Representation of Extreme Wet and Dry Events over Indonesia:
Insights from High Resolution MESACLIP CESM-HR and CESM1-BGC Simulations

Donaldi Permana[1*], Ummu Ma'rufah[1], Nurdeka Hidayanto[1], Nurul Tyas Rahmadani[1], Danang Eko Nuryanto[1], Radyan Putra Pradana[1], Ratih Prasetya[2], Rahmat Triyono[1]

[1]Center for Standardization Instrument (PSI MKG), Indonesian Agency for Meteorology, Climatology and Geophysics [BMKG]
[2]Center for Human Resources Development (PPSDM MKG), Indonesian Agency for Meteorology, Climatology and Geophysics [BMKG]

*Contact : **donaldi.permana@bmkg.go.id**

Introduction and Objectives

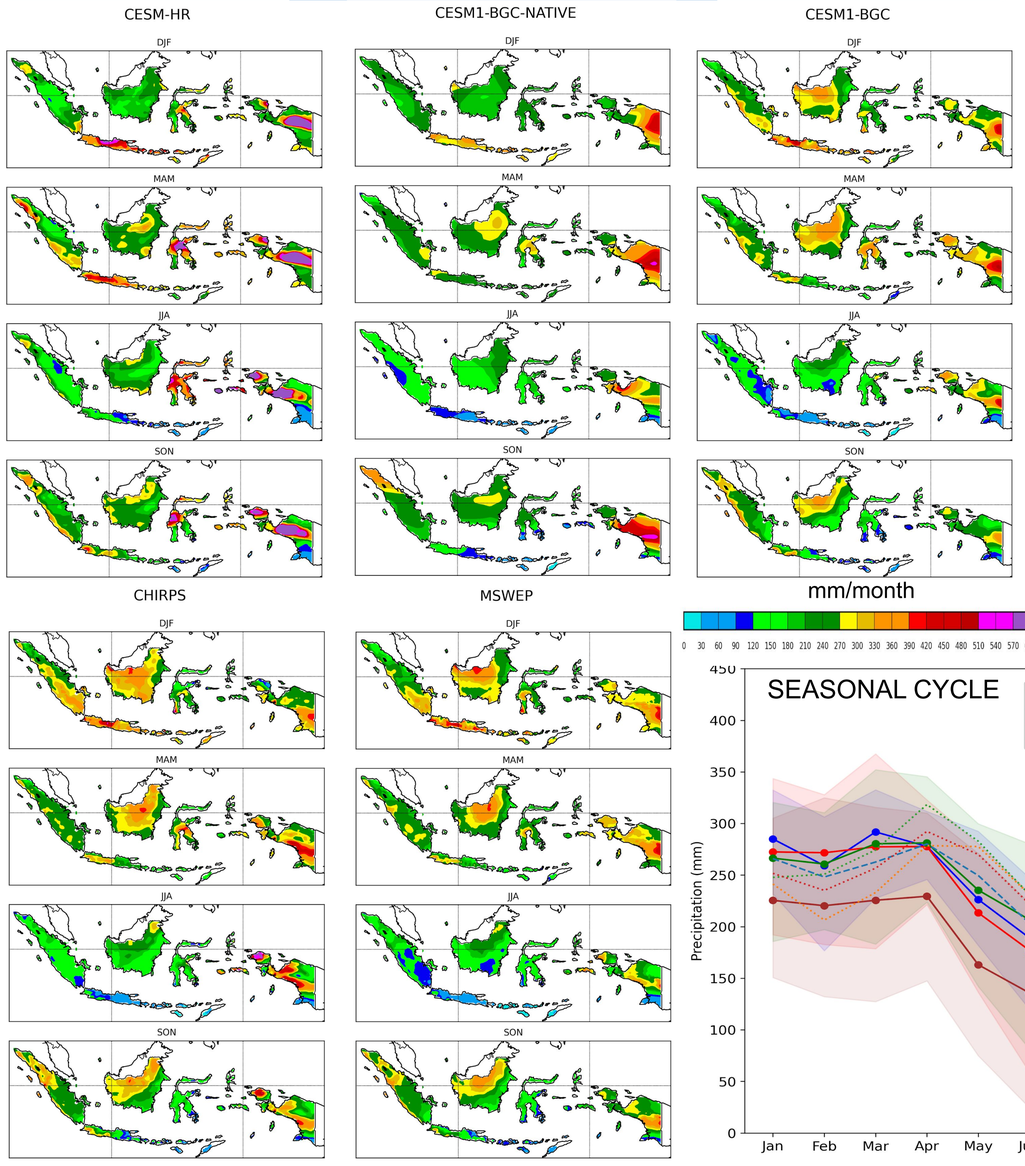
Introduction

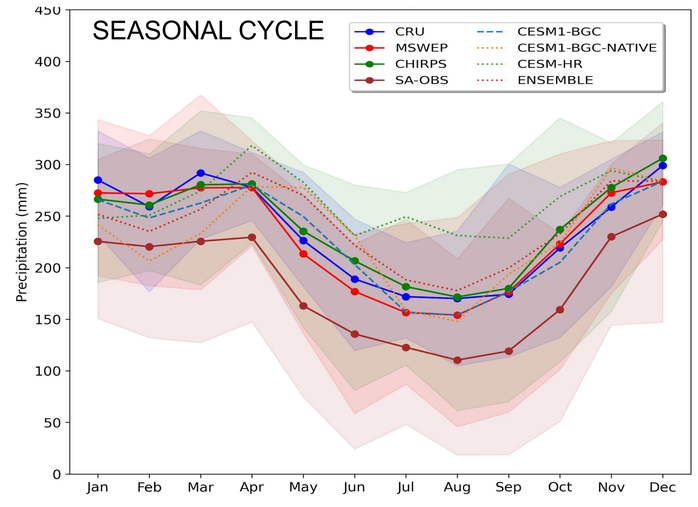
- Indonesia is highly vulnerable to extreme wet and dry events driven by complex convection, monsoon variability, and topography.
- Precipitation extremes and dry spells remain challenging to represent in climate models.
- Dynamical and statistical downscaling offer complementary approaches to improve climate information at regional scales.
- Their ability to reproduce Indonesian hydroclimatic extremes requires systematic evaluation across regions and seasons.

Objectives

- Evaluate CESM-based simulations of Indonesian extreme wet and dry events (1981–2005).
- Compare **MESACLIP CESM-HR, CESM1-BGC downscaled, and CESM1-BGC-NATIVE** against references (MSWEP and CHIRPS).
- Assess performance using **ETCCDI indices, bias, spatial correlation, and variability**.
- Identify **regional/seasonal strengths and added value** of dynamical and statistical downscaling.

Seasonal Climatology





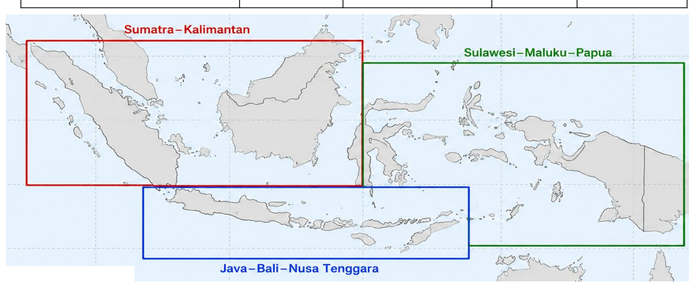
Data and Methods

- **Period:** 1981–2005 (25 years)
- **Datasets:** 3 CESM-based daily precipitation datasets [1,2,3]
- **References:** MSWEP (~10 km) and CHIRPS (~25 km) [4,5]
- **Indices:** ETCCDI — **Rx1day, Rx5day, SDII, R10/20/50mm, R95p, R99p, CWD, CDD, PTOT**
- **Metrics:** Spatial correlation (**r**), RMSD, mean bias, and SD ratio
- **Scales:** Annual and seasonal

Dataset	Type	Model	Res.	Ens.
CESM-HR (MESACLIP)	Dyn. High-res	CESM1.3/CAM5	0.25°	Member #1
CESM1-BGC (NEX-GDDP-CMIP5)	BCSD	CESM1-BGC	0.25°	r1i1p1
CESM1-BGC Native (CMIP5)	Native Sim	CESM1-BGC	~1.25° × 0.94°	r1i1p1

Regional Domains

- **Sumatra–Kalimantan**: Equatorial / bimodal
- **Java–Bali–Nusa Tenggara**: Monsoonal / unimodal
- **Sulawesi–Maluku–Papua**: Maritime / variable seasonality

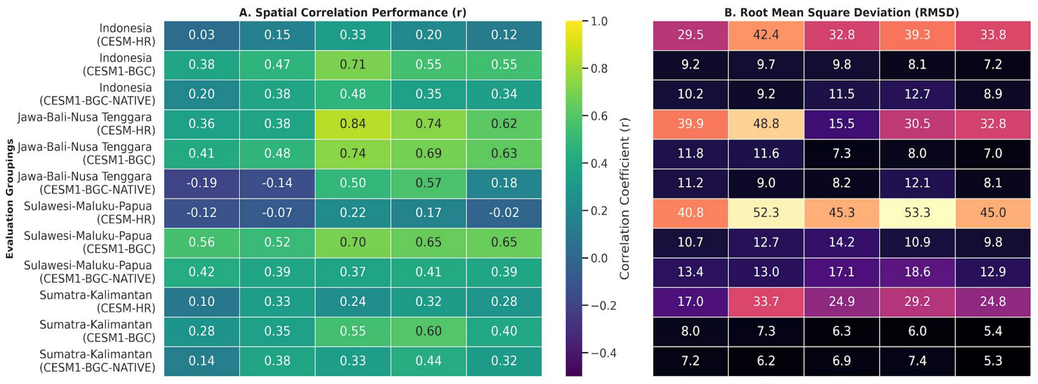


Analysis Framework

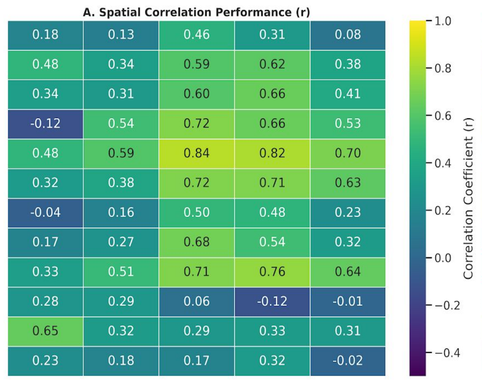
CESM simulations → Seasonal climatology → ETCCDI extremes → Statistical evaluation → Downscaling comparison

ANNUAL

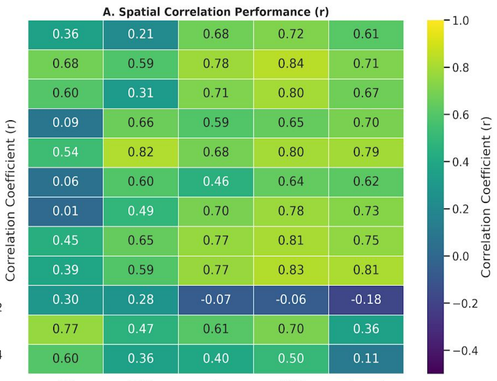
SEASONAL — RX1DAY



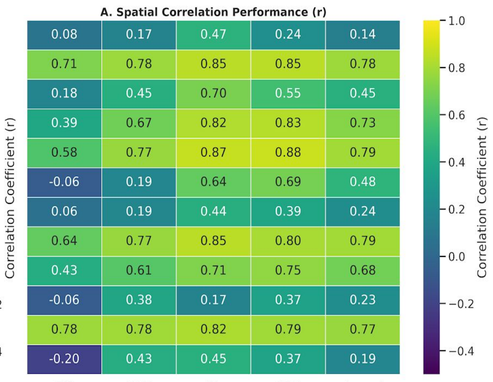
CWD



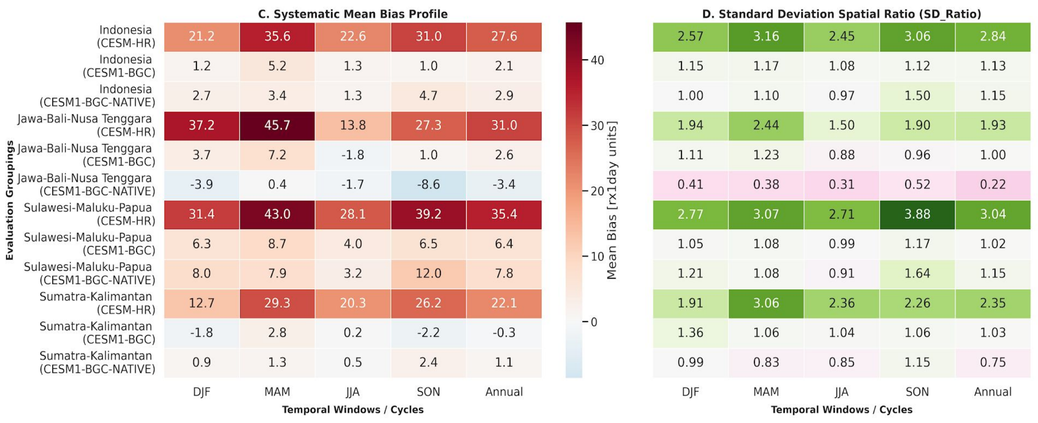
CDD



PTOT



SEASONAL — RX1DAY



Take-Home Points (https://link.bmkg.go.id/usclivar2026workshop)

CESM1-BGC (BCSD)

- **Best overall performance** across CDD, CWD, and PTOT.
- Strong annual spatial correlation (**r = 0.51–0.81**) and realistic spatial variability.
- Slight wet bias in **RX1DAY/RX5DAY** and dry bias in **CWD**.

CESM-HR (Dyn. Downscaled High-Res)

- **Added value for localized drying**, especially in JJA–SON.
- CDD correlation reaches **r = 0.59–0.78** over eastern/monsoonal regions.
- **Strong wet bias** in PTOT and extreme rainfall; poor annual CDD and excessive spatial variability (**SD Ratio > 2**).

CESM1-BGC-NATIVE (Low-Res)

- **Reasonable bias and spatial variability**.
- Weaker spatial correlations than downscaled CESM1-BGC.
- **Underestimates heavy-rainfall frequency** (R10mm, R20mm).

Overall: *BCSD provides the best overall fidelity, while CESM-HR adds value for localized dry-spell characteristics.*

References

1) Castruccio, F. S., et al. (2024). *MESACLIP: 10-member CESM-HR historical simulations*. NCAR. doi:10.5065/7N1X-K278.
2) Thrasher, B., et al. (2012). *Bias correcting climate model simulated daily temperature extremes with quantile mapping*. NASA.
3) Lindsay, K. (2013). *CESM1-BGC CMIP5 Historical Model Output*. WDCC/DKRZ.
4) Beck, H. E., et al. (2019). *MSWEP v2 global precipitation*. BAMS, 100, 473–500.
5) Funk, C., et al. (2015). *CHIRPS: Climate Hazards Infrared Precipitation with Stations*. Scientific Data, 2, 150066.

Presented at Broadening Earth System Research Across Scales with High-Resolution Modeling Workshop | 14 - 17 September 2026, Boulder, Colorado, US