Using satellite-derived land surface characteristics for land surface analysis at the UK Met Office

Samantha Pullen

Gabriel Rooney , Brett Candy, Imtiaz Dharssi, Keir Bovis, Lizzie Good, Malcolm Brooks, Penny Boorman, Debbie Hemming

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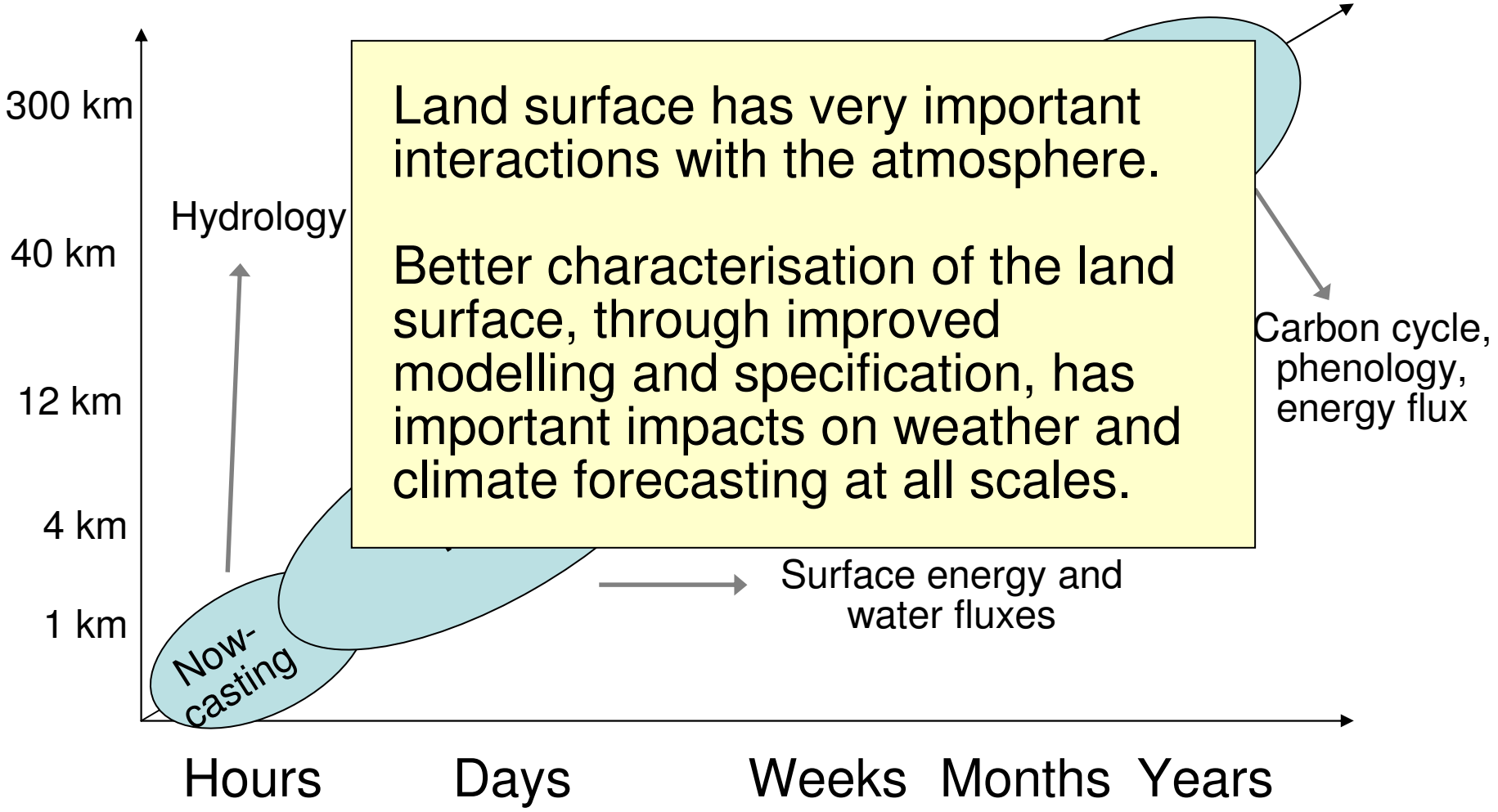
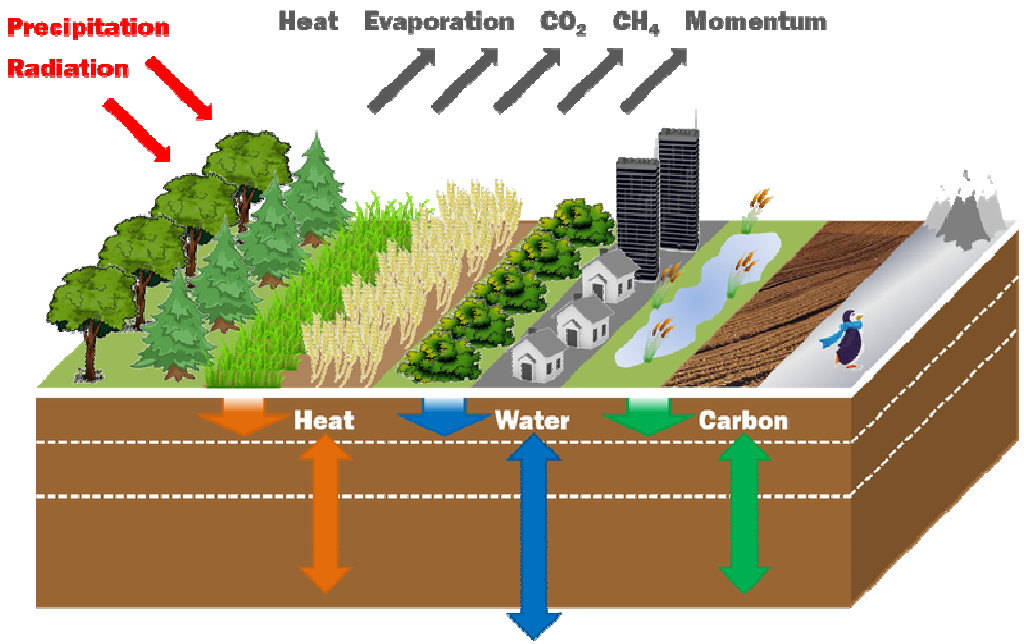
- Summary

Met Office Seamless Forecasting



JULES - Surface exchange model



- Multi-layer land surface model
- Multi-layer snow model
- Lake model
- Urban
- Fire
- River routing scheme
- Dynamic vegetation model
- Phenology
- Tiled sub-grid heterogeneity

Coupled to atmospheric model at lowest atmospheric level

Use of land surface observations

Land surface analysis

- Data assimilation for operational f/c e.g. snow, soil moisture
- Ancillary data – climatology, fixed data for initialisation e.g. albedo, LAI
- Reanalysis – historical dataset, modern DA

Validation and monitoring

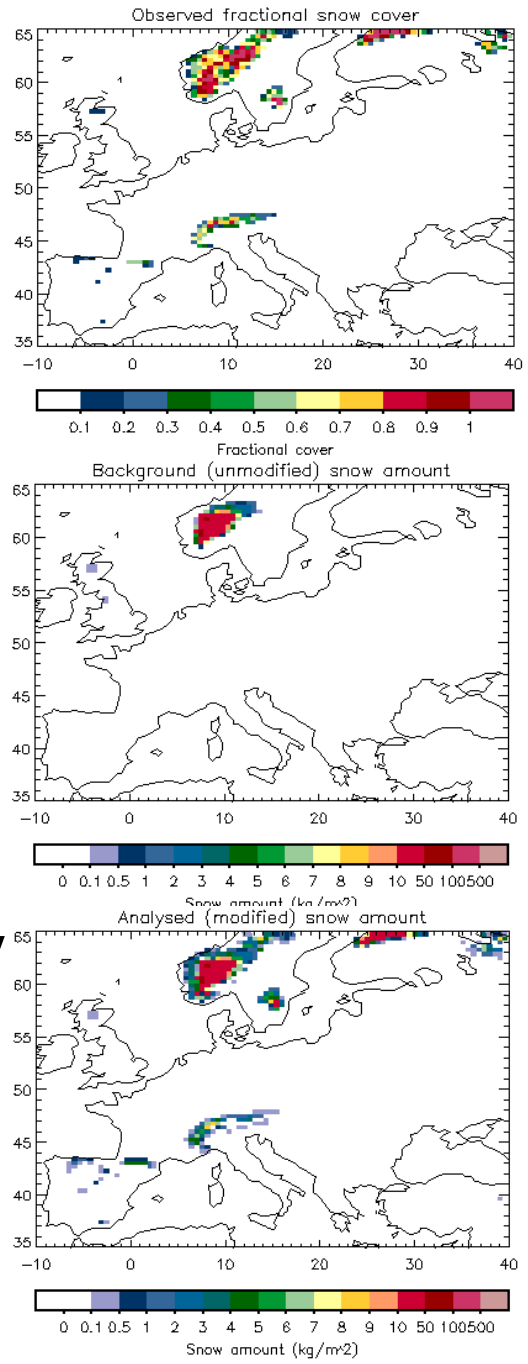
- f/c verification with independent data
- Climate model validation e.g. plant responses to climate change
- Continuous climate data for climate monitoring e.g. land-use, snow cover, rainforest degradation

- Driving data for offline JULES runs for climate modelling studies e.g. soil moisture
- Understanding physical processes through analysis of observational datasets

Snow

Pullen, Rooney

10-11-2008



- Analysis operational since 2008
- NESDIS Interactive Multisensor Snow and Ice Mapping System (IMS)
- Daily 4km NH snow cover, variety of sources
- Used to adjust model snow where IMS and model first guess disagree as to presence of snow
- Average IMS snow cover onto UM grid to create fractional cover
- To add snow, relate fractional cover to areal density using

$$S = (- \log_e (1 - f_c)) / D$$

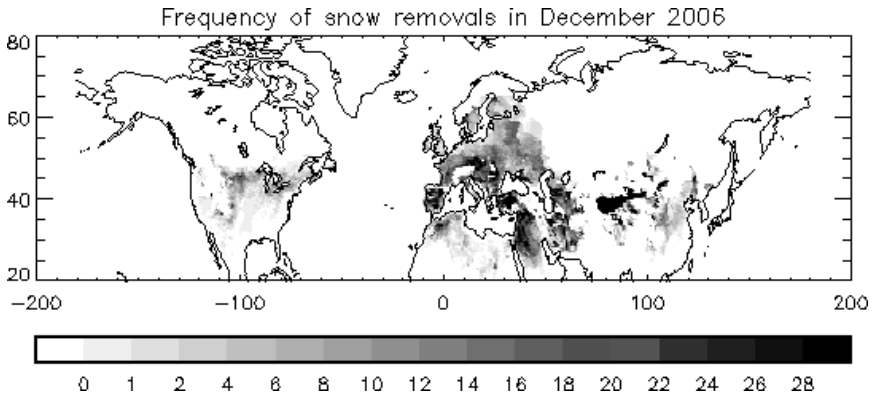
Performance of the snow analysis

Improved analysed snow cover verified against SYNOP snow reports

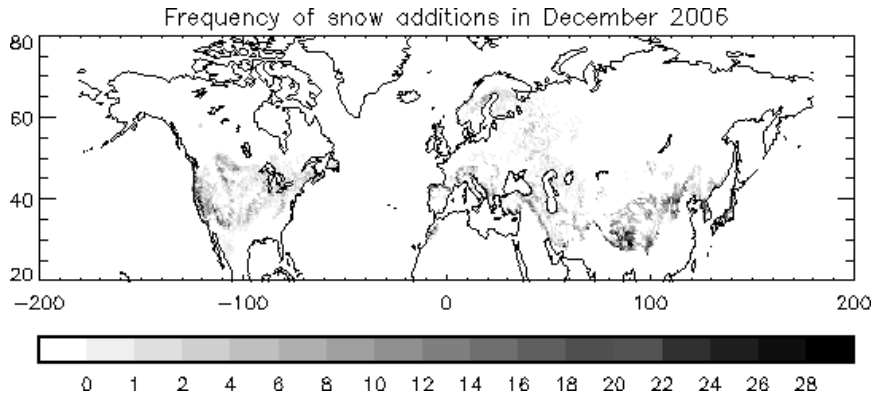
Some improvement to screen level temperature and humidity forecasts, especially where snow removed

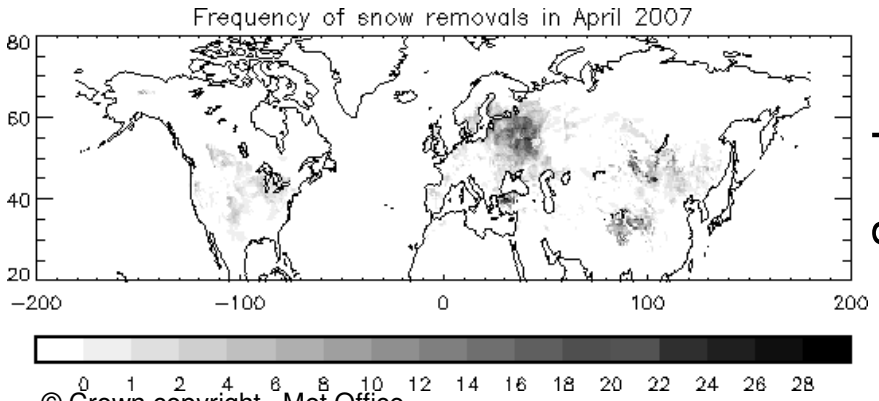
Snow removed

Snow added

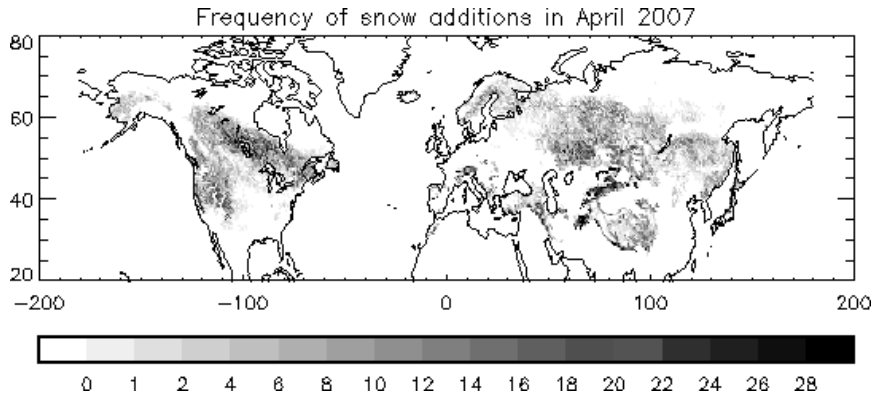


Winter

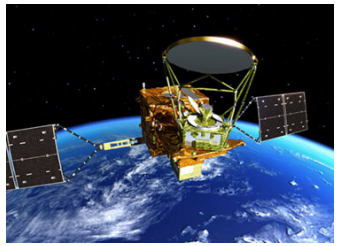


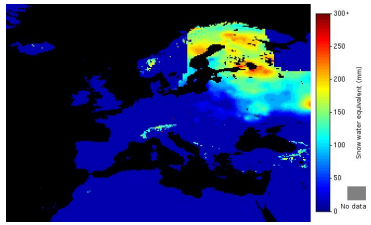


Spring



Plans for snow



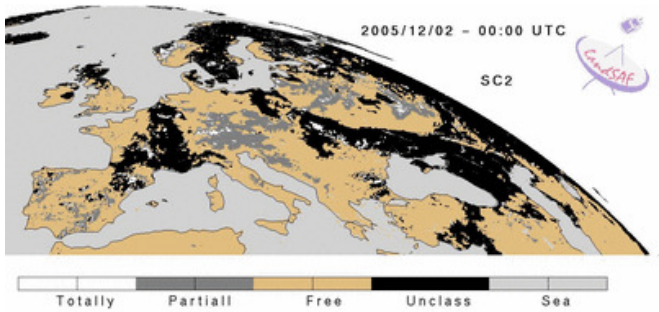


SWE

AMSR-2?

H-SAF?

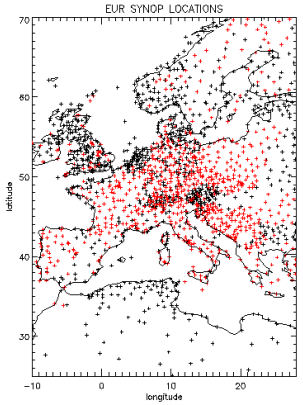
To evaluate as potential assimilation candidates



Snow cover

LSA-SAF for UK assimilation

Global coverage planned? Would like to replace IMS as data source in global model



Snow depth

SYNOP snow depth obs

Project to validate this summer

Potential assimilation

Analysis

Develop more sophisticated snow analysis making use of both snow cover and snow depth obs from different sources

EKF longer term

Soil moisture

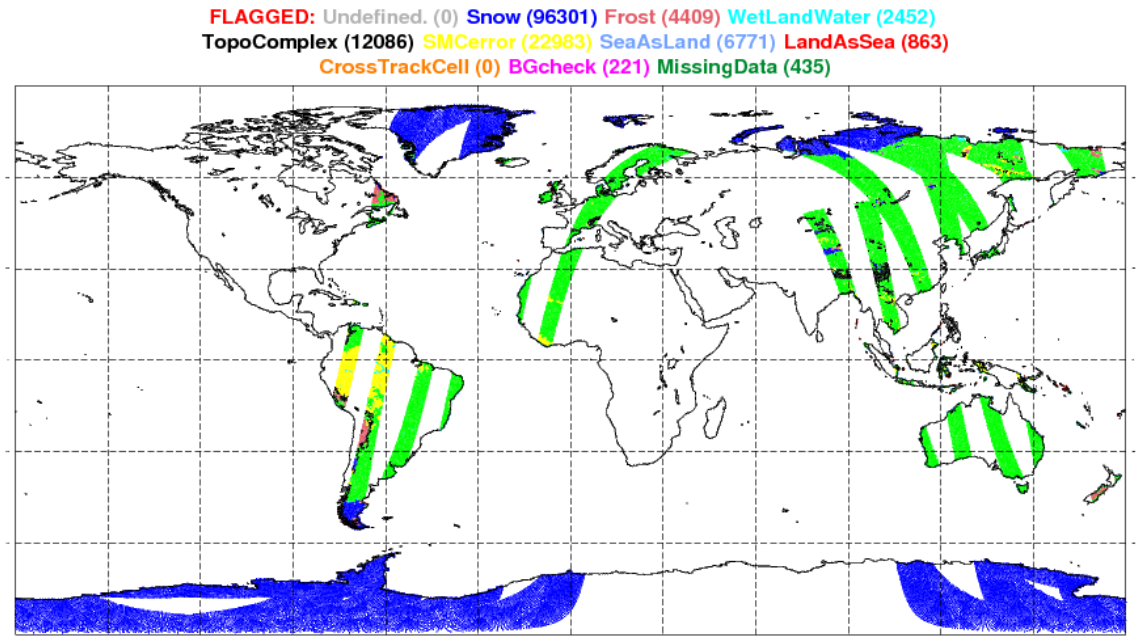
Candy, Dharssi, Bovis

Analysis of soil moisture content

- Screen errors of humidity and temperature
- Satellite estimates of surface soil moisture
  - ASCAT L2 soil wetness product (Metop - Eumetsat)
- Extended Kalman Filter 6-hourly (implemented 2013)
  - Uses perturbed JULES runs

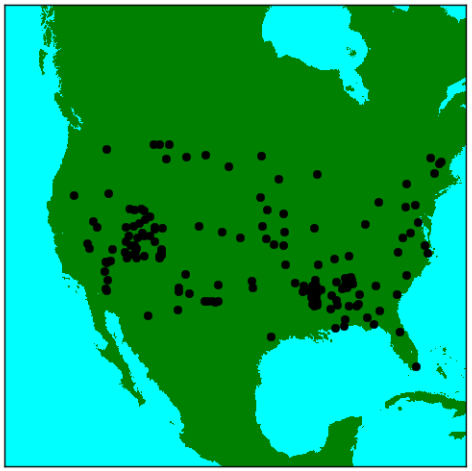
ASCAT observations rejected:

- Over snow and frozen surfaces
- Complex topography
- Inland water
- Large associated observation error



Impacts versus Independent data

Level 1 **soil moisture** compared to the US SCAN network: three month run Aug-Nov



Run	Bias (m3/m3)	Standard dev diff (m3/m3)	Correlation
Nudging	*-0.064*	*0.045*	*0.66*
EKF	*-0.052*	*0.044*	*0.68*

- Small improvements in soil moisture error vs in situ data
- Most of impact in top soil layer
- Results of impact trials largely neutral.
- Background errors to be reviewed
- Also analyse soil temperature

Land Surface Temperature

(NWP) Candy

- *Model assessment* – how realistic is the near surface temperature of the forecast model over different surfaces? Potential improvements to the land surface model parameters
- *Assimilation* – LST has the potential to improve both the soil temperature and soil moisture analyses
- In both applications geo (resolution) and polar (coverage) are useful. Also quality flags and indication of error with the retrieval
- LSA-SAF LST product is currently being assessed as potential data source
- Future candidate for EKF assimilation

Comparisons of SEVIRI LSA SAF with In Situ Radiometer located at Cardington , UK

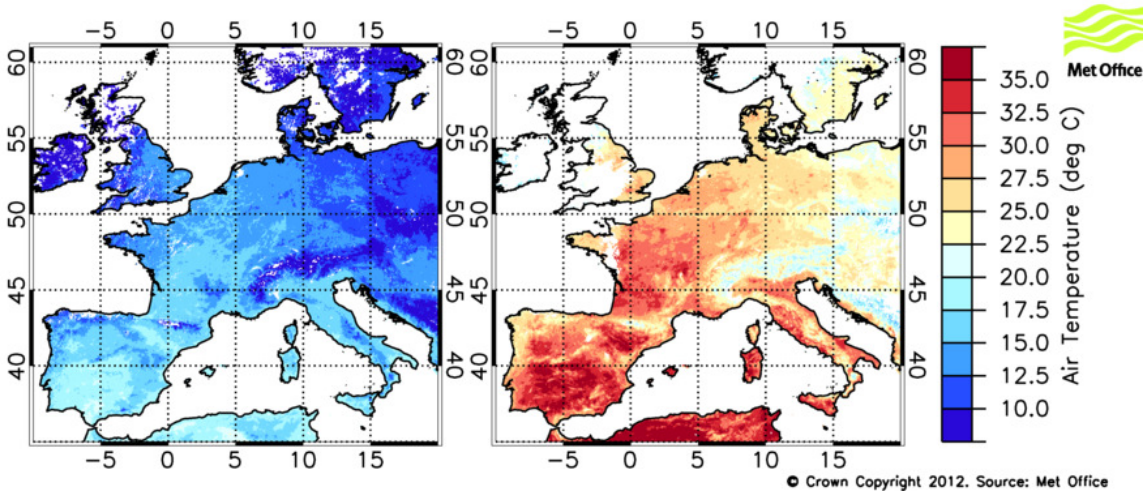
- 1 Years worth of data 2012 from SEVIRI compared with LST measurements from Met Office observation site at Cardington. A rural site at 52ºN
- Correction needs to be applied to obtain skin temperature from in situ radiometer measurements.
- SEVIRI LST processed into 3x3 supercells. Night time results

Number of clear pixels	**Number of collocations**	**SEVIRI LST – Cardington LST**		**Correlation coefficient**
		Mean (K)	**Sd (K)**	
1+	647	-2.10	3.11	0.94
5+	430	-1.31	2.59	0.96
8+	317	-0.87	2.32	0.97

Results suggest that SEVIRI observation error is 2K (taking into account uncertainties in *in situ* LST)
Similar results found with other sources of LST

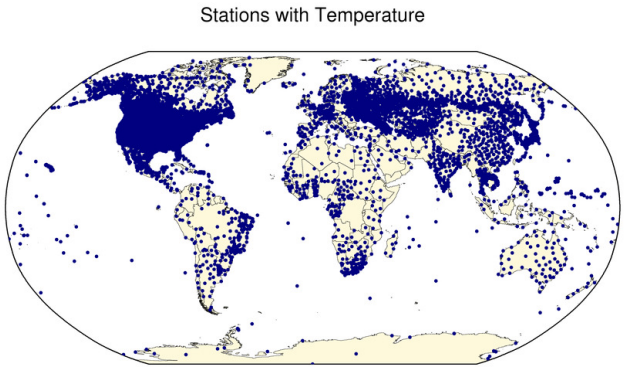
Land Surface Temperature

(Climate) Good



Heat stress

- Monitoring extremes of weather, e.g. heat waves
- LSA-SAF LSTs
- Real-time monitoring



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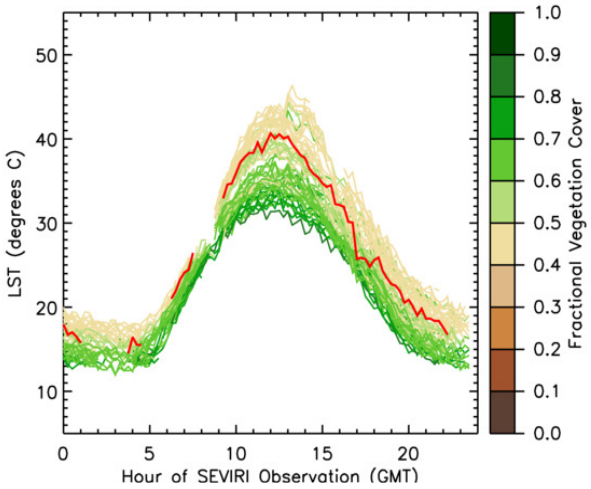
Climate data records

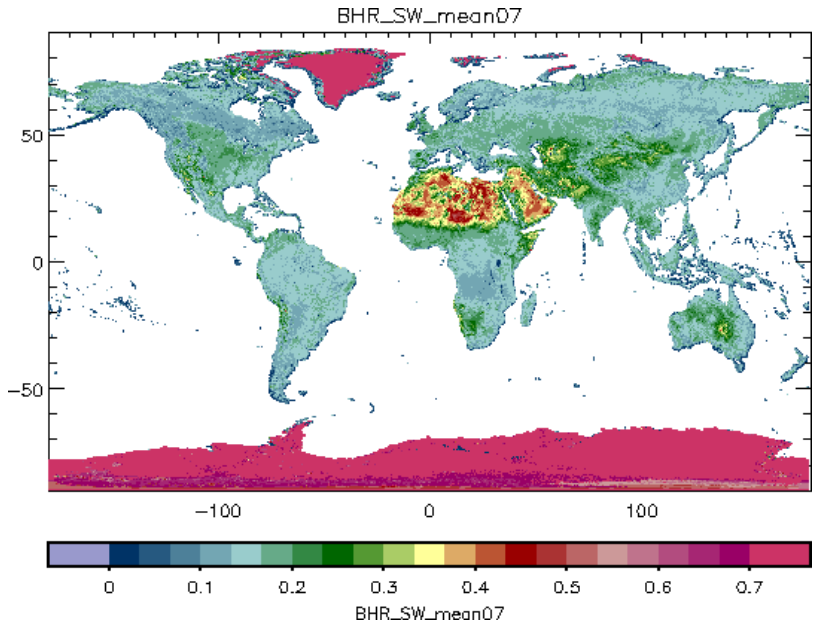
- 'Infill gaps' in current in situ data sets
- Completing timeseries of station data, using pixel-to-pixel temperature relationships

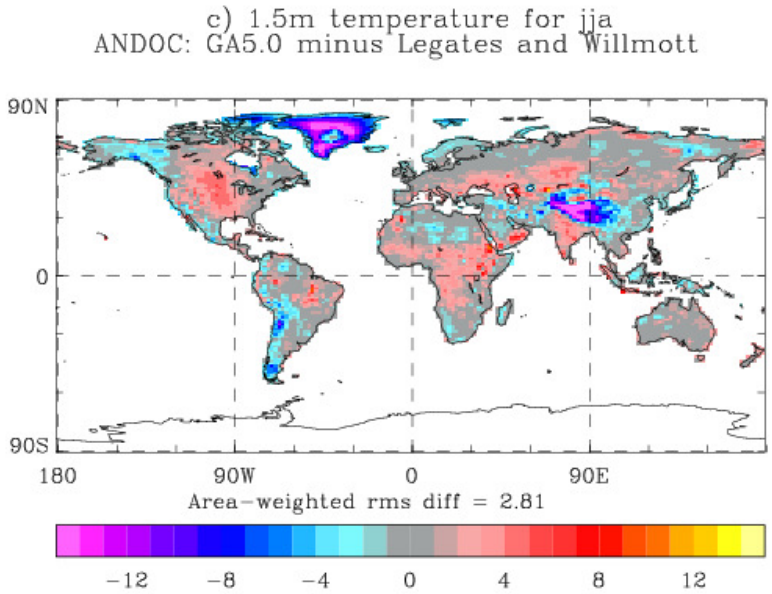


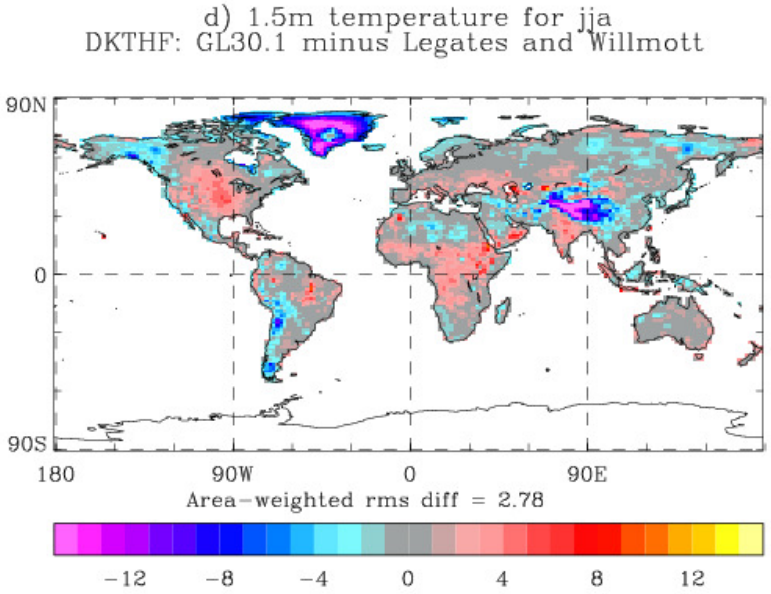
Albedo

Pullen, Brooks

- New monthly climatology derived from GlobAlbedo (ESA)
- Snow-free, meaned over 10 years
- SW broadband, and VIS and NIR
- Improvement in summer warm bias (1.5 m T)



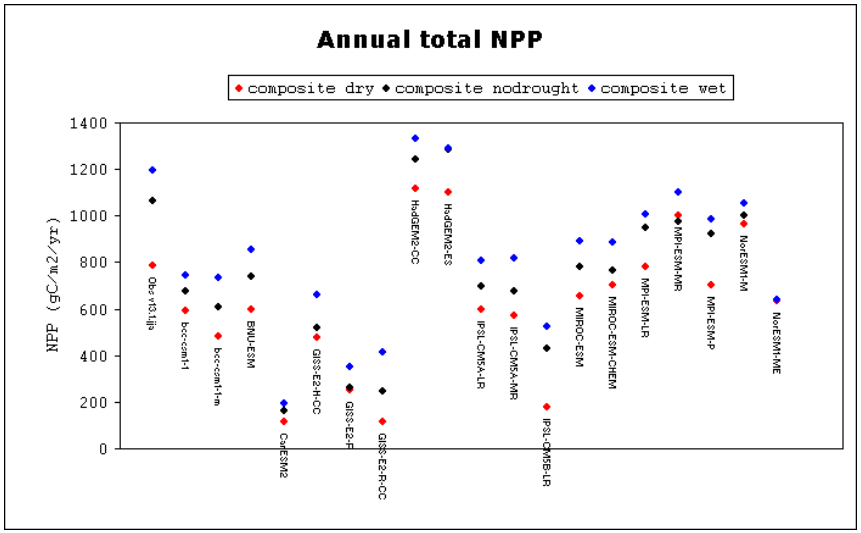


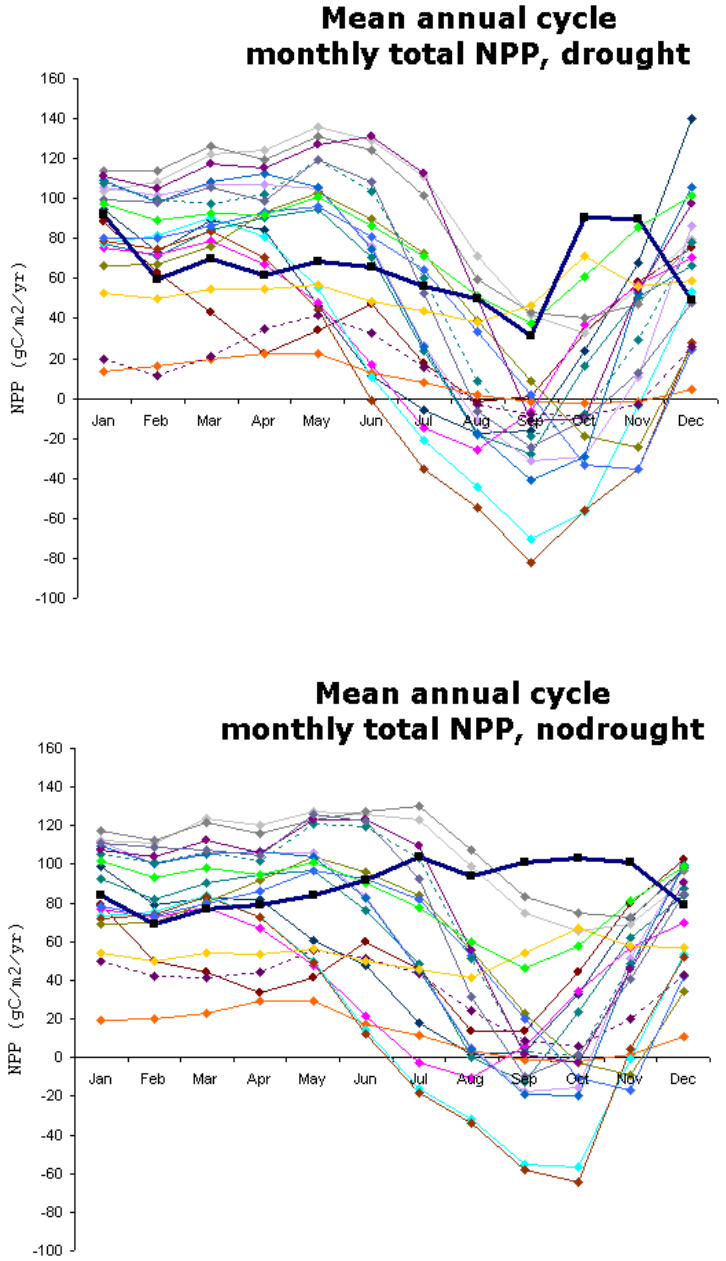


Net Primary Productivity

(Boorman, Hemming)

- Understanding plant responses to climate changes
- Observations from MODIS NPP monthly dataset (9yrs)
- Model data from CMIP5 (100yrs baseline)
- Dry/'Nodrought'/Wet composites
- Eastern Amazon domain





Others…

- Leaf Area Index - monthly climatology of MODIS LAI (2005-2009) used as ancillary data in NWP
- LAI and NDVI – phenological responses to climate change
- Fire radiative power – validation data for developing JULES fire module

Summary

- Development of land surface modelling and data assimilation now high priority in NWP.
- Land surface responses are understood to be at least as important as cloud feedbacks in the climate system.
- Requirement for land surface products for real-time, operational assimilation, ancillary data, validation, monitoring, driving climate models, understanding physical processes, and for reanalysis.
- LSA-SAF products are being used in climate area. NWP area has plans to start making use of some in data assimilation systems. Global coverage would be a huge benefit.

Questions