Intercomparison of modeled and observed net ecosystem productivity during drought

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Carbon and Water in the Earth System

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Motivation

- Model development never finished
- Site-years spatially and temporally coincident with 2 large-scale drought events in North America
- Leverage unique data product: 44 tower sites, ≈ 225 site-years, 10 biomes, 22 terrestrial biosphere models
- Model performance as *f*(various factors)

Model validation analyses

Compare simulated and observed monthly mean NEP (<u>non-gap-filled data only</u>)

- Taylor diagrams (ρ, σ, RMSE)
- Predictive skill [bound by zero and unity]:
  1) NEP_{obs} ± 2 SE overlap NEP_{sim} ± 2 RMSE
  2) ρ ≥ 0.2
  3) Relative RMSE ≤ 1 (=RMSE/mean NEE_{obs})

NEP_{obs} = monthly mean observed NEP
NEP_{sim} = monthly mean simulated NEP
SE = standard error
RMSE = Root mean square error
ρ = correlation between NEP_{obs} and NEP_{sim}

Overall predictive skill

Predictive skill across all biomes by drought level and climatic season

Climatic season	Dry	Normal	Wet	Overall
Winter	0.42	0.49	0.47	0.47
Spring	0.27	0.35	0.22	0.31
Summer	0.45	0.54	0.42	0.49
Fall	0.28	0.30	0.33	0.30
Overall	0.35	0.42	0.36	0.39

Predictive skill by biome

Code	Description	Overall
CRO	cropland	0.37
DBF	grassland	0.36
ENFB	evergreen needleleaf forest – boreal climatic zone	0.41
ENFT	evergreen needleleaf forest – temperate climatic zone	0.59
GRA	grassland	0.30
MF	mixed (deciduous/evergreen) forest	0.38
SHR	shrubland	0.04
WET	wetland	0.26
WSA	woody savanna	0.22
Overall	all sites (n = 26747 months)	0.39

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39% of all model-data pairs showed predictive skill

Overall model performance was poor

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Only normal moisture regime in climatic summer group shows > 50%

Abnormally wet conditions in spring

Drought indexed to 3-month SPI:
Dry < -0.8
Wet > +0.8
Otherwise Normal

Overall predictive skill

Biome rankings:

ENFT > ENFB, MF, DBF, CRO > GRA, WET, WSA > SHR

Forested biomes > Non-forested biomes

Overall	0.35	0.42	0.36	0.39

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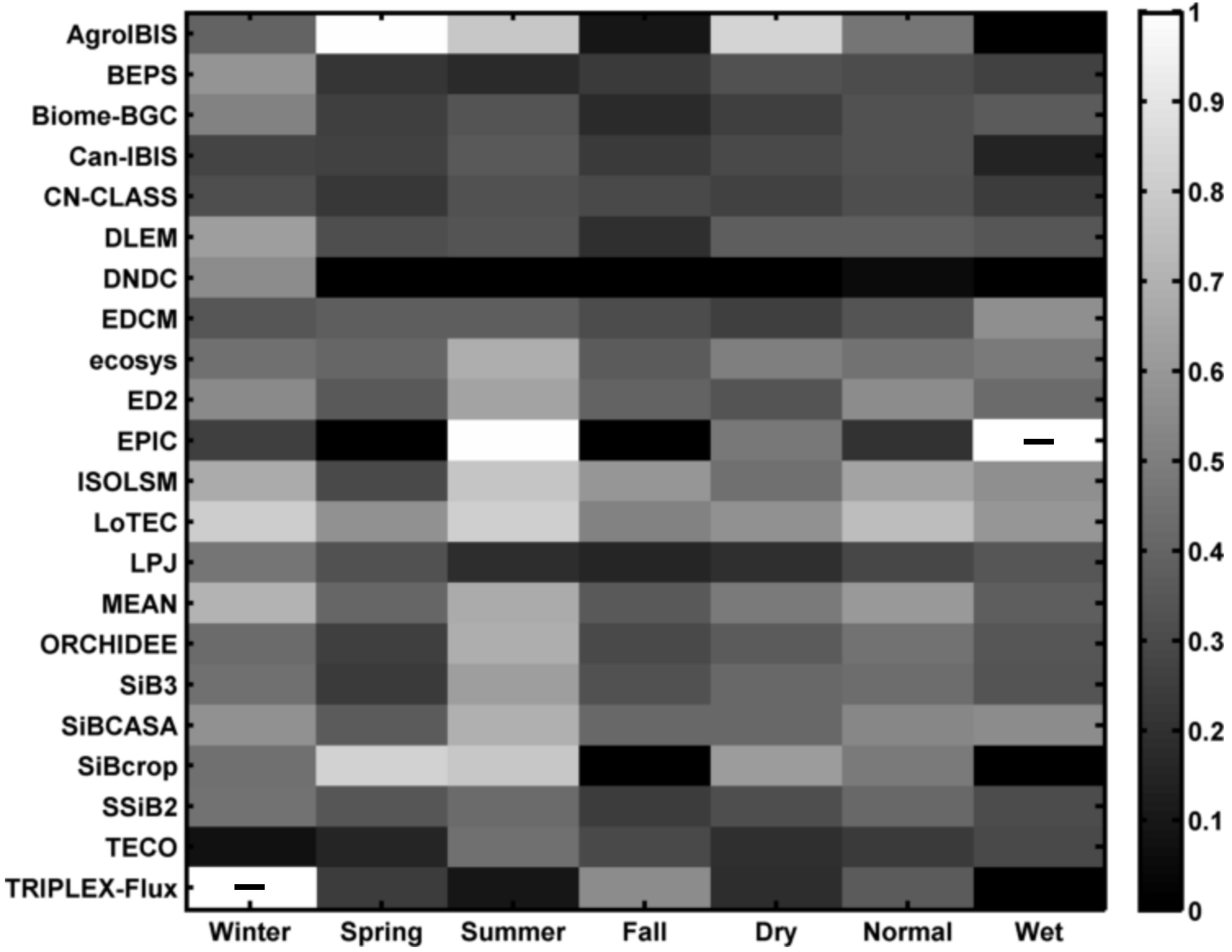
Only biome [ENF in temperate climate] with > 50%

Worst biome: SHR

Predictive skill by model, climactic season, and drought level



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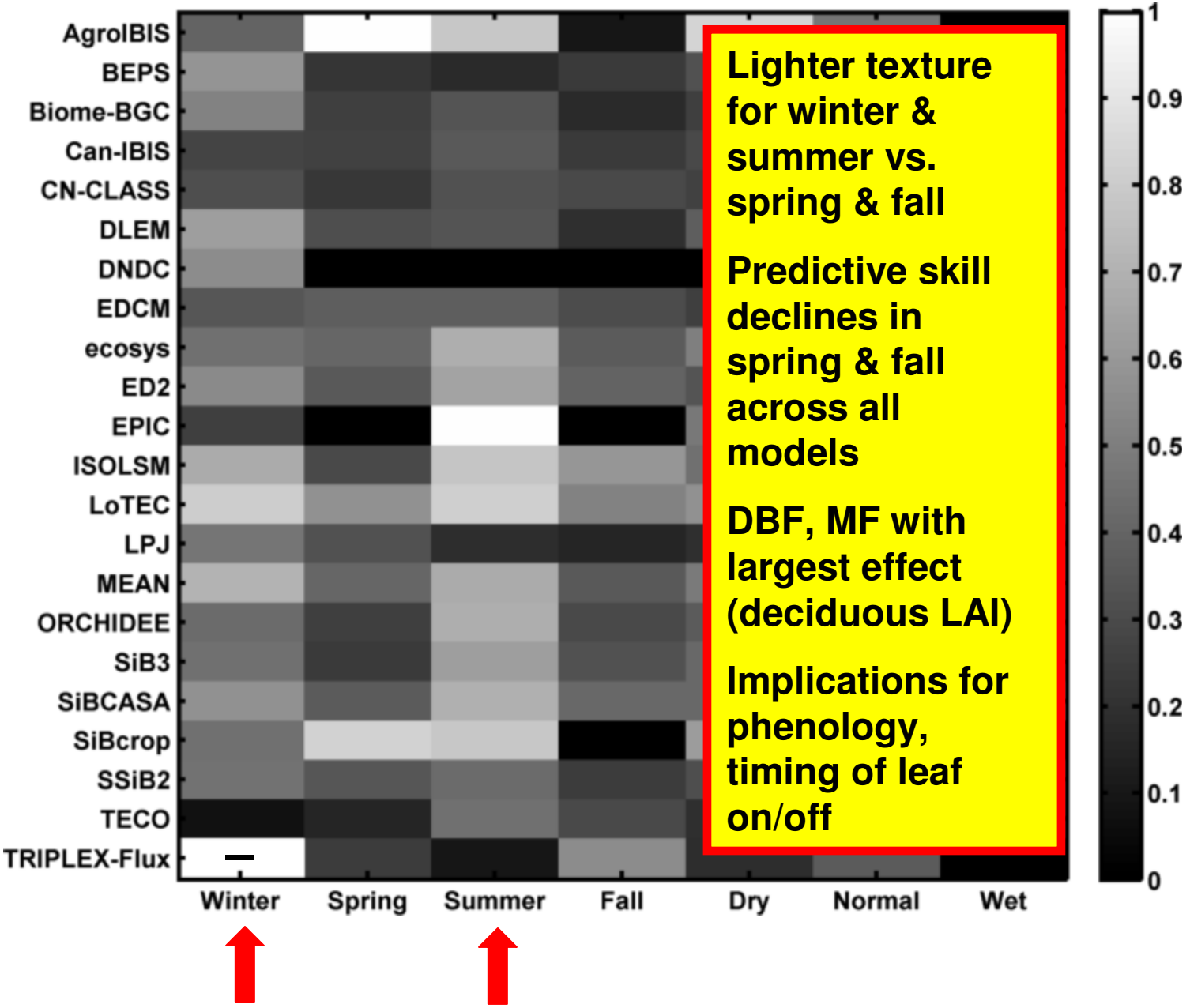

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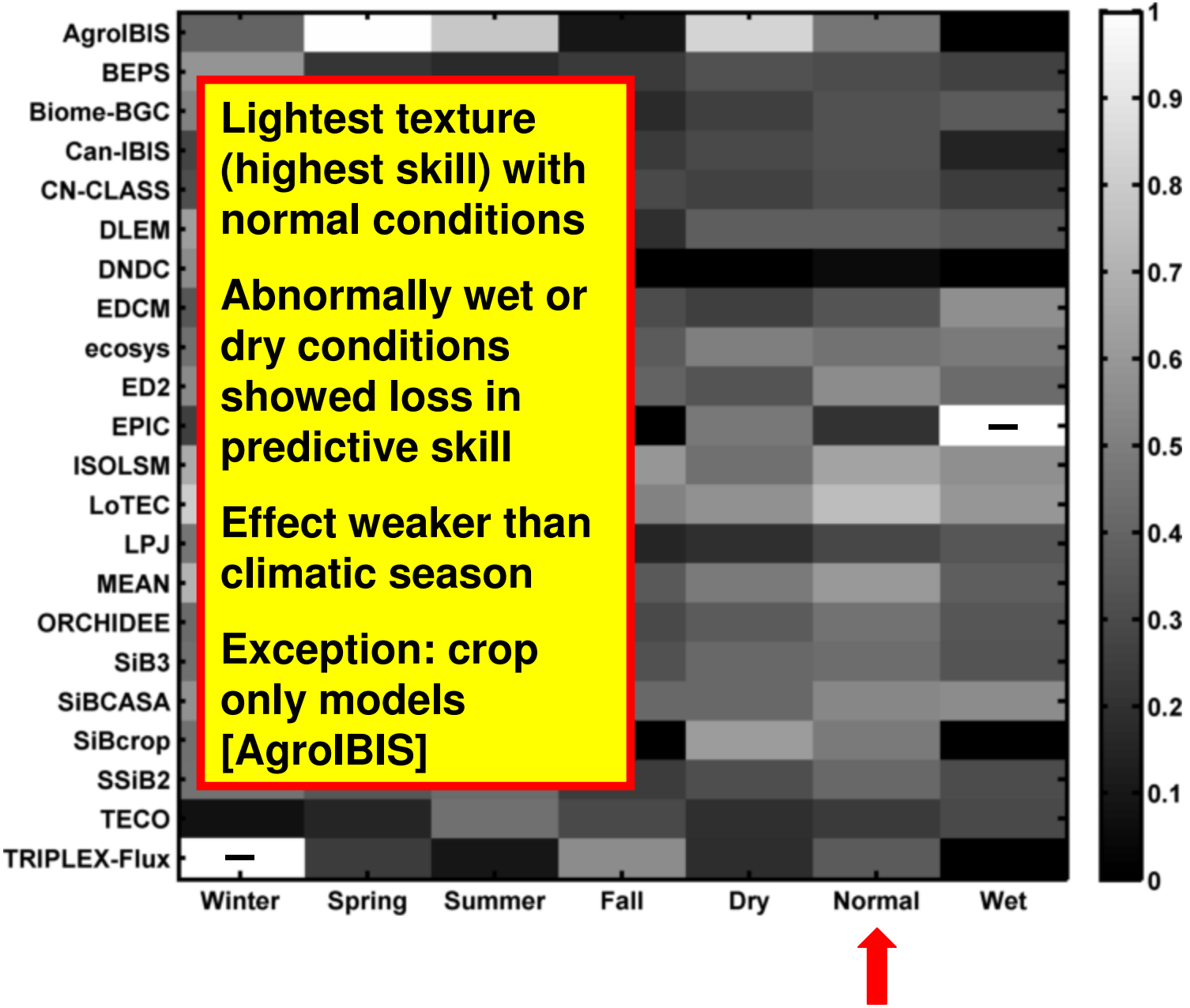

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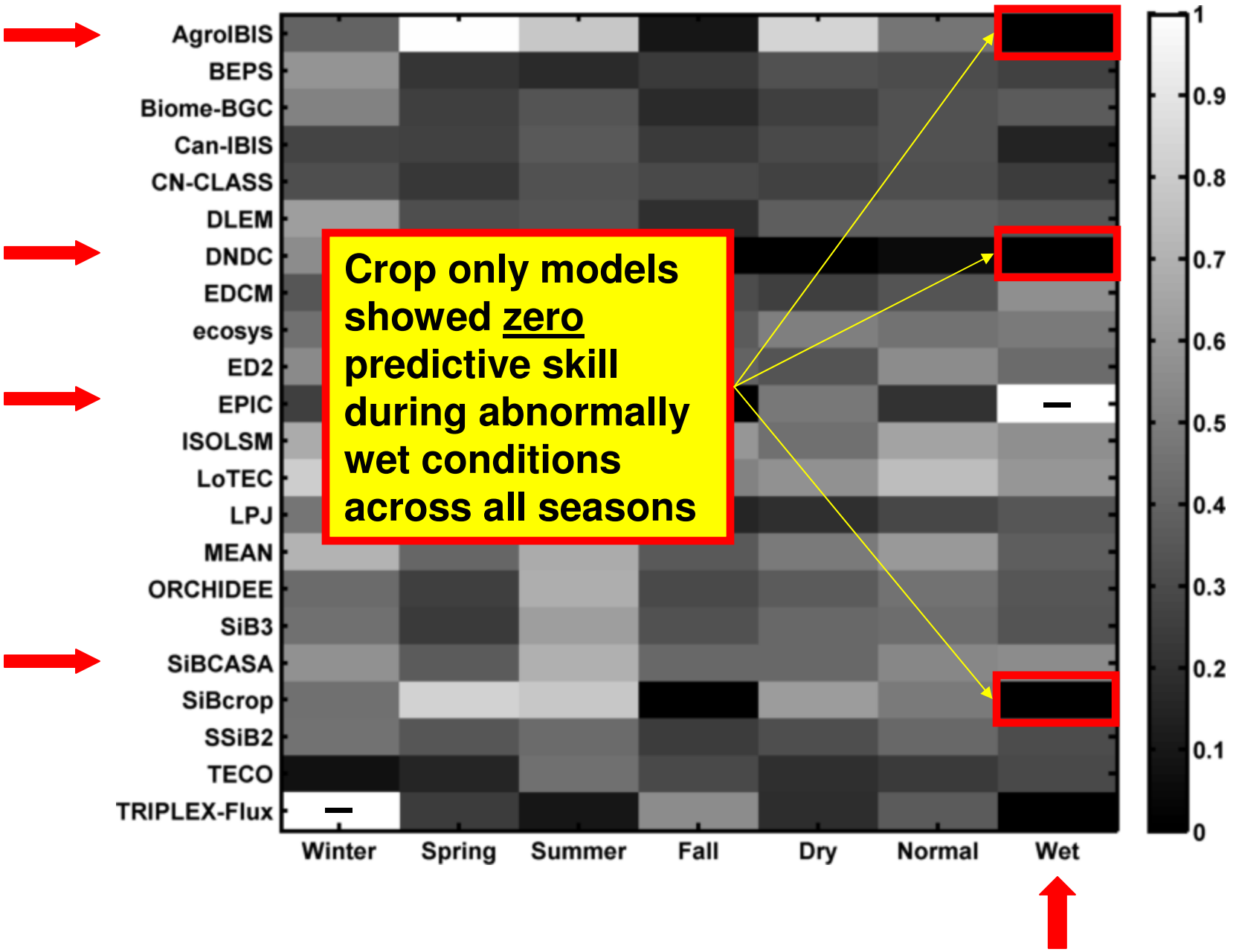
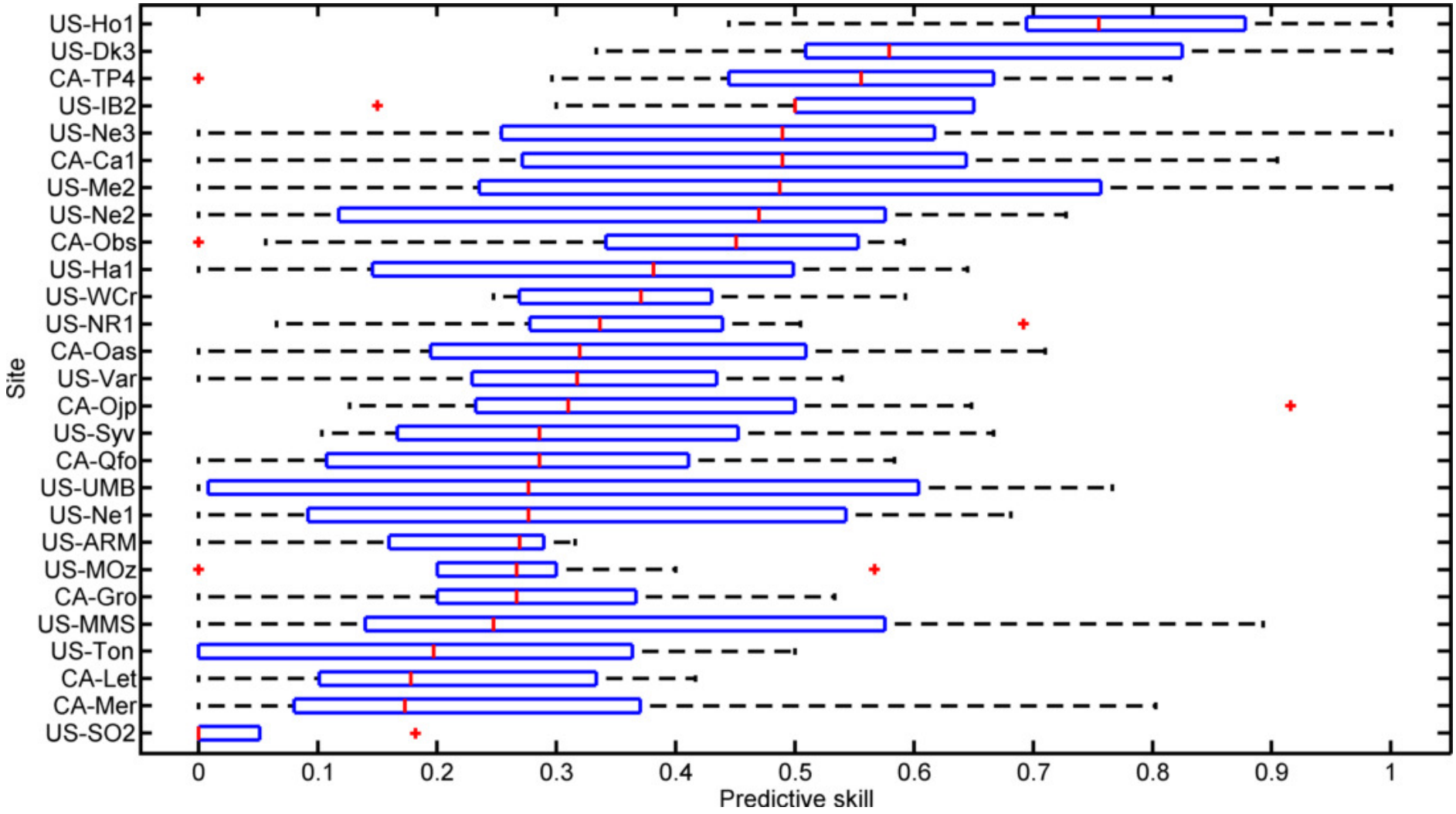
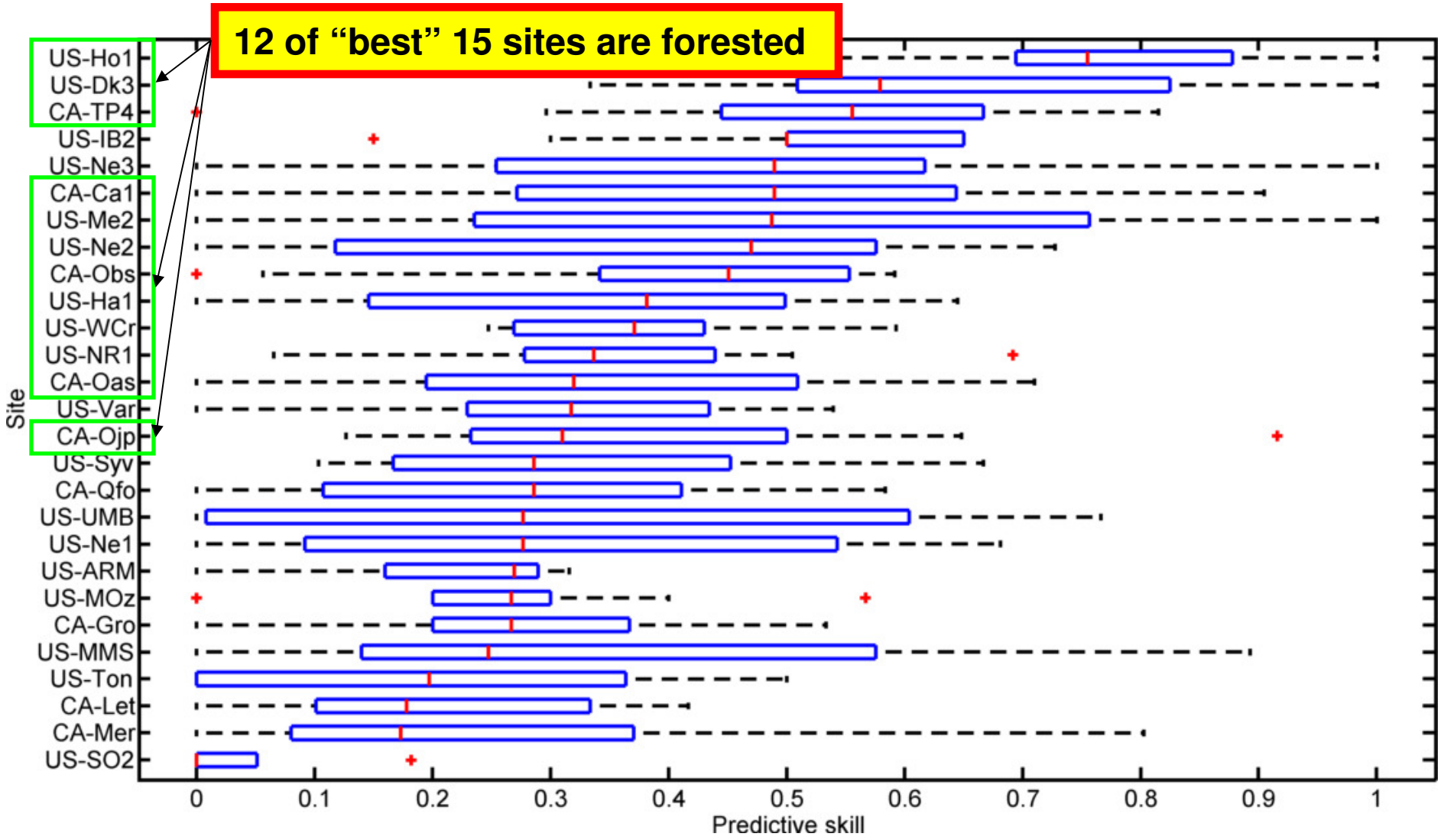




Boxplot of predictive skill by site. Panels show interquartile range (blue box), median (solid red line), range (whiskers), and outliers (red cross; values more than 1.5 x interquartile range from the median). Only sites (n = 27) simulated with at least 10 unique models using steady state spinup shown. Sites sorted by median predictive skill.



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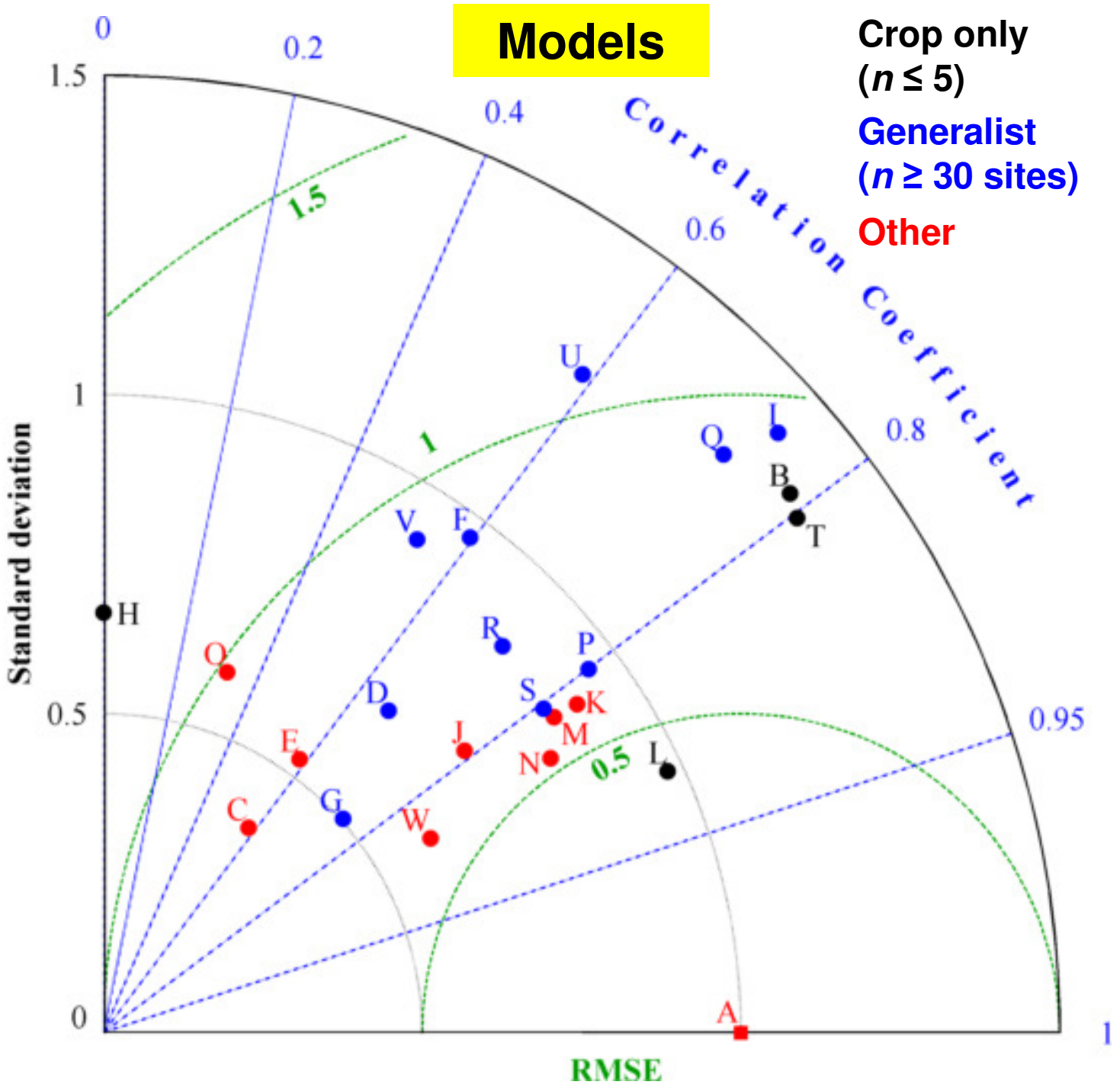
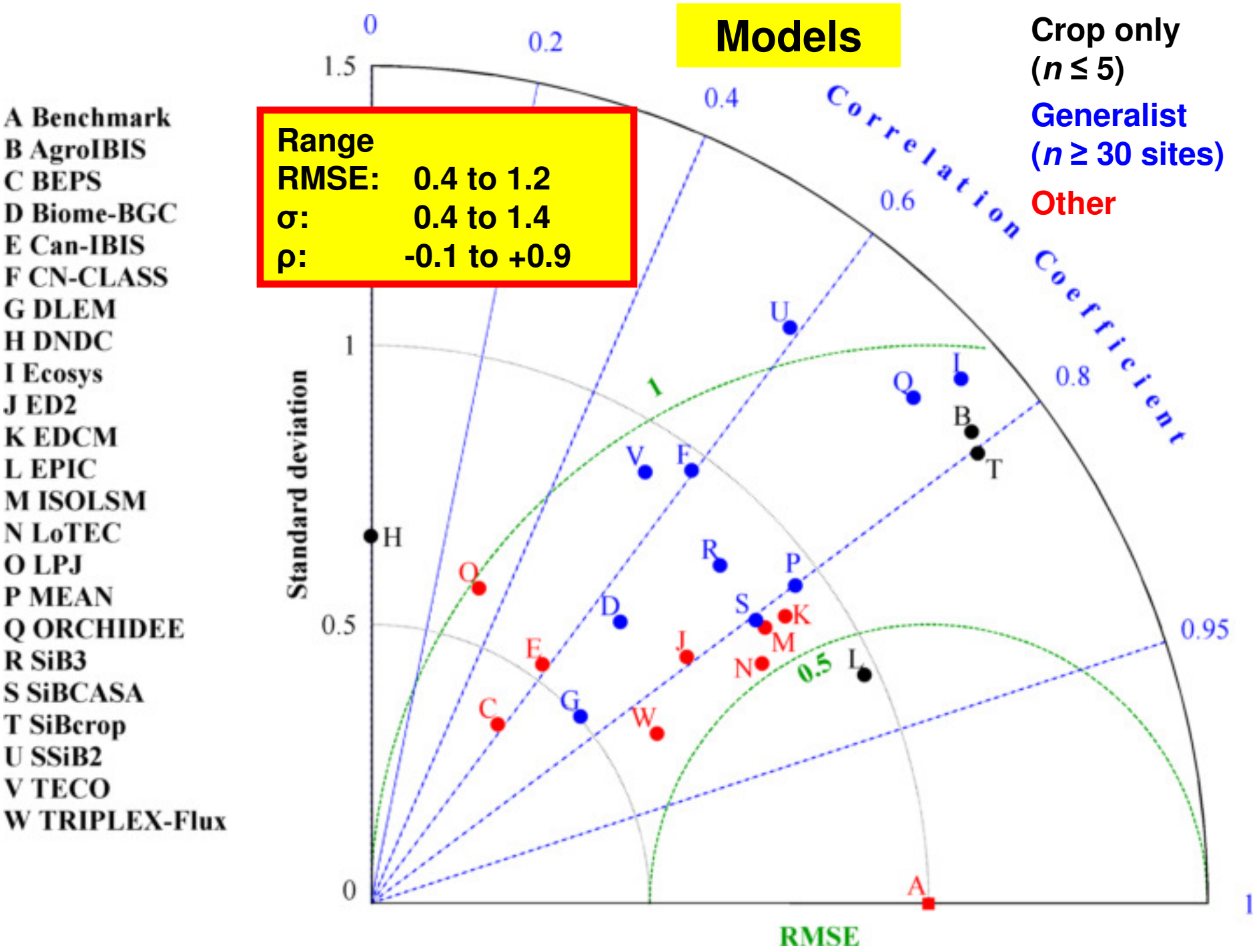
A Benchmark
B AgroIBIS
C BEPS
D Biome-BGC
E Can-IBIS
F CN-CLASS
G DLEM
H DNDC
I Ecosys
J ED2
K EDCM
L EPIC
M ISOLSM
N LoTEC
O LPJ
P MEAN
Q ORCHIDEE
R SiB3
S SiBCASA
T SiBcrop
U SSiB2
V TECO
W TRIPLEX-Flux




Models
Crop only
(n ≤ 5)
Generalist
(n ≥ 30 sites)
Other
Range
RMSE: 0.4 to 1.2
σ: 0.4 to 1.4
ρ: -0.1 to +0.9
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U SSiB2
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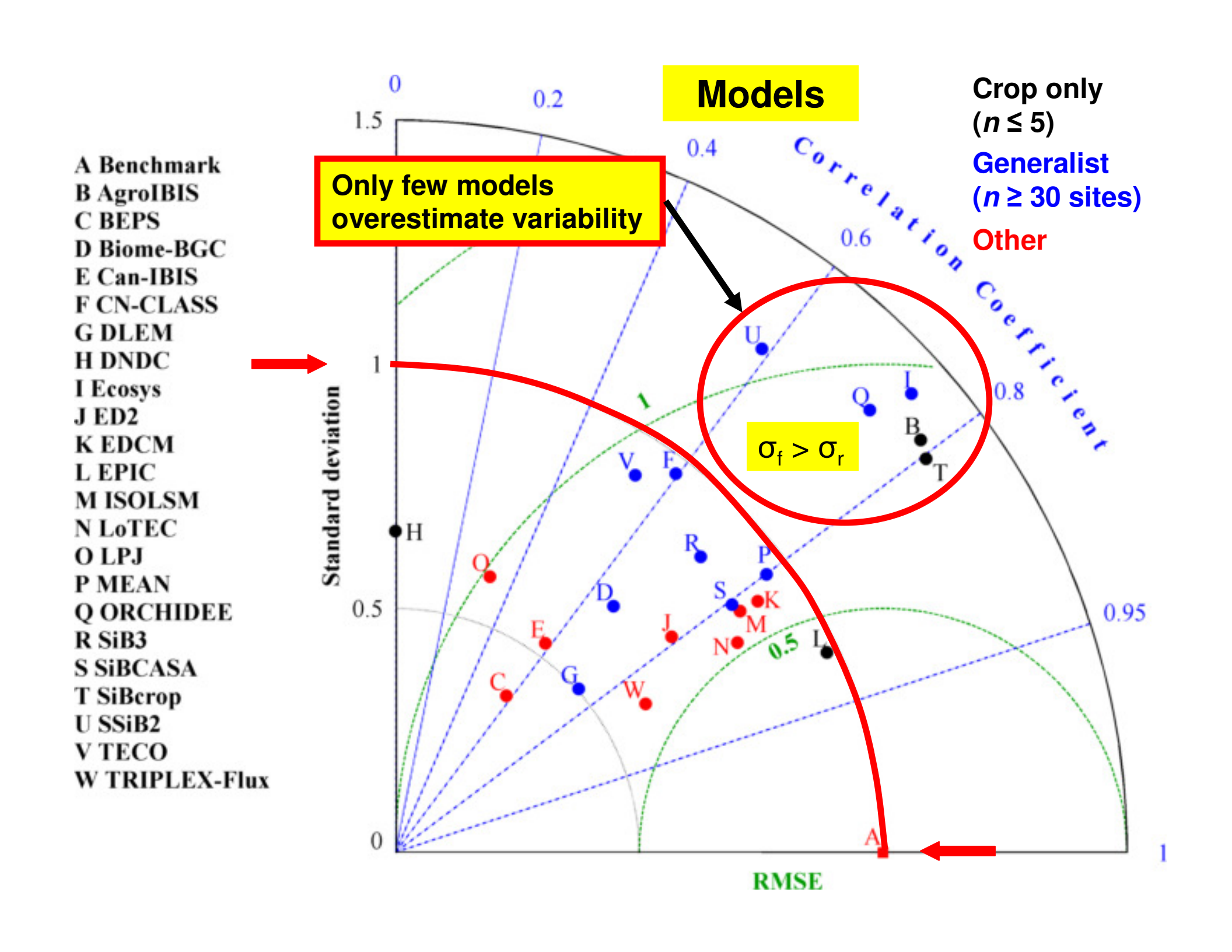
W TRIPLEX-Flux
Correlation Coefficient
Standard deviation
RMSE
0
0.2
0.4
0.6
0.8
0.95
1
1.5
0.5
0.5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W TRIPLEX-Flux
Only few models overestimate variability
σf > σr
Correlation Coefficient
Standard deviation
RMSE
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0.2
0.4
0.6
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0.95
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1.5
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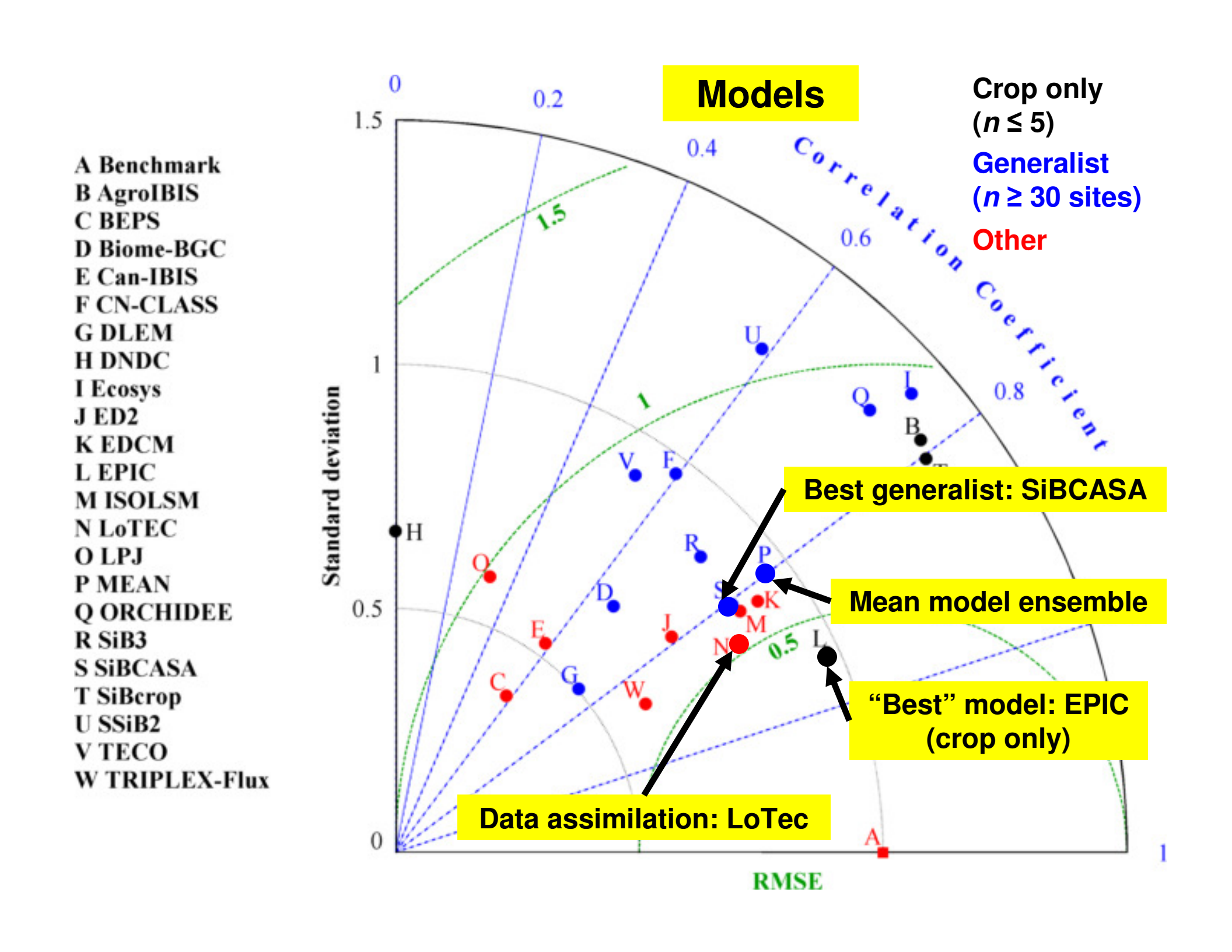
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Crop only
(n ≤ 5)
Generalist
(n ≥ 30 sites)
Other
Correlation Coefficient
Standard deviation
RMSE
Best generalist: SiBCASA
Mean model ensemble
"Best" model: EPIC
(crop only)
Data assimilation: LoTec

Conclusions

- Overall model performance is poor
- Forested biomes > non-forested biomes
- Winter and summer > spring and fall
- Normal moisture > non-normal moisture
- Generalist models ≈ specialist models
- Temporal evolution > ecological controls
- Best performance through assimilation and model ensembles
- Additional simulations/observations needed in non-forested biomes and younger forested stands