[1]LS3MIP and [2]GSWP3

[1]Land Surface, Snow, Soil-moisture Model Intercomparison Project
[2]Global Soil Wetness Project Phase 3

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[4]Sonia Seneviratne, [5]Chris Derksen, and [1]Taikan Oki

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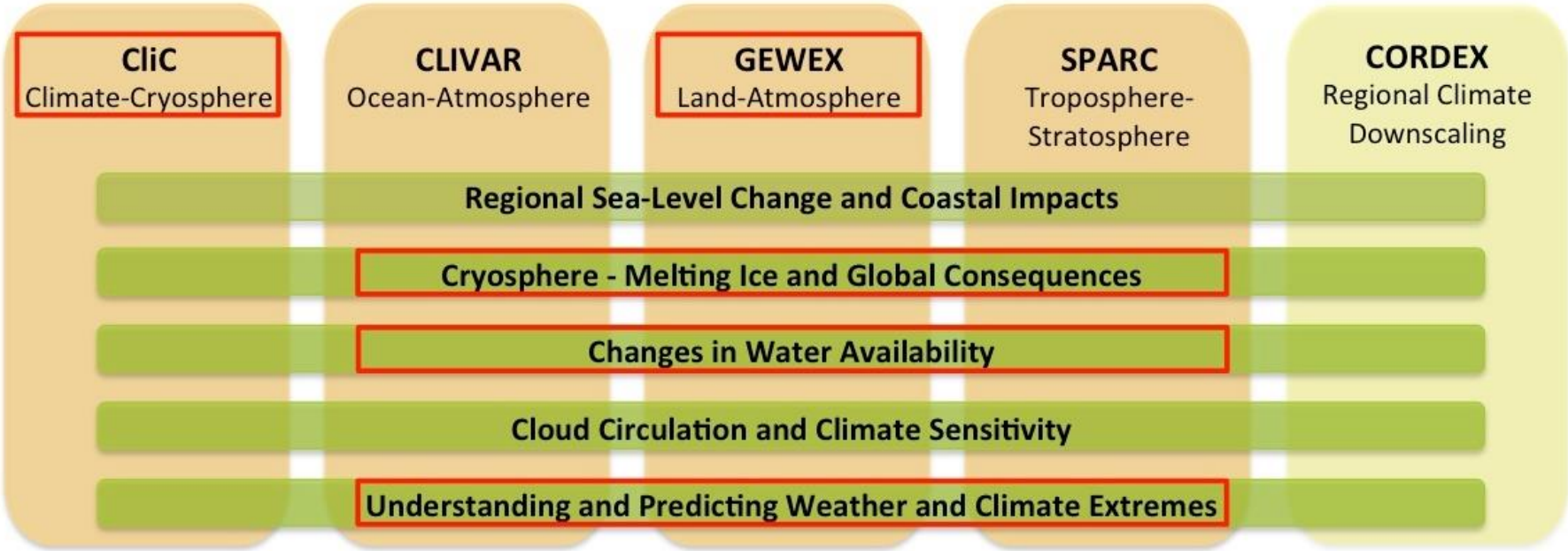
[4]ETH Zürich Switzerland; [5]Environment Canada

Land Surface, Snow, Soil moisture Model Intercomparison Project

Bart van den Hurk, Gerhard Krinner, Sonia Seneviratne, Chris Derksen, Hyungjun Kim and Taikan Oki

~ + GLACE-CMIP (GEWEX) + ESM-SnowMIP (CliC)

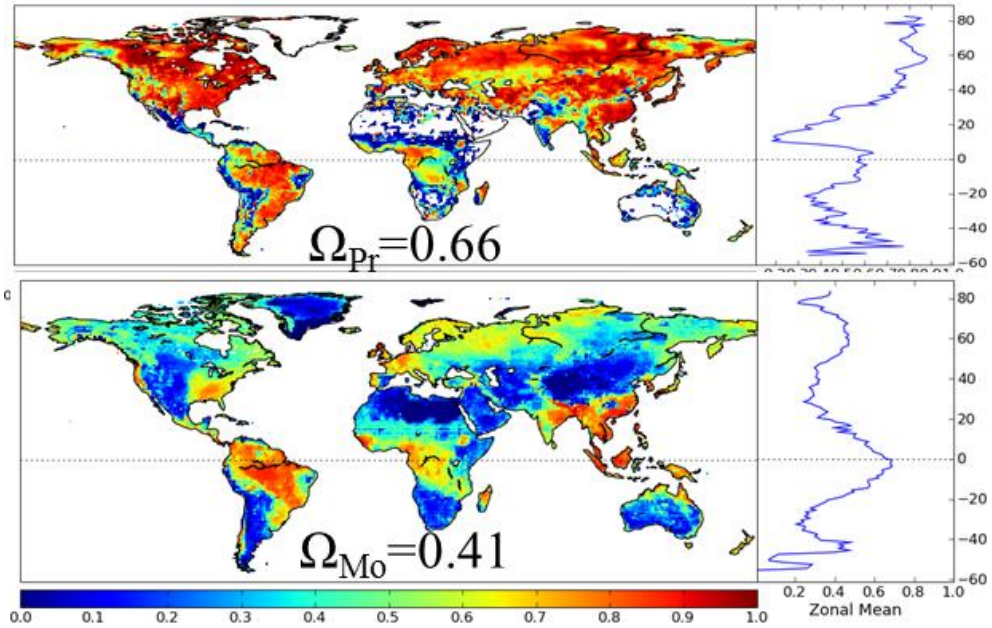
Scientific Goal: To provide the means to quantify the associated uncertainties and better constrain climate change projections, which is of particular interest for highly vulnerable regions for ESMs in CMIP6.

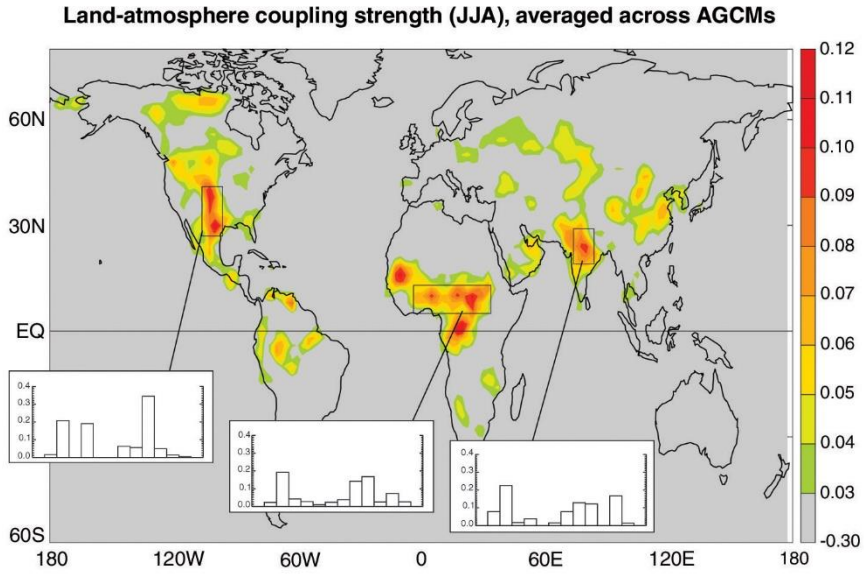


Gaps to be Filled by LS3MIP

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

  Kim (2010) showing that disparity in simulated runoff from uncertainty in ensemble precipitation is much less than model uncertainty :
  LMIP/GSWP3





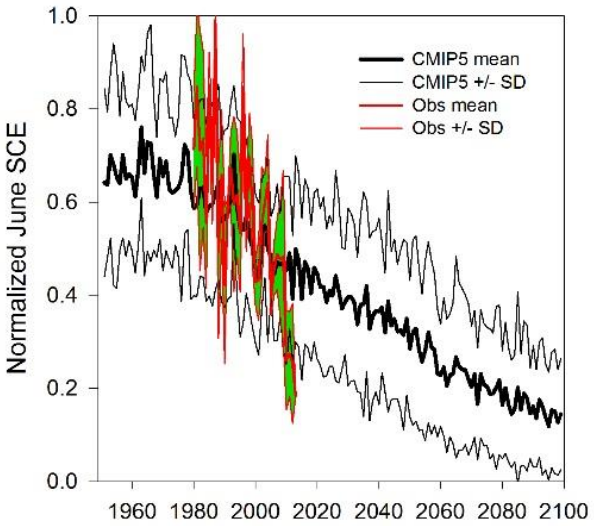
+ Explore model-dependent land-atmospheric coupling

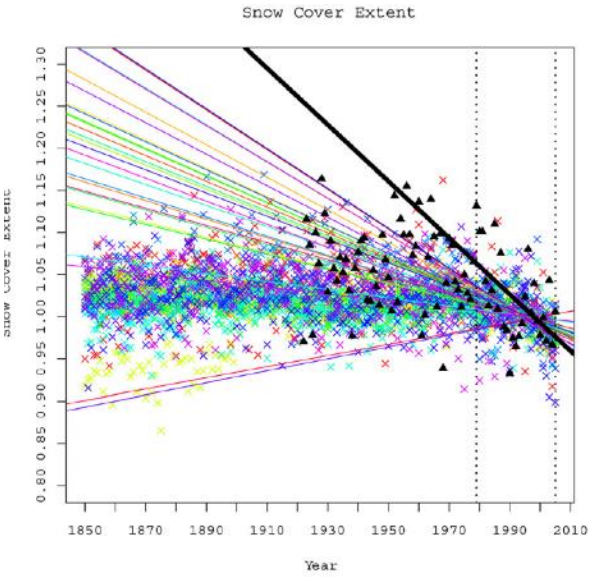
  Koster et al (2006): GLACE result showing model-specific land-atmospheric coupling strength :
  LFMIP

Gaps to be Filled by LS3MIP

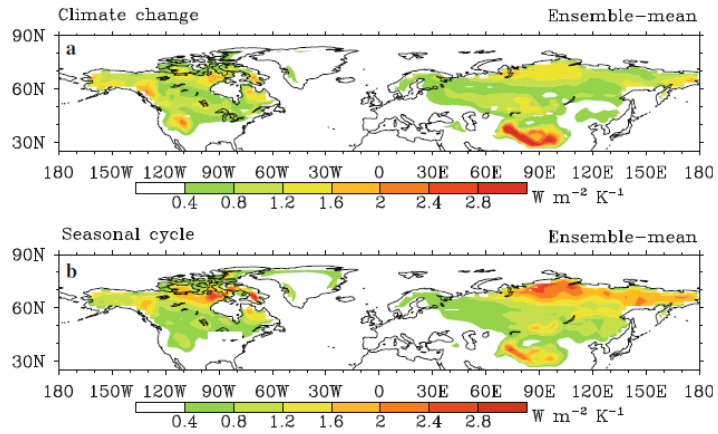
+ Ability of climate models to capture observed rates of spring snow cover reductions

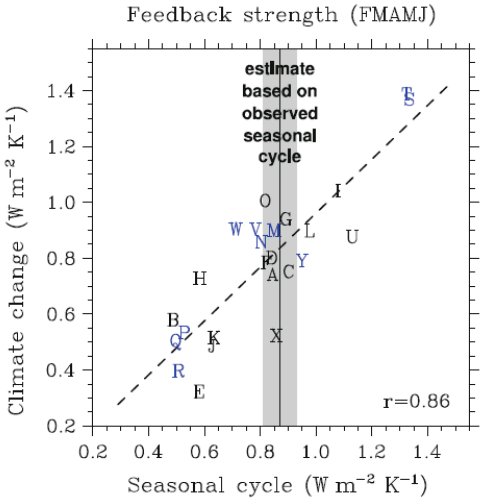
Brutel-Vuilmet et al. (2012); Derksen and Brown (2012): CMIP5 models underestimate the significant reductions in spring snow cover extent observed during the satellite era : **ESM-SnowMIP**





+ Linkage between snow-albedo feedback and 21st century warming



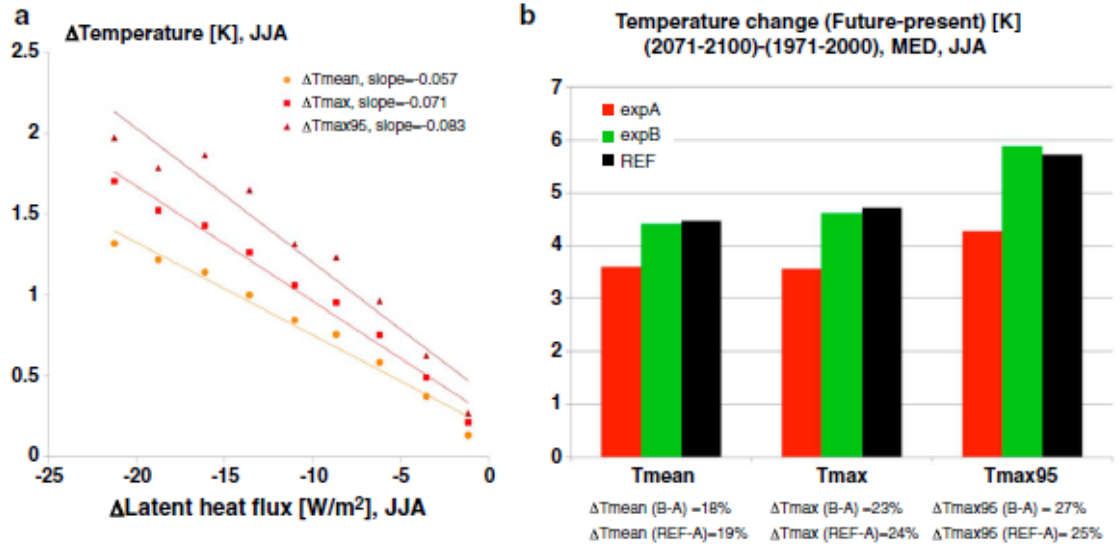


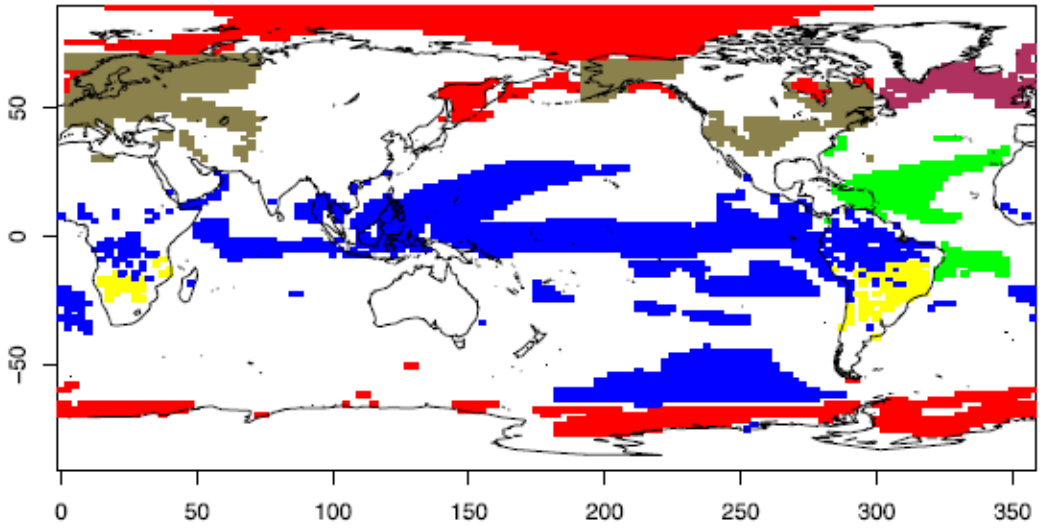
Qu and Hall (2013): The spread in snow albedo feedback accounts for much of the CMIP5 spread in the 21st century warming of Northern Hemisphere land masses : **ESM-SnowMIP**

Gaps to be Filled by LS3MIP

+ Soil moisture affecting the climate change signal

Seneviratne et al (2014): GLACE-CMIP5 result showing effect of prescribing 20th century soil moisture climatology : **LFMIP**

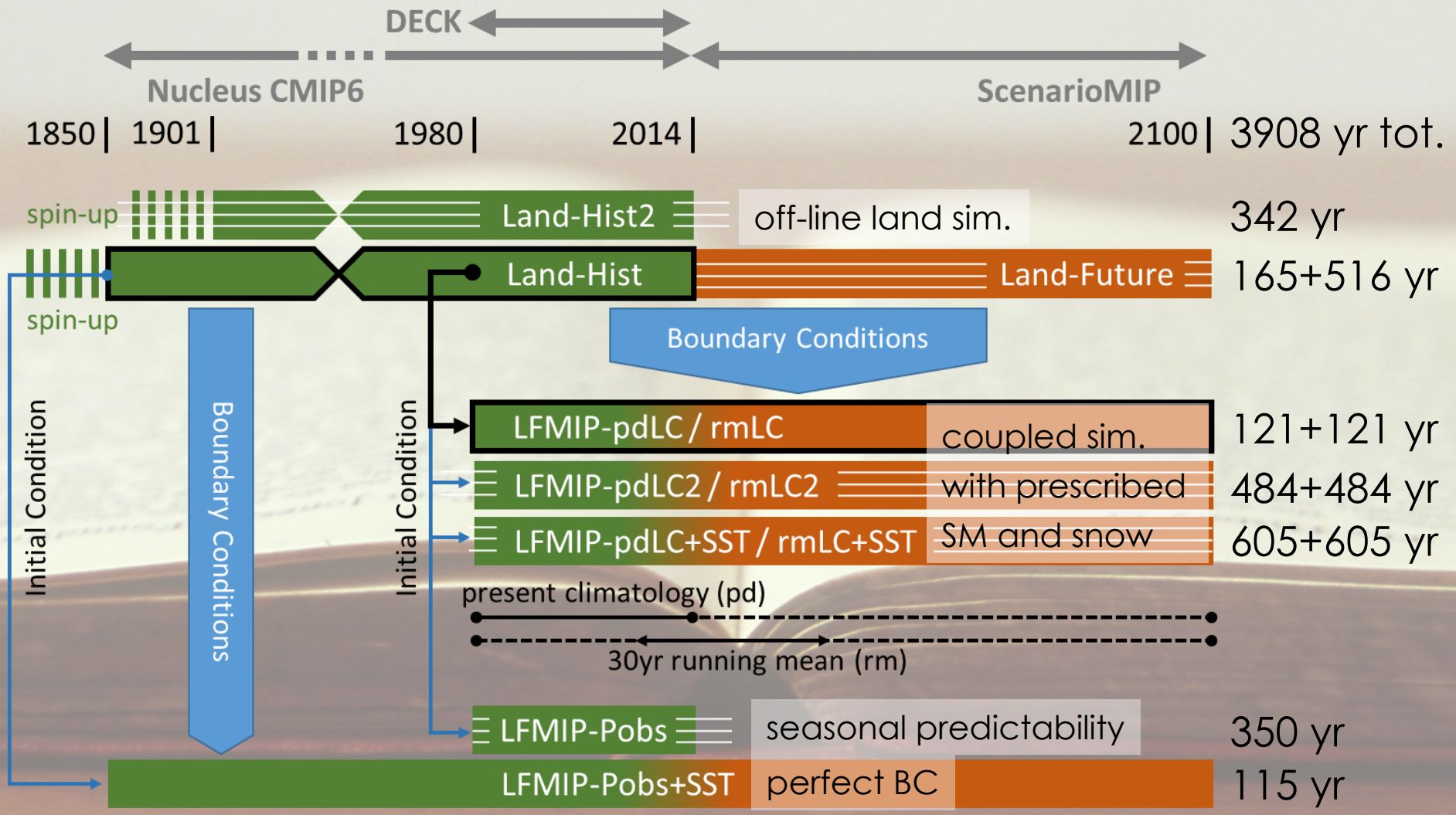




+ (Seasonal) Predictability can alter in a warmer climate

Del Sole et al (2014): Changes in seasonal predictability as a result of a trade-off between more signal and more noise in a warmer world : **LFMIP**

Experiment Structure



an evaluation of the land processes representation

long-term terrestrial energy/water/carbon cycles **LMIP**

role of snow and soil moisture feedbacks to climate forcing

contribution of land processes to the predictability **LFMIP**

Global Soil Wetness Project Phase 3

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

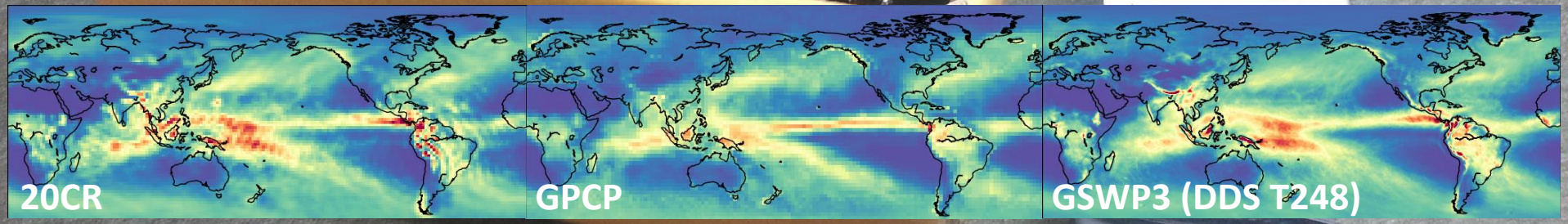
* LDMF Daily Correction (Kim et al., in prep.)
* Parametric Monthly Correction (Watanabe et al., 2012)

GSWP3 EXP1 Forcing

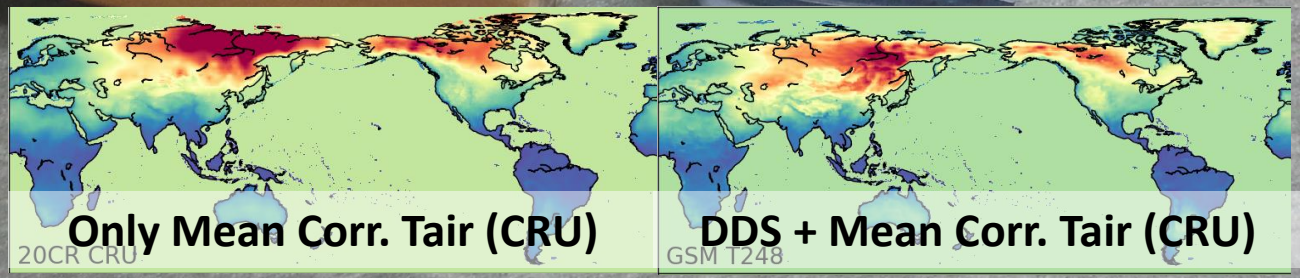
20CRv2c (Compo et al., 2011)
1831-2011 6hr / 2°x2°(91x180)

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

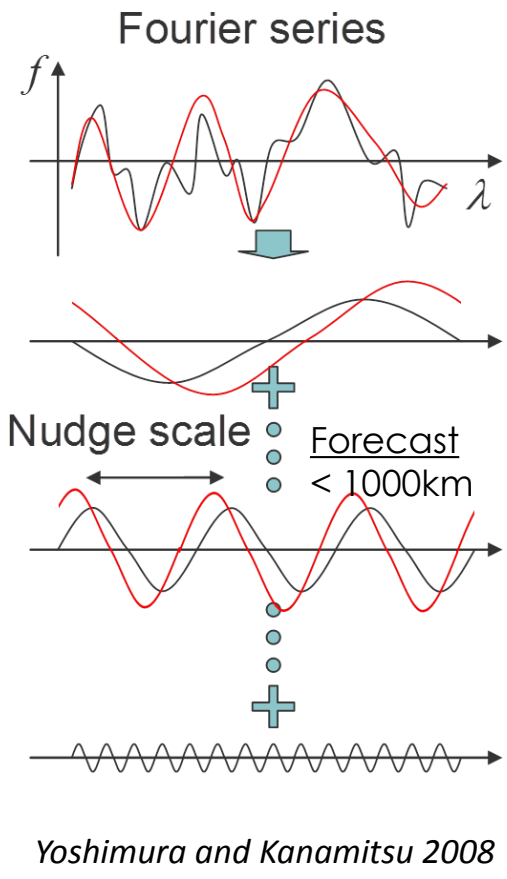
0.5°x0.5°
1901-2010 3hr



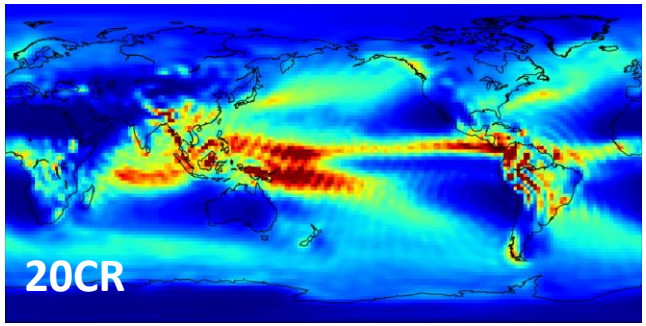
Better representation of mean and **variability** in high-frequency domain



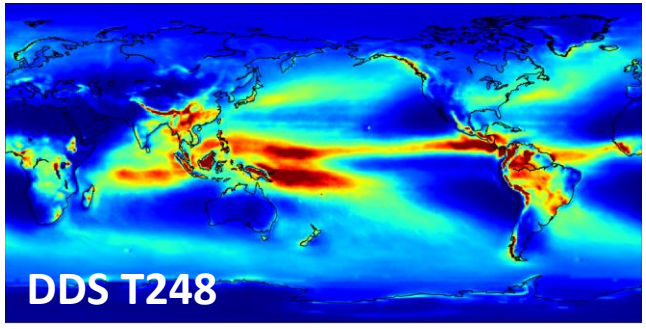
Spectral Nudging for Global Dynamical Downscaling



Yoshimura and Kanamitsu 2008

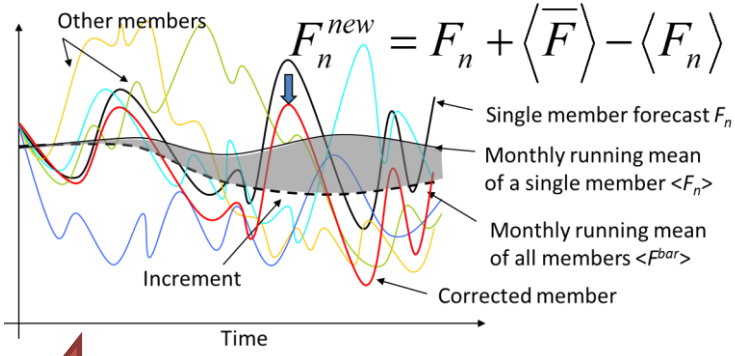


Nudging U, V, T, P



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

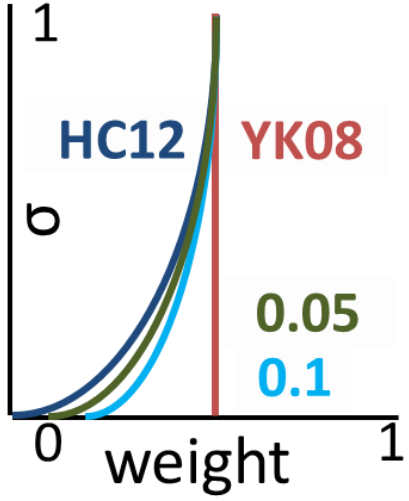
$$A_{(m,\phi)} = \begin{cases} A_{f(m,\phi)} & \left(|m| > \frac{2\pi R_E \cos\phi}{L}\right) \\ \frac{1}{\alpha+1}\left[A_{f(m,\phi)} + \alpha A_{a(m,\phi)}\right] & \left(|m| \le \frac{2\pi R_E \cos\phi}{L}\right) \end{cases}$$



Incremental Correction of Single Member

Yoshimura and Kanamitsu 2013

Vertically Weighted Damping Coef.



Hong and Chang 2012

Successfully generate high frequency signals preserving low frequency background.

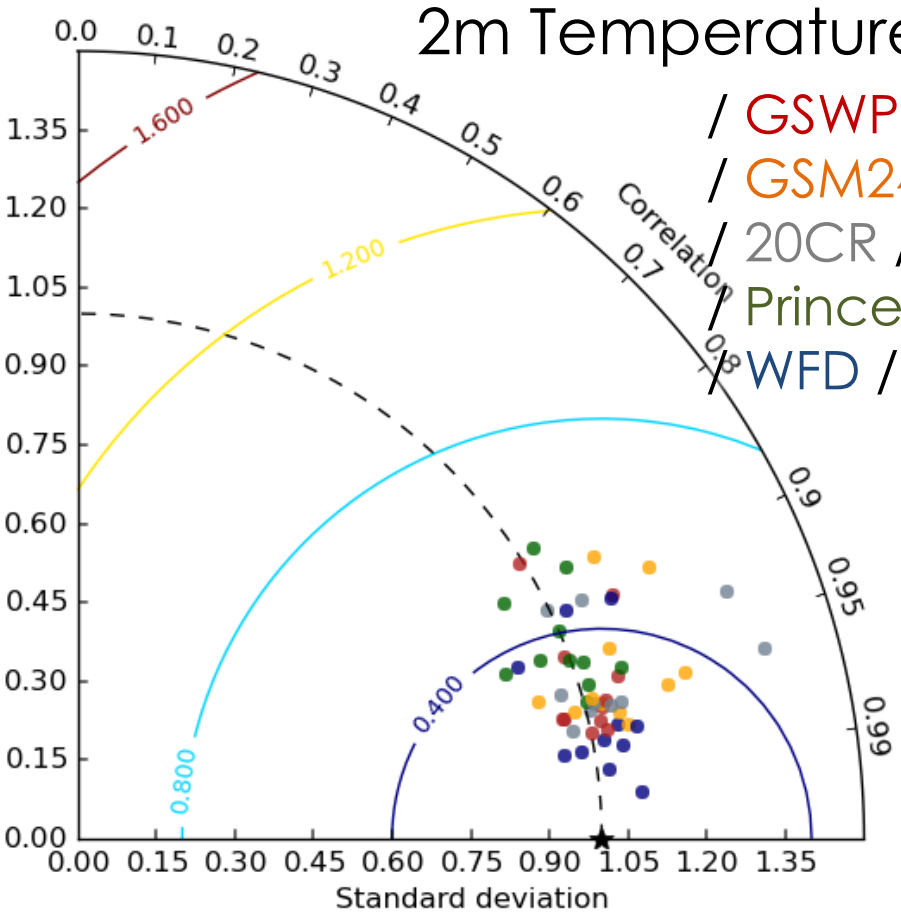
Effectively relieves ripple-like pattern (an artifact of 20CR due to high-res. topography mismatch)

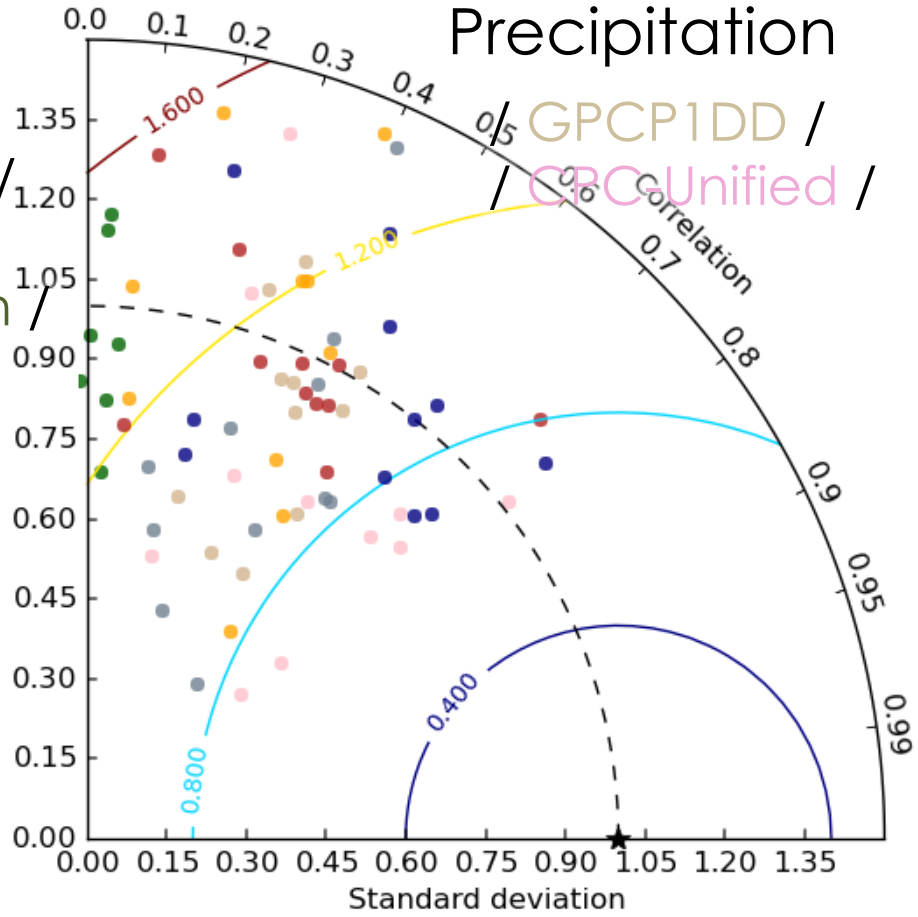
Comparison Table for Existing Forcing Data

	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.)

Preliminary Results and Known Problems

+ Beta-version of Land Surface Forcing Data Ready

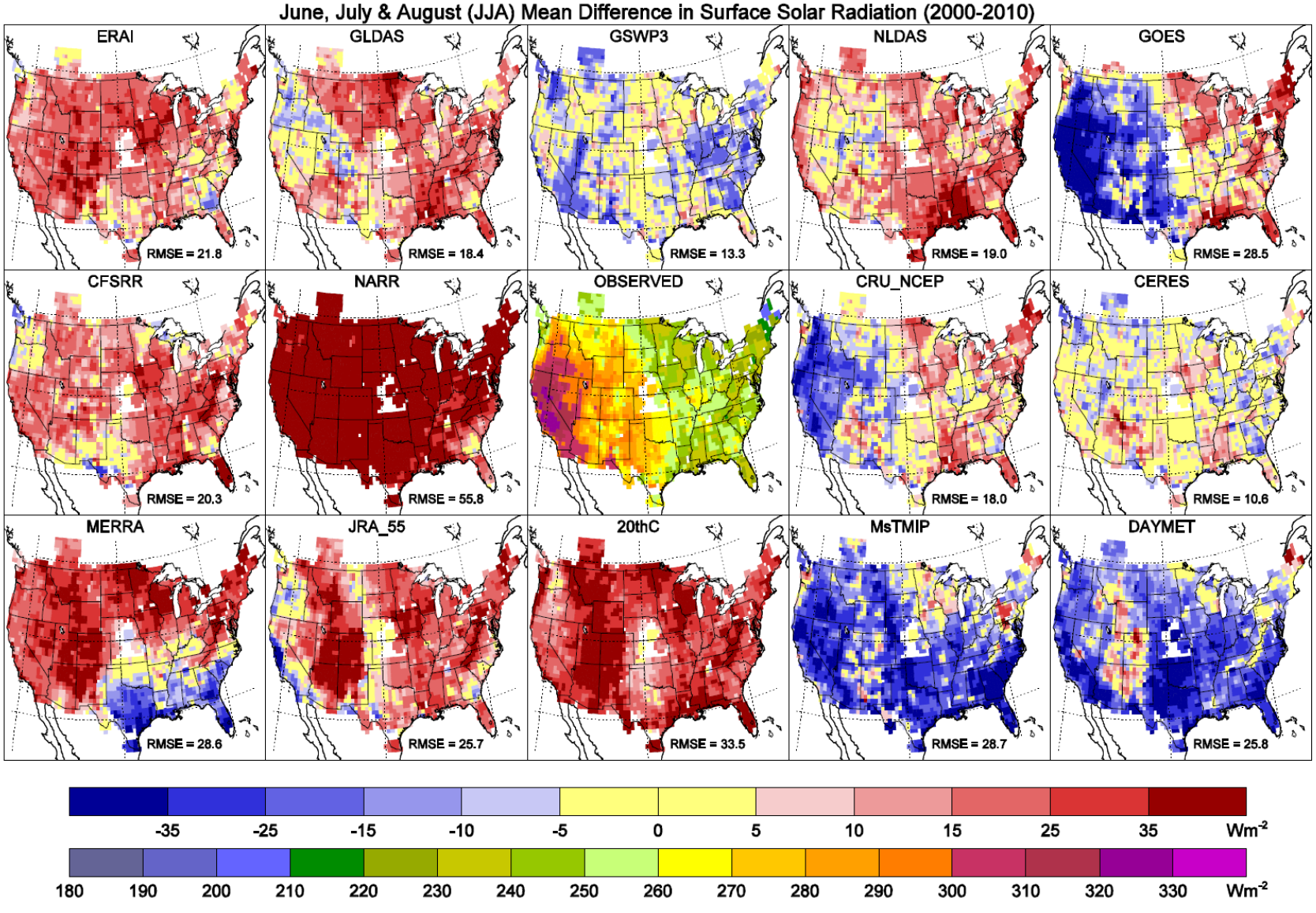




20th Century Reanalysis (Compo et al., 2011) is dynamically downscaled using GSM, and observational dataset is incorporated to reduce modeled fields.

Preliminary Results and Known Problems

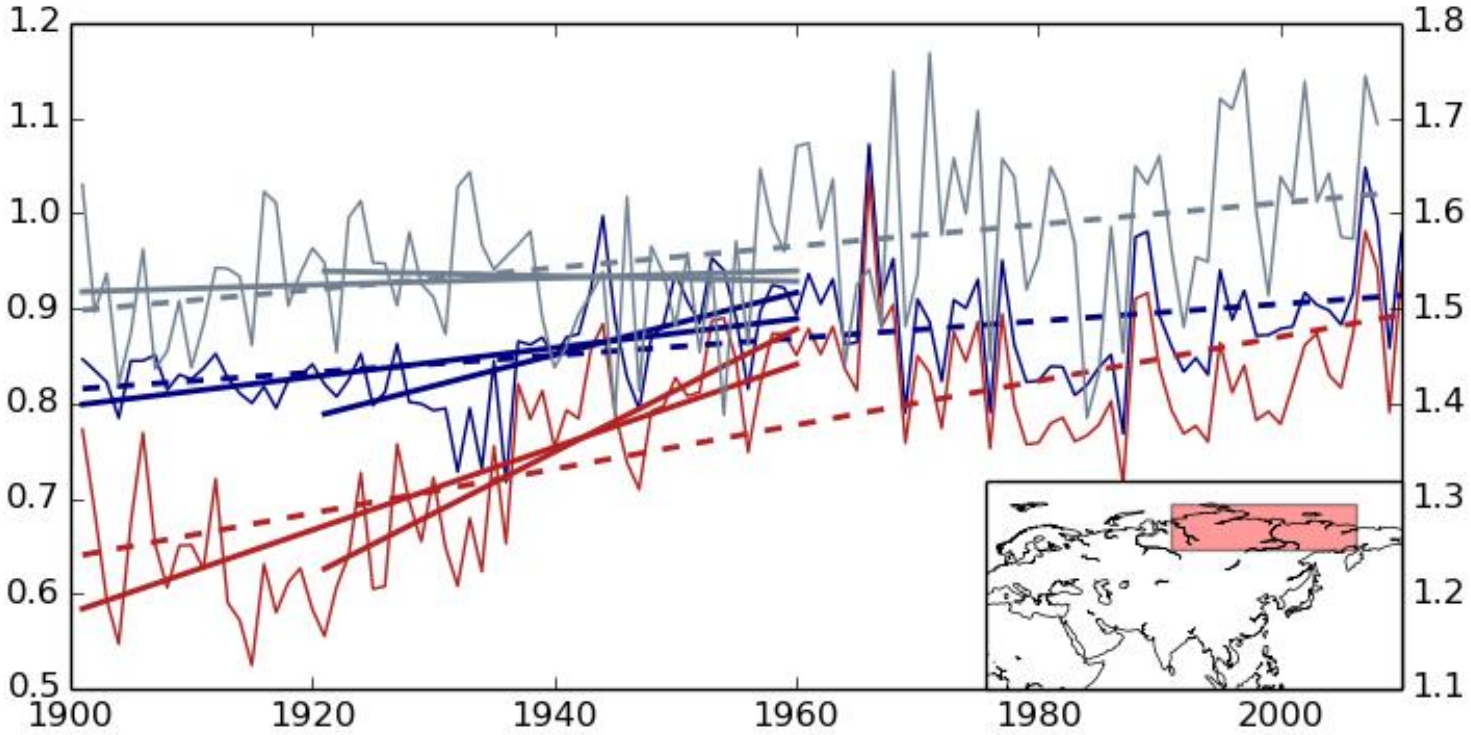
+ Relatively small bias of solar radiation



Slater, 2015

Preliminary Results and Known Problems

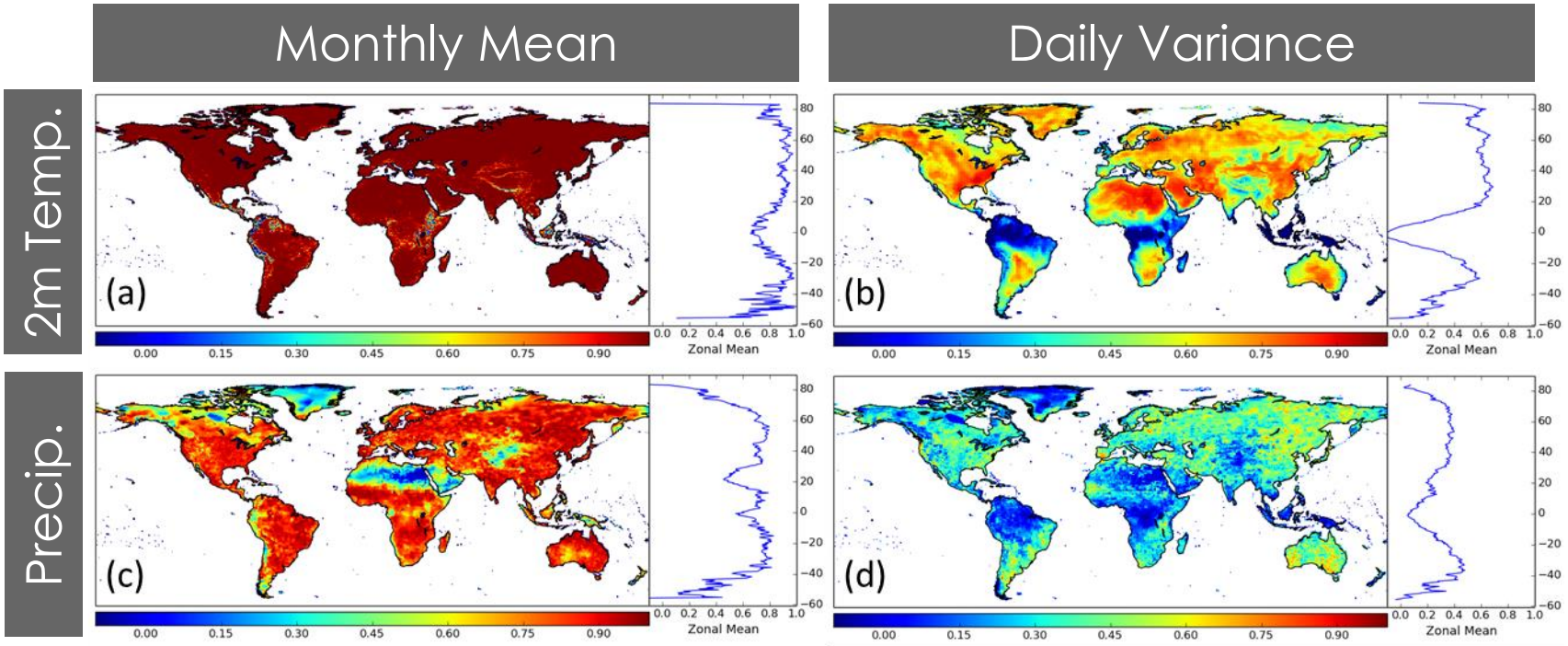
+ Spurious(?) trend at high latitude in early 20th Century



	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

Preliminary Results and Known Problems

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

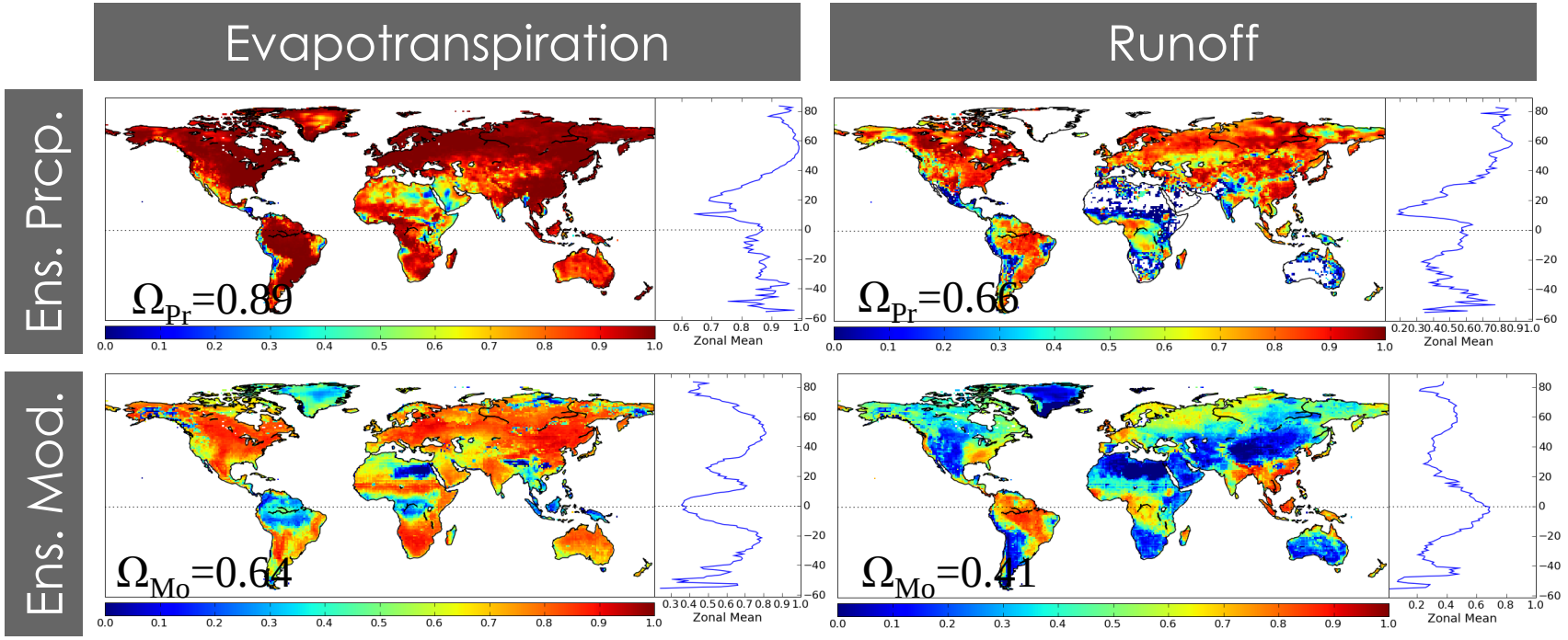


Global distribution of the similarity index (Ω) for 2001-2010 of monthly mean and variance calculated from different dataset.

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

Preliminary Results and Known Problems

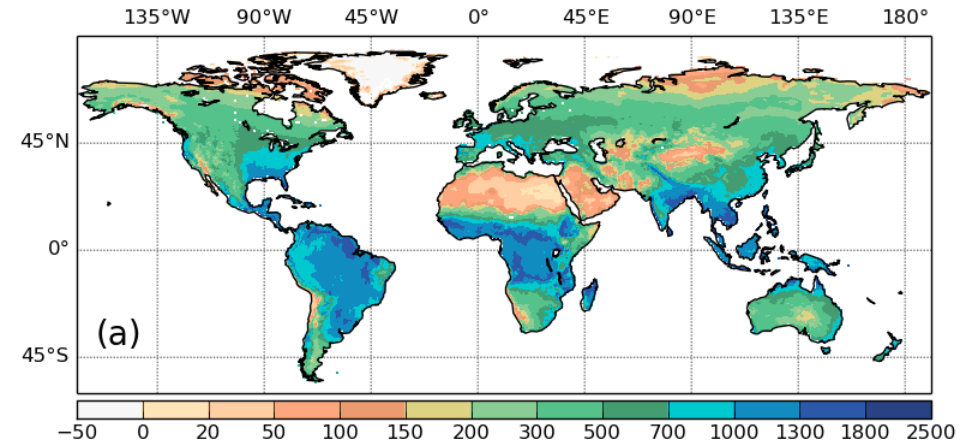
+ Map (uncertainty of) water resources over the 20th century (and beyond)



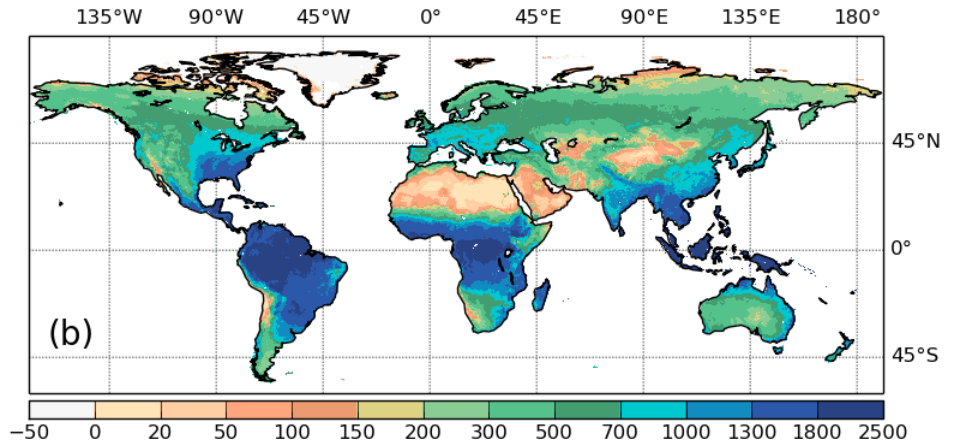
Uncertainty in simulated evapotranspiration and runoff introduced by different land surface schemes in GSWP2 are larger than precipitation uncertainty-induced uncertainty by 28% and 40% in the similarity index (Ω) globally.

Preliminary Results and Known Problems

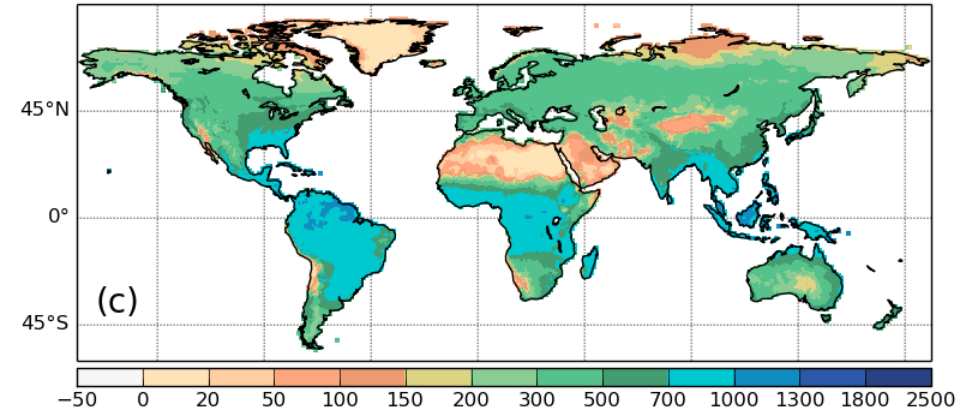
+ Significant discrepancy of spatial distributions found between models but no apparent changes or shifts in temporal variability (Here, Evapotranspiration in 20th Century)



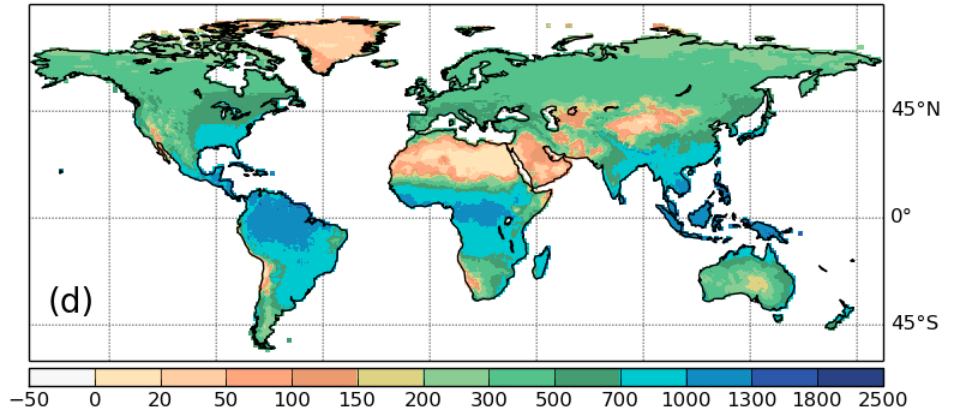
MATSIRO



CLM4.5



ETH with Rnet $_{MATSIRO}$



ETH with Rnet $_{SRB}$


Thank you

Connection to DECK (Diagnostic, Evaluation and Characterization of Klima) and other MIPs

Land-Hist (LMIP; off-line land only)
+ Baseline for C4MIP, LUMIP, & CMIP6-historical

Historical runs for 1900-2014 serve as reference runs
+ Forcing datasets joint with other projects (GSWP3, WFDEI, Princeton, CRU-NCEP: Links to GSWP3, ISI-MIP and Trendy projects)

Future simulation to be selected from Scenario-MIP portfolio

Participants

ACCESS, BCC-CSM2-MR, CanESM, CESM, CMCC, CNRM-CM, EC-Earth, FGOALS, GFDL, GISS, IPSL-CM6, MIROC6-CGCM, MPI-ESM, MRI-ESM1.x, NorESM, UKESM

Further Goals and Contributions of LS3MIP

Routine multi-model reanalysis:
Trend/variability on water resources & general hydrological quantities

Analysis toolkit:
Detections and attributions of climate change impacts on the trends

Of course, one of the expected challenges is the quantification of feedbacks from human activities, such as irrigation, to the future climate predictions by AOGCMs.

Scenario engine:
Future assessments based on full combinations of RCPs and SSPs, including anthropogenic interventions on water cycles

LS3MIP Overview

LMIP

+ **an evaluation of the land processes representation** in CMIP6 DECK runs, revealing main systematic biases and their dependencies

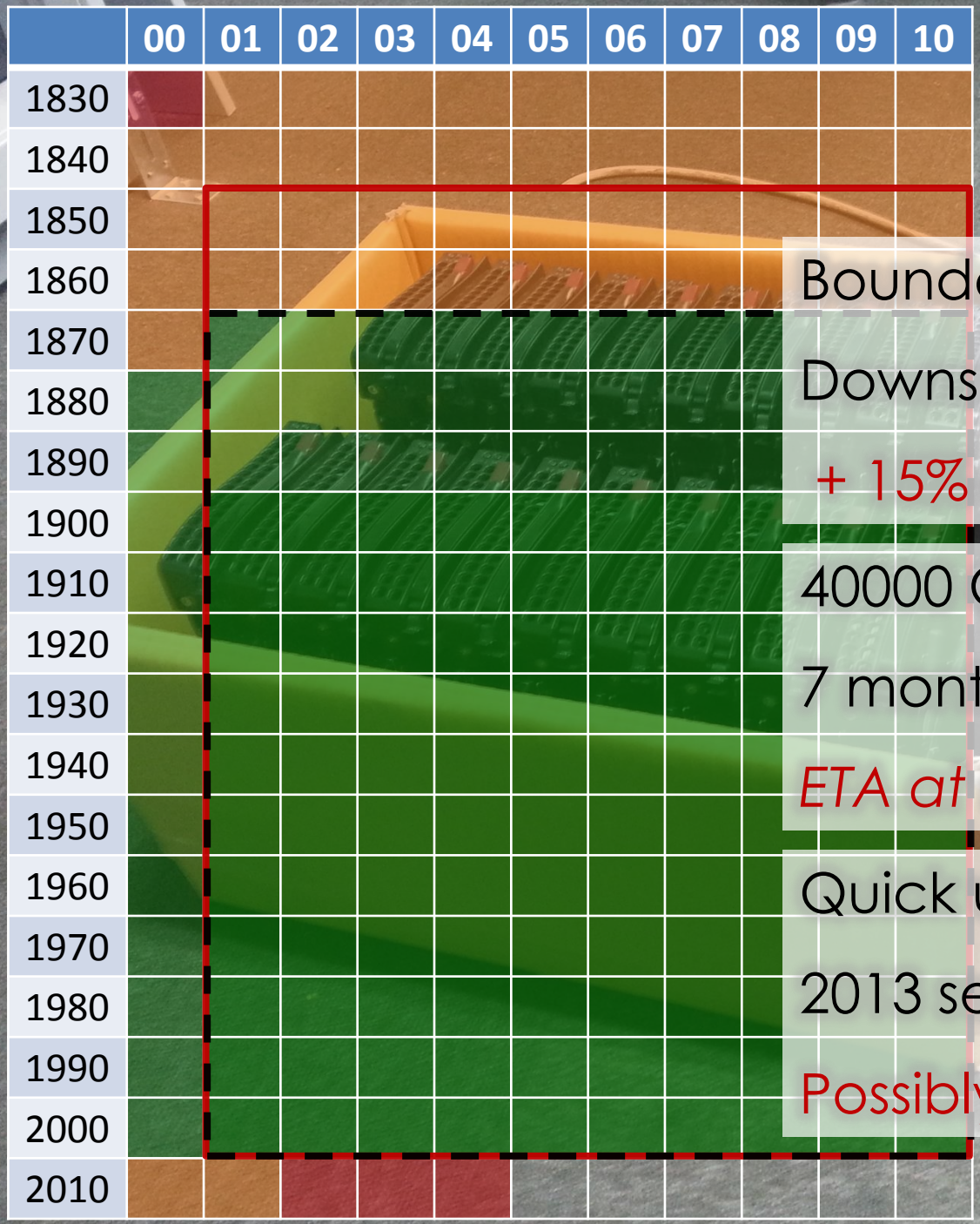
+ **an estimation of the long-term terrestrial energy/water/carbon cycles** under observation constrained historical (land reanalysis) and future (impact assessment) conditions considering LUCC.

LFMIP

+ **an assessment of the role of snow and soil moisture feedbacks** in the regional response to altered climate forcings, focusing on controls of climate extremes, water availability and high-latitude climate

+ **an assessment of the contribution of land surface processes** to systematic Earth System model biases and the current and future predictability of regional temperature/precipitation patterns

Forcing Data Update



Boundary Conditions ~10TB

Downscaled Data ~ 40TB

+ 15% additional data

40000 CPU Hours

7 months actual ETA

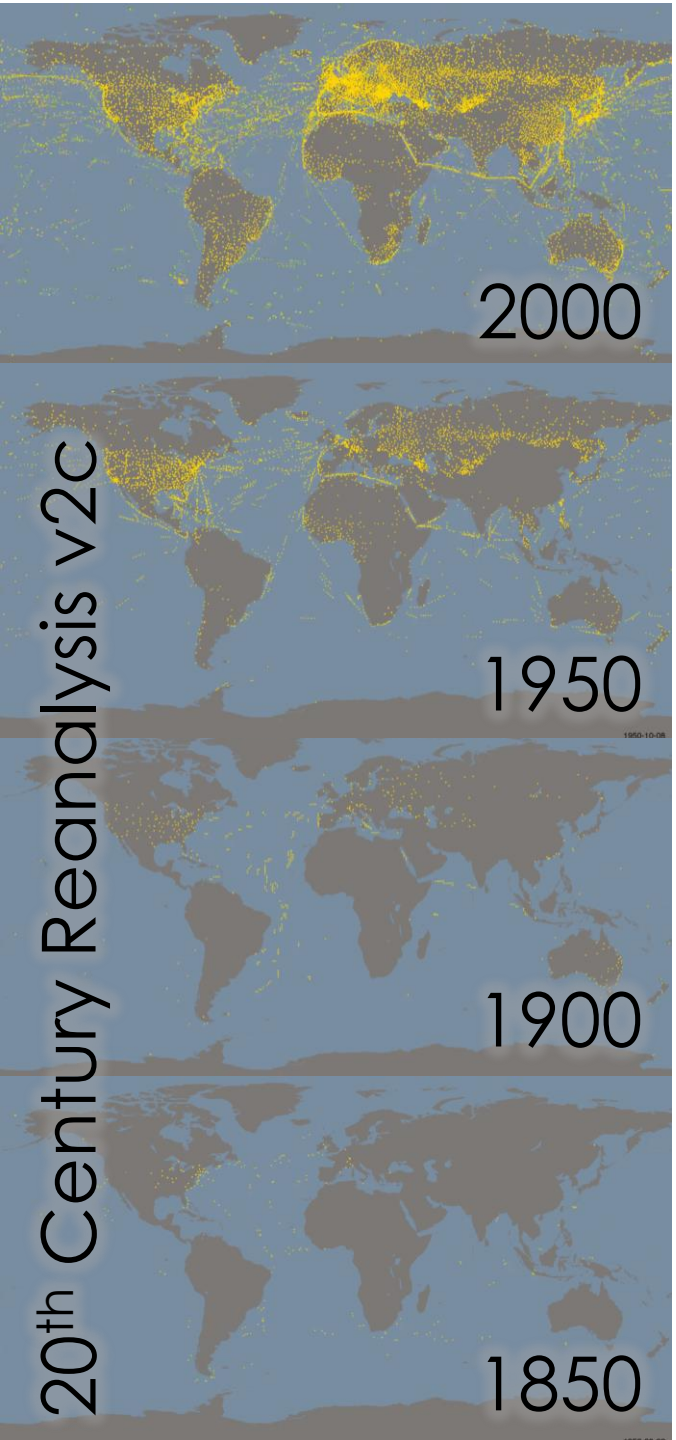
ETA at early-June

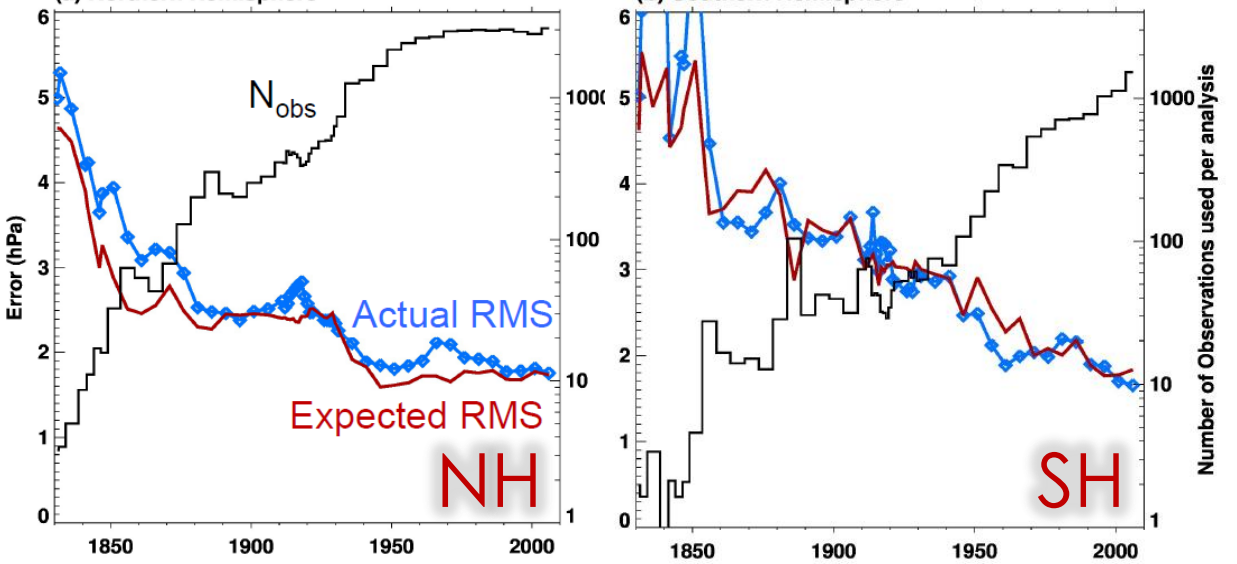
Quick update up to 2012

2013 seems not so optimistic

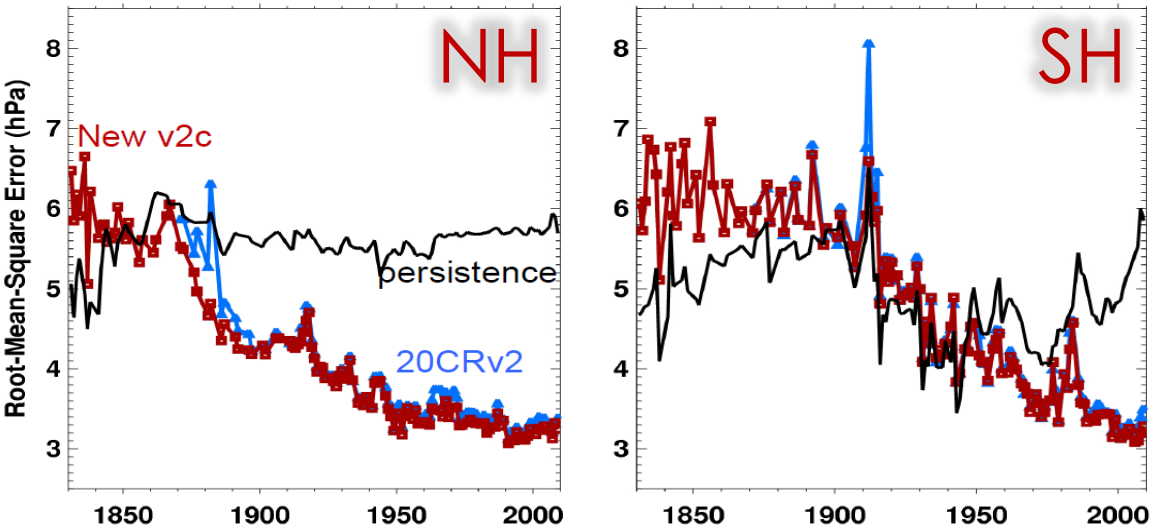
Possibly up to 2014?

2014, Be606, IIS





Uncertainty consistency through three order of magnitude changes in observation network



24 hr forecast of 20CR beats in NH (comparable to in SH) persistence forecast using NRA