Earths's Dune Systems A Synthetic, Data-driven Approach

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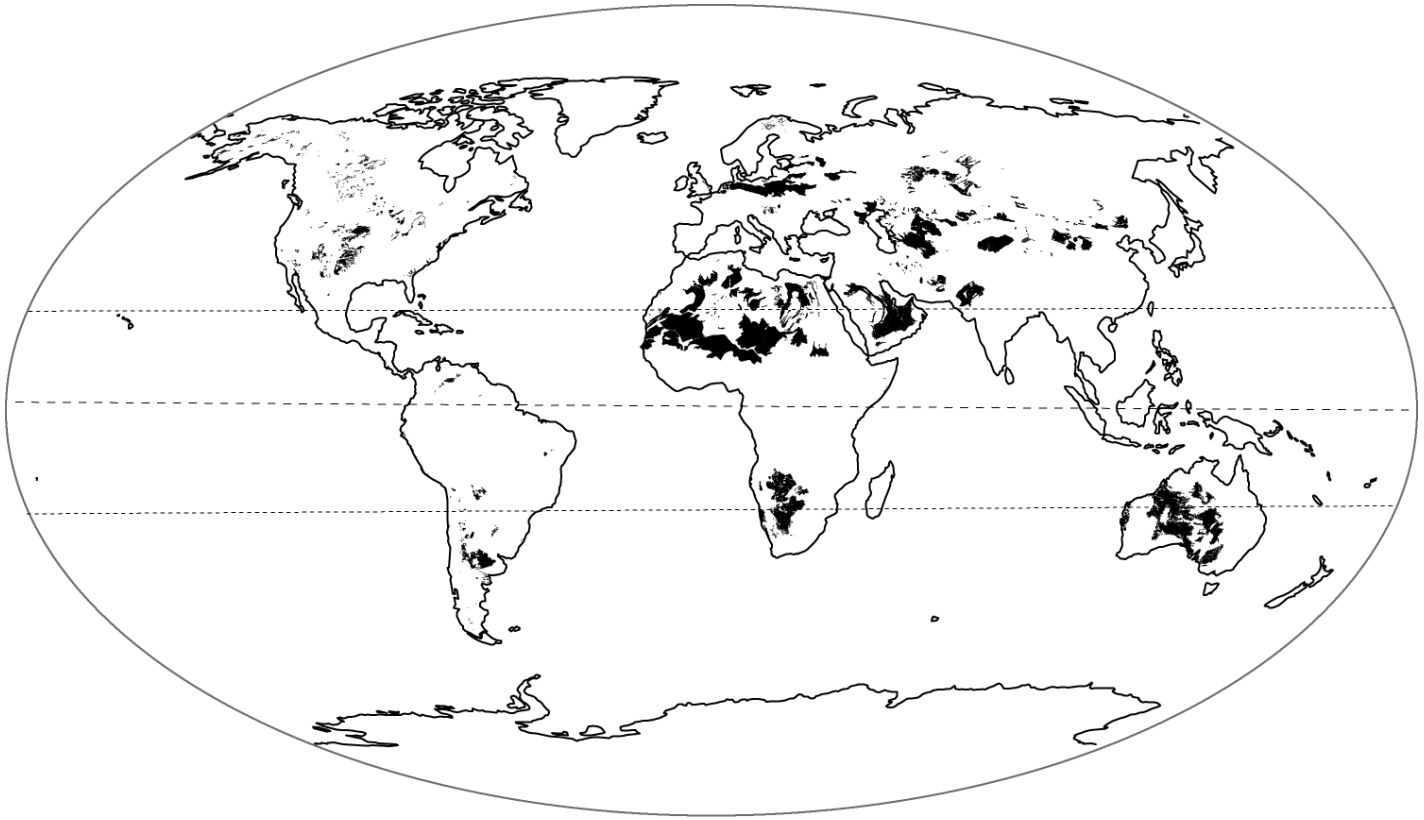
Sand seas and dune fields occur at all latitudes and on every continent



Area is approximately 10 million sq km; 6.74% of land surface area

Historical Perspective

ERGS

I.G. WILSON
*Department of Geology, University of Ife, Ile Ife (Nigeria)**

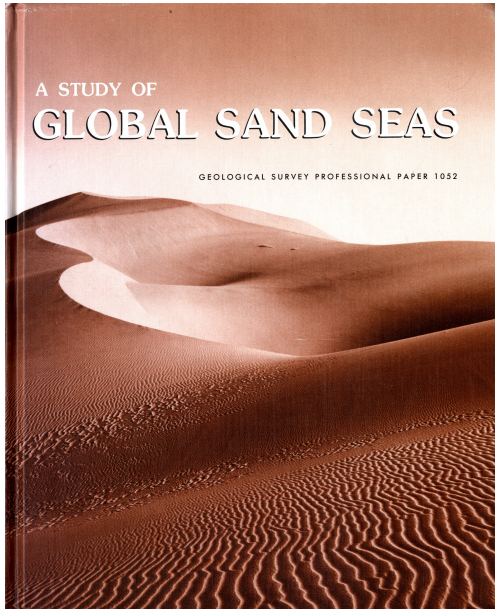
(Accepted for publication April 12, 1973)

ABSTRACT

Wilson, I.G., 1973. Ergs. *Sediment. Geol.*, 10: 77—106

Ergs (areas of aeolian sand deposits) invariably have bed forms usually with a 3-order hierarchy of ripples, dunes and draas (large sandy bed forms). Ergs may occur in any relatively vegetation-free area with an adequate sand supply. The virtual absence of ergs from highland areas is attributed largely to acceleration and divergence of the winds which makes the sandflow undersaturated. Ergs with thick sand deposits and draa development in the Sahara, Arabia and Asia are contrasted with thinner dune ergs in Australia which lack draa development. Sand thickness, proportion of sand-cover, bed-form height, spacing and orientation vary in a significant way with position within the Algerian ergs. This may partly be due to regional variations in the wind regime but more probably to regional grain-size variations which, because they determine the threshold velocity of sand movement, control the *effective wind regime* in an area. Grain-size variations can be interpreted from aerial photographs to a large extent because of their effect on the size and shape of the bed form. A study of the northern Algerian ergs shows that regional patterns of sandflow may vary according to the grain size considered and that there is no simple relation between wind directions and the draa trends in any area even although the latter are maintained consistently for large distances.

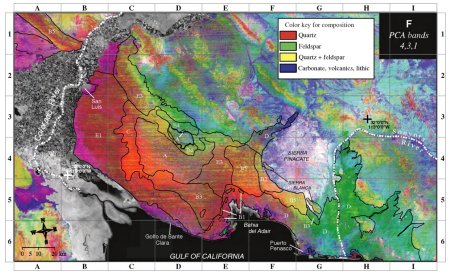
Wilson, I.G., 1973. Ergs. Sedimentary Geology 10, 77-106.



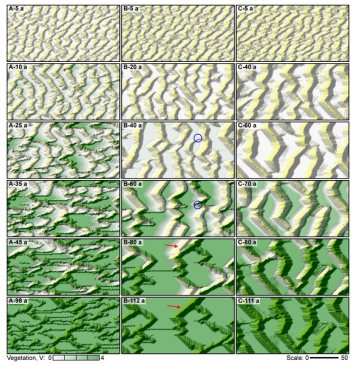
McKee, E.D., 1979. A Study of Global Sand Seas. United States Geological Survey. Professional Paper 1052.

Many new data sets and approaches

- Data sets
  - Remote sensing image/spectral data
  - Digital Elevation Models
  - Luminescence dating
  - Ground Penetrating Radar
  - Geochemistry/Mineralogy of sand
  - Climate model data
- Approaches
  - Statistical analysis of dune patterns
  - Numerical modeling of dunes and dune fields



Scheidt et al., 2011



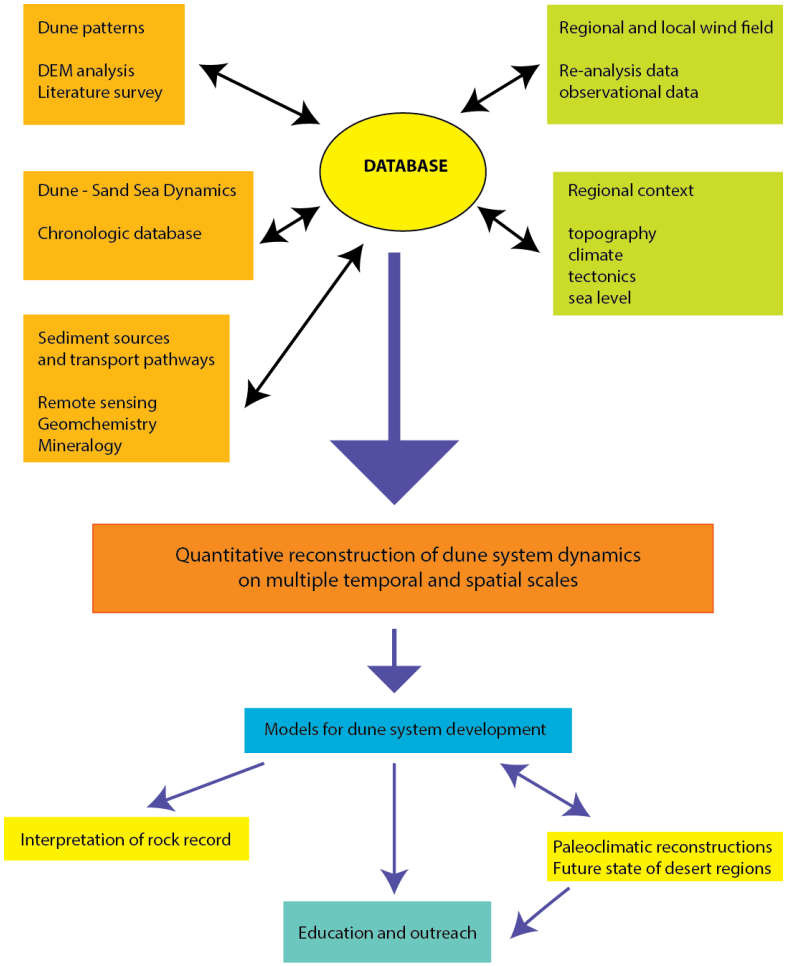
Barchyn and Hugenholtz, 2012

The challenge(s)

- How do we use these multiple datasets to understand dune systems in space and time?
- How do we integrate data on dune patterns, dune sediments, and dune ages?
- How do we synthesize multiple-scale field, remote sensing, and modeling datasets to inform dune system response to climate change, past and future?

A framework for dune systems research

Data-intensive approach to explore multiple-scale field, remote sensing, and modeling datasets



Existing data centric approaches

- Mars Global Digital Dune Database – MGD^3 (Hayward et al., 2007, 2010, 2012)
  - Data for > 550 dune fields – emphasis on morphology and morphometry
- Namib Sand Sea database (Livingstone et al., 2010)
  - Multiple GIS layers for dune morphology, DEM data, winds etc.
- INQUA Dunes Atlas (Lancaster et al., 2016)
  - Geo-located chronologic and (some) morphologic data

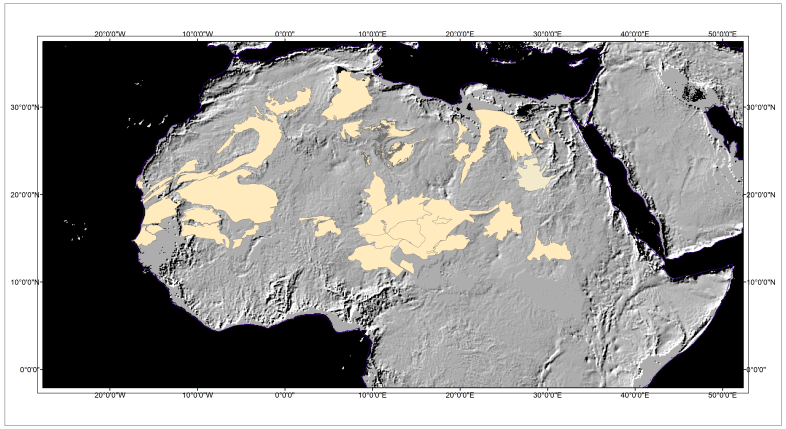
A new global approach

- Spatial Database
  - Digital mapping of dunefield and sand sea extent
  - Climatic, topographic, vegetation, chronology datasets
- Assessment and mapping of dune activity state
- Quantification of boundary conditions
  - Climate, topography, tectonics

Mapping of dune field and sand sea extent
(with Paul Hesse and Matt Telfer)

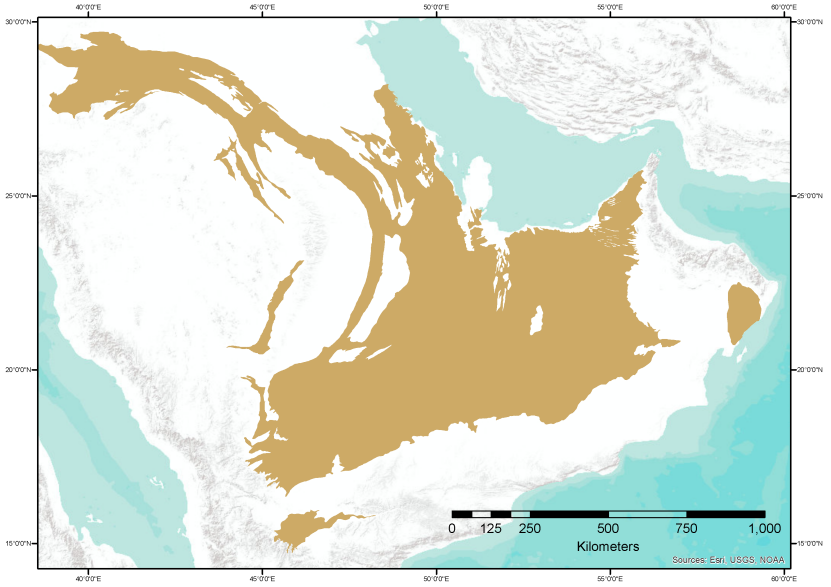
- Spatial Database
    - Compilation from published maps (digital and otherwise)
    - Mapping from image data
- All desert dunes, regardless of activity, preservation, vegetation cover, or size
    - excluded sand sheets and streaks
- Information on dune field and sand sea morphometry
    - Center latitude and longitude
    - Area
    - Major dune types

Example dune maps

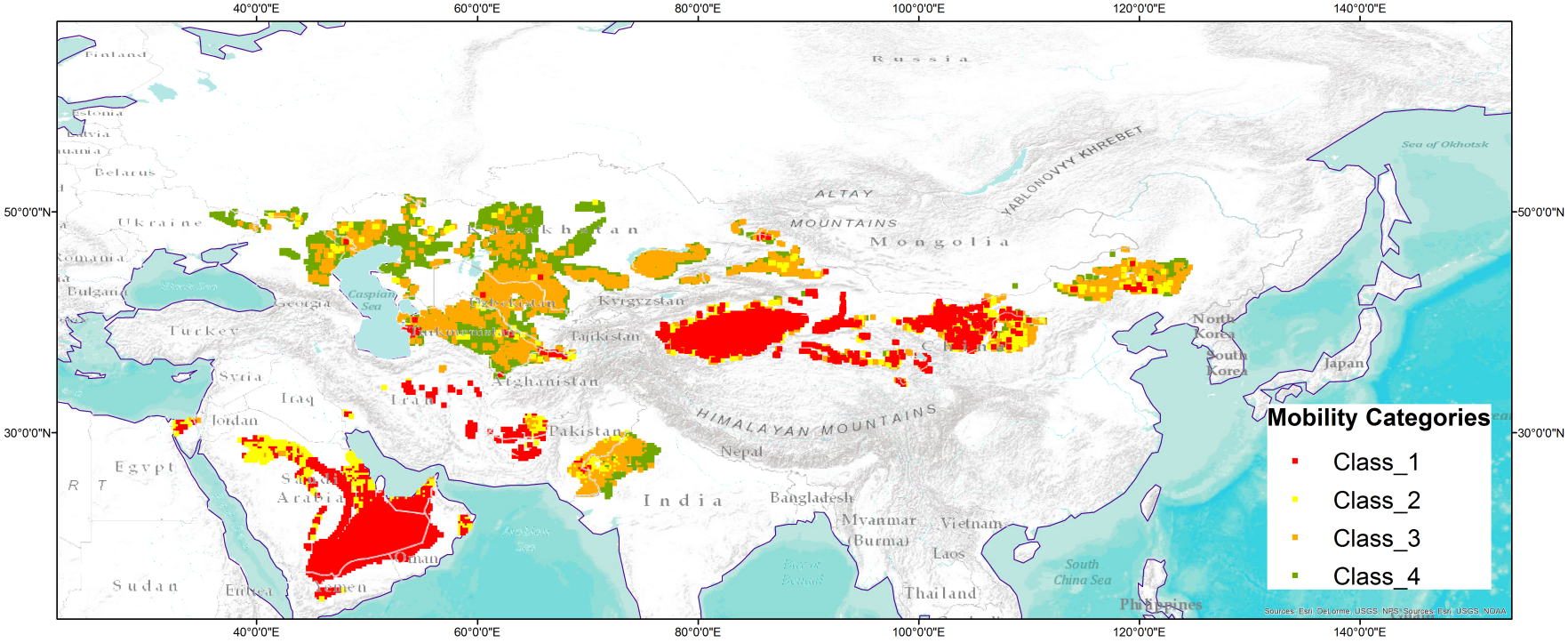


Sahara

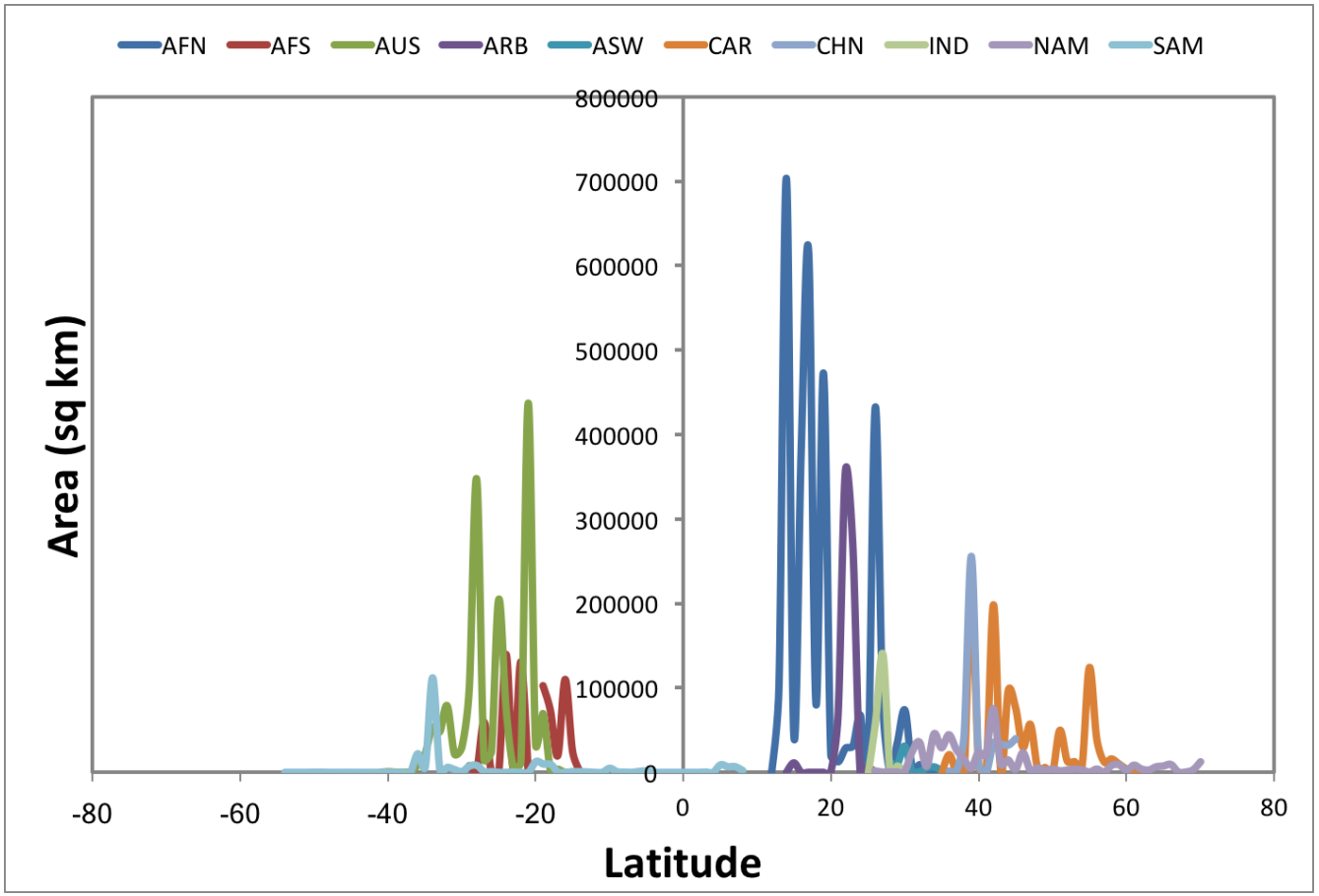
Arabia



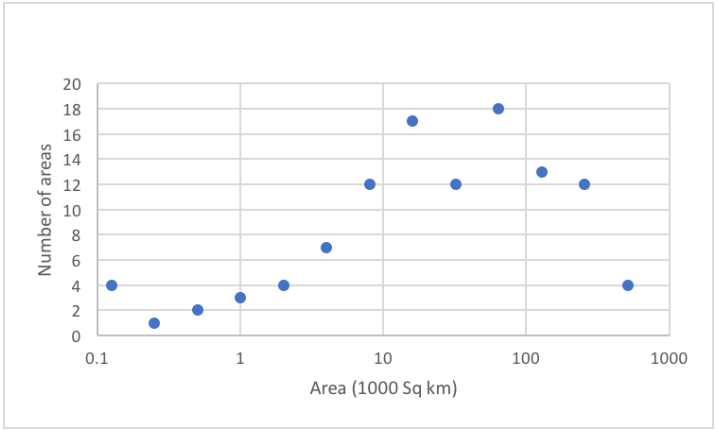
Dune activity map example



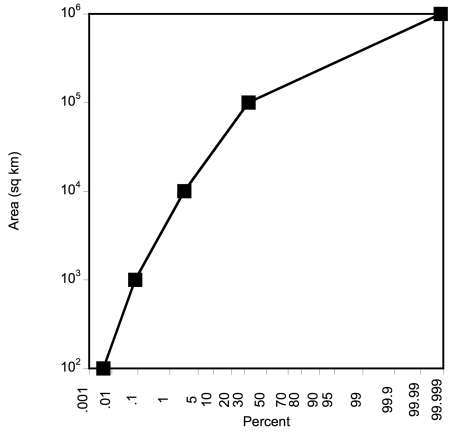
Latitudinal distribution of dunefields



Statistical Analysis of dune fields and sand seas indicates significance of large sand seas

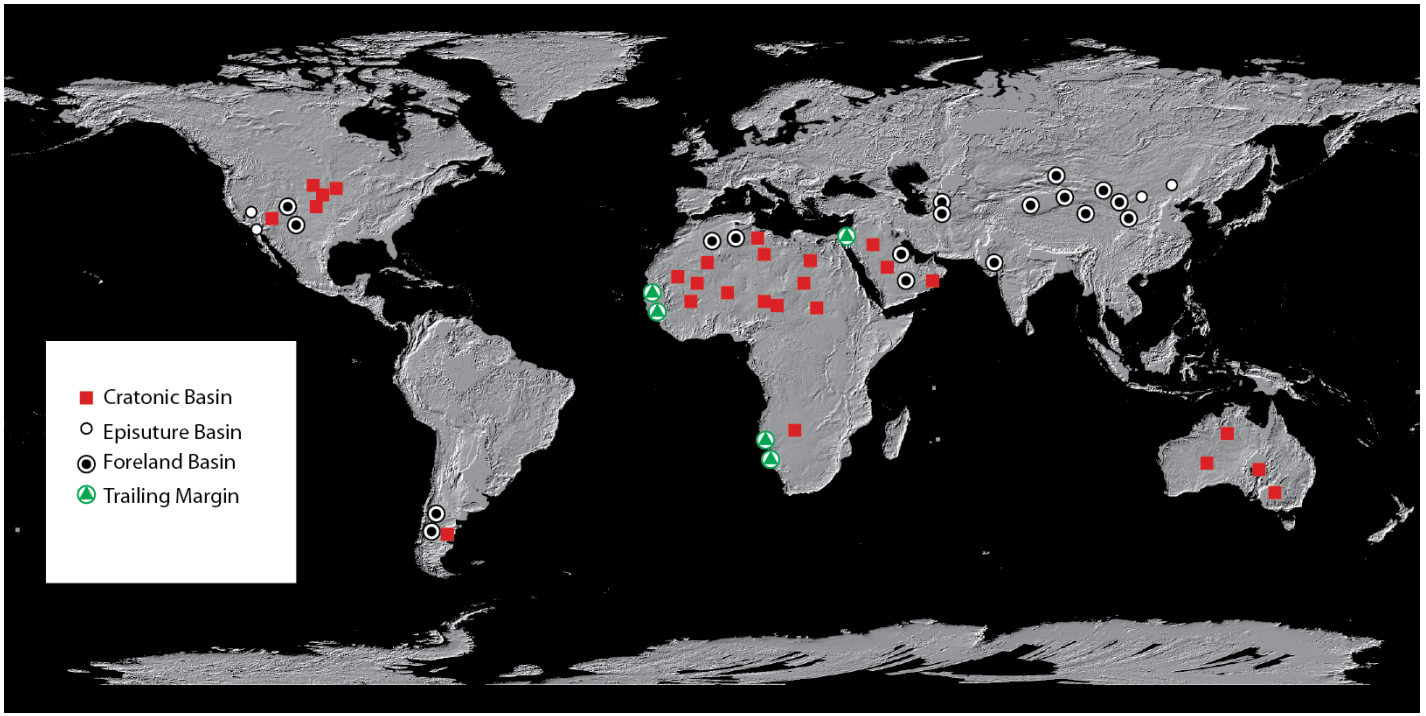


Data from Australia, Southern and Northern Africa, Arabia, India, China



50% of sand in sand seas > 100,000 sq km

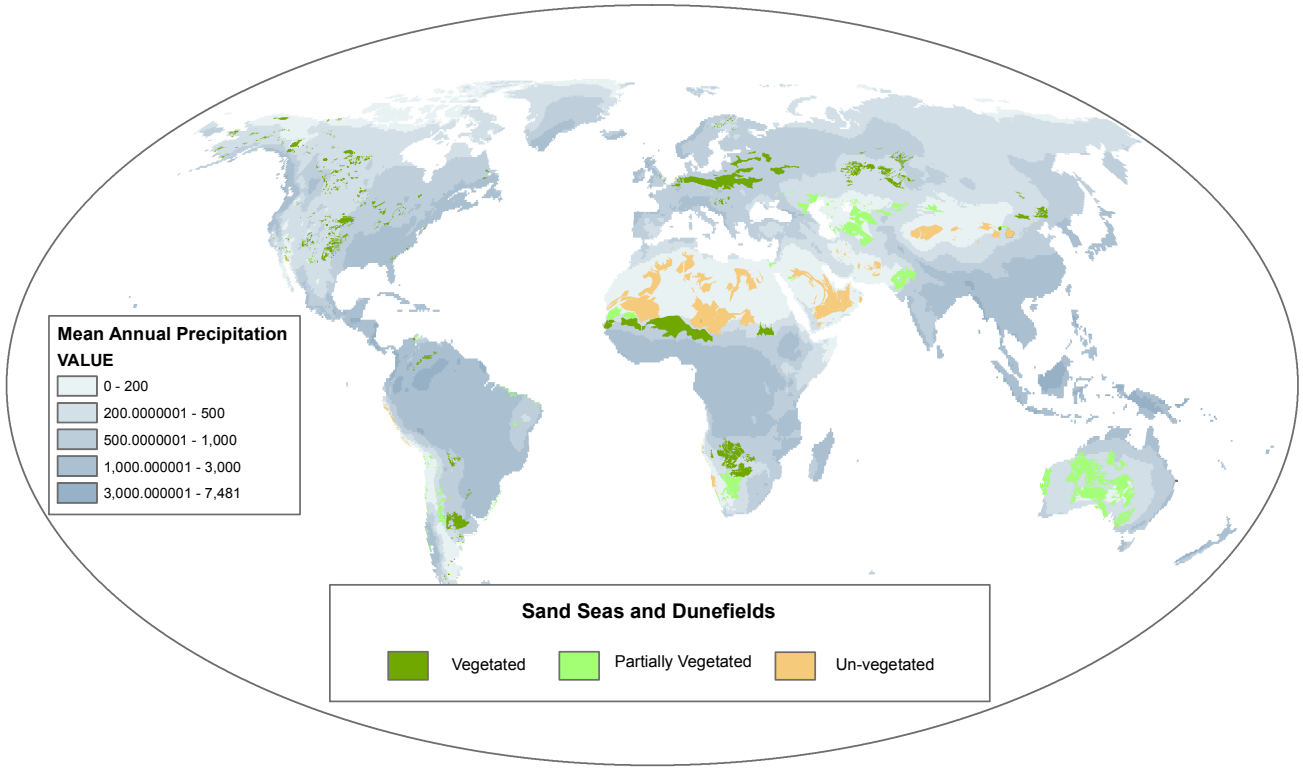
Tectonic settings of some sand seas



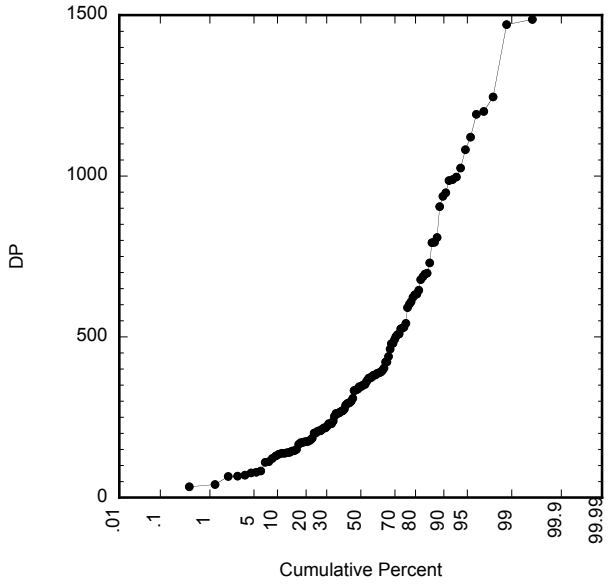
Tectonic data from Fugro Tellus Sedimentary Basins of the World

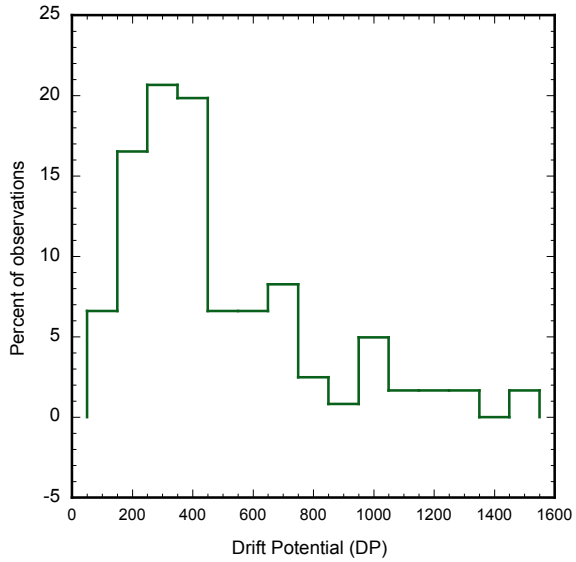
http://www.datapages.com/AssociatedWebsites/GISOpenFiles/FugroTellusSedimentaryBasinsoftheWorldMap.aspx

Sand seas and rainfall



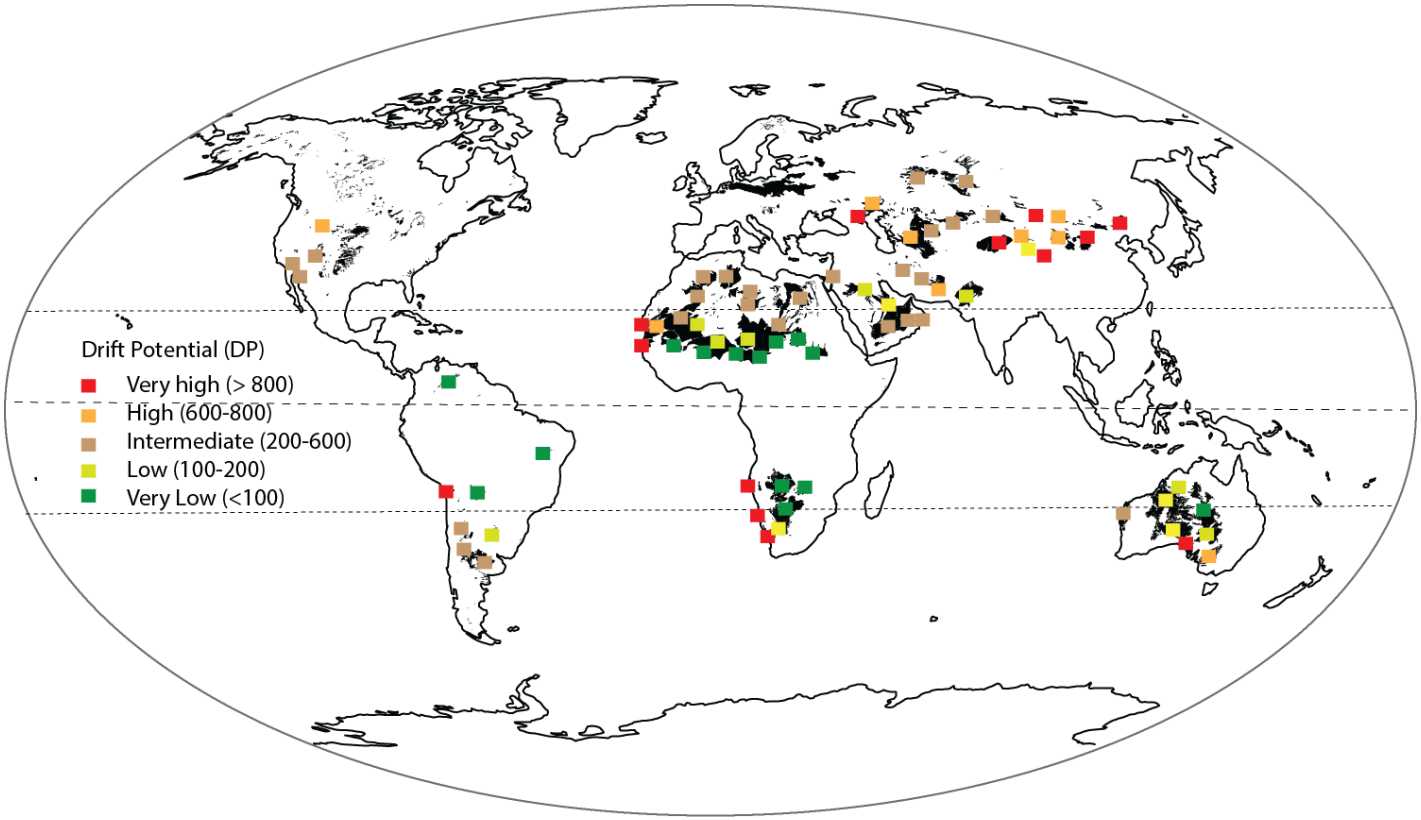
Sand seas and dune fields occur in a wide range of sand transport intensity (DP)

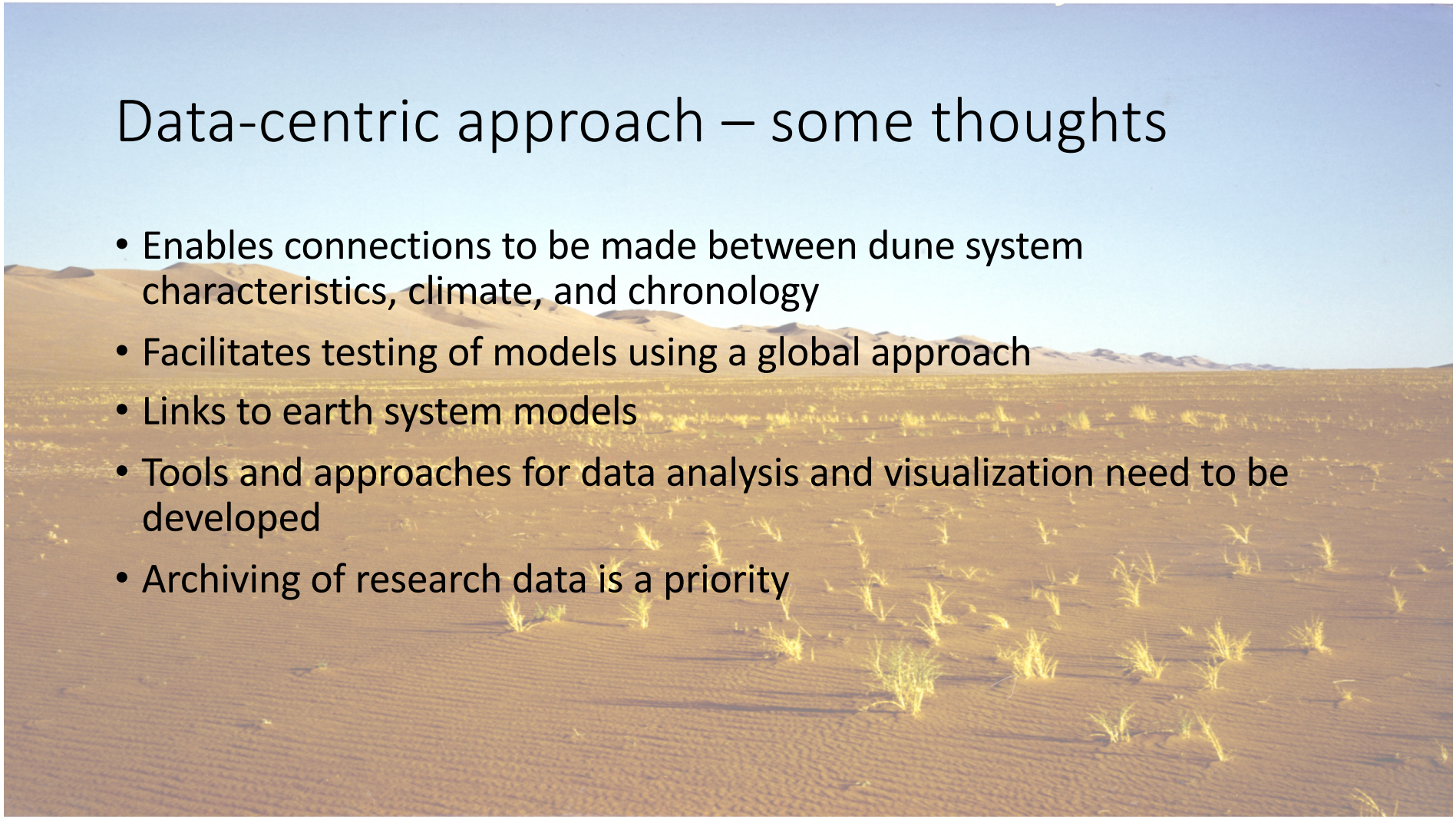




Modal range (50% of all sand seas) is 100-400 DP units

Sand Seas and Drift Potential





Data-centric approach – some thoughts

- Enables connections to be made between dune system characteristics, climate, and chronology
- Facilitates testing of models using a global approach
- Links to earth system models
- Tools and approaches for data analysis and visualization need to be developed
- Archiving of research data is a priority