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Deep learning-based phenology extraction and crop classification in arid oasis using Sentinel-2 time series

Key words: Remote sensing classification; Deep learning; Sentinel-2 imagery; Multi-scale feature fusion; Crop phenology

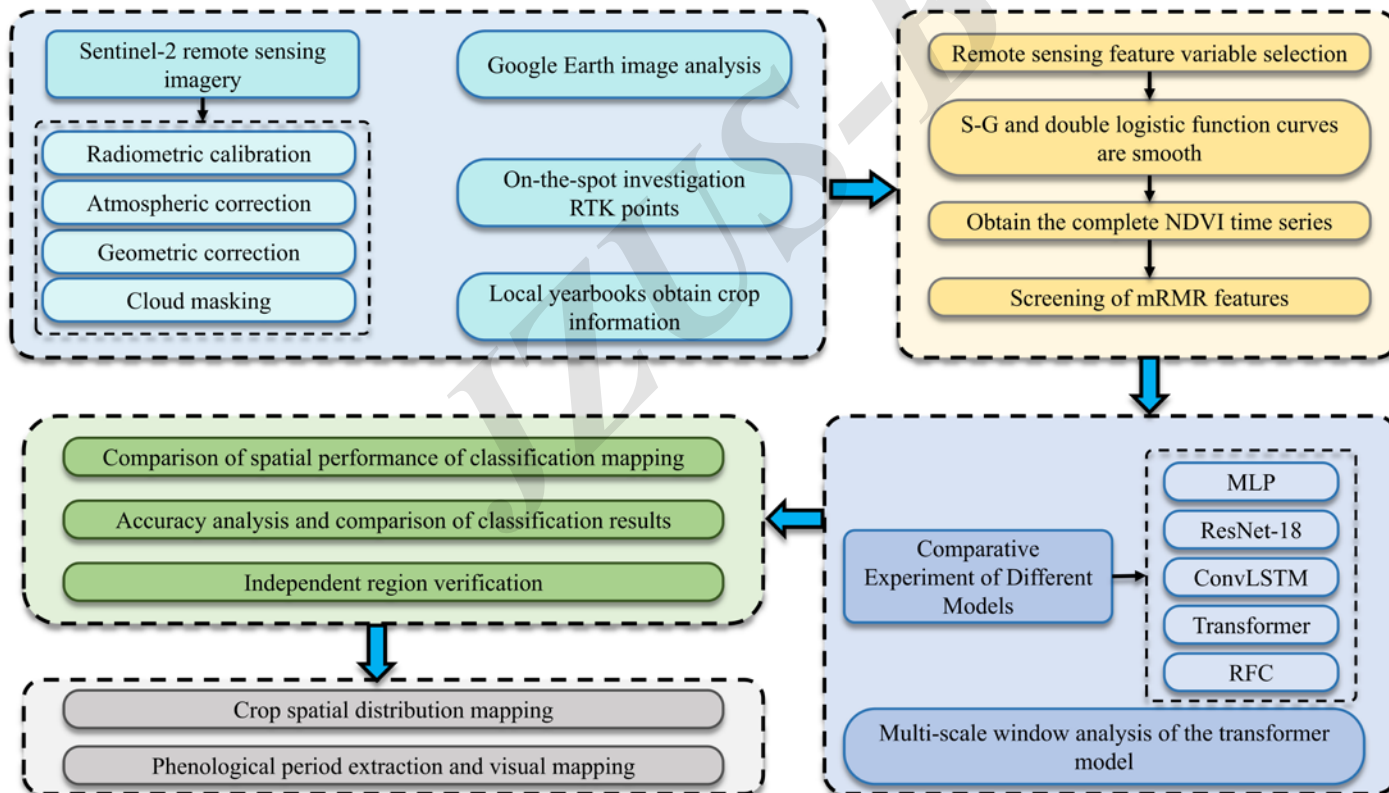
Research Summary

研究背景与意义

- 干旱绿洲地区作物种植结构复杂，精准化管理需求迫切。
- 多时相遥感技术为大规模作物物候识别与分类提供有效手段。

- **数据源：Sentinel-2多时相影像 + 归一化差异植被指数（NDVI）时间序列。**

通过辐射校正、大气校正等步骤处理Sentinel-2遥感影像，并利用Google Earth图像和现场调查等信息获取作物信息。然后，进行遥感特征变量选择，并筛选mRMR特征。接着，通过比较不同分类模型（如MLP、ResNet-18等）和分析卷积性能，最终绘制作物空间分布图和生长周期图。



RTK: Real-Time Kinematic

MLP: Multi-Layer Perceptron

RFC: Random Forest Classifier

NDVI :Normalized Difference Vegetation Index

ResNet-18:Residual Network-18

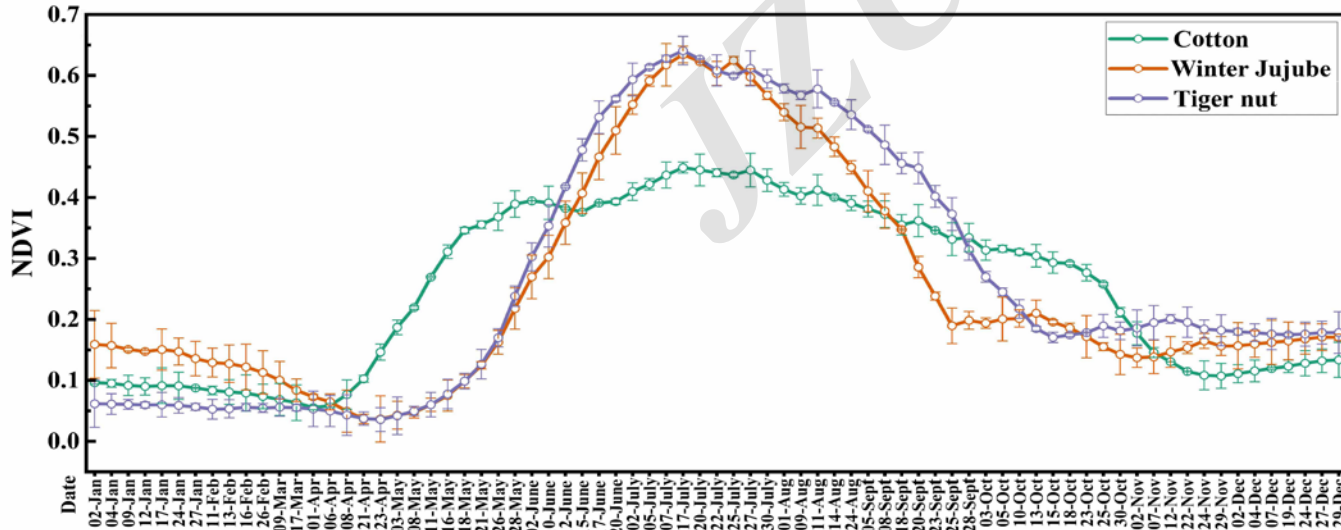
mRMR:Maximum Relevance Minimum Redundancy

ConvLSTM :Convolutional Long Short-Term Memory

Innovation points

Month	Mar.			Apr.			May			June			July			Aug.			Sept.			Oct.		
	Time Range	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid
Cotton				Seeding Stage			Seedling Stage			Flower Bud Formation			Flowering Stage			Boll Setting Stage			Boll Opening Stage					
Winter Jujube				Budding Stage			New Shoot Growth Stage			Flowering Stage			Fruit Setting Stage			Fruit Enlargement Stage			Maturity Stage					
Tiger nut							Tillering Stage			Ear Emergence Stage			Flowering Stage			Pod Formation Stage			Maturity Stage					
Time window				Sowing period			Rapid growth			Vigorous stage			Mature harvest period											

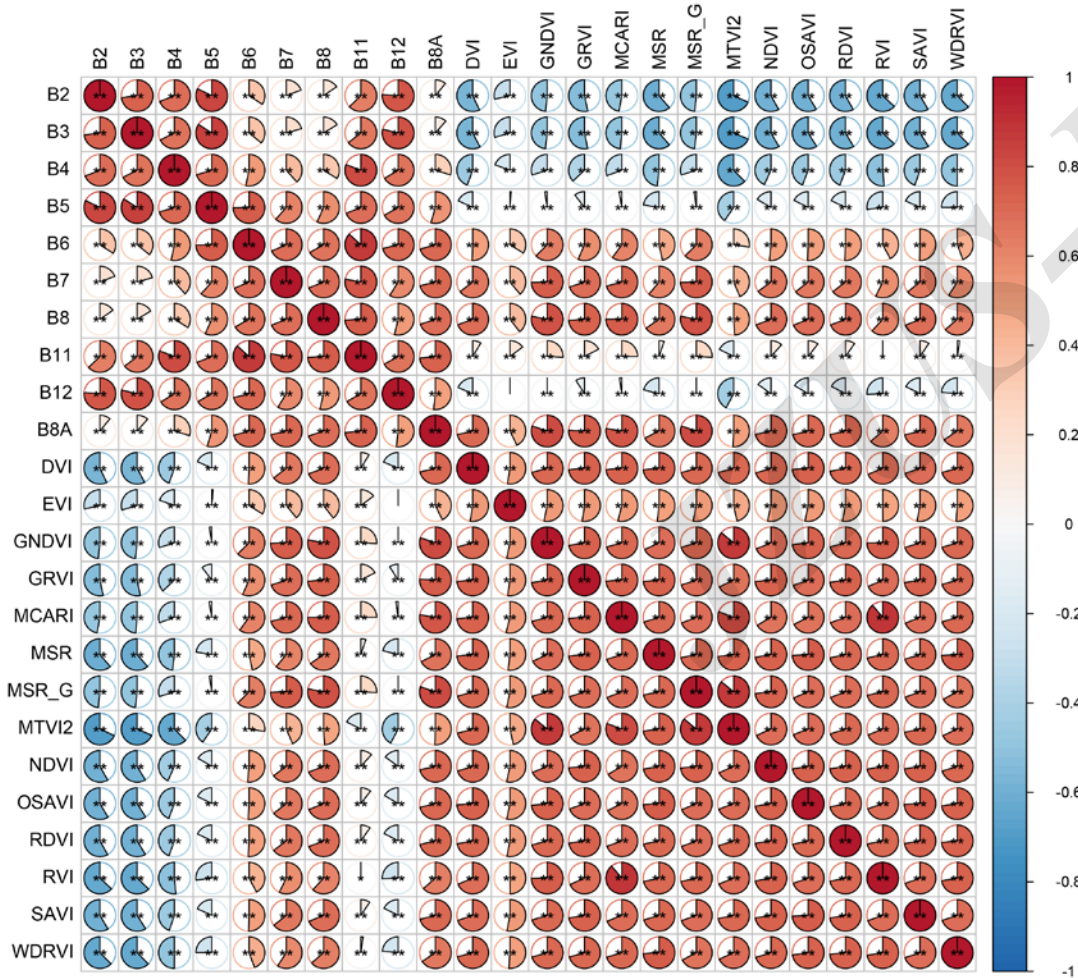
- 研究区内三种主要作物——棉花、冬枣和油莎豆——的物候历和遥感时间窗口。



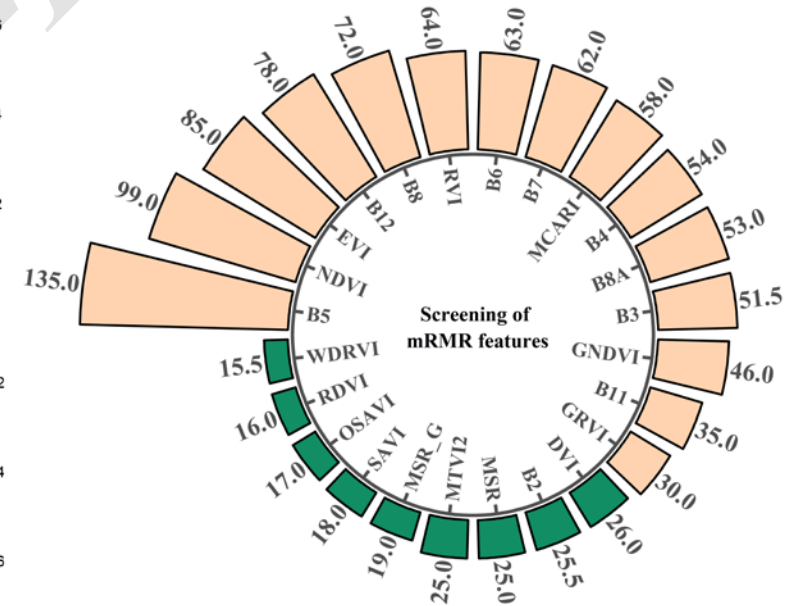
2024年棉花、冬枣和虎坚果的NDVI时间序列曲线，使用 Savitzky-Golay (S-G) 滤波器进行平滑处理。

Innovation points

Sentinel-2光谱波段与植被指数之间的Pearson相关性热图



基于mRMR的输入变量特征重要性排序



Innovation points

实验设计与模型比较

对比模型：MLP、ResNet-18、ConvLSTM、Transformer、RFC在三种作物大面积种植区域分类效果。

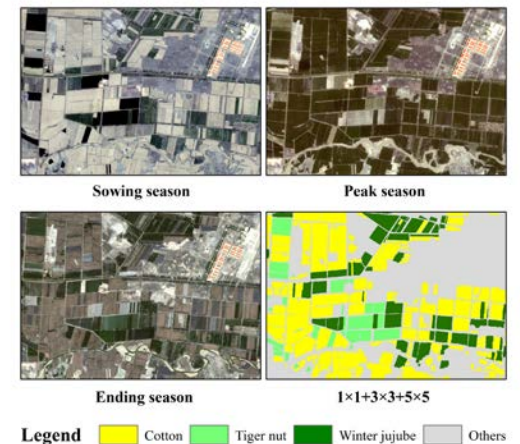
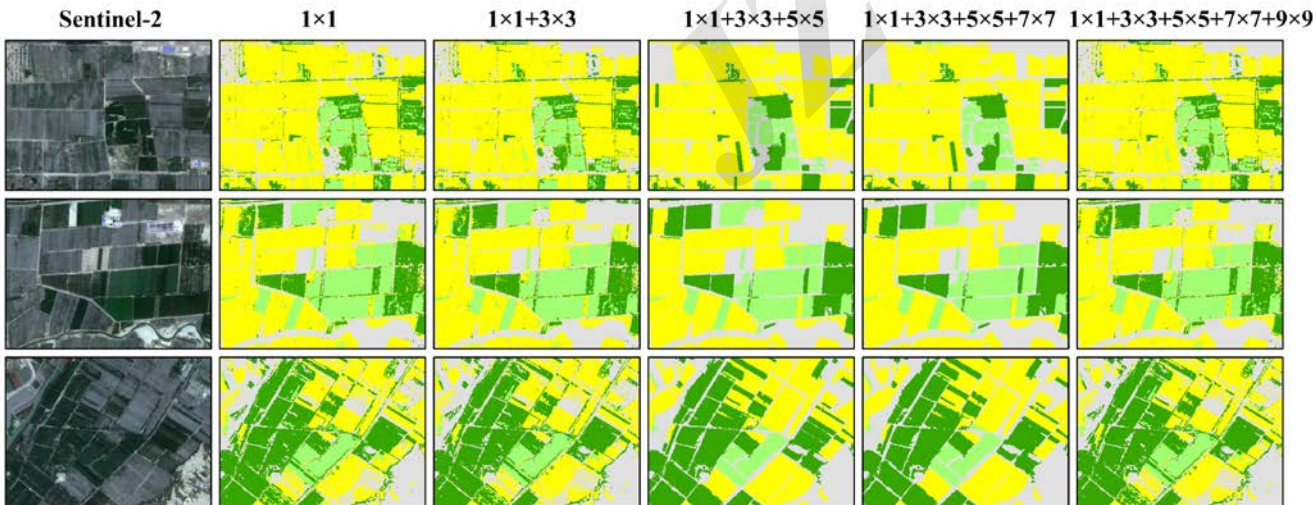
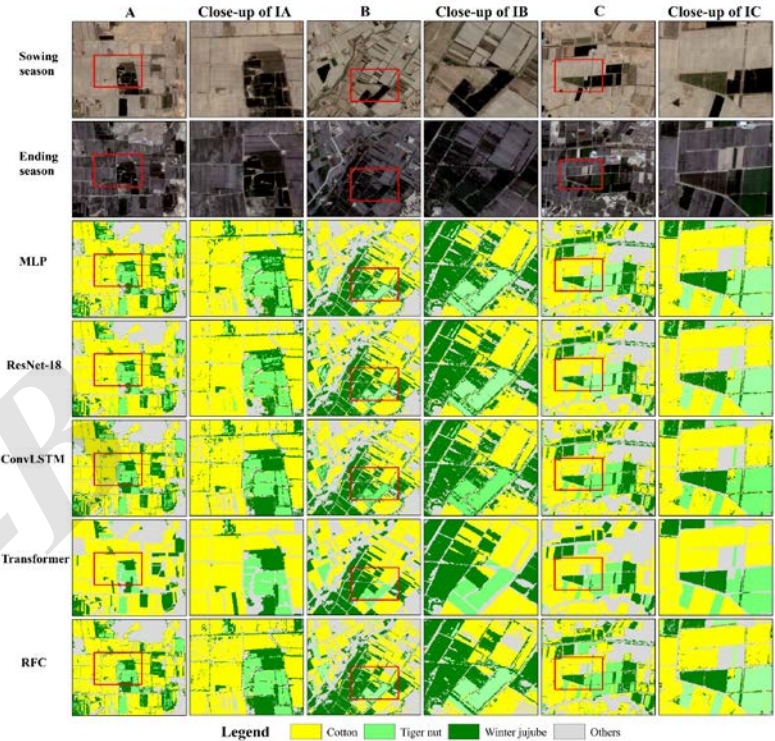
空间优化：通过多尺度窗口进一步优化最优模型（Transformer），确定最佳卷积窗口为 $1 \times 1 + 3 \times 3 + 5 \times 5$ 。并

在独立区域进行验证，验证分类精度：

棉花：F1分数 94.37%

冬枣：F1分数 87.75%

油莎豆：F1分数 86.35%，实验方法具备良好的泛化能力



Legend

- Cotton
- Tiger nut
- Winter jujube
- Others