## The Pan-Arctic Community-wide Hydrological Analysis and Monitoring Program (Arctic-CHAMP)



### Feedbacks of High Latitude Ecosystems to the Earth's Climate System



**McGuire** 

### Future Feedbacks to the Climate System

(based on Chapin et al., 2001, Global Change Biology)

- Positive feedbacks associated with warming climate
  - Temperature Sensitivity of Decomposition CO<sub>2</sub> release
  - Thermokarst leading to wetland formation CH<sub>4</sub> release
  - Thermokarst leading to soil drainage CO<sub>2</sub> release
  - Increased Fire CO<sub>2</sub> release
- Negative Feedbacks associated with warmer climate
  - Increased nitrogen cycling greater plant uptake of CO<sub>2</sub>
  - Longer growing seasons greater uptake of CO<sub>2</sub> during the growing season
  - Treeline advance + more shrubs greater uptake of  $CO_2$



## Shrub density has increased



Sturm

2000

1949

### Climate feedbacks from shrub expansion



## Area burned in W. North America has doubled in last 20 years



Kasischki





Feedbacks relevant to ice sheet and glaciers: Increased Precip. -> IS - high elevation storage; low elevation ? Increased Melt -> increased runoff; increased ice discharge Increased Melt for small glaciers -> increased runoff; loss of ice -> decreased late summer flow



# EVAPOTRANSPIRATION More Energy More ET & Drier Active Layer Higher Temp and Precip >??????

Water & Environmental Research Center

## Discharge is increasing in major Eurasian rivers



Peterson et al.

# PERMAFROST

### Warmer Climate Deeper and Drier Active Layer

Water & Environmental Research Center





There may or may not be *increased* discharge in the coming years. Either way, we want to know how freshwater affects the <u>shelf</u>, the <u>arctic ocean</u>, and the <u>north atlantic ocean</u>.

On the shelf increased discharge =>

higher stratification => more ice (negative feedback)

warm river water => earlier sea ice melt (positive feedback)

### In the Arctic Ocean, freshwater controls

... the thermohaline circulation (OK, but there's also wind-driven flow and other forcings... what are the relative roles?)

... biological productivity

In the North Atlantic Ocean, deep convection is in fluenced by

- ... sea ice outflows through Fram St. & the Canad. Arch.
- ... ocean outflows, both fresh upper and salty lower (but what are the relative roles?)

### Change in Area of Lakes and Ponds In a Discontinuous Permafrost Region of Alaska



**Copper River Basin 1985** 



**Copper River Basin 1995** 

Source: Landsat Thematic Mapper band 5 images from mid summer 1985, 1995 *Courtesy of Dave Verbyla* 

Uni-variate linkages between variables	Univariate "Model" evidence	Level of Confidence in Univariate Linkage	Have we observed this?	Level of confidence linkage	Is a better understanding critical to understanding of the Arctic System?
Does increased Air T cause decreased sea ice and increased Open Water?	Yes	High	Yes	High	Yes
Does increased Air T causes increased ocean evaporation?	Yes	High	No data	N/A	yes
Does increased ocean evaporation cause more cloud cover?	Undecided	Low	No data	N/A	Yes
Does increased cloud cover cause increase precipitation?	No	High	Yes	High	No
Does decreased sea ice cause increased marine biological activity?	Ask the crowd				

Uni-variate linkages between variables	Univariate "Model" evidence	Level of Confidence in Univariate Linkage	Have we observed this?	Level of confidence linkage	Is a better understanding critical to understanding of the Arctic System?
Does increased precipitation cause increased					
discharge?	Yes	High	Yes	High	Yes
Does increased discharge influence sea ice formation?	Ask the crowd				Yes
Does increased precipitation cause increased snow					
cover extent?	Yes	High	Undecided	Low	Yes
Do changes in snow cover affect					
human behavior?	Yes	High	Yes	High	Yes

Uni-variate linkages between variables	Univariate "Model" evidence	Level of Confidence in Univariate Linkage	Have we observed this?	Level of confidence linkage	Is a better understanding critical to understanding of the Arctic System?
Does increased precipitation cause increased snow	Voc	High	No	Low	Yos
Does increased snow lead to increased permafrost temperature?	Yes	High	Yes	Medium	Yes
Does increased snow lead to increased river discharge?	Yes	High	No	Low	Yes
Does increased snow cover lead to more evaporation?	Yes	High	No data	N/A	yes

Uni-variate linkages between variables	Univariate "Model" evidence	Level of Confidence in Univariate Linkage	Have we observed this?	Level of confidence linkage	Is a better understanding critical to understanding of the Arctic System?
Does increased SWE lead to more evaporation?	No	High	No data	N/A	Yes
Does increase net moisture from lower latitudes increase precipitation?	Yes	High	Yes	High	Νο
Does increased land evaporation increase cloud cover?	Yes	High	No data	N/A	Yes
Does increase biological activity in the ocean increase cloud cover?	Ask the crowd				

Uni-variate linkages between variables	Univariate "Model" evidence	Level of Confidence in Univariate Linkage	Have we observed this?	Level of confidence linkage	Is a better understanding critical to understanding of the Arctic System?
<u> </u>					
Does an increase in					
evapotranspiration?	Ask the crowd				ves
Does an increase in					
shrubiness					
decrease soll	Ask the crowd				
Does increase					
coastal baroclinicity					
increase summer	Vaa	Lliab	Vaa	Llich	No
precipitation?	res	nign	res	nign	
Does increased					
precipitation					
increase DOC and					
nutrient transport?	Yes	High	No	Medium	

Uni-variate linkages between variables	Univariate "Model" evidence	Level of Confidence in Univariate Linkage	Have we observed this?	Level of confidence linkage	Is a better understanding critical to understanding of the Arctic System?
Does increase in precipitation cause increase carbon dioxide?	Ask the crowd				
Does increase in precipitation cause increase methane?	Yes	High			
Does increase in precipitation cause increase in shrubiness?	Ask the crowd				
Does increasing temperature increase runoff from glaciers and ice					
Greenland)?	Ask the crowd				

Uni-variate linkages between variables	Univariate "Model" evidence	Level of Confidence in Univariate Linkage	Have we observed this?	Level of confidence linkage	Is a better understanding critical to understanding of the Arctic System?
Does increase in freshwater export from the Arctic reduce NADW					
formation?	Ask the crowd				