FLEX-UM: The Flexible Model Framework for the UK Met Office Unified Model

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Introduction

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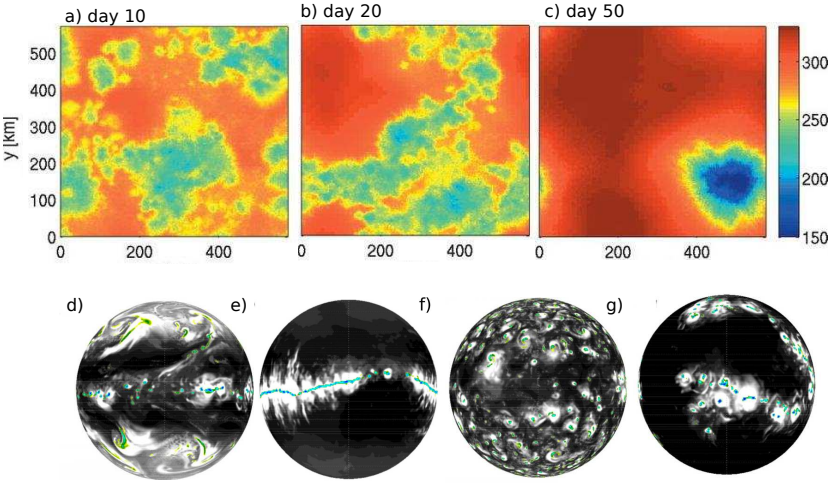

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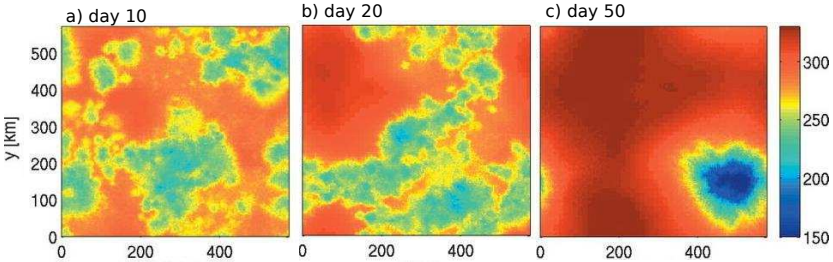

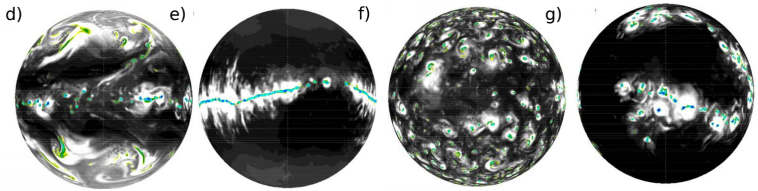

a-c) Bretherton et al. 2005

d-f) Satoh et al. 2016

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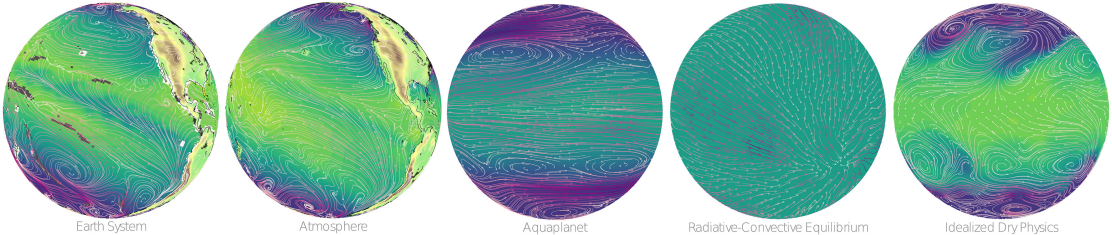
Simple models connect to the real world via a climate model hierarchy



Complexity

Adapted from Maher et al. 2019

Introduction

dynamical (equation)
barotropic
quasi-geostrophic
dry primitive equations
moist primitive equations
non-hydrostatic

process (diabatic)
dry Newtonian cooling
moist gray radiation without clouds
full radiation without clouds
prescribed clouds and aerosols
prognostic clouds and aerosols

process (boundary condition)
prescribed (uniform) SST
prescribed (spatially varying) SST
slab ocean
interactive ocean

Hierarchies for
atmospheric circulation

scale (convective organization)
convective turbulence
cloud scale
mesoscale convective systems
synoptic to planetary scale

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Current capabilities for the Met Office Unified Model (UM)

1. Idealised configurations:
   - 1.1 Dry atmosphere (Held-Suarez)
   - 1.2 Exo-planets
   - 1.3 Radiative convective equilibrium
2. Full physics boundary conditions
   - 2.1 Aquaplanet
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This motivated the development of Flex-UM, the flexible model framework for the UM.

Motivation

Aim: To implement idealised parameterisations within the UM for form part of the model hierarchy.

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Bench mark against the GFDL aquaplanet (Frierson et al. 2007) model.

- Gray radiation,
- simple boundary layer,
- slab ocean aquaplanet,
- no clouds,
- constant isolation, and
- simple Betts-Miller convection scheme.

$$P_q = -\frac{1}{g}\int_{p_0}^{lzb}\left(-\frac{q-q_{ref}}{\tau}\right)dp$$

$$P_T = \frac{c_p}{L}\int_{p_0}^{lzb}\left(-\frac{T-T_{ref}}{\tau}\right)dp$$

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1. Why do we want simple parameterisations? (or idealised models in general?)
   1.1 Deeper understanding is possible by removing complexity, eg identify mechanism, feedbacks or sensitivities.
   1.2 Excellent test bed for new parameterisations.
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4. Why is this helpful?
   4.1 Avoiding separate models. Flex-UM is part of the UM infrastructure - ie just flags!
   4.2 Now have different parameterisation options that were not previously available.

Progress

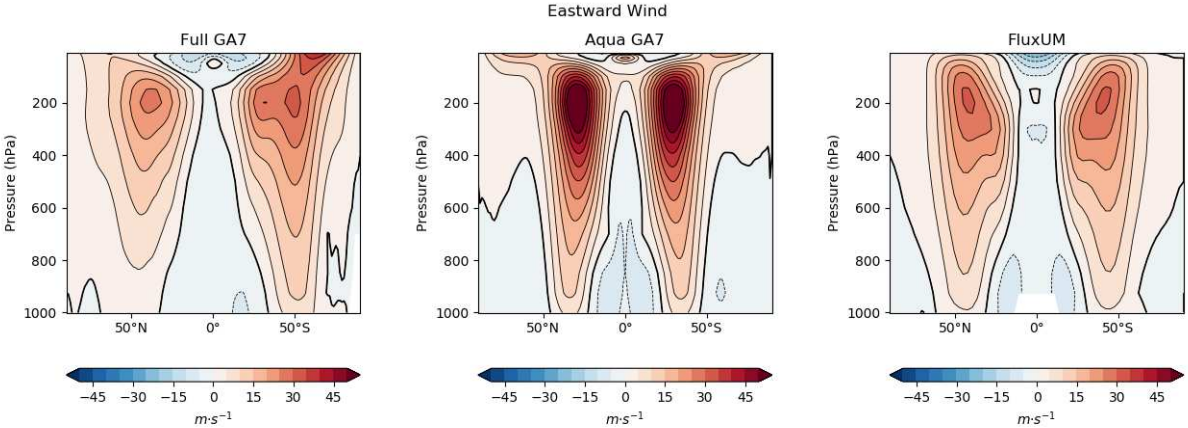

Figure: Prescribed SST (GA7) / Aquaplanet/ Flex-UM

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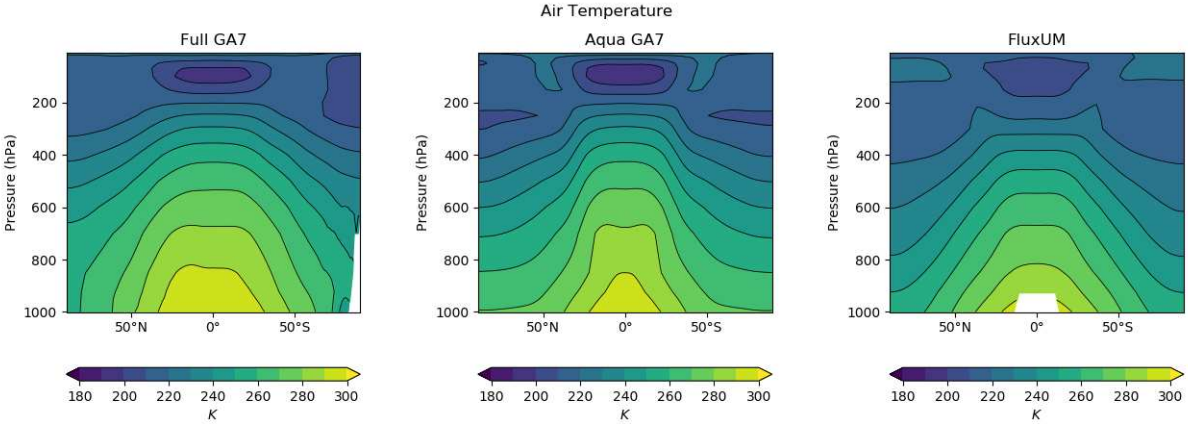

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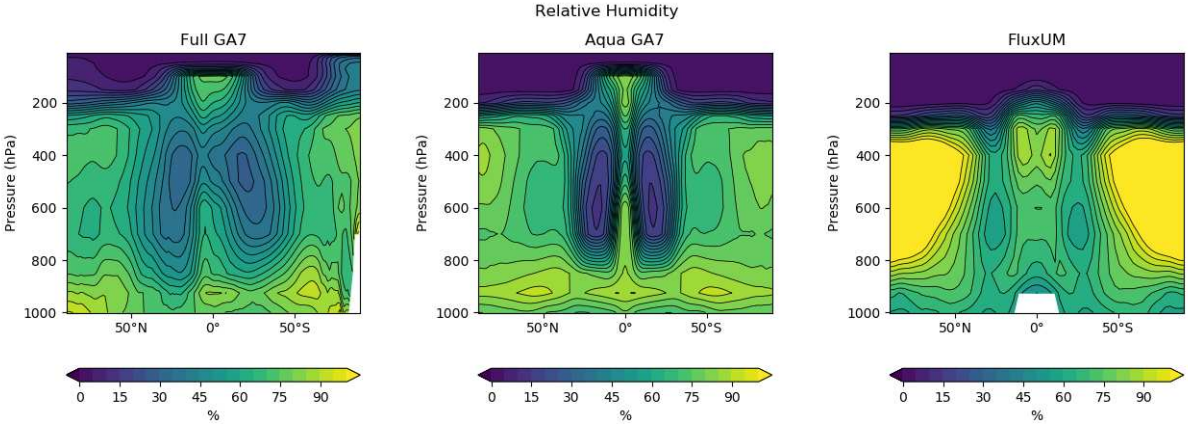

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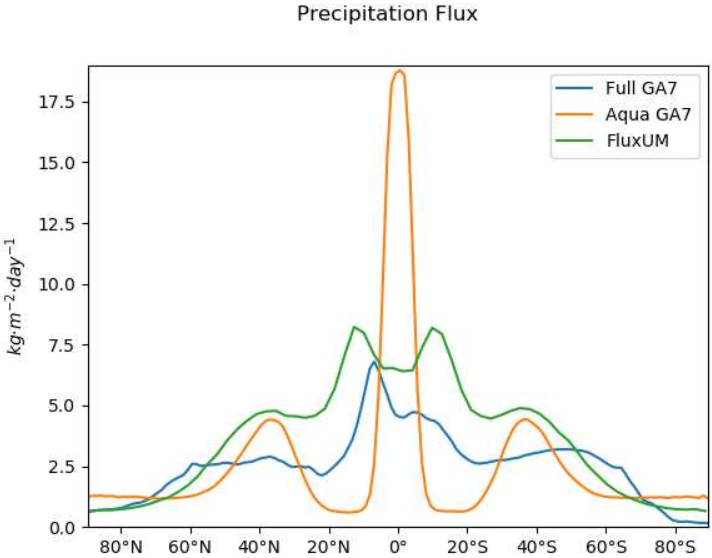
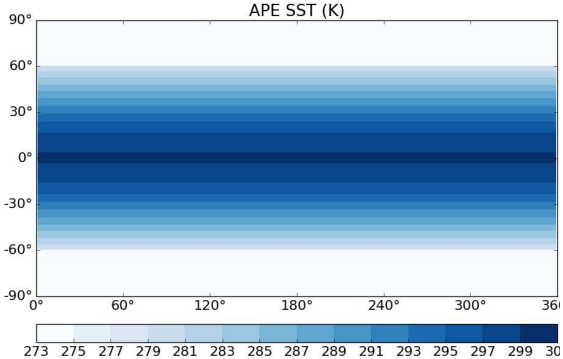

Precipitation Flux
Full GA7
Aqua GA7
FluxUM
$kg \cdot m^{-2} \cdot day^{-1}$
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S

Progress and Plans

1. The simple Betts-Miller convection code is on the UM trunk at v11.3 (current release).
2. We aim to have the other parameterisations in review during the next two revision cycles.
3. After the review, we will write this up in a GMD paper.

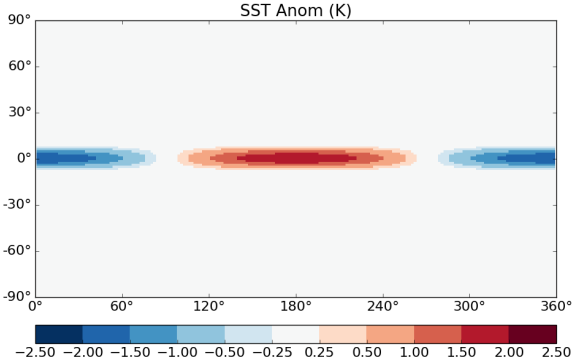
Plans for using Flex-UM?

Moch-Walker circulation simulations similar to Bretherton et al. 2006 but on a sphere.



(a) APE SST

$27^\circ\mathrm{C} \times \left(1 - \sin^2\left(\frac{3}{2}\phi\right)\right)$



(b) Adapted Bretherton et al. 2006

$-2\cos(\lambda) \times \left(1 - \sin^2\left(\frac{\pi}{2}\phi\right)\right)$

Summary

1. Flex-UM is aimed to fill in the gaps between the idealised UM and the comprehensive UM.
2. We are in the final stages of validation and aim to have all the code on the UM trunk this year.
3. When Flex-UM is available for use, we plan to run Mock-Walker simulations, run some RCE cases, and CP evaluation for CoMorph and other schemes.