



ESA-MOST Dragon Cooperation

中国科技部-欧洲空间局“龙计划”合作

2017 DRAGON 4 SYMPOSIUM

2017年“龙计划”四期学术研讨会

26-30 June 2017 | Copenhagen, Denmark

2017年6月26-30日, 丹麦 哥本哈根

DRAGON 4 ID. 32437 EARTH OBSERVATION TO INVESTIGATE THE CHARACTERISTICS AND CHANGES OF THE CRYOSPHERE IN HIGH MOUNTAIN ASIA (EOCRYOHMA) SUMMARY

LIs: Prof. Yao Tandong, Dr. Tobias Bolch

PIs: Prof. Noel Gourmelen, Prof. Liu Shiyin, Prof. Che Tao, Prof. Roderik
Lindenbergh

Sub-projects and themes:

Id. 32437_1

Mapping of (rock)glaciers and observation of glacier area and volume changes in High Mountain Asia using earth observation data (EOGlacHMA)

Id. 32437 _2

Observation of extent and characteristics of snow and permafrost in High Mountain Asia (EOSnoPeHMA)

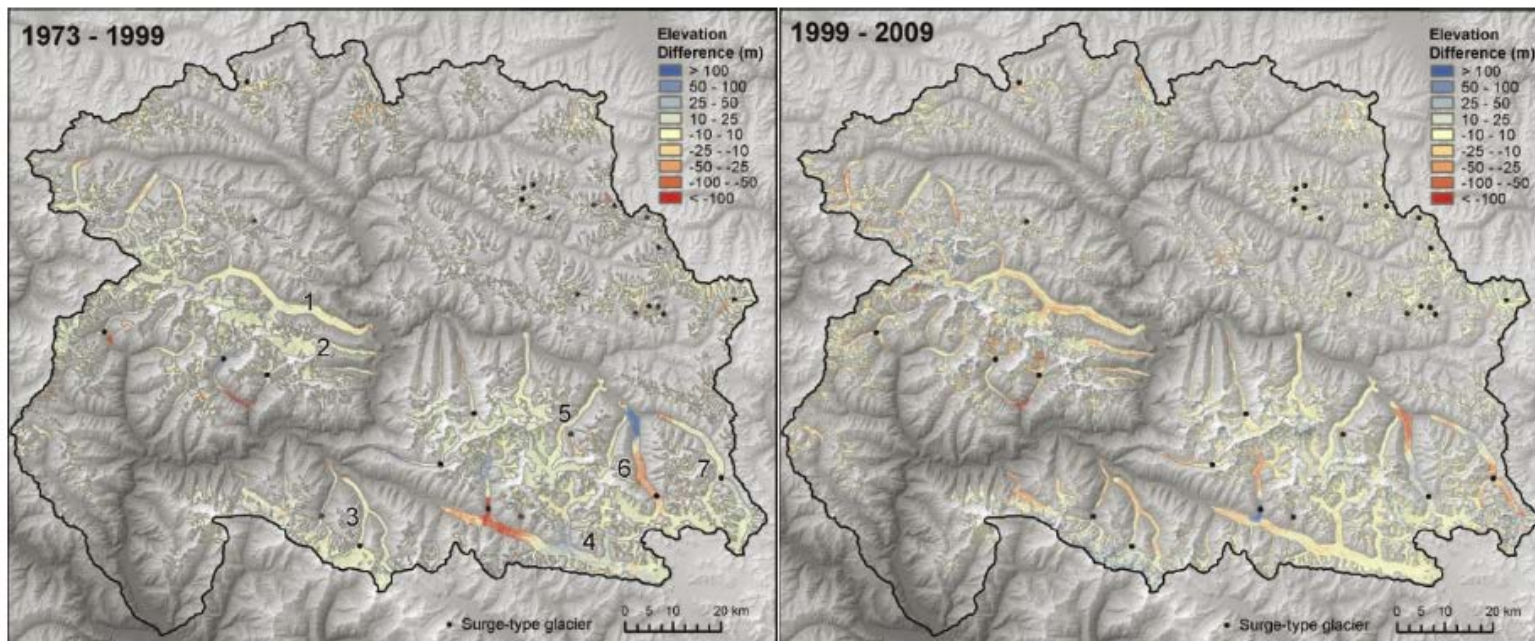
Id. 32437 _3

Observation of surface velocity over ice covered terrain with microwave and multispectral imager (EOGlacVelHMA)

Summary EO data exploitation – cumulative stats all subprojects

| ESA & ESA TPM DATA | Nos. scenes or inform if by FTP | SENTINELS 1, 2 & 3 DATA | Nos. scenes | CHINESE EO DATA | Nos. scenes |
|--------------------|---------------------------------|-------------------------|-------------|-----------------|-------------|
| ERS SAR | ~10 | Sentinel 1-A/B SAR | ~ 40 | HJ-A/B | 0 |
| ASAR | 0 | Sentinel 2-A/B MSI | ~30 | GF-1 | ~ 150 |
| MERIS | 0 | Sentinel 3-A OLCI | 0 | GF-2 | 0 |
| AATSR | 0 | Sentinel 3-A SLSTR | 0 | HY-A | 0 |
| SMOS | 0 | Sentinel 3-A SLAR | 0 | FY-1 | 0 |
| etc. | 0 | Etc. | 0 | Etc. | 0 |
| TOTAL | ~10 | TOTAL | ~70 | TOTAL | ~150 |

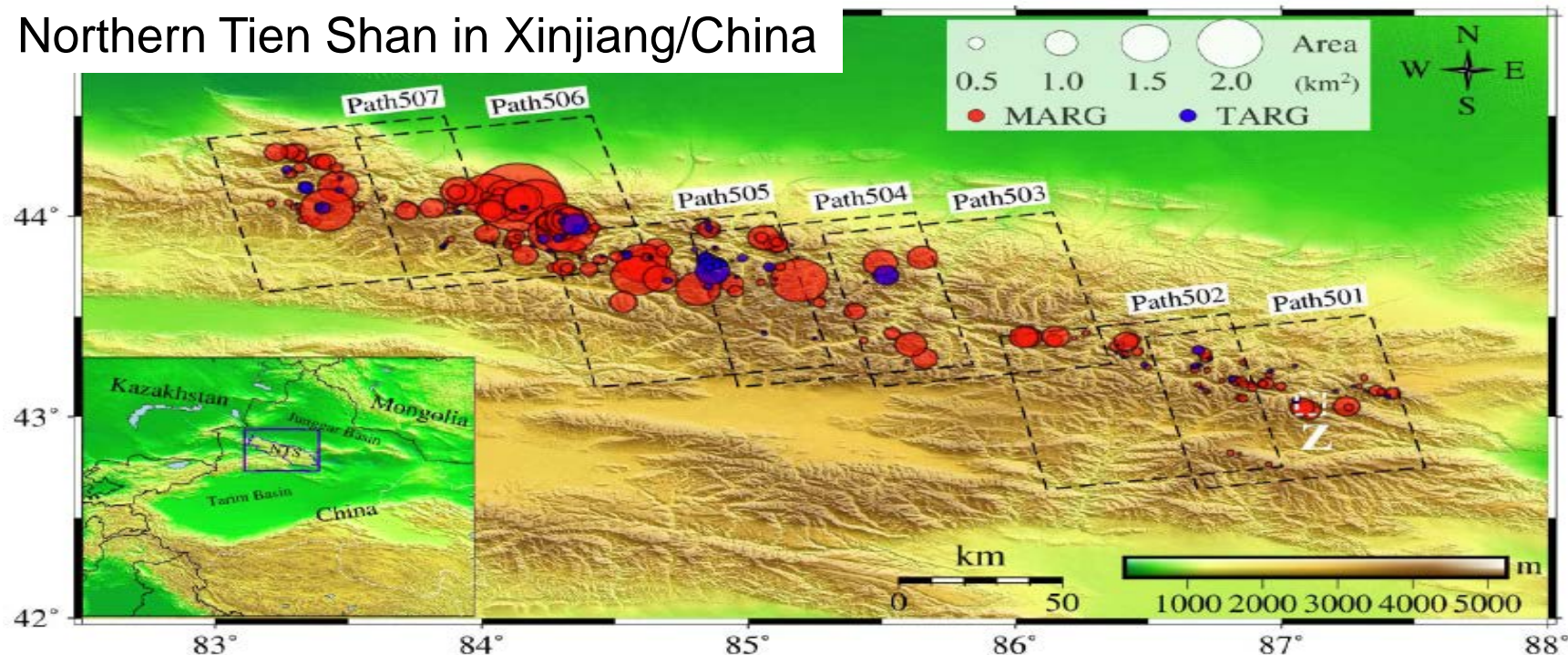
Surface elevation changes in the Hunza basin (Karakoram)



Bolch et al., 2017, TC

Rockglacier Inventory

Northern Tien Shan in Xinjiang/China

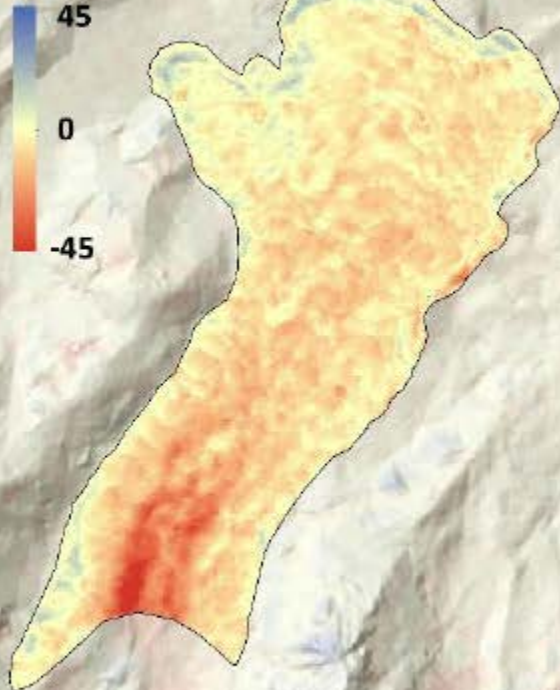


Overall, more than 700 rockglaciers were identified.

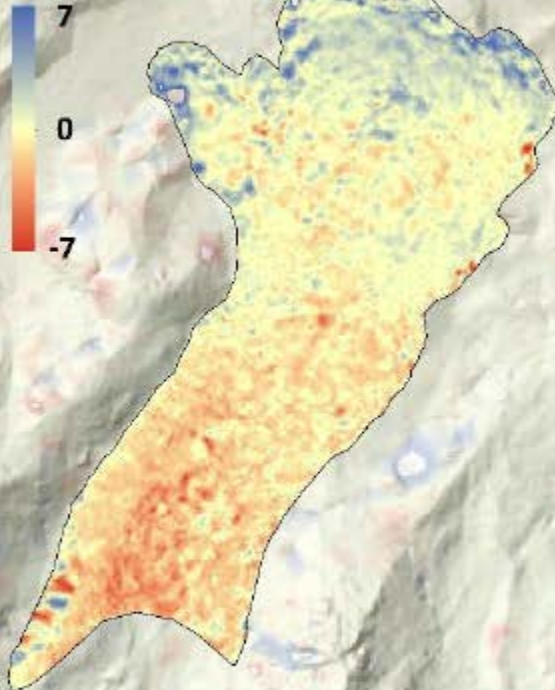
Wang et al., 2017, TC

Morennij rockglacier

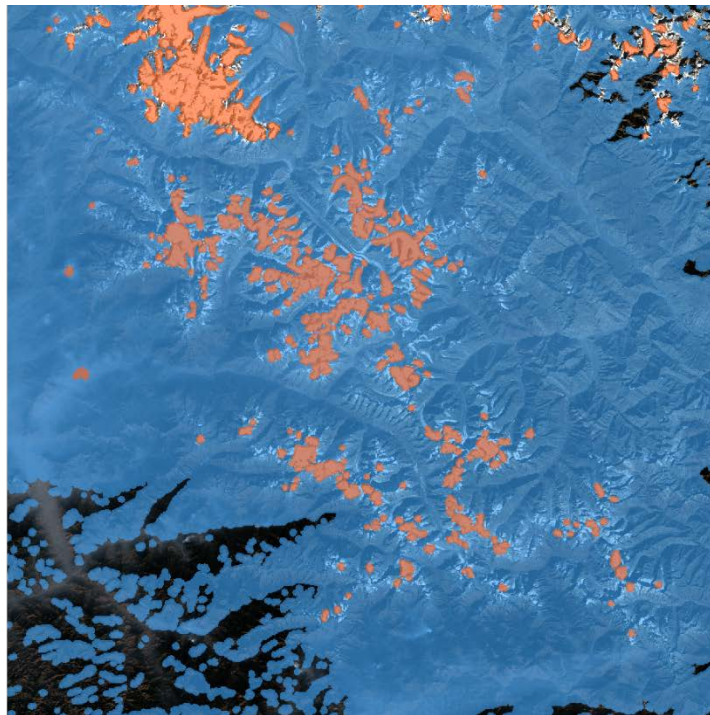
Surface Elev. Change (m)
1971 - 2012



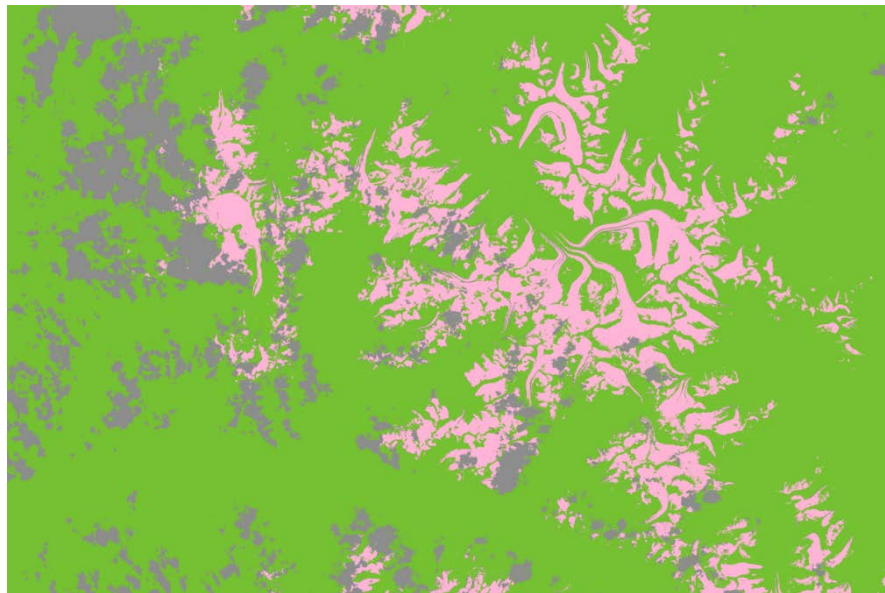
Surface Elev. Change (m)
2012 - 2016



Example of Cloud Detection over Mountains – 1

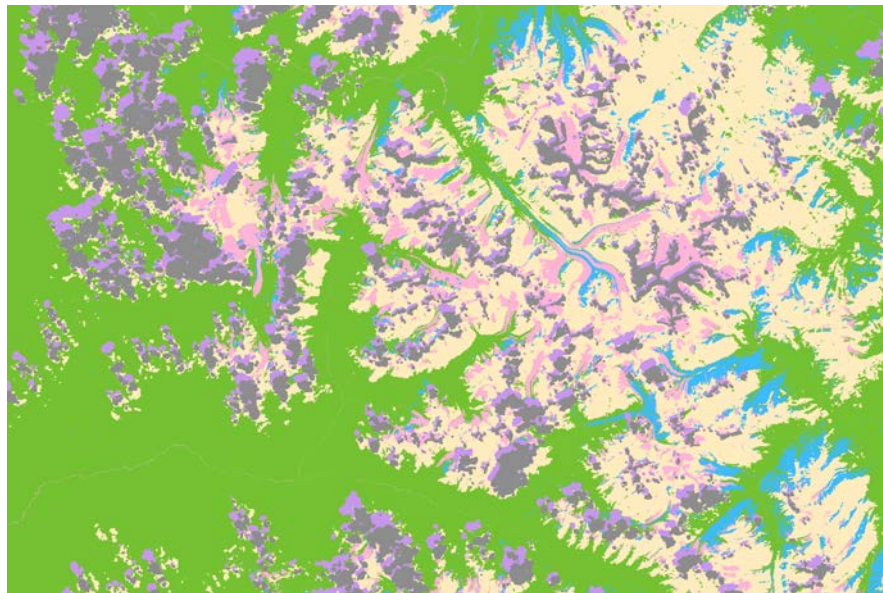


Output – MLC



Grey = Cloud, Green = Clear (Cloud-free), Pink = Snow/Ice

Fmask



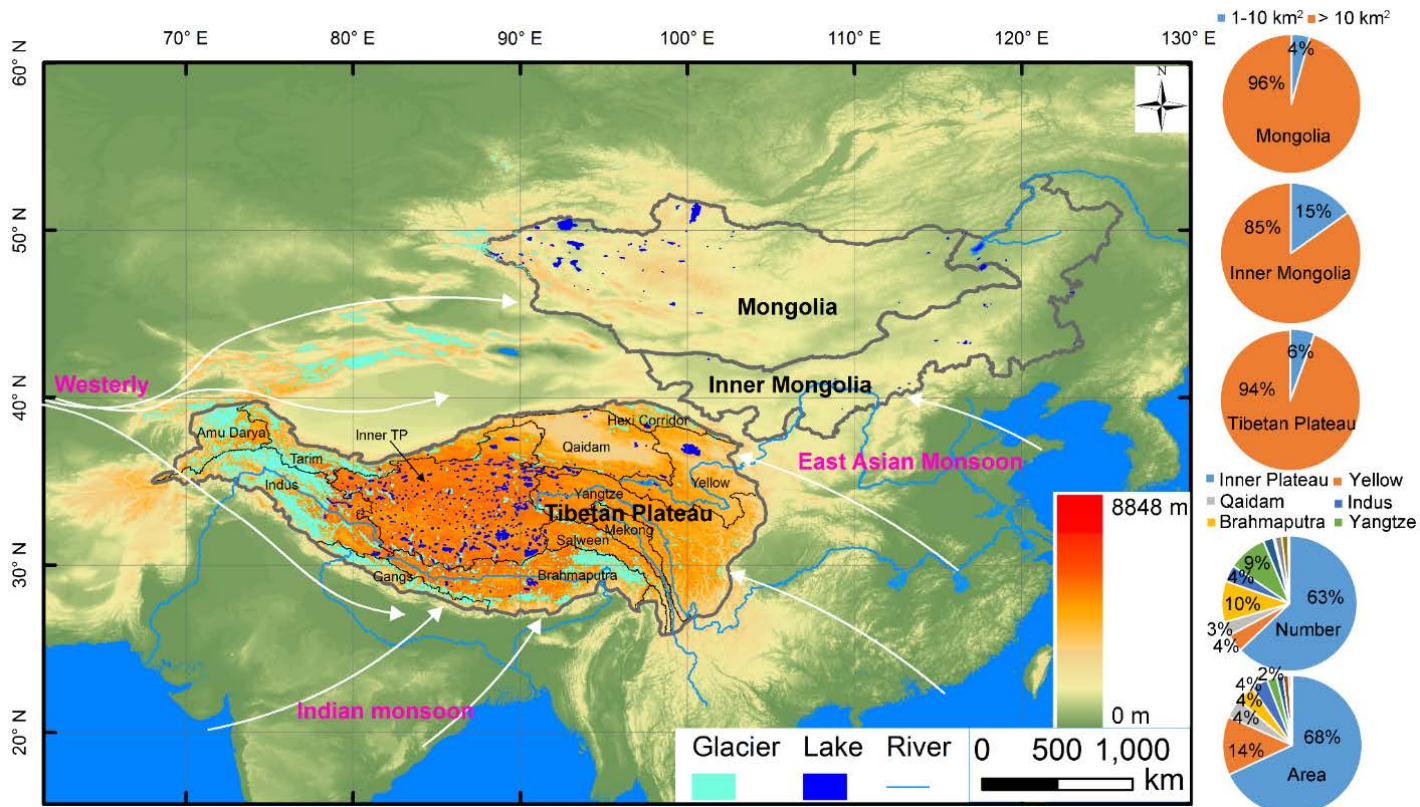
Grey = Cloud, Green = Clear (Cloud-free), Yellow = Thin Clouds, Pink = Snow/Glacier, Purple = Shadow, Blue = Water

Method Strengths and Weakness

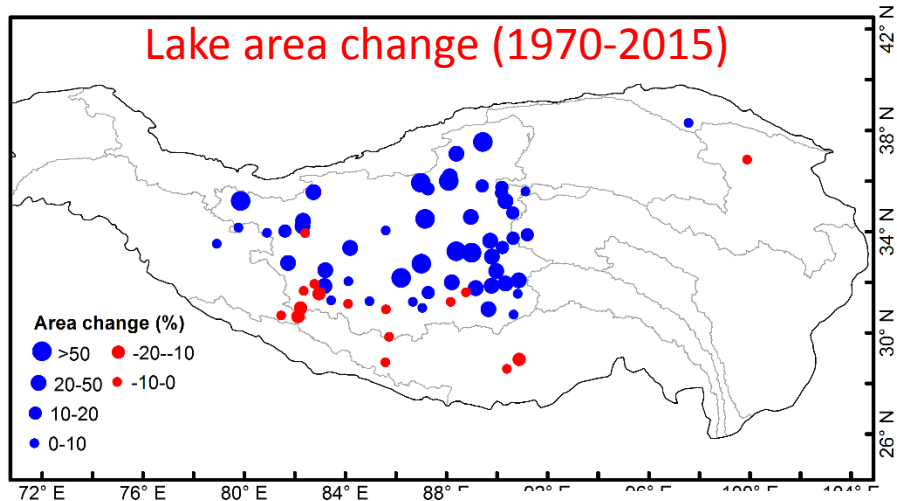
| | Advantages | Disadvantages |
|---------------|---|---|
| Def. L1C | Included with L1C products | Worst results |
| S2C | High quality, automated | Chaotic interpretation, many classes, slow |
| Fmask | Automated, fast | Originally for Landsat, varies per implementation |
| MLC | High quality, fast once trained | Requires training, slow training |
| Temporal Ave. | Easy to implement, large potential to improve | Needs temporal inputs, underclassifies |
| Manual | Very high quality | Very time consuming to make, not automated |

=> The automated cloud detection is not reliable for High Asia and need to be improved

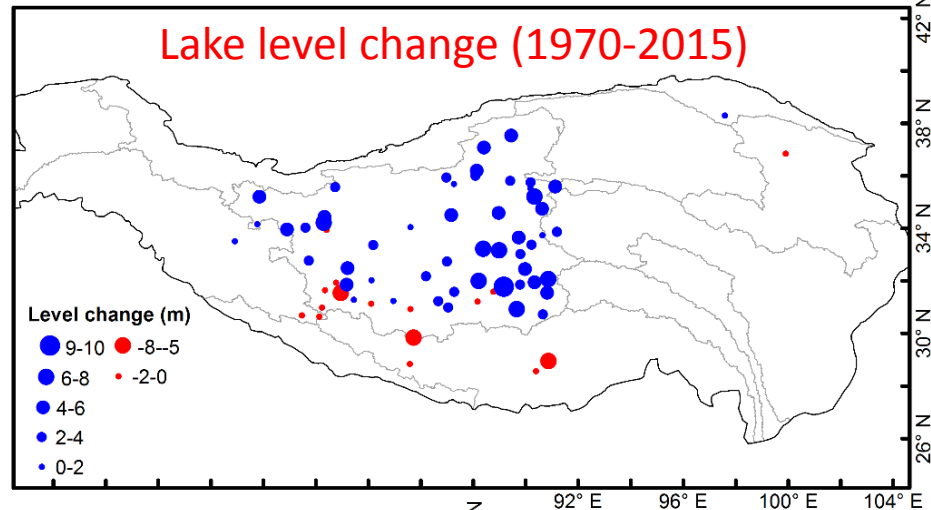
Contrasting pattern of lake change driven by cryosphere changes



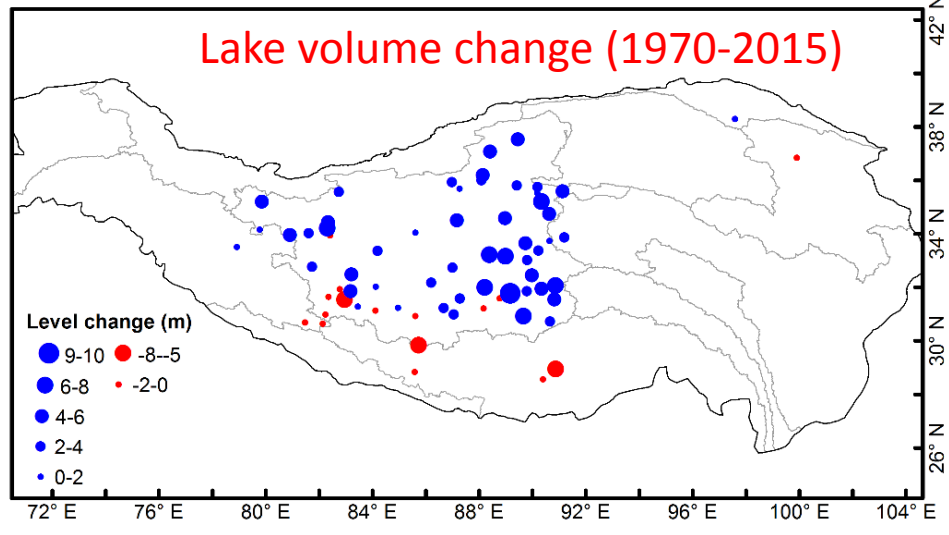
Lake area change (1970-2015)



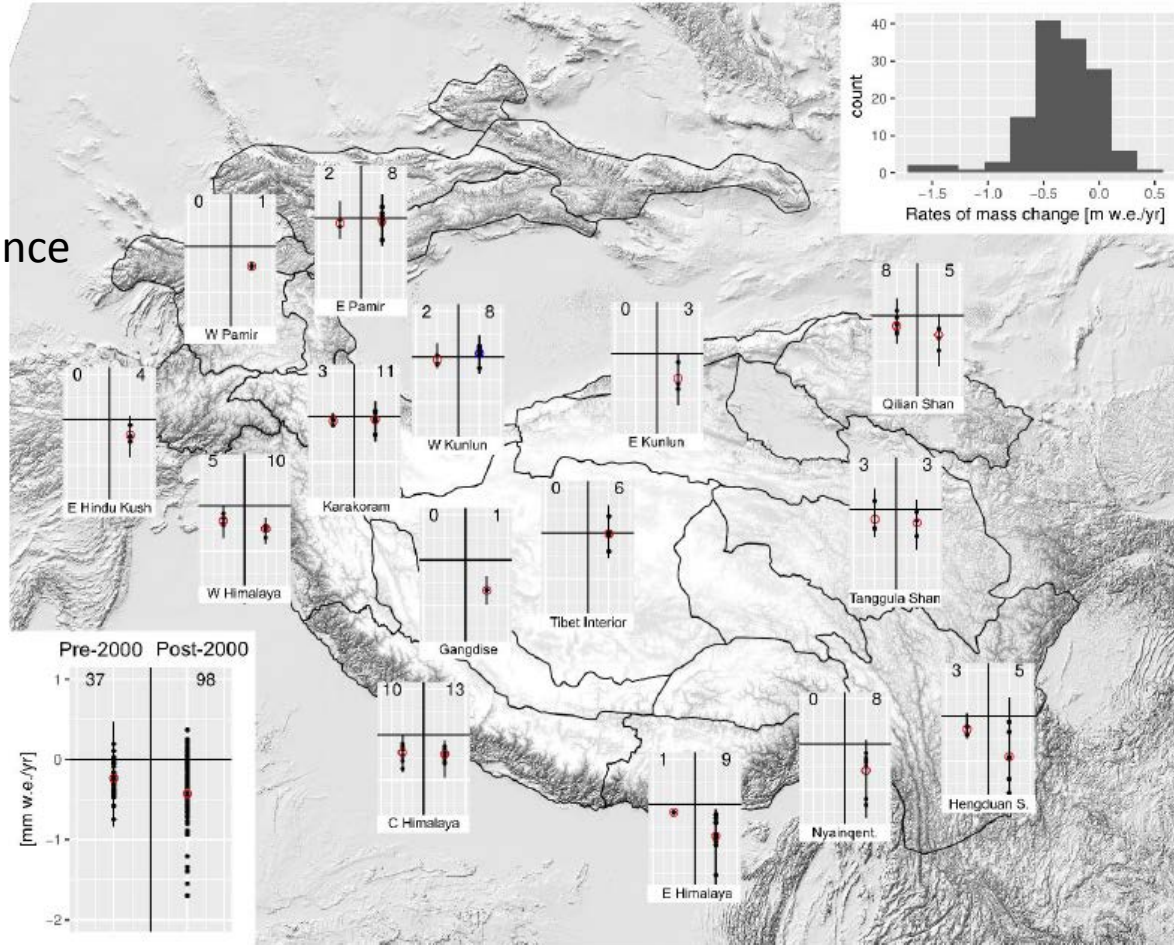
Lake level change (1970-2015)



Lake volume change (1970-2015)

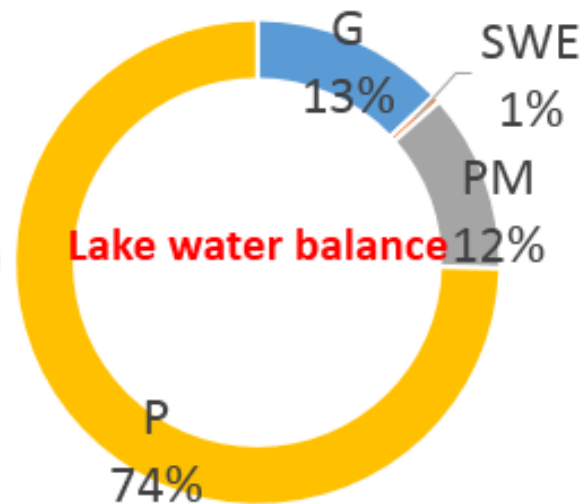
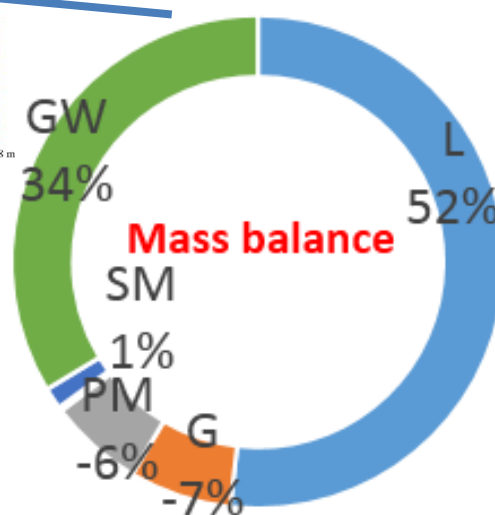
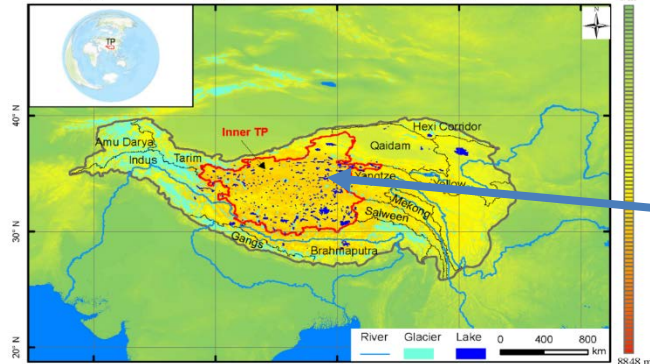


Review of Glacier Mass Balance over High Asia



Bolch et al., HIMAP
in review

Water balance for the Inner TP



lake water (L), glacier (G), snow water equivalent (SWE), soil moisture (SM), permafrost (PM), groundwater (GW)

Young scientists contributions

European YS

Philip van der Lugt, MSc student,
cloud detection in S2 at TU Delft

Stijn Pinson, MSc student, TU Delft -
> Edinburgh – glacial velocities from
Landsat archive

Allie Strel, TU München: Rockglacier
investigations

Chinese YS

Dr. Weicai Wang, ITPCAS, glacier lake
investigations

Dr. Yang Xiang, ITPCAS, glacier area
change

Dr. Jinyuang Yu, ITPCAS, snow cover
change

Master Student Nitesh, ITPCAS,
glacier lake investigations

Dr. Xiaowen Wan, Chinese Univ. of
Hongkong: Rockglacier mapping

Academic exchanges & joint publications

Academic exchanges & cooperation

Joint field work on the Tibetan Plateau scheduled for October 2017

Dr. Guoqing Zhang will visit Uni Zurich for one year starting end 2017

Joint publications

Zhang, G., T. Yao, C. K. Shum, S. Yi, K. Yang, H. Xie, W. Feng, T. Bolch, L. Wang, A. Behrangi, H. Zhang, W. Wang, Y. Xiang, and J. Yu (2017), Lake volume and groundwater storage variations in Tibetan Plateau's endorheic basin, *Geophys. Res. Lett.*,

Zhang, G., T. Yao, S. Piao, T. Bolch, H. Xie, D. Chen, Y. Gao, C. M. O'Reilly, C. K. Shum, K. Yang, S. Yi, Y. Lei, W. Wang, Y. He, K. Shang, X. Yang, and H. Zhang (2017), Extensive and drastically different alpine lake changes on Asia's high plateaus during the past four decades, *Geophys. Res. Lett.* 44(1), 252–260.

Bolch, T., T. Pieczonka, K. Mukherjee, and J. Shea (2017), Brief communication: Glaciers in the Hunza catchment (Karakoram) have been nearly in balance since the 1970s, *The Cryosphere* 11(1), 531–539.

Bolch, T., Shea, Liu, S., Azam, F., Gao, Y., Gruber, S., Immerzeel, W., Kulkarni, A., Li, H., Tahir, A., Zhang, G., Zhang, Y. (in review): Status and Change of the HKH Cryosphere. In: HIMAP Comprehensive Assessment of the HKH

Summary on progress and collaboration

- Knowledge about changes of the lakes on the Tibetan Plateau and the contribution of the different components of the cryosphere significantly improved.
- Knowledge about glacier mass changes in High Asia further improved.
- Methodology to investigate rockglaciers developed and successfully applied.
- Cloud detection algorithms for Sentinel-2 data tested.
- The existing collaboration between Chinese and European scientists further intensified and new collaboration established.
- The detailed study areas to investigate glaciers, snow and permafrost in the Tibetan Plateau refined.
- Plans for field work on the Tibetan Plateau to investigate glaciers, glacial lakes and ground temperature for this October refined.

Plans for the next 2 years

- Acquire additional funds to hire a young scientist within Dragon 4.
- Compile an inventory of rockglaciers for the whole of High Asia.
- Refine the exiting glacier inventory for High Asia using Sentinel-2 data.
- Investigate velocity of all High Asian glaciers using Sentinel-1 and Sentinel-2 data.
- Test Chinese satellite data for glacier investigations.
- Investigate rockglacier and glacier area, mass and velocity changes in detail for the selected benchmark sites and compare to field investigations.
- Investigate snow cover, permafrost and active layer thickness and thickness changes for the selected benchmark sites.
- Collaborate with colleagues from the hydrology subprojects to improve the knowledge about glacio-hydrological modelling.
- Exchange visits and training of young scientists.