University of Reading

Quantifying forestation's climate impact with AerChemMIP2

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Jules Annual Meeting 2025

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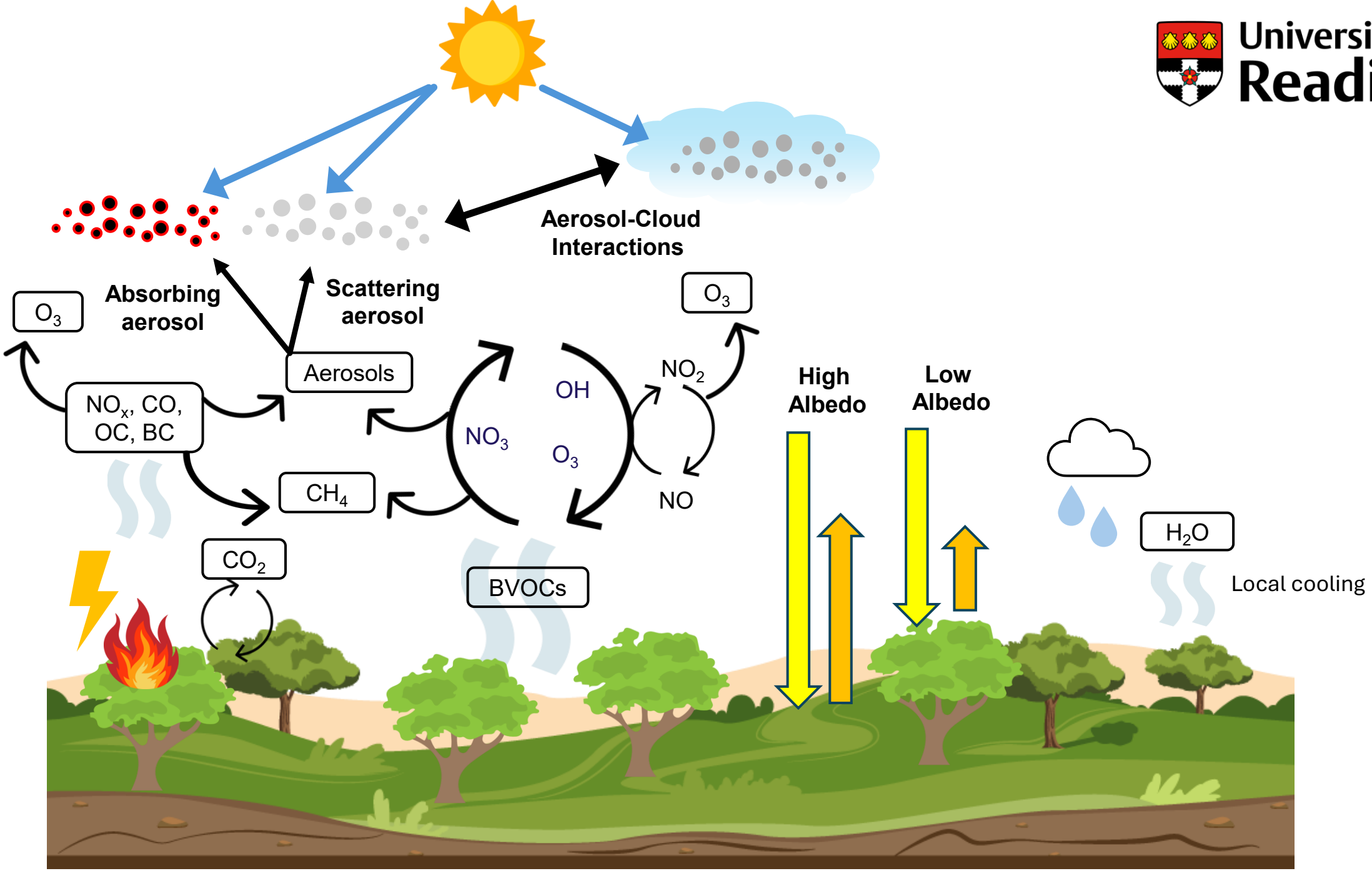
Aerosol-Cloud Interactions
Absorbing aerosol
Scattering aerosol
O_3
Aerosols
NO_x, CO, OC, BC
CH_4
CO_2
NO_3
OH
O_3
NO_2
NO
O_3
BVOCs
High Albedo
Low Albedo
H_2O
Local cooling

Some Selected Literature

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Scott 2018 - global <u>deforestation</u> leads to RF from changes in O_3, CH_4, aerosol (+0.12 Wm^{-2}), CO_2 (+2.22 Wm^{-2}) and surface albedo (-0.96 Wm^{-2})

Weber 2024 – future <u>forestation</u> leads to positive RF from combined O_3, CH_4, aerosol changes, positive RF from albedo and negative RF from CO_2 changes. Net negative RF but 15-30% offset by non-CO_2 factors, also scenario dependent.

Gomez 2025 CMIP6 – future <u>forestation</u> surface cooling from increased evapotranspiration and downwelling SW radiation

Boysen 2020 CMIP6 – global <u>deforestation</u> leads to (estimated) warming from CO_2, cooling from surface albedo reduction and other responses which vary between models

Key Questions

1. How does future forestation, as a climate change mitigation strategy, influence TOA radiative balance, relative to an evolving non-forestation counterfactual?

2. How does surface temperature respond to forestation?

3. How does this depend on background climate and composition (i.e., low v. high warming scenario)?

4. What are the separate contributions from changes to surface albedo and from BVOC, fire and dust emission changes?

esm-scen7-vllo (low warming)

esm-scen7-h (high warming)

A3. esm-scen7-vllo-SST
(LU follows vllo, B/F/D respond to evolution of <u>all</u> forcings)

VLLO LU

B3. esm-scen7-h-SST-vllo-LU
(LU follows vllo, B/F/D respond to evolution of <u>all</u> forcings)

B/F/D from A3 prescribed for A2

RF due to change in surface albedo.

B/F/D from B3 prescribed for B2

A2. esm-scen7-vllo-SST-PD-LU
(LU at present day, B/F/D from A3)

RF due to change in surface albedo, BVOC, fire and dust emissions.

B2. esm-scen7-h-SST-PD-LU
(LU at present day, B/F/D from B3)

RF due to change in BVOC, fire and dust emissions

A1. esm-scen7-vllo-SST-PD-LU-BFD
(LU at present day,
B/F/D respond to evolution of all forcings <u>except LU</u>)

NB. Not static present day

B1. esm-scen7-h-SST-PD-LU-BFD
(LU at present day,
B/F/D respond to evolution of all forcings <u>except LU</u>)

A1/A2/A3 have **<u>time-evolving</u>** anthropogenic aerosol and O_3 precursor emissions, SSTs and $CO_2/CH_4/N_2O$/CFC/HCFCs from **<u>esm-scen7-vllo-SST</u>**

B1/B2/B3 have **<u>time-evolving</u>** anthropogenic aerosol and O_3 precursor emissions, SSTs and $CO_2/CH_4/N_2O$/CFC/HCFCs from **<u>esm-scen7-h-SST</u>**

B/F/D – BVOC, fire and dust emissions

Prescribed transient SST simulations

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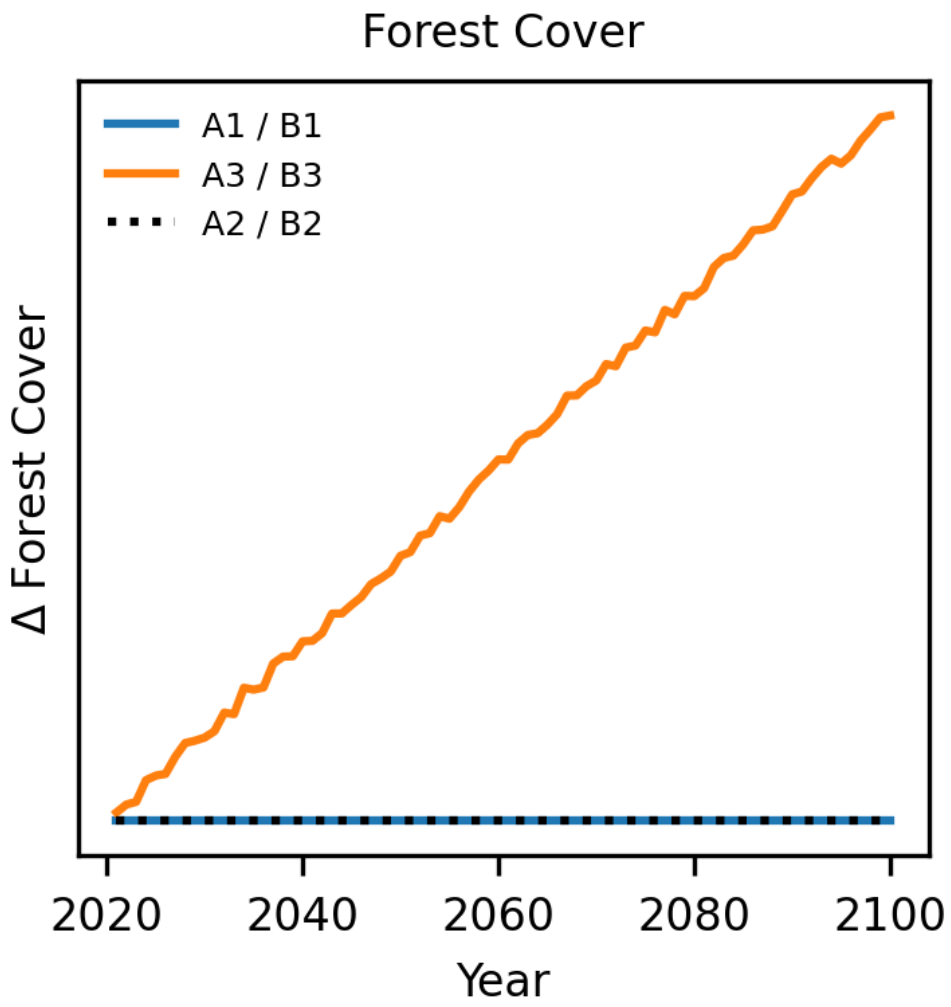

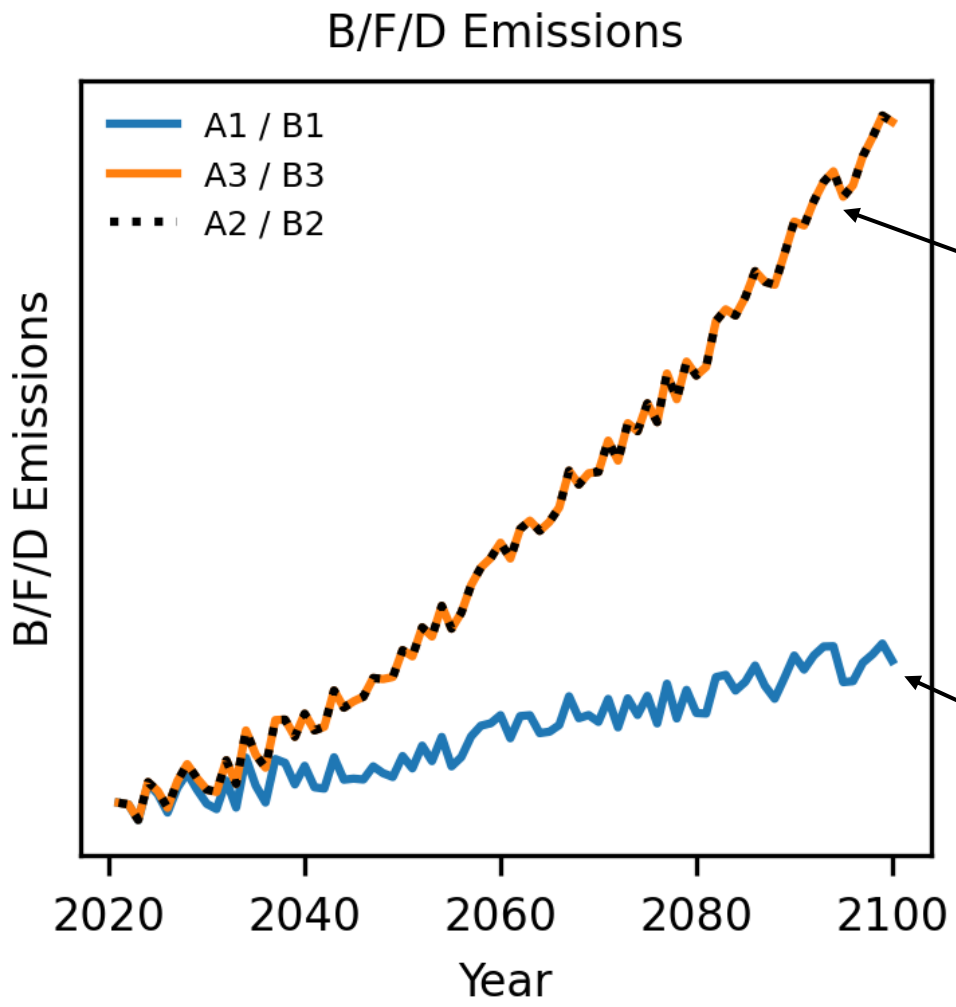

Impact of everything

Impact of everything except land cover change

Forest Cover and B/F/D Emissions Illustrative

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Key Questions

1. How does forestation influence TOA radiative balance?

A1 vs. A3 / B1 vs. B3

2. How does surface temperature respond to forestation?

A1 vs. A3 / B1 vs. B3

3. How does this depend on background climate and composition (i.e., low v. high warming scenario)?

How does A1 vs. A3 differ from B1 vs. B3?

4. What are contributions from changes to surface albedo and, separately, from BVOC, fire and dust emission changes?

Surface Albedo: A2 vs. A3 / B2 vs. B3

B/F/D: A1 vs. A2 / B1 vs. B2

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Further run specifications

Period: 2021 – 2100, 1 ensemble member

Prescribed transient SST from baseline (vllo or h) scenario (AMIP setup), similar to SSP370SST from AerChemMIP

Time-evolving anthropogenic aerosol and O_3 precursor emissions, SSTs and CO_2/CH_4/N_2O/CFC/HCFCs from

- esm-scen7-vllo-SST (A1, A2, A3)
- esm-scen7-h-SST (B1, B2, B3)

Emission-driven CH_4 ideal but prescribed CH_4 approach ok.

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CO_2

- Full climate response not captured with use of transient prescribed SSTs.
- Modelling centres asked to make available net biosphere carbon diagnostics (cLit, cVeg, cSoil).
- Change in atmospheric carbon can then be estimated using method in Weber et al (2024) → convert CO_2 changes to RF.
- Pragmatic approach – supplying modelling centres with revised CO_2 LBCs / emissions was explored but deemed too complex.
- That said, other suggestions welcome!

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Surface Impacts

- Land surface temperature will respond in AMIP mode, but potentially not as much as it would with interactive oceans.

- Nevertheless, changes to evapotranspiration and surface albedo, among other processes, and impact on surface temperature informative.

- Surface Energy Balance approach (e.g., Gomez et al., 2025) useful for analysis.

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JULES specific contributions

- AerChemMIP2 primarily atmospheric scientists → we need land surface expertise!

- Particularly keen to get expertise in surface energy balance processes, evapotranspiration and land/atmosphere exchange.

- **If you are interested in contributing, please do get in touch!**

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