

UKCA dust: Addition of a third insoluble mode and sensitivity to ageing rates

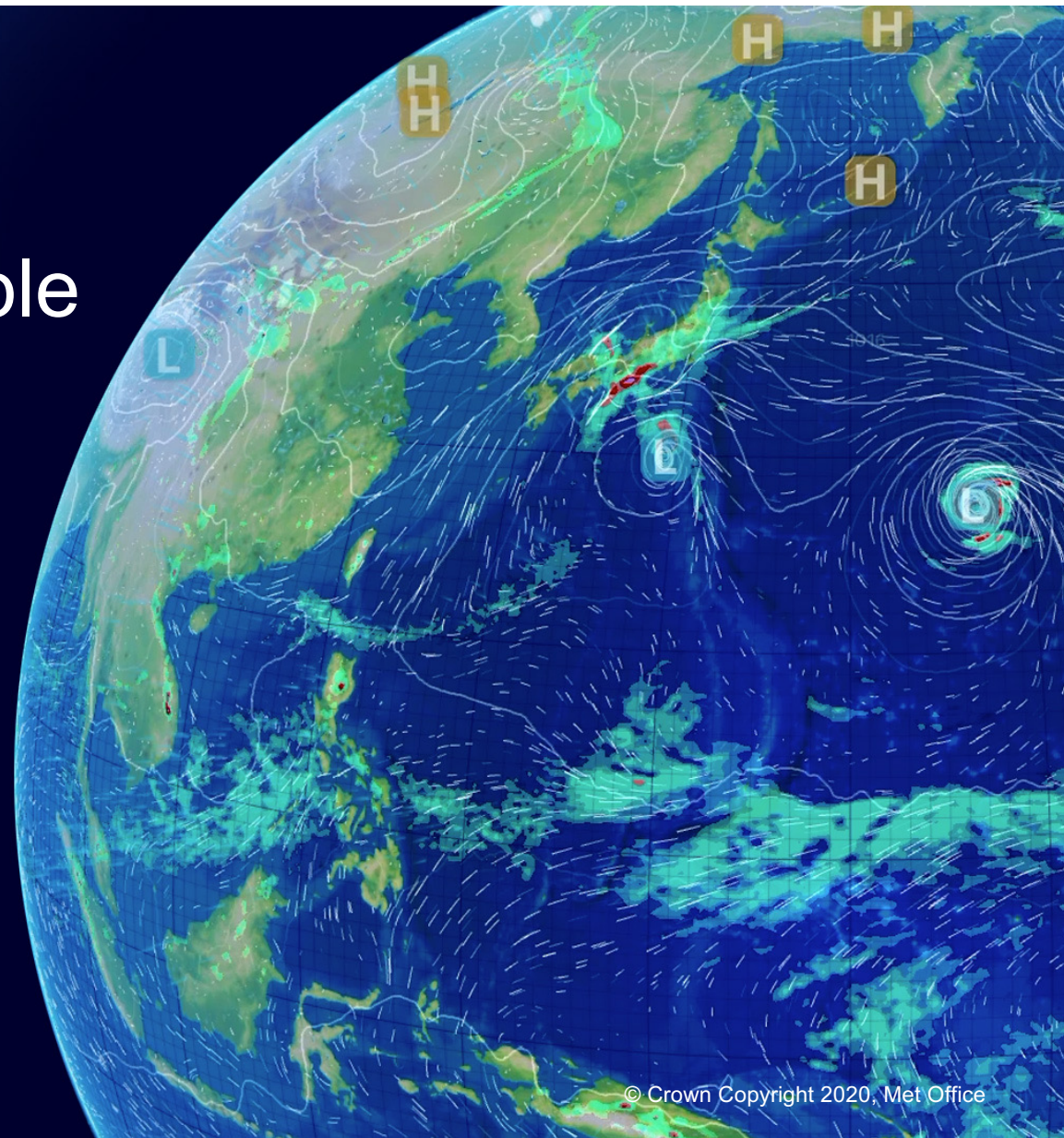
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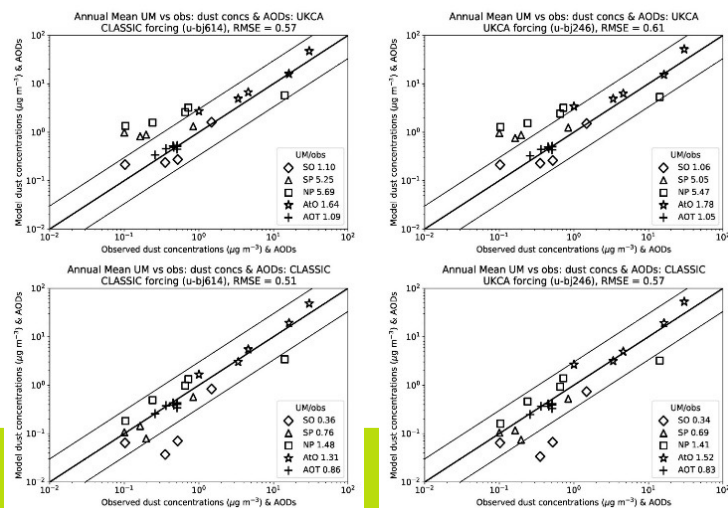
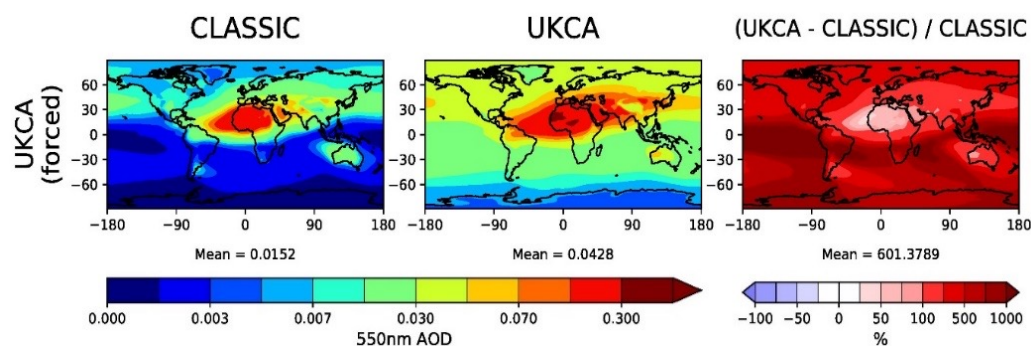
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- Previous studies have found issues with UKCA 2-mode dust:
 - Too much dust away from source regions without ageing
 - With ageing on, a significant fraction of dust in the soluble mode

Action plan to address issues



Who?	Why?		What?
AJ	*Clim	1	Add 3rd insoluble mode – UKCA, UM, Rose, diagnostic changes + inputting mode widths via Rose
SW (+BJ?)	*Clim	2	Radaer changes for 3 modes
?	*Clim	3	RCF changes for 3 modes (AJ has already done some of this)
SW	*Clim	4	Set mode widths & limits & map emissions to modes, for 3 modes
SW+AH, AS	*Clim	5	Improve sedimentation
SW	*Clim	6	Improve impactation scavenging. Step 1: dust only
SW	*Clim	7	Implementation
SW + AJ			Write up! (possibly with Climate/ NWP split?)
SW + ?	*Clim +NWP	8	Re-tuning (separately for each configuration)
?	NWP	9	D A changes for 2 mode dust
?	NWP	10	Set mode widths limits & map emissions to modes, for 2-modes
?	NWP	11	Radaer optimisation/rewrite
SW	Clim +NWP	12	Improved impactation scavenging. Step 2: extend to other species

3rd mode and dust ageing

Branch: anthony.jones/vn11.7_ukca_dust_3modes

- New mode setup (MS12) with super-coarse insoluble (sup_ins) mode ($\sigma = 1.8$)
- Coarse insoluble mode ($\sigma = 1.59$)
- sup_ins is radiatively interactive

Mode	Emissions Mapping 1 (M3E1)	Emissions Mapping 2 (M3E2)
ACC_INS	Bin 2 + 0.5 x Bin 3	Bin 1 + Bin 2
COA_INS	0.5 x Bin 3 + Bin 4 + 0.5 x Bin 5	Bin 3 + Bin 4
SUP_INS	0.5 x Bin 5 + Bin 6	Bin 5 + Bin 6

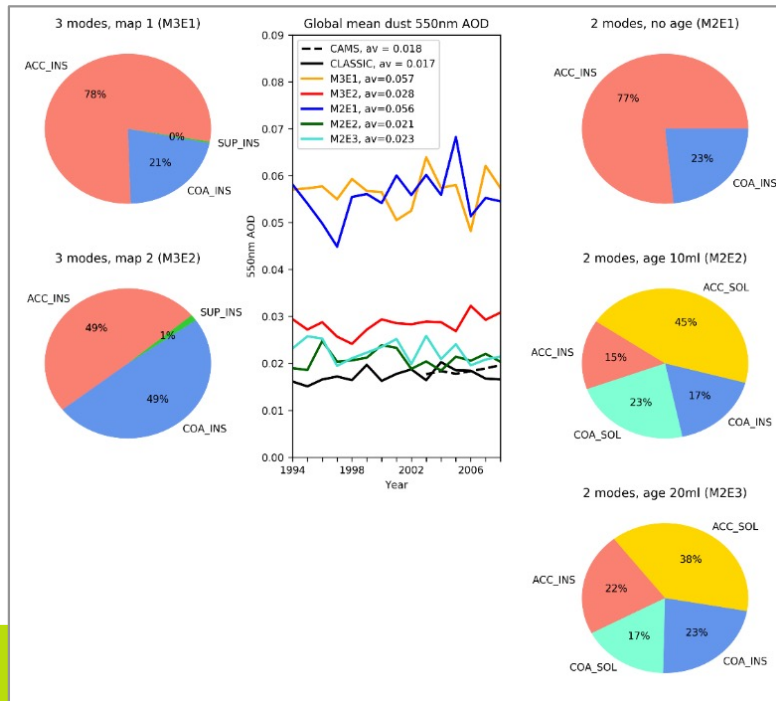
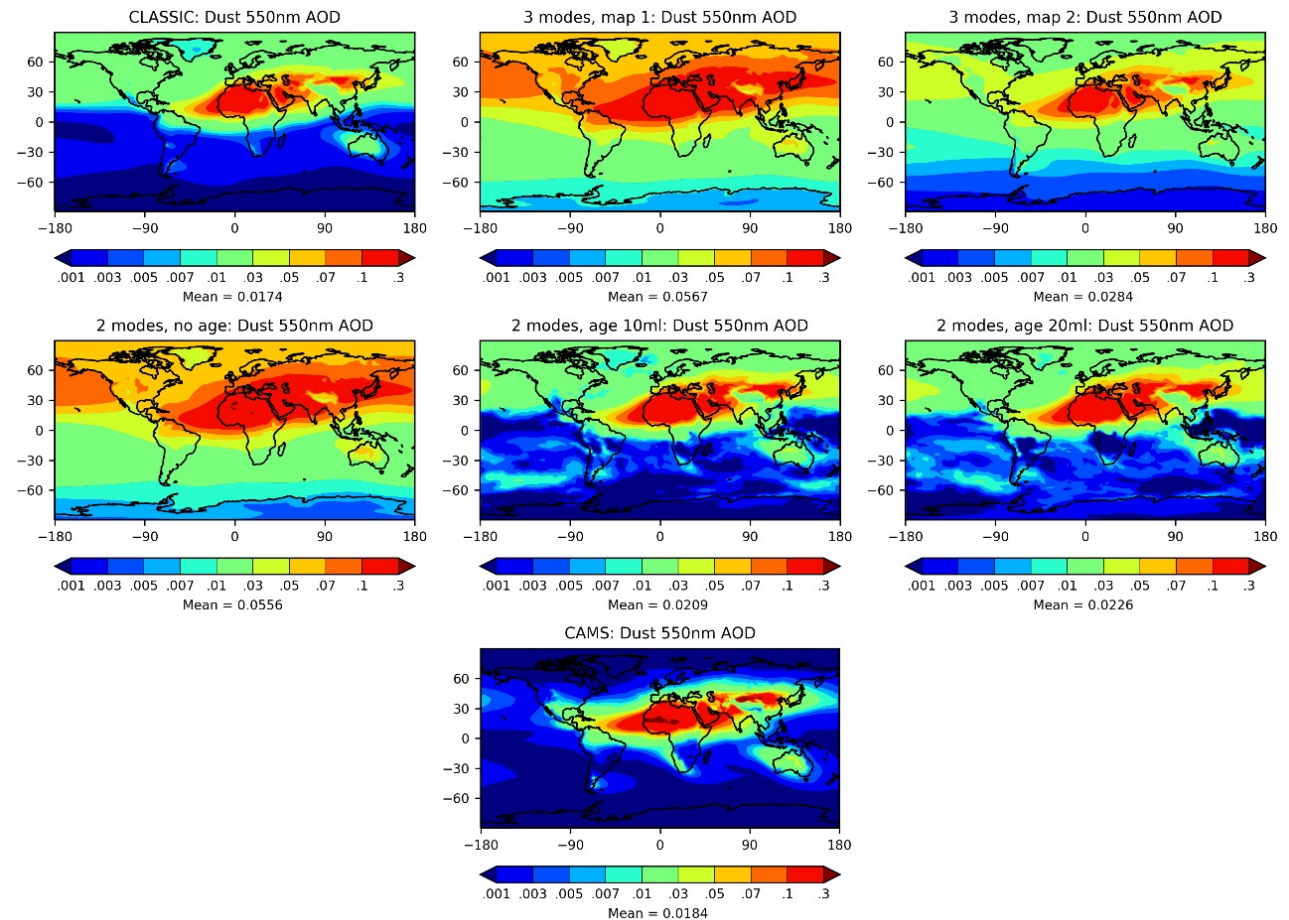
- UKCA_ageing: Number of aged particles inversely proportional to number of microlayers defined as the threshold (N_{ml})
- $N_{ml} = 10$ microlayers default
- What is the impact of setting $N_{ml} = 20$?

$$N_{aged}(i) = \left(\underbrace{\frac{a_{geterm1}(i)}{M_g/M_x}}_{\text{condensation}} + \underbrace{\frac{\sum_{j=1,3} a_{geterm2}(i,j)}{M_g/M_x}}_{\text{coagulation}} \right) \div \frac{\overline{D_{w,i}}^2}{D_g^2} \times \frac{1}{N_{ml}}$$

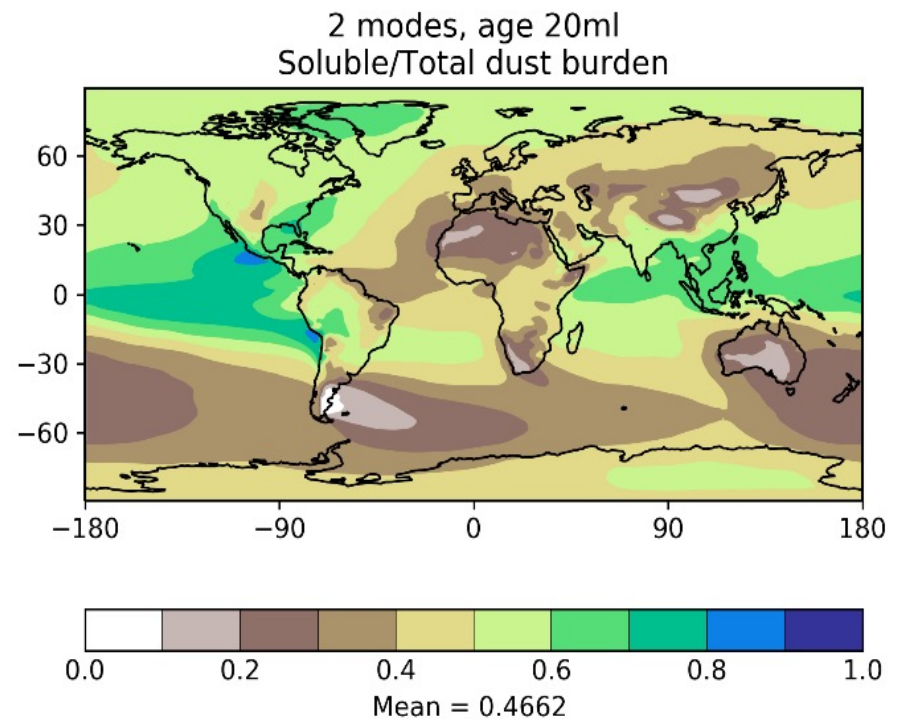
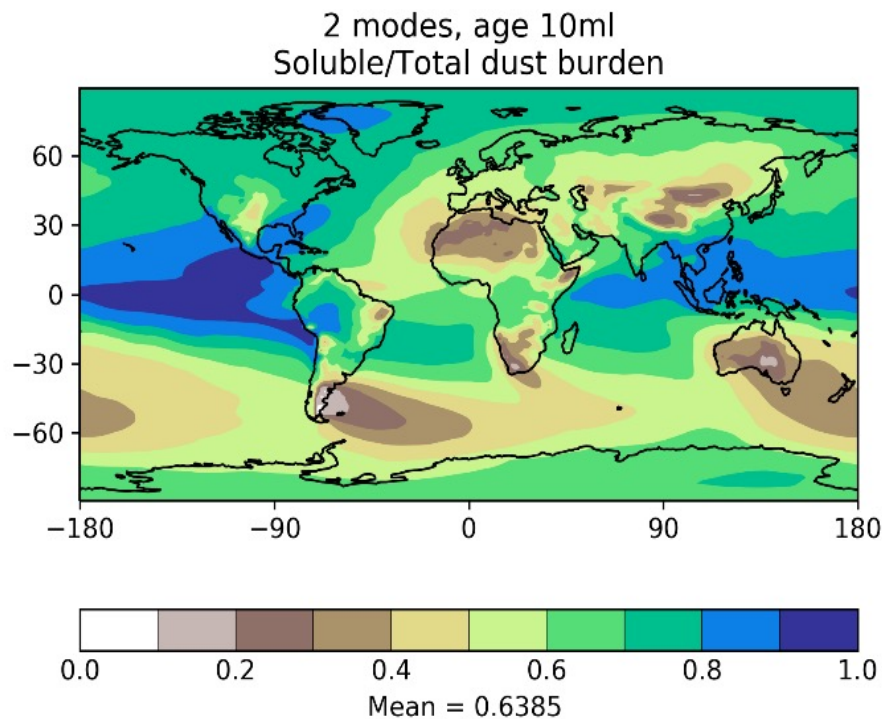
Rose suite	Name	Information
u-bx892	CLASSIC	CLASSIC 6 bin dust, AMIP, N96, offline oxid., UM11.7
u-by556	M3E1	UKCA 3-mode dust, emissions mapping 1
u-by986	M3E2	UKCA 3-mode dust, emissions mapping 2
u-cb937	M2E1	UKCA 2-mode dust, no ageing
u-cb946	M2E2	UKCA 2-mode dust, ageing with 10 micro-layers
u-cb950	M2E3	UKCA 2-mode dust, ageing with 20 micro-layers

- Significant sensitivity to mapping in 3-mode sims
- 3-modes not appreciably better than 2 modes with no ageing
- 2-modes with ageing is similar to CLASSIC

Dust optical depth

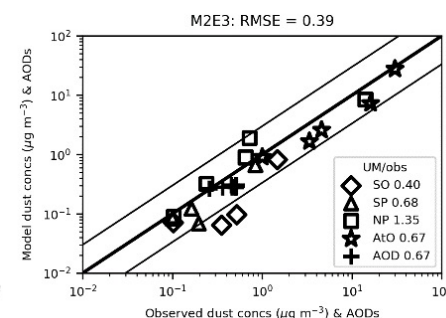
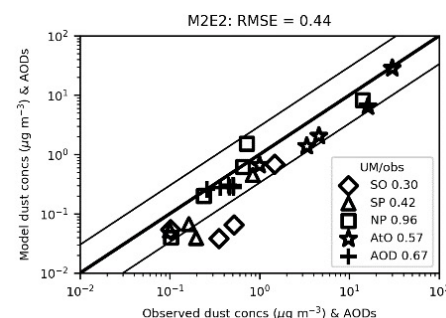
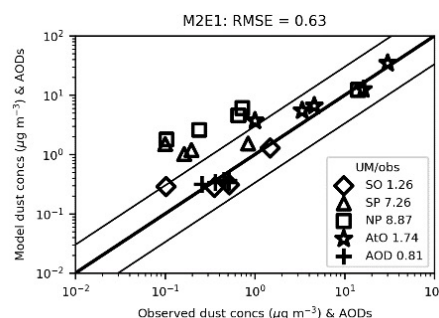
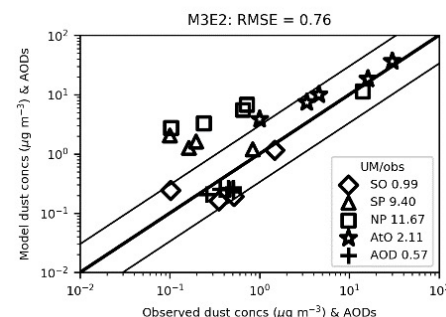
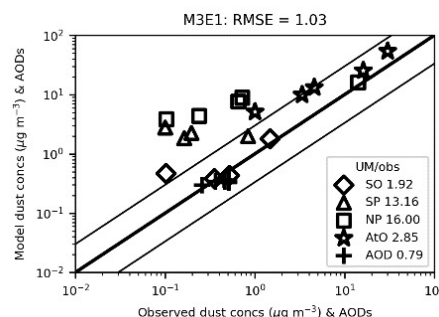
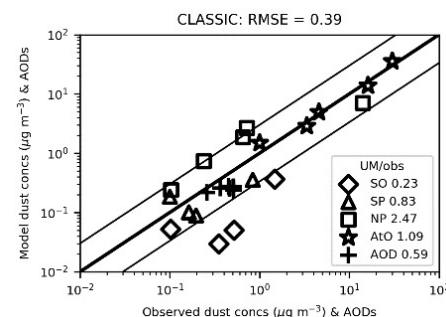
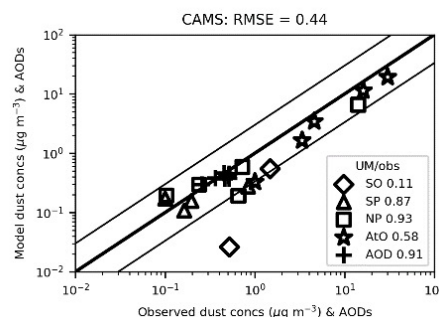


- 50% of total dust in soluble mode in M2E1 and 38% in M2E2
- Is this an issue?



Surface dust in remote regions

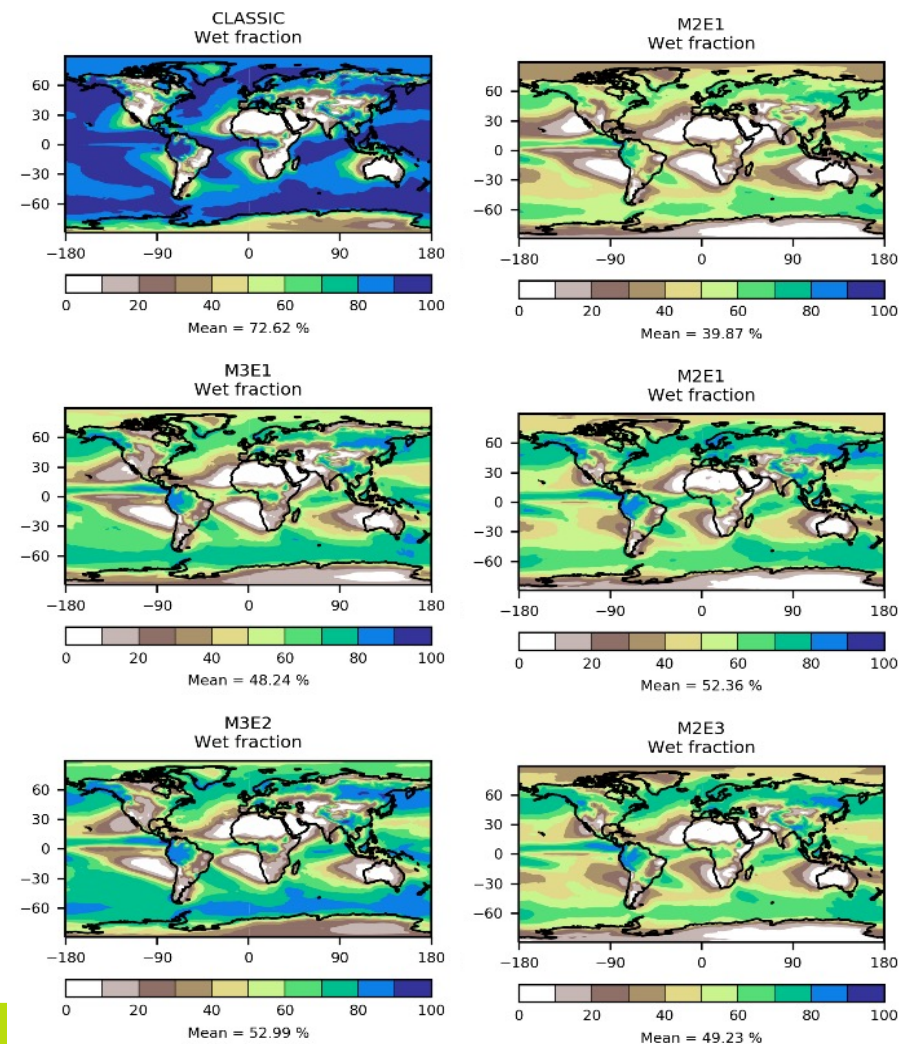
- CLASSIC and 2-mode with ageing in close agreement with U. of Miami concentration observations
- Too much dust in 3-mode sims and 2-mode without ageing – a factor of 10 too great over Pacific



- Too much wet deposition in CLASSIC and not enough in UKCA regardless of whether ageing is on
- 3-mode increases wet deposition relative to 2-mode with no ageing

Location	Coords	Wet deposition fraction (%)						
		Obs.	CLASSIC	M3E1	M3E2	M2E1	M2E2	M2E3
Bermuda	[32.3N, 64.9W]	17-70	89	56	60	42	61	56
Amsterdam Island	[37.8S, 77.6E]	35-53	82	53	61	43	53	51
Cap Ferrat	[43.7N, 7.2E]	35	83	66	69	62	72	73
Enewetak Atoll	[11.3N, 162.3E]	83	94	58	63	47	58	55
Samoa	[14.3S, 170.6W]	83	95	72	76	59	62	57
New Zealand	[34.5S, 172.8E]	53	83	63	70	43	54	53
Midway Island	[28.2N, 177.4W]	75-85	87	44	49	26	52	46
Fanning Island	[3.9N, 159.3W]	75-85	97	61	66	57	74	71
Greenland	[65.2N, 43.8W]	65-80	86	69	78	54	58	58
Coastal Antarctica	[75.6S, 28.8W]	90	86	49	60	37	42	40

Wet deposition fraction



Questions raised?

- Is it necessary to have a third insoluble mode given the skill of the 2-mode simulations with ageing on?
- Is having a significant fraction of dust in the soluble mode “wrong”?
- The ageing rates are too high, for instance, the mass accommodation coefficient in condensation set to 1 for insoluble mode. Should be < 0.3 ?
- Should sedimentation and impaction scavenging schemes still be altered? If ageing is tuned down should impaction scavenging be tuned up to increase wet deposition?