# 气候变化背景下中国北安至黑河高速公路地质问题及工程对策

## Geological Problems and Engineering Countermeasures of Beian-Heihe Highway of China in the Context of Climate Change

东北林业大学寒区科学与工程研究院
Institute of Cold Regions Science and Engineering

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New Highway in Heilongjiang Province
2000 km in 3 years.

Highway construction plan of Heilongjiang Province (2008-2011)

**Background**
（*Frozen area in NE China*）

- Topography and Geomorphology
- Geological structure
- Climate and weather
- Distribution of frozen soil

**Climate change & degradation of permafrost**
（*study area*）

- Change of Permafrost Southern Boundary (in NE China )
- Distribution characteristics of permafrost

**Types and characteristics of geological disasters**
（*Beian-Heihe Highway*）

- Landslide
- Icing
- Foundation settlement

**Other environmental geological issues**
（*study area*）

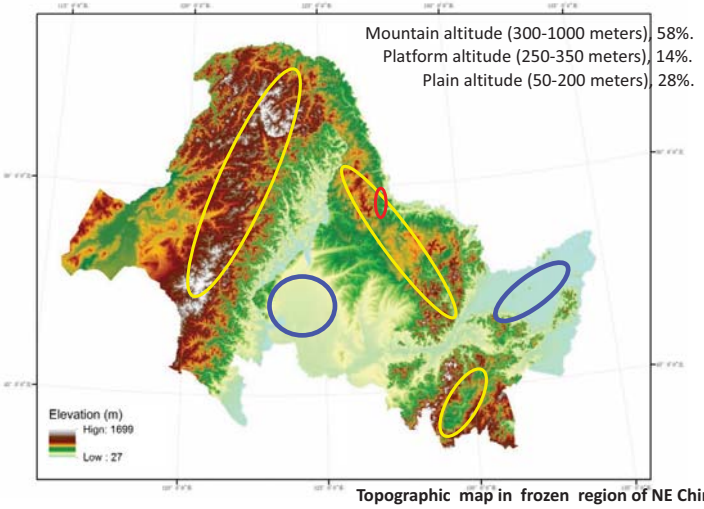
**1.背景**
（东北冻土区）

- 地形与地貌
- 地质构造
- 气候
- 冻土的分布

**1.Background**
（*Frozen area in NE China*）

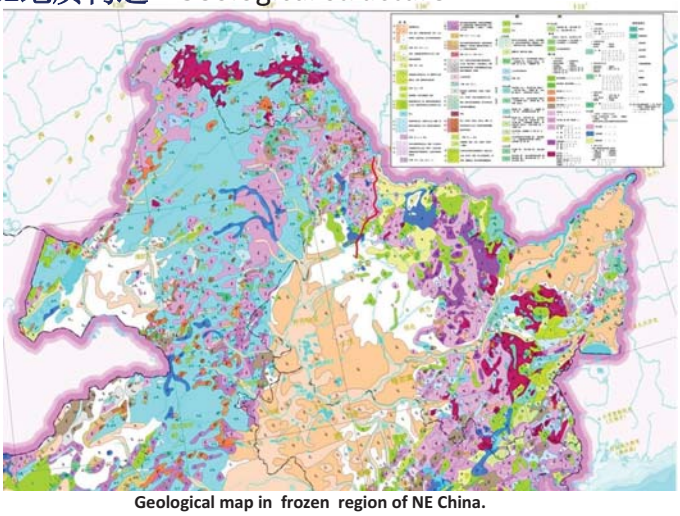
- Topography and Geomorphology
- Geological structure
- Climate
- Distribution of Frozen soil

## 1.1地形与地貌 Topography and Geomorphology

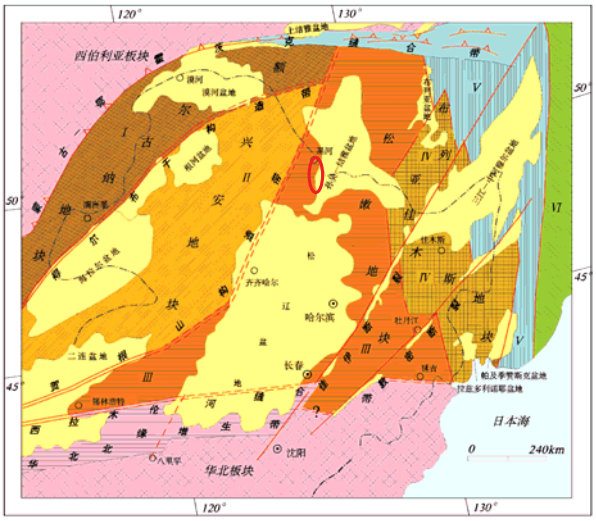



Topographic map in frozen region of NE China.

## 1.2地质构造 Geological structure

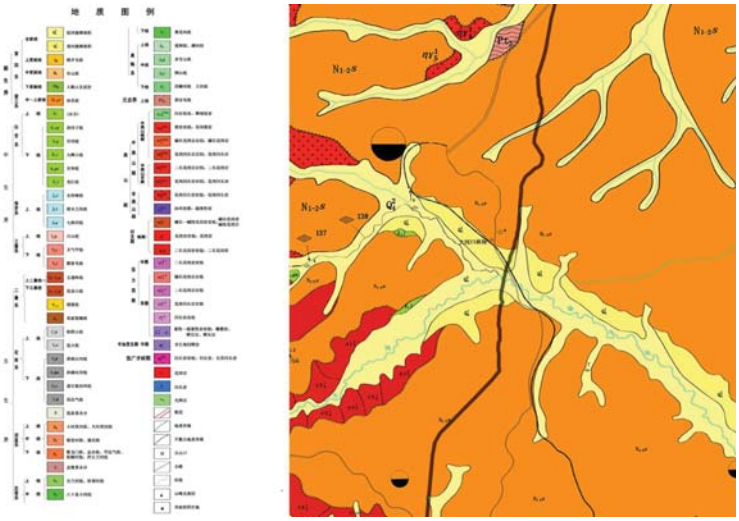


Geological map in frozen region of NE China.



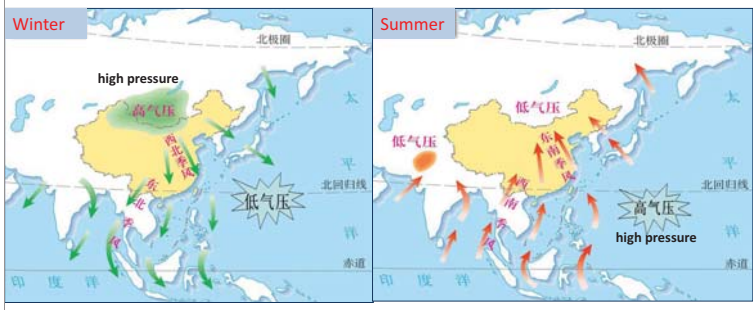

东北地区大地构造分区图

Geological Structure map in frozen region of NE China.



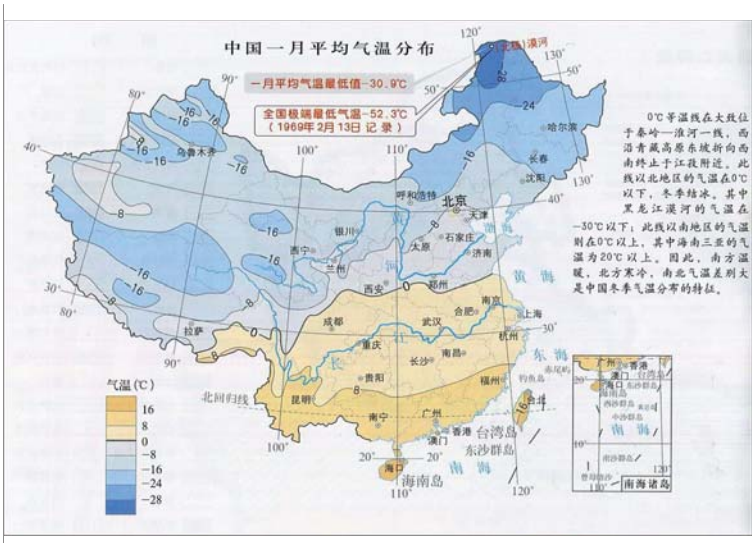
Geological map along Beian-Heihe Highway in NE China.

## 1.3 气候与气象 Climate and weather

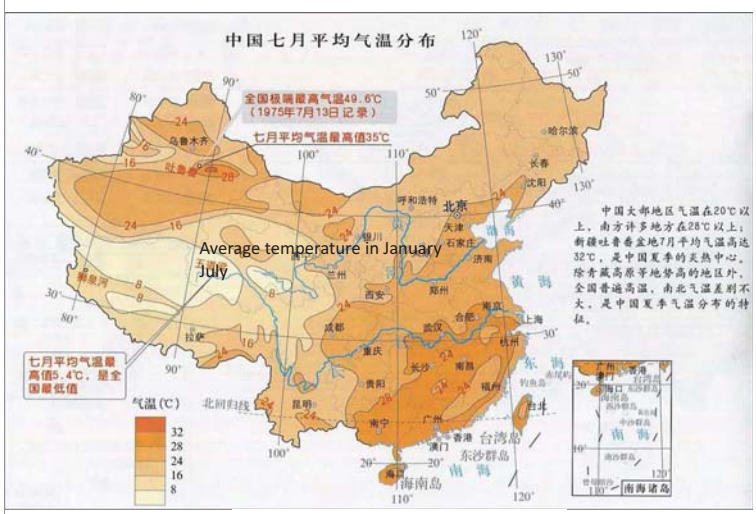



**Medium - temperate continental monsoon climate**
*long winter ,short summer, obvious four seasons.*

**Spring**: warmer, windy and drought.
**Summer:** controlled by the southeast monsoon , mild and rainy;
**Autumn:** cooling fast, early
**Winter**: high pressure (Siberia, Mongolia) long, Cold and dry.



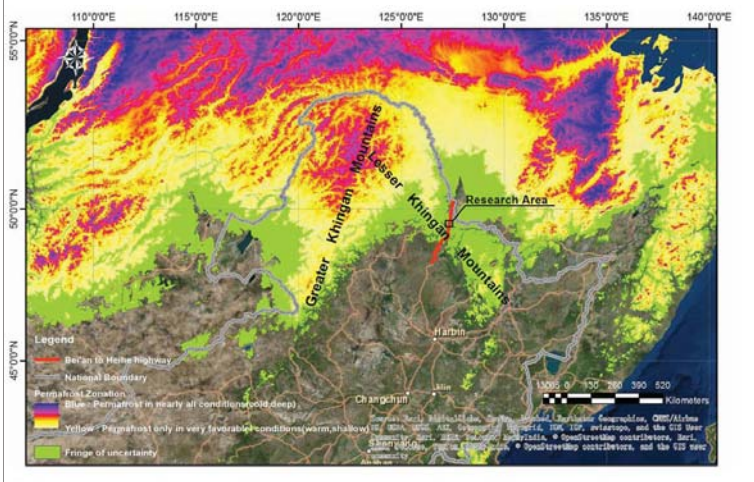

Average air temperature in January in China




Average temperature in January
July

Average air temperature in July in China

## 1.4 冻土的分布 Distribution of Frozen soil




| High-latitude permafrost distribution in Northeast China (data from Zurich University, Switzerland), and the location of study area.

## 2.气候变化与多年冻土退化（研究区）

•多年冻土南界演变（东北）
•多年冻土分布特征

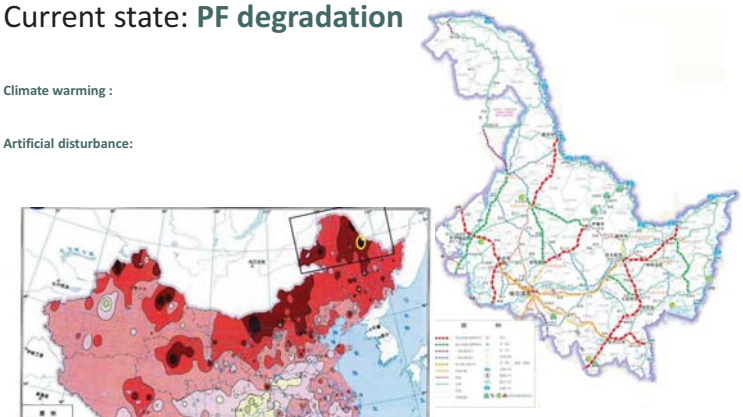
## 2. Climate change & degradation of permafrost
*（ study area ）*

•Change of Permafrost Southern Boundary (in NE China )
•Distribution characteristics of permafrost

## Current state: PF degradation

**Climate warming :**

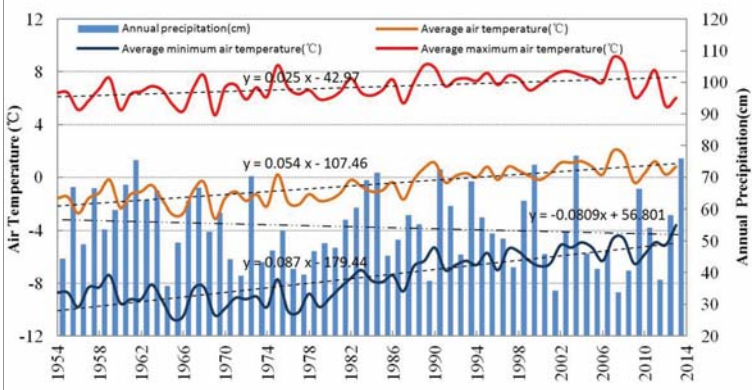
**Artificial disturbance:**





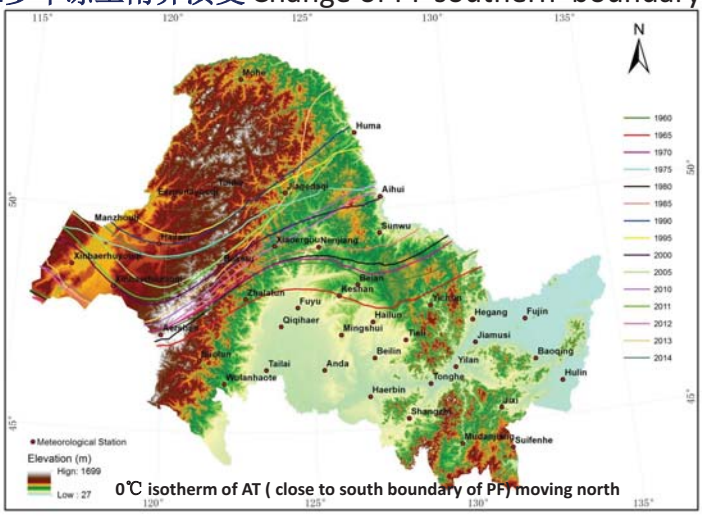
Average annual temperature changing 1957 ~ 2007 (℃/10Years)

New Highway in Heilongjiang Province
2000 km in 3 years.




Average annual temperature changing near study area（1954-2014）

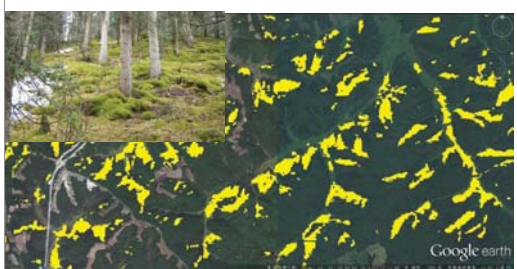
## 2.1多年冻土南界演变 Change of PF southern boundary



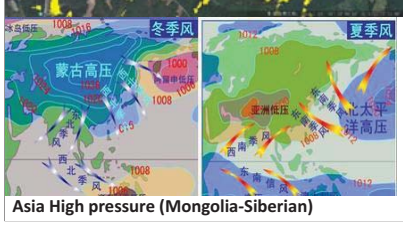

0℃ isotherm of AT ( close to south boundary of PF) moving north

## 2.2多年冻土分布特征 PF distribution characteristics

**Kinggan-Baikal Permafrost**



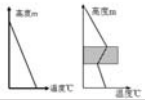

- Inverse AT layer in winter
- Surface vegetation reduce solar radiation & ST rising.
- Location:
  Lower place (valley, shadow slope, wetland)
- T difference: 1-5℃.
- Normal height band:>700m

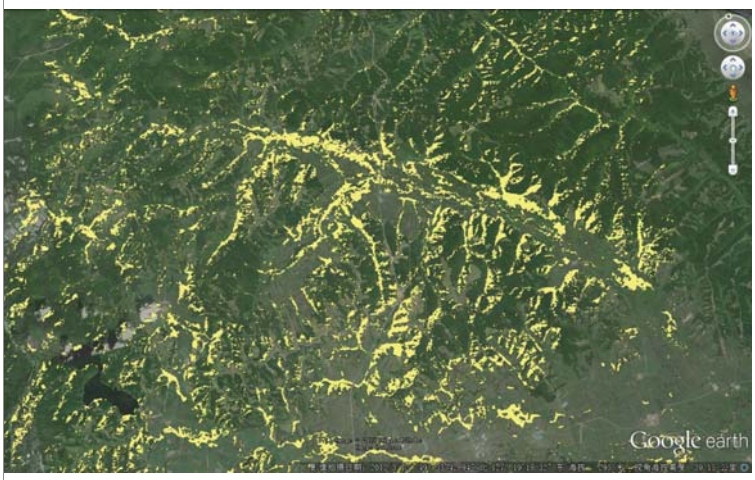



Asia High pressure (Mongolia-Siberian)

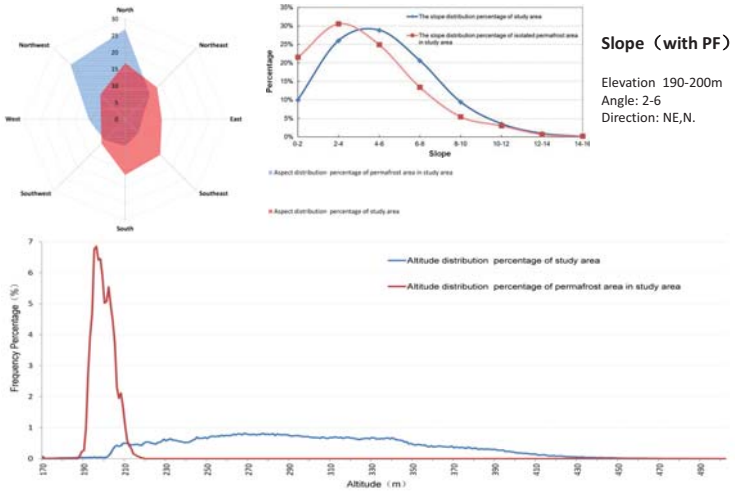
**Inversion layer of AT :**

- Asia High pressure (Mongolia-Siberian)
- Control by inverse AT layer in winter





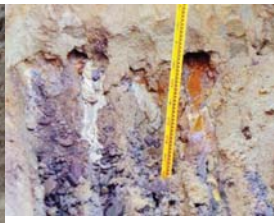

PF distribution using Landsat 7 ETM+ Imagine data,2012




**Slope（with PF）**

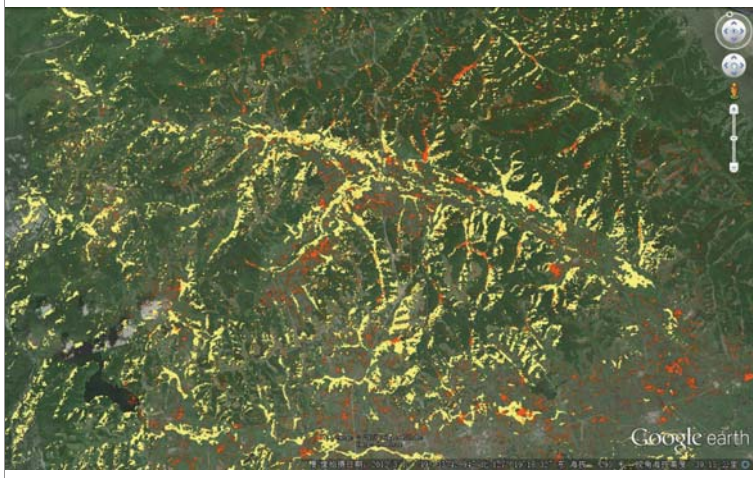
Elevation 190-200m
Angle: 2-6
Direction: NE,N.

**Elevation & Direction distribution of PF in the study area (From Landsat data & DEM)**



**Excavation site (2.1m depth)**
**Seepage trace (Φ20mm)**

## 冻土分布与地表形变




**PF distribution and the surface deformation（same data source）**

### 3.地质灾害类型及特征（北黑高速沿线）

- 滑坡
- 涎流冰
- 地基沉降

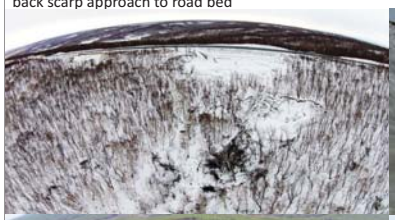
### Types and characteristics of geological disasters（*Beian-Heihe Highway*）

- Landslide
- Icing
- Foundation settlement

## 3.1 滑坡 Landslides

**Embankment section:**
Multiple, irregular shape ,creeping movement, back scarp approach to road bed

**Excavation section:**
icing in winter， landslide in Spring.

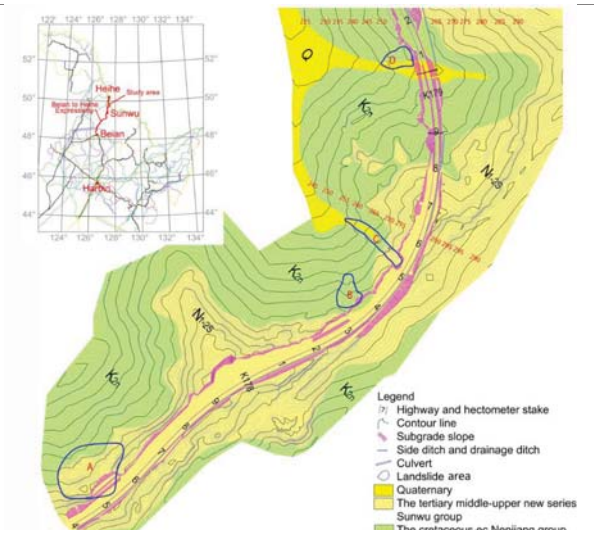


**Foundation settlement：**

## 3.1 滑坡 Landslides

1999: 17 seg.; Roadbed Landslides
2009: 06 seg.; >2000m3 lanslsides mass


Bei'an-Heihe Highway (Blue line is the boundary of the landslides, the orange area is corn field).




Geological map of K177+400-K179+200 section of Bei'an-Heihe Highway.

A Landslide :
shell shape,
set anti-slide pile(17*24m, DIS 3m),
the back edge stop moving.
the second creep landslide occur ahead

Site picture:

a) cutting off (under the front edge of landslide )
b) The whole front edge of landslide
c) The second creep landslide just in front of original the front edge of landslide

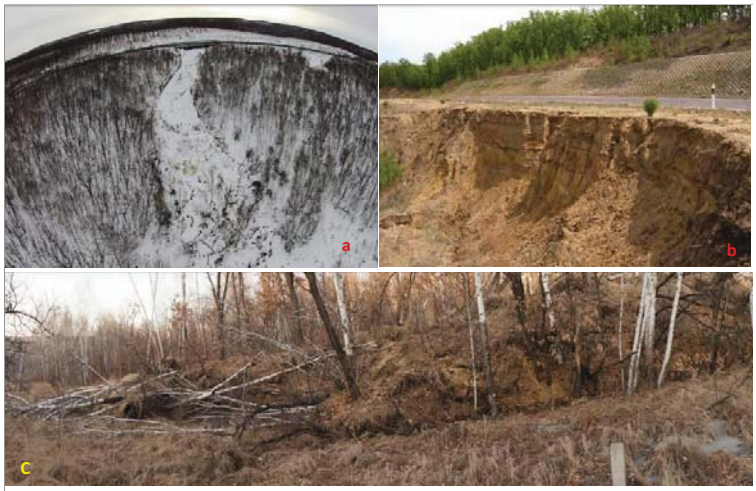



C Landslide :

Site picture:

a) Side edge of the LS.
b) Whole picture of side edge of LS.
c) the front edge of LS(many trees fall down).


Satellite photos of K176 + 500 - K179 + 900 section of Bei'an-Heihe Highway (Google earth).



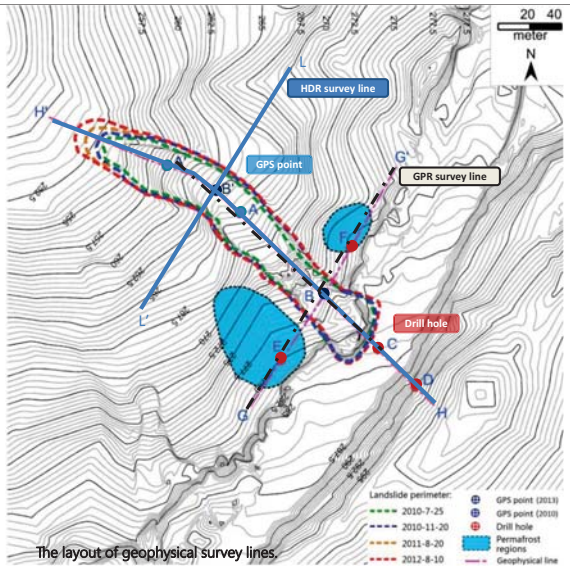

Landslide scene photos:
a) Panoramic view of landslide (in November 2014);
b) The back edge of landslide (in June 2010);
C) The front edge of landslide (in October 2013)

## Method

**Drilling detection**
- Survey geological map
- Bury sensors in drilling hole
- Sample from drilling hole

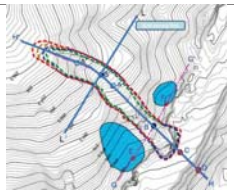
**Geophysical prospecting**
- High density resistivity (HDR)
- Ground-penetrating radar (GPR)

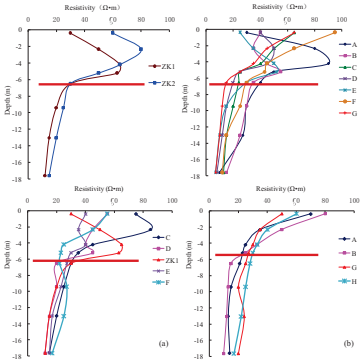
**Monitoring by sensors**
- Soil temperature
- Pore water pressure



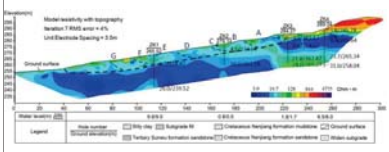

The layout of geophysical survey lines.

High density resistivity (HDR)

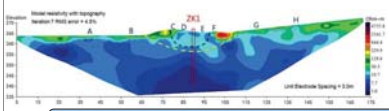




H-H'

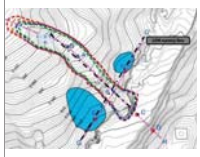


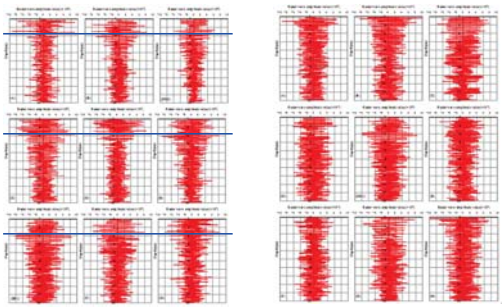
L-L'



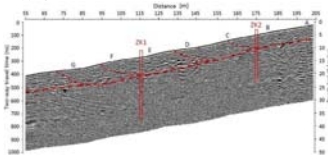
(HDR) : sliding surface – soil resistivity values decreased suddenly.

Ground-penetrating radar (GPR)

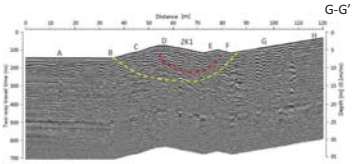




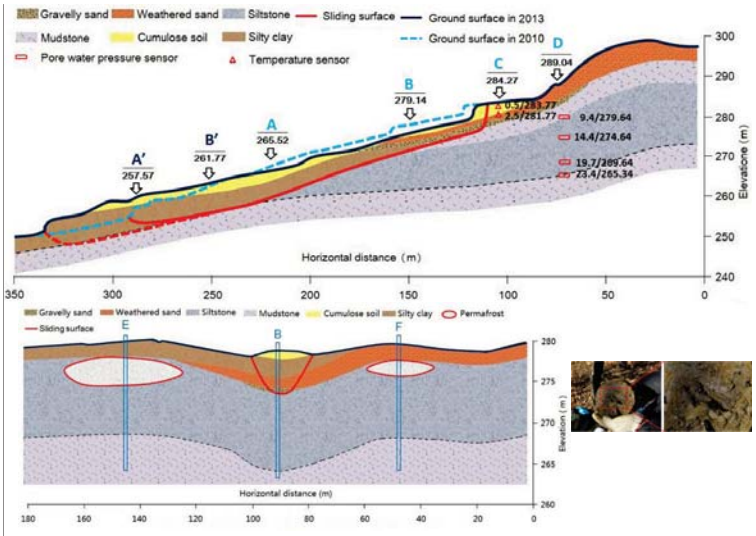
A' -C



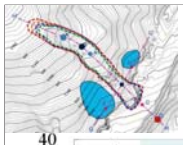
G-G'

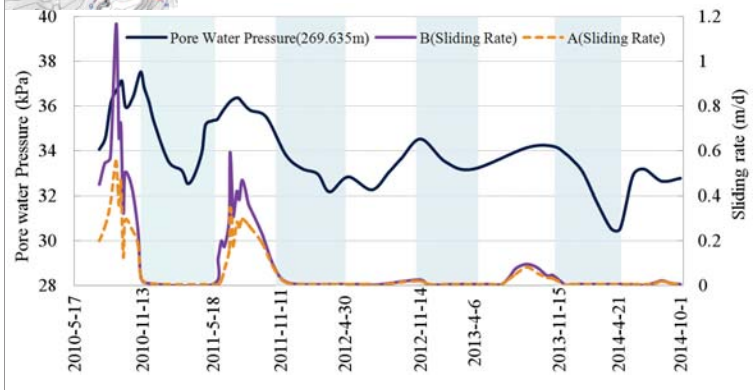


(GPR) : sliding surface – radar wave amplitude rise rapidly.

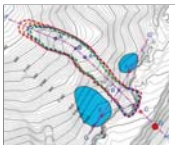


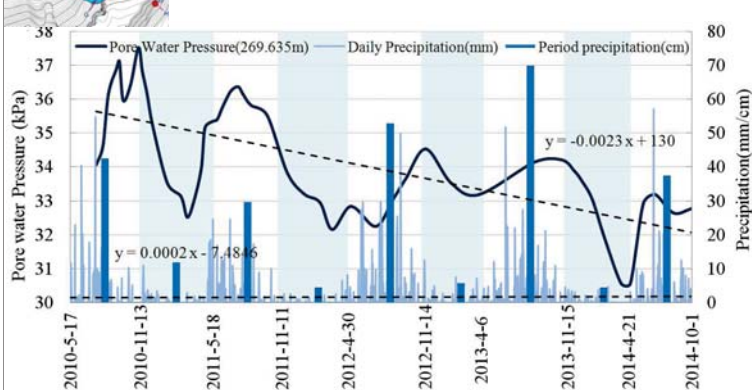

Geological profile of K178+530 section of Beian-Heihe Highway






Horizontal displacement rates of point A & point B( on the landslide mass )
pore water pressure of point D (19.4m depth)






Daily precipitation and pore water pressure in the depth of 19.4 m of D point in K178 + 530 section of Bei'an-Heihe Highway.