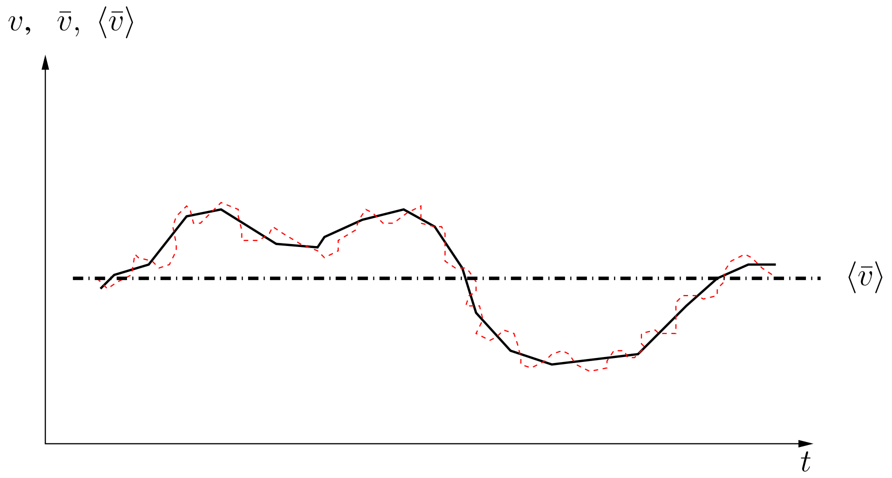
¶See Section 19, URANS: Unsteady RANS

▶URANS. The usual Reynolds decomposition is employed

$$\bar{v}(t) = \frac{1}{2T}\int_{t-T}^{t+T} v(t)dt, \ v = \bar{v} + v''$$

URANS eqns=RANS, but with the unsteady term retained



- Decomposition of velocities: $v = \bar{v} + v'' = \langle\bar{v}\rangle + \bar{v}' + v''$. —— : $\bar{v}$; - - : v; -·- $\langle\bar{v}\rangle$.
- In theory, T should be $\ll$ resolved time scale. This is called *scale separation*. In practice, it is seldom satisfied.
- RANS turbulence models are used: one should choose a model with small dissipation (i.e. small ν_t) in order to not kill/dampen resolved turbulence
- Modelled dissipation (turbulence model) and numerical dissipation (discretization scheme) may be of equal importance

¶See Section 20, DES: Detached-Eddy-Simulations

▶DES=Detached Eddy Simulations: Use RANS near walls and LES away from walls

The S-A one-equation model (RANS) reads

$$\frac{d\rho\tilde{\nu}_t}{dt} = \frac{\partial}{\partial x_j}\left(\frac{\mu+\mu_t}{\sigma_{\tilde{\nu}_t}}\frac{\partial\tilde{\nu}_t}{\partial x_j}\right) + \text{cr. term} + P - C_{w1}\rho f_w\left(\frac{\tilde{\nu}_t}{d}\right)^2, \quad d = x_n$$

▶Replace d with $\tilde{d}$:

$$\left(\frac{\tilde{\nu}_t}{d}\right)^2 \Rightarrow \left(\frac{\tilde{\nu}_t}{\tilde{d}}\right)^2, \quad \tilde{d} = \min\{C_{DES}\Delta, d\}, \quad \Delta = \max\{\Delta x_1, \Delta x_3, \Delta x_3\}$$