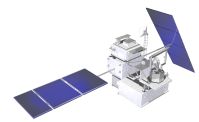
Background

The variable nature of the underlying surface emissivity (and radar backscatter cross section) are limiting factors for improved microwave precipitation products over the range of Earth land surfaces

Analyze some key physical factors that control emissivity, which may be useful to enhance existing radiometer algorithms for improved selection of candidate precipitation profiles that take surface conditions into account

Update of earlier presentation at PMM-2013 meeting: Discussion of 2015-updated version of TMI-based physical zero-order physical model (originally developed for Aqua AMSR-E and Coriolis/WindSat soil moisture)

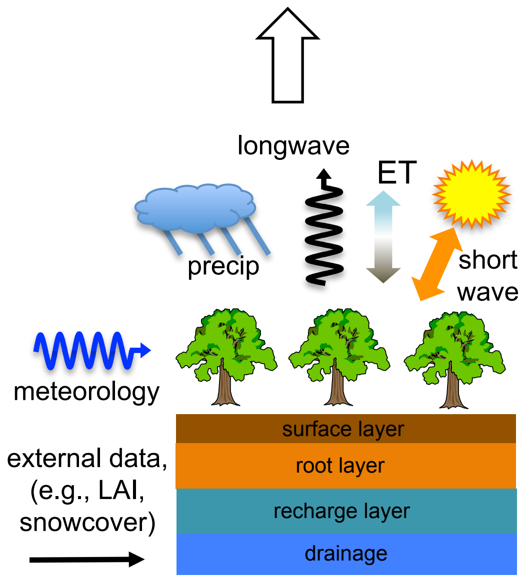
Difference & Similarity Between LSM & Simple Physical



Land Surface Model

Diverse dynamic land model carrying many surface, subsurface and near-surface parameters that are fed to forward simulations

Forward simulator for any sensor supported in CRTM, CMEM



oversimplified and non-complete

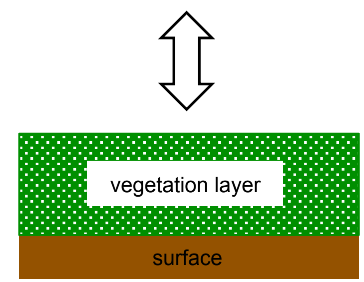
Simple Physical

Only key physical parameters that control surface emissivity (vegetation water content, soil moisture)

Works off of MW satellite observations

By design the retrieval agrees with TB observations, in a TB minimization sense

Adjust physical parameters to bring simulated and observed TB (10H/V, 19H/V, 37H/V GHz) into simultaneous accord



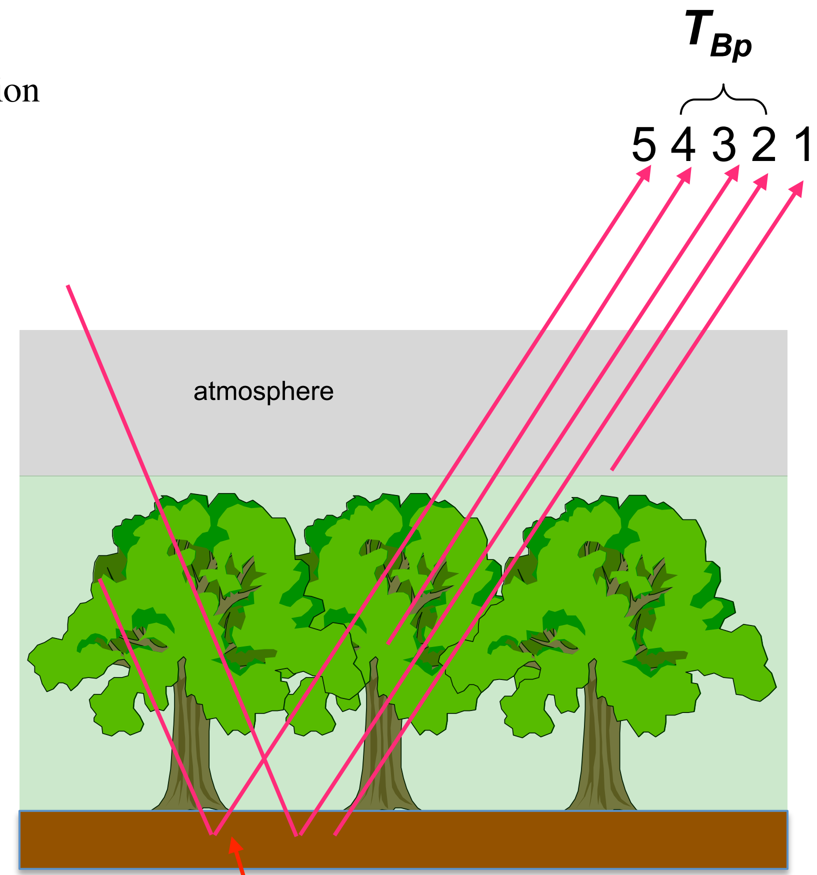
Two-layer, zero-order model

vegetation $= f(\tau, \omega)$

Parameterized Radiative Transfer and Land Retrievals

$$T_{Bp} = T_u + e^{-\tau_a}\left[\left\{T_d r_{sp} e^{-2\tau_c}\right\} + T_e\left\{\left(1-r_{sp}\right)e^{-\tau_c} + \left(1-\omega_p\right)\left(1-e^{-\tau_c}\right)\left(1+r_{sp}e^{-\tau_c}\right)\right\}\right]$$

p denotes polarization
T_u and T_d are the upwelling and downwelling atmospheric emission
τ_a and τ_c is the atmospheric and vegetation opacity
T_e is the effective land surface/vegetation temperature
r_{sp} is the soil reflectivity
ω_p is the vegetation single scattering albedo



(not to scale)

Sensing skin depth varies depending upon soil type/ moisture and frequency

Soil reflectivity surface roughness model (*Wang and Choudhury, 1981*):

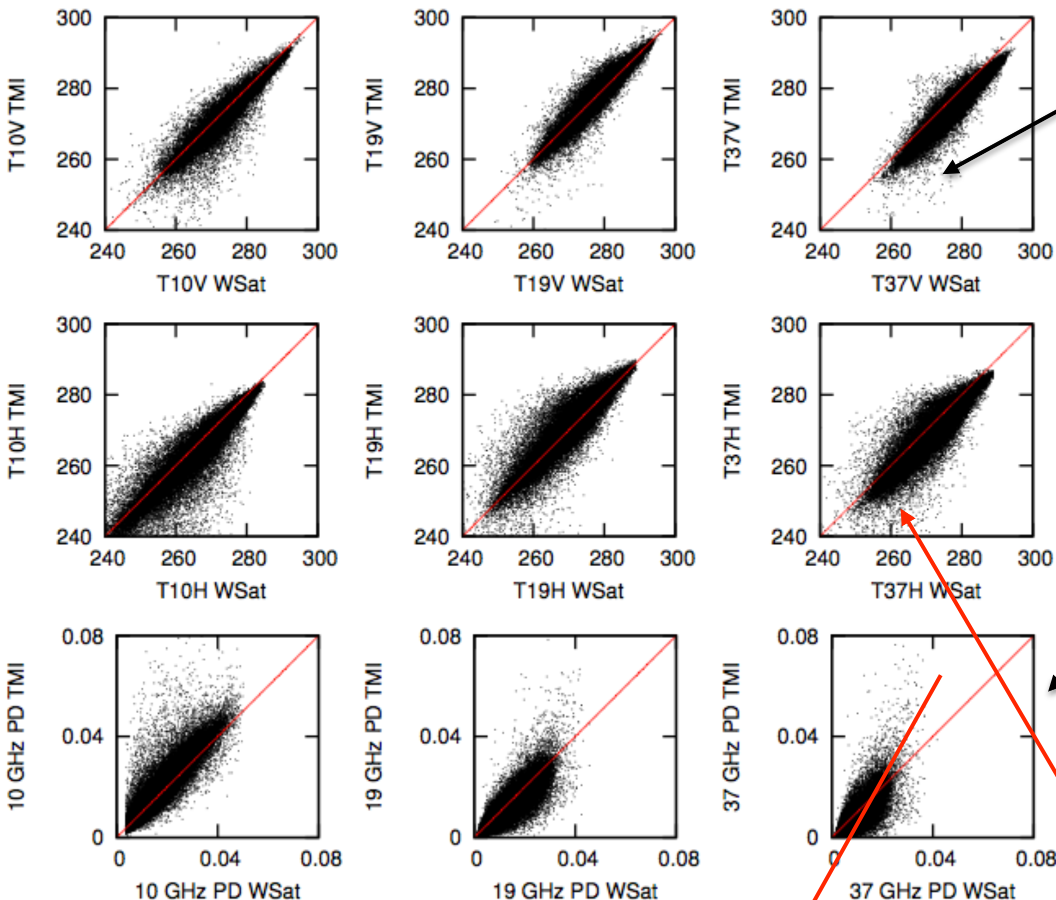
$$r_{sp} = e^{-h}[(1-Q)r_{op} + Q_{oq}]$$

r_{op} is the flat surface reflectivity and related to the soil dielectric constant ε by the Fresnel equations

Physical Retrieval:

- Maximum Likelihood Estimation using dual-polarization at three frequencies (10, 18, and 37 GHz) simultaneously.
- Simultaneous retrievals of soil moisture, vegetation water content (VWC), and Ts

WindSat-TMI 1B11 Vers 7 5-minute matchups MJJA 2003-2011 Observations (Earlier work)



37V (TMI) < 37V (WindSat)

$PR=(TB^{V}-TB^{H})/(TB^{V}+TB^{H})$

A few K can have a big effect on polarization ratio, most noted here at 37 GHz

Wilheit et. al. IGARSS-2011 Table 1 shows TMI too cold

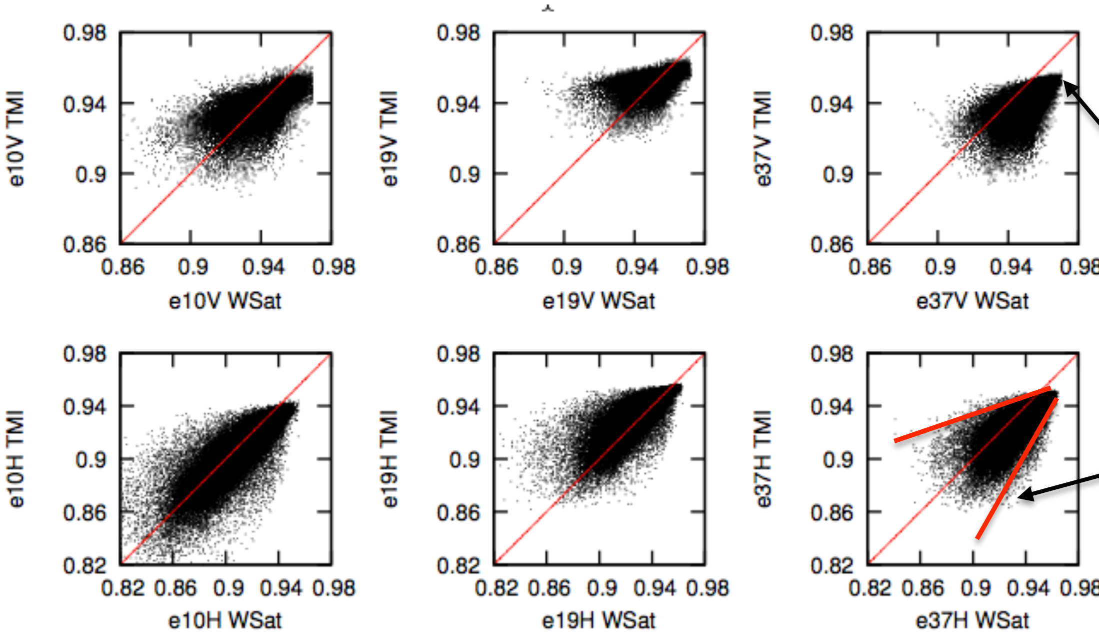
Table 1
DIFFERENCES BETWEEN TMI AND WINDSAT

Channel	Δ TB	@ TB	Δ TB	@ TB
10V	0.31K	163K	-0.76K	281K
10H	-1.66	85	-0.92	280
19V	-0.61	188	-1.20	285
19H	-3.20	109	-1.43	284
21V	-1.89	200	-3.37	284
37V	-3.24	206	-3.17	281
37H	-2.41	135	-3.16	281

Turk, F.J., Li, L. & Haddad, Z.S., 2014, A Physically Based Soil Moisture and Microwave Emissivity Data Set for Global Precipitation Measurement (GPM) Applications, *Geoscience and Remote Sensing, IEEE Transactions on*, 52(12), pp. 7637-50.

WindSat-TMI 1B11 Vers 7 5-minute matchups MJJA 2003-2011
Comparison of Retrievals (Earlier work)

emissivity



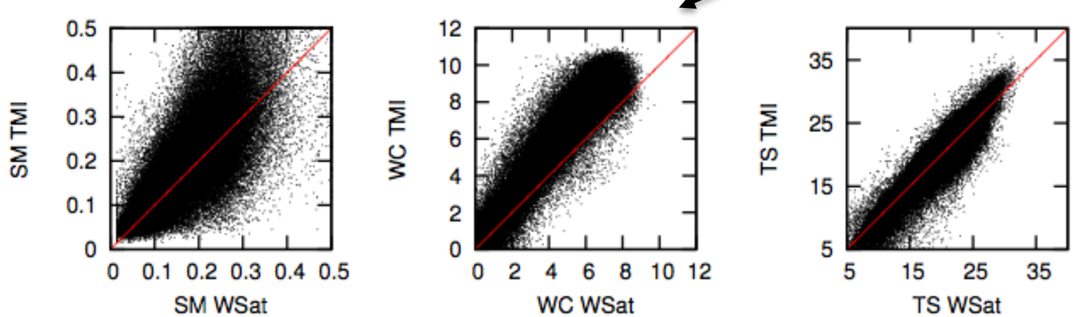
In general, bias or offsets at the cold end are more likely to be noted in wet surface scenes with reduced emissivity

Overall bias in TMI retrieval e37V (TMI) < e37V (WindSat)

Cone-shaped scatter at cold end

physical parameters

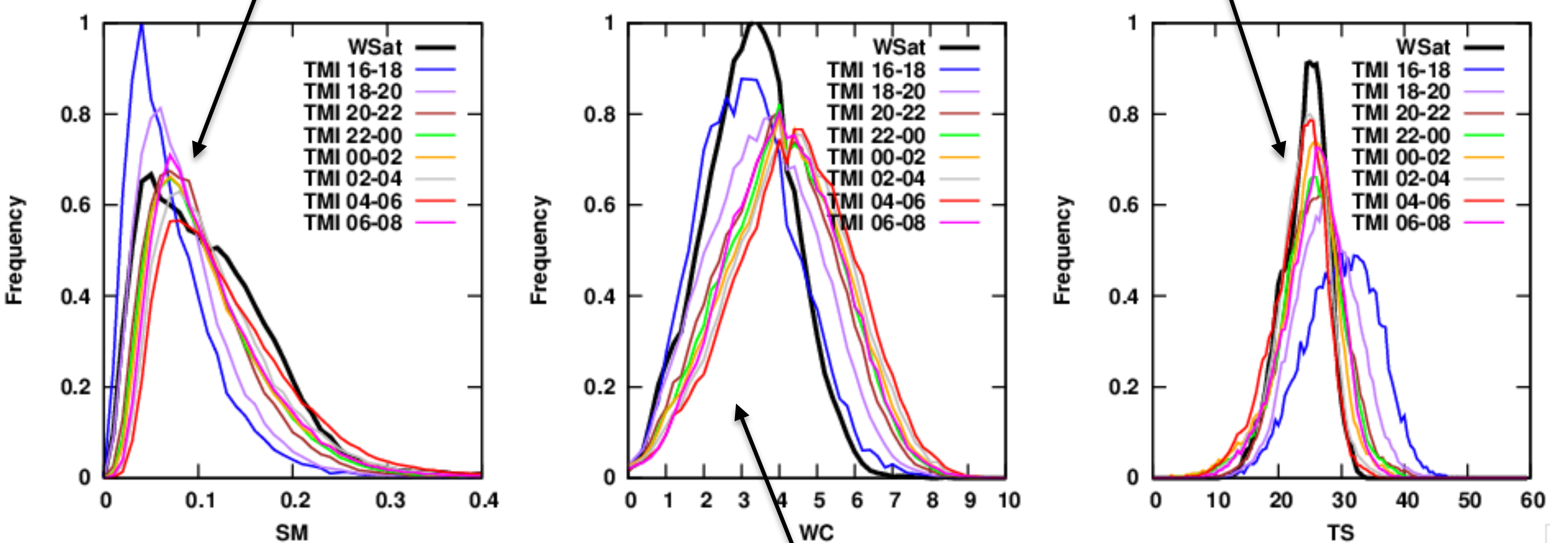
Most notable in WC differences



WindSat-TMI 1B11 Vers 7 Binned by TMI local time MJJA 2003-2011 (Earlier work)

TMI (various colors indicate the local time bin) SM histograms best align with WindSat (black color, 6 AM local time) for early morning hours

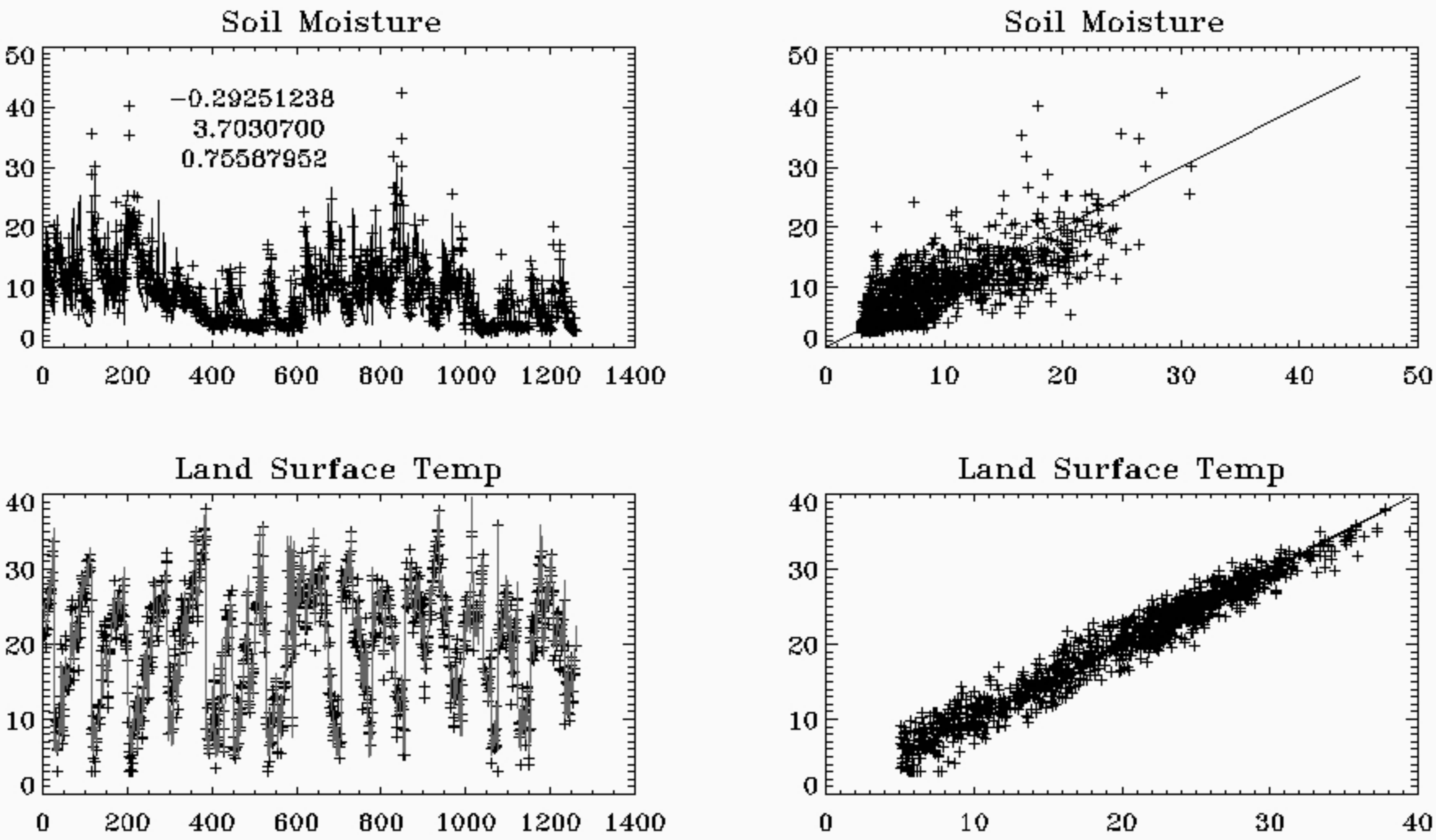
TMI Ts histograms best align with WindSat for early morning hours

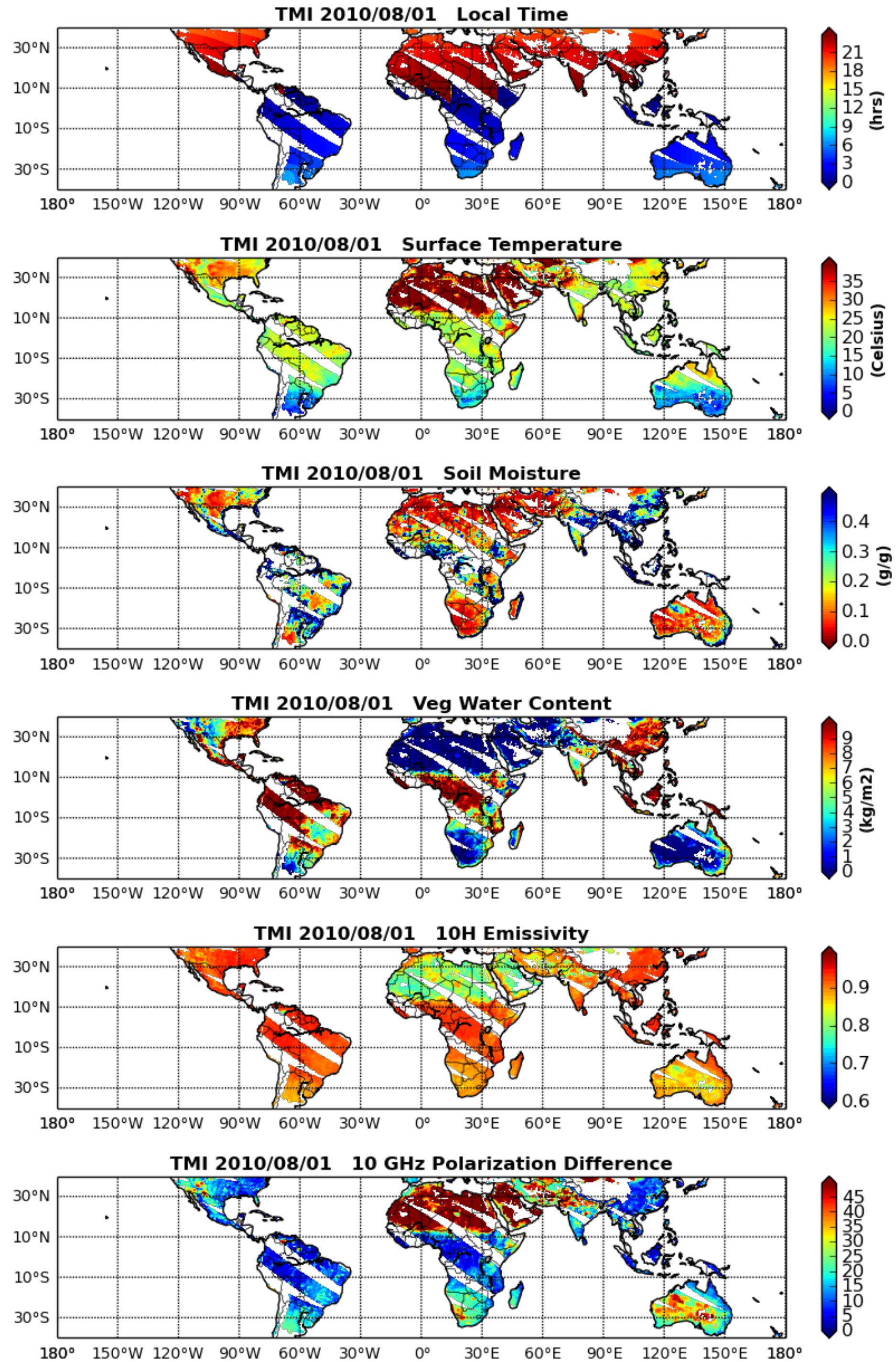


Still issues with TMI VWC to be addressed in next TMI reprocessing

Turk, F.J., Li, L. & Haddad, Z.S., 2014, A Physically Based Soil Moisture and Microwave Emissivity Data Set for Global Precipitation Measurement (GPM) Applications, *Geoscience and Remote Sensing, IEEE Transactions on*, 52(12), pp. 7637-50.

2015 Updated TMI Comparison with station data in OK and AZ



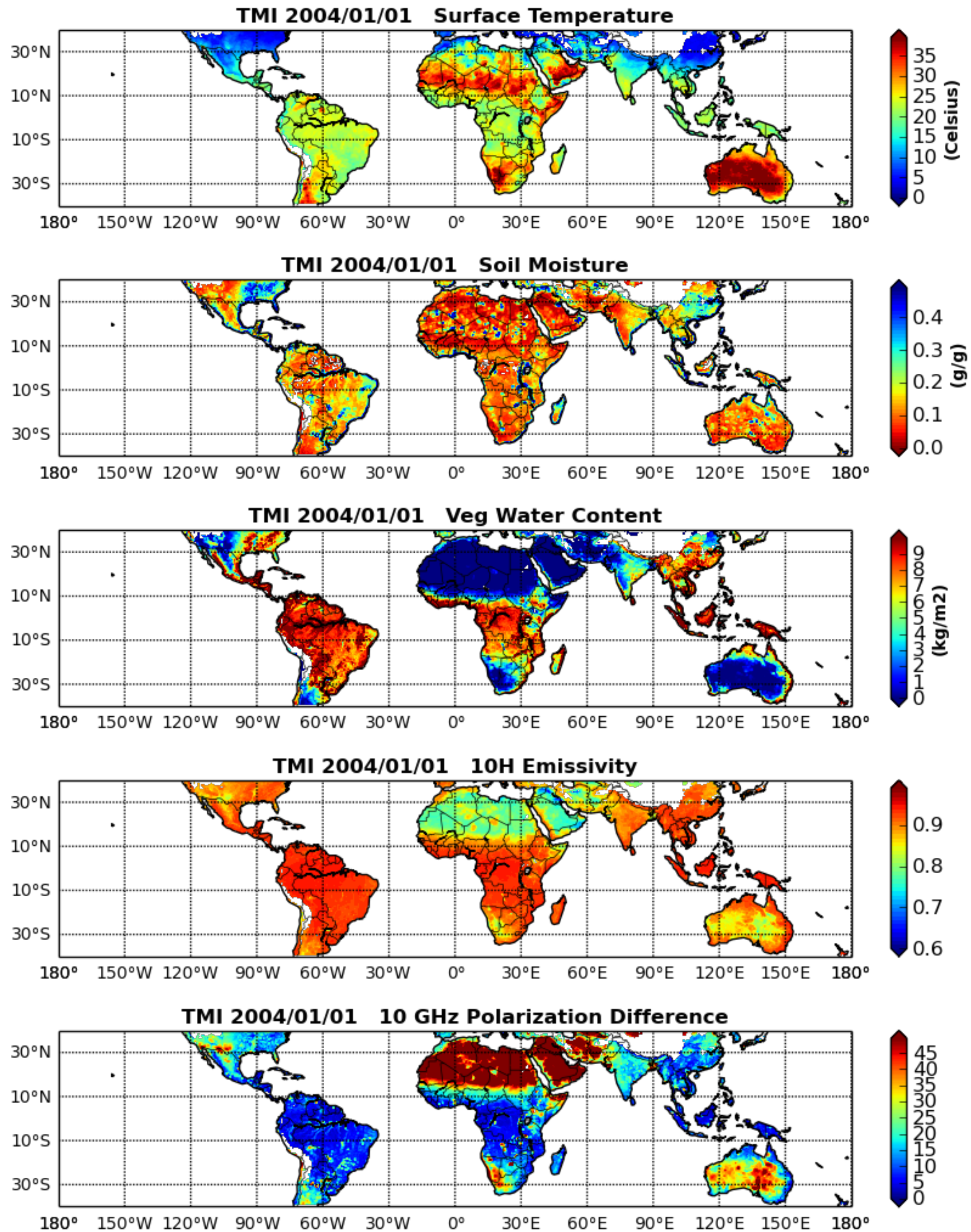


Daily Example

1 Aug 2010
(descending)

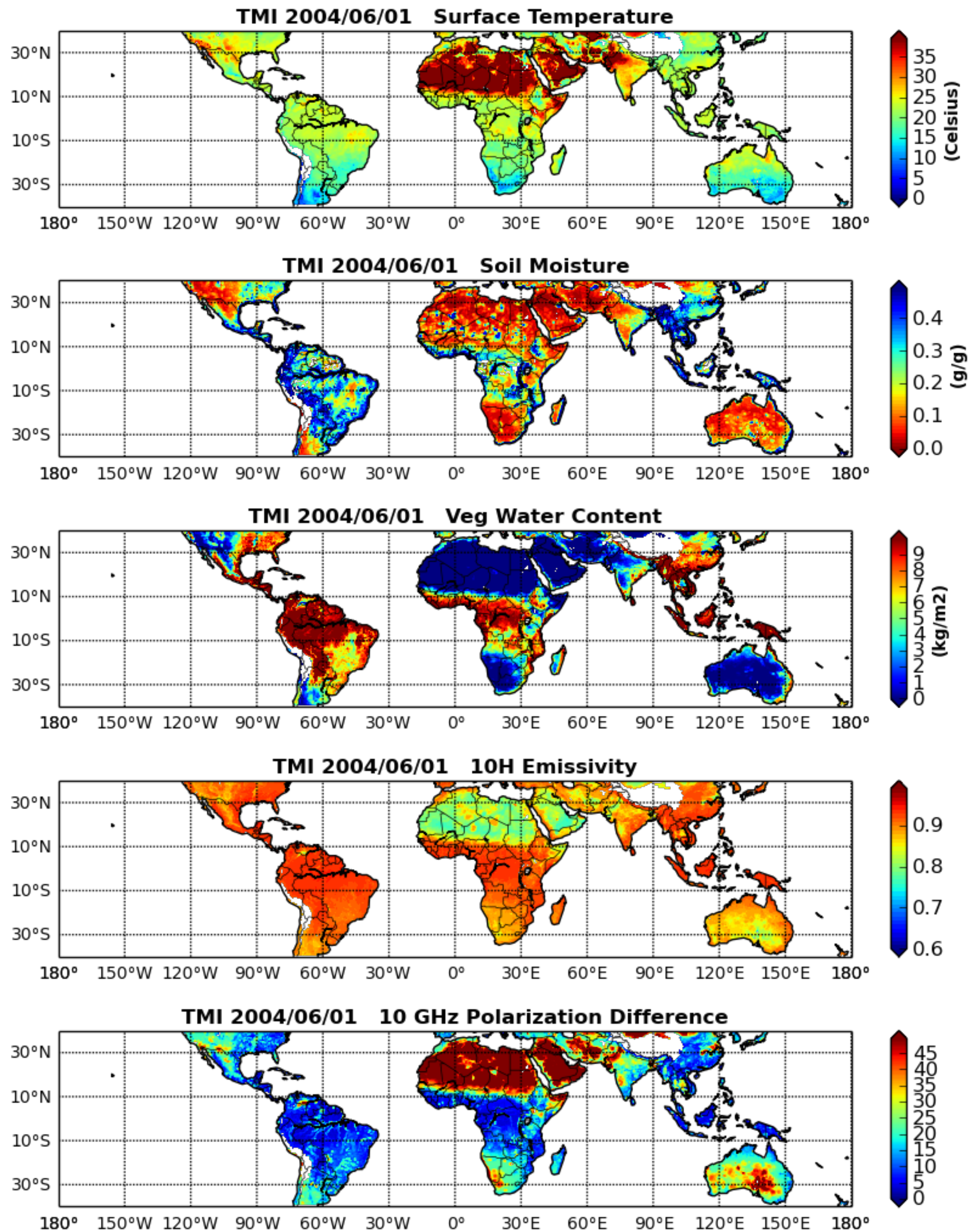
Majority of daylight hours (7 AM-9 PM local) excluded, owing to temperature difference between surface and vegetation

Only e10H shown



Monthly Example

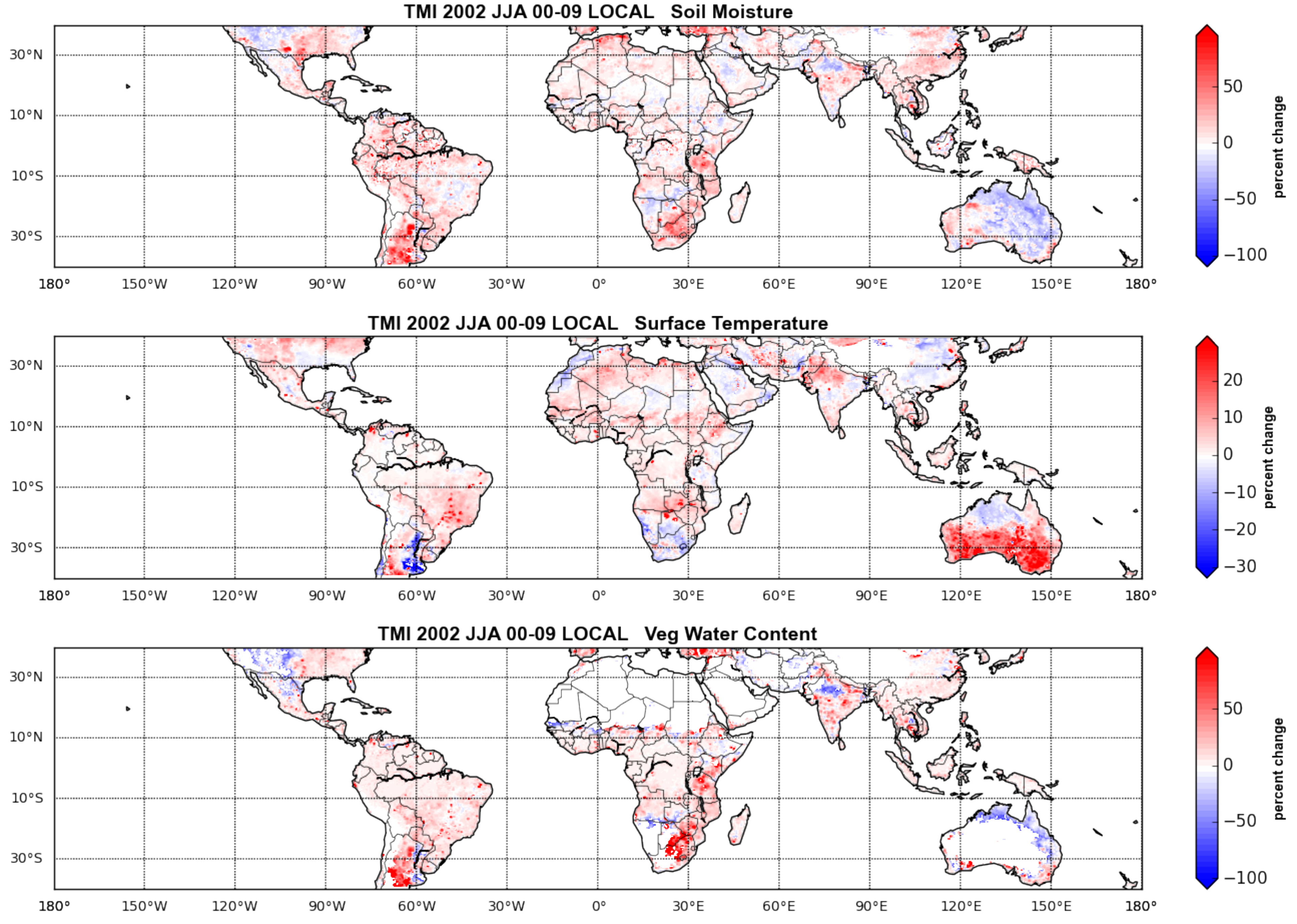
1 Jan 2010 (all data)



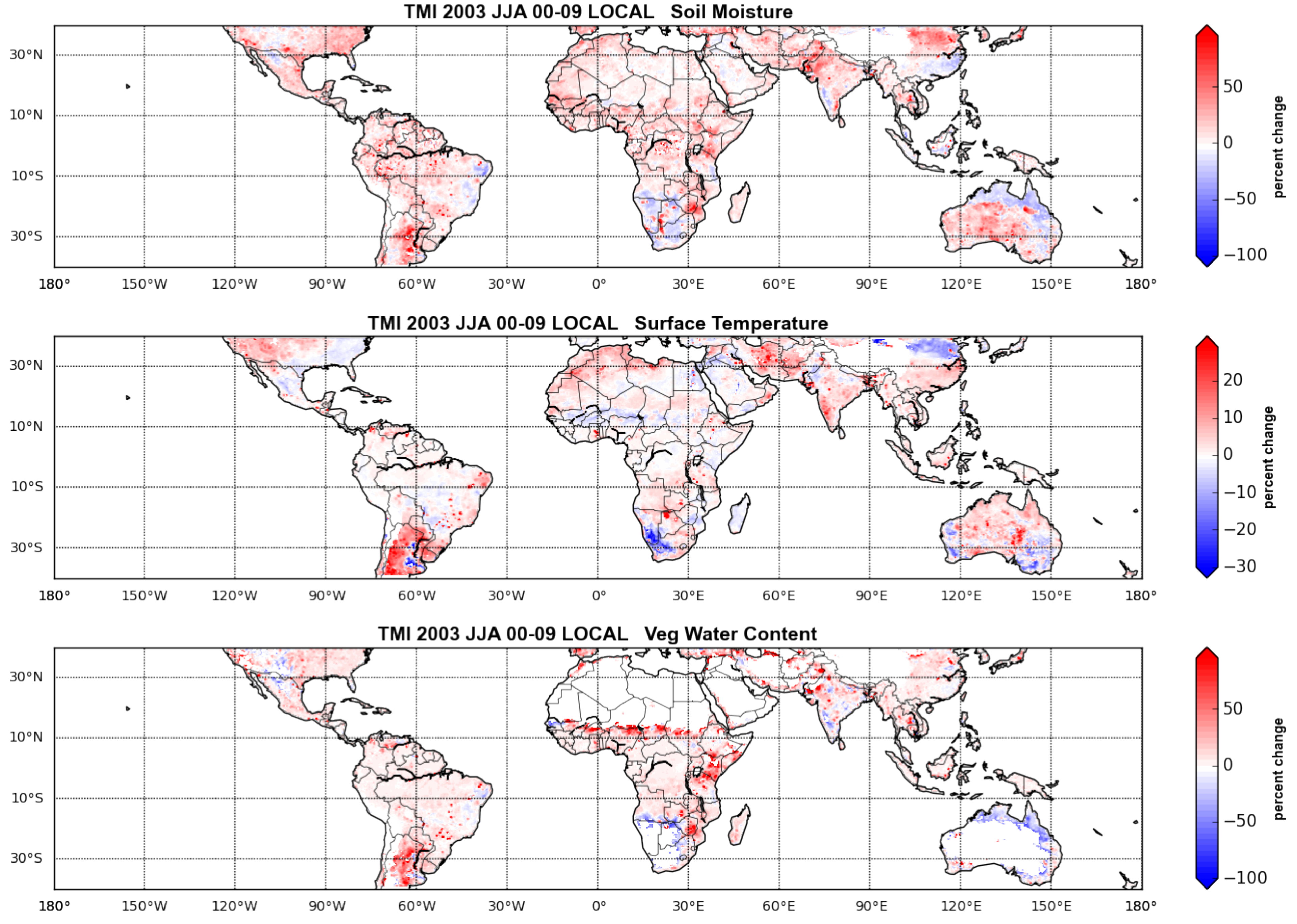
Monthly Example

1 June 2010
(all data)

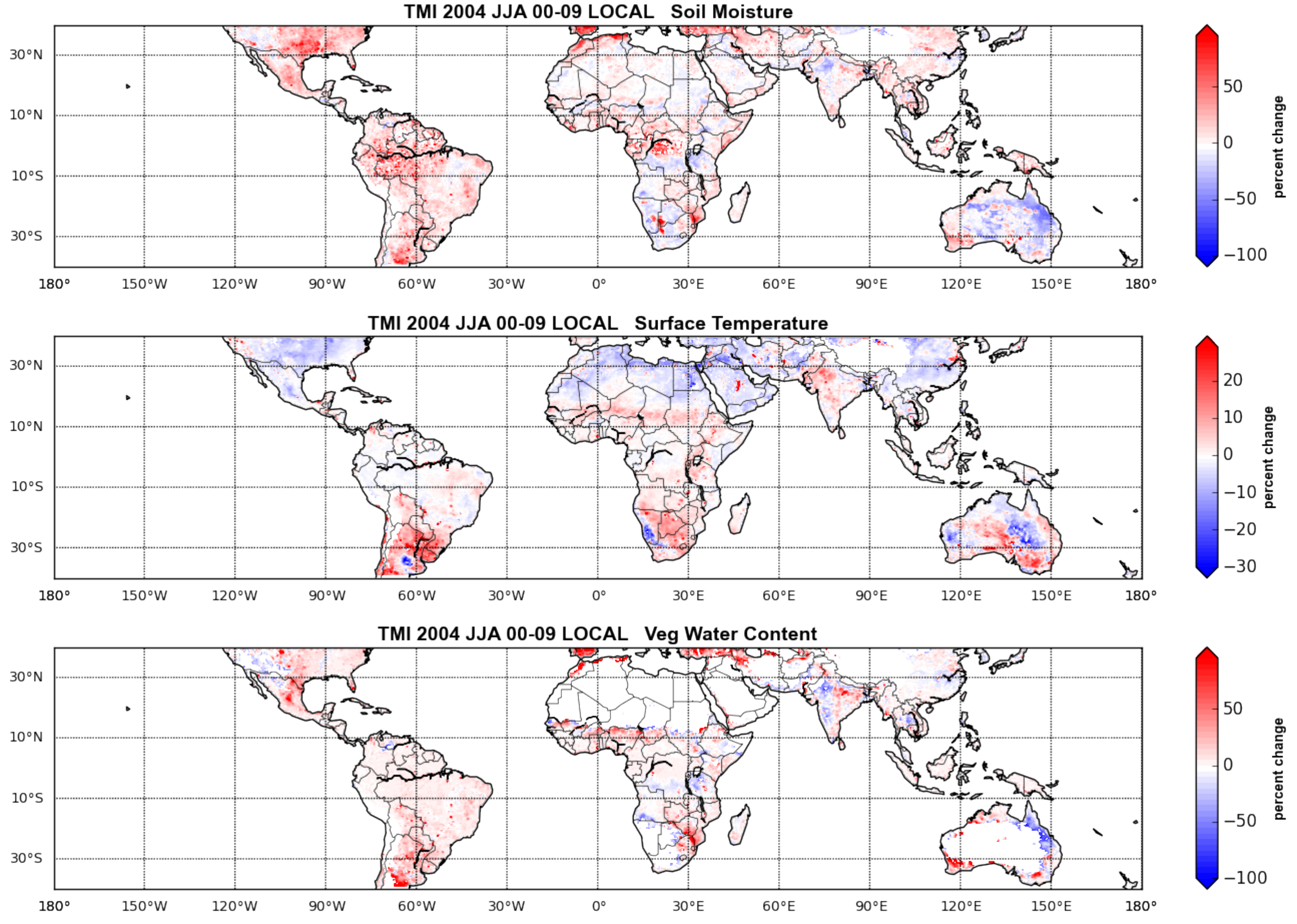
2002 relative to 2002-2012 average



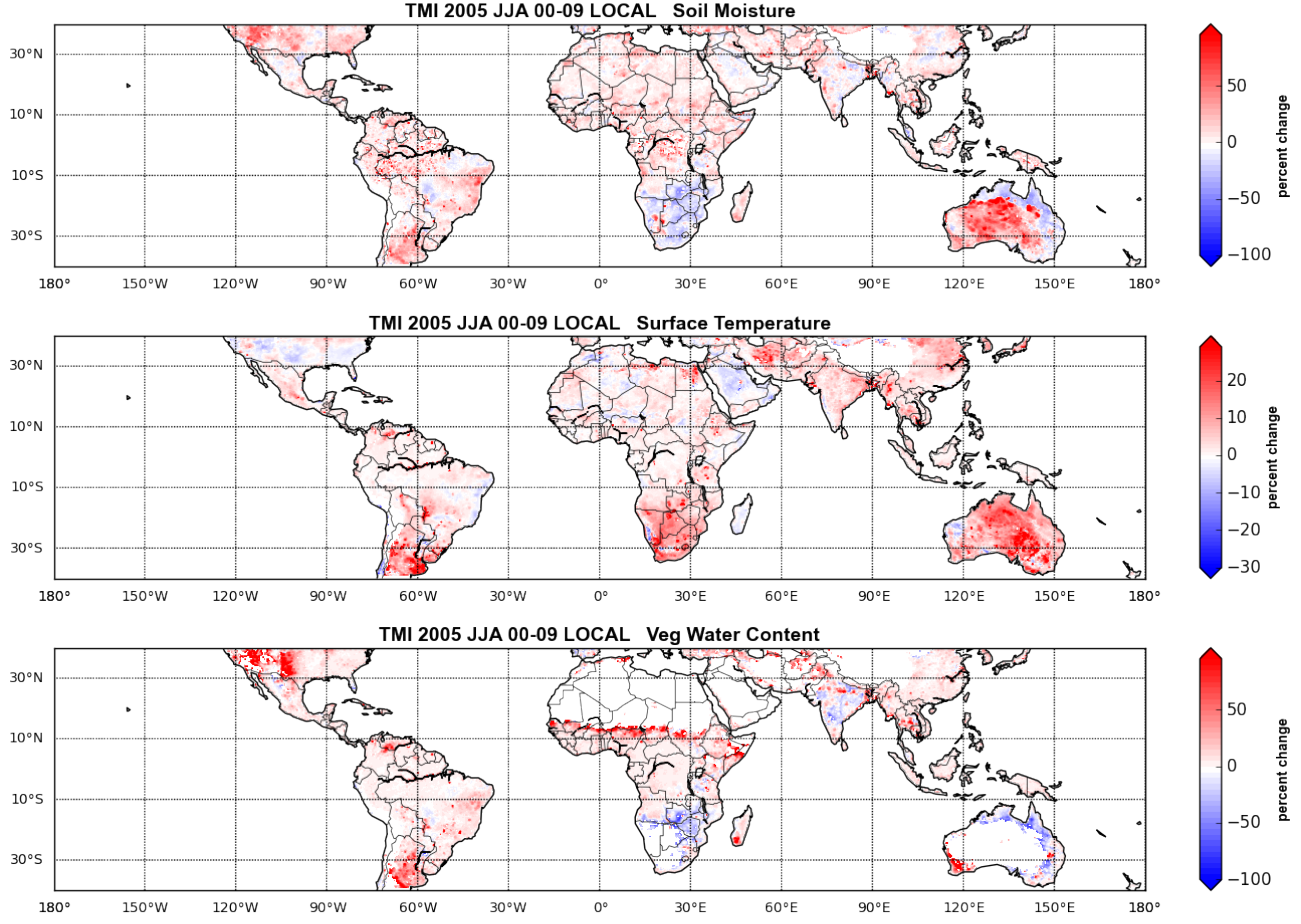
2003 relative to 2002-2012 average



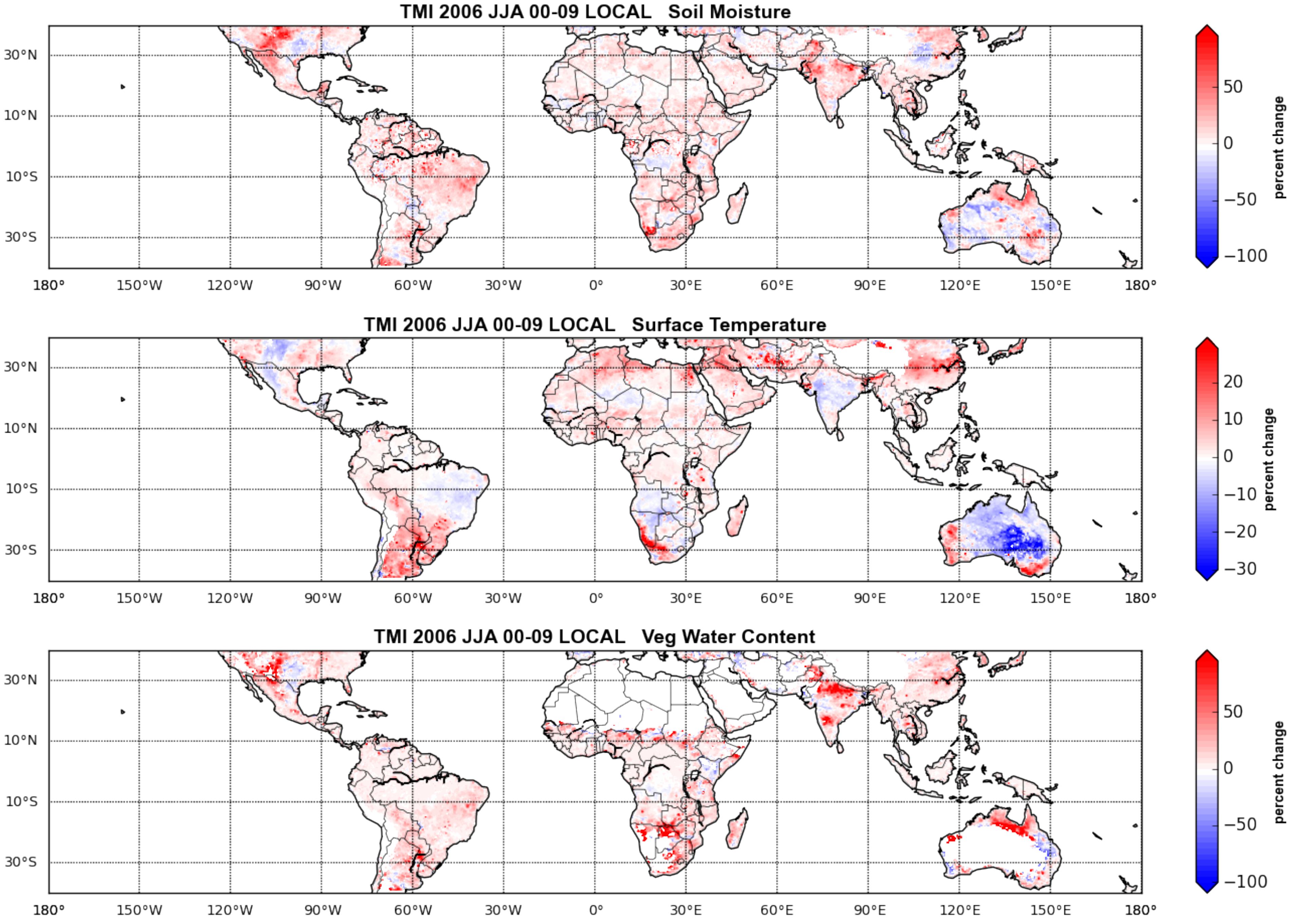
2004 relative to 2002-2012 average



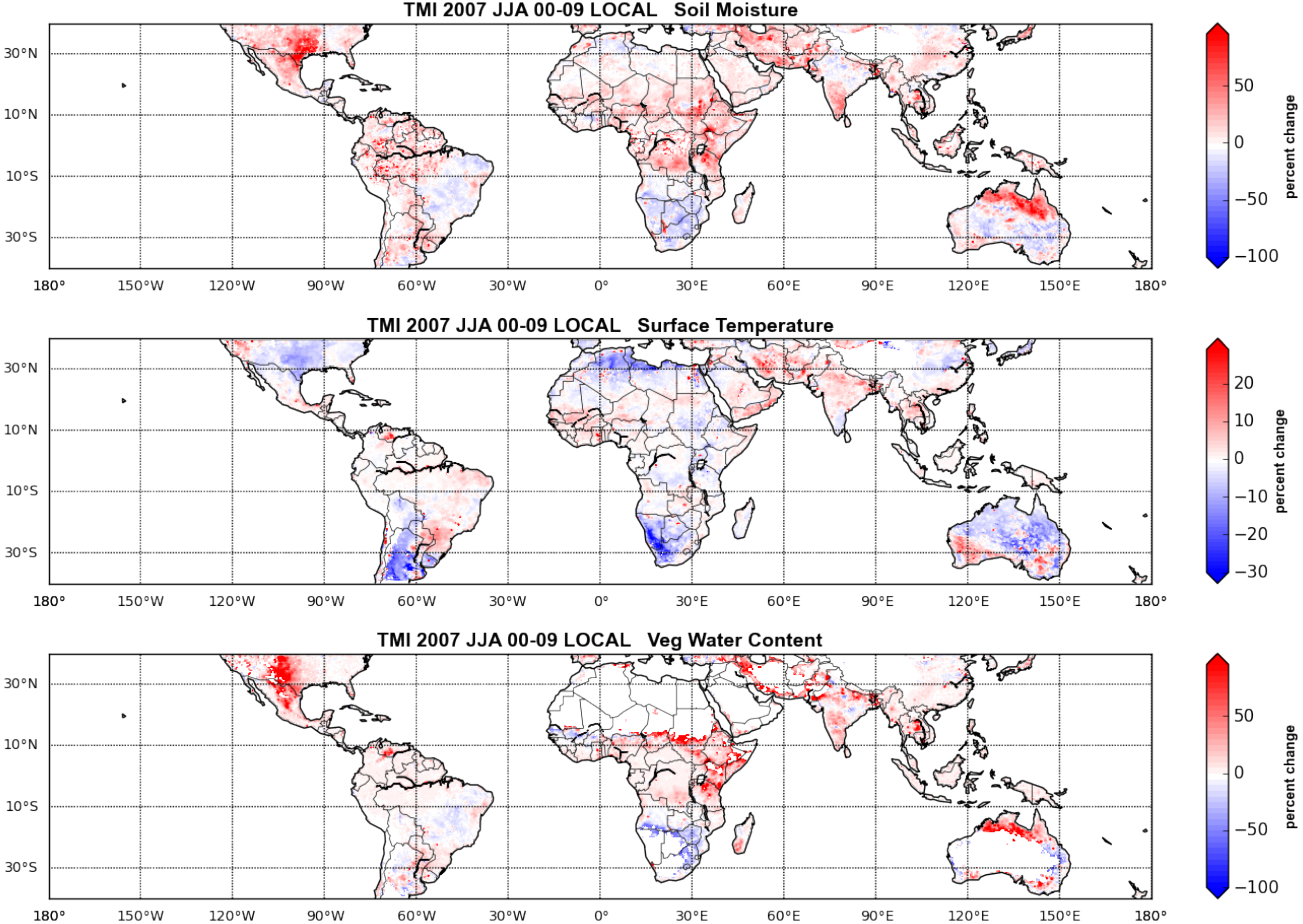
2005 relative to 2002-2012 average



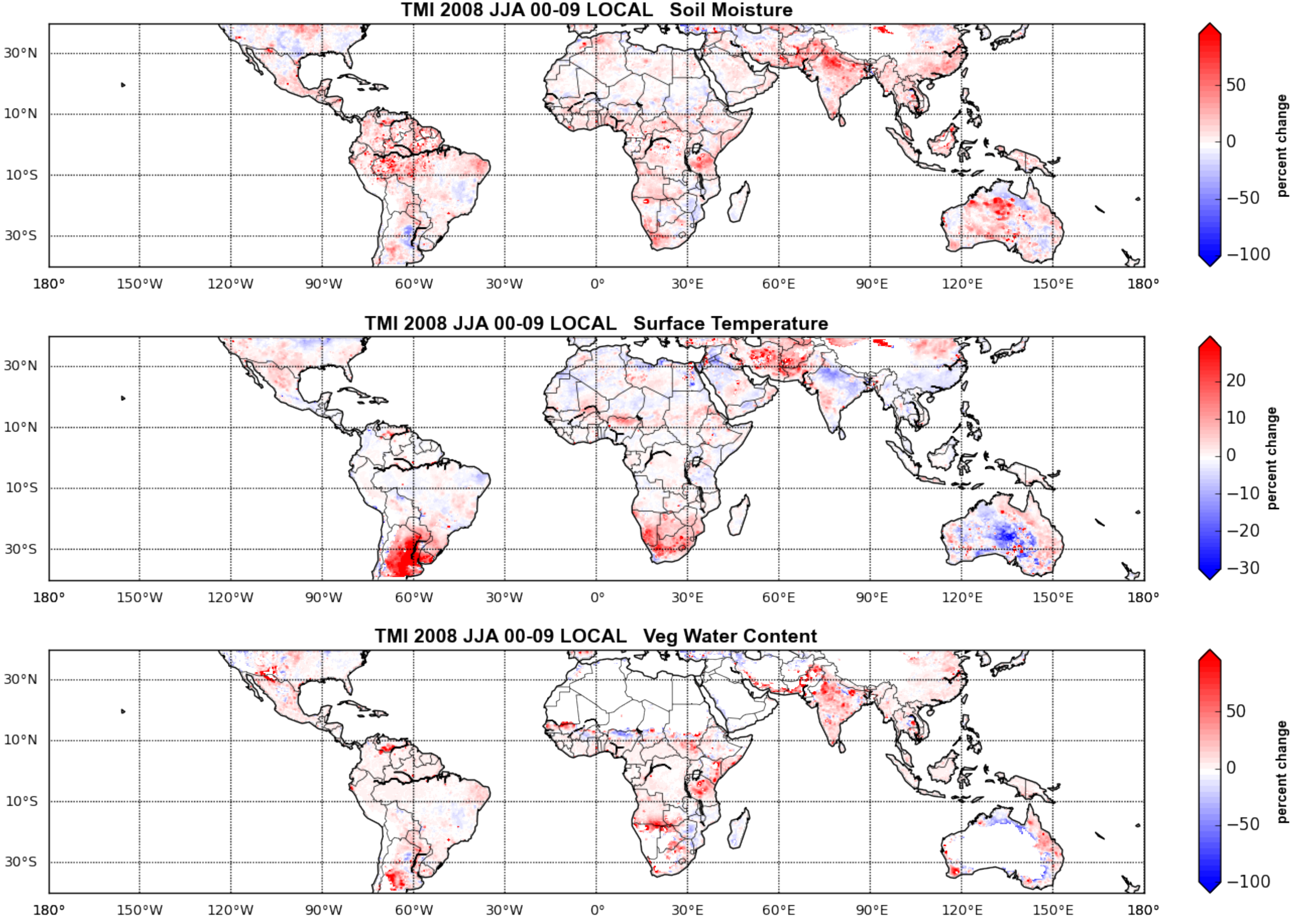
2006 relative to 2002-2012 average



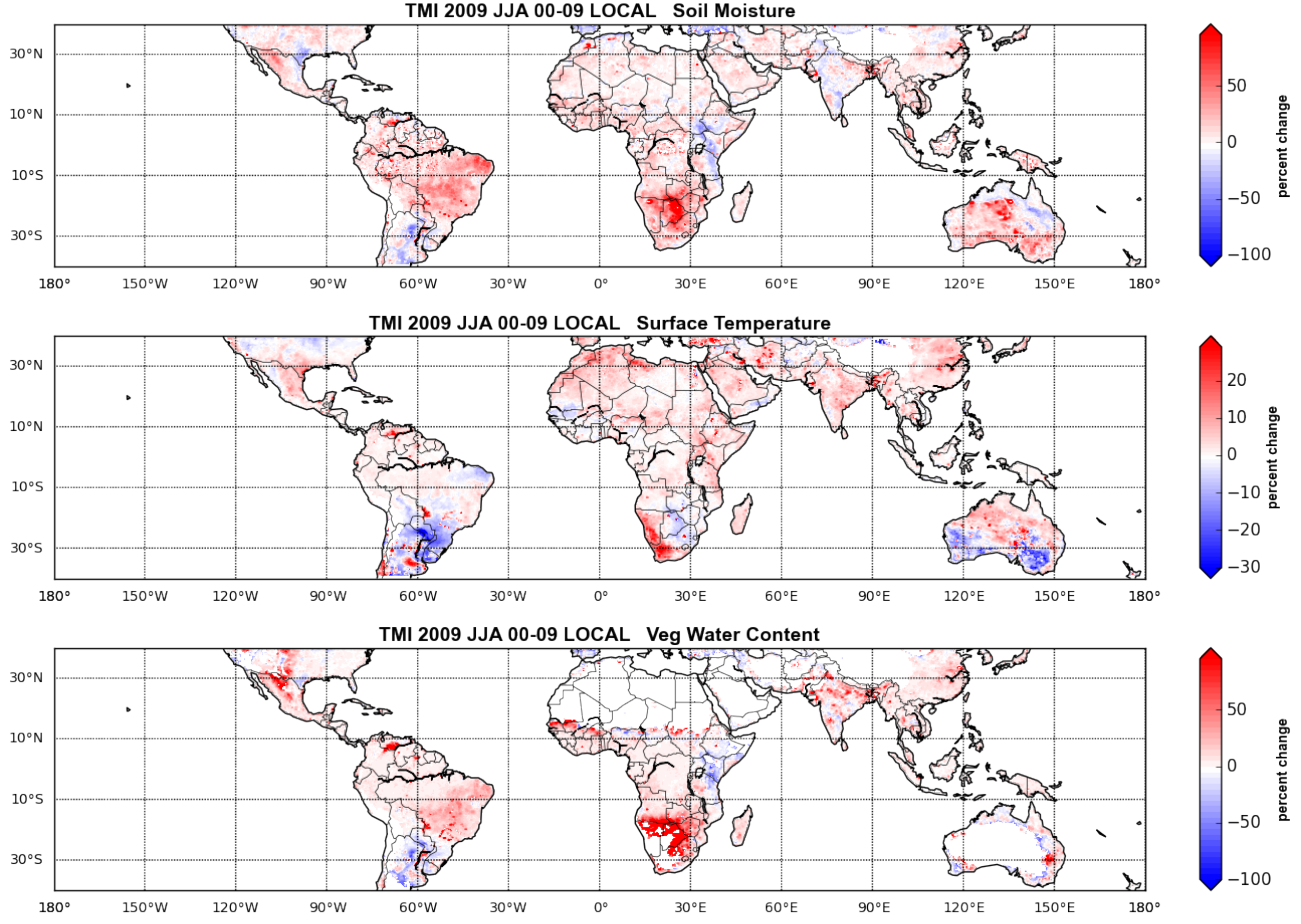
2007 relative to 2002-2012 average



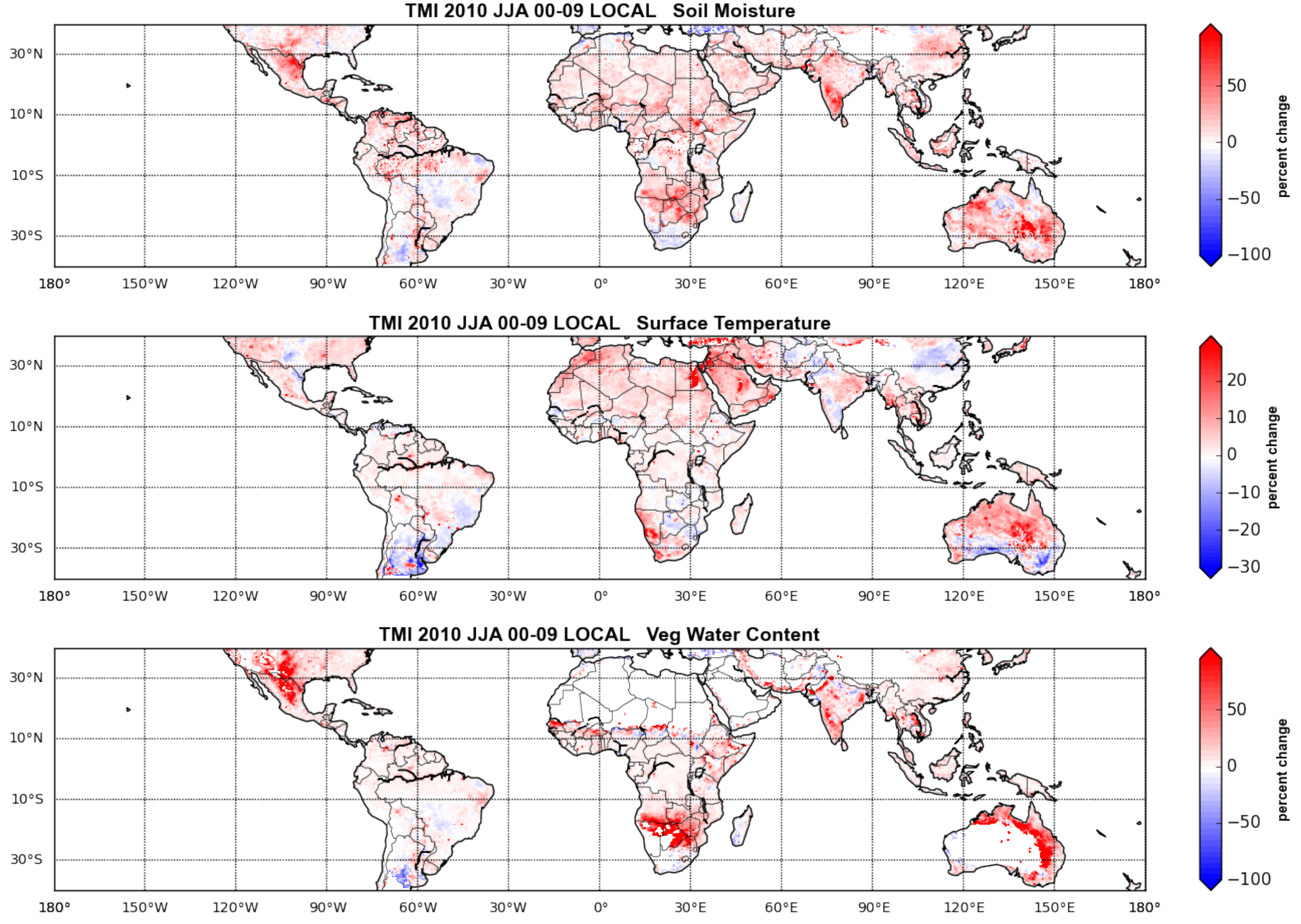
2008 relative to 2002-2012 average



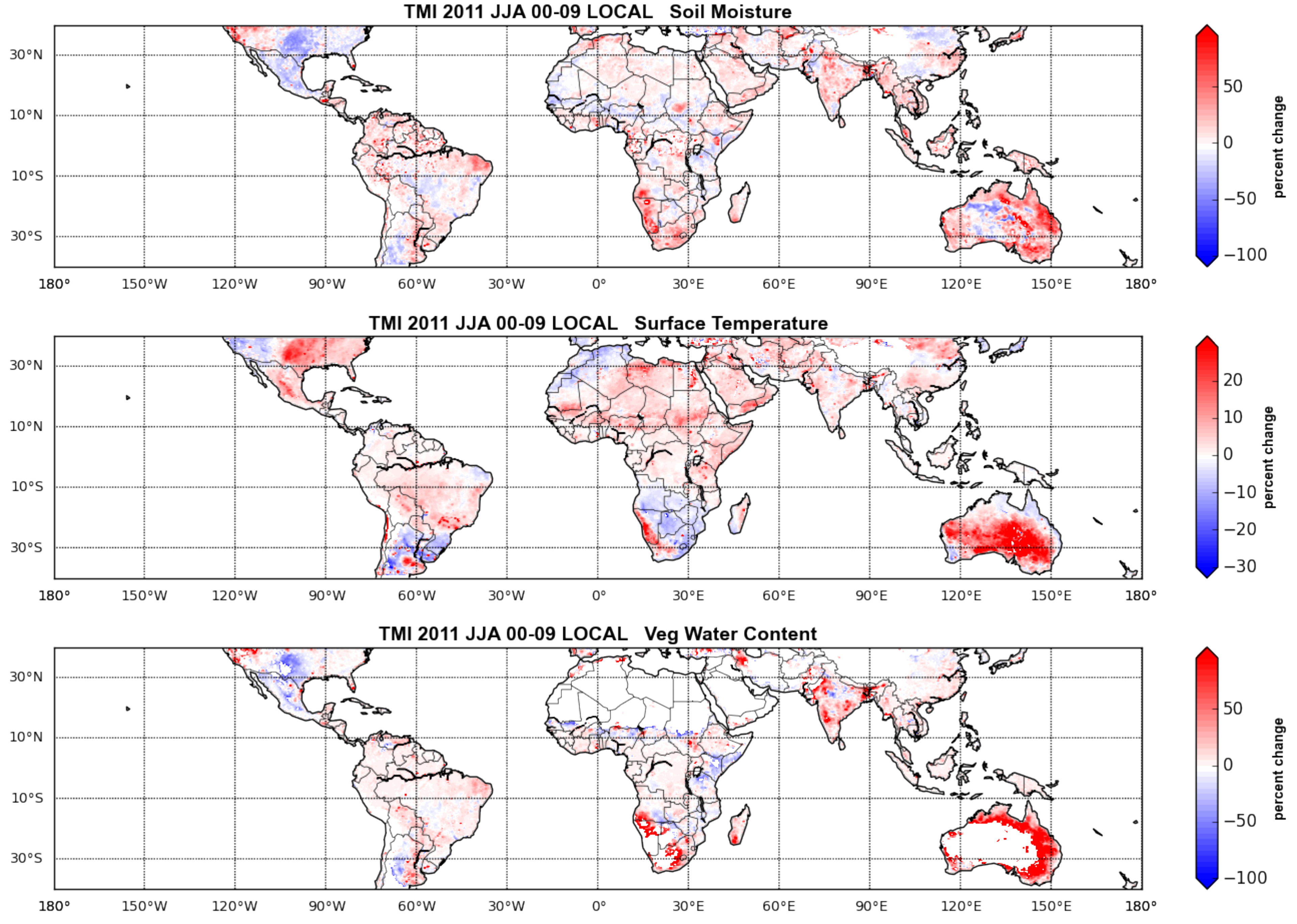
2009 relative to 2002-2012 average



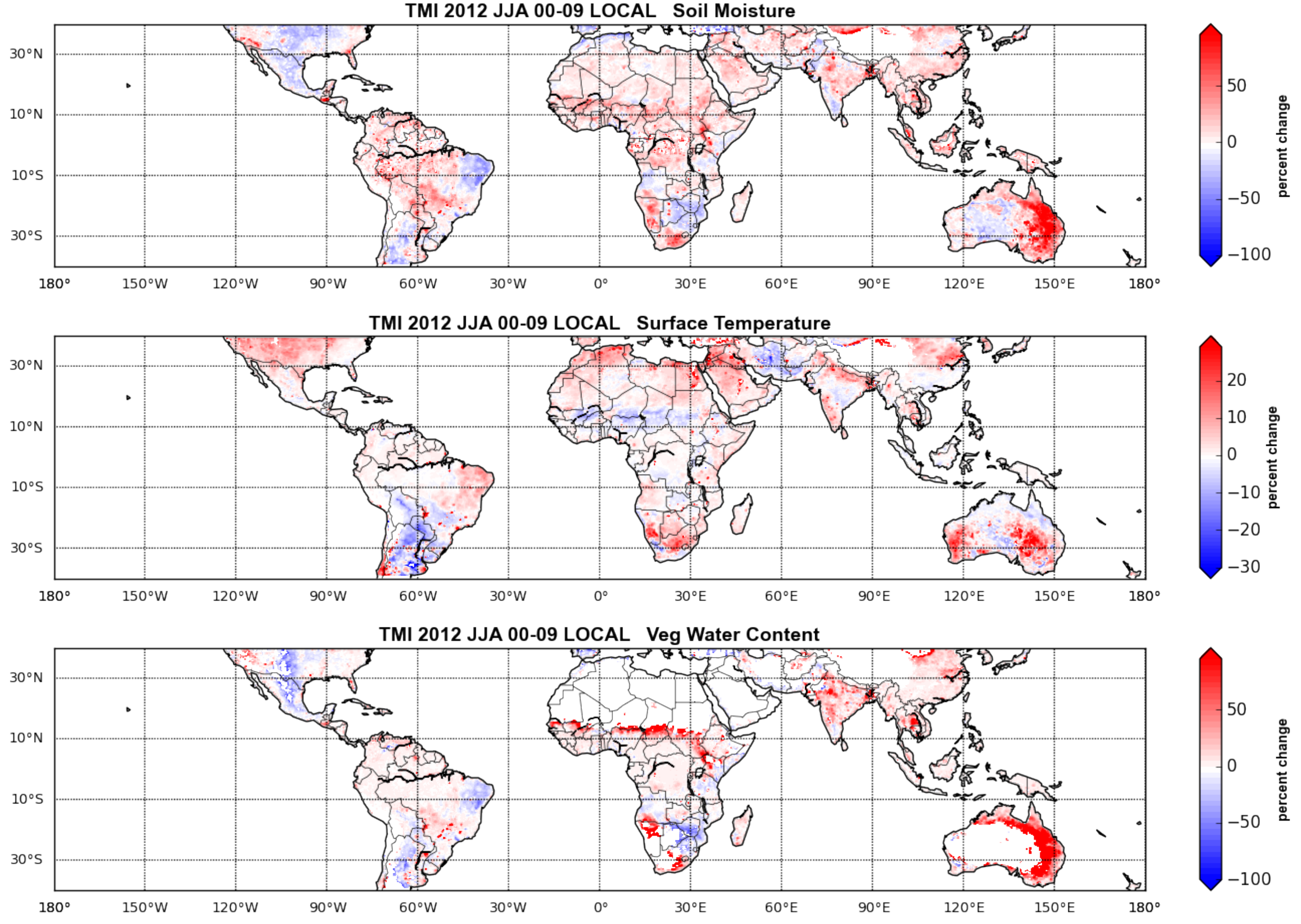
2010 relative to 2002-2012 average



2011 relative to 2002-2012 average



2012 relative to 2002-2012 average



Current Status

Processing and testing of TMI physical retrievals is complete from 2002-2012, other TRMM years currently being processed (WindSat at 6AM only already complete from 2003-2012)

Data packaged in daily netCDF files on 25-km EASE grid (586x1383) used for AMSR-E land products: latitude, longitude, epoch time, local time (0-24 h), soil moisture, vegetation WC, surface temperature, emissivity*6

Add in NDVI and EVI interpolated from 16-day MODIS, to compare VWC and NDVI (any interest?)

Dataset available by request, or may host at PPS