Forecasting fog with a very high resolution model

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Contents

- Why do we care about fog?

- A very high resolution model

- Overview of foggy cases

- Some specific examples

- Conclusions

Low visibility and fog forecasting

- Significant high impact weather, particularly for aviation
- Fog at airports reduces take off/landing rates
- At Heathrow, this means cancellations or diversions
  - 3rd busiest airport in the world, running at 95-99% capacity
  - Costs airlines and CAA millions of £/$/€
  - Annoys passengers!!
- Fog is complicated…
  - Interaction of dynamics, radiation, microphysics, turbulence and land surface
- It's also quite rare…
  - If it were more common, we'd probably be better at it!
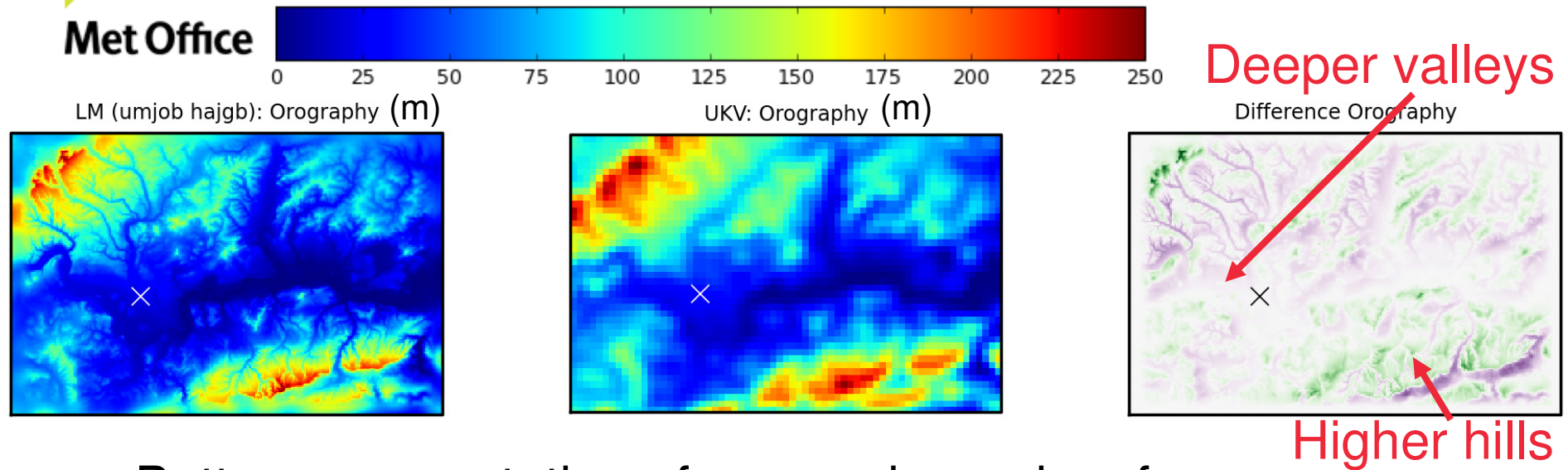 - Means significant chance of a forecast bust when it does happen

The London Model (LM)

- Currently, the 1.5km UKV model is used for short-range forecasts over the UK
- Nest a 333m grid-length model inside this
- 300x200 grid-points (100x66km domain)
- Would this be useful?

Heathrow

LM – UKV comparison

LM (umjob hajgb): Orography (m) UKV: Orography (m) Difference Orography

Deeper valleys

Higher hills

- Better representation of orography and surface characteristics in LM

- Use 3D Smagorinsky turbulence scheme in LM rather than 1D BL parametrization

- Use higher critical relative humidity value for cloud parametrization

- All assuming more detail is resolved & less parametrized

Summary of cases

- 13 cases in past year with fog near Heathrow (observed or forecast, not necessarily both)

- Group cases according to type/extent of fog:
  - 2 cases of large-scale (radiation) fog covering the entire region
  - 4 cases of hill fog to the north and south of the airport – low cloud base in the valleys, but good visibility beneath the cloud
  - 7 cases of patchy (advection) fog moving across the region – good visibility (possibly clear skies) outside the fog

- 2 "busts" – 1 false alarm and 1 miss

Visibility: 6Z & 7Z

Visibility at 1.5m inc ppn: 2013/12/10 06:00Z

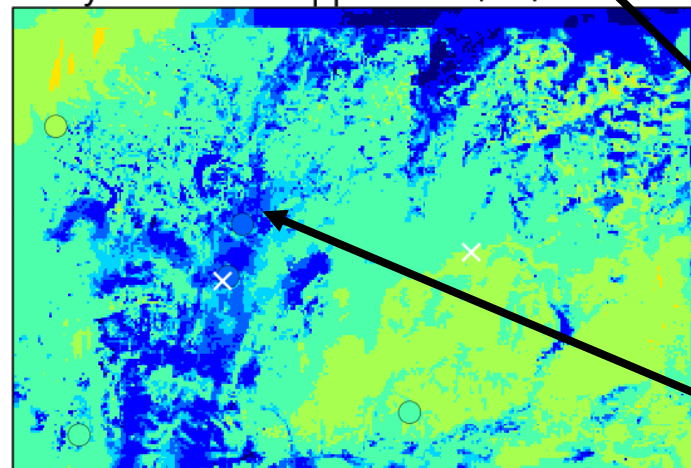UKV Visibility at 1.5m inc ppn: 2013/12/10 07:00Z (T+4)
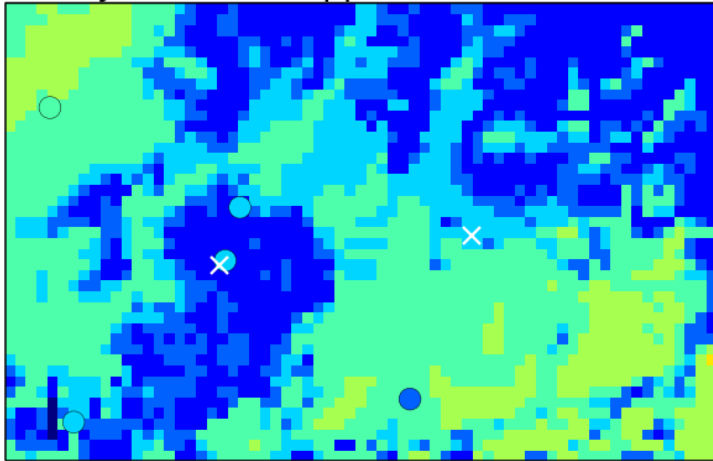
UKV
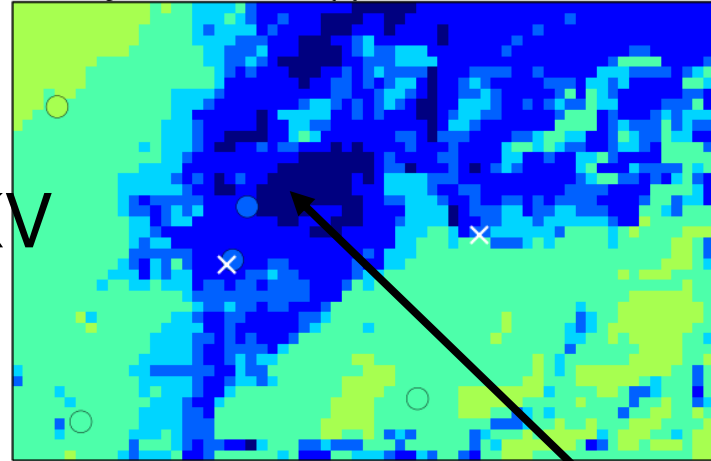
Fog moving from SW

Visibility at 1.5m inc ppn: 2013/12/10 06:00Z

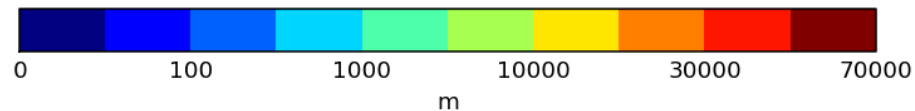LM Visibility at 1.5m inc ppn: 2013/12/10 07:00Z (T+4)
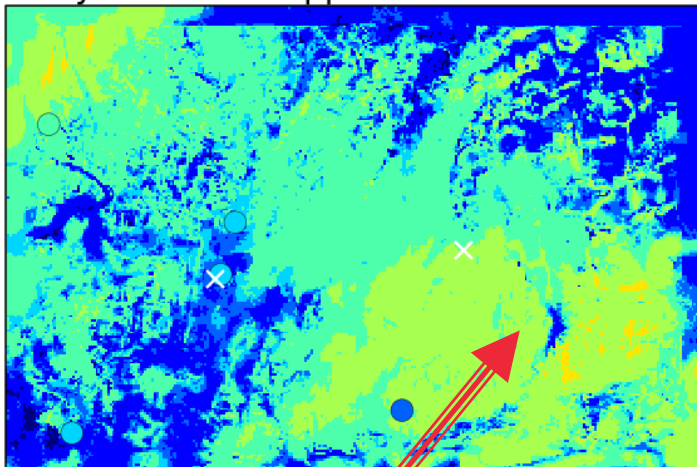
LM

Too thick in UKV
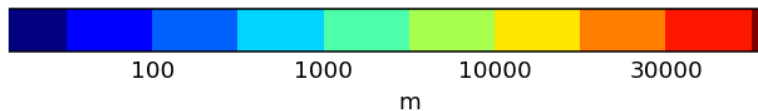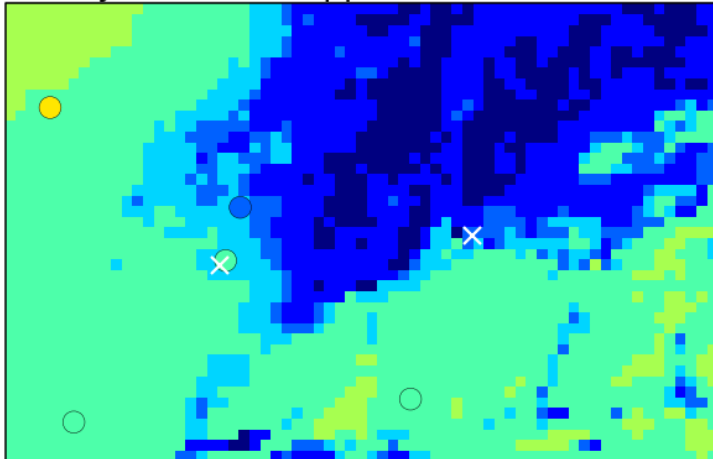
Better in LM

Wind direction

100   1000   10000   30000
m

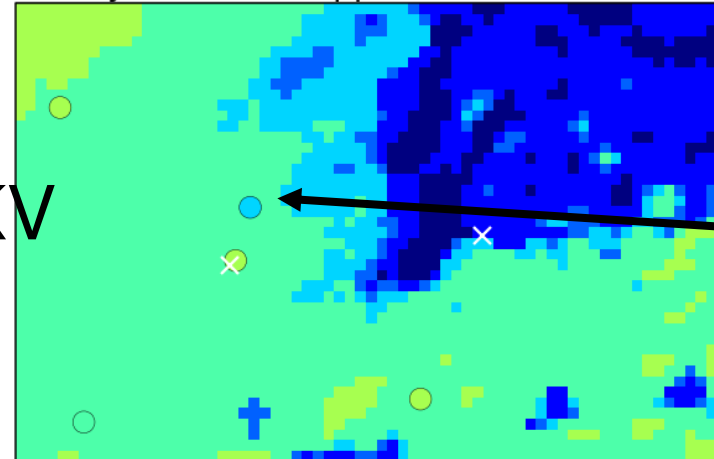0   100   1000   10000   30000   70000
m

Visibility: 8Z & 9Z

/ Visibility at 1.5m inc ppn: 2013/12/10 08:00Z (T+5)   isibility at 1.5m inc ppn: 2013/12/10 09:00Z (T+6)
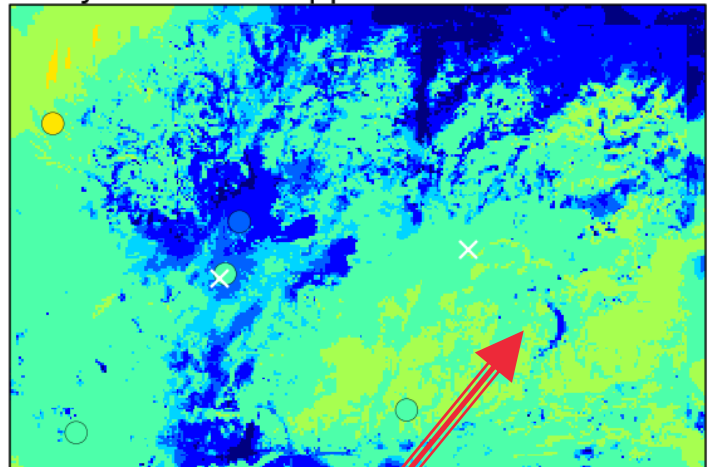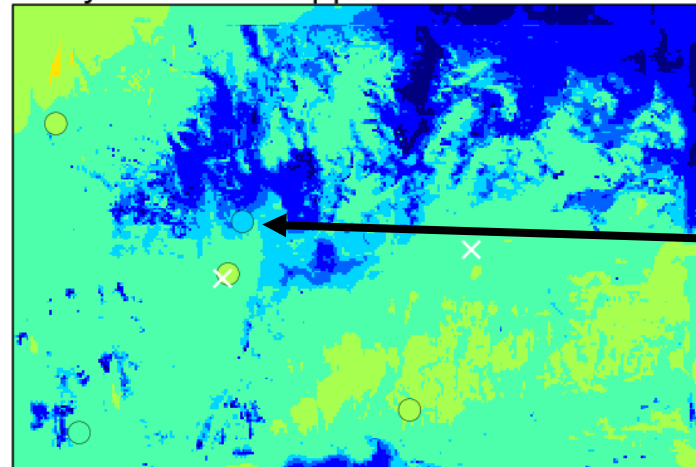
UKV

Clears
too
quickly
in UKV

Visibility at 1.5m inc ppn: 2013/12/10 08:00Z   LM Visibility at 1.5m inc ppn: 2013/12/10 09:00Z (T+6)
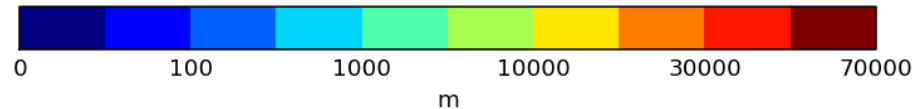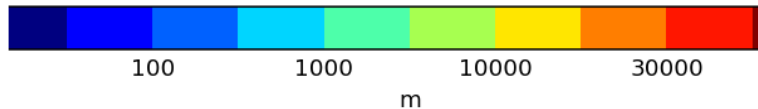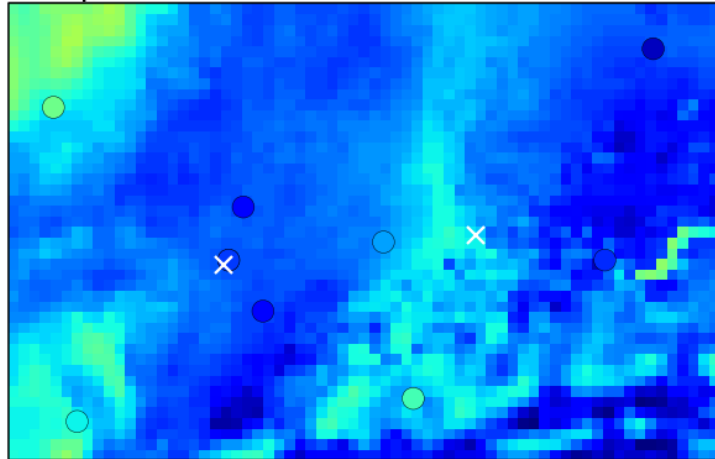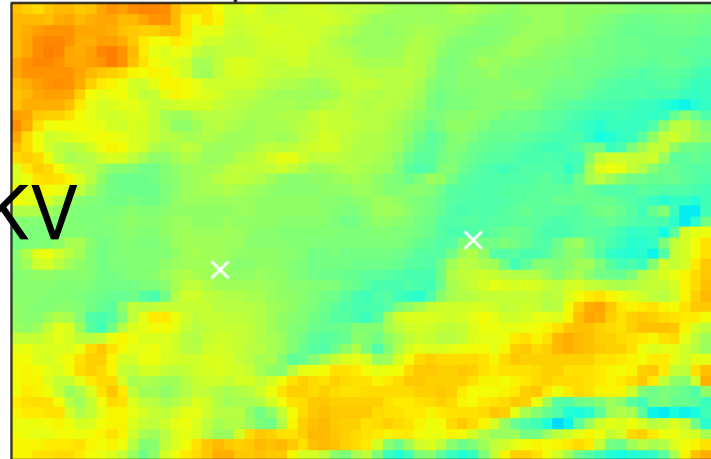
LM

Better in
LM

Wind direction

100   1000   10000   30000
m

0   100   1000   10000   30000   70000
m

Temperature and v-wind: 8Z

Temperature at 1.5m: 2013/12/10 08:00Z (T+5)
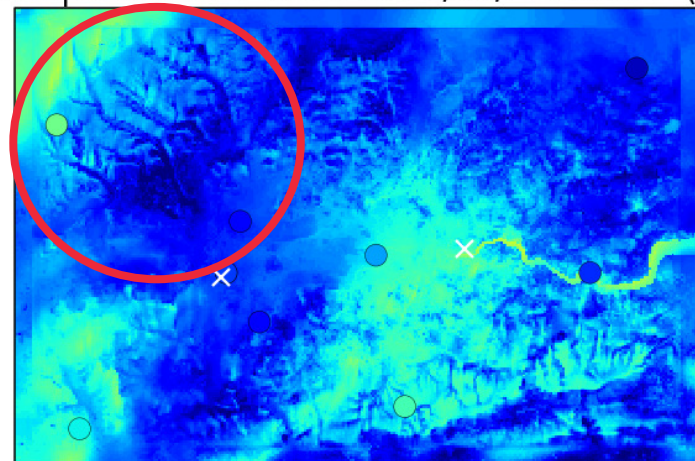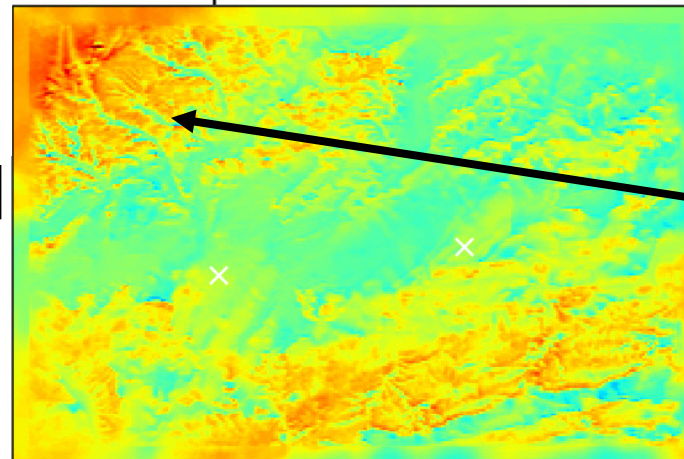
onal Wind Speed at 10m: 2013/12/10 08:00Z (T+5)
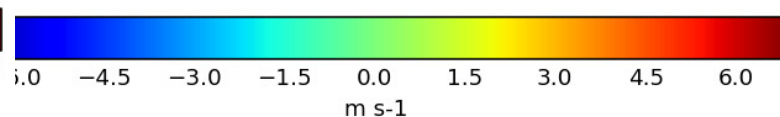
UKV

Cold air pools in LM valleys, not in UKV

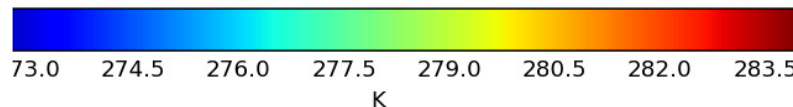Temperature at 1.5m: 2013/12/10 08:00Z (T+5)

onal Wind Speed at 10m: 2013/12/10 08:00Z (T+5)

LM

Down-slope flow opposite to wind direction

73.0   274.5   276.0   277.5   279.0   280.5   282.0   283.5
K

−4.5   −3.0   −1.5   0.0   1.5   3.0   4.5   6.0
m s-1

Summary so far

- Broken appearance of patchy fog in LM much closer to reality
  - Resolved surface heterogeneity leads to inhomogeneous surface fluxes, helps to break up fog – patches of warmer air break the fog, mixing of clear and cloudy air keeps it thin
  - Uniform fog in UKV thickens too much – radiative cooling from the fog top acts as positive feedback, nothing can break the fog until daytime SW heating is significant

- Slower advection of fog in LM also an improvement
  - Cold air pooling in resolved valleys keeps the surface cool at the back edge of fog patch, keeping the fog in the vicinity of the airport for longer
  - No representation of this in UKV means fog simply advects away with the wind
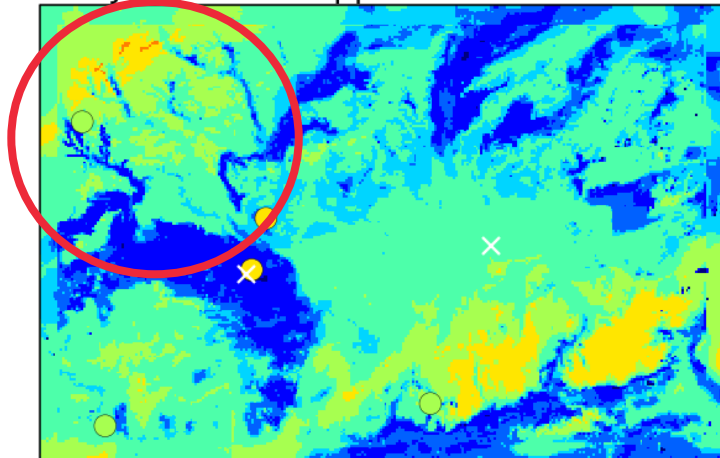
Not always a good thing...

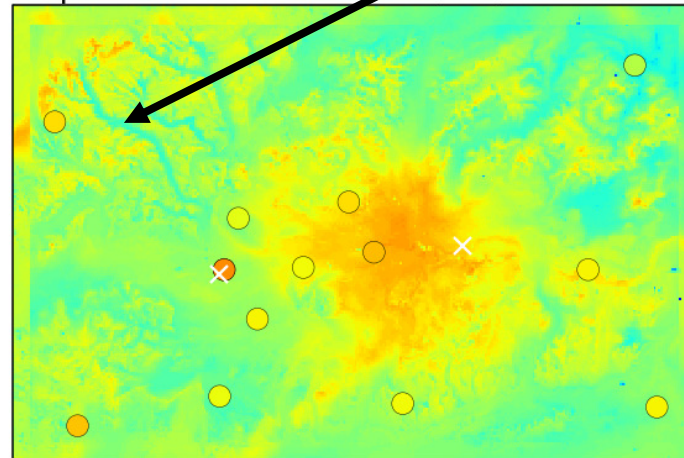/ Visibility at 1.5m inc ppn: 2013/09/23 07:00Z   UKV Temperature at 1.5m: 2013/09/23 07:00Z (T+4)

UKV

Visibility at 1.5m inc ppn: 2013/09/23 07:00Z (T   LM Temperature at 1.5m: 2013/09/23 07:00Z (T

LM
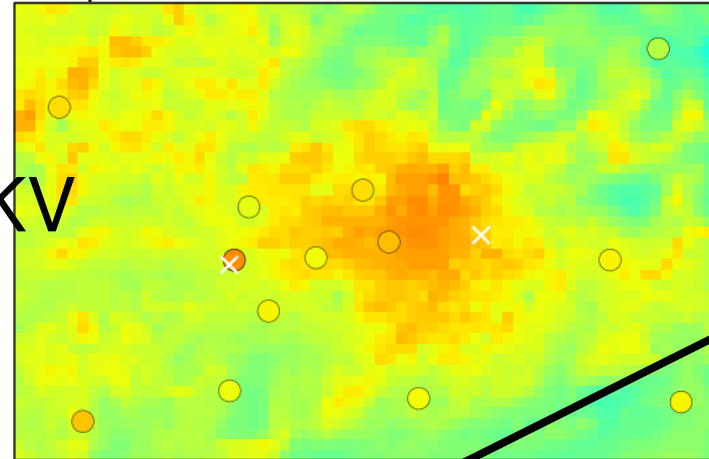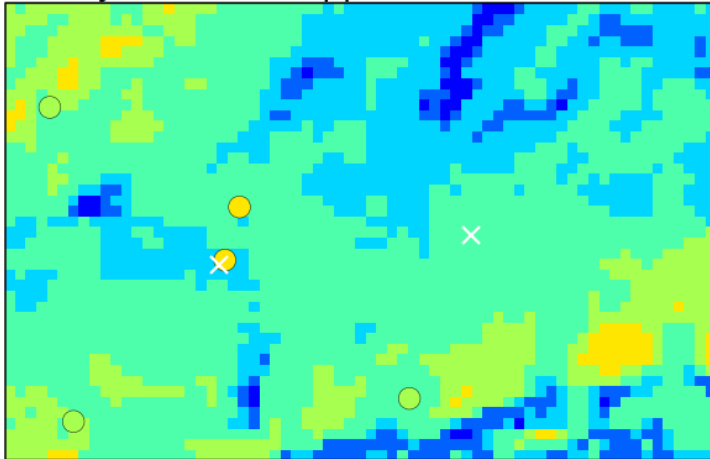
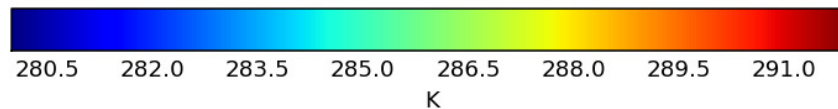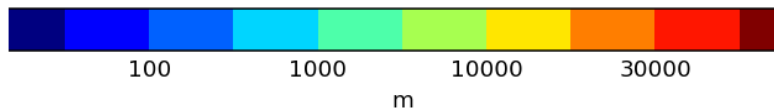Similar cold air pooling in valleys makes valley far too cold

Incorrect formation of thick fog in valley

Conclusions

- LM can produce a forecast which differs from the UKV

- This comes mainly from better representation of surface characteristics (surface heterogeneity, resolved valleys)

  - No evidence (yet) that the higher resolution dynamics is actually improving the stable BL representation
  - This is likely to require much higher resolution (100m or less)

- Bulk temperature and humidity errors are just inherited from driving model, and can be exacerbated in some situations

- Worth trying to develop & tune physics of this model

Questions and answers