

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

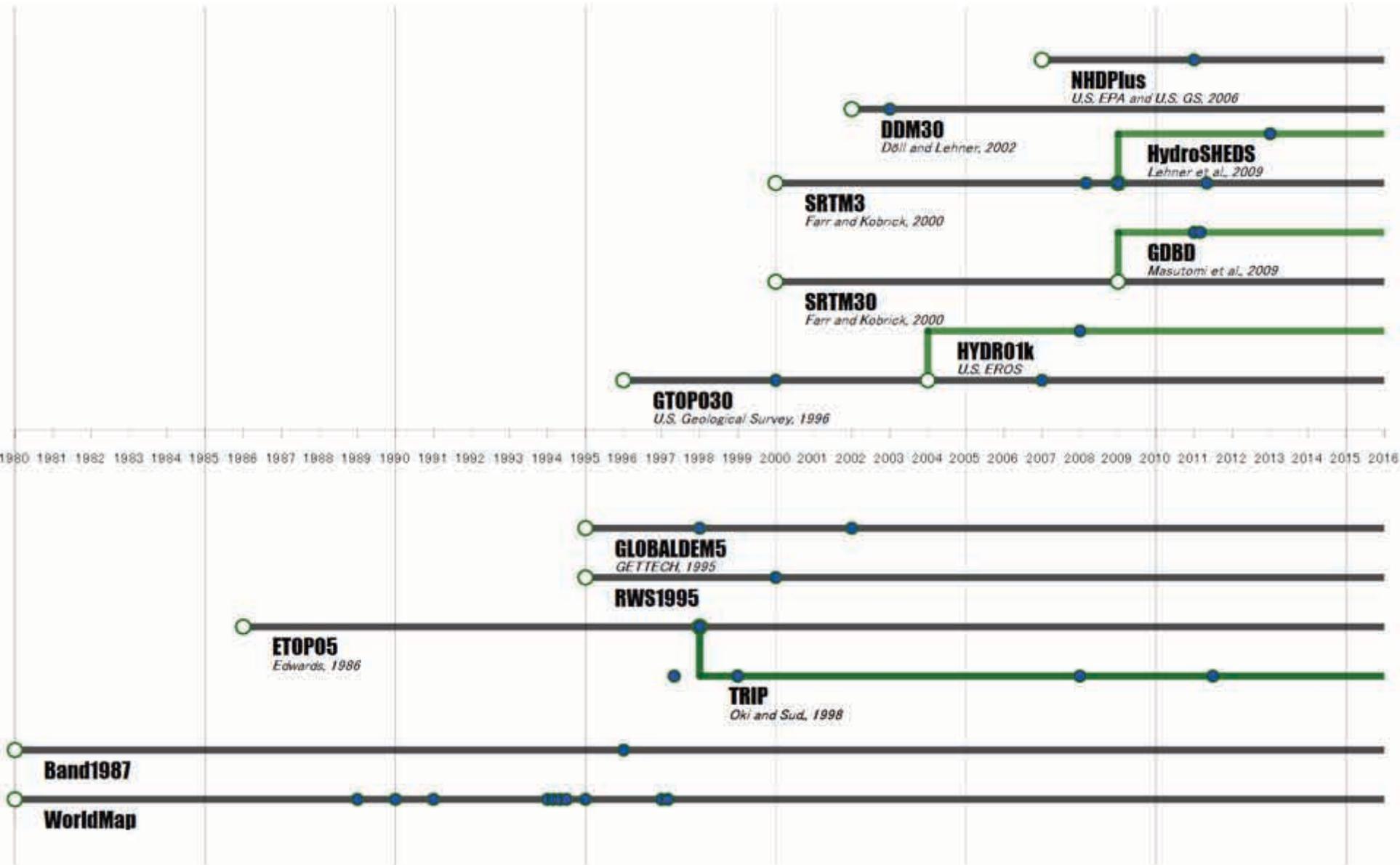
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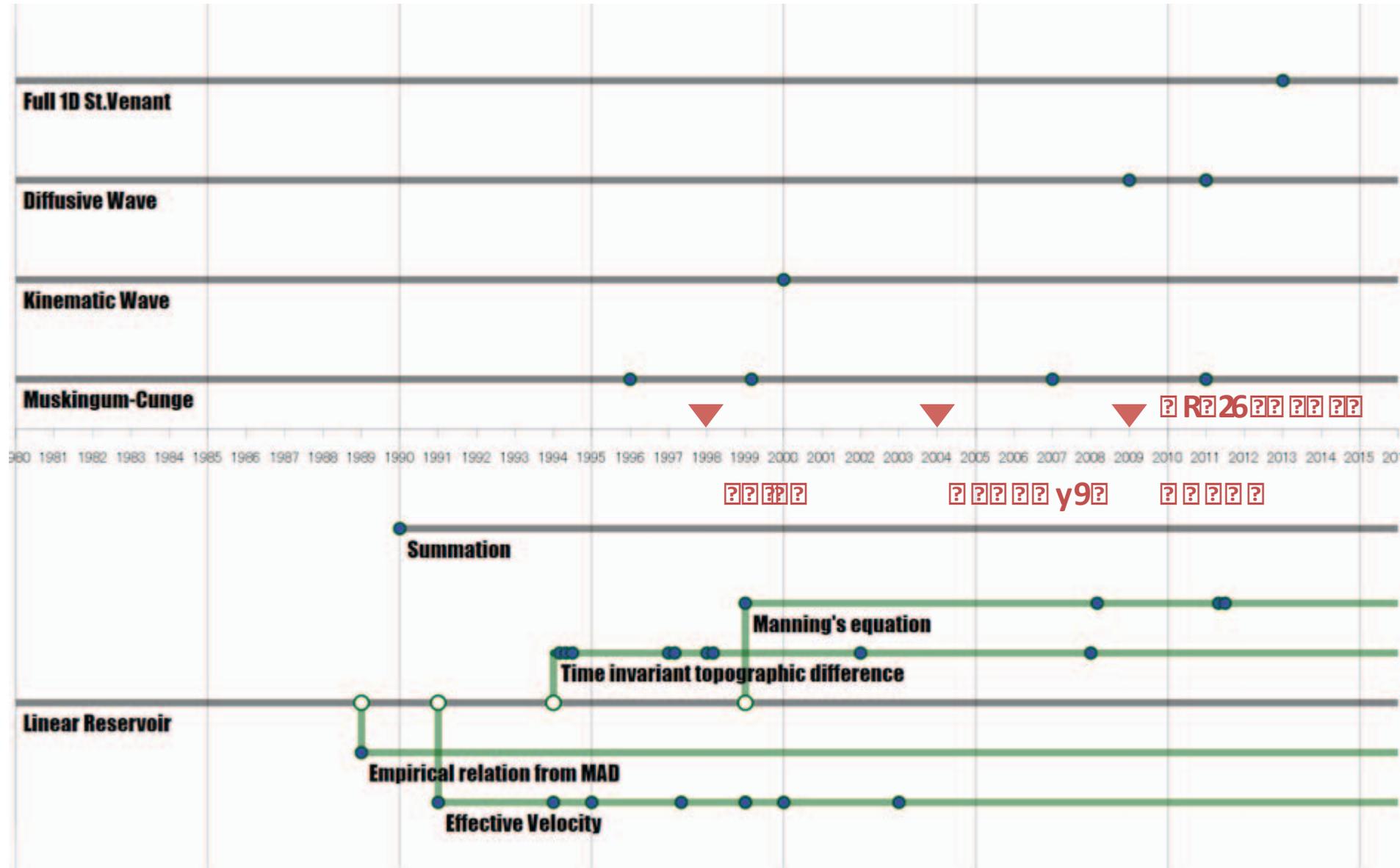
& Thanks to : Tomoko Nitta, Yuta Ishitsuka, Dai Yamazaki, Naota Hanasaki,  
Tomohito Yamada, Kei Yoshimura, Taikan Oki



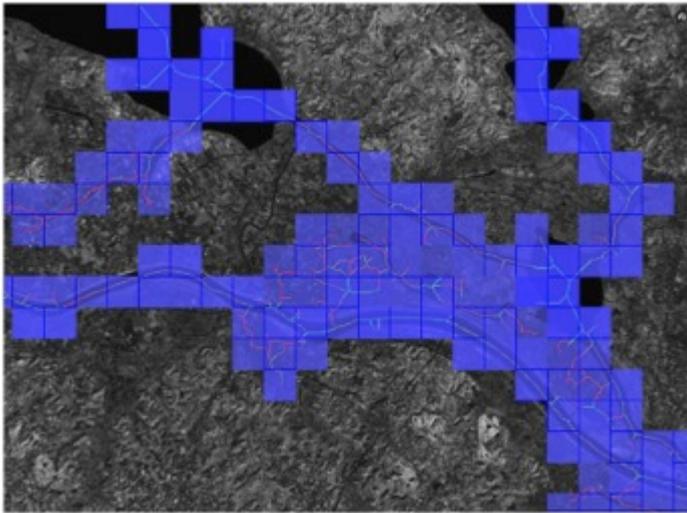
# River Network and Routing Scheme Development



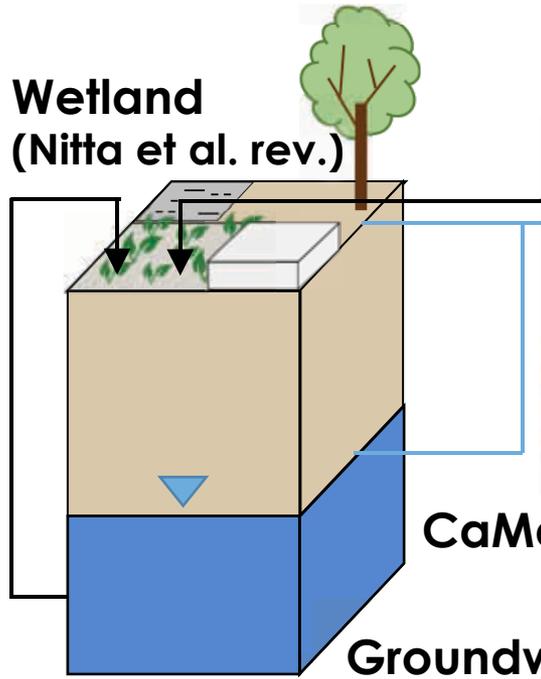
# River Network and Routing Scheme Development



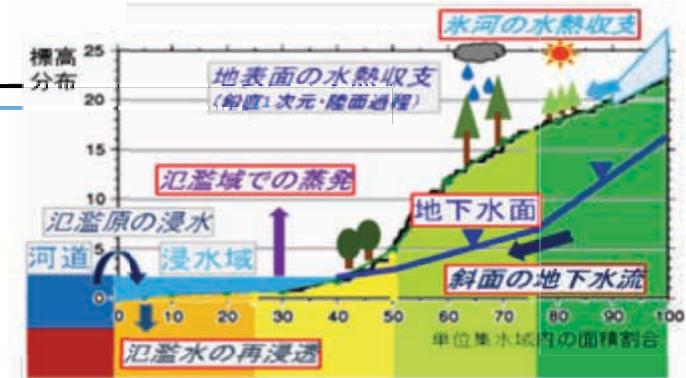
**TRIP (Oki and Sud, 1998)**  
based on ETOPO5, global 0.5°



**MATSIRO (Takata et al. 2003)**  
SiB2 + TOPMODEL

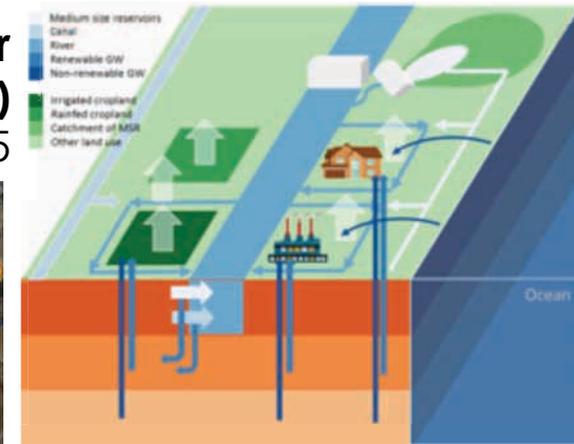


**STRIP (Oki et al. 1999)**  
linear reservoir type  
**Reservoir (Hanasaki et al. 2006)**



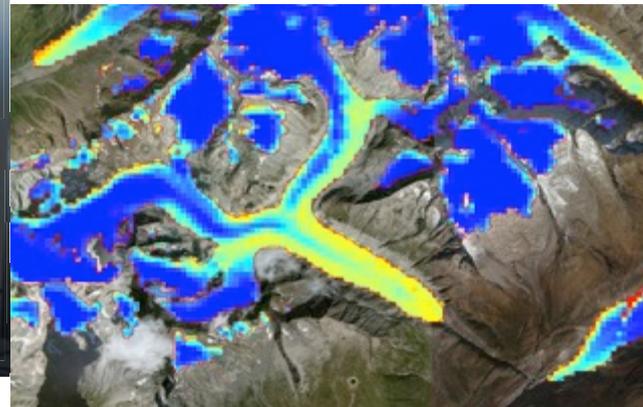
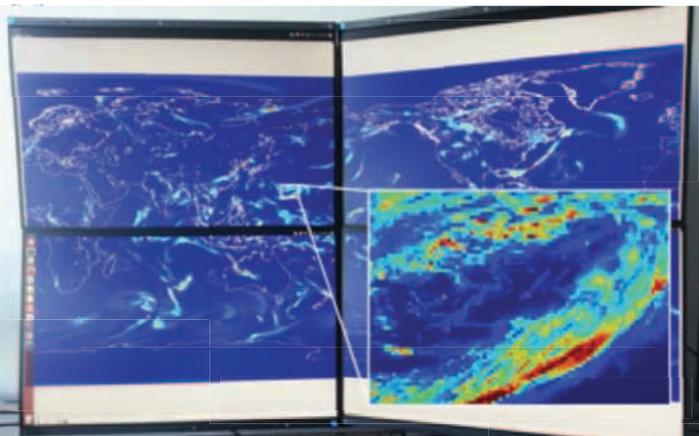
**CaMa-Flood (Yamazaki et al. 2011)**  
Inundation + Diffusive wave

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



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

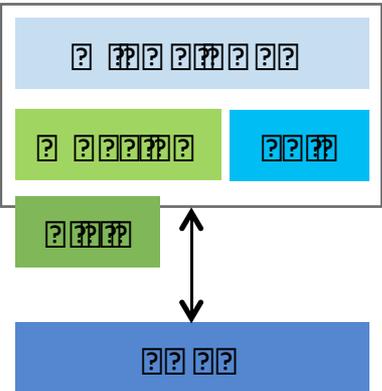
**FLOW (Yamazaki et al. 2009)**  
based on SRTM30, flexible res.



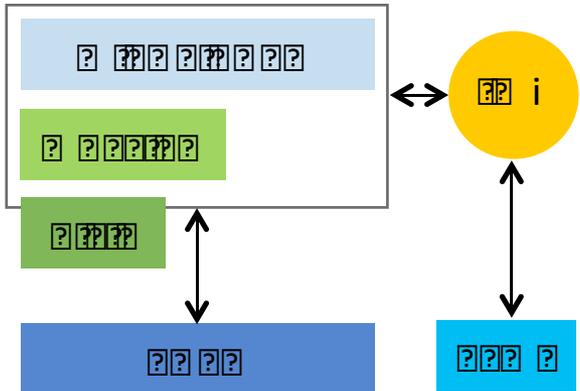
**ELSE (Kim et al. 2009)**  
based on JRA25 and multiple precipitations, global 1.0°

# Structure of MIROC-ESM and Development Plan

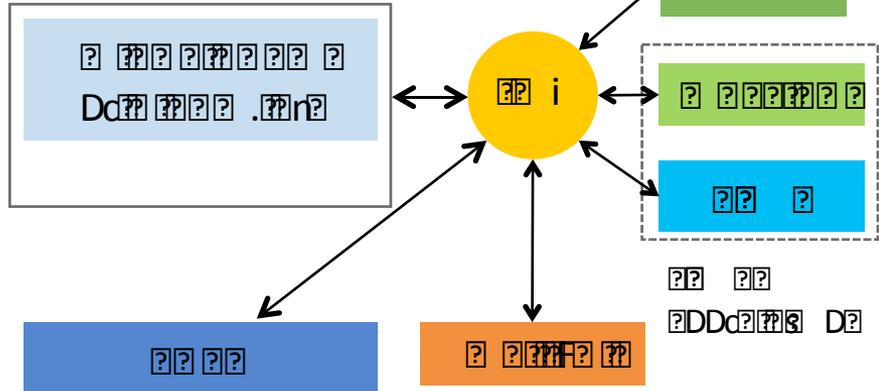
MIROC-ESM Development Plan



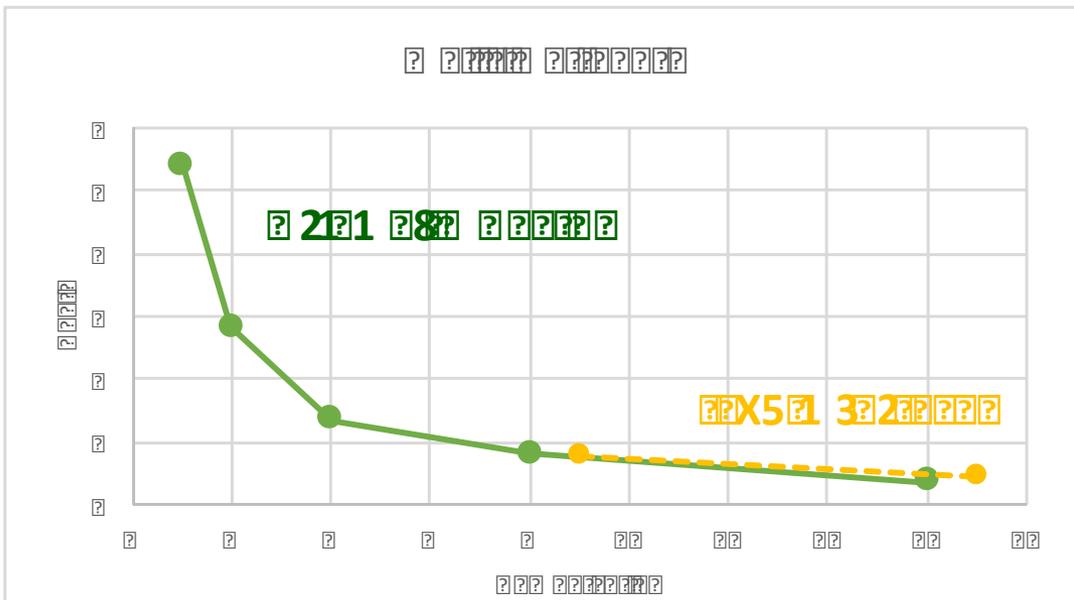
MIROC-ESM Development Plan



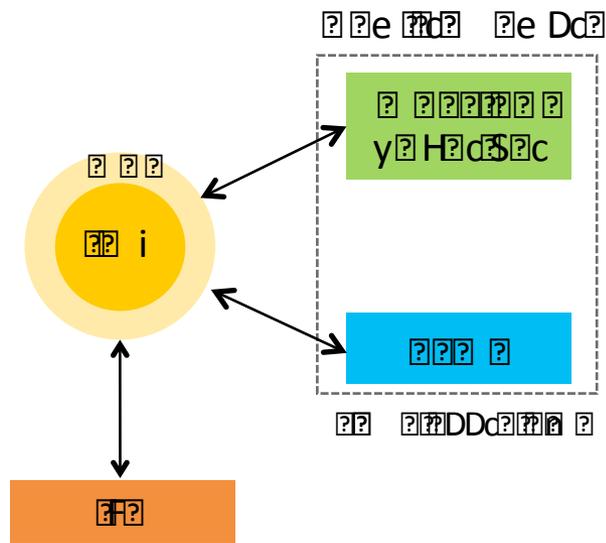
MIROC-ESM Development Plan



MIROC-ESM Development Plan

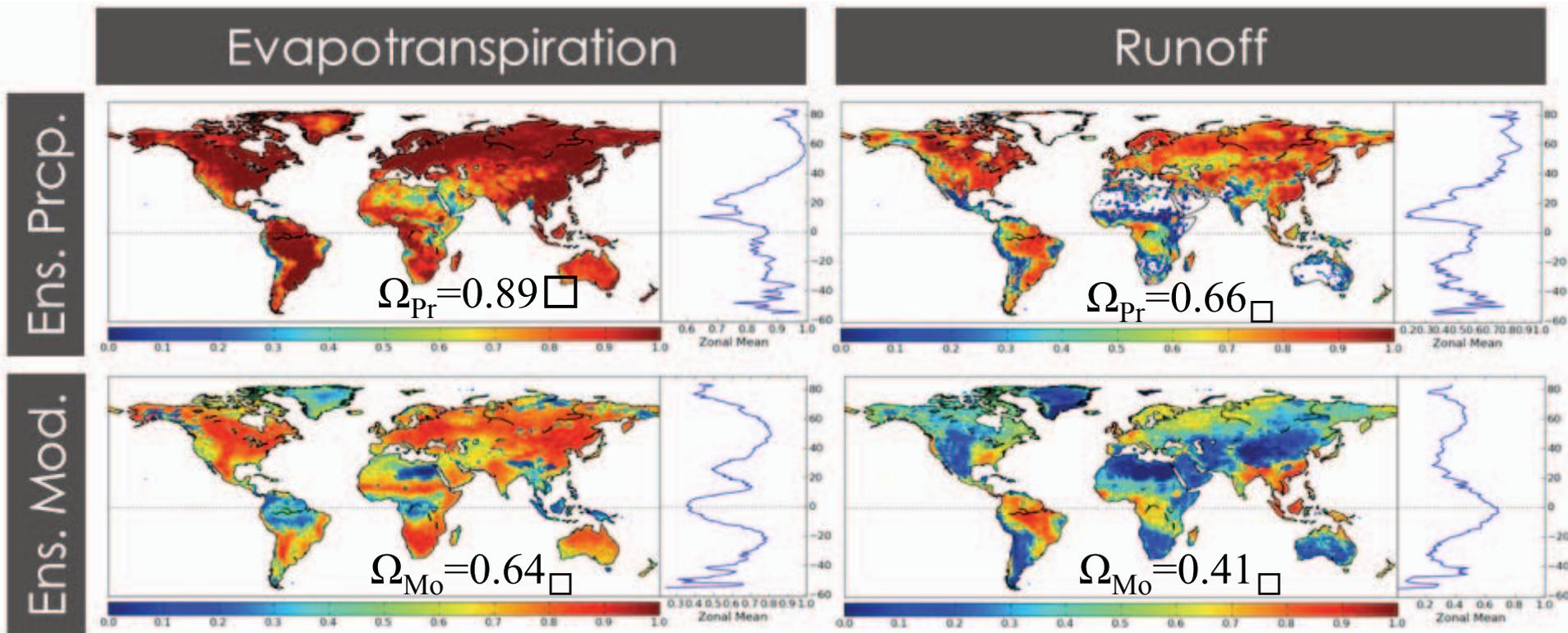


MIROC-ESM Development Plan





# 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 ( $\square$ ) 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

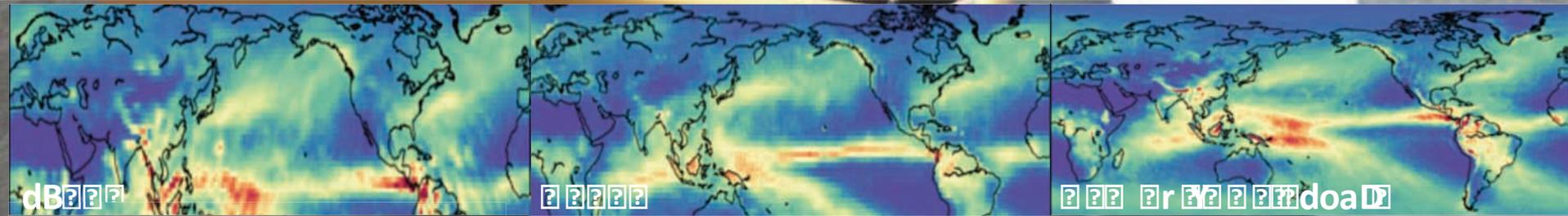
- \* LDMF Daily Correction (Kim et al., in prep.)
- \* Parametric Monthly Correction (Watanabe et al., 2012)

**GSWP3  
LS3MIP  
Forcing**

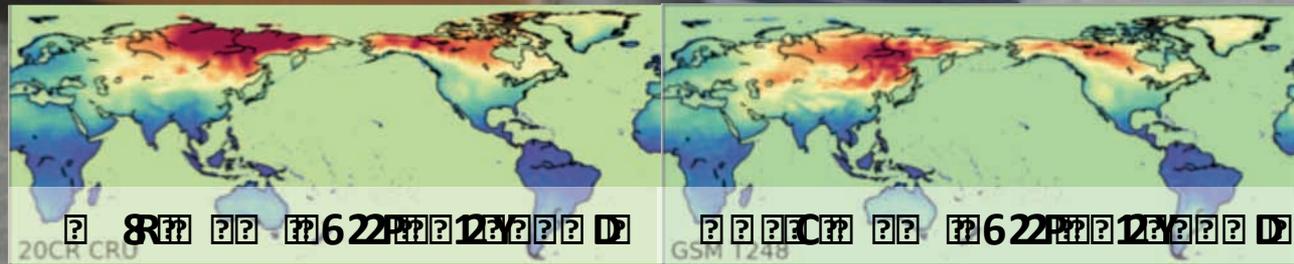
20CR (Compo et al., 2011)  
1871-2010 6hr / 2°x2°(91x180)

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

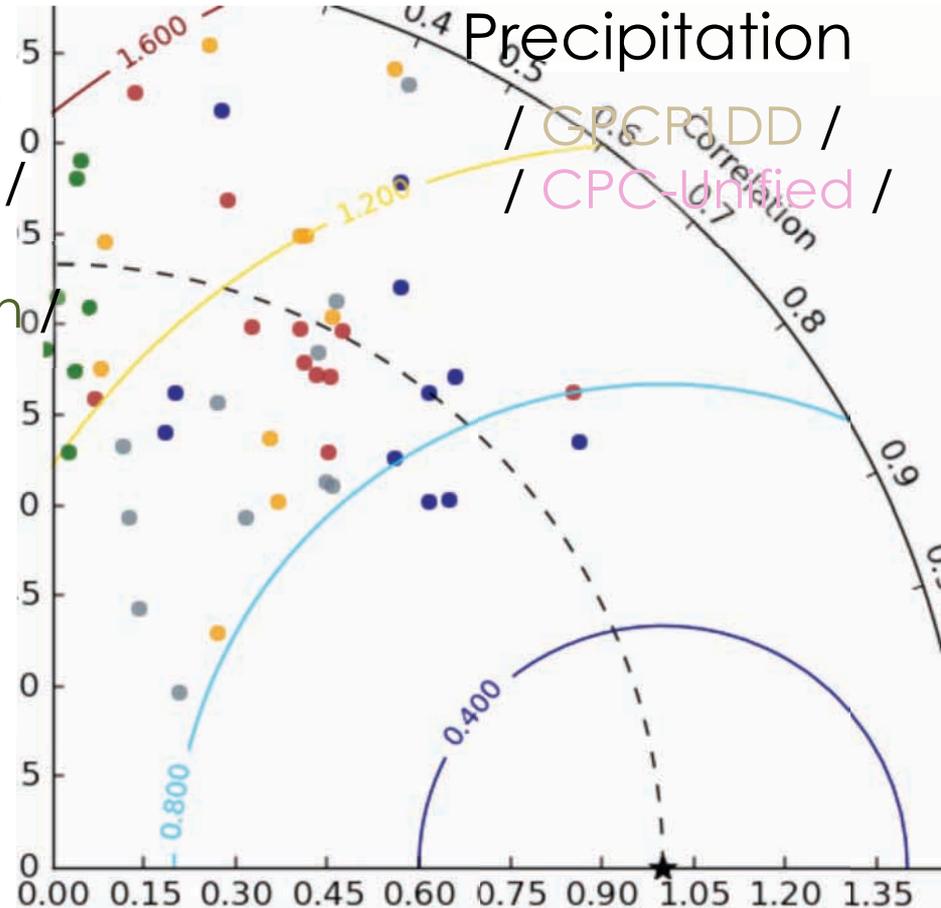
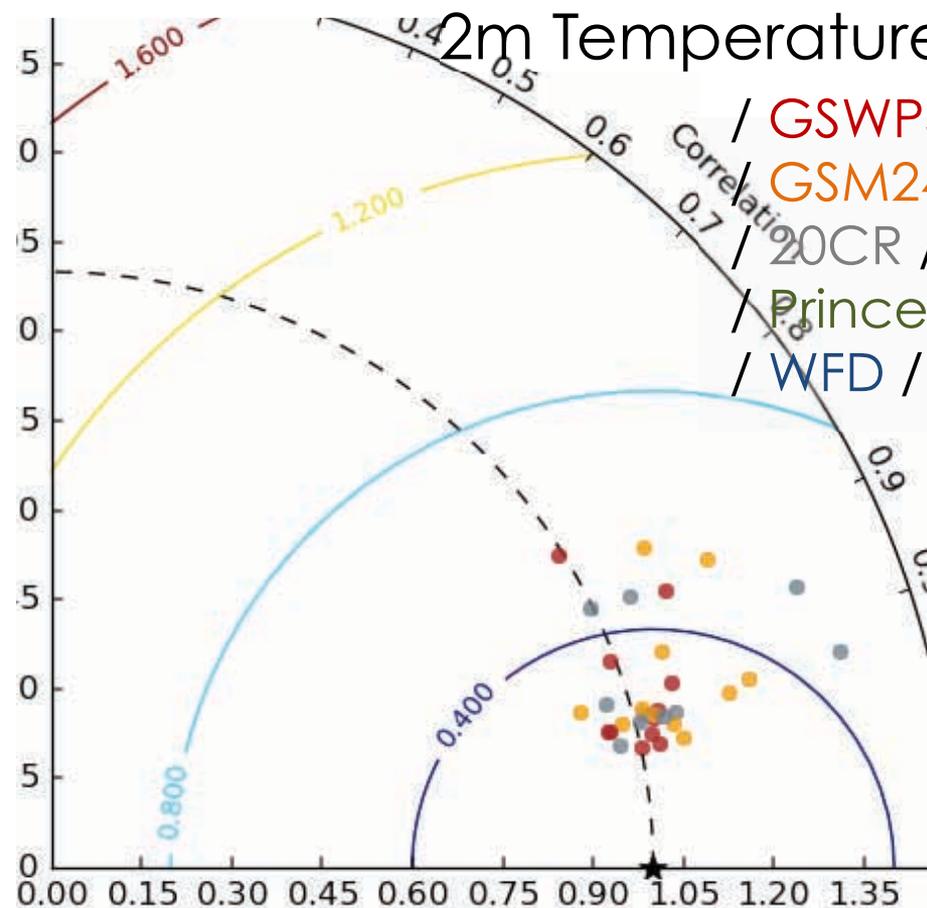


# Comparison Table for Existing Forcing Data

	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	<b>1851-2011</b> <b>161 years</b>
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	<b>20CRv2c</b> <b>1851 - 2011</b> 2 deg. / 6hr
Spa. Dis-aggregation	Bi-linear	Bi-linear	Bi-linear, Bayesian	Bi-linear	Bi-linear	<b>Dynamical Downscale</b>
Temp. Dis-aggregation	N/A	Variability from Obs.	Variability from Obs.	N/A	Variability from Obs.	<b>Dynamical Downscale</b>
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) & <b>Daily</b> <b>(Non-para.)</b>

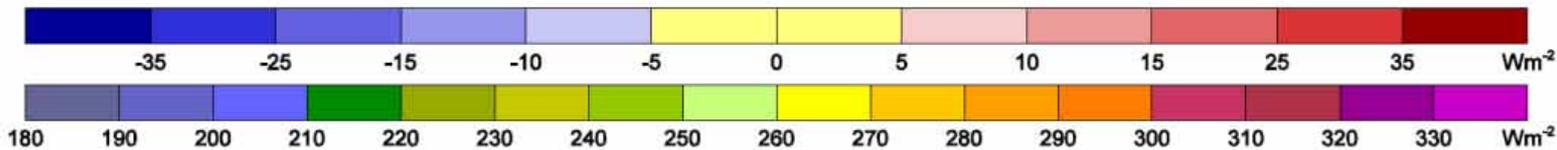
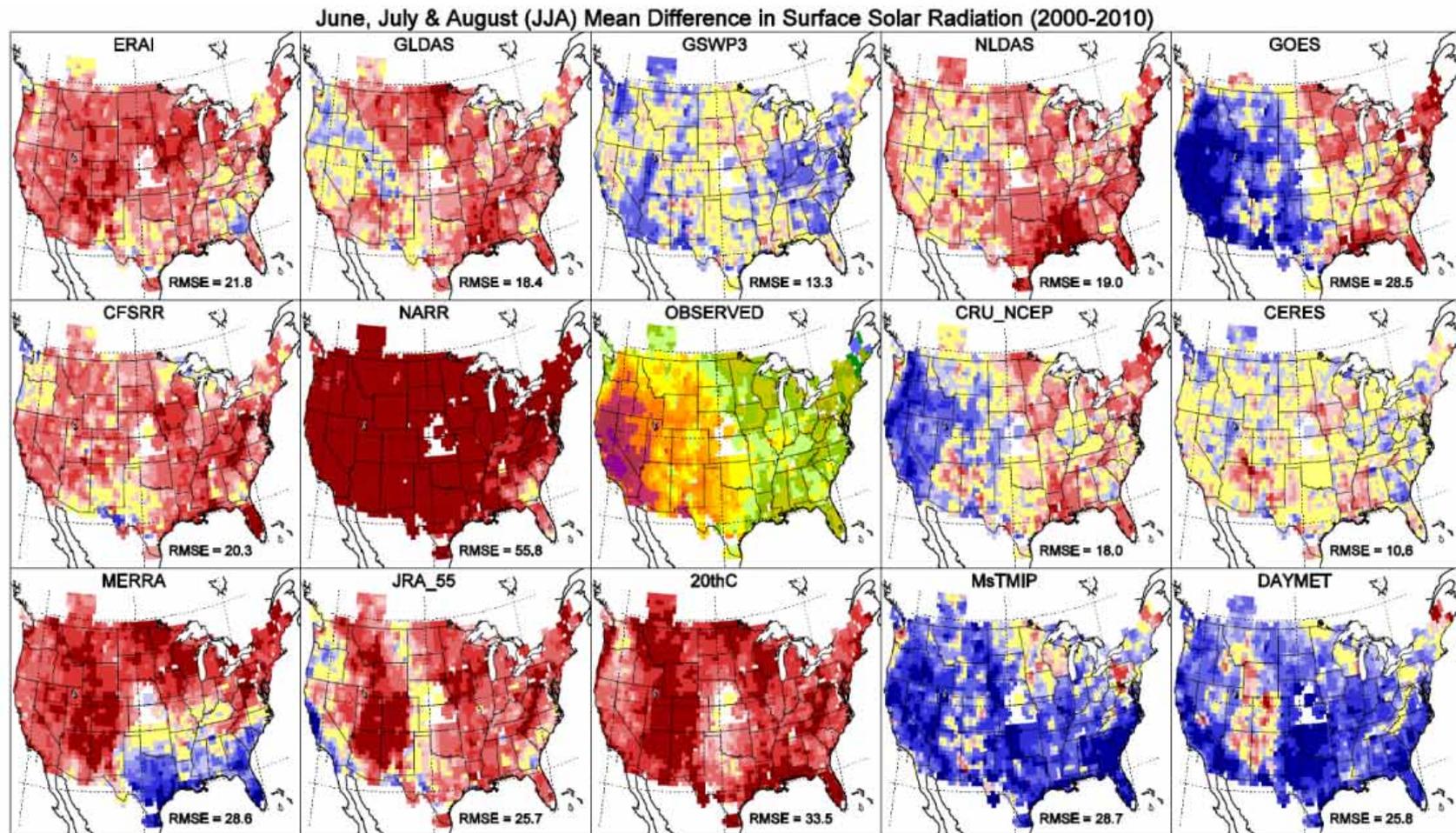
# Data Quality Evaluation

- + 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



# ILAMB: International Land Model Benchmark

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

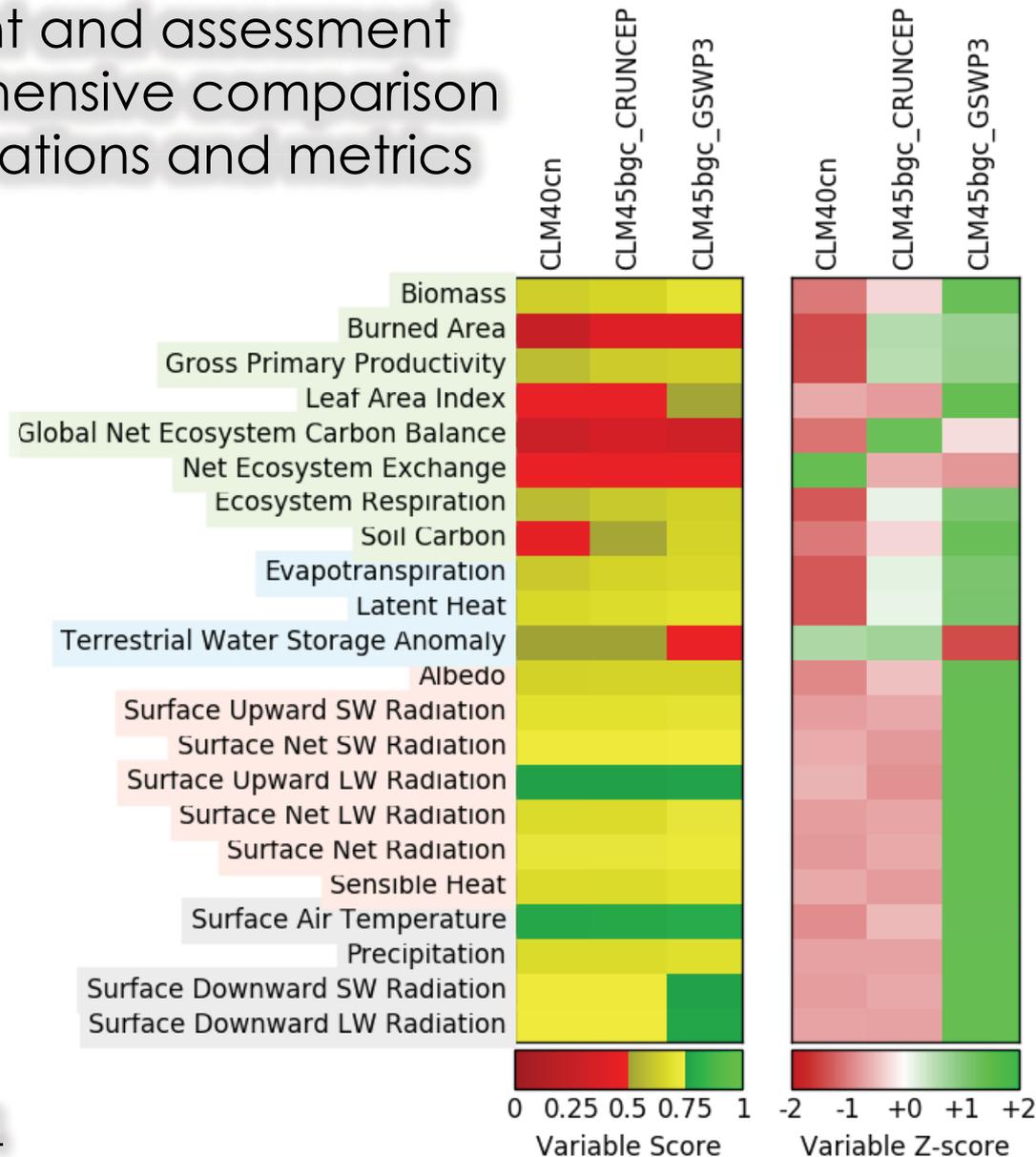
\* C-cycle (8): Above ground live biomass, burned area, CO<sub>2</sub>, GPP, LAI, global net ecosystem carbon balance, NEE, ER, soil carbon

\* W-cycle (6): ET, LE, S, R, evaporative fraction, TWSA

\* E-cycle (6): albedo, SW<sub>up</sub>, SW<sub>net</sub>, LW<sub>up</sub>, LW<sub>net</sub>, R<sub>net</sub>

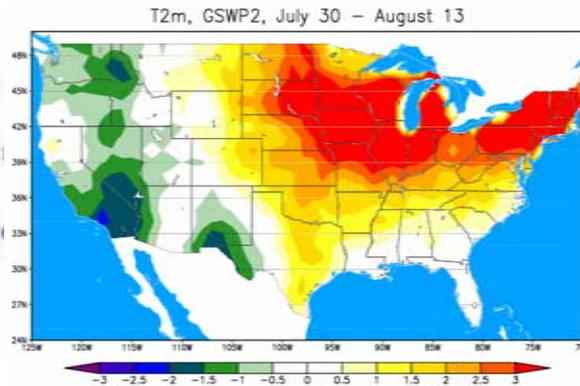
\* Forcing (5): T<sub>air</sub>, precipitation, RH, SW<sub>down</sub>, LW<sub>down</sub>

**Integrates 25 variables in 4 categories from ~60 datasets**

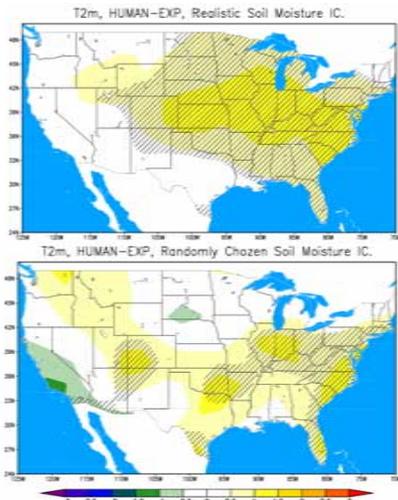


# Land-atmosphere Interaction in a Global Climate Model in Association with Human Activities

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

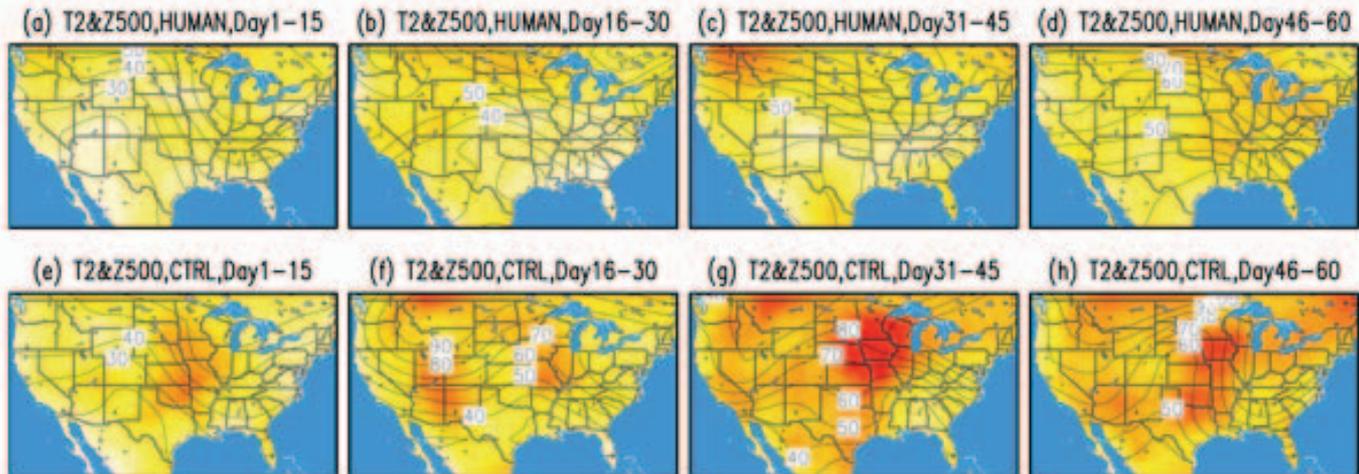


+ Sub-seasonal forecast skill for near surface air temperature (Day16-30) was improved by using realistic land initializations in the fully coupled AGCM with surface-groundwater-human models.

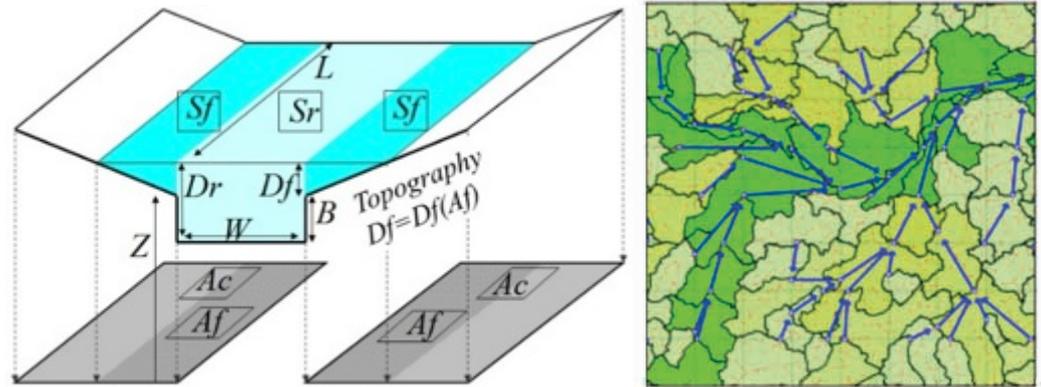
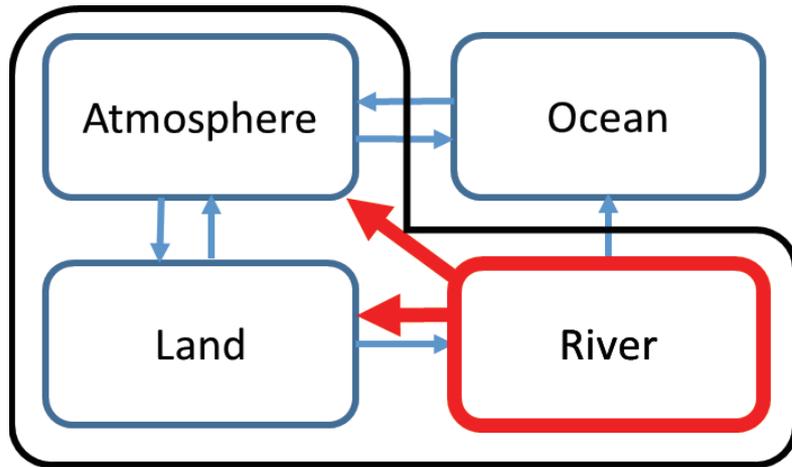


With HI

W/O HI



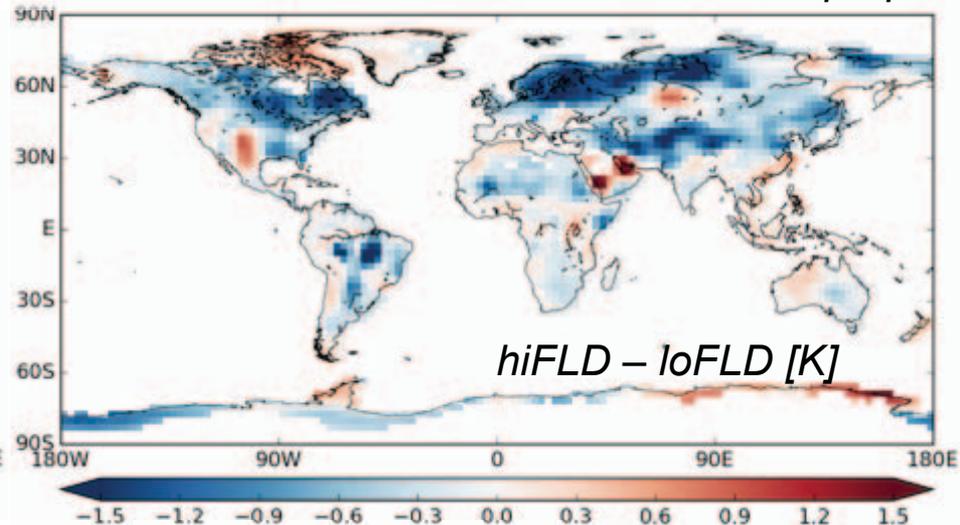
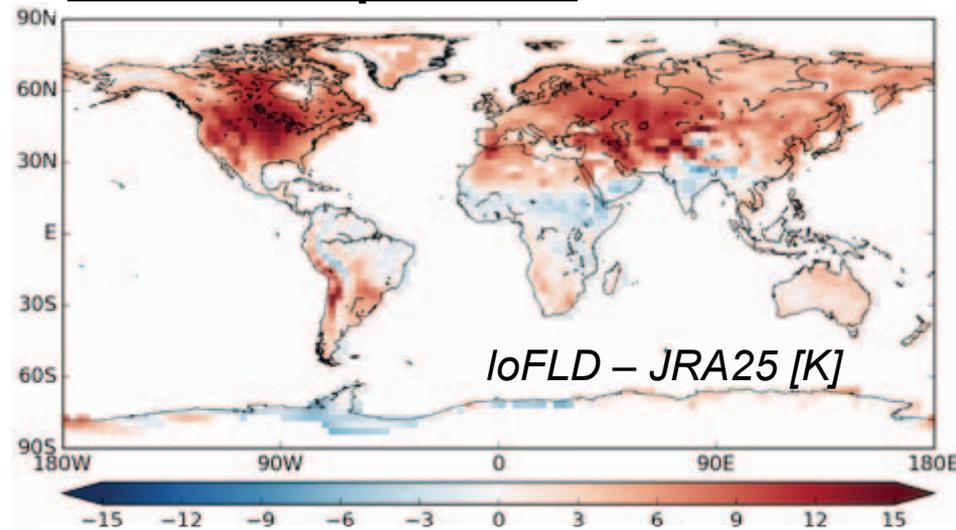
# River Inundation Process in a Climate Model



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

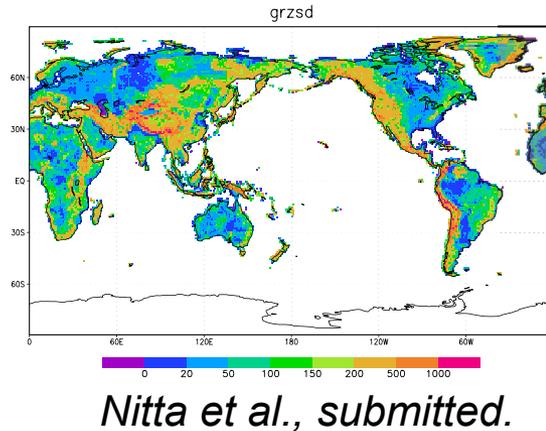
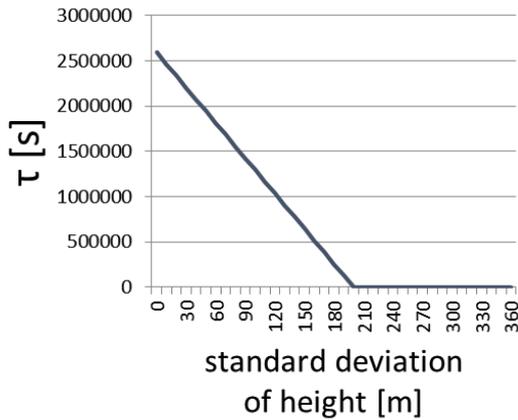
## 2m Air Temperature

Hatono et al., in prep.



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

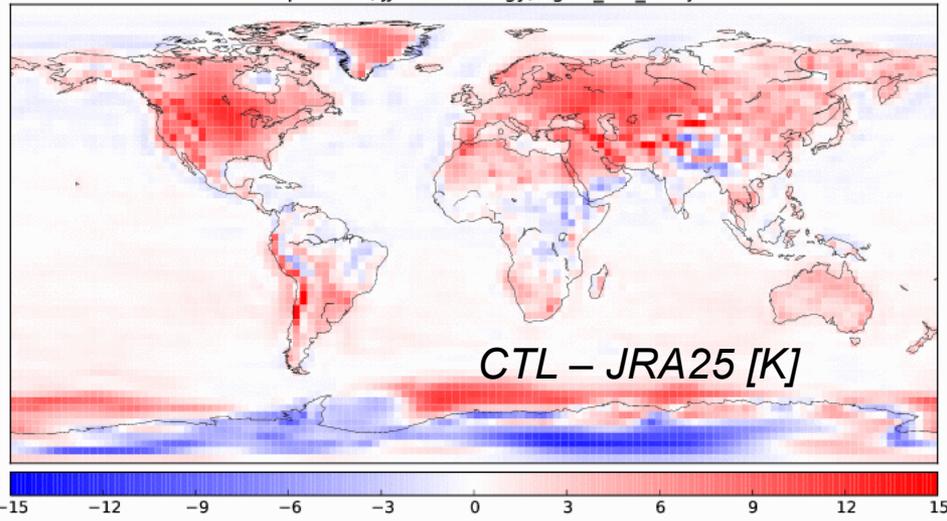
# Impact of Arctic Wetlands on Climate System



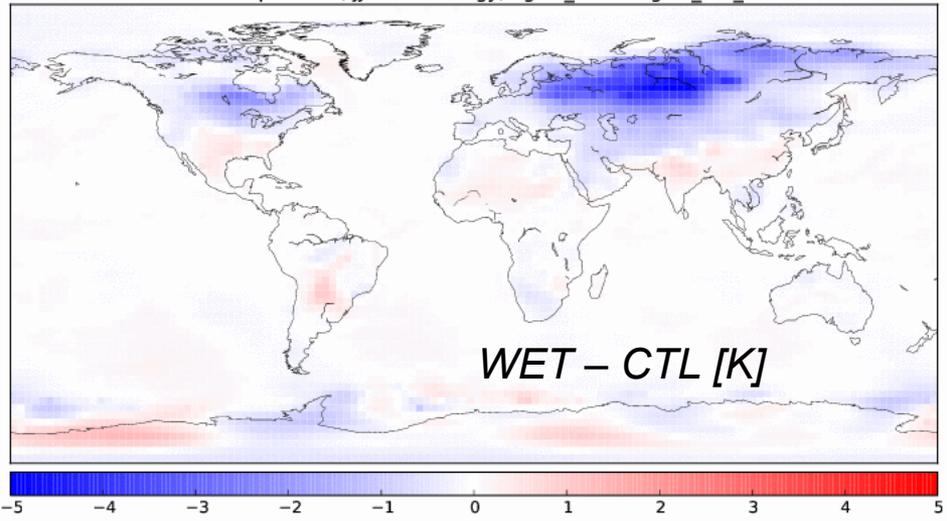
+ Add a surface tank that stores part of (1- ) snowmelt surface runoff  
 + Topography dependent time constant (a)

$\tau = \frac{h}{v} \left( \frac{1 - \alpha_s}{\alpha_s} \right) \left( \frac{1 - \alpha_s}{\alpha_s} \right) \left( \frac{1 - \alpha_s}{\alpha_s} \right)$

2m temperature, JJA Climatology, agcm\_run\_ctl - jra55

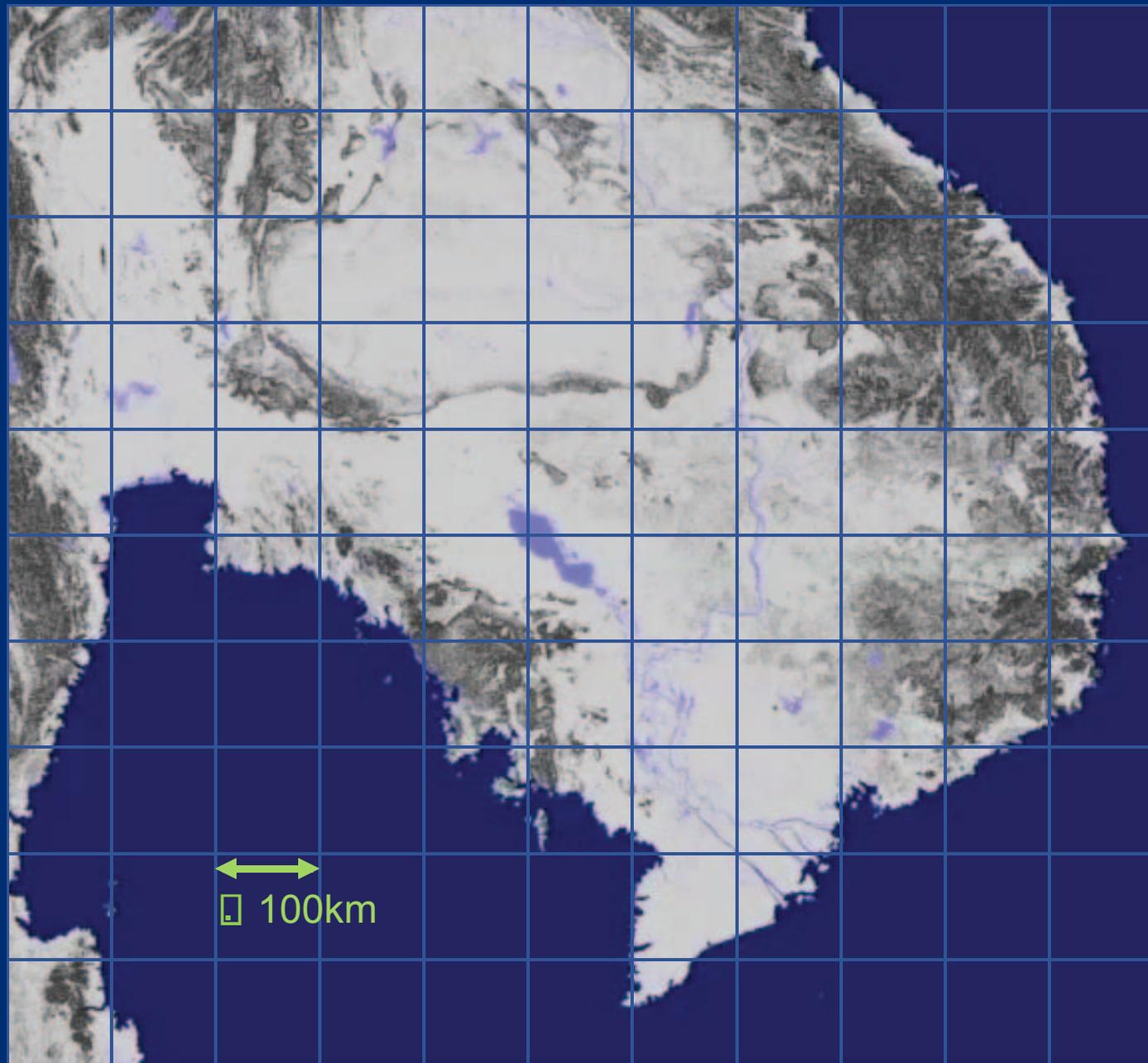


2m temperature, JJA Climatology, agcm\_run1 - agcm\_run\_ctl



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

2016.9.29

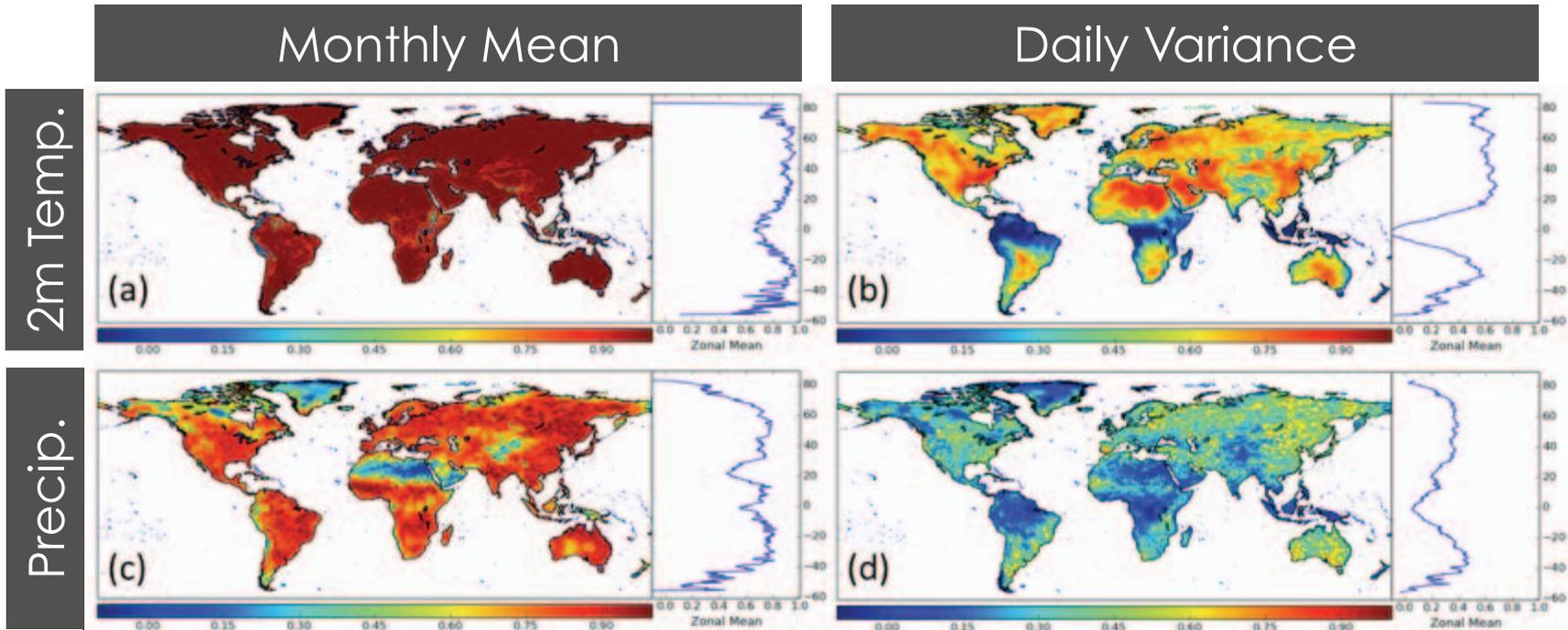


Thank you!



# Preliminary Results and Known Problems

+ Map (uncertainty of) water resources over the 20th century (and beyond)



Global distribution of the similarity index ( $\bar{\rho}$ ) for 2001-2010 of monthly mean and variance calculated from different dataset.

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