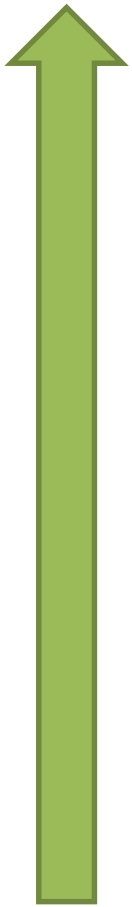
Phase 6 Watershed Model: Prototype-I

Modeling Workgroup Conference Call

Gopal Bhatt (gopal.bhatt@psu.edu)
Research Associate, Penn State University

Evolution of Phase 6 Watershed Model



Phase 6 Jul'15	*Phase-6 land segmentations and land use*
Phase 6 Apr'15	Expand simulation period to 2014
Phase 6 Oct'14	Incorporate lag-time to the nutrient transport
Phase 6 Jul'14	Build sensitivities in the modeling framework
Phase 6 Apr'14	1985-2005, Incorporate NLDAS-2 forcing (P, T, E, …)
Phase 6 Apr'14	1985-2005, Replace AGCHEM with PQUAL
Phase 6 Jul'13	2002-2011, Refine sediment calibration, PQUAL
Phase 5.3.2	Phase 5 watershed model

Outline of presentation

Phase 6 Watershed Model – Jul'15 [Prototype-I]

objective: provisional data, put process in place

1. Model structure updates
2. Hydrology parameterization & calibration
3. Sediment parameterization & calibration
4. Water temperature parameterization & calibration

1. Model Structure Updates

*** P6 LAND-SEGMENTS SPECIFIC ***

- config/catalog/geo/p600/landnames.csv
- config/catalog/geo/p600/land_water_area.csv
- config/catalog/geo/p600/watershed_area.csv
- config/catalog/geo/p600/river_met_wdm.csv
- config/catalog/geo/p600/river_prad_wdm.csv
- config/catalog/iovars/p600/variable_l2r_factors/SEDM_to_CLAY.csv
- config/catalog/iovars/p600/variable_l2r_factors/SEDM_to_SAND.csv
- config/catalog/iovars/p600/variable_l2r_factors/SEDM_to_SILT.csv
- config/seglists/all_P6.land
- config/seglists/all_P6.riv

*** P6 LAND-USE SPECIFIC ***

- config/catalog/iovars/p600/implnd
- config/catalog/iovars/p600/land_to_river
- config/catalog/iovars/p600/load_simulation
- config/catalog/iovars/p600/perlnd
- run_bhatt/fragments/set_landuse
- run/fragments/set_landuse
- code/src/lib/inc/land_use.inc [& re-compile (1) code/src/makebinarytransfer (2) code/src/lug (3) code/src/etm/etm_and_postproc (4) code/src/postproc/del/dfs (5) code/src/postproc/del/tfs (6) code/src/postproc/del/otherDF_delload (7) code/src/postproc/del/delload (8) code/src/calibration_utils/change_param/calib_iter/SEDMNT_wFourParameters]

*** BOTH LAND-SEGMENTS & LAND-USES ***

- input/scenario/land/spec_flags/p600/spec_flags.csv
- input/param/transport/QNPSas1s.csv
- code/src/etm/make_binary_transfer_coeffs/gettransport.f [900 to 1200]

*** UNRELATED ***

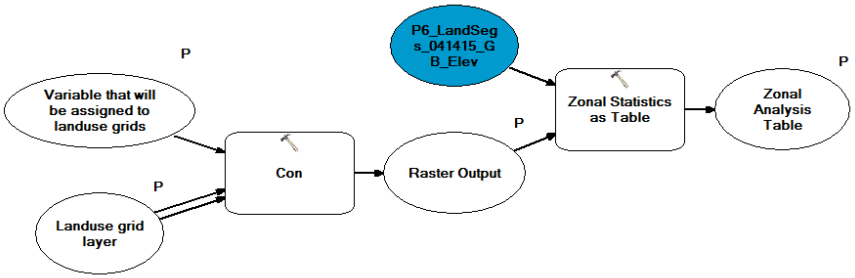
- config/catalog/modules/tables [updated VNN to VMN (manning's n) for consistency]
- input/param/transport/QNPSas1s.csv [flow, nitrogen, phosphorous, sediment as 1]

2.1 Hydrology Parameters

(a) geospatial parameters

- Phase-6 Landuses
  - Agriculture
    - Agriculture
      - Feeding Space
        - Non-Permitted Feeding Space (fnp)
      - Hay
        - Legume Hay (lhy)
        - Other Hay (ohy)
      - Other Ag
        - Ag Open Space (aop)
        - Farmstead (far)
      - Pasture
        - Pasture (pas)
      - *! Riparian Pasture*
        - *! Riparian Pasture Deposition (rpa)*
      - Row Crops
        - Grain without Manure (gom)
        - Grain with Manure (gwm)
        - Other Agronomic Crops (oac)
        - Specialty Crop High (sch)
        - Specialty Crop Low (scl)
        - Small Grains and Grains (sgg)
        - Small Grains and Soybeans (sgs)
        - Silage without Manure (som)
        - Full Season Soybeans (soy)
        - Silage with Manure (swm)
    - Regulated Agriculture
      - Feeding Space
        - Permitted Feeding Space (fsp)
  - Developed
    - Non-Regulated Stormwater
      - Extractive
        - Abandoned Mines (abn)
        - Active Mines (ext)
      - Impervious Developed
        - Non-Regulated Roads (nir)
        - Non-Regulated Buildings and Other (nnr)
      - Pervious Developed
        - Non-Regulated Tree Canopy (ntc)
        - Non-Regulated Turf Grass (ntg)
    - Regulated Stormwater
      - Construction
        - CSS Construction (ccn)
        - MS4 Construction (mcn)
      - Impervious Developed
        - CSS Roads (cir)
        - CSS Buildings and Other (cnr)
        - MS4 Roads (mir)
        - MS4 Buildings and Other (mnr)
      - Pervious Developed
        - CSS Tree Canopy (ctc)
        - CSS Turf Grass (ctg)
        - MS4 Tree Canopy (mtc)
        - MS4 Turf Grass (mtg)
  - Natural
    - Forest
      - Forest
        - Disturbed Forest (dfr)
        - Forest (for)
        - Harvested Forest (hfr)
      - Open Space
        - Open Space (osp)
      - Wetland
        - Floodplain Wetland (fwt)
        - Headwater Wetland (hwt)
        - Tidal Emergent Wetland (twt)
    - Non-Tidal Water Deposition
      - Non-Tidal Water Deposition
        - Water (wat)
  - Point Source
    - ! Wastewater
      - ! Wastewater
        - *! Industrial (ind)*
        - *! Municipal (mun)*
    - ! Wastewater CSO
      - ! Wastewater CSO
        - *! Combined Sewer Overflow (cso)*
  - Septic
    - ! Septic
      - ! Septic
        - *! Septic-30 (s30)*
        - *! Septic-40 (s40)*
        - *! Septic-50 (s50)*
        - *! Septic-80 (s80)*

geospatial data processing



(a) geospatial parameters

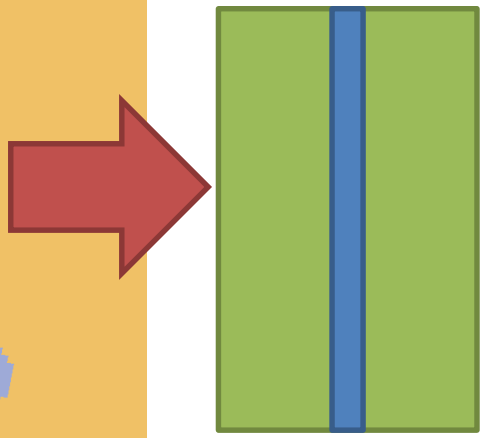
Raw Geospatial Data:
10-meter land cover marks
10-meter digital elevation

Derived Geospatial Data:
Slope
Length of flow plane

elevation

slope of flow plane

*length of flow plane**



**λ = A/2L*

2.1 Hydrology Parameters

(b) other parameters

forest
harvested forest
disturbed forest
other forest

impervious developed
pervious developed

feeding space
hay
other ag
pasture
row crops

2.1 Hydrology Parameters

(b) other parameters

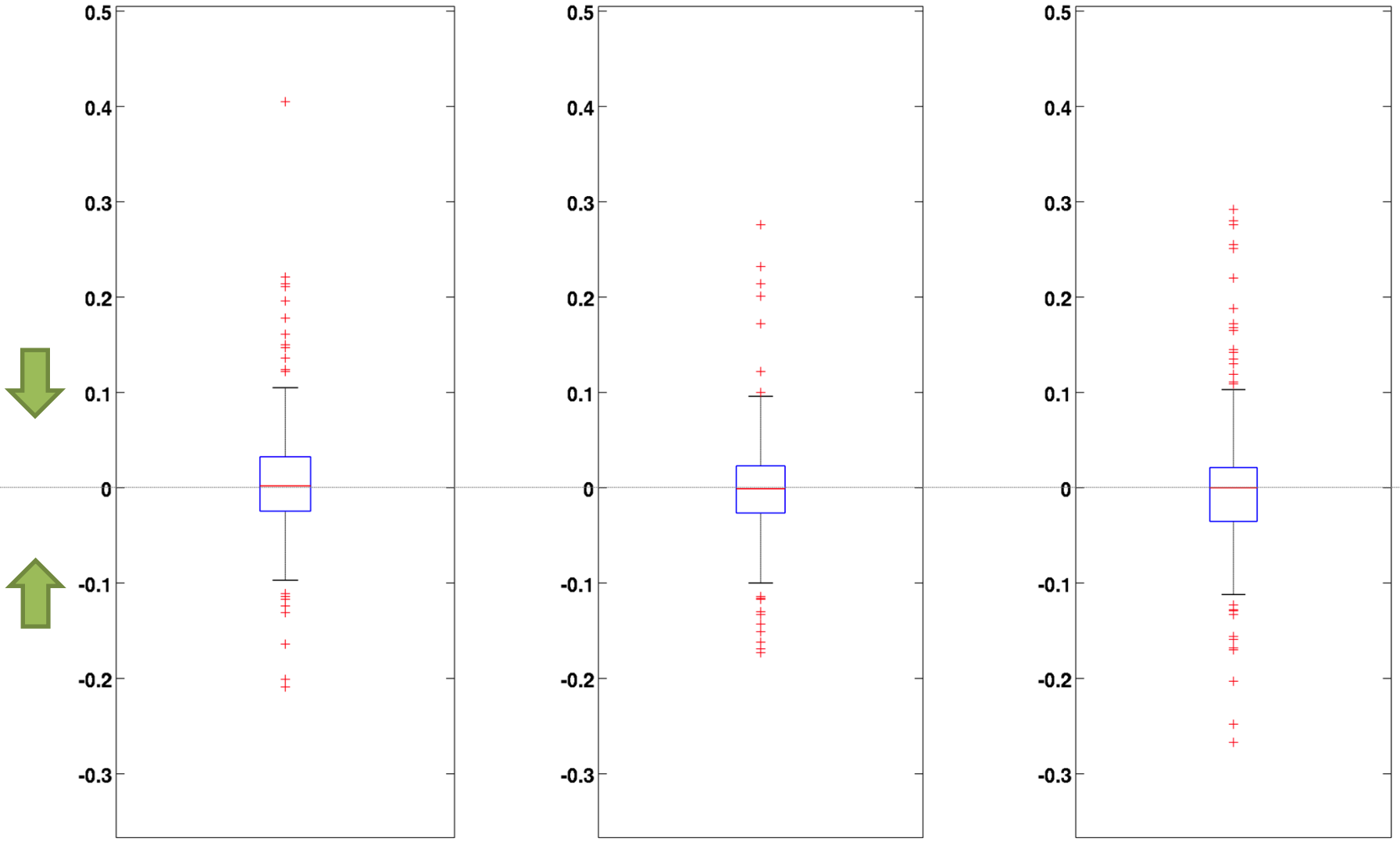
Parameter	INTFW	INFILT	AGWETP	UZSN
for	1.25	1.6	6	0.12
hvf	1	1.3	3	0.1
pas	1	1.5	1.5	0.1
npa	1	1.5	1.5	0.1
alf	1	1.5	1	0.12
nal	1	1.5	1	0.12
hyw	1	1.5	1	0.12
nhy	1	1.5	1	0.12
hyo	1	1.5	1	0.12
hwm	1	1	1	0.14
hom	1	1	1	0.14
nhi	1	1	1	0.14
nho	1	1	1	0.14
lwm	1	1.5	1	0.14
nlo	1	1.5	1	0.14
rpd	1	0.8	2	0.1
cpd	1	0.8	2	0.1
npd	1	0.8	2	0.1
trp	1	0.8	0.1	0.07
urs	1	0.8	0.1	0.07
rex	0.7	0.8	0.1	0.08
nex	0.7	0.8	0.1	0.08
cex	0.7	0.8	0.1	0.08
rcn	0.5	0.7	0.1	0.08
ccn	0.5	0.7	0.1	0.08

Phase 5

Parameter	INTFW	INFILT	AGWETP	UZSN
for	1.25	1.6	6	0.12
fwt	1	1.6	6	0.12
hwt	1	1.6	6	0.12
twt	1	1.6	6	0.12
dfr	1	1.5	5	0.11
hfr	1	1.3	3	0.1
osp	1	1.5	1	0.1
pas	1	1.5	1.5	0.1
lhy	1	1.5	1.5	0.1
ohy	1	1.5	1.5	0.1
gom	1	1	1	0.14
gwm	1	1	1	0.14
oac	1	1	1	0.14
sch	1	1	1	0.14
scl	1	1	1	0.14
sgg	1	1	1	0.14
sgs	1	1	1	0.14
som	1	1	1	0.14
soy	1	1	1	0.14
swm	1	1	1	0.14
aop	0.9	0.9	2	0.1
far	0.9	0.9	2	0.1
abn	0.9	0.9	2	0.1
ext	0.9	0.9	2	0.1
ctc	0.7	0.8	2	0.1
ctg	0.7	0.8	2	0.1
mtc	0.7	0.8	0.1	0.08
mtg	0.7	0.8	0.1	0.08
ntc	0.7	0.7	0.1	0.08
ntg	0.7	0.7	0.1	0.08
ccn	0.5	0.7	0.1	0.07
mcn	0.5	0.7	0.1	0.07

Phase 6

Model Bias at 191 Calibration Stations



Phase 5 [1985-2005]

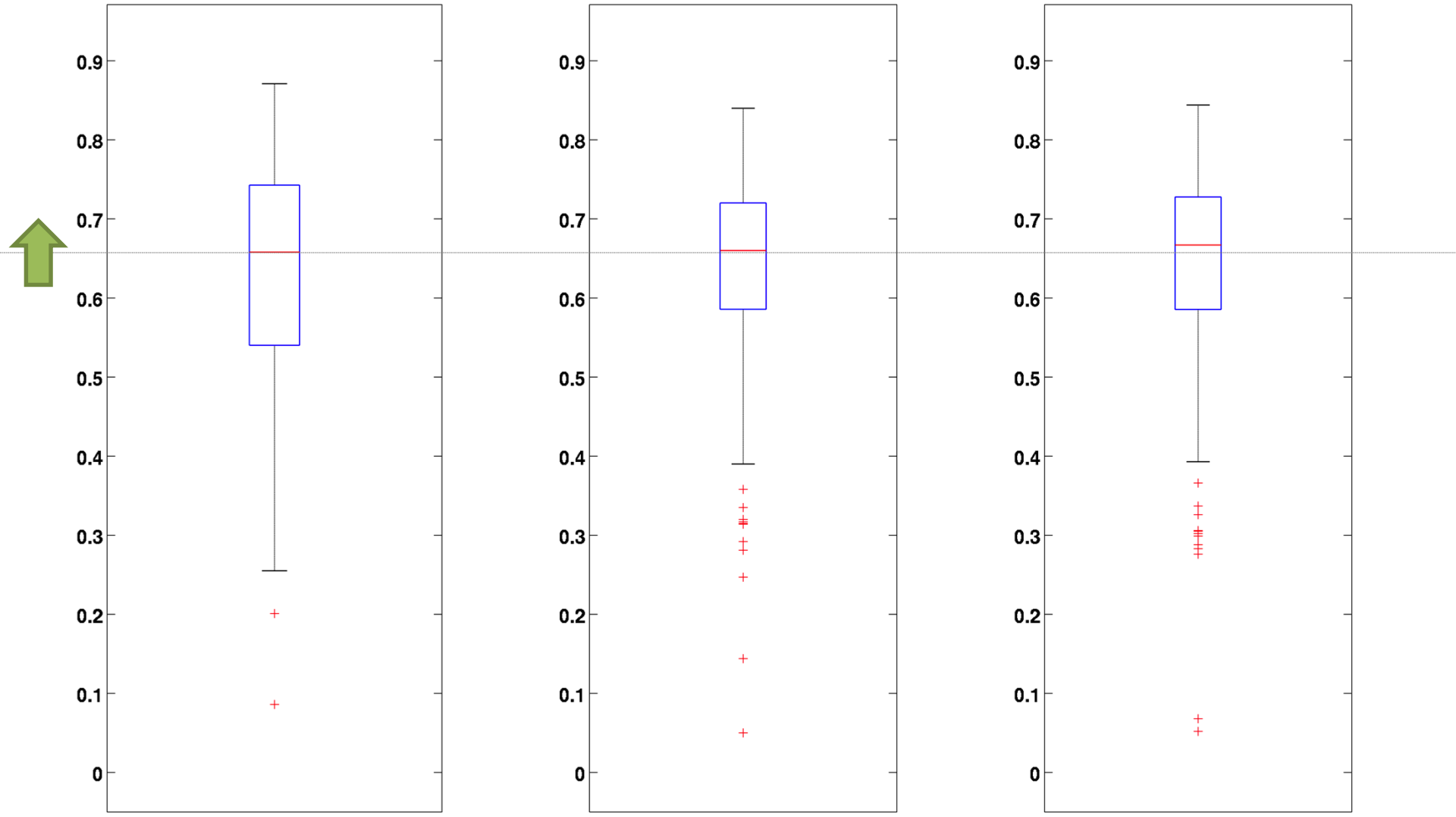
Phase 6 [1985-2014]
{precipitation and meteorology}

Phase 6 [1985-2014]
{P6 land segments and landuse}*

2.2 Hydrology Calibration

* provisional land-use acres

Nash-Sutcliffe Efficiency at 191 Calibration Stations



Phase 5 [1985-2005]

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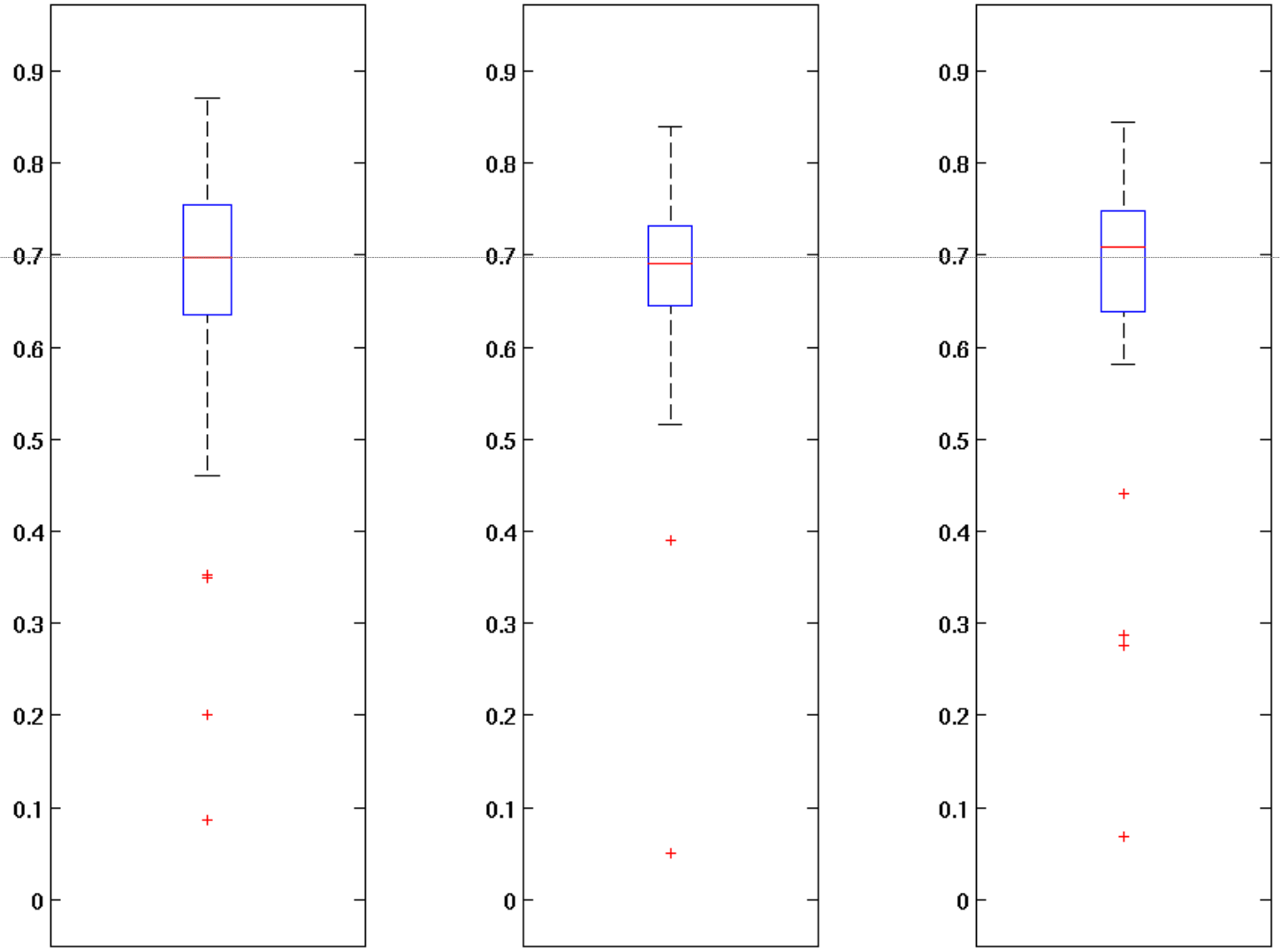
{P6 land segments and landuse}*

2.2 Hydrology Calibration

* provisional land-use acres

Nash-Sutcliffe Efficiency at Susquehanna (73 stations)



Phase 5 [1985-2005]

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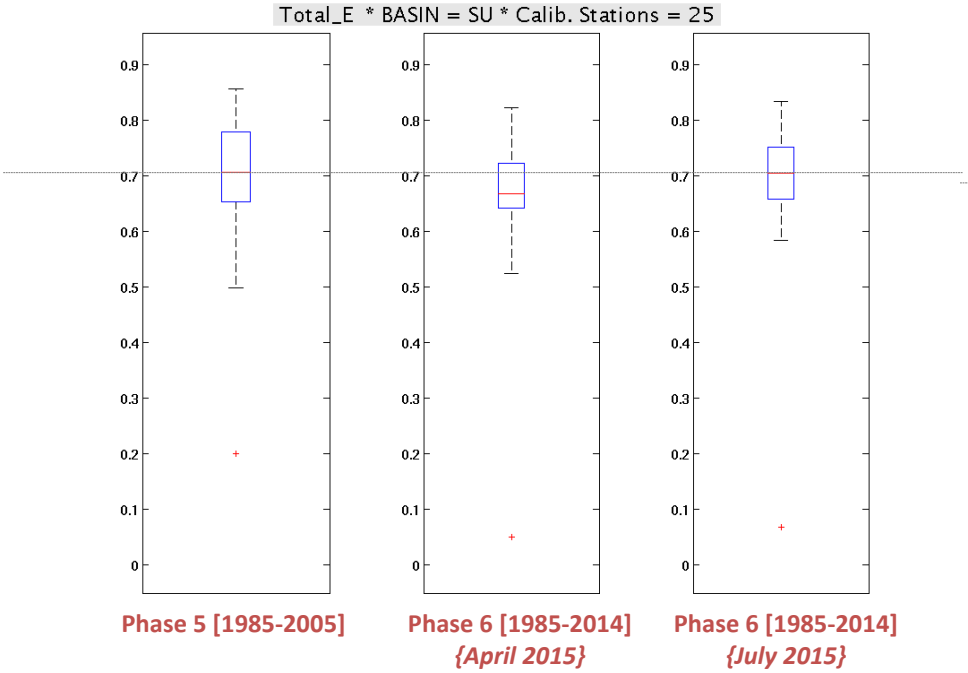
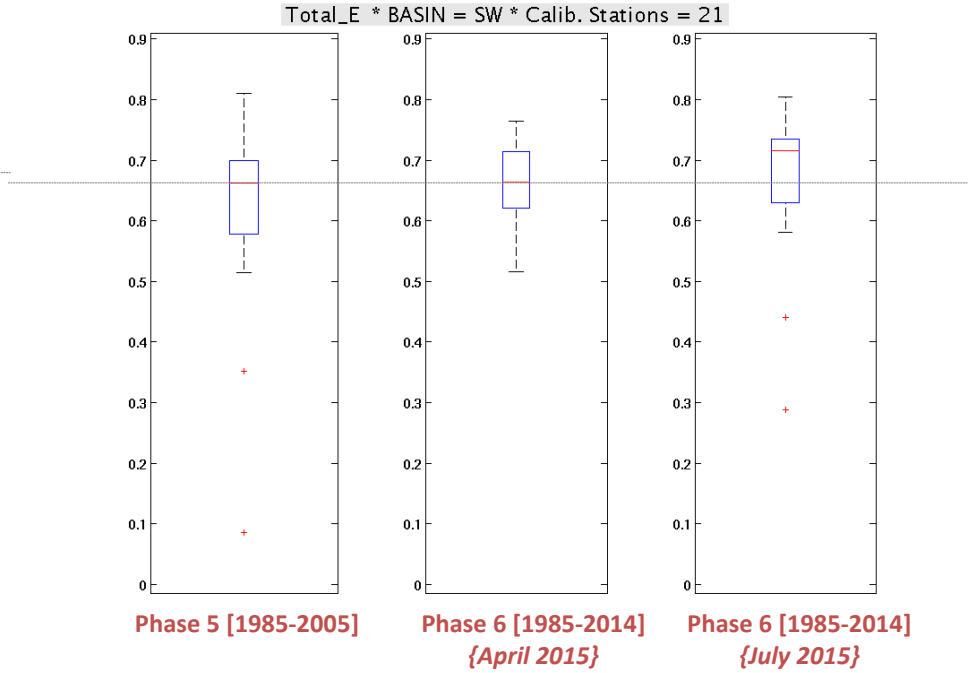
2.2 Hydrology Calibration



Phase 5 [1985-2005] | Phase 6 [1985-2014] *{April 2015}* | Phase 6 [1985-2014] *{July 2015}*



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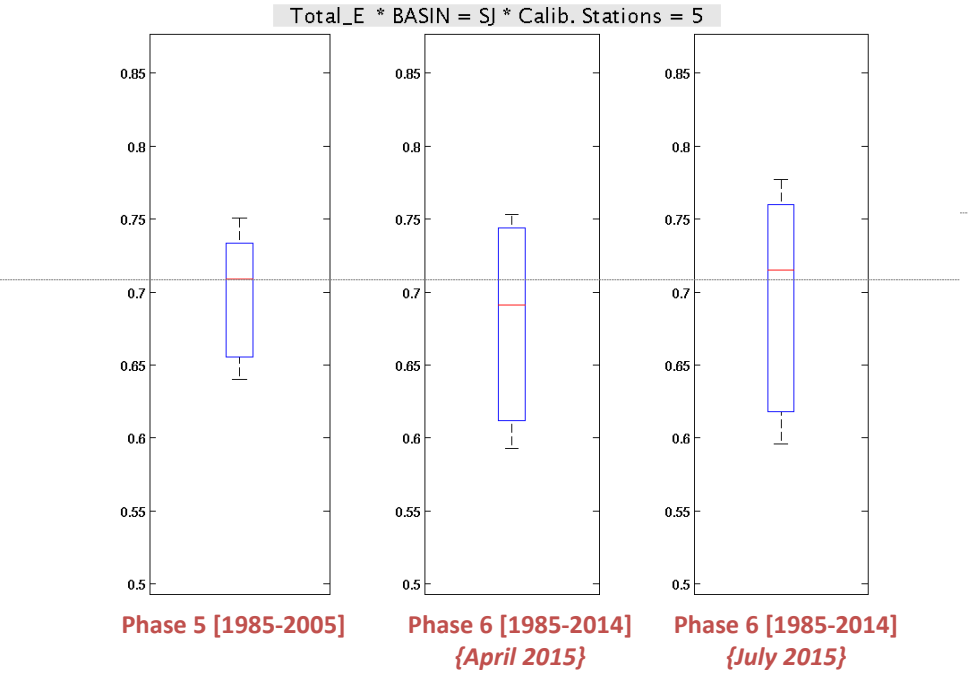

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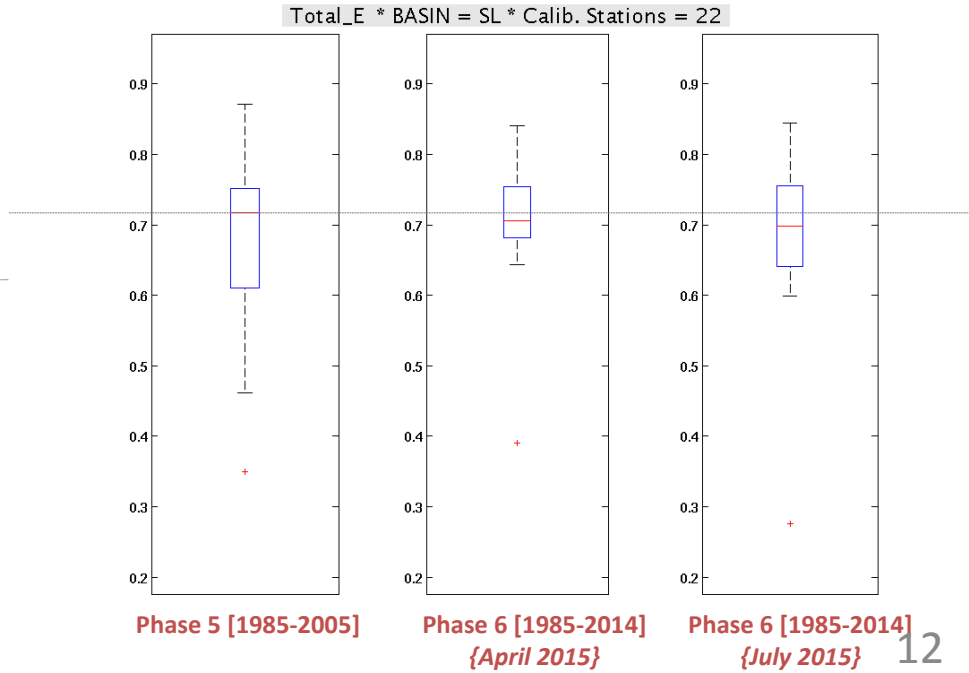
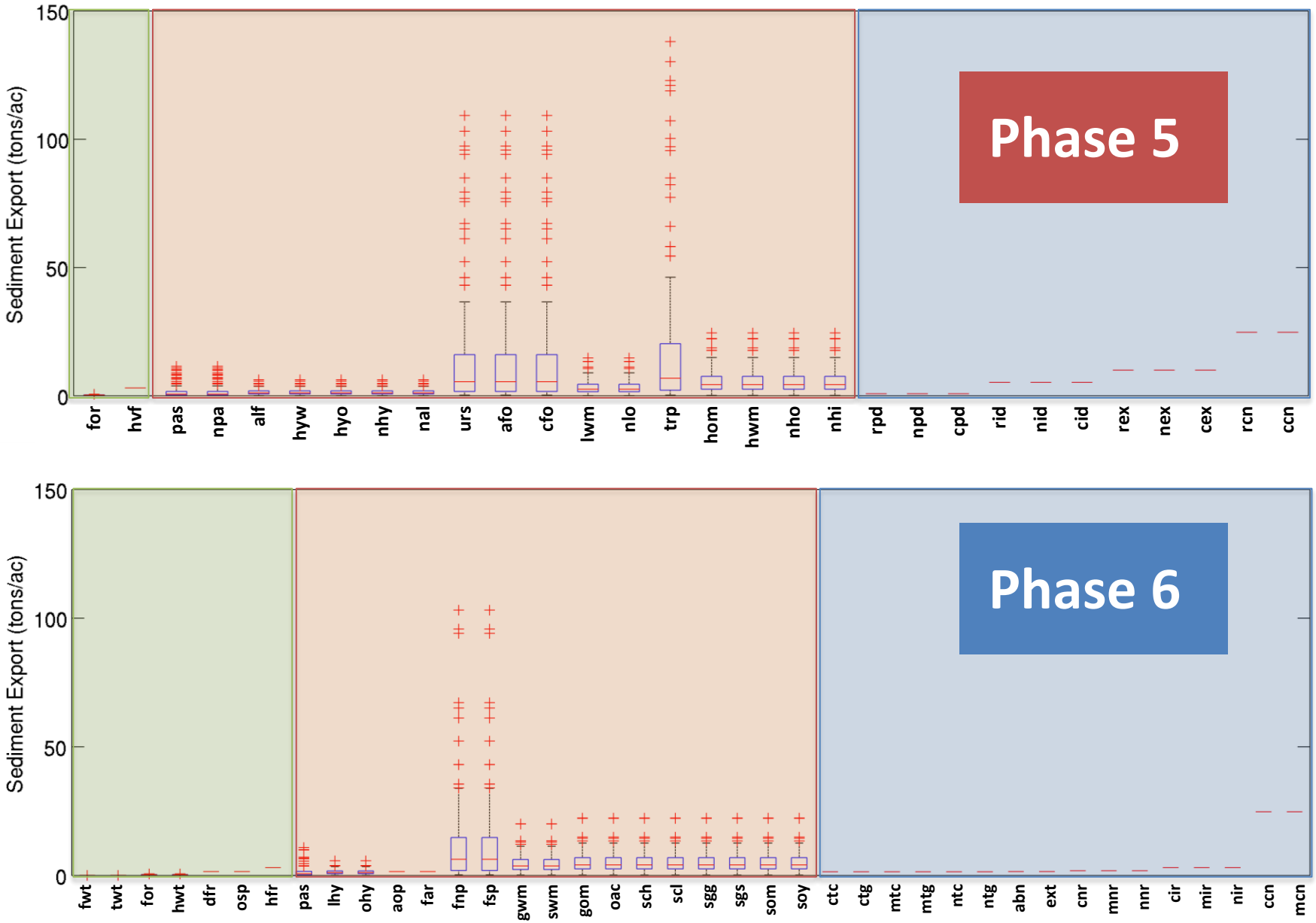
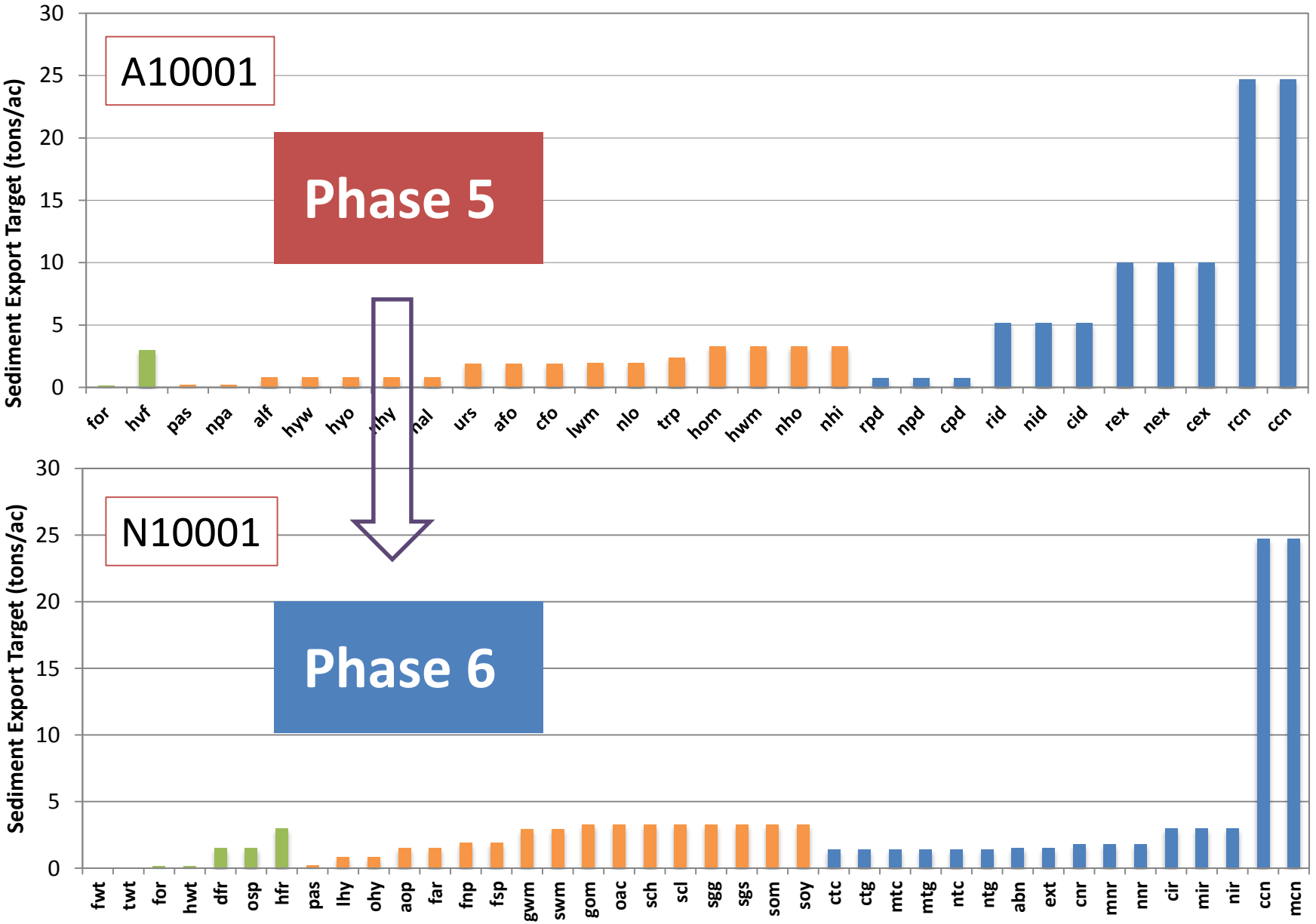


Phase 5 [1985-2005] | Phase 6 [1985-2014] *{April 2015}* | Phase 6 [1985-2014] *{July 2015}*

3.1 Land-use Sediment Export Targets

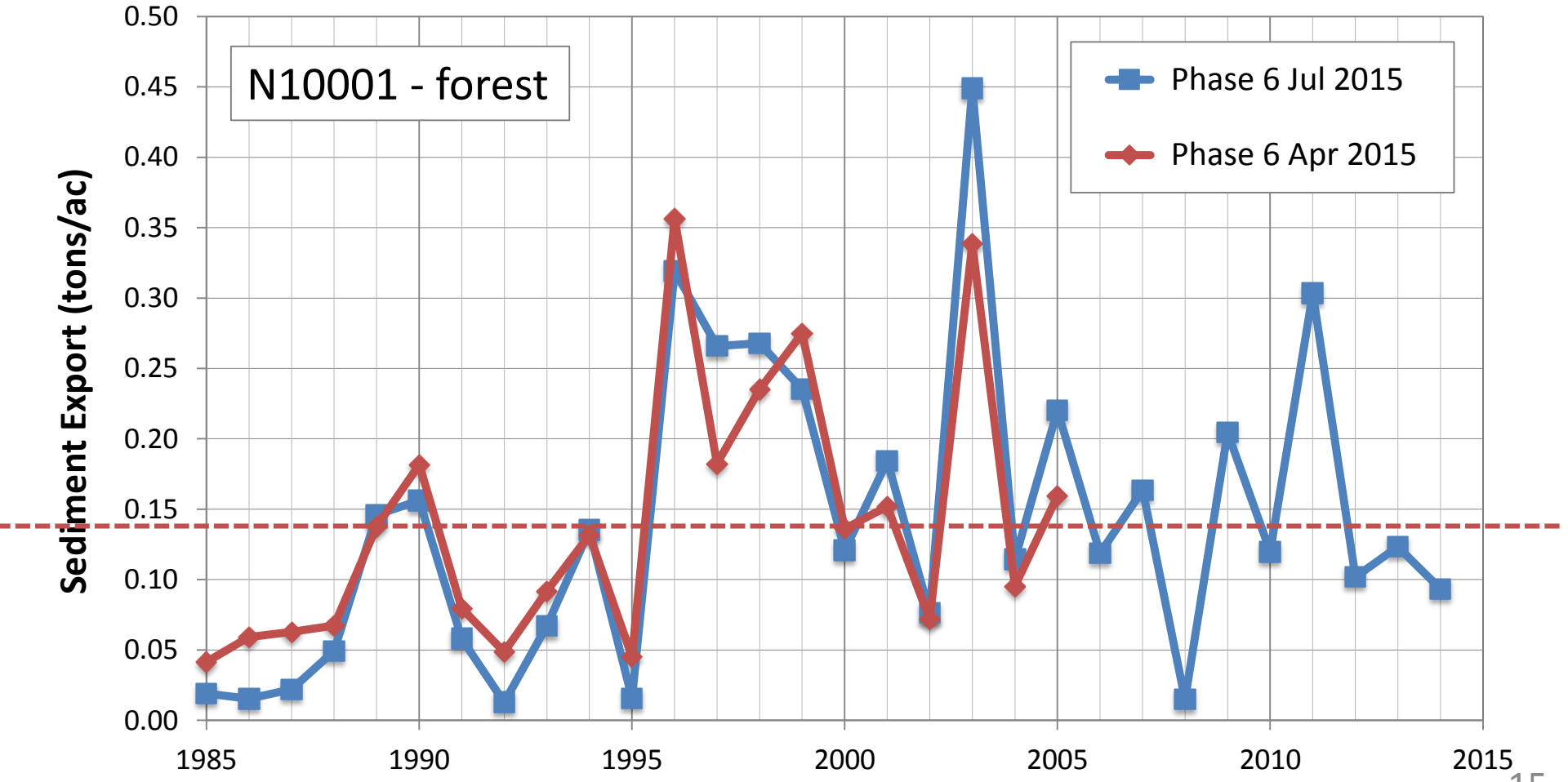


3.1 Land-use Sediment Export Targets



3.2 Land-use Sediment Calibration

- Out of 9400 (235x40) land-segment x land-use pairs, 10 (< 0.1%) had sediment wash-off deficit.



4.1 Water Temperature Parameterization

- An empirical transfer function for estimating monthly groundwater temperature from monthly ground surface temperature:

Kurylyk et al. 2013

$$GWT = MAGST + D' \left\{ GST_{i-L} - MAGST \right\} + B$$

GWT *is groundwater temperature for month* i *in* C

$MAGST$ *is average of monthly GST temperature*

GST *is the GST for month* $(i - L)$ *in* C

D ~ *damping effect of subsurface termal diffusivity*

L ~ *lag parameter* (*months*)

B ~ *accounts for shallow heat transfer*

4.1 Water Temperature Parameterization

- Kurylyk et al. 2013 used this equation for estimating future ground temperatures from global climate model projected air temperatures.

$$GWT = MAGST + D' \left\{ GST_{i-L} - MAGST \right\} + B$$

SURFACE	
Depth	**0.1 m**
D	0.963
L	0
B	2 °F

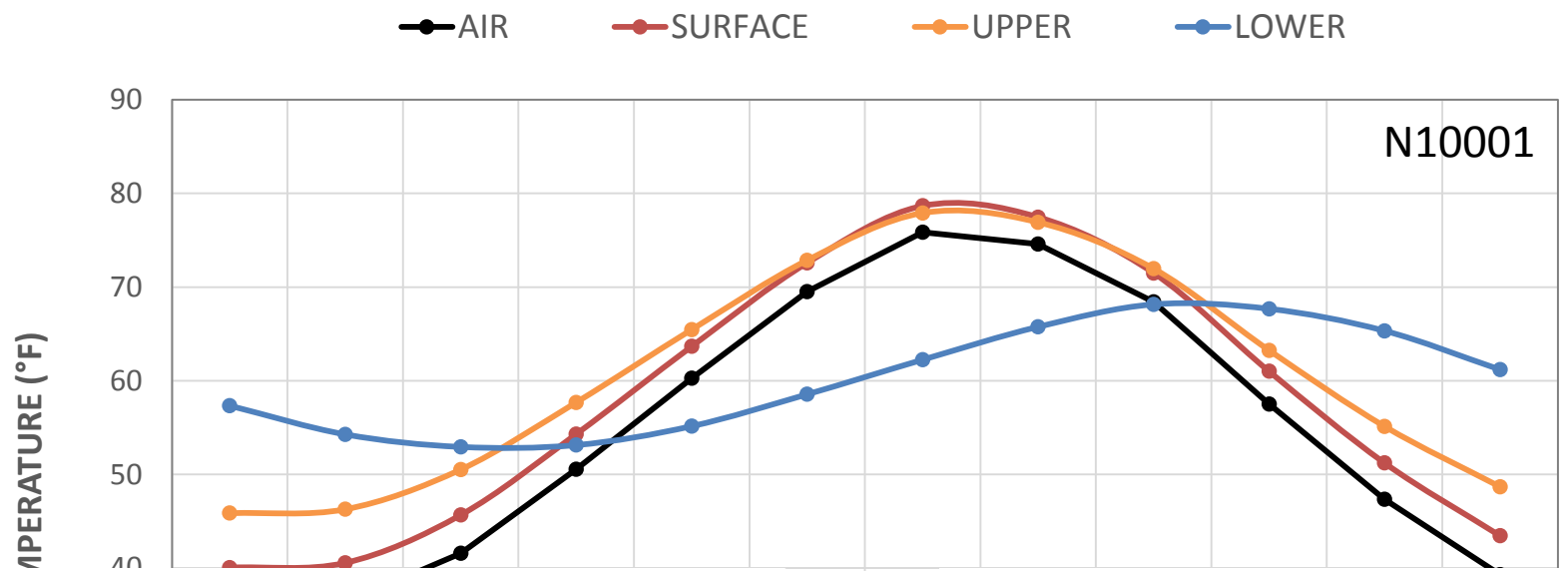
UPPER	
Depth	**0.5 m**
D	0.830
L	0
B	1.5 °F

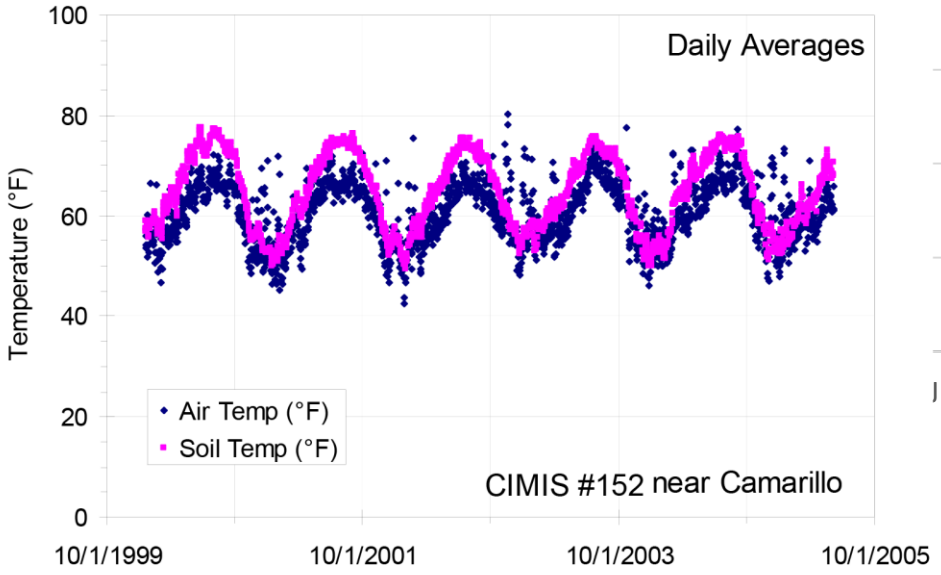
LOWER	
Depth	**2.5 m**
D	0.394
L	2
B	1 °F

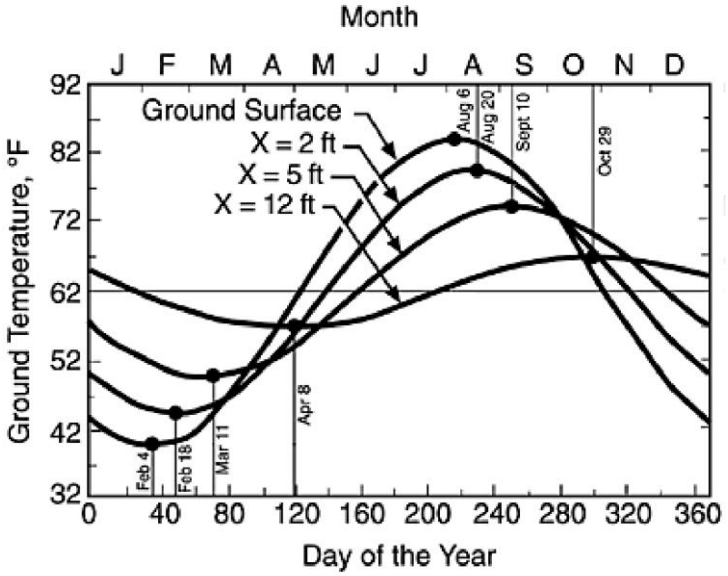
$$D = EXP\,[-3.724 \times Depth]$$

$$L = 0.6504 \times Depth$$

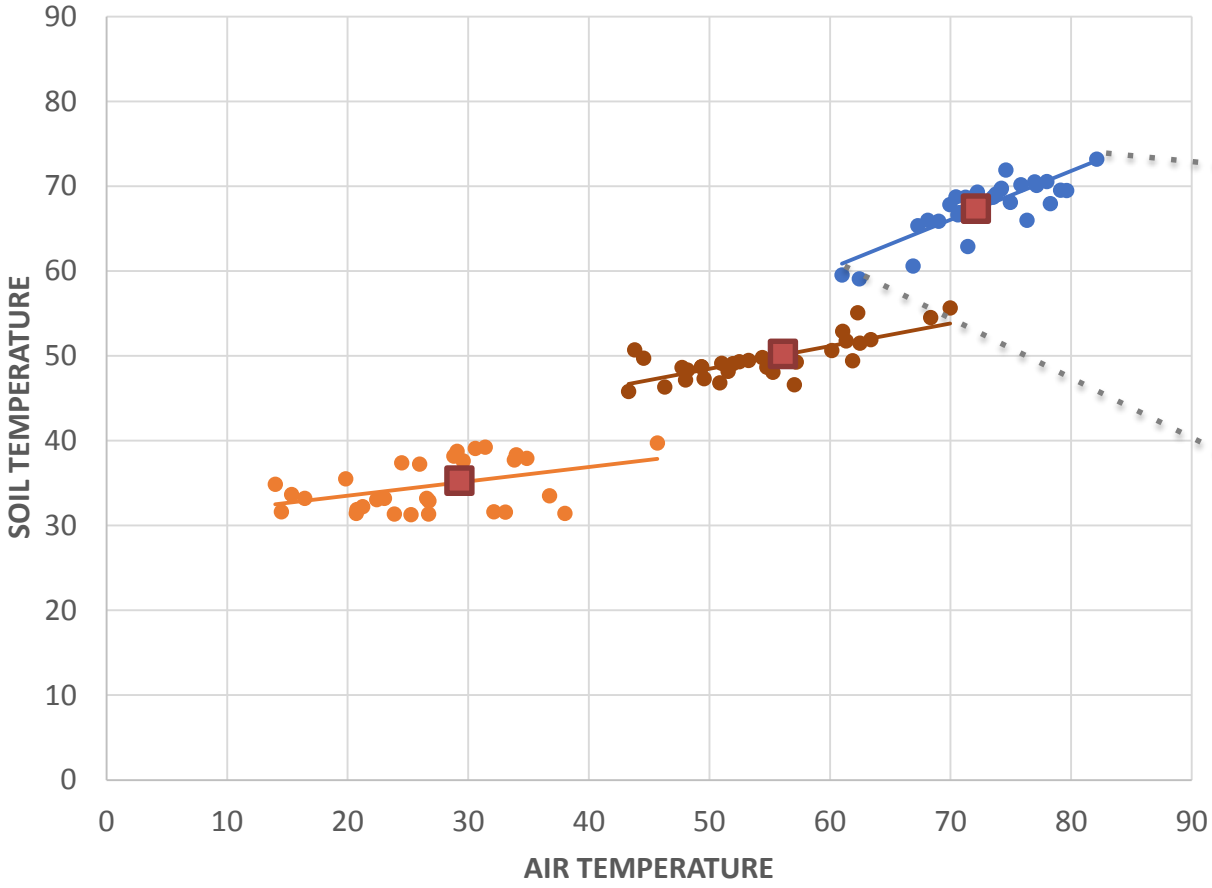
4.1 Water Temperature Parameterization







4.1 Water Temperature Parameterization (Slope & Intercept)



$$Slope = \frac{\Delta\ Soil\ Temperature}{\Delta\ Air\ Temperature}$$

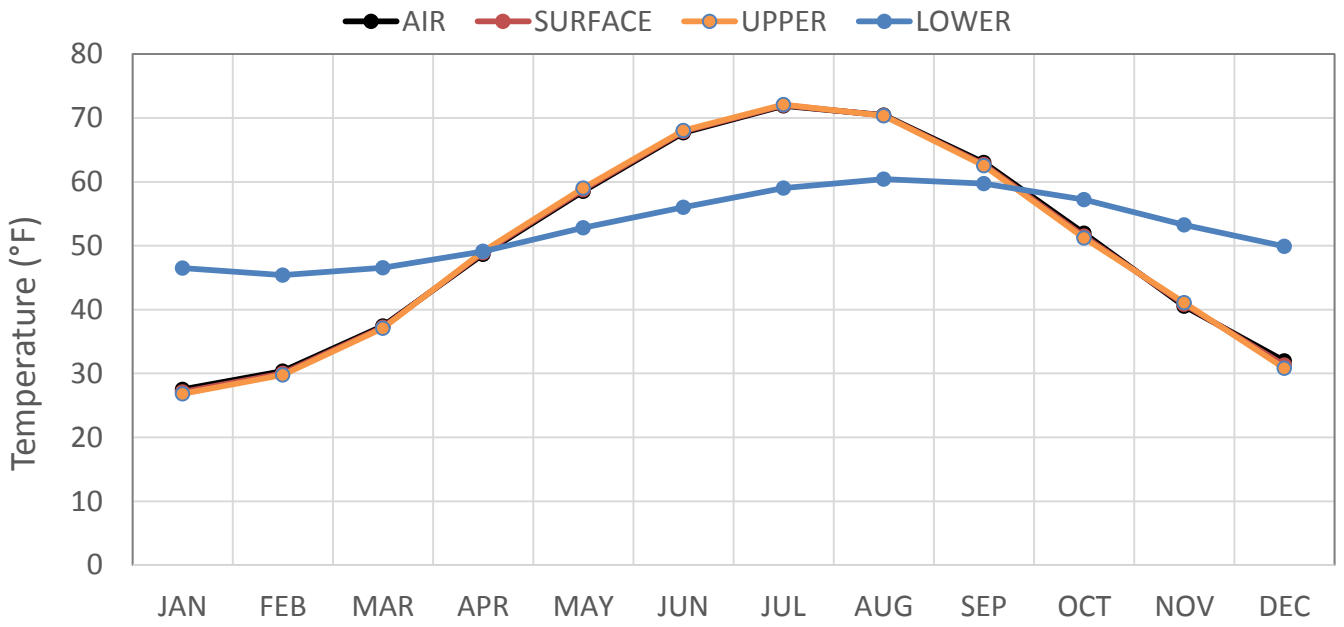
Δ hourly soil temperature was estimated as $2 \times \Delta$ monthly soil temperature

Δ hourly air temperature was calculated from the air temperature time series

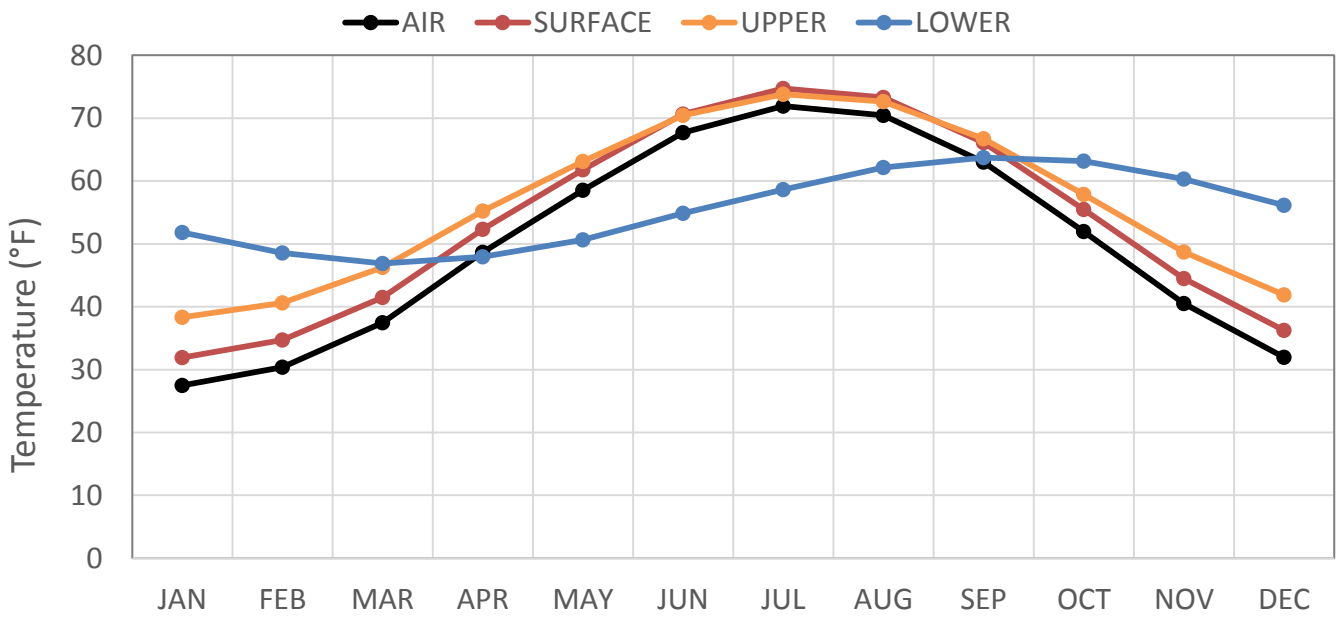
the intercept was calculated from slope and a known point (the monthly average)

4.1 Water Temperature Parameterization

Phase 5

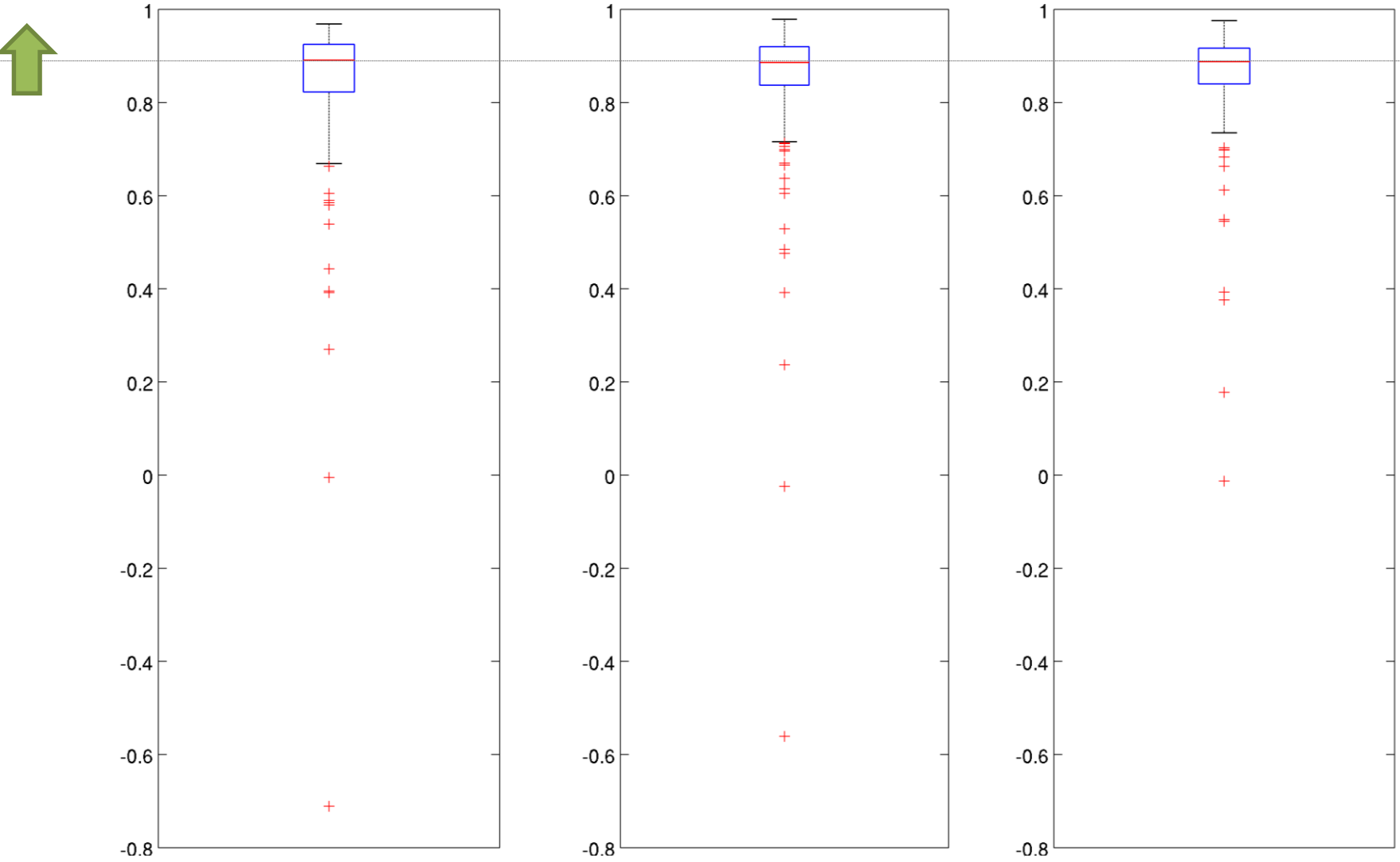


Phase 6



4.2 Water Temperature Calibration

Nash-Sutcliffe Efficiency at 209 Calibration Stations



Phase 5 [1985-2005]

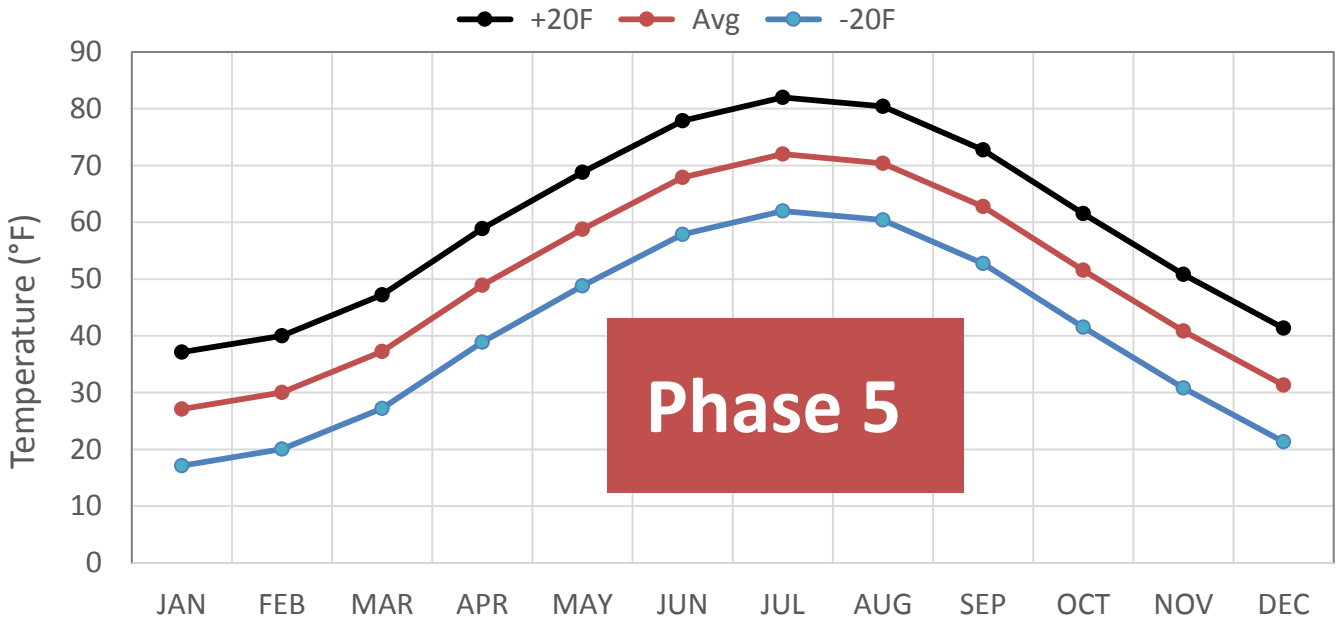
Phase 6 [1985-2014]
{precipitation and meteorology}

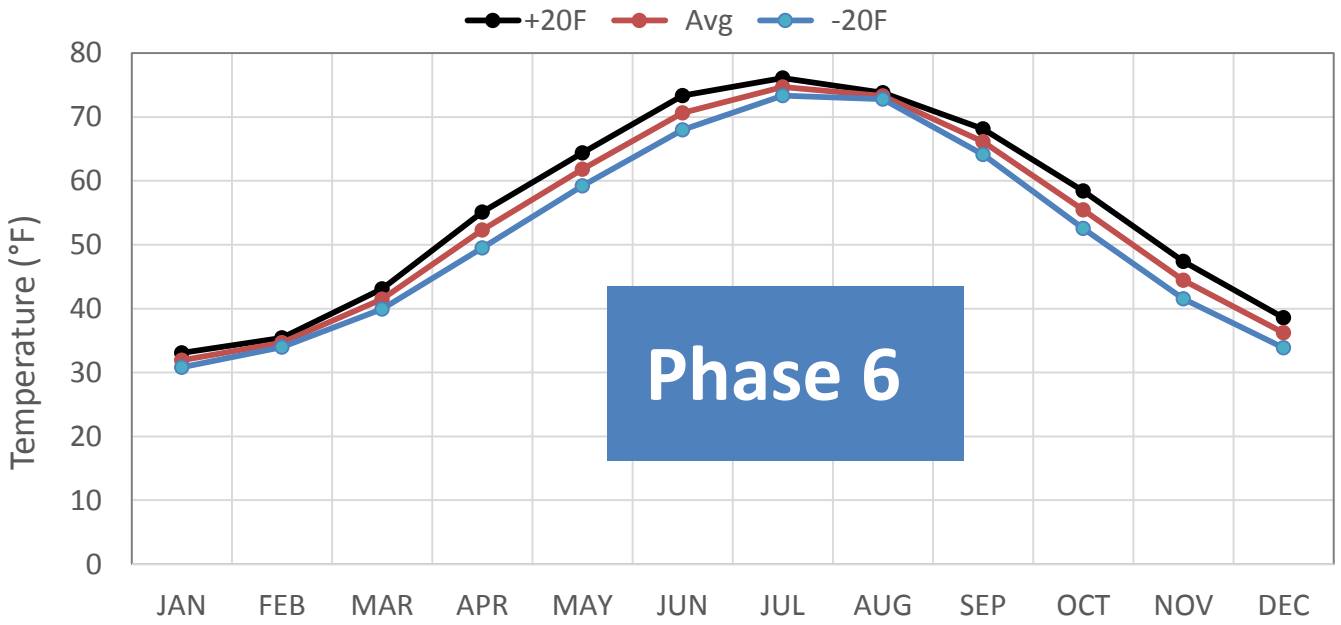
Phase 6 [1985-2014]
{P6 land segments and landuse}*

Next Steps …

- Nutrient calibration
  - estimate atmospheric deposition
  - land-use export targets (provisional)
  - refinements to the incorporation of lag-time estimates
- River calibration
  - point source data
  - new methodology for simulating effects of BMPs
  - incorporation of revised expanded water quality observations
  - revised L2W variances and S2R factors
- Sensitivities
  - minor updates to the code and sensitivity tables

Estimated response of average monthly surface temperature





Estimated response of average monthly soil temperature