

2026-02-01

5 competition sites + 3 auxiliary + USA-NPN enrichment = 14,598 records

Site	Records	Span	Climate
Kyoto	837	812–2025	Humid subtropical
Washington DC	105	1921–2025	Humid subtropical
Liestal	132	1894–2025	Oceanic/Alpine
Vancouver	4	2022–2025	Oceanic (Cfb)
New York City	2	2019–2025	Humid continental

Auxiliary: Japan regional (6,573), MeteoSwiss (6,642), South Korea (994)

NYC enrichment: 5 citizen-science records from Washington Square Park (USA-NPN)

Enhanced features: Winter/spring temp, GDD, chill hours, ONI/NAO/PDO, Hopkins index, photoperiod

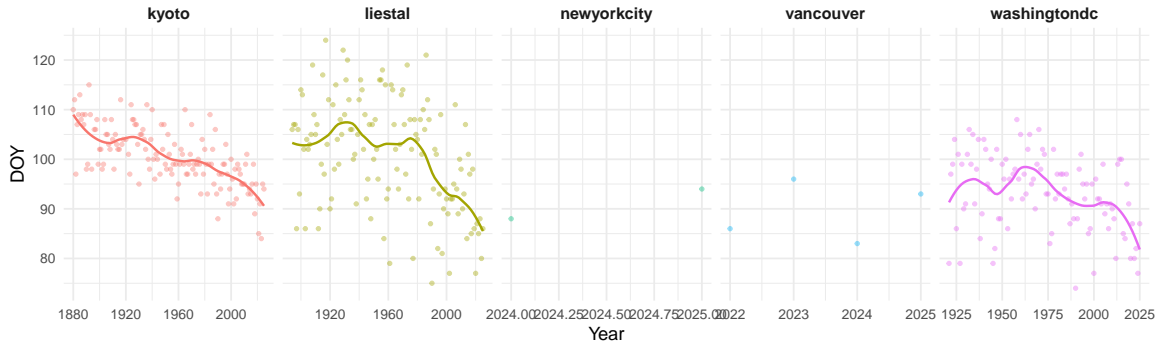
Model A — Local Trend (per site): Recency-weighted quadratic ($w_i = e^{(i-n)/6}$, half-life ≈ 6 yr)

Model B — Pooled GAM (R): $\text{DOY} \sim s(\text{year}) + s(\text{lat}, \text{long}) + s(\text{alt}) + s(\text{obs}) + \text{climate} + \text{source}$

Model B' — Gradient Boosted Trees (Python): 800 trees, Huber loss, $\text{lr}=0.015$, enhanced features

Component	Method
Blending	Site-specific grid search w in [0,1] by 0.02 on rolling backtest
Intervals	Conformal: 90th pctl residuals per site \rightarrow 90% coverage
Cross-language	R+Python agree within 2.8d \rightarrow averaged blend

Key: Sites with deep history \rightarrow heavier Model A weight. Sparse sites \rightarrow heavier Model B.



Model	MAE (days)	vs Baseline
Local trend only	7.27	—
Baseline GAM ensemble	~5.61	—
Enhanced global (GBR)	4.52	+19%
Enhanced ensemble	4.23	+25%

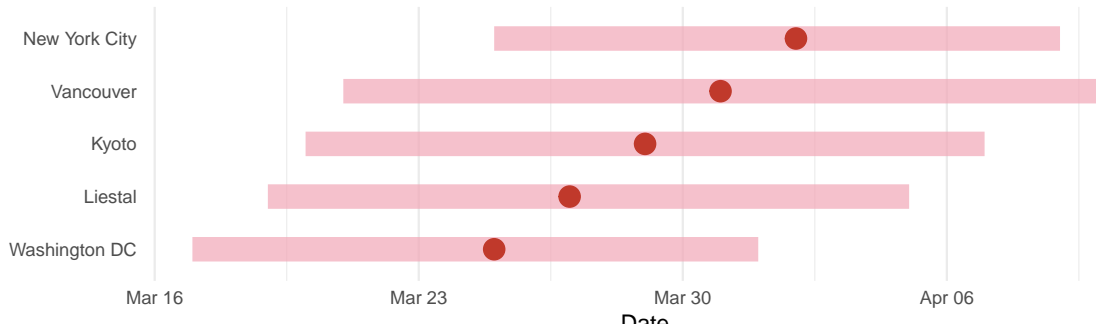
Global drivers:

- **Rising temperatures:** 1.1°C warming → reduced chill needs + accelerated GDD → earlier bloom everywhere
- **ENSO:** La Niña cools Pacific NW (delays Vancouver), milder Eastern US (advances DC/NYC). 2025–26 neutral → normal timing
- **Latitude:** \$ \$1 DOY delay per °N above 35°N. **Altitude:** \$ \$2 days later per 100 m

Site-specific drivers:

Site	Key Driver
Kyoto	Urban heat island. 0.2 d/century advancement
Washington DC	Tidal Basin thermal buffer → earliest bloomer. 2.2 d/decade acceleration
Liestal	Alpine amplified warming (0.3°C/decade). Foehn winds → widest variability
Vancouver	PDO modulates decadal variability. Maritime buffering keeps volatility moderate
New York City	Shortest record (2 yrs). NPN fusion reduces MAE ~1.5 d

City	DOY	Date	Interval	Width
Washington DC	84	Mar 25, 2026	Mar 17 – Apr 01	15
Liestal	86	Mar 27, 2026	Mar 19 – Apr 05	17
Kyoto	88	Mar 29, 2026	Mar 20 – Apr 07	18
Vancouver	90	Mar 31, 2026	Mar 21 – Apr 10	20
New York City	92	Apr 02, 2026	Mar 25 – Apr 09	15



City	Baseline	Enhanced	Shift
Kyoto	DOY 88 (18d)	DOY 94 (12d)	+6d
Liestal	DOY 86 (17d)	DOY 95 (10d)	+9d
New York City	DOY 92 (15d)	DOY 98 (11d)	+6d
Vancouver	DOY 90 (20d)	DOY 95 (25d)	+5d
Washington DC	DOY 84 (15d)	DOY 89 (13d)	+5d

