



Assessing satellite-derived snow cover products over the UK for use in NWP

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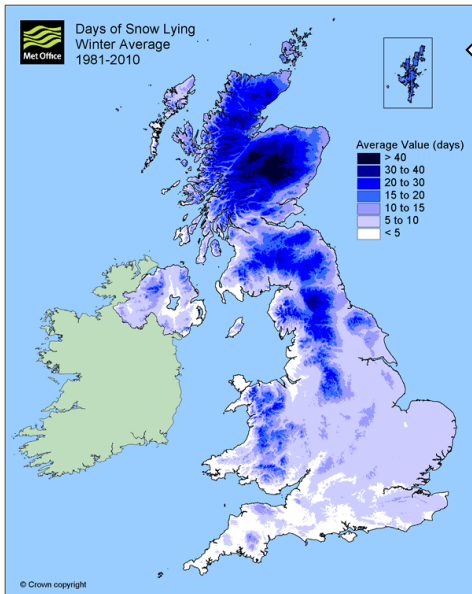
CryoLand Dissemination Workshop, 4th December 2014



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- Assessment of H-SAF snow cover product for assimilation into the UK NWP system
- Cloud cover and optical snow cover products
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 - Potential use for NWP
 - Comparison with UK model
- Conclusions

Snow in the UK



- The UK does not experience regular widespread snowfall except in the Highlands of Scotland
- Snow tends to be transient, often wet, shallow, multiple snowfall/melt cycles in one season.
- Low frequency, but high impact event – accurate analyses and forecasts of snowfall and lying snow extremely important
- Currently no snow observations are assimilated in the UK NWP model





Snow data assimilation at the Met Office

Snow model

Upgrading from a single snow layer with constant density, to a multi-layer model with varying layer density, temperature, ice and liquid water content

- Global model upgrade 2015
- UK model already upgraded

Global model data assimilation - current

- Daily northern hemisphere snow analysis is run at 0600 UTC
- Simple update based on NOAA/NESDIS IMS snow cover product
- Snow removed, or small amount added, where there is a mis-match between observed and model presence of snow

UK model data assimilation – plans (2015-16)

Optimal interpolation of ground-station snow depth reports, with additional information from satellite snow cover products

- Currently in development
- Initially use H-SAF snow cover product (MSG-SEVIRI)



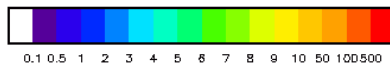
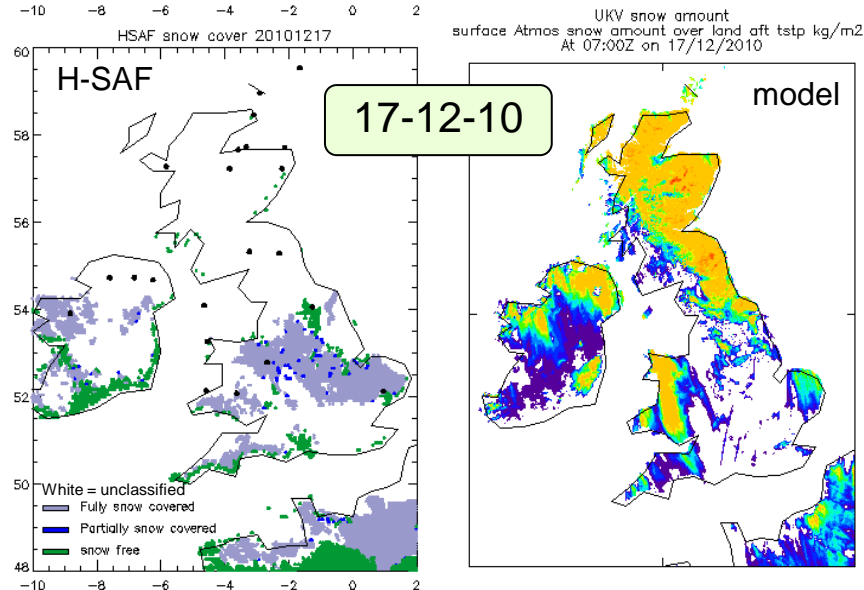
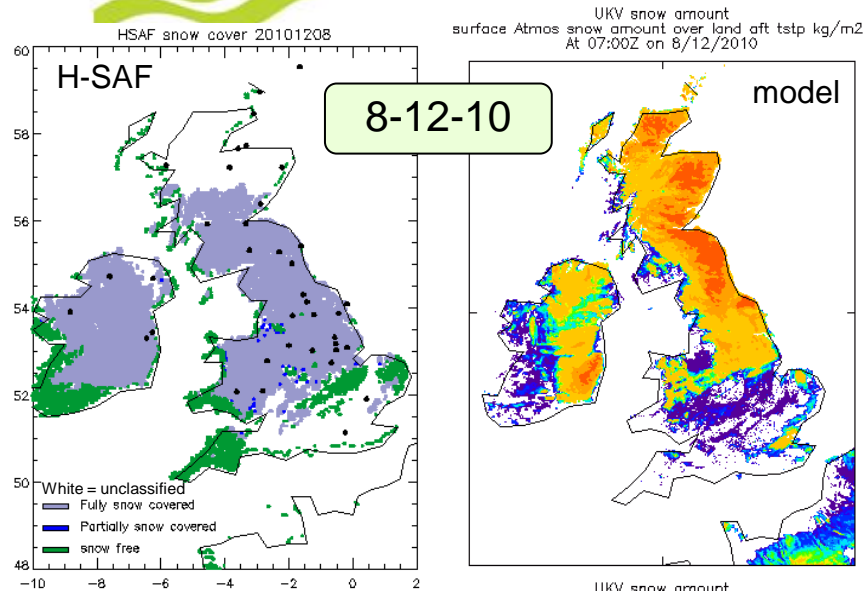
H-SAF snow cover - comparison with model

Some examples...

- Good comparison with model snow-covered area in general
- Good match between H-SAF snow-covered areas and SYNOP snow obs
- More snow-free area in H-SAF than model in southern Ireland – assimilation could improve model snow extent here

- Large proportion of UK un-classified (cloud-covered)
- H-SAF has more snow cover than model in South/Central UK, but H-SAF snow cover is supported by SYNOP snow obs

Assimilation of H-SAF snow cover could improve model snow extent in these cases





Quantitative comparison

H-SAF vs model

A correct snow-free classification is as important as a correct snow-affected classification for snow cover assimilation, so the rates calculated are:

		H-SAF	
		snow	snow-free
model	snow	TRUE POSITIVE (TP)	FALSE NEGATIVE (FN)
	snow-free	FALSE POSITIVE (FP)	TRUE NEGATIVE (TN)

Correct classification rate

$$100 \times (TP + TN) / \text{Number classified obs}$$

In this case:

Overestimation rate

$$100 \times FP / \text{Number classified obs}$$

correct = match

Underestimation rate

$$100 \times FN / \text{Number classified obs}$$

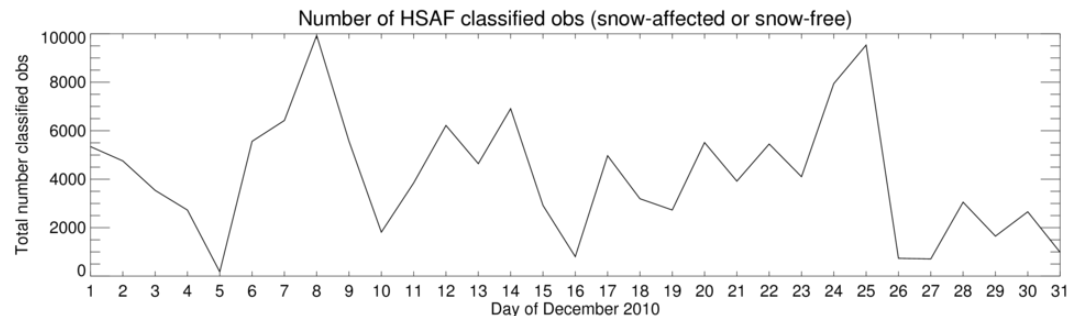
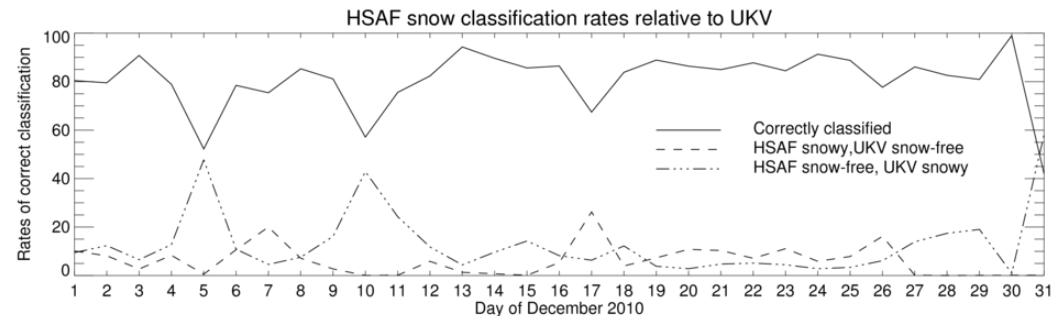
Mean rates for December 2010

Correctly classified: 80.8%

Overestimated: 6.2%

Underestimated: 13.1%

Rates strongly affected by instances of low numbers of classified pixel – QC to be explored to make optimal use of data





Cloud cover limitations...

- Overall comparisons between model and H-SAF snow cover are good, where cloud cover allows. Positions of SYNOP obs of snow coincide almost entirely with areas where H-SAF is classified as snow-covered (where not cloud-covered).
- High temporal sampling of H-SAF product results in significant reductions of cloud-affected pixels in composite product relative to products from sun-synchronous sensors. This has been shown to result in comparable or higher mapping accuracy, despite the coarser spatial resolution of SEVIRI product (Surer et al., 2013).
- The UK has a very high instance of cloud cover associated with snowy conditions. This limits the value from optical sensors - transient snow may never be seen. The extent to which cloud cover affects a product becomes very important for use over the UK.
- Wet snow mapping, from SAR, could provide useful complementary data to optical snow extent products, in cloud-affected areas. Initial investigations, using a wet snow mapping product from NORUT, show that it is potentially well-suited to detection of UK snow, which is often wet and begins to melt straight away.



CryoLand Pan-European fractional snow cover

- CryoLand fractional snow cover is not currently a candidate for operational assimilation for 2 reasons:
 - Not yet an operational product – need assured continuity, operational robustness to justify development work of introducing new observation data source into operational NWP system
 - Cloud coverage very high for UK snow-affected periods investigated
- However, where cloud cover allows, the comparison of snow-covered area with that of the UK model is extremely good
- High resolution allows comparison of fine structure in snow extent field
- It already provides a very useful independent validation dataset
- Transition to an operational service would be of great benefit to the NWP community. The product would then become viable for consideration for operational assimilation, and would provide ongoing validation data for existing snow analyses.

Some examples over the UK....



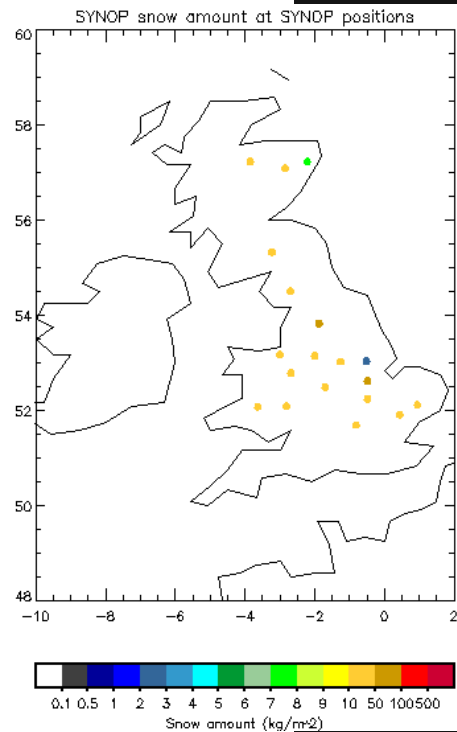
March 2013 – a late snowfall event for the UK

- Dominated by cloudy conditions
- Good representation of snow-free areas
- Where classified, snow covered areas are also snow covered in model

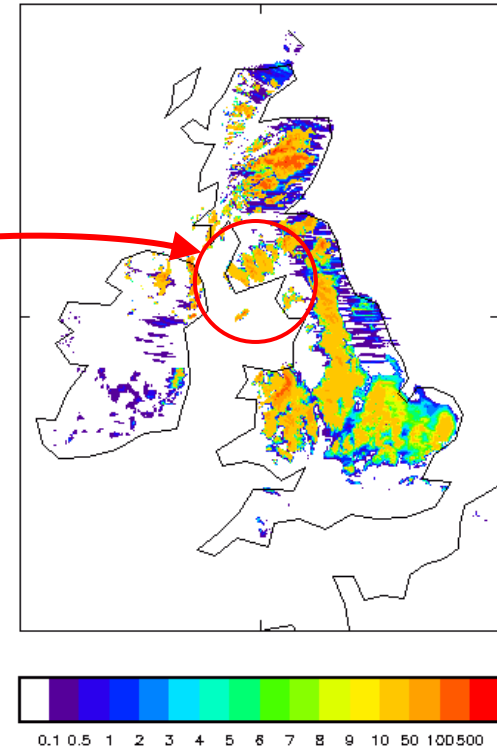
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Met Office model

SYNOP snow reports



UKV snow amount
surface Atmos snow amount over land aft tstp kg/m²
At 07:00Z on 25/ 3/2013





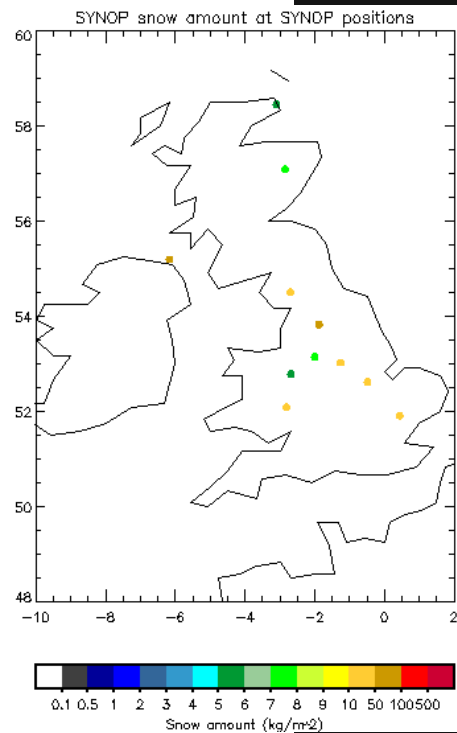
A few days later...more classified pixels, less cloud cover

- evidence of good representation of transition between snow-free and snow-covered surface
- detailed structure of snow extent matches model well

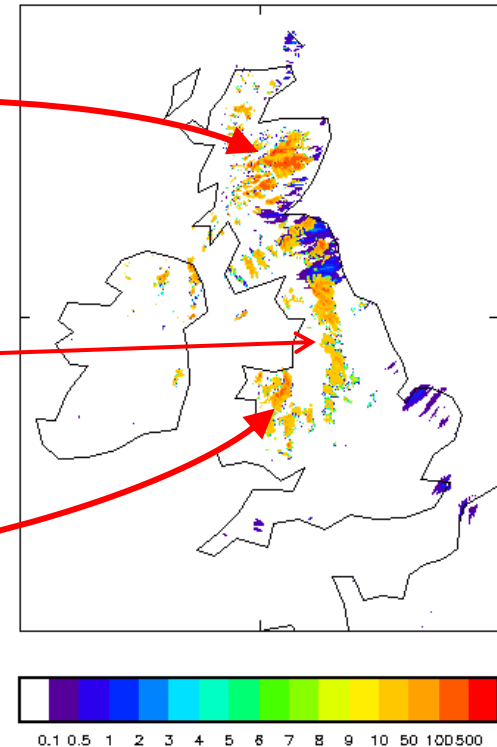
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Met Office model

SYNOP snow reports



UKV snow amount
surface Atmos snow amount over land aft tstp kg/m²
At 07:00Z on 29/ 3/2013



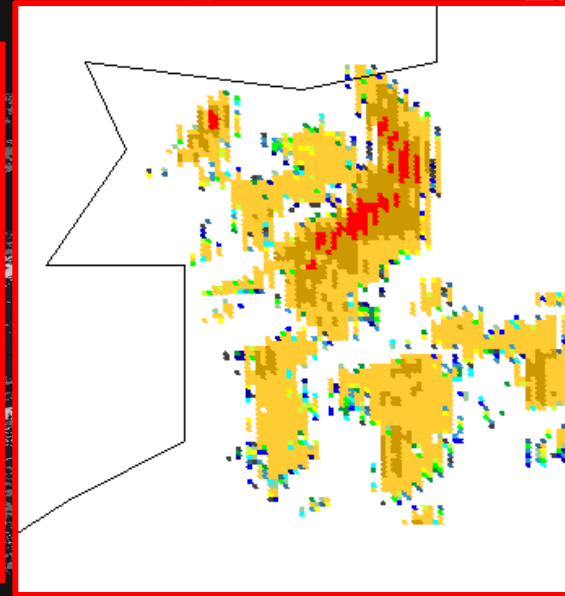
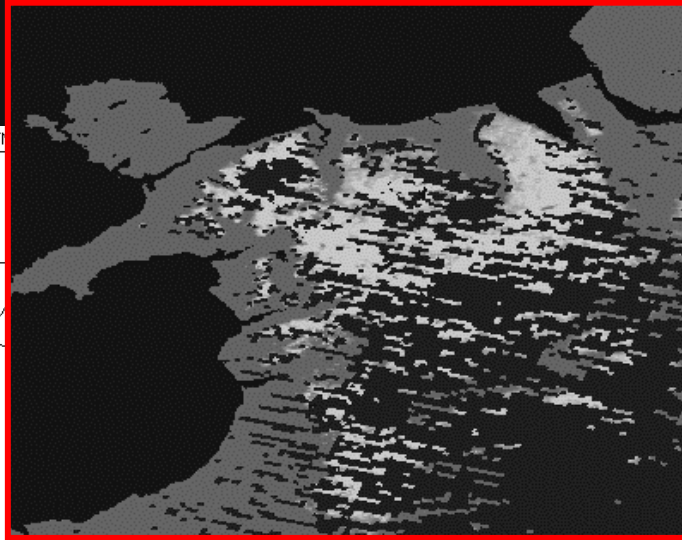
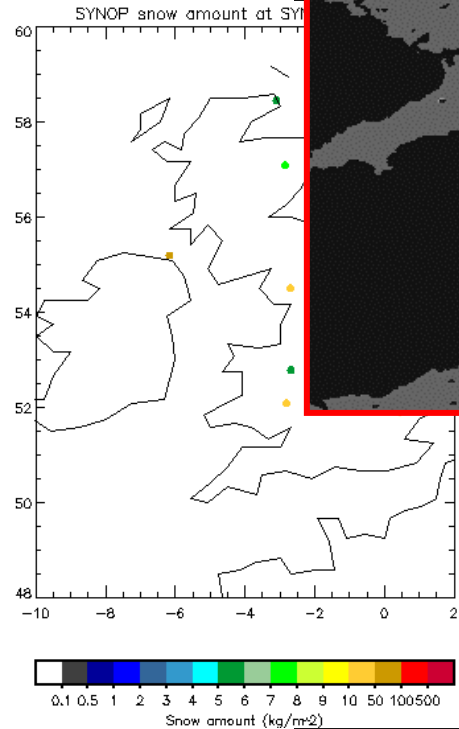
Snow-free/snow-cover transition



...same day, close-up of North Wales...
comparison with pattern of model snow cover is astonishing!

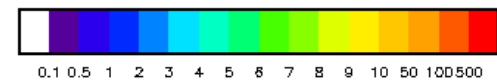
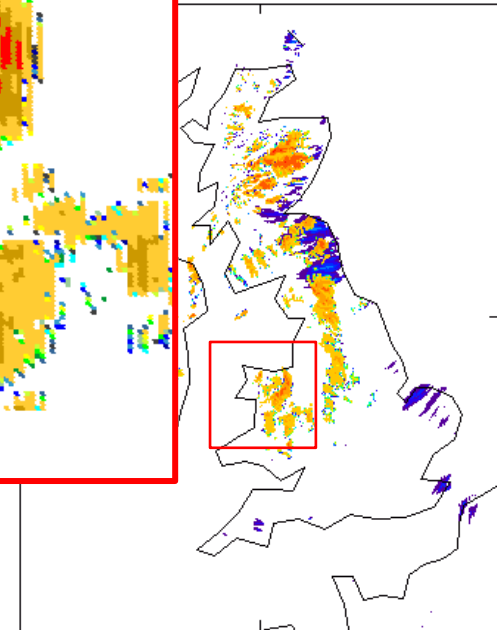
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SYNOP snow reports



Met Office model

UKV snow amount
Snow amount over land aft tstp kg/m²
7:00Z on 29/ 3/2013



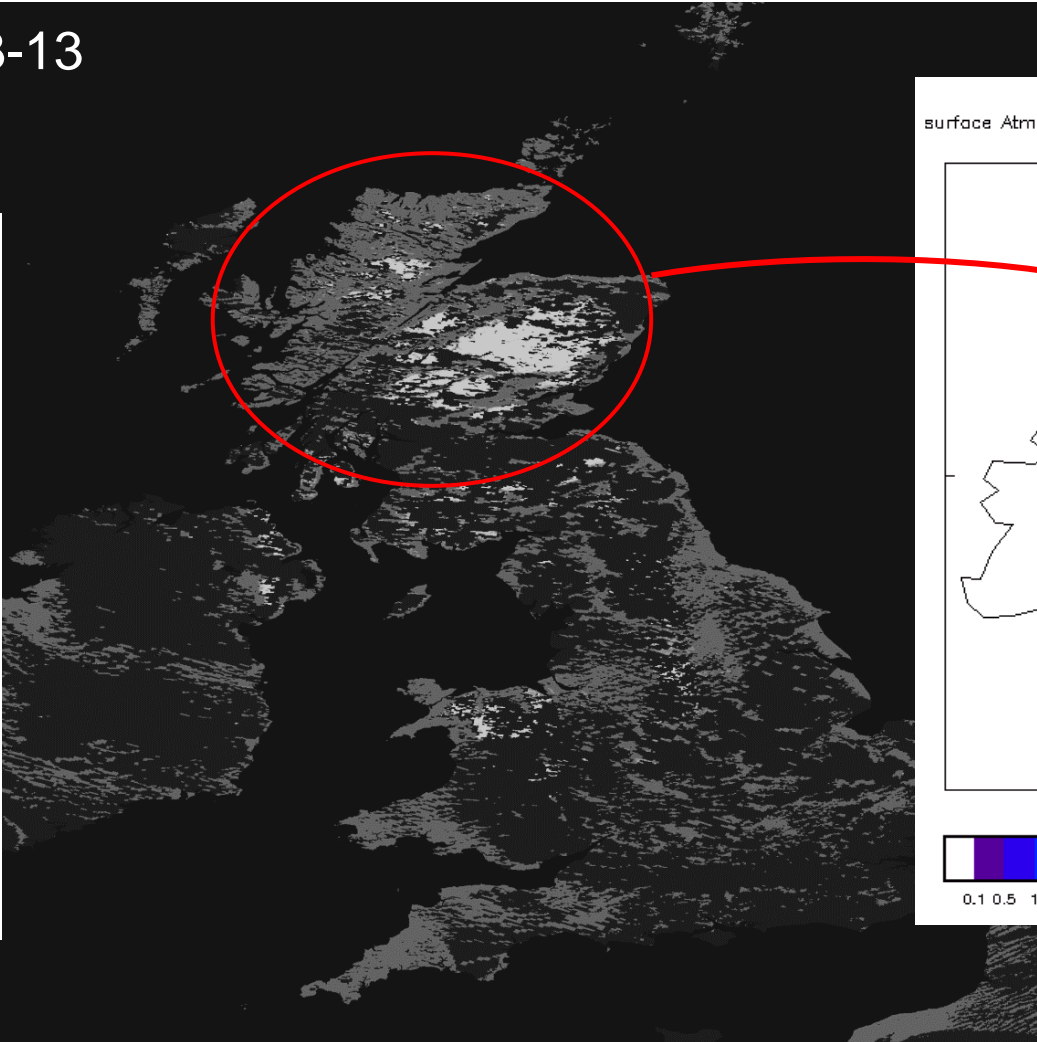
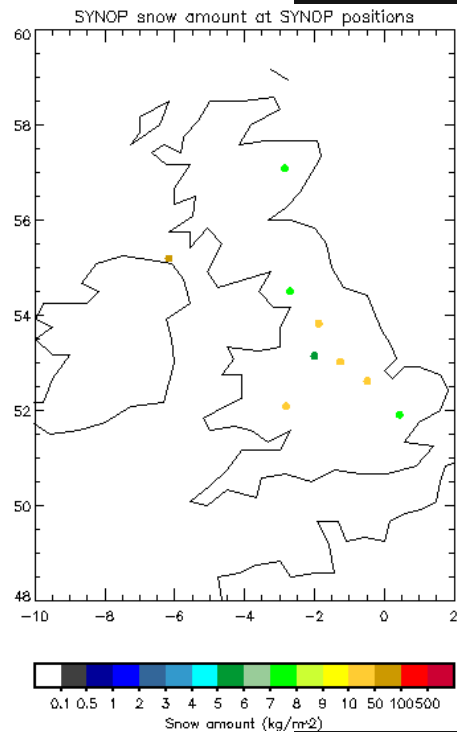


Extremely good comparison of distinction between snow-free and snow-covered area in Scotland – an area of very high topographical variation

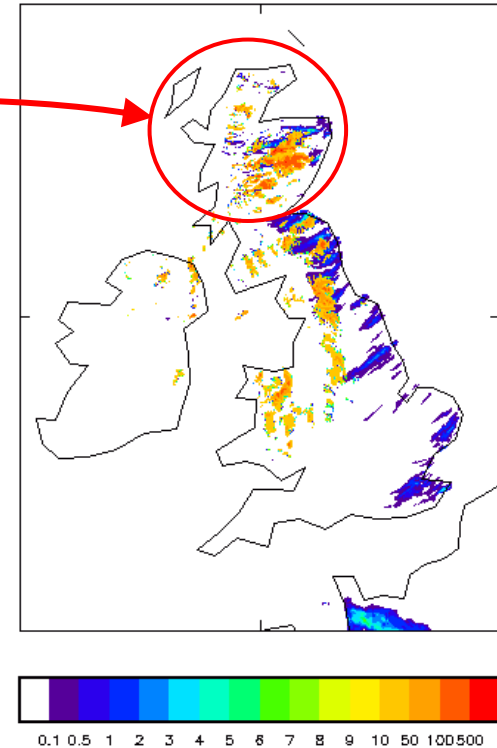
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Met Office model

SYNOP snow reports



UKV snow amount
surface Atmos snow amount over land aft tstp kg/m²
At 07:00Z on 30/ 3/2013





Conclusions

- The Met Office is currently developing a snow assimilation system for its high resolution UK NWP model, using both satellite-derived snow cover, from H-SAF, and SYNOP snow depth observations.
- The H-SAF snow cover product compares well against SYNOP and model snow distribution in general. However, there are clear instances where H-SAF representation of snow cover is better than the model, and assimilation could improve the model snow extent.
- CryoLand fractional snow cover, though currently not suitable for assimilation, shows extremely good comparisons with the UK model where cloud cover allows. In particular, fine structure of the snow edge in topographically complex terrain is very well represented.
- Use of satellite-derived snow products by NWP requires sustainable, operational services. Although many good products are developed, few are pulled through into operational capability. Long-term funding and continuity of products are crucial to ensure we can fulfil the potential of satellite missions, such as Sentinel.



Met Office



Thank you for your attention