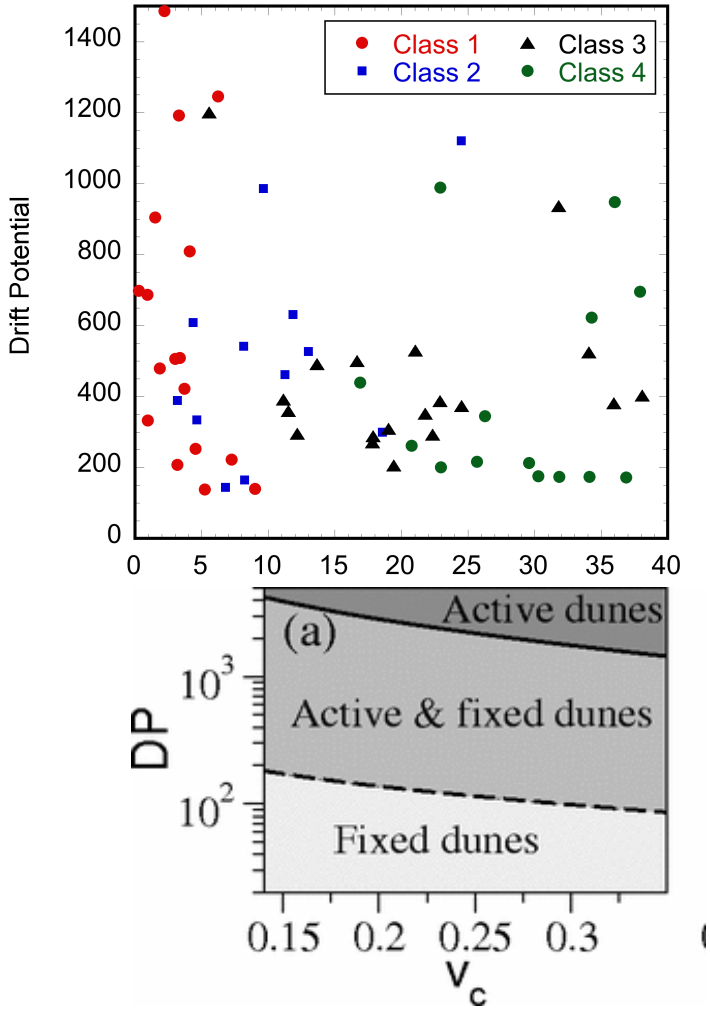
Mobility Index and Vegetation Cover





Process domains

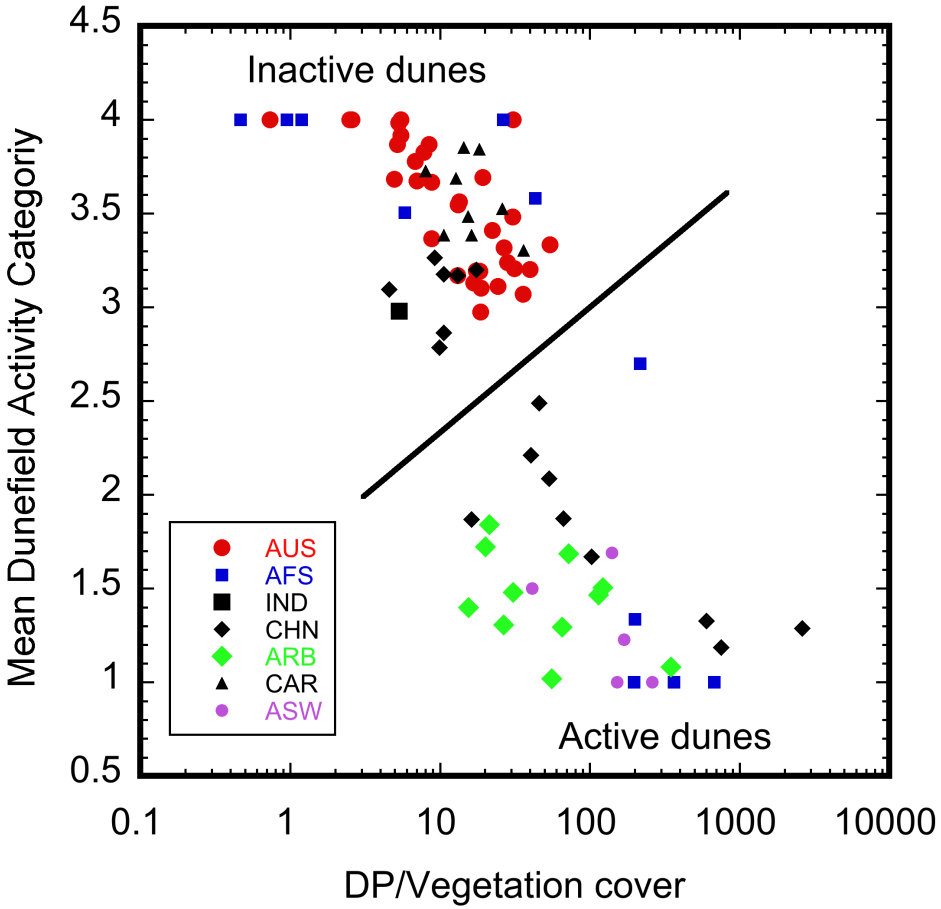




Compare to Yizhaq et al. (2007)

A new index of dune activity?

- Ratio between drift potential and vegetation cover
- Captures driving force (DP) and resisting effect of vegetation via surface protection and shear stress partitioning
- Discriminates between “active” and “inactive dunes”
- Scatter suggests other factors are involved



Conclusions

- Broad-scale relationships between dunefield mean activity, climate, and vegetation cover
- Scatter in data suggest other factors at work
- Intra-dune field patterns complex
- Much more work to be done to gain a full understanding of controls at different spatial and temporal scales