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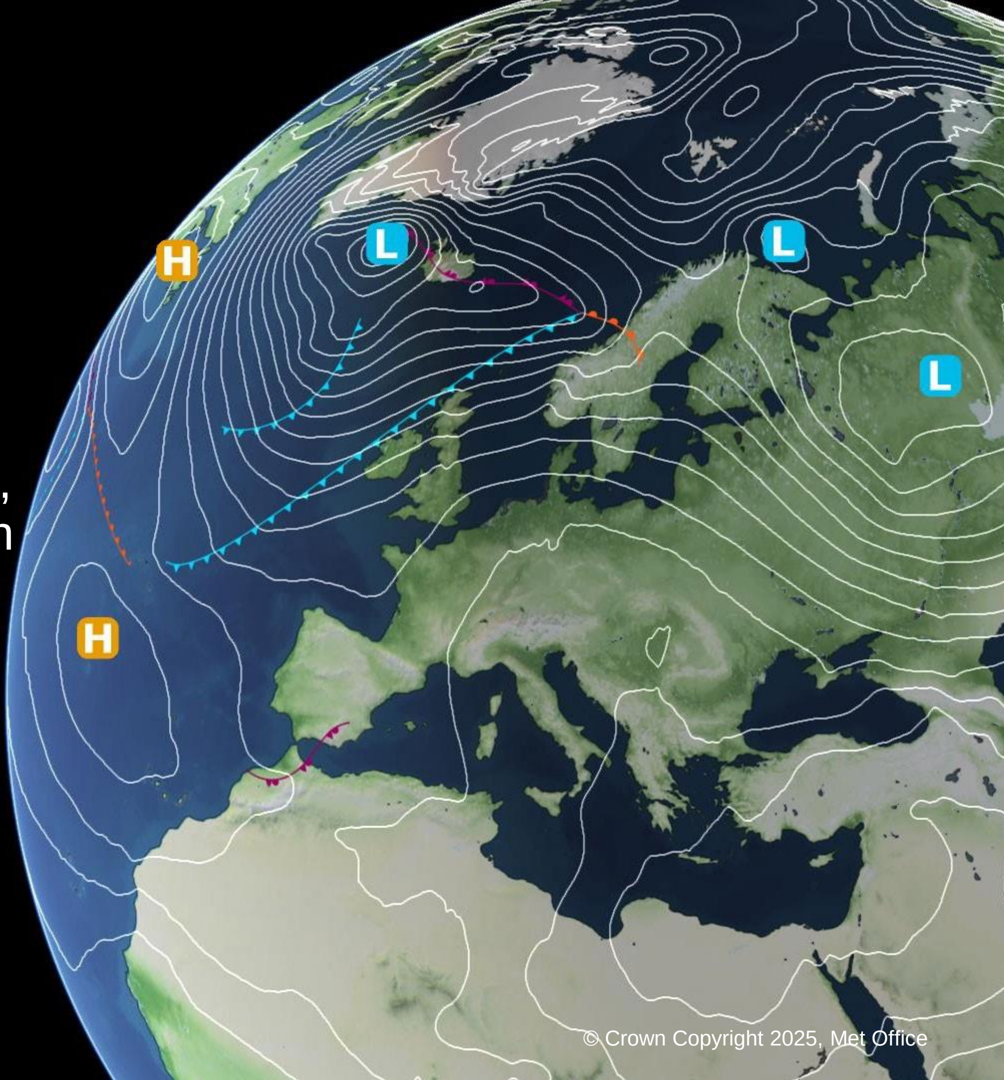
Ancillary Data in the Momentum Partnership: Modelling Across Scales

John Edwards, Martin Best, Anurose TJ, Stuart Moore, Jorge Bornemann, Siyuan Tian and Kalli Furtado

Workshop on ancillary data for land surface and Earth system modelling

ECMWF, Bonn, 9th April 2025



Overview

- The Momentum Partnership and the modelling framework
- Current core ancillary data
- Current issues and plans for the near future
- Issues for the longer-term future

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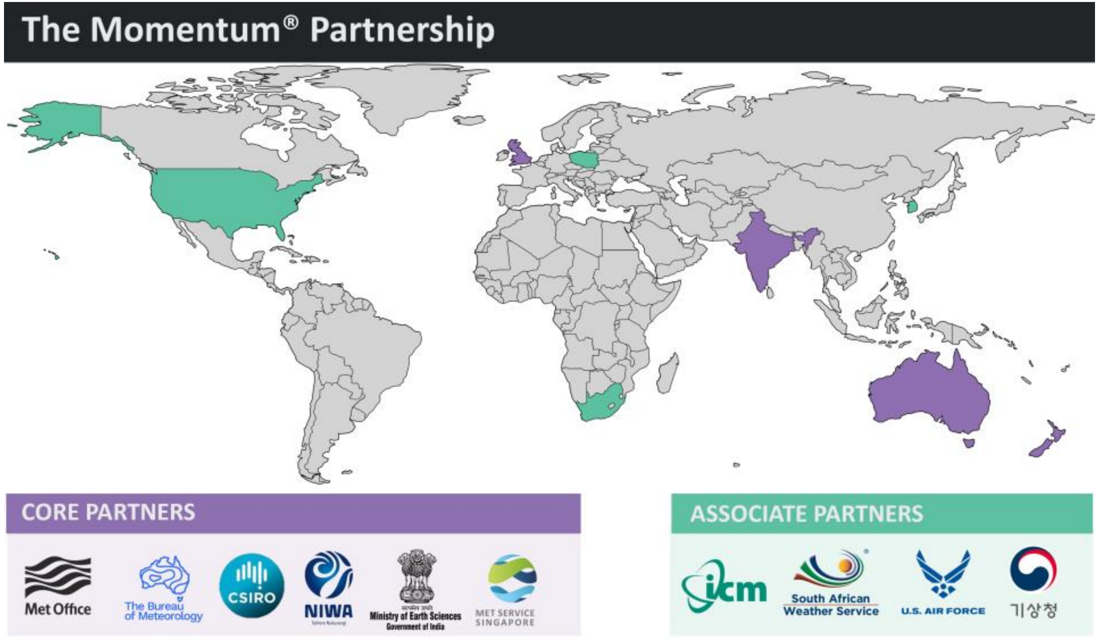
The Momentum Partnership



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Forecasting and Modelling Applications

- We aim at seamless modelling across scales
- Current applications and resolutions

Earth System/Climate ~100 – 200 km	Global NWP ~10 km	Regional (CP) NWP 1 – 10 km	Urban/Hectometric 100 m – 1km	(LES) O(10m)

- For comparison, 20 years ago the deterministic global resolution was 60 km
- The long-term aspiration is to develop a global forecasting configuration with a resolution of about 1 km
- There is great interest across the partnership in developing city-scale models

Land-surface Scheme

- Land-surface model: JULES (Best et al., 2011)
  - Standard configuration has 9 surface tiles:
    - BL, NL Trees, C3 and C4 short vegetation, shrubs, urban, lakes, soil, land ice
  - For urban applications using the MORUSES urban scheme, the urban tile is split into roof and canyon tiles
  - Originally developed for earth-system modelling, there is also a 17-tile configuration with more PFTs and C3/C4 vegetation split into natural, crop and pasture tiles
    - We are exploring the more general use of this configuration.
    - Ancillary support is still developmental.
- Processing of raw ancillary data
  - Processing and regridding for the target domain and resolution in the ancillary toolkit, ANTS, written in Python and replacing older legacy code
  - Land cover classes are mapped to tiles using a cross-walking table.

Core Ancillary Data

	Global Willett et al. in preparation, Walters et al. 2019	**Convection-permitting** Bush et al. 2024
Land Mask / Fraction	Set from ocean model	Mainly CCI v1.16 300 m
Land Cover	CCI v1.6 300 m	CCI v1.6 300 m and local sources (25-100m)
Orography	GMTED and RAMP2 for Antarctica 1 km	GLOBE 1 km and SRTM 100 m
Soil Hydrology	HWSD, STATSGO and ISRC-Wise 1 km	HWSD v2 1 km
Soil Albedo	MODIS 5 km	MODIS Coll. 4 5 km
Soil Roughness	Prigent et al. (2012) 5.5 km	Prigent et al. (2012) 5.5 km
Topographic Index	HydroSHEDS 500 m	HydroSHEDS 500 m
Leaf Area Index	MODIS Coll. 5 4 km	MODIS Coll. 5 4 km
Canopy Height	Simard et al. (2011) 1 km	Simard et al. (2011) 1 km
Rivers	TRIP 1 degree	

Other Data currently in use

- Some partners use proprietary local land cover data for high-resolution modelling
  - Land cover data for 1.5 km operational forecasts for the UK is ITE data at a resolution of 25 m
  - NCMRWF has 56 m resolution data derived by ISRO
  - Local data are also in use in Australia and New Zealand
- We also make use of satellite data in setting model parameters, e.g. GlobAlbedo
- Climatologies are used within the system, currently derived using WFDEI at a resolution of 0.5 degrees based on CRU data

Land Cover

- Identification of and discrimination within urban areas is a key issue for all partners
- The standard data source (CCI v 1.6, 300 m) does not distinguish heavily built-up and suburban areas; urban areas are too extensive
- Alternatives being considered
  - Reprocessed CCI data (CCIv2 still at 300 m)
  - Alternative regional sources (e.g. CORINE at 100 m for Europe)
  - Deriving tile fractions directly (NCMRWF and the Indian Space Research Organization, ISRO)
  - Local datasets (e.g. NIWA: LCDB data)
  - Very high-resolution urban data from WorldCover
- What land cover classes do we regard as essential?

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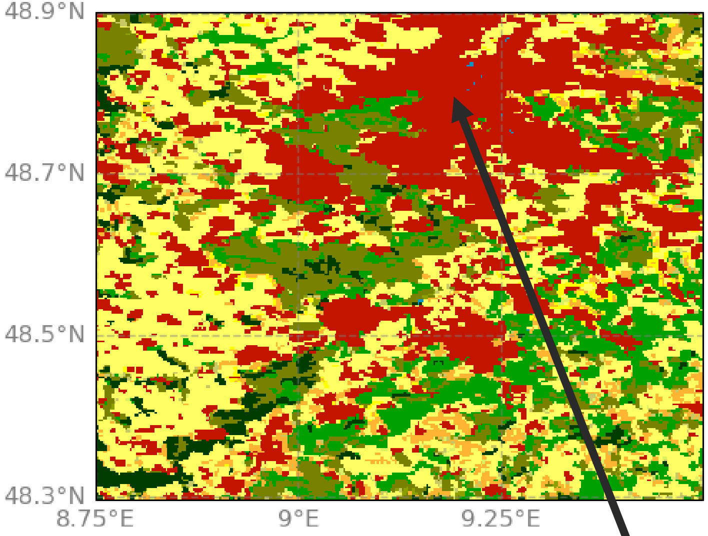
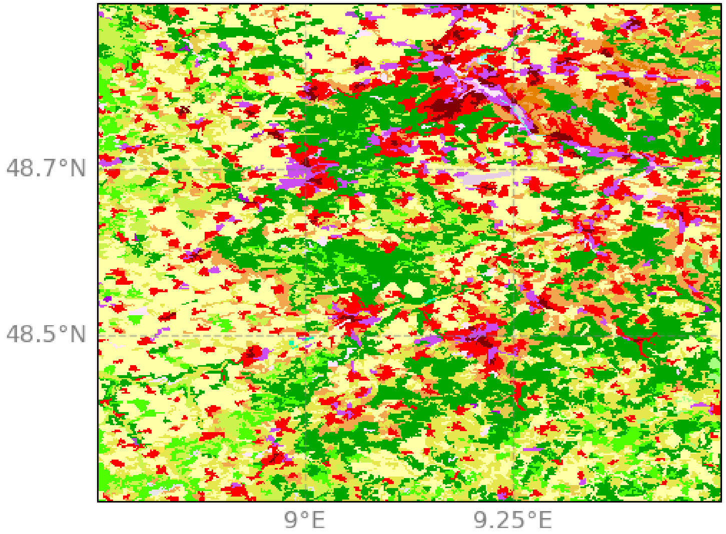
Urban Areas: Stuttgart

Land cover classes: Red = urban



Default CCIv1p6 has a single urban class, including suburbs



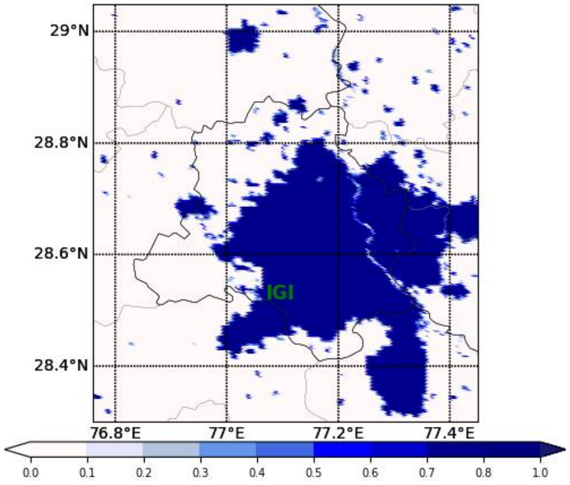
Other data sources, e.g. CORINE (100 m), have more discrimination

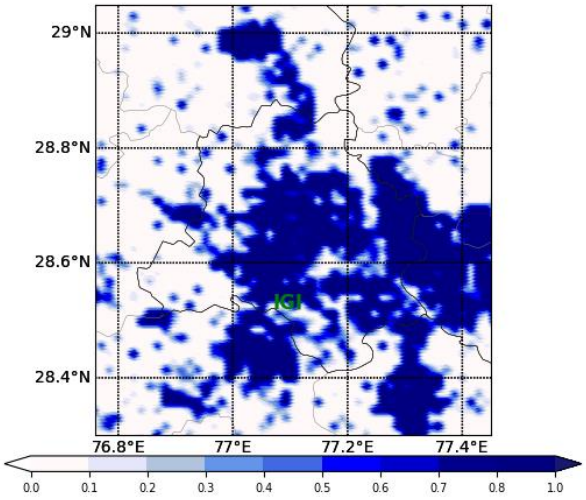
Urban fraction from CCI (left) and ISRO LuLc for Delhi city (330 m resolution)

ISRO AWiFs LuLc data (2018-2019), Source res. 56 m

Climate Change Initiative (CCI) LuLc data (2015-2016), Source res. 300m

Urban fraction

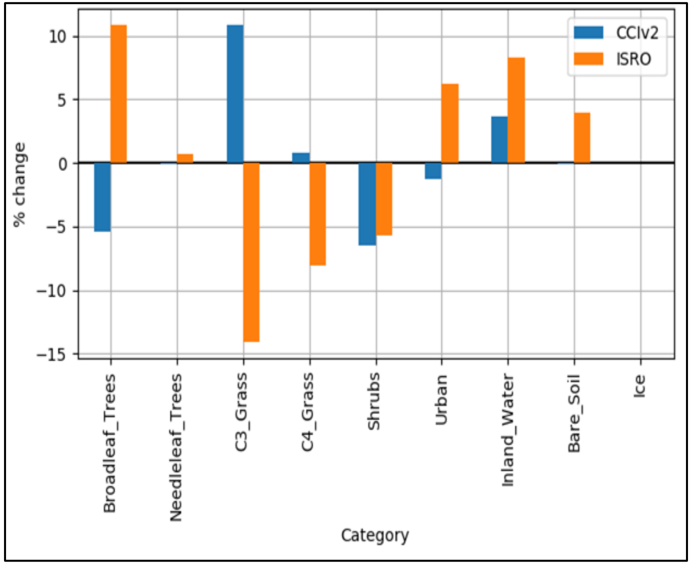




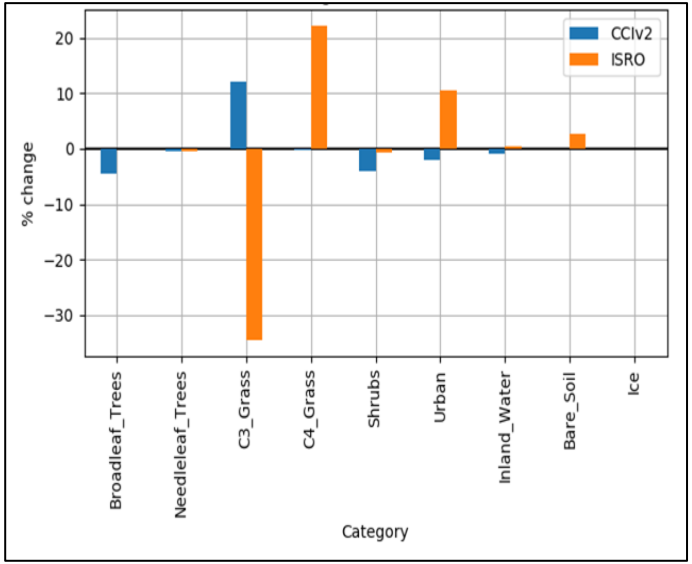
Courtesy of NCMRWF, India

Change in area with respect to CCI LULC (based on 1.5 km resolution)

Bhubaneshwar



Delhi

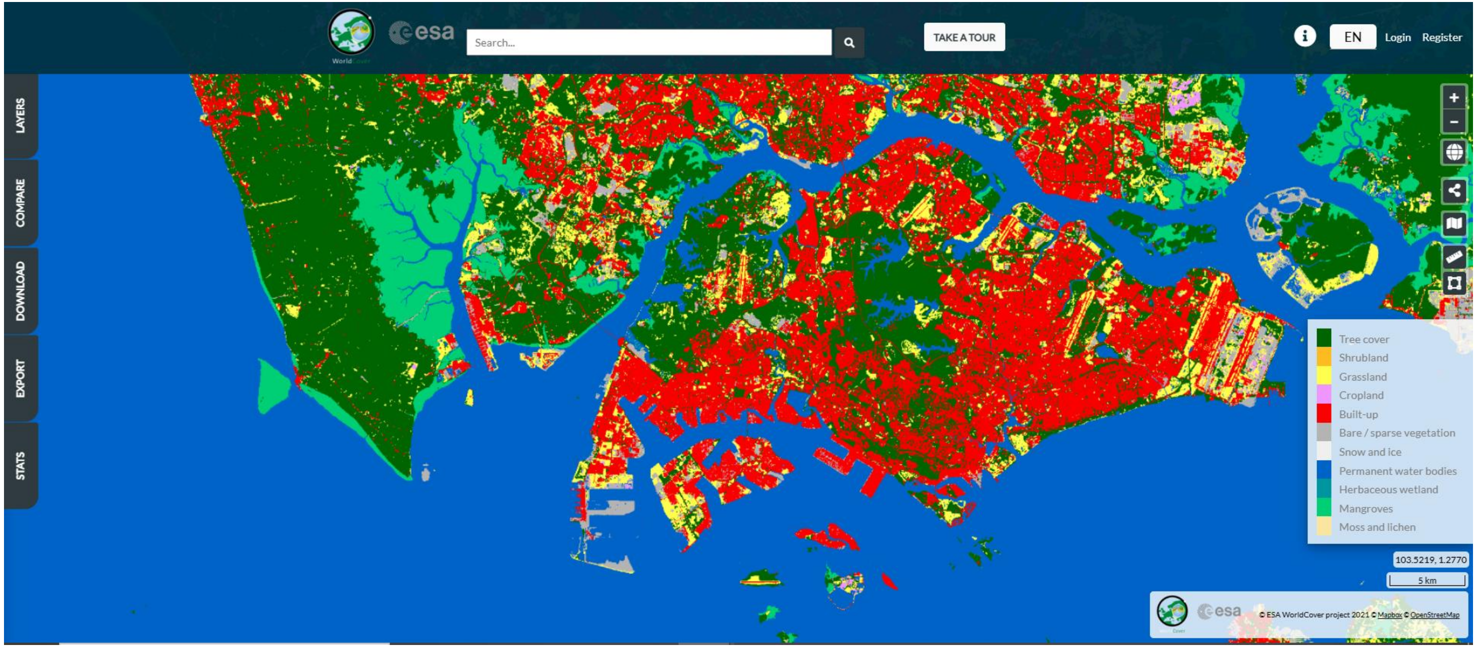


- Major changes in ISRO LuLc are associated with C3 and C4 tiles over Delhi.
- Whereas most of the tiles show changes over Bhubaneswar except needle leaf and ice

Courtesy of NCMWRF, India

High-resolution Land Cover Data

- ESA World Cover at 10 m
- Processed into urban fraction at various resolutions (Patel & Roth, 2022)

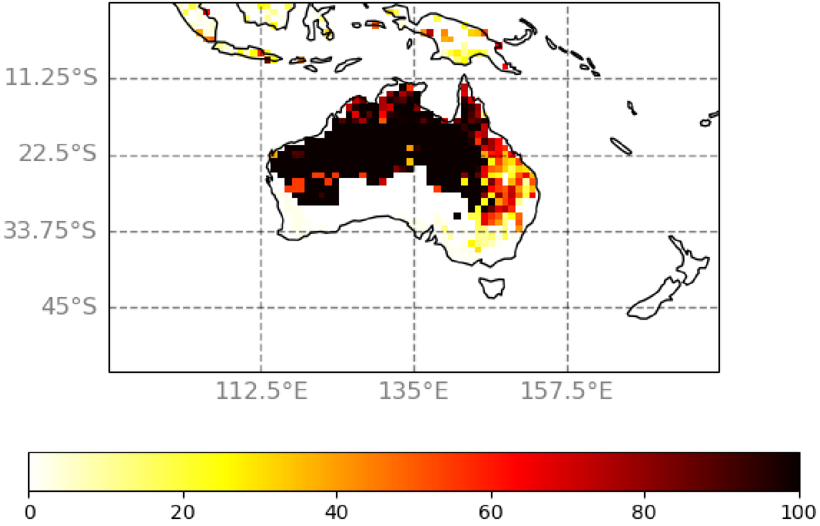


Starting to be used at the Met Office and CCRS, Singapore

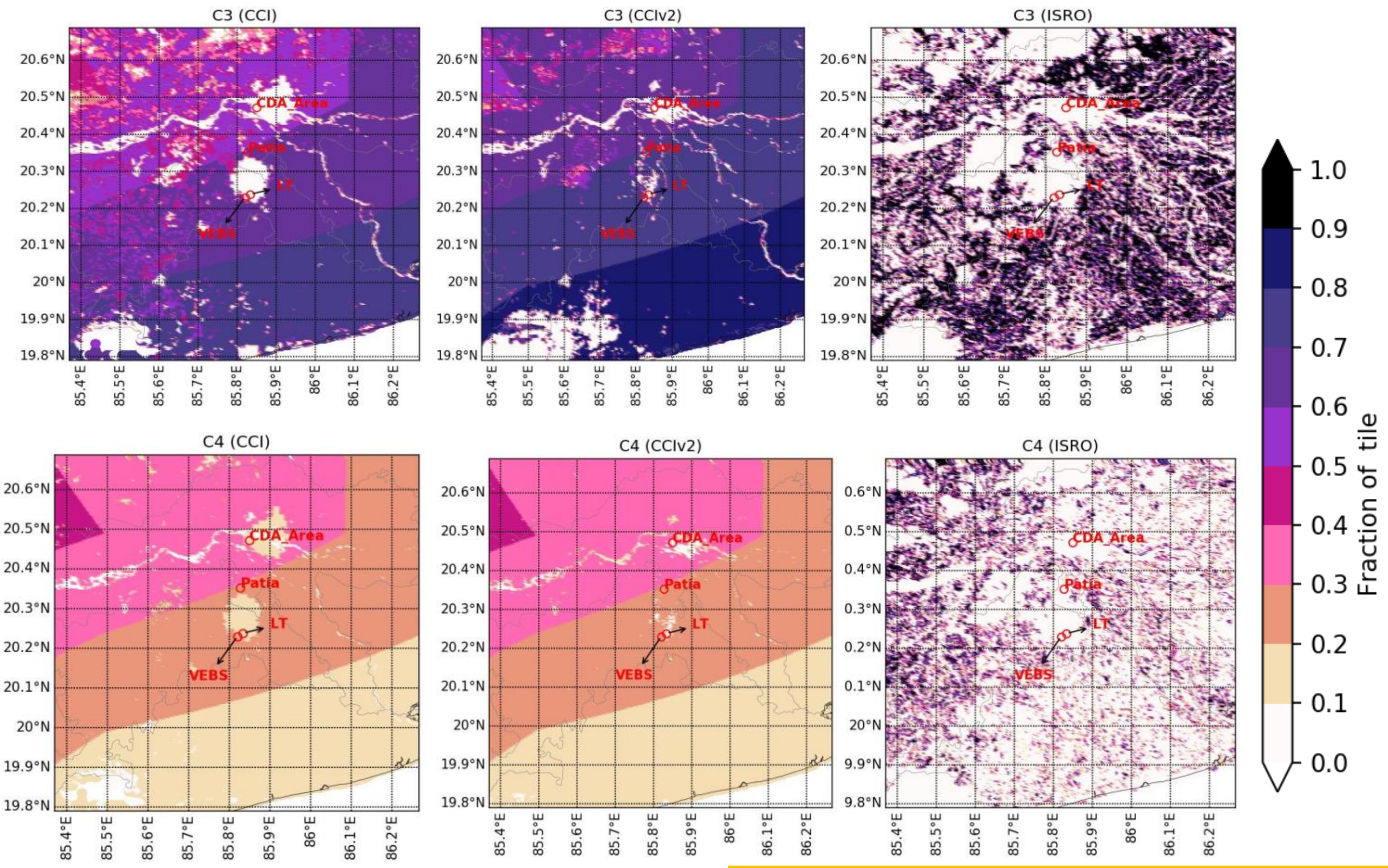
Subdividing vegetation

- We generate fractions of C3 grass from the land cover data and split this between C3 and C4 vegetation using 1-degree data from [Still et al. (2009)]
- Similar issues arise when splitting tree cover in the ESM configuration
- Some higher-resolution data is available for limited areas

Percentage of C4 grass in Australia

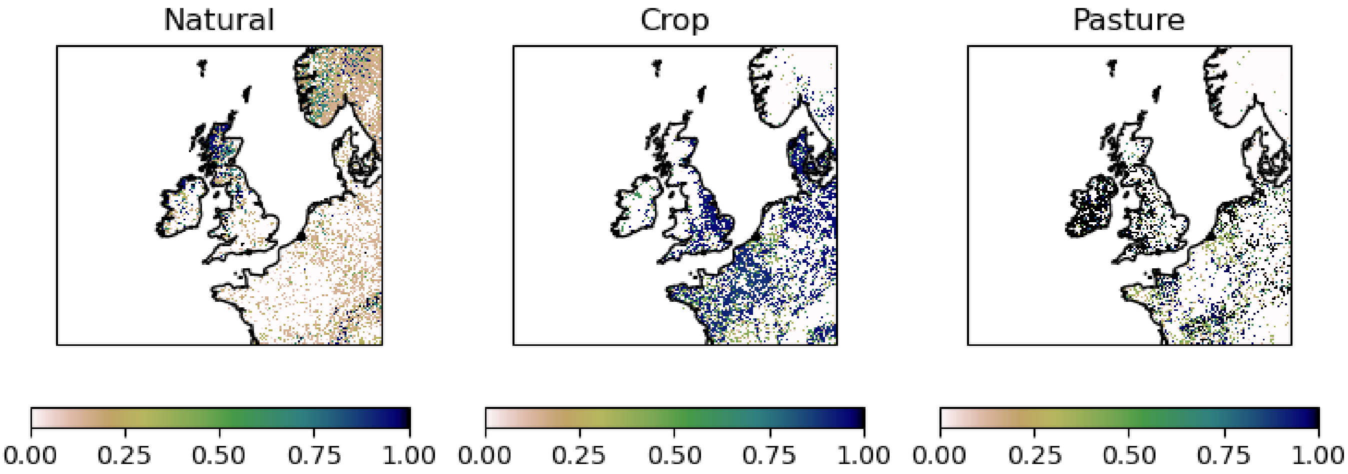


Change in different LULC tiles of JULES over Bhubaneshwar (based on 1.5 km resolution)



Courtesy of NCMWRF, India

- The 17-tile ESM configuration offers more discrimination in land cover by splitting natural vegetation, crops and pasture
- Provisional fractions for the 1.5-km UK domain based on CORINE data

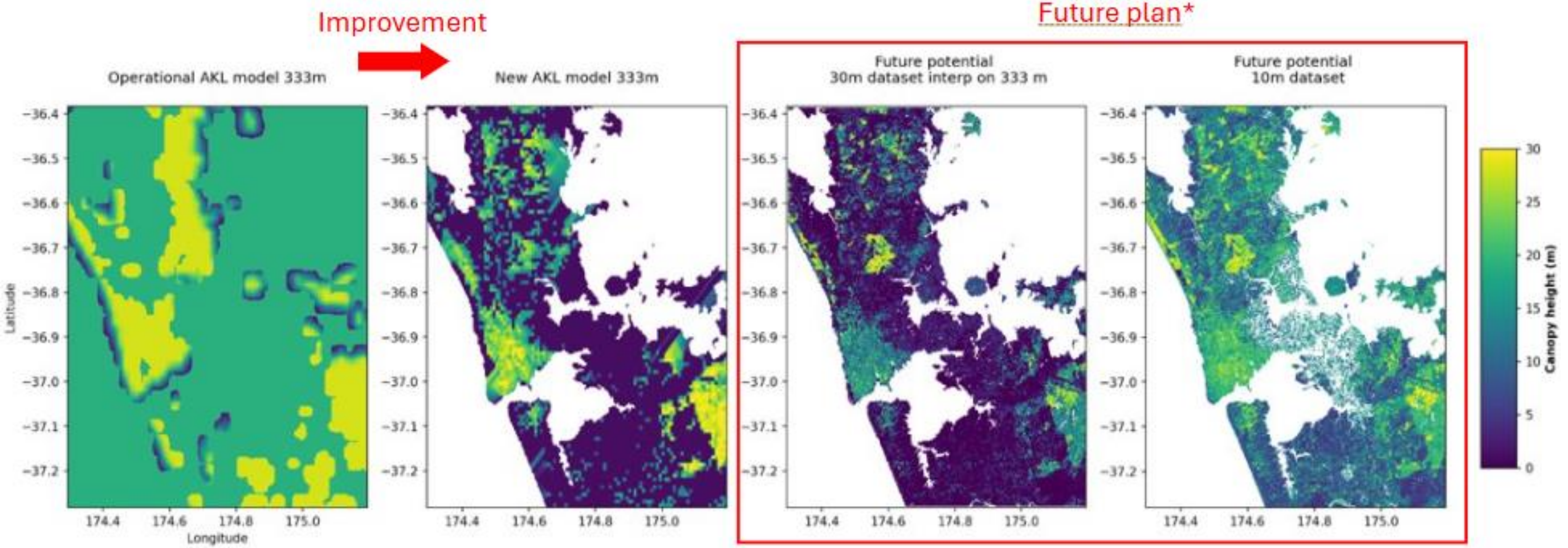


Vegetation

- LAI data
  - At 4 km, this is now some of the most poorly resolved raw data, though higher-resolution data are now available
  - A mismatch in resolution can lead to problems when generating ancillary data for models with finer resolution (small urban areas resolved in land-cover data in largely wooded pixels in more coarsely resolved vegetation data)
  - Problems with missing data in urban areas and polar night
- Canopy height was substantially improved by using Simard et al. (2011)
- Experiments with newer vegetation data are in progress at NIWA
  - 333 m model over Auckland
  - 4 km model for the whole of New Zealand
- What other vegetation data do we need to support future requirements?

Canopy height comparison

AKL 333m model



* Global Forest Canopy Height at 30 m resolution, 2019 (GEDI)
https://glad.umd.edu/dataset/gedi

ETH Global Sentinel-2 10m Canopy Height (2020)
https://gee-community-catalog.org/projects/canopy/

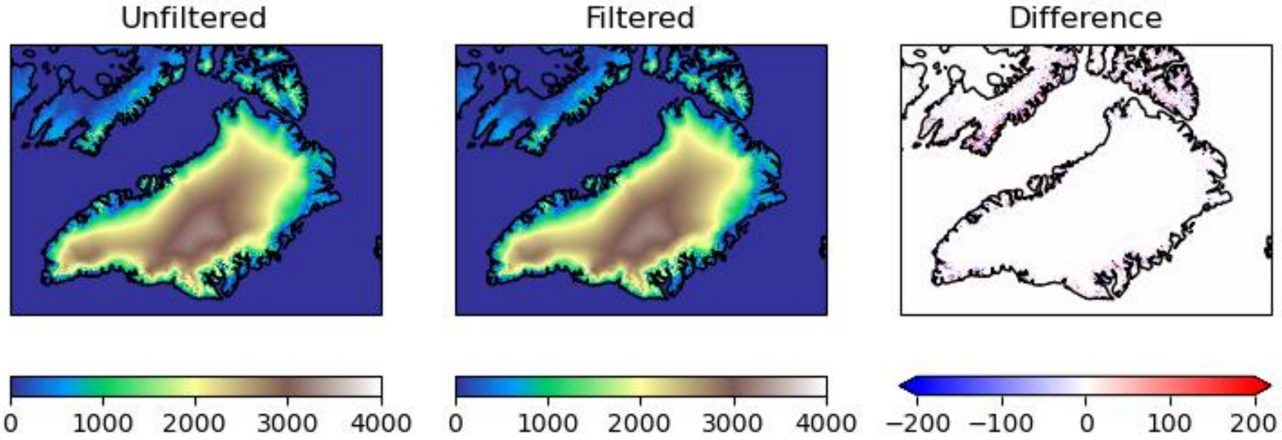
Courtesy of NIWA

Soils

- Currently we use HWSD v2
- Some experimentation with Soilgrids in JULES at Reading University
- Soils raise additional issues
  - Should we use dominant or interpolated soil properties?
  - Pedotransfer functions are needed to use the data

Orography

- What resolution is required for orography?
- High resolution is needed for high resolution hydrological modelling and shading in the radiation code
- In forecasting models, orography must often be smoothed for stability



Future Directions and Additional Data

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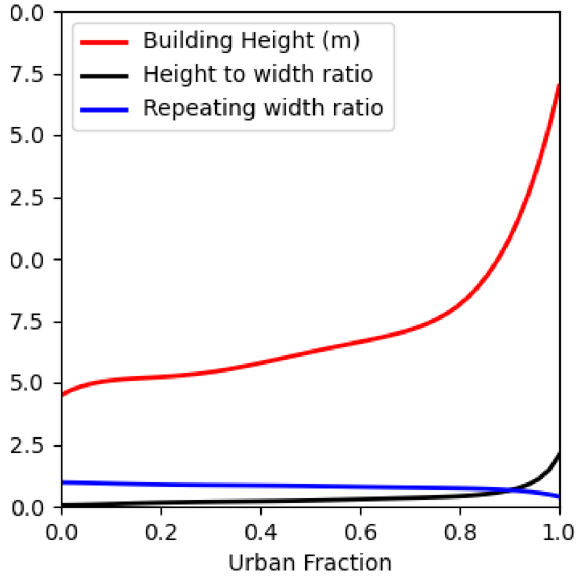
Enhancing Hydrological Modelling

- Integrated hydrological modelling is currently in development at the Met Office: this requires additional ancillary data, currently sourced from the British Geological Survey
    - Bedrock permeability 2.5 km resolution
    - Soil depth (based on ease of digging) 1km resolution
- Including irrigation is increasingly important
    - Land cover datasets should distinguish irrigated areas
    - We need data on the source of the water
- Lakes. Improved representation in development
    - Lake depth Choulga et al. (2024)

Urban Modelling

- Great interest in urban forecasting and climate change
- Issues with urban fraction already noted
- Urban morphology is currently calculated from empirical relationships derived for London ([Bohnenstengel et al., 2011](#))
  - Not all cities are the same
- Potential to use lidar data to derive more appropriate data for individual cities (NIWA)



Further Needs for Urban Modelling

- Thermal properties of buildings, including radiative properties
  - Currently fixed in MORUSES
- Improved data for and models of anthropogenic heat sources
- Anthropogenic moisture sources
- Urban Hydrology including drainage
- AQ applications of urban models also need improved aerosol sources (NCMRWF)

… And Some Technical Issues

- Licensing and IPR:
  - Restrictive IPR on the underlying data impedes collaboration
  - Open-source data is generally to be preferred
- Time variation and the consistency of different sources of data
- The volume of data
  - WorldCover is a global 10-m dataset
  - Cloud-based IT solutions will be essential

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Conclusions

- Urban modelling emerges as a key focus for future work
  - We lack information on many key variables
- There is scope for improvement in our use of existing data by updating our sources
- Our technical solutions for the future must be compatible with the large size of emerging datasets