Application of RegCM3 for regional climate studies

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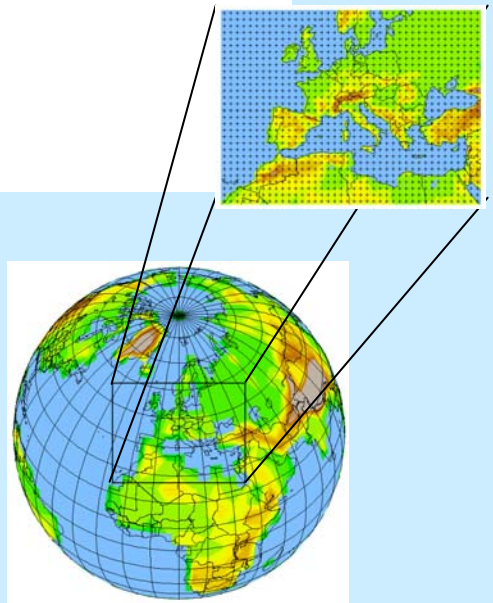
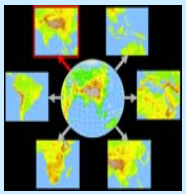


RegCM3
International Centre for Theoretical Physics, Trieste

Filippo Giorgi, Xunqiang Bi, Jeremy Pal, Erica Coppola, Nellie Elguindi, Elfatih Eltahir, Raquel Francisco, Sara Rauscher, Sonia Seneviratne, Eric Small, Ashraf Zakey, Fabien Solmon, and many more

Summary of RegCM3

- Dynamics:
  - MM5 Hydrostatic (Grell et al 1994)
  - Non-hydrostatic (Bi; in progress)
- Radiation:
  - CCM3 (Kiehl 1996)
- Large-Scale Clouds & Precipitaion:
  - SUBEX (Pal et al 2000)
- Cumulus convection:
  - Grell (1993) + FC80 Closure
  - Anthes-Kuo (1977)
  - Emanuel (1991)
  - Betts-Miller (1993)
- Boundary Layer:
  - Holtslag (1990)
- Tracers/Aerosols/Mineral Dust:
  - Qian et al (2001); Solmon et al. 2006
  - Zakey et al (2006)
- Land Surface:
  - BATS (Dickinson et al 1991)
  - SUB-BATS (Giorgi et al 2003)
  - CLM (Dai et al 2003, In progress)
  - IBIS (Foley; In progress)
- Ocean Fluxes
  - Zeng et al (1998)
  - BATS (Dickinson et al 1991)
- Computations
  - Parallel Code (Yeh, Gao)
  - Multiple Platforms
  - More User-Friendlier Code



Applications

High resolution climate change simulation for the Jordan River Project with RegCM3

by
Simon Krichak, P. Alpert, R. Samuels, J. Breitgand

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Resolution: 25 km/18L

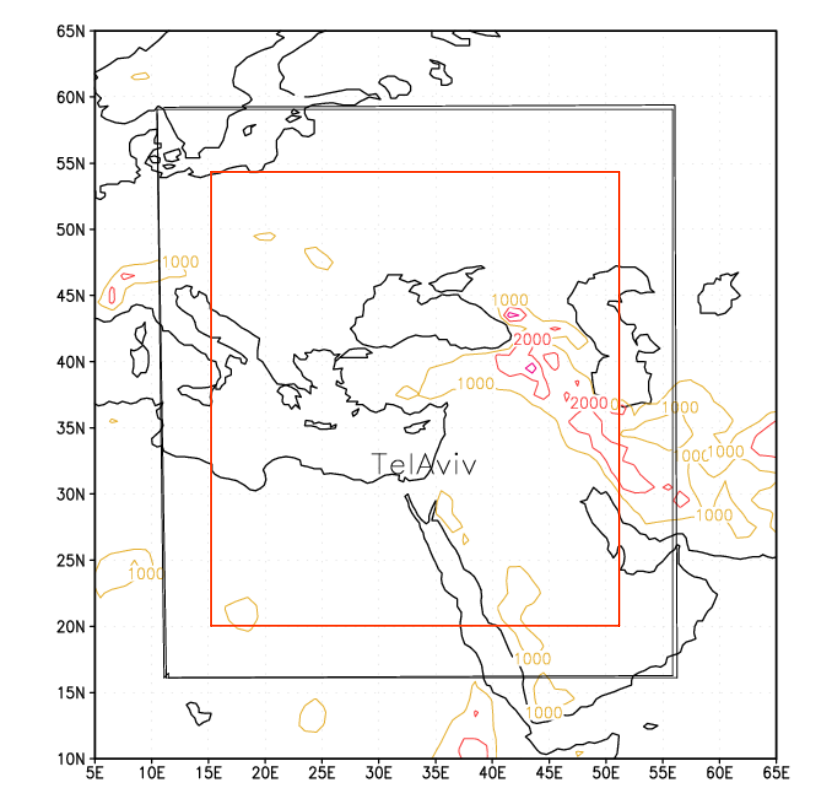
Period of simulation: 1960-2060

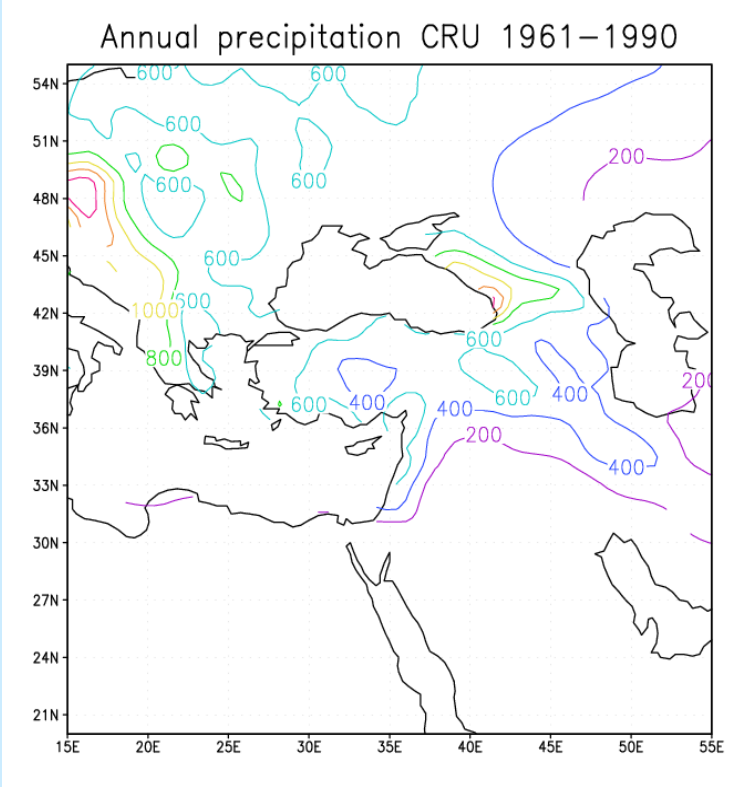
Driving data: ECHAM5/OM

GHG emission scenario: A1B

Optimal domain configuration

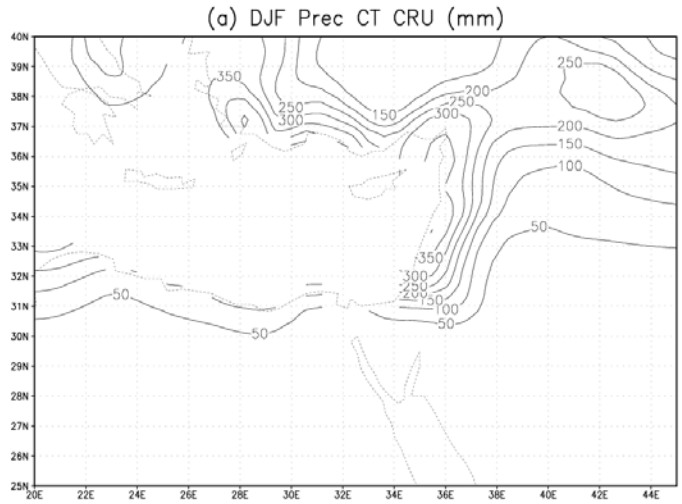
accounting for climate effects of topography of the region

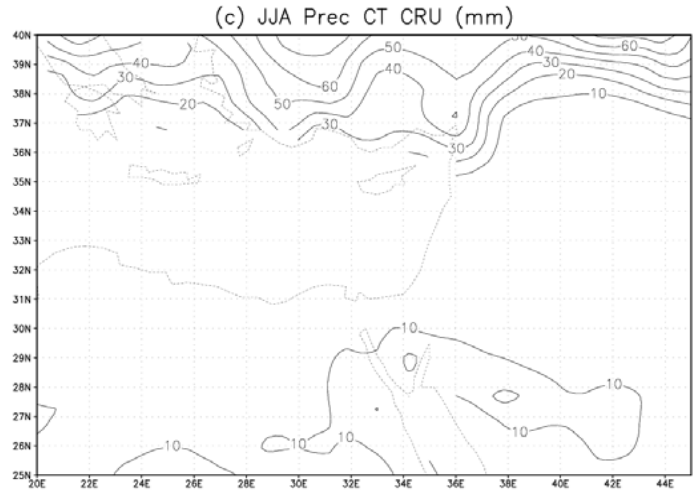


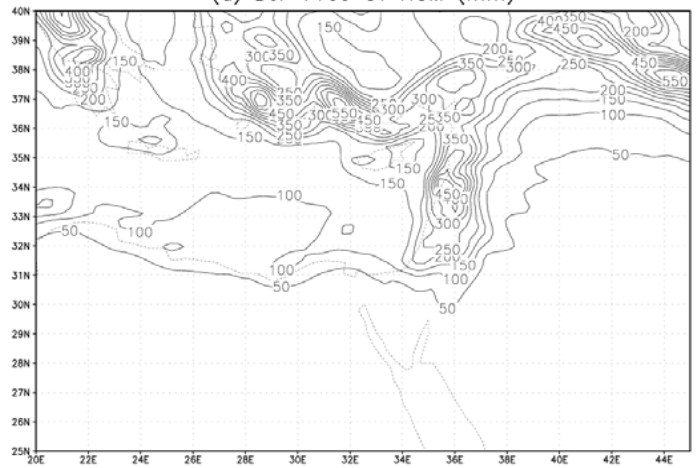


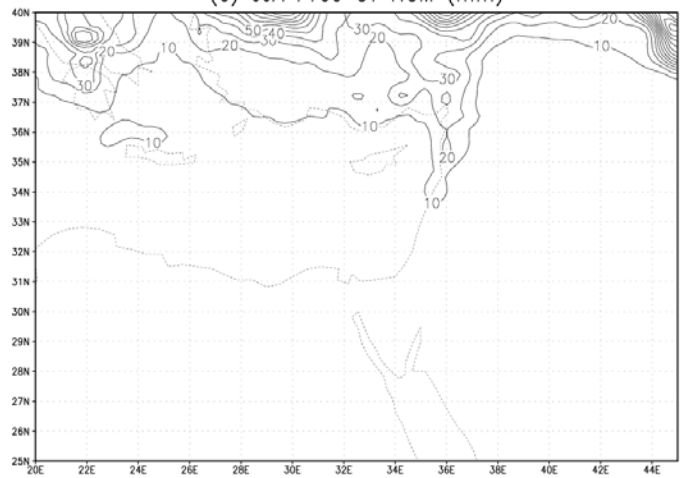
Krichak et al. 2009 Climate Dynamics

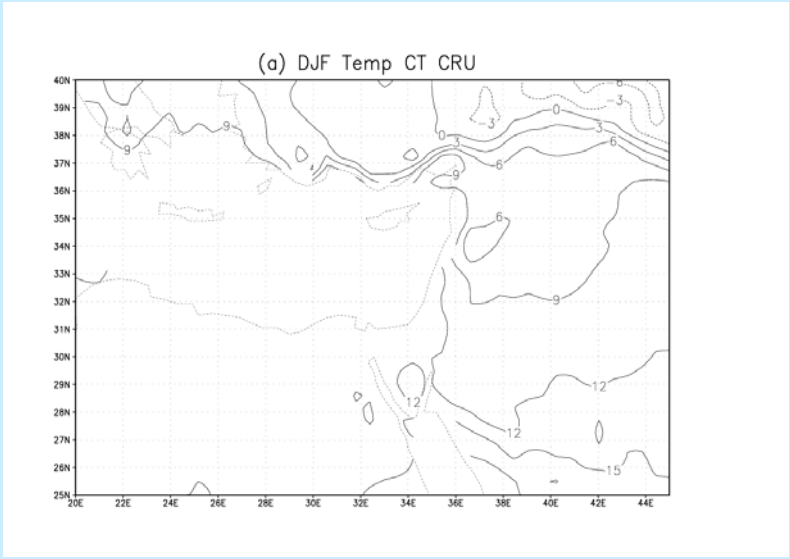
Precipitation

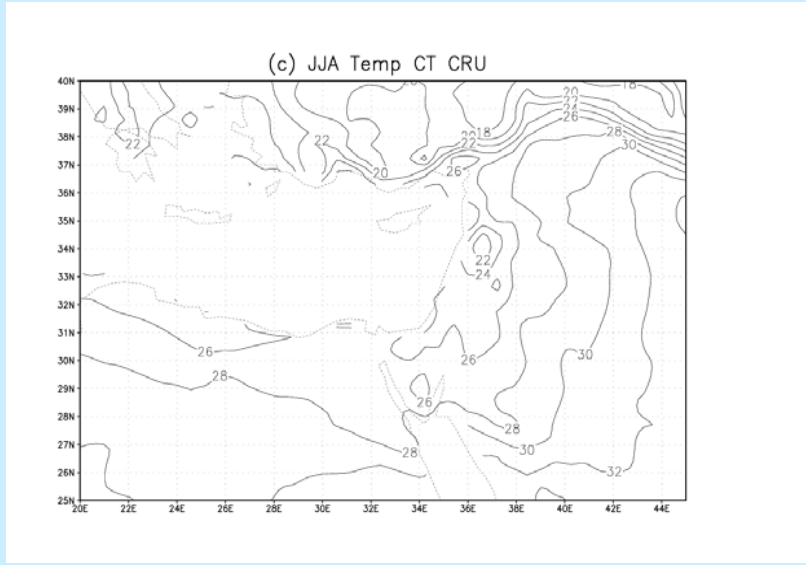


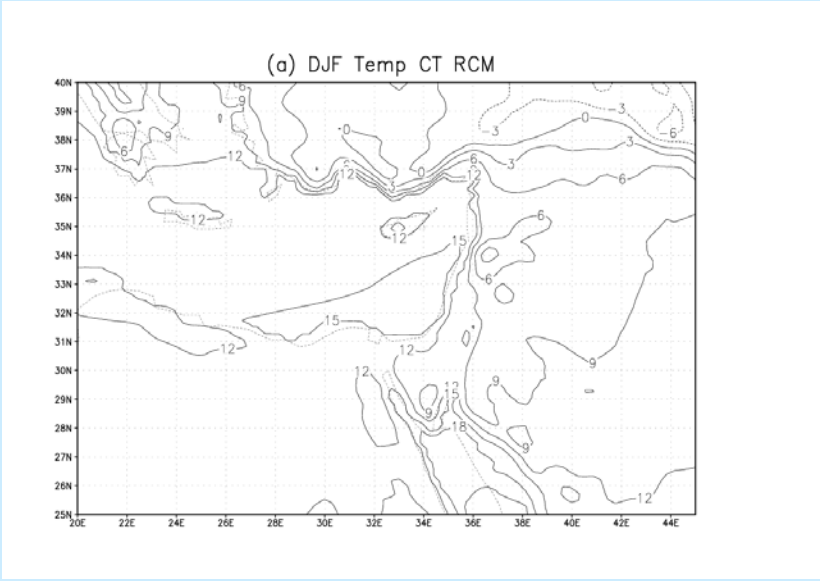


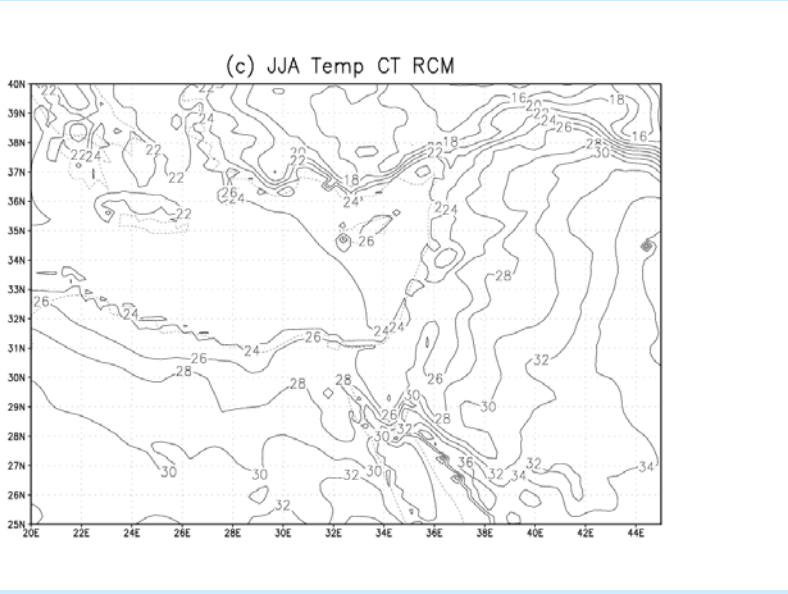




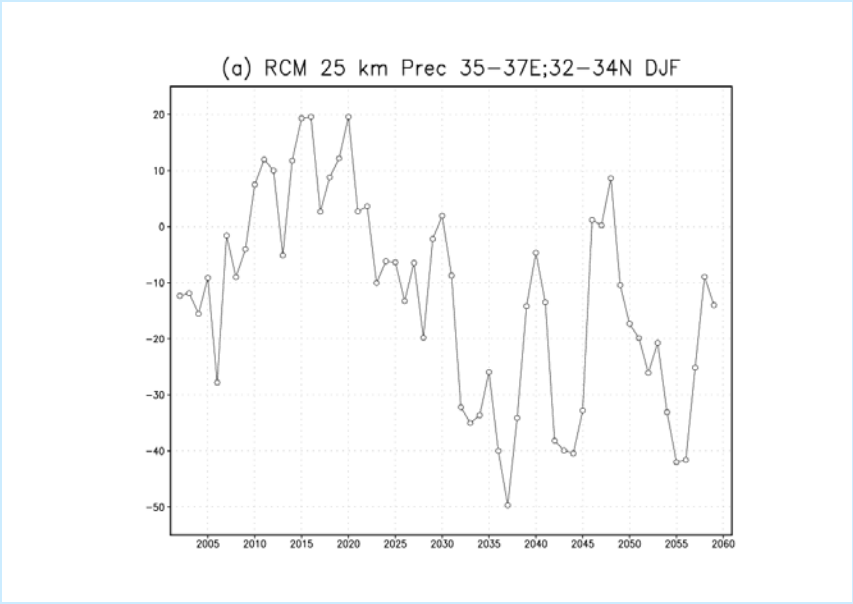

(a) DJF Temp CT CRU

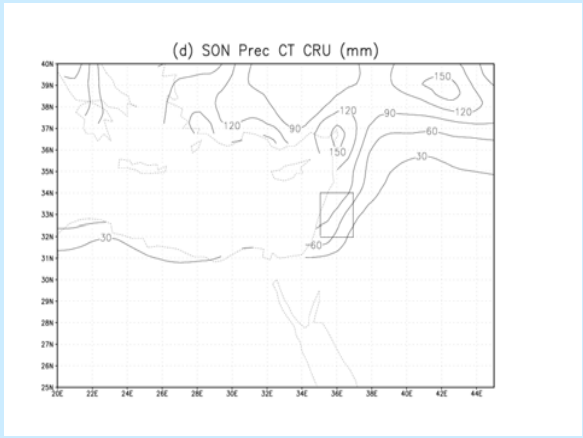

(c) JJA Temp CT CRU

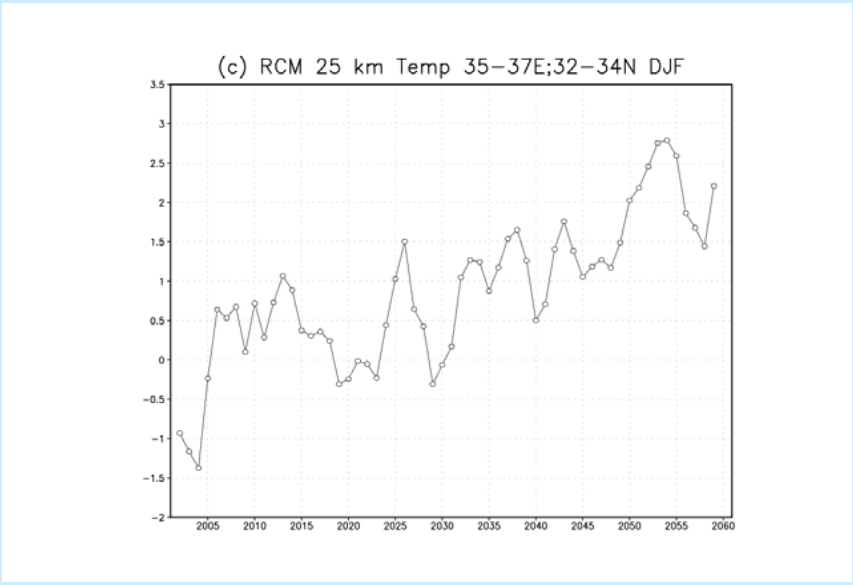

(a) DJF Temp CT RCM

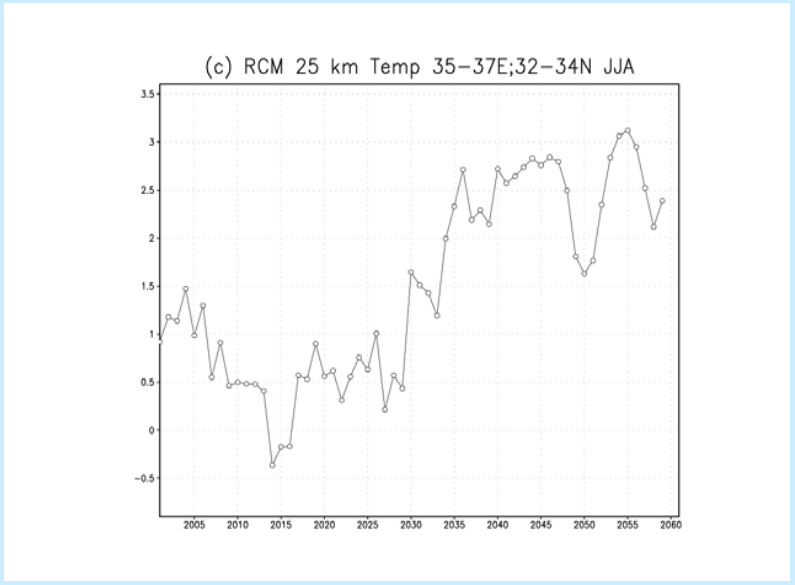

(c) JJA Temp CT RCM

Anthropogenically induced climate change trends till 2060 vs multiyear mean for 1961-1990

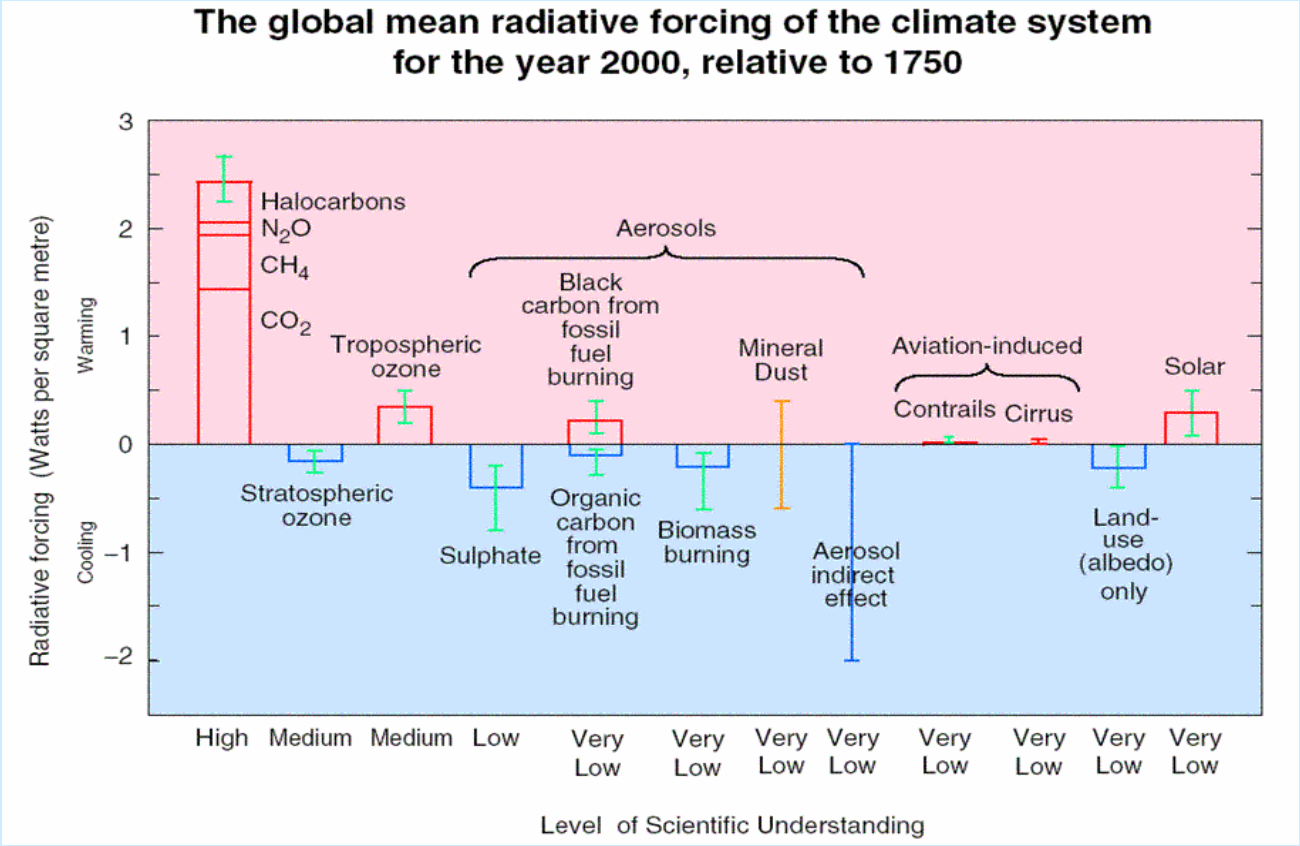








Aerosols in RegCM3



- **Tropospheric aerosols : Importance of regional scale processes**
- **First step : simulation of sources, physico-chemical nature and atmospheric content of aerosol**
- **Second step : radiative forcing, climatic and ecological feedback**

Aerosols in RegCM3

- **General approach** ⟺ Tracer model / RegCM3 (from Giorgi et al., Qian et al.)

$$\frac{\partial \chi}{\partial t} = -\bar{V} \cdot \nabla \chi + F_H + F_V + T_{CUM} + S_\chi - R_{w,ls} - R_{w,cum} - D_{dep} + \sum Q_p - Q_l$$

Transport | Primary Emissions | Removal terms | Physico – chemical transformations

Strongly dependent on the nature of the tracer

- **Particles and chemical species considered.**

SO_2 ⟺ SO_4^{--}		**BC** (soot)		**OC** (total organic carbon)		**DUST** (4 bins)			
Aqueous and gazeous conversion (Qian et al., 2001)		*Hydrophilic (20% at emission)*	*Hydrophobic* (80%at emission)	*Hydrophilic (50%at emission)*	*Hydrophobic(50%at emission)*	0.01-1 µm	1-2.5 µm	2.5-5 µm	5-20 µm

Aerosols processes

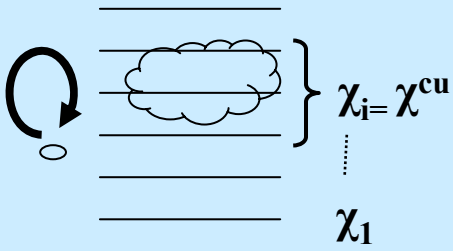
- **Transport of tracers**

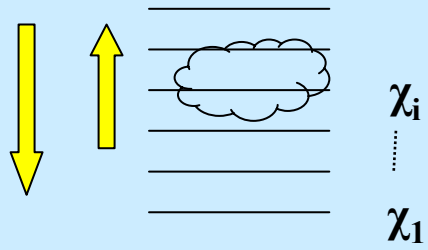
Advection / diffusion ⟺ Cloud mmr (mm5 options)

- **Convective transport**

Based on Grell scheme mass fluxes

Simple mixing hypothesis





- **Wet removal by large scale rainfall:**

$$R_{w,ls} = \chi f_{sol}(\chi)\frac{1-\exp\left(-\Delta t/\tau_{w,ls}\right)}{\Delta t}$$

(Giorgi et al., 1989)

- **Wet removal by cumulus convective rainfall:**

$$R_{w,cum} = \chi f_{cum}\ f_{sol}(\chi)\frac{1-\exp\left(-\Delta t/\tau_{w,cum}\right)}{\Delta t}$$

$\tau_{w,cum} \sim$ 20min

- **Dry deposition : 1 prescribed deposition velocities (nature tracer / surface)**
  2 on-line settling and dry deposition.

Aerosols processes

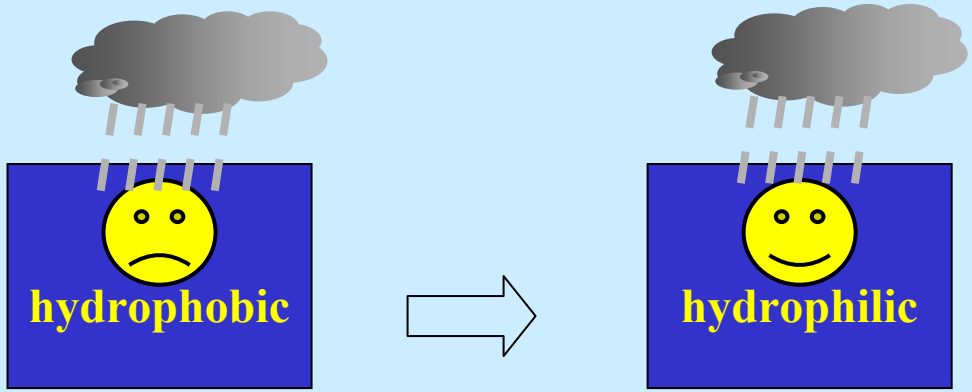
- **Sulfur Aerosol Model** (Kasibhalta et al., 1997, Qian et al., 2001)

Gas phase: $SO_2 + OH \rightarrow SO_4^{2-} + HO_2$

Aqueous phase: $HSO_3^- + H_2O_2 \rightarrow SO_4^{2-} + 2H^+ + HO_2$

[OH] : constant profile + diurnal evolution (max for cosθ = 1)

- **Aging of carbon aerosol** (Cooke et al.,1999)



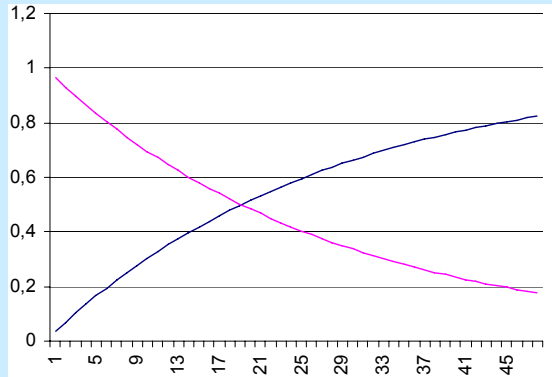
Simple approach :

τ_{aging}= 1,15 days

Deposition (dry, wet)

Optical properties

CCN



Aerosol dust source and deposition parameterization in RegCM

Input parameters

Soil texture (12 types, USDA)

Soil erodible dry agregates distribution

Land surface properties (BATS)

(roughness, soil humidity, cover fractions)

Regcm atmospheric variables

(surface wind, air temperature, air density)

DUST emission scheme

Saltation (Marticorena et al. 1995)

Roughness and humidity correction

Sand-blasting (Alfaro et al., 1997, 2001)

Dust flux distribution

(3 log-normal emission modes)

4 Transport bins

0.01 -1 µm

1 - 2.5 µm

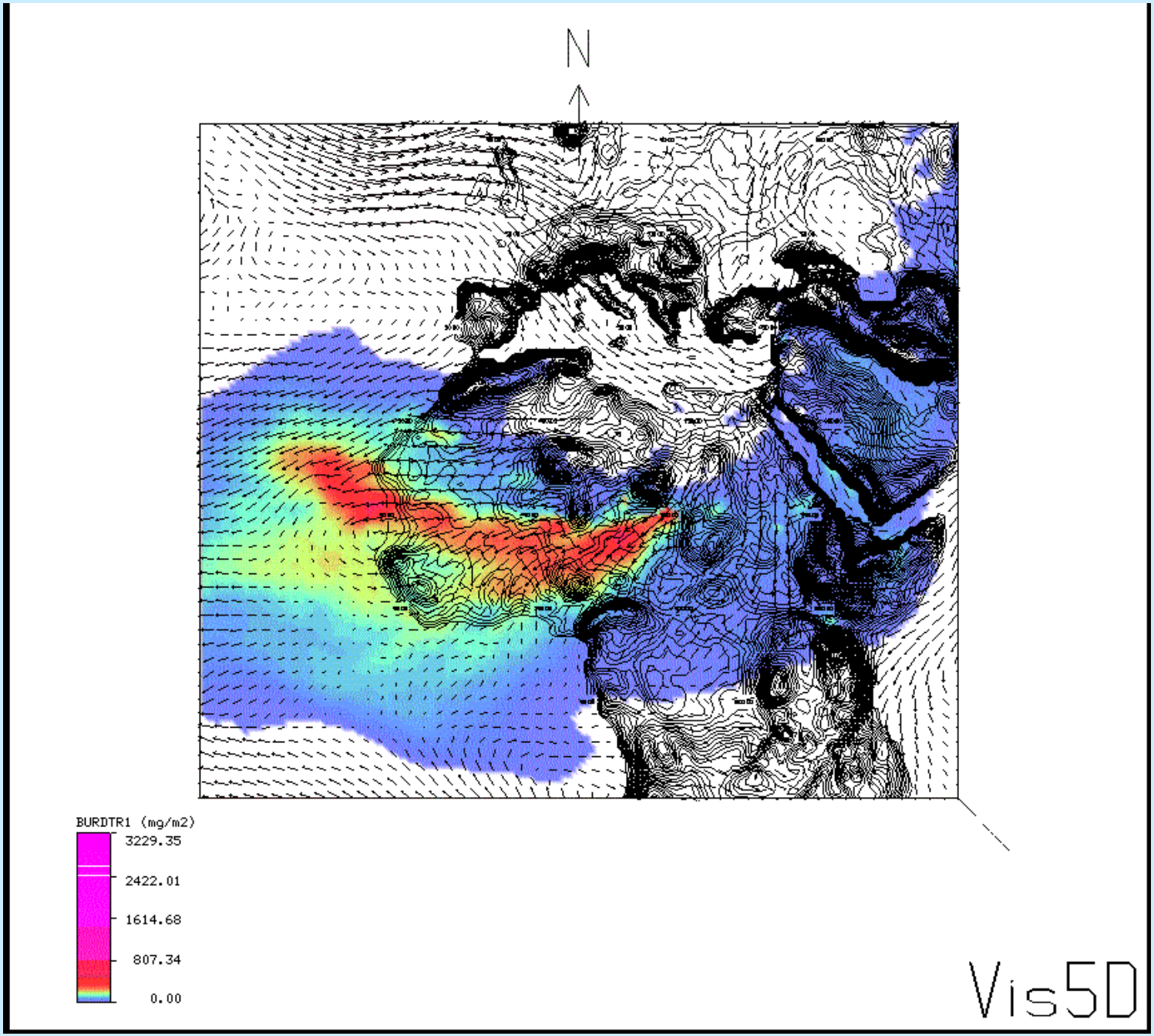
2.5 - 5µm

5 - 20 µm

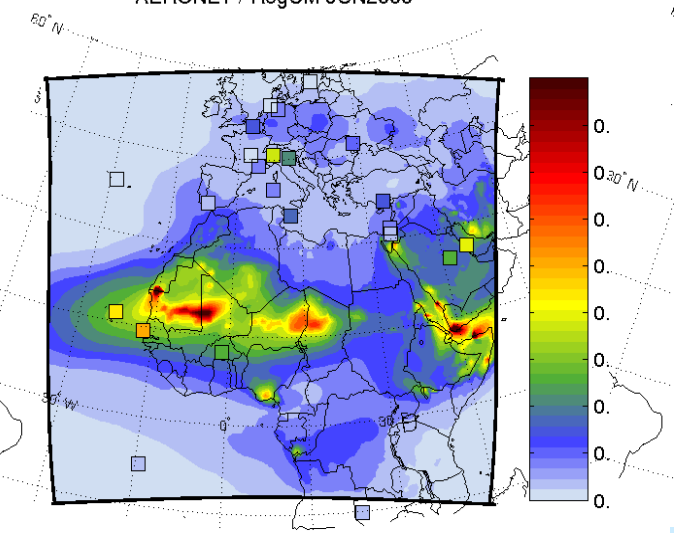
AOP / radiation

Size dependent settling and surface déposition

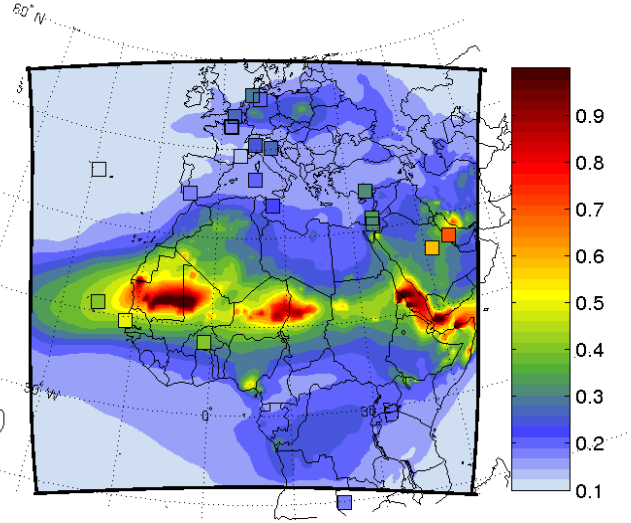
DUST emission and transport, Feb 2000



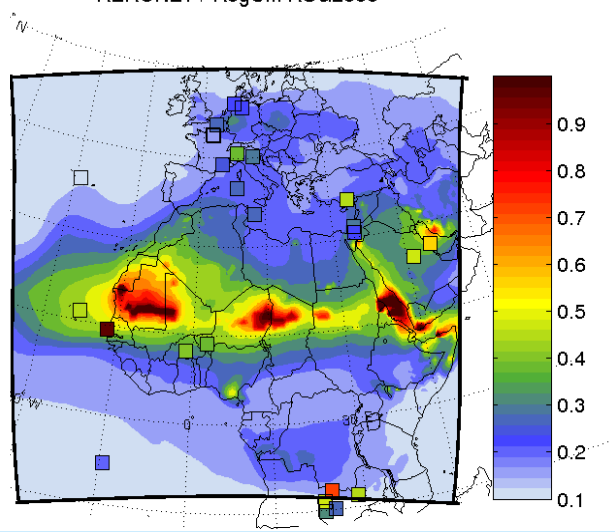
AERONET / RegCM JUN2000



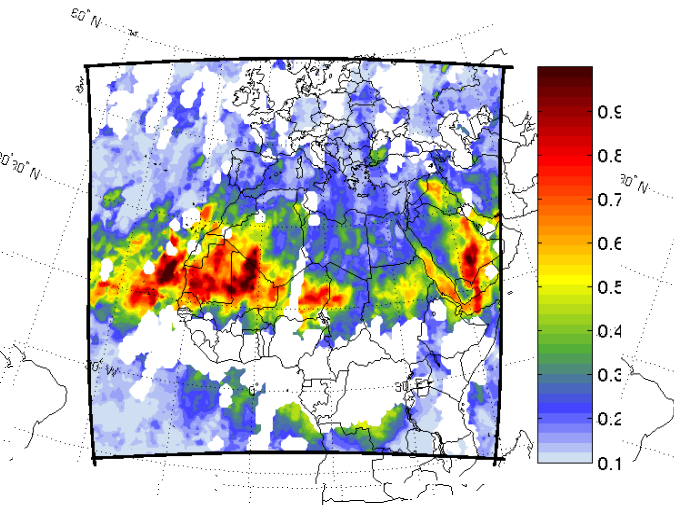
AERONET / RegCM JUL2000



AERONET / RegCM AUG2000



MISR JUN2000



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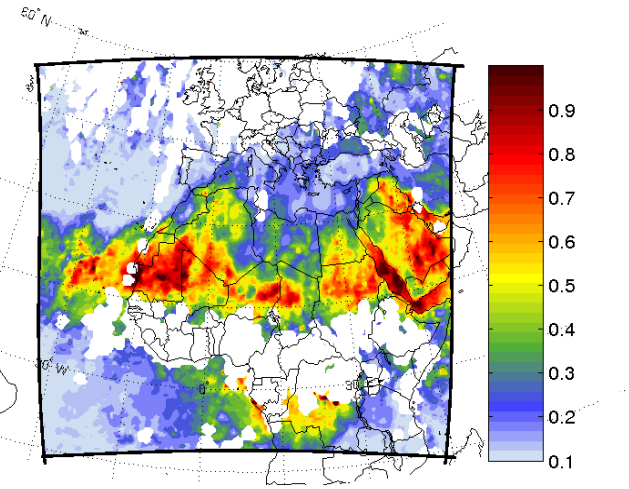
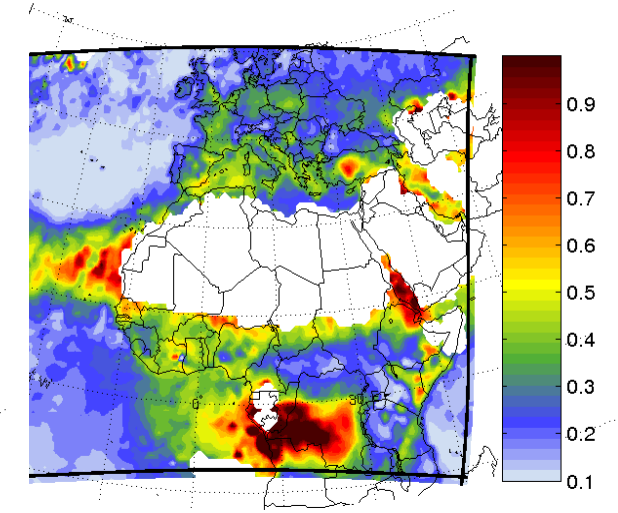


MODIS AUG2000



Thank you