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Sandia National Laboratories

Validation of Irradiance Simulations for WWSIS: Quicklook

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Summary

- DOE requested Sandia to provide technical support to WWSIS
- NREL and Sandia agreed to a technical review and validation of the irradiance and PV power simulation
- Preliminary analysis results and conclusions follow
- Quantitative review of irradiance simulation results
  - Applied algorithm to 2010
  - Compared to measured irradiance data at 27 locations
  - Examined overall irradiance distributions, ramps, and spatial correlations
- Qualitative review of irradiance to power conversion
  - Consider smoothing algorithm and power calculations
  - Not complete

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Validation locations

- 27 sites where irradiance data are available and where WWSIS assumed concentrations of solar power systems
  - 16 sites in southern CA/southwest AZ
  - Albuquerque, Las Vegas, Salt Lake City, Cedar City UT, Alamosa CO, Denver area, Sacramento CA, and Seattle WA
- Three locations where data from 2010 were used to calibrate irradiance simulation
- Three locations where data from earlier years were used to calibrate the simulation
- 11 sites with either 1 or 3 minute irradiance data
- 10 sites in AZ where only hourly average data are available

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Validation approach

- Compare annual and seasonal distributions of GHI
  - Agreement confirms that power levels occur at appropriate probabilities
- Compare annual and seasonal distributions of ramps in GHI
  - Agreement confirms that power ramps occur at appropriate probabilities
- Compare correlation in clearness index and change in clearness index among locations
  - Agreement confirms that, across locations, concurrent power levels and power ramps occur with appropriate probabilities

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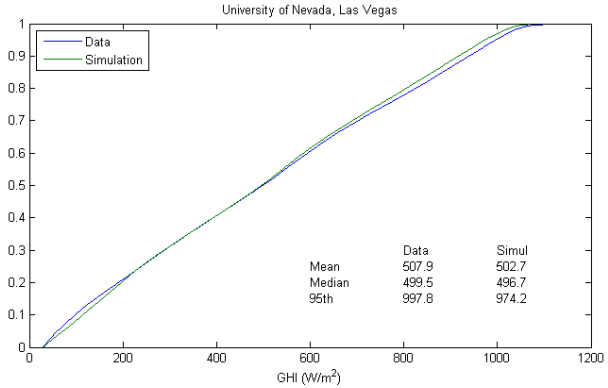
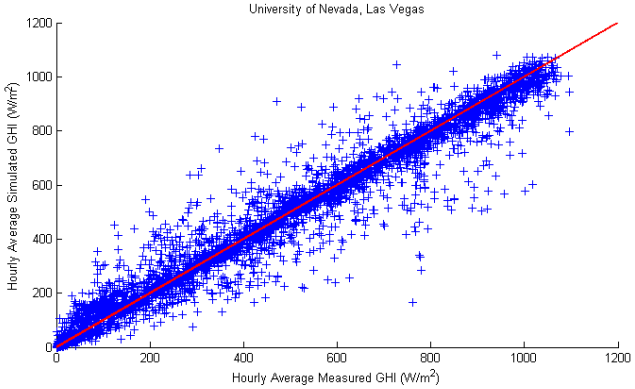
Distributions of GHI

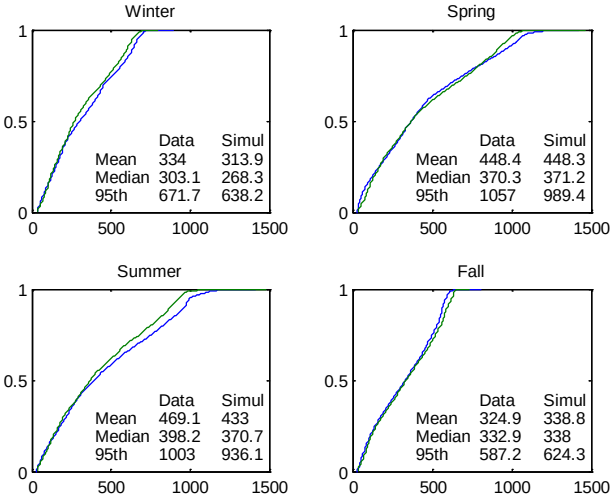
Distribution of One-Minute GHI



Compare hourly averages of GHI



- Good agreement at most locations
  - Exceptions at SLC, Seattle
  - Remote from locations where calibration data was obtained
- Acceptable agreement within each season



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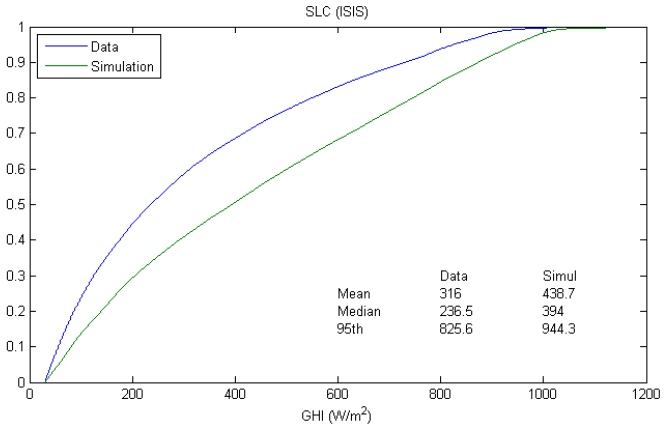
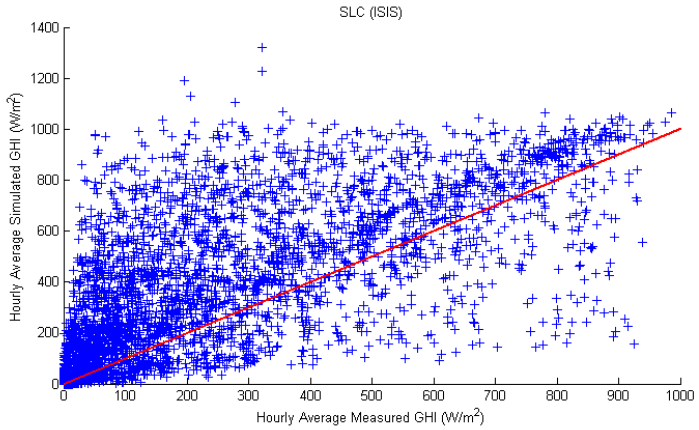
Improvements to GHI

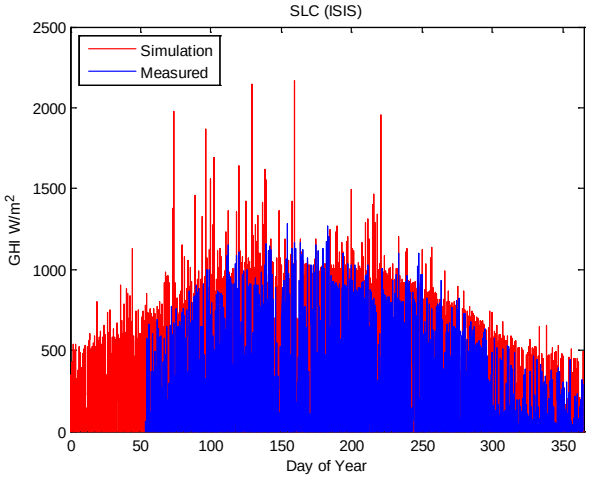
Better calibration at SLC, Seattle



Acknowledge and apply upper bound

- GHI appears to be unbounded (at all locations)
- Exceeds 125% of Clear Sky at 5% of time steps





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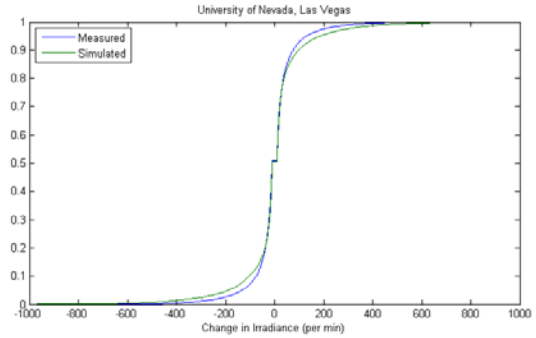
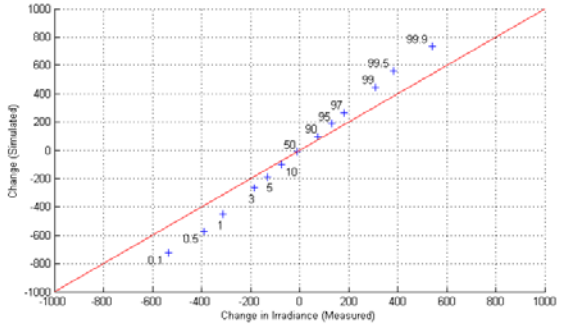
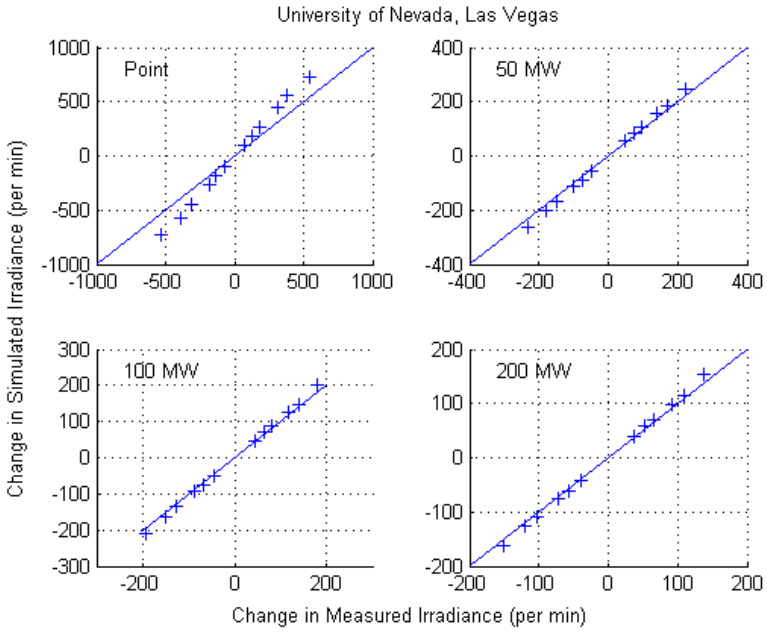
Distributions of Changes in GHI

Point irradiance overstates (one minute) ramps





Good agreement when irradiance is smoothed



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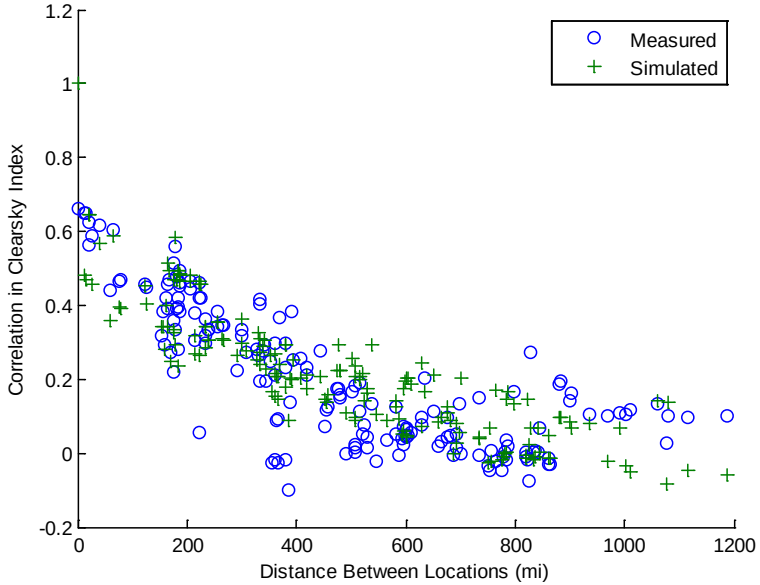
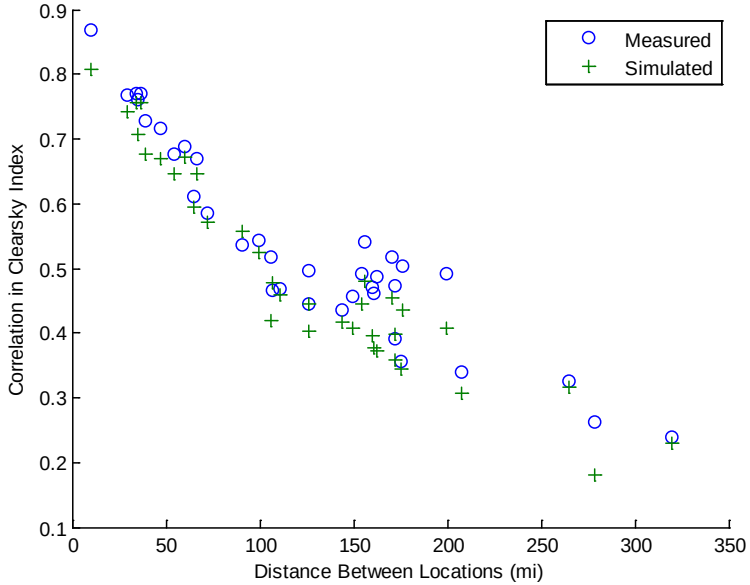
Spatial correlation in clear sky index

One- and three-minute data



Hourly average data



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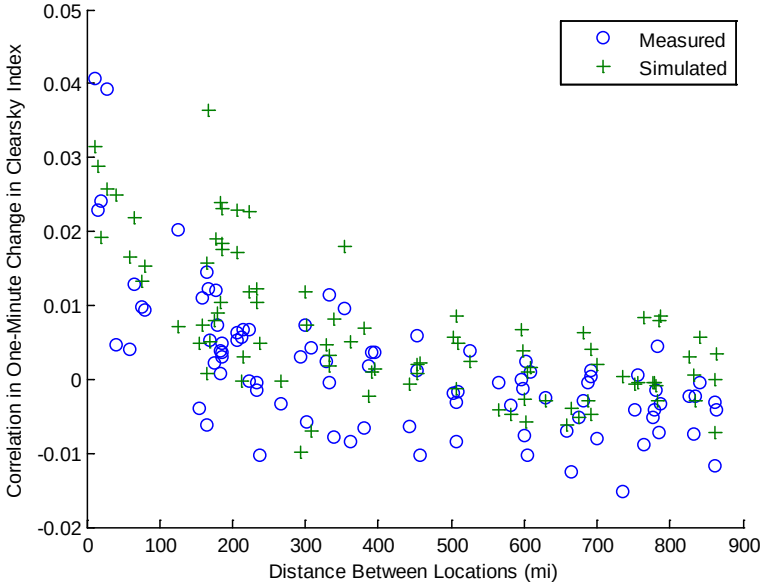
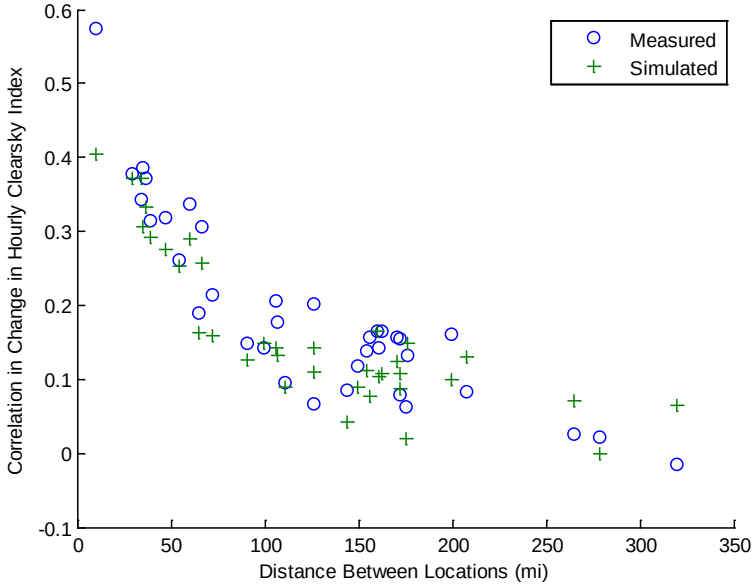
Spatial correlation of changes in clear-sky index

Results compare favorably with published analyses

One- and three-minute data



Hourly average data



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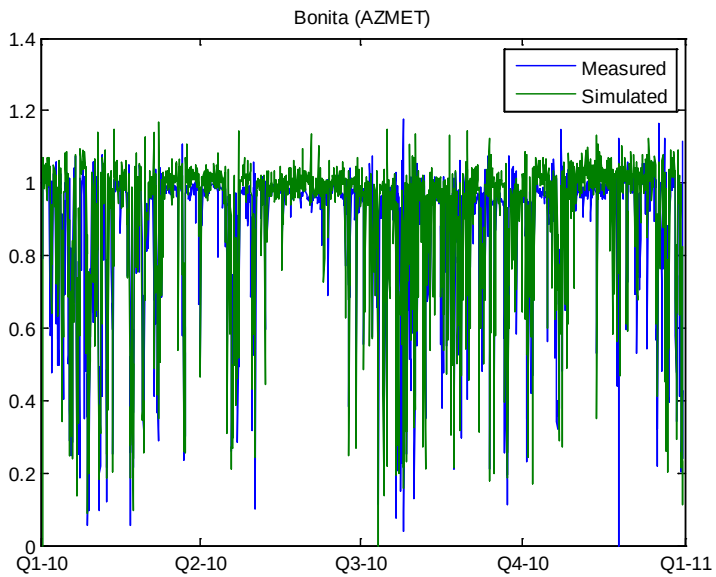
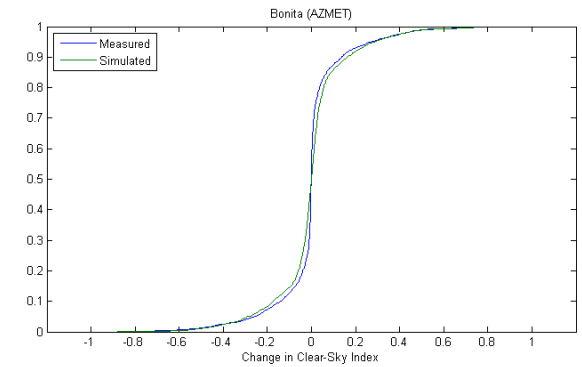
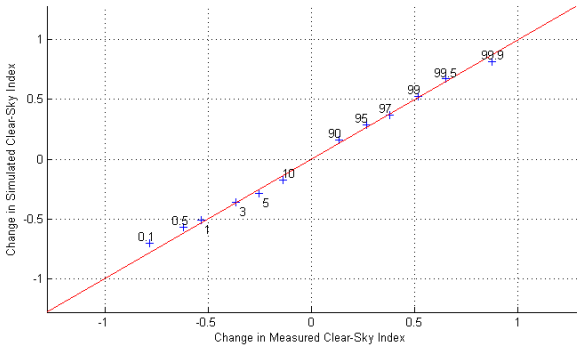
Additional comparison of clear-sky index

- Annual time series show similar behavior (measured and simulated)



- Distributions are similar





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Conclusions

- Irradiance data set appears suitable for use in WWSIS analysis
  - Analysis time-scales down to 10-15 minutes
  - 5-10% inaccuracy in probability of occurrence of power level
- Appropriate spatial correlations are represented
- Improvements:
  - Apply upper bound to simulated GHI
  - Examine Salt Lake City and Seattle in detail
    - Perhaps add ISIS data to calibration
- Small (not meaningful) but persistent GHI bias at locations in AZ
  - Could be an issue with satellite-to-irradiance translation, systematic error in ground sensors, by-product of hourly averaging, ???

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