Modelling Global Fresh Surface Water Temperature

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Introduction

Modelling global fresh water temperature because:

- Water temperature influences physical, chemical and biological processes: ice formation, hydro-geochemistry, aquatic habitats.
- Rivers transport heat along the Earth's drainage network: local effects v. regional effects.

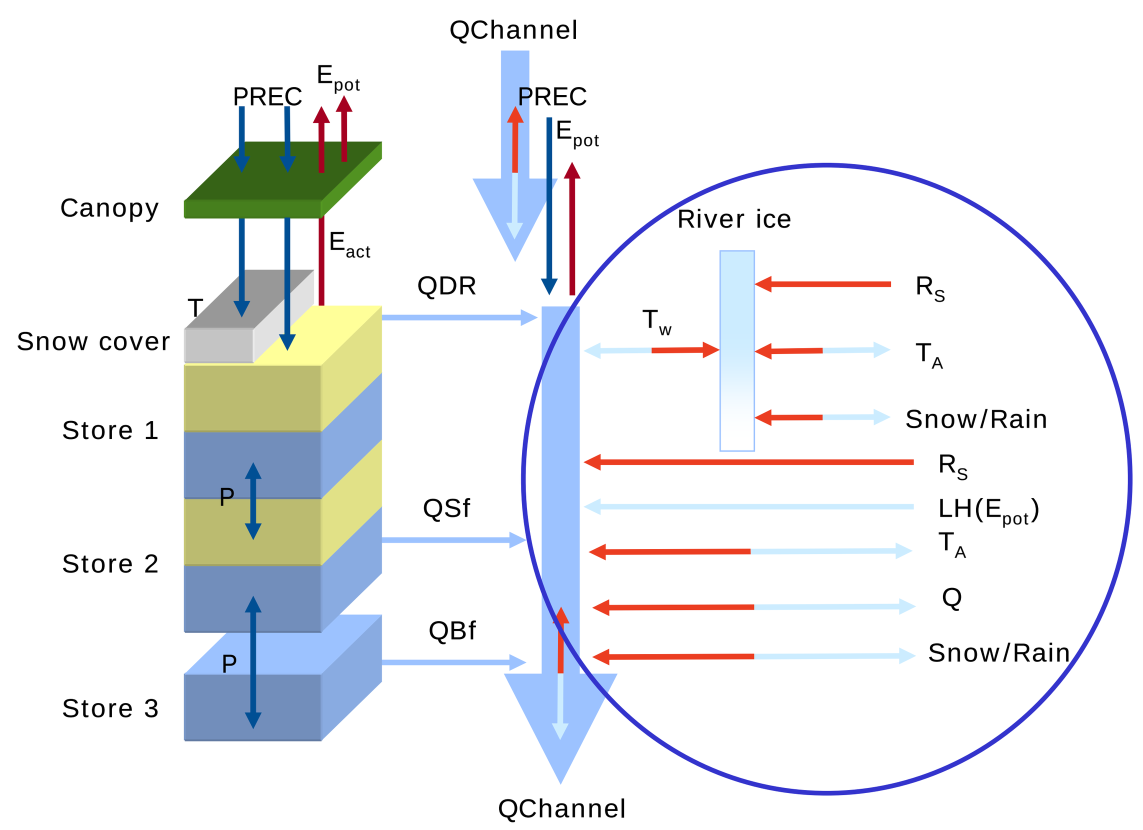
Objectives

1. Develop a physically-based global surface freshwater temperature model;
2. Validate simulated surface freshwater temperatures against observations for different environmental settings.

Model setup

Incorporation of a physical-deterministic energy-balance model for surface freshwater in the global-scale hydrological model PCR-GLOBWB.

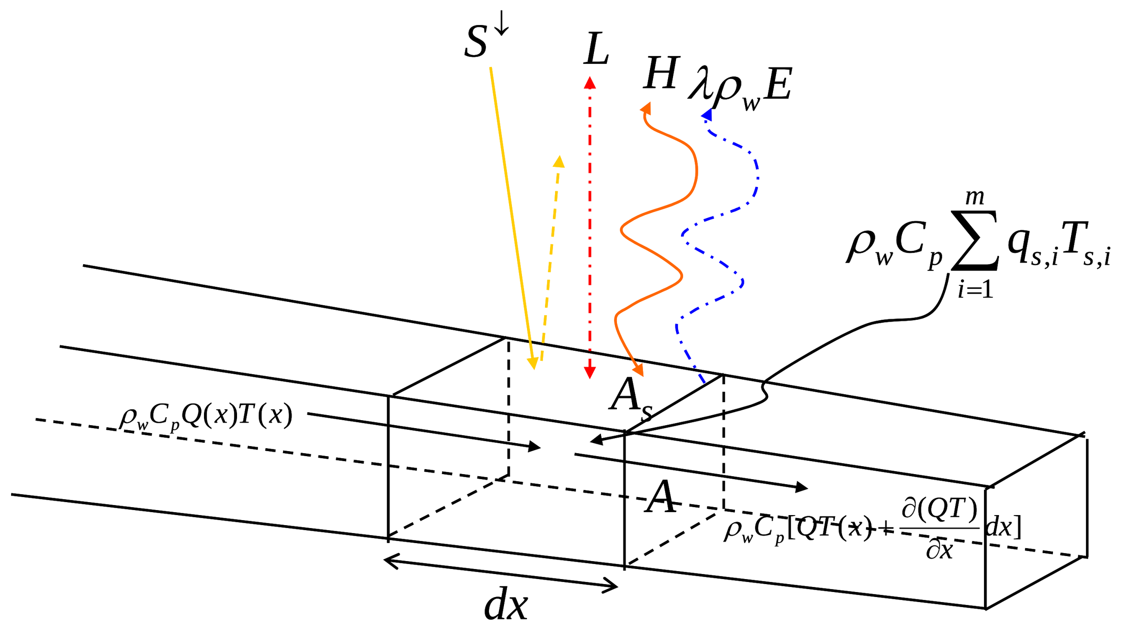
Model structure of PCR-GLOBWB



Conclusions

- Good reproduction of zonal and seasonal temperature variations; over-estimation in tropics; reasonable reproduction of daily temperatures.
- Large anomalies between surface water and atmospheric temperatures, especially for high latitudes and rivers traversing multiple climate zones: dedicated water temperature model is a necessity.

Water energy balance model for a rectangular channel



Water Temperature

$$\rho_w C_p \frac{\partial(hT)}{\partial t} = -\rho_w C_p \frac{\partial(vhT)}{\partial x} + S^{\downarrow}(1-\alpha_w) + L^{\downarrow} - L^{\uparrow} - H - \lambda\rho_w E + \rho_w C_p \sum_{i=1}^{M} q_{s,i} T_{s,i}$$

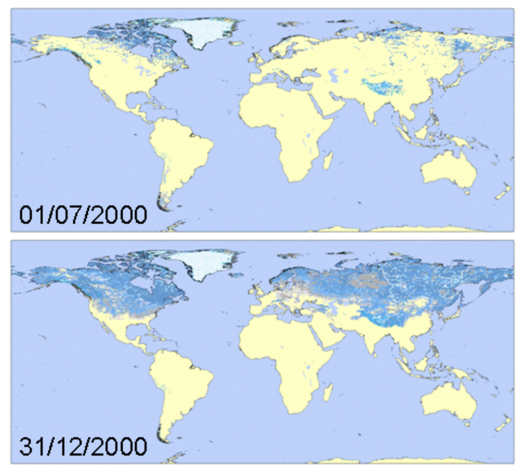
$$\rho_w C_p \sum_{i=1}^{M} q_{s,i} T_{s,i} \equiv \rho_w C_p \left\{ pT_a + \left[\frac{1-f_w}{f_w}\right]\left(q_{dr} T_a + q_{sf} T_a + q_{bf} \overline{T}_a\right)\right\}$$

River ice formation

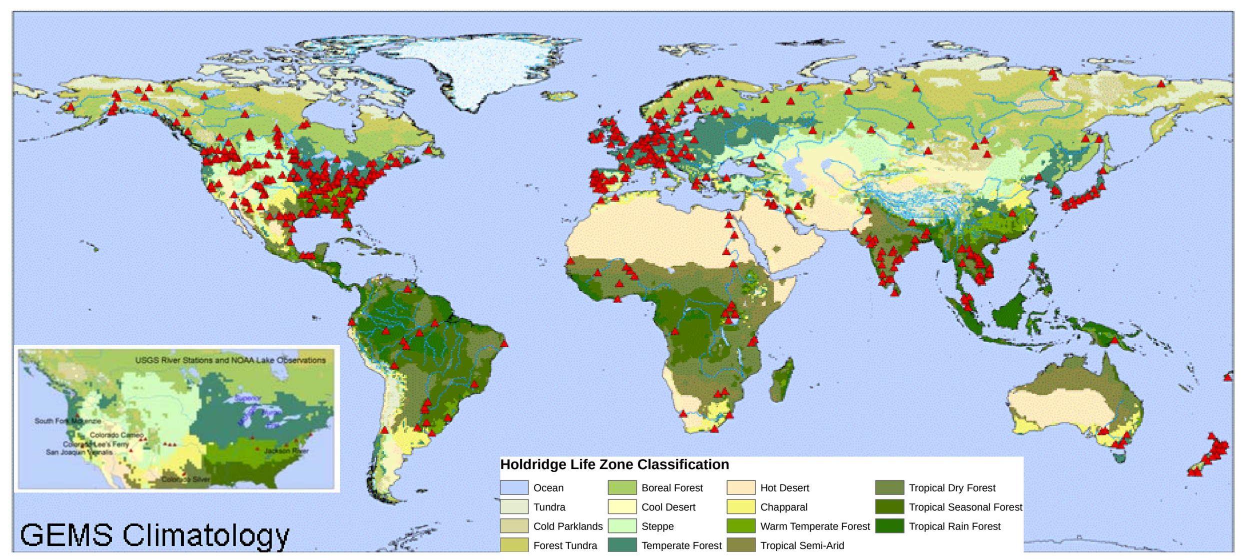
$$\lambda_f \rho_w \frac{dz_i}{dt} = -H_1 + H_2 - S^{\downarrow}(1-\alpha_i) - L^{\downarrow} + L^{\uparrow}$$

$$P = 2h + W \rightarrow P = 2(h + W)$$

$$n_c = \left(\frac{n_i^{3/2} + n_b^{3/2}}{2}\right)^{2/3} \qquad n_i = 0.0493 h^{-0.23} z_i^{0.57}$$



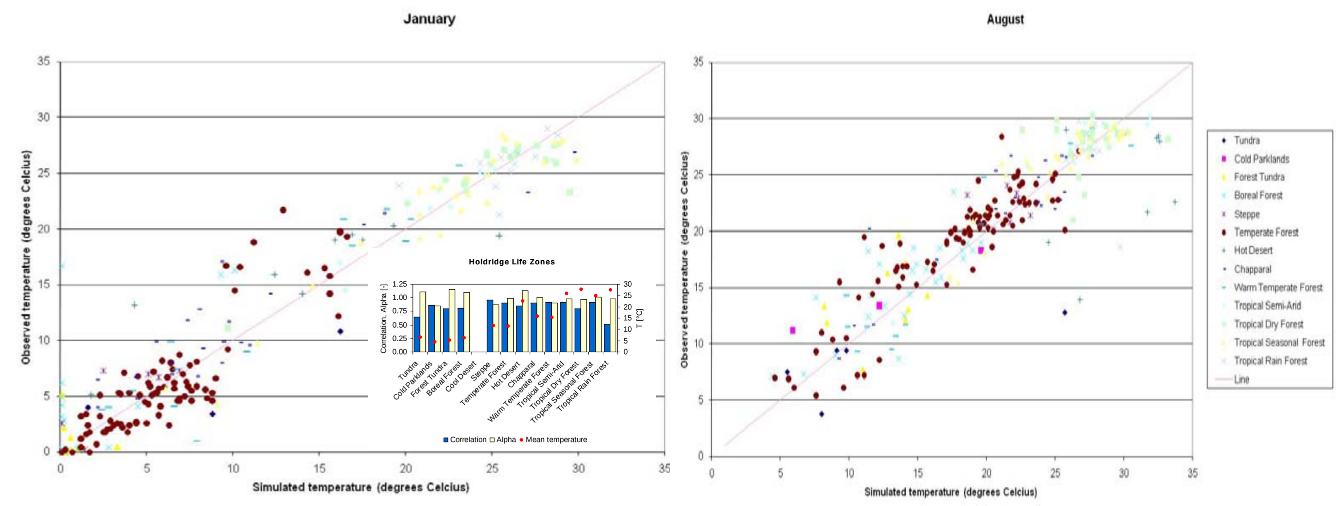
Data and validation



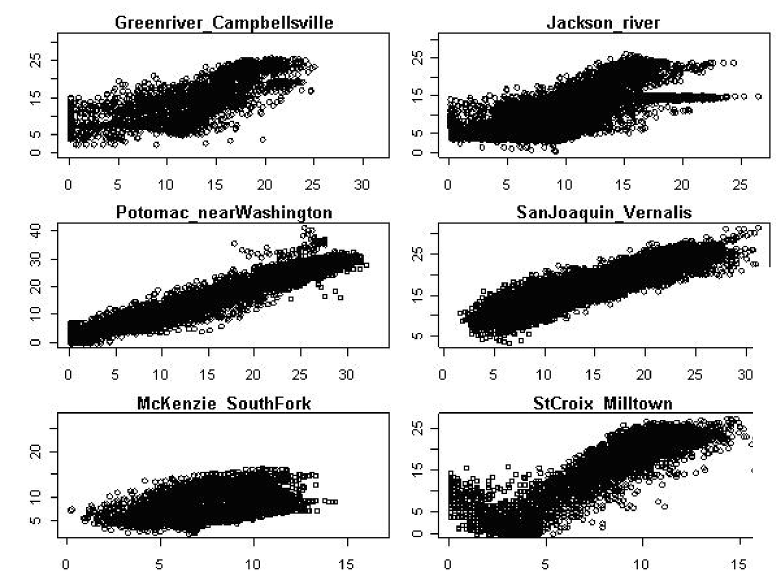
Variable	Source	Temporal resolution	Extent	Period
Discharge	GRDC	Long-term / Monthly / Daily	Global	Variable, > 10 years
Discharge + Temperature	USGS	Daily	North America	1975-2004
Temperature	NOAA	Daily	Great Lakes	1960-1990
Temperature	GEMS	Monthly climatology	Global	1975-2004

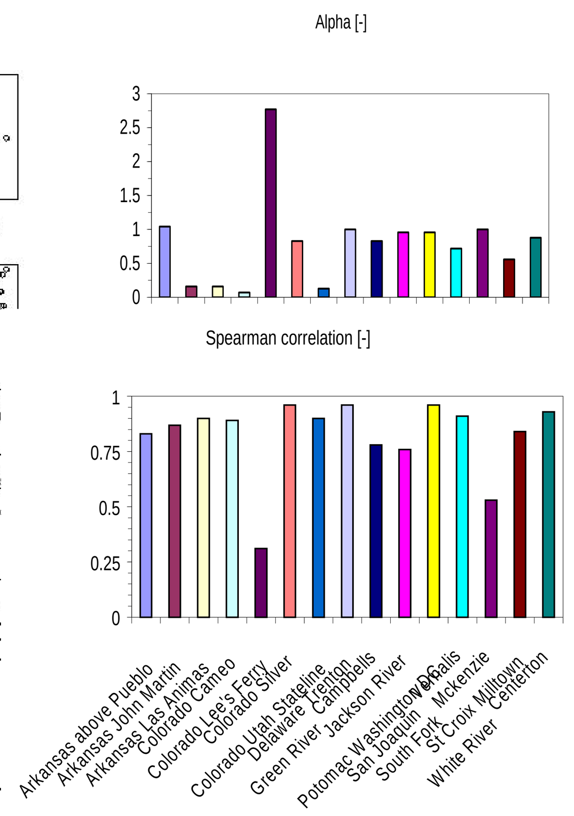
Validation

GEMS Climatology



USGS/NOAA dayly data





Lake	Spearman Correlation	Slope	Standard er
Erie	0.93	1.11	3.58
Huron	0.88	0.98	3.65
Michigan	0.92	0.99	3.13
Superior	0.87	1.20	3.70

Seasonal anomalies water-air temperatrure