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**Novel methods for the quantification of atmospheric
turbulence strength in the atmospheric surface layer.**

by

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Abstract

Atmospheric turbulence is a random and chaotic process brought about by energy transport mechanisms in the atmosphere. Of particular focus in this research program is the energy transport occurring in the atmospheric surface layer between ground heated air parcels and the air directly above. This dynamic process is impacted by so many apparently random initial conditions and boundary states that a precise analytical description of the process is beyond current computation. The process of turbulence can, however, be statistically analysed and characterised empirically. Observable phenomena such as scintillation have been found to have a range dependence and even the micro-meteorological structure of the turbulent eddies (chiefly responsible for the convective energy transport) have had their spatial distribution, scale size and power spectra examined in detail.

As complex as the field is, one is left in no doubt, when viewing a scene through strong turbulence, that this dynamic and random process disrupts and perturbs the passage of visible radiation and is seen to severely degrade the quality of imagery. So the question raised is: “How can the strength of atmospheric turbulence be determined from either physical measurements of meteorological data or from sequences of perturbed imagery?” In order for imagery to be corrected for turbulence-induced degradation, or even the reliability of the imagery for uses such as object recognition and identification, an accurate measure of the current turbulence strength is required.

After exploring the turbulence phenomenon and its impact upon laser spots and imagery, three parallel approaches to the determination of the current turbulence strength were pursued in this research program.

The first was a controlled laboratory experiment where an artificial turbulent air-stream generated above a hot plate was investigated. Using sensitive temperature probes the temperature structure function (a quantity specifically developed to describe the spatial nature of a turbulent field) in a region of relatively high turbulence strength was determined. The homogeneity and isotropy of this turbulent space was then assessed. The instrument and processes developed were also applied in the field to studies of an ambient turbulent field. Measurements of turbulence strength made in this way were compared to results from a commercial scintillometer.

The second line of research was field based. It involved the assessment of a range of observable features of the effects of turbulent air masses upon visible imagery. These features included analysis of the apparent motion of an incoherent light source and features of the scene. These observable effects were assessed along a horizontal path 1.5 m above the ground for their ability to infer the strength of the turbulent air mass through which the radiation had passed.

The third line of research involved the development of an understanding of the impact of specific local meteorological parameters on the strength of turbulence. A major outcome from over one hundred days of data was the development of an empirical model of turbulence strength that improves upon previous models from the literature.

The merits and shortcomings of each of these approaches to the characterisation of atmospheric turbulence conditions are compared. Ultimately, the ability to use imagery sequences acquired through turbulence, the temperature structure function of a sample volume or an empirical model using meteorological parameters to determine the strength of that turbulence, were assessed. This information is a necessary first step in the development of techniques for the mitigation of turbulence-induced, image distortion.

Declaration

I confirm that this work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Raymond Oermann and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Contents

1	Introduction	1
1.1	Background	1
1.1.1	Motivation	2
1.1.2	Historical treatment	3
1.1.3	Descriptors of turbulence	4
1.1.4	Statistical measures of turbulence strength	5
1.1.5	Impact of turbulence on optical propagation	7
1.2	Structure of this thesis	11
1.2.1	The theory of turbulence measurement	11
1.2.2	Structure function	12
1.2.3	Angle of arrival fluctuations	13
1.2.4	Scintillation index	13
1.2.5	Predictive modelling	14
1.3	Review of methods	14
2	Theory	17
2.1	Introduction	17
2.2	Classical description of turbulence	18
2.3	Structure functions	23
2.4	Angle of arrival and the phase structure function	28

2.4.1	Mechanism of ray refraction	28
2.4.2	Phase structure function	29
2.4.3	Analysis of imagery data	31
2.4.4	Path weighting	32
2.5	Power spectral density of refractive index	33
2.6	Scintillation index	36
2.6.1	Modelling scintillation using the wave equation	37
2.6.2	Characterising turbulence using a scintillometer	39
3	The structure function	41
3.1	Background	41
3.2	Measurement of the structure function using a two-thermocouple system .	43
3.2.1	Introduction	43
3.2.2	Instrumentation	43
3.2.3	Data conditioning	49
3.2.4	Results	52
3.2.5	Temperature structure function	59
3.3	Measurement of the structure function using four thermocouples	65
3.3.1	Introduction	65
3.3.2	Offset and gain equalisation	66
3.3.3	Laboratory test	67
3.3.4	Temperature Structure Functions	67
3.3.5	Summary	72
3.4	Field measurement of the structure function	72
3.4.1	Introduction	72
3.4.2	Apparatus	73
3.4.3	Equalisation	73
3.4.4	Data collected	73

3.4.5	Temperature structure function derivation	78
3.4.6	Field test summary	82
3.5	Summary	83
4	Determination of C_n^2 from imagery	87
4.1	Introduction	87
4.2	Preliminary experiment	89
4.2.1	Location of the image of the lamp	91
4.2.2	Frame rate required	94
4.2.3	Number of samples required	96
4.2.4	Spectral analysis	97
4.2.5	Comparison of AoA and scintillometer C_n^2 values	100
4.3	Long-term experiment	102
4.3.1	Introduction	102
4.3.2	Instrumentation	102
4.3.3	Data collection schedule	105
4.3.4	Data	108
4.3.5	Treatment of error	113
4.3.6	AoA analysis using a lamp image	115
4.3.7	AoA analysis using edges in imagery	123
4.3.8	Spectral analysis	137
4.4	Summary	141
5	Scintillation index analysis	145
5.1	Introduction	145
5.2	Measuring scintillation index using a commercial scintillometer	147
5.2.1	System description	147
5.2.2	Scintillometer data	148

5.2.3	Analysis of scintillometer data	152
5.3	Scintillation index from imagery	158
5.3.1	Instrumentation	158
5.3.2	Data collected	159
5.3.3	Data analysis	161
5.3.4	Fluctuation distribution characterisation	164
5.3.5	Scintillation index image	165
5.4	Summary	169
6	Predictive modelling of C_n^2	171
6.1	Introduction	171
6.2	Data	172
6.3	Literature models	177
6.3.1	Model 1	179
6.3.2	Model 2	180
6.3.3	Model 3	181
6.3.4	Assessment of the “literature” models	182
6.3.5	Quantifying accuracy of predictions	186
6.3.6	Comparison of literature models	187
6.4	An improved model	188
6.4.1	Meteorological factors affecting turbulence strength	188
6.4.2	Multivariate analysis	202
6.4.3	Regression analysis	206
6.4.4	Bounds of variables	207
6.4.5	Assessment of improved models	207
6.5	Summary	211
7	Conclusion	213

7.1	Overview of achievements	213
7.2	Structure functions	214
7.3	Turbulence strength from imagery	216
7.4	Scintillation index	217
7.5	Empirical models	218
7.6	Comparison of methods	219
A	Scintillometer analysis methodology	221
B	LabView data acquisition virtual instrument	227
C	LabView video acquisition virtual instrument	229
D	Matlab thermocouple function	231
E	Frame rate determination for angle of arrival analysis	233
F	Determination of temporally resolved C_n^2	237
G	Imagery sequence summary file	241
H	Diurnal plots of angle of arrival derived C_n^2	245
I	Diurnal plots of model estimated C_n^2	289
J	Matlab modelling scripts	313

List of Figures

1.1	Observation of an object through the turbulent boundary layer [1].	2
2.1	The Richardson representation of the cascade of turbulence cells used by Richardson and Kolmogorov to develop the theory of the energy transport process in turbulence. As illustrated in the lower portion by the yellow cells, the energy cascades from larger scale sizes until it is ultimately dissipated into the environment by diffusion from the smallest scale sizes. The representation of the random arrangement of cells, as illustrated, does not represent the spatial distribution of turbulence cells or the dynamics which are under constant mixing, but aims to aid the visualisation of the refractive bending of a ray of light as it passes through the fluid.	21
2.2	An image of turbulent flow [2]. Notice that the turbulence does not manifest as discrete cells and that the scale sizes are not apparent. Structures of different sizes, however, can be identified	23
2.3	Plot of refractive index vs air temperature according to Whellon [3].	29
2.4	Tilt of the wavefront and subsequent displacement of the image at the focal plane.	30
2.5	Plot of the spatial power spectra as estimated by the Kolmogorov, Modified von Karman and Hill-Clifford models.	35
2.6	Plot of the ratio of the Hill-Clifford and Von Karman models of spatial power spectra.	36

3.1	FW05 thermocouple probe fitted with cold junction compensator.	44
3.2	Thermocouple output vs junction temperature plot for E-type thermocouple using three different computational methods. The tabular data was obtained from standard E-type thermocouple look up tables that can be found in Appendix D.	45
3.3	Plots of the power spectral density of the thermocouples above a 300°C hotplate (blue plot) and exposed to a high temperature and high speed heat gun (red plot). The knee in the lower temperature turbulent field at 60Hz is clearly evident and a line with a slope of $\frac{1}{f}$ is added for reference.	47
3.4	Schematic of the laboratory based two thermocouple temperature structure function measurement using the hotplate turbulence generator.	48
3.5	Experimental set-up showing the hotplate turbulence generator, two fine-wire thermocouple probes (mounted horizontally) and the micro-positioner. The two-channel signal conditioner is at the rear.	48
3.6	Two raw temperature acquisition using thermocouples spaced 1mm apart in the heated air stream illustrating the higher reading of thermocouple 2.	50
3.7	Difference between the un-corrected temperatures recorded by two co-located thermocouples in heated air stream illustrating an average offset of -2.28°C.	50
3.8	Corrected temperatures from the thermocouples spaced 1mm apart in the heated air stream illustrating the better agreement (linear correlation coefficient of 0.987) between the two thermocouples.	51
3.9	Difference between the corrected temperatures recorded by two co-located thermocouples in heated air stream illustrating a mean temperature difference of approximately 0°C.	51

3.10	Power spectral density of one thermocouple output channel. Notice the remnant spike at 50Hz due to induced pick-up and the $\frac{1}{f}$ noise beyond approximately 60Hz. The smoothing applied to the data reduced high frequency oscillations using a sliding window of only 20 samples. This had little impact upon the 50 Hz spike.	53
3.11	Plots characterising the raw temperature difference distributions. The 20000 temperature differences do not display a normal distribution.	54
3.12	Plots characterising the distribution of the logarithm of the temperature difference. The log of the 20000 temperature differences displays normal behaviour.	54
3.13	Plot of thermocouple temperatures and differences for a vertical separation of 1mm . Linear correlation is 0.99.	55
3.14	Plot of thermocouple temperatures and differences for a vertical separation of 5mm . Linear correlation is 0.90.	56
3.15	Plot of thermocouple temperatures and differences for a vertical separation of 10mm . Linear correlation is 0.73.	56
3.16	The linear correlation coefficient between two thermocouples in a horizontal configuration as a function of separation distance.	58
3.17	The linear correlation coefficient between two thermocouples in a vertical configuration as a function of separation distance.	58
3.18	Logarithmic plot of the temperature structure function at small spatial scales for the horizontal orientation. Quadratic and $\frac{2}{3}$ power law best fits are also plotted, yielding an estimate of the inner scale, l_0 of 5.2mm.	62
3.19	Linear plot of the measured temperature structure function versus probe separation for the horizontal orientation. The curves of best fit obtained from Figure 3.18 are also plotted.	62

3.20	Logarithmic plot of the temperature structure function at small spatial scales for the vertical orientation. Quadratic and $\frac{2}{3}$ power law best fits are also plotted, yielding an estimate of the inner scale, l_0 of 6.3mm.	63
3.21	Linear plot of the temperature structure function versus probe separation for the vertical orientation. The curves of best fit obtained from Figure 3.20 are also plotted.	63
3.22	Four-thermocouple set-up showing the four thermocouple probes, the bracket and the hotplate on the left.	66
3.23	A logarithmic plot of the horizontal temperature structure function 62 mm above a 250°C hotplate. The red dots show the ten measured values with the mean value indicated by the blue dot with error bars showing one standard deviation either side of this mean for the ten readings. The $\frac{2}{3}$ power law temperature structure function is indicated by the green line. . .	69
3.24	Logarithmic plots of the horizontal temperature structure function 62 mm above a hotplate at a range of temperatures. The red dots show the ten measured values with the mean value indicated by the blue dot with error bars showing one standard deviation either side of this mean for the ten readings. The $\frac{2}{3}$ power law temperature structure function is indicated by the green line.	70
3.25	Logarithmic plot of the temperature structure parameter, C_T^2 (red plot) as a function of the hotplate temperature and fitted exponential functions. . .	71
3.26	Aerial view of the DSTO laser range showing the 700 m optical path and the site of the localised temperature structure function measurement. The fetch of the measuring site is also shown as low grassland with no major obstructions for over 200 m. The various colourations of the bare surface at the time this photograph was taken were not present at the time of my field experiments where short grass covered the entire area.	74

3.27	Weather parameters for 11 th September 2012 spanning the period of the experiment. All green plots are temperatures, with the coincident plots corresponding to the air temperatures at various heights. The green dashed line shows the ground temperature.	75
3.28	Linear plot of the refractive index structure parameter as measured by the BLS900 scintillometer for 20 th December 2013 during the field experiment. The collection times of the different configurations or series are illustrated by coloured bands at the top of the plot.	76
3.29	Illustration of the three configurations established for the field test showing different orientations with respect to the ground and the wind direction. . .	77
3.30	The averaged temperature structure function $\mathcal{D}_T(\rho)$, in the vertical configuration, from 20 Series-1 acquisitions. The dotted black line indicates the best two-thirds power law fit and the dotted magenta line a quadratic power law.	78
3.31	The averaged temperature structure function $\mathcal{D}_T(\rho)$, in the horizontal - aligned configuration, from 50 Series-2 acquisitions. The dotted black line indicates the best two-thirds power law fit and the dotted magenta line a quadratic power law.	79
3.32	The averaged temperature structure function $\mathcal{D}_T(\rho)$, in the horizontal - transverse configuration, from 20 Series-3 acquisitions. The dotted black line indicates the best two-thirds power law fit and the dotted magenta line a quadratic power law.	79

3.33	Temporal plot of BLS900 measured C_T^2 (red plot) and structure function estimates of C_T^2 , during three different orientation measurements broken up into nine separate five minute segments. Series-1 two red markers (*), series-2 five green markers and series-3 two blue markers. The vertical bar on the marker indicates the standard deviation in the mean value over this five minute segment.	80
3.34	Scatter Plot comparing Structure Function estimated C_n^2 to that measured by the path integrating BLS900.	82
4.1	Schematic of the preliminary angle of arrival experiment over 1500m. . . .	89
4.2	Single frame within an image sequence of the lamp at 1500 m.	90
4.3	Effect of threshold percentage on centroid position.	92
4.4	Location of the centroid of the blob in all 42000 frames of the 60 s image sequence (700 fps). The variance of the centroid's spatial fluctuation in pixel space is given on the respective axes labels.	93
4.5	Location of the centroid of the blob in a 5 s subset of the original 60 s image sequence.	93
4.6	Calculated values of the variance of angle of arrival fluctuations in the horizontal direction with increasing sampling rates and subsequently increasing sample lengths.	95
4.7	Calculated values of the variance of angle of arrival fluctuations in the vertical direction with increasing sampling rates and subsequently increasing sample lengths.	95
4.8	Temporal sequence of turbulence strength as indicated by the variances of angle of arrival fluctuations using a bin size of 200 ms yielding 50 values in 10 s.	97
4.9	Power Spectral Density of the lamp centroid fluctuations in the X (horizontal) direction for run 04 sampled at 700 fps	99

4.10	Power Spectral Density of the lamp centroid fluctuations in the Y (vertical) direction for run 04 sampled at 700 fps	99
4.11	Comparison of Horizontal and Vertical Angle of Arrival derived C_n^2 values with scintillometer derived values. A similar comparative plot is given in the long-term experiment as Figure 4.24	101
4.12	HOBO U30 weather station.	103
4.13	Camera coupling to the Maksukov-Cassegrain telescope.	105
4.14	Weather parameters for 16 th December 2010.	108
4.15	Diurnal plot of refractive index structure parameter measured by the BLS900 on 16 December 2010.	109
4.16	Diurnal plot of scintillation index measured by the BLS900 on 16 December 2010.	110
4.17	Diurnal plot of temperature structure parameter measured by the BLS900 on 16 December 2010.	110
4.18	Frame number 51 from the image sequence collected at 0830 on 16 th Dec 2010.	112
4.19	Scatter plot of the centroid of each frame in the 1002 frame sequence collected between 8:30:53 and 8:31:13 on 16 th Dec 2010.	112
4.20	Diurnal plot of C_n^2 estimates from horizontal and vertical lamp centroid variances on 22 nd September 2010.	119
4.21	Diurnal plot of C_n^2 estimates from horizontal and vertical lamp centroid variances on 17 th November 2010.	119
4.22	Diurnal plot of C_n^2 estimates from horizontal and vertical lamp centroid variances on 16 th December 2010.	120
4.23	Diurnal plot of C_n^2 estimates from horizontal and vertical lamp centroid variances on 18 th December 2010.	120

4.24	Scatter plot of C_n^2 estimates from horizontal (red markers) and vertical (blue markers) lamp centroid variances compared to the BLS900 measured values in the night time period on 22 nd September 2010, 17 th November 2010, 16 th December 2010 and 18 th December 2010. This comparison takes the same form as that presented in Figure 4.11.	122
4.25	Single frame from the 07:06 image sequence acquired on 21 st September 2010 showing the row passing through the vertical edge on the left side of the hut opening.	125
4.26	Waterfall plot for row number 310 in the 7:06 AM image sequence on 21 st September 2010.	126
4.27	Waterfall plot for the 9:06 AM image sequence on 21 st September 2010. . .	127
4.28	Waterfall plot for the 11:06 AM image sequence on 21 st September 2010. .	127
4.29	Waterfall plot for the 1:06 PM image sequence on 21 st September 2010. . .	128
4.30	Waterfall plot for the 4:06 PM image sequence on 21 st September 2010. . .	128
4.31	Typical plots of pixel intensity along the line passing through the edge. The horizontal blurring of the edge can clearly be seen. The 25 pixels before and after the edge are indicated together with the midpoint between these two intensities. The defined location of the edge is constructed	133
4.32	Horizontal fluctuations in the position of the vertical edge relative to its mean position determined to be column 313.5. The horizontal lamp variance was impacted by high local brightness at that time, which reduced its variance	133
4.33	Diurnal plot of C_n^2 estimates from horizontal and vertical edge variances on 21 st September 2010.	134
4.34	Diurnal plot of C_n^2 estimates from horizontal and vertical edge variances on 23 rd September 2010.	134

4.35	Diurnal plot of C_n^2 estimates from horizontal and vertical edge variances on 16 th December 2010.	135
4.36	Diurnal plot of C_n^2 estimates from horizontal and vertical edge variances on 17 th December 2010.	135
4.37	Scatter plot of C_n^2 estimates from horizontal (red markers) and vertical (blue markers) edge motion variances compared to the BLS900 measured values on 21 st September 2010, 23 rd September 2010, 16 th December 2010 and 17 th December 2010. Notice the “roll off” at values in excess of $4 \times 10^{-13} m^{-2/3}$	136
4.38	Power spectral density of the horizontal fluctuations of the left side vertical edge. Notice the high frequency end is limited by the Nyquist limit of 25 Hz (half the 50 Hz frame rate) and the 10 s sample enabled a frequency resolution of 0.1 Hz to be examined.	138
4.39	Horizontal and Vertical waterfall plots corresponding to the last frame captured at 11:06 AM on 21 September 2010	139
4.40	A comparison between the vertical variance of a horizontal edge and the horizontal variance of a vertical edge for assessing isotropicity on 21 st September 2010.	140
5.1	Scintec BLS900 Scintillometer.	148
5.2	Scintillation index - daily variation 30 th October 2010.	150
5.3	Daily variation of temperature structure parameter, C_T^2 - 30 th October 2010.	150
5.4	Daily variation of refractive index structure parameter, C_n^2 (linear) - 30 th October 2010.	151
5.5	Daily variation of refractive index structure parameter, C_n^2 (logarithmic) - 30 th October 2010.	151

5.6	Logarithmic scatter plot of scintillation index vs. C_n^2 to verify the linear relationship between them. The clustering gives an indication of the spread of C_n^2 values for a given scintillation index and the discretization at low scintillation index values is due to the five decimal place accuracy $\Delta\sigma_I^2 = 0.00002$ with which the scintillation index values are saved.	154
5.7	Rytov method coefficient derived from the ratio of the scintillation index and C_n^2 together with radiation wavelength and path length. The almost constant value across the entire day's variations in turbulence strength is different from the coefficients from the literature owing, principally to the large aperture diameter enabling significant aperture averaging.	156
5.8	Rytov method coefficient derived from the ratio of the scintillation index and C_n^2 together with radiation wavelength and path length and including the receiver gain factor.	157
5.9	Telescope and CCD camera assembly.	159
5.10	Frame 250 of the 9:01 AM image sequence. The box merely highlights the location of the single pixel used at that time to collect scintillation data.	160
5.11	Frame 251 of the 9:01 AM image sequence.	160
5.12	Intensity fluctuations from pixel position (488,168). Notice that during this sequence, this pixel saturated at 255 digital levels since the image only has an 8 bit dynamic range. The variance of pixels that saturate at some time during the sequence is lower than that of pixels that do not saturate. This explains the "donut" appearance of the lamp in many scintillation index images where the centre pixels of the lamp have been saturated during the sequence.	162
5.13	Power Spectral Density of the intensity fluctuations from pixel position (488,168).	163
5.14	Normal probability plot of intensity fluctuations from pixel position (488,168).	164

5.15	Normal probability plot of the log of intensity fluctuations from pixel position (488,168).	165
5.16	Scintillation index image from the 9:01 AM image sequence.	166
5.17	Scintillation index image from the 11:01 AM image sequence.	166
5.18	Diurnal Scintillation index plot for 17 th November 2010. The black plot is the measured value from the BLS900. The blue plot is derived from the maximum value of scintillation index image in the vicinity of the lamp and the red plot is the scintillation index from the same pixel throughout the day. The impact of the camera's AGC during the low light (night time) periods. The time axis is simply the index of the daily sample with one sample collected every ten minutes. There were 144 samples collected from mid-night to midnight. Time index 72 corresponds to midday.	168
6.1	Plot of the weather data recorded by the HOBO weather station on 14 th February 2010. The red horizontal lines indicate the required bounds of each parameter for all models.	174
6.2	Linear plot of typical diurnal variations in C_n^2	175
6.3	Logarithmic plot of typical diurnal variations in C_n^2	176
6.4	Diurnal weighting function used in models 1, 2 and 3.	178
6.5	Diurnal variations in C_n^2 with Model 2 output and with two height corrections applied.	179
6.6	Model 1 prediction of C_n^2 for 14 th February 2010 with no height scaling (black), $-\frac{2}{3}$ (green) and $-\frac{4}{3}$ (magenta) height scaling. C_n^2 measured by the BLS900 scintillometer is plotted in red. The steps in the plot at 0 and 12 solar hours are due to the separate night time and daytime components of the model.	184

6.7	Model 2 adjusted prediction of C_n^2 for 14 th February 2010 with no height scaling (black), $-\frac{2}{3}$ (green) and $-\frac{4}{3}$ (magenta) height scaling. C_n^2 measured by the BLS900 scintillometer is plotted in red. At night time the model still returns negative C_n^2 values.	185
6.8	Model 3 adjusted prediction of C_n^2 for 14 th February 2010 with no height scaling (black), $-\frac{2}{3}$ (green) and $-\frac{4}{3}$ (magenta) height scaling. C_n^2 measured by the BLS900 scintillometer is also plotted in red.	185
6.9	Scatter plot of the solar flux that yields the given value of C_n^2 . The blue points indicate the range of values for solar flux that result in a given turbulence strength. The roughly linear relationship for the majority of the point plotted is illustrated more clearly in Figure 6.10.	192
6.10	Plot of the mean value of solar flux (red markers) that, in conjunction with other environmental factors, yields the given value of C_n^2 . The horizontal error bars shown in blue are derived from one standard deviation either side of the mean. The data obeys two different power laws changing at around $2.5 \times 10^{-13}m^{-2/3}$	193
6.11	Plot of the mean value (red markers) of temperature difference values between the ground and air at 1.5 m height that, in conjunction with other environmental factors, yields the given value of C_n^2 . The blue horizontal error bars are derived from one standard deviation either side of the mean.	194
6.12	Plot of the mean value (red markers) of temperature difference values between the air at 1 m and the air at 2 m height that, in conjunction with other environmental factors, yields the given value of C_n^2 . The blue horizontal error bars are derived from one standard deviation either side of the mean.	194

6.13	Plot of the mean value (red markers) of relative humidity that, in conjunction with other environmental factors, yields the given value of C_n^2 . The blue horizontal error bars are derived from one standard deviation either side of the mean.	195
6.14	Plot of the mean value (red markers) of wind speed that, in conjunction with other environmental factors, yields the given value of C_n^2 . The blue horizontal error bars are derived from one standard deviation either side of the mean.	195
6.15	Plot of the mean value (red markers) of air temperature at 1.5m that, in conjunction with other environmental factors, yields the given value of C_n^2 . The blue horizontal error bars are derived from one standard deviation either side of the mean.	196
6.16	Plot of the mean values of solar flux (red markers) showing the blue lines of best fit (R-squared = 0.97 and 0.99) to the data and slopes of 0.90 ± 0.06 and 1.91 ± 0.03 respectively.	198
6.17	Plot of the mean values of temperature difference (red markers) showing the blue line of best fit (R-squared = 0.95) to the data and slope of 2.57 ± 0.09	198
6.18	Plot of the mean value of temperature difference between air at 1 m and the air at 2 m (red markers) showing the blue line of best fit (R-squared = 0.99) to the data and slope of 2.46 ± 0.03	199
6.19	Plot of the mean value of relative humidity (red markers) showing the blue line of best fit (R-squared = 0.96) to the data and slope of -7.19 ± 0.20 . Notice the negative slope indicates the inverse relationship between Relative Humidity and C_n^2	199

6.20	Plot of the mean value of wind speed (red markers). The data obeys two different power laws changing at around $2.5 \times 10^{-13}m^{-2/3}$ or a wind speed of 3 m.s^{-1} . The plot shows the blue lines of best fit (R-squared = 0.65 and 0.53) to the data and slopes of 3.11 ± 0.72 and 9.41 ± 1.47 respectively.	200
6.21	Plot of the mean value of air temperature at 1.5m (red markers). The data obeys two different power laws changing at around $4 \times 10^{-13}m^{-2/3}$ or a temperature of 26°C . The plot shows the blue lines of best fit (R-squared = 0.94 and 0.66) to the data and slopes of 10.36 ± 0.65 and 14.21 ± 1.87 respectively.	200
6.22	3D scatter plot of TDiff, SF, Cn2.	203
6.23	2D scatter plot of SF vs ΔT_{gnd}	203
6.24	2D scatter plot of C_n^2 vs SF.	204
6.25	2D scatter plot of C_n^2 vs ΔT_{gnd}	204
6.26	2D scatter plot of C_n^2 vs ΔT_{gnd} - Night.	205
6.27	2D scatter plot of C_n^2 vs WS - Night.	205
6.28	$\chi_{reduced}^2$ for the daytime ($0 < \text{solar hour} < 12$) estimates of C_n^2 for sixty days. The red markers indicate the $\chi_{reduced}^2$ from the new model and the blue markers for the model 3 estimates.	208
6.29	All model estimates of C_n^2 and actual measurement (black) on 3 rd February 2010.	209
6.30	All model estimates of C_n^2 and actual measurement (black) on 10 th February 2010.	209
6.31	All model estimates of C_n^2 and actual measurement (black) on 22 nd December 2010.	210
6.32	All model estimates of C_n^2 and actual measurement (black) on 22 nd February 2012.	210

B.1	National Instruments LabView Virtual Instrument to collect thermocouple output	228
C.1	National Instruments LabView Virtual Instrument to collect image sequences	230
E.1	Temporal plot of the refractive index structure parameter calculated in a 200 ms bin from data sampled at 700 fps.	234
E.2	Temporal plot of the refractive index structure parameter calculated in a 200 ms bin from data re-sampled at 350 fps.	234
E.3	Temporal plot of the refractive index structure parameter calculated in a 200 ms bin from data re-sampled at 100 fps.	235
E.4	Temporal plot of the refractive index structure parameter calculated in a 200 ms bin from data re-sampled at 50 fps.	235
E.5	Summary plot of the refractive index structure parameters calculated for all re-sampled frame rates in the X direction.	236
E.6	Summary plot of the refractive index structure parameters calculated for all re-sampled frame rates in the Y direction.	236
F.1	Temporal plot of the refractive index structure parameter calculated from bins of 5 s duration and sampled at 50 fps.	238
F.2	Temporal plot of the refractive index structure parameter calculated from bins of 1 s duration and sampled at 50 fps.	238
F.3	Temporal plot of the refractive index structure parameter calculated from bins of 0.5 s duration and sampled at 50 fps.	239
F.4	Temporal plot of the refractive index structure parameter calculated from bins of 0.2 s duration and sampled at 50 fps.	239
H.1	Lamp and edge determined values of C_n^2 for 20100921	247
H.2	Lamp derived scatter plot for 20100921	248
H.3	Edge derived scatter plot for 20100921	248

H.4	Meteorological parameters for 20100921	249
H.5	Lamp and edge determined values of C_n^2 for 20100922	250
H.6	Lamp derived scatter plot for 20100922	251
H.7	Edge derived scatter plot for 20100922	251
H.8	Meteorological parameters for 20100922	252
H.9	Lamp and edge determined values of C_n^2 for 20100923	253
H.10	Lamp derived scatter plot for 20100923	254
H.11	Edge derived scatter plot for 20100923	254
H.12	Meteorological parameters for 20100923	255
H.13	Lamp and edge determined values of C_n^2 for 20101023	256
H.14	Lamp derived scatter plot for 20101023	257
H.15	Edge derived scatter plot for 20101023	257
H.16	Meteorological parameters for 20101023	258
H.17	Lamp and edge determined values of C_n^2 for 20101024	259
H.18	Lamp derived scatter plot for 20101024	260
H.19	Edge derived scatter plot for 20101024	260
H.20	Meteorological parameters for 20101024	261
H.21	Lamp and edge determined values of C_n^2 for 20101030	262
H.22	Lamp derived scatter plot for 20101030	263
H.23	Edge derived scatter plot for 20101030	263
H.24	Meteorological parameters for 20101030	264
H.25	Lamp and edge determined values of C_n^2 for 20101031	265
H.26	Lamp derived scatter plot for 20101031	266
H.27	Edge derived scatter plot for 20101031	266
H.28	Meteorological parameters for 20101031	267
H.29	Lamp and edge determined values of C_n^2 for 20101116	268
H.30	Lamp derived scatter plot for 20101116	269

H.31 Edge derived scatter plot for 20101116	269
H.32 Meteorological parameters for 20101116	270
H.33 Lamp and edge determined values of C_n^2 for 20101117	271
H.34 Lamp derived scatter plot for 20101117	272
H.35 Edge derived scatter plot for 20101117	272
H.36 Meteorological parameters for 20101117	273
H.37 Lamp and edge determined values of C_n^2 for 20101215	274
H.38 Lamp derived scatter plot for 20101215	275
H.39 Edge derived scatter plot for 20101215	275
H.40 Meteorological parameters for 20101215	276
H.41 Lamp and edge determined values of C_n^2 for 20101216	277
H.42 Lamp derived scatter plot for 20101216	278
H.43 Edge derived scatter plot for 20101216	278
H.44 Meteorological parameters for 20101216	279
H.45 Lamp and edge determined values of C_n^2 for 20101217	280
H.46 Lamp derived scatter plot for 20101217	281
H.47 Edge derived scatter plot for 20101217	281
H.48 Meteorological parameters for 20101217	282
H.49 Lamp and edge determined values of C_n^2 for 20101218	283
H.50 Lamp derived scatter plot for 20101218	284
H.51 Edge derived scatter plot for 20101218	284
H.52 Meteorological parameters for 20101218	285
H.53 Lamp and edge determined values of C_n^2 for 20101219	286
H.54 Lamp derived scatter plot for 20101219	287
H.55 Edge derived scatter plot for 20101219	287
H.56 Meteorological parameters for 20101219	288
I.1 Daily met parameters and model limits for 1 February 2010	292

I.2	Whole day Model comparison - linear	293
I.3	Whole day Model comparison - logarithmic	293
I.4	Daily met parameters and model limits for 2 February 2010	294
I.5	Whole day Model comparison - linear	295
I.6	Whole day Model comparison - logarithmic	295
I.7	Daily met parameters and model limits for 4 February 2010	296
I.8	Whole day Model comparison - linear	297
I.9	Whole day Model comparison - logarithmic	297
I.10	Daily met parameters and model limits for 14 February 2010	298
I.11	Whole day Model comparison - linear	299
I.12	Whole day Model comparison - logarithmic	299
I.13	Daily met parameters and model limits for 22 December 2010	300
I.14	Whole day Model comparison - linear	301
I.15	Whole day Model comparison - logarithmic	301
I.16	Daily met parameters and model limits for 25 December 2010	302
I.17	Whole day Model comparison - linear	303
I.18	Whole day Model comparison - logarithmic	303
I.19	Daily met parameters and model limits for 26 February 2012	304
I.20	Whole day Model comparison - linear	305
I.21	Whole day Model comparison - logarithmic	305
I.22	Daily met parameters and model limits for 16 March 2012	306
I.23	Whole day Model comparison - linear	307
I.24	Whole day Model comparison - logarithmic	307
I.25	Daily met parameters and model limits for 25 March 2012	308
I.26	Whole day Model comparison - linear	309
I.27	Whole day Model comparison - logarithmic	309
I.28	Daily met parameters and model limits for 27 March 2012	310

I.29	Whole day Model comparison - linear	311
I.30	Whole day Model comparison - logarithmic	311

List of Tables

2.1	Constants for the phase structure function for different wave-fronts assuming a Kolmogorov spatial power spectrum [4].	31
3.1	Thermocouple separations. Separations shown in red are less than the inner scale and were used to estimate the quadratic portion of the structure function. Separations shown in blue are within the inertial sub-range and were used to determine the temperature structure parameter, C_T^2	52
3.2	Table of the Gaussian coefficients that best fit the correlation functions given in Figures 3.16 and 3.17.	57
3.3	Equalisation constants (gain and offset) of the four thermocouples related to Channel 1, which was assumed to be reading the correct ambient temperature.	67
3.4	Table of mean values of the square of the temperature differences for each of the ten acquisitions above a 250°C hotplate. The mean and standard deviation for each separation is also given and the data represented graphically in Figure 3.23.	68
3.5	C_T^2 and C_n^2 derived from the four-thermocouple array for a set of hotplate temperatures.	71
3.6	Equalisation constants (gain and offset) from the equalisation processes prior to and after the field experiment using the four-thermocouple array. .	74
3.7	Acquisition details for the field temperature structure function measurement	76

3.8	Results of the measurement of C_T^2 and C_n^2 using the four thermocouple assembly compared to the 700 m path integrated value from the BLS900 scintillometer. The $\langle \dots \rangle$ brackets signifies the average value for that series.	81
4.1	High frame rate angle of arrival experiment schedule conducted on 24 th April 2008.	90
4.2	Slopes of the power Spectral Density plots in the regions either side of the “knee” that is indicative of a change in spatio-temporal characteristics of the turbulent field.	100
4.3	Schedule of scintillometer, weather station and imagery collections.	107
4.4	Data acquisition details of imagery collections.	107
4.5	Parameters and data saved for each video sequence file in the daily summary.	117
4.6	Pearson product-moment correlation coefficient quality of fit data for lamp centroid derived C_n^2 compared to the BLS900 scintillometer at different periods within the day.	122
4.7	Pearson product-moment correlation coefficient quality of fit for edge derived C_n^2 compared to the BLS900 scintillometer during the day-time.	132
5.1	Table of turbulence parameters calculated by the BLS900	147
6.1	Table of fitted parameters for each of the empirical models.	182
6.2	Average of the χ^2 and $\chi_{reduced}^2$ measures of goodness of fit (GoF) for about 60 days collected every minute (over 85000 data points) from each model and height scaling factor. The red values indicate the best scaling model for a given Model and time of day.	187
6.3	Matrix of linear correlation coefficients for day time observations of meteorological parameters and turbulence strength for the period from 9th January 2010 till the 29th January 2010. This period comprised 28800 individual sets of meteorological and turbulence data	189

6.4	Matrix of linear correlation coefficients for night time observations of meteorological parameters and turbulence strength for the period from 9th January 2010 till the 29th January 2010. This period comprised 28800 individual sets of meteorological and turbulence data	190
6.5	Table of the χ^2 and $\chi_{reduced}^2$ measures of goodness of fit for model 3 and the new model averaged over sixty days of data.	207
H.1	Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	247
H.2	Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	250
H.3	Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	253
H.4	Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	256
H.5	Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	259
H.6	Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	262
H.7	Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	265
H.8	Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	268
H.9	Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	271
H.10	Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	274

H.11 Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	277
H.12 Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	280
H.13 Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	283
H.14 Linear correlation coefficient between edge and lamp determined C_n^2 with scintillometer measurements during different periods of the day.	286