GLM Flash Properties & LNOx Estimates: A Comparison Between Winter and Summer Storms Over CONUS

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GLM Science Meeting

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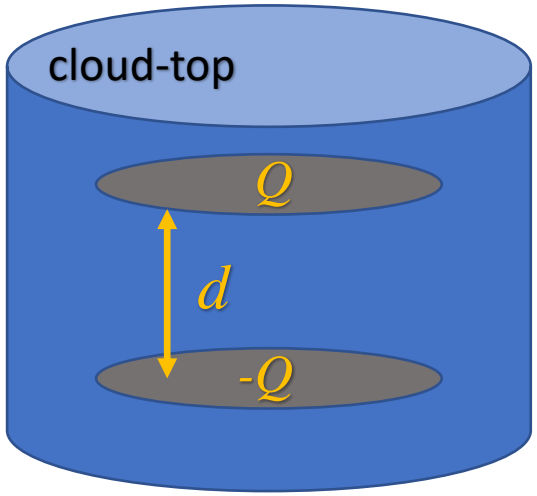
Virtual Capacitor Model (VCM)

(see Koshak 2021 AMS paper for details)

- **Plate area estimated by GLM flash area A. Can be an over- or under- estimation.**
- **Plate separation d :** *6.5 km (-CG), 10 km (+CG), 3.5 km (IC). NLDN used to determine flash-type.*
- **Plate surface charge density estimated from GLM flash optical energy ε .**
- **Total Flash Energy U estimated by capacitor energy: $U = U_1 - U_2$.**
- **Flash LNOx is YU/N_A**

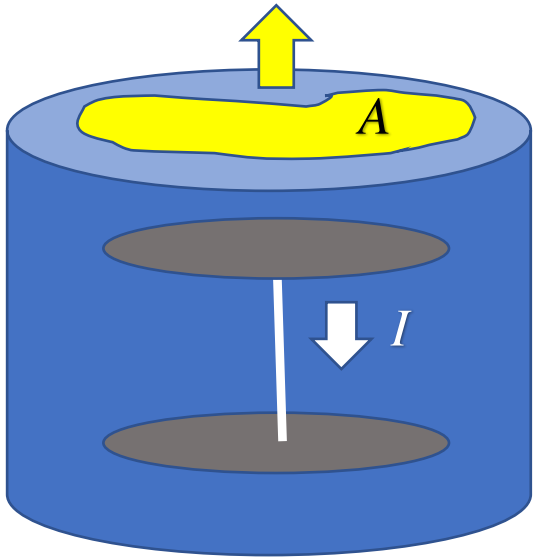
Just Before Flash



$$U_1 = dQ^2/(2A\in_o)$$

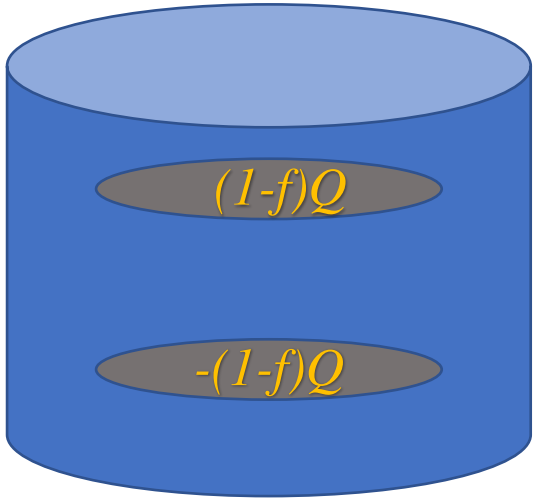
During Flash

(Energy ε *to* GLM)



$$I\,\tau = f\,Q$$

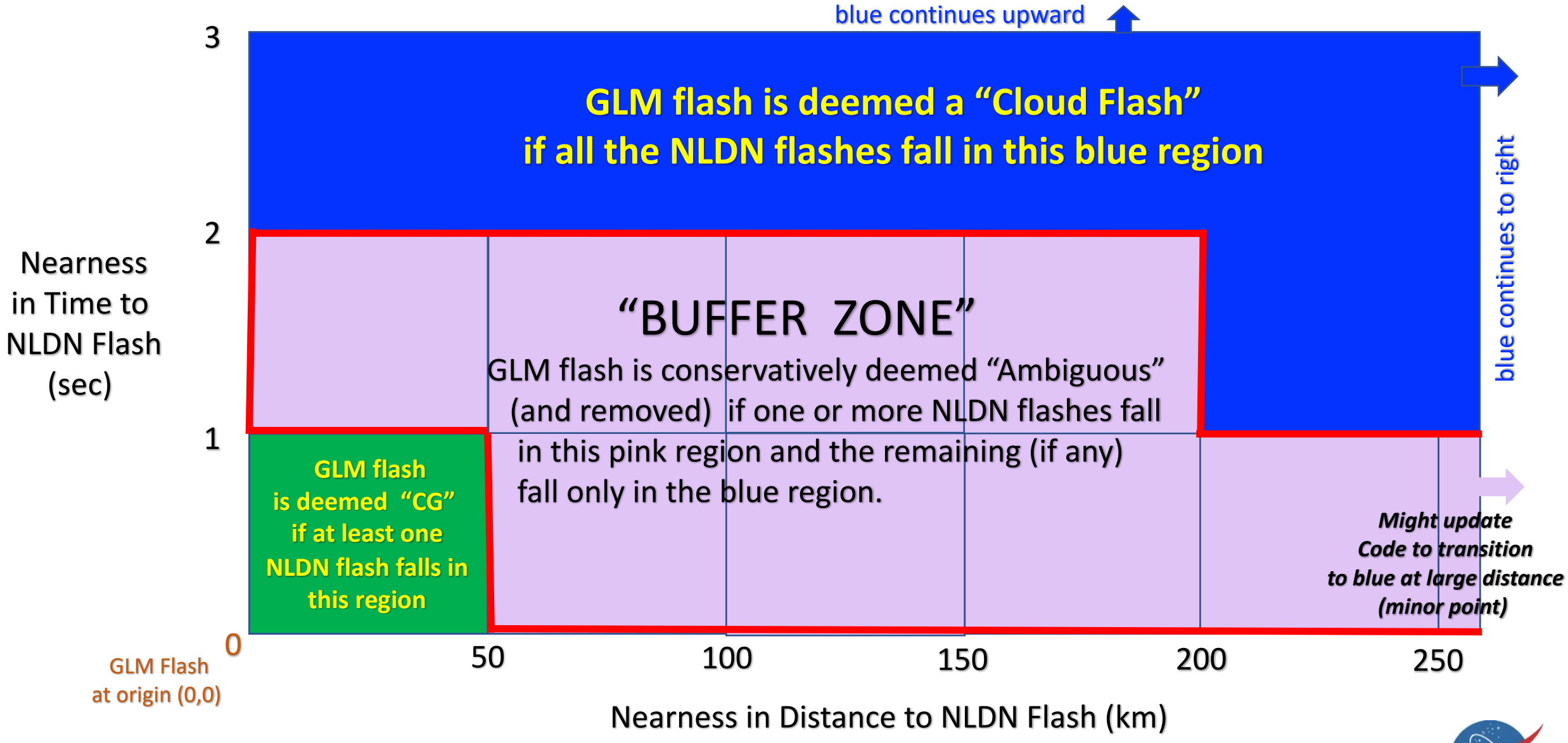
Just After Flash



$$U_2 = d\,[(1-f)\,Q]^2/(2A\in_o)$$

Matching Criteria

Plot the NLDN flashes below to decide GLM flash-type



Analyses

Period: June 2020

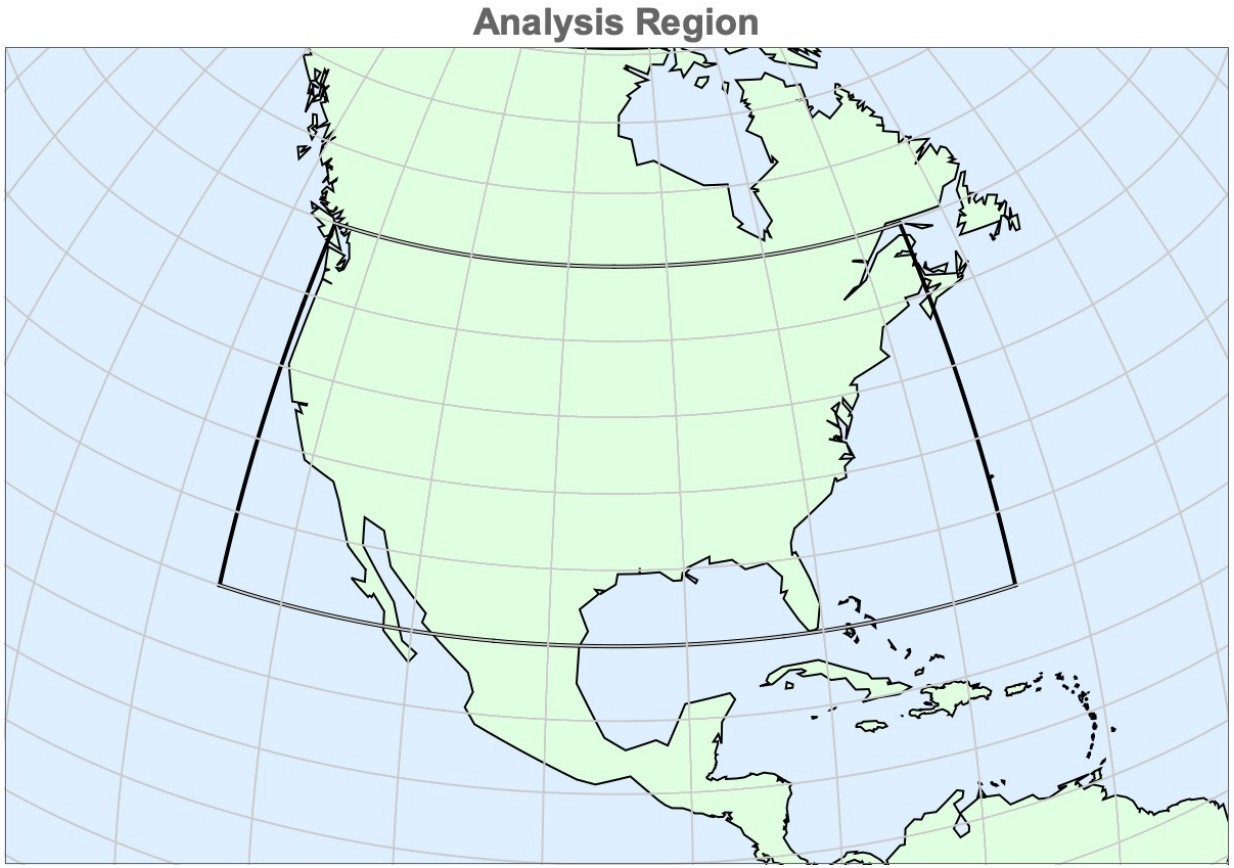
Flash-typed: GLM flashes using NLDN

- **4,369,525 GLM flashes typed**
- 2,076,981 typed Ground
- 2,292,544 typed Cloud

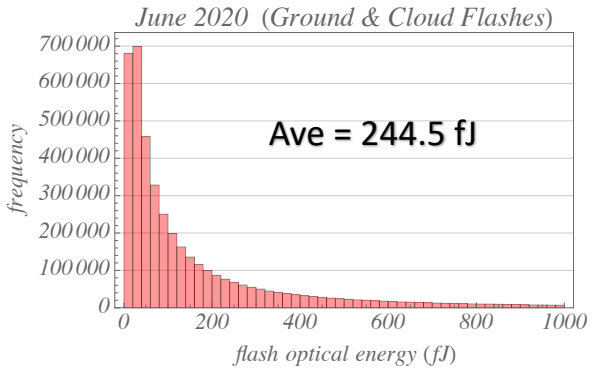
Period: January 2020

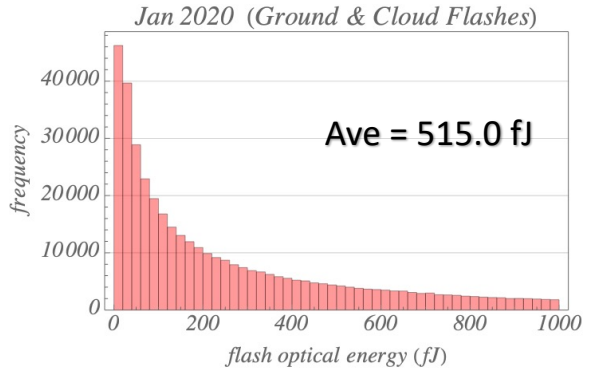
Flash-typed: GLM flashes using NLDN

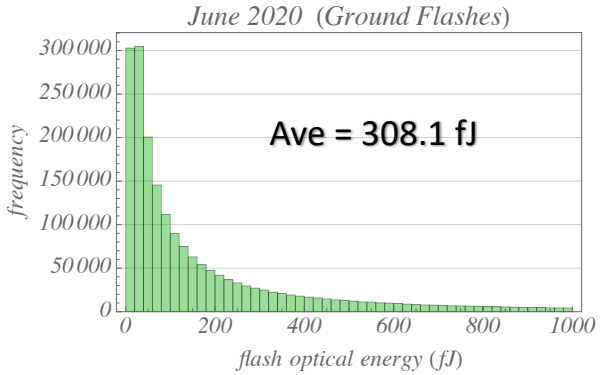
- **460,449 GLM flashes typed**
- 191,092 typed Ground
- 269,357 typed Cloud

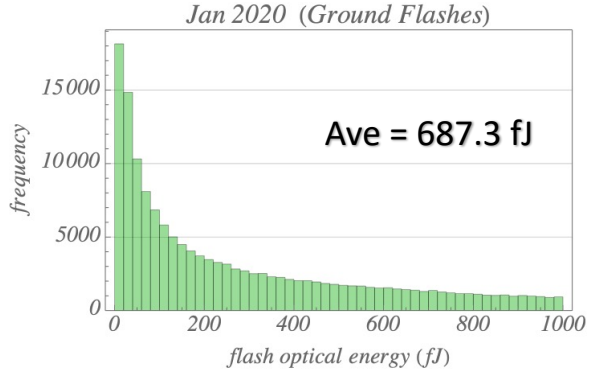


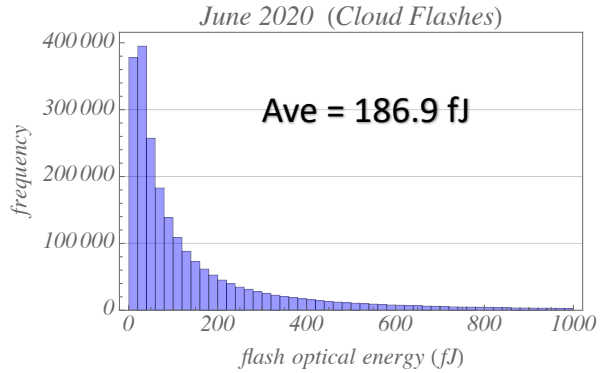
GLM Flash Optical Energy

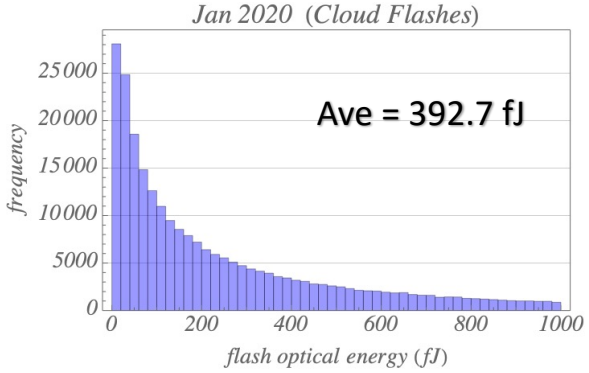












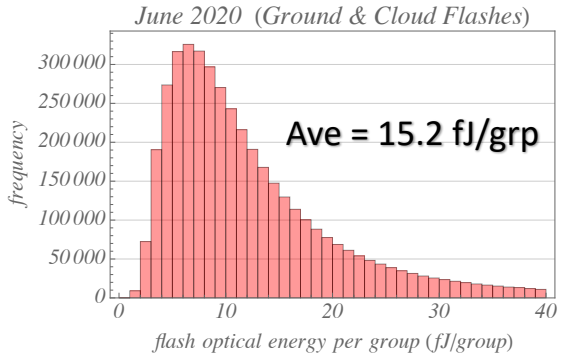
Ratio Winter/Summer: 2.1

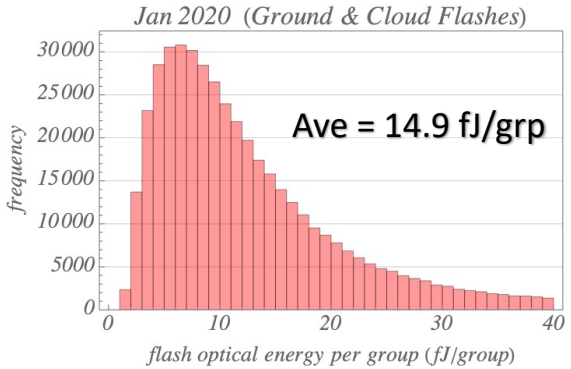
(i.e. ratio of averages shown, 515.0/244.5 = 2.1)

Ratio Winter/Summer: 2.2

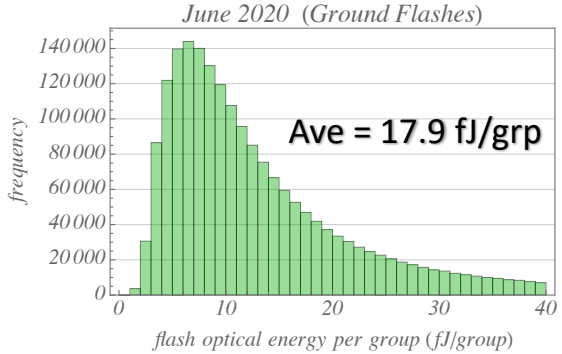
Ratio Winter/Summer: 2.1

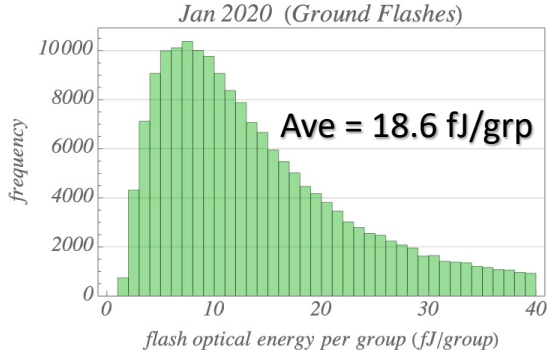
GLM Flash Optical Energy per Group



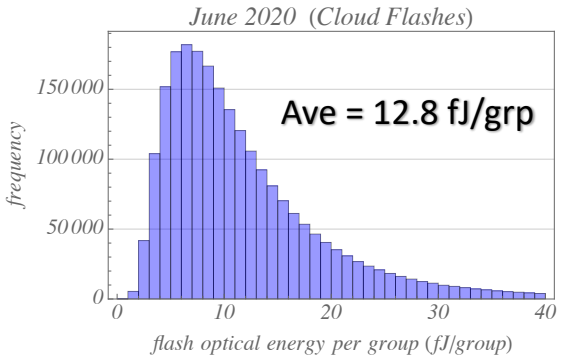


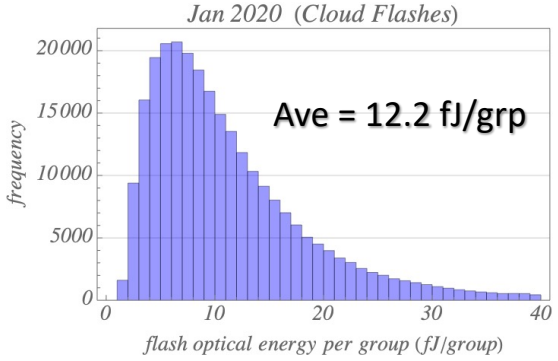
Ratio Winter/Summer: 0.98





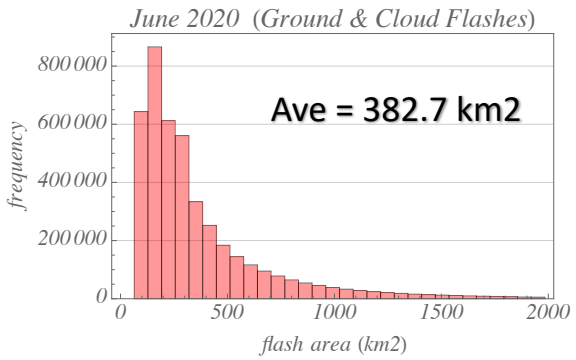
Ratio Winter/Summer: 1.03

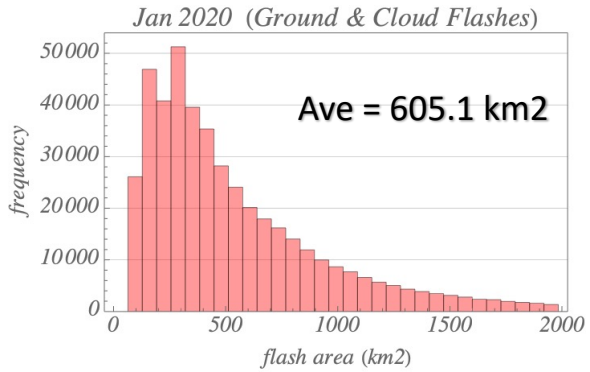




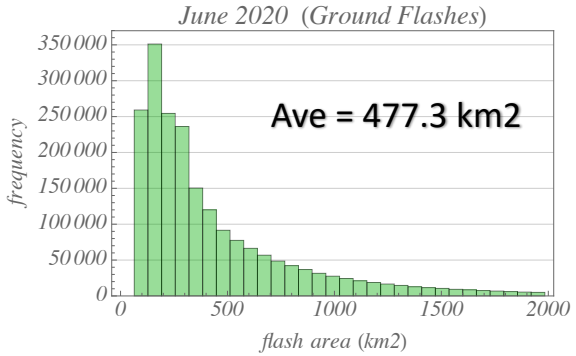
Ratio Winter/Summer: 0.95

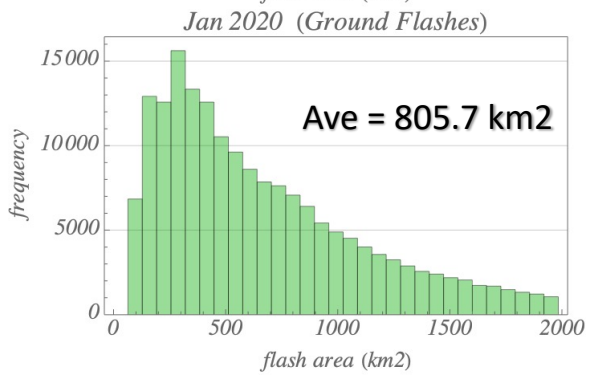
GLM Flash Optical Area



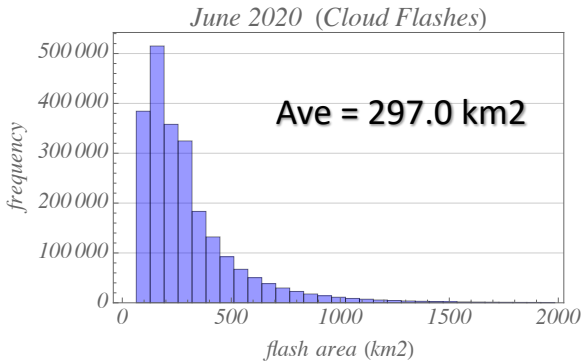


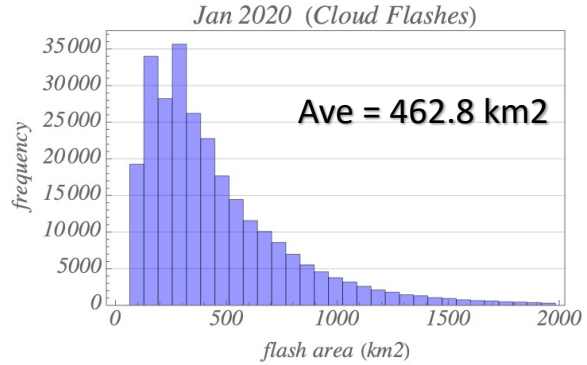
Ratio Winter/Summer: 1.6





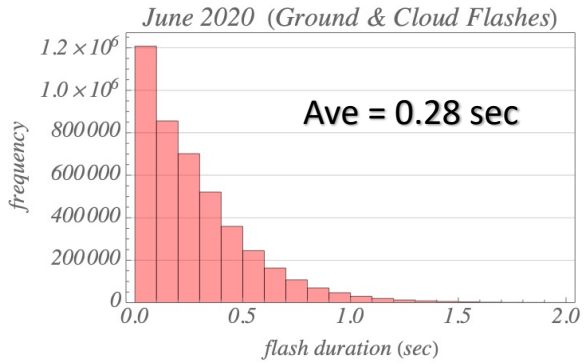
Ratio Winter/Summer: 1.7

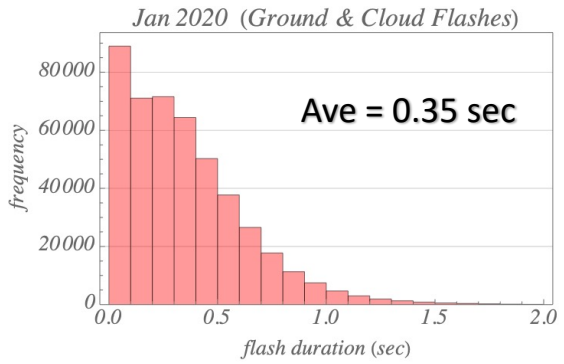




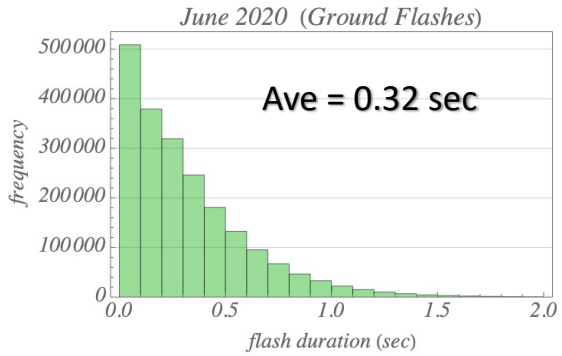
Ratio Winter/Summer: 1.6

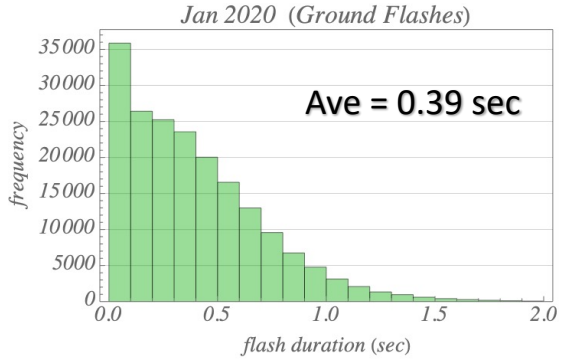
GLM Flash Optical Duration



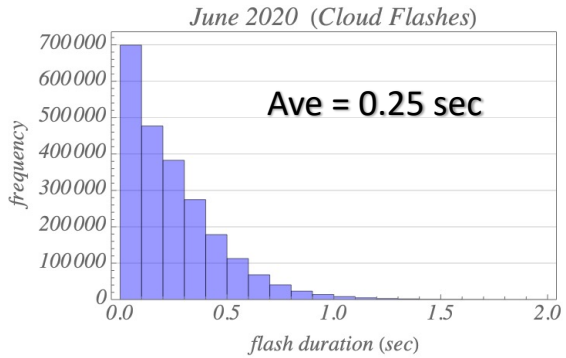


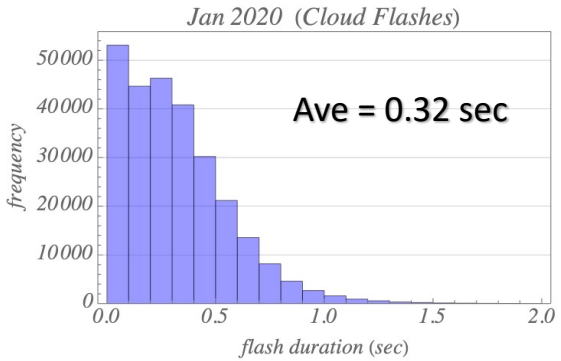
Ratio Winter/Summer: 1.3





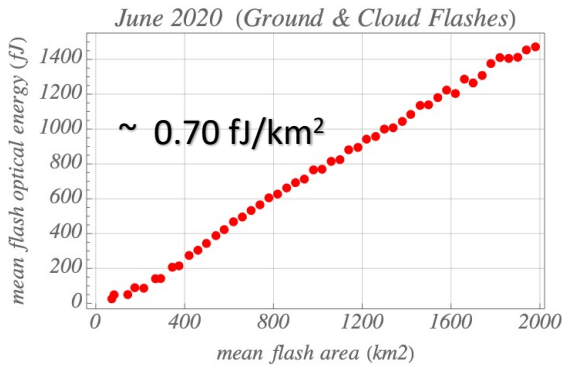
Ratio Winter/Summer: 1.2

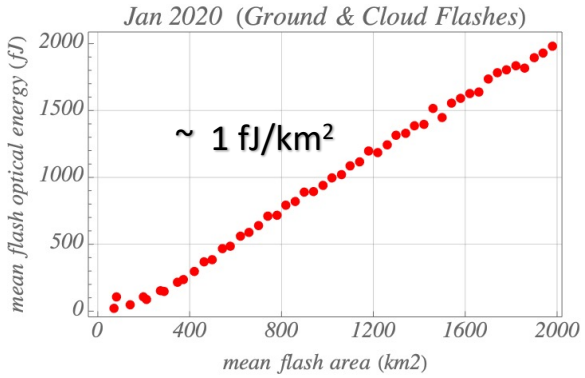




Ratio Winter/Summer: 1.3

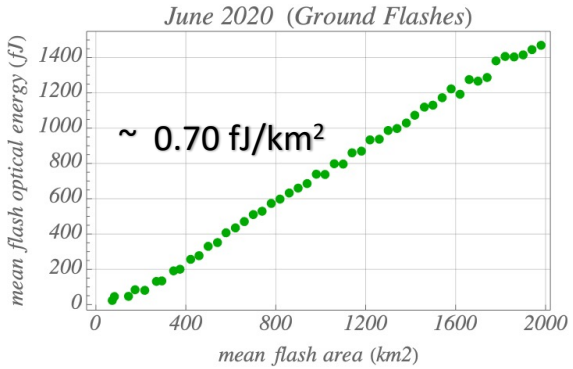
GLM Flash Optical Energy vs. GLM Flash Optical Area

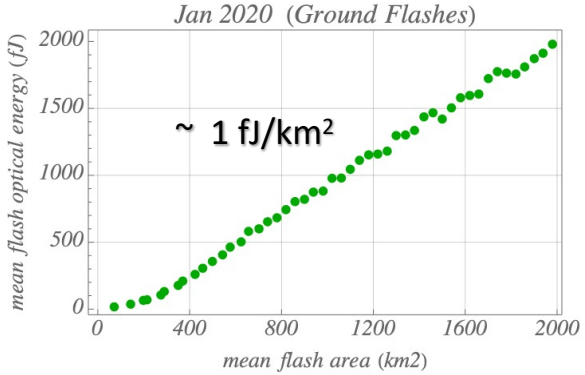




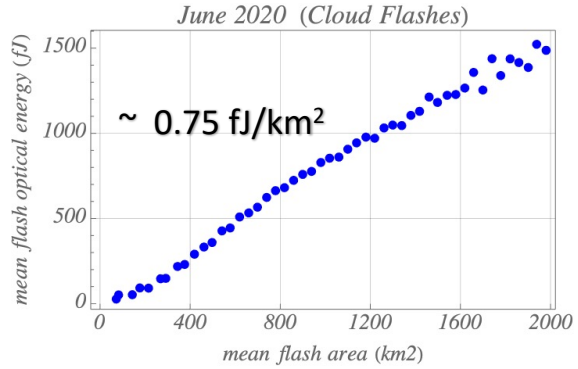
Ratio Winter/Summer: 1.4

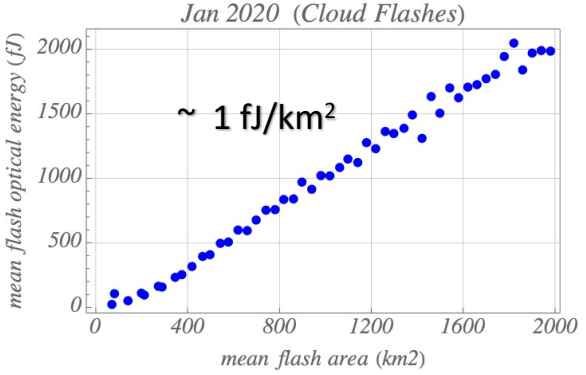
More "optical bang" for the "areal buck" in Winter





Ratio Winter/Summer: 1.4





Ratio Winter/Summer: 1.3

There is scatter, so these are plots of mean vs mean

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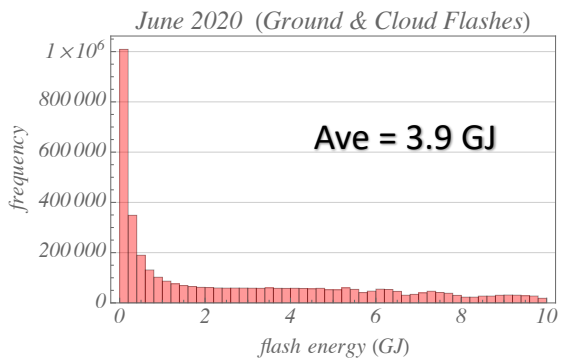
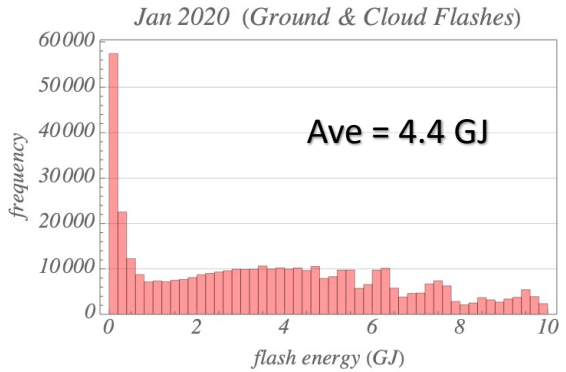
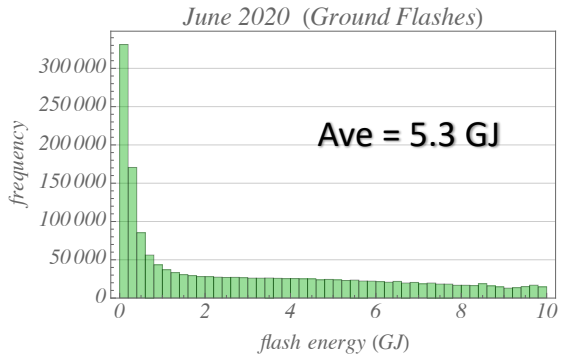
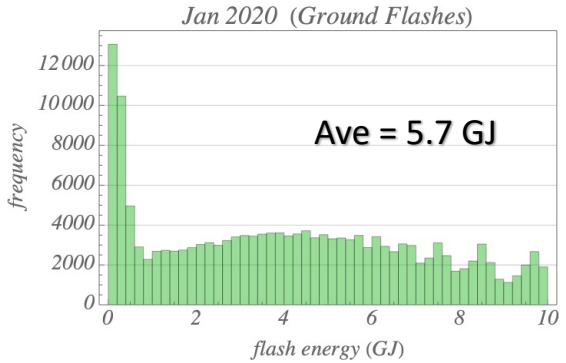
VCM Total Electrostatic Flash Energy



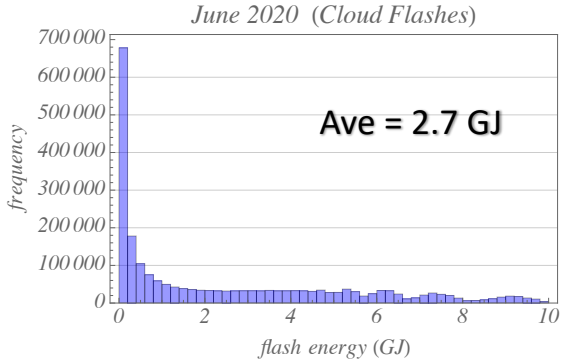


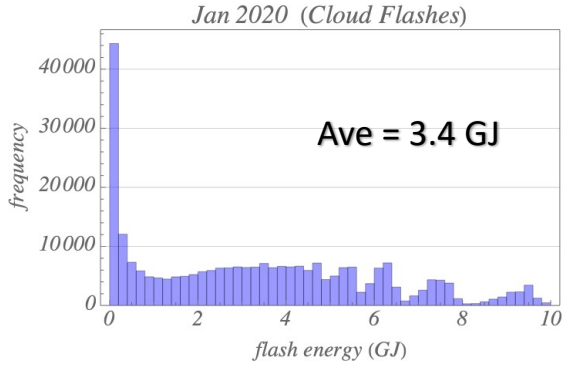
Ratio Winter/Summer: 1.1





Ratio Winter/Summer: 1.1

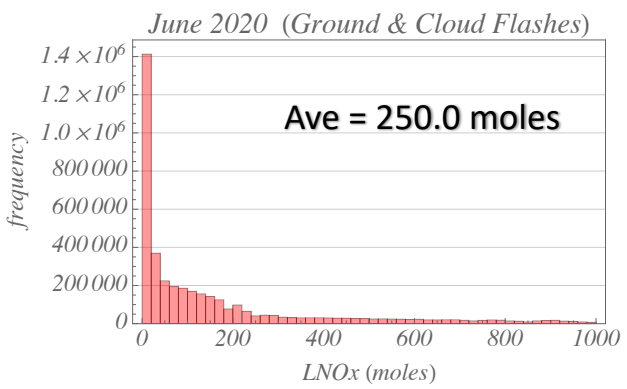


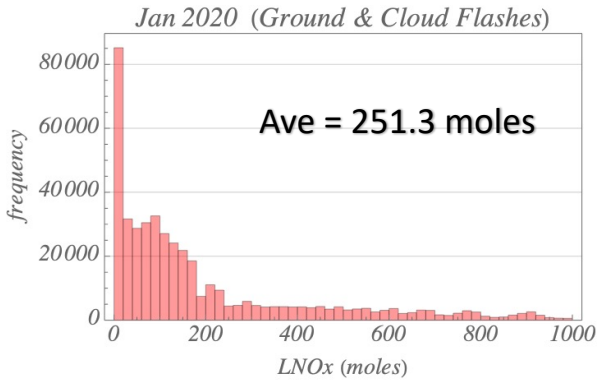


Ratio Winter/Summer: 1.3

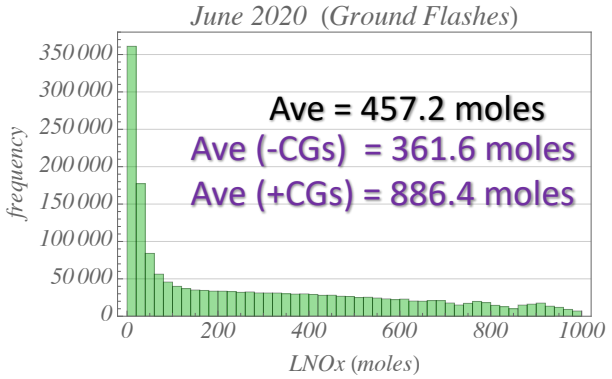
VCM LNOx

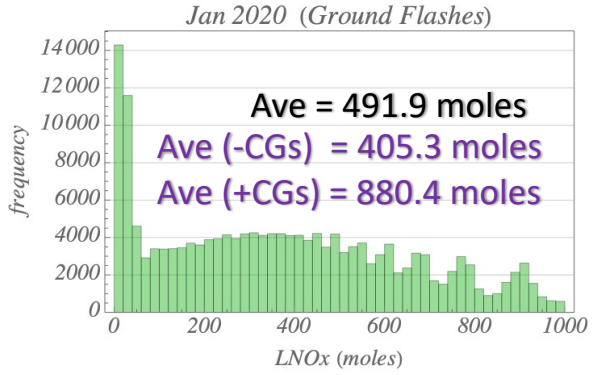
f = 0.1807 chosen to force mean in June 2020 to 250 moles; i.e.~ 18% of Q discharged by each flash)



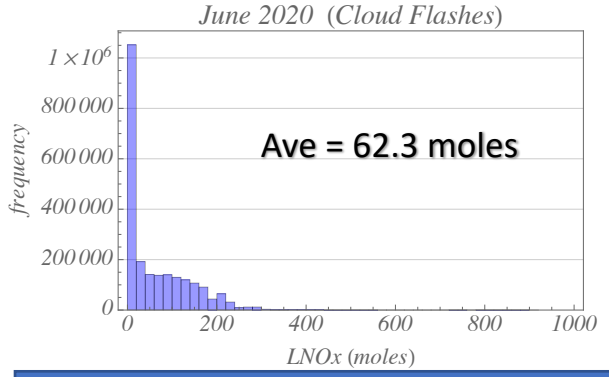


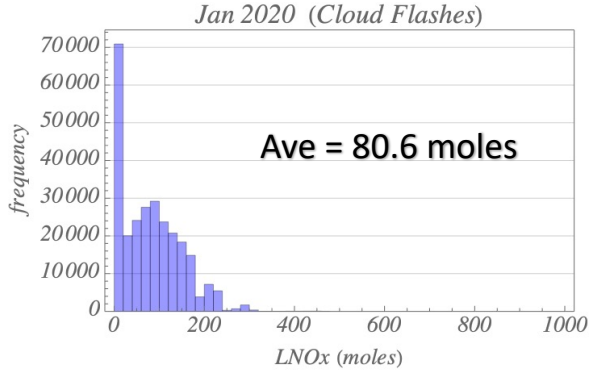
Ratio Winter/Summer: 1.0





Ratio Winter/Summer: 1.1





Ratio Winter/Summer: 1.3

Summary

On average:

- Optical energy/flash in Winter storms is about twice as large as in Summer storms.
- But, optical energy/group about the same in Winter & Summer storms.
- Flash optical area is about 60% larger in Winter storms compared to Summer storms.
- Flash optical duration is about 30% larger in Winter storms compared to Summer storms.
- Flash optical energy per flash optical area is close to 1 fJ/km^2, and is about 40% larger in Winter storms compared to Summer storms.
- VCM-derived electrostatic flash energy U & LNOx only slightly larger in Winter storms compared to Summer storms. (Mapping from optical energy & area space to U/LNOx space is complicated: nonlinear, depends on shape of distributions, depends on relative # ICs and CGs.)