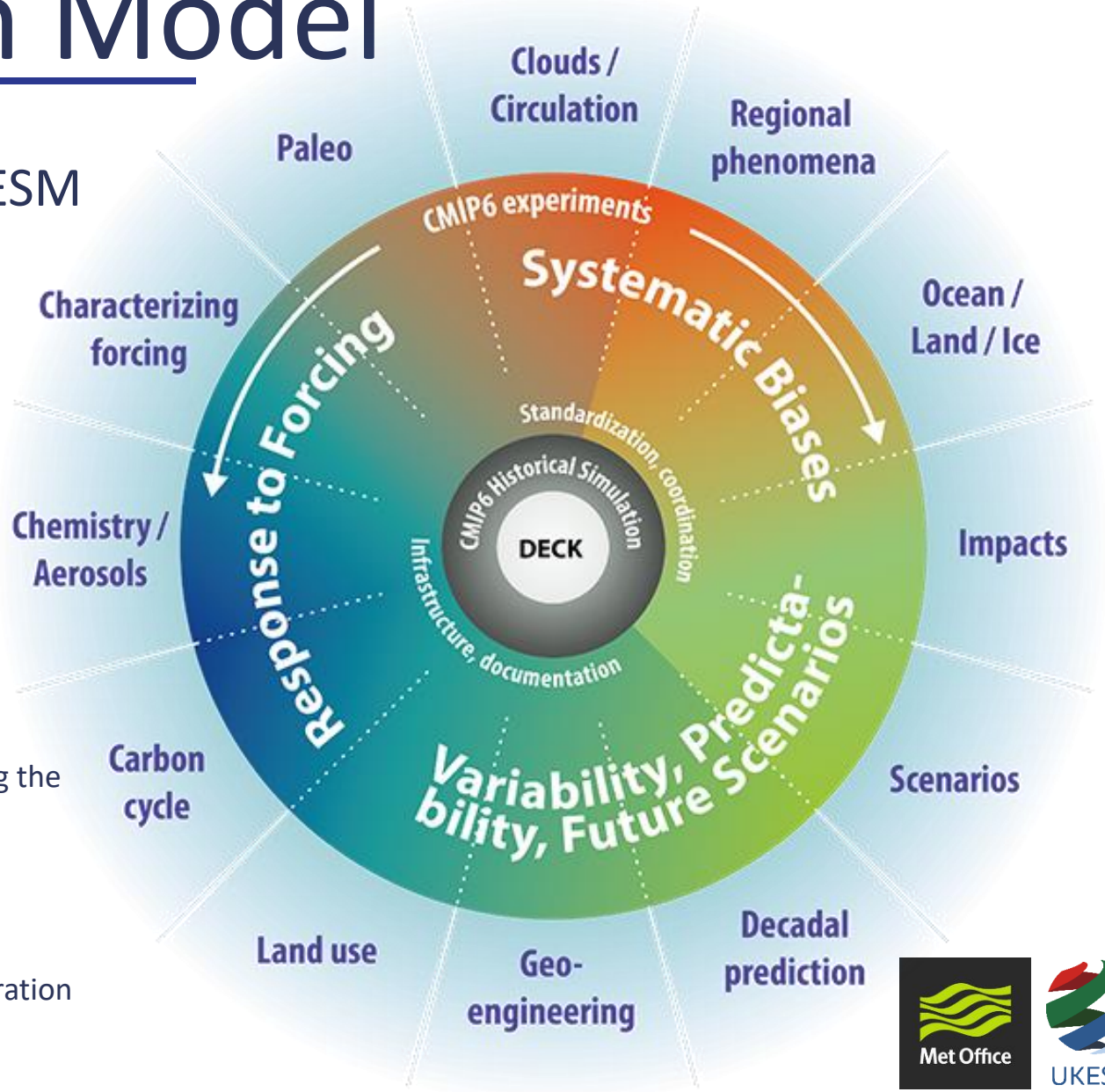
The UK Earth System Model

Rob Parker

Contributions from: NCEO-UKESM Team, UKESM Core Group, European Space Agency



UKESM @ NCEO Conference

- Rob Parker – The UK Earth System Model
- Tim Trent - Evaluation of Total Column Water Vapour in CMIP6 models using the G-VAP Archive – Presentation
- Adam Povey – A new perspective on satellite data – Poster
- Ranjini Swaminathan - Using the ESMValTool and Observation Data Sets for Evaluating Land-Atmosphere interactions with Vegetation in Earth System Models - Poster
- Ranjini Swaminathan - ESMValTool Training Tutorial – this afternoon (registration required)

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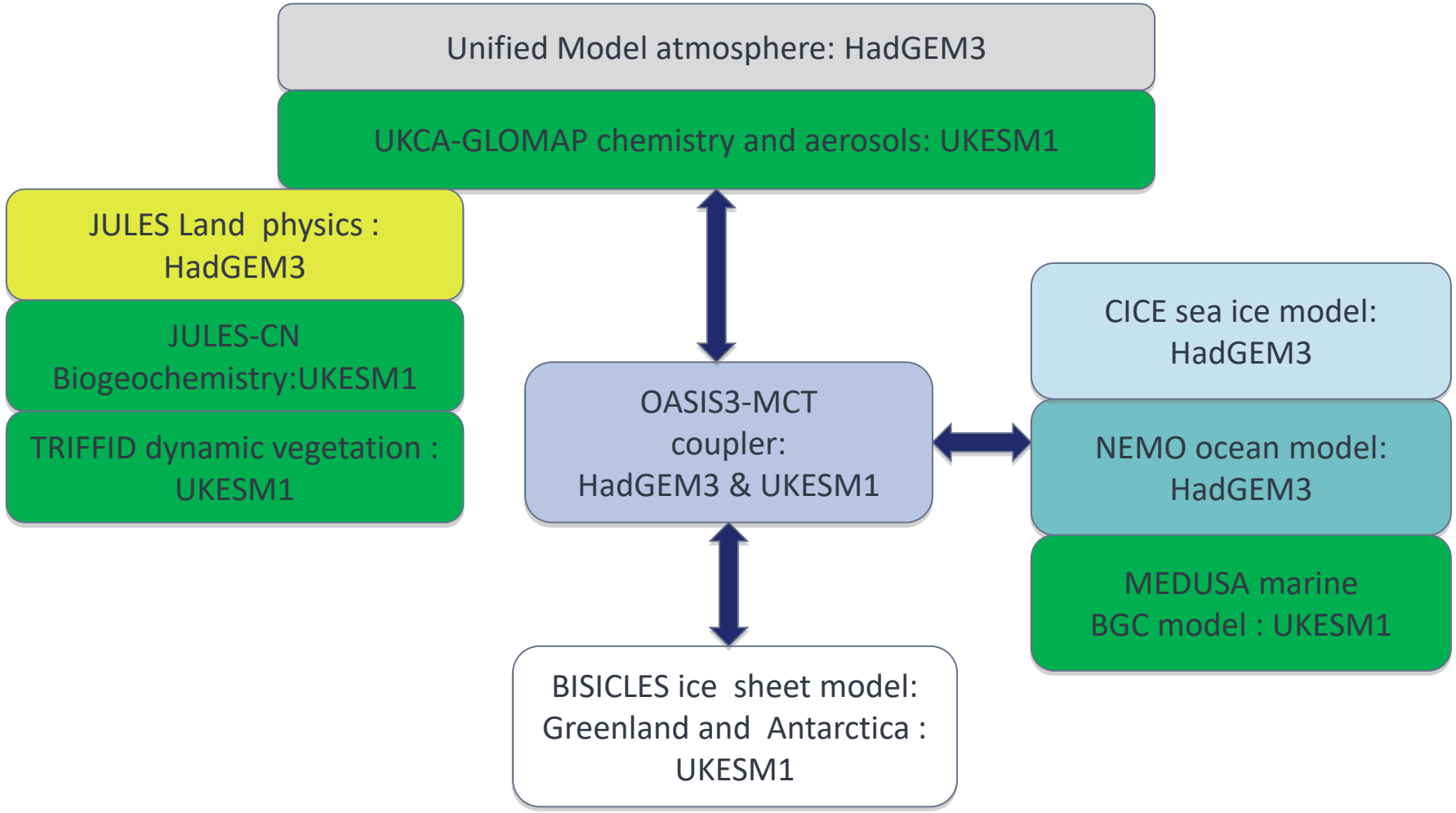
UKESM Model Components



UKESM: Primary Project Aims

- Aims
  - To develop a world-leading Earth system model (UKESM1) to contribute to 6th Coupled Model Intercomparison Project (CMIP6), the primary international modelling support for IPCC AR6.
  - Make UKESM1 available to the NERC research community.
  - To advance (e.g. through peer reviewed publications) the science of Earth system modelling, our understanding of the coupled Earth system and its future sensitivity to human activities.
  - To provide a comprehensive set of future Earth system projections for use by UK scientists, government departments and regulatory bodies.
- Status
  - The core set of CMIP6 simulations have all been completed
  - UKESM1 was released for use by the NERC community in January 2019
  - 1st papers documenting UKESM1 and its scientific performance now appearing
  - UKESM-LTSM mid-term review passed in May
- Future
  - An emphasis will be placed on using the full range of observations for **evaluation** of UKESM1, following both a ***top-down (full model)*** and ***bottom-up (process-level)*** approach.
  - Analysis will cover process/feedback interactions across components of the Earth system and with the (simulated) physical climate.
  - **The primary emphasis over the coming year is on peer-reviewed publications**

NCEO UKESM-LTSM Project

- NERC Multi-Centre National Capability funding in collaboration with MOHC
- Currently a 5 year project, started 2016 and ending 2021, expectation that it will continue beyond this
- NCEO leading model evaluation
- NCEO contributes 2 members to the core team (RP and RS): responsibility for identifying relevant EO datasets, providing advice to core team on usage, developing evaluation metrics, putting data/metrics into a common format compatible with existing evaluation tools
  - Science focus areas:
    - Biophysical links between land-atmosphere (Ranjini Swaminathan, NCEO-Reading)
    - Biogeochemical links between land-atmosphere (Rob Parker, NCEO-Leicester)
- 3 non-core members (each funded at 0.5 FTE):
  - Phil Harris (NCEO-CEH) – Land surface energy balance
    - Phil has now moved fully into the UKESM Core Group and CEH are advertising for his NCEO role - https://www.ceh.ac.uk/careers/research-associate-land-atmosphere-scientist-3-years-fixed-term-based-wallingford
  - Richard Pope (NCEO-Leeds) – Atmospheric composition/chemistry
  - Adam Povey (NCEO-Oxford) – Atmospheric aerosols
- + 0.1 FTE Management (Helen Brindley, NCEO-Imperial)

UKESM: Status

DECK:
- piControl
- 1pctCO2 (4 members)
- 4xCO2
- AMIP
- Complete and delivered to ESGF

Historical (1850-2014):
- 16 members complete (+3 at KMA)
- 9 delivered to ESGF

C4MIP + LUMIP
- Tier 1 runs complete
- Data delivery planned in autumn 2019

GEOMIP
- Tier 1 runs complete
- Delivery planned for autumn 2019

AerChemMIP
- Tier 1 runs mostly complete or running
- Includes simulations on ARCHER
- Delivery started, should be complete by end 2019

OMIP
- Underway – delivery planned late 2019/early 2020

Scenarios
Tier 1:
- SSP1-2.6
- SSP2-4.5
- SSP3-7.0
- SSP5-8.5
- 5 members complete and delivered

Tier 2:
- SSP1-1.9
- SSP4-3.4
- SSP5-3.4-overshoot
- 5 members complete – to be delivered soon

Accessing UKESM CMIP6 Data

- First place to visit is UKESM CMIP6 website:
  - https://ukesm.ac.uk/cmip6/
- This contains a link to the ESGF where all CMIP6 data can be searched and downloaded
  - https://esgf-index1.ceda.ac.uk/projects/cmip6-ceda/
- JASMIN users can access CMIP6 data directly at **/badc/cmip6/data/CMIP6**

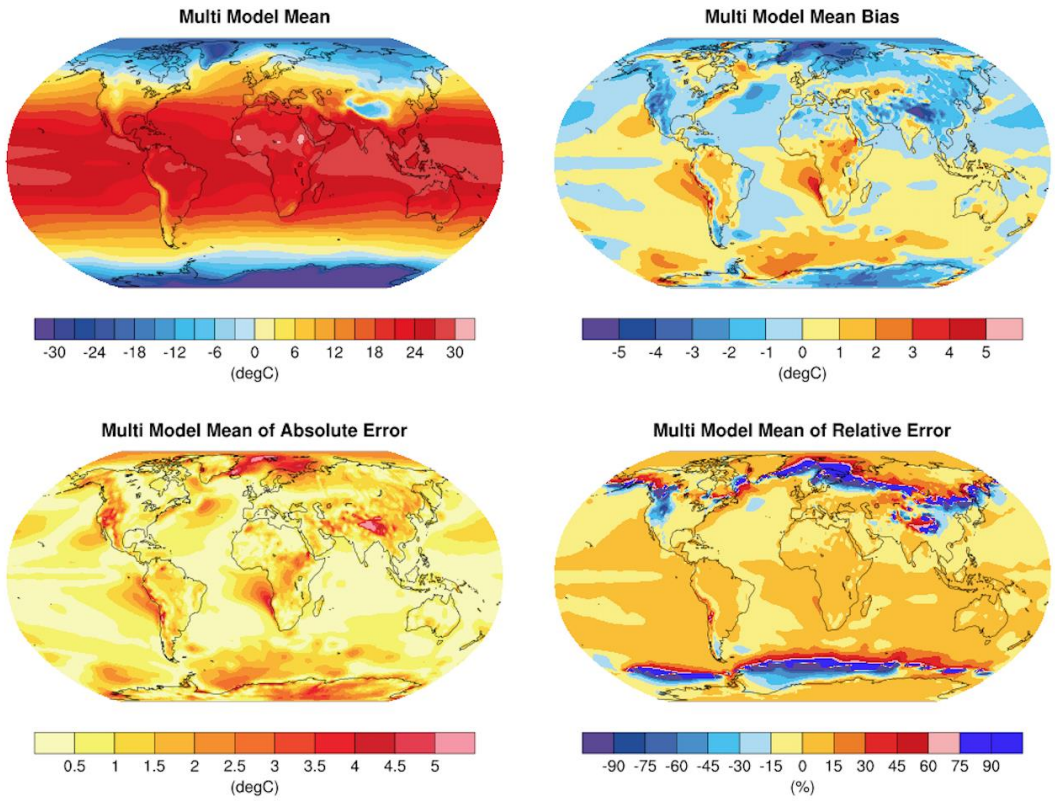
- In addition to standard CMIP6 data, we also have a dedicated UKESM run performed for NCEO that covers the satellite period and is output at high temporal resolution (3 hourly vs daily/monthly).
- This doesn't contain every variable you might want but majority of standard things have been output
- Available at **/gws/nopw/j04/ukesm_nceo**
- Apply for access on JASMIN: **Group Workspace : ukesm_nceo**

Running UKESM

- Running UKESM is supported by NCAS-CMS
- http://cms.ncas.ac.uk/wiki/UM/Configurations/UKESM
- Getting Started – see Release Notes
- http://cms.ncas.ac.uk/wiki/UM/Configurations/UKESM/RelNotes1.0
- Can currently be run on these NERC machines: Monsoon, NEXCS and Archer.
- Atmosphere-only and Fully-Coupled configurations available.
- Any questions - http://cms.ncas.ac.uk/wiki/CmsHelpdesk

ESMValTool for Model Evaluation

- **E**arth **S**ystem **M**odel E**val**uation **Tool** - Coupled Model Intercomparison Project (CMIP) Evaluation
- Community Driven (~40 participating institutions and > 70 CMIP models)
- Synergy with international modelling groups and earth observation centres
- Standardized evaluation of model vs model, model vs obs, versions of same model
- Well established analysis from peer reviewed literature
- Flexible - new diagnostics can be written in Python/R/NCL etc
- NCEO providing observational expertise
- NCEO leading development and implementation of new model vs observation metrics



14:00-17:30 Today, Room PO7 Plaza level: ESMVALTOOL TRAINING

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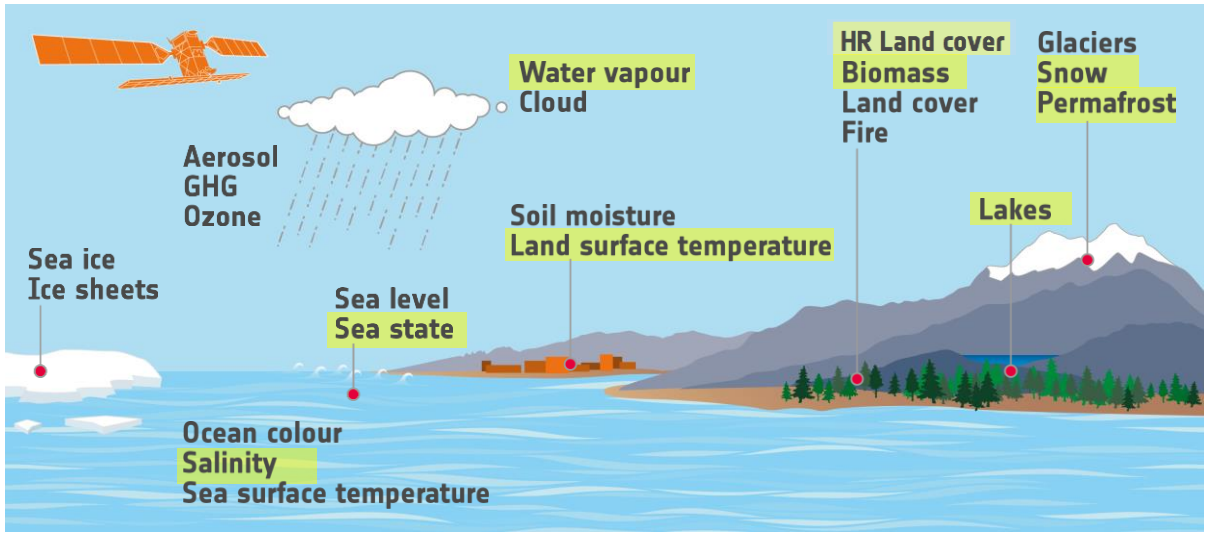
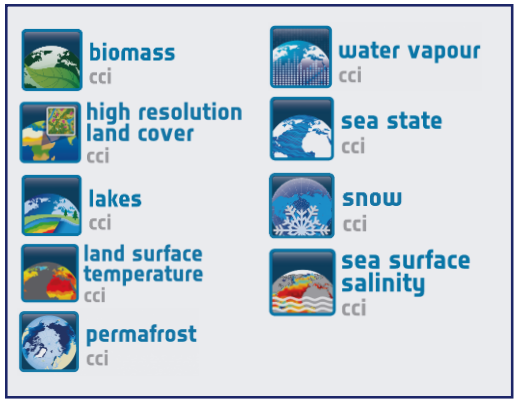
ESA Climate Change Initiative

- 23 ECV projects, 2 budget closure projects, a data support project, a toolbox for data analysis and a climate modelling project currently comprise the CCI.
- 9 new ECVs were included in CCI+, and they will start to deliver data in 12-18 months from now
- Climate Modelling User Group (CMUG) will then use those data in the ESMValTool
- NCEO makes significant contribution to CCI and CCI+:
  - Chair of CCI Science Leads: D. Ghent (NCEO-Leicester)
  - CCI: (Aerosol), Cloud, Fire, GHG, Ocean Colour, Ozone, SST
  - CCI+: Biomass, (Lakes), LST, Water Vapour
  - R. Parker (NCEO-Leicester) represents UKESM on CMUG

*"Realise the full potential of the **long-term global EO archives** that ESA, together with its Member states, has established over the last thirty years. ... as a significant and timely contribution to the **ECV databases** required by the **United Nations Framework Convention on Climate Change.**"*





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UKESM 2 Development

- IPCC AR5: 2013, AR6: 2021, **AR7: 2028/2029 ??**
- CMIP5: ~2010-2015
- CMIP6: ~2016-2021
- **CMIP7: ~2022-2028 ??**

- Implies UKESM2 fully ready for CMIP7 ~mid 2024 through 2025.
- Implied development window for UKESM2 : **early 2020** to mid 2024

- Plan to have discussions/meetings in early 2020 to gather input from community

- Development work already progressing on incorporating fire into UKESM2
- Given NCEO's vast expertise on fires and fire emissions this should provide us a lot of opportunities so please do get in touch if interested in being involved

Summary of Engagement and Impact

NCEO Contributions

- Organised tutorials for ESMValTool to provide training to UKESM group and wider LTSM.
- Participated in the Royal Society Summer Science Exhibition in 2017 for “A Model Earth”.
- Participated in BlueDot Music and Science Festival (July 2019).
- Presented CMIP/UKESM model evaluation at various national/international conferences
- Organised and chaired a “Satellite Observations for Earth System Model Evaluation” session at the UK National Earth Observation Conference 2018.
- Represents UKESM on the ESA Climate Change Initiative Climate Modelling User Group which is a vital link between the observation and modelling communities.
- Membership of UK CMIP6 Analysis Team, coordinating scientific analysis of UK (and other) CMIP6 simulations.

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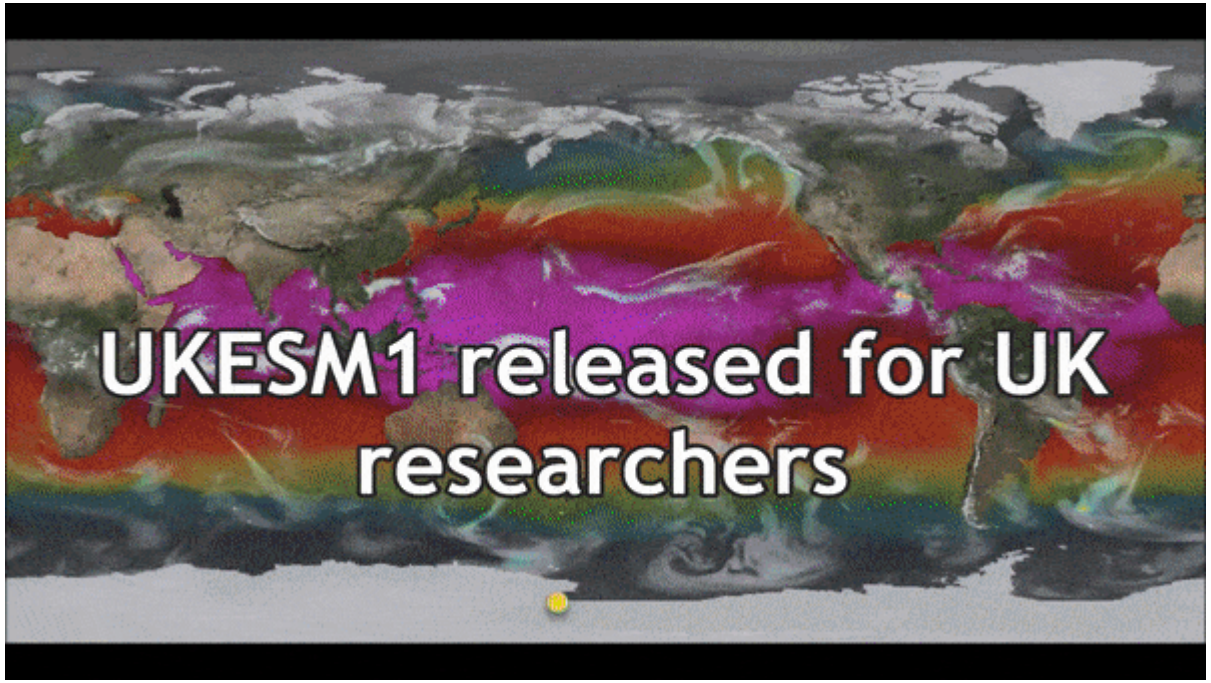
Earth System Allegro

- Produced by Lee de Mora, PML
- https://www.youtube.com/c/LeedeMora
- Time series data from Run4 historical (u-bb075) and SSP 1 1.9 (u-bh210)
- Each dataset is played by a different range on the piano.
- Drake is high notes.
- SO temperature is low notes.
- CO_2 and Ice are mid range.
- 3 pieces produced and online
- 2 more complete and uploading soon
- PDF sheet music available

Summary

- UKESM 1 is now available to the community
- CMIP6 data has been delivered and is now available
- Training for ESMValTool is available (please contact Ranjini)
- Key focus now (for NCEO) is on evaluation of UKESM data



- A lot of expertise in this room on the “correct” ways to do this evaluation
- ESA CCI observations are key to much of this evaluation and NCEO plays a huge role in generating this CCI data
- Lots of new variables will be available from CCI+ and give new opportunities for new evaluation and science
- UKESM 2 development will start soon – please do engage!