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A NEW APPROACH TO RAIN FORECASTING
(Secular Changes In Teleconnections : Causes & Remedies)

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ABSTRACT: Spectral analysis of past data reveals a ***61-year cycle*** in Indian and global rainfall, NAO (North Atlantic Oscillation), North Atlantic SST (Sea Surface Temperature), El Niño, Darwin pressure, etc. Waveform of annual Indian rainfall almost replicates that of 61 years ago for nearly half of this cycle, and this half-cycle also exhibits strong coupling between Indian monsoon rainfall and its predictors, the other half-cycle lasting about three decades being rather chaotic for which neither any of the existing forecasting methods nor this 61-year cycle delivers tolerable predictions. The predicand (rainfall) as well as physical predictors are both guided by this common 61-year mysterious cycle which cannot be explained on the basis of hitherto known physical processes. Comparison with waveforms distanced 122 years suggest that this 61-year cycle may be a stochastic manifestation of some unknown annual process which may throw light on the real causes hidden underneath the apparent chaos of climatic systems.

If we organise relevant data and forecasts according to the **climatic year** beginning from mid-April, this 61-year cycle shows a better contrast between chaotic and predictable phases, and standard deviation of spectra 61 years apart also gets diminished. Since delinking and relinking of teleconnected phenomena also occur at the beginning of this climatic year, some mysterious phenomenon may be said to occur at the beginning of each climatic year in April, which influences the overall annual performance of rainfall and related phenomena. Physical conditions in April or May may sometimes fail to predict events in June, such as in 1997 when En Niño failed to predict ISMR (Indian Summer Monsoon Rainfall) or in 2002 when Indian drought could not be predicted, while the waveforms of 61 years ago were replicated even during these unusual years. Thus, some long range regularity overrides short range vagaries of monsoons.

In addition to the precaution needed in keeping time frame in proper order, geographical distribution of teleconnections and the magnitude of their mutual correlations must be up to date too. Geographical distribution of annual relative rainfall suggests a phenomena which may be described in terms of **Climatic Meridians**, with poles at Mt Kenya and Mid-Pacific, in reference to which correlations between teleconnections can be understood properly . An annual fluctuation of upto a maximum limit of 16 degrees in these climatic longitudes, occurring in mid-April, gives rise to secular change in the magnitudes and often signs of correlation coefficients . If these precautions are followed carefully, a highly reliable annual rain forecast beginning from mid-April can be made for the whole world.

1. 61 - YEAR CLIMATIC CYCLE

Researchers have noted a ~60 year cycle in the variability of ISMR (as well as of Chinese monsoons), with two 30-year phases of above and below normal performance of ISMR. Hastenrath and Parthasarathy et al think that data length of 30-years is necessary and sufficient to establish a stable correlation for prediction purposes. Their opinion was based on the observations over a period which was comparatively a more predictable period according to the results of spectral analysis presented by us below. Parthasarathy and Mooley carried correlogram and spectrum analysis of 108-year series and noticed that smaller cycles of 14 and 2.8 years had developed within a 30-year period [1]. Many other time series analyses by researchers of summer or annual rainfall over India have shown a quasi-60 year periodicity.

Mooley and Parthasarthy [1] and Parthasarathy et. al. [2, 3, 4] derived time-series of all India average rainfall on seasonal and monthly time-scales as a weighted average of the data at 306 stations obtained from the IMD (Indian Meteorological Department). We used it to carry out some simple time series analyses. Departure of ISMR from long term average in percents is shown in the Fig-1, in which data of 136 years are shown in two series,1871-1945 (years being numbered from 1 to 75 along x-axis shown in red) and 1932-2006 (years being numbered from 62 to 136 along x-axis shown in blue). For instance, 1957 AD is numbered 87 (= 1957 - 1870) and will be found in the second series in blue . When the second curve was superimposed upon the first one, ***shape of both waveforms coincided in a majority of cases when the gap between both series was chosen to be 61 years*.** Waveform of 1891-1923 (year nos. 21-53) had an similarity in shape with that of 1952-1984 (year numbers 82-114) in 25 out of 33 years , only 8 years were out of phase . Similarly, Since 1950-2006 , only 19 years had out of phase waveforms out of 57 years . Only the shape of wave is copied after 61 years, and not the magnitude (amplitude).

Since the onset and withdrawal of summer monsoon does not have a definite date , data organised according to four calendar months of June-September does not give us a realistic idea about the seasonal quantum of ISMR . Sometimes significant portions of ISMR occur in May and October too . Artificiality of calendar months is the main cause behind failures to discriminate signal from noise in the time series data processing of Indian monsoons . Total annual rainfall in India is a better index than ISMR if we want to analyse total quanta of hydrological exchanges between land and ocean in the larger context of land-sea-interaction . Waveform comparisons of total annual rainfall with that of 61 years ago produce a clearer picture : the contrast between weak and strong correlation periods is more faithfully represented by total annual rainfall series than by ISMR series. FIG - 2,3,4,5 show annual spectral comparisons . Fig-2 presents weakly coupled (chaotic) and Fig-3 presents strongly coupled (predictable) phases.

M. Raajeevan observed : "(The) relationship (between the predictors and ISMR) was weak in 1930s and 1940s and during the recent years. During the 1960s to 1990s this relationship was, however,very strong. Obviously, the skill of the model also shows similar type of variations. " [5] .What M. Raajeevan says about the relation of ISMR and its physical predictors applies equally well to the relation between ISMR value of any given year with that of 61 years ago . When ISMR waveform shows poor resemblance with that of 61 years ago, correlation coefficients of physical predictors are also poor. And when predictors behave more rationally, ISMR waveform almost copies the waveform of 61 years ago ! Not a mere coincidence !

Without using any physical predictor, we have obtained nearly same results about 6-decade periodicity of Indian Monsoon which many researchers had noticed in the case of physical predictors. There are periods of strong coupling of annual rainfall spectrum with that of 61 years ago, preceded and followed by periods of weak coupling . Timings of these periods of strong and weak couplings also coincide with those obtained from analysis of time series of correlation coefficients (CCs) between rainfall and its physical predictors . It is a strange conclusion, which suggests a *redundancy of all physical parameters* ! If rainfall waveforms of 61 years ago are used as the sole predictor, we can make equally good (or bad) forecasts (it is, however, not advisable) ! For instance, 1941 drought was exactly reflected in 2002, and the difference in magnitudes of rainfall was also nearly equal to the trend rate, while all modelers were predicting a normal monsoon in 2002 . Same is the case with 1997, when En Niño failed to serve as a good predictor, while waveform of 61 years ago was admirably replicated . Meteorological wisdom is that the accuracy of forecasts decreases if range is increased. But in cases like those of 1997 and 2002 ISMR, we witness the opposite : while physical conditions of April failed to predict events of June, certain unknown conditions of 61-years ago were related to such changes in physical conditions during May so as to create a drought in June-July of 2002 . Entire waveform of 1894-1924 is almost copied by 1955-1985 rainfall spectrum (Fig- 3, Fig-5), with just 3 exceptions during 31 years ! Such a behaviour for 3 decades cannot be a mere coincidence. But while emphasizing the importance of this 61-year cycle, it must not be forgotten that it may deceive us too, especially during the chaotic period .

When annual South Oscillation Index (SOI) for 1876-2006 (Darwin-Tahiti) in two series distanced 61 years apart are superimposed upon each other, no definite trace of 61-year cycle is seen. Correlation of ENSO (El Niño and South Oscillation) with ISMR [5], however, suggests that ENSO also ought to have a periodicity similar to that witnessed in the case of ISMR . ISMR and its correlation with ENSO show same long term periodicities , but Darwin-Tahiti SO fails to show such a 61-year cyclicity . Pressure data for Darwin, however, shows a similar 61-year cycle. Clearly, Darwin-Tahiti SO ought to be replaced with some other type of SO in order to find a better index for predicting ISMR. ISMR-ENSO correlation is substantial but incomplete. A more appropriate type of SO may enhance the correlation of ENSO with ISMR . Another possible explanation of this incomplete correlation is the chaotic half of 61-year cycle which reduces overall long-term correlation to about 50% or less .

During periods of weak coupling between predictors and ISMR, prediction becomes difficult and often impossible . Immediately after Walker's time, there was a long spell of unpredictable and chaotic period, and a long period after 2007 is expected by us to be highly chaotic. If indices of any period are used to make predictions for a chaotic period, good results cannot be obtained . Values of CCs are relative to the length and position of data window in the time domain . Modelers have sometimes to tailor their training periods and data windows so as to make forecasting feasible . But this selectivity is not recommendable. Procedures suggested in the section dealing with Climatic Meridians may perhaps improve correlations.

2. CLIMATIC YEAR

Many researchers have thrown light on monthly variations in CCs. Yasunari likes the idea of a Monsoon Year starting just before the northern summer monsoon season" [6]. Gershunov et al [7] show monthly plot of El Niño correlation with ISMR during 124 years, with most negative value during Aug-Nov,which remains strong till March and starts strengthening negatively from June owards. Hence, April-May is the weakest period when affinity of ISMR and Niño-3.4 (SST averaged over 5°S–5°N,170°–120°W) gets delinked. Hence, the monsoon year must begin around April [6]. Kripalani also notes : "monsoon related events over geographically separated regions seem to get linked (or delinked) around the same time"[8]. We arrived at same conclusion from internal analysis of Indian rainfall data , without any consideration of physical predictors, which implied that the monsoon year may start somewhere around March-April. Considering other evidences also,**mid-April seems to be the beginning of *Climatic Year*, when past year's teleconnections get delinked throughout the world, and a thorough reorganisation takes place for another year** . To call it monsoon year is to reduce its significance. Over 3 weeks are needed after vernal equinox for the climatic transition to take effect, due to some unknown factors . Year beginning from April is the nearest approximation to this climatic year . Fig. 2-4 show data belonging to year beginning from April, while fig-5 shows data in year beginning from January . Even a visual comparison of Fig-3 and fig-5, which belong to same period, shows that the climatic year reduces the overall difference between both spectra 61 years apart . ***ISMR, annual global precipitation, Niño-3, NAO, SST in North Atlantic, Darwin pressure, etc. all show 61-year periodicity*** . All other climatic phenomena also need to be similarly examined . This 61-year cycle, however, should not be used simplistically for rain forecasting.

A. Gershunov et al [7] have used August–November Niño-3.4 as the pertinent ENSO index because of maximum negative correlation during these months . After the annual relinking between teleconnected phenomena at the start of each climatic year in mid-April , ISMR is the among the first major climatic events in the world , and other phenomena like Niño develop fully much later . A later event cannot predict an earlier event . Therefore , in order to study the impact of ENSO upon ISMR many researchers make use of ENSO–ISMR correlation indices *contemporaneous* with ISMR. However, ENSO of previous year seems to bear stronger correlation with ISMR recently due to secular changes. Krishnamurthy and Goswami [9] have noted that the correlations between IMR and ENSO indices on the interannual timescale do not follow the interdecadal oscillation . While Niño-3 exhibits undeniable proofs of relations with ISMR and other events in the world, there are major exceptions in short term which may result from secular changes and from current practices of data sampling , which may be improved if data is sampled in accordance to climatic longitudes as shown in the next section.

Since strengths of teleconnections undergo a global reshuffle in April, while selecting initial conditions predictor indices belonging to any period prior to mid-April should not be used for predicting events after April. Quasi-biennial oscillation in rainfall also suggests a similar precaution. This caution applies to indices like sea surface temperature too, although oceans evolve slowly and are often supposed to keep memories of previous year . There is no physical mechanism through which a memory of previous climatic year can be transferred to events of the next year, and therefore any previous year's memory must be treated as a mere coincidence.

3. GLOBAL CLIMATIC POLES AND MERIDIANS

Bin Wang and Zhen Fan write "The equatorial western Pacific winds exhibit a considerably higher correlation with the ISM convection than with the Philippine convection" [10]. Kripalani and Kulkarni also conclude that the rainfall variations over north China are in-phase with South Asian rainfall [8]. *Long-term comparison of annual relative rainfall* over big chunks of land and geographical distribution of relatively strong and well established teleconnections suggest a global climatic dipole whose longitudes appear as crescent like regions of correlated phenomena upon a mercator map as shown in Fig-6 . Pattern analysis of geographical distribution of annual relative rainfall suggests ***Mt Kenya to be climatic North Pole and central Pacific to be Climatic South Pole.*** Tropical rains, esp. monsoons , result from land-sea heat contrast, and therefore it is logical that they should be related to land-sea distribution. Central Pacific is the centre of biggest concentration of water, and on its opposite side we find Mt Kenya, which is the highest mountain on equator in a region nearest to the centre of the biggest landmass (Afro-Eurasia). Large areas of the world, however, have not been thoroughly investigated as yet, especially rainfall over oceans for which adequate data is lacking. Whatever available data has been analysed to date by us corroborates the idea of this global climatic dipole. Mapping and analysis of rain related events during climatic years suggest that at the beginning of each climatic year an abrupt displacement of climatic longitudes occurs, always within less than ±17° (-7° in 2006-7, -10° in 2007-8, year beginning from mid-April), climatic latitudes remaining unchanged always. This annual variation in climatic zones is the sole **cause behind secular changes** in correlation coefficients (CCs) and delinking or relinking of global teleconnections . The magnitude and direction of this mysterious annual shift in climatic longitudes can be predicted much in advance, which may facilitate the difficult task of readjusting CCs in all physical models. **Instead of varying the CCs of predictors, climatic grid-longitudes are made variable in our model.** Annual global forecasts are made with reference to this flexible grid. But fortnightly and 12-hourly forecasts for South Asia in our model are made from a different grid, with centre on the Tropic of Cancer near Bhopal in India.

Significance of the connections of equatorial bulge in Africa with gyroscopic regulation of earth's motions has been known since the days of Newton, but its connections with long term periodicities in climatic penomena has never been properly investigated. The near-omnipresence of 61-year periodicity in almost all major climatic phenomema often leads to discoveries of fake teleconnections, which have to be discarded later when they fail to deliver goods for long. This problem will make the task complicated. Hence we suggest a global mapping of relative rainfall every year for examining the proposed notions of climatic longitudes and their annual shifts. It will solve many problems . The notion of climatic poles and meridians is much more important than that of 61-year cycle.

In a climatic hemisphere east or west of Mt Kenya, regions represented with positively correlated teleconnections are shaded in same colours (Fig-6). For instance, most of India, China,and a big chunk of Western Pacific is shaded in blue. But these regions are negatively correlated to regions of same colour-shading in the other climatic hemisphere. For instance, India or China is negatively correlated to equatorial regions west of Mt Kenya which includes the Niño near Peru. Fig-7 depicts a long term extended average of Indo-Chinese-Mid NW Pacific zone, with maximum probability of climatic events in the centre of a zone and minimum probability 17° above and below a zone(Fig-7). Magnitude of average rainfall within a zone varies linearly along the climatic latitude . But the quality of climate within a particular zone remains the same for the entire zone, with notable regional differences along climatic latitudes which can be accounted for according to a different set of rules . This model has been thoroughly tested for India for 1871-2006, without a single exception, and many tests have been carried out for other continents as well . Annual global rainfall forecast for the year beginning from mid-April 2007 have been attached to this paper. Verification of annual or fortnightly forecasts generated from this model need data reorganisation according to the aforementioned grids for wanted periods, which is a time-consuming job**.**

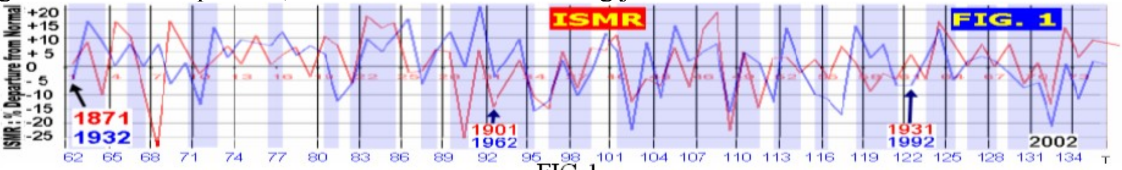

FIG-1

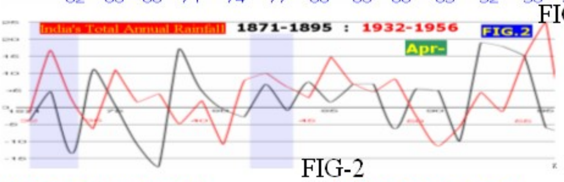

FIG-2

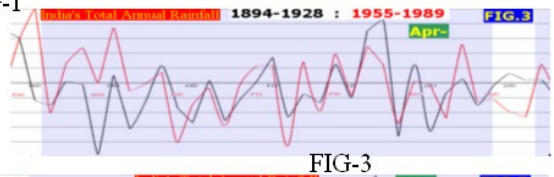

FIG-3

FIG-4

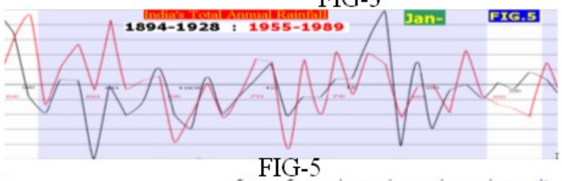

FIG-5

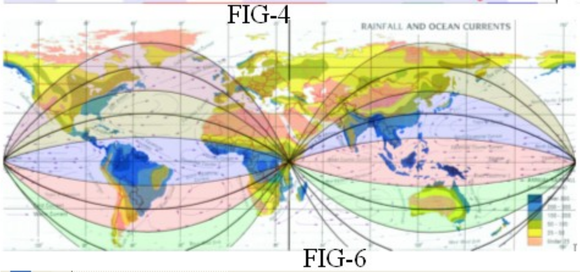

FIG-6

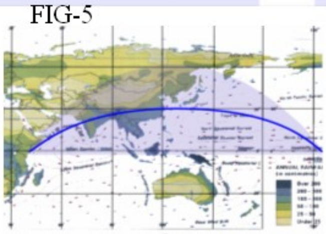

FIG-7

ACKNOWLEDGEMENTS

All major conceptual notions as well as the entire mathematical framework of new models named in this paper are based upon the ideas of Late Dr Laksman Jha, a former Vice Chancellor of Mithila University in Bihar, India, none of whose works on this or related topics is extant**.** Data used in this work are taken from IITM tables based upon IMD data, and NOAA of USA**.**

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