Supplementary information

Skillful Prediction of Length of Day One Year Ahead in Multiple Decadal Prediction Systems

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Supplementary Table 1. Seasonal variability of LOD. The standard deviations (σ) for each season (January–March (JFM); April–June (AMJ); July–September (JAS); October–December (OND)) and all seasons are listed in the 3rd column. Their 95% confidence interval (CI) and the number of monthly data (n) used are provided in the 4th and 5th columns, respectively. For observation, all months with valid LOD anomaly after removing the 5-year running mean are used (1964.07–2017.07). Data from 1960–2019 (60 years) are used for JRA-55, and 1-year predictions from 1960–2016 (57 years) are used for MMM.

Data	Season	σ (unit: ms)	CI (unit: ms)	n
Observation	JFM	0.24	[0.22, 0.27]	159
	AMJ	0.16	[0.15, 0.19]	159
	JAS	0.18	[0.17, 0.21]	160
	OND	0.17	[0.15, 0.19]	159
	All	0.19	[0.18, 0.20]	637
JRA-55	JFM	0.19	[0.17, 0.21]	180
	AMJ	0.12	[0.11, 0.13]	180
	JAS	0.13	[0.12, 0.15]	180
	OND	0.12	[0.11, 0.13]	180
	All	0.14	[0.14, 0.15]	720
MMM	JFM	0.13	[0.12, 0.15]	171
	AMJ	0.08	[0.07, 0.09]	171
	JAS	0.05	[0.05, 0.06]	171
	OND	0.06	[0.05, 0.06]	171
	All	0.09	[0.08, 0.09]	684

Supplementary Table 2. Seasonal skewness of LOD. The skewness values (G_1) for each season (January–March (JFM); April–June (AMJ); July–September (JAS); October–December (OND)) and all seasons are listed in the 3rd column. Their standard deviation (SD), 95% confidence interval (CI), and the number of monthly data (n) used are provided in the 4th, 5th, and 6th columns, respectively. For observation, all months with valid LOD anomaly after removing the 5-year running mean are used (1964.07–2017.07). Data from 1960–2019 (60 years) are used for JRA-55, and 1-year predictions from 1960–2016 (57 years) are used for MMM.

Data	Season	G_1	SD	CI	n
Observation	JFM	0.56	0.19	[0.18, 0.93]	159
	AMJ	0.17	0.19	[−0.21, 0.54]	159
	JAS	0.18	0.19	[−0.20, 0.55]	160
	OND	0.31	0.19	[−0.07, 0.68]	159
	All	0.39	0.10	[0.20, 0.57]	637
JRA-55	JFM	0.49	0.18	[0.13, 0.84]	180
	AMJ	0.30	0.18	[−0.05, 0.66]	180
	JAS	0.27	0.18	[−0.08, 0.63]	180
	OND	0.20	0.18	[−0.15, 0.56]	180
	All	0.41	0.10	[0.23, 0.59]	720
MMM	JFM	0.68	0.19	[0.31, 1.04]	171
	AMJ	0.41	0.19	[0.05, 0.78]	171
	JAS	−0.15	0.19	[−0.52, 0.21]	171
	OND	−0.00	0.19	[−0.36, 0.36]	171
	All	0.48	0.10	[0.30, 0.67]	684

Supplementary Table 3. Correlation of LOD with different ENSO indices. Correlation coefficient (r), its 95% confidence interval (CI), degree of freedom (DOF), and P-value (p) are provided. Months with valid LOD anomaly after removing 5-year running mean are used (1964.07–2017.07; n = 637).

ENSO region	r	CI	DOF	p
Niño3	0.44	[0.38, 0.50]	635	$p < 0.05$
Niño3.4	0.44	[0.37, 0.50]	635	$p < 0.05$
Niño4	0.36	[0.29, 0.42]	635	$p < 0.05$

Supplementary Table 4. Correlation of LOD with different QBO indices. Correlation coefficient (r), its 95% confidence interval (CI), degree of freedom (DOF), and P-value (p) are provided. Months with valid LOD anomaly after removing 5-year running mean are used (1964.07–2017.07; n = 637).

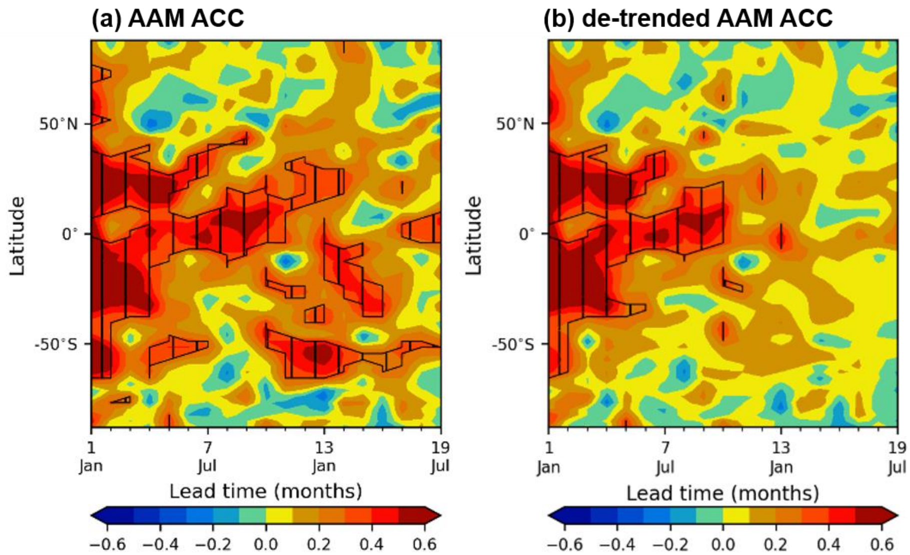
QBO level	r	CI	DOF	p
10-hPa	0.00	[−0.08, 0.08]	635	$p = 0.95$
20-hPa	0.23	[0.16, 0.30]	635	$p < 0.05$
30-hPa	0.28	[0.20, 0.35]	635	$p < 0.05$
50-hPa	0.16	[0.09, 0.24]	635	$p < 0.05$
70-hPa	0.08	[0.01, 0.16]	635	$p < 0.05$

Supplementary Table 5. Summary of multiple linear regression of LOD onto ENSO and QBO. Standard errors of regression coefficients and intercepts are given in parentheses. Parameters statistically significant at the 95% confidence level based on the two-tailed Student's t-test are denoted with double asterisks. The coefficient of determination (R^2) is given in the last column. For observation, 52 years (1965–2016) of LOD and 1-month lagged ENSO and QBO data ($n = 12 \times 52 - 1 = 623$) are used. For MMM, 57 years (1960–2016 or 1961–2017) of 1-year predictions with no lag ($n = 684$) are used.

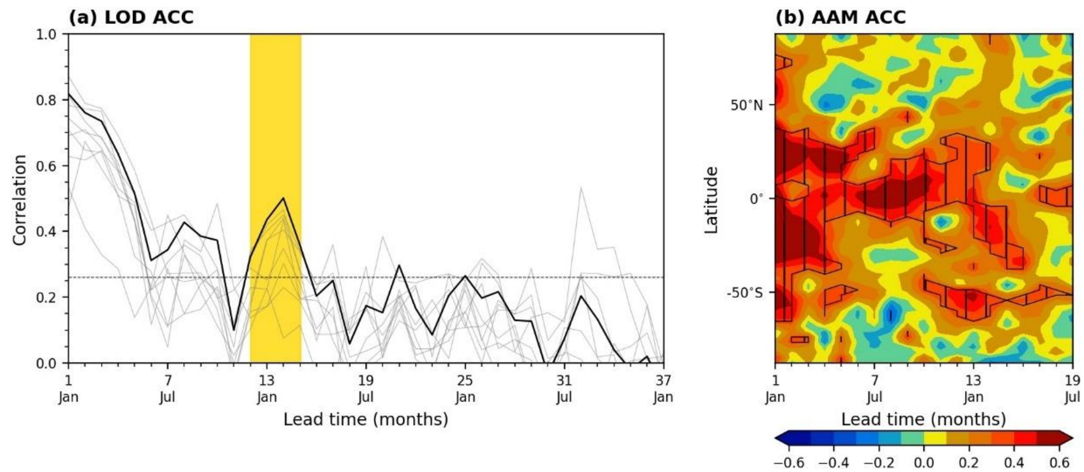
Data	ENSO coefficient (unit: $\times 10^{-4}$ s K^{-1})	ENSO lag month	QBO coefficient (unit: $\times 10^{-6}$ s^2 m^{-1})	QBO lag month	Intercept (unit: $\times 10^{-6}$ s)	R^2
Observation	1.0** (± 0.074)	−1	3.9** (± 0.44)	−1	5.7 (± 6.5)	0.30
MMM	1.2** (± 0.027)	0	3.0** (± 0.30)	0	1.9 (± 1.6)	0.77

Supplementary Table 6. Summary of multiple linear regression of LOD onto ENSO. Standard errors of regression coefficients and intercepts are given in parentheses. Parameters statistically significant at the 95% confidence level based on the two-tailed Student's t-test are denoted with double asterisks. The coefficient of determination (R^2) is given in the last column. For observation, 52 years (1965–2016) of LOD and 1-month lagged ENSO data ($n = 12 \times 52 - 1 = 623$) are used. For MMM, 57 years (1960–2016 or 1961–2017) of 1-year predictions with no lag ($n = 684$) are used.

Data	ENSO coefficient (unit: $\times 10^{-4}$ s K^{-1})	ENSO lag month	Intercept (unit: $\times 10^{-6}$ s)	R^2
Observation	1.0** (± 0.078)	−1	5.1 (± 6.9)	0.22
MMM	1.3** (± 0.029)	0	1.8 (± 1.7)	0.74



Supplementary Figure 1. AAM prediction skills of CMIP6 DCPP models. (a) AAM prediction skill of CMIP6 DCPP MMM as a function of latitude and lead time. Statistically significant values at the 95% confidence level, based on the two-tailed Student's t-test, are hatched. **(b)** Same as **(a)** but for detrended AAM prediction skill.



Supplementary Figure 2. LOD and AAM prediction skills of CMIP6 DCPP models. Same as Figure 2 but when JRA-55 is replaced to the European Centre for Medium-Range Weather Forecasts Reanalysis version 5 (ERA5).