

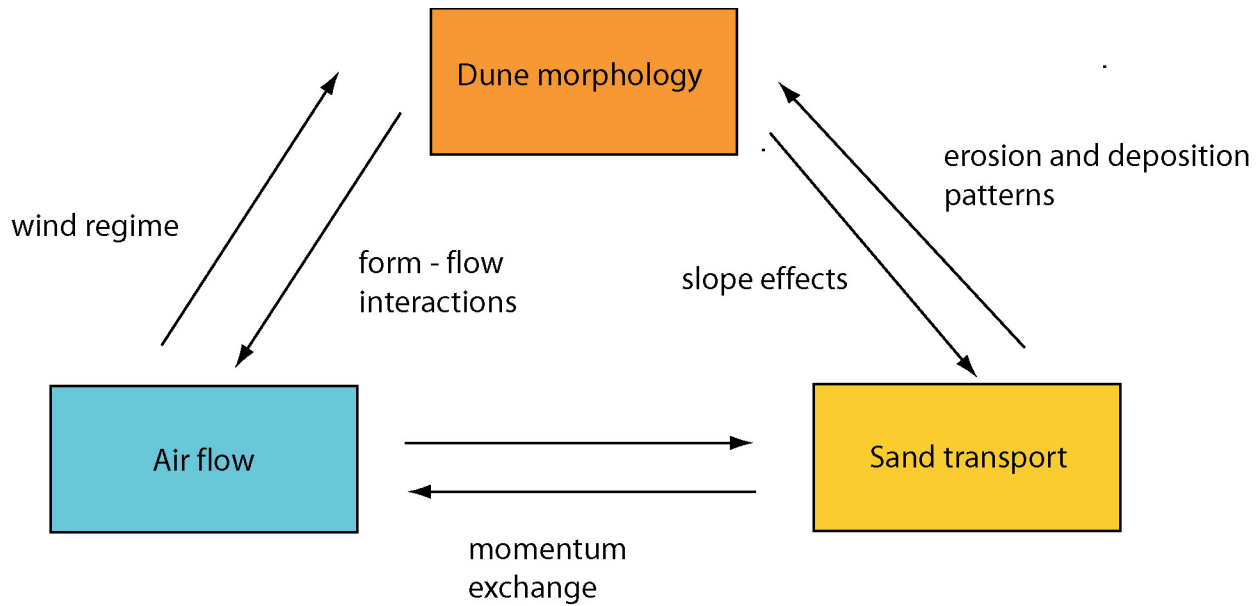
The background of the slide is an aerial photograph of a desert landscape. The terrain is characterized by numerous small, rounded sand dunes in shades of orange and brown. A prominent, light-colored, winding feature, likely a dry riverbed or a path, cuts through the dunes from the upper right towards the lower left. The overall scene is arid and textured.

Assessing dune dynamics from space

Nick Lancaster, Desert Research Institute

Assessing dune dynamics from space

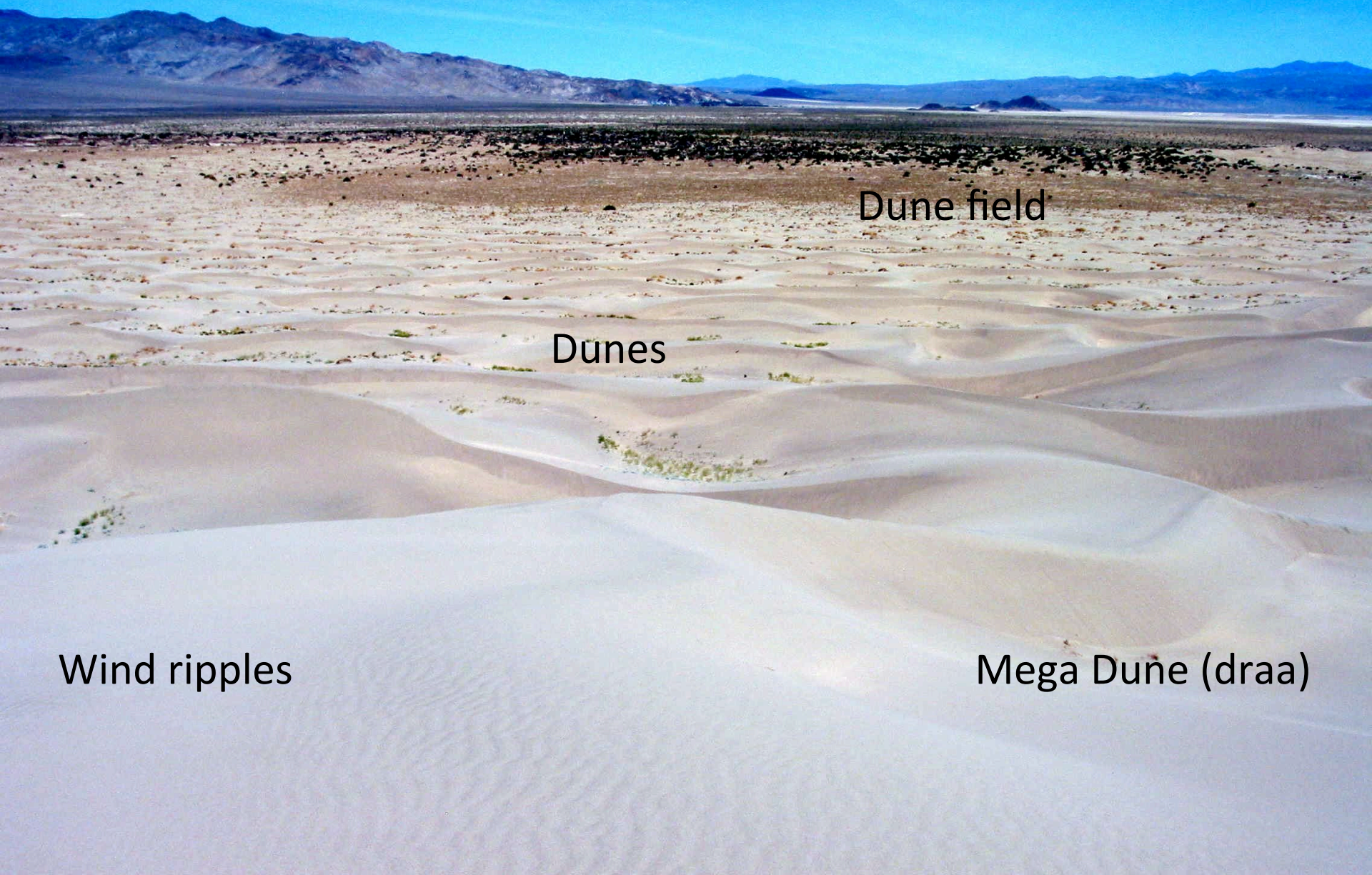
- Relevant temporal and spatial scales
- Major research questions
- Measurements of dune dynamics
- Examples of changes that could be/are being detected from remote sensing data
- Measurement needs and constraints



Fundamentals of dune dynamics



Hierarchical system of bedforms



Dunes

Dune field

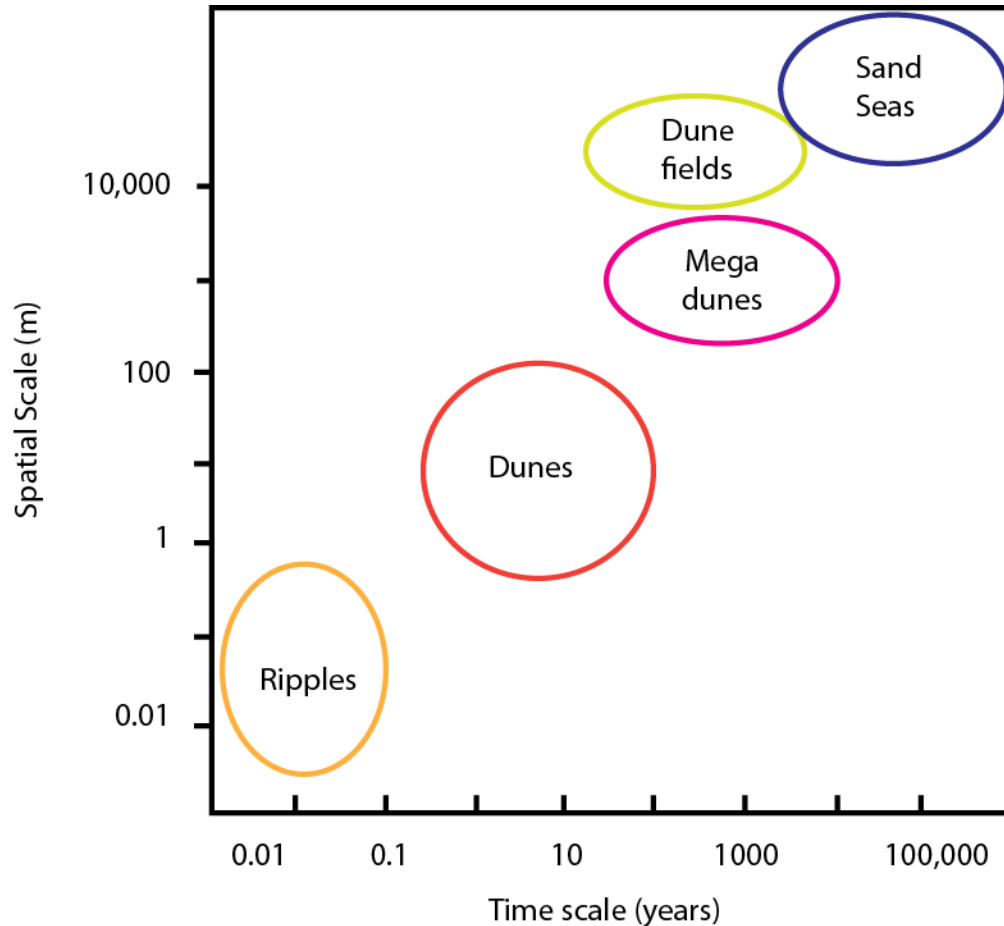
Wind ripples

Mega Dune (draa)

Scales of dune processes

MODIS
LANDSAT
ASTER

Geo-Eye
Ikonos
UAV



Dune-scale
dynamics
Are the most
amenable for
study by gazing
from space

Major questions

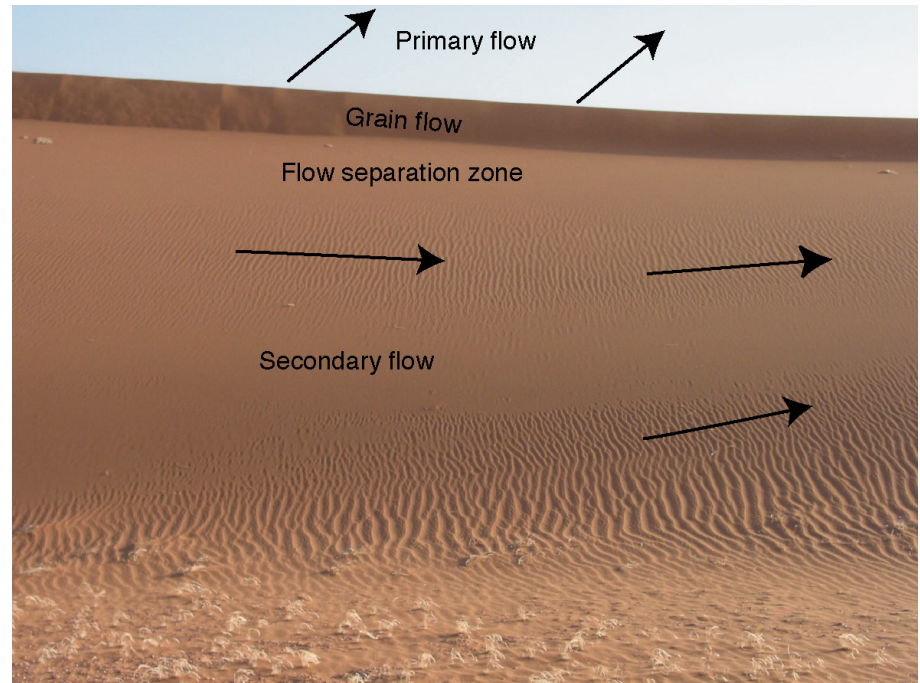
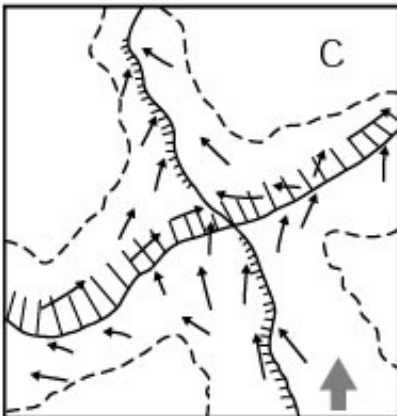
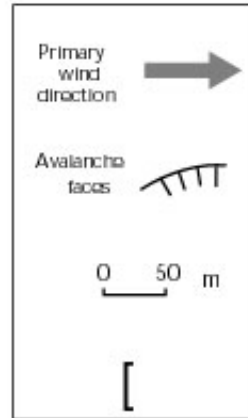
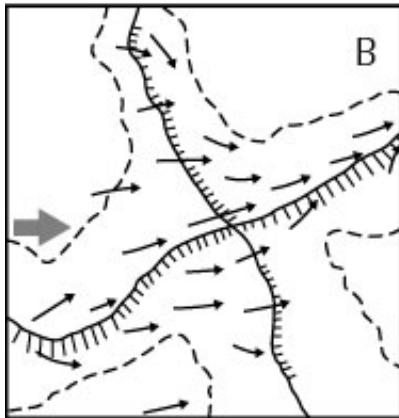
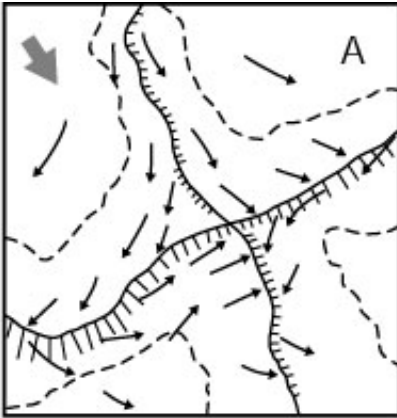
- How do dunes and dune systems change through time?
- How do dunes respond to and interact with changing boundary conditions?
- How do dunes and dune systems originate and evolve?
- What are the rates of processes in dunes?

Manifested by changes in morphology and sand volume that can be assessed in the field or remotely

Dune-scale processes

- Airflow patterns
 - Event scale – wind ripple orientation
- Patterns of erosion and deposition
 - Event scale
 - Seasonal
 - Annual
- Rates of dune migration/extension
- Dune-dune interactions
 - Dune/dunefield pattern development

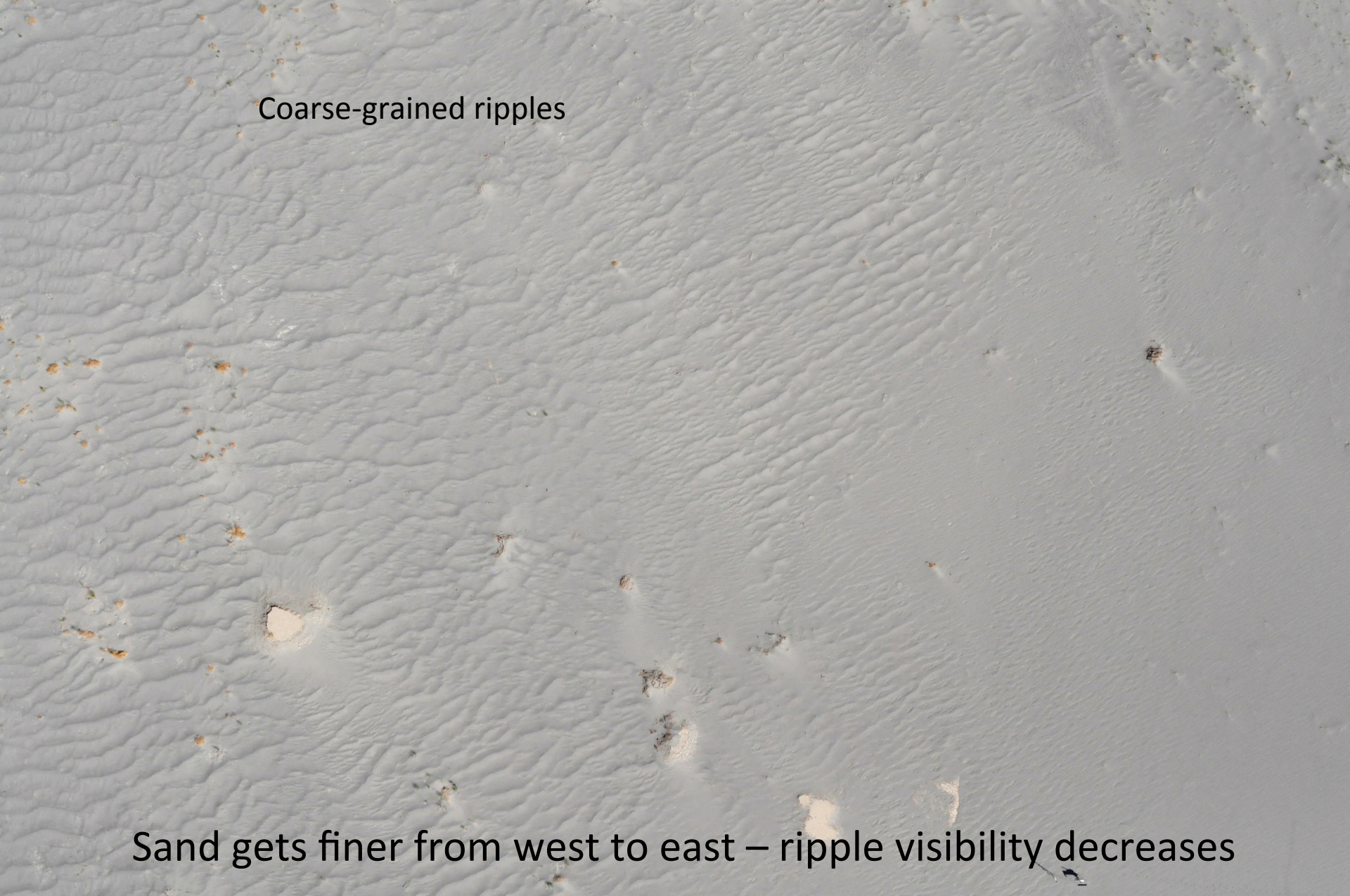
Airflow patterns



- Mapped using wind ripple orientations
- Primary and secondary flow directions
- Changes in winds (event, seasonal)

High resolution, low altitude aerial photographs

Coarse-grained ripples



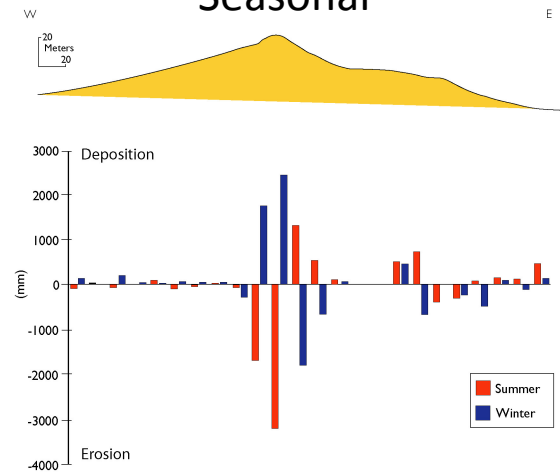
Sand gets finer from west to east – ripple visibility decreases

Erosion and deposition patterns

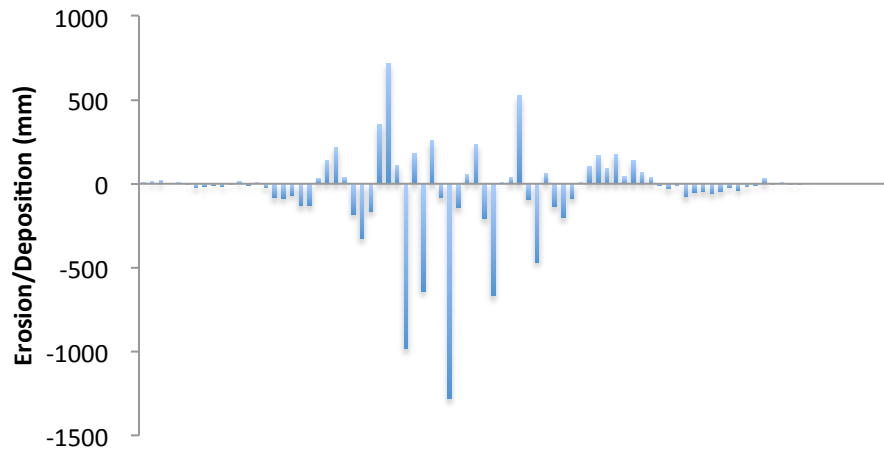
Event-based (1 week)



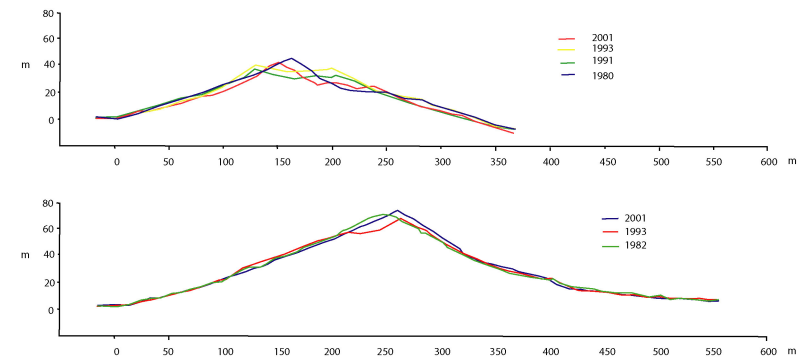
Seasonal



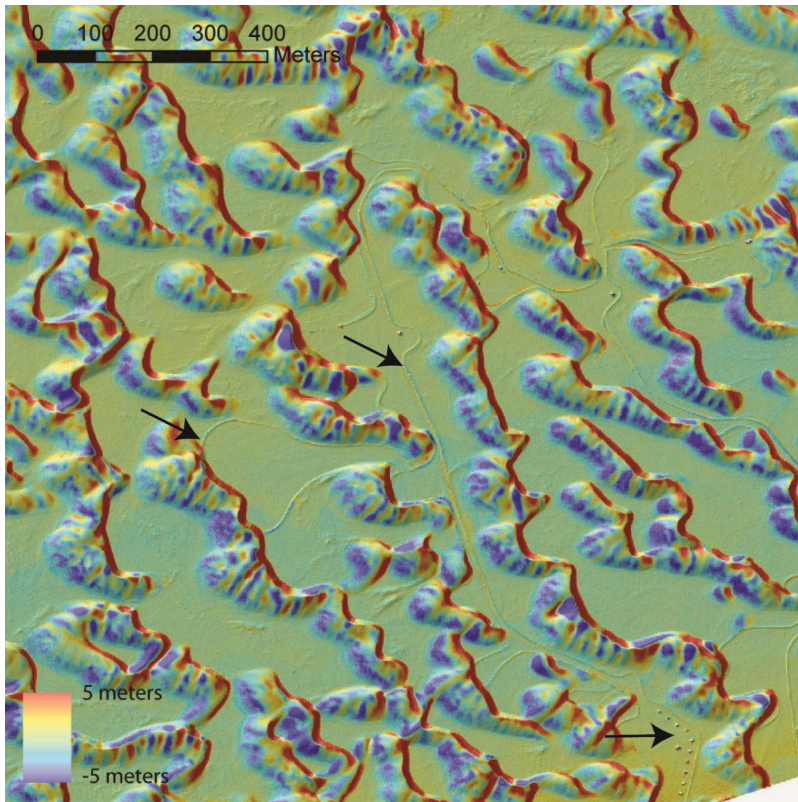
Annual



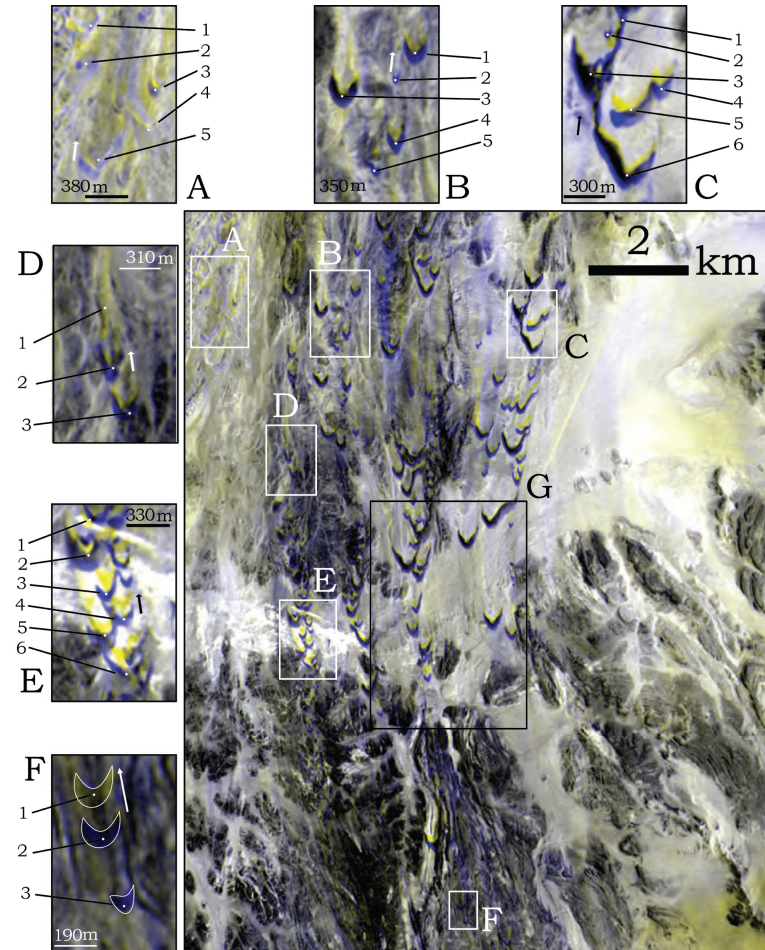
Multi-year



Remote monitoring of erosion and deposition



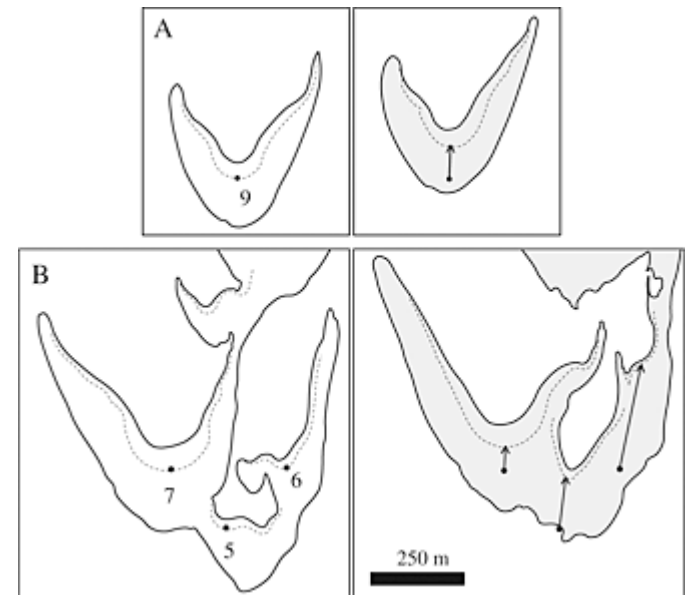
Lidar DEM difference image (2007-2008)
Kocurek et al. (2011)



WMFI image analysis using 2002 and 2006
ASTER data (Scheidt and Lancaster 2013)

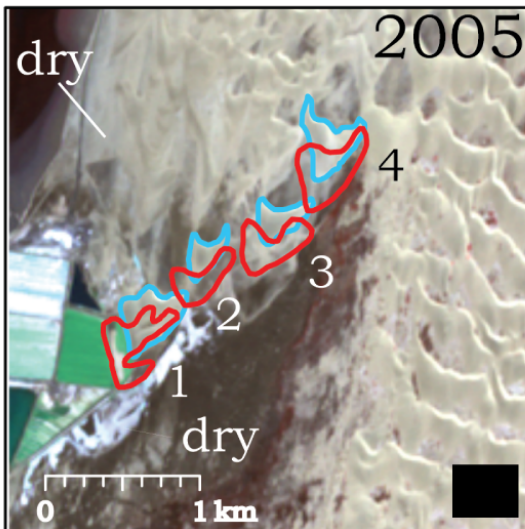
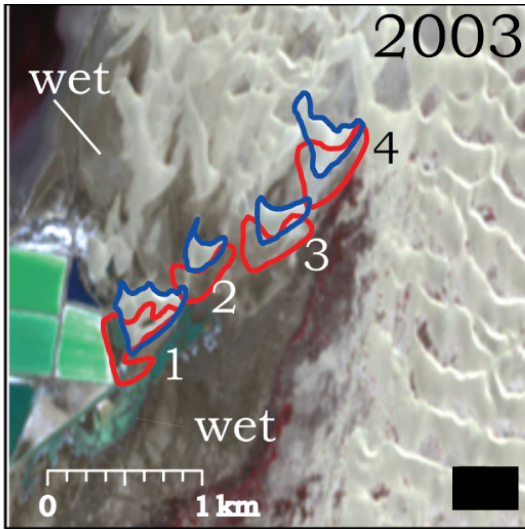
Dune change

- Migration downwind and laterally
 - Rigid or plastic
- Extension
 - Dune tip
- Changes in dune volume
 - Dune growth or wasting



Product of erosion and deposition patterns

GIS comparison of dune positions

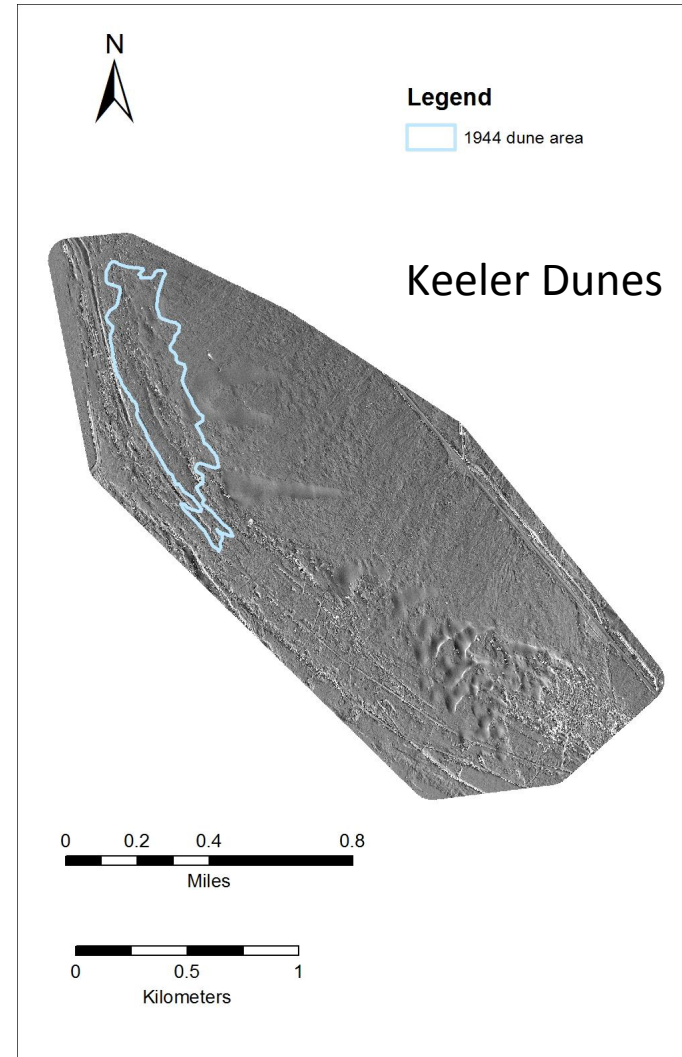


Key

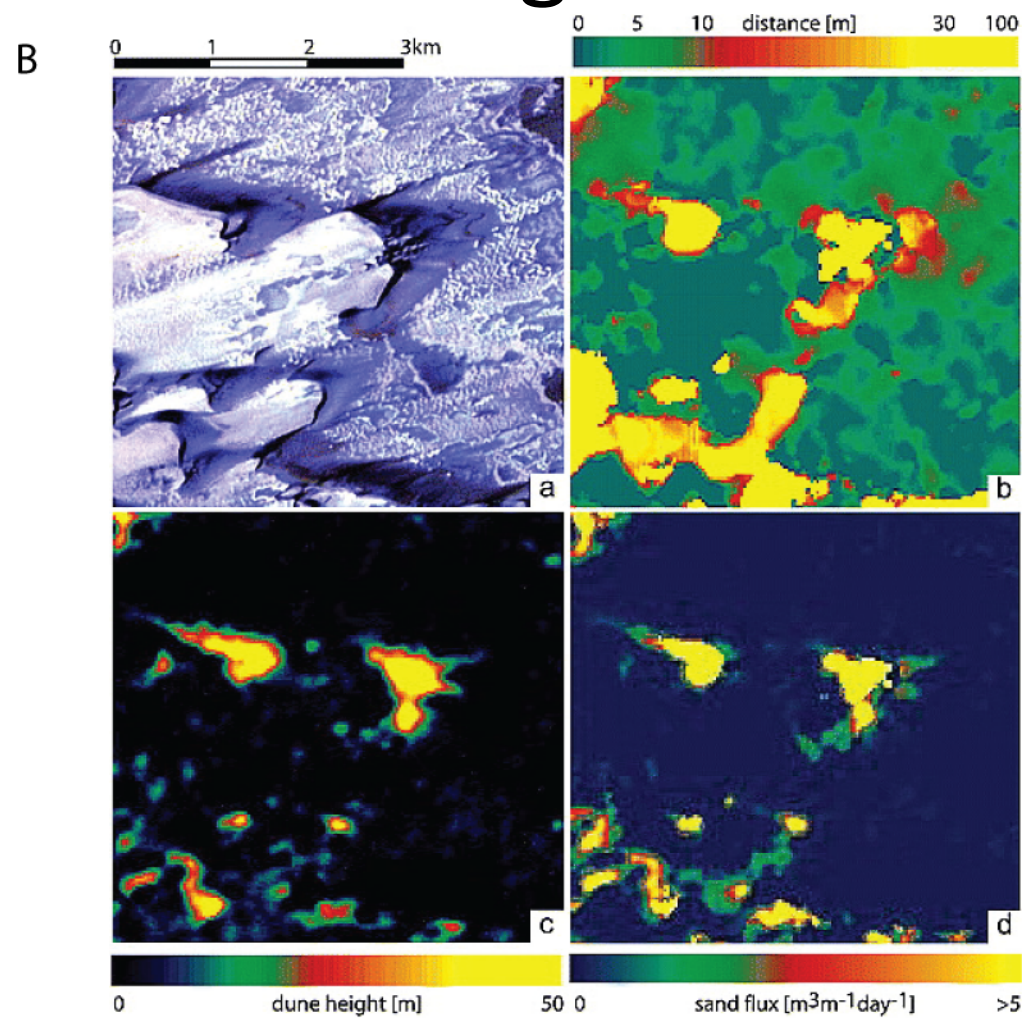
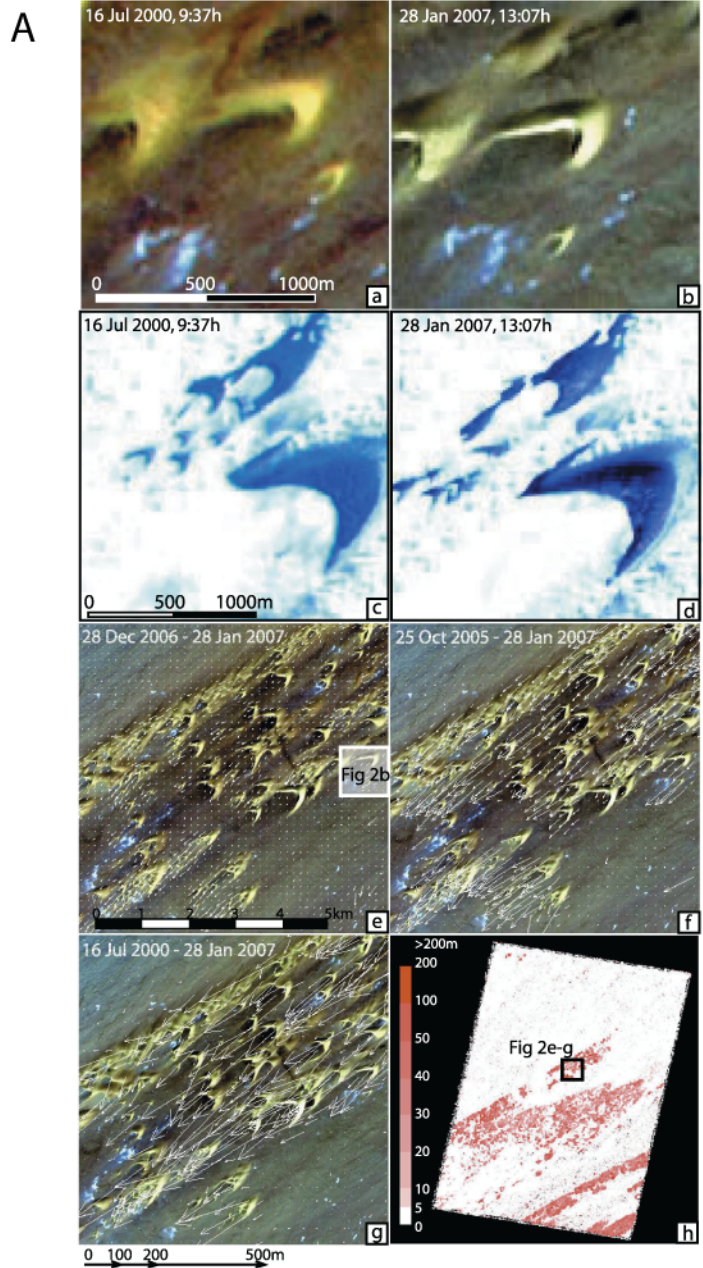
1976

2005

2003

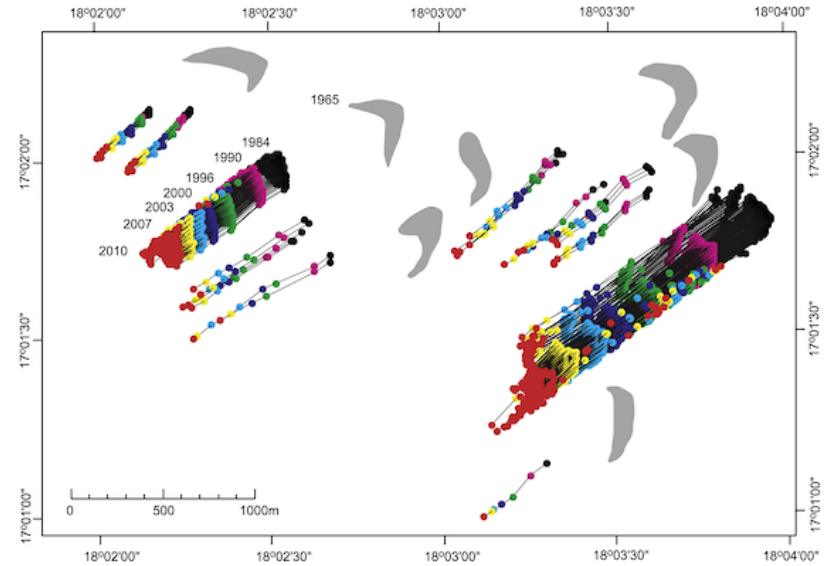
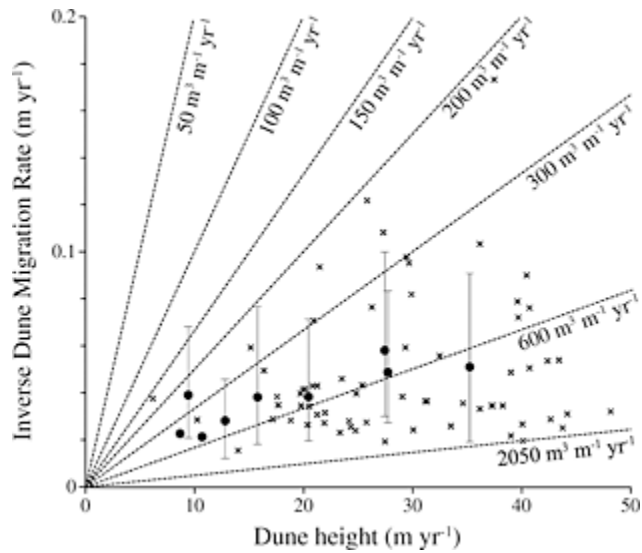


COSI-Corr dune change

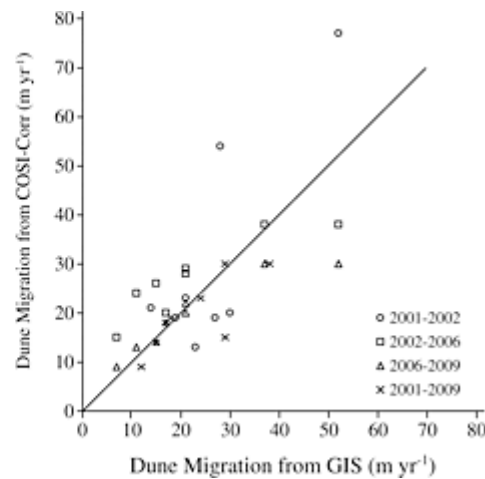
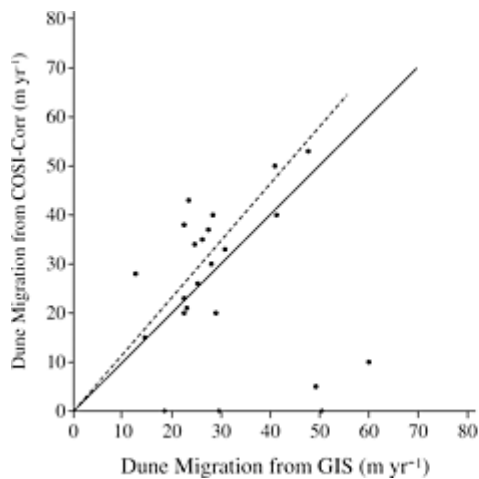


From Vermeesch and Drake (2008)

Dune migration via COSI-Corr



Vermeesch and Leprince 2012



Scheidt and Lancaster 2013

1/1/2004

Complexity of
morphologic
changes

Image © 2014 DigitalGlobe

Google earth

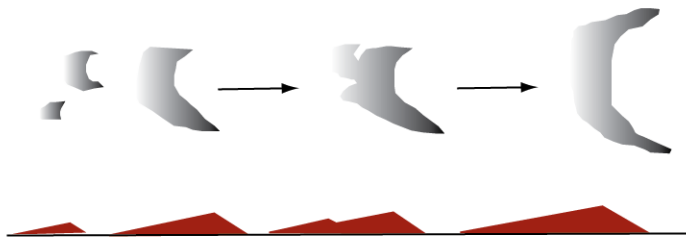
200 m

2002

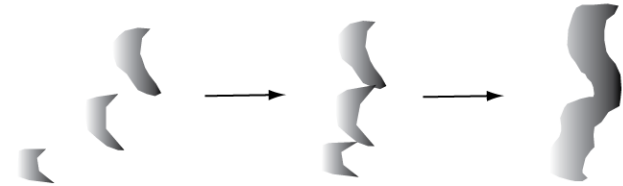
Imagery Date: 7/15/2002 lat -23.540247° lon 14.901687° elev 385 m eye alt 1.19 km

Dune-dune interactions = pattern development

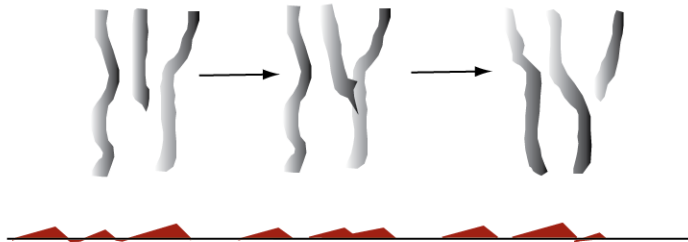
Merging



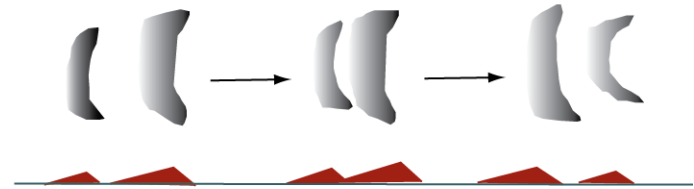
Lateral linking



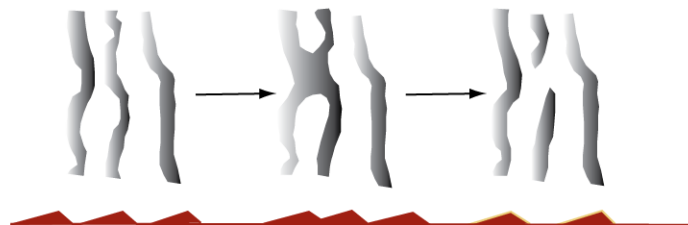
Defect Migration



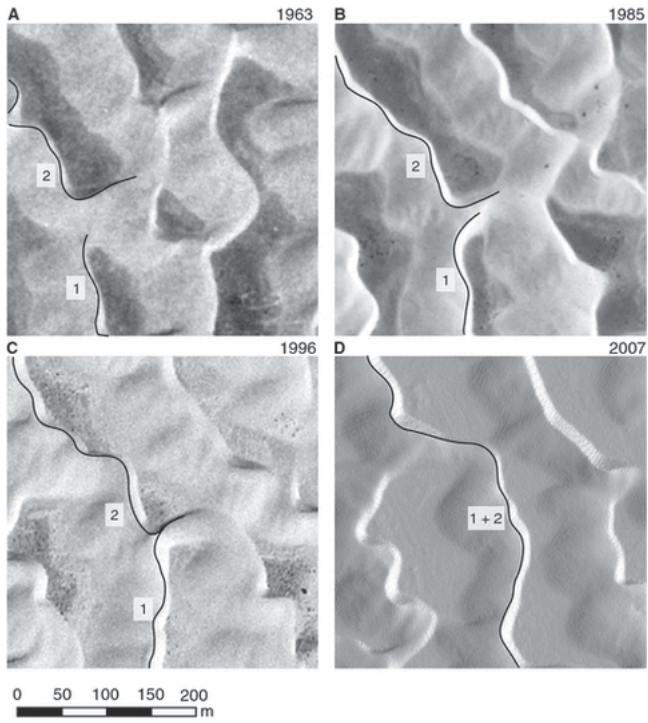
Repulsion



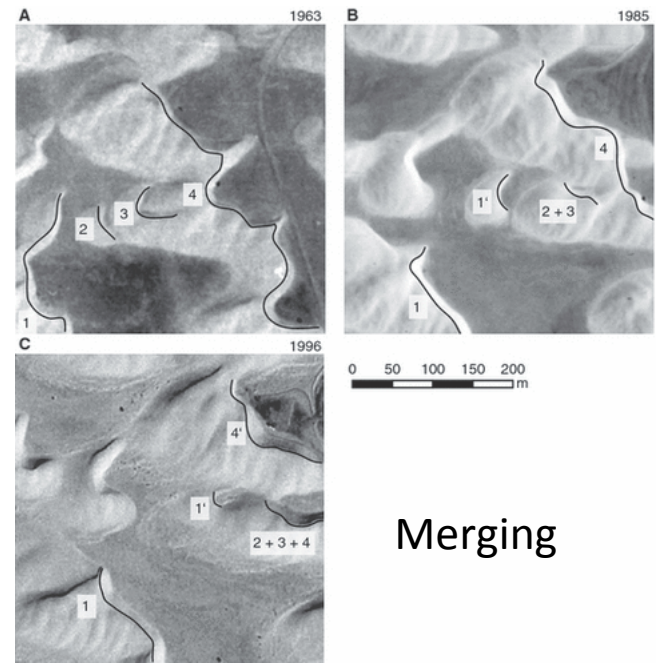
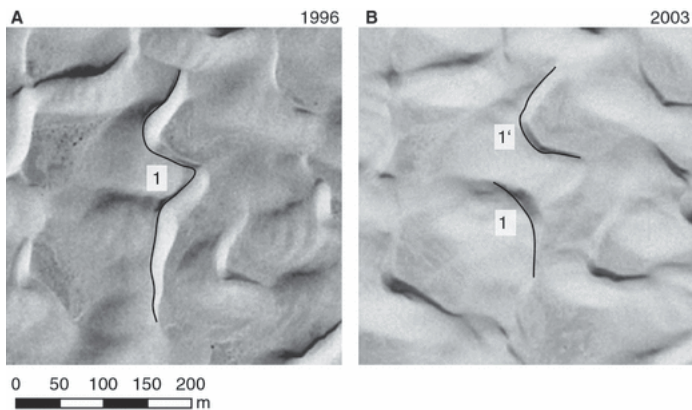
Termination creation



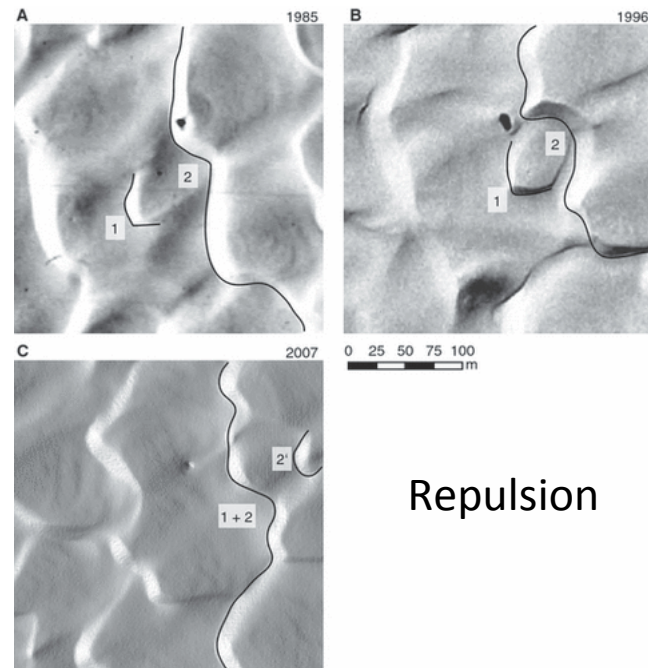
Lateral Linking



Defect creation



Merging



Repulsion

Challenges

- Signal – noise ratio
 - Small magnitude of changes relative to dune size
 - Complexity of changes
- Change detection
 - Unambiguous
 - Event, seasonal, annual
- Boundary conditions
 - Need to correlate observed change to weather/
climate data
 - Magnitude and frequency of events

Measurement and analysis needs

A photograph of a desert landscape featuring rolling sand dunes. The dunes are light brown and have some small, dark green shrubs scattered across them. The sky is a clear, pale blue. The overall scene is bright and sunny.

- Data

- Repeated targeted observations to match seasonal wind cycle(s)
- High resolution DEM data to detect volume changes

- Algorithms

- Change detection
- Pattern recognition and description

- Metrics to parameterize dune dynamics



DUNE CONDITIONS
ARE ALWAYS
CHANGING

BE
PREPARED
FOR SUDDEN
DROP-OFFS

