Met Office

Natural Environment Research Council

UKESM

UKESM2

National Centre for Atmospheric Science NATURAL ENVIRONMENT RESEARCH COUNCIL

National Oceanography Centre

UK Centre for Ecology & Hydrology

National Centre for Earth Observation NATURAL ENVIRONMENT RESEARCH COUNCIL

PML Plymouth Marine Laboratory

British Antarctic Survey NATURAL ENVIRONMENT RESEARCH COUNCIL

cpom Centre for Polar Observation and Modelling Natural Environment Research Council

BGS 1835 British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL

UKESM1 (Sellar et al. 2019)
(& main science developments from HadGEM2-ES)

Met Office

UKRI Natural Environment Research Council

- **HadGEM3-GC3.1 physical GCM core** (Kuhlbrodt et al. 2018, Mulcahy et al. 2019)
- **Terrestrial carbon-nitrogen cycle**: TRIFFID prognostic vegetation (9 PFTs), RothC soil carbon, nitrogen-limitation scheme (Wiltshire et al. 2020)
- **Ocean biogeochemistry**: MEDUSA2 intermediate complexity plankton ecosystem model, including prognostic diatoms/non-diatoms, with variable C:N, iron deposition coupled to atmosphere-land dust emissions (Yool et al. 2021)
- **Aerosols**: GLOMAP-mode, 2-moment, 5-mode aerosol scheme, DMS and marine primary organic emissions coupled to MEDUSA, dust coupled to JULES (Mulcahy et al. 2020)
- **Atmospheric Chemistry**: UKCA stratosphere-troposphere chemistry including isoprene chemistry, BVOC emissions (Archibald et al. 2020)
- **Ice sheets**: BISICLES land ice model (Cornforth 2013) over Antarctica and Greenland. In a specific model release; UKESM1-ice: Smith et al. (2021)
- **Resolution**: N96L85/1°L75 standard for all UKESM1 CMIP6 simulations

UKESM1: key ES couplings

- Atmos-ocean coupling: CO_2, DMS, Iron (in dust), DMS, marine organic aerosol
- Atmos-land coupling: CO_2, BVOCs (interactive isoprene and monoterpene emissions from plants, monoterpene coupled to secondary organic aerosols)
- Chemistry-physics coupling: radiatively active O_3, CH_4, N_2O, methane oxidation source of water vapour
- Chemistry-aerosol coupling: sulphate chemistry → aerosol, aerosol surface area → heterogeneous chemistry *(prescribed in CMIP6 expts)*
- Ice sheets/shelves: snow accumulation → ice sheet model, ice shelf basal melt (mass loss) → ocean freshwater and ice shelf geometry

Plans for UKESM2 (early days so still evolving)

UKESM2 will be built on HadGEM3-GC5 (available ~ mid 2022, see Jane's talk)

Aim for UKESM2 to be "operational" / science ready ~end of 2024

Target developments:

- Workhorse will stay at N96L85 – ORCA1L75
- Have an exploratory configuration at higher resolution (ideally using hybrid approach)
- Ability to run model with emissions of CO_2, CH_4 and Nr/N_2O
- Interactive Greenland and Antarctic ice as standard
- Wildfires fully interactive with carbon cycle and atmospheric composition
- Thermal acclimation of plant photosynthesis
- Improved representation of human land use
- Nitrate aerosol
- Improved stratospheric ozone
- Modal dust (?)
- and **potentially** other things we here about today

- Develop a "fast" version (after main configuration is released)

- We aim to have a functioning UKESM2 by late 2024
- To fit with an assumed CMIP7 schedule
- Continue to aim for “maximal” degree of prognostic, interactive coupling (to allow numerous Earth system feedbacks to be explored)
- This assume the core physical model (HadGEM3-GC5) is the “safe” option
- UKESM2 should also be useable by students/researchers for their own work
- It will (almost certainly) be the final UM based UKESM version
- We (mainly Jane and myself) are interacting with GC5 development to get early info on e.g. Historical performance, climate sensitivity etc
- I would like to avoid the problems last time with “discovering” poor historical performance and high climate sensitivity late in the day. Try to get an early heads up on potential problems.

Please note

- While we are starting from an existing model and greater knowledge than for UKESM1
- We will have less time ~ 2.5 years
- And less people available in the core team to put the model together
- We learned with UKESM1 (probably too late) that we really cannot cope with too many large new developments and we need to be hard on deadlines
- So being early and well tested will increase the chance of making it into UKESM2
- UKESM1.1 is a pretty good back-up option ☺