A Novel perspective on the 'Sun-Ocean Time-lag' and a Proposed Mechanism for Bottom-up (Ocean-Atmosphere) Climate Forcing: Implications for Decadal Climate Predictions

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In this three-part study, I propose a novel data-driven approach to estimate and quantify the time-varying effects of solar irradiance (TSI) on sea surface temperature (SST) in order to uncover time-lag of temperature in response to long-term changes in TSI, at a regional scale encompassing the South China Sea. The study seeks to revisit the question of solar radiative forcing of regional temperature and climatic changes over the recent century, propose a plausible mechanism for sun-ocean-climate interaction and finally proceed to predict decadal changes in the regional climate system over decadal time scales. The results reveal a maximum time-lag of approximately 42 – 42.5 years between solar irradiance and SST. By applying this lag, the linear association between SST and TSI/SSN improves by orders of magnitude. The observed oscillatory patterns of SST are found to further correspond closely with high frequency 11 year solar cycles (moderate: 5.0 to strong 7.1 correlations) once the background lag is applied. Consequently, it has been uncovered that the period identified as the modern solar optimum (1910-1957) contributed significantly to the sea's and climate thermal optimum from 1951-1998; a time-lag of about four decades. Furthermore, the study proposes a 'bottom-up, double bridge mechanism' by which the sun may be influencing long term temperature and regional climatic changes. First, an 'ocean bridge', is based on the ocean's large heat capacity, capable of accumulating excess heat during periods of intense solar activity or solar optimum and shedding off excess heat during periods of solar minima, mediated by the 40 – 42-year time lag; and an 'atmospheric bridge' governed by atmospheric green-house gases, predominantly water vapour and CO_2 which trap evaporative heat and long-wave radiation from predominantly the ocean, coupled with the initial short-wave energy trapped directly by gas molecules in the atmosphere, and wind systems which redistribute air-masses and heat laterally and vertically. Finally, in guise of a climate prediction, a graphical model was constructed by plotting TSI against SST (moved forward40 years) to implement the lag time, using the moving average filter. The results confirm that changes in SST tracks each 11-year solar irradiance (SI) cycle almost perfectly once the maximum time lag of approximately 40 years is applied allowing for temperature and climate predictions to be made for the period 2016 - 2043. Six alternating warming and cooling patterns of ocean-climatic change are predicted to occur cyclically, each spanning approximately 10-11-year periods. In the first cycle, it is predicted that the large positive temperature anomalies caused by the 2016/2017 El Nino marks the end of the warming hiatus and the onset of renewed warming from 2016-2023. This will be followed by a slow-down of warming and probably a cooling trend from 2023-2028. The phenomenon styled 'global warming hiatus' of 1999-2015 is thus found to have a very plausible solar origin. The study concludes that while solar radiative forcing is the major forcing of the regional climate system and changes therein, but the relationship between solar irradiance and climate is not a direct one; it is largely determined and modulated by the oceanic thermal lag and associated feedback loops.

Key words: Sun-Ocean Time-lag, Bottom-up Forcing, Decadal Predictions, Double-bridge mechanism