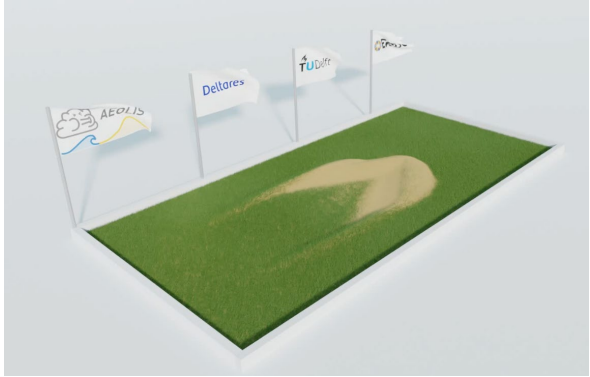


AEOLIS

Short Course Coastal Sediments

New Orleans - 2023

AeoLiS – Short Course

General introduction

Sierd de Vries

Schedule short course

8.00 presentation/coffee/networking/install Aeolis
8.30-9.00 Setup and running models
1a. zandmotor base case (1 grainsize, no supply limitations)
9.00-9.30 Aeolis supply limitation concept (Sierd)
9.30-10.15 Running models and COFFEE
1b. zandmotor grain size (supply limitation)
10.15 – 10.30 Sediment sorting/grain size variability – mixing (Christa)
10.30-11.30 Running models
2a. Zandmotor grain size + Tide + Moisture (10yr)
2b. Zandmotor grain size + Tide + Waves + Moisture (10yr)
11.30-12.00 wrap up based on questions, plenary explanations.

PART 1

12.00-13.00 Lunch

13.00-13.15 Vegetation and Dune Landscapes (Bart)
(ASK THE PARTICIPANTS TO START ALL SIMULATIONS WHILE LISTENING TO THE PRESENTATIONS)
13.15 – 13.30 Introduction 1D case DIFD (Glenn)
13.30 – 13.45 Moisture (Caroline)
13.45 - 14.00 Sand fence (Nick)
14.00 – 16.15 Running models and COFFEE
3a. 1 D case without vegetation without moisture (Glenn)
3b. 1 D case without vegetation with moisture (Caroline)
4a. 1D with sand fence (Nick)
4b. 1D cases with vegetation (Glenn)
5. Model Playground (go nuts! Barchan, Parabolic, etc. ask Bart)
16.15 – 16.30 wrap up based on questions, plenary explanations
16.30-17.00 Quiz with a prize

PART 2

TU Delft

Part 1 - Morning Program

8.00 presentation/coffee/networking/install Aeolis

8.30-9.00 Setup and running models

1a. zandmotor base case (1 grainsize, no supply limitations) (Sierd)

9.00-9.30 Aeolis supply limitation concept (Sierd)

9.30-10.15 Running models and COFFEE

1b. zandmotor grain size (supply limitation) (Sierd)

10.15 – 10.30 Sediment sorting/grain size variability – mixing (Christa)

10.30-11.30 Running models

2a. Zandmotor grain size + Tide + Moisture (Sierd)

2b. Zandmotor grain size + Tide + Waves + Moisture (Sierd)

11.30-12.00 wrap up based on questions, plenary explanations.

12.00-13.00 Lunch

Part 2 - Afternoon Program

13.00-13.15 Vegetation and Dune Landscapes (Bart)
(ASK THE PARTICIPANTS TO START ALL SIMULATIONS WHILE LISTENING TO THE PRESENTATIONS)

13.15 – 13.30 Introduction 1D case DIFD (Glenn)

13.30 – 13.45 Moisture (Caroline)

13.45 - 14.00 Sand fence (Nick)

14.00 – 16.15 Running models and COFFEE

- 3a. 1 D case without vegetation without moisture (Glenn)
- 3b. 1 D case without vegetation with moisture (Caroline)
- 4a. 1D with sand fence (Nick)
- 4b. 1D cases with vegetation (Glenn)
- 5. Model Playground (go nuts! Barchan, Parabolic, etc.)

16.15 – 16.30 wrap up based on questions, plenary explanations

16.30-17.00 Quiz with a prize

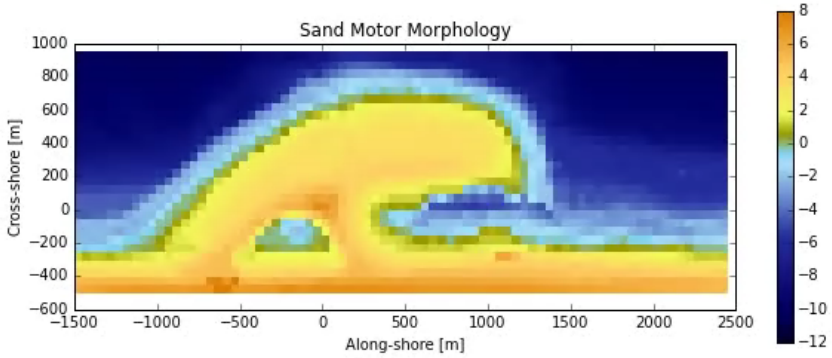
AeoLiS?

Why: Living in/with dynamic dunes is easier when you can understand and predict their behaviour.

How: Developing/Using a knowledge base to understand and predict dune behaviour.

What: AeoLiS is the ‘Delft Model’ that predicts coastal aeolian sediment transport and dune development.

AeoLiS - Morphodynamic Loop



Definition of space
- Morphology
- Vegetation
- Grain size
- etc.

Forcing
- Wind
- Tide

Sediment transport

Change in space

Typical applications picture show:

Re-introducing dynamic dunes

Managing for habitat development

- Room for dynamic processes

VAN DER WIEL

Human-made dunes

TU Delft

Hondsbosche Duinen

TU Delft

Zandmotor!!

UTRECHT

ORANJE

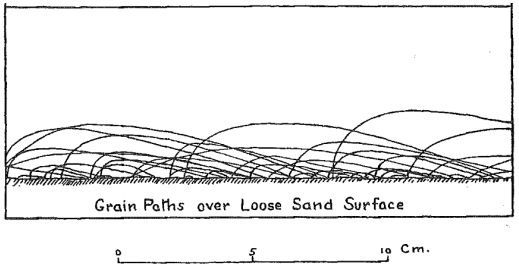
After construction Natural process
govern the development

TU Delft

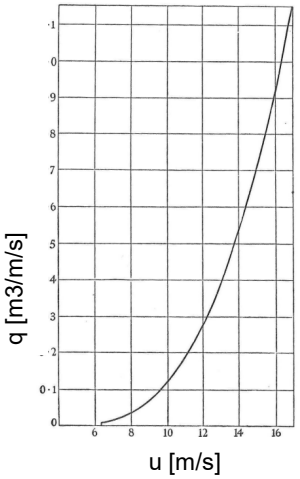
AeoLiS and Predicting Aeolian Sediment Transport

- Bagnold
  - Transport (capacity) limited sediment transport
- Spatial gradients in sediment transport
  - Measurements
  - Conceptual model
- Supply limited sediment transport
  - Numerical implementation
- Application AEOLIS

Fundamental theory by Bagnold



$$q = \alpha C_b \frac{\rho}{g} \sqrt{\frac{d}{D}} (u_z - u_t)^3$$



Bagnold's Legacy

$$q = \alpha C_b \frac{\rho}{g} \sqrt{\frac{d}{D}} (u_z - u_t)^3$$

- Many transport models for desert are inspired by the work of Bagnold and use 3rd power sediment transport formulations (e.g. Sauerman et al., 2001)
- Many formulae for marine sediment transports are based on the principles by Bagnold (e.g. Van Rijn, 1994)
- Several coastal studies have presented comparison between field measurements and 3rd power functions with moderate success only (e.g. Sherman 2012)
  - **General overprediction** is present in many beach related studies

- How well does Bagnold’s desert theory work on beaches?
- Let’s measure in the field!

$$q = \alpha C_b \frac{\rho}{g} \sqrt{\frac{d}{D}} (u_z - u_t)^3$$

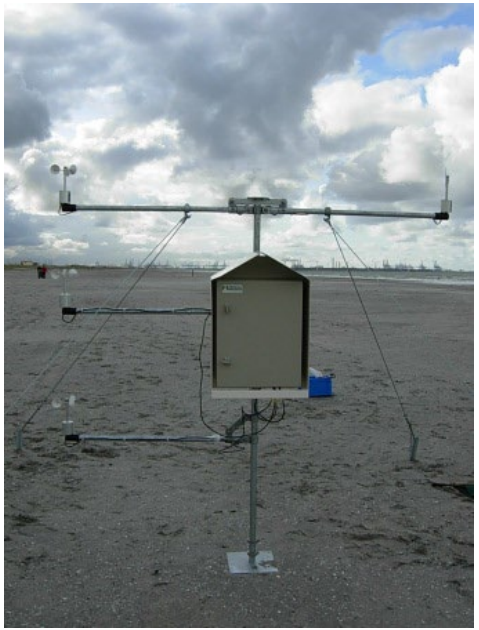
Bagnold formulation too simplistic?

No Transport

Large Transport

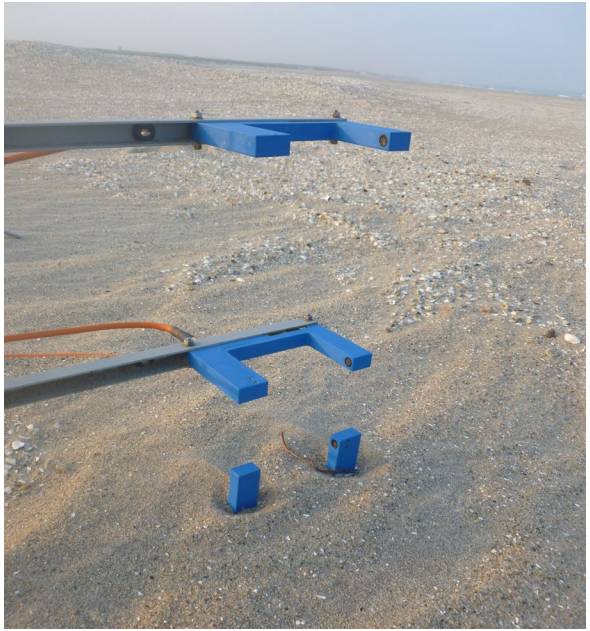
Similar wind condition??

Data collection



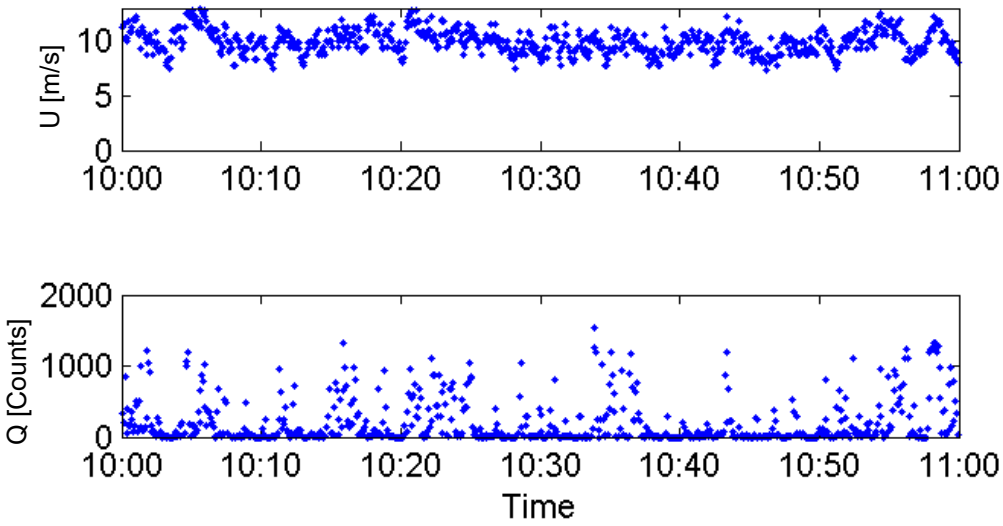
Wind Station

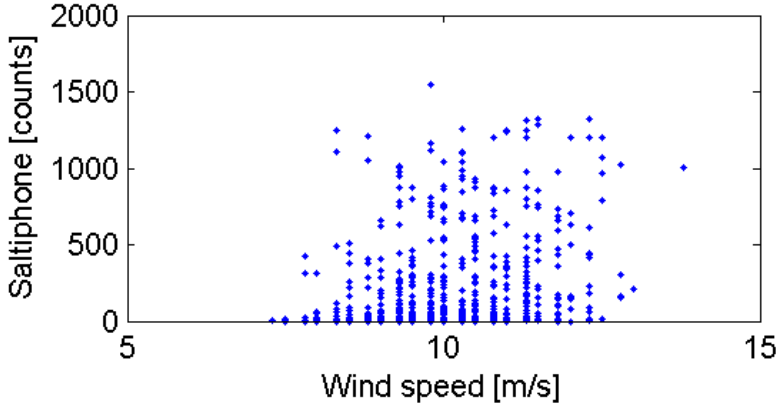
Saltiphone



Wenglors

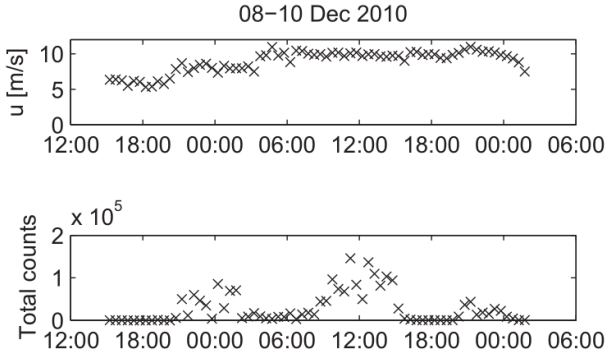
Data collection

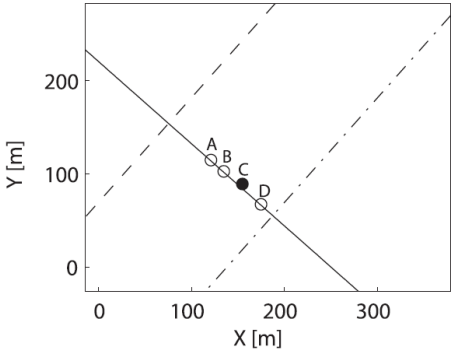


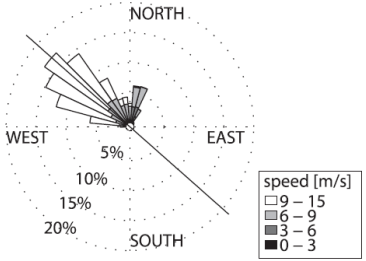


Data collection

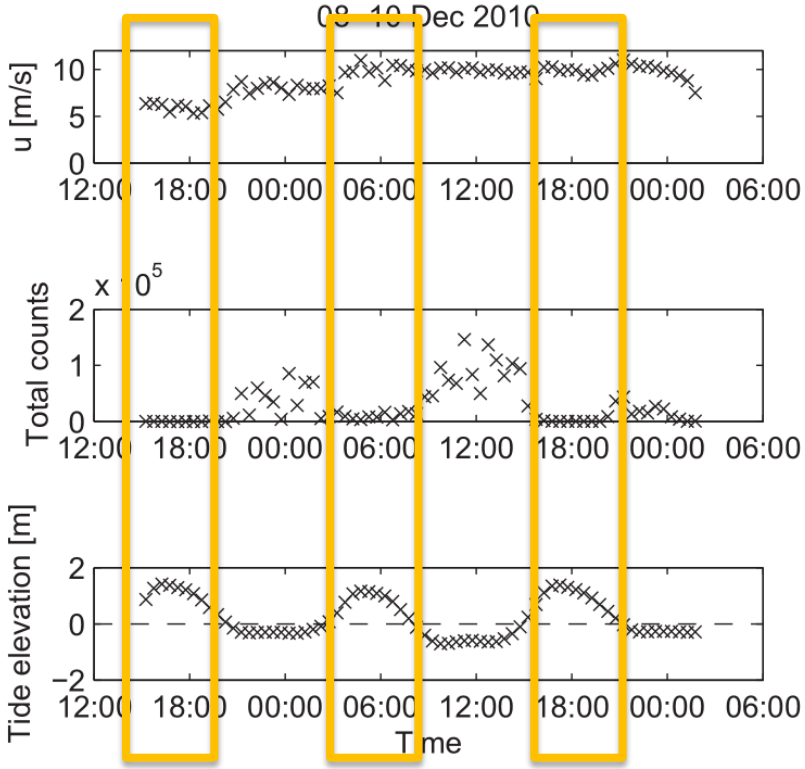
- After some filtering





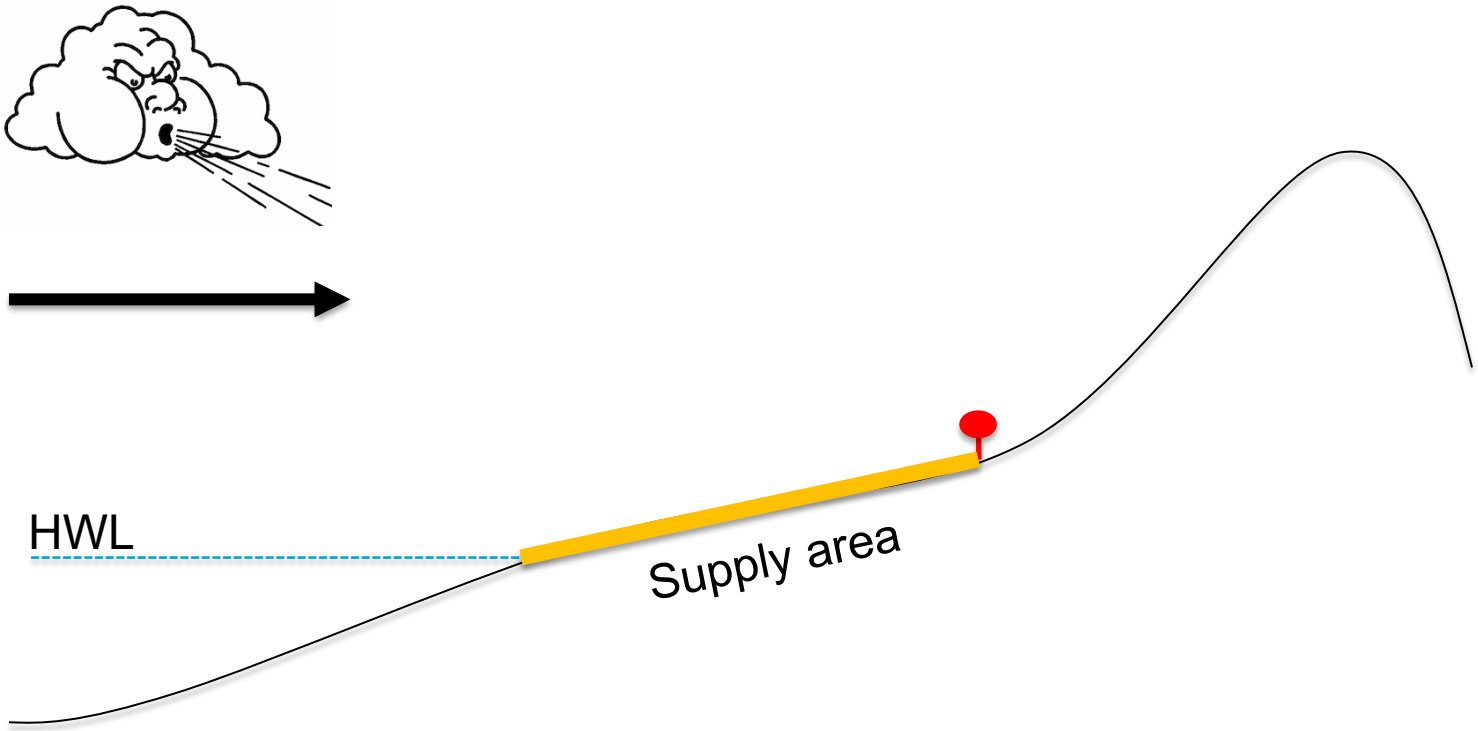


Let's formulate a conceptual model including sediment supply

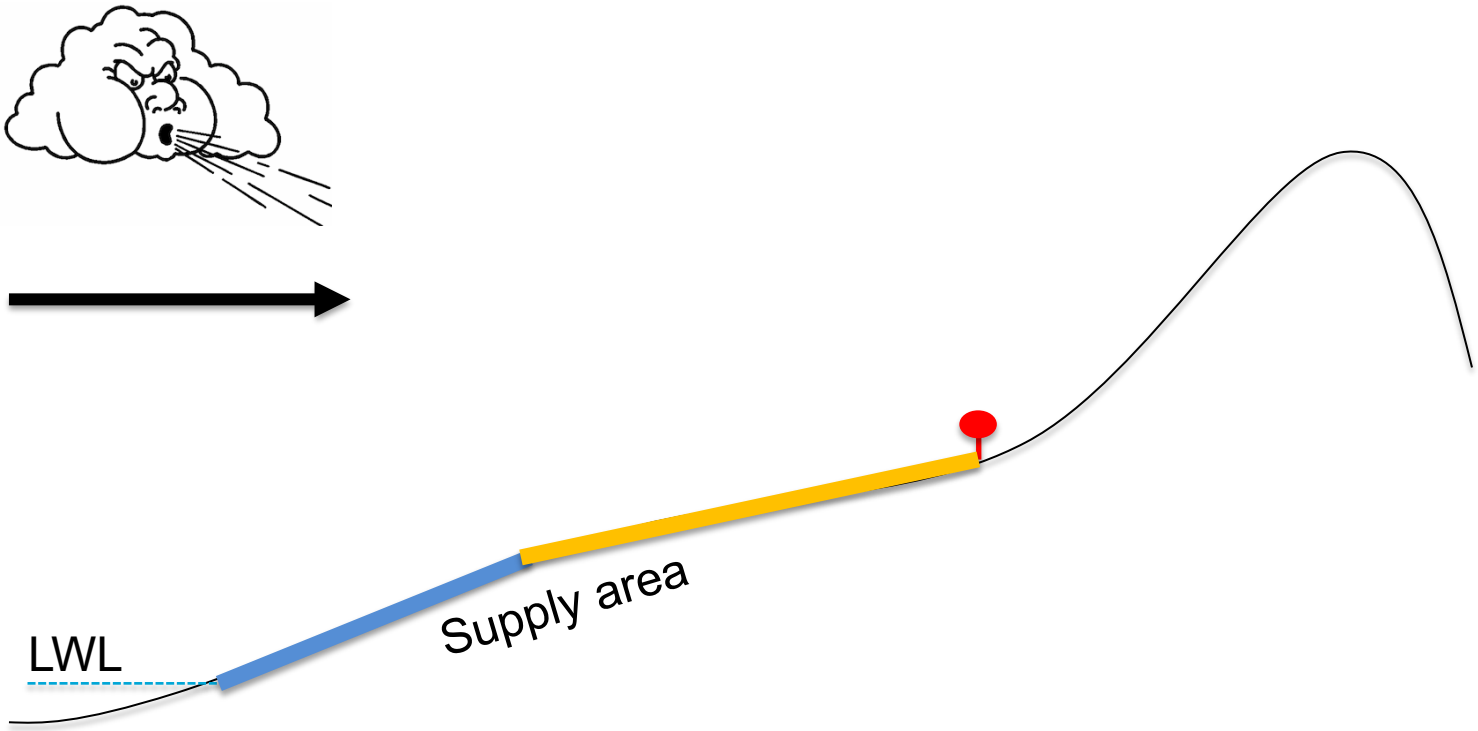


De Vries et. al. (2014)

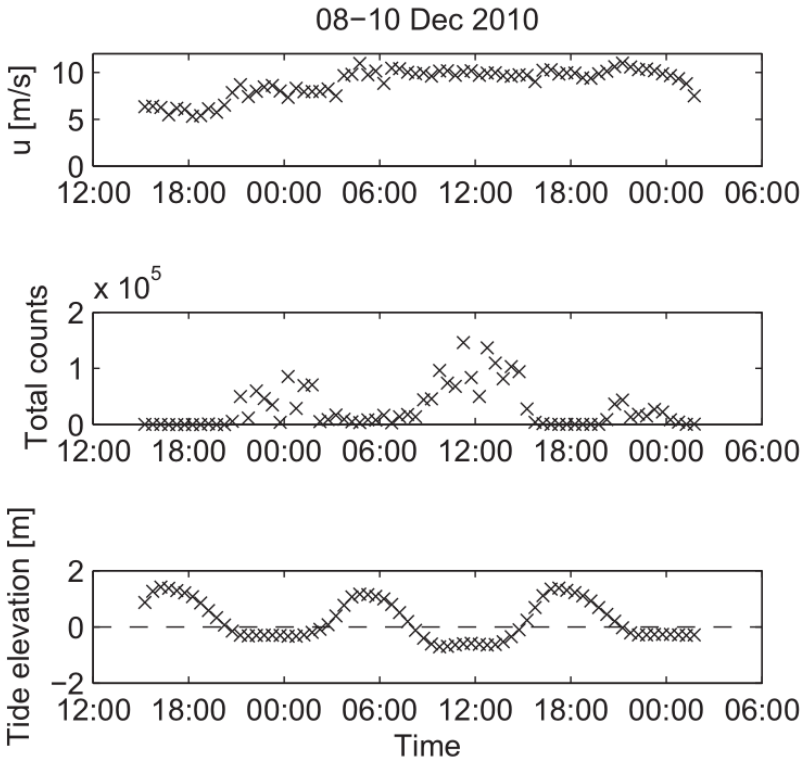
Conceptual model of sediment supply



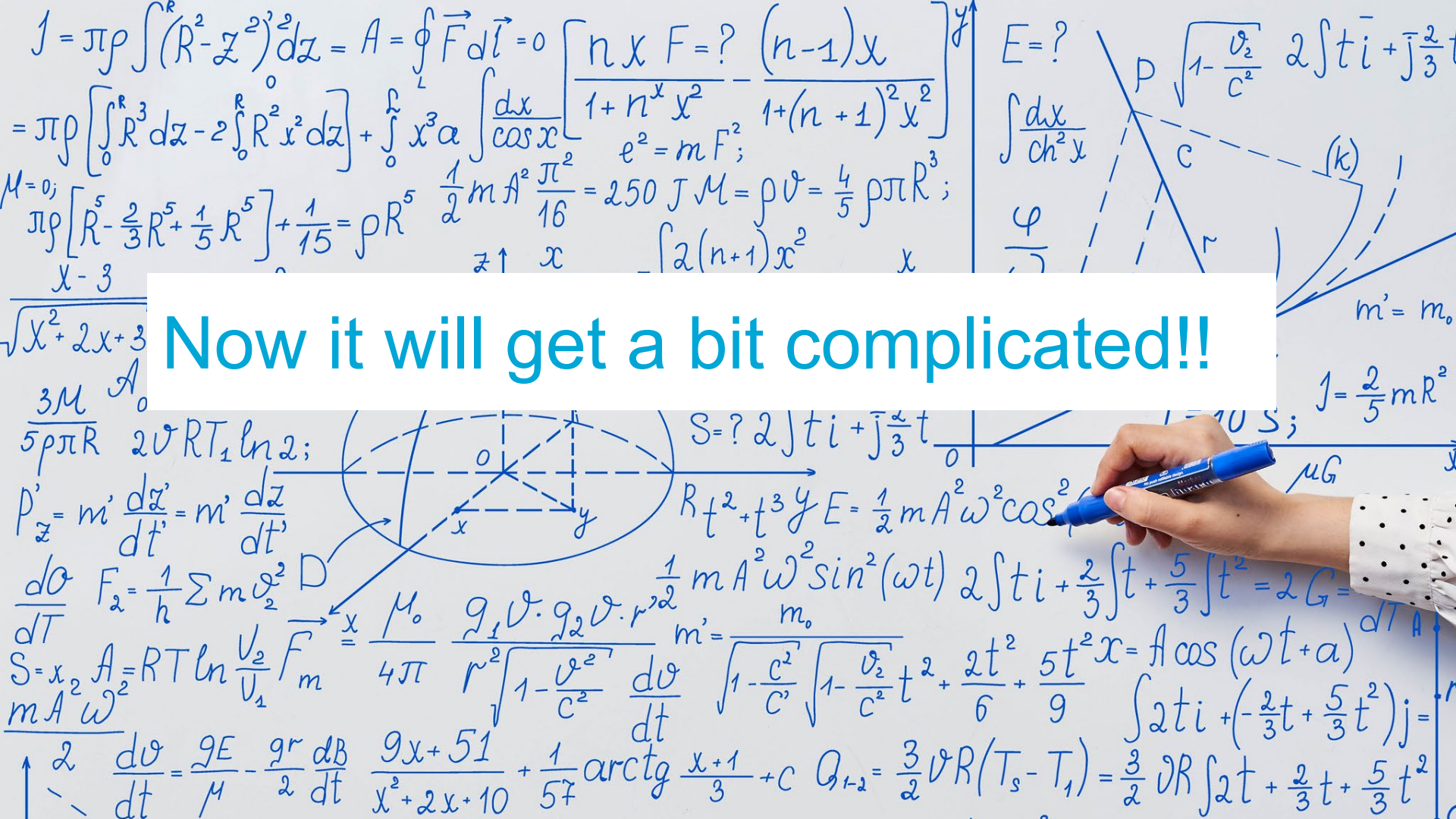
Tide and aeolian transport



Measuring supply limited aeolian sediment transport on the beach



De Vries et. al. (2014)



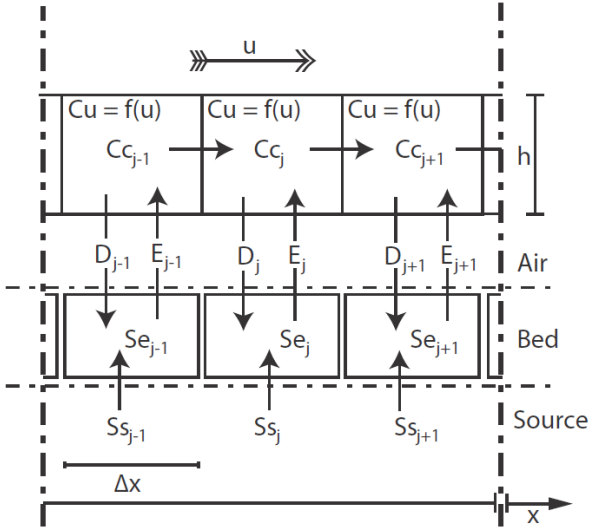
Now it will get a bit complicated!!

Supply limiting approach to aeolian sediment transport modelling

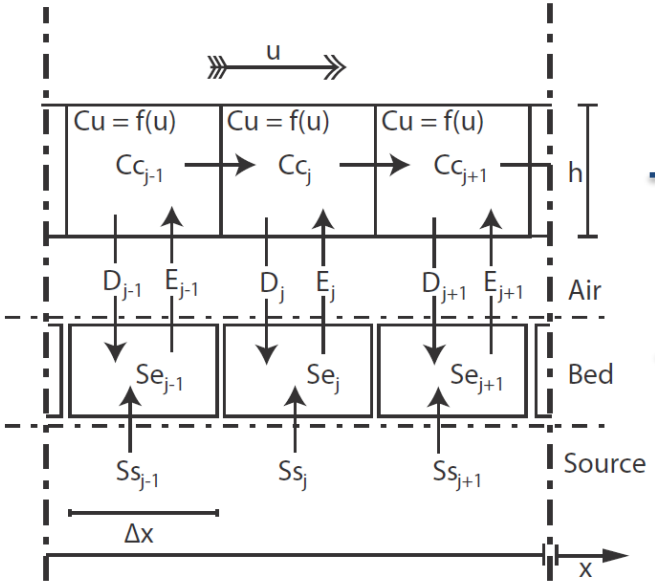
- We assume a (constant) sediment source upwind (supply zone)
- Simulate pickup and sedimentation according to 3rd power functions (Bagnold)

Schematization

- Cu is the wind driven transport capacity (Bagnold)
- Cc is sediment concentration in the air.
- Se is the sediment that is erodible at the bed.
- We assume bed exchange through erosion (E) and deposition (D)



Model with bed exchange



advection in air

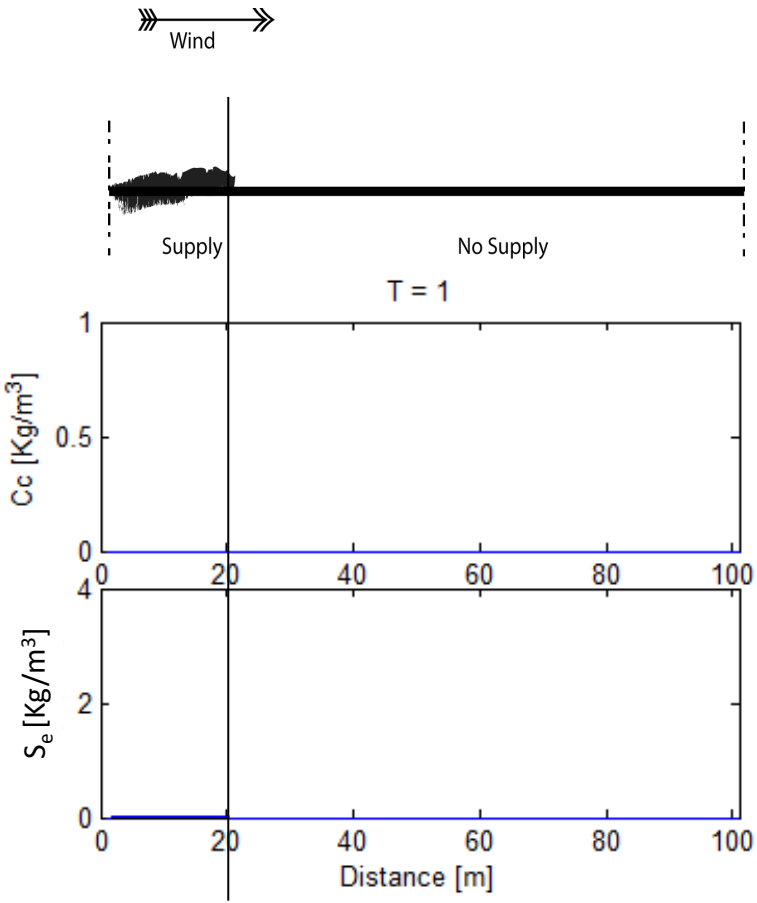
$$h\frac{\partial C_c}{\partial t} + \zeta u_w h \frac{\partial C_c}{\partial x} = E - D$$

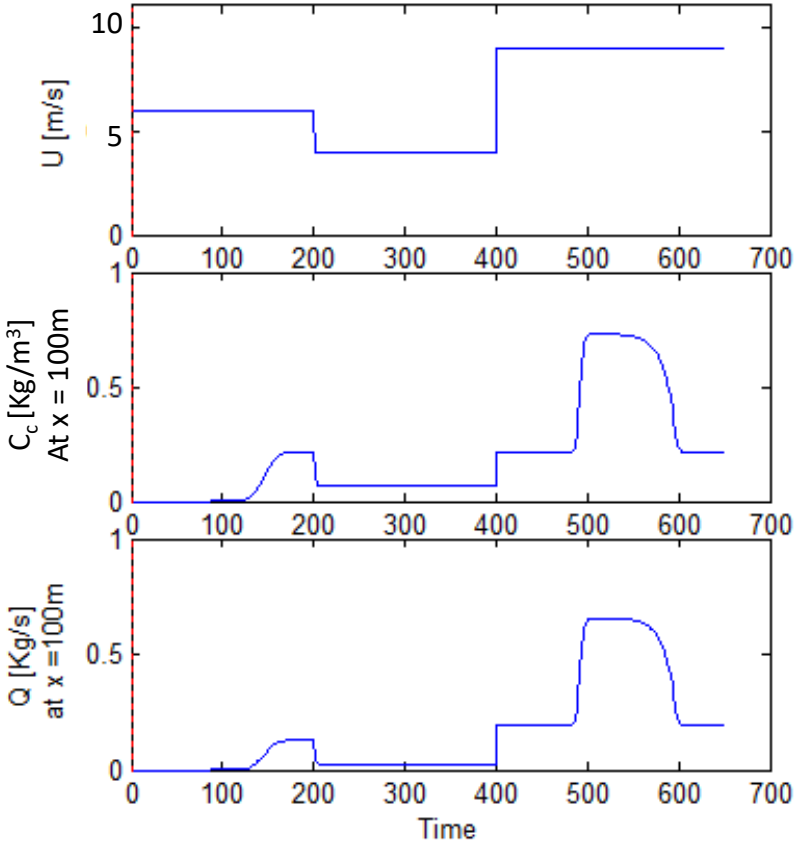
sediment at bed

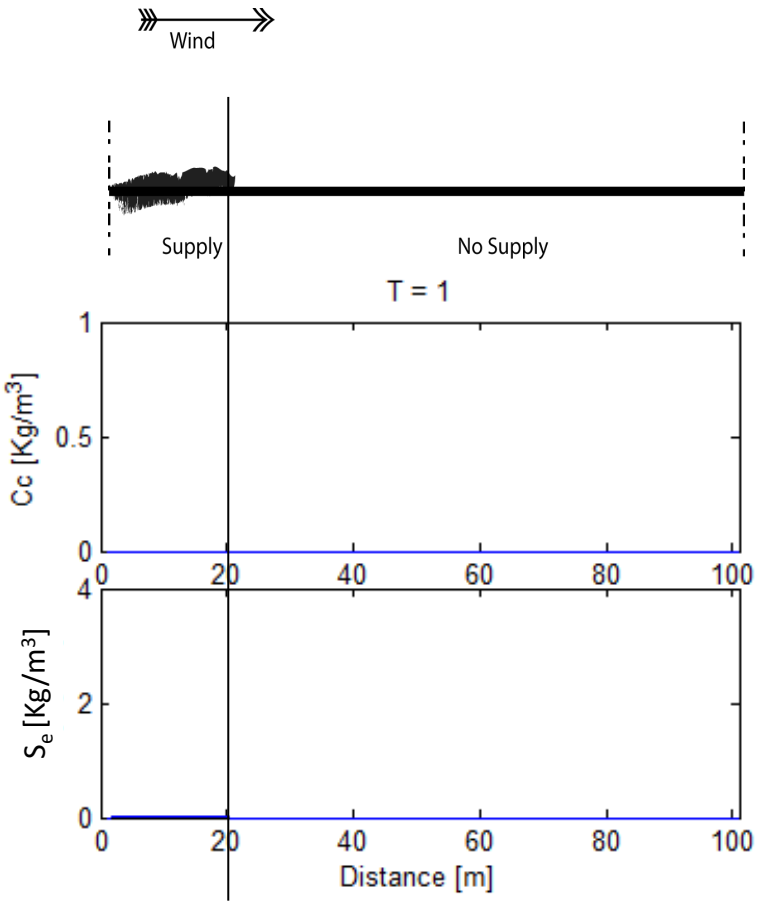
$$\frac{\partial S_e}{\partial t} = S_s - (E - D)$$

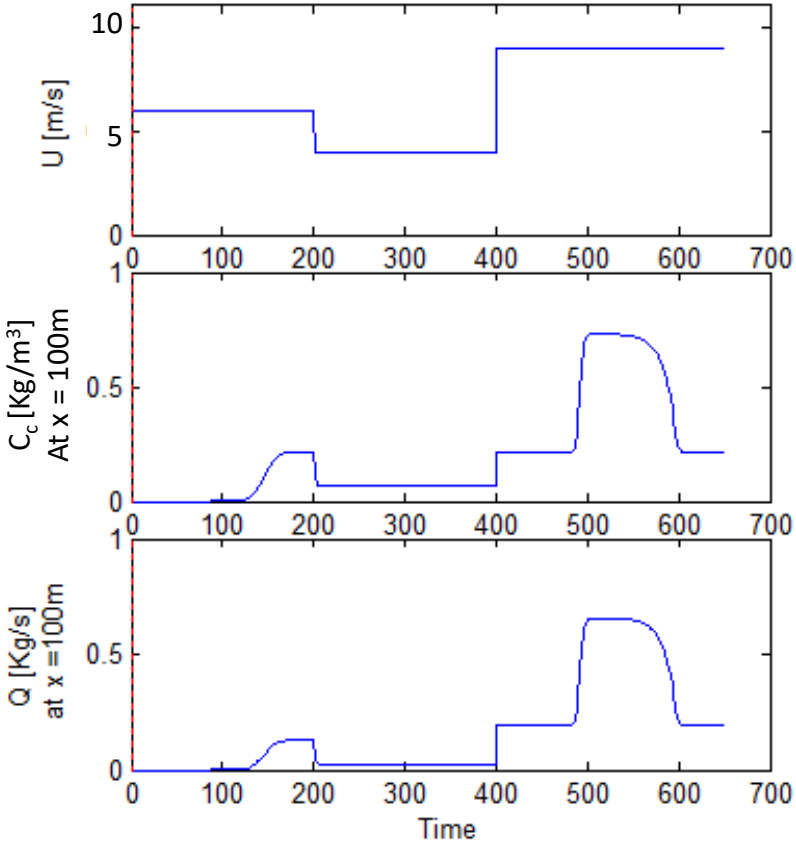
$$\frac{\partial C_c}{\partial t} + \zeta u_w \frac{\partial C_c}{\partial x} = \min\left(\frac{C_u - C_c}{T}, \frac{S_e/h}{T}\right)$$

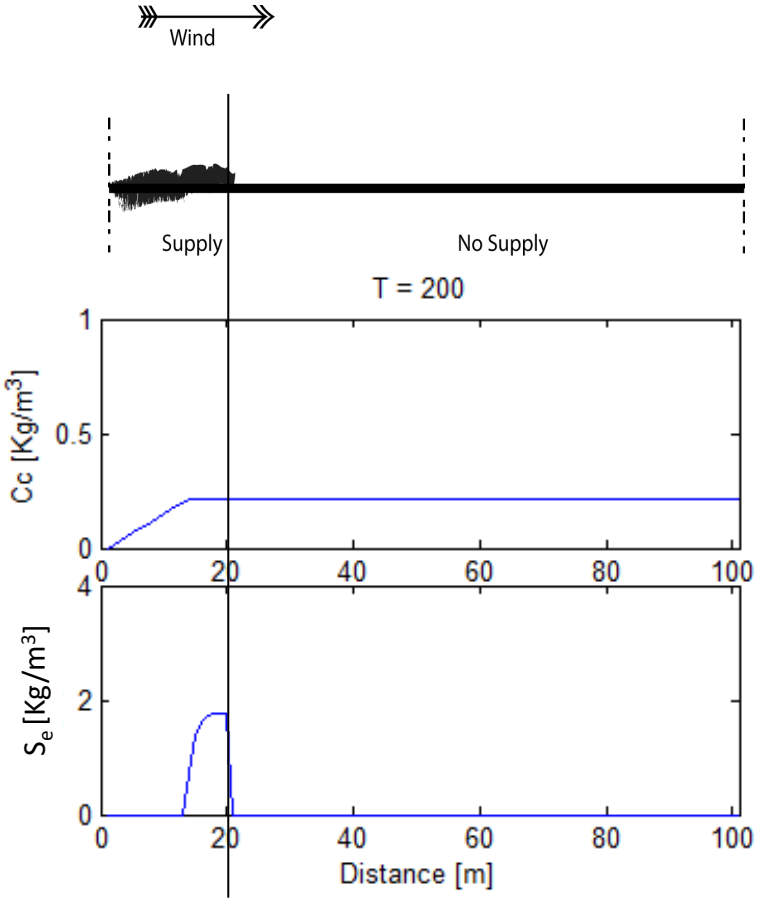
$$\frac{\partial Se/h}{\partial t} = S_s/h - \min\left(\frac{C_u - C_c}{T}, \frac{S_e/h}{T}\right)$$

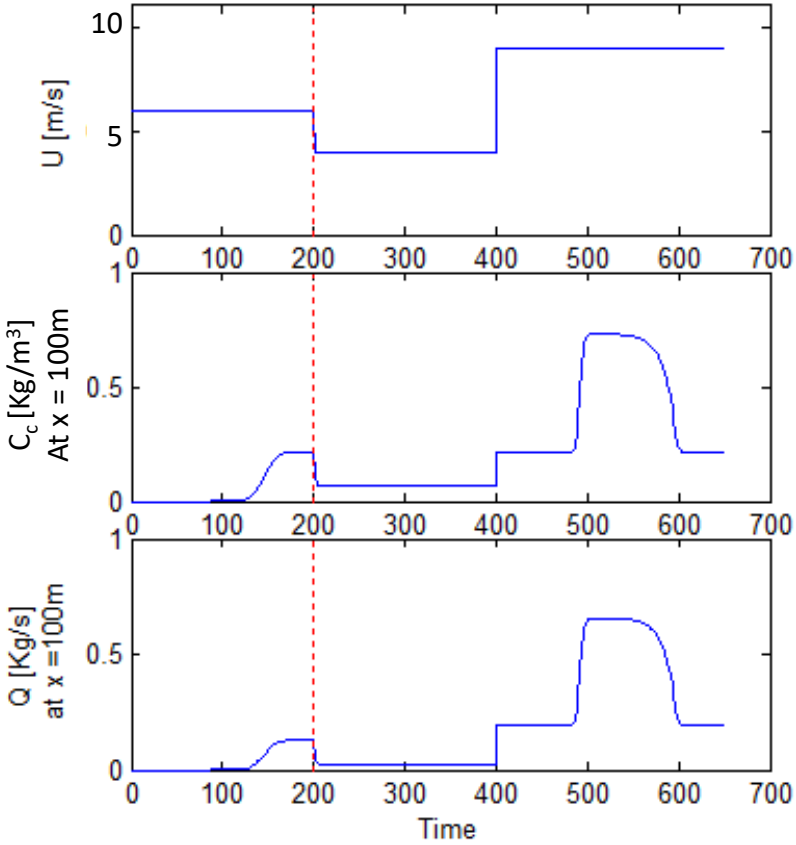

Wind
Supply
No Supply
T = 1
Cc [Kg/m3]
Se [Kg/m3]
Distance [m]

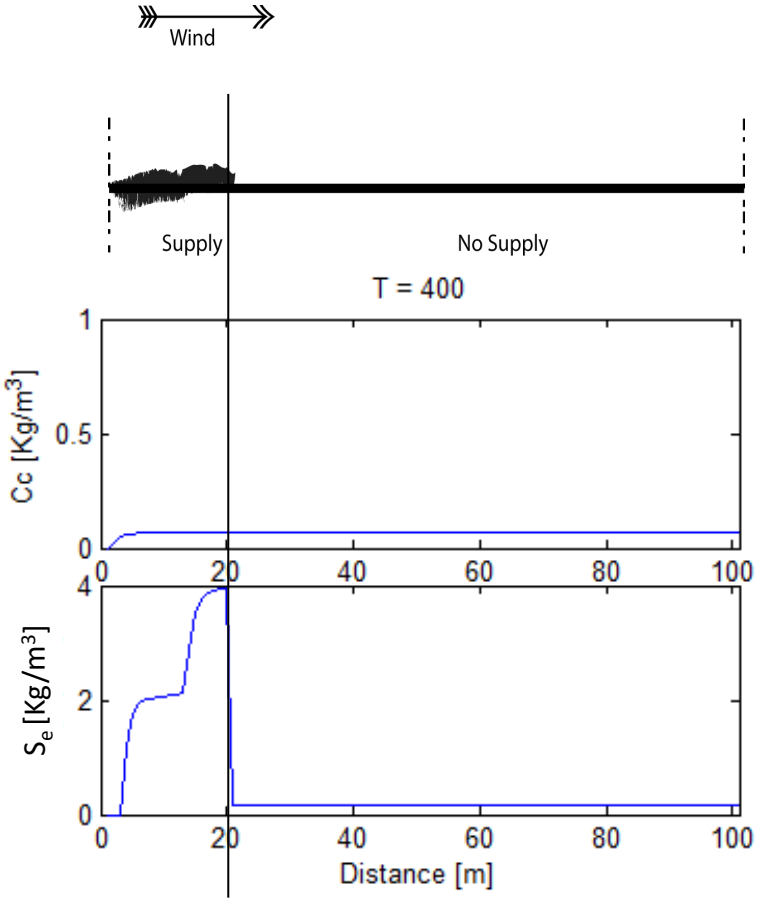

U [m/s]
Cc [Kg/m3]
At x = 100m
Q [Kg/s]
at x =100m
Time

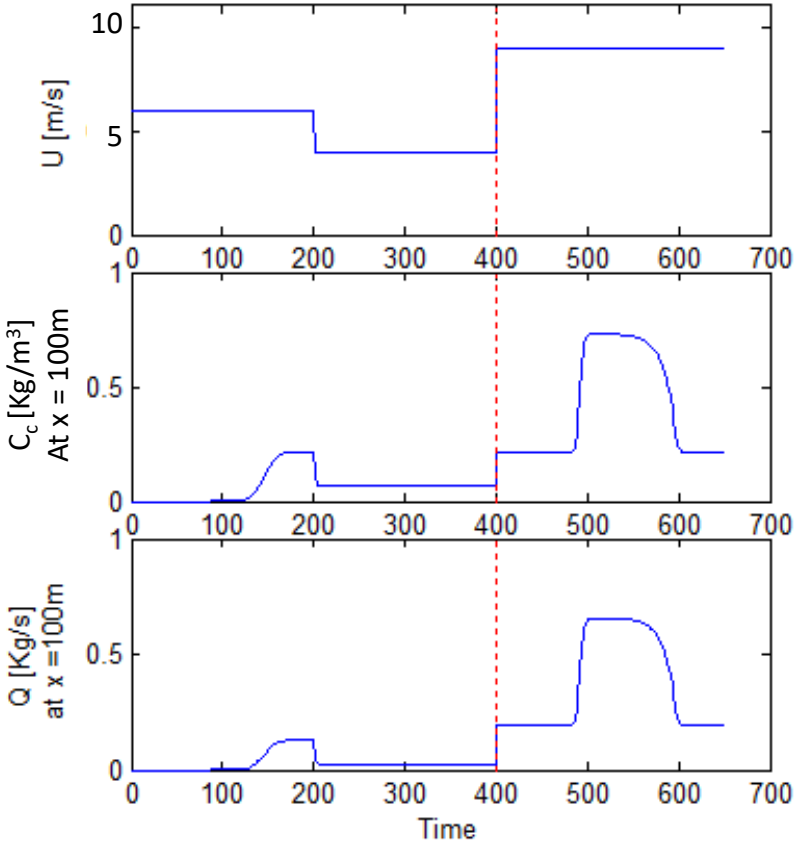

Wind
Supply
No Supply
T = 1
Cc [Kg/m3]
Se [Kg/m3]
Distance [m]

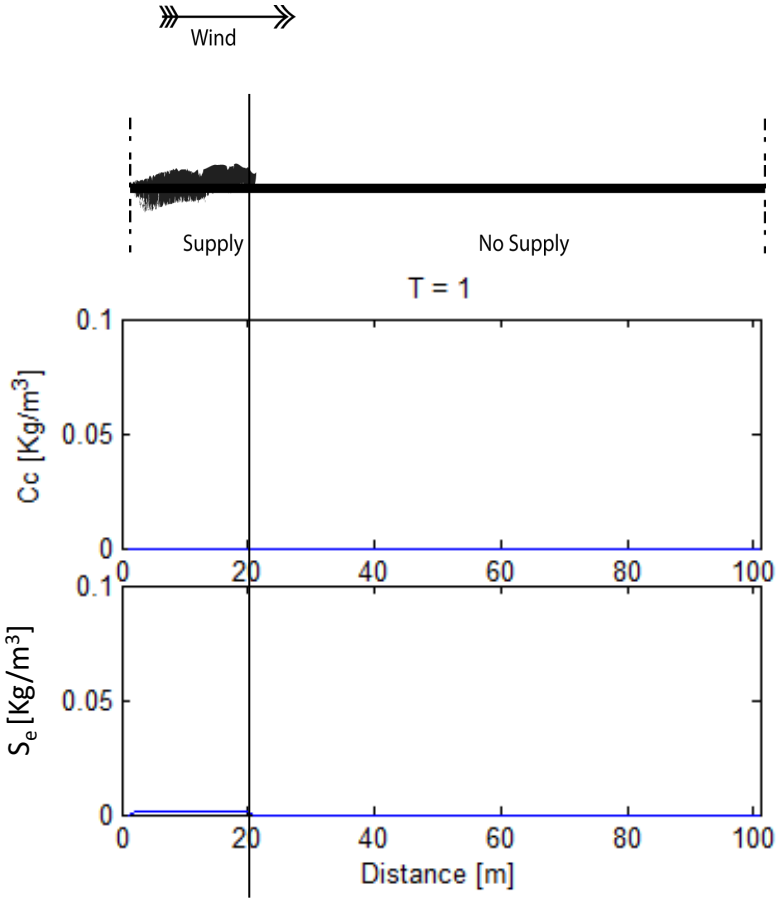

U [m/s]
Cc [Kg/m3]
At x = 100m
Q [Kg/s]
at x =100m
Time

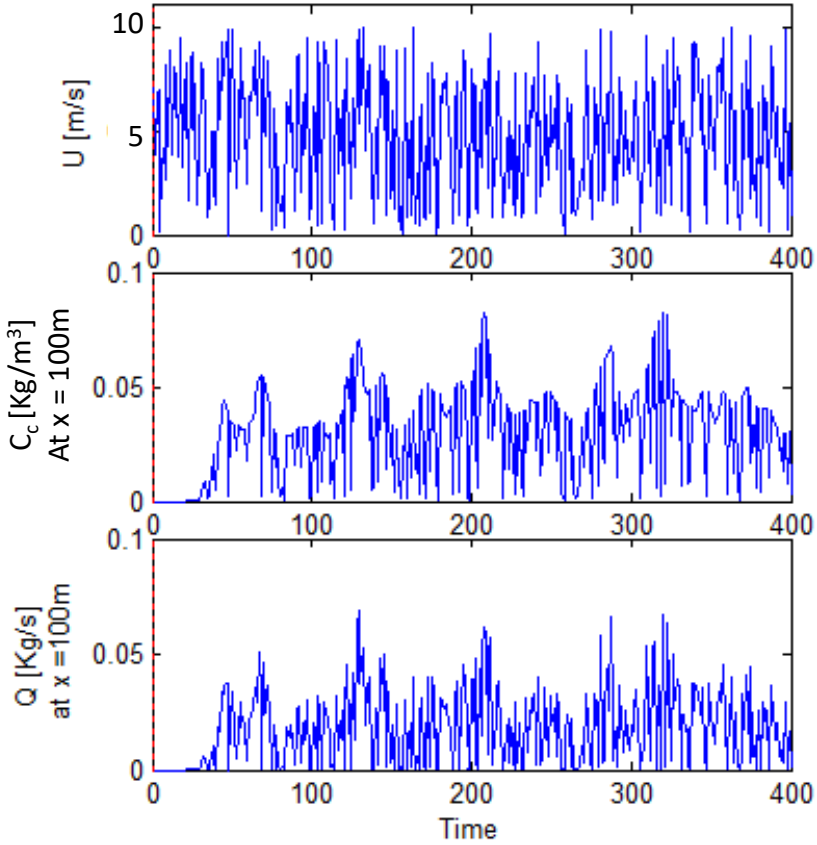

Wind
Supply
No Supply
T = 200
Cc [Kg/m3]
Se [Kg/m3]
Distance [m]

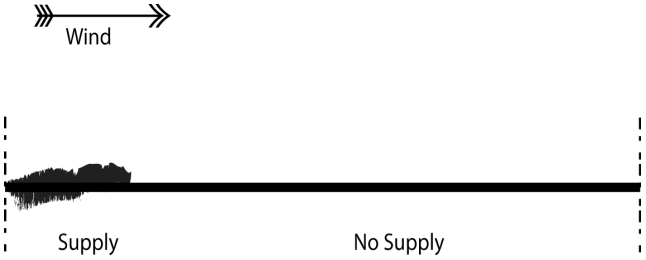

U [m/s]
Cc [Kg/m3]
At x = 100m
Q [Kg/s]
at x =100m
Time

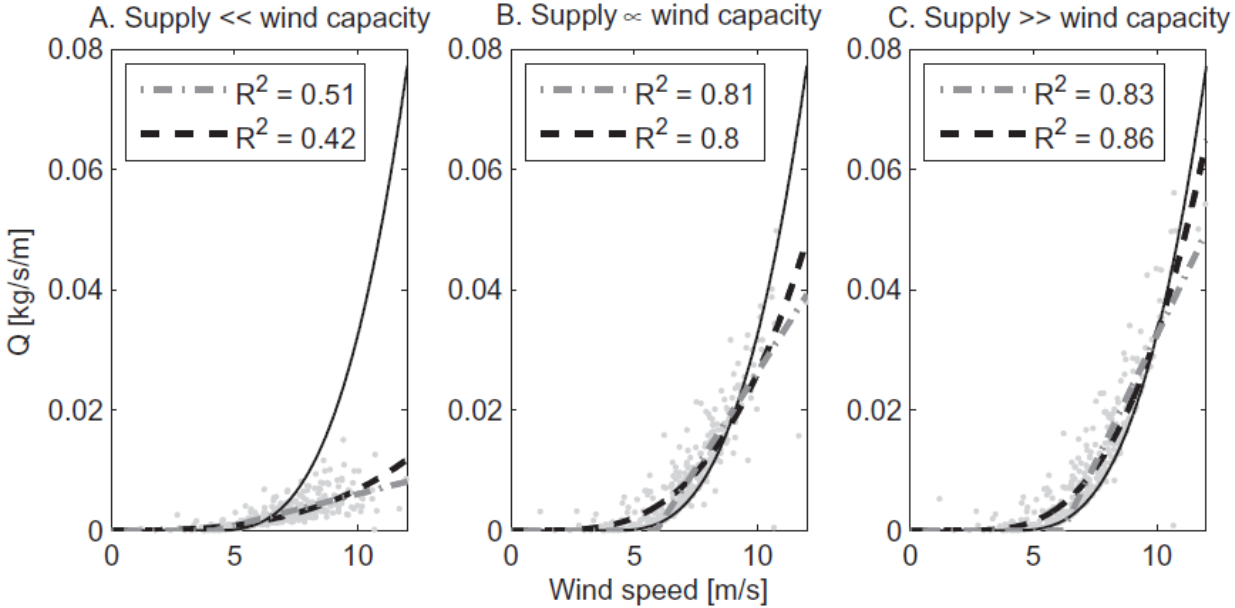

Wind
Supply
No Supply
T = 400
Cc [Kg/m3]
Se [Kg/m3]
Distance [m]

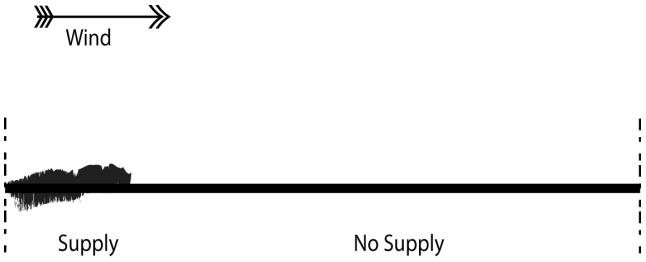

U [m/s]
Cc [Kg/m3]
At x = 100m
Q [Kg/s]
at x =100m
Time


Wind
Supply
No Supply
T = 1
Cc [Kg/m3]
Se [Kg/m3]
0.1
0.05
0
0
20
40
60
80
100
Distance [m]

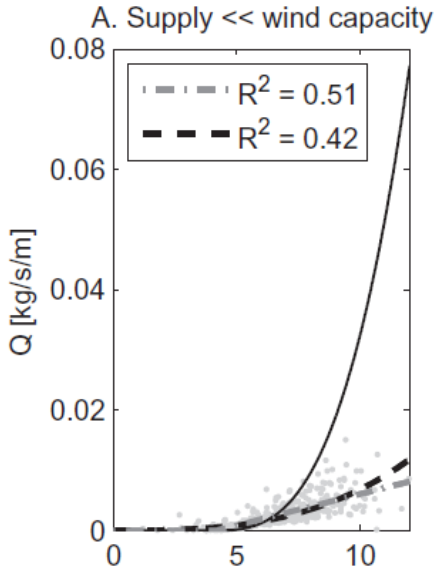

U [m/s]
10
5
0
Cc [Kg/m3]
At x = 100m
Q [Kg/s]
at x =100m
0.1
0.05
0
0
100
200
300
400
Time


Wind
Supply
No Supply


A. Supply << wind capacity
B. Supply ∝ wind capacity
C. Supply >> wind capacity
R2 = 0.51
R2 = 0.42
R2 = 0.81
R2 = 0.8
R2 = 0.83
R2 = 0.86
Q [kg/s/m]
Wind speed [m/s]
0.08
0.06
0.04
0.02
0
0
5
10

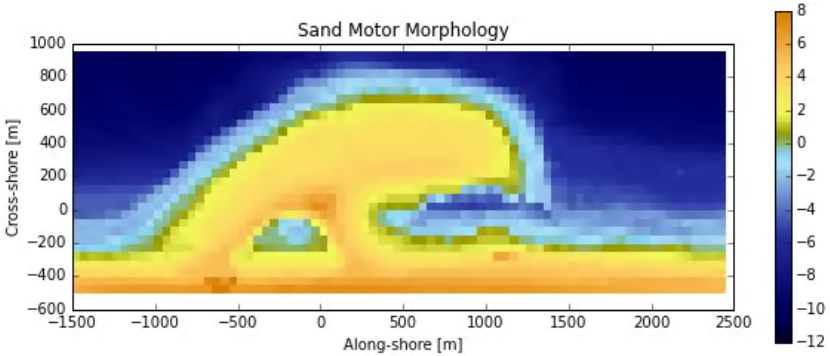


- The traditional 3rd power relationship is not reflected in model results when supply is limited
- Sediment supply can be the main governing process determining sediment transport rates.
- It is crucial to estimate sediment supply
  - How?
    - This is an open research question



AEOLIS - model

- Numerical implementation of supply limited aeolian **sediment transport**
- Allowing for **transport limited** (Bagnold) conditions



AEOLIS - model

- 2D aeolian sediment transport model for supply limited situations
  - Sediment sorting
  - Moisture
  - Vegetation
  - Hard structures
  - …

Lets work!

- Run the 2 zandmotor simulations
  - *sandmotor_10year_sorting0_tide0_waves0*
  - *sandmotor_10year_sorting1_tide0_waves0*

- Notebook 1 will help analysing results.
- Background is available on: https://aeolis.readthedocs.io
- Ask the team for assistance
- …