Land surface impacts on seasonal forecasts

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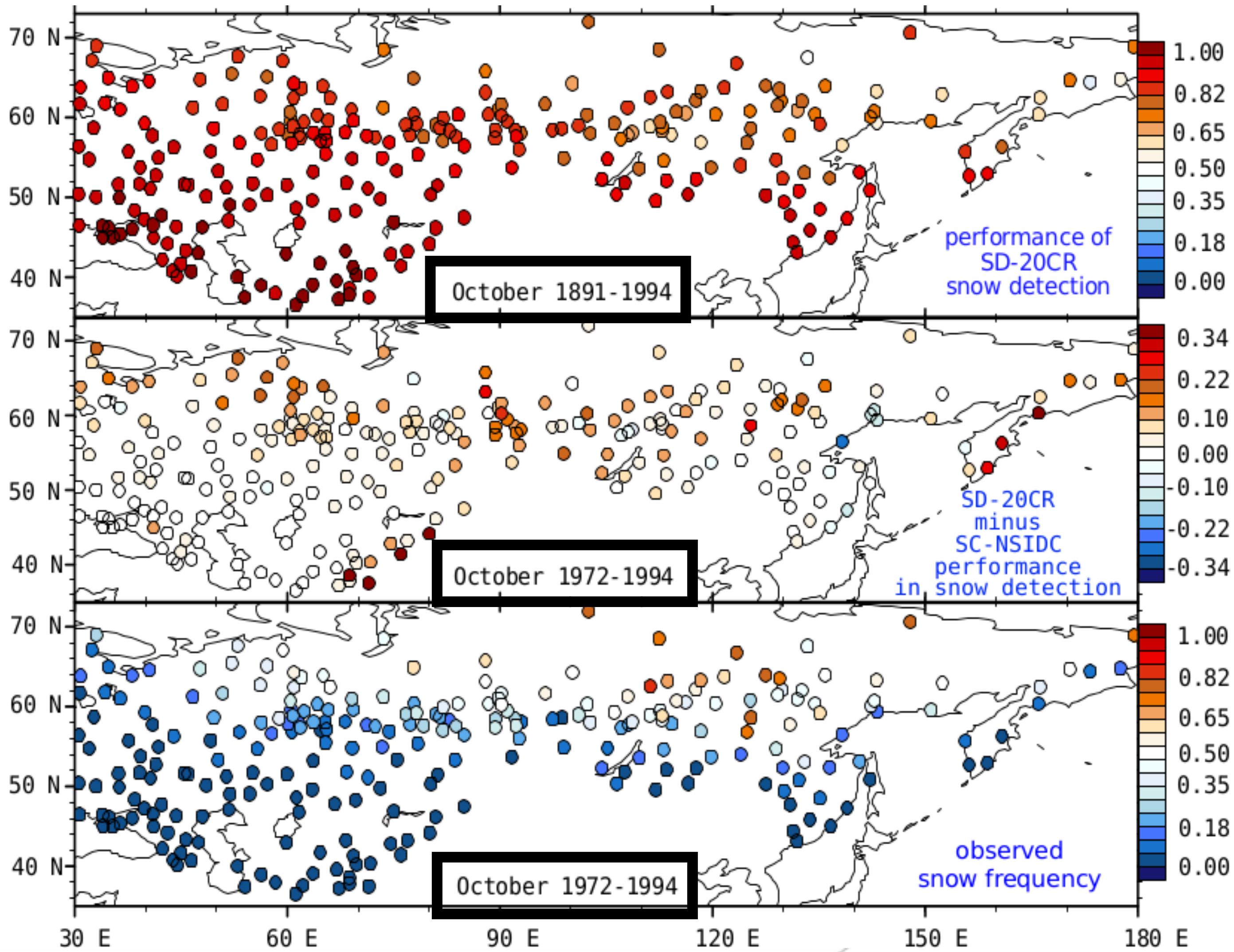
(Lack of) Global land surface datasets

- Satellite observations
  - o Visible and near infra-red: snow cover, vegetation cover, surface albedo
  - o Passive & active microwaves: soil moisture, SWE, vegetation
  - o Gravimetry (since 2002): total water storage variations
  - o …
- Off-line land surface model simulations
  - o GSWP-2 (1986-1995): 13 models driven with ISLSCP2 forcing data
  - o GLDAS (1979-present): 4 models driven with bias-corrected reanalyses or NOAA/GDAS *real-time* analyses (since 2000)
  - o Princeton Univ. (1950-2008) (Sheffield et al. 2006)
  - o …
- On-line LDAS systems
  - o Soil moisture analysis based on the assimilation of screen-level temperature and humidity (e.g. Météo-France, ECMWF, Met Office, …)
  - o Assimilation of NESDIS snow extent (e.g. ECMWF since 2004)
  - o Assimilation of ASCAT soil moisture (e.g. Met Office since July 2010)
  - o 20CR (1871-2010) (Compo et al. 2011)
  - o …

Snow data intercomparison
20CR & NSIDC vs daily *in situ* data

20CR early snow cover as good as NSIDC satellite data



Peings et al. (to be submitted)

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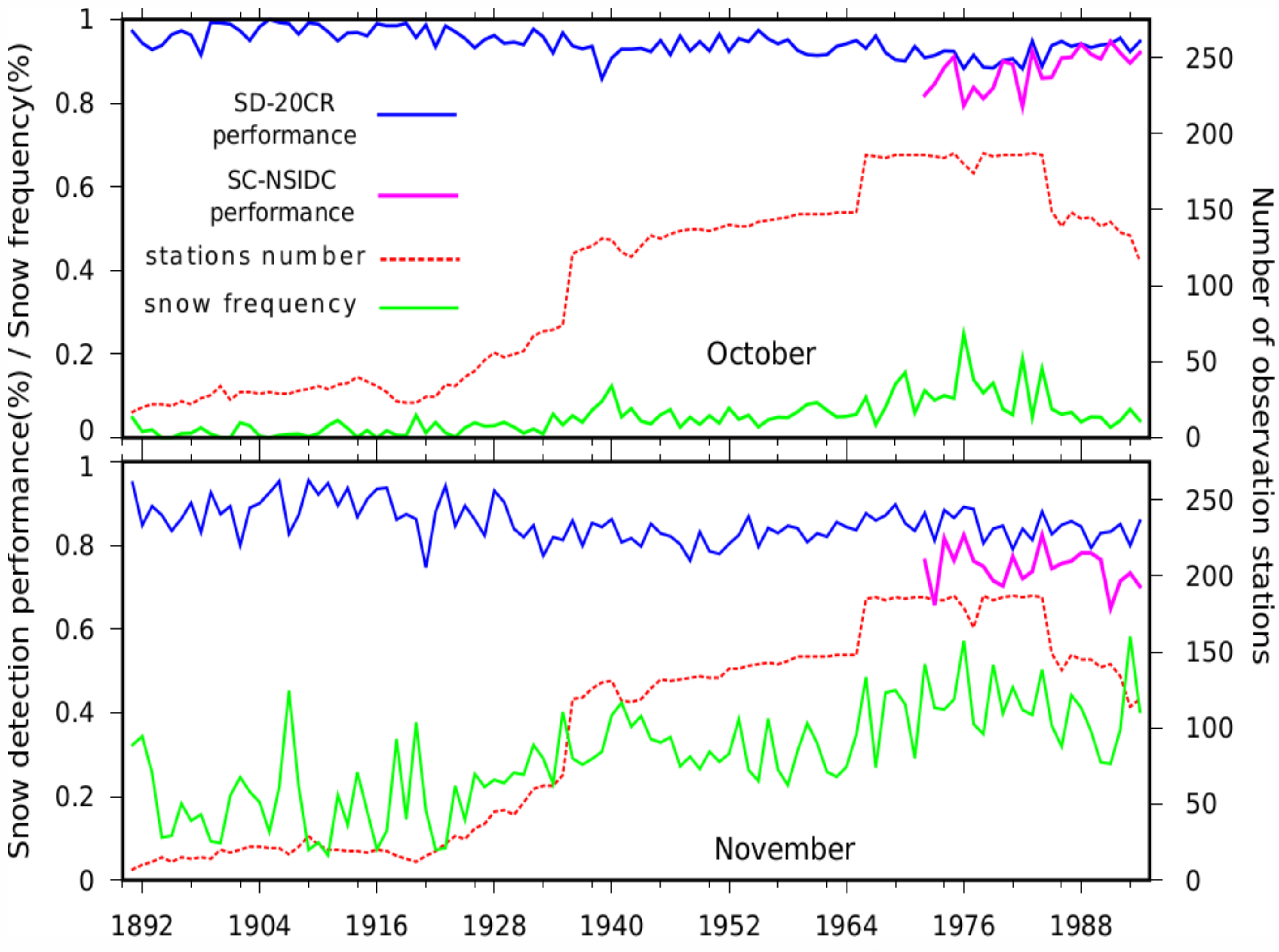
Snow data intercomparison
20CR & NSIDC vs daily *in situ* data

20CR early snow cover as good as NSIDC satellite data and of steady quality back to 1891



Peings et al. (to be submitted)

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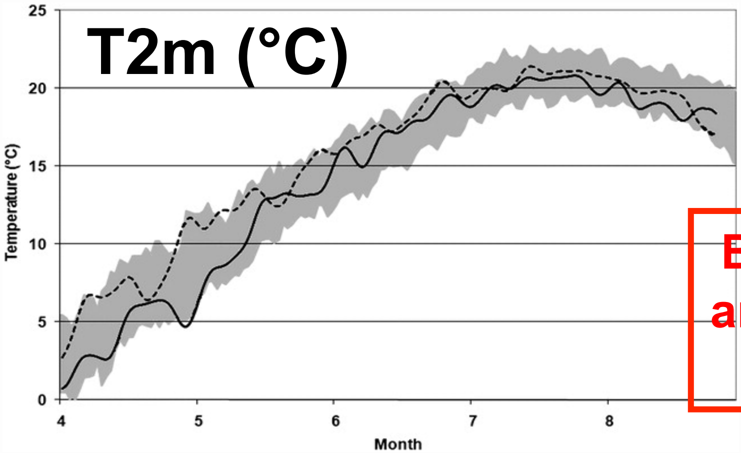
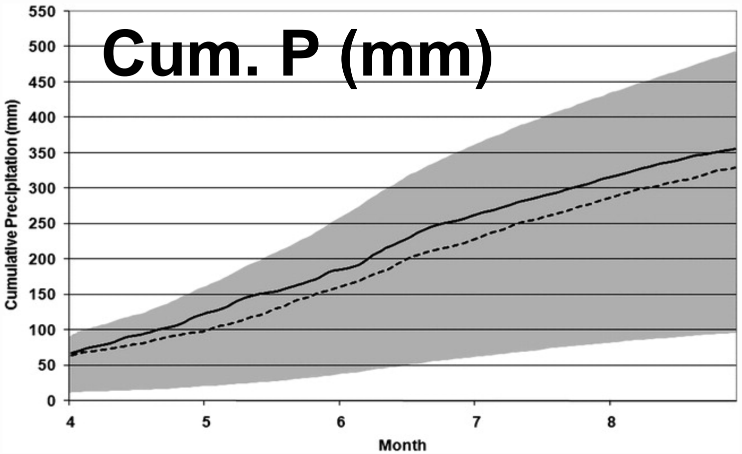
Statistical evidence of snow mass / cover impacts

Northern Great Plains heavy & light AM snowfall composites (1929-1999) with interquartile range
Quiring and Kluver 2009





Both local and remote impacts

Relationship between fall Eurasian snow cover and winter Arctic Oscillation (1973-1996)
Cohen and Entekhabi 1999

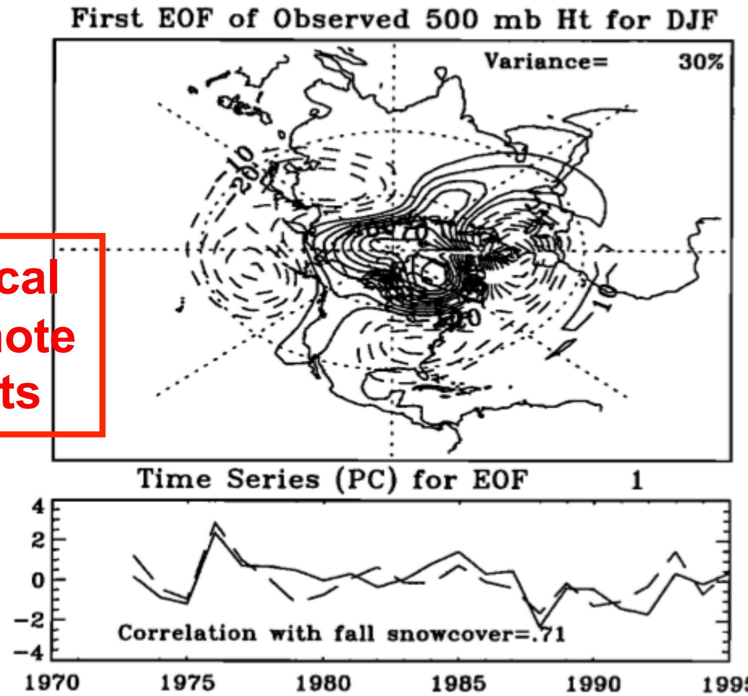
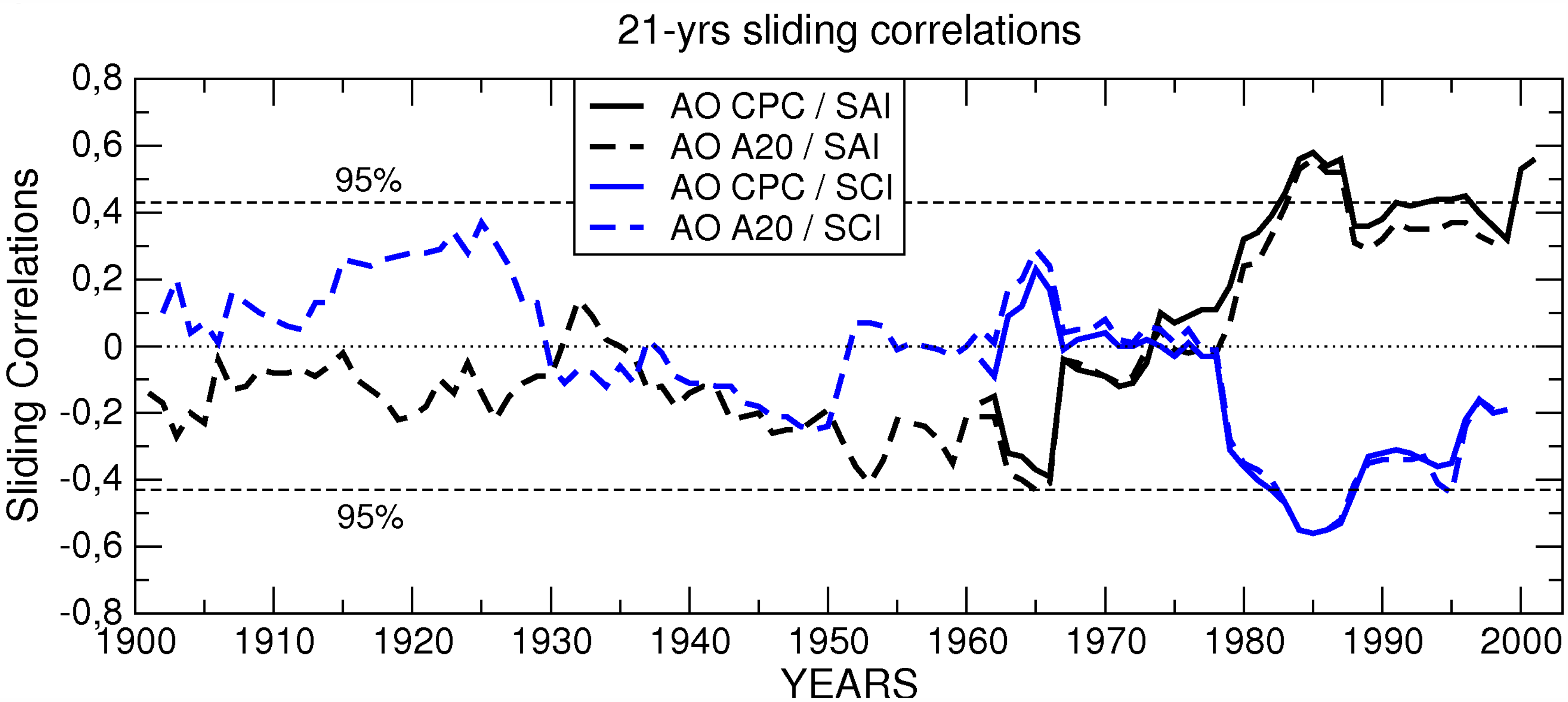


Figure 1. First Empirical Orthogonal Function (EOF) of NH 500 mb heights based on data of 23 winters (DJF) 1973/1974-1995/96. Also shown is fraction of variance attributed to the first EOF. (b) Time series or Principal Component (PC) of first EOF (solid line). Included is time series of Eurasian snow cover standardized anomalies (dashed line) and correlation coefficient between the two time series.

Non stationarity of snow-AO relationship



Stochastic artefact or non-linear interactions with other potential forcings (including QBO) ?

Peings et al. (to be submitted)

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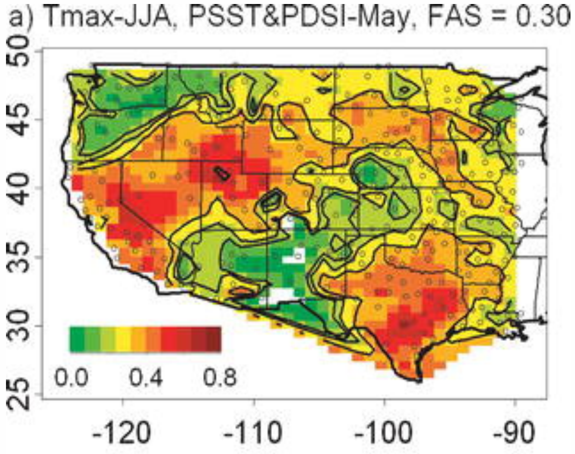
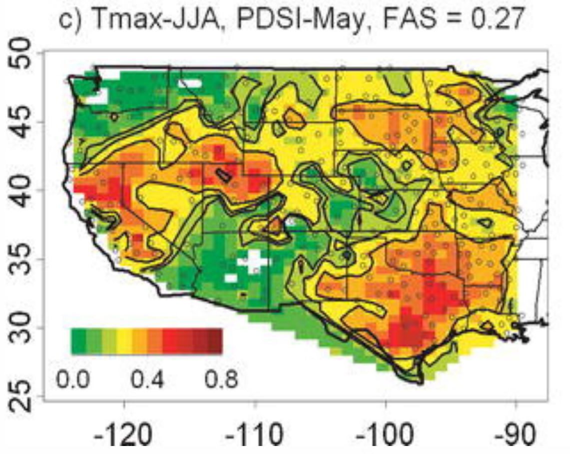
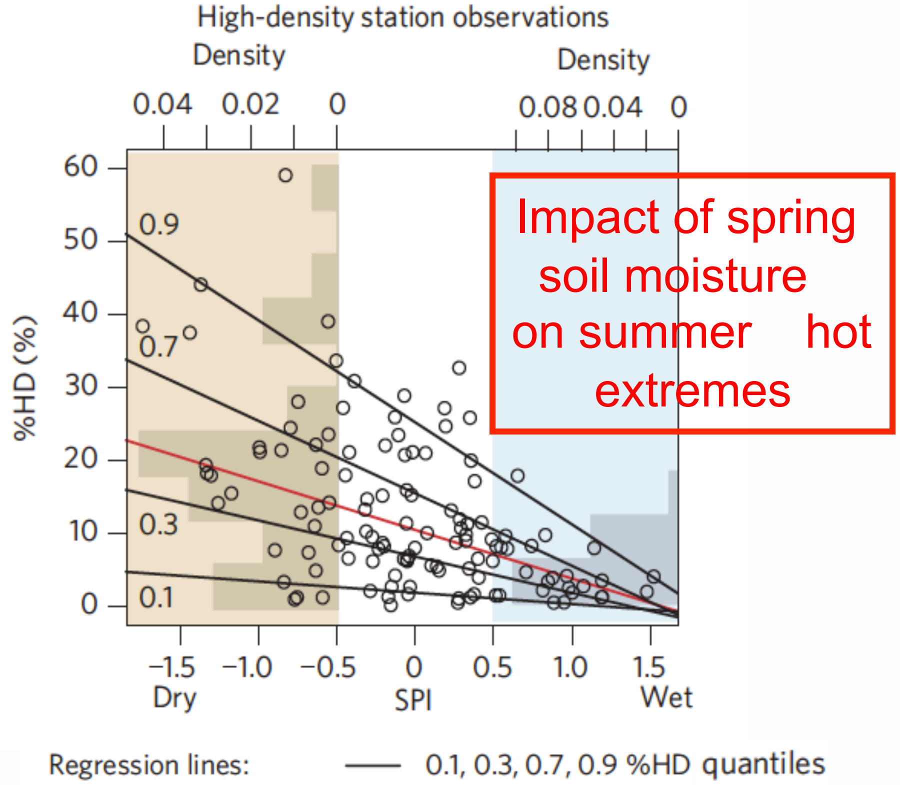
Statistical evidence of soil moisture impacts

JJA Tmax prediction skill
(cross-validation over 1950-2001)
using May Pacific SST and/or PDSI
(soil moisture proxy) predictors
Alfaro et al. 2006





Quantile regression of %
of JJA hot days with 6-month
SPI (soil moisture proxy)
over Southeastern Europe
Hirschi et al. 2011



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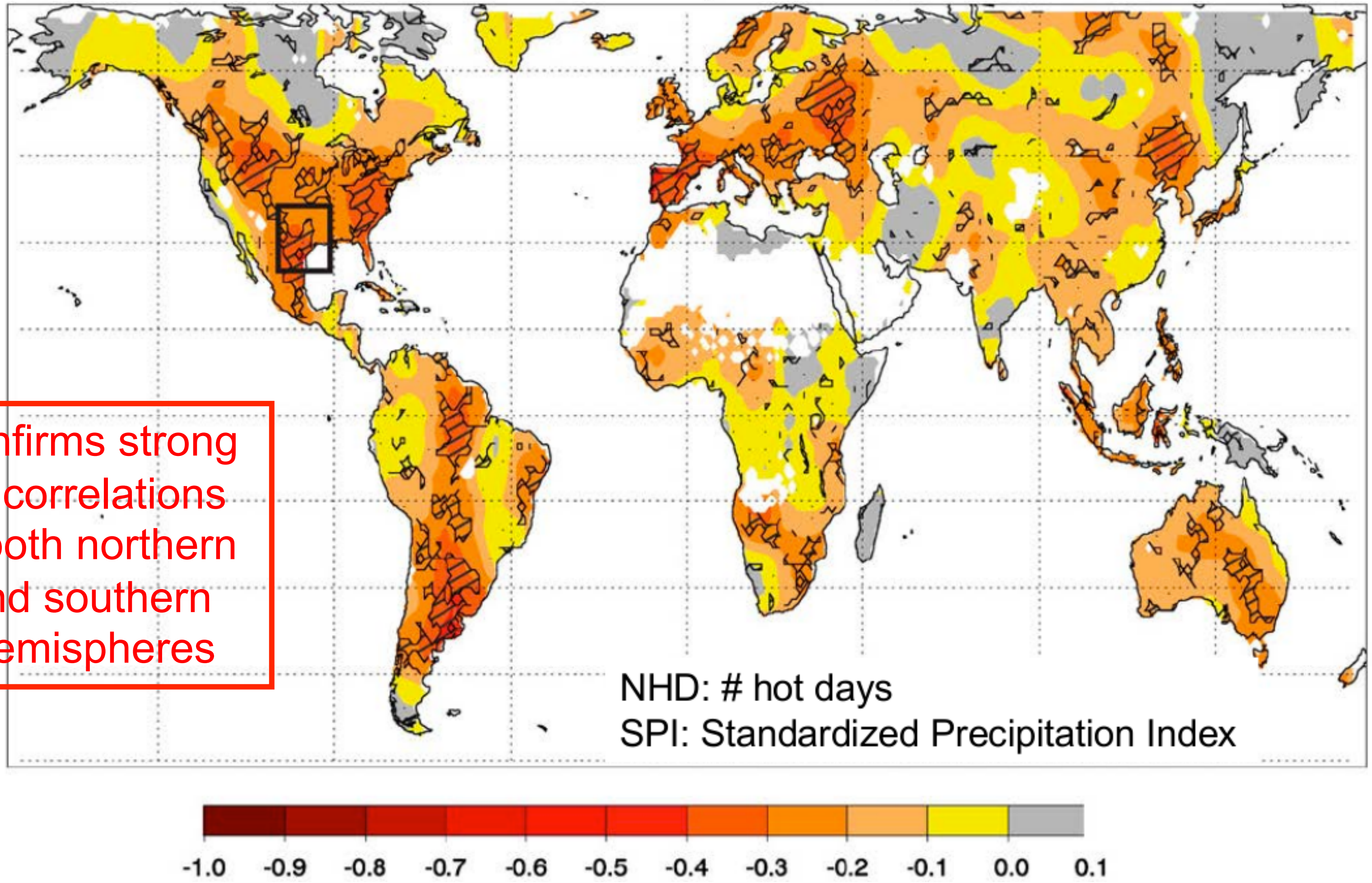
Statistical evidence of soil moisture impacts

Correlation NHD E-Int and preceding 3mn SPI CRU



Confirms strong lag correlations in both northern and southern hemispheres

Mueller and Seneviratne 2012

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Numerical evidence
"Consensus" skill due to land initialization

Impact on potential predictability (r^2_{ideal})

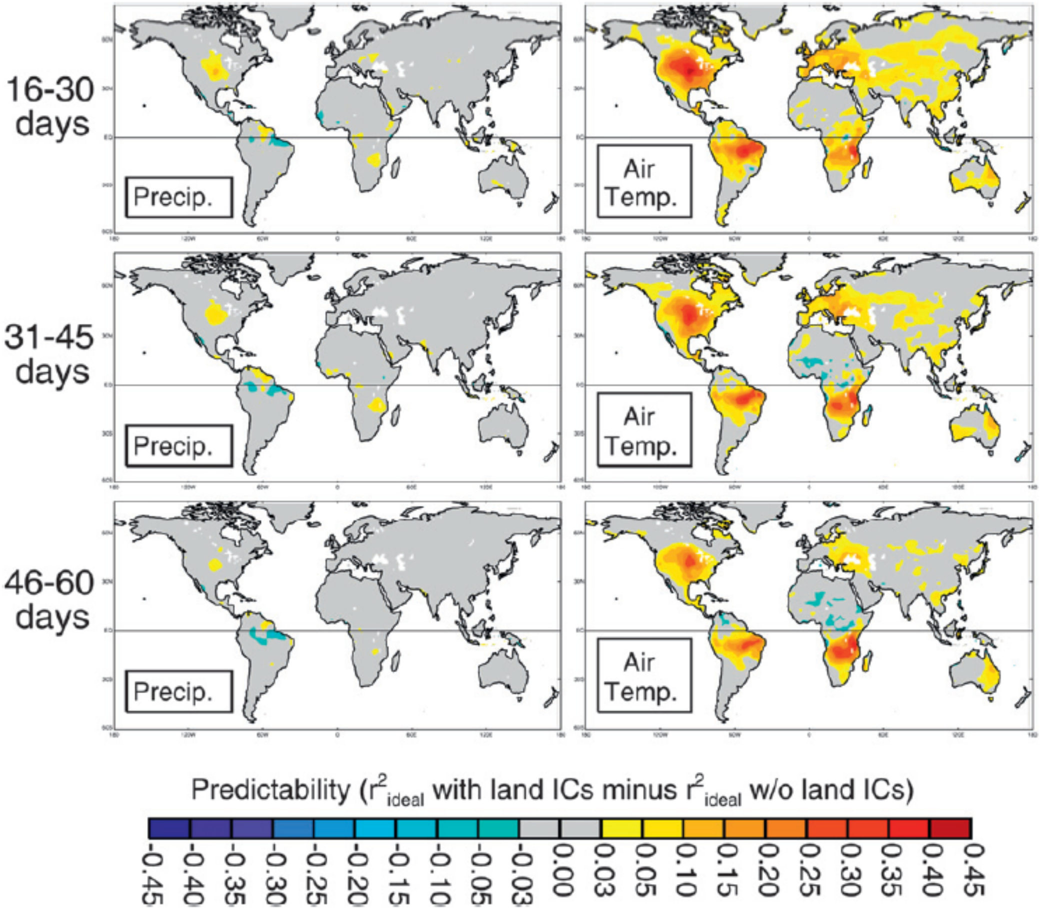

FIG. 3. Multimodel-consensus estimate of (left) precipitation and (right) air temperature predictability associated with soil moisture initialization—in essence a quantification of how one ensemble member in a given forecast reproduces the synthetic truth produced by the remaining ensemble members in that forecast: (top to bottom) all 15-day forecast periods.

Koster et al. 2011

GLACE-2

✓ 2-month hindcasts initialized on Day 1 & 15 of each month
x 10 years (1986-1995)
x 10 members

✓ 11 models

✓ 2 series: realistic (e.g. GSWP-2) vs "random" land surface initialization

✓ Focus on **JJA**

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Numerical evidence
"Consensus" skill due to land initialization

Impact on skill (r²)

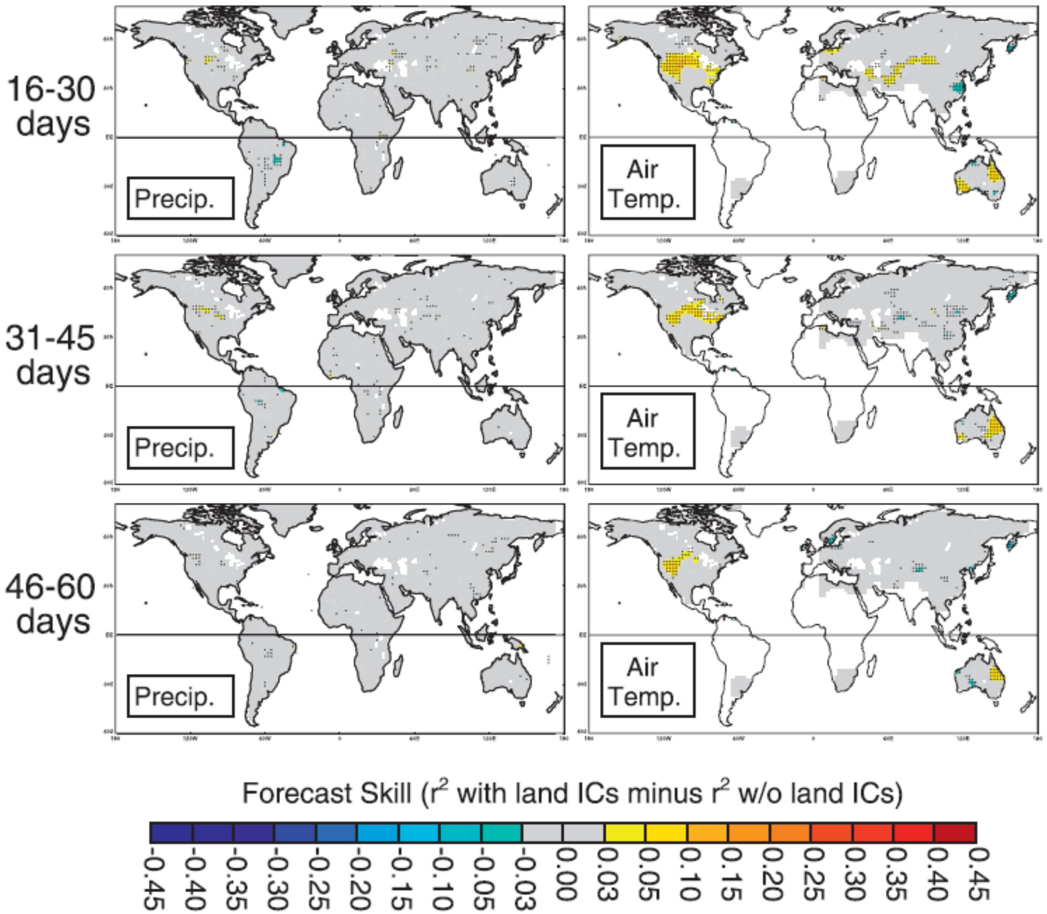

FIG. 2. Consensus (left) precipitation and (right) air temperature forecast skill (r^2 against observations for Series 1 minus that for Series 2) as a function of lead, considering (top to bottom) all 15-day forecast periods during JJA. (See text for details.) Dots are shown where the plotted results are statistically different from 0 at the 99% confidence level; white areas lack available validation data.

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Koster et al. 2011

GLACE-2

- ✓ Significant impact over North America
- ✓ Overall limited impact on actual skill
- ✓ Stronger for temperature than precipitation
- ✓ Stronger where high gauge density
- ✓ Stronger for extreme initial conditions

Beyond consensus, do we understand the inter-model spread ???

Numerical evidence for snow mass boundary / initial conditions

Peings et al. (2011)

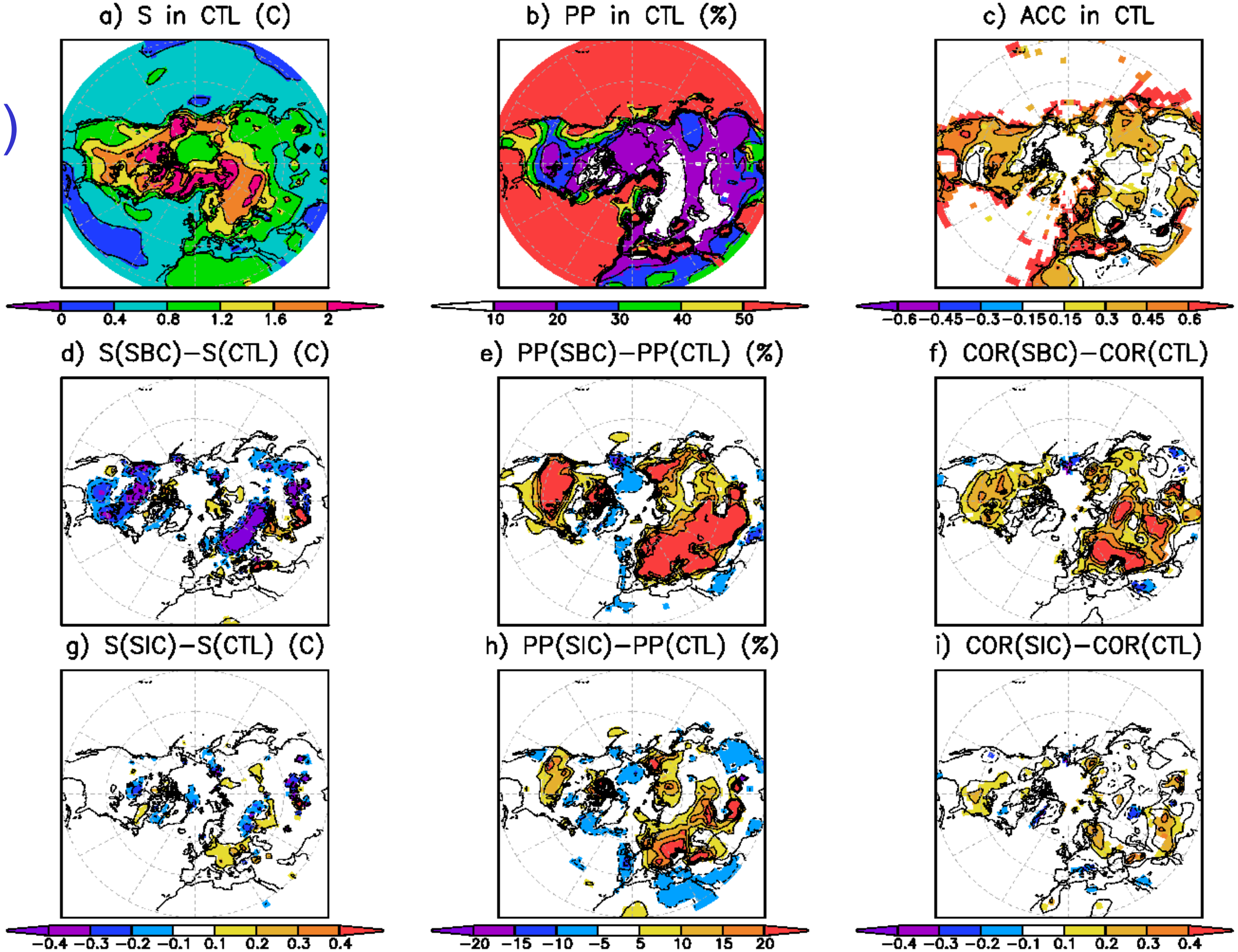
MAM T2M

Total Stdev | Pot. Predictability | Skill

Control (CTL)
Interactive snow cover

SBC – CTL
Impact of snow relaxation

SIC – CTL
Impact of snow initialization



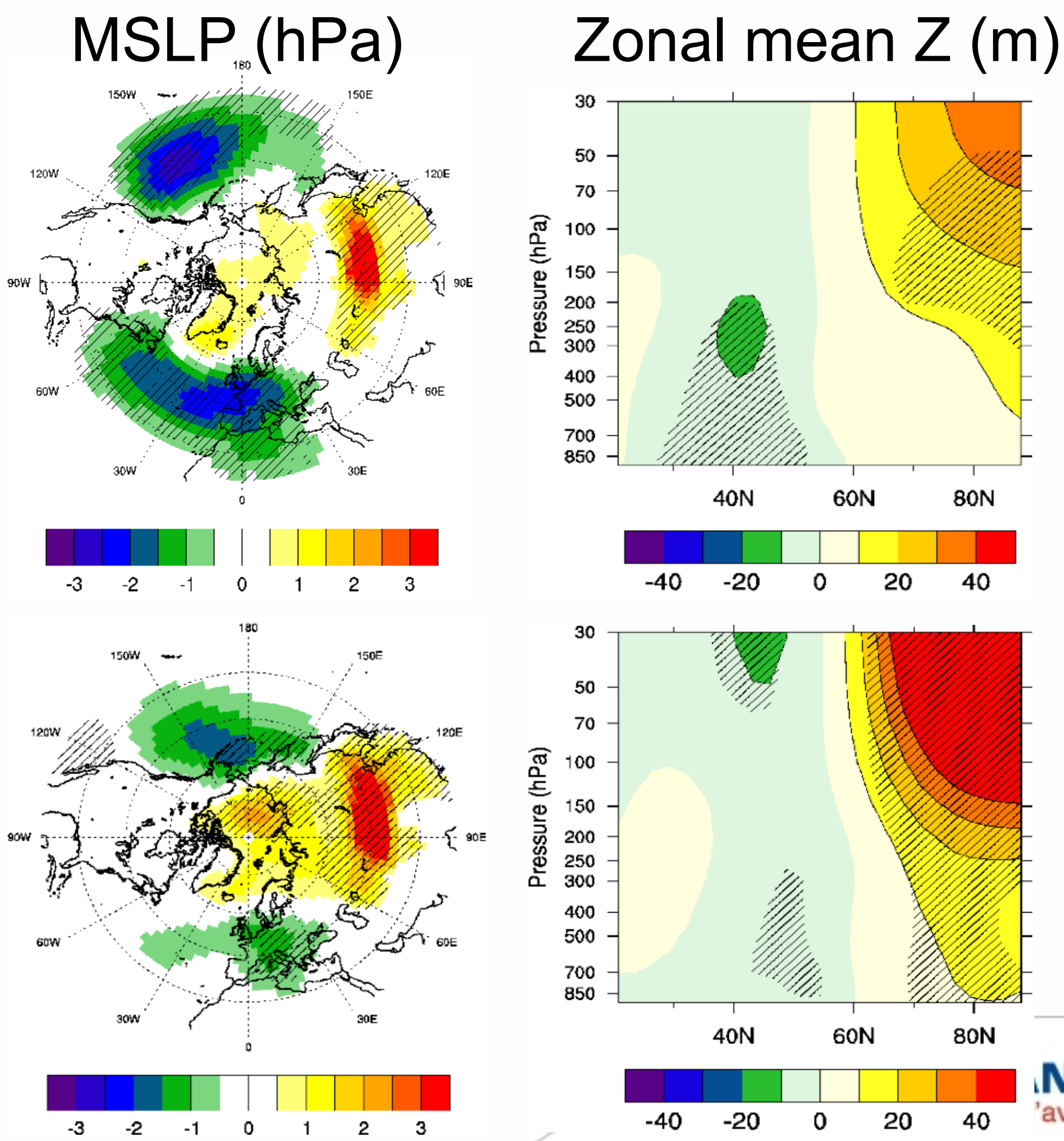
Numerical evidence of snow-NAO relationship

Results sensitive to model biases

2 pairs of 50-member ensemble experiments:

DSS - CTL
***D**eep **S**now over **S**iberia*

DSS* - CTL*
Improved polar vortex climatology through equatorial stratospheric nudging



Peings et al. (2012)

CONCLUSIONS

- Growing statistical and numerical evidence of both local and remote land surface impacts on climate predictability but some results should be considered with caution;
- Such impacts are highly model-dependent, stronger for temperature (including extremes) than precipitation, variable across regions and seasons;
- Land surface predictability seems limited (mainly due to the low predictability of precipitation) but needs further evaluation;
- Need of improved observations and land surface data assimilation systems for both reanalyses and real-time initialization.

PROSPECTS ?

- Observations: improved use of passive & active microwave data for snow and soil moisture (SMOS since 2010, SMAP in 2015?), GRACE total water storage variations, …
- Land Surface Models & Data Assimilation Systems: improved models (e.g. groundwaters, snow under canopy), global off-line inter-comparison (GSWP-3?), on-line versus off-line data assimilation techniques
- Sensitivity experiments: follow-on of GLACE-2 looking at both soil moisture and snow impacts, GLACE-type versus operational (rather than random) initialization, coupled ocean-atmosphere sensitivity experiments, process-oriented case studies rather than idealized sensitivity experiments ?

End

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