Evaluation of Ensemble Forcing Data and Uncertainty Propagation

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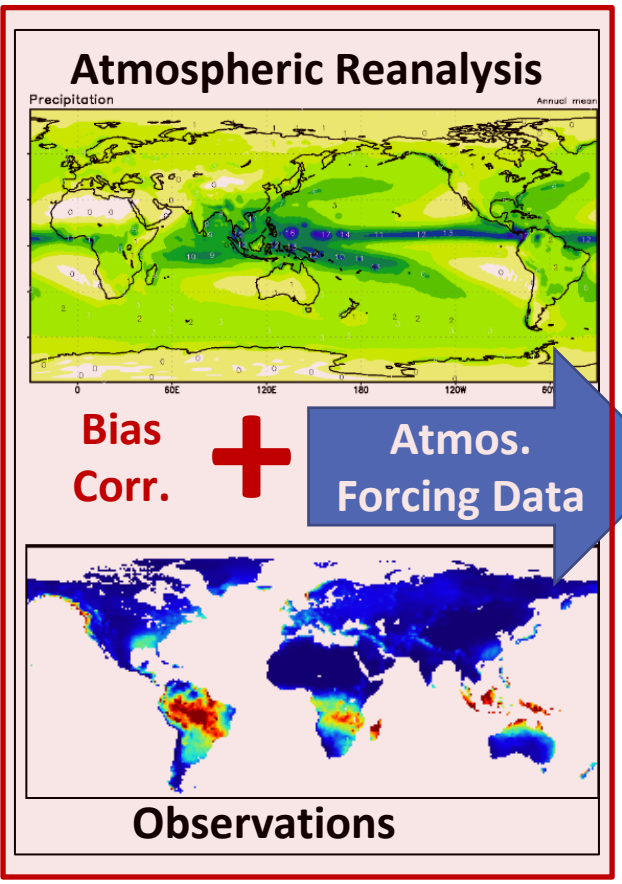
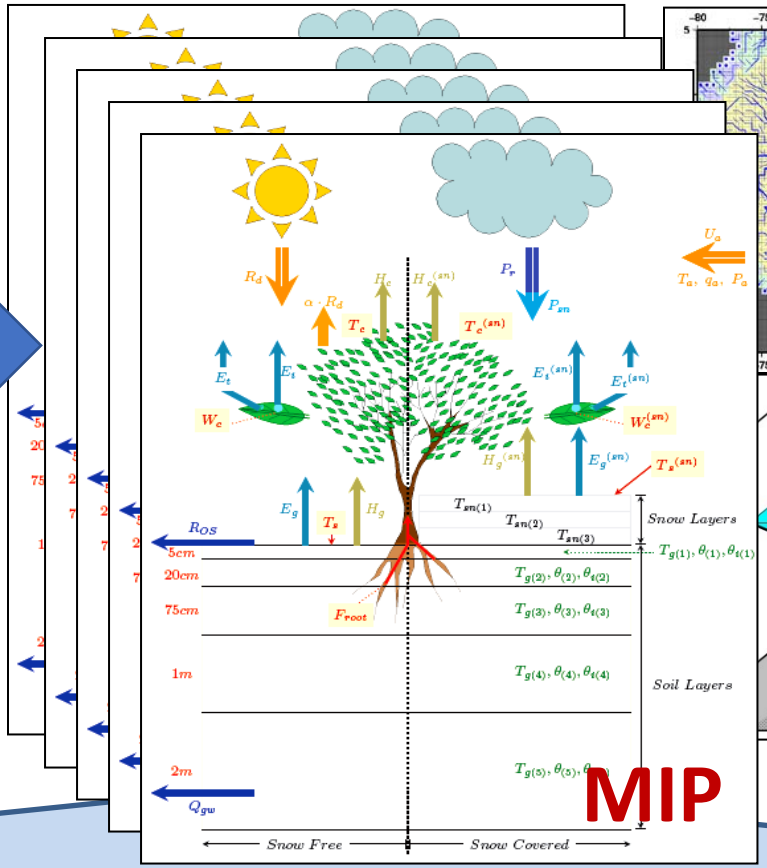
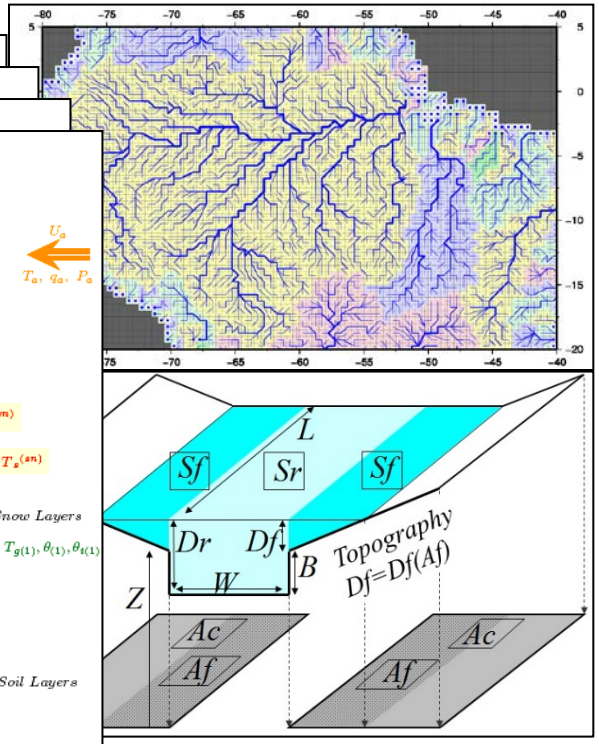
Off-line Framework for Large-scale Land Simulation



Land Surface Model



River Model



Evaluation / Benchmarking System for Model Simulations and Input Data

How are they different?

	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 - 2014** 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.)

How are they different?

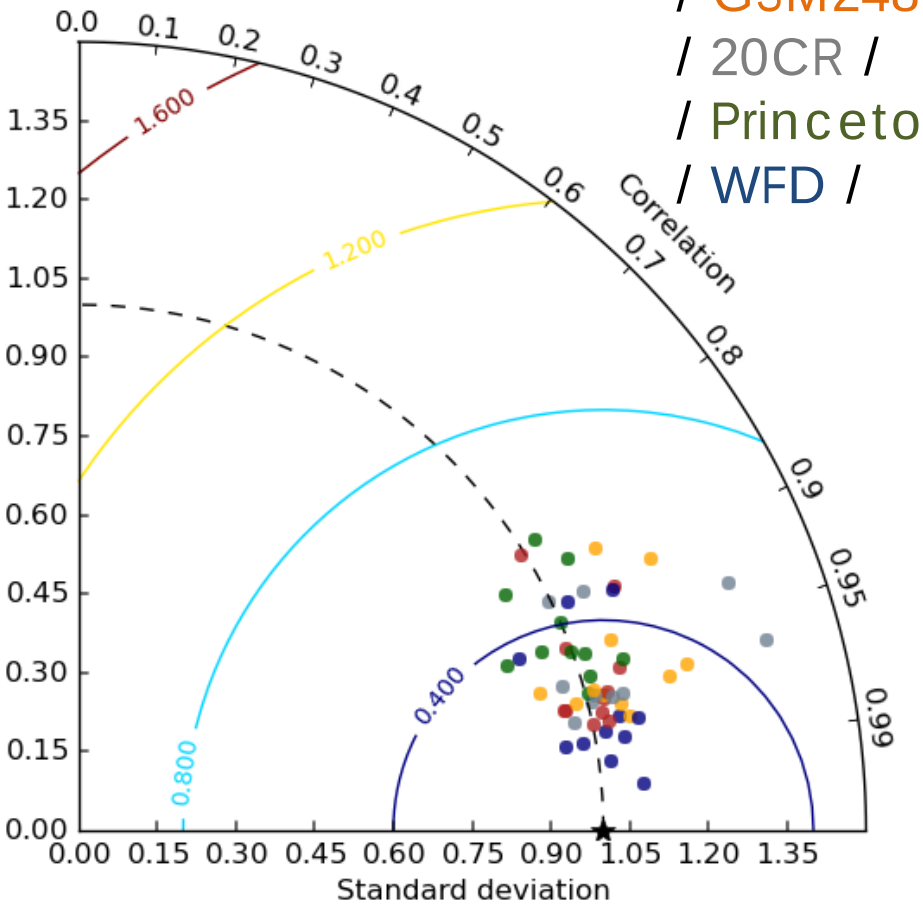
	NCC	GSWP2	Princeton	ELSE	WATCH	GSWP3
Variables	P, T, q, Sw, Lw, U, Press	P, T, q, Sw, Lw, U, Press	P, T, q, Sw, Lw, U, Press, CCOV	P, T, q, Sw, Lw, U, Press, CCOV	P, T, q, Sw, Lw, U, Press, CCOV	P, T, q, Sw, Lw, U, Press, CCOV
Prcp.	CRU (Mult.)	CRU (Mult., Wind Corr.)	CRU (Mult., Wind Corr.), TRMM(3hr)	GPCC, CU, CMAP, GPCP, PREC/L (Mult.)	CRU, GPCC (Mult., Wind Corr.)	GPCC (Mult., Wind Corr.), CU, GPCP-1DD (Non-parametric)
Temp.	CRU (Add.), Elev. Corr	CRU (Add.), Elev. Corr	CRU (Add.), Elev. Corr	CRU (Add.), Elev. Corr	CRU (Add.), Elev. Corr	CRU (Add.), Elev. Corr
RSDN, CCOV	SRB (Mult.)	SRB (Mult.)	SRB (Mult.)	SRB (Mult.)	Aerosol, SRB (Mult.)	SRB
RLDN	SRB	SRB	SRB	SRB	SRB	SRB
Spec. Hum., Pressure	Elev. Corr. only	Elev. Corr. only	Elev. Corr. only	Elev. Corr. only	Elev. Corr. only	Elev. Corr. only
Wind	No Corr.	No Corr.	No Corr.	No Corr.	No Corr.	No Corr.

+ Existing global forcing datasets shares a small pool of global monthly observations, mostly, CRU (Tair, Prcp), GPCC (Prcp), SRB (SW/LWdown)

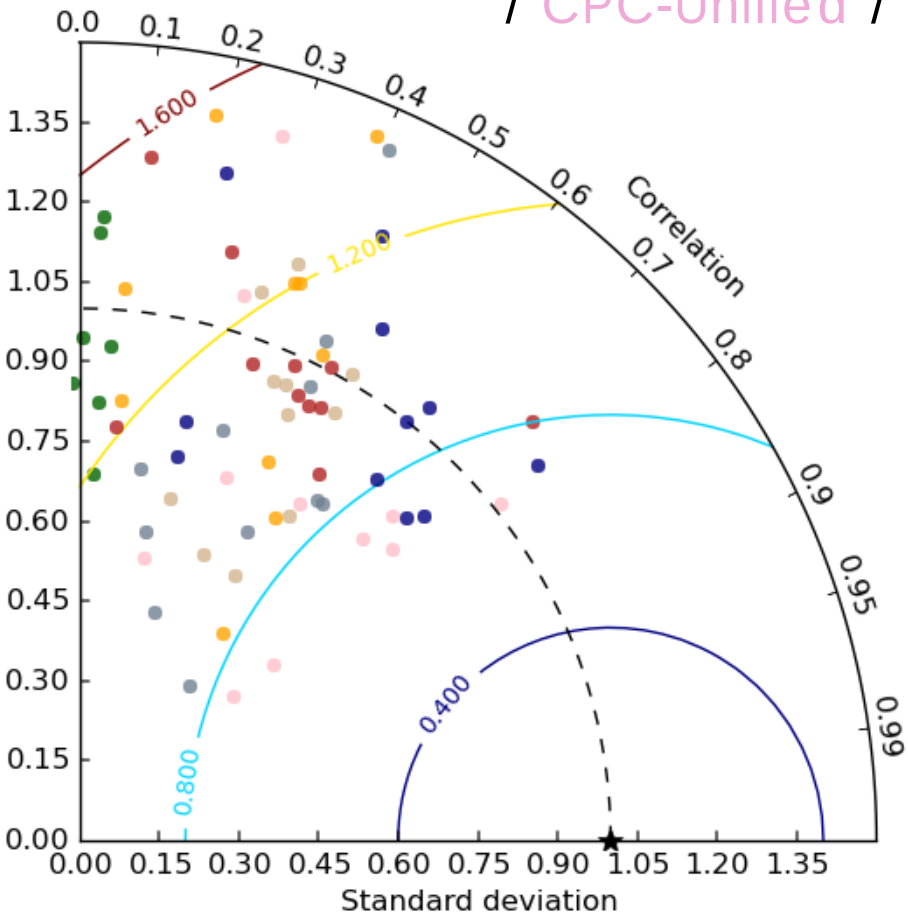
Data Quality Evaluation: Tair and Precipitation

+ 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.

2m Temperature / GSWP3 / / GSM248 / / 20CR / / Princeton / / WFD /

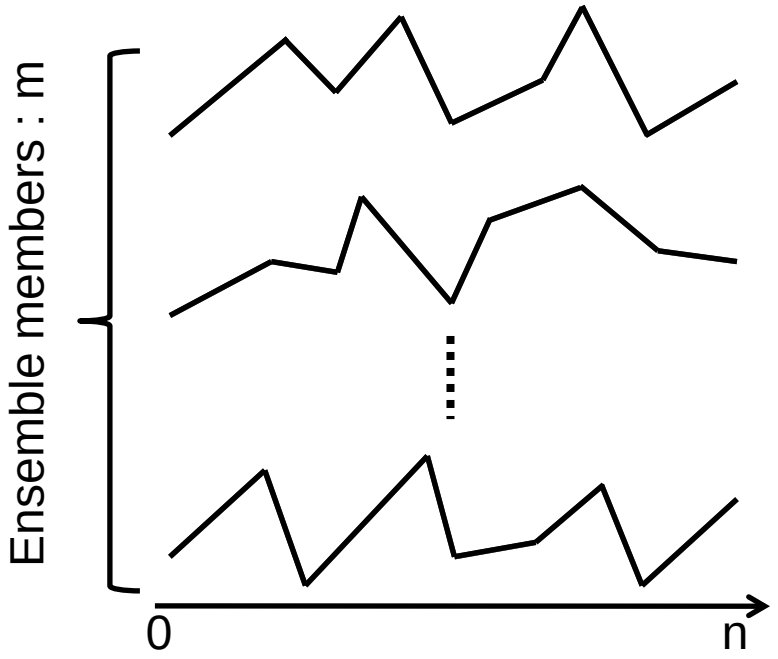


Precipitation / GPCP1DD / / CPC-Unified /



Similarity Index: Ω

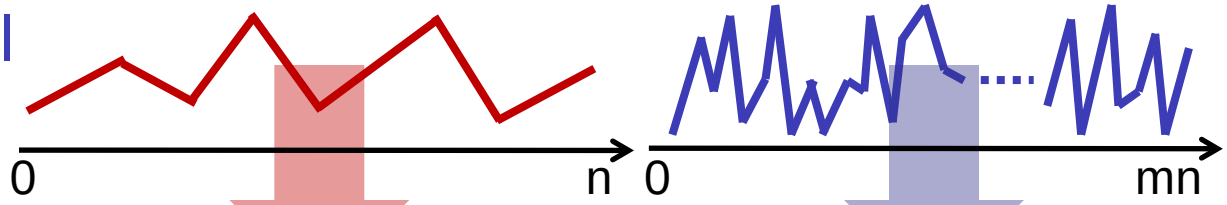
Ω : Index to measure the **similarity** of individual time series of ensemble members [*Koster et al., 2000*]



Very different

-0 ~ 1

Identical



$$\Omega_a = \frac{m\sigma_{\hat{a}}^2 - \sigma_a^2}{(m-1)\sigma_a^2}$$

$$\sigma_{\hat{a}}^2 = Var[\frac{1}{m}\sum_{i=1}^{m} a_{ij}]$$

Mean Variability

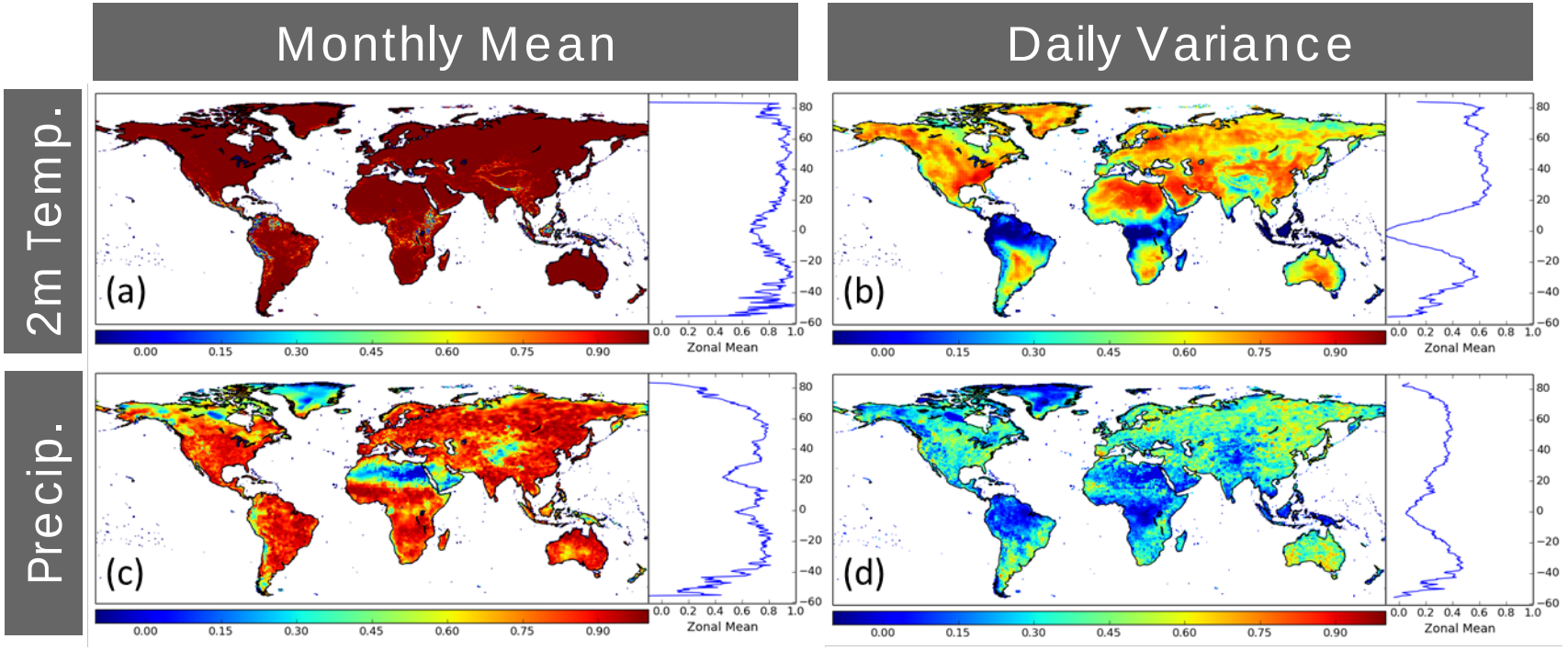
$$\sigma_a^2 = Var[a_{ij}]$$

Total Variability

Similarity between Ensemble Forcing Variables

+ 4 Datasets: CRUNCEP, WFD+WFDEI, Princeton, and GSWP3

Global distribution of the similarity index (Ω) for 2001-2010



+ Similarity of temperature fields is higher than of precipitation possibly because of single reference data (CRU) and a better skill of current GCMs.

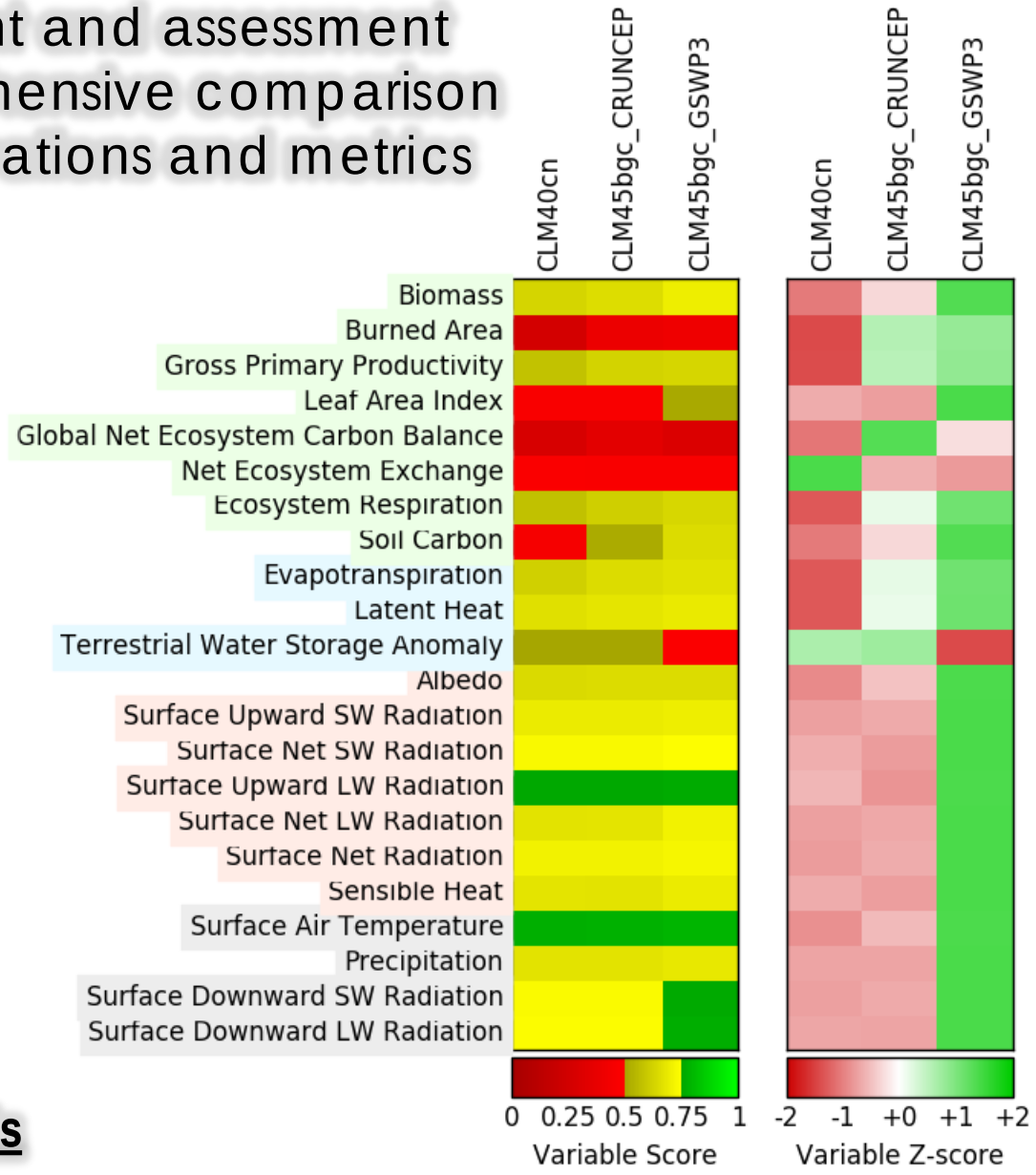
+ Since sharing observations to correct monthly bias, higher similarities are found in monthly mean fields than daily variance.

ILAMB: International Land Model Benchmark

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

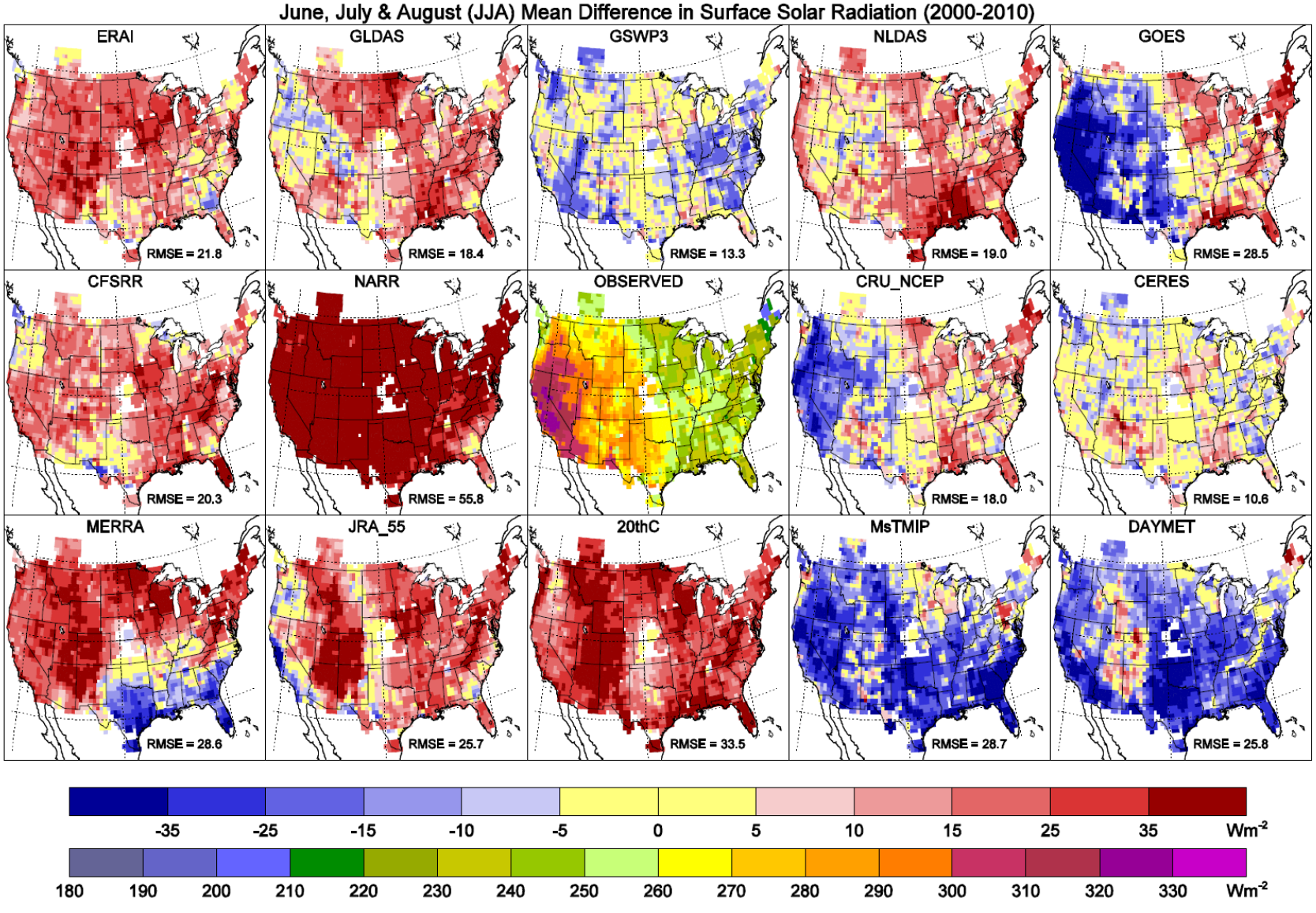
* C-cycle (8): Above ground live biomass, burned area, CO2, GPP, LAI, global net ecosystem carbon balance, NEE, ER, soil carbon
* W-cycle (6): ET, LE, S, R, evaporative fraction, TWSA
* E-cycle (6): albedo, SWup, SWnet, LWup, LWnet, Rnet
* Forcing (5): Tair, precipitation, RH, SWdown, LWdown

Integrates 25 variables in 4 categories from ~60 datasets



Preliminary Results and Known Problems

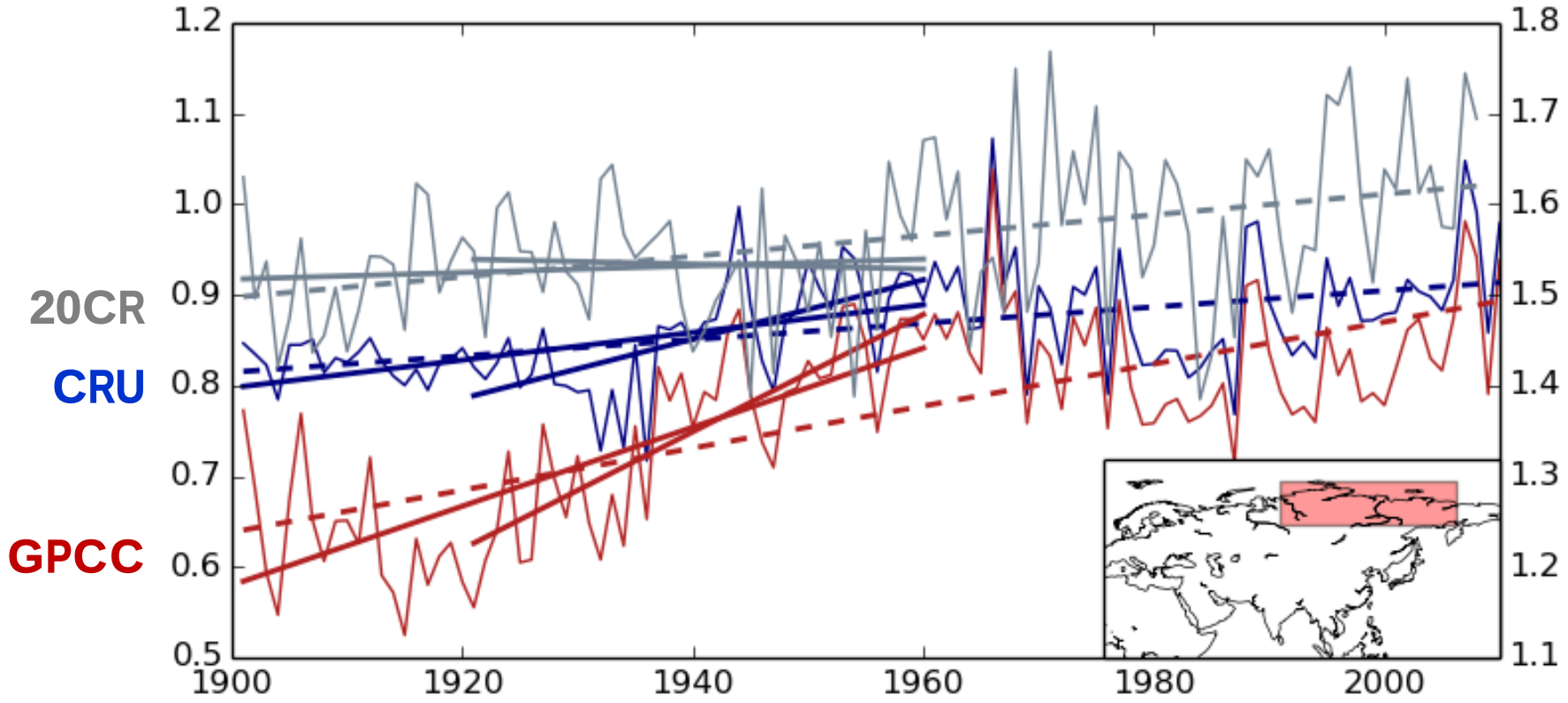
+ Relatively small bias of solar radiation



Slater, 2015

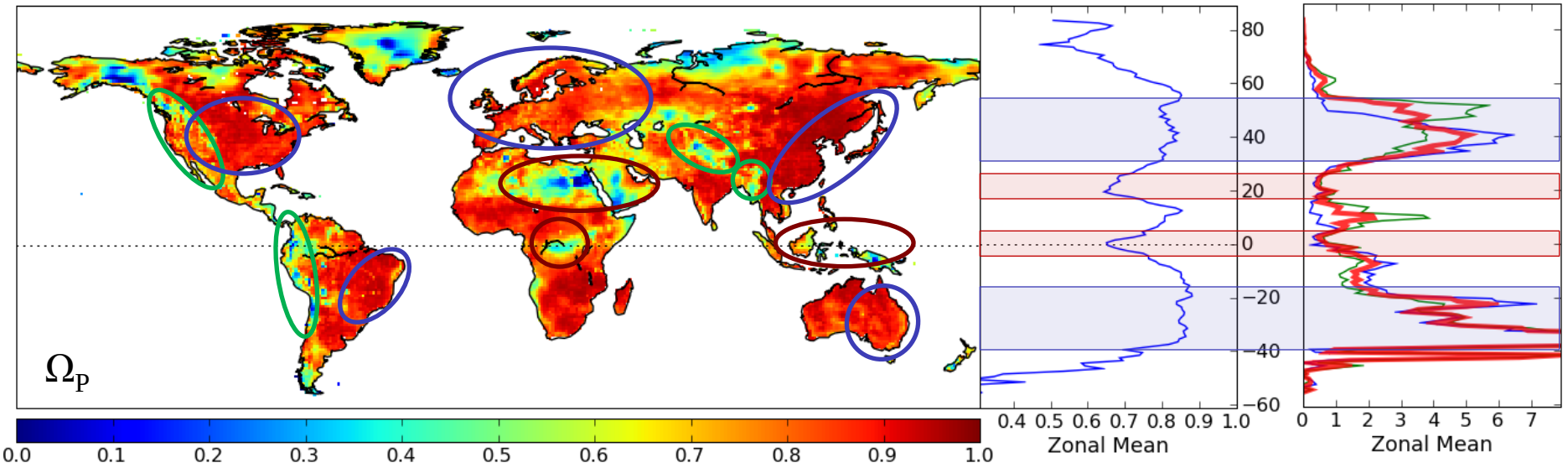
Preliminary Results and Known Problems

+ Spurious(?) trend at high latitude in early 20th Century



	Mean	1920-1960	1901-1960	1901-2010
20CR	1.56	-0.0003	0.0004	0.0011
GPCC	0.77	0.0064	0.0044	0.0023
CRU	0.86	0.0033	0.0015	0.0009

Uncertainty in Input Data: Precipitation



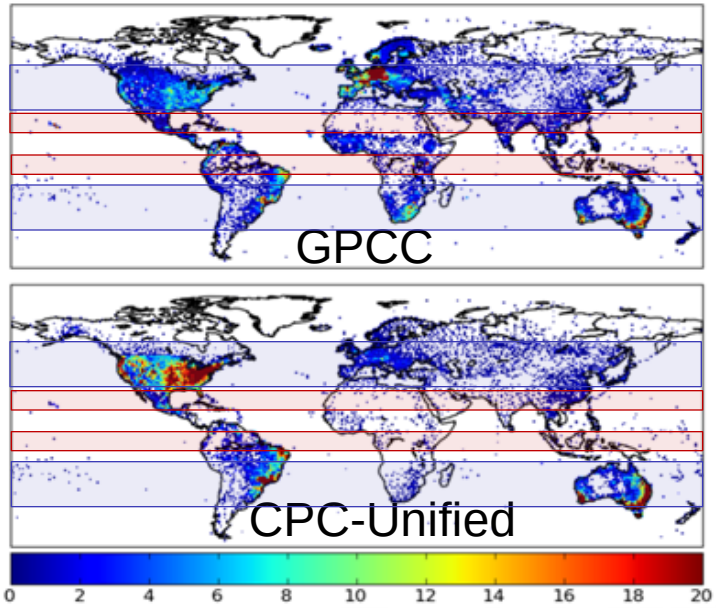
1. Non-uniform Rain Gauge Distributions

Minimum rain gauge density is required to prevent the effect of poor forcing precipitation

[*Oki et al., 1999*]

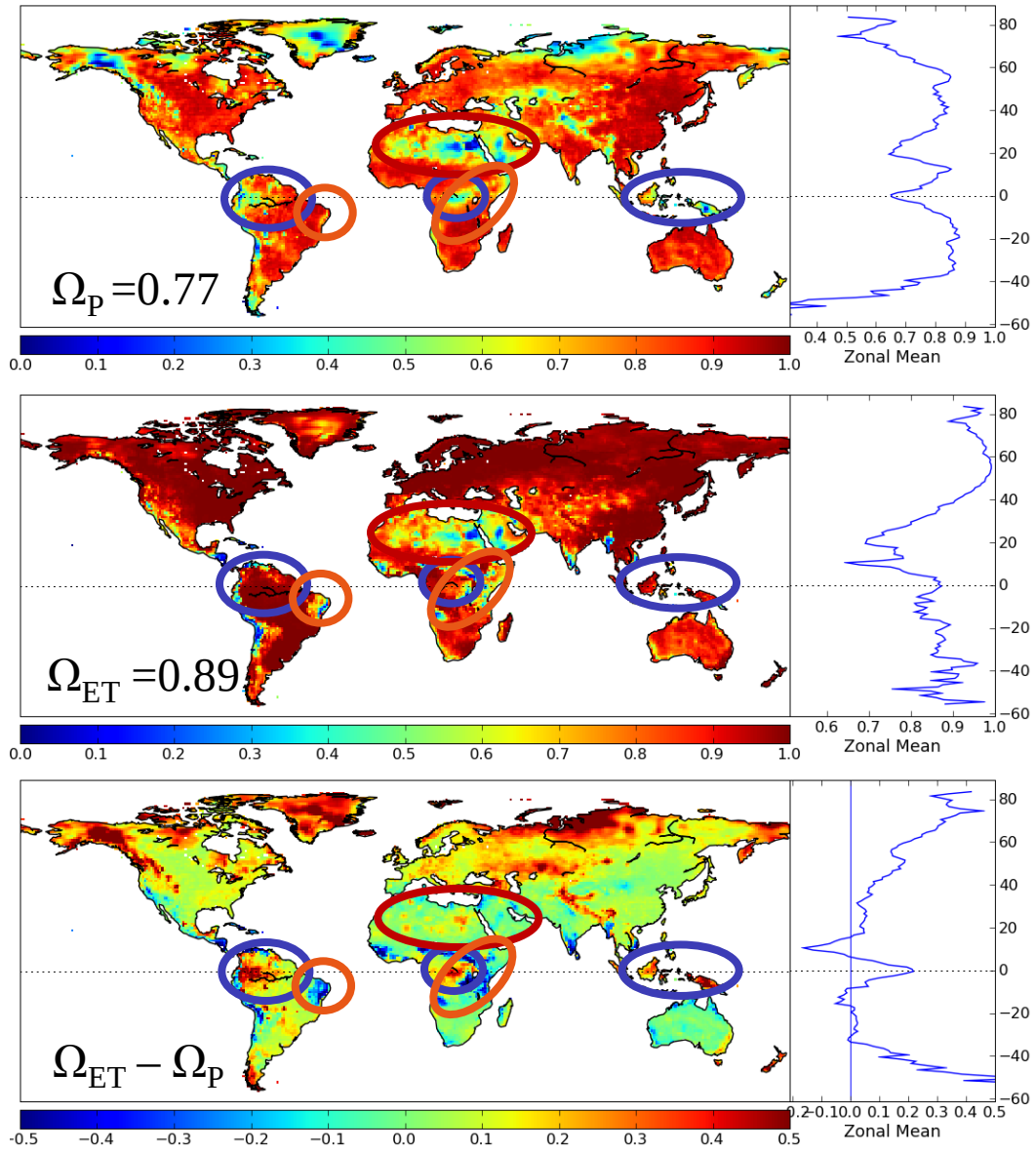
2. Different Methodologies

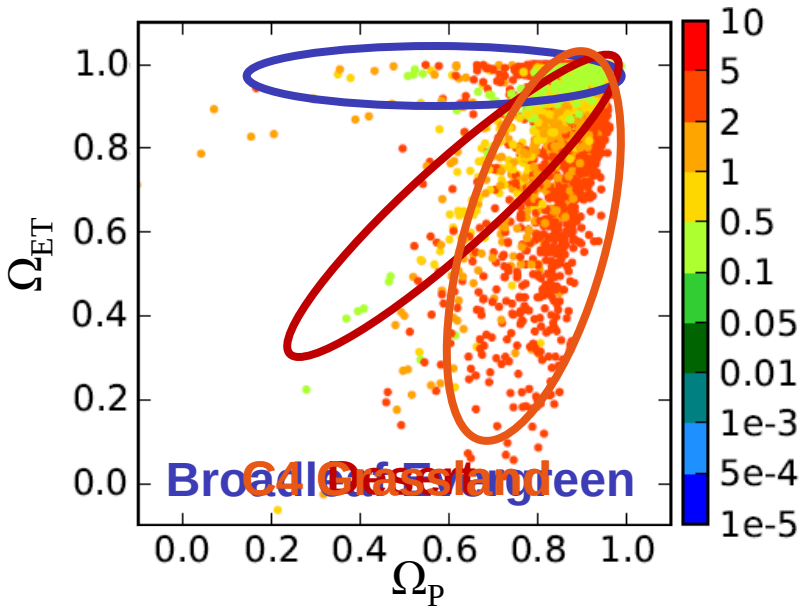
Effects of spatial resolutions, measurement types, and interpolation schemes are emphasized in complex terrain.



Kim et al., 2010

Uncertainty Propagation : Evapotranspiration





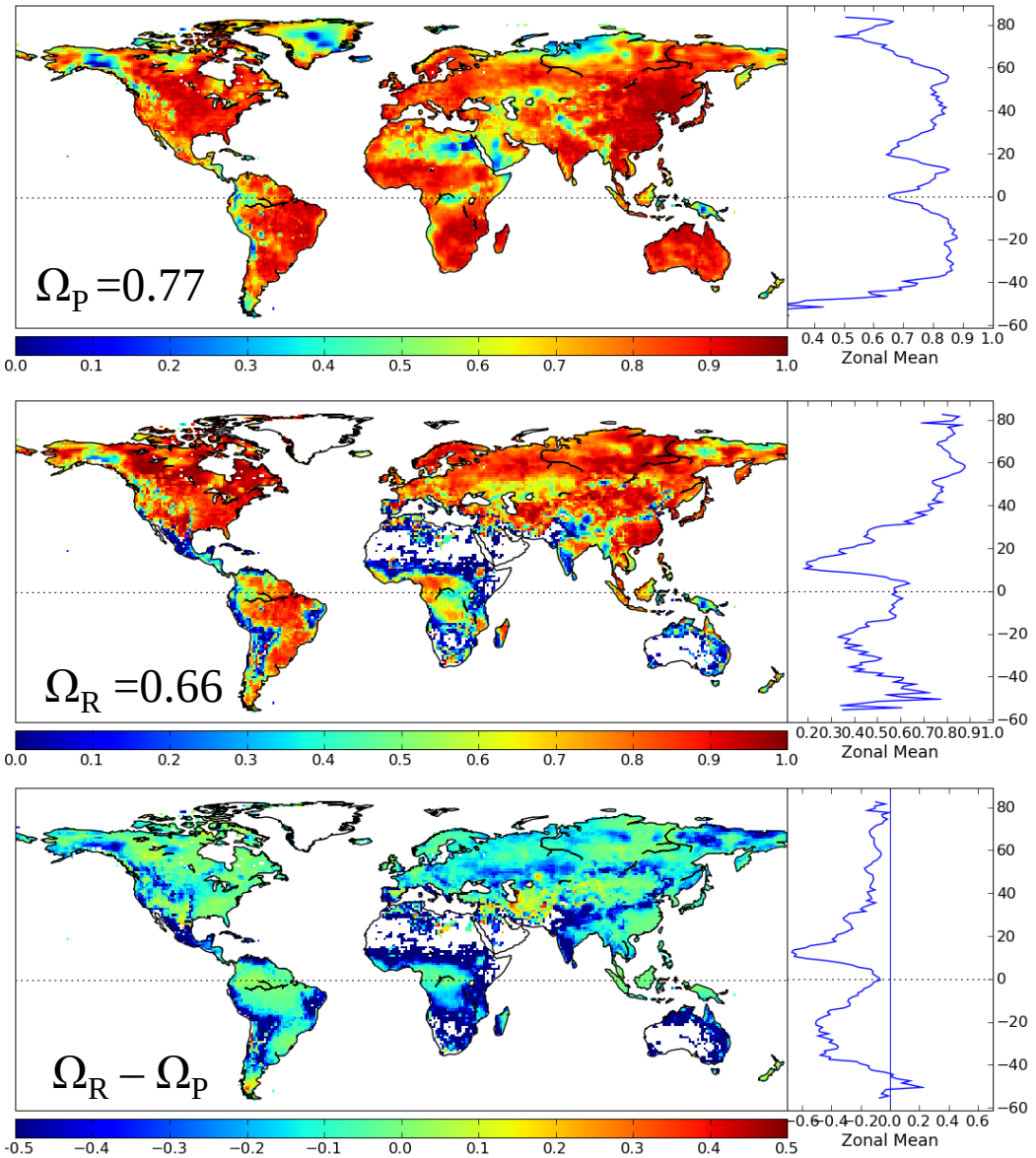
Wet region (*Energy constrained*)
Ω_{ET} is ***insensitive*** to Ω_P

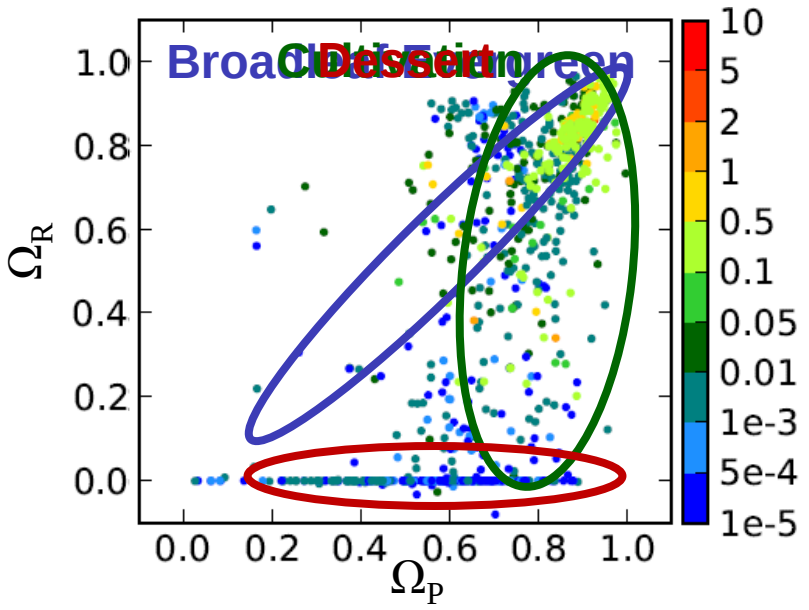
Dry region (*Water constrained*)
Ω_{ET} is ***proportional*** to Ω_P

Semi-arid region
Ω_{ET} is ***sensitive*** to Ω_P

Kim et al., 2010

Uncertainty Propagation : Runoff





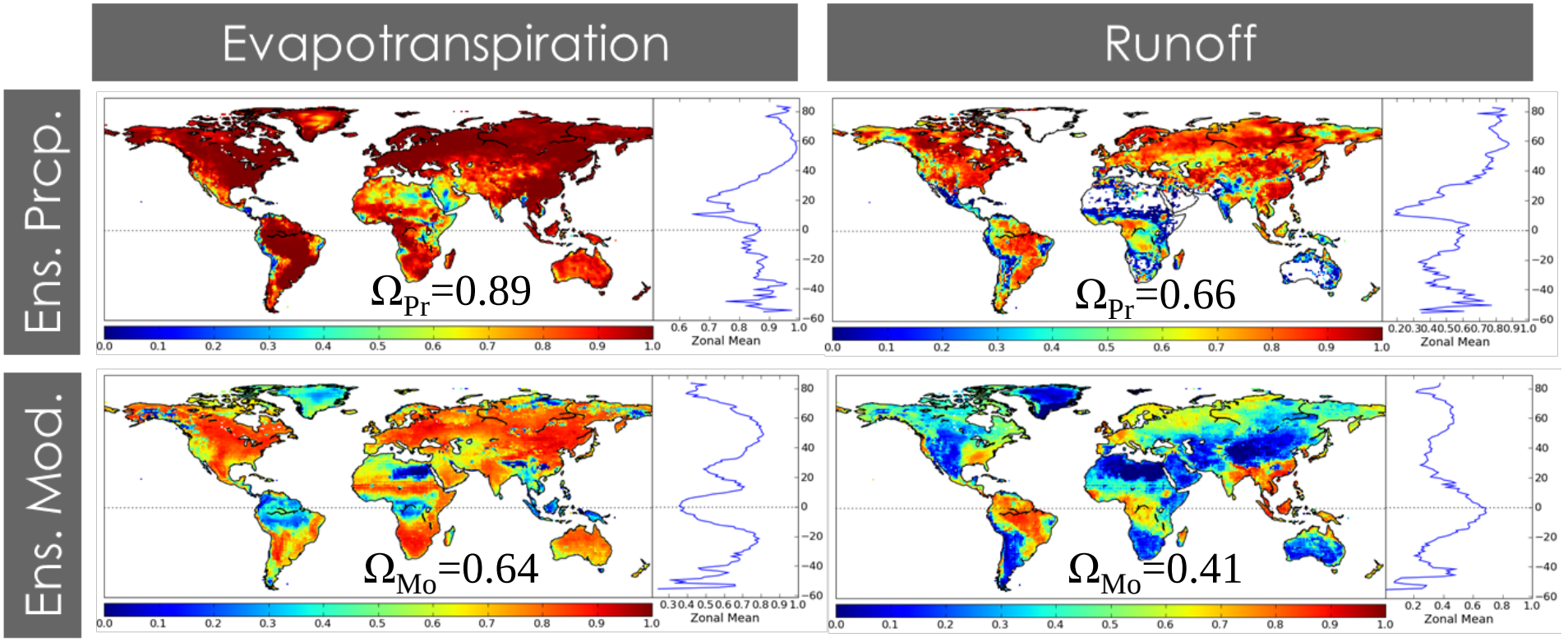
Wet region (*High soil moist.*)
Ω_R is ***proportional*** to Ω_P

Very dry region (*Low soil moist.*)
Ω_R is ***insensitive*** to Ω_P

Moderate region
Ω_R is ***very sensitive*** to Ω_P

Kim et al., 2010

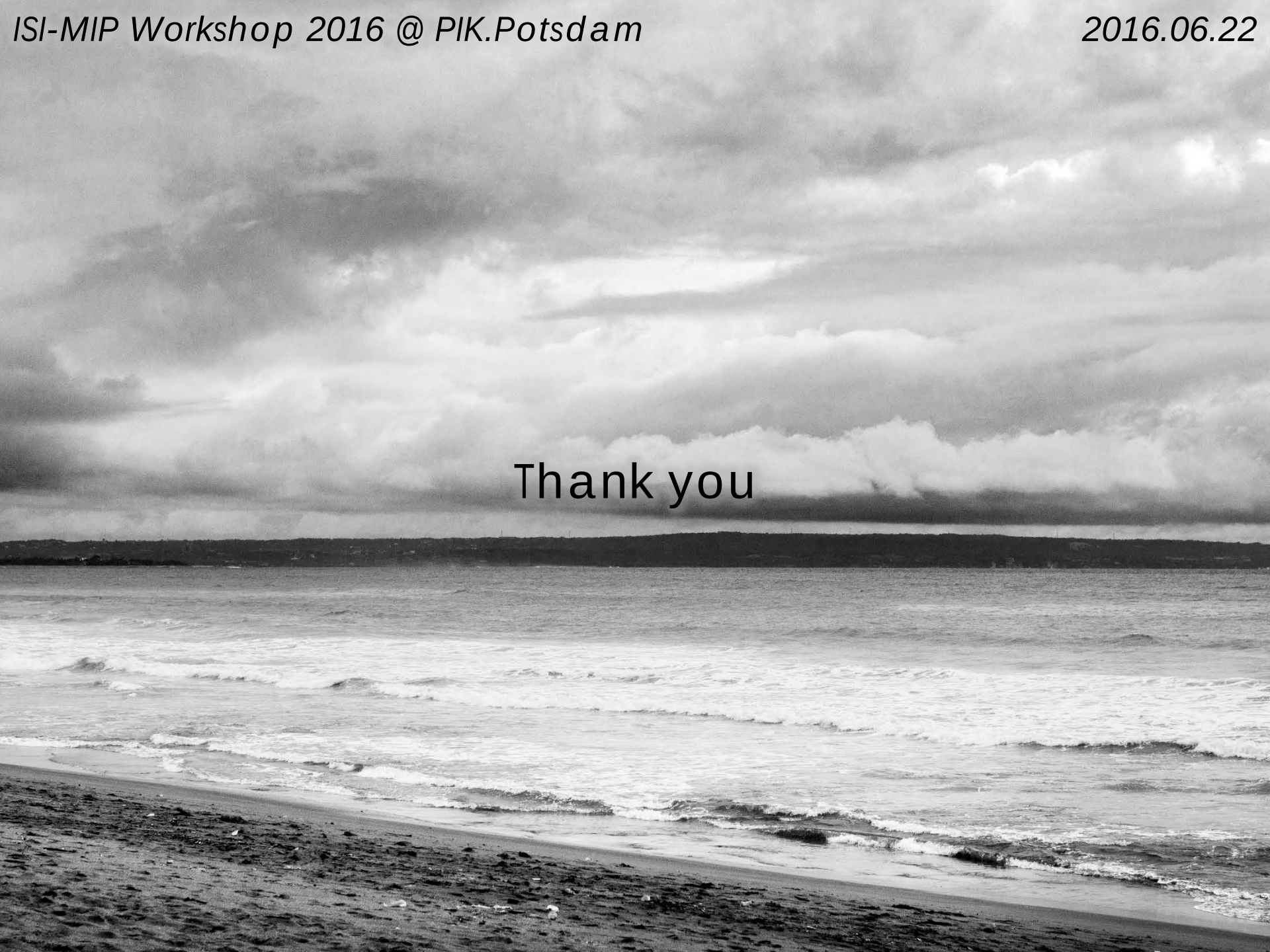
Simulation Uncertainty – model vs input data –



Kim, 2010

Uncertainty in precipitation translates into evapotranspiration in a reduced way, but into runoff in an amplified way.

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.


Thank you