Development of Off-line Simulation Framework for Terrestrial Energy Water Cycles Incorporating Anthropogenic Processes

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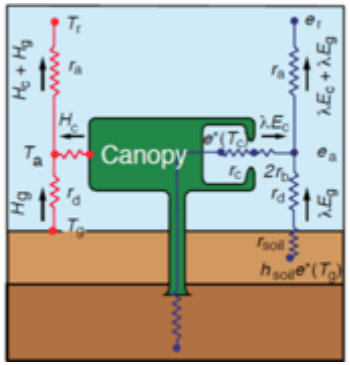
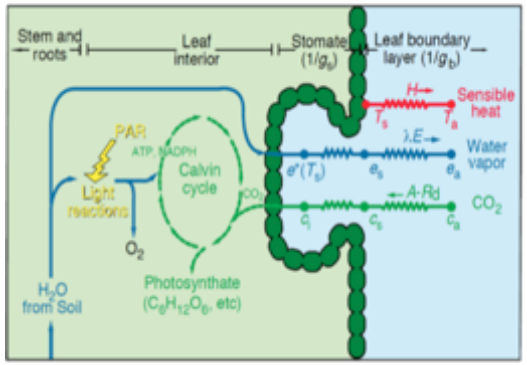
& Thanks to : Tomoko Nitta, Yuta Ishitsuka, Dai Yamazaki, Naota Hanasaki, Tomohito Yamada, Kei Yoshimura, Taikan Oki

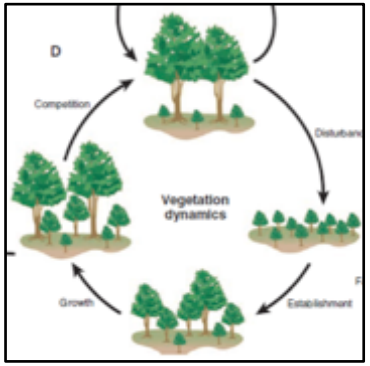
1984 Dickinson
1986 Sellers et al.



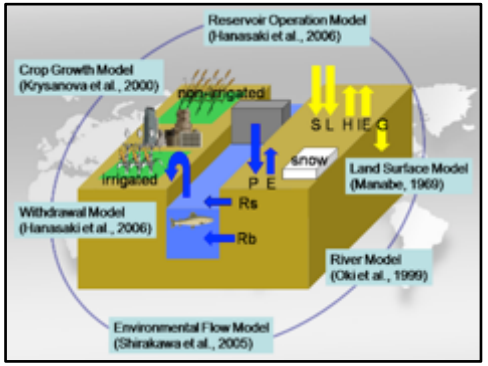
1995 Bonan
1996 Sellers et al.



1996 Foley et al.
2003 Sitch et al.
2003 Bonan et al.



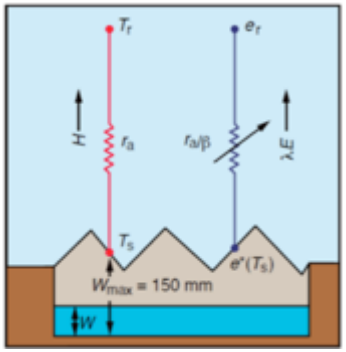
2006 Hanasaki et al.
2008 Hanasaki et al.
2011 Pokhrel et al.



NEXUS

1st Integration

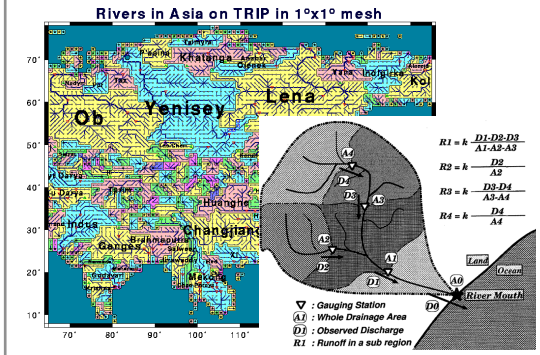
NEXT GEN



1969 Manabe

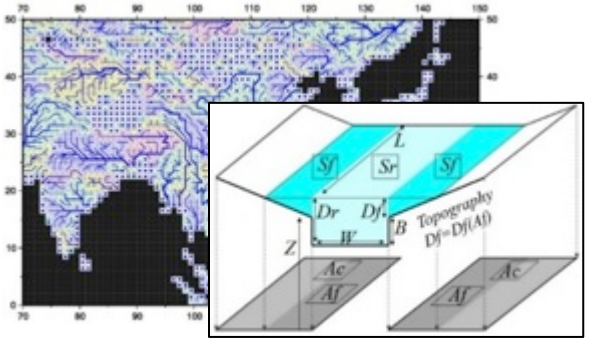
River

1st Generation



1998 Oki and Sud

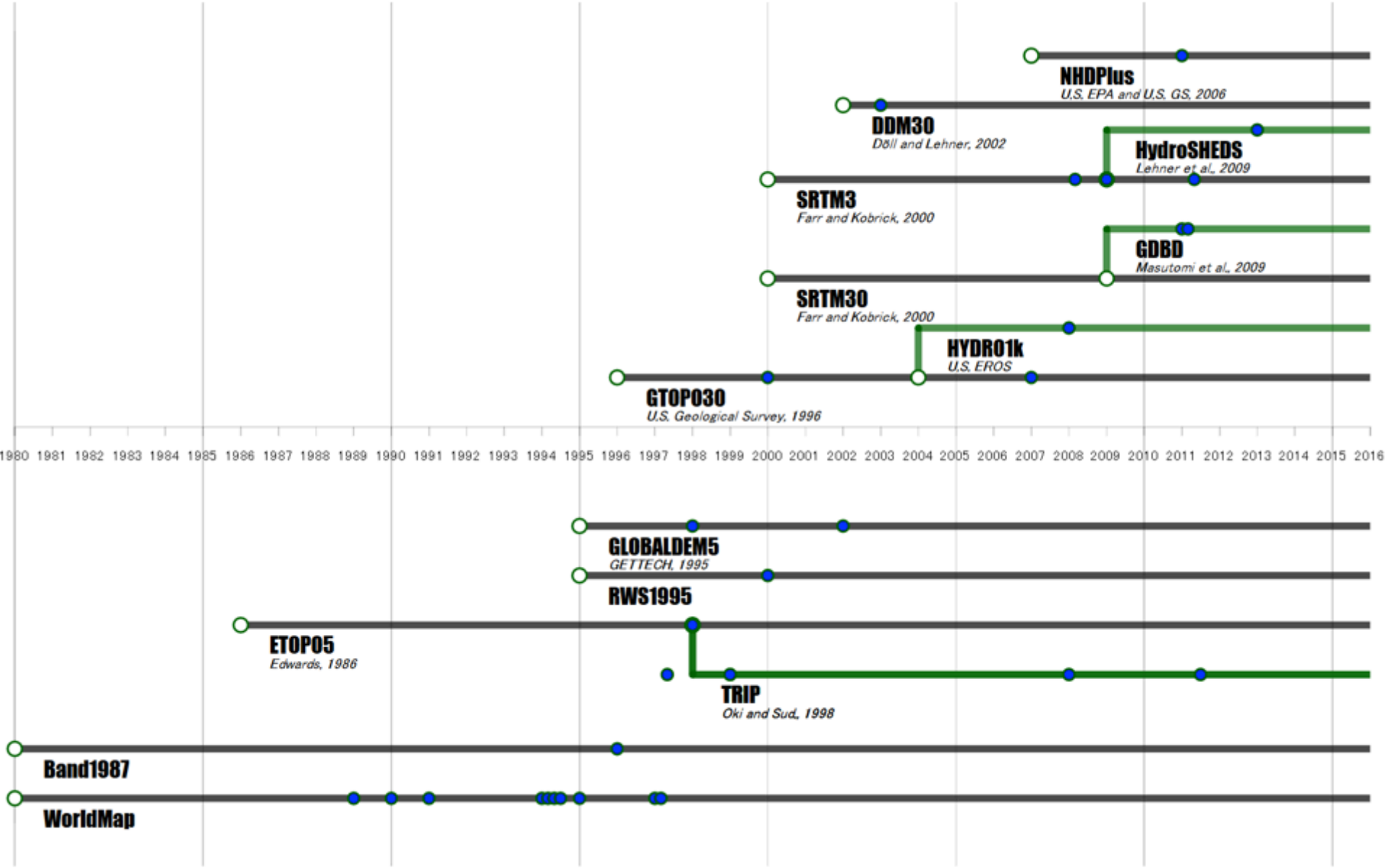
2nd Generation



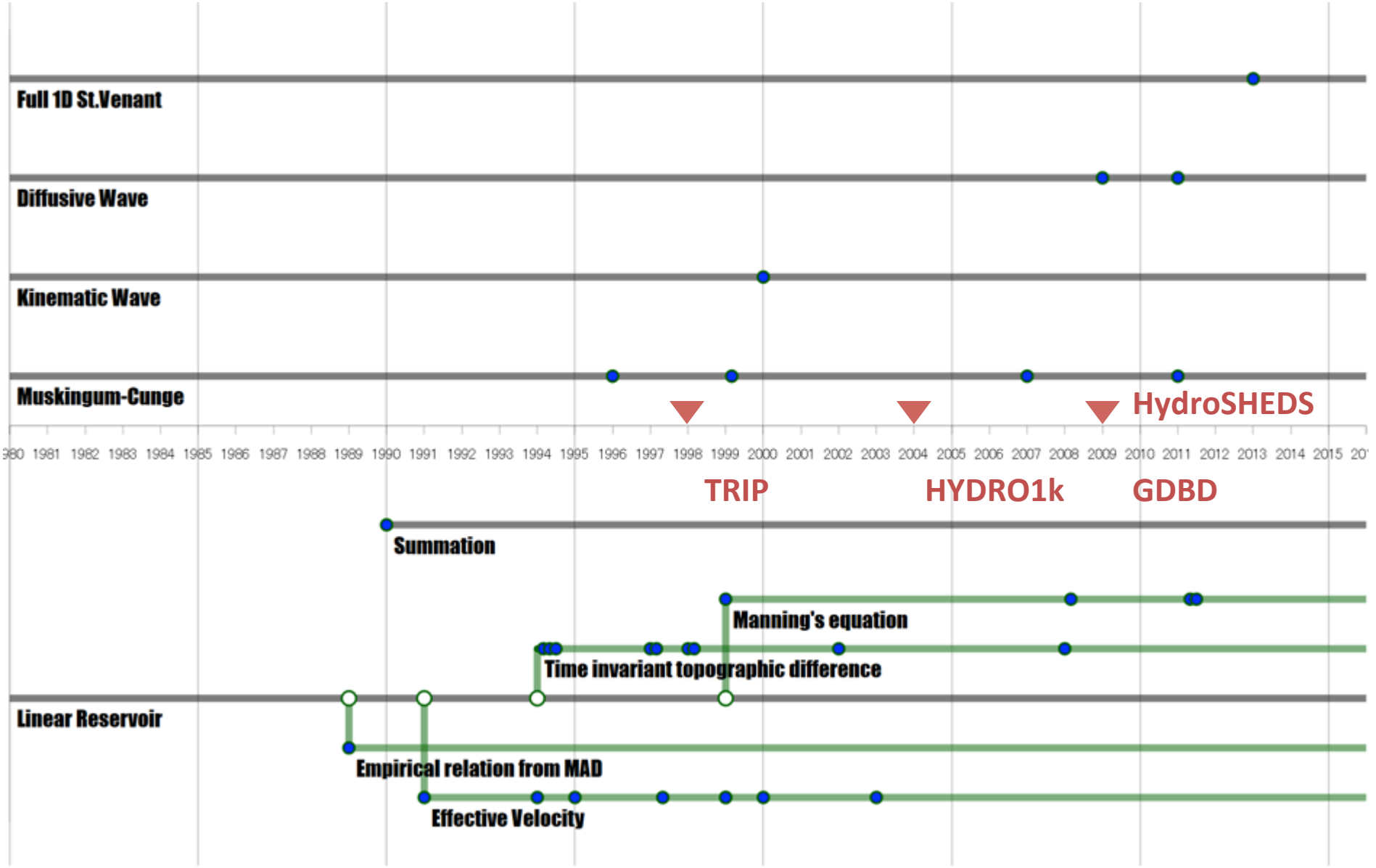
2011 Yamazaki et al.

Land

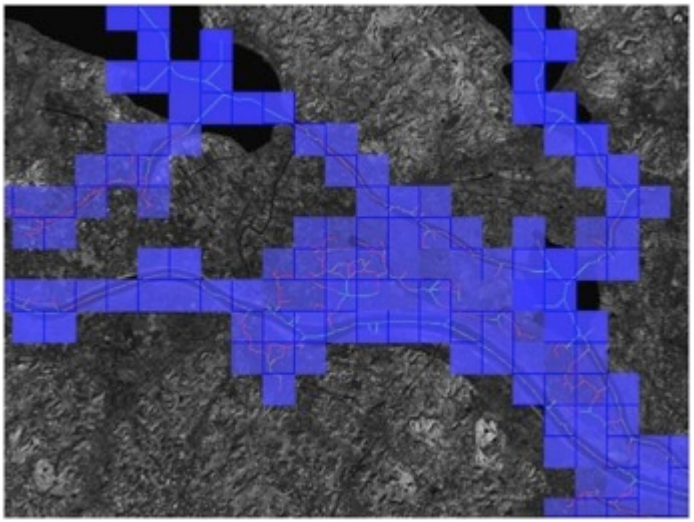
River Network and Routing Scheme Development



River Network and Routing Scheme Development



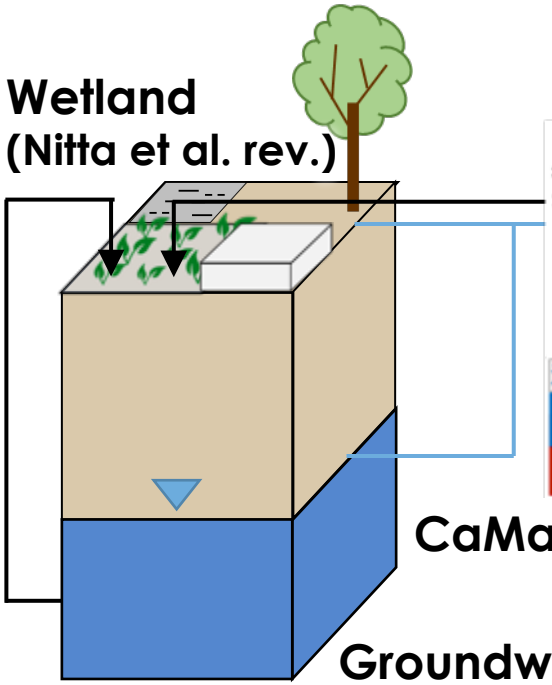
TRIP (Oki and Sud, 1998)
based on ETOPO5, global 0.5°



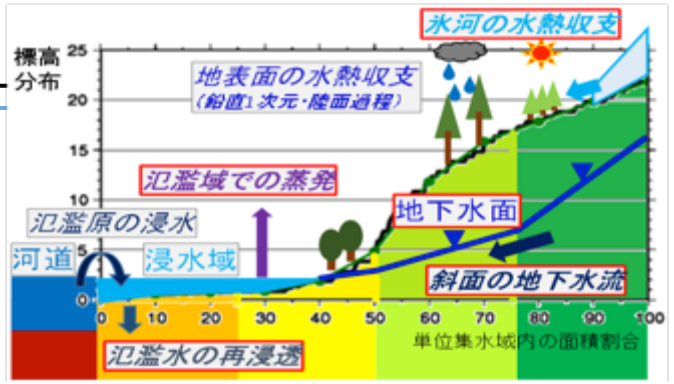
MATSIRO (Takata et al. 2003)
SiB2 + TOPMODEL

STRIP (Oki et al. 1999)
linear reservoir type

Wetland
(Nitta et al. rev.)



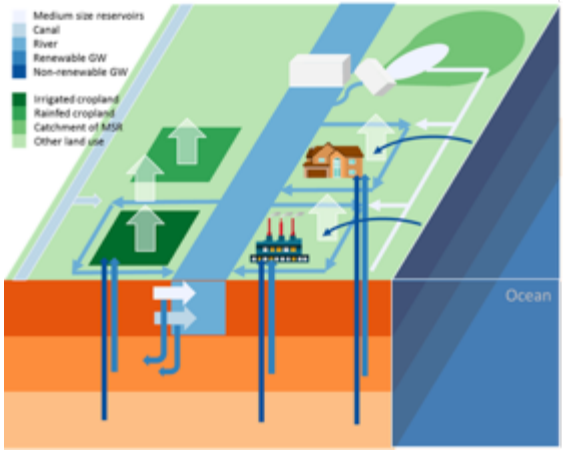
Reservoir
(Hanasaki et al. 2006)

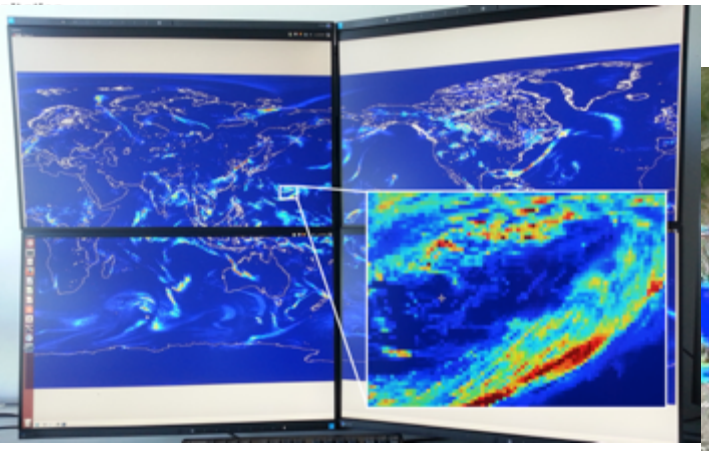


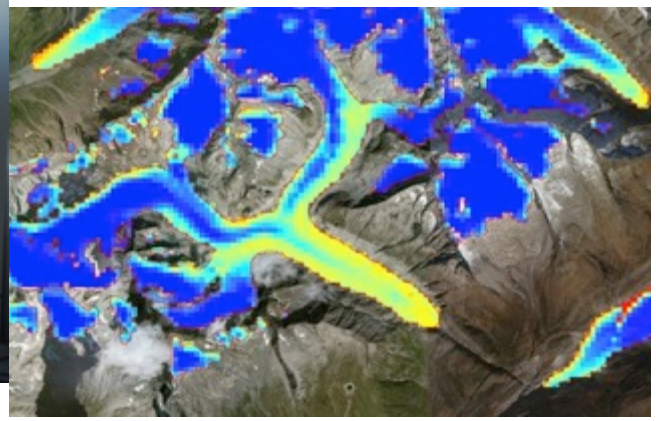
CaMa-Flood (Yamazaki et al. 2011)
Inundation + Diffusive wave

FLOW (Yamazaki et al. 2009)
based on SRTM30, flexible res.

Groundwater
(Koirala et al. 2014)
Yeh and Eltahir 2005



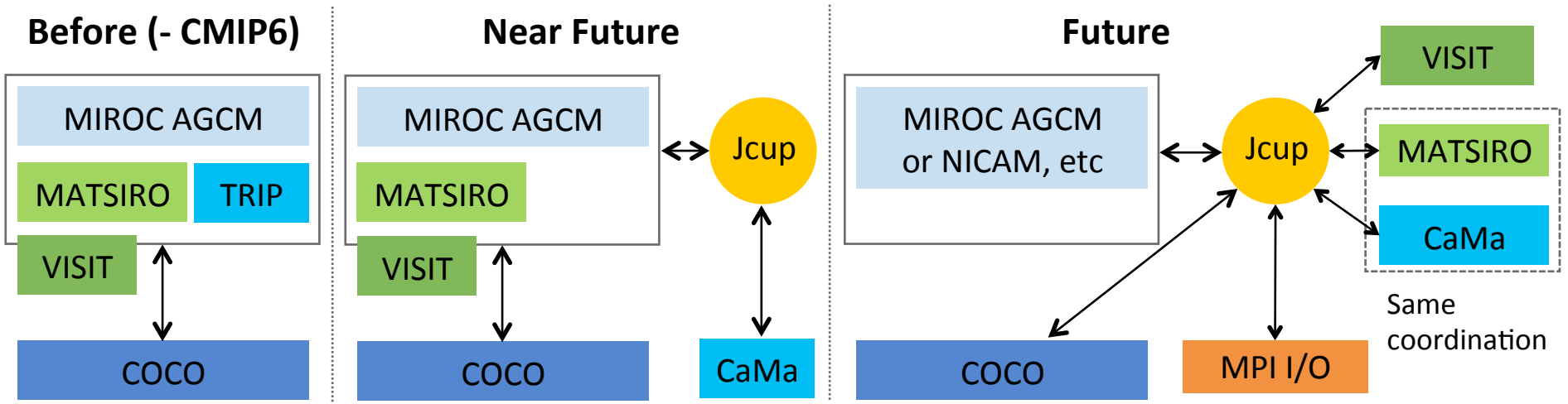




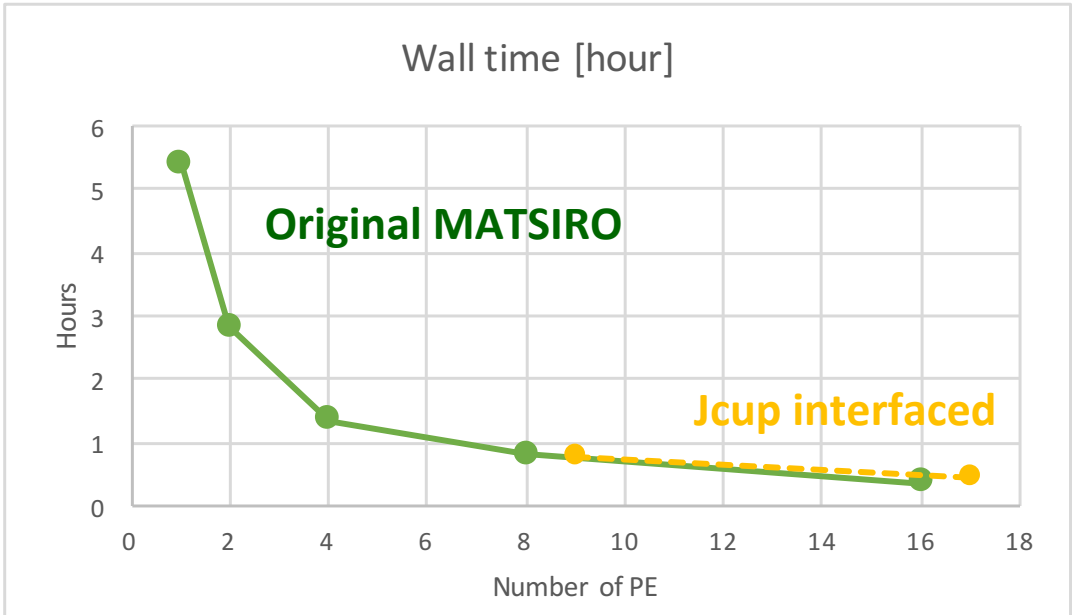
H08 (Hanasaki et al. 2008)
Bucket LSM + TRIP + SWIM + Reservoir + Env. Flow + Water Withdrawal

ELSE (Kim et al. 2009)
based on JRA25 and multiple precipitations, global 1.0°

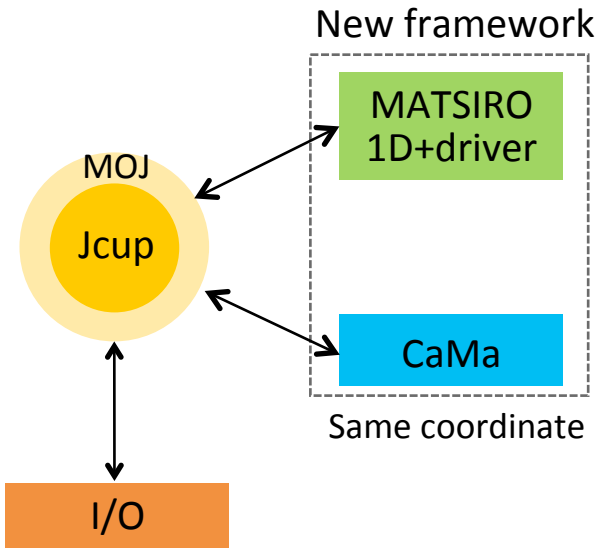
Structure of MIROC-ESM and Development Plan



Off-line Mode Benchmark

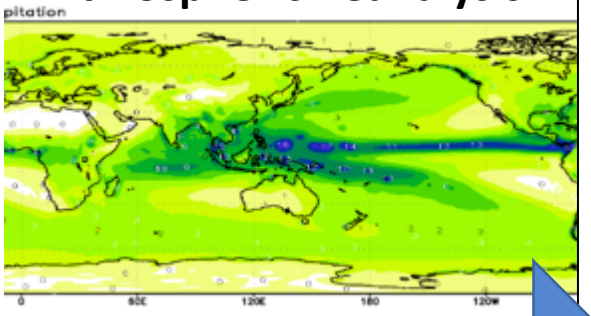


New Off-line Mode

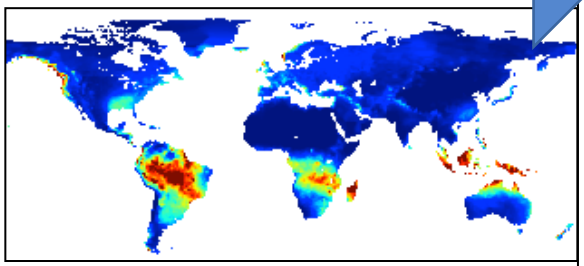


Off-line Framework for Large-scale Land Simulation

Atmospheric Reanalysis

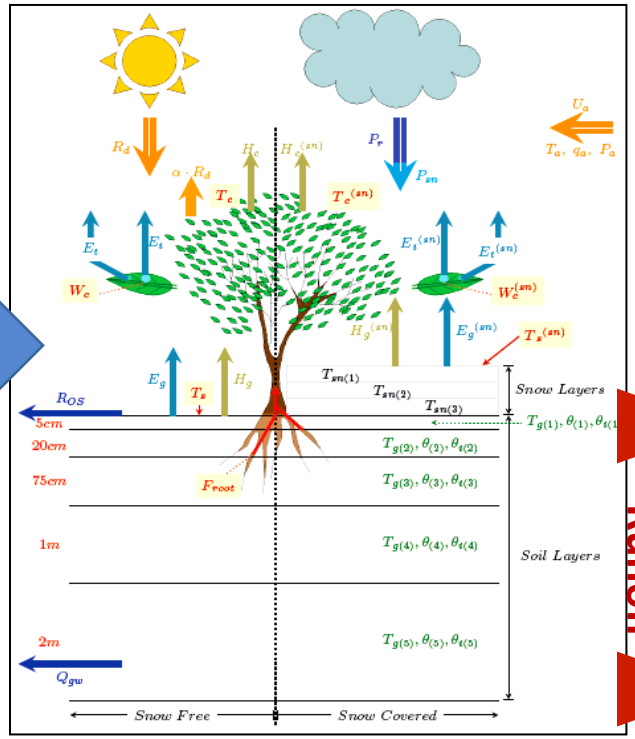


Bias Corr. + **Atmos. Forcing Data**

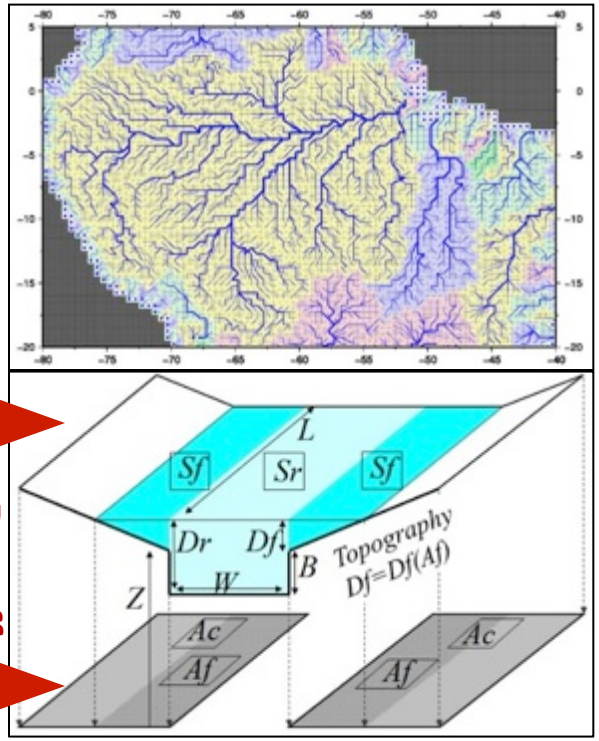


Observations

Land Surface Model



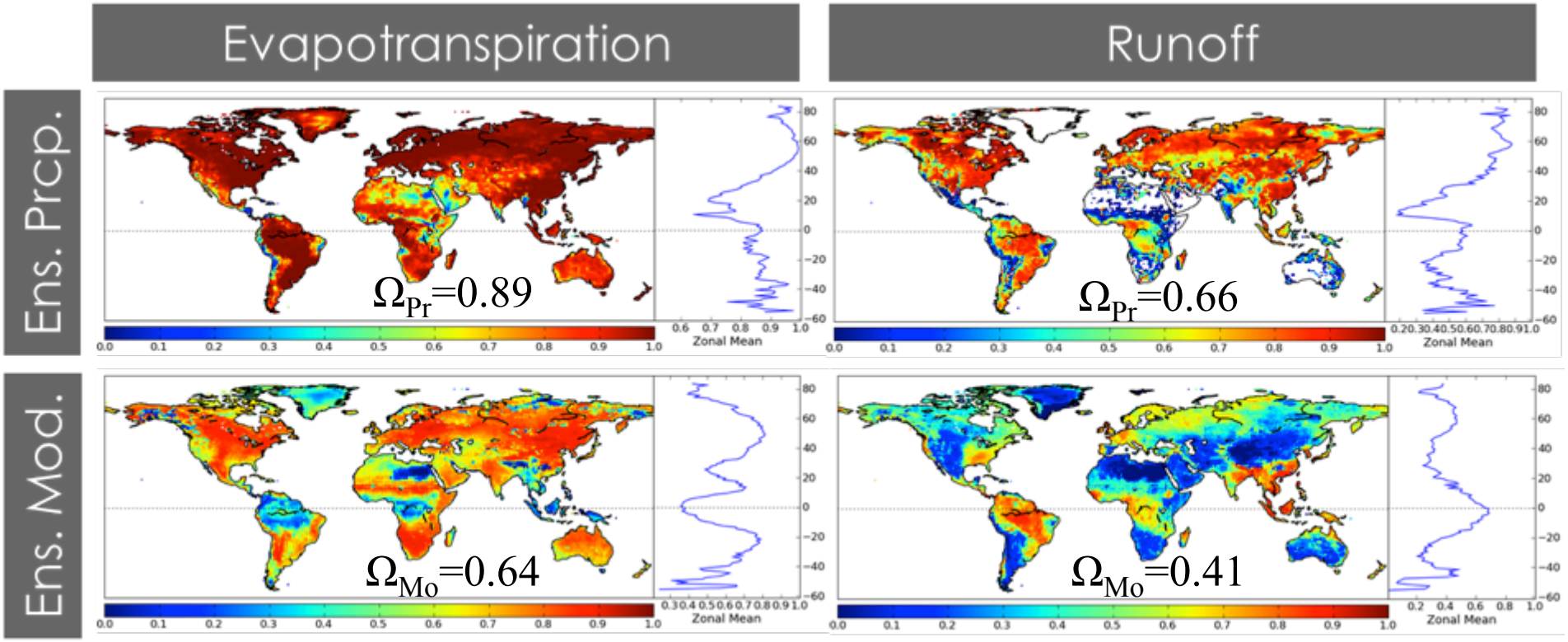
River Model



Runoff

Evaluation / Benchmarking System for Model Simulations and Input Data

Simulation Uncertainty – model vs input data –



Kim, 2010

Uncertainty in simulated evapotranspiration and runoff introduced by different land surface schemes in GSWP2 are larger than precipitation uncertainty-induced uncertainty by 28% and 40% in the similarity index (Ω) globally.

Generation Atmospheric Boundary Conditions

Model Input Data for EXP1 *(long-term retrospective)*

Dynamical Global Downscaling

* Spectral Nudging using GSM (Yoshimura and Kanamitsu, 2008)
* Single Ensemble Correction (Yoshimura And Kanamitsu, 2013)
* Vertically Weighted Damping (Hong and Chang, 2012)

Two-pass Bias Correction

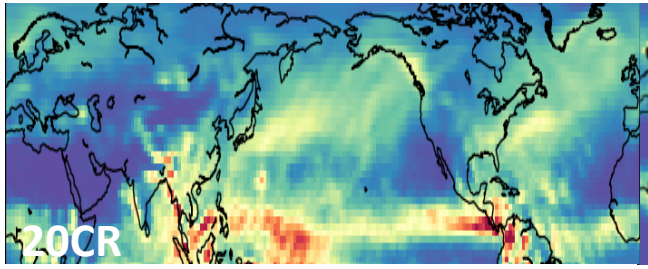
* LDMF Daily Correction (Kim et al., in prep.)
* Parametric Monthly Correction (Watanabe et al., 2012)

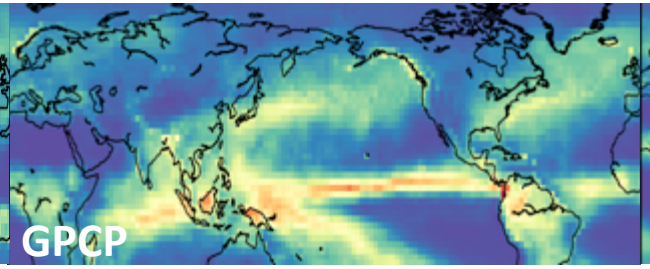
GSWP3 LS3MIP Forcing

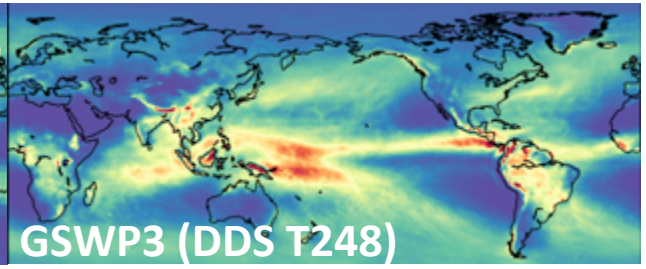
20CR (Compo et al., 2011)
1871-2010 6hr / 2°x2°(91x180)

Observations (Prcp: GPCC, CPC-Unified; Tair: CRU; Rad.: SRB)

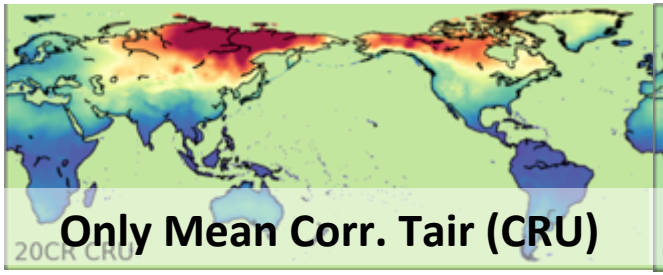
0.5°x0.5°
1901-2010 3hr

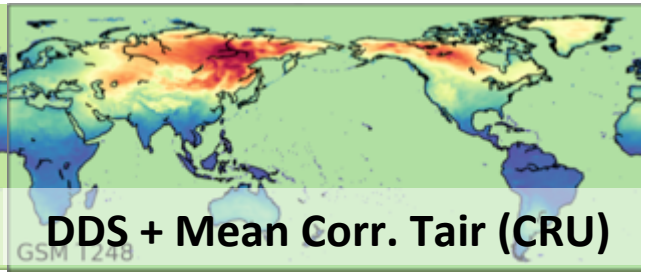






Better representation of mean and **variability** in high-frequency domain



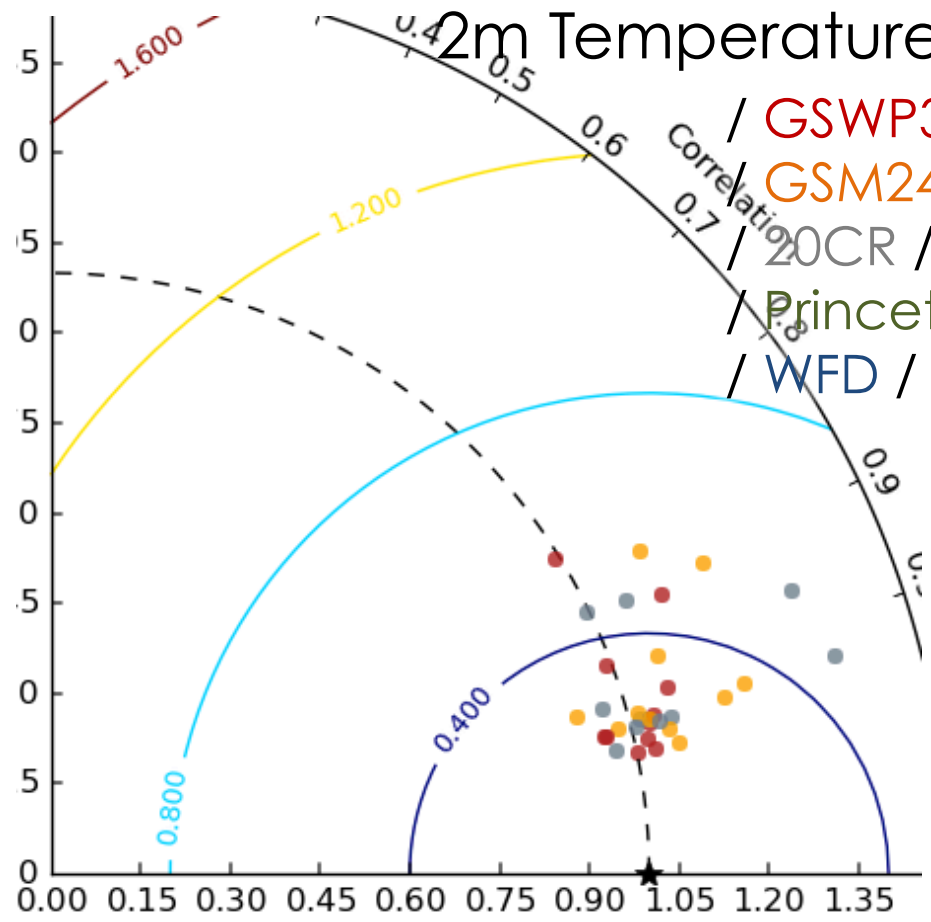


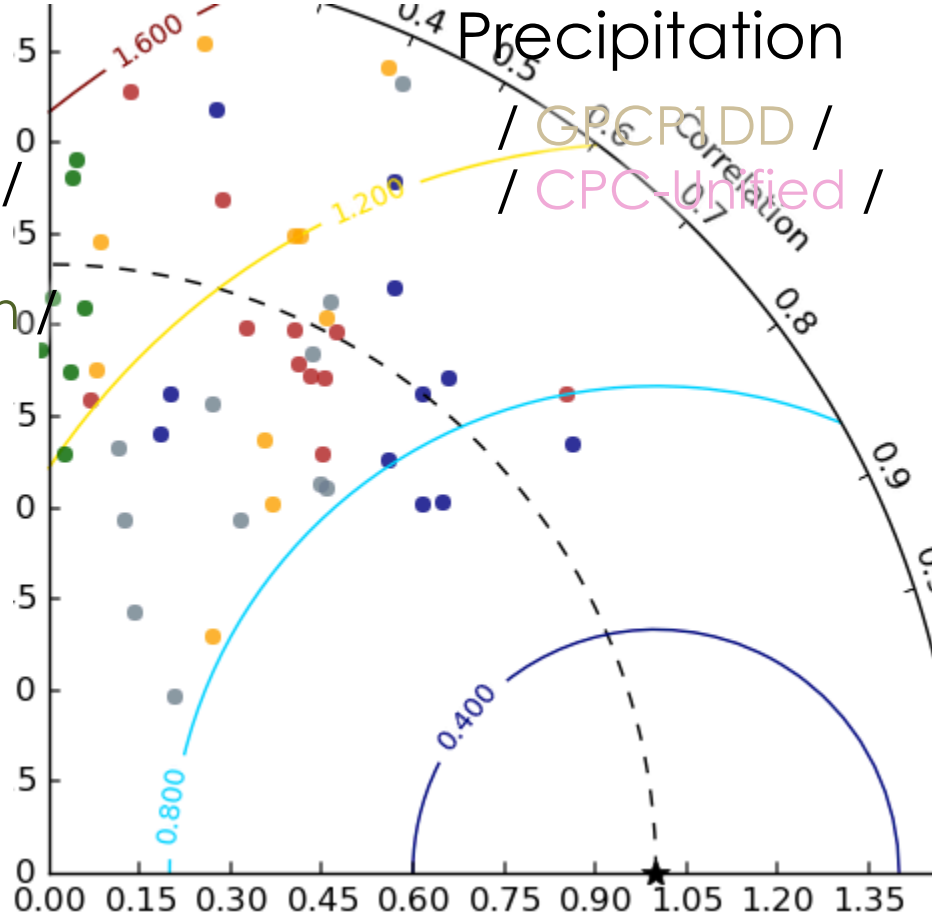
Comparison Table for Existing Forcing Data

	NCC	GSWP2	Princeton	ELSE	WATCH	GSWP3
Reference	Ngo Duc et al., 2005	Dirmeyer et al., 2006	Sheffield et al., 2006	Kim et al., 2009	Weedon et al., 2011	Kim et al., in prep.
Temporal Coverage	1948-2000 53 years	1982-1995 14 years	1948-2008 61 years	1979-2010 32 years	1901-2001 101 years	**1851**-2011 161 years
Spa./Temp. Resolution	1 deg. 6 hours	1 deg. 3 hours	1 deg. 3 hours	1 deg. 6 hours	0.5 deg. 3 or 6 hours	0.5 deg. 3 hours
Base Reanalysis	NCEP/NCAR 1948 - now T62 / 6hr	NCEP/NCAR 1948 - now T62 / 6hr	NCEP/NCAR 1948 - now T62 / 6hr	JRA25 1948 – now T106 / 6hr	ERA-40 1957 - 2002 TL159 / 6hr	**20CRv2c** **1851 - 2011** 2 deg. / 6hr
Spa. Dis-aggregation	Bi-linear	Bi-linear	Bi-linear, Bayesian	Bi-linear	Bi-linear	Dynamical Downscale
Temp. Dis-aggregation	N/A	Variability from Obs.	Variability from Obs.	N/A	Variability from Obs.	Dynamical Downscale
Bias Correction	Only monthly (Add/Ratio)	Only monthly (Add/Ratio)	Only monthly (Add/Ratio)	Only monthly (Add/Ratio)	Only monthly (Add/Ratio)	Monthly (Add/Ratio) & Daily (Non-para.)

Data Quality Evaluation

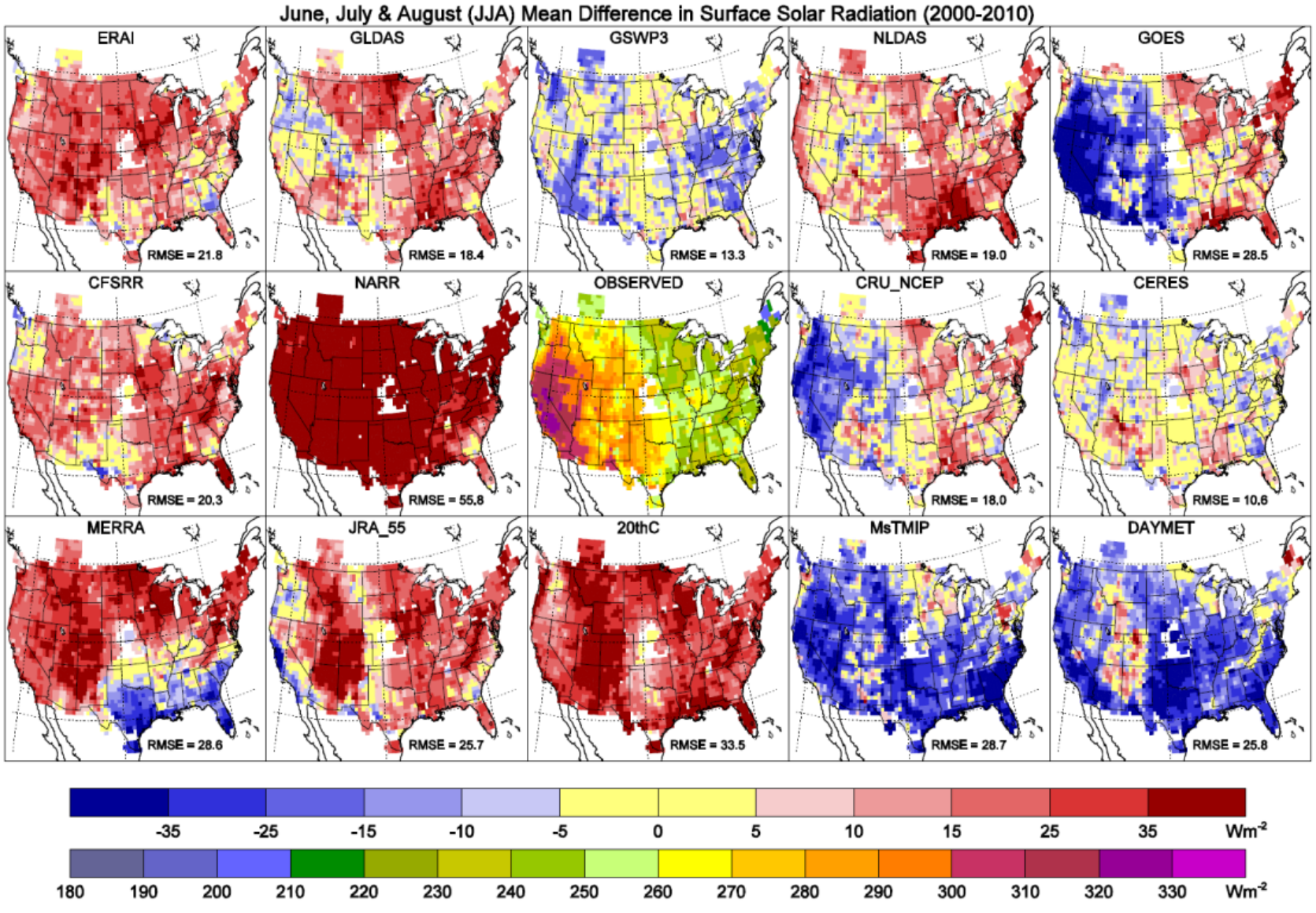
+ Beta-version of Land Surface Forcing Data Ready
+ Being used as a standard off-line climate driver of GSWP3, ISIMIP2, LS3MIP/LUMIP/CMIP6, and modeling groups.





Preliminary Results and Known Problems

+ Relatively small bias of solar radiation



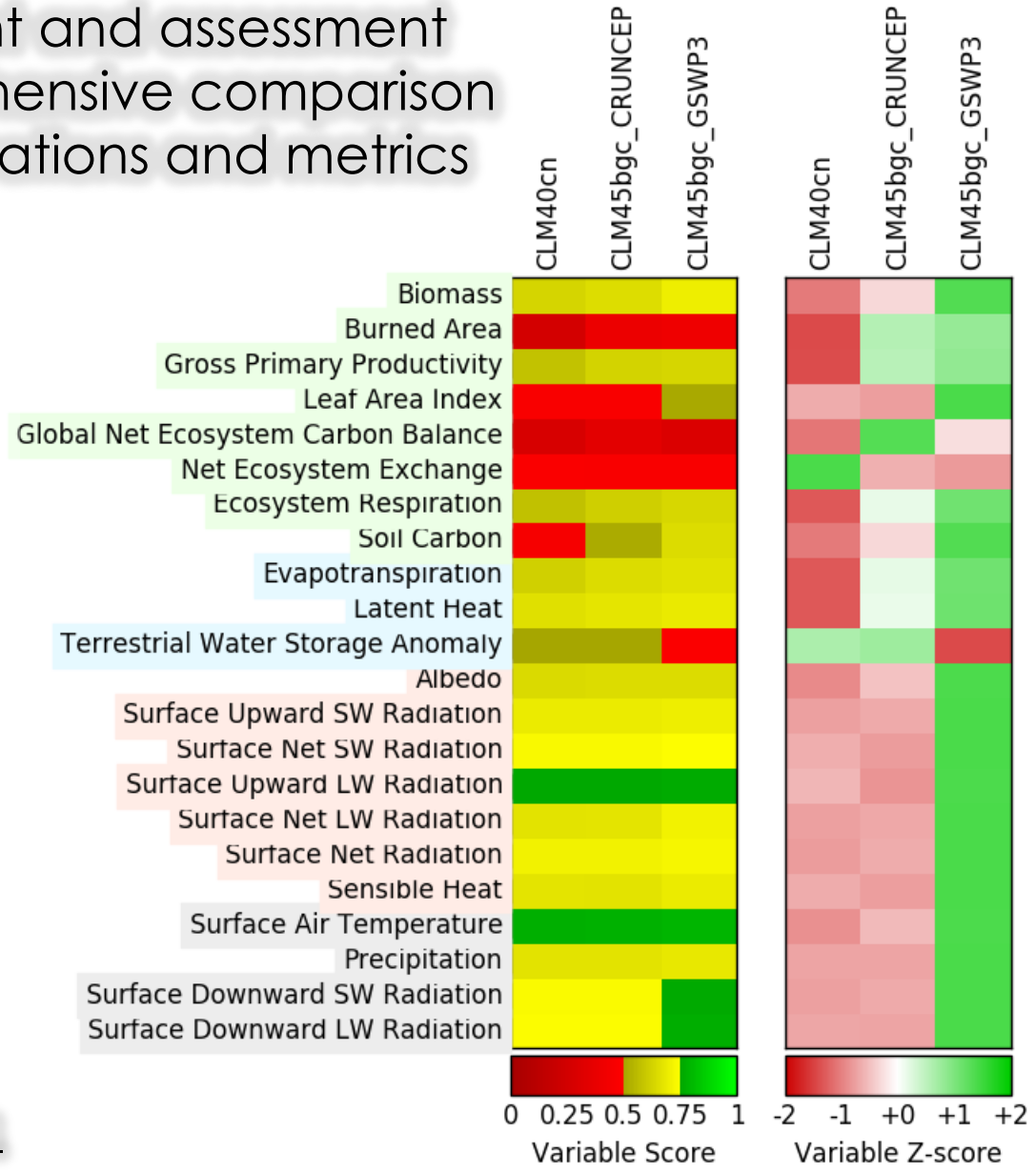
Slater, 2015

ILAMB: International Land Model Benchmark

A tool for model development and assessment providing quick and comprehensive comparison against growing set of observations and metrics

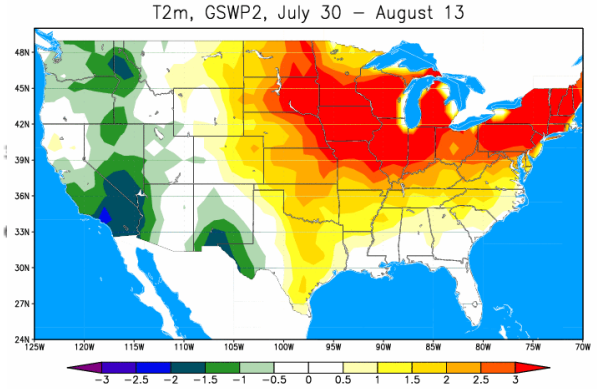
* C-cycle (8): Above ground live biomass, burned area, CO2, GPP, LAI, global net ecosystem carbon balance, NEE, ER, soil carbon
* W-cycle (6): ET, LE, S, R, evaporative fraction, TWSA
* E-cycle (6): albedo, SWup, SWnet, LWup, LWnet, Rnet
* Forcing (5): Tair, precipitation, RH, SWdown, LWdown

Integrates 25 variables in 4 categories from ~60 datasets

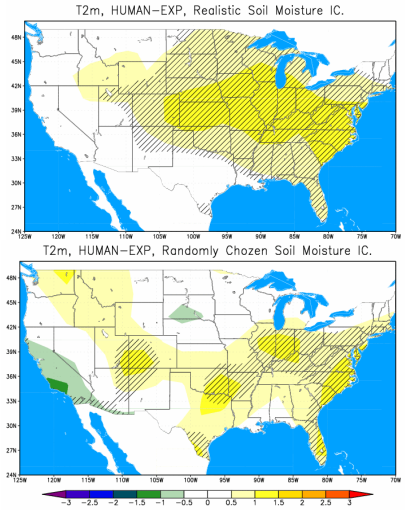


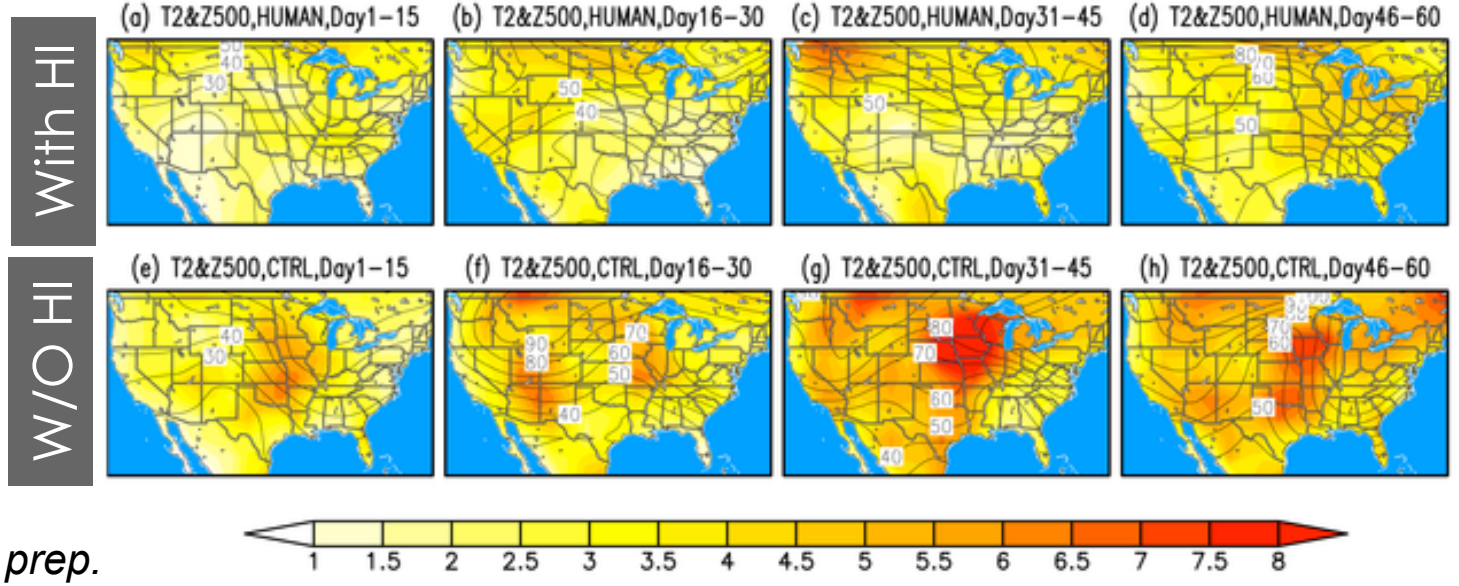
Land-atmosphere Interaction in a Global Climate Model in Association with Human Activities

+ Spread of near surface temperature (2m Tair) among ensemble members becomes smaller by incorporating surface water-groundwater-human models in the AGCM.



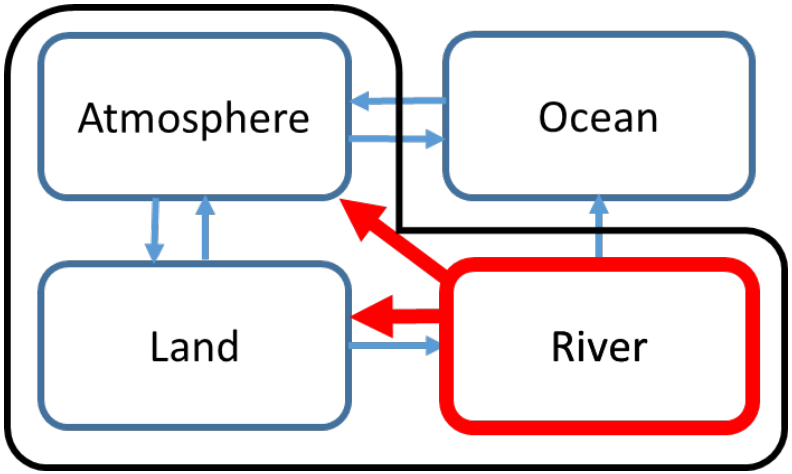
+ Sub-seasonal forecast skill for near surface air temperature (Day16-30) was improved by using realistic land initializations in the fully coupled AGCM with surface-groundwater-human models.

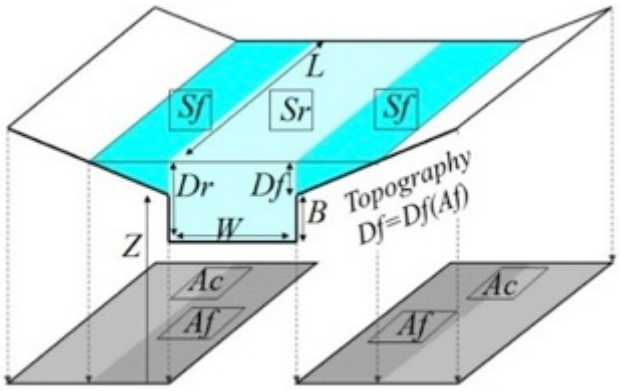


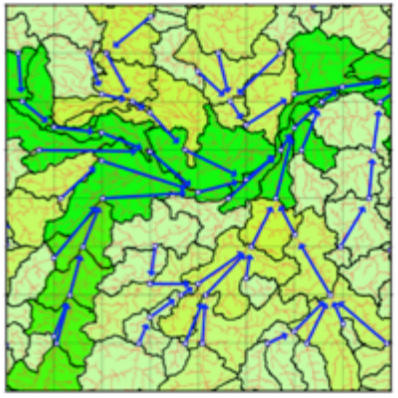


Yamada et al., in prep.

River Inundation Process in a Climate Model



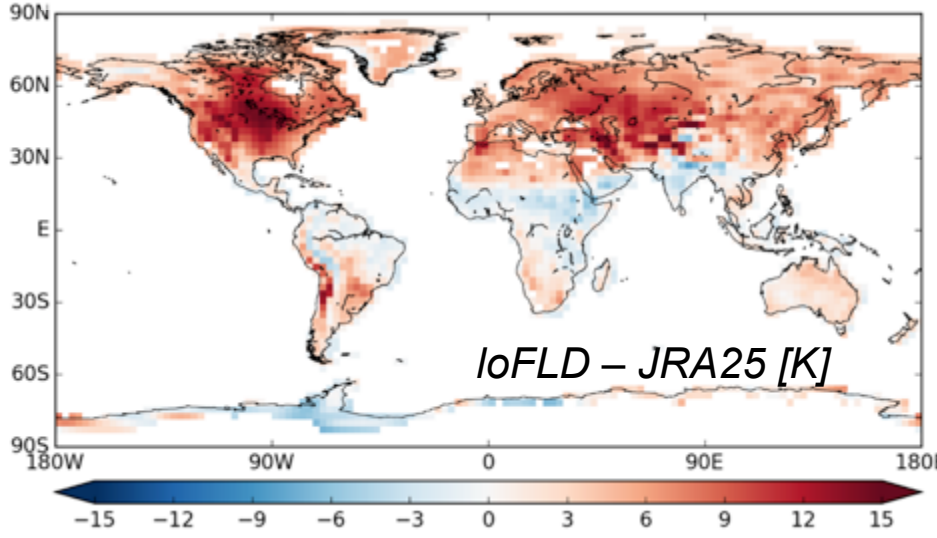


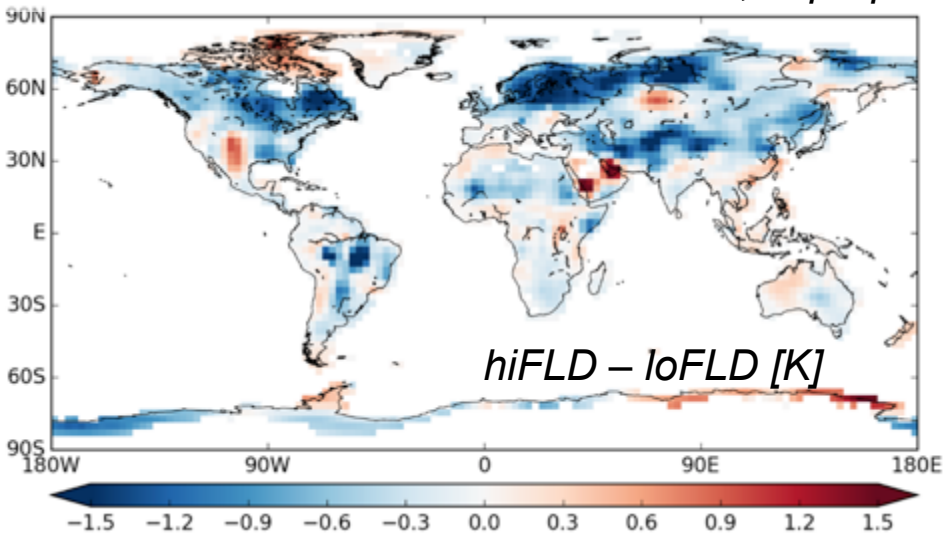


CaMa-Flood – Yamazaki et al., WRR, 2011

2m Air Temperature

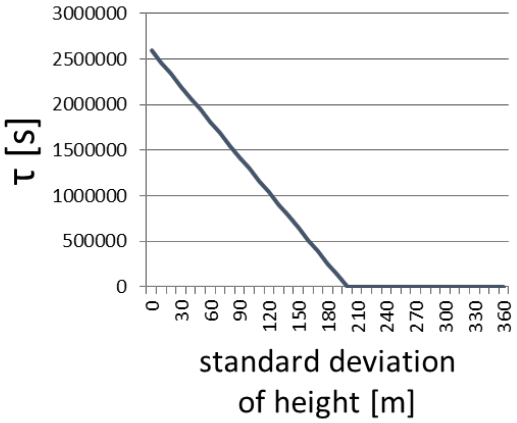
Hatono et al., in prep.

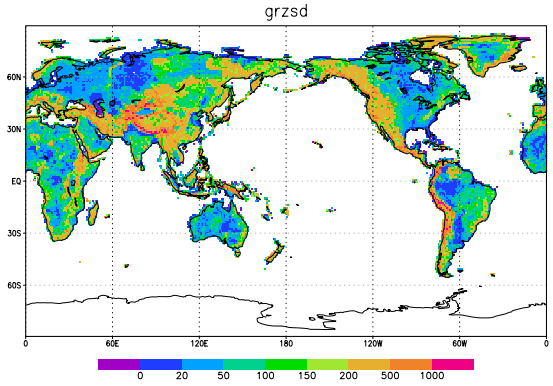




+ Warm bias at high latitudes is slightly (~10%) alleviated.

Impact of Arctic Wetlands on Climate System

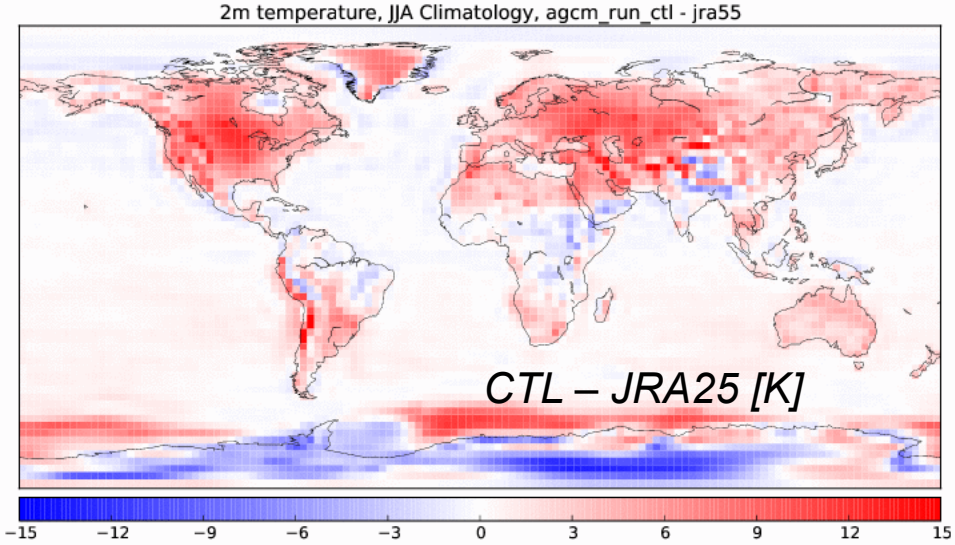


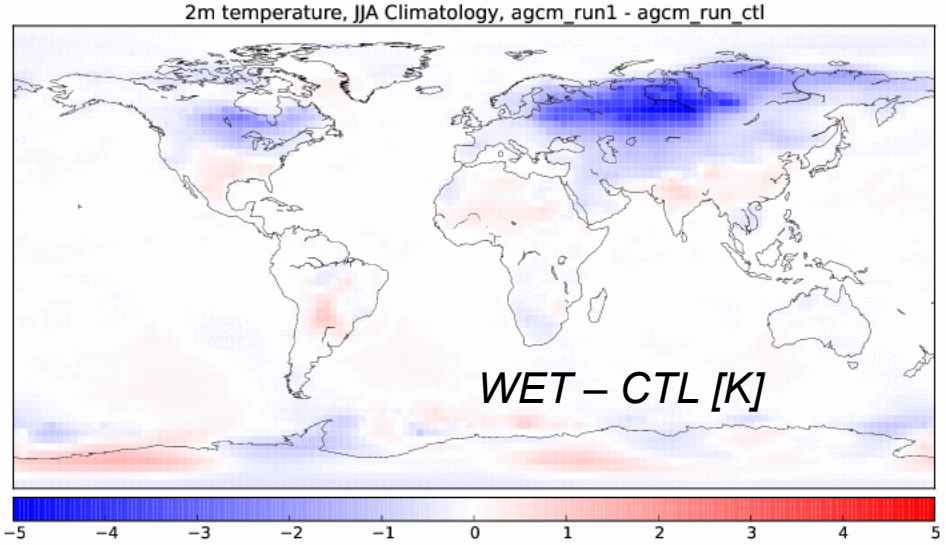


Nitta et al., submitted.

+ Add a surface tank that stores part of (1-α) snowmelt surface runoff
+ Topography dependent time constant (τ)

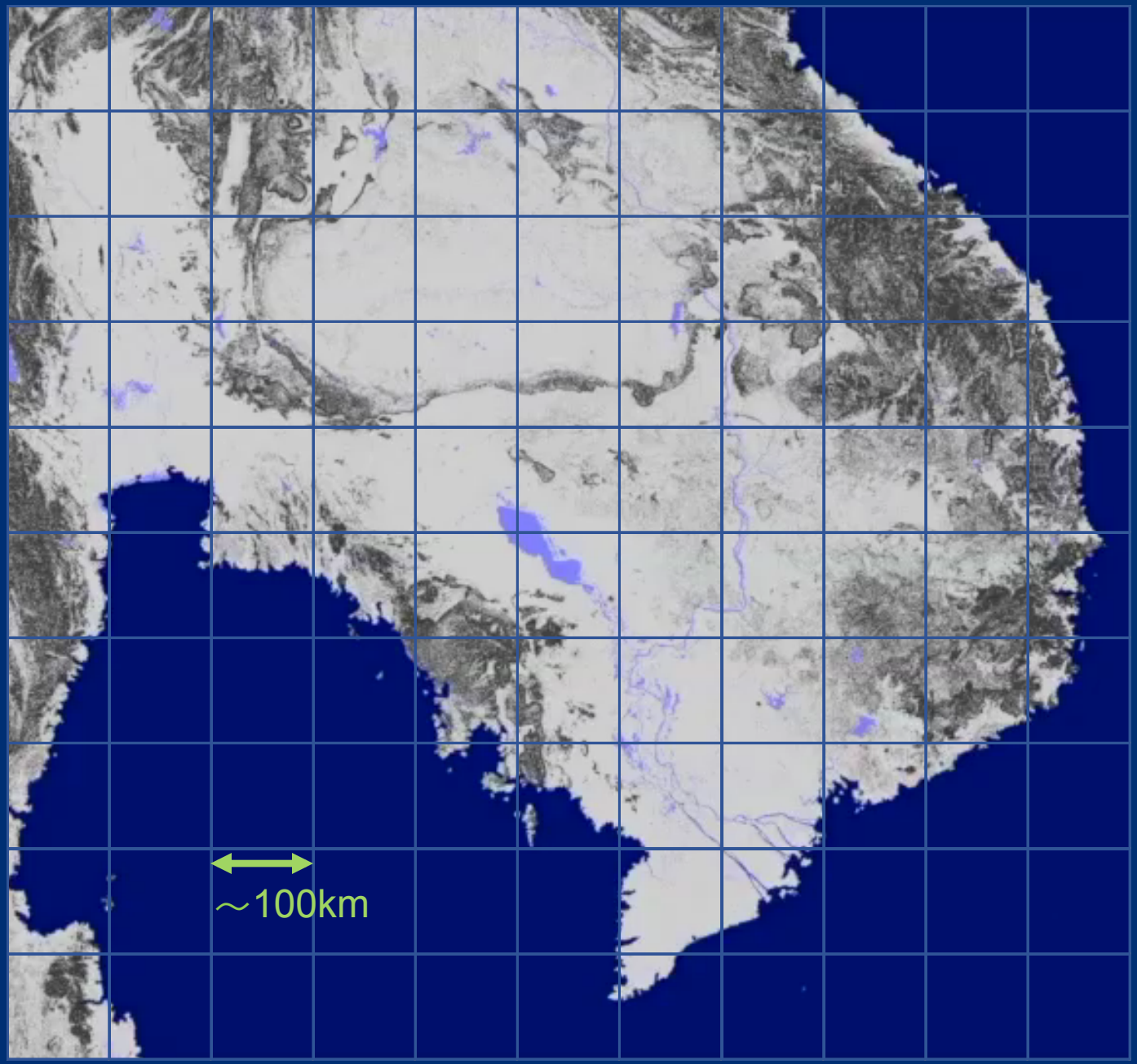
$$S_t = S_{t-1} - (S_{t-1}/\tau + (1-\alpha)R_s)dt$$





+ Warm bias at high latitudes is considerably (up to ~30%) alleviated.

2016.9.29



Thank you!