1. Objectives

- The Cryosphere dynamics in the Tibetan Plateau by the synergistic use of microwave and optical earth observations as well as ground measurements.

- The interaction between cryosphere (including frozen ground and glacier), hydrosphere will be investigated through algorithm development and Virtual Geographic Environment (VGE) system integration.
The proposed VGE framework of TP cryosphere dynamics.
Main Results

• Glacier surging at Puruoganri Ice Field detection with topography differencing.

• Glacier surging at Geladandong Ice Field detection with feature tracking.

• Glacier melting’s contribution to Nam Co Lake’s increasing.

• Glacier flow rate extraction and evaluation with Landsat-7 SLC-off images.
The velocity of ice tongue estimation in Purogangri glacier using ERS-1/2 InSAR and GPS

Purogangri Ice Field

- Located in the middle of Tibetan Plateau
- The largest glacier in the plateau of Asia
DEM extraction with TSX/TDX and elevation change from 2000 to 2012

- **Data**
  - TanDEM-X/TerraSAR-X on 26th Jan 2012
  - SRTM DEM product in 2000

- **Method**
  - Bistatic SAR Interferometry for TDX DEM generation
  - DEM differencing for elevation change estimation
Main Results

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Offset-tracking algorithm were applied to SAR images, and surging glaciers in Geladandong Ice Field were found. In the right we present velocity maps for 1996-1997 and 2005-2006. The velocity maps between 1996 and 1997 was validated by D-InSAR processing to ERS TanDEM images obtained on Apr 6\textsuperscript{th} - 7\textsuperscript{th}, 1996.

Glacier A (Jianggudiru, water head of Yangtze River) and B forward 160m and 610m during the surging period by identifying glacier outline with NDSI.

君住長江頭 我住長江尾
日日思君不見君 共飲一江水
Glacier velocity dynamic from 1990 to 2000s by ERS and ASAR images offset-tracking study. Figures on right shows the glacier velocity change. During surging period, velocity could be 3-10 times higher than normal years.

We applied 64*192 window to extract flow information. Also a pair ETM+ optical images obtained in winter were also applied with offset tracking.

In the next phase, bistatic TSX/TDX will be applied to generate DEM and together with SRTM data, we will quantitatively analysis the contribution of glacier melting to each basin.

For more details please refer to Li Gang, et al., ‘Monitoring glacier flow rates dynamic of Geladandong Ice Field by SAR images interferometry and offset tracking’ IGARSS,2014
Main Results

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Glacier melting’s contribution to Nam Co Lake’s increasing

• Background

-Nam Co Lake is the second largest close lake at Inner Tibetan Plateau (ITP), also the height salt lake in the world. From 2000, almost all close lake at TP experienced sharp increasing, and among them all, Nam Co Lake’s increased at 0.26m/a during 2003-2009. (Zhang et al., 2011)

-Reasons for close lakes increasing are under debating, most researches support increasing precipitation and glacier degradation should take responsibility.

-Nyainqentanglha glacier suffered from quick retreat. Taking field working at Zhadang Glacier yields that thinning rate was 0.59m/a, and glaciers in Nam Co’s drainage area contributes 28% of its increasing. Among five close lakes at ITP studied, glaciers melting contribution ratio for Nam Co is the largest. (Lei et al., 2013)
Lake elevation changes during 2003-2009, monitored by ICESat. (Zhang Guoqing, et al., 2011)

Simulated and measured lake elevation changes for several closed lake in ITP. (Lei Yanbing, et al., 2013)
Glacier melting’s contribution to Nam Co Lake’s increasing

- Instead of using biased field observations, we applied topographic differencing method based on C and X band SRTM and bistatic X-band TerraSAR-X and TanDEM-X images.

- Five pairs images were employed to cover whole range except northeast part.

- Glacier height changes at overlapped area were employed for evaluate precision.
Glacier melting’s contribution to Nam Co Lake’s increasing

Nam Co Lake’s expansion in last few decades

Nyainqentanglha Glacier’s decadal height changes
Glacier melting’s contribution to Nam Co Lake’s increasing water level

Cross validation

Cross Validation to Glacier Elevation Changes detecting by SAR Interferometry

- Measured glacier changes with the same track
- Linear regression to same track measuring $R^2 = 0.86543$
- Measured glacier changes with cross tracks
- Linear regression to cross tracks measuring $R^2 = 0.69526$

Correlation Between Glacier Elevation Changes and the Heights

- Pixels inside Nam Co Basin
- Pixels outside Nam Co Basin
- Fitting to Pixels inside Nam Co Basin $R^2 = 0.24542$
- Fitting to Pixels outside Nam Co Basin $R^2 = 0.21239$
Glacier melting’s contribution to Nam Co Lake’s increasing

- The RMSE of bistatic SAR interferometry survey to glacier height is 3.1m and 3.9m by same track and across-track validation.

- The maximum thinning rate was -80m/decade found at glacier tongue in Nyainqentanglha, mean thinning rates was ~-0.18m/decade.

- ZELs were ~5942m and 5933m for north and south slope of Nyainqentanglha Range.

- By presuming all the melted glacier flows into the lake, its contribution to lake increasing was 5.6% in last decade, much smaller than previous study.

- See more detail with POSTER NO.30 😊
Main Results

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Study area
Siachen Glacier at Karakoram

Location of the Siachen Glacier (AA' is the central line)
### Method

- **Gap-filling methods:** the localized linear histogram match (LLHM) and the weighted linear regression (WLR)
- **Glacier velocity:** feature tracking

### Data

#### Used for fill the gaps

- **Landsat ETM+**
  - 2009-08-12: 148/35, 15 m
  - 2009-07-27*: 148/35, 15 m

#### Used for cross validation

- **Landsat TM**
  - 2009-08-04: 148/35, 30 m
  - 2010-08-23: 148/35, 30 m

* denotes filled data

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**Image 1**

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Comparison of a SLC-off image before and after filling-gap. (a) Landsat ETM+ SLC-off image acquired on 12 Aug 2009; (b),(c) the results recovered by LLHM and WLR, respectively.

Annual surface velocities in Siachen Glacier:
(d) Annual surface velocities derived from Landsat TM images; (e) Annual surface velocities derived from SLC-off images recovered by LLHM; (f) Annual surface velocities derived from SLC-off images recovered by WLR.

Surface velocities along center line (AA' in study area).
The recovered results show that the WLR method achieves a better performance of gap recovering than the LLHM method.

The surface velocities estimated with the recovered SLC-off images are highly agreement with those of the TM images, which demonstrates that Landat ETM+ SLC-off data can be utilized to estimate the surface velocities of mountain glaciers.

The annual mean velocity of the Siachen glacier is approximately 70 m/yr between 2009 and 2010 with a maximum of 280 m/yr close to the glacial equilibrium line that are similar with the results in previous studies.

For more details please refer to POSTER No. 31
Recommendations

- An Eoli-SA liked EO data search and order platform for Chinese satellite data and Sentinel-1.

- More related symposiums or training courses for academic exchanges and young scholar learning.
EO data planning – 2015 and 2016

1. ERS1/2 RA data, Topex/Poseidon and Jason 1/2 data will be acquired for Tibetan Plateau.
2. More TerraSAR-X and TanDEM-X strip map images for Chongce, Geladandong and Puruogangri Ice Cap, and karaoram will be acquired.
3. Envisat/ASAR and ERS 1/2 SAR data for Silin Co, Beiluhe and QTP Railway.
4. Sentinel-1 A, TOPSAR images and Stripmap images for interferometry and feature tracking. Sentinel-2A optical images will be tested after their releasing.
5. ALOS-2 PALSAR images.

For glacier and lake outlines and dynamic
1. Beijing-1/2 optical images.
2. HJ-1 A/B optical images.
3. CBERS 01 02 02B optical images.

For permafrost distribution
HJ-1 C Strip Map and ScanSAR data.
Project Planning – 2015 and 2016

July, 2015~June, 2016

• Methodologies development for glacier flow rate monitoring with Sentinel-1 and -2.
• Permafrost’s active layer deformation modeling and studying with multi-temporal SAR interferometry analyzing.
• Field work in Puruogangri and Geladandong ice field in autumn of 2015.
• Prof Hooper will visit The Chinese University of Hong Kong after September 2015.
• Finish proposed objects.
• Write proposal for the DRAGON IV.
Scientists from interdisciplinary (e.g. geoscience, remote sensing, geology, hydrology) will work together. Academic exchange will generate new ideas for the complicated phenomena explanation, which in turn is beneficial for broadening the scope of young scientists’ knowledge.

Li Gang visited University of Leeds during Jan and Apr for four months this year.
List of Publications

- Fulong Chen; Hui Lin; Zhen Li; etc. Interaction between permafrost and infrastructure along the Qinghai–Tibet Railway detected via jointly analysis of C- and L-band small baseline SAR interferometry. Remote Sensing of Environment 123(2012) 532-540.
- Fulong Chen, Hui Lin., Surface deformation detected by the space-observed small baseline SAR interferometry over permafrost environment in Tibet Plateau, China. The Cryosphere Discussions, 6, 4071-4099, 2012.