



Enhancements of ozone-depleting substances in the lower stratosphere from Asian Monsoon outflow

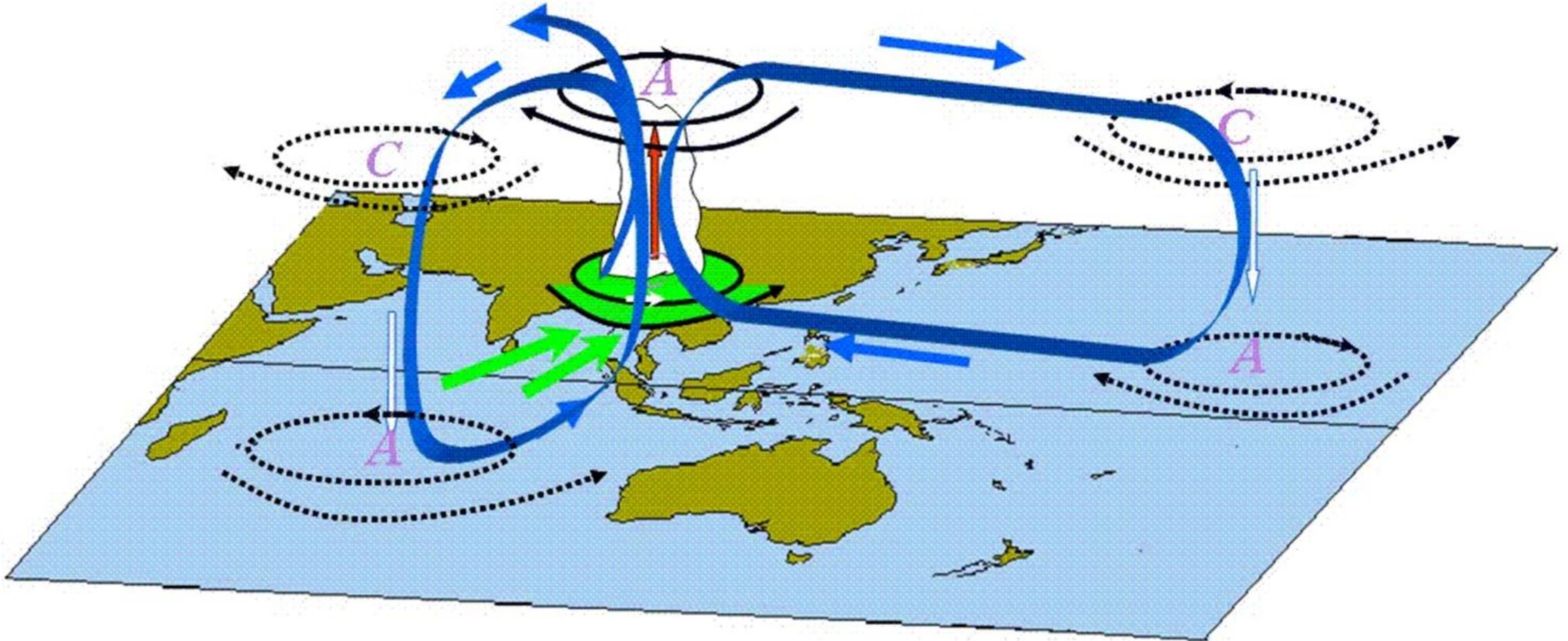
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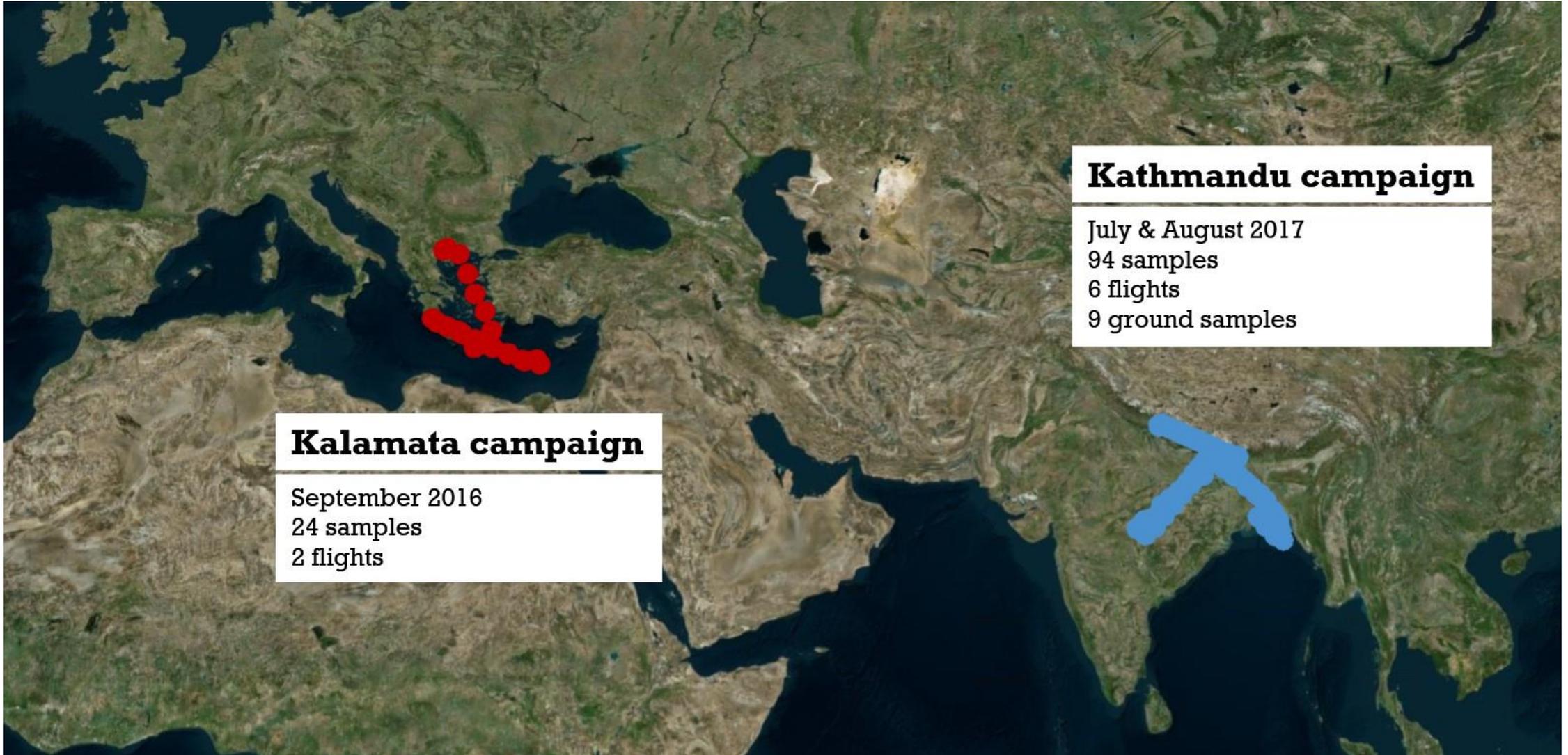
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Summer Asian Monsoon



Short-lived ozone-depleting substances transport into the lower stratosphere

Aircraft campaigns



Kalamata campaign

September 2016
24 samples
2 flights

Kathmandu campaign

July & August 2017
94 samples
6 flights
9 ground samples

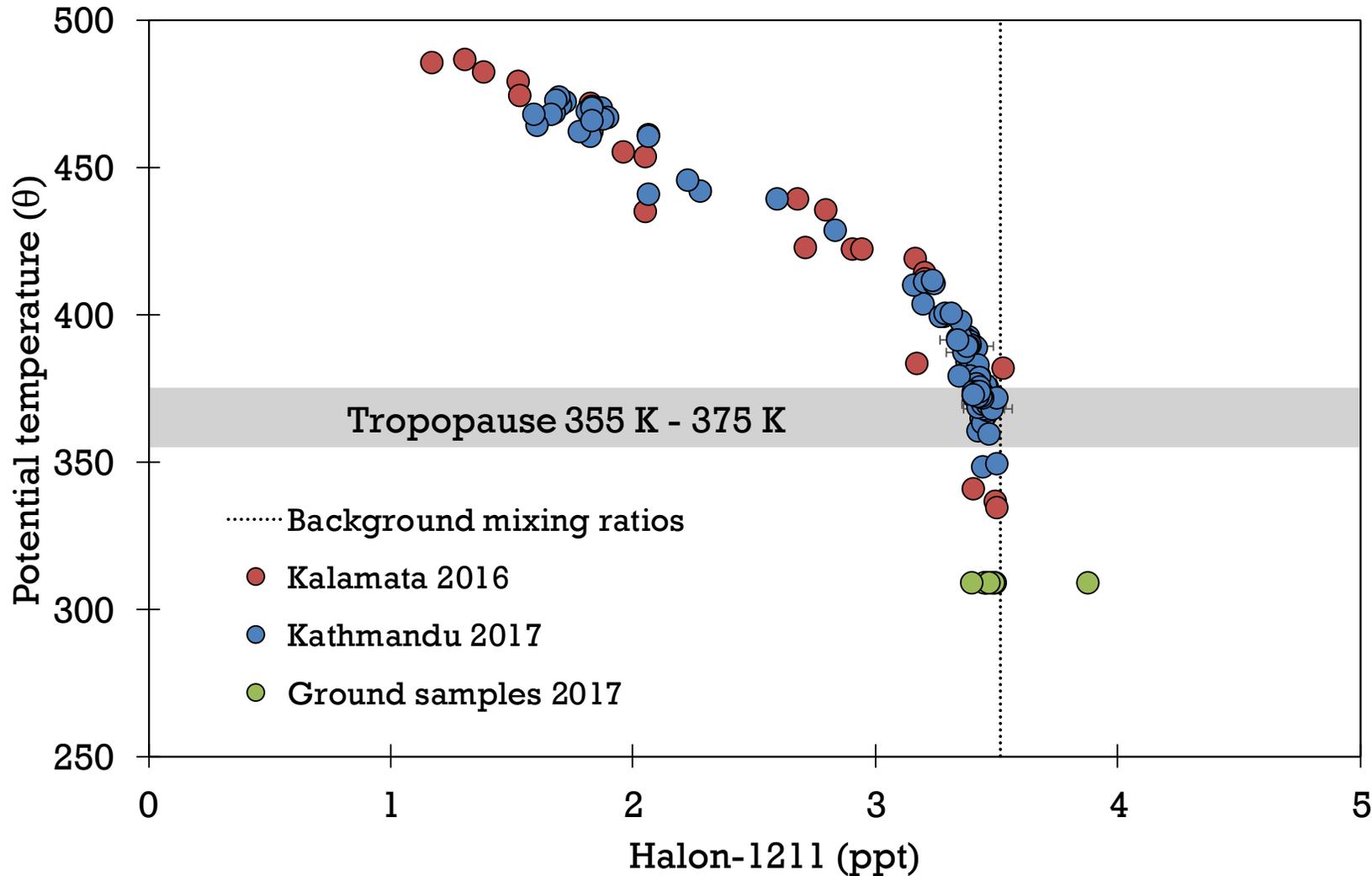
Sample analysis



- High sensitivity GC-MS
- 50 trace gases
- Focused on 28 – mostly ODS's



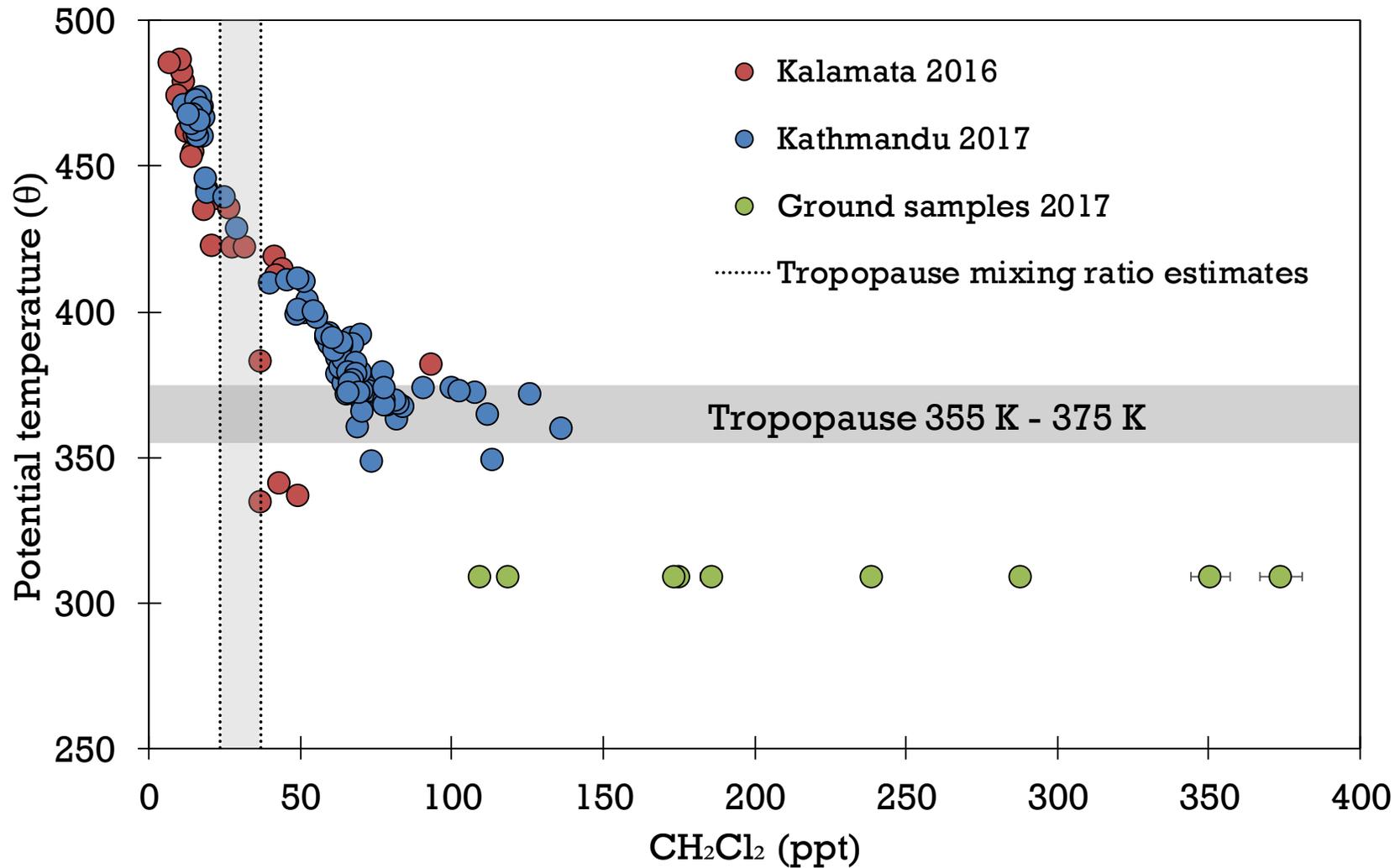
Halon-1211



→ Long-lived ozone-depleting substance

→ Agrees well with global background mixing ratios

Dichloromethane (CH_2Cl_2)



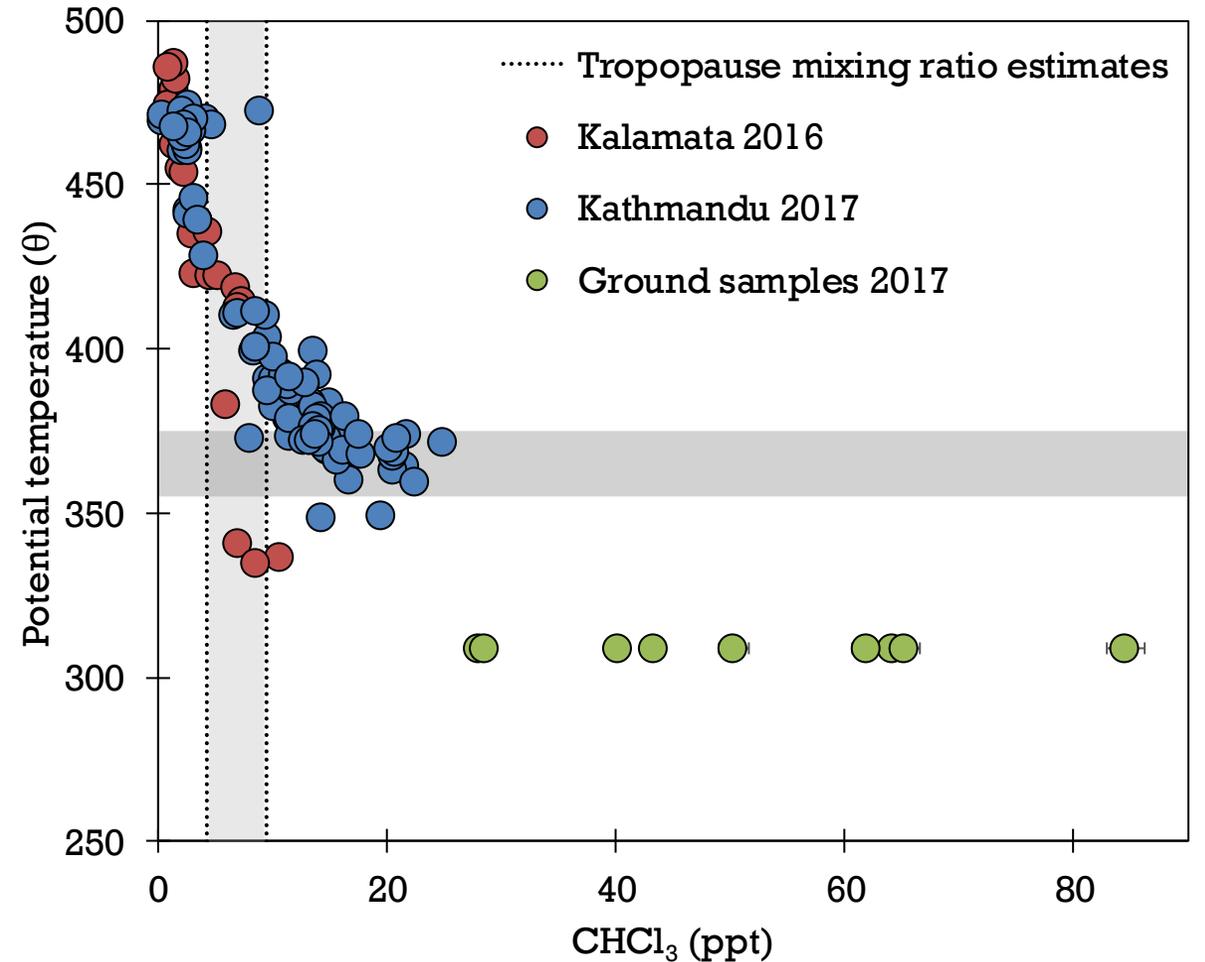
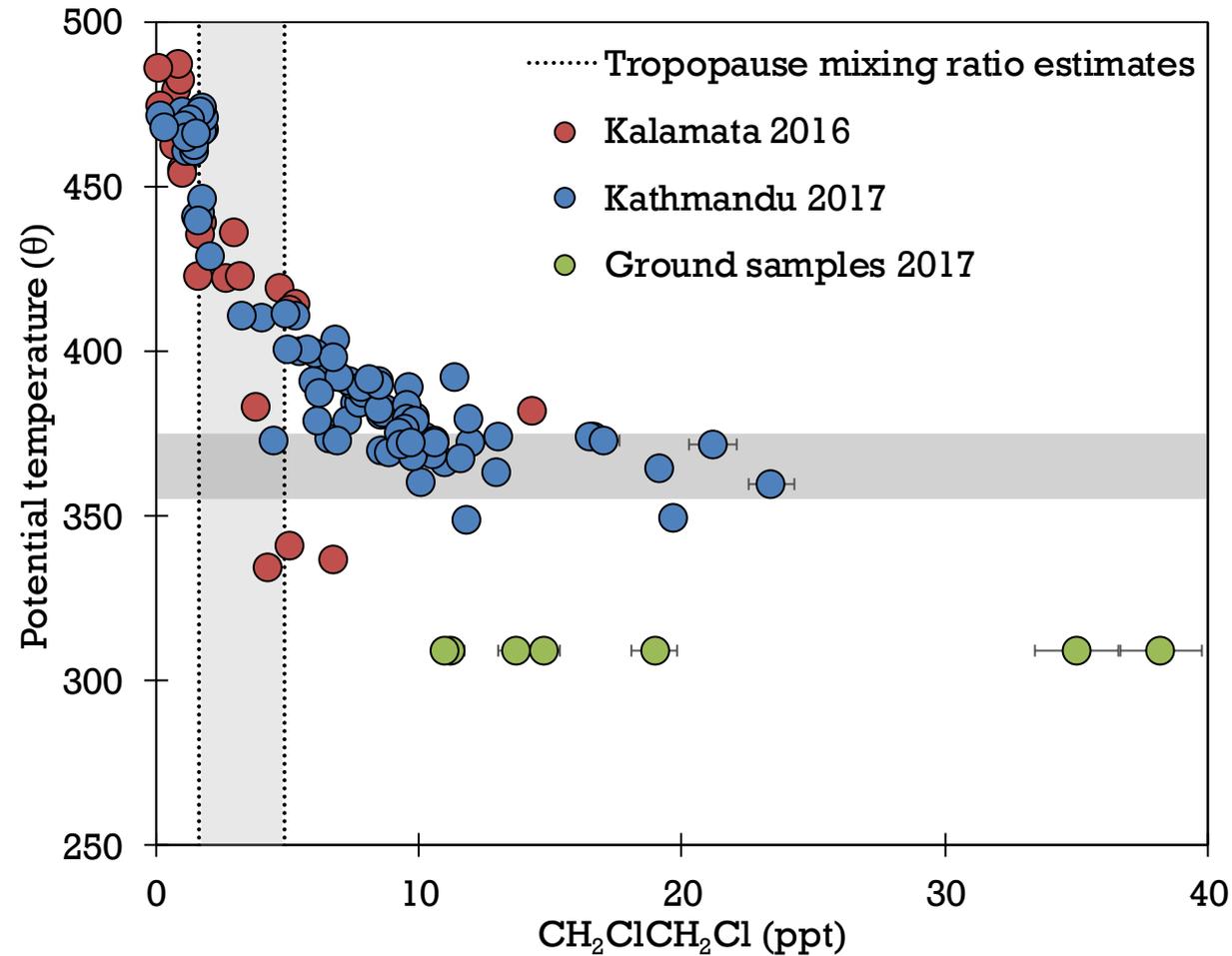
→ Short-lived ozone-depleting substance

→ Higher and more variable mixing ratios

1,2-dichloroethane ($\text{CH}_2\text{ClCH}_2\text{Cl}$)

Chloroform (CHCl_3)

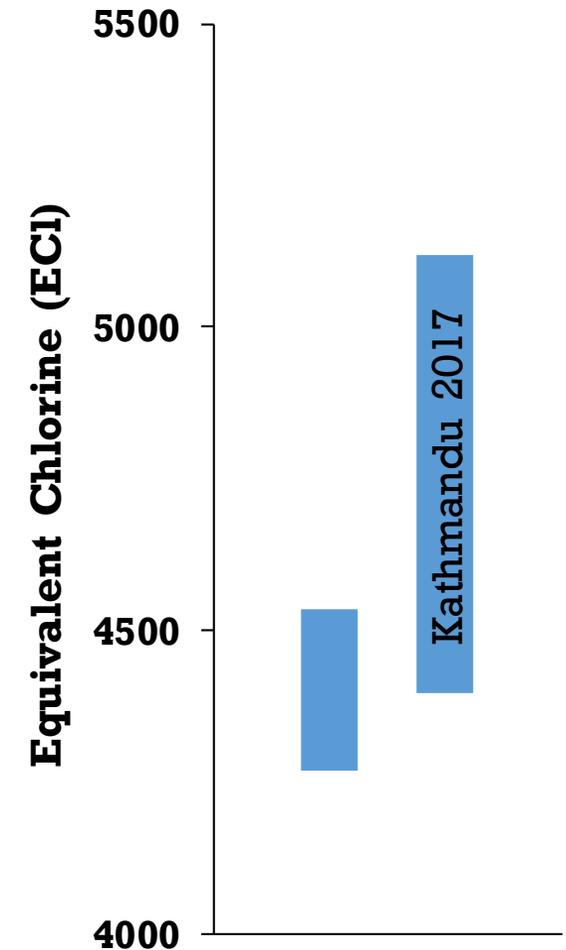
Other short-lived ODS's – similar pattern



Equivalent Chlorine (ECl)

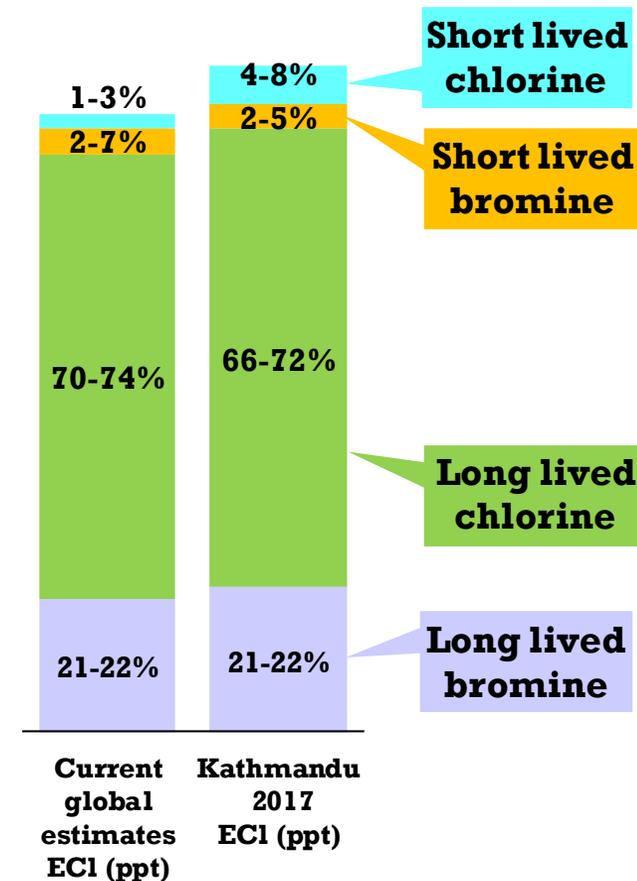
	Current global estimates ECl (ppt) 355 K – 365 K	Kathmandu 2017 ECl (ppt) 355 K – 375 K
Short lived chlorine	64-118 (1%-3%)	165-399 (4%-8%)
Short lived bromine	88-299	75-270
Long lived chlorine	3168	3195-3359
Long lived bromine	950	962-1091
Total ECl (ppt)	4270-4535	4396-5119

- ECl – measure of total organic chlorine and bromine going into the stratosphere
- Higher and more variable ECl in the Asian Monsoon



Equivalent Chlorine (ECI)

	Current global estimates ECI (ppt) 355 K – 365 K	Kathmandu 2017 ECI (ppt) 355 K – 375 K
Short lived chlorine	64-118 (1%-3%)	165-399 (4%-8%)
Dichloromethane	47-74	130-272
Chloroform	12-28	24-74
1,2 - dichloroethane	3-10	9-47
Short lived bromine	88-299	75-270
Long lived chlorine	3168	3195-3359
Long lived bromine	950	962-1091
Total ECI (ppt)	4270-4535	4396-5119



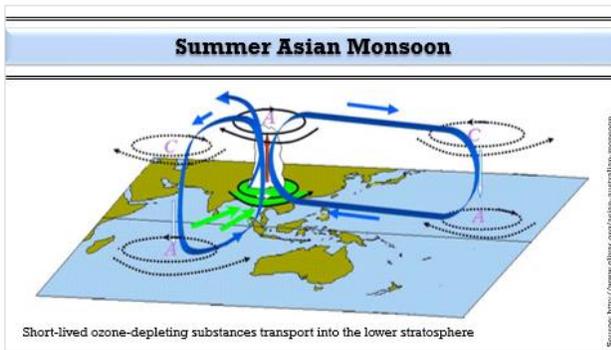
➔ Short lived substances – higher in Asian Monsoon but still small amount of total

Further work

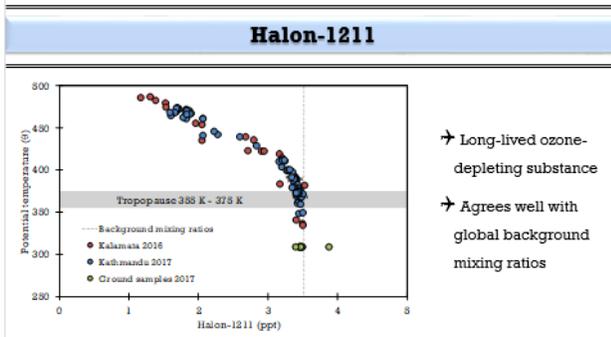
- **Equivalent Effective Stratospheric Chlorine (EESC)**
- **CLaMS model**
 - Chemical Lagrangian Model of the Stratosphere (CLaMS)
 - Three-dimensional chemistry transport model
 - Backward trajectories

Conclusion

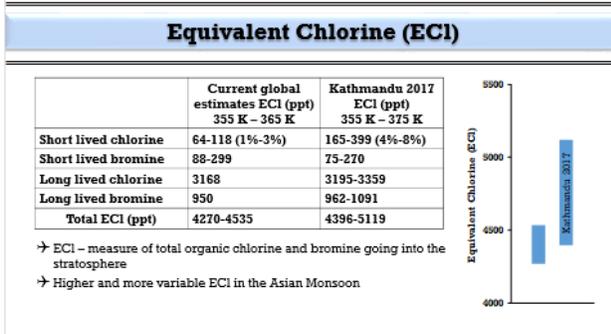
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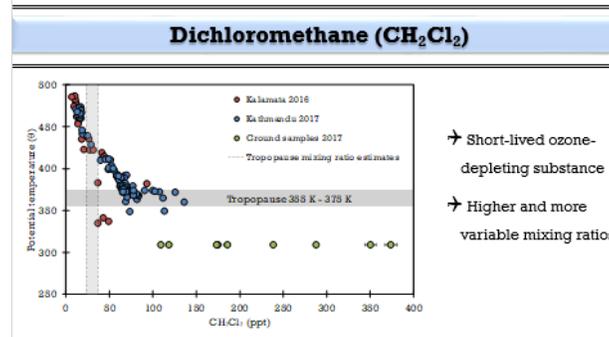
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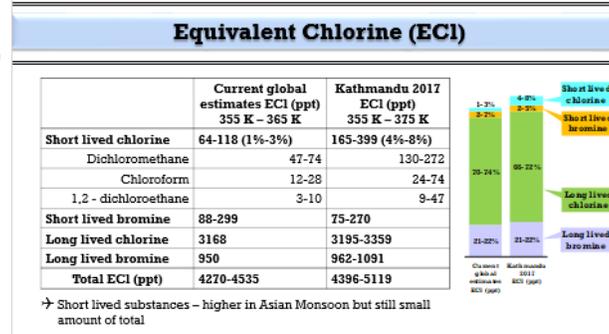
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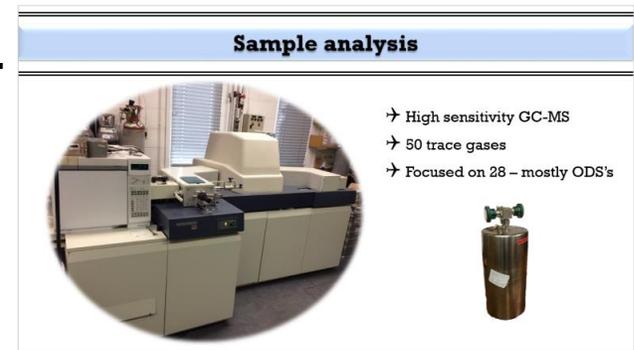
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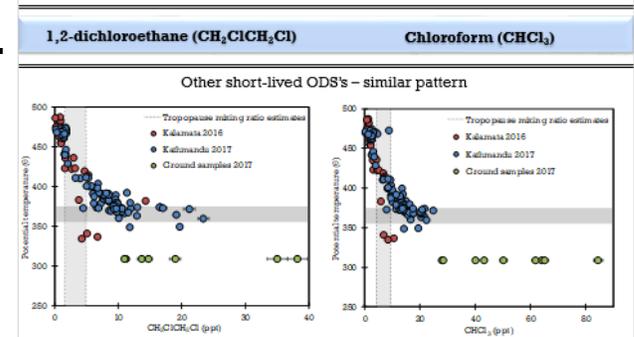
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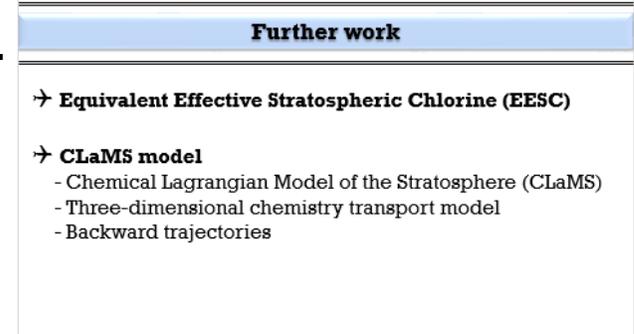
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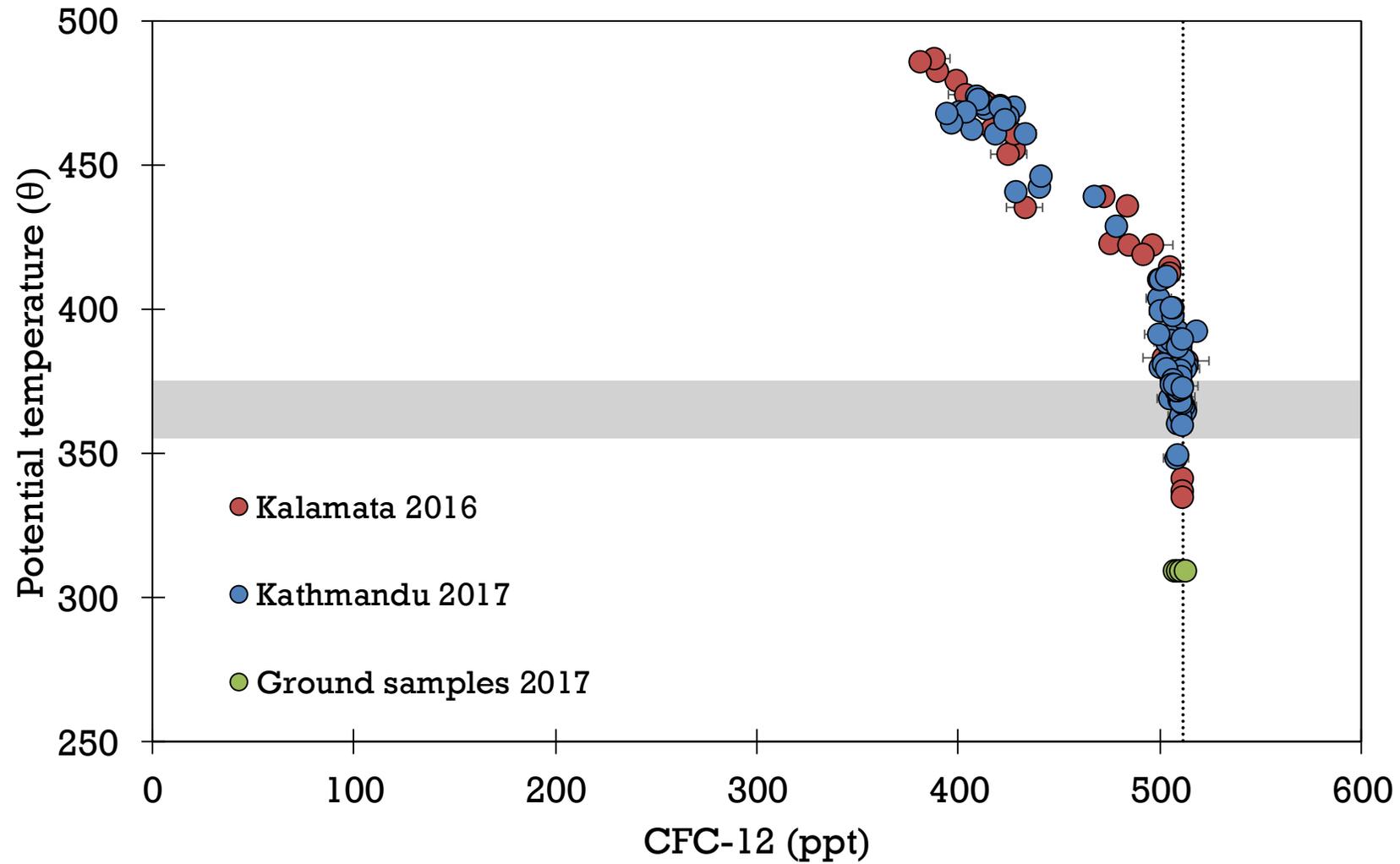
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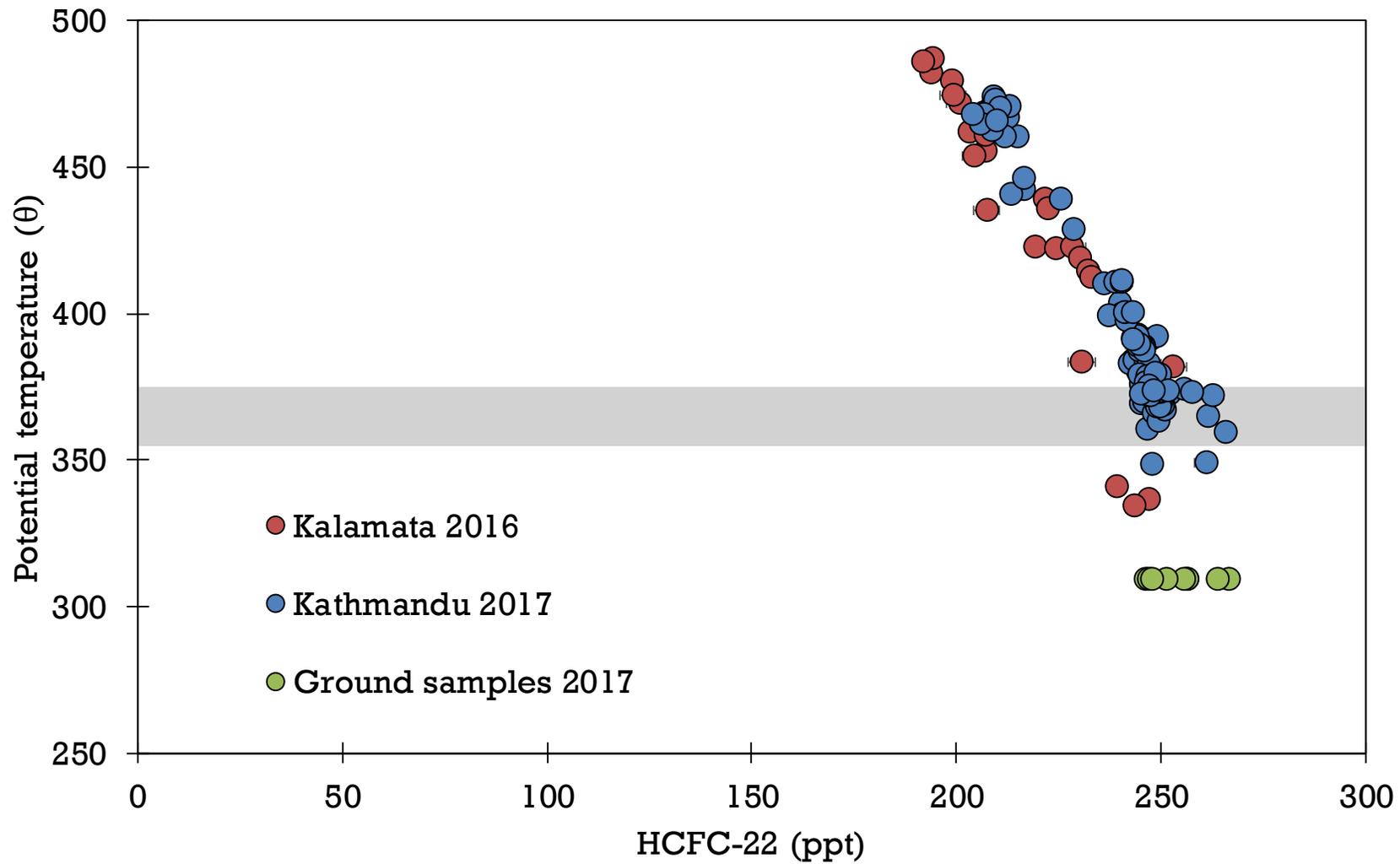
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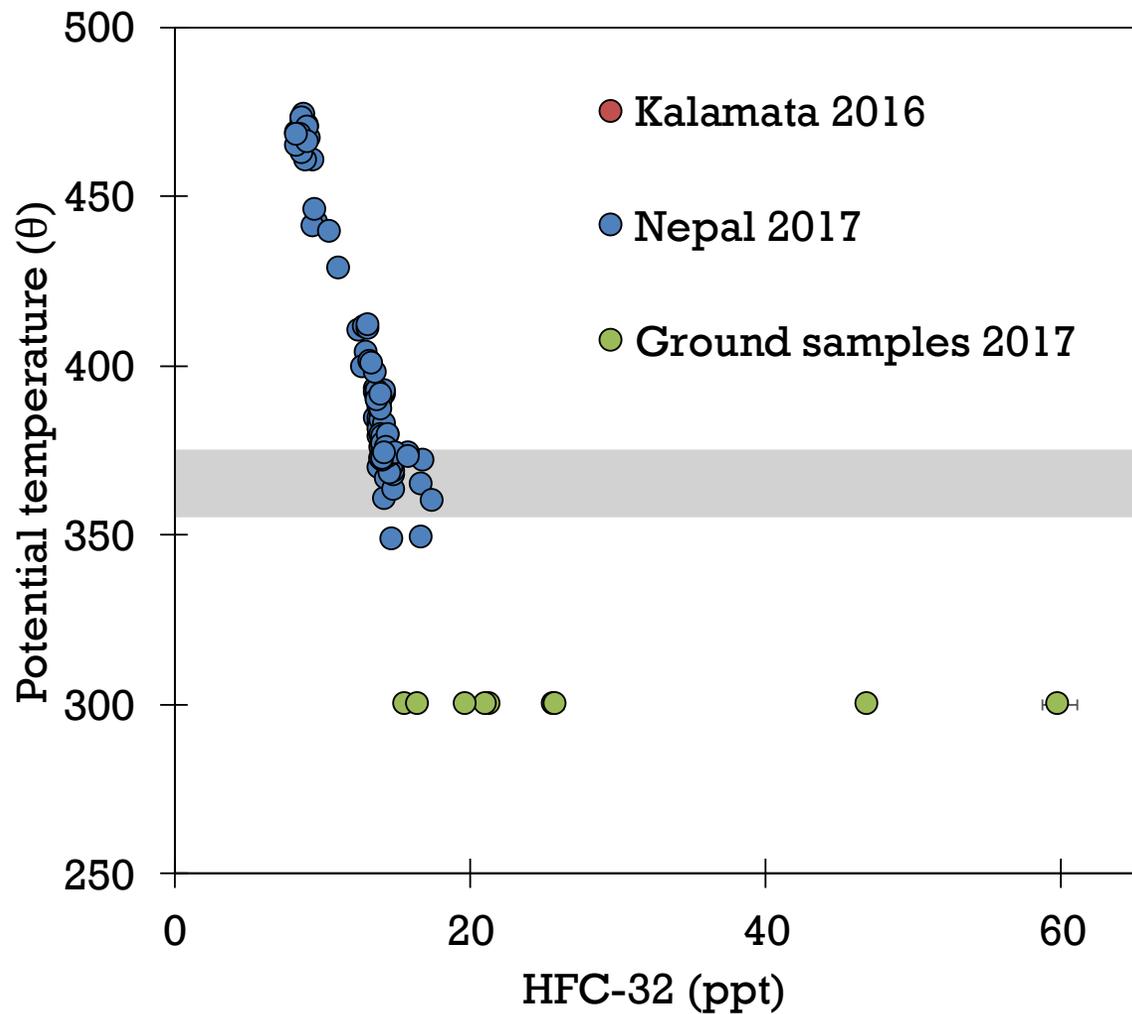
CFC-12



HCFC-22



HFC-32 (CH_2F_2)



HFC-125 (CF_3CHF_2)

