21st century North Africa as simulated in the CCSM4/CESM1

Sam Levis
Terrestrial Sciences Section
CGD/NESL/NCAR
Boulder, Colorado, USA
Outline/Summary

• 21st c. North Africa progressively wetter/greener
• Photosynth. less limited by soil moisture due to
  – increased water use efficiency and
  – increased wet season precip
• The increase in veg. cover decreases the albedo

CAVEATS
1. Shortage of N delays vegetation response
2. DGVM feedbacks NOT included in what I show
The simulations

1. Transient **CCSM4CN** simulations
   A. 1850 to 2005
   B. 2006 to 2100 (RCP8.5)

2. Transient **CLM4CNDV** \(\text{BUT NO land use + wood harvest}\) driven with met data simulated in 1A and 1B
Pre-Industr. | ANN PRECIP (mm d^{-1} OR %) | 2080 to 2099 - PI

1986 to 2005 - PI | 2011 to 2030 - PI | 2046 to 2065 - PI
Examples of simulations with increased future precip:

- ECHAM5 (A1B) used in Scheiter and Higgins (2009)
- CLIMBER-2 (1%) Claussen et al. (2003)

-SSTs lag the land in warming; this enhances monsoon circulation; temporary?
-Increased humidity increases moist static energy and precipitation
Pre-Industrial

JAS SLP (hPa)

2080 to 2099 - PI

1986 to 2005 - PI

2011 to 2030 - PI

2046 to 2065 - PI

(hPa)
JAS sea-level pressure (hPa)  JJA
2080 to 2099 – PI  6 ka BP - PI

(image from CAM diagnostic package courtesy of B. Otto-Bliesner)
0-30°N  20°W-60°E

JANUARY  warmer...  JULY

2-m Temperature (K)

2-m Temperature (K)
JANUARY  0-30°N  20°W-60°E  JULY

P-E (mm d⁻¹)

Bowen Ratio (H/LE)

wetter?
drier
Soil Moisture Control on Photosynth.

Soil Moisture Control on Photosynth.

Soil Moisture top 3.4 m (kg m\(^{-2}\))

Soil Moisture top 3.4 m (kg m\(^{-2}\))

wetter!
JANUARY 0-30°N 20°W-60°E JULY

Leaf Area Index (m² m⁻²)

Surface Albedo

greener!
0-30°N  20°W-60°E

JANUARY  JULY

Area Burned (fraction)

more flammable
The talk so far...

- 21st c. North Africa progressively wetter/greener
- Photosynth. less limited by soil moisture due to
  - increased water use efficiency and
  - increased wet season precip
- The increase in veg. cover decreases the albedo

CAVEATS

1. Shortage of N delays vegetation response
2. DGVM feedbacks NOT included in what I show
Pre-Industrial PFT cover (%)
Pre-Industrial PFT cover (%)
Potential vegetation feedbacks

• Biogeophysical enhancement of NA Monsoon
  – Albedo
  – Evapotranspiration

• Biogeochemical
  – Net Ecosystem Exchange
  – Dust mobilization
Summary/Outline

• 21\textsuperscript{st} century N. Africa progressively wetter
• Photosynth. less limited by soil moisture due to
  – increased water use efficiency and
  – increased wet season precip
• The increase in veg. cover decreases the albedo

CAVEATS
1. Shortage of N delays veg. response... REALISTIC?
2. DGVM feedbacks NOT included in what I show
Extra slides...
PFT trends
0-30°N 20°W-60°E
0-30°N 20°W-60°E

Soil Moisture top 10 cm (kg m⁻²)

JANUARY

Soil Moisture top 10 cm (kg m⁻²)

JULY