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DEVELOPMENT OF A NEW OREGON ANNUAL PRECIPITATION MAP USING THE PRISM MODEL

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Introduction

Development of precipitation maps (also known as isohyetal analyses) is a lengthy and difficult process, particularly in areas with significant terrain features. In the western United States, the problem of complex terrain is compounded by lack of precipitation stations in many areas. Increasingly, however, scientific needs demand more accurate precipitation information. Ecological and hydrological information are becoming increasingly linked with spatial representations, and the need for high quality digital data is increasing.

The latest isohyetal analysis for the state of Oregon was published in 1964. It was hand-drawn by scientists using data from existing stations, and represented the period 1930-1957. In recent years, several attempts have been made to procure funding for a new analysis, but the labor-intensive nature of typical isohyetal analyses has made such an effort prohibitively expensive.

Many methods exist for interpolating precipitation from monitoring stations to grid points. Some provide estimates of acceptable accuracy in flat terrain, but none have been able to adequately explain the extreme, complex variations in precipitation that occur in mountainous regions. Inadequacies in these methods typically must be overcome by adding numerous estimated "pseudo-stations" to the data set and tediously modifying the resulting output by hand. Even then, there is no provision for easily updating the precipitation maps with new data or developing maps for other years or months.

Significant progress in this area has recently been achieved through the development of PRISM (Precipitation-elevation Regressions on Independent Slopes Model). PRISM is an analytical model that uses point data and a digital elevation model (DEM) to generate gridded estimates of monthly and annual precipitation. PRISM is

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uniquely suited to regions with mountainous terrain, because it incorporates a conceptual framework that addresses the spatial scale and pattern of orographic precipitation.

Overview of PRISM

In general, on a given mountain slope face, precipitation increases with increasing elevation. However, orographic effects typically respond to smoothed topographic features rather than detailed variations in terrain (Burns, 1953; Henry, 1919; Schermerhorn, 1967; Spreen, 1947). Relationships between measured precipitation and elevation are generally strengthened when the elevation of each data point is given in terms of its height on a smoothed terrain, termed its "orographic" elevation. The relationship between precipitation and orographic elevation varies from one slope face to another, depending on location and orientation. Thus, a mountainous landscape can be thought of as a mosaic of smoothed topographic faces, or "facets," each experiencing a different orographic regime.

In operation, PRISM performs the following:

- (1) uses a Digital Elevation Model (DEM) to estimate the "orographic" elevations of precipitation stations;
- (2) uses the DEM and a windowing technique to group stations onto individual topographic facets;
- (3) estimates precipitation at a DEM grid cell through a regression of precipitation vs. DEM elevation developed from stations on the cell's topographic facet; and,
- (4) when possible, calculates a prediction interval for the estimate, which is

an approximation of the uncertainty involved.

Evaluation of PRISM

PRISM has been compared to kriging, detrended kriging, and cokriging in the Willamette River Basin, Oregon. In a jackknife cross-validation exercise, PRISM exhibited lower overall bias and mean absolute error (Daly and Neilson, 1992; Phillips, et al, 1992; Daly, et al, 1993). PRISM was also applied to northern Oregon and to the entire western United States. Detrended kriging and cokriging could not be used in these regions because there was no overall relationship between elevation and precipitation. PRISM's cross-validation bias and absolute error in northern Oregon increased a small to moderate amount compared to those in the Willamette River Basin; errors in the western United States showed little further increase. PRISM has recently been applied to the entire United States in three separate runs (western, central, and eastern) with excellent results, even in regions where orographic processes do not dominate precipitation patterns.

By relying on many localized, facet-specific precipitation/DEM-elevation relationships rather than a single domain-wide relationship, PRISM continually adjusts its frame of reference to accommodate local and regional changes in orographic regime with minimal loss of predictive capability.

Development of a new Oregon isohyetal model

Development of the updated analysis for Oregon began with collection of precipitation data from Oregon locations and nearby stations within

contiguous states (Washington, Idaho, Nevada, and California). This included two primary data sets: National Climatic Data Center (NCDC) cooperative stations and Soil Conservation Service (SCS) SNOTEL stations. The period 1961-90 was used for the analysis. Mean monthly values for stations which had at least 27 years of data were used without modification. Data sets for those with at least 15 but less than 27 years of data were modified by applying a least-squares fit to data from a representative nearby station, yielding a 30-year average.

PRISM was run for each monthly data set as well as for the annual averages. Output consisted of precipitation values for each grid cell. The gridded output was then imported into a geographic information system (GIS) for plotting and map creation. Data were made available to interested users in both hard copy (map) and digital (numerical matrix) format. Data have been successfully imported into a variety of GIS programs and other spatial-distribution software, including ARC/INFO, GRASS, IDR-ISI, and Spyglass Transform.

Based on suggestions from prospective users of the product, it was decided to offer three different versions of the map. The smallest is an 11x17 inch color shaded polygon map of the state (1:2,000,000 scale). A black-and-white contour map, with 5-inch resolution, was also produced (scale 1:1,000,000). Finally, a large (36x50 inch) color map, showing 5-inch contours, lakes and rivers, and urban areas, was printed; scale was 1:600,000.

Conclusions and Future Work

The updated isohyetal analysis is thought to be of quality and accuracy comparable to that of traditional labor-intensive isohyetal methods at a fraction of the cost.

Currently PRISM is being studied for use in predicting distribution of other meteorological parameters, such as temperature, snowfall, evapotranspiration, and degree day totals. Other current research topics include the following:

1. Investigation of optimal grid resolution for precipitation modeling;
2. Application of the model to short-term extreme events, including updating of precipitation frequency-duration information;
3. Use in stream flow forecasts;
4. Use in conjunction with water balance and ecological models to provide predictions of the effects of future climate change scenarios on native vegetation;
5. Comparison of distribution of precipitation during different climatic regimes (e.g., ENSO events) with those during normal years;
6. Research into rainfall and snowfall undercatch, especially for high elevation stations; and,
7. Studying the optimal placement of sensors for temperature and precipitation measurement.

References

- Burns, J. I. , 1953: Small-scale topographic effects on precipitation distribution in San Dimas Experimental Forest. *Trans. Amer. Geophys. Union*, 34, 761-768.
- Daly, C. and R.P. Neilson, 1992: A Digital Topographic Approach to Modeling the Distribution of Precipitation in Mountainous Terrain. *Interdisciplinary Approaches to Hydrology and Hydrogeology*. M.E. Jones and A. Laenen, editors. American Institute of Hydrology. Pages 437-454.
- Daly, C., R.P. Neilson, and D.L. Phillips, 1993: A Digital Topographic Model For Distributing Precipitation Over Mountainous Terrain. In review for publication in the *Journal of Applied Meteorology*.
- Henry, A.J., 1919: Increase of precipitation with altitude. *Mon. Wea. Rev.* 47, 33-41.
- Phillips, D. L., J. Dolph, and D. Marks, 1992: A comparison of geostatistical procedures for spatial analysis of precipitation in mountainous terrain. *Agric. For. Meteorol.*, 58:119-141.
- Schermerhorn, V. P., 1967: Relations between topography and annual precipitation in western Oregon and Washington. *Wat. Res. Res.*, 3, 707-711.
- Spreen, W. C., 1947: A determination on the effect of topography upon precipitation. *Trans. Amer. Geophys. Union*, 28, 285-290.

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ACWDPU Meeting, July 14-15, 1993

The Advisory Committee on Water Data for Public Use (ACWDPU) met in Washington, DC, on July 14-15, 1993. This committee is a USGS-sponsored intergovernmental agency working group (under the Office of Water Data Coordination) which discussed water data issues in federal, state, and local agencies. Their primary focus is water quality, but water quantity issues are also a concern of the group. The AASC is a new member on the committee, and was represented by Pam Naber Knox, the Wisconsin SC. She also represented AASC at the last meeting of this committee in Minneapolis in 1991 as an unofficial participant.

Each ACWDPU meeting has a specific theme concentrating on one aspect of water resources data. The previous meeting in Minnesota looked at wetlands issues; the most recent meeting in July 1993 was on water data standards. The first day of the meeting was devoted to briefings on the history and purpose of the committee (which was rechartered after a two-year break), reports on new data collection activities by various organizations, and a panel discussion on groups that are trying to organize data collection standards.

The major reports presented were on NWS modernization and the new National Water Quality Assessment (NAWQA) program. Gene Stallings of the NWS Office of Hydrology described the modernization program and discussed the hydrologic capabilities of the NEXRAD system. Pat Leahy of USGS described the NAWQA program and the 20 field projects which are currently taking place. A total of 60 projects is planned over the duration of the NAWQA program. Some of these

projects concentrate on surface water quality, while others are looking at groundwater contamination in agricultural areas. Each project is designed independently to look at regionally important water quality issues, and consists of a planning phase, field observations, and post-collection analysis. Ultimately, the intent of NAWQA is to build up the base "climate" of water quality across the entire U.S.

The panel discussion focused on ways that various organizations are trying to get scientists to agree on "standards" for data collection. The intent of these groups is not to impose regulatory thresholds, but to describe acceptable data collection methods for each variable. For example, the nitrate concentration of streams can be measured in several ways; these groups are working to define appropriate techniques for each method and to determine the accuracy that can be expected with each approach. Ideally, the use of standard techniques would allow data to be more easily shared between agencies, encouraging wider use of the gathered information.

On the second day, the committee broke into working groups that looked at how to promote comparability of water data between federal and state agencies. They concluded that:

- a. The intent of the committee is to encourage standard methods of analysis, NOT to regulate pollutants;
- b. The use of compatible water data records will encourage the sharing of information between groups (both measurement techniques used and data base storage methods are important);

- c. Collection of metadata must be included in the data accumulation process;

- d. Groups should communicate their standard techniques to others so that compatible data can be collected;

- e. A national council should be established to lead the coordinating effort, with federal agencies taking the major role;

- f. Comparability of records between federal agencies should be promoted in laws like the Clean Air Act, since many states base their methods on the requirements imposed by federal regulatory agencies; and,

- g. We need to recognize that not all regions and users have the same set of water data needs.

The meeting concluded by asking the members whether their organizations would like to be represented on the newly formed advisory committee for the NAWQA program. Based on discussion with AASC members at the AASC meeting in Idaho, it was determined that representation of AASC is probably not needed.

The ACWDPU met in November in the Delmarva Peninsula to look at problems with groundwater contamination, and will meet again in April 1994 in Orange County, California, to look at water conservation issues. If you have any questions or comments about this committee, please feel free to contact Pam Naber Knox (1225 W. Dayton Street, Madison WI 53706, 608-263-2374, email: naber@macc.wisc.edu).

Pam Naber Knox
Wisconsin State Climatologist

Acceptance Speech for the American Association of State Climatologists' Helmut Landsberg Award

First, I want to thank the Association for the honor it has given to me. I will value this award because it comes from a group of climatologists whom I admire, both professionally and personally, and the award is in honor of a remarkable man both as a scientist and as a person.

Second, I want to apologize for not being able to personally receive this award, but I am sure to see many of you at future meetings.

I would like to convey a few thoughts I have about the role of the Association in the field of climatology and the atmospheric sciences.

- It is clear that the need for SCs is now greater than ever. Perhaps we have come full circle from the time when the Weather Bureau decided it could no longer support the SC program. We have an active SC program in virtually every state. Nonetheless, there are many areas in which the Program can and should make its presence more strongly felt.

- The SCs in many ways can be regarded as the practicing family physician. As such, they are frequently relied upon to provide a diagnosis or prognosis on an immense variety of practical problems related to some aspect of climate. Much information is gained through these hands-on practical encounters. Because of this the SC is in a unique position to understand the climate information needs and the capability of users to benefit from this information. The users know this, but I fear

that too often the knowledge of the SCs does not make its way back to the specialists in the field. As a result, many applied programs constantly struggle with inadequate funds to accomplish this important work, which too often is the weakest link in the chain of translating our knowledge about climate to the users.

- The challenge to us is clear. We must be more articulate in the value of our work to our colleagues as well as policy/decision makers in government and in business. More Journal articles and committee work must be combined with our normal business.

Finally, I want to thank all of you again, and wish you the best of success in your Annual Meeting.

Thomas R. Karl
Senior Scientist
National Climatic Data Center

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ISMCS Version 2.0 (\$50.00)

National Climate Information Disk
Vol. 1 (\$50.00)

Marine Climatic Atlas Version 1.0
(\$50.00)

Global Upper Air Climatic Atlas
(GUACA) Version 1.0 (\$200.00)

Historical U.S. Climate Data
(CLIVUE/CLISNOOP) Version 1.0
(\$50.00)

Solar and Meteorological Surface
Observational Network (SAMSON)
Version 1.0

Individual Regions (specify Eastern, Central, or Western) (\$100.00)
Complete Set (\$300.00)

Add \$11.00 service and handling charge to each order.

JUST ISSUED

Radiosonde Data of North America 1946-1992. Contains all available radiosonde data for North America (U.S., Canada, Mexico, and Caribbean Islands) through the 100-mb level on four disks. Disk periods are 1946-1965, 1966-1979, 1980-1989, and 1990-1992. Data include significant, mandatory, and special wind levels for all observation times and include geopotential height, temperature, dew point, wind direction, and scalar speed. The user can select for output to printer, screen, or file, a single station or multiple stations for a defined time period, or all stations within a specified geographic region in either synoptic or station sort. The CD also contains available station metadata. (4 disks, \$100.00 per disk)

FUTURE PRODUCTS

Global Tropical and Extratropical Cyclone Climatic Atlas (GTECCA). This single volume CD-ROM will contain all global historic tropical storm track data available for five tropical storm basins. Periods of record vary for each basin, with the beginning as early as the 1870s and 1992 as the latest year. Northern hemispheric extratropical storm track data will be included from 1965 to 1992. Tropical track data include

time, position, storm stage (and maximum wind, central pressure when available). The user will have the capability to display tracks and track data for any basin or user-selected geographic area. The user will also be able to select storm tracks passing within a user-defined radius of any point. Narratives for all tropical storms for the 1980-1992 period will be included as well as basin-wide tropical storm climatological statistics. (Available December 1993)

Global Daily Data. This CD-ROM will provide access to a 10,000-station set of daily maximum/minimum temperature, daily precipitation, and 3-hourly present weather for the 1977-1991 period of record. Data can be selected for viewing or output to file for geographic areas or by a predefined user-selected list of stations. Each data record includes element flags for suspected erroneous data. A data inventory contains station name, latitude/longitude, elevation, period of record, and the number of observations of available data. (Available December 1993)

OUTLOOK FOR 1994

ISMCS Version 3.0
GTECCA Version 2.0
Marine Climatic Atlas Version 2.0
Global Sea Ice
Station Climatic Data Daily
Statistics
Northern Hemisphere Historic
Fields
Russian Hourly

John Hughes presenting the Helmut Landsberg Award to Tom Karl. The award was given at the 1993 AASC Annual Meeting.



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