Met Office

The effect of ice fall speed in the structure of surface precipitation

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Contents

This presentation covers the following areas

- Introduction
- Experiment description
- Results
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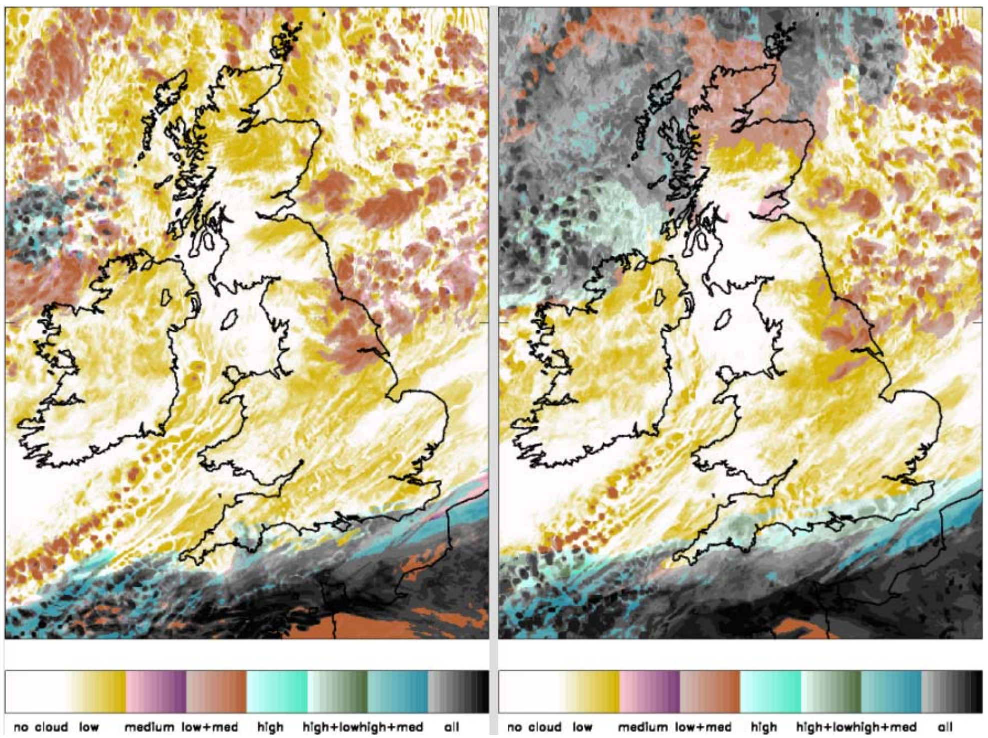
Introduction

Motivation

- Sensitivity tests on ice fallspeed to improve the radiative balance of the model through better representation of ice clouds.
- Test revealed also a sensitivity in surface precipitation.

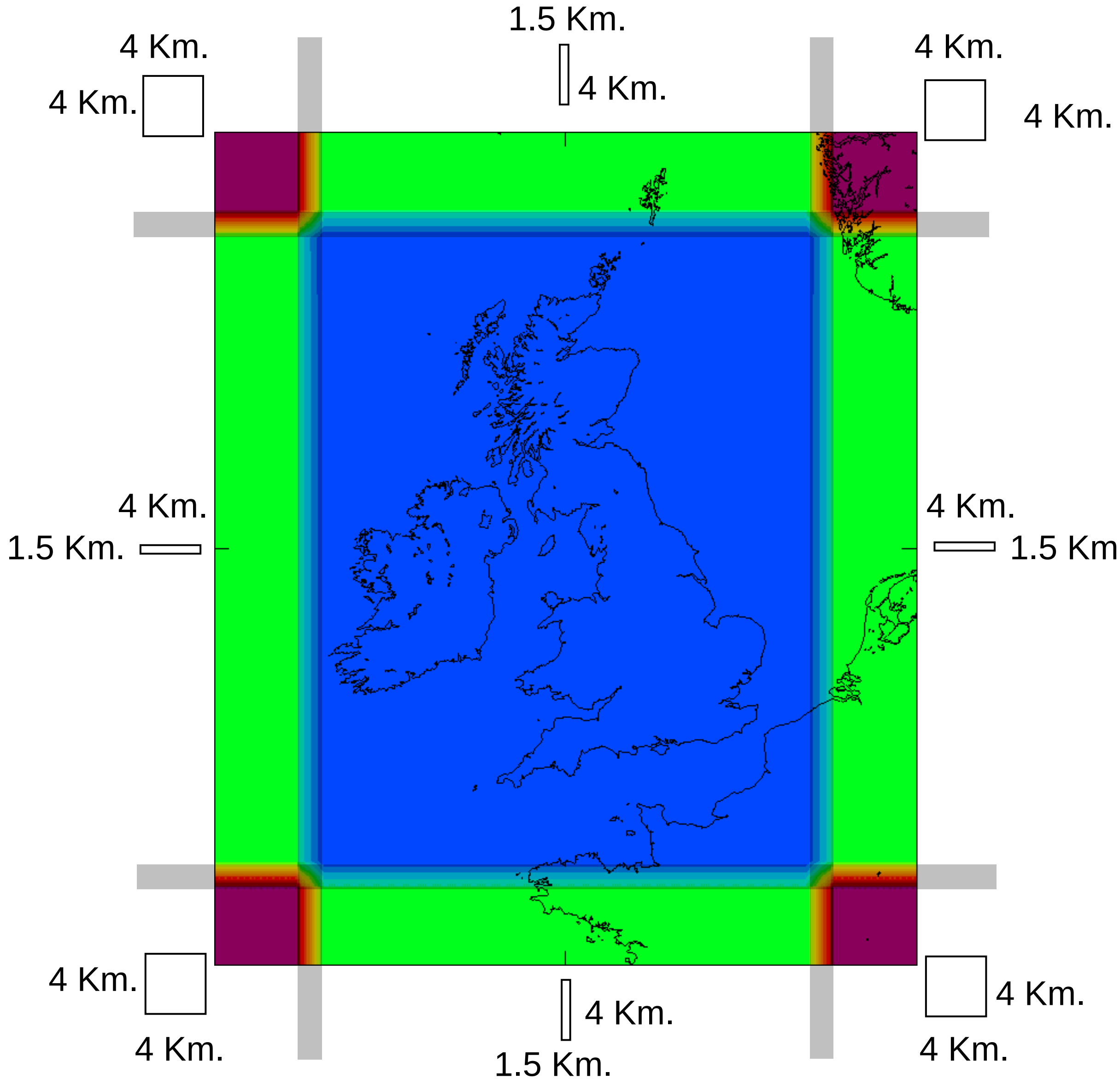


Seviri channel 9 reconstructions

(Courtesy Mark Weeks)

UKV Model formulation

- Nested in Global (25 Km gridlength)
- LBC update frequency: 1 hr.
- 70 vertical levels (38 Boundary Layer). Model top: 40000 m.
- Timestep: 50 sec.
- Forecast length: 36 hours
- No convection scheme



UM Microphysics scheme

- Multi-phase scheme based on Wilson and Ballard (1999)
- 4 phases: Liquid, vapour, ice aggregates and rain (recently graupel has been added as a prognostic variable)
- Rain is advected as it falls through the model levels
- Ice Particle Size Distribution based on Field et al. (2007)

- Wilson, D. R., and S. P. Ballard, 1999: A microphysically based precipitation scheme for the UK Meteorological Office Unified Model. Quart. J. Roy. Meteor. Soc., **125**, 1607–1636
- Field, P. R., Heymsfield, A. J., and Bansemer, A. (2007). Snow size distribution parameterization for midlatitude and tropical ice clouds. *J. Atmos. Sci.*, **64**, 4346–4365.

Ice fallspeed parametrization

- Based on Mitchell (1996)
- Mass-diameter relationship: $m(D)=Ai*D^{Bi}$
- Best-Reynolds relationship: $Re(X)=Alpha*X^{Beta}$
- Ai and Bi are derived from observations
- Alpha and Beta are determined empirically
- The two relationships provide a correspondence between the particle diameter and the terminal velocity.

- Mitchell, D. L. (1996). Use of mass- and area-dimensional power laws for determining precipitation particle terminal velocities. *J. Atmos. Sci.*, **53**, 1710–1723.

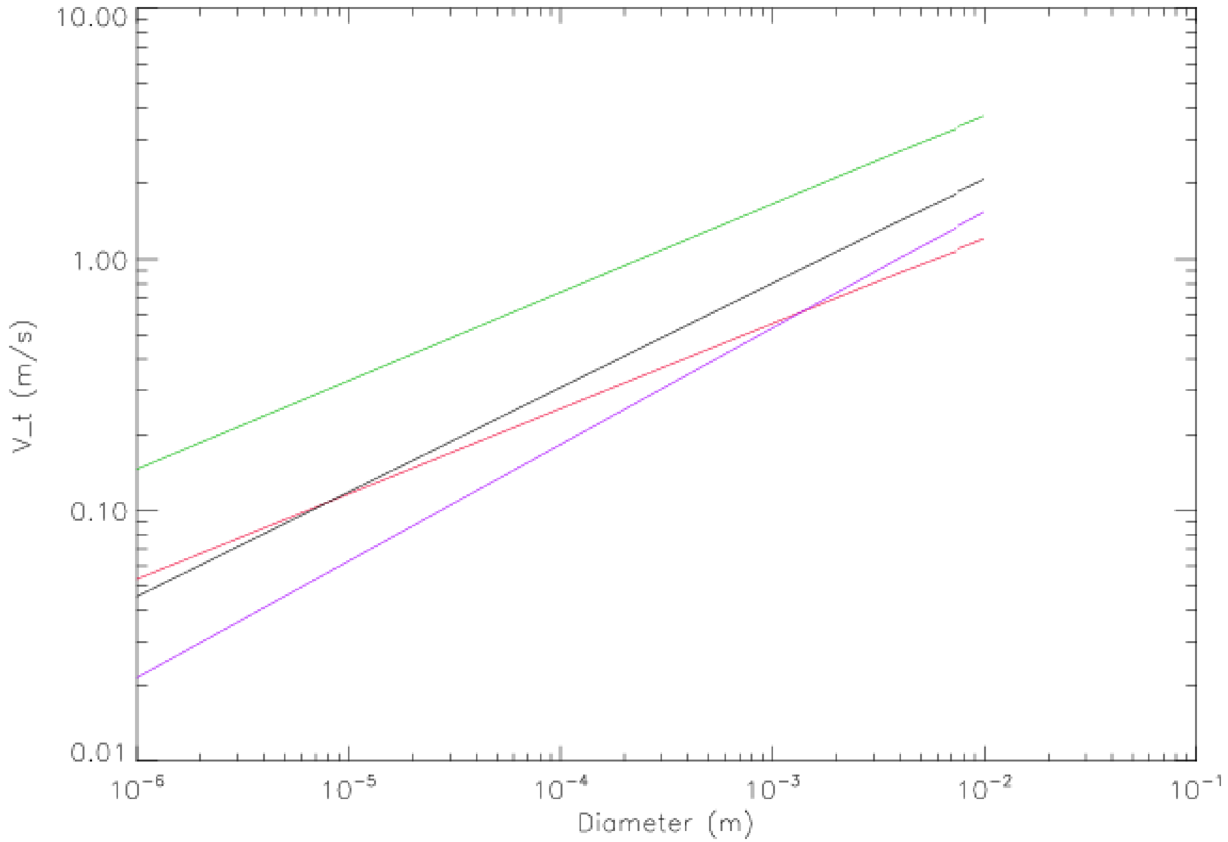
Experiment description

Ice fallspeed

	Ai	Bi	Alpha	Beta
Control (PS28)	0.069	2.0	0.2072	0.638
Test 1 (PS29)	0.069	2.0	0.07331430	0.63198
Test 2 (PS31)	0.023	2.0	0.156102	0.668094
Test 3 (exp1)	0.023	2.0	0.0851974	0.690943

All values are chosen within the range specified in the literature. The control run has fallspeeds near the higher limit and Test-1 and Test-3 near the lower limit

Ice fallspeed



Control (PS28)

Test 1 (PS29)

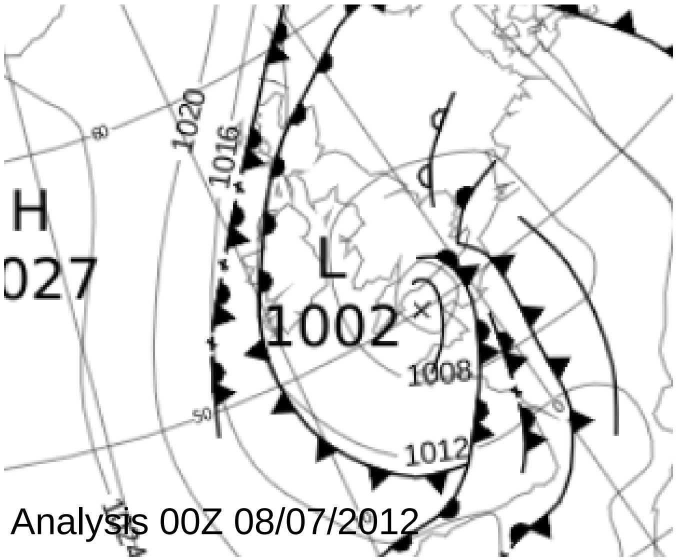
Test 2 (PS31)

Test 3 (exp1)

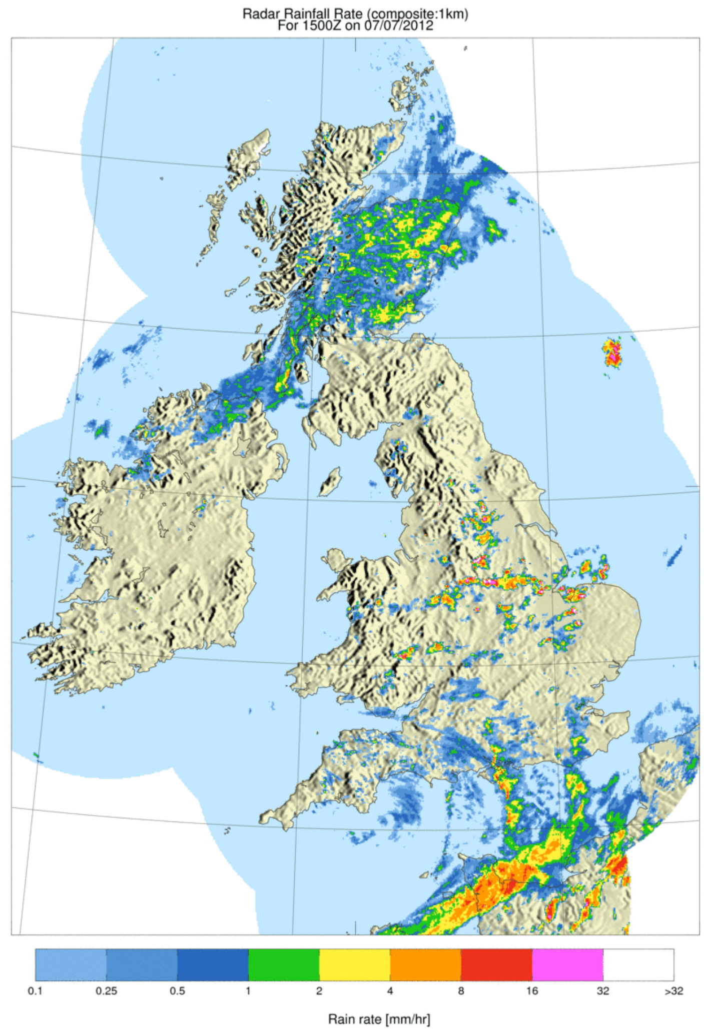
Cases

- **Dynamically Driven Summer Convection. 7th of July 2012.**
- Summer frontal system plus convection in post frontal cold air. 12th of August 2012.
- Winter frontal system. 6th of December 2012.
- **NW cold outbreak. 4th of February 2013.**
- Easterly snow. 11th of March 2013.

Case 07/07/2012.

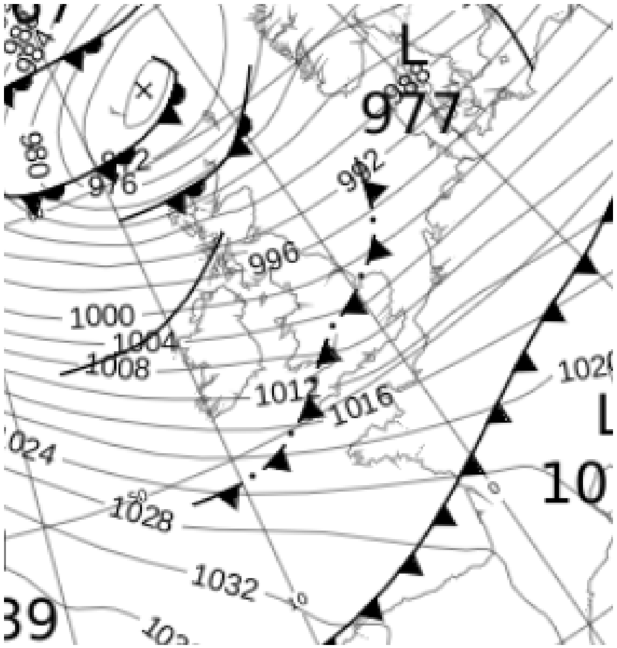


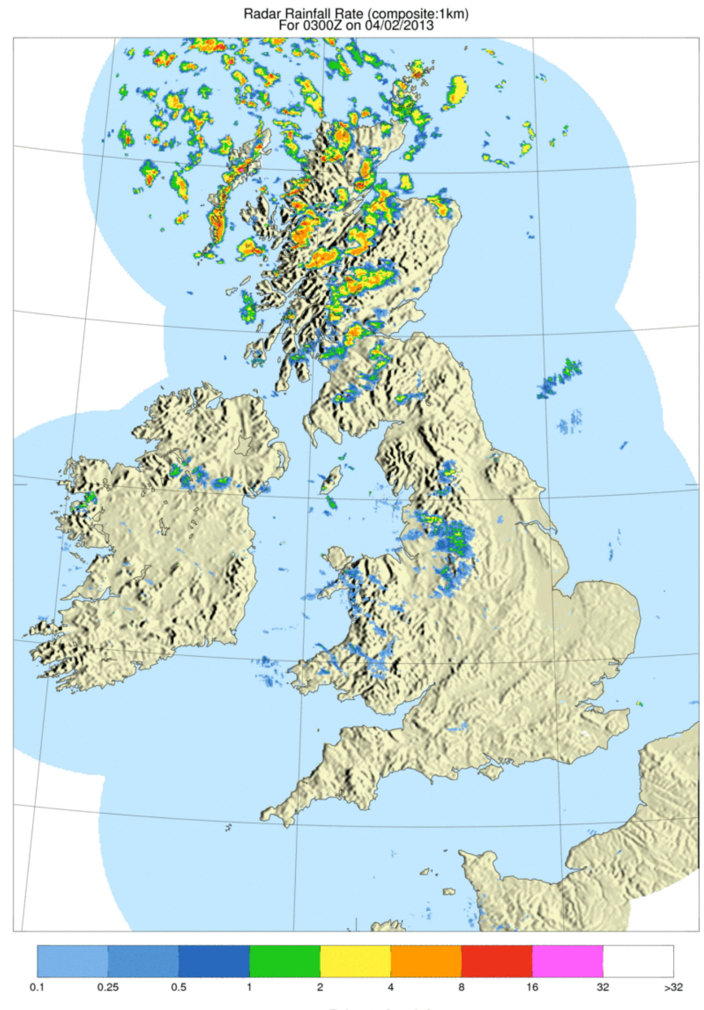
Analysis 00Z 08/07/2012



- Start 15Z 07/07/2012
- End 03Z 09/07/2012

Case 04/02/2013.

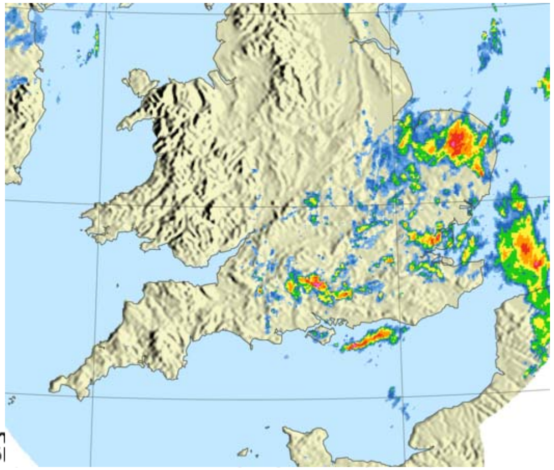




- Start 03Z 04/02/2013
- End 12Z 05/02/2013

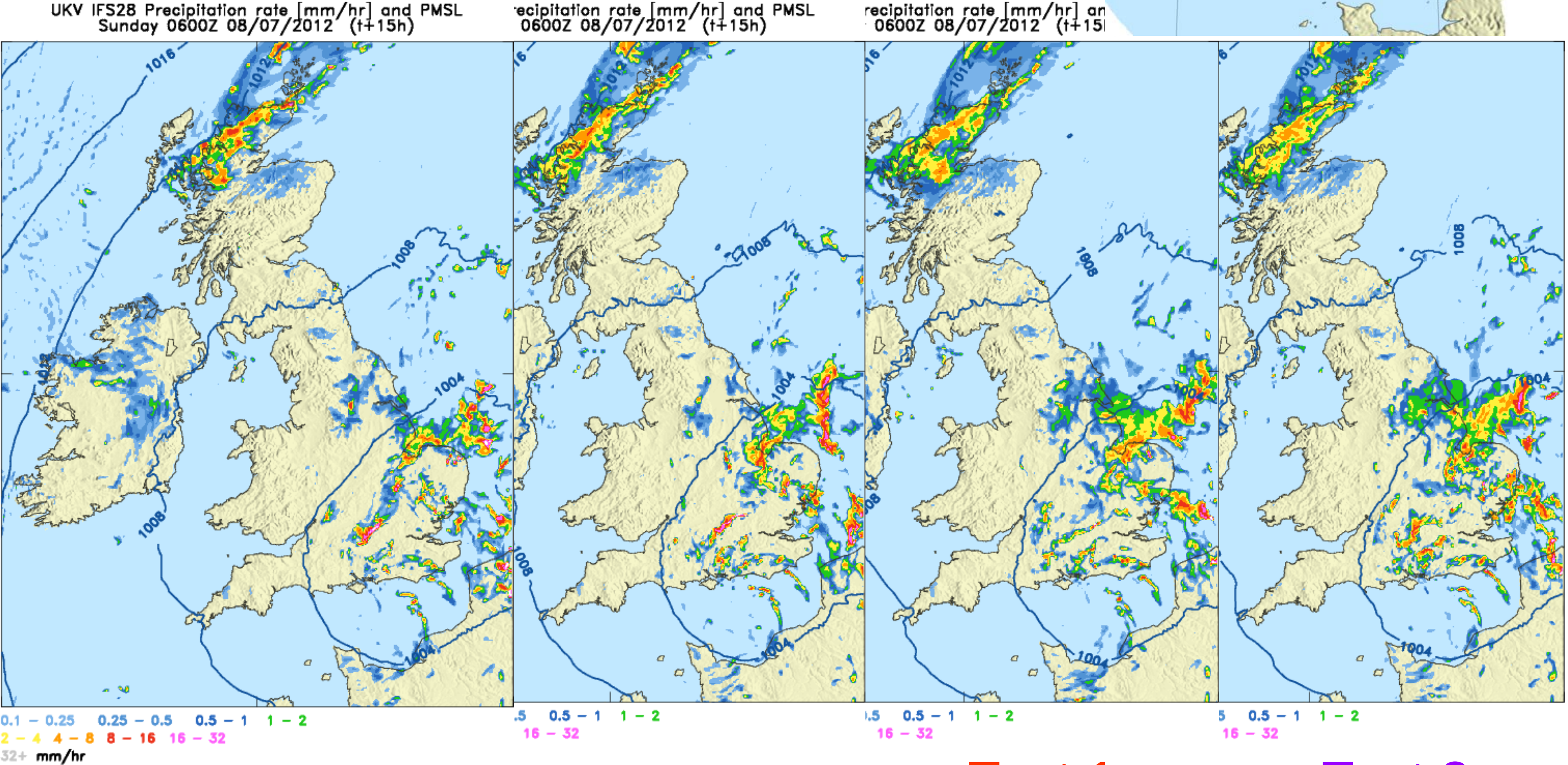
Results

Case 1



Control

Test 2



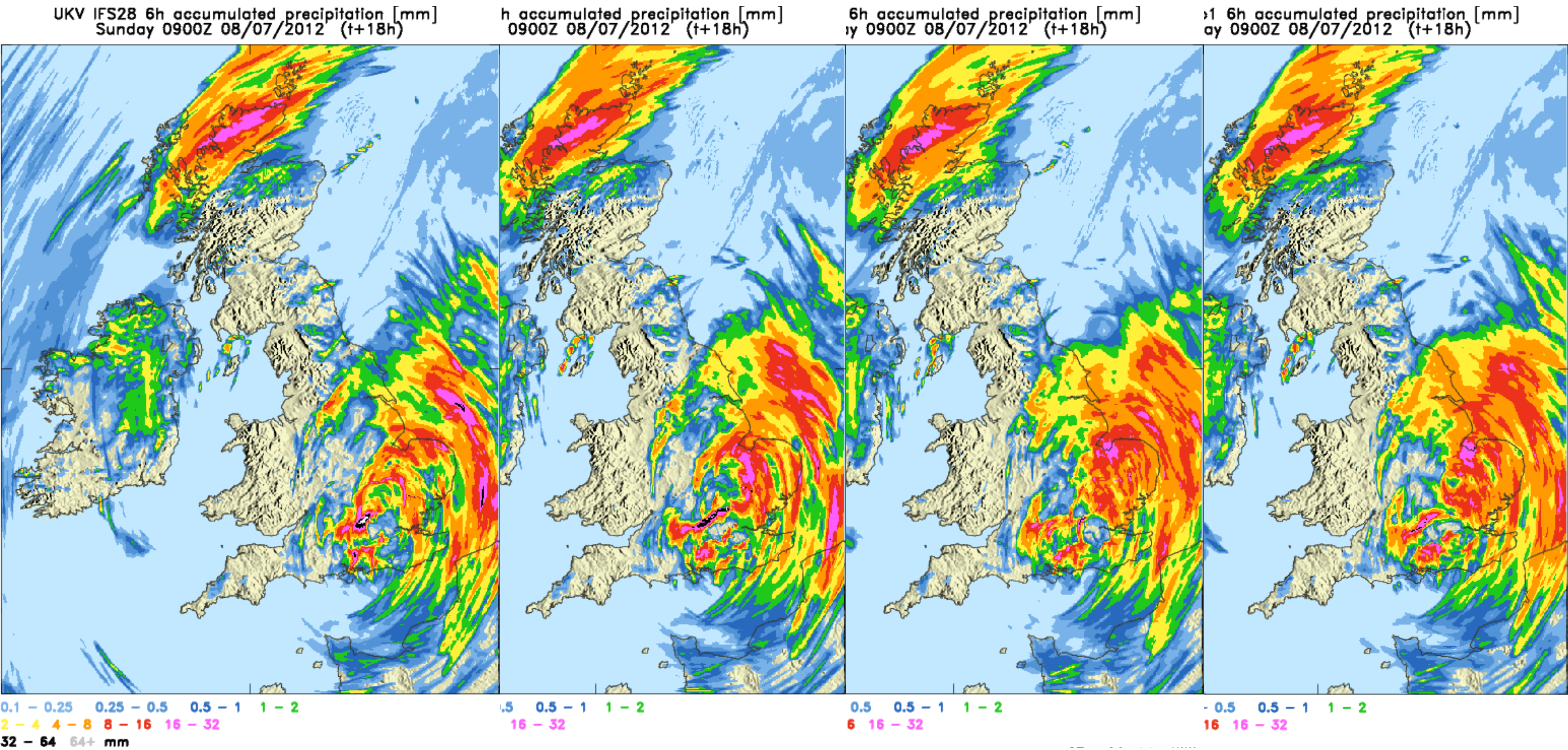
Test 1

Test 3

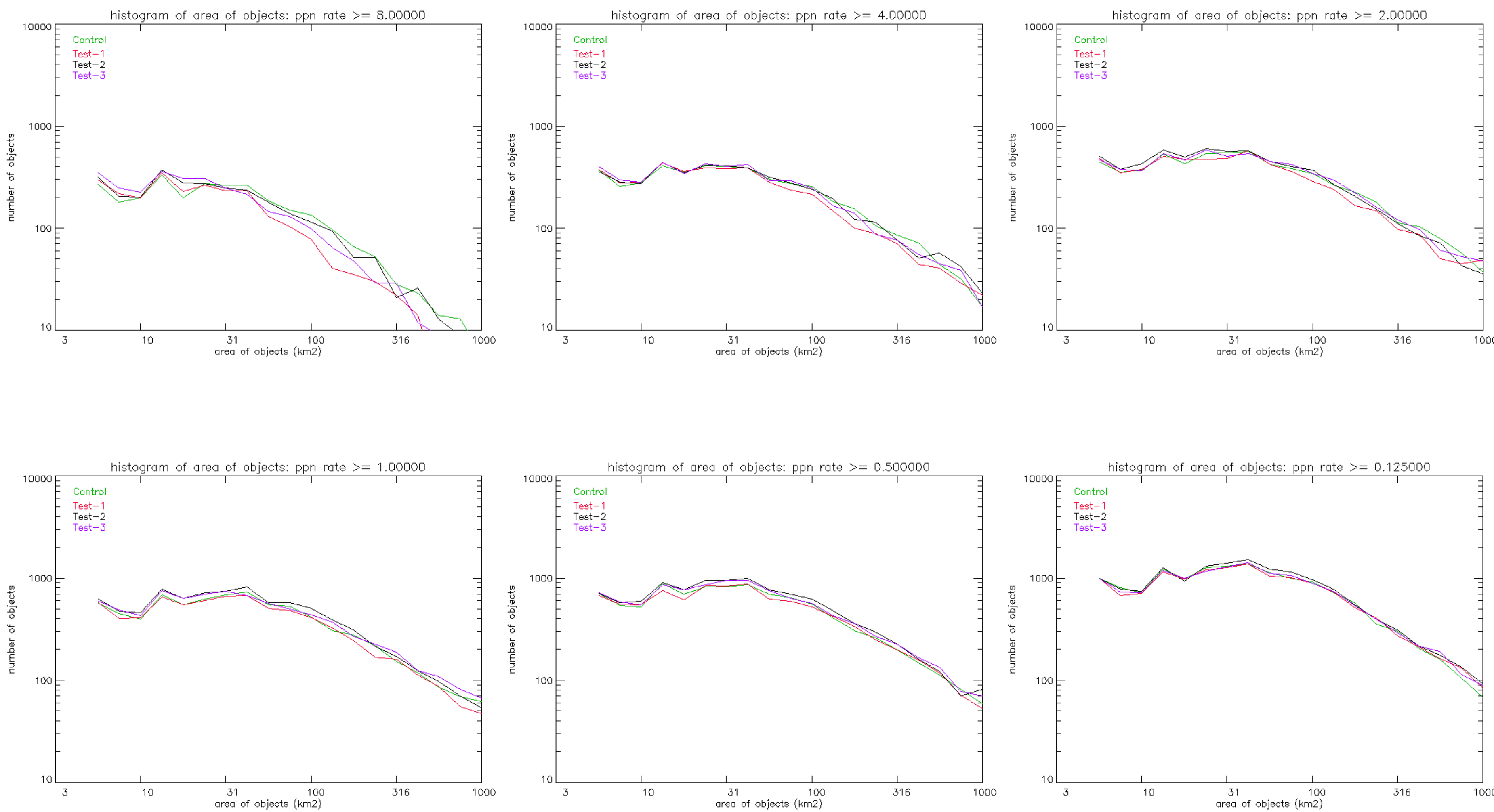
Case 1

Met Office

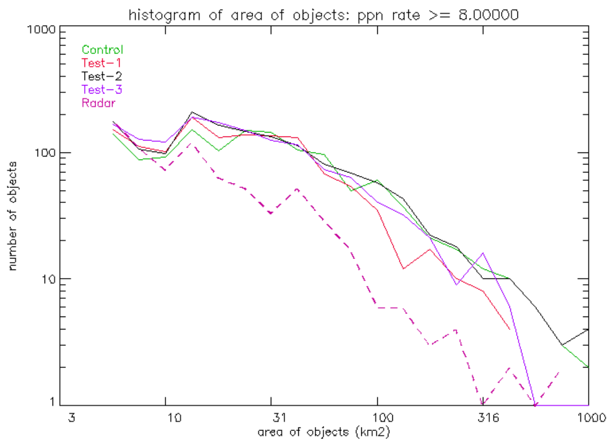
Control | Test 2 | Test 1 | Test 3

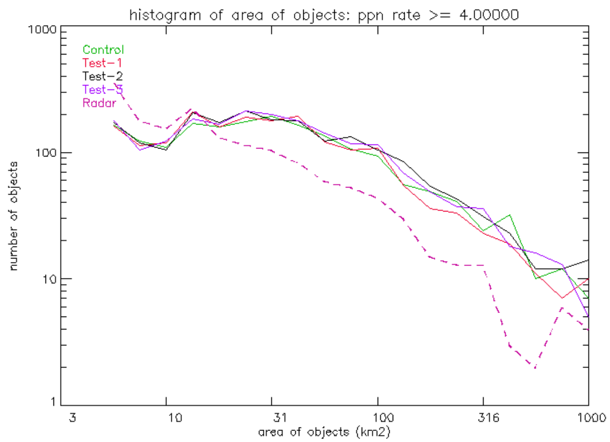


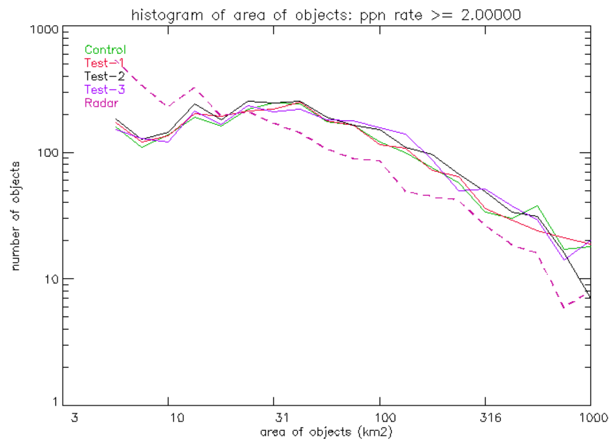
Case 1. Whole domain cell statistics

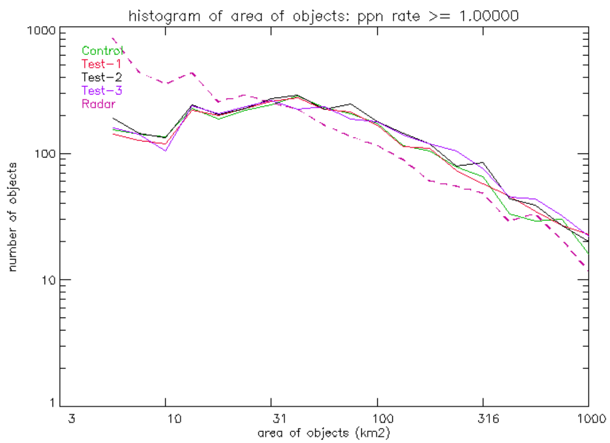


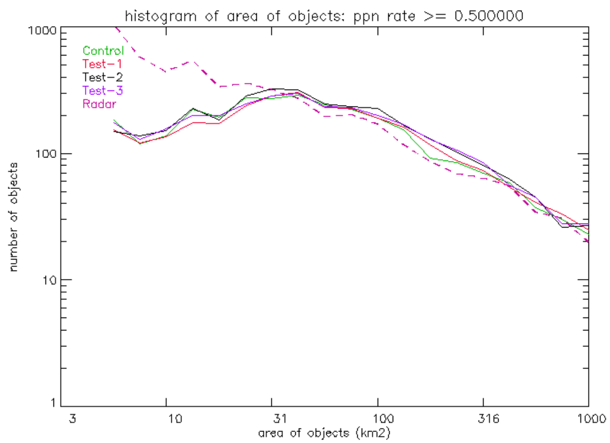
Case 1. Radar comparison. S. England

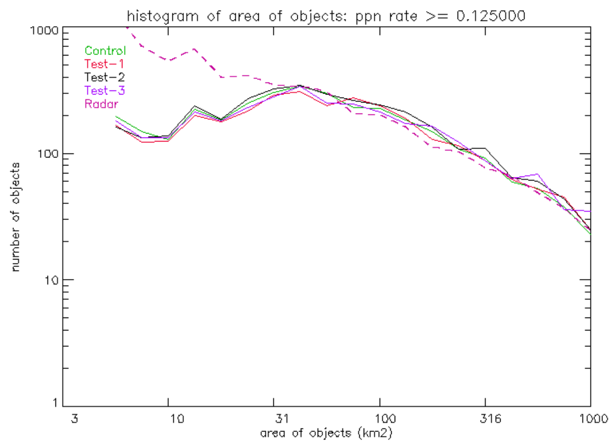












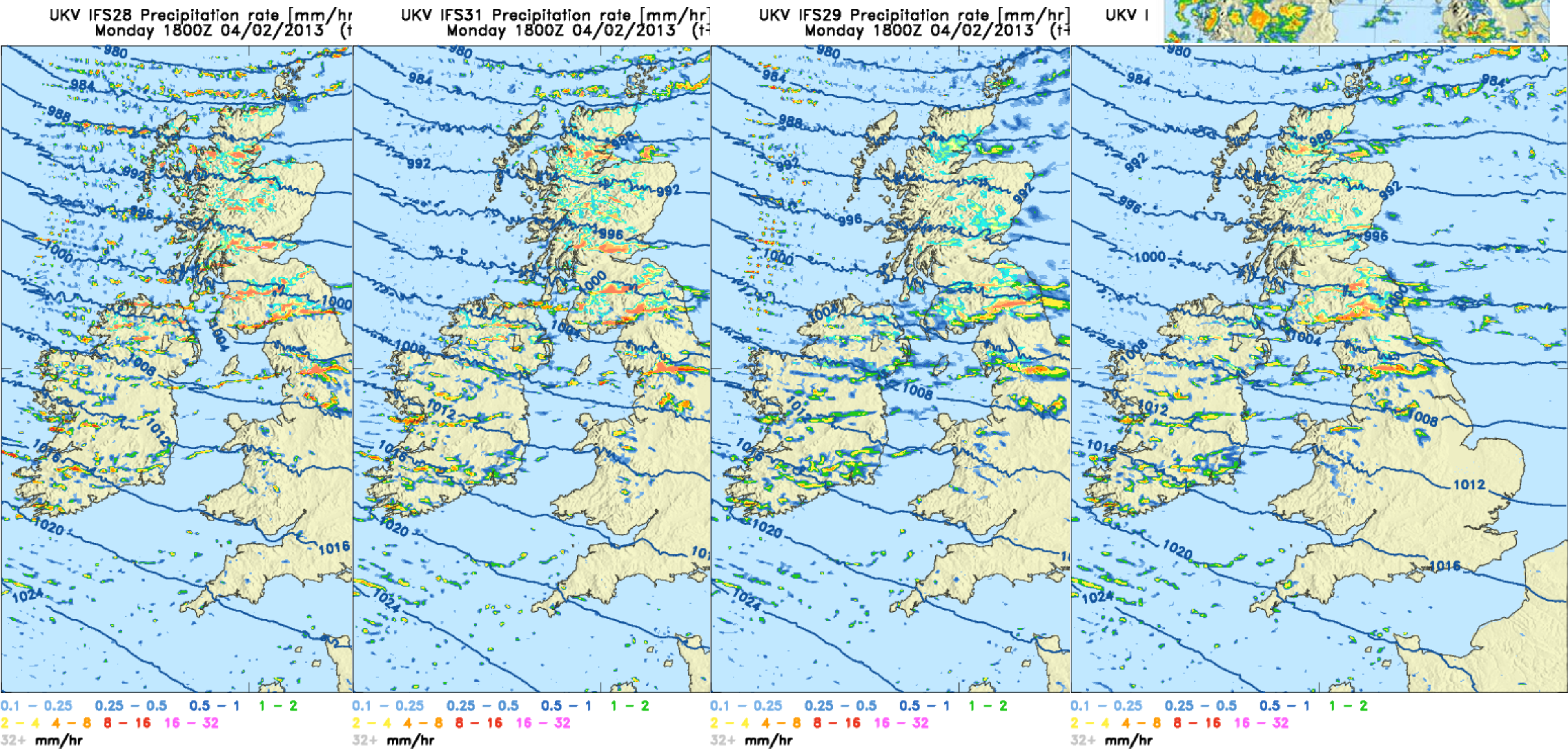
Case 1

- Peak instant precipitation rates are higher with higher ice fallspeed.
- Precipitation rates over 16 mm./hr are less frequent with lower ice fallspeed.
- Cells are smoother with lower ice fallspeed.
- 6 hr accumulations very similar below the 4mm. Threshold, but…
- Lower Ice fallspeeds don't produce accumulations above 16mm/6hr.
- Cell size histograms very similar in all experiments up to a rainfall threshold of 4 mm/hr.
- All configurations have a significantly higher number of cells between 15 km^2 and 1000 km^2 for thresholds above 2 mm/hr compared with the radar.

Case 4

Control

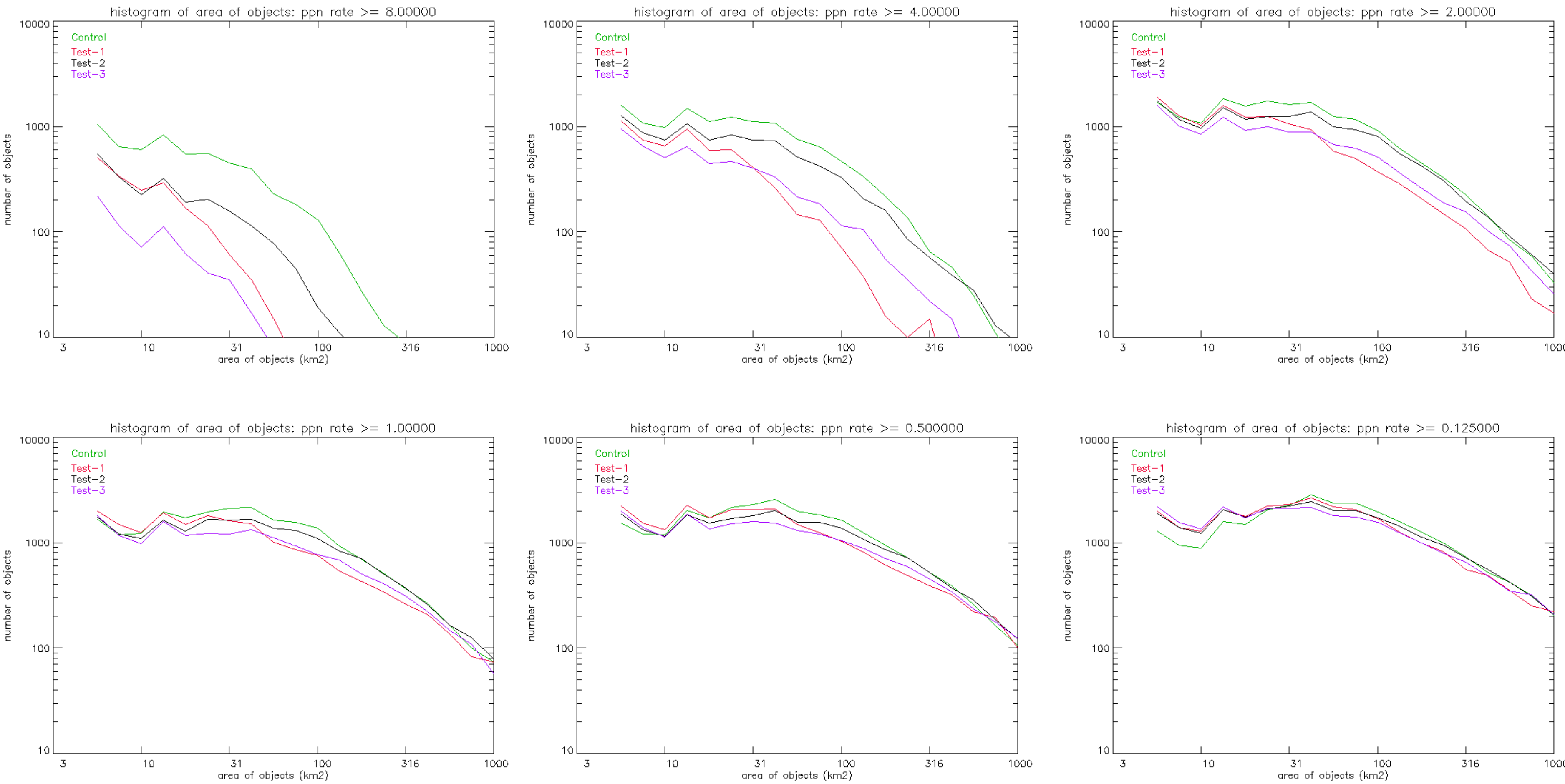
Test 2



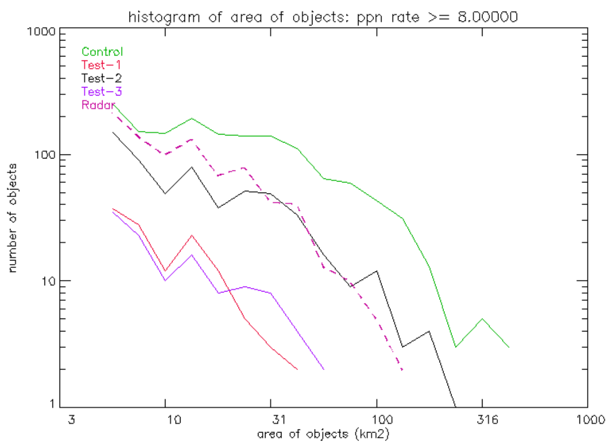
Test 1

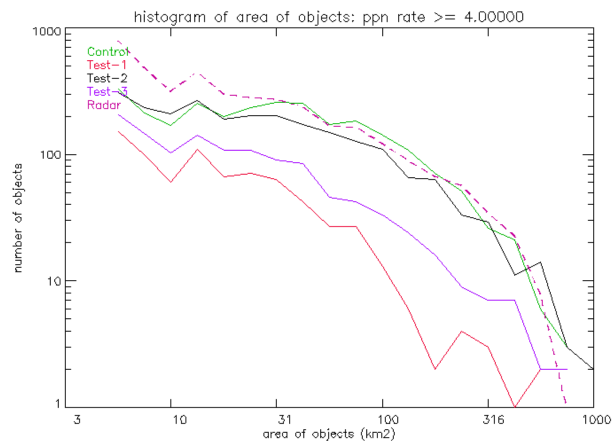
Test 3

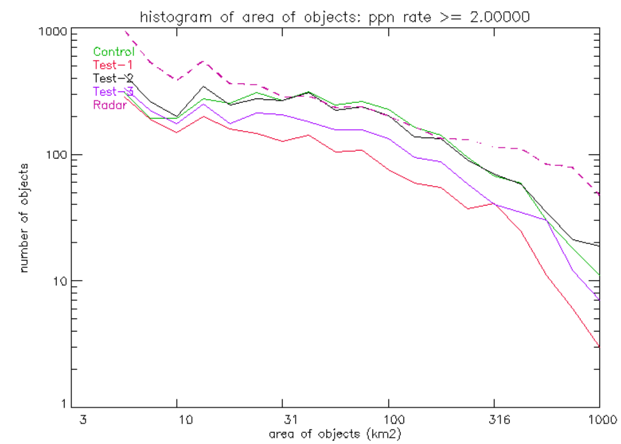
Case 4. Whole domain cell statistics

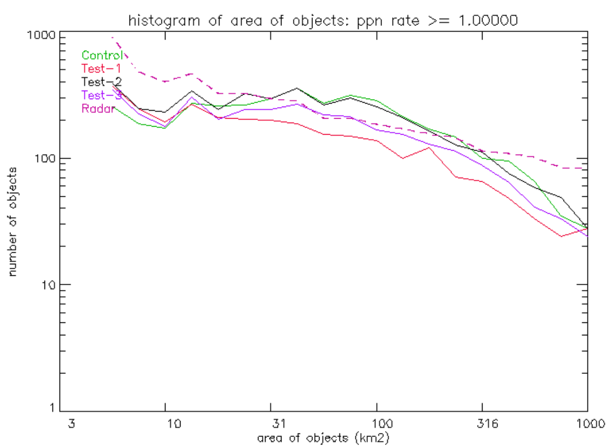


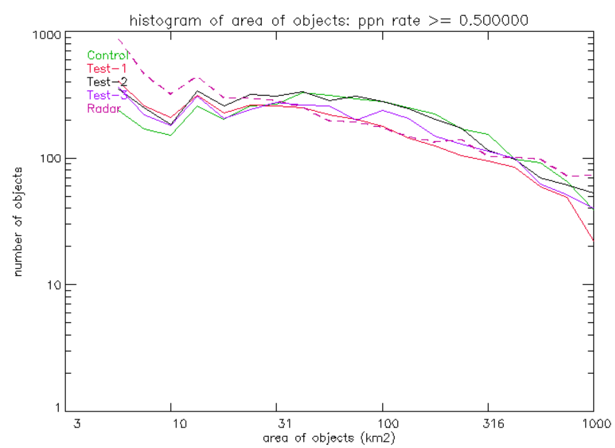
Case 4. Radar comparison, Scotland

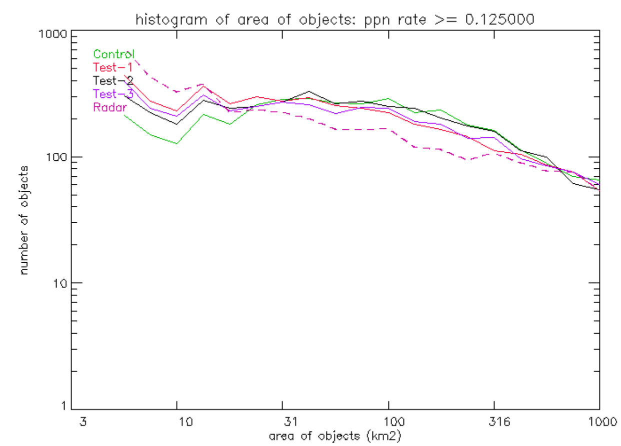












Case 4

- Spin-up from the boundaries visible in the West edge of the model in all experiments.
- Snow rates significantly lower on tests with lower ice fallspeed, particularly over Scotland.
- Convection over the sea in the inflow area North of Ireland dies out quickly after spin-up in all 3 tests, particularly noticeable in Test-2 and Test-3.
- Significant reduction of number of cells of all sizes (up to 1000 km^2) for thresholds above 2 mm/hr on the tests with lower ice fallspeeds.
- Comparison with radar over Scotland points to underforecasting of snowfall in lower ice fallspeeds experiments.

Conclusions

Conclusions

- Modifications to ice fallspeed affect noticeably the structure of surface precipitation.
- Increasing ice fallspeeds produces more intense precipitation and sharper cells.
- Lower ice fallspeeds reduce peak precipitation rates and accumulations significantly. May impact forecast of severe events.
- Impact is more clearly seen in snow showers.
- The UKV model has introduced recently different ice fallspeed parameters for crystals and for aggregates, so improvements to ice cloud are decoupled from surface precipitation.

Further work

- Analysis of upper air fields and experiments without advection of precipitates in order to understand mechanisms.
- Understand difference in number of cells smaller than 20 km2 between model and radar.
- More sensitivity studies in order to find best parameters.
- Assess impact in flooding events.

Questions and answers