NoFADE: Analyzing Diminishing Returns on CO2 Investment

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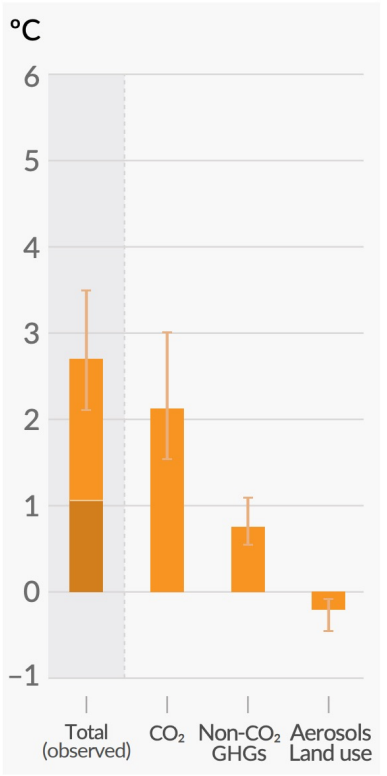
Motivation

- Reducing CO2 emissions is essential for curbing climate change effects.
  - IPCC warns that warming of 1.5-2.0°C is likely in the coming decades.
- Previous work on CO2 emission-CV model relationships is not dataset agnostic.
- **NoFADE**: **Normalized FLOPS for Accuracy-Dataset Entropy**
  - Evaluation metric for model-dataset pair complexity.
  - Show diminishing returns on higher complexity/emissions.

SSP2-4.5 [1]



[1] : IPCC 2021 Report

Diminishing Returns

- Extracted **Top-1 Test-accuracy**, **mAP** or **mIOU**, **FLOPS**, GPU hours and GPU type.
  - 13 Classification, 22 Segmentation, and 10 Detection papers
- Formula for **CV model power draw**:

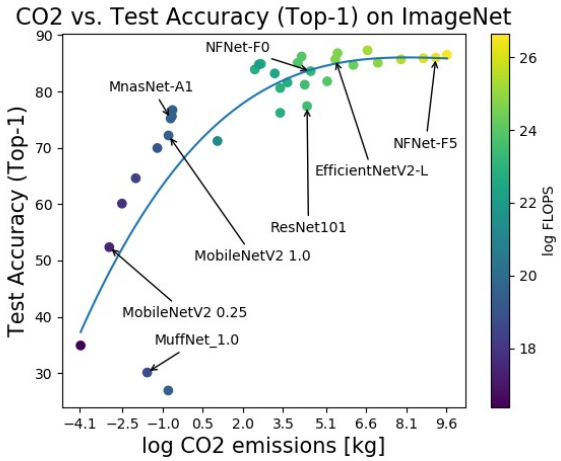
$$P_m[Wh] = f \times \left(\omega_g + \omega_c\right) \times GPU\ hours$$

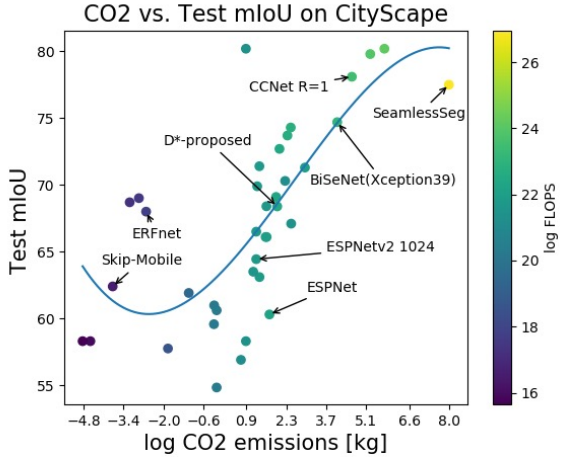
- **Conversion to emissions**:

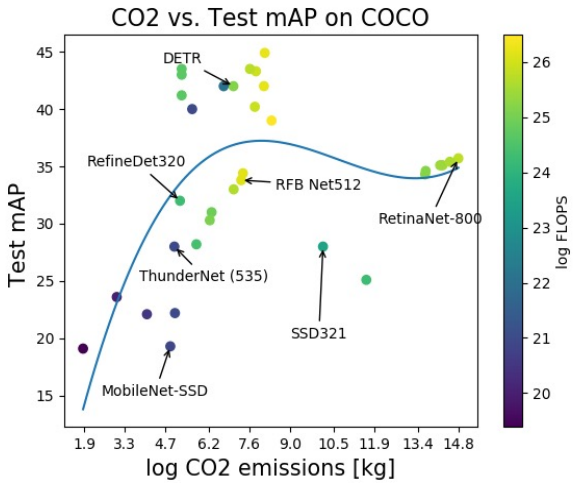
$$CO2 = P_m \cdot 0.707 \times 10^{-3}$$

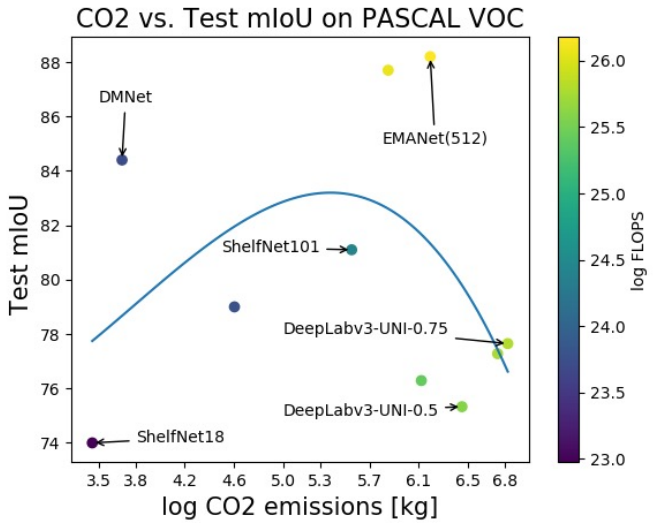
Diminishing Returns

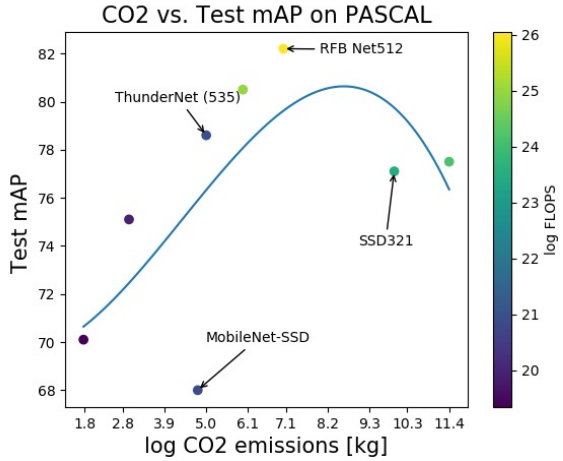
- Most datasets show accuracy saturation at higher complexity
  - Diminishing returns on CO2 investment











NoFADE Development

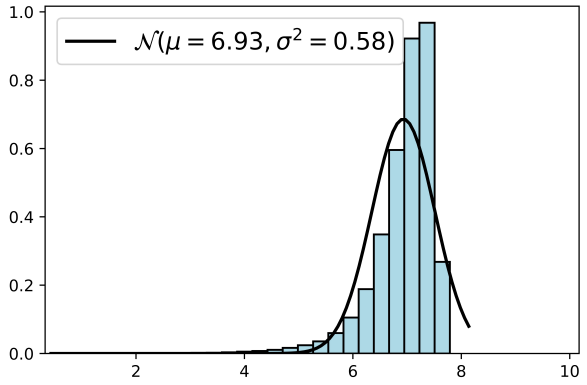
- NoFADE allows for **model-dataset-complexity agnostic comparisons**.
- **Dataset Complexity**
  - **Shannon entropy** (segmentation, detection)
    - $H(image) = -\sum_{i=1}^{K} p_i \cdot log\ p_i$
  - **Sum of Jensen-Shannon distances between classes** (classification)
    - $JSD(P||Q) = \sqrt{\frac{1}{2}D_{KL}(P||M) + \frac{1}{2}D_{KL}(Q||M)}$
- **Relationship between models and datasets**, normalized for computational complexity by log FLOPS:

$$NoFADE = \frac{test\ accuracy \times Entropy\ or\ JSD}{\log FLOPS}$$

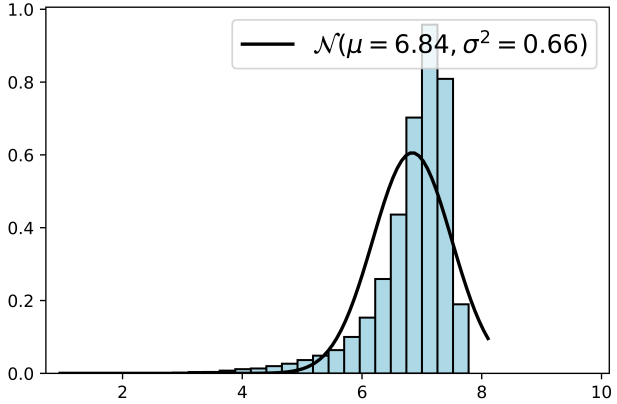
NoFADE: Dataset Complexity

- **Jensen-Shannon distances**
  - CIFAR-10, CIFAR-100
- **Shannon entropy**
  - COCO, Cityscapes, Pascal VOC

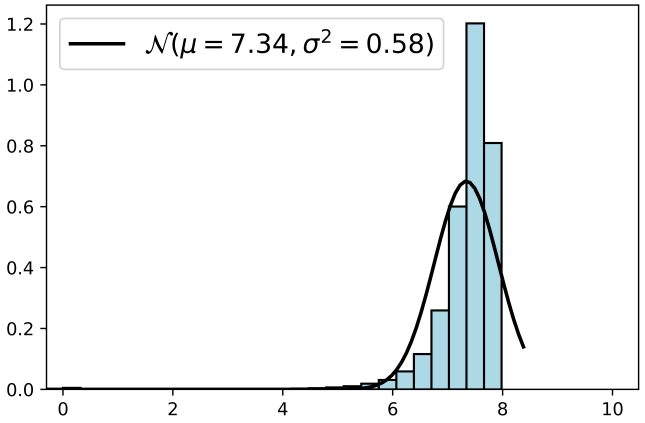
CIFAR-10



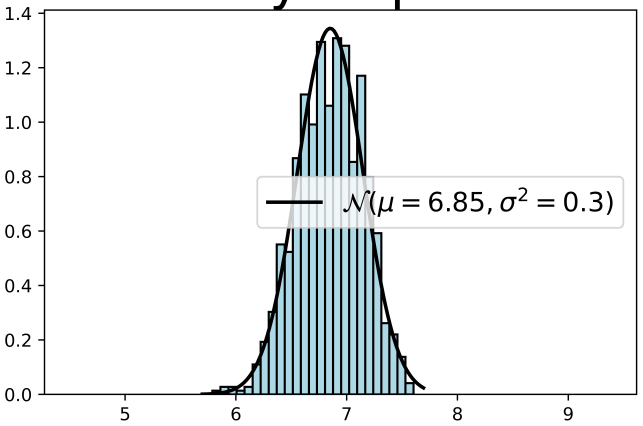
CIFAR-100



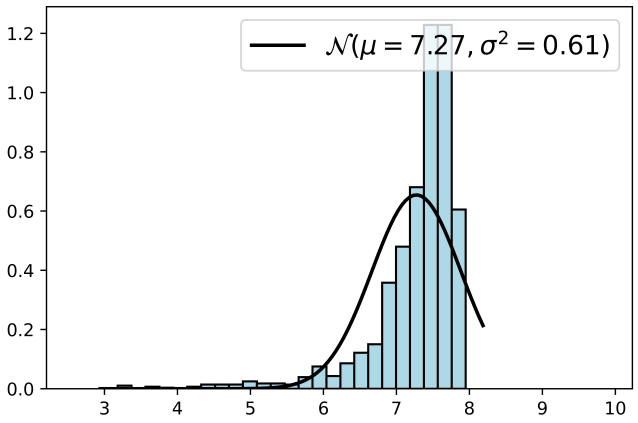
COCO-Stuff



Cityscapes

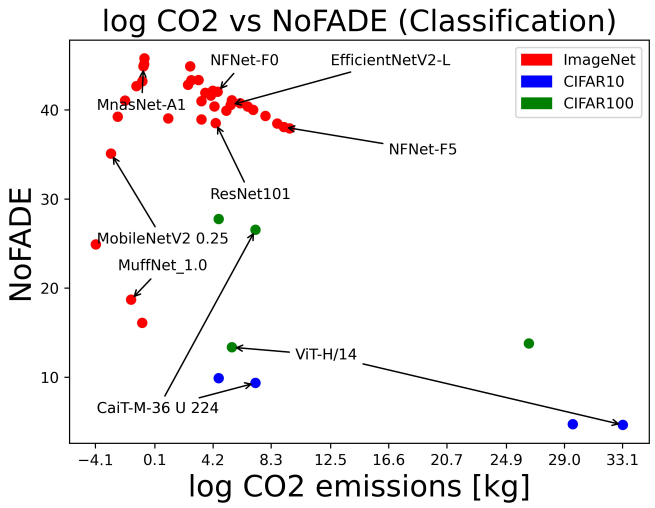


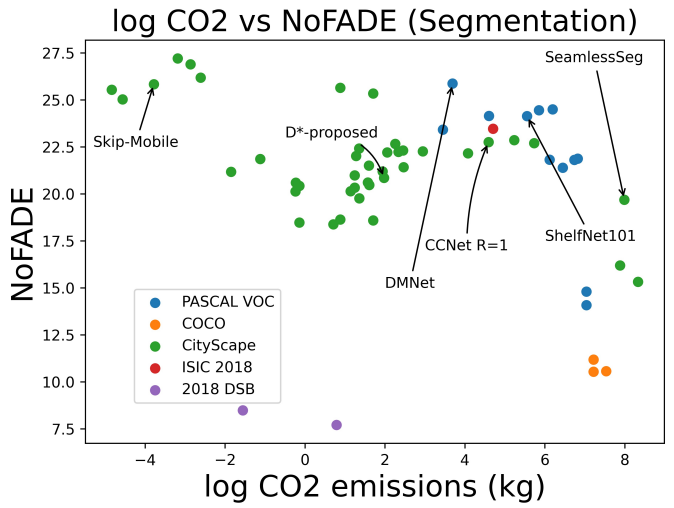
PASCAL VOC

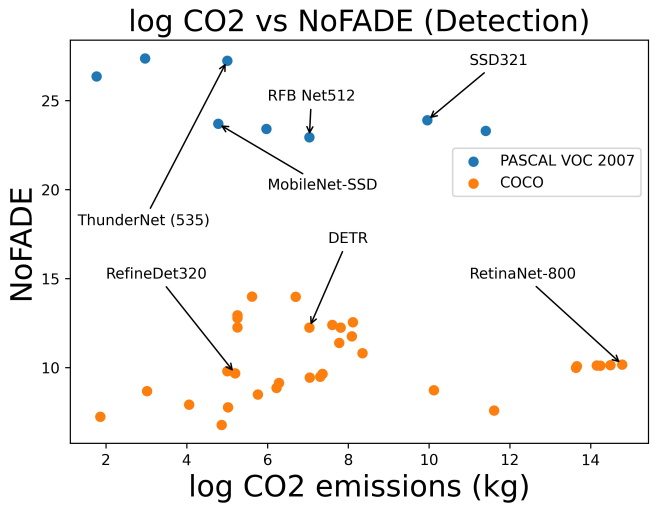


NoFADE Results

- **Models with high accuracy and large FLOPS** have **low NoFADE scores** (eg. ViT transformer models).
  - Complexity cost is penalized.
  - Aim for higher NoFADE scores.







Conclusion

- Established role of the CV community in global climate change.
- Proposed a metric to track CO2 emissions arising from model training.
- Promote environmental consciousness and model efficiency.
- Encourage researchers to use NoFADE in model-dataset selection to reduce environmental impact.