Chinesisch-Deutsches
Zentrum für
Wissenschaftsförderung

中德科学中心

Climate Change and Yangtze Floods

Edited by T.JIANG
L.KING
M.GEMMER
Z.W.KUNDZEWICZ

SCIENCE PRESS
www.sciencep.com

Climate Change and Yangtze Floods

Edited by T.JIANG
L.KING
M.GEMMER
Z.W.KUNDZEWICZ

SCIENCE PRESS
Beijing

Responsible Editor: Junlin Hou

图书在版编目(CIP)数据

气候变化与长江洪水 = Climate Change and Yangtze Floods/姜彤等编．—北京：科学出版社，2004

ISBN 7-03-014436-8

Ⅰ．气…　Ⅱ．姜…　Ⅲ．①气候变化—研究—学术会议—文集—英文　②长江流域—区域洪水—研究—学术会议—文集—英文

Ⅳ．①P467—53　②P331.1—53

中国版本图书馆 CIP 数据核字（2004）第 100161 号

Climate Change and Yangtze Floods

Published by Science Press
16 Donghuangchenggen North Street
Beijing 100717, China

Printed in Beijing

ISBN 7-03-014436-8
RMB 80.00

Proceedings of a Sino-German Workshop
held in Nanjing, P. R. China, April 4–8, 2003

Climate Change and Yangtze Floods

Chief Editors

Tong JIANG
Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, China

Lorenz KING
Department of Geography, Justus Liebig University (JLU), Giessen, Germany

Marco GEMMER
Center for International Development and Environmental Research (ZEU), JLU, Germany

Zbigniew W. KUNDZEWICZ
Potsdam Institute for Climate Impact Research, Germany, and Research Centre of Agricultural and Forest Environment, Polish Academy of Sciences, Poznan, Poland

Editors

Deliang CHEN
National Climate Center, China Meteorological Administration, Beijing, China

Klaus FRAEDRICH
Meteorological Institute, University of Hamburg, Germany, and German Climate Computing Centre, Hamburg, Germany

Nianxiu QIN
Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, China

Yafeng SHI
Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, China

Jun WANG
Hydrological Bureau, Changjiang Water Resources Commission, Wuhan, China

English Editor

Norm HOFFMAN
Nanjing Olivia Translation Co., Ltd.

The workshop and this book were financed by Sino-German Center for Research Promotion of DFG and NSFC

Preface

Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences (CAS), and the Center for International Development and Environmental Research (ZEU) of the Justus Liebig University in Giessen, Germany, jointly organized a workshop on Climate Change and Yangtze Floods. This Sino-German workshop was held in Nanjing, China, on April 4–8, 2003, and more than 100 Chinese and German scientists attended it. The objectives of the workshop were to exchange research experiences on climate change and floods in the Yangtze River catchment as well as to set up a research network on these topics. Moreover, further research on these important topics was planned and coordinated. The previous Sino-German meetings were held in Walberberg (2000), Wuhan (2001) and Shanghai (2002). They made much progress in interdisciplinary research and were financed by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) as well as the Sino-German Center for Research Promotion of DFG/NSFC in Beijing and the National Natural Science Foundation of China (NSFC).

Based on intensive discussions during the Nanjing Workshop in 2003, the idea to publish this book was initiated. It was emphasized that the exchange of the results of basic and applied science on the workshop topics should be strengthened, and in consequence "Climate Change and Yangtze Floods" was edited by an international interdisciplinary board. Many contributions from Chinese and German scientists could be collected, which contained the state of the art of climate change detection and flood research with special regard to the Yangtze River catchment. In addition to this specific topic, German and European flood experiences were introduced by German experts on climate change and floods. On behalf of the editorial board, we would like to express our thanks to the authors who have contributed to this book and the organizing committee of the workshop. Our deepest gratitude will go to the Sino-German Center for Research Promotion of DFG and the National Natural Science Foundation of China (NSFC), for they have financed the workshop in Nanjing and the publication of this book.

We are optimistic that this publication will enhance the Sino-German Research Cooperation Nanjing-Giessen which was established in 1986, as well as many other joint research programs. It will be of great benefit to the members of different working groups, as European and Chinese scholars can learn from each other's experiences. The book aims at the international exchange of knowledge in the field of Climate Change and Yangtze Floods, and there is an important call for action in this scientific field. We believe that this publication will initiate the required joint Sino-German research in future.

Lorenz King

Center for International Development and
Environmental Research (ZEU)
Justus Liebig University, Giessen, Germany

Yafeng Shi

Nanjing Institute of Geography
and Limnology, Chinese
Academy of Sciences, China

CONTENTS

Preface iii

Section A: Climate Change and Precipitation

Climate Change in China and Its Contributions to Yangtze River Floods
S. BECKER et al. 2

On Global Climatic Change and Its Countermeasures in China
Y. J. WU et al. 16

Dryness and Wetness Variability of Eastern China Watersheds
I. Bordi et al. 25

Climate Change in the East-Asian Monsoon-Introduction of a New Method of Time Series Analysis
H. X. CAO et al. 36

Atmospheric Intra-seasonal Oscillation and Summer Rainfall over the Yangtze-Huai River Valley
C. Y. LI et al. 46

Centennial Variations and Recent Trends in Summer Rainfall and Runoff in the Yangtze River Basin, China
Q. HU 63

21st Century Impact of Greenhouse Effects on the Middle and Lower Reaches of the Yangtze River
Y. XU et al. 73

Precipitation Trends in Hubei Province Since the 1960s
Z. H. CHEN et al. 82

Recent Trends of Heavy Rain Events in the Yangtze River Valley
H. Q. YANG et al. 93

Rainstorm and Precipitation Trends in the Yangtze River Catchment 1951 – 2002
B. D. SU et al. 101

Regional Response in Hunan Province to Global Climate Warming
L. LI et al. 122

Section B: Climate Change and Runoff

Precipitation Scenarios for Hydrologic Climate Impact Studies
G. BÜRGER 134
Impact Study of Climate Change on Runoff in the Yuanjiang River Basin
X. CHEN et al. 144
Impact of Climate Change on Runoffs from Hanjiang and Ganjiang in the Yangtze River Basin
D. L. CHEN et al. 155
Scenario-Based Modelling Studies to Assess the Impact of Climate Change on Floods in the German Rhine Catchment
A.THIEKEN et al. 168
Yangtze Floods—Observations and Scenarios
Y. F. SHI et al. 182
An Analysis of Abrupt Changes in Monthly Streamflow at the Yichang Section of the Yangtze River, China
J. M. JIANG et al. 203
Prediction Studies on the Annual Maximum Flow of the Hanjiang River in Guangdong Province
L. P. LIU et al. 214
Variation of Precipitation and Runoff in the Yangtze River Catchments Since 1960
G. Y. REN et al. 224
The Decadal Scale Variation of Rainfall-Runoff in the Yangtze River Basin
H. Y. SHEN 235

Section C: Yangtze River Floods

Flood Risk in the Changing World—Yangtze Floods in Perspective
Z. W. KUNDZEWICZ 246
Influences of the Tibetan Plateau Winter-Spring Snow on Summer Rainfall in the

Basin of the Yangtze River

Z. G. WEI ··· 259

Fluctuation of Historical Floods and Droughts in the Yangtze River Catchment

Z. S. HUANG et al. ··· 273

Historical Floods in the Yangtze River Catchment

Y. HUANG et al. ··· 283

Large Floods on the Chuanjiang Reaches of the Yangtze River Since the Middle Holocene—A Primary Analysis

D. Y. YANG et al. ··· 291

Big Floods Sediments During the Past 30,000 Years in the Yangtze River Basin

Z. S. GE et al. ··· 298

Connections Between Sea Level Changes and Paleofloods Since the Holocene in the Yangtze Delta

Q. ZHANG et al. ··· 305

Heavy Floods in the Yangtze River Since 1990

H. Y. CHENG et al. ··· 315

Hydromorphological Characteristics of the Yangtze River of China

Z. Y. CHEN ··· 325

Section D: Flood Hazards and Flood Defence

New Demands for Flood Protection in the Yangtze River Catchment

M. GEMMER et al. ··· 342

Flood Risks and Risk Reduction—a Re-insurer's Viewpoint

W. KRON ··· 356

The Cause of Flooding in the Yangtze River Valley and Measures for Disaster Reduction

Z. Z. LI ··· 377

Flood Characteristics of the Yangtze River and Countermeasures for Flood Control

J. WANG ··· 385

The Three-Gorge Project: Its Influence on the Flood Risk Along the Middle Reaches of the Yangtze River and on the Economy of the Region Surrounding the Reservoir

H. HARTMANN et al. ··· 396

Interdisciplinary Risk Analyses as a Contribution to Disaster Prevention: Experiences of the German Research Network Natural Disasters

B. MERZ et al. ······ 405

Simulated Storage Capacity of Flood and Water Logging in the Typical Wetland Region of the Jianghan Plain

X. L. WANG ······ 416

Floods in the River Rhine in the Context of Climate Change and the Flood Action Plan of the ICPR (International Commission for the Protection of the Rhine)

H. ENGEL ······ 424

Application of the SWAT Model for River Flow Forecasting in Sri Lanka

H. A. P. HAPUARACHCHI et al. ······ 436

Authors' CorresPondence ······ 445

Section A: Climate Change and Precipitation

Climate Change in China and Its Contributions to Yangtze River Floods

Stefan Becker[1], Marco Gemmer[2], Lorenz King[3], Tong Jiang[4]

[1]Department of Geography & Urban Planning, University of Wisconsin-Oshkosh, Oshkosh WI 54901, USA

E-mail: stefan.becker@geogr.uni-giessen.de

[2]Center for International Development and Environmental Research, Justus Liebig University, D-35394 Giessen, Germany

[3]Department of Geography, Justus Liebig University, D-35390 Giessen, Germany

[4]Nanjing Institute of Geography and Limnology, CAS, Nanjing 210008, China

Abstract The analyses in the present paper summarise results which have been previously achieved by Becker et al. (2003); Gemmer et al. (2003) and Gemmer et al. (2004): Monthly precipitation and temperature trends in the China were analysed from 1951 to 2002. Trends of 160 stations have been calculated by applying the Mann-Kendall trend test. Significant positive precipitation trends at many stations can be observed for the summer months which naturally show precipitation maxima. They were preceded and/or followed by negative trends. Positive temperature trends can be detected in north, north-east, and west China. They can be visualised for large regions every month and explain a warming trend of northern and western China. Negative temperature trends can only be found from October-December with a relatively limited spatial distribution. A spatial interpolation of the detected trends was carried out. The spatial analysis of the observed trends reveals distinct spatial patterns for the months which emphasizes the aggravation of the situation in a region which is particularly prone to flood disasters. Reasons for the observed trends were found in the earlier onset of the mei-yu.

Keywords East Asian Monsoon, Climate Trends, Mann-Kendall Trend Test, Yangtze River Catchment

1. Introduction

The Yangtze River flooding in the 1990's and the increasing losses due to floods started a new discussion on possible implications of climatic change. Although heavy monthly precipitation in the Yangtze River catchment occurred regularly in the 20th century, summer precipitation in the 1990s is claimed to be higher than in earlier decades (Li et al., 1999; Xu, 2001). Simultaneously, the north of China became much drier according to Gong et al. (2001) and Xu (2001).

Causes and regional impacts of climatic change or variability have been widely discussed under various aspects. The latest IPCC report (IPCC 2001) indicates a 30% –50% increase of precipitation in southern China in the winter months (December, January and February) from 1900 to 1999. An inconsistent pattern with an increase in the western and a decrease in the eastern Yangtze catchment is detected in the summer months (June, July and August). Zhai et al. (1999) showed a significant increase in precipitation over the middle and lower reaches of the Yangtze River and west China during the latter part of the 20th century, while also detecting a declining trend in precipitation over northern China (from IPCC, 2001). The IPCC report also describes an increase of the surface temperature in east China between 0.5 and 2°C and up to 3°C in northern China from 1949 to 1997. The increase of temperature in northern China adds up to 1°C per decade from 1976 to 2000. This is mainly due to strong increases in the absolute minimum temperatures since the 1950s and an increase of hot days in the same period of time. This process can be described by the decreasing number and intensity of cold waves (Zhai et al., 1999b).

Much attention has been paid to the evaluation of the summer precipitation (May-August) in the Yangtze River catchment and the East Asian monsoon as these data are strongly related to flood risks (Gong et al., 2001; Zhu and Wang, 2001). Huang et al., 2001 gave an updated contemplation of the progresses of recent studies on the variabilities of the East Asian monsoon and their causes. Various trends of summer precipitation amounts, such as a negative trend for east China from 1954 to 1976 and a positive trend between 1977 and 1988 have been detected by Gong and Wang (2000). Qian and Zhu (2001) observed an increase of summer precipitation in northern China in the same period. Jiang and You (1996) describe an abrupt reduction of the summer rainfall from the 1960s to the 1980s in central China and a somewhat weaker jump from a dry to a wet period in the middle and lower Yangtze River catchment which started in the 1970s. Nevertheless, below average rainfall appeared in the same area between 1981 and 1985 (Yang and Yuan, 1996). Schaefer (2001) found positive trends of summer precipitation in the southeast of China and negative trends in the north since 1951.

Fu and Wen (1999) mentioned a change in East Asian monsoon characteristics that started in the 1920s which might contribute to the explanation of those findings. Summer rainfall over central China is associated with the East Asian summer monsoon. It begins with a trough forming over the South China Sea in mid-May that moves northward in concert with the expansion of the North Pacific High and reaches central China in early June (Ho et al., 2003). Predictions of the East Asian monsoon are important for disaster precaution. Precipitation in the lower and middle reaches of the Yangtze River is below average and deficient in a strong summer monsoon year such as 1992 or 1997 whereas it is sufficient in the same area during weak monsoon years such as 1991 and 1998 (Li et al., 2001; Zhang and Tao, 1998). In general, the rainbelt moves faster northward during a strong summer monsoon year.

The most recent example is the greater number of floods in the Yangtze River catchment in the 1990s and the water shortage in the Yellow River catchment which have both been aggravated by human activities and impacts of climatic change (Gemmer and King, 2003; King et al., 2001). With regard to these tendencies, the detailed analysis of precipitation and temperature variations are important for the assessment of climate induced risks and countermeasures. Examples of monthly trends of precipitation and temperature in China from 1951 to 2002 will therefore be analysed in the current study. Geographic techniques will be used for a spatial visualisation of climate trends.

2. Data and Methods

The data set of 160 National Meteorological Observatory (NMO) stations with long-term monthly precipitation and temperature data in China have been analysed in this study. They have been provided by the National Climatic Centre (NCCC) of the China Meteorological Administration (CMA) and contain values from January 1951 to December 2002. The density of stations is lower in the sparsely populated high mountainous and desert area of west and north-west China.

The homogeneity of the precipitation and temperature records was analysed by calculating the von Neumann ratio (N), the cumulative deviations (Q/n-0.5 and R/n-0.5), and the Bayesian procedures (U and A) (Buishand, 1982; Maniak, 1997). The data sets of all stations which have been used in the present study are homogeneous with significance beyond the 95% confidence level.

The trends of monthly precipitation and temperature sums have been analysed by applying the Mann-Kendall trend test for all of the 160 stations. Confidence levels of 90%, 95%, and 99% were taken as thresholds to classify the significance of positive and negative precipitation trends. Trends at significance below the 90% confidence level were not considered.

The observed trends were spatially interpolated by applying the Inverse Distance Weighted (IDW) interpolation method. IDW creates a raster surface. The raster cell values are calculated by averaging the values of station data in the vicinity of each cell. Station data in this paper refer to the confidence levels of trends at 160 stations. IDW implies that each station has a local influence that decreases with distance (De By, 2001). The interpolated raster surface is based on a weighed average of the station values. The value of each cell is mostly influenced by nearby points and less by more distant points. The IDW method requires the specification of the power parameter and the search radius. The power parameter controls the significance of calculated station values upon the interpolated values. By defining a high power, more emphasis is placed on the nearest points, and the resulting surface will have more details. The power parameter in the IDW interpolation was set to 6.

The choice of the relatively high power ensures a high degree of local influence and giving the output surface increased detail. The search radius has been specified by choosing a number of 4 neighbouring stations, i.e. the spatial interpolation has been carried out within a fixed radius of 4 neighbouring stations (see Bill, 1999). It is not meaningful to analyse the regional structure of precipitation and temperature trends for the whole of China by applying and comparing different interpolation methods. Applying other interpolation methods (e.g. kriging) result in similar output maps. This is due to the available number of stations, the scale of the projection, and the magnitude of the research area respectively. The interpretation of the results of different interpolation methods would only be feasible for smaller areas or a higher station density.

Data on time series of mei-yu characteristics were obtained from Nanjing Bureau of Water Resources (Nanjing Hydrological Data, data from 1951 to 1994) which has been replenished by data from the Yangtze River Yearbook.

3. Observed Precipitation Trends

Both positive and negative precipitation trends at all confidence levels exist in each month. January, July, September, and November are the months which show the highest number of trends in both positive and negative direction. The smallest number of trends can be observed in March, October, and December. Also Schäfer (2001) points out inconsistent annual precipitation trend patterns in the Yangtze River catchment with positive trends in some parts of the middle and lower catchment since 1951. Many positive trends can be noted in January, June, and July. Negative trends prevail in February, September, and November. A relatively equal number of stations with both positive and negative trends can be detected in August, October, and December.

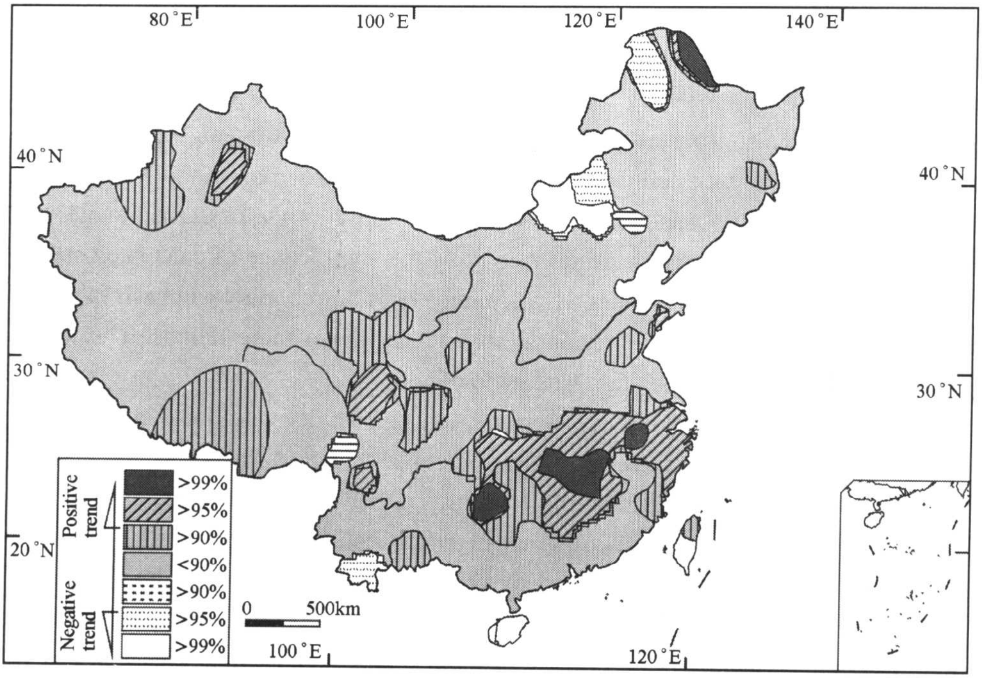

Fig. 1 Mann-Kendall precipitation trend test January 1951–2002

In the following, the interpolated precipitation trends for January and July are presented as examples in the period from 1951 to 2002. The projection of the map illustration is Lambert Equal-Area Azimuthal (central meridian 108°). The displayed classes are based on the confidence levels which are discussed in Chapter 2. As can be seen, the spatial illustration of the detected precipitation trends enables a better understanding of climatic changes or variations in China within the last 50 years, especially regarding the uneven spatial distribution of precipitation trends.

Fig. 1 reveals that a relatively high number of positive trends in January mainly refers to stations which are located in a belt which covers the middle and lower Yangtze River catchment as well as Dongting and Poyang lake catchments. These stations are mainly situated in the lowland and the foothills of the adjoining mountain ranges. Another agglomeration of positive precipitation trends is located in the highlands of Sichuan and Qinghai provinces. Moreover, some isolated stations with positive and negative precipitation trends can be found in the very west and north-east of China.

Precipitation trend patterns in July (Fig. 2) follow three topographical features of China. Whereas large parts of the south-east Lowland and the western mountainous regions are dominated by positive trends we observe negative trends along the transition zone of the middle ranged mountain axis from central to north-east China.

The magnitude of the July precipitation increase and decrease in the Yangtze catchment is displayed in Fig. 3. The interpolated regions are based on the deviation of average July precipitation of 1991–2000 in comparison with the period 1951–1990 in percent. The values vary between –38.1% in Mianyang in the northern region and +119.6% in Yueyang in the central region.

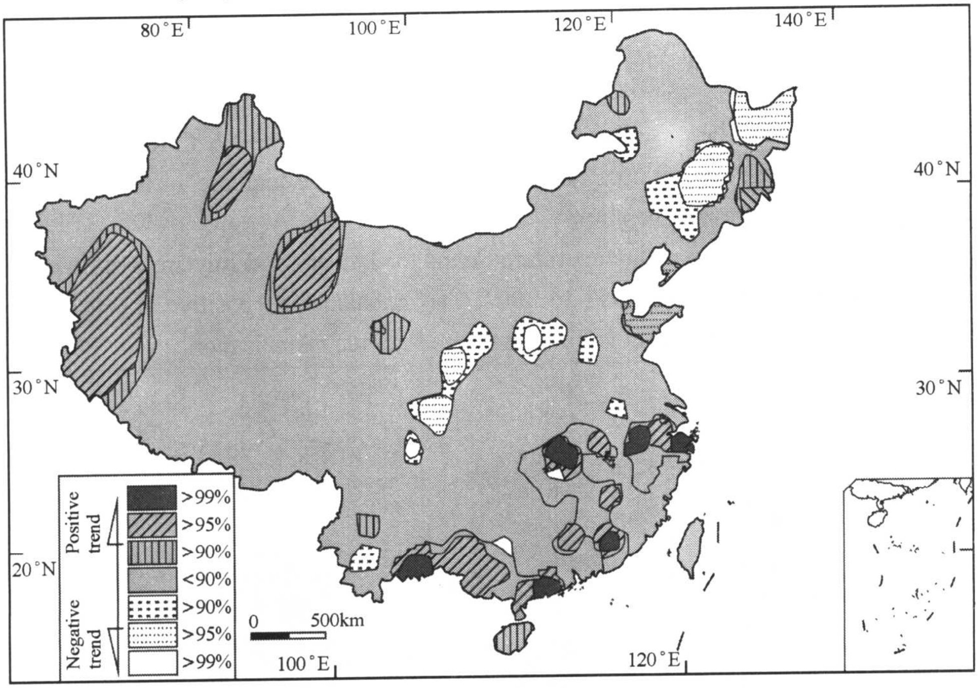

Fig. 2 Mann-Kendall precipitation trend test July 1951–2002

4. Observed Temperature Trends

One of the most apparent features of the temperature analysis is a distinct trend towards higher air-temperature. Both, positive and negative trends, can be detected for the temperature time-series in China from 1951 to 2002. However, in contrast to the precipitation trends, positive and negative temperature trends are unbalanced. Positive trends predominate the Mann-Kendall trend test results. In January, February and April more than 100 of the 160 stations underlie trends which are mostly positive. The highest number of negative trends can be assigned to July and August. The