Research issues on water cycle in cold terrestrial regions

partly from discussion at CliC/CPA1

Tetsuo Ohata

Institute of Observational Research for Global Change (IORGC), JAMSTEC

CliC SSG Member

<Objectives>

(1) Improve understanding of the physical processes and feedbacks through which the cryosphere interacts within the climate system.

(2) Improve the representation of cryospheric processes in models to reduce uncertainties in simulations of climate and predictions of climate change.

(3) Assess and quantify the impacts of past and future climatic variability and change on components of the cryosphere and their consequences, particularly for global energy and water budgets, frozen ground conditions, sea level change, and maintenance of polar sea-ice covers.

(4) Enhance the observation and monitoring of the cryosphere in support of process studies, model evaluation, change detection.

CliC Project Area (CPA)

(1) Terrestrial Cryosphere and Climate

(Snow cover, frozen ground, glacier, lake/river ice)

(2) Glacier/Ice cap/Ice sheet and their relation to Sea-level

(Glacier, ice sheet)

(3) High latitude ocean and marine cryosphere

(Sea ice)

(4) Links between Cryosphere and the Global Climate

From CliC Science and Coordination Plan (CliC Project Area (CPA1))

- **5 INTERACTIONS BETWEEN THE ATMOSPHERE, SNOW AND LAND 12**

- 5.1 INTRODUCTION AND KEY SCIENTIFIC QUESTIONS 12
- 5.1.1 Climate System Interactions with the Terrestrial Cryosphere 12
- 5.1.2 Key Land Cryospheric Processes and their Role in the Hydrological Cycle 14
- 5.1.3 Precipitation in Cold Regions 15
- 5.1.4 Frozen Ground/Permafrost and Surface and Atmospheric Exchanges 17
- 5.2 SCIENCE STRATEGY FOR ATMOSPHERE-SNOW-LAND INTERACTIONS 20

CPA4: Cryosphere and Global Climate should have relation with CEOP (John Turner)

Why cold region water cycle?

- Global warming, strongest warming and precipitation increase expected in cold regions.

  →surface/sub-surface ice will melt more, decrease of frozen ground?

  →snow cover amount and period will change

  →ground water should be influenced

  other land components, vegetation affected by change in water.

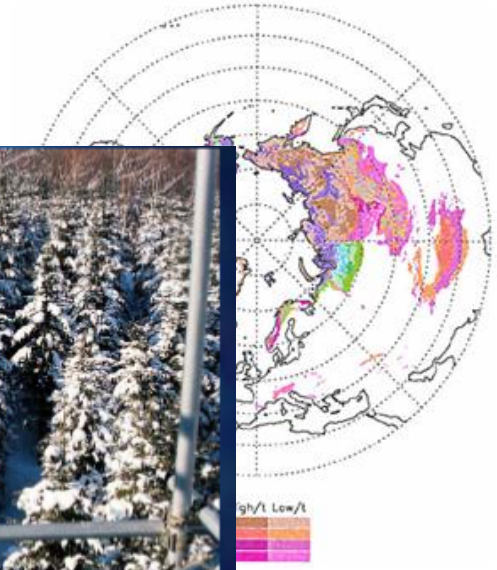
- From these change, direct and indirect effect to hydrological cycle will occur. Perhaps intensifying/changing the whole hydrological cycle
- These hydrological changes will Feedback to atmosphere and climate system. What kind of effect to total climate system?.
- Therefore, very important to understand the present condition of cold region especially snow/ice condition, maintenance process of hydrological phenomena and its variability in cold regions.

FACT: Ice underground. How much? Will it melt?

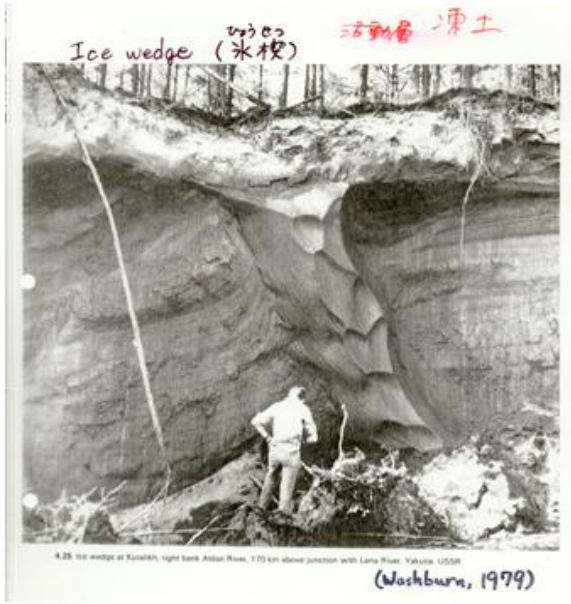
PROCESS: Snow on tree canopy, How does it behave? Sublimation

地球上の雪氷(5) 凍土

凍土は陸地の24%を占める。



場所によっては氷の塊もある。 氷楔

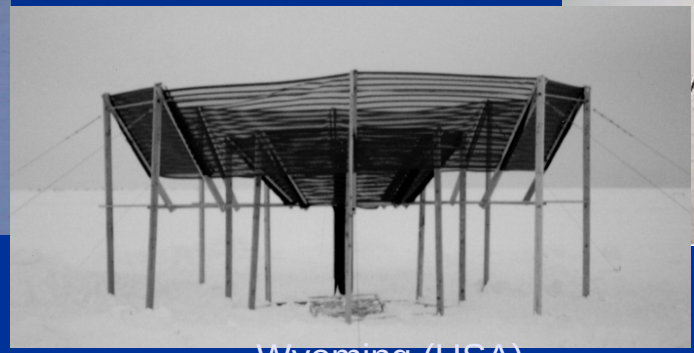


UNCERTAINTY in Solid Precipitation:

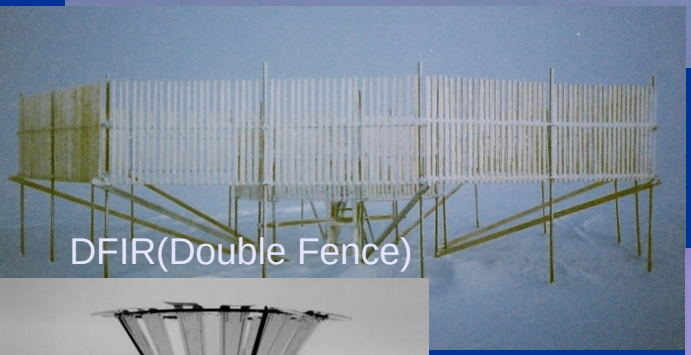
- Correction for past/present used gauges under high wind cases
- Development of better precipitation measurement technique

Observation Layout. Barrow, Alaska

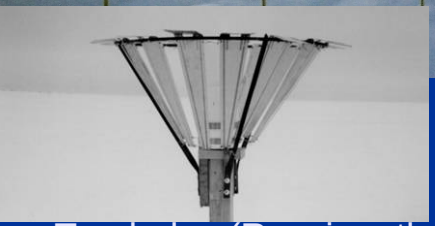
Snow Particle Counter



Wyoming (USA)



DFIR(Double Fence)



Trechakov(Russia, others)

RT-4 (Japan)

US8inch (USA)

Nipher(Canada)

NOAH (USA)

Hellman (Greenland, Denmark, etc.

Main issues

1. Identify the present condition and needed observation network for detecting cryosphere change (Snow cover, frozen ground and glaciers) and expand and/or improve observation for related hydrological components, atmospheric (eg. Solid precipitation, moisture), vegetation etc. related to water/energy cycle.
2. Improve understanding of processes and land surface models in cold regions for better climate and hydrological prediction.
   - Sub-grid scale non-uniform snow cover
   - Forest snow processes
   - Blowing/drifting snow processes
   - Drainage runoff processes (1-1000km^2) uniform climate
3. Climatologically important hydrological phenomena
   - Increase/Variability in the runoff of Arctic draining large rivers.
   - Water (Liquid/Solid) balance of the large basins.
4. Improve the quality and amount of the hydrological and cryosphere data-sets of past and present.
5. Improve representation of snow/frozen ground in large scale models.

Implementation

(1)Measurement network of snow/ice and other hydrometeorological components at several levels in cold regions under different climate. Super-station, basin-scale to single element measurement on Eurasia and North America.

(2) Process, model, local/regional to large scale specialist gather to get optimum results. Snow and ice specialists need to corporate more with specialists in hydrology and atmospheric science. (Integrated land surface process)

(3) Even in cold regions, influence of human activity need to be considered!
(Dams, Contamination of snow cover)

(4) Work in relation to international projects and framework.
- GEWEX Cold Region Projects, Inter-comparison Activities
- Northern Research Basin activity.
- How will cryosphere component come in the GEOSS framework?

(5) IPY International Polar Year (2007-2008)?
Will CEOP Ⅱ initiate intensive observations?
Enhanced radio-sonde obs. and increased surface obs. in Artic??
(Better image of Artic water cycle based on reanalysis)

Northern Research Basin water balance

- Workshop on "Northern Research Basin Water Balance" (Doug Kane, Yang Daqing) Victoria, Canada March 22-24, 2004.

  IAHS Publ. (Red book) No. 290

- Results from 39 Research Basin from

  USA, Canada, Japan, Russia, Norway, Greenland Finland.

  The research there are done under various background such as hydrological, ecological and glaciological framework

- Relation with CEOP

  Some can be reference stations for CEOP Ⅱ,

  Some can use derivatives from CEOP data -------- to evaluate water balance

Questions?

(1)Can CEOP provide good data-sets in the Polar Regions?

(2) What kind of movement will be needed to incorporate snow/ice people to CEOP activities.

(3) Can CEOP core person come to Beijing in April and talk about phase Ⅱ.