Proc. 12th Agric. & For. Meteorol. Conf.,
4/14-16/75, Tucson, AZ, p. 33-34

CLIMATE MODIFICATION OF DRY DESERT AIR BY A LARGE IRRIGATION PROJECT

R. D. Burman, J. L. Wright and J. D. Marwitz

University of Wyoming, Laramie, Wyoming, Agricultural Research Service, Kimberly, Idaho
University of Wyoming, Laramie, Wyoming

INTRODUCTION

Climatic changes caused by the evapotranspiration of large amounts of irrigation water may be important in irrigation scheduling, weather forecasting and the management of irrigated farmland. Results from previous studies are often in disagreement as to the magnitude of climatic modification by irrigation. Some studies show only minimal changes (Fritschen and Nixon, 1967, Fowler and Helvey, 1974) and others show sizeable modifications (Davenport and Hudson, 1967). Beebe (1974) reports that severe storms as indicated by tornado's are more prevalent over irrigated land in Texas. A recent statistical report (Schickendanz, 1976) shows rainfall increases, temperature anomalities, and hail increases, all caused by irrigation. Schickendanz work covered a very large area in the Great Plains of the United States. Previously reported studies differ greatly in size of area involved and objectives. The studies reported here had the objective of showing the possible climate modification caused by a large irrigation project in Idaho surrounded by a non-irrigated sagebrush grass desert.

The data in this paper have previously been reported by Burman, Wright and Jensen (1975). The reader is referred to this paper for more detail. This paper is an updated, corrected version of a paper reported by Burman, Wright and Marwitz (1975).

Temperatures, vapor pressures and wind speeds were measured at an elevation of 2 meters along a transect extending from the surrounding desert into the center of a large irrigated region in Idaho during the summers of 1972 and 1973. Measurements were taken at stations located in uniform alfalfa fields of approximately 4 hectares in size or larger.

Table 1 is a summary of measurements taken in May 1972. An examination of Table 1 reveals only minimal differences in temperature, dew point, wind speed and estimated potential evapotranspiration. Both the desert and irrigated areas appeared to have uniformly moist soil moisture conditions at this time.

Table 1. Average climatic conditions, May 16 through May 19, 1972.

Traverse from desert to Kimberly, Idaho

Site	Distance from Desert*	Temperature Max.	Temperature Min.	Temperature Avg.	Dew Point†	Wind Speed	E_{tp}
	km	°C	°C	°C	°C	km/day	mm/day
1	-6	19.6	8.2	13.9	1.8	159	5.0
2	2	20.9	7.5	14.2	3.6	174	5.1
3	10	21.1	6.9	14.0	6.2	150	4.6
4	25	21.3	7.2	14.2	5.7	182	5.0
5	32	21.1	6.9	14.0	6.4	164	4.7
6	36	21.8	6.2	14.0	6.1	161	4.8‡
Mean		20.9	7.1	14.0	---	165	4.9
Standard Dev.		0.7	0.7	0.1	---	11	---

*East-West transect, † at 0800 hours, calculated per hygrothermograph data, ‡ Kimberly (lysimeter site)

A series of transect measurements were made in August 1972 when the sagebrush desert was obviously very dry and many of the irrigated fields were moist. The daytime temperatures were 3.1° cooler, the vapor pressure nearly double, and the wind speeds were 30% lighter over the irrigated region compared to the desert (see Table 2).

Table 2. Average climatic conditions, August 1 through August 10, 1972.

Traverse from desert to Kimberly, Idaho

Site No.	Distance from Desert*	Max.	Min.	Avg.	Wind Speed	E_{tp}
	km	°C	°C	°C	km/day	mm/day
1	-6	33.1	16.6	24.8	260	10.0
2	2	33.4	14.5	23.9	204	9.2
3	10	33.3	13.4	23.3	164	8.2
4	25	32.2	13.6	22.9	169	8.9
5	32	33.9	13.7	23.8	160	8.5
6	46	30.9	12.3	21.7	152	7.9†
Mean		32.8	14.0	23.4	185	8.8
Standard Dev.		1.1	1.4	1.1	40	0.8

*East-West transect, †Kimberly (lysimeter site)

A variety of the thermodynamic parameters were derived from the basic state parameters. They include specific static energy σ, virtual potential temperature Θ*, and water vapor pressure

e. As shown in Tables 3 and 4 the results indicated that σ and e were greater over the irrigated region while Θ* was less than over the desert.

Table 3. Average climatic conditions, August 16, 1973.

Distance From Desert	Virtual Potential Temperature Θ*	Vapor Pressure e	Vapor Pressure Deficit
km	°C	mb	mb
-6	314	6.0	32.9
23	311	11.9	17.1
46	310	12.3	16.7

On August 16, 1973 σ was 33,085 X 10^5 cm^2/sec^2 in the irrigated and was 32,391 X 10^5 cm^2/sec^2 in the desert according to Table 4.

Table 4. Components of specific static energy

All figures divided by 10^5 in cm^2/sec^2

Date	Location	C_pT	gz	$\frac{V^2}{2}$	Lq	σ
8-16	Desert	30,080	1233	1.5	107.4	32391
8-16	Kimberly	29,550	1313	.2	2222	33085

The largest cause of increased energy is the higher vapor pressure of the air inside the project. Although the most dramatic climatic change in 1972 and 1973 was the large reduction in wind velocity inside the project, wind velocity itself contributes little to total specific energy.

In 1972 estimates of potential evapotranspiration by the Penman Method vary by 20% with the irrigated area having the lowest magnitude. The observed variations were found to be dynamically consistent.

Air flow over the project appeared to have been altered by the addition of water on August 16, 1973. A brisk wind from the west was evident on the outside of the project area. Wind was from the south, southwest on the edge of the project and was from the east at a distance of 2 Km into the irrigated area, (see Table 5).

Table 5. Transect wind conditions, August 16, 1973, P.M.

Distance from Boundary	Wind Direction	Wind Speed	Time
km		m/sec	
-6	W	4-6	1:25 p
0	SSW	2-4	1:40 p
2	E	<2	2:15 p
10	E	---	2:08 p
25	NE	---	1:27 p

The implications to inadvertent climate modification are as follows:

1. The number of thunderstorms which generate over the irrigated region could be decreased because of the decrease in Θ* within the irrigated land.

2. Thunderstorms which generate elsewhere and move over the irrigated region could be intensified because of the increase in σ.

3. The amount of potential evapotranspiration within the irrigated area will be less than over the desert because of the higher e, lower daytime temperatures and decreased horizontal and vertical ventilation due to the colder Θ*.

LITERATURE CITED

Beebe, R. C. (1974). Large scale irrigation and severe storm enhancement. Mimeo. paper, Symp. Diffusion and Air Pollution. Am. Meteorol. Soc., Santa Barbara, California, Sept. 9-13.

Burman, R. D., J. L. Wright and M. E. Jensen (1975). Changes in climate and estimated evaporation across a large irrigated area in Idaho. Reprint from Transactions of the ASAE, Vol. 18, No. 6, pp 1089-93.

Burman, R. D., J. L. Wright and J. D. Marwitz, (1975). Inadvertent climate modification near the surface of a large irrigated area. Preprints, Twelfth Conf. on Agric. and Forest Meteor., Tucson, Arizona, AMS.

Davenport, J. C. and J. P. Hudson, (1967). Meteorological observations and Penman estimates along a 17 km transect in the Sudan Gerzira. Agric. Meteorol. 4:405-414.

Fowler, W. B. and J. D. Helvey, (1974). Effect of large-scale irrigation on climate in the Columbia Basin. Science 184 (4133):121-127.

Fritschen, L. J. and P. R. Nixon, (1967). Microclimate before and after irrigation. Publ. No. 68, Am. Assn. for the Advancement of Science, Washington, D. C., p. 351-356.

Schickendanz, Paul T., (1976). The effect of irrigation on precipitation in the Great Plains. National Science Foundation, NSF GI 43871, University of Illinois, Urbana, Illinois.