Anthropogenic influence on multi-decadal changes in reconstructed global EvapoTranspiration (ET)

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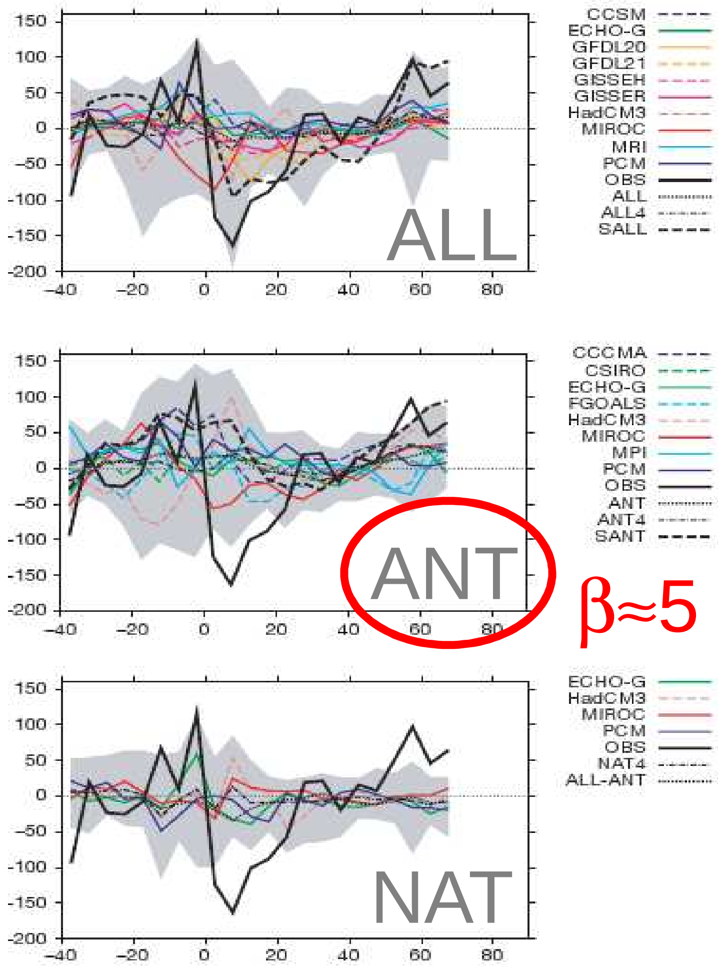
Toujours un temps d'avance

Early D&A studies of changes in the terrestrial hydrological cycle

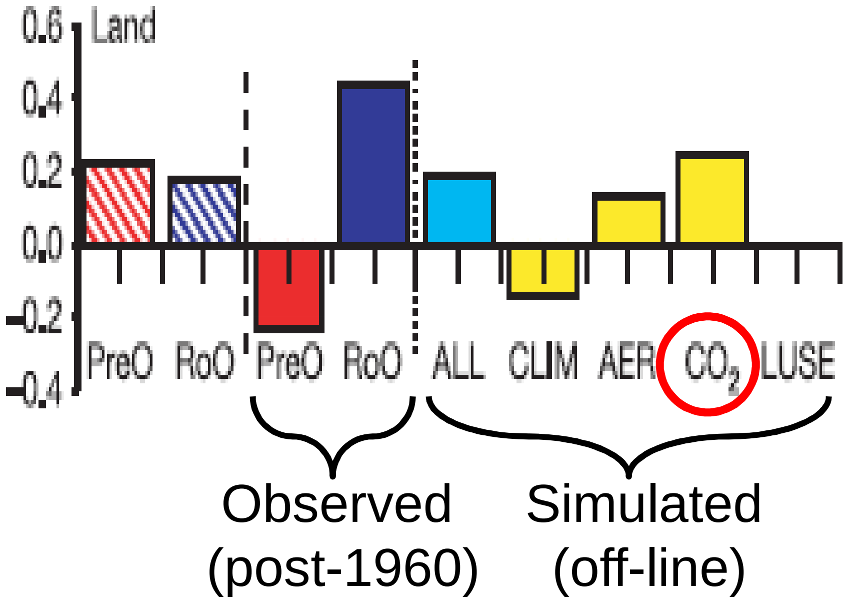
1950-1999 trends in Precip as a function of latitude



β≈5 !

Zhang et al., Nature 2007

1960-1994 trends in Precip & Runoff per continent (here global average)



Gedney et al., Nature 2006

Not confirmed by further studies !

No D&A study about ET

Reconstructed global ET variations

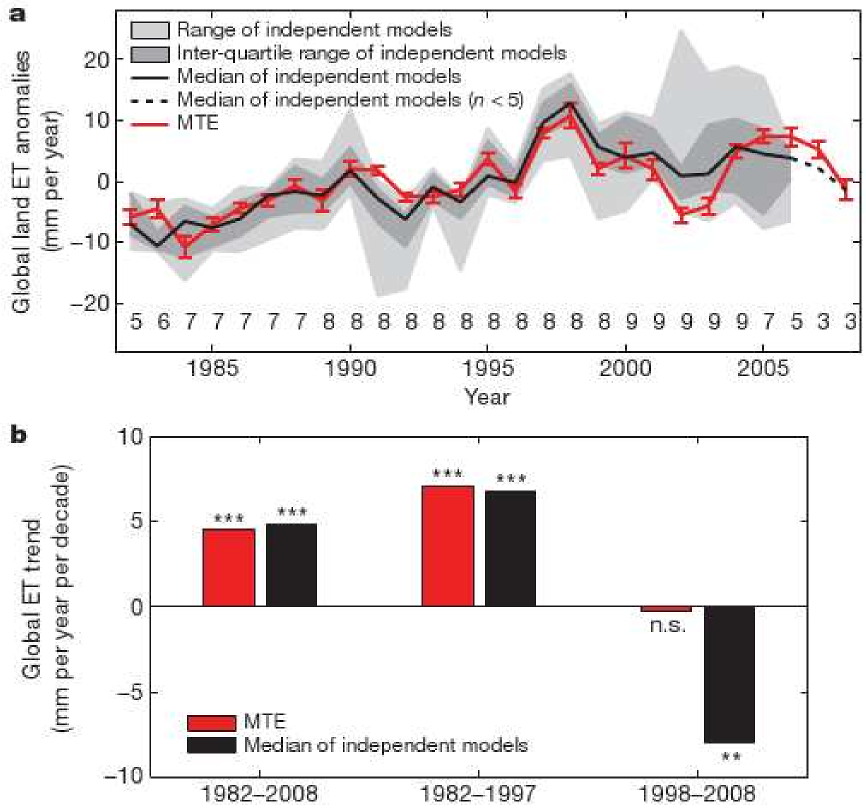


Figure 2 | Global land-ET variability according to MTE and independent models. **a**, Annual global land ET anomalies based on MTE and an ensemble of up to nine independent process-oriented models. Error bars indicate one s.d. within the MTE. Numbers at the bottom show the number of models available each year. **b**, Trends in ET based on MTE estimates and based on the median of the independent models for three different time periods. ***, significance of the trends at the 99% confidence interval; **, significance of the trends at the 95% confidence interval; n.s., not significant.

Jung et al., Nature 2010

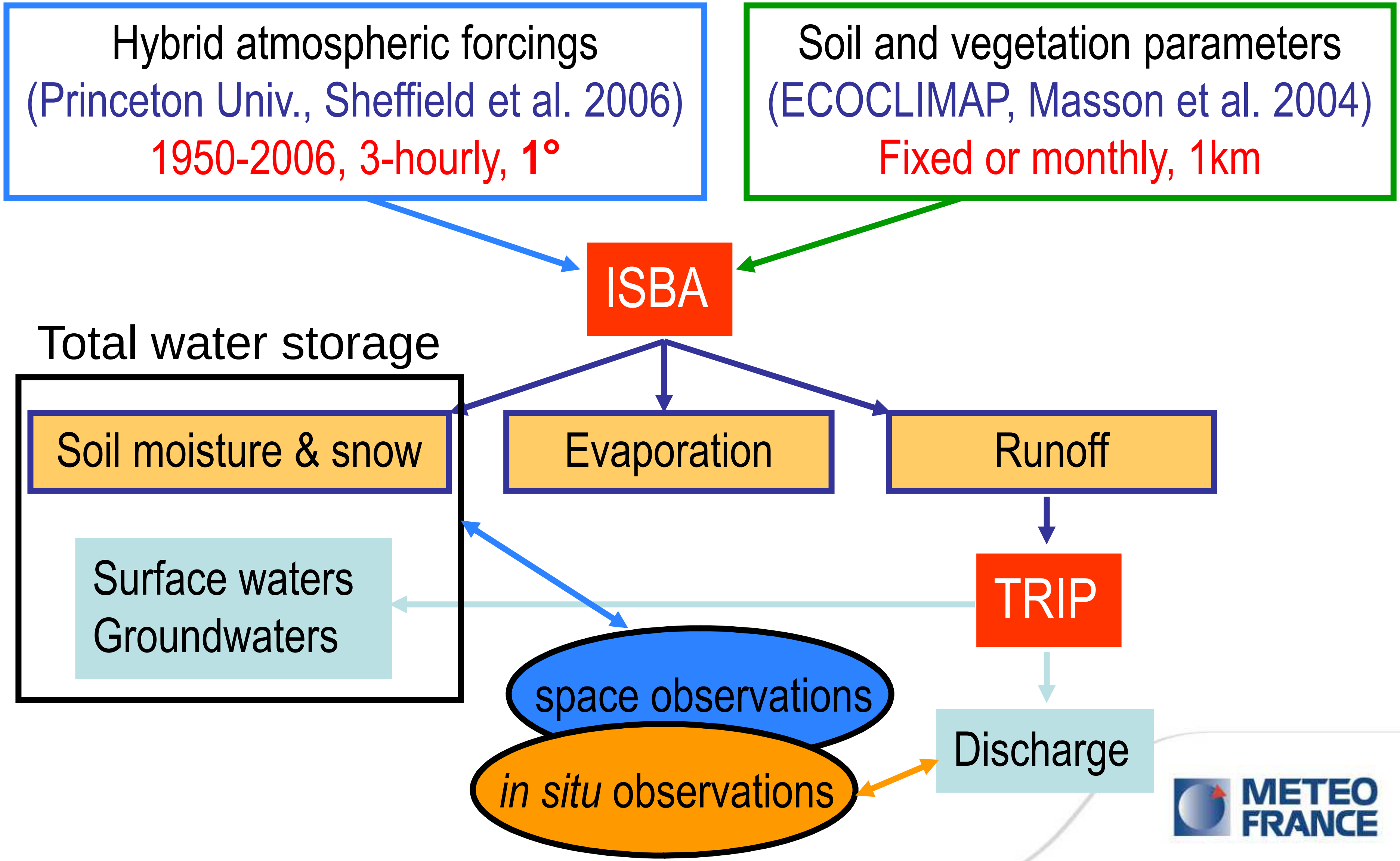
1982-2008 global land ET variability from:
- MTE (a machine-learning algorithm based on FLUXNET data)
- an ensemble of off-line LSMs (including the ISBA contribution to GSWP2)

Is there a recent decline in global land ET trend due to limited soil moisture supply?

Objectives

- Produce and evaluate global ET reconstructions from 1950 to 2006 (using ISBA and VIC off-line land surface models) ?
- Detect and attribute changes in reconstructed ET (using CNRM-CM5 ensembles of 20th century climate and a formal optimal fingerprint method) ?

The off-line ISBA-TRIP hydrological system



Global evaluation vs GRACE (2002-2006)

Alkama et al., J. Hydromet. 2010

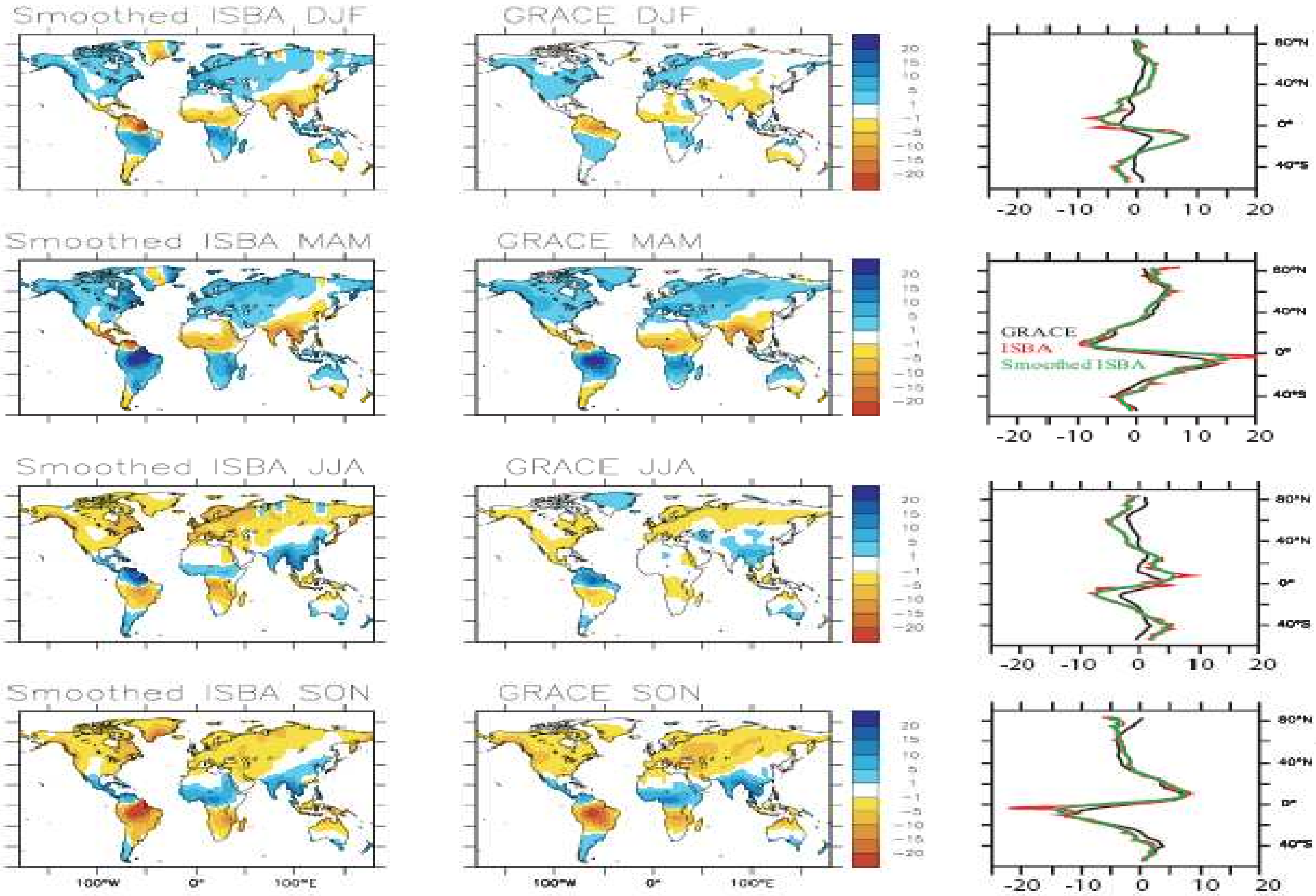
Seasonal variations in total water storage (cm)

Winter

Spring

Summer

Autumn

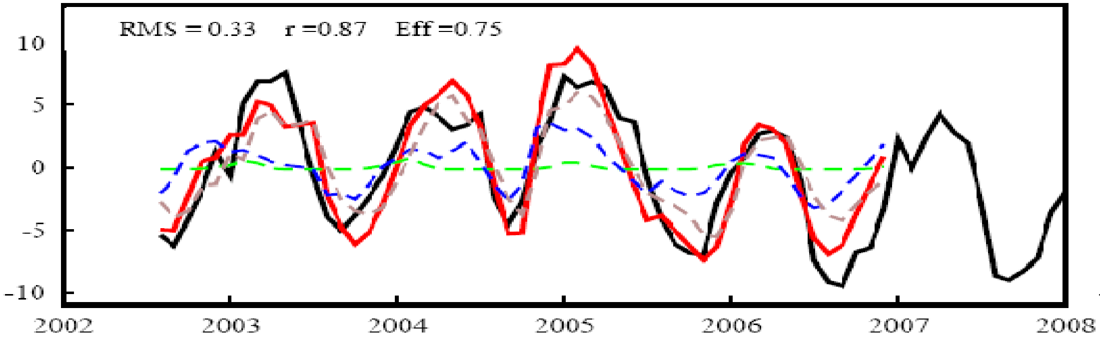


Basin-scale evaluation (e.g. Mississippi)

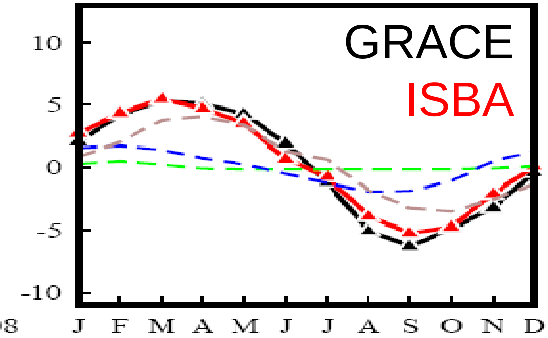
Alkama et al., J. Hydromet. 2010

Evaluation of interannual variability & mean annual cycle

(cm) Monthly water storage variations

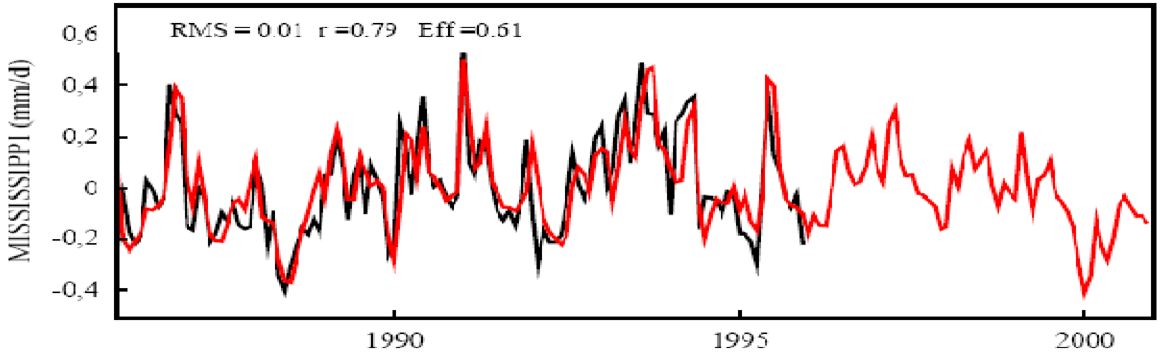


(cm) Mean annual cycle

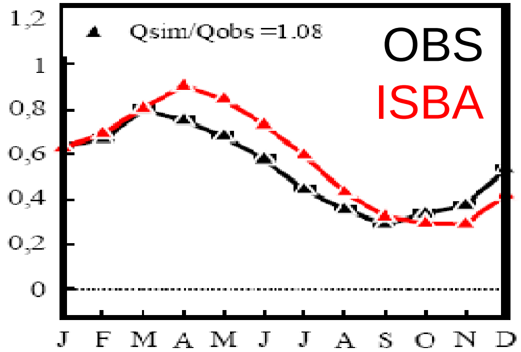


Δ Water Storage = Δ Soil Moisture + Δ Snow + Δ Rivers

(mm/d) Monthly river discharge anomalies



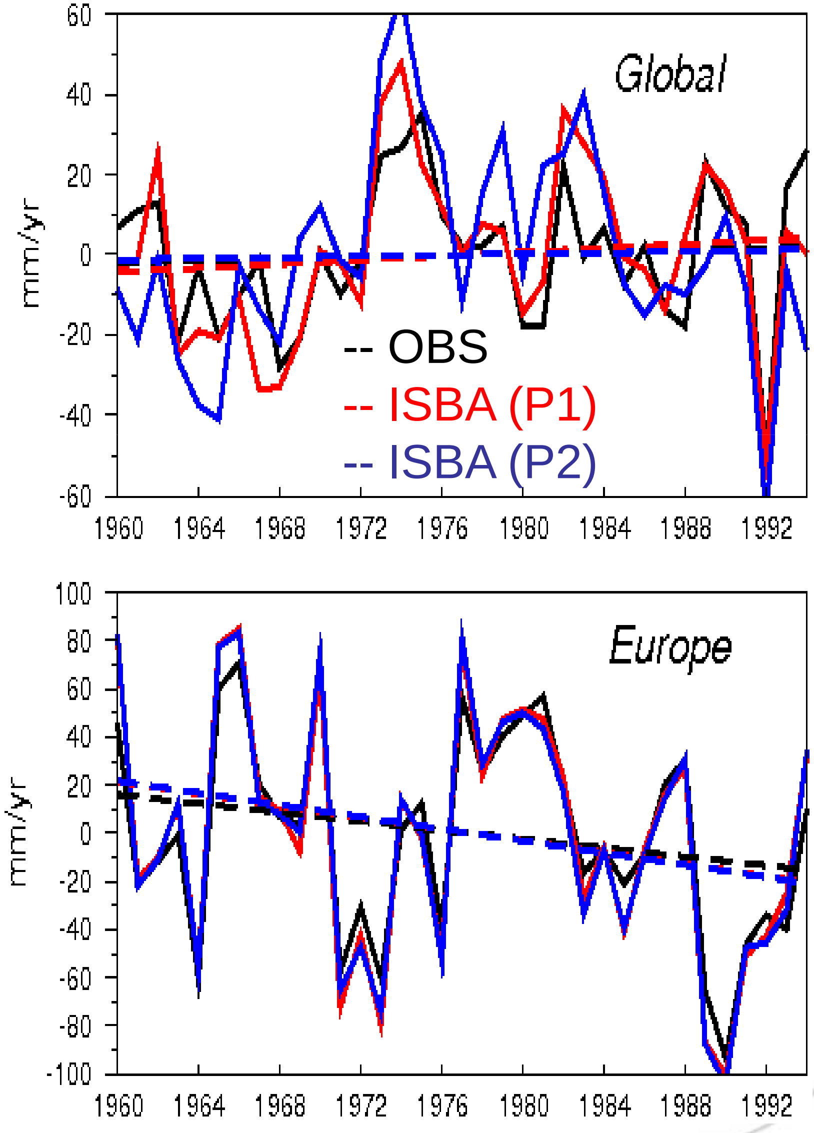
(mm/d) Mean annual cycle



Continental runoff anomalies (1960-1994)

Alkama et al., J. Climate 2011

Despite uncertainties in precipitation, ISBA captures the observed variability of runoff => the multi-decadal variability of the simulated evapotranspi-ration is robust and reliable



ISBA land surface model driven by Princeton's 3-hourly atmospheric forcings hybridized with GPCC or VASCLIMO monthly precipitation

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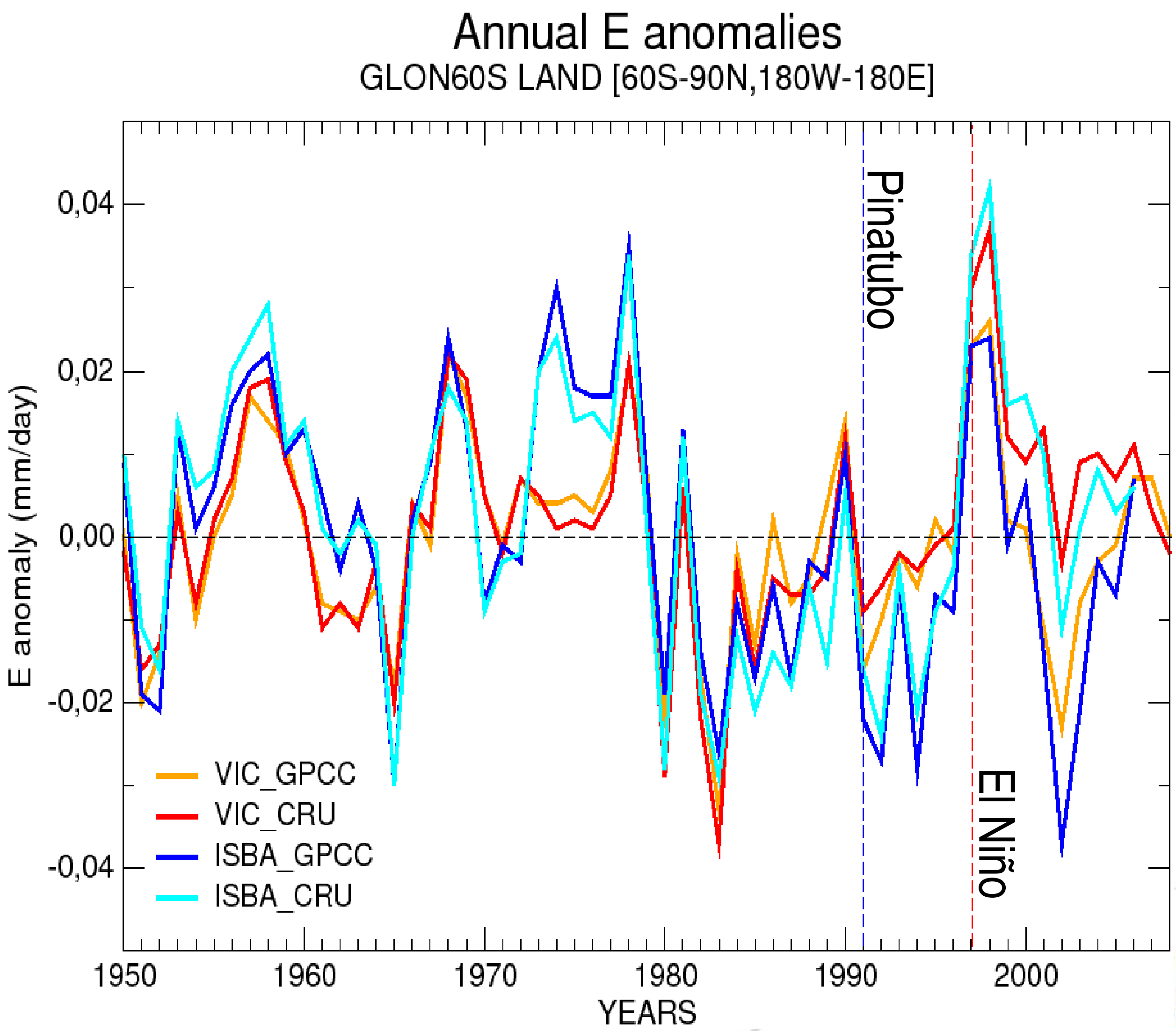
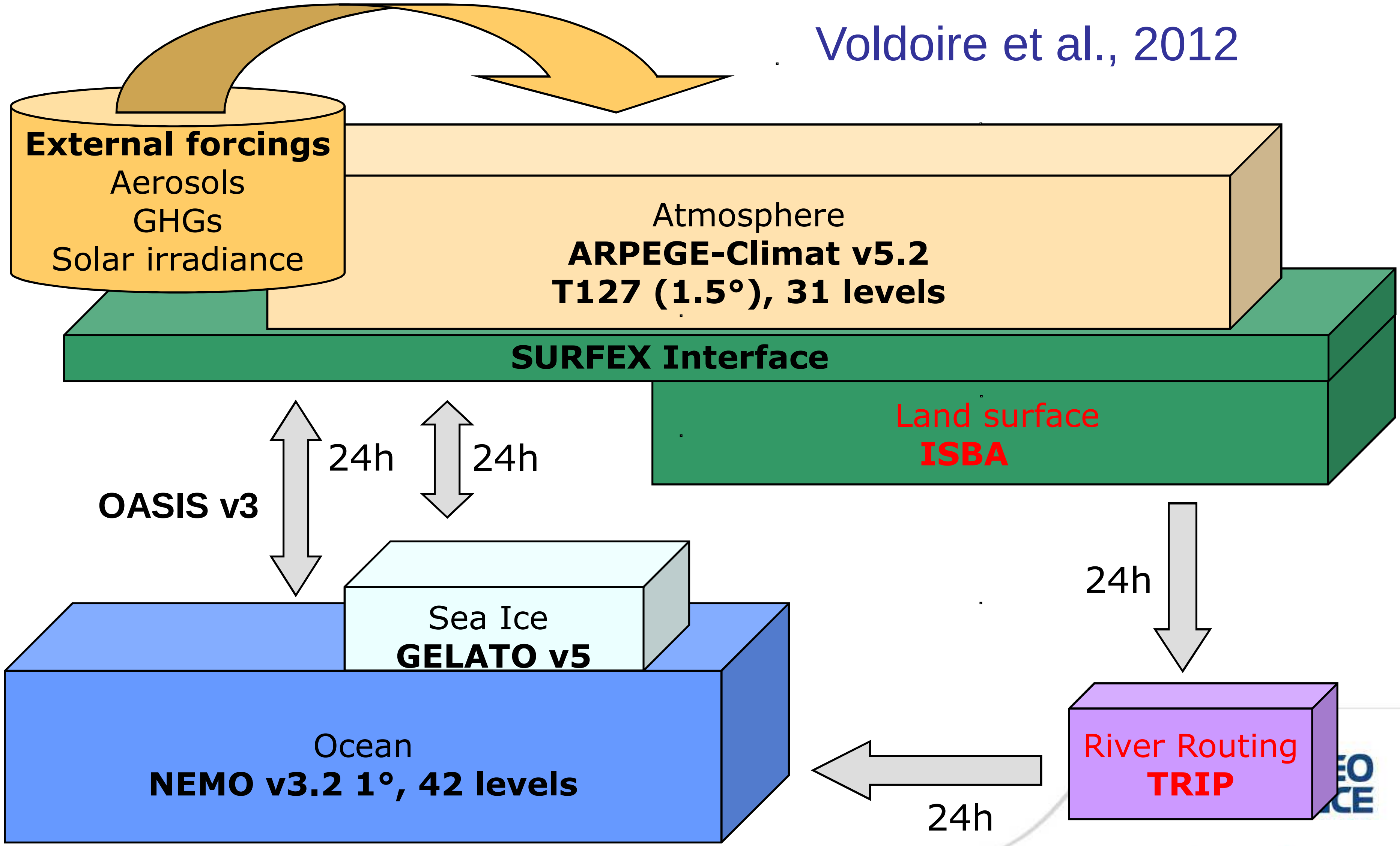
Global annual mean evapotranspiration anomalies

No global trend, but significant and **robust** variations due to both internal variability (e.g. ENSO) and external forcings (e.g. Pinatubo)



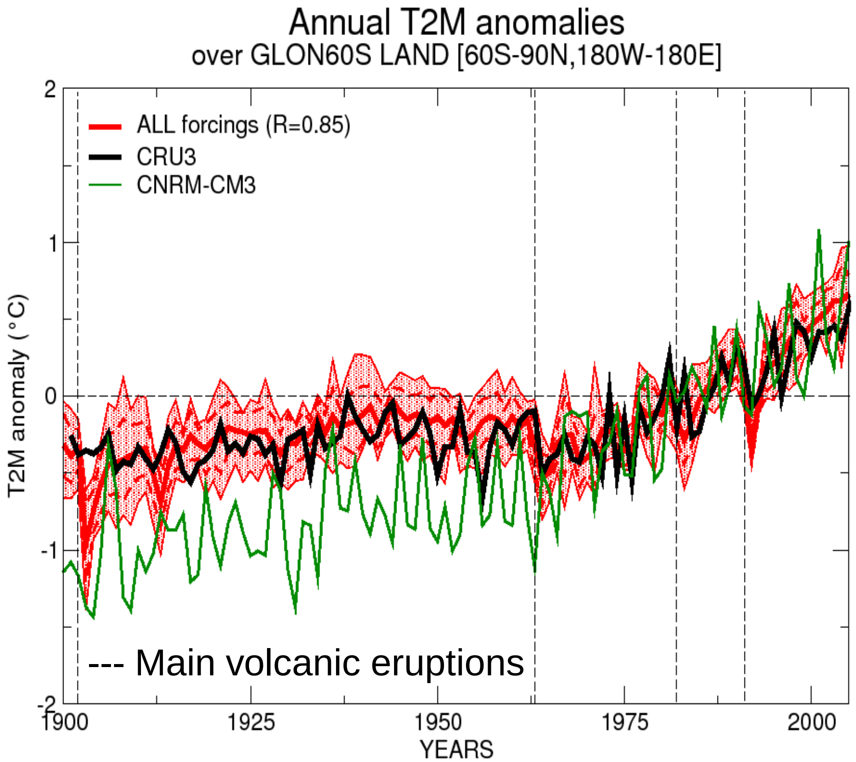
The CNRM-CM5 global climate model

Voldoire et al., 2012

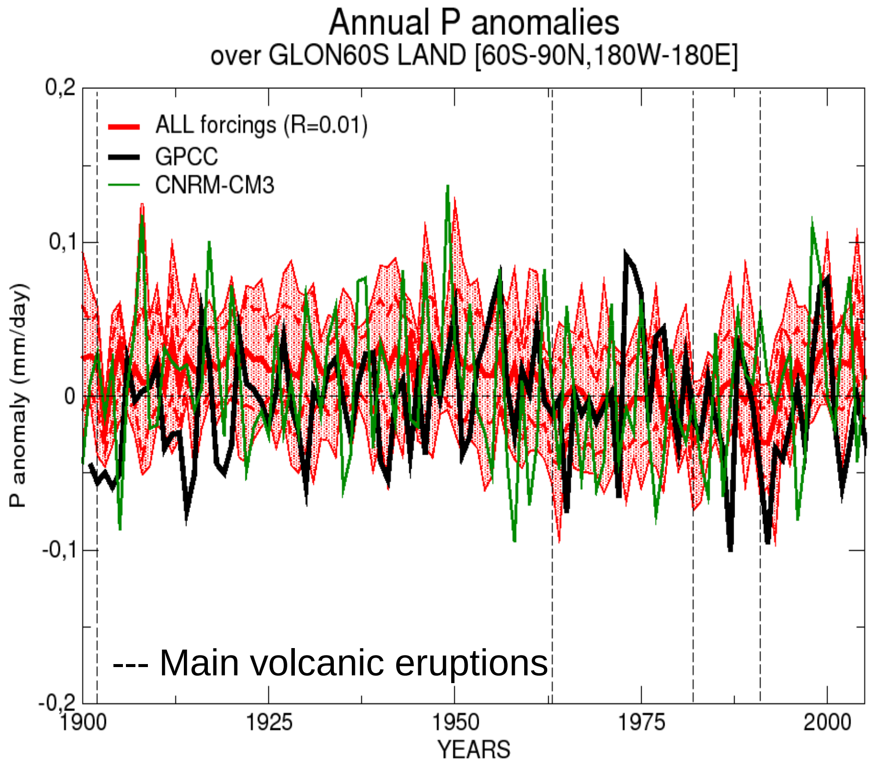


Annual mean T2m and P anomalies (1900-2006)
(Global land average except Antarctica)

2-meter temperature (℃)



Precipitation (mm/day)



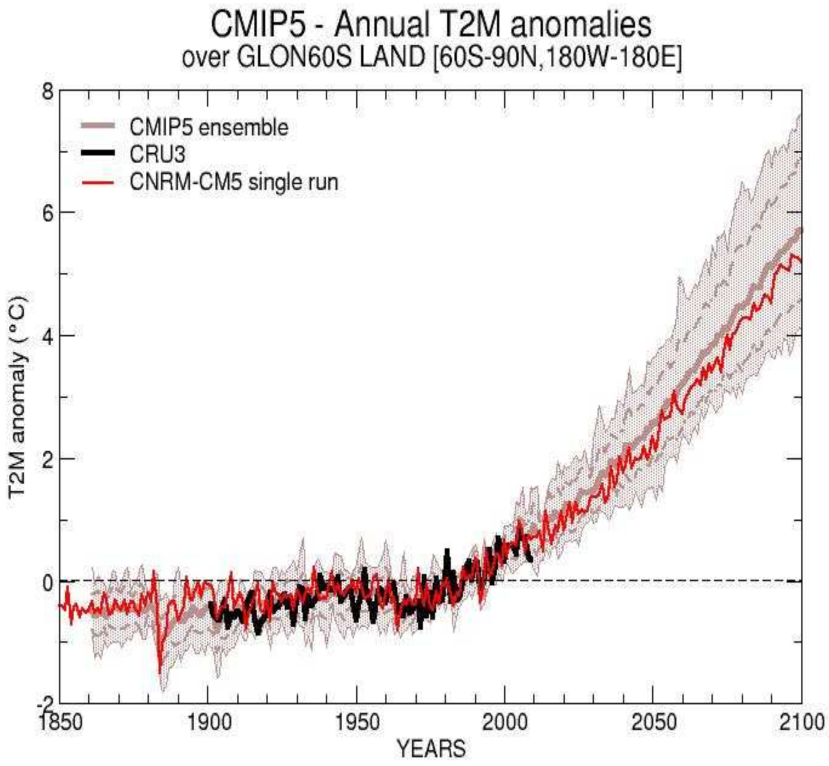
Annual anomalies relative to 1971-2000

CNRM-CM5 (10 runs)
CNRM-CM3 (1 run)

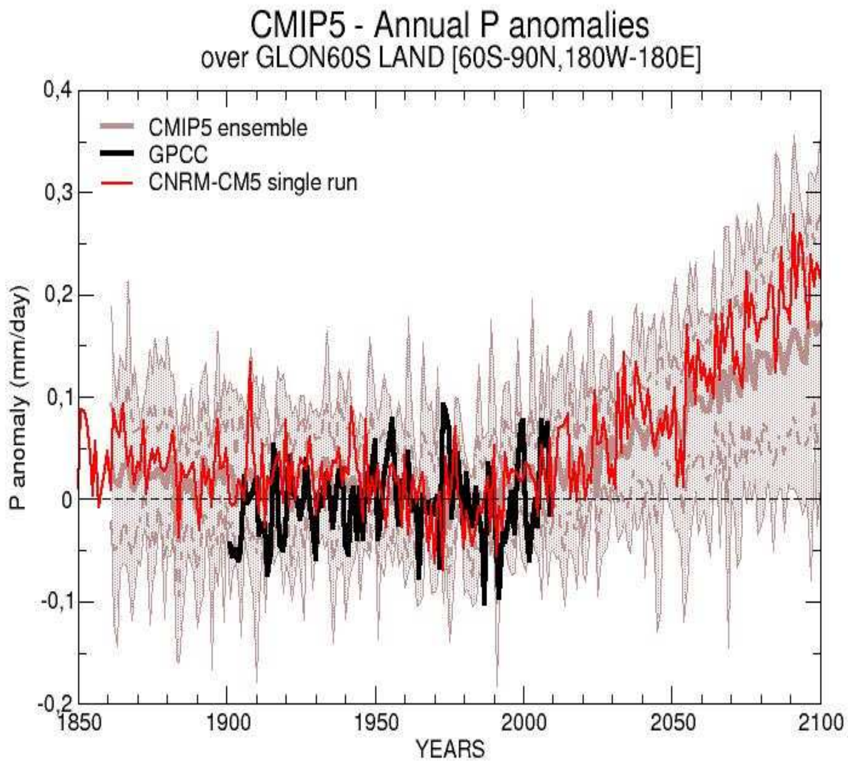
Globally improved simulation of the 20th century climate

CNRM-CM5 within CMIP5 (1850-2100)
(Global land average except Antarctica)

2-meter temperature (℃)



Precipitation (mm/day)

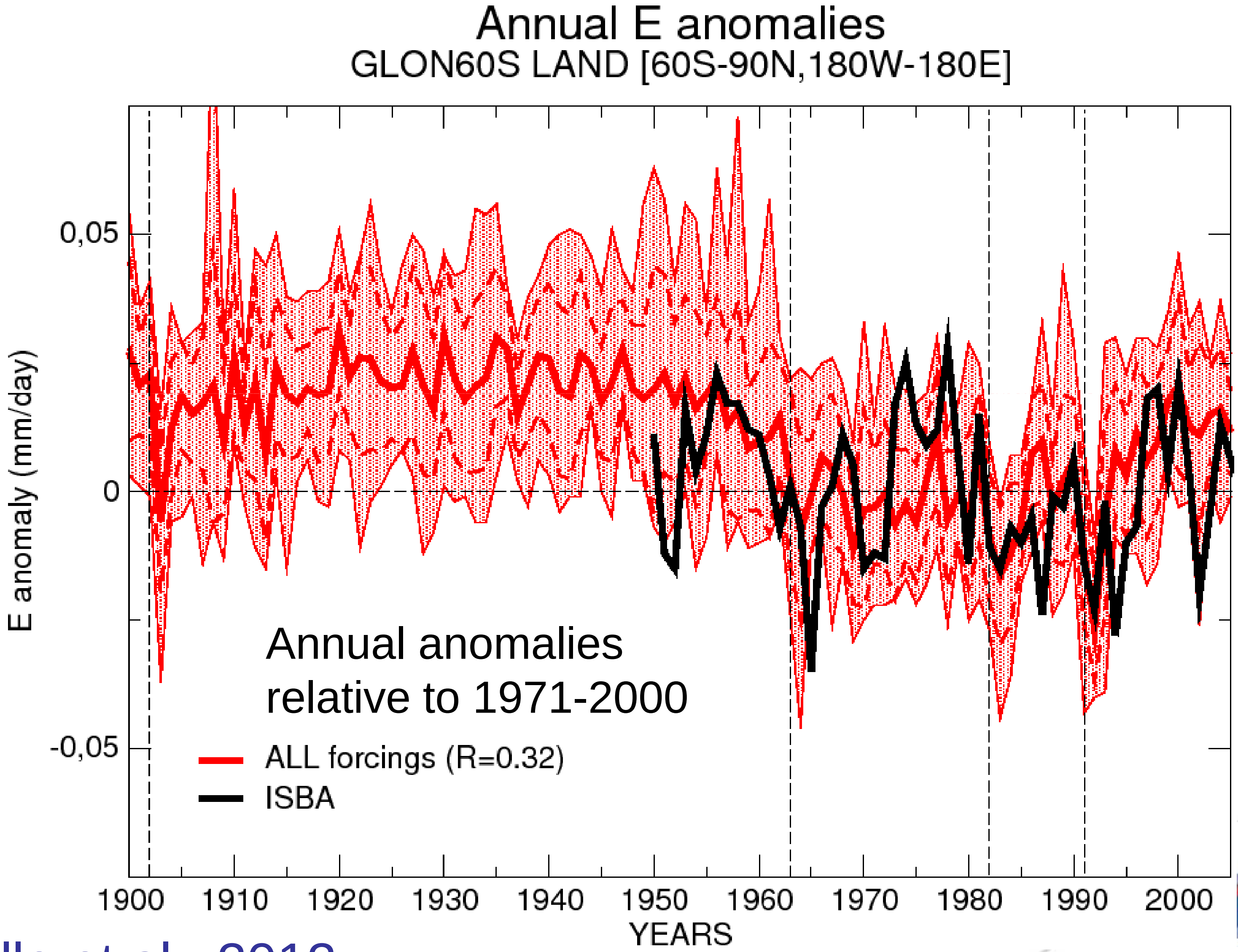


Annual anomalies relative to 1971-2000

CNRM-CM5 (1 run)
CMIP5 (13 models)

Globally consitent with the multi-model ensemble mean

Annual mean anomalies in evapotranspiration
(Global land average except Antarctica)



Douville et al., 2012

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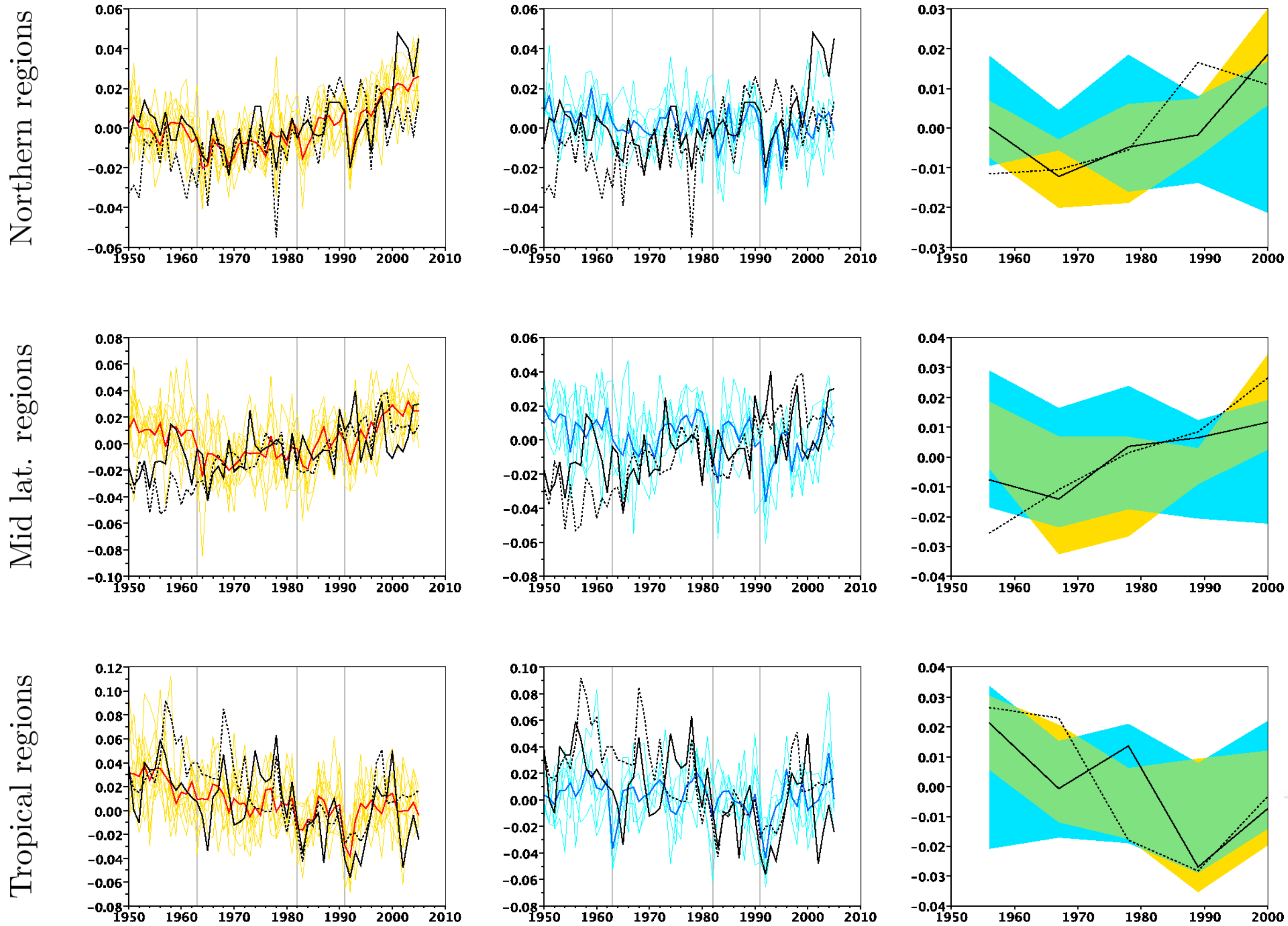
Annual & decadal mean anomalies over 3 latitudinal domains

ALL forcings Annual anomalies | NAT forcings only Annual anomalies | ALL & NAT forcings 11-yr mean anomalies

Northern latitudes

Middle latitudes

Tropics



Douville et al., 2012

Optimal fingerprint D&A: method & results

- Method (Ribes et al. 2009):

$$Y=\sum_i \beta_i g_i+\varepsilon$$

Y : « observations »

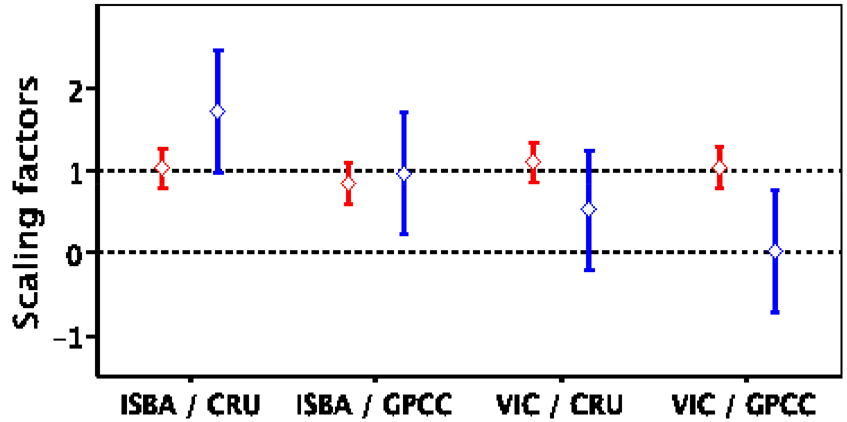
β_i : unknown **scaling factor**
$\neq 0$ => detection
≈ 1 => consistent

g_i : climate response to the i^{th} external forcing (estimated from CNRM-CM5 ensembles)

ε : internal variability

Douville et al. 2012

- Results: β_i best estimates for i=ANT & i=NAT



Recent variations in reconstructed ET cannot be accounted for without invoking anthropogenic forcings

Conclusions

- The off-line ISBA simulation (1950-2006) compares favorably with observed river discharges and total water storage variations;
- The coupled CNRM-CM5 ensemble of 20th century climate simulations (with ALL radiative forcings) captures the observed global warming over land and is close to the CMIP5 multi-model for both T2m and P
- The optimal fingerprint technique shows that the spatio-temporal variability of our global ET reconstructions (ISBA & VIC) cannot be understood without invoking both anthropogenic (GHG & aerosols) and natural (solar activity & volcanoes) radiative forcings

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Prospects

- Understand what are the main atmospheric drivers of regional ET trends;
- Assess the physiological influence of CO_2 increase and/or of changing vegetation on regional ET trends;
- Assess the sensitivity of both off-line and on-line ET trends to recent developments in ISBA-TRIP (ISBA-DIF, groundwaters, floodplains, …)
- Constrain CMIP model uncertainties in projected regional ET anomalies at the end of the 21st century
- …

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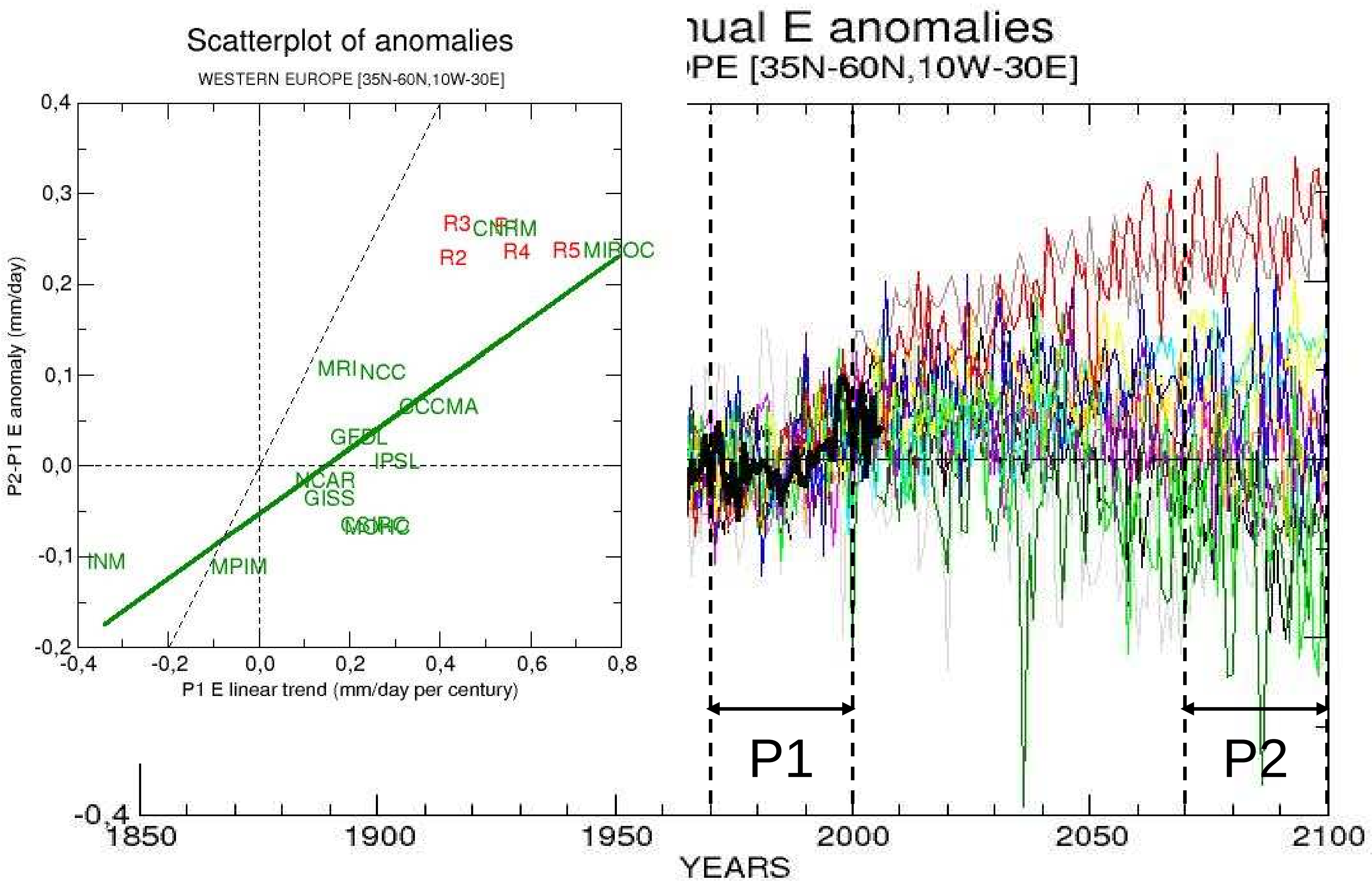
Prospects


Scatterplot of anomalies
WESTERN EUROPE [35N-60N,10W-30E]
P2-P1 E anomaly (mm/day)
P1 E linear trend (mm/day per century)
R3
CNRM
R2
R4
R5
MIROC
MRI
NCC
CCCMA
GFDL
IPSL
NCAR
GISS
CSIRO
MOHC
INM
MPIM
ual E anomalies
PE [35N-60N,10W-30E]
P1
P2
YEARS
1850
1900
1950
2000
2050
2100