Machine Learning for Precipitation Nowcasting from Radar Images

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Introduction:

·High-resolution precipitation nowcasting is the problem of forecasting precipitation in the near-future at high spatial resolution.

·Traditional methods: *optical flow* (OF) model or *numerical* model.

·*OF models* attempt to identify how objects move through a sequence of images, but are unable to represent the dynamics of storm initiation or decay (which arguably drive most real-world decisions by those using weather forecasts).

·*Numerical methods* explicitly simulate the underlying atmospheric physics, and can provide reliable forecasts, but typically take hours to perform inferences, which limits their ability to be used in nowcasting.

Method and Data:

Treat as an image-to-image translation problem/a data-driven input&output problem, *instead of modeling the complex physics involved in atmospheric evolution of precipitation.*

Data:

·MRMS (multi-radar multi-sensor system):

- update every 2 minutes,
- 1km spatial resolution,
- within the continental United States (256km x 256km),
- based on data from NEXRAD (a network of 159 high-resolution weather radar stations operated by National Weather Service(NWS), an agency of the National Oceanic and Atmospheric Administration (NOAA)).

Methods:

· U- Net CNN
· Label images: [0, 0.1), [0.1, 1.0), [1.0, 2.5)and[2.5, ∞)
· Training period: 2018 January-December
· Testing period: 2017 July-December and 2019 January-July

Results:

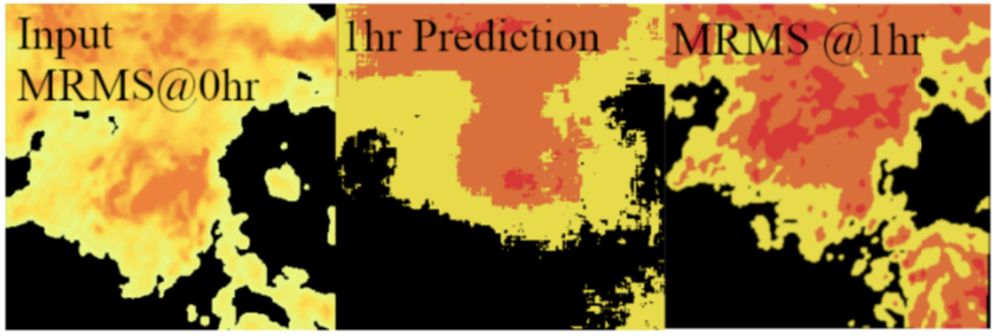


Figure 1: Sample MRMS Image and Predicted Precipitation

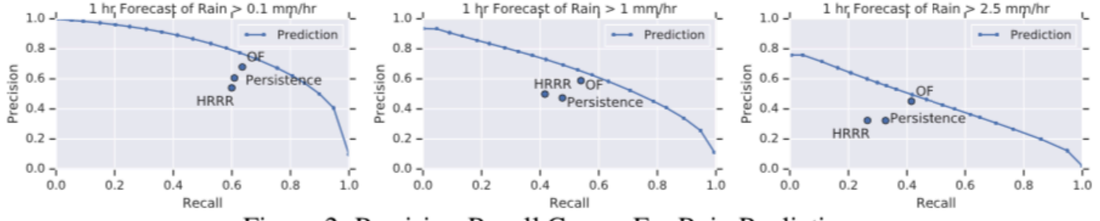
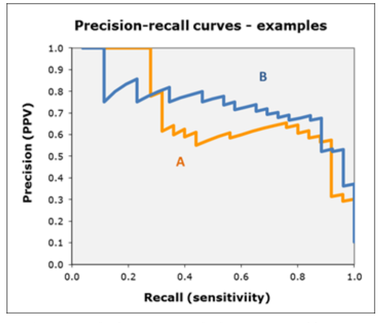
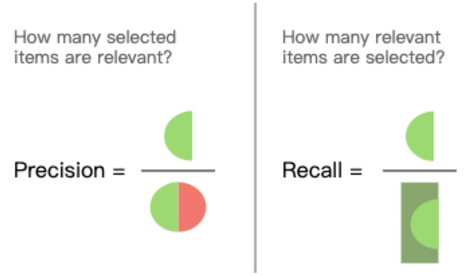


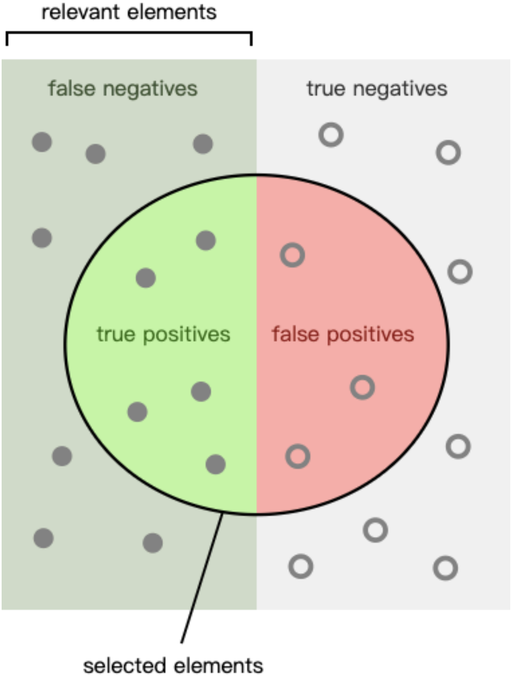
Figure 2: Precision-Recall Curves For Rain Prediction

ID#	Parameter, concentration	Disease Yes/No	Y (sum)	N (sum)	Precision (PPV)	Recall (sensitivity)
1	33.63	Y	1	0	1.00	0.013
2	10.63	Y	2	0	1.00	0.025
3	9.90	N	2	1	0.67	0.025
4	6.87	Y	3	1	0.75	0.038
5	6.15	Y	4	1	0.80	0.050
6	6.15	Y	5	1	0.83	0.063
7	5.53	Y	6	1	0.86	0.075
8	5.08	Y	7	1	0.88	0.088
....	....	....	....	....	....	....
....	....	....	....	....	....	....
151	0.0041	N	77	74	0.51	0.96
152	0.0039	Y	78	74	0.51	0.98
153	0.0039	N	78	75	0.51	0.98
154	0.0039	Y	79	75	0.51	0.99
155	0.0038	N	79	76	0.51	0.99
156	0.0038	Y	80	76	0.51	1.00
157	0.0038	N	80	77	0.51	1.00
158	0.0038	N	80	78	0.51	1.00
159	0.0036	N	80	79	0.50	1.00
160	0.0036	N	80	80	0.50	1.00



- The x-axis showing recall (= sensitivity = TP / (TP + FN))
- The y-axis showing precision (= positive predictive value = TP / (TP + FP))





参考文献: https://acutecaretesting.org/en/articles/precision-recall-curves-what-are-they-and-how-are-they-used

Conclusions:

·无论机器学习数据驱动方法 (Machine Learning data-driven approaches)如何调节，结果都超过了传统的数字方法，特别是在关于一小时预报上，HRRR方法由于需要两小时的计算时间，所以只能使用2小时前的3小时预报数据；

·然而，如果把预报窗口扩大到5h，那么HRRR方法将始终表现的比新方法好；

·不过，有可能最终，最好的预报方法是将两个方法适当结合。

2020/04/07

Report

2020.4.14

張慕琪

Methods

实验设计：

已完成图片记录： time series (Beijing, China); Maps_differences; taylor diagram (Beijing)

待完成绘图：

1. taylor diagram (*China*)；
2. histgram(Beijing, China).

时间： Train & validation (=historical)

数据： CCSM, GMFD, ANN(before BC) , ANN(after BC), Linear

变量：

·Temperature

Results

Taylor diagram China

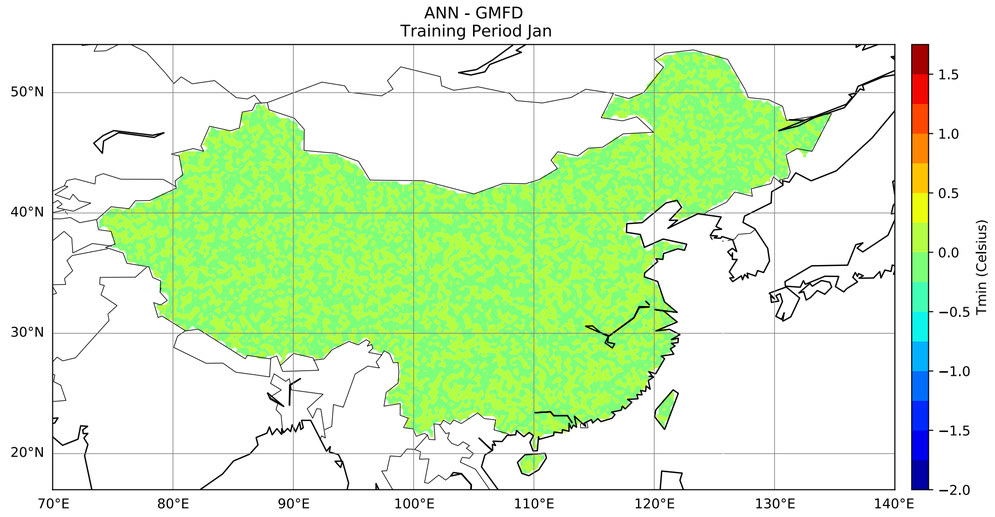
```
Traceback (most recent call last):
  File "taylor_tmax_China.py", line 62, in <module>
    taylor_stats1 = sm.taylor_statistics(data['bigMax_ann_china'],
data['bigMax_ground'], 'data')
  File "/home2/muqi/.local/lib/python3.7/site-packages/skill_metrics/
taylor_statistics.py", line 58, in taylor_statistics
    ccoef = np.corrcoef(p,r)
  File "<__array_function__ internals>", line 6, in corrcoef
  File "/opt/anaconda3/lib/python3.7/site-packages/numpy/lib/function_base.py", line
2526, in corrcoef
    c = cov(x, y, rowvar)
  File "<__array_function__ internals>", line 6, in cov
  File "/opt/anaconda3/lib/python3.7/site-packages/numpy/lib/function_base.py", line
2390, in cov
    X = np.concatenate((X, y), axis=0)
  File "<__array_function__ internals>", line 6, in concatenate
MemoryError: Unable to allocate array with shape (2, 915712000) and data type float64
```

Results

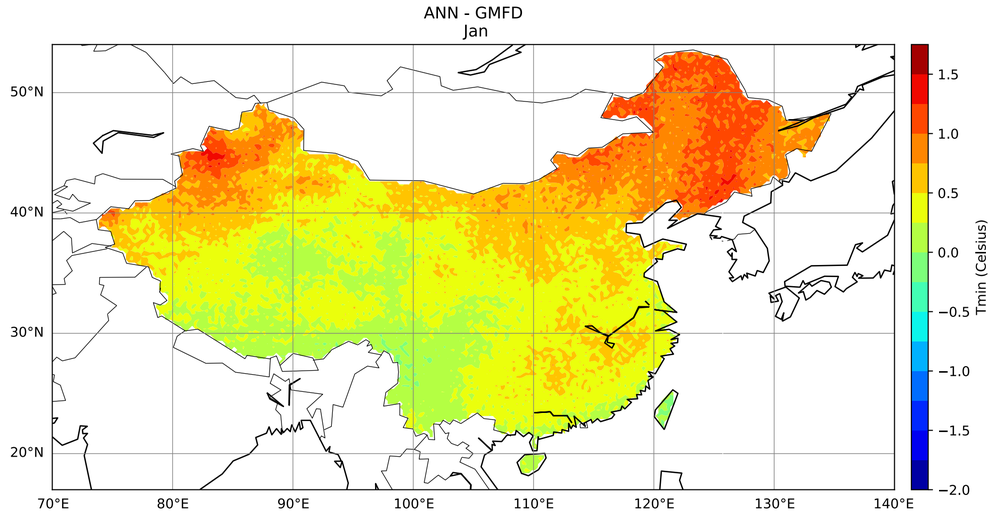
Maps

Beijing

Tmin (Train)



Tmin (Historical)

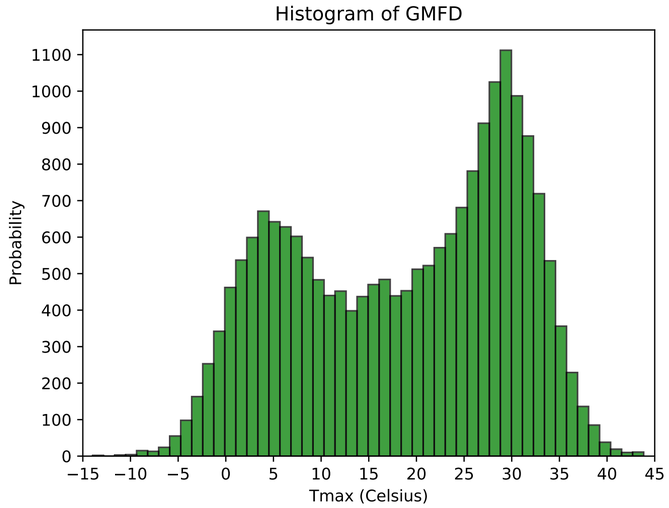


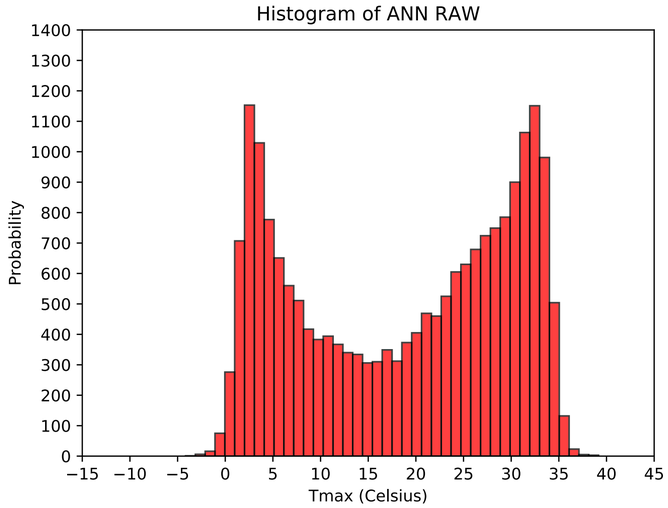
Results

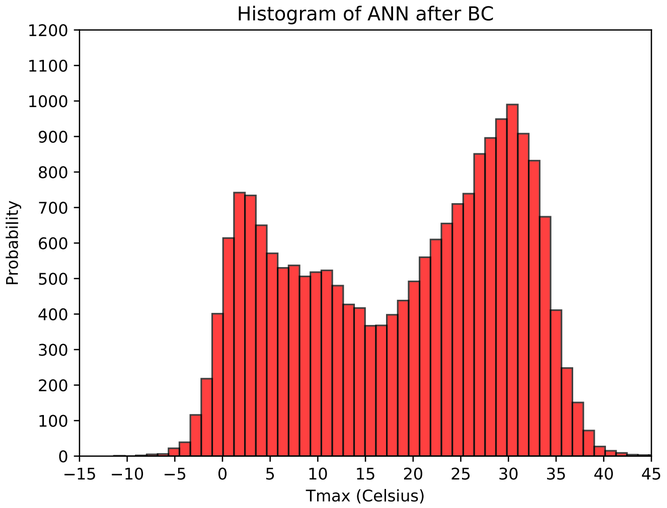
Histogram

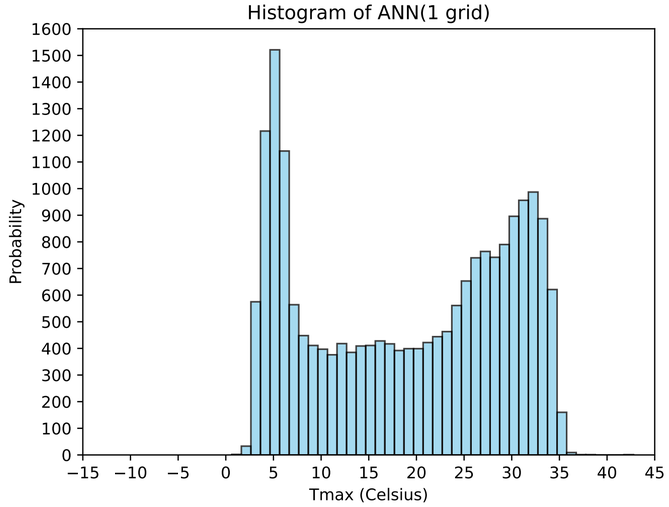
Beijing

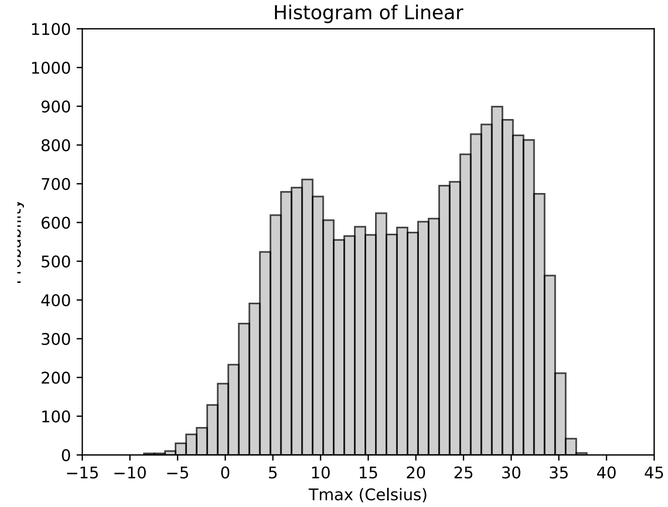
Tmax









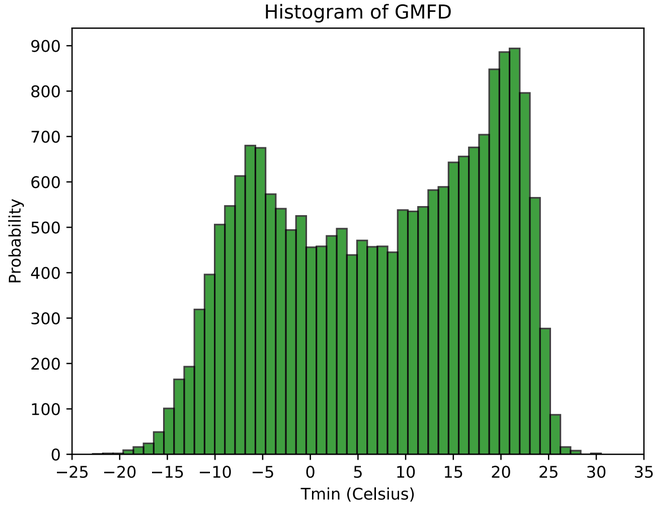


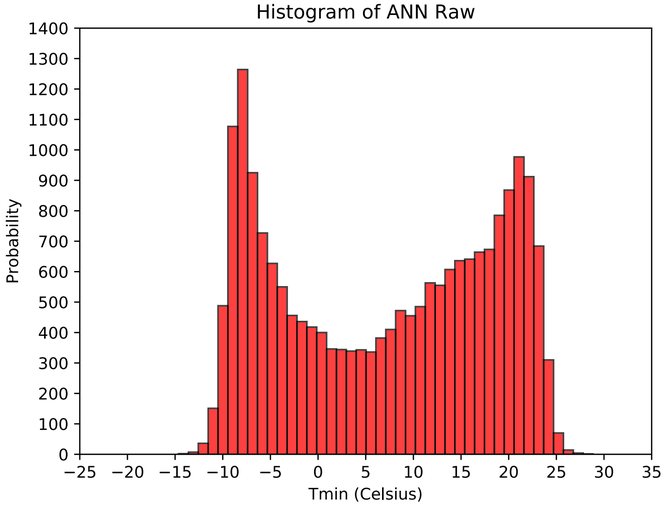
Results

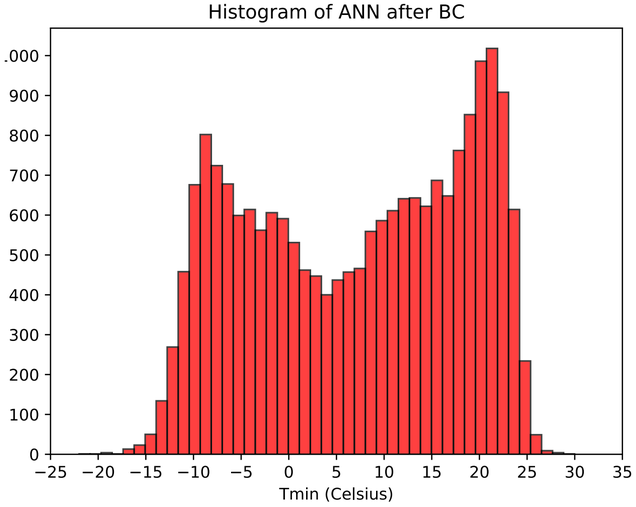
Histogram

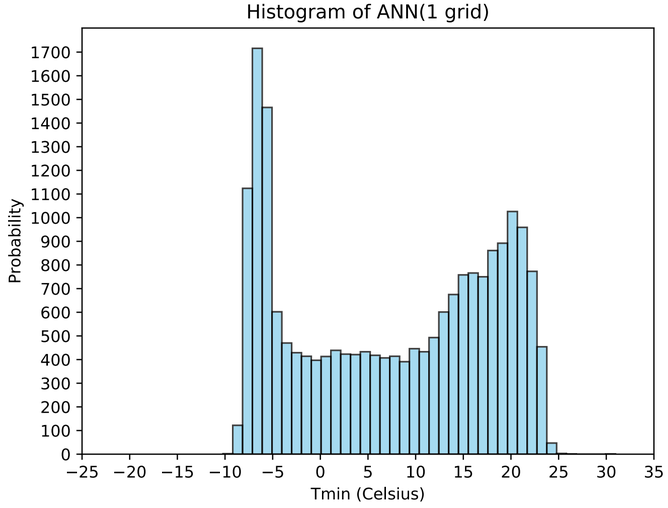
Beijing

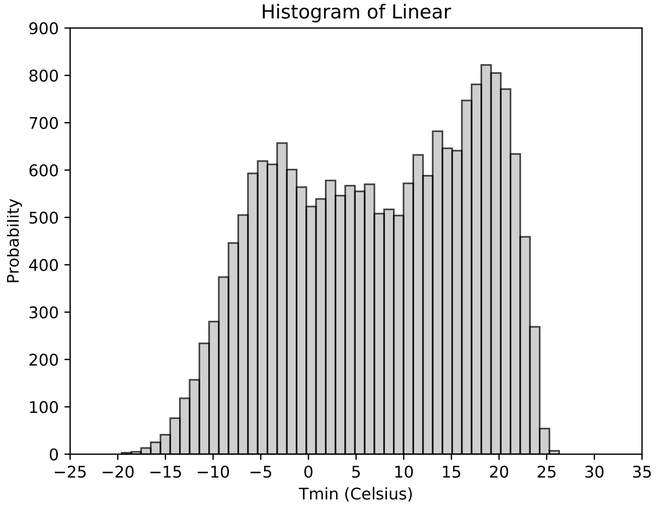
Tmin











谢谢