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Aerosol absorption and precipitation in CMIP6 projections

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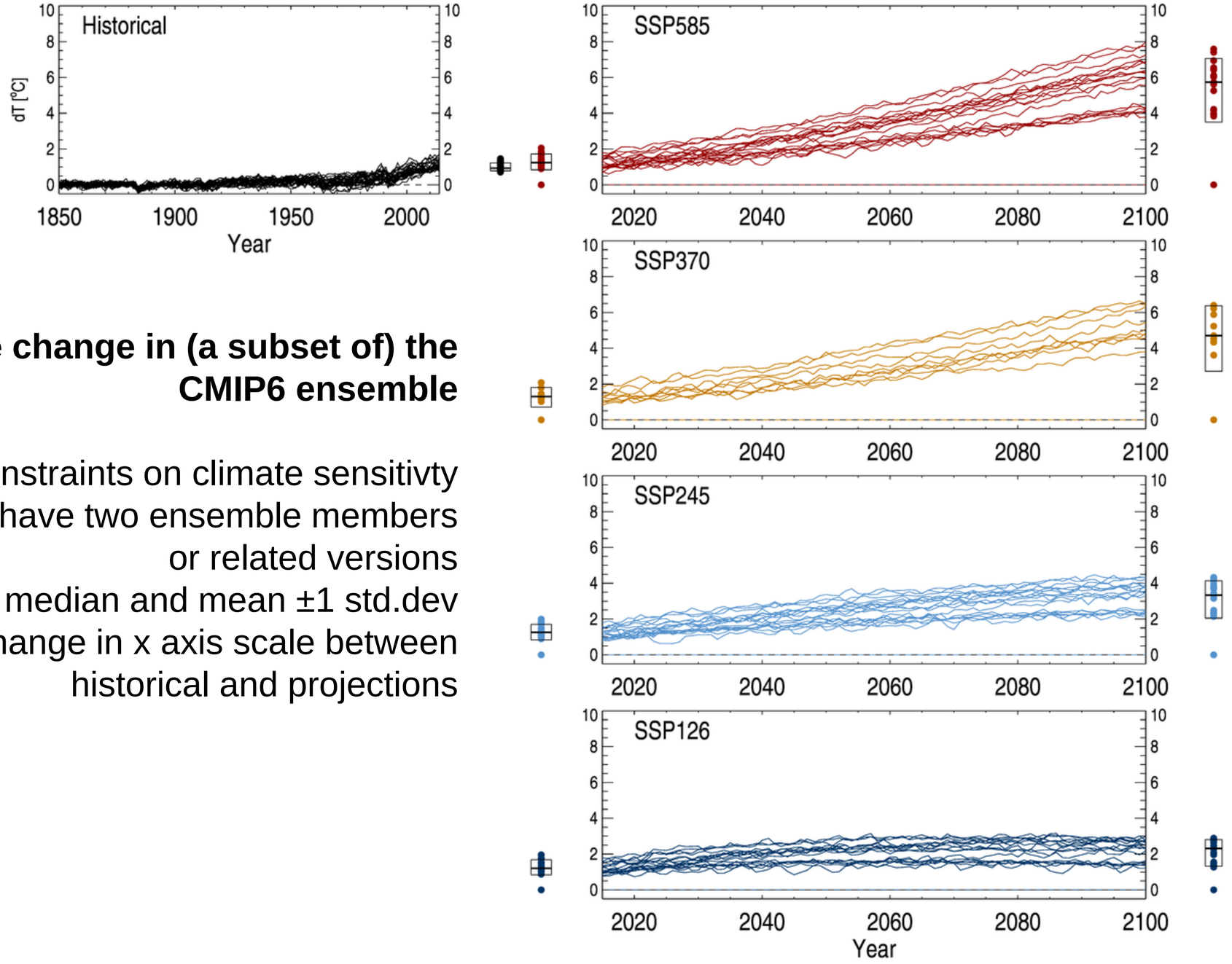
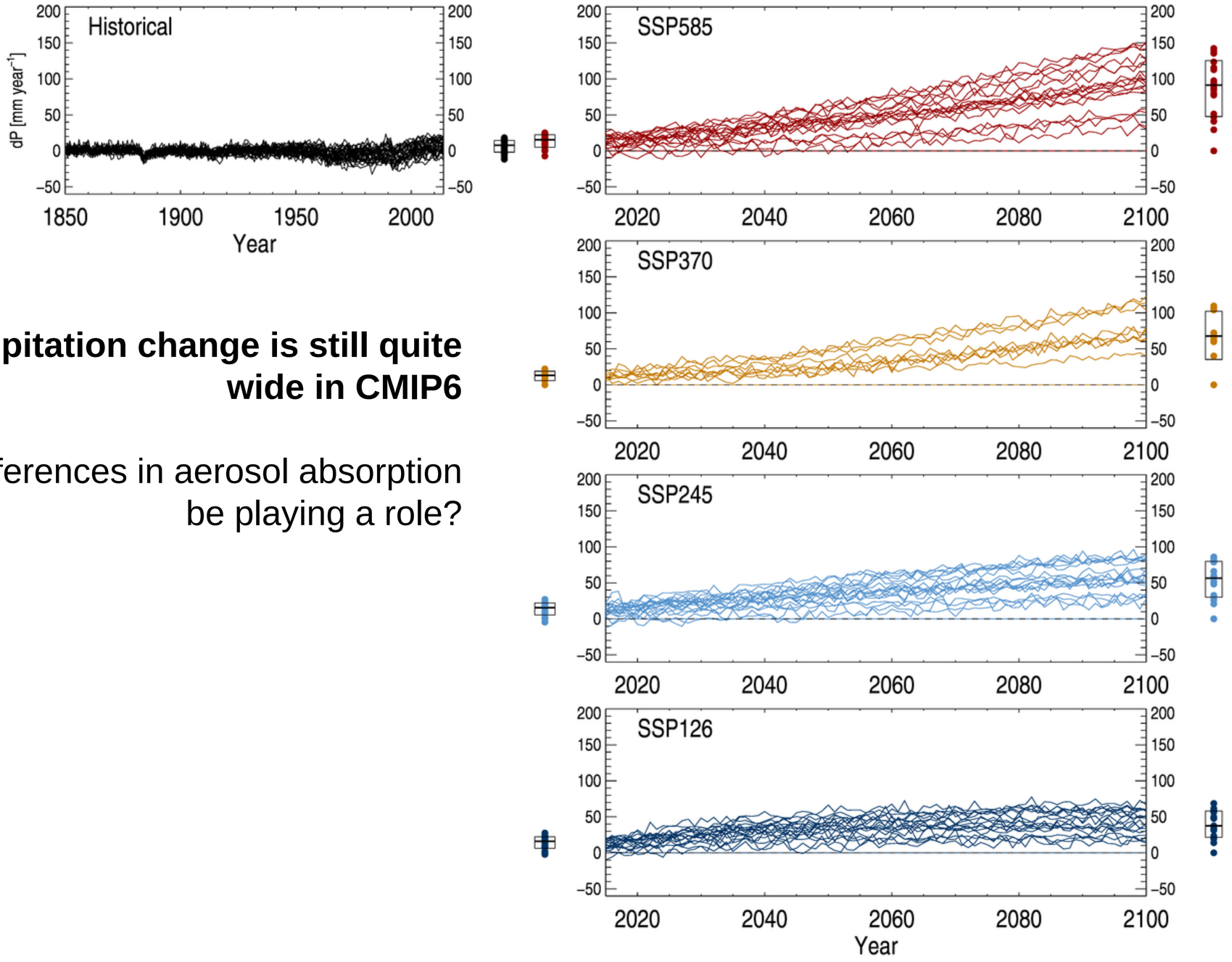
(NB: Work in progress…)



Temperature change in (a subset of) the CMIP6 ensemble

- No constraints on climate sensitivty
- Some models have two ensemble members or related versions
- Boxes show median and mean ±1 std.dev
- Note the change in x axis scale between historical and projections



Projected precipitation change is still quite wide in CMIP6

- Can model differences in aerosol absorption be playing a role?

Atmospheric absorption inhibits precipitation formation

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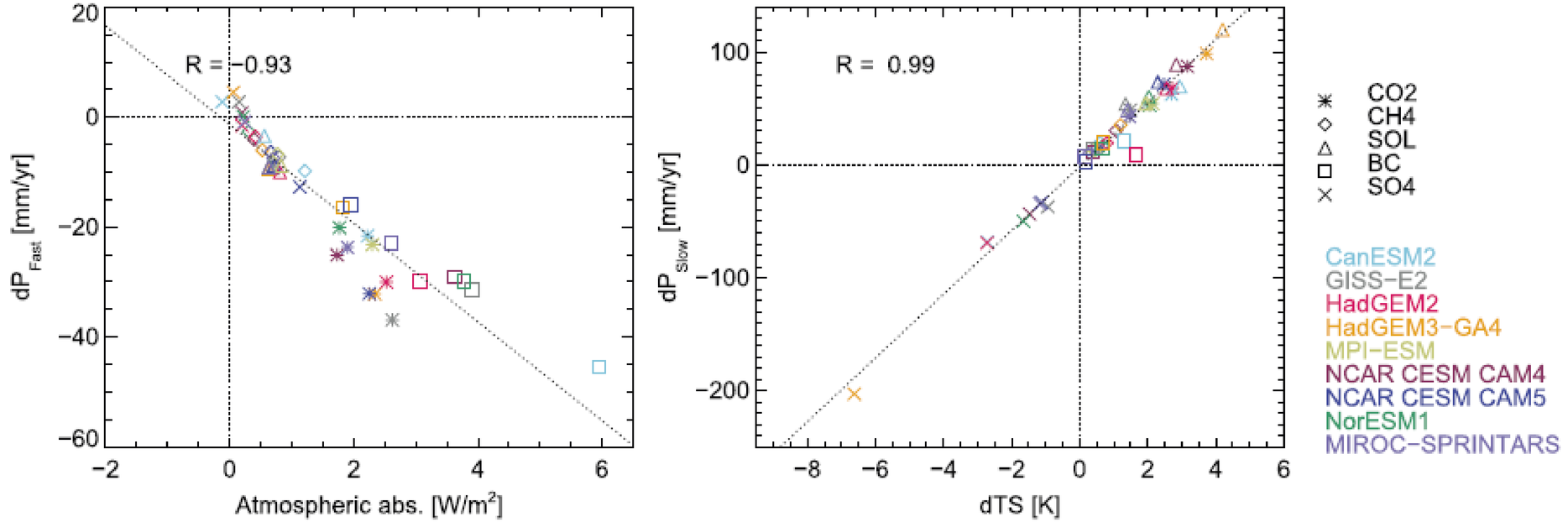
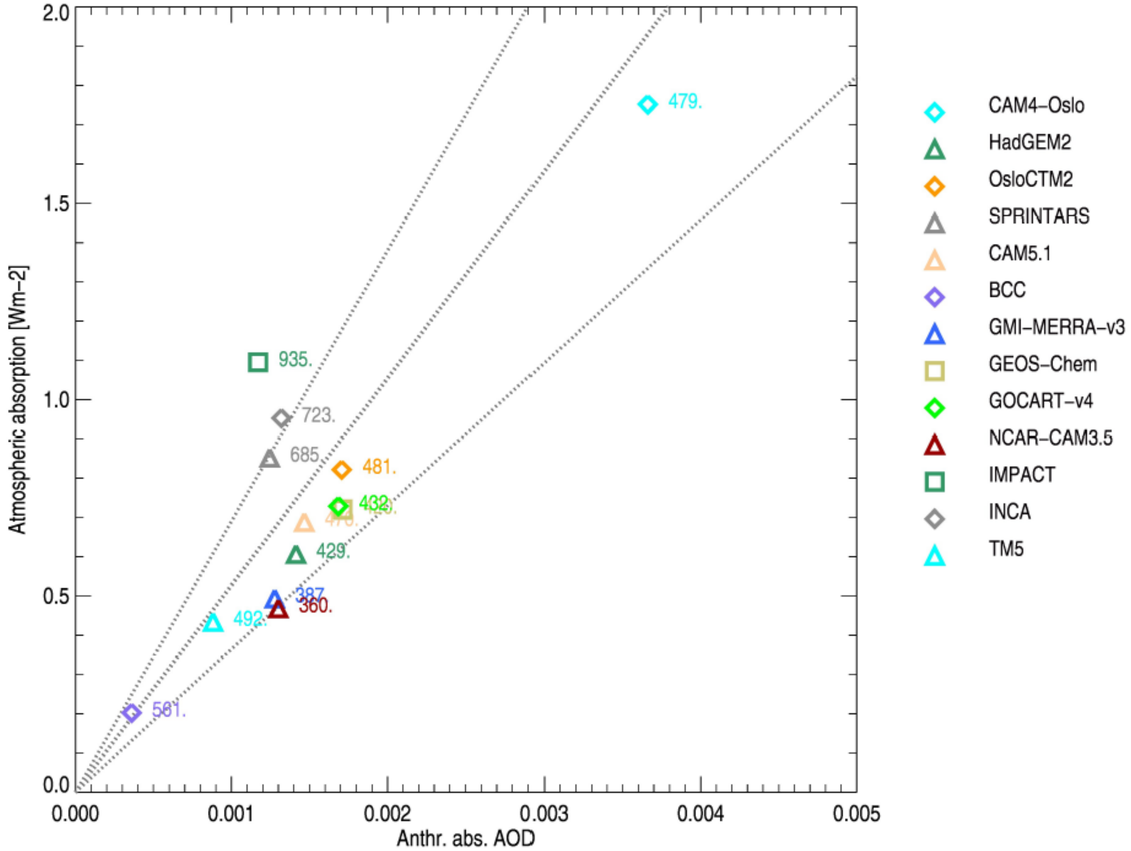


Figure 2. Regression of (left) fast precipitation change versus atmospheric absorption and (right) slow precipitation change versus surface temperature change. The shown regression lines and Pearson coefficients of correlation (*R*) are for the combined data from all models and climate perturbations.

Atmospheric absorption scales with AAOD (absorption aerosol optical depth)



Model	RF All-sky [W m^{-2}]	RF Clear-sky [W m^{-2}]	NRF Clear-sky [W m^{-2}]	Atm.abs. [W m^{-2}]	Atm.abs/AAOD [W m^{-2}]
BCC	−0.18	−0.75	−76.0	0.20	561
CAM4-Oslo	−0.08			1.75	479
CAM5.1	−0.016	−0.35	−23.6	0.69	470
GEOS_CHEM	−0.26	−0.61	−20.7	0.66	387
GISS-MATRIX	−0.58	−0.79	−19.9		
GISS-modelE	−0.32	−0.46	−20.9		
GMI	−0.52	−0.91	−24.7	0.49	387
GOCART	−0.36	−0.58	−21.8	0.73	432
HadGEM2	−0.31	−0.72	−27.2	0.61	429
IMPACT-Umich	−0.21	−1.01	−23.7	1.10	935
INCA	−0.36	−0.73	−17.4	0.95	723
ECHAM5-HAM	−0.15	−0.44	−17.8		
NCAR-CAM3.5	−0.28	−0.74	−24.7	0.47	360
OsloCTM2	−0.17	−0.69	−25.0	0.82	481
SPRINTARS	−0.14	−0.71	−27.4	0.85	685
TM5	−0.32	−0.51	−24.5	0.43	492
Mean	−0.27	−0.67	−26.8	0.75	525
Median	−0.26	−0.71	−23.7	0.69	479
Stddev	0.15	0.18	14.5	0.38	165

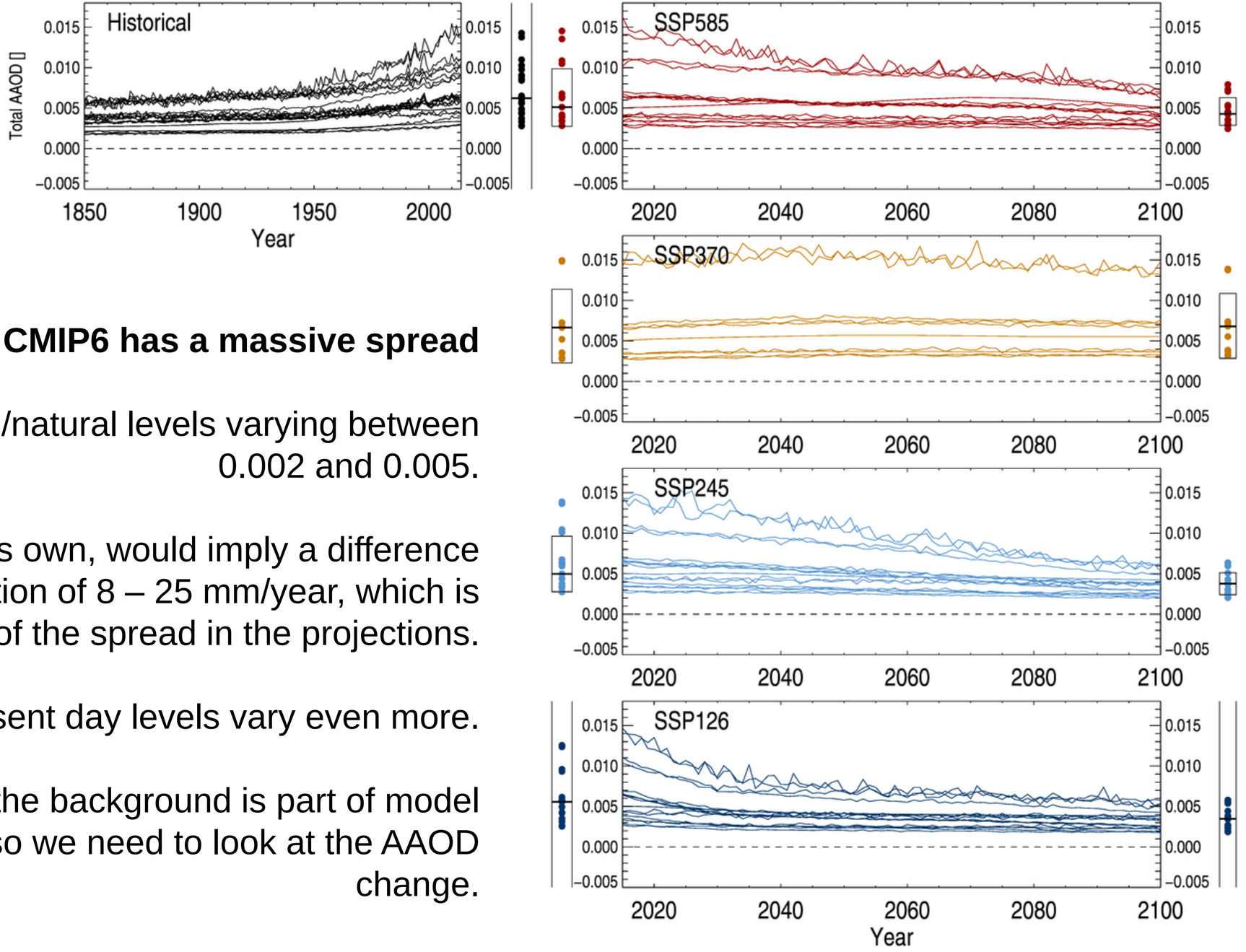
So, we can make a simple estimate of precipitation inhibition per unit AAOD change:

dPfast = dPfast/AtmAbs * AtmAbs/AAOD * dAAOD

= -8.5 mm/y / Wm-2 * 525 Wm-2/AAOD * dAAOD

= -4462.5 mm/y / AAOD * dAAOD

(Suppressing uncertainties for now, which are of course substantial.)



Total AAOD in CMIP6 has a massive spread

Background/natural levels varying between 0.002 and 0.005.

This, taken on its own, would imply a difference in precip inhibition of 8 – 25 mm/year, which is about half of the spread in the projections.

Present day levels vary even more.

However, the background is part of model tuning, so we need to look at the AAOD change.

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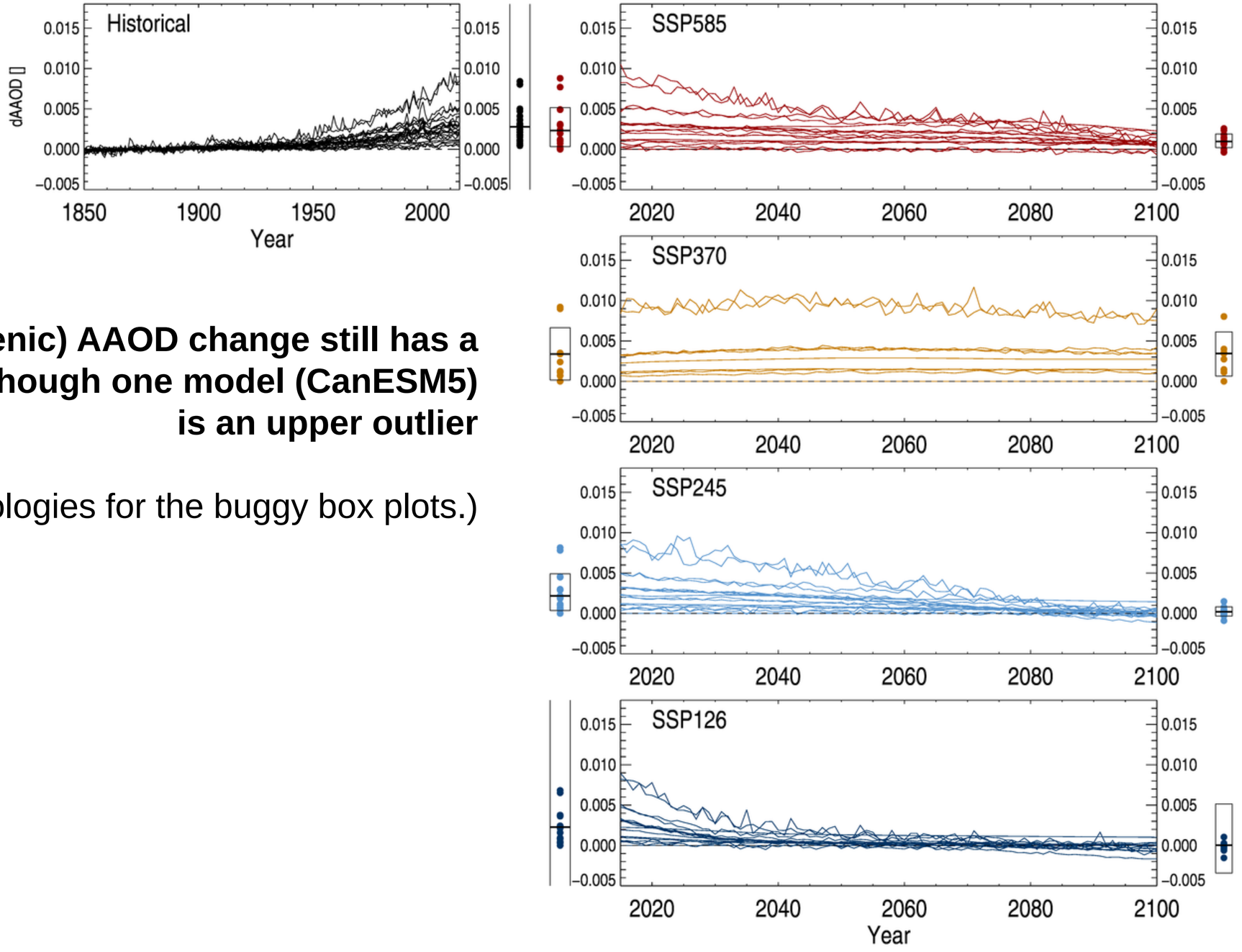

(Anthropogenic) AAOD change still has a wide spread, though one model (CanESM5) is an upper outlier

(Apologies for the buggy box plots.)

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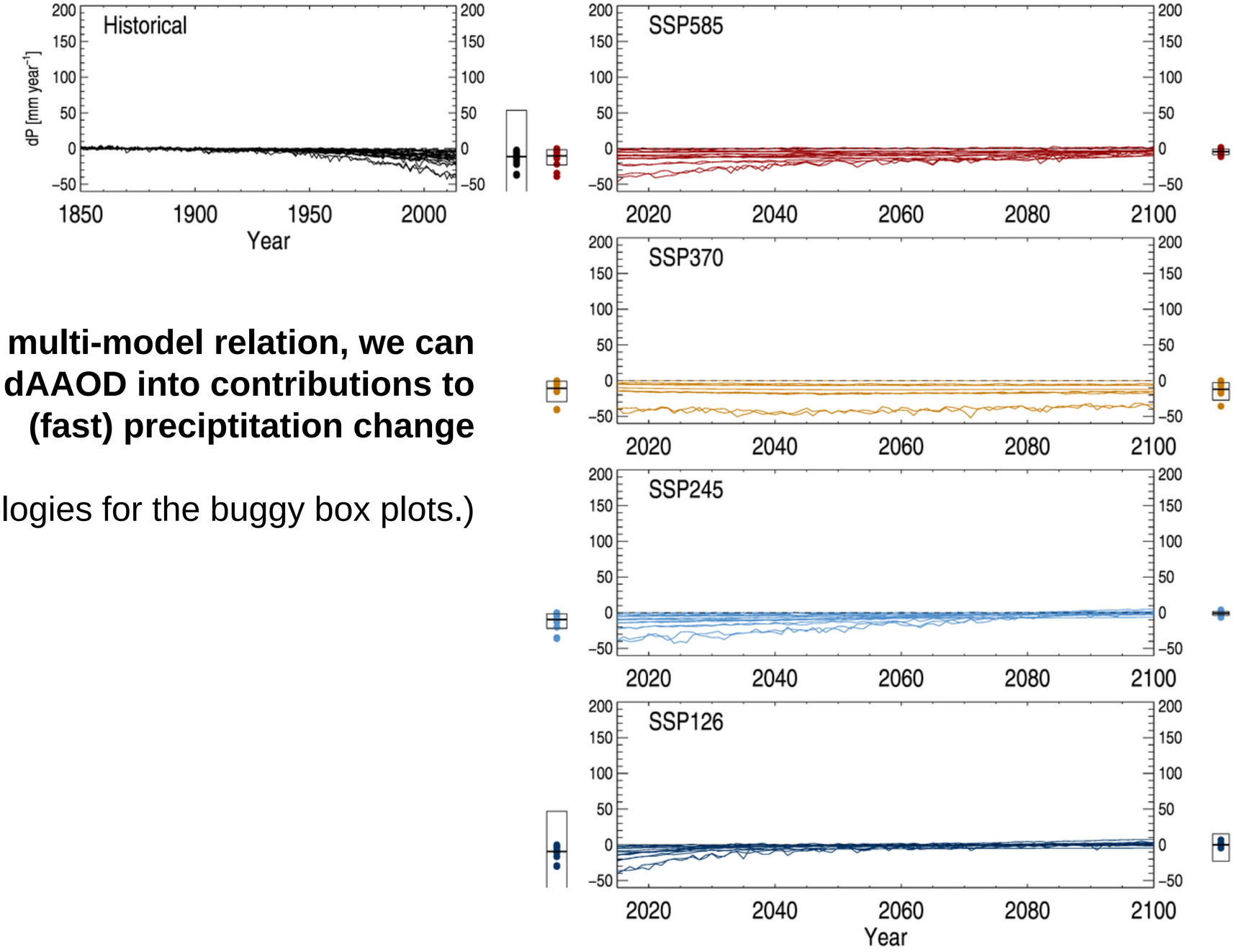
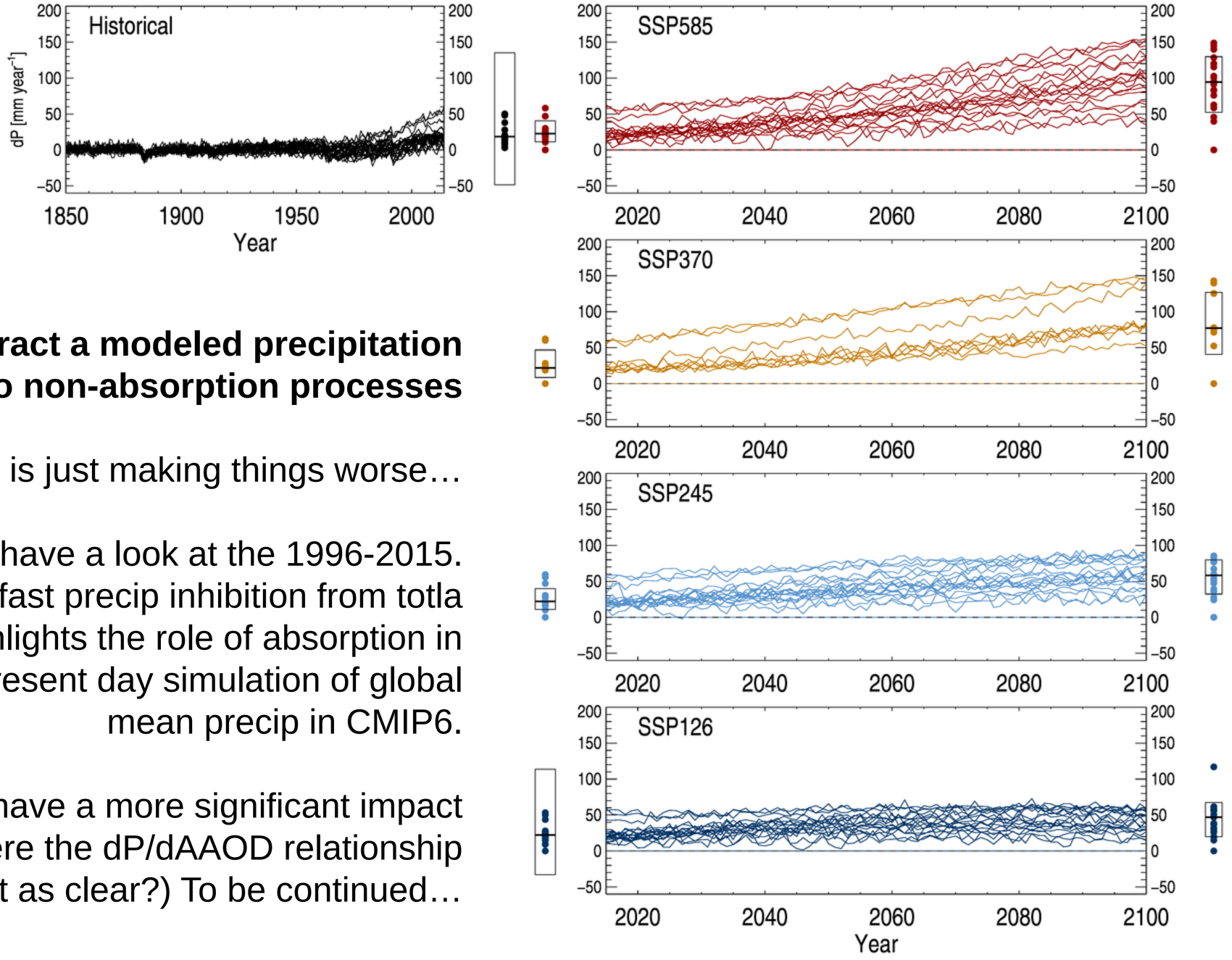


Using the multi-model relation, we can convert dAAOD into contributions to (fast) preciptitation change

(Apologies for the buggy box plots.)



…and extract a modeled precipitation change due to non-absorption processes

Initially, this is just making things worse…

But, have a look at the 1996-2015. Removing the fast precip inhibition from totla precipitation highlights the role of absorption in shaping the present day simulation of global mean precip in CMIP6.

Does this have a more significant impact regionally? (Where the dP/dAAOD relationship isn't as clear?) To be continued…

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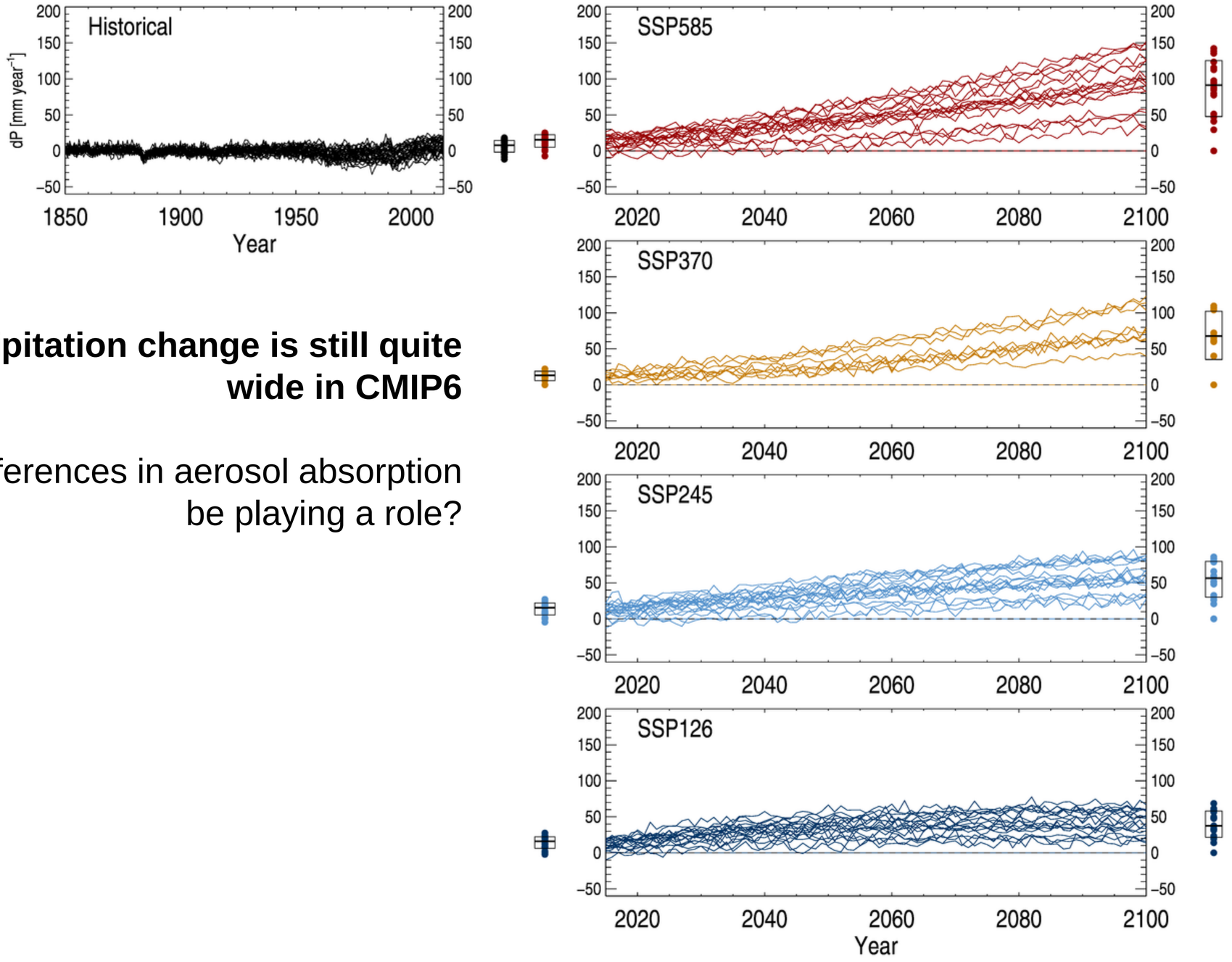

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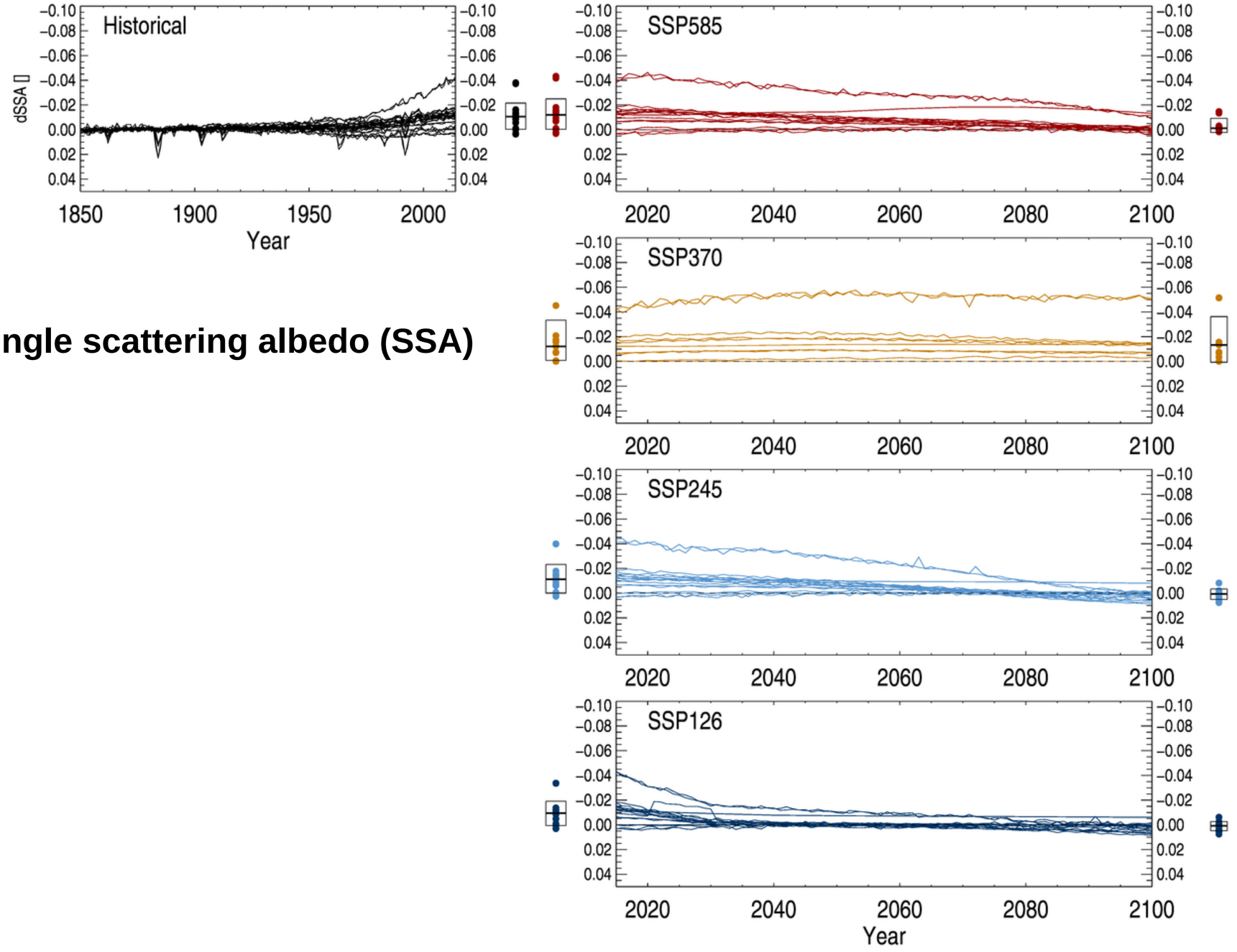
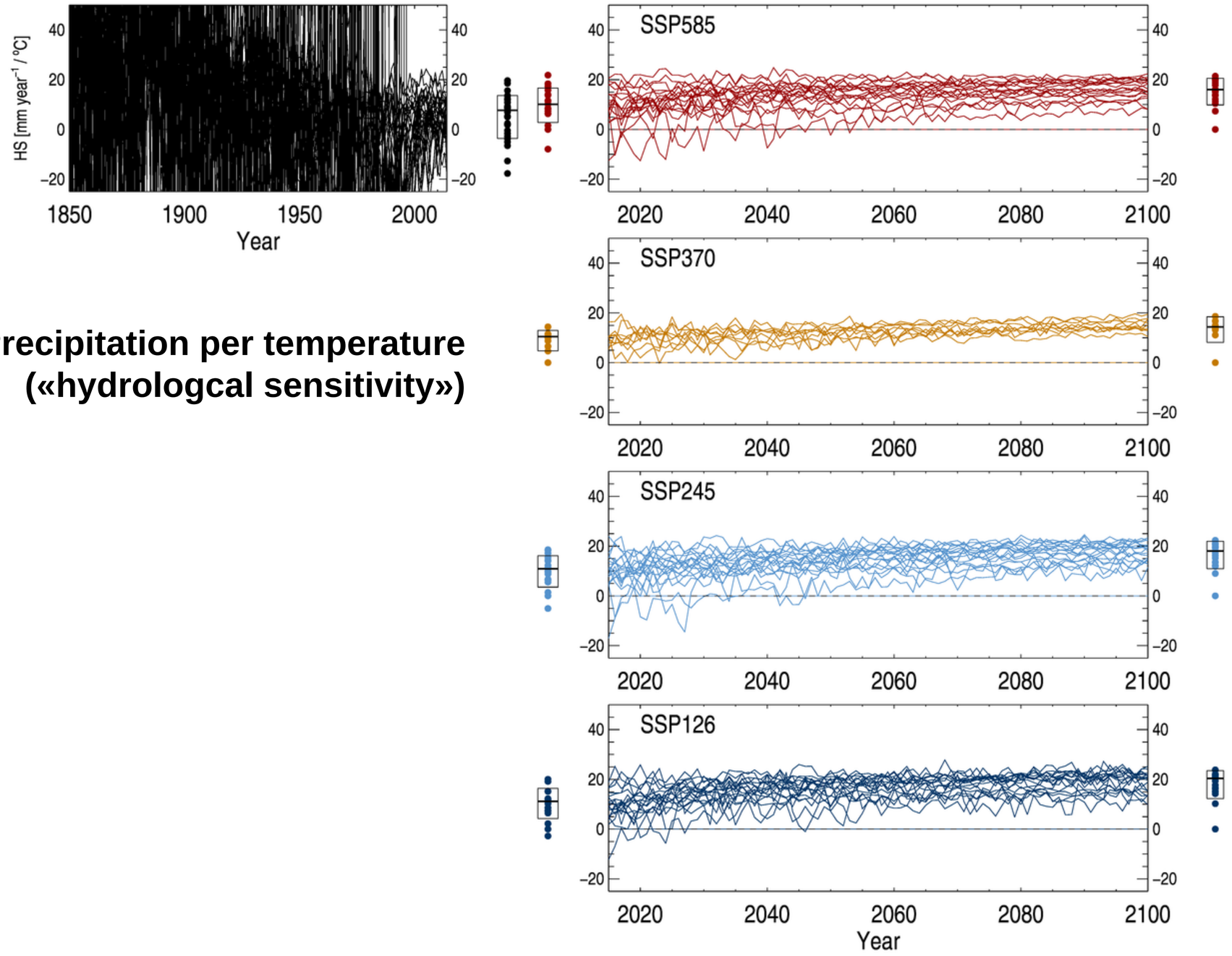
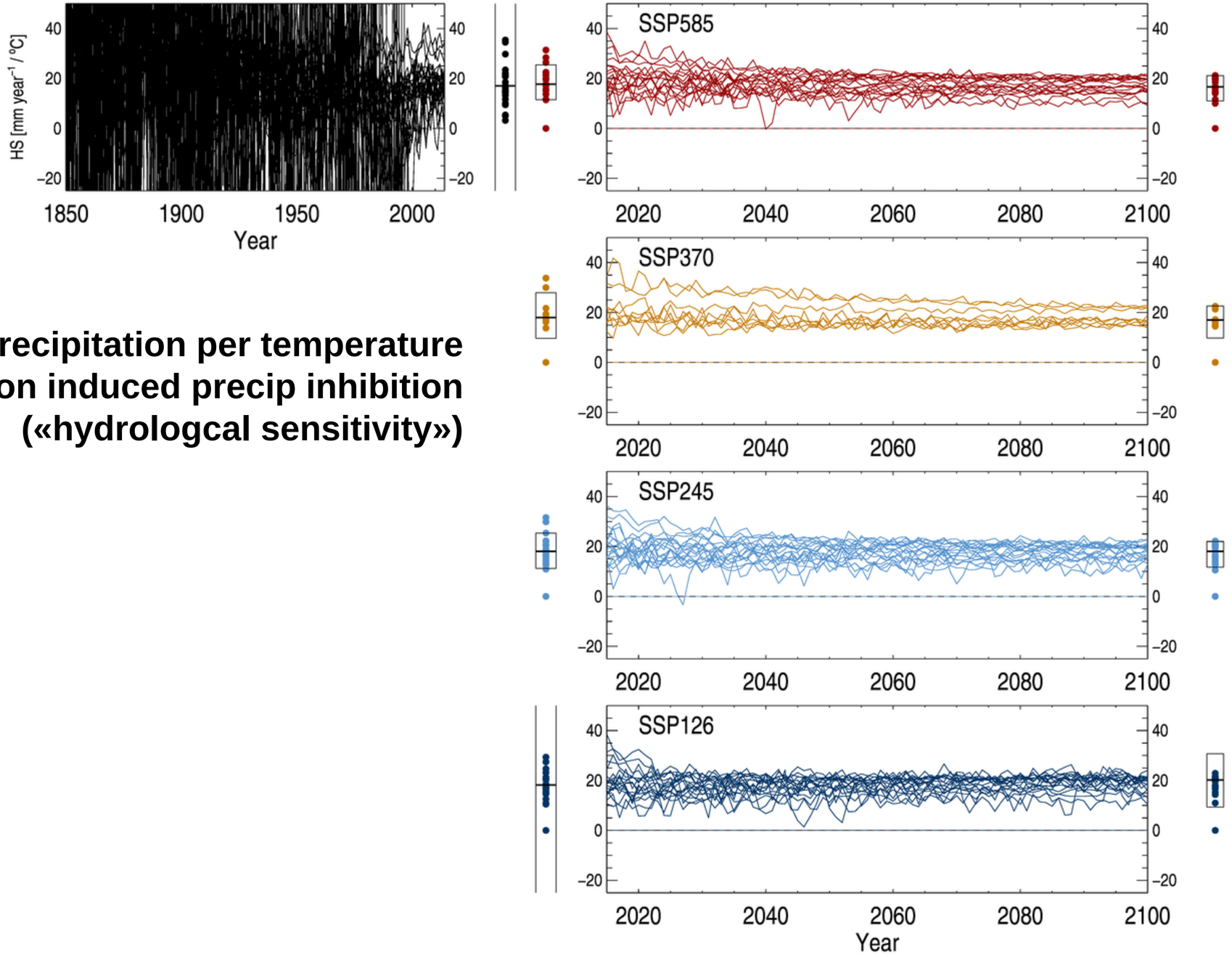
Backup / analysis



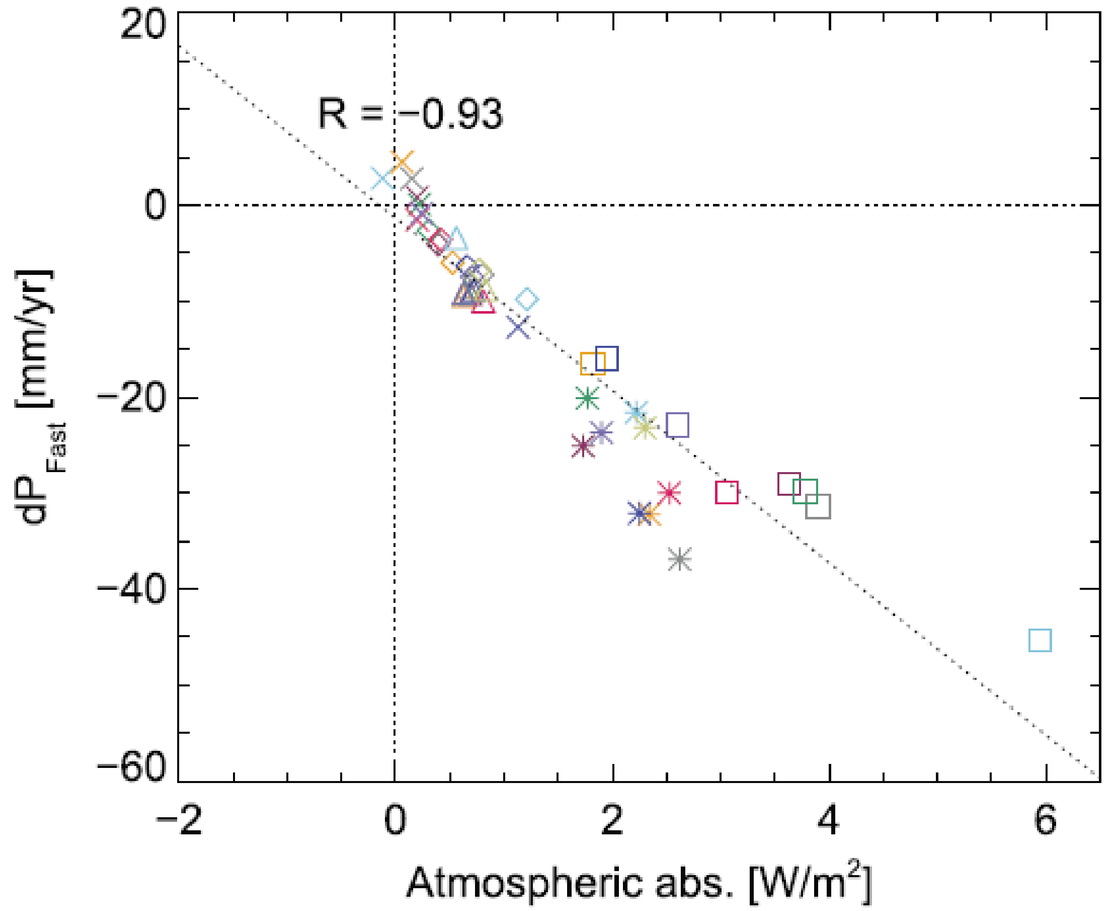
Single scattering albedo (SSA)



Precipitation per temperature («hydrologcal sensitivity»)



Precipitation per temperature without absorption induced precip inhibition («hydrologcal sensitivity»)



	Abs	dPfast	dP_fast/Abs	dPfast	dP_fast/Abs
CCCma	5,59	-4,55	-0,81	-45,4	-8,1
CESM_CAM4	3,36	-2,82	-0,84	-29,0	-8,6
CESM_CAM5	2,29	-1,45	-0,63	-16,0	-7,0
GISS	3,53	-2,66	-0,75	-31,4	-8,9
HadGEM2	5,48	-2,66	-0,49	-29,9	-5,5
HadGEM3	1,41	-1,47	-1,04	-16,5	-11,7
NorESM	3,49	-2,85	-0,82	-29,8	-8,5
SPRINTARS	2,45	-1,92	-0,78	-22,9	-9,3
IPSL	2,36	-1,73	-0,73	-17,6	-7,5
Mean	3,33	-2,46	-0,77	-26,50	-8,35
Median	3,36	-2,66	-0,78	-29,00	-8,54
Stddev	1,34	0,92	0,14	8,90	1,62
	Wm-2	%	% / Wm-2	mm/year	mm/year / Wm-2
		R	-0,84772	R	-0,8685

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