Regional climate projection of the Maritime Continent using the MIT Regional Climate Model (MRCM)

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Introducing the MIT Regional Climate Model (MRCM)

• During the last decade researchers at MIT have worked on improving the skill of Regional Climate Model version 3 (RegCM3) in simulating climate over different regions through the incorporation of new physical schemes or modification of original schemes. The MIT Regional Climate Model (MRCM) features several modifications over (RegCM3) including coupling of Integrated Biosphere Simulator (IBIS), a new surface albedo assignment method, a new convective cloud and rainfall auto-conversion scheme, and a modified boundary layer height and cloud scheme.
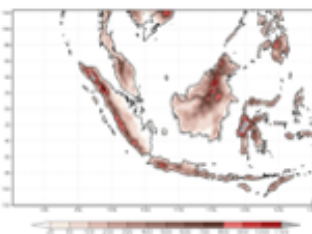
New Features	Key References
Coupling of Integrated Biosphere Simulator (IBIS) Land Surface Scheme	Winter J., et al. 2009: J. Climate, 22, 2743-2756. Im, E.-S, et al. 2014: J. Climate, 27, 2209-2229.
New surface albedo assignment	Marcella, M. P., and E. A. B. Eltahir, 2012: J. Climate, 25, 704-719.
Sub-grid variability of dust emission	Marcella, M. P., 2012: Ph.D. dissertation, MIT, 282 pp.
New irrigation module	Marcella, M. P., and and E. A. B. Eltahir, 2014: J. Climate, In press. Im, E.-S, et al. 2014: J. Climate, 27, 994-1009.
New convective cloud scheme	Gianotti, R. L., and E. A. B. Eltahir, 2014a: J. Climate, 27, 1488-1503.
New convective rainfall autoconversion scheme	Gianotti, R. L., and E. A. B. Eltahir, 2014b: J. Climate, 27, 1504-1523.
Modified boundary layer height and boundary layer cloud scheme	Gianotti, R. L., 2012: Ph.D. dissertation, MIT, 306 pp.

Experimental Design for the Climate Simulation of the Maritime Continent

• Maritime Continent is a representative region that highlights the downscaling necessity due to its complicated geographical features. For the fine-scale climate information suitable for representing well geographical complexity, we develop and optimize the MRCM modeling system with 27 km grid spacing focusing on the Maritime Continent.

• To assess the MRCM performance and the added value of fine-scale simulation, we carried out a series of experiments within the research strategy composed of three steps.
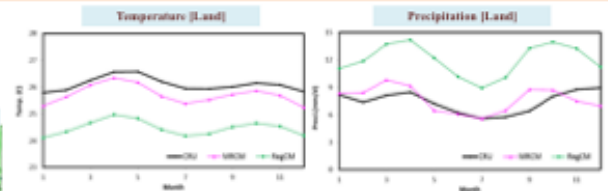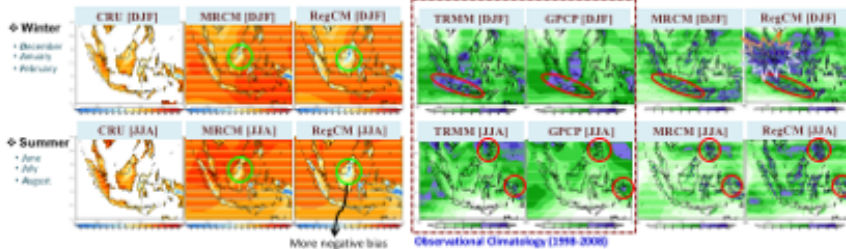
Domain & Topography

Experiment Design

STEP I — Perfect LBC Experiment
• IC and BC from analysis observation (NCEP/NCAR, ECMWF …)
• Validation of the model performance against observation

STEP II — GCM-driven Reference Exp.
• IC and BC from GCM simulation of present-day climate
• Assessment of added fine scale information provided by RCM

STEP III — GCM-driven Future Exp.
• IC and BC from GCM simulation of future climate
• Comparison of future & present climate statistics in order to identify the change signal

Downscaling of ERA40 Reanalysis [Step I]

Seasonal Mean Temperature & Precipitation

❖ Winter
• December
• January
• February

❖ Summer
• June
• July
• August

CRU [DJF], MRCM [DJF], RegCM [DJF], TRMM [DJF], GPCP [DJF], MRCM [DJF], RegCM [DJF]
CRU [JJA], MRCM [JJA], RegCM [JJA], TRMM [JJA], GPCP [JJA], MRCM [JJA], RegCM [JJA]

More negative bias

Observational Climatology (1998-2008)
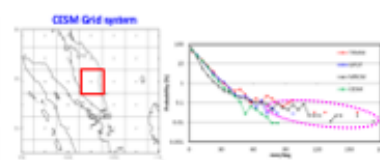
Temperature [Land]   Precipitation [Land]

• The MRCM is capable of reproducing the major features of observed temperature and precipitation over the Maritime Continent.
• The MRCM also represents a significant improvement over RegCM, showing the reduction of strong cold bias as well as strong wet bias.

Downscaling of CESM Global Projection [Step II & Step III]

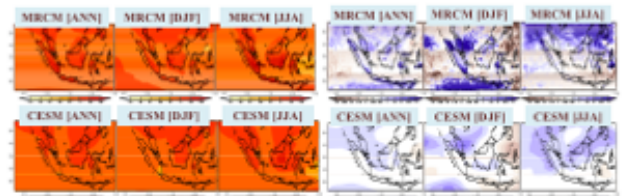### Long-term Trend of Temp. & Preci.

Whole [ANN], Whole [ANN]
Whole [DJF], Whole [DJF]
Whole [JJA], Whole [JJA]
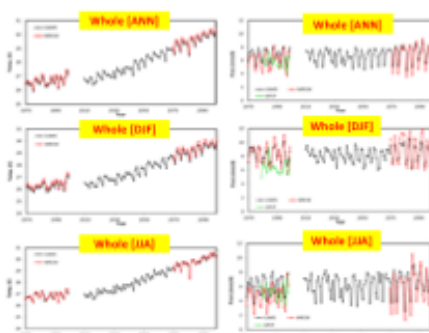
Frequency distribution of Daily Preci.

CESM Grid system

• Daily precipitation from MRCM is capable of capturing some extreme values closer to TRMM observation compared CESM used as boundary condition.

Spatial Distribution of Future Changes in Temp. & Preci.

MRCM [ANN], MRCM [DJF], MRCM [JJA]   MRCM [ANN], MRCM [DJF], MRCM [JJA]
CESM [ANN], CESM [DJF], CESM [JJA]   CESM [ANN], CESM [DJF], CESM [JJA]

• Temp. & Preci. change features from MRCM generally show the similar patterns with those from CESM global projection, however MRCM produces much detailed and stronger magnitude of change signals due to local process.

SMART