ADDRESSING ABRUPT GLOBAL WARMING, WARMING TREND SLOWDOWN AND RELATED INDIAN SUMMER MONSOON FEATURES IN RECENT DECADES

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ABSTRACT: This study addresses abrupt global warming and a slowdown thereafter that happened in recent decades. It separated the role of anthropogenic CO2 led linear trend to that from natural factors (volcano and the sun). It segregates a period 1976–1996 where two explosive volcanic eruptions occurred in active phases of strong solar cycles and also the period covers two whole solar cycles. That same period coincided with abrupt global warming. This study suggests that domination of a particular type of ENSO, the Central Pacific (CP) type ENSO and related feedback from water vapour played a crucial role. A plausible mechanism was proposed that could be triggered by explosive volcanos via a preferential North Atlantic Oscillation (NAO) phase. It modulates the CP ENSO via extratropical Rossby wave and affects the Aleutian Low. From that angle, it is possible to explain the disruption of ENSO and Indian Summer Monsoon teleconnection during the abrupt warming period and how it recovered subsequently afterward. Interestingly, individual models and also the CMIP5 model ensemble fails to agree with the observation. This study further explores important contributions due to natural drivers those are missed by models.

Keywords: ENSO, ISM, NAO, Hiatus, volcano, Sunspot Number

INTRODUCTION

The role of natural factors on climate is identified in various research (Roy and Kriplani, 2019a,b) though models miss many important contributions from natural drivers. The sun is one of the main drivers of natural factors, and solar influence on climate is discussed, in detail addressing various controversies (Roy, (2010, 2020b, 2021, 2018b). Model biases are another area that deserve attention too (Roy, Gagnon and Siingh, 2019). This study discussed mechanisms based on observed data and gave directions where models can improve.

RESULTS

Two decades of the last century were segregated where two explosive volcanic eruptions (El Chichon in 1982 and Pinatubo in 1991) occurred in active phases of strong solar cycles (Fig.1). Global temperature had risen .13ºC/decade during that period; whereas, the rise for overall period is 0.07ºC/decade. There was a slowdown of the rise in global temperature afterwards.

The influence of strong volcanic eruptions is shown using Sea Level Pressure (SLP) data for Dec-Jan-Feb (DJF) in Fig. 2 [Roy (2018a)]. Signals of SLP using Multiple Linear Regression (MLR) and anomaly technique are presented. Aerosol Optical Depth (AOD) represents volcano in the top plot. Both techniques identify strong positive North Atlantic Oscillation (NAO)

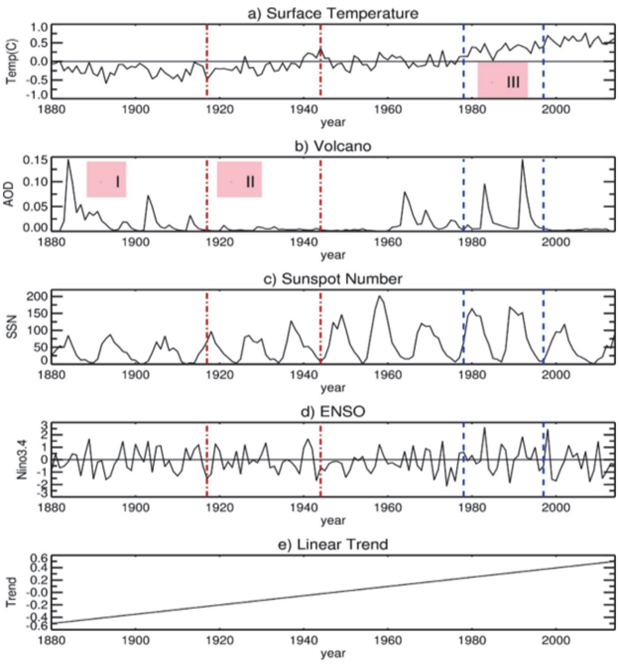

Fig. 1 Timeseries of various parameters. a) shows surface temperature from GISS data which is influenced by various parameters b) volcano, c) solar cyclic variability represented by Sunspot number (SSN), d) ENSO and e) Linear Trend. Main interest is period III and after. In period III two major volcanos erupted in active phases of strong solar cycles. ENSO in period III was strongest in terms of amplitude and variability. Global temperature had risen abruptly. [Roy (2020a)]

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pattern for strong volcanos. Signals in North Atlantic region are even extended high up in the stratosphere (Roy 2018a, not shown here).

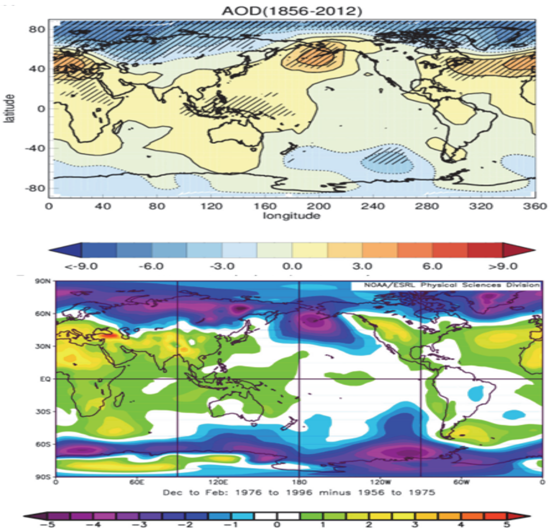

Fig. 2. The influence of strong volcanic eruptions are shown using SLP data, for DJF. The top plot shows signals for HadSLP2 data of Volcano using Multiple Linear Regression (MLR), where ENSO, SSN and trend removed. Significant regions at 95% levels are marked by hatching. Bottom plot shows SLP anomaly for the period 1976-1996 w.r.t. two previous decades (1956-1975). For both cases, strong positive NAO pattern is identified for strong volcanos.

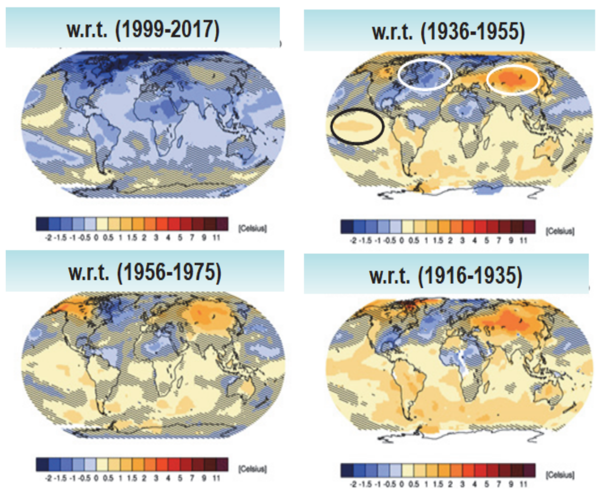

Fig. 3. The anomaly of surface temperature (ºC) in observation (DJF), using GISTEMP data [after, Roy (2018a)]. Anomaly during (1976-1996) is presented w.r.t. three other periods (covering two decades each). The first plot is an anomaly w.r.t. recent two decades. Significant regions (95% level) are shown without hatching. Central Pacific warming and cooling in the north Atlantic, while warming in Eurasian sectors are very distinct.

Fig. 3 detects significant warming in the Central Pacific, cooling in north Atlantic, while warming in Eurasian sector during DJF for '1976-1996'. Signals are similar using other data sources too (either GISTEMP or NOAA, ERSST, [Roy, 2018a]). Models however, do not capture those observed signals. Some models capture signature say, in Eurasian Sector, but not in N. Atlantic or Central Pacific and vice versa. It is true for all individual model as well as CMIP5 model ensemble [Roy (2018a)].

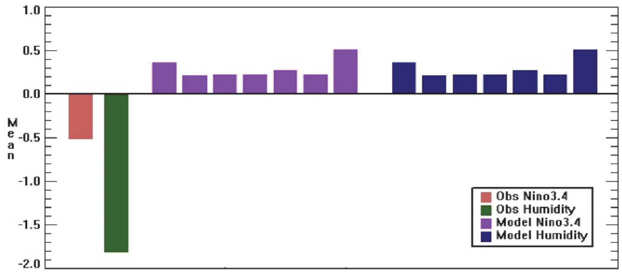

Fig. 4. Mean difference between '1999-2017' to '1976-1996' for Nino3.4 and specific humidity. The first two bar plots are for Niño3.4 and specific humidity using observed or reanalyses products. Seven arbitrary models are also presented; purple for Niño3.4 and blue for sp. humidity. Interestingly signs are different in models from observation. Though only a few models are presented, all models suggest similarly [Roy (2018a)].

Time Series (DJF) of various meteorological parameters indicate that though there is a steady rise in various parameters (e.g., Specific humidity, Nino 3.4 temperature etc. in CMIP5 models, that is not the case for observation and reanalyses (Roy 2018a, not shown here). The mean difference between '1999-2017' to '1976-1996' for Nino 3.4 and specific humidity suggest that signs of change are even different in models to that from observation (Fig. 4).

Studies indicated ENSO, Indian Summer Monsoon (ISM) usual teleconnection weakened in later two decades of the last century, which reverted back again in recent decades. In period of disruption, teleconnection of ISM via north Atlantic and Eurasian sector was strengthened. That feature of ISM disruption was identified using correlation between ISM (JJAS) and different regional temperature fields (Roy, 2018a, not shown here).

Figure 5 shows solar Max or peak years for high solar cycles (SSN>120) are biased towards cold event side of ENSO. Moreover, we find that the sun and ENSO (DJF) have different connections (which is cold event type) after 1998 and before 1957 in all active solar years (SSN >120) and not only to solar maximum or peak years. Such feature is however missed by all models (Roy, 2018a, not shown here). Thus, the solar contribution to warming as observed via ENSO in later decades of the 20th century is missing in all models.

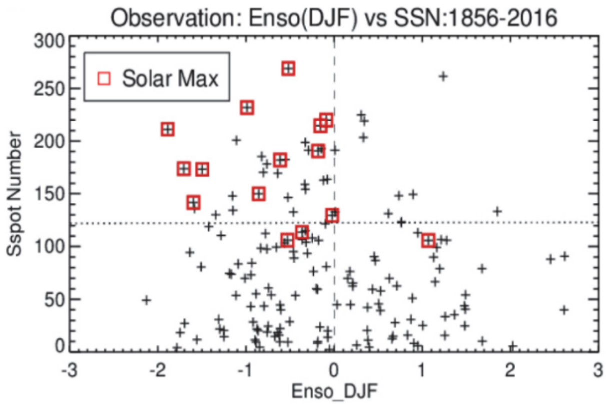

Fig. 5. Solar Max or peak years (marked by red) for high solar cycles (SSN>120) are biased towards the cold event side of ENSO. Interestingly, all points of the top right quarters are for the period 1958-1997.

CONCLUSIONS

Very strong influence from volcanoes was observed around the north Atlantic during 1976-1996, DJF by MLR as well as anomaly technique. The signal is also extended high up in the stratosphere. Temperature anomaly during '1976-1996' detected warming in the central Pacific, cooling in the north Atlantic, while warming in the Eurasian sector. Such pattern is noticed using different anomaly periods of two decades, earlier or later and various observed data sources. Performance of individual CMIP5 models and AR5 CMIP5 subsets were analysed but those fail to match with observation. No Consistency is found among those models too. Analyses on specific humidity and Nino 3.4 show observation and models even show different sign of change in recent period to that from previous two decades. ISM and ENSO teleconnection was shown weakened in those two decades. A series of mechanisms are proposed which are initiated by explosive volcanos that erupted during 1976-'96 and coincided with active phases of strong solar cycles. It modulates NAO, Aleutian Low (AL), Eurasian Snow, Central Pacific (CP) ENSO and ISM. Those also caused abrupt warming and disruption of ISM-ENSO teleconnections (Fig.6).

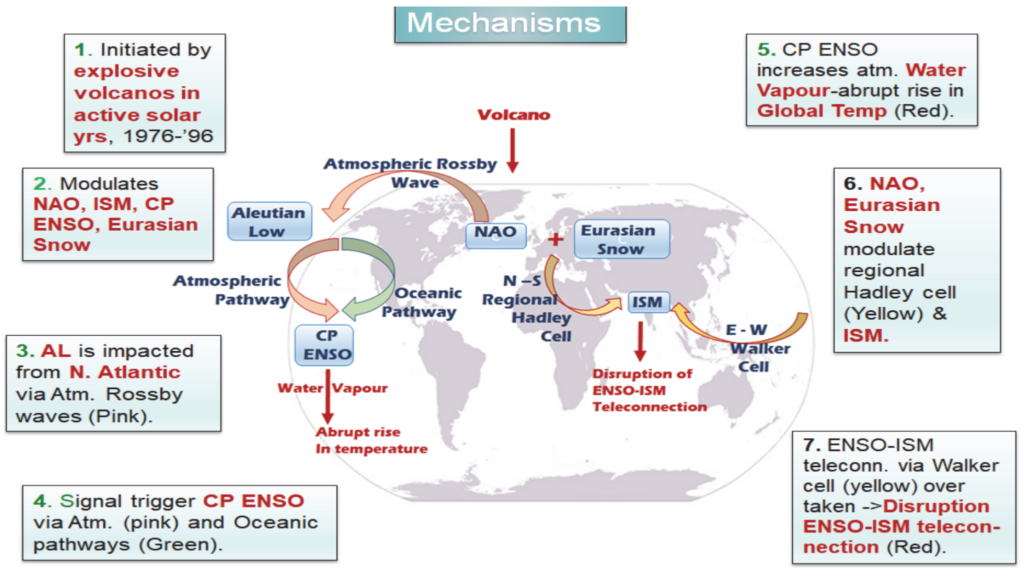

Fig. 6. Mechanisms are proposed following discussions earlier. Those are initiated by explosive volcanos in active phases of strong solar cycles. That modulated various features e.g, NAO, AL, ISM [after, Roy (2018a); Roy and Kriplani (2021)].

References

Roy I , 2010,, PhD Thesis, Imperial College, London, Doi: 10.25560/6038.

Roy, I, 2018a,. Front. Earth Sci. 6:136. doi: 10.3389/feart.2018.00136.

Roy, I, 2018b, Springer Nature, DOI: 10.1007/978-3-319-77107-6.

Roy, I. and Kriplani R, 2019a, Theor. and Appl. Clim., 137, 469–480. Doi: 10.1007/s00704-018-2597-z.

Roy I., and Kriplani R., 2019b, Theoretical and Appl. Clim., doi: 10.1007/s00704-019-02864-2.

Roy, I., Gagnon, A. and Siingh, D., 2019, Theo. and Appl. Clim., https://doi.org/10.1007/s00704-018-2536-z.

Roy I., 2020a, Pure and Appl. Geophy., Springer Nature, https://doi.org/10.1007/s00024-020-02522-z.

Roy, I. 2020b, Pure Appl. Geophys, Springer Nature. Doi: 10.1007/s00024-020-02564-3.

Roy, I and Kriplani R, 2021. Elsevier, DOI 10.1016/C2019-0-04482-2.

Roy, I , 2021, Natural Hazards, Springer Nature, https://doi.org/10.1007/s11069-021-04653-5.