Update on the Met Office Regional Atmosphere and Land Configuration (RAL3)

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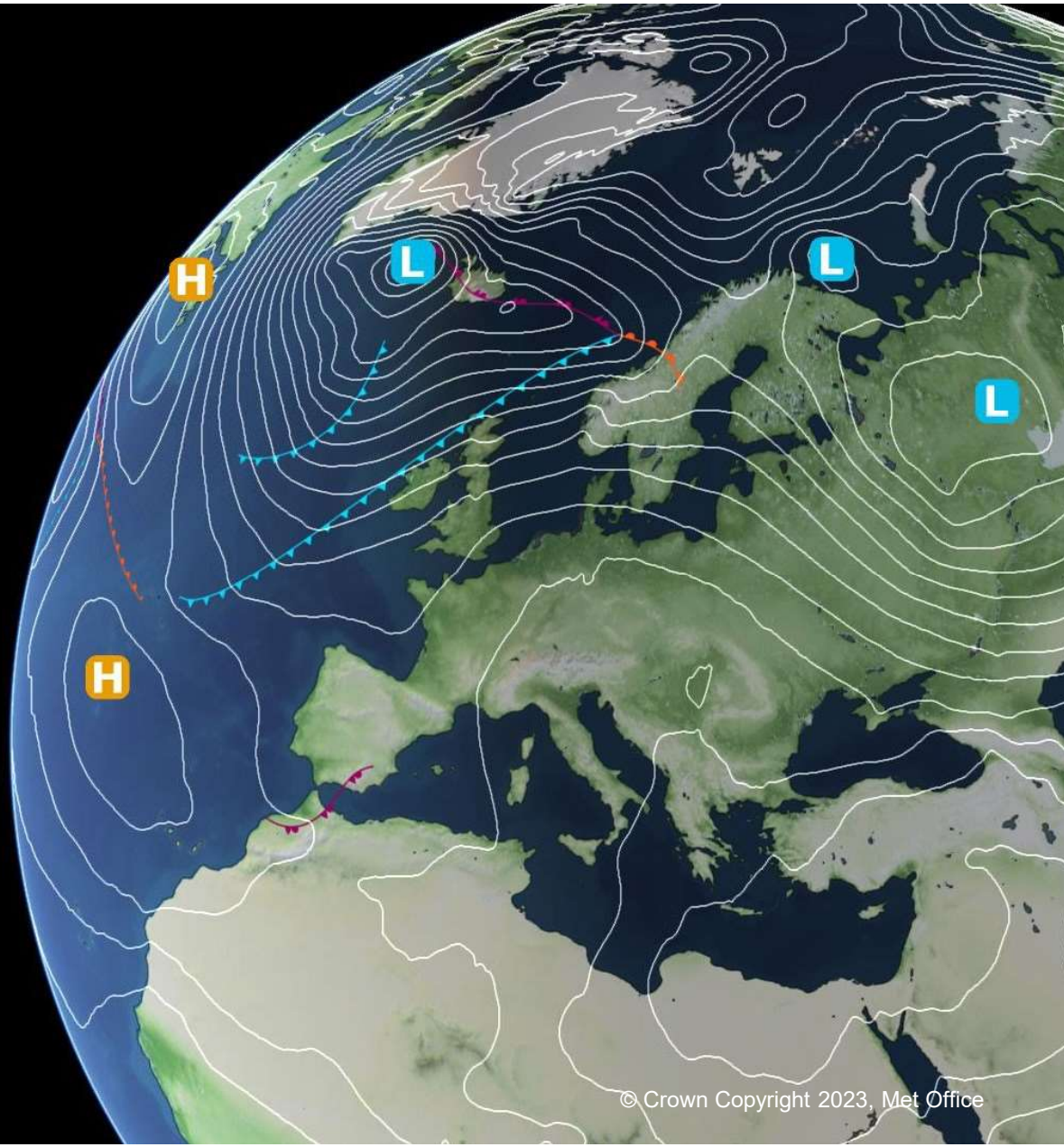

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RAL - the “Regional Atmosphere and Land” configuration

- RAL provides a single configuration for use in NWP operations, climate applications and research projects and ensures a coherent programme of model development
- RAL2 used operationally since December 2019
- RAL3 operational implementation planned for summer 2024
    - Bi-modal cloud scheme
    - CASIM double moment microphysics
    - Changes to land surface configuration
    - Unification of mid-latitude and tropical RAL configurations

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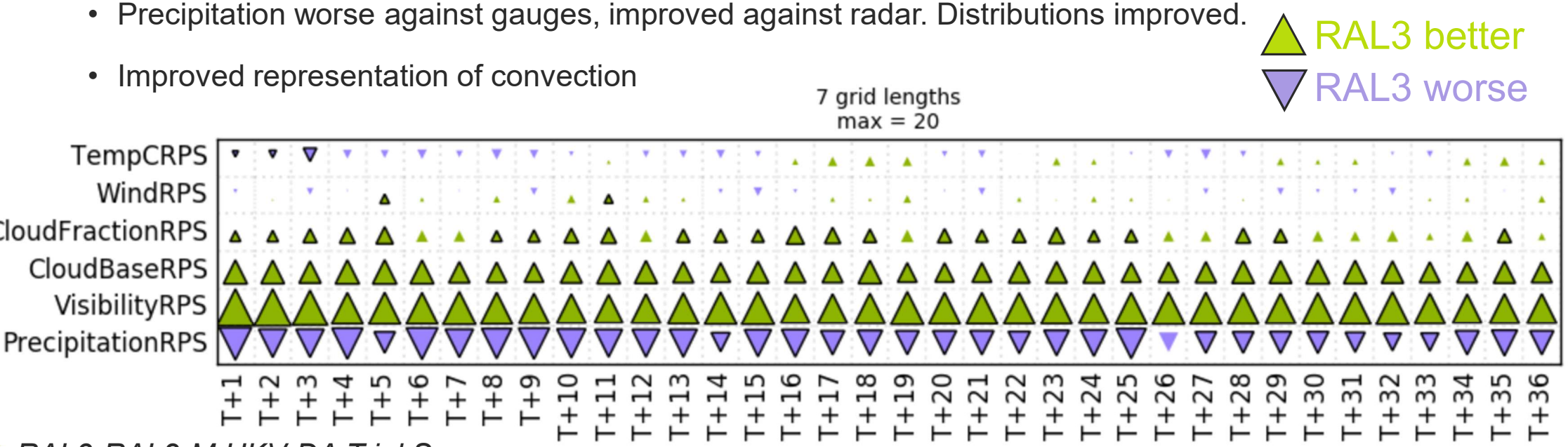
RAL3 was released in August 2022 showing overall improvements over RAL2

- Exacerbation of existing cold temperature bias
- Improved representation of clouds
- Improved visibility
- Precipitation worse against gauges, improved against radar. Distributions improved.
- Improved representation of convection



RAL3-RAL2-M UKV DA Trial Summer

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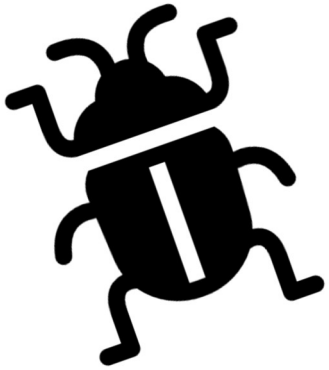
~~THE END~~

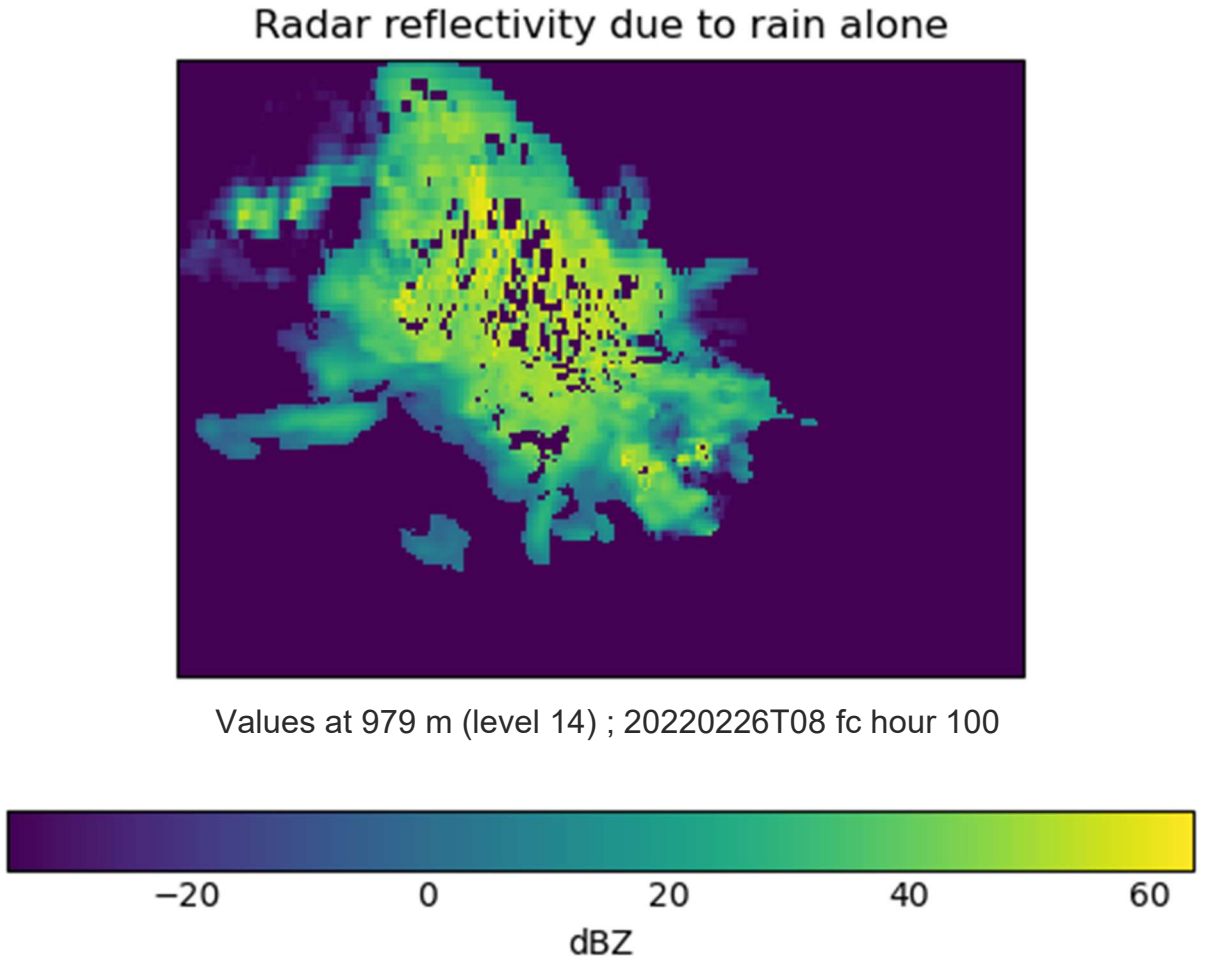
- Radar Holes → RAL3.1
- Hot Spots → RAL3.2



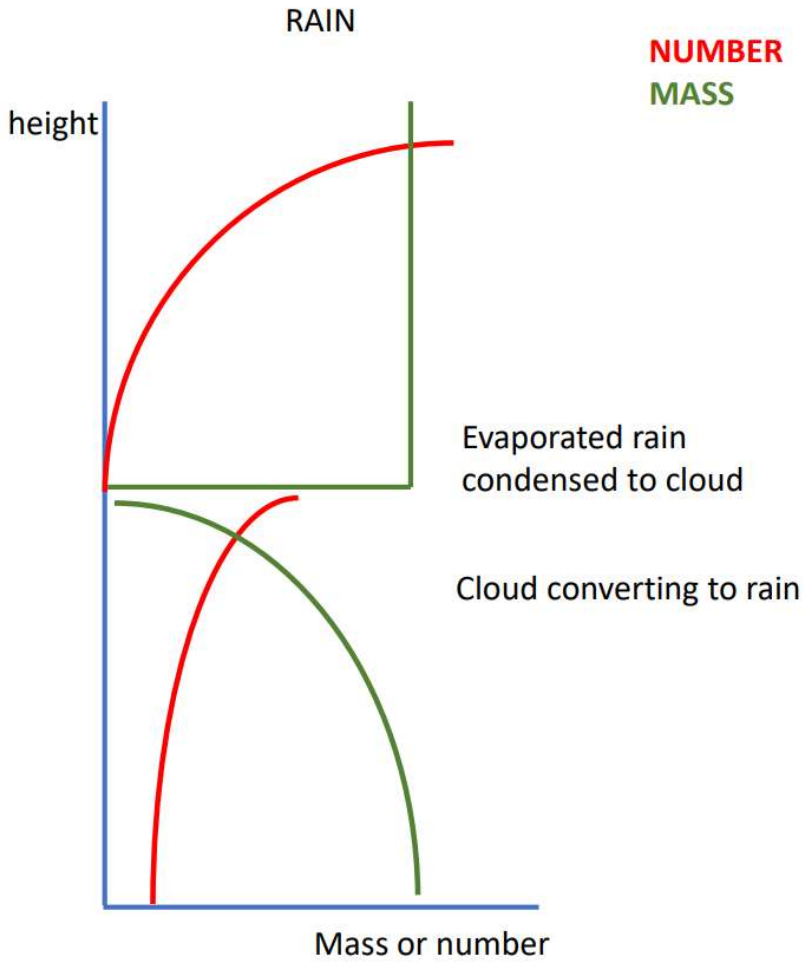
Radar Holes

Example of problem highlighted by colleagues at the Australian Bureau of Meteorology (BoM)

Reflectivity holes appearing in extreme conditions where highest reflectivities and rain rates are expected



- Rain collecting rain → change of number concentration per timestep too large in extreme conditions
- Microphysics detect significant mass but no number and evaporate the rain
- Later in the same timestep the vapour is condensed to cloud
- Cloud is converted back to rain in following timesteps
- Abrupt change from rain to cloud causes radar holes
- CFL limit added: Removal of number concentration capped at rate of 0.5



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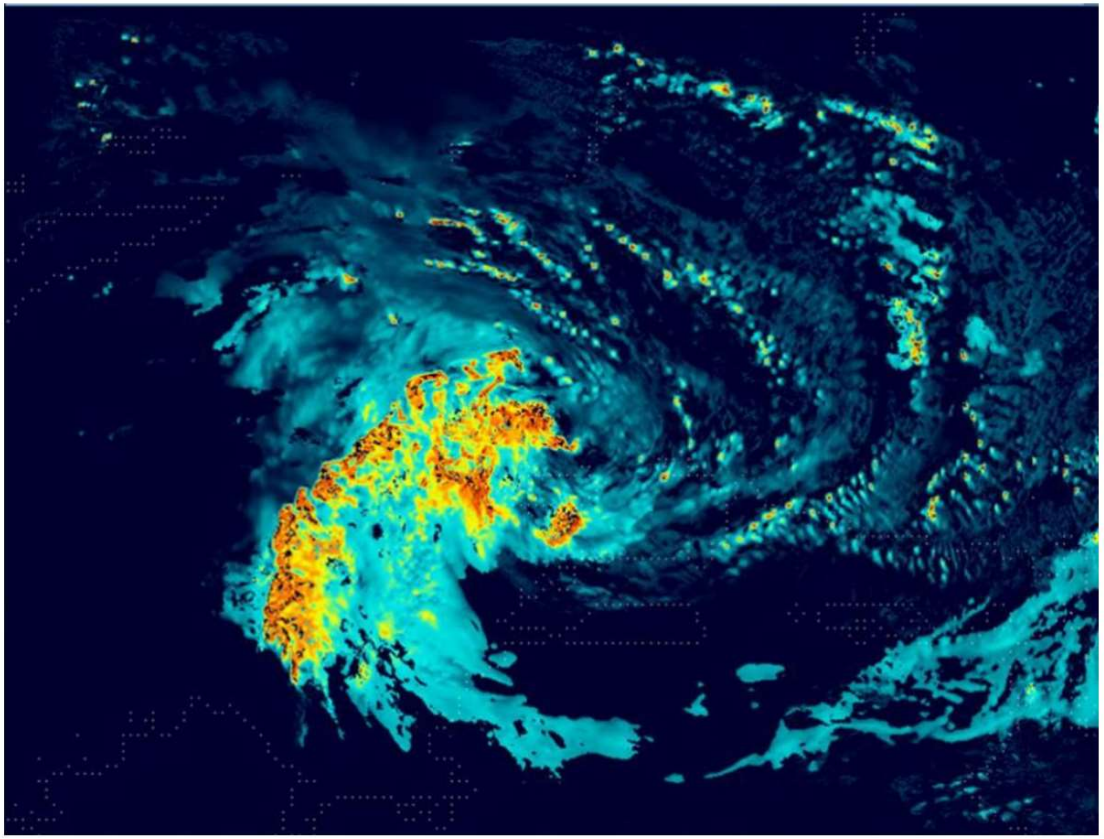
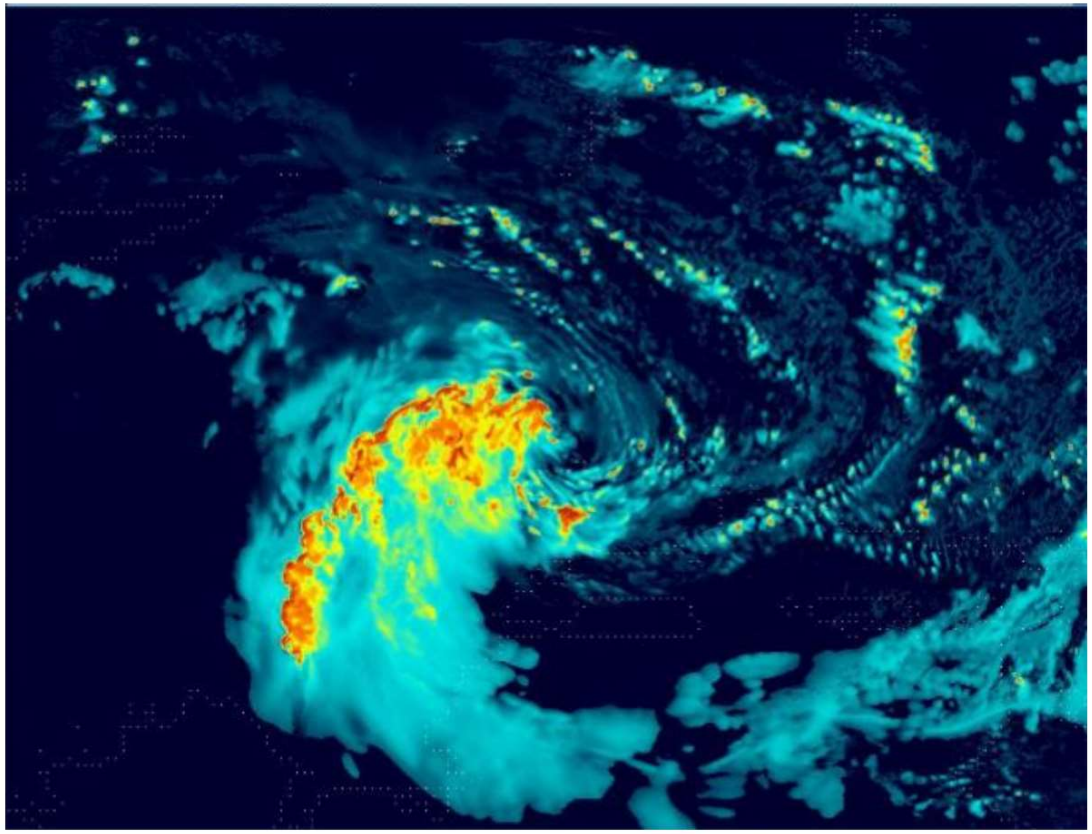
RAL3



RAL3.1



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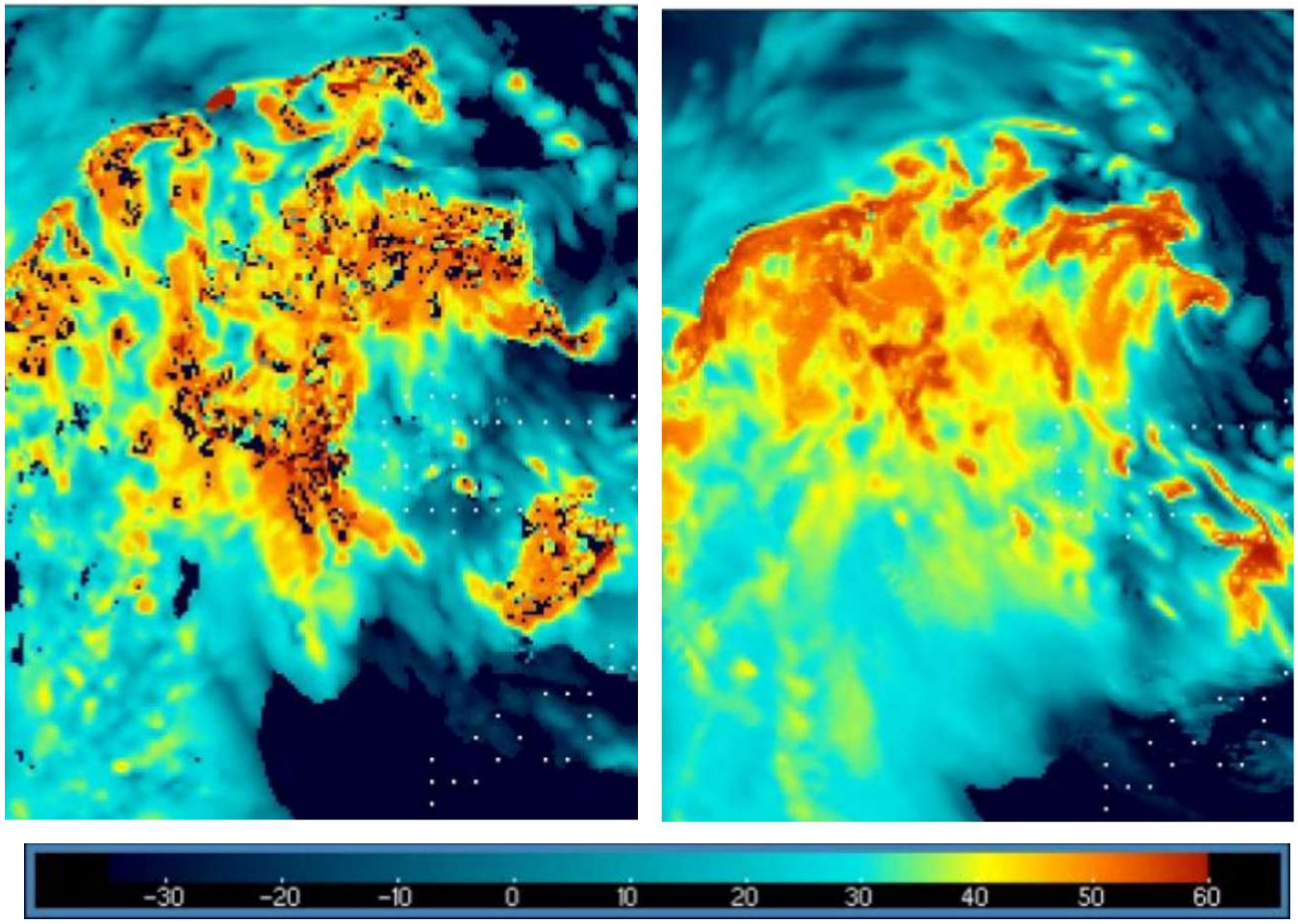
Limiting rate of number concentration decrease per timestep removes holes in radar reflectivity fields.

RAL3

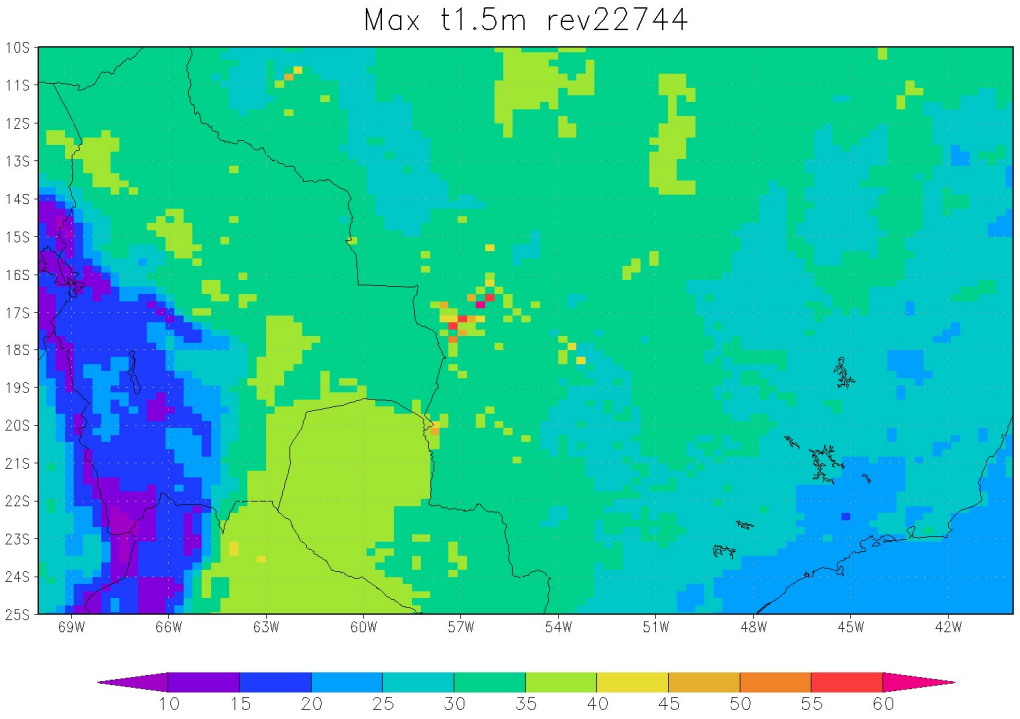
Darwin 04/03/2017 12Z (T+6)
Reflectivity at 1km (dbz)

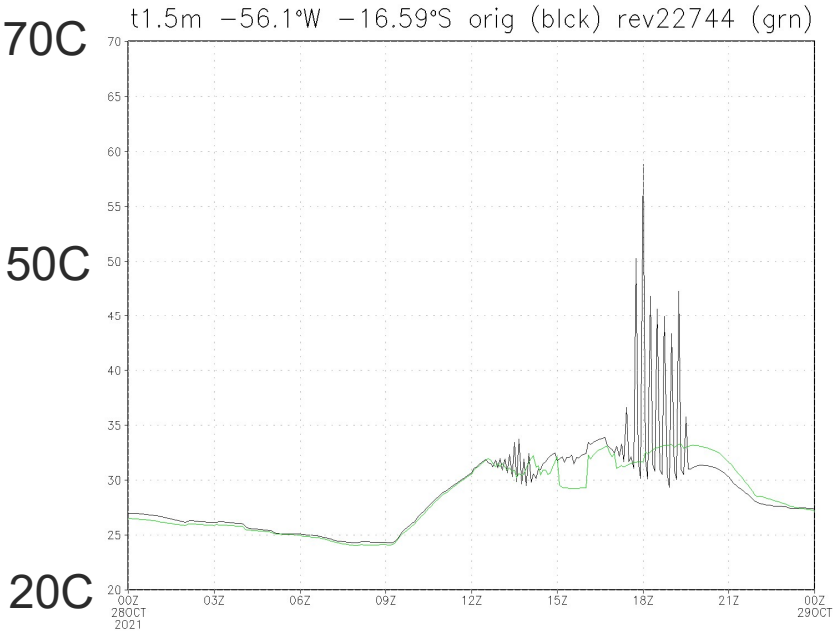
RAL3.1



Hot spots

Example over South America: $T_{1.5m}$ can be 30C warmer at isolated points





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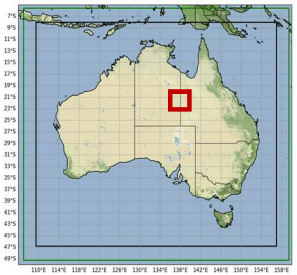
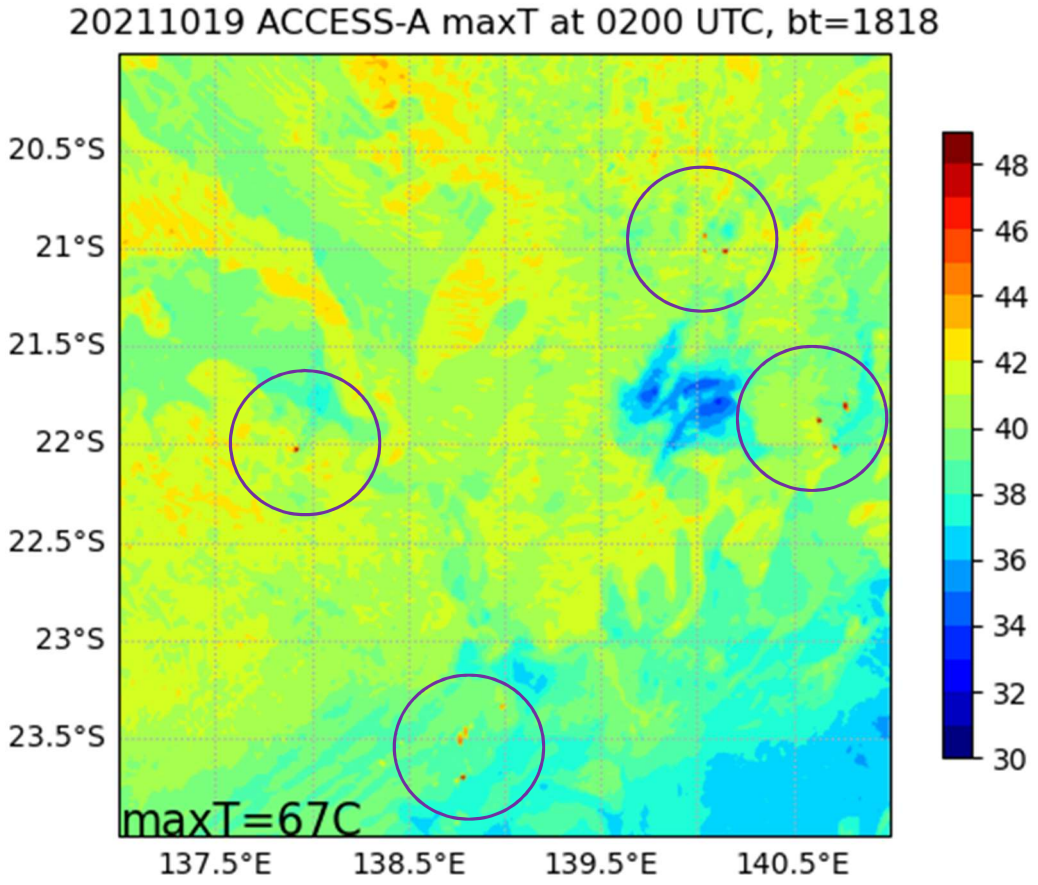
- Only last for one timestep, recovering to normal values on subsequent timesteps
- Very small impact on time-mean surface or atmospheric temperatures
- Sufficiently rare to be unlucky to see in e.g. hourly instantaneous output
- More prominent in maximum (timestep sampled) temperatures

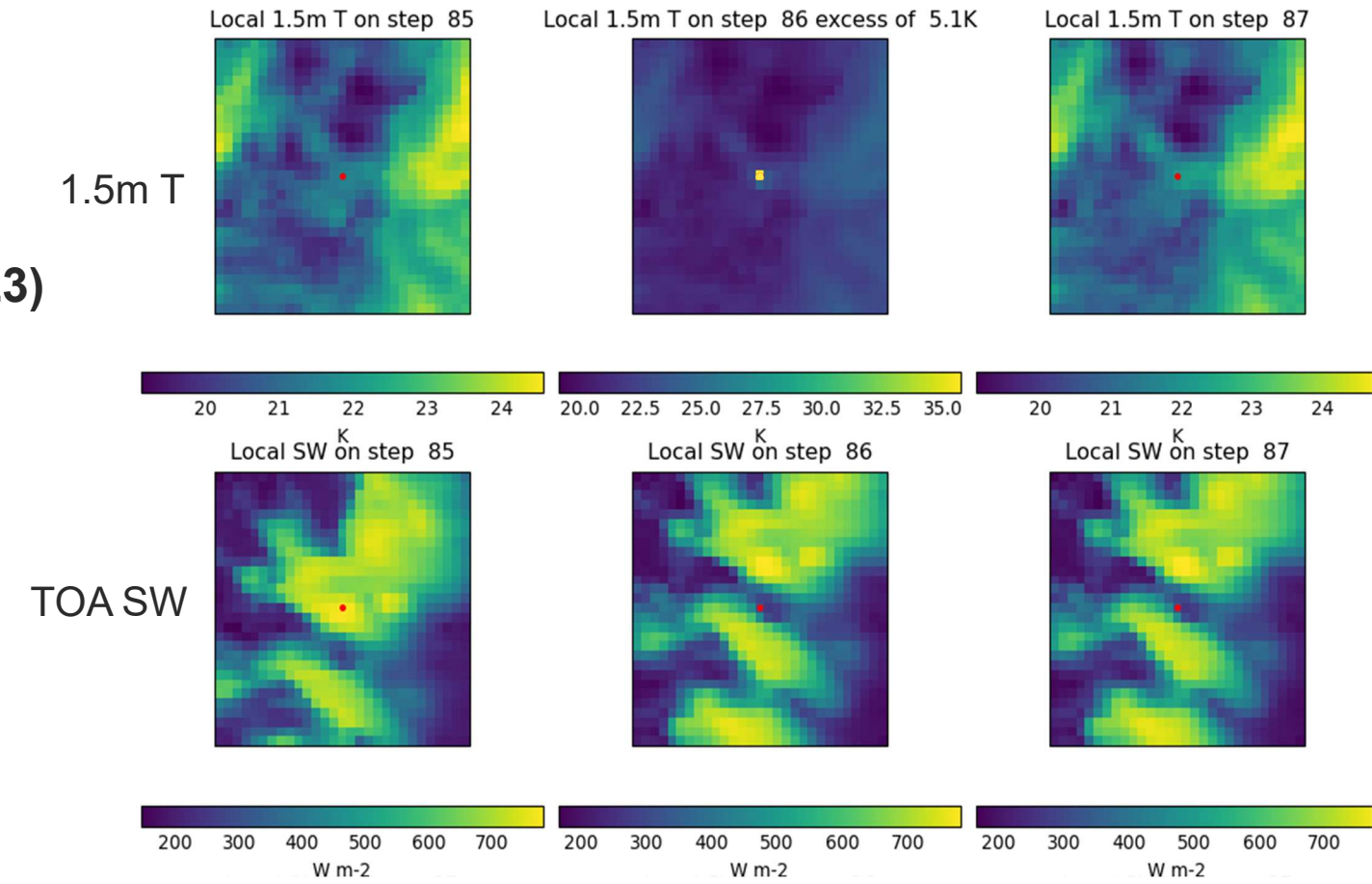
Example from BoM





UKV case study example (RAL3)

- Rapid and significant variations in amount of SW radiation reaching the surface
- note the radiation-cloud timestep is 5 minutes so clouds can move significantly between calls



Successive timesteps from left to right with the hot spot occurring only for one timestep (middle column)

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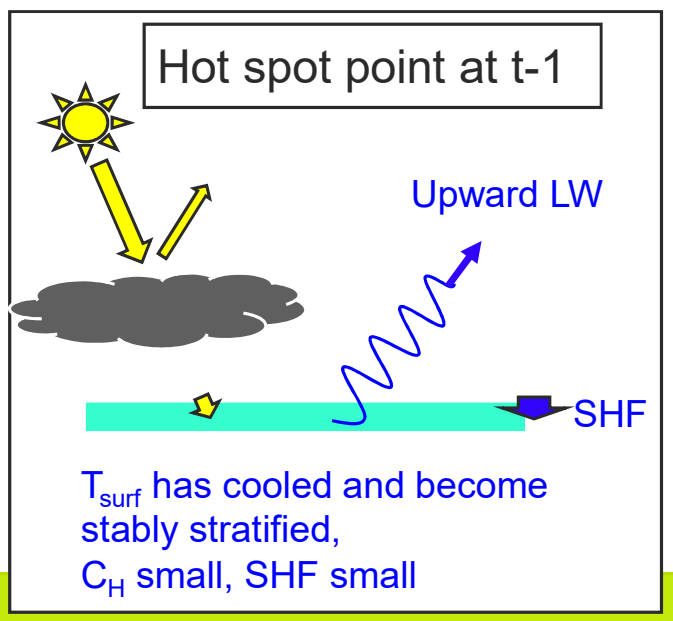
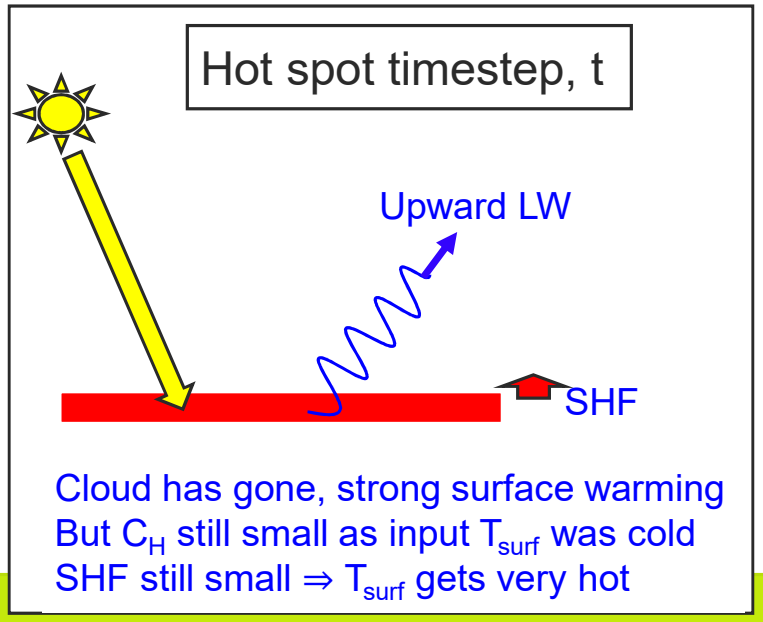
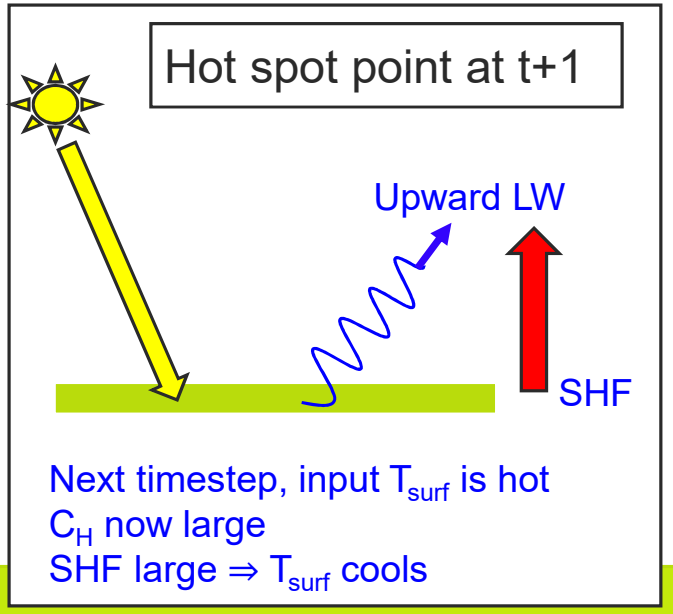
- Surface Energy Budget includes contributions from net SW + net LW + SHF + LHF
- Hot spots were associated with dramatic changes in downwelling surface SW
- Turbulent sensible heat flux dependent on exchange coefficient C_H
- C_H calculated from input fields at start of timestep, very sensitive to surface stability
  → **Solution: update T_{surf} within timestep**







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Summary

- RAL3 showed unphysical model behaviour in form of radar holes and hot spots
- Bug fixes implemented in releases of RAL3.1 and RAL3.2
- Minor impact on NWP verification statistics due to localised nature of the problems

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more on LFRic in Christine Johnson's talk
Thursday 11:00

What's next?

- Transition from UM to LFRic
- Initial focus on like-for-like replacement of RAL3.2
- RAL4 development building on RAL3-LFRic
- Operational implementation of regional LFRic models at RAL4 science (currently planned for summer 2027)