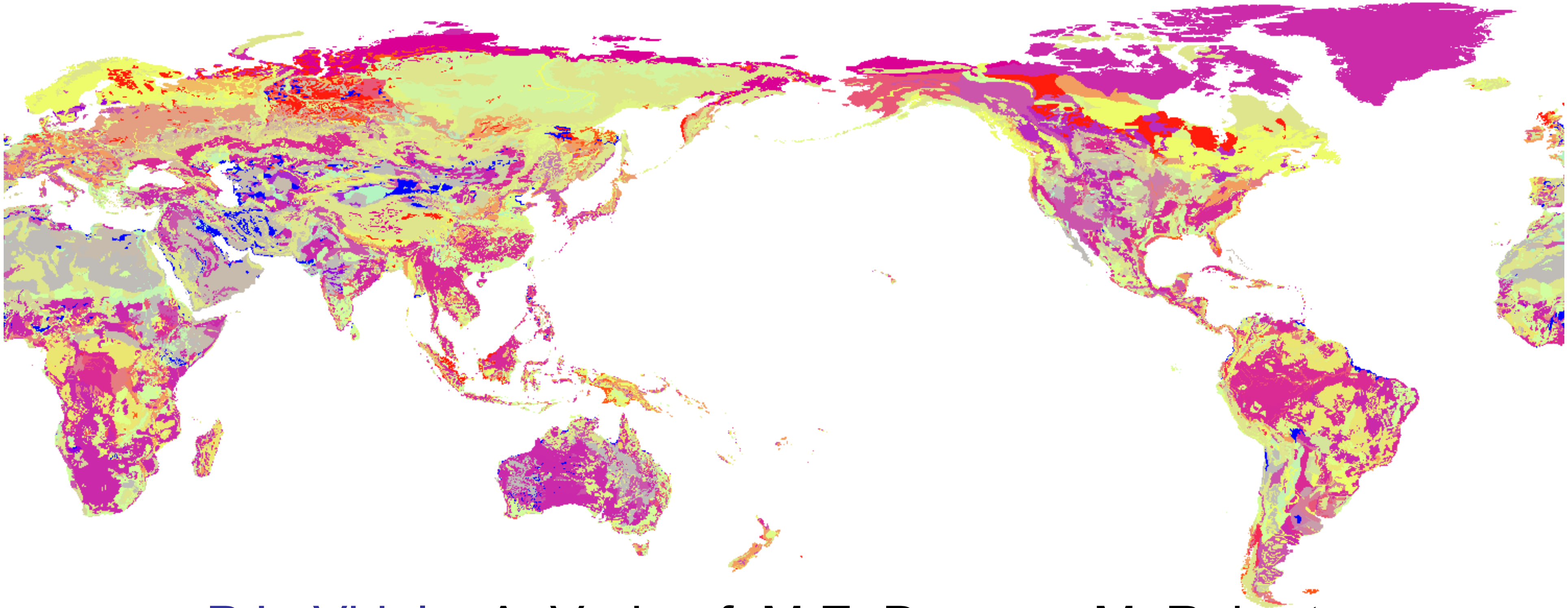
日英気候共同研究
UK-Japan Climate Collaboration

Impact of the land surface in modelling climate: the importance of soil physical parameters



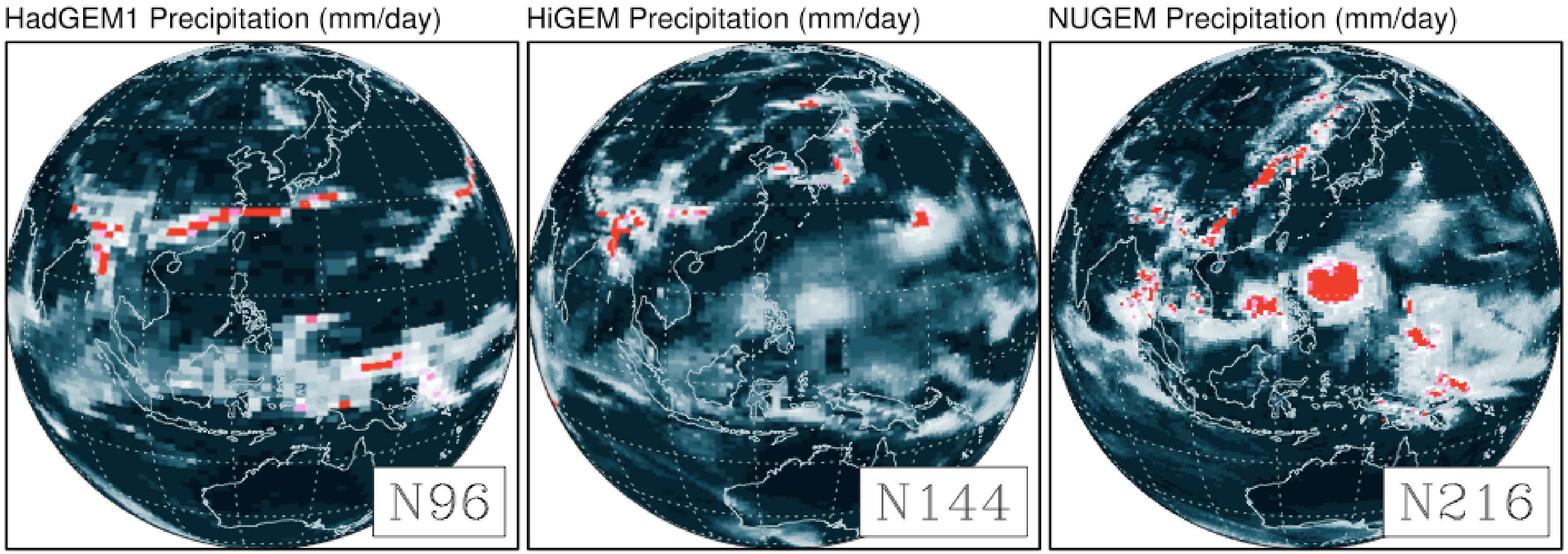
P.L. Vidale, A. Verhoef, M.E. Demory, M. Roberts, M. Best, H. Ashton, R. Ellis, C. Van den Hoof

National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

Walker INSTITUTE

Our main line of research: *UK-Japan Climate Collaboration* investigating weather-scale processes in the climate system with high-res AOGCMs and AGCMs

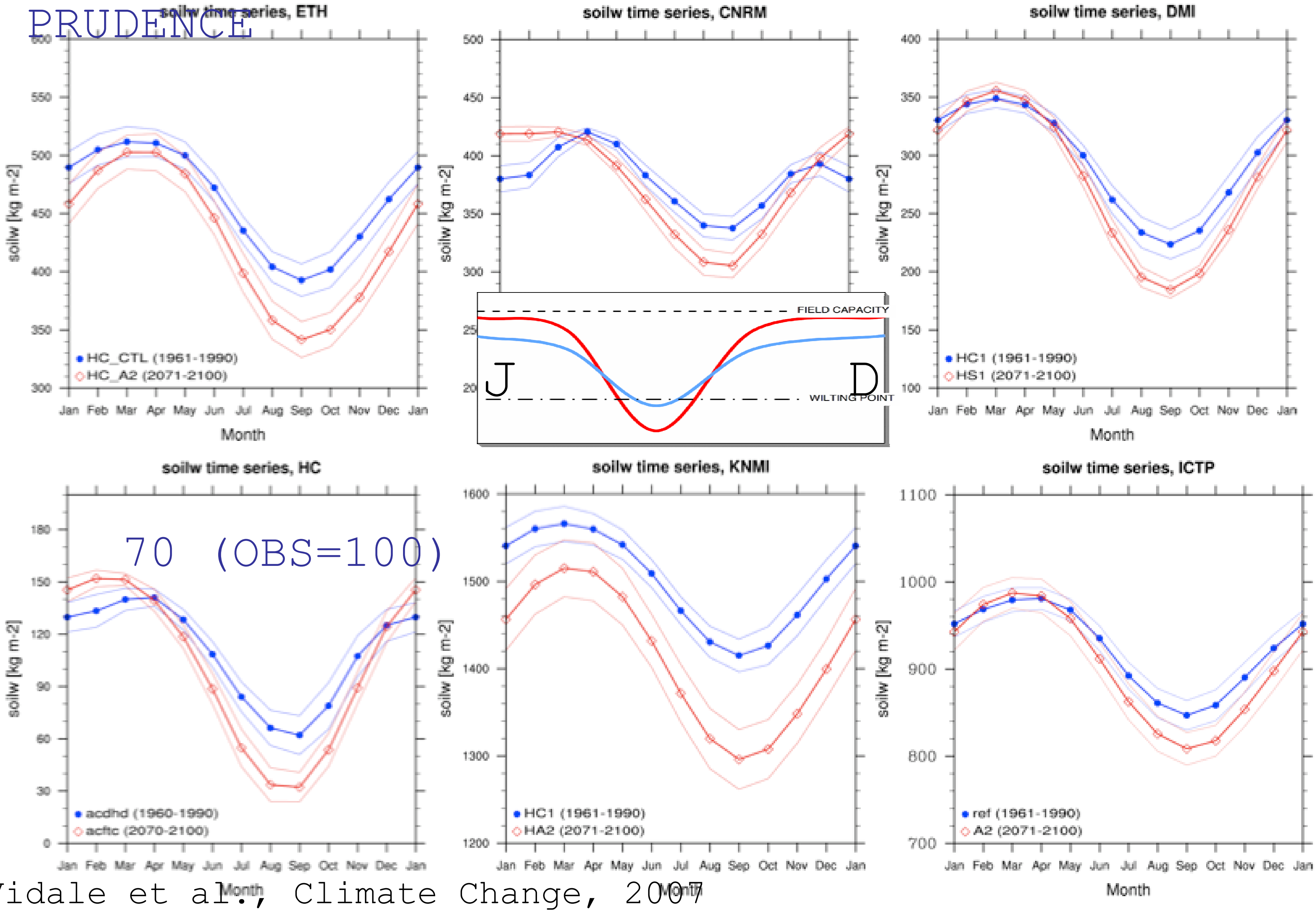
日英気候共同研究
UK-Japan Climate Collaboration



Δx = 135 km Δx = 90 km Δx = 60 km

Only AMIP2 (atmosphere-only) simulation results today summers:

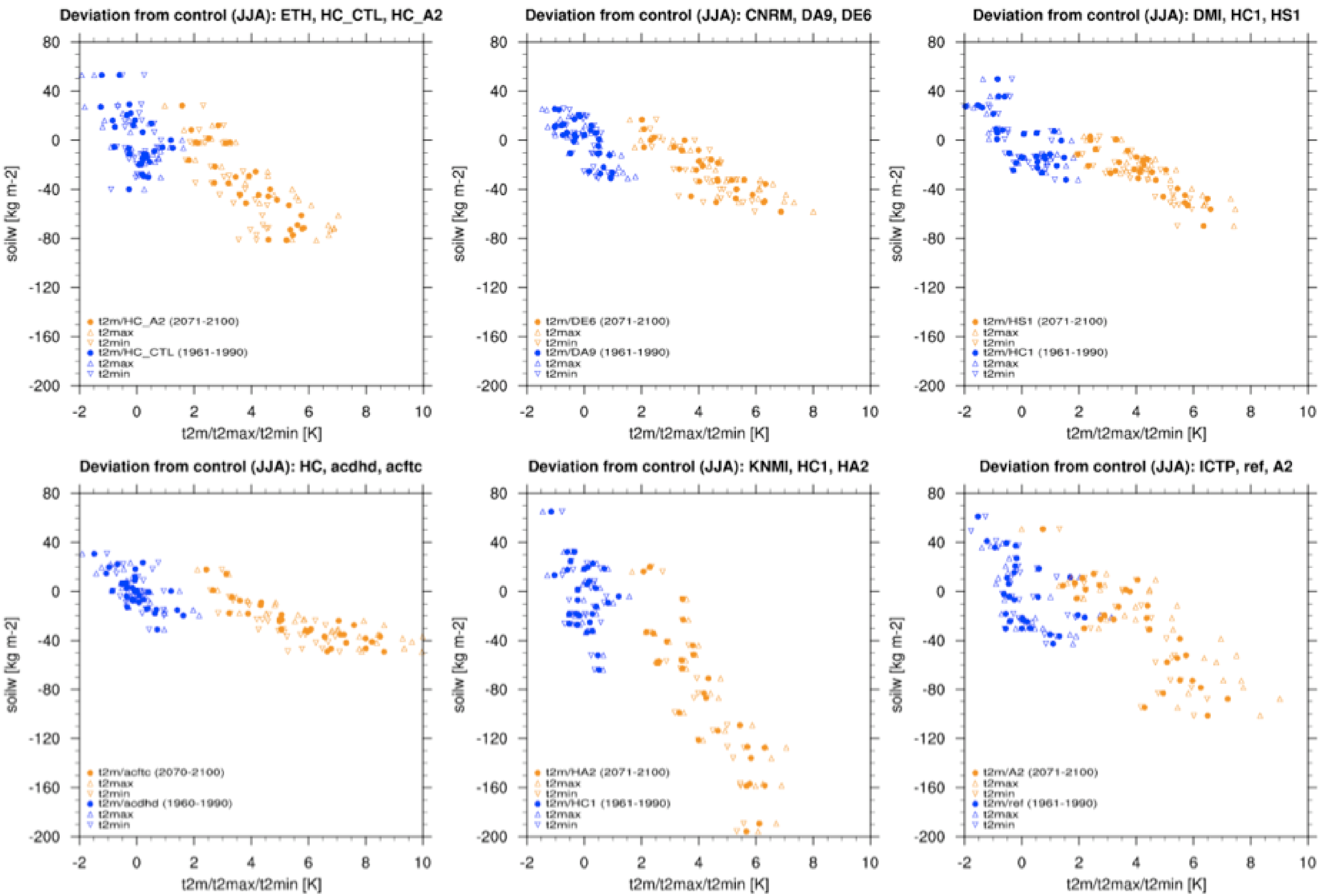
Soil moisture mean evolutions (and IV) in PRUDENCE



70 (OBS=100)

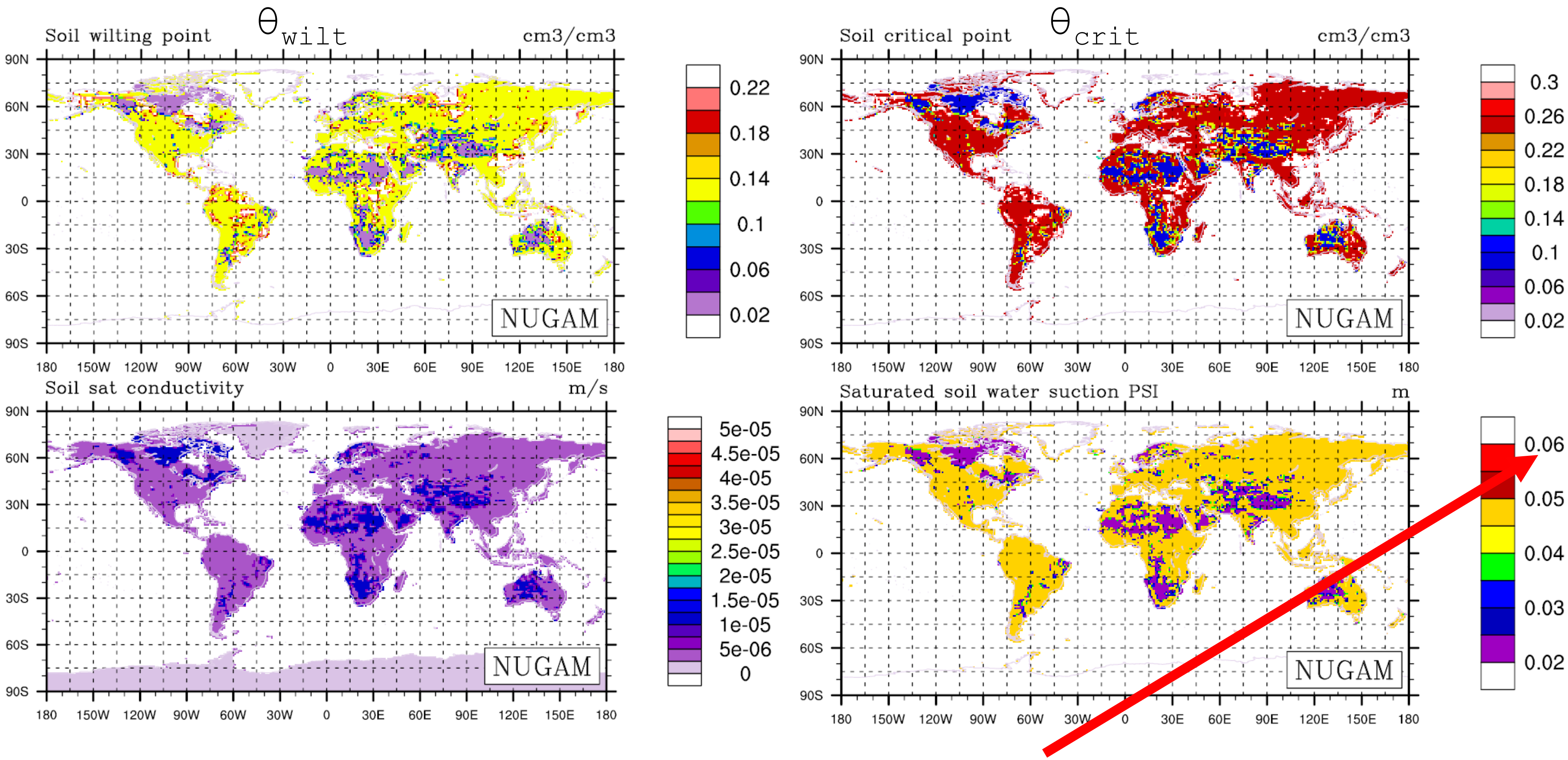
Vidale et al., Climate Change, 2007

Soil moisture and T2m anomalies



Soil parameters received while building NUGAM (our 60km model)… not exactly “high resolution”

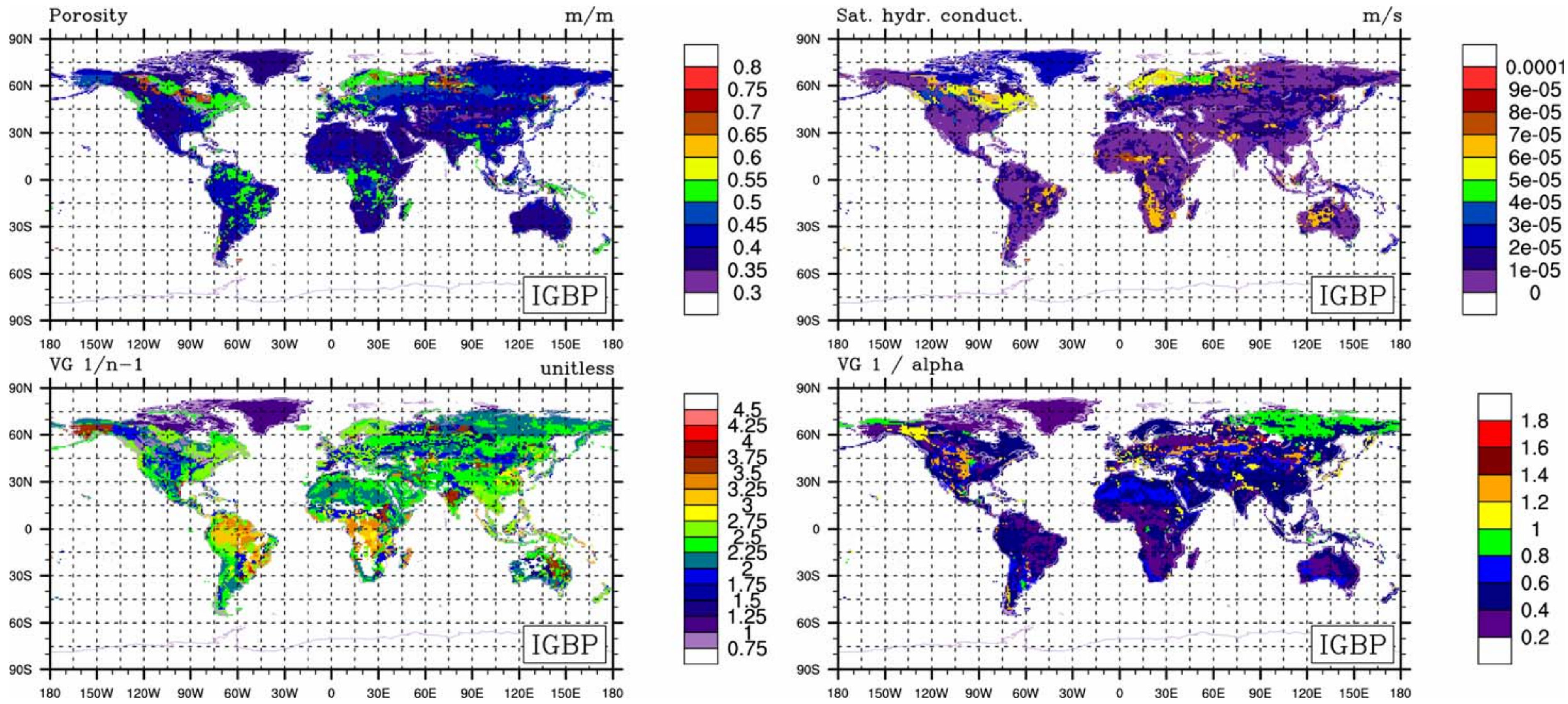
Reasons: WHS database + ancillary production r



See PLV’s Dec. 2006 report for more

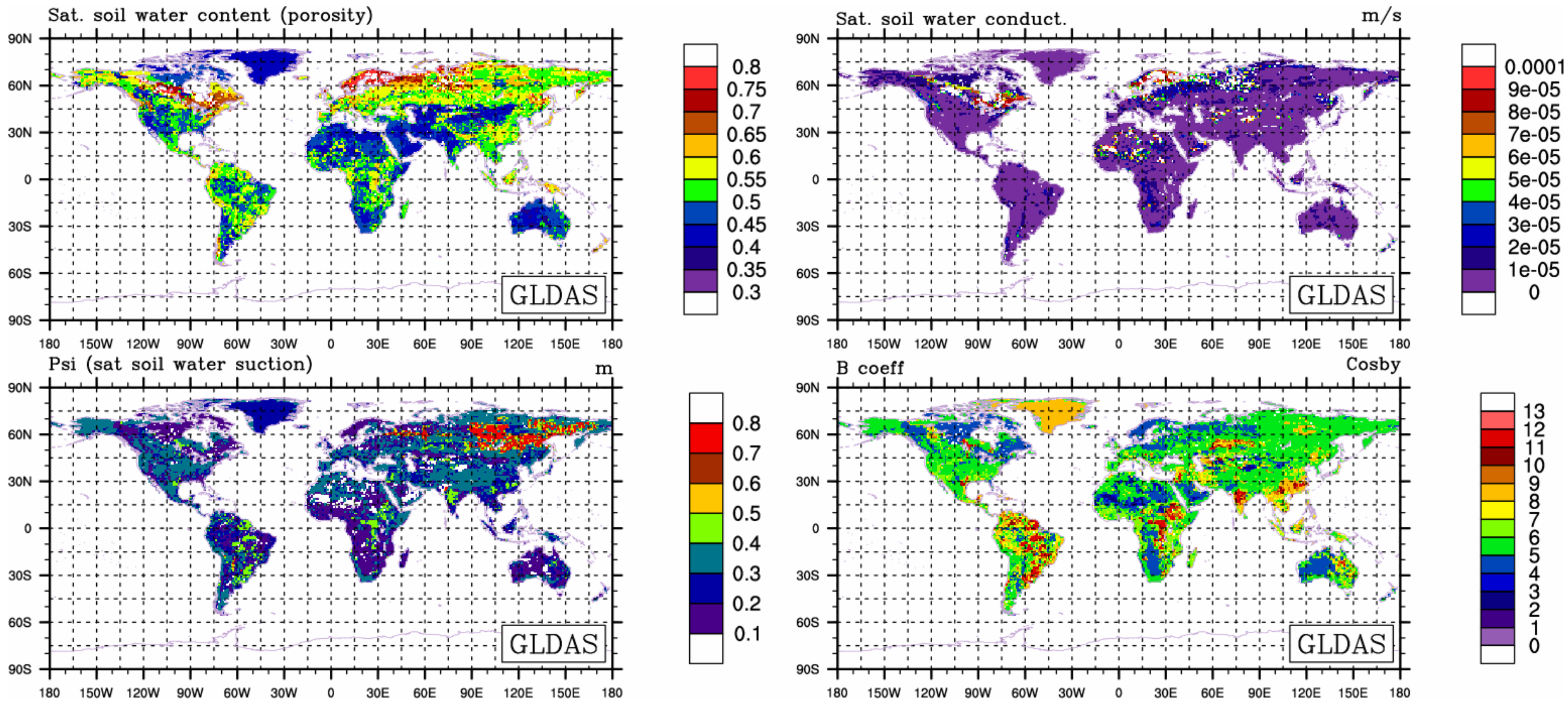
FACTOR OF 10 TOO SMALL !

"The QUEST for NUGAM soils"
IGP-DIS soil parameters



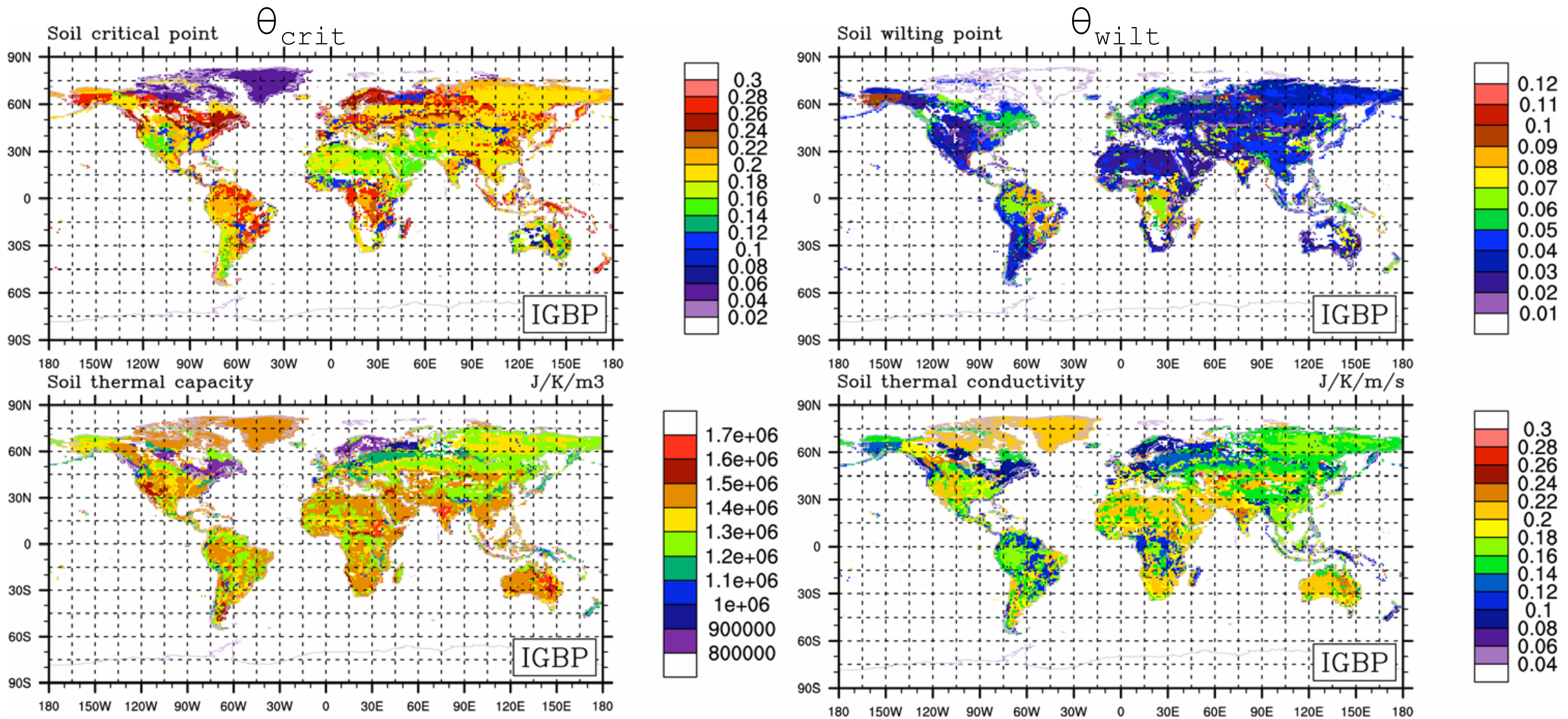
But only Van Genuchten…

"The QUEST for NUGAM soils"
Soil parameters from GLDAS



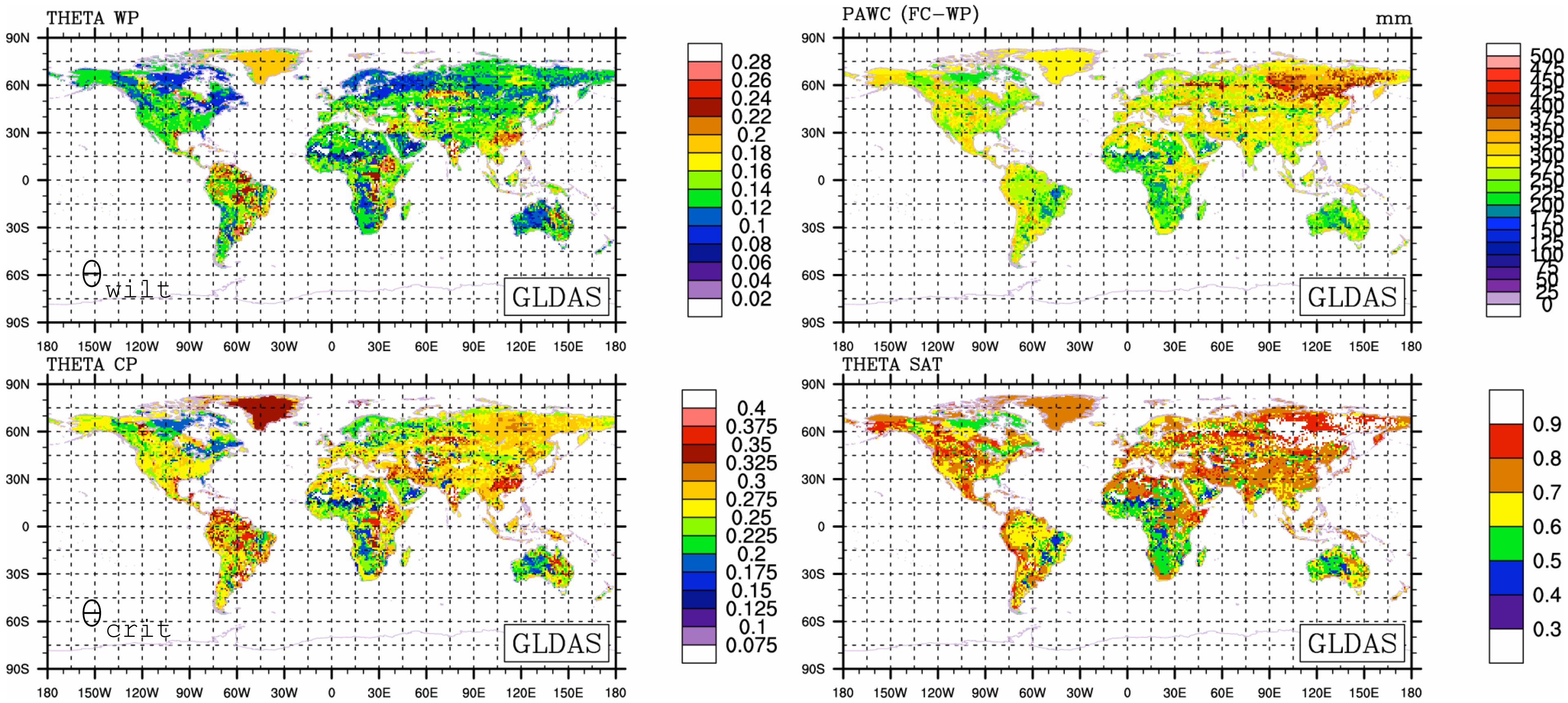
…but very porous, due to peats -> numerical instability

Thetas, IGBP



Soil critical point
θcrit
IGBP
0.3 0.28 0.26 0.24 0.22 0.2 0.18 0.16 0.14 0.12 0.1 0.08 0.06 0.04 0.02
Soil wilting point
θwilt
IGBP
0.12 0.11 0.1 0.09 0.08 0.07 0.06 0.05 0.04 0.03 0.02 0.01
Soil thermal capacity
J/K/m3
IGBP
1.7e+06 1.6e+06 1.5e+06 1.4e+06 1.3e+06 1.2e+06 1.1e+06 1e+06 900000 800000
Soil thermal conductivity
J/K/m/s
IGBP
0.3 0.28 0.26 0.24 0.22 0.2 0.18 0.16 0.14 0.12 0.1 0.08 0.06 0.04
90N 60N 30N 0 30S 60S 90S
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180

Thetas, GLDAS



The Dec-Feb warnings and the April 2007 UKMO discovery of a bug in the central ancillary program

Table 1. Hydraulic parameters and critical and wilting point soil moisture content calculated from Eq. 1 for the Clapp and Hornberger (CH) parametrisation (Eqs. 1&2), for three soil textural types. Three sets of standard parameter values (CAH, COS, JUL) were taken from the literature.

Matric potential (suction)

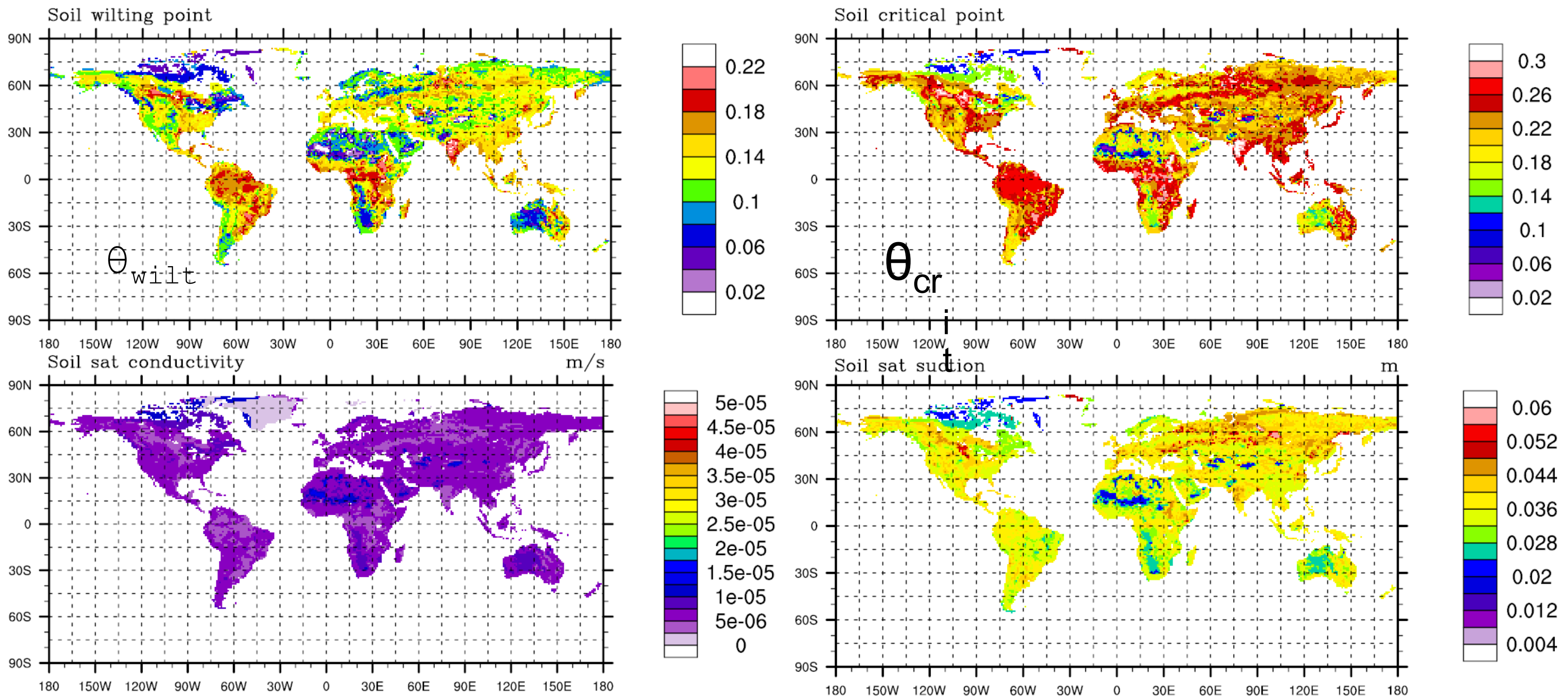
Soil texture	b (-)	θ_s ($m^3\ m^{-3}$)	ψ_s (m)	K_s ($mm\ s^{-1}$)	θ_c ($m^3\ m^{-3}$)	θ_{wp} ($m^3\ m^{-3}$)
CAH						
Loamy sand	4.38	0.410	0.090*	0.15633	0.18	0.075
Loam	5.39	0.451	0.478*	0.00695	0.315	0.155
Clay	11.40	0.482	0.405*	0.00103	0.401	0.287
COS						
Loamy sand	4.26	0.421	0.036	0.01408	0.146	0.06
Loam	5.25	0.439	0.354	0.00338	0.287	0.139
Clay	11.5	0.468	0.468	0.00097	0.395	0.283
JUL						
Loamy sand	3.6	0.382	0.022	0.011	0.095	0.033
Loam	6.6	0.458	0.049	0.0047	0.242	0.136
Clay	11.2	0.456	0.045	0.0036	0.311	0.221

** Alternative, lower, values are given in C&H of 0.0178, 0.146 and 0.186 m, for loamy sand, loam and clay, respectively, based on a logarithmic averaging procedure.*

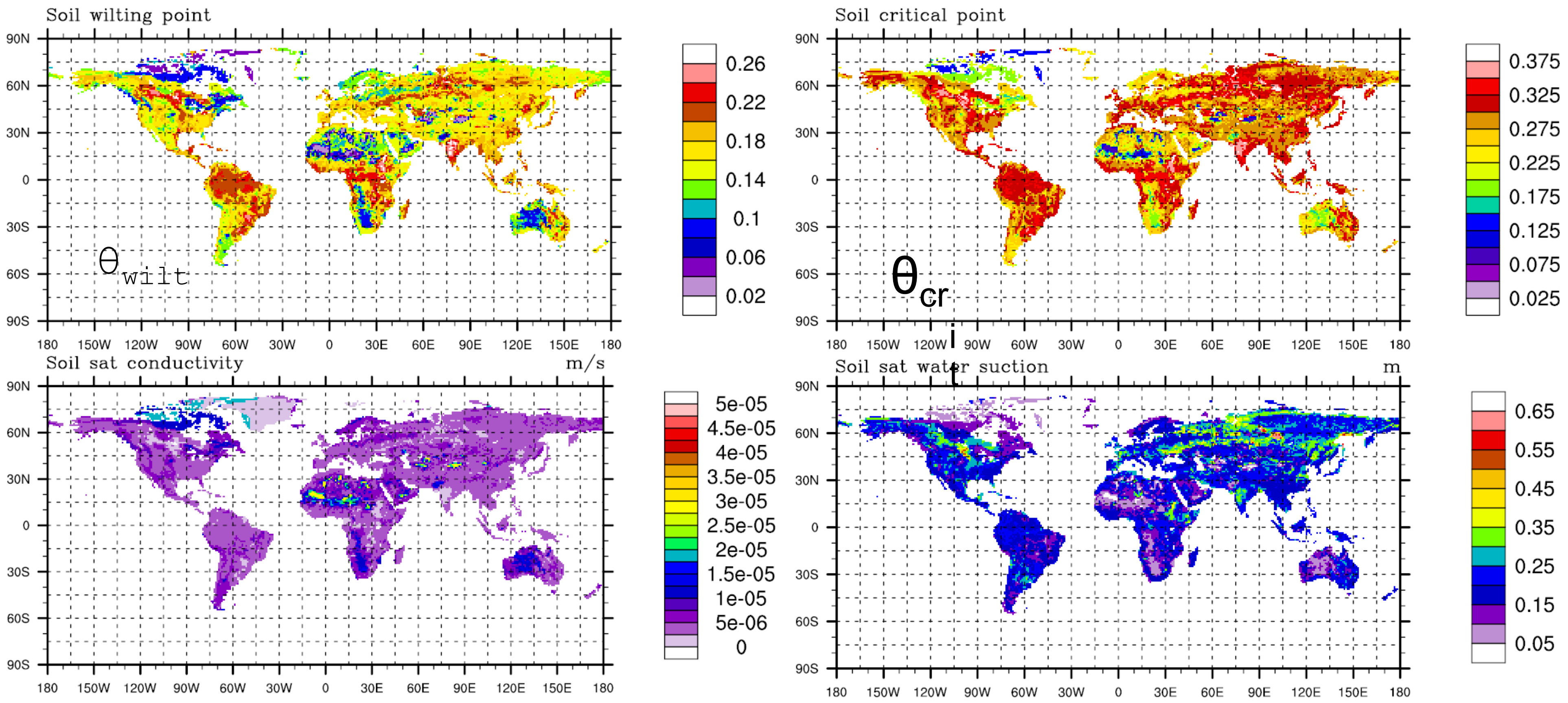
1. PSI too low, θ_c and θ_{wp} too low
2. Soil can become quite dry
3. Soil moisture range is underestimated (mainly due to θ_c)
4. Consequences for variability

A. Verhoef, Feb. 07

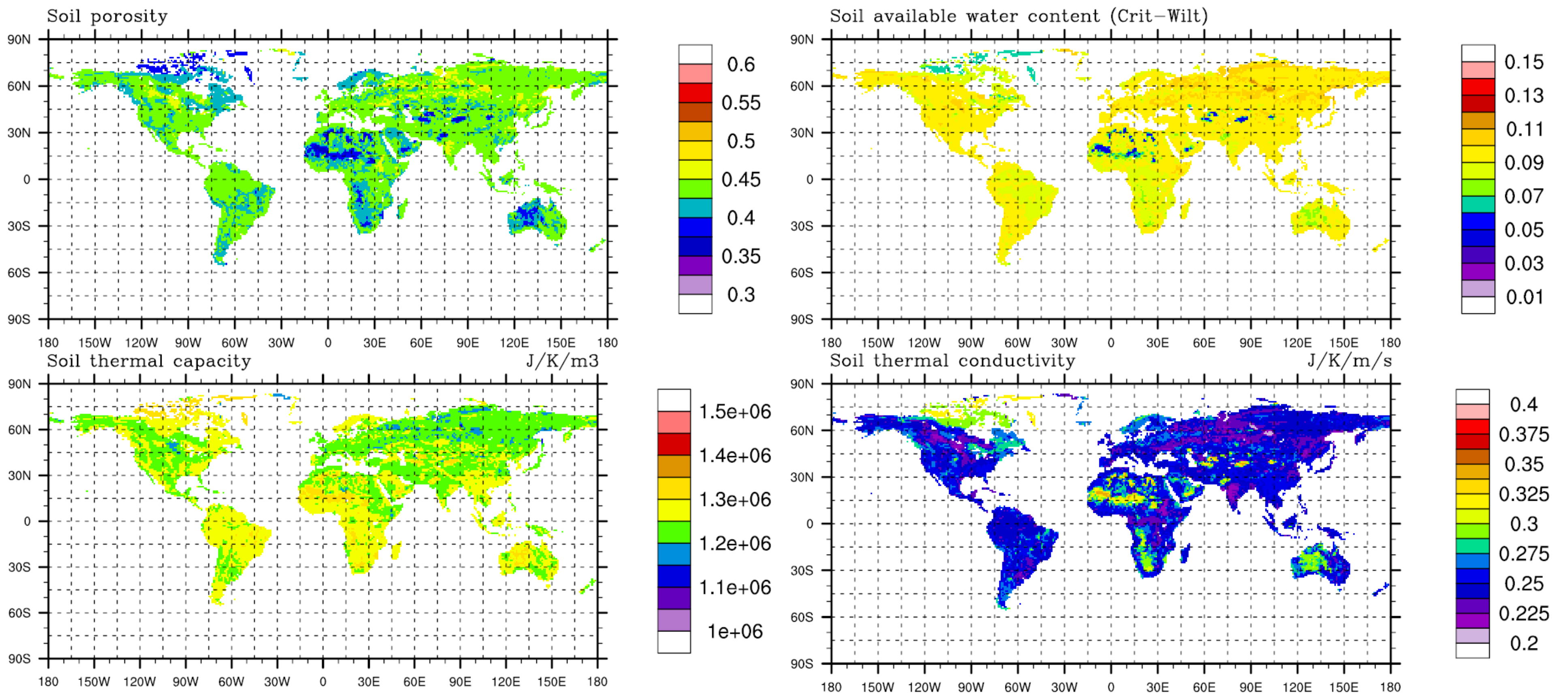
Original (WRONG) UKMO Cosby parameters



Corrected UKMO Cosby parameters

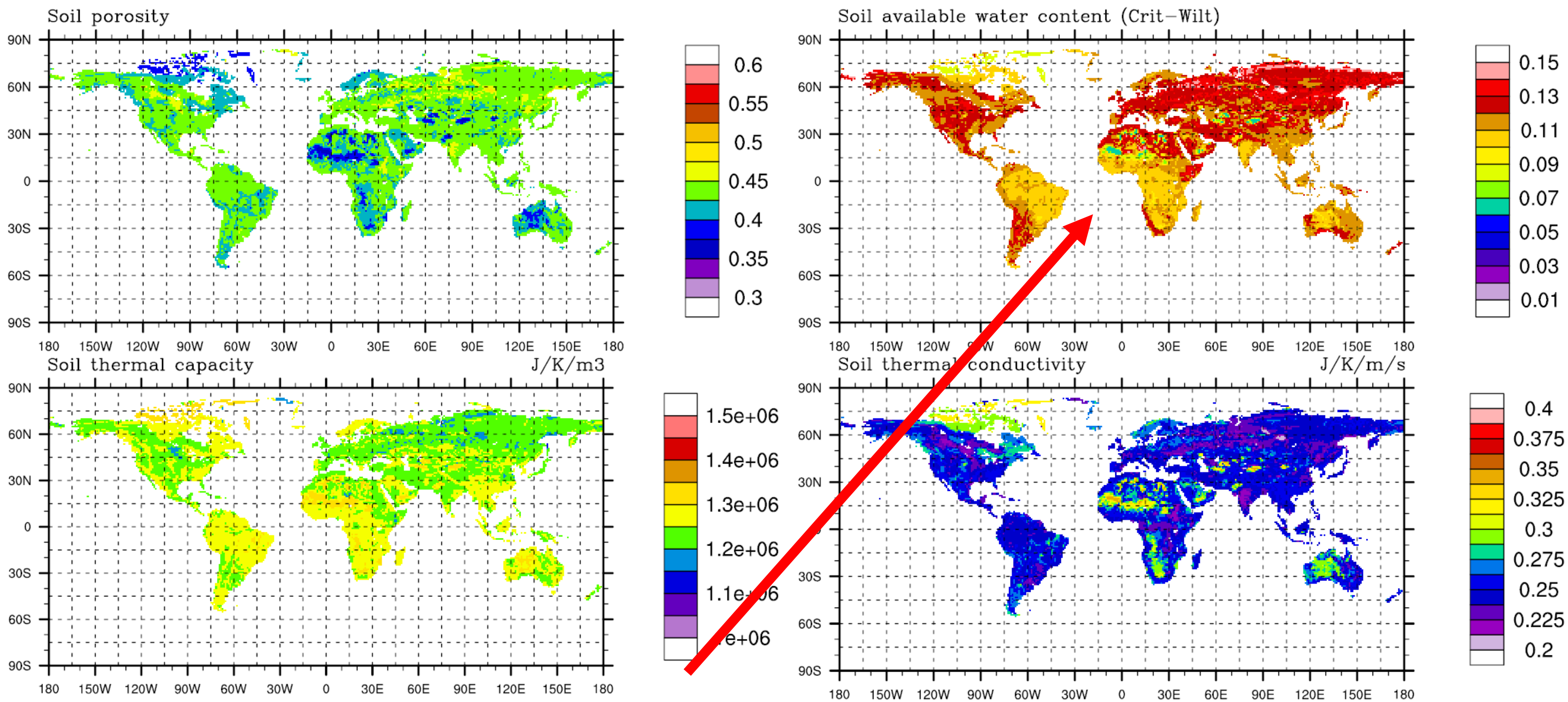


Original (WRONG) UKMO Cosby parameters



The most important change: a larger available soil water content

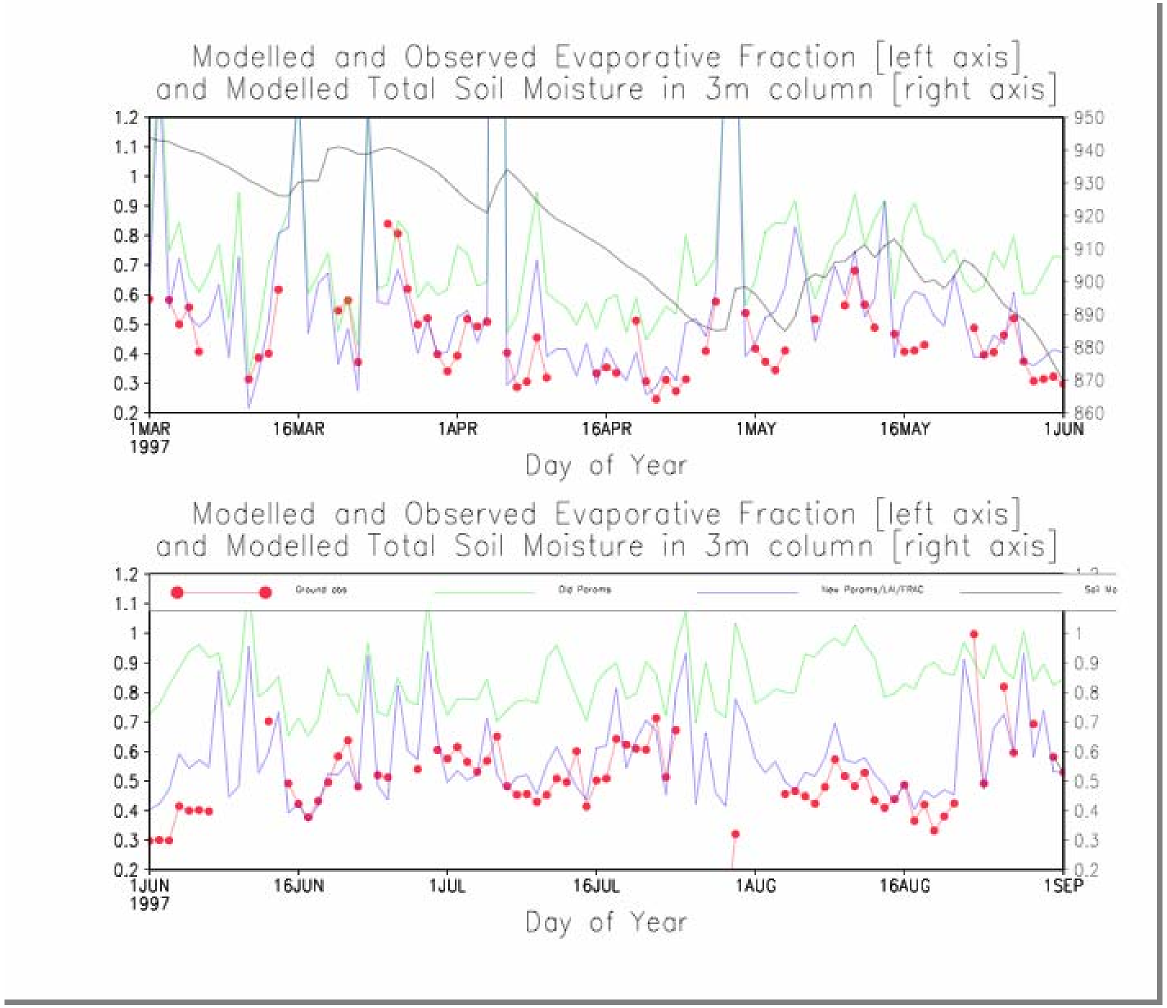
Corrected UKMO Cosby parameters



This explains part of my PSICC result

I will show results from HadGAM/NUGAM, using these corrected soils, but simulations using IGBP soils and/or the Van Genuchten parameterisation produce very similar

Offline work on summer droughts:
can MOSES2/JULES simulate <u>short</u> dry+warm periods ?



H. Ashton

Apparently JULES is not "ready out-of-the-box"…

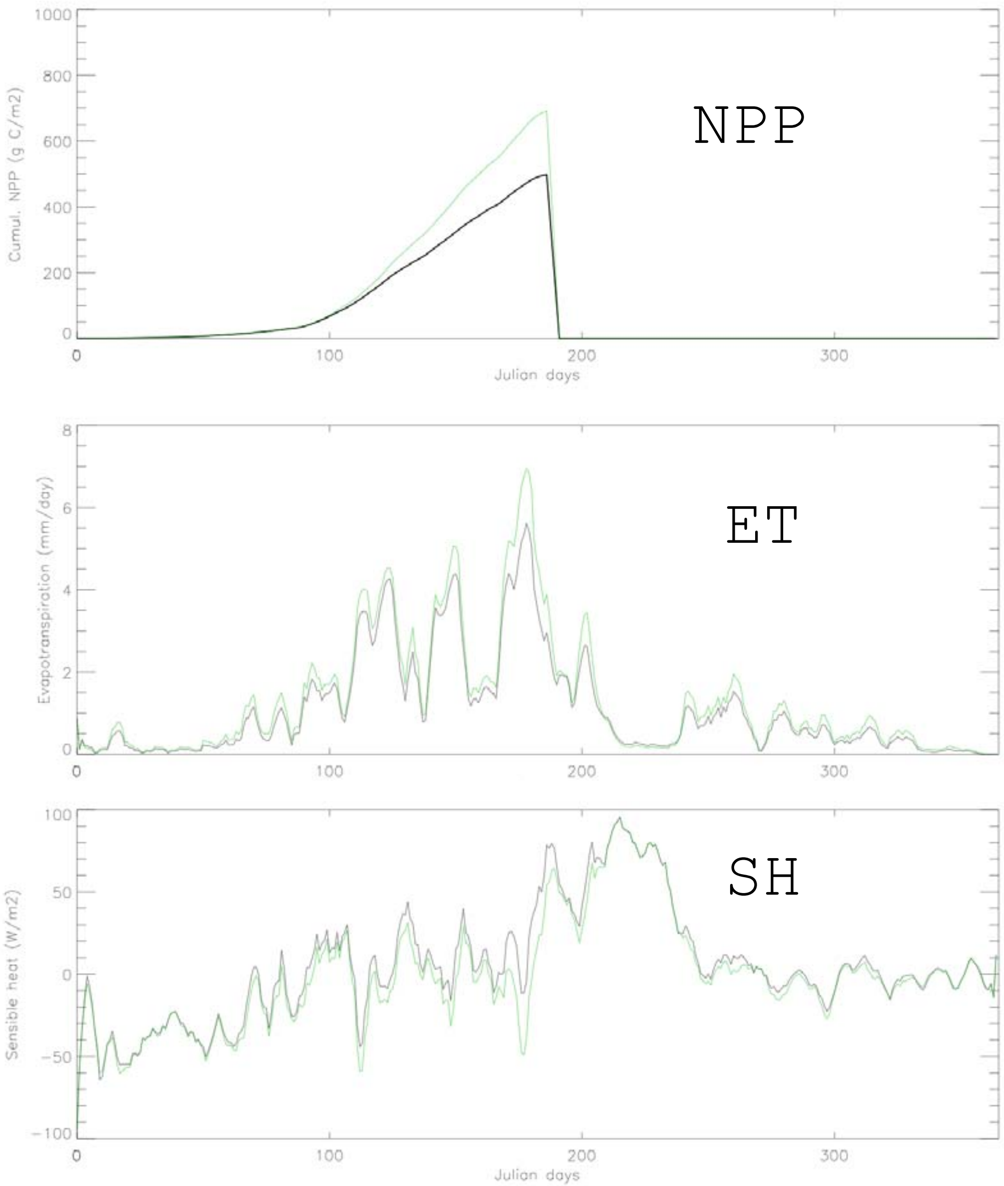
1) Soil parameters have a massive effect of evaporative fraction at Loobos
2) "Loobos" vegetation parameters in standard namelist are not really from

Can JULES model crops ?

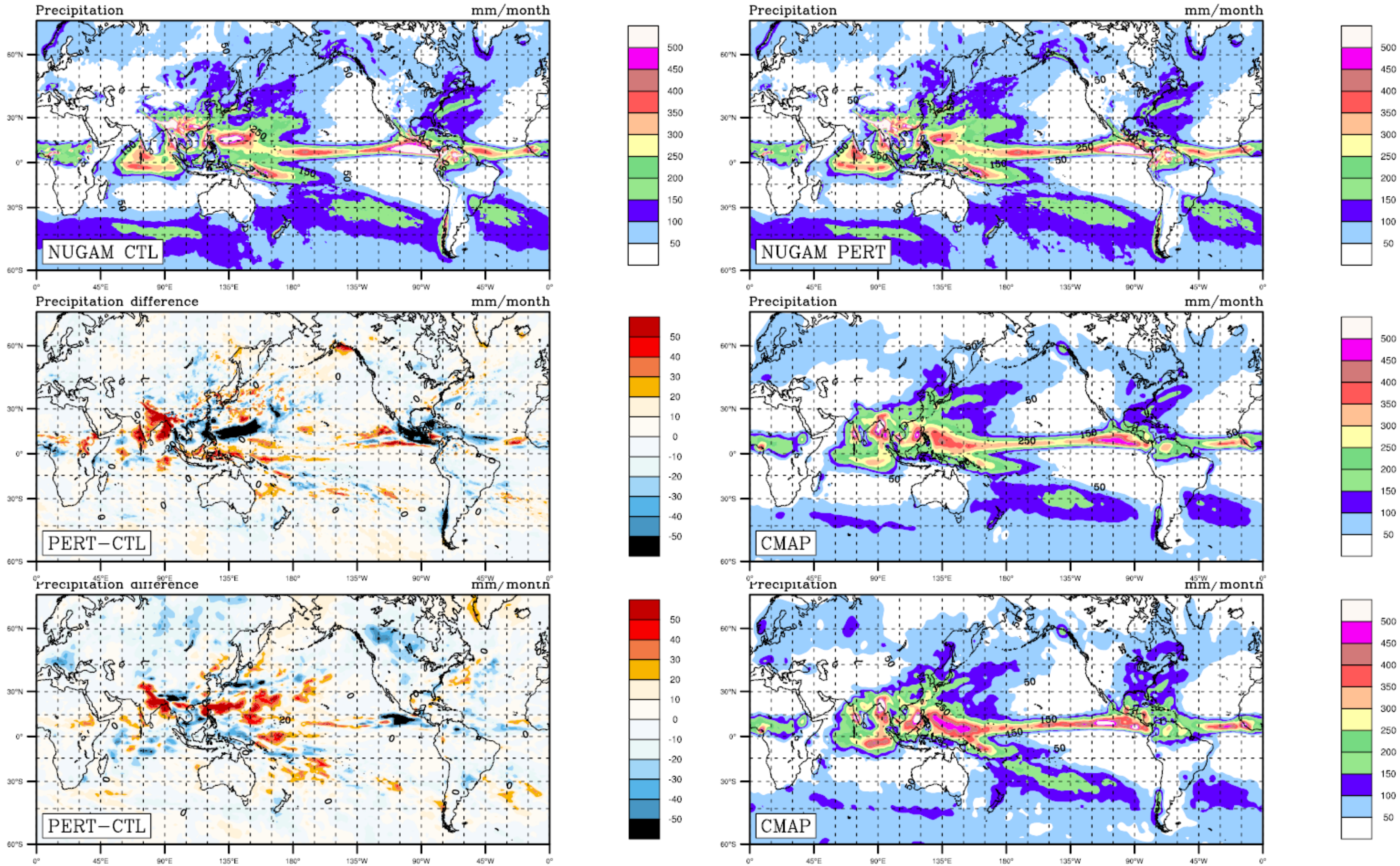
- C.V.d.H adapting JULES to model managed ecosystems (idealised: potential growth only);
- Found nice sensitivity to crop-type phenology (imposed from Remote Sensing) and crop-type physiology;
- Will soon add phenology, allocation routines from WOFOST;
- What happens when we correct the soils in these Grignon experiments ?

C. – Van den Hoof

Loss of NPP, ET; increase in SH

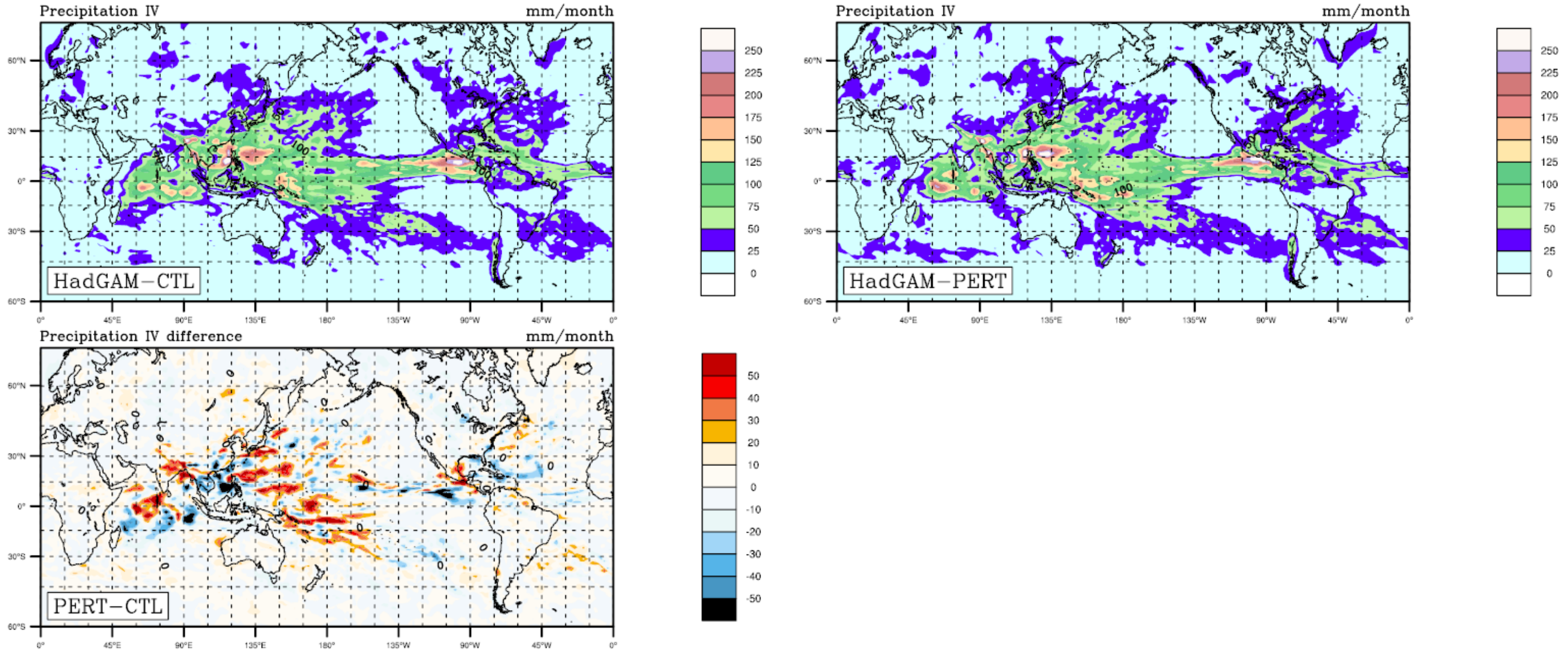


Average JJA Precipitation (mm/month)



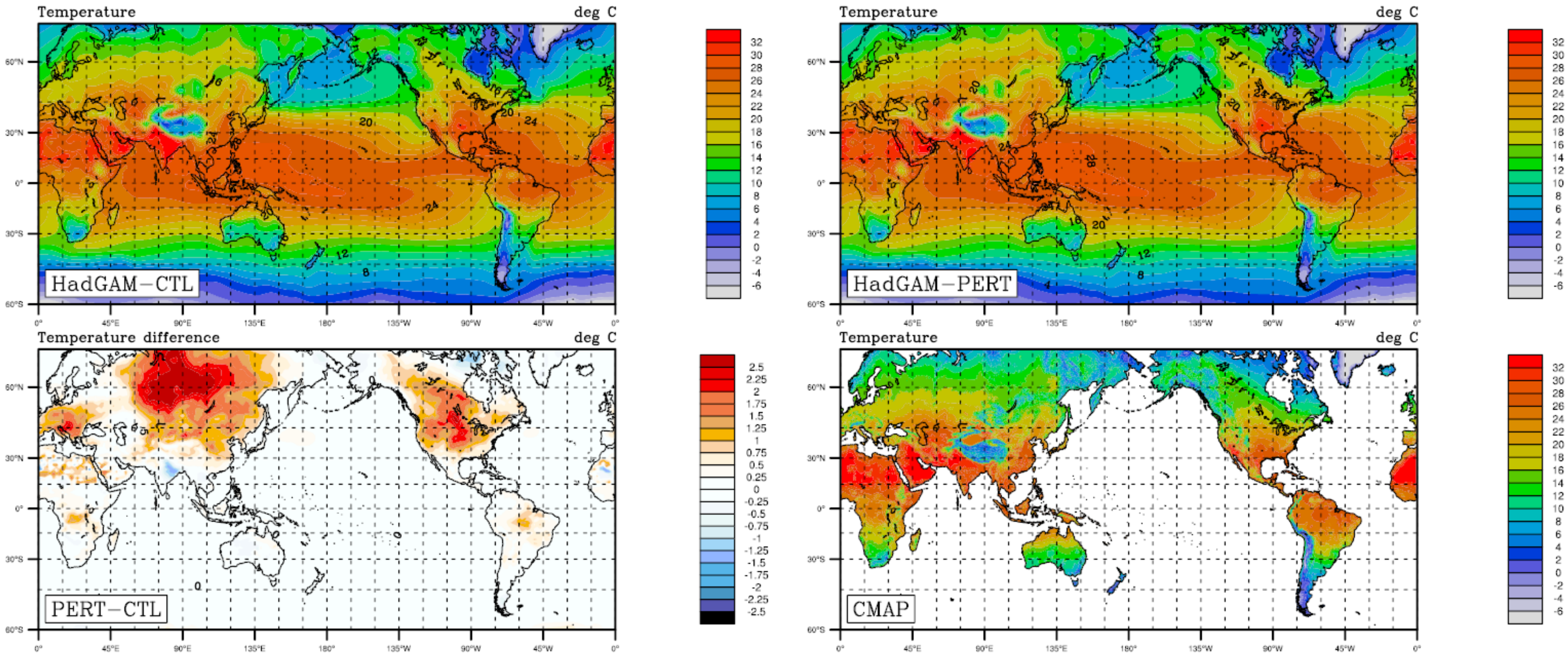
At both GCM resolutions: India !

JJA Precipitation IV (mm/month)

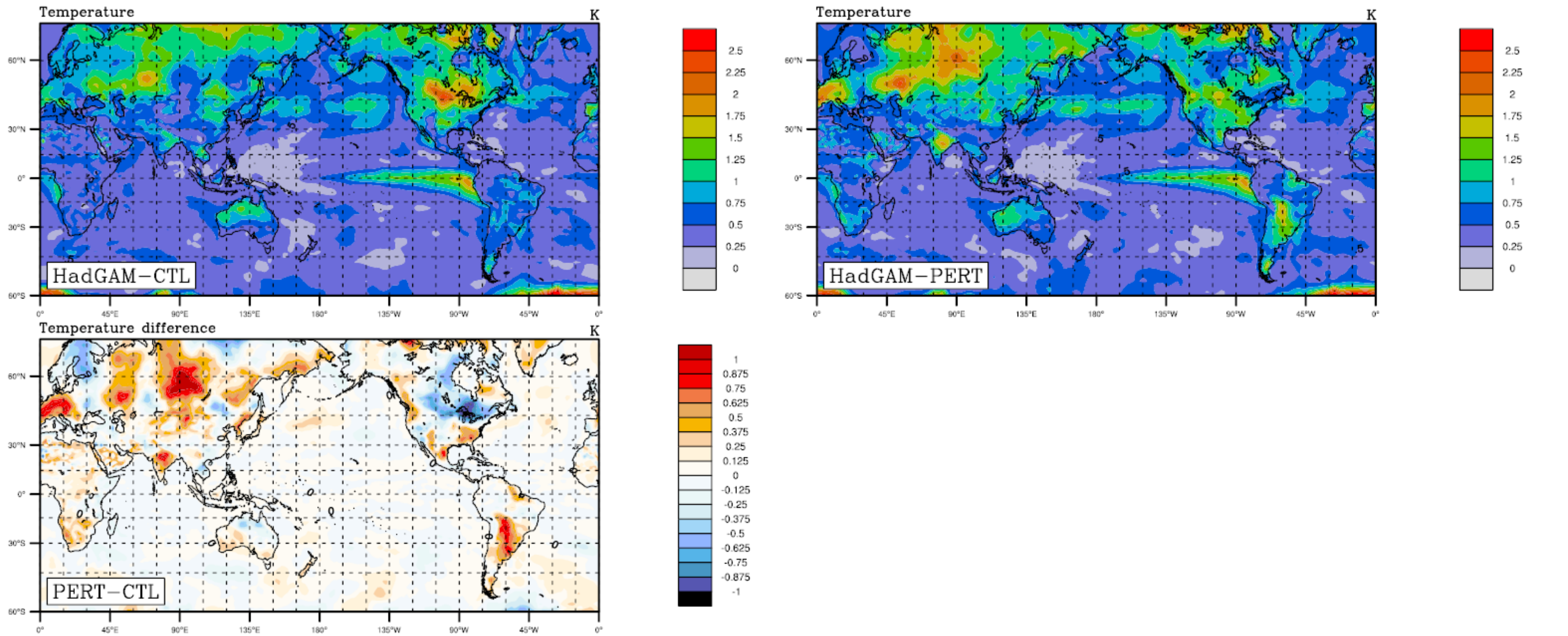


And a very bad thing…

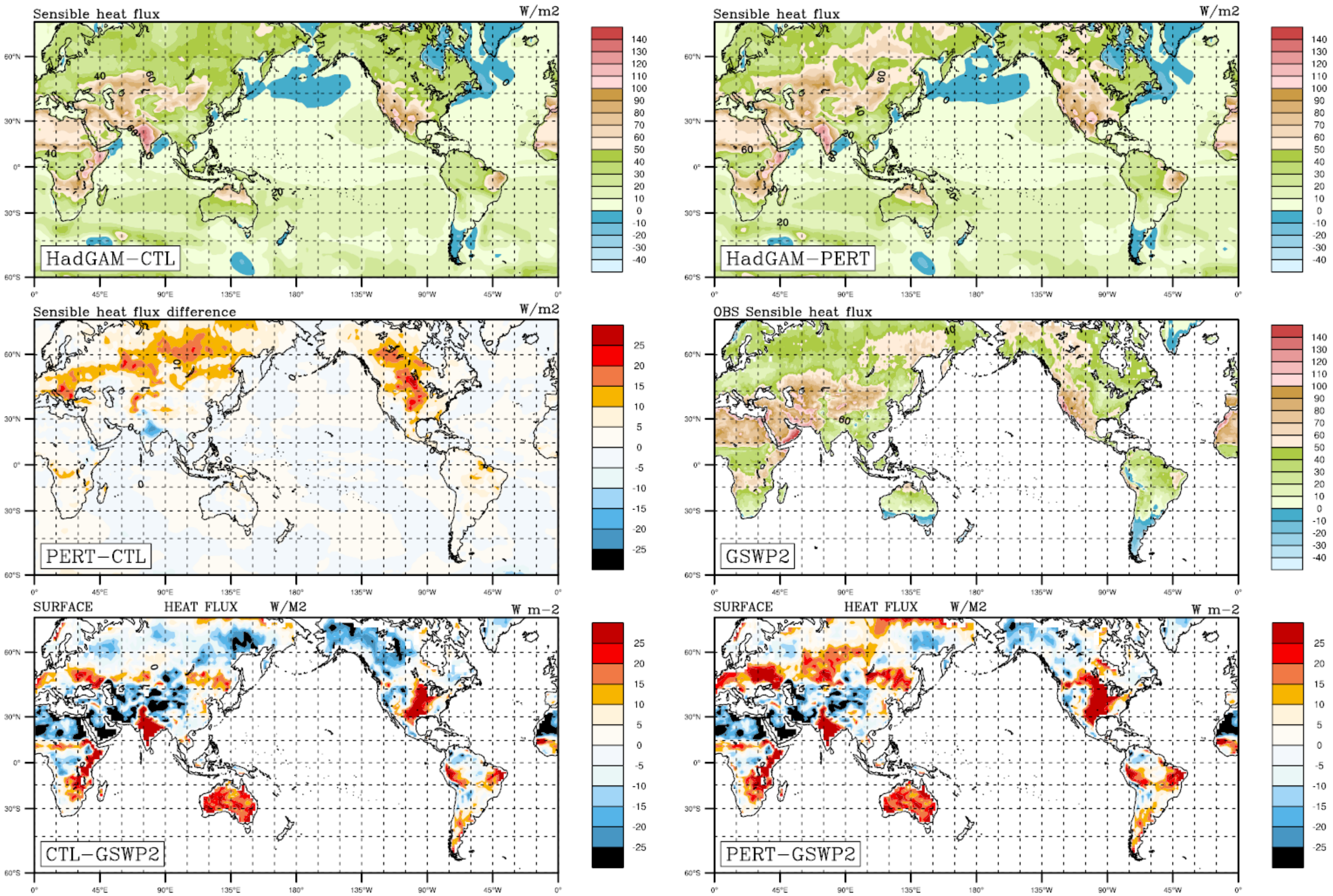
Average JJA Temperature (deg C)



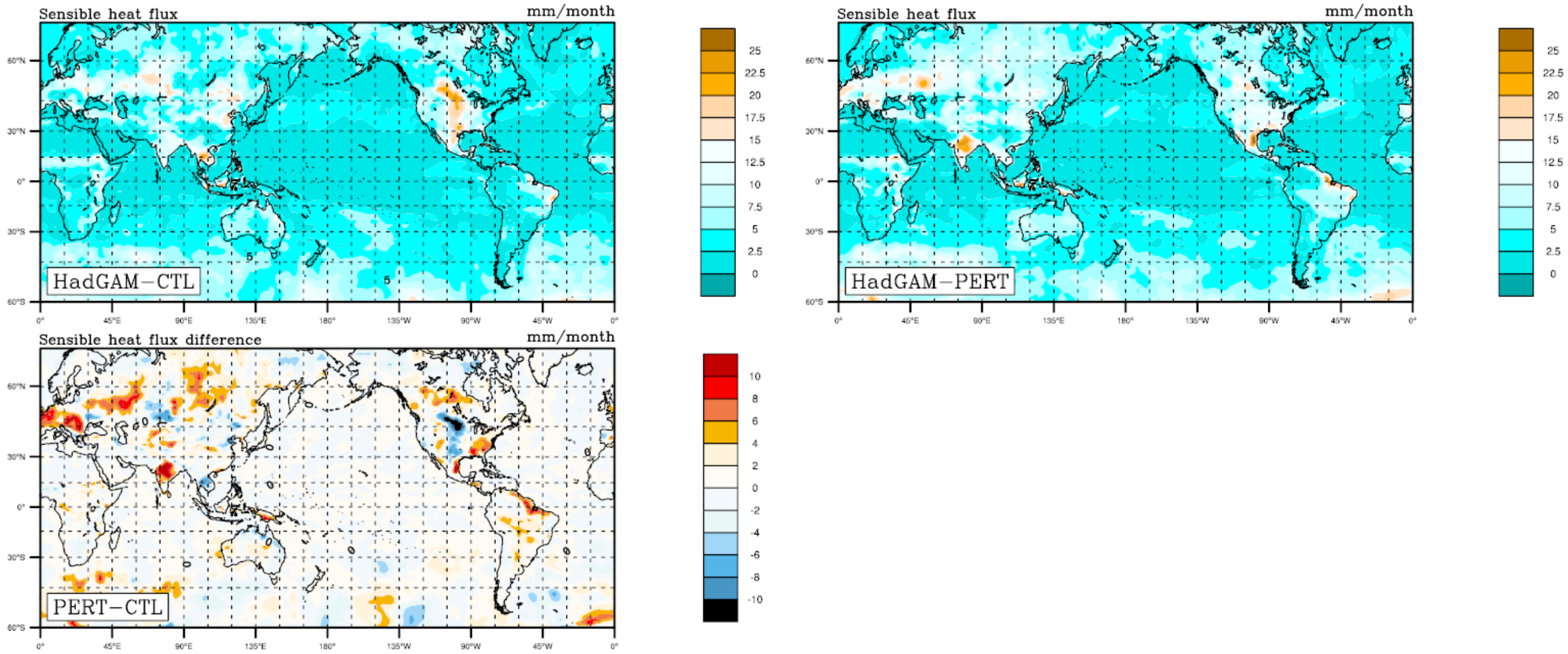
JJA Temperature IV (K)



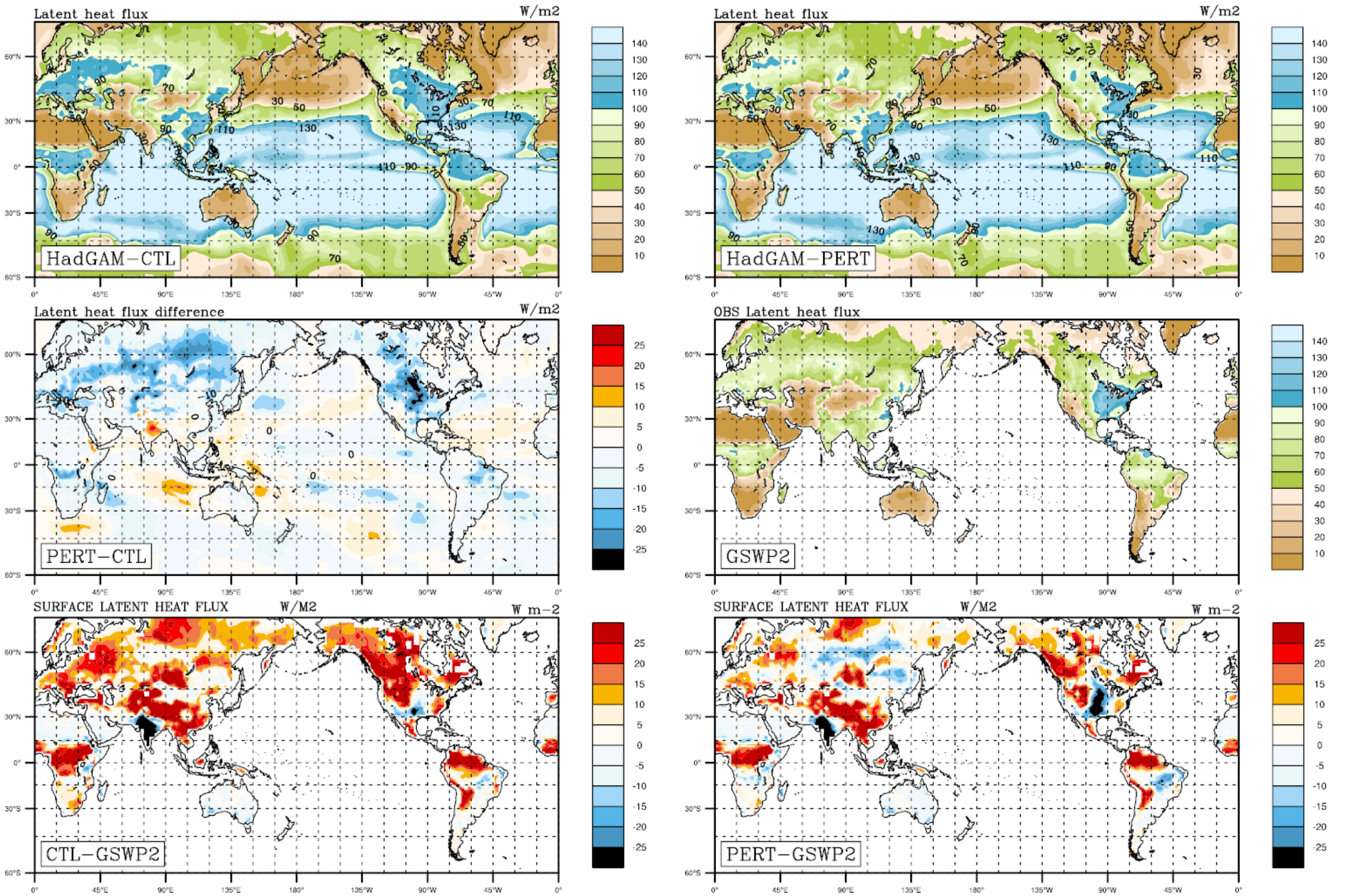
Average JJA sensible heat flux (W/m2)



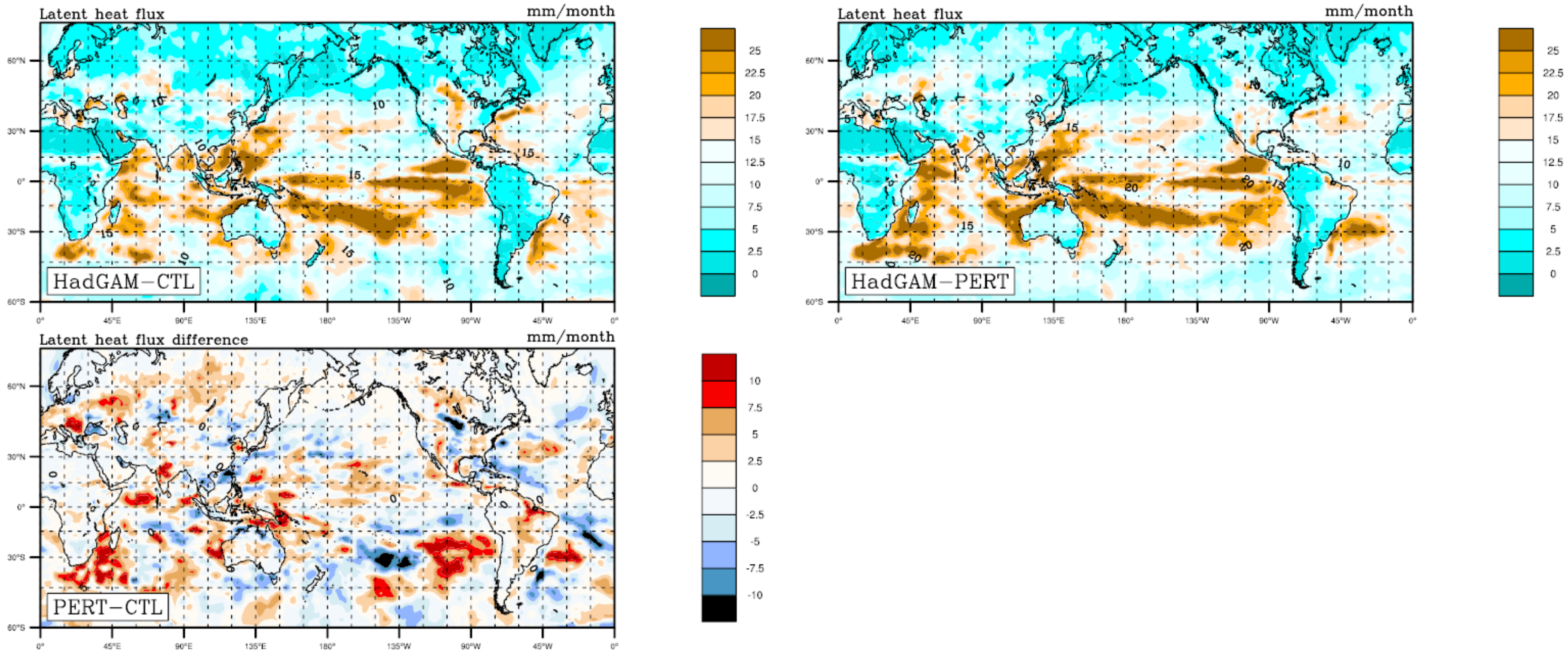
JJA sensible heat flux IV (W/m2 s)



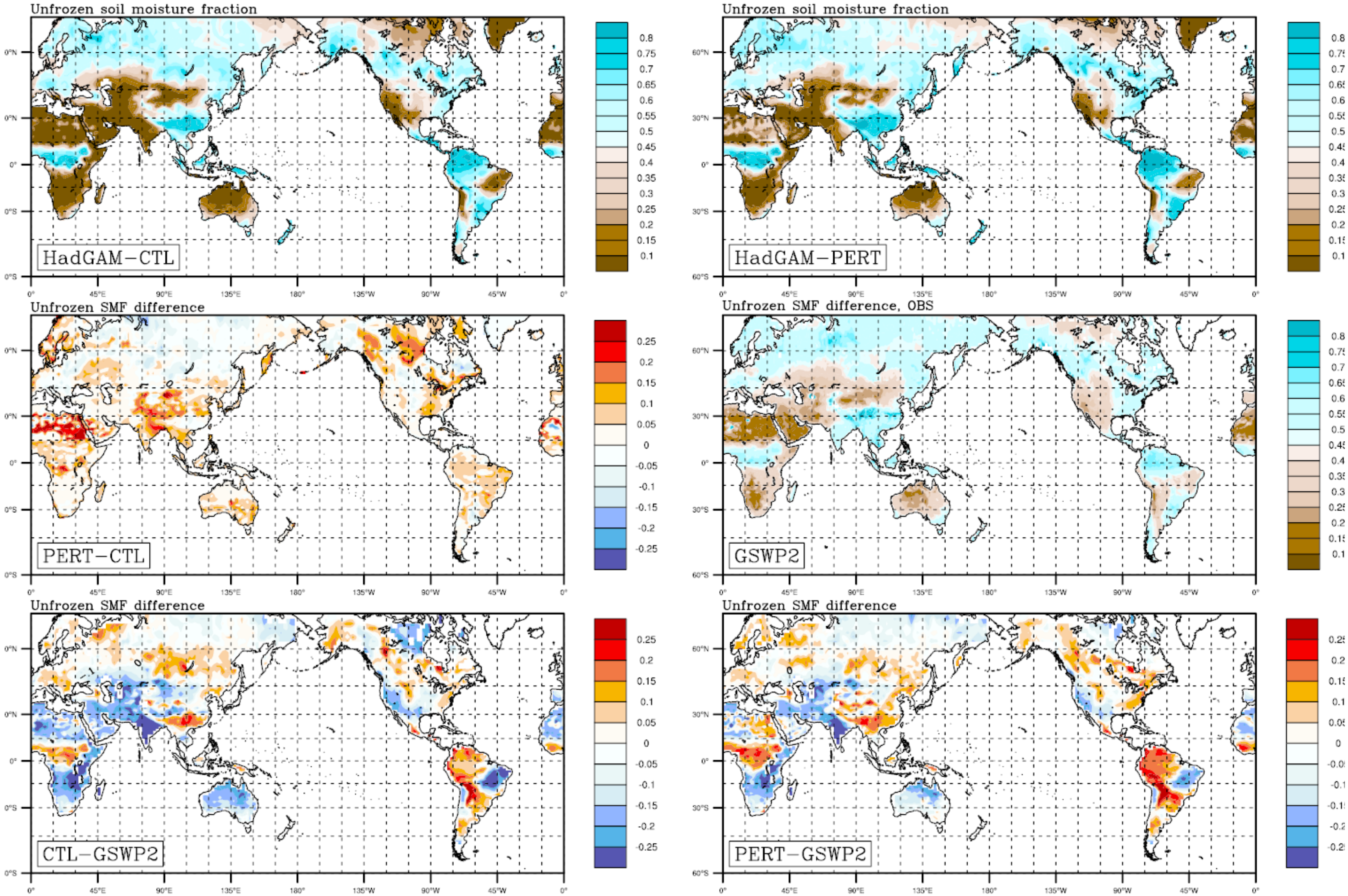
Average JJA latent heat flux (W/m2)



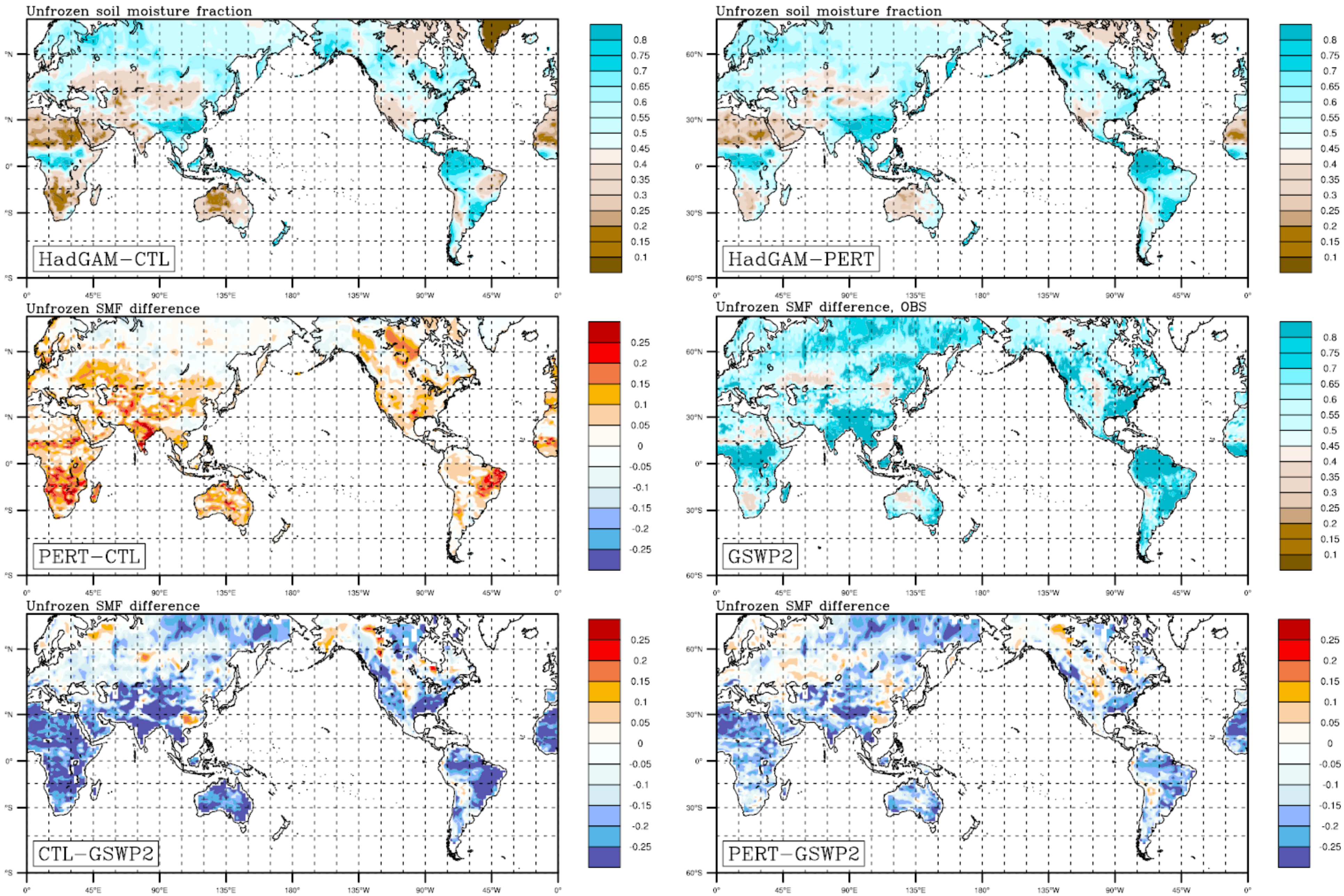
JJA latent heat flux IV (W/m2 s)



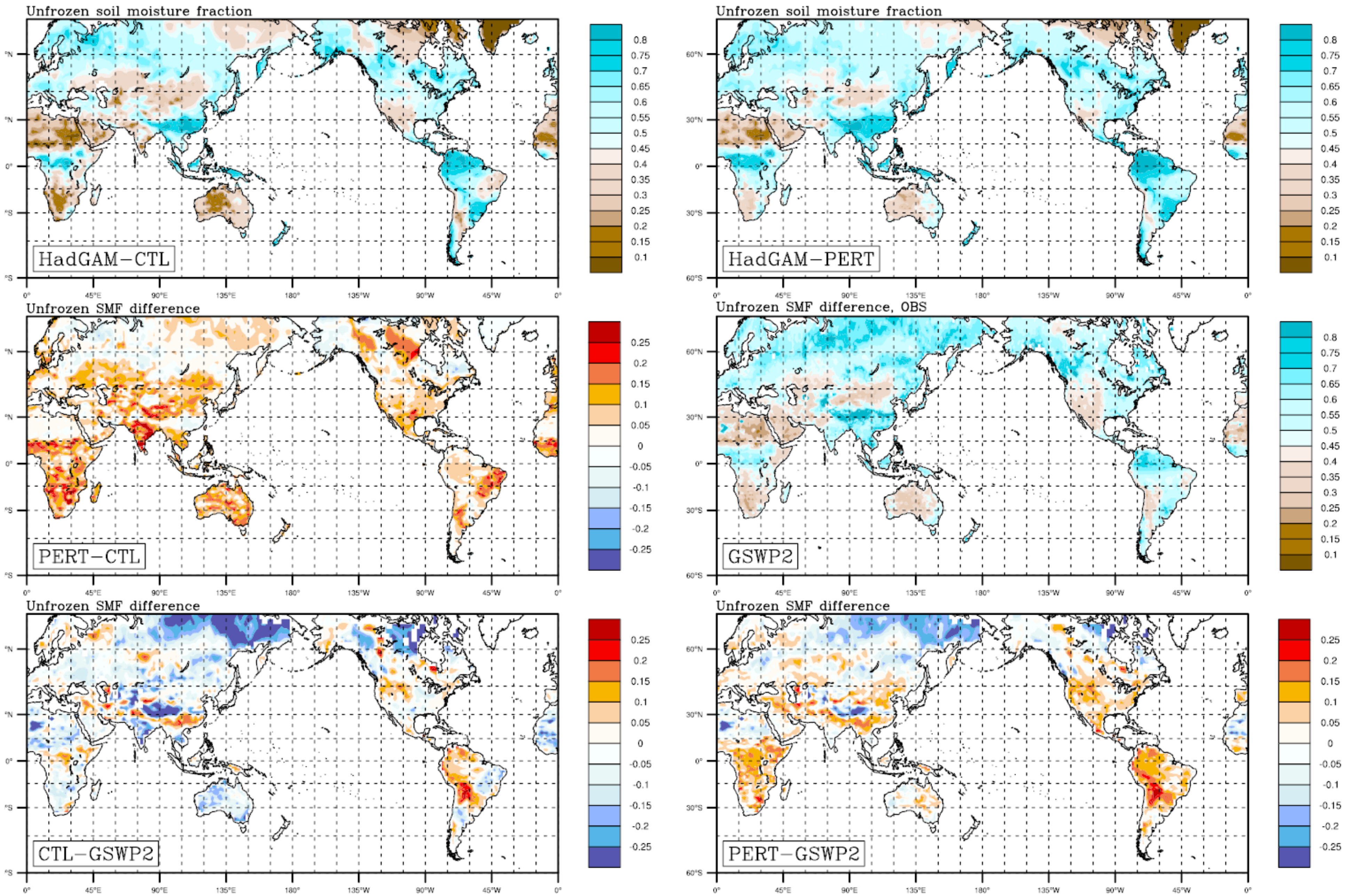
Average JJA Soil moisture fraction (L1)



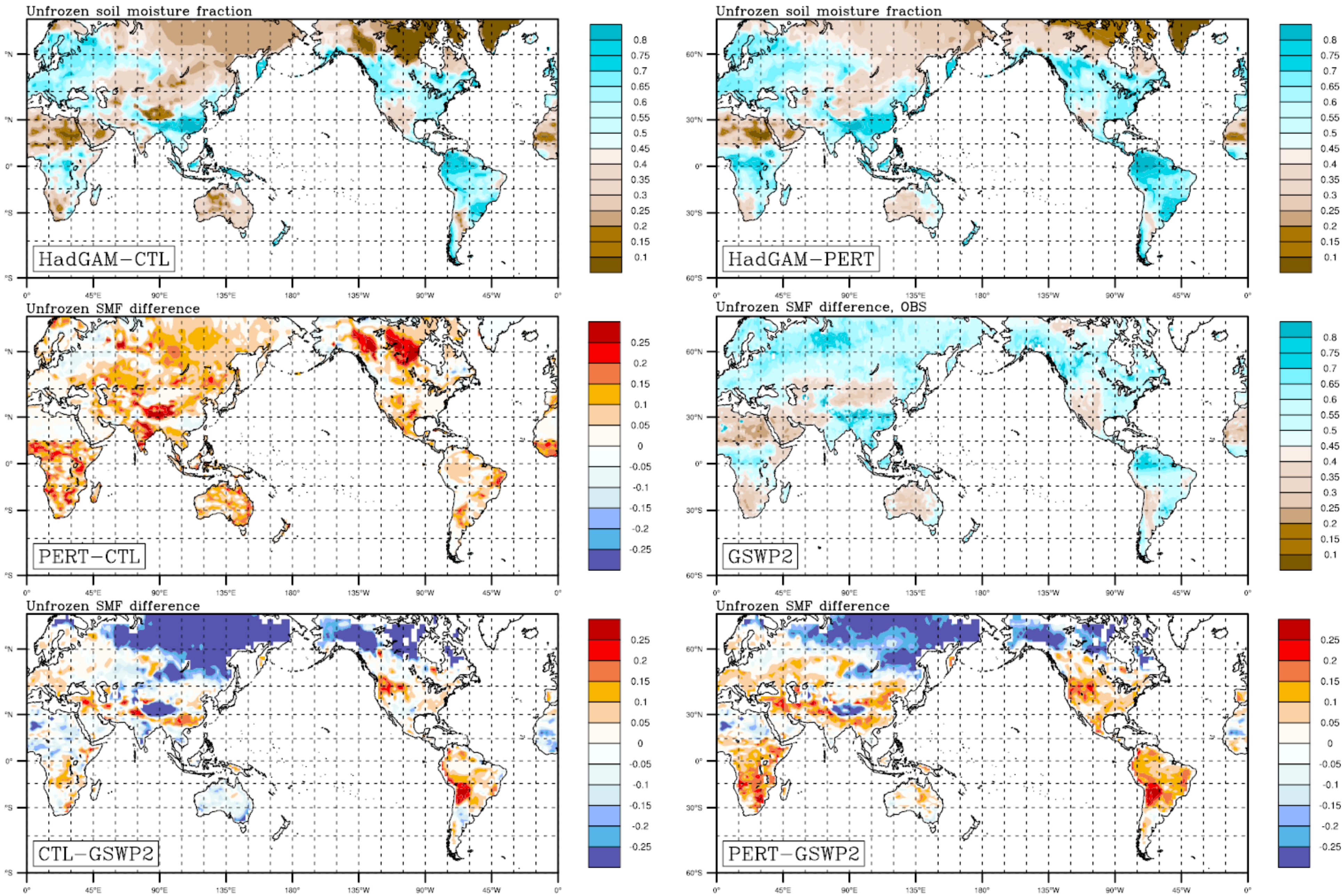
Average JJA Soil moisture fraction (L2)



Average JJA Soil moisture fraction (L3)



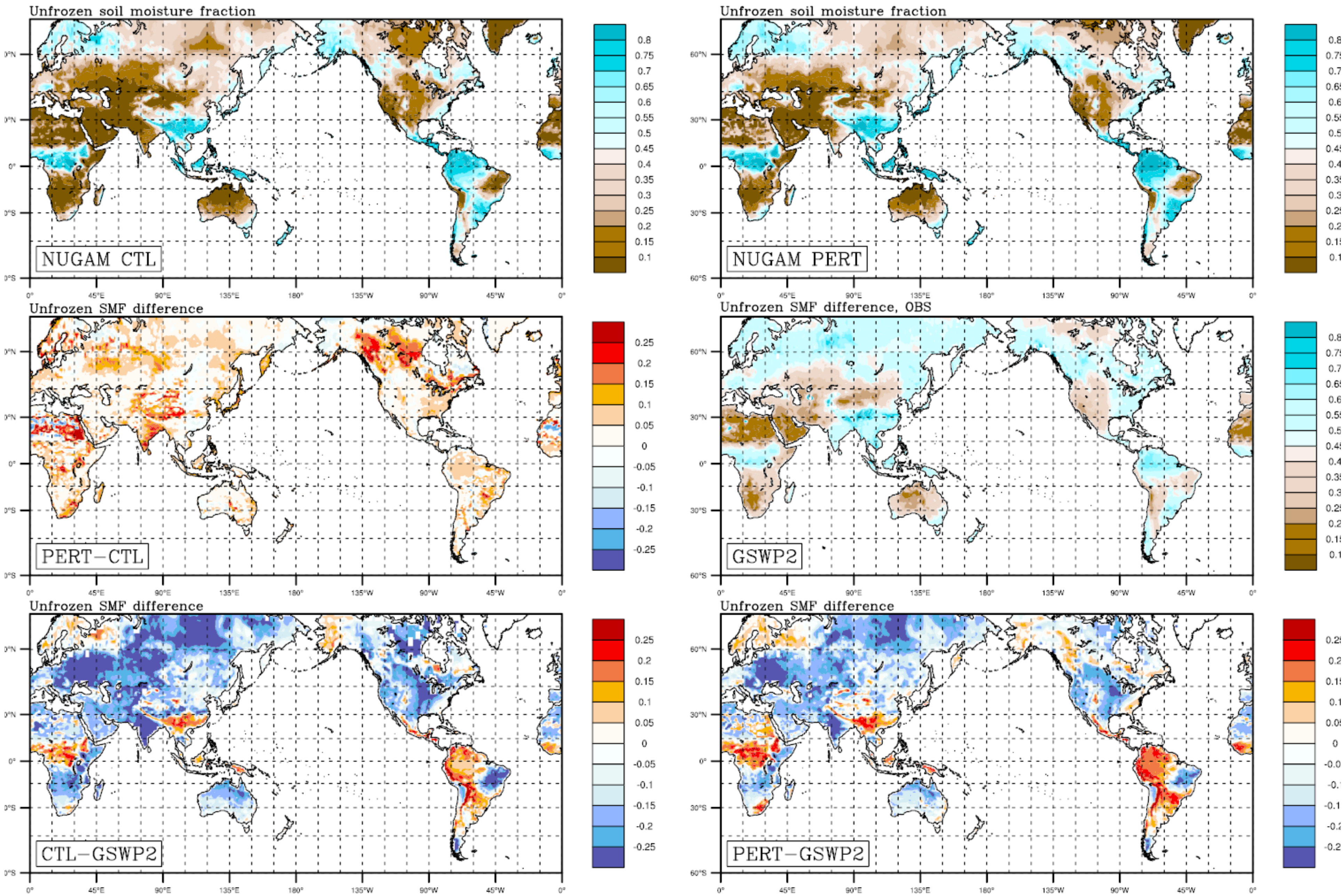
Average JJA Soil moisture fraction (L4)



NUGAM

Average JJA Soil moisture fraction (L1)

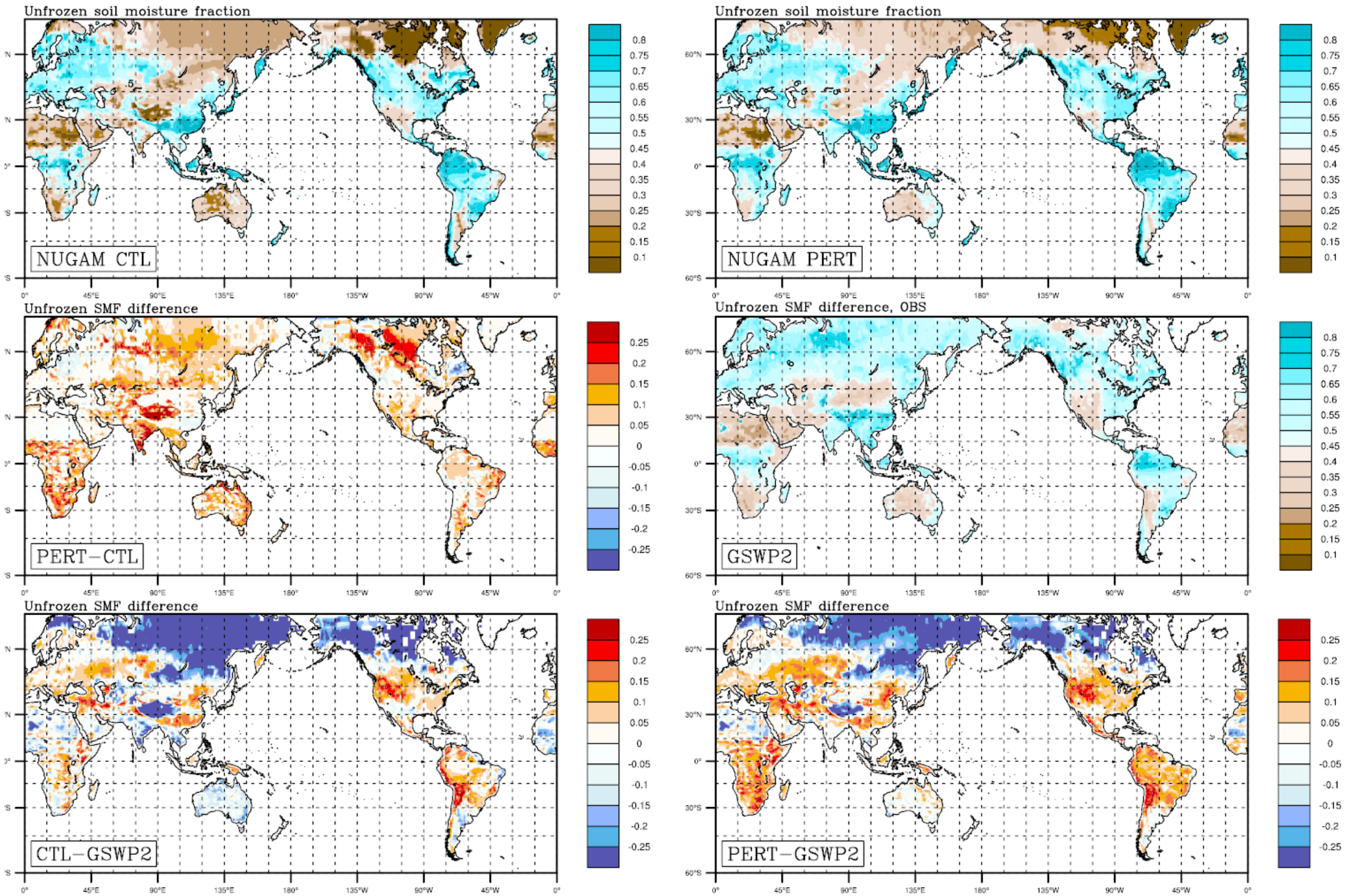
60km AGCM



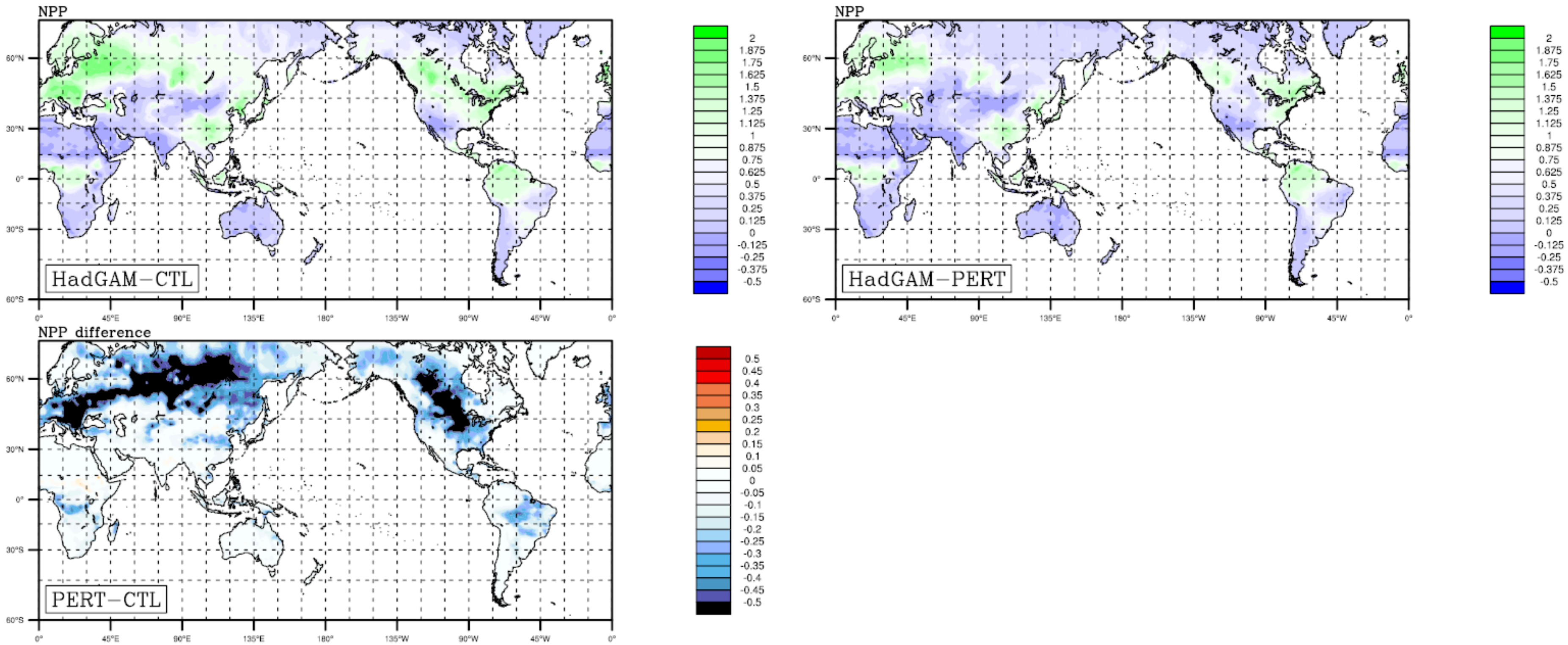
NUGAM

Average JJA Soil moisture fraction (L4)

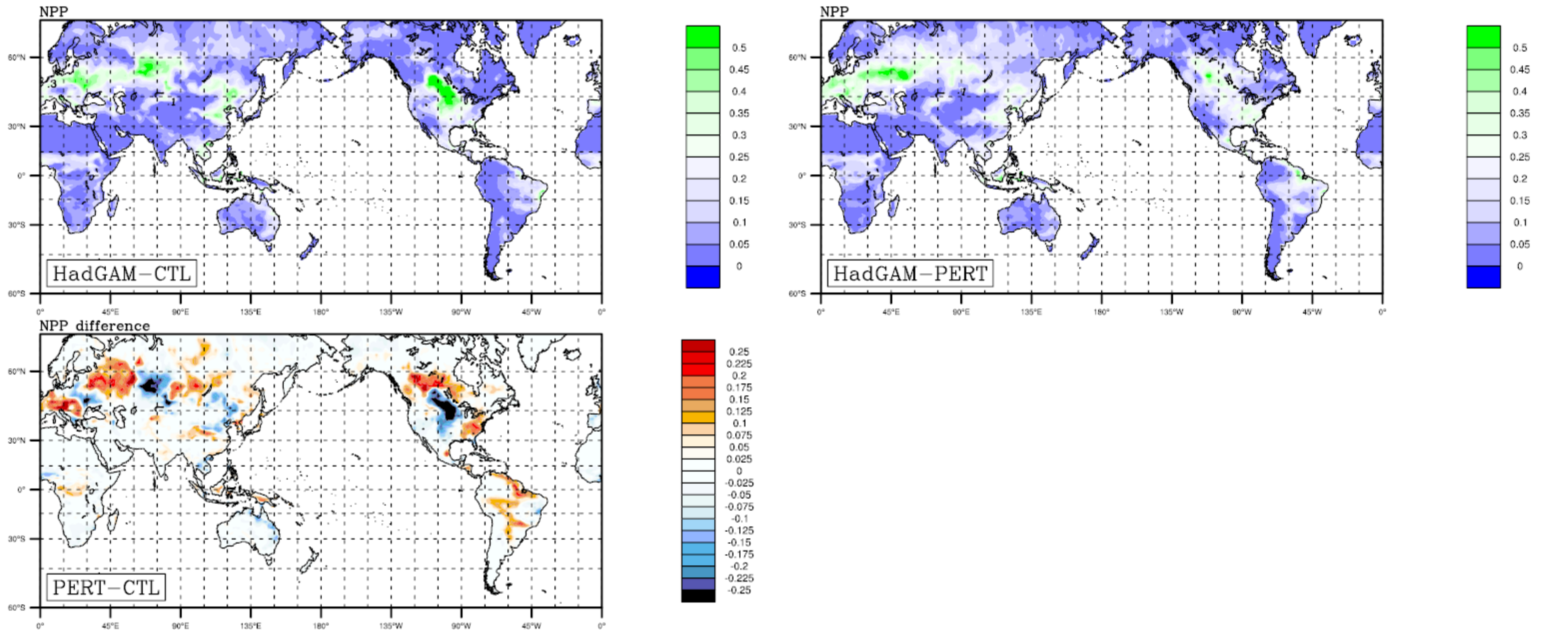
60km AGCM



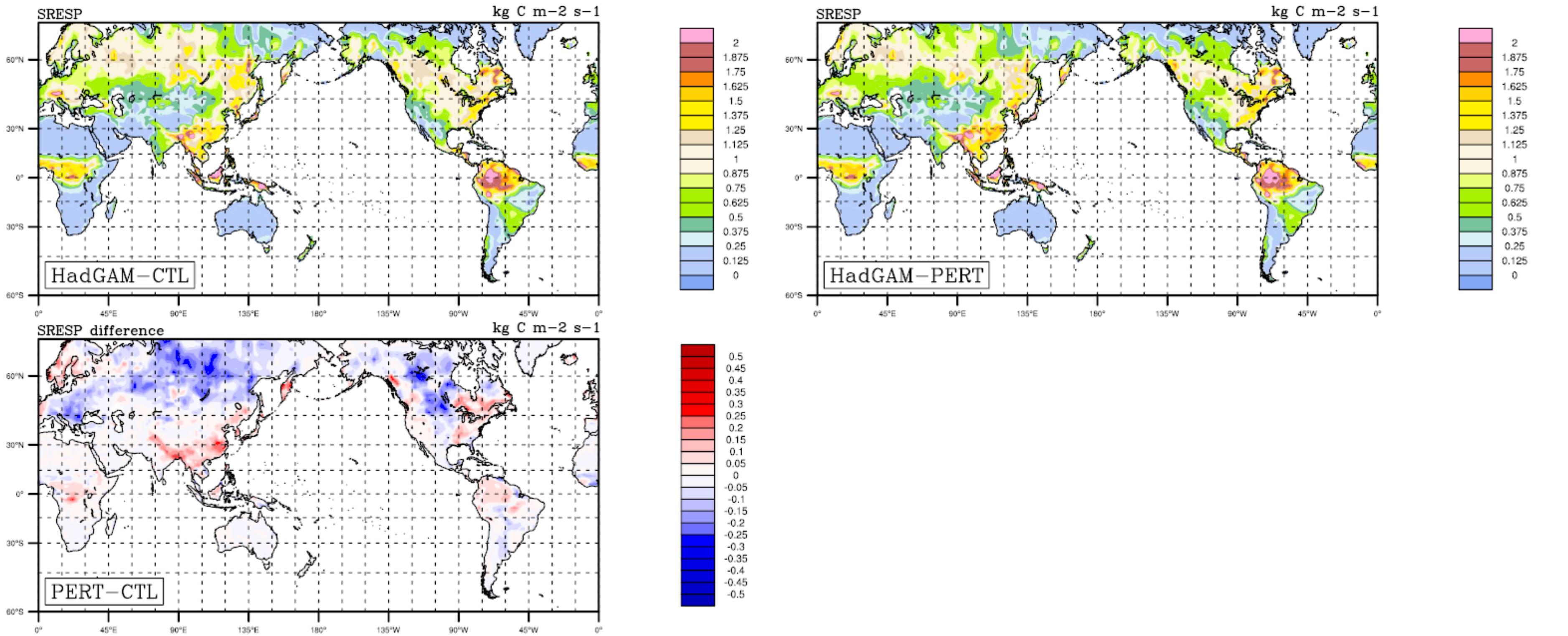
Average JJA NPP (Kg C / m2 yr)



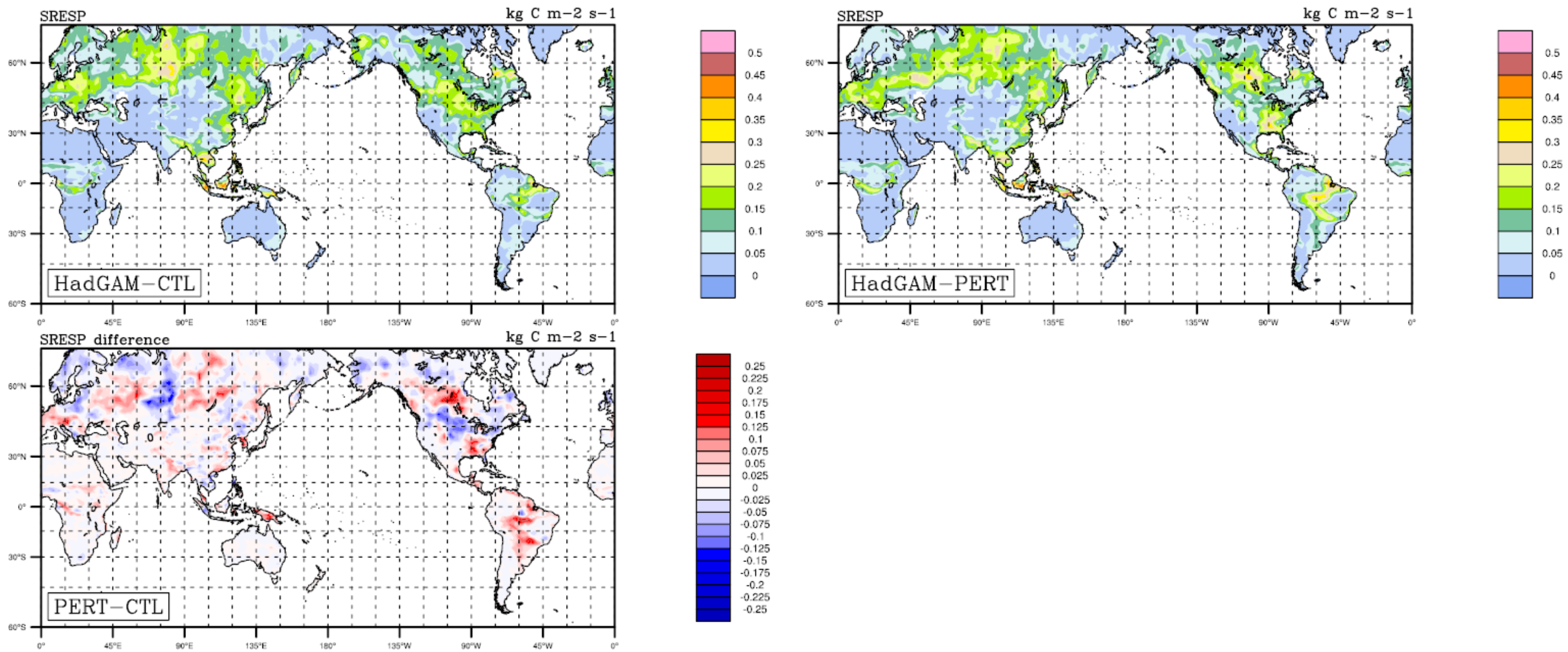
JJA NPP IV (Kg C / m2 yr)



Average JJA SRESP (Kg C / m2 yr)



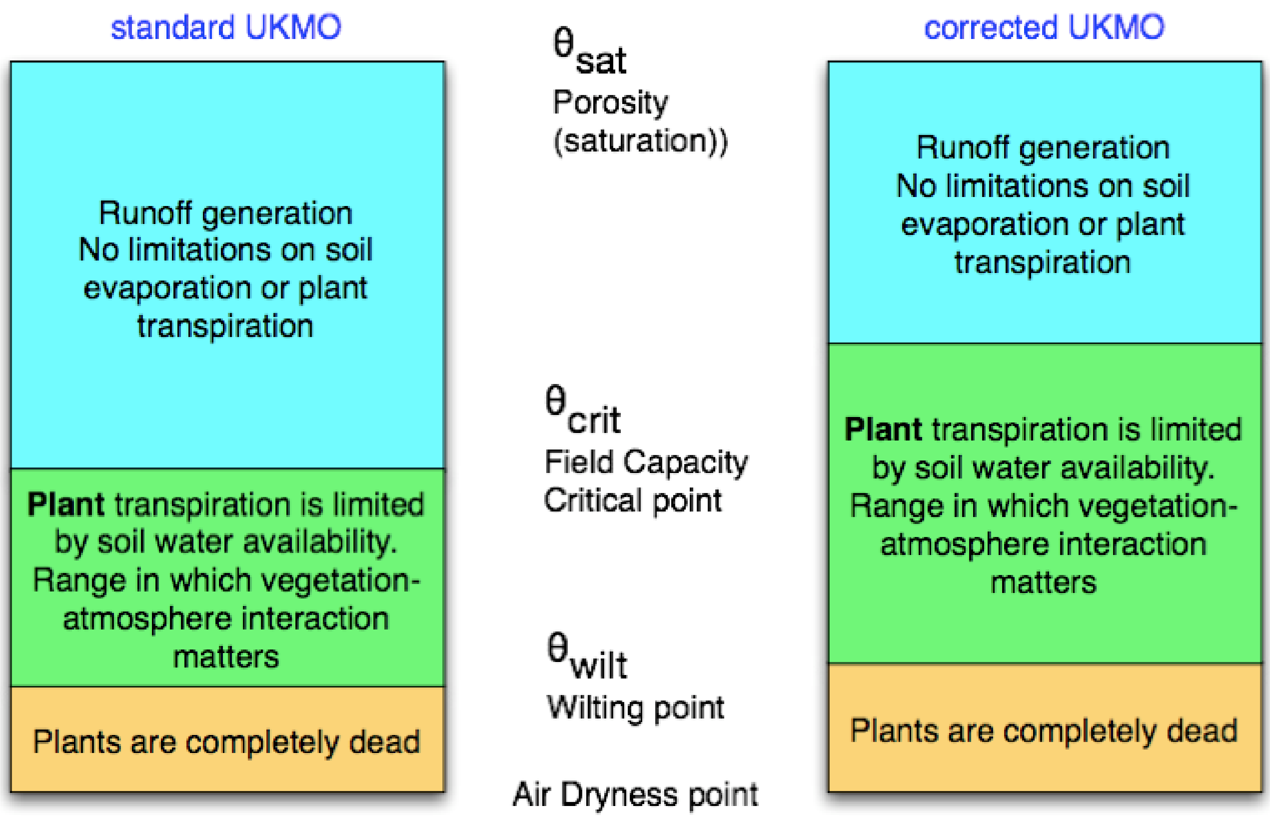
JJA SRESP IV (Kg C / m2 yr)



Summary of UKMO bug fix and its meaning

- Completely compatible with our literature review
- Bug not in the UM, but in central ancillary program !

Soil water thresholds in a land surface model grid box



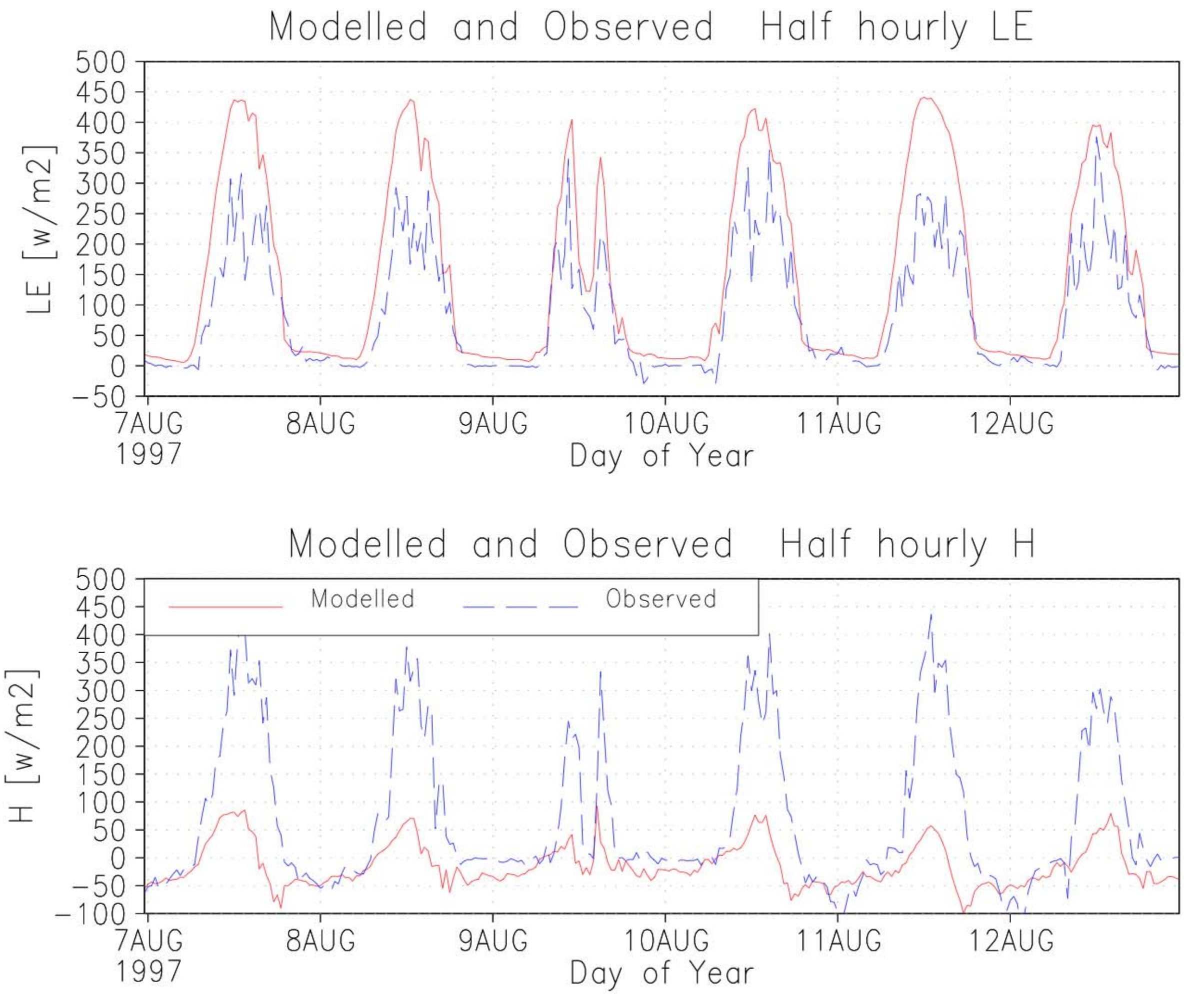
Modern soil parameters at work: impacts on climate

- Started in 2006, with off-line work at Fluxnet sites, to explore sensitivity (H. Ashton, A. Verhoef): errors we found were later confirmed by UKMO;
- Huge sensitivity; most important parameter is θ_c, via:
  - surface resistance, g_s
  - deep soil control on transpiration, via PSI, K_sat and θ_c
- ISLSCP2 sand/silt/clay fractions aggregated to N96, in conjunction with:
  - Peters-Lidard thermal parameterization (Schaeltz et al. does not make any sense)
  - OPTIONAL: Van Genuchten soil moisture parameterization (off-line work showed that this alone made little difference when compared to changing the θ values): very consistent results, but soils drier.
  - Offline JULES at Loobos and Grignon: consistent reduction in latent and increase in sensible heat fluxes;
  - Parallel offline distributed work by R. Ellis (CEH) with ISLSCP2/Ecoclimap soils
  - PLV: 10-yrs AMIP simulations with HadGAM1.1 (135km), consistent results
  - Parallel work on Earth Simulator at N216 (60km), consistent results
- Need chain of sensitivity studies, using JULES off-line (H.A. + A.V. with FLUXNET, R. Ellis, CEH with GSWP2) and coupled (HadGAM, PLV);
- We now need to allow more photosynthesis/transpiration: increase V_max ?
- PLV: GLDAS parameters proved **unstable** in coupled work (HadGAM, NUGAM) , due to low thermal capacity and extremely high porosity connected with peat soils
- We need to produce, verify/test, hand out and manage a complete modelling suite, which comprises initial conditions, boundary conditions etc. The model, without proper parameters, can perform quite poorly.

summary and future work

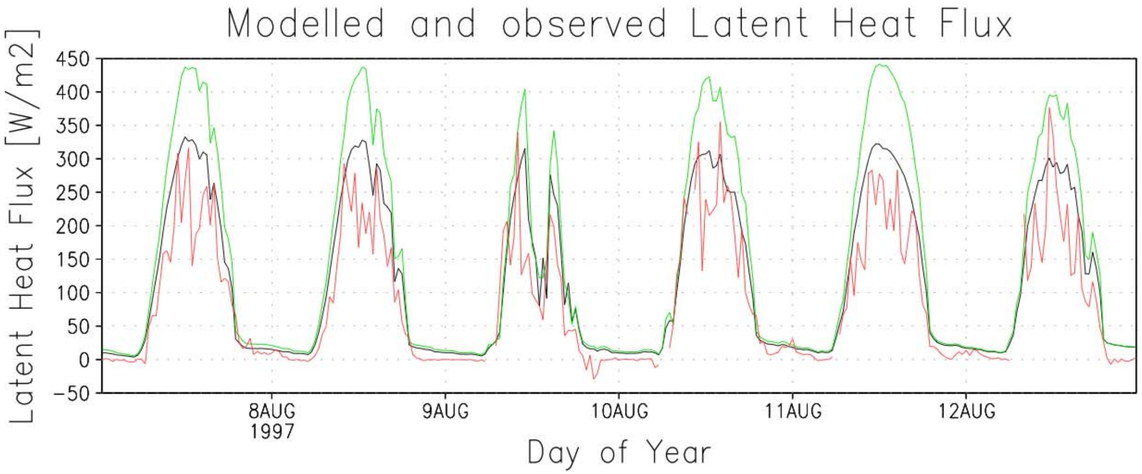
- Since November 2006, many problems found in standard UKMO soil physical parameters:
  - Heterogeneity/aggregation, especially for the higher resolution work
  - Values: range in standard dataset was wrong, especially for Ψ
- Survey of modern datasets revealed IGBP and GLDAS as candidates
- Work with soils physical parameters showed important impact on all land surface variables
  - Improvements in precipitation, temperature, soil moisture, clearly connected;
  - Improvements in interannual variability: locations point to <u>better coupling of land surface and atmosphere</u>
- UKMO have found an important **bug in central ancillary program** (and we have found a second one, once given access to their code) affecting their soils parameters. The fix makes UKMO soil parameters them more compatible with our dataset survey: sensitivity experiments ?
- We need to run the same experiment, adding CLASSIC2 MODIS albedo (PLV+CMT+UJCC+Swansea group already have a separate 10yr simulation);
- What are we going to do about ancils generation in the future ?
- GLDAS has extreme values due to peat soils, which make model unstable

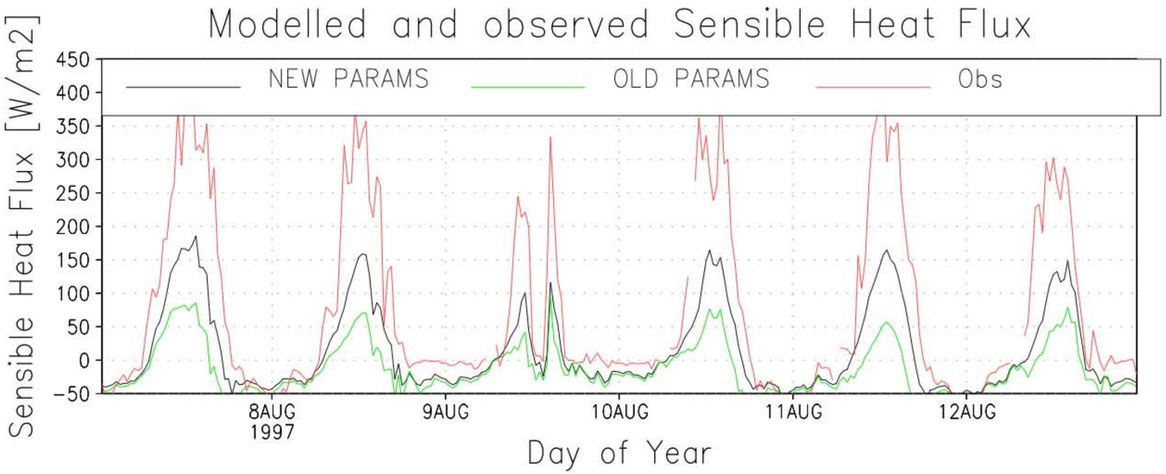
Offline work on summer droughts: can JULES model short dry periods ?



H. Ashtor

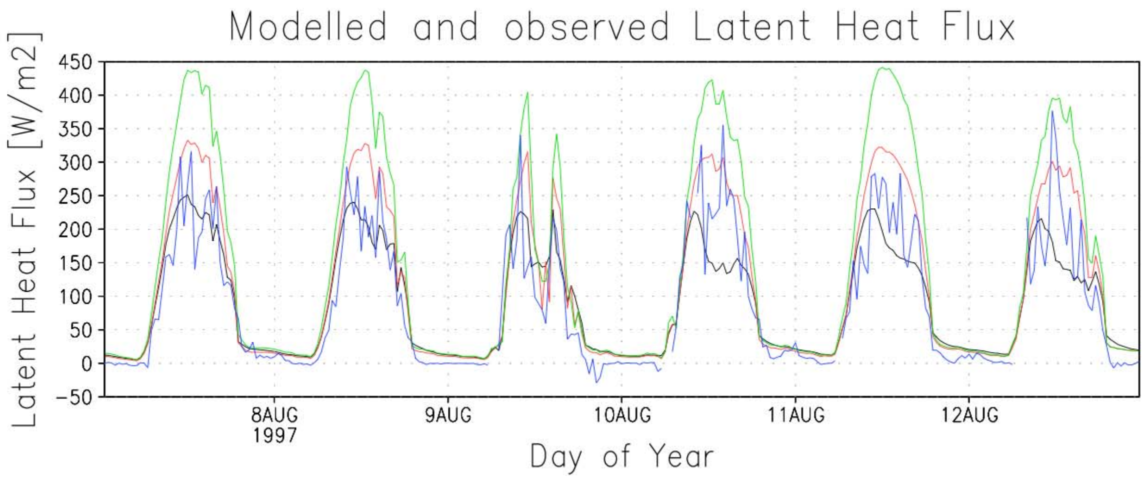
Using corrected soils

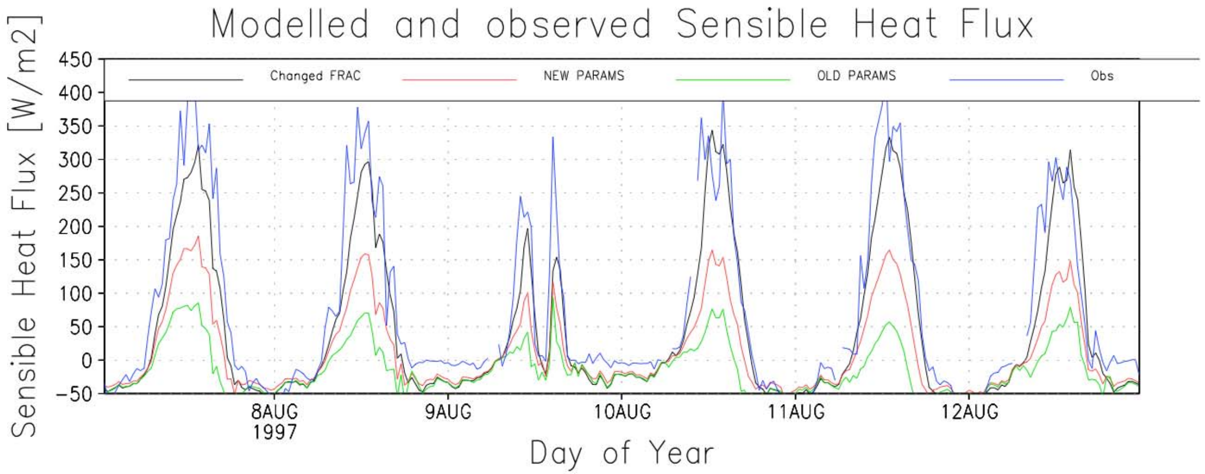




H. Ashtor

and using proper info on vegetative cover





H. Ashtor