Assessment of vertical CCN retrieval methods against in-situ CCN measurements

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Poster session 2 #88

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Integrated Cloud, Land-Surface,& Aerosol System Study ICLASS

Pacific Northwest
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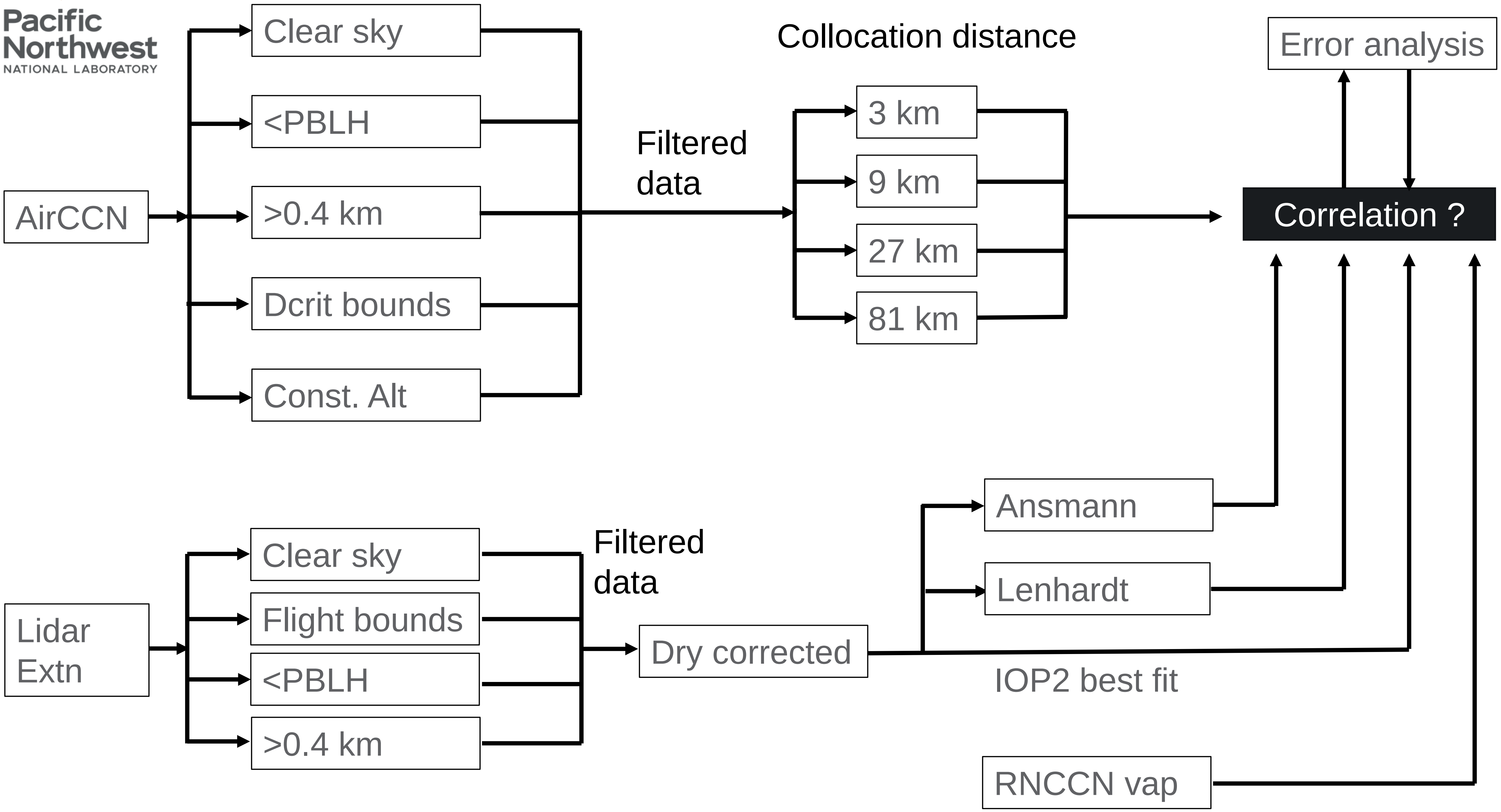
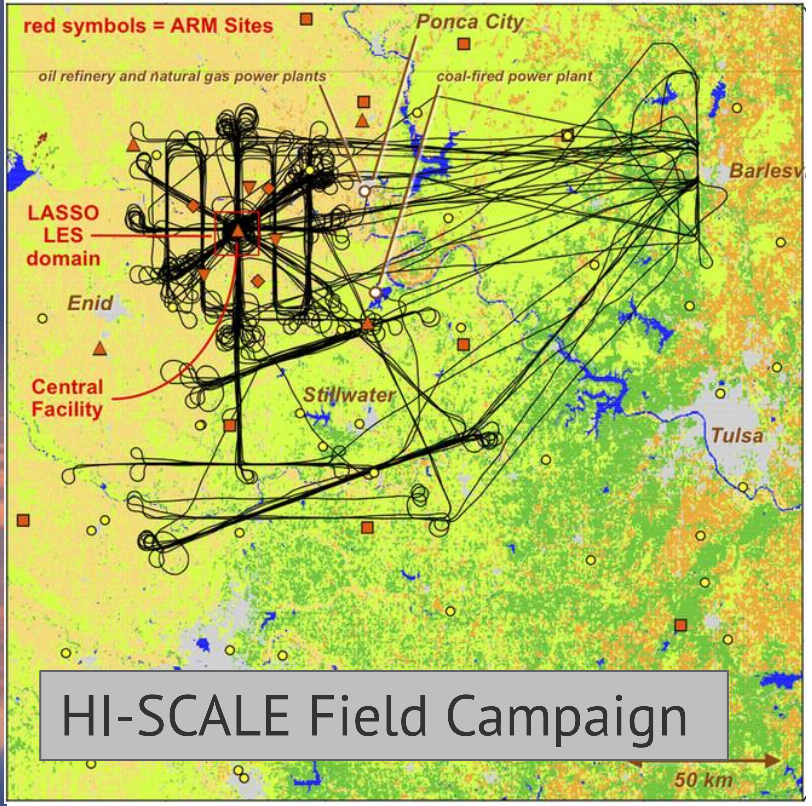
Objective:
Assessment of vertical CCN retrieval methods against in-situ CCN observations.
How measured CCN agree with the retrieved CCN?

Data:
HI-SCALE observations; Ground – RL, PBL, CCN, Aerosol, Met data; RNCCN ARM vap; CCN retrieval methods

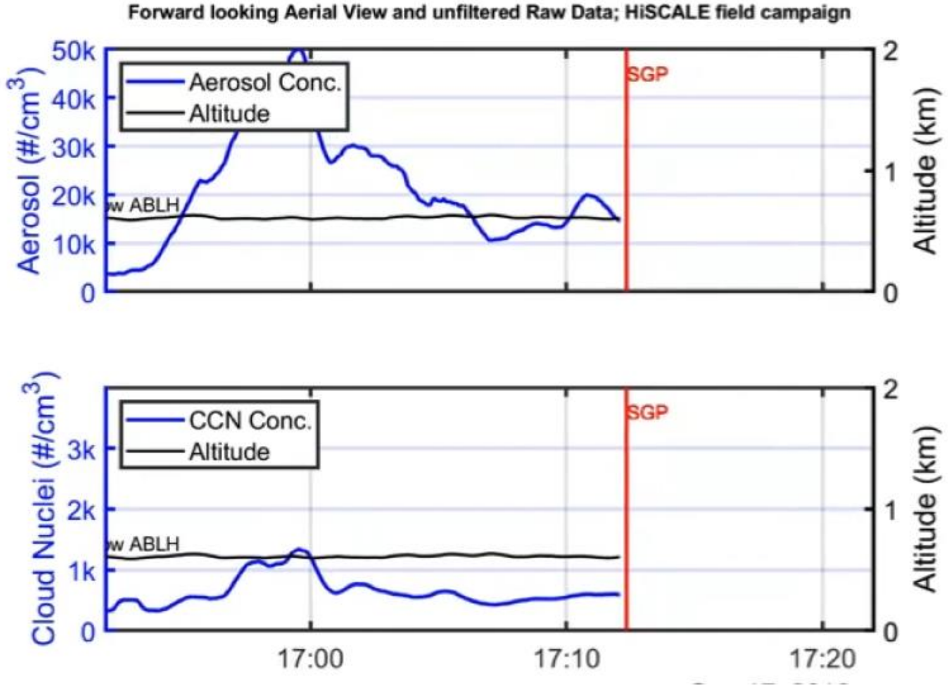
Implications:
This work will help us *to routinely calculate vertically resolved CCN to study ACI processes*. Construct a CCN climatology to better quantify ACI effects.
It should be noted that estimating CCN budget at the base of a liquid cloud remains highly uncertain.

Assessment Methodology





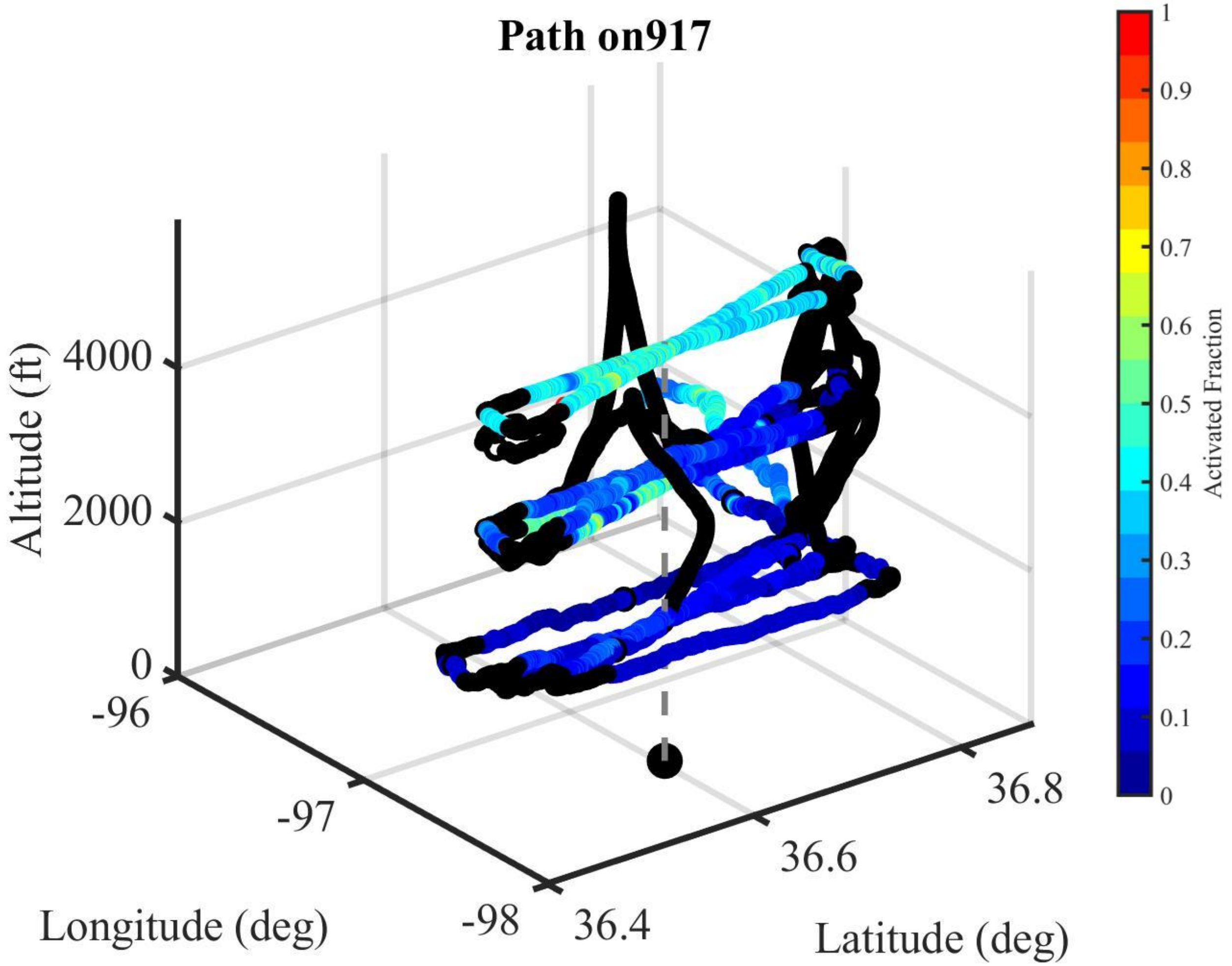
Fast et al. 2019



Forward looking aircraft movie; Supplementary, Kulkarni et al. 2023

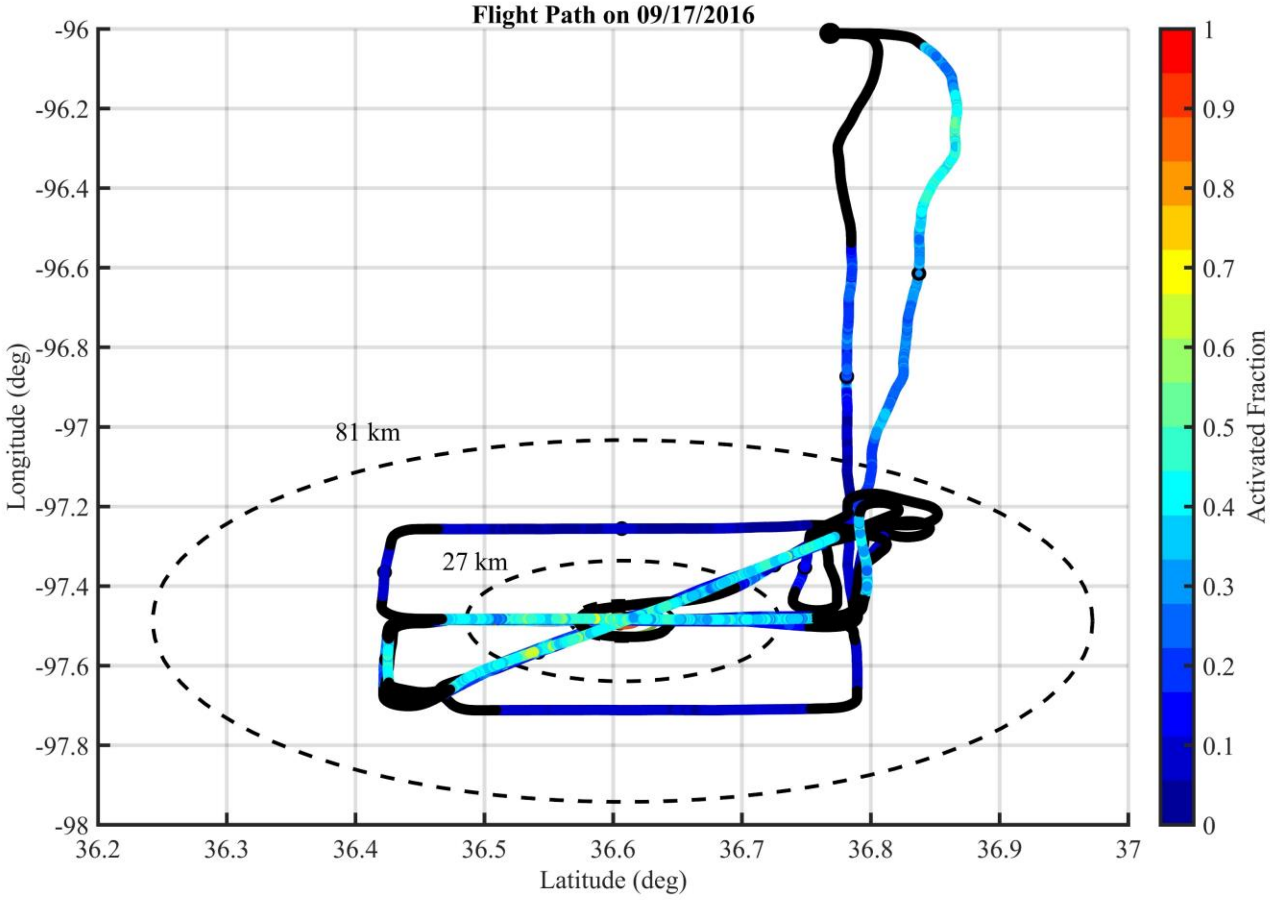
We have time series of airborne Aerosol and CCN data + air met data

IOP2 flights (#16):
Aug30a, 30b ;
Sept 1, 3, 4a, 4b, 6, 7a, 7b, 9, 10, 11, 13, 15a, 15b, **17**



Assessment at constant altitude within ± 100 m vertical distance.

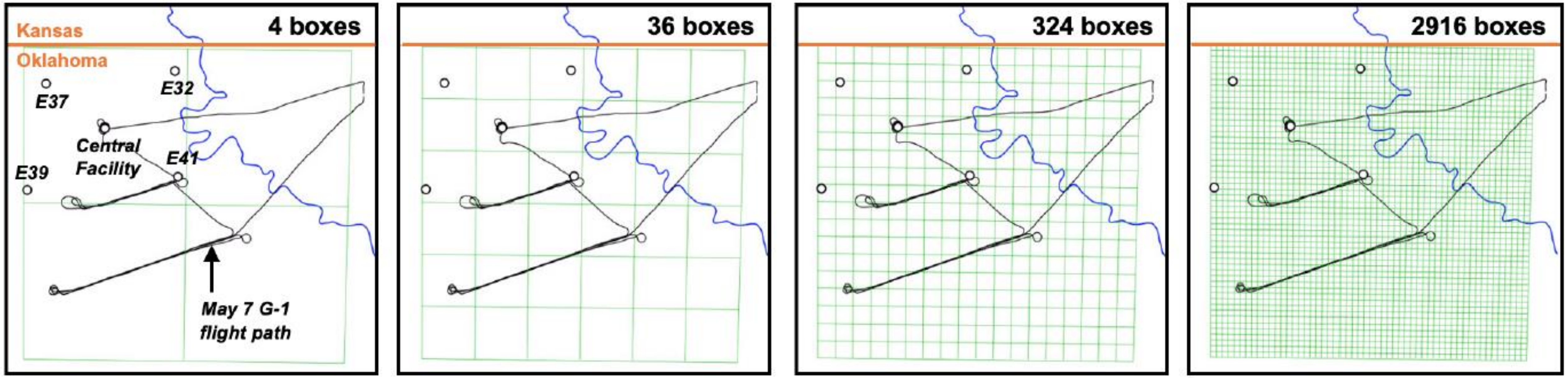
CCN data from multiple legs (#27) but that are at constant altitude are binned and averaged.



Collocation distance window: 3, 9, 27, and 81 km horizontal distance away from the site.

Data is screened based on the distance away from the site.

Fast et al. 2022

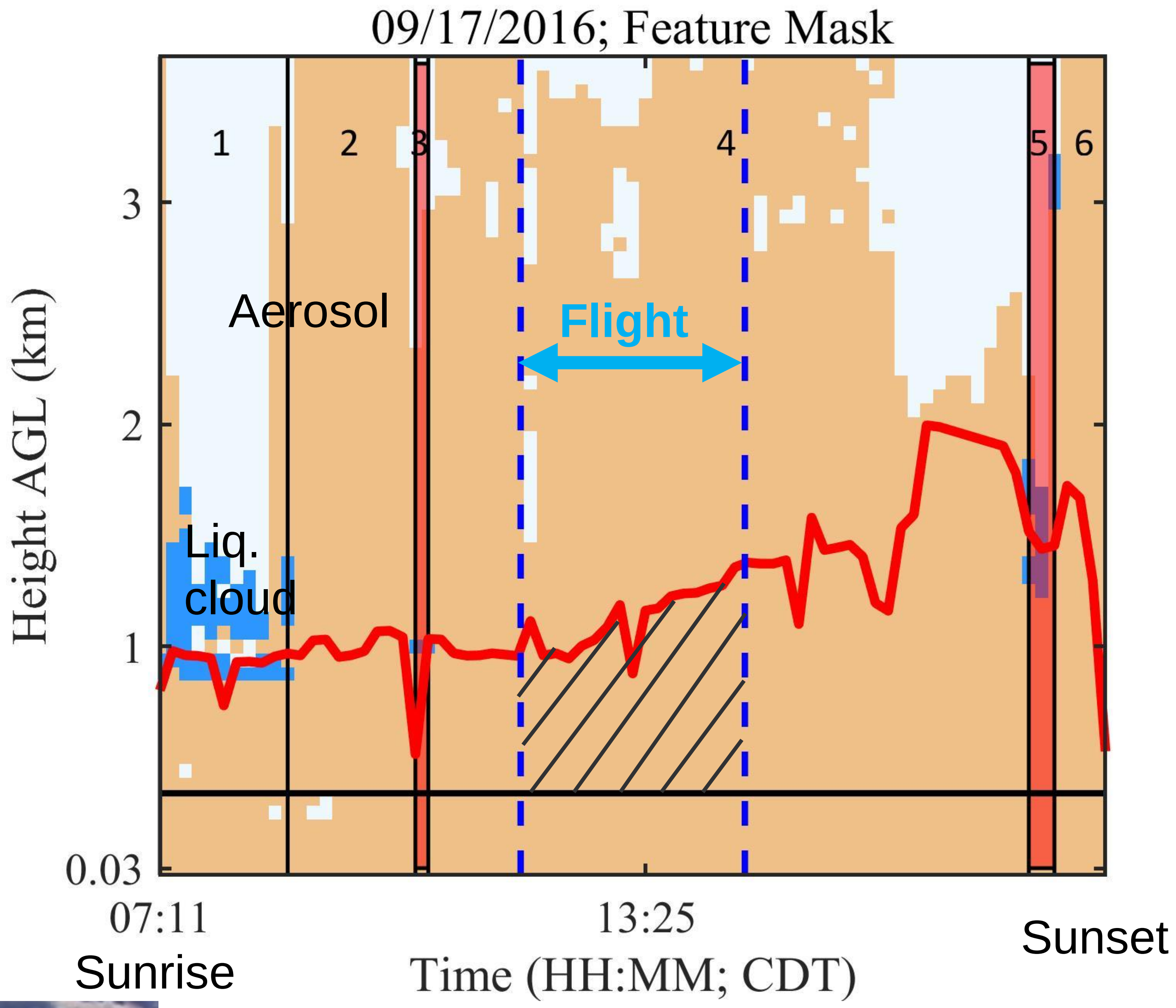


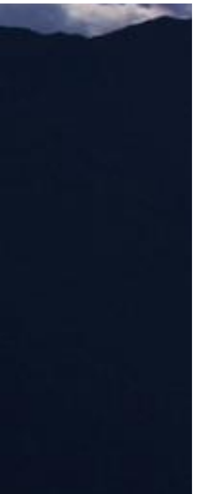
(a) Δx = 81 km boxes ~ current climate models

(b) Δx = 27 km boxes ~ near-future climate models

(c) Δx = 9 km boxes ~ current global forecast models

(d) Δx = 3 km boxes "cloud-system resolving" model





Time-Height display of feature mask

RL product provides feature mask:

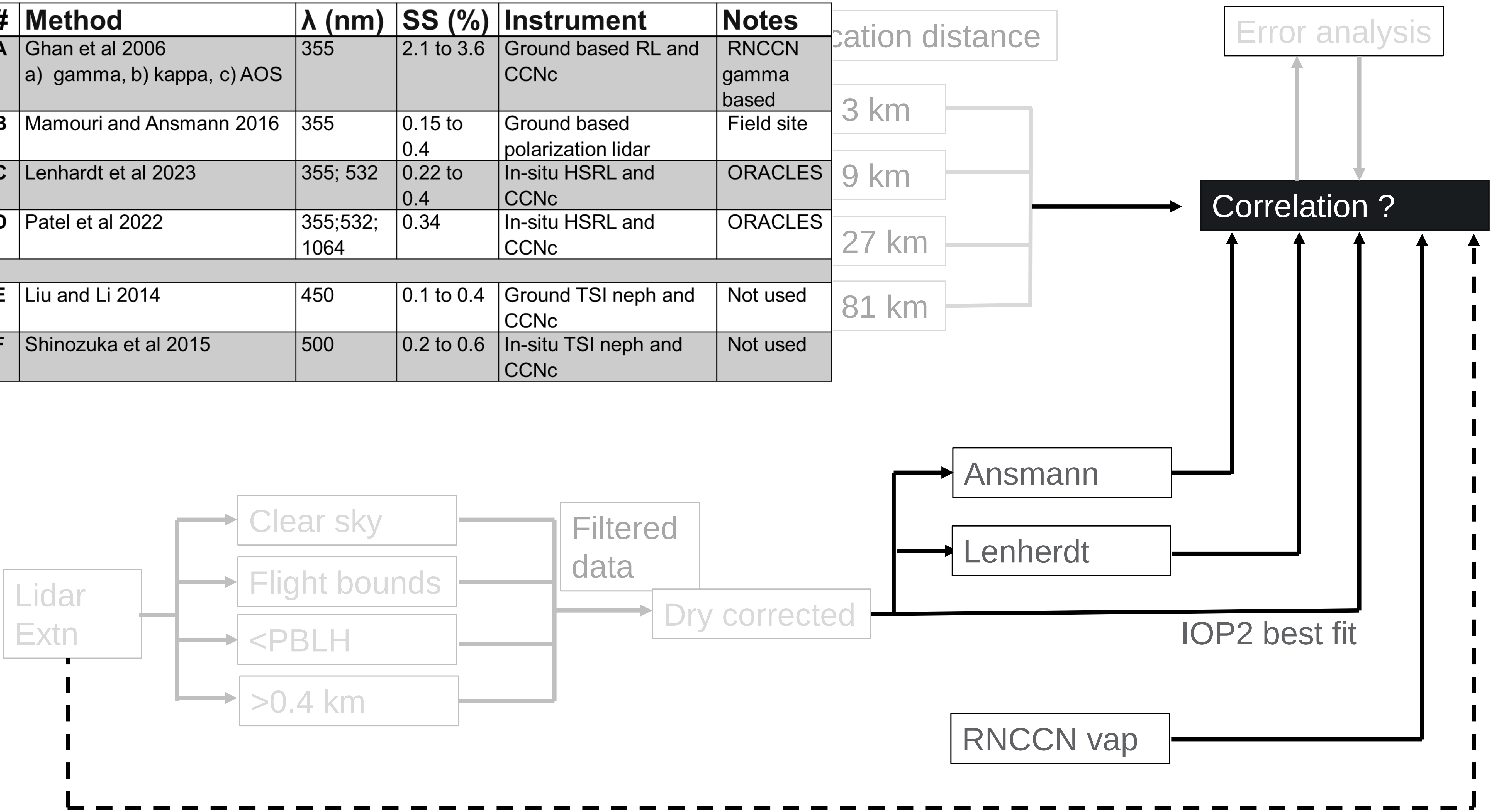
Aerosol,
rain,
liq_cloud,
ice_cloud

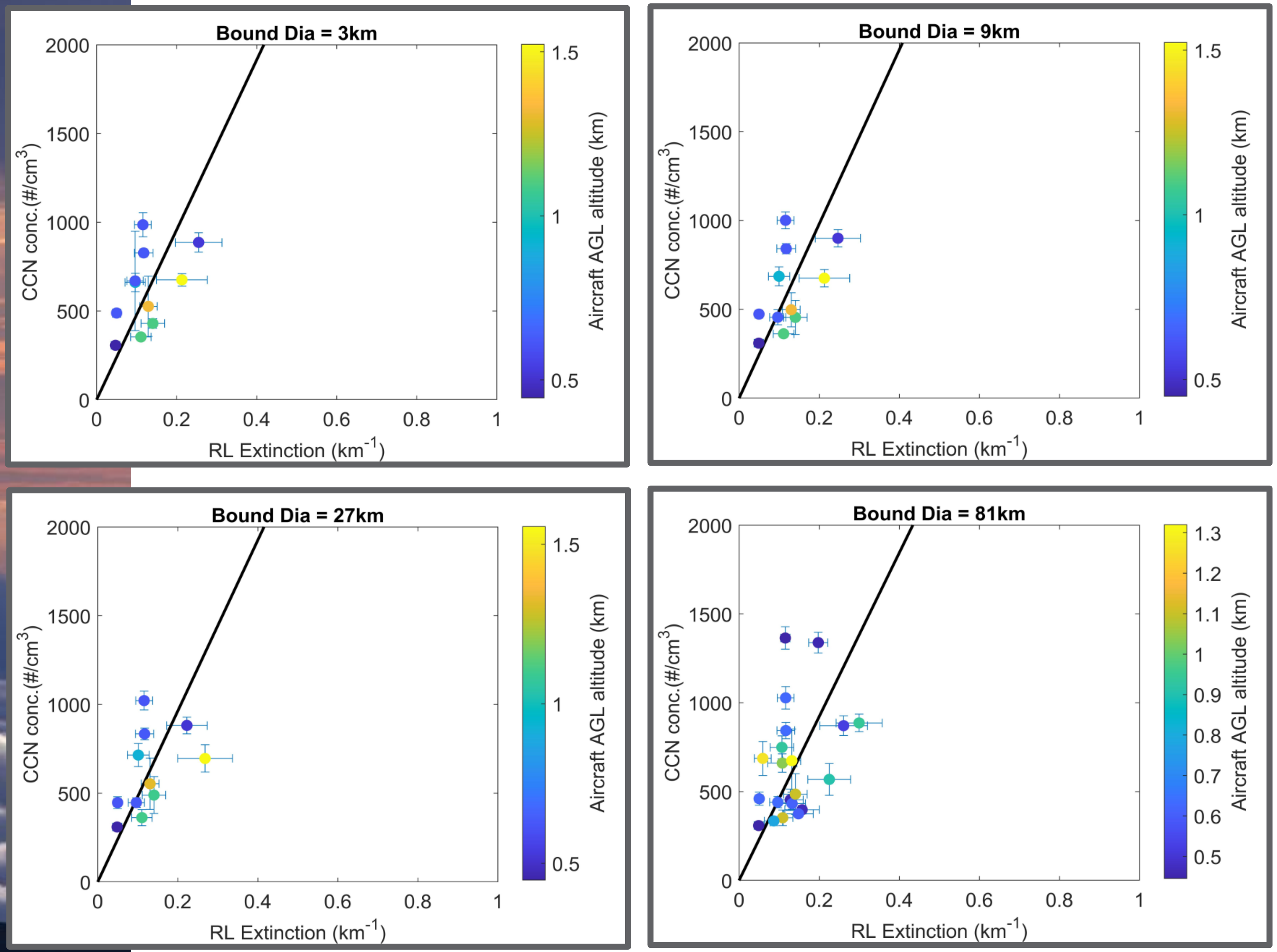
Clear sky days are used in this analysis.

Extn values that overlap with flight periods are used.

Literature Methods

#	Method	λ (nm)	SS (%)	Instrument	Notes
A	Ghan et al 2006 a) gamma, b) kappa, c) AOS	355	2.1 to 3.6	Ground based RL and CCNc	RNCCN gamma based
B	Mamouri and Ansmann 2016	355	0.15 to 0.4	Ground based polarization lidar	Field site
C	Lenhardt et al 2023	355; 532	0.22 to 0.4	In-situ HSRL and CCNc	ORACLES
D	Patel et al 2022	355;532; 1064	0.34	In-situ HSRL and CCNc	ORACLES
E	Liu and Li 2014	450	0.1 to 0.4	Ground TSI neph and CCNc	Not used
F	Shinozuka et al 2015	500	0.2 to 0.6	In-situ TSI neph and CCNc	Not used



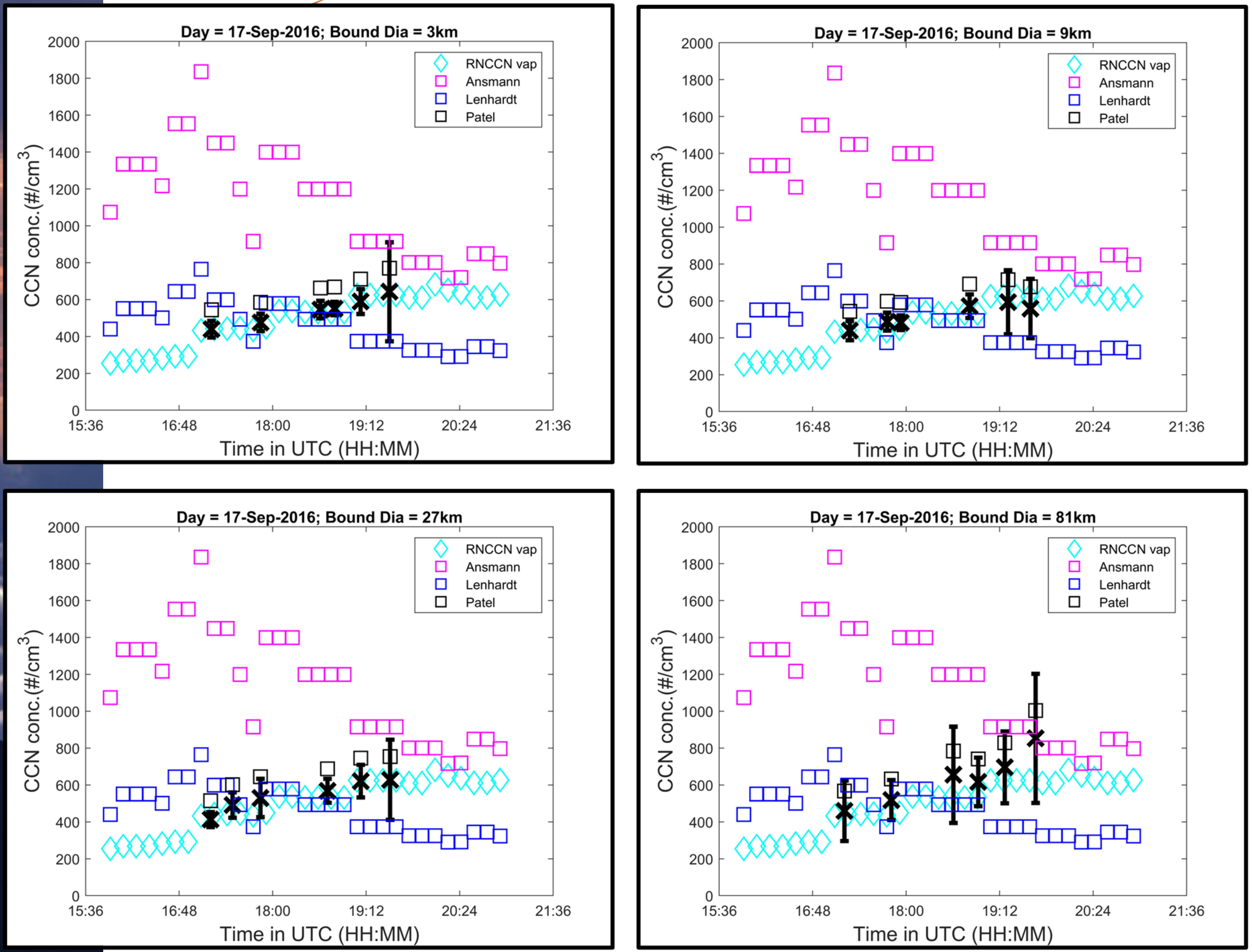


R is better when distance is short.

Z transformation (measure of 95% CI in the R) shows wide range.

One can derive best fit slope (with intercept = 0) and compare against previous methods.

Grid (km)	R^2	Z_r; 95% CI	RMSE ($\#/cm^3$)	Best fit slope
3	0.55	0.27-0.94	170	4785
9	0.6	0.31-0.93	159	4902
27	0.52	0.21-0.92	187	4813
81	0.35	0.21-0.81	253	4609



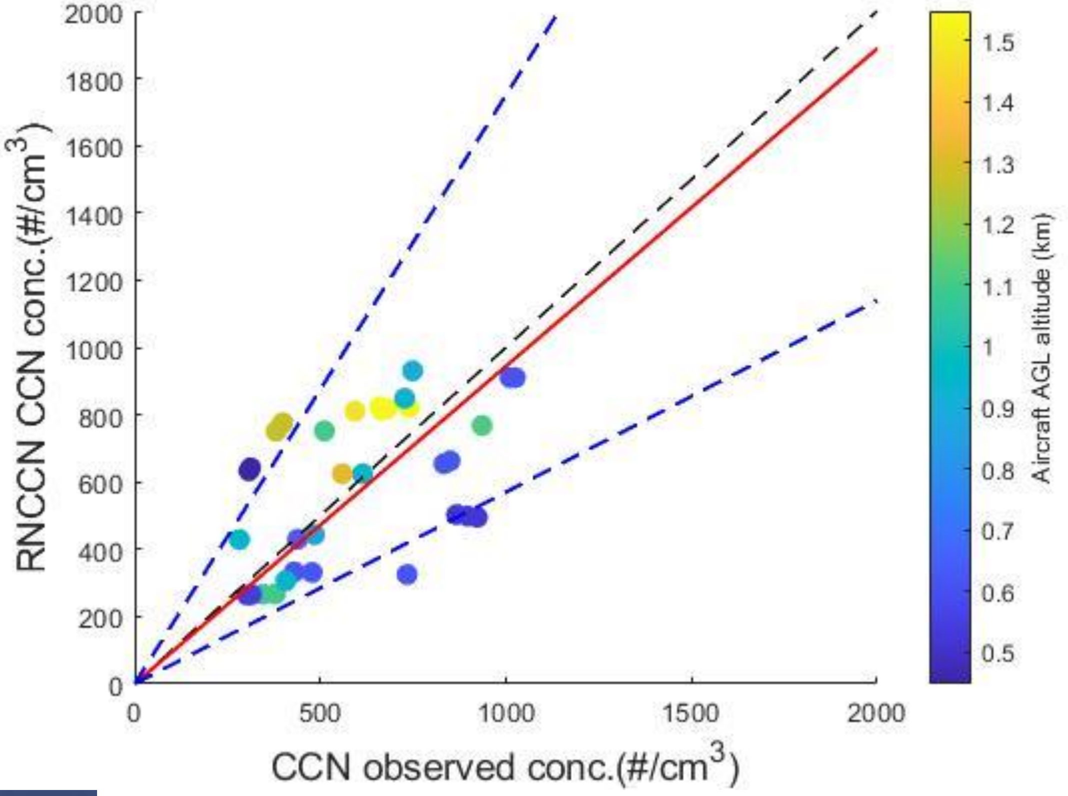
Mean (x) and range (1SD) of airCCN from the constant altitude legs were compared with the retrieved CCN.

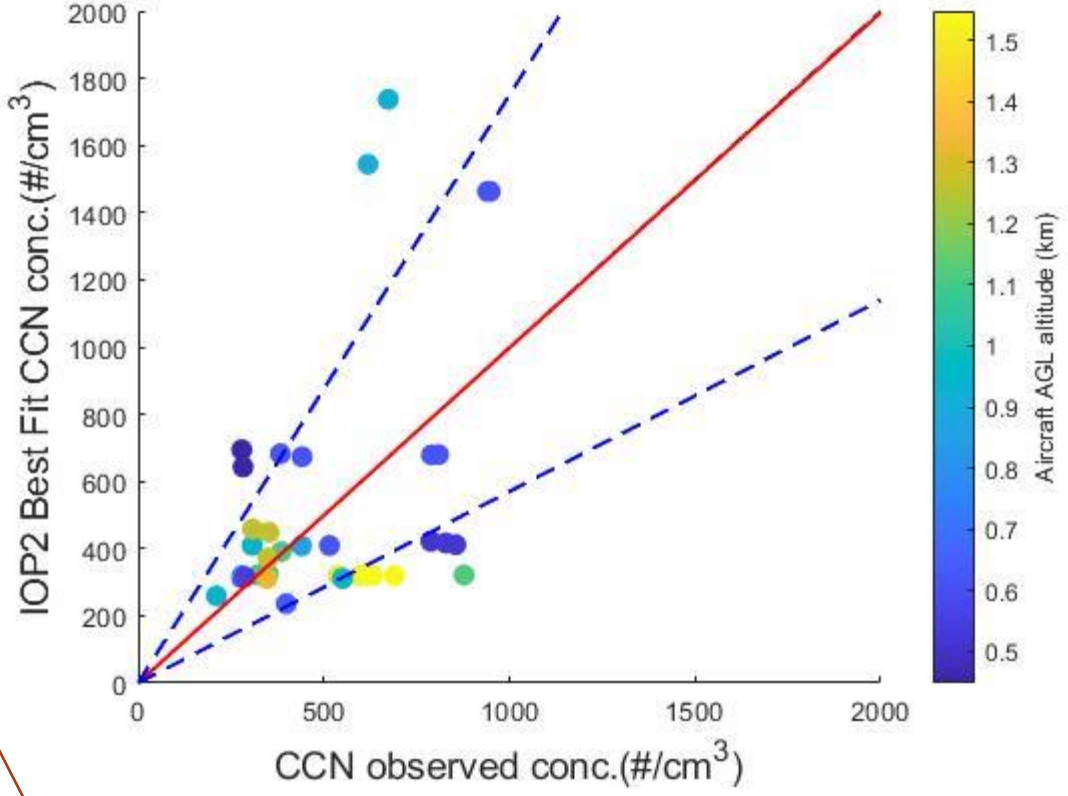
In-situ retrieval methods (Lenhardt and Patel) and RNCCN vap show agreement within one order of magnitude.

Ansmann method which is developed in a region dominated by dust shows poor agreement.

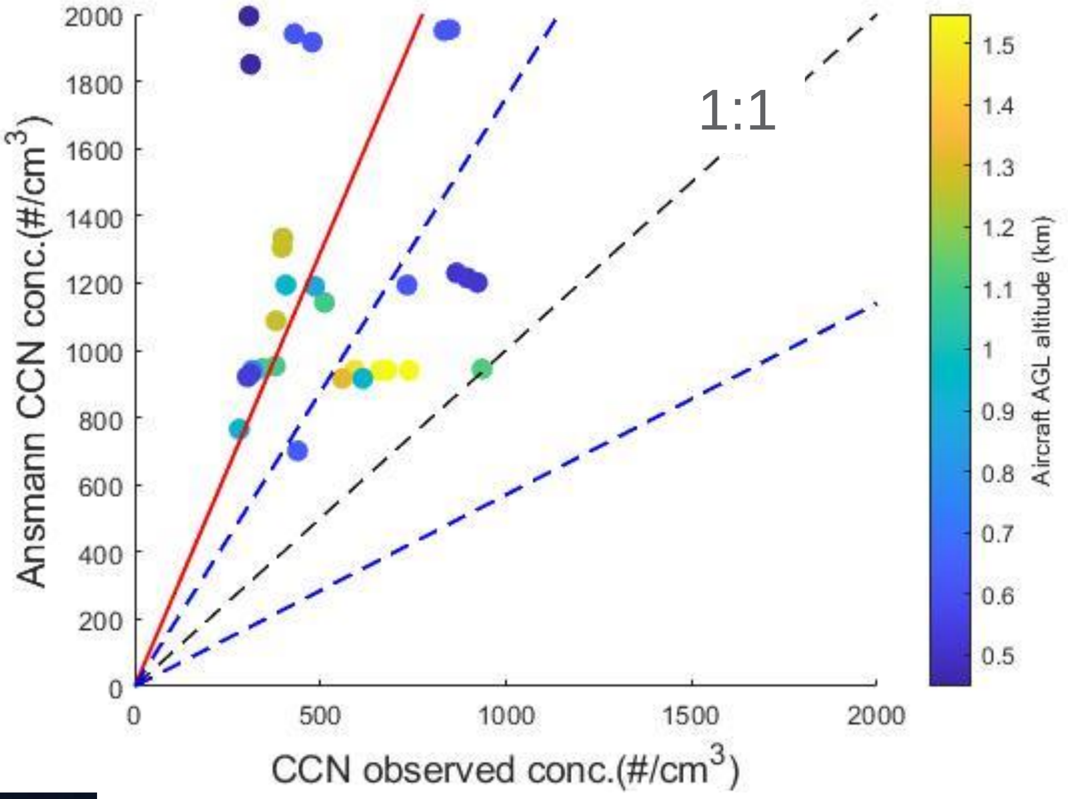
At 81km, the airCCN range (1SD) increases. Retrieval methods do not capture spatial variability.

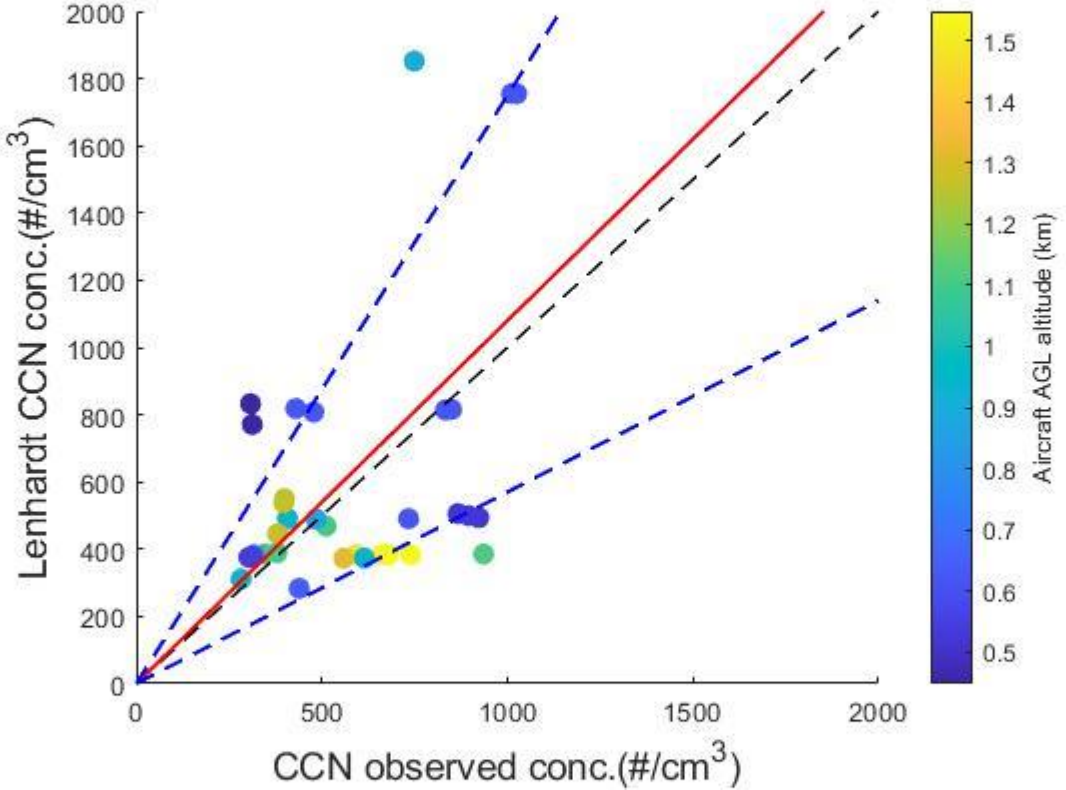
Agreement within ±75% uncertainty.





Summary of all IOP2 days





9 km collocation distance

Summary

Preliminary analysis show:

- Estimating vertical CCN budget is still challenging. Under well mixed boundary layer conditions, certain existing retrieval methods show agreement within order of magnitude.
- Correlation between airCCN and just extinction can be obtained with $R^2 = 0.5$.
- For certain days, the airCCN data shows broader range when using 81km distance window indicating presence of broader range of aerosol properties. Sensitivity to the sampling region.
- For all IOP2 days, certain methods agree within one order of magnitude.

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Thank you