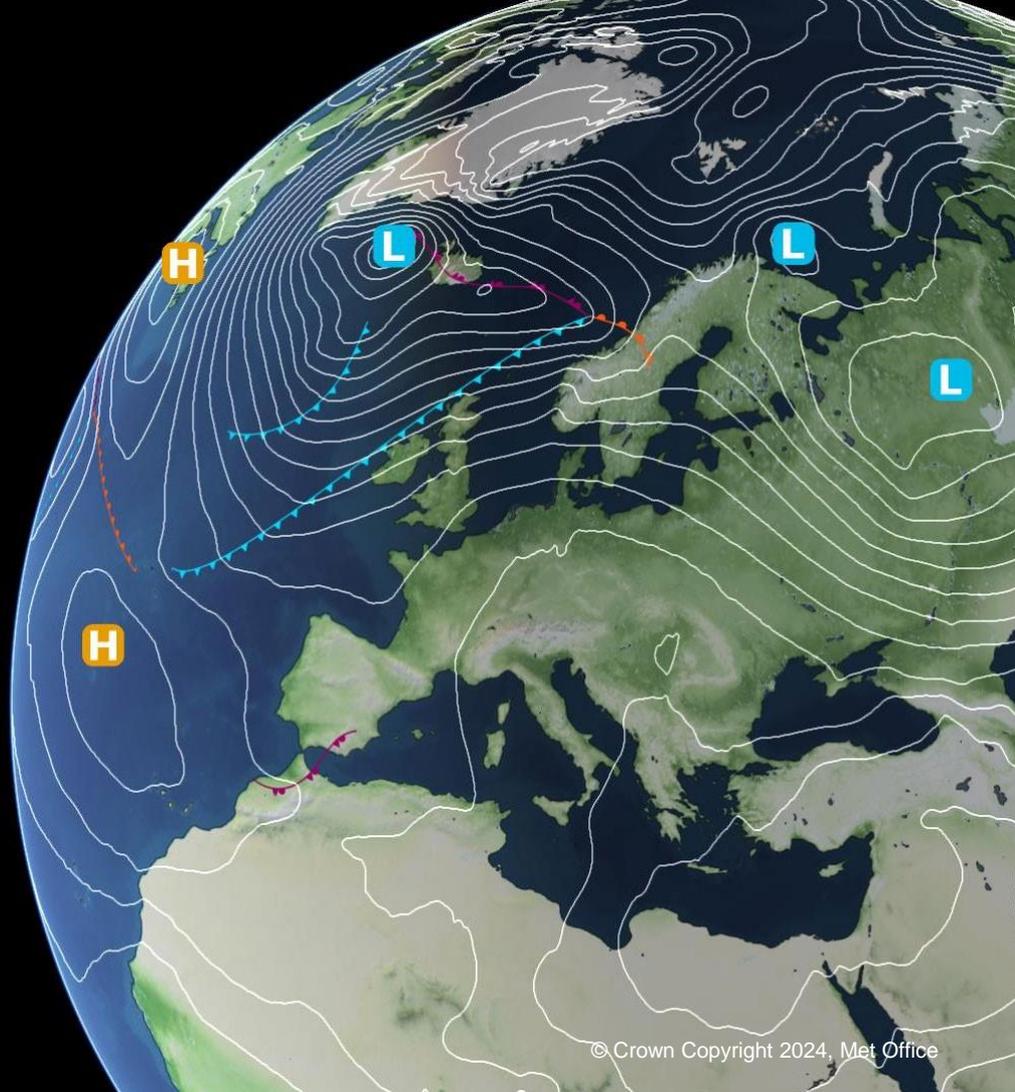![Met Office]

Current and Future Regional (UKV) Land Surface Data Assimilation

Cristina Charlton-Perez

Samantha Pullen
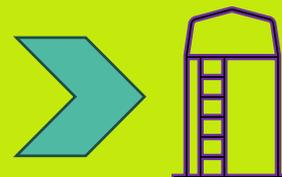
EWGLAM-SRNWP

1 October 2024

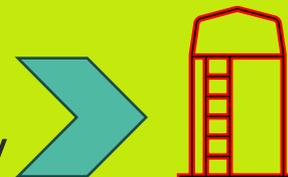# SURF: Current operational Regional **L**and **S**urface **D**ata **A**ssimilation (LSDA) system

- SYNOP Station snow depth
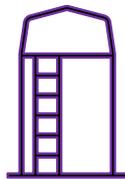- EUMETSAT H SAF Snow cover product H31

- ASCAT soil wetness product
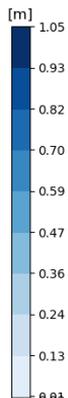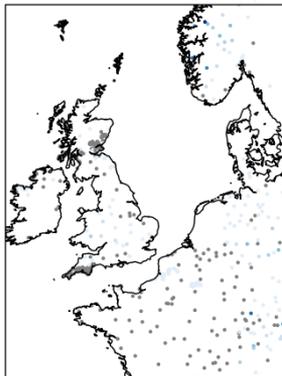- Pseudo-observations of near surface temperature and humidity

Operational Regional Snow DA

Met Office

Observations

Ground-based Synop network

- snow depth
- state of ground (snow or no snow)
- 4 times per day
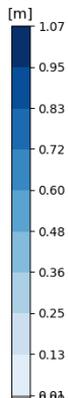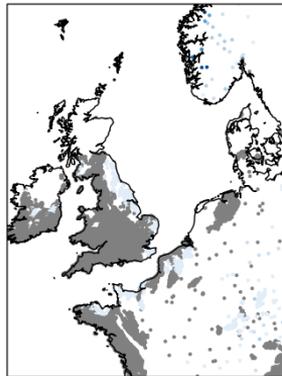
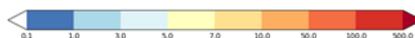**Satellite data from MSG-SEVIRI**

- H SAF daily snow cover product H31
- Once per day

"Observed" snow depth

(0.05 m snow depth from snow-cover product where model snow-free)

Background snow amount

2D Optimal Interpolation

Analysed snow amount

A Global Analysis of Snow Depth for NWP (Brasnett, 1999)
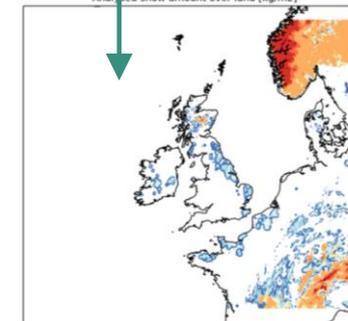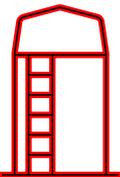
Operational Regional Soil DA

Observations

ASCAT soil wetness index
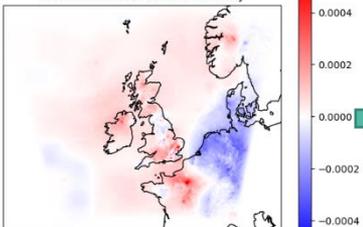
1.5 m Hum (Gridded)
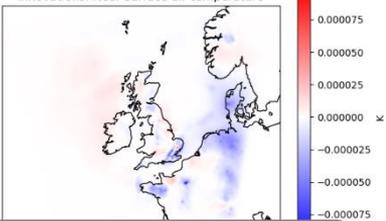
1.5 m Temp (Gridded)

1. ASCAT Bias Correction

2. Simplified Extended Kalman Filter

$$x_i^a = x_i^b + K_i[y_i^o - H_i(x_i^b)]$$

$$K_i = BH_i^T[H_iBH_i^T + R]^{-1}$$

- Column-based system (1D)
- JULES land surface model used to estimate Jacobian
- UKV regional analysis every hour

Analysed variables

- Soil T and moisture on 4 layers
- Snow T up to 3 layers and tiles
- Skin T on tiles
- Global: 9 tiles (1 urban)
- UKV: 10 tiles (2 urban)

The Met Office Operational Soil Moisture Analysis System (Gomez, Charlton-Perez, Lewis, Candy, 2020)
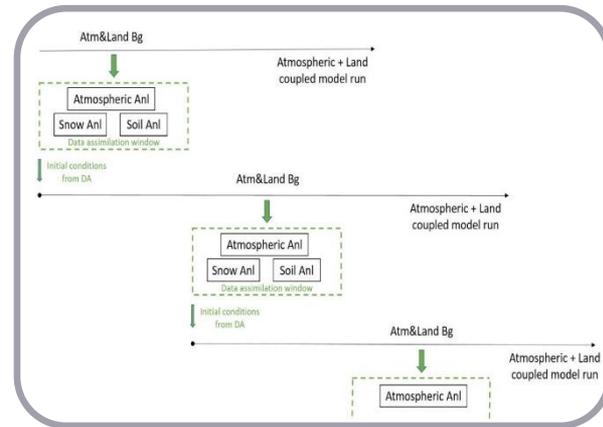
Impact of regional soil moisture DA on hydrological prediction

Output of offline routing of OS42 and PS43 runoff diagnostics using JULES RFM river routing code (default parameters) [Daily mean flows]

Severn at Bewdley

- Gauge obs (Daily Mean) [-2.32,52.38]
- OS42 (DM) (NSE=-5.39 Bias=145.88%)
- PS43 (DM) (NSE=0.45 Bias=30.49%)

Routing initialised from zero 17 July 2019
Flows simulated using JULES (FORTRAN) routines

Bush at Seneirl Bridge

- Gauge obs (Daily Mean) [-6.52,55.16]
- OS42 (DM) (NSE=-0.28 Bias=36.52%)
- PS43 (DM) (NSE=-0.02 Bias=8.11%)

Swale at Crakehill

- Gauge obs (Daily Mean) [-1.35,54.15]
- OS42 (DM) (NS=-3.20 Bias=84.09%)
- PS43 (DM) (NS=0.52 Bias=-0.82%)

Tamar at Gunnislake

- Gauge obs (Daily Mean) [-4.22,50.53]
- OS42 (DM) (NSE=0.21 Bias=54.85%)
- PS43 (DM) (NSE=0.56 Bias=-18.47%)

- Clear improvement to simulated river flows relative to observations using PS43 runoffs
- Substantial high bias when using OS42
- The basis of a hydrologically useful system?

Slide courtesy Huw Lewis   **For more see Gomez, et. al. (2020)**
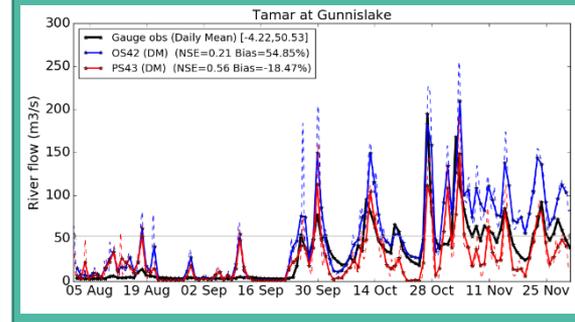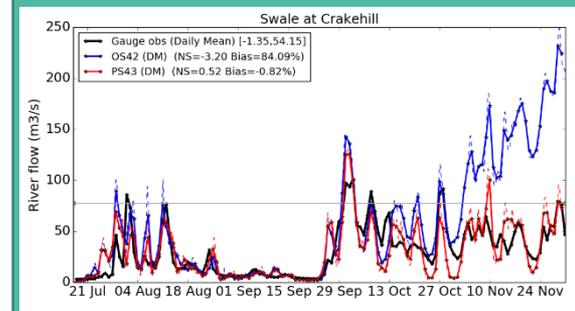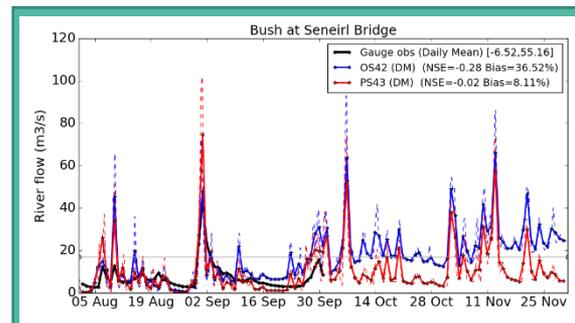
Met Office regional requirements

For the **regional UK system (UKV)** there is much greater focus on the representation of the land surface variables themselves in the analysis state, in particular soil moisture and snow depth for:

- Hydrological applications will become increasingly important so soil moisture assimilation (continuation and improvements to) should be a priority area for UK LSDA

- Urban scale modelling and hydrology – future requirement for high resolution LSDA

LFRic and the UKV
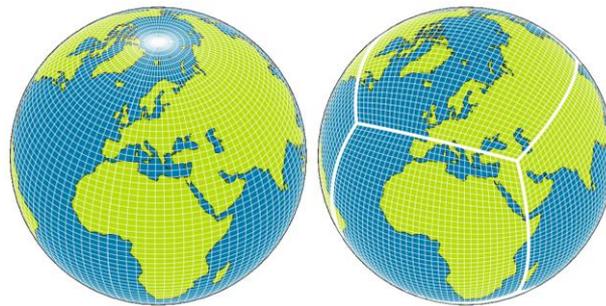
- The UKV will be moving to the cubed sphere mesh

- SURF is already able to operate natively on the LFRic mesh for the global model

- Some SURF code will need to be changed for the UKV

- Next generation LSDA will be working on LFRic mesh

Next generation regional LSDA
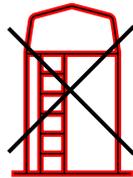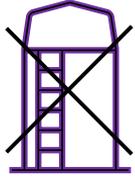
- **Harmonised multi-variate system** for consistent analysis of all current variables. Easier to extend to new analysis variables and observation types
- **Leverage** existing code by extending atmospheric observation processing
- **Align** with atmospheric DA to facilitate stronger coupling in the future

Coupled model background state

Observations   Observations

Common framework

Land surface DA System   Atmospheric DA System

Analysis increments   better consistency   Analysis increments

Coupled model analysis state
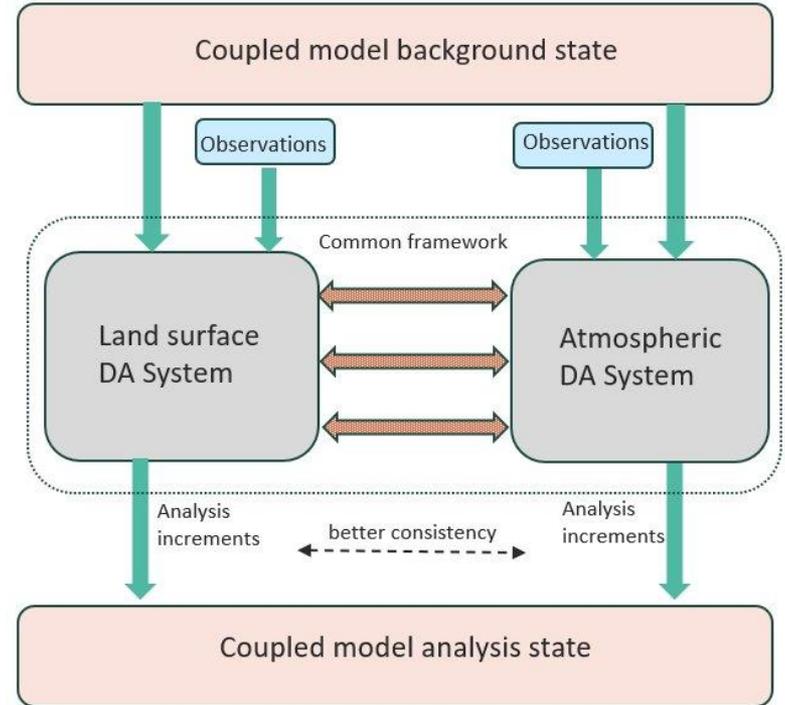
Plans: Next Generation DA

Using JEDI: **J**oint **E**ffort for **D**ata assimilation **I**ntegration code framework developed by the Joint Centre for Satellite Data Assimilation (JCSDA), we will create a regional data assimilation system to replace SURF.

JEDI
- offers modularity and flexibility using a generic object-oriented (C++) programming
- is based on a standard interface between models, observation, and data assimilation algorithms.
- is agnostic to the model and method choices reducing need for customised code in operational systems
- is collaborative and advances quickly (github)
- makes system development easier via use of configuration files (yaml) to experiment with new observations or methods (separation of concerns)

Plans: Next Generation DA

The Met Office has 2 projects to implement JEDI for our next generation DA systems:

JOPA: **J**EDI-Based **O**bservation **P**rocessing **A**pplication
New observation processing system will select, quality control, bias correct and transform observations as required for assimilation.

JADA: **J**EDI **A**pplication for **D**ata **A**ssimilation
Brand-new DA system.

Current Timeline

SURF LSDA system remains operational
Continued maintenance and support

JOPA Global (atm. & marine obs. processing)	JOPA UKV (atm. & marine obs. processing)	LFRic Global Coupled Science Configuration	JADA Global atm. DA	JADA UKV atm. DA	JOPA & JADA Global LSDA	JOPA & JADA UKV LSDA

2025 2026 2027 2028 2029

First steps for Next Generation LSDA

- We will use current operational observations.
- NG LSDA must use an ensemble DA method to provide initial conditions for our ensemble NWP system.
- Observation processing will build on JOPA capability introduced for our atmospheric DA.
- Aim is to align LSDA with atmospheric DA. **Choice of DA method should enable future enhanced coupling between atmosphere and land surface.**
- **Global LSDA** will use an **ensemble of 3D-Vars** because the atmospheric DA will be a variational system.
- **Regional LSDA** will follow the atmospheric DA where the plan is to use an Ensemble Kalman Filter. The atmospheric regional DA development has not started yet.

Summary

- Current SURF LSDA operational system is no longer under scientific development

- SURF technical development to work with LFRic globally is complete

- Met Office has adopted the JEDI framework for processing observations (JOPA) and performing DA (JADA)

- JEDI is a collaborative effort with JCSDA

- JEDI framework is flexible, modular and agnostic (to observations, model, etc.)

- Next Generation JEDI-based LSDA will start by assimilating the same observations that are in operations now

- LSDA will be harmonised producing a single multi-variate analysis

- LSDA methods will align with atmospheric DA methods for easier coupling

Met Office

Please get in touch with any questions

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