Mapping Earth's terrestrial change with multi-source data

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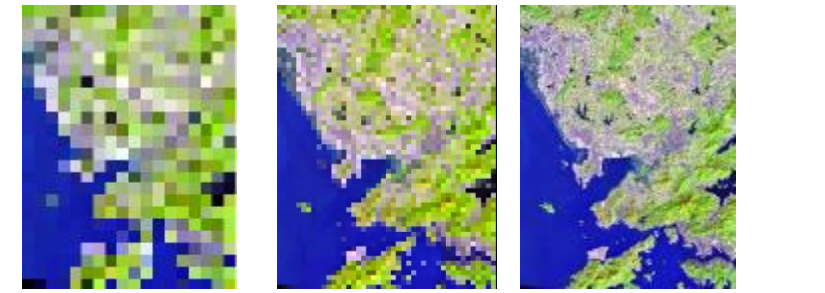
1 Research background

Resolution tradeoffs among Remote Sensing data

Spatial resolution

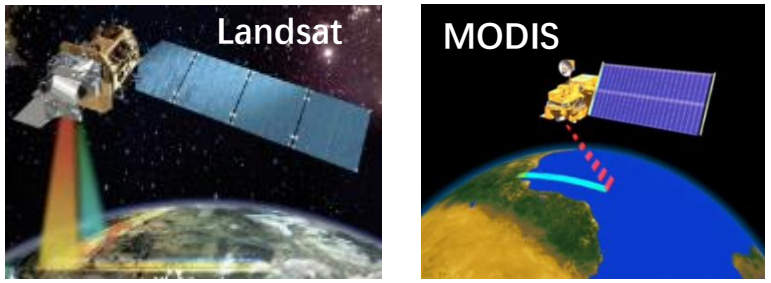
The smallest size of pixel can be differentiated by sensor.



Low (250 m) **Moderate (120 m)** **High (10 m)**

Temporal resolution

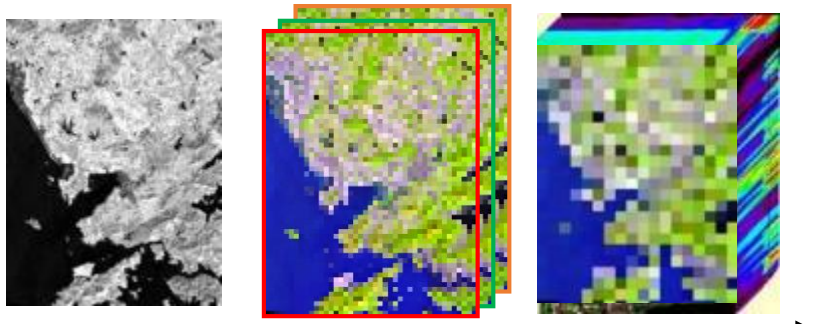
The smallest temporal range of revisiting the same places.



Low (16 days) **High (1 day)**

Spectral resolution

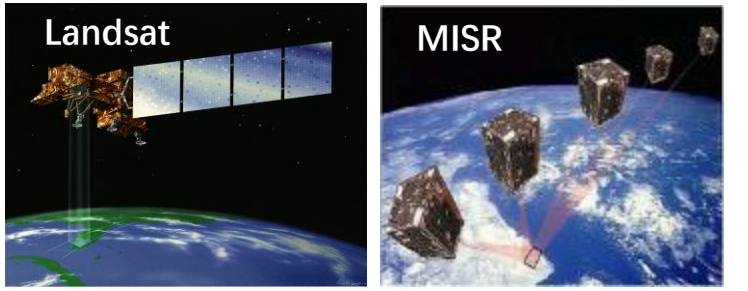
The smallest spectral wavelength can be detected by sensor.



Low **Moderate** **High**

Angular resolution

The ability of multi-angle observations over the same places.



One angle **Multi-angle**

Resolution tradeoffs among Remote Sensing data

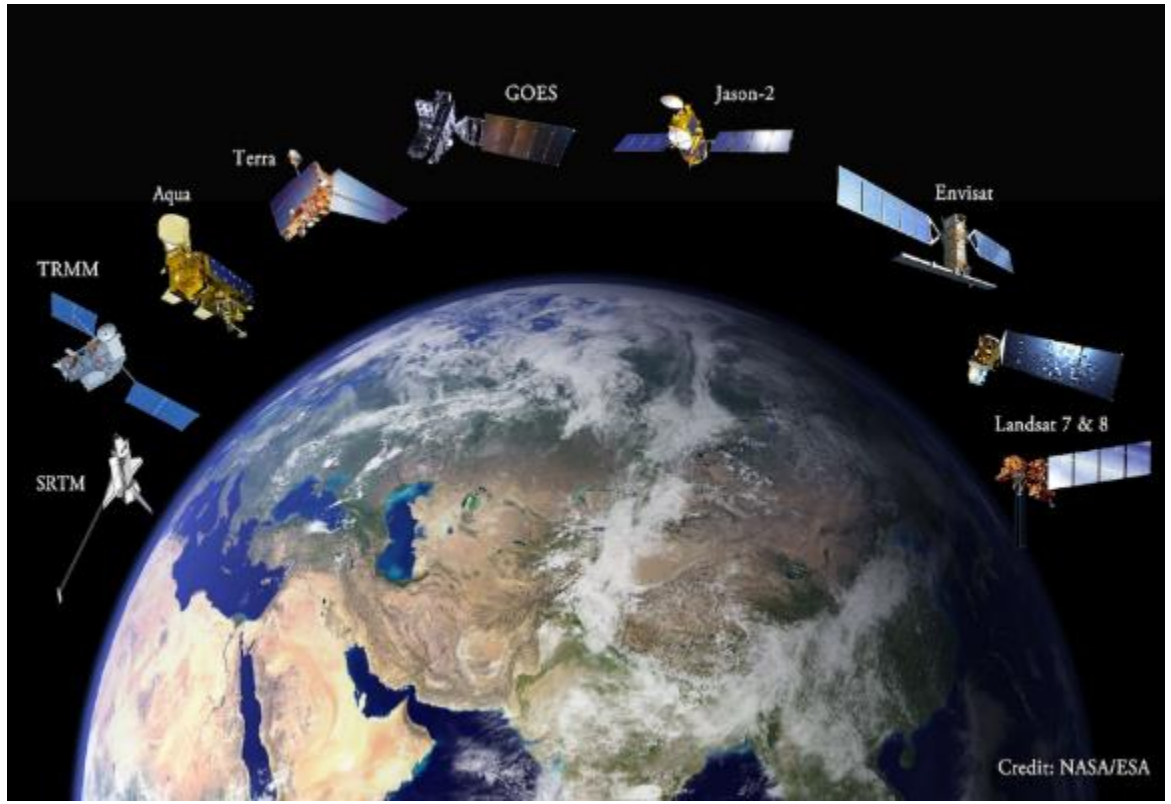
Spatial-temporal-spectral resolutions of representative sensors

Satellite/ Sensor	Band type	Spatial resolution	Temporal resolution	Spectral resolution	Operational period	Access
Worldview	Panchromatic	***	*	*	2007-	Commercial
	Multispectral	***	*	*	2007-	Commercial
Geoeye	Panchromatic	***	*	*	2008-	Commercial
	Multispectral	***	*	*	2008-	Commercial
Quickbird	Multispectral	***	*	*	2001-	Commercial
IKONOS	Panchromatic	***	*	*	1999-	Commercial
	Multispectral	***	*	*	1999-	Commercial
SPOT	Panchromatic	***	*	*	1986-	Commercial
	Multispectral	**	*	*	1986-	Commercial
ALOS	Panchromatic	***	*	*	2006-2011	Commercial
	Multispectral	**	*	*	2006-2011	Commercial
ZY-3	Panchromatic	***	*	*	2012-	Commercial
	Multispectral	**	*	*	2012-	Commercial
Landsat	Panchromatic	**	*	*	1972-	Free
	Multispectral	**	*	*	1972-	Free
ASTER	Multispectral	**	*	*	1999-	Free
Hyperion	Hyperspectral	**	*	***	2000-	Free
HJ-1A/B	Multispectral	**	*	*	2008-	Free
	Hyperspectral	*	*	***	2008-	Free
MERIS	Multispectral	*	*	*	2002-2012	Free
MODIS	Multispectral	*	***	**	2000-	Free
AVHRR	Multispectral	*	***	*	1982-2000	Free
SPOT-VGT	Multispectral	*	***	*	1998-	Free
GOES	Multispectral	*	***	*	1975-	Free

- **Tradeoff among spatial-, temporal-, spectral- and angular resolutions in sensors' design.**
- **Researchers and users often use the data they can get, not the data they truly need.**
- **The effective utilization of remote sensing big data is continuously low.**

Spatial	**High*** (<5m)**	**Medium** (5-30m)**	**Low* (>30m)**
Temporal	**High*** (<3 days)**	**Medium** (3-15 days)**	**Low* (>15 days)**
Spectral	**High*** (>100 bands)**	**Medium** (20-100 bands)**	**Low* (<20 bands)**

Motivations and scientific questions?



- How to better blend multi-source remotely sensed data to produce synthetic fusions with fine resolutions?
- How to incorporate these advanced techniques into practical applications to better perform dynamic monitoring of our planet?

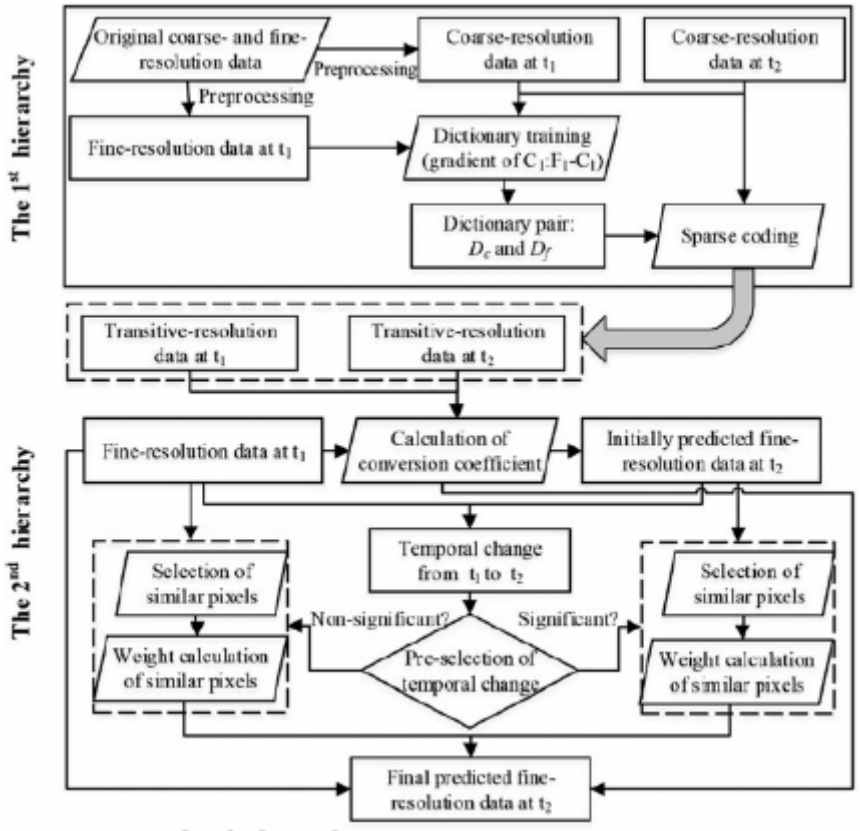
2 Related works

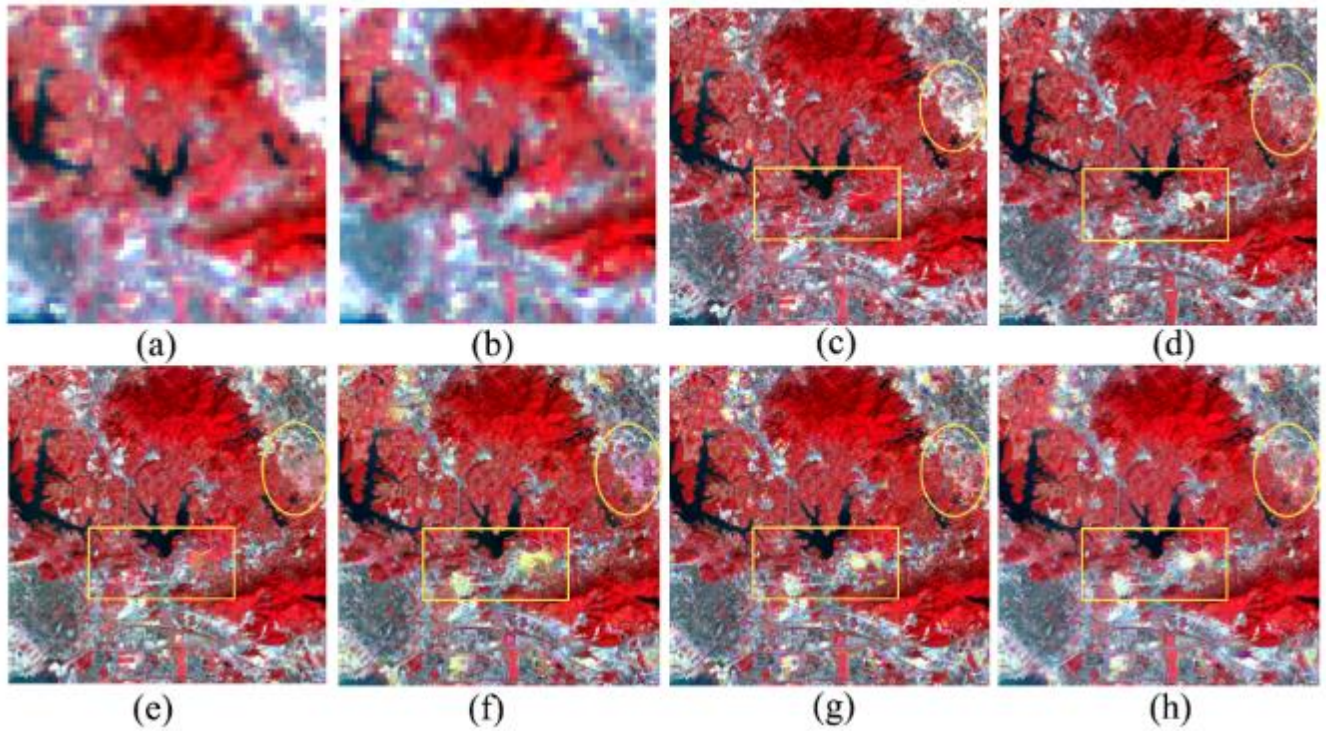
(a) Spatial-temporal fusion

INTERNATIONAL JOURNAL OF DIGITAL EARTH, 2016
http://dx.doi.org/10.1080/17538947.2016.1235621

A hierarchical spatiotemporal adaptive fusion model using one image pair

Bin Chen[a], Bo Huang[b] and Bing Xu[a,c,d]



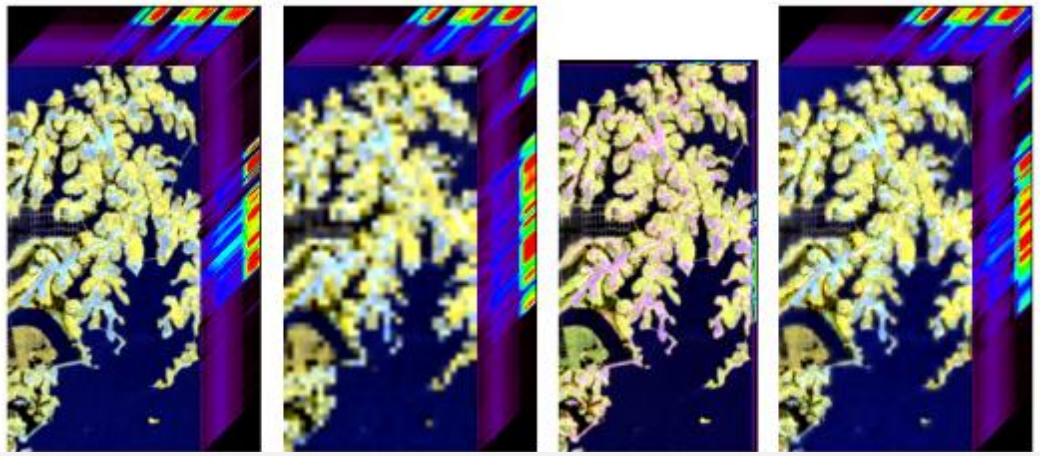


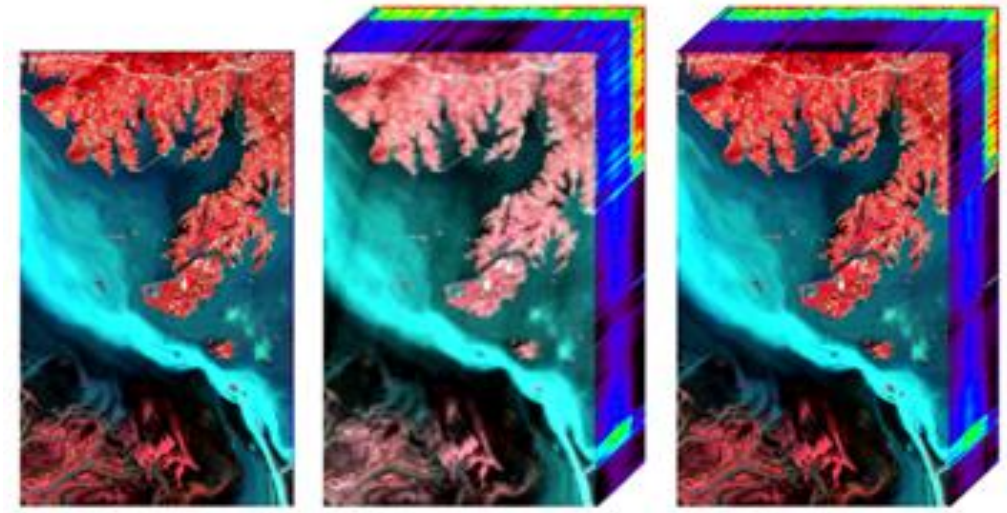
Models	R^2			AAD			RMSE		
	Green	Red	NIR	Green	Red	NIR	Green	Red	NIR
STARFM	0.7022	0.6690	0.7925	0.0102	0.0153	0.0164	0.0163	0.0249	0.0244
FSDAF	0.6909	0.6834	0.7733	0.0103	0.0144	0.0170	0.0163	0.0235	0.0248
SP-One	0.7475	0.7914	0.8495	0.0090	0.0116	0.0134	0.0145	0.0191	0.0200
HSTAFM	**0.7576**	**0.7994**	**0.8510**	**0.0087**	**0.0114**	**0.0128**	**0.0139**	**0.0185**	**0.0200**

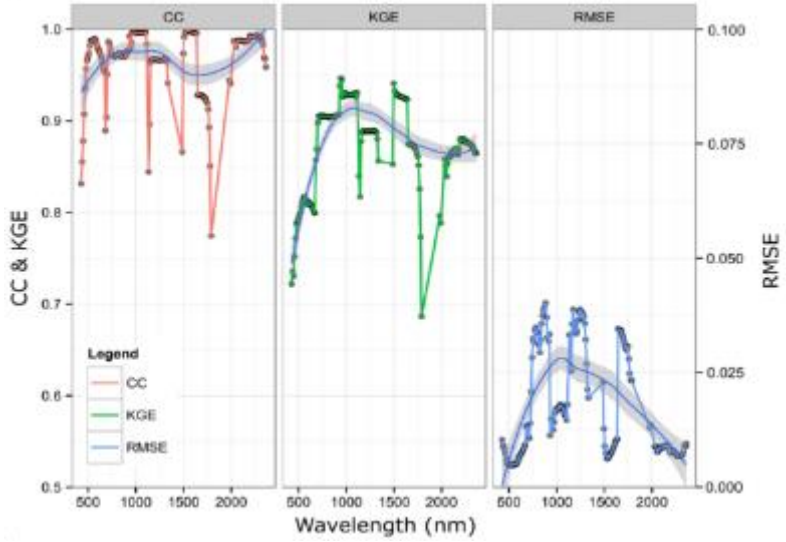
Note: The bold values represent the best accuracy performance.

Machine-learning/Sparse representation theory and **physical terrestrial change process**

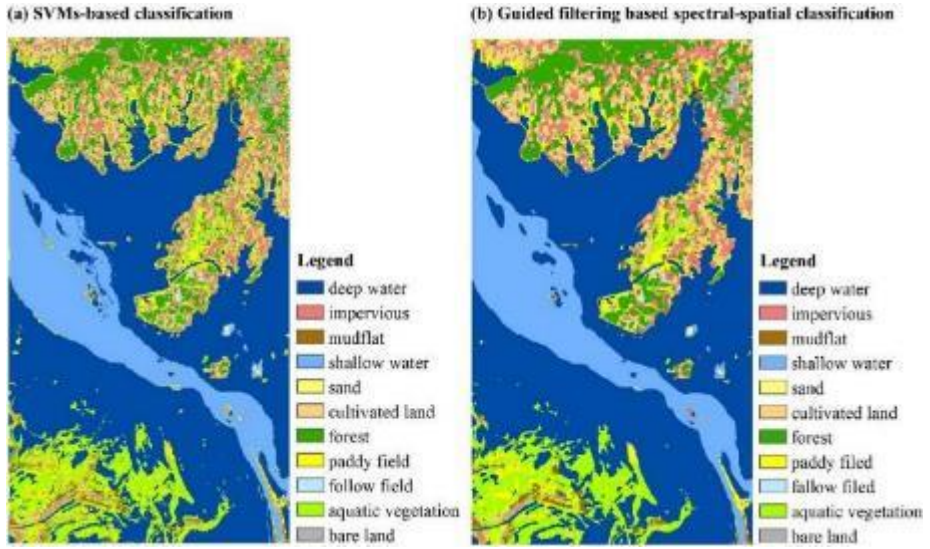
(b) Spatial-hyperspectral fusion model





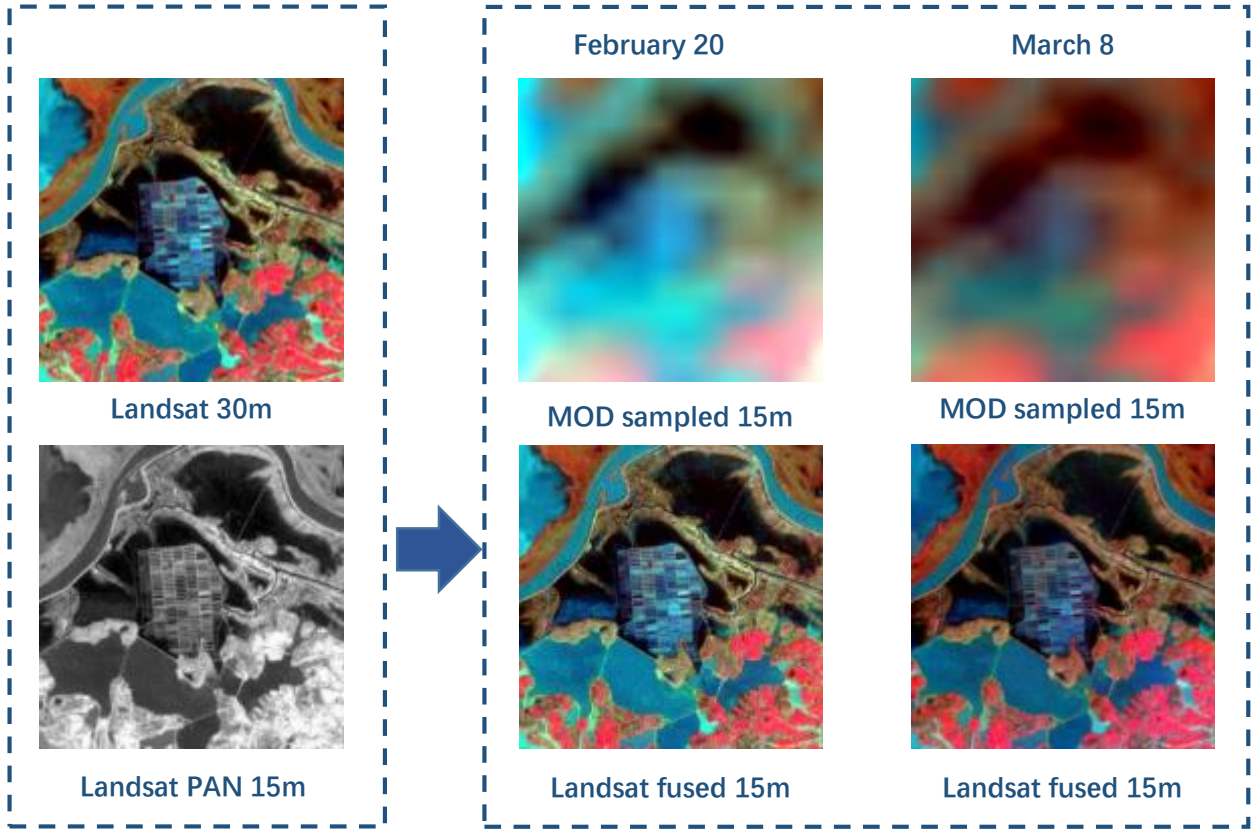


Fusion accuracy assessment

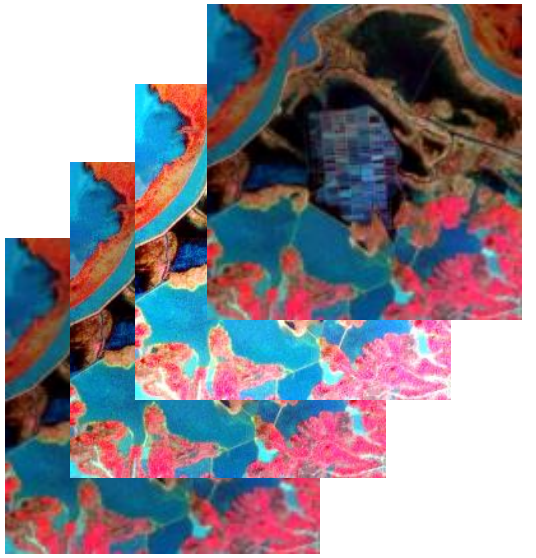


Chen B., Chen L., Lu M. and Xu B. (2016) Wetland mapping by fusing fine spatial and hyperspectral resolution images. *Ecological Modelling.*

(c) Spatial-temporal-spectral fusion model



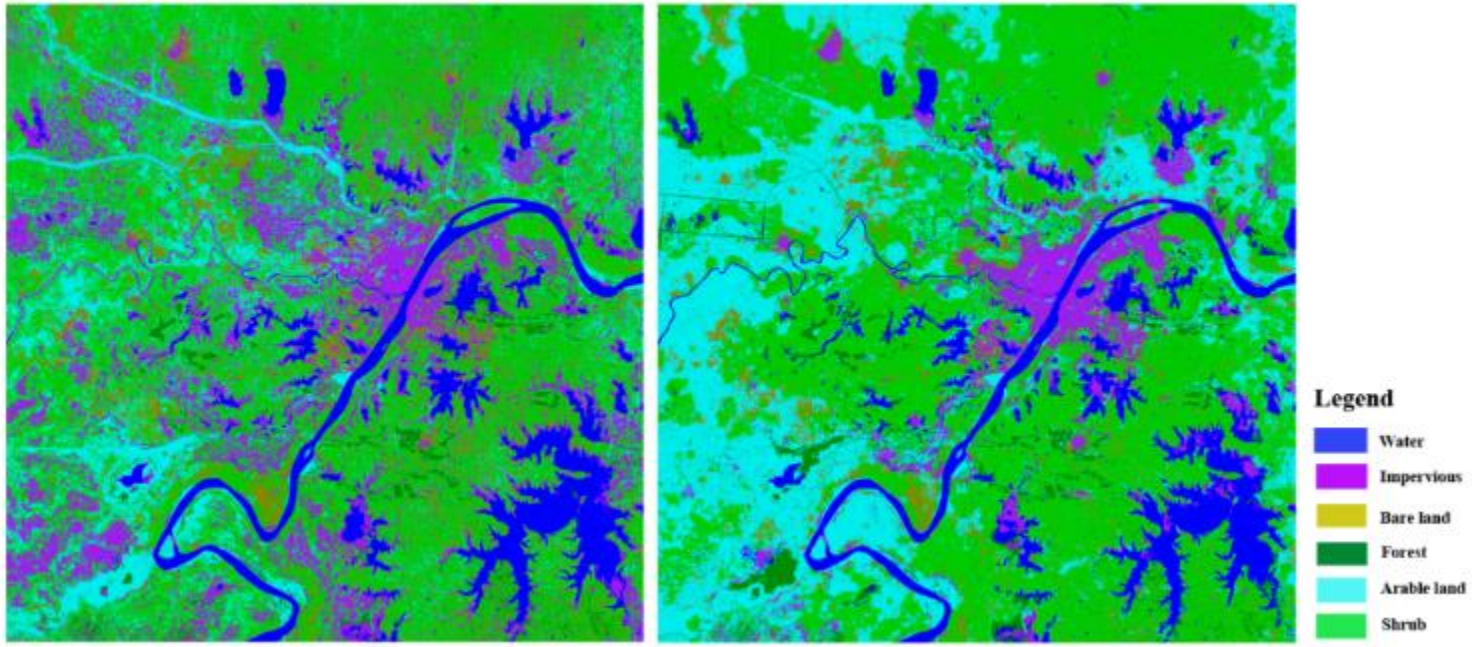
Spatial-temporal-spectral fusion



Daily 15-m Landsat-like synthetic images

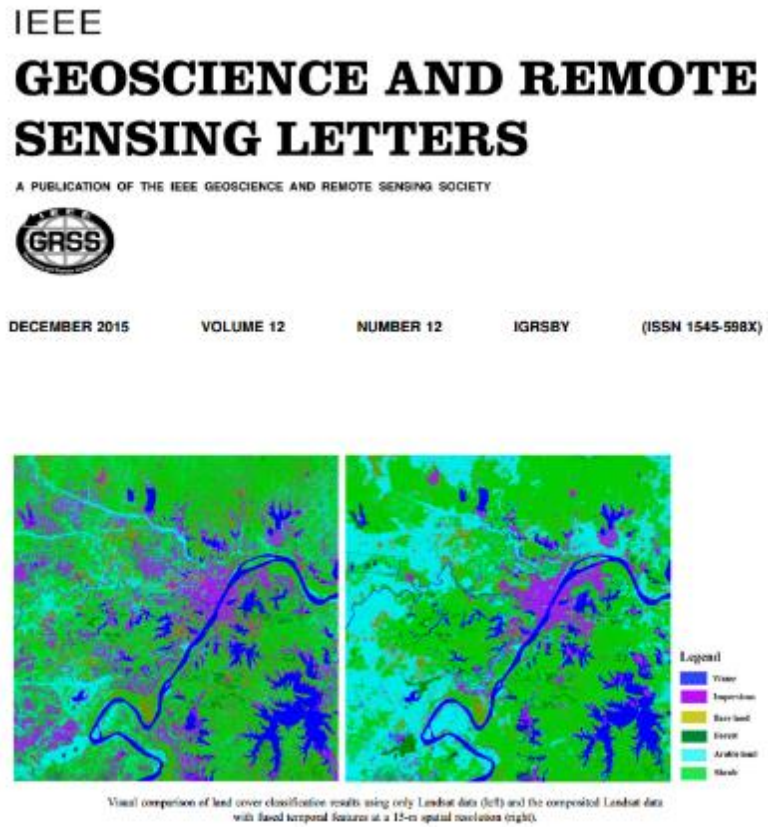
Chen B. and Xu B., "A unified spatial-spectral-temporal fusion model using Landsat and MODIS imagery," International Workshop on Earth Observation and Remote Sensing Applications (EORSA), pp.256-260, 11-14 June 2014. doi: 10.1109/EORSA.2014.6927890. (**Best Student Paper Award**)

(c) Spatial-temporal-spectral fusion model



(left) Classification result derived from ETM+ (right) Classification result derived from fused ETM+ series

Overall accuracy： 87.8 %	Overall accuracy： 92.6 %
Kappa coefficient： 0.85	Kappa coefficient： 0.91

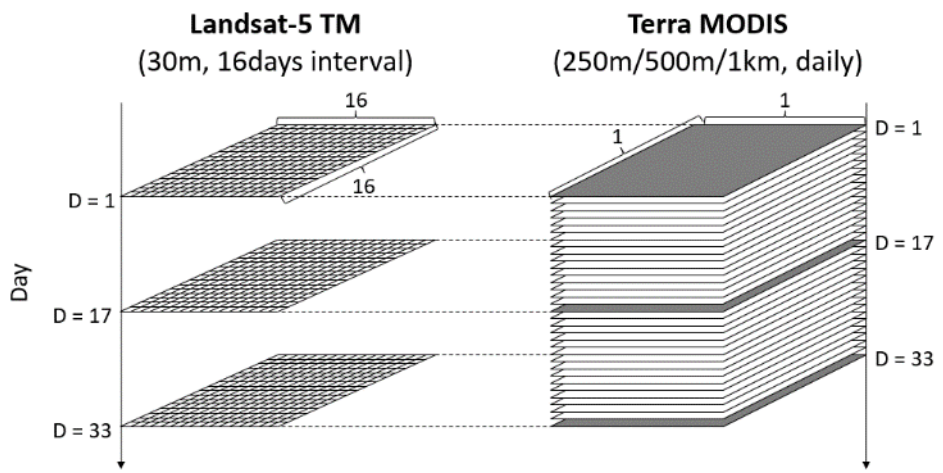


IEEE GRSL Front Cover

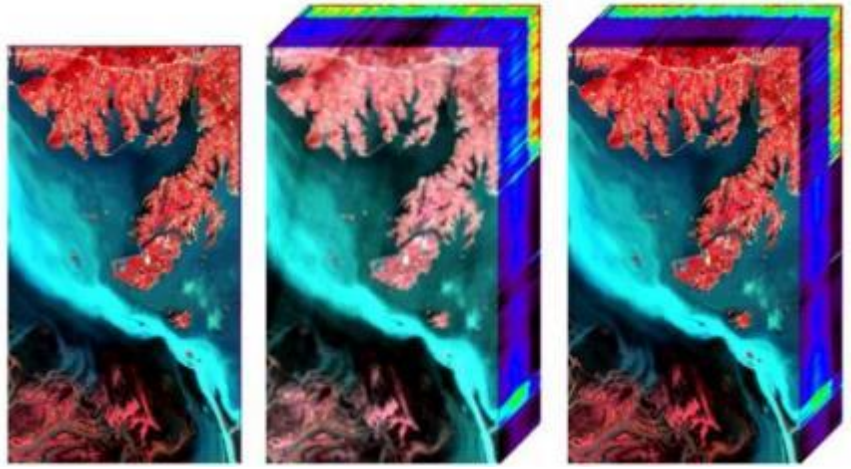
Chen B., Huang B. and Xu B., Fine land cover classification using daily synthetic Landsat-like images at 15-m spatial resolution. *IEEE Geoscience and Remote Sensing Letters*. 2015, 12(12):2359-2363. (**Issue Front Cover Paper**)

(d) Multi-source data fusion

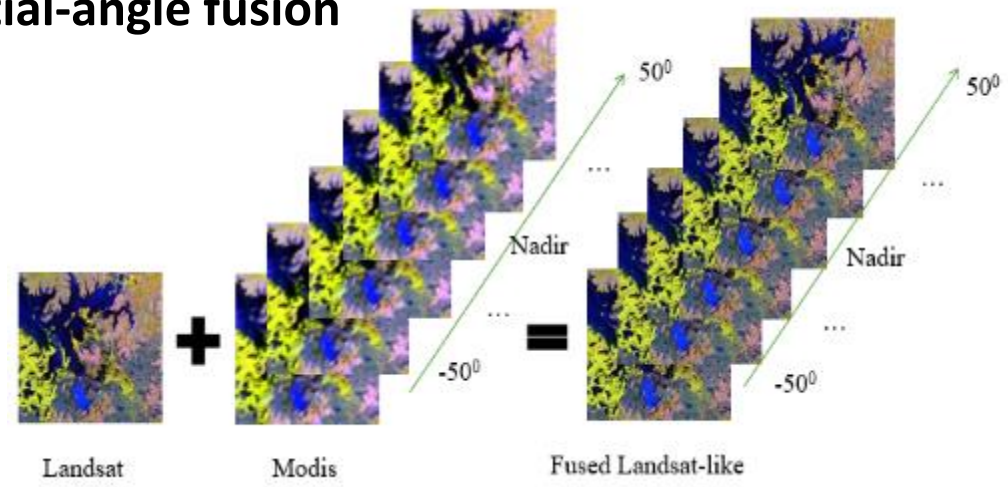
Spatial-temporal fusion

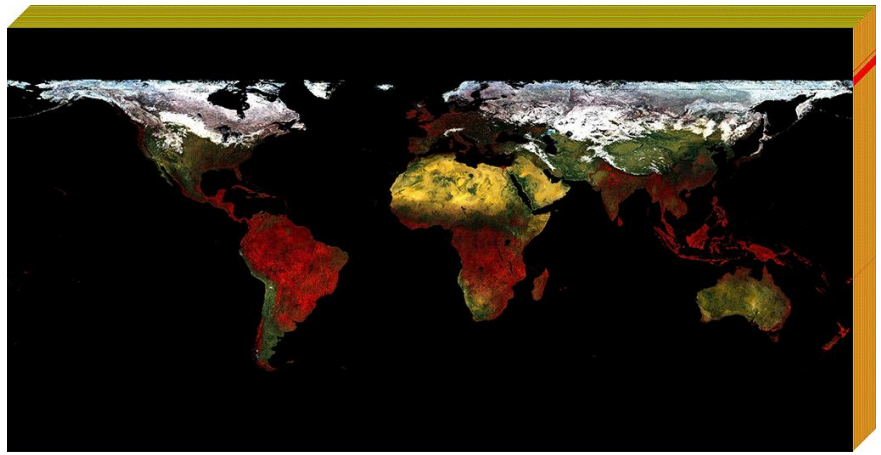


Spatial-hyperspectral fusion

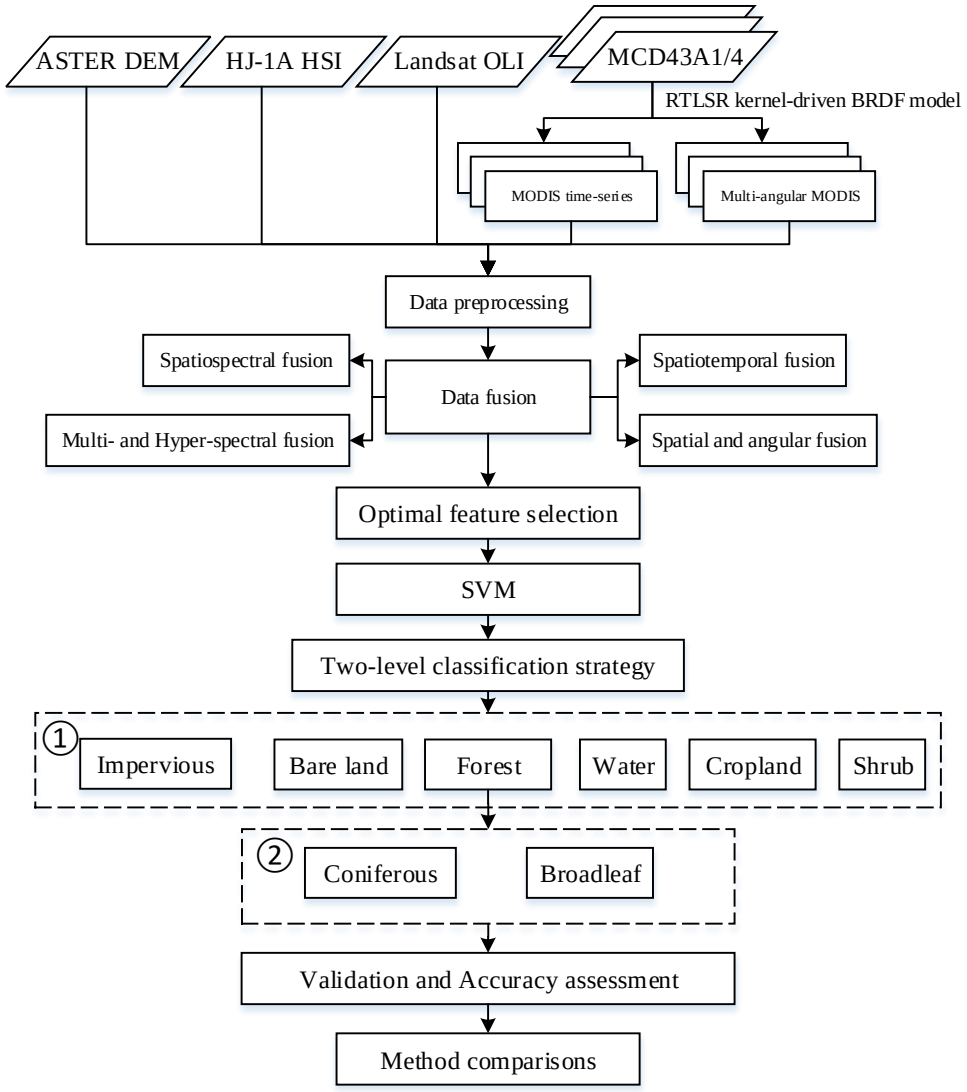


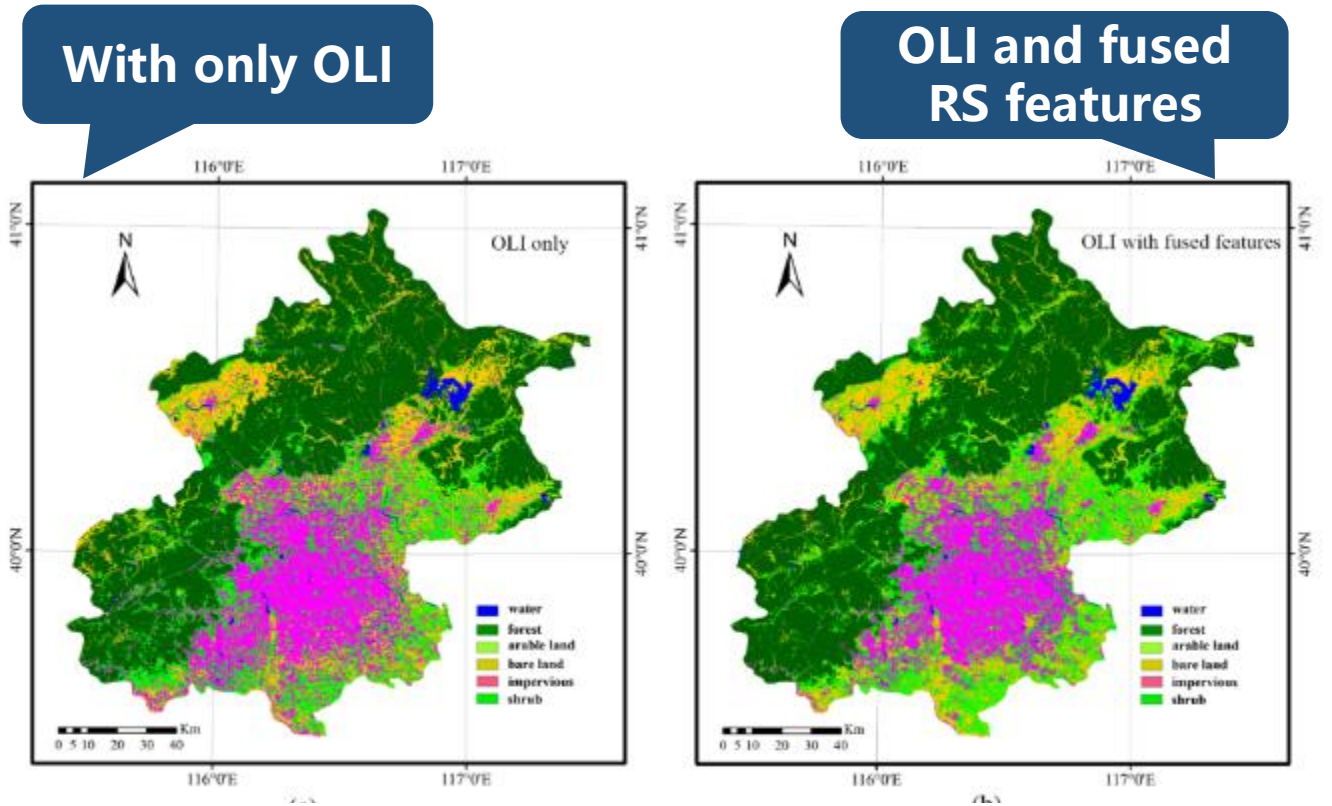
Spatial-angle fusion





Applications: Land cover classification





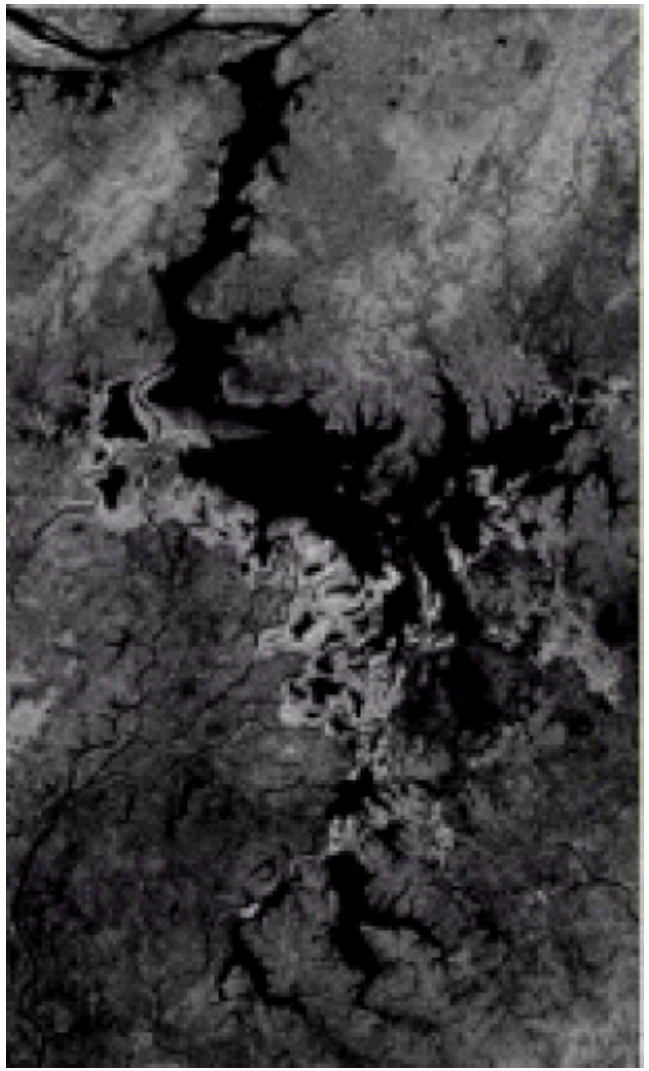
(1) Overall accuracy: 87.78%; and kappa coefficient: 0.84.

(2) Overall accuracy: 92.31%; and kappa coefficient: 0.90.

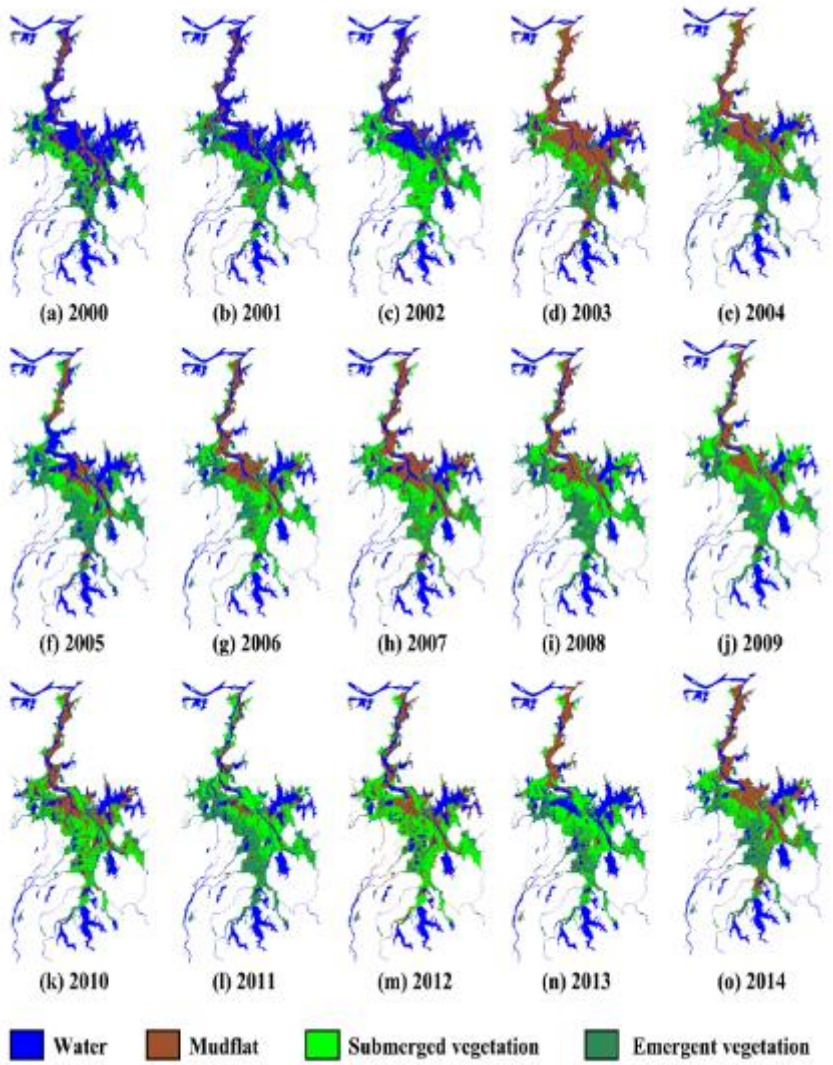
Temporal feature → **Angular feature** → **Topographic feature**

Chen B., Huang B. and Xu B., Multi-source remotely sensed data fusion for improving land cover classification. *ISPRS Journal of Photogrammetry and Remote Sensing*. DOI: 10.1016/j.isprsjprs.2016.12.008.

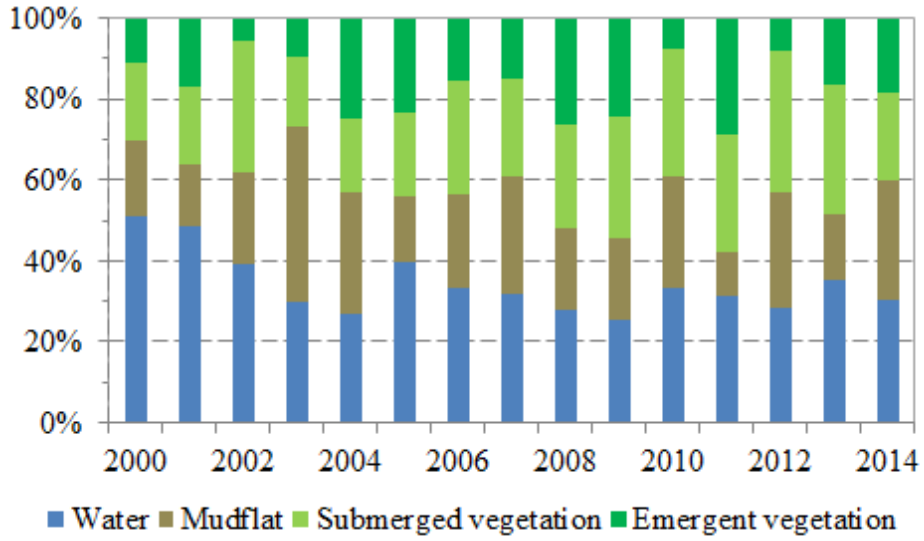
Applications: Dynamic monitoring of wetland



2000-2014 (342 scenes)



Spatiotemporal change of four wetland covers (2000-2014)

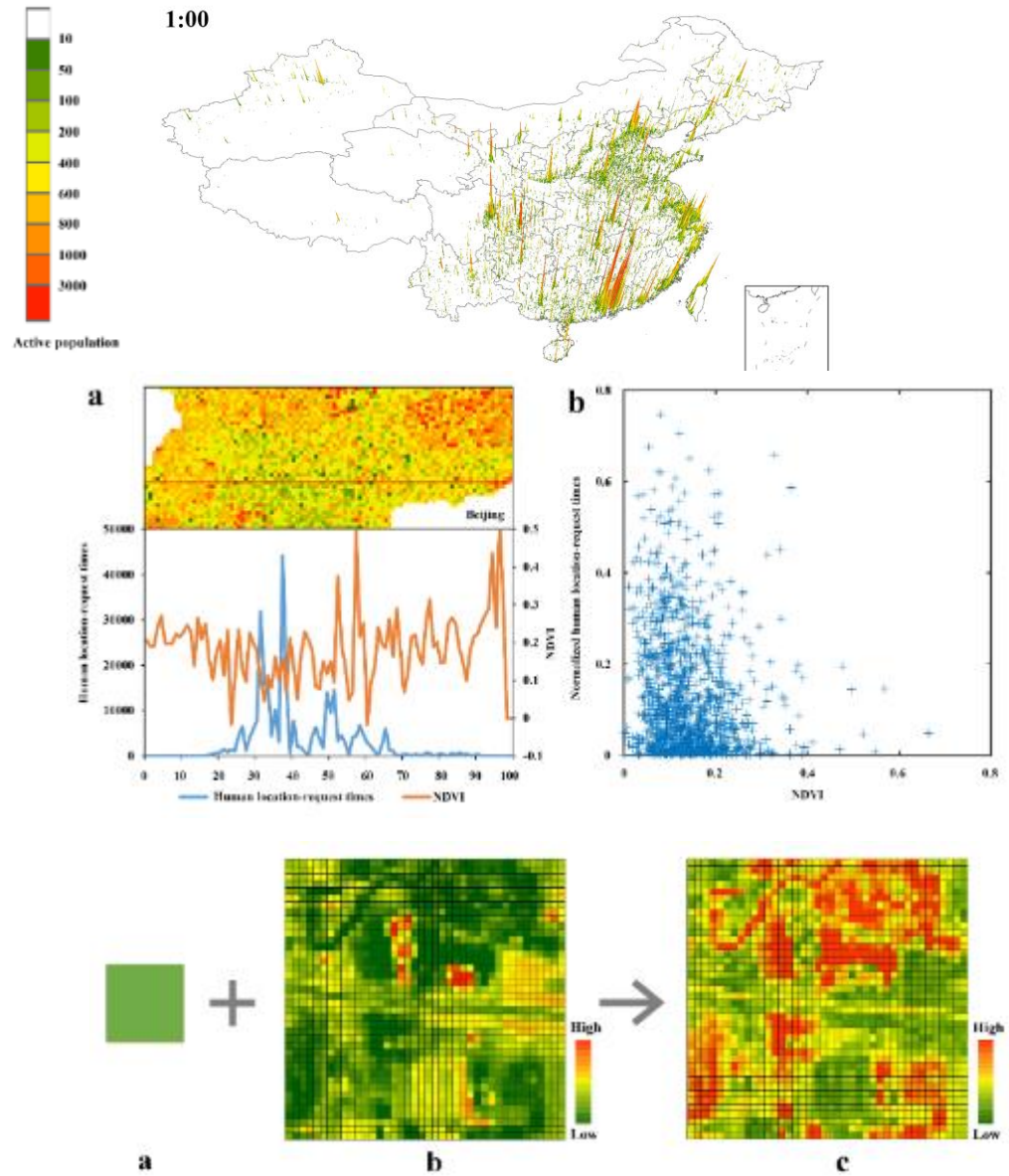


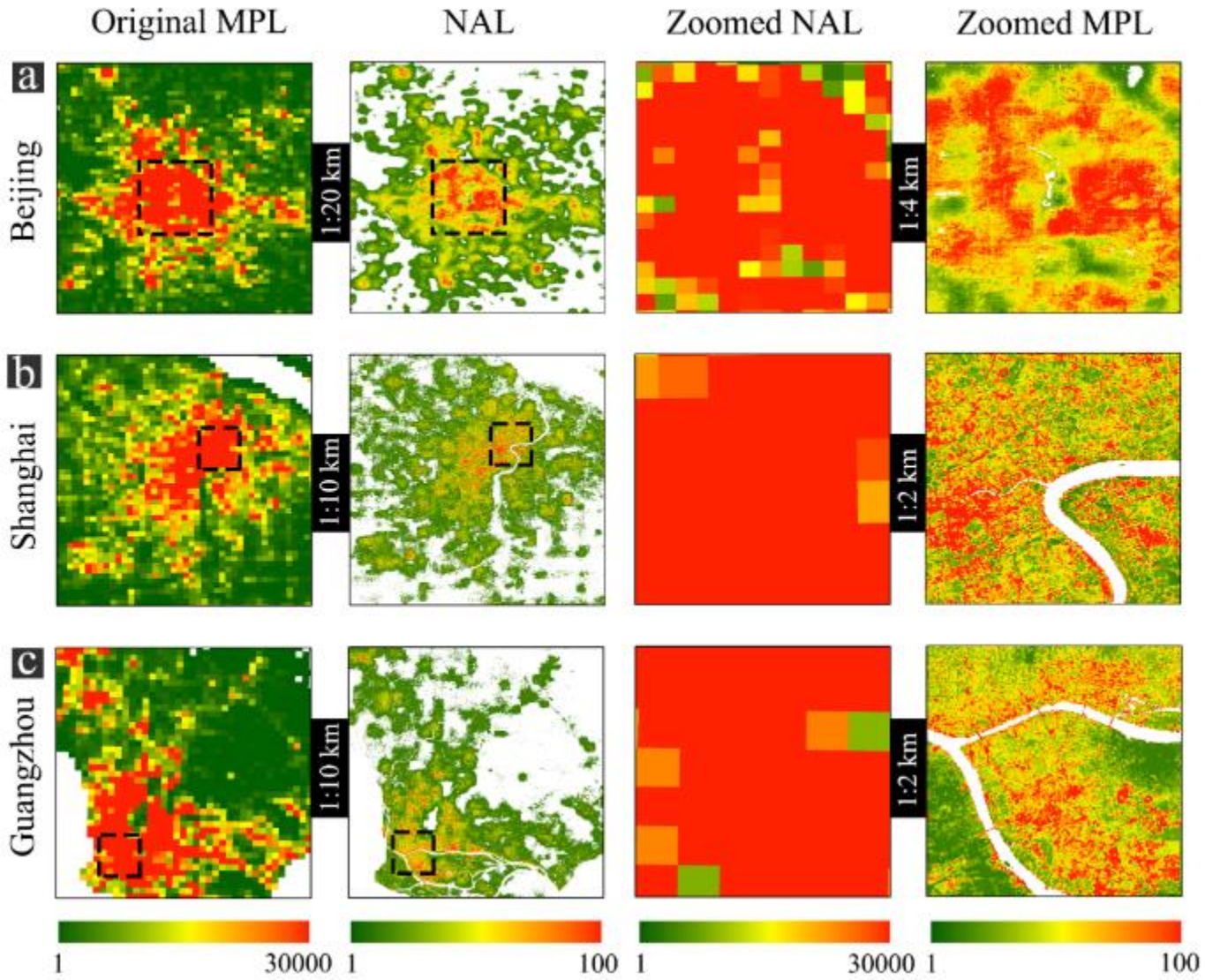
Wetland cover percentage changes (2000-2014)

Over the past 15 years, the lake is becoming drier, in particular within the dry season

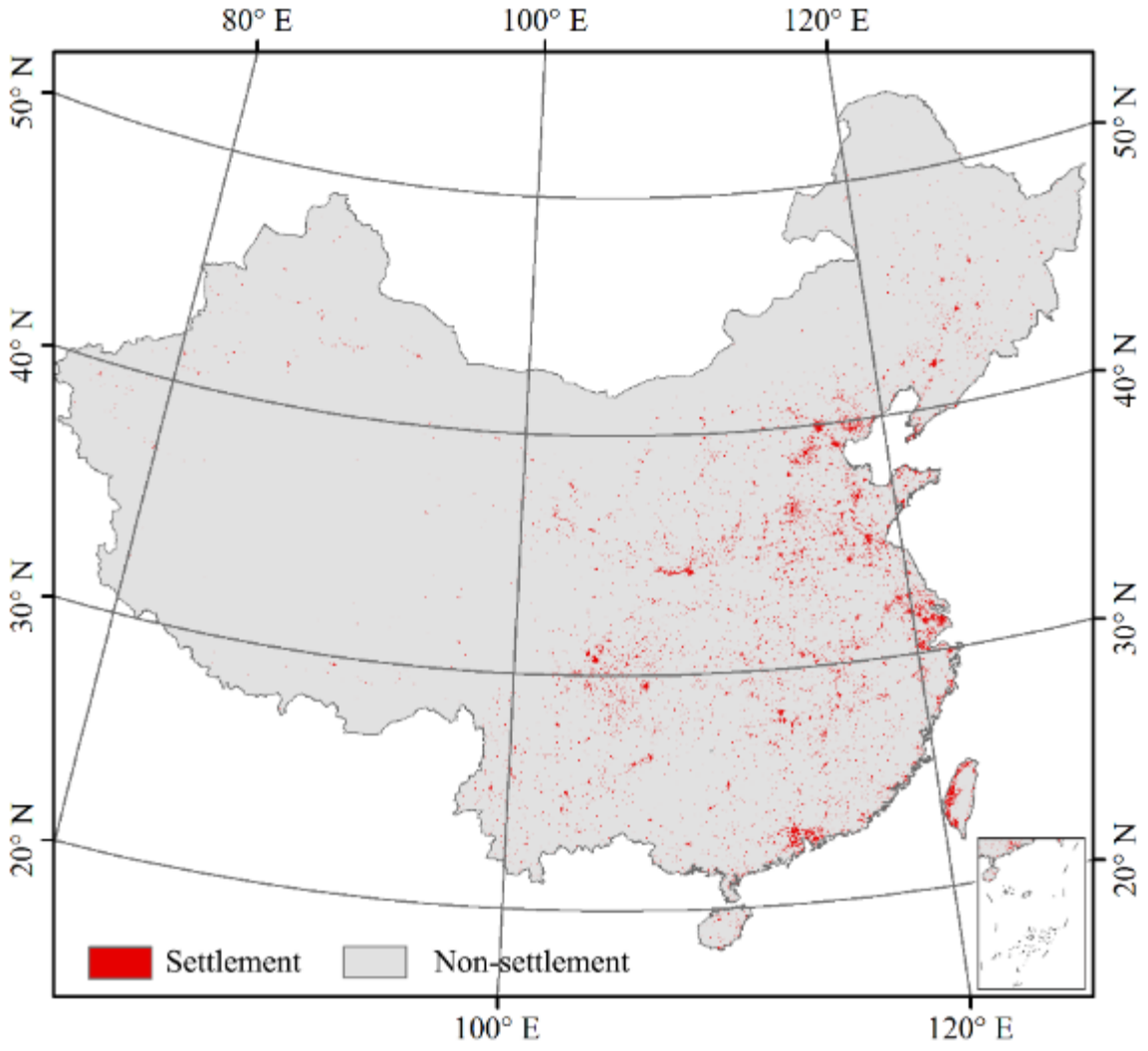
Chen B., et al. *ISPRS Journal of Photogrammetry and Remote Sensing*. (Accepted)

Applications: Human settlement extraction

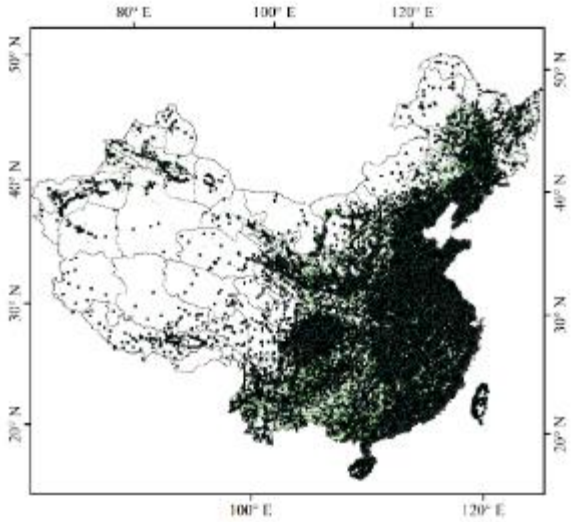


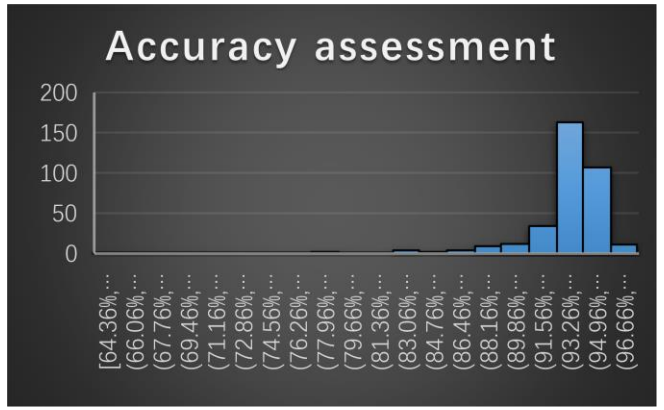


Applications: Human settlement extraction

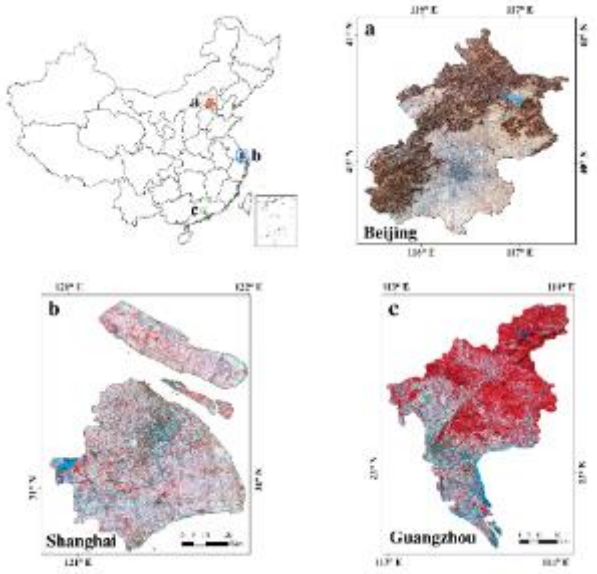


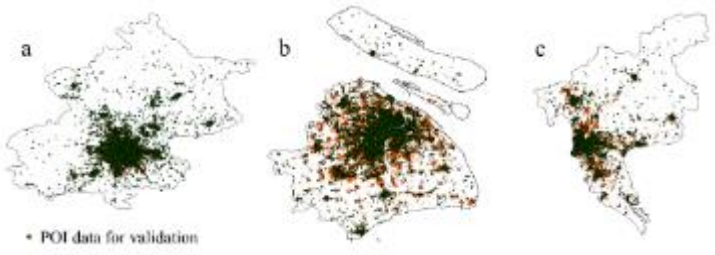
National human settlement mapping





Average accuracy: 93.70%





30-m human settlement mapping

Chen B., et al. (2017). *Landscape and Urban Planning (In revision).*

3 Conclusions

Conclusions

Data-model fusion

Dynamic monitoring of Earth's terrestrial change

Interactions between land cover change, human activities, and climate change

Environmental impacts on public health

GRS lab works for a sustainable world!