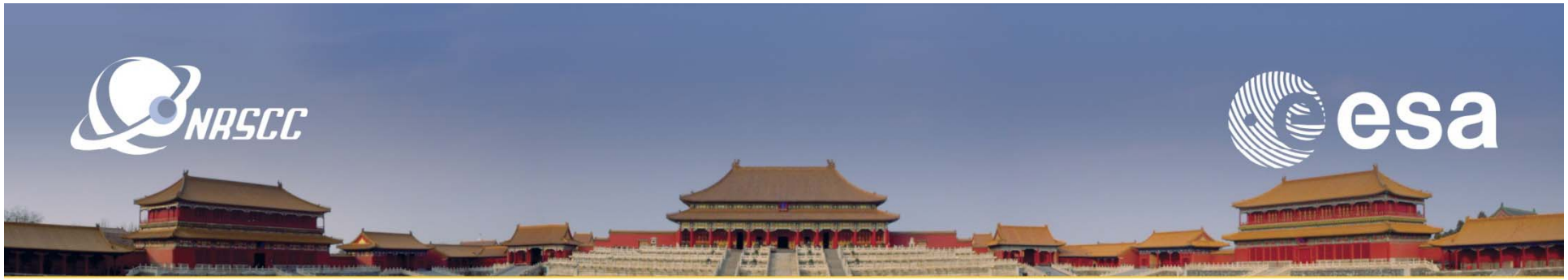


ESA-MOST Dragon Cooperation

中国科技部-欧洲空间局合作“龙计划”

DRAGON 2 FINAL RESULTS AND DRAGON 3 KO SYMPOSIUM

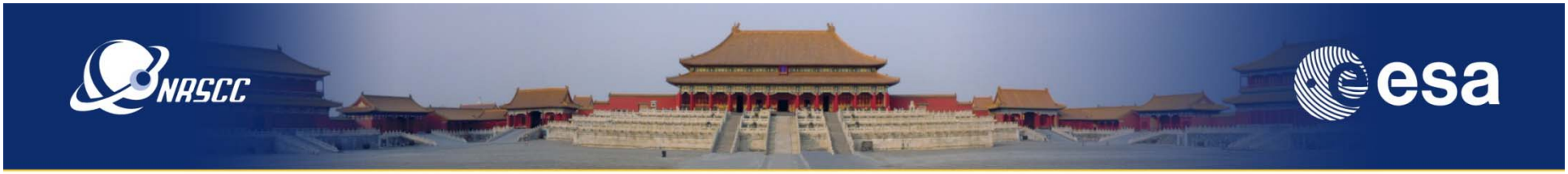
“龙计划”二期总结研讨会暨三期启动会

Detecting Anomalies from Satellite and Ground Based Electromagnetic Data Using Pattern Recognition Approaches (DASGED)

Dr 3 project ID, 10671

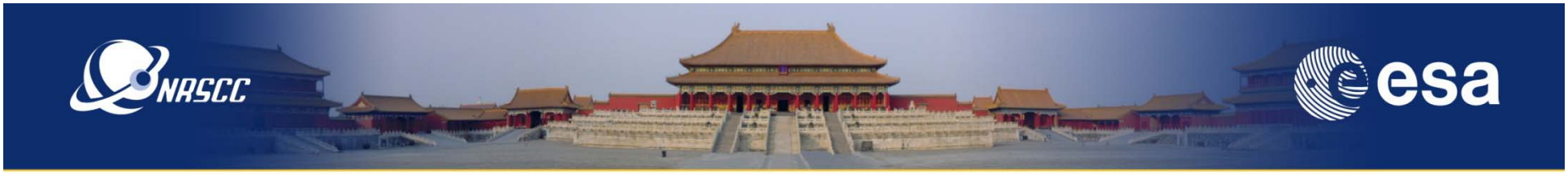
Dr Yaxin Bi, Prof Terry Anderson

Prof Guoze Zhao, Prof Yan Zhan



Outline

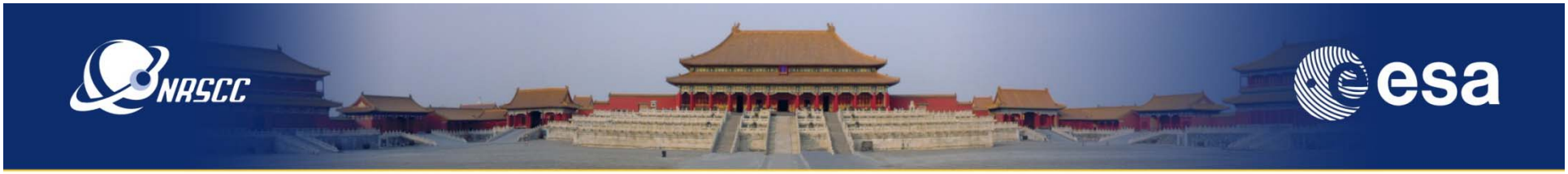
- Objectives
- Team composition
- Methodology
- Acquisition of satellite and ground based data
- Training of young scientists
- Expected results
- Project schedule



Objectives

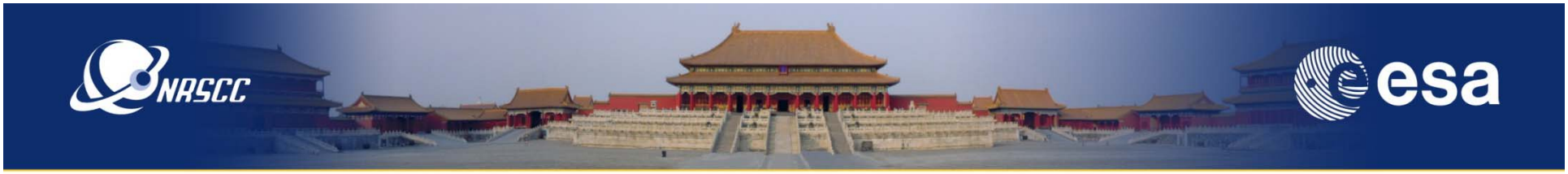
- To develop methodologies for detecting a range of anomalies in the ionosphere and lithosphere, which are believed to be precursors of large earthquakes and to investigate correlations between the detected anomalies and seismic activities. The data will come from the SWARM, CSES CBERS-01&02 and Sentinel-3 satellites and from ground-based CSELF networks.

CSES – China Seismo-Electromagnetic Satellite
CSELF – Control Source Extremely Low Frequency



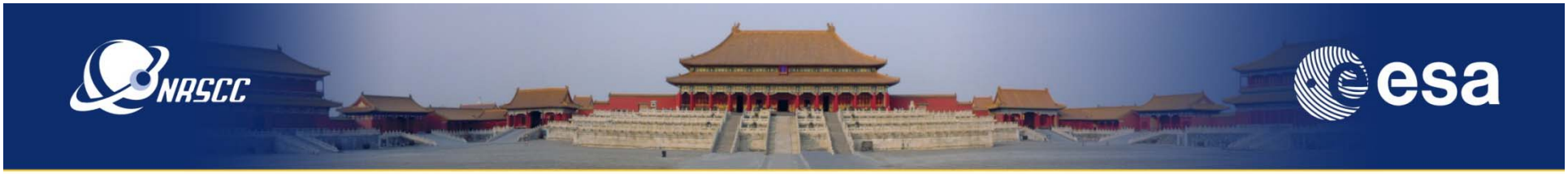
Team Composition

- Dr Yaxin Bi, University of Ulster, United Kingdoms
  - Data mining, pattern analysis and data fusion for satellite and ground-based data exploitation
- Prof Terry Anderson, University of Ulster, United Kingdoms
  - Interactive computing and data visualization
- Prof Guoze Zhao, Institute of Geology, China Earthquake Administration
  - EM Geophysics, analyzing electromagnetic data, and seismology
- Prof Yan Zhan, Institute of Geology, China Earthquake Administration
  - EM Geophysics, acquisition and modelling of electromagnetic data



Team Composition (cont'd)

- Dr. Michel Parrot, a research scientist (DEMETER satellite) in LPC2E/INSU/CNRS (France)
- Prof Angelo De Santis, research area of geomagnetism and seismology (Italy).
- Prof Hui Wang, research interests in machine learning (UK)
- Prof Dongmei Yang, Geophysics (China)
- Dr Lingling Ma is assistant professor (China)
- Dr Meihua Chen is assistant professor (China)
- Mr Yufei He, Geophysics (China)
- Xiangzeng Kong (PhD, UK)
- Mr Linqiang Zhao (MSc, China)
- Others



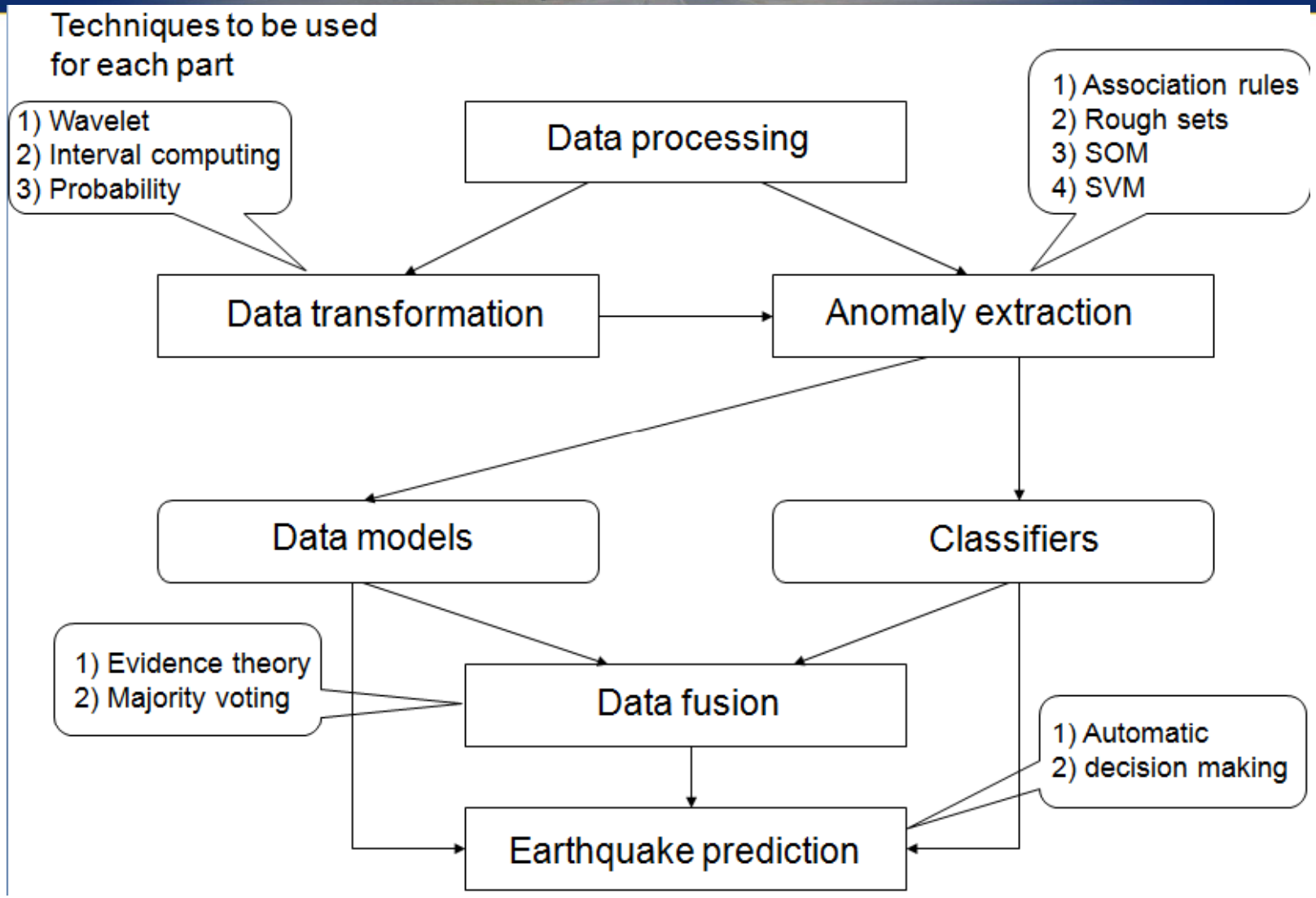
Scientific challenges

- Characterise abnormal electromagnetic changes observed from both space and ground using pattern recognition methods
- Detect anomalies in the abnormal changes using data mining and machine learning
- Carry out comparative analyses between the anomalies in the same spatio-temporal domains by statistics methods
- Investigate relationship between the anomalies and seismic activities

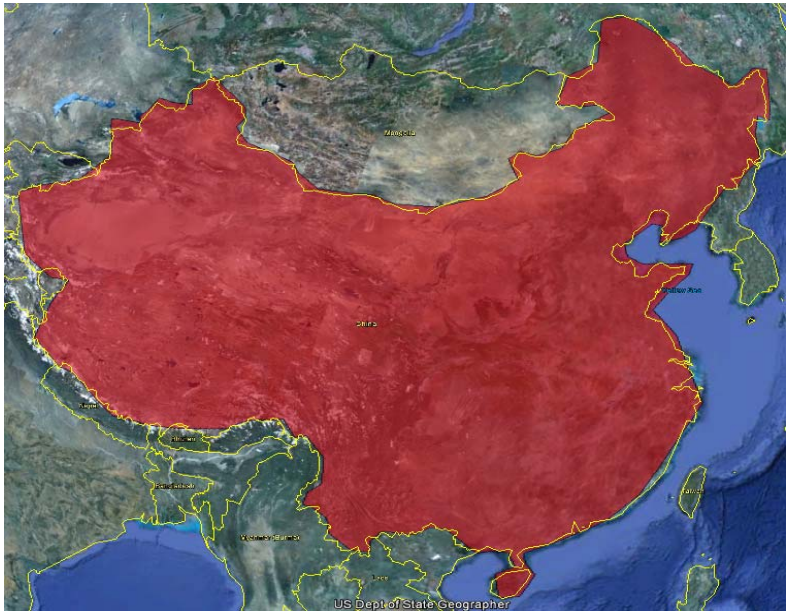
Methodology

- Define study areas
- Collect satellite and ground-based data

Methodology

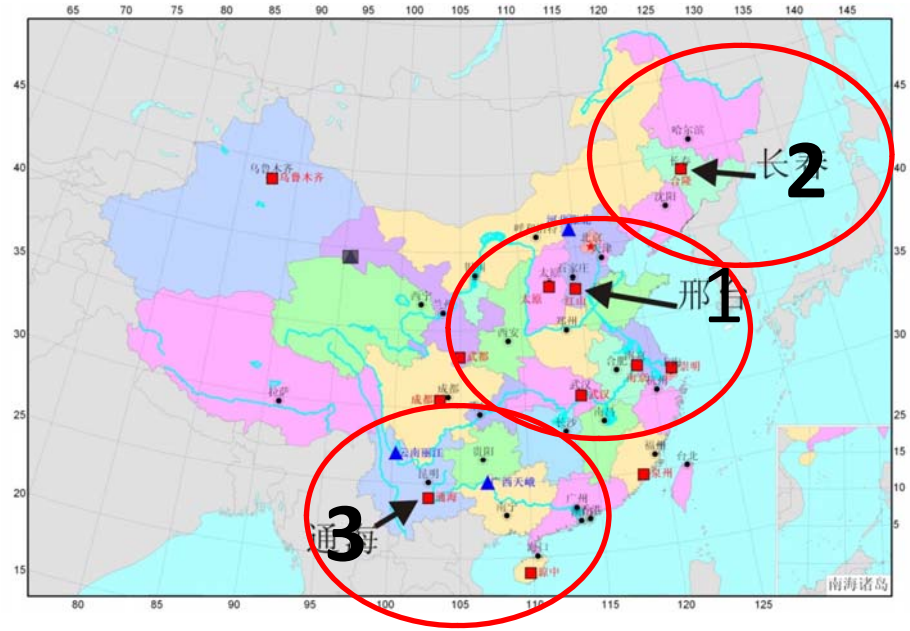


Study areas



- The study areas are selected on the basis of
  - tectonic background
  - seismic activities
  - the coverage of SWARM and CSES and other satellites
  - the ground based networks

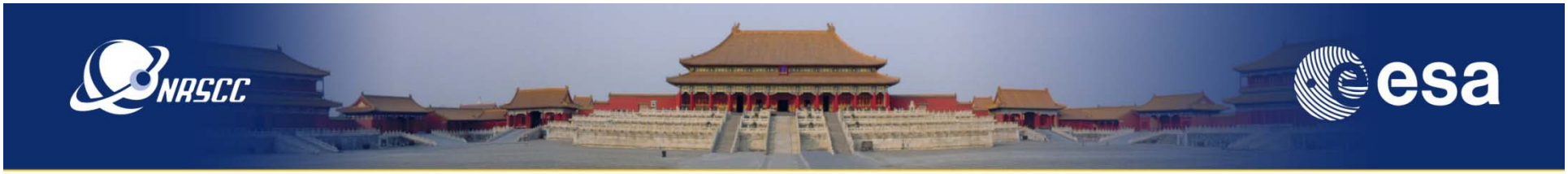
Study area (cont'd)



1. Beijing Capital area – a seismic-active zone
2. Northeast China – in the Pacific plate subduction zone
3. Yunnan province – in the southeast seismic-active zone

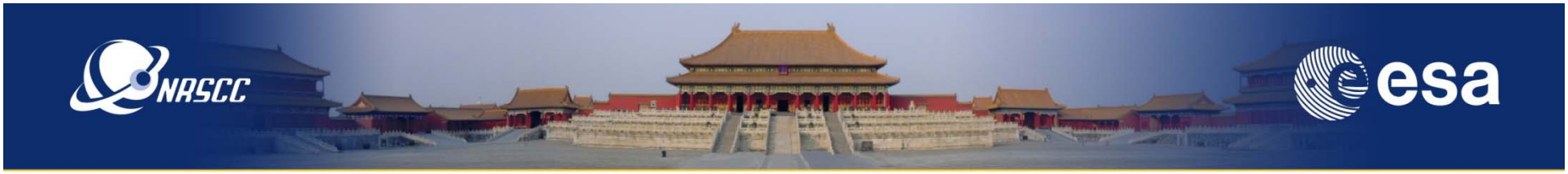
Ground-based networks

- Three areas are intensively monitored by advanced seismic observation networks
  - 12 observation stations
  - Two electric and magnetic fields are recorded along NS and EW directions.
  - The frequency bands are in a range of 0.1 – 800Hz (SLF/ELF/ULF),
  - The power spectrum density, apparent resistivity and impedance phase in the different frequency domains will be calculated



Scientific payloads (CSES)

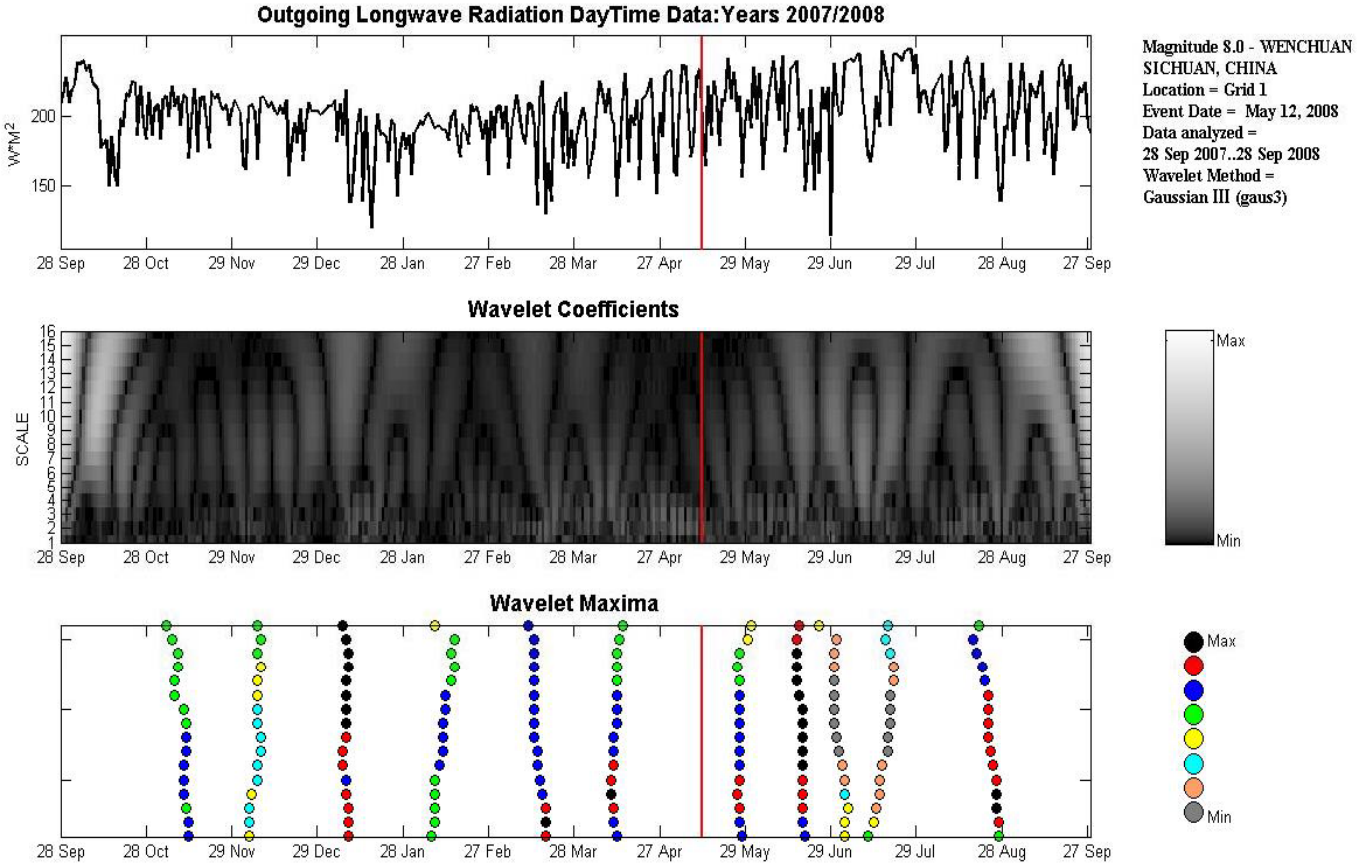
Physical Parameter	Payloads	Main Specification
Electromagnetic Field	Search Coil magnetometer	Frequency Range: 10Hz - 20 kHz
	Fluxgate Magnetometer	Frequency Range: DC - 15Hz
	Electric field detector	Frequency Range: DC - 3.5MHz
Plasma Construction	GNSS Occultation Receiver	Tomography and TEC by GNSS Occultation Signal
	Tri-Frequency Transmitter	Tomography and TEC by VHF/UHF/LF Signal
In situ Plasma	Plasma analyzer	Composition: H^+, He^+, O^+ Ion density: $5\times10^2 \div 1\times10^7$ cm^{-3} Ion temperature: 500K÷ 10000K
	Langmuir probe	Electron density: $5\times10^2 \div 1\times10^7$ cm^{-3} Electron temperature: 500K÷ 10000K
Energetic Particle	Energetic particle detector	Proton: 3MeV ÷ 200MeV Electron: 200KeV ÷ 10MeV

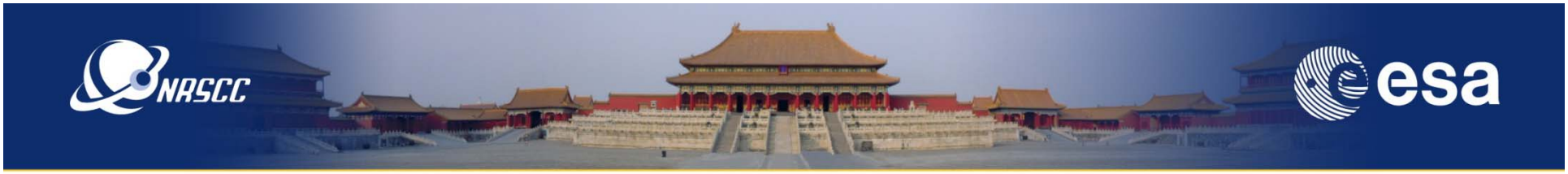


Existing studies from DEMETER

- The studied physical parameters include below
  - electron density (Ne) measured by ISL
  - electron temperature (Te) measured by ISL
  - ion density (Ni) measured by ISL
  - ion Temperature (Ti) measured by IAP

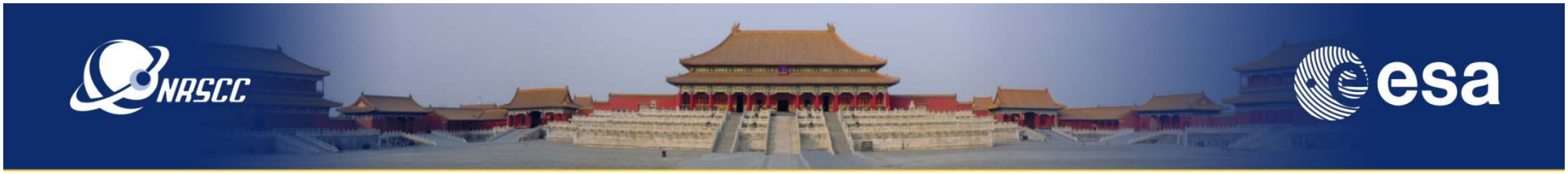
Existing studies from DEMETER(cont'd)





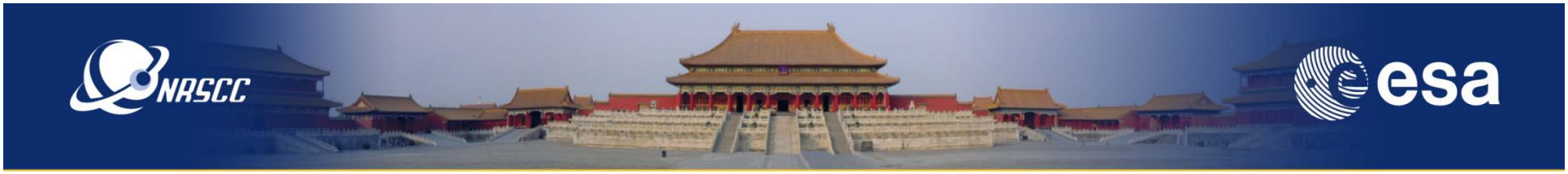
Workpackage

- WP1: Literature review
- WP2: Development of a data base and gridding methods
- WP3: A unified grid modelling for gaining access to a range of satellite and ground data
- WP4: Characterise and detect anomalies from electromagnetic data observed from both space and ground
- WP5: Detect anomalies from thermal infrared images
- WP6: Investigate methods for aggregating the resulting anomalies from electromagnetic and thermal parameters and their correlation with earthquakes



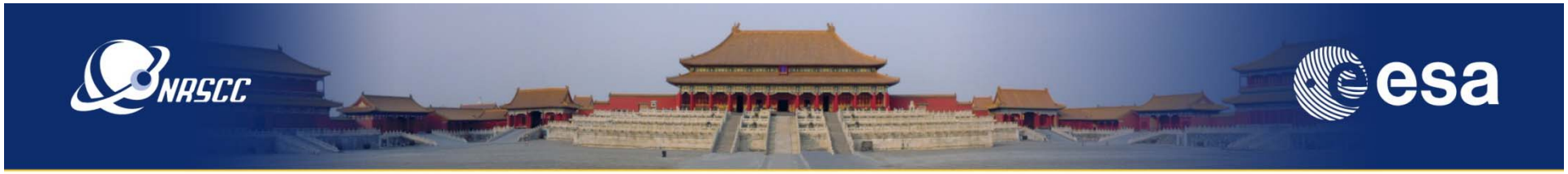
Expected results

- A grid-based model for acquiring satellite and ground data from different sources and linking them to other sources
- A set of methods for detecting electromagnetic and thermal infrared anomalies from satellites and ground networks in the same spatio-temporal axes
- A unified entropy-based measure which can be used to represent the results from electromagnetic and thermal infrared spectrum sources in a uniform way
- Insights into the relationships among parameters (*Pspace*, *Pground*, *Pquake*)
- Establishment of models for representing and interpreting the identified relationships (*Pspace*, *Pground*, *Pquake*) .



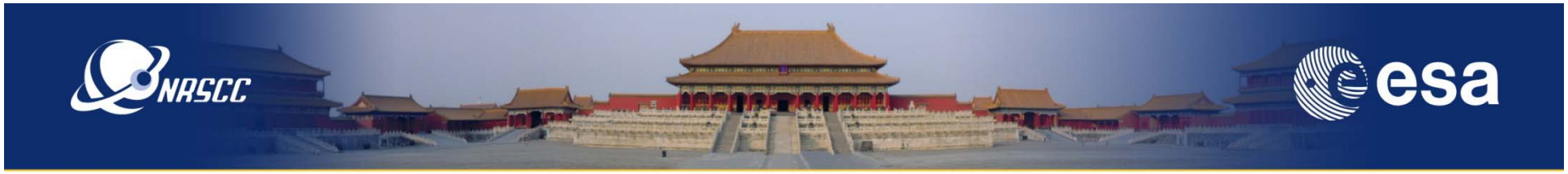
Training for young scientists

- To address the current skills shortage in this multidisciplinary area, a training programme for young scientists in theory and practice including:
  - Co-supervision of PhD and MSc students
  - Provide short courses for the members of the DRAGON 3 programme in detecting anomalies from electromagnetic data using pattern analysis/data mining
  - Provide workshops for result dissemination



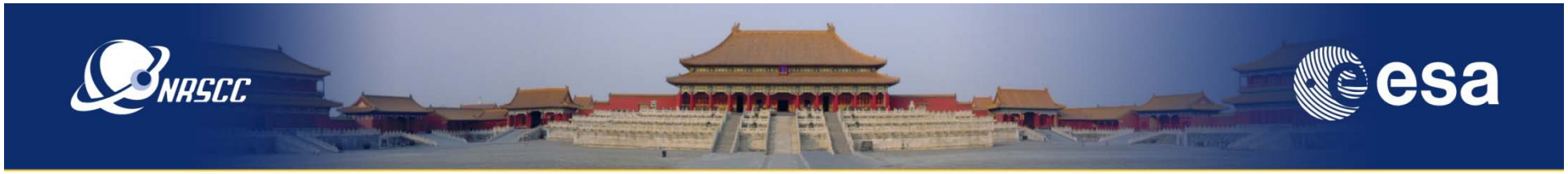
Project schedule

- Milestone one: June 2013
  - Complete WPs 1 and 2, and part of WP 3
  - Finalize study areas and acquire satellite and ground observation data
  - Review a range of methods for detecting anomalies.
- Milestone two: June 2014
  - Complete WP 3
  - Develop effective methodologies for detecting abnormal changes in electromagnetic data, complemented by thermal infrared data
  - Carry out preliminary experiment studies, which are part of WPs 4 and 5.



Project schedule (cont'd)

- Milestone three: June 2015
  - Compete the development of all methods and models specified in WPs 4, 5 and 6
  - Scale up empirical studies over acquired data
  - Carry out correlation analyses among the already identified anomalies, and among the anomalies and earthquakes, and also make comparisons between the results obtained from space and ground data.
- Milestone four: June 2016
  - Complete WP 6
  - Prepare two deliverables



Pattern Recognition of Electromagnetic Anomalies From Satellite and Terrestrial Sources (PREMASATS)

Thanks for your attention