In order to study whether CO2 is a major factor causing global warming, we collect 6 variables that may have impacts on land-ocean temperature, including • number of sunspots z1 • all sky surface shortwave downward irradiance (SWDR) z2 (in W/m2 ) • outgoing longwave radiation irradiance (OLR) z3 (in W/m2 ) • CO2 concentration in atmosphere z4 (in PPM) • CH4 concentration in atmosphere z5 (in PPM) • N2O concentration in atmosphere z6 (in PPM) Among these variables, z1, z2 and z3 are connected to solar activities and radiation, while z4, z5 and z6 are about correlated to greenhouse gases. To find out which of the factors beer bear the most severest impacts on temperature, we adapt the Grey Relational Analysis method. The algorithm allows us to calculate the Grey Relational Grade (GRG), which quantify quantifies the correlation between our measurement facters factors(Z) and the target sequences c.

To calculate GRC, we have to first yield the Grey Relational Coefficients (GRC). We calculate GRC between the i-th factor(zi) and the targetz0 on k-th data point, which is referred to as ζi(k), with formula (25). ζi(k) = mini mink |z0(k) − zi(k)| + r · maxi maxk |z0(k) − zi(k)| |z0(k) − zi(k)| + r · maxi maxk |z0(k) − zi(k)| (25) Later, we can calculate GRG of some factor ??? zi : GRGi = 1 m ∑m k=1 ζi(k) (26) Based on data ranging from 1959 to 2021, we compute GRG for z1 ∼ z6. The computation result is displayed in Figure.11.

As shown in Figure.11, the three greenhouse gases are all closely related to land-ocean temperature changes, while the impacts from solar activities are less significant. Among all the greenhouse gases, GRG of CO2 is the greatest, which convinced us that CO2 is a major factor accelerating global warming. 5.2.2 Quantitative Analysis To measure To closer inspect on the impacts of CO2 on land-ocean temperature and how the impacts vary in a wider range of time, we introduce the Spearman’s coefficient ρ, which reflects how well are closely the two variable Team # 12664 Page 20 of 21 are related with each other. The Spearman’s coefficient gives a number between −1 and 1. The closer are the two variables related more closely the two variables are related, the smaller |1 − ρ| will be. This coefficient is determined by the following formula. ρ(a, b) = ∑ i (ai − a¯)(bi − ¯b) √∑ i (ai −¯i) 2 + ∑ i (bi − ¯b) 2 (27) As usual As commonly defined, a¯ and ¯b represent the mean of a and b. Spearman’s coefficient of three or more variables gives a matrix. ρ(a, b, c) =   ρ(a, a) ρ(a, b) ρ(a, c) ρ(b, a) ρ(b, b) ρ(b, c) ρ(c, a) ρ(c, b) ρ(c, c)   (28) In order to study how CO2 concentraion and land-ocean temperature are related in different periods of time, we adapt a kind of 去partial estimating strategy. Specifically, we take every interval of time interval chronologically with length l and compute Spearman’s coefficient matrix of four variables: CO2 predicition made by model 1, 2, 3 and temperature prediction made by model 4 (The models also make ”predicitions” of the past according to the formula). This makes produces three curves, respectively describe describing the correlation between temperature and three CO2-predicting models respectively. These curves are shown in Figure.12.

As we see from the Figure, the three curves are all overlapped by each other before 2050. Yet, in 2060 and 2080, respectively, curves of model 3 and model 2 begins去 to fall slide dramatically. This shows that after 2060, temperature and CO2 concentration(predicted by model 2 & 3) no longer have similar trends. This fact thereby convinceds us that our model predicting land-ocean temperature will be no longer accurate after 2060.