R: Why Does the ACME v1 Model Drizzle Too Much and What Impact Does This Have?

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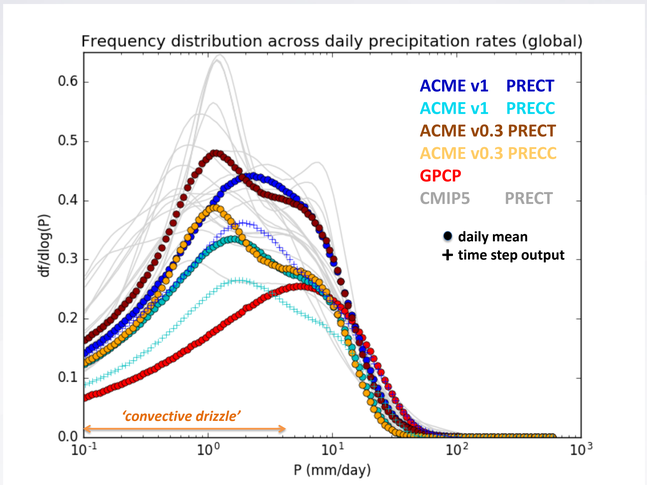
The Frequent Drizzle Problem



Background

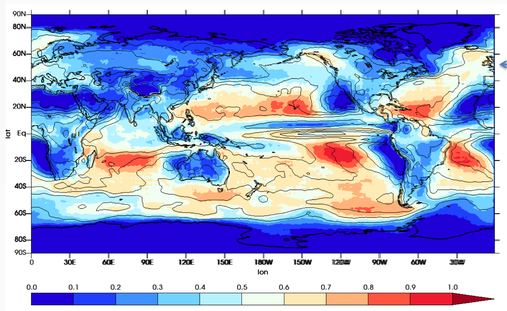
The problem of too frequent convective drizzle ($0.1 < P < 5$ mm d^{-1}) in the v0.3 model still persists in the v1 model (**FC5AV1-04**). This motivates us to look at how the drizzle forms in the v1 model.

Questions we examine in this poster

- Under what conditions do convective drizzle events occur?

- What impacts does artificially suppressing the drizzle have on the modeled climate?

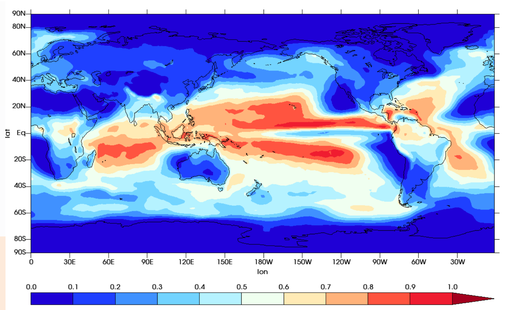
Frequency Map of ZM 'Drizzle'



Frequency map of 0.1 < PRECC < 5 mm d^{-1}

Colors *– Frequency of observing convective drizzle (0.1 < PRECC < 5 mm d^{-1}) in a 1° x 1 ° box over a day.*
Contours *– Annual mean precipitation rate from convective precipitation (PRECC). (0.2,0.5,1,2,4,8,16 mm d^{-1})*

* Based on 1-year simulation of FC5AV1C-04.



Frequency map of ZM-convection

Colors *– Frequency of how often ZM-convection is triggered in the model (FREQZM)*

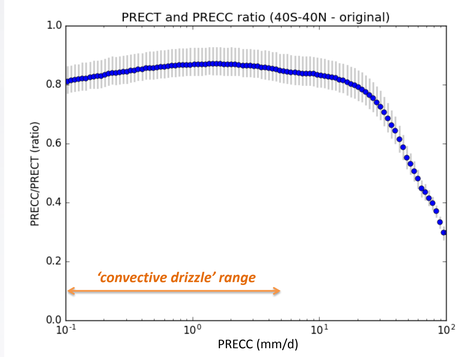
* Based on 1-year simulation of FC5AV1C-04.

Convective drizzle events appear to happen often (>70%) in trade wind cumulus regions, often where ZM-convection also triggers often.

Conditions that Produce Drizzle in the Model

Q: What fraction of the drizzle is due to convective precipitation?

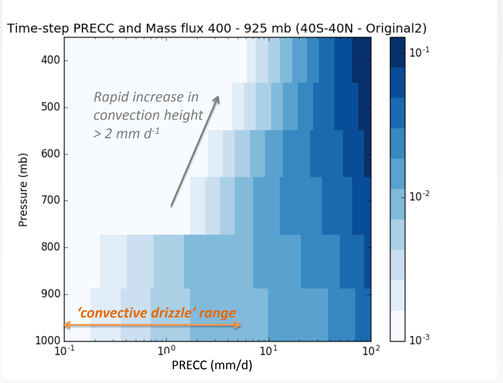
A: More than 80% in the range of 'drizzle' (0.1 and 5 mm d^{-1}).



Above *- The ratio between convective precipitation and total precipitation as a function of total precipitation rate. The relationship is spatially averaged over 40°S and 40°N and is based on 1 month of simulation. Circles represent means and vertical bars, the interquartile spread.*

Q: How deep does ZM-convection extend?

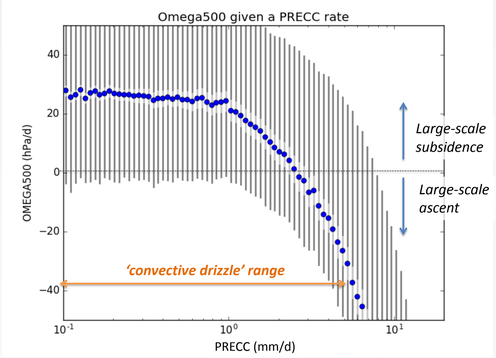
A: At precipitation rates > 10 mm d^{-1}, convection reaches above 400 mb, but in the range of 'drizzle', it seldom reaches above 700 mb (~3 km).



Above *- The convective mass flux from the ZM-scheme (CMFMCDZM) as a function of pressure level and* ***convective*** *precipitation rate. The relationship is spatially averaged over 40°S and 40°N and is based on 1 month of simulation.*

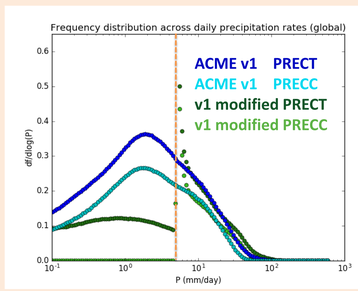
Q: What is the large-scale circulation?

A: The convective drizzle mostly occurs under large-scale subsidence. Only at higher rates (PRECC > 3 mm d^{-1}) do the conditions become mostly large-scale ascent.



Above *- The 500mb large-scale vertical circulation (ω_{500}) as a function of convective precipitation rate. The relationship is spatially averaged over 40°S and 40°N and is based on 1 month of simulation. Circles represent means and vertical bars, the interquartile spread.*

What Happens When the Drizzle Is Suppressed?



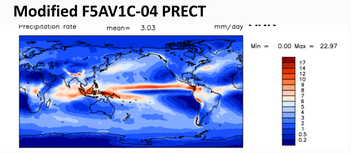
Model Experiment

After ZM-convection is called, we diagnose the convective precipitation rate and keep the convection from triggering if it produces PRECC < 5 mm d^{-1}.

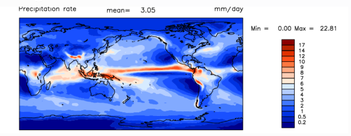
Left *– Frequency of time-step PRECT and PRECC rates from FC5AV1-04 and the modified model with drizzle suppressed.*

Precipitation

Modified F5AV1C-04 PRECT



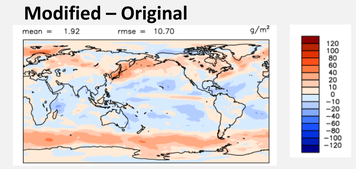
Original F5AV1C-04 PRECT



Cloud water content

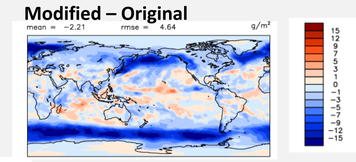
LIQUID

Modified – Original



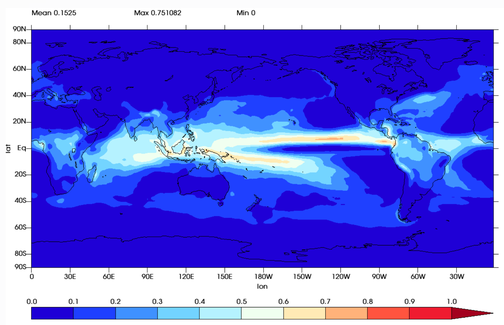
ICE

Modified – Original



The amount of cloud liquid water increases (~30%) and the amount of cloud ice water decreases (~40%) in the modified simulation.

Frequency of ZM-convection

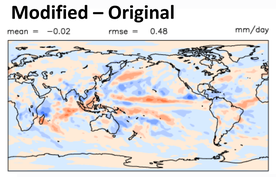


Colors *– Frequency of how often ZM-convection is triggered in the modified model (FREQZM)*

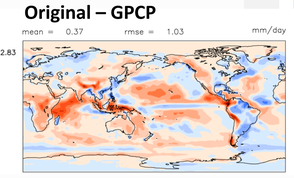
*Based on 1-year of output in Year3 of simulation

There is a considerable decrease in the frequency of ZM convection with the modification.

Modified – Original



Original – GPCP



Surprisingly, there are modest changes in the spatial distribution of precipitation with the modifications. In general, there are increases in regions with heaviest precipitation and decreases on the flanks of these regions.

Future directions

- Run the models for longer time periods to verify that the climatological differences are robust.
- Make model modifications, where the convective autoconversion coefficient will contain a minimum threshold on cloud water mixing ratio. We welcome any other suggestions.
- Obtain a better observational estimate of how frequent drizzle occurs.

ACME Accelerated Climate Modeling for Energy

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U.S. DEPARTMENT OF ENERGY

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