4th Summer School on
Theory, Mechanisms and Hierarchical Modeling of Climate Dynamics: Atlantic Variability and Tropical Basin Interactions at Interannual to Multi-Decadal Time Scales

July 30, 2023

1. Observations and reanalysis

1. ERA5 monthly Surface dataset (1940-2022): SST, Precipitation, Surface Air Temperature (2m), Mean Sea Level Pressure (1x1 degree spatial resolutions all fields)
2. ERA5 monthly Pressure Level dataset (1940-2022) on selected levels: Geopotential Height, U-winds, V-winds, Temperature, Specific humidity (1x1 degree spatial resolutions all fields)
3. ERA5 monthly Pressure Level dataset (1940-2022) on selected levels: Atmospheric Pressure dataset in point (2) is also available on SPEEDY Model grid.
4. Hadley Centre monthly Sea Surface temperature dataset (1870-2022) (1x1 degree spatial resolutions)
5. ERSST Version 5 monthly Sea Surface temperature dataset (1854-2022) (1x1 degree spatial resolutions)
6. GPCP monthly precipitation field (1x1 degree spatial resolutions)

All datasets are here:
`/home/esp-shared-a/Distribution/Workshops/cli_dy_summer_school_2023/observations`

3. Model datasets

1. CMIP6
   - piControl simulation from at least one model out of: CESM2, HadGEM3-GC31-MM, MIROC6, MRI-ESM2-0, CanESM5, GFDL-ESM4, BCC-ESM1, ACCESS-CM2
   - required variables:
     - 2D: ts, uas, vas, tauu, tauv, pr, psl, ps, hfls, hfss, rsds, rsus, rlds, rlus, rlut, sfcWind; tos, zos, sos; msftmz (or msftmrho)
     - 3D: (desirable): ua, va, wap, zg, ta, hus; thetao, uo, vo, wo, so
2. NorESM pacemaker
   - 30 members of historical run (1980-2020)
   - 5 members of full field pacemaker run (1980-2020)
   - 5 members of anomaly pacemaker run (1980-2020)
3. NorCPM predictions
   - 10 members of seasonal forecast as control run (HIND_CTRL). From 1982-2020, initial on 15th of Jan, Apr, Jul and Oct.
   - Same as HIND_CTRL, but 30 members of seasonal forecast with anomaly pacemaker nudge.

   All datasets are here:
   `/home/esp-shared-a/Distribution/Workshops/cli_dy_summer_school_2023/Nor_ESM1_data/`
4. CESM1
   - CESM1_2_deg_Fu
   - CESM1_1_deg_HuEtAl

All datasets are here:
/home/esp-shared-a/Distribution/Workshops/cli_dy_summer_school_2023/CESM1_2_deg_Fu/
/home/esp-shared-a/Distribution/Workshops/cli_dy_summer_school_2023/CESM1_1_deg_HuEtAl/

5. SPEEDY-NEMO PACEMAKER

   - 10 members anomaly pacemaker run (1870-2022).

   Total 10-ensemble members are here:
   http://clima-dods.ictp.it/Users/mabid/Speedy_atl_pacemaker/atmos_data/

2. Available models

(a) SPEEDY

(b) SPEEDY-TOM3 (https://egusphere.copernicus.org/preprints/2023/egusphere-2023-1103/)

(c) SPEEDY-NEMO (https://doi.org/10.1007/s00382-015-2705-z)

SPEEDY Coupled Model pacemaker experiments are performed using a spin-up of about 1000 years of the coupled model experiment restart files. For the pacemaker, the model SST are replaced with the observed SST anomalies from HadISST in the Atlantic region.

Term project descriptions

We expect 7-8 Groups of 5 students, with mix of experience and background

1. **How much Indo-Pacific variability is driven by equatorial Atlantic SST variability?**
   The NorESM pacemaker experiments can be used to address this question, as they provide an estimate of how much climate around the globe is influenced by equatorial Atlantic SST. The runs can be compared to observations, and used to identify mechanisms and whether they may change over the simulation period. Comparison of the full field and anomaly pacemaker experiments can provide insight on the effects of model biases.
2. **How much can equatorial Atlantic SST variability enhance ENSO predictions?**
   Here we will make use of NorCPM predictions with and without equatorial Atlantic SST restored o observations. This exercise will provide hands on introduction to analysing seasonal predictions. Comparing the two predictions experiments will provide an estimate of the influence of the equatorial Atlantic SST on prediction skill. Different forecast start months and lead times can be examined.
3. **How does the magnitude of the low-cloud feedback strength under global warming influence the nature AMV (or TBIs)**
   Here we would use the simulations from Erfani and Burls, 2019
4. **CMIP6 piControl simulation**
   Use long-term simulations (e.g. 1000-year) to identify positive and negative AMV phases. Examine how TBI changes between AMV+ and AMV-, with a focus on the Atlantic-Pacific connection. If there is a modulation of TBI, is it consistent with observations (e.g., comparison with Martin-Rey et al. 2014)?
5. **Use the same long-term simulation as in 4. to examine decadal modulation of the Atlantic-Pacific connection from the other direction**
   Identify periods of weak and strong Atlantic-Pacific linkage (e.g., by using at 30-year running correlation Niño 3.4 and ATL3 SST indices) and examine how their respective mean states differ. Are the differences AMV-like? What other differences emerge?
6. **Pacemaker experiments**
   They are a popular tool for analyzing interactions among ocean basins. In these experiments SSTs are modified to follow some specified target SST. The strength of the SST restoring is a crucial consideration in such experiments: if it is too strong, unrealistic surface heat fluxes can have negative impacts on the simulation, if it is too weak the SST will stray too far from the target. Perform tropical Atlantic pacemaker experiments with SPEEDY (SPEEDO?) to examine this issue, using, e.g., 10-day, 30-day and 60-day restoring over 50m. The focus could be on one particular year, depending on the available computing resources. How well are the SSTs in the restoring region reproduced? How do the remote influences change?
7. **Investigating how ENSO/AMV relate to Gulf Stream variability**
   with a particular focus on Gulf Stream properties that can be mechanistically linked to weather variability such as the SST gradient or path length.
8. **Perform LFA analysis (https://github.com/rcjwills/lfca) on both the PI (E280) and PI_pacsalt (E280_pacsalt) runs and see if / how the low frequency modes of variability for the Pacific Basin change when the PMOC is present**
9. **Indealized experiments with SPEEDY model**

   - Investigate observed Atlantic 'modes' of variability (Atlantic Niño, Tropical North Atlantic) impact on Pacific using SPEEDY in AGCM setting. The SST anomalies are monthly varying, but interannually constant SST anomaly composites in Atlantic region, based on linear regression.
   - Same as a) but using SPEEDY coupled to a mixed-layer ocean and an Atlantic pacemaker strategy.
   - Investigate the impact of a gaussian SST anomaly of constant magnitude in different positions in the Atlantic region to identify the roles of position and seasonality in Pacific responses to Atlantic SST anomalies. Use the AGCM setting.
   - same as c), but using the SPEEDY coupled to a mixed-layer ocean and an Atlantic pacemaker strategy.