## A. Theoretical Sediment Transport Volumes

The cumulative theoretical sediment transport volume $Q$ [m$^3$] in the Sand Motor domain between September 1, 2011 and September 1, 2015 is estimated from hourly averaged measured wind speed $u_{10}$ [m/s] and direction $\theta_u$ [°] measured at 10 m height by the KNMI meteorological station in Hoek van Holland (Figure 1). The wind time series are used in conjunction with the formulation of Bagnold (1937) to obtain the instantaneous theoretical sediment transport rate $q$ [kg/m/s] following:

$$q = C \frac{\rho_\mathrm{a}}{g} \sqrt{\frac{d_\mathrm{n}}{D_\mathrm{n}}} \left( u_* - u_{*\mathrm{th}} \right)^3 \tag{A.1}$$

with the shear velocity $u_* = \alpha \cdot u_{10}$ m/s, the shear velocity threshold $u_{*\mathrm{th}} = \alpha \cdot 3.87$ m/s, the conversion factor from free-flow wind velocity to shear velocity $\alpha = 0.058$, the air density $\rho_\mathrm{a} = 1.25$ kg/m$^3$, the particle density $\rho_\mathrm{p}$ $= 2650.0$ kg/m$^3$, the gravitational constant $g = 9.81$ m/s$^2$, the nominal grain size $d_\mathrm{n} = 335$ $\mu$m and a reference grain size $D_\mathrm{n} = 250$ $\mu$m.

The cumulative theoretical sediment transport volumes in onshore ($Q_\mathrm{os}$ [m$^3$]) and alongshore ($Q_\mathrm{as}$ [m$^3$]) direction are computed by time integration and conversion from mass to volume following:

$$\begin{array}{lclcl} Q_\mathrm{os} & = & \sum q \cdot \frac{\Delta t \cdot \Delta y}{(1-p) \cdot \rho_\mathrm{p}} \cdot f_{\theta_u,\mathrm{os}} & = & 110 \cdot 10^4 \ \mathrm{m}^3 \\ Q_\mathrm{as} & = & \sum q \cdot \frac{\Delta t \cdot \Delta x}{(1-p) \cdot \rho_\mathrm{p}} \cdot f_{\theta_u,\mathrm{as}} & = & 3 \cdot 10^4 \ \mathrm{m}^3 \end{array} \tag{A.2}$$

where the temporal resolution $\Delta t = 1$ h, the alongshore span of the measurement domain $\Delta y = 4$ km, the approximate lateral beach width $\Delta x = 100$ m, the porosity $p = 0.4$ and $f_{\theta_u,\mathrm{os}}$ and $f_{\theta_u,\mathrm{as}}$ are factors to account for respectively the onshore and alongshore wind directions only, defined as:

$$\begin{array}{lcl} f_{\theta_u,\mathrm{os}} & = & \max \left( 0 \quad ; \quad \cos \left( 312\,^\circ - \theta_u \right) \right) \\ f_{\theta_u,\mathrm{as}} & = & \sin \left( 312\,^\circ - \theta_u \right) \end{array} \tag{A.3}$$

where $\theta_u$ [°] is the hourly averaged wind direction and $312\,^\circ$ accounts for orientation of the original coastline.

Note that the difference between the onshore and alongshore cumulative theoretical sediment transport volumes (Equation A.2) of a factor 40 is determined solely by the difference between the onshore and alongshore cross-sections of 4 km and 100 m respectively. The sediment transport volumes per meter width in onshore and alongshore direction are of the same order of magnitude (275 m$^3$/m and 267 m$^3$/m respectively).

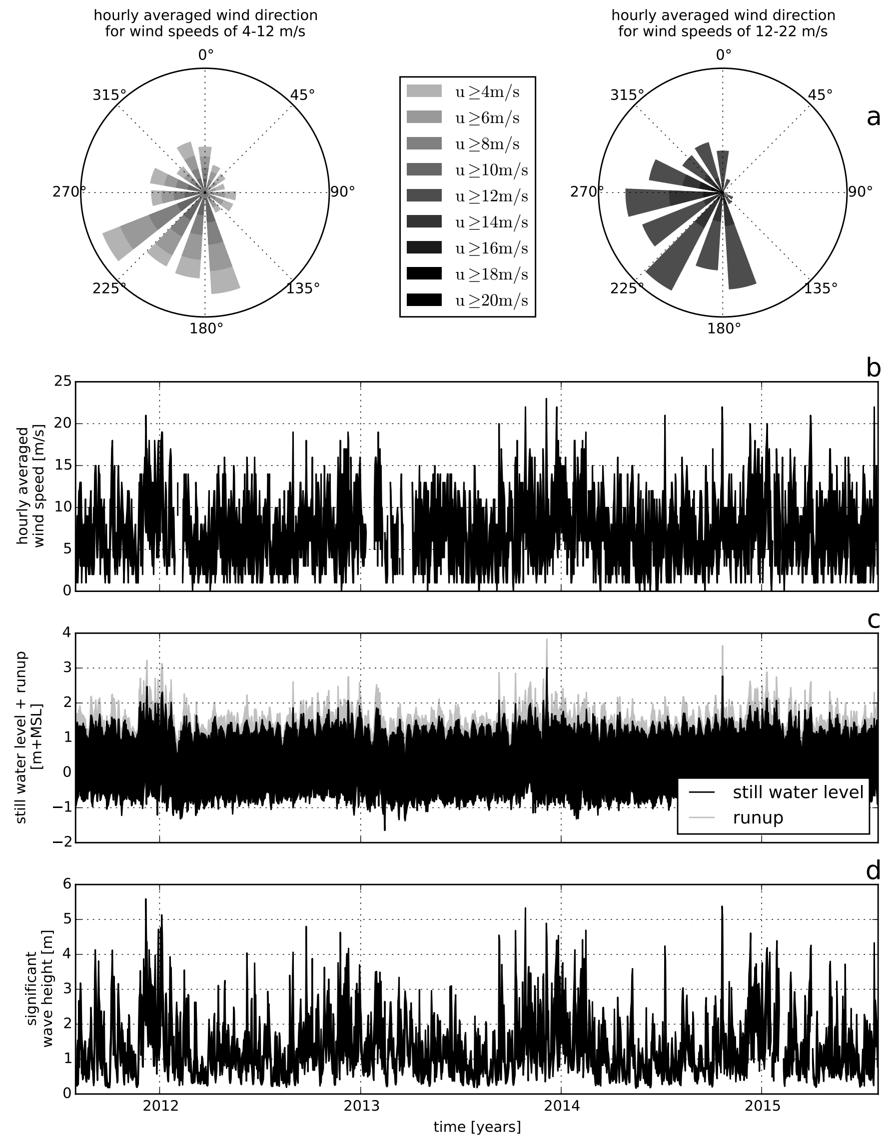


Figure 1: Wind and hydrodynamic time series from 2011 to 2015. Hourly averaged wind speeds and directions are obtained from the KNMI meteorological station in Hoek van Holland (upper panels). Offshore still water levels, wave heights and wave periods are obtained from the Europlatform (lower panels). Runup levels are estimated following Stockdon et al. (2006).

## References


Bagnold, R. (1937). The transport of sand by wind. *Geographical journal*, pages 409–438.

Stockdon, H. F., Holman, R. A., Howd, P. A., and Sallenger, A. H. (2006). Empirical parameterization of setup, swash, and runup. *Coastal engineering*, 53(7):573–588. doi:10.1016/j.coastaleng.2005.12.005.