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Joint Weather & Climate Research Programme – a partnership in weather and climate research

UKESM

UKESM-hybrid: focusing resolution where it's most needed

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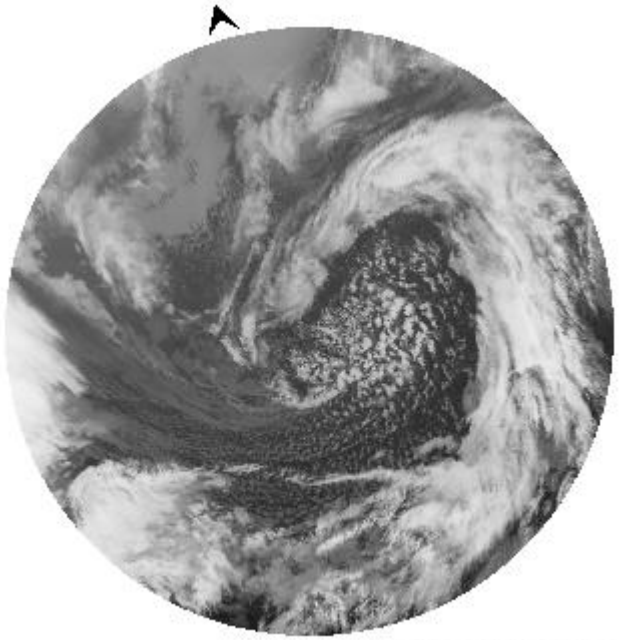
Which atmospheric sciences benefit most from high resolution?

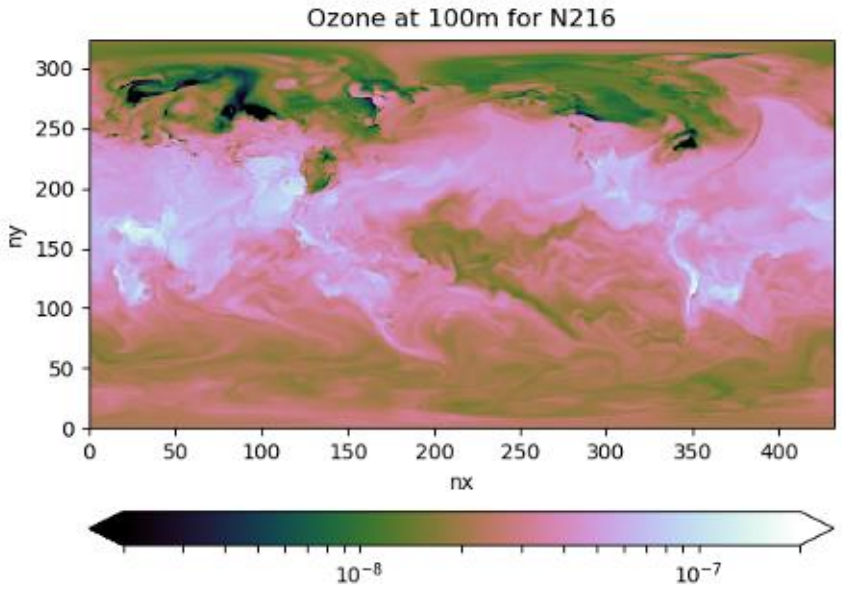
Core Dynamics
(Jung et al, 2012)

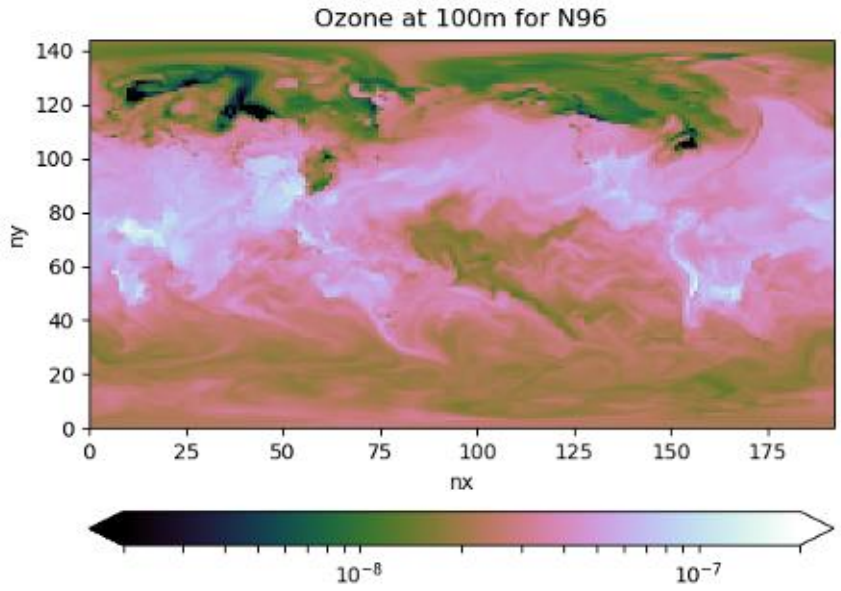


Convection
(Tao and Chern, 2017)

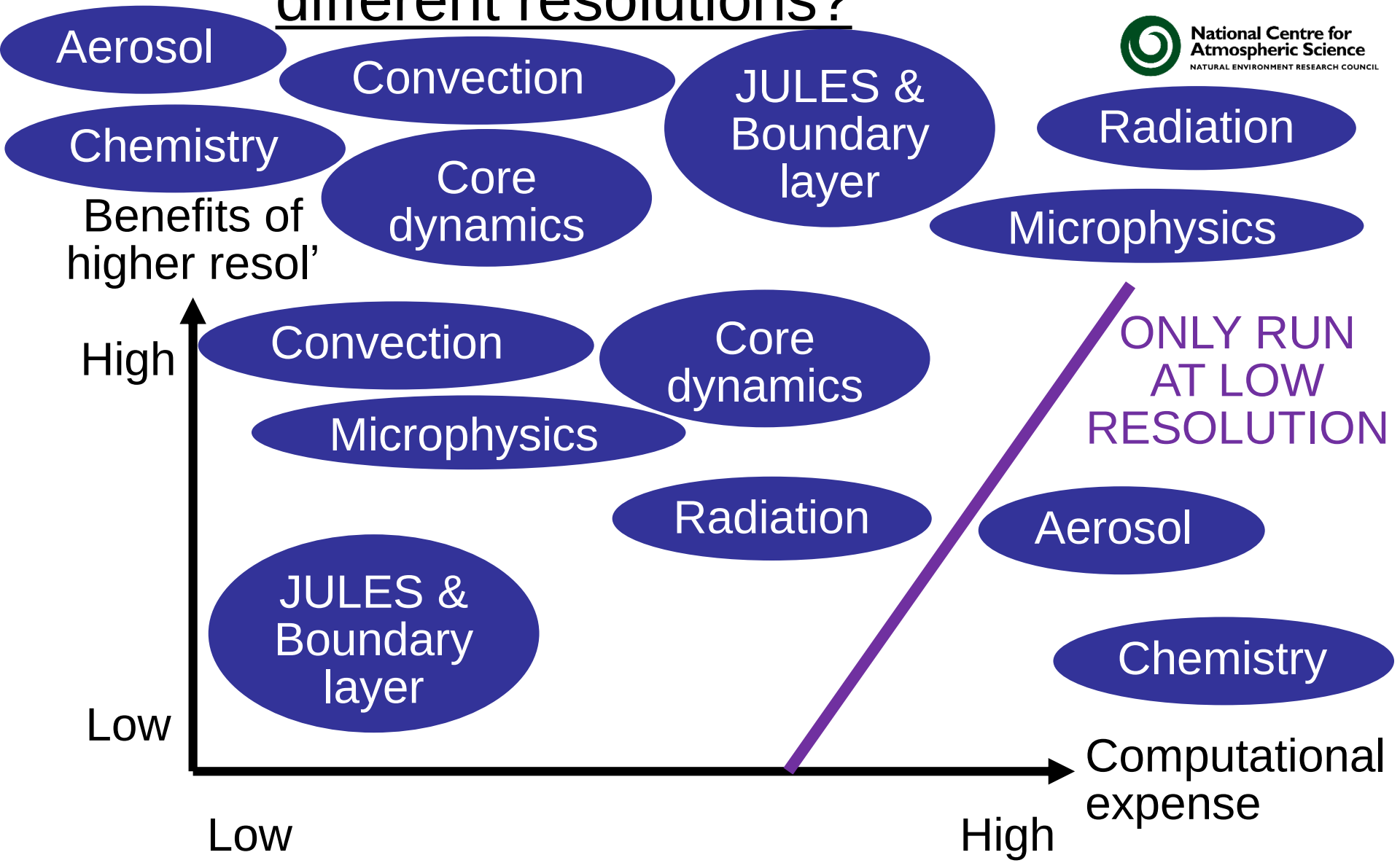
Which sciences have the greatest share of the computation?

2/3rd of total computation is required for Aerosol and Chemistry (4 years ago it was 4/5th of the computation).

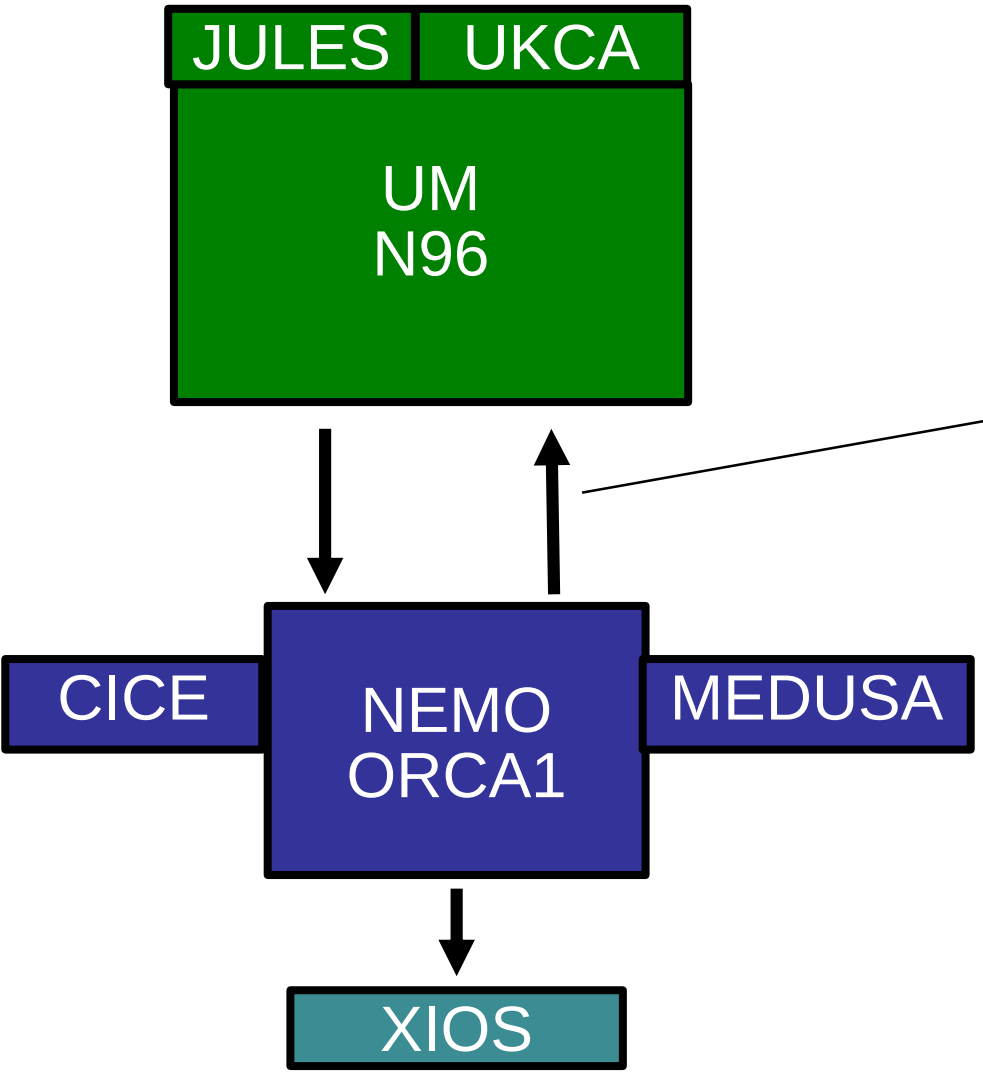




Should we run the sciences at different resolutions?

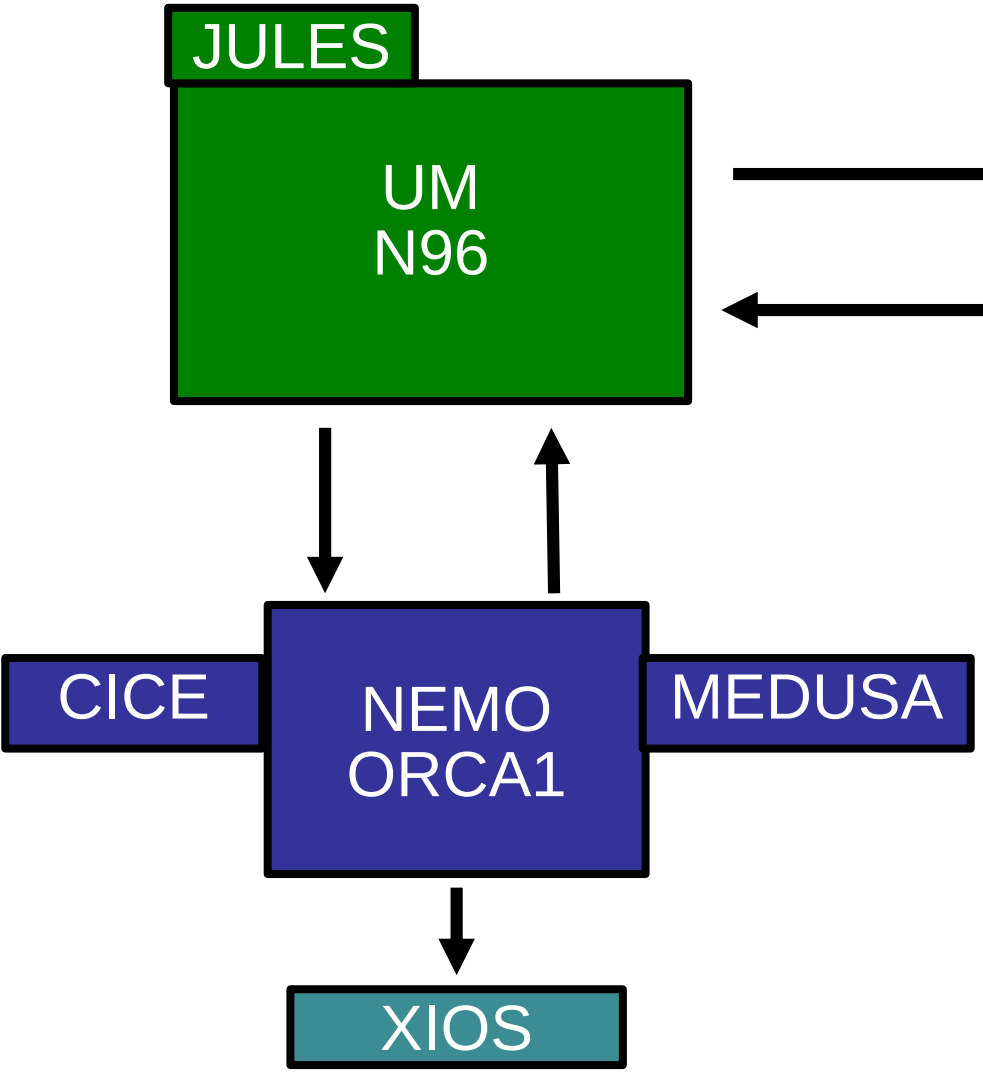


UKESM N96 ORCA1



Except XIOS, all coupling and re-mapping are done with the OASIS3-MCT coupler

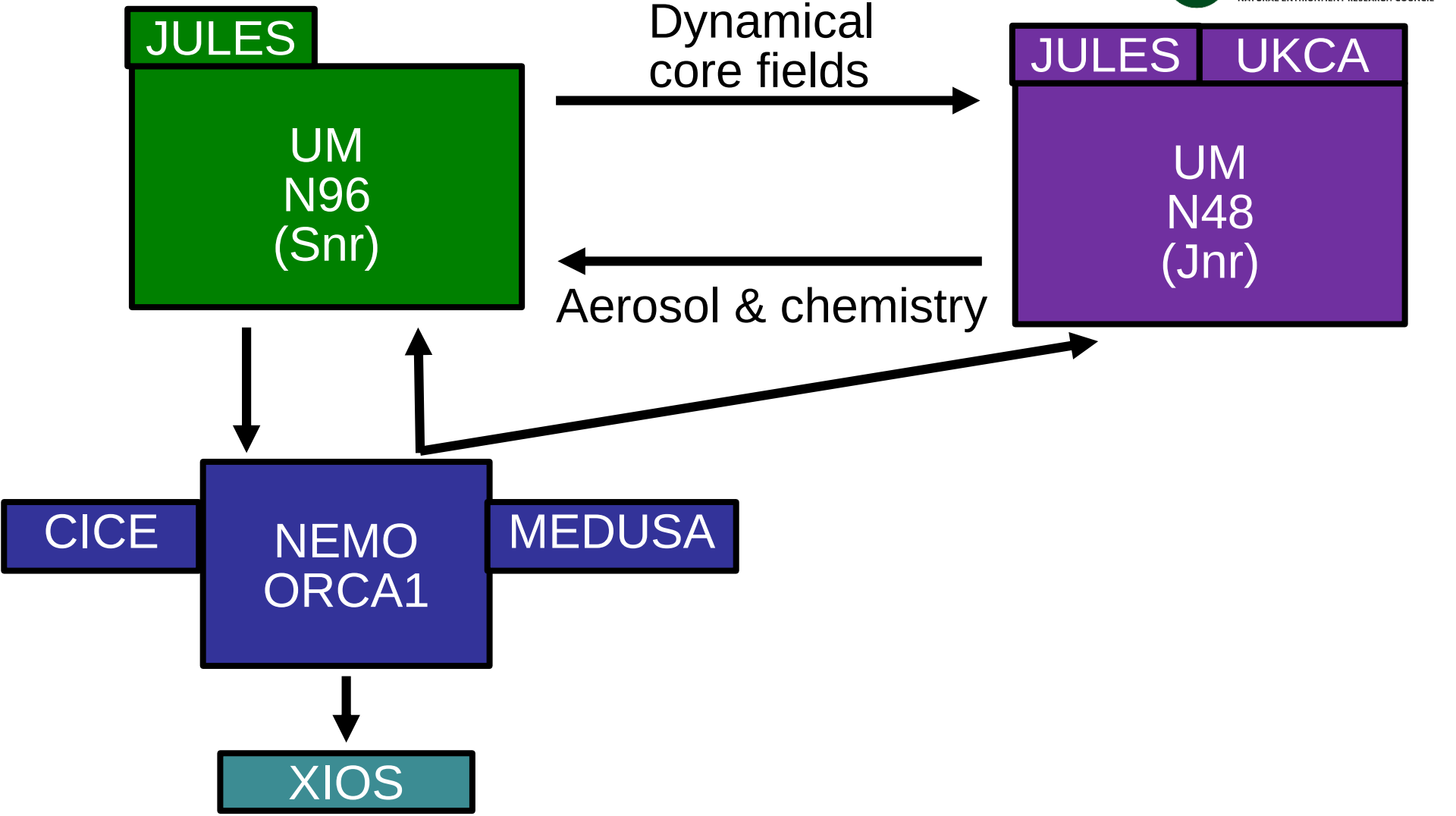
We tried just reducing the resolution of UKCA



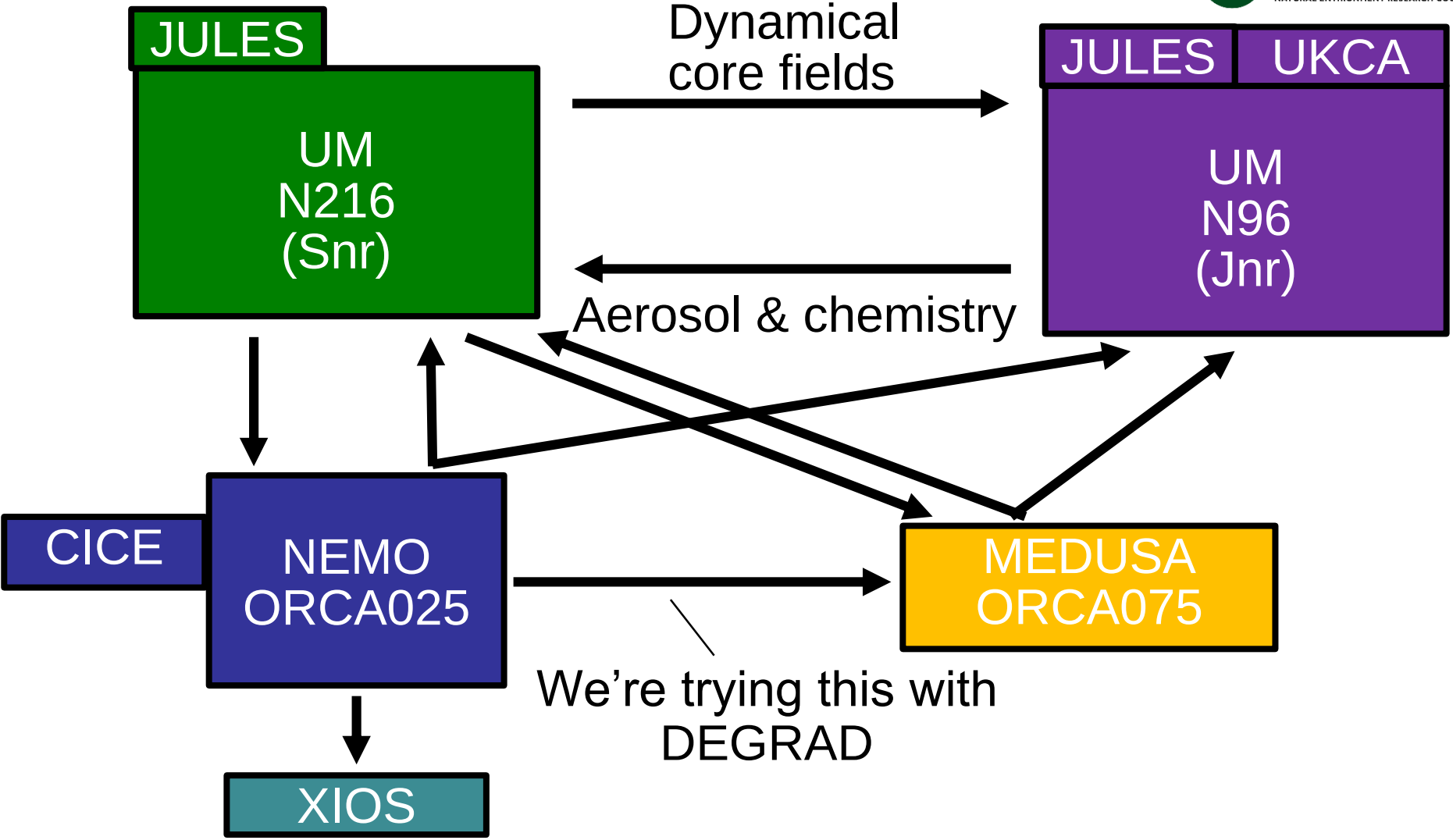
Problems

- Coupling ~200 3D fields
- How do you degrade integer and logical fields?

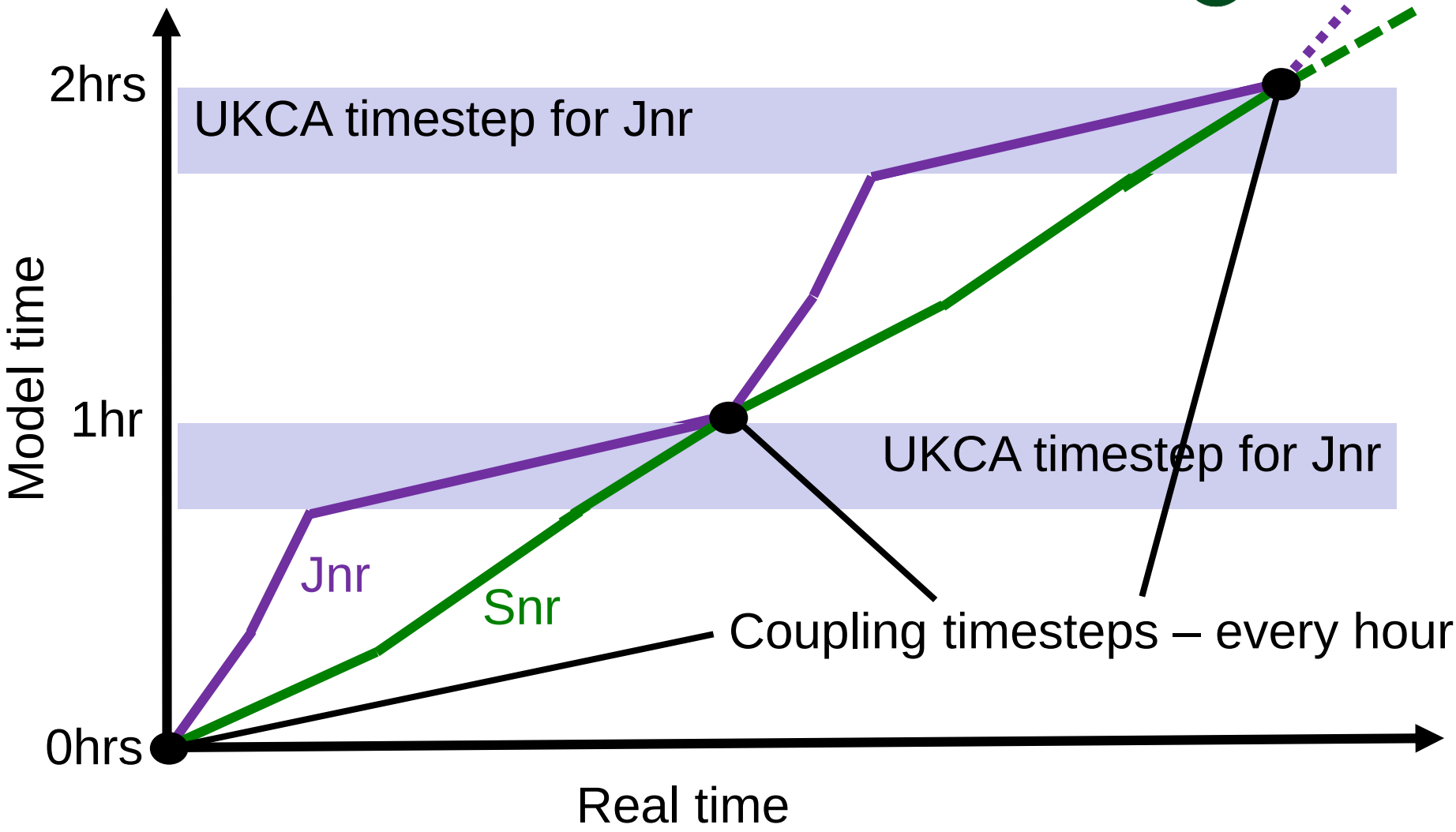
UKESM-hybrid N96 N48 ORCA1



UKESM-hybrid N216 N96 ORCA025 ORCA075



Coupling frequency between Snr and Jnr



Locking the physical atmosphere of Jnr to that of Snr

Which dynamical core fields from Snr should overwrite those over Jnr?

- Definitely: U, V and θ_{vd}
- Maybe: moisture fields, W, $D\eta/Dt$ and π.
- Definitely not: ρ_d (ruins mass conservation in Jnr)

Which JULES fields?

- Probably: soil moisture and temperature

How we're measuring success of locking?

- Trying to minimise drift of all dynamical core fields
- Minimise energy errors in Jnr's atmosphere
- Using the standard evaluation tools, e.g. valnote

The feedbacks from Jnr to Snr

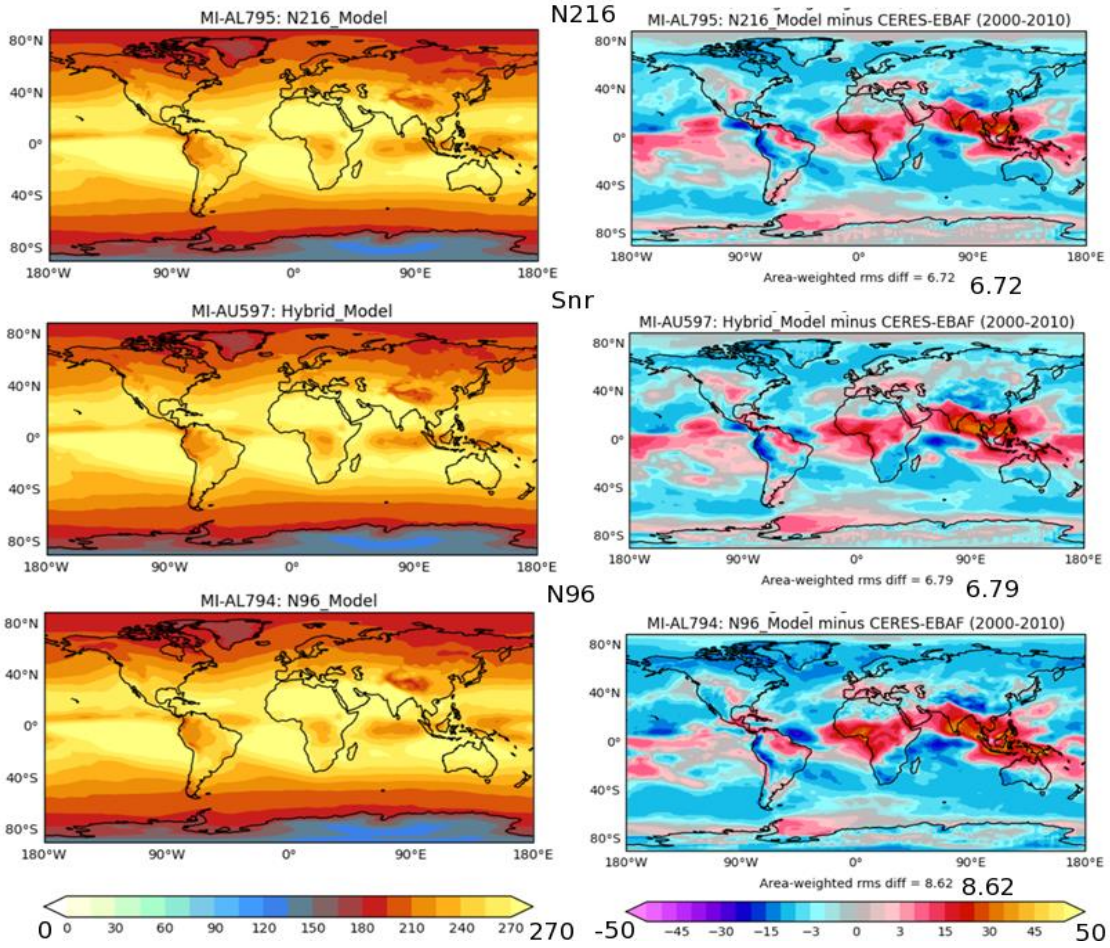
Fields passed from Jnr to Snr are remapped to the higher resolution with the OASIS3-coupler, they will be a slightly smudged version of the lower resolution field.

These 49*3D fields are

- 44 GLOMAP-mode fields for RADAER (optical properties for radiation)
- O_3, N_2O & CH_4 to calculate gas mixing ratios for radiation
- Total number of activated aerosol particles (for calculating cloud droplet number concentration)
- Δq (UKCA has a feedback on the moisture)

Comparing UKESM AMIP N216 vs UKESM-hybrid AMIP N216 N96 vs UKESM AMIP N96

Absolute annual mean TOA Outgoing Longwave Radiation (left column) and bias in TOA OLR against CERES observations (right column).



Speed of UKESM-hybrid

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UKESM vs UKESM-hybrid with the same nodes

Configuration	Nodes	Speed (model years/day)	% faster
UKESM AMIP N96	20	2.24	
UKESM-hybrid AMIP N96 N48	20 (10 for Snr; 10 for Jnr)	3.73	67%
UKESM N96 ORCA1	25 (20 for Atm; 5 for Ocn)	2.14	
UKESM-hybrid N96 N48 ORCA1	25 (10 for Snr; 10 for Jnr; 5 for Ocn)	3.48	63%
UKESM AMIP N216	60	1.10	
UKESM-hybrid AMIP N216 N96	60 (36 for Snr; 24 for Jnr)	1.82	65%

For the same resources, hybrid model is about 65% faster

Speed of UKESM-hybrid II

Top speeds on two OpenMP threads

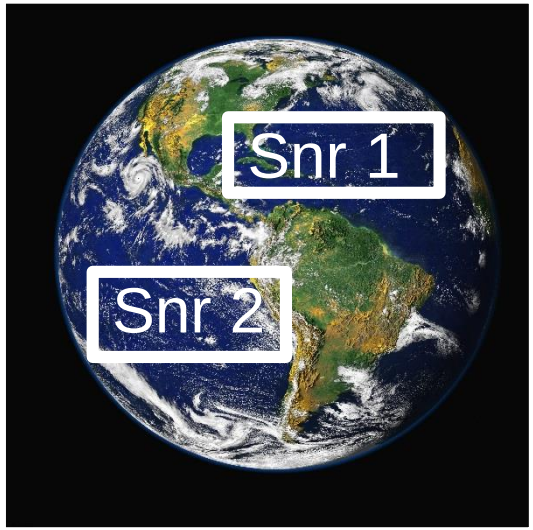
Configuration	Nodes	Speed (model years/day)	% faster
UKESM AMIP N216	242	2.16	
UKESM-hybrid AMIP N216 N96	207 (130 for Snr; 77 for Jnr)	3.72	72%
UKESM N216 ORCA025*	191 (160 for Atm; 31 for Ocn)	1.67	
UKESM-hybrid N216 N96 ORCA025*	242 (98 for Snr; 77 for Jnr; 67 for Ocn)	2.85	71%

*Run without MEDUSA, otherwise MEDUSA would limit speed

Top speed of hybrid model is about 71% faster

Options to improve speed of hybrid model

- Reduce the resolution of Jnr
- Move more science out of Snr, such as
  - ❑RADAER (optical properties of radiation)
  - ❑Radiation
- Reduce the domain of Snr
  - ❑Reduce the computation in Stratosphere for Snr
    - Radiation column needs thinking about (we could apply BC on radiation or just reduce the vertical levels in Snr's stratosphere)
  - ❑Run Snr(s) as a limited area model (LAM)



Next phase is developing UKESM-hybrid N96 N48 ORCA1

Reasons

- N96 N48 ORCA1 is computationally cheap – possible to run many long simulations
- It can be compared with UKESM (a model we know well)

What needs doing?

- Finish developing UKESM N48 ORCA1
  - ❑ It did have too much cloud and was too warm

Summary

- 2/3rd of computation for UKESM is for Aerosol and Chemistry
- Compared to running everything at the higher resolution
  - ❑The hybrid model is about 65% quicker
  - ❑Produces similar results (at least up to about 5 years)