Impact of urban atmospheric conditions on radiation receipt in London

Emily McKie – energy budgets

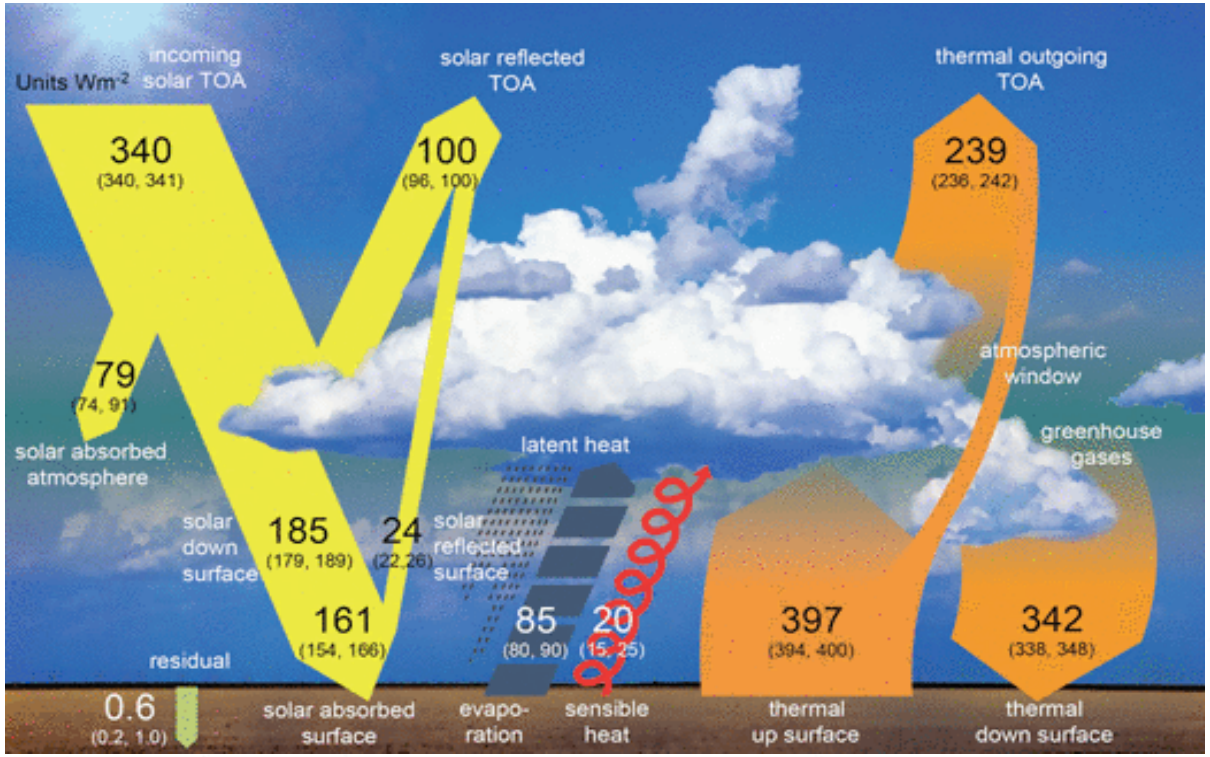
John Lally – data stratification and shortwave radiation

Elizabeth Ehrbar – longwave radiation

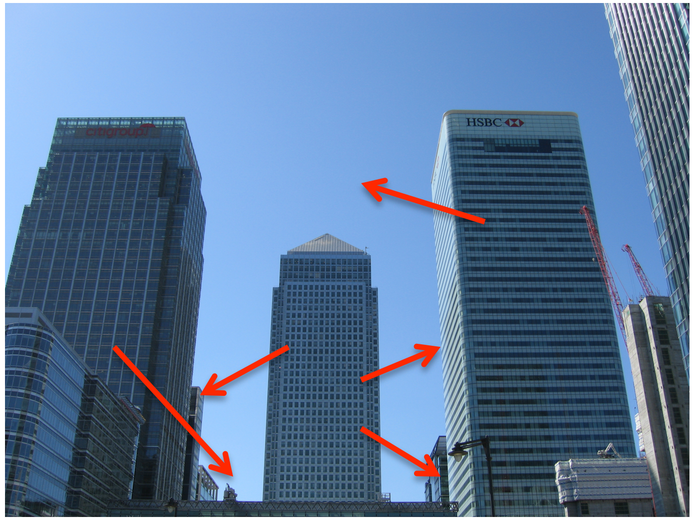
James Shaw – modelling

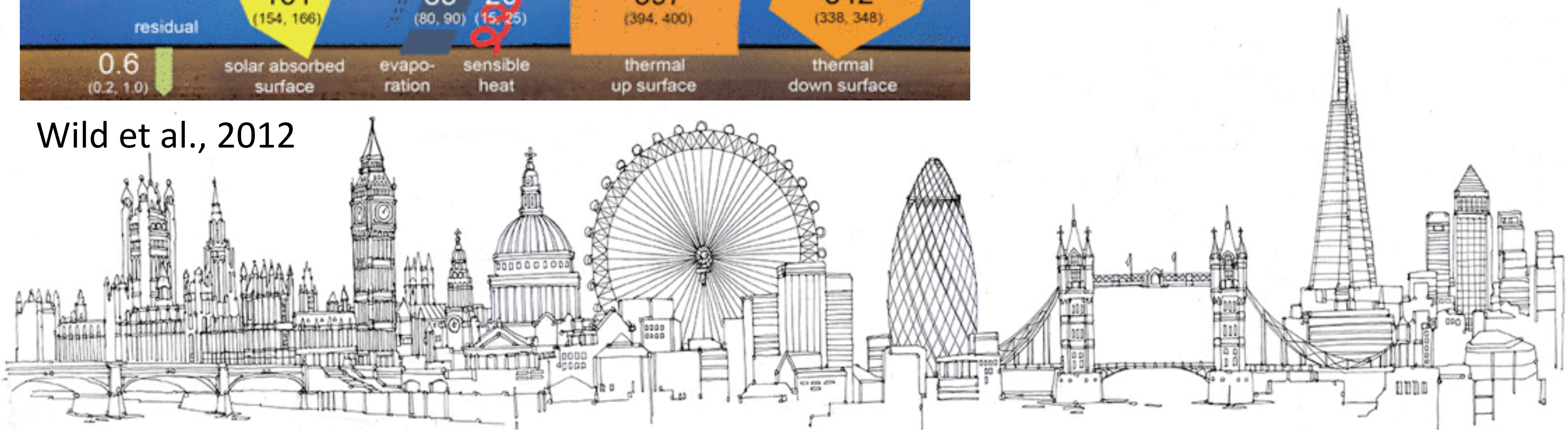
Global energy budget

$$Q^* = (K\downarrow - K\uparrow) + (L\downarrow - L\uparrow)$$



Wild et al., 2012



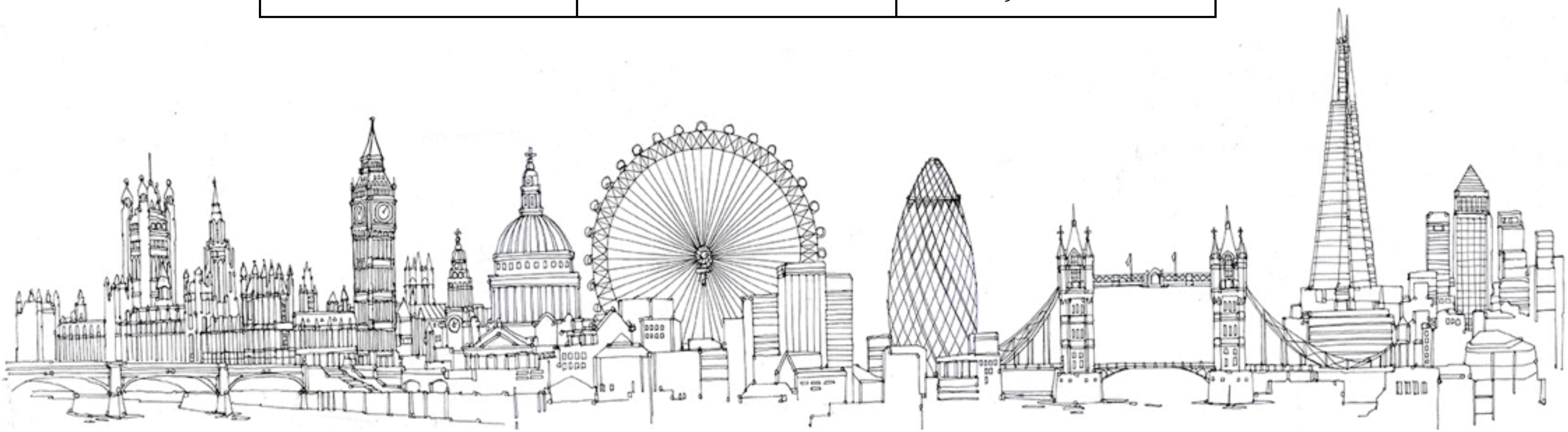


Impact of the atmosphere

- Cloud cover
- Aerosols
- Precipitation

Reduction in shortwave radiation

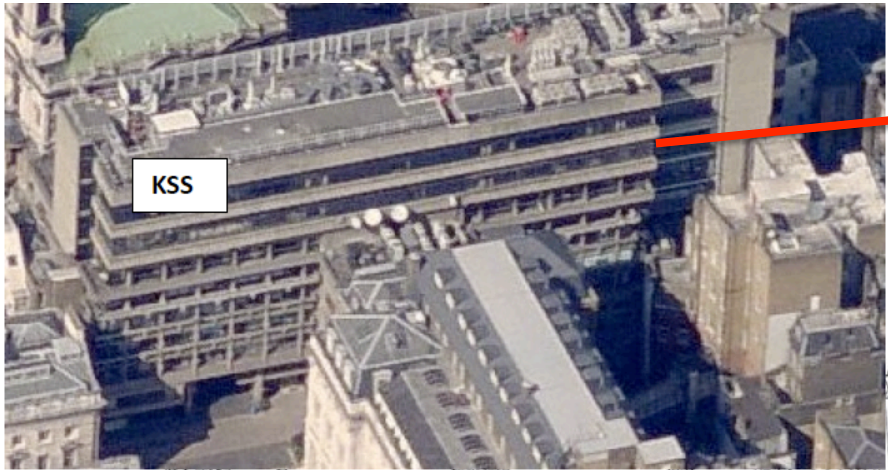
Source	Location	Reduction of incoming shortwave
Chameides et al., 1999	NE China (model)	5 - 30%
Cleugh and Grimmond, 2012	Global	5% if low aerosol concentration Up to 30%, eg. Hong Kong
Ball and Robinson, 1981	Eastern US	8%
Ramanathan et al., 2001	Indian Ocean	-20Wm-2 (6%)
IPCC, 2007	Global model estimate	-1.3 to -3.3 Wm-2 (less than 1%)

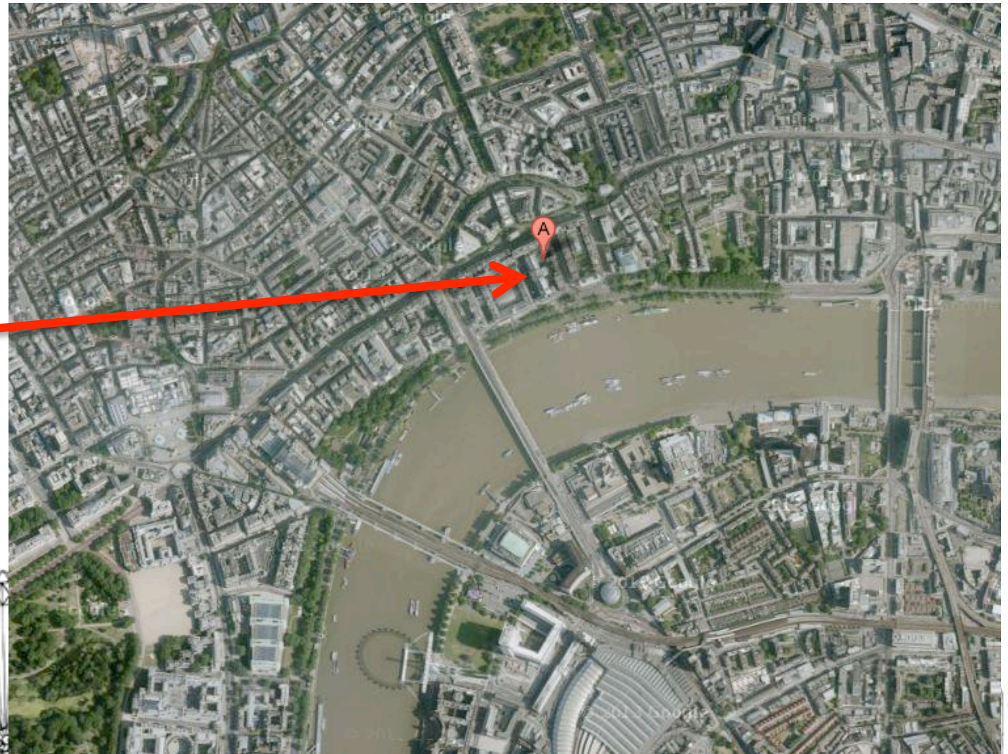


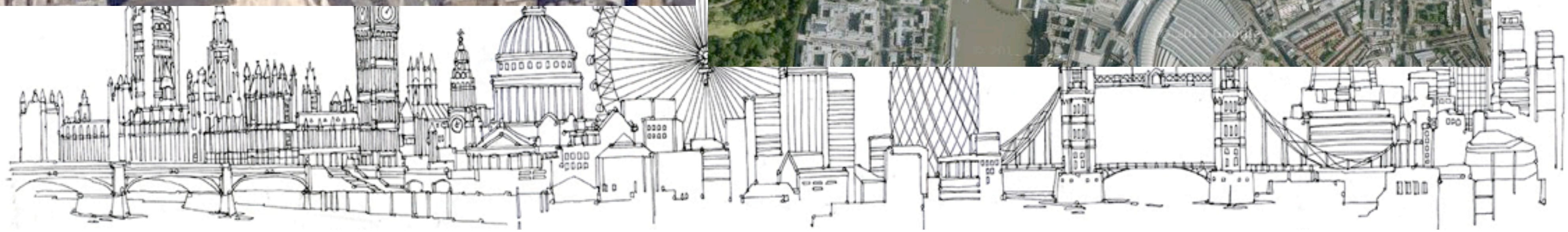
Data Collection

Ceilometer

Net radiometer

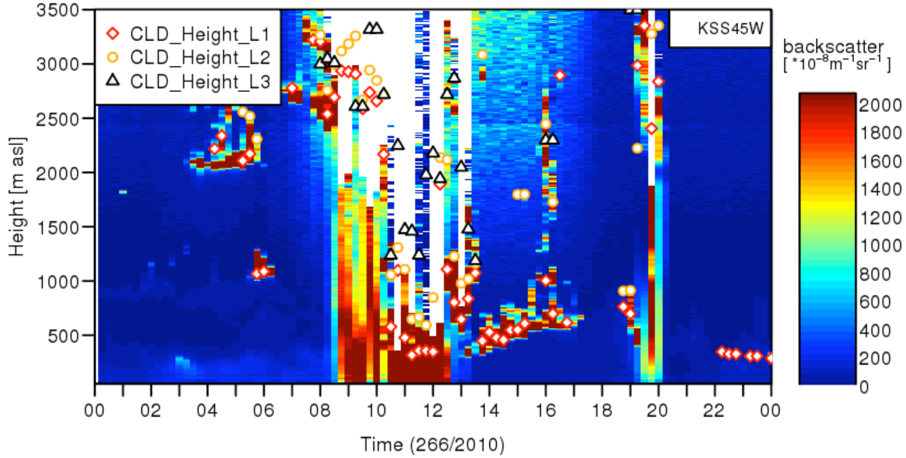


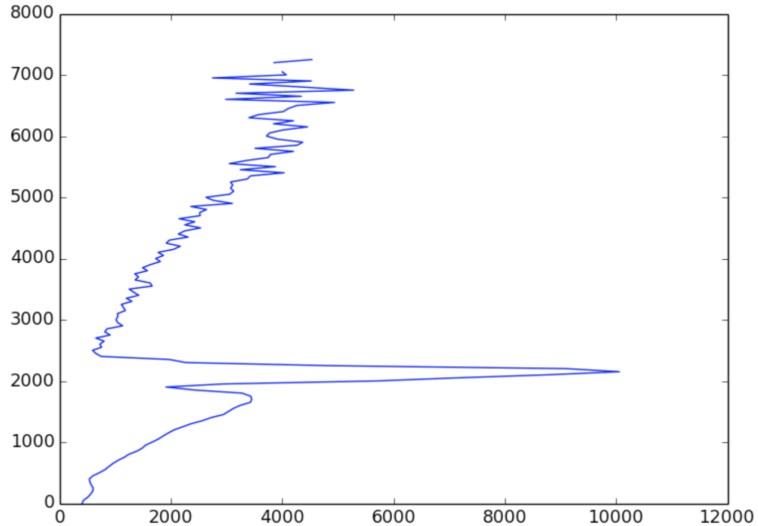


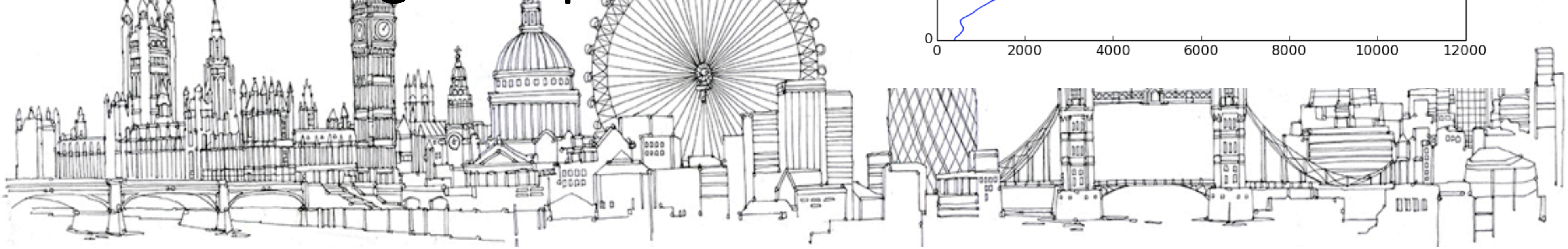


Ceilometer data

- Typical backscatter plot
- High Backscatter from cloud
- From aerosols
- From rain
- Lower Backscatter after rain
- Noise higher up

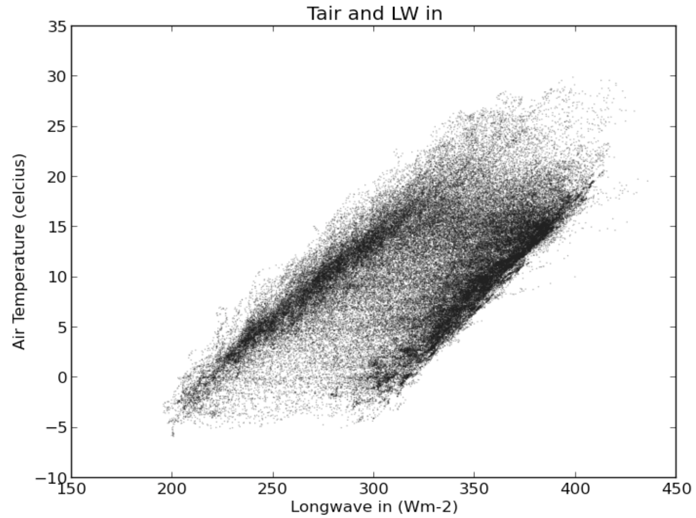


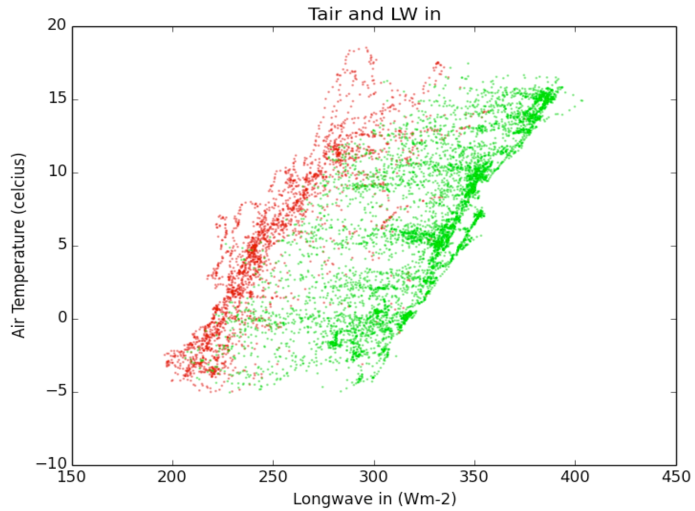




Data Stratification

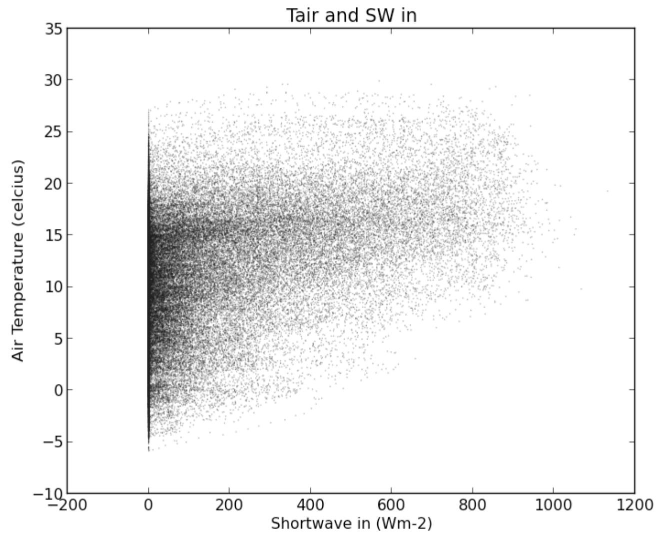
- Multi-variate dataset
- Real atmosphere – no controls
- Variation due to more than one variable simultaneously
- Can define subsets (strata) so that simpler relationships can be found

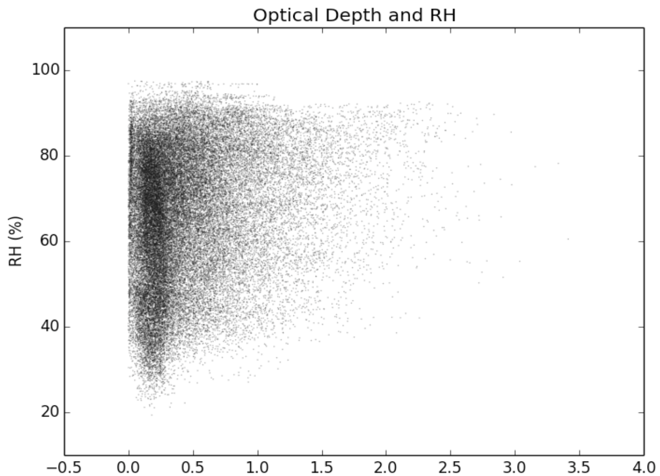




Some Results

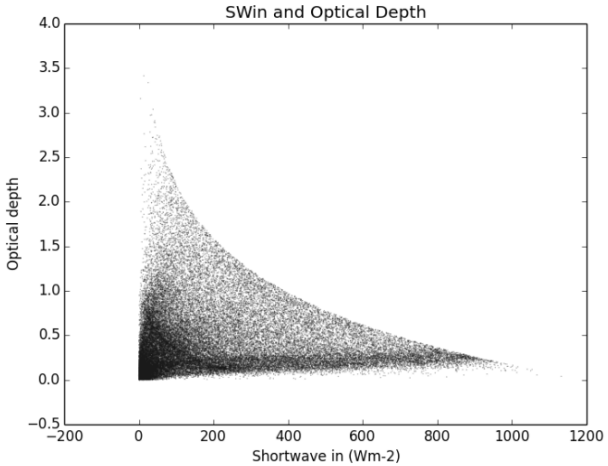
- SW decreases with cloud cover
- LW has two separate modes in clear and cloudy conditions, SW less so
- LW very dependent on air temperature
- Optical depth has background value 0.2 increases in high RH

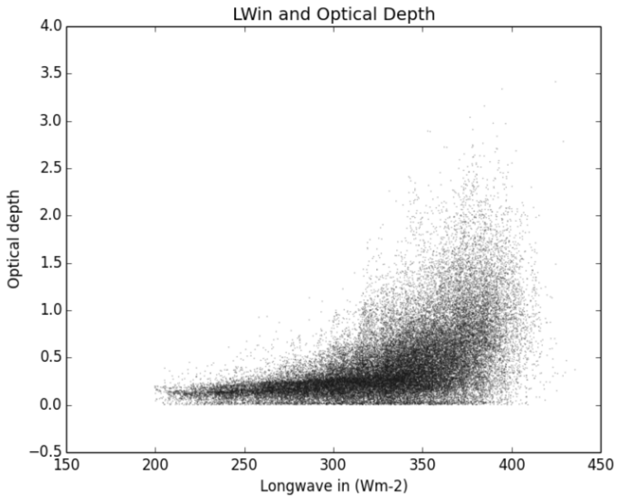


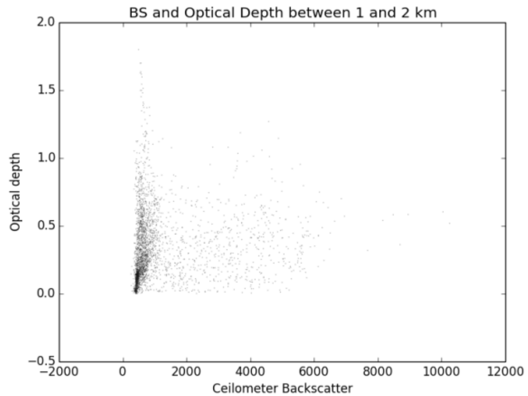


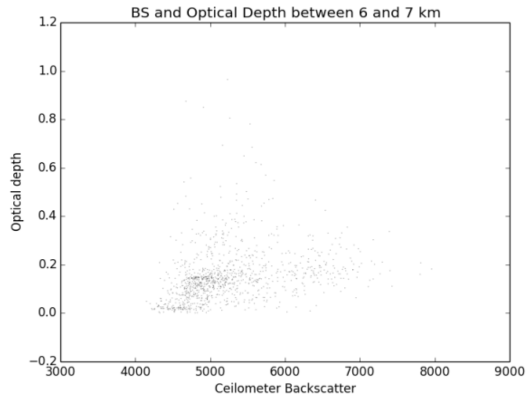
More Results

- LW in and optical depth
- SW in and optical depth
- Optical depth and ceilometer backscatter



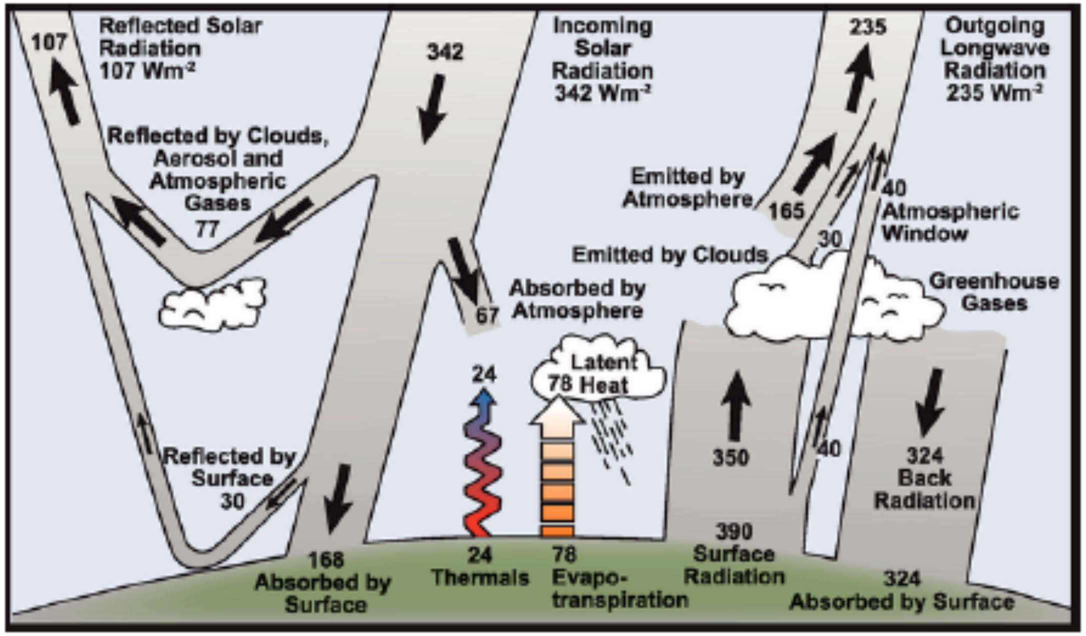




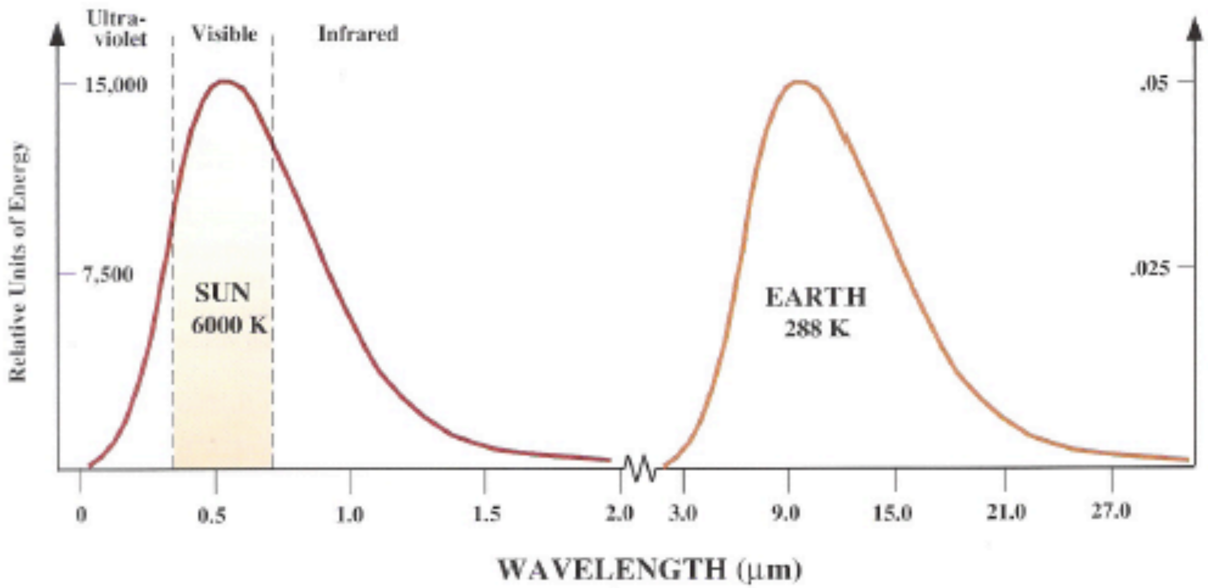


Longwave Radiation

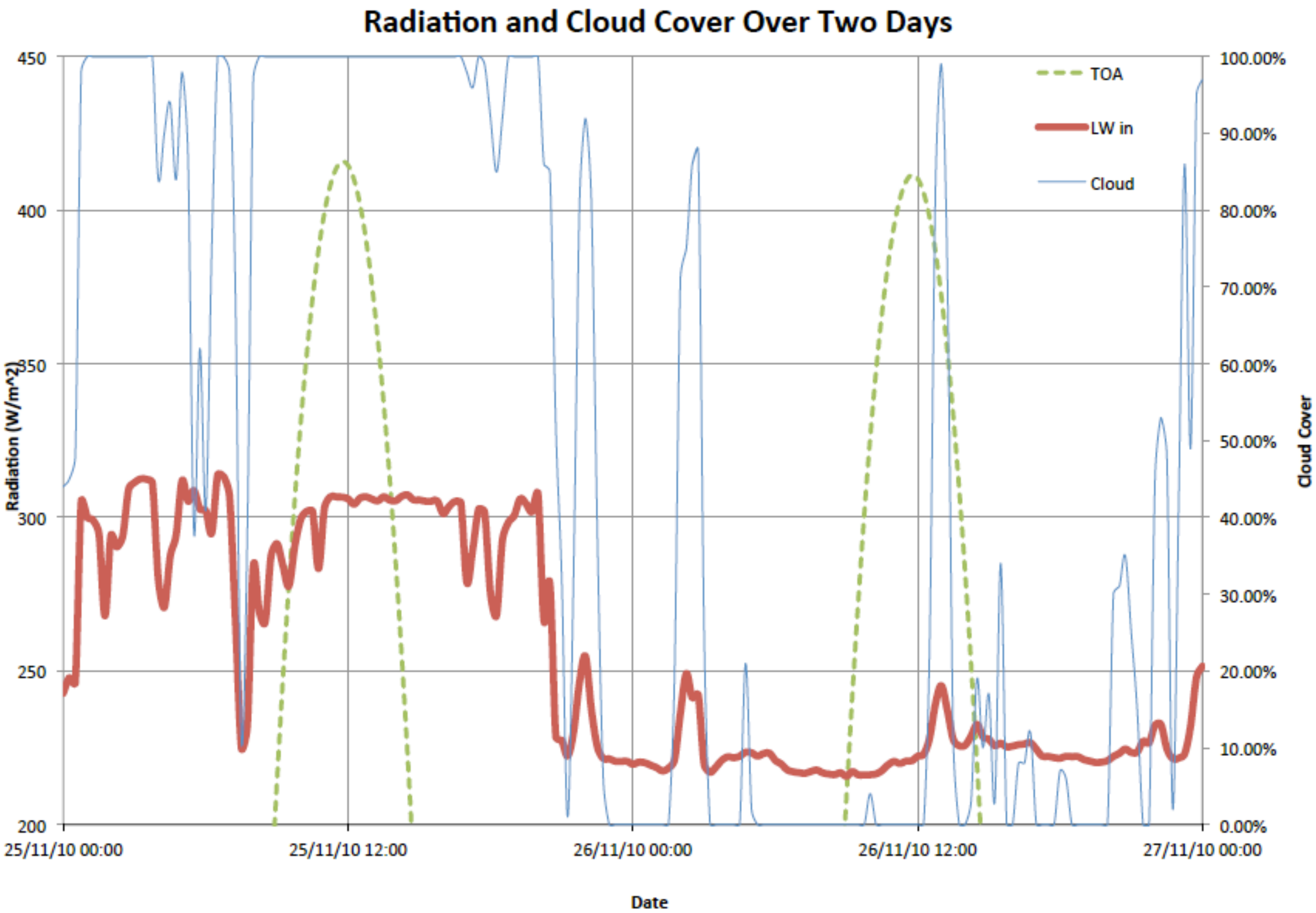
Source: http://www.nsf.gov/news/news_images.jsp?cntn_id=104484

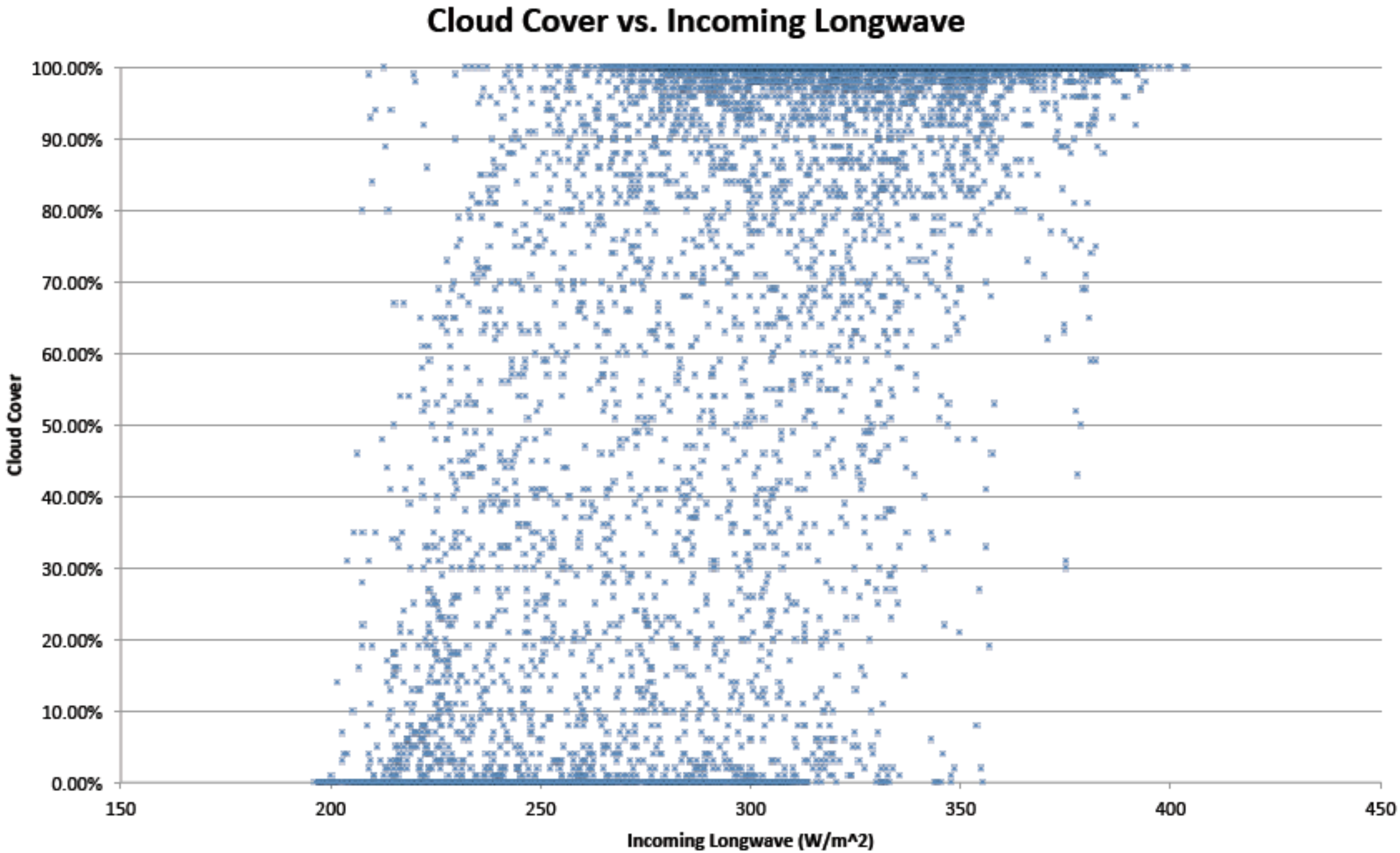


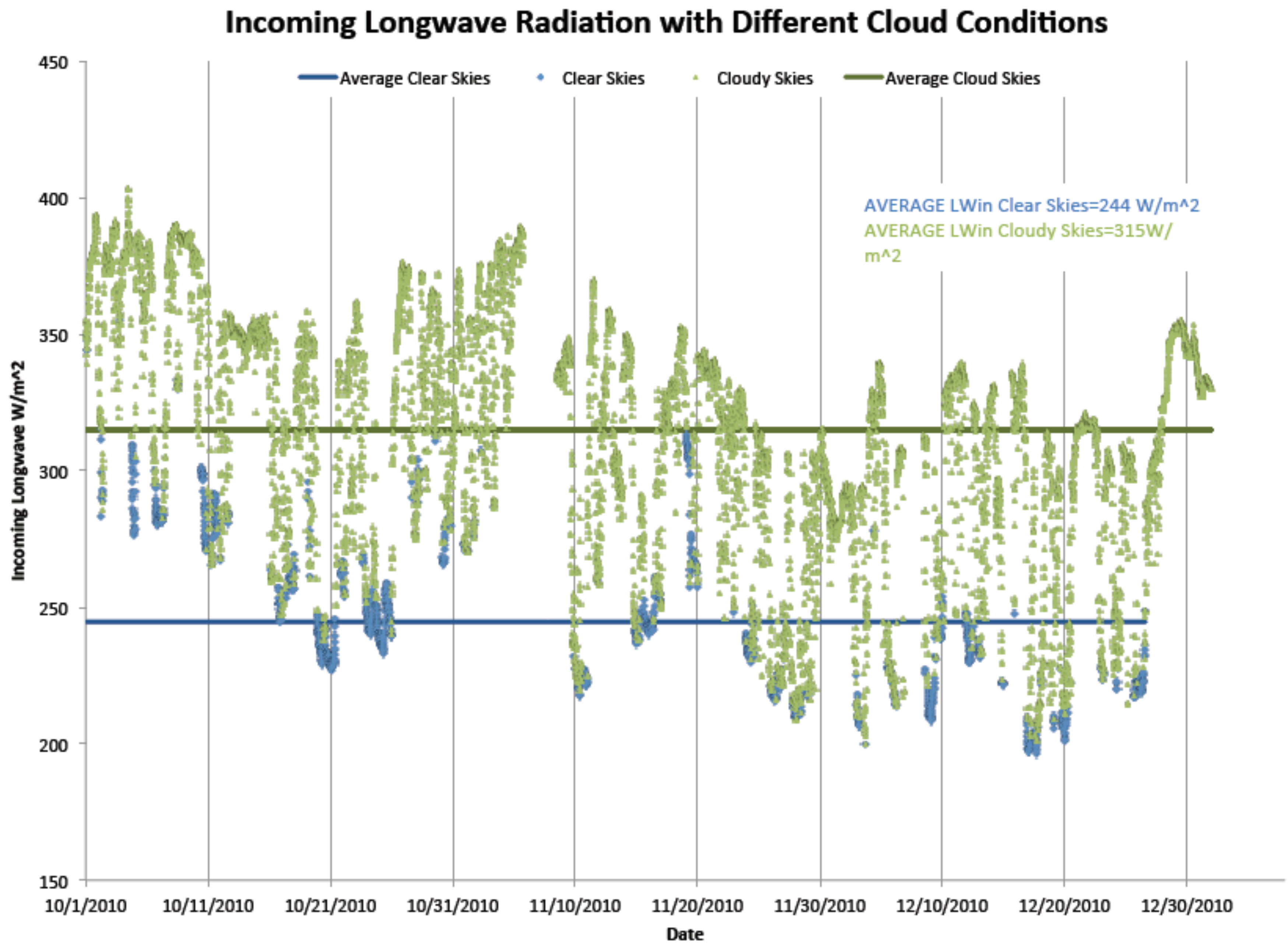
Source: Kiehl and Trenberth (1997)

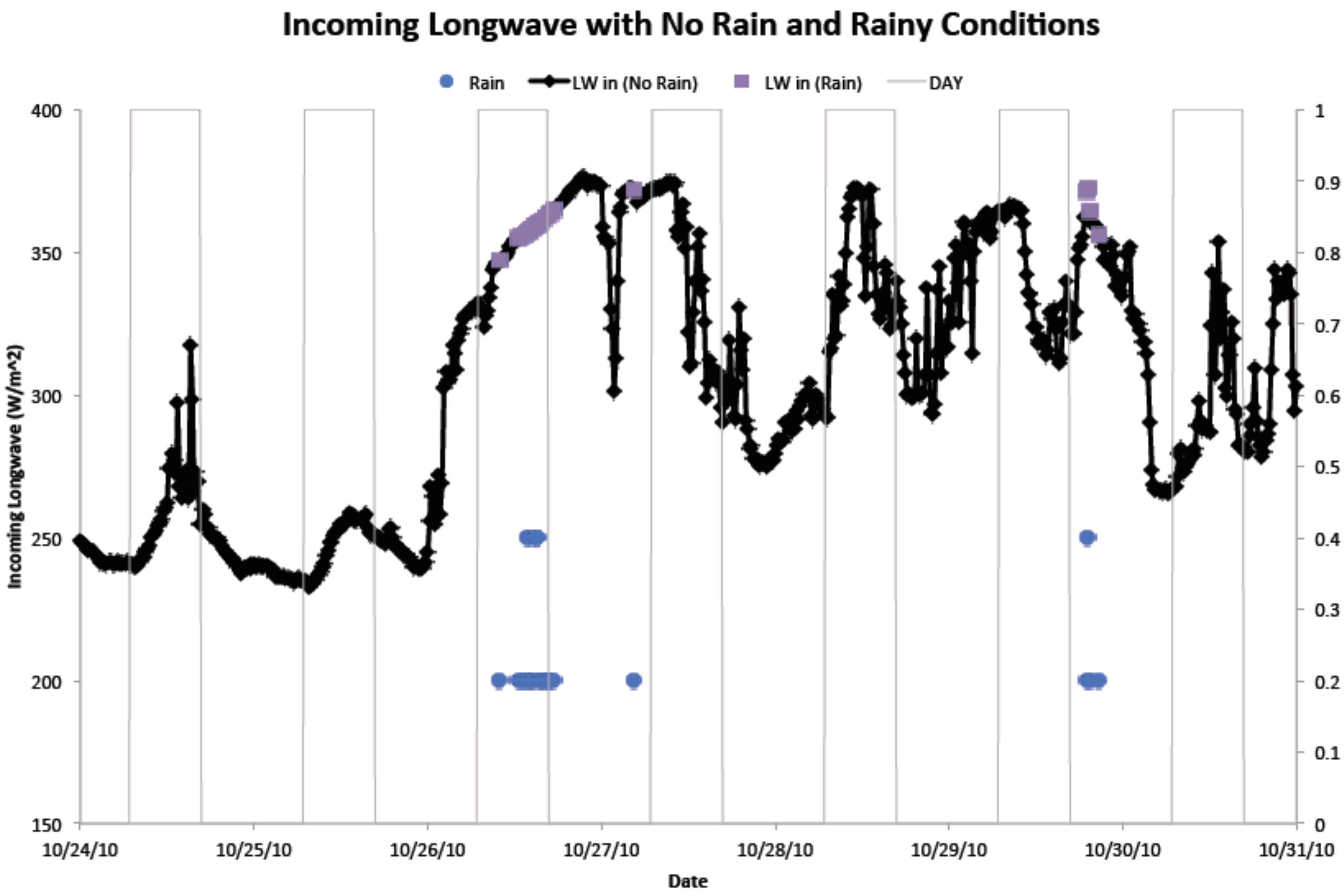


Source: http://www.meteo.psu.edu/~j2n/2_8_spectrum.jpg

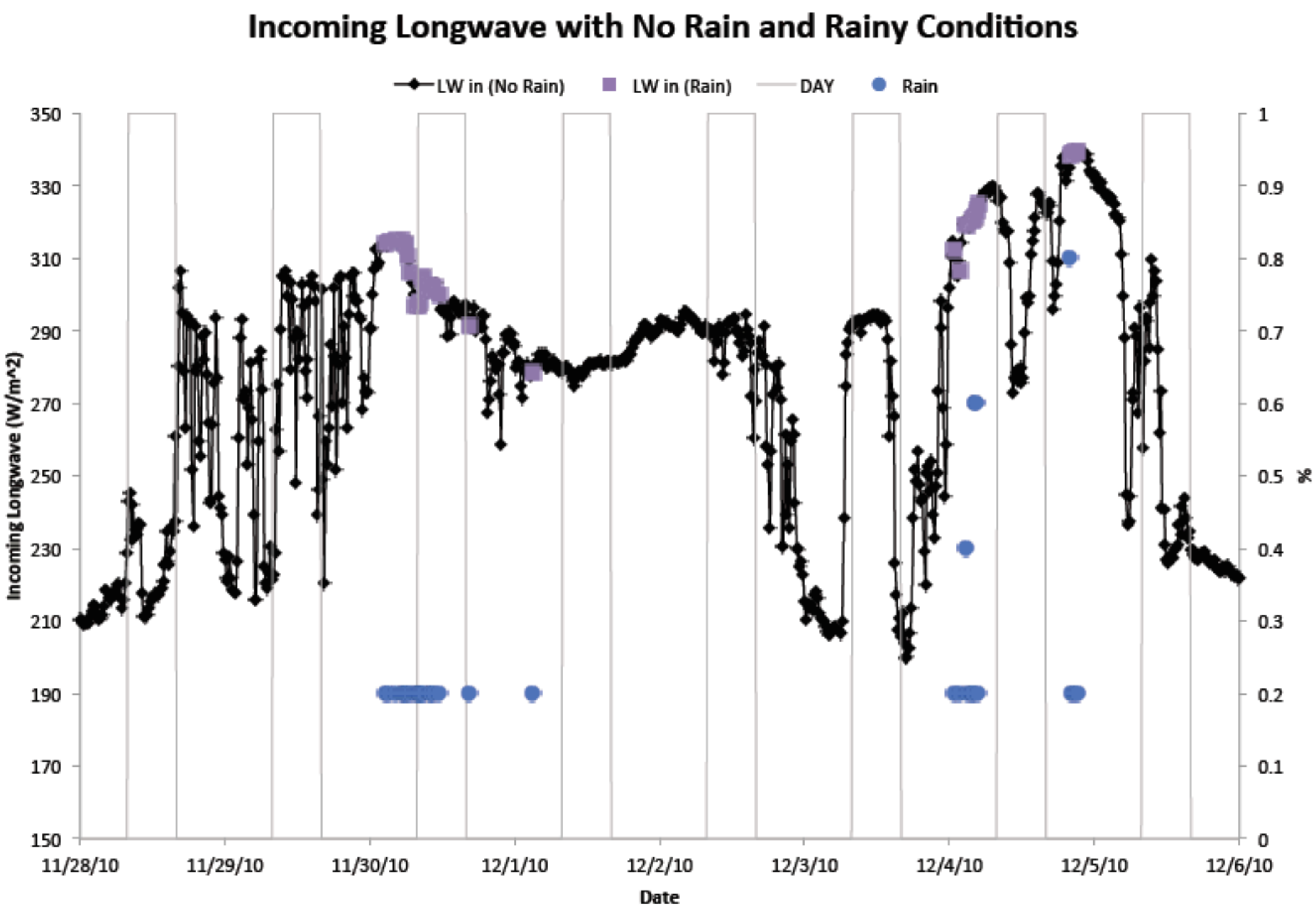

Radiation and Cloud Cover Over Two Days
TOA
LW in
Cloud
Radiation (W/m^2)
Cloud Cover
Date
450
400
350
300
250
200
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
25/11/10 00:00
25/11/10 12:00
26/11/10 00:00
26/11/10 12:00
27/11/10 00:00


Cloud Cover vs. Incoming Longwave
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Cloud Cover
150
200
250
300
350
400
450
Incoming Longwave (W/m^2)

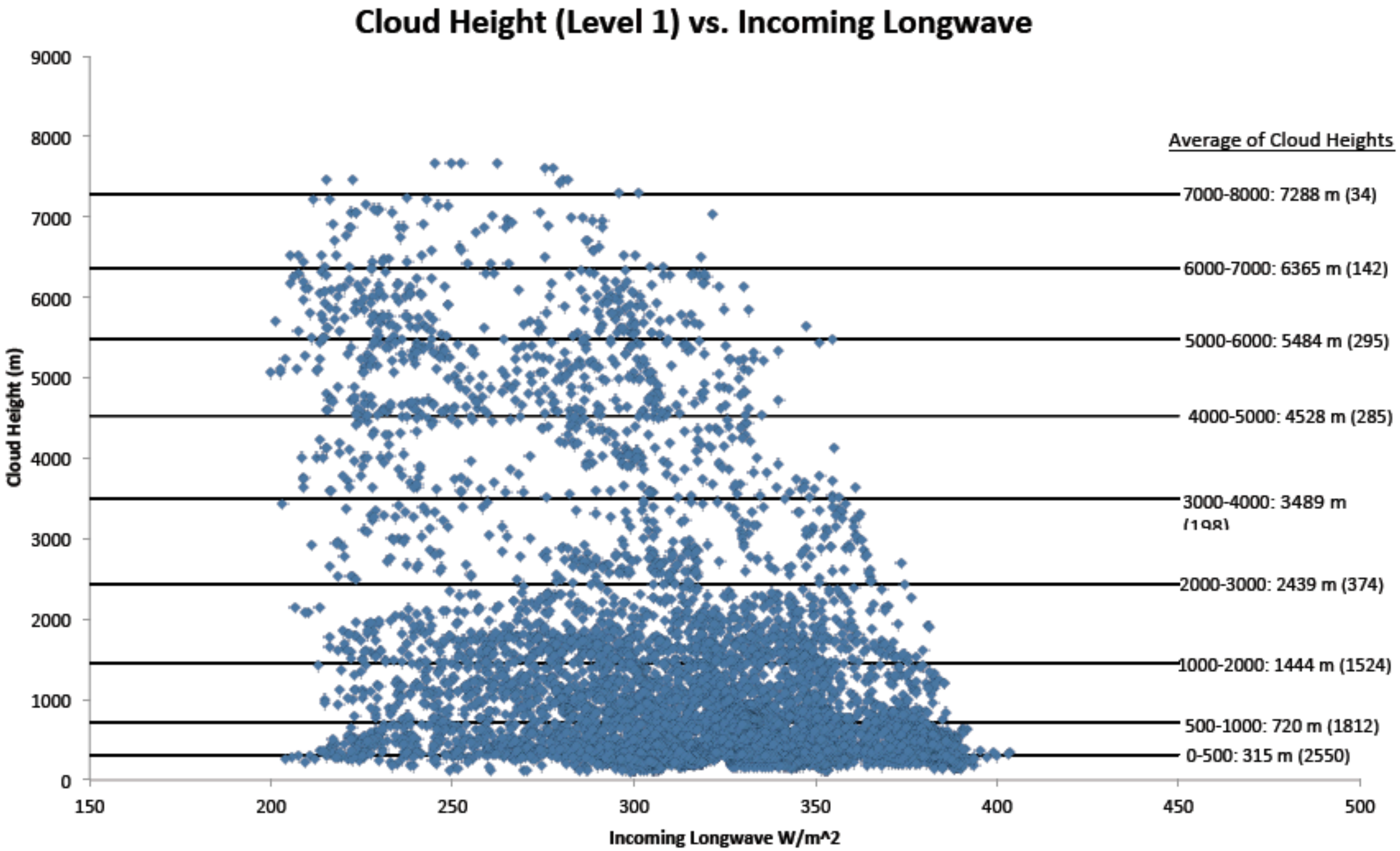

Incoming Longwave Radiation with Different Cloud Conditions
Average Clear Skies
Clear Skies
Cloudy Skies
Average Cloud Skies
AVERAGE LWin Clear Skies=244 W/m^2
AVERAGE LWin Cloudy Skies=315W/m^2
Incoming Longwave W/m^2
450
400
350
300
250
200
150
10/1/2010
10/11/2010
10/21/2010
10/31/2010
11/10/2010
11/20/2010
11/30/2010
12/10/2010
12/20/2010
12/30/2010
Date



Incoming Longwave with No Rain and Rainy Conditions
Rain
LW in (No Rain)
LW in (Rain)
DAY
Incoming Longwave (W/m^2)
400
350
300
250
200
150
%
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10/24/10
10/25/10
10/26/10
10/27/10
10/28/10
10/29/10
10/30/10
10/31/10
Date



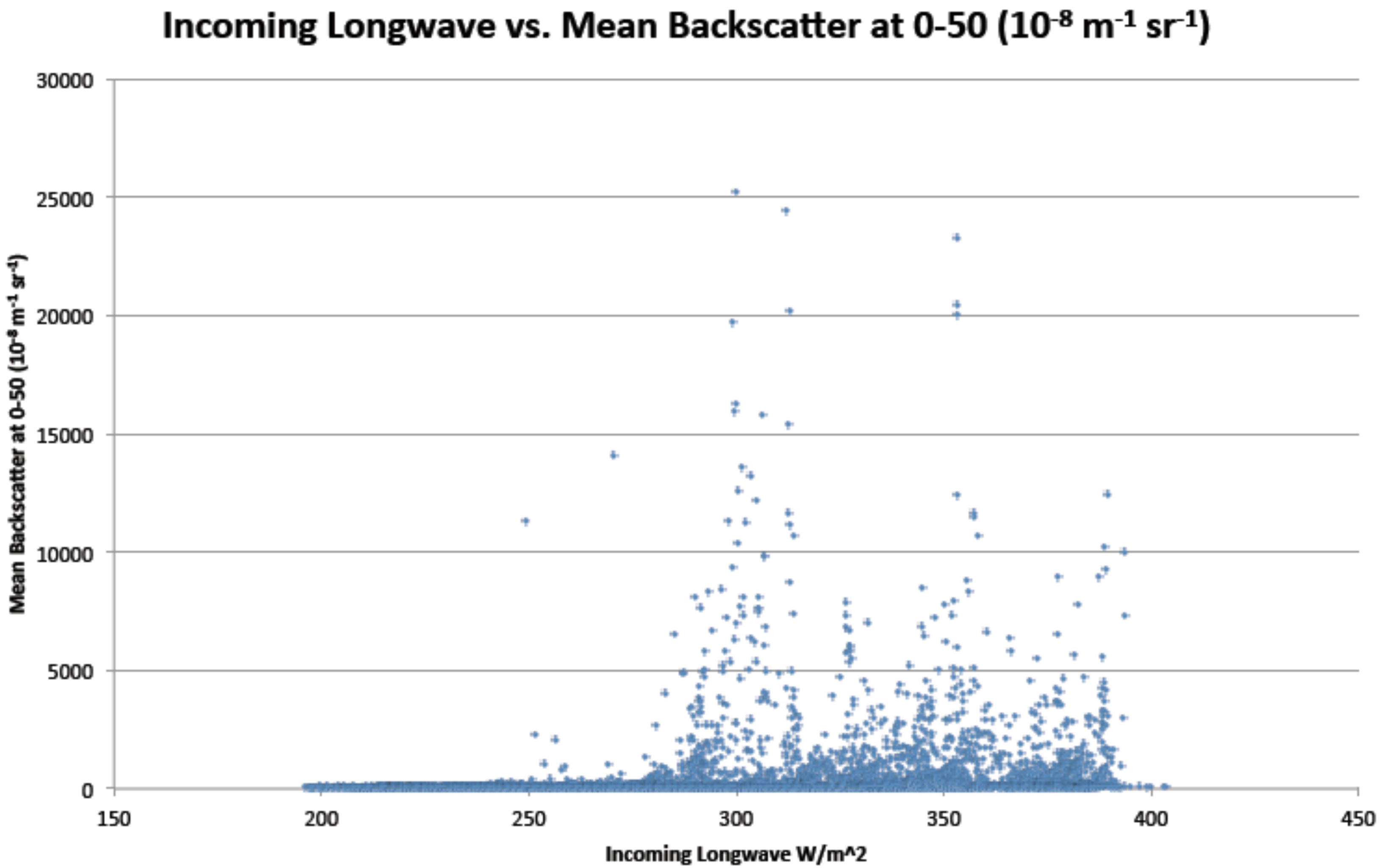
Incoming Longwave with No Rain and Rainy Conditions
LW in (No Rain)
LW in (Rain)
DAY
Rain
Incoming Longwave (W/m^2)
%
Date
350
330
310
290
270
250
230
210
190
170
150
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
11/28/10
11/29/10
11/30/10
12/1/10
12/2/10
12/3/10
12/4/10
12/5/10
12/6/10



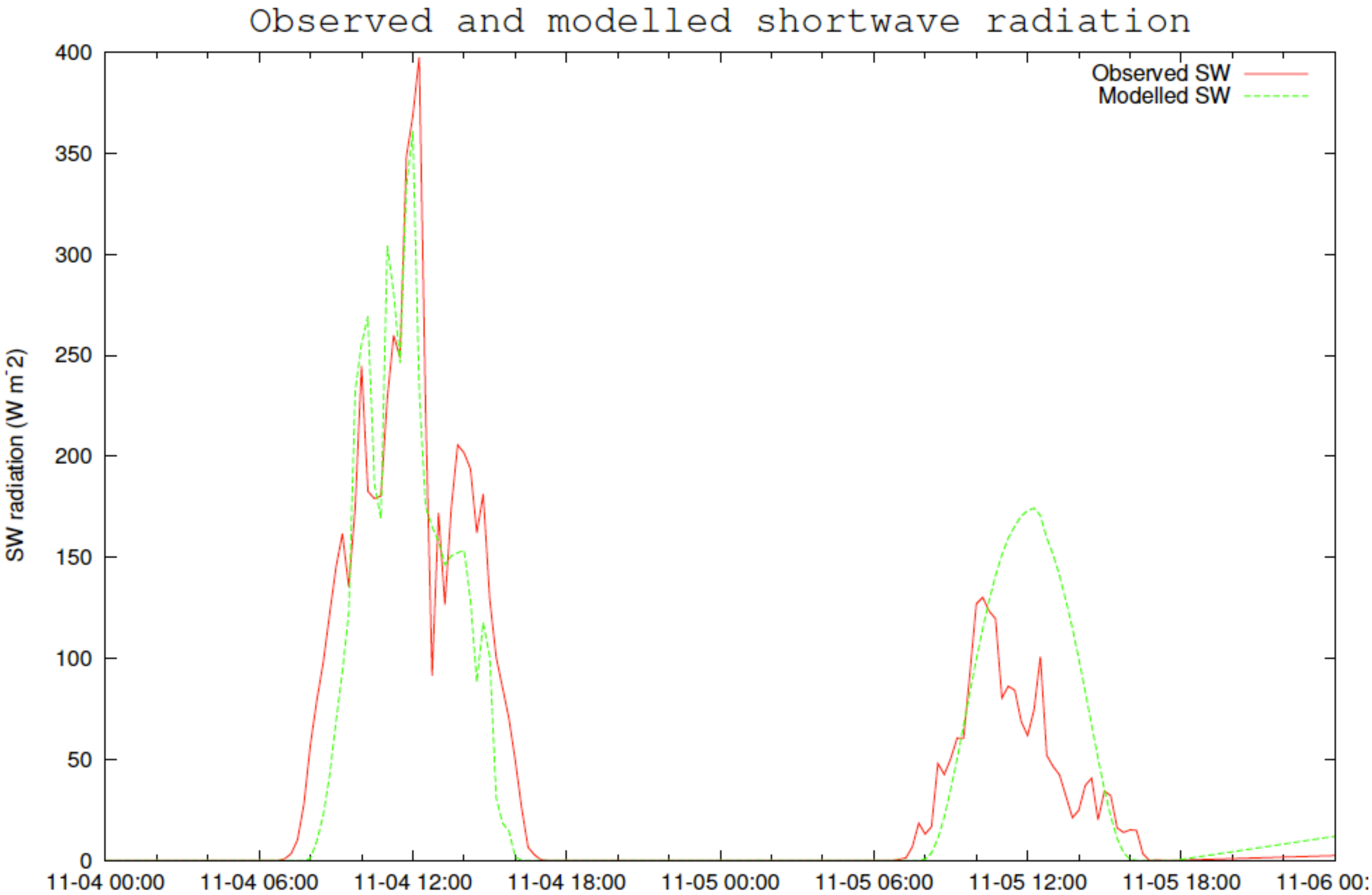
0-2000 meters: Nimbostratus, Stratus, Stratocumulus, Cumulus, Cumulonimbus

2000-7000 meters: Altocumulus, Altostratus

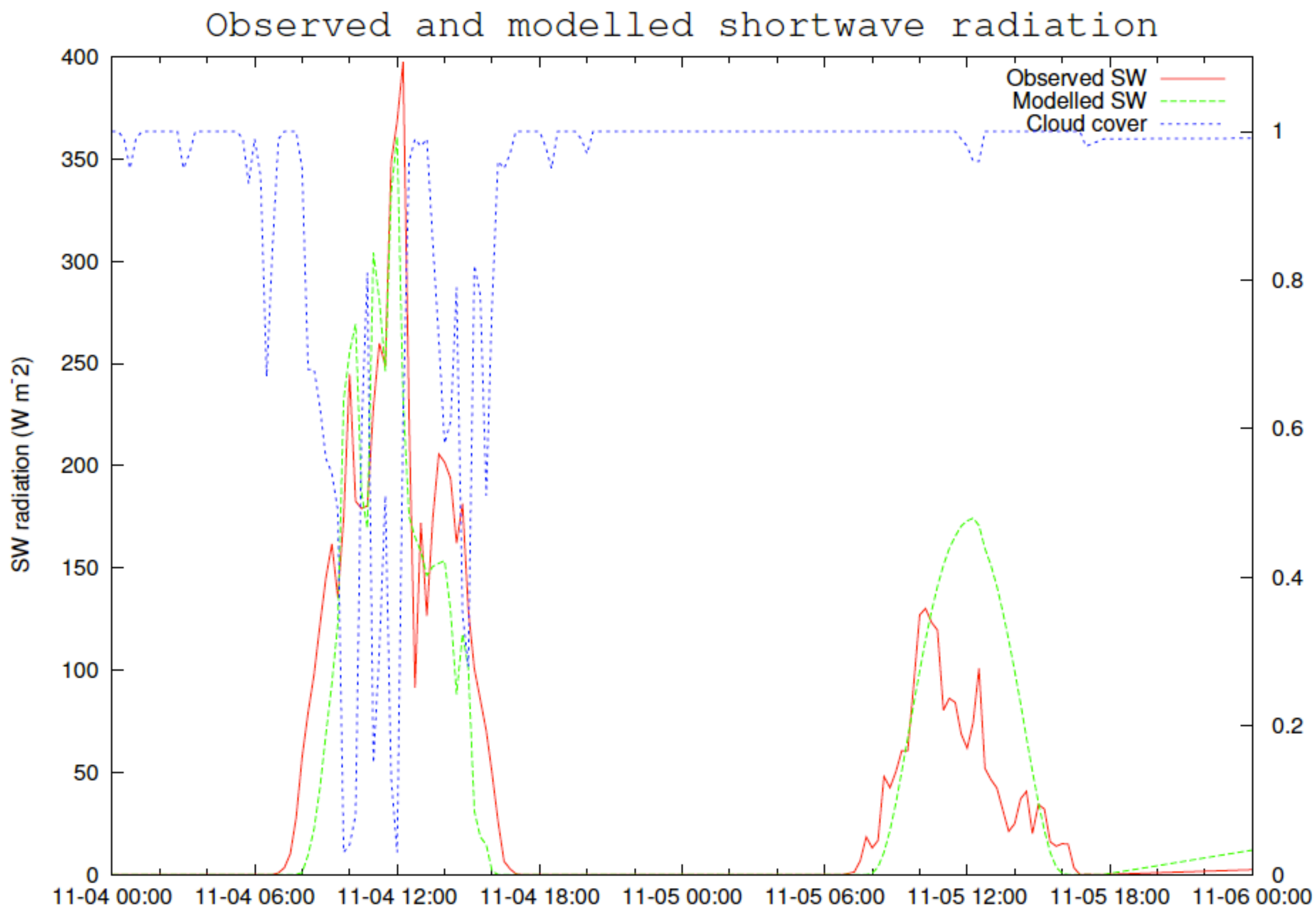
5000-13000 meters: Cirrus, Cirrocumulus, Cirrostratus

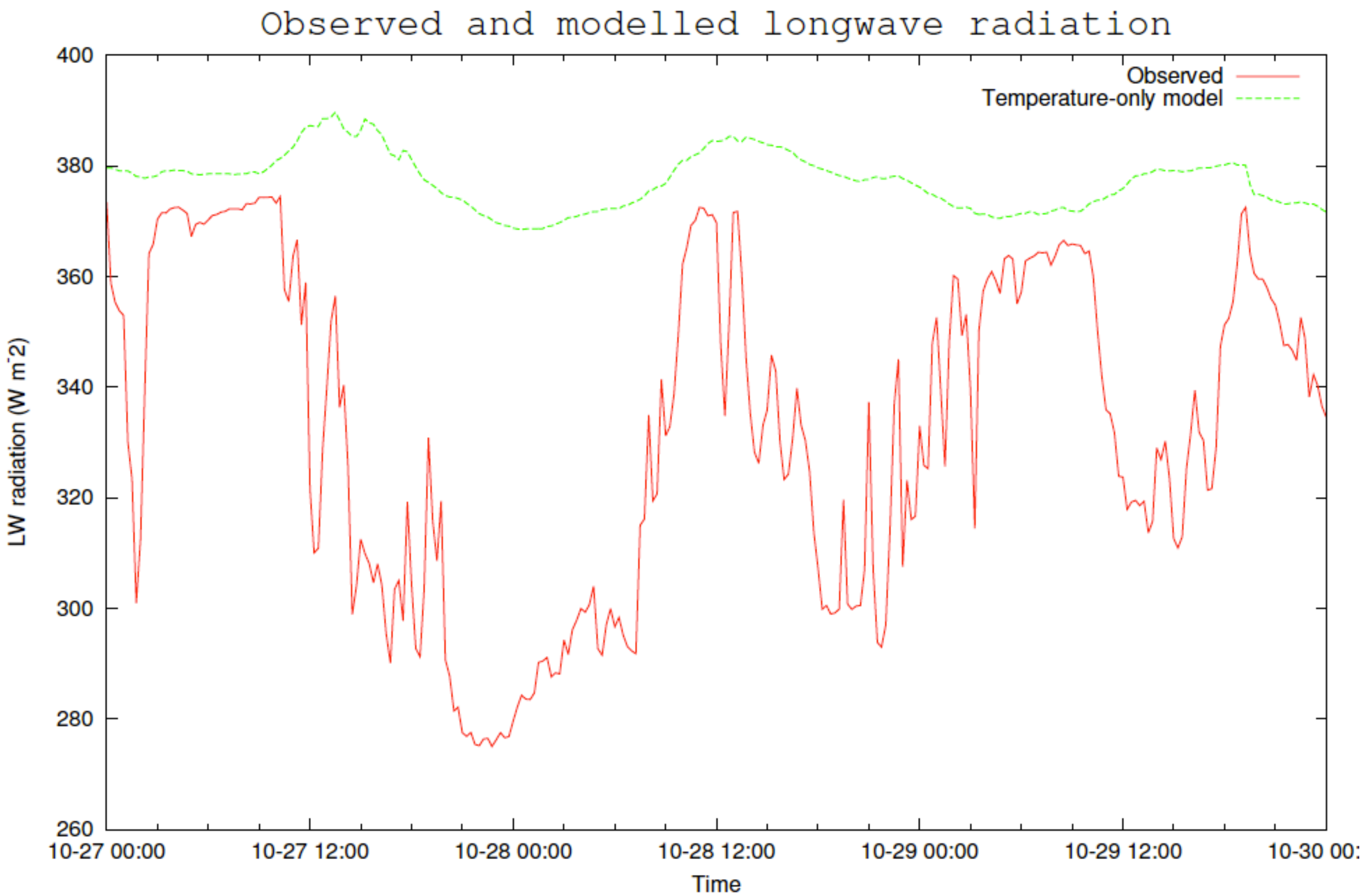


Mean Backscatter- Backscatter block averaged to 15 minute intervals values for each later of 50 meters.

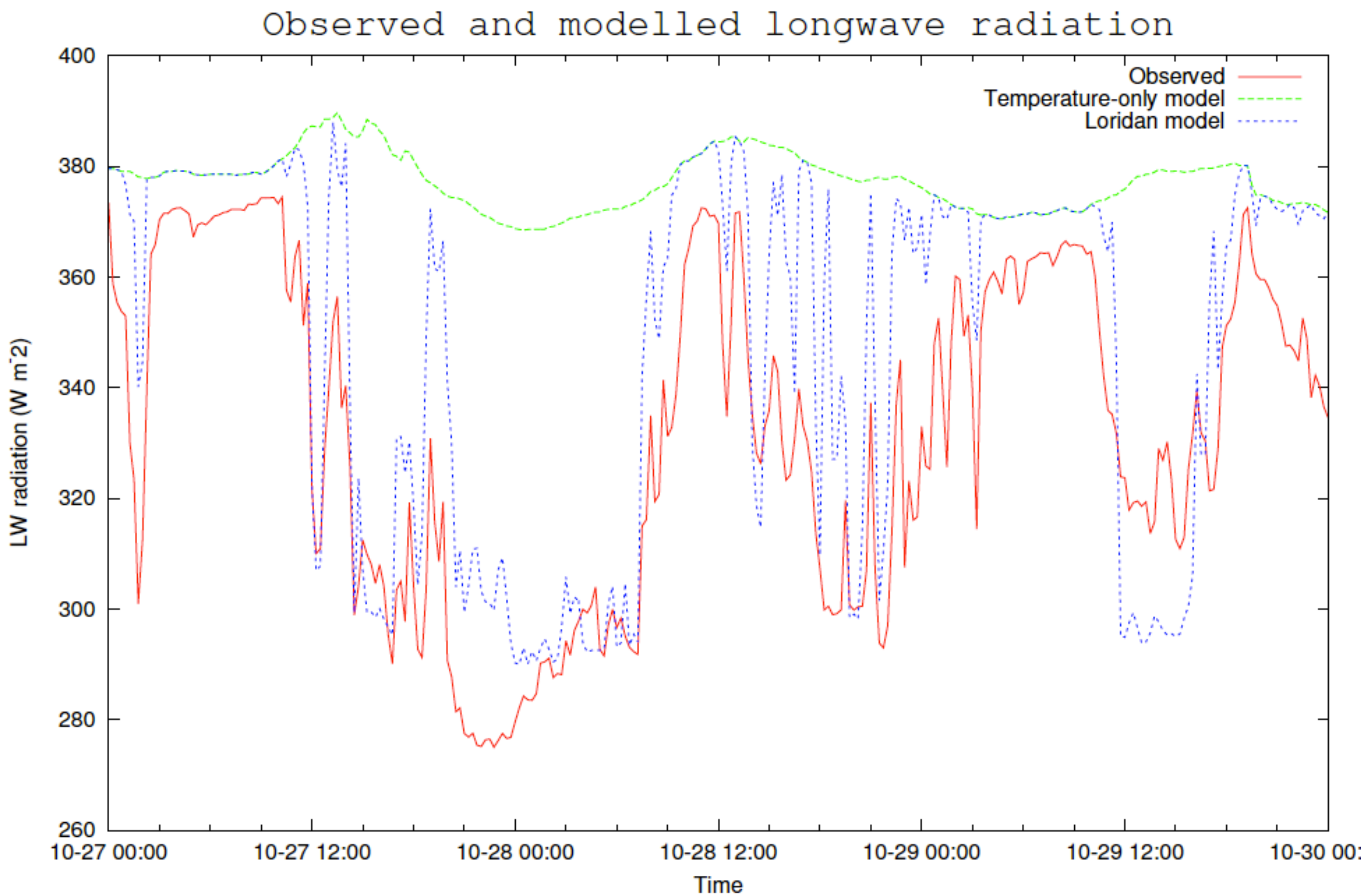


Observed and modelled shortwave radiation
Observed SW
Modelled SW
SW radiation (W m^-2)
400
350
300
250
200
150
100
50
0
11-04 00:00
11-04 06:00
11-04 12:00
11-04 18:00
11-05 00:00
11-05 06:00
11-05 12:00
11-05 18:00
11-06 00:

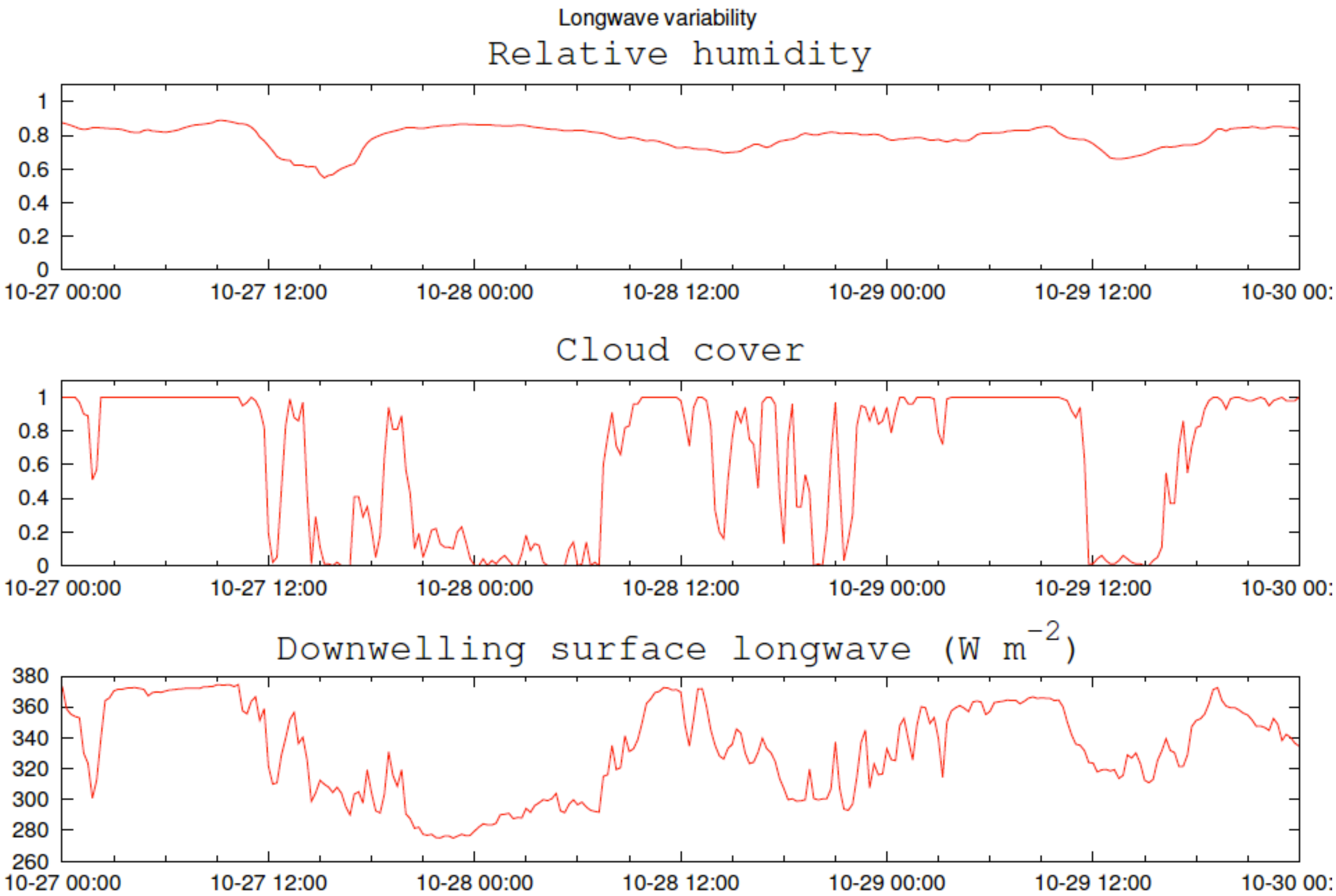

Observed and modelled shortwave radiation
Observed SW
Modelled SW
Cloud cover
SW radiation (W m^2)
Cloud cover
0
50
100
150
200
250
300
350
400
0
0.2
0.4
0.6
0.8
1
11-04 00:00
11-04 06:00
11-04 12:00
11-04 18:00
11-05 00:00
11-05 06:00
11-05 12:00
11-05 18:00
11-06 00:00



Observed and modelled longwave radiation
Observed
Temperature-only model
LW radiation (W m^-2)
400
380
360
340
320
300
280
260
10-27 00:00
10-27 12:00
10-28 00:00
10-28 12:00
10-29 00:00
10-29 12:00
10-30 00:
Time



Observed and modelled longwave radiation
Observed
Temperature-only model
Loridan model
LW radiation (W m^2)
400
380
360
340
320
300
280
260
10-27 00:00
10-27 12:00
10-28 00:00
10-28 12:00
10-29 00:00
10-29 12:00
10-30 00:
Time



Longwave variability
Relative humidity
1
0.8
0.6
0.4
0.2
0
10-27 00:00
10-27 12:00
10-28 00:00
10-28 12:00
10-29 00:00
10-29 12:00
10-30 00:
Cloud cover
1
0.8
0.6
0.4
0.2
0
10-27 00:00
10-27 12:00
10-28 00:00
10-28 12:00
10-29 00:00
10-29 12:00
10-30 00:
Downwelling surface longwave (W m^{-2})
380
360
340
320
300
280
260
10-27 00:00
10-27 12:00
10-28 00:00
10-28 12:00
10-29 00:00
10-29 12:00
10-30 00:

Conclusions

- Different strata exist in the data
- Aerosols smaller role day to day
- For near-surface aerosols to cause local LW warming at the surface, the concentration has to be extremely high, sand storm-like.