Specific Topics on Microwave Remote Sensing in Geosciences

2 Credits

Time: 1.00 to 2.50 pm on Tuesday from week 1 to week 16
Room: College of Urban and Environmental Sciences Building R460
Instructor: Xie HU (hu.xie@pku.edu.cn; Office R464)
Office hour: Schedule as needed

Objectives

本课程将开展雷达影像测地学在地球与环境科学领域的高级应用，研究生将广泛阅读合成孔径雷达 SAR 相关教材和文献，将针对 SAR 技术或应用主题，承担组织讨论的任务，锻炼学生自主学习和口头表达的能力。

Schedule

Week	Dates	Themes	Form	Laptop	Presenter
01	9/12	Introduction	Intro		
02	9/19	SAR/InSAR principals	Journal club 01		Group I
03	9/26	SAR/InSAR data processing	Journal club 02		Group II
04	10/3	Break (National holiday 🎉🎉)			
05	10/10	SAR amplitude and pixel offset tracking	Seminar talk 01	💻	Dr. Yang LEI
06	10/17	SAR coherence	Journal club 03		Group III
07	10/24	Change detection based on SAR amplitude and coherence	Lab	💻	
08	10/31	PSInSAR, SBAS and SqueeSAR principals	Journal club 04		Group IV
09	11/7	Atmospheric error identification and correction	Journal club 05		Group V
10	11/14	Noise reduction: double differences	Journal club 06	💻	Group I
11	11/21	SAR application and AI EARTH	Seminar talk 02	💻	Dr. Yongsheng LI
12	11/28	Thickness inversion for landslides and glaciers based on ground deformation	Journal club 07	💻	Group II
13	12/5	Deformation and precipitation: 1D diffusion model	Journal club 08	💻	Group III
14	12/12	Strain computation (TBD – AGU)	Journal club 09	💻	Group IV
15	12/19	Elastic stress from loading	Journal club 10	💻	Group V
16	12/26	Final Project ✌✌			

Weekly plans on the reading materials are available in the end of this syllabus.

Grades

Form	Grades (%)	Notes
Journal club	30	Students can join in groups and select reading materials. **Each group** will lead discussions in the style of PPT presentation for two times. Datasets shall be gathered for the class when needed. All students shall read the assigned reading materials before the class and actively join the discussion.
Lab	30	**Each group** will complete the assigned computer lab exercise 💻
Project	40	**Every student** is encouraged to select their area of interest and topics on the Earth and environmental scientific questions, to download the relevant remote sensing and auxiliary datasets, propose and implement their research approaches. A project report in less than 3,000 words shall be submitted. PPT presentation 10% | Q&A 10% | Difficulty 10% | Report 10%

⚠ATTENTION PLEASE⚠

- Please read *Before the Class* and complete the tasks (literature reading, account registration, data download, etc.) prior to the class
- HARD DUE for lab turns in
- Please ask for leave when you have to BEFORE the class
- PKU Policy

Thank you for your cooperation 🌹🌹

微波遥感地学应用专题

Specific Topics on Microwave Remote Sensing in Geosciences
2 Credits

Instructor: 胡燮 研究员 | 助理教授 (hu.xie@pku.edu.cn)
北京大学城市与环境学院自然地理与自然资源系
Office: 城环院楼 464
Office hour: Schedule as needed
Time: 1 ~ 16 周，周二 5 ~ 6 节 (1.00~2.50 pm)
Room: 城环院楼 460

课程目标

Objectives

本课程将开展雷达影像测地学在地球与环境科学领域的高级应用，研究生将广泛阅读合成孔径雷达 SAR 相关教材和文献，将针对 SAR 技术或应用主题，承担组织讨论的任务，锻炼学生自主学习和口头表达的能力。

课程安排

Schedule

周	日期	主题	Style	Laptop	Presenter
01	9/12	课程简介	Intro		
02	9/19	SAR/InSAR 基本原理	Journal club 01		Group I
03	9/26	SAR/InSAR 原理与数据分析	Journal club 02		Group II
04	10/3	国庆节 🎉🎉			
05	10/10	SAR 幅度与像素偏移追踪技术	Seminar talk 01	💻	Dr. Yang LEI
06	10/17	SAR 相干性	Journal club 03		Group III
07	10/24	基于 SAR 幅度与相干图的变化检测	Lab	💻	
08	10/31	PSInSAR、SBAS 和 SqueeSAR	Journal club 04		Group IV
09	11/7	大气相位误差识别与改正	Journal club 05		Group V
10	11/14	干涉图噪音消减: 空间域双差滤波	Journal club 06	💻	Group I
11	11/21	SAR 影像综合应用与 AI EARTH	Seminar talk 02	💻	Dr. Yongsheng LI
12	11/28	基于地表形变的滑坡/冰川深度反演	Journal club 07	💻	Group II
13	12/5	形变与降水：一维孔隙压力渗透模型	Journal club 08	💻	Group III
14	12/12	从形变（率）到应变（率）（待定 AGU）	Journal club 09	💻	Group IV
15	12/19	质量荷载：弹性应力应变	Journal club 10	💻	Group V
16	12/26	Final Project ✌✌			

每周阅读清单请参见本课程大纲最后页。

成绩评定

Grades

类型	占比%	说明
Journal club	30	同学**组队**选择阅读材料，每个团队负责两次 PPT 制作，准备必要的数据集并组织全班同学讨论 其他同学也需提前阅读材料并参与讨论情况
Lab	30	同学**组队**完成课程中穿插的上机任务💻
Project	40	**每位**学生根据感兴趣的研究区和地球与环境科学问题，选择、查询并下载适宜的遥感和环境数据集，提出解决方案，并撰写三千字以内的项目报告 PPT 展示 10% | Q&A 10% | 难度 10% | 书面报告 10%

⚠ATTENTION PLEASE⚠

- 请提前完成课前任务(阅读文献、注册账号…)
- Hard due for lab turn in
- 如遇不可抗拒的特殊情况无法到堂，请**提前**请假
- 北京大学规教务部章制度

感 谢 理 解 与 配 合 🌹🌹

Reading materials

Week 01 | Intro
ESA_InSAR_Principle_A

Week 02 | SAR/InSAR I | Journal club 01 (Group I)
Ramon Hanssen: Data Interpretation and Error Analysis Chapter 02

Week 03 | SAR/InSAR II | Journal club 02 | (Group II)
Zhong Lu & Daniel Dzurisin: InSAR Imaging of Aleutian Volcanoes: Monitoring a Volcanic Arc from Space
Chapter 01 Introduction to Interferometric Synthetic Aperture Radar
Chapter 02 Practical Issues in InSAR Analysis
Chapter 03 Recent Advances in InSAR Image Processing and Analysis

Week 04 | BREAK

Week 05 | SAR amplitude | Seminar talk 01 (Dr. Yang LEI 雷洋 研究员 中国科学院空天信息创新研究院)
AutoRIFT: a Python module of a fast and intelligent algorithm for finding the pixel displacement between two images
https://github.com/nasa-jpl/autoRIFT

Week 06 | SAR coherence | Journal club 03 (Group III)
Zebker, H.A., & Villasenor, J., 1992. Decorrelation in interferometric radar echoes. IEEE Transactions on Geoscience and Remote Sensing, 30(5): 950-959. https://doi.org/10.1109/36.175330
Yun, S. H., Hudnut, K., Owen, S., Webb, F., Simons, M., Sacco, P. et al., 2015. Rapid damage mapping for the 2015 Mw 7.8 Gorkha earthquake using synthetic aperture radar data from COSMO–SkyMed and ALOS-2 Satellites. Seismological Research Letters, 86(6), 1549–1556. https://doi.org/10.1785/0220150152
Yun, S. H., et al., 2015. Damage proxy map from interferometric synthetic aperture radar coherence. Patent. https://core.ac.uk/download/pdf/42701653.pdf
Xu, S., Dimasaka, J., Wald, D.J. et al., 2022. Seismic multi-hazard and impact estimation via causal inference from satellite imagery. Nature Communications, 13, 7793. https://doi.org/10.1038/s41467-022-35418-8

Week 07 | Change detection | Lab 01
Google Earth Engine | ASF Vertex

Week 08 | Multi-temporal InSAR analysis | Journal club 04 (Group IV)
PSInSAR
Ferretti, A., Prati, C., & Rocca, F., 2000. Analysis of permanent scatterers in SAR interferometry. IEEE International Geoscience and Remote Sensing Symposium, Honolulu, HI, USA, 2000, 761-763. https://doi.org/10.1109/IGARSS.2000.861695
Ferretti, A., Prati, C., & Rocca, F., 2001. Permanent scatterers in SAR interferometry. IEEE Transactions on Geoscience and Remote Sensing, 39(1): 8-20. https://doi.org/10.1109/36.898661

SBAS
Berardino, P., Fornaro, G., Lanari, R. et al., 2002. A new algorithm for surface deformation monitoring based on small baseline differential SAR interferograms. IEEE Transactions on Geoscience and Remote Sensing, 40(11): 2375-2383. https://doi.org/10.1109/TGRS.2002.803792

Hooper, A., 2008. A multi-temporal InSAR method incorporating both persistent scatterer and small baseline approaches. Geophysical Research Letters, 35(16). https://doi.org/10.1029/2008GL034654

SqueeSAR

Ferretti, A., Fumagalli, A., Novali, F. et al., 2011. A new algorithm for processing interferometric data-stacks: SqueeSAR. IEEE Transactions on Geoscience and Remote Sensing, 49(9): 3460-3470. https://doi.org/10.1109/TGRS.2011.2124465

Week 09 | Atmospheric correction | Journal club 05 (Group V)

Li, Z., Muller, J.-P., Cross, P., & Fielding, E. J., 2005. Interferometric synthetic aperture radar (InSAR) atmospheric correction: GPS, Moderate Resolution Imaging Spectroradiometer (MODIS), and InSAR integration. Journal of Geophysical Research: Solid Earth, 110, B03410. https://doi.org/10.1029/2004JB003446

Tymofyeyeva, E., & Fialko, Y., 2015. Mitigation of atmospheric phase delays in InSAR data, with application to the eastern California shear zone. Journal of Geophysical Research: Solid Earth, 120, 5952–5963. https://doi.org/10.1002/2015JB011886

Yu, C., Li, Z., Penna, N. T., & Crippa, P., 2018. Generic atmospheric correction model for Interferometric Synthetic Aperture Radar observations. Journal of Geophysical Research: Solid Earth, 123(10), 9202-9222. https://doi.org/10.1029/2017JB015305

Week 10 | Double difference spatial filtering | Journal club 06 (Group I)

Bekaert, D. P. S., Handwerger, A.L., Agram, P., & Kirschbaum, D. B., 2020. InSAR-based detection method for mapping and monitoring slow-moving landslides in remote regions with steep and mountainous terrain: An application to Nepal. Remote Sensing of Environment, 249, 111983. https://doi.org/10.1016/j.rse.2020.111983

Week 11 | AI EARTH | Seminar talk 02 (Dr. Yongsheng LI 李永生 研究员 应急管理部国家自然灾害防治研究院)

https://engine-aiearth.aliyun.com/#/

Week 12 | Landslide/glacier thickness inversion | Journal club 07 (Group II)

Booth, A. M., Lamb, M. P., Avouac, J.-P., & Delacourt, C., 2013. Landslide velocity, thickness, and rheology from remote sensing: LaClapière landslide, France. Geophysical Research Letters, 40, 4299–4304. https://doi.org/10.1002/grl.50828

Hu, X., Lu, Z., Pierson, T. C., Kramer, R., & George, D. L., 2018. Combining InSAR and GPS to determine transient movement and thickness of a seasonally active low-gradient translational landslide. Geophysical Research Letters, 45, 1453–1462. https://doi.org/10.1002/2017GL076623

Week 13 | Temporal analysis: diffusion | Journal club 08 (Group III)

Handwerger, A. L., Rempel, A. W., Skarbek, R. M., Roering, J. J., & Hilley, G. E., 2016. Rate-weakening friction characterizes both slow sliding and catastrophic failure of landslide. Proceedings of the National Academy of Sciences of the USA, 113(37), 10,281–10,286. https://doi.org/10.1073/pnas.1607009113

Hu, X., Bürgmann, R., Lu, Z., Handwerger, A. L., Wang, T., & Miao, R., 2019. Mobility, thickness, and hydraulic diffusivity of the slow-moving Monroe landslide in California revealed by L-band satellite radar interferometry. Journal of Geophysical Research: Solid Earth, 124, 7504–7518. https://doi.org/10.1029/2019JB017560

Week 14 | Spatial analysis: strain | Journal club 09 (Group IV)

Bradley, K., Mallick, R., Andikagumi, H. et al., 2019. Earthquake-triggered 2018 Palu Valley landslides enabled by wet rice cultivation. Nature Geoscience. 12, 935–939. https://doi.org/10.1038/s41561-019-0444-1

Handwerger, A. L., Huang, M.-H., Fielding, E. J., Booth, A., & Bürgmann, R., 2019. A shift from drought to extreme rainfall drives a stable landslide to catastrophic failure. Scientific Reports, 9 (1), 1569, https://doi.org/10.1038/s41598-018-38300-0

Week 15 | Mass loading | Journal club 10 (Group V)

Amos, C.B., Audet, P., Hammond, W.C., Bürgmann, R., Johanson, I.A., & Blewitt, G., 2014. Uplift and seismicity driven by groundwater depletion in central California. Nature, 509, 483–486. https://doi.org/10.1038/nature13275

Johnson, C.W., Fu, Y., & Bürgmann, R., 2017. Seasonal water storage, stress modulation, and California seismicity. Science, 356 (6343), 1161-1164. https://doi.org/10.1126/science.aak9547

Yu, C., Penna, N. T., & Li, Z., 2020. Ocean tide loading effects on InSAR observations over wide regions. Geophysical Research Letters, 47, e2020GL088184. https://doi.org/10.1029/2020GL088184

Week 16 | Final project