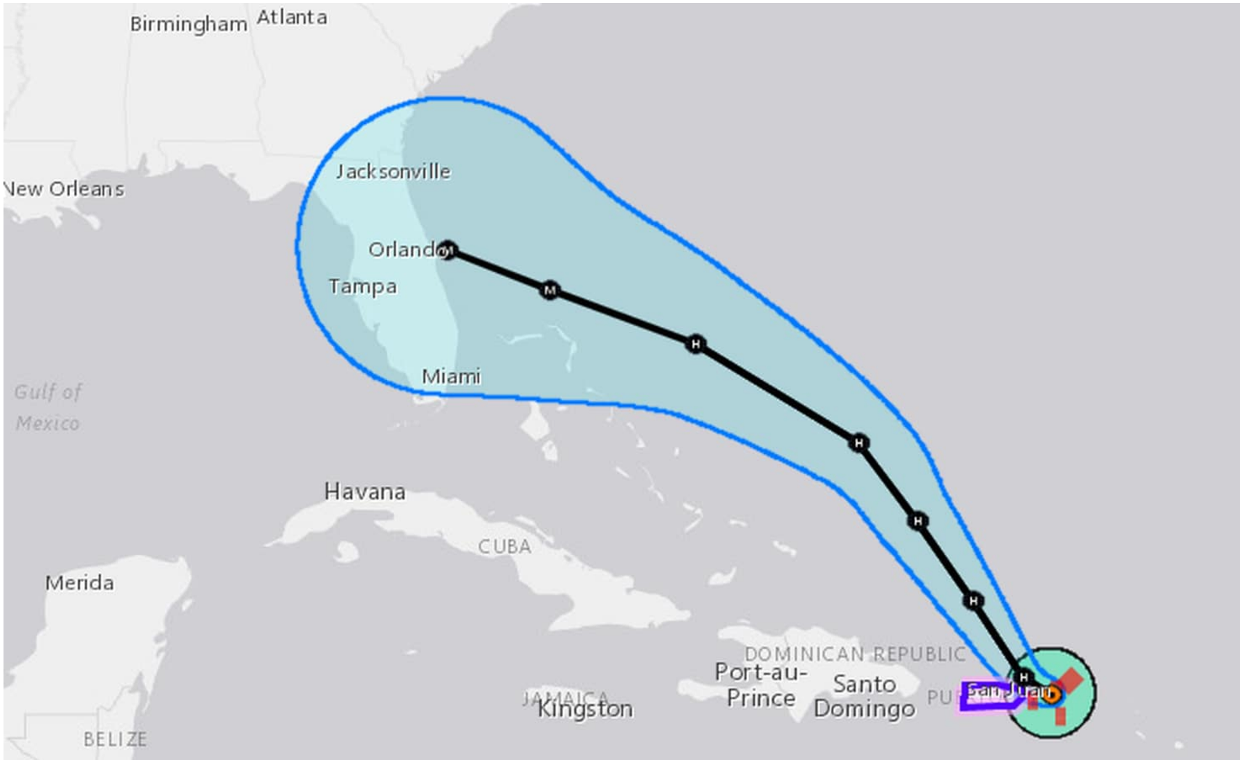
Measurement Uncertainty – Part 2 of 2



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Propagation of Uncertainty

$$R = R(x_1, \ldots, x_N)$$

$$\delta R_{x_n} = R(x_1, \ldots, x_n + \delta x_n, \ldots, x_N) - R(x_1, \ldots, x_n, \ldots, x_N)$$

$$\delta R_{x_n} = \left[\frac{R(x_1, \ldots, x_n + \delta x_n, \ldots, x_N) - R(x_1, \ldots, x_n, \ldots, x_N)}{\delta x_n}\right]\delta x_n$$

$$\delta R_{x_n} \approx \frac{\partial R}{\partial x_n}\delta x_n$$

$$\delta R = \sqrt{\left(\delta R_{x_1}\right)^2 + \cdots + \left(\delta R_{x_n}\right)^2 + \cdots + \left(\delta R_{x_N}\right)^2}$$

$$u_{R_{x_n}} = \frac{\delta R_{x_n}}{R} \approx \frac{1}{R}\frac{\partial R}{\partial x_n}\delta x_n$$

$$u_R = \sqrt{u_{R_{x_1}}^2 + \cdots + u_{R_{x_n}}^2 + \cdots + u_{R_{x_N}}^2}$$

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Notes:

1. Use absolute pressure and absolute temperature when calculating uncertainties.

2. The uncertainty of some quantities may be so small compared to the other uncertainties that they can be neglected.

3. Uncertainty analysis can be used in experimental design to indicate where design improvements should be made.

Example:

Determine the of the density of air at a temperature of 20 ± 1 °C and pressure of 100 ± 5 kPa (abs). The gas constant for air is 0.28705 kJ/(kg.K).