

# Permafrost Science Workshop

## Workshop on State of the Science at ESS

## EO-based Modelling and Mapping of Permafrost

Presenter: Yu Zhang

Contributors:

CCRS: Xiping Wang, Wenjun Chen, Junhua Li, Robert Fraser, Aining Zhang, Josef Cihlar

GSC: Wendy Sladen, Larry Dyke, Daniel Riseborough, Sharon Smith, Lynda Dredge

PCA: Donald McLennan, Jean Poitevin (Gatineau), Wanli Wu (Winnipeg), Heather Stewart, Sheldon Kowalchuk (Churchill)

AAFC: Charles Tarnocai CFS: Dan McKenney

Universities: Peter Kershaw (Alberta), William Quinton (Wilfrid Laurier), Masaki Hayashi (Calgary)



## Scientific Background:

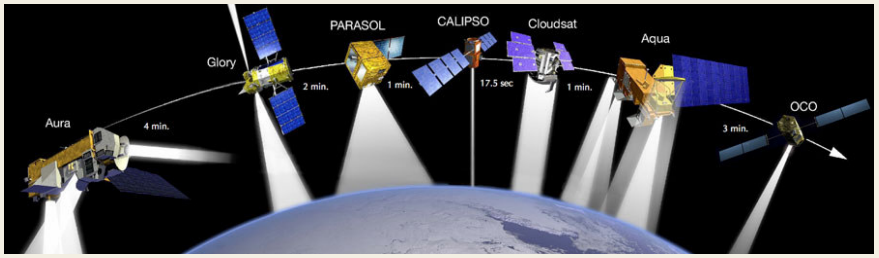
- Observations have shown that climate is warming, and permafrost is thawing;
- Questions facing us now are what are its impacts and consequences, and what we can do about it;
- To answer these questions, we need to know more details about permafrost thaw, such as how (top or bottom), where, when, and how much;
- Field observations are essential, but they are limited in spatial and temporal coverages.

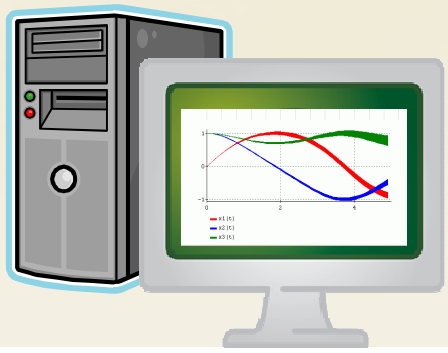
# EO-based permafrost modelling/mapping



## Scientific Background:

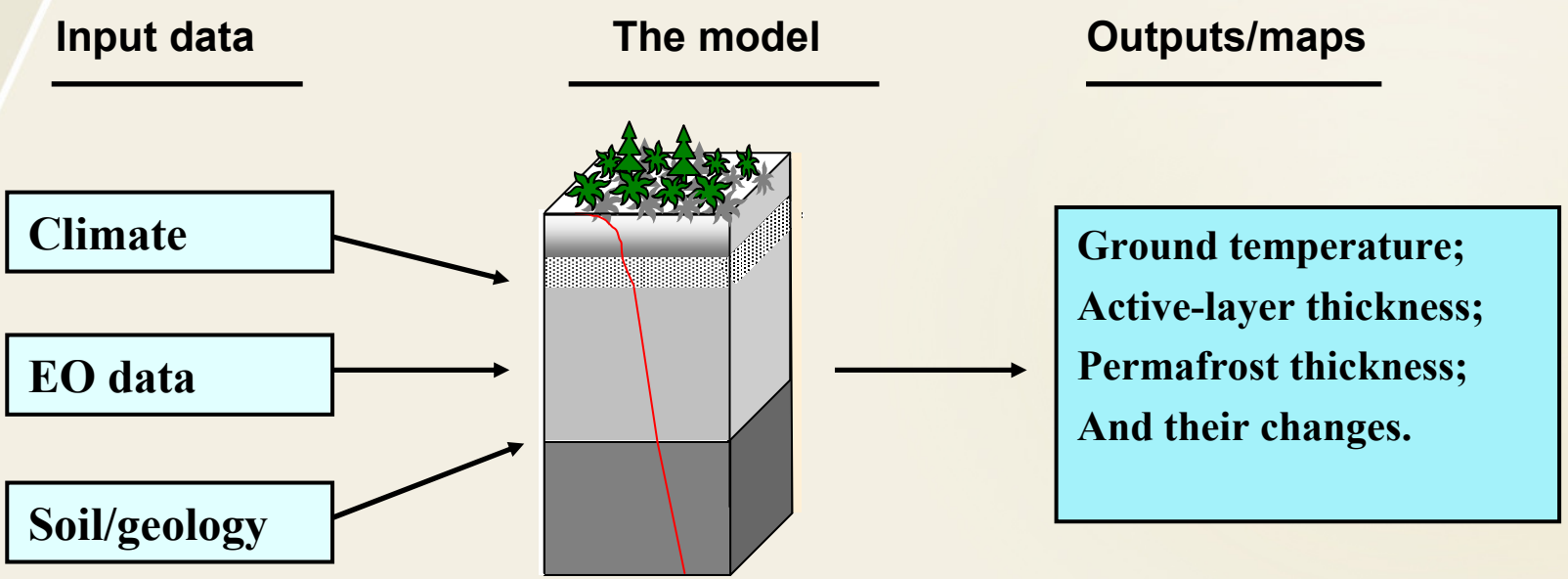
- Remote sensing can provide detailed spatial info. about land surface;
- Process-based models are important tools for data synthesizing, process understanding, and future predictions;
- EO-based modelling can provide spatial distributions and changes with time.



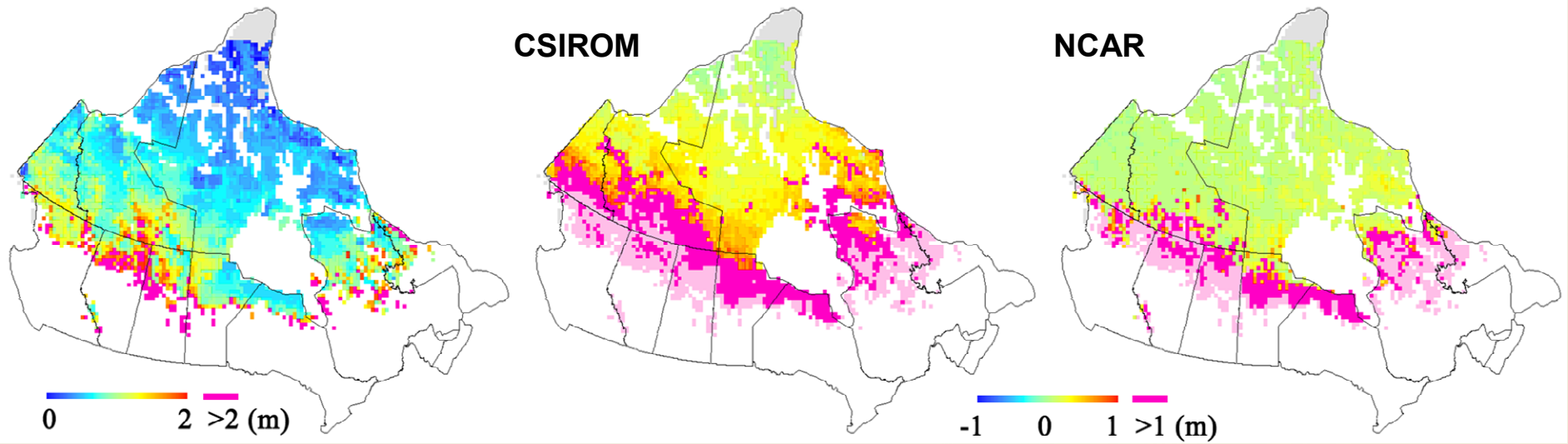
# EO-based permafrost modelling/mapping

## Scientific applications:



# EO-based permafrost modelling/mapping

## Active-layer thickness and its projected changes



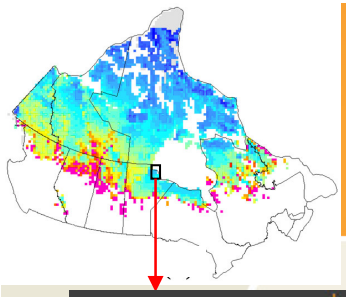

In the 1990s

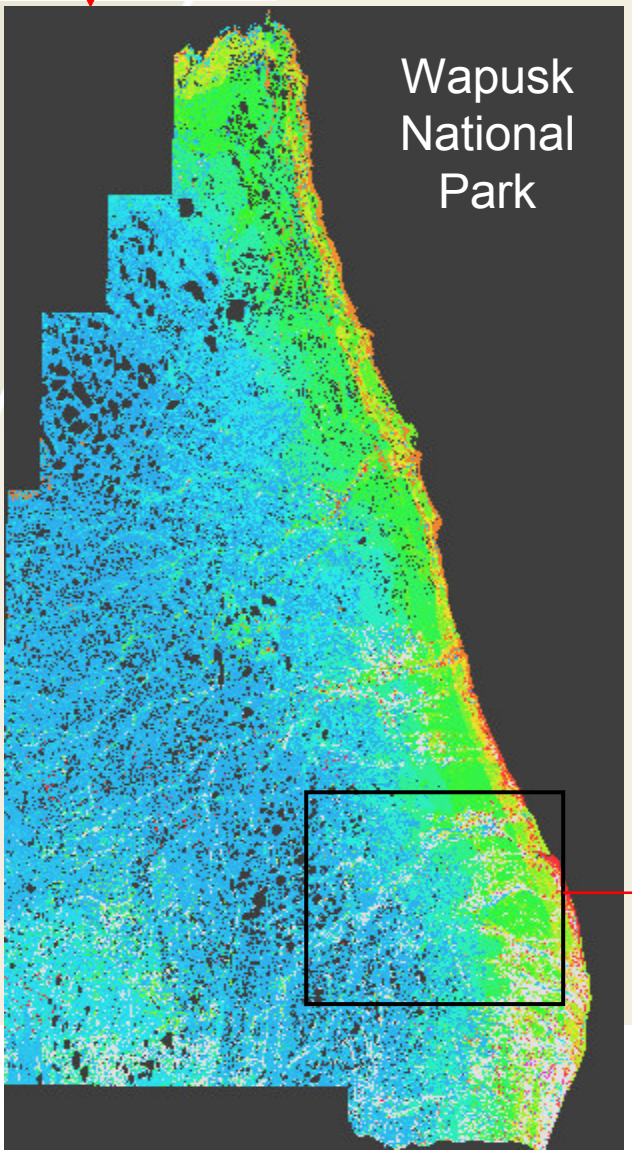
Projected changes to the 2090s

(Zhang et al., 2008)

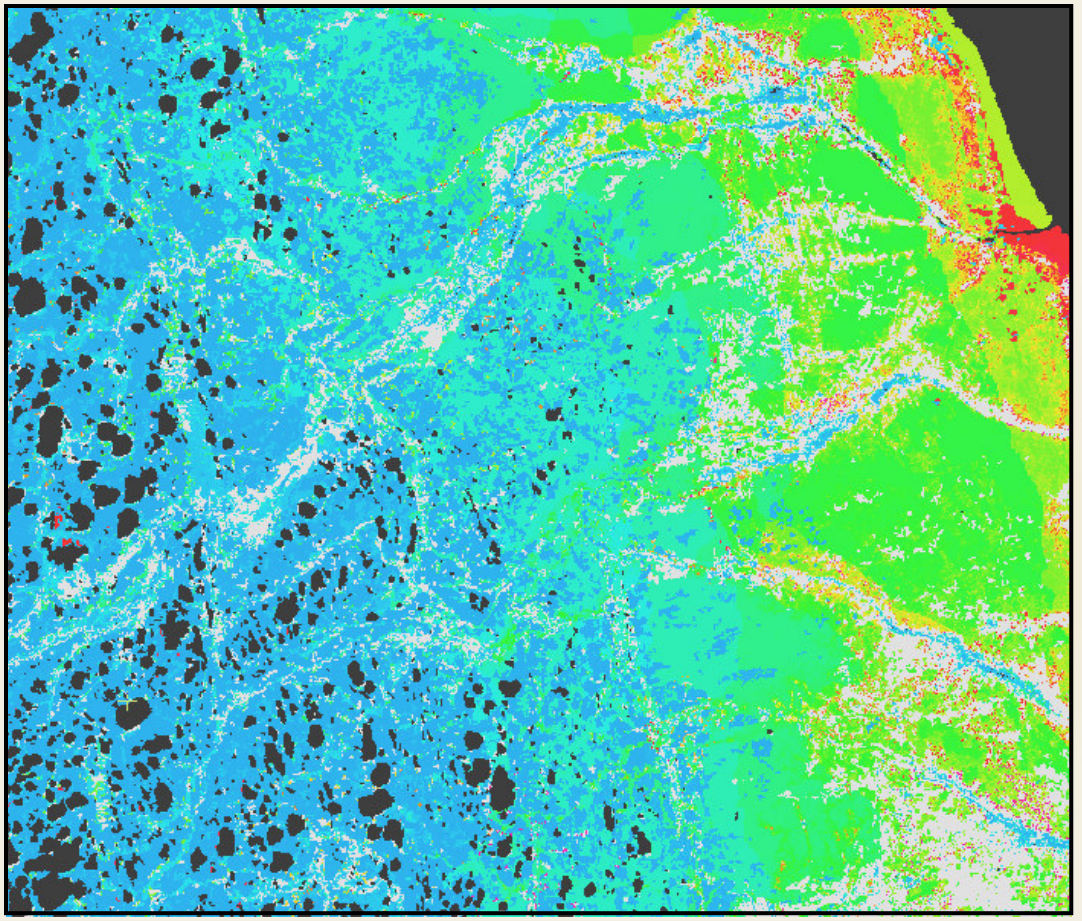
Perm. disappeared  Glacier

# EO-based permafrost modelling/mapping






## Active-layer thickness



0 0.5 1 1.5 2 2.5 3 (m) No permafrost



# EO-based permafrost modelling/mapping

## Scientific Gaps

- Need more spatially detailed soil, geological and hydrological datasets;
- In situ observations need to include ground temperature, vegetation, snow, water dynamics, etc.
- Need to emphasize the impacts of permafrost thaw on hydrology, ecosystems, soil organic carbon, and feedbacks on climate.

# EO-based permafrost modelling/mapping



## Scientific Activities

- Climate change program in ESS
- ParkSPACE: Towards an operational satellite based system for monitoring ecological integrity of arctic national parks (GRIP project funded by CSA)
- CiCAT: Climate change impacts on Canadian Arctic tundra (IPY project)

# EO-based permafrost modelling/mapping



## Scientific Products


- Zhang, Y., W. Chen, and D.W. Riseborough. Disequilibrium Response of Permafrost Thaw to Climate Warming in Canada over 1850-2100, *Geophysical Research Letters,* 35, L02502, doi:10.1029/2007GL032117, 2008.
- Zhang, Y., W. Chen, and D.W. Riseborough. Transient projections of permafrost distribution in Canada during the 21st century under scenarios of climate change. *Global and Planetary Change*, 60: 443-456, doi:10.1016/j.gloplacha.2007.05.003, 2008.
- Zhang, Y., W. Chen, and D.W. Riseborough, Modeling the long-term dynamics of snow and their impacts on permafrost in Canada. In: Kane, D.L. and K.M. Hinkel (eds), *Ninth International Conference on Permafrost*, Institute of Northern Engineering, University of Alaska Fairbanks, p2055-2060, 2008.
- Zhang, Y., W. Chen, and D.W. Riseborough. Temporal and spatial changes of permafrost in Canada since the end of the Little Ice Age. *Journal of Geophysical Research* 111, D22103, doi:10.1029/2006JD007284, 2006.
- Zhang, Y., W. Chen, S.L. Smith, D.W. Riseborough, and J. Cihlar. Soil temperature in Canada during the 20th century: complex responses to atmospheric climate change. *Journal of Geophysical Research,* 110, D03112, doi:10.1029/2004JD004910, 2005.
- Chen, W., Y. Zhang, J. Cihlar, S.L. Smith, and D.W. Riseborough. Changes in soil temperature and active-layer thickness during the 20th century in a region in western Canada. *Journal of Geophysical Research, 108*(D22), 4696, doi:10.1029/2002JD003355. 2003.
- Zhang, Y., W. Chen, and J. Cihlar. A process-based model for quantifying the impact of climate change on permafrost thermal regimes. *Journal of Geophysical Research, 108*(D22), 4695, doi:10.1029/2002JD003354, 2003.
- Zhang, Y., C. Li., C.C. Trettin, H. Li, and G. Sun. An integrated model of soil, hydrology and vegetation for carbon dynamics in wetland ecosystems. *Global Biogeochemical Cycles,* Vol. 16, No. 4, 1061, doi:10.1029/2001GB001838. 2002.