Demistify: an LES and NWP fog modelling intercomparison

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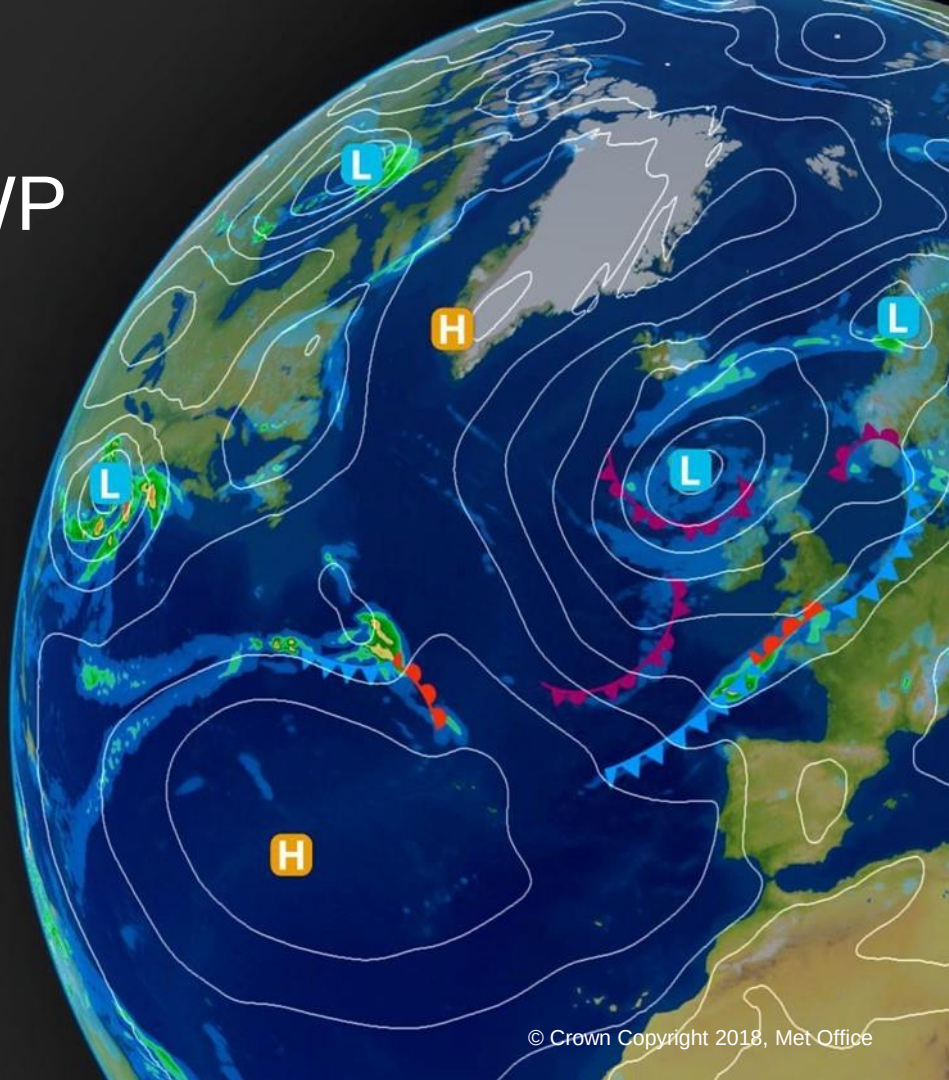

Fog NWP

- Most operational NWP centres will list errors in fog forecasting amongst their top model problems, with the requirement for improvement considered high-priority.
- Aviation is the key customer driving this
- ~40% of all delays (~50% of weather relayed delays) at busy airports due to low visibility events
- Very expensive + lots of grumpy passengers
- With accurate forecasts, can plan ahead to mitigate the effects
- How can we improve our forecast accuracy?

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Background and aims

- Long history of LES & SCM intercomparisons under GASS/GCSS/GABLS
- Time would seem appropriate to bring stable boundary layer & cloud modelling communities together for a fog case
- Key questions:
  - How well can models simulate the development of radiation fog?
  - What are the key processes governing the development of radiation fog, i.e. aerosol, cloud microphysics, radiation, turbulence, dew deposition, ...?
  - What level of complexity is required from NWP models to adequately simulate these processes?
  - What role does land-surface interaction play in the development of radiation fog?

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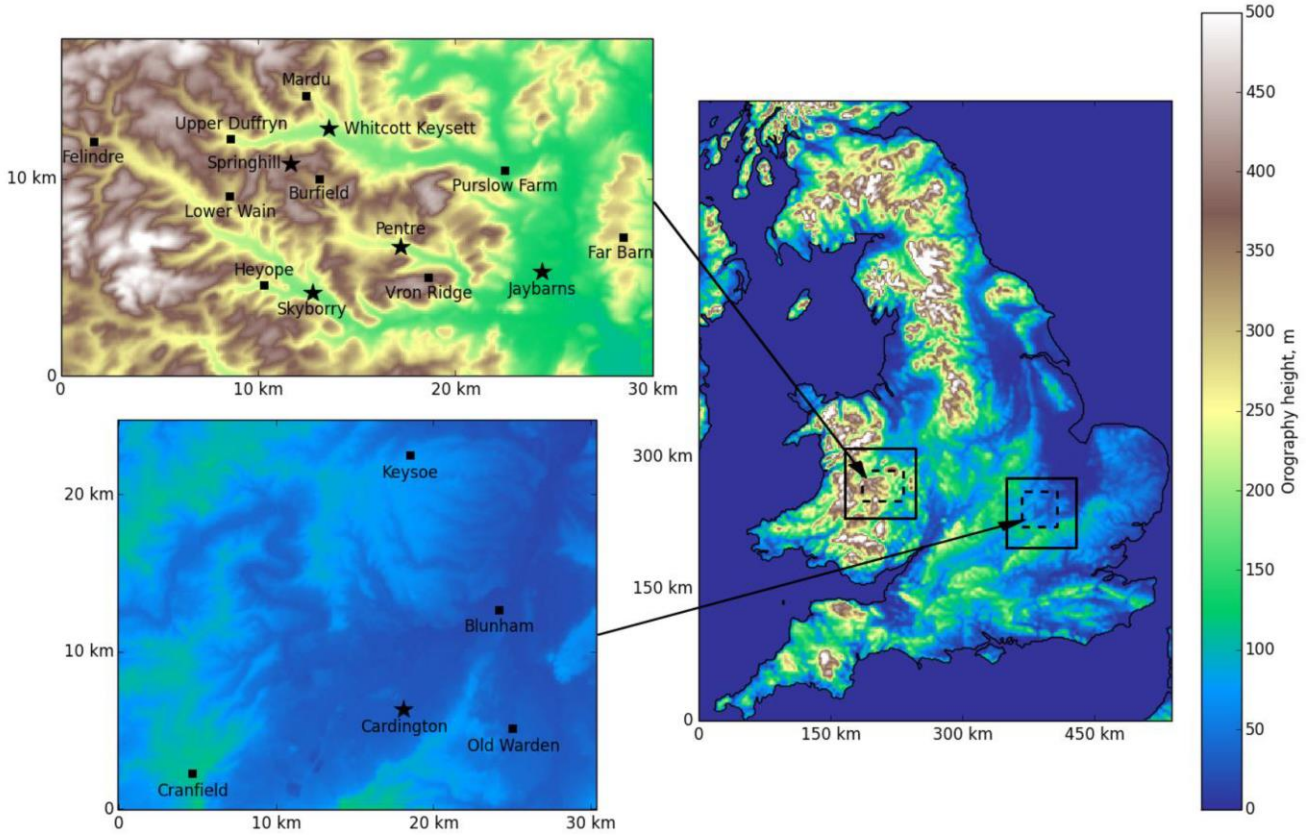
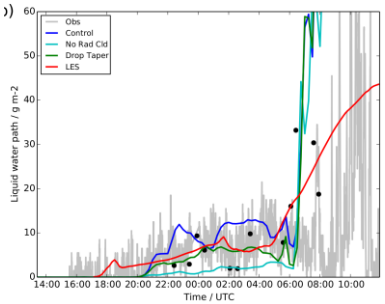
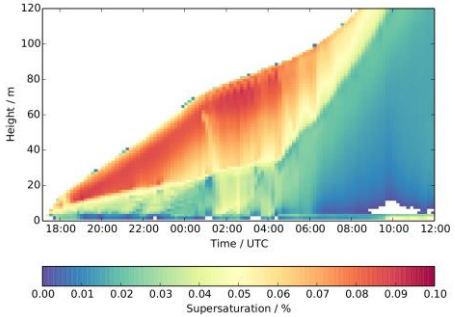
Initial case and plans

- Based on Lanfex IOP1 (Boutle et al., 2018, ACP)
- First stage ran as UCLALES-SALSA was for that paper
- Most constrained example possible – really focus on cloud, turbulence, radiation interaction
- Later stages will look at interactive land-surface and 3D NWP models
- Look for other good cases (SOFOG3D, WIFEX) & build community

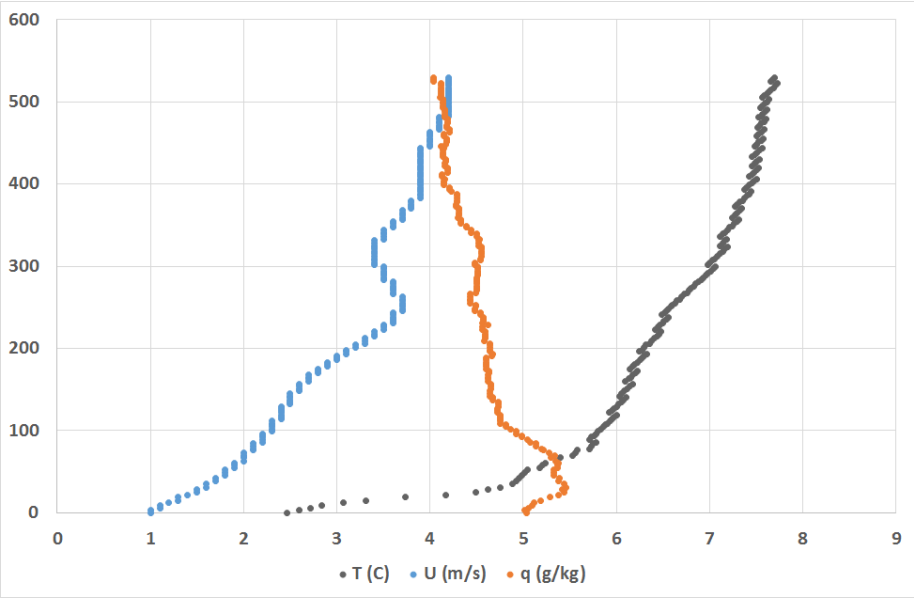

Mardu
Upper Duffryn
Whitcott Keysett
Felindre
Springhill
Burfield
Purslow Farm
Lower Wain
Pentre
Far Barn
Heyope
Vron Ridge
Jaybarns
Skyborry
10 km
0
10 km
20 km
30 km
Keysoe
20 km
Blunham
10 km
Cardington
Old Warden
Cranfield
0
10 km
20 km
30 km
300 km
150 km
0
150 km
300 km
450 km
500
450
400
350
300
250
200
150
100
50
0
Orography height, m

Plan – stage 1

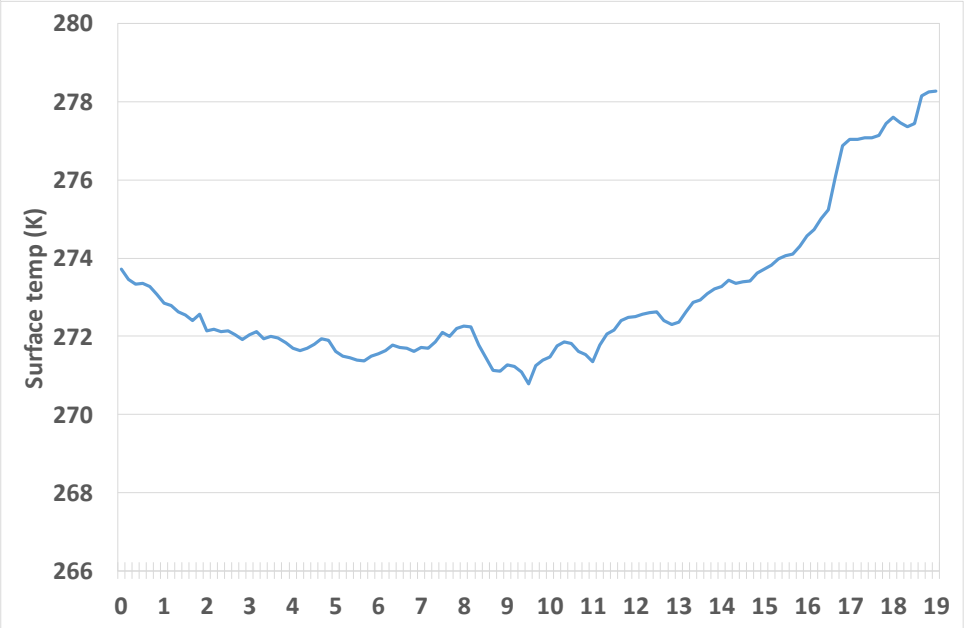




- Models initialised from a radiosonde profile and forced by surface temperature throughout. No other forcing is required. Either initial aerosol or cloud droplet number concentrations will be specified, depending on the model microphysical parametrization.
- LES models to be run at ~4m resolution (possibly higher).
- NWP models to be run in single-column (SCM) mode, with vertical resolution of the native NWP model.
- Provides a baseline on the current level of agreement between LES & SCM models – which may well be very low!
- Sensitivity tests adjusting various aspects of the model parametrizations to improve agreement with observations if initial agreement is poor.



No advection, U_geo =0.



O3 and CO2 concentrations prescribed

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Domain setup:

LES:

Domain size (km)	1-2
Max horizontal grid-length (m)	4
Max vertical grid-length below 150m (can stretch above this) (m)	1.5
Minimum domain top (m)	700

Participants are welcome to submit higher resolution runs.

SCM:

Please run at a vertical resolution and timestep typical of the native operational NWP model.

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Surface characteristics:

Flat, homogeneous grass surface. There should be no restriction on evaporation, i.e. it can act like a sea-surface.

Momentum roughness length z0m (m)	0.1
Heat roughness length z0h (m)	0.001
Leaf area index (if required)	2
Albedo (if required)	0.25
Emissivity (if required)	0.98

Sensitivity test to droplet no concentration: 10 & 50 cm^{-3}

Plan – stage 2

- Using the best setup from stage 1, replace surface temperature forcing with interactive land surface model & repeat analysis.
- Most important for the NWP models (still being run in SCM mode), but also interesting for LES models with interactive land-surface capabilities.

Plan – stage 3

- Using the best setup from stage 2, run the NWP models in 3D forecast-mode, at a range of resolutions from 1km to 100m.
- To be decided whether this will be initialised from an analysis with forced LBCs, or idealised profiles with bicyclic LBCs.
- Most important for the NWP models, but also interesting for LES models that can be run at this range of resolutions.

Institute	NWP	LES	Participants
Met Office	Met Office Unified Model (UM)	Met Office NERC Cloud Model (MONC)	Ian Boutle Adrian Hill
Meteo France	AROME/Meso-NH	Meso-NH	Christine Lac Thierry Bergot Benoit Vie Leo Duconge Yann Seity
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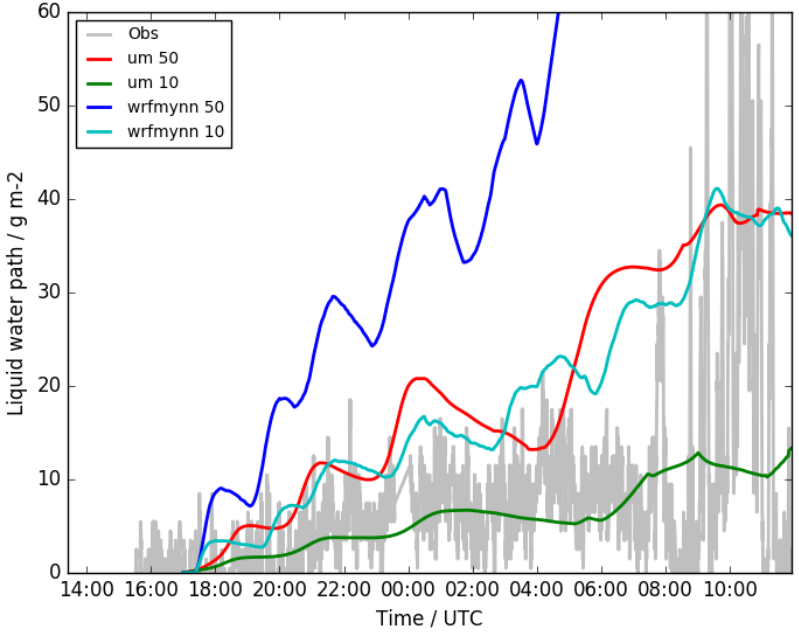
Wageningen University	WRF		Gert-Jan Steeneveld
Hannover University		PALM	Bjorn Maronga Johannes Schwenkel
DWD	ICON	ICON-LES	Tobias Goecke
Frankfurt University	COSMO	COSMO-LES	Juerg Schmidli
NOAA	WRF		Wayne Angevine
NOAA	FV3		Jian-Wen Bao Evelyn Grell
ECMWF	IFS		Richard Forbes
UC Davis		RAMS	Adele Igel
IITM	WRF		Sachin Ghude

Some very preliminary results

- Thanks to Wayne Angevine for the WRF results!
- Already showing an interesting difference in fog development between UM and WRF – WRF much deeper & optically thicker than UM, to point where low CDNC WRF run looks similar to high CDNC UM run



Conclusion & plans

- Already seems like plenty to investigate & understand for this case
  - Stable BL turbulence and interaction with fog
  - Aerosol-fog-radiation interaction
- Keen for feedback and input – let us know if you'd like to get involved
  - Ian can send full case details & setup
  - Would like stage 1 results asap, but quite relaxed on timeline
- Any other questions or comments/suggestions?