Development of Integrated Terrestrial Surface Water State Indicators for Climate Assessment

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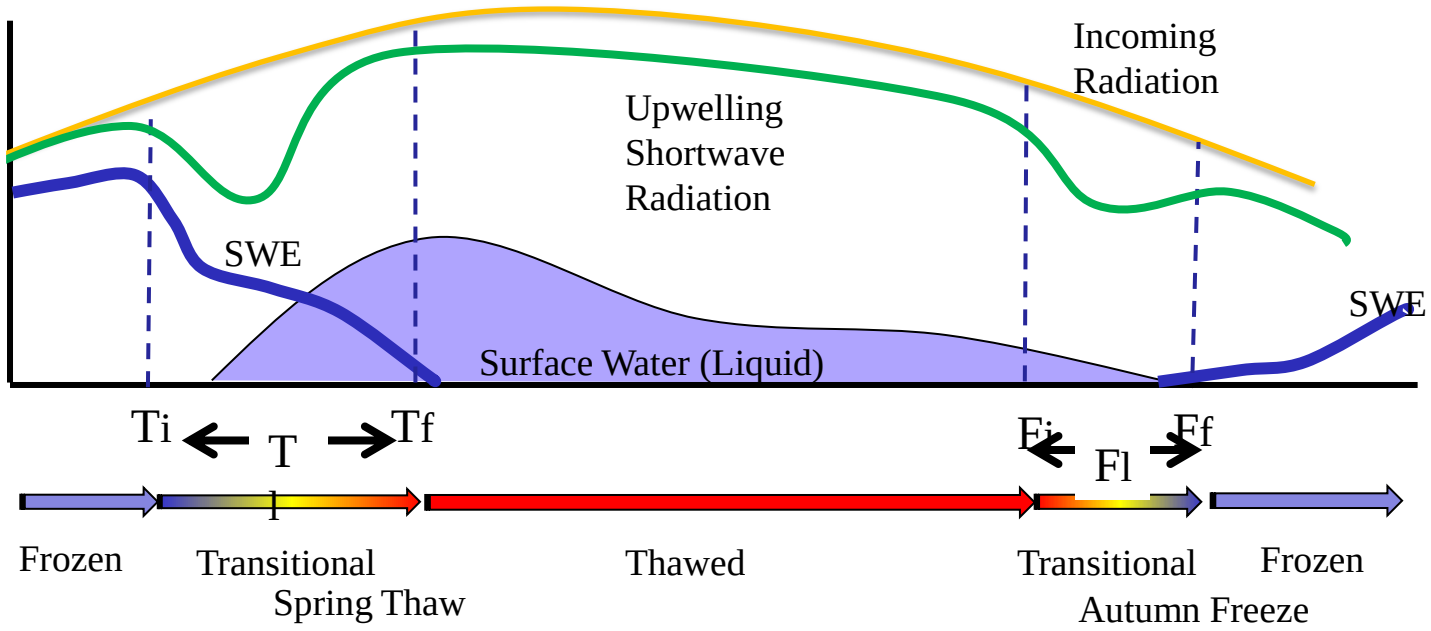
Integrated Terrestrial Hydrologic State Indicators



Indicator	Inputs	Key derivatives (with units)
Freeze/thaw: Growing season length Frozen & non-frozen seasons	Landscape freeze/thaw state	Day of thaw start (Ti) & end (Tf) (day of year) Duration of thaw transition (Tl = Tf – Ti) (days) Day of freeze start (Fi) & end (Ff) (day of year) Duration of freeze transition (Fl = Ff – Fi) (days) Annual max & min thawed and frozen areas (km^2) Potential growing season (days)
Land Surface Inundation	Inundated area fraction (Fw) Fw on days of thaw completion and freeze initiation	Days of max. and min. inundation (day of year) Annual max. and min. inundation area (km^2) Annual integrated inundated area days (days * km^2)
Snow melt duration and melt rate	Freeze/thaw state SWE at time of initial thaw	SWE(Ti)/transition length = SWE/(Tf – Ti) (mm/day)
Hydrology - Radiation Balance	Radiative flux; Freeze/thaw state; SWE	Integrated long and short wave radiative flux (upwelling and downwelling) over key seasonal periods (frozen seasons, thawed seasonal, and transition periods) reported by grid cell and by hydrologic basin.

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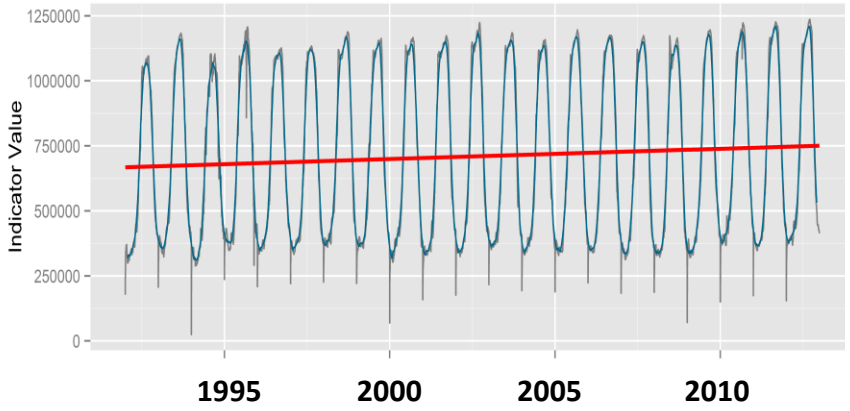
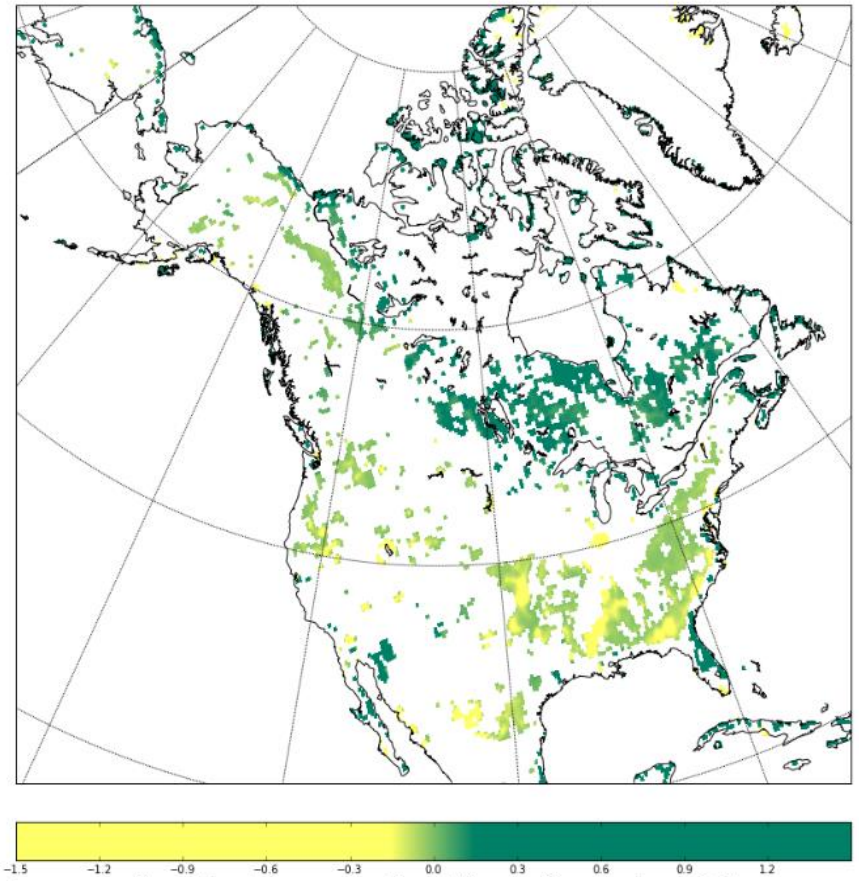
Hydrologic State Indicator: Inundated Area

North America Inundated Area Trend



Annual Inundated Area Trend (1992-2012)



Inundated Area Trend: Areas of significance (p-value < 0.1)

Annual Inundated Area by Basin

Basin	1992	1999	2005	2012	Trend	p-value	Area (Km^2)
Columbia	5.3E+05	5.0E+05	4.7E+05	4.3E+05	---	< 0.05	668,000
Mackenzie	1.4E+06	1.6E+06	1.6E+06	1.5E+06	+++	> 0.05	1,805,200
Mississippi	1.1E+07	1.3E+07	9.7E+06	8.9E+06	---	< 0.05	3,220,000
Nelson	1.1E+07	1.3E+07	1.2E+07	1.3E+07	+++	< 0.05	1,072,300
St. Lawrence	6.0E+07	5.1E+07	5.9E+07	6.0E+07	+++	> 0.05	1,344,200
Yukon	1.2E+06	1.1E+06	1.8E+06	1.3E+06	---	> 0.05	832,700

The Integrated inundated area line plot shows inundated area is increasing over North America. The trend map shows that this increase is occurring primarily in the Hudson Bay region and decreasing in temperate areas in the United States. These trends are corroborated by the results in the table showing statically significant decreases in annual inundation in the Mississippi and Columbia basins and statistically significant increases in the Nelson Basin.

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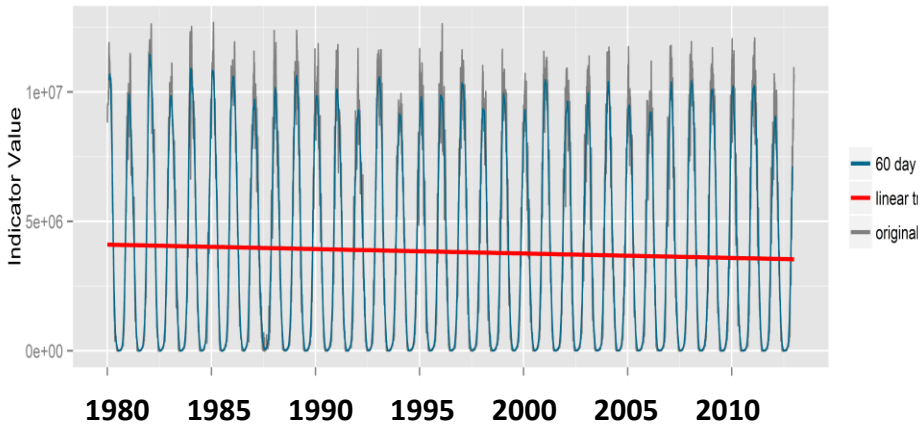
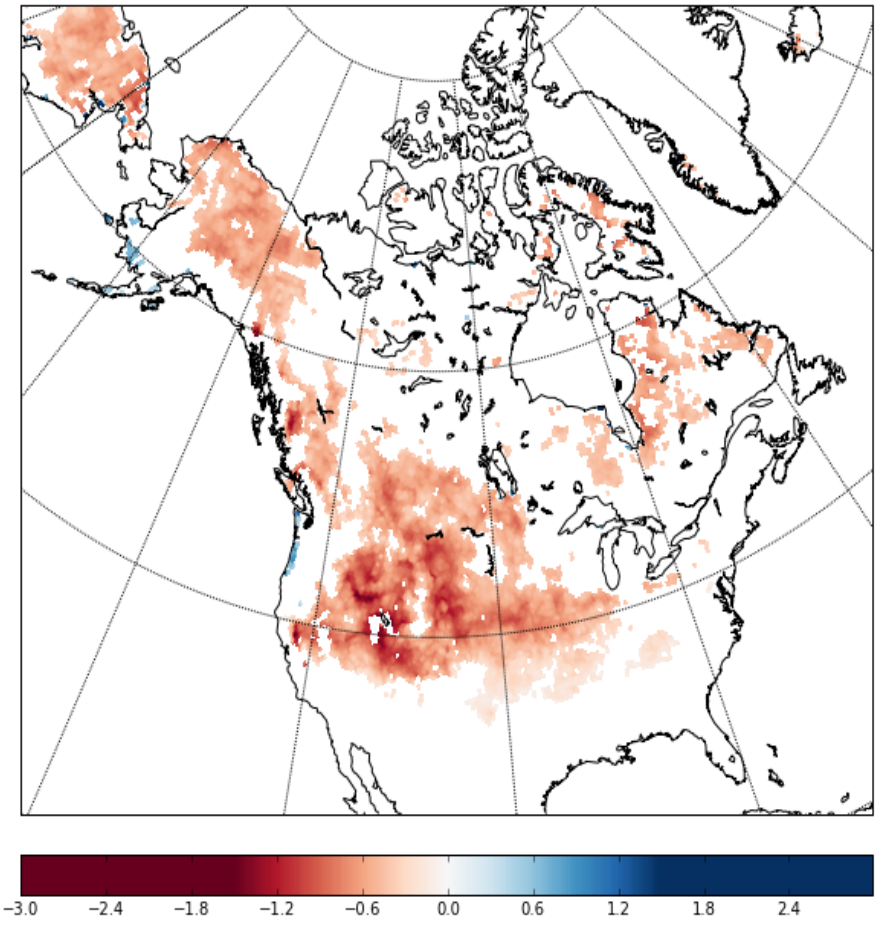
Hydrologic State Indicator: Frozen Season

North America Frozen Area Trend



Frozen Season Trend (1980-2012)



Trend in Frozen Season by Day: Areas of significance (p-value < 0.1)

Integrated Annual Frozen Area by Basin

Basin	1980	1990	2000	2010	Trend	p-value	Area (Km^2)
Columbia	5.5E+07	5.4E+07	5.3E+07	5.1E+07	---	< 0.05	668,000
Mackenzie	2.6E+08	2.5E+08	2.5E+08	2.5E+08	---	> 0.05	1,805,200
Mississippi	1.5E+08	1.1E+08	1.2E+08	1.1E+08	---	< 0.05	3,220,000
Nelson	1.1E+08	1.0E+08	1.1E+08	1.0E+08	---	< 0.05	1,072,300
St. Lawrence	1.0E+08	7.1E+07	9.3E+07	8.7E+07	None	> 0.05	1,344,200
Yukon	1.4E+08	1.5E+08	1.4E+08	1.3E+08	---	< 0.05	832,700

The Integrated frozen area line plot shows that frozen area is decreasing over North America. The trend map shows this decrease is primarily impacting the Western United States, Alaska, and the western and polar regions of Canada. These trends are corroborated by the results in the table showing decreasing frozen area by river basin.

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Summary of Individual Hydrologic State Indicator Trends

Daily Indicator Trends Integrated by Basin

Basir.	Frozen	SWE	LWUP	Transitional	Inundation
Albany	---	---	+++	p > .05	+++
Churchill (Arctic)	---	---	+++	+++	+++
Churchill (Hudson)	---	---	+++	+++	+++
Colorado (Arizona)	---	---	+++	+++	+++
Colorado (Texas)	---	---	+++	---	---
Columbia	p > .05	---	+++	+++	---
Connecticut	---	+++	+++	---	---
Copper	p > .05	---	+++	p > .05	---
Delaware	---	---	p > .05	---	---
Hayes	---	---	+++	+++	+++
Klamath	p > .05	+++	+++	+++	---
Kuparuk	---	+++	+++	+++	p > .05
Mackenzie	---	---	+++	+++	+++
Mississippi	---	+++	+++	p > .05	---
Nelson	---	---	p > .05	+++	+++
Pototmac	---	+++	p > .05	---	---
Rio Grande	---	---	+++	---	---
St. Lawrence	p > .05	---	+++	---	+++
Yukon	---	---	+++	+++	p > .05

Individual Indicator Trends

- 15/20 basins exhibiting significant decreasing trends in daily frozen area
- 15/20 basins exhibiting significant decreasing trends in daily integrated SWE.
- 17/20 basins exhibiting significant increasing trends in longwave upwelling radiation
- Basins with temperate climate showing decreases in inundation while higher latitude basins showing increases in daily integrated inundation.

Web Portal Supporting Integrated Analyses