



The representation of drizzle in the Met Office Unified Model (MetUM)

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VOCALS Science Meeting, Miami, 21st – 23rd March 2011



Contents

This presentation covers the following areas

- Some current issues with drizzle in the Met Office forecast model
- High resolution VOCALS modeling case study (1km horizontal)
 - Model set-up
 - Sensitivity to autoconversion and accretion schemes
 - Poor representation of drizzle size spectra
- Conclusions and future work
- Data acknowledgements
 - Paquita Zuidema (LWP data), Chris Fairall and Ken Moran (Wband radar data), Simon de Szoeki (cloud boundary data), Ian Crawford and Jonny Crosier (particle size spectra data)

Drizzle in the MetUM

Californian Stratocumulus - DJF 2006

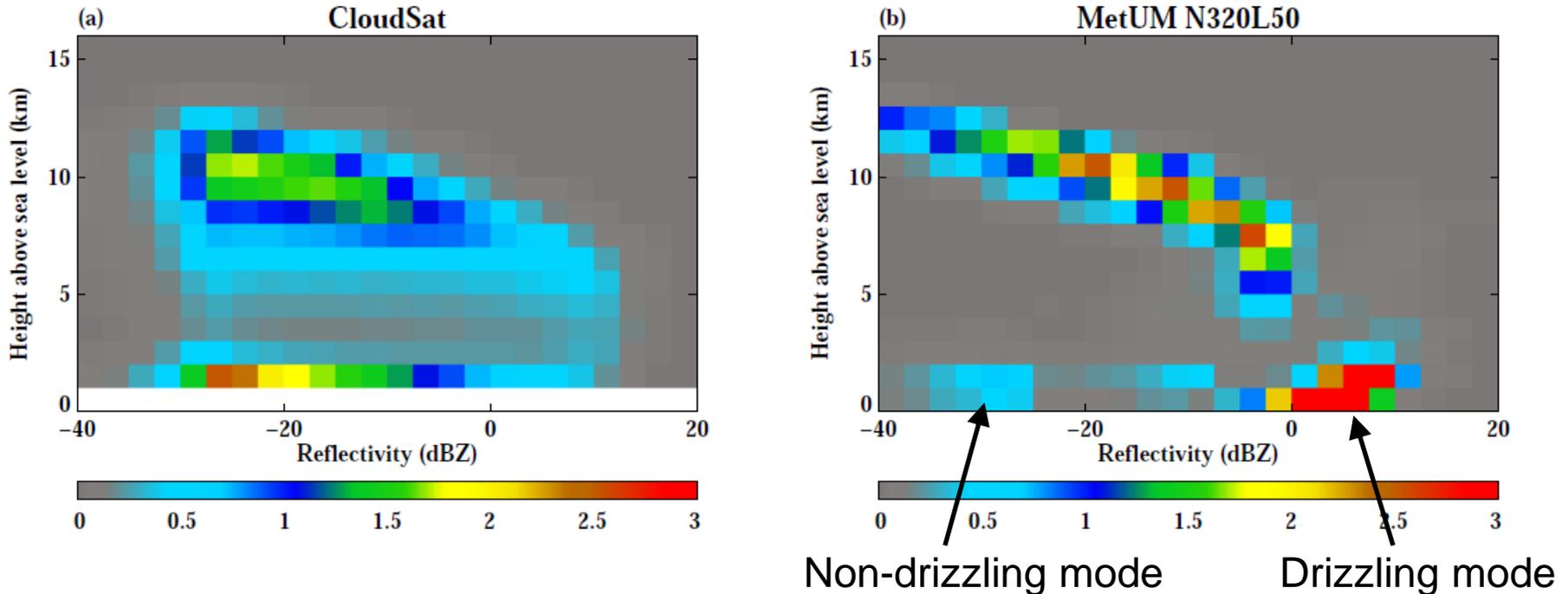
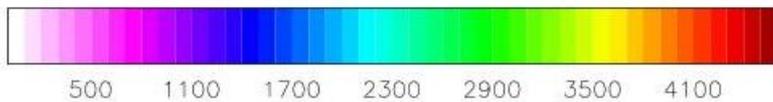
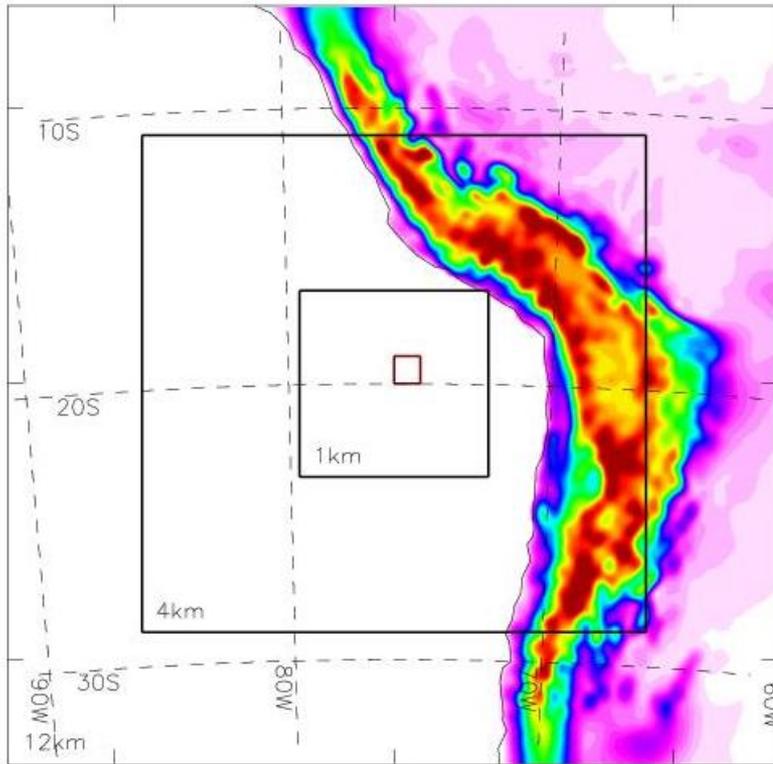


Figure adapted from Bodas-Salcedo et al. (2008)

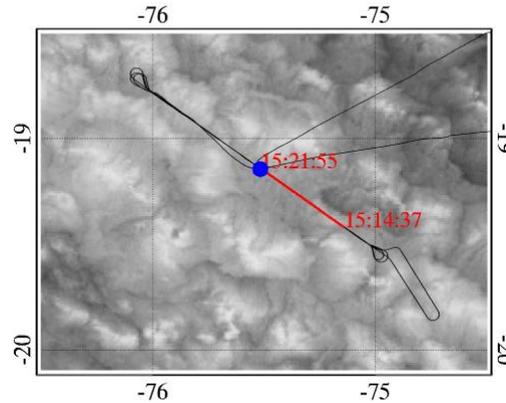
Other studies that show that drizzle is poorly represented in the MetUM e.g. Wyant et al. (2007), Abel et al. (2010).

Case study and model set-up

12th – 13th Nov 2008



goes-10.200811121515.vis_raw.nc (R15 3.8 kft)



- Nested runs down to 1km in horizontal
- 70 vertical levels (24 below 2 km ASL)
- Boundary conditions from operational global NWP
- Standard simulation: set-up as current UK operational high resolution NWP
- Modified simulation: change autoconversion and accretion scheme to Khairoutdinov and Kogan (2000)



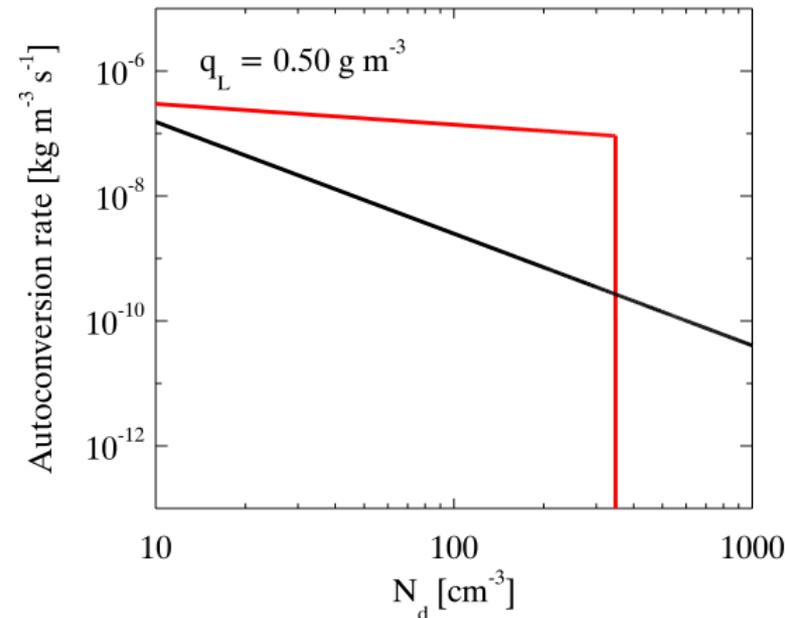
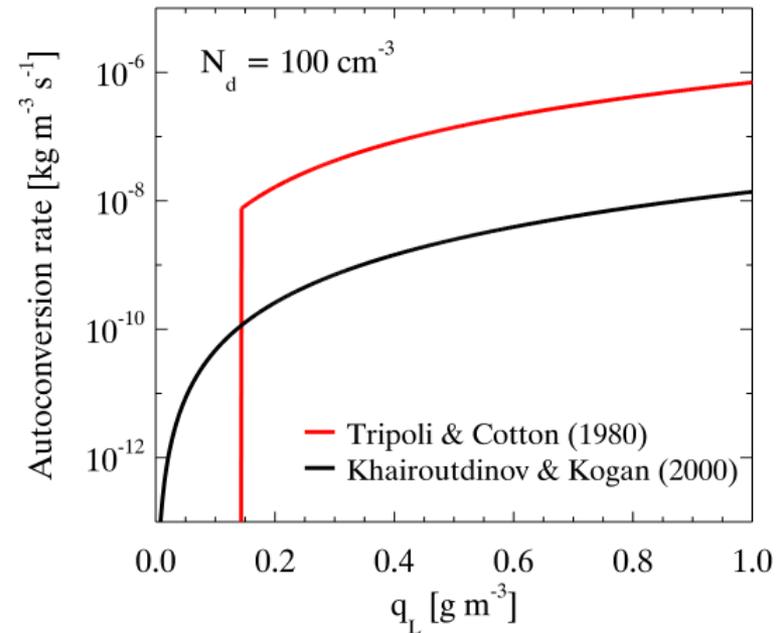
Autoconversion

Model assumes cloud droplet number concentration (N_d) of 100 cm^{-3} over Ocean

Khairoutdinov and Kogan (2000) autoconversion rate is derived from Sc simulations from a large-eddy model with bin resolved microphysics.

Wood (2005) show that KK autoconversion rates are in better agreement with that derived from aircraft measurements in Sc.

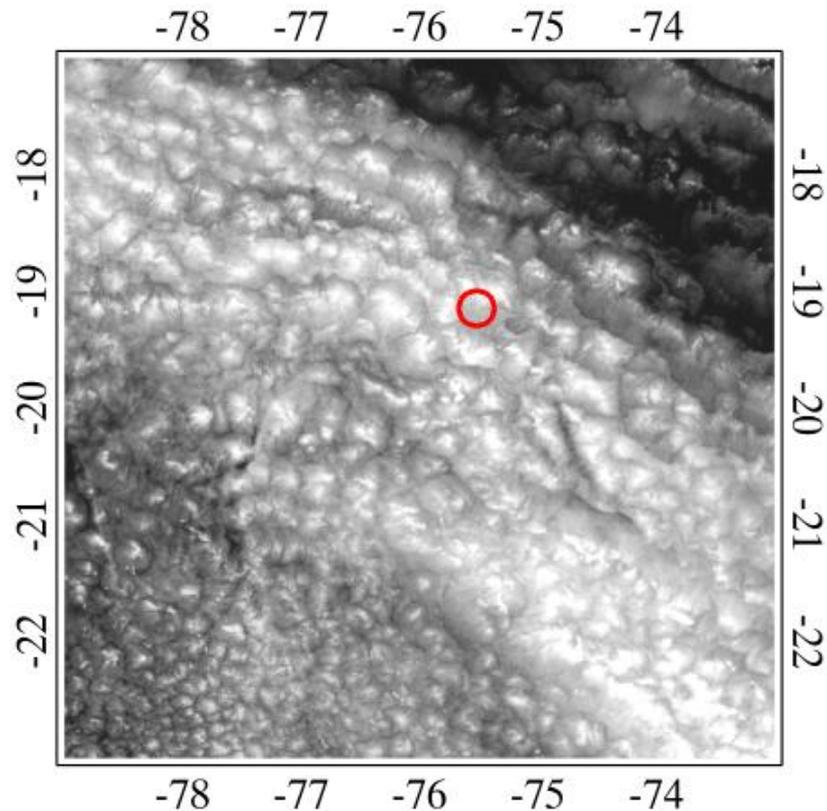
KK autoconversion rate is significantly lower than standard MetUM microphysics (Tripoli and Cotton (1980)).



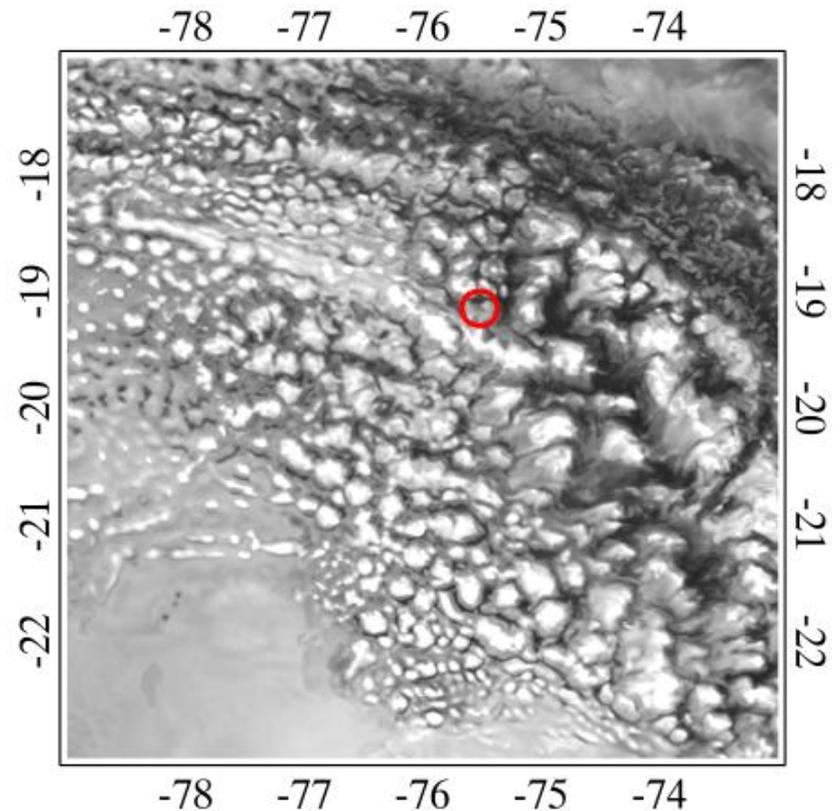
Snapshot of cloud field

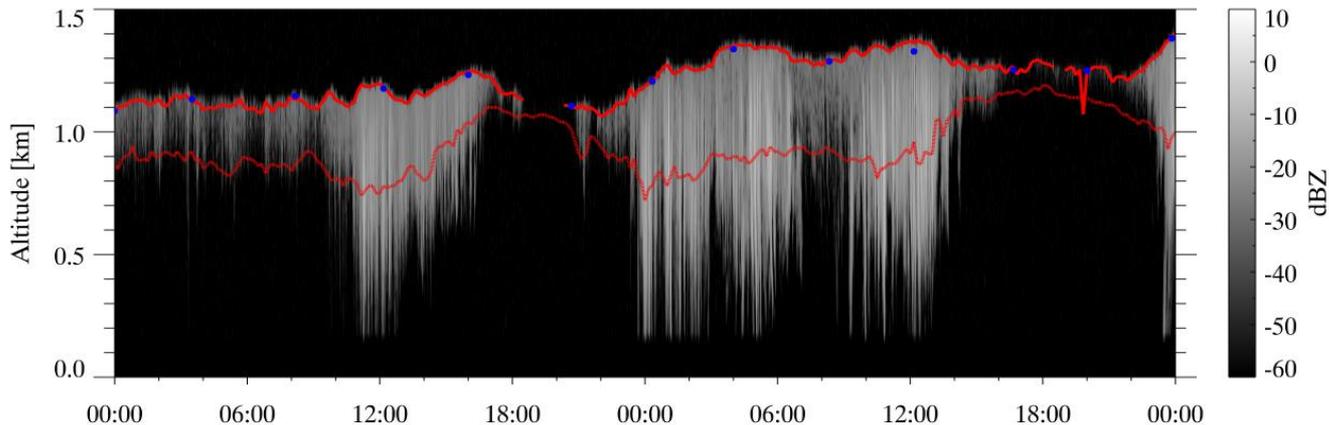
15 UTC on 12th Nov 2008

GOES-10 visible image

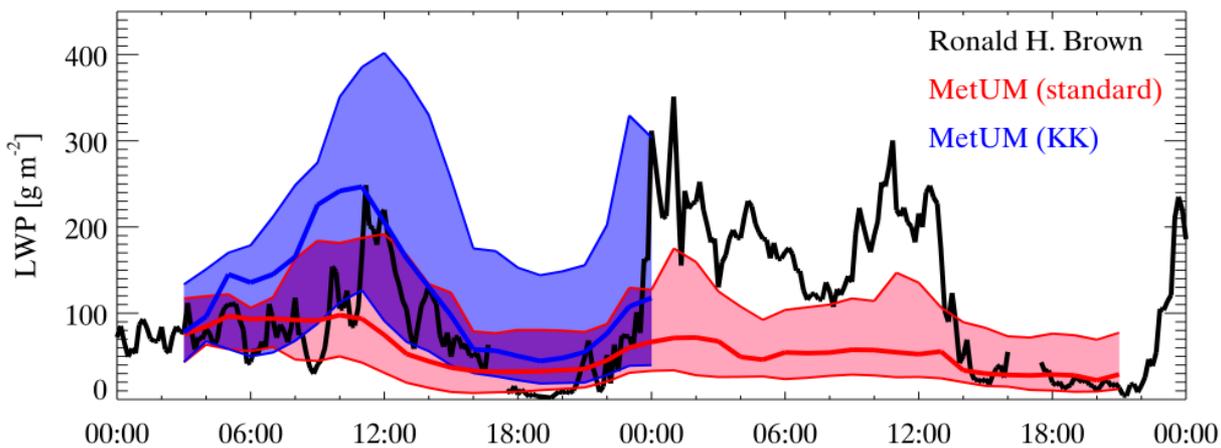


MetUM SW flux at TOA

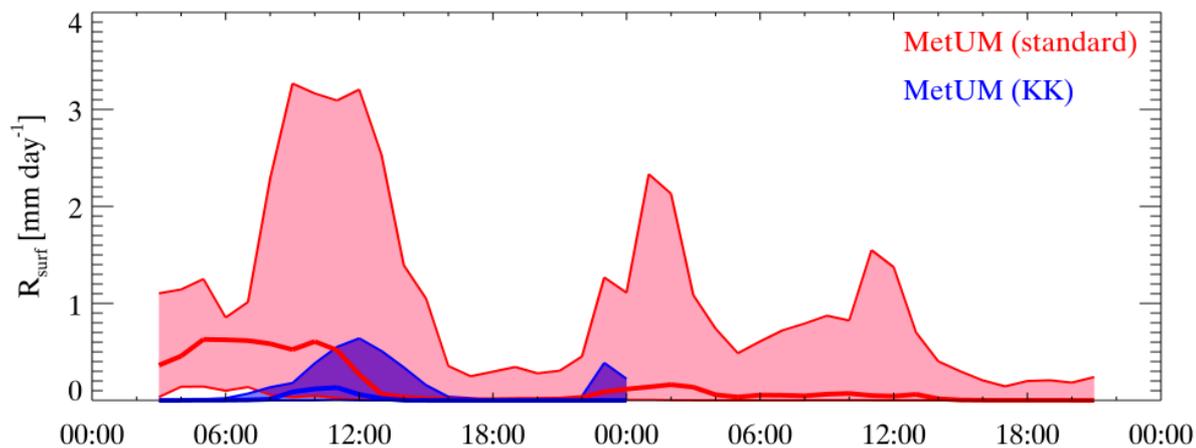




W-band radar and cloud boundaries



Observed (microwave radiometer) and modelled LWP

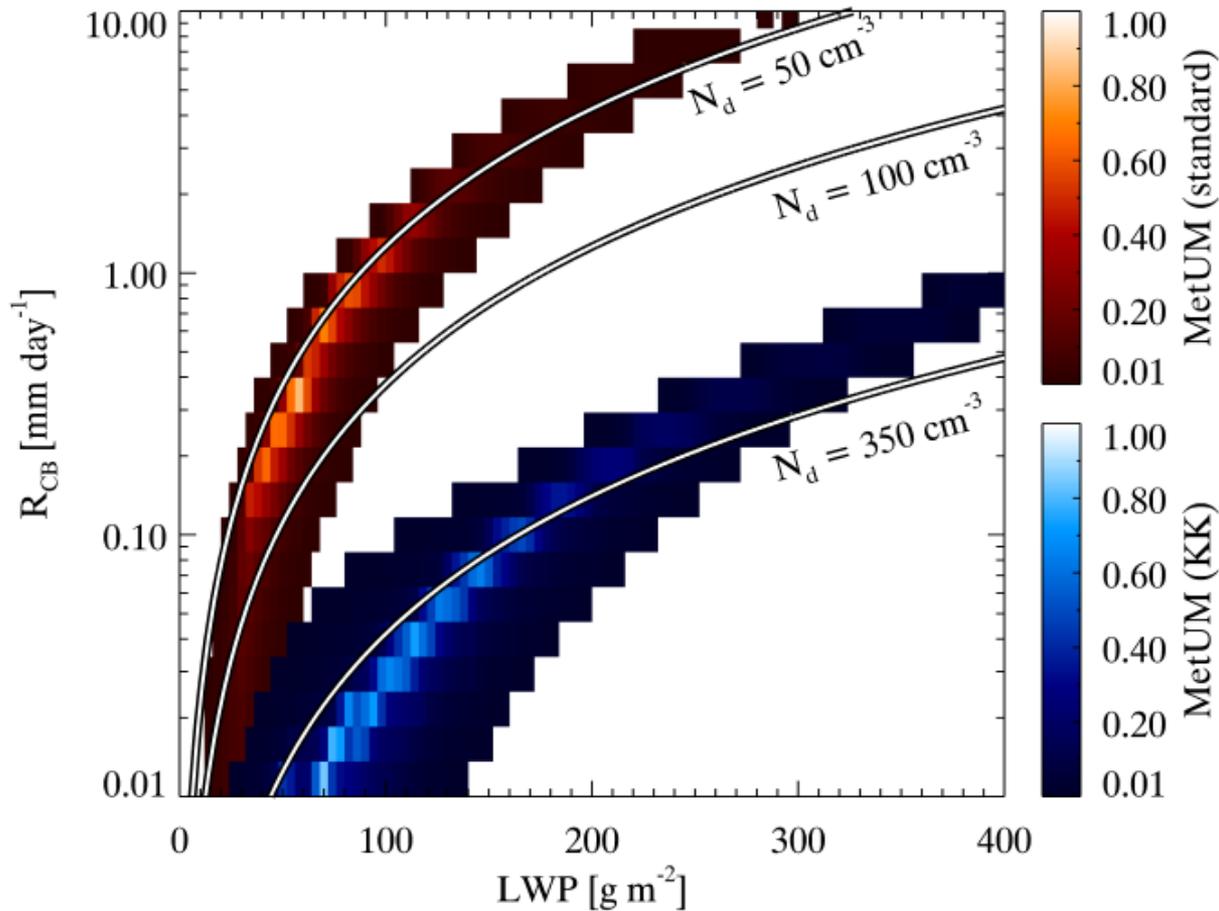


Modelled surface rain rate



Drizzle Efficiency

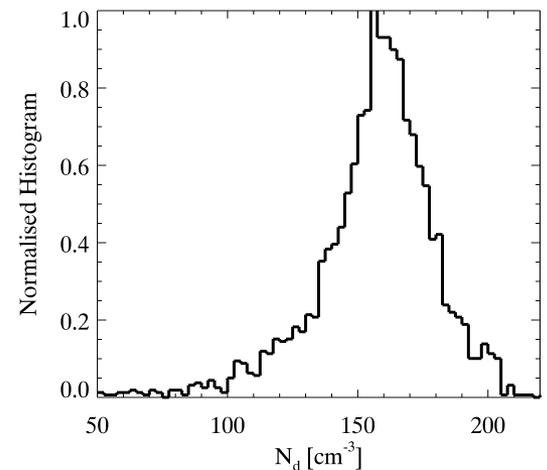
Model assumes cloud droplet number conc (N_d) = 100 cm⁻³ over Ocean

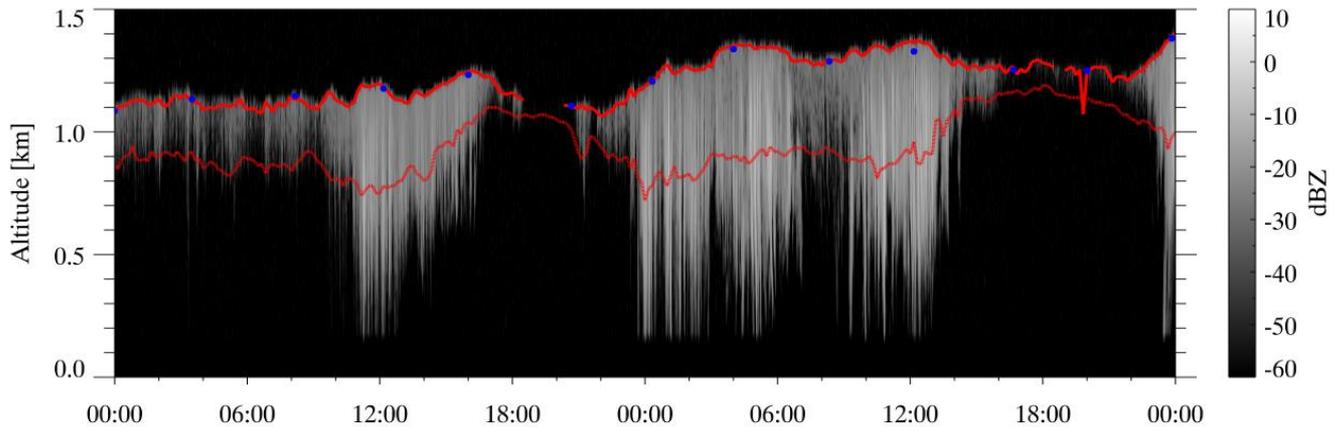


White curves are the Comstock et al. (2004) EPIC relation at various N_d

$$R_{CB} = 0.3744 \left(\frac{LWP}{N_d} \right)^{1.75}$$

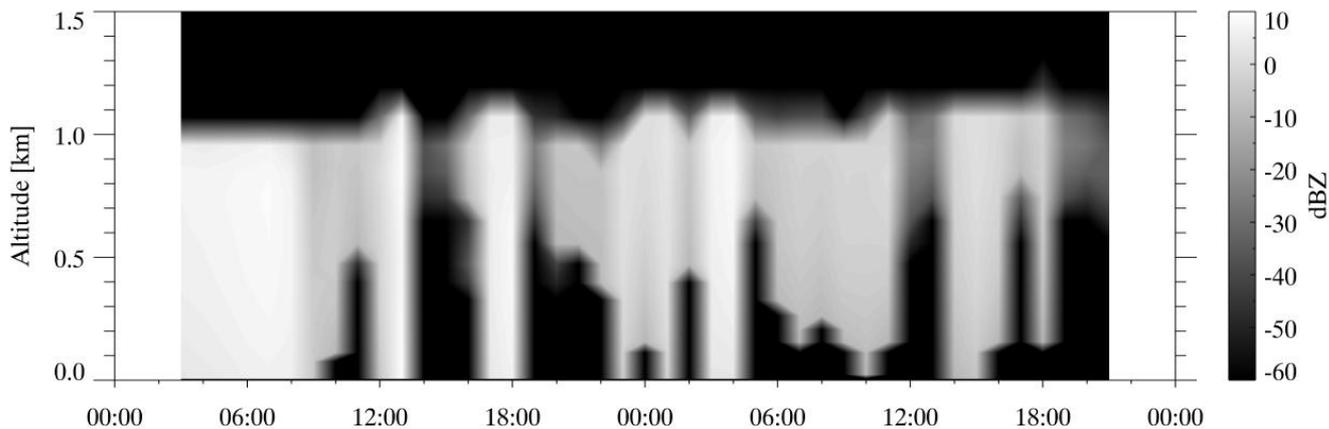
Measured N_d over ship



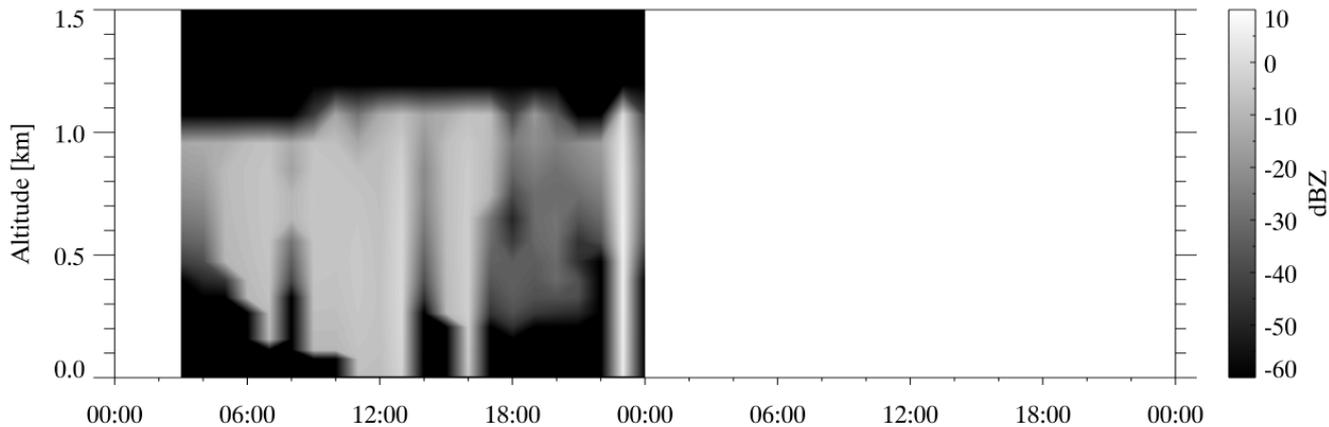


Radar Reflectivity

W-band radar



MetUM (standard)



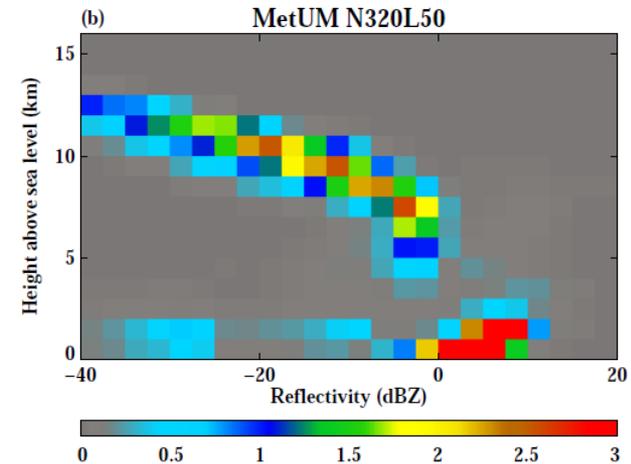
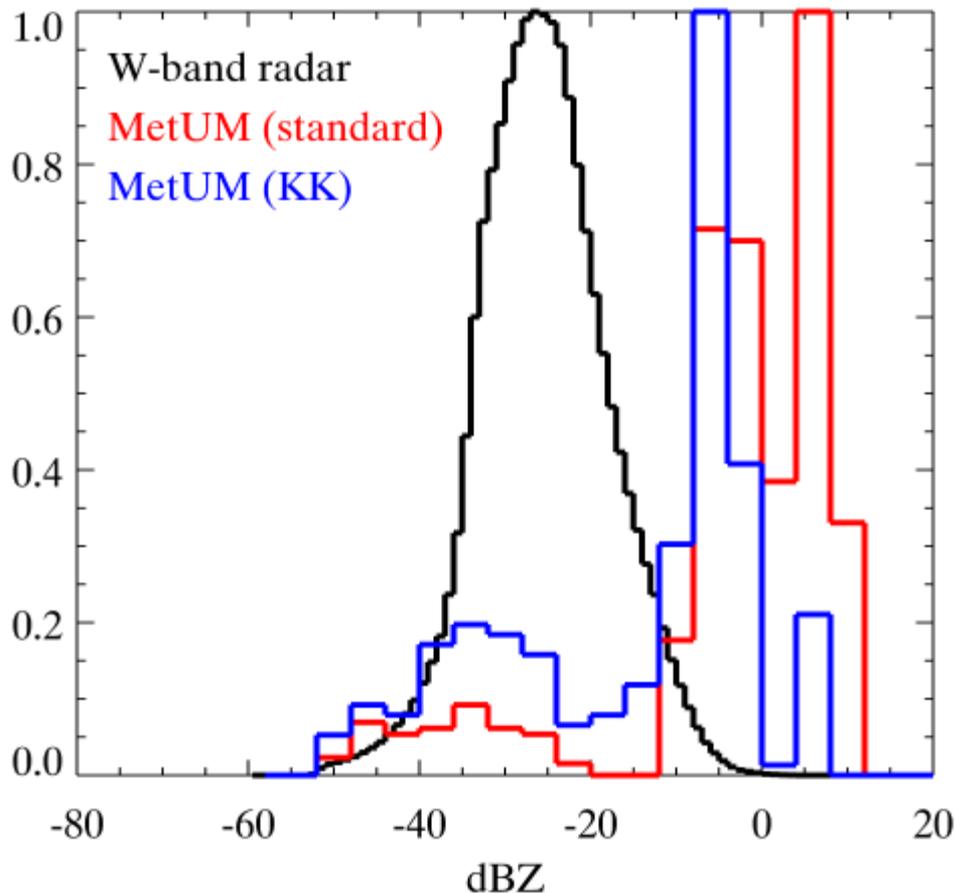
MetUM (KK)

12 Nov 2008

13 Nov 2008

14 Nov 2008

Normalised histogram of dBZ

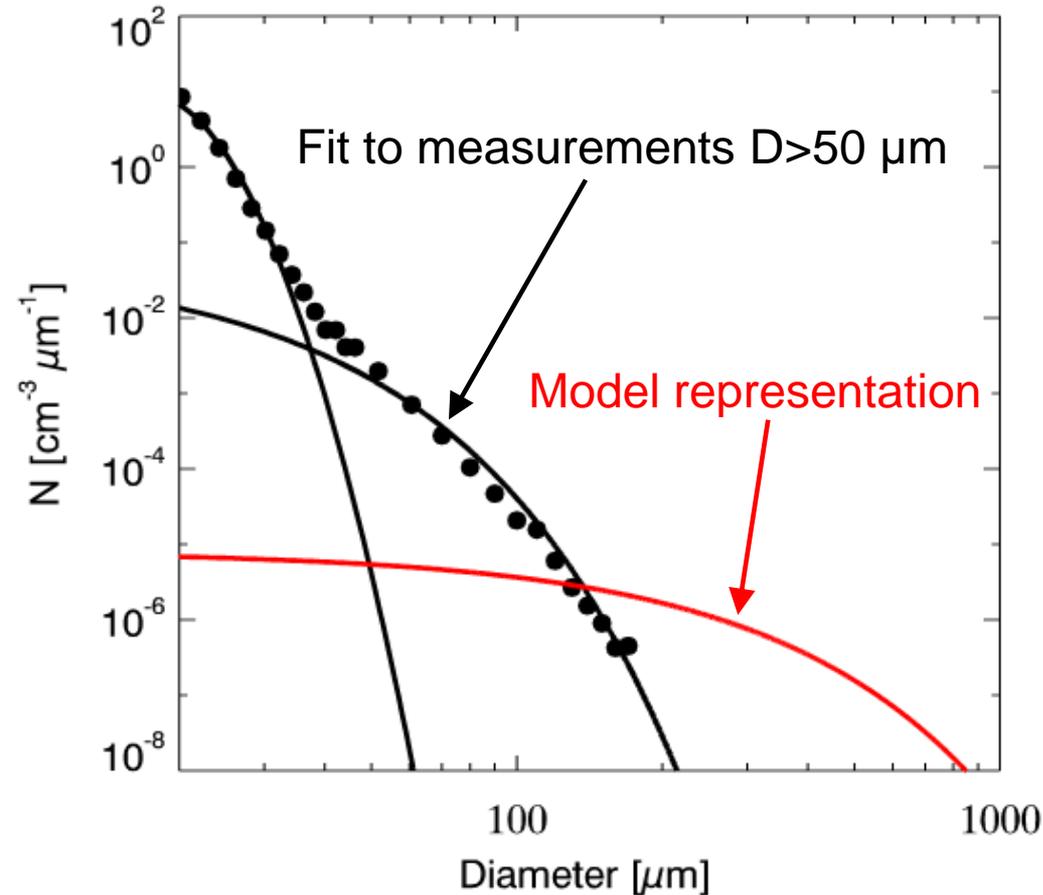


1. Non-drizzling mode (low dBZ)
2. Drizzling mode (high dBZ)

Apparent in both global N320 (40km) and high resolution (1km) models

What about drizzle drop size?

Example of aircraft measurements of droplet size spectra over the Ronald H. Brown



Rain drop size spectra in the model is represented with a gamma distribution

$$N(D) = N_0 D^\alpha \exp(-\lambda D)$$

Model: 8×10^6 0 function of q_R

Black and red lines have the same rain mass (q_R)



Conclusions and future work

- The operational MetUM NWP set-up does not have a good representation of drizzle (model has generally been “tuned” for higher rain-rates)
- Cloud macrophysical properties and drizzle rates are highly sensitive to the autoconversion and accretion scheme. Diurnal cycle of LWP improved in KK run.
- Size spectra assumptions in the model lead to larger drizzle drops than typical in stratocumulus cloud. Implications are as follows:
 - Drop fallspeed too large
 - Accretion rates too high
 - Rain rate too high
 - Sub-cloud evaporation too low
 - Reflectivity too high
- Utilise VOCALS-REx aircraft measurements of drizzle size spectra to improve models representation



Met Office



Questions