AEOLIS SHORTCOURSE:

SURFACE MOISTURE PROCESSES IN AEOLIS

Caroline Hallin 2023-04-11

TU Delft

Surface moisture influence erodibility and transport

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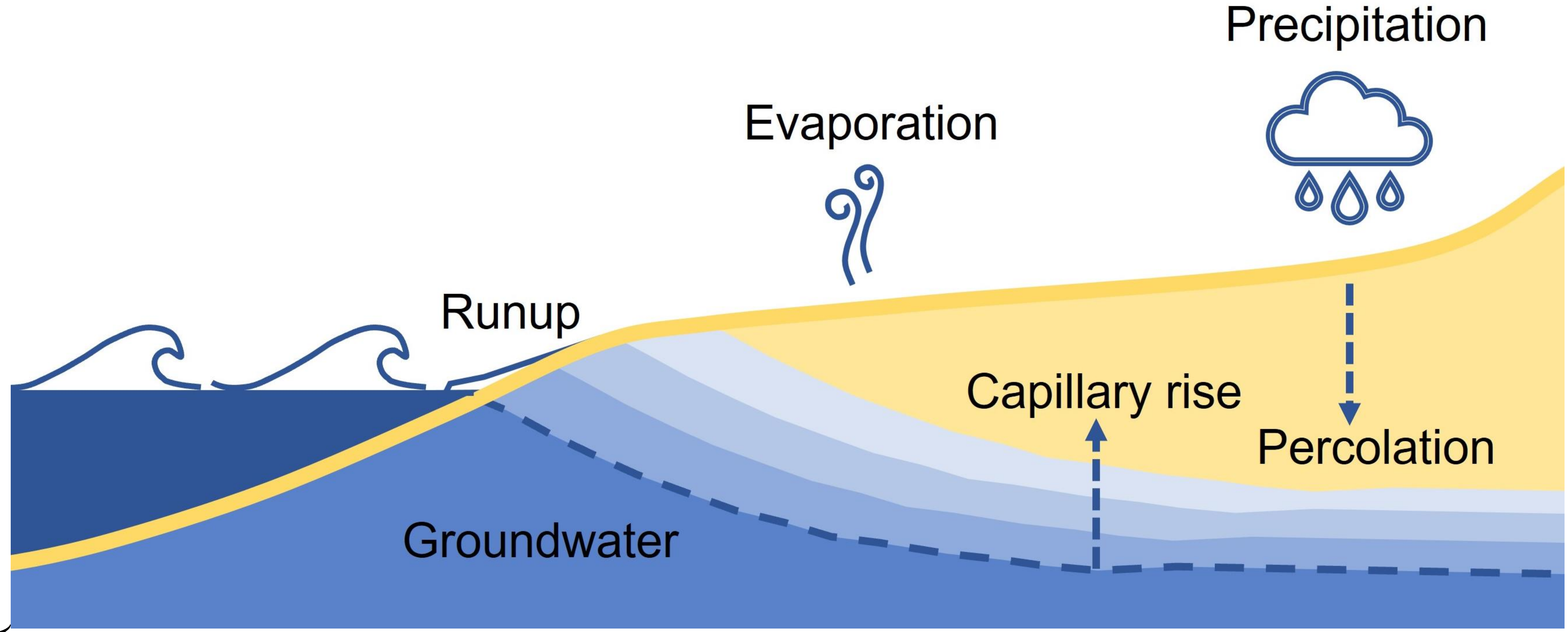
New surface moisture module in AeoLiS



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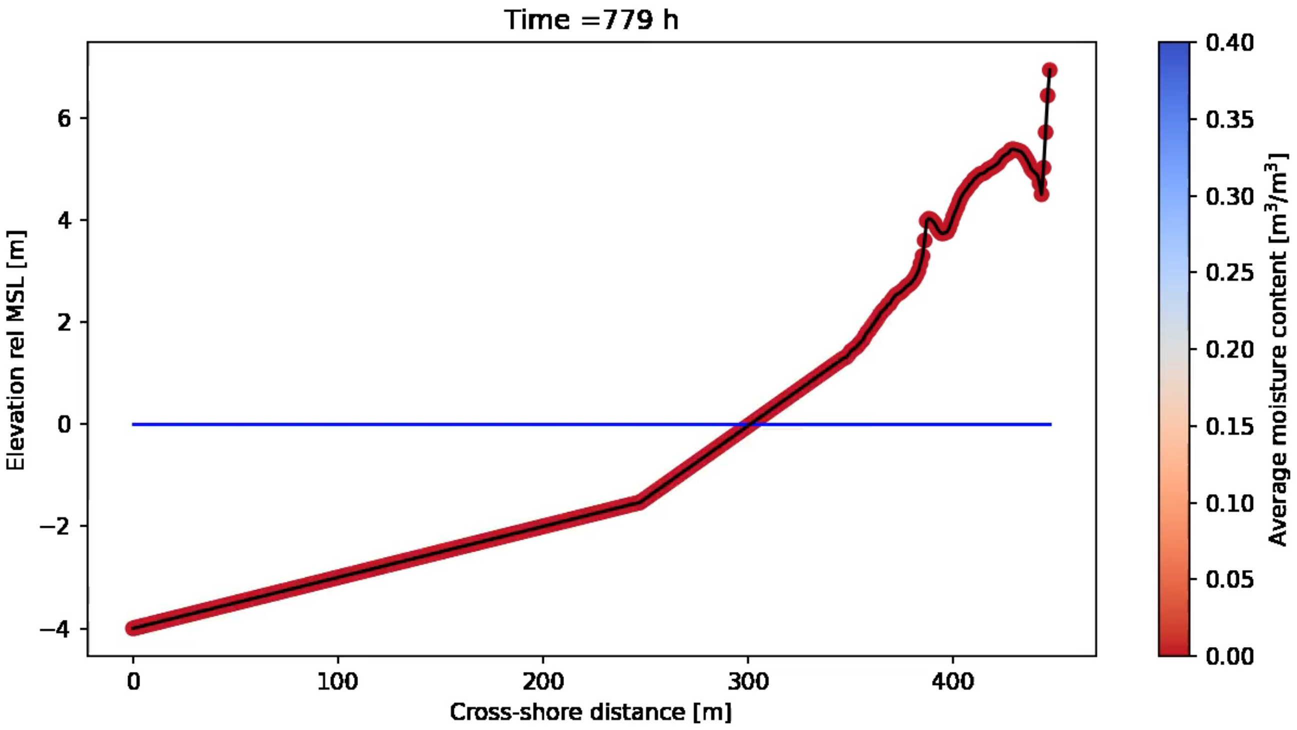
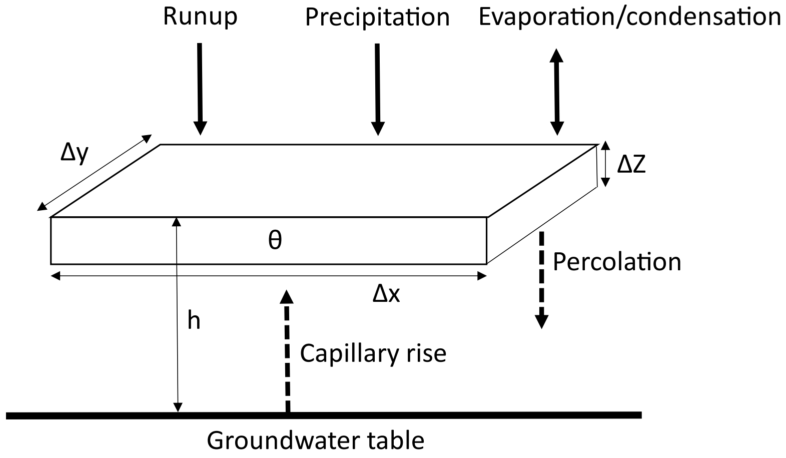
Governing equations





- Groundwater – Boussinesq equation including runup
- Soil water retention relationship, including hysteresis
- Scanning curves describe transition between wetting and drying conditions
- Penman equation
- Percolation follow exponential decay function to field capacity

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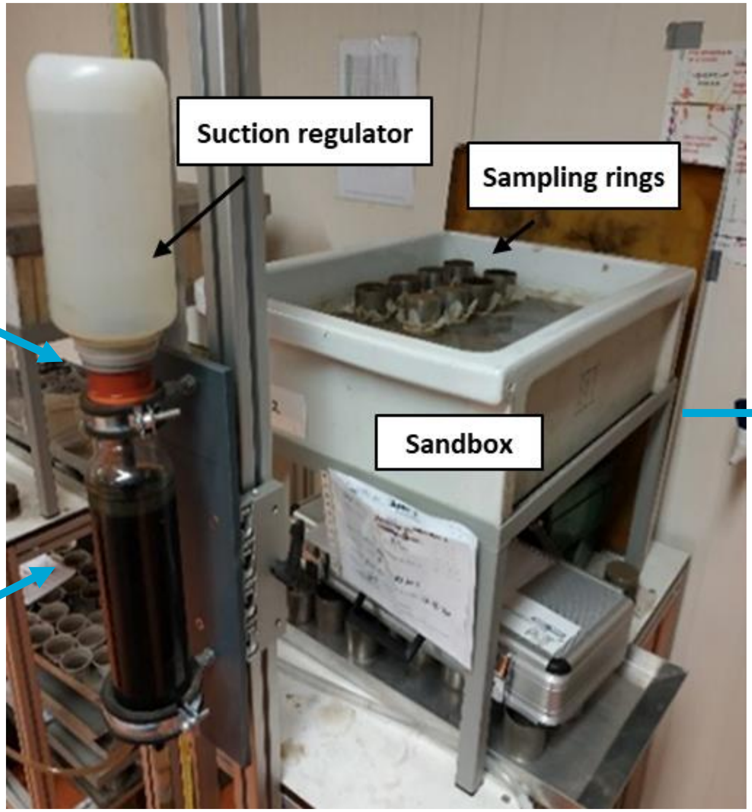
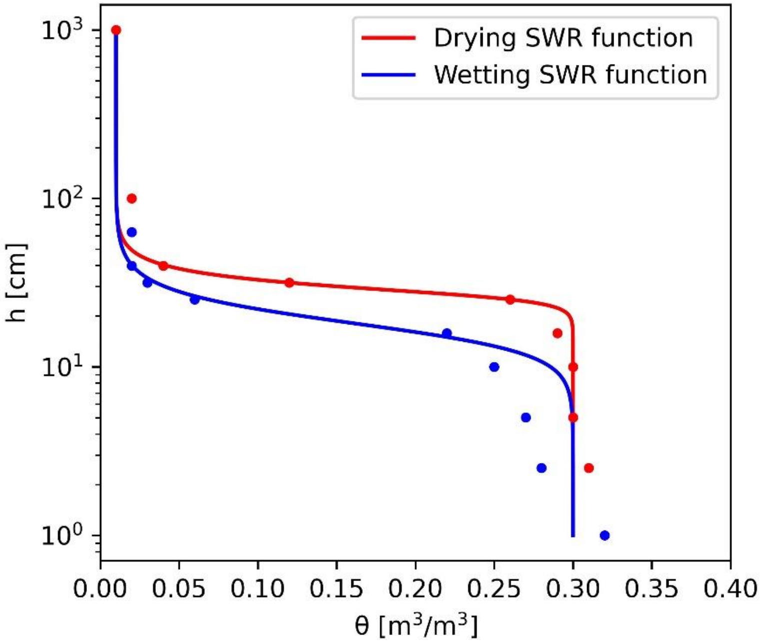
Ref: Hallin et al (in review); Raubenheimer et al, 1999; Nielsen et al 1988; van Genuchten, 1980; Mualem, 1974; Shuttleworth, 1993

Soil water retention data from 10 beaches





Model input

```
%% -------------------- [Flags Processes] -------------------- %%
process_wind           = T                          % (T) [T/F] Enable the process of wind
process_threshold      = T                          % (T) [T/F] Enable the process of threshold
process_transport      = T                          % (T) [T/F] Enable the process of transport
process_bedupdate      = T                          % (T) [T/F] Enable the process of bed updating
process_shear          = F                          % (F) [T/F] Enable the process of wind shear
process_tide           = T                          % (F) [T/F] Enable the process of tides
process_wave           = T                          % (F) [T/F] Enable the process of waves
process_runup          = T                          % (F) [T/F] Enable the process of wave runup
process_moist          = T                          % (F) [T/F] Enable the process of moist
process_mixtoplayer    = F                          % (F) [T/F] Enable the process of mixing
process_wet_bed_reset  = T                          % (F) [T/F] Enable the process of bed-reset in the intertidal zone
process_meteo          = T                          % (F) [T/F] Enable the process of meteo
process_avalanche      = F                          % (F) [T/F] Enable the process of avalanching
process_separation     = F                          % (F) [T/F] Enable the including of separation bubble
process_vegetation     = F                          % (F) [T/F] Enable the process of vegetation
process_fences         = F                          % (F) [T/F] Enable the process of sand fencing
process_dune_erosion   = F                          % (F) [T/F] Enable the process of wave-driven dune erosion
process_groundwater    = T                          % (F) [T/F] Enable the process of groundwater
process_seepage_face   = T                          % (F) [T/F] Enable the process of groundwater seepage
process_scanning       = F                          % (F) [T/F] Enable the process of scanning curves
```

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Model input

```
%% -------------------- [Soil moisture] ---------------------- %%
Tdry                   = 5400.000   % (5400.) [s] Adaptation time scale for soil drying
eps                    = 0.001      % (0.001) [m] Minimum water depth to consider a cell "flooded"
method_moist_process   = surf_moisture  % (infiltration) Name of method to compute soil moisture content(infiltration or surface_moisture)
method_moist_threshold = belly_johnson  % (belly_johnson) [-] Name of method to compute wind velocity threshold based on soil moisture content
fc                     = 0.11       % (0.11) [-] Moisture content at field capacity (volumetric)
w1_5                   = 0.02       % (0.02) [-] Moisture content at wilting point (gravimetric)
resw_moist             = 0.01       % (0.01) [-] Residual soil moisture content (volumetric)
resd_moist             = 0.01       % (0.01) [-] Residual soil moisture content (volumetric)
satw_moist             = 0.30       % (0.35) [-] Satiated soil moisture content (volumetric)
satd_moist             = 0.30       % (0.5) [-] Satiated soil moisture content (volumetric)
nw_moist               = 5.0        % (2.3) [-] Pore-size distribution index in the soil water retention function
nd_moist               = 13.7       % (4.5) [-] Pore-size distribution index in the soil water retention function
mw_moist               = 0.80       % (0.57) [-] m, van Genuchten param (can be approximated as 1-1/n)
md_moist               = 0.40       % (0.42) [-] m, van Genuchten param (can be approximated as 1-1/n)
alfaw_moist            = 0.058      % (-0.07) [cm^-1] Inverse of the air-entry value for a wetting branch of the soil water retention function
alfad_moist            = 0.038      % (-0.035) [cm^-1] Inverse of the air-entry value for a drying branch of the soil water retention function
K_gw                   = 0.0001     % (0.00078) [m/s] Hydraulic conductivity
ne_gw                  = 0.3        % (0.3) [-] Effective porosity/specific yield
D_gw                   = 12         % (12) [m] Aquifer depth
Cl_gw                  = 0.2        % (0.7) [m] Groundwater overheight due to runup
in_gw                  = 0          % (0) [m] Initial groundwater level
tfac_gw                = 30         % (10) [-] Reduction factor for time step in ground water calculations
```

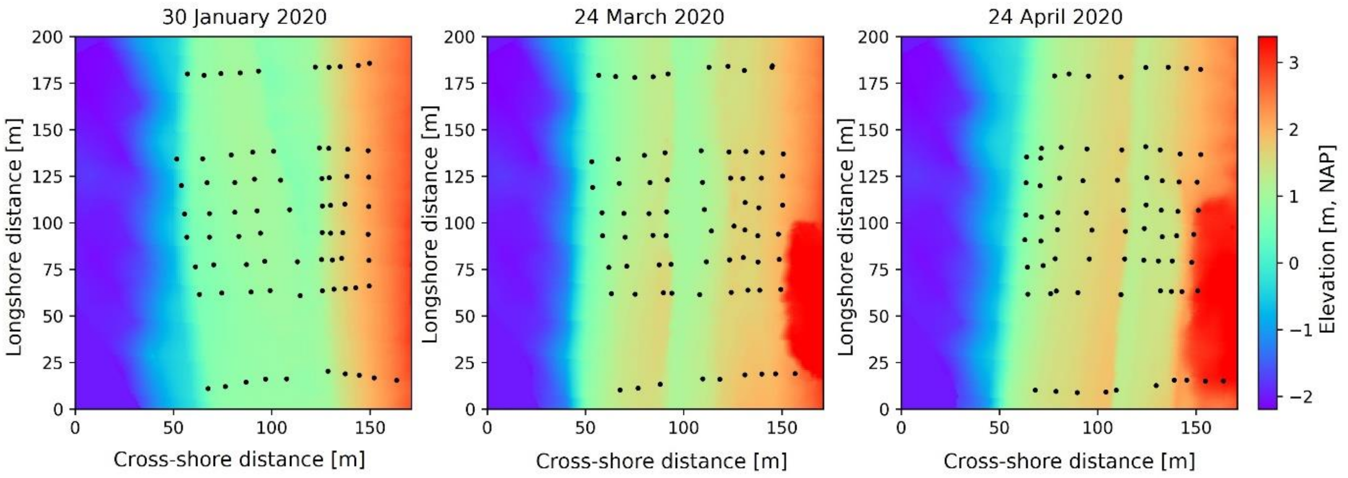
Percolation

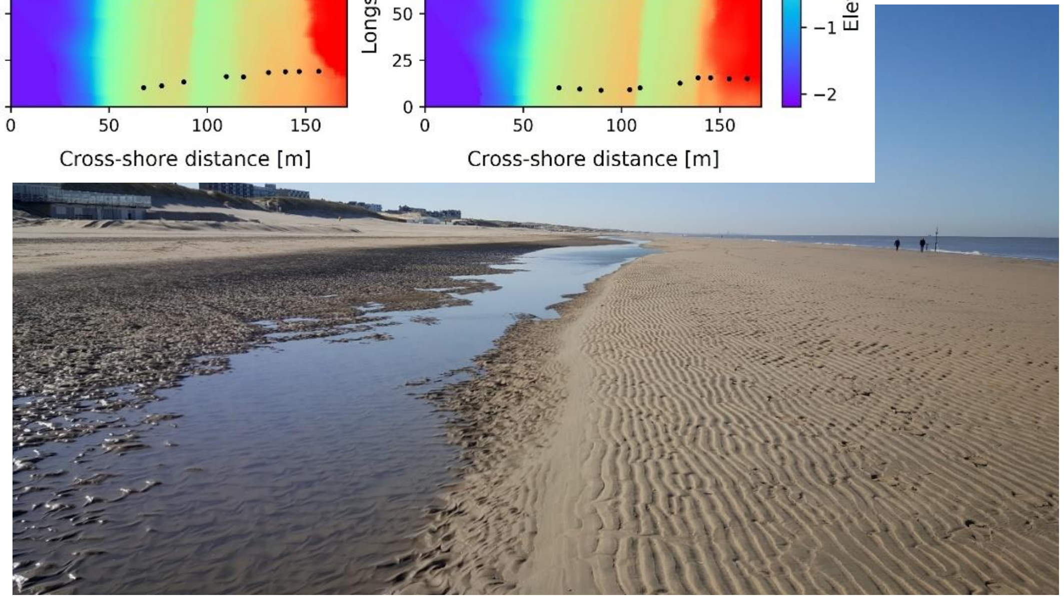
SWR properties

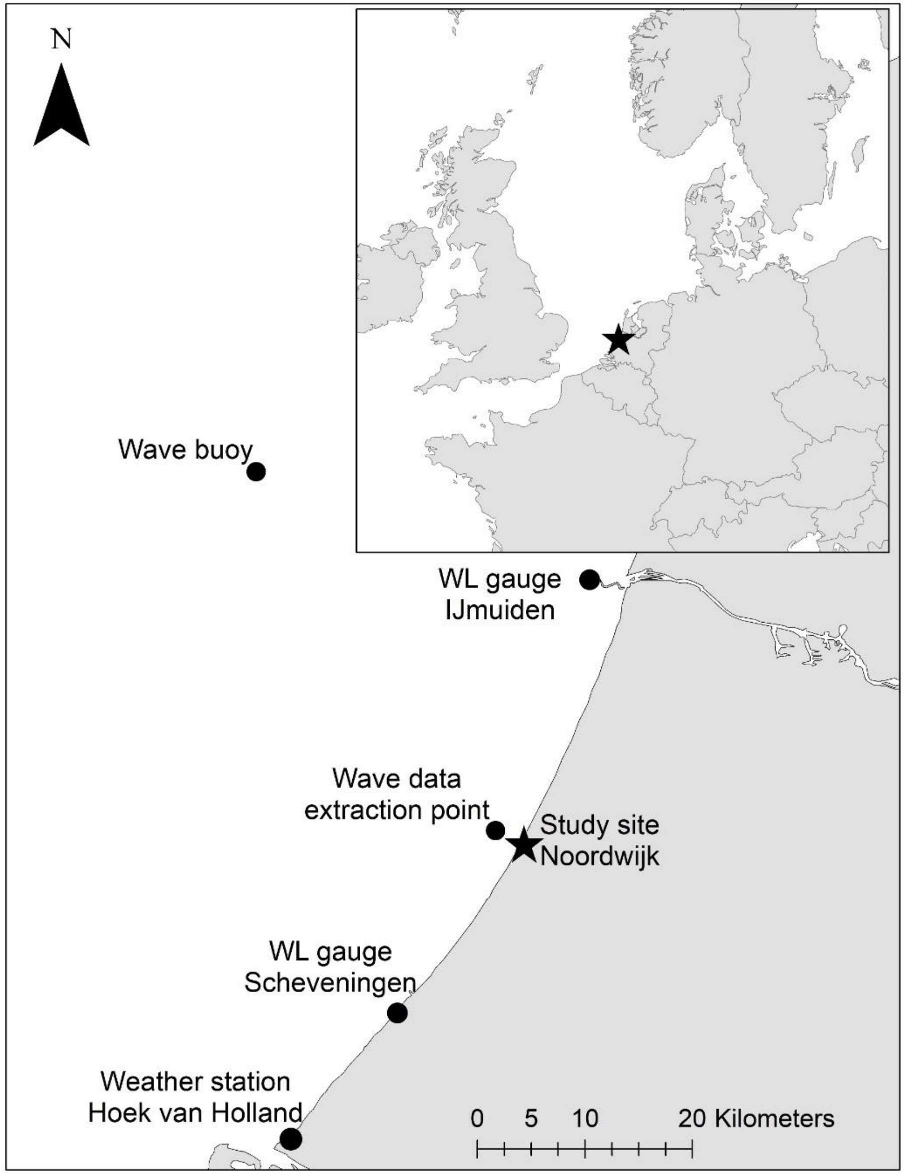
Groundwater

Noordwijk – validation against field data

221 sediment samples from the upper 2 mm of the beach at three occasions:

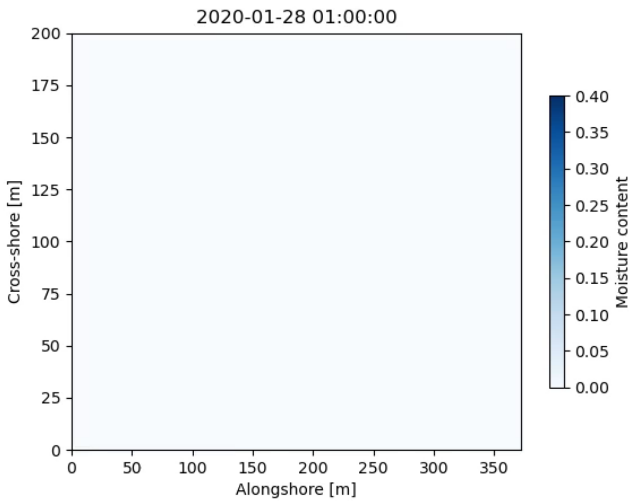


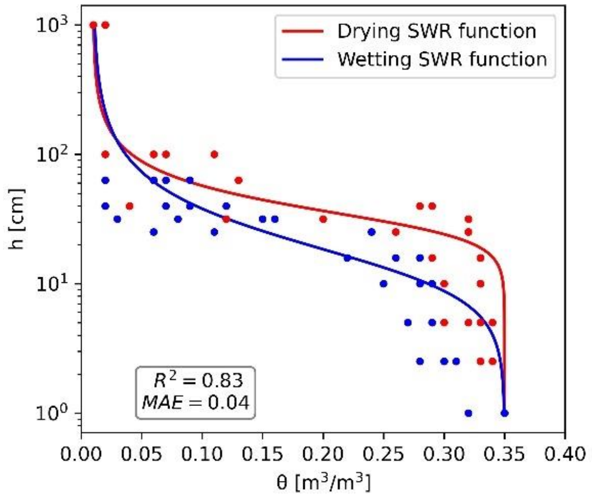


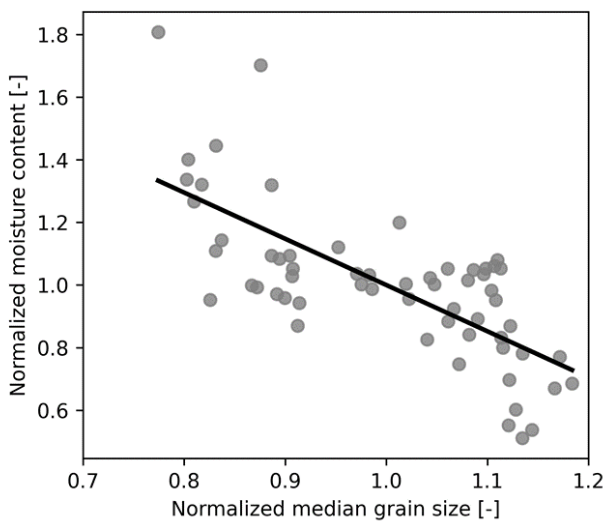


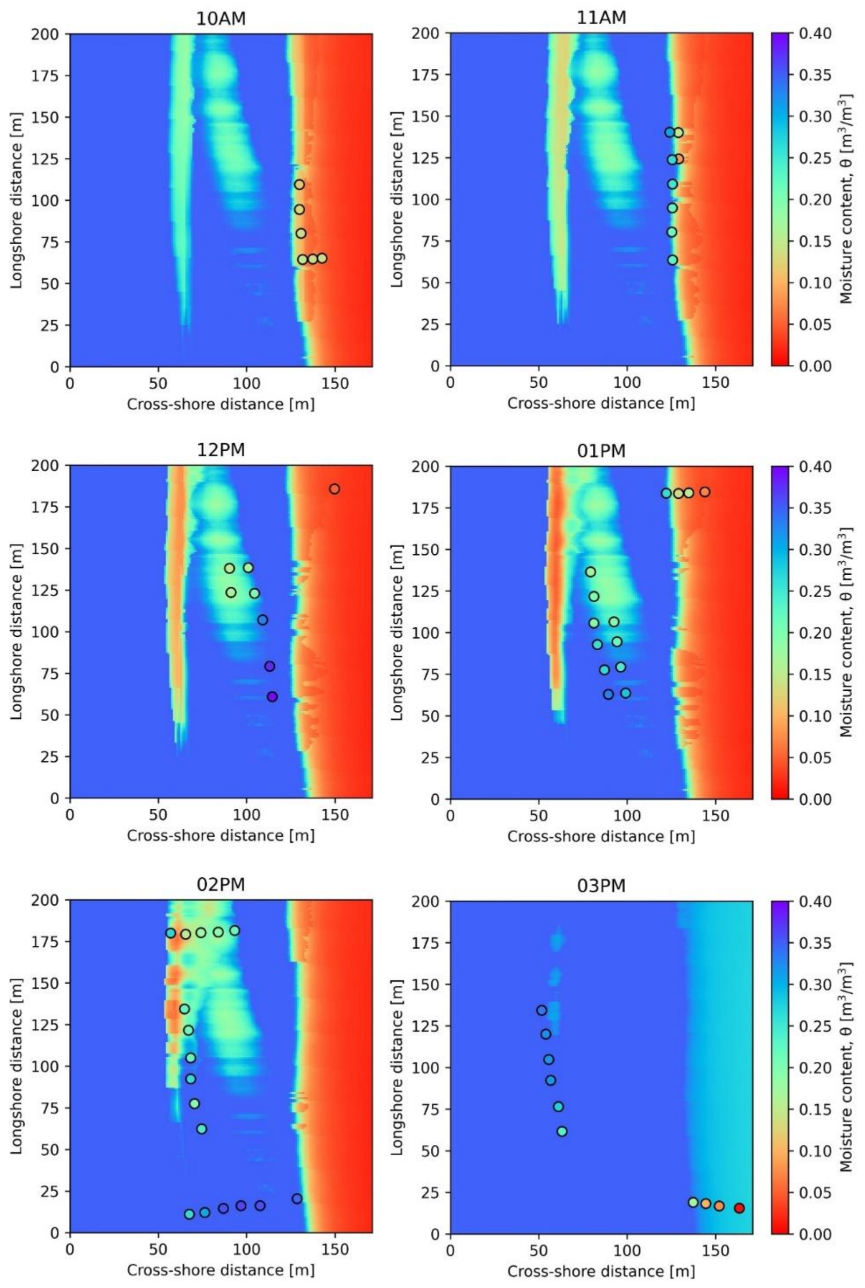
Results

ME: -0.01 m^3/m^3
MAE: 0.07 m^3/m^3









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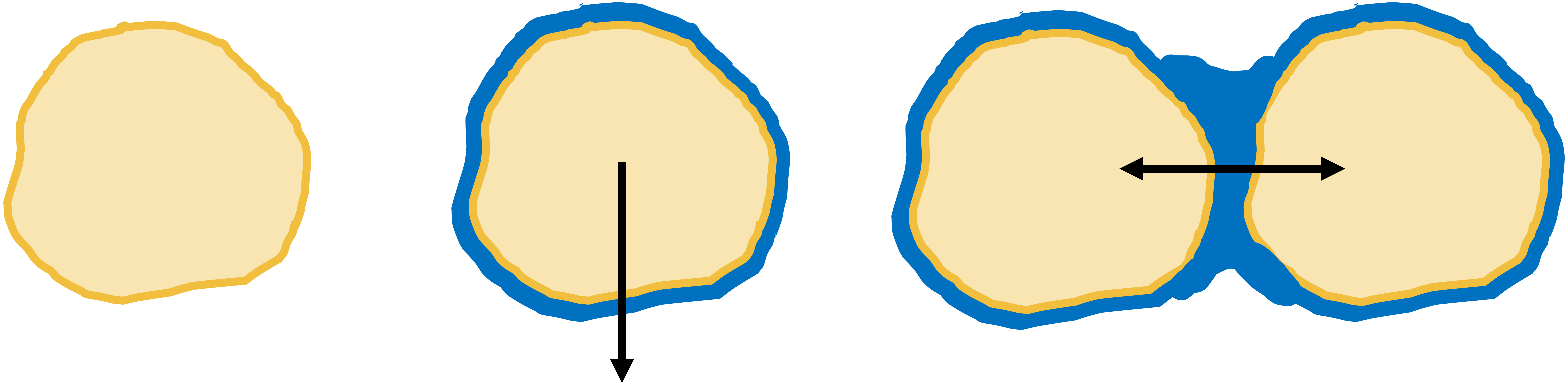
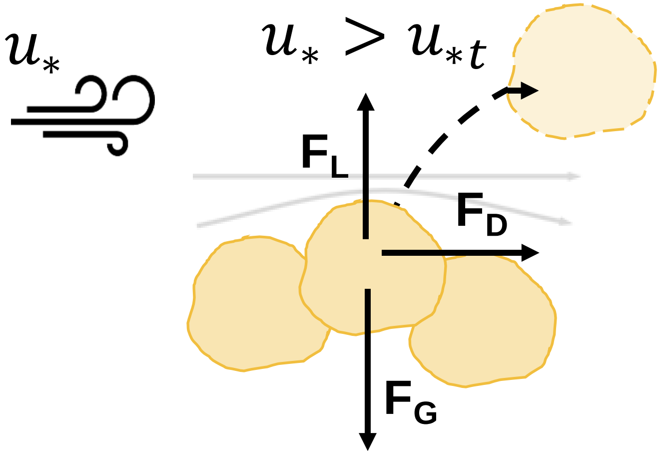
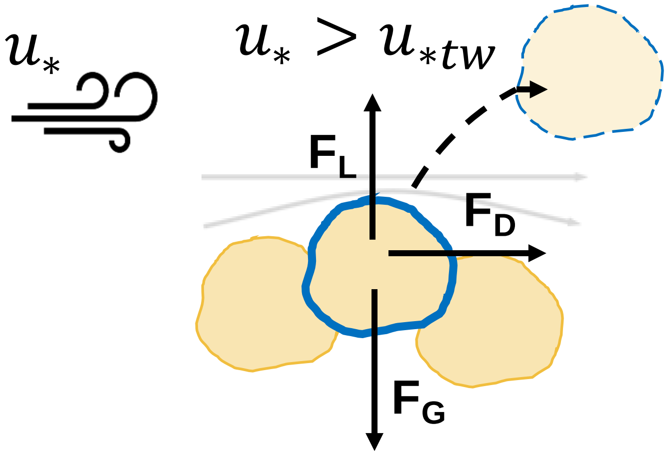
Influence of moisture on aeolian transport

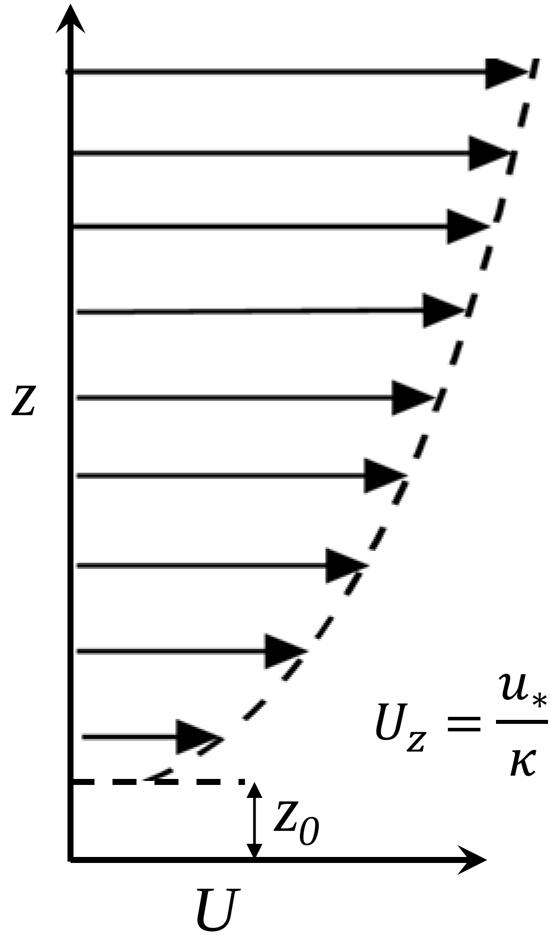
Dry sand grain　　Adhesion　　Cohesion



Effect of moisture on aeolian transport simulations







$$U_z = \frac{u_*}{\kappa} ln\left(\frac{z}{z_0}\right)$$

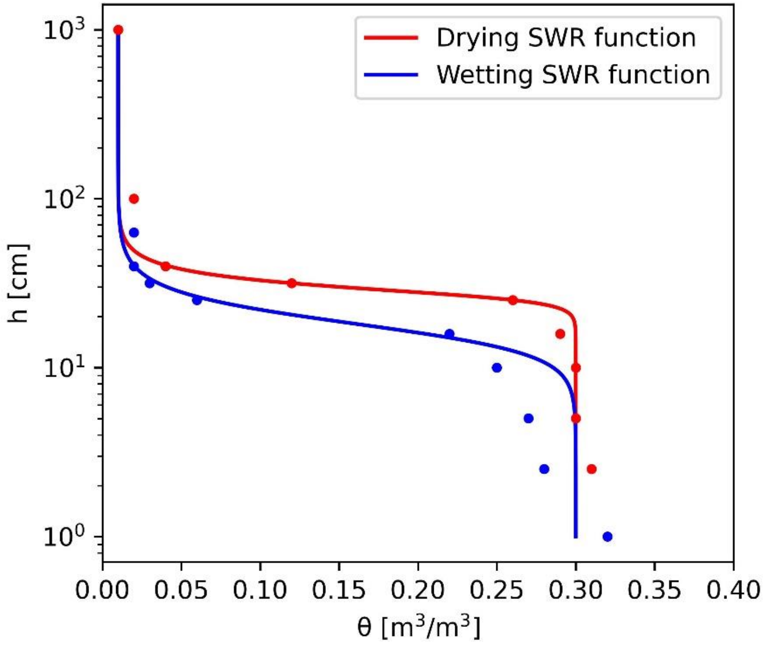
$$q = C\sqrt{\frac{d}{d^{ref}}}\frac{\rho_{air}}{g}(u_* - u_{*t})^3$$

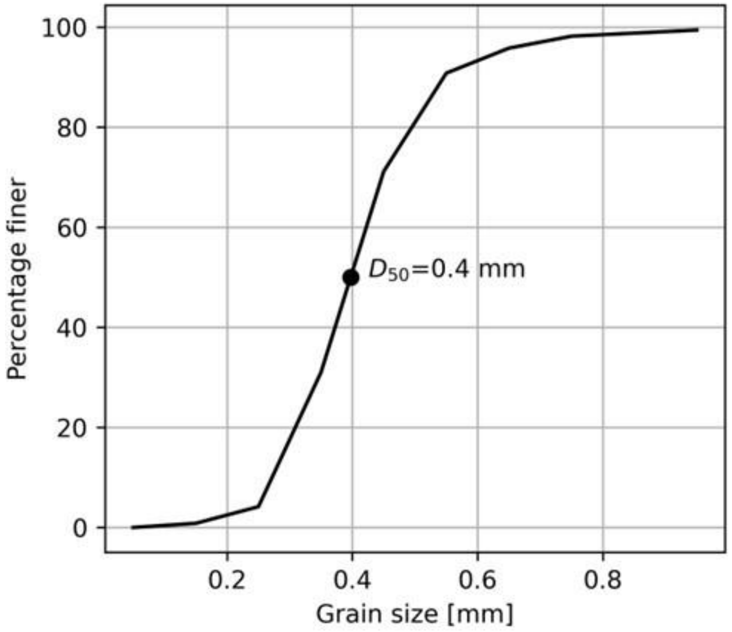
$$u_{*t} = A \cdot \sqrt{\frac{\rho_s - \rho_{air}}{\rho_{air}} g \cdot d}$$

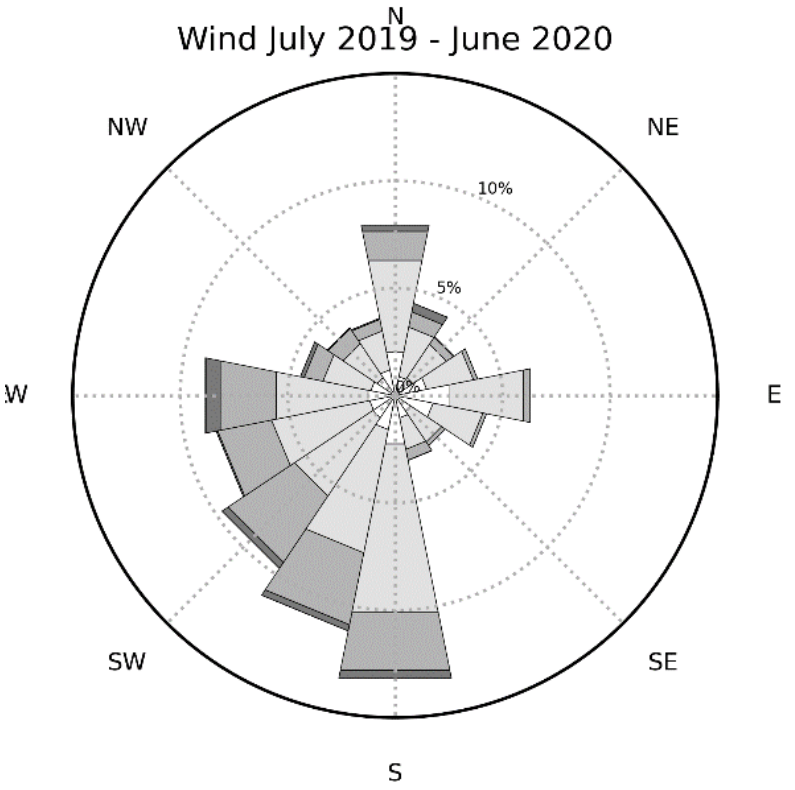
$$u_{*tw} = u_{*t}(1.8 + 0.6log_{10}w)$$

Ref: Bagnold, 1937; Belly, 1964

Case study - Noordwijk



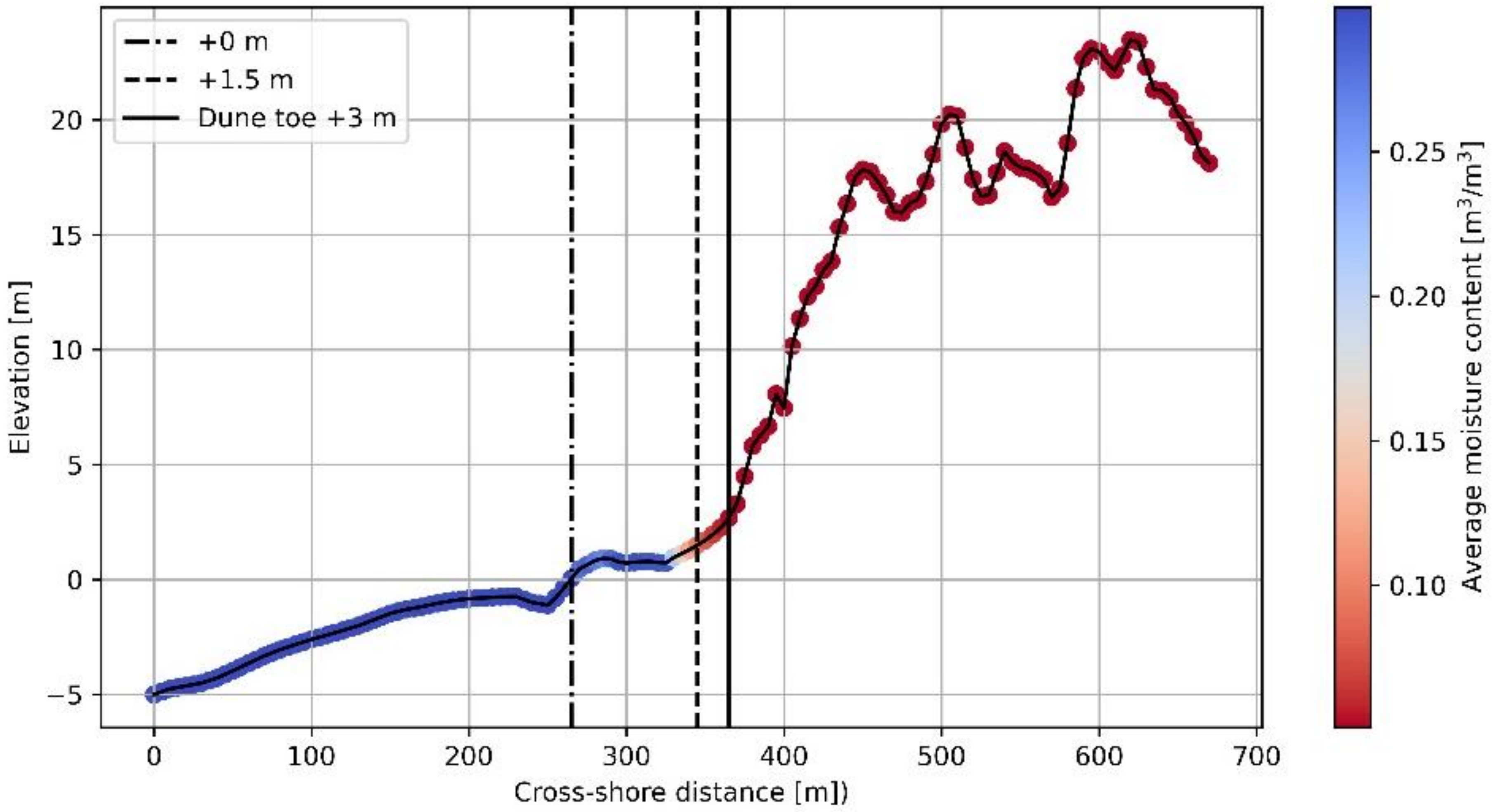




- One year simulation
- Tested different equations to calculate wet threshold
- Moisture module validated against field data in previous study

Ref: Hallin et al (in review)

Results – yearly average surface moisture



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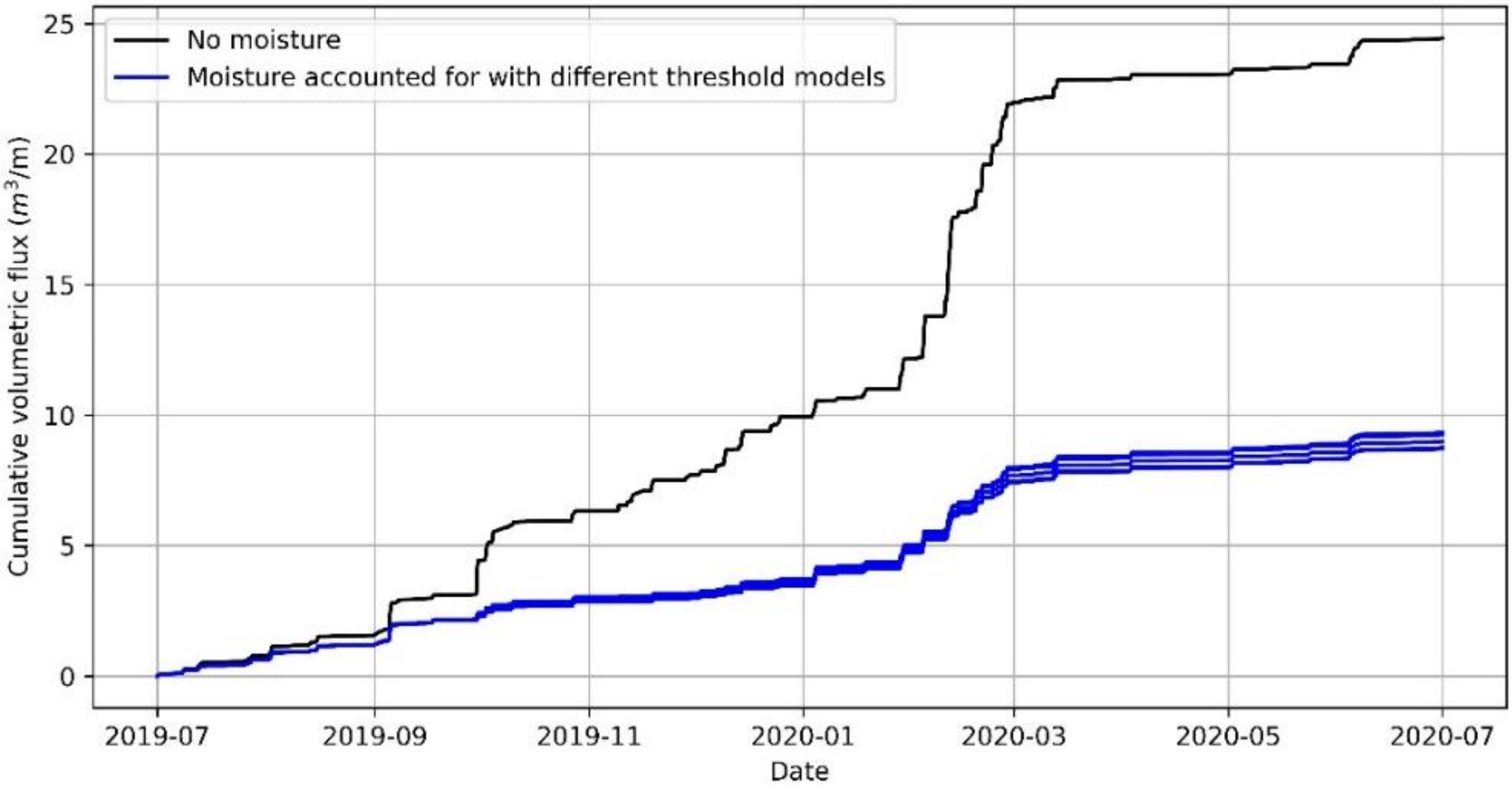
Results - aeolian transport



Summary

- Surface moisture may have a large influence on yearly transport rates towards the dunes
- In the field, surface moisture display large spatial variability due to heterogeneity of the hydraulic properties of the surface sediment
- The surface moisture module in AeoLiS can be applied to account for moisture effects in meso-scale transport simulations
- Require input of meteorological parameters (precipitation, temperature, global radiation, relative humidity, air pressure, wind) and hydraulic properties (aquifer properties and SWR)

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