Wind Data Quality Factors & Metrics*

“Friends/Partners in Aviation Weather” Forum
1 November 2012

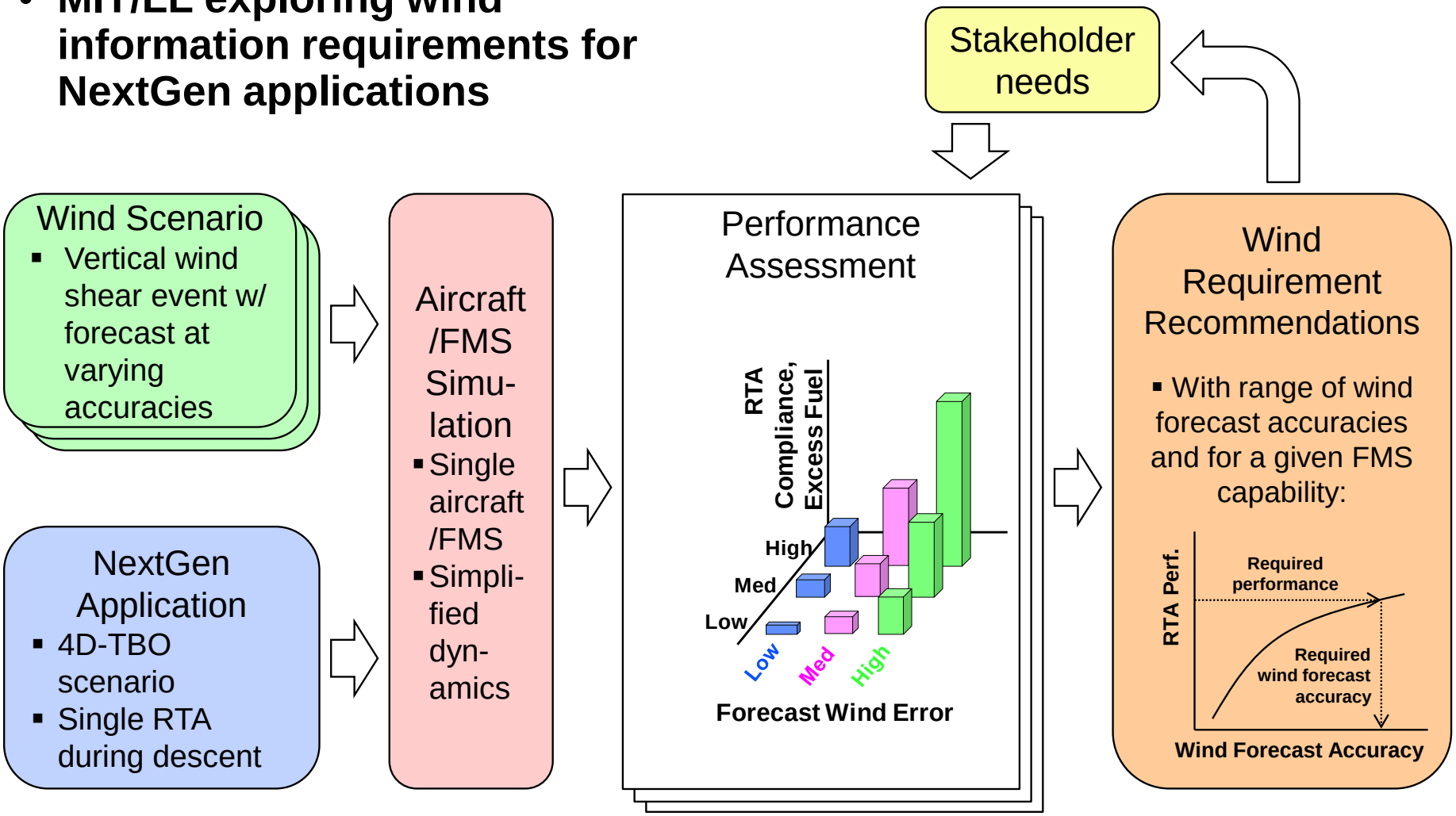
Michael D. McPartland

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

*This work was sponsored by the Federal Aviation Administration under Air Force Contract No. FA8721-05-C-0002. Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the United States Government.

Wind Information Analysis Framework

- **MIT/LL exploring wind information requirements for NextGen applications**



Sample Wind Data Quality Factors

- **Timeliness**
  - Update rate of wind observations or forecast model outputs
  - Latency (data assimilation + computation time + dissemination)
- **Spatial resolution**
  - Forecast or observation data availability at target locations
  - Interpolation between coarse grid points increases likelihood of error, especially with rapidly changing winds
- **Temporal resolution**
  - Time resolution of forecast intervals (forecast steps)
  - Forecast horizon
- **Intrinsic forecast model accuracy**
  - Model parameterizations, physics, observation errors (coverage and sensor errors, errors in assimilation and analysis)
  - Divergence of forecasts from truth with increasing forecast lead time due to unmeasured (e.g., sub-scale) and unrepresented processes

Some Wind Forecast Quality Metrics

- **RMS Vector Error is most commonly reported wind forecast accuracy statistic**

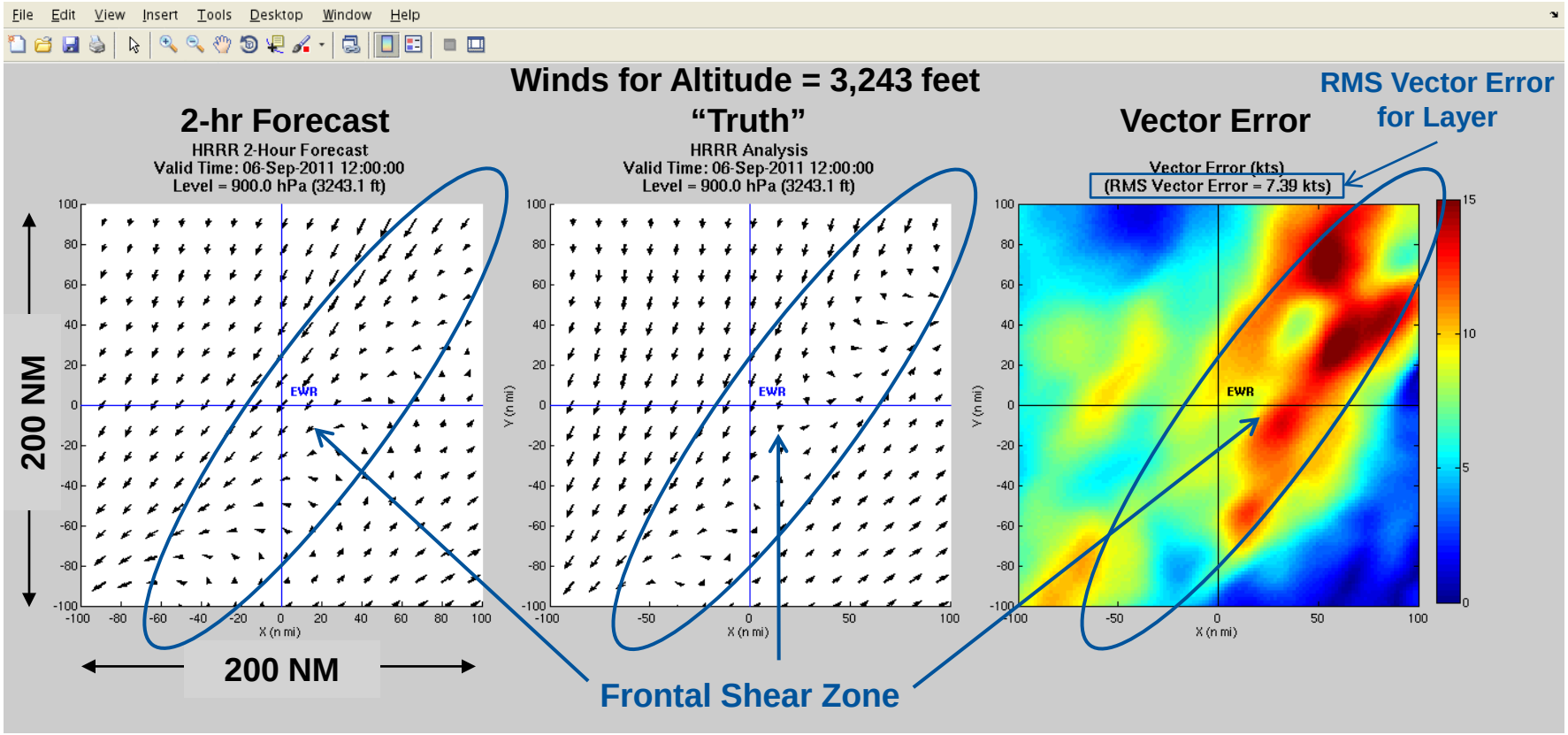
$$\mathrm{RMSVE} = \sqrt{\frac{1}{\mathrm{N}} \sum_{n=1}^{N} \left(u_f - u_o\right)^2 + \left(v_f - v_o\right)^2}$$

  - **Performance studies compared model wind forecasts against aircraft or radiosonde wind measurements**
  - **RMSVE generally 5-12 kts for current models (RUC/RAP, HRRR)**
  - **RMS wind forecast errors found to increase with wind speed, rapidly changing wind conditions, and with increasing forecast lead time**

- **Aggregate RMS wind forecast error statistics may mask occasional large errors (> 20 kts) that may significantly affect time-to-fly estimates**
  - **Large numbers of "benign" wind events in broad performance studies may mask larger errors during dynamic wind events**

NY Vertical Wind Shear Event 09/06/2011

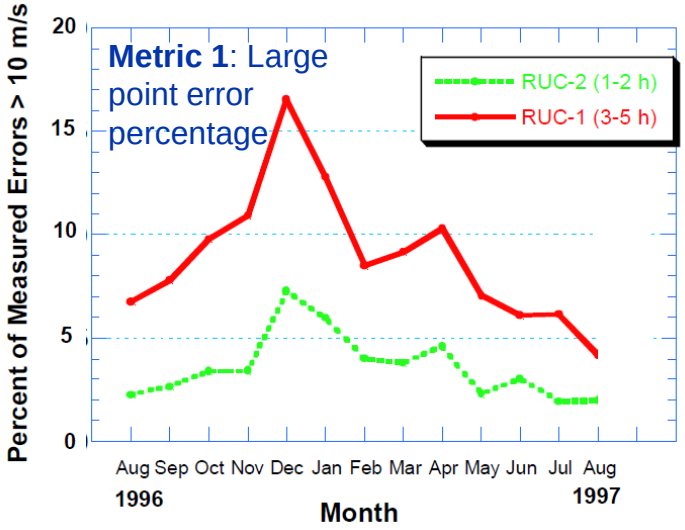
- **Strong shear at 3,000’ with near 180 degree reversal of winds with altitude and laterally across frontal boundary**
- **Note locally large (> 15 kts) forecast errors in frontal shear zone**

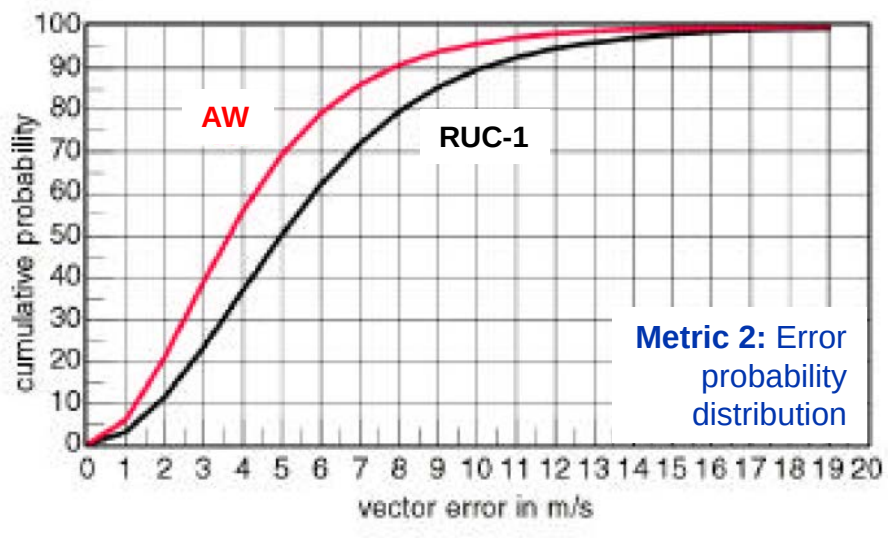


Alternative Wind Accuracy Metrics for ATM

Metrics to quantify extent and durations of large point errors

From Cole, R. E., Green, S., Jardin, M., Schwartz, B., Benjamin, G., 2000, Wind prediction accuracy for air traffic management decision support tools





- **Key take-aways:**
  - **Many wind quality factors**
  - **RMSVE is a common metric to quantify impacts of factors**
  - **Other metrics possible, but suitability depends on specific application**

Metric 3: Large hourly error percentage

Variable	>7m/s	>10m/s	>15ms
RUC-1 25th percentile	42	0	0
AW 25th percentile	5	0	0
RUC-1 50th percentile	829	46	0
AW 50th percentile	124	1	0
RUC-1 75th percentile	4160	834	45
AW 75th percentile	1913	203	8

"AW" = Augmented Winds = 10-km Terminal Winds w/ RUC-1 and MDCRS