A phenomenon-based tracking scheme for high-resolution climate models

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Outline

A slightly modified tracking scheme
HWG results using this tracking scheme
Comparison to other HWG tracking results
Some comments on conditions for TC formation in climate models versus actual formation

Acknowledgments: CLIVAR, GFDL, CSIRO, Naomi and co-chairs
Previous version of CSIRO tracking scheme

- Weak vorticity threshold (only used to speed up routine)
- Warm core thresholds (comparison of upper-level and lower-level winds and temperatures)
- 10 m wind speed resolution-dependent threshold (Walsh et al. 2007 J. Climate)
- Must be satisfied for at least 24 hours
- Problem: despite warm-core check, still required latitude limit to formation of 30°
CMIP3 model cyclone tracks (with annual average genesis by basin) with previous version of CSIRO tracking scheme

Old version of tracking scheme applied to HWG data

HWG MRI model tracks for 20 years of Present Day experiment (tropical detections only)
Same scheme as previously, with the following modifications:

- warm-core temperature anomaly check is removed
- distinguish TCs from extratropical cyclones based on the presence of TCs equatorwards of the extratropical ridge in each hemisphere
- can this be used for a very different climate? NO. Not if TCs form well into midlats
Original CSIRO tracking scheme (applied to CMCC ECHAM5 1980)
Relaxation of dynamical criteria removed
Latitude restriction removed

- Warm core criteria are not eliminating all extratropical detections.
With temperature anomaly check removed

- Very little difference in tropical detections, substantial improvement in processing time
Imposing phenomenon-based latitude criterion
Models and HWG experiments analysed so far

• Experiments
  – Present day SST, CO2
  – Uniform 2K added to SST, present day CO2
  – Present day SST, 2xCO2
  – 2K added to SST, 2xCO2

• Models
  – CMCC ECHAM5 T159 L31
  – NCEP GFS T126 L64
  – GISS 1 degree
  – MRI TL319 L64 (slightly different experimental methodology)
January to March TC genesis density per 4 degree box per 10 years, present day

GISS numbers are low
Same for JAS
Simulated present day TC max windspeed distributions from the MRI (large) and GISS (inset) models.
Percentage changes in TC numbers in the three altered climate experiments compared to the present day experiment for each model.
Changes in the duration distribution of TCs in the 2K SST increase plus CO2 increase experiment compared to the present day experiment for each model.
Percentage changes in the intensity distribution of TCs in the 2K SST increase plus CO2 increase experiment compared to the present day experiment for the MRI model; inset figure gives absolute changes.
CMCC model changes in intensity distribution for 2K+2xCO2 experiment
NCEP model changes in intensity distribution for combined experiment
MRI TC genesis (per 4 degree box per 10 years) for the (present day) AMIP and future 2K+2CO2 experiments
HWG (or similar exp.) TC genesis tracking comparison (this workshop)

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Red: decrease  
Blue: no change  
Green: increase  
White: no data
Another possible approach

• “Marsupial pouch” detector (Dunkerton et al 2009 Atmos Chem Phys)
  – Formation of a closed protective circulation as a prerequisite for tropical cyclone formation

• Detection scheme based on identification of closed circulation feature (Tory et al. 2013 submitted to J Climate)
CMIP5 models (those within 50% of observed numbers)
Blue: TCs
Red: subtropical storms

Tory et al. (2013) submitted to J Climate
• Can we determine why the model results differ among each other for the same forcing?

• Can we determine why individual model results differ for different forcing?

• Can we use this analysis to inform a quantitative theory of tropical cyclone formation?
Summary

• Slightly modified version of CSIRO tracking scheme
  – runs much faster with no decrease in skill
  – needs fewer input variables
  – more scientifically justifiable latitude limits

• The direction of changes in TC numbers for a particular experiment in a model is not profoundly altered by using a different tracking scheme
  – Need to examine more quantitatively

• Summary of TC genesis changes in experiments:
  – 2K: combination of increases and decreases
  – 2CO2: mostly decreases
  – combined: mostly decreases (with one or two exceptions, those with a strong +ve response to 2K)