Land Surface Data Assimilation: Current Status

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Global soil moisture analysis

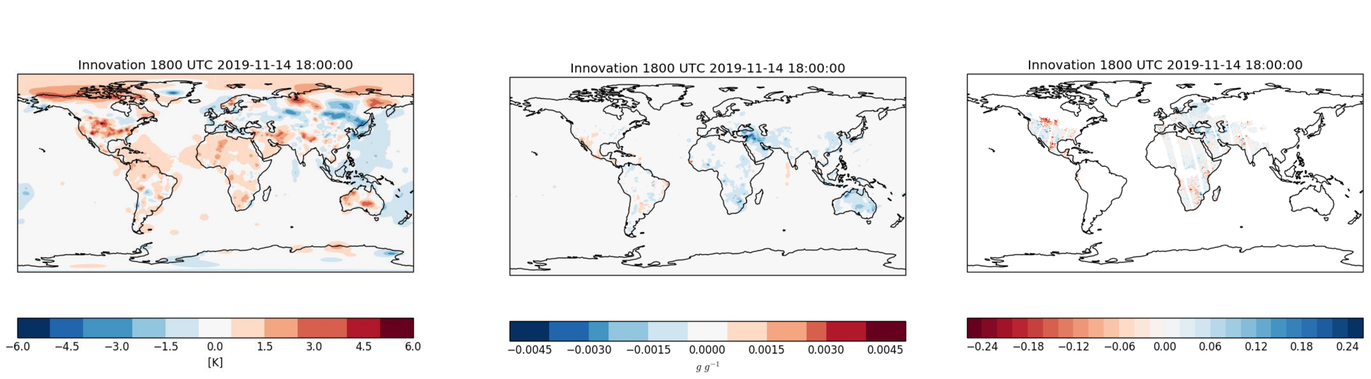
via **S**implified **E**xtended **K**alman **F**ilter with 6-hourly cycling.

$$x^a = x^b + K\left(y - \mathcal{H}(x^b)\right)$$

$$K = \mathrm{BH}^T(\mathrm{HBH}^T + \mathrm{R})^{-1}$$

Observations assimilated:

- Pseudo-observations of 1.5m temperature and humidity computed using 3DVar on surface observations
- Soil wetness (SW) product from ASCAT aboard MetOp-A, B and C platforms.



ASCAT SW is interpolated to the model grid using an inverse distance weighting scheme.

ASCAT SW is converted to soil moisture content (θ) and bias corrected via first-moment scheme. The dynamic range (DR) of the model soil moisture climate for top layer and of the ASCAT product is used to rescale the SW anomaly which is then added to the model soil moisture mean.

$$\theta_{ob} = \overline{\theta_{model}} + \frac{\theta_{model\ DR}}{SW_{ob\ DR}}(SW - \overline{SW})$$

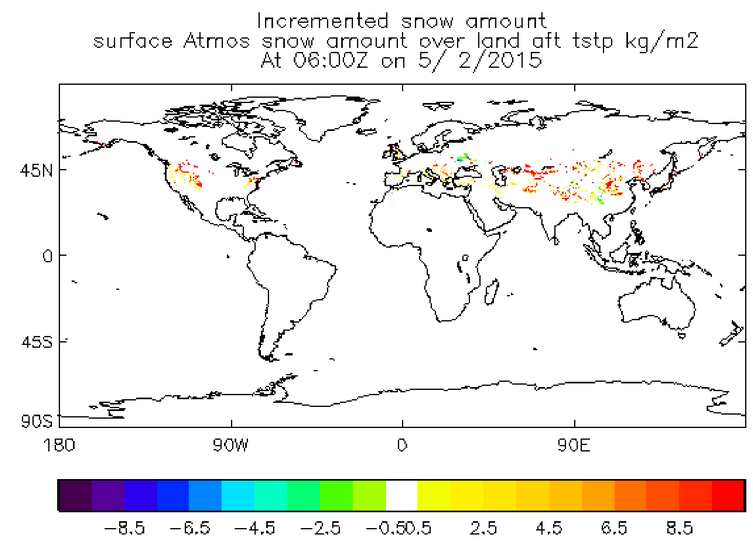
JULES (**J**oint **U**K **L**and **E**nvironment **S**imulator) community land surface model is used with 4 soil layers of thickness: 0.1, 0.25, 0.65 and 2.0 m.

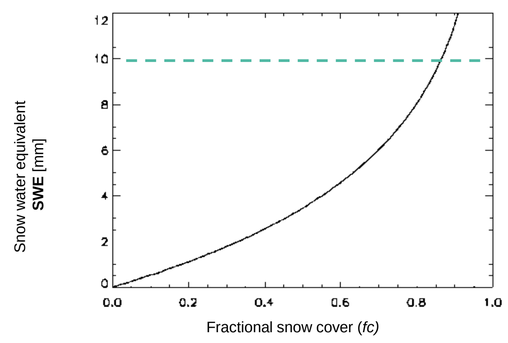
Global snow cover analysis created daily using a logical scheme.

Observations assimilated:

- NESDIS Interactive Multi-sensor Snow and Ice Mapping System (IMS)
- Daily binary snow cover product
- 4 km resolution in Northern Hemisphere

IMS binary snow cover used to calculate fractional cover per model grid box. Empirical relationship relates fractional cover to snow amount (kg m^{-2})





$$SWE = \frac{[-\ln(1 - fc)]}{D}$$

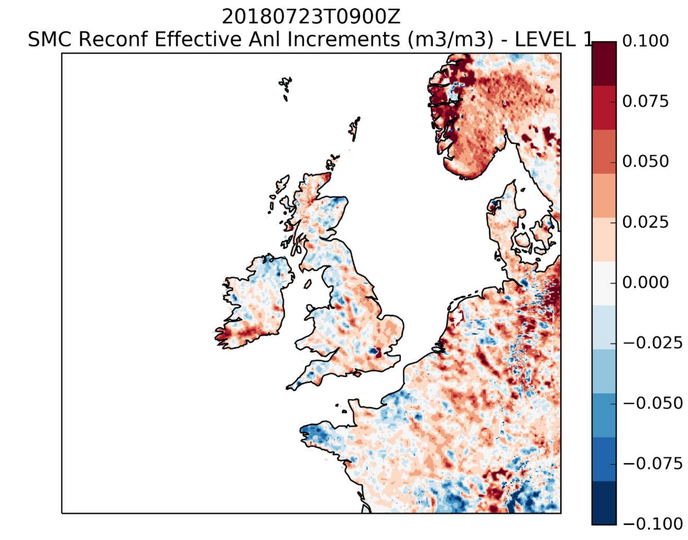
D = masking depth of vegetation (0.2 m^2 kg^{-1})

To create analysis of snow amount:

- Add snow where observation is snow-covered and model is snow-free using empirical relationship to relate fractional cover to snow amount.
- Remove snow where observation is snow-free and model is snow-covered.
- IMS snow product may contain data up to 36 hours old and observation of a snowfall event may be delayed which could lead to incorrect removal of snow. Where the model forecasts a snowfall event well, IMS data may compare better with the previous day's background than the current one. In cases of snow removal, we compare IMS data to previous day's model background snow to confirm whether the model evolution is correct, and if they compare well, *snow is not removed.*
- Snow amount analysis is interpolated into global model at 6Z.

Regional soil moisture analysis

via interpolation of the global soil moisture analysis daily into the UK domain.

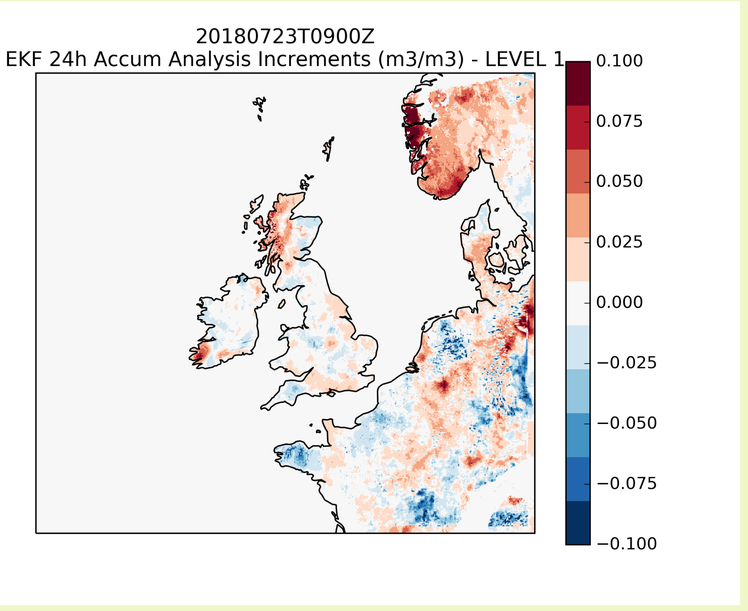


The UK convection-permitting, variable resolution model (UKV) then evolves the land surface according to JULES physics.

Upcoming developments and research

*Regional (UKV) Soil moisture analysis**

- ***About to become operational***, soil moisture analysis via **S**implified **E**xtended **K**alman **F**ilter with hourly cycling assimilating observations:
  - Pseudo-observations of screen temperature and humidity from 4DVar atmospheric analysis and
  - ASCAT soil wetness product.



*Regional (UKV) snow depth analysis***

We are evaluating snow depth (SD) analysis created with optimal interpolation assimilating observations:

- SD > 0 from ground-based Synop network and SD = 0 from snow-free state-of-ground report and
- H-SAF daily snow product from MSG-SEVIRI.

Global and Regional (UKV) land temperature analysis

Improvements to bias correction of observations and soil moisture climatologies

See talks on Wednesday 27 November 2019:

***Impact of UKV soil moisture data assimilation on potential operational forecast of river flows** Breo Gomez

****Development of snow depth assimilation for the Met Office UK forecasting system** Sam Pullen

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