SHORT TERM FORECASTING OF DRY SPELLS IN DRY ZONE OF SRI LANKA

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Degree of Doctor of Philosophy

Department of Mathematics

University of Moratuwa

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(08/8011)

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DECLARATION

"I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any University or other institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text."

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ABSTRACT

Droughts and dry spells are a recurrent feature of the natural climate in the dry zone of Sri Lanka. The unpredictable pattern of dry spells cause significant damages to the agricultural system, livelihood of people and the economy of the country. This research was initiated to investigate the temporal and spatial variability of the starting time and the lengths of dry spells in the dry zone (DZ) of Sri Lanka using daily rainfall data (1950-2005) in 11 rain gauge locations and to explore the possibility of forecasting properties of critical dry spells.

A review on statistical anlysis on dry spells noted that n o studies were reported to predict the starting date or length of dry spells. The mean number of dry spells ($\geq$ 7 dry days) per year, irrespective of locations, was 12 while the duration varied from 15 to 23 days with a mean of 19 days. The four longest dry spells within a year according to the time of occurrence were considered as critical dry spells. The mean lengths of such critical dry spells in the dry zone were 31, 33, 38 and 33 days respectively. The mean length of the critical dry spell increased from the first to the fourth in some locations while it decreased in some locations. In a few locations the longest spell occurred during the middle of the year, i.e. the third spell. Based on the results obtained on the temporal and spatial variability of critical dry spells, climate charts were developed to be used by the decision makers in the respective locations.

Linear and non linear regression with or without autoregressive error models ($p<0.05$) were developed to forecast the starting dates of second, third and fourth critical dry spells separately for all locations. Validity of models were confirmed using various statistical indicators and they were also validated using an independant data set (2000-2005).

It was not possible to develop standard models for the four critical dry spell length series separately. Thus one critical length series was formed by pooling all four series for a given location. New types of models known as non linear bilinear type with one, two or three customer-specific input variables were developed for each location separately. A new approach was developed to identify customer-specific input

variables using the same series. The prediction performance of the proposed models was demonstrated using a real data set of 12 individual points.

The results obtained in this study will be helpful in minimizing unexpected damage due to droughts and will help effective and efficient planning for farmers, irrigation engineers, coconut growers, policy makers and researchers.

Key words

Bilinear type models, Critical dry spells, Forecasting, Non linear ARIMA models

DEDICATION

To my husband , two sons and

to the

memory of

my dearest

father and mother……..……

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LIST OF ABBREVIATIONS

Abbreviation	Description
ACF	Auto Correlation Function
AD	Anderson Darling
ADF	Augmented Dickey Fuller
AER	Agro-Ecological Region
AIC	Akaike's Information Criteria
AR	Auto-Regressive
ARMA	Auto-Regressive Moving Average
ARIMA	Integrated Auto-Regressive Moving Average
AMDSL	Annual Maximum Dry Spell Length
ANDSP	Annual Number of Dry Spell Period
ANOVA	Analysis of Variance
APCC	Asia-Pacific Coconut Community
BIC	Bayesian Information Criteria
BL	Bilinear
BP	Breush-Pagan
BPQ	Box-Pierce Q statistic
CDM	Conditional Mean
CDS	Critical Dry Spell
CDS_1	First Critical Dry Spell
CDS_2	Second Critical Dry Spell
CDS_3	Third Critical Dry Spell
CDS_4	Fourth Critical Dry Spell
COOKD	Cook's Distance
COVRTIO	Covariance Ratio
CV	Coefficient of Variation
D	Dry
df	degree of freedom
DFFITS	Difference of Fits
DL1	Low country D ry zone 1
DL2	Low country D ry zone 2

DL3 Low country D ry zone 3

DL4 Low country D ry zone 4

DL5 Low country D ry zone 5

DSF Frequency of Dry Pentads

DW Durbin Watson

DZ D ry Zone

ESACF Extended Sample Auto Correlation Function

ENSO El Nino-Southern Oscillation

FDS Frequency of the Dry Spell

FIM First Inter Monsoon

G_1, G_2, G_3 Godfrey's serial correlation values

GCM G lobal Circulation Models

IPCC Inter-government Panel for Climate Change

IZ Intermediate Zone

LCDS Length of Critical Dry Spell

L Low country

LBQ Ljung-Box Q statistc

$LCDS_1$ Length of First Critical Dry Spell

$LCDS_2$ Length of Second Critical Dry Spell

$LCDS_3$ Length of Third Critical Dry Spell

$LCDS_4$ Length of Fourth Critical Dry Spell

LDS Length of the Dry Spell

M Mid country

MA Moving Average

MAX Maximum

MINIC Minimum Informatin Criteria

MDS Maximum Dry Spell

MLGD Mixture of Log series with Geometric Distribution

MSE Mean Square Error

NAR Non Linear Auto-Regressive

NLARMA Non Linear Auto-Regressive Moving Average

NLMA Non Linear Moving Average

NLBX Non Linear Bilinear with X

NCB Non Calic Brown

NEM	North East Monsoon
NWN	Not White Noise
NCV	Not Constant Variance
NN	Non Normal
OLS	Ordinary Least Squares
PACF	Partial Auto Correlation Function
RBE	Reddish Brown Earth
RMSE	Root Mean Square Error
SAS	Statistical Analysis Systems
SBC	Schwarz Bayesian Criteria
SCAN	Squared Canonical Correlation
SDCDS	Starting Date of Critical Dry Spell
$SDCDS_1$	Starting Date of First Critical Dry Spell
$SDCDS_2$	Starting Date of Second Critical Dry Spell
$SDCDS_3$	Starting Date of Third Critical Dry Spell
$SDCDS_4$	Starting Date of Fourth Critical Dry Spell
SDS	Start of Dry Spell
SE	Standard Error
SIM	Second Inter Monsoon
SST	Sea Surface Temperature
STDRES	Standardized Residuals
STURES	Studentized Residuals
SW	Shapiro Wilk W test
SWM	South West Monsoon
t/ha	tons per hectare
U	Up country
W	Wet
wk	week
WN	White Noise
WT	White's Test
WZ	Wet Zone

LIST OF APPENDICES