

PANDA-FINE: jointly improving the quality of DMSP-like PANDA using multimodality fusion and super-resolution

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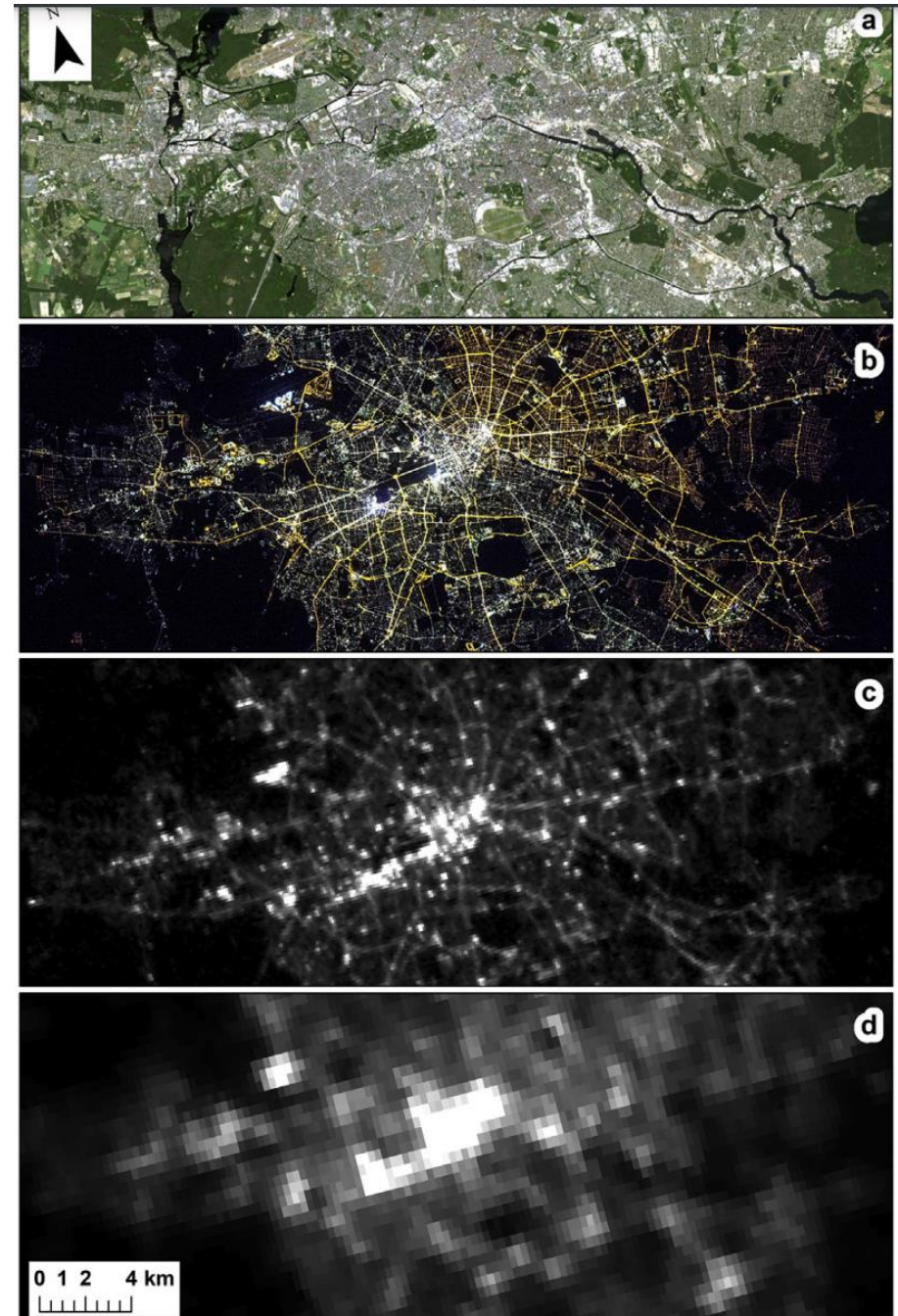


Wissen für Morgen



General background

- Nighttime light is an important data source for many applications
 - mapping long-term urbanization processes, such as urban boundaries, built-up areas, and impervious surface
 - inferring the demographic and socioeconomic information, such as population, the gross domestic product (GDP), incomes, and the poverty
 - Quantitatively identifying environment-related factors, such as electricity consumption, CO₂ emissions, PM_{2.5} emissions, and surface temperature



General background

– The quality of existing nighttime light datasets limits its application

– DMSP

- Temporal availability:
1992~2012
- Resolution: 1km

– The Luojia-01

- Temporal availability:
2018-2019
- Resolution: ~120m

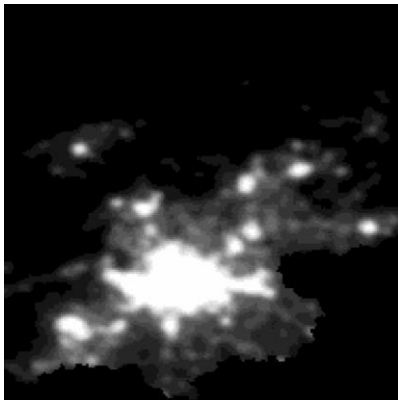
– The PANDA datasets (ours):

- Advantages: long time span
1984~2020
- Disadvantages: quality as the same as DMSP

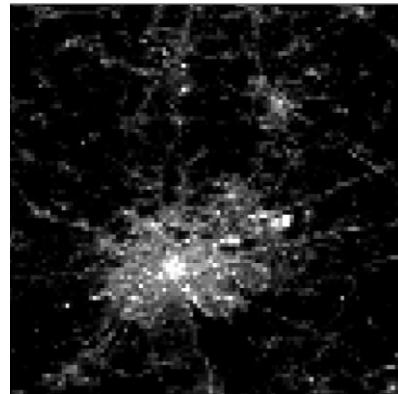
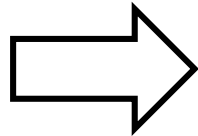


General background

- Ultimate goal
 - Improve the quality of the NTL images



PANDA (DMSP)



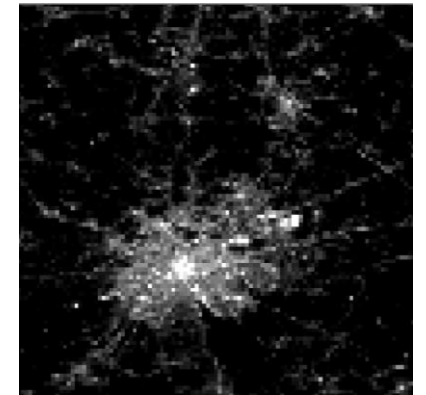
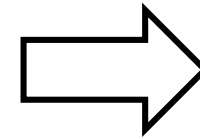
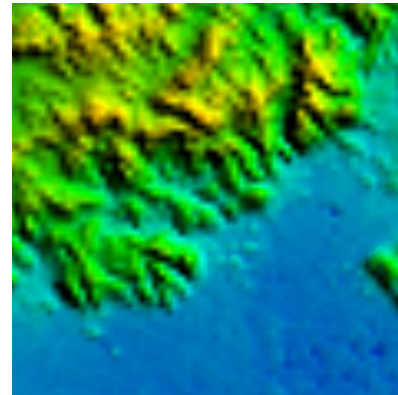
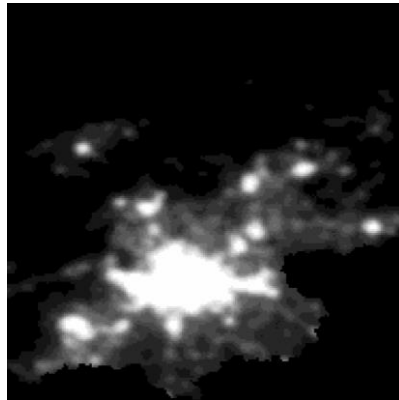
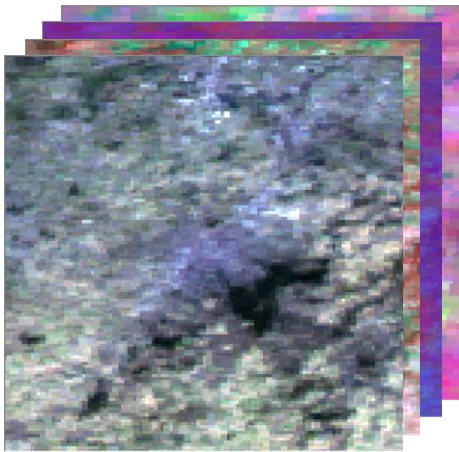
Luojia-01

- Quality evaluation aspects
 - Spatial resolution
 - Provide more high-frequency information
 - Spatiotemporal alignment
 - Overcome the over-saturation phenomenon.
- Challenges
 - Cross-modality feature fusion
 - Details improvement
 - Spatial alignment

Study area and datasets

- Landsat
 - Temporal generalization and variation
- DEM
 - Temporal consistency
- Local alignment
 - Spatial consistency and alignment

- Current period:
 - Overlapped 2018



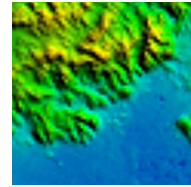
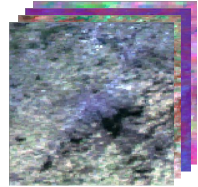
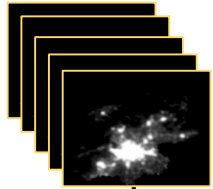
Methodology

Step1: data preprocessing

Luojia-01 frames
in 2018/2019

Landsat 8 (7 bands)
in 2018/2019

DEM



Inter-calibration

Denoising

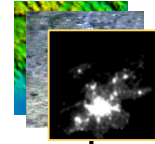
Spatially weighted Average

Resampling

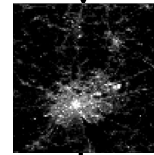
Randomly split into
training/testing/validating datasets

Step2: model training

Multimodality input

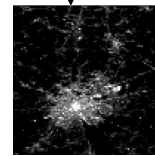


MMNTLSR Model



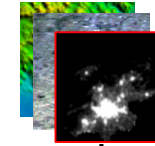
Output NTL frames

Loss function



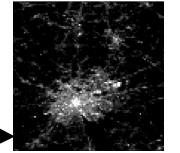
Supervised frames

Step3: model validation

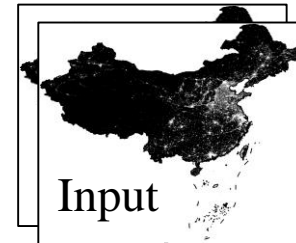


MMNTLSR Model

Evaluation

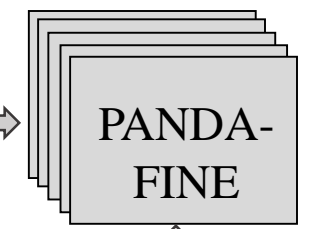


Step4: PANDA-FINE generation



Input

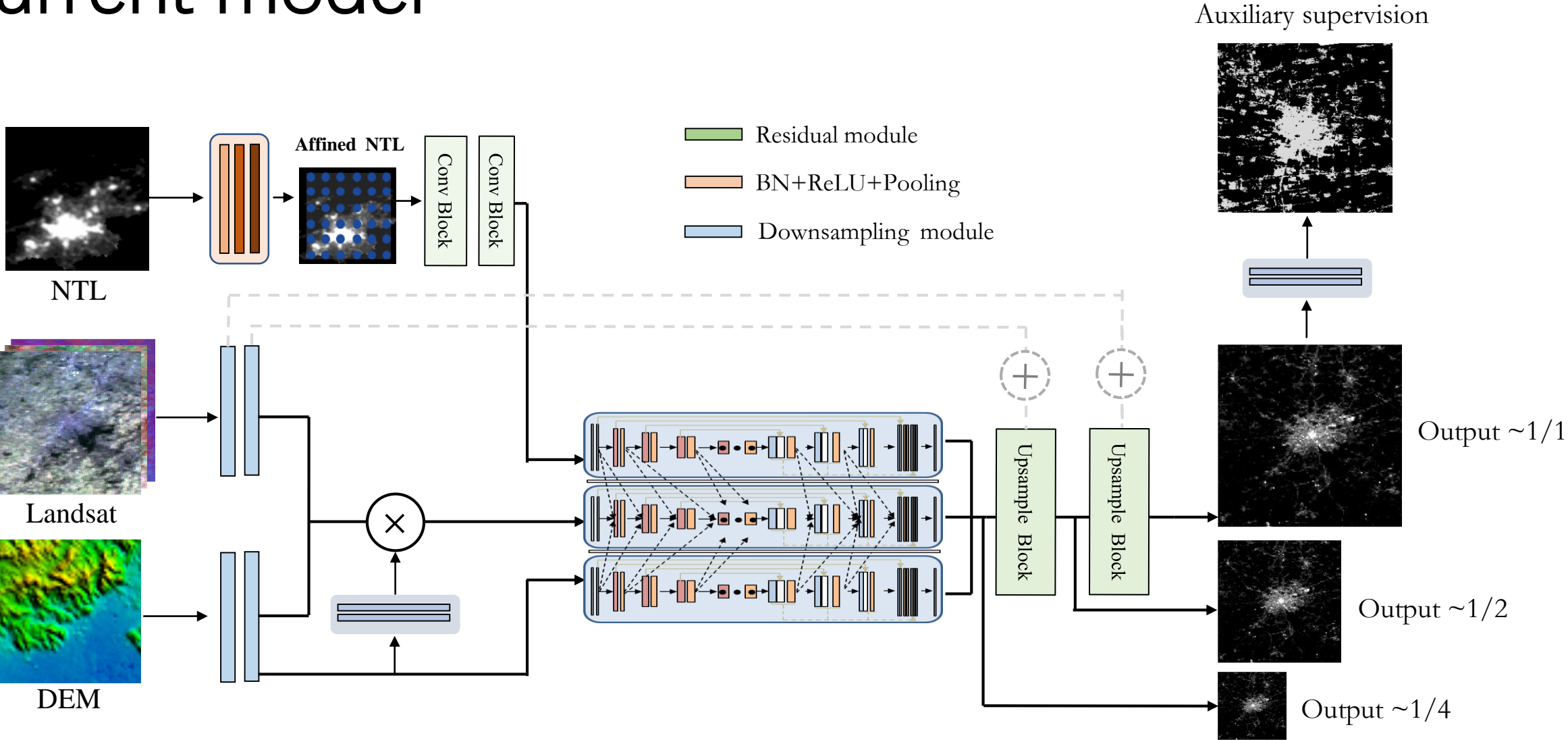
MMNTLSR Model



PANDA-FINE

Output

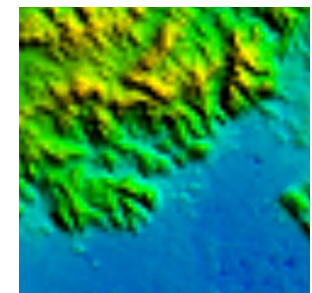
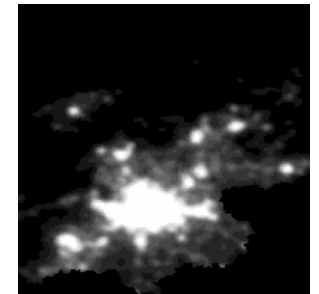
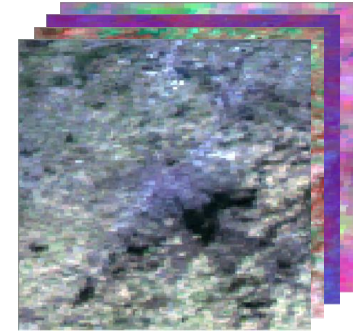
Current model



Multi-modality data fusion module

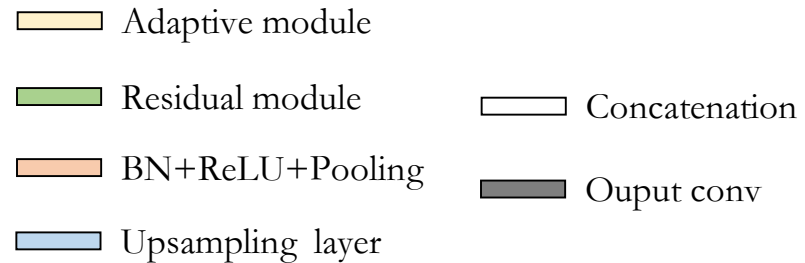
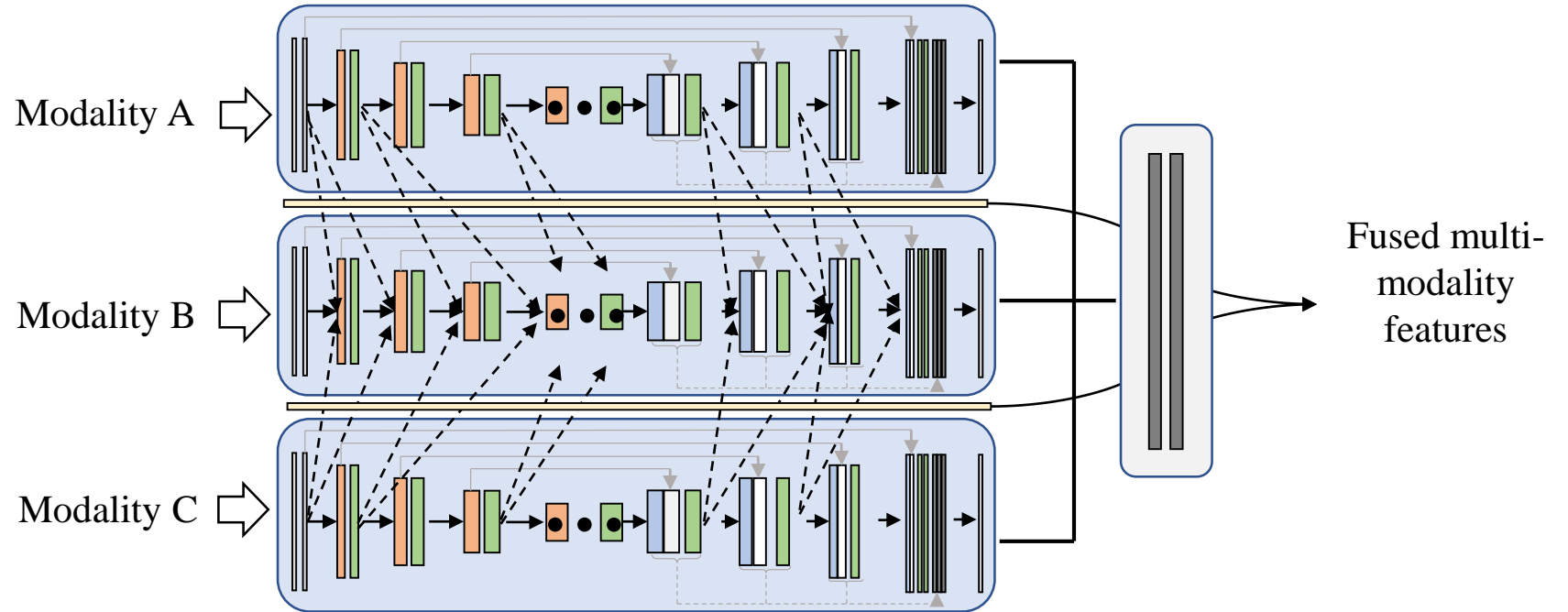
- Motivation
 - Overcome the gap between each input modality

	Landsat	PANDA	DEM
Original resolution	30m	1000m	90m
Acquisition time	10~11 am	7:30~9:30 pm	—
Temporal consistency	poor	medium	strong
Spatial consistency	medium	poor	strong
Numbers of bands	7	1	1
Datatypes	12 (8) bit integer	6 bit integer	16 bit integer
Data range	~about 3000	0~63	0~8776



Multi-modality data fusion module

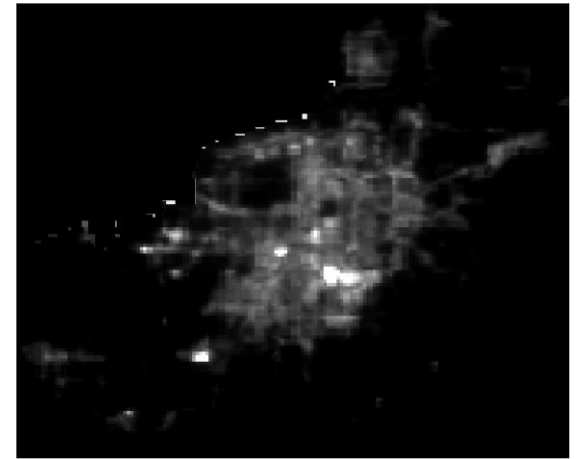
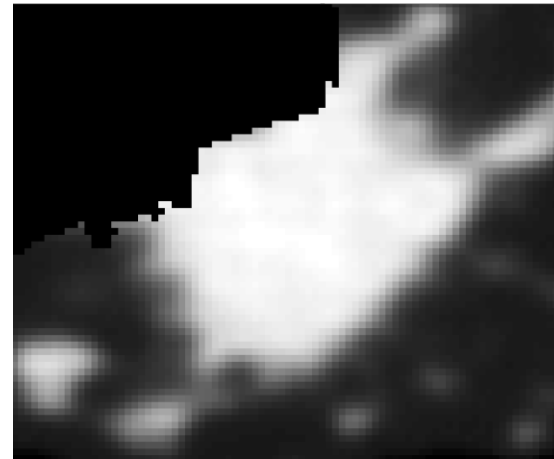
- Fuse multi-modality features parallelly from high to low
- It significantly improves the fused results compared to simply the concatenation



Local-global refinement module

super-resolution + auxiliary supervision + multi-scale prediction losses

- Super-resolution heads improve the global performance
- Auxiliary supervision helps the model to implicitly learn how to predict in over-saturation areas
- Multi-scale prediction loss furtherly improves the underestimation area

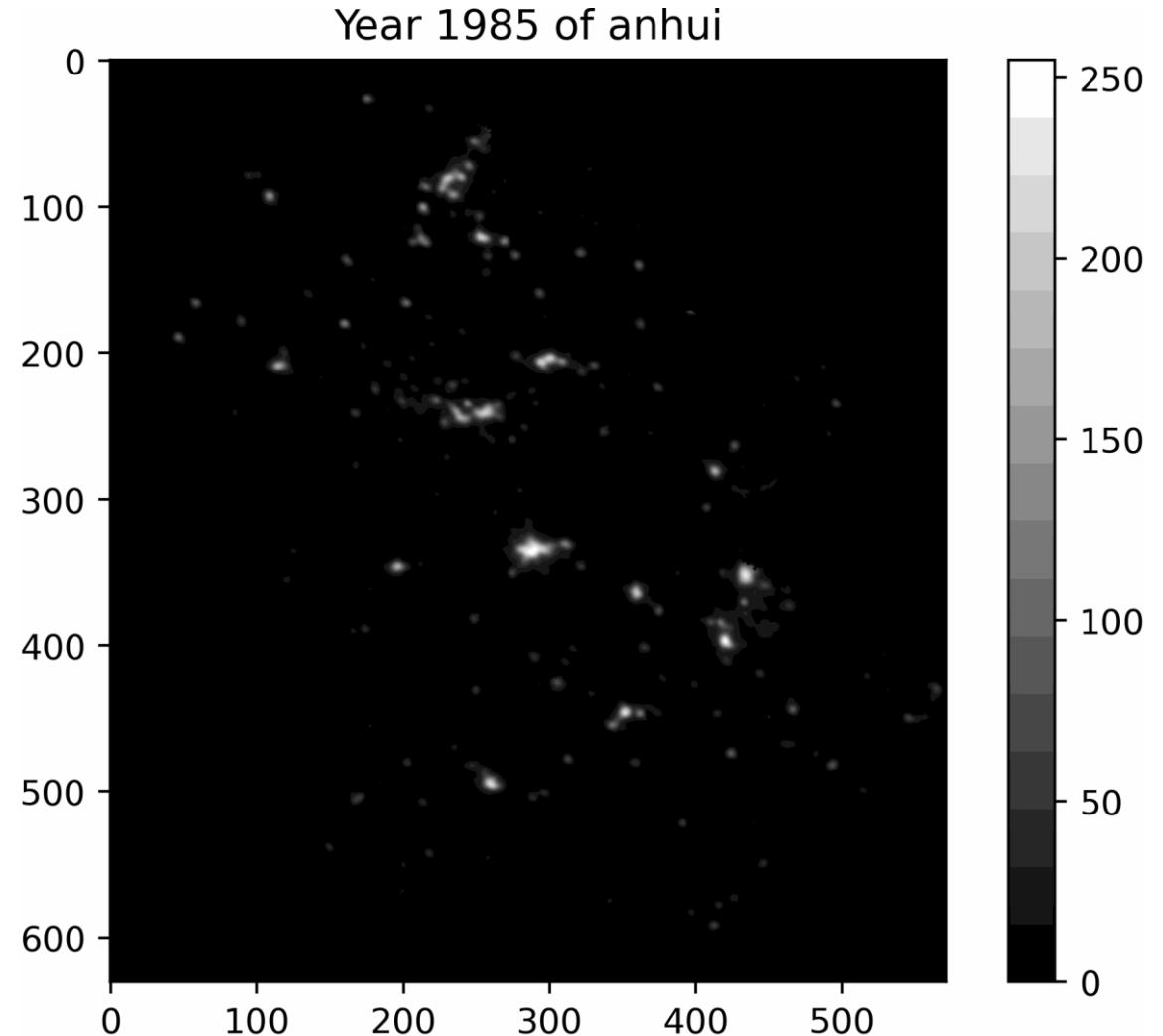


- Improve the resolution
- Overcome the over-saturation phenomena

Spatial alignment module

Local deformation + deformable CNN + affine transformation

- Local deformation
 - already proved its effectiveness in local alignment in previous work
- Affine transformation
 - Works with deformation parameters
- Deformable CNN
 - Is relatively small in parameters
 - Efficient in tackling global misalignment



Experimental results

- September
 - Best results: PSNR 15.656

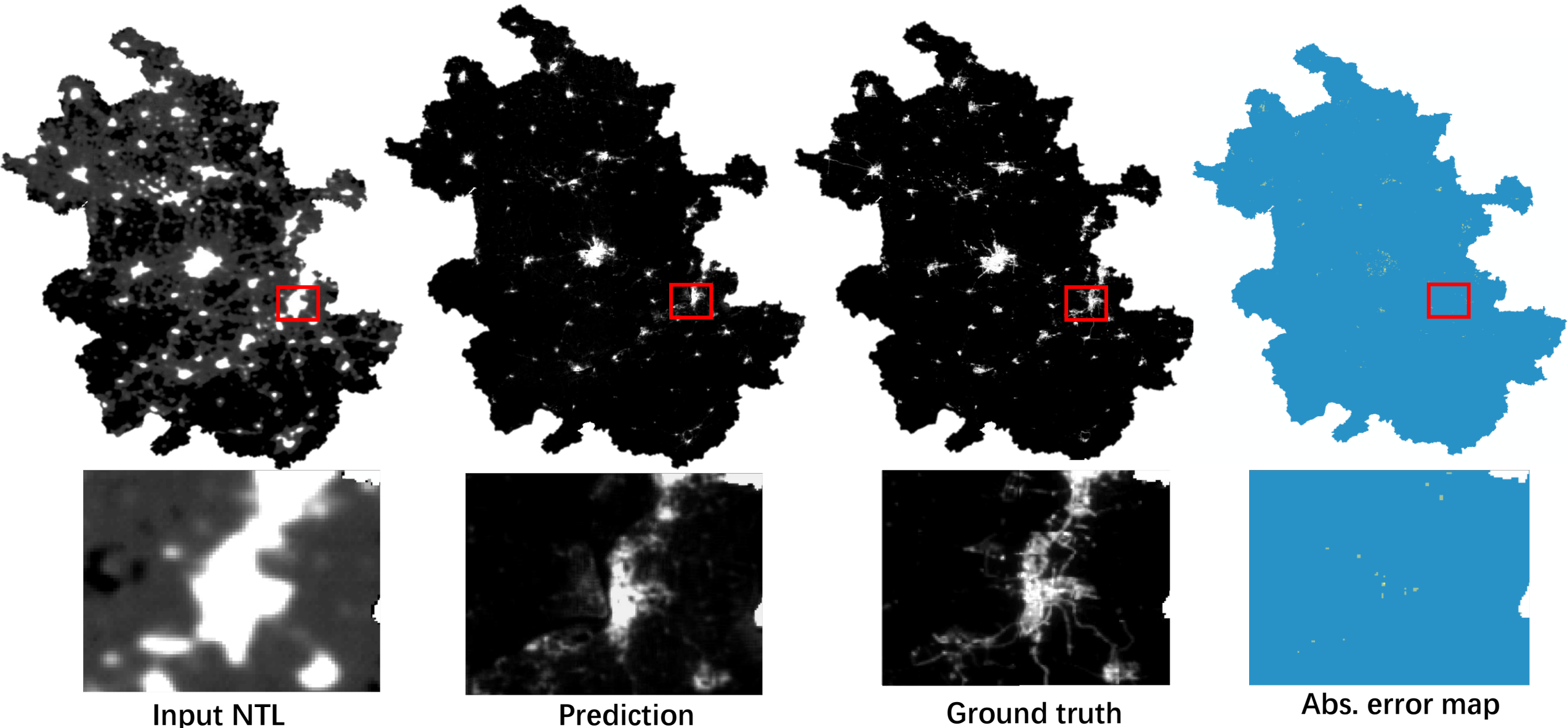
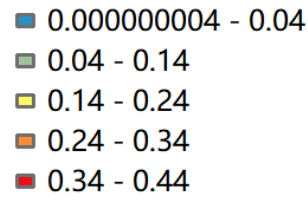
- Current results achieve significant improvements regarding visual performance

- Continuingly making progresses in PSNR

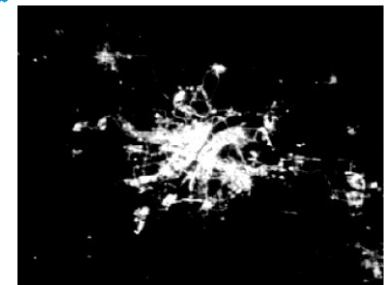
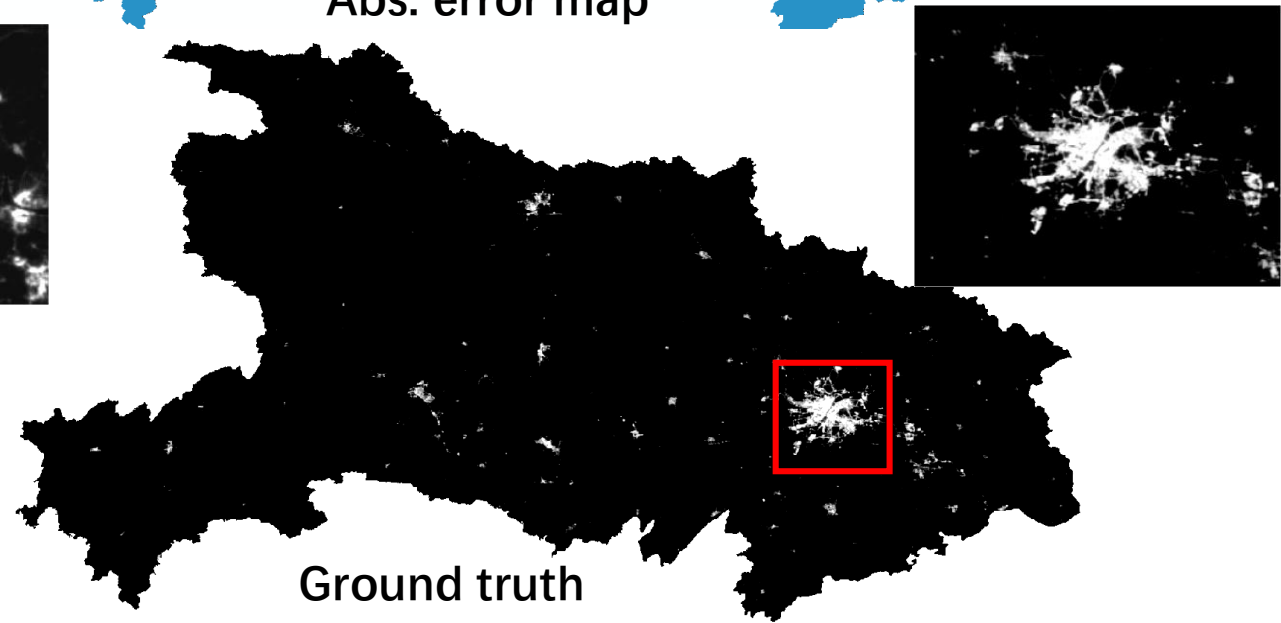
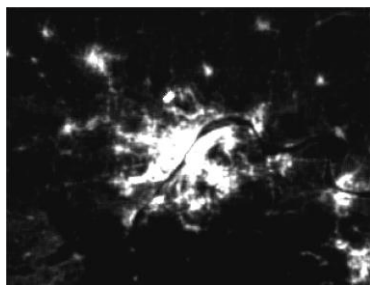
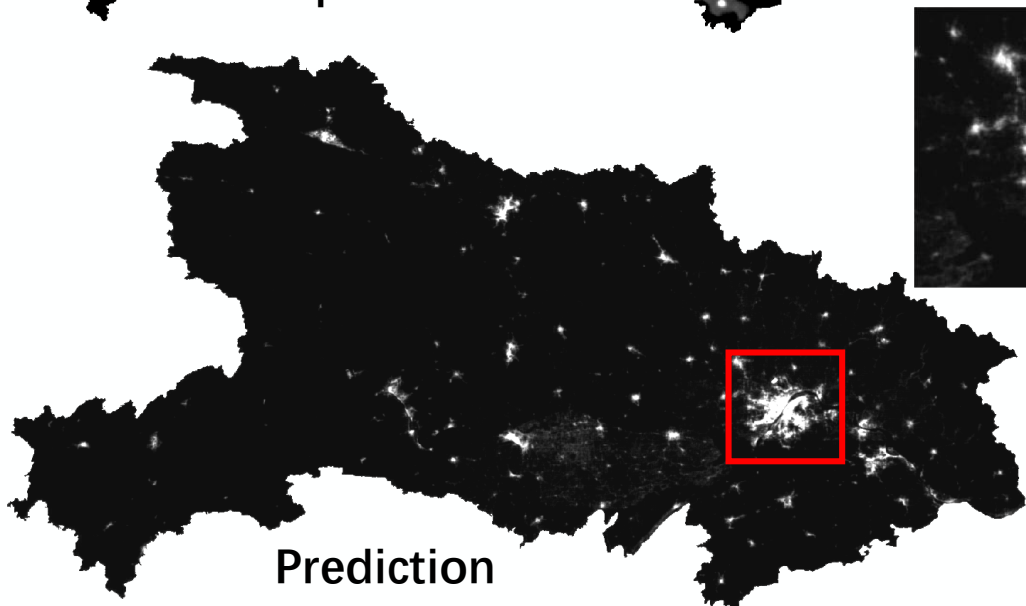
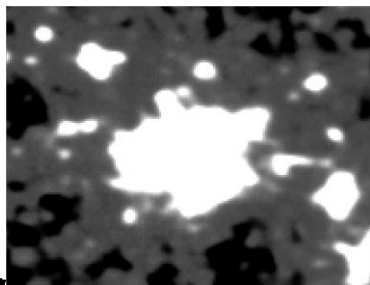
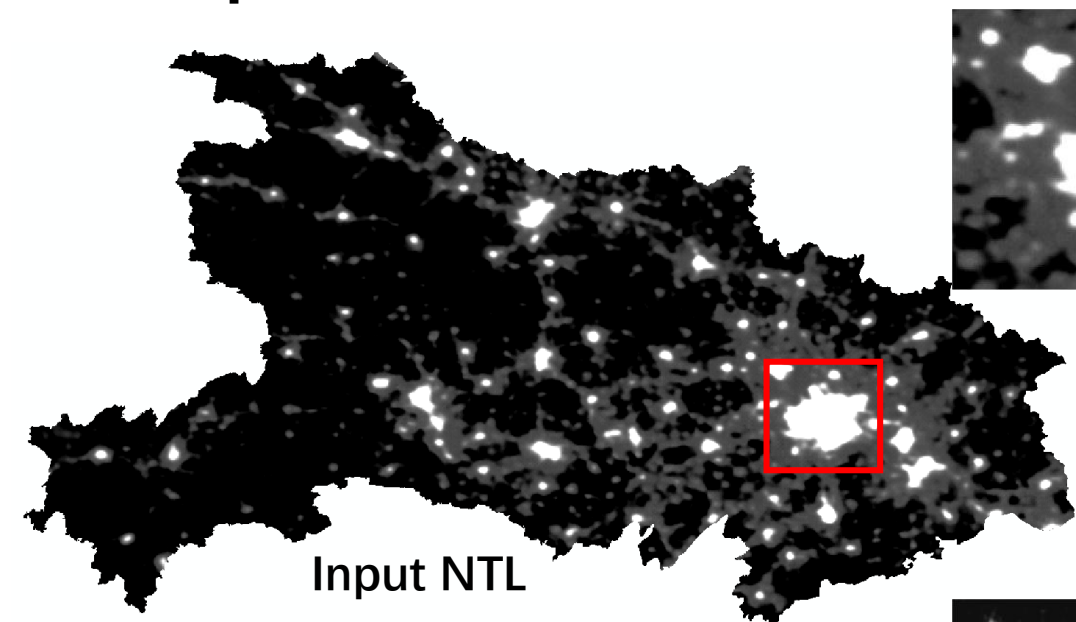
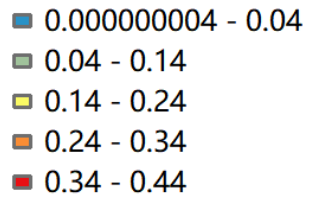
- Further improvements in the local area are needed in the future

Baseline(September)	deformable CNN	affine transformation	auxiliary supervision	multi-scale prediction loss	PSNR
√	×	×	×	×	15.656
√	√	×	×	×	19.314
√	√	√	×	×	24.066
√	√	√	√	×	29.199
√	√	√	√	√	32.395

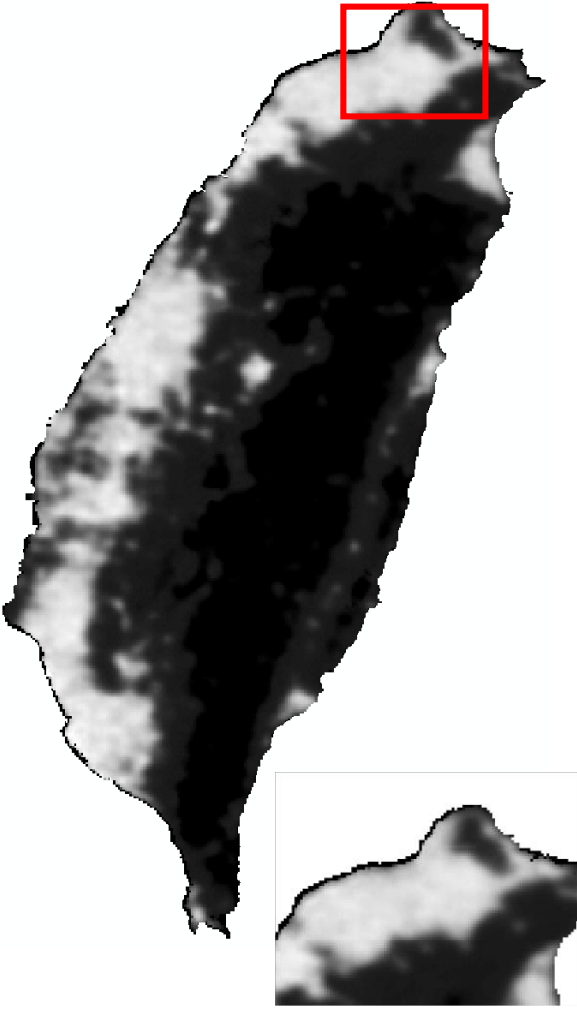
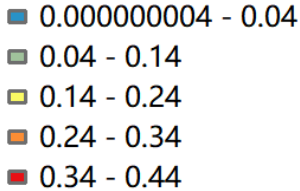
Experimental results



Experimental results



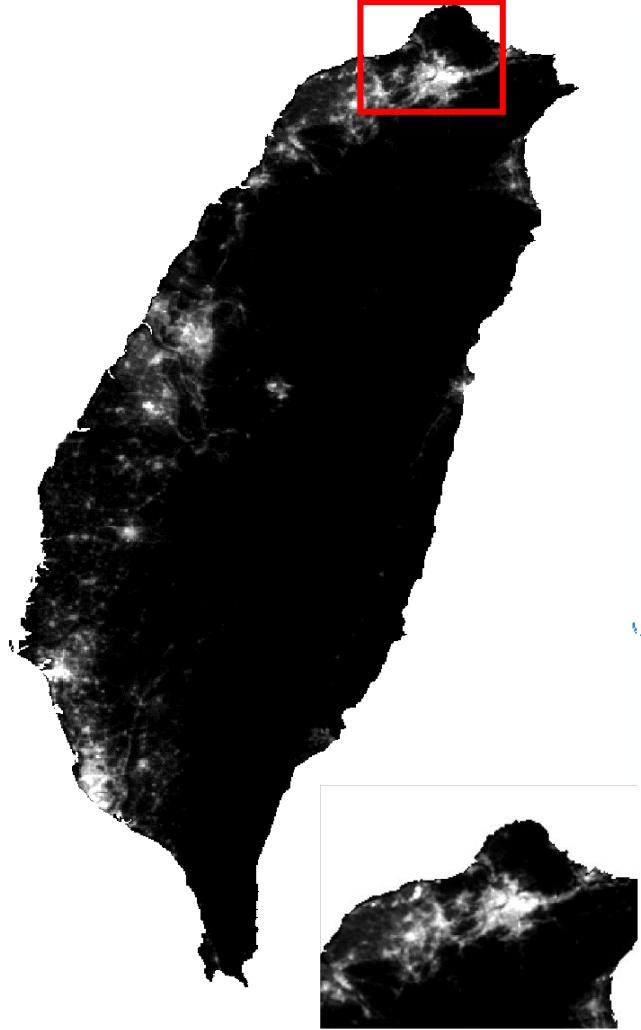
Experimental results



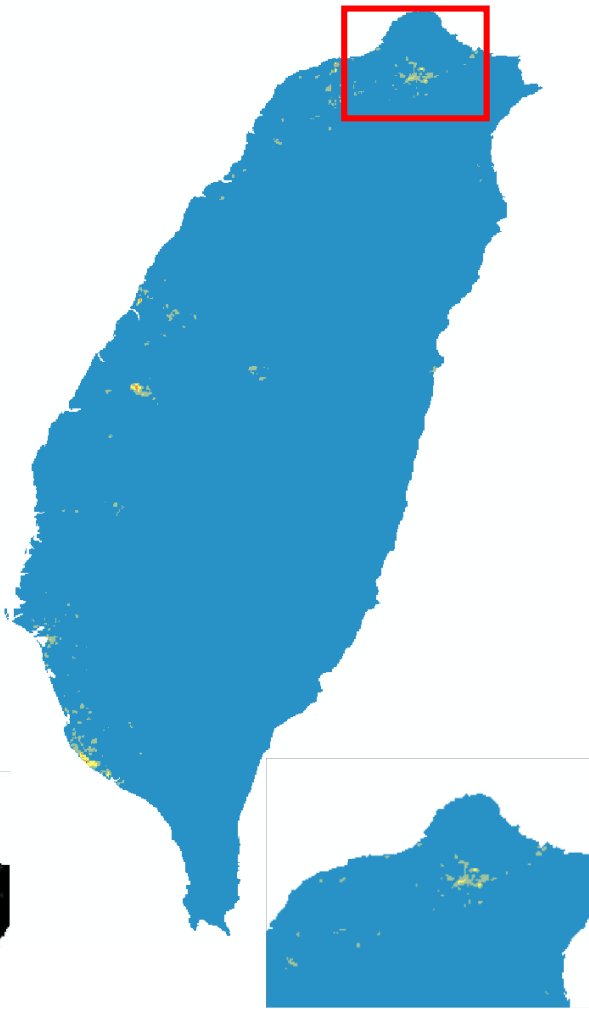
Input NTL



Prediction



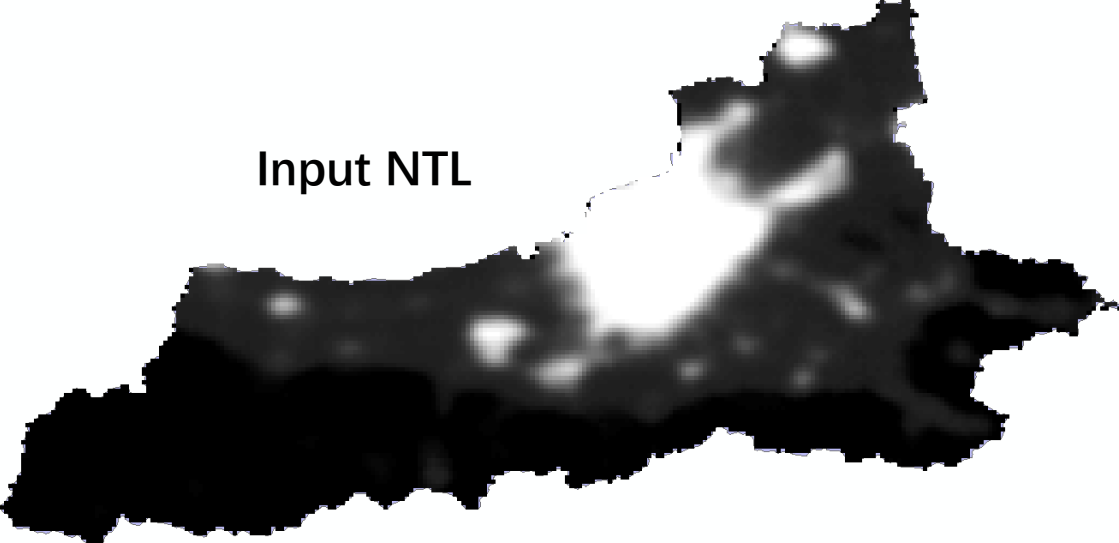
Ground truth



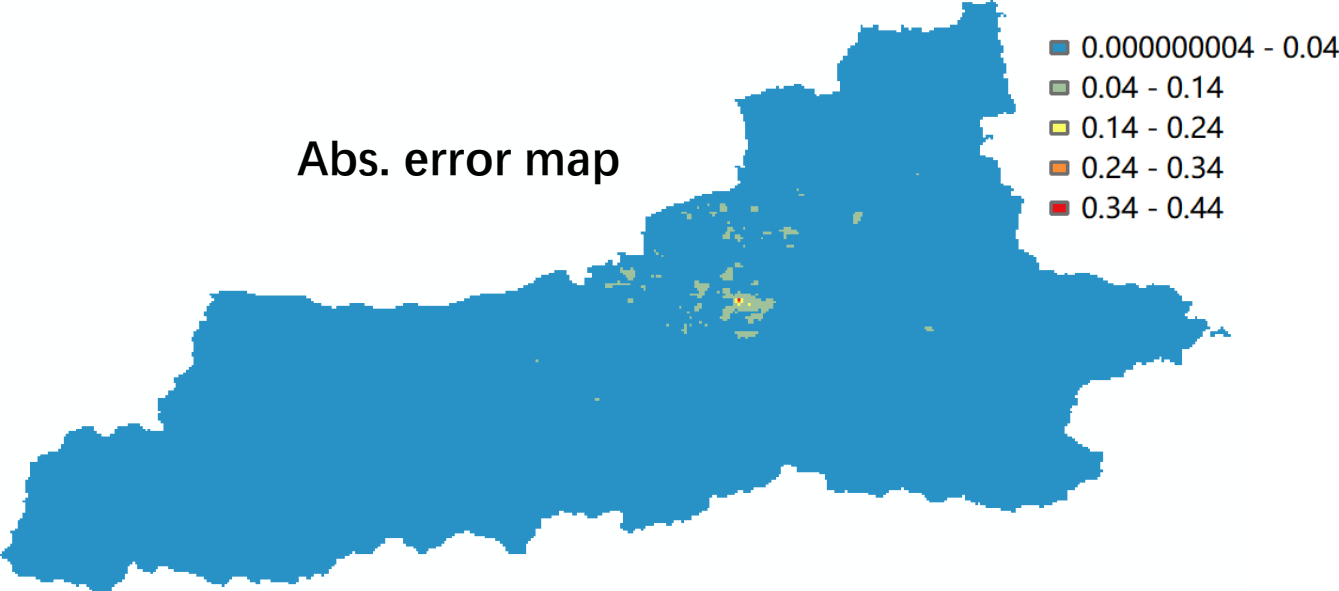
Abs. error map

Experimental results

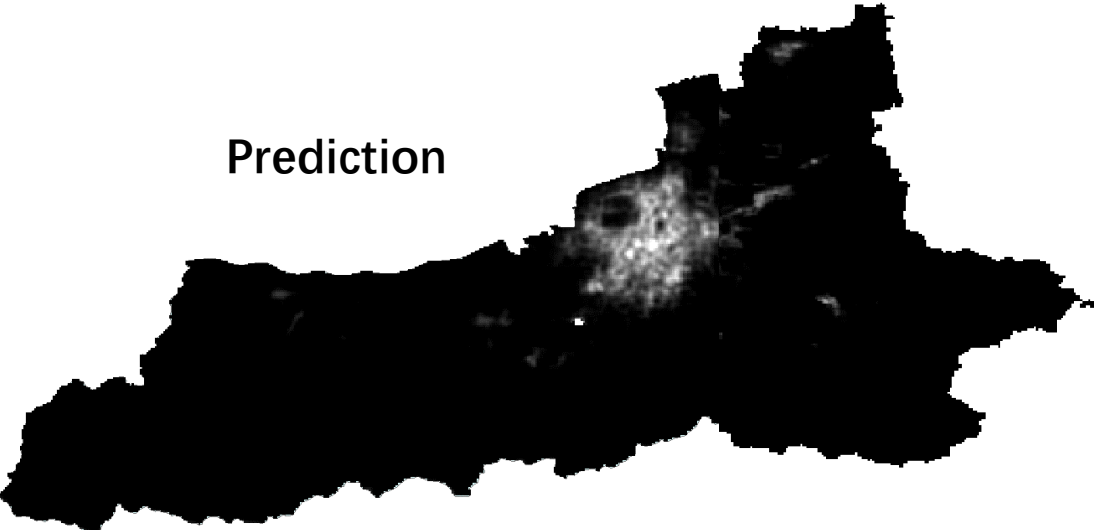
Input NTL



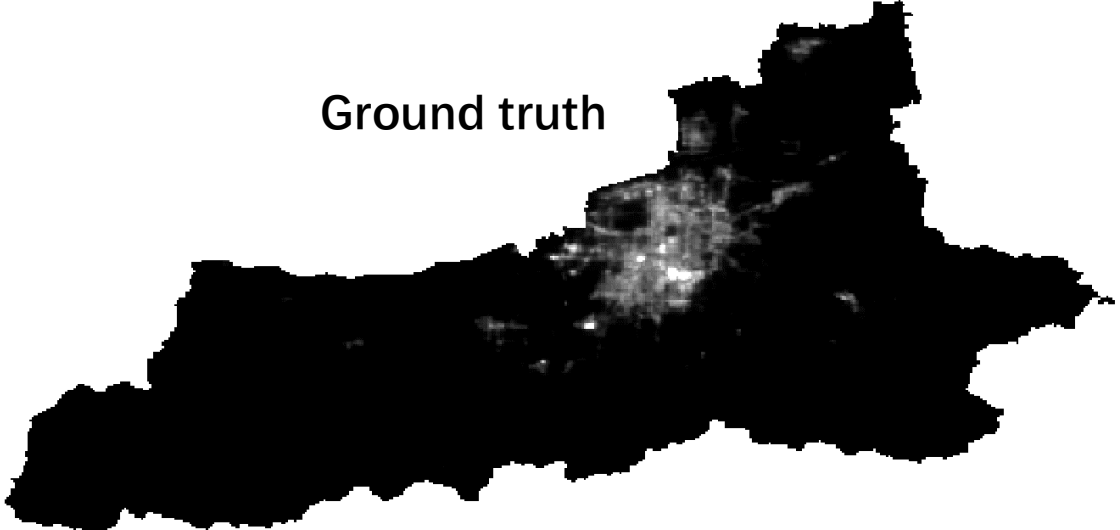
Abs. error map



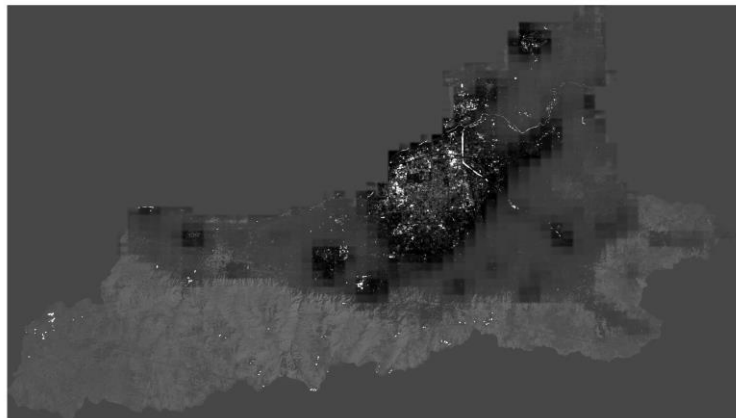
Prediction



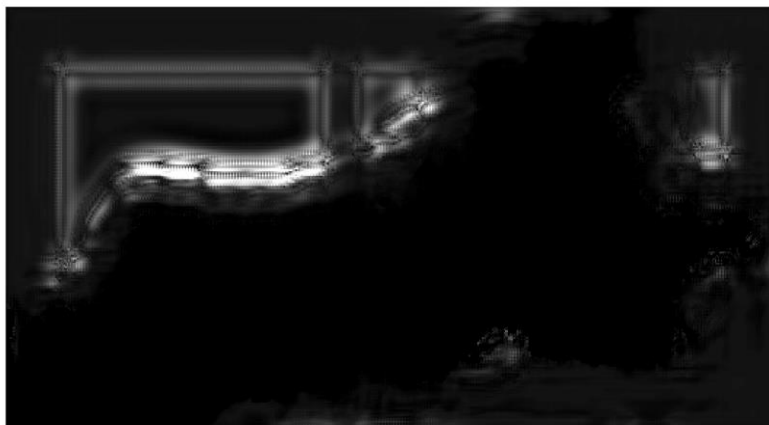
Ground truth



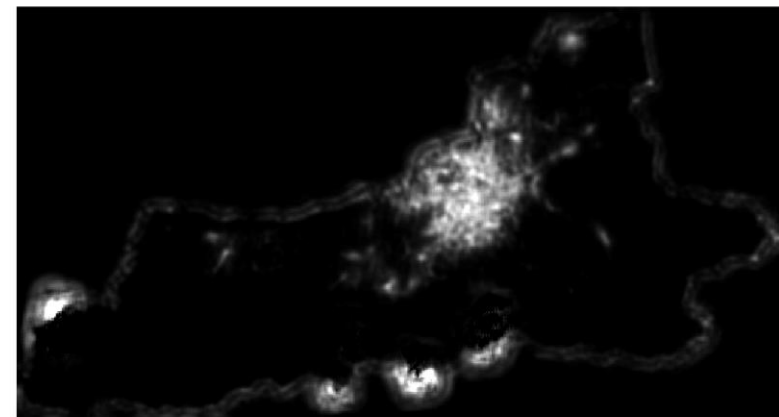
Discussion



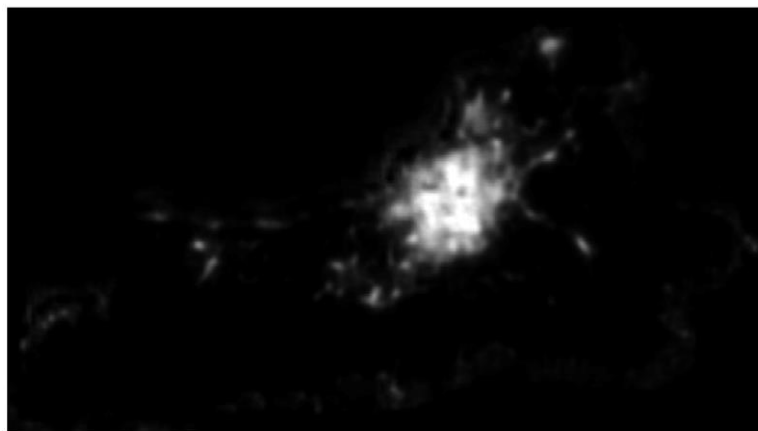
w/o multimodality fusion



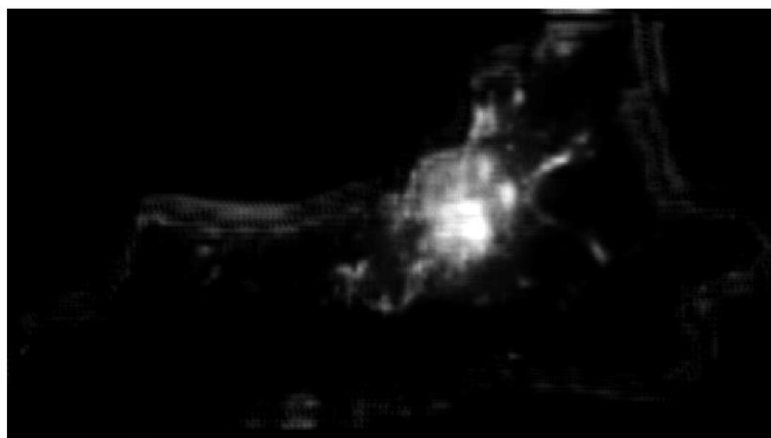
w/o Local deformation



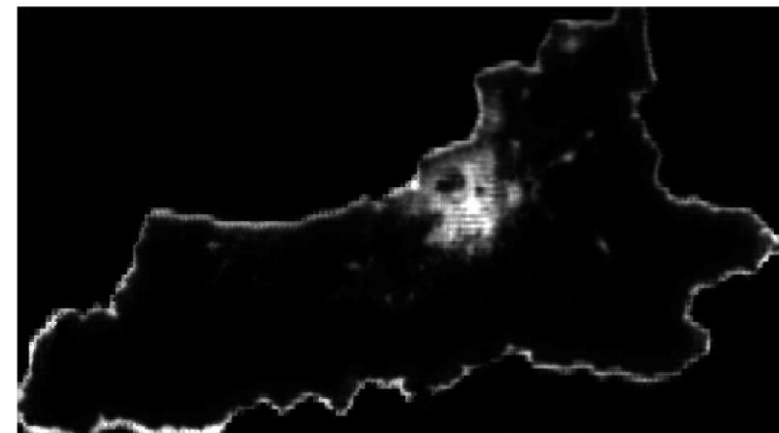
w/o deformable CNN



w/o affine transformation

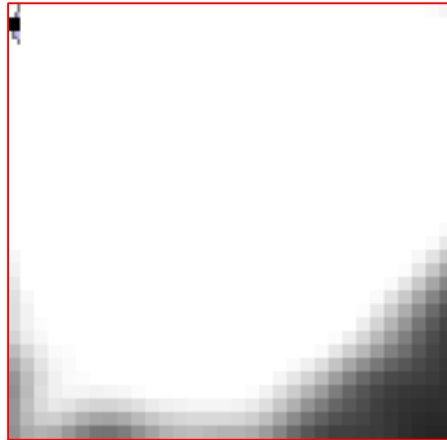


w/o multi-scale prediction loss

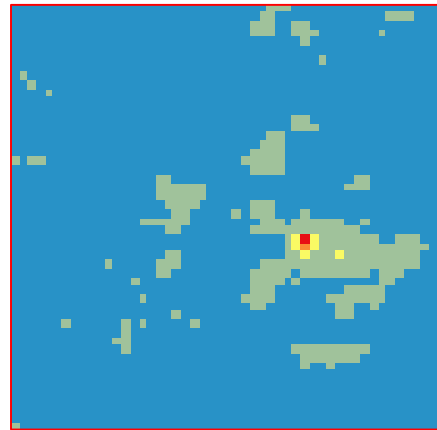


w/o auxiliary supervision

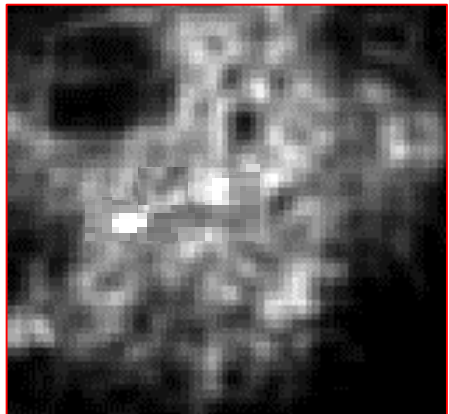
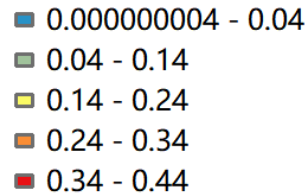
Discussion



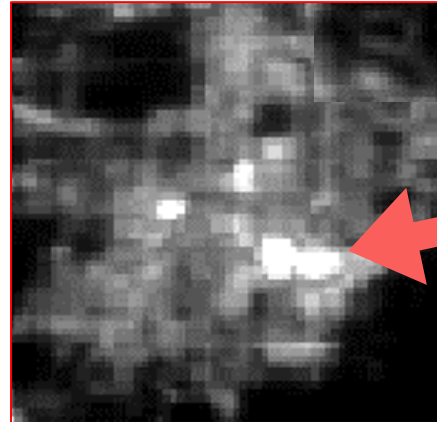
Input NTL



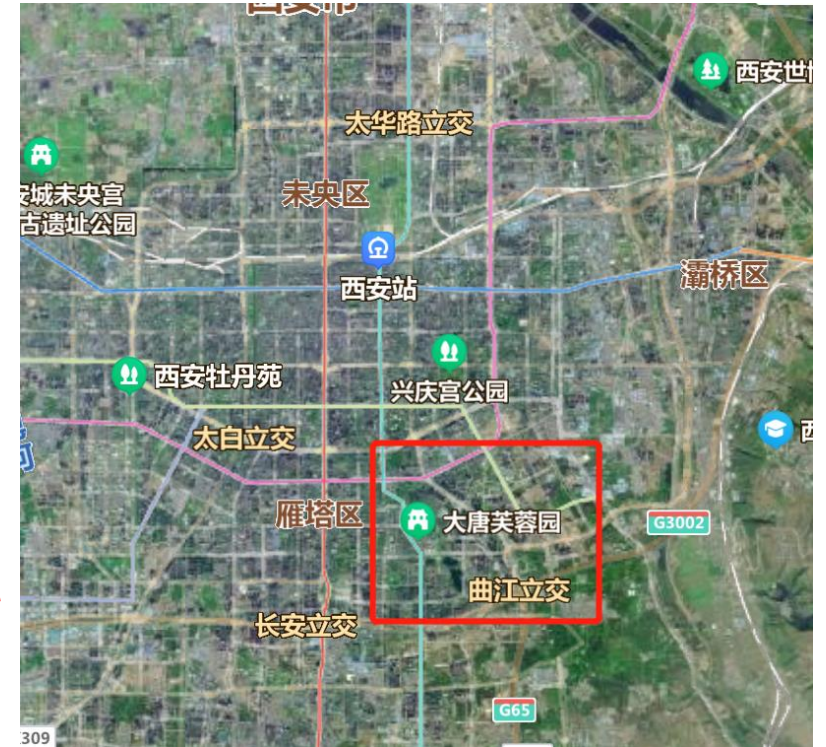
Abs. error map



Prediction

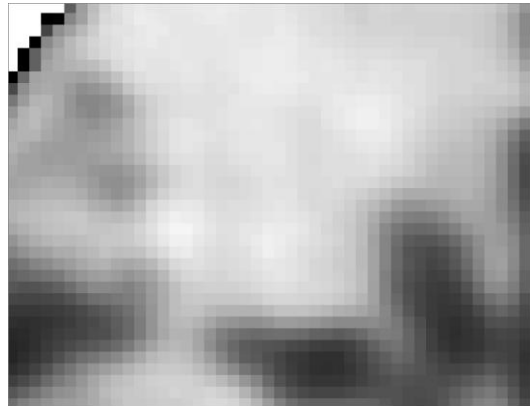


Ground truth

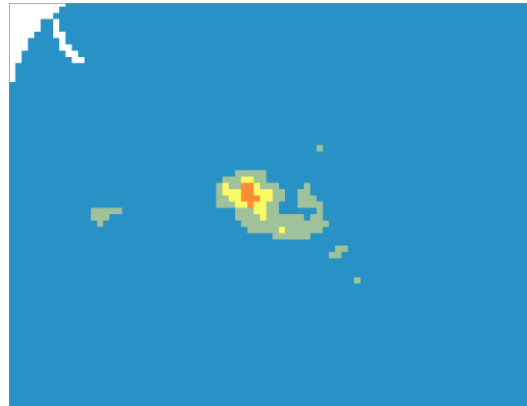


- Underestimate area
- tourist attractions (大唐不夜城: Tang Dynasty Everbright City)

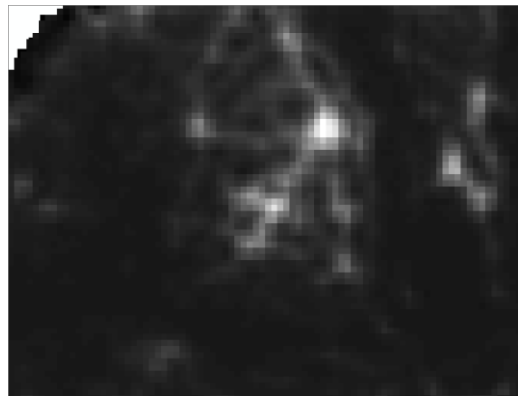
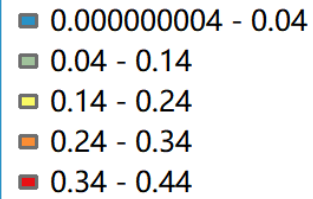
Discussion



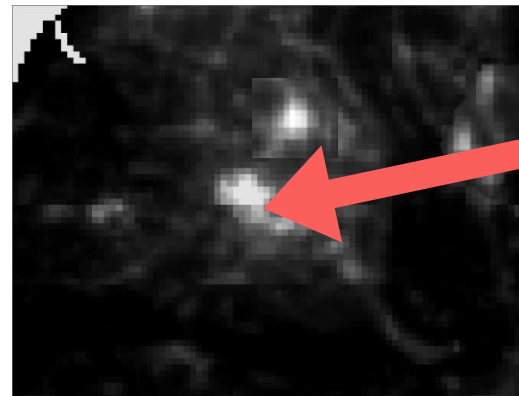
Input NTL



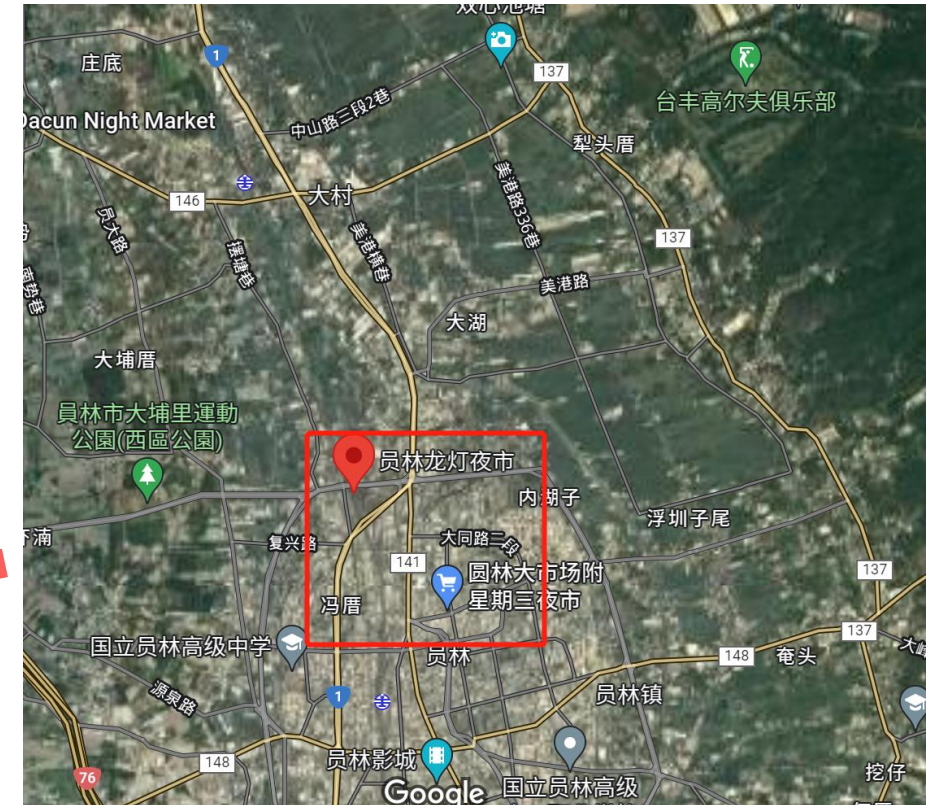
Abs. error map



Prediction



Ground truth



- Underestimate area
- tourist attractions (员林龙灯夜市: Yuanlin Dragon Lantern Night Market)

Conclusions

- We propose an integrated algorithm for jointly improving the quality of DMSP-like PANDA with multimodality fusion and super-resolution
- We propose a multimodality data fusion module for efficiently fusing three different modality data sources, including DEM, Landsat, and NTL images.
- We propose a Local-global refinement module to achieve better performance in the local and global areas.
- We propose a spatial alignment module to tackle the misalignment in the input data source.

In the future

- Furtherly improve the performance
- Evaluate the temporal generalization of the proposed algorithm
- ???

Thanks for your listening

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Wissen für Morgen

