Toward Detecting and Attributing Past and Future Climate Variations with Ensemble Simulations, Data Assimilation, and Climate Predictions

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Database for Policy Decision making for Future climate change: d4PDF SOUSE Program for Risk Information on Climate Change 候変動リスク情報創生プログラム

http://www.miroc-gcm.jp/~pub/d4PDF/index_en.html

NHRCM 20 km



1 ensemble

140 (mm/day)

- aiming at uses for the adaptation decision making
- High-res Global and regional Atmos climate simulations
- Past-climate simulations: 60 yrs X 100 ens.
- Future-climate simulations: 60 yrs X 90 ens. under +4K SAT warming relative to the preindustrial
- different Initial-conditions and monthly SST pertutbations. +4℃ Past
- Data volume: 2PB



Mizuta et al. (2017, BAMS) and 15 papers

MRI-AGCM 60km

画像:気象庁提供

Smoother PDF as more mem.

Daily precipitation of 10-yr return period



Less noisy in space→ helps to estimate local climate changes



Future Changes of Tropical Cyclone

Yoshida et al. (2017, sub judice)



statistically robust estimations even for extreme events Consistent with our 20-km exp & IPCC AR5 overall



an application of d4PDF for impact-assessment study

Future changes in coastal risks

50-year return values of surface wind and storm surges



Obviously, risk of storm surge will increases, corresponding to the future changes of ocean surface wind.

Mori et al. (2017, submitted)



+2K future climate simulations

Daily Maximum Temperature Frequencies in August at TOKYO





year 2040 cond. of RCP8.5

for assessment of the differences of future changes of mean climates and extreme events between +2K and +4K exp.



Event Attribution

Is this extreme event due to the past human activity?

Attributing how much natural variations and global warming contribute to specific climate/weather extreme events by comparing a number of simulations w/ observed SST & natural and anthropogenic forcing ("factual"; d4PDF past-clim sim.) to simulations w/o SST trend & anthropogenic forcing ("counterfactual"; a subset of d4PDF)





BAMS special report 2015

Event attribution using ensemble regional climate experiments (RCM-EA)

Historical and natural-only experiments with AGCM

→ Dynamical downscaling using RCM with 20km

Ex. Aug. 2010; the warmest summer

Histogram of maximum temperature at Tokyo



Sea Level Pressure in August



Black contour: climatology of 2000s Shading: impact of annual variability of SST in 2010 Blue and red contour: impact of global warming

RCM-EA hopefully enables to evaluate the influence of global warming on extreme events affecting humanliving environment.

Missing Air-Sea Interactions (1)

Air-sea interactions are intrinsically missing in AGCM simulations. This point has to be taking into account when we discuss the uncertainties in past and future climate changes.

Future Changes in Summer-Time Monsoon JJA Precipitation



In AGCM (d4PDF),
Clock-wise circulation around Philippine
→ no future change/drier state over Japan

In CMIP5 - opposite signs Hidden uncertainties must be considered,

Missing Air-Sea Interactions (2)

Biases in *Intense* Tropical Cyclone Frequencies

Future Changes in Intense Tropical Cyclone Frequencies

Ogata et al. (2016)



Too-intensified TCs in mid-latitudes in AGCM Biases reduced much in AOGCM

Models/Systems used currently and next

1) MRI-ESM2

2) Initialization and Ensemble-generation schemes incorporated to the MRI-ESM2



Model Application



developed for operational uses at JMA.

- LETKF (Hunt et al. 2007)
- Variables to be assimilated Atmos: T, q, u, v Ocean: T, S, u, v
 - Sea ice: c, h, s, u, v
- Assimilation interval: 6 hours for Atmos. and 5 days for Ocean
- Observations
 - Surface Pressure (ISPD v.3.2.8)
 - Typhoon tracks (IBTrACS v03)
 - SST: COBE-SST2 (Hirahara et al. 2014) + SST perturbations
 - Updated ocean subsurface T and S (Ishii et al. 2017)
 - Sea ice concentration
- Loosely coupled



Climate Reanalysis

- EnKF-based scheme for model initialization and 150-yr climate reanalysis.
- tested for climate reanalysis with MIROC3



Surface pressure observations over Japan are very few before WW-II. Data rescue is an urgent work!



Estimating Longer-Term Ocean T and S

In the 150-yr reanalysis, gridded observations are used, after thinning as VATs of the data profiles used take local minima/maxima and as homogeneously distributing as Argo.



1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 Year



• Large ensemble data base of past, present-day, and future climate states by model simulation, data assimilation, and prediction.

 The data base are useful for detecting & attributing climate signals and long-term climate prediction as well as impact assessment studies.