Surface Roughness Length for Offshore Wind Energy

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INTRODUCTION:
• The Northeastern U.S. coast will increase its offshore wind capacity to 86 GW by 2050 [1].
• The power production of the turbines is proportional to the cube of wind speed at hub height [2].
• Measurements of wind speeds are usually not available offshore at the hub height of the wind turbines.
• Extrapolation is often required using the surface roughness length $z_0$.

RESEARCH GOALS:
• To estimate the surface roughness length off the Northeastern coast of the U.S.
• To analyze the accuracy of three methods used to calculate $z_0$.

DATA:
• Field measurements from Nantucket Sound, MA.
• Data are from two field campaigns, Cape Wind (CW, 2003-2011) and IMPOWR (2013-2014).

RESULTS:
• A correlation between the calculated and observed wind speeds is presented for each method (Fig. 1).
• A comprehensive error analysis for each of the three methods is provided.
• A recommended regional $z_0$ value of $6\times10^{-4}$ m [3].
• A recommendation to use the median $z_0$ value rather than the mean, as it is a more robust statistic.
• Despite unrealistic $z_0$ values at times, the statistical method has better results than either of the other two methods.
• The unrealistic $z_0$ values obtained from the statistical method are caused by non-monotonic wind speed profiles, which occur approximately 41% of the time.
• Charnock and analytical methods underestimate the wind speeds in more stable cases (Fig. 3).
• The wider scatter in unstable cases indicates higher uncertainty by the Charnock method in unstable conditions that are dominant in the offshore (Fig. 3).

REFERENCES: