Using VOCALS to improve stratocumulus representation in the Met Office Unified Model

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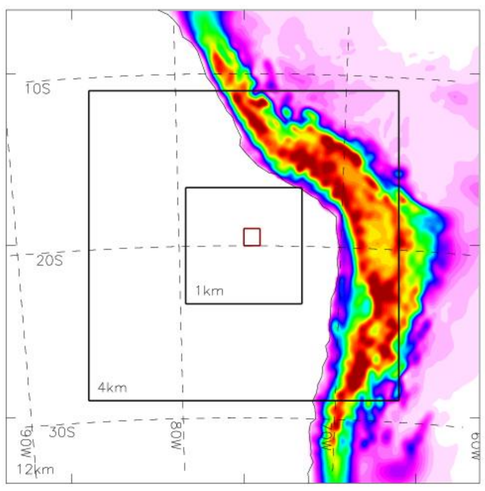
Abstract

Observations from the VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS) are compared to simulations at 1 km horizontal-resolution using the Met Office Unified Model (MetUM). It is shown that the MetUM typically under-estimates cloud liquid-water path (LWP) during the night, whilst drizzle rates are typically over-estimated throughout the diurnal cycle. It is shown that the cloud base drizzle rate and LWP are highly sensitive to the autoconversion and accretion parametrizations used. Aircraft measurements of drizzle size spectra also show that the model contains fewer and larger droplets than reality, and a new size spectra is derived and tested.

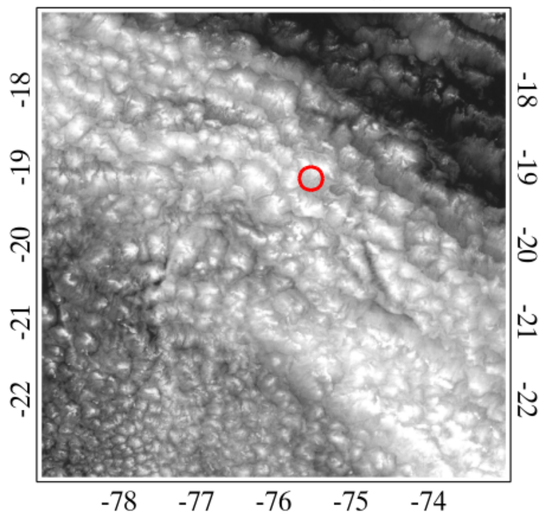
VOCALS

- Field experiment conducted during October and November 2008, observing the marine stratocumulus to help improve modelling.
- Case study on 12th and 13th November 2008.
- Focus here on the 1km resolution results from a suite of nested MetUM simulations.
- Ronald H. Brown Research vessel located at centre of 1km domain, and the FAAM BAE-146 flew a research flight through the domain during the case study period.
- General structure and evolution of the cloud field is well-represented in the MetUM.

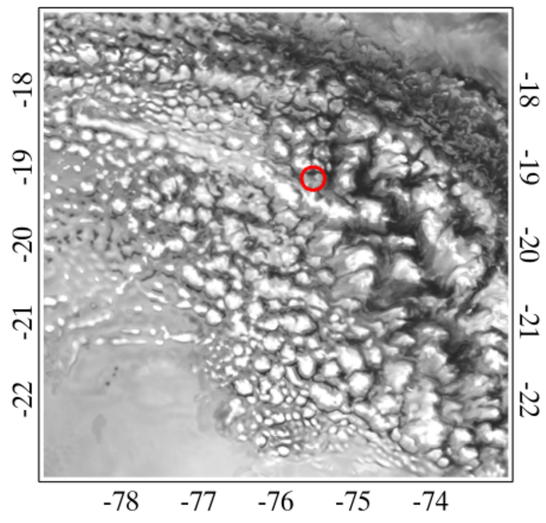
Nested Domains



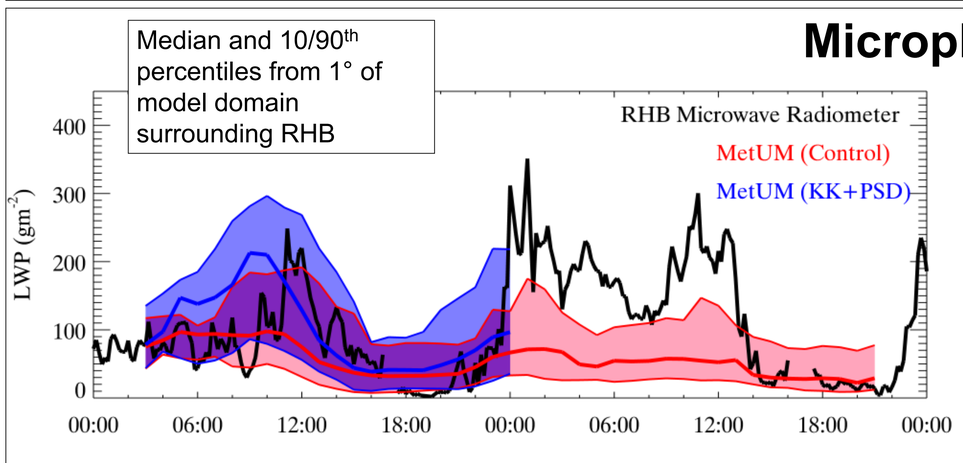
GOES-10 Visible Image at 15Z



MetUM SW flux at TOA at 15Z



Microphysics observations and modelling

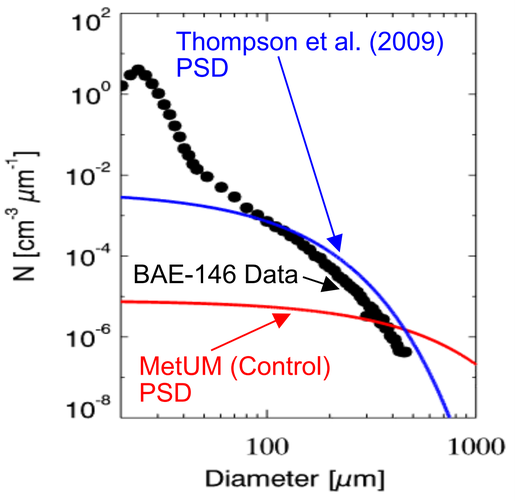


Comparison of LWP to the Ron Brown measurements shows MetUM has too low LWP during the night. There is also excessive cloud base drizzle, suggesting that the microphysical parametrizations are too efficient at converting cloud water into rain water.

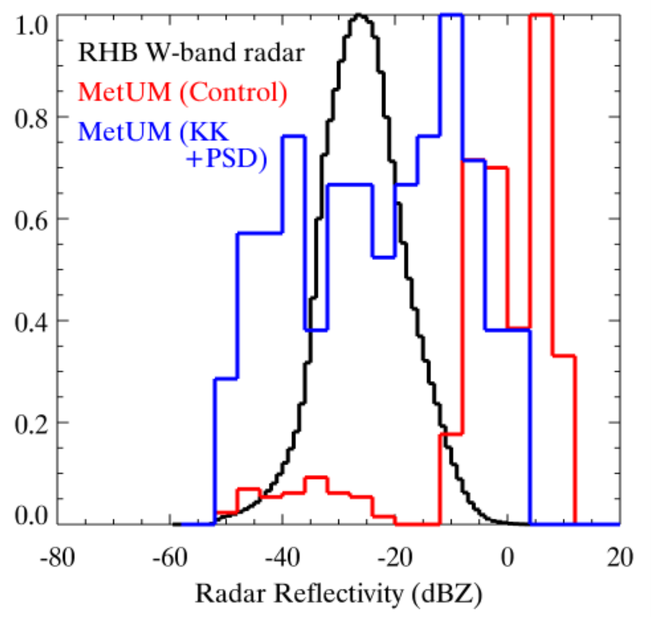
Modification 1 (KK): Replace the Tripoli and Cotton (1980) autoconversion parametrization with that of Khairoutdinov and Kogan (2000), which has a lower autoconversion rate and compares better with observations of Wood (2005).

Measurements of the cloud and drizzle size spectra from the BAE-146 flight shows that the assumed size spectra in the model is not good. The model representation assumes drizzle particles are too few in number and too large in size. This leads to greater accretion and less evaporation of drizzle. It also makes model simulation of radar reflectivity much too high because larger drops give larger returns.

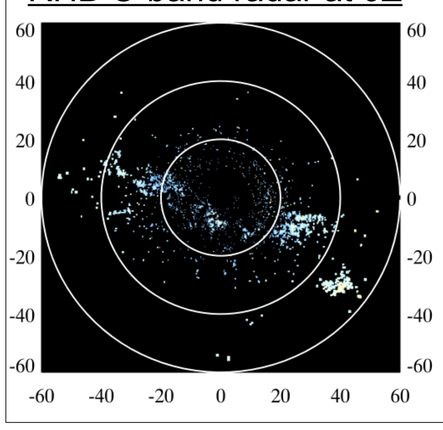
Modification 2 (PSD): Use a particle size distribution (PSD) that is a closer fit to observations. Here we take the Thompson et al. (2009) parametrization, but intend to use all the data to construct a new PSD.



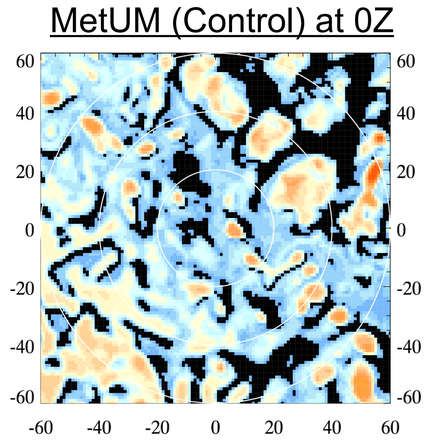
Histogram of Ron Brown observations show a continuous transition from cloud to drizzle. Control model does not show this – the distribution is bi-modal with a cloud mode around -40dBZ and a drizzle mode around 0dBZ. Modified simulation improves this, although the distribution still appears too wide.



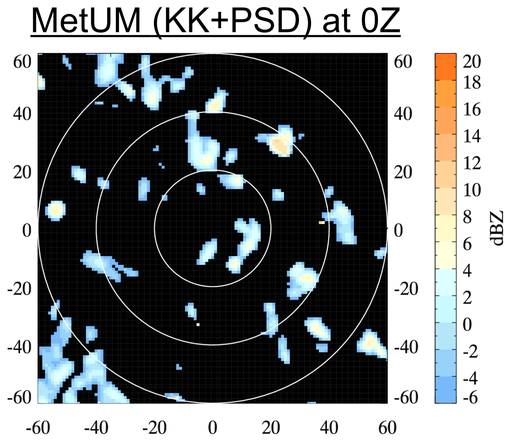
RHB C-band radar at 0Z



MetUM (Control) at 0Z



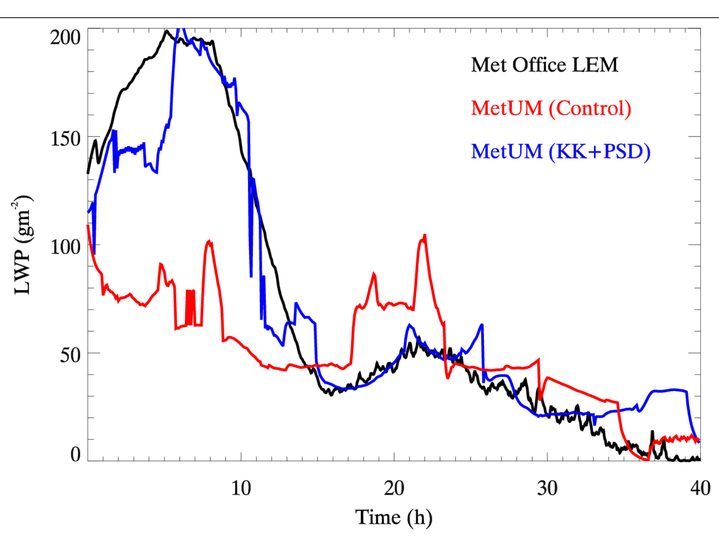
MetUM (KK+PSD) at 0Z

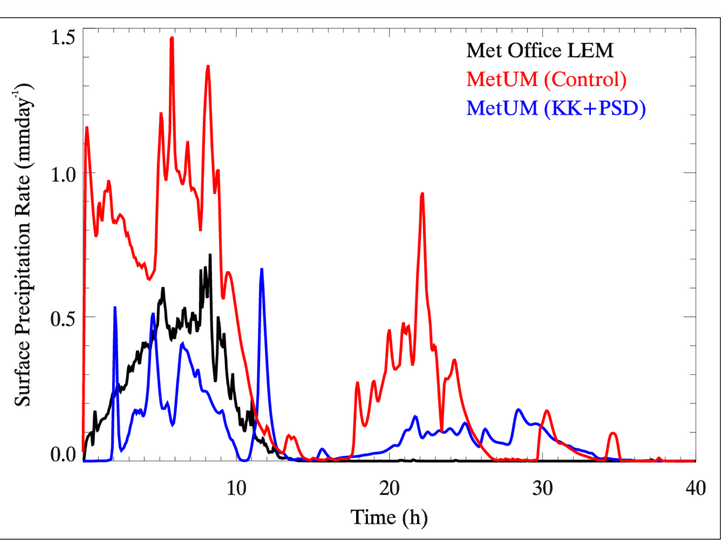


Scanning radar on the Ron Brown shows that the control model has drizzle that is far too widespread and far too heavy. Modified simulation reduces both the spatial extent of the drizzle and the intensity of the cells.

ASTEX-Lagrangian

- Stratocumulus to Cumulus transition experiment conducted in June 1992.
- Case-study used as EUCLIPSE SCM & LES intercomparison case.
- Comparison of Met Office LEM and SCM shows that the SCM has a much lower LWP than the LEM during the first night. The SCM also has a much greater surface (and cloud base) precipitation rate throughout the simulation.
- Running the SCM with the above modifications improves the LWP during the first night, without degrading the rest of the simulation.
- The precipitation rate is also much better throughout the simulation.





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