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A Kolmogorov-Brutsaert Structure Function Model for Evaporation from a Rough Surface into a Turbulent Atmosphere

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In his 1881 acceptance letter of the Rumford Medal, Gibbs declared that *"One of the principal objects of theoretical research is to find the point of view from which the subject appears in the greatest simplicity"*. Guided by this quotation, the subject of evaporation into the atmosphere from rough surfaces by turbulence offered in a 1965 study by Brutsaert is re-examined. Brutsaert proposed a model that predicted mean evaporation rate $\overline{E}$ from rough surfaces to scale with the $3/4$ power-law of the friction velocity (u_*) and the square-root of molecular diffusivity (D_m) for water vapor. This result was supported by a large corpus of experiments and spawned a number of studies on inter-facial transfer of scalars, evaporation from porous media at single and multiple pore scales, bulk evaporation from bare soil surfaces, as well as isotopic fractionation in hydrological applications. It also correctly foreshadowed the much discussed $1/4$ 'universal' scaling of liquid transfer coefficients of sparingly soluble gases in air-sea exchange studies. In arriving at these results, a number of assumptions were made regarding the surface renewal rate describing the contact durations between eddies and the evaporating surface, the diffusional mass process from the surface into eddies, and the cascade of turbulent kinetic energy sustaining the eddy renewal process itself. The anzats explored here is that $\overline{E} \sim \sqrt{D_m} u_*^{3/4}$ is a direct outcome of the Kolmogorov scaling for inertial subrange eddies modified to include viscous-cutoff thereby by-passing the need for a surface renewal assumption. It is demonstrated that Brutsaert's model for $\overline{E}$ may be more general than its original derivation assumed. Extensions to canopy surfaces as well as other scalars with different molecular Schmidt numbers are also featured.