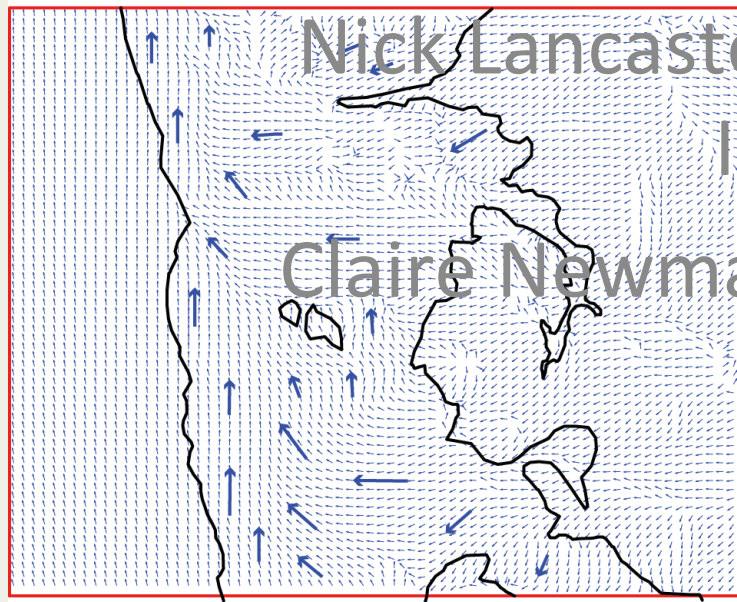
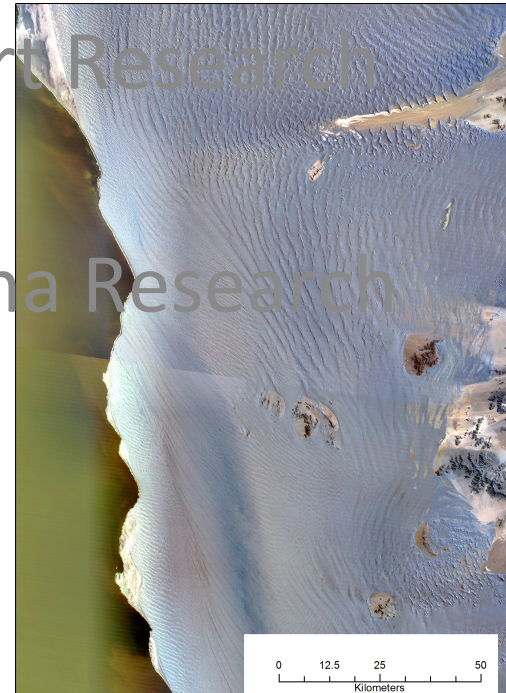


Linking atmospheric models and dune morphology – testing a forward modeling approach



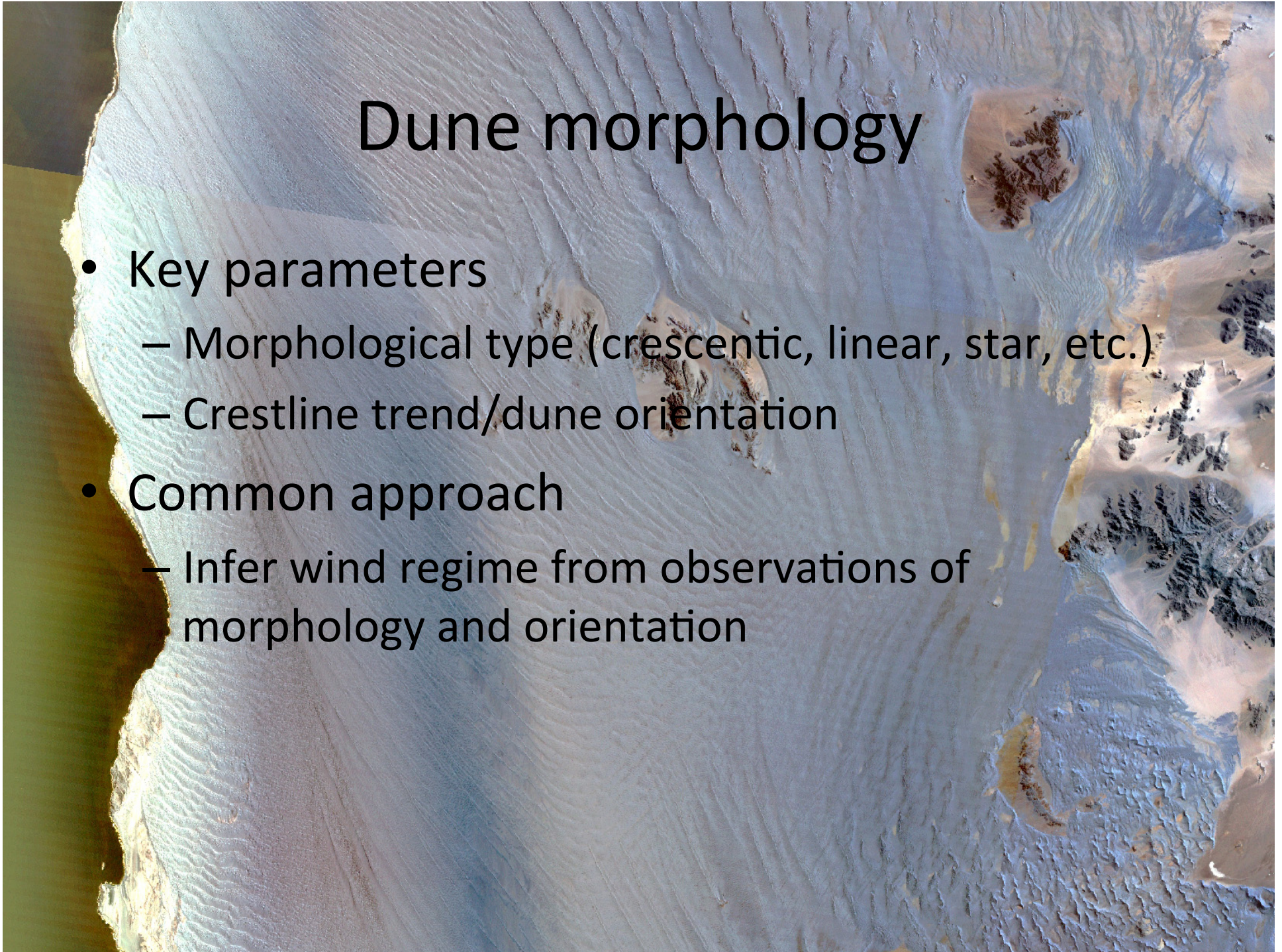
Nick Lancaster, Desert Research
Institute

Claire Newman, Ashima Research



Dune morphology

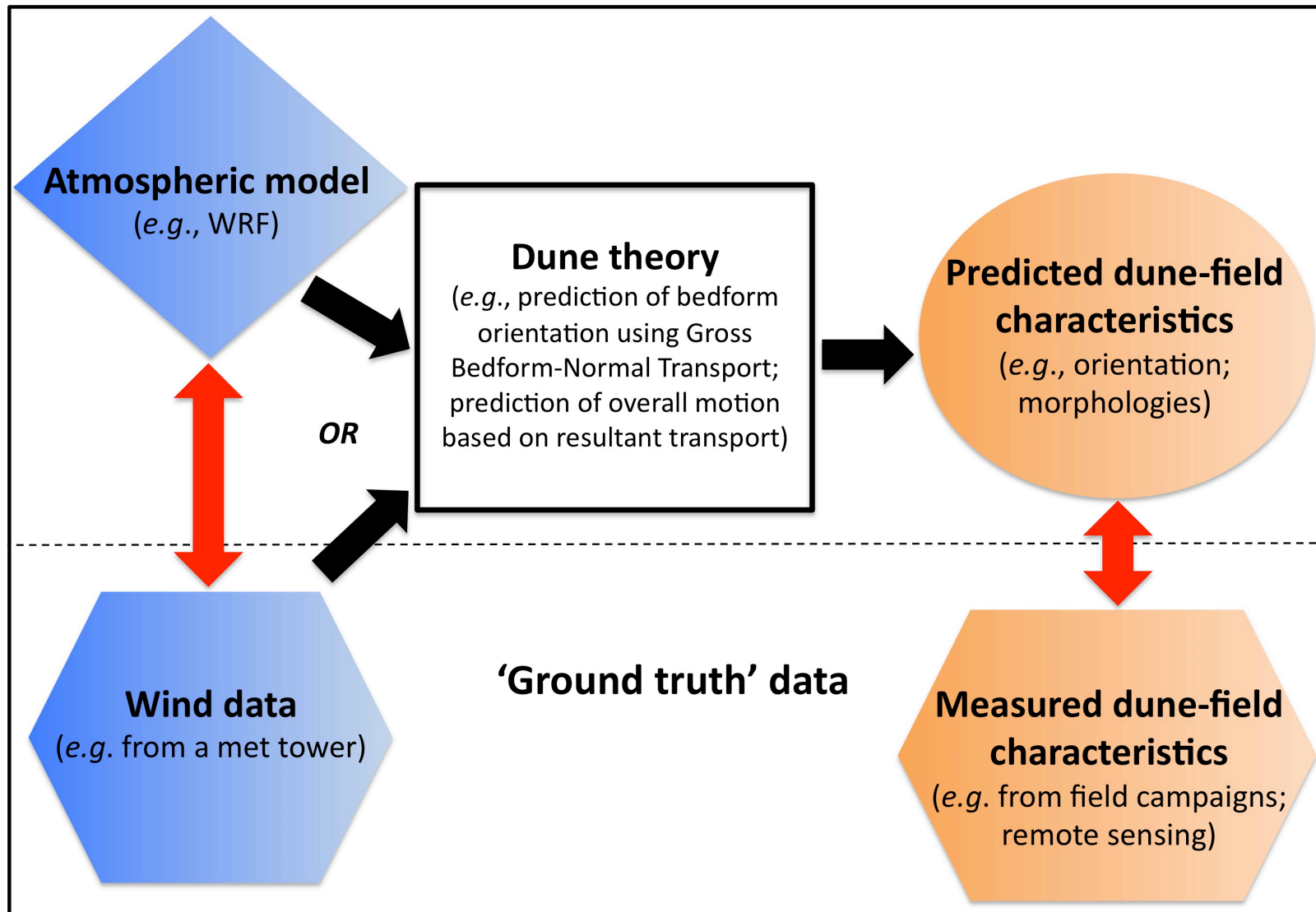
- Key parameters
 - Morphological type (crescentic, linear, star, etc.)
 - Crestline trend/dune orientation
- Common approach
 - Infer wind regime from observations of morphology and orientation



Predicting wind regimes from morphology and orientation

- Winds on other planetary bodies
 - Mars
 - Titan
- Paleowinds on Earth
- Need to rigorously assess if wind field estimates match observations

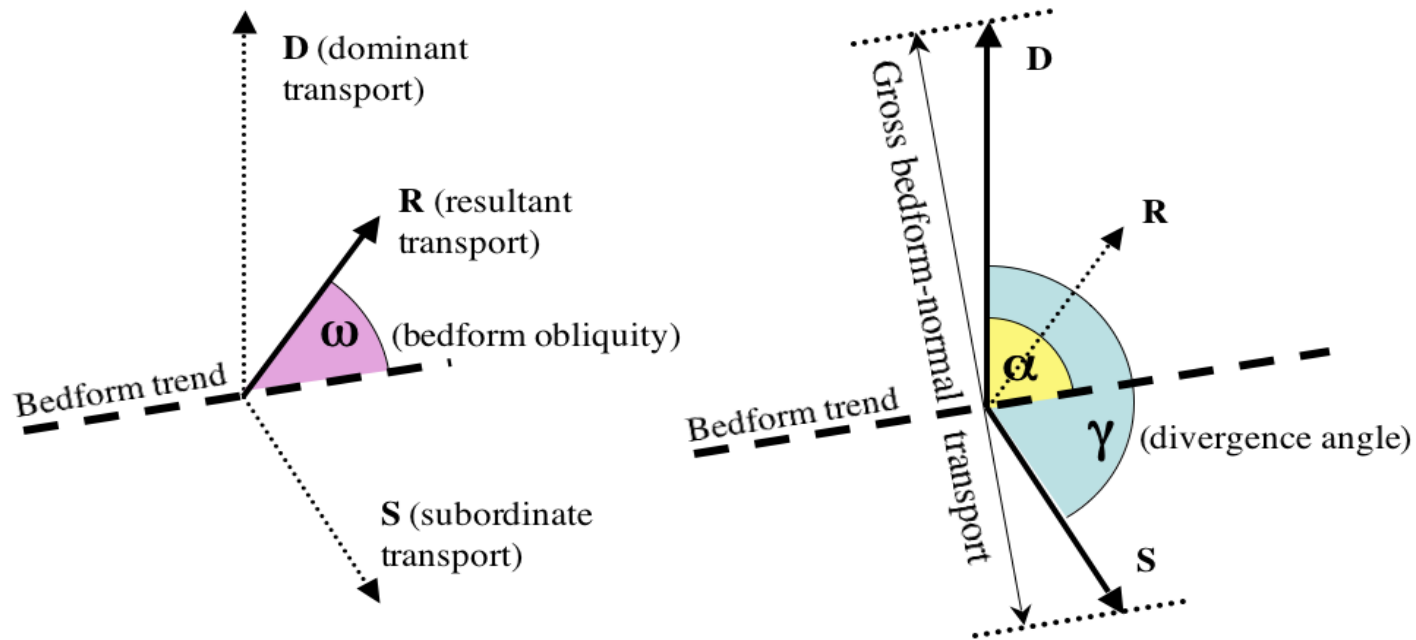
The Forward Modeling Approach



Dune Theory

- Gross Bedform Normal (GBNT)
 - Dunes oriented to maximize *gross* transport normal to crest
- Resultant Model (R)
 - Dunes oriented relative to *net* transport
 - Migrate normal to resultant (transverse dunes)
 - Extend parallel to resultant (longitudinal dunes)
 - Oblique trend (combines extension and lateral migration)
- Sand availability model (Courrech Du Pont et al)
 - Dune orientation mode controlled by sand availability

Modes for dune orientation

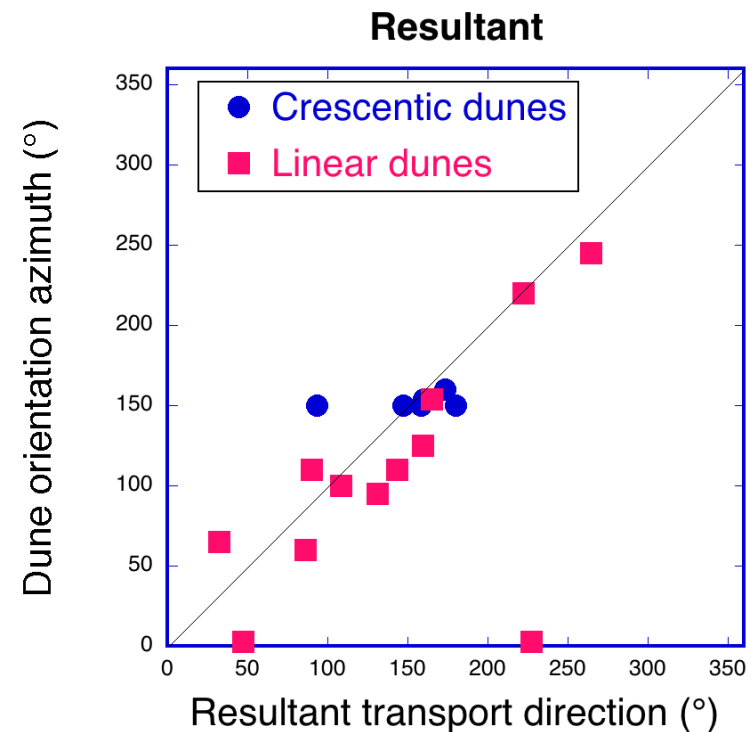
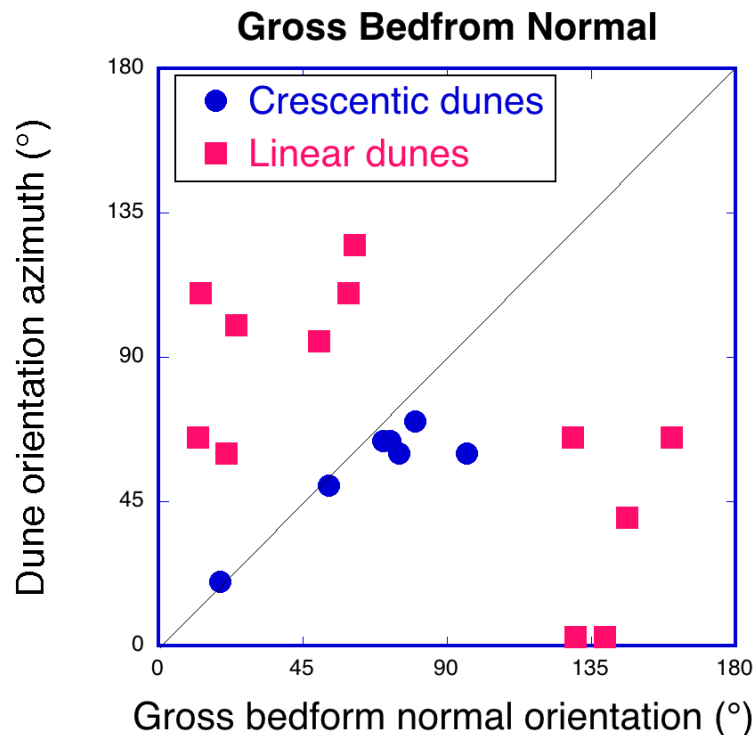


Testing the models

- Wind data for Arabian Peninsula
 - 10 year record (2000-2009) for 20 stations close to or within dune areas
 - NCDC Global Climate Station Summaries
- Potential sand flux calculated using Fryberger method
- Gross bedform normal and resultant trend predicted using “Trend” (Rubin and Ikeda, 1990)



Predicted and observed trends compared

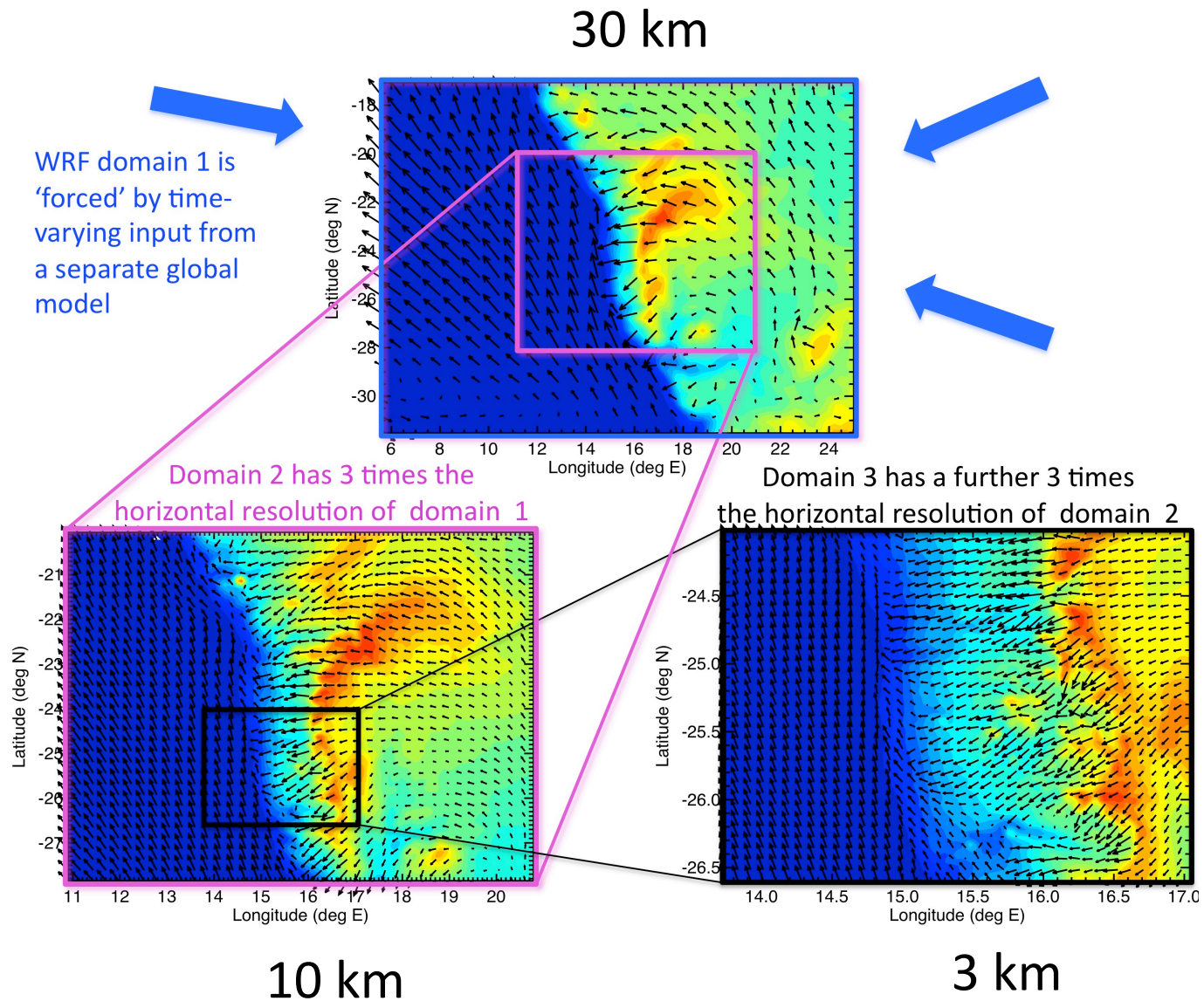


- GBNT good predictor of crescentic orientation
- Resultant good predictor of both linear and transverse (crescentic) orientation

Modeling of sand transport and dune orientations

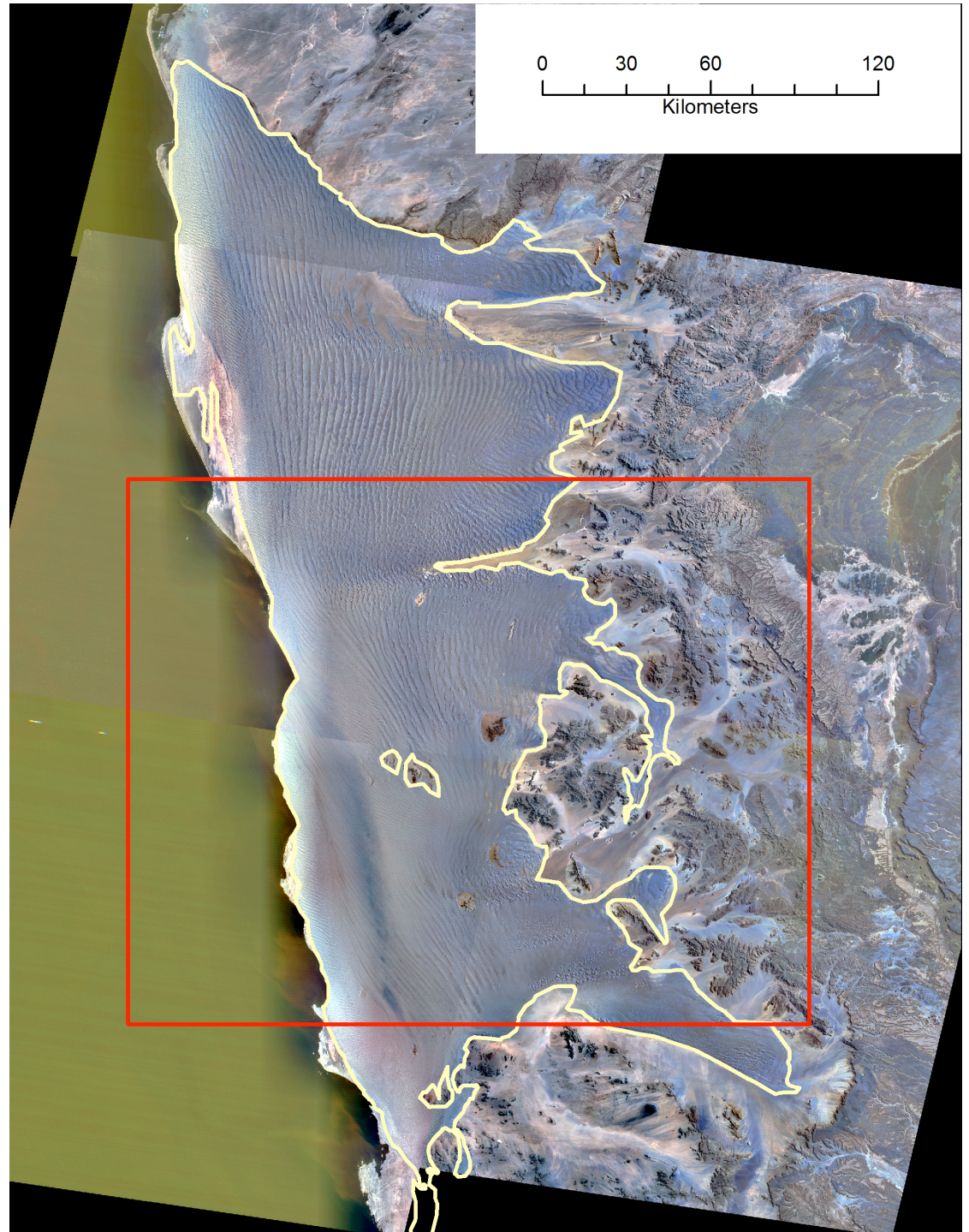
- Mesoscale Weather, Research and Forecasting (WRF) model
 - surface wind stress and wind direction every 10 minutes for year
 - sand flux calculated at each 10 minute interval, using the Fryberger [1979] equation, for 18 different values of the saltation threshold ranging from 0 to 3.4 Pa.
- Resultant sand transport direction (R) and Gross Bedform-Normal Transport (GBNT) calculated from sand flux data

Model set up

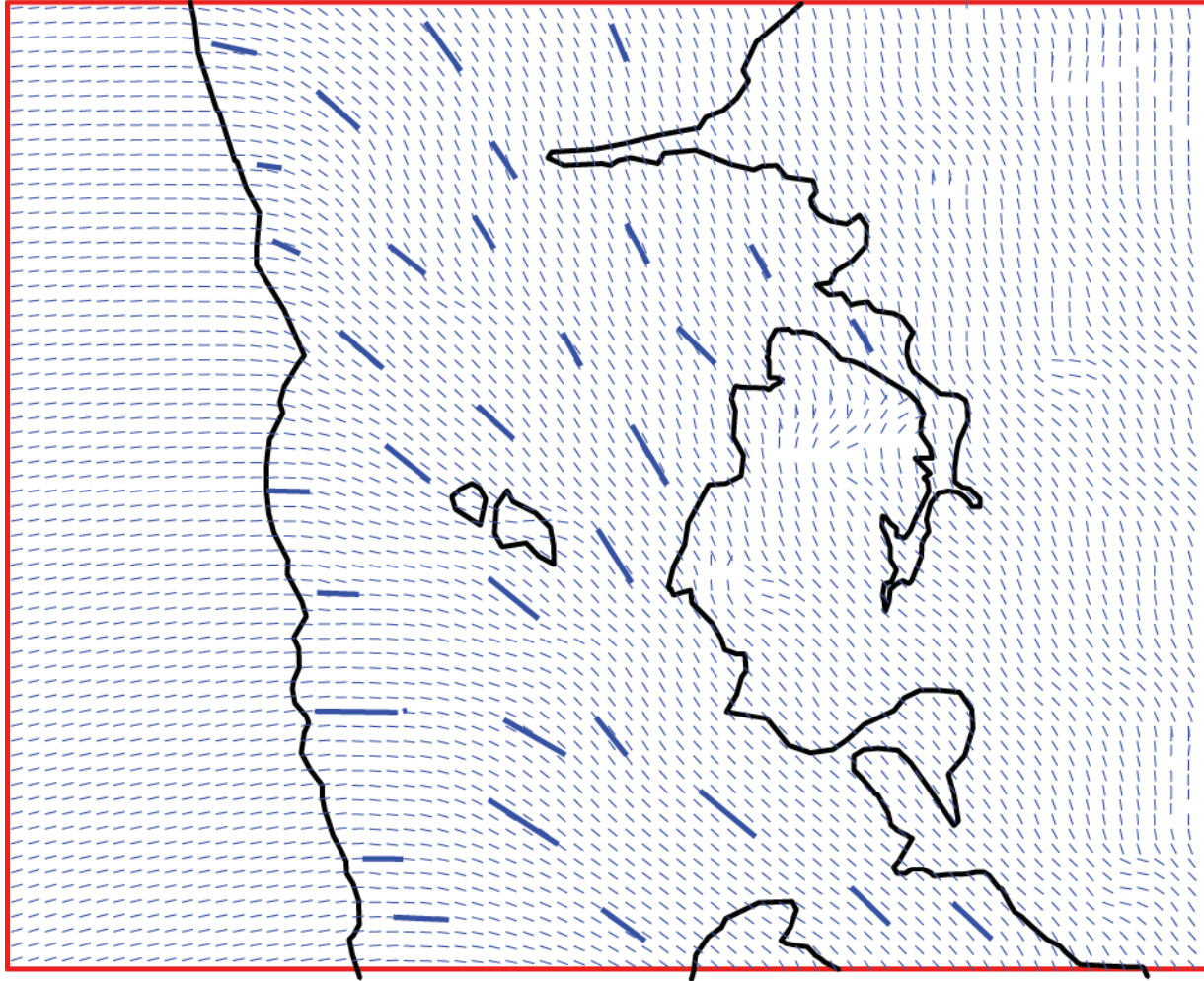


Namib Test Area

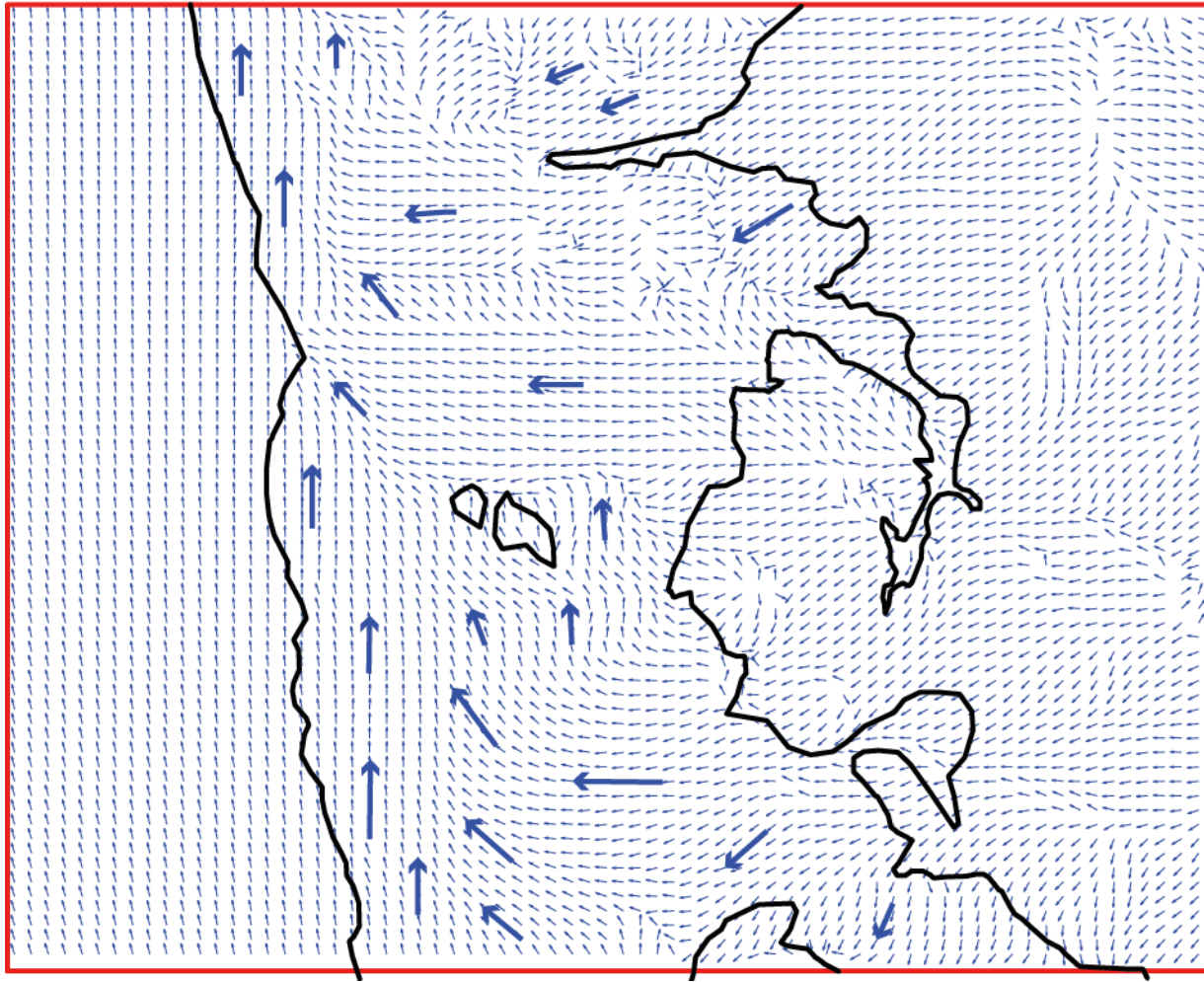
- Variety of dune types
 - Crescentic on coast
 - Linear in center
 - Star dunes to east
- Threshold – 0.2 N/m^2
($u_{*t} = 0.4 \text{ m sec}^{-1}$)



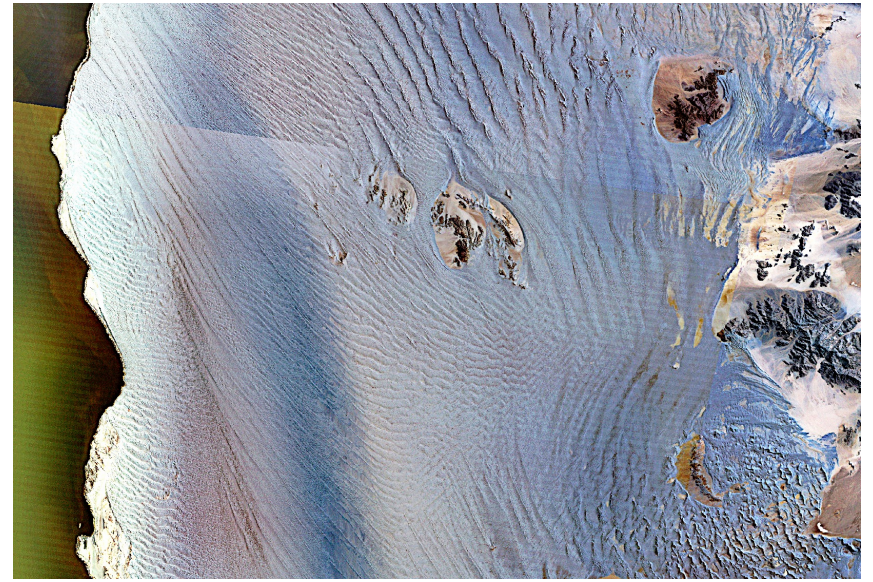
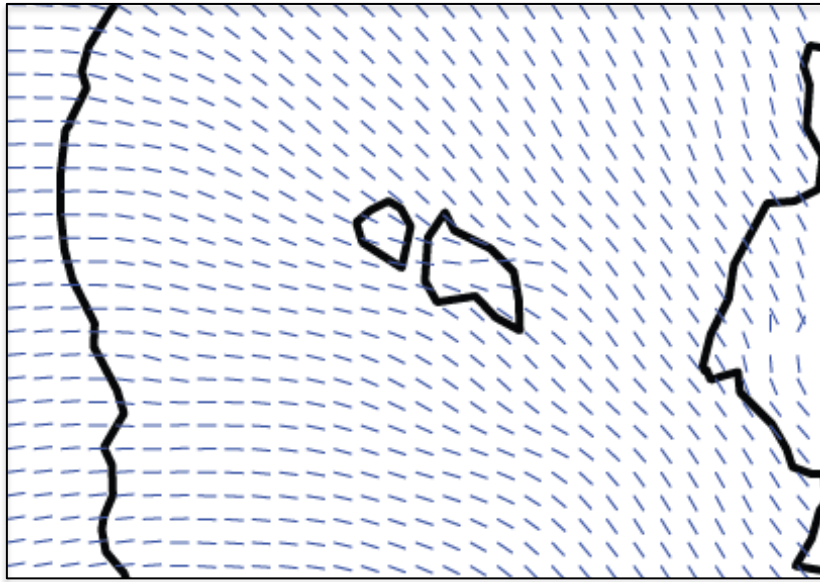
Model results – Gross Bedform Normal Transport direction



Model Results – Resultant transport direction

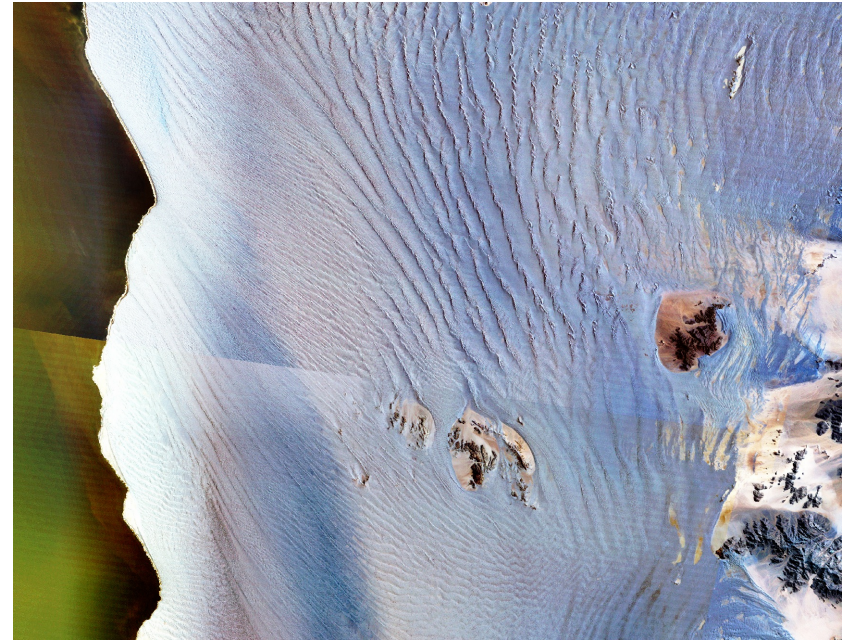
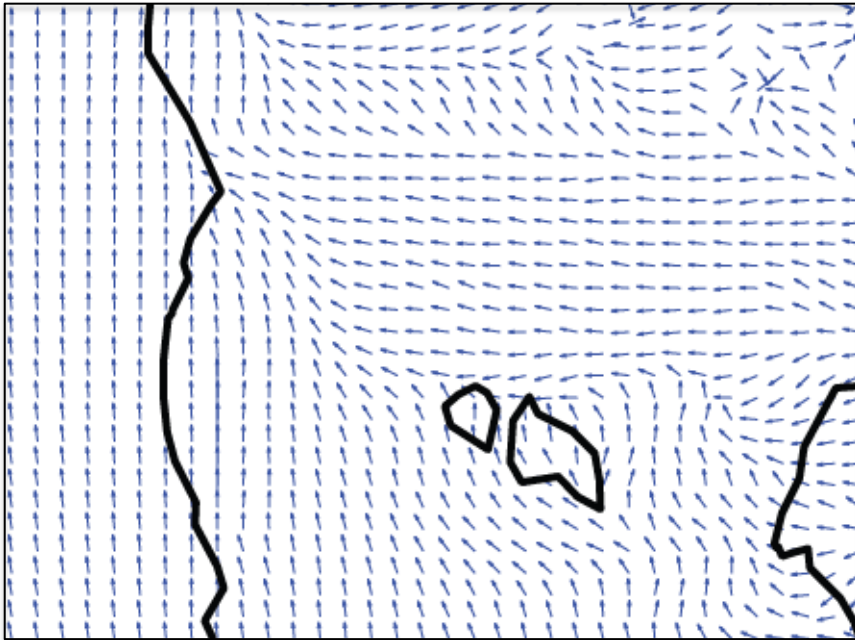


GBNT and dune orientations compared



Reasonable agreement in many areas

Resultant transport direction and dune orientations compared



Note strong disagreement in area of linear dunes to north

Model – data comparison

Compare modeled GBNT and
Resultant trends with
observed dune trends

Model output at 3.33 km
intervals

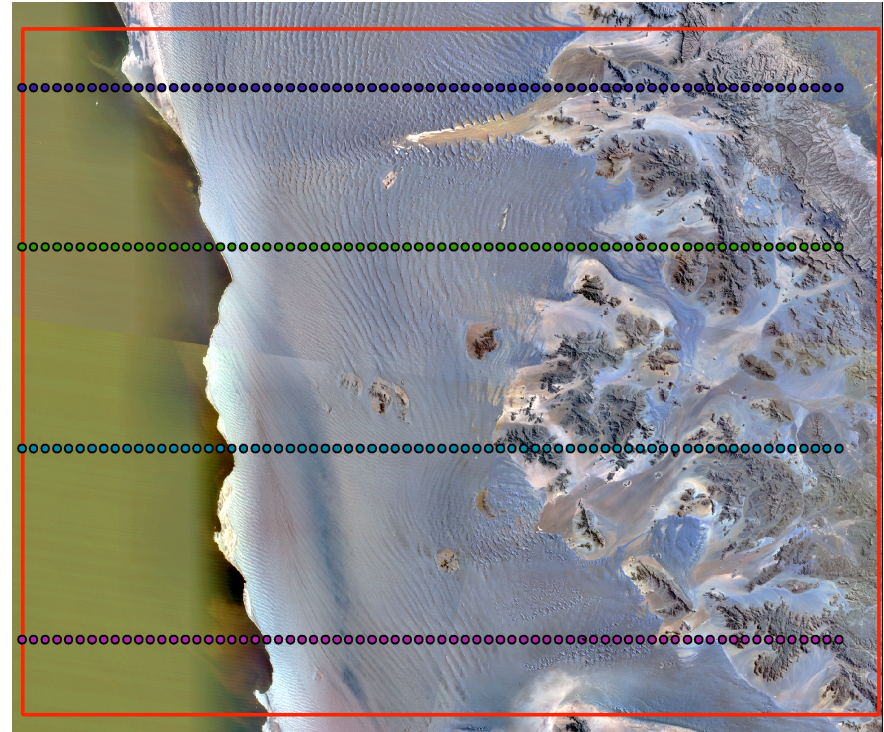
4 transects across sand sea

Total of comparisons – 126

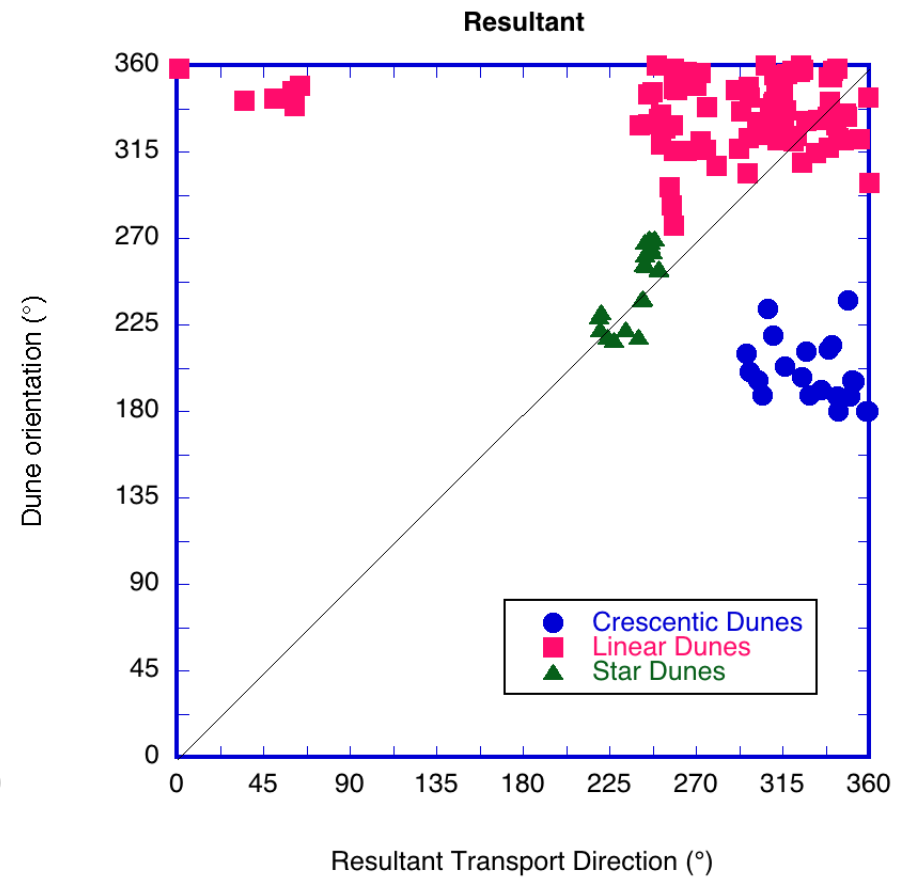
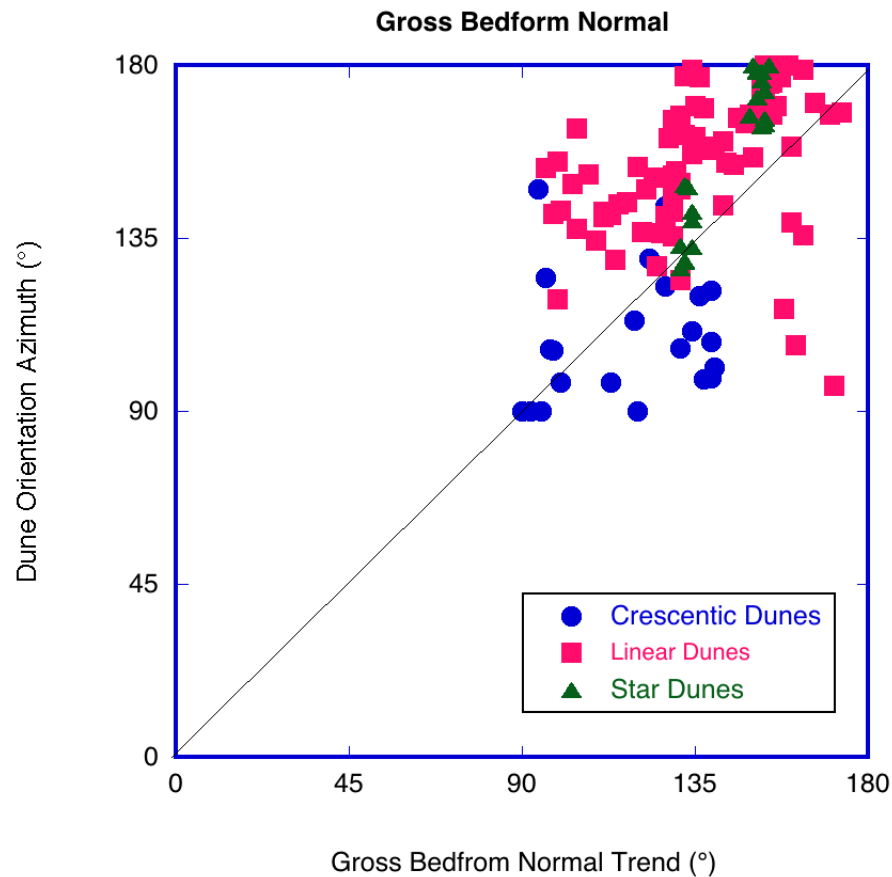
Crescentic – 22

Linear – 82

Star - 22



Predicted and Observed Trends Compared



Namib Comparisons

- Modeled GBNT appears to be a good predictor of crescentic and star orientation; also some linear dunes
- Modeled resultant is acceptable predictor of crescentic, linear and some star dune orientations, but poor for some crescentic and star dunes

Conclusions

- Observational data and climate model output can be used to predict dune orientation using GBNT and Resultant models
- Climate model parameters and resolution very important to end result
- Verification by surface wind data valuable