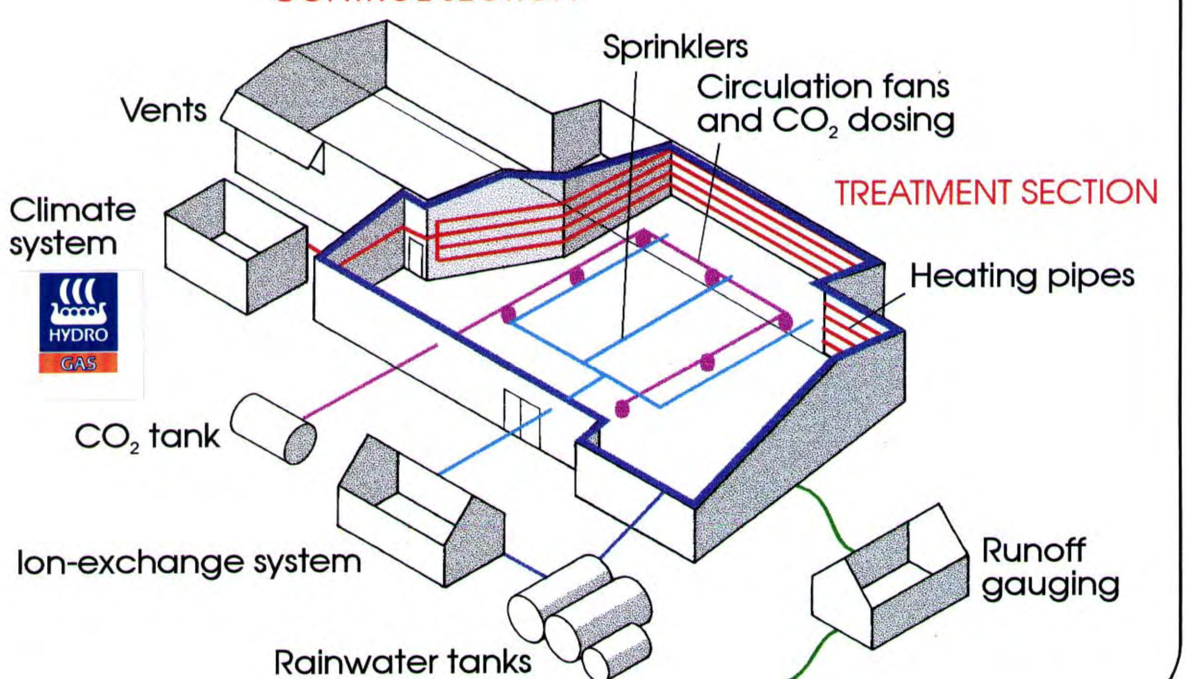
CLIMATE CHANGE RESEARCH

REPORT 5/1995

CLIMEX project: climate data for the first year of treatment

April 1994 - March 1995



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Abstract: Climate change treatment began in April 1994 at the 2 experimental catchments. At KIM CO_2 is increased (to 560 ppm) and air is heated (by 3° C in summer and 5° C in winter). At EGIL soil is heated. Except for an initial period of control problems the systems have functioned satisfactory during the first year of treatment. Meteorological and system data are recorded by several data loggers. The climate data has been organised in a CLIMEX data base.

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CLIMEX PROJECT

Climate data for first year of treatment April 1994 - March 1995

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Oslo, October 1995

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PREFACE

CLIMEX (Climate change experiment) is an interdisciplinary, international research project in which temperature and CO_2 concentrations are altered to whole forest catchment ecosystems. CLIMEX involves 7 institutions in 4 European countries. Financial support for CLIMEX during the period April 1994-May 1995 came from the European Commission, the Dutch Global Change Programme, the Research Council of Norway, the Norwegian Ministry of Environment, the National Environment Research Council (UK), Hydrogas Norge A/S, and the Norwegian Institute for Water Research.

CLIMEX project is a contribution to core research category 1 of the Global Change & Terrestrial Ecosystems (GCTE) core project under the International Geosphere-Biosphere Programme (IGBP).

INTRODUCTION

The CLIMEX project began in December 1992 using the former RAIN project facilities at Risdalsheia near Grimstad, Norway. CLIMEX treatments with increased CO_2 and increased air temperature (KIM-T) or increased soil temperature (EGIL-T) began in April 1994 (Table 1).

Table 1. *Overview of the 5 catchments at Risdalsheia included in the CLIMEX project. The first three were run by the RAIN project for 11 years (June 1983 - May 1994). RAIN treatment began in June 1984. CLIMEX treatment began in April 1994. KIM and EGIL were divided in April 1994 to an upper control section (KIM-C, EGIL-C, no climate change) and lower treatment section (KIM-T, EGIL-T, climate change).*

catchment	*area m^2*	*enclosure*	*rain quality*	*climate treatment*	*monitor start*
KIM	*860*	*roof*	*clean*	*CO_2+air warming*	*June 1983*
EGIL	*400*	*roof*	*acid*	*soil warming*	*June 1983*
ROLF	*220*	*no roof*	*acid*	*none*	*June 1983*
METTE	*650*	*no roof*	*acid*	*none*	*June 1993*
CECILIE	*380*	*no roof*	*acid*	*none*	*June 1993*

Data collection at Risdalsheia started in 1983. These data are compiled in:

January 1983 - November 1985: Wright et al. 1986. Acid Rain Research Report 10/1986.
November 1985 - December 1986: Wright. 1987. Acid Rain Research Report 13/1987.
December 1986 - December 1987: Wright. 1988. Acid Rain Research Report 16/1988.
December 1988 - August 1990: Wright. 1991. Acid Rain Research Report 24/1991.
June 1990 - May 1994: Wright. 1994. Acid Rain Reassert Report 36/94.

Acid Rain Research Reports are published by the Norwegian Institute for Water Research, Oslo, Norway.

A complete list of publications and reports from the RAIN and CLIMEX projects is given in Appendices 1 and 2.

A list of ongoing research activities within CLIMEX is given in Appendix 3.

We present here the major meteorological data for the first year of treatment April 1994 - March 1995, and the climate data base for CLIMEX.

TECHNICAL DESCRIPTION

KIM catchment: CO_2 and air warming

At KIM catchment (roof, clean rain) the existing structure was fitted with transparent air-tight walls and equipment for dosing CO_2 and heating the air (Figure 1). A transparent wall is installed across the uppermost part of the catchment such that the upper 20% of the catchment receives clean rain only and ambient CO_2 and temperature. This upper 20% serves as a control area for plant and soil studies.

CO_2 is added to the air at 6 points inside the treatment section. The target is 560 ppmv for all times when the temperature is above 4^{o}C and below 42^{o}C. CO_2 concentration is measured at 6 points via a central infra-red analyser located in the control hut. Maximum dosing rate is 55 kg hour^{-1} (1.3 tons day^{-1}). Total storage of CO_2 on site is 40 tons.

The air is warmed by means of a central heating system in which heated fluid is circulated through ranks of steel pipes mounted on the insides of the walls around the entire treated section. Temperature is monitored continuously at 6 points. The target for air warming is +5^{o}C above ambient in January and +3^{o}C in July with intermediate temperatures in the intervening months. The targets are averages for the 6 measurement points.

Mixing of the air within both the treated and control sections is accomplished by means of large fans (6 in treatment and 2 in control) hung from the roof. These have a maximum capacity of 1000 $m^3\ hr^{-1}$ and the speed is adjusted continuously to maintain an even temperature within each section. Ventilation (cooling) is achieved by means of ranks of windows mounted along the entire length of the 4 sides of the structure. These can be opened to an angle of up to 45^o.

Temperature and CO_2 dosing are automatically regulated by a climate computer. The computer doses CO_2 and regulates the electric furnace, degree of opening of the windows and speed of circulation fans to meet these criteria.

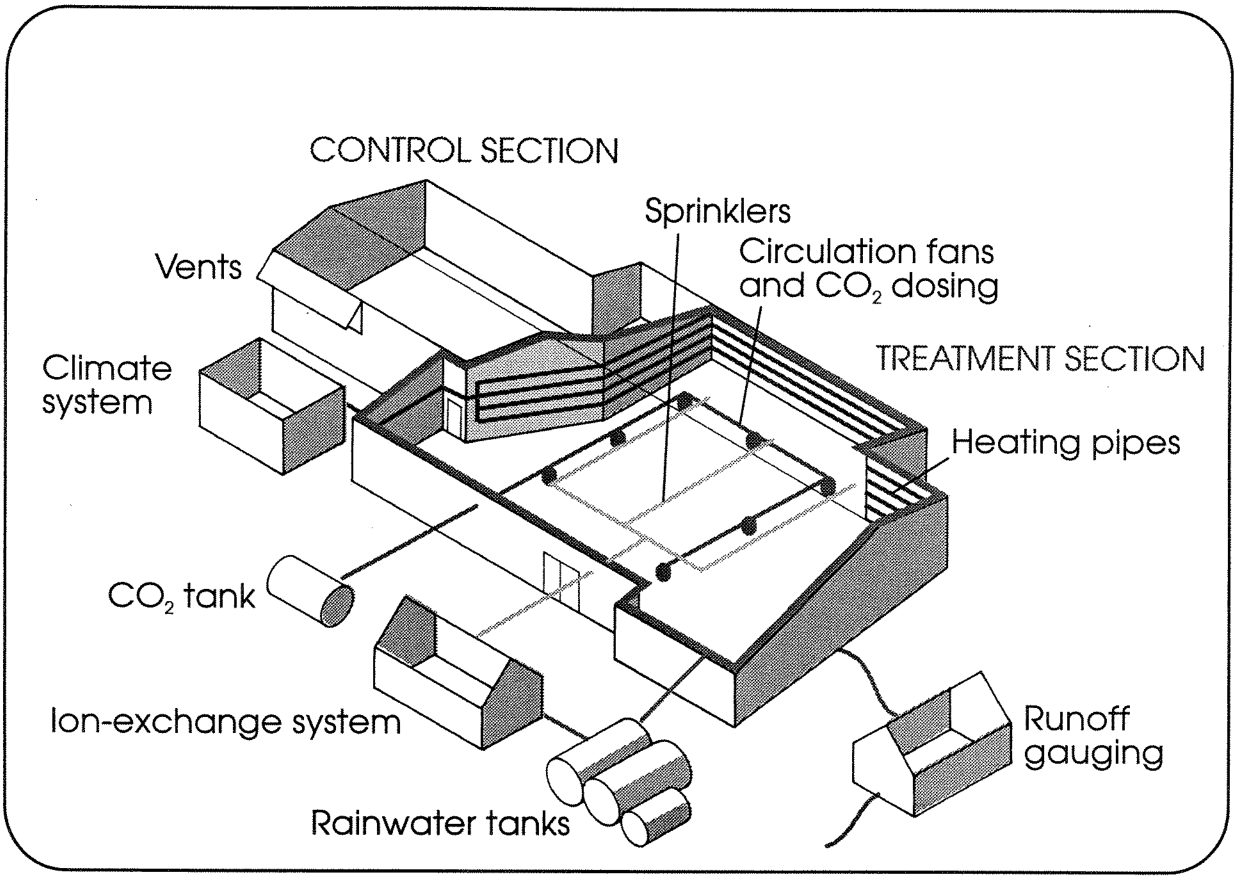

Figure 1. Schematic diagram of KIM catchment greenhouse

EGIL catchment: soil warming

Soil warming at EGIL catchment is accomplished by means of electric heating cables placed on the soil surface beneath the litter layer. The heating system consists of 2 independent networks, the heating cable power system and the measurement and control system. Installation was carried out with minimal disturbance to the soil. The cables are spaced approximately 10 cm apart and were installed in autumn 1993 and May 1994 in the treatment part of EGIL (lower 80%). The temperature is controlled using a total of 120 thermistors. The upper 20% of EGIL is left as an unheated control.

The experimental target for the soil warming is the same as at KIM catchment: +5^{o}C above ambient soil temperature in January and +3^{o}C in July, with intermediate temperatures in the intervening months.

CLIMATE DATA APRIL 1994 - APRIL 1995

KIM catchment. Heating and addition of CO_2 at KIM catchment began in April 1994. During the first year of treatment the system functioned satisfactorily except during the first few months (Figure 2a-c). Initial adjustments and running in of the system during the early summer resulted in somewhat higher temperatures in both KIM-T (treatment) and KIM-C (control) than targeted.

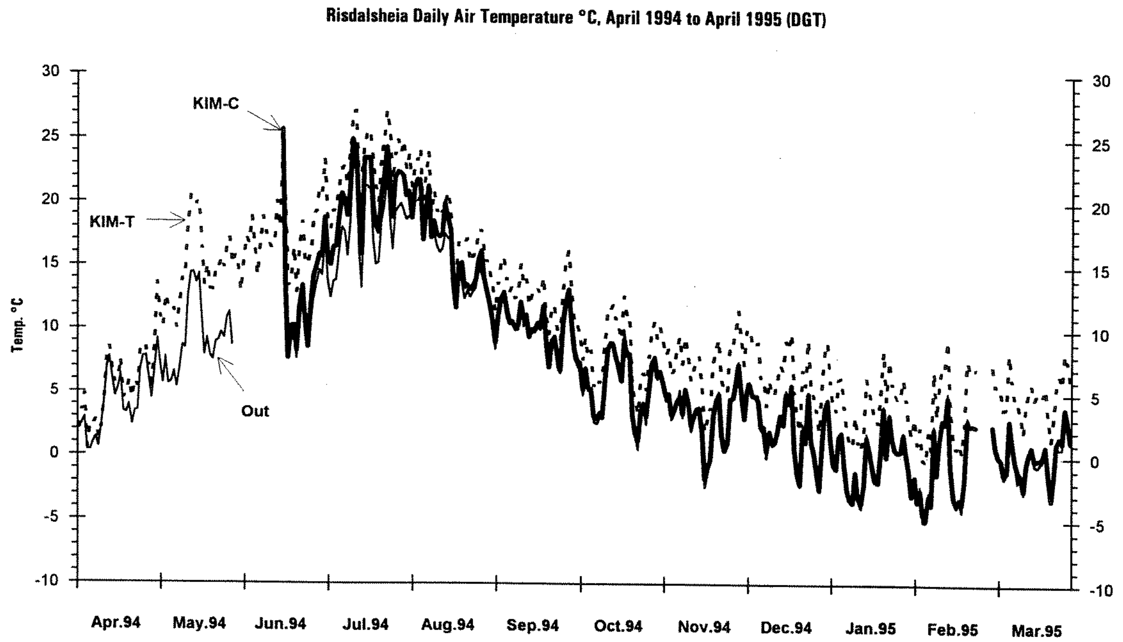

Figure 2a. Mean daily air temperature at KIM catchment (KIM T treatment; KIM C control; OUT outside) for the first year of treatment April 1994 - March 1995.

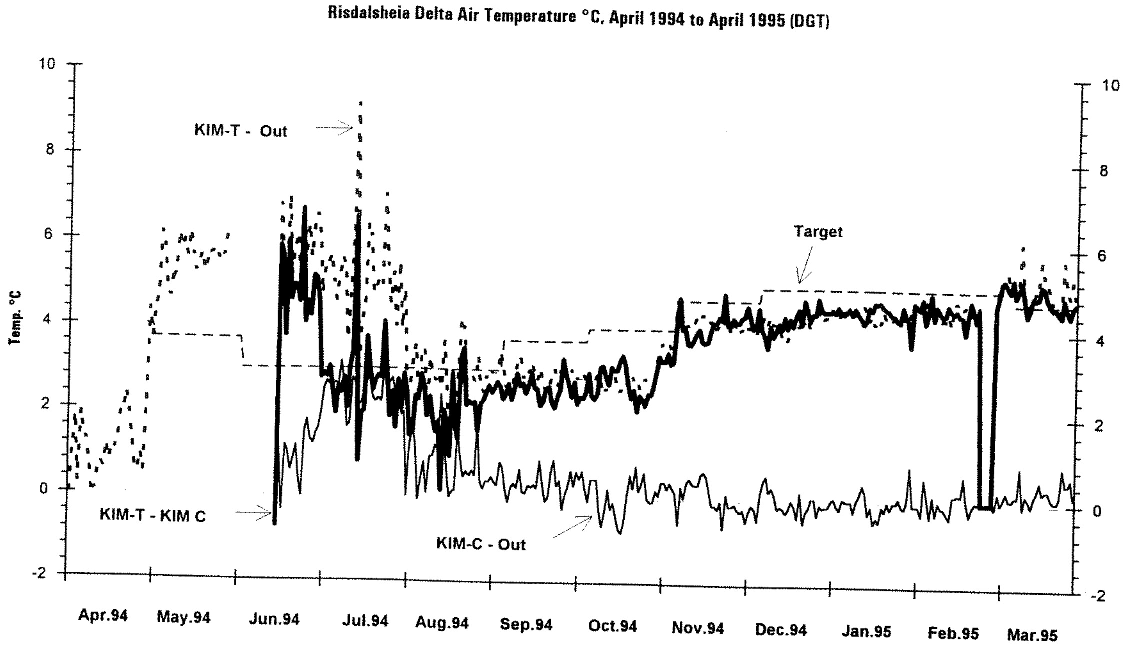

Figure 2b. Difference in mean daily air temperature at KIM catchment (KIM T treatment; KIM C control; OUT outside) and target values for the first year of treatment April 1994 - March 1995.

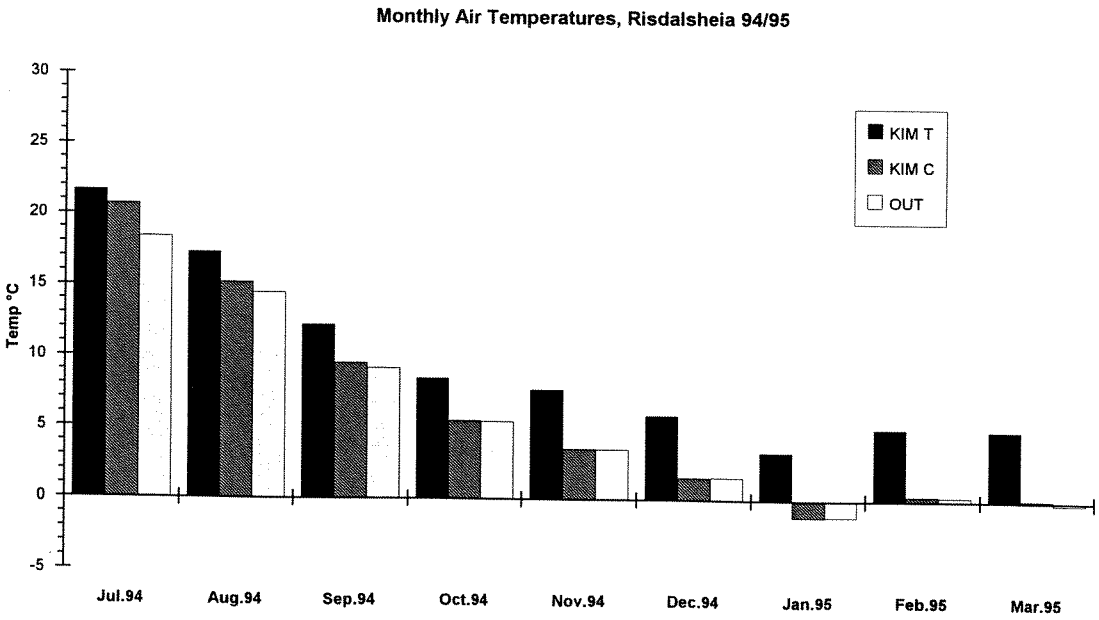

Figure 2c. Monthly mean air temperature at KIM catchment (KIM T treatment; KIM C control; OUT outside) for the first year of treatment April 1994 - March 1995.

During the first year of treatment there were significant difficulties in controlling the CO_2 concentrations (Figure 3). These difficulties consisted mainly of system overshoot due to the slow response time of the CO_2 monitor system. In August 1994 the system was modified and control of CO_2 concentrations improved. Dosing of CO_2 is conducted from 1 April to 31 October.

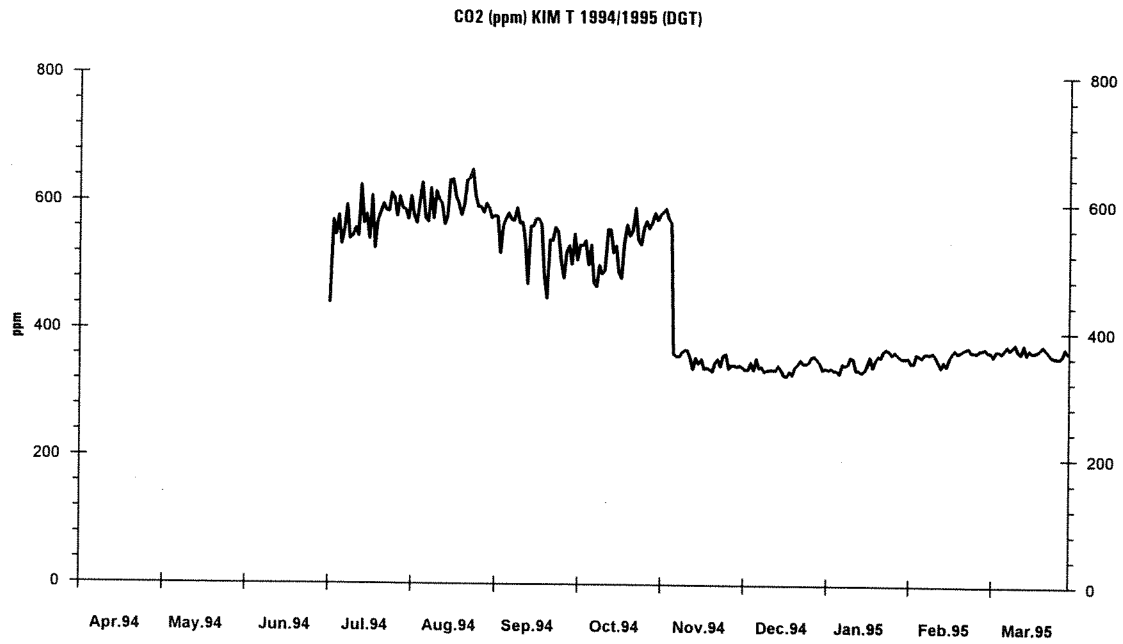

Figure 3. CO_2 concentrations in air at KIM-T during the first year of treatment April 1994-March 1995.

The experimental treatment affects relative humidity. The system is not regulated with respect to humidity. During the summer of the first year of treatment the relative humidity in KIM-T was somewhat higher than KIM-C and similar during the winter (Figure 4a-c).

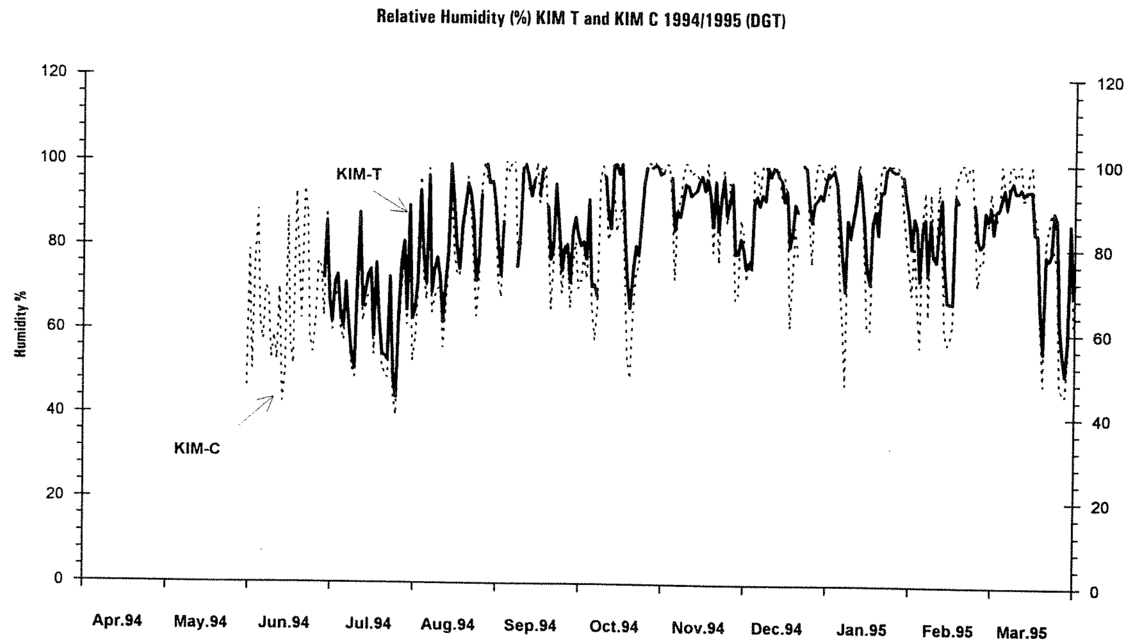

Figure 4a. Relative humidity at KIM catchment (KIM T treatment; KIM C control) for the first year of treatment April 1994 - March 1995.

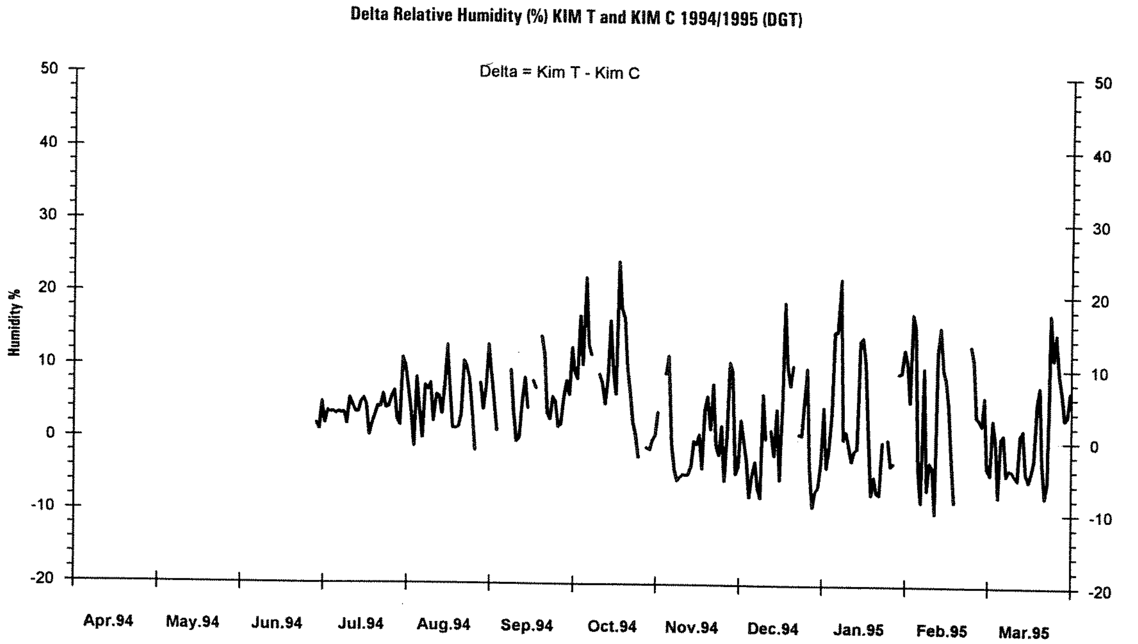

Figure 4b. Difference in relative humidity at KIM catchment (KIM T treatment; KIM C control) for the first year of treatment April 1994 - March 1995.

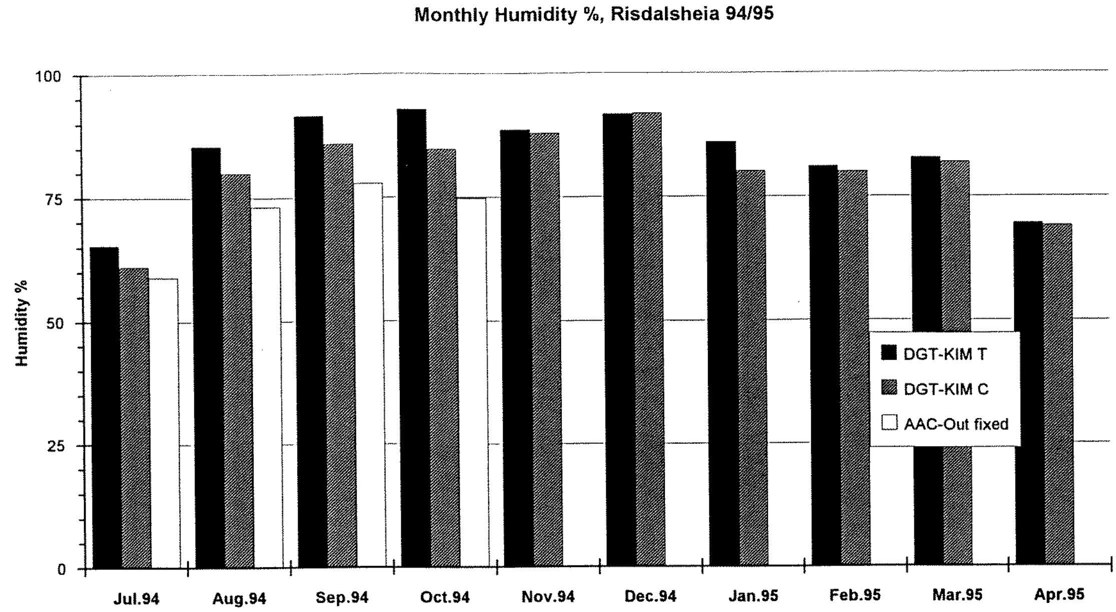

Figure 4c. Monthly mean humidity at KIM catchment (KIM T treatment; KIM C control) for the first year of treatment April 1994 - March 1995.

The experimental enclosure at KIM also modifies the light regime. Radiation measured by the LI-CORR sensor is reduced by about 50% under the roof (Figure 5a-b), in part due to shading by the structural elements, in part due to reflection from the roof surface and in part due to absorption by the plastic panels themselves.

In August 1995 the light adsorbance by the roof at KIM was measured over the range covering the photosynthetically active part of the spectrum (400 - 700 nm). A LICORR 1000 with indoor / outdoor quantum sensors was used. The spectrometer has a frequency range of 300 - 850 nm. Measurements are in $Wm^{-2}nm^{-1}$ (spectral radiance at a given wavelength, per unit wavelength interval). The measurements indicate that the greenhouse structure has a neutral density of 0.57 (Figure 6). Radiant energy (Wm^{-2}) is reduced by a factor of 3.7. Acceptable scans were obtained in early afternoon sunshine. Quantum measurements and partially compensated scans indicate that the results are representative for cloudy conditions as well.

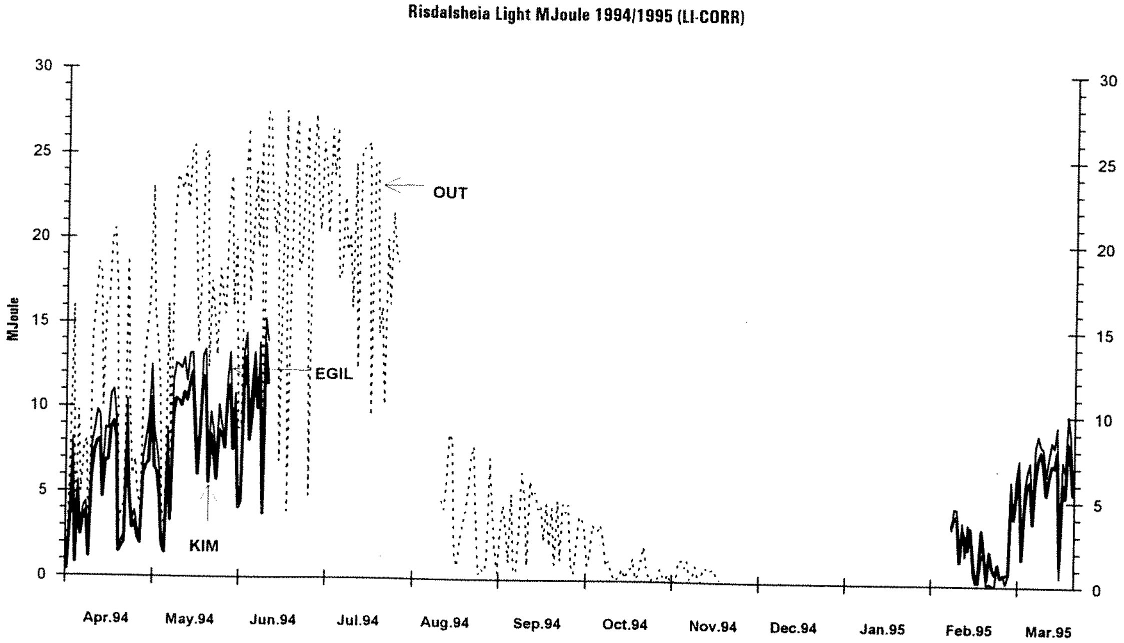

Figure 5a. Radiation measured at KIM catchment (KIM T treatment; KIM C control; OUT outside) for the first year of treatment April 1994 - March 1995.

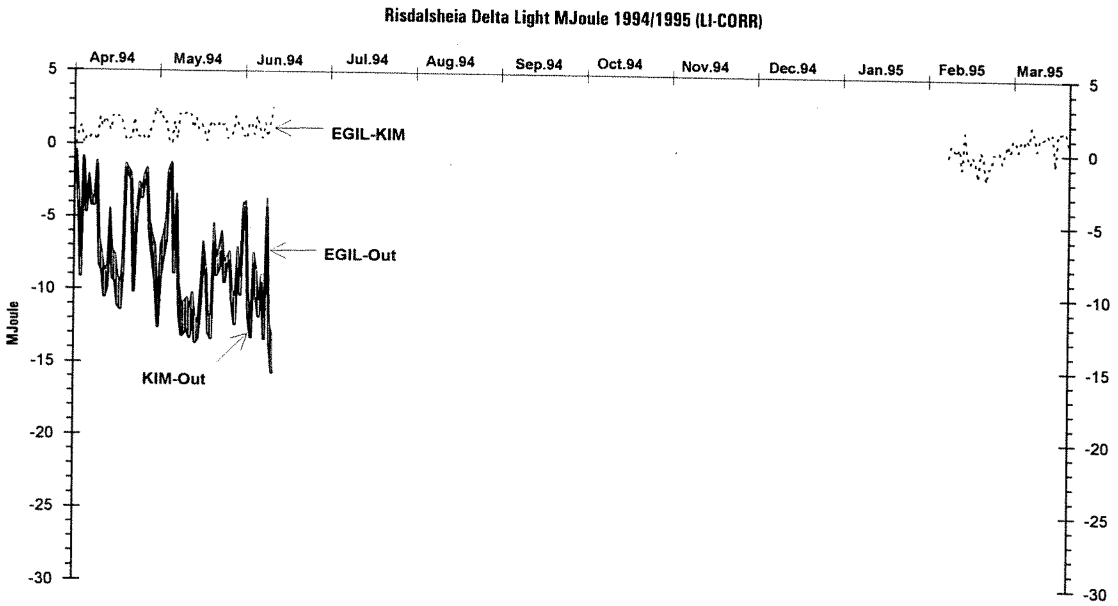

Figure 5b. Difference radiation at KIM catchment (KIM T treatment; KIM C control; OUT outside) for the first year of treatment April 1994 - March 1995.

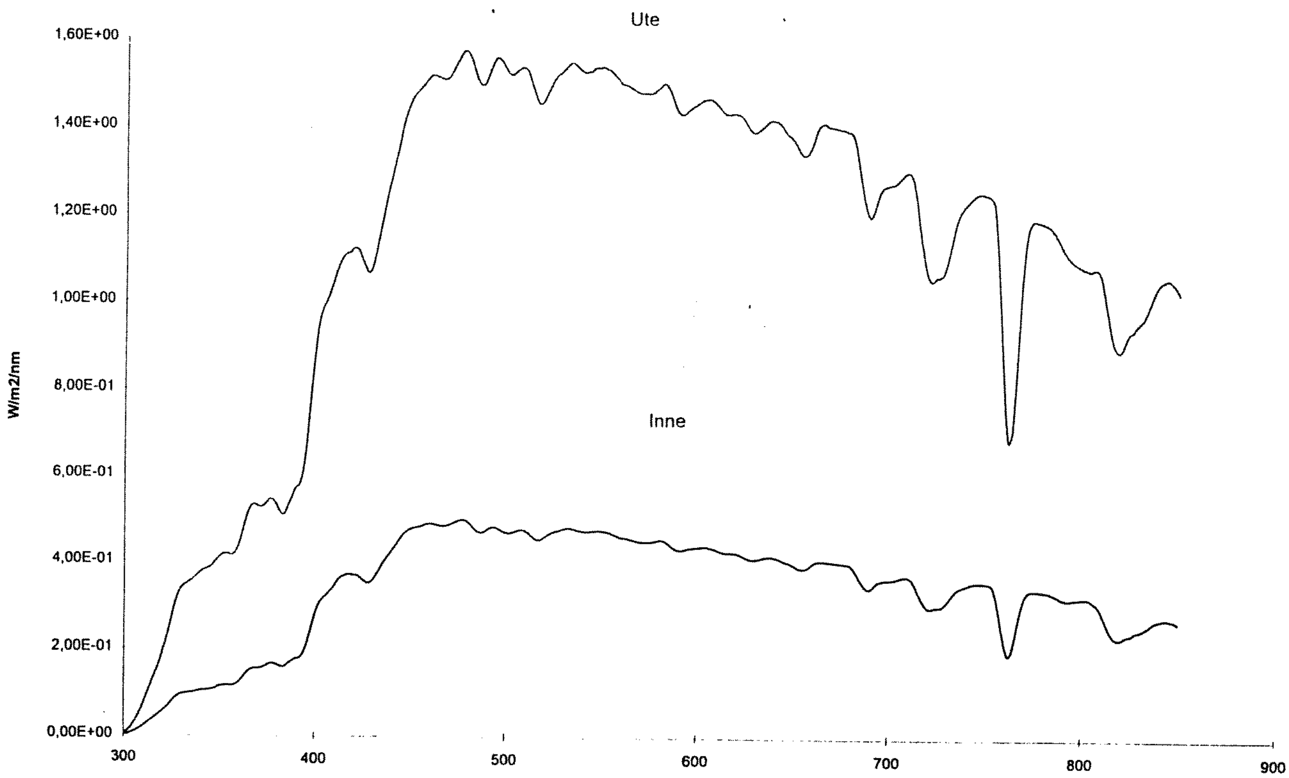

Figure 6. Spectral radiance outside (ute) and under the roof (inne) at KIM-catchment as measured by spectral radiometer in August 1995 over the frequency range 300-850 nm.

EGIL catchment: Soil heating at EGIL catchment began in May 1994, but continuous operation was first achieved in June 1994. During the first year of treatment the system was able to nearly maintain the target temperature at the soil surface (and also deeper in the soil, not shown) during the summer and autumn, but less successful during the winter months (Figure 7a-b). This is in part due to the fact that the cables are not covered with soil and the heating system has insufficient capacity.

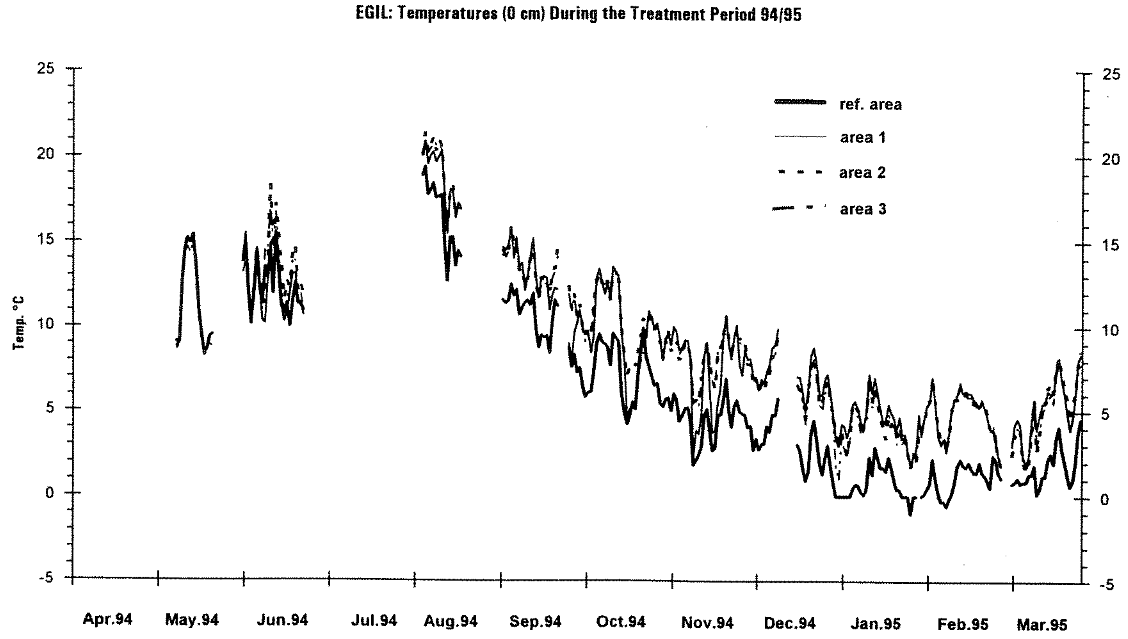

Figure 7a. Mean daily air temperature at EGIL catchment (heated areas 1, 2 and 3 and reference area) for the first year of treatment April 1994 - March 1995.

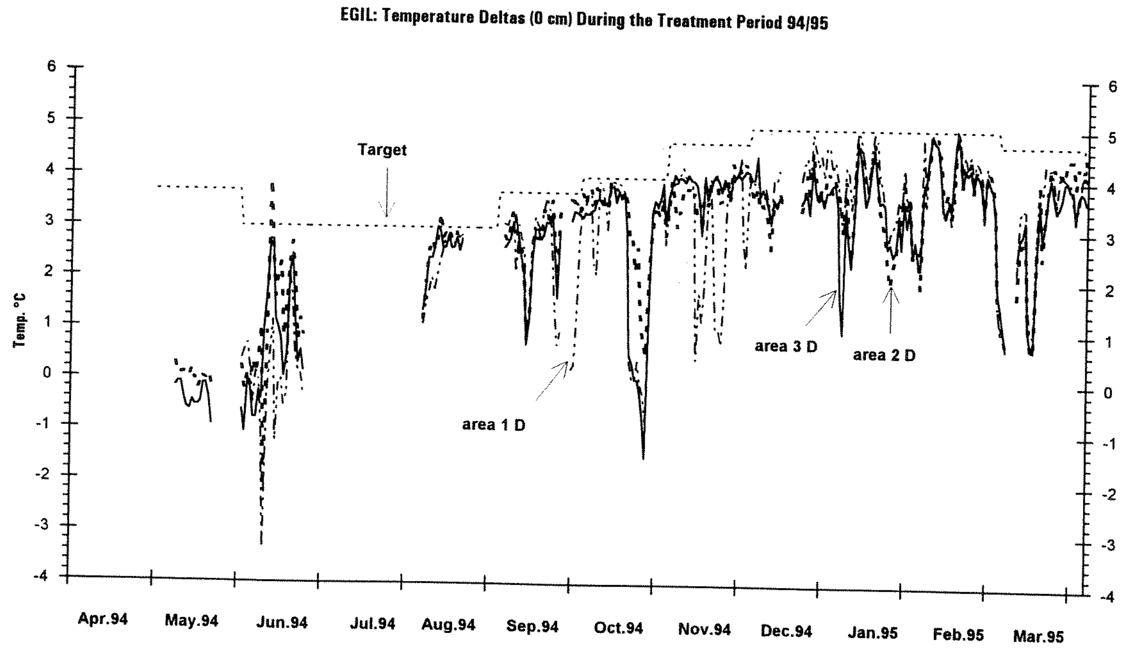

Figure 7b. Difference in mean daily air temperature at EGIL catchment (heated areas 1, 2 and 3 and reference area) and target values for the first year of treatment April 1994 - March 1995.

THE CLIMEX DATA BASE

Together 5 data loggers are used at Risdalsheia to record meteorological parameters and to control the systems at the 2 manipulated catchments. Data from these loggers are compiled and stored as a CLIMEX data base, managed and maintained at NIVA in Oslo for use by CLIMEX participants (Table 2).

DGT logger: climate control data. The DGT logger was delivered as part of the treatment and control system for KIM catchment. The logger collects data on air temperature, CO_2, humidity, wind speed, vent openings, and light. These are compiled as hourly means in the data base. The DGT logger began routine functioning in June 1994.

LI-CORR logger: Three LI-CORR climate stations were installed in 1992 as part of the RAIN project, and now continue under CLIMEX. These record daily mean, max and min air temperature, soil temperature, light and precipitation.

AAC-Tiny talk logger. The AAC logger is used primarily to collected hydrological data on precipitation and runoff from 3 catchments. These are recorded as hourly means. Logging began in April 1994.

AAC-CLIMEX logger. This second AAC logger is used to monitor temperature and light at several points within the manipulated catchments. These are recorded as hourly means. Logging began in June 1994.

CR-10 logger. The Campbell logger is used to record soil temperatures at several depths and locations in EGIL catchment. Hourly mean values are recorded beginning in May 1995.

Table 2. CLIMEX database

KIM T: KIM treatment area, measurements: *air temperature, soil temperature, CO_2,, humidity, radiation, vent. openings*
KIM C: KIM control area, measurements: *air temperature, humidity, radiation, vent. openings*
OUT: Outside area, measurements: *air temperature, windspeed, humidity, radiation*
EGIL: EGIL treatment area, measurements: *air temperature, soil temperature, radiation*

Dataloggers:	Climate data:	Periods:	Parameters:	Notes:
Climate control data - DGT humid-kc.xls humid-kt.xls	Humidity	30.6.94-16.5.95	date, time (hour), 11	Humidity, **KIM T, KIM C** 11: Code for Relative Humidity %
CO2-kt.xls	CO_2	30.5.94-16.5.95	date, time (hour), 14	CO_2, **KIM T, KIM C, OUT** 14: Code for CO_2 ppm/10
tmean-kc.xls t146-kc.xls t5-kc.xls t-kc.xls	Air temperature	13.6.94-16.5.95	date, time, 1	Temperature, **KIM C** 1: Code for Temp °C
t123-kt.xls t456-kt.xls	Air temperature	13.6.94-16.5.95	date, time, 1 - 6	Temperature 6 points, **KIM T**
tmean-kt.xls	Air temperature, mean	18.8.94-16.5.95	date, time (hour), 1	Mean temperature 6 points, **KIM T** 1: Code for Temp °C
outdoor.xls	Out data	13.6.94-16.5.95	date, time (hour), 55,50,56,6	Temperature °C **OUT** 55: Out-temp. 50: Windspeed m/s 56: Light W/m2 6: Vent openings %
LI-CORR li-kim95.xls li-ute95.xls li-egl95.xls	Climate stations	1992-15.05.95	date, max air, min air, mean air, mean soil, precipitation, light	Daily mean data for **KIM T, EGIL** and **OUT**, Temp °C, mm and mJ
AAC - tinytalk hum95.xls	Humidity	28.6.94-16.5.95	date, time (hour), fixed outside %, alternating kim-t,-kim-c,-outside	Data from tinytalk 1 canal loggers. One at **fixed point outside** kim-building, one **alternating between KIM T, KIM C** and **OUT**
hydr95.xls	Hydrology	8.4.94-16.5.95	date, time (hour), kim t (in), kim t (out), egil, mette	Hydrology data for **KIM T, EGIL** and **METTE**, ltr (Data for IH)
CLIMEX - AAC light95.xls	Light	14.6.94-16.5.95	date, time (hour), kim t , egil	Light - insolation for **KIM T** and **EGIL**, mJ
temp95.xls	Air temperature	1994-16.5.95	pr canal (1-19), date, mean, min, max	Hourly and daily mean 19 points Temp °C for **KIM T**
CR-10 08059501.dat	Air and soil temperature	8.5.94-9.8.95	date, time (hour), median air (above soil), median soil (soil), delta ref./ treatm.	Temp °C sensors in 4 areas (3 treat., 1 ref.), 6 depths in **EGIL**

APPENDICES

Appendix 1.

RAIN PROJECT publications April 1995

1. Wright, R.F. 1985. RAIN project. Annual report for 1984. Acid Rain Res. Rept. 7/1985 (Norwegian Institute for Water Research, Oslo), 39 pp.

2. Lotse, E., and E. Otabbong, 1985. Physiochemical properties of soils at Risdalsheia and Sogndal. RAIN project. Acid Rain Res. Rept. 8/1985 (Norwegian Institute for Water Research, Oslo), 48 pp.

3. Wright, R.F. 1985. RAIN-prosjektet. Limnos nr. 1: 15-20 (in Norwegian).

4. Wright, R.F., E. Gjessing, N. Christophersen, E. Lotse, H.M. Seip, A. Semb, and B. Sletaune, 1986. Project RAIN: Changing acid deposition to whole catchments. The first year of treatment. Water Air Soil Pollut. 30: 47-64.

5. Wright, R.F. and E. Gjessing 1986. RAIN project. Annual report for 1985. Acid Rain Res. Rept. 9/1986 (Norwegian Institute for Water Research, Oslo), 33 pp.

6. Wright, R.F., E. Gjessing, A. Semb and B. Sletaune. 1986. RAIN project. Data report 1983-85. Acid Rain Res. Rept. 10/86 (Norwegian Institute for Water Research, Oslo), 62 pp.

7. Wright, R.F. and B. J. Cosby, 1987. Use of a process-oriented model to predict acidification at manipulated catchments in Norway. Atmos. Environ. 21: 727-730.

8. Wright, R.F. 1987. RAIN project: Results after 2 years of treatment. p. 14-29, In H. Barth (ed.) Reversibility of Acidification (Elsevier Applied Science, London), 175pp.

9. Hauhs, M. 1986. Relation between chemistry of soil solution and runoff in two contrasting watersheds: Lange Bramke (West Germany) and Risdalsheia (Norway), p. 207-217, In S. Haldorsen and E.J. Berntsen (eds.) Water in the Unsaturated Zone (Nordic Hydrologic Programme Report 15, P.O. Box 5091, 0301 Oslo), 284 pp.

10. Hauhs, M. 1987. The relation between water flow paths in the soil and runoff chemistry at Risdalsheia, a small headwater catchment in southern Norway (RAIN-project), p. 173-184, In Acidification and Water Pathways, vol. I. (Norwegian National Committee for Hydrology, P.O.Box 5091, 0301 Oslo 3), 458 pp.

11. Wright, R.F., 1987. RAIN project. Annual report for 1986. Acid Rain Res. Rept. 13/87 (Norwegian Inst. Water Research, Oslo, Norway), 90pp.

12. Parmann, G. 1988. Det nytter å redusere sur nedbør. Populærvitenskapelig Magasin 3/88: 8-11 (in Norwegian).

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15. Wright, R.F., Norton, S.A., Brakke, D.F and Frogner, T. 1988. Experimental verification of episodic acidification of freshwaters by seasalts. Nature 334: 422-424.

16. Wright, R.F., Lotse, E., and Semb, A. 1988. Reversibility of acidification shown by whole-catchment experiments. Nature 334: 670-675.

17. Wright, R.F. 1989. RAIN project: Role of organic acids in moderating pH change following reduction in acid deposition. Water Air Soil Pollut. 46: 251-259.

18. Lotse, E. 1989. Soil chemistry 1983-86 at the RAIN project catchments. Acid Rain Research Report 18/1989 (Norwegian Institute for Water Research, Oslo), 66 pp.

19. Reuss, J.O. 1989. Interpretation of soil data from the RAIN project. Acid Rain Research Report 19/1989 (Norwegian Institute for Water Research, Oslo), 81 pp.

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26. Wohlfeil, I.C. and Müller, D.I. 1992. RAIN project: vegetation mapping at Risdalsheia 1991. Acid Rain Research Report 26/92 (Norwegian Institute for Water Research, Oslo), 42 pp.

27. Kroglund, F., and Rosseland, B.O. 1992. Reversibility of acidification: fish responses in experiments at Risdalsheia, Norway. Acid Rain Research Report 27/92 (Norwegian Institute for Water Research, Oslo), 50 pp.

28. Wright, R.F., Lotse, E. and Semb, A. 1994. Experimental acidification of alpine catchments at Sogndal, Norway: results after 8 years. Water Air Soil Pollut. 72: 297-315.

29. Cosby, B.J., Wright, R.F., and Gjessing, E. 1995. An acidification model (MAGIC) with organic acids evaluated using whole-catchment manipulations in Norway. J. Hydrol. 170: 101-122.

30. Wright, R.F. 1994. RAIN project: Risdalsheia data report for June 1990-May 1994. Acid Rain Research Report 36/94 (Norwegian Institute for Water Research, Oslo), 165pp.

Appendix 2.

CLIMEX Publication List August 1995

Jenkins, A., Schulze, E.D., van Breemen, N., Woodward, F.I. and Wright, R.F. 1992. CLIMEX -climate change experiment. In, Teller, A., Mathy, P. and Jeffers, J.N.R. (Eds) Responses of Forest Ecosystems To Environmental Changes. Elsevier, London.

Arp, W. and Berendse, F. 1993. Plant growth and nutrient cycling in nutrient-poor ecosystems. In, Van de Geijn, S.C., Goudriaan, J. and Berendse, F. (Eds) Climate Change; Crops and Terrestrial Ecosystems. Agrobiologische Thema's 9, CABO-DLO, Wageningen, The Netherlands.

Jenkins, A., Wright, R.F., Berendse, F., van Breemen, N., Brussaard, L., Schulze, E.D. and Woodward, F.I. 1993. The CLIMEX project - climate change experiment. In, Rasmussen, L., Brydges, T. and Mathy, P. (eds) Experimental Manipulations of Biota and Biogeochemical Cycling in Ecosystems. Ecosystems Research Report 4, CEC, Brussels.

Jenkins, A. and Wright, R.F. 1993. The CLIMEX project - raising CO2 and temperature to whole catchment ecosystems. In, Schulze, E.D. and Mooney, H.A. (Eds) Design and Execution of Experiments on CO_2 Enrichment. Ecosystems Research Report No. 6., CEC. Brussels.

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Appendix 3. List of ongoing research activities under CLIMEX September 1995

Activity	Institute	Principal investigator
Hydrology	Institute of Hydrology, UK	A. Jenkins
Greenhouse gas fluxes	Institute of Terrestrial Ecology, UK	D. Fowler
Modelling	Institute of Hydrology, UK	A. Jenkins
Tree physiology	University of Sheffield, Department of Biological Sciences, UK	I. Woodward
Tree growth and nutrition	Danish Forest and Landscape Research Institute, DK	C. Beier
Soil chemistry	Wageningen Agricultural University, Department of Soil Science and Geology, NL	N. Van Breemen
Shrubs	Wageningen Agricultural University, Department of Terrestrial Ecology and Nature Conservation, NL	F. Berendse
Soil fauna	Wageningen Agricultural University, Biological Station, Centre for Soil Ecology, NL	L. Brussaard
Sulphur pools	Stockholm University, Department of Geology, S	P. Torssander
Water Fluxes and aquatic effects	Norwegian Institute for Water Research, N	R. Wright
Sr-isotopes and weathering rates	Norwegian Institute for Water Research, N	B-L. Skjelkvåle

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