Notes for Paper

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1 Introduction

1.1 Rationale

1.1.1 Greenhouse emissions are increasing global temperatures (breifly state)

1.1.2 ENSO is a change in the temperature of the pacific ocean with effects around the world

1.1.3 If climate change affects ENSO, then we need to find out now

1.2 Review of literature:

1.2.1 Climate change affects ENSO

1. Comparison of amplitude between many models with CMIP5 is mostly inconclusive
2. CESM-LE shows increase in amplitude that is significant

1.2.2 Role of multiple natural and artificial factors

1. Greenhouse gasses may be increasing ENSO amplitude
2. aerosol emissions dampen GHG increase in amplitude
3. What about everything else?
4. Not using a large ensemble mostly

1.3 Gap

1.3.1 not enough analysis on how ghg, aer, and others affect ENSO amplitude

1. how the two factors interact
2. how their effects look compared to internal variability
3. What physical mechanisms mediate their effect

1.3.2 Use some interesting methods: wavelet analysis

1.4 Variables:

1.4.1 Independent variable: external forcing

1. input climate models with observed and predicted greenhouse gas, aerosol, biomass burning, land use/cover, etc
2. GHG:
   (a) Observed and predicted to increase due to industrial burning
   (b) Lead to higher air (and water) temperature due to greenhouse effect
3. AER:
   (a) Aerosols produced by industry (smoke) and nature (volcanoes)
   (b) Usually reduce global temperatures by reflecting oncoming sunlight
   (c) Location of emission may change as industry moves from US to China
4. BMB:
   (a) Increased frequency of forest and grassland fires probably due to global warming
   (b) Releases CO_2 (GHG) and smoke (AER)
5. LULC:
   (a) Deforestation and desertification
   (b) Greenery reduces land temperature
   (c) Greenery reduces CO_2 levels
   (d) Modifies water cycle as leaves increase evaporation

2 Data

2.1 CESM1

2.1.1 Full forcing

1. Observed emissions levels 1920-2005
2. RCP8.5 (worst case) emissions levels 2005-2100

2.1.2 Single forcing

1. All but one forcing group
   (a) GHG
   (b) AER
   (c) BMB
   (d) LULC
2. Observed 1920-2005
3. Predicted emissions 2005-2080

2.1.3 Control

1. 1850 fixed emissions levels

2.2 CESM2

2.2.1 Higher ensemble size

2.2.2 Longer record length

2.2.3 Newer code

2.2.4 Full forcing

1. SMBB vs CMIP6 discrepancy
2. Observed forcing levels 1850-2005
3. Worst case emissions 2006-2100

2.2.5 Single Forcing

1. Similar to CESM1
2. Not all members are done yet

2.2.6 Control

1. Similar to CESM1

2.3 Observed data

2.3.1 Might mention in introduction?

2.3.2 Used for introductory presentation figures, not yet for actual methods

3 Methods and Results

3.1 For all ensembles and all variables:

3.1.1 Subtract ensemble mean from each member to derive internal variability i.e. ENSO

3.2 Niño 3.4 index

3.2.1 Mean temperature in Niño 3.4 region

3.2.2 20-year rolling variance for each member

3.2.3 Ensemble statistics: mean and standard error (dependent on ensemble size)

3.2.4 Control?

3.2.5 Figure 1: CESM1 and CESM2 FF Niño 3.4 variance ensemble means

3.2.6 Explanation:

1. CESM1
   (a) Starts with low variance, steeply increasing from 1950-2050, dropping slightly after 2050
   (b) Probably nonlinear response to forcing: does not keep increasing
      i. Are emissions slowing down post-2050?

2. CESM2
    (a) Exponential? increase in variance until 2025, then sharp decrease
        i. Why?

3.3 Single forcing ensembles

3.3.1 SF ensembles for CESM1 and CESM2

3.3.2 All-but one

3.3.3 Figure 2: ENSO amplitude index for SF and FF models

3.3.4 Explanation

1. -BMB and -LULC means are pretty close to FF mean, signaling little impact
2. -AER and -GHG means are mostly unchanged, signaling stronger impact

3.3.5 Bootstrap

1. Subtract random SF member from random FF member
2. Leaves behind isolated effect of single factor
3. aeu