LANDSCAPE-SCALE MONITORING IN A CHINESE ENVIRONMENT

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Sanjiangyuan – Study region

- The Sanjiangyuan Nature Reserve, also known as Three Rivers Region, is located in the northern Tibet Plateau (in Qinghai Province), with an average altitude of 3500m~4800m and an area of over 300,000 km^2.
- Geographic extent: 31°39‘N□36°12’N, 89°45‘E□102°23’E
- Population: 0.56 million.

The ecological environmental problems of Sanjiangyuan

- Experiencing a long period of grassland degradation, especially the increased area of the black soil patches
- major causes include:
  - 17% of total Sanjiangyuan area is affected by the rodents

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Remote sensing monitoring methodologies:
NCAS − Australian National Carbon Accounting System

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Remote sensing monitoring methodologies:
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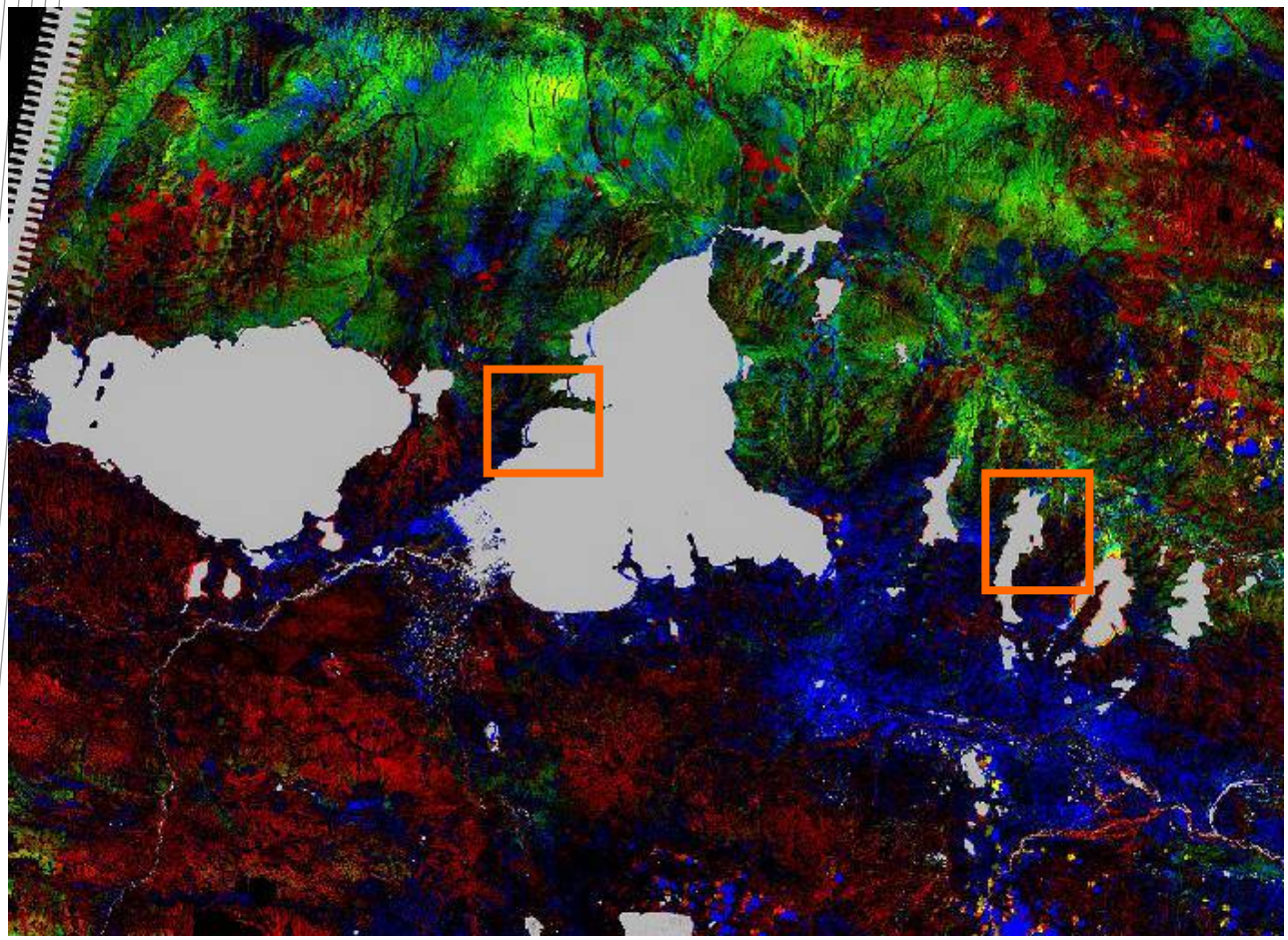
Glacier changes and movements:
− using satellite SAR images to monitor

Example: Result − Trend Image 1999-2009 using Cover Index

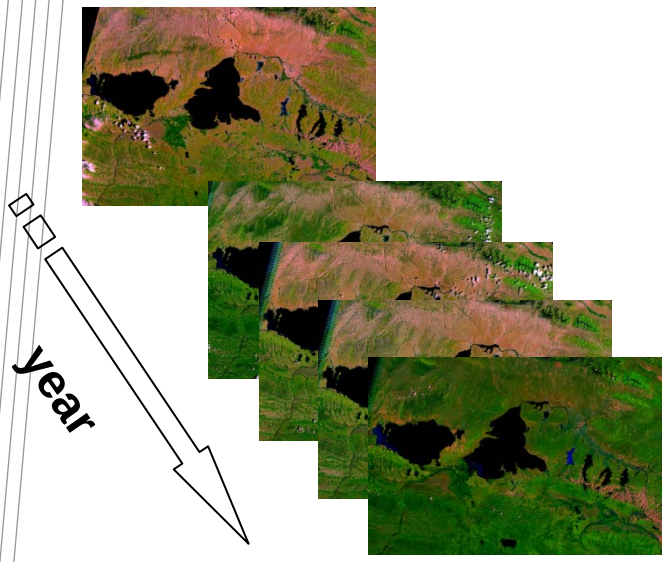


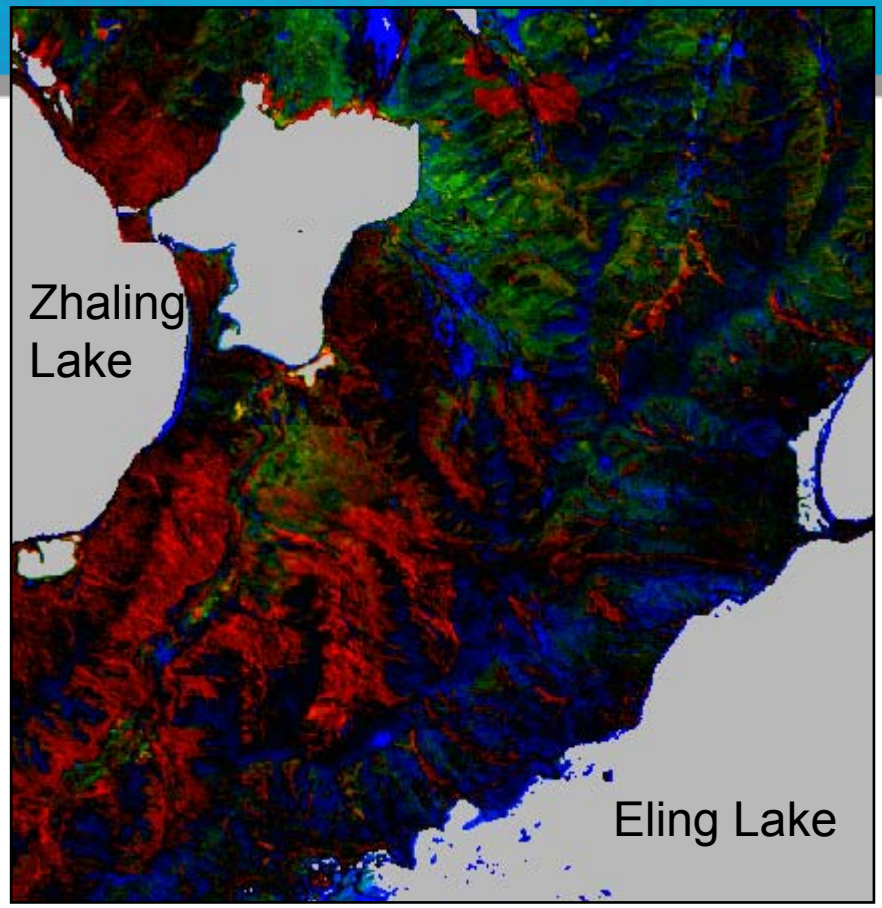
Key Message:
Different colours mean different changes over time in ground cover

Red: decline
Blue: increase
Green: decline then recovery

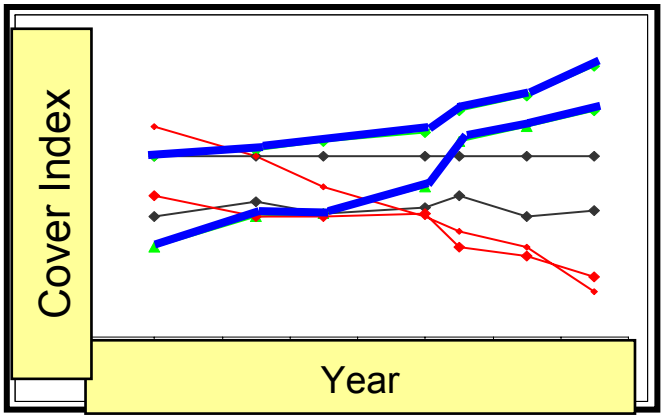
Deliver and validate: experts with understanding and knowledge

Rangelands and forest monitoring: Index trends from image time series



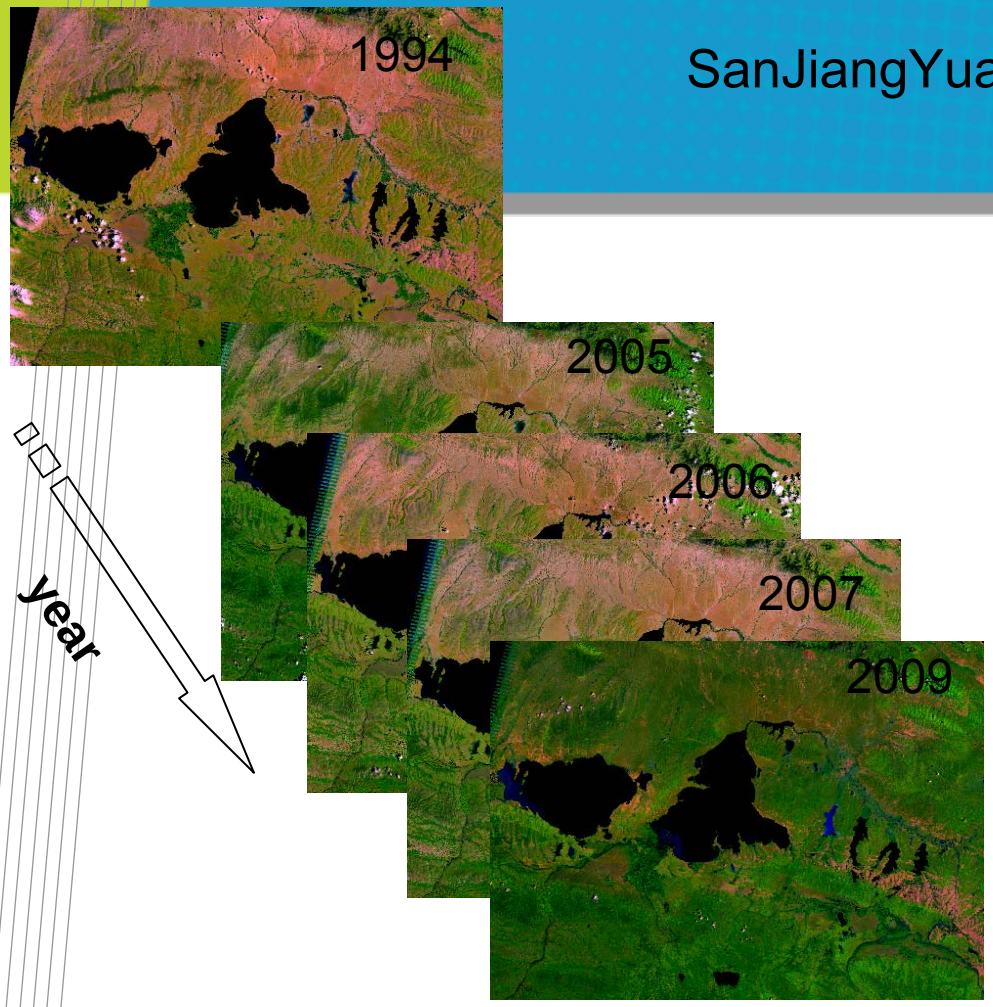


Trend image 1999-2009



Schematic: Index changes over time for a pixel or larger unit of land

SanJiangYuan Landsat Image Time series

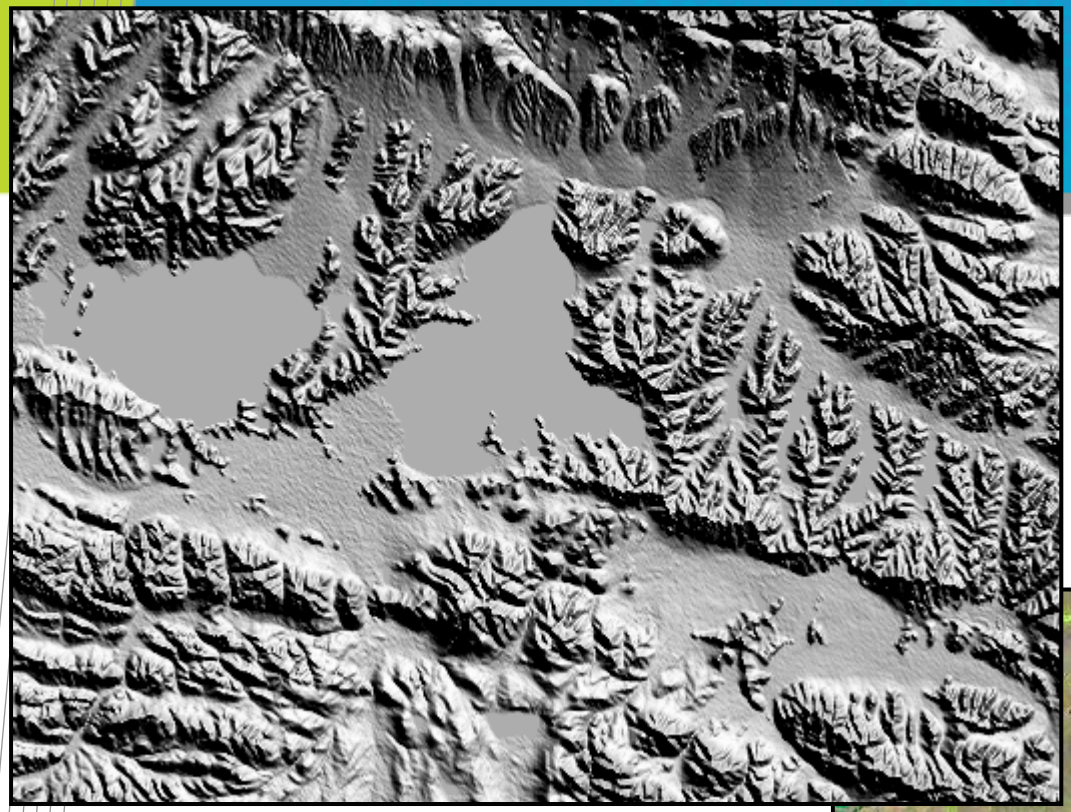


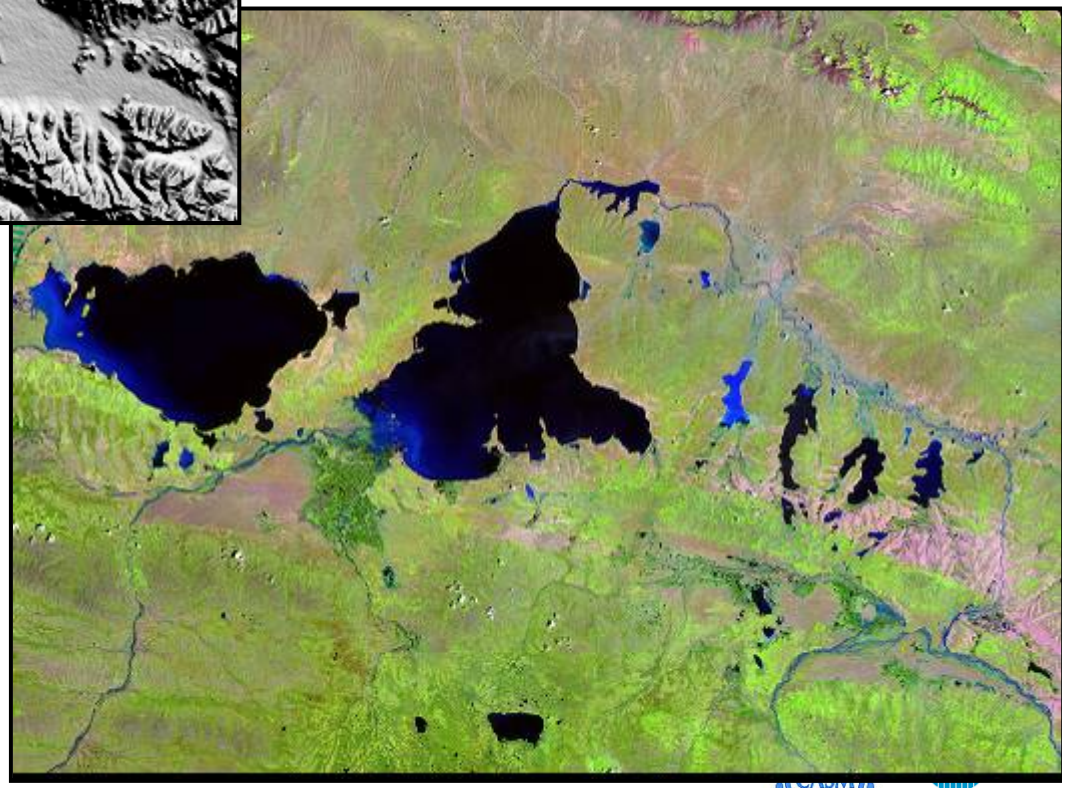
1994 July
1999 July
2000 June
2001 July
2001 September
2002 September
2005 August
2006 July
2007 August
2009 July

1. Processed, BRDF corrected, Calibrated..
terrain correction
Operational NCAS specifications

2. Calculated Cover Indices and Greenness Index, Calculated trends for indices

DEM Digital Elevation Model
SRTM (90m) ASTER (30m)





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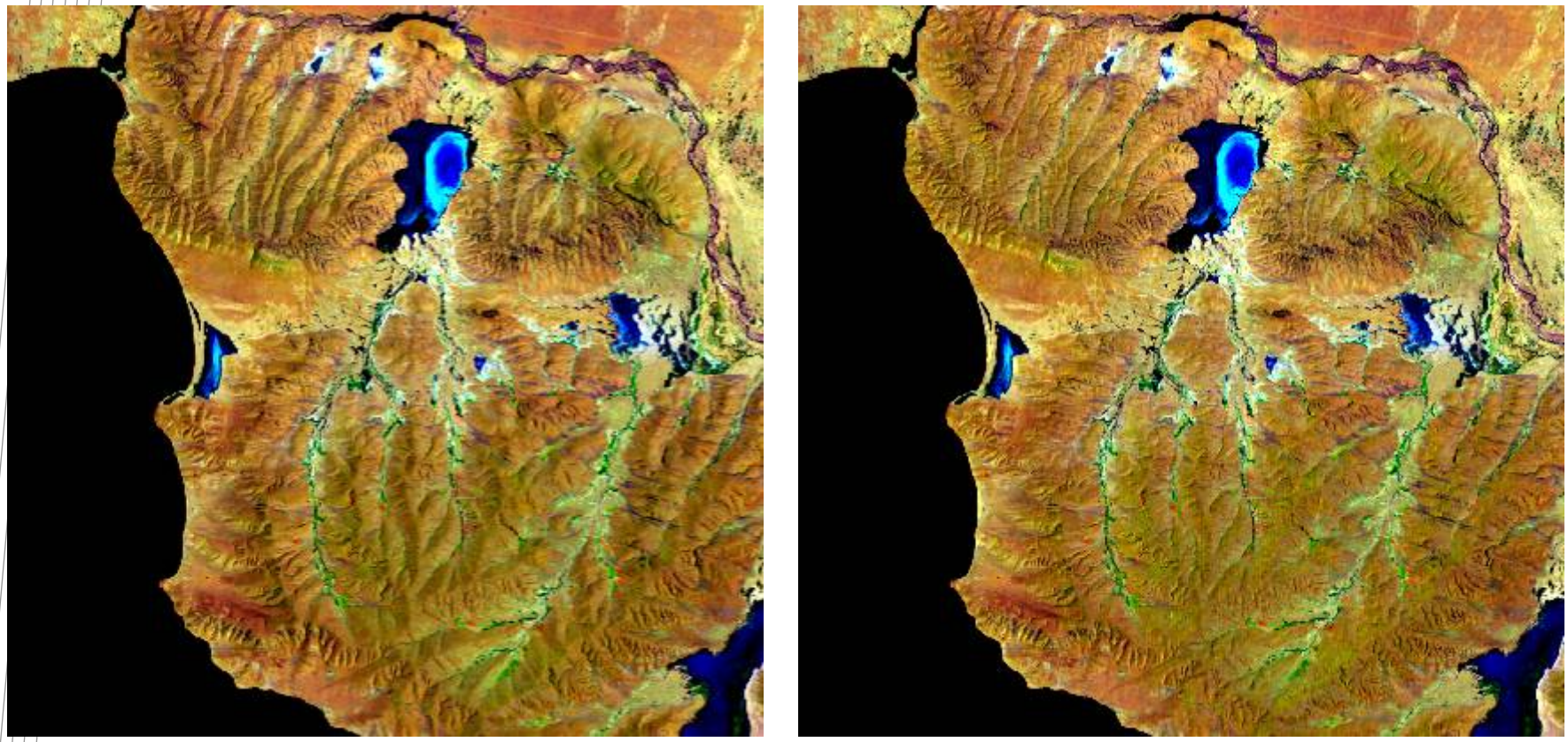
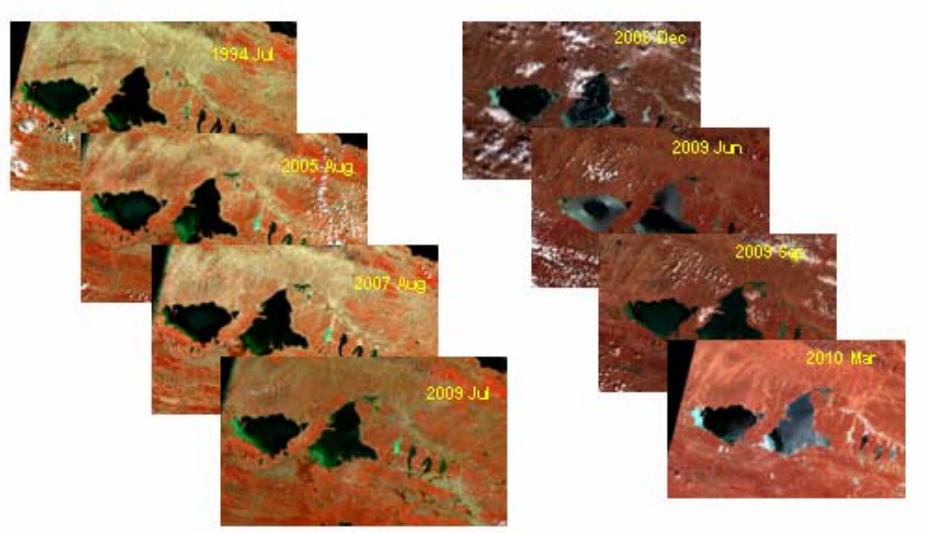
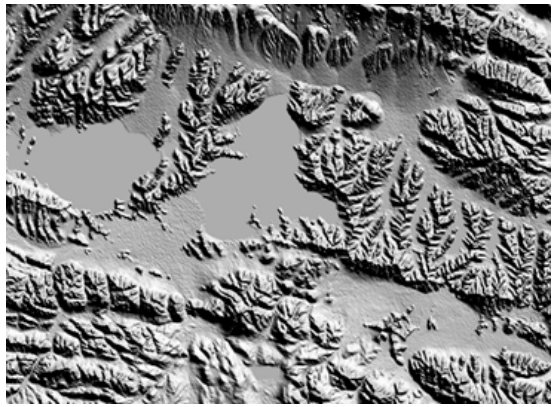
Terrain Illumination Correction of images – using ASTER DEM

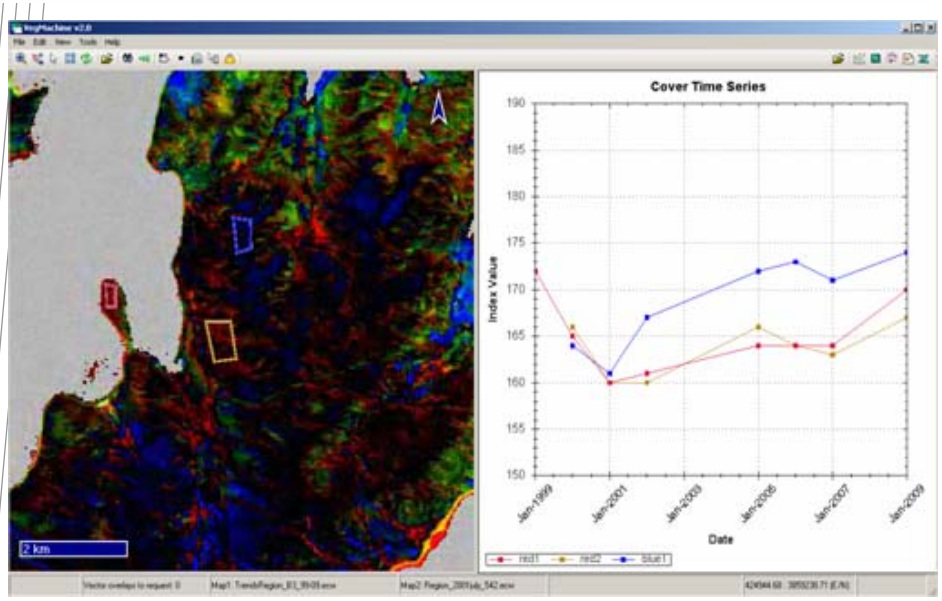


Terrain Illumination Correction before and after

Remote sensing monitoring methodologies:
NCAS − Australian National Carbon Accounting System



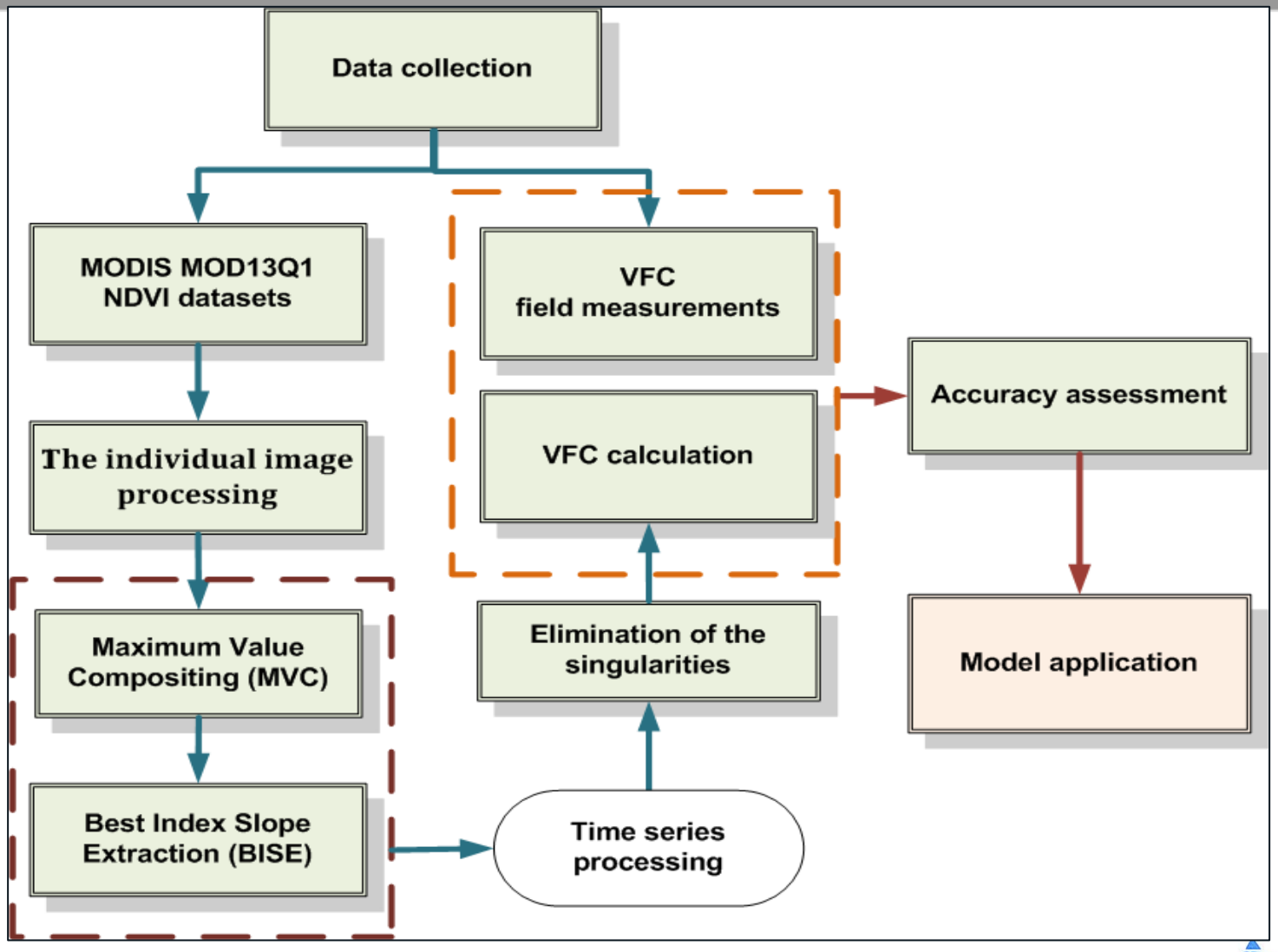




Data Source

- Satellite Data:
  - Terra/MODIS 250m 16-days VI data, 2000~2009
  - Landsat TM images, 1980~2009
  - HJ-1 images, 2009~2010
- Ancillary Data:
  - Black soil patch classification data
  - Field data

VFC Inversion Procedure



Vegetation Fractional Cover calculation

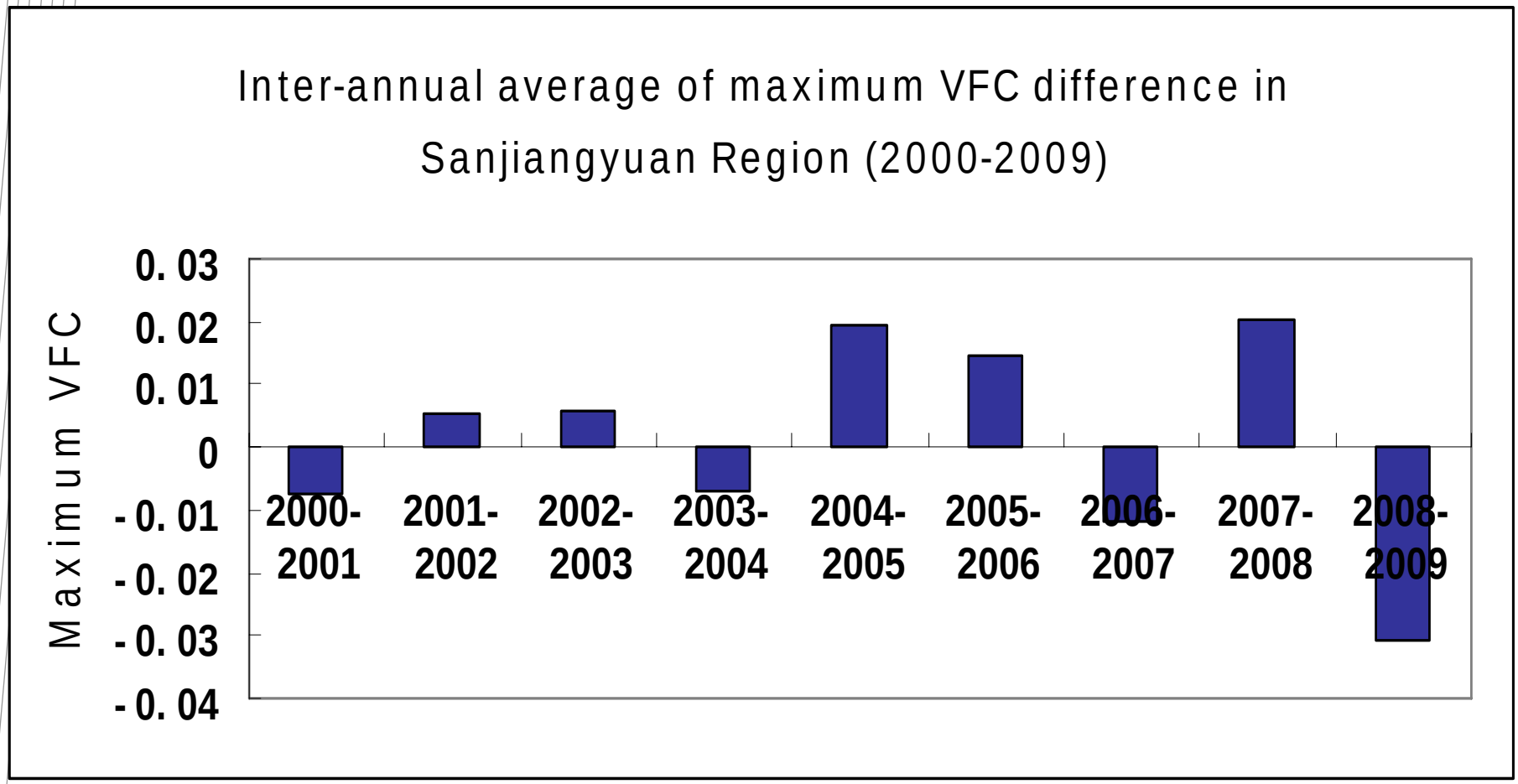
$$fc = (\mathrm{NDVI} - \mathrm{NDVI}_{soil}) / (\mathrm{NDVI}_{veg} - NDVI_{soil})$$

Where:

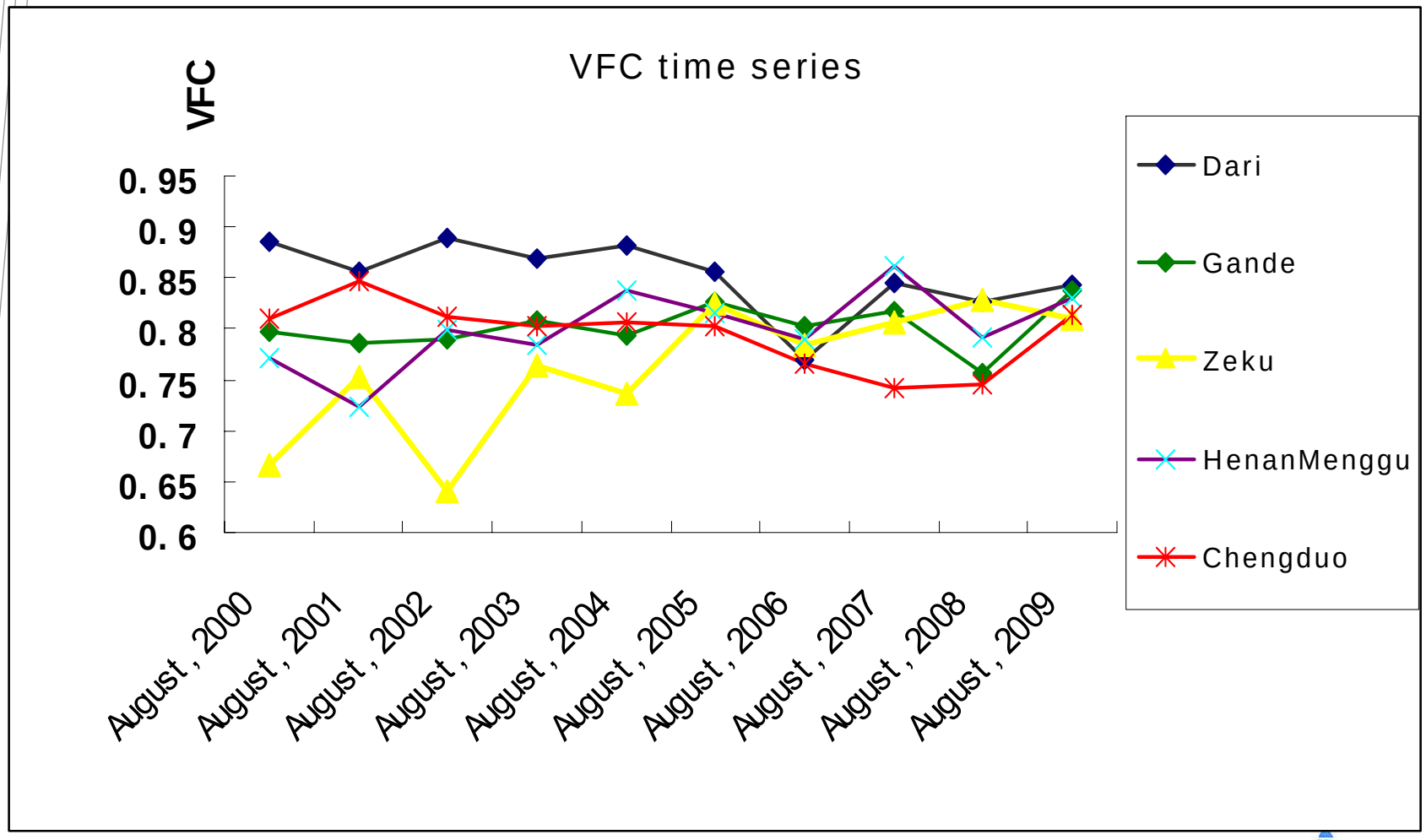
$NDVI_{veg}$: the NDVI value of the pure vegetation pixel

$NDVI_{soil}$: the NDVI value of the pure soil pixel

Interannual average of maximum VFC difference in Sanjiangyuan (2000~2009)



VFC time series (2000-2009)



Field trip 16-22 June 2010, Qinghai Province

Rats !

Optical remote sensing monitoring summary

- Focused on the Sanjiangyuan Region – environmentally sensitive, remote and sparsely populated
- Evaluated the utility of mixed sensor systems for estimating land use and land use change
- Developed a baseline for monitoring and modelling past and future changes in the Sanjiangyuan Region
- NCAS technologies applied in Chinese environments successfully (Landsat, HJ satellite data, terrain illumination, trends etc) through field validation and local knowledge inputs
- CASM provides rich information about the Sanjiangyuan region (Landsat TM/ETM+, MODIS, HJ-1A/1B etc), USGS data.
- Local provincial bureaus (Surveying and Mapping, Development and Reform Committee, Environmental Protection Agency) are accessing and using results and findings from such projects
- Contributed knowledge towards current understanding of the ecological and environmental changes taking place (VegMachine or alike)

CASM CSIRO

Glaciers in the Geladandong Area

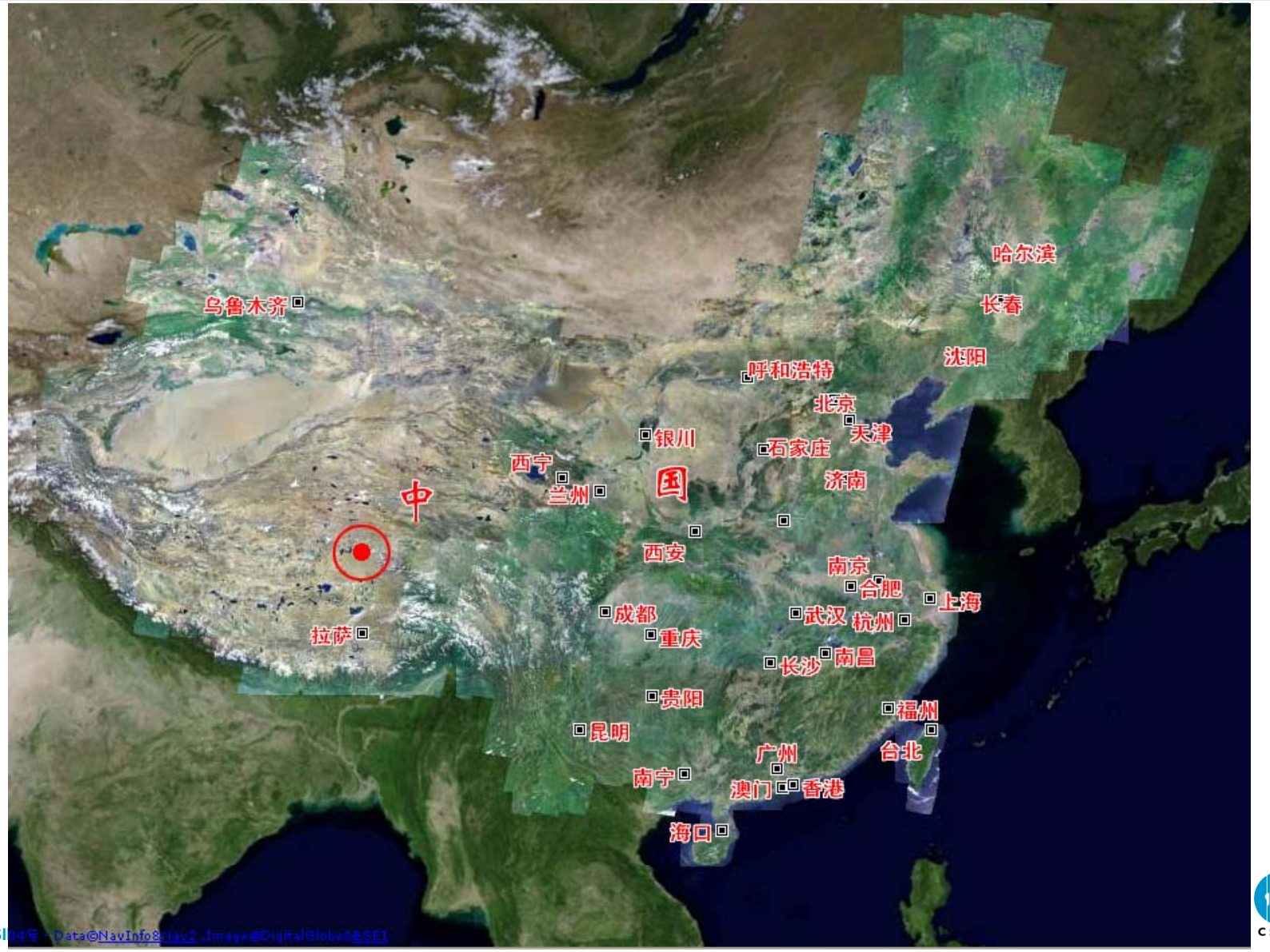
- Using satellite SAR images to Monitor
  - Changes of glacial area
  - Glacier movements

Glacier monitoring using satellite SAR images in Sanjiangyuan region

- glacier movement driving forces
  - Topographic factors, e.g. slope, aspect
  - climate factors, such as temperature, precipitation…

- glacier movement analysis
  - The movement velocities at glaciers A, B and C show significant variations during the years of 1997, 2003, 2007 and 2009, which may have some connections with the climate conditions of these years. But further investigation needed.

Glaciers in the Geladandong Area



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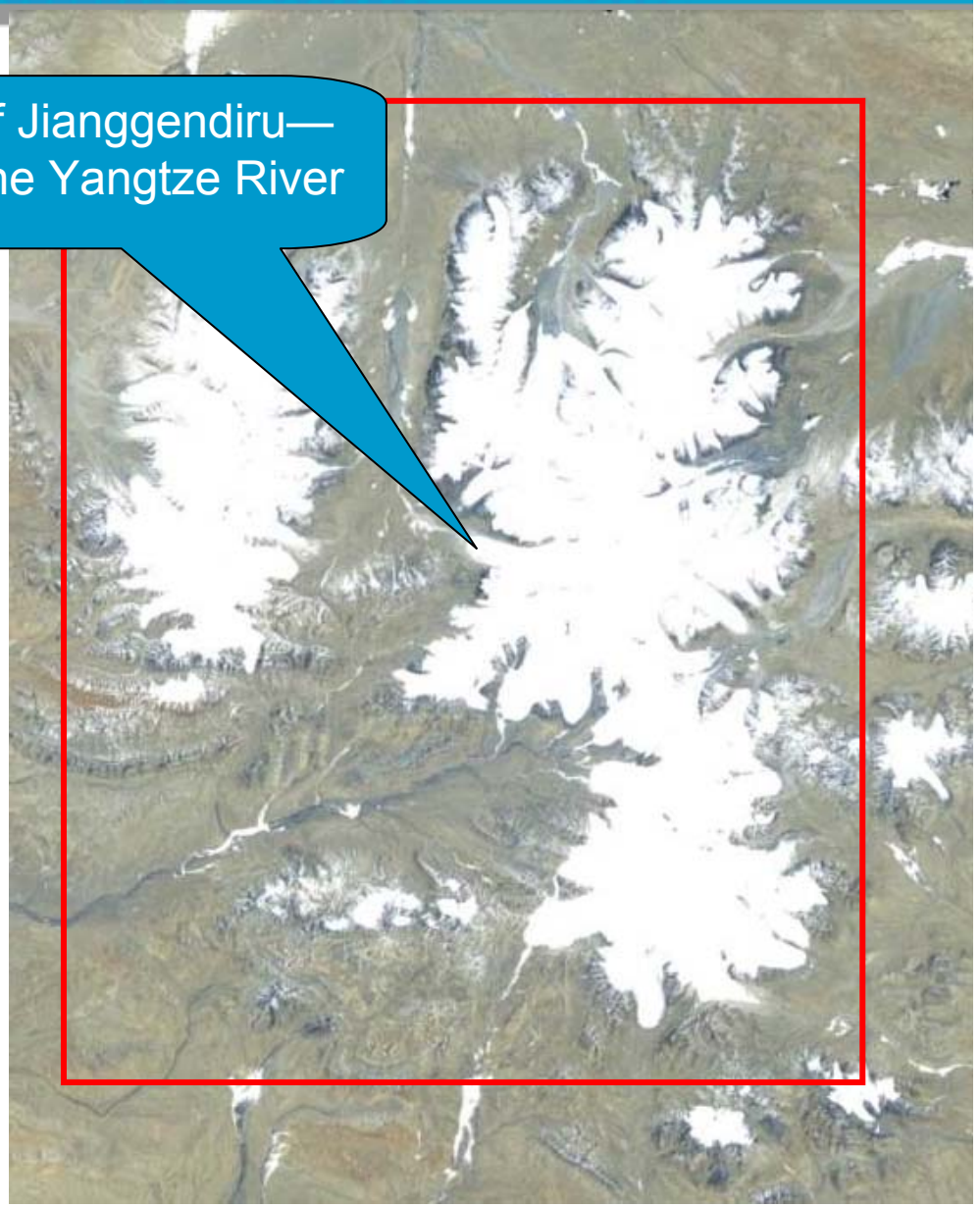
Glaciers in the Geladandong Area

- 50km long in N-S
- 30km wide in E-W

- 130 glaciers distributed
- Covering 790.4 km^2



SAR data and interferometric coherence analysis

- SAR data collection
  - 19 ERS/ENVISAT SAR images were ordered from 1993 to 2009, except 1995, 1999 and 2002
  - 4 interferometric pairs were formed with temporal baseline of 35 days

Pair	Mission	Master image	Slave image	Temporal Baseline/ day	Perpendicular Baseline/m
1	ERS2-SAR	19970810	19970914	35	62
2	ENVISAT-ASAR	20030615	20030720	35	108
3	ENVISAT-ASAR	20070624	20070729	35	59
4	ENVISAT-ASAR	20090802	20090906	35	-289

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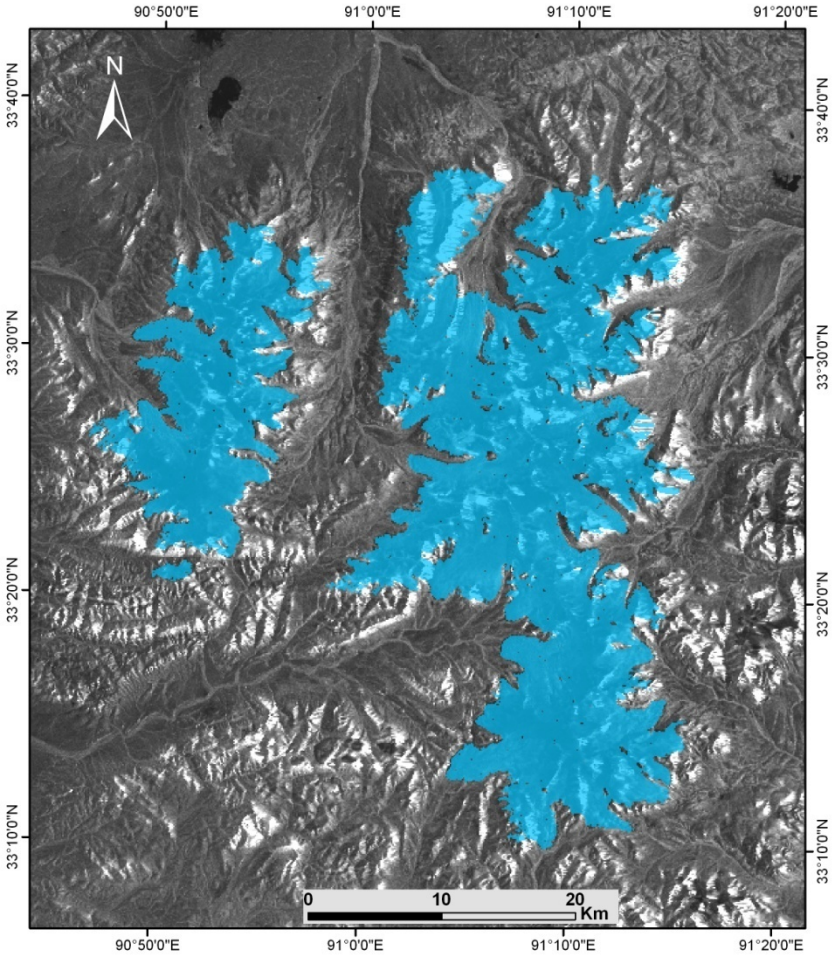
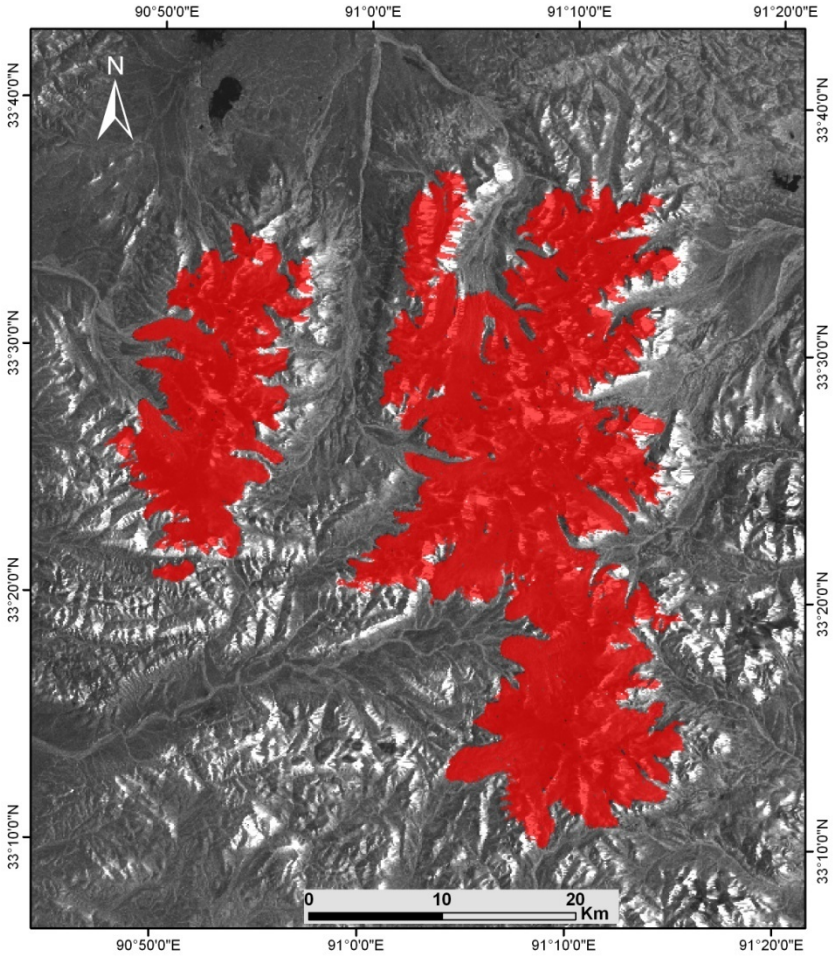
Glacial change results

- glacial area extraction in 1997 and 2007



1997□862.05km^2

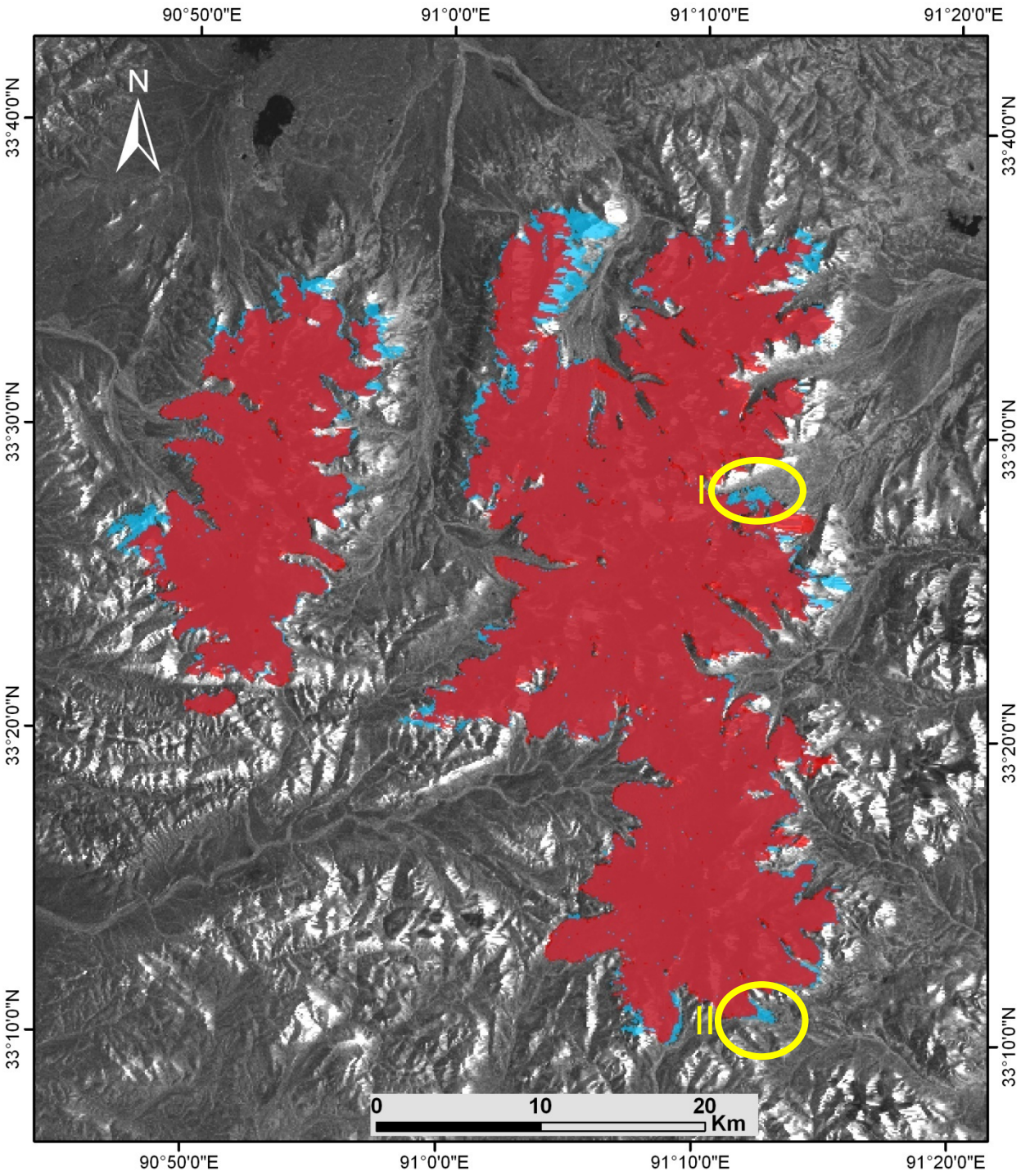


2007□840.34km^2

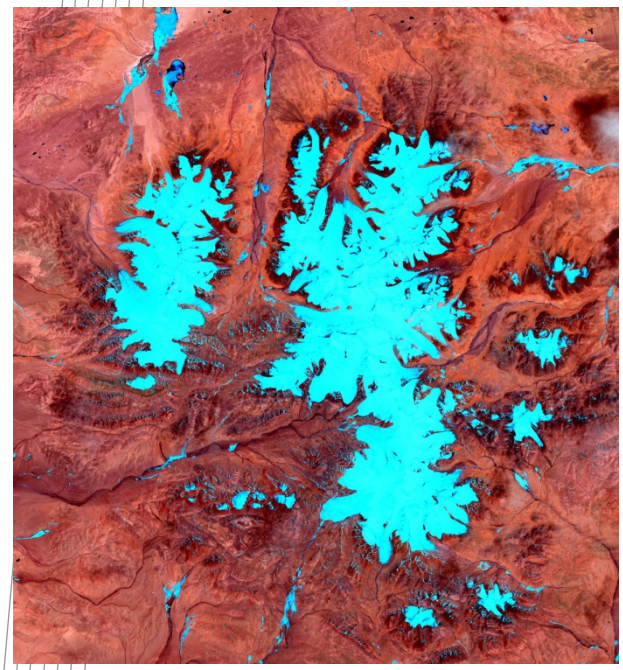
- Change of glacial area

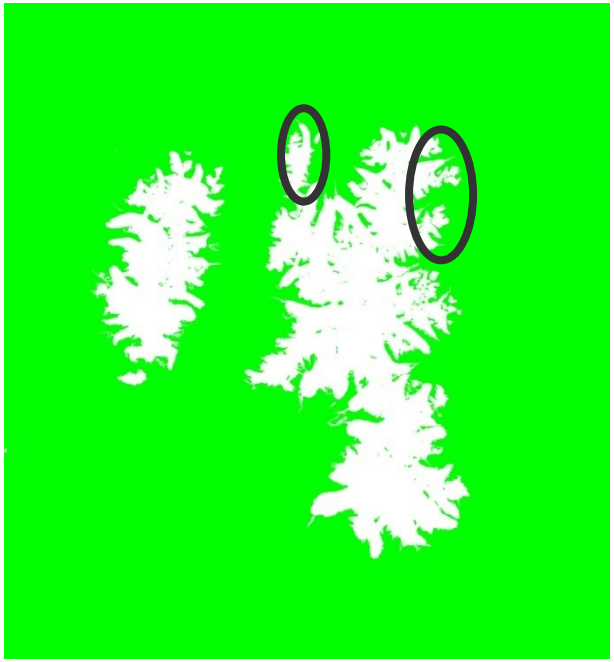
- 1997：862.05km^2
- 2007：840.34km^2

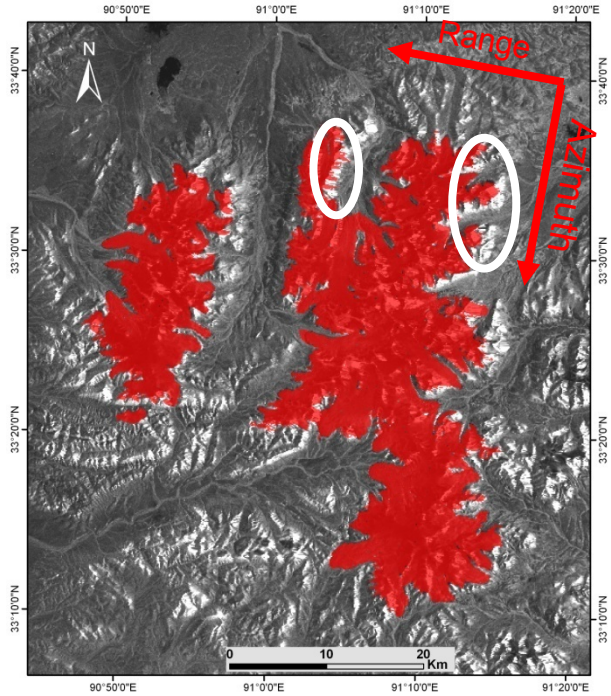
- Shrinking area: 21.71km^2



Comparison of extracted glacial areas with Landsat TM data







Landsat5 TM image-20070505
(543 band combination)

2007 TM area
825.61km^2

2007 ASAR area
840.34km^2

The relative difference of glacial area extracted from ASAR and TM is 1.78%

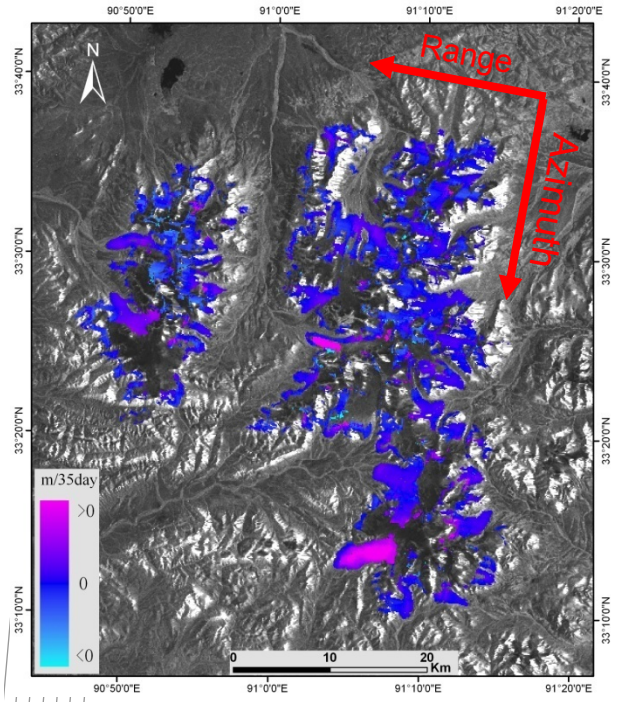
SAR layover is the main reason for ASAR's underestimate.

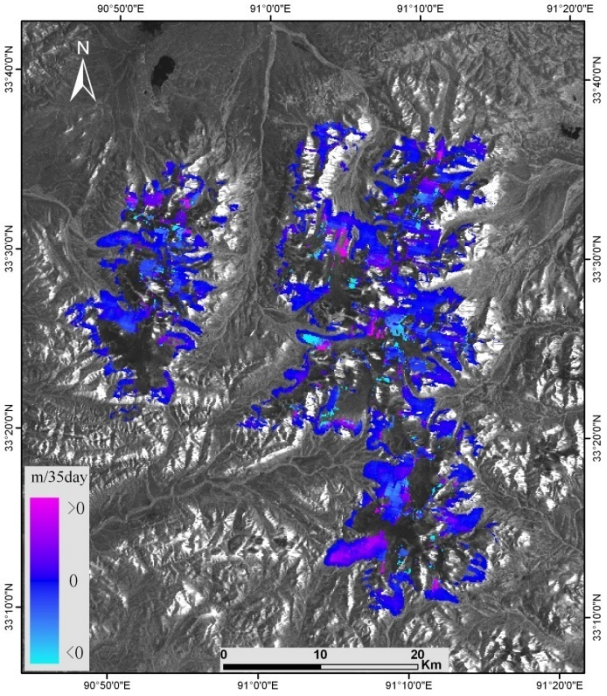
Glacial movement monitoring

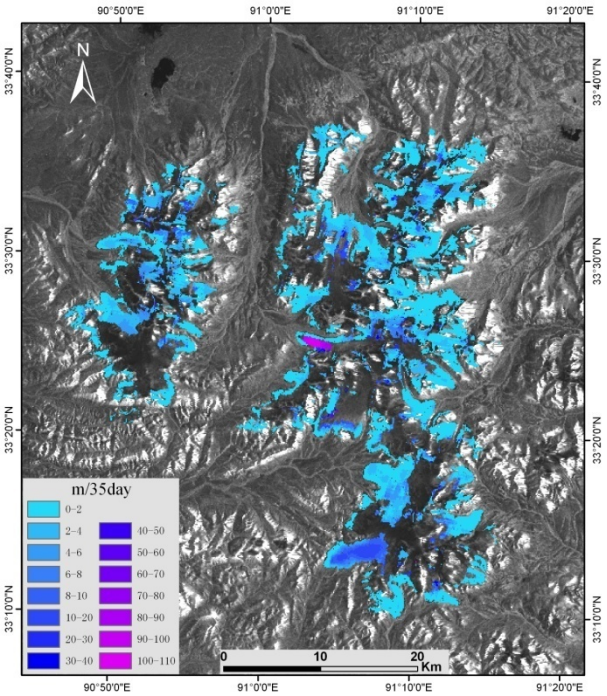
- Glacier movement monitoring with offset-tracking technique
  - The coherence of two SAR images with only 35-day time interval is very low, which indicates interferometry can not be used for glacier movement monitoring for C-band SAR.
  - Offset-tracking technique is to detect large movement directly through analyzing the offsets of two SAR images in slant-range and azimuth directions.

- Rational of offset-tracking method
  - Determining the offsets of two SAR images in specified grids by area cross-correlation.
  - The offsets of non-glacial area, which is caused by satellite orbit difference, is modeled with polynomial functions.
  - In glacial area, the movement is calculated by subtracting the modeled offset from the offset determined with cross-correlation.

glacier movement velocity - 1997







ground range direction

>0: ←

<0: →

azimuth direction

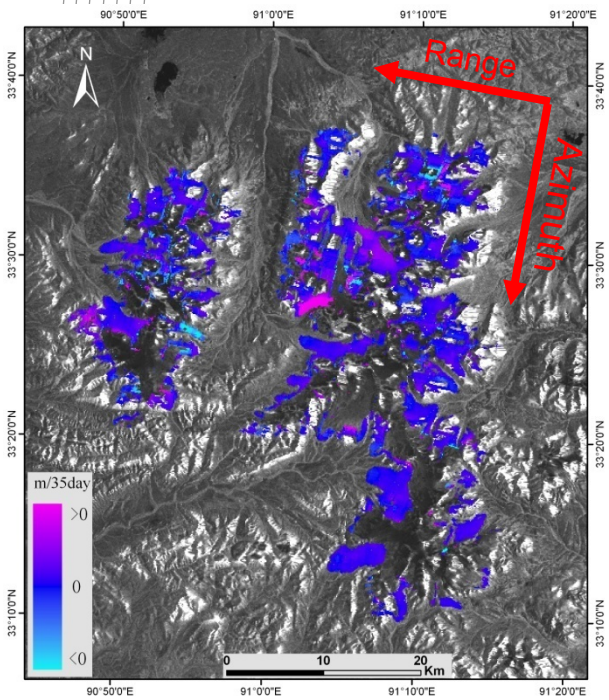
>0: ↓

<0: ↑

Intensity of glacier movement

Most movements are detected in glacier tongues, because of higher intensity correlation SNR, while inner glacier with SNR below 0.7 cannot be estimated.

glacier movement velocity - 2003



ground range direction

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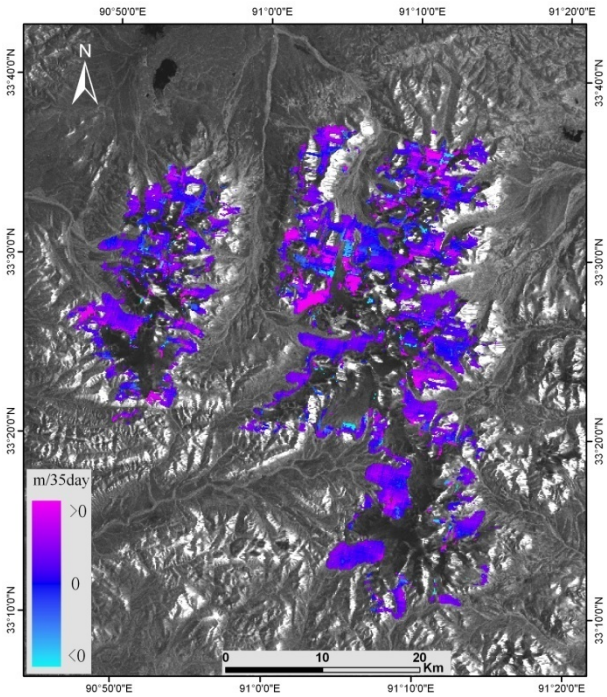

azimuth direction

>0:

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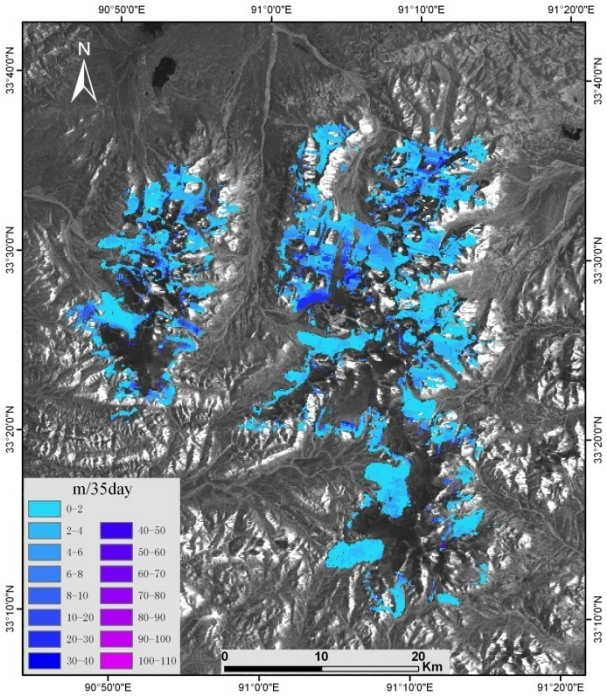
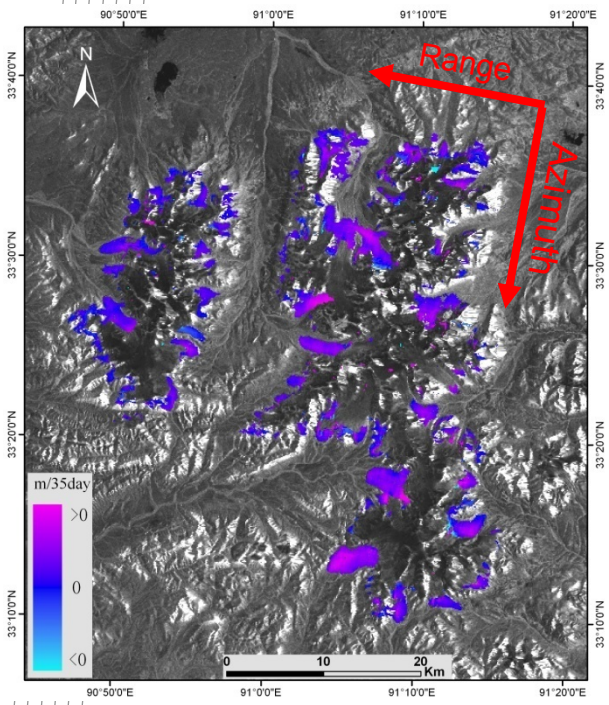


Intensity of glacier movement

glacier movement velocity - 2007



ground range direction

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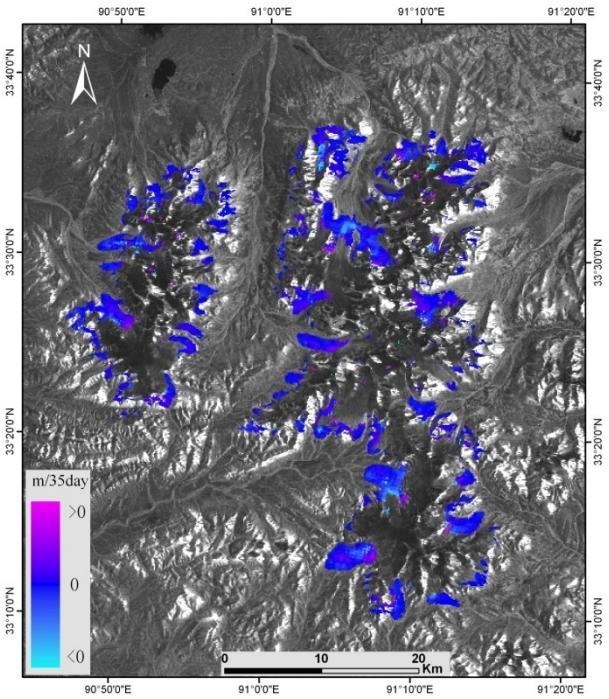

azimuth direction

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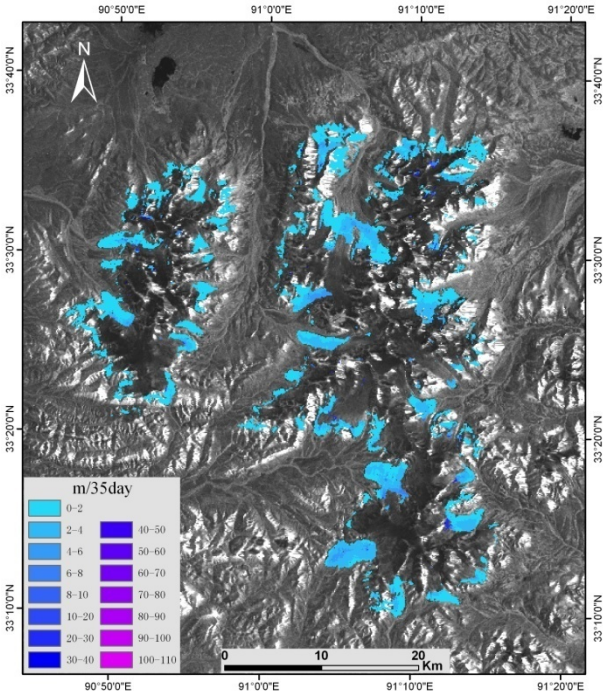
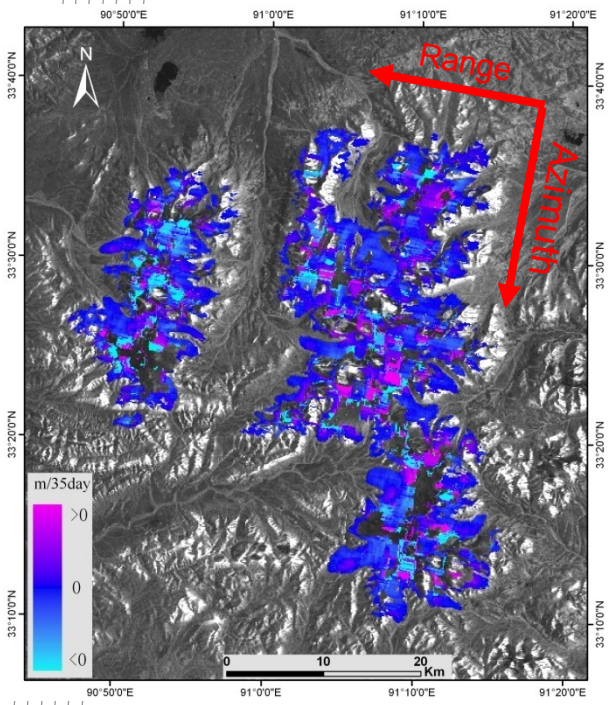


Intensity of glacier movement

glacier movement velocity - 2009



ground range direction

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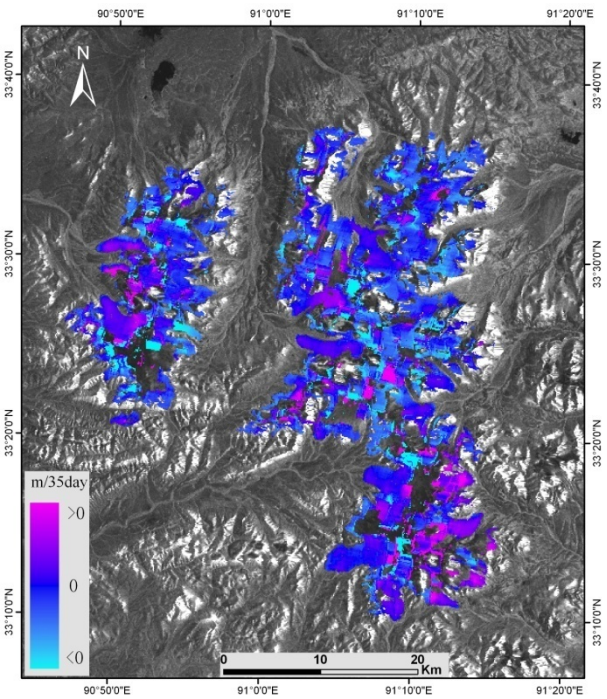

azimuth direction

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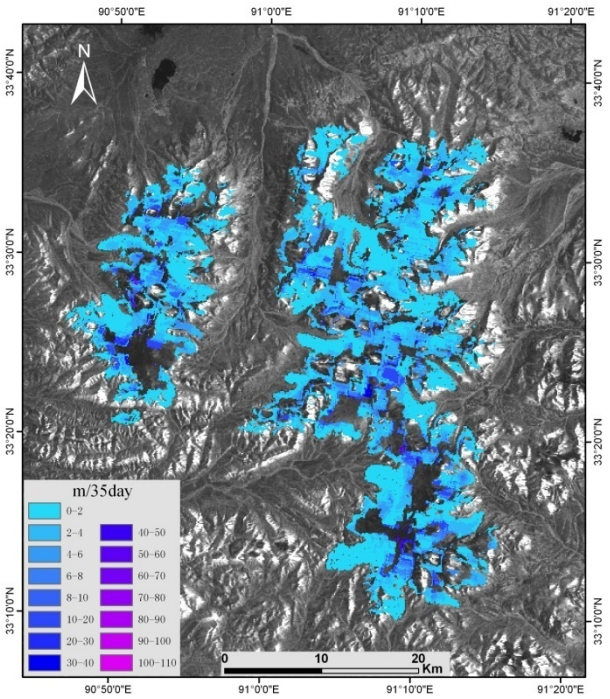
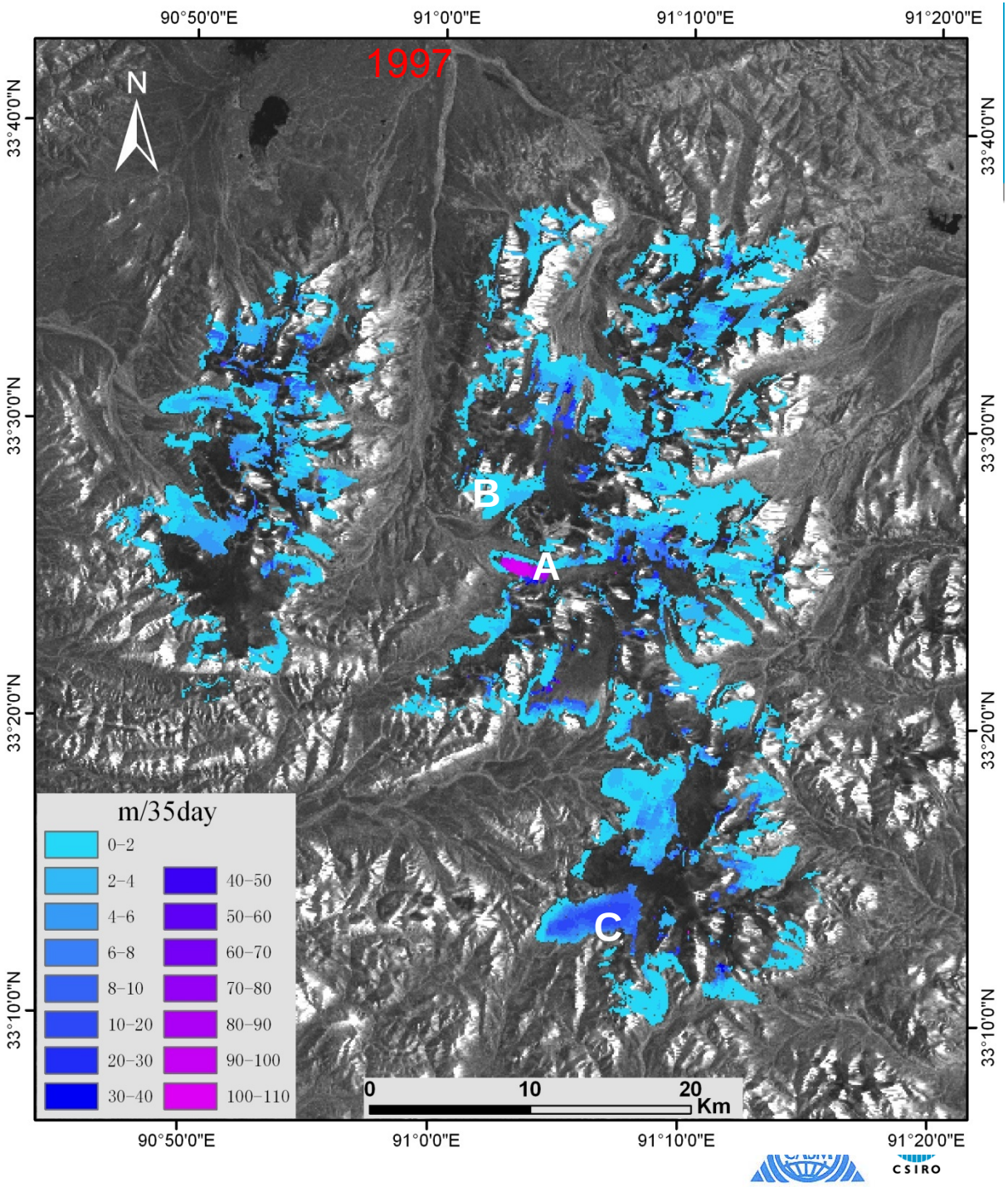


Intensity of glacier movement

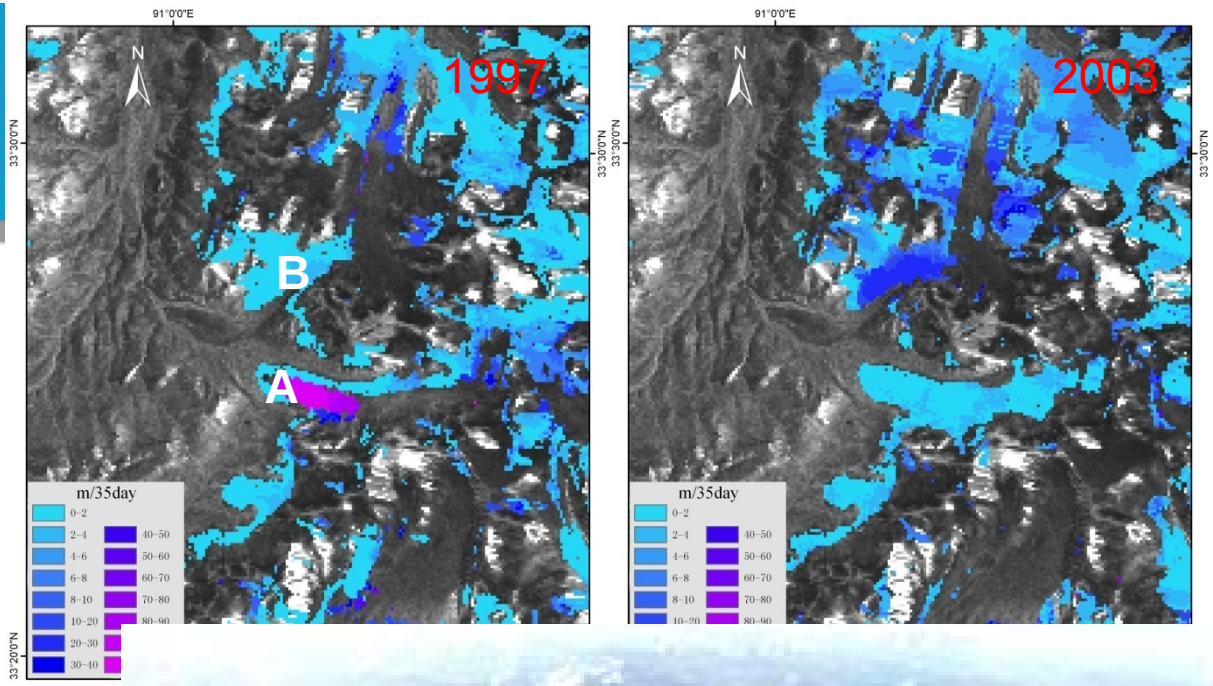
- Variation of glacier movement in the 4 years

3 glaciers (A, B and C) change obviously from 1997 to 2009

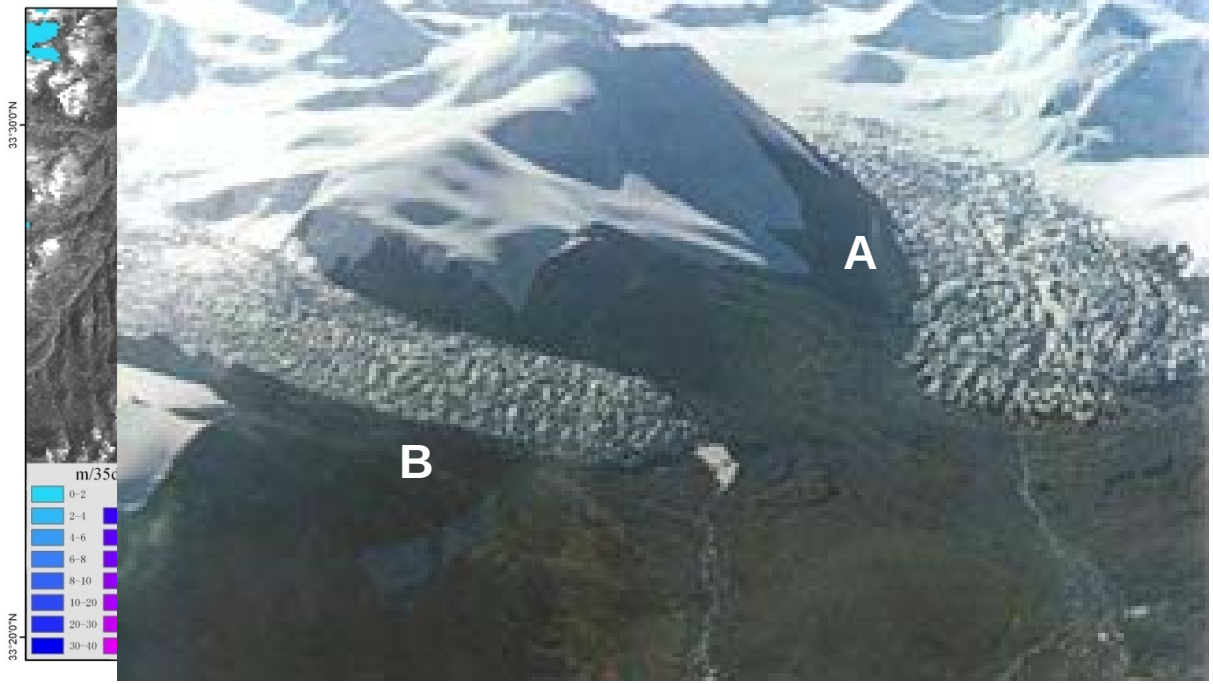


Glacier A	Velocity (m/35day)
1997	~101
2003	~1.5
2007	~2.4
2009	~0.7

Glacier B	Velocity (m/35day)
1997	~3
2003	~25
2007	~4.5
2009	~1



Gla



Glacial monitoring summary

- C-band SAR data is not suitable for glacier monitoring with interferometry technique. SAR data with longer wavelength may be better, such as L-band ALOS PALSAR.
- It is nearly impossible to distinguish glaciers from SAR intensity images.
- Although 35-day interferogram is suitable for movement monitoring, the consistently low coherence of glacial area provides a good means to extract them.
- Alternatively, offset-tracking is a promising technique to monitor glacier movement.
- The glacial area in Geladandong region shrinks 21.71km2 between 1997 and 2007
  - 1997□862.05km^2
  - 2007□840.34km^2
- With offset-tracking, glacier movement over Geladandong area in 1997, 2003, 2007, 2009 are estimated. The movement velocities of different glaciers have very different scenarios, with significant inter-annual variations. The causes need to be further investigated.

Key References

[1] Furby, S.L., 2002. Land Cover Change: Specification for Remote Sensing Analysis, National Carbon Accounting System - Technical Report No. 9, *Australian Greenhouse Office.*

[2] Cleary, P. et al., 2011. Environmental Informatics for the Development of Landscape Scale Monitoring and Modelling, *CSIRO Technical Report No: EP113108*

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