

Developments in
Atmospheric Science 6

Developments in Atmospheric Science, 6

PHYSICAL PRINCIPLES OF MICRO-METEOROLOGICAL MEASUREMENTS

by

PETER SCHWERDTFEGER

*Professor of Meteorology,
The Flinders University of South Australia,
Bedford Park, S.A., Australia*



ELSEVIER SCIENTIFIC PUBLISHING COMPANY
Amsterdam - Oxford - New York 1976

Contents

Preface	V
CHAPTER 1. AIR TEMPERATURE AND SENSIBLE HEAT TRANSFER	1
1.1. Methods of temperature measurement.	1
1.2. Sources of error in temperature measurement.	2
1.3. Sensor thermal inertia	3
Experiment I. Thermal inertia of a thermometer	5
Experiment II. Measurement of the heat transfer coefficient for a plane surface	6
1.4. The effect of radiation on temperature sensors	7
Experiment III. Effect of radiation on shielded thermometers	10
1.5. Electrical resistance thermometers	11
Experiment IV. The dissipation of heat from a resistance thermometer	12
1.6. A ventilated shield for resistance thermometers.	16
CHAPTER 2. SOLAR AND TERRESTRIAL RADIATION.	19
2.1. Specific intensity and radiant flux density	19
2.2. Radiation scales	20
2.3. The fluxes of solar and terrestrial radiation.	21
Experiment V. The measurement of radiation by a thermometric method	22
2.4. Radiation instruments	23
Experiment VI. Calibration of a pyranometer against a pyrhelimeter	27
2.5. Lambert's or the Cosine Law	28
Experiment VII. Cosine response of a radiometer	29
2.6. Direct beam and diffuse calibrations for a radiometer.	29
Experiment VIII. Dependence of albedo on solar elevation	31
2.7. Radiation measurements over finite plane surfaces.	32
Experiment IX. Measurement of the albedo over finite surfaces	33
Experiment X. The measurement of long- and short-wave radiation fluxes	34
Experiment XI. A basic pyrhelimeter.	35
2.8. The extra-terrestrial solar flux	36
Experiment XII. Determination of the solar constant.	36
CHAPTER 3. AIR AND WATER VAPOUR PRESSURE.	39
3.1. Atmospheric pressure.	39
3.2. Liquid column barometers	40
Experiment XIII. A short water barometer.	41
3.3. Aneroid barometers.	44
Experiment XIV. The isothermal atmosphere	45
3.4. Atmospheric humidity	46
3.5. Parameters specifying humidity	46
3.6. The measurement of humidity	48
Experiment XV. Observation of the dew point	49
Experiment XVI. The hair hygrometer	50
3.7. Dry- and wet-bulb thermometry and the psychrometer.	50
Experiment XVII. The ventilated wet-bulb thermometer.	53
Experiment XVIII. Measurement of the Bowen ratio	54

CHAPTER 4. WIND VELOCITY AND TURBULENT TRANSFER	55
4.1. Methods of wind speed measurement	55
Experiment XIX. The comparison of anemometers	57
4.2. The wind velocity profile in the atmospheric boundary layer	59
Experiment XX. Observation of the mean wind profile.	61
Experiment XXI. The effect of obstructions on the wind profile	63
Experiment XXII. Determination of momentum transfer by the eddy correlation method.	63
4.3. The scale of turbulence.	65
Experiment XXIII. The time scale of turbulent fluctuations	67
4.4. Turbulent transfer.	67
Experiment XXIV. Turbulent transfer of heat and water vapour.	69
CHAPTER 5. GROUND TEMPERATURE AND HEAT CONDUCTION	73
5.1. Methods of ground temperature measurement.	74
5.2. Thermo-electric effects.	75
5.3. The theory of ground heat conduction	77
Experiment XXV. Determination of thermal diffusivity from temperature profile observation	81
Experiment XXVI. Diurnal temperature and heat flux waves in the ground . .	83
5.4. Heat flux meters	84
5.5. Thermopiles	85
Experiment XXVII. Calibration of a heat flux meter	86
Experiment XXVIII. Comparison of temperature and heat flux waves.	86
CHAPTER 6. ELECTRICAL ANALOGUE MODELLING OF THERMAL PROCESSES	89
6.1. Steady state heat conduction.	89
6.2. The performance of a heat flux meter	91
Experiment XXIX. Analysis of the steady state response of a heat flux meter — using conducting paper	92
6.3. Thermal diffusion	95
Experiment XXX. Modelling of temperature waves in the ground	96
6.4. Simulation of latent heat processes	97
Experiment XXXI. The growth of ice floating on water	99
6.5. Sensible heat transfer in the atmospheric boundary layer	101
6.6. Long-wave radiation transfer simulation.	105
Experiment XXXII. A micro-meteorological model	106
REFERENCES.	109
INDEX	111