Assessing satellite snow products for assimilation into the UK regional forecasting model

Samantha Pullen, Chelsey Cooper

7th EARSeL Workshop SIG Remote Sensing of Land Ice and Snow, 3-6th February 2014

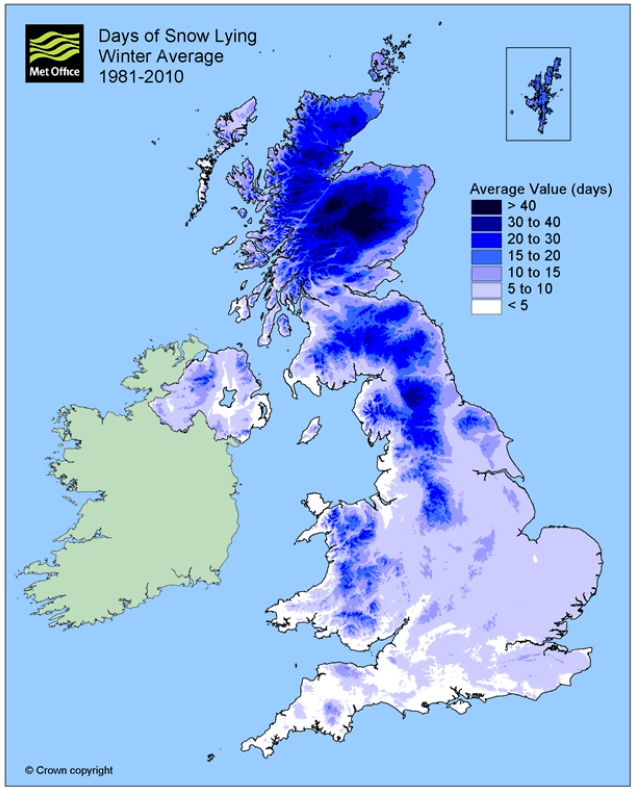
Contents

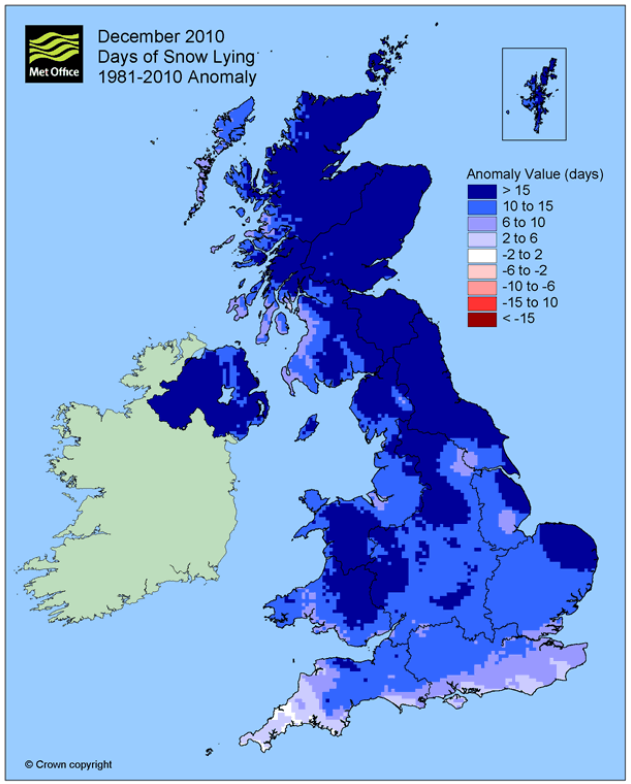
- Snow forecasting at the Met Office
- Case study periods
- Comparisons of synop snow depth obs with high resolution UK models
- Satellite snow extent datasets
- H-SAF product assessment
- GlobSnow, CRYOLAND examples
- Satelite snow water equivalent
- Conclusions and next steps

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Snow in the UK

Not much, not often…





But when it happens…

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Chaos!













Snow forecasting at the Met Office

Data assimilation

Global NWP model – 25 km

- Daily NH snow analysis at 06Z
- Simple update based on NESDIS IMS snow cover product
- Small amount added or all removed – no changes to existing snow depths

UK NWP model (UKV) – 1.5 km inner area

- No observational snow information used

UKPP Nowcasting system (non-NWP)

- Hourly hydrology analysis using radar precipitation data
- Phase of precipitation and behaviour of fallen snow determined by model T, RH etc…

Snow model
Currently single-level, constant density.

Upgrading to multi-level model with varying layer density, temperature, ice and liquid water content

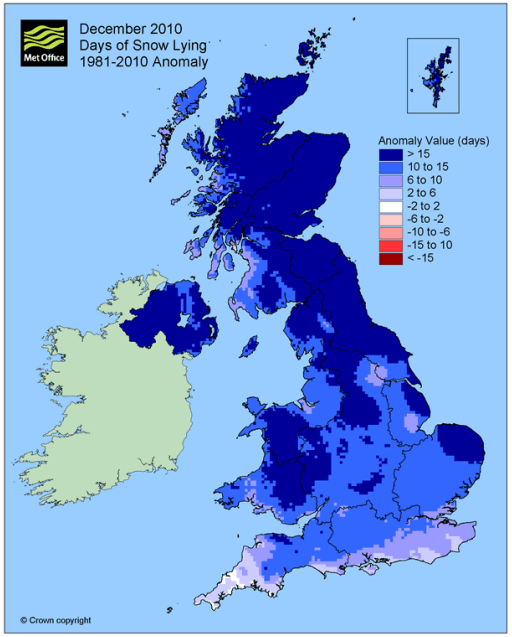
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Assessing assimilation options for the UK

- Nowcasting system (UKPP) snow analysis
- Synop snow depth observations
- Satellite snow cover/extent products
- Satellite SWE
- Others?

2 case study periods

Significant UK snow events



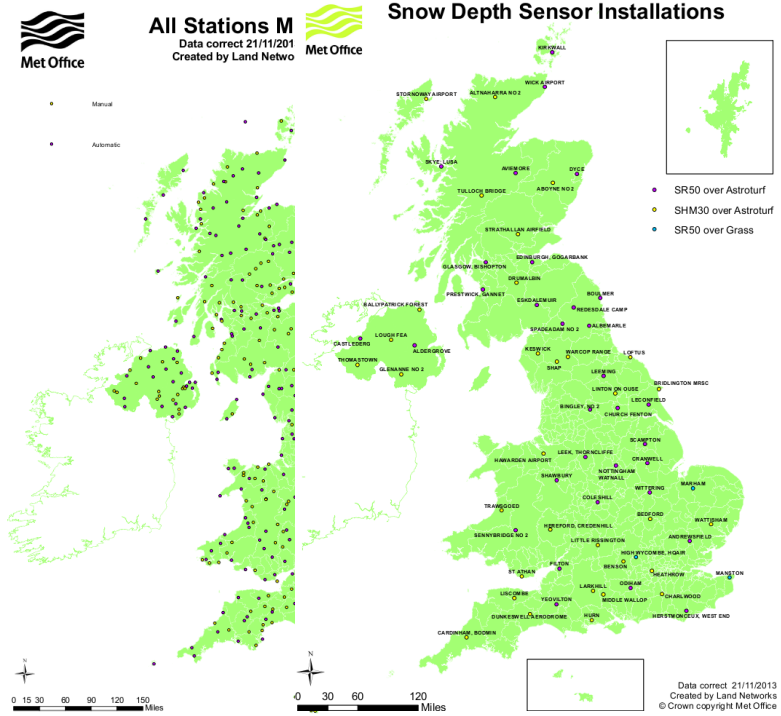
December 2010

Late March 2013



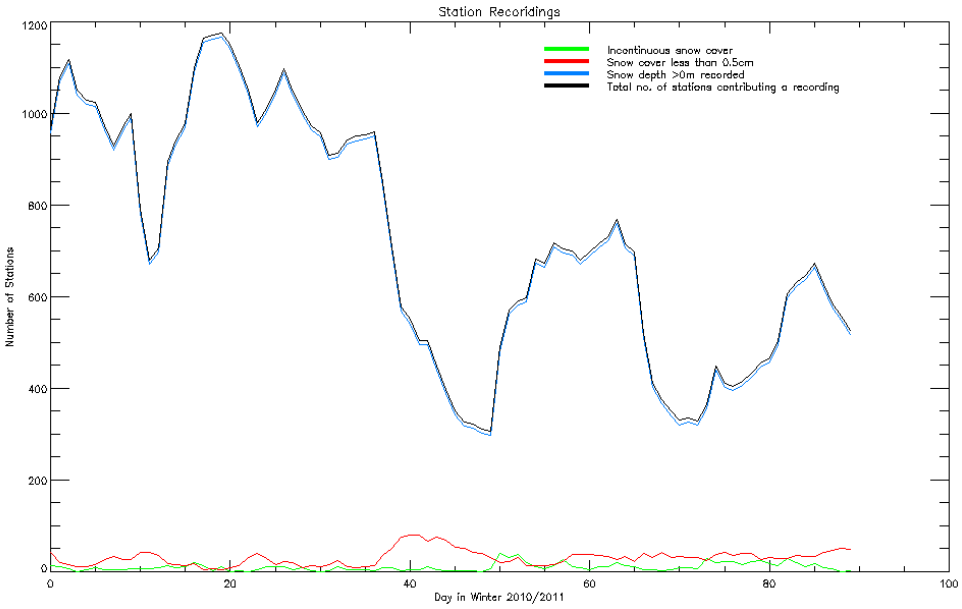
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Ground-based snow observations









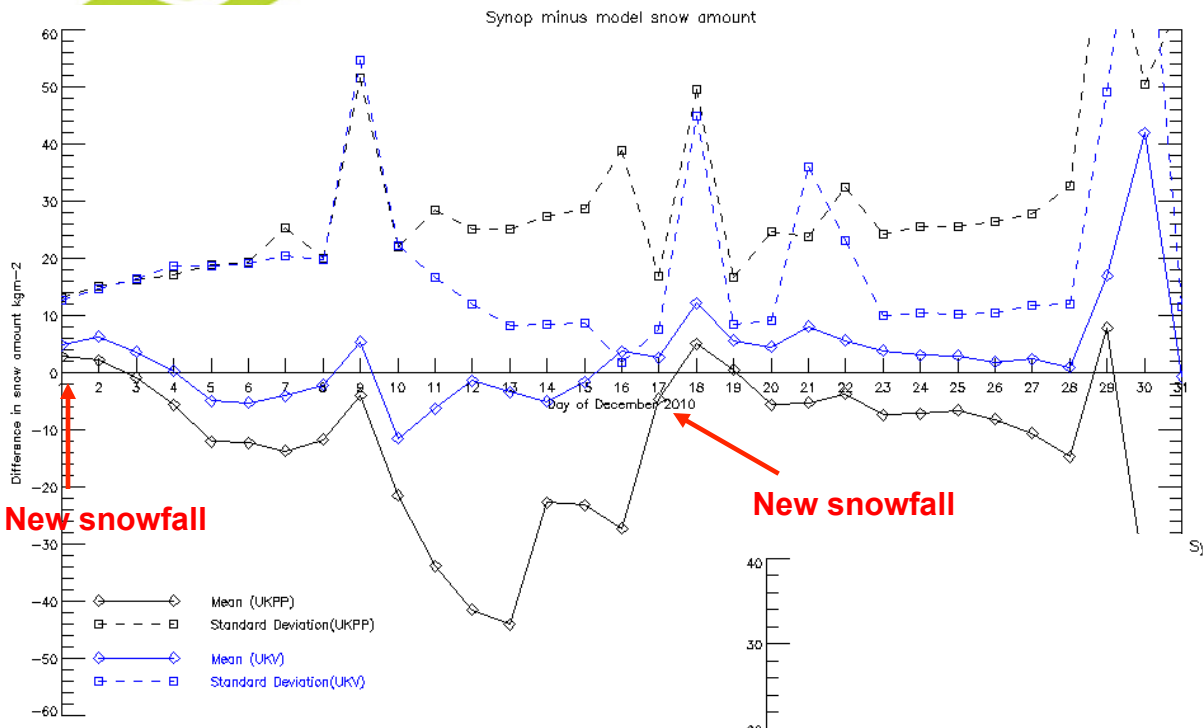
Most stations only report non-zero snow depth

No distinction between missing data and no snow

Loss of valuable information

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Synop minus model snow amount



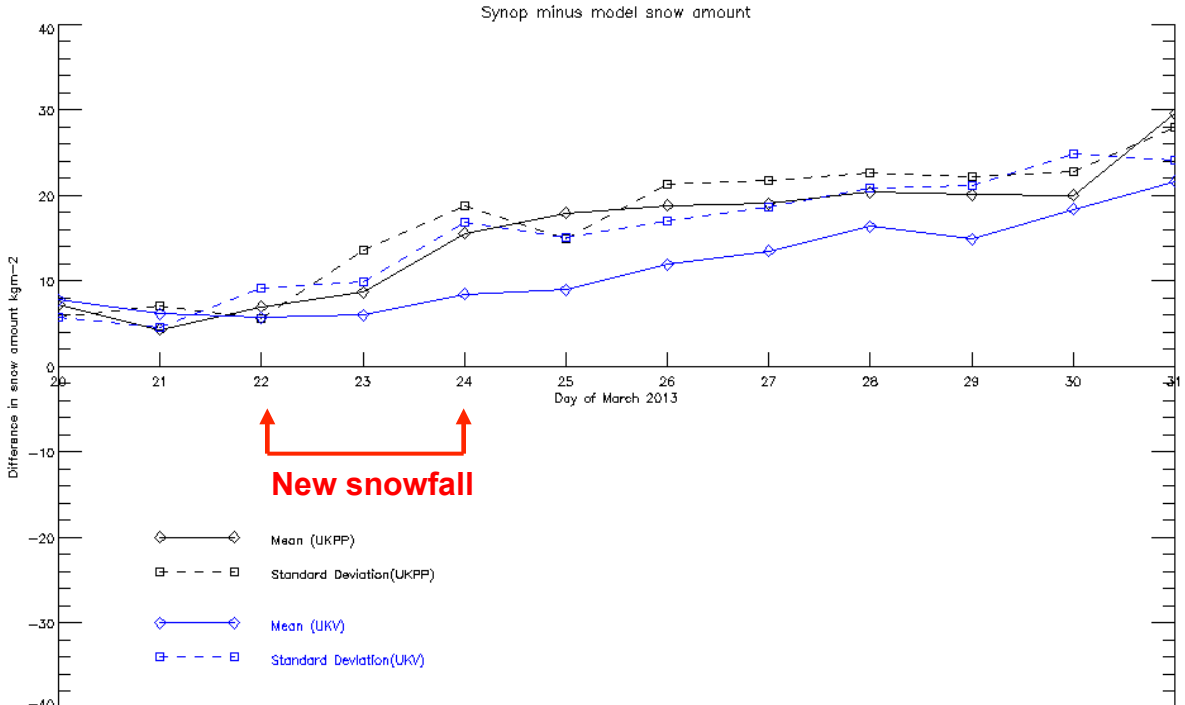
New snowfall

New snowfall

December 2010

UKV (NWP)

UKPP (Nowcasting)



New snowfall

Solid = mean

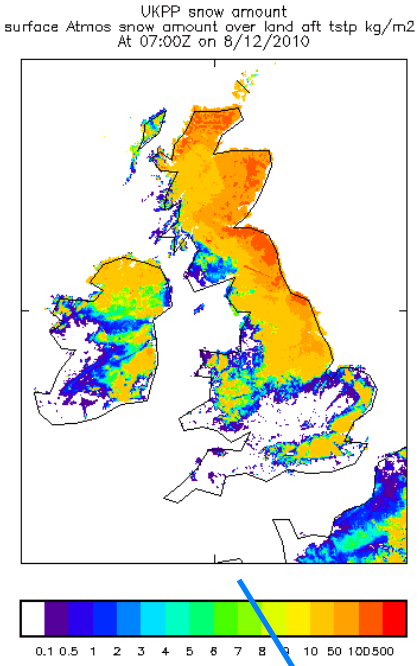
Dashed = SD

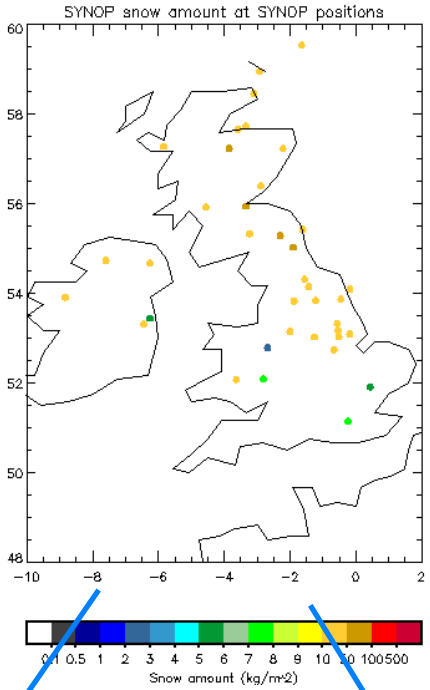
March 2013

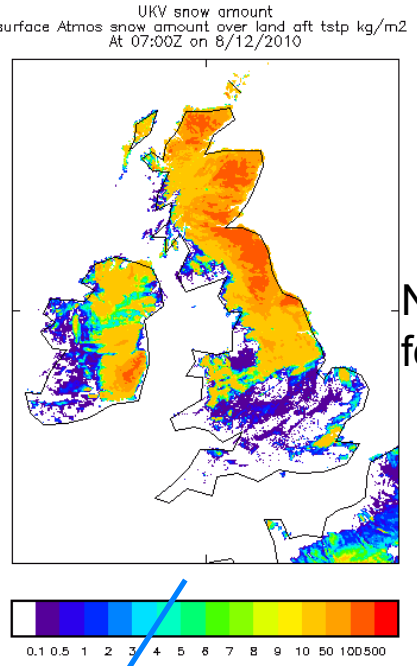
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Nowcasting analysis

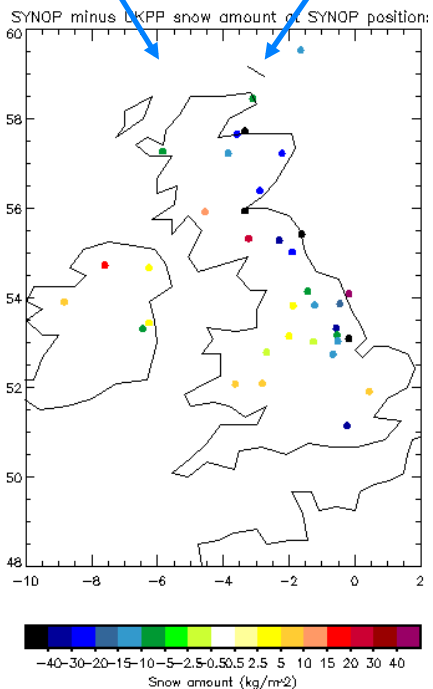


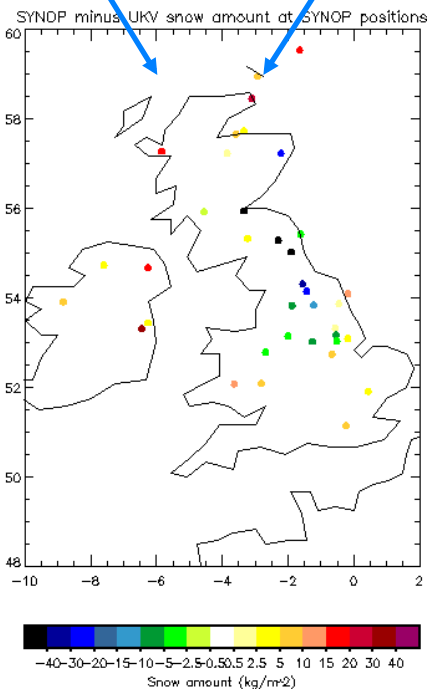




NWP T+1 forecast

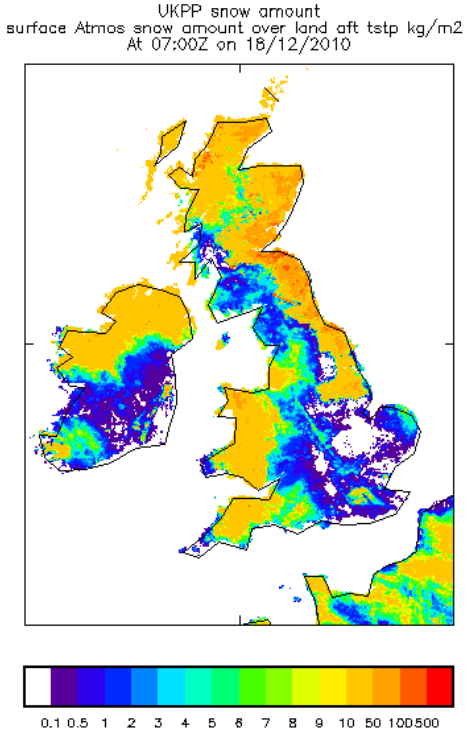
8th December 2010

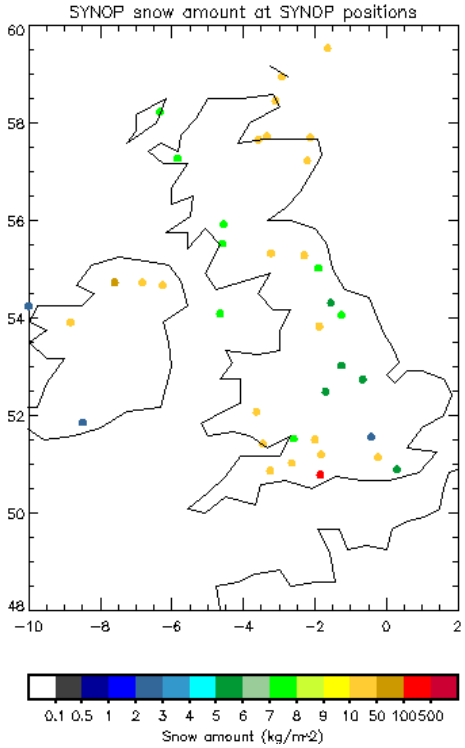


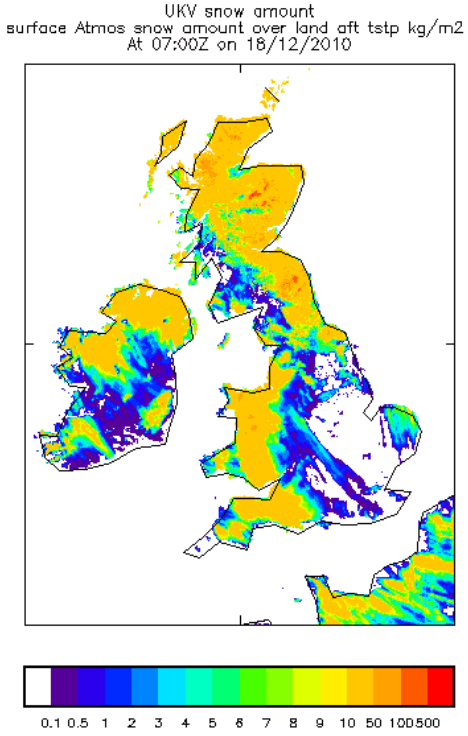


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18th December 2010 fresh snowfall







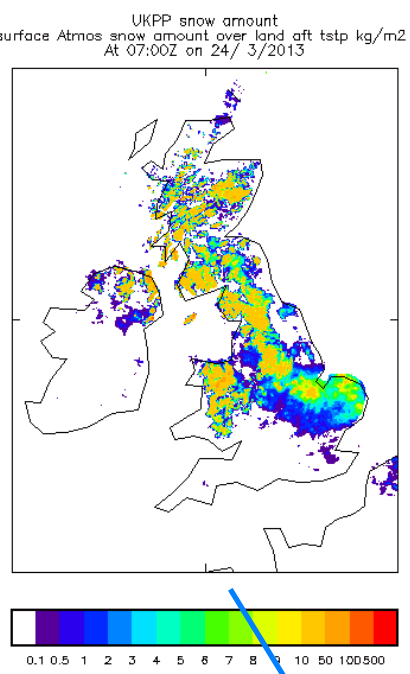
Nowcasting analysis

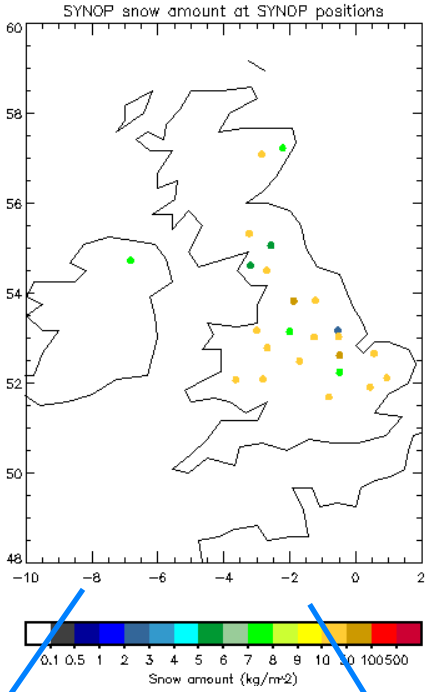
NWP T+1 forecast

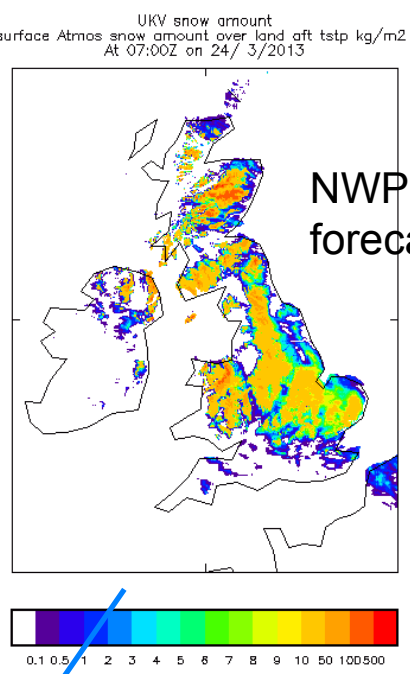
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Nowcasting analysis

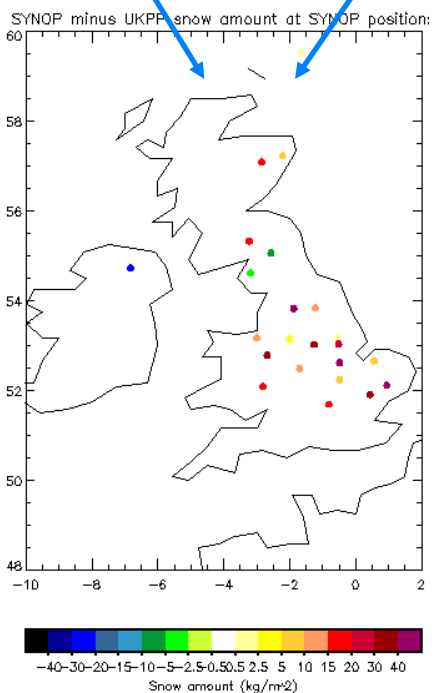


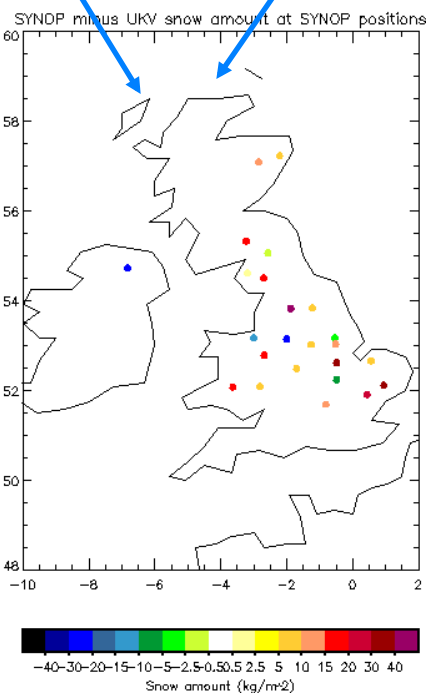




NWP T+1 forecast

24th March 2013



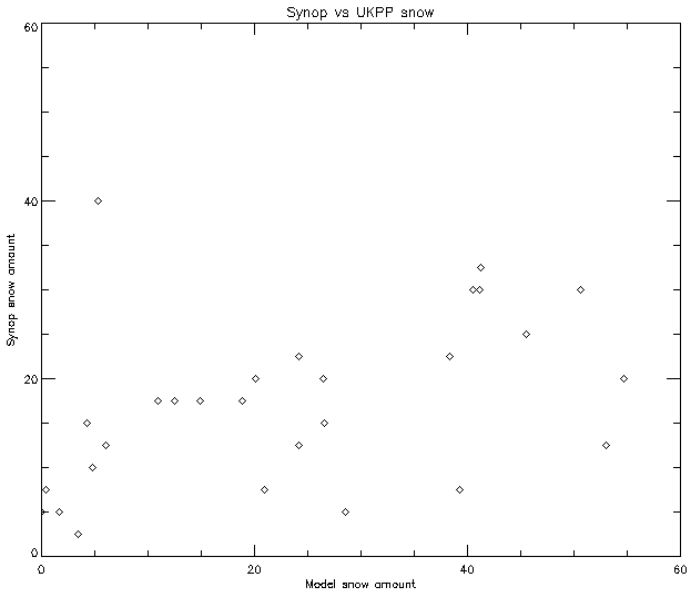


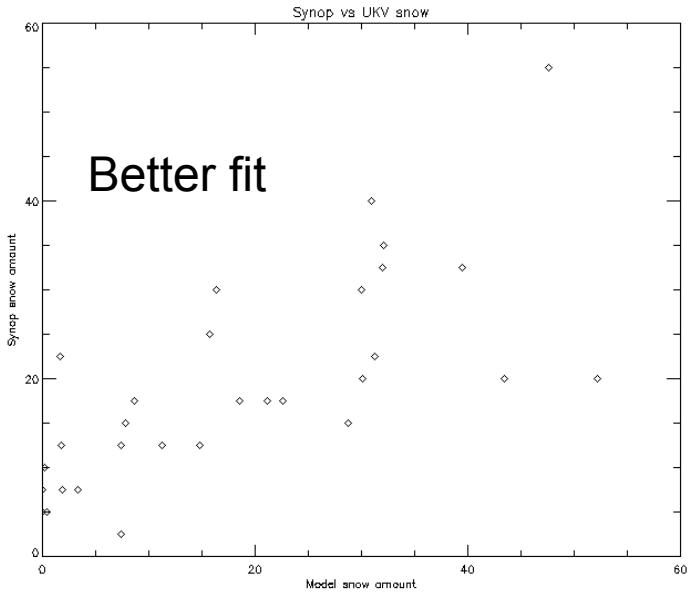
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Synop vs UKPP

Synop vs UKV

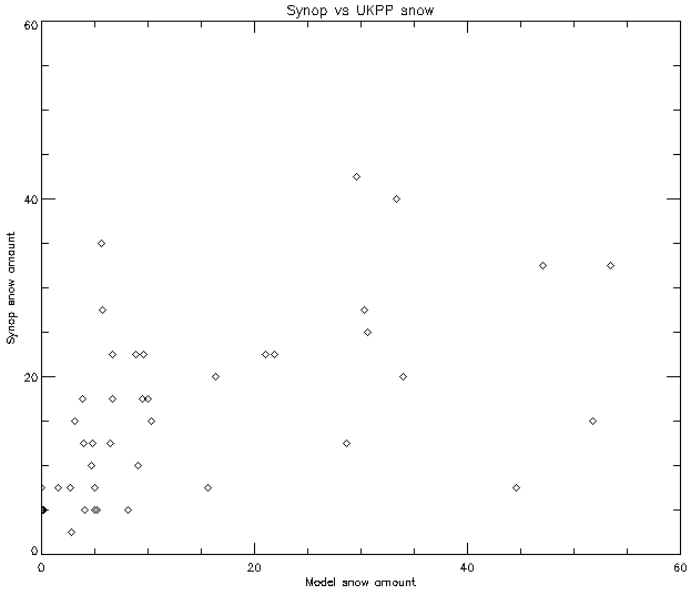
6-12-10

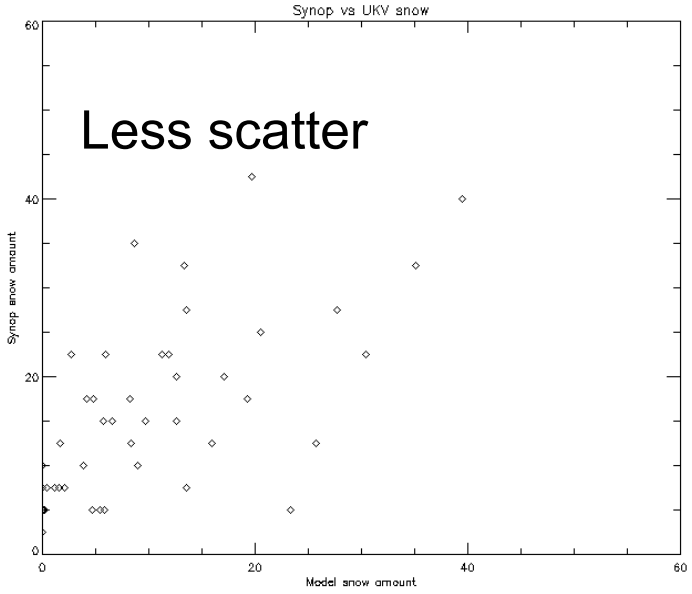




Better fit

19-12-10





Less scatter

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But scope for improvement by assimilating synops

Satellite-derived snow extent products

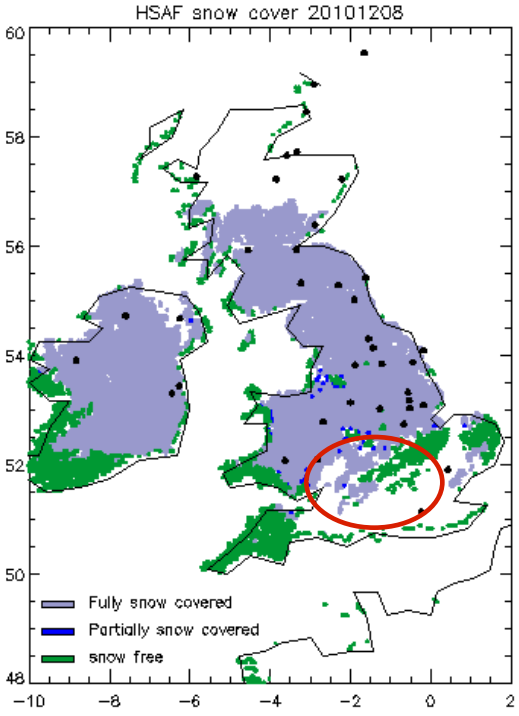
Product	Strengths	Weaknesses	Potential assimilation?
NOAA/NESDIS IMS	All points valid data Already processed in MO system Operational, nrt	4km resolution Validity time-delays	 Not UK
H-SAF SC (SEVIRI)	High temporal sampling (cloud reduction) Whole winter UK coverage Operational, nrt	3-4km resolution No global coverage	
GlobSnow SE (AATSR/ATSR-2)	High spatial resolution Better cloud reduction in weekly aggregate	Historical – validation only No UK coverage mid-Nov to mid-Feb High proportion cloud-affected	No
GlobSnow SE (VIIRS then Sentinel)	High spatial resolution nrt Better cloud reduction in weekly aggregate	1-2 day delay No UK coverage beginning Nov – end Jan High proportion cloud-affected	No
CRYOLAND (MODIS, then Sentinel)	Very high spatial resolution nrt	UK coverage? High proportion cloud-affected	

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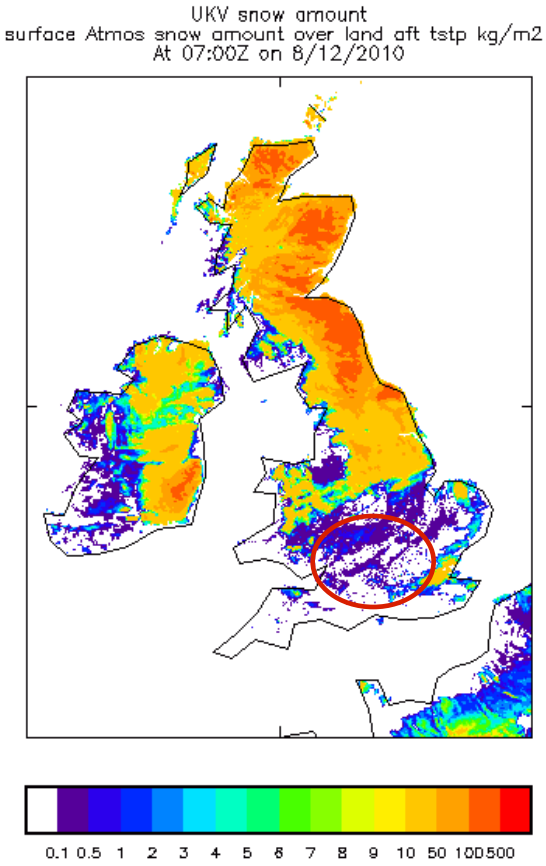
H-SAF snow cover

8th December 2010

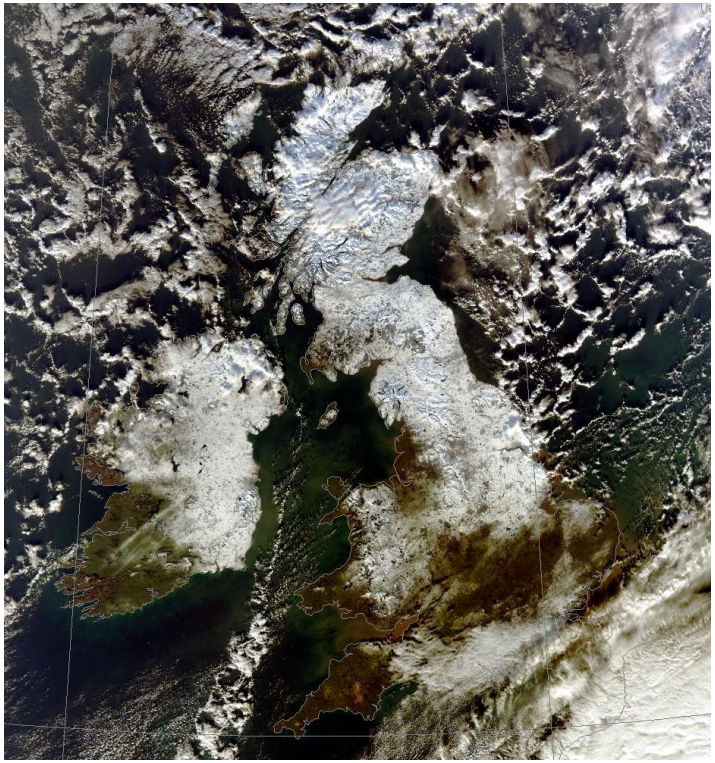
H-SAF snow cover



UKV model



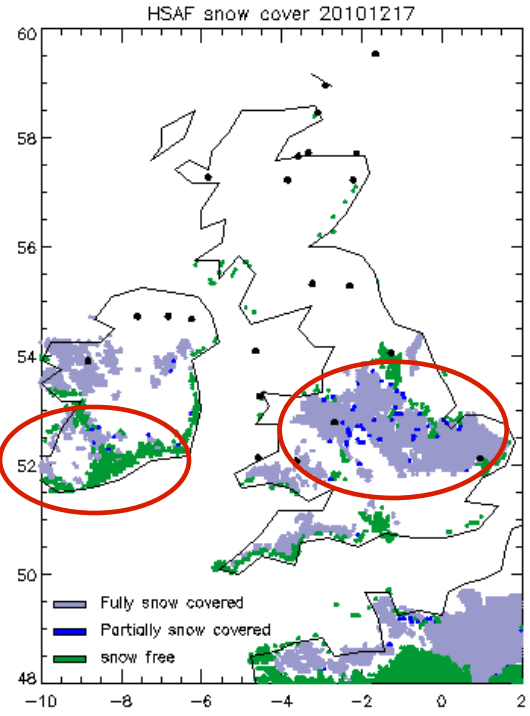
MODIS image



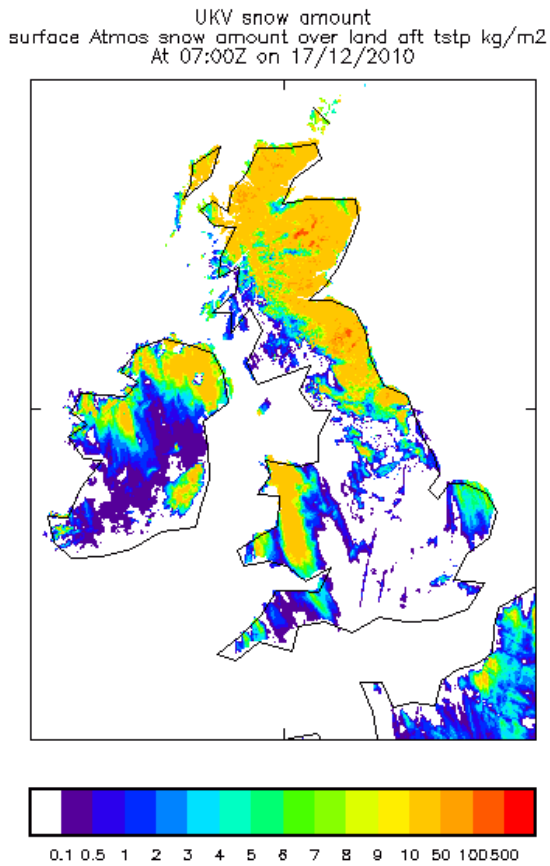
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17th December 2010 – after recent snowfall

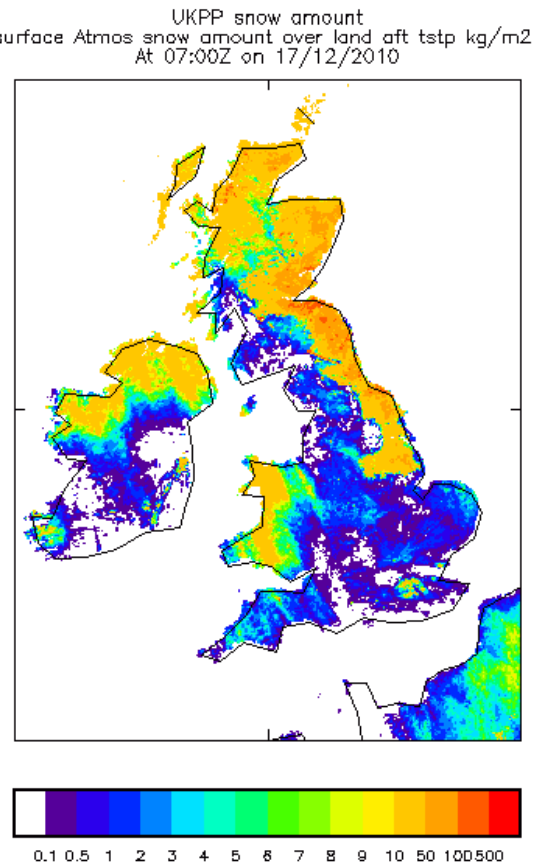
H-SAF snow cover



UKV model

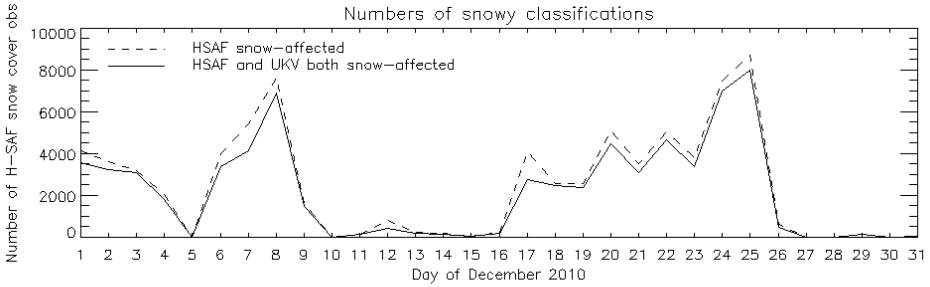


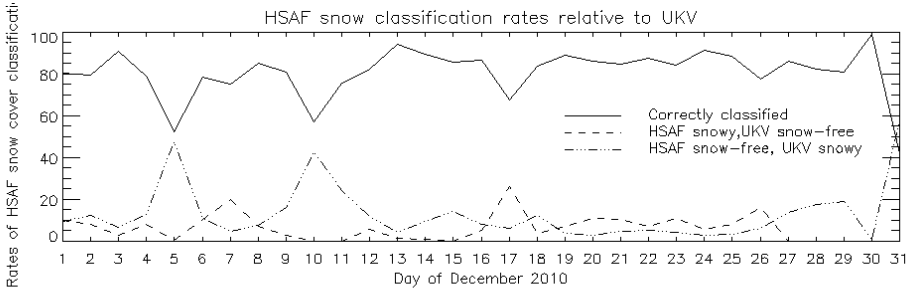
UKPP nowcasting

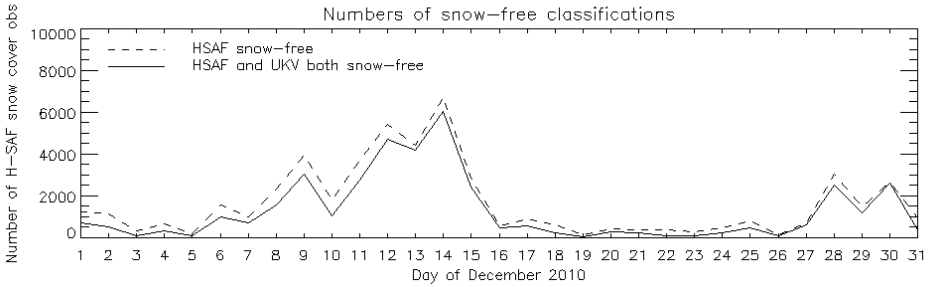


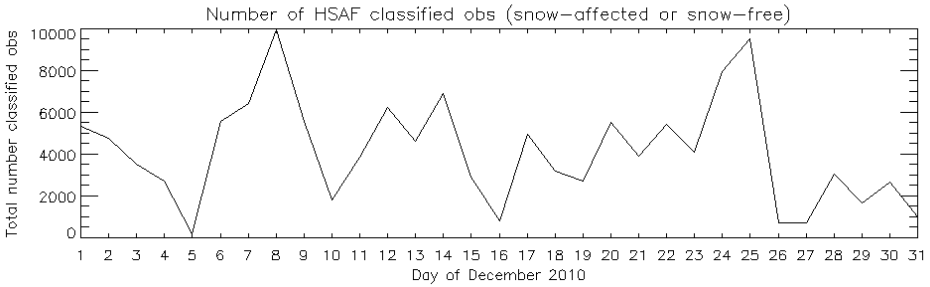
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H-SAF Classification rates relative to UK model









Correct classification rate (snowy and snow-free) = 80.8 %

Overestimation rate = 6.2 %

Underestimation rate = 13.1 %

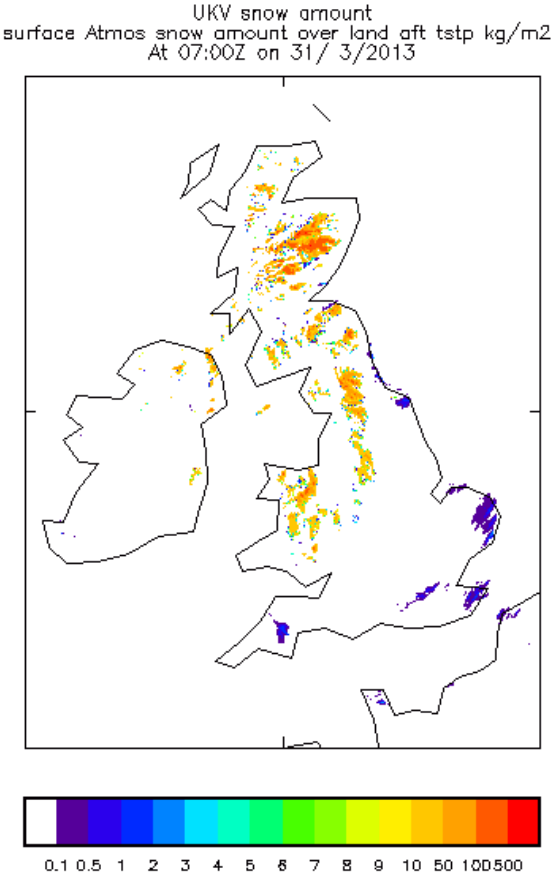
Percentage of snow-affected classifications that are correct = 86.8 %

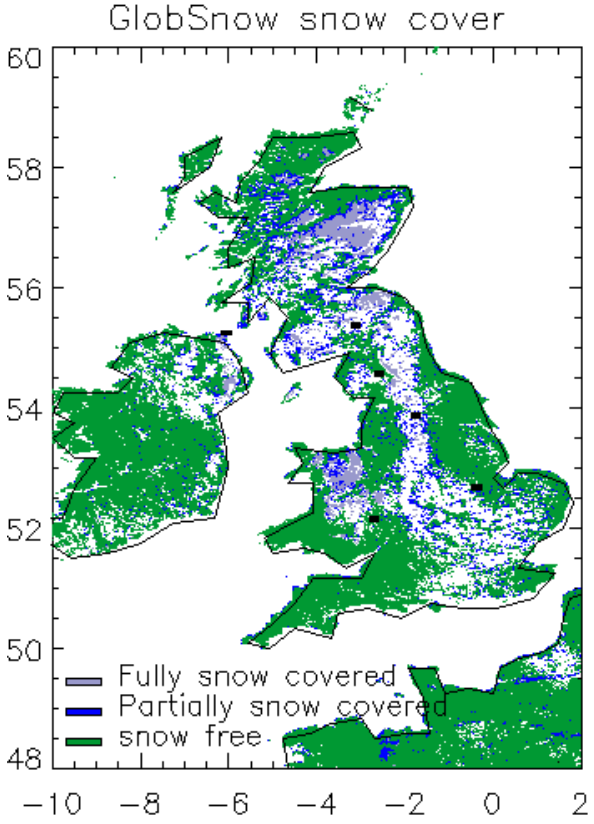
Percentages of snow-free classifications that are correct = 63.6 %

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GlobSnow VIIRS

Weekly aggregated fractional snow cover for 31st March 2013.





0-2% snow-free

2-50% partially snow covered

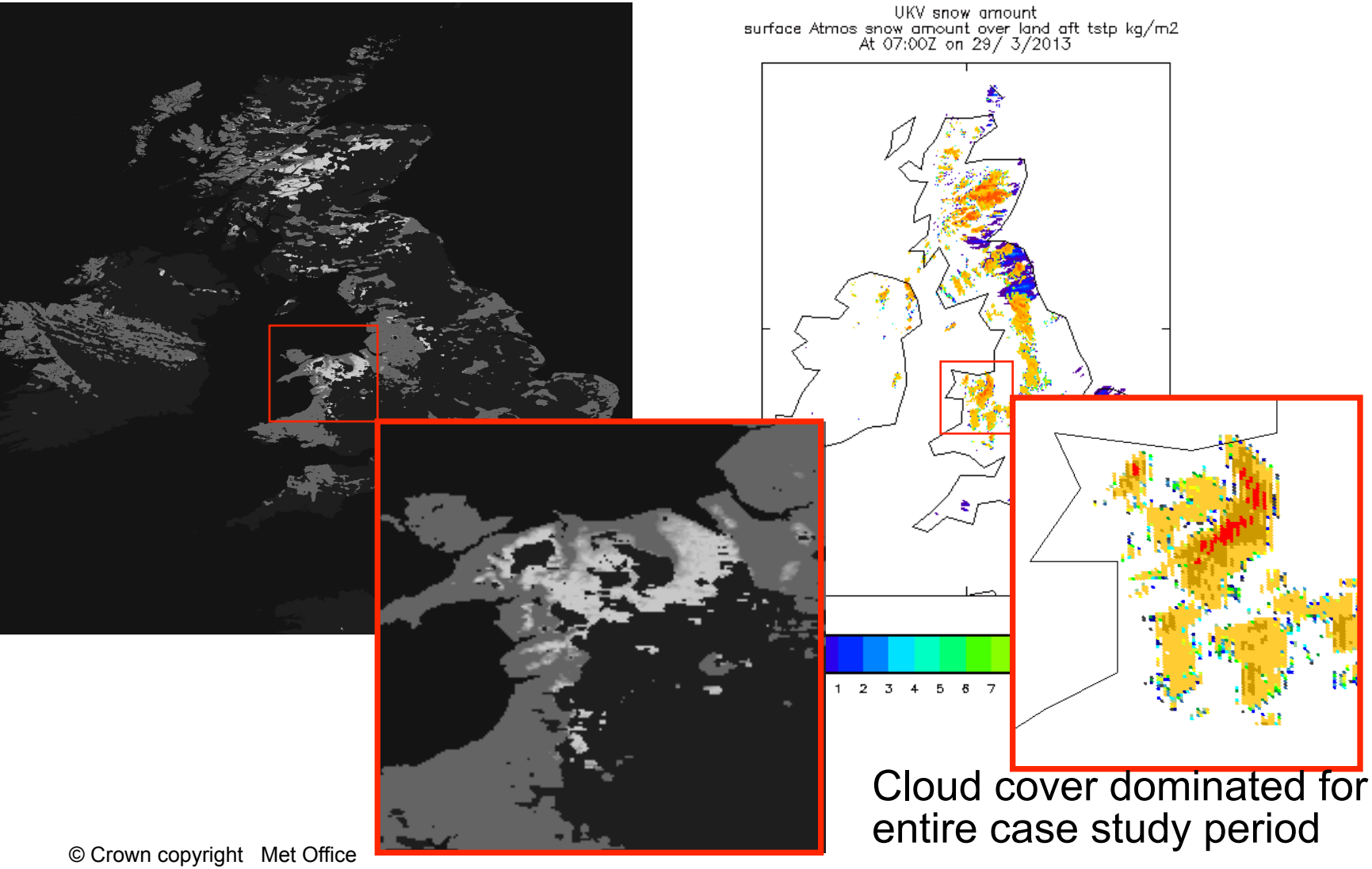
50-100% fully snow-covered

Large proportion of snow-affected area covered by cloud, even in weekly aggregate

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CRYOLAND Pan-European fractional snow extent

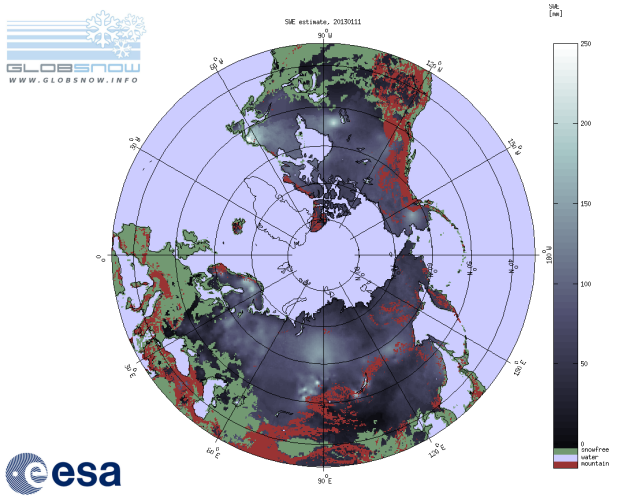
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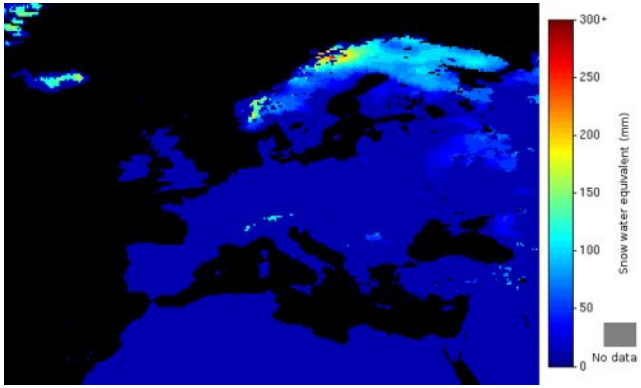


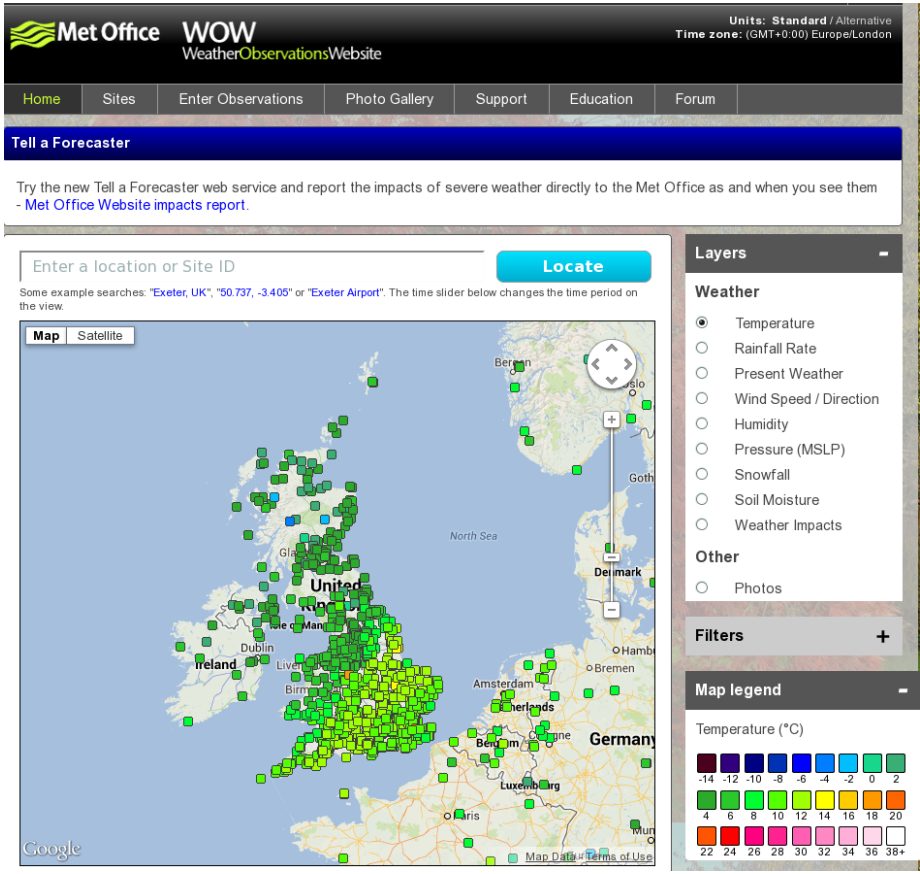
Cloud cover dominated for entire case study period

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Potential sources of snow depth data



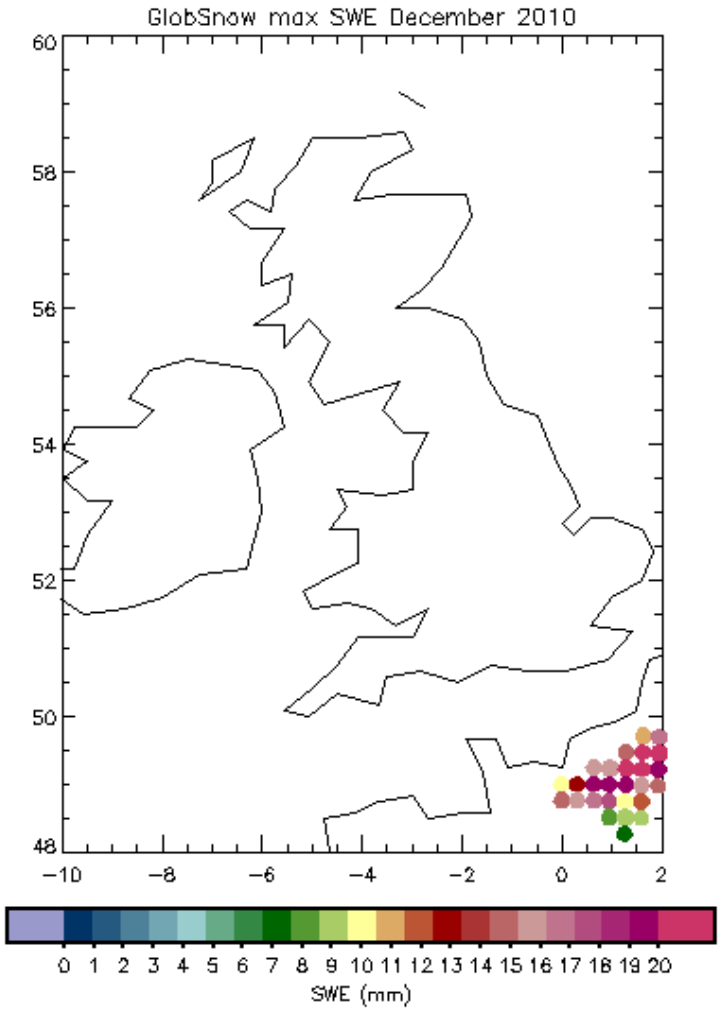


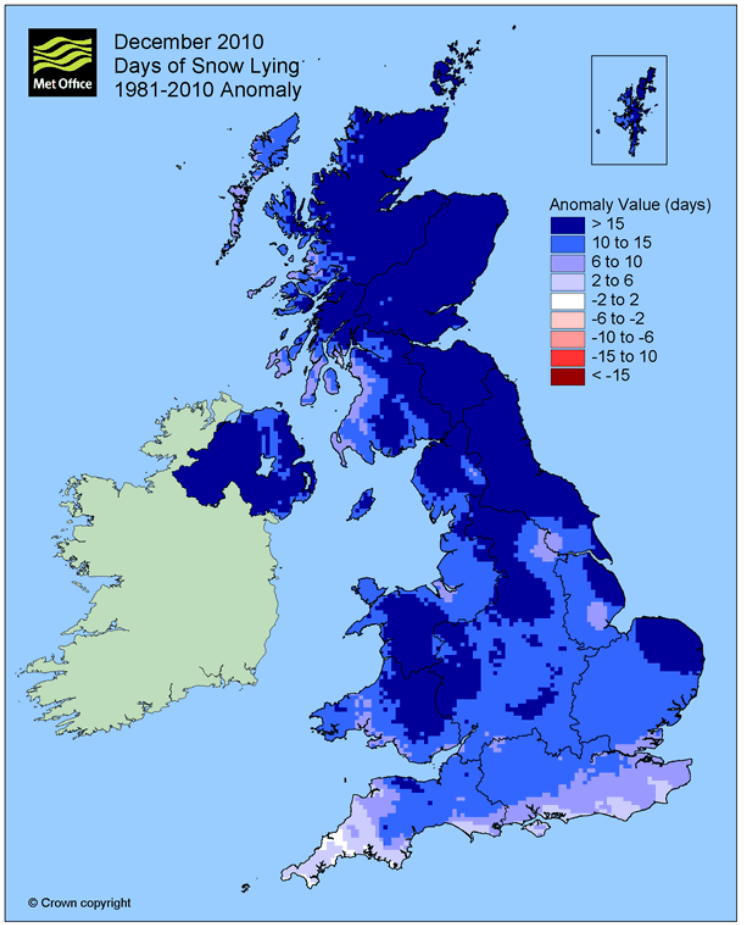


GPS receivers – modulation of GPS signal to measure snow depth

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GlobSnow Snow Water Equivalent
December 2010





Influence of Synops?

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Conclusions

- UKPP nowcasting system snow analysis would not provide significant value to the UKV NWP model
  - UKV snow performs better overall than UKPP snow, with respect to in situ observations, for both snowy periods studied.
  - UKPP is as good or better immediately after snowfall but treatment of the lying snow is better in the UKV.
- Synop snow depth obs are suitable for assimilation and could provide improvements to forecast snow depth
  - Change in and regulation of reporting practice to report zero snow would be beneficial
- H-SAF snow cover product promising for assimilation – good classification rates
  - Global coverage would be very welcome for use in global model

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Conclusions

- GlobSnow snow extent useful validation data, but not currently suitable for UK assimilation
  - solar zenith cutoff too low, too much cloud-affected data
- GlobSnow SWE not able to detect UK snow – too wet? SAR may be better?

Next steps…

- New UK snow assimilation system
  - Synop snow depth reports
  - Satellite snow extent (H-SAF)
  - Optimal interpolation (ECMWF)
  - Other ground-based snow depth obs to supplement Synop
  - Extend to global model in time

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Thank you for listening

7th EARSeL Workshop SIG Remote Sensing of Land Ice and Snow, 3-6th February 2014