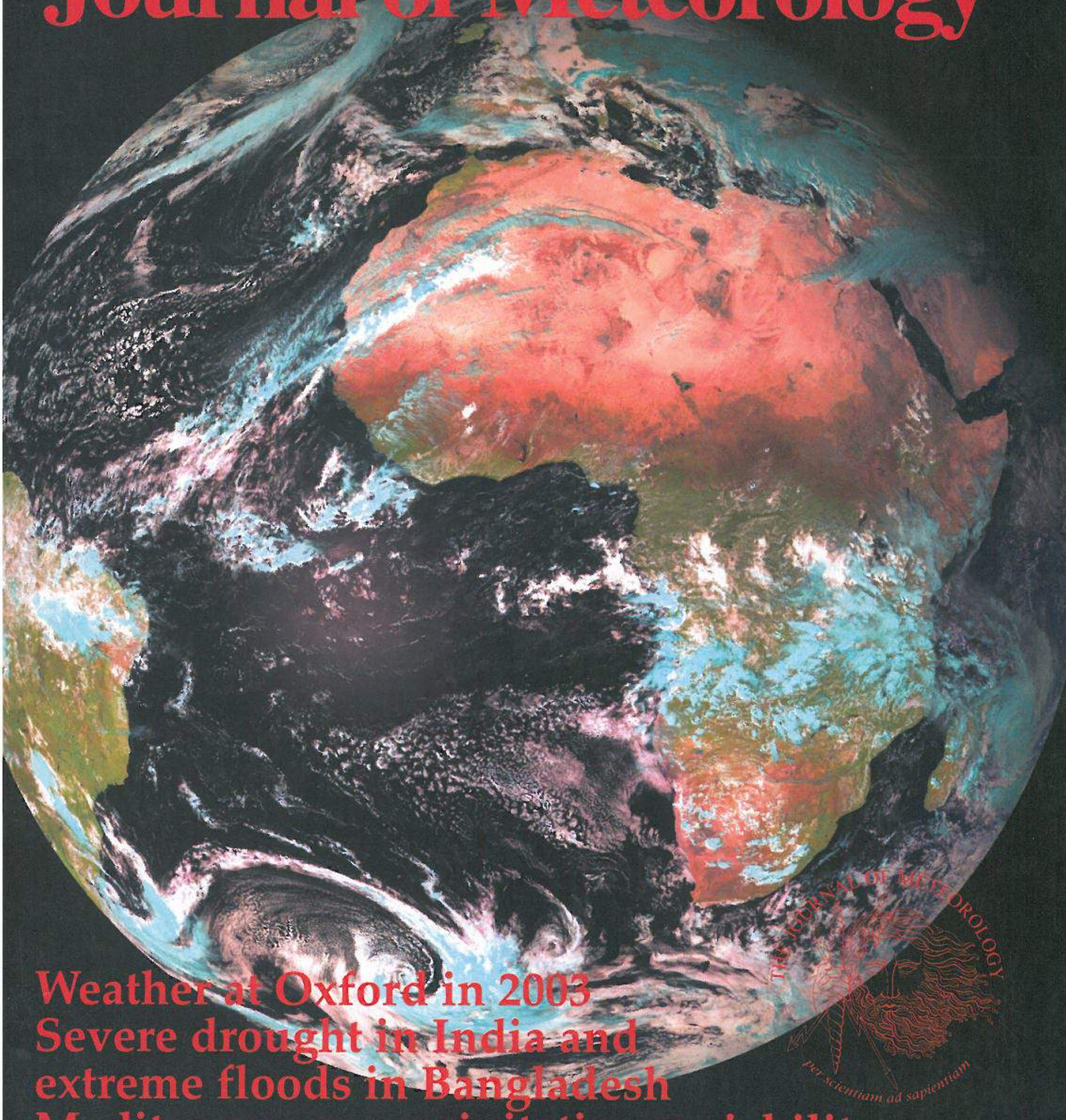
Meteorology from the air ▪ *Ball lightning in Germany?*

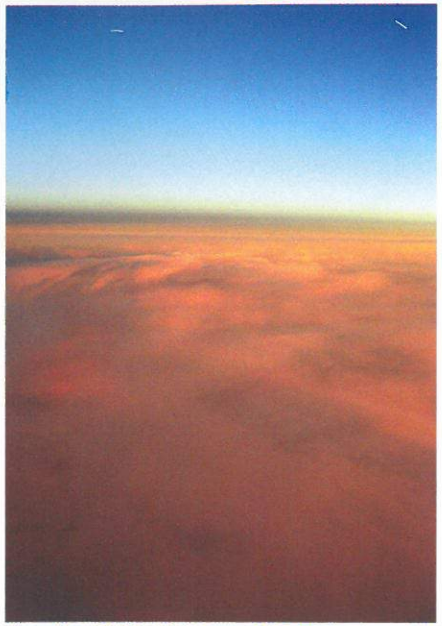
The Journal of Meteorology



Weather at Oxford in 2003
Severe drought in India and extreme floods in Bangladesh
Mediterranean precipitation variability

Volume 29, number 289 **May / June 2004**

METEOROLOGY FROM THE AIR



Sunrise 27,000 ft above Belgium en route to Salzburg, Austria - 21 January 2004
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33,000 ft mid Atlantic heading west to New York - 10 February 2003
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Approx. 18,000 ft above Oxford, UK en route to Geneva - 10 August 2003
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Contents

FRONT COVER: Meteosat-8 Visible (artificially coloured) - 12 February 2003, 1345 UTC
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BACK COVER (top): Pacific sunset over Malibu beach, Los Angeles, USA - 28 February 2004
© Robert Doe
BACK COVER (bottom): Atlantic sky en route to Dallas Fort Worth - 3 May 2003
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PRECIPITATION VARIABILITY OVER THE MEDITERRANEAN AND ITS LINKAGE WITH EL NINO SOUTHERN OSCILLATION (ENSO)

By H.M. HASANEAN

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Abstract: Mean seasonal and annual precipitation recorded at 125 weather stations distributed across Mediterranean region were analysed for the period 1951 to 1998 to reveal spatial and temporal patterns of long-term trends associated with El Nino Southern Oscillation (ENSO). For analysis, various statistical techniques were used. The coefficient of variability method was used to evaluate variability of precipitation. Man-Kendall rank test was used to detect any possible trend in precipitation series. A classical correlation method was used to detect any relationship between precipitation and ENSO.

The high temporal rainfall variability is a distinguishing characteristic of the Mediterranean climate. The coefficient of variability is very high over the southern and central to northern Mediterranean regions, which confirms that the precipitation regime has a high variability and not durable. This means these regions cannot depend on rainfall as a principle water resource. Whereas central eastern and central western Mediterranean have low variability in all seasons and consequently the average is more dependable and durable. The behaviour pattern of precipitation over southern Mediterranean over the period 1951-1998 indicated an increase in precipitation in all seasons and years. Records for the period 1951 onwards show a slight tendency towards decreasing rainfall in almost all central and northern Mediterranean regions and in all seasons with the exception of Italy. A significant negative trend of precipitation over the northeast Mediterranean region is observed in winter, autumn, and also annually. In winter, a precipitation decrease was observed during the last 48 years in the central west Mediterranean.

No detectable connection was found between Mediterranean precipitation pattern and ENSO during winter. Autumn precipitation has been affected by ENSO in central western Mediterranean regions with positive signs and vice versa in spring season. A positive relationship is also found in south east Mediterranean region in spring season. South west Mediterranean regions have been affected by ENSO in winter and summer season. In addition north east Mediterranean regions have been affected by ENSO in summer with positive correlation and vice versa in winter.

INTRODUCTION

Precipitation is a key factor in shaping the vegetation hydrology and water quality throughout the earth. Precipitation is particularly critical to agriculture. Along with temperature, the occurrence and variability of precipitation, to a large extent determine which crops can be grown in different regions throughout the world. As additional insight into precision farming is gained, the importance of rainfall variability becomes more important. An accurate understanding of precipitation characteristics and soil variability is critical to optimizing production and to precision farming. Precipitation varies across a range of space and time scales. Large scale variations occur at longer time scales, and are associated with correspondingly larger scale phenomena in the atmosphere or ocean-atmospheric system.

For example, scales of variability within an individual convection storms may vary from metres and seconds to kilometres and hours, while the El Nino Southern Oscillation (ENSO) related scales of variability are regional to hemispheric in extent and multi-year in length, (Daly, 1991). However, these different scales are not unrelated: precipitation within individual storms is likely to be more intense and of longer duration when ENSO is causing a general enhancement in precipitation across a region. At all these time and space scales, precipitation is inherently more variable than other commonly reported climate variables, such as temperature and pressure, with the result that precipitation measurement and analysis are more demanding. Overlying this variability of precipitation within the climate system is the potential for secular changes in the intensity and distribution characteristics of precipitation. Long term precipitation variations can affect vast areas and their inhabitants, negatively or positively, given the effect they produce on human activities based particularly on intensive weather-sensitive agriculture. While in certain areas an increase of rainfall is expected, other areas will suffer from decreased rainfall.

Precipitation gauge data indicated that global land precipitation (excluding Antarctica) increased by about 9 mm over the twentieth century (a trend of 0.89 mm/decade), which is relatively small compared with inter-annual and multi-decadal variability (New *et al.*, 2001). Within this century, long trend global precipitation exhibits considerable variability on decadal time-scales, with departures of up to ± 40 mm from the century mean of about 950 mm, (New *et al.*,2001). The Mediterranean climate is characterised by a complex pattern of spatial seasonal variability, with wide and unpredictable rainfall fluctuations from year to year. Since 1900, precipitation decreased by over 5% over much of the land bordering the Mediterranean Sea, with the exception of the stretch from Tunisia through to Libya where it increased slightly (Nicholls *et al.*,1996). Within these overall trends, regular alternations between wetter and drier periods are discernible. The early 1990s were characterised by extreme drought over much of this region. In 1995, precipitation was less than 75% of normal (1961-1990) over much of the western Mediterranean (CRU, 1997). Over 1994 and 1995, Spain received less than 50% of normal at some locations (CRU, 1997).

Both the unusual coldness over the eastern Mediterranean over the last decade and the dry conditions afflicting most of the region have been linked with exceptionally high values in the North Atlantic Oscillation (NAO) (Hurrell, 1995; Palutikof and Wigley, 1996; Trenberth and Shea, 1997). The ENSO event is the best known mode of inter-annual variability and many studies attempt to relate anomalous precipitation patterns over the globe to the ENSO (Ropelewski and Halpert, 1996). The dominant mode of variability in global and hemispheric land precipitation is related to ENSO, which explains about 38% of the inter-annual variance in globally averaged land precipitation (35% and 15% of Southern Hemisphere and Northern Hemisphere precipitation respectively) and about 8% of the space-time variability of global precipitation (New *et al.*, 2001).

In this research, three questions posed were: 1) is the variability in seasonal and annual precipitation, over time, consistent across the Mediterranean region? 2) What are the potential causes for the observed variability? 3) Is there a relationship between precipitation variability over the Mediterranean region on an inter-annual time scale and the circulation patterns represented by the teleconnection indices such as El Nino Southern Oscillation (ENSO)?

The author examined seasonal and annual precipitation amounts over a span of 48 (1951-1998) years to determine the temporal and spatial variability characteristics and its relationship with ENSO.

DATA AND METHODOLOGY

Monthly data of precipitation (125 weather stations) for the Mediterranean region and global sea surface temperature (SST) anomalies Nino3 during the period from 1951 to 1998 were obtained from National Centre for Atmospheric Research (NCAR). The Nino3 index which covers the area between 5° N - 5° S latitude and 150° W - 90° W longitude is often used an index of SST anomalies associated with ENSO cycle (WMO, 1996).

Each station's 48 year seasonal and annual mean coefficient of variation was determined. This is defined as:

$$COV = 100^{*}\, SD / \overline{P}$$

where, SD is the standard deviation defined as:

$$SD = \left((N-1)^{-1} \sum_{i=1}^{n} (P_i - \overline{P})^2 \right)^{1/2}$$

and P_i is the monthly precipitation, and $\overline{P}$ is the temporal mean for n years.

The non-parametric Mann-Kendall (M-K) rank correlation test (Sneyers, 1990; and Schonwiese and Rapp, 1997) was used to detect any possible trend in precipitation series, and to test whether or not such trends are statistically significant. A detailed assessment for testing of climate data unevenly distributed in time and a comparison of methods for estimating the significance level of trend can be found in recent study performed by Huth (1999). The M-K test statistic $u(t)$ is a value that indicates direction (or sign) and statistical magnitude of the trend in a series. When the value of $u(t)$ is significant at the 5% significance level, it can be decided whether it is an increasing or a decreasing trend depending on whether $u(t)>0.0$ or $u(t)<0.0$. A 1% level of significance was also taken into consideration. In order to obtain such a time series plot, sequential values of the statistic $u(t)$ was computed from the progressive analysis of the M-K test. Following Sneyers (1990), this procedure is formulated as follows: first, original observations are replaced by their corresponding rank y_i, which are ranged in ascending order. Then, for each term y_i, the number n_k of terms y_j preceding it ($i>j$) is calculated with ($y_i > y_j$), and the test statistic t_i is written as

$$t_i = \sum_{k=1}^{i} n_k$$

The distribution function of the test statistic has a mean and variance derived by

$$E(t_i) = i(i-1)/4 \quad \text{and} \quad \mathrm{var}(t_i) = [i(i-1)(2i+5)]/72$$

Values of the statistic $u(t_i)$ are then computed as

$$u(t_i) = [t_i - E(t_i)] / \sqrt{\mathrm{var}(t_i)}$$

The test statistic $u(t_i)$ is:

$$u(t_i)_t = \pm t_g \sqrt{\frac{4N+10}{N(N-1)}}$$

Here t_g is the value of at the probability point in the Gaussian distribution appropriate to the two-tailed test. Finally the classical correlation method was used to detect the relationship between precipitation over Mediterranean region and ENSO. Programs for all computations and statistical analyses were prepared using the FORTRAN programming language. The interpolation method of minimum curvature was used in order to produce the contours shown on the spatial distribution maps. It was applied to the resultant coefficient of variation, test statistics *u(t)* of precipitation trends from the M-K test, and correlation coefficient by means of a mapping package.

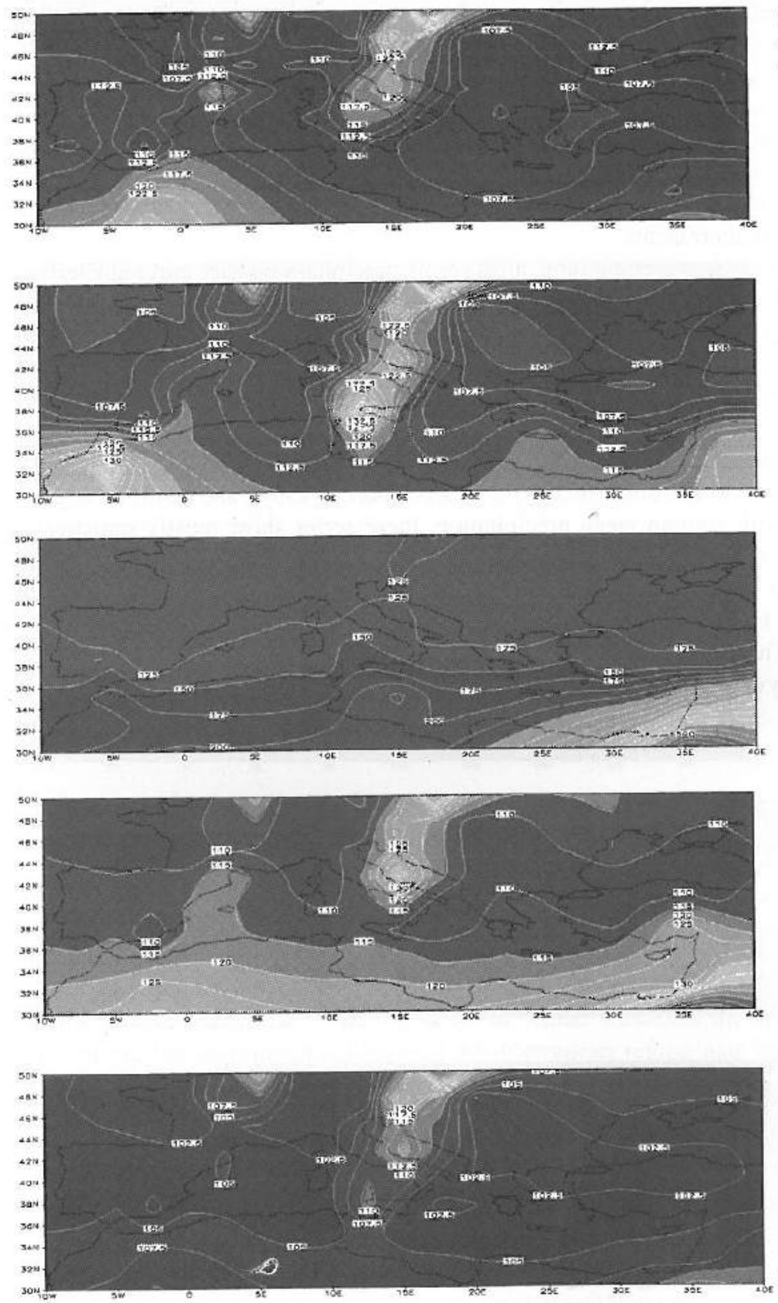
COEFFICIENT OF VARIATION

In order to deduce a clear and representative analysis of the rainfall in Mediterranean, the coefficient of variation (COV) is adopted to assess the durability and stability of the precipitation regime in all climatic regions of the Mediterranean. The COV is a good way to evaluate variability of precipitation and a better indicator of predictability for rainfall. Also, the COV offers an indication of the reliability of the average. The higher the COV the less reliable the average is, and the lower the more dependable.

The coefficient of variability distribution over Mediterranean of a) winter, b) spring, c) summer, d) autumn, and e) annual mean are presented in Figure 1. In Figure 1a for winter, the COV is much lower in east and central west Mediterranean than it is for central to the north and southwest Mediterranean regions. This indicates that the winter precipitation for east and central west Mediterranean is more predictable than the rainfall for north and southwest Mediterranean regions. The results of COV in spring season, Figure 1b, seem to be similar to the results of COV in winter season. Summer seasons have different characteristics than the winter, spring, autumn, and annual (Fig. 1c). The standard deviation is very high and consequently high COV over the climatic regions (especially over southeast Mediterranean) reflects the high variability of the rainfall regime in Mediterranean regions. According to Radrigo (2002) precipitation increases during the winter season but decreases during summer in the southern Europe. However, the changes in winter, spring, autumn may be important because rainfall occurs predominantly in these season. In autumn season, Figure 1d, the COV over southern and central to the north Mediterranean regions experienced the greatest changes in variability, with COV values increasing more than 1.25. East and west Mediterranean regions experienced the decrease in variability. This pattern of increased variability in the southern and central to the north areas and decreased variability in the east and west areas indicate that there can be significant spatial differences in variability across the Mediterranean. The small range in annual COV for the most regions with the exception of central to the north area indicates that there is little spatial variability across Mediterranean regions (Figure 1e).

PRECIPITATION TREND

Mann-Kendal rank (M-K) statistics, which make no assumption about probability distribution for the original data, are tested for significance using a standard normal distribution. The spatial distribution pattern is not complex, even though the resultant test statistics M-K test give both negative and positive trends.



(a) Winter coefficient of variability

(b) Spring coefficient of variabilty

(c) Summer coefficient of variabilty

(d) Autumn coefficient of variabilty

(e) Annual coefficient of variabilty

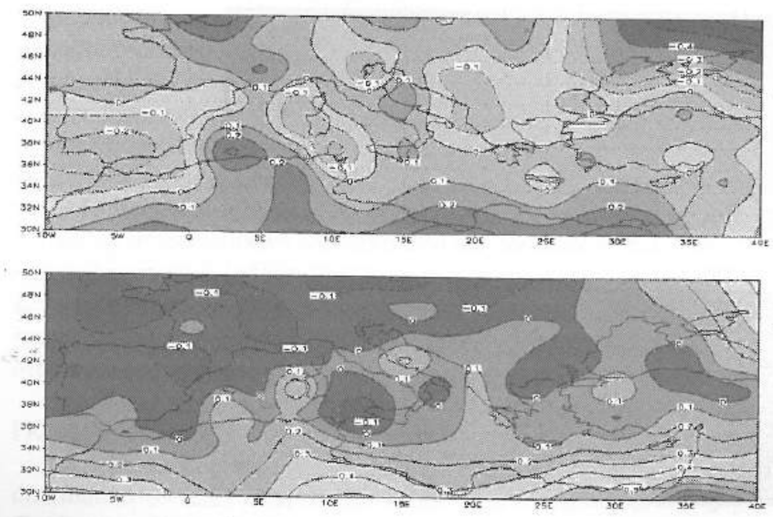
Fig. 1. The coefficient of variability distribution over the Mediterranean for a) winter, b) spring, c) summer, d) autumn, and e) annual mean

Lower U values indicate the absence of a significant trend and the mean can be considered independent of time. Figure 2 shows spatial distribution of the M-K test (u) in a) winter, b) spring, c) summer, and d) autumn precipitation.

In winter season precipitation, both weak negative and positive trends characterise the winter mean precipitation series. Gradually decreasing trends are evident over the northeast Mediterranean, whereas slightly increasing trends are found over the Southern Mediterranean. A precipitation decrease was observed as well during the last 48 years in the central-west Mediterranean.

For spring season precipitation, most spring precipitation series are characterised by a negative trend that is mostly insignificant. Increasing trends with high significance confidence level over southern Mediterranean are found. Summer season patterns of precipitation indicate stronger increasing trends are mostly observed in the southern Mediterranean area. On the other hand, decreasing trends that occurred are mostly insignificant and show an apparent spatial coherence over the most Mediterranean region.

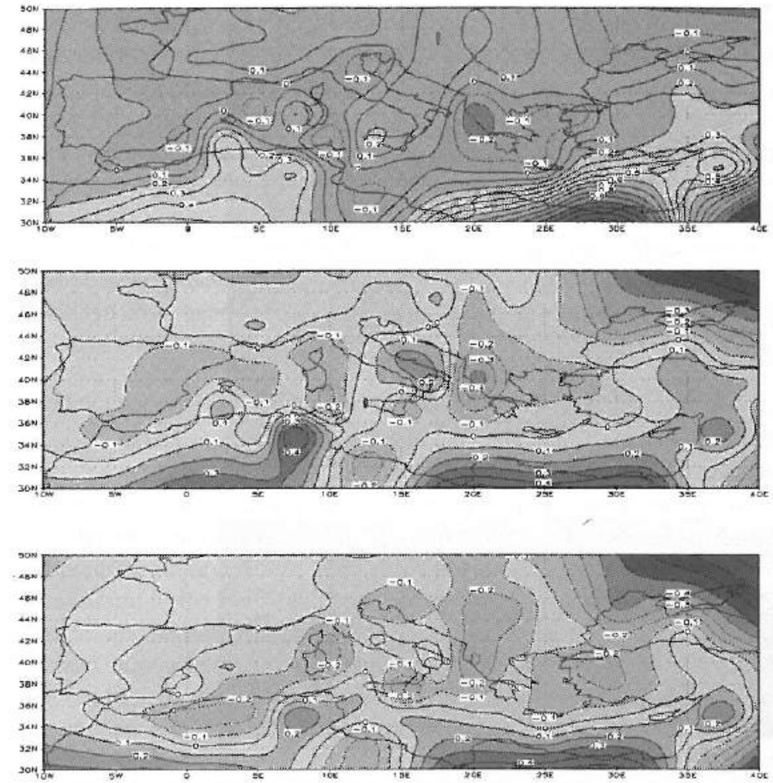
Autumn precipitation trends are not significant in most stations. Significant positive trends are evident over the north of Egypt, western part of Libya and north of Algeria (Figure 2d). As with autumn mean precipitation, these series show mostly statistically insignificant increasing and decreasing trends over much of Mediterranean. The slightly decreasing trends over northeast Mediterranean region appear with high significant confidence level. For annual precipitation, the behaviour pattern seems to be similar to the autumn season. These results agree with numerous researchers such as Maheras (1987), Maheras and Kolyva-Machera *et al.*, (1990, 1996), Palutikof *et al.*, (1996) and New *et al.*, (2001).



(a) Winter mean precipitation trend

(b) Spring mean precipitation trend

Fig. 2. Spatial distribution of the M-K test (u) in a) winter, b) spring, precipitation.



(c) Summer mean precipitation trend

(d) Autumn mean precipitation trend

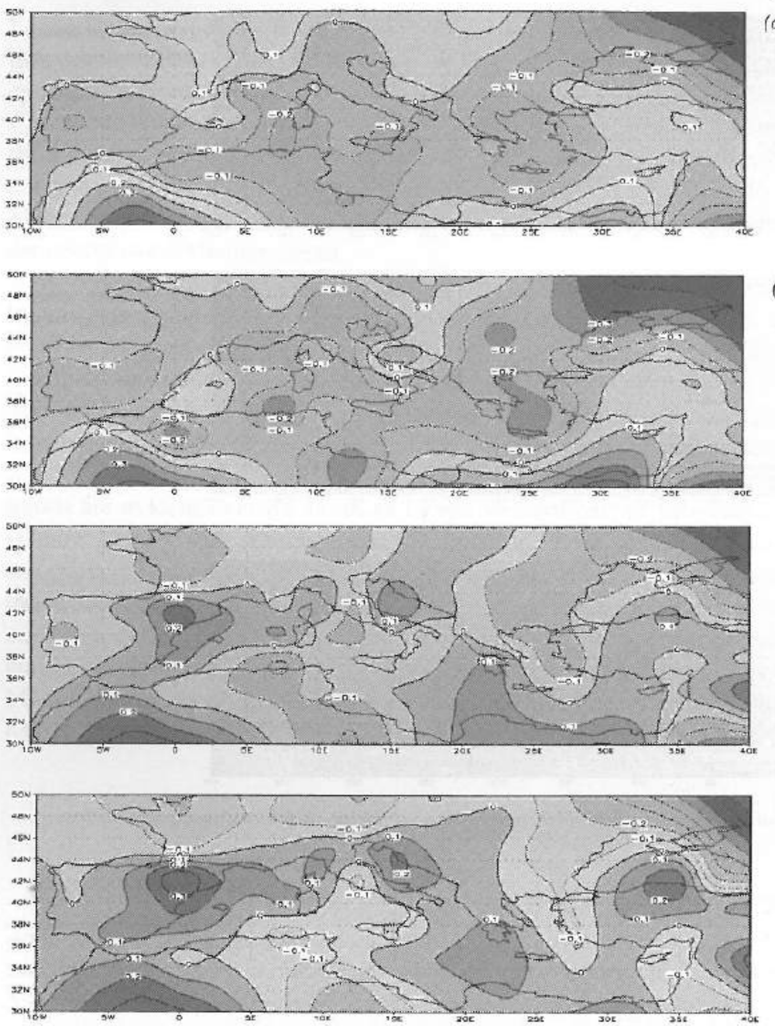
(e) Annual mean precipitation trend

Fig. 2. (cont.) Spatial distribution of the M-K test (u) in c) summer, and d) autumn precipitation.

PRECIPITATION AND EL NINO SOUTHERN OSCILLATION

The ENSO is the best-known mode of inter-annual variability and many studies attempt to relate precipitation patterns over the globe to the ENSO (Ropelewski and Halpert, 1996). To explore the consequence of the ENSO events on seasonal precipitation over Mediterranean region the SSTs anomalies of Nino3 was used. In order to detect the relationship between precipitation over Mediterranean region and EL Nino Southern Oscillation (ENSO) the classic correlation method was used.

For relationships between winter season precipitation and season ENSO, most relationships are negative and have a non-significant confidence level (Figure 3). So, no relationship between winter precipitation and ENSO over Mediterranean regions was found. This result is corroborated by Quadrelli *et al.*, (2001). From Figure 3b one can see that the relationship between winter precipitation and spring ENSO such as winter-winter relationship, Figure 3a. Winter-summer pattern of correlation, Figure 3c is the same approximately to winter-autumn pattern of correlation, Figure 3d.



(a) Winter

(b) Spring

(c) Summer

(d) Autumn

Fig. 3. Spatial distribution of the correlation coefficient between seasonal precipitation and seasonal ENSO

In general, the associations between spring precipitation and seasons of ENSO exhibit a positive relationship in the southern Mediterranean and this extends to the central and eastern Mediterranean regions in all seasons. Negative relationships between winter ENSO and spring precipitation occupies a large area in central western of Mediterranean. Positive correlation with a high significance confidence level is concentrated in the south and east part of the Mediterranean while most negative correlation is evident in central western Mediterranean.

Spatial distribution of correlation between summer precipitation and ENSO seasons was analysed. The analysis showed the behaviour pattern of the summer correlation was different than the other seasons (winter, spring, and autumn). In general a positive relationship is found in all regions of the Mediterranean. The most positive correlation a with high significant confidence level appears in all season mainly in France, Turkey, Greek, Israel and Syria. While a negative relationship with a high significant confidence level appears only in summer - spring in a small number of sites. Association between autumn precipitation and seasons ENSO is positive in the most Mediterranean regions with the exception northeast Mediterranean. Central western Mediterranean region are affected by ENSO in this season. A similar result was also extracted by Trenberth and Shea (1997). High negative correlation is found mainly in German and Turkey.

CONCLUSION

In this research, the precipitation observations for the seasons and annual period over the Mediterranean region have been examined to characterise the variability in precipitation and to explain the variations by finding teleconnections with EL Nino Southern Oscillation (ENSO). The results of coefficient variability indicate that, in general, the high temporal variability of rainfall is a distinguishing characteristic of the Mediterranean climate. The central to the northern region of the Mediterranean has the highest variability in all seasons and annually. Whereas central east and central west Mediterranean has the lowest variability in all seasons and consequently the average is more dependable and durable. The coefficient of variations is high in summer over all Mediterranean regions especially in the southeast region.

From trend analysis for the precipitation time series using Mann-Kendall test in the period from 1951 to 1998 one can conclude that; the behaviour pattern of precipitation over central and northern Mediterranean region over the period from 1951-1998 indicated a decrease in precipitation in all seasons and annually with the exception of Italy. Increase in total precipitation is observed over southern Mediterranean region in all seasons and annually. Both weak negative and positive trends characterise the winter mean precipitation series. Gradually decreasing trends are evident over the northeast Mediterranean, whereas slightly increasing trends are found over the southern Mediterranean. In winter, precipitation decrease has been observed during the last 48 years in the central-west Mediterranean. Decrease in spring precipitation series is observed but it is mostly insignificant. On the other hand, decreasing trends that occurred are mostly insignificant and show an apparent spatial coherence over most of the Mediterranean region. Autumn and annual mean precipitation series showed mostly statistically insignificant increasing and decreasing trends over much of Mediterranean. The slightly decreasing trends over northeast Mediterranean region were appearing with a high significant confidence level.

The main finding with regard to the relationship between seasonal precipitation and seasonal ENSO is that; no link was detected between winter precipitation and season ENSO over Mediterranean regions. The southwest Mediterranean region is affected by ENSO in winter and summer season with positive signs.

Positive relationship is found between spring precipitation and seasons ENSO in southern region of Mediterranean and extends to the central Mediterranean in the eastern region of Mediterranean. A negative relationship between spring precipitation and seasons ENSO is found over central western Mediterranean region and vice versa in autumn. While positive a relationship is found in southeast Mediterranean region in the spring season. With summer precipitation, the southwest and northeast Mediterranean regions are affected by ENSO with a positive sign. Autumn precipitation over German and Turkey countries has been affected by ENSO with negative sign.

ACKNOWLEDGMENT

The author wishes to thanks the National Centre for Atmospheric Research for providing station data of precipitation and sea surface temperature of El Nino3; the anonymous reviewers for their recommendations and comments; the Abdus Salam International Centre for Theoretical Physics, ICTP, for making available the computer for this work.

REFERENCES

CLIMATE RESEARCH UNIT (CRU) (1997) *Climate Monitor*, 24 (5). Norwich: Climate Research Unit.
DALY, R. (1991) *Atmospheric data analysis*. Cambridge University Press: Cambridge.
HURREL, J.W. (1995) Decadal trends in the north Atlantic oscillation: regional temperatures and precipitation. *Science*, 269, 676-679.
HUTH, R. (1999) Testing of trends in data unevenly distributed in time. *Theoretical and Applied Climatology* 64, 151-162.
MAHERAS, P. (1987) Temporal fluctuations of annual precipitation in Palma and Thessaloniki. *J. Meteorol.*, 12, 305-308.
MAHERAS, P. and KOLYVA-MACHERA, F. (1990) Temporal and spatial characteristics of annual precipitation over the Balkans in the twentieth century. *Int. J. Climatol.*, 10, 495-504.
NEW, M., TODD, M., HULME, M., and JONES, P. (2001) Precipitation measurements and trends in the twentieth century. *Int. J. Climatol.*, 21, 1899-1922.
NICHOLLS, N. *et al.*, (1996) Observed climate variability and change. In: Houghton, J.T., *et al.*, (Eds). Climate change 1995: *The science of climate change*. Report of IPCC working Group I, pp. 137-192. Cambridge, Cambridge University Press.
PALUTIKOF, J.P. and WIGLEY, T.M.L. (1996) Developing climate change scenarios for the Mediterranean region. In: Jeftic, L., S. Keckes, and J.C. Pernetta (Eds). *Climate change and the Mediterranean*. Volume 2, pp. 27-55. London: Edward Arnold.
RODRIGO, F.S. (2002) Change in climate variability and seasonal rainfall extremes: a case study from San Fernando (Spain), 1821-2000. *Theor. Appl. Climatol.*, 72, 193-207.
ROPELEWSKI, C.F. and HALPERT, M.S. (1996) Quantifying Southern Oscillation precipitation Relationships. *J. Climate*, 9, 1043-1059.
SCHONWIESE, C.D. and RAPP, J. (1997) *Climate trend atlas of Europe*. Based on observations 1891-1990. Kluwer, Dordrecht, The Netherlands.
SNEYERS R. (1990) *On the statistical analysis of series of observations.* World Meteorological Organisation (WMO), Technical Note, No. 143, Geneva, 192pp.
TRENBERTH, K.E. and Hoar,T.J. (1996) The 1990-1995 El Nino Southern Oscillation events: longest on record. *Geophys. Res. Lett.*, 23, 57-60.
TRENBERTH, K.E., T.J., and D. SHEA (1997) Atmospheric circulation changes and links to changes in rainfall and drought. Paper presented to: *Seventh conference on climate variation*, Long Beach, California, February 2-7, 1997, pp. J14-J17. Boston: American Meteorological Society.
QUADRELLI, R., PAVAN, V. and MOLTENI, F. (2001) Wintertime variability of Mediterranean precipitation and its links with large-scale circulation anomalies. *Climate Dynamic*, 17, 457-466.

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CO-EXISTENCE OF SEVERE DROUGHT IN INDIA AND EXTREME FLOODS IN BANGLADESH DURING THE 1987 MONSOON SEASON

By O.N. DHAR and S. NANDARGI
Indian Institute of Tropical Meteorology, Pashan, Pune 411 008

Abstract: The year 1987 was a severe drought year for India due to failure of summer monsoon over most of the country except for the seven sub-divisions of northeast India which received above normal rainfall. In the monsoon season of 1987, extreme floods in Bangladesh were caused by cross-border floods of three Indian rivers, namely the Brahmaputra, the Ganga and the Meghana and due to heavy monsoon rains over Bangladesh. This study has also confirmed that in some years, during summer monsoon season, there is an inverse relationship between rainfall over northeast India and rest of India.

INTRODUCTION

Mirza (2003) in his flood study stated that Bangladesh experienced three extreme floods in the years 1987, 1988 and 1998 which left a trail of devastation and human misery on an unprecedented scale. Of the above three years, the year 1987 is considered to be one of the five 'phenomenal' drought years in the adjacent India. The other four 'phenomenal' drought years of India being 1877, 1899, 1918 and 1972 (Kulshrestha, 1997). Apart from heavy summer monsoon (hereafter 'monsoon') rains, floods in Bangladesh were caused by large inflow of flood waters by the three major rivers, namely the Brahmaputra, the Ganga and the Meghana, which originate in north India and enter Bangladesh from three directions, the north, the west and the east respectively (Fig.1). In the event when simultaneous floods occur in all these three rivers, practically, more than 50% of Bangladesh gets inundated.

Due to large-scale failure of monsoon over India in 1987, severe drought conditions prevailed over most of the Indian region. The magnitude of monsoon rainfall deficiency over Indian region was estimated to be of the order of -19% of its long-period weighted average rainfall. Dhar and Nandargi (1989) have discussed floods in Indian rivers during the contrasting monsoon seasons of 1987 and 1988. During the severe drought which prevailed over India during the 1987 monsoon, it was found that some seven sub-divisions of northeast India experienced above normal rainfall while the remaining 26 sub-divisions were reeling under deficient rainfall. It appears that the heavy rainfall over northeast India and the consequent floods in its major rivers crossing into Bangladesh, caused extreme floods.

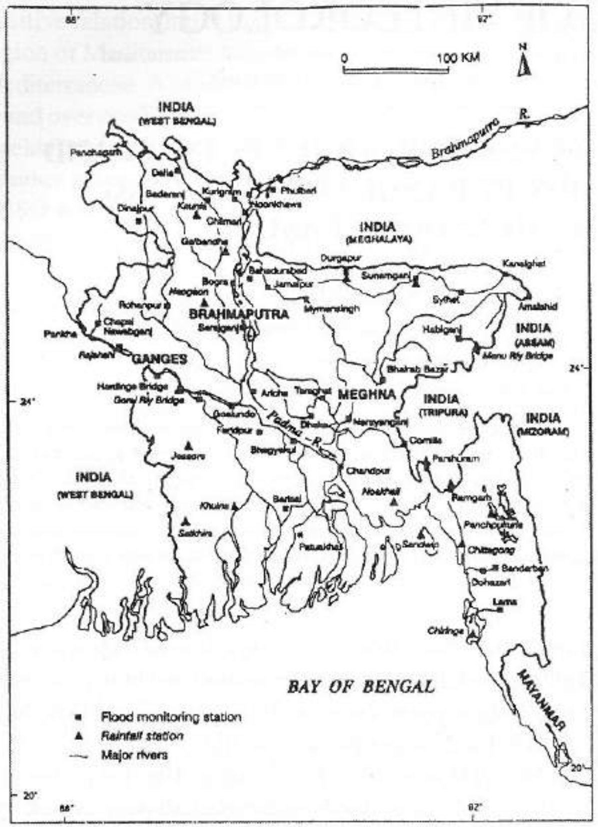


Fig.1. Map of Bangladesh showing rivers, rainfall and flood stations. (Courtesy: Mirza, 2003)

The aim of this study was to examine the co-existence of drought and floods in the Indian sub-continent during the summer monsoon of 1987.

THE INDIAN SEVERE DROUGHT OF 1987

Several researchers, Kulshrestha (1997), Sikka (1998), Rajendra Prasad *et al.* (2003) have studied in detail the 1987 monsoon failure in India. From their findings it is seen that the failure of monsoon was caused due to the following meteorological factors before and during the monsoon months:

a) The surface pressure was above normal over north India between Lat. 15°N to 28°N.

b) Persistence of anomalous anticyclonic vorticity in the lower troposphere.

c) Warm ENSO episode which had become significant from October-November, 1986 had reached its peak in June-July, 1987.

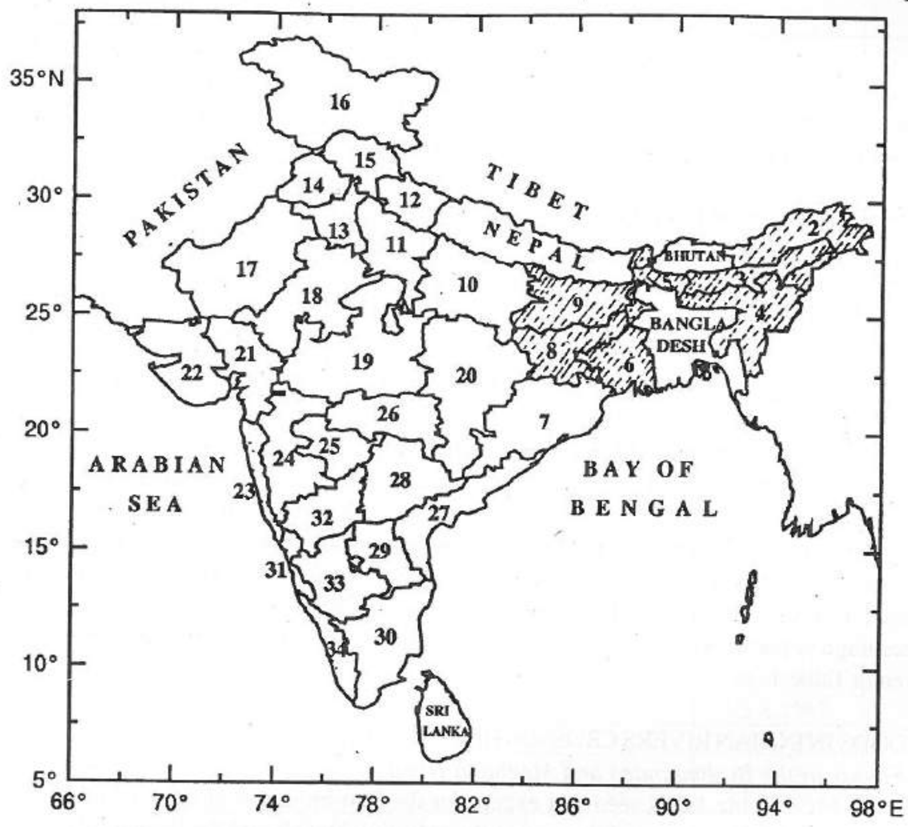
d) There was an absence of mid-latitude tropospheric cyclone (MTC) over the Arabia Sea.

e) The seasonal monsoon trough remained in its northward position close to the foot hills of the Himalayas for major part of the monsoon period, creating 'break' monsoon type situations.

f) Seasonal low pressure area over south Pakistan, also called the heat low over Sindh, was not well marked.

g) The upper level tropical easterly jet (TEJ) remained weak over the Indian peninsula.

h) The frequency of cyclonic disturbances, low pressure areas and depressions moving through the Indian area was below normal. Only 3 depressions mostly of land origin and 10 low pressure areas with short tracks moved through the Indian region.



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5 Sub–Himalayan West Bengal & Sikkim
6 Gangetic West Bengal
7 Orissa
8 Bihar Plain (Jharkhand)
9 Bihar Plateau
10 East Uttar Pradesh
11 Plains of West Uttar Pradesh
12 Hills of West Uttar Pradesh (Uttaranchal)
13 Haryana, Chandigad and Delhi
14 Punjab
15 Himachal Pradesh
16 Jammu and Kashmir
17 West Rajasthan
18 East Rajasthan
19 West Madhya Pradesh
20 East Madhya Pradesh and Chattisgarh
21 Gujarat region
22 Saurashtra and Kutch
23 Konkan and Goa
24 Madhya Maharashtra
25 Marathwada
26 Vidarbha
27 Coastal Andhra Pradesh
28 Telangana
29 Rayalaseema
30 Tamil Nadu and Pondicherry
31 Coastal Karnata
32 North Interior Karnataka
33 South Interior Karnataka
34 Kerala

Fig. 2: Map of India showing meteorological sub-divisions. Rainfall of shaded sub-divisions contribute to floods in Bangladesh.

Sub-divisions	June (%)	July (%)	August (%)	September (%)
Arunachal Pradesh	-36	89	45	63
Assam and Meghalaya	-24	32	-14	55
Nagaland and Manipur	32	-26	-9	35
Sub-Himalayan West Bengal & Sikkim	-6	12	84	15
Gangetic West Bengal	-29	52	47	23
Bihar Plateau	-55	12	17	27
Bihar Plains	-19	48	86	64

(Source : Mausam, 1988)

Table 1 : Percentage departures of rainfall from normal for 7 sub-divisions of northeast India

MONSOON RAINFALL DISTRIBUTION, NORTHEAST INDIA 1987

India Met. Dept. (IMD) has divided contiguous Indian areas into 33 meteorologically homogeneous sub-divisions mostly on the basis of rainfall, temperature, orography, etc.(Fig.2). It was found that during the monsoon period of 1987, 26 sub-divisions experienced deficient (-20 to -59%) to scanty (< -60%) rainfall and only 7 sub-divisions located in northeast India experienced normal (-19 to +19%) to excess (> +20%) rainfall. The percentage departures of rainfall from the long-term normal for these 7 sub-divisions are given in Table 1.

FLOODS IN INDIAN RIVERS CROSSING INTO BANGLADESH

a) Floods in the Brahmaputra and Meghana rivers:

From Table 1 it is seen that except for the first monsoon month of June, rainfall distribution was above normal in most of the sub-divisions except for the sub-division of Nagaland and Manipur for the month of July. These sub-divisions of northeast India (see Fig. 2) are geographically located around Bangladesh. The two major Indian rivers, of northeast India the Brahmaputra and the Meghana collect the drainage of these sub-divisions and also flow through some of these sub-divisions. As a result of heavy monsoon rainfall in these sub-divisions, which are by and large mountainous with steep slopes, severe floods were generated in these rivers which on crossing into Bangladesh caused major floods in that country.

b) Floods in the Ganga river:

The Ganga River has its origin in northwest India in the hills of Garhwal Himalayas. It passes through the states of Uttar Pradesh, Bihar, West Bengal and finally crosses into Bangladesh. The Ganga River has a good number of its major tributaries in the Himalayas. During the 'break' monsoon situations the Himalayan catchments of these tributaries get heavy to very heavy rainfall and cause severe flooding in them. Flood study of the Himalayan tributaries of the Ganga River has been studied by Dhar and Nandargi (2002). During 'break' monsoon situations, although, the north Indian plains are reeling under severe drought conditions due to weak monsoon, the Himalayan tributaries of Ganga bring heavy flood discharge which on flowing into the main river Ganga cause severe floods.

	River	G/D site	Deviation from D.L. (m)*	Date of occurrence
A)	Brahmaputra river and its tributaries in India			
1.	Brahmaputra	Dibrugarh	1.62	12.8.1987
		Nematighat	1.97	13.8.1987
		Tezpur	1.29	26.7.1987
		Guwahati	1.41	15.8.1987
		Dhubri	1.14	16.8.1987
2.	Burhi Dihing	Khowang	1.60	13.8.1987
3.	Dhansiri	Numaligarh	1.83	26.7.1987
4.	Kopili	Dharamtul	1.14	02.10.1987
5.	Subansiri	Badatighat	1.11	13.8.1987
6.	Pagladiya	N.T.Rd.Crossing	1.27	1.7.1987
7.	Manas	N.H.Crossing	2.00	1.7.1987
B)	Ganga river and its tributaries in India			
1.	Ganga	Gandhighat (Patna)	1.52	13.9.1987
		Colgong	1.41	18.9.1987
		Farakka	2.60	19.9.1987
2.	Bagmati	Hayaghat	3.24	14.8.1987
3.	Burhi Gandak	Sikandarpur	1.76	15.8.1987
		Samastipur	3.36	16.8.1987
		Rossera	3.72	16.8.1987
4.	Kamla Balan	Jhanjharpur	2.67	12.8.1987
5.	Kosi	Baltara	2.55	15.8.1987
6.	Mahananda	Jawa	2.11	14.8.1987
7.	Adhwara Group	Ekmighat	2.33	14.8.1987
8.	Sone	Koelwar	2.85	12.9.1987
		Maner	1.60	15.9.1987
9.	Pun Pun	Sripalpur	2.90	15.9.1987
10.	Mundeshwari	Harinkhola	1.41	29.8.1987
11.	Puthimari	N.H.Crossing	2.16	13.8.1987

Note: *a) Danger level (D.L.) at a particular Gauge/Discharge (G/D) site is the flood level which is above the warning level.

b) Similar flood data for the Meghana river are not available.

Table 2 : Highest flood levels recorded at G/D sites of Brahmaputra and Ganga rivers and their tributaries in India during 1987 monsoon

It has been seen that in the 1987 monsoon, Ganga was in high floods downstream of Patna (in Bihar) right up to the Bangladesh border. On its crossing into Bangladesh, cross border floods caused further deterioration in flood situation in Bangladesh as Brahmaputra and Meghana rivers had already caused severe flood inundation within Bangladesh.

In Table 2 flood levels at some prominent gauge/discharge (G/D) sites of the two major Indian rivers flowing into Bangladesh has been given up to the Bangladesh border in order to show that despite of drought conditions in rest of India, floods did occur in the Ganga downstream of Patna and also in the Brahmputra river up to Bangladesh border due to heavy rainfall in northeast India.

	Basin / Station	July		August		September	
		Rainfall (cm)	Deviation from normal	Rainfall (cm)	Deviation from normal	Rainfall (cm)	Deviation from normal
A)	***Brahmaputra basin***						
1.	Kurigram	870	415	607	310	311	15
2.	Kaunia	1555	1051	644	326	270	71
3.	Rangpur	1378	935	525	196	396	116
4.	Dewanganj	1062	602	535	217	425	181
5.	Jamalpur	865	425	702	339	604	351
6.	Dhaka	541	181	464	131	340	106
7.	Bogra	582	181	734	413	214	-23
B)	***Ganga basin***						
1.	Panchagarh	1149	313	1238	670	809	533
2.	Dinajpur	947	492	843	525	415	132
3.	Rajshahi	405	71	424	183	235	14
4.	Jessore	533	204	751	442	159	-80
5.	Kulna	570	200	666	365	168	-81
6.	Faridpur	424	87	375	75	433	189
C)	***Meghana basin***						
1.	Sylhet	1290	569	735	136	953	514
2.	Sunamganj	1629	219	690	-389	170	1105
3.	Molvi Bazar	584	132	490	99	209	-60
4.	Habibganj	548	146	443	50	276	21
5.	Durgapur	941	-89	659	51	629	103
6.	Chandpur	771	391	527	207	251	16

(Source : Mirza, 2003)

Table 3 : Monthly rainfall (cm) at some important stations in the basins of Brahmaputra, Ganga and Meghana rivers in Bangladesh during 1987 monsoon season

From Table 2 it is seen that the Brahmaputra and the Ganga rivers were in high floods in 1987 monsoon season. Cross border floods of these rivers were augmented by the heavy rainfall in the basins of these three rivers in Bangladesh. In Table 3, monthly rainfall magnitudes in the basins of these three rivers in Bangladesh is given for individual monsoon months of July to September for some important stations. It is thus evident that 'extreme floods' in Bangladesh were caused by the cross-border floods of the three Indian rivers and also due to heavy rainfall within Bangladesh.

INVERSE RAINFALL BETWEEN NORTHEAST INDIA AND REST OF INDIA

During 1987 monsoon, it is seen that in the northeast region of India and Bangladesh, there has been above normal rainfall activity while there was severe drought in the rest of India. Bedi and Bindra (1980), Shukla (1987), Sikka (2000) have briefly touched this aspect. According to them, in some monsoon years, like 1899, 1905, 1918, 1966, 1968 and 1974, there was above normal rainfall activity in northeast India while the rest of India has been experiencing drought like situation as happened in the 1987 monsoon. It, therefore, looks that in some years, there is some sort of inverse relationship between rainfall over northeast India and the rest of India. This requires in depth study to find out the possible meteorological factors responsible for the occurrence of this type of rainfall distribution in some years only. In Table 4 average weighted rainfall over northeast India and over India as a whole for the years mentioned above has been given to illustrate the point.

	NE India	All India	Difference	% departure (AI & NEI)
1899	164	63	-101	-161
1905	155	72	-83	-116
1918	179	65	-114	-175
1966	154	74	-80	-108
1968	154	76	-78	-104
1974	170	75	-95	-127

Table 4 : Monsoon rainfall magnitudes (cm) received in Northeast India and all India

CONCLUSION

The year 1987 was a severe drought year for the Indian region when the country experienced -19% deficient rainfall of the normal weighted monsoon rainfall. The area of the country under deficient monsoon rainfall was of the order of 64%. However, it was also seen that the seven sub-divisions in the northeast of the country received normal to excess rainfall the three Indian rivers which finally crossed into Bangladesh carried the flood waters into that country. During the 1987 monsoon months, Bangladesh itself experienced heavy to very heavy rains in the basins of these three rivers which aggravated the flood situation and due to that Bangladesh experienced one of the three 'extreme' floods in recent years. It was also observed that in some years in the past, some sort of inverse relationship has been experienced between the monsoon rainfall of northeast India and rest of India. Since this does not occur every year, in-depth study is required to find out under what meteorological conditions such a situation becomes repeated.

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REFERENCES

BEDI H.S. and BINDRA, M.M. (1980) Principal components of monsoon rainfall. *Tellus*, 32, 296-298.
DHAR, O.N. and NANDARGI, S. (1989) Floods in Indian rivers during contrasting monsoon seasons of 1987 and 1988. *J. of Hydrology*, 12, 1&2, 21-34.
DHAR, O.N. and NANDARGI, S. (2002) Floods study of the Himalayan tributaries of the Ganga river. *Meteoral. Appl.* 9, 63-68.
KULSHRESTHA, S.M. (1997) *Drought management in India and potential contribution of climate prediction*. Report No.1, Joint COLA / CARE Technical. Centre for Ocean-Land-Atmosphere Studies, Calverton, MD, USA, 1-105.
MIRZA, M.M.Q. (2003) Three recent extreme floods in Bangladesh, A hydro-meteorological analysis. *Natural Hazards*. Kluwer Acad. Publisher, Netherland, 28, 35-64.
SHUKLA, J. (1987) Interannual variability of monsoon. In, *Monsoon* Eds. J.Fein & P.L. Stephens, John Willey & Sons, New York, 399-464.
SIKKA, D.R. (1998) *Monsoon drought in India*. Report No.2, Joint COLA / CARE Technical. Centre for Ocean-Land-Atmosphere Studies, Calverton, MD, USA, 1-270.
SIKKA, D.R. (2000) *Monsoon floods in India*. Report No.4, Joint COLA / CARE Technical. Centre for Ocean-Land-Atmosphere Studies, Calverton, MD, USA, 1-154.

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A POSSIBLE BALL LIGHTNING WEBCAM RECORD FROM ZWOENITZ, GERMANY

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Abstract: Digital photography and computer Internet camera (web cam) technology make the documentation of ball lightning more probable, but alleged records should be examined as strictly as photographs. The author was contacted by two teenagers from Zwoenitz, Saxony, Germany, about a light phenomenon they had recorded via a web cam by chance on 19 April 2003. They assumed ball lightning. Data from telephone interviews, questions and answers via e-mail, a film inspection with video software and weather data are presented. Further international research and comment is recommended.

INTRODUCTION

Video or film documents of ball lightning are highly desirable, but practically nonexistent. Even valid photographic material is sparse. Published and examined documents in connection with ball lightning are listed by Barry (1980) and Stenhoff (1999). The January 1973 Aylesbury film is not thunderstorm-related. The 12 November 1976 Transvaal video from an automatic station pictured a detached round shape near the main channel of lightning (Eriksson, 1977). The 10 September 1989 Ashford video showed an internal reflection image of the camcorder (Jennison, Lobeck and Cahill, 1990; Meaden, 1990; Stenhoff, 1990; Bergstrom and Campbell, 1991). Recently, Abrahamson published the Australian film of a very large 5 minute object "presumed to be ball lightning" (Weiss, 2002). The widespread use of digital photography and web cams makes the accidental documentation of ball lightning more probable, but forthcoming records should be examined as strictly as alleged ball lightning photographs in the past.

THE ZWOENITZ, SAXONY CASE

On 22 April 2003, an e-mail message was sent to the author:

"Dear Dr. Keul, we have filmed a phenomenon during a thunderstorm which we assume could be ball lighting. We would like to have this video analysed by an expert. We hope to get an answer."

Attached was a 332 KB avi-file containing a video sequence of about eight seconds. The author asked for their telephone number and did a telephone interview on April 25. They were the two teenage children of a family from Zwoenitz, southern Saxony (Germany), 20 kilometres south-southwest of Chemnitz and 20 kms from the Czechian border. The family lived in an apartment block near the centre of the small town. [The family desired anonymity].

In the evening of 19 April 2003 the young man had fixed his web cam to the back of a chair. It was pointing eastwards through the closed room window on the third floor to record possible lightning. The sky was overcast, some thunder of discharges less than 1 km distant, but no rain fell. The web cam soundtrack was set to zero. The web cam recording started at 6:44 pm CEST (Central European Summer Time, UTC +2 hrs). The young man left the room to eat and returning after four minutes, stopped the recording. Looking through the web cam video later, his sister found a moving light source on the film.

INITIAL EXAMINATION

On the video sequence, the flat roofs of other prefab apartment blocks are visible under a dark, cloud-covered sky. After four seconds, half of the avi-file, a yellow-orange, bright light source rapidly moves upwards in the sky, following an undulatory, unsteady track with jerks and two brightness maxima before it dims out or disappears into clouds after two seconds. The jerky, wavy and blurred appearance let the author first think of a reflection similar to that experienced in a train window for example.

DATA PROCESSING

More data were forthcoming via e-mail. The web cam used was a three year old Mustek WCam300 with a 1/3 inch colour CMOS sensor of 640x480 pixels maximum resolution. The camera had manual focus, fixed f-stop of 2.0, auto exposure, auto white balance and a built-in microphone. The view angle is under 54°. To record and process the digital data, the teenagers used VirtualDub 1.51 with DivX compression. The 19 April record had a frame rate of 15 fps (frames per second). The computer connected to the Mustek web cam via USB cord was a Toshiba notebook with 200 MHz and 64 MB RAM.

Video recorders take 25 frames per second. The Mustek frame rate of 15 fps with maximum resolution meant that 10 possible video frames per second are lost. System capacity leads to a lower data rate being captured and saved to disk. The phenomenon is called "dropped frames" in digital video processing and causes synchronisation problems, image jerks and soundtrack stutters. The young web cameraman wrote:

"Had I used JPGL instead of RBG24, and 320x240 instead of 640x480, it should have resulted in 30 fps and no dropped frames. But it was just a recording experiment with the notebook..."

The 19 April file has a time line. 4 minutes and 3 seconds were recorded from 6:44 until 6:48 pm CEST. On the full 2.49 MB film record which was also sent to the author, the bright object becomes visible on frame 45.19, i.e. 45 seconds after the web cam record started, and disappears after frame 47.24.

The web cam was 80 centimetres from the closed window, somewhat tilted vertically (the frame looks like 20°), but distortion was minimal and the double-glazing window clean and dry. A dark shape visible in the left-hand upper corner is an adjustment stick for the Venetian blinds. From the orientation of the right flat rooftop it is obvious that the web cam axis was slightly (about 1°) tilted to the left. The family lives in five-storey prefab blocks typical for former GDR housing. In-between the blocks captured on film is a meadow with small trees and a playing ground, but no road with traffic. The blocks are an extension of the small town into open, hilly countryside 500 to 700 metres above sea level.

No other visual report was forthcoming in spite of two local press calls. A minor railroad line and a high-tension power line run south-north west of the location. The camera pointed into the east. Its direction is shown in a daylight photo (Figure 1). No airfield or military installation is near. No fireworks or festival took place in the community. One of the teenagers, together with the manager, even went onto the flat roof of the block visible below the light source. The rooftop protrusions are exhaust air chimneys. No damage was found.

Fig.1 Zwoenitz web cam direction in a daylight photo.

The two teenagers go to local secondary schools. First a bit taciturn, they were highly cooperative and competent, sent 20 digital photos of the camera position, views from the window and from the opposite rooftop, a local map, an aerial photo, web cam details and five short web cam films to test effects of camera motion and reflections. The teenagers were not interested in money and/ or publicity, which would have been a motive for fabricating a hoax, but wanted to keep the video out of the media until it was properly analysed. Their parents were also interested in the event.

FILM INSPECTION WITH VIDEO 2.0 DELUXE

The 332 KB file "Kugelbitz.avi" received as an e-mail attachment was examined with the video software program Video 2.0 deluxe from Magix. The program offers a timeline for digital video post-production. The original file remained unchanged and was inspected as a loop as well as frame-by-frame. The Video 2.0 software counts from frame 00 until 24 every second, i.e. frames follow every 40 milliseconds (msec). The whole avi-file "Kugelbitz" runs for 16 seconds plus 8 frames. It is empty after frame 8-02 (=second 8, frame 2). Avi file information says it was recorded with 640x480 resolution, a 10 kBit/sec data rate, 24 Bit video file and MS-MPEG4 V2 compression.

The web cam first recorded a stationary scene with two apartment block flat roofs low in the frame and a dark, overcast sky. In a frame-by-frame analysis, the sky remains empty until frame 04-10. Frame 04-11 shows a blurred light source rapidly rising over or behind the right rooftop. It increases in brightness in frame 04-12 with a track nearly vertically upwards. Frame 04-14 shows an upward leap of the light source, still blurred and flaring up brightly. Figure 2 shows a frame 04-15 snapshot. It is very bright until frame 04-17 when it moves on and decreases in brightness on frame 04-18. Frame 05-02 shows another jerk of motion and a moderate rise in brightness. The light source is clearly oval on frame 05-04 and again decreases in brightness with frame 05-07. A third brightness maximum is reached between frames 05-19 and 05-23. Figure 3 is a frame 05-20 snapshot. The dimmer light source, blurred again, seems quasistationary between frames 06-00 and 02, and 06-04 and 07. It moves on slower, possibly due to perspective, until frame 06-15, gets very dim, as if entering clouds, on frame 06-16, and is invisible on frame 06-17.

Fig.2 Frame 04-15 snapshot of the Zwoenitz video (Original in colour)

Total visibility counted in frames lasts from 04-11 until 06-16 - 56 frames covering two seconds and 240 msec. As the Mustek WCam300 view angle lies under 54°, the angular track leads about 30° into the picture and ends at about 30° elevation in the sky. There are no good cues to estimate the distance of the light source.

The boy operating the Zwoenitz web cam later wrote a program to get superimpositions of the 56 frames on one image (Figure 4). Processing further distorted the light source, but what is clearly discernible is the undulatory trajectory deviating from a parabola, the two flare phases and the three jerks (marked "x" - frames 04-13 to 04-14, 05-01 to 05-02, and 06-23 to 06-24) where the light source seems to jump.

The frame-by-frame analysis identified other discontinuities of motion. The light source appears immobile from frames 04-12 to 04-13, 04-15 to 17, 04-19 to 22, 04-24 to 05-01, 05-03 to 04, 05-07 to 08, 05-10 to 13, 05-15 to 16, 05-17 to 18, 05-20 to 22, 06-00 to 02, 06-04 to 07 and 06-11 to 15. Flare phenomena, undulations and motion discontinuities point to a quick, somewhat random physical process. The avi soundtrack file shows 0 dB as the film was recorded in sound off-mode. Amplifying the soundtrack by +20 dB with Video 2.0 deluxe, continuous electrostatic crackling is heard.

Fig.3 Frame 05-20 snapshot of the Zwoenitz video (Original in colour)

WEATHER CONDITIONS

The German weather service DWD recorded a flat high over Scandinavia with Germany on its south border on the 6 UTC ground map of 19 April. At 18 UTC, the warm front of a low over France had reached southern Germany with showers and thunderstorms on the ground map. This warm front was almost stationary on the 0 UTC ground map of 20 April. Dresden-Klotsche station reported light rain, rain showers and an evening thunderstorm on the 19 April. Barometric pressure was falling, evening wind speed between 10 and 15 mph. Chemnitz station reported falling pressure, easterly winds around 15 km/h, only one hour of sunshine, 8 degrees C maximum and 95% relative humidity.

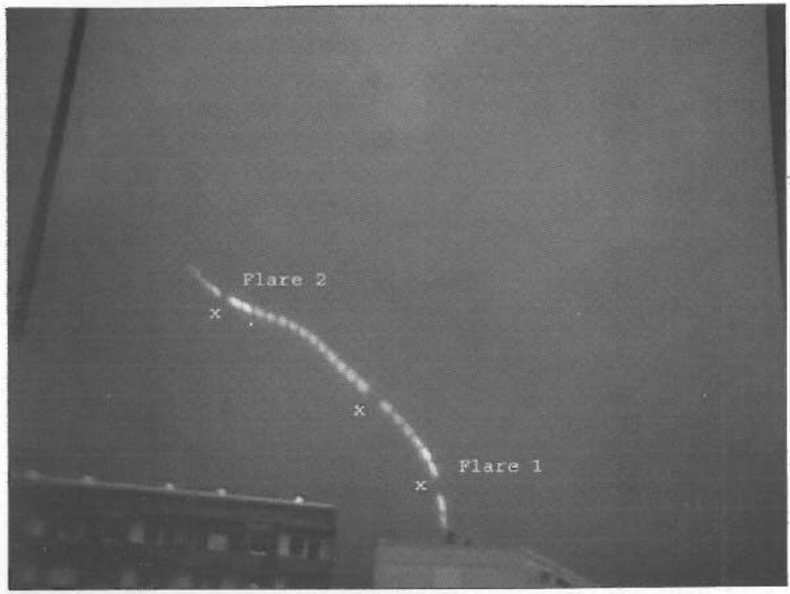

Fig.4 Superimposition of the 56 Zwoenitz video frames.

The Sfloc spherics record for 19 April showed a cluster of discharges in Czechia and Saxony between 17 and 21 UTC. Activity started over the Czechian border with 20 discharges per 30 minutes and, moving northwards, diminished to 10 discharges per 30 minutes and some single discharges. Radiosonde data from the local station 10468 Oppin showed NE to E wind up to 1.000 m, a CAPE of 0.00 and precipitable water of 13.28 on April 19, 12 UTC. On 20 April, 0 UTC, up to 1.000 m, winds blew from NE to NW. The CAPE remained at 0.00, precipitable water at 13.08. It was bad weather, overcast, with embedded rain showers and scattered lightning discharges, but not very active thunderstorm conditions.

FURTHER RESEARCH

Similar as with alleged ball lightning photographs, the critical analysis has to use an explanation per reductionem approach (Keul, 1993). A meteor does not appear below clouds of an overcast sky. Ordinary lightning? The Zwoenitz video was shown to Dr.Gerhard Diendorfer, electrical engineer and director of ALDIS, the Austrian Lightning Detection and Information System. He said that it has nothing to do with cloud-ground lightning (Diendorfer, 2003). Reflection - what could have reflected in the dark window causing the intricate track? A short video with the Zwoenitz web cam was produced to check the effect of room illumination (which was off on 19 April). It is a line of four stationary white blobs of light that go on and off. Fireworks are not very likely on a rainy evening with lightning. There was no festival. The light source on film neither resembles a fireworks rocket nor a signal flare fired from a pistol. This type of explanation has been discussed at length about the St. Gallenkirch ball lightning photograph (Keul, 1992, 1993, 1996). A 1992 time-exposure of a small flare (Keul, 1993) also has nothing in common with the Zwoenitz trajectory. Flares show parabolic, ballistic trajectories, not waves.

Military flares often exhibit an upward/rising and a downward/falling trajectory part. The Zwoenitz object moves upwards following an undulatory, almost irregular track. Two marked light bursts are visible on the superimposition picture (Fig. 4). The colour temperature is in the yellowish area, getting whiter when flaring up. No blue-white, as in lightning photographs, is present. Like the Montafon alleged ball lightning photograph (Keul, 1992, 1996), this again looks like low energy.

In a statistical evaluation of 152 German ball lightning cases (Keul & Stummer, 2002), Saxony had the highest number of spontaneous witness reports (16%). 87% of the German cases were recorded in summer, mostly from 1400-1800 hours. The duration median was 5 seconds. 55% were yellow or orange, 1% moved upwards, 2% with a jerky, 1% with an oscillating secondary motion. Therefore, the Zwoenitz video shows a light source under thunderstorm conditions, compatible with German ball lightning, but with rare motion characteristics. To finally distinguish phenomena on the Zwoenitz film into artefacts of data processing and captured real-world, the expertise of a professional video analyst is necessary. There are frames with a blurred light source (e.g. 04-11) and some with a rather clear shape (e.g. 05-04). What was the motion of the light source without "dropped frames" jerks? What are the chances that this could be a mundane terrestrial light source? The advantage of the Zwoenitz, Saxony, case is that the technical production conditions of the film are well-known. Therefore, a convincing solution will not come from the theorist's armchair, but from an empiricist willing to test his explanatory hypothesis with identical computer equipment. Further international analysis of the document is encouraged. 30 snapshots of different phases were exported as bmp-files. A selection of 11 single frames is available for further inspection by interested experts as jpeg-files (640x480, 96 dpi) together with the avi video file via the author.

REFERENCES

BARRY, J.D. (1980) Ball lightning and bead lightning. New York: Plenum.

BERGSTROM, A. and CAMPBELL, S. (1991) The Ashford "ball lightning" video explained. *J. Meteorology* (U.K.), 16, 185-190.

DIENDORFER, G. (2003) *Personal communication*. May 12.

ERIKSSON, A.J. (1977) Video tape recording of a possible ball lightning event. *Nature*, 268, 35-36.

JENNISON, R.C., LOBECK, R.C. and CAHILL, R.J. (1990) A video recording of ball lightning. *Weather*, 45, 151-152.

KEUL, A.G. (1992) Possible ball lightning colour photograph from St. Gallenkirch, Vorarlberg, Austria. *J. Meteorology* (U.K.), 17, 73-82.

KEUL, A.G. (1993) What is a ball lightning photograph? Reply to R. White's comment. *J. Meteorology* (U.K.), 18, 257-259.

KEUL, A.G. (1996) Ball lightning photographs - testing the limits. *J. Meteorology* (U.K.), 21, 82-88.

KEUL, A.G. & STUMMER, O. (2002) Comparative analysis of 405 Central European ball lightning cases. *J. Meteorology* (U.K.), 27, 385-393.

MEADEN, G.T. (1990) Preliminary analysis of the video recording of a rotating ball-of-light phenomenon which happened at Ashford, Kent, in England on 10 September 1989. *J. Meteorology* (U.K.), 15, 128-140.

STENHOFF, M. (1990) Comments on video tape of a possible ball lightning event at Willesborough, Ashford, Kent on 10 September 1989. *J. Meteorology* (U.K.), 15, 141-143.

STENHOFF, M. (1999) *Ball lightning*. New York: Kluwer-Plenum.

WEISS, P. (2002) *Anatomy of a lightning ball*. Science News Online, 161 - www.sciencenews.org/0020209/bob8.asp

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SHORT COMMUNICATION

VIDEO ANALYSIS OF THE ZWOENITZ WEBCAM DATA

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Abstract: A web cam video filmed by two teenagers at Zwoenitz, Saxony, Germany, on 19 April 2003, was obtained on CD-ROM from the copyright holders by Alexander G. Keul in September 2003 and analysed at the Salzburg University of Applied Sciences and Technologies, School of Digital Television and Interactive Services. The authors, a director for video, film and post-production, and a cameraman, tested the web cam data file for possible fabrication and falsification. No signs of compositing or other video post-production were found in the analysis. A brownish haze was detected around the object when enlarging the single frames for analysis.

GENERAL REMARKS

Various compression algorithms are used for the digital recording of pictures and sound. These codecs (code-decode) help to reduce the data volume when recording or transmitting the digital document. Only the original codec used to encode the data record guarantees optimum reproduction/playback quality. In the case of the Zwoenitz webcam video, the free Microsoft MPEG4 V2 Codec (short name: mp42) was used.

Every record produced with a web cam is compressed video material. A frame rate lower than 25 fps means that the codec will automatically duplicate frames which gives movements on the resulting 25 fps video a jerky quality. Applications that run on the PC simultaneously with the web cam, such as an on-line provider, antivirus software, multimedia applications, time management systems, auto-update etc. will cause overload and disturb the stable video flow via the bus system of an average home PC. Therefore, frames will be left out or "dropped" during the recording. This produces gaps in the video recording of motion.

MATERIAL AND METHODS

Alexander G. Keul informed the authors about the Zwoenitz web cam recording allegedly showing ball lightning (pp168-173). To get a good data file for our analysis, we asked him, when field investigating the case in September 2003, to let the Zwoenitz teenagers duplicate the original .avi file on CD-ROM. The original file would show mp42 compression, but no additional compression used to send (parts of) the material via the Internet. The CD-ROM brought to Salzburg contained a video file capture.avi with a file size of 9.24 MB, a total duration of 0:04:03:29, an average data rate of 38,83 KB per second and an image size of 640x480 pixels. Pixel depth was 24 bits, frame rate 25 fps. The video track size was 6.50 MB (average frame=1.52 KB), with 16 key frames, 3040 delta frames, 3037 empty frames and some dropped frames.

The audio track size was 2.55 MB with a rate of 11025 samples/second and an 8 bit sample size. Our subsequent analysis of the Zwoenitz video file dealt with the video track and used standard Premiere Pro and Photoshop 7.0 tools.

FRAME SUCCESSION ANALYSIS (MATCHING)

The first step of our analysis converted the mp42 video stream into single frames. As the luminous object has no smooth linear motion in the video, we started a succession analysis (=matching) of the single frames to reveal possible compression artefacts and errors. The luminous object on the Zwoenitz video lasts 58 frames from its emerging until its complete fade out. 31 frames were recorded, 3 frames dropped - the dark gaps in the trajectory (see Keul, p.172 Fig.4). Of the 31 frames, 17 were recorded as single frames. Other 5 frames were recorded twice, 5 frames were recorded three times, 4 frames were recorded four times. This gives the total of 58 frames. Only 12-14 frames per second were originally recorded and automatically duplicated by the mp42 codec to fill the 25 fps timebase with video information.

The jerks and gaps visible in the capture.avi file are not due to irregularities of the moving luminous object but are caused by the mp42 compression as well as by an overload of the PC bus system resulting in dropped frames. In a fabrication, the dropouts and irregular intervals would have to be added deliberately. But why? As they reduce the visual quality of the Zwoenitz record, they can be interpreted as evidence for a genuine web cam recording.

FRAME CONTRAST ANALYSIS

After the frame matching of single Zwoenitz frames we performed a frame contrast analysis. Eight frames of the record were picked out in Photoshop 7.0, enlarged and examined via colour picker and pixel marker. To detect possible cues for compositing (assembling objects or animations into a video record via post-production) in the videostream, one has to look for marked contrast differences between elements of the luminous object and its environment in the video.

Figure 1 shows the very first webcam frame of the moving luminous object. The object area was cut out and enlarged. To prevent a loss of contrast at the object's edges, pixel repetition was selected at Photoshop 7.0, not bilinear or bicubic interpolation. The typical square pixel group pattern of MPEG codec operation is visible. The compression process groups together areas of the original picture that have similar colour/brightness values. The figures give RGB colour values of edge pixels selected. The RGB differences were moderate, which means that the luminous object does not show a high contrast to the environment (sky) typical for a post-production implementation.

What about an attempt to "iron out" RGB differences by several MPEG encodings after a possible compositing? A clue for several generations of compression would be size differences of the macro blocks (8*8, 16*16 pixels) and their colour reduction. However, such differences are not detectable in the pixel matrix of the Zwoenitz material. The same analysis was done with seven single frames of the Zwoenitz webcam video. The general results were the same.

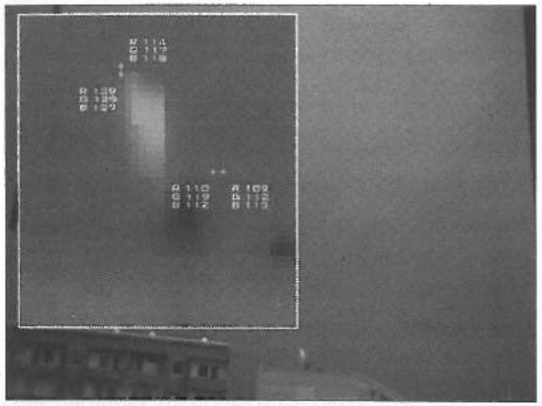

Figure 1. Contrast analysis of enlarged frame no.1 of Zwoenitz trajectory (Original in colour)

When enlarging the video frames, a brownish shape, haze or film is noticeable around the luminous object in all single frames. It is no compression artefact.

CONCLUSION

As video recording and post-production specialists, we have not tested hypotheses from the natural sciences, but concentrated on examining the possibility to fabricate the Zwoenitz film document, i.e. by implementing a strange object in post-production. A lens flare as origin of the luminous object does not seem very probable for us. Flares have a different appearance. What about a coincidental light reflection in the window pane? This is not very probable, either, because the luminous object enters the video frame from behind the mantelpiece of a rooftop chimney. This fit with the horizon does not look like coincidence or fabrication.

By close examination of the .avi frames in succession and via enlargement and contrast detection it became clear that the luminous object was not implemented and that an attempt to erase post-production traces by several compression runs is not detectable, either. We conclude that with a high probability the visual material of the Zwoenitz video was directly filmed. We do not speculate about the nature of the luminous object.

REFERENCE

KEUL, A.G. (2004) Possible ball lightning webcam record from Zwoenitz, Germany. *The Journal of Meteorology* (UK) Vol.29, No. 289, pp 168-173

JOURNAL OF METEOROLOGY

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SHORT COMMUNICATION

FURTHER RESULTS OF THE ZWOENITZ WEBCAM CASE

By ALEXANDER G. KEUL

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Abstract: A first report presented the web cam video from Zwoenitz, Saxony, Germany, of April 19, 2003 (pp. 168-173). A field investigation at the case location on 16-17 September 2003, studied the object trajectory, the case geography and sociology and obtained a CD-ROM copy of the original file to be analysed at the Salzburg University of Applied Sciences and Technologies (Schrattenecker & Baumegger, 2004 pp.174-176).

Lightning data of EUCLID, the European lightning detection network, data of the Vattenfall high-tension power grid and of a local rescue centre were linked with the case. A study of 29 enlarged and contrast-enhanced video frames revealed a dynamic "haze" phenomenon around the luminous object.

FIELD INVESTIGATION

First data reported about the Zwoenitz video case were gathered via e-mail and telephone contacts with the two teenagers who recorded the film. As a "remote diagnosis" is not desirable in such a complex case, family holidays of the author at Thuringia and Saxony were used to pay Zwoenitz a visit on 16-17 September 2003. After an interview with the teenagers (who desire anonymity to avoid adverse social effects) and their parents, the web cam site was inspected and trajectory measurements taken. A discussion with Joerg Lehmann, a local journalist, followed. On 17 September the author inspected the area where the object originated.

The window of the room at Zwoenitz is a standard double-glazing construction. As the closed window did not blur the author's view through binoculars, the windowpane cannot explain the semi-erratic path of the object on video. Figure 1 gives a panoramic view to the east. Tree groups, lawn and a playground lie between the apartment blocks. A grey square marks the rooftop chimney where the object first appears on the video. To get trajectory data, the filmed trajectory was marked on a transparent foil over the composite picture and mirrored down onto the building image to obtain measurement targets. The object trajectory started at 85° azimuth NESW (almost east) and 7° elevation. Using the targets it was found that the end of the visible trajectory was at about 70° azimuth and 20° elevation. This means that the trajectory had an angular length of 20 to 25°. Thus, the angular speed of the object in the sky had been at least 10° per second. For an assumed object distance of 100 meters, this would be 65 kilometres per hour, for 200 meters distance, 130 kilometres per hour.

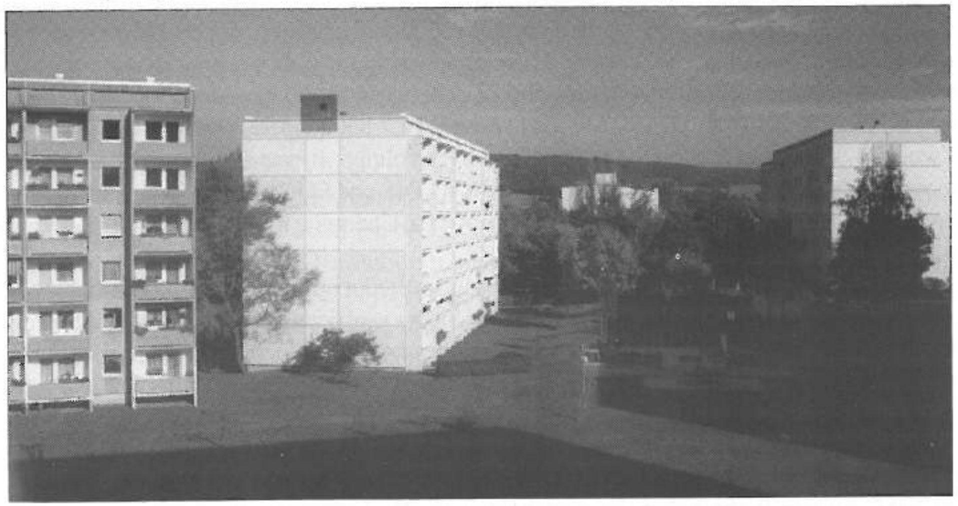

Fig.1 - View of the Zwoenitz surroundings from the web cam position. The grey square marks the starting point of the object trajectory.

CASE GEOGRAPHY

The surroundings are a typical East German new residential area with prefab high-rise blocks and small buildings and green spaces in-between. The 70°-azimuth ray runs over the rooftop of the opposite prefab block and over a kindergarten behind it, then over the next housing blocks. 300 m east of the camera position a storehouse of the Zwoenitz district heating company and of an energy systems corporation called Zeus is situated. 350 m WSW of the camera position, but 20° south of the trajectory onset, there is a production facility for lightning appliances.

Enquiries of Joerg Lehmann, journalist of "Freie Presse" at Stollberg, into the case revealed that at 6:45 pm CEST (Central European Summer Time), the Chemnitz rescue centre ("RLZ") - a regional coordination centre for fire, police and ambulance services - received a fire alarm from a fire alarm box at the Roth garden centre, Wehrgasse 2, Zwoenitz, which subsequently turned out as a false alarm (Lehmann, 2003). This company is situated at Niederzwoenitz, 1.700 m away from the camera position. 6:45 pm CEST is one minute after the object recording time on the Zwoenitz video. However, the teenagers said that the video recording time could have been 2 or 3 minutes wrong as the computer clock was not checked and reset before the 19 April video. Asked about the frequency of fire alarms going off during thunderstorms, a fire brigade official said that technical problems like over voltage in the grid were quite common (RLZ Chemnitz, 2003).

EUCLID LIGHTNING AND POWER GRID DATA

Dr. Gerhard Diendorfer, director of ALDIS, the Austrian lightning detection system and of the EUCLID data centre at Vienna, where lightning data from Luxembourg, Belgium, the Netherlands, Germany, Switzerland, Czechia, Slovakia, Poland, Hungary, Slovenia, Italy, France and Norway are collected and computed, was so friendly to print out lightning data recorded 20 kilometres around Zwoenitz on 19 April between 6:40 and 6:50 pm CEST (Diendorfer, 2003). In the ten minute interval, 13 lightning flashes occurred in the circular area - seven cloud-to-ground flashes and six cloud-to-cloud. Nine were negative, four were positive discharges. There was no recorded flash between 6:43:31 and 6:46:14 CEST. Then, two flashes at 6:46:14 and 6:46:15 with -11.8 and -14.7 Kiloampere, about 14 km WSW of Zwoenitz, were possible candidates for grid over voltage. It was a cloud-to-cloud flash, closely followed by a cloud-to-ground flash. As ALDIS and EUCLID use GPS time and are correct within a 3 millisecond interval, whereas RLZ Chemnitz uses computer time, a time difference of one minute looks not unusual.

The next investigation step critically inspected a possible transmission line over voltage as hypothetical origin of the Zwoenitz object via official records of the local energy supply company. The 110 and 220 kV power lines around Zwoenitz belong to the high-tension power grid of Saxonia operated by Vattenfall Europe Transmissions and its south regional centre at Chemnitz. According to the company, no internally or externally caused over voltage was present in the Saxony grid on 19 April 2003, between 6:30 and 7:00 pm CEST. No over voltage discharge was noticed (Meyer, 2003). Thanks to Alfred Geiswinkler, BEWAG Austria, for his help to locate the company. The hypothesis of a lightning-triggered grid over voltage is not supported by the Vattenfall data. Nevertheless, a local fire alarm started and cloud-to-ground flashes were present.

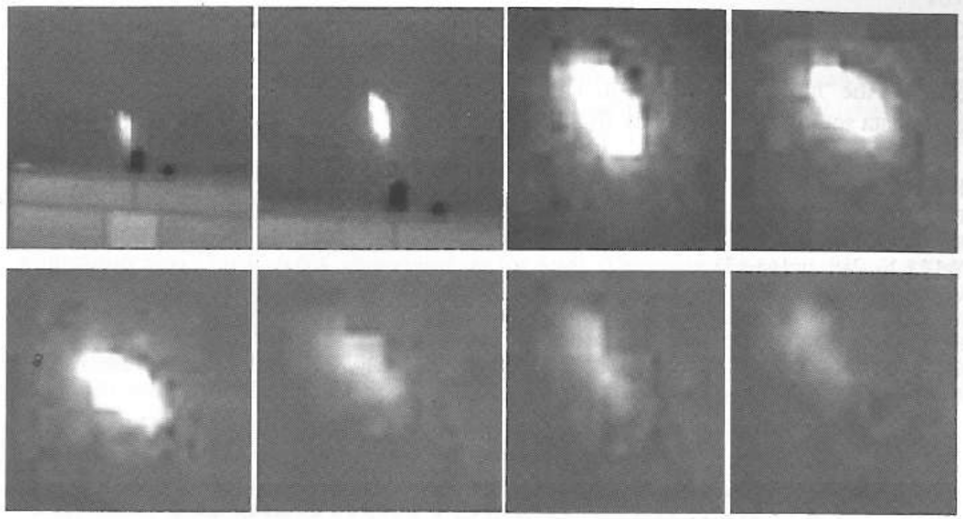

Fig.2. Enlargements of single Zwoenitz video frame sectors using Photoshop bicubic interpolation and manual overall tone adjustment. Enlarged frame sectors 4519, 4520, 4523, 4703 (top row), 4706 4711, 4712 and 4719 (bottom row) (Original in colour).

CASE SOCIOLOGY

Speaking to the two videographers (age group 15-20 years) and their parents in September 2003, the case sociology was examined. Both parents have a background of technical education, so the technical interest of their children should be no surprise. With good results in school and social contacts, no financial interest and the wish for anonymity, their milieu has no UFO flavour. Asked why he had left the room with the web cam running, the boy answered he was not allowed to eat at the computer keyboard. Coming back after the snack he stopped the recording. His sister later looked through the avi file and found the moving object. It was also her who contacted the author via e-mail three days later.

OBJECT DETAILS ON THE VIDEO

The video study of the Salzburg specialists (Schrattenecker & Baumegger, 2004) produced enlargements of eight exported video frames. Pixel repetition was selected to prevent a loss of contrast. The authors noticed that "a brownish shape, haze or film is noticeable around the luminous object in all single frames. It is no compression artefact."

The video analysts gave no physical interpretation of their interesting finding. To study the whole "haze" phenomenon, all 29 original (i.e. non repetitive) single frames of the Zwoenitz video were enlarged six times by Photoshop 6.0 - using bicubic interpolation for a smoother result - and enhanced with the manual overall tone adjustment. Figure 2 shows several frames. The thickness of the brownish "haze" varies around the luminous object and, at the last frames of the disappearing object, it is noticeable that "haze" structures detach from the object body and seem to scatter behind it. Detachment is also visible in other earlier frames.

Compared to single frames with enlargements of a magnesium match thrown across the camera field of the same web cam, in a later experiment the smoke gives a similar optical effect as the "haze" in the Zwoenitz video. If this object was ball lightning, we have a fine grain data set of its two seconds' flight.

REFERENCES

DIENDORFER, G. (2003) *Personal communication.* May 15 and November 12.
KEUL, A.G. (2004) Possible ball lightning web cam record from Zwoenitz, Germany. J. *Meteorology UK.* Vol.29 No.289, pp168-173.
LEHMANN, J. (2003) *Personal communication.* October 12.
MEYER, C. (2003). *Personal communication.* November 25.
RLZ Chemnitz (2003). *Personal communication.* November 12.
SCHRATTENECKER, R. & BAUMEGGER, S. (2004) Video analysis of the Zwoenitz web cam data. *J. Meteorology UK.* Vol.29 No.289, pp174-176

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THE WEATHER AT OXFORD IN 2003

By GILLIAN KAY
Radcliffe Meteorological Observer

In 2002, we reported that the year was generally wetter, warmer and duller than expected from past records. 2003 was again warmer than expected, but in contrast to the previous year it was also drier and sunnier.

January was a very sunny month, with 34.9 hours more sunshine than expected. This made it the brightest since 1952, and the second brightest since sunshine recording began in 1881. Rainfall was 28.9 mm above the expected value, but this was only the wettest since 1999. January was also slightly warmer than expected, in keeping with the general trend towards warmer winters seen at this site over recent years.

Temperatures in **February** were broadly as expected, but more unusual was the amount of sunshine and rainfall received. Although only the brightest since 1998, February 2003 was the 11th sunniest since records began in 1881 and enjoyed 0.9 hours more sunshine per day than expected. It has also been the 36th driest on record, and the driest since 1998. The season of winter as a whole was warmer, wetter and sunnier than expected. The mean temperature of 5.1°C was 1.1°C above the average, and there were 53.6 hours of sunshine more than expected. Although February was a dry month, the high rainfall of December 2002 and January 2003 gave a rainfall total of 46.9 mm above the long-period mean for the season.

March was warmer, drier and sunnier than expected. The mean maximum temperature of 13.3°C was 3.3°C above the long-period mean, making it the 7th highest mean maximum temperature ever recorded at the station (records began in 1881), and the highest since 1997. With 1.3 hours of sunshine per day over the expected value, March 2003 was the 15th sunniest on record, and the brightest since 1995.

April saw more temperature variation than expected from the long-period means, with warmer maximum and lower minimum values recorded. The absolute maximum air temperature was 27.6°C, 6.6°C above average for April. The mean air temperature of 9.8°C was 1.6°C above average, in keeping with a trend seen in values of this parameter over the last few years. Following on from February and March 2003, April was drier and sunnier than expected, with just 36.8 mm rain and a total of 169.8 hours of sunshine. This makes April 2003 in Oxford the driest since 1997, but only the brightest since last year.

May was an unexceptional month in comparison to the long period data. Temperatures, following recent trends, were of the order of a few degrees above the expected values. Rainfall, sunshine and wind records for May 2003 were very close to the long period means. Spring 2003 was sunnier, warmer and drier than expected from the long-period means. Mean air temperature for the season was 1.5°C above average, there were 60.2 hours of sunshine above the expected, and the season's rainfall total of 110.1 mm was 24.7 mm below average.

June was a warmer and sunnier month than expected, with all temperature measures over 1 degree higher than the long-period mean data. The 213.6 hours of sunshine gave Oxford half an hour more sunshine on average per day than expected from the long period mean. **July** was warmer than expected, with relatively average amounts of rainfall and sunshine. The absolute maximum temperature of 32.5°C was 4.6°C above the long-period mean, and was the 6th highest on record for July and also the 15th highest temperature ever recorded at the station. The absolute minimum air temperature of 10.2°C was the highest ever recorded during July, and follows a general trend towards higher minima seen over the last decade.

August was very warm, sunny and dry compared to the long-period mean data for the month. The absolute maximum temperature of 35.6°C (recorded on the 9th of the month) was the 4th highest recorded at the Radcliffe since records began in 1881, and the highest since 1990. Likewise, the 228.4 hours of sunshine gave Oxford 1.6 hours per day more than expected, making August 2003 the 13th brightest on record. The monthly rainfall total of just 3.0 mm went against the general recent trend of wetter Augusts, and was the third driest August since rainfall records began in 1767, and the driest since 1940. Summer 2003 brought exceptionally high maximum and minimum temperatures. Mean air temperature for the season was 2.4°C above the long-period mean. It was also a sunny season in Oxford, with 69.9 hours above the average recorded. Rainfall was 60.5 mm below the long-period mean for summer, although this was largely due to a very dry August.

September was characterised in general by warmer maximum and cooler minimum temperatures than expected from the long term record. Following on from August, it was also very dry with total rainfall of 17.4 mm, 43.3 mm below the long period mean. This made September 2003 the 24th driest on record at the Radcliffe, and the driest since 1979.

October was colder than the long period mean across all of the temperature measures. The mean minimum air temperature of 3.8°C is the 8th lowest since records began in 1881, and the lowest since 1919. It was a dry month, with total rainfall of 31.7 mm making it the driest October since 1985. It was also a very sunny month, with 134.8 hours, which is the 10th sunniest on record and the sunniest since 1999.

Temperatures in **November** were warmer than expected from the long period means. Mean maximum air temperature (12.0°C) was 6th highest on record. Additionally this month was placed 12th in our records for fewest days with ground temperature below 0°C. The monthly rainfall total of 89.6 mm made this a wetter month than expected, but the sunshine total, 15.0 hours greater than the long term mean, indicates that rain fell in relatively intense events. It was a very foggy month, with 10 days with fog at 0900 GMT equalling the record set in 1936 for highest number of days with fog. Autumn 2003 was sunnier (63.4 hours above average) and drier (47.3 mm below average) than the long period means. Foggy morning conditions throughout the season, and particularly in November, equalled the 1953 record for number of days with fog during autumn.

Temperatures in **December** were relatively unremarkable, with recorded values generally falling within 0-2°C of the long period mean for most temperature measures. Rainfall was above average. Following a very foggy November, the total of 11 days with fog at 0900 GMT made this December exceptional, equalling 1958's record for the highest number of days with fog since records began in 1926.

As noted in the introduction, 2003 has been a warmer, drier and sunnier year than expected from the long-term averages. Although December's sunshine total was incomplete due to gaps in data, the January to November 2003 total of 1699.7 hours bright sunshine is 248.9 hours above the long-period mean for January to November.

WORLD WEATHER DISASTERS

NOVEMBER 2003

Compiled by RICHARD MUIRHEAD

3: Flash floods sweep through tourist resort in Sumatra, Indonesia, killing at least 90 including foreign tourists.
11-12: At least 13 killed and many others injured in central Argentina after several major storms sweep through area.
12: Storm hits parts of S. California with up to 5 inches of rain and hail.
12-15: Strong winds in N.E. U.S.A. and Mid-West knock out power to almost 1 million homes in 8 states.
13: Wales hit hard by gales. Winds of up to 82 mph in N. Wales.
14-16: At least 50 killed after severe floods in much of Vietnam.
17: Flood and mudslide in Semarang, Indonesia sweep away at least 2 houses and inundate dozens of hectares of farmland.
18: Powerful storms in Texas injure at least 20.
18: Line of thunderstorms in Deep South, U.S.A. unleash tornado in Mississippi and Alabama strong enough to knock out power to 50,000 customers.
18-19: Shetland, U.K. hit by 80mph gales, disrupting transport and causing thousands of homes to lose power.
19: Tornado in Lake Cullulleraine, Australia leaves Australian $1 million trail of destruction.

19: At least 8 die as storm system moves through central Appalachians into Eastern Seaboard U.S.A. with heavy rain and floods.
20: Thirteen killed after heavy rain and flooding in Nador region of N.E. Morocco.
20: Typhoon Nepartak hits Chinas Hainan island causing 1.63 billion Yuan in economic losses.
24: Floods in E. Java province, Indonesia, kill 3 and force more than 3000 to flee homes.
25: Typhoon Lupit strikes Ulithi atoll, Micronesia, severely damaging trees and crops.
26: Floods in central Vietnam kill 3 and leave 1 missing.
29: At least 7 die and about 2000 forced to leave homes amid heavy rains and flooding in Brazil. *(BBC teletext).*
30: Storm crossing Ontario, Canada leaves 21,000 in dark.

DECEMBER 2003

1-3: Six die as flash floods sweep south and east France. Fifteen thousand have to evacuate homes. Floods block roads and disrupt rail services. Two nuclear reactors shut down. Up to 200mm of rain falls between 1st and 3rd in Rhone valley and between Marseille and Cassis. *(Lloyds List, B.B.C. teletext and pers. comm. Jonathan Webb)*
2: Worst storm to hit Melbourne, Australia in 100 years leaves multi-million dollar trail of devastation. Homes and shops flooded, trees downed.
4: Storm passes over Newcastle area of New South Wales, Australia, damaging homes at Lake Macquarie and leaving thousands without power.
4: At least 7 die as mud slide is triggered by very heavy rain in central Colombia.
4: Winds of up to 80mph topple trees and cut power to more than 193,000 customers in W. Washington, U.S.A.
6-7: Near hurricane force winds batter Norway. Tromsoe's airport closed on 7th. Electricity cut in some areas for a few days.
7: Nine die in N.E. U.S.A.'s first major snow storm of the season. Boston gets about 10 inches of snow. About 8000 power cuts along Massachusetts coast.
7: Five die as severe winter storm hits New Brunswick, Canada.
8: Tropical storm "Odette" kills at least 8 in Dominican Republic due to floods.
9: Severe hail storm hits Gladstone Australia. Power lines downed, damage to at least 100 homes.
11: Four die due to floods and landslides in N. Sumatra, Indonesia.
11: Thousands of homes hit by flash floods in many parts of Nakhon Si Thammarat, Songkhla, Surat Thani and Yala provinces, Thailand after several days of heavy rain.
12: Over a thousand flood victims evacuated from homes in Malaysia.
13: Over 2500 evacuated from Costa Rica's Caribbean Zone after 4 days of continuous rain wipes out bridges and roads. One dead and 1 missing.
13: Unseasonal flooding in Thailand's southern provinces leaves 8 dead.
13: King County residents, U.S.A. report $2 million in damage from recent windstorm.
15-16: Heavy snow storm covers parts of N.E. U.S.A. At least 7 die.
16: Powerful cyclone hits India's southern coast killing at least 9 with winds of 100kph.
16: Storm in Atlantic Canada closes schools and snarls transport.
16-17: Four killed and 4 missing after landslide triggered by heavy rain swamps food stall in S. Sulawesi, Indonesia. Floods in Jambi province.
19: Landslides in Leyte, Philippines, kill 200. *B.B.C. teletext.*
20: Tropical storm in Bay of Bengal kills 105 fishermen.
22: Blizzards leave at least 2 dead and 100,000 without power in Denmark, Finland and Sweden.
22: More than 70 feared dead after ferry disappears in rough seas in Philippines.
23: Flood waters hit central Bolivia. At least 6 die.
24: At least 31 killed, mainly in road accidents as dense fog engulfs N. India.
25: At least 19 missing from landslides and flash floods in central Philippines.
26: At least 6 die in floods in S.Turkey. *B.B.C. teletext.*
26: Mudslide kills 14 people north of San Bernardino, California.

Sources: Lloyds List unless otherwise stated

NEWS

Complied by Greg Spellman

Sourced news and press releases on any aspects of weather and climate should be sent digitally to the News Editor: greg.spellman@northampton.ac.uk

RARE HURRICANE IN SOUTH ATLANTIC

A rare South Atlantic hurricane was reported off the coast of South America on March 26th. The report marked the first time since 1966, when satellite tracking began, that the National Oceanic and Atmospheric Administration has recorded a hurricane-strength storm in the South Atlantic Ocean, said Jack Beven, a hurricane specialist with the National Hurricane Centre in Miami, Florida. He described the Category 1 storm, which was packing 85 mph winds, as moving southwesterly toward the coast at about 9 mph and predicted it would not gain strength. Tropical storm-strength winds extended less than 100 miles from the eye. "The whole thing is only about 200 miles across, at best," Beven said. "Size-wise, it's a very small system." The storm was about 220 miles east of Porto Alegre, a city of 1.5 million, and about 540 miles from Rio de Janiero, home to more than 6 million. Such storms are so rare that there is no system for naming them. In the North Atlantic, hurricanes are identified according to a yearly list of alternating men's and women's names. "We're just calling it the South Atlantic Hurricane for the moment," Beven said. Vertical shear -- unfavourable upper-level winds -- and a lack of viable disturbances that can become tropical cyclones make hurricanes exceedingly rare in the South Atlantic, he said. *Source: CNN News 27 March 2004*

GREENHOUSE GAS LEVELS HIT RECORD HIGH

The level of carbon dioxide in the Earth's atmosphere has hit a record high, according to new data from the United States National Oceanic and Atmospheric Administration.

Average levels of carbon dioxide had risen to about 376 parts per million for 2003, representing a steady annual increase of 2.5 parts per million over the two previous years. One suggestion is that economic development in China and India, with resultant increases in fuel use, could be a key factor in the raised carbon dioxide levels. *Source BBC News 27 March, 2004*

BEIJING SHROUDED IN YELLOW DUST

Northern China, including the capital of Beijing, was shrouded in a veil of yellow dust (Monday 29), with visibility in some places falling to 100 metres as citizens sought to shield themselves from swirling clouds of sand and grit. Some 70 million people in 11 northern Chinese provinces and municipalities were affected by the sandstorms, with the worst occurring in Xilingol prefecture of northern Inner Mongolia, On Sunday, visibility in many places in the region was limited to between 100 and 400 metres, in what meteorologists are calling some of the strongest dust and sandstorms so far this year. *Source Terradaily 29 March 2004*

TORNADO FORECASTING IMPROVES IN THE USA

Improved technology has pushed average warning times for tornadoes to between 12 and 14 minutes in the USA - a critical period for people to get out of harm's way and to find shelter. Computers now allow meteorologists to pinpoint where severe weather might occur as far as 72 hours ahead of time and, as a result, deaths from twisters have declined steadily over recent decades. However, predicting tornadoes is still an inexact science until severe weather actually gathers, the experts cautioned.

An even more advanced technology - phased array radar - promises to give forecasters still more accurate storm data.

"The trend is clear. There is better forecasting, more accurate forecasting, and a better ability to disseminate warnings," said Ron McPherson, executive director of the American Meteorological Society in Boston. A vast network of weather radio stations broadcasting continuous forecasts and warnings to specific locations has grown from a scattering of about 100 sites in 1974 to more than 880 now in the USA. *Source The Associated Press 5 April, 2004*

BUSY HURRICANE SEASON FORECAST FOR NORTH ATLANTIC

The Atlantic will probably see 14 named storms this year, eight of them hurricanes and three of them intense hurricanes, researchers from Colorado have said. The long-term average is about 10 named storms, including six hurricanes. Of those, two are "intense" hurricanes, defined as those with sustained wind of at least 111 mph. The Colorado State team also warned the chances of at least one intense hurricane making landfall in the United States is 71 percent, much higher than the long-term average of 52 percent. Hurricane season in the Atlantic runs from June 1 through November 30.

Higher hurricane numbers over the past seven to nine years indicate the United States has entered a period of increased storms that will last two or three decades, The change correlates to an increase in surface temperatures in the North Atlantic and a decline in surface pressure in the tropical Atlantic. The team said it didn't attribute the changes to human-caused global warming. The Atlantic hurricane names for 2004 are: Alex, Bonnie, Charley, Danielle, Earl, Frances, Gaston, Hermine, Ivan, Jeanne, Karl, Lisa, Matthew, Nicole, Otto, Paula, Richard, Shary, Tomas, Virginie and Walter. *Source CNN News 7 April 2004*

PHOTOGRAPHY COMPETITION 2004

The competition is now closed and the organisers would like to thank all those who entered. Winning pictures will appear in the July/August 2004 Journal of Meteorology.

MELTING GREENLAND ICE THREATENS GLOBAL RISE IN SEA LEVEL

Predictions show that if Greenland's climate warms up by more than about 3 °C, the massive ice sheet that has covered it for millennia will disappear, raising sea levels around the world by around seven metres. Although it would take longer than 1,000 years for all the ice to melt, new research shows that there are likely to be enough greenhouse gases in the atmosphere to produce this warming by as early as the middle of the century. We would then be locked into a change in our climate that would inevitably and increasingly threaten coastal and small island communities across the planet, adding significantly to the rise in sea levels already expected to occur due to the expansion of a warming ocean and the melting of mountain glaciers. *Source Met Office 7 April 2004*

AIR POLLUTION FROM VEHICLES CAN CAUSE ASTHMA

Major new scientific findings suggest that air pollution from vehicles can cause asthma in previously healthy people as well as triggering attacks in people with the disease. Until now, scientists had believed traffic fumes simply worsened everyday life for asthmatics. But research on both sides of the Atlantic now suggests that tiny "particulates" from exhausts can sidestep the body's natural defences and set off asthma. Diesel, which is being heavily promoted by ministers as a "green" fuel that can help combat global warming, is most to blame.

"These microscopic particles are a major threat to human health," said Professor Stephen Holgate, one of the Government's most senior advisers on air pollution. "There is a strong suspicion that particulates in air pollution are playing a much greater role in the causation of asthma than has previously been realised," said Professor Holgate, who chairs the official Expert Panel on Air Quality Standards. "The latest scientific evidence suggests that particulates are now the most important type of air pollutant that threatens human health." *Source: The Independent 11 April 2004*

LETTERS TO THE EDITOR

The Editor invites comments, questions and responses on all aspects of weather and climate. Letters to the Editor should be sent preferably by email to editorial@journalofmeteorology.com. Letters by post should be clearly written or typed and sent to the Editorial Office address. Opinion expressed is that of the individual and the Editor reserves the right to edit any letter as appropriate.

TORNADO VORTEX

Dear Sir,

It seems just possible the well known feature of the Tornado vortex defies mathematical analysis because simple explanation has been ignored, that the highly visible and often threatening central core has been allowed to obscure the fact that it is enclosed by a relatively gentle vortex ring "bubble" contributing to recirculation. This is fairly natural, for example, Lanchester suggested that an aircraft or fairly rigid wing in fact combines the lifting surfaces of an aerofoil with a less visible vortex system trailing from either the wing-tip or both.

The suggestion here is that a fairly ordinary "Coanda saucer" inverted to generate a vortex by virtue of tangential deflection of fixed vanes before the radially-issuing jet stream extends across the inverted camber flap, sets up a superimposed circulation when immersed within a reservoir of additional fluid, such as the same water, with a visible up flow core followed by rotary motion and down flow as the walls of a transparent container are approached. It is even possible to drive the recirculatory fluid by separate or external rotary pump that takes water from the same reservoir (vertically) before returning it towards the centre to power the Coanda saucer. As a result of the secondary circulation and concentration of vorticity, a reduced pressure core surrounds the central axis complete with up flow, only to be followed by down flow in proximity to the walls of the reservoir and the vortex ring both compressing and reducing pressure within the core. One effect of the secondary vortex ring is to accelerate axial component along the core, and also permit occasional instabilities due to the aerodynamic sleeve.

Such a rearrangement is quite stable, and is best illustrated by the so-called "Rocket" model that allows buoyant coloured particles to complete the radial re-circulation, using an impeller at the base to draw down a simulated vortex core in fairly stable fashion, in fact a direct opposite of the tornado situation.

Hon. G. B. Bathurst, Cirencester, UK.

Picture: Tornado vortex. Cover shot of The Journal of Meteorology, Vol. 28, No.275, January 2003 International tornado and waterspout issue.

Tornado 20 miles north of South Dakota, USA. 23 June 2002. © Karen Leszke

EUROPEAN WEATHER SUMMARY

FEBRUARY 2004

Compiled by
DAVID BOWKER, ROBERT DOE, JOHN TYRRELL and JONATHAN WEBB

High pressure dominated the western Mediterranean during the first week and very mild south-westerly winds affected much of north-west Europe with spring-like conditions across northern France and Belgium. Brussels reported 16°C at 1200 GMT on the 4th, and this compared favourably with many Mediterranean resorts. By the 12th, the main focus of high pressure had transferred to the UK and on its north-west flank, warm southerly winds affected Iceland. Akureyri, in the north, reported a maximum of 13.1°C on the 13th, some 12°C above the February average. This contrasted dramatically with the weather in south-east Europe on the same day, where there were icy north-north-east winds on the other side of the high. Athens achieved a maximum of only -0.2°C and unusually heavy snowfalls created a Christmas card Acropolis. Schools were shut and emergency services advised the public to stay at home as transport in the city was halted. Turkey also experienced disruptive snowfalls a week later, when Erzurum received the equivalent of 69 mm of rain on the 21st and 22nd - but as snow.

Late February saw strong high pressure in mid-Atlantic and as a deep depression transferred to Scandinavia on the 24th, cold northerlies affected north-west Europe. Low pressure was dominant in the Mediterranean during the last ten days of the month, and northern Spain, western France and northern Italy endured heavy snowfalls and strong winds. Nearly 5,700 homes were without electricity in Brittany, 5000 trucks were stranded after the main crossing point to Spain was closed and snow fell as far south as the Cote d'Azur. Those trying to find sanctuary from the rigours of winter in the sunshine of the Canaries may have been disappointed, for these islands too had their share of the unsettled weather and Las Palmas recorded 29 mm in a deluge on the 19th. On the 27th February - 35-50 cm of snow was reported in the Rennes area of Brittany, NW France.

Meanwhile in Ireland February began dramatically in the west with thunderstorms embedded in a strong southwest surface circulation. This lay immediately beneath the core of an upper westerly jet stream that remained close to, or above Ireland until 8th of the month. The period had very disturbed weather during which most stations recorded strong gusts between 40 and 70 kts on most days. Thunderstorms occurred on the 1st, 5th, 6th and 7th and the same period had the highest daily rain totals of the month. These were particularly high in southern regions (mostly between 15 and 22 mm) due to a lingering warm front. This also introduced warm air so that maximum temperatures reached double figures at most stations (12°C-14°C). There was a sharp change from 9th when the weather became dominated by anticyclonic conditions. The upper jet moved far away to the north of Ireland and a surface high pressure expanded from the south to introduce many days of light winds with very little precipitation. From the beginning of this period the inland stations reached minimum temperatures below freezing and continued to do so for the rest of the month. Around the coast temperatures were marginally warmer, but frosts were locally frequent even there.

A slight break in this weather occurred 13-17th when weak frontal systems managed to cross the country, initially causing morning fog problems in the south. But the displacement of the high-pressure centre far to the east resulted in cold but dry continental air crossing Ireland until 20th over most of the country. The relatively clear skies led to high sunshine hours during the day (7-9 hours) and Dun Laoghaire recorded 9.2 hours on 18th (about the maximum possible for February). But daytime temperatures were very moderate. Freezing night temperatures became much more widespread than before. Throughout the period weak pressure gradients resulted in light winds. On 22nd the winds turned to a more northerly direction and became arctic rather than continental in origin. Temperatures fell accordingly and some of the lowest temperatures of the month occurred during this period. Most stations reported temperatures below freezing from the 25th to the end of the month. From 25th to 27th snow fell, the heaviest (up to four inches) occurring in Northern Ireland on 26th.

February in the United Kingdom was mostly mild and dry. Between the 1st and 6th a vigorous low pressure to the north and north-west brought very mild, wet and windy weather to the region. The rain was often heavy especially in north Wales and Cumbria, where severe local flooding occurred. There was heavy rain in Scotland, with 26 mm at Eskdalemuir. The warm front on the 2nd gave much rain in the west of Scotland with 59 mm at Sloy. The Conwy Valley in Wales was also badly hit as heavy rain and snow melt resulted in some villages being cut off by floods. Capel Curig registered 260 mm in 48 hours during the 3rd and 4th. The temperature reached 17°C at Lossiemouth on the 3rd (a new station record for February) and the wind gusted to 83 mph at Fair Isle. Gravesend (Kent) achieved 17.9°C on the 4th (new high for first week of February) while central London reached 17.8°C. On the 7th showers in the north and west turned to snow, with gusts to 77 mph at Barra and South Uist. Mild air soon returned, tracking around an anticyclone that developed close to the English Channel. There was 38 mm of rain at Cassley on the 9th.

The 11th to 15th stayed mild with high pressure over the UK. There was a little rain on the 17th and a few showers along North Sea coasts on the 18th. Southern England had some snow flurries on the 20th with rain in the south-west on the 21st. On the 26th bands of snow affected Wales, northern England and the east coast areas of England including East Anglia at first, giving significant accumulations of snow in places. An area of moderate snow moved across central southern England, with ten to twelve centimetres reported from Bournemouth early on the 27th. Sennybridge (Powys) fell to minus 10.9°C that same morning; overnight frost became widespread and severe in places. Persistent snow showers during the 27th and 28th gave further moderate accumulations over Wales, northern England and north-east coastal areas, most places, however, saw good sunny periods. Some parts adjacent to the North Sea as far south as Kent also received a few centimetres of snow. There were also some reports of thunder. An anticyclone developed across Scotland on the 29th, by which time Glenlivet reported 18 cm of snow on the ground and the temperature fell to -10.8°C at Loch Glascarnoch. Boltshope Park in N England boasted 16 cm on the 29th, however, rising pressure restricted snow showers to south-east England that day.

United Kingdom data supplied courtesy: Met Office, UK
Data correct at time of press

METEOROLOGY FROM THE AIR

Skyscape from a hot air balloon, Newbury, UK - 25 May 2003
© Fiona Williams

Puffy cumulus illuminated by late afternoon sun far below a NOAA P-3 returning to base
© NOAA

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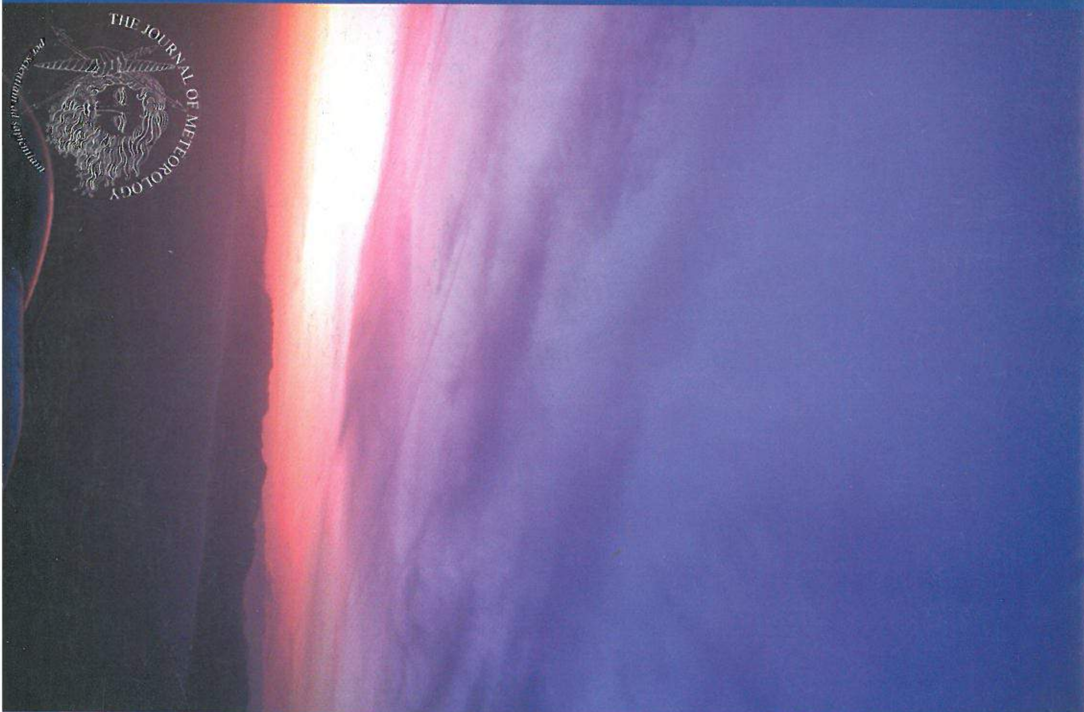

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