RCEMIP: Radiative-Convective Equilibrium Model Intercomparison Project

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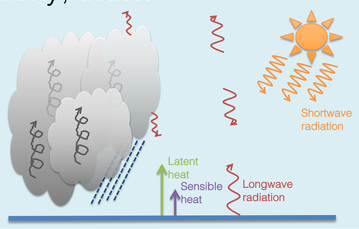
http://myweb.fsu.edu/awing/rcemip.html

Motivation

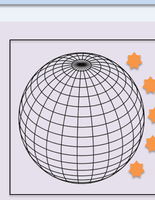
- RCE: Simplest possible description of climate system. Balance between net radiative cooling and convective heating
- Long history of simulating RCE, remains popular for addressing questions about coupling of clouds and convection to climate, climate sensitivity, etc…
- Emerging theme is self-aggregation of convection – open question as to how/whether real atmosphere aggregates, and to what extent this is important for climate
- Progress hindered by absence of common baseline
- No other framework accessible by so many model types



Themes of RCEMIP

1. What is the response of **clouds** to warming and the **climate sensitivity** in RCE?
2. What is the dependence of **convective aggregation** and tropical circulation regimes on temperature in RCE?
3. What is the **robustness** of the RCE state, including the above results, across the spectrum of models?

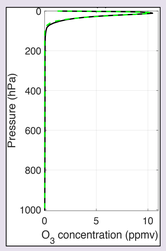
Simulation Design



Same solar insolation everywhere, for all time
S_o = 551.58 W/m^2,
Zenith angle = 42.05°

Homogenous boundary conditions and forcing

- No rotation.
- Same SST everywhere, no land or sea ice.
- Initialize with same sounding everywhere, zero wind.
- Random noise to break symmetry.
- Calculate surface fluxes interactively, minimum wind speed 1 ms^{-1}
- Calculate radiative tendencies interactively
- Fixed, spatially homogeneous trace gases. CO_2= 384 ppmv; CH_4=1650 ppbv; N_2O=306 ppbv.
- Surface albedo = 0.07
- Initialize RCE_small from analytic sounding. Initialize RCE_large from equilibrium sounding of RCE_small.



O_3=[3.6478*p$^{0.83209}$]
*exp(-p/11.3515)

Two Sets of Simulations

Each at SST of 295 K, 300 K, 305 K

1. **RCE_small**: Small, square domain for CRMs, single column for GCMs
2. **RCE_large**: Large, rectangular domain for CRMs global for GCMs & GCRMs

	RCE_small domain	RCE_small grid spacing	RCE_large domain	RCE_large grid spacing	Length of simulation
CRM	~100 km x ~100 km	~1 km, 74 levels	~6000 km x ~400 km	~3 km	100 days
GCM	Single column	Standard vertical grid	Global	As in CMIP6	1000 days
GCRM	< R_E/32	~1-3 km	Global	~3-14 km	100 days
LES	~100 km x ~100 km	~100m, ~100 levels	N/A	N/A	50 days
SCM	Single column	Standard vertical grid	N/A	N/A	1000 days

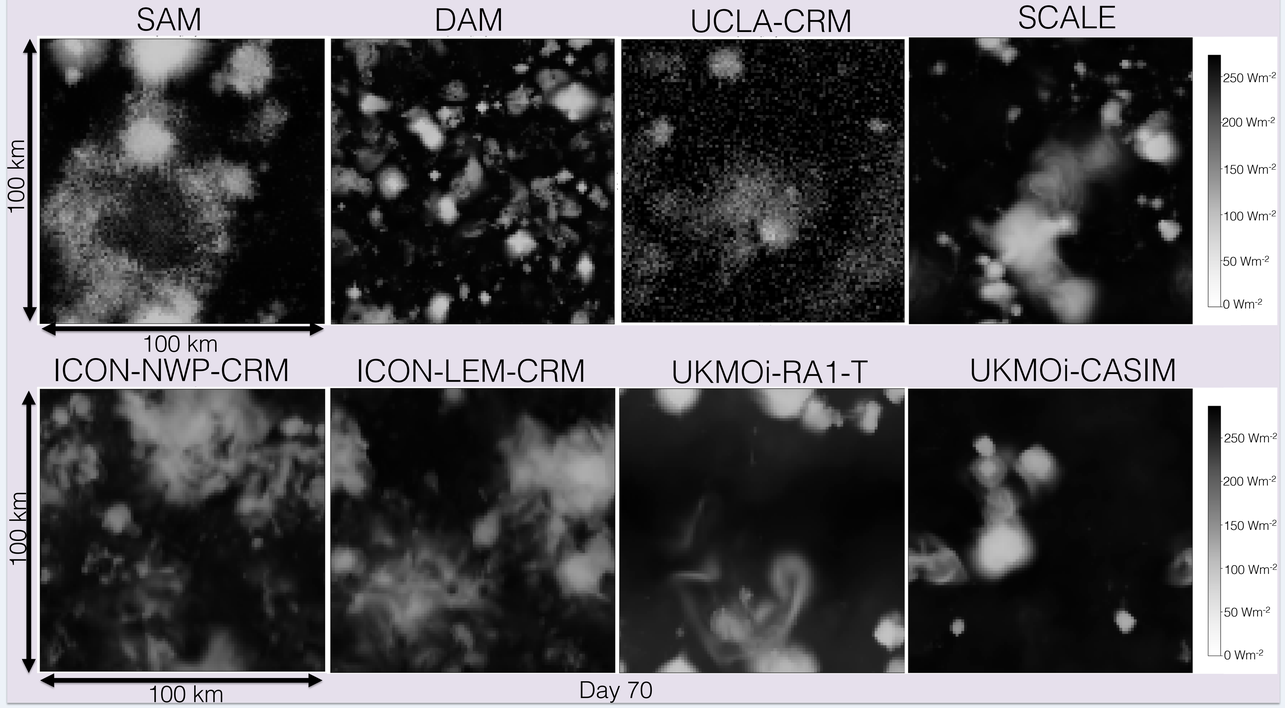
Expected Participation from 20+ Models

CRMs (17), GCMs (8), GCRMs (2)
SCMs (3), LES (4)

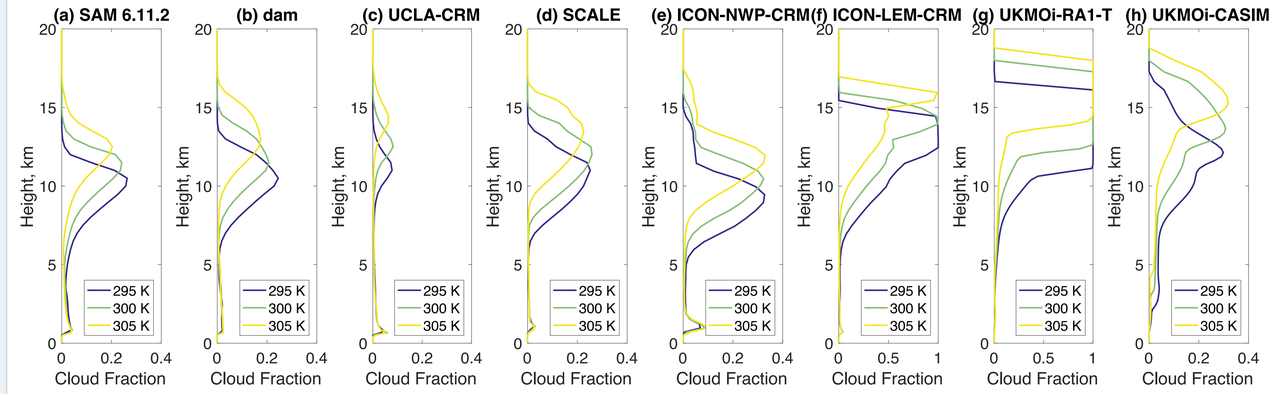
Model Contributors (So far! As of 12/4/2018)

Tobias Becker (ICON-LEM, ICON-NWP, ECHAM6), Cathy Hohenegger (UCLA-CRM), Shuhei Matsugishi (SCALE), David Romps (dam), Todd Jones (UKMOi-vn11.0)

Preliminary Results: OLR in RCE_small300 in CRMs



Preliminary Results: Clouds in RCE_small in CRMs



Anvil cloud fraction decreases with warming in SAM, dam
overall decreases with warming in UCLA & SCALE
increases with warming in UKMOi-CASIM
doesn't change with warming in ICON, UKMOi-RA1-T

Clouds shift upward with warming

Vision for Evolution of RCEMIP

These simulations are just a starting point! We hope to build a RCE community. Future experimentation may include:

- Robustness of RCE results to experimental design
- Sensitivity to model physics and dynamics – *simple-physics*
- Mechanisms of convective aggregation
- Impact of ocean-atmosphere interactions
- Impact of rotation

Wing et al. (2018), Geosci. Model Dev., doi:10.5194/gmd-11-793-2018.