Frozen ground – FFGS

CARFFG SCM4 – Astana Kazakhstan

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NWSRFS Frost Index model (Anderson & Neuman, 1984)

- The importance of simulating frozen ground

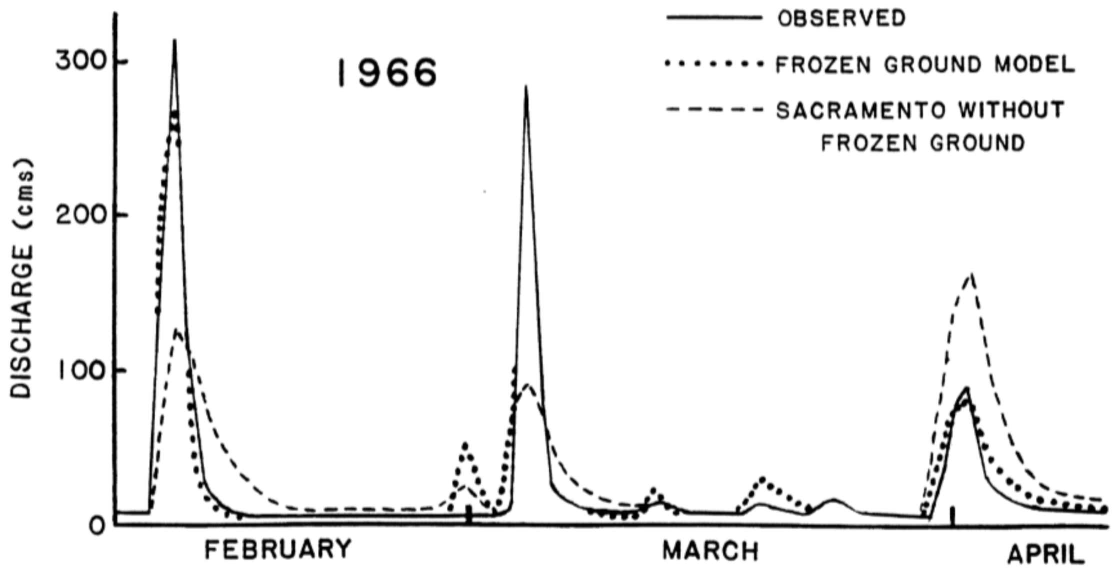
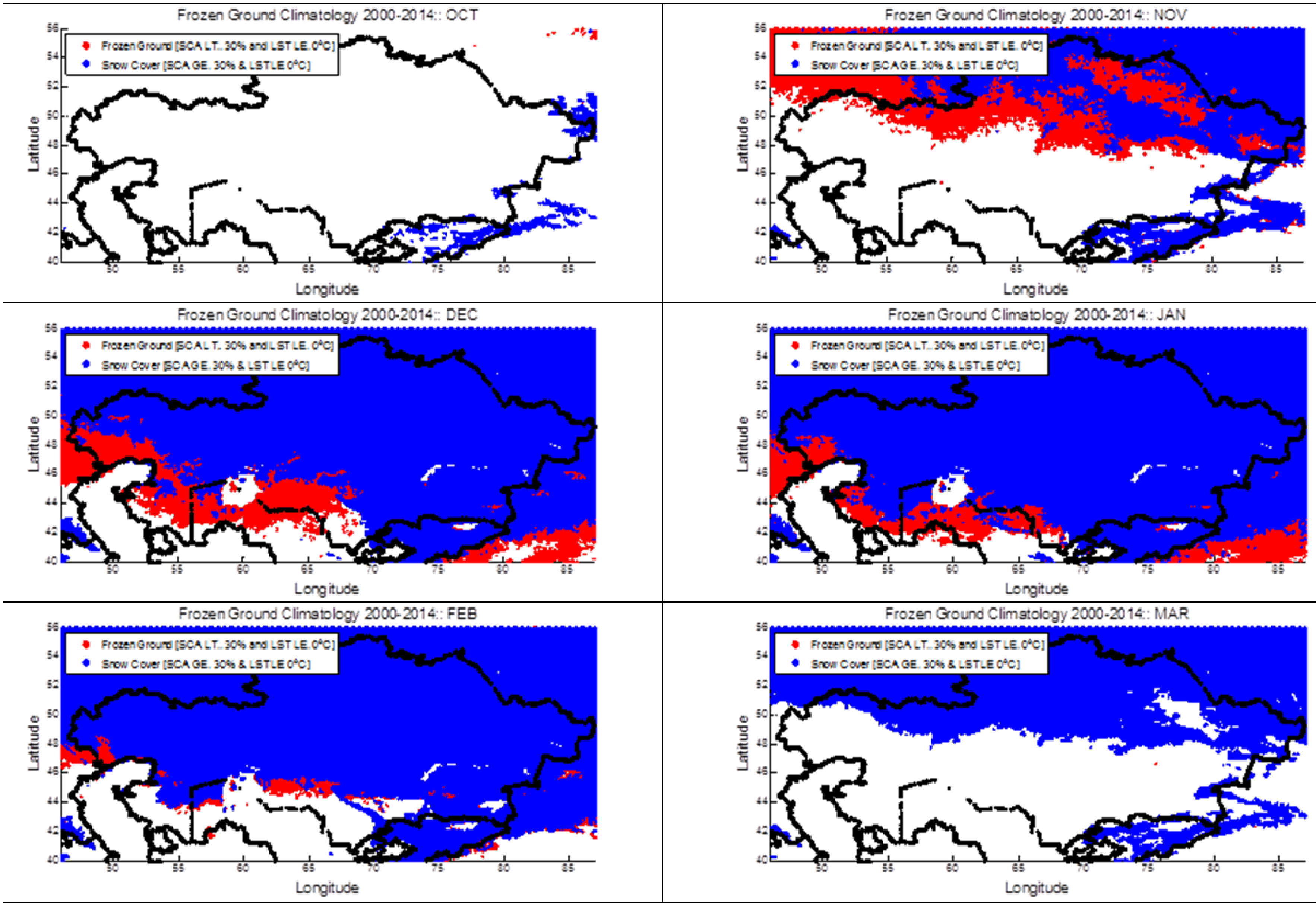


Figure 5. Hydrograph comparisons for the Root River during the two winters when frozen ground had the largest effect on runoff.

MODIS/Terra 8day LST vs. SCA 2000-2014

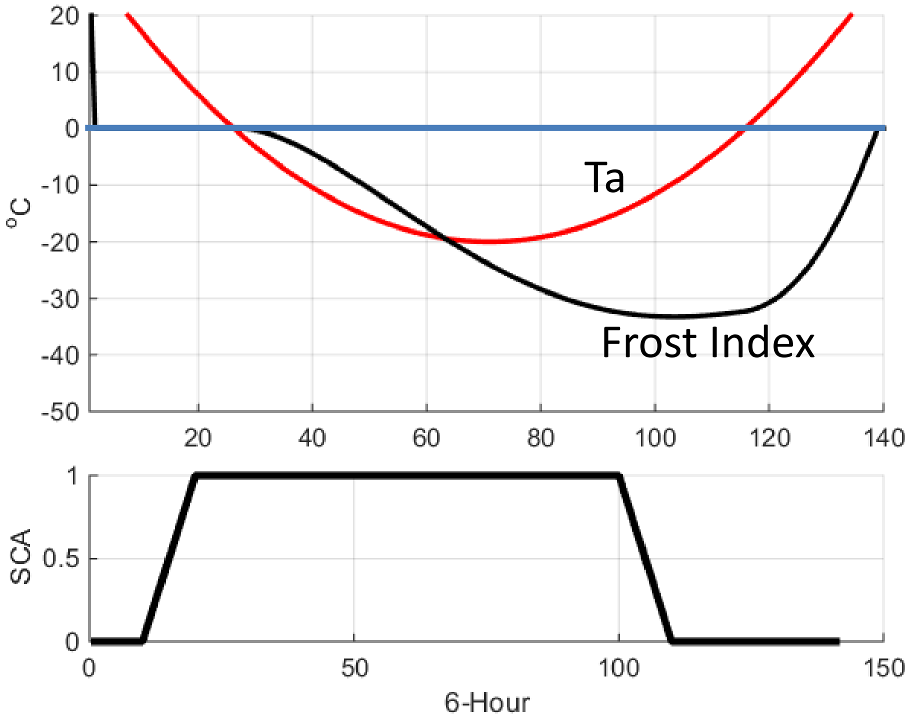


FFG Modeling of Frozen Ground

- Frozen ground can have a significant effect on streamflow
- The modeling of frozen ground using a Frost Index (FI)
- Operational data source that can be used operationally in the FFGS (CFSv2)
- Evaluation of Regional Frost Index

Frost Index [FI]

- Calculating an empirical Frost Index [FI] as a function of:
  - Air Surface Temperature [Ta]
  - Snow depth [SD]
  - Snow cover area [SCA]



NWSRFS Frost Index model (Anderson & Neuman, 1984)

Frost Index [FI]

The FI for a given time steps (t) is calculated as followed:

$$FI_t = FI_{t-1} + \Delta FI$$

The change of the Frost Index (ΔFI) is calculated as:

$$\Delta FI = -C\sqrt{T_a^2 + FI_{t-1}^2} - C \cdot FI_{t-1} + H_c, \quad [T_a < 0\,°C]$$

$$\Delta FI = (C \cdot T_a) + (C_t P) + H_c, \quad [T_a > 0\,°C]$$

where

$$C = C_g(1 - SCA) + C_g SCA(1 - C_s)^{swe}$$

T_a – Air surface temp Assumed Land Surface Temperature (LST)

SCA – fraction of snow cover (Fraction)

SWE – Snow Water Equivalent (mm)

P – infiltrated water (assumed 0)

Parameters

Hc – Daily thaw rate from ground heat [0.1-0.12]
Cg – Bare ground frost coefficient [0.1 for open area 0.05 forest]
Cs – Fraction reduction in the Cg per mm of SWE [0.08]
Ct – Thaw coef for water entering the soil [0.1]

Reduction Factor [R]

R- a multiplier that reduce percolation and interflow

$$R = R_s + (R_d - R_s)D_L^x$$

Where Rs is the reduction at saturated conditions and is calculated as:

$$R_s = (1 - C_r)^{FI_L - FI}$$

FI_L -The FI value that has the maximum reduction in percolation and interflow,

Cr - The reduction of per °C for FI <FI_L in saturated conditions,

DL - lower zone soil moisture deficiency ratio,

Rd - 1.

X = 1 – (lower zone content / lower zone capacity)

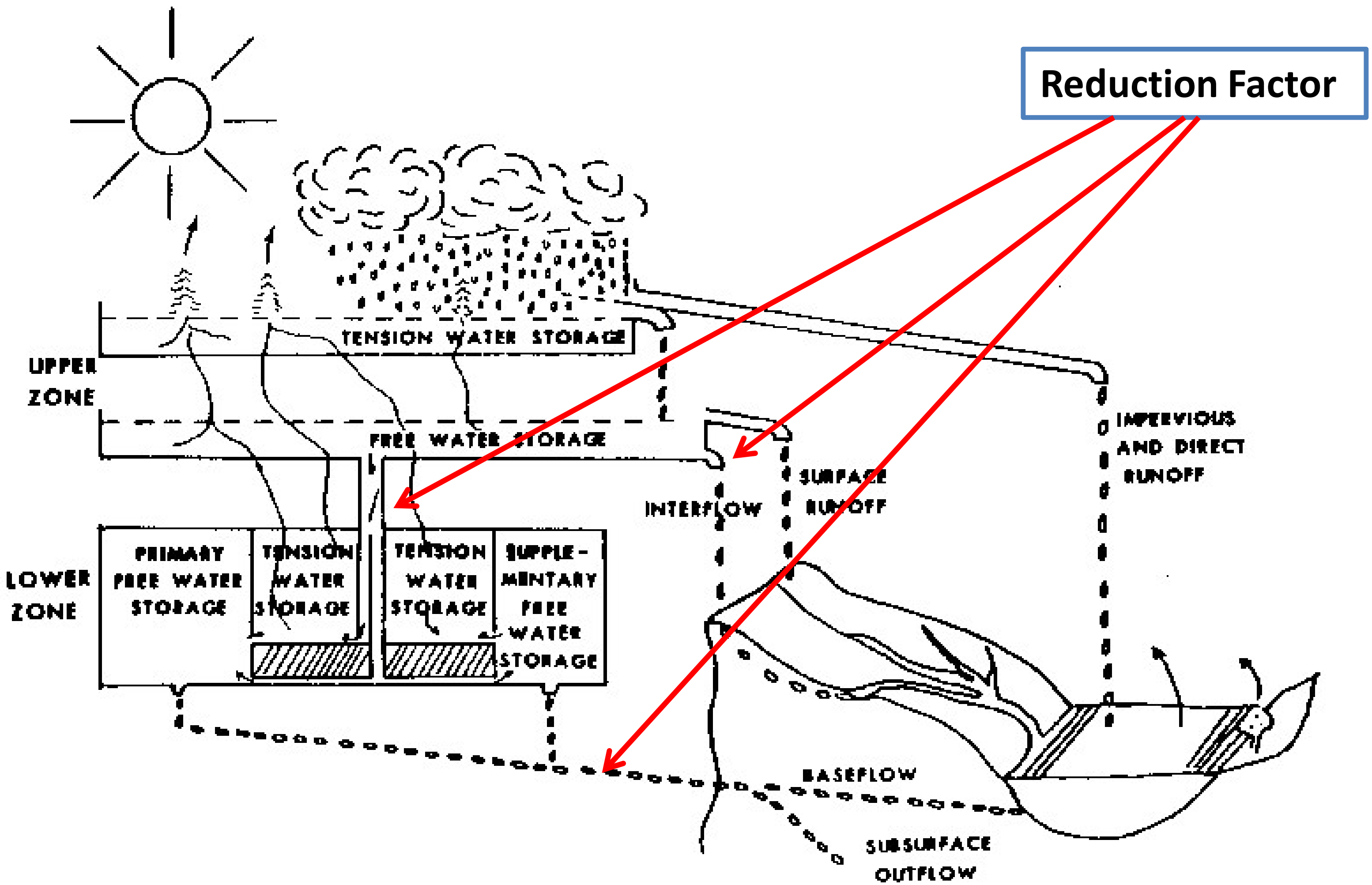
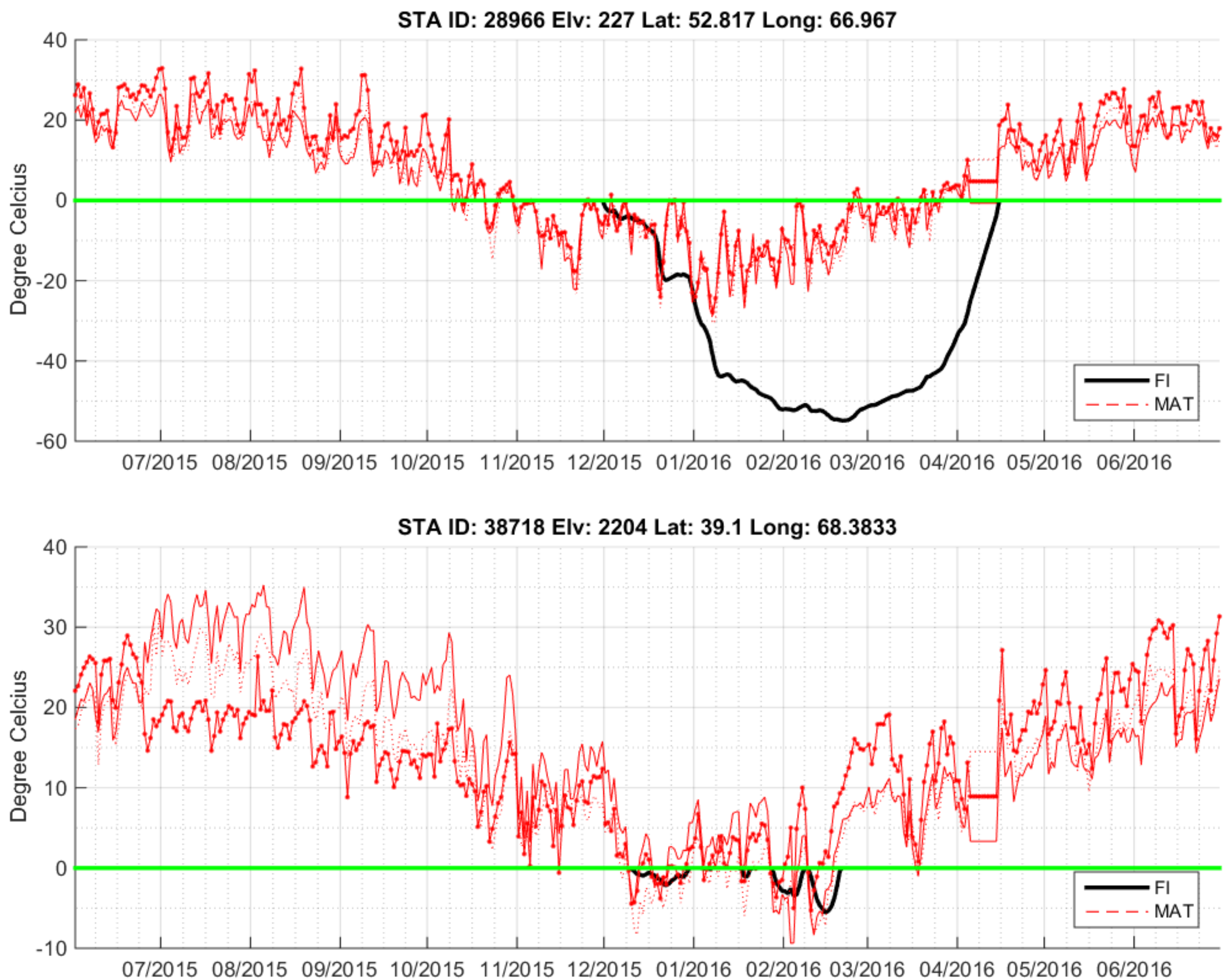


Figure 1. Illustration of a generalized hydrologic model.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FI
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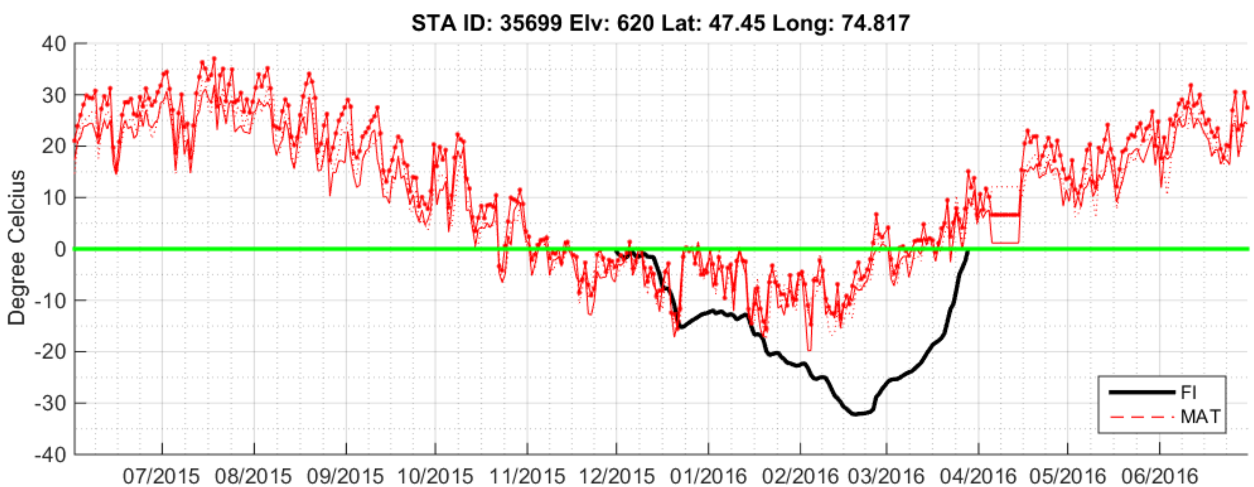
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