Multi-frequency analysis of modeledversus-observed variability in tropospheric temperature

Regional & Global Model Analysis Program Area PI Meeting

October 13-16, 2020

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Research outcome

Developed a statistical framework to compare the **spectral**

features of TMT variability in the model ensembles and satellite data under different analyst choices:

To explore whether the last two generations of climate models underestimate observed low-frequency variability of mid- to upper — the climate model ensemble and type of simulation (HIST and CTL) tropospheric temperature (TMT)

- the method for separating signal and noise (MMA-r, LIN, QUAD and CUB)
- the frequency range considered (ALL, HIGH, LOW)
- the statistical model used to represent observed natural variability (AR, ARMA, FARIMA)

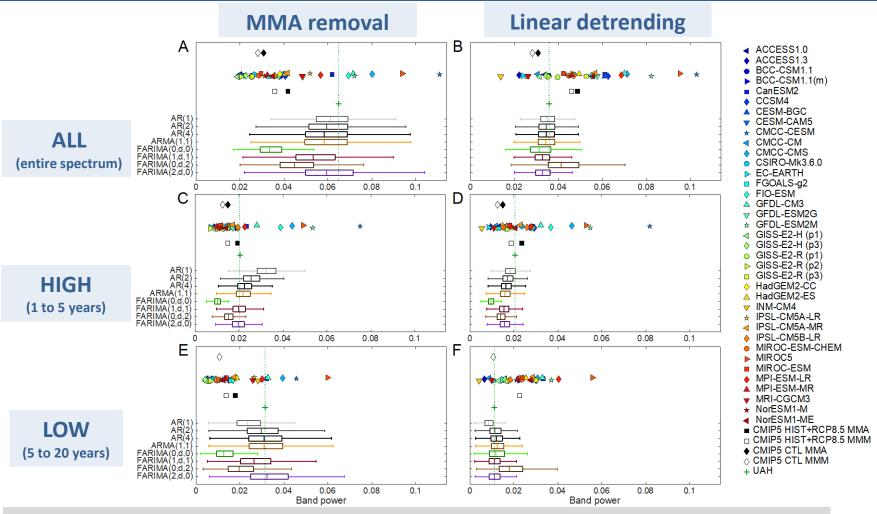






Program for Climate Model Diagnosis and Intercomparison

Distributions of band power values from the statistical models estimated on UAH dataset

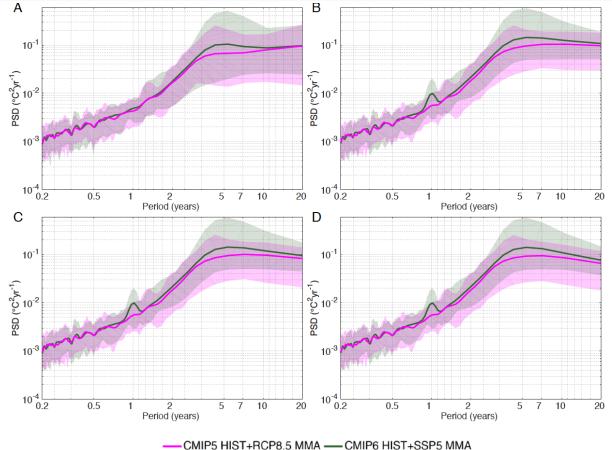








Comparing CMIP5 and CMIP6 spectra



Comparison of the average spectra for the HIST+RCP8.5 simulations performed with 37 different CMIP5 models and for the HIST+SSP5 simulations performed with 21 different CMIP6 models.

All spectra were calculated for TMT data spatially averaged over 82.5N-82.5S.

The analysis period is from January 1979 to December 2018.

The shaded areas represent the 5-95% variability intervals on the power spectral densities.

A: MMA removal

B: Linear detrending

C: Quadratic detrending D: Cubic detrending





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Probability that CMIP HIST simulations have *larger* band power Prash observations

| | r | MMA(ALL) | MMA(HIGH) | MMA(LOW) | LIN(ALL) | LIN(HIGH) | LIN(LOW) | QUAD(ALL) | QUAD(HIGH) | QUAD(LOW |) CUB(ALL) | CUB(HIGH) | CUB(LOW) | Average | |
|---------------|--------------|----------------------------------|---------------------|-----------------|-------------------|---------------------------|--------------|--------------------|----------------------|-----------------|-----------------|--------------|-------------------------|--------------|----|
| RSS | AR(1) | 0.23 | 0.18 | 0.44 | 0.87 | 0.72 | 0.98 | 0.85 | 0.72 | 0.98 | 0.81 | 0.72 | 0.97 | 0.71 | |
| | AR(2) | 0.26 | 0.28 | 0.29 | 0.87 | 0.76 | 0.93 | 0.85 | 0.76 | 0.91 | 0.82 | 0.76 | 0.89 | 0.70 | |
| | AR(4) | 0.27 | 0.34 | 0.27 | 0.87 | 0.80 | 0.90 | 0.85 | 0.80 | 0.88 | 0.82 | 0.80 | 0.85 | 0.70 | _ |
| • W• | 2MA(1,1) | d:4th | at₃oı | | 1esc | ales | Ot.95- | - 12@ ∨ | rears | . © 50 | 5e#V | 20 79 | V p. \$ 6 | 0.70 | |
| FARIM | 1A(0,d,0) | 0.65 | 0.87 | 0.64 | 0.91 | 0.99 | 0.88 | 0.89 | 0.99 | 0.86 | 0.86 | 0.99 | 0.83 | 0.86 | |
| √ 7211 | M(MA) | i∣∳≢₹∕ | is to | nºæv | erag | ℮℣℀℩ | /PP2 | \$ †∮ ฅา | ated | 17/9 1 † | h 2 36 2 | a 5482t v | V 0.58 | 0.73 | |
| FARIM | 1A(0,d,2) | 0.34 | 0.62 | 0.35 | 0.68 | 0.88 | 0.67 | 0.64 | 0.88 | 0.63 | 0.60 | 0.88 | 0.58 | 0.65 | |
| FARIN | (2d.0) | t ⁰ i ² Ar | c ^{0.33} f | clim | 295 | måd | <u></u> | Thic | ragu | 140.91 | raist | +i\981\ | 0.89 | 0.72 | |
| TAISCI | AR(1) | 1 6i38 | 0.28 | 0.68 | C _{0.87} | 11892 | 0.98 | 600 | 1 6.72 U | 0.98 | 0.82 | LIV.74I) | 0.98 | 0.75 | |
| inc | AR(2) | 0.40 | 0.38 | liffor | 0.87 C D T | 0.76 | C 1931 | SS'n- | 10.76 10.76 | ch 0.92 | 0.83 | 0.77 | 0.91 | 0.74 | |
| | eas | | | litter | 'ent | plau | SHOKE | | 7 | CWOI | Ces | 0.79 | 0.89 | 0.74 | |
| | RMA(1,1) | 0.42 | 0.45 | 0.43 | 0.87 | 0.80 OFNIR | His | 0.85 | 0.80 | 0.88 | 0.83 | 0.81 | 0.87 | 0.74 | |
| FARIM | 1A(0,d,0) | 0.65 | 0.87 | 0.64 | 0.89 | 90018 | .88 | 0.88 | 0.99 | 0.85 | 0.85 | 0.99 | 0.82 | 0.86 | - |
| FARIM | /A(1,d,1) | 0.41 | 0.43 | 0.45 | 0.91 | "Chi. | 0.93 | 0.89 | 0.81 | 0.92 | 0.88 | 0.82 | 0.92 | 0.77 | |
| A C | IA(0,d,2) | 0.36 | 0.64 | 0.37 | • | $\mathbf{v}_{\mathbf{l}}$ | _ | 0.62 | 0.87 | 0.62 | 0.58 | 0.87 | 0.57 | 0.64 | |
| | | <u>ገ</u> | <u> </u> | men | 1 <u>9.45</u> | <u>tpat</u> | <u> TWYO</u> | COM | <u>119901</u> | <u>n byz U</u> | sed | <u>Stati</u> | <u>strea</u> | 0.76 | |
| JAH | AR(1) | 0.13 | 0.12 | 0.20 | 0.91 | 0.75 | 0.99 | 0.90 | 0.75 | 0.98 | 0.85 | 0.75 | 0.98 | 0.69 | |
| mo | oďel | S°OT | SPOr | t≗teı | rm¹a | ndeld |) [약 - | term | nme | mer | v Ma | ve.7de | 219Cie | neie | 25 |
| | AR(4) | 0.15 | 0.25 | 0.15 | 0.91 | 0.81 | 0.93 | 0.89 | 0.81 | 0.91 | 0.86 | 0.81 | 0.89 | 0.70 | |
| i naga | | r ₀ 46b | | t q :15a | ηξυι | re åh | e_0 c | mple | ex ^{.8} \$h | ape | Q_{89}^{0} | bser | ved | $\Gamma M T$ | |
| FARIM | 1A(1,d,1) | 0.20 | 0.33 | 0.20 | 0.94 | 0.85 | 0.95 | 0.93 | 0.85 | 0.94 | 0.90 | 0.84 | 0.92 | 0.74 | |
| SAR | SCT U | $a_{0.32}$ | 0.59 | 0.33 | 0.71 | 0.90 | 0.69 | 0.68 | 0.89 | 0.65 | 0.64 | 0.89 | 0.60 | 0.66 | _ |
| • | 1A(2,d,0) | 0.21 | 0.42 | 0.22 | 0.94 | 0.84 | 0.95 | 0.93 | 0.84 | 0.94 | 0.90 | 0.83 | 0.92 | 0.74 | |
| | Average | 0.33 | 0.43 | 0.37 | 0.87 | 0.83 | 0.90 | 0.85 | 0.83 | 0.88 | 0.82 | 0.83 | 0.86 | 0.73 | |







Future work

- We operate on "signal removed" TMT data. We will investigate the use of raw data and study its impact on the estimated observed natural variability
- We also intend to expand our suite of signal removal methods:
 - scaled MMA removal
 - Energy Balance Models (EBMs) for estimating "noise free" anthropogenic signals from observations in the presence of uncertainties in ECS and anthropogenic aerosol forcing
- We plan to use of large initial condition ensembles (LEs) for comparing the efficacy of signal removal approaches

