

CESM2 (MA) Feedforward and Feedback Estimates

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Table 1: Temperature Targets

	T0	T1	T2
Member 1	288.51	2.64	-29.35

Targets are defined as the average over the 2020-2039 period in the SSP 245 runs (CESM2, middle atmosphere chemistry).

Table 2: Sensitivity Estimates (includes significant digits)

	My MA				My TSMLT				My CESM 1				GLENS CESM 1		
	ℓ_0^{-1}	ℓ_1^{-1}	ℓ_2^{-1}		ℓ_0^{-1}	ℓ_1^{-1}	ℓ_2^{-1}		ℓ_0^{-1}	ℓ_1^{-1}	ℓ_2^{-1}		ℓ_0^{-1}	ℓ_1^{-1}	ℓ_2^{-1}
T ₀	-4.1				-7.95				-6.66				-5.2		
T ₁	-3.0	-3.9			-4.8	-7.6			-2.43	-3.7			-3.7	-4.4	
T ₂	-1.5	-1.6	-0.5		-2.6	0.0	-2		-2.29	-2.0	-2.49		-2.4	-2.2	-1.6

My estimates for CESM2 TSMLT sensitivities are drawn from the data of Tilmes et al 2020.

My estimates for CESM2 MA sensitivities are drawn from Daniele Visoni's matrix runs.

Table 3: Temperature increase seen in SSP 245 relative to temperature targets, beginning from ~0 in 2030 (in other words, how much temperature increase needs to be offset)

Metric	Behavior	Forcing required to offset
T ₀	+0.0273 K per year	enough ℓ_0 to offset this change
T ₁	erratic - no detectable change	enough ℓ_1 to cancel out whatever ℓ_0 is doing to T ₁
T ₂	+0.0115 K per year	enough ℓ_2 to offset this change, minus whatever ℓ_0 and ℓ_1 are already doing

Feedforward calculations

- ℓ_0 :
 - $-0.0273 \text{ K/yr} \div -4.1 \text{ K}/\ell_0 = \mathbf{0.0067 \ell_0 \text{ per year}}$
- ℓ_1 :
 - $-3.0 \text{ K}/\ell_0 \times 0.0067 \ell_0/\text{yr} = -0.0201 \text{ K/yr}$ to offset
 - $0.0201 \text{ K/yr} \div -3.9 \text{ K}/\ell_1 = \mathbf{-0.0051 \ell_1 \text{ per year}}$
- ℓ_2 :
 - -0.0115 K/year required in total
 - $-1.5 \text{ K}/\ell_0 \times 0.067 \ell_0/\text{yr} = -0.0099 \text{ K/yr}$ from ℓ_0
 - $-1.6 \text{ K}/\ell_1 \times -0.051 \ell_0/\text{yr} = 0.0082 \text{ K/yr}$ from ℓ_1
 - $-0.0115 \text{ K/yr total} - -0.0099 \text{ K/yr from } \ell_0 - 0.0082 \text{ K/yr from } \ell_1 = -0.0098 \text{ K/yr left}$
 - $-0.0098 \text{ K/yr} \div -0.5 \text{ K}/\ell_2 = \mathbf{0.0197 \ell_2 \text{ per year} \rightarrow 0.0016 \text{ (constraint)}}$

Table 4: Injection rates

Latitude	Equation	All feeds	ℓ_0 feed only
30N	$20\ell_1^N + 40\ell_2$	$0.0639*(t-2030) \text{ Tg/yr}$	0
15N	$30(\ell_0 - \ell_1^N - \ell_1^S - \ell_2) + 45\ell_1^N$	0	$0.2010*(t - 2030) \text{ Tg/yr}$
15S	$30(\ell_0 - \ell_1^N - \ell_1^S - \ell_2) + 45\ell_1^S$	$0.2296*(t-2030) \text{ Tg/yr}$	$0.2010*(t - 2030) \text{ Tg/yr}$
30S	$20\ell_1^S + 40\ell_2$	$0.1659*(t-2030) \text{ Tg/yr}$	0

Table 5: Feedback gains

Metric	Old Gain	GLENS sens.	New sens.	Ratio	New gain
ℓ_0	0.028	-5.2	-4.1	1.27	0.0356
ℓ_1	0.13	-4.4	-3.9	1.13	0.1469
ℓ_2	0.39	-1.6	-0.5	3.2	1.2480