東京大学 THE UNIVERSITY OF TOKYO

Development of a New Global Dataset for Offline Terrestrial Simulations

- for Global Soil Wetness Project Phase 3 -

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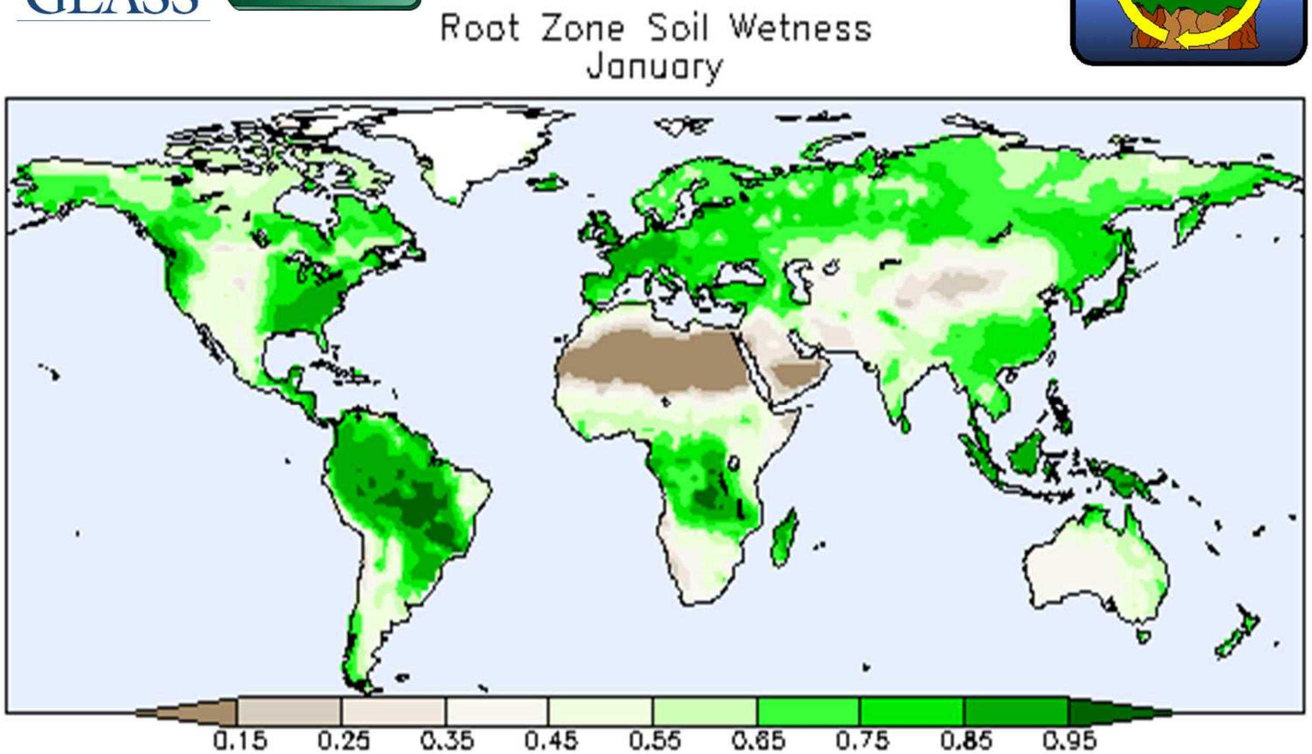
Global Soil Wetness Project

GSWP



- GSWP was a GEWEX project, led by COLA (P. Dirmeyer) and supported by IIS/UT involving over a dozen modeling groups on four continents.
- GSWP1 used the ISLSCP I-1 data to examine 1987-1988.
- GSWP2, a 10-year (1986-1995) global land-surface analysis, will begin next year
- Regional studies are investigating issues of aggregation, sub-grid variability, and assimilation of remote sensing data.

Unlike the ocean, the land surface state variables (soil moisture, snow depth and coverage, soil temperature) are not routinely measured and reported. Land-surface models driven by observed meteorology give us a means to generate a surrogate 'observed' data set.

(Dirmeyer, et. al, 1998, 2006, BAMS)

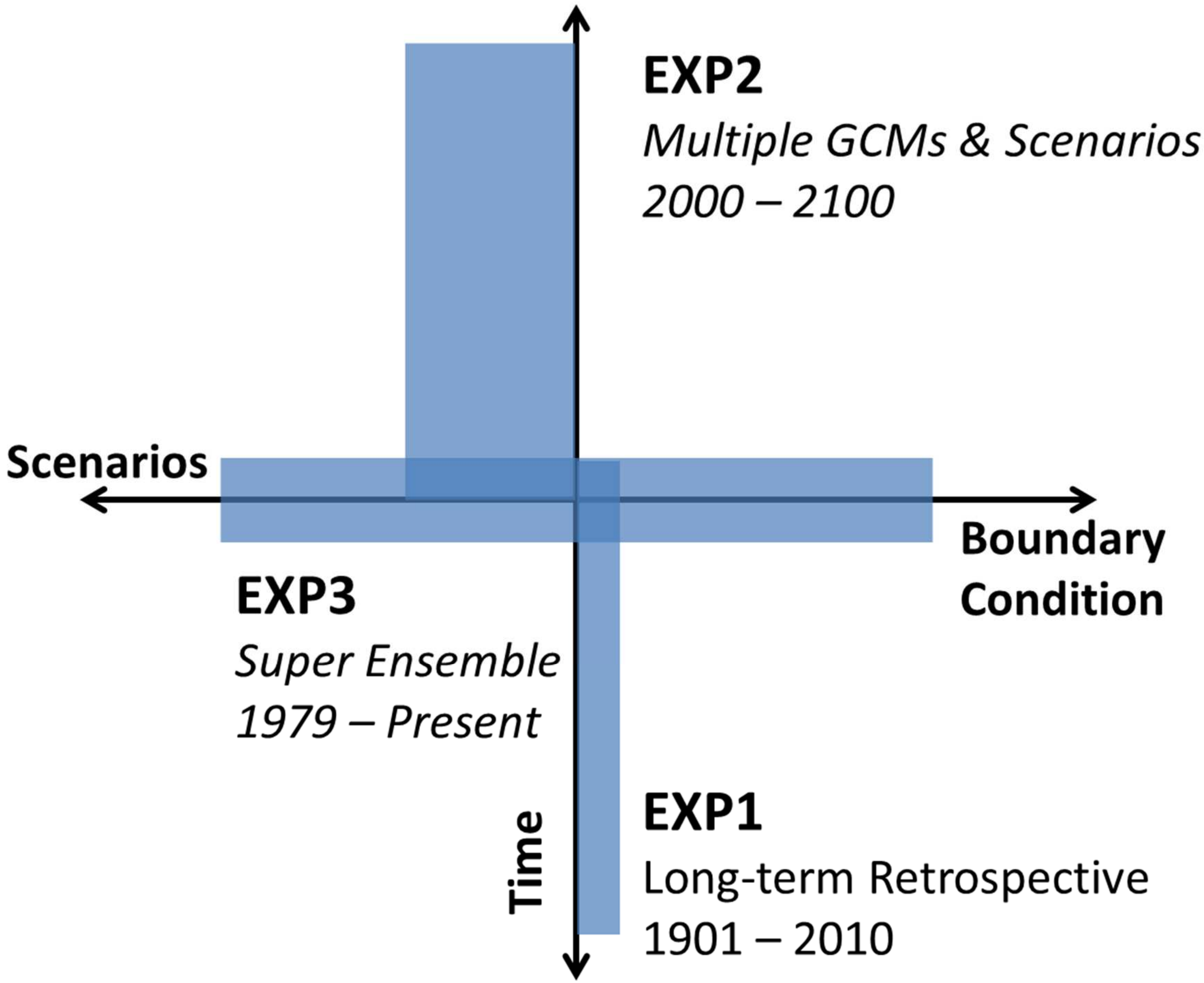
Scope of the GSWP3

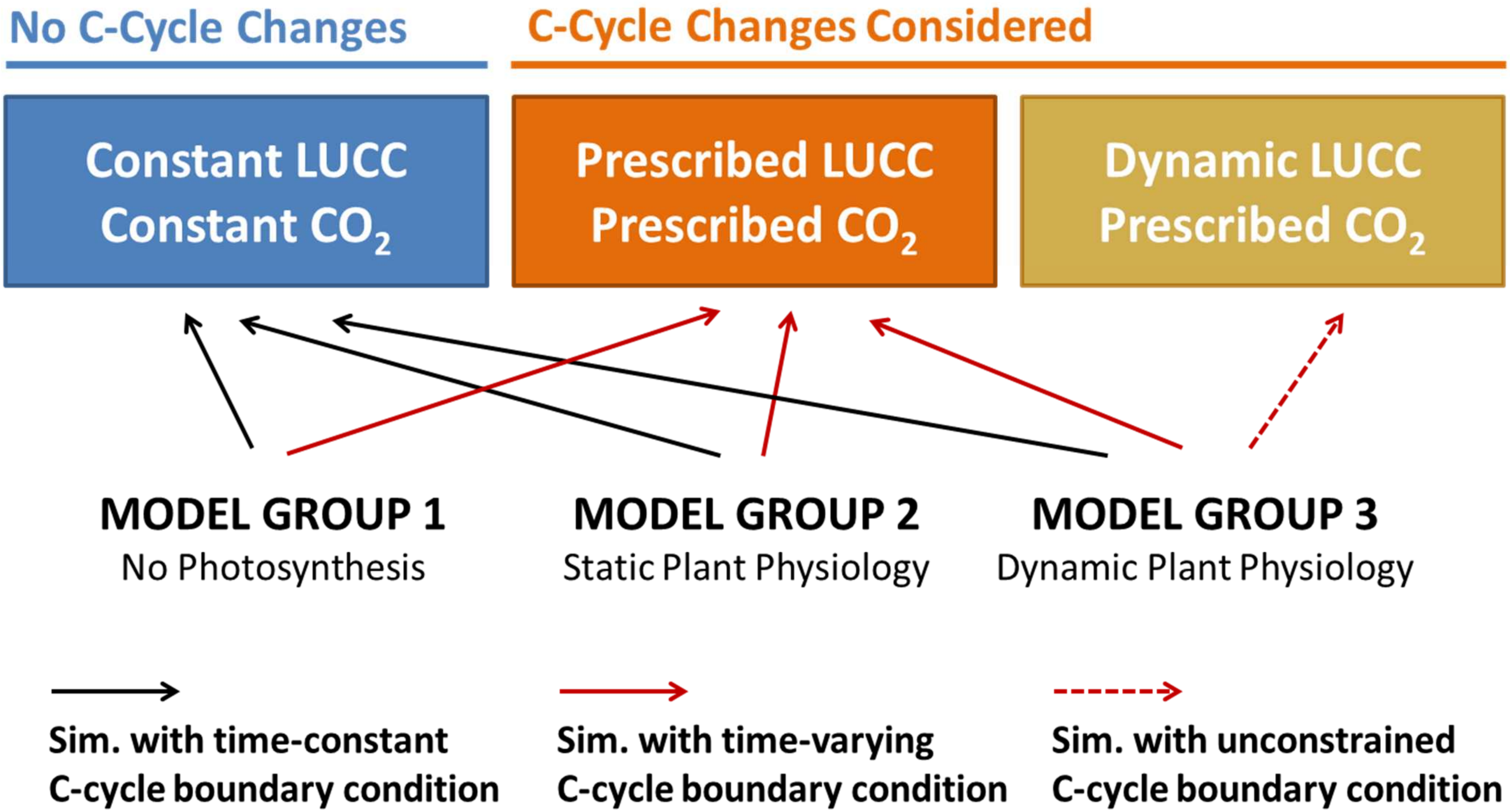
Water-MIP (EU-WATCH)
ISI-MIP (Phase2)

TRENDY
iLEAPS

Coupled Hydro-Energy-Eco System Experiment	Century long timespan (EXP1: 1901-2010)	Time varying Land Use Change CO^2

"+" Shape Experiments Design




No C-Cycle Changes
C-Cycle Changes Considered
Constant LUCC
Constant CO_2
Prescribed LUCC
Prescribed CO_2
Dynamic LUCC
Prescribed CO_2
MODEL GROUP 1
No Photosynthesis
MODEL GROUP 2
Static Plant Physiology
MODEL GROUP 3
Dynamic Plant Physiology
Sim. with time-constant C-cycle boundary condition
Sim. with time-varying C-cycle boundary condition
Sim. with unconstrained C-cycle boundary condition

We are in **'Data Rich Era'**, and one single flux is **not enough** to ensure even simple water budget closure.

Area Representative Validations

Global Large Basins,
Sub-basins,
Large Catchments

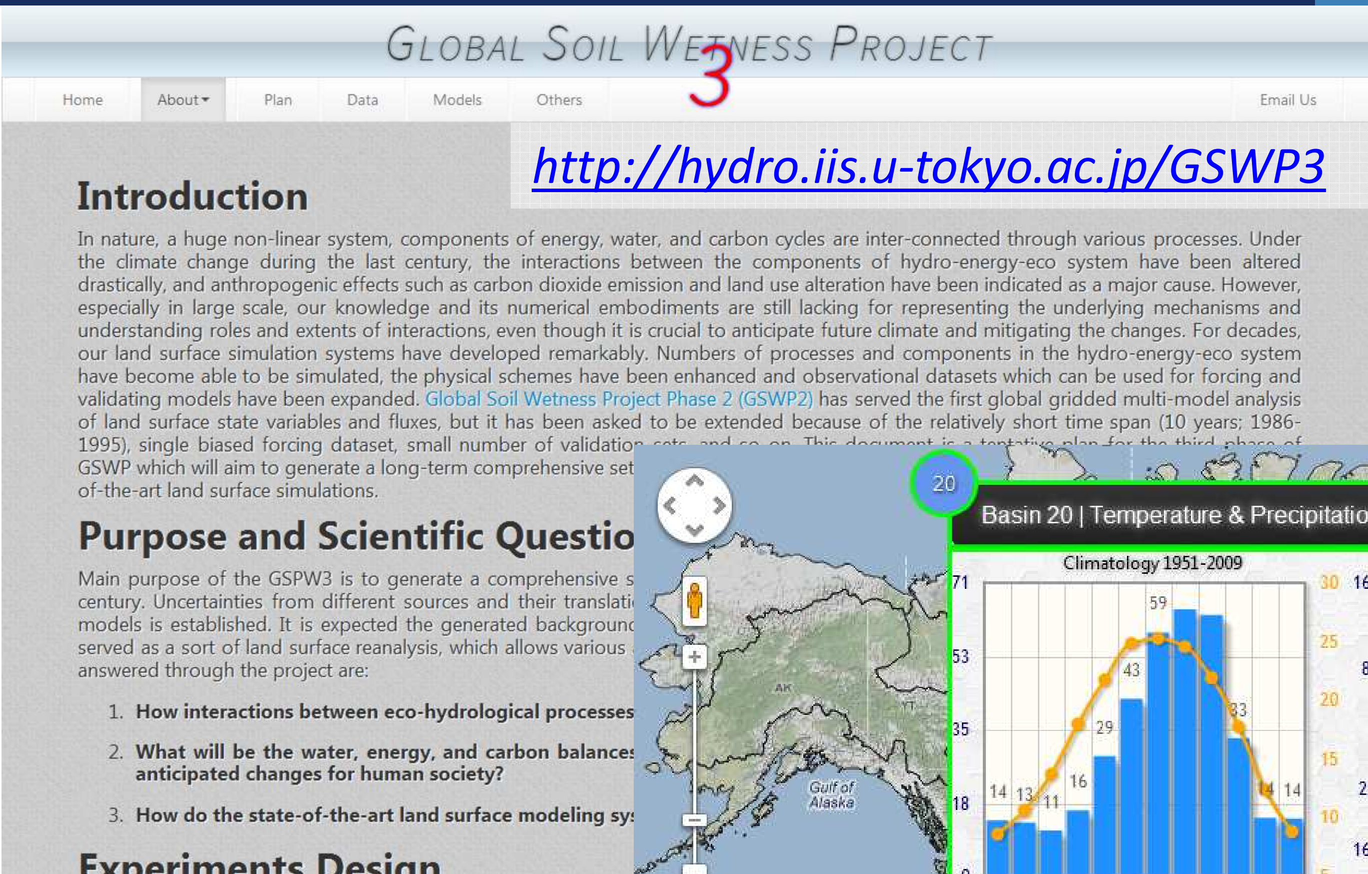
Pixel-based Validations

CEOP Reference Sites,
FLUXNET Sites,
Data Rich Regions (e.g., Illinois, USA)

Multi-way Validation

River Discharge (In-situ or Altimetry estimated)
GRACE Measure TWS Variations

Tower Flux Measurements
Soil Moisture (In-situ)
Water Table Depth

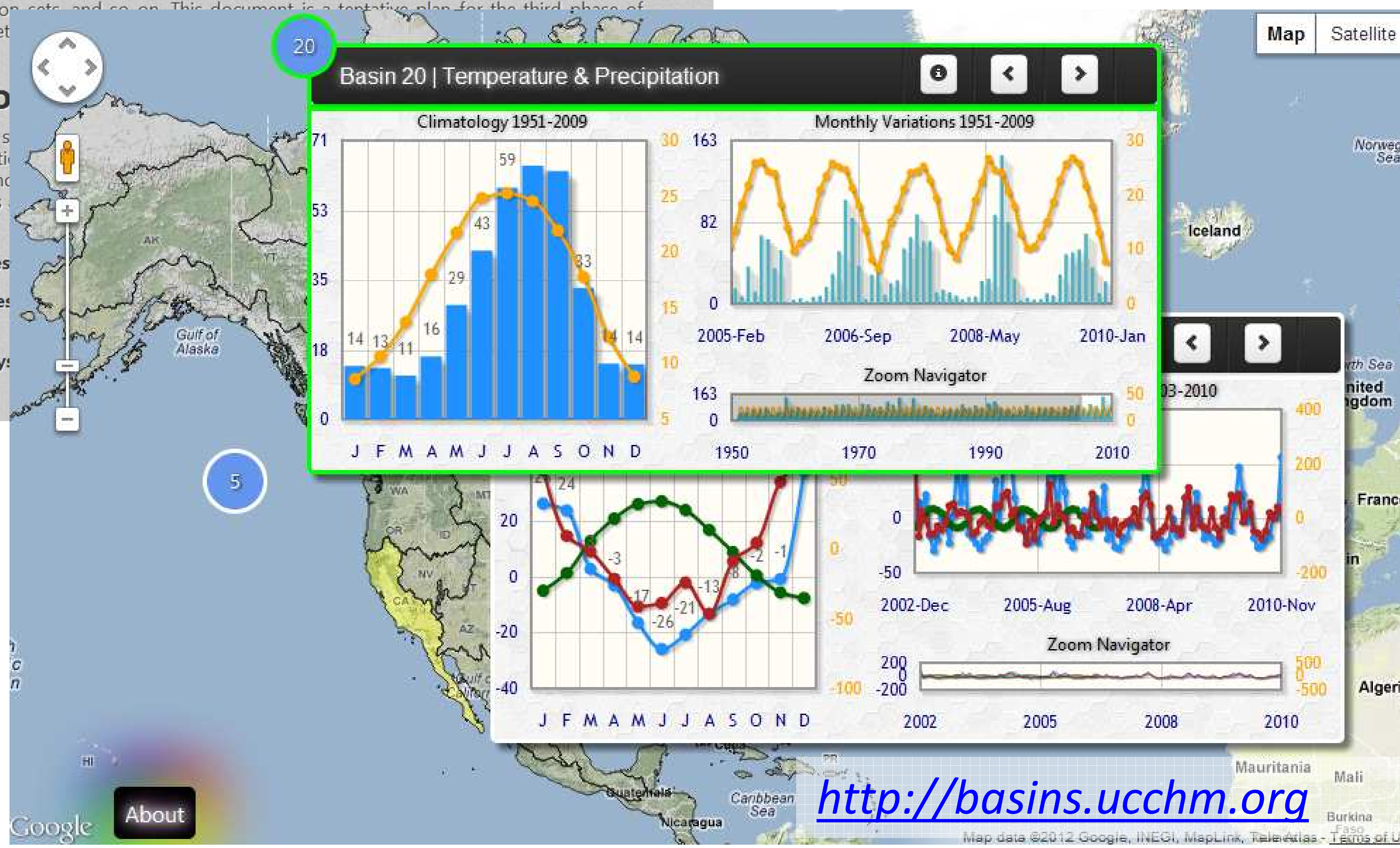


http://hydro.iis.u-tokyo.ac.jp/GSWP3

Mirrored Data Center

Distribute / Collect Data

Web-based User Interface for Data Manipulation and Analysis



http://basins.ucchm.org

Project Web Page

Provide Experiment Information

Update Progress

Existing Forcing Data Available Globally

Review

	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	1871-2010 140 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	20CR 1871 - 2010 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.)

Existing Forcing Data Available Globally

Review

	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.

Revising Forcing 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 Ensemble Bias Correction

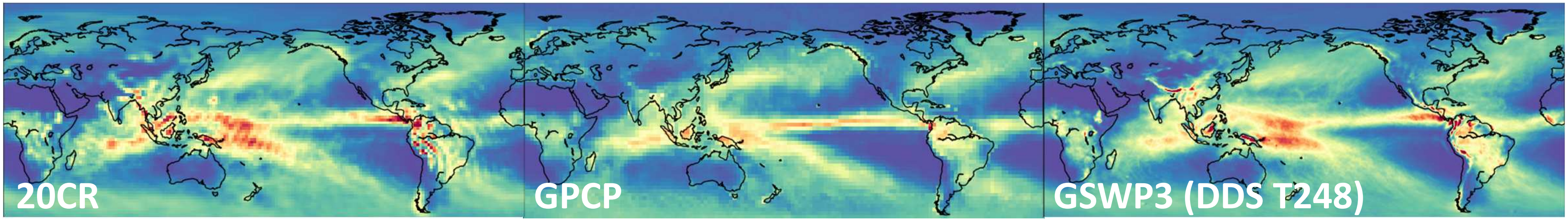
* LDMF Daily Correction (Kim et al., in prep.)
* Parametric Monthly Correction (Watanabe et al., 2012)

GSWP3 EXP1 Forcing

20CR (Compo et al., 2011)
1901-2010 6hr / 2°x2°(91x180)

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

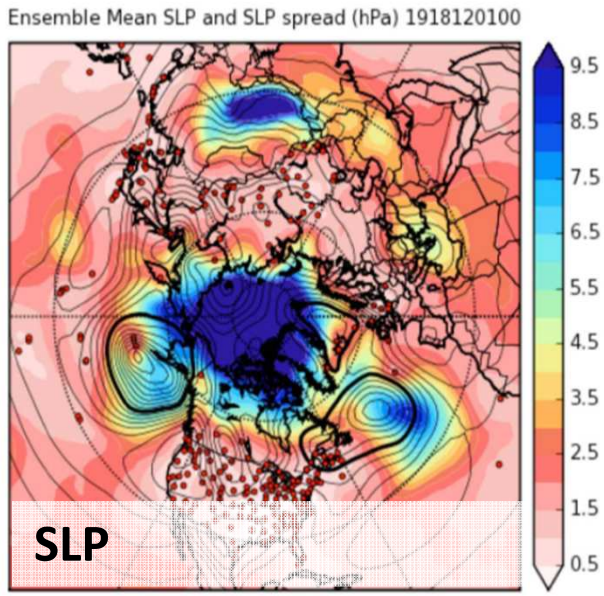
0.5°x0.5°
1901-2010 3hr

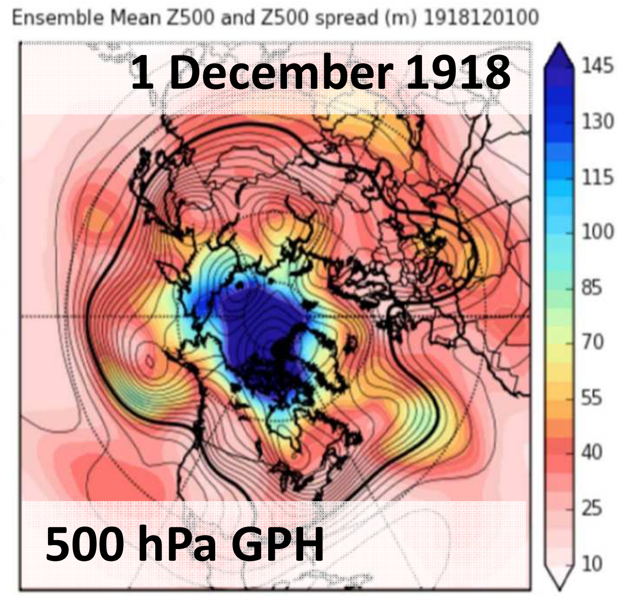


20th Century Reanalysis

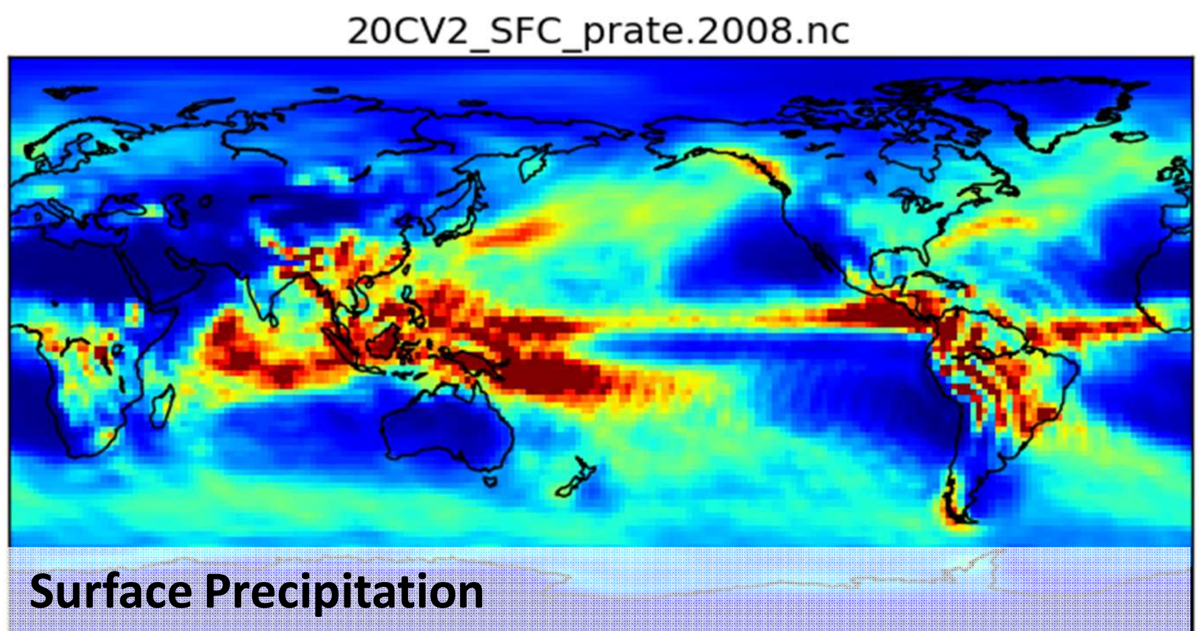
Compo et al., 2010

- Using only surface pressure data historically recorded since 1871's
- Ensemble Kalman Filter with 56 members
- T62L28 GFS with NOAH LSM
- Reanalysis skill is comparable to current Day-3 forecast skill (Whitaker et al., 2009)
- Ripple-like pattern due to spectral model interacting with the high resolution orography



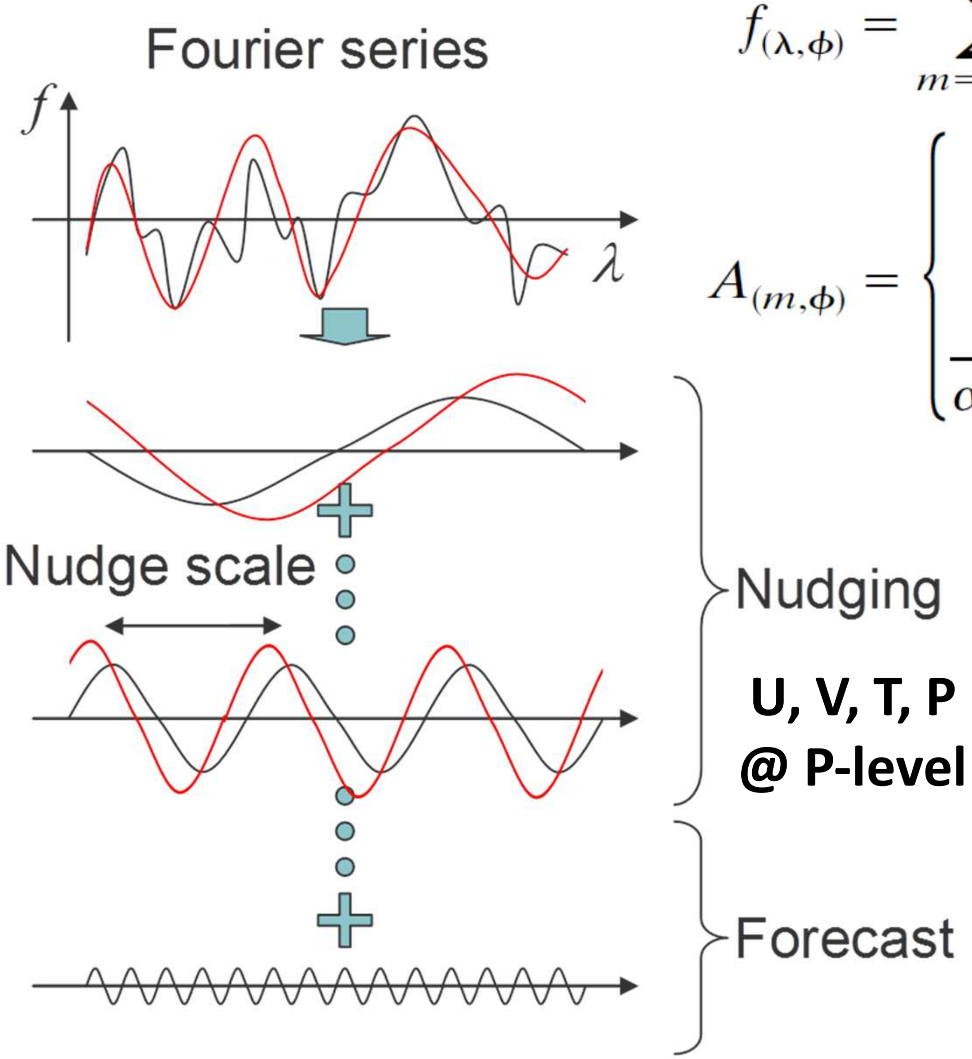


Whitaker et al. (2009)



Global Dynamical Downscaling by Spectral Nudging Using GSM

Data and Method



U, V, T, P @ P-level

Yoshimura and Kanmitsu 2008

$$f_{(\lambda,\phi)} = \sum_{m=-M}^{m=M} A_{(m,\phi)} e^{im\lambda}, \quad \text{with}$$

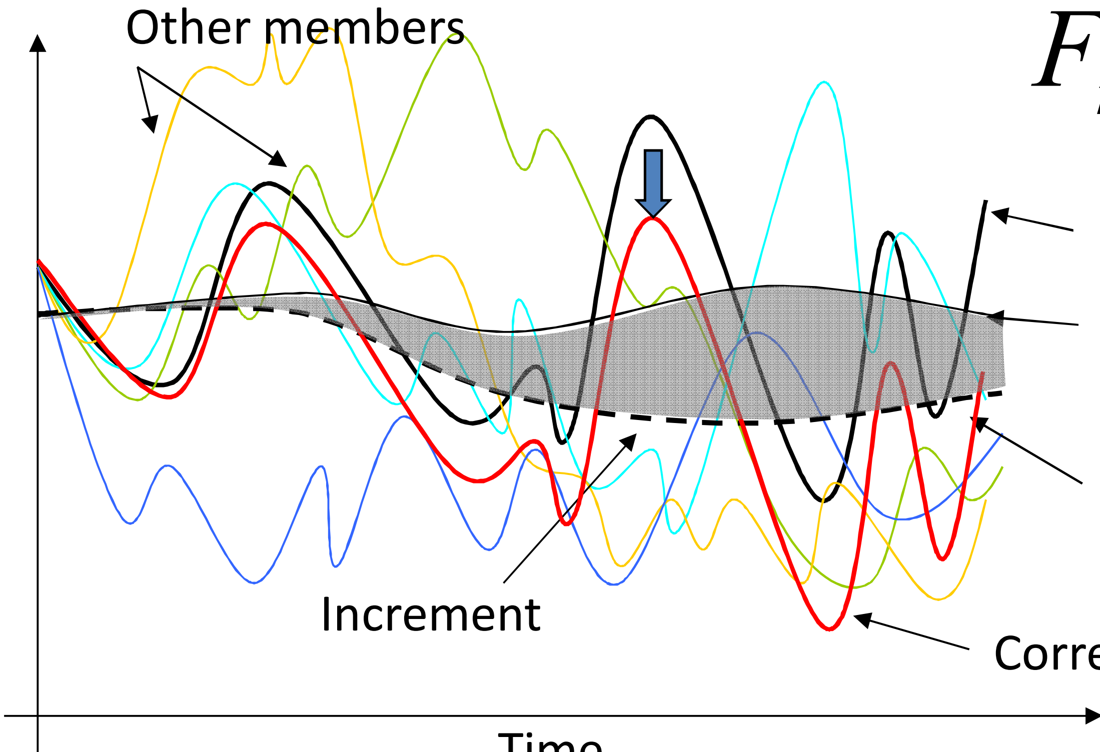
$$A_{(m,\phi)} = \begin{cases} A_{f(m,\phi)} & \left(|m| > \dfrac{2\pi R_E \cos\phi}{L} \right) \\ \dfrac{1}{\alpha+1}\left[A_{f(m,\phi)} + \alpha A_{a(m,\phi)}\right] & \left(|m| \le \dfrac{2\pi R_E \cos\phi}{L} \right) \end{cases}$$

Successfully generate high frequency signals preserving low frequency background.

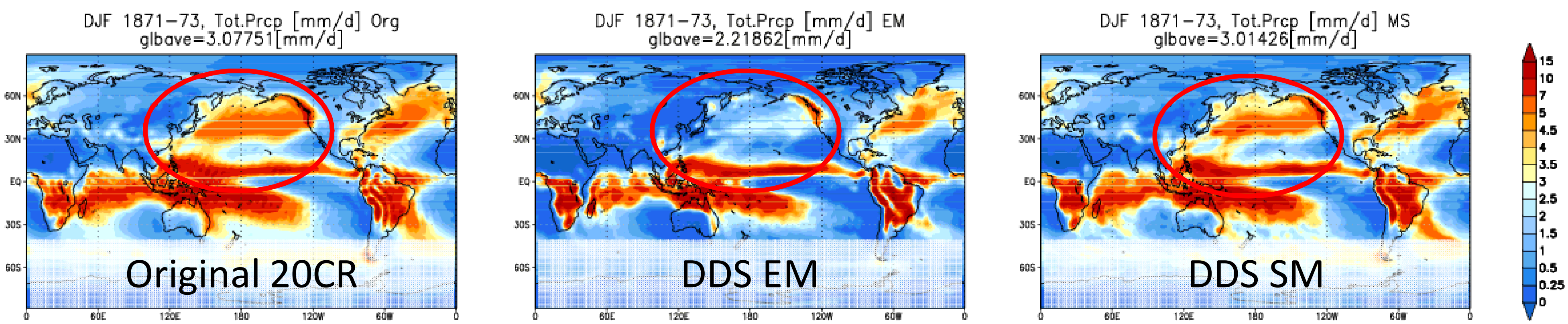
Effectively relieves ripple-like pattern (an artifact of 20CR due to high-res. topography mismatch)

Single Member Correction Using Ensemble Mean

$$F_n^{new} = F_n + \left\langle \overline{F} \right\rangle - \left\langle F_n \right\rangle$$

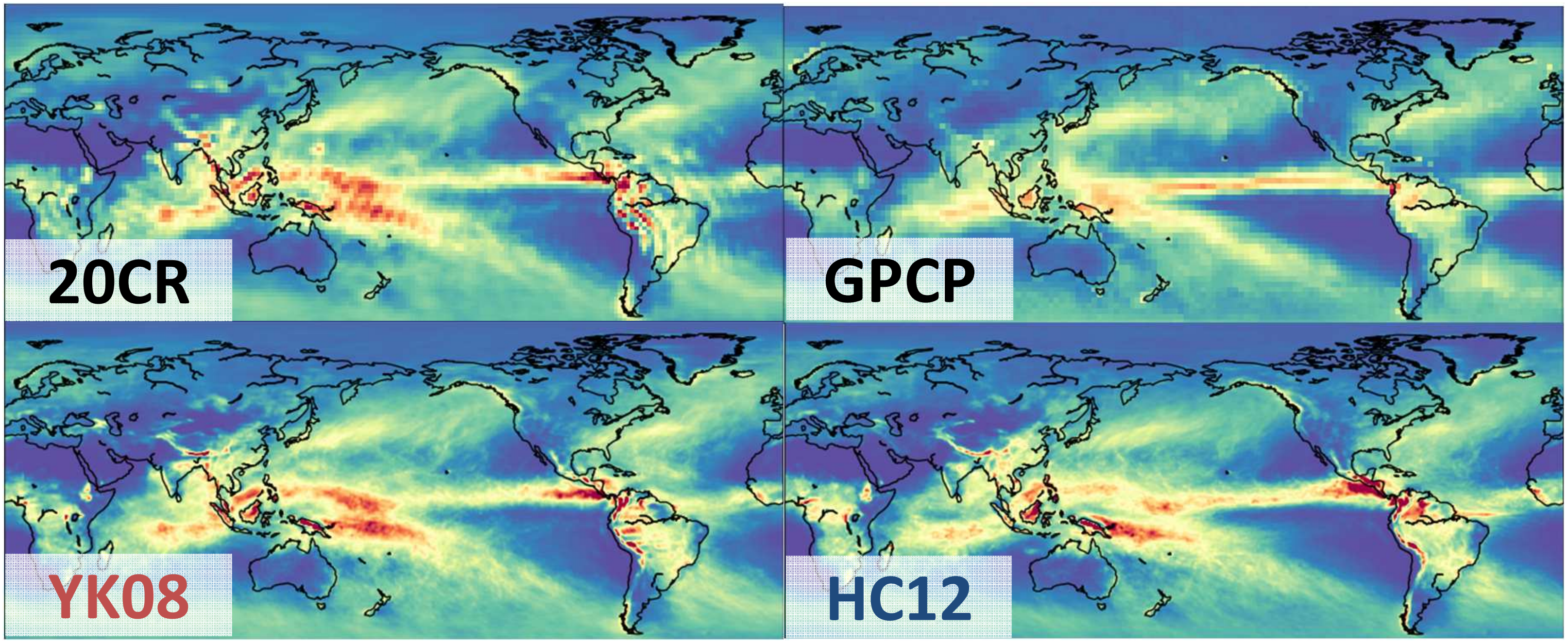


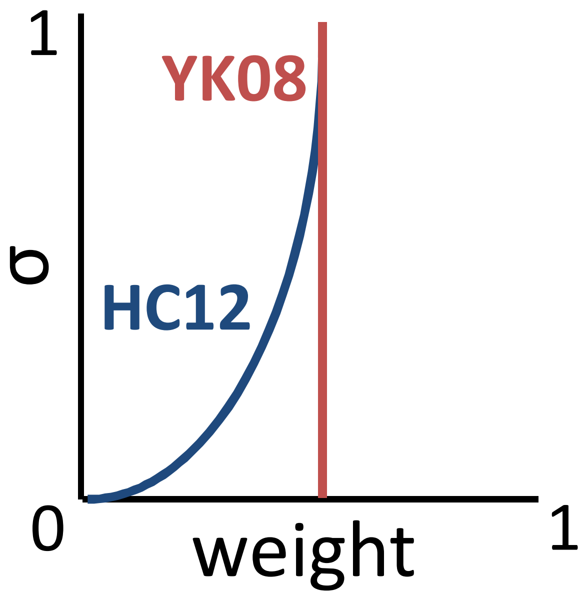
Yoshimura and Kanamitsu 2013



Vertically Weighted Damping Scheme

Hong and Chang, 2013

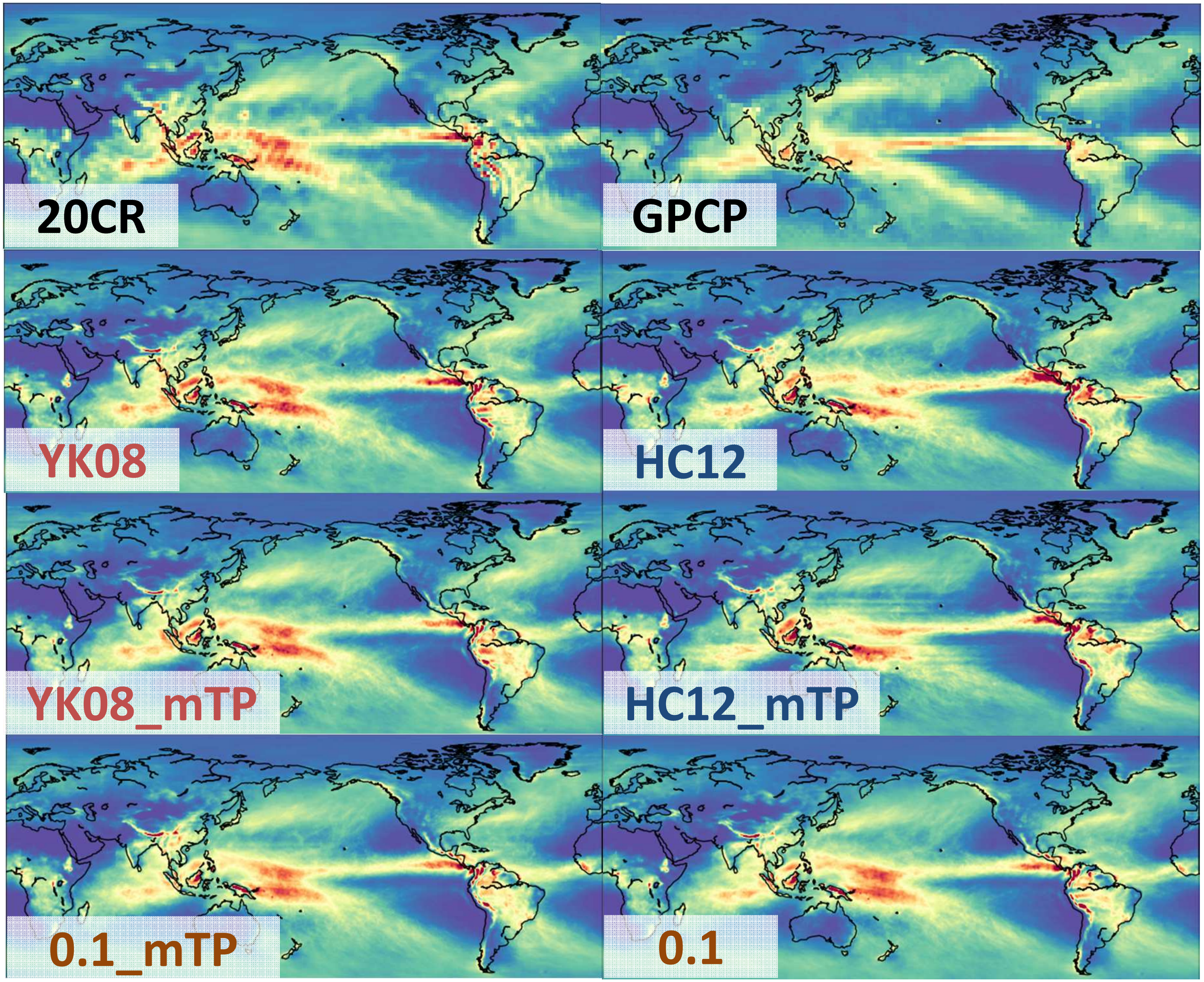


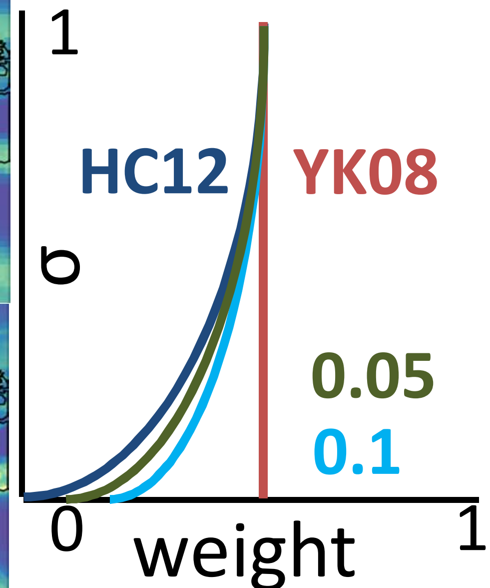


YK08 well constrains large scale features and downscale high frequency domain, but somewhat over-ruled by original reanalysis dataset.

HC12 shows more realistic representation in Amazon avoiding pre-existing artifacts of original 20CR, but is not able to keep original large scale pattern effectively.

Vertically Weighted Damping Scheme





Spectral Nudging in all domains > 1000m half-width for U, V, T, P

OR

only degree 0, 1 is assimilated for T, P **(_mTP experiment)**

Simulations Streams — Current Status

	00	01	02	03	04	05	06	07	08	09	10
1870											
1880											
1890											
1900											
1910											
1920											
1930											
1940											
1950											
1960											
1970											
1980											
1990											
2000											

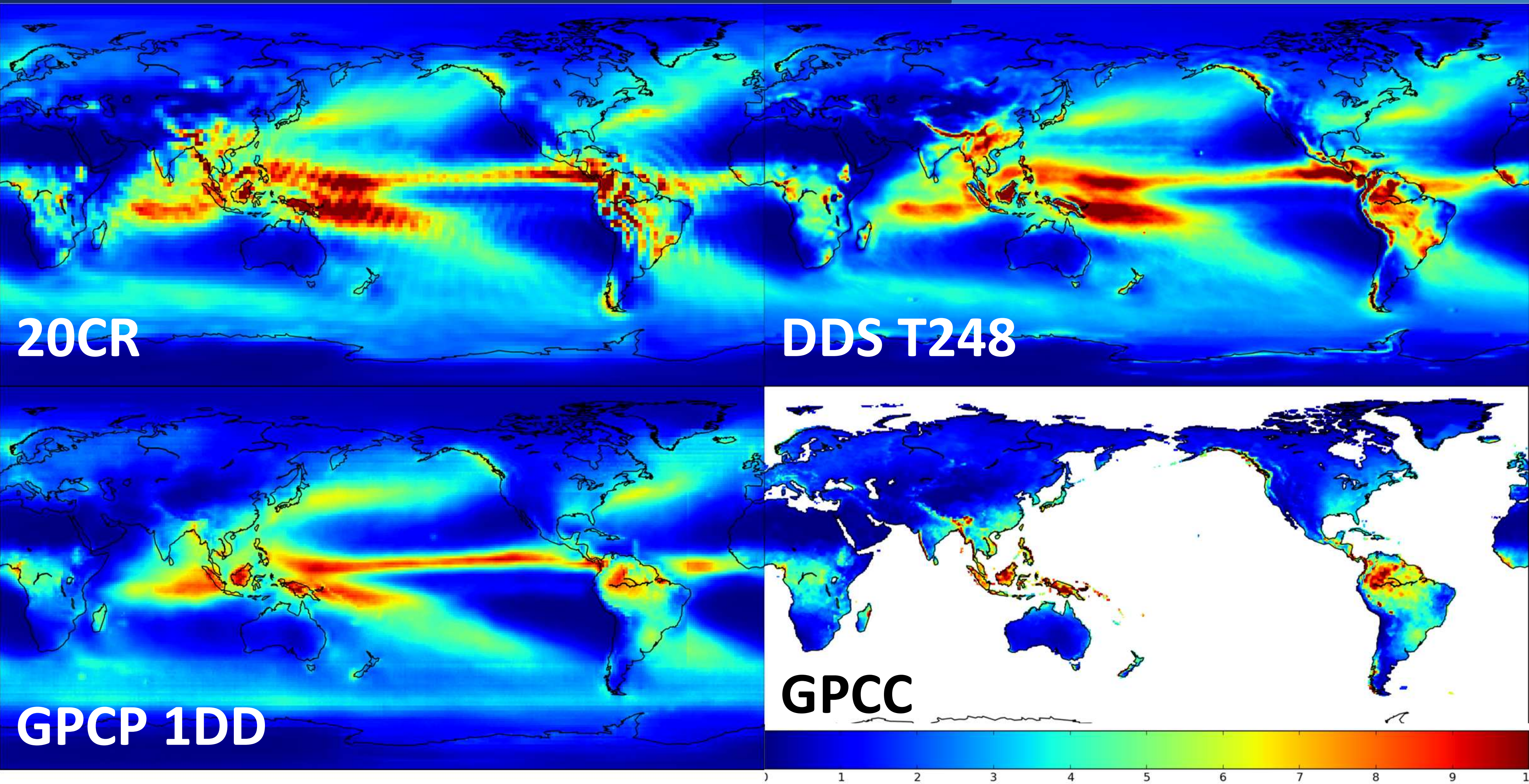
- **Boundary Conditions : ~ 10TB**
- **Simulation Results : ~ 40TB**
- **CPU Time: ~40000 Hours @ T2K Supercomputer**

100%

(ETA: ~7 months)

Annual Precipitation 1993 – 2008

Preliminary Result

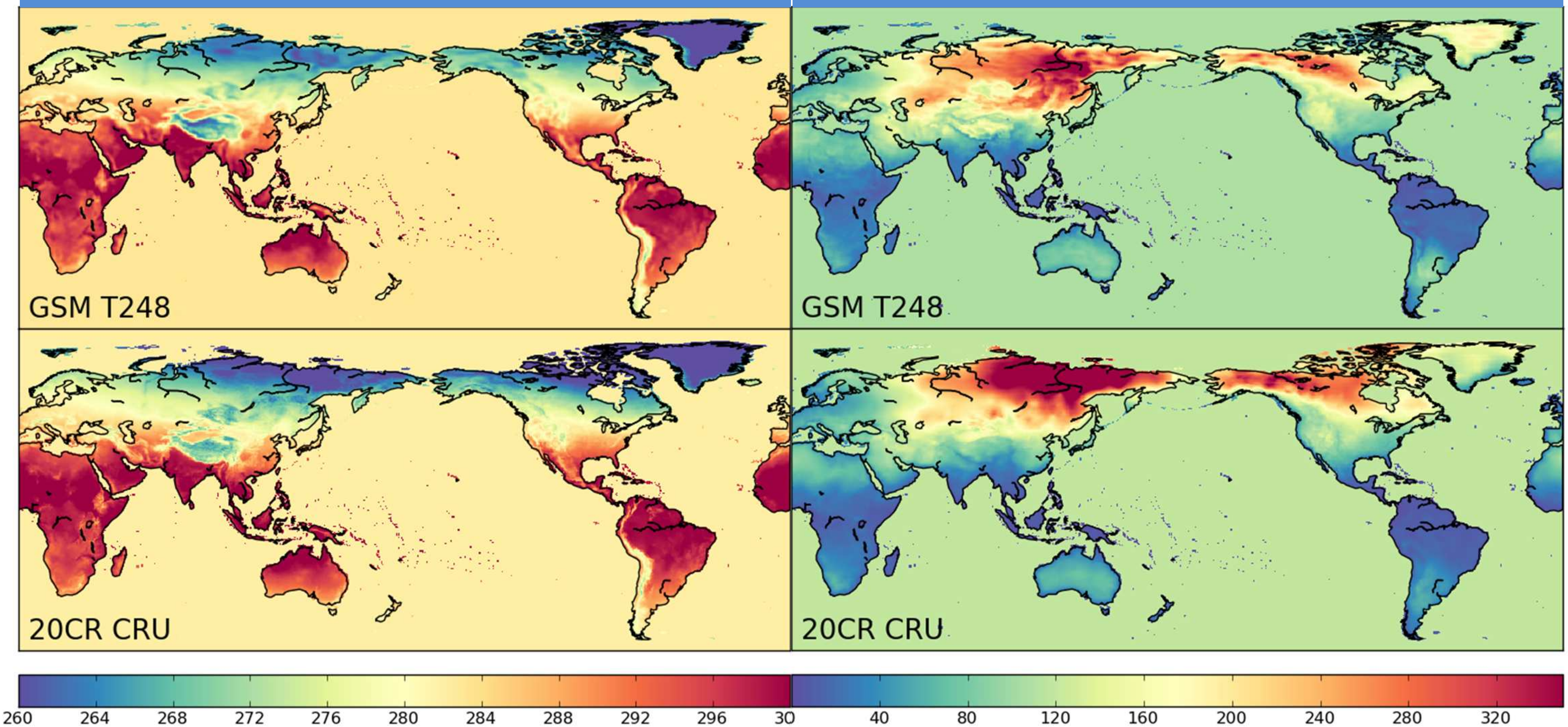


Products	20CR	DDS T248	GPCP 1DD	GPCC
[mm/d] (land)	2.6 (-)	2.5 (2.5)	1.5 (-)	N/A (2.0)

Comparison between Statistical and Dynamical Downscaling

Preliminary Result

MEAN (2m Tair)	VARIANCE (2m Tair)



Represent high-res geographical details pretty well, and small signal loss comparing to actual 0.5 deg. Obs.

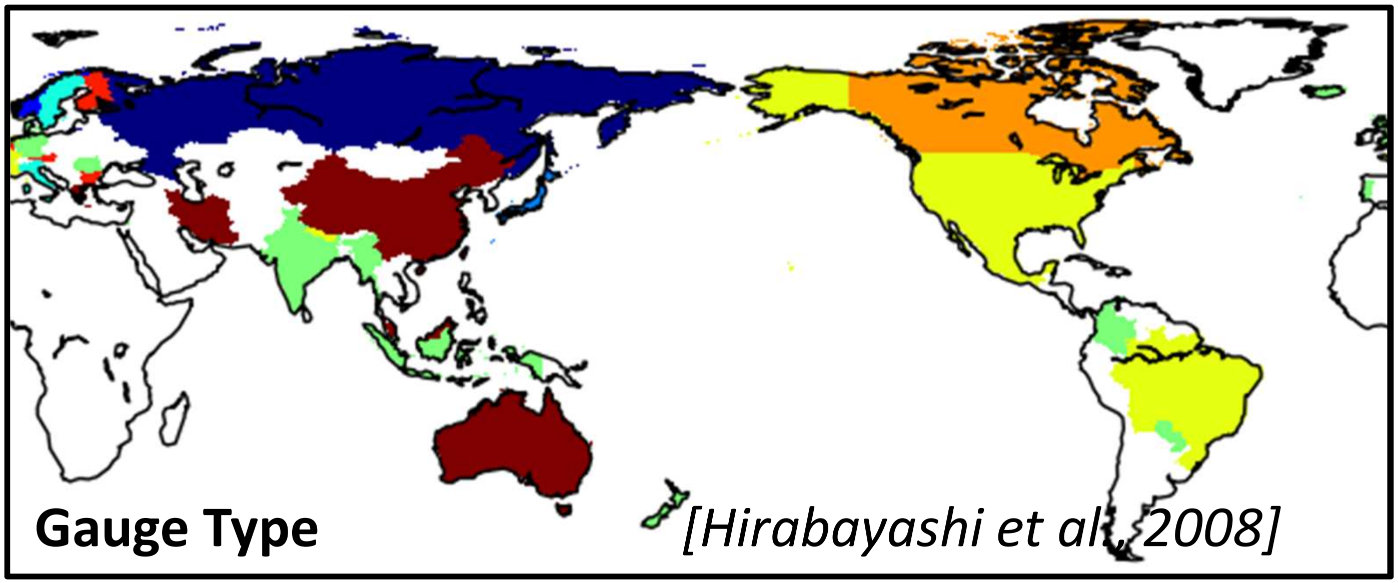
Variability in higher frequency remains depending on the model of the analysis product after bias correction

‘Two-pass’ Bias Correction for Precipitation

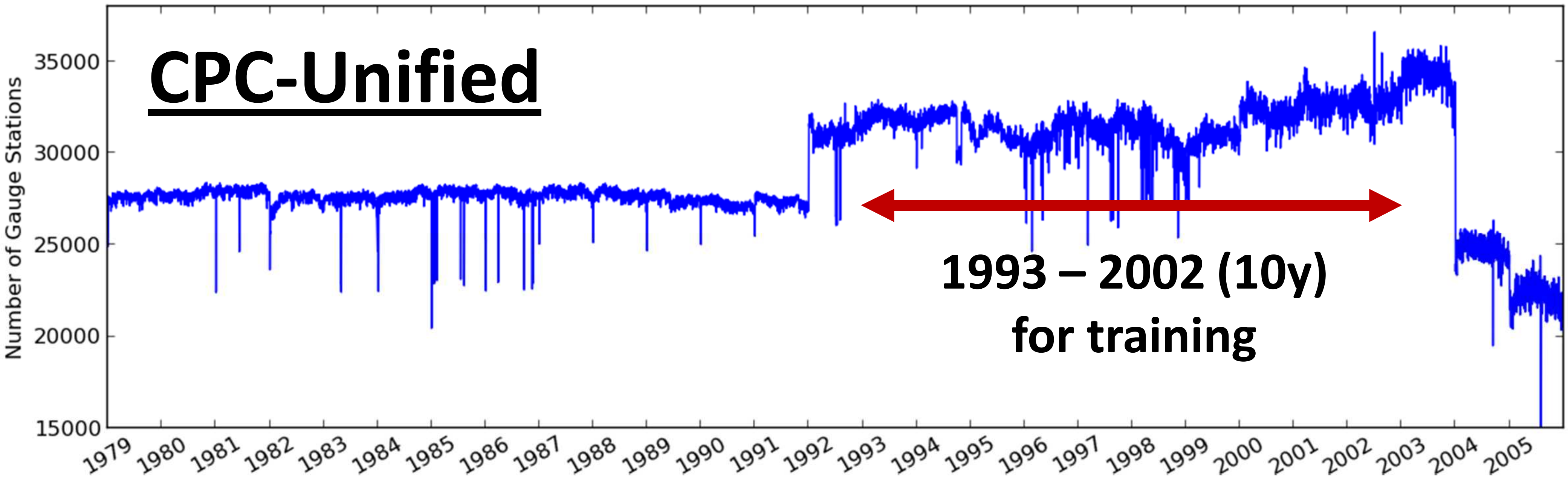
Implementation

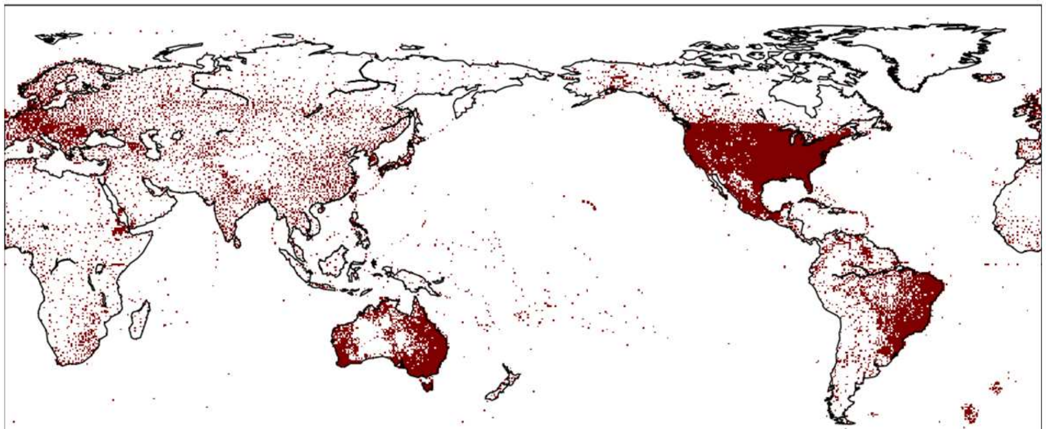
Name	Global Precipitation Climatology Centre (GPCC)	**Timespan**	1901.01 – 2010.12
Version	Version 6 full data reanalysis	**Temp. Res.**	Month
Reference	Rudolf et al. (2010)	**Spa. Domain**	Global
Source	http://gpcc.dwd.de	**Spa. Res.**	0.5 degree

Name	Climate Prediction Center (CPC) Unified	**Timespan**	1979.01 – 2005.12
Version	Version 1	**Temp. Res.**	Daily
Reference	Chen et al. (2007)	**Spa. Domain**	Global
Source	ftp://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_GLB	**Spa. Res.**	0.5 degree

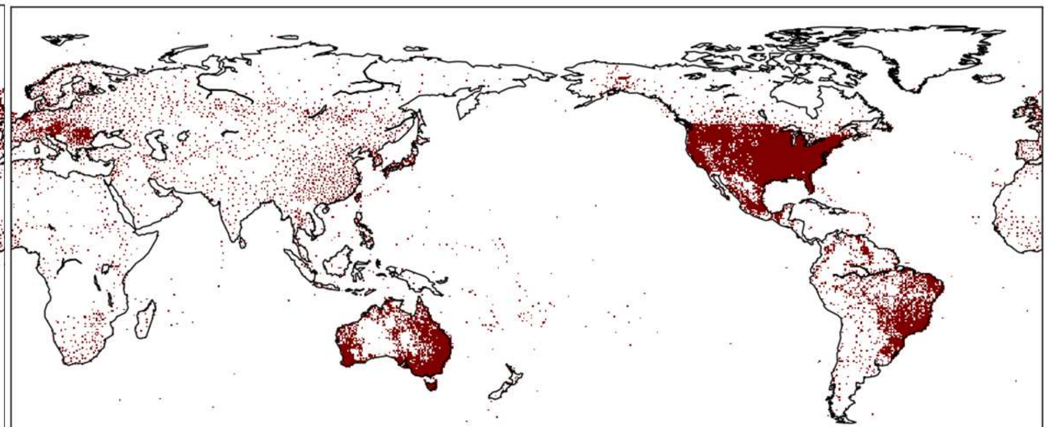


1. Canadian Nipher
2. Chinese standard
3. Hellmann like*
4. Wild like
5. Tretyakov
6. Norwegian standard
7. Japanese (average)
8. NWS 8 inch like
9. Unknown





# of Stations$_{avg}$ > 0.0 (6.3% coverage; 16406)



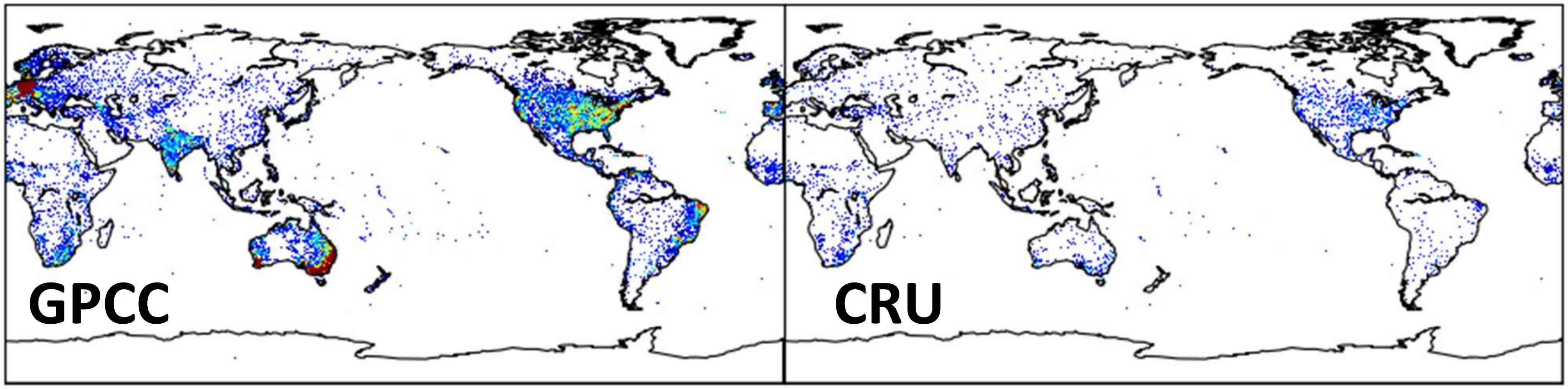
# of Stations$_{avg}$ > 0.5 (4.5% coverage; 11573)

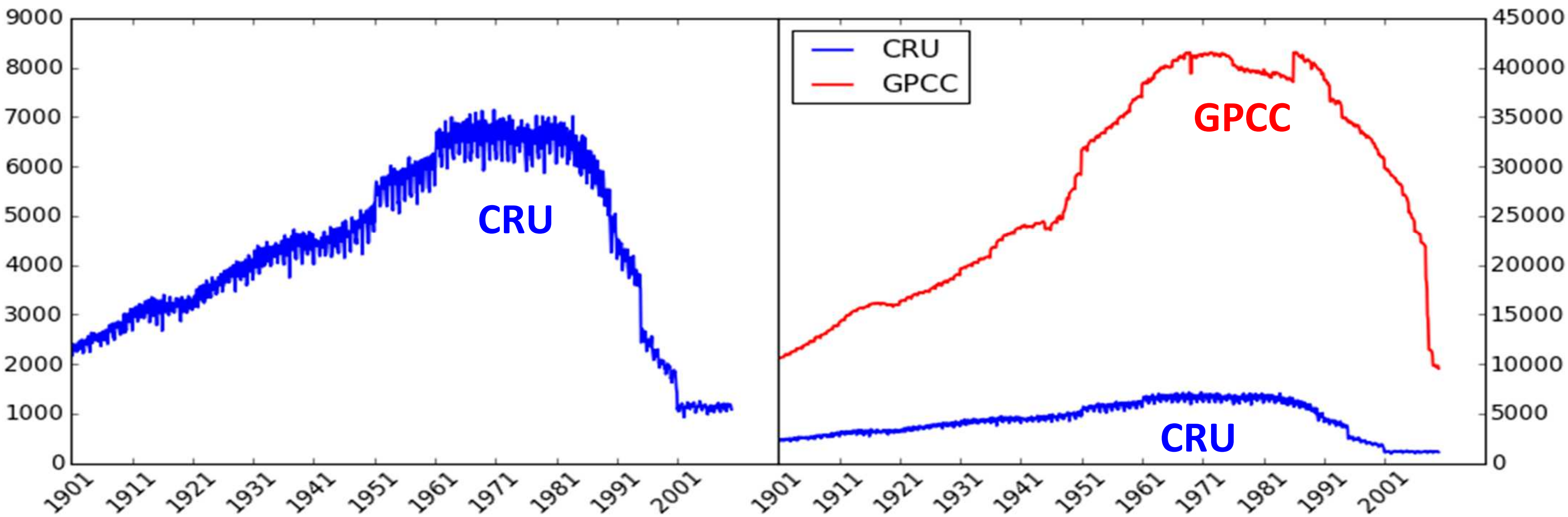
GPCC (6.8% coverage; 17612/259200)

GPCC (6.0% coverage; 15602/259200)

'Two-pass' Bias Correction for Precipitation

Second pass: Long-term monthly bias correction





$$LDMF\ (\mu, \sigma, \varepsilon)$$

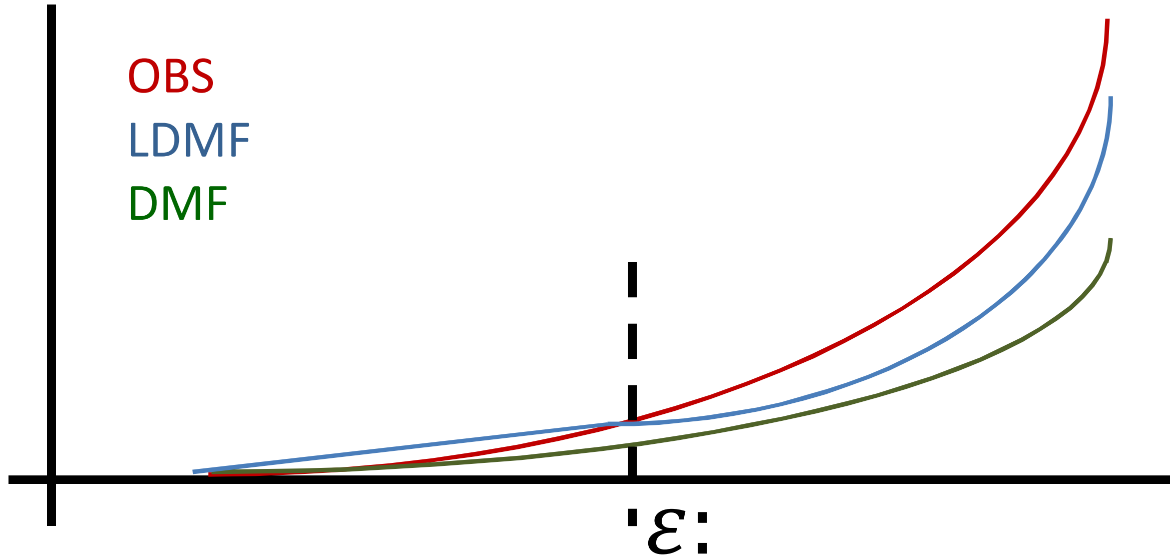
μ: Location

σ: Scale

ε: Limit

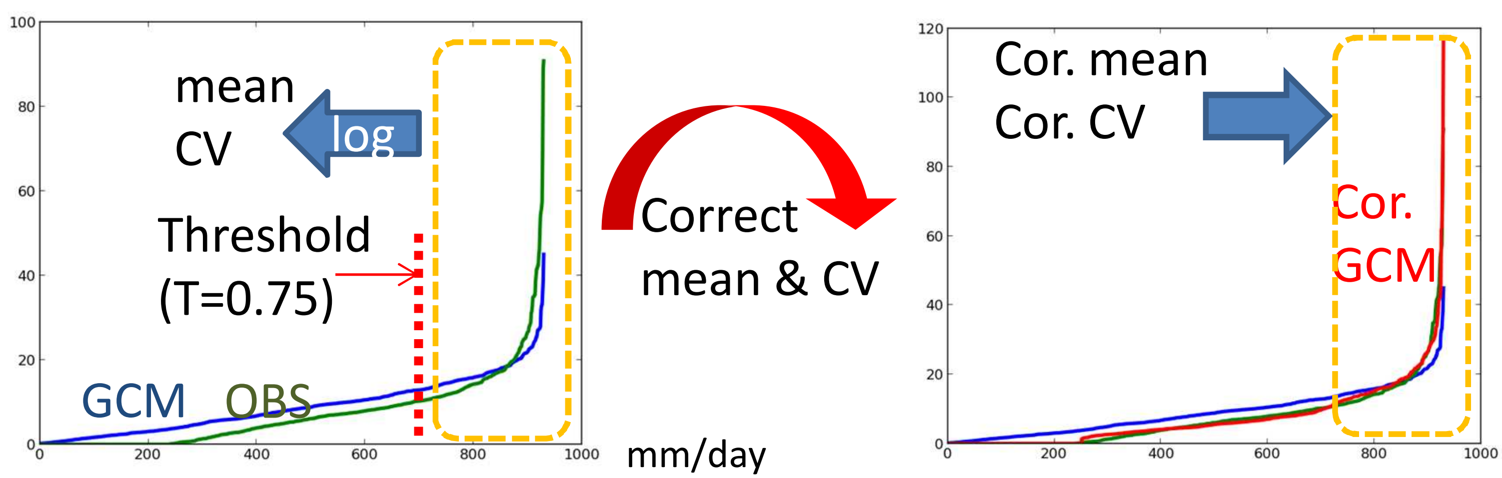
$$P_{day} < \varepsilon$$

$$P_{day} > \varepsilon$$



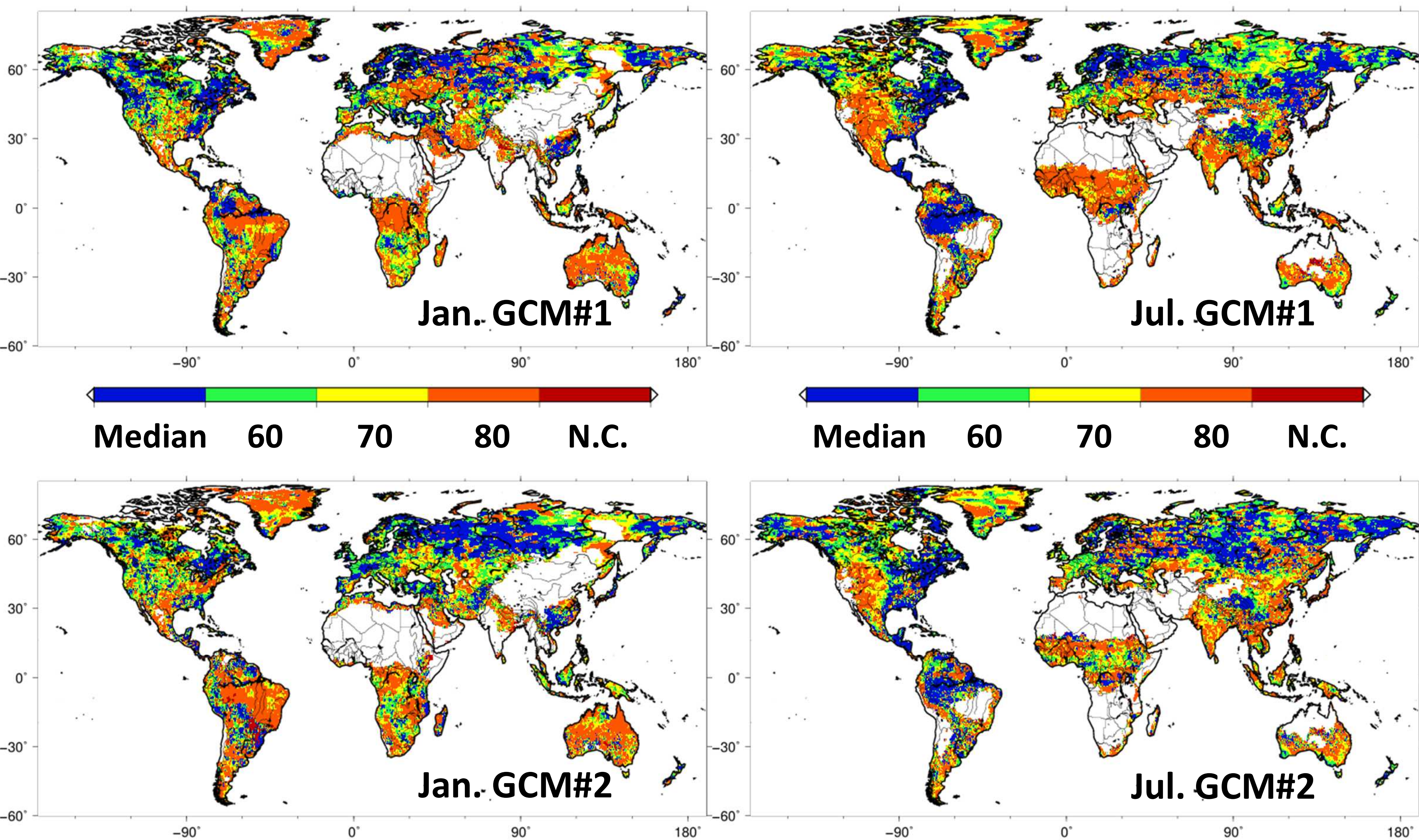
Linear ratio bias correction

Correct mean and standard deviation

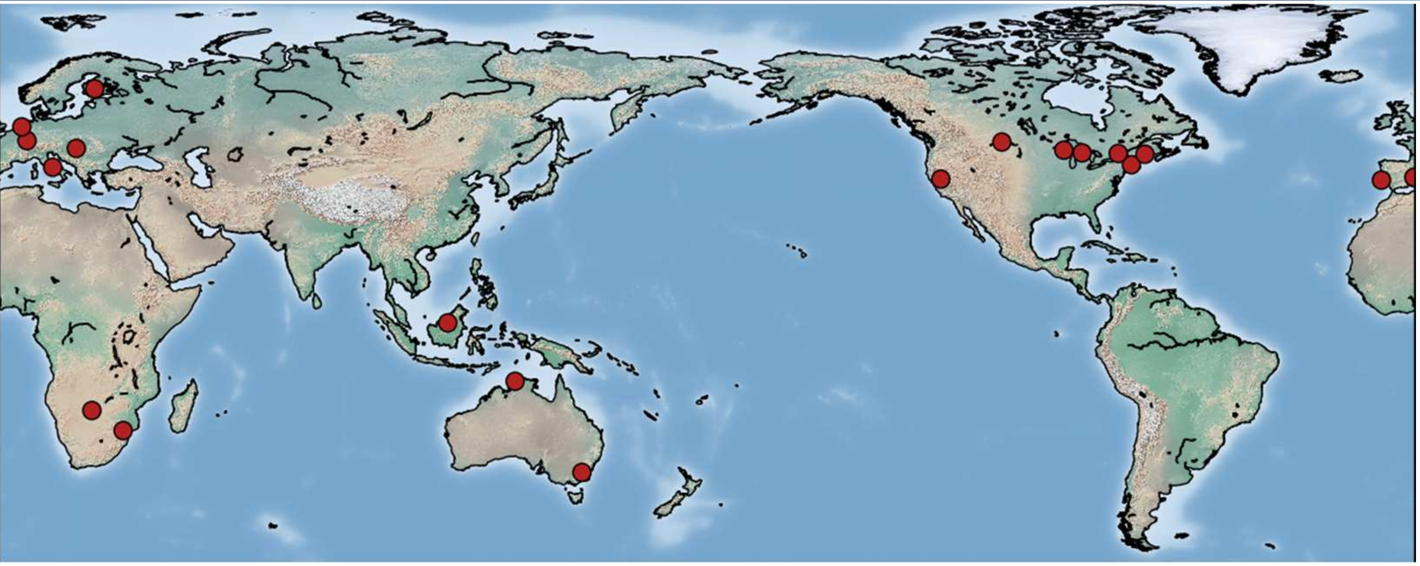


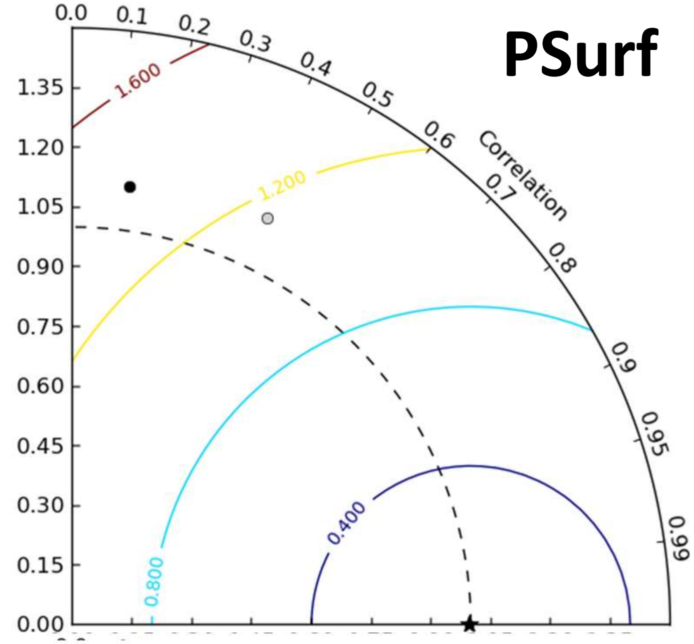
Localized Dual Moment Fitting

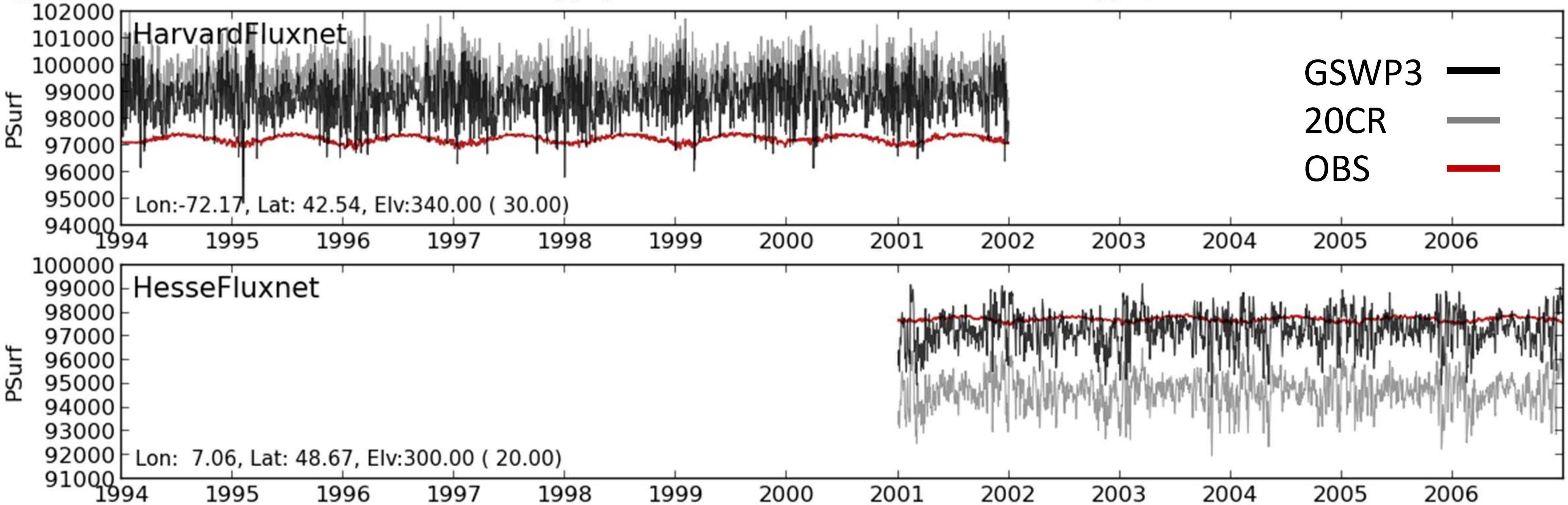
Implementation



Validation

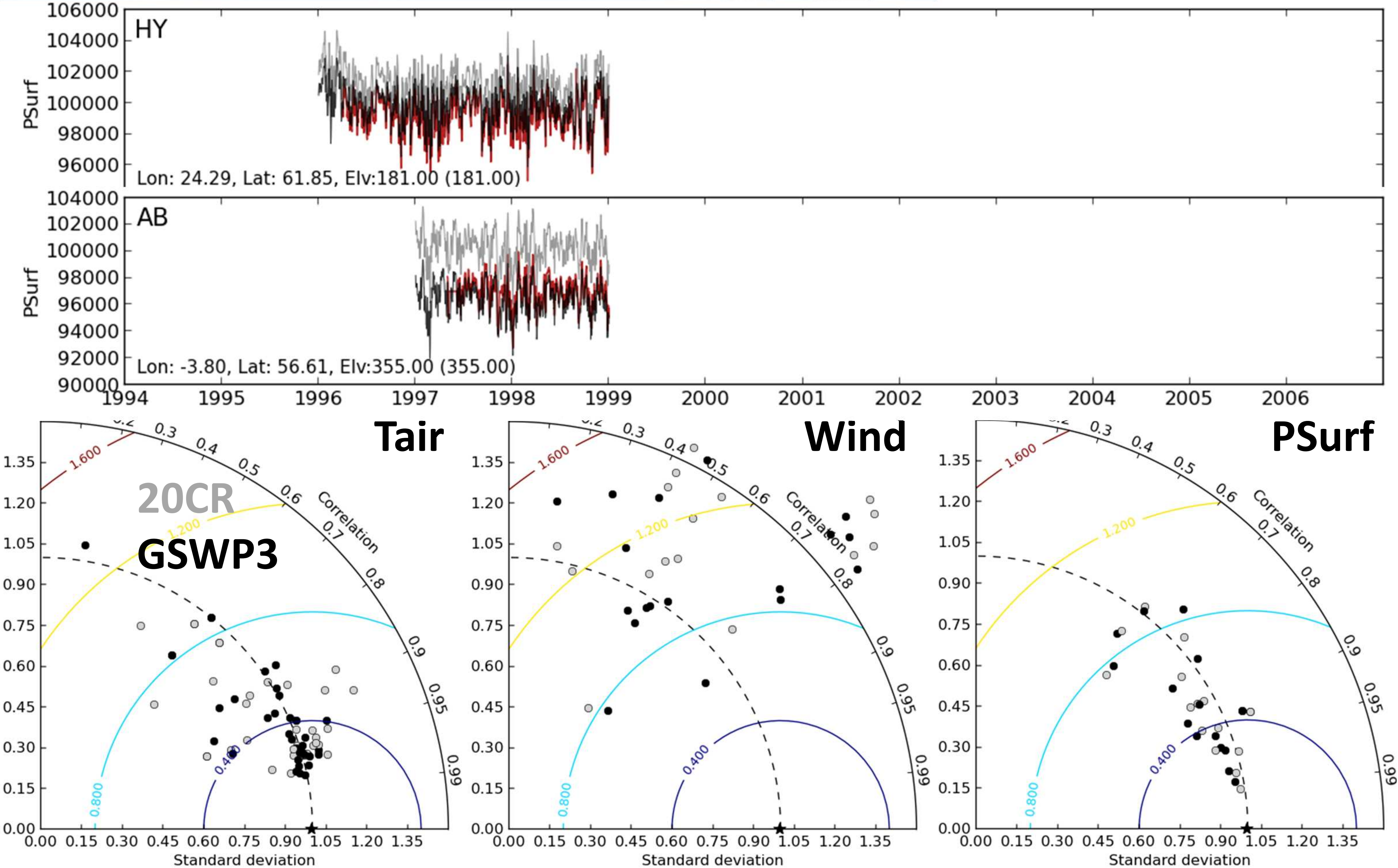



PSurf
Correlation
1.600
1.200
0.800
0.400


HarvardFluxnet
PSurf
Lon:-72.17, Lat: 42.54, Elv:340.00 (30.00)
GSWP3
20CR
OBS
HesseFluxnet
Lon: 7.06, Lat: 48.67, Elv:300.00 (20.00)

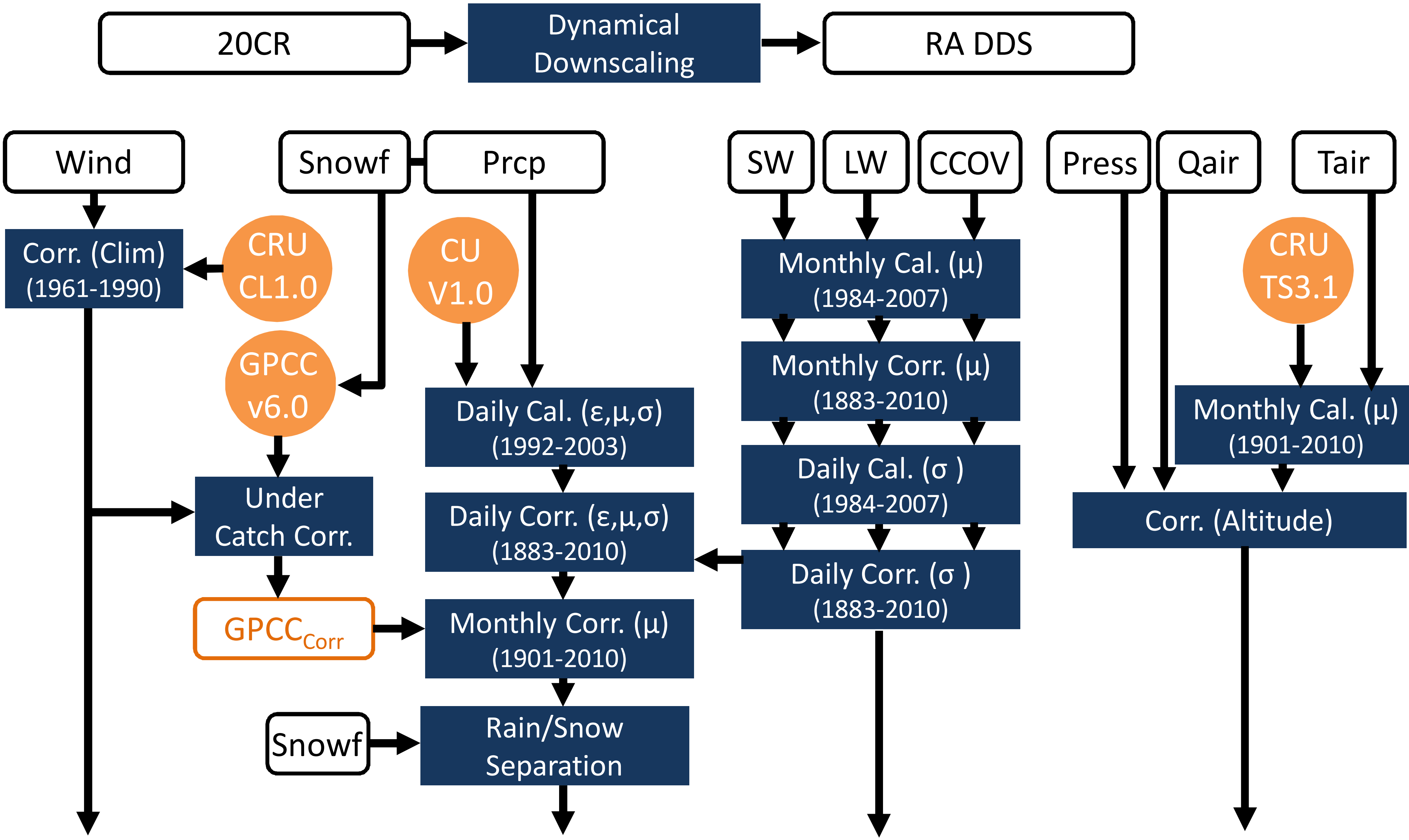
FLUXNET Marconi Conference Gap-Filled Flux and Meteorology Data

Validation



Thank you

Overall Strategy



Air Temperature Correction

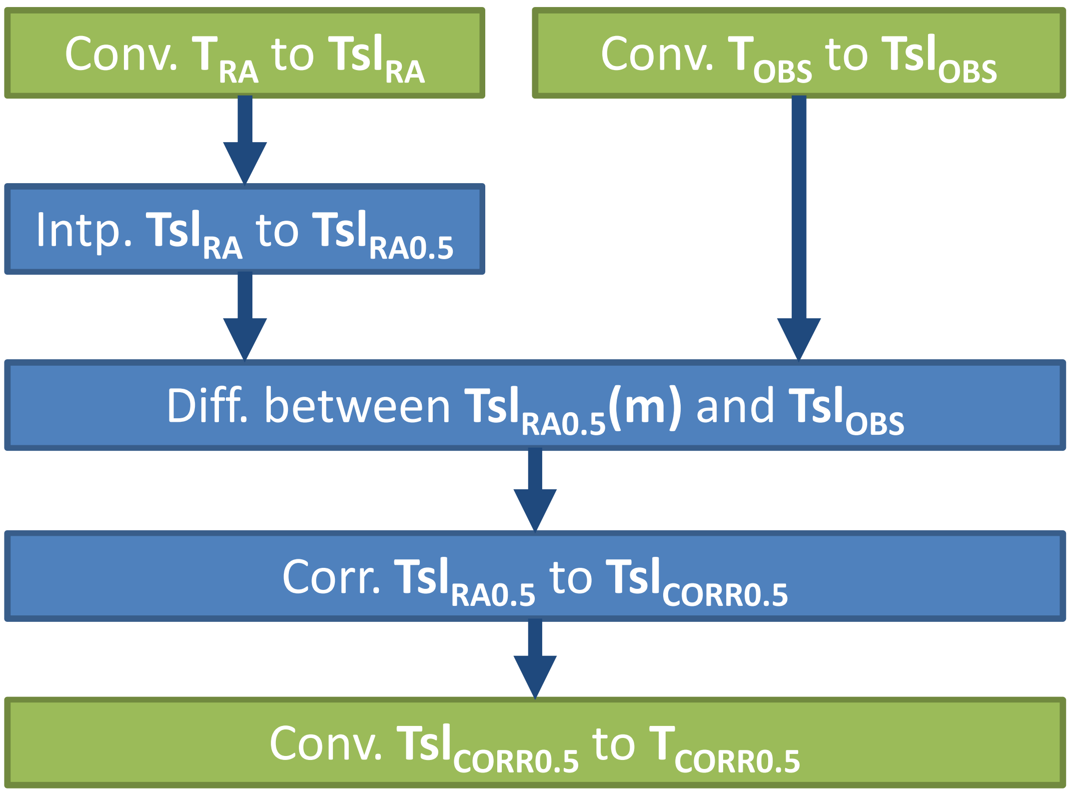
Sources of Bias

1. Simulation in Reanalysis & DDS
2. Reference Observation
3. Spatial Resolution
4. Elevation Mismatch

Biases to be Corrected

1. Geographical Biases [S3, S4]
2. Monthly Mean [S1]
3. Diurnal Temperature Range [S1]

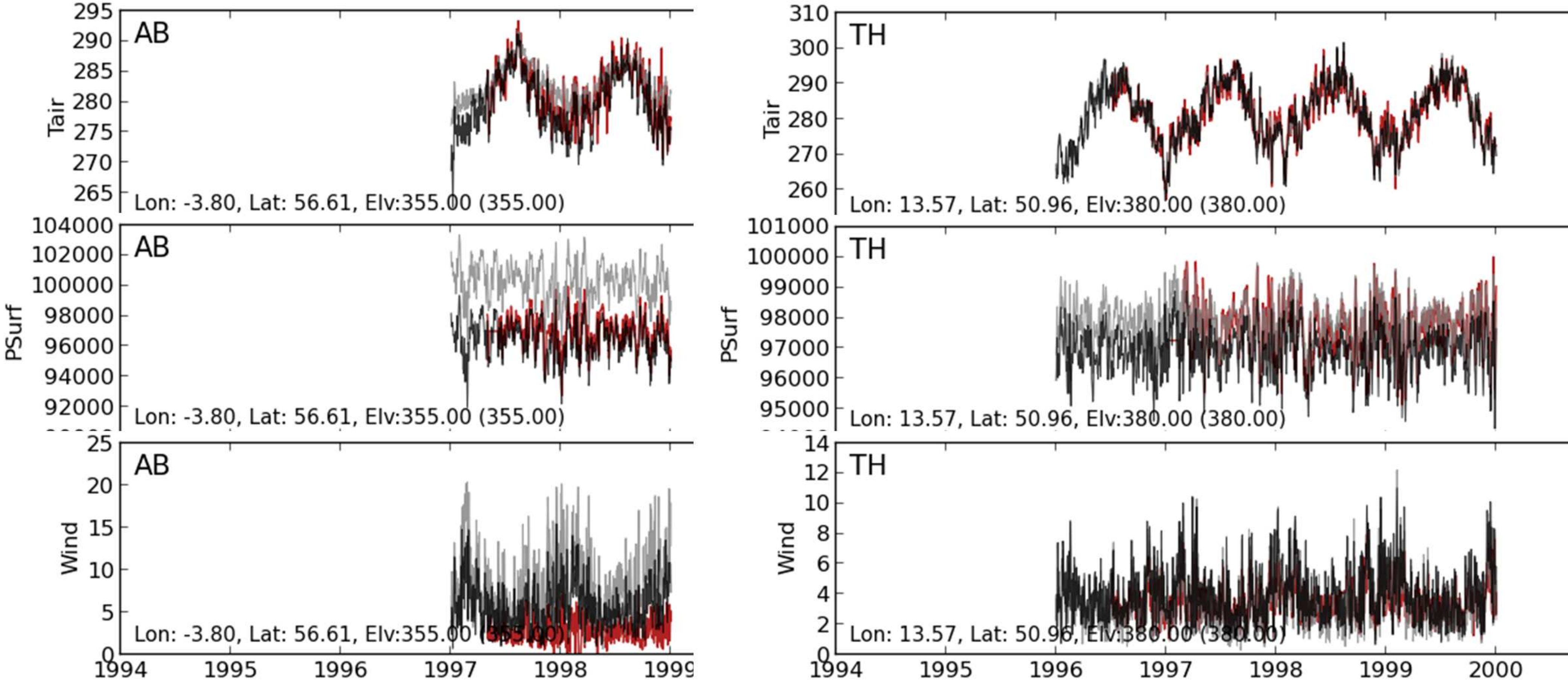
	Temporal Res.	Spatial Res.
Reanalysis	Hourly	2°
Observation	Monthly	0.5°



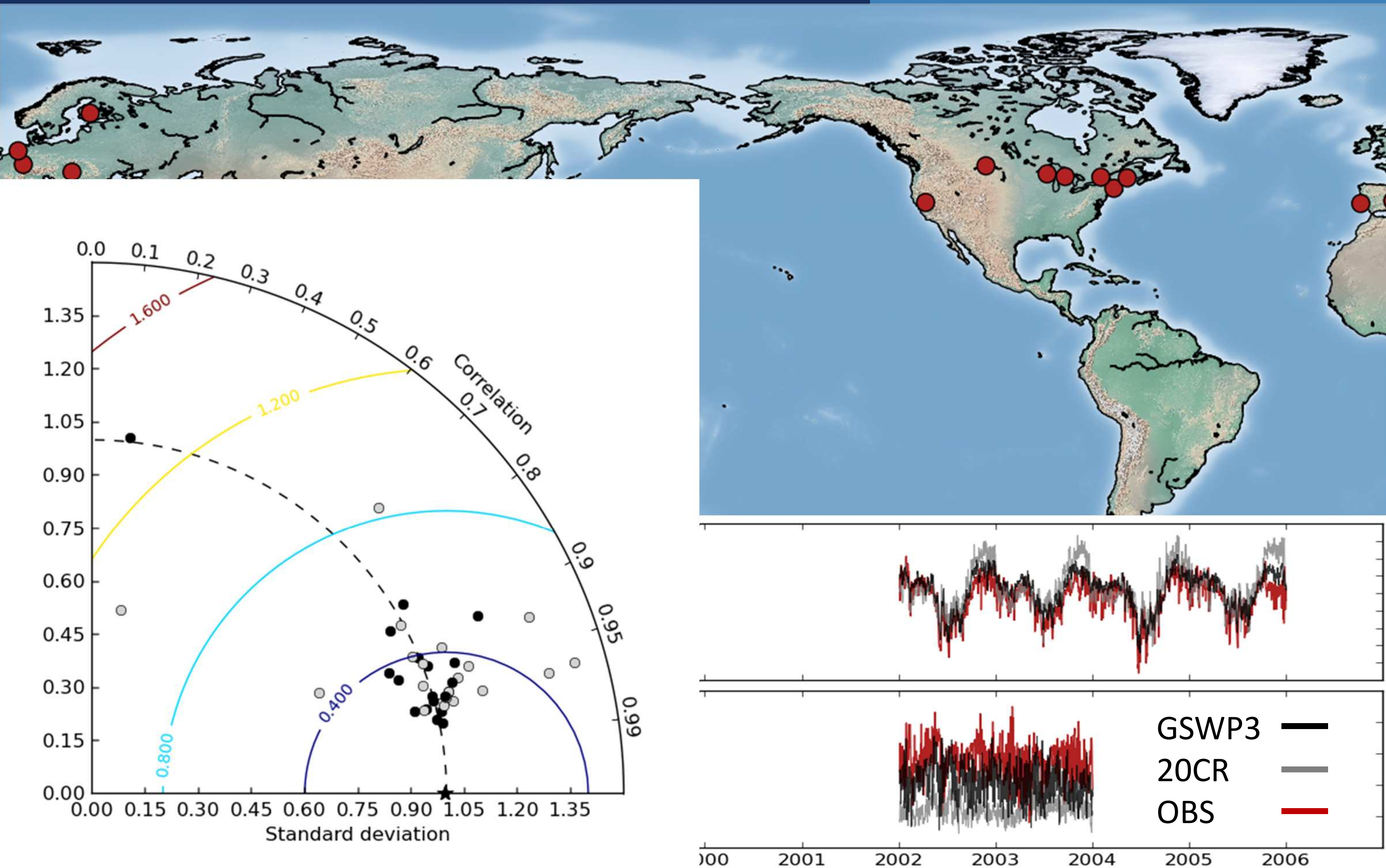
hjkim@rainbow.iis.u-tokyo.ac.jp

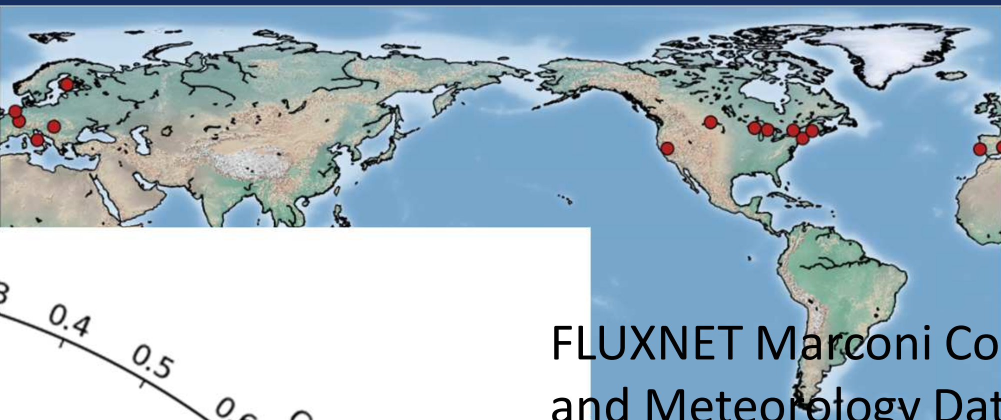
MARCONI: Griffin, Aberfeldy, Scotland

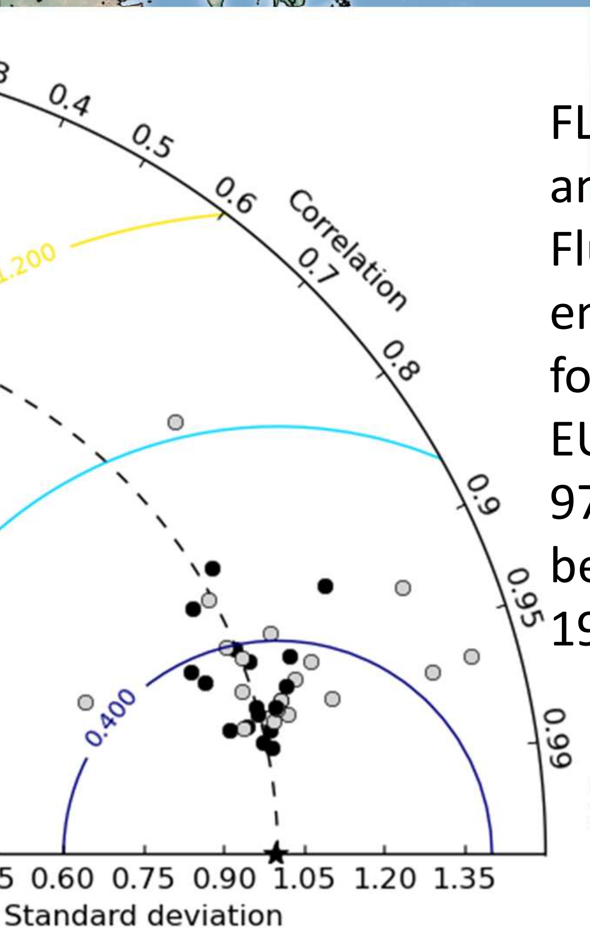
Validation



Validation


Correlation
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0.95
0.99
1.600
1.200
0.800
0.400
Standard deviation
0.00 0.15 0.30 0.45 0.60 0.75 0.90 1.05 1.20 1.35
GSWP3
20CR
OBS
2001 2002 2003 2004 2005 2006





FLUXNET Marconi Conference Gap-Filled Flux and Meteorology Data, 1992-2000

Fluxes of carbon dioxide, water vapor, and energy exchange have been measured at 38 forest, grassland, and crop sites as part of the EUROFLUX and AmeriFlux projects. A total of 97 site-years of data were compiled, primarily between 1996 and 1998 but also for 1992-1995 and 1999-2000.