Analysis of PARSL PIR Calibration, Comparison of Operational Agreement

Chuck Long

PNNL

Instruments

- PARSL Tracker System
  - Unshaded PSP
  - Shaded B&W
  - Shaded PIR
  - NIP
  - Ventilated with 12V high-speed fans
  - T/RH probe

Instruments

- **Small Radiometer Systems (RadSys)**
  - Unshaded PSP
  - Unshaded PIR
  - SPN-1 Total/Diffuse radiometer
  - Ventilated with 12V high-speed fans
  - T/RH probe

RadSys 1 PIR Calibration

- Deployed RadSys1 to NREL April 2009
  - Usable data from April 18-29 (11 days)
- Used NREL Ventilated PIR as reference
- Tested both 2- and 3-coefficient formulas
- Used 1-minute average data
- LWdn from 230 – 350 Wm^{-2}
- T_{air} from -1 to 25^{O}C
- RH from 10 – 100%

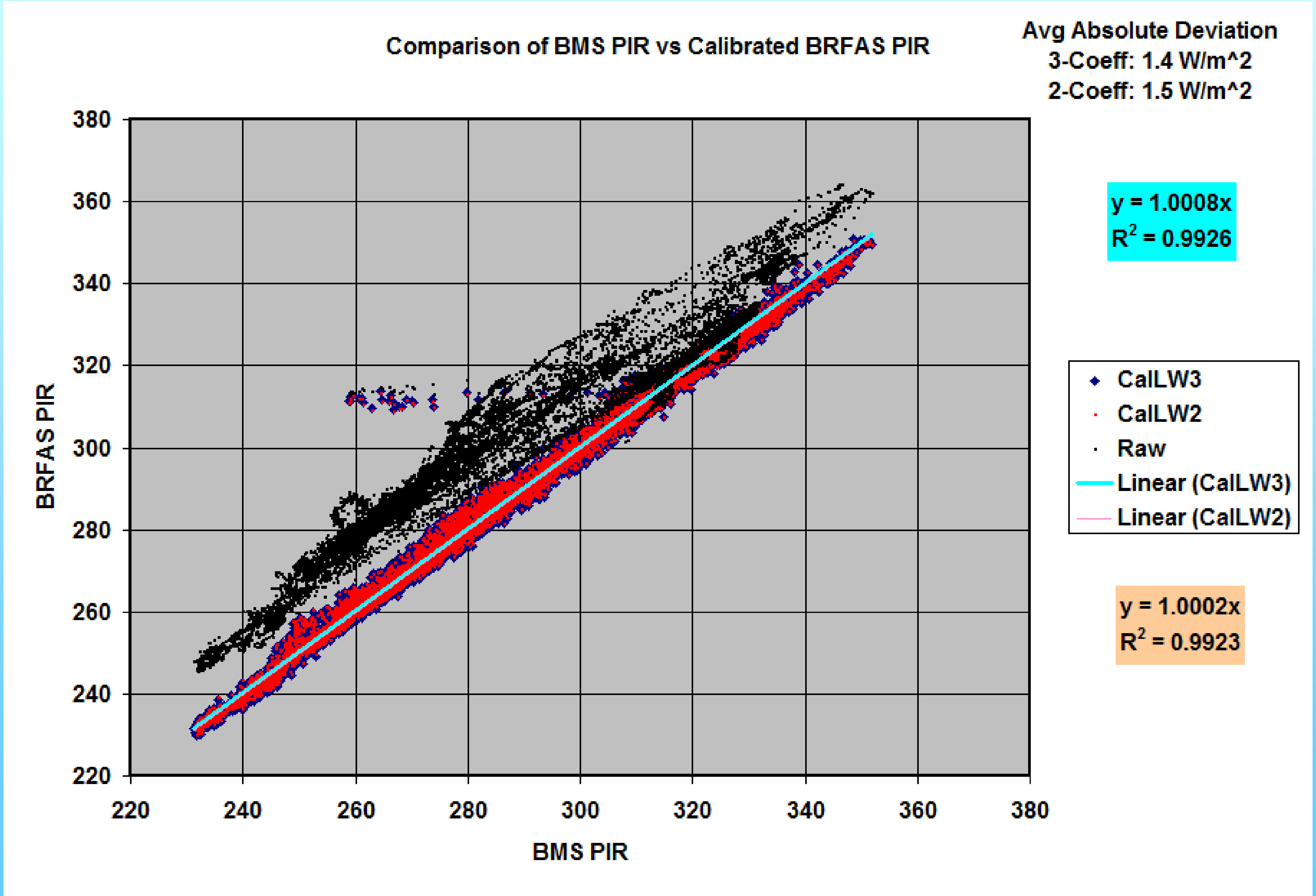
PIR Formula

- $LW = C_1*V + C_2*\sigma*T_c^4 + C_3*\sigma*(T_c^4 - T_d^4)$
  - Det Case Case-Dome Difference
- Where:
  - LW = the calculated broadband longwave irradiance
  - V = voltage signal from the thermopile
  - T_c = case temperature reading
  - T_d = dome temperature reading
  - σ = Stephan-Boltzman constant, 5.67 X 10-8
  - C_i = coefficients determined by multivariate fitting
- For 2-coefficient formula set $C_2 = 1$

Multivariate Fitting

- Fit coefficients simultaneously using least-squares multivariate fitting algorithm
  - Run initially on all data
  - Run again omitting all data that fell outside 1.5 absolute deviations from the initial fit to remove outliers
- "MultFit" subroutine
  - Eigenvalue, Matrix – based
  - Maximum 9000 data points

Comparison: Reference vs RS1



RS 2/3 Calibration Conditions

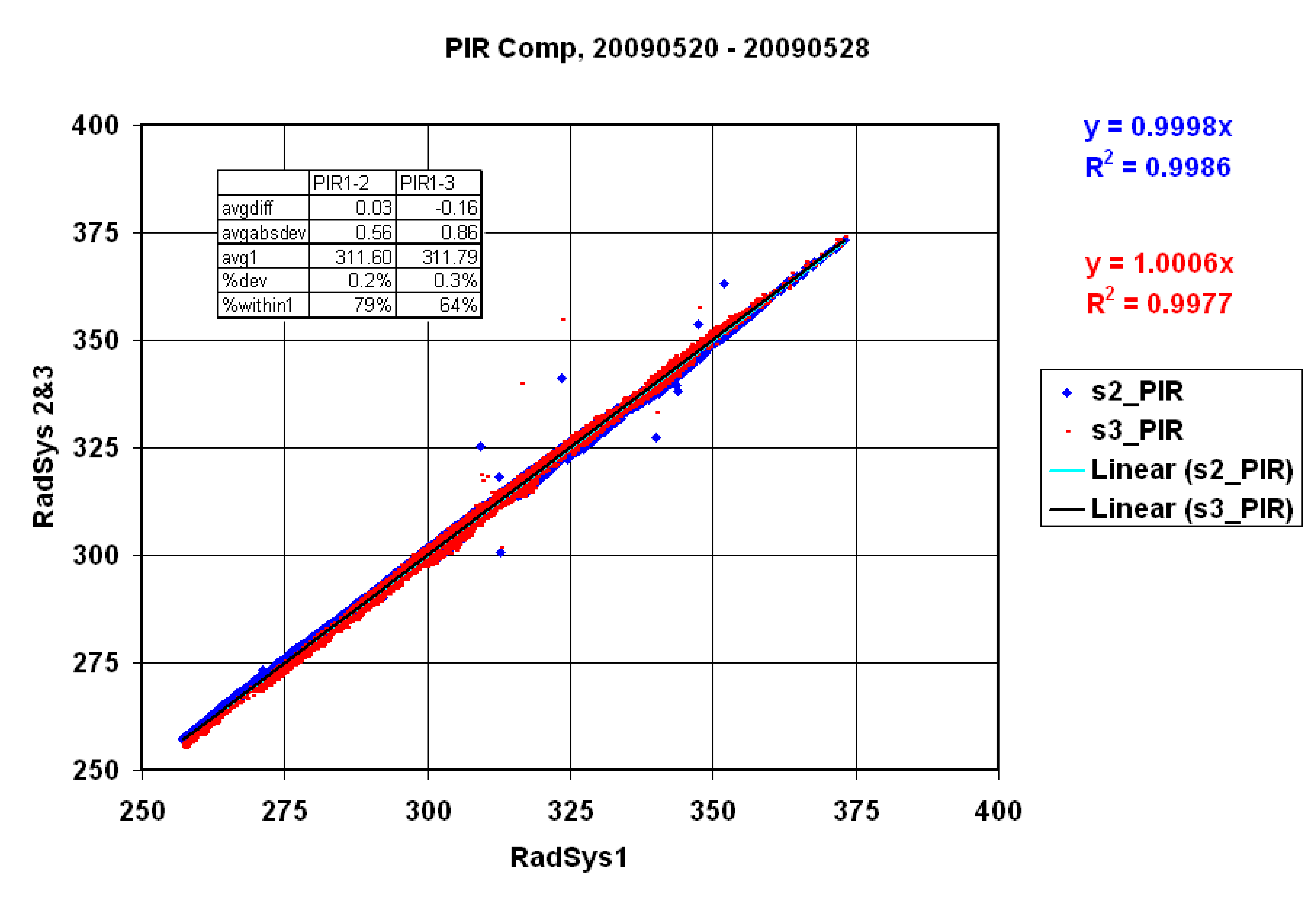
- Data from May 8 – 18, 2009 at PNNL
  - 11 days
- LWdn 250 – 390 Wm^{-2}
- T_{air} 2 to $42^{O}C$
- RH 13% to 93%
- Again used 1-minute average data

RS 2/3 Calibration (RS1 as reference)

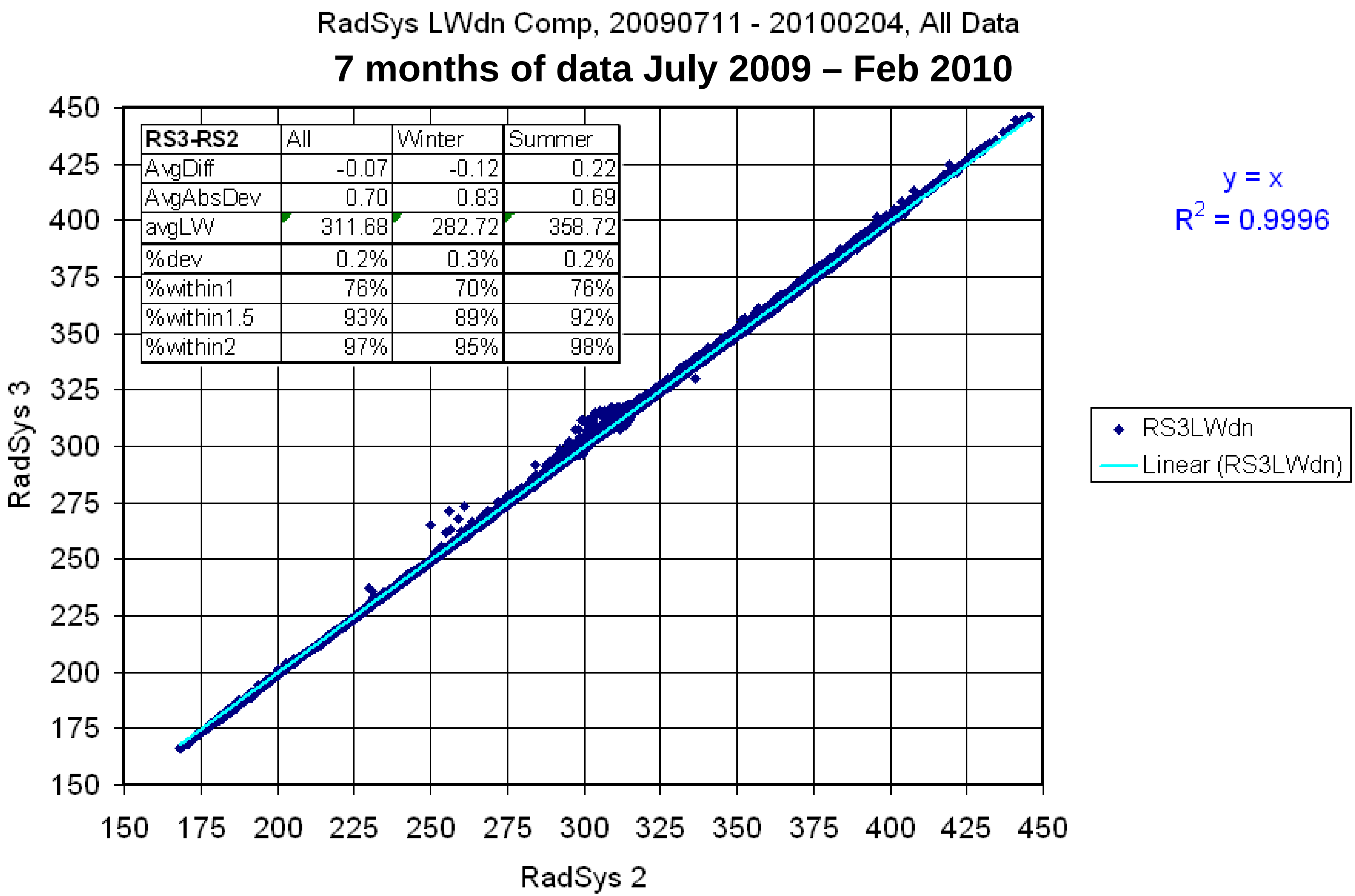
- RadSys cals use "FastLTS" code
  - Subsamples data, uses about half
  - Again 2nd pass to eliminate outliers
  - Allows 1,000,000+ data points
- Results comparison: **0.6% difference**

For RS2:		FastLTS	MultFit
Det:	mV	1.026425	1.027029
Case:	TcF	1.000497	1.000622
Case-Dome:	TcTd	2.910362	2.904295

Post-Cal 8-day Comparison

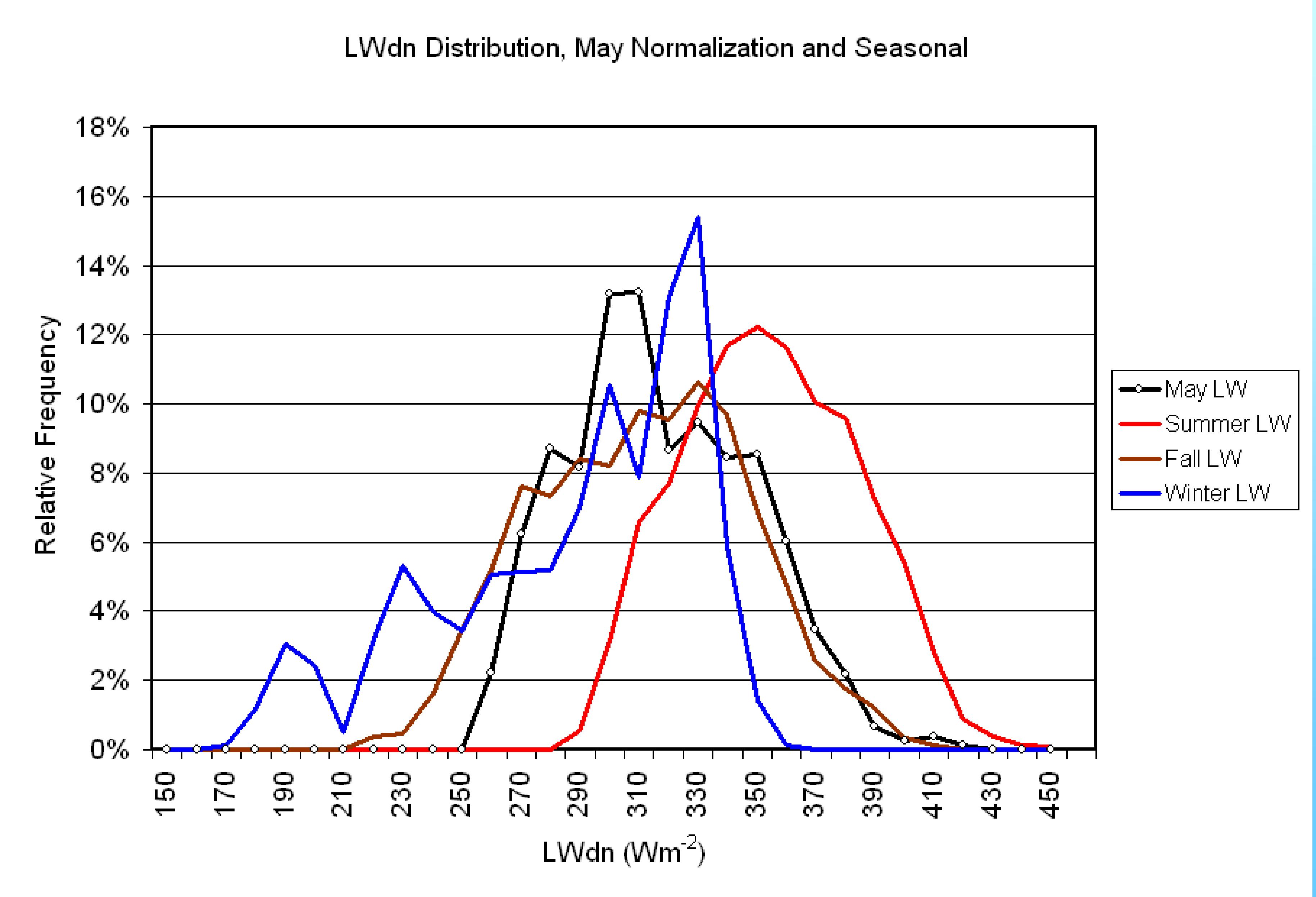


RS2 – RS3 Seasonal Comparison

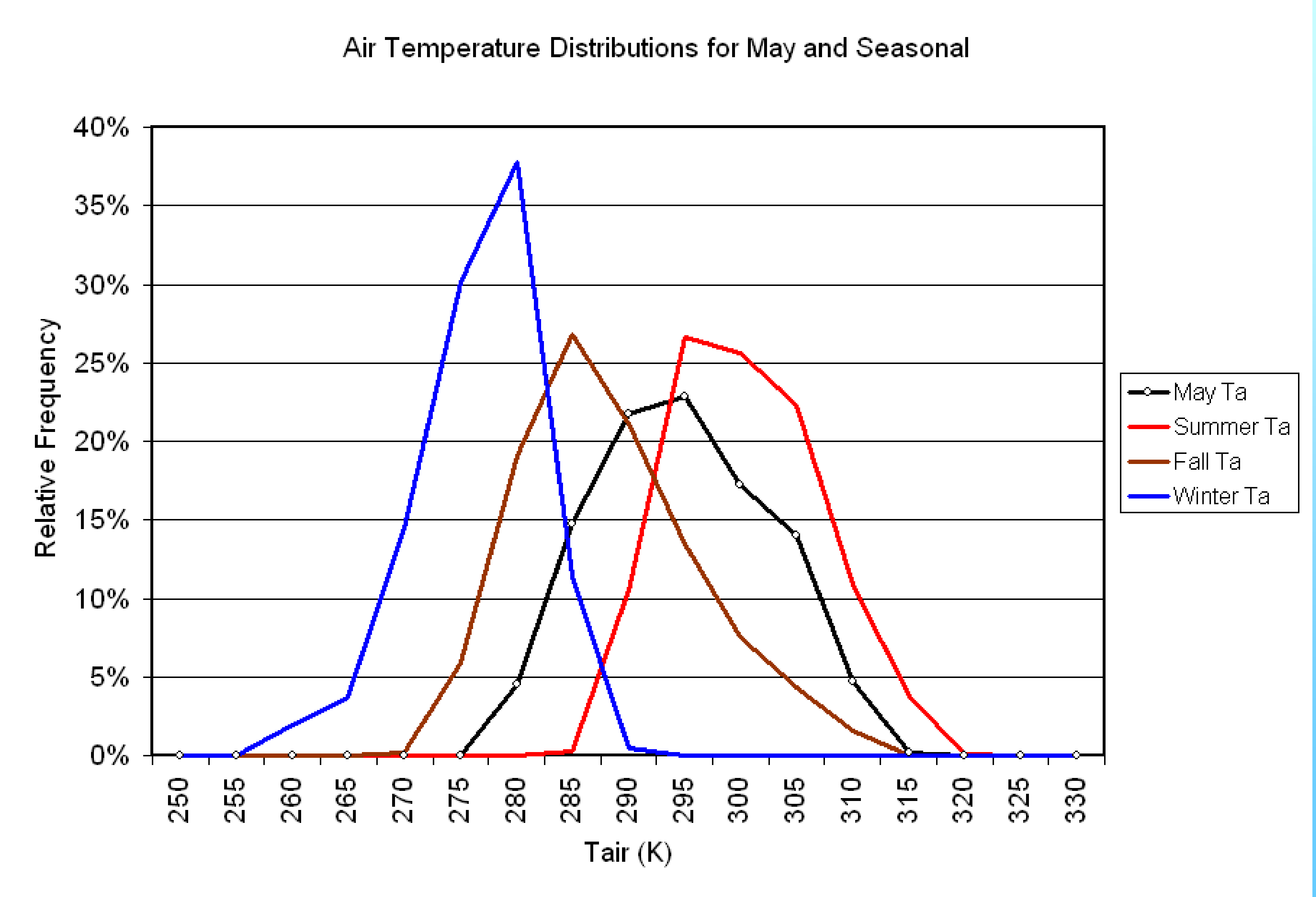


RS3-RS2	All	Winter	Summer
AvgDiff	-0.07	-0.12	0.22
AvgAbsDev	0.70	0.83	0.69
avgLW	311.68	282.72	358.72
%dev	0.2%	0.3%	0.2%
%within1	76%	70%	76%
%within1.5	93%	89%	92%
%within2	97%	95%	98%

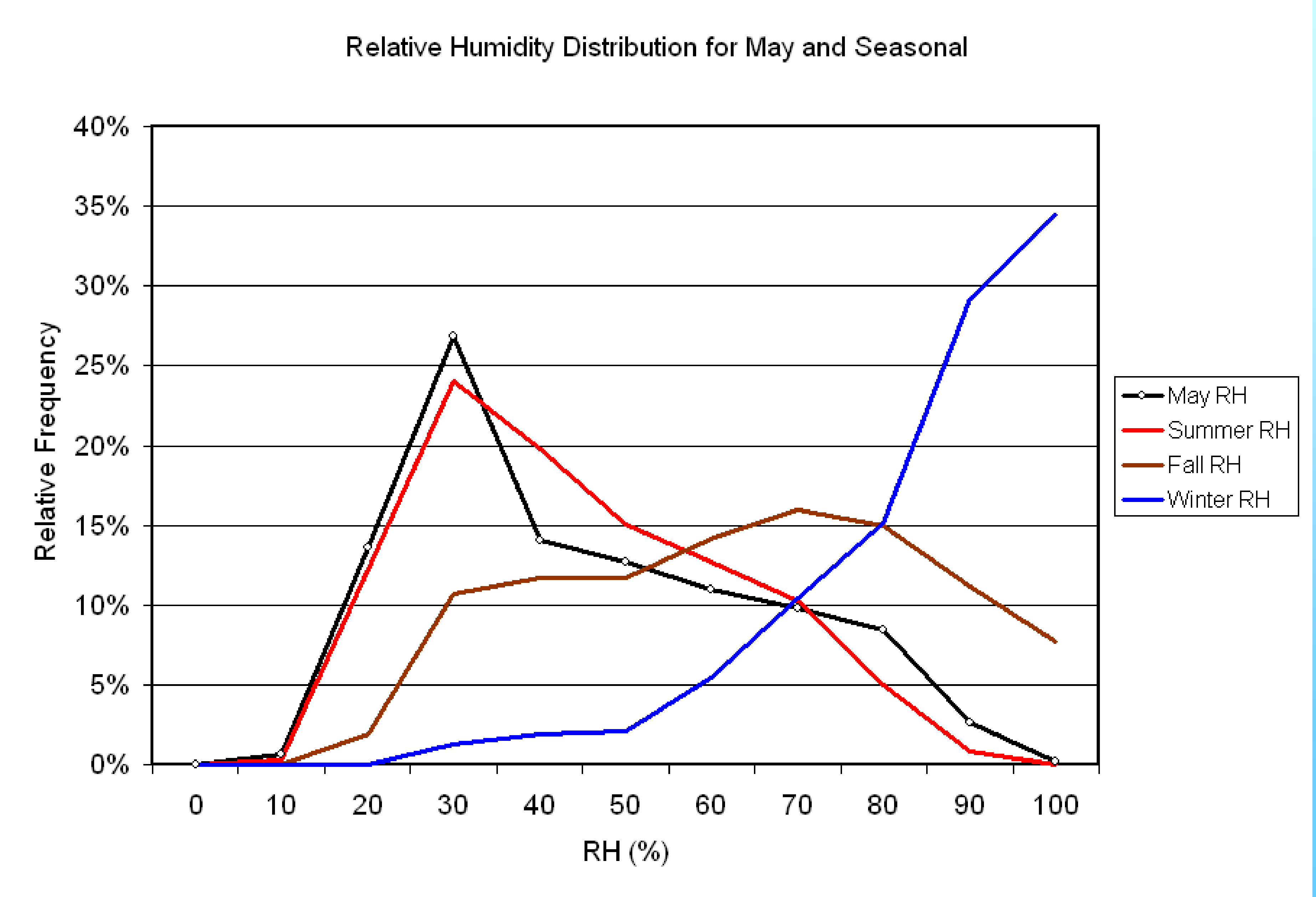
Seasonal Distributions



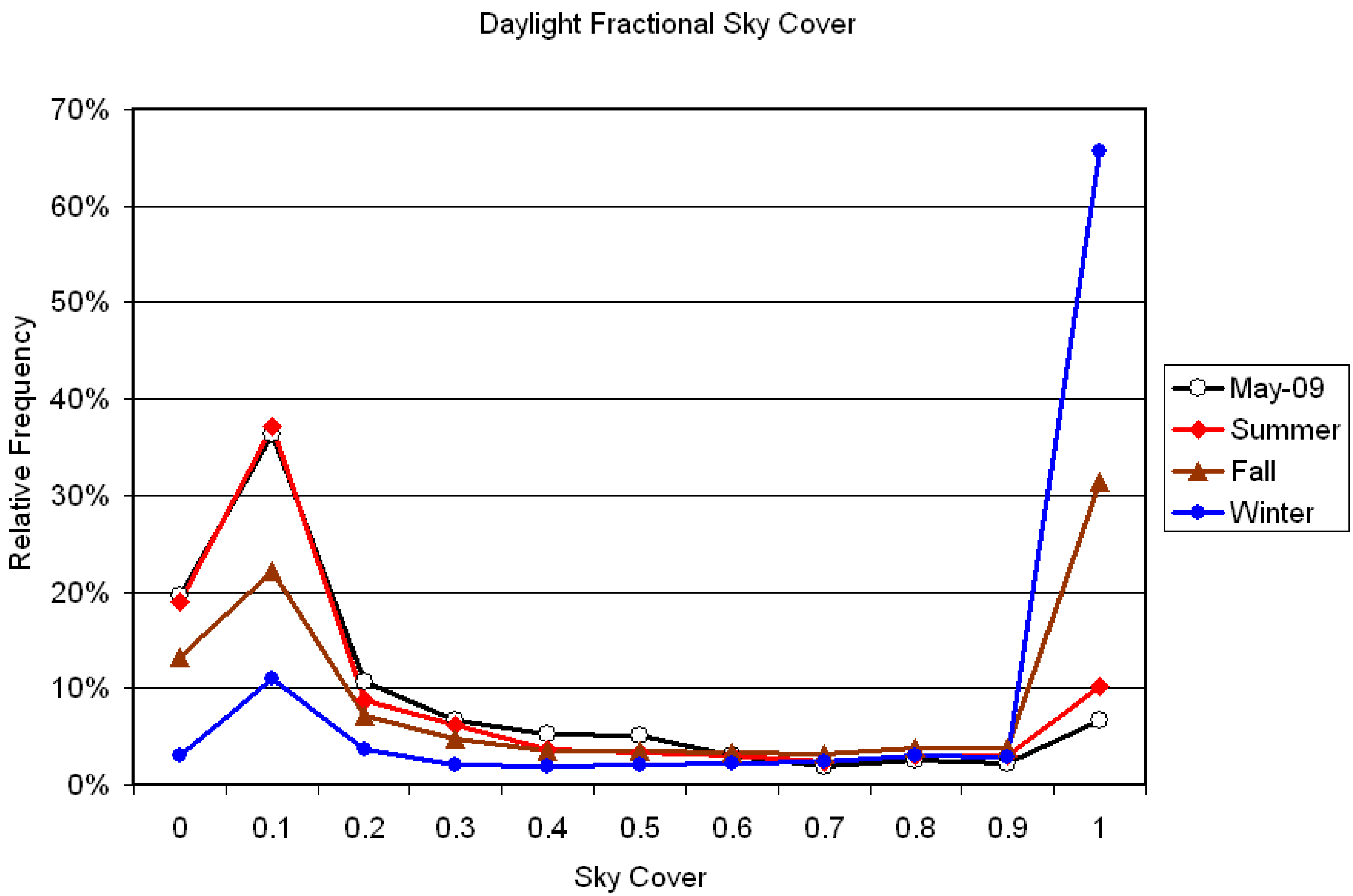
Seasonal Distributions



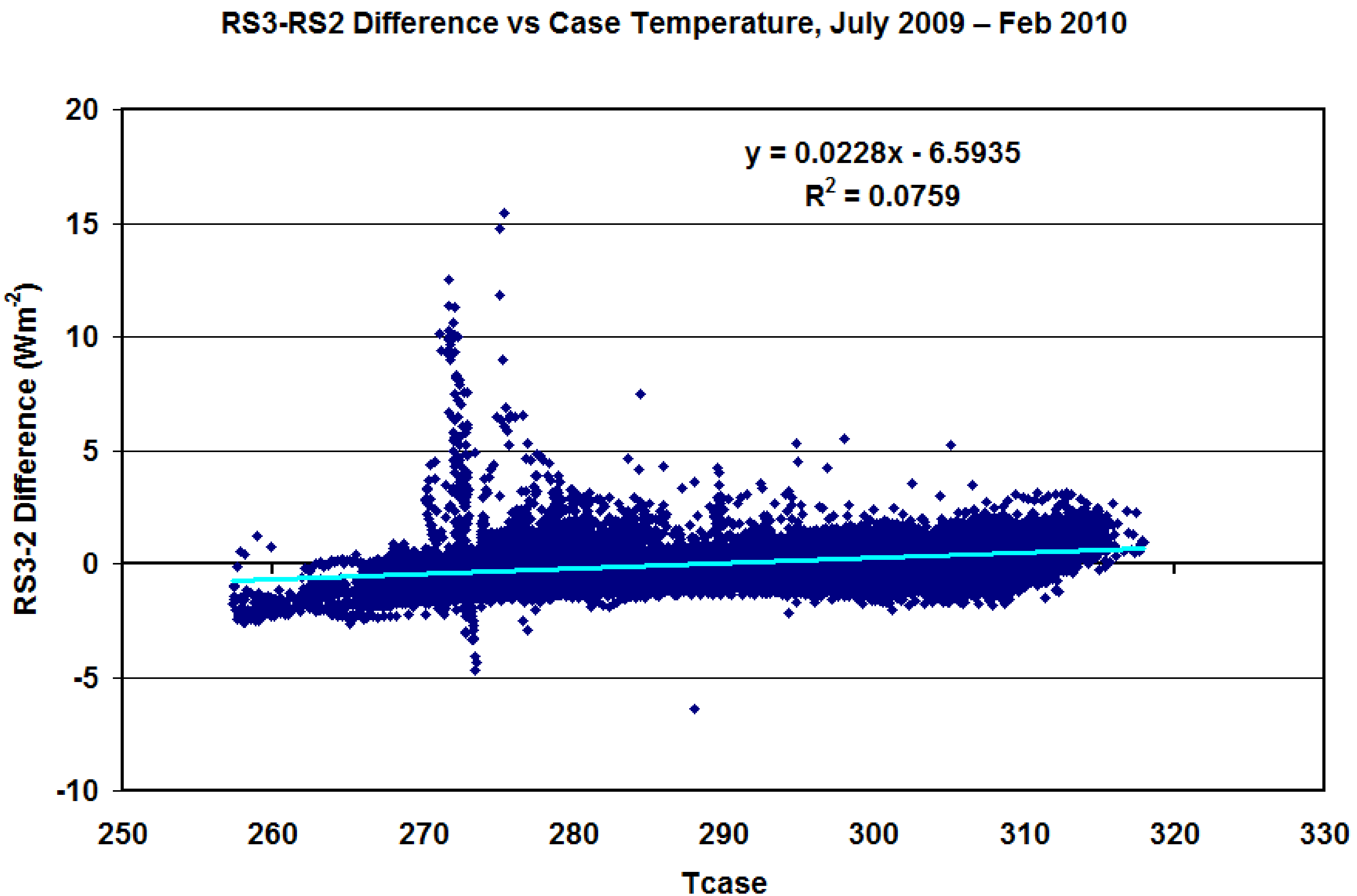
Seasonal Distributions



Seasonal Distributions



Temperature Dependence



It seems to me…

- I used 11 days of 1-minute data spanning 120 and 140 Wm^{-2} range of LWdn for NREL-RS1 and RS1-RS2&3 cals
- Using multivariate fitting to simultaneously determine coefficients worked well in both cases
  - evidenced by good performance in all seasons and differing conditions
- Not shown: if reference shaded, so should units being calibrated
  - but can be done unshaded given reference is same make & model as unit being calibrated
  - Alternately can use only night time data for calibration (no solar input) if that gives good range of LWdn

It seems to me…

- Given enough data, full eigenvalue/matrix "MultFit" or sub-sampling "FastLTS" makes no appreciable difference in coefficients
- The exact form of the equation is of secondary importance to having a statistically robust data set and using 3 coefficients
- There might be some minor improvement to including the Reda et al. case temperature adjustment term

It seems to me…

- **"…adjusting the k2 coefficient under cloudy skies, adjusting the k1 coefficient under clear skies, then adjusting the k3 coefficient to minimize the scatter between the instrument being calibrated and the reference."**
  - **Not needed nor a good idea**
  - **Adds unnecessary complexity and less robustness for determining coefficients**
  - **My cal period had about 55% clear or nearly clear skies, yet calibration works just as well in winter with 65% overcast skies**

Recommend

- Gather 2 weeks of data (maybe in Spring?)
  - or refinement: in winter months for NSA, summer for TWP
- Check to make sure data spans at least 120 - 140 Wm^{-2} of LWdn and includes some clear and overcast skies
- Use multivariate fitting, 2-pass to eliminate outliers
- Other:
  - Shade or unshade?
  - Use Reda et al formula for temp dependence?