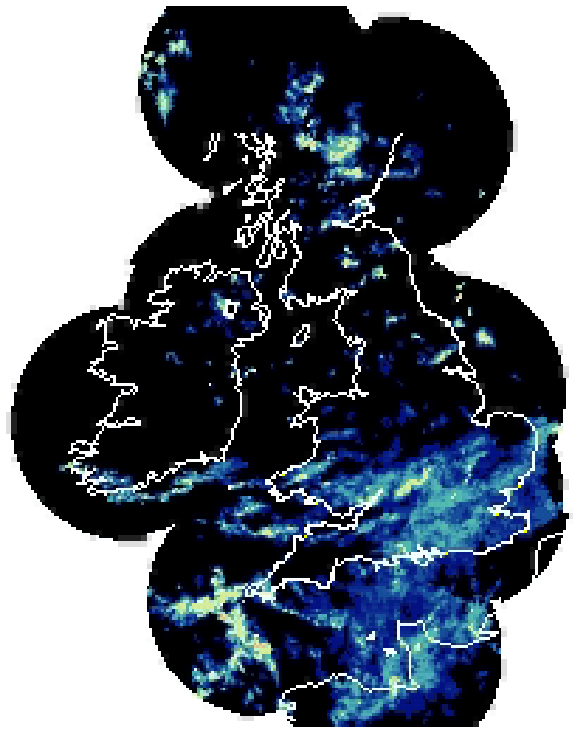
Statistical aspects of convection parametrization

by

Glenn Shutts



parametrization of convection

- explicit representation of convective clouds requires a horizontal grid spacing < 2 km
- deep convective clouds may extend over 100's km and remote influence ~ 1000 km
- global NWP and climate models need parametrization

Convection parametrization based on a "quasi-equilibrium hypothesis" where the ensemble average fluxes of heat, moisture and momentum are supposed to be determined by the large-scale (resolved) flow

Stochastic physics

- assume that parametrization is tuned to give correct ensemble-mean
- account for statistical fluctuations using random numbers

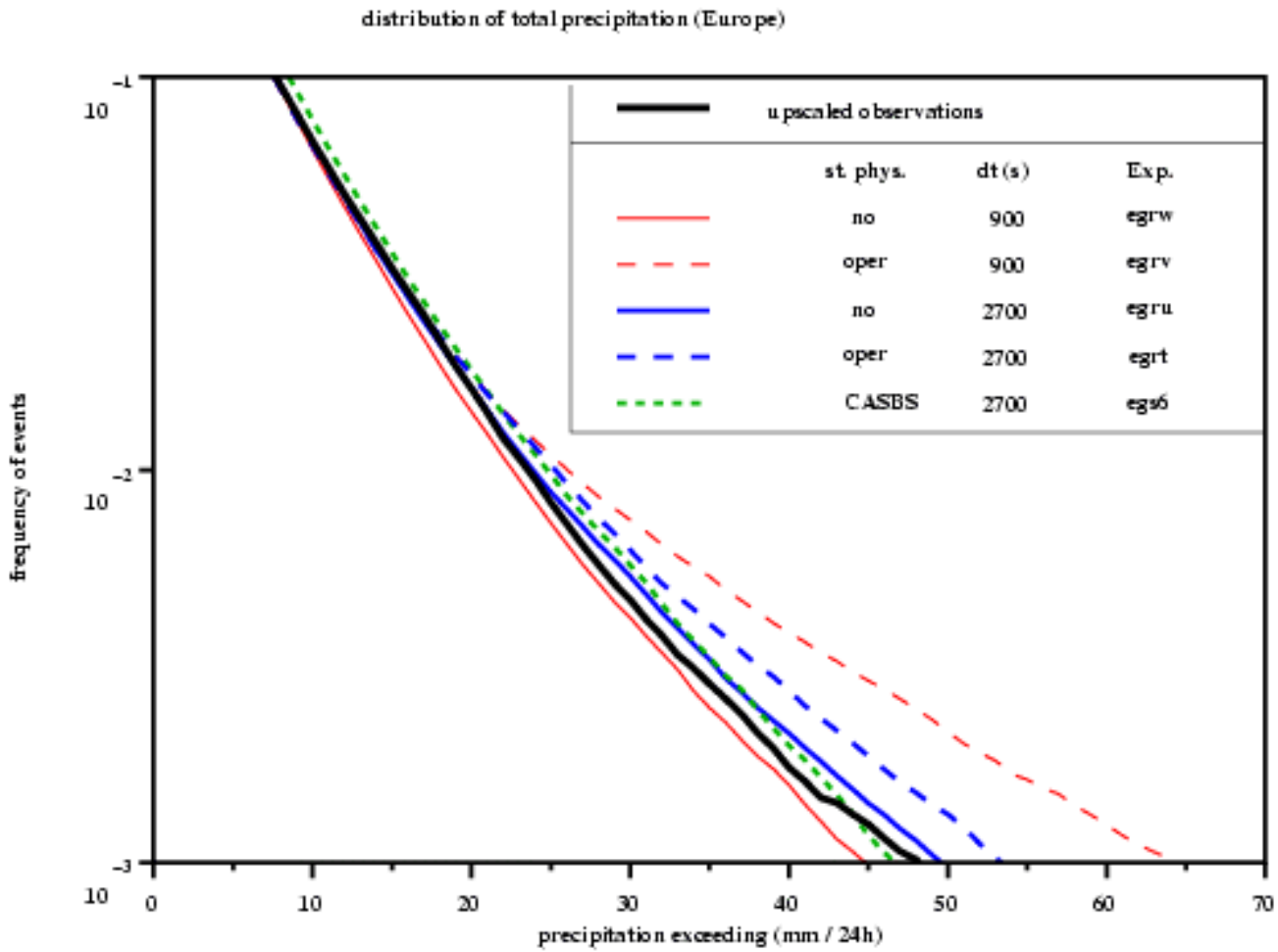
ECMWF IFS scheme:

- assign random numbers in the range 0.5 to 1.5 to boxes defined by a 10 degree latitude/longitude grid
- multiply model parametrization tendencies by these numbers according to which box a model gridpoint lies in
- assign new random numbers every 6 hours

drawbacks:

- calibrated for EPS impacts rather than physical basis
- contribution to enhanced EPS forecast spread is small
- over-predicts frequency of heavy precipitation events

Heavy precipitation event forecasting in the EPS



(from work by Martin Leutbecher)

calibration of convective statistics with a cloud-resolving model

Use the Met Office 'Large Eddy Model' to simulate a population of tropical convective clouds under constant thermal forcing

$\Delta x = \Delta y = 1.5$ km 1024 x 1024 x 40 points

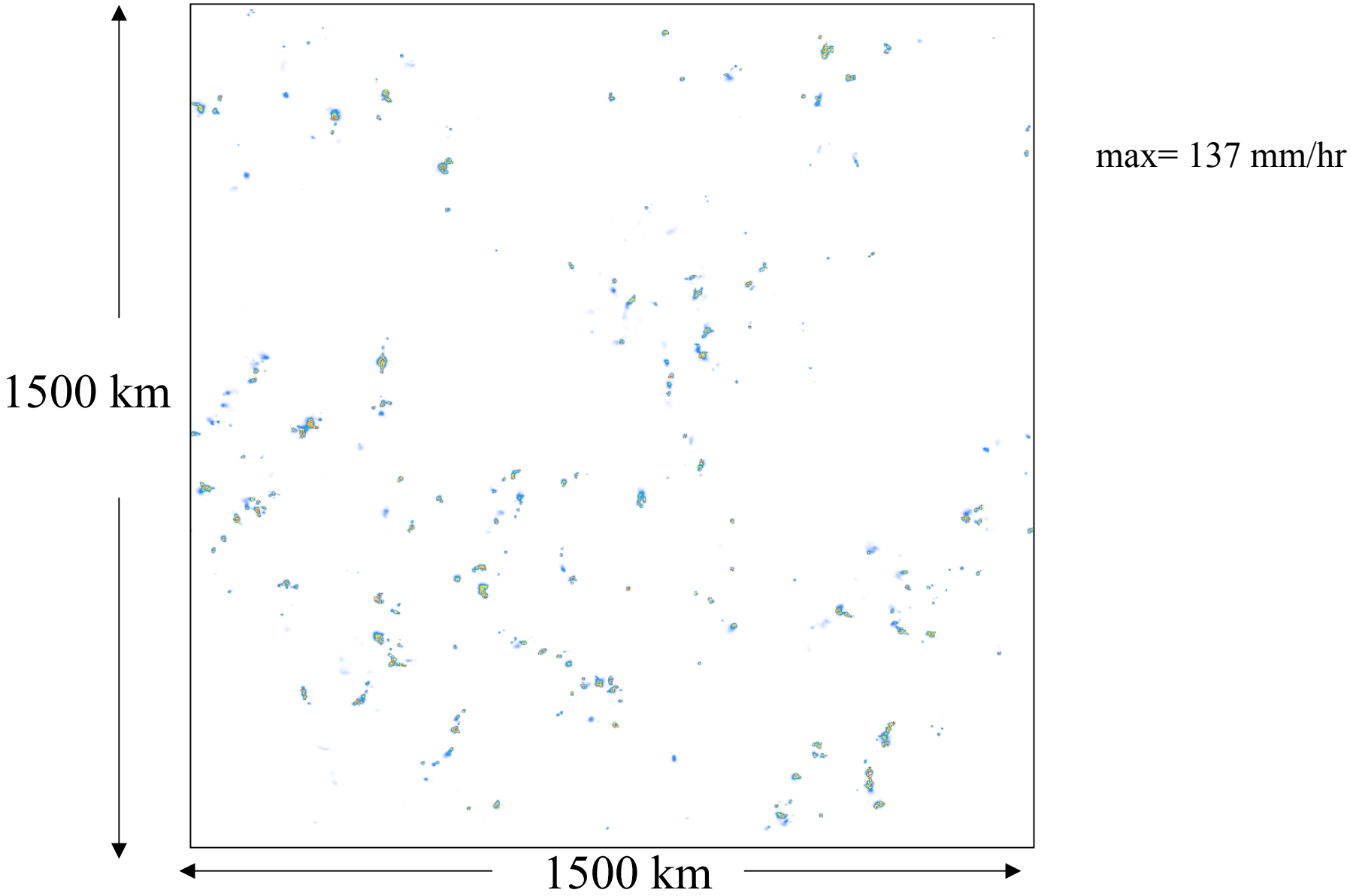
SST= 26 C 3-phase cloud microphysics

fixed cooling rate of 1.5 K/day in troposphere

Objective:

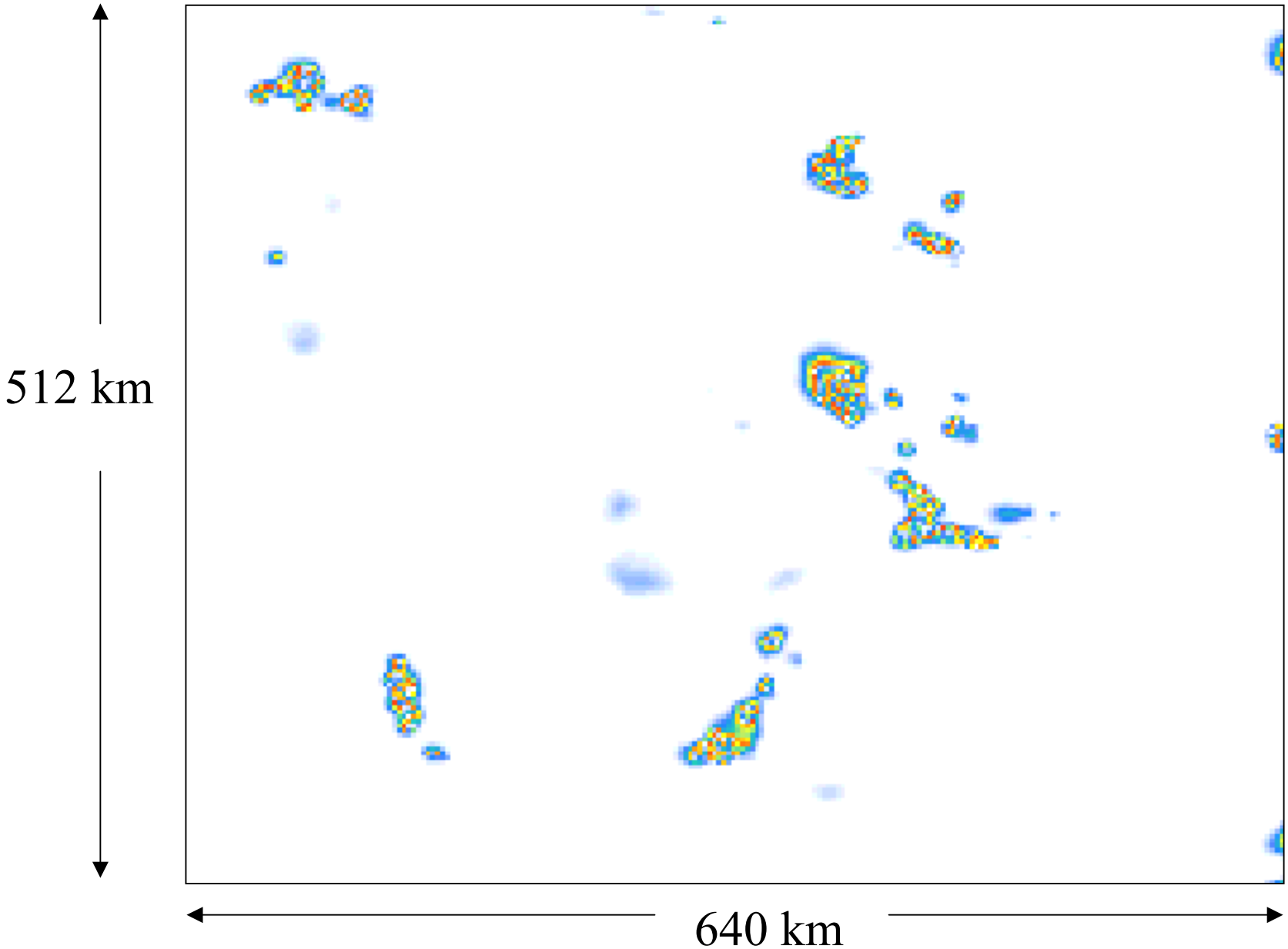
• compute coarse-grained tendency statistics compatible with NWP model grids

Instantaneous rainfall rate at day 5

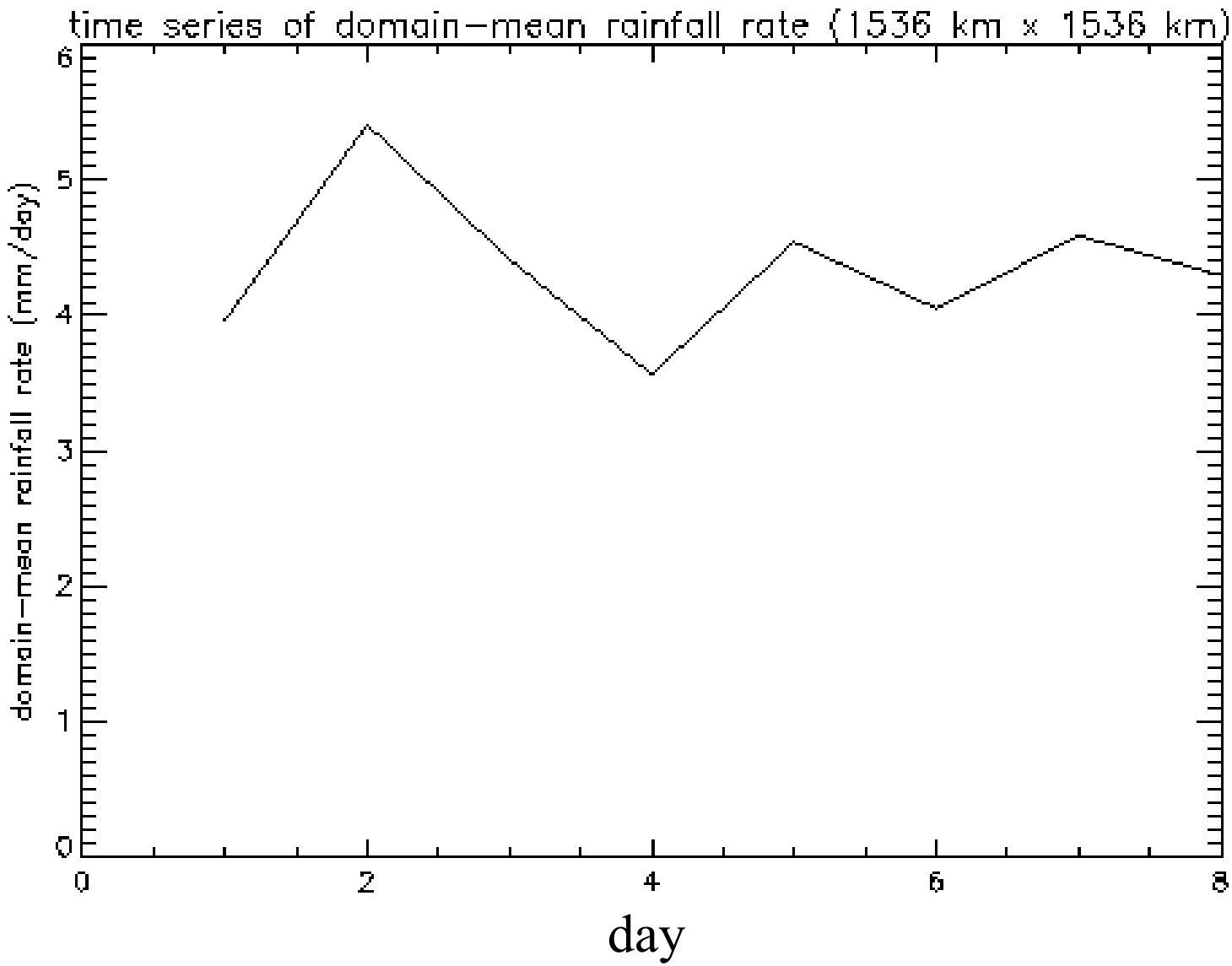


max= 137 mm/hr

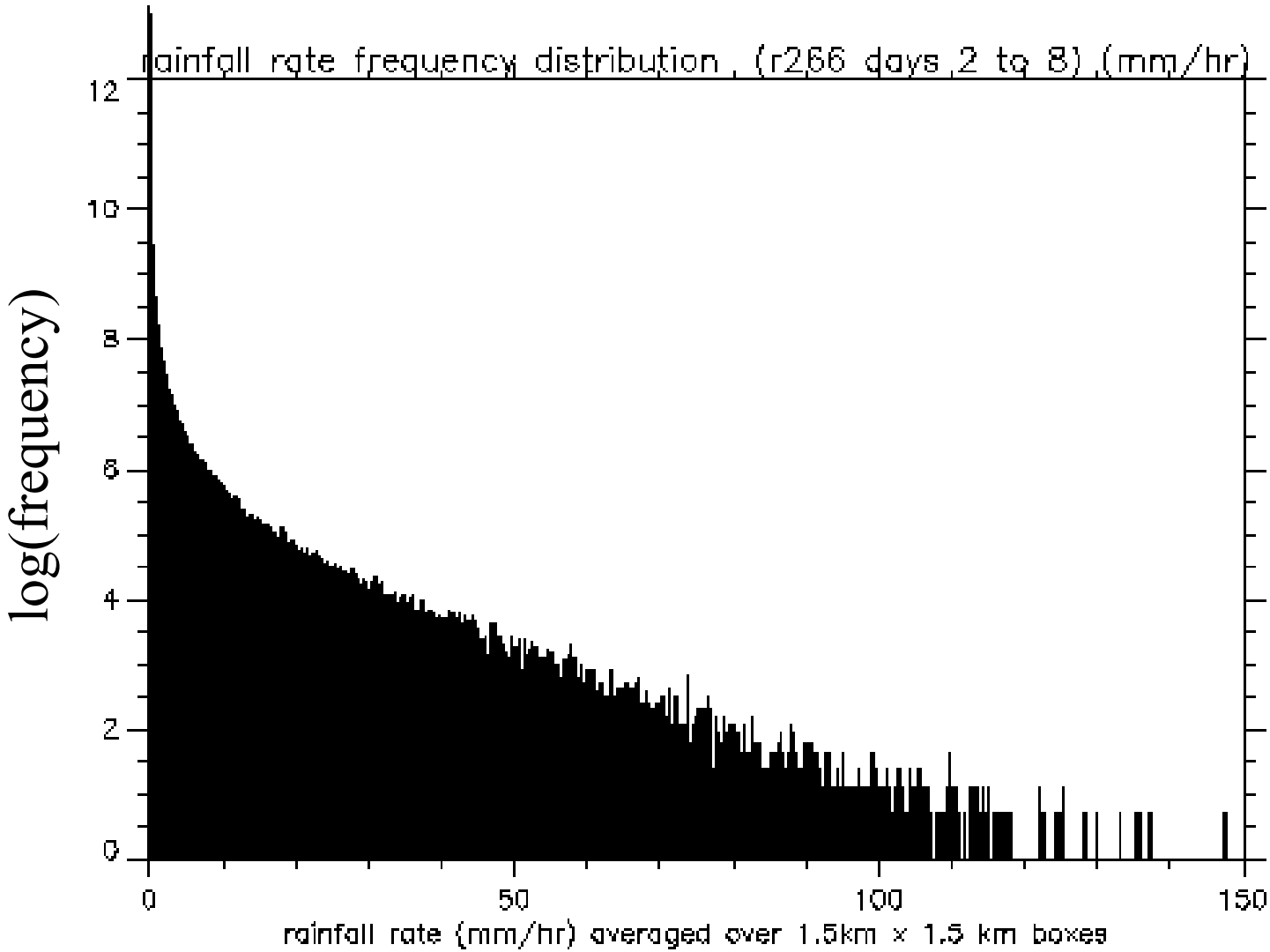
zoomed plot of rainfall rate



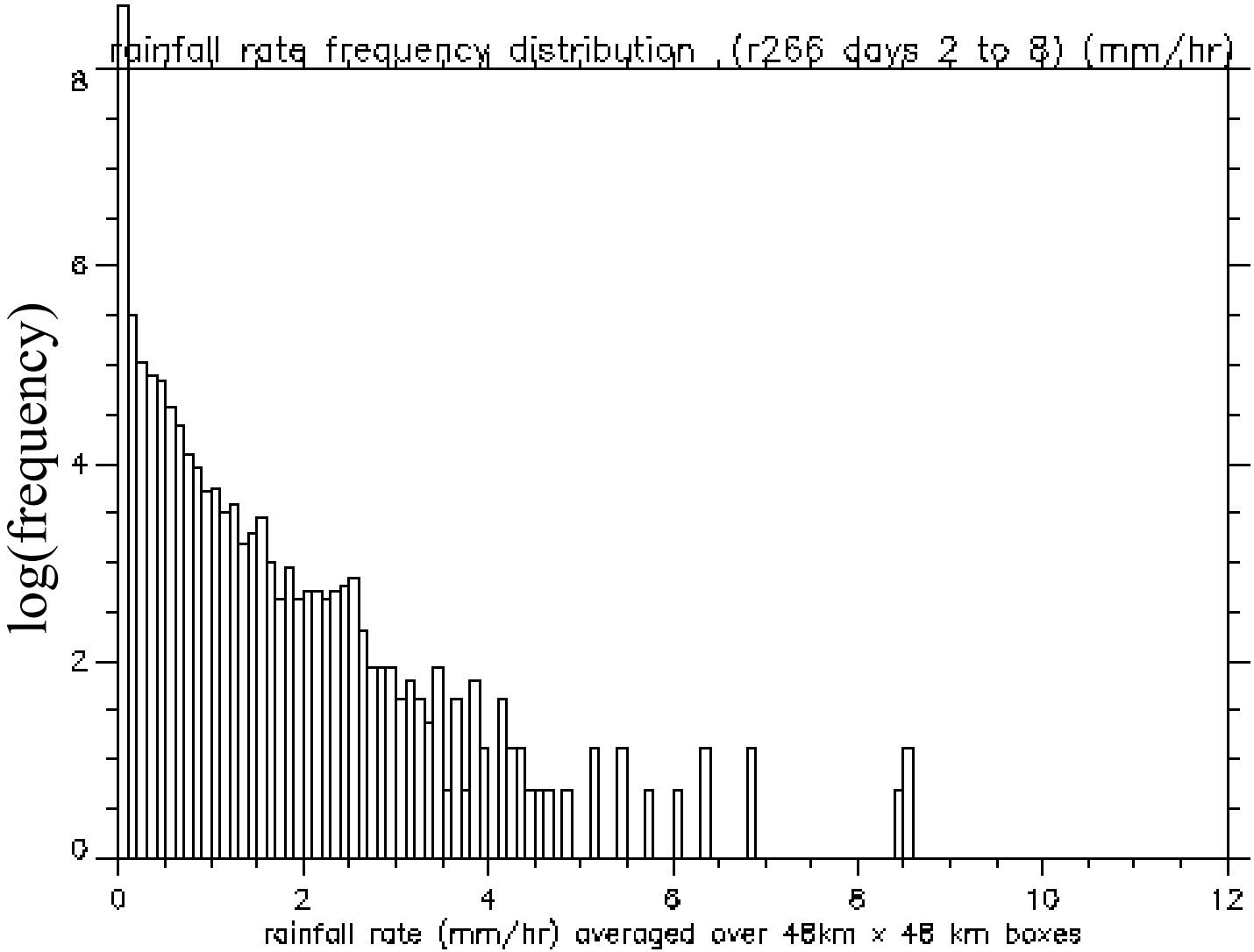
time series of domain-mean rain rate



histogram of instantaneous rainfall rate



histogram of rainfall rate coarse-grained to 48 km x 48 km



Summary

- statistical description of cumulus convection seems appropriate in ensemble prediction systems
- current convective parametrization in operational NWP already stochastic at the near-grid scales due to numerical noise ?
- stochastic convective parametrization schemes need to be designed from scratch
- no guarantee that their impact will be substantially better than current parametrization philosophy