

Deep Learning in Environmental Data Science

Dr Ce Zhang

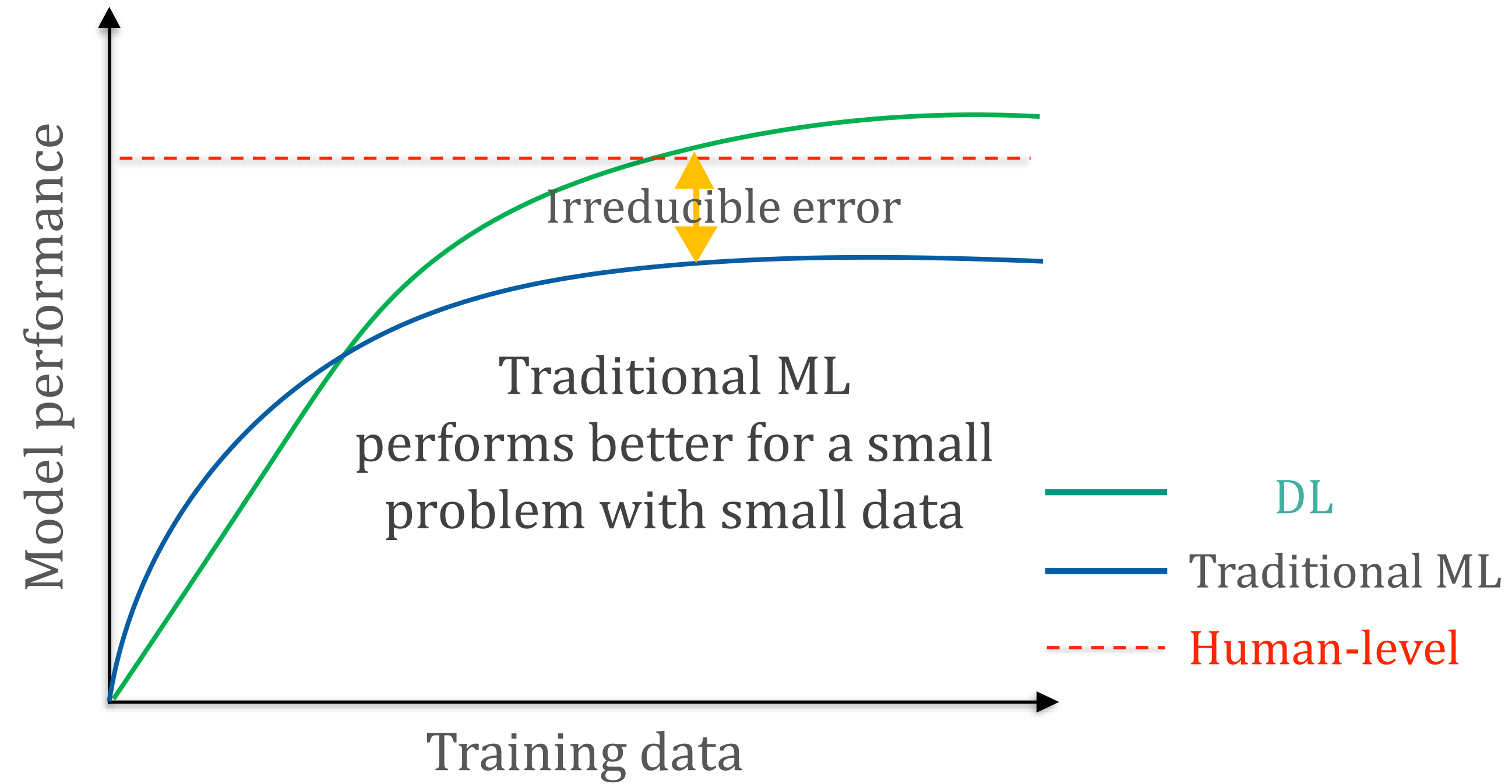
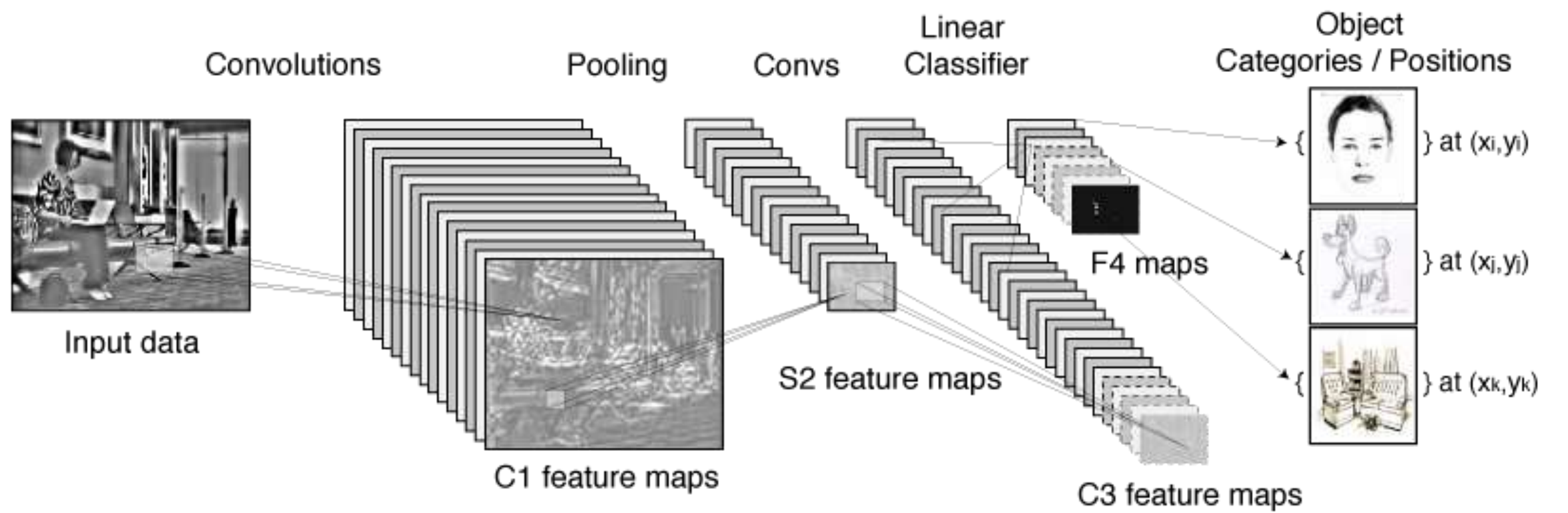
Centre of Excellence in Environmental
Data Science (*CEEDS*)

Lancaster University
UK Centre for Ecology & Hydrology

Deep Learning

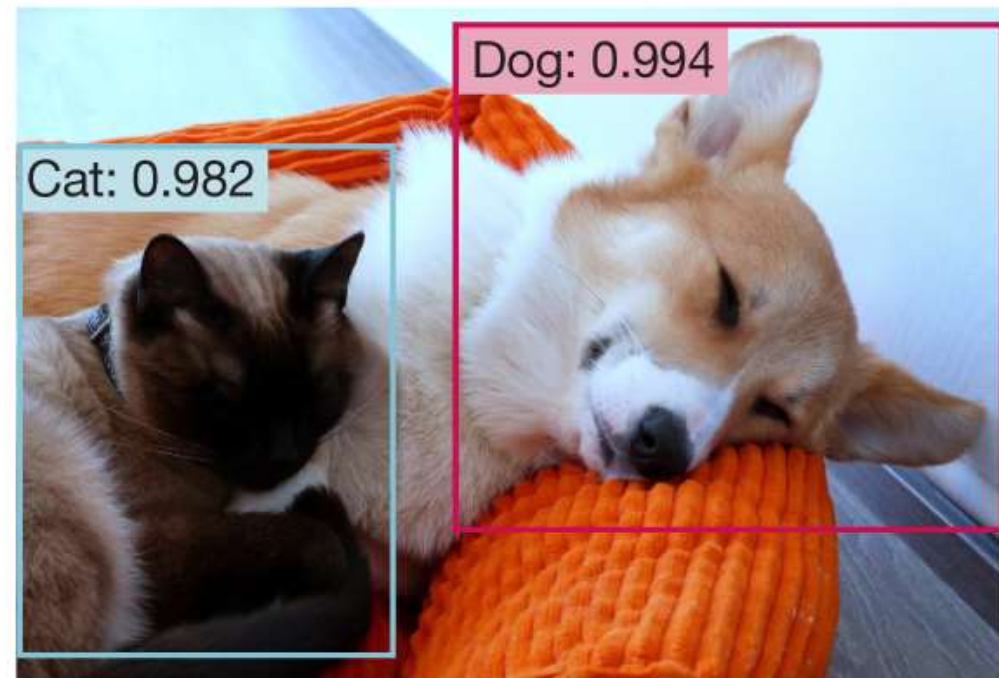
Huge development over the past five years

State-of-the-art AI and Machine Learning

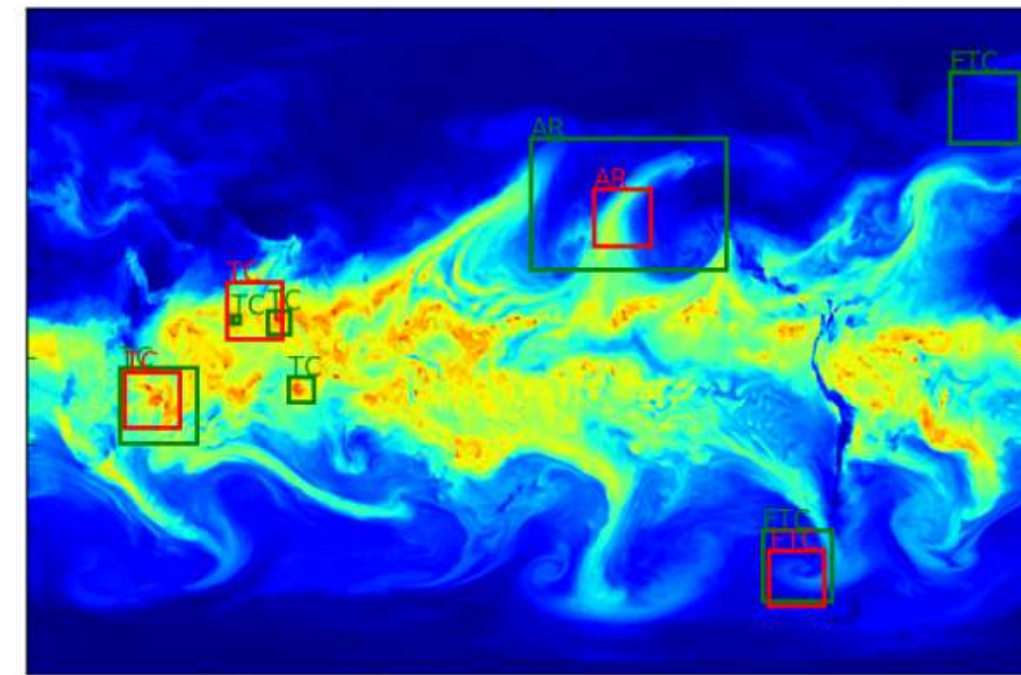


Deep Learning in Environmental Data Science

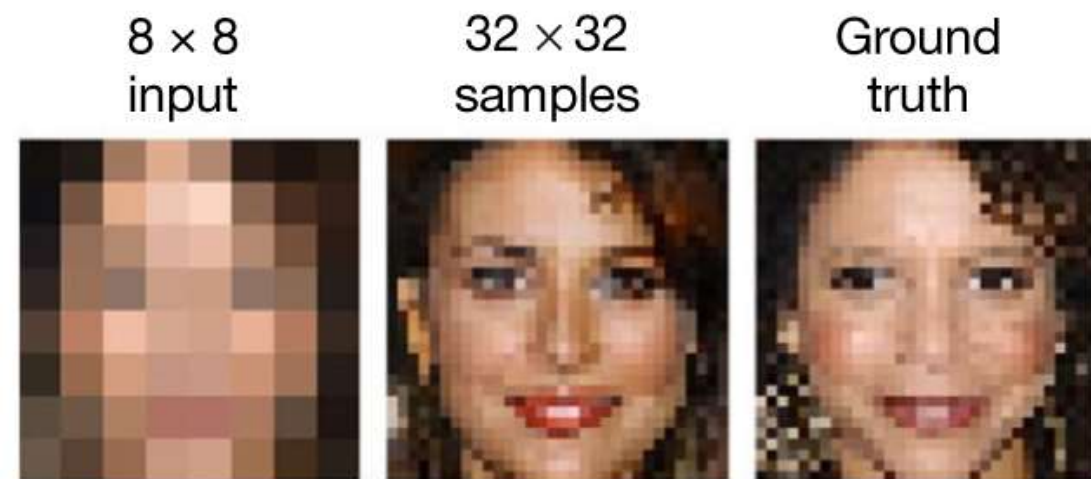
a Object classification and localization



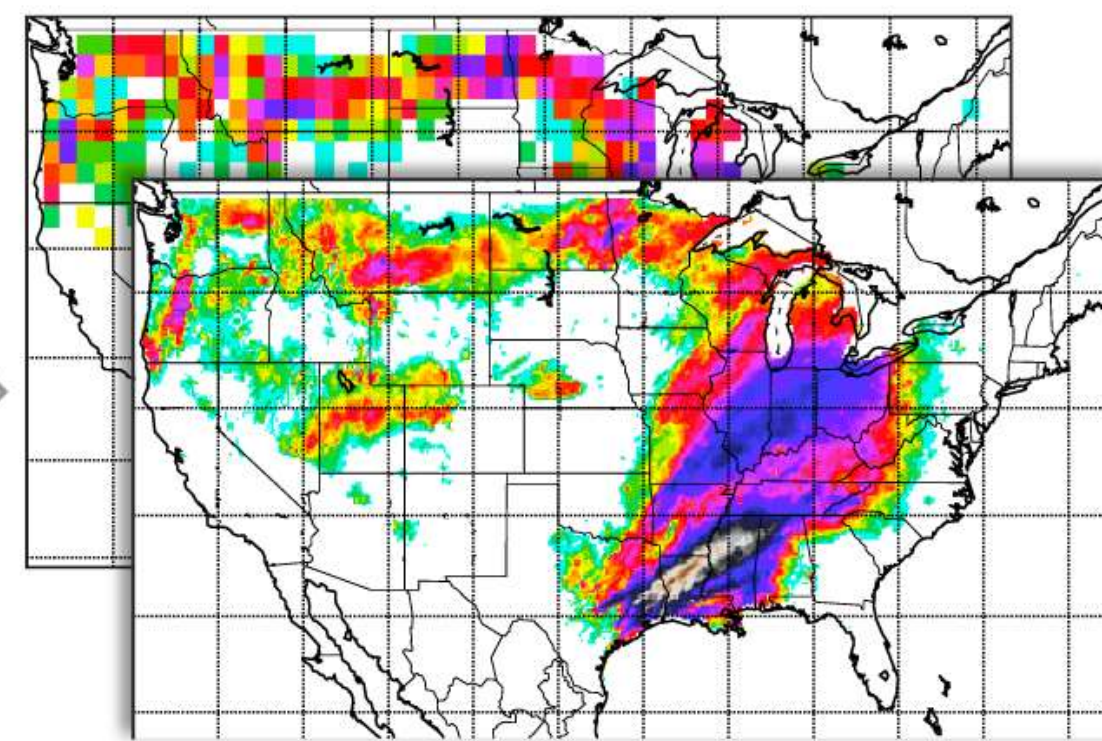
Pattern classification



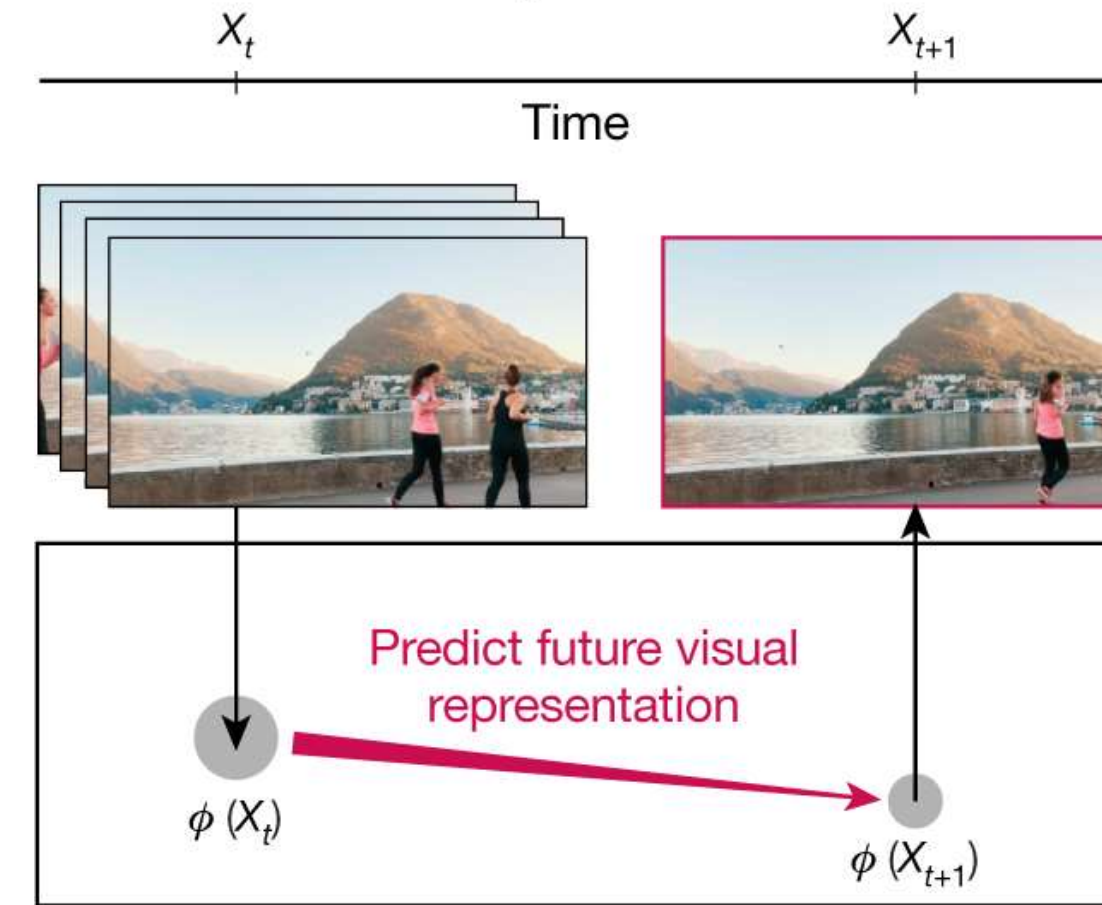
b Super-resolution and fusion



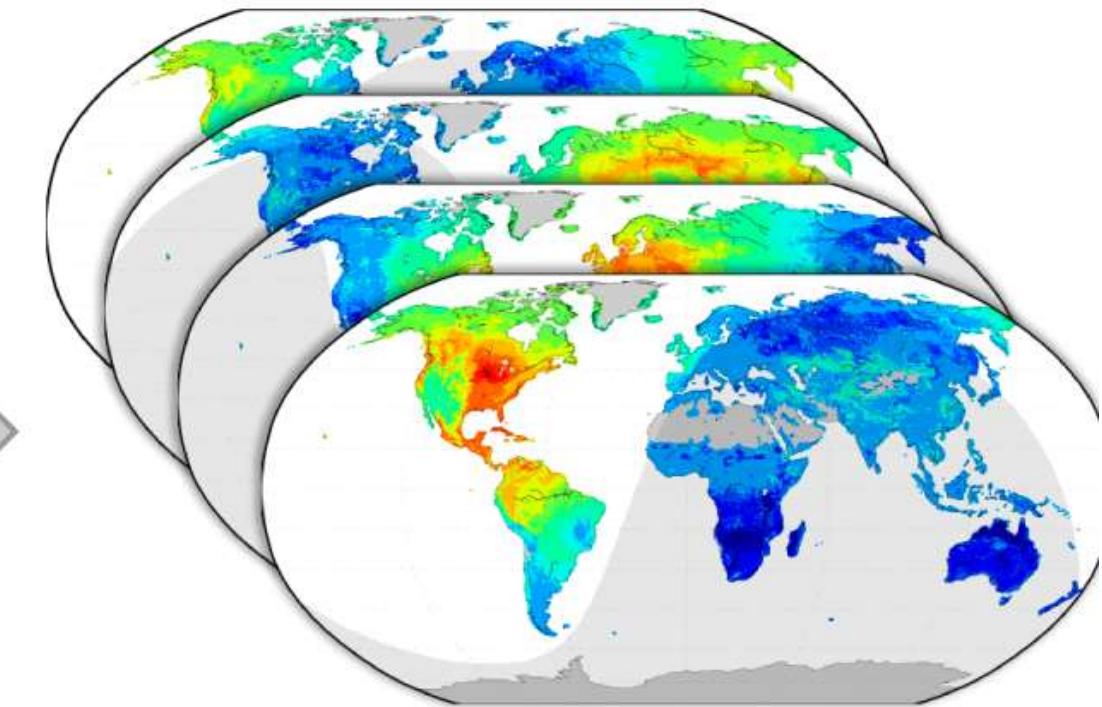
Statistical downscaling and blending



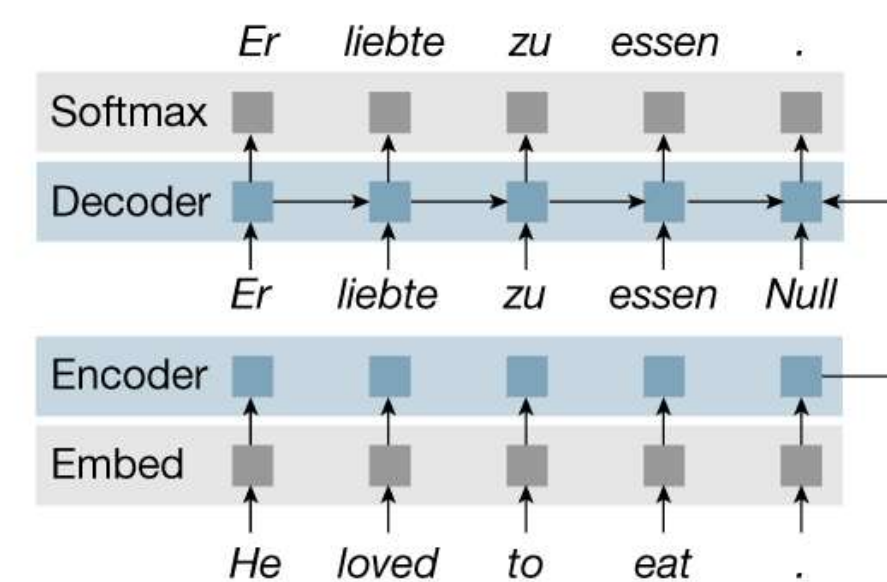
c Video prediction



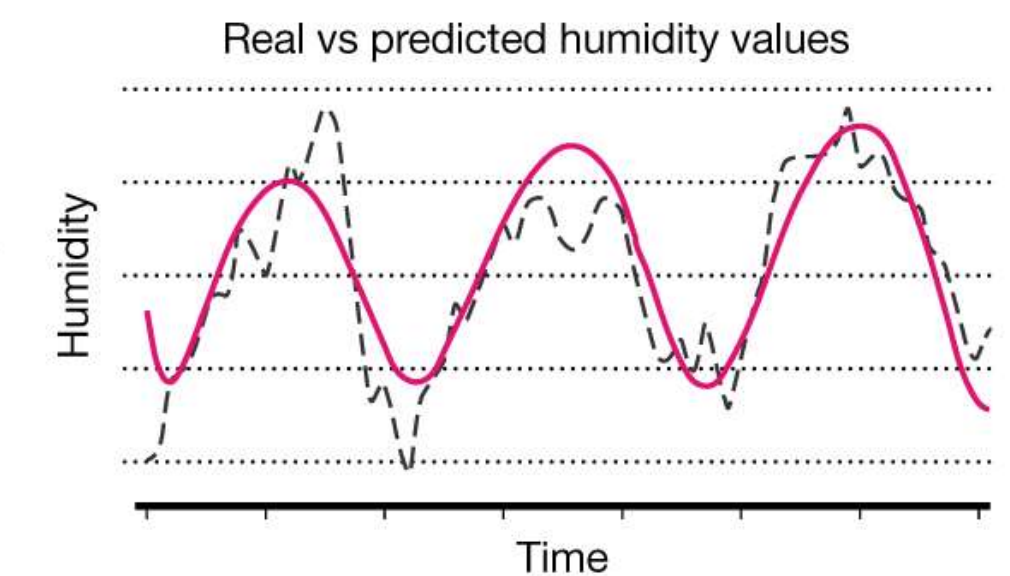
Short-term forecasting



d Language translation



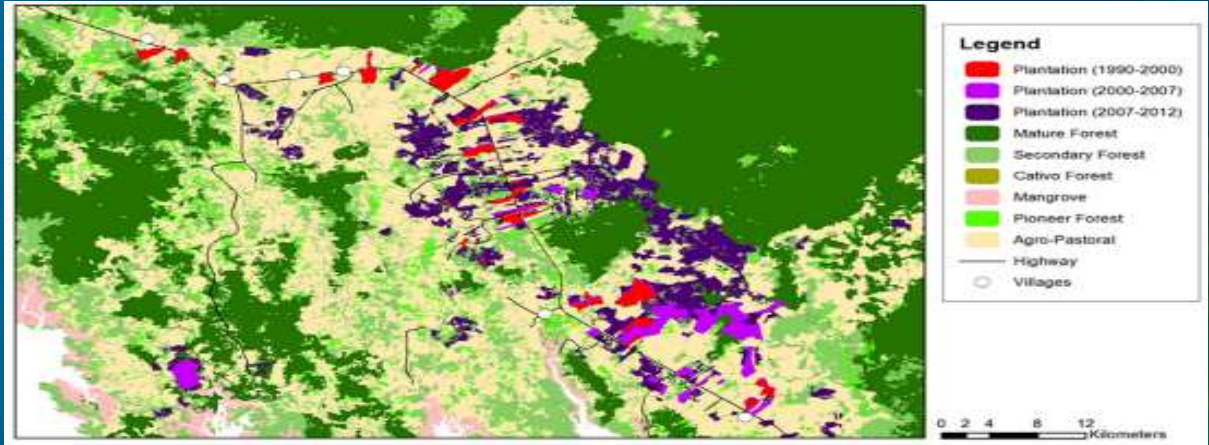
Dynamic time series modelling



Markus et al., 2019, Deep learning and process understanding for data-driven Earth system science. *Nature*, 566(7743), 195.

Environmental Grand Challenges

Forestry / Ecology



Meteorology



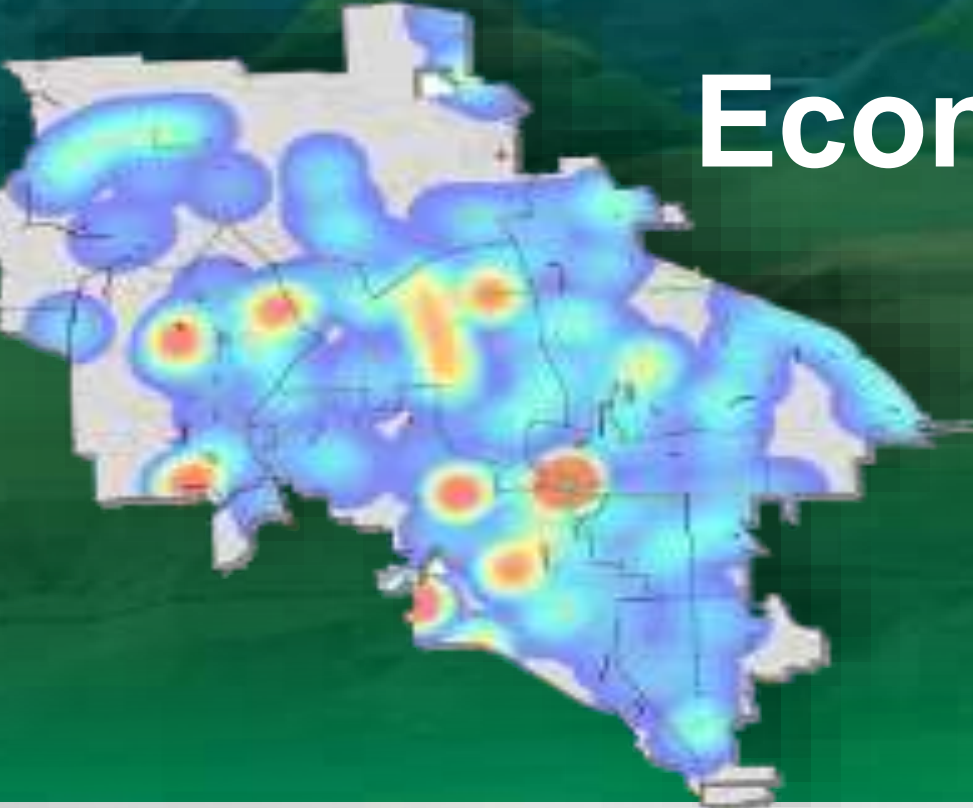
Smart Farming



Soil Sensing



Biogeochemistry

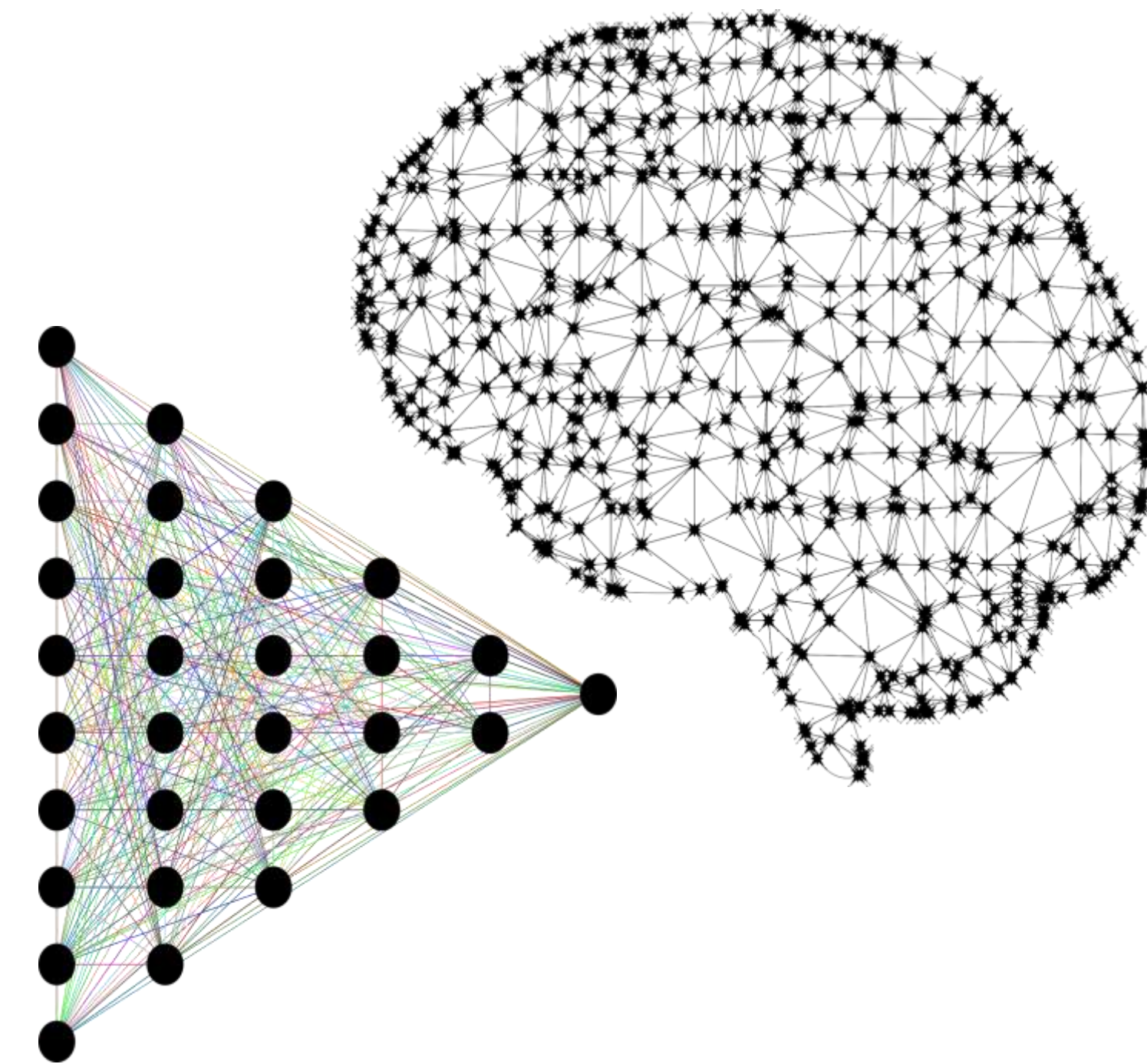
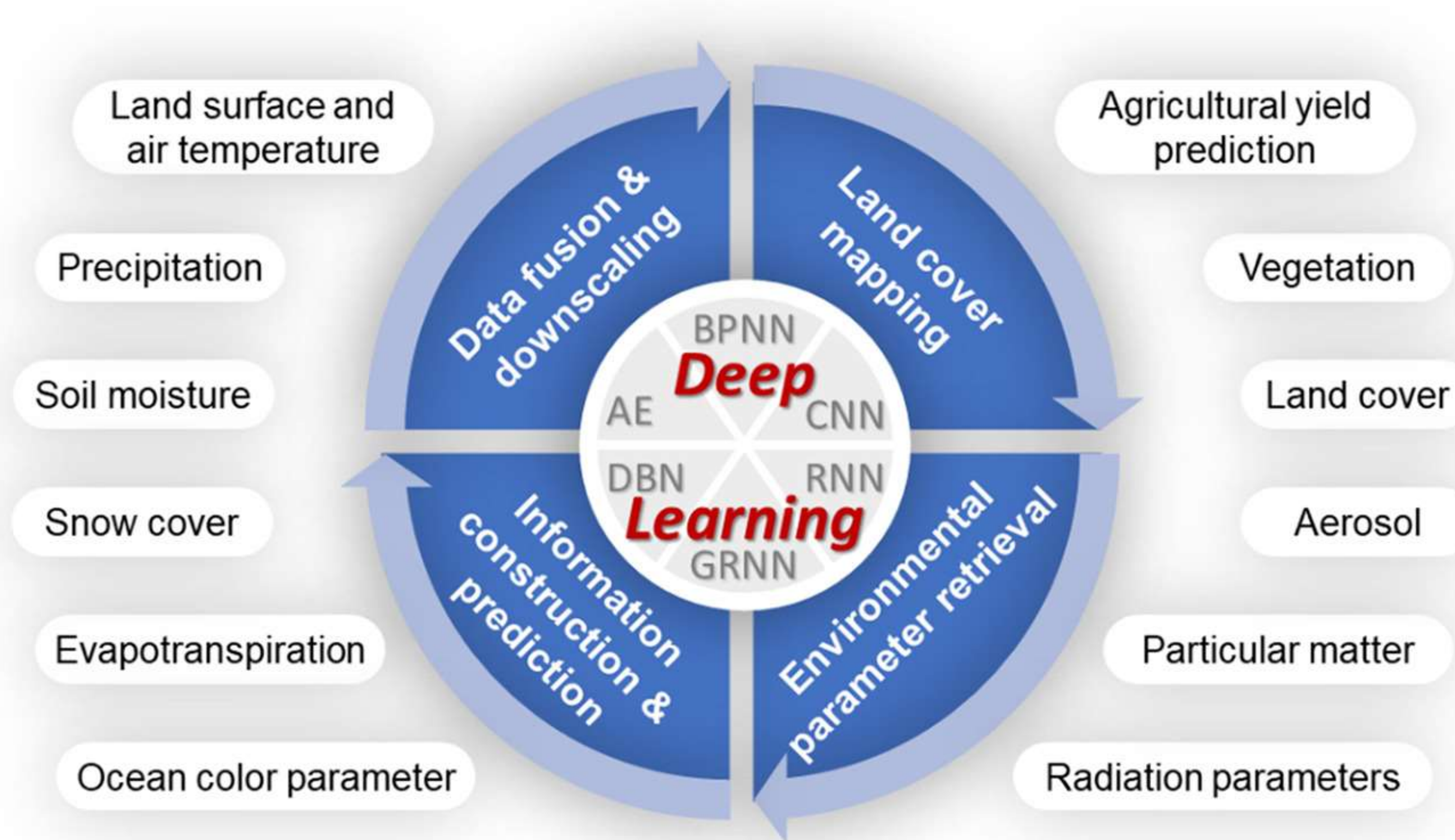


Economy

Sustainability Science



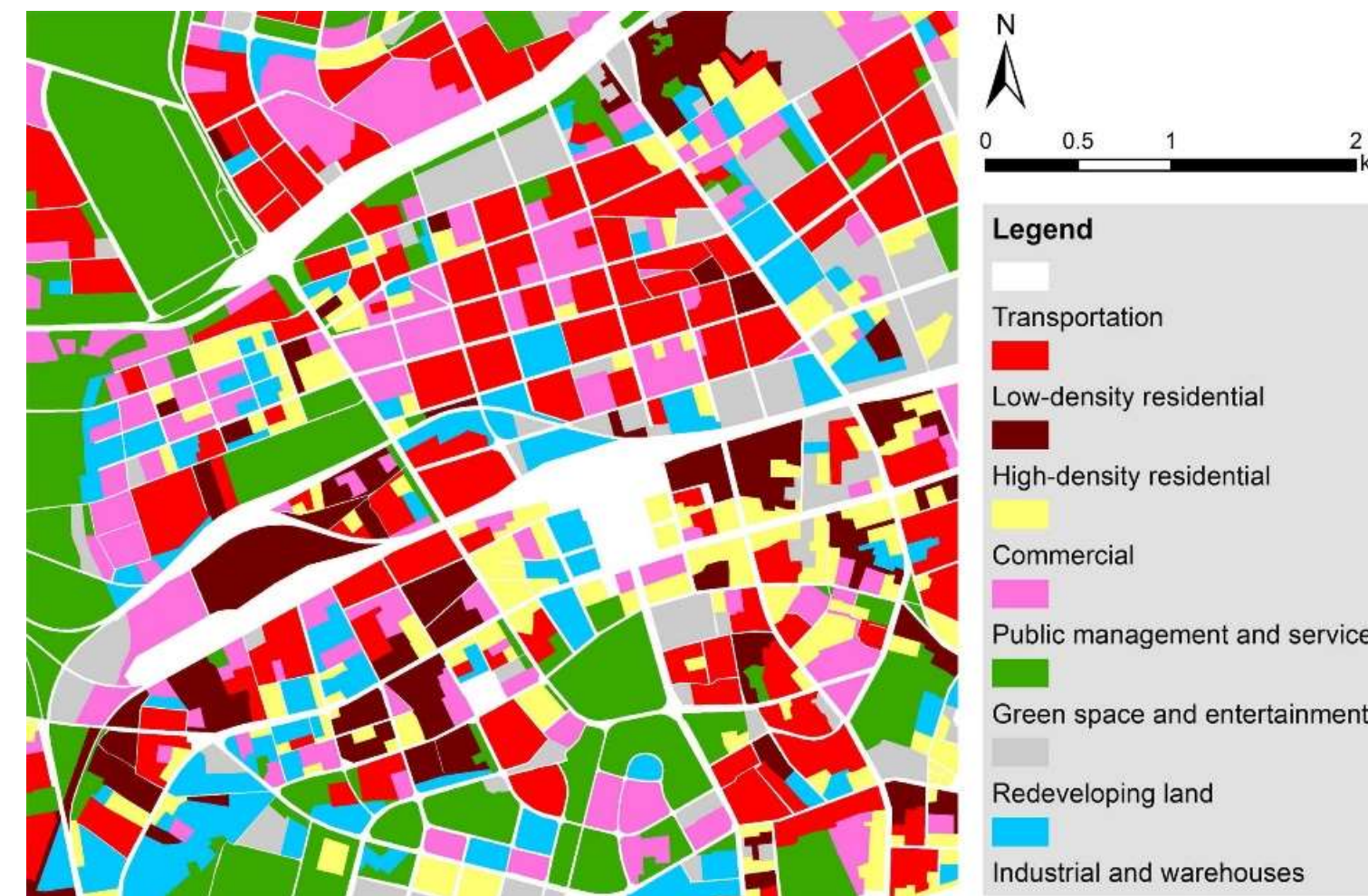
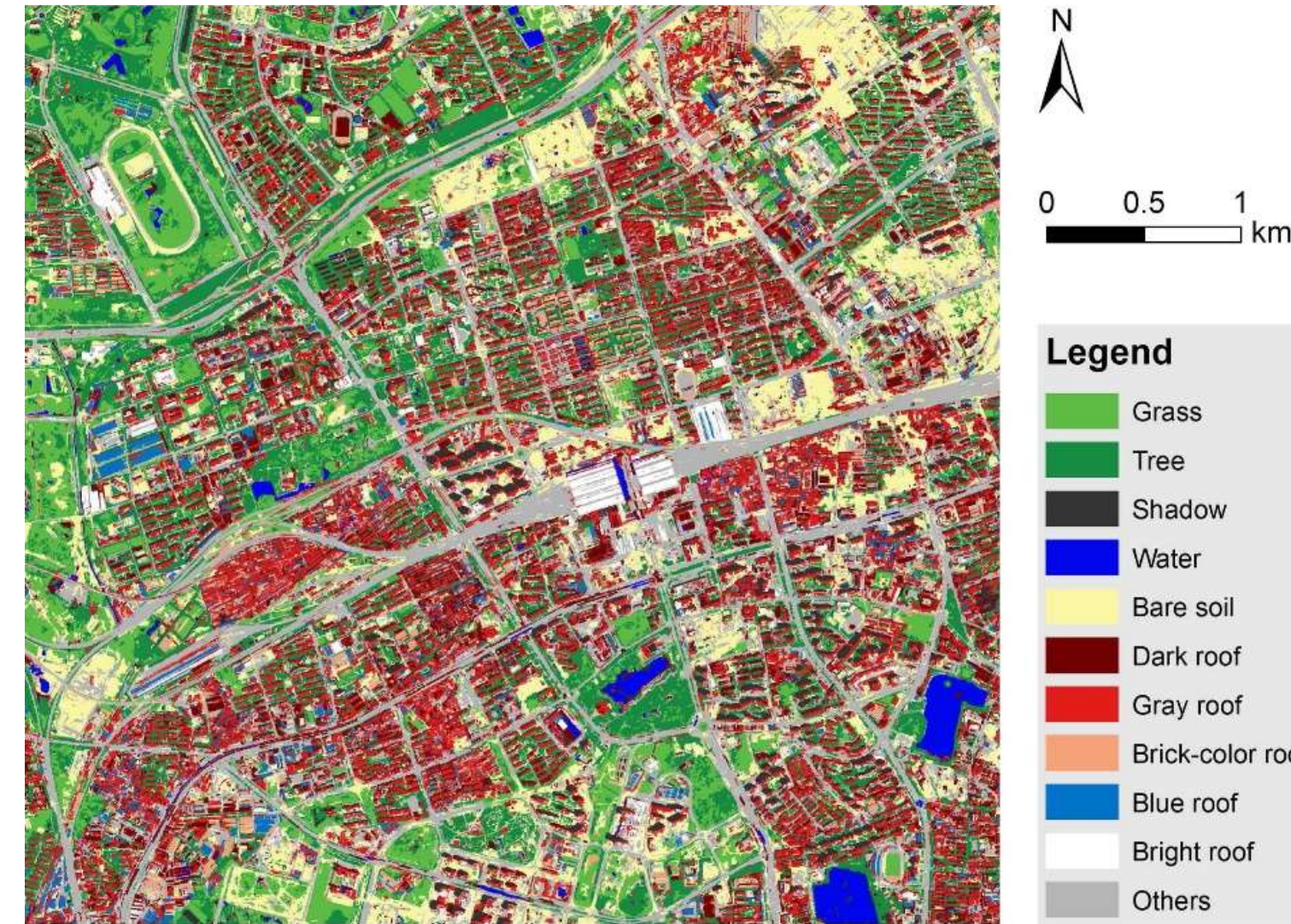
DL to answer environmental questions



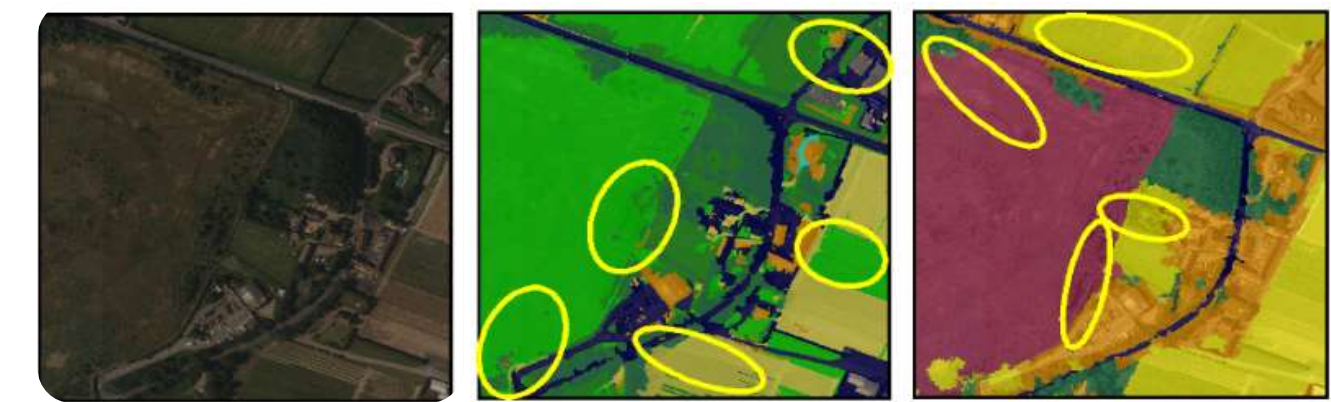
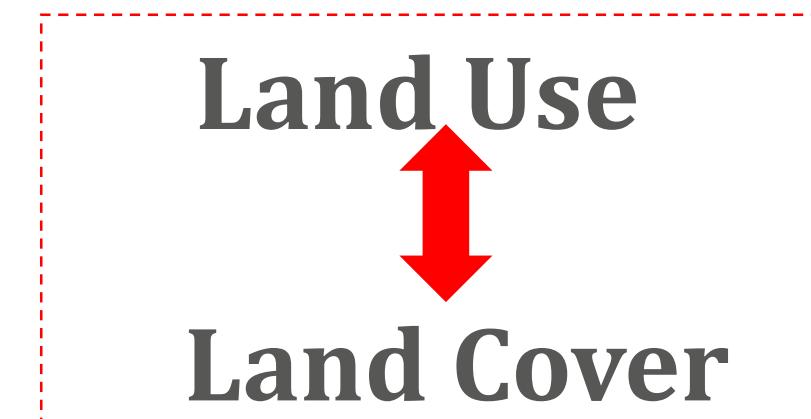
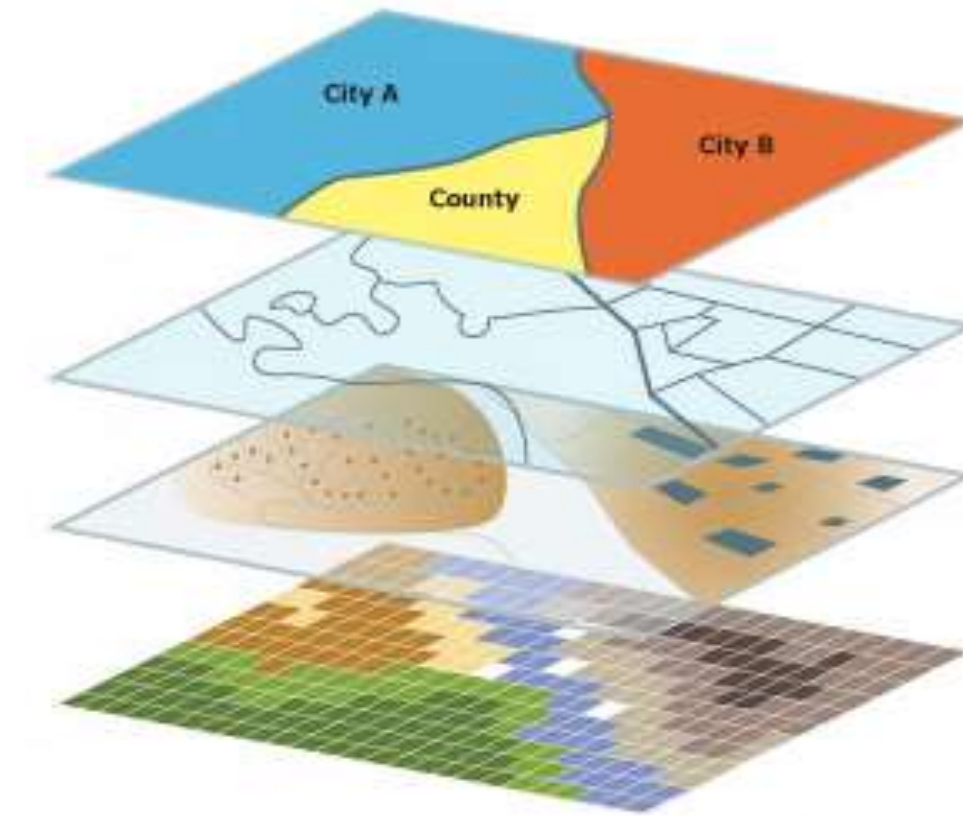
Yuan et al. 2020, Deep learning in environmental remote sensing: Achievements and challenges. *Remote Sensing of Environment*. 241: 111716

Successful applications

1. Joint Land Cover and Land Use Classification



High-order Functions



Land Cover Land Use

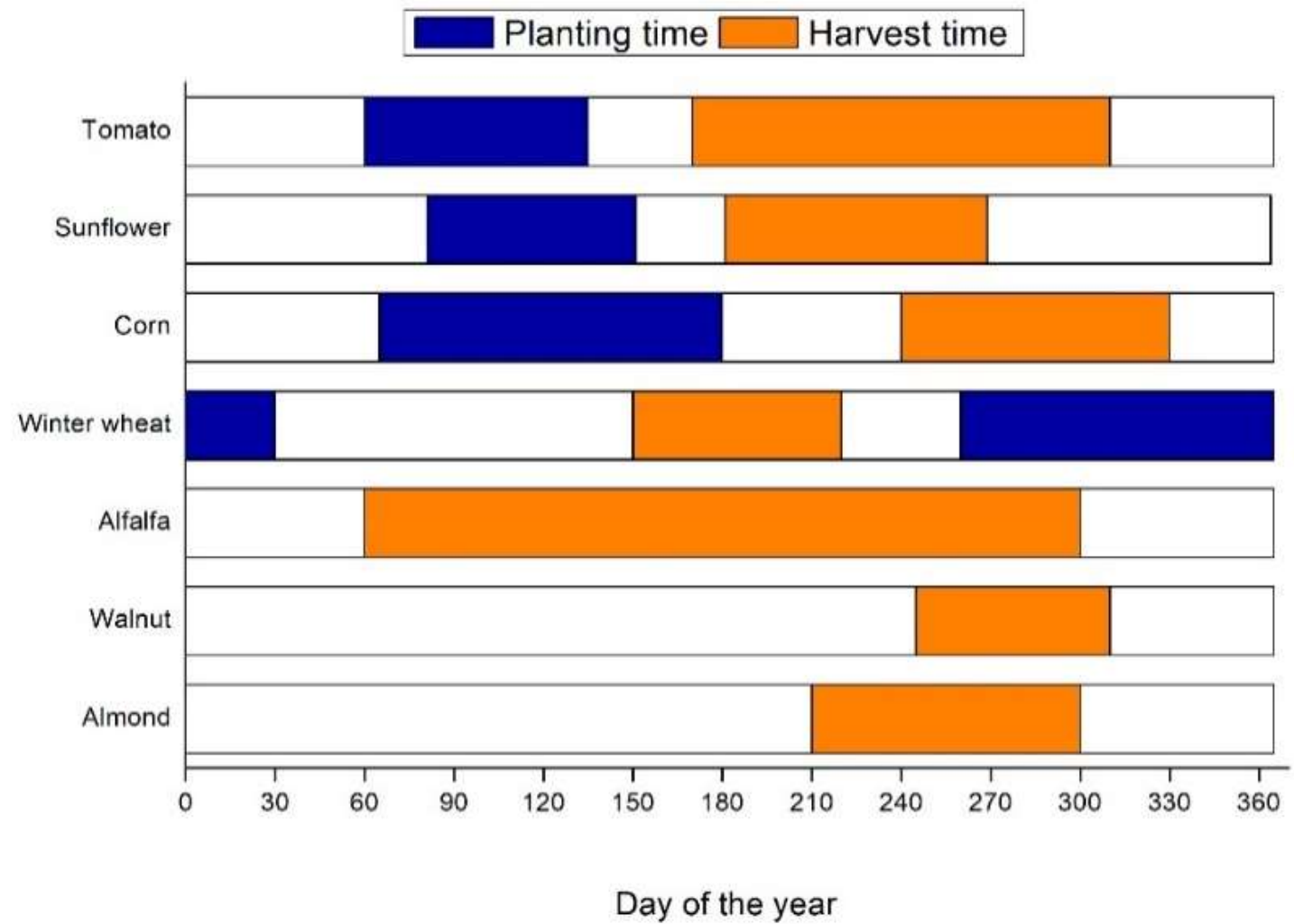
Zhang et al., 2020, Scale Sequence Joint Deep Learning (SS-JDL) for land cover and land use classification. *Remote Sensing of Environment*, 237: 111593

Zhang et al., 2019, Joint Deep Learning for land cover and land use classification. *Remote Sensing of Environment*, 221: 173-187.

2. Multi-type crop classification using time-series SAR images



- Almond
- Walnut
- Grass
- Alfalfa
- Hay
- Clover
- Wheat
- Corn
- Sunflower
- Tomato
- Pepper



Corn



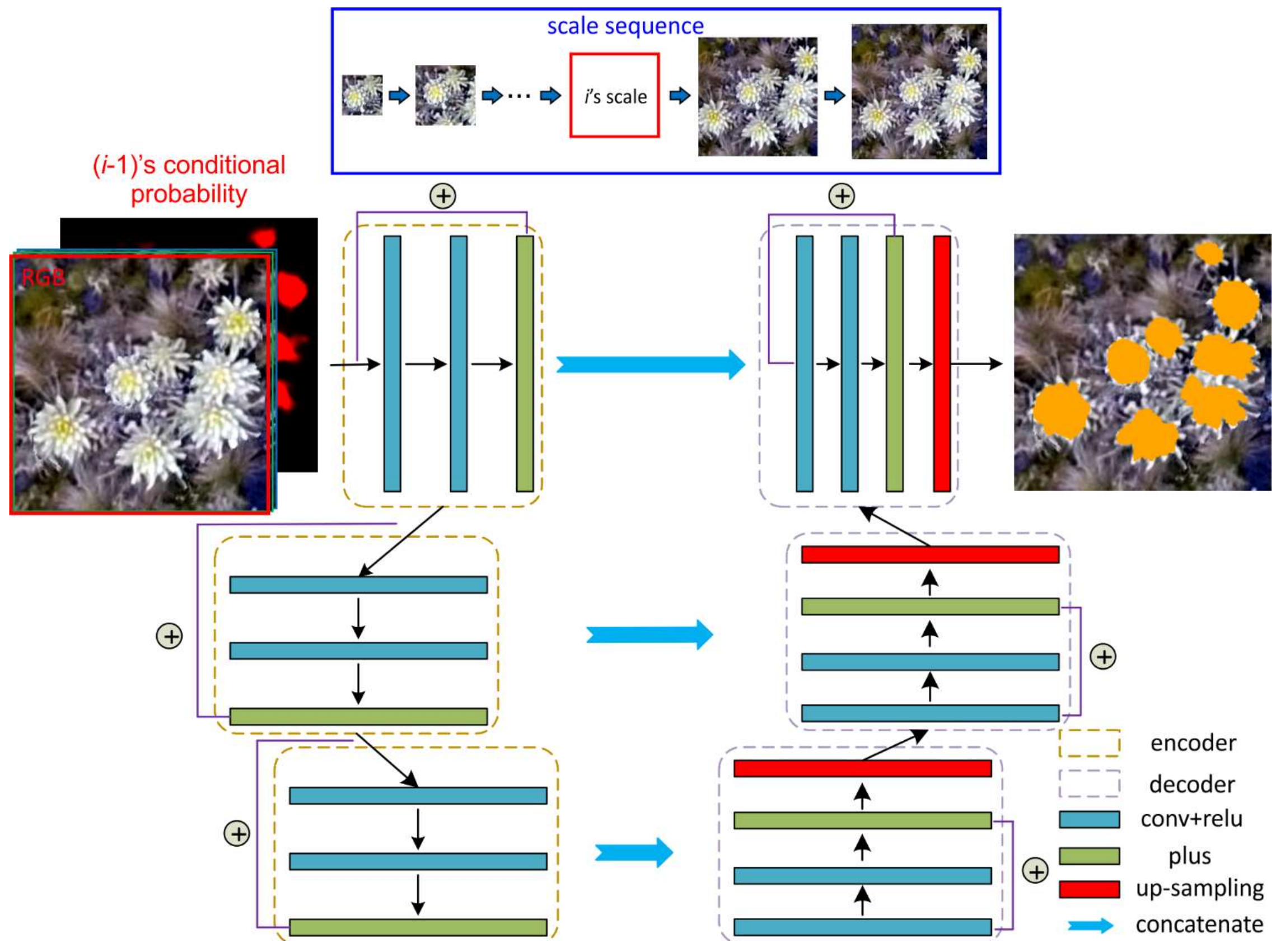
Sunflower



Tomato

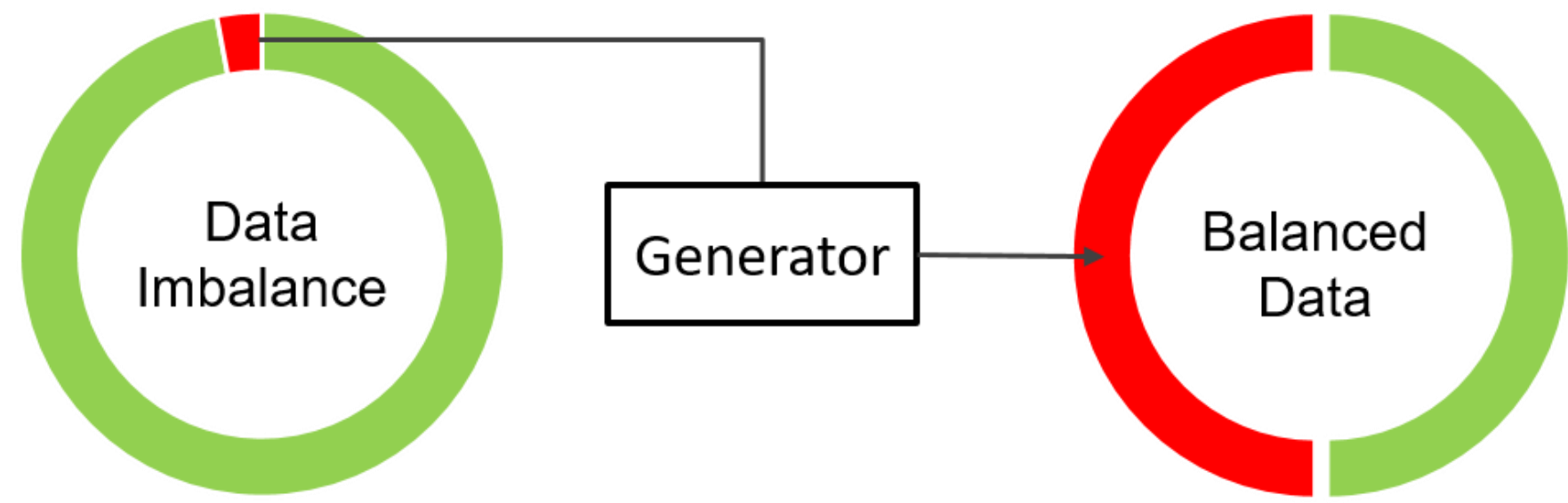
Huapeng Li, **Ce Zhang***, etc. 2020. *International Journal of Applied Earth Observation and Geoinformation*, 87: 102032.
 Huapeng Li, **Ce Zhang***, etc. 2019. *Remote Sensing*, 11(20): 2370.

3. Individual plant identification and mapping using UAV and deep learning

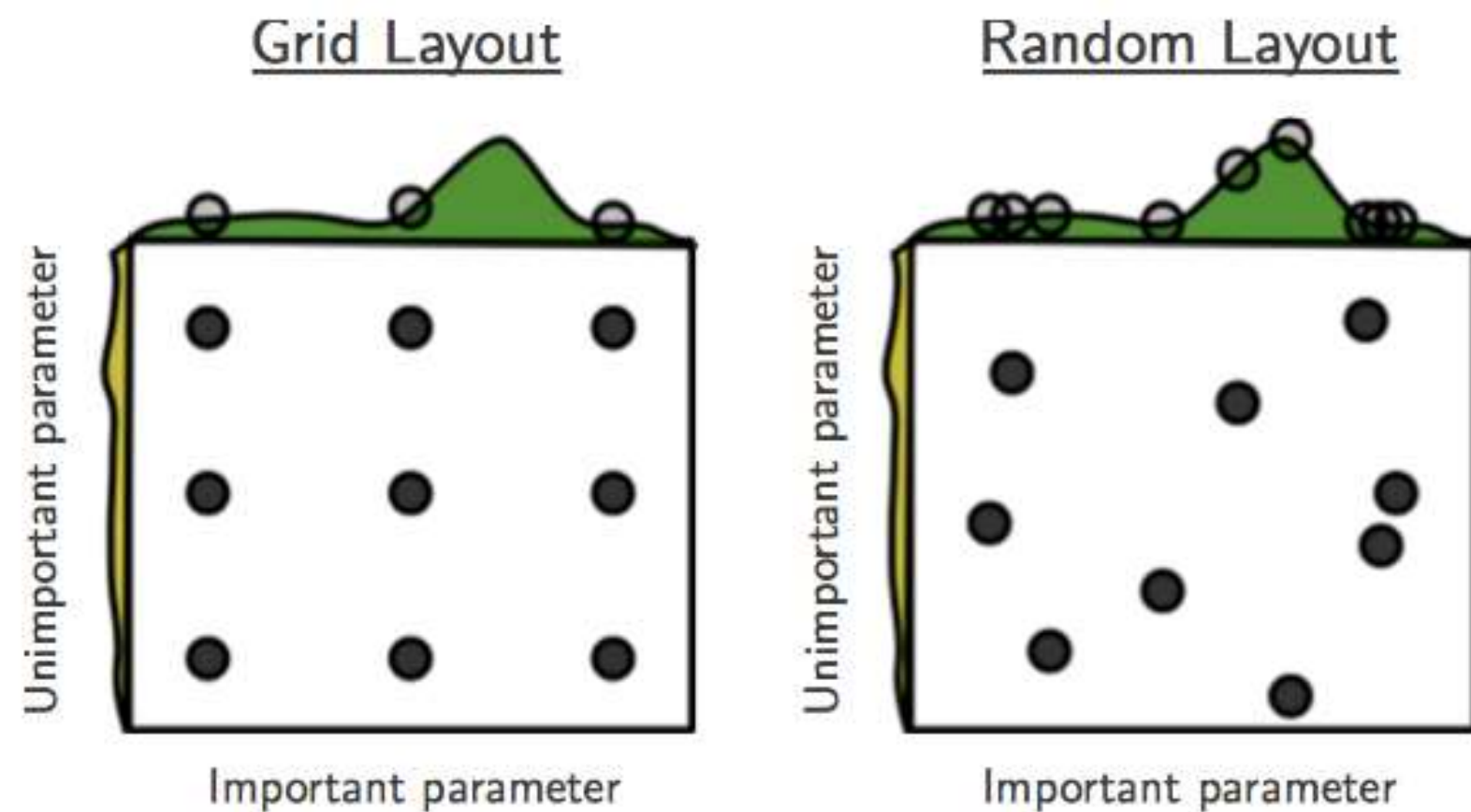


Zhang et al., 2020, Identifying and mapping individual plants in a highly diverse high-elevation ecosystem using UAV imagery and deep learning.

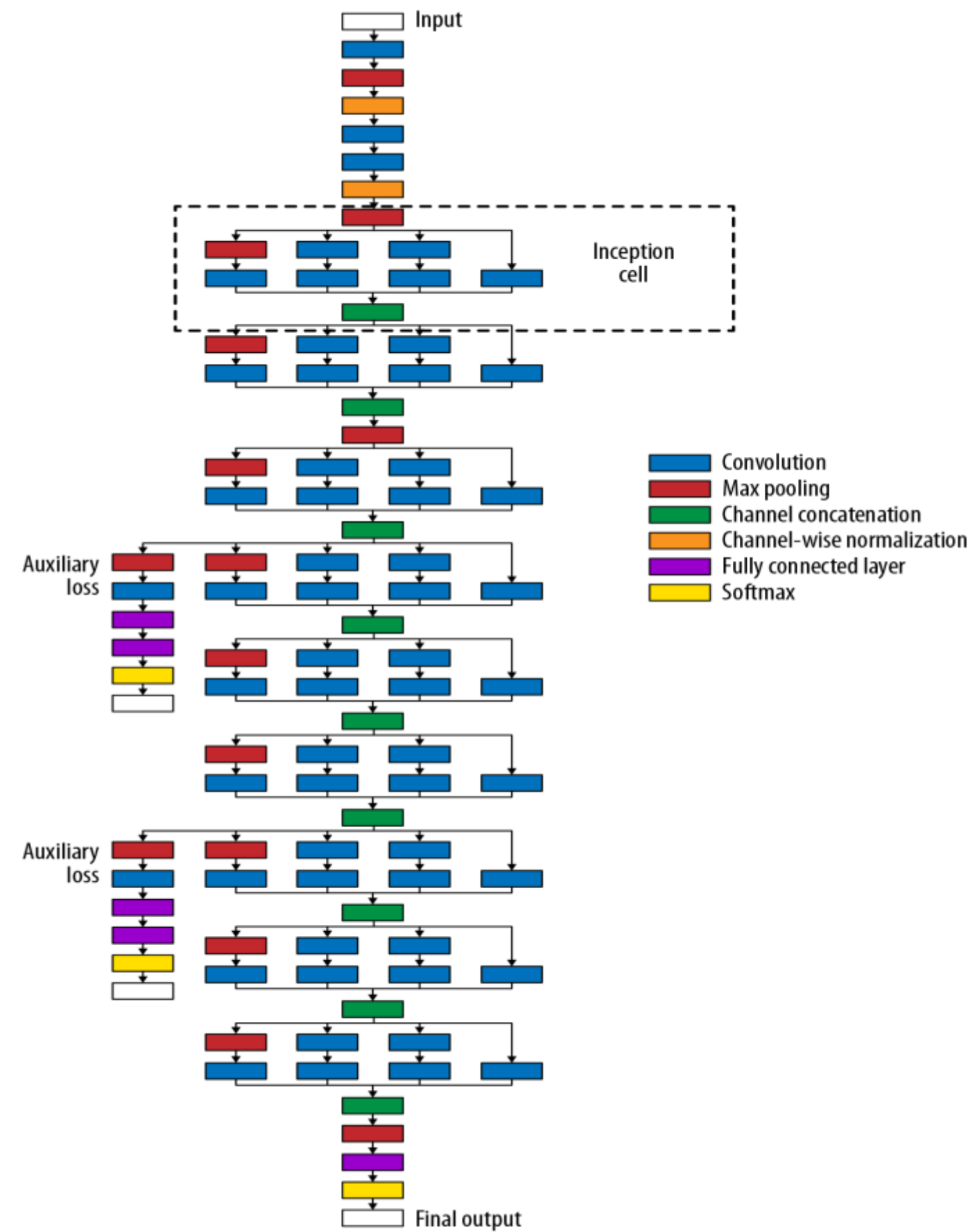
Technical challenges



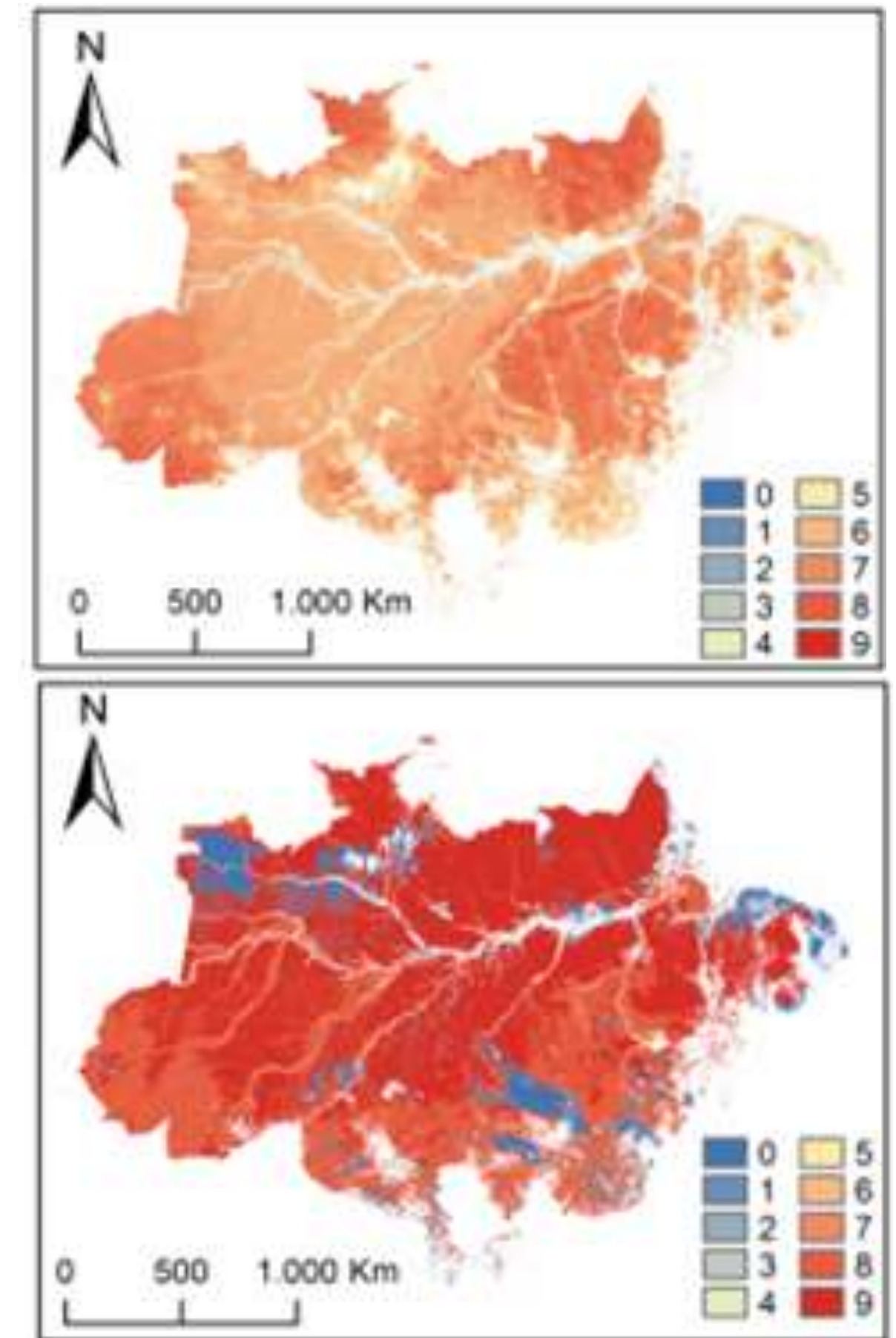
Uncertainty in sample distribution



Uncertainty in hyper-parameter selection



Deep Learning model structure

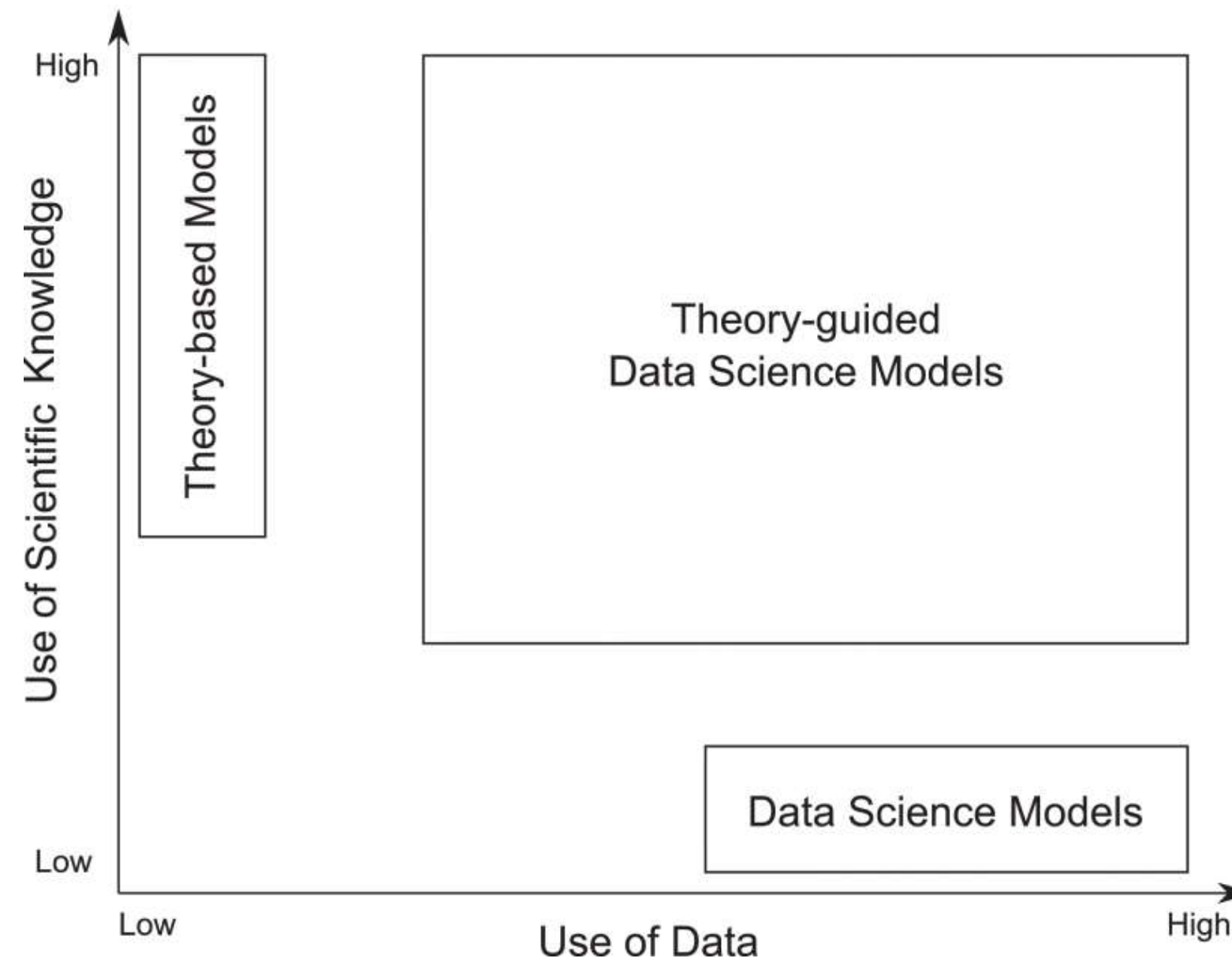


Spatial uncertainty in model prediction

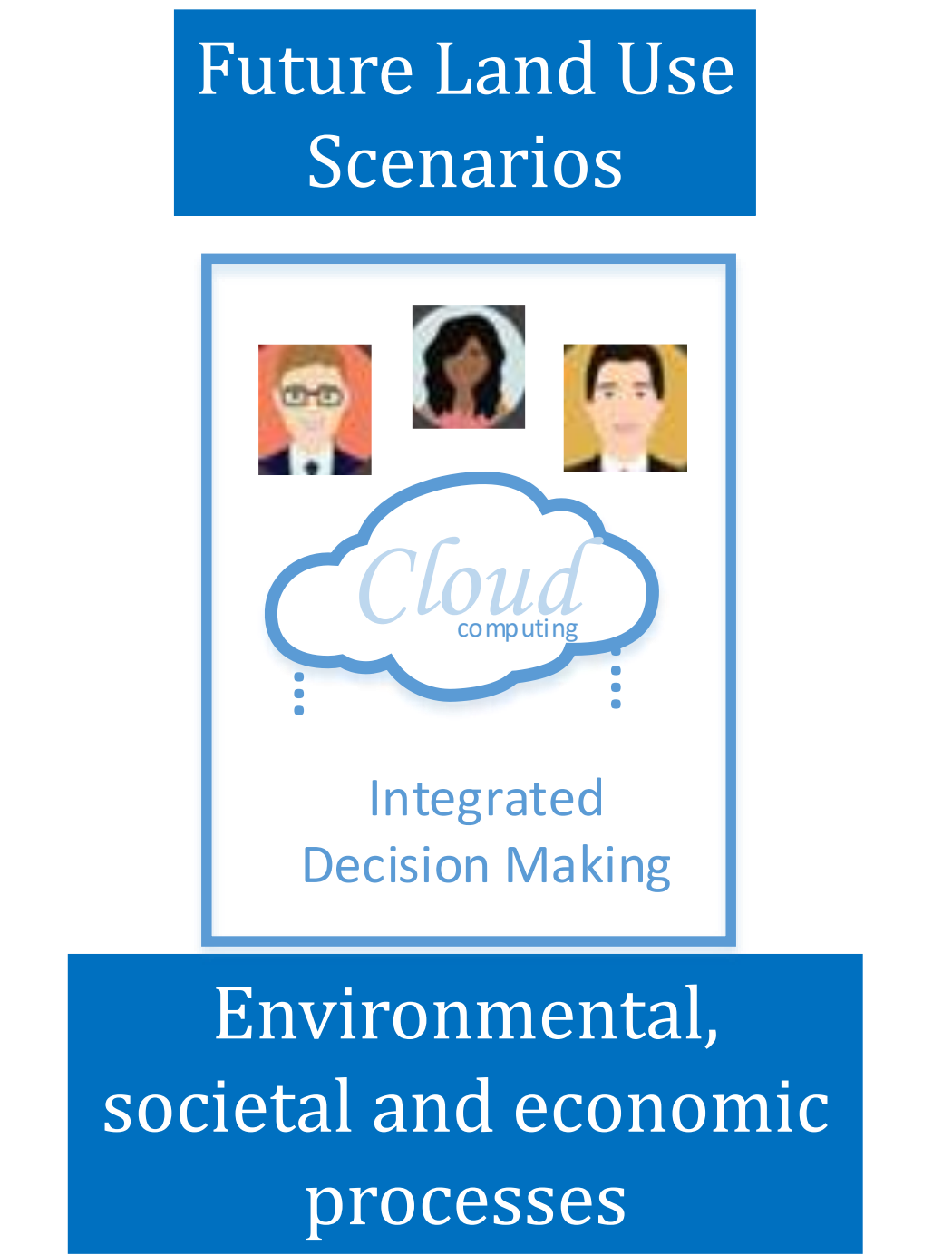
Future directions



Heterogeneous data integration



Domain knowledge and theory guided



Land use decision-making

Conclusion

- **Deep learning** transforms environmental data science
- Current focus mostly on **classification** and pattern recognition
- **Data integration** to leverage environmental big data
- **Domain knowledge** and **theory guided** data science
- Deep Learning for integrated land use **decision-making**

Thank you

Any questions?

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