Validation of CRCM5 Simulations over Africa

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MDCR
Réseau canadien de modélisation et diagnostics du climat régional

UQÀM

Canada Environnement Canada Environement Canada

RPN
recherche en prévision numérique

CRCM5 - History

1997: GEM (**G**lobal **E**nvironmental **M**ultiscale) Model (MWR, 1998)
implemented for NWP at MSC (Meteorological Service of Canada)

- Global uniform and variable resolution
- Two-time-level implicit semi-Lagrangian
- Terrain-following hydrostatic-pressure vertical coordinate
- Shared-memory (OpenMP)

2002: Fully elastic non-hydrostatic option (MWR, 2002)

2003: GEMDM (Distributed-Memory)
=> Adapted for massively parallel computers (MPI and OpenMP)

2005: Limited-area nested option created in GEMDM (GEM-LAM)

2005: CRCM5 (also called GEMCLIM)
NWP physics + CLASS 3.5
=> Used at **UQAM**
for many projects incl. CORDEX

2010: CanRCM4
CanGCM4 physics incl. CLASS 2.7
=> Used by **CCCma**
for CORDEX and AR5 projections

CRCM5

- Rotated lat-lon grid (regional, global uniform, global variable)
- no vertical staggering
- hydrostatic
- Nesting follows Davies over the sponge zone (10 resp. 20 grid points), plus halo region (10 grid points)
- Optional spectral nudging - **NOT** used

Physical parameterizations

- Radiation: correlated-K radiation (Li and Barker)
- Land-surface scheme: CLASS 3.5 (Canadian LAnd Surface Scheme)
  3 soil layers, standard configuration
- Deep convection: Kain-Fritsch

Simulation setups

- **0.44 deg**
- Lateral boundary conditions: ERA-Interim
- Lower boundary conditions: AMIP2 SST and sea ice fraction
- 236 x 241 points (free 196 x 201)
- 56 vertical levels
- Top at 10 hPa
- Δt = 1200 sec
- 128 cores (8x8x2) => < 9 h/yr

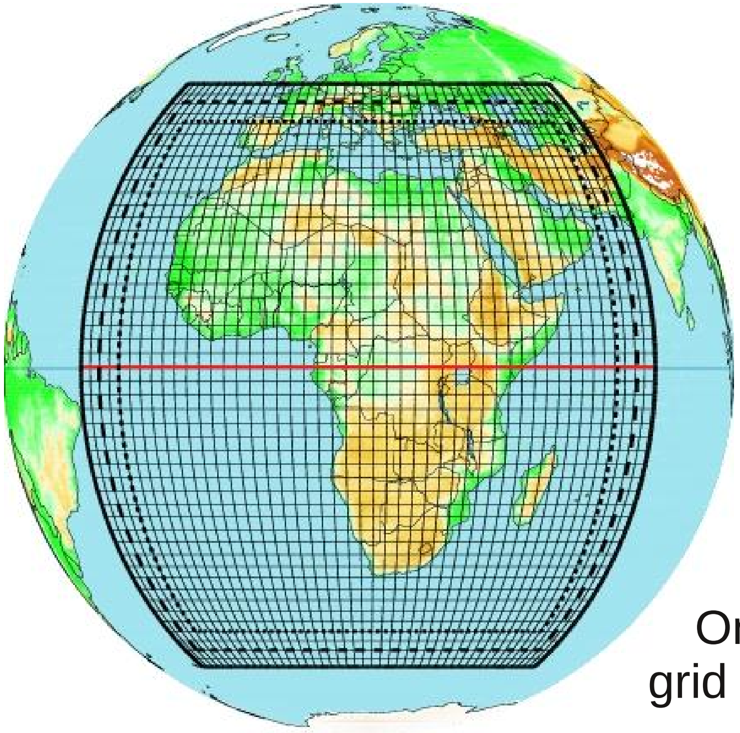
- **0.22 deg**
- 452x462 (free 392 x 402)

→

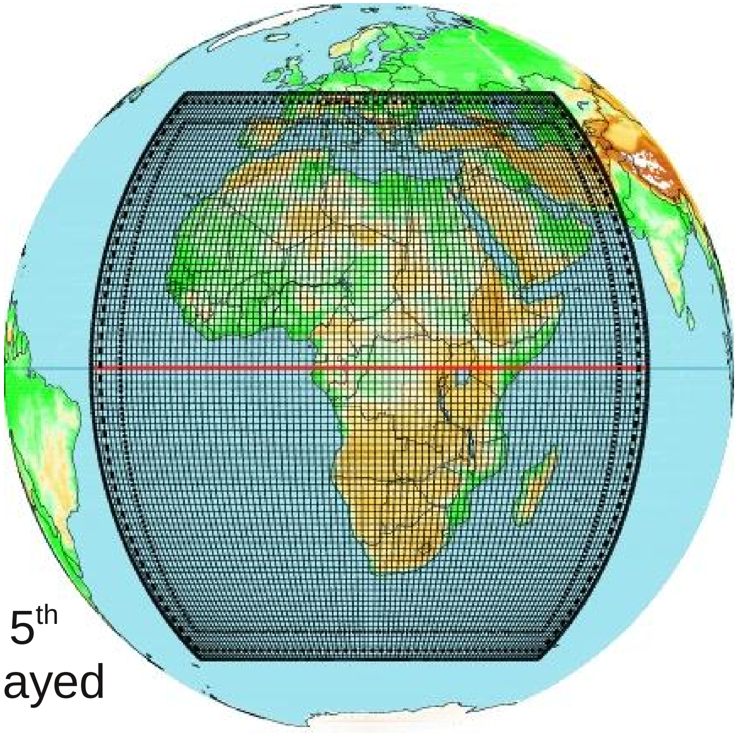
→

- Δt = 600 sec
- 200 cores (10x10x2) => 1 ½ d/yr

Africa_0.44deg_03L_pfix



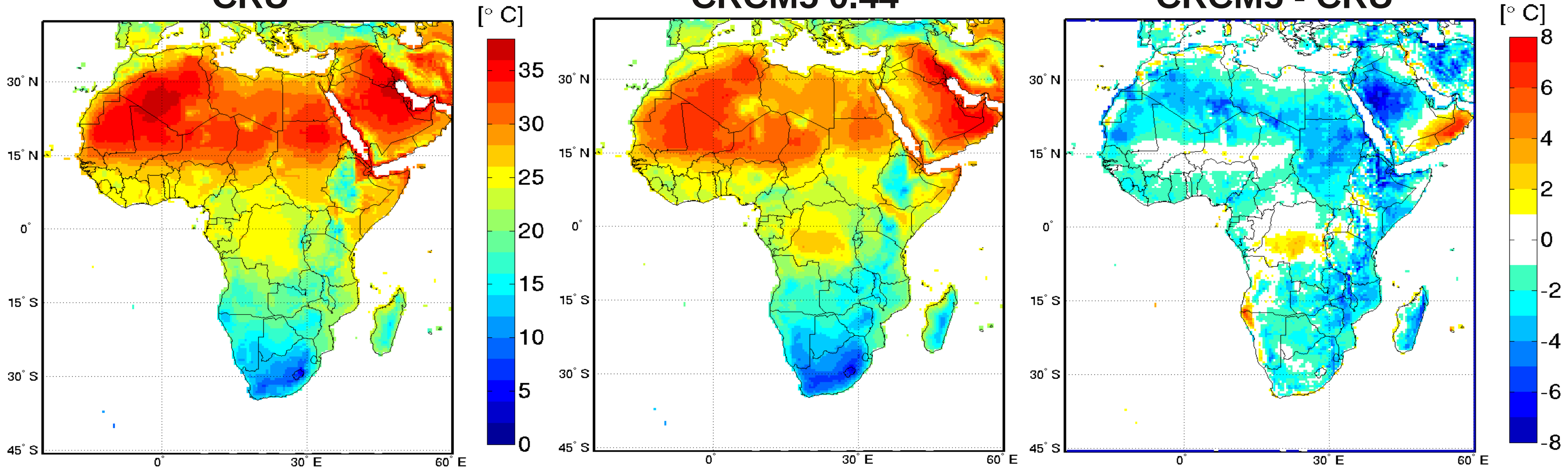
Africa_0.22deg_03L



Only every 5th grid box displayed

2 m temperature

JJA 1993 - 2002



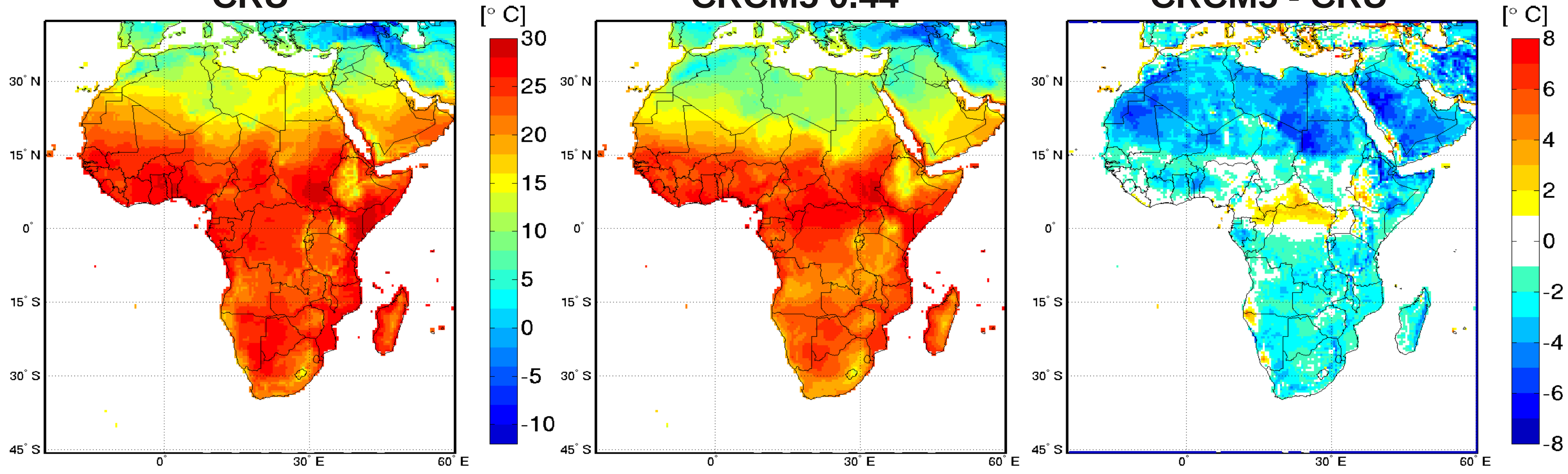
CRU

CRCM5 0.44°

CRCM5 - CRU

[° C]
35
30
25
20
15
10
5
0
[° C]
8
6
4
2
0
-2
-4
-6
-8
30° N
15° N
0°
15° S
30° S
45° S
0°
30° E
60° E

DJF 1992 - 2001



CRU

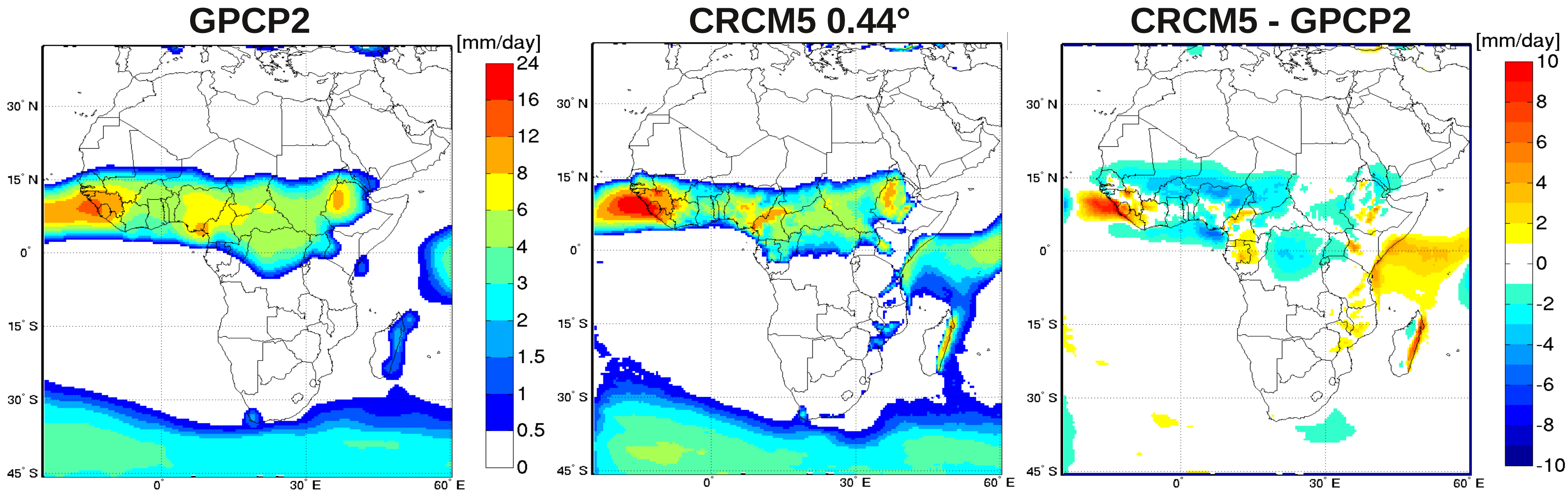
CRCM5 0.44°

CRCM5 - CRU

[° C]
30
25
20
15
10
5
0
-5
-10
[° C]
8
6
4
2
0
-2
-4
-6
-8
30° N
15° N
0°
15° S
30° S
45° S
0°
30° E
60° E

Precipitation

JJA 1994 - 2008



GPCP2

CRCM5 0.44°

CRCM5 - GPCP2

[mm/day]
24
16
12
8
6
4
3
2
1.5
1
0.5
0
[mm/day]
10
8
6
4
2
0
-2
-4
-6
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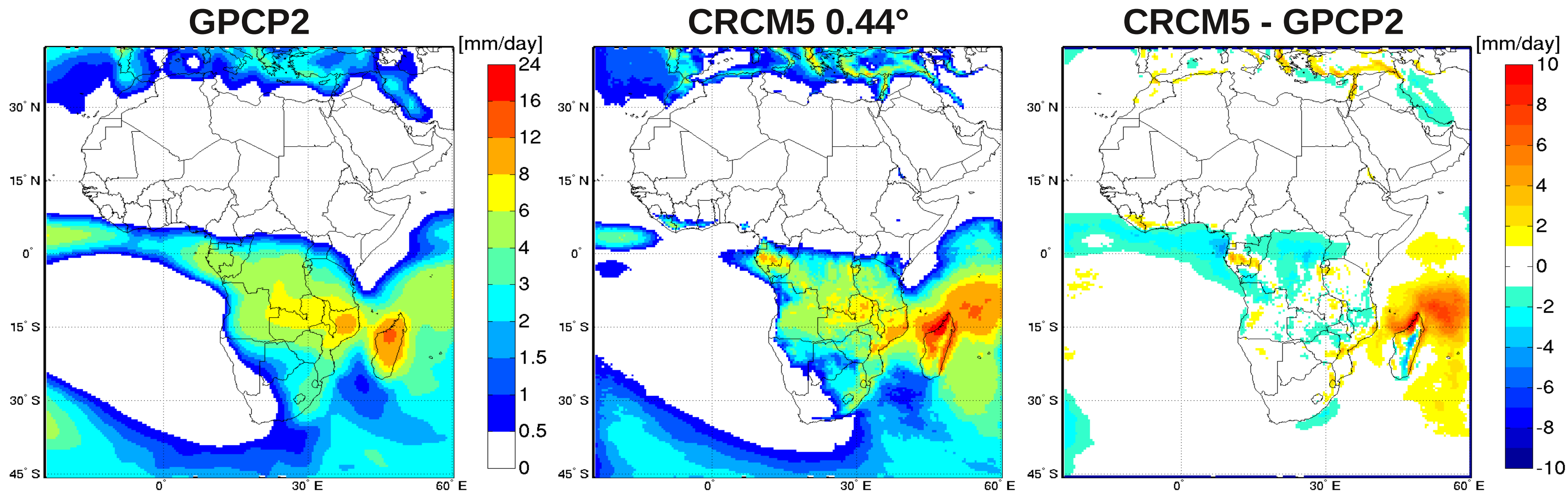
-10
30° N
15° N
0°
15° S
30° S
45° S
0°
30° E
60° E

DJF 1993 - 2007



GPCP2

CRCM5 0.44°

CRCM5 - GPCP2

[mm/day]
24
16
12
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[mm/day]
10
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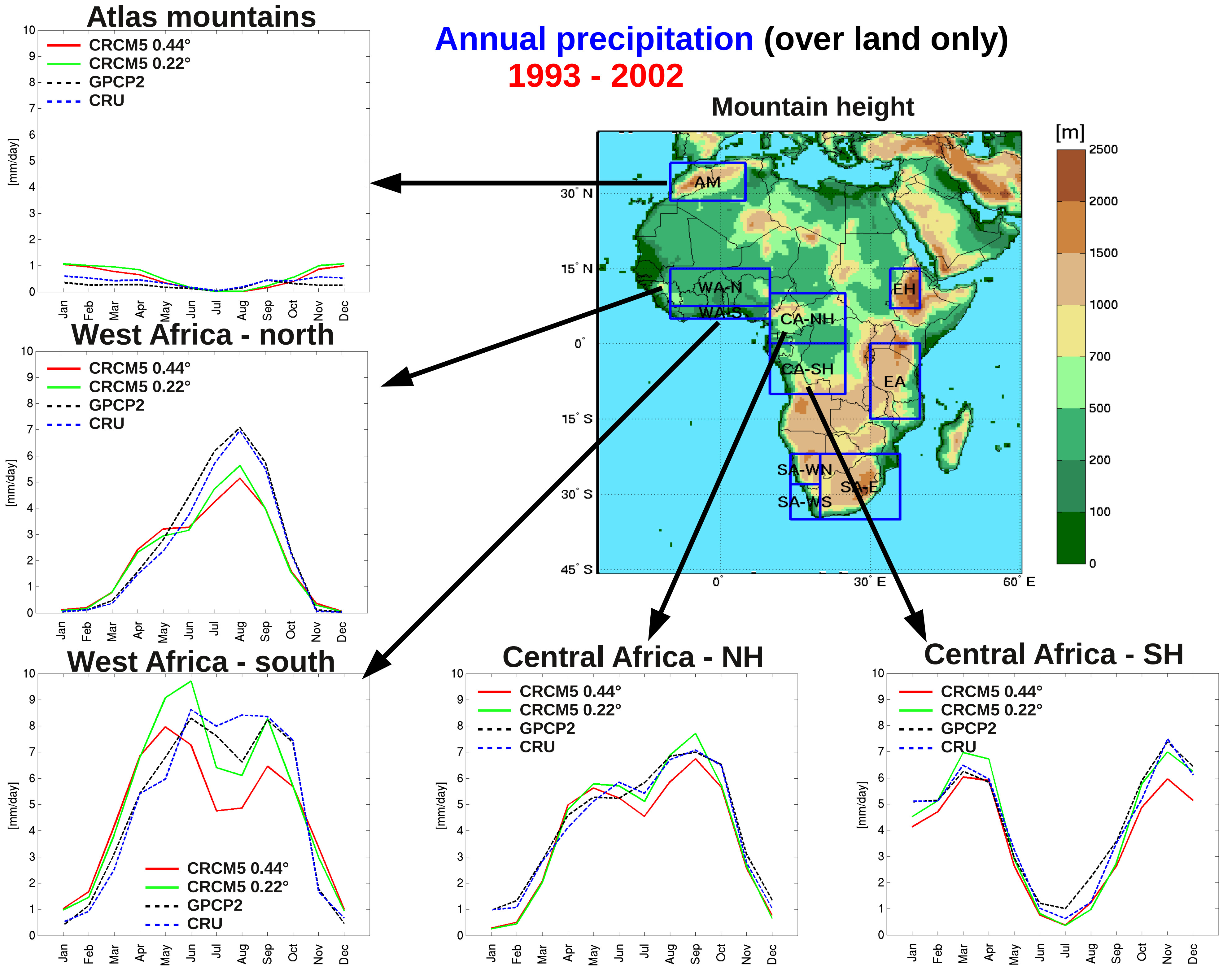
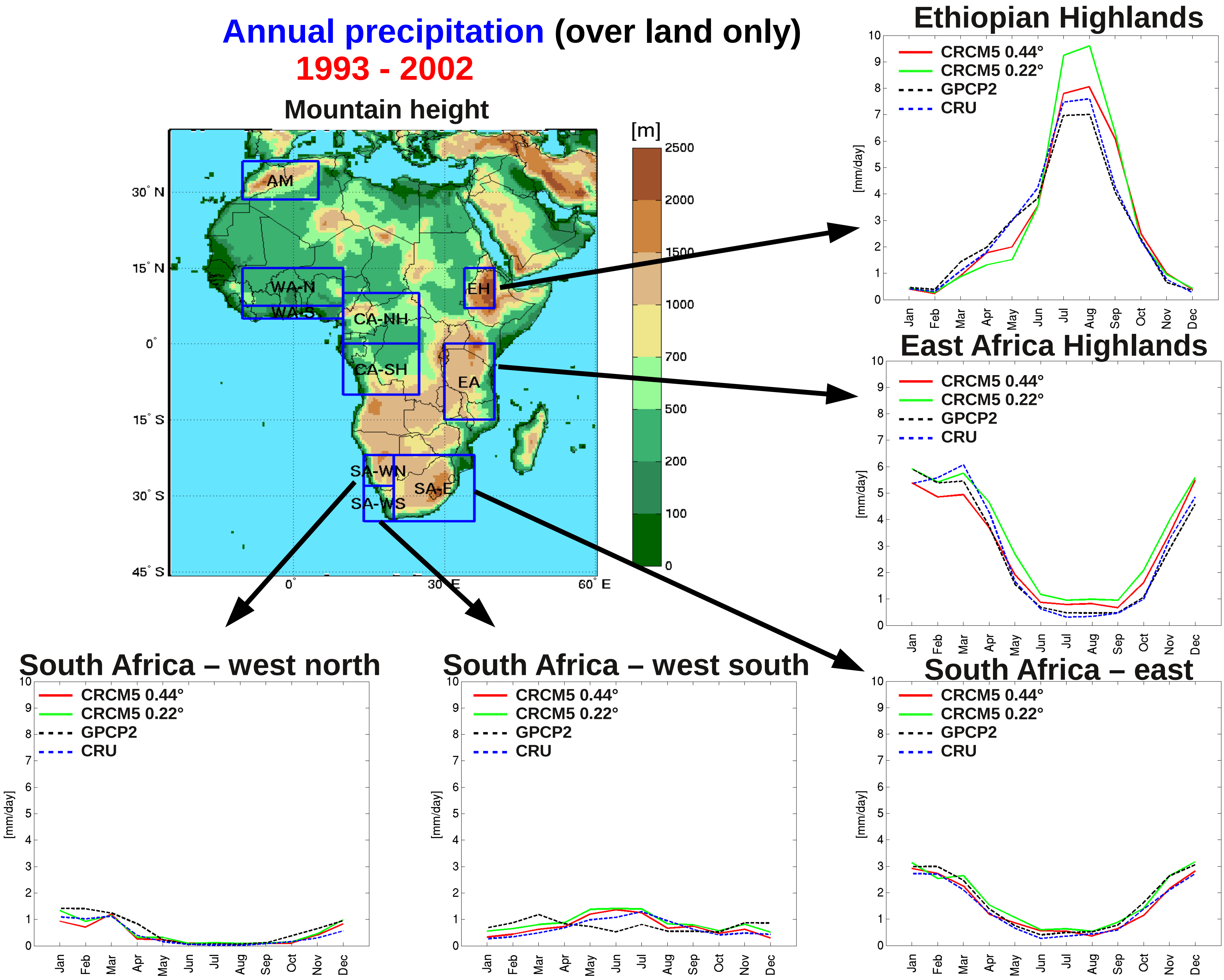
-2
-4
-6
-8
-10
30° N
15° N
0°
15° S
30° S
45° S
0°
30° E
60° E

Annual precipitation (over land only)
1993 - 2002

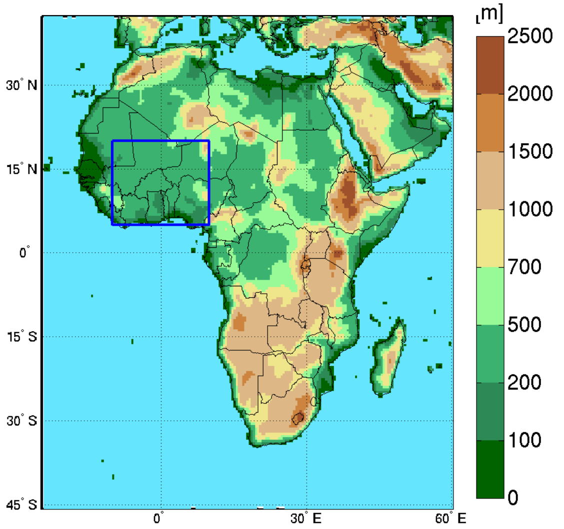


Annual precipitation (over land only)
1993 - 2002



Precipitation, 1997 - 2008

31 day running zonal mean (10W – 10E)



Mountain height

[m]
2500
2000
1500
1000
700
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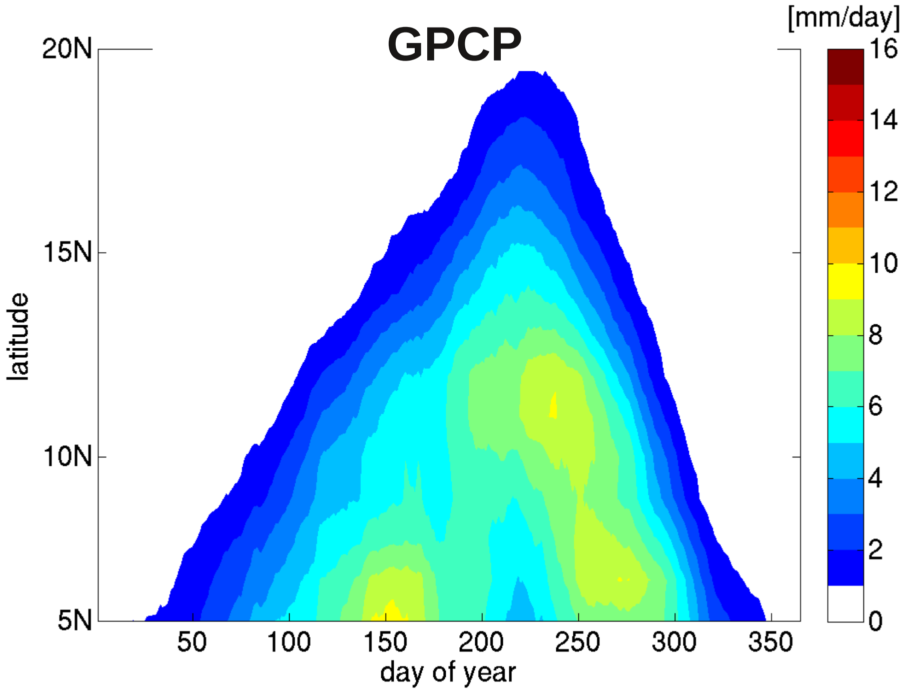
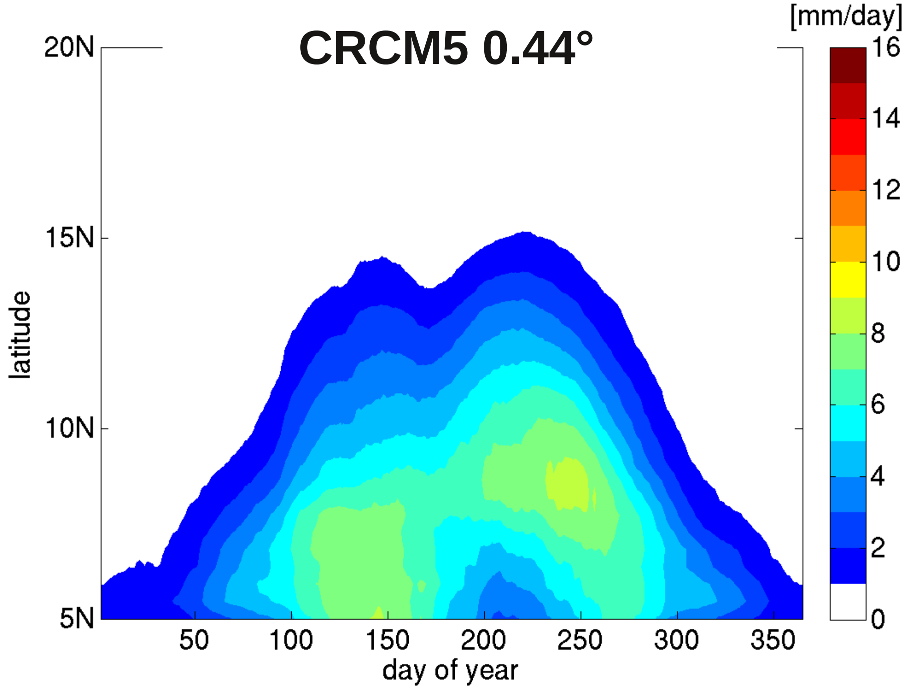
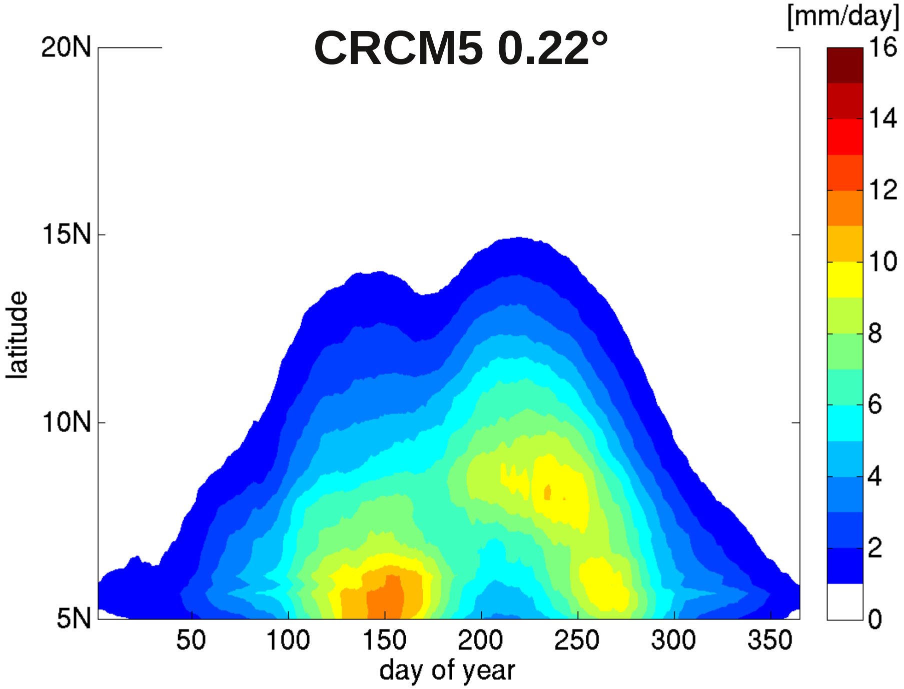
30° N
15° N
0°
15° S
30° S
45° S
0°
30° E
60° E



GPCP

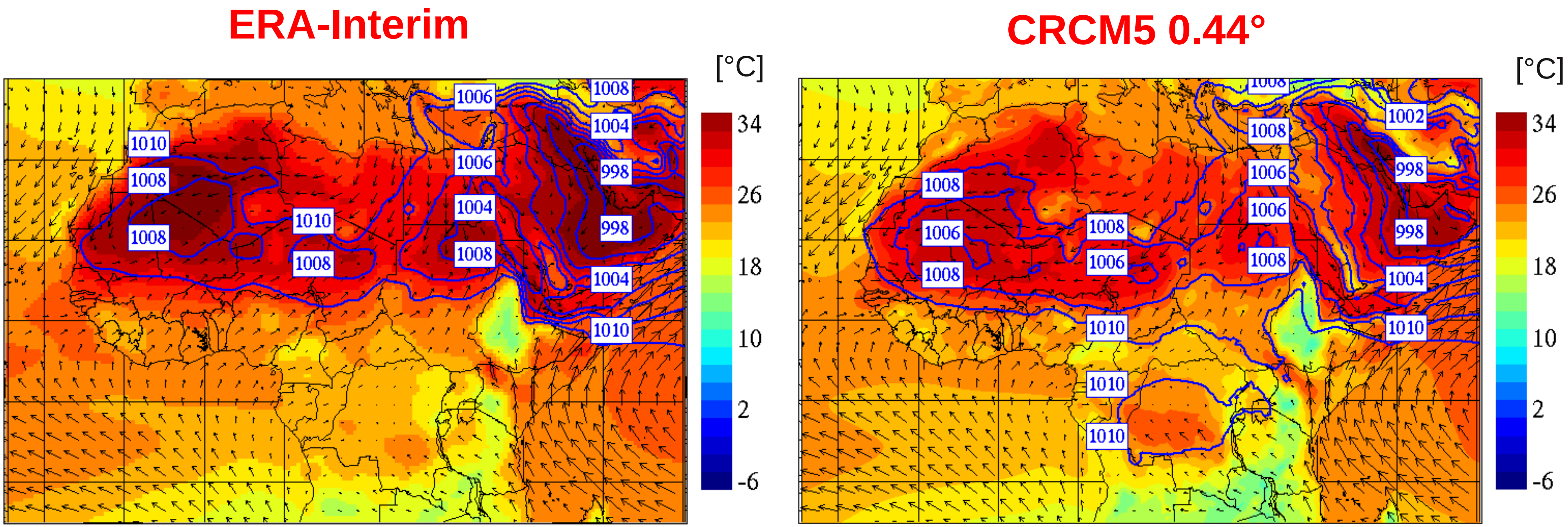


CRCM5 0.44°



CRCM5 0.22°

2m temperature, 925 hPa winds, sea level pressure
JJA 1994 - 2008



ERA-Interim

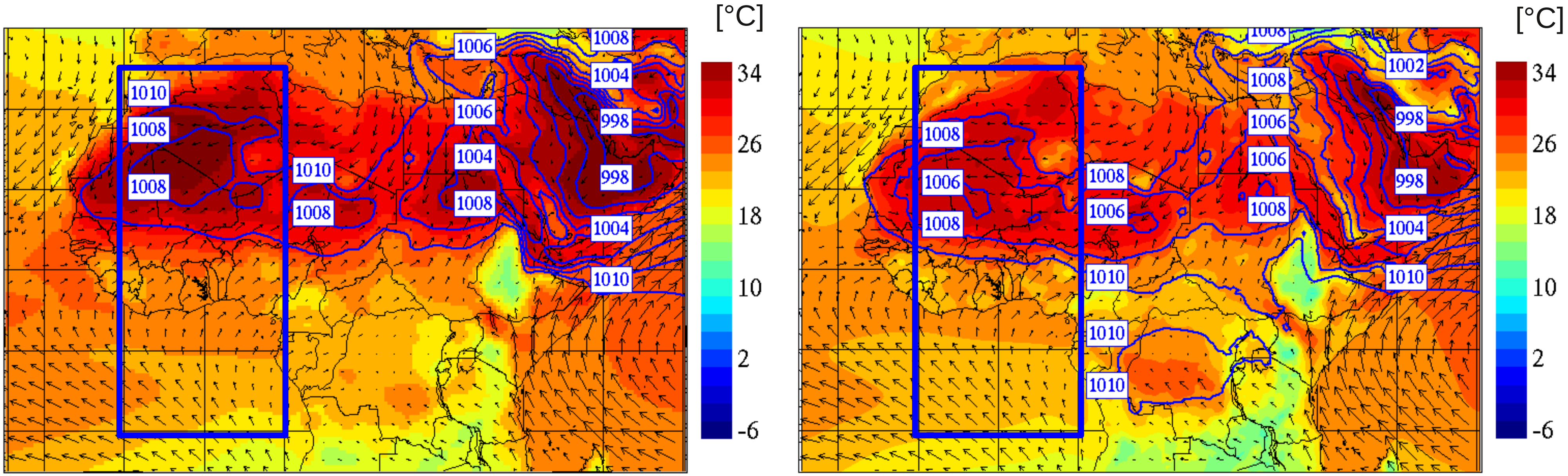
CRCM5 0.44°

[°C]
34
26
18
10
2
-6
1010
1008
1006
1004
998
1002

2m temperature (shading, °C),
925 hPa wind (vectors, m/s) and
sea level pressure contours of 1010 hPa and lower are superimposed (contour interval 2 hPa).

2m temperature, 925 hPa winds, sea level pressure

JJA 1994 - 2008



[°C]
34
26
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-6
1006
1008
1004
998
1010
1002

ERA-Interim

CRCM5 0.44°

2m temperature (shading, °C),
925 hPa wind (vectors, m/s) and
sea level pressure contours of 1010 hPa and lower are superimposed (contour interval 2 hPa).

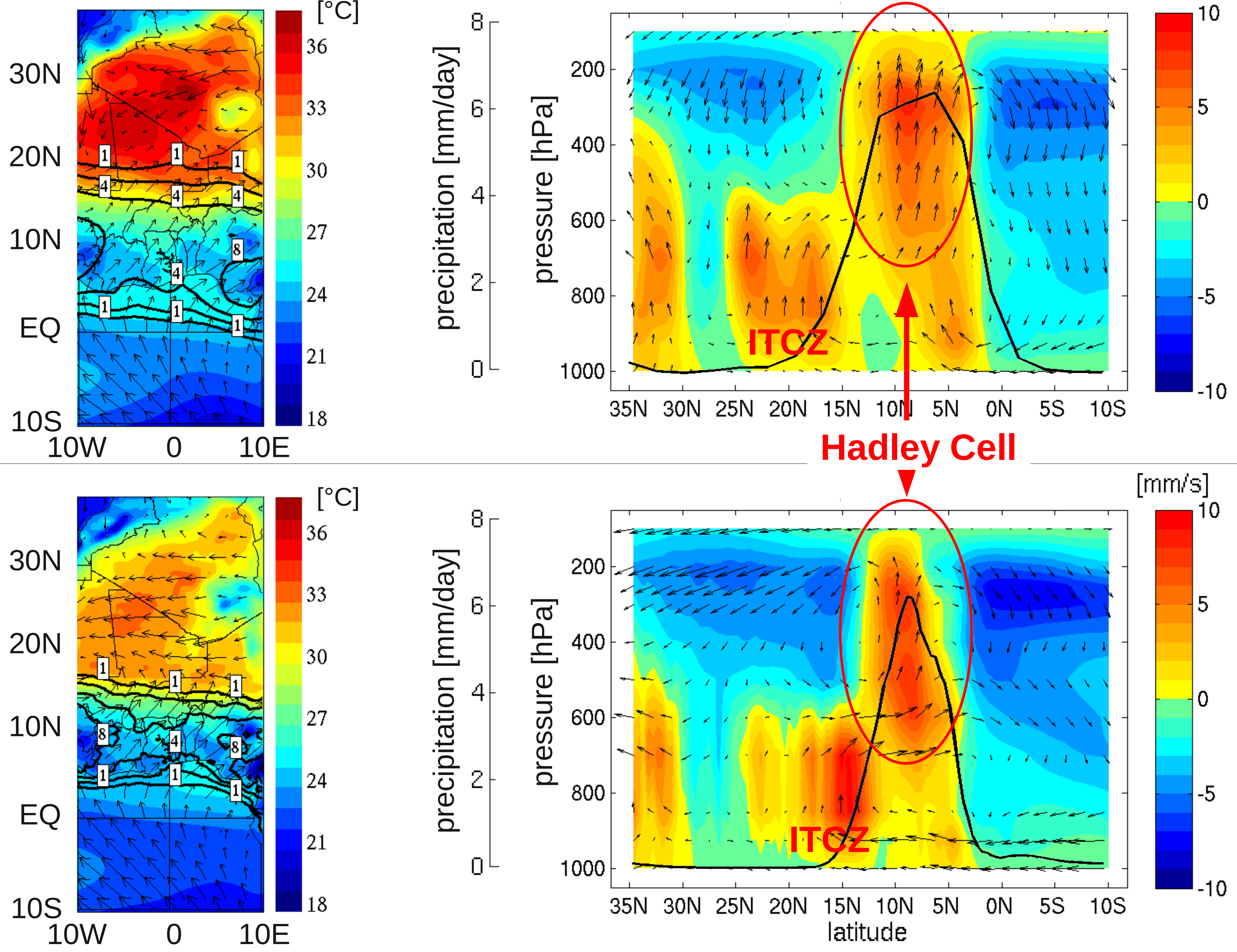
2m temperature, 925 hPa winds
precipitation

zonal mean (10W-10E), **vertical (and N-S) wind**
precipitation

JJAS 1994 - 2008

ERA-Interim / GPCP2

CRCM5 0.44°

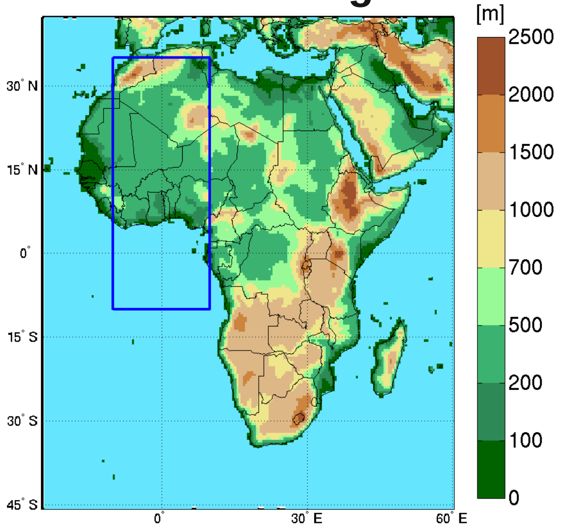


Hadley Cell

zonal wind

JJAS 1994 - 2008

Mountain height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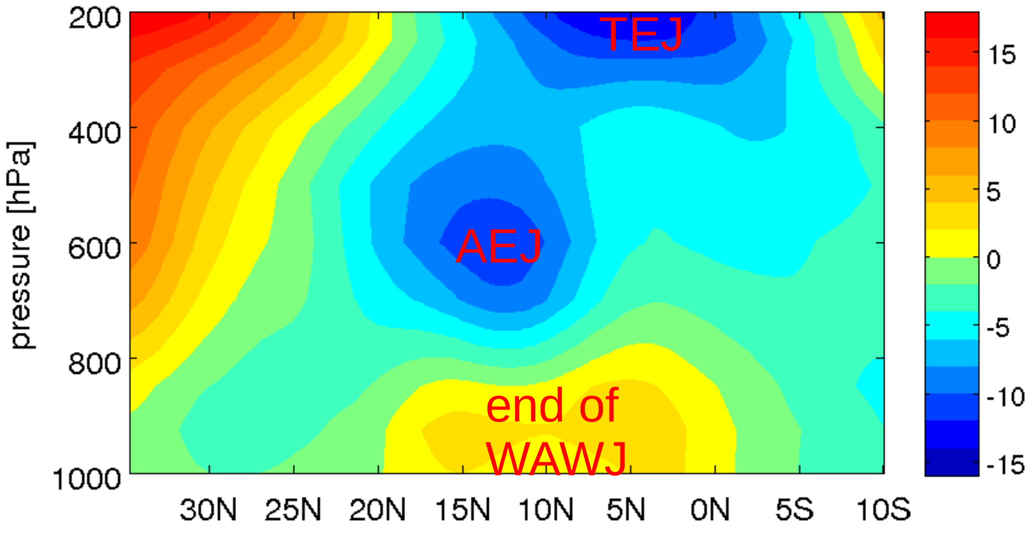
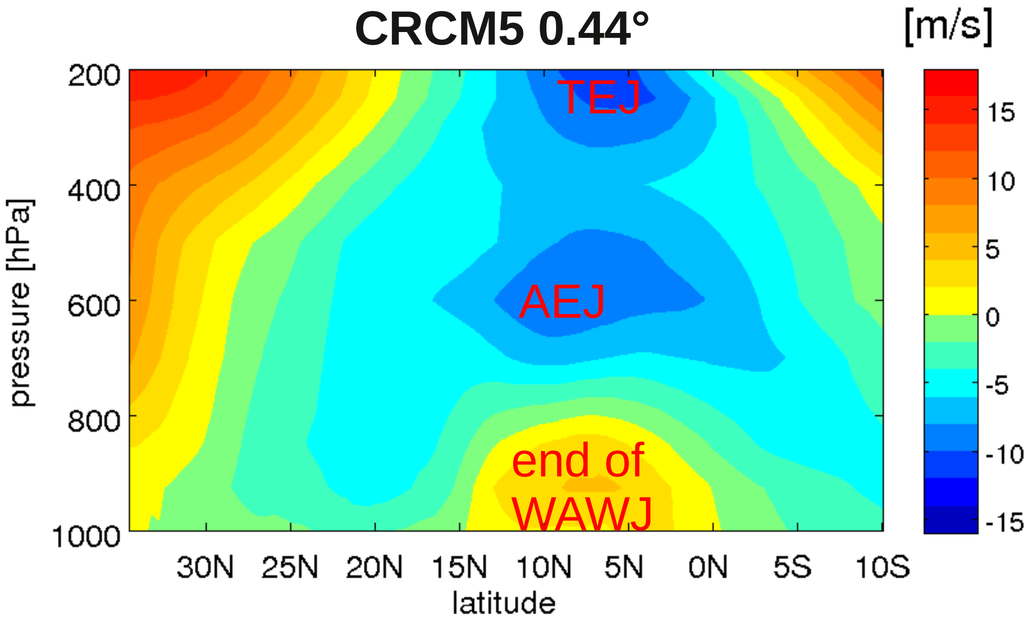
30° E
60° E

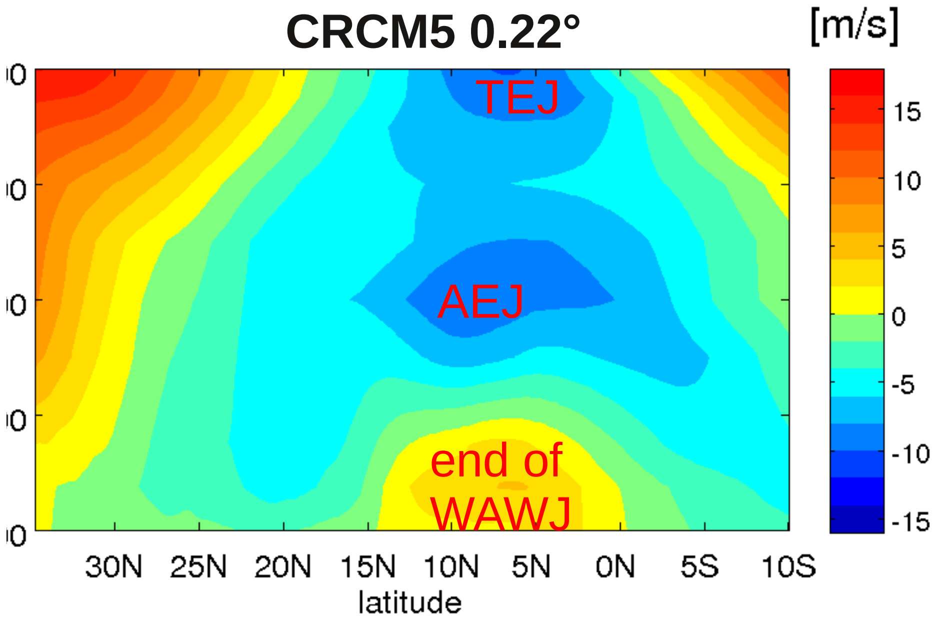
ERA-Interim



CRCM5 0.44°

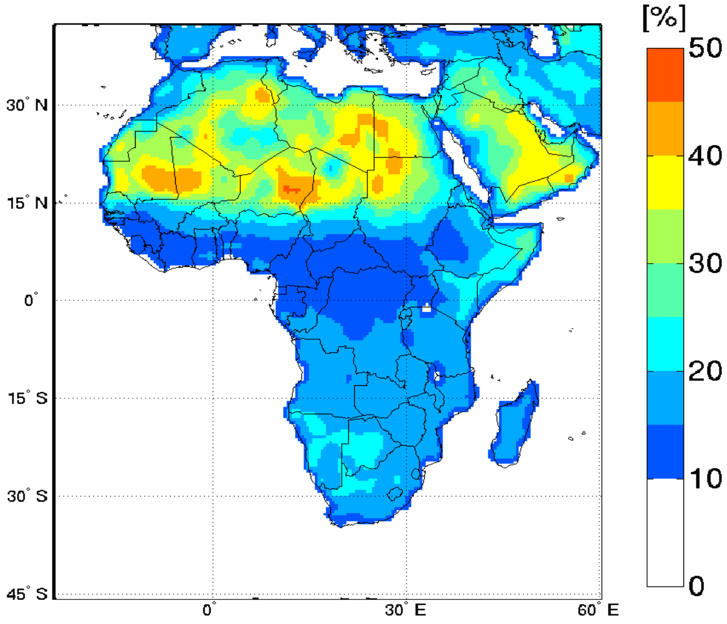


CRCM5 0.22°



Surface albedo

ERA-Interim



[%]
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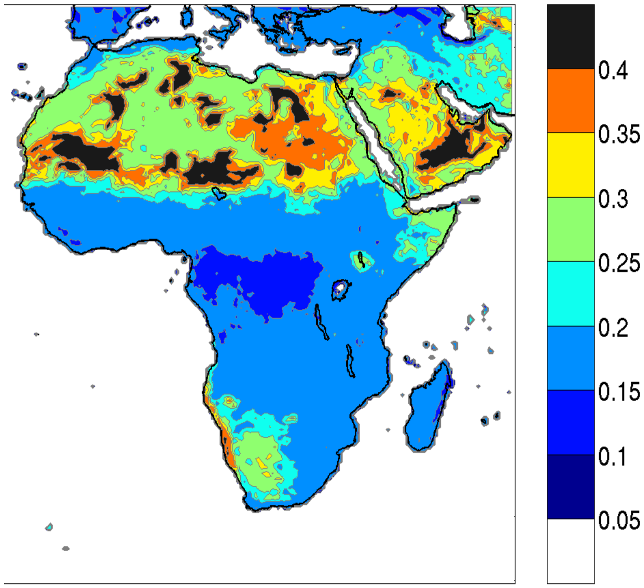
ECOCLIMAP



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0.2
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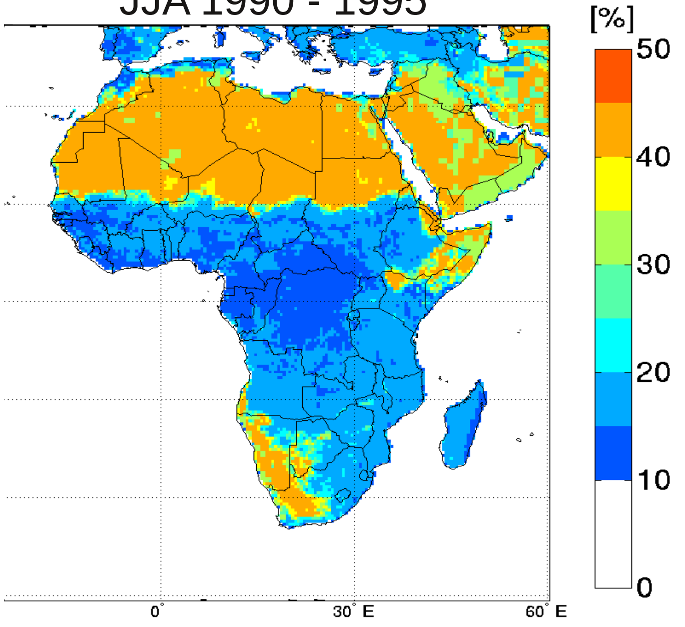
CRCM5 0.44° original

JJA 1990 - 1995



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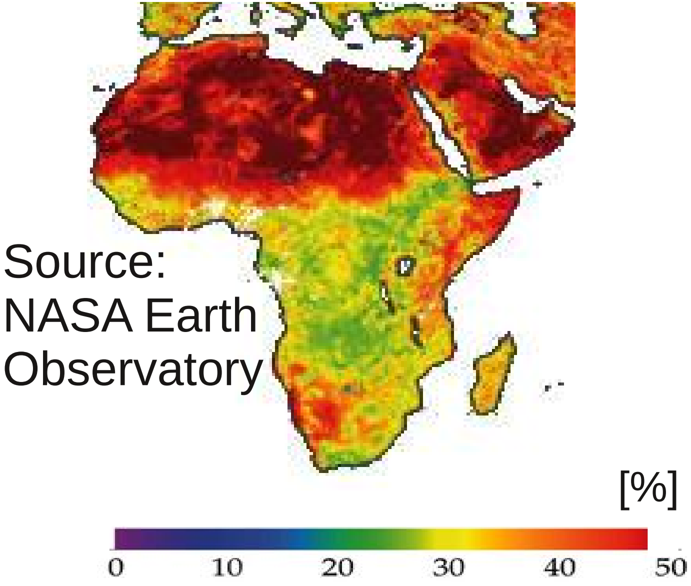
30° E
60° E

NASA

April 2002



[%]
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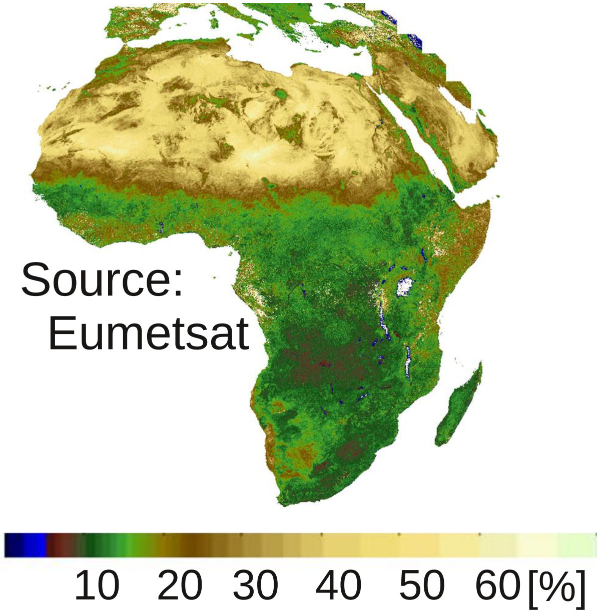
Source:
NASA Earth
Observatory

Meteosat



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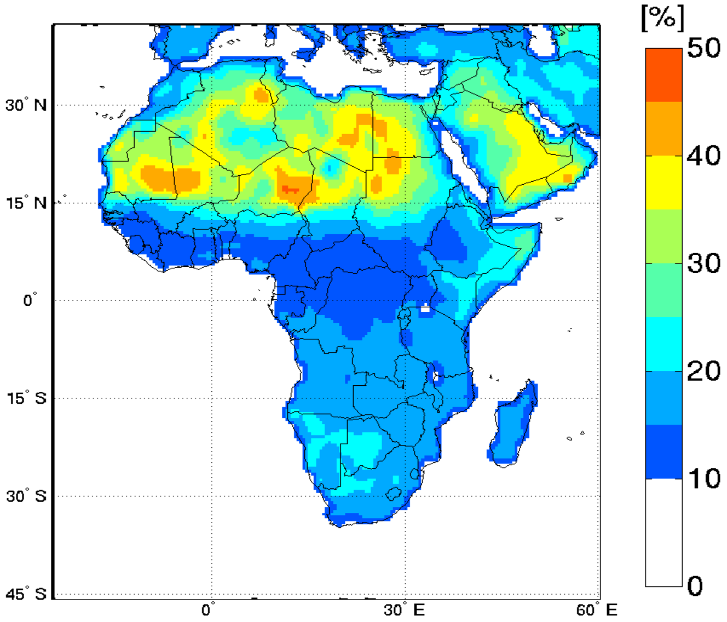
Source:
Eumetsat

Surface albedo

ERA-Interim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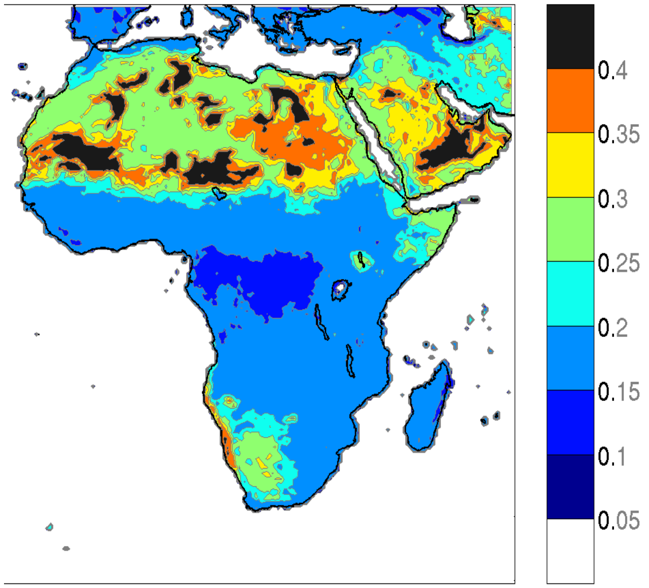
ECOCLIMAP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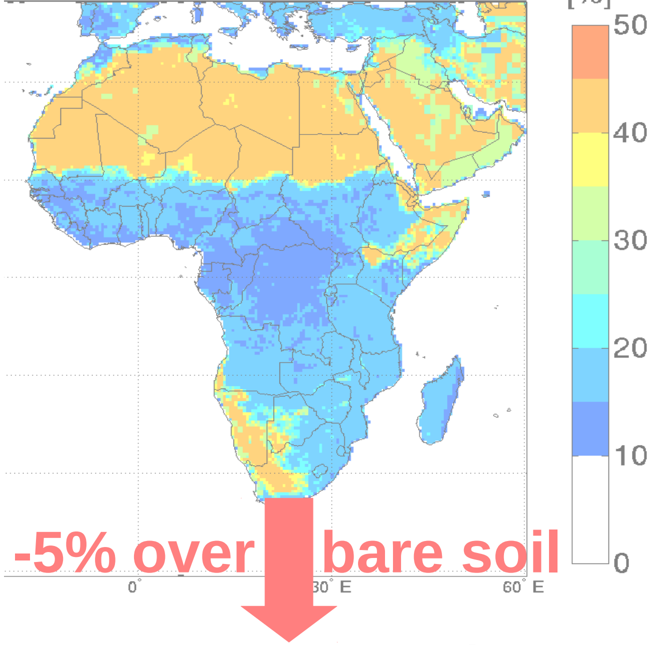
0.2
0.15
0.1
0.05

CRCM5 0.44° original

JJA 1990 - 1995


[%]
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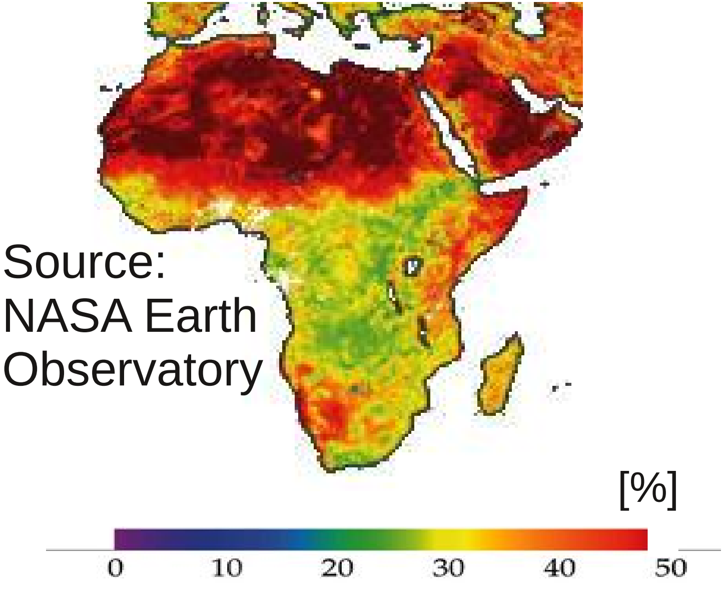
0°
30° E
60° E

-5% over bare soil

NASA

April 2002


[%]
0
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40
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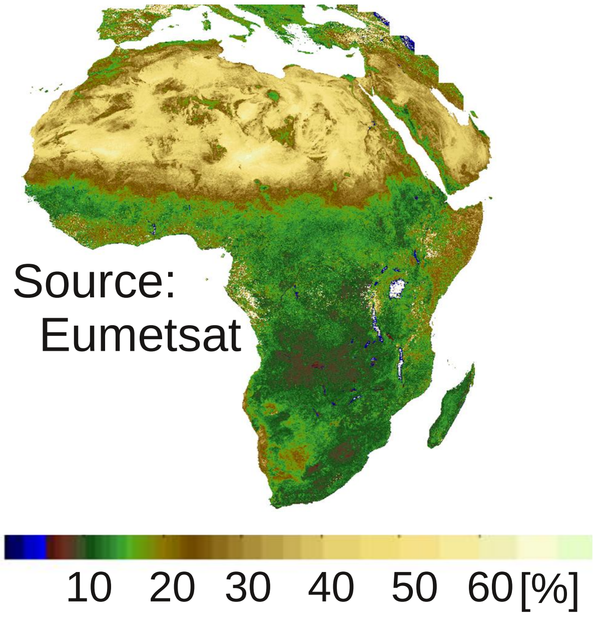
Source:
NASA Earth
Observatory

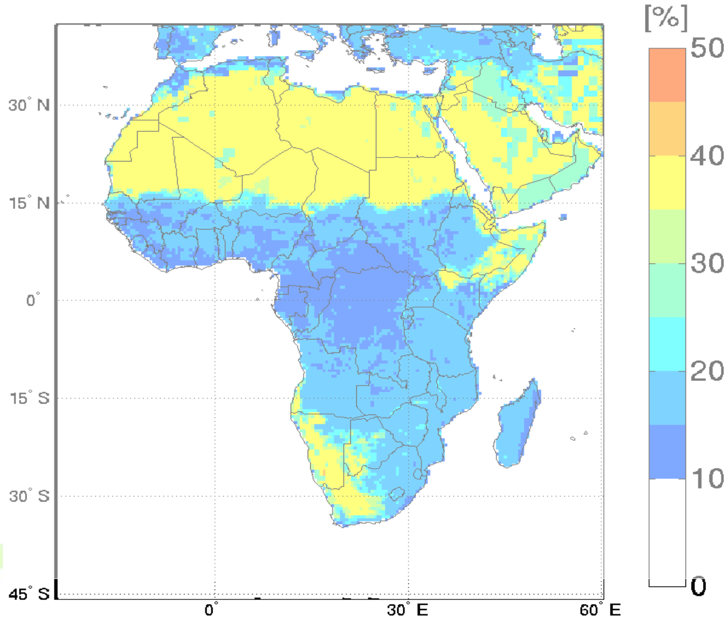
Meteosat


10
20
30
40
50
60
[%]

Source:
Eumetsat

CRCM5 0.44° - 5% over desert

JJA 1990 - 1995


[%]
50
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30° N
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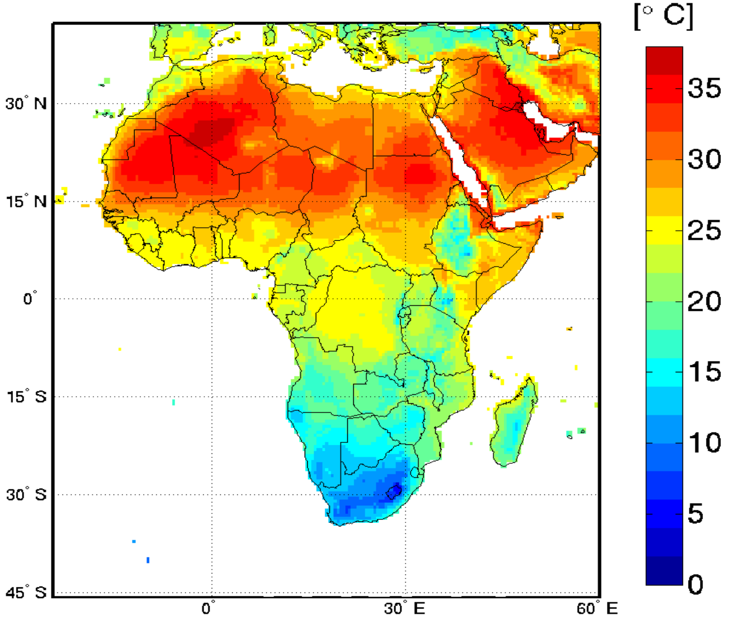
15° S
30° S
45° S
0°
30° E
60° E

2m temperature

JJA 1990 - 1995

CRU


30° N
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15° S
30° S
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30° E
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[° C]
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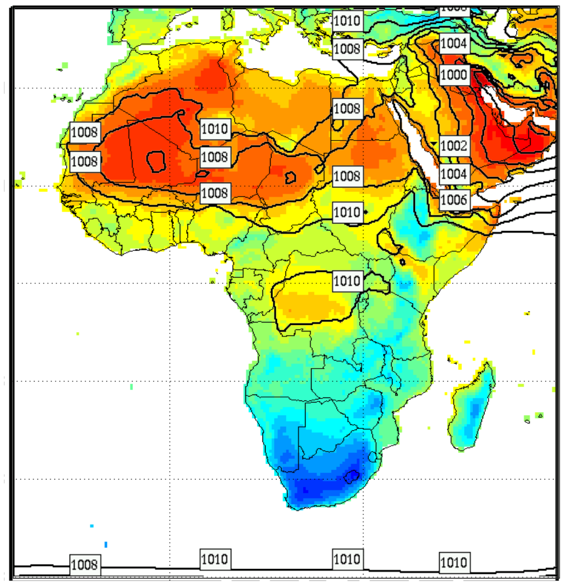
CRCM5 0.44°
original albedo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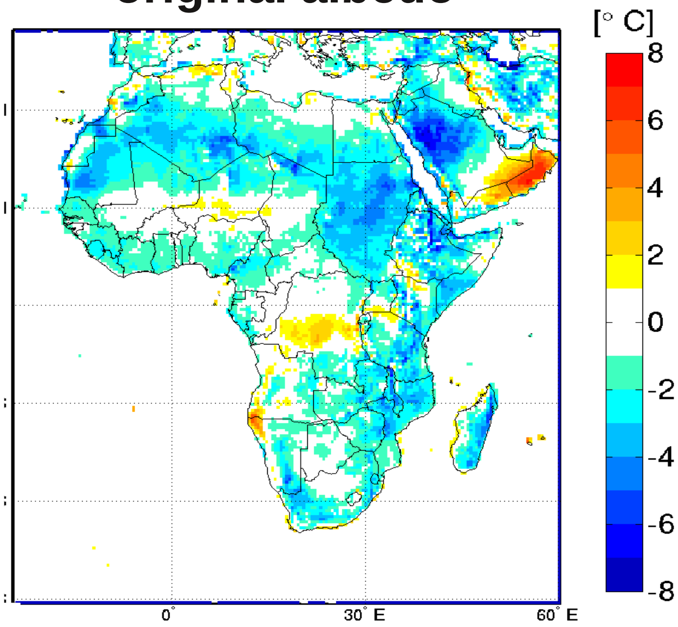
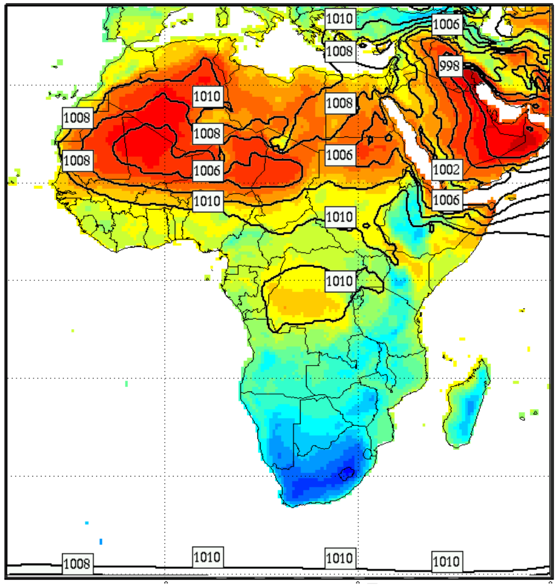
1010

CRCM5 0.44° - CRU
original albedo


[° C]
8
6
4
2
0
-2
-4
-6
-8
0°
30° E
60° E

CRCM5 0.44°
- 5% albedo over desert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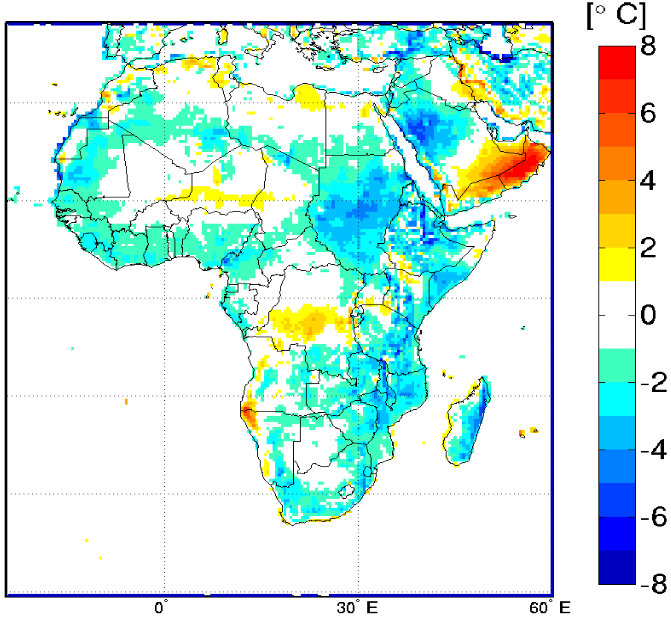
CRCM5 0.44° - CRU
- 5% albedo over desert


[° C]
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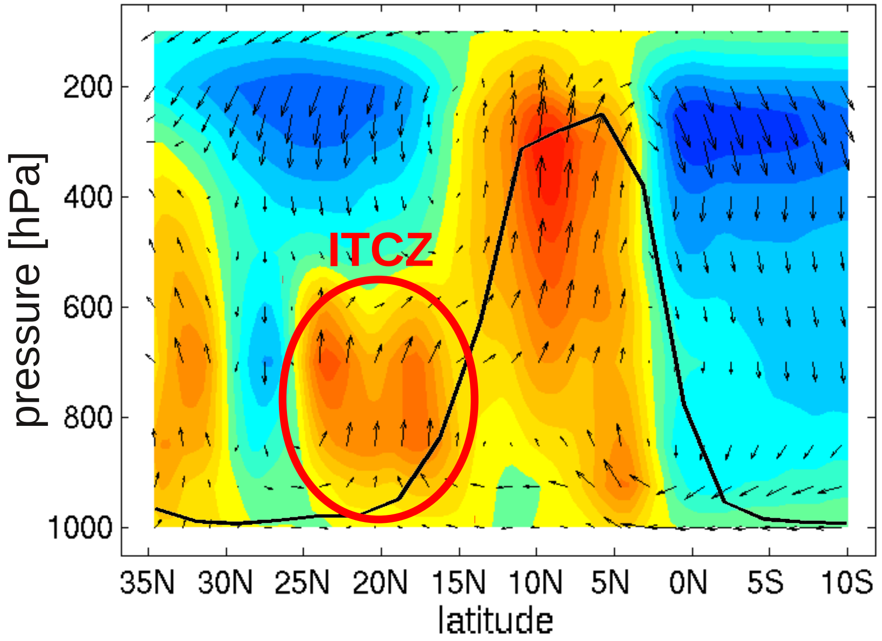
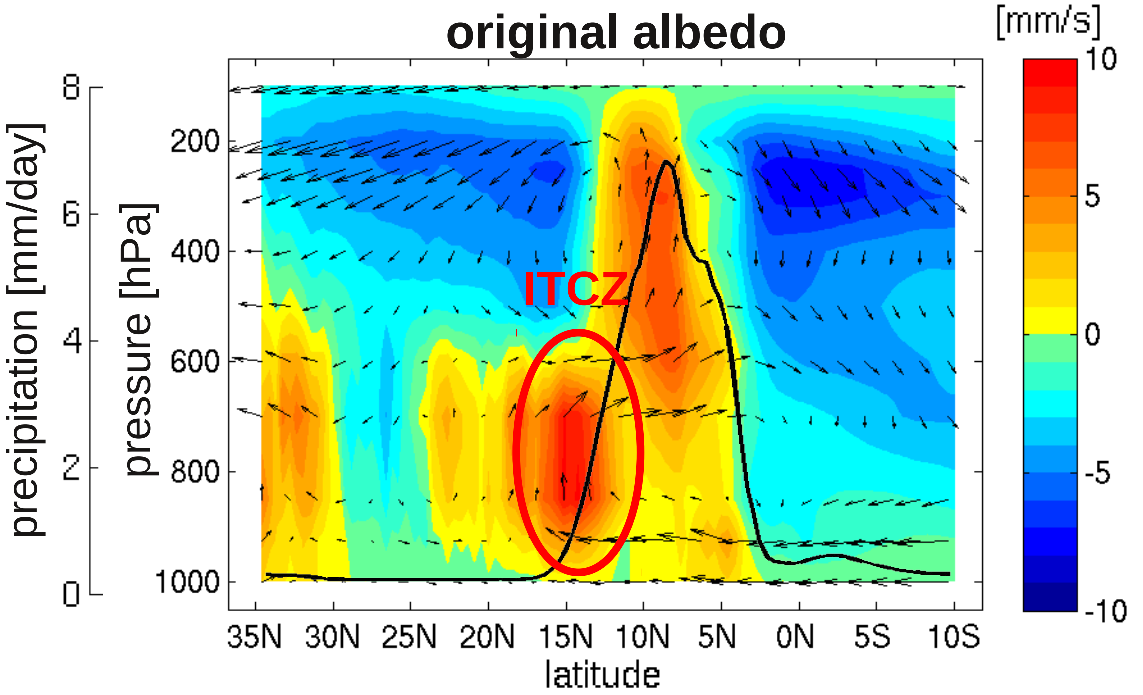
30° E
60° E

zonal mean (10W-10E)
vertical (and N-S) wind, precipitation
JJAS 1990-1995

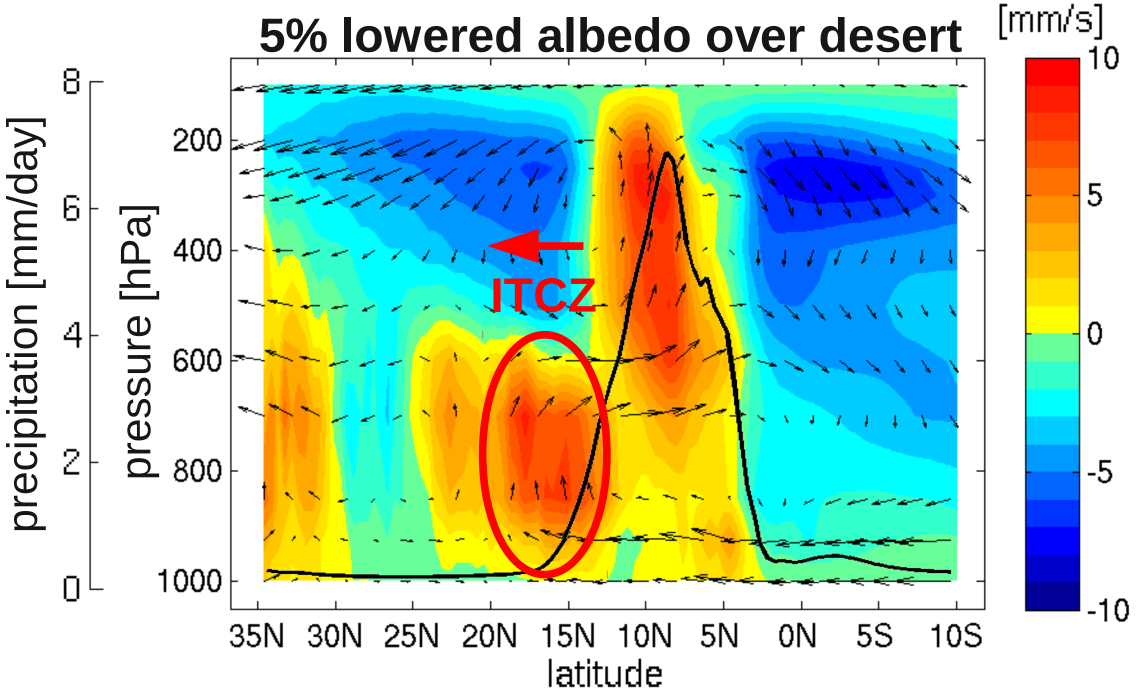
ERA-Interim



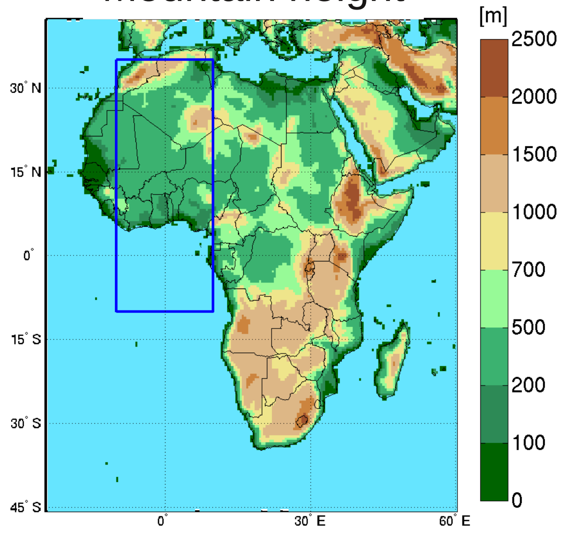
CRCM5 0.44°
original albedo



CRCM5 0.44°
5% lowered albedo over desert



Mountain height


[m]
2500
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700
500
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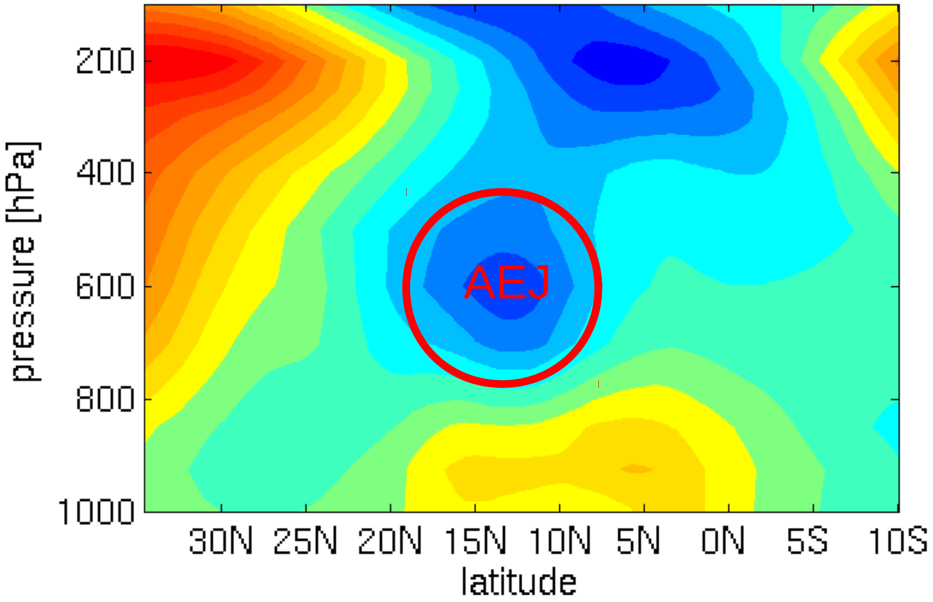
100
0
30° N
15° N
0°
15° S
30° S
45° S
0°
30° E
60° E

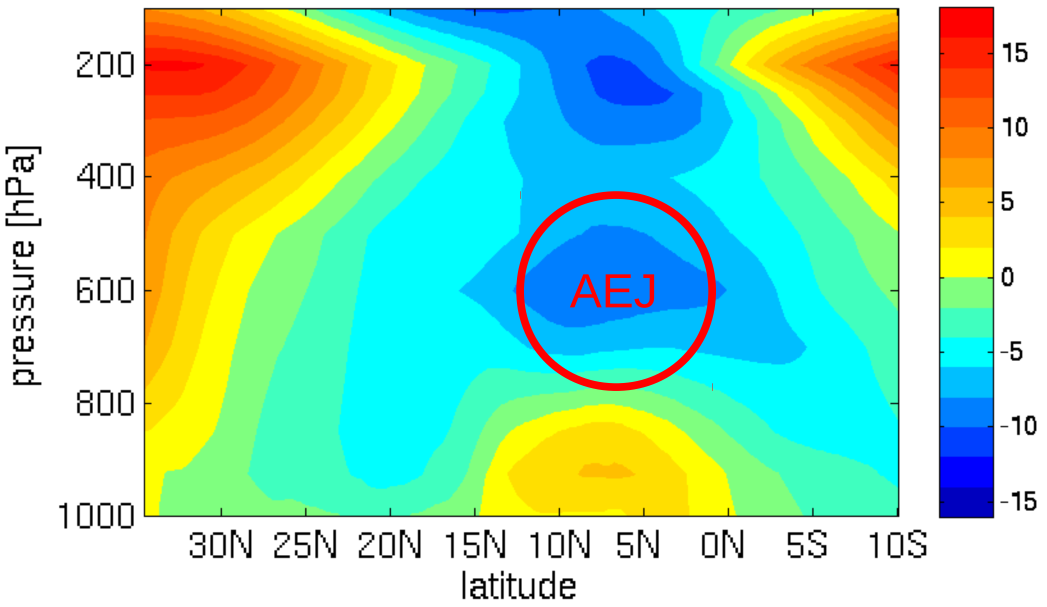
zonal wind

JJAS 1994 - 2008

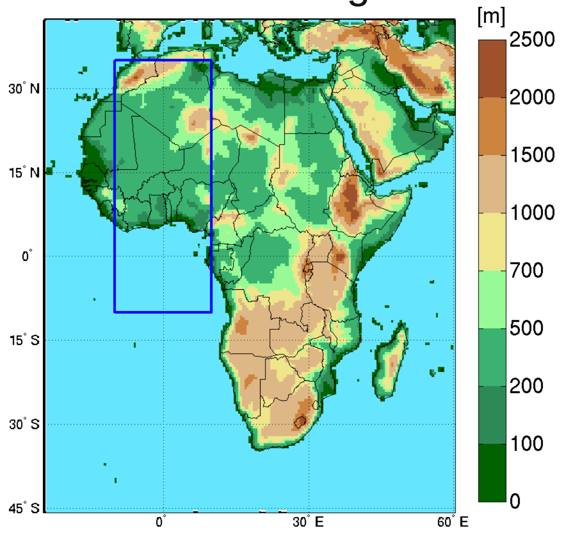
ERA-Interim



CRCM5 0.44°
original albedo



Mountain height


[m]
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30° N
15° N
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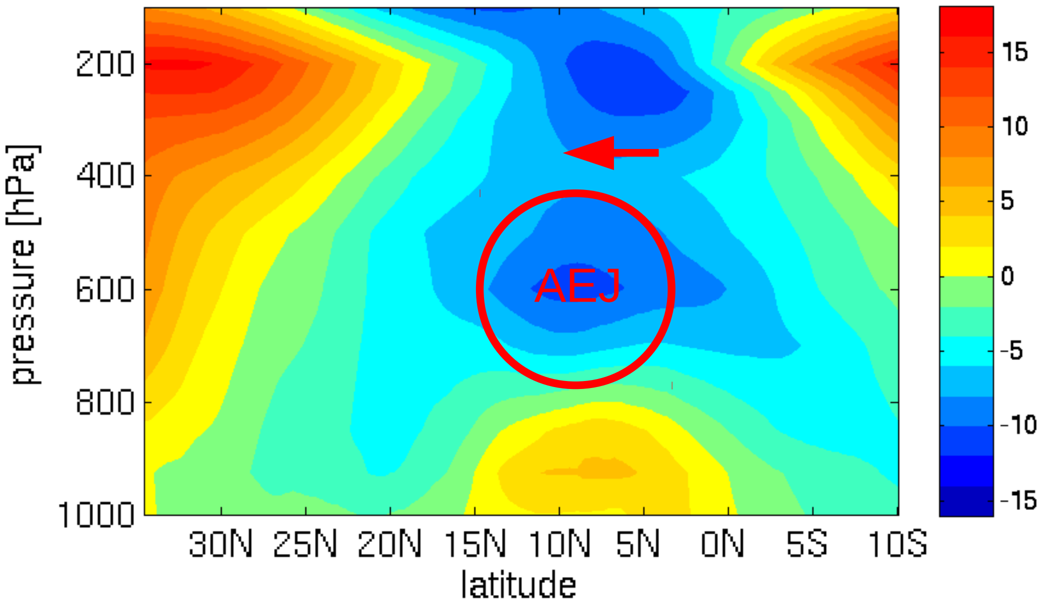
15° S
30° S
45° S
0°
30° E
60° E

CRCM5 0.44°
5% lowered albedo over desert



Conclusions / Outlook

- Cold bias in Sahara: under investigation => surface albedo
- Succeeds in capturing the main characteristics of the annual cycle of precipitation and its large geographical differences
- Summer dry bias in Sahel and on the Coast of the Gulf of Guinea: under investigation => convection
- Meridional cross-section over West Africa for summer shows
  - a good representation of the deep upward motion associated with the Hadley Cell
  - a good representation of location and intensity of maximum precipitation
  - a southward displacement of the low-level convergence and shallow upward motion associated with the Saharan heat low that is too far south over the Sahel
  - an African Easterly Jet that is at the right height and almost right strength, but located too far to the South

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Thank you

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Réseau canadien de modélisation et diagnostics du climat régional

UQÀM

Canada Environnement Canada Environement Canada

RPN
recherche en prévision numérique

Sponsors Acknowledgements

Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)
Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA)

MITACS

Hydro Québec

CRSNG
NSERC

Développement économique, Innovation et Exportation
Québec

OURANOS

Fonds de recherche sur la nature et les technologies
Québec

GEC3EG
GLOBAL ENVIRONMENTAL AND CLIMATE CHANGE CENTRE
CENTRE SUR LES CHANGEMENTS CLIMATIQUES ET L'ENVIRONNEMENT GLOBAL