3rd Virtual Unified Model (UM) User Workshop

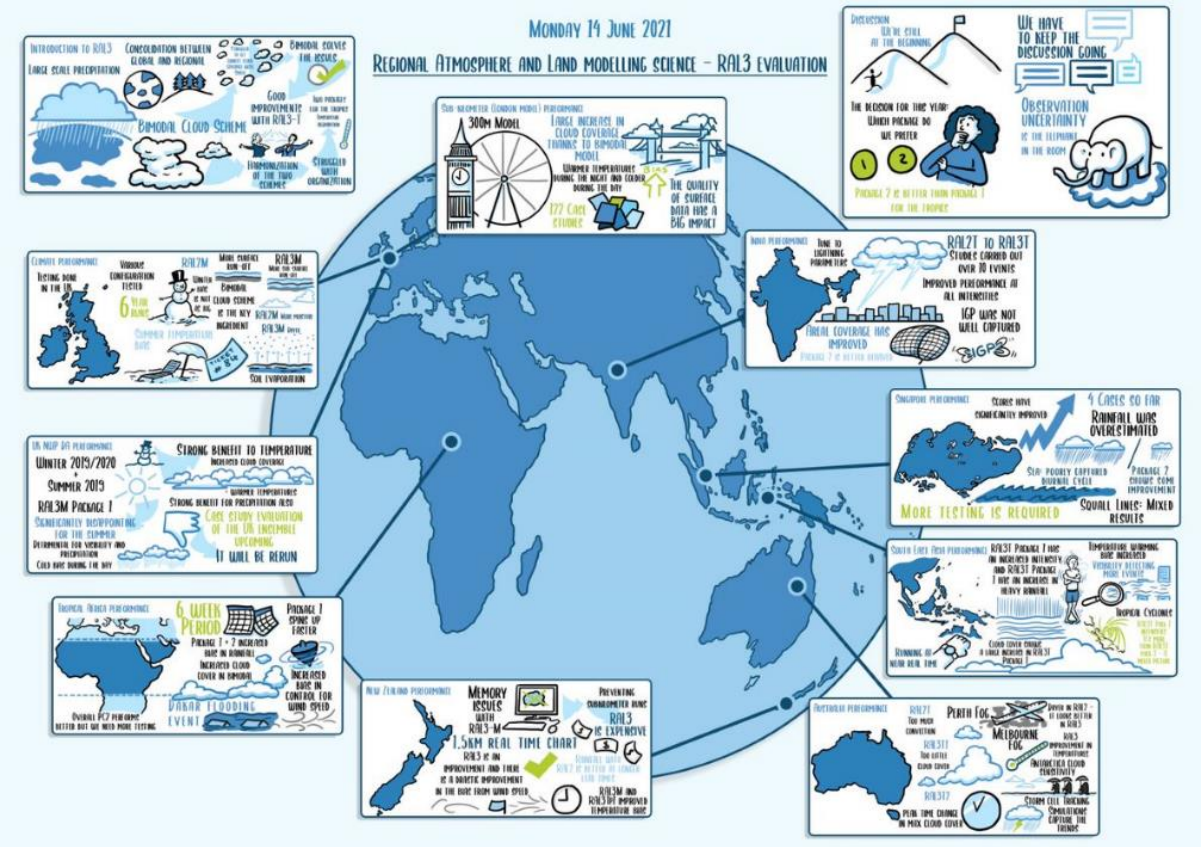
June 2021 - The UM Partnership's third virtual UM User Workshop took place with over 450 registrations.

The UM Partnership consists of operational and research centres that use and develop the UM. Core and Associate Partners use the UM for operational weather forecasts and climate modelling, and Research Partners contribute in non-operational ways to the quality of the UM by using, testing and developing the model for their research activities.

To enable collaborative working and provide opportunity for valuable contribution, an n-person UM User Workshop takes place, but s a result of COVID-19 restrictions, these were moved to virtual events since March 2020.

Using Microsoft Teams, the UM Users virtual workshop consisted of live plenary sessions and breakouts groups spread over four half days covering key areas of the UM Partnership, namely: Regional Atmosphere and Land (RAL) modelling science; Next Generation Modelling Systems (NGMS); Technical Infrastructure (TI) development; Global Coupled (GC) modelling science; and Data Sciences.

Regional Atmosphere and Land Modelling Science - RAL3 evaluation (Chair: Mike Bush, Met Office)



The session provided an overview of RAL3 package testing activities. There were 10 talks covering the breadth of testing conducted across timescales from Numerical Weather Prediction (NWP) to climate, resolutions from sub-kilometre to kilometre-scale and domains covering the U.K, Australia, New Zealand, India, Singapore, Southeast Asia, Tropical Africa and even a simulation over Antarctica.

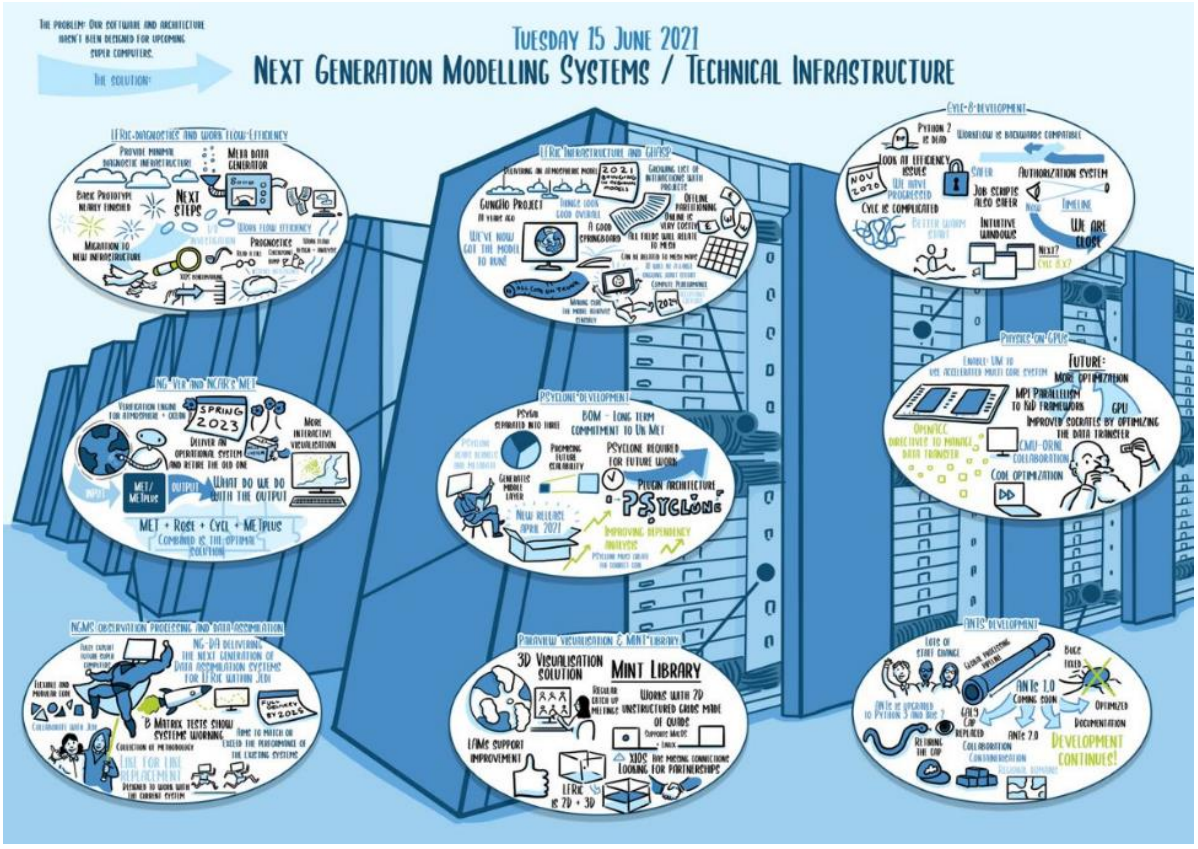
For the first time with RAL3 development, we've been able to test RAL candidate configurations on extended timescales. The climate simulations presented at the session looked at the impact of the RAL3-M package on seasonal biases in both the mean and the extremes of temperature and daily

precipitation accumulations. The distribution of daily precipitation rates was compared against National Climate Information Centre (NCIC) gauge observations and the amplitude of diurnal cycle against radar observations.

Among the breadth of UM partner testing shared at the session, results revealed improved winds and cloud fraction in both mid-latitudes and tropics and improved screen temperatures and fog fraction in the mid-latitudes. There was also a focus on lightning and the distribution of rain rates including the tail of the distribution.

The RAL3 evaluation session represented a real landmark towards embedding a more collaborative approach into development and evaluation of new regional science configurations, at a much earlier stage in the process than previously. This has fed directly into evidence drawn together for review by the RAL Governance Group in mid-July 2021, enabling decisions to be made on the best approach towards defining the next RAL configuration for application across timescales.

Technical Infrastructure Session (Chair: Hilary Oliver, National Institute of Water and Atmospheric Research (NIWA))



This session successfully showcased various exciting activities within the Partnership Technical Sub-programme.

PSyclone: overview of the new 2.0 release; work beginning on LFRic tasking + concurrent components, and automatic generation of adjoint kernels for DA (Ruper Ford, NSTC). New NGMS team to spin up at BOM; PSyData plugin architecture for tool development; and a stripped-down LFRic library for PSyclone (Joerg Henrichs, BOM).

Paraview 3D visualization for LFRic: better LAM support; publication of LFRic reader plugin to Conda Forge; XIOS development needed to overcome deficiencies affecting visualization, regridding, and other post-processing (Wolfgang Hayek, NIWA).

MINT mimetic regridding library: publication to Conda Forge; Python interface; mimetic computation of vector field components. Science use cases sought. (Alex Pletzer, NIWA)

Cylc Workflow Engine: overview and demos of the upcoming Cylc 8.0 release, built around Python 3 and web technologies with a new scheduling algorithm (Hilary Oliver, NIWA).

Physics on GPU: good speed-ups demonstrated for UM radiation and cloud microphysics on GPU with optimized data transfer; code destined for the UM trunk; upcoming evaluation of improved fog simulation (Wei Zhang, ORNL).

ANTS: new 0.16 release for Python 3 and Iris 2 with improved LFRic support; upcoming 1.0 release for GAL9 and landsea mask; 2.0 to focus on regional coverage for RAL; opportunities for collaboration on containerization and regional domains. (Esther Turner, Met Office)

Next Generation Modelling Systems (NGMS) Session (Chair: Keir Bovis, Met Office)

The aim of this session was to showcase achievements from projects comprising the Met Office's NGMS Programme and give plans for the coming 12 months.

Nigel Wood (NGMS Senior Science Supplier) introduced the session giving a reminder of the motivation and aims of the Programme together with an outline of currently active projects and high-level Programme plan.

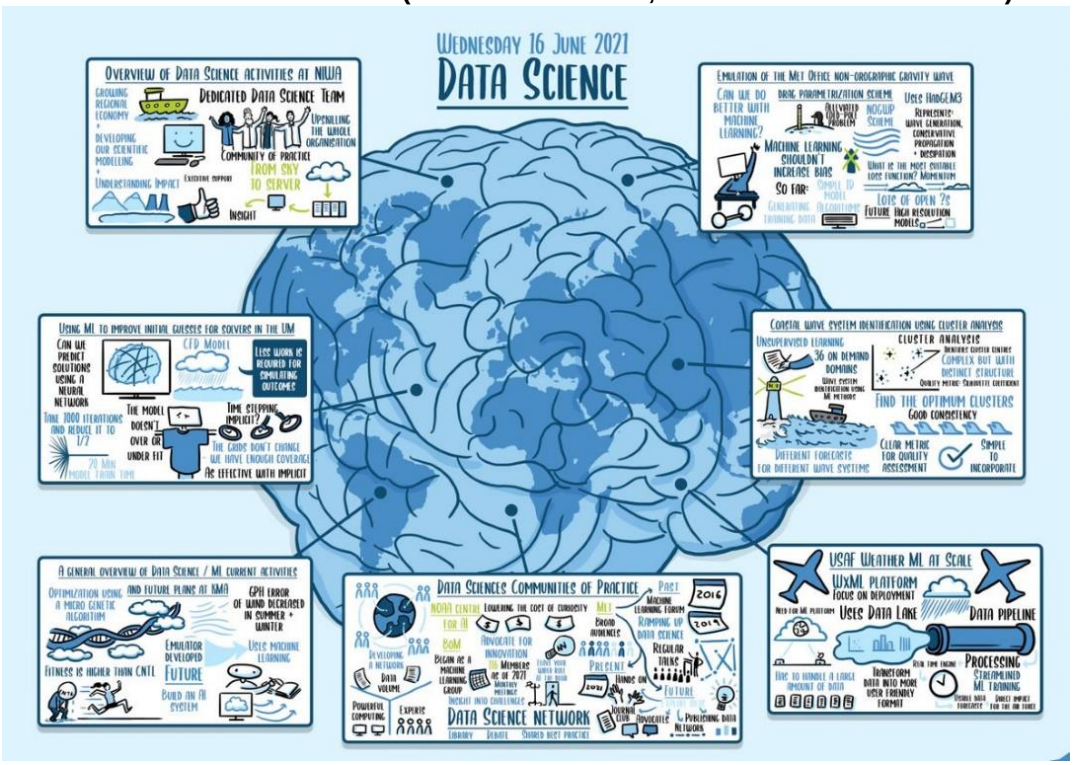
LFRic diagnostics and workflow efficiency: Stuart Whitehouse summarised development of new capability to configure model diagnostics for use with LFRic, the NGMS replacement for the Unified Model (UM).

NG-Ver and NCAR's MET: progress towards the development of a next generation NWP verification system based on NCAR's MET/METplus tools was summarised by Marion Mittermaier (NG-VER). The talk highlighted work interfacing developed capability with the UM.

NGMS observation processing and data assimilation: the adoption of the JEDI framework by NGMS enables collaboration with an established community in developing next generation observation processing and data assimilation systems. David Simonin (NG-OPS) and Stefano Migliorini (NG-DA) gave a brief account of achievements and plans for the coming year including planned operational implementation of NG-OPS alongside the UM.

LFRic Infrastructure and GHASP: finally, two well-received presentations by Ben Shipway (GHASP) and Steve Mullerworth (LFRic) provided an overview of development of the new LFRic atmospheric model. A significant has been met in the delivery of a 'Basic-GAL' configuration providing a stable basis for evaluation of LFRic weather and climate configurations to get underway.

Data Sciences Session (Chair: Sam Adams, Met Office/ Informatics Lab)



This was the first ever Data Sciences session for the UM User Workshop! The session provided an overview of activities across several UM Partnership organisations and additionally included a talk from our special guests at NOAA. Talks ranged from technical topics to general overviews of Data Science activities and strategies.

Since many UM partners have already established or are establishing a Data Science Community of Practice, we included a special section devoted to this where staff from the Met Office and BoM talked about their activities over the last year. A 'network' of Data Science Communities of Practice was proposed to share knowledge and resources going forward.

Using Machine Learning to improve initial guesses for solvers. Justin Freeman (BoM) described some of his work using a convolutional autoencoder to learn to reproduce a converged pressure solution from an initial value. Initial results showed the method worked very well and was able to reduce solver iterations.

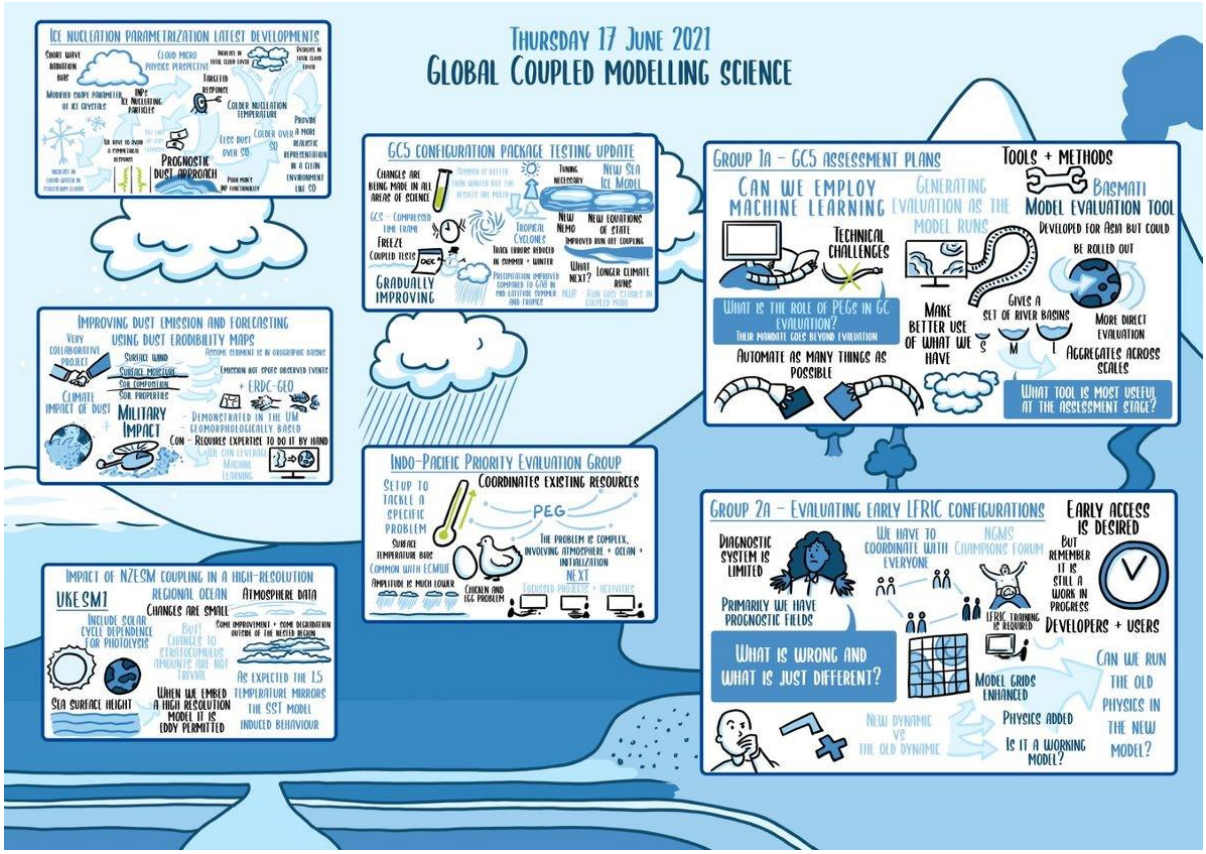
Emulation of the UM non-orographic gravity wave drag scheme. Steven Hardiman introduced this relatively new project at the Met Office. The project aim is to improve GWD schemes over the next 5 years but is starting with a straightforward emulation of the current scheme. A variety of ML algorithms have been tried and Initial results show that a neural network using dilated convolutions is very promising.

Coastal wave system identification using cluster analysis. Andre J. van der Westhuysen, our special guest from NOAA described some work using unsupervised Machine Learning (k-means clustering) to identify regimes in coastal waves. This work was incorporated into NOAA's operational system in Feb 2021.

USAF Weather ML at Scale. Brianna Maze talked about the USAF technical pipeline for operationalizing ML applications for Air Force Weather using Global Synthetic Weather Radar (GSWR) as a test case (due to be operational in 2021). Many important points were raised regarding the transition from research to operations, and deployment in the cloud and at scale.

In summary, we had a very interesting and positive first Data Science session and we hope Data Sciences can become a regular UMUW fixture.

Global Coupled Modelling Science session (Chair: Charline Marzin, Met Office)



Ice nucleation parametrization latest developments

Vidya Varma (NIWA) presented her work on ice nucleation parametrization in the UM. These developments are currently being tested in GC5 package testing.

Impact of NZESM coupling in a high resolution regional ocean

Jonny Williams (NIWA) showed the impact of including a high resolution ocean nest with 2 way coupling in the region around New Zealand. Results included improvements to surface temperatures within the nest, increased heat transport from the tropics to the subtropics due to eddies and improvements to the shortwave cloud radiative effect.

Indo-Pacific Priority Evaluation Group

The Indo-Pacific PEG has been formed to address issues with the SST and hydrological cycle. It currently has members from the Bureau of Meteorology, Met Office and ECMWF. Oscar Alves presented the results of a pilot study showing that the problem is related to enhanced easterlies over the equatorial Indian Ocean. He went on to summarise the packages of work that are planned for the future as part of the PEG.

Improving dust emission and forecasting using dust erodibility maps

Melissa Brooks presented work to improve dust emission forecasting in the UM using maps of geomorphic classifications and observed dust emissions for each of these sites. A pilot study has shown promising results but is limited because the classification is currently done by hand. Future work will aim to train a machine learning algorithm to automate and expand the method.

GC5 configuration package testing update

Martin Willet and Tim Graham presented an update on the package testing for the GC5 model. The model is due to be frozen by the end of December with the assessment phase taking place next year. The main changes going into GC5 were presented and early results from NWP and climate performance were shown.

For the 2nd half of the GC session breakout groups were formed to discuss various topics and gather input from around the UM partnership.

GC5 Assessment Plans

The assessment phase of GC5 is planned to begin in early 2022. This breakout group reviewed plans for standard assessment runs covering weather, seasonal and climate timescales, and how the UM partnership can best share expertise to exploit these runs. Some new ideas arising from the discussion included the use of regional model evaluation tools to assess regional aspects of global model trials, and seamless methods for tracking tropical cyclones that could be applied across timescales.

Coupled NWP

With the Met Office planning to implement coupled NWP early in 2022 this breakout group discussed plans of other centres for future NWP and how those wishing to get involved in coupled NWP evaluation could do so. A clear recommendation was to setup a working group to coordinate coupled NWP research and share results.

Evaluating early LFRIC configurations

Early LFRic configurations are beginning to be evaluated and examples of current capability were shown. This breakout group discussed plans for the future evaluation of early LFRic configurations. There were discussions on the technical issues associated with the evaluation, how partners could become involved and the timescales for such involvement.

GC evaluation and diagnostic tools

This breakout group discussed plans to implement MetPLUS and ESMValTool as standard tools for use in GC evaluation and diagnostic work. The group gathered information on current experience of using the tools within the UM partnership and discussed possible ways forward for their implementation.

Side sessions (Chair: Martin Best, Met Office)

Hydrology session

Following on from some individual partner meetings last autumn on hydrology, this was the first meeting open to all partners.

Brief highlights of the talks include:

NASA's Global Hydrological Intelligence (GHI) system: This post processing system is based on a blend of satellite derived atmospheric observations and GALWEM data for short to medium range forecasts to force an ensemble of land surface models within the LIS data assimilation system. The resulting runoff is subsequently routed through the Hydro and RAPID river routing schemes to give stream flows that can be verified using the LVT part of LIS. The system is being extended to cover sub-seasonal to seasonal timescales using atmospheric forcing data from NASA GMAO's GEOS5 forecasts with statistical downscaling and bias correction. Results showed that the system has comparable skill to that of high-latency reanalysis products.

BoM's Seamless Hydrologic Modelling Plan: This is a collaborative project including UKCEH and the Met Office to move BoM's hydrological services towards a seamless national water status and outlook that is coupled to environmental prediction. Future plans involve a number of projects including seamless hydrologic modelling, next generation hydrological modelling, precipitation standardisation, next generation flood forecasting, land surface data assimilation, satellite water extent mapping and seamless hydrological services. These plans have been put within a 7 ½ year roadmap with the aim of delivering an operational system before the end of the decade.

Met Office regional environmental prediction approach to the water cycle: Results from a study using the fully coupled regional environmental prediction model for the UK winter of 2013/14 were presented. The simulations were using an older RAL1-M configuration, but the results showed that

whilst there are differences and scope for improvement compared to observations, hydrological outputs were comparable to some other post processing systems. In terms of the fresh water fluxes to the ocean the coupled system captured some of the seasonal variations in the outflows that are not present in a climatology, whilst errors in salinity around the UK/Ireland continental shelf were noticeably decreased compared to turning off the source of fresh water from rivers.

Hydro-JULES project update: Progress has been made on a number of components to the Hydro-JULES project. Some initial results showed the potential for improving soil moisture estimates in the UK based on using data assimilation techniques to optimise the uncertain soil parameters used in land surface models. An update was given on progress towards global and UK scale developments for both river flow routing and inundation modelling, and the inclusion of groundwater schemes.

Land surface data assimilation session

This side meeting provided an opportunity for all partners to give an update of their progress on land surface data assimilation activities since the LIS training workshop hosted by NASA in 2020.

Brief highlights of the talks include:

USAF's research and operational updates using NASA LIS: A recap overview of the capabilities of the NASA LIS system was presented along with recent updates towards its use in operations. Bias correction for precipitation was shown to be comparable to a number of reanalysis products. This has now been used with an ensemble assimilation system to provide soil moisture that can successfully be used to initialise a number of test case GALWEM forecasts. In collaboration with the Met Office, a scheme has also been developed to enable the ensemble of multi-layer snow states to be combined into a single state that is appropriate for GALWM initialisation, whilst remaining consistent with JULES physics.

BoM's high resolution soil moisture analysis system: Following on from the severe fires in Australia in 2020, a new high resolution soil moisture analysis system has been developed, primarily for fire danger prediction. Validation of the system against ground based observations demonstrates a high level of skill across a range of land cover types. A comparison between offline JULES driven by observation based rainfall and the SURF EKF system showed that the observational based rainfall method provides additional benefits over the assimilation system for COSMOS observations and NWP forecast verification. Some initial work has also been done in collaboration with NASA on the use of LIS for the assimilation of surface and root zone soil moisture using SMAP vegetation optical depth retrievals.

Land surface modelling activities and NIWA: The current land data assimilation system at NIWA includes the reconfiguration of soil moisture from the Met Office global model each cycle, soil temperatures updated using IAU increments and reconfigured SSTs from OSTIA once per day, but there is a hypothesis that some (and perhaps a significant) component of poor surface verification arises from an inadequate surface analysis. Longer term objectives include an update to soil ancillaries using local datasets, use of local soil moisture observations in a local data assimilation scheme, and looking at developing a snow analysis based on remotely sensed products. Following on from the LIS workshop, recent versions of LIS have been successfully built and work has been done with NASA to create domains that can cross the dateline. Work required for a rotated pole projection is ongoing.

Update on operational land surface data assimilation at the Met Office: For the global model a new 40 year soil moisture climatology has been derived using an off-line JULES GL9 configuration with WFDEI atmospheric forcing to give a scientifically consistent ancillary that can be used for ASCAT bias correction including monthly mean, maximum and minimum values. For the regional model the skin, soil and snow temperature increments are now provided by a regional land surface data assimilation system. This includes improved ASCAT soil moisture bias correction and snow optimal interpolation once per day. Results from the model demonstrated improved near surface temperature forecasts during drier periods. For snow assimilation ground-based observations are now used four times a day instead of once which should help with quickly evolving snow events in winter,

whilst partially snow covered pixels in the satellite product is treated as snow free rather than snow covered to help reduce cases of overestimation of snow-affected surfaces.

Plans for next generation land surface data assimilation at the Met Office: A project has been underway to determine the preferred option for the next generation of land surface data assimilation within the Met Office. Requirements for this included a priority for initialising coupled forecasts rather than offline land applications, to have at least weekly (and extending to more strongly) coupled data assimilation, and must meet the requirements of the next generation modelling system and help deliver expected benefits. After considering a number of options, the decision made was to adopt JEDI as it enables more strongly coupled land-atmosphere data assimilation scientifically, technically and collaboratively. Short term plans are likely to support a SURF-LFRic system, whilst the longer term plan will be to develop a JEDI based LSDA system for operational NWP. Plans will build on existing snow DA developments at JCSDA, make as much use of the atmospheric JEDI-based infrastructure as possible and collaborate with the LIS team to help pull through LIS capabilities into JEDI.

The workshop was a remarkable success with over 450 participants registered from across the UM Partnership, Met Office Academic Partnership (MOAP) and Microsoft with around 200 attending live sessions per day. The UM partnership team would like to extend a huge thank you to everyone who helped to organise and contribute to the workshop. All presentations are available at the June 2021 Virtual UM User Workshop and visual summaries for each session were created by a scribe hired for the workshop.