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A Multi-Temporal Polarization SAR Classification Method Based on Time-Variant Scattering Features

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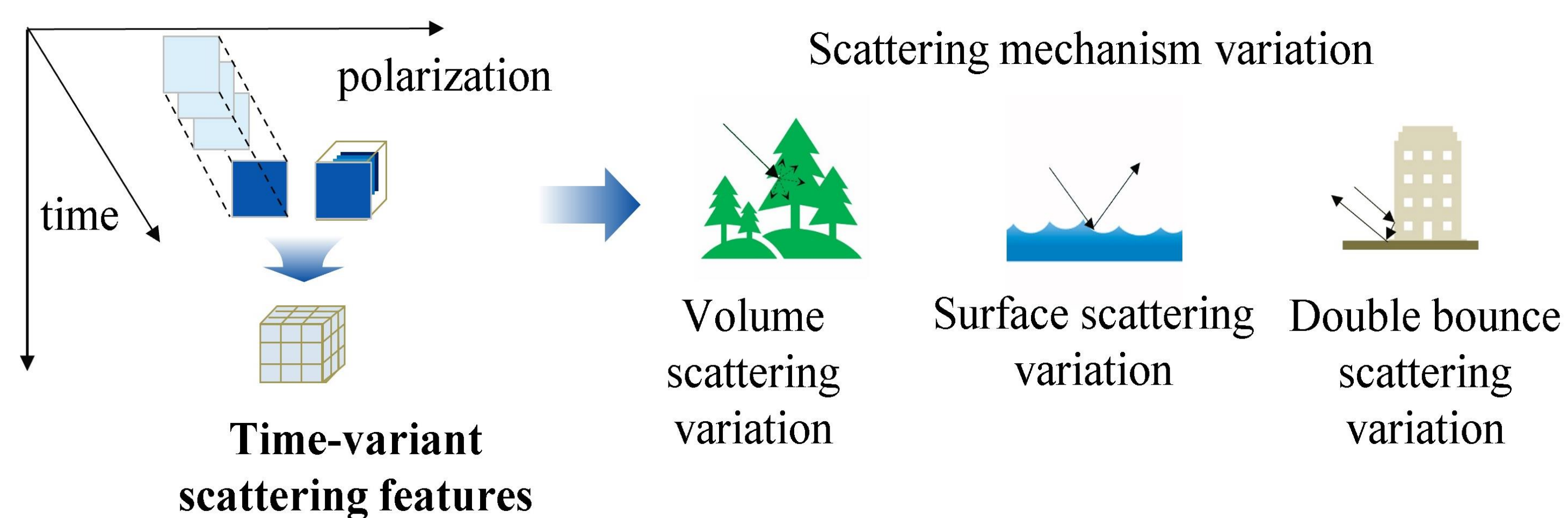yinq@mail.buct.edu.cn

ABSTRACT

The multi-temporal PolSAR data provides the difference of scattering characteristics in time dimension for terrain classification, hence it could reflect the time-variant characteristics of the same scene. However, the features of time and polarization dimension used for classification basically are from the data at each certain time. To solve the problem, based on the specific data representation models, this paper extracts time variant scattering features.
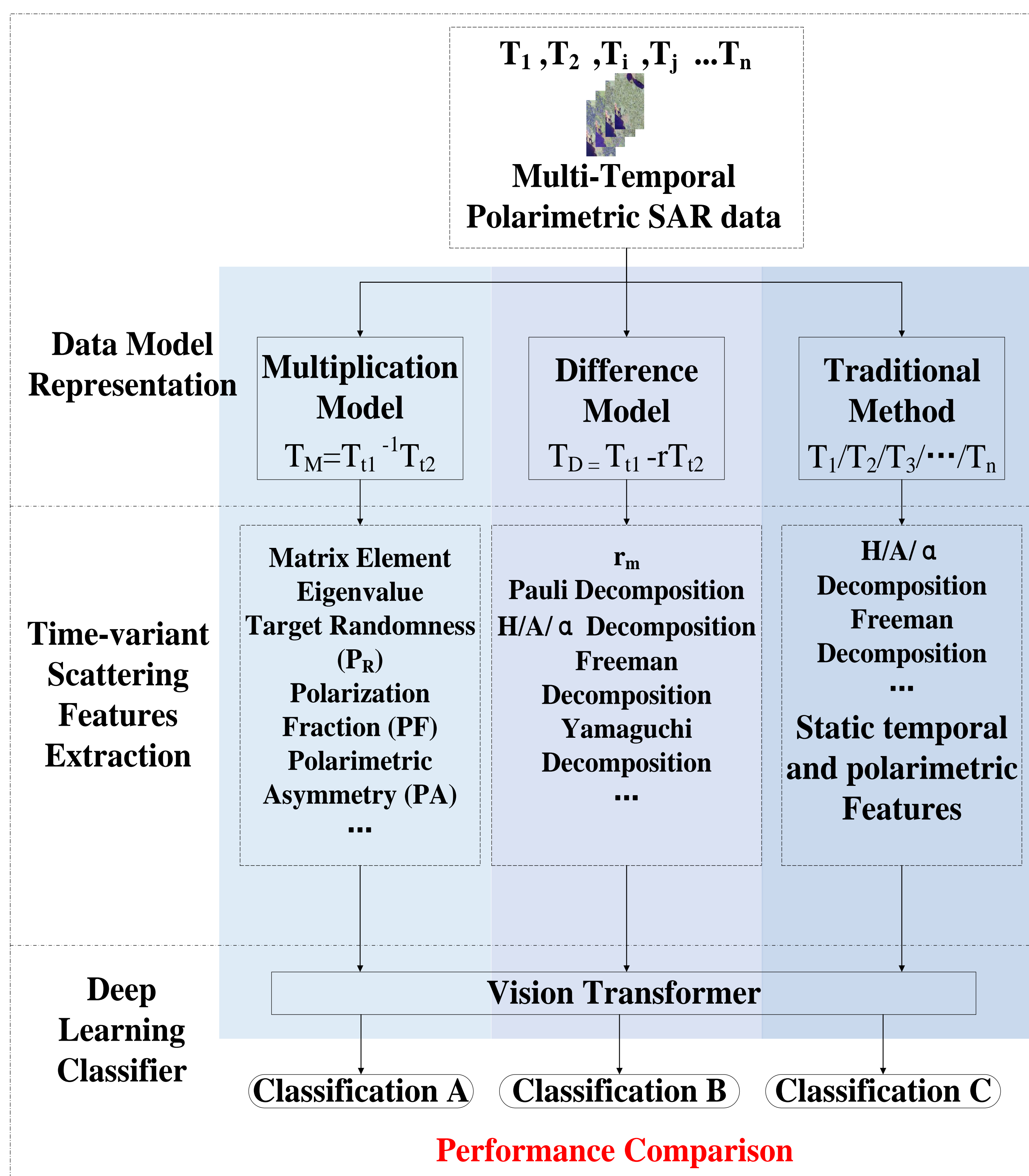
METHODOLOGY

➤ Three key points:

- Two data representation models (multiplication model, difference model) are both applied.
- Based on these two multi-temporal PolSAR data representation models, a new series of time-variant scattering features are extracted. The features can provide the information of change type and interpret the variation of time series scattering mechanism.

Scattering mechanism variation

Volume scattering variation — Surface scattering variation — Double bounce scattering variation
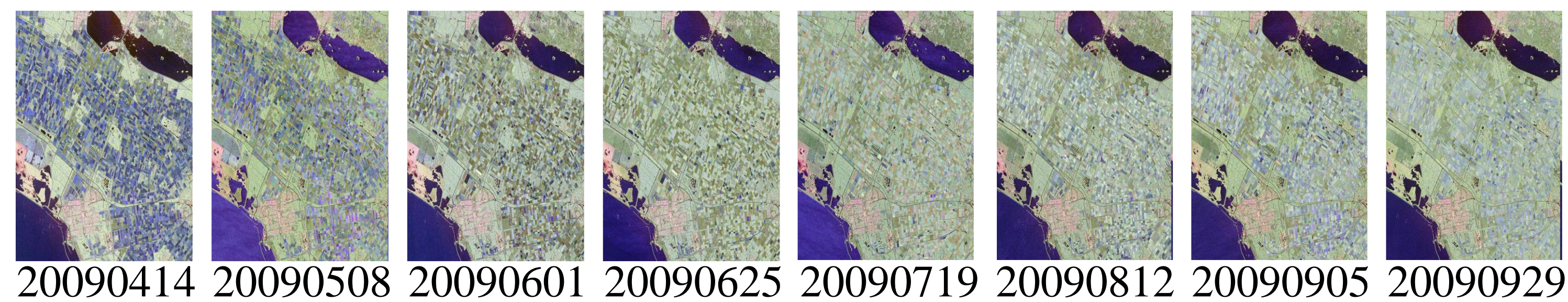
Time-variant scattering features

- By comparing the classification results, we analyze the performance of the two data representation models. Furthermore, the classification performance with the static temporal and polarimetric features are compared with our proposed method.
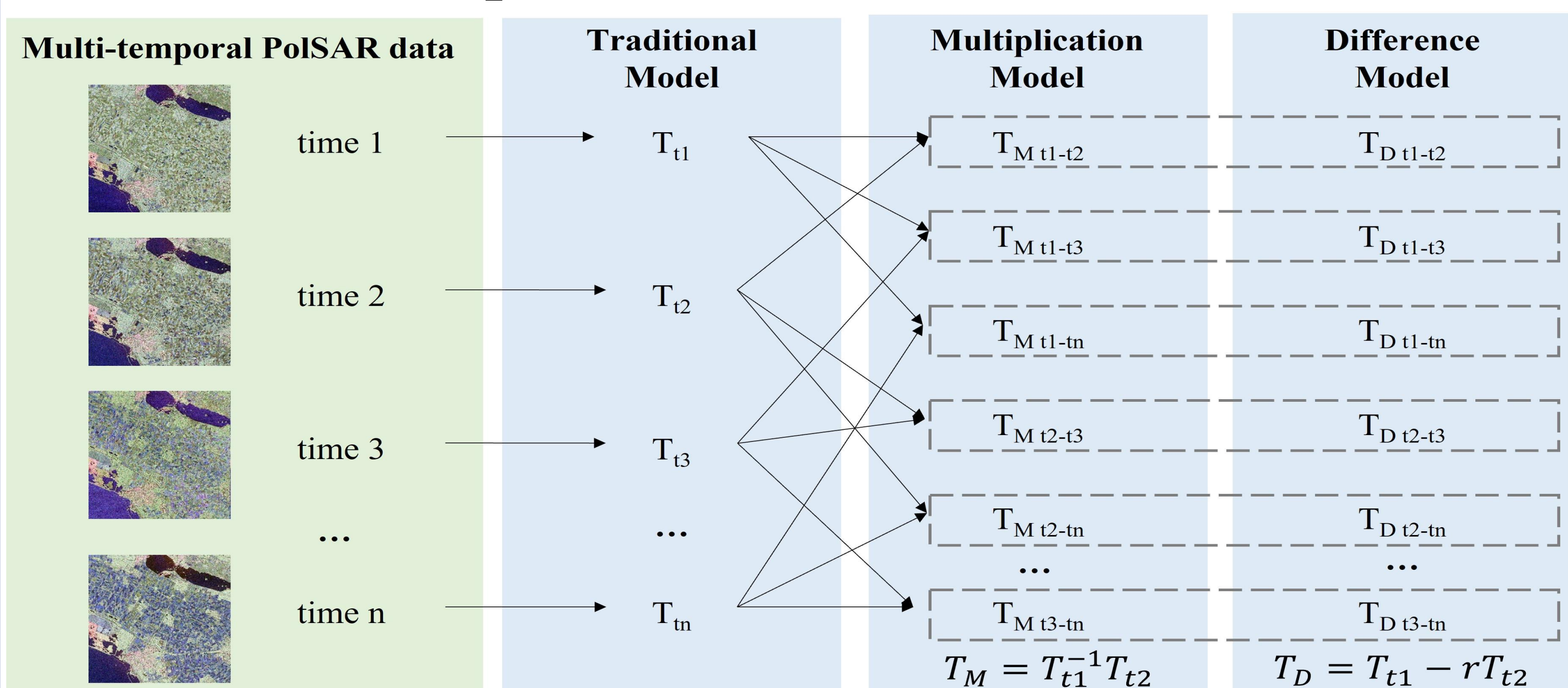

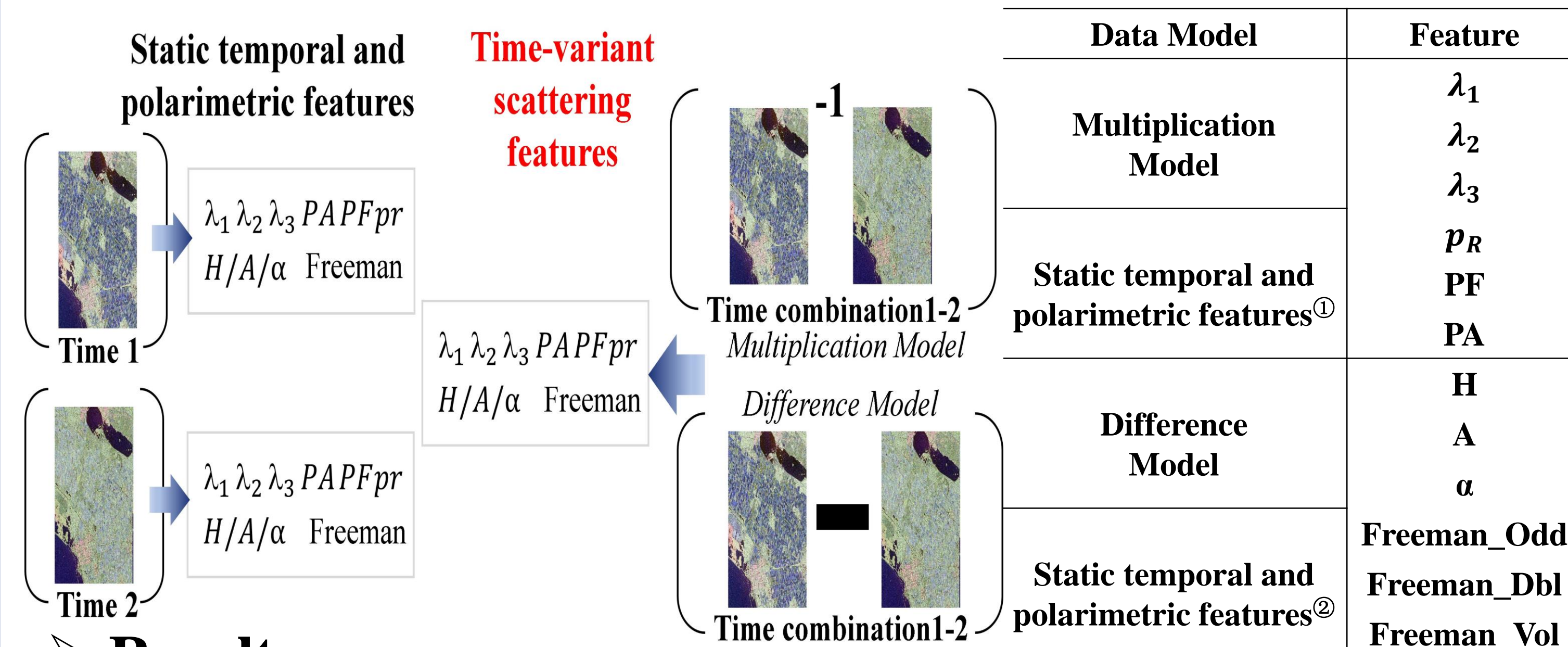$T_1, T_2, T_i, T_j \dots T_n$

Multi-Temporal Polarimetric SAR data

Data Model Representation

Multiplication Model	Difference Model	Traditional Method
$T_M = T_{t1}^{-1} T_{t2}$	$T_D = T_{t1} - rT_{t2}$	$T_1/T_2/T_3/\cdots/T_n$

Time-variant Scattering Features Extraction

| Matrix Element Eigenvalue Target Randomness (P_R) Polarization Fraction (PF) Polarimetric Asymmetry (PA) ... | r_m Pauli Decomposition H/A/α Decomposition Freeman Decomposition Yamaguchi Decomposition ... | H/A/α Decomposition Freeman Decomposition ... **Static temporal and polarimetric Features** |

Deep Learning Classifier — Vision Transformer

Classification A   Classification B   Classification C

Performance Comparison

EXPERIMENT

➤ Data

Radarsat-2, 8 Fully PolSAR images, 5300*3100, 22 categories

20090414 20090508 20090601 20090625 20090719 20090812 20090905 20090929

➤ Data Model representation

Multi-temporal PolSAR data	Traditional Model	Multiplication Model	Difference Model
time 1	T_{t1}	$T_{M\,t1-t2}$	$T_{D\,t1-t2}$
time 2	T_{t2}	$T_{M\,t1-t3}$	$T_{D\,t1-t3}$
		$T_{M\,t1-tn}$	$T_{D\,t1-tn}$
time 3	T_{t3}	$T_{M\,t2-t3}$	$T_{D\,t2-t3}$
...	...	$T_{M\,t2-tn}$	$T_{D\,t2-tn}$
time n	T_{tn}	...	...
		$T_{M\,t3-tn}$	$T_{D\,t3-tn}$

$T_M = T_{t1}^{-1}T_{t2}$ $T_D = T_{t1} - rT_{t2}$

➤ Time-variant scattering features extraction

Static temporal and polarimetric features

Time-variant scattering features

Time 1: $\lambda_1 \lambda_2 \lambda_3$ $P_A P_F p_r$ $H/A/\alpha$ Freeman

Time 2: $\lambda_1 \lambda_2 \lambda_3$ $P_A P_F p_r$ $H/A/\alpha$ Freeman

$\lambda_1 \lambda_2 \lambda_3$ $P_A P_F p_r$ $H/A/\alpha$ Freeman

Time combination1-2 *Multiplication Model*

Time combination1-2 *Difference Model*

Data Model	Feature
Multiplication Model	λ_1
	λ_2
	λ_3
Static temporal and polarimetric features[①]	p_R
	PF
	PA
Difference Model	H
	A
	α
Static temporal and polarimetric features[②]	Freeman_Odd
	Freeman_Dbl
	Freeman_Vol

➤ Results

Multiplication Model   Difference Model   Ground Truth

Data Model	Accuracy
Multiplication Model	87.69%
Static temporal and polarimetric features[①]	89.23%
Difference Model	88.96%
Static temporal and polarimetric features[②]	88.23%

CONCLUSION

- The time-variant scattering features have the potential in multi-temporal change analysis.
- The time-variant scattering features have the same good classification effect of crops as static temporal and polarimetric features.
- The Difference model performs better than the Multiplication model.