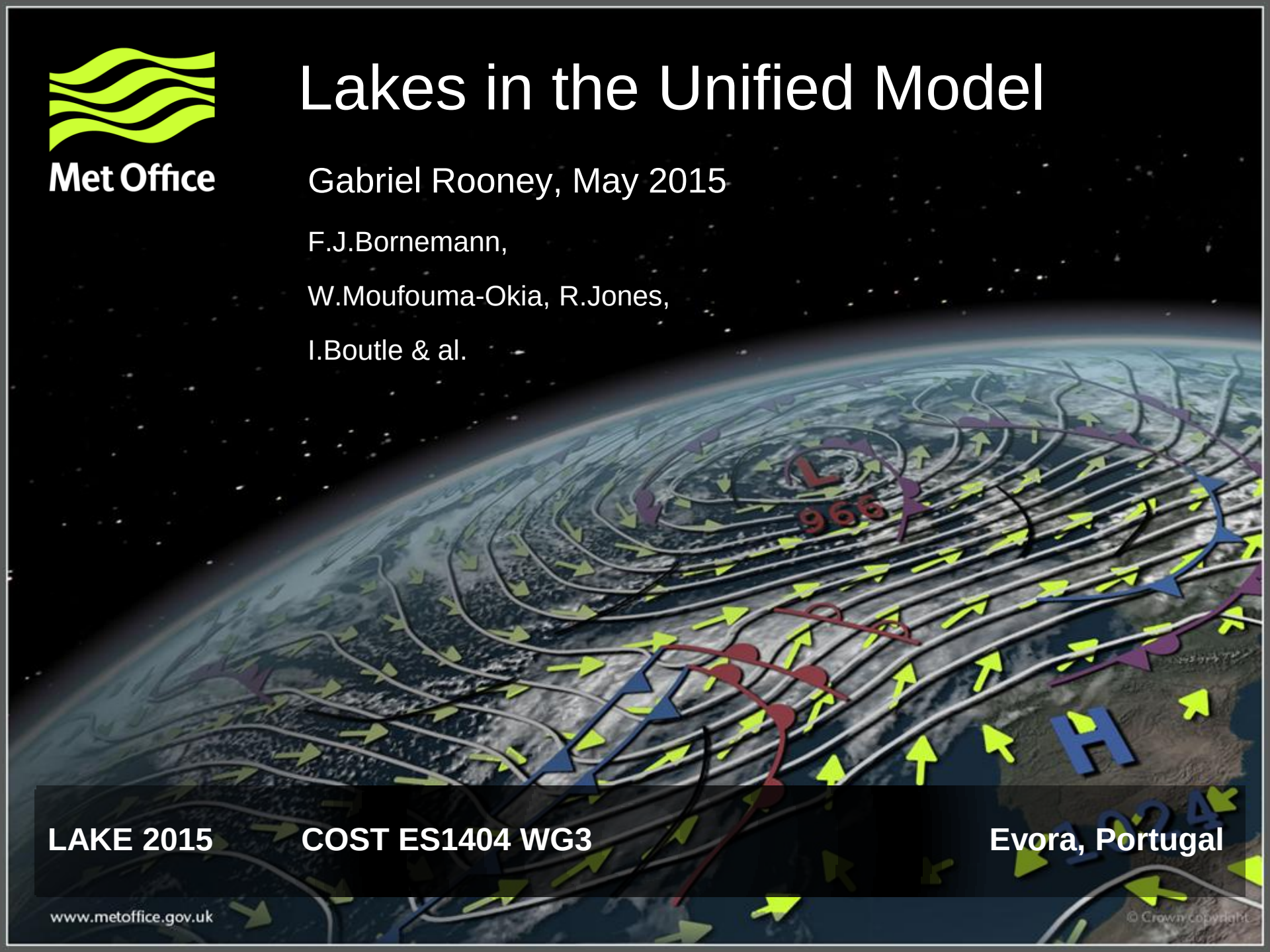
Lakes in the Unified Model

Gabriel Rooney, May 2015

F.J.Bornemann,

W.Moufouma-Okia, R.Jones,

I.Boutle & al.



LAKE 2015 **COST ES1404 WG3** **Evora, Portugal**

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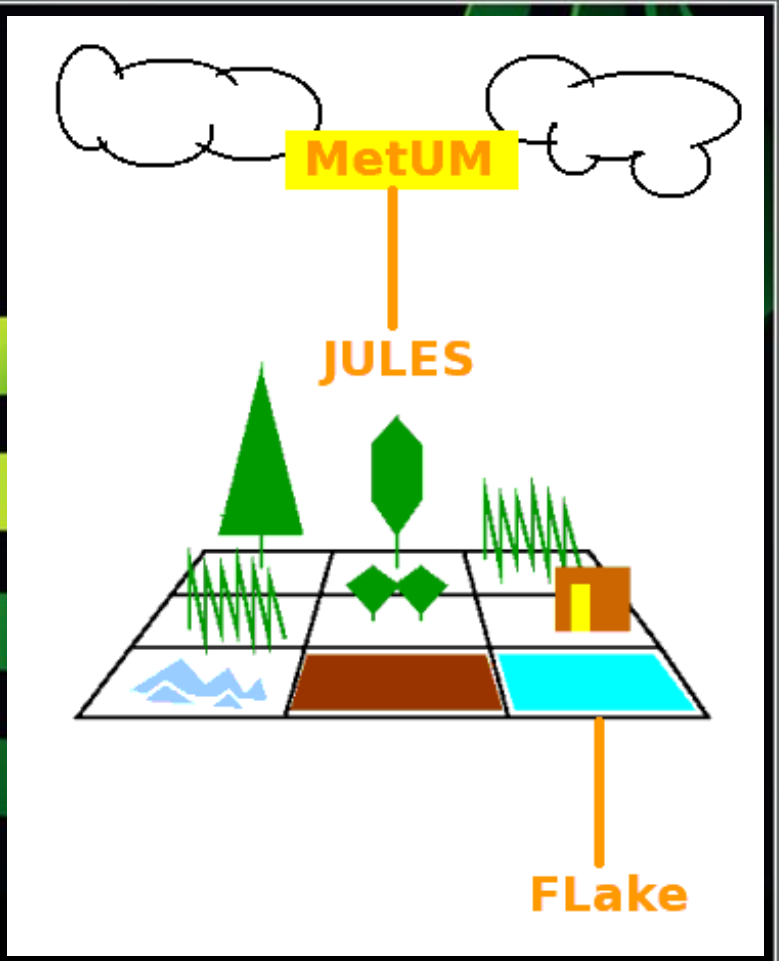
Outline

- FLake/MetUM
  - coupling, tests and modifications
- NWP and climate tests
  - screen temperature
- licensing and Intellectual Property
- other lake activity



FLake-MetUM coupling tests

Lake ice as a (negative) indicator of coupling strength

Rooney & Bornemann (2013)

FLake – MetUM coupling

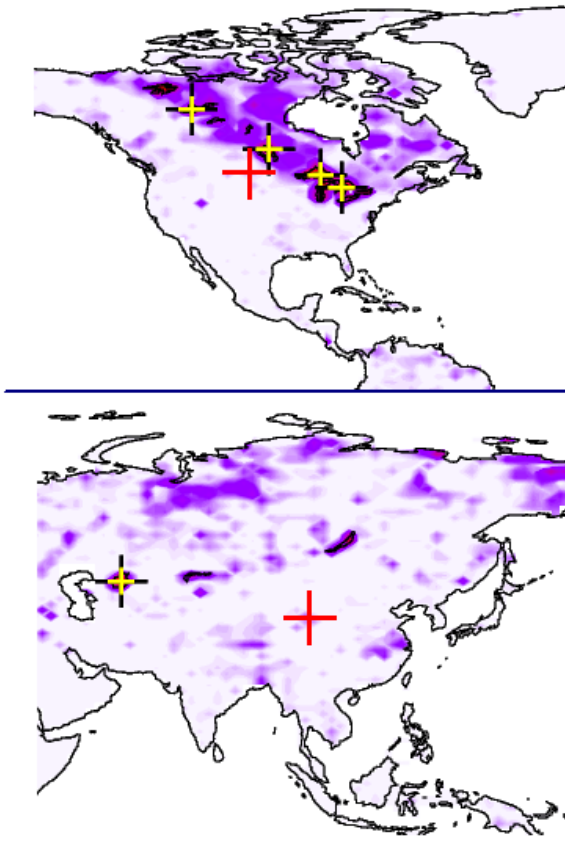
- MetUM : the **Met Office Unified Model** for weather and climate prediction
- Separate code repositories are combined into a single executable.
- Coupling through the MetUM / **JULES** land-surface tile scheme.
  - JULES : Best et al. *and* Clark et al. (GMD, 2011)
- **FLake** provides the subsurface temperature and conductivity for the lake tile.
  - Rooney & Jones (BER, 2010)
- *Lake depths* come from the dataset accompanying FLake.
  - Kourzeneva et al. (Tellus, 2012)
- *Initialisation* is based on the MetUM surface and soil temperatures.

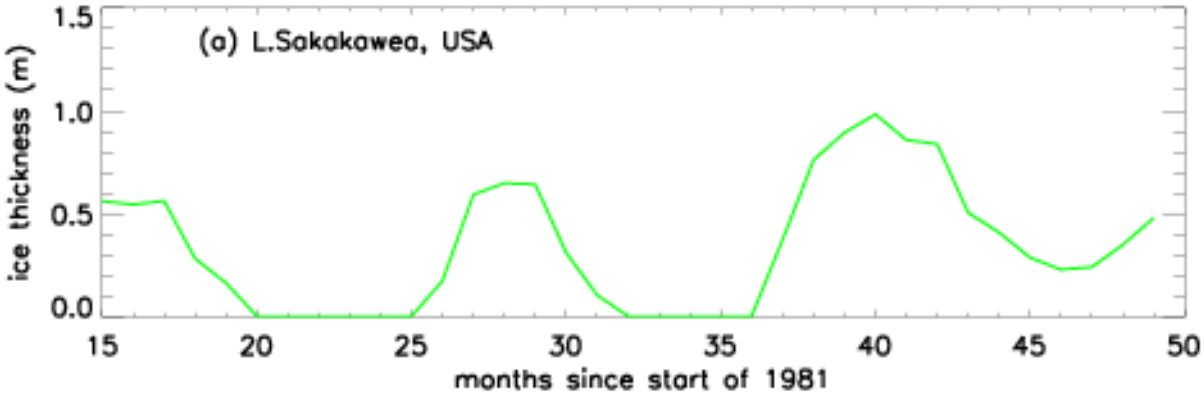
Assessment of the coupled model

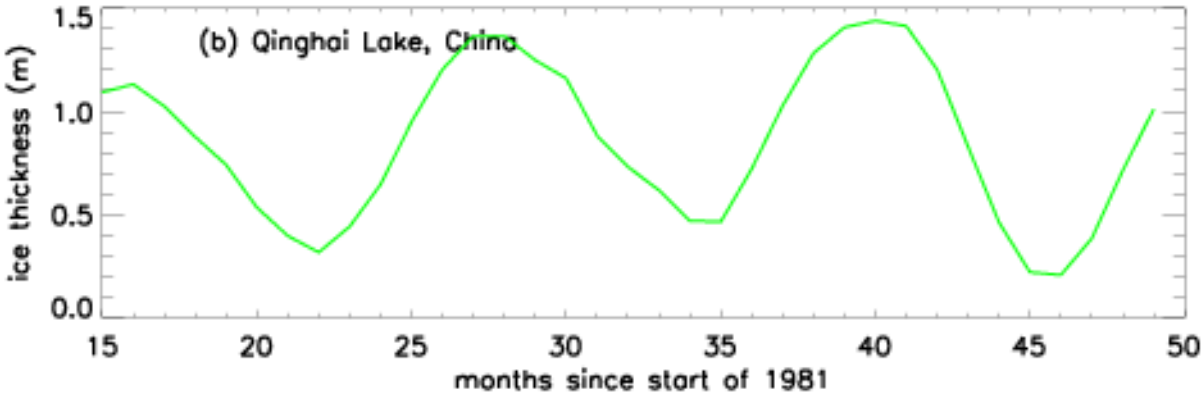
- Differences over regions with high lake fraction, as expected.
  - Mainly North America.
- Summer cooling in the Canadian Shield.
- An accompanying reduction in latent heat flux around the Great Lakes.
  - Change in the energy balance.
  - Similar to results reported previously.
- Cooling in N. Canada and E. Europe in winter.
- Overall, not a very big impact on the forecast.
- However, ***lake ice anomalies*** are problematic.

multi-year lake ice (thickness)

Testing of the initial coupling set-up.







- MetUM in climate mode.
- Persistent lake ice is not expected at these locations.

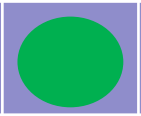
Effect of orographic drag?

	Lake fraction	Lake depth (m)	Orog. height (m)	Orog. Roughness length (mm)
L.Sakakawea, USA	0.03	27	710	10.4
Qinghai Lake, China	0.08	18	3690	65.0

- Lake-ice problems are encountered at particular types of locations.
- Orographic-roughness scheme represents drag from subgrid orography with an enhanced roughness length **(Wood & Mason, 1993)**.
- Gives correct upper winds, but may slow surface winds unrealistically.
    - **Lindvall et al. (J.Clim, 2013)**
- An alternative is the form-drag scheme, which adds additional stress in the boundary layer **(Wood & al, 2001)**.

Possible modifications of the models

Some of these inspired by the last lake workshop!

Unmodified		
Increase the “relaxation constant” C_{rc} in FLake, and decrease the extinction coefficient, γ.		
Change the orographic stress scheme in MetUM.		
Increase the lake tile Z_0 by 10^3.		
Decrease the lake tile Z_0 by 10^3.		
Archimedean conversion of lake snow to lake ice.	X	

Red is a combination of two of the most effective changes.

Results of modifications at the problem locations

Default

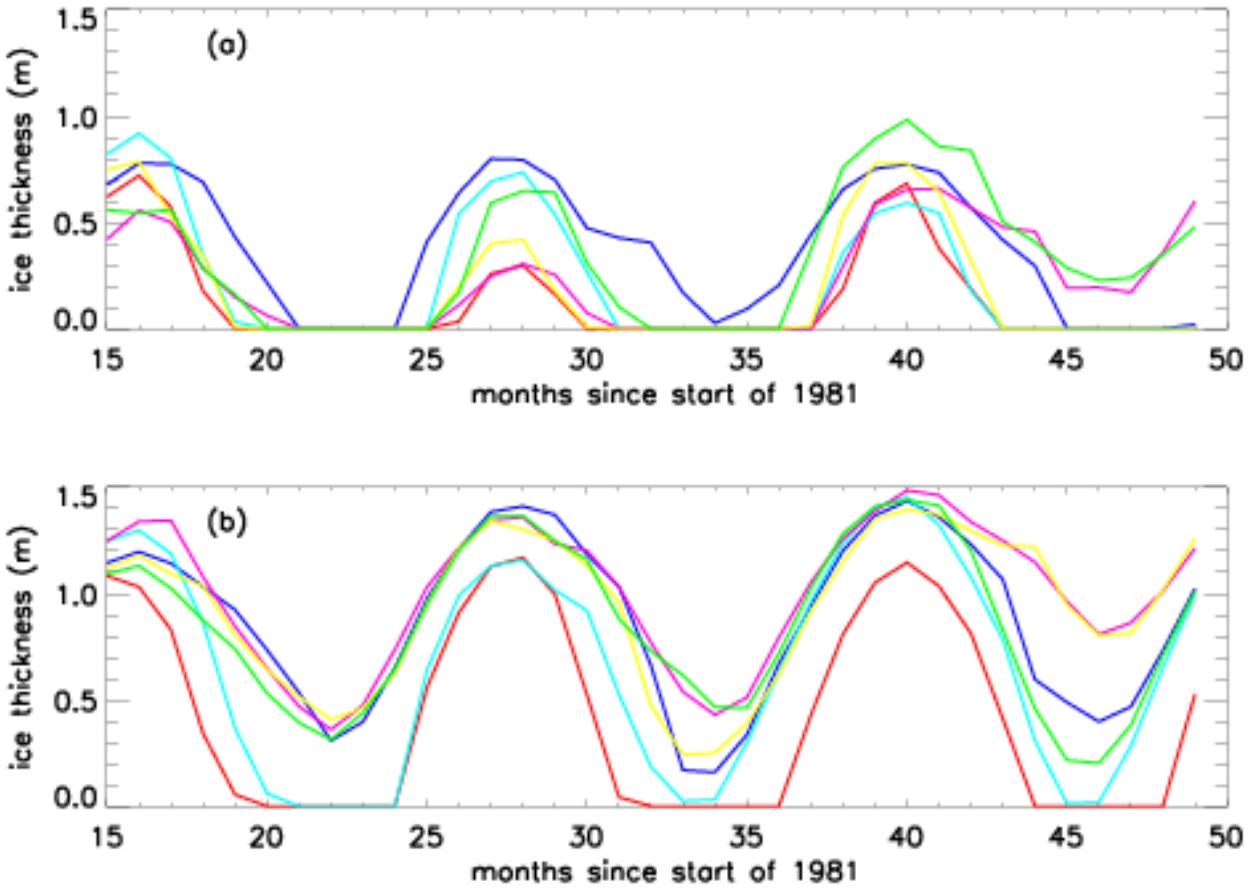
FLake mod

MetUM mod

Z_0 increase

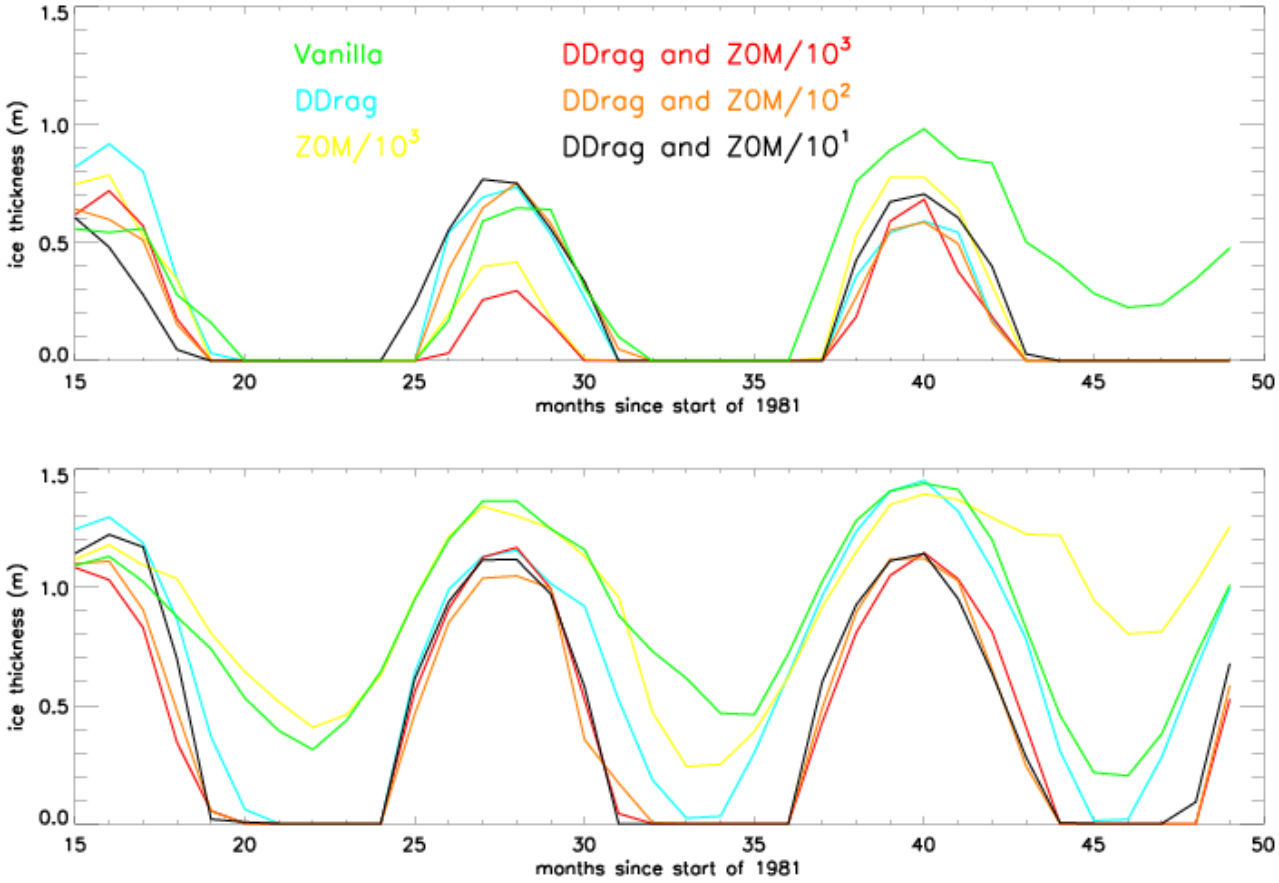
Z_0 decrease

(2) and (4) ✔



Further testing

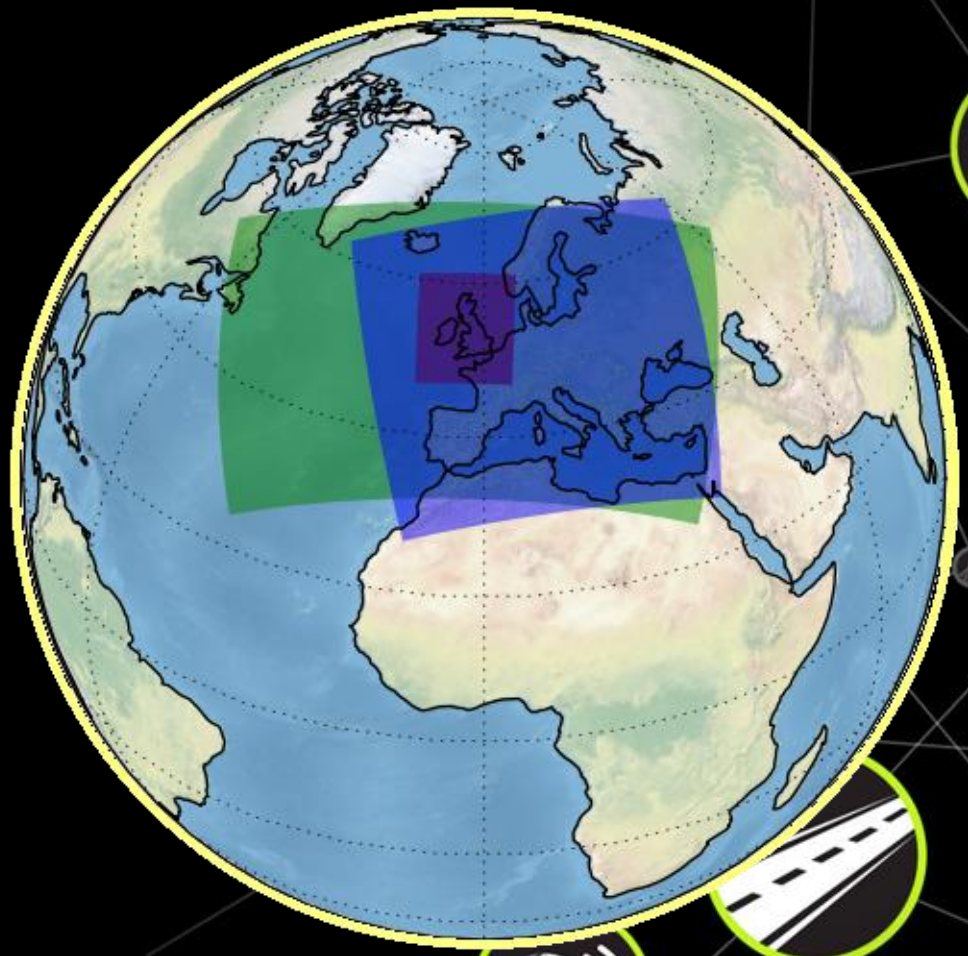
with less severe perturbations to the roughness length.



Much of the benefit can be retained with a smaller change to Z_0.

Pre-implementation trials

Screen-temperature results



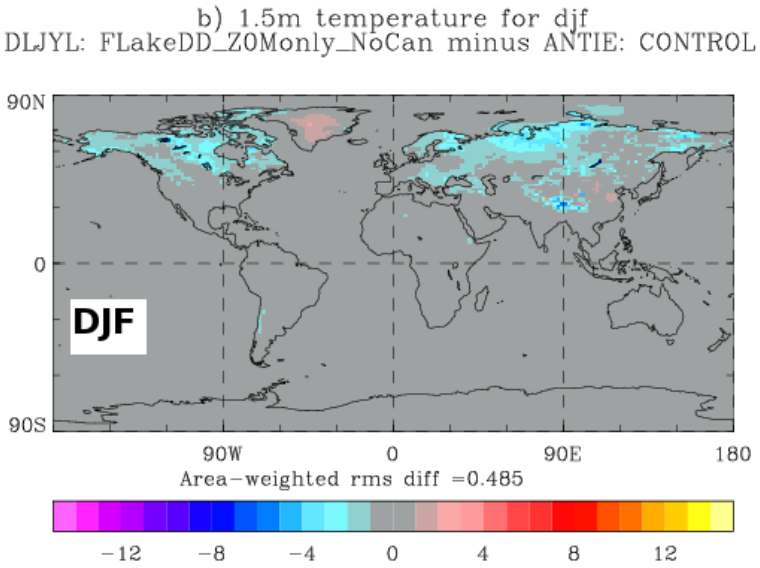
NWP and climate trials for implementation

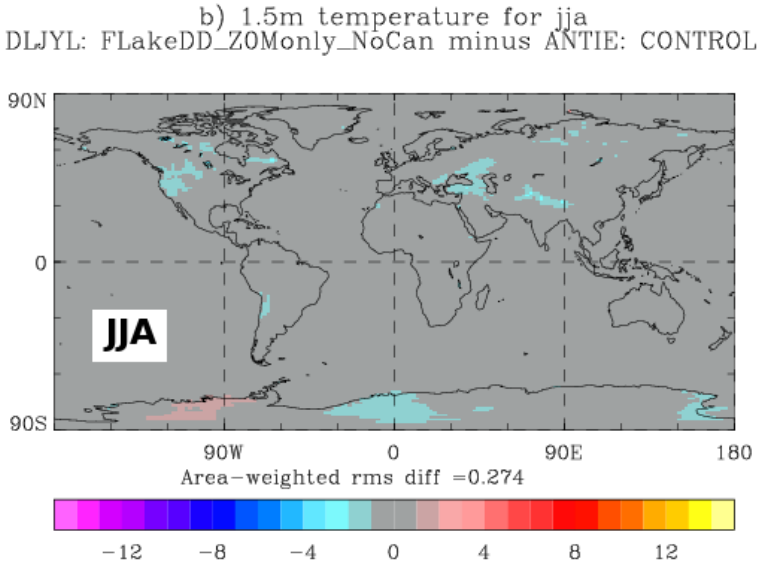
FLake *plus* the drag / Z_0 changes, trialled as a package.

Results shown here of the effects on screen temperature.

20-year climate run comparison

1.5m temperature, v. Control



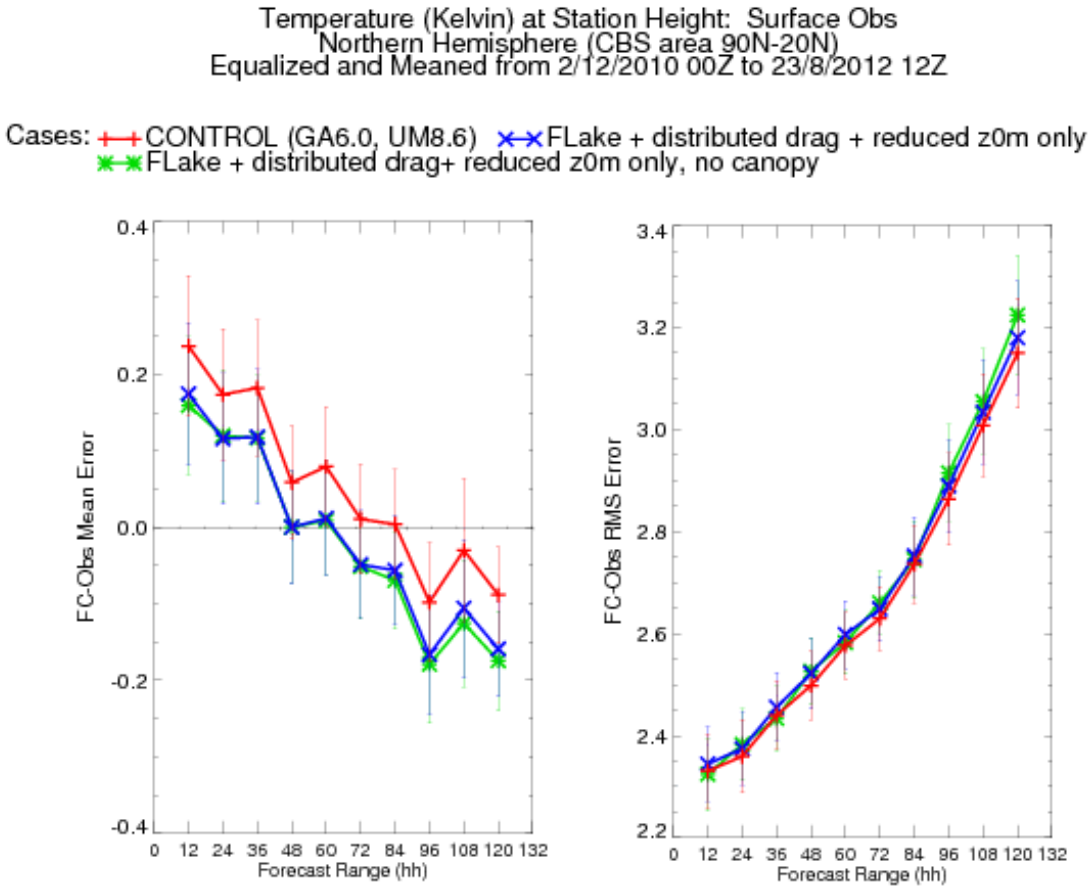


NWP and climate trials for implementation

Basket of 5-day forecasts

1.5m temperature, v. Control

Mean error



RMS error

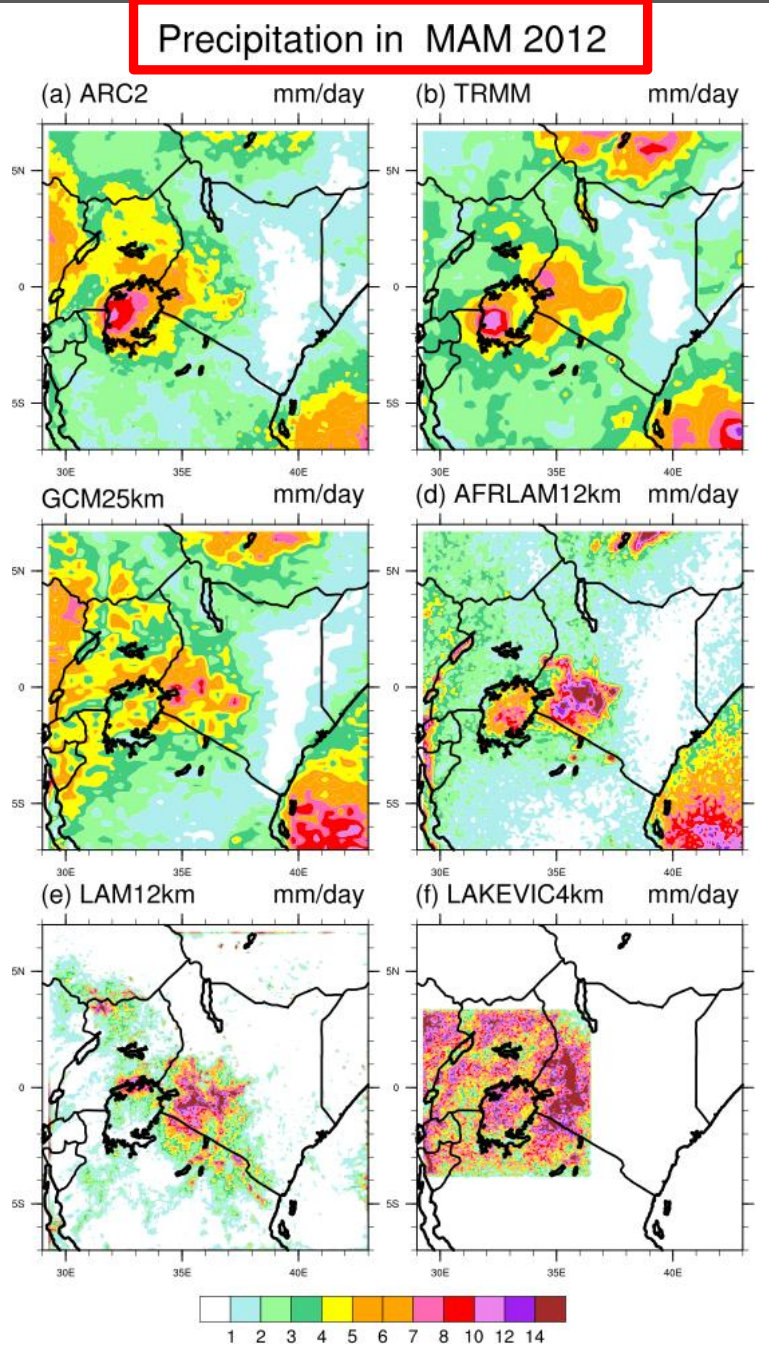
Other lake-related activity at the Met Office

Lake Victoria

Comparison of downscaling approaches for regional climate modelling in Africa.

Plots show a case-study over 3 months in the region around Lake Victoria.

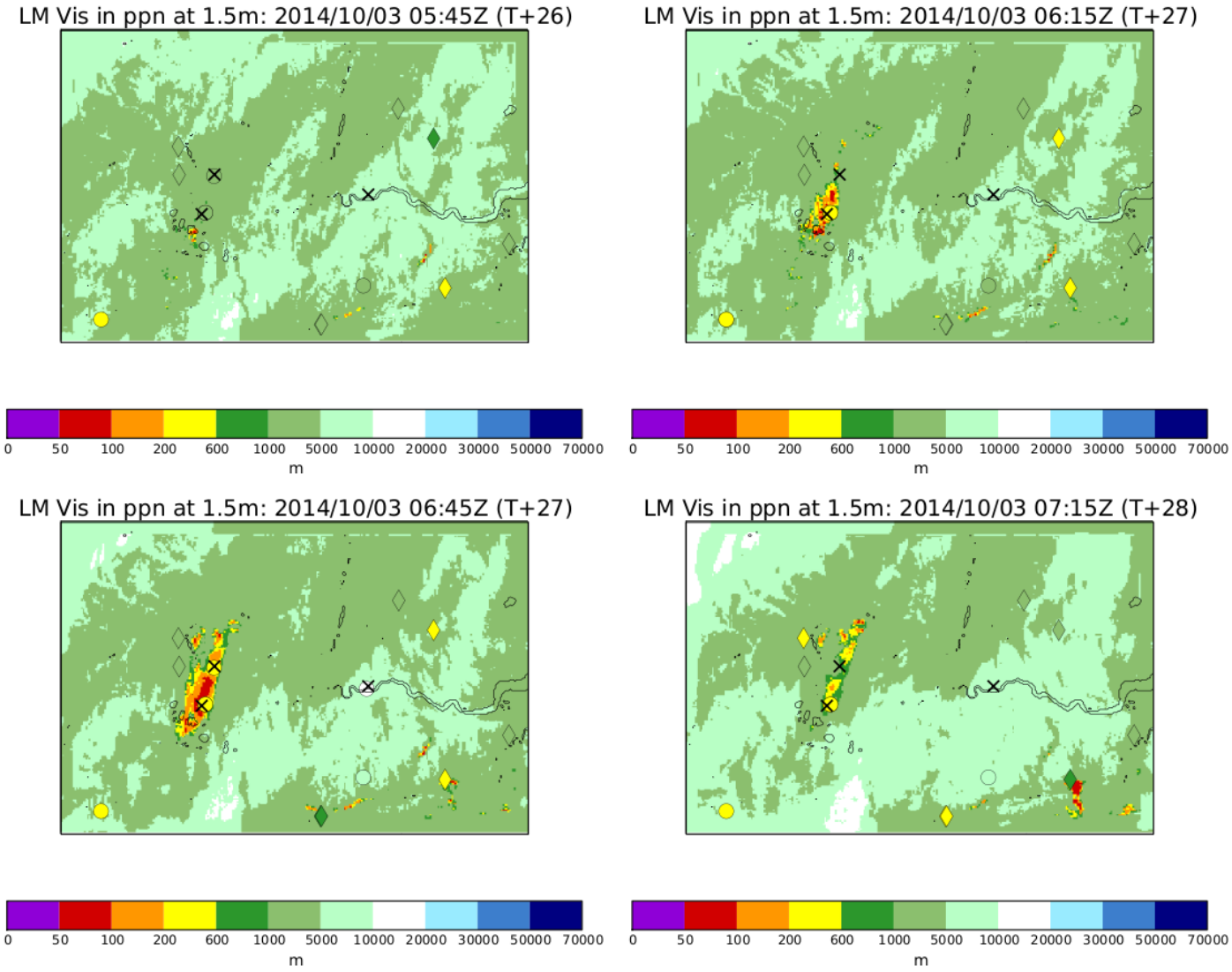
data	description
ARC2	Africa Rainfall Climatology
TRMM	Satellite-derived tropical rainfall
GCM25km	MetUM Global forecast configuration
AFRLAM12km	MetUM Africa LAM
LAM12km	MetUM nested suite
LAKEVIC4km	MetUM higher-res Lake Victoria LAM



W. Moufouma-Okia & R. Jones; Further work at higher resolution by Eagle, Lean & Webster (Met O, 2015)

Do lakes cause fog at Heathrow?

- Narrow band of fog appears to form from lake SW of Heathrow and advect across airfields.
- LM forecast is very good.



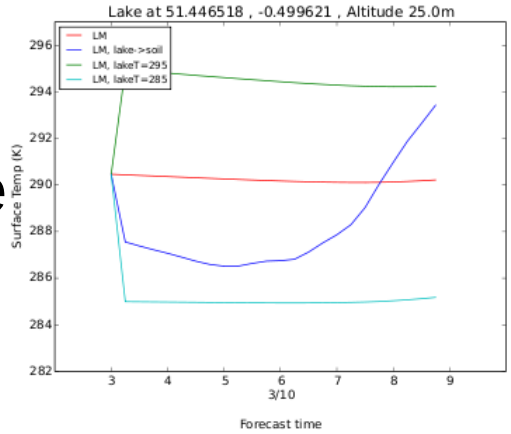
Visibility in the London Model, 333m resolution

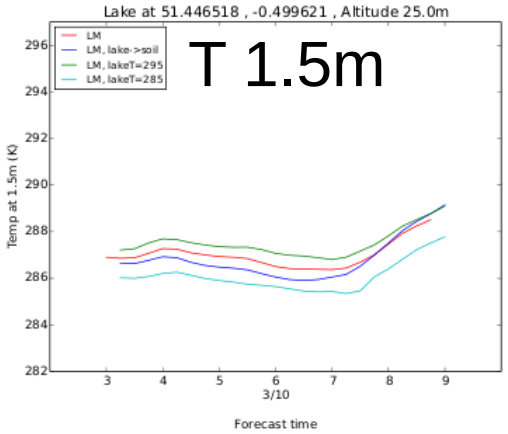
I.Boutle, A.Finnenkoetter, A.Lock, C.Morcrette, H.Wells (Met O, 2015)

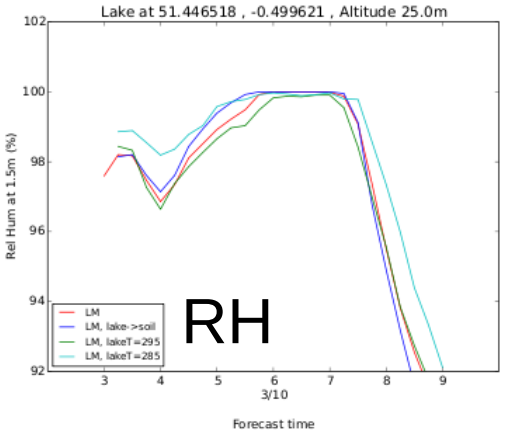
Sensitivity tests:

LM Control | Lake -> soil | Lake T=295K | Lake T=285K

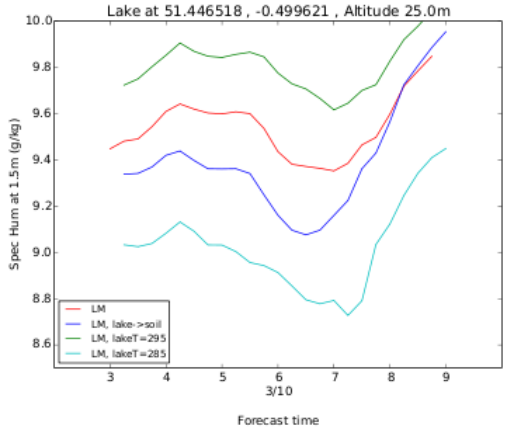
Lake surface T

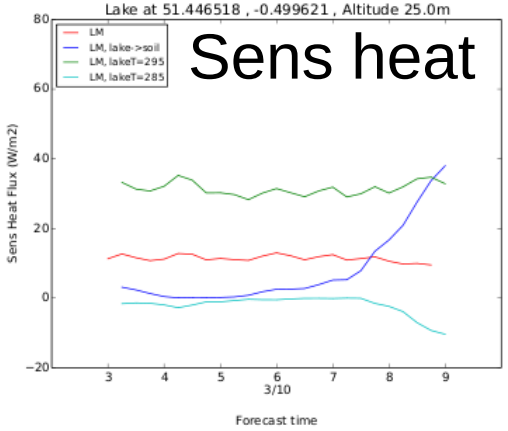


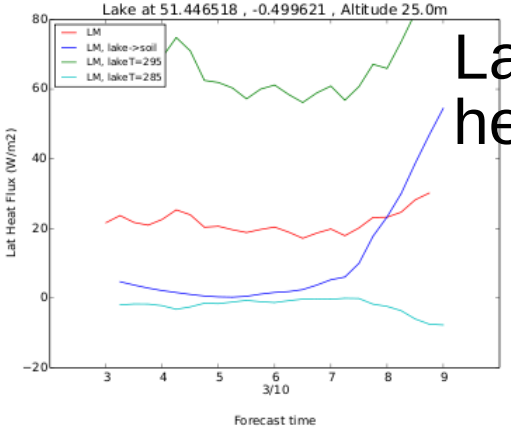




Spec Hum







- Very little effect on RH – increased heat from lake balanced by increased moisture

Conclusions

- FLake/MetUM coupling and testing has been carried out successfully.

- FLake performance seems to be a gauge of atmosphere - surface coupling strength.

- Licensing issue is delaying further use of FLake!

- Lakes are a current area of interest, particularly the model representation of African lakes for NWP/climate modelling.

Met Office

Questions & Answers