MetNet: A Neural Weather Model for Precipitation Forecasting

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What kind of neural network is best for modelling weather?

Neural Weather Models

Neural Weather Models

- Probabilistic models
- Spatiotemporal structure
- Discrete distributions

Neural Weather Models

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- Discrete distributions

(Probabilistic) DNNs

Spatiotemporal Structure

Spatiotemporal Structure

Spatiotemporal Structure

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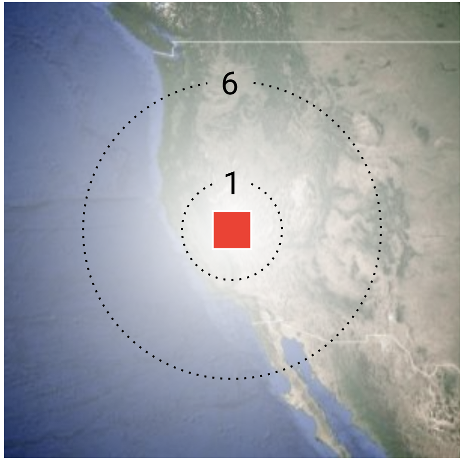
Spatiotemporal Structure



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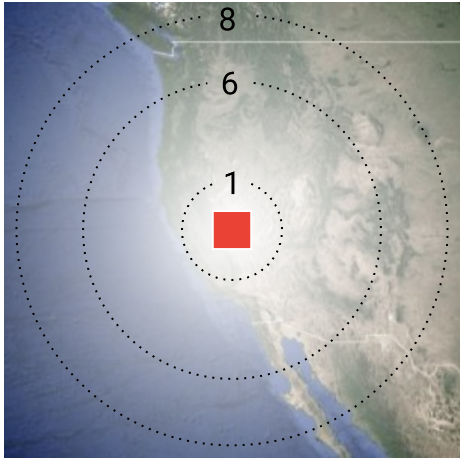
Spatiotemporal Structure



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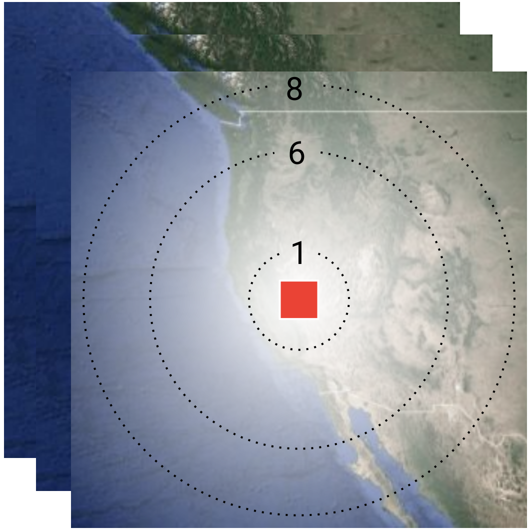
Spatiotemporal Structure



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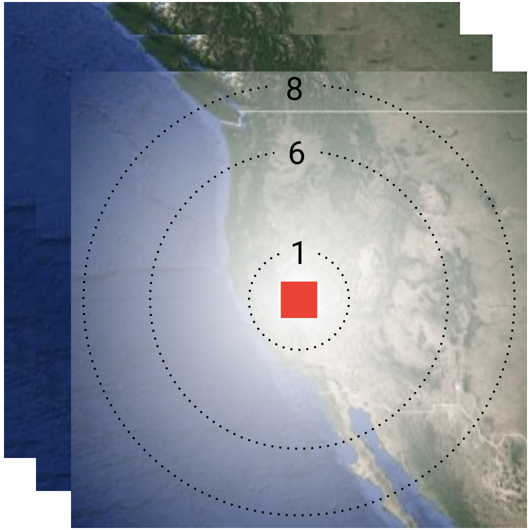
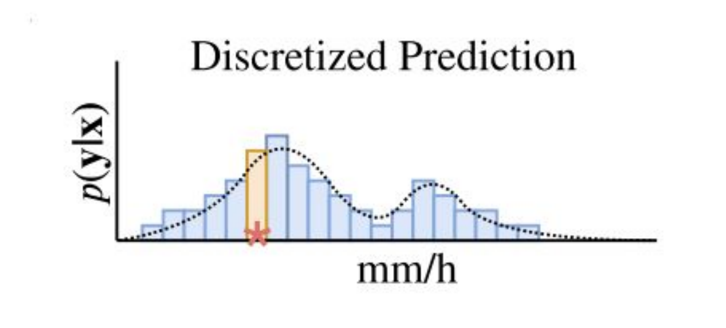
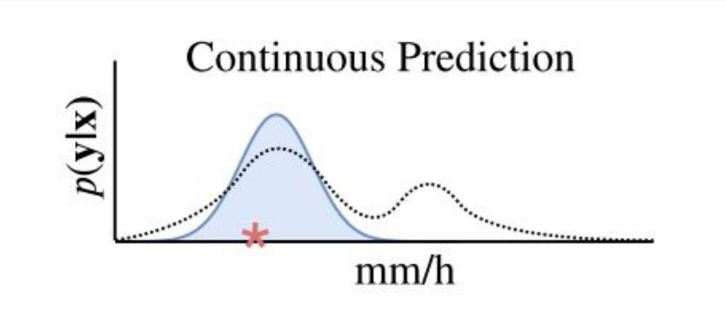
Spatiotemporal Structure



Discrete Variables





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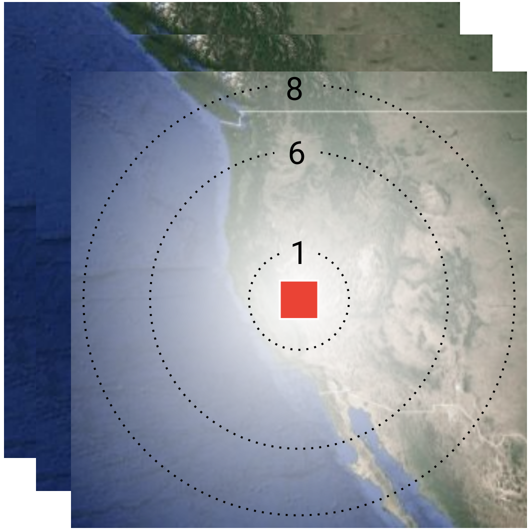
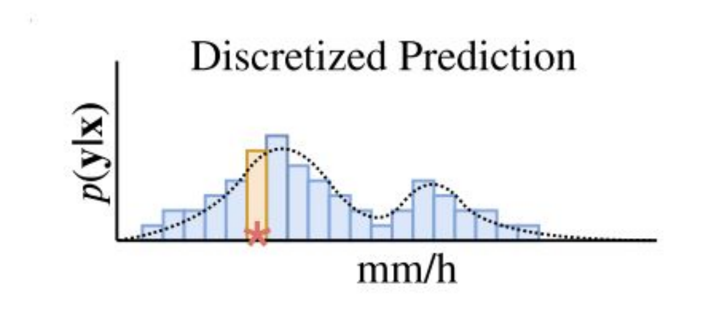
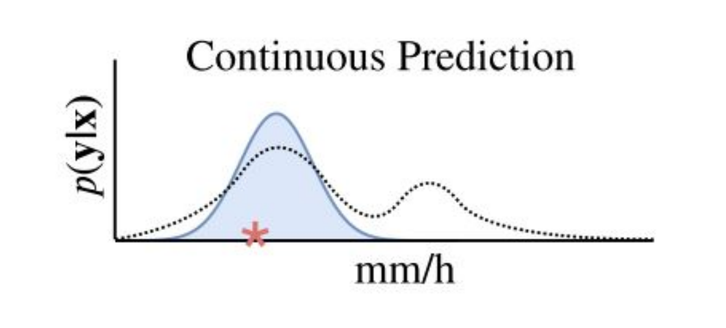
Spatiotemporal Structure



Discrete Variables

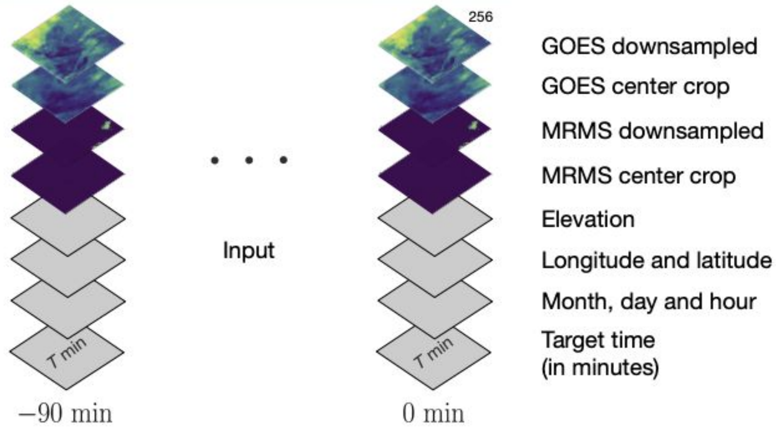


[0.0, 0.2, 0.4, 0.6, ..., 100.0]

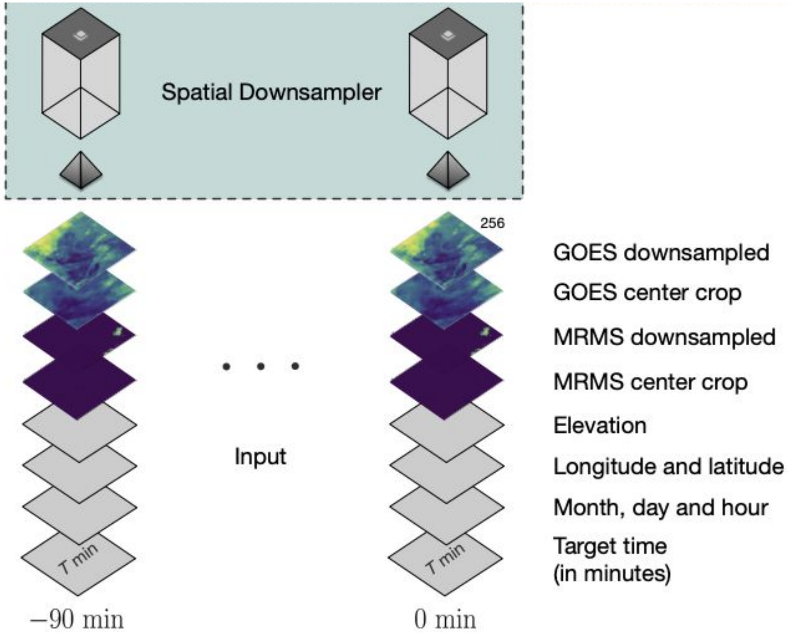


MetNet Architecture

MetNet Architecture



MetNet Architecture



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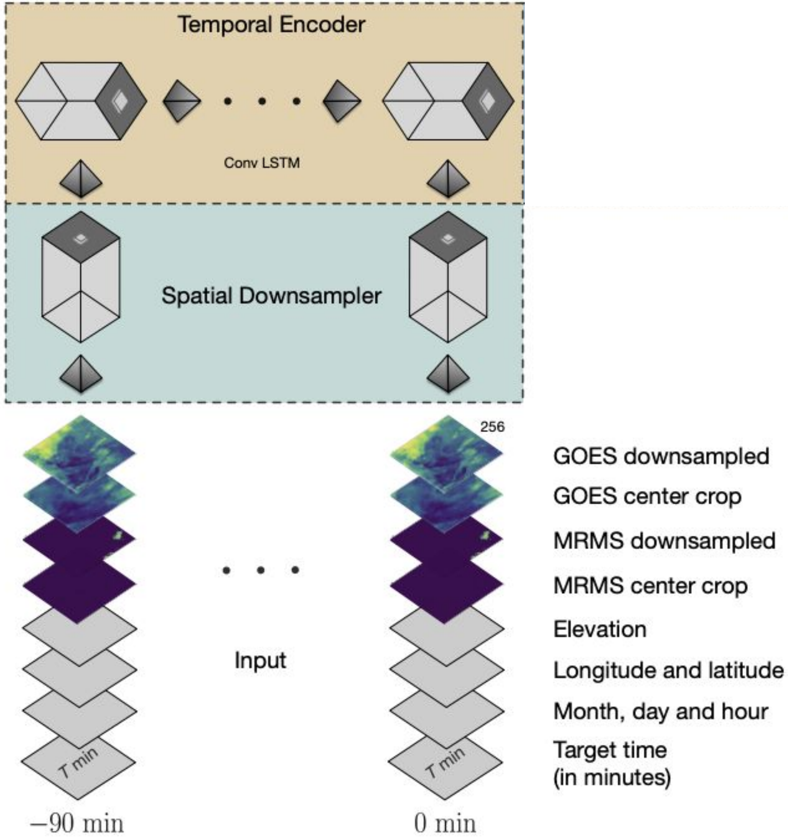
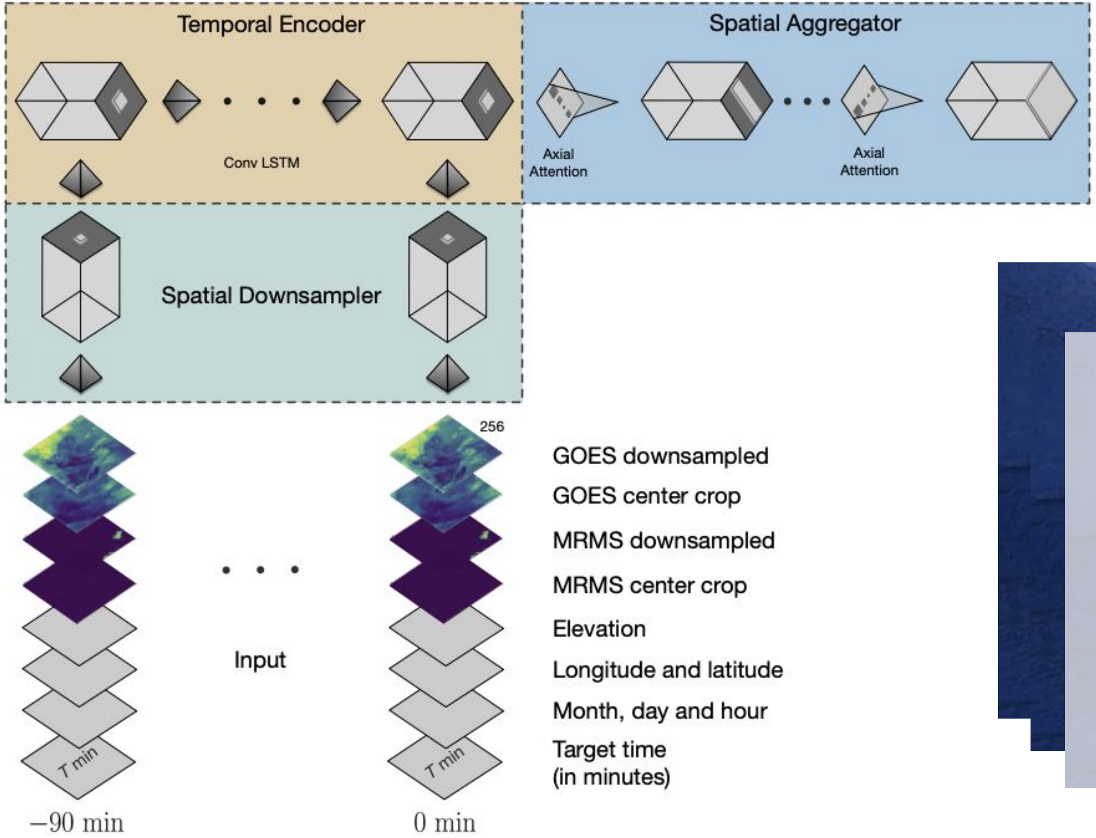
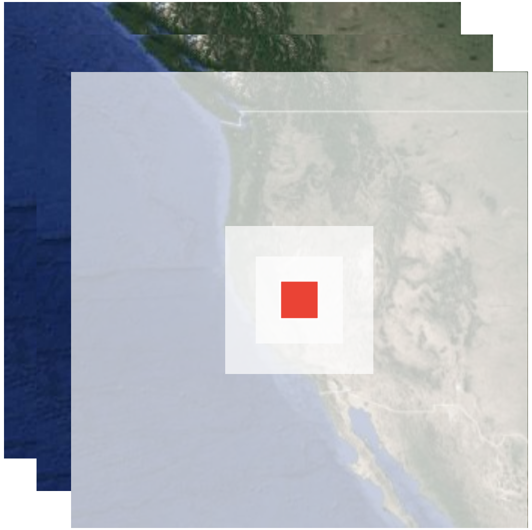
MetNet Architecture



MetNet Architecture





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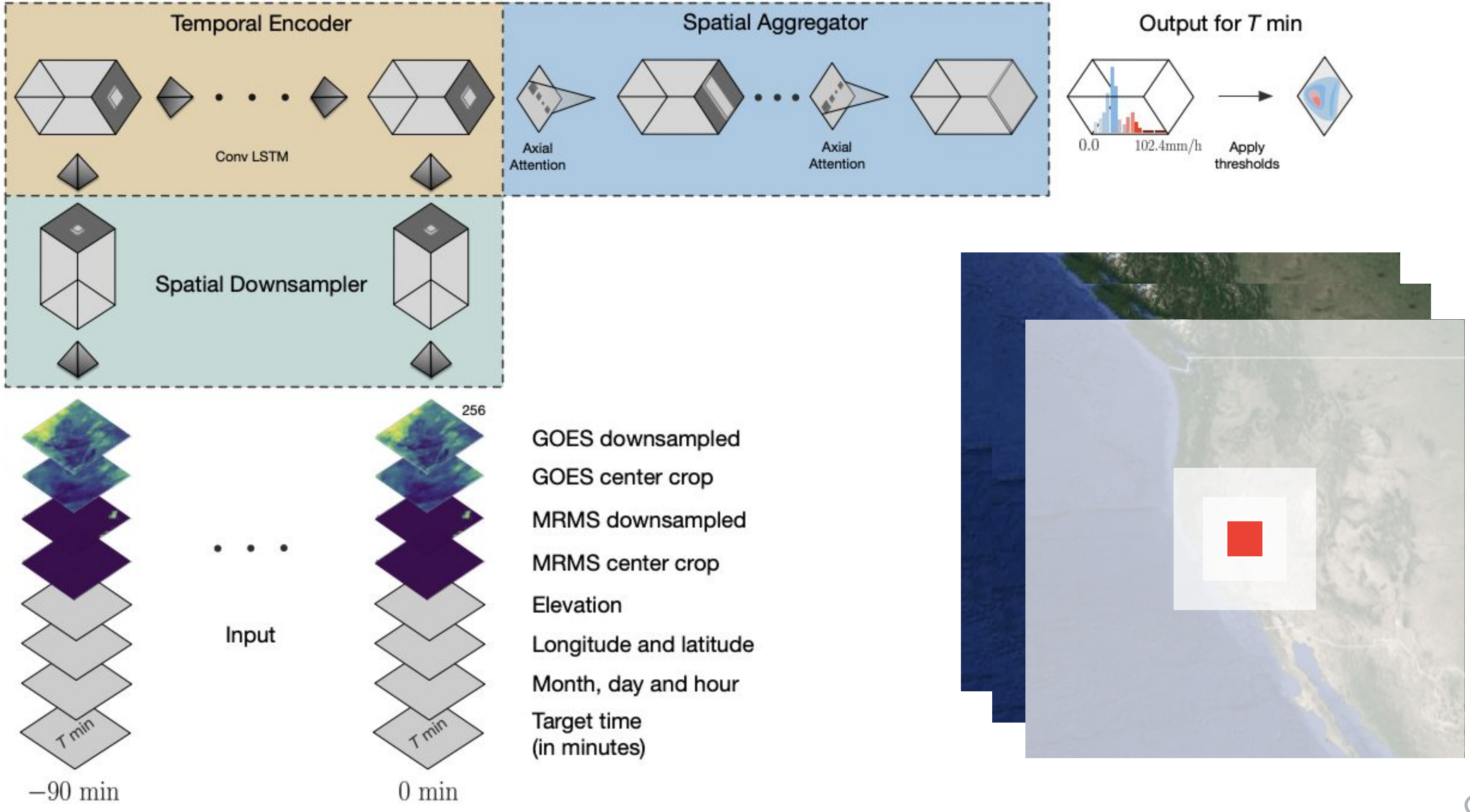
MetNet Architecture



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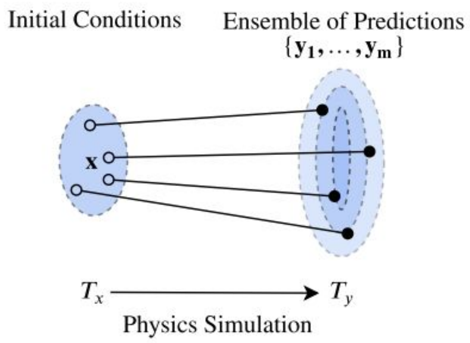
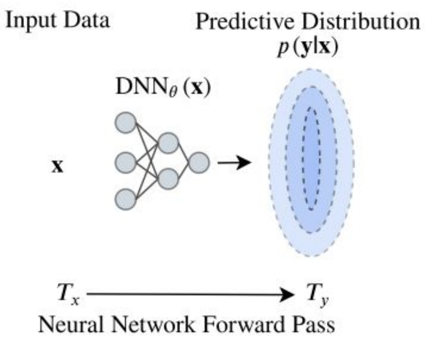
Numerical Weather Prediction	Neural Weather Models

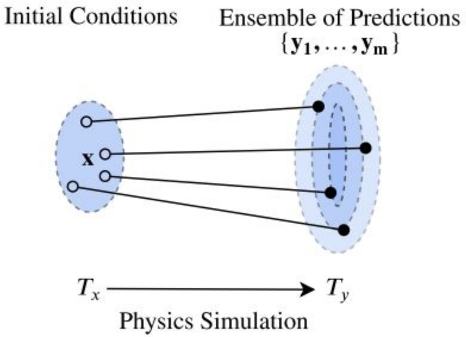


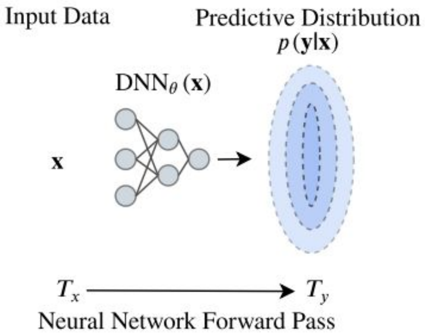


Numerical Weather Prediction

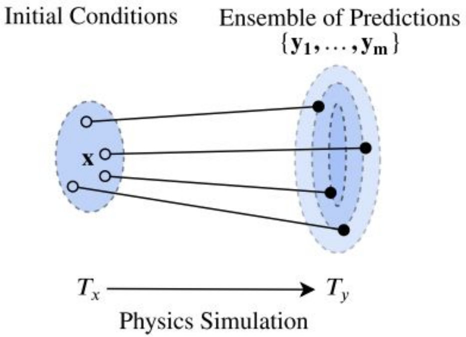
Neural Weather Models

Uncertainty through ensembling	Uncertainty from direct probabilistic model

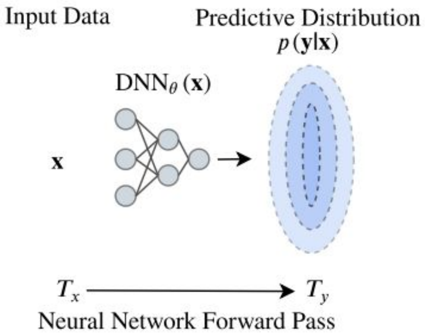




Numerical Weather Prediction	Neural Weather Models
Uncertainty through ensembling	Uncertainty from direct probabilistic model
Relies on equations of physics	Relies on generic learnable transformations (and requires data)

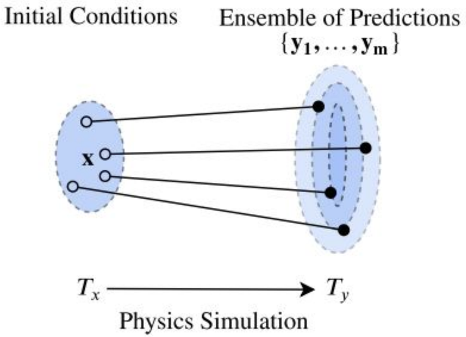


Numerical Weather Prediction

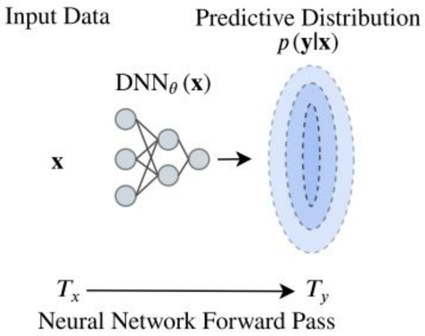


Neural Weather Models

Uncertainty through ensembling	Uncertainty from direct probabilistic model
Relies on equations of physics	Relies on generic learnable transformations (and requires data)
Latency of prediction is generally linear as a function of lead time	Latency of prediction is constant (or logarithmic) as a function of lead time. MetNet takes under a second for any lead time of up to 8 hours



Numerical Weather Prediction



Neural Weather Models

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Accuracy depends on underlying resolution. Doubling resolution requires ~ 8 times more computation.	Accuracy does not depend on underlying resolution. Doubling resolution requires ~ 4 times more computation.

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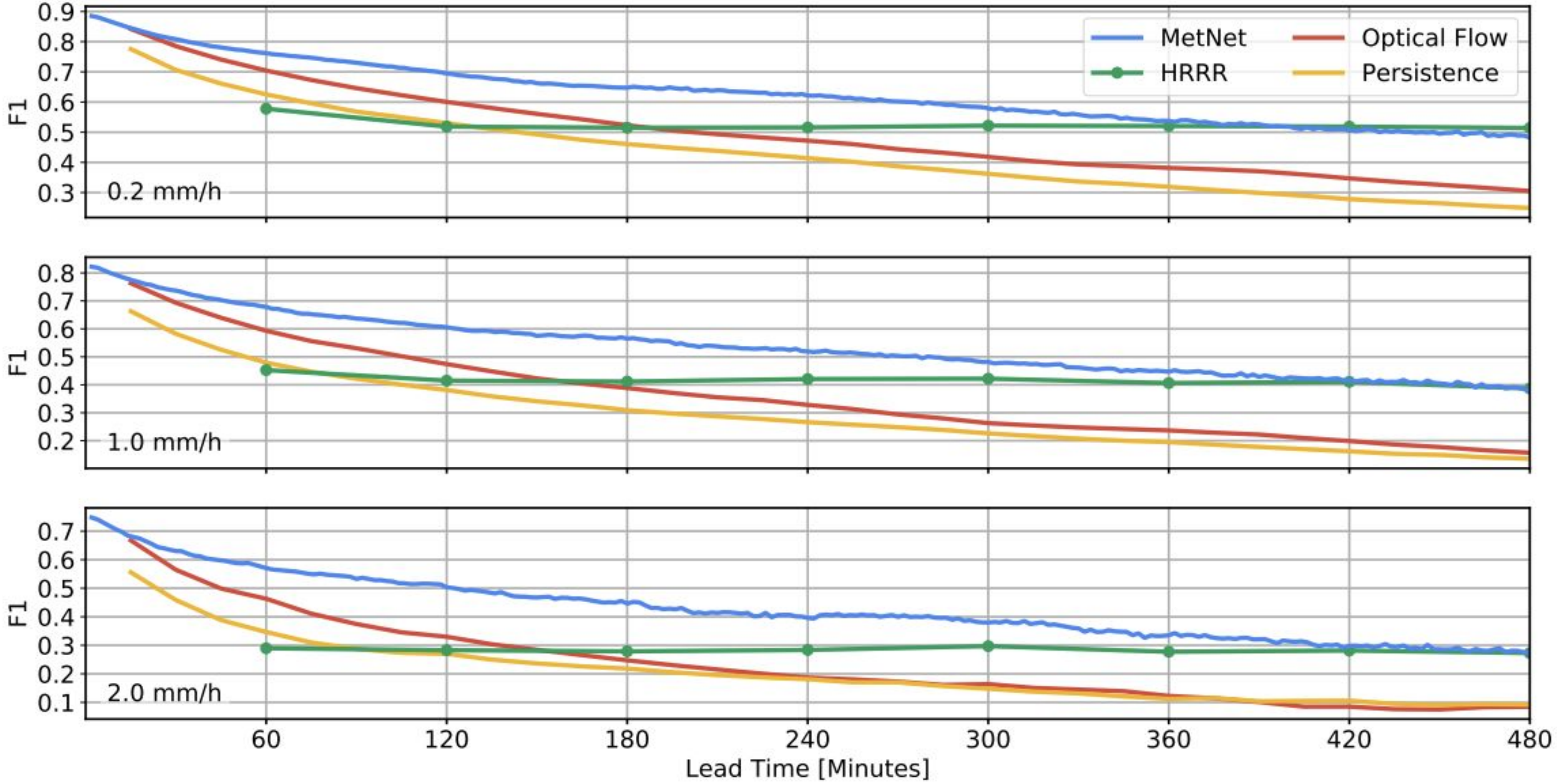
Results

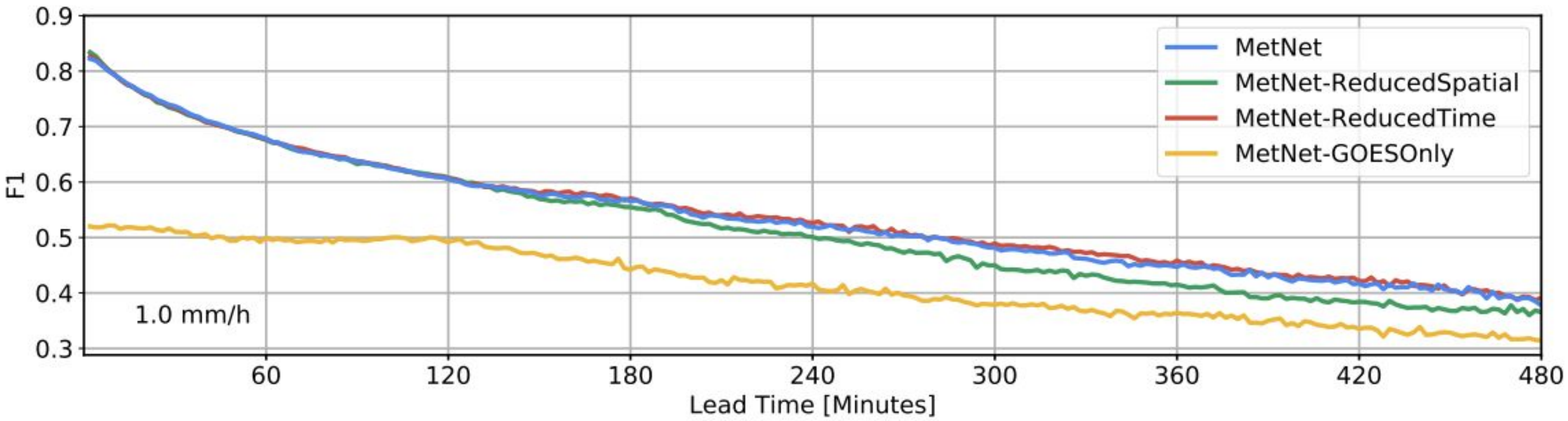
Results



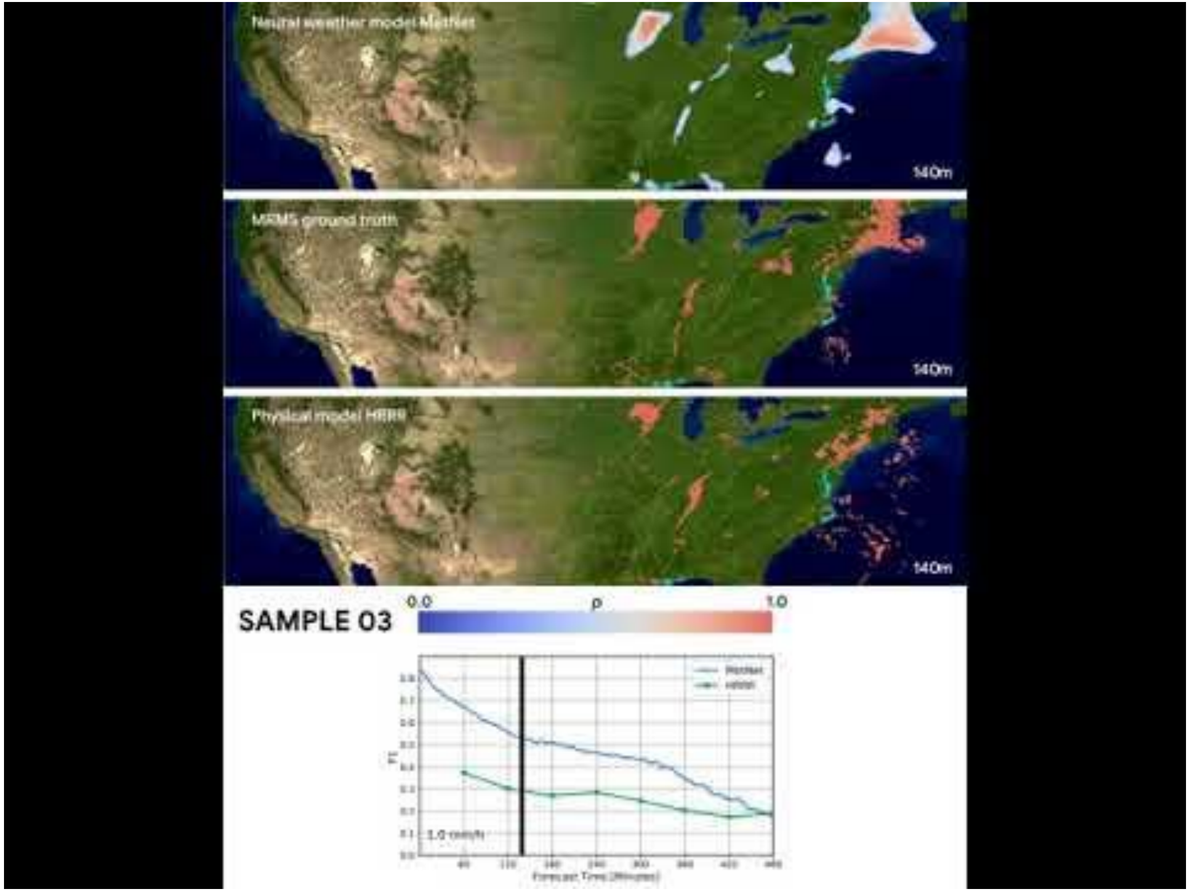
MetNet
HRRR
Optical Flow
Persistence
F1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2 mm/h
1.0 mm/h
0.2
2.0 mm/h
0.1
60
120
180
240
300
360
420
480
Lead Time [Minutes]

Ablation Results

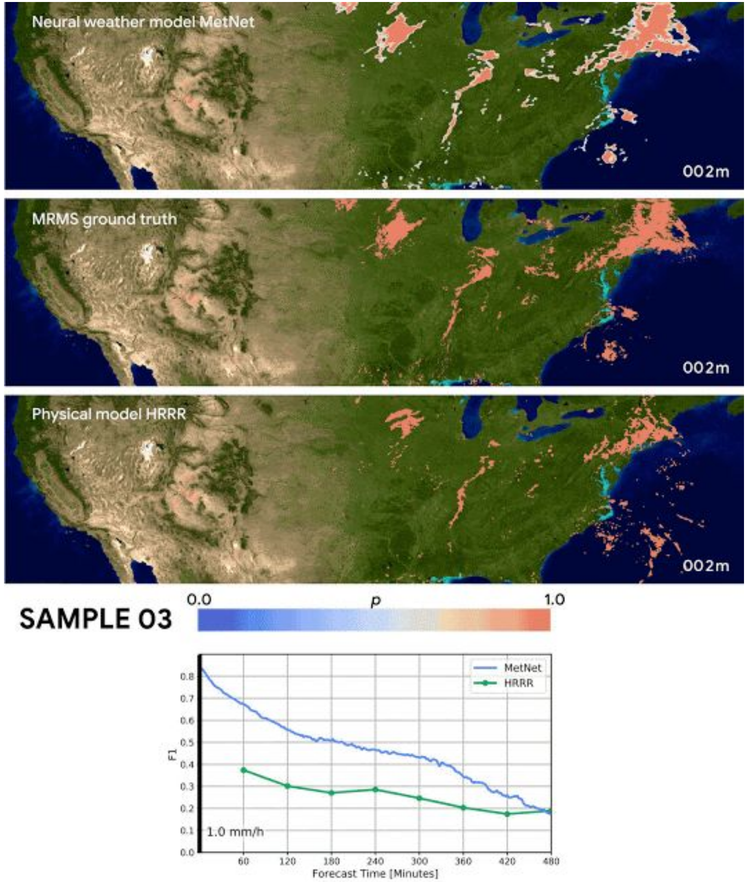
Configuration	Spatial Context (km)	Temporal Context (min)	Data Sources
MetNet	1024	90	MRMS, GOES-16
MetNet-ReducedSpatial	512	90	MRMS, GOES-16
MetNet-ReducedTemporal	1024	30	MRMS, GOES-16
MetNet-GOESOnly	1024	90	GOES-16



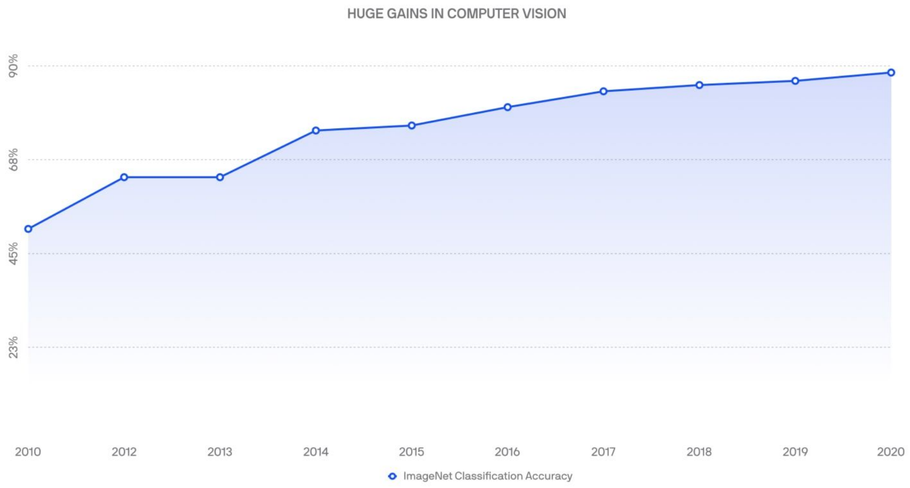
Sampled predictions

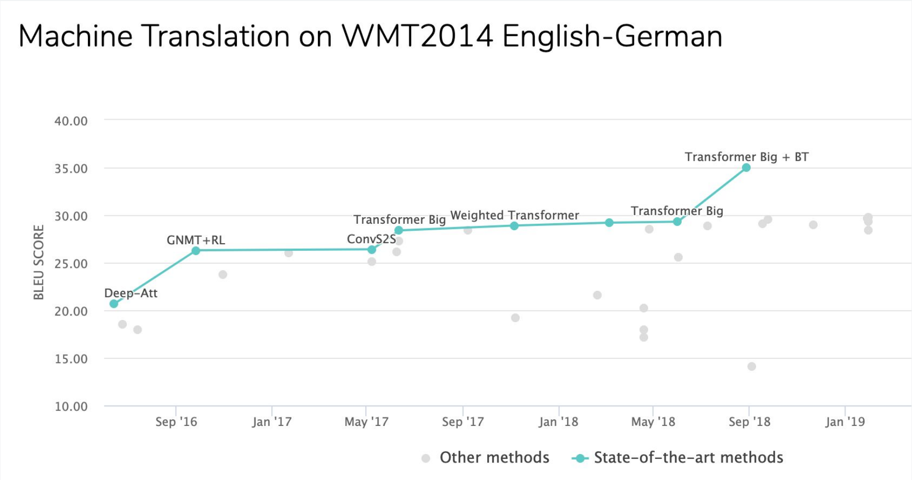


Sampled predictions



Prospects


HUGE GAINS IN COMPUTER VISION
90%
68%
45%
23%
2010
2012
2013
2014
2015
2016
2017
2018
2019
2020
ImageNet Classification Accuracy


Machine Translation on WMT2014 English-German
BLEU SCORE
40.00
35.00
30.00
25.00
20.00
15.00
10.00
Transformer Big + BT
Transformer Big
Weighted Transformer
Transformer Big
ConvS2S
GNMT+RL
Deep-Att
Sep '16
Jan '17
May '17
Sep '17
Jan '18
May '18
Sep '18
Jan '19
Other methods
State-of-the-art methods