Global glacier modeling

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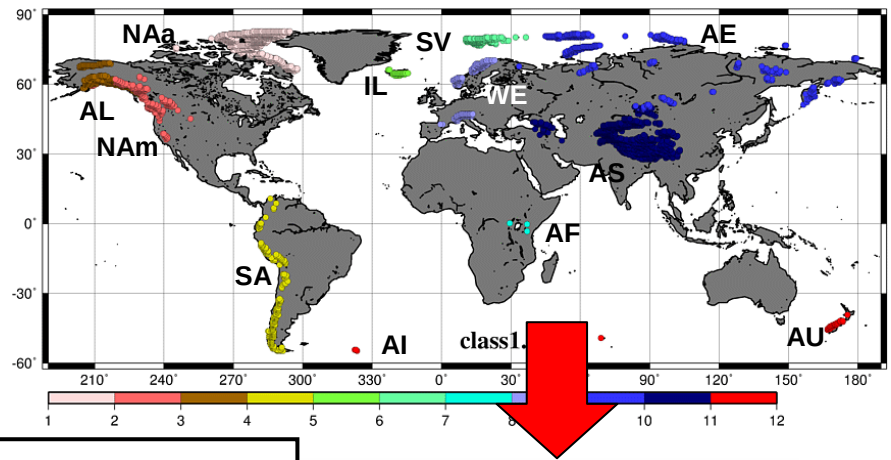
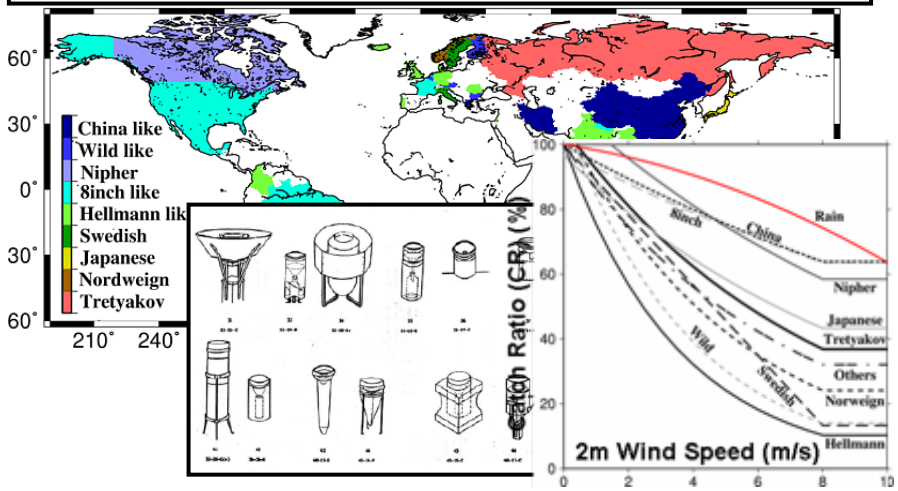
Global glacier model



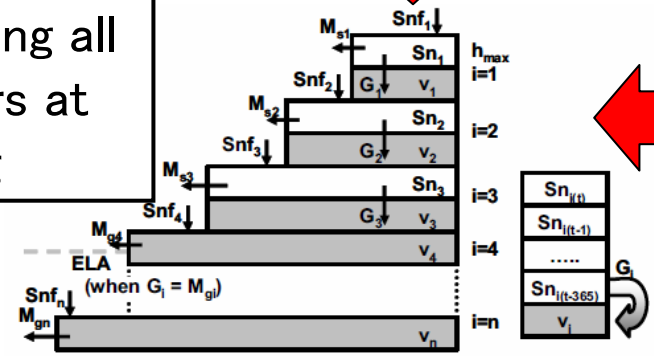
Total glacier area and location at each 0.5deg from 70,000 glacier statistics + digital maps

Reconstruction of historical daily climate data (P, T, q, Rad) with gauge undercatch correction



Hirabayashi *et al*., 2008a, 2008b, HRL,

Modeling all glaciers at 0.5deg



Hirabayashi et al, (2010), Journal of Hydrology 390

Glacier mass changes for 1948-2007

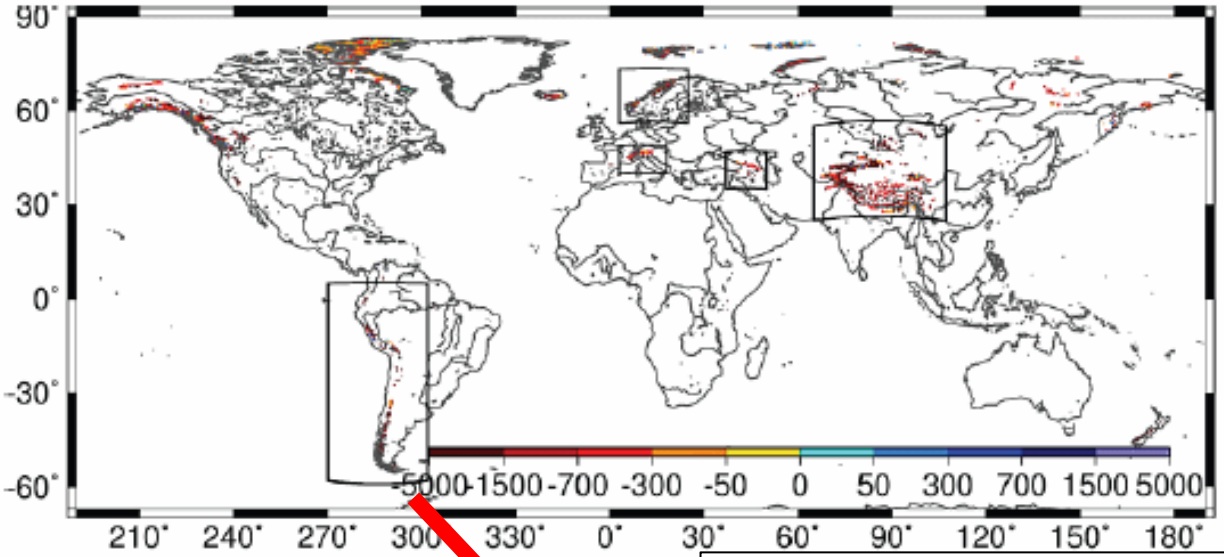
Global glacier model "HYOGA"

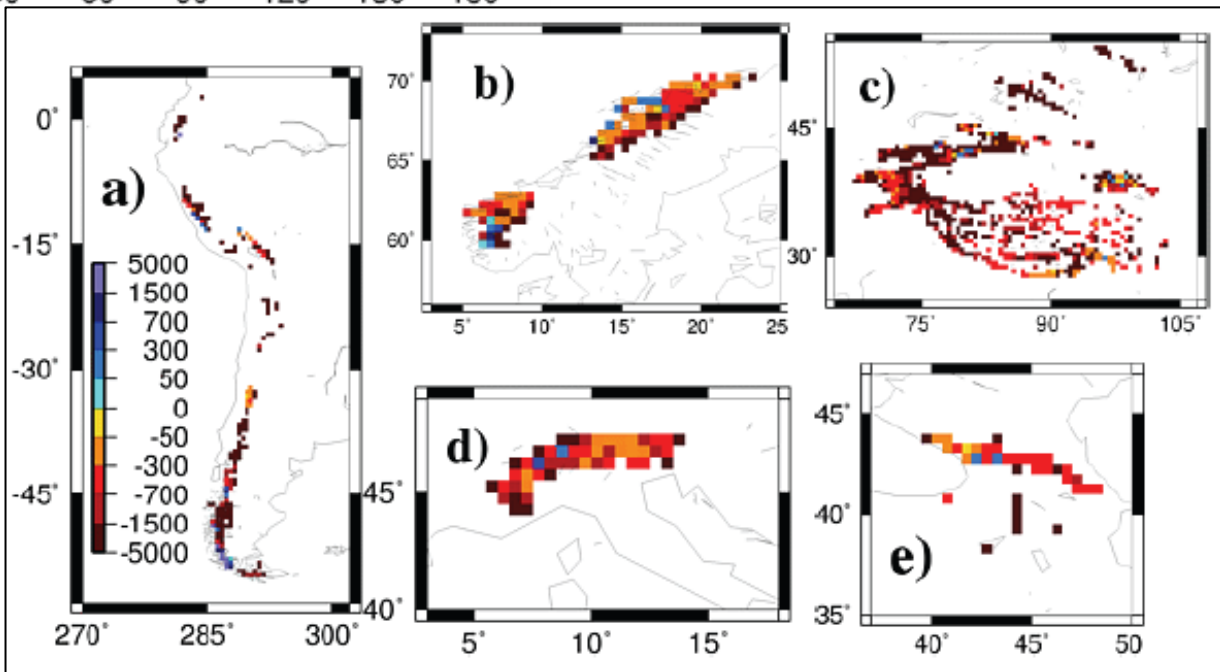
Hirabayashi et al., 2010, Journal of Hydrology

- **0.5° x 0.5° global glacier model with daily time step.**
- **Mass balance of snow pack and glaciers are estimated at each 50m vertical sub-grid of the 0.5° grid.**
- **Glacier and snow melting: Empirical Degree-Day Factor (another method (e.g., energy balance) will be developed..)**
  Melt water [mm/day] = DDF [mm/C/day] x (T_a – T_0)
  (T_0 is critical temp. (many use 0[C]), T_a is temp. >T_0)

✓ **Calibration of the model is done against climatology of measured mass balance.**
(regional averages of climatology are used for glaciers without mass balance observations)

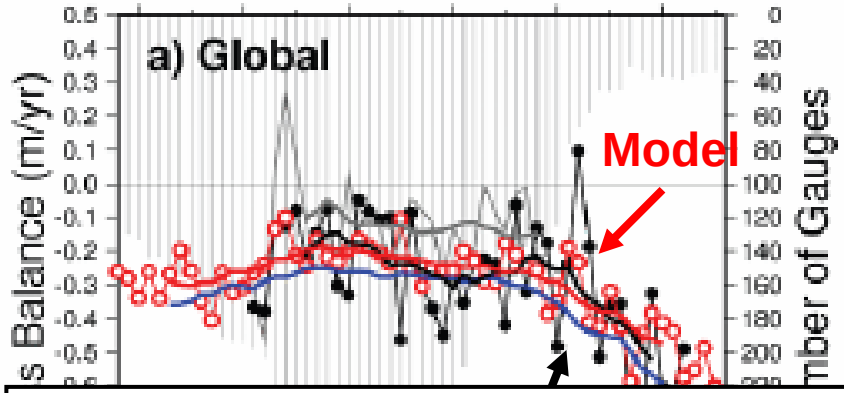
Glacier mass change 1948-2006 (mm/yr water eq.)

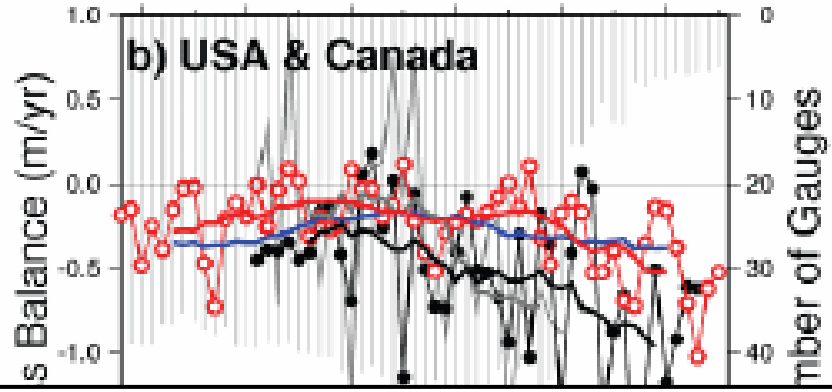


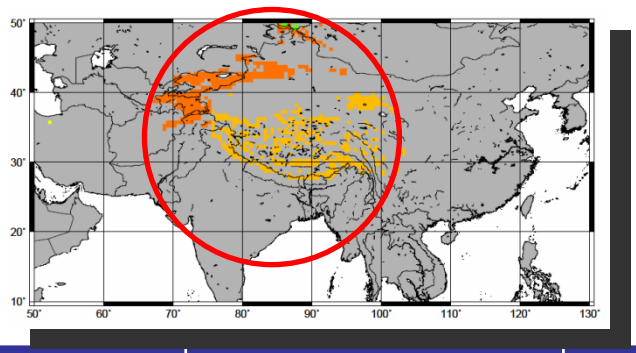


Hirabayashi *et al.*, 2010,

Glacier mass change 1948-2006

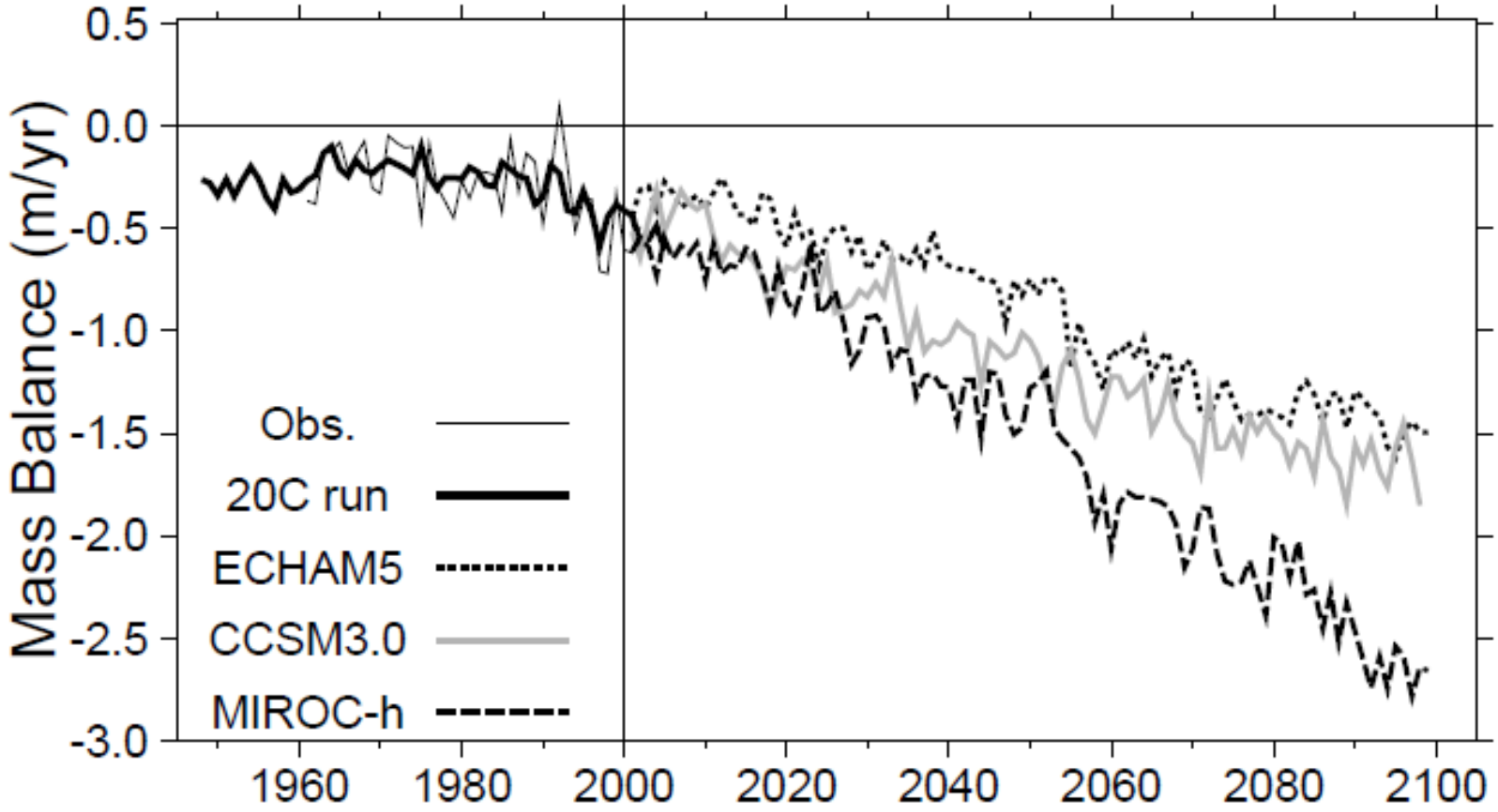






Source	Dyurgerov and Meier, (2005)	Hirabayashi et al., (2010)		Matsuo and Heki (2010)
Methods	Direct Observation	Numerical Simulation		GRACE
[Gt/year]	24	25	37	47±7
	(1961-2003)	(1961-2003)	(2003-2009)	(2003-2008)

Future projections of glacier melt

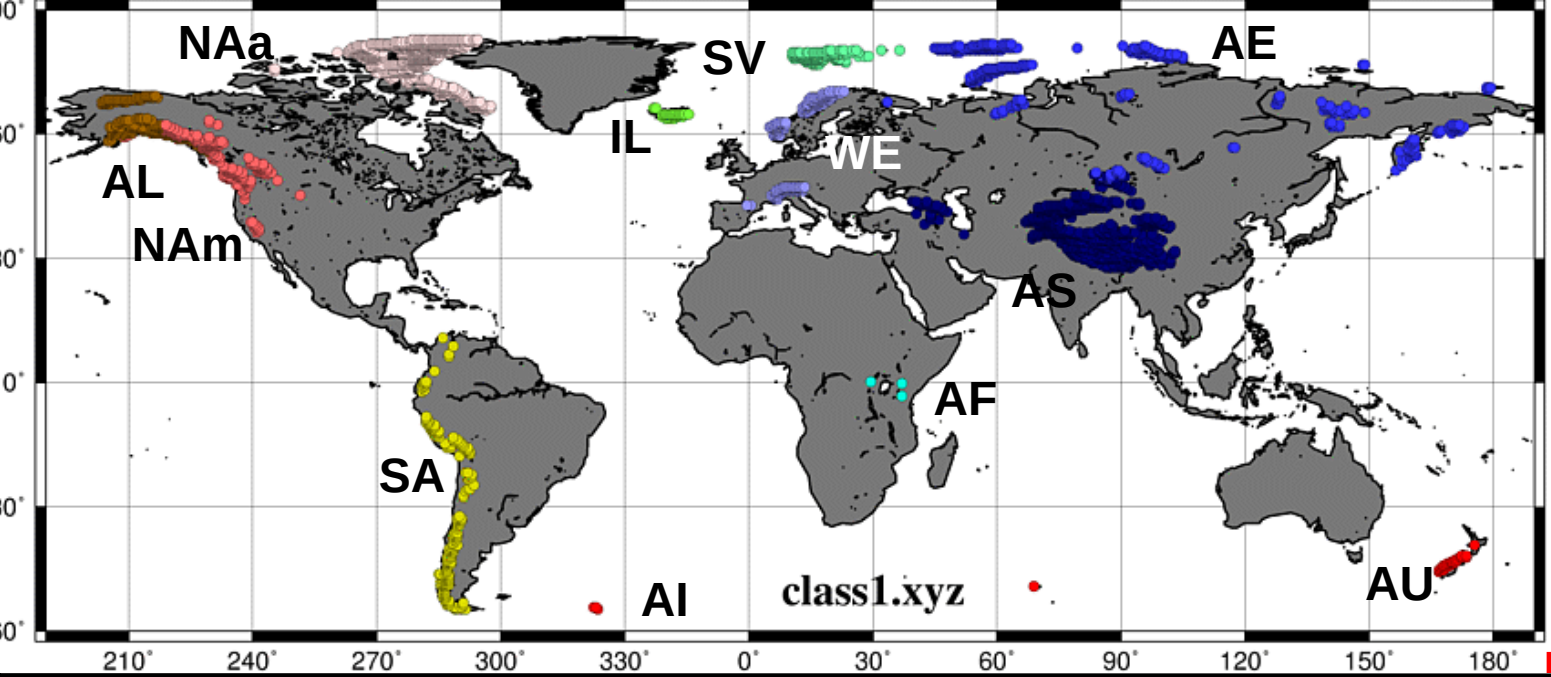


Estimation using bias-corrected climate forcing by GCMs

Analysis of impact on water resources, flood and drought frequencies are now investigating.

Problems of the current model

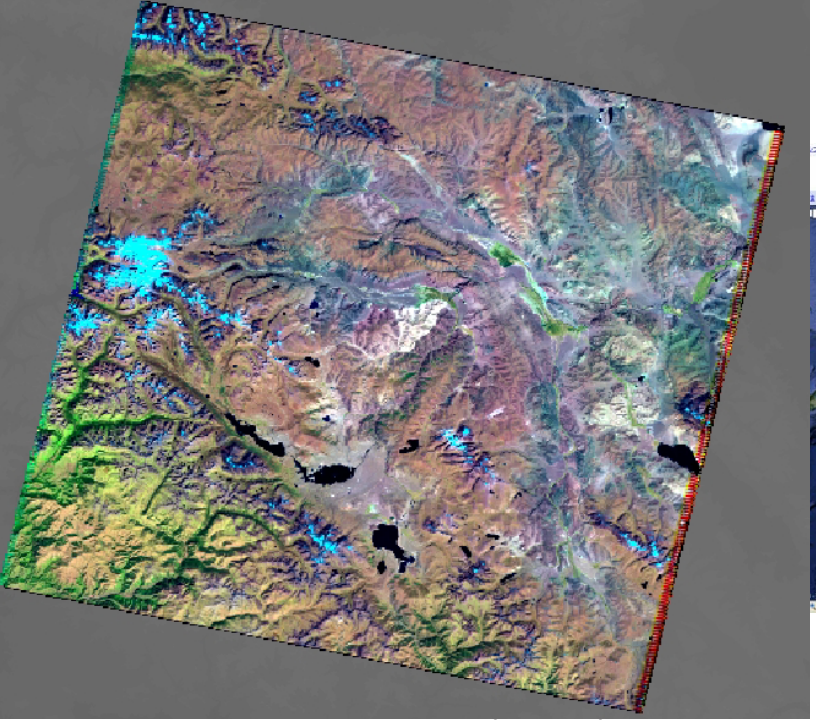
1. "Virtual" total volume
   - Detailed glacier area / type/ altitude information is limited. (We only have total area in 0.5-degree) (e.g. WGMS)
     - ➢Fraction of glacier size
     - ➢Location of glaciers, glacier types
2. Simple mass balance model
   - Check applicability under future climate change with different radiation forcing.
3. Limited validation at local scale
   - Validation of model performance at well observed glacier sites.



Base Glacier Area (km^2)

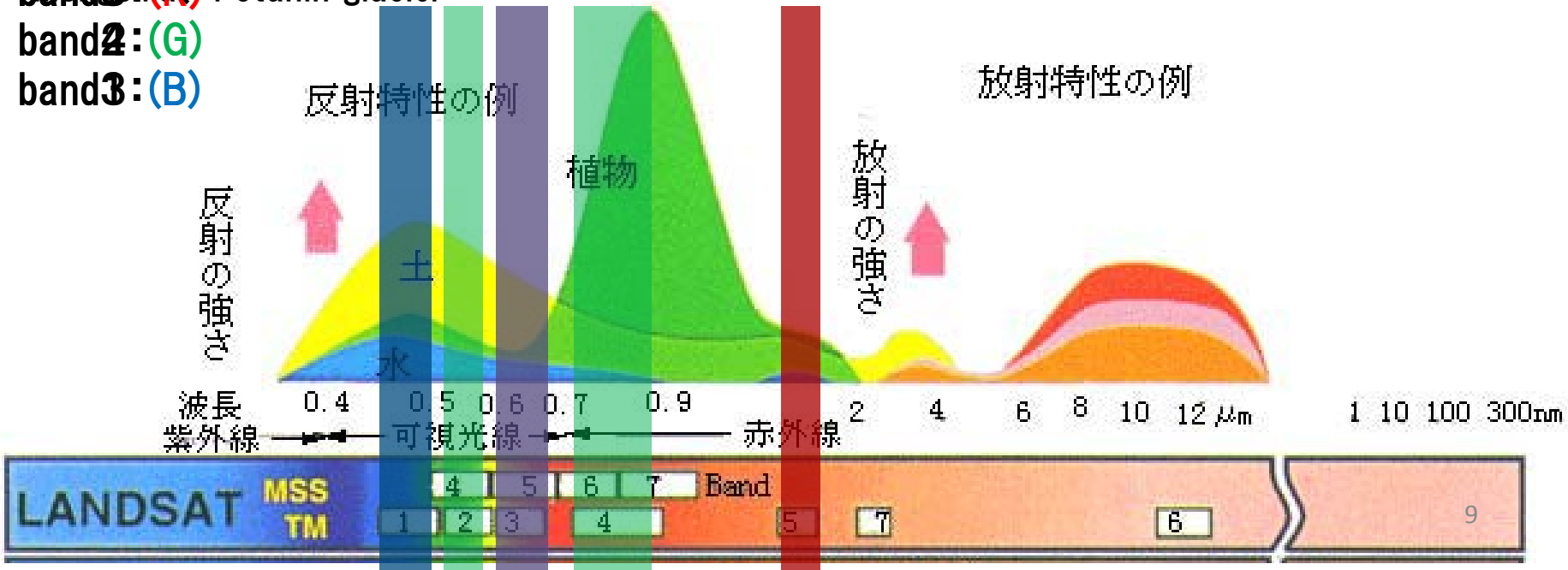
WGMS+GGHYDRO

		Meier (1984)	Haeberli et al. (1989)	Oerlemans (1993)	Braithwaite and Raper. (2002)	Dyurgerov and Meier (1997)	Hirabayashi et al. (2010)	
N. America (Arctic)		150,600	151,758	149,900	153,184	244,500	139,922	210,578
Arctic Eurasia		56,100	56,135	55,696	60,723		70,656	
W. Europe (Mainland)		6,000	6,095	5,625	6,758	18,000	9,022	19,693
Iceland		11,300	11,260	10,938	11,160		10,671	
N. America (Mainland)		125,210	124,342	109,680	101,505	49,000	44,949	101,161
	Alaska					74,700	56,213	
Svalbard		38,800	36,612	36,612	33,685	36,600	36,305	
Africa			10	11			11	
Former USSR + Asia		111,900	129,076	117,129	121,711	119,000	128,444	
Australasia		1,000	860	1,007	433	35,000	1,158	38,754
S. America		36,250	25,908	36,298	31,521		36,099	
sub-antarctic Islands		5,000	7,000	5,000	2,646		1,497	
Excluding Ice sheets		500,910	516,148	486,598	489,159	576,800	497,349	

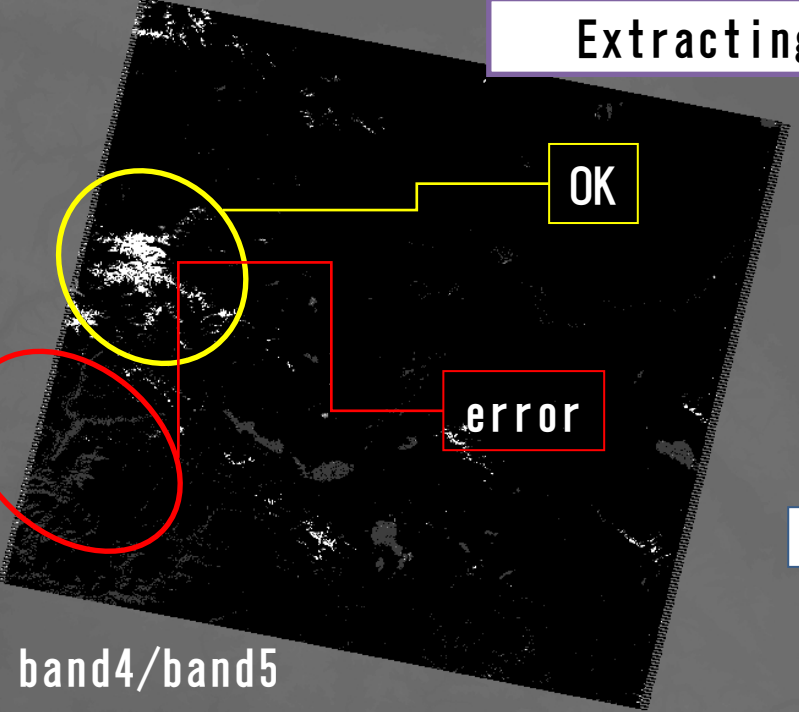


	wave length		reso.	
band1	0.45-0.52 μm	visible	30m	blue
band2	0.52-0.60 μm	visible	30m	green
Band3	0.63-0.69 μm	visible	30m	red
band4	0.76-0.90 μm	near-infrared	30m	chlorophyll
band5	1.55-1.75 μm	near-infrared	30m	water,veg.
band6	10.4-12.5 μm	thermal infrared	120m	surface temperature
band7	2.08-2.35 μm	intermediate-infrared	30m	mine resources

band5 (R) Potanin glacier
band2 (G)
band1 (B)



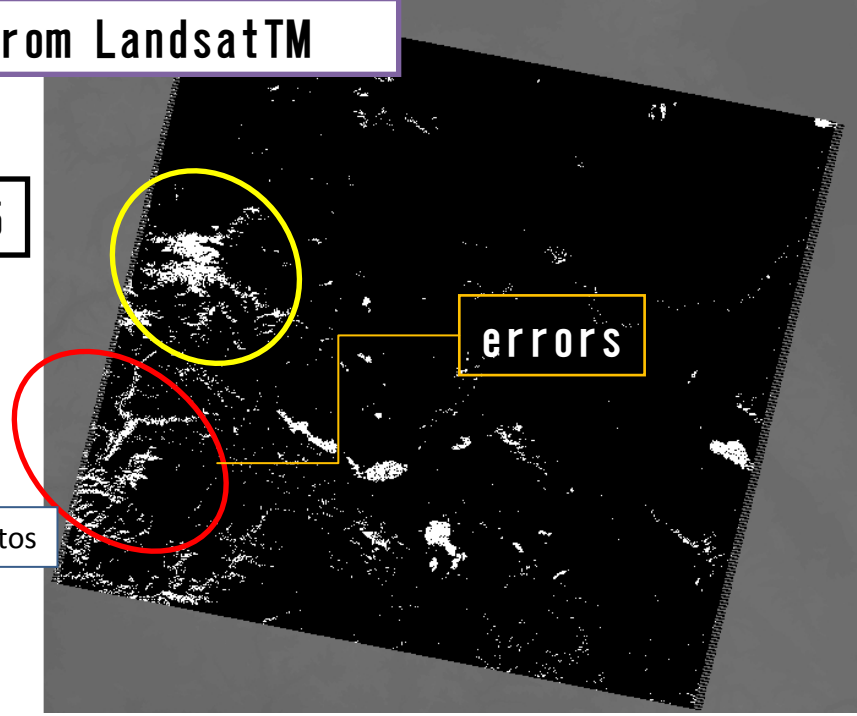
Extracting glacier from LandsatTM



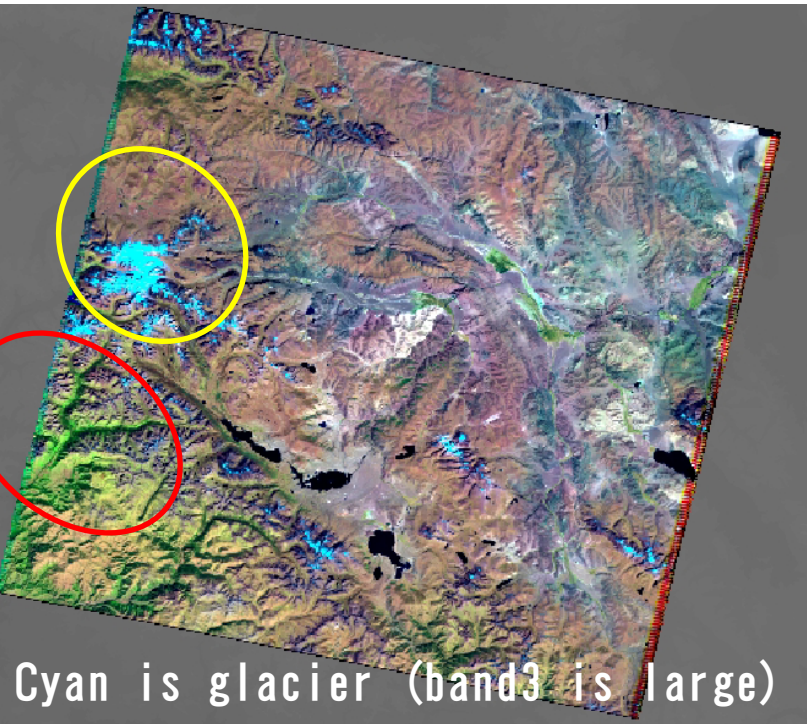
band4/band5

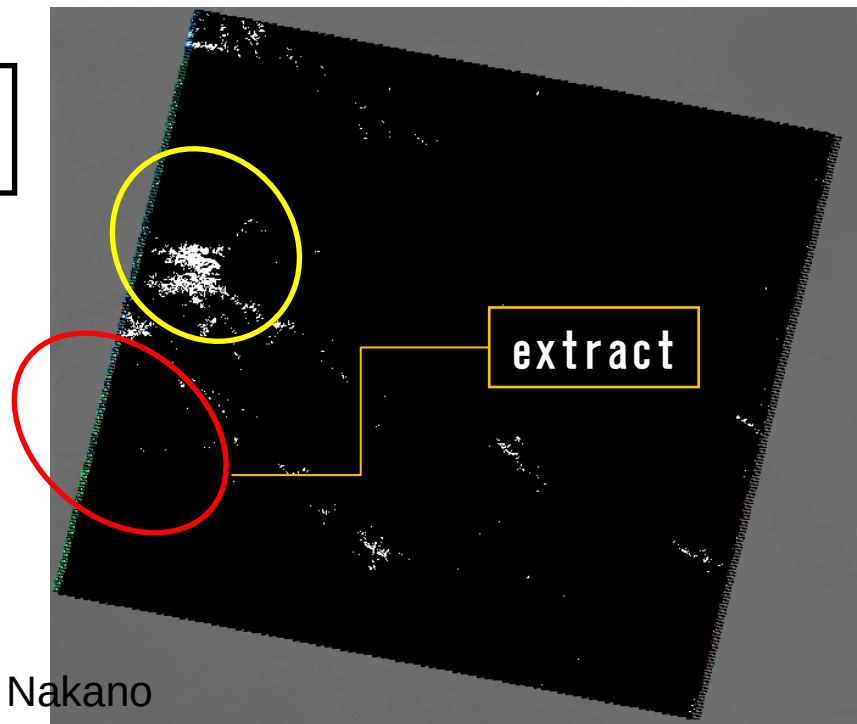
band3

+ maps, digital photos



Adequate threshold





work by K Nakano

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     Energy balance model

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     Switzerland, India, Nepal