Sensitivity study of Tropical cyclone activity for a long-term simulation using MPAS_VM with 120-23km

Atsushi Hashimoto[1], James M. Done[2], Laura D. Fowler[2], Cindy L. Bruyère[2]

CRIEPI Central Research Institute of Electric Power Industry

1. *Central Research Institute of Electric Power Industry, Japan; hasimoto@criepi.denken.or.jp*
2. *National Center for Atmospheric Research, US*

NCAR NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Abstract

Physics sensitivity simulations were conducted from May 1997 to April 1999 to evaluate the TC activity over North West Pacific Ocean. To evaluate physics sensitivities, a variable resolution mesh from 120km to 23km (MPAS_VM) and combinations of KF and Tiedtke with CAM and RRTM radiation were used.

The simulations with Tiedtke produced only very weak intensity TCs and there are locations of excessive rainfall. Tiedtke is good for 4km grid spacing, but we run at 23km and sensitivity simulations suggest KF captures better intensity TCs and reasonable rainfall patterns. However, TC frequency and also rainfall are overestimated. These overestimation are explored by modifying the KF trigger function.

Basic Model Description

Model : MPAS-Atmosphere Version 5.2
Global variable mesh with refinement overNorthwest Pacific from 120km to 23km
Period : 2 year continuous run from May 1997 to April 1999
Forcing data (including SST) : ECMWF – Interim (1.0°), 6 hourly updated

Simulation Cases

CASE1 : WSM6 + YSU + **K-F** + **CAM**	(time step = 60s)
CASE2 : WSM6 + YSU + **K-F fixed (w_0=1cm)** + **CAM**	(time step = 60s)
CASE3 : WSM6 + YSU + **New Tiedke** + CAM	(time step = 60s)
CASE4 : WSM6 + YSU + **New Tiedke** + RRTMG	(time step = 60s)

MPAS model physics (CASE1)

```
config_sst_update = true
config_sstdiurn_update = true
config_deepsoiltemp_update = true
config_radtlw_interval = '00:30:00'
config_radtsw_interval = '00:30:00'
config_bucket_update = 'none'
config_physics_suite = 'mesoscale_reference'
config_microp_scheme = 'mp_wsm6'
config_convection_scheme = 'cu_kain_fritsch',
config_lsm_scheme = 'noah'
config_pbl_scheme = 'bl_ysu'
config_radt_cld_scheme = 'cld_fraction'
config_radt_lw_scheme = 'cam_lw'
config_radt_sw_scheme = 'cam_sw'
config_sfclayer_scheme = 'sf_monin_obukhov'
config_radt_cld_scheme = 'cld_fraction'
config_gwdo_scheme = 'bl_ysu_gwdo'
```

Threshold vertical velocity (K-F scheme)

$C(z) = w_0(Z_{LCL} / 2{,}000)$ if $Z_{LCL} <= 2{,}000$m
w_0 if $Z_{LCL} > 2{,}000$m
w_0 = 2cm/s (CASE1)
-> 1cm (CASE2)

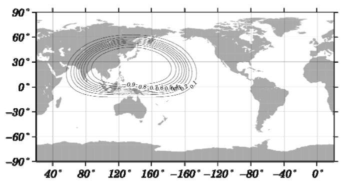


Fig. 1 Mesh density distribution of the global MPAS with 120-23km

Tropical Cyclone Tracker

Tracking method based on Suzuki-Parker (2012) and Hart (2003), and 6 hourly model output data are used for identifying and tracking Tropical Cyclones (A. Hashimoto, 2015).

Step1: A cyclone is defined using the following criteria
SLP: less than 1020hPa, and SLP gradient: 2hPa within a 250km circle
10m wind speed: more than 17 m/s within 100km
850 hPa relative vorticity: greater than 1.0x10-5/s.

Step2: Thermal wind and warm core structure are checked

Step3: The Cyclone thermal symmetry is checked using the cyclone phase parameters defined by Hart

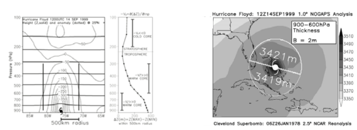


Fig. 2 Cyclone thermal wind and Cyclone thermal symmetry check (Hart, MWR 2003)

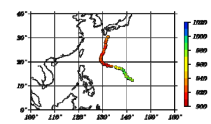


Fig.3 Examples of cyclone tracking

Results – Tropical Cyclones

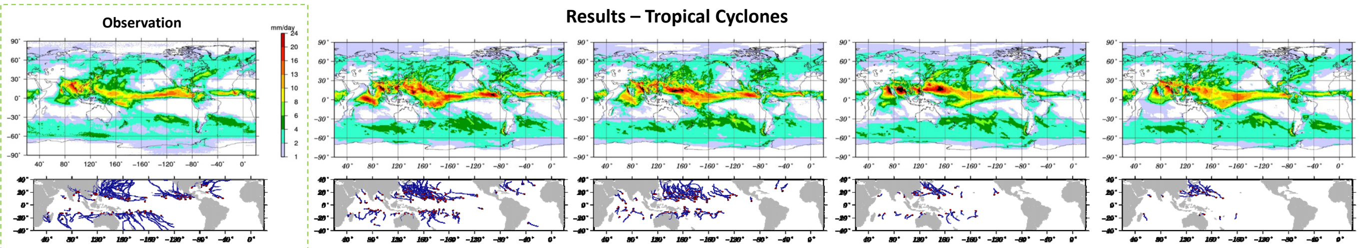
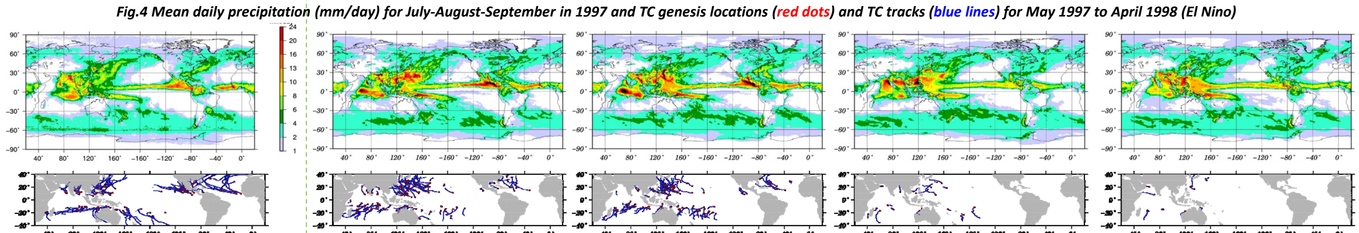


Fig.4 Mean daily precipitation (mm/day) for July-August-September in 1997 and TC genesis locations (red dots) and TC tracks (blue lines) for May 1997 to April 1998 (El Nino)



(a) Obs. GPCP (upper), IBTrACS(bottom) (b) CASE1(YSU + K-F+ CAM) (c) CASE2 (YSU + K-F fixed+ CAM) (d) CASE3 (YSU +Tiedke+ CAM) (e) CASE4 (YSU +Tiedke+ RRTMG)

Fig.5 Mean daily precipitation (mm/day) for July-August-September in 1998 and TC genesis locations (red dots) and TC tracks (blue lines) for May 1998 to April 1999 (La Nina)

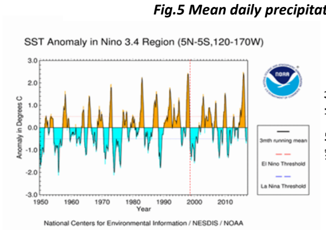
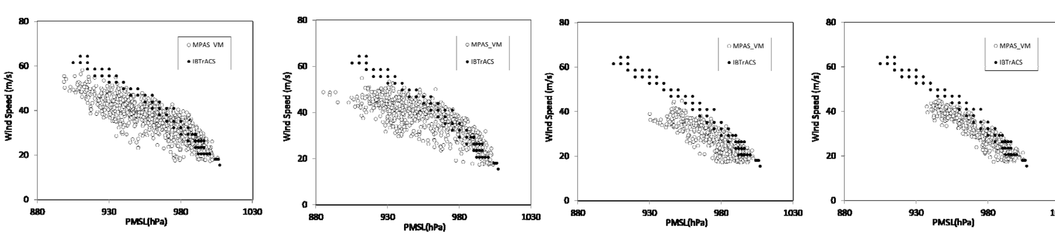


Fig. 6 SST Anomaly
(https://www.ncdc.noaa.gov/teleconnections/enso/indicators/sst/)



(a) CASE1(YSU + K-F+ CAM) (b) CASE2 (YSU + K-F fixed+ CAM) (c) CASE3 (YSU +Tiedke+ CAM) (d) CASE4 (YSU +Tiedke+ RRTMG)

Fig.7 Wind-pressure relationship for all 6-hourly TC points over North West Pacific Ocean for May 1997 to April 1998 (El Nino)

Conclusions and Future work

- All cases reproduced reasonably well the spatial precipitation patterns in the region of the ITCZ under the warm phase of El Nino and the cold phase of La Nina.
- The cases using Tiedtke scheme produced only very weak intensity TCs over NWP, and the case using "Tiedtke +CAM" schemes had the locations of excessive rainfall.
- In this case, K-F scheme works well compared with Tiedke scheme, but TC frequency and also rainfall are overestimated.
- The modified the K-F trigger function case had the locations of excessive rainfall over NWP compared with the non-modified K-F case.
- We have a plan to conduct the present and future climate change experiment using MPAS_VM with 120-23km and " YSU + K-F + CAM" schemes.