Development and testing of RegCM version 4, RegCM4 The RegCM4 Team Abdus Salam ICTP, Trieste, Italy

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A brief history of the RegCM modeling system

- RegCM1 (1989)
 - Dickinson et al., CCH, 1989; Giorgi , JC, 1990
- RegCM2 (1993)
 - Giorgi et al., MWR, 1993a,b
- RegCM2.5 (1999)
 - Giorgi and Mearns JGR, 1999
 - JGR Special Issue 1999
- RegCM3 (2006)
 - TAC Special Issue 2006
 - Pal et al., BAMS, 2007
- <u>RegCM4 (2011)</u>
 - Giorgi et al., CR, 2011
 - CR Special Issue 2011



ICTP Regional Climate Model RegCM4, Basic model (Giorgi et al. 2011)

• Dynamics:

Hydrostatic (Giorgi et al. 1993a,b) Adaptable to any region <u>Non-hydrostatic in progress</u>

- Radiation: CCM3 (Kiehl 1996)
- Large-Scale Clouds & Precipitaion: SUBEX (Pal et al 2000)
- Cumulus convection:

Grell (1993) Anthes-Kuo (1977) MIT (Emanuel 1991) <u>Mixed convection</u> <u>Tiedtke (in progress)</u>

- Planetary boundary layer: <u>Modified Holtslag</u>, Holtslag (1990) <u>UW-PBL (O'Brien et al. 2011)</u>
- Land Surface: BATS (Dickinson et al 1993) SUB-BATS_(Giorgi et al 2003) CLM (Steiner et al. 2009)
- Ocean Fluxes
 BATS (Dickinson et al 1993)
 Zeng (Zeng et al. 1998)
 Diurnal SST
- Configuration
 Adaptable to any region
 <u>Tropical belt configuration</u>
- Extensive code remake

ICTP Regional Climate Model RegCM4, coupled components

Coupled ocean

<u>MIT ocean model (Artale et al.</u> <u>2010)</u> <u>ROMS (Ratnam et al. 2009)</u>

Interactive lake

<u>1D thermal lake mode reactivated</u> (Hostetler et al. 1994; Small et al. 1999)

Interactive biosphere
 Available in CLM but never tested

Interactive hydrology
 <u>CHYM hydrological model</u>
 <u>available in "off line mode"</u>

 Aerosols: OC-BC-SO4 (Solmon et al 2005) Dust (Zakey et al 2006) <u>Sea Salt (Zakey et al. 2009)</u>

Gas phase chemistry: <u>Various schemes and solvers</u> <u>tested (Shalaby et al. 2011)</u> <u>CBMZ-Sillmann solver being</u> <u>implemented</u>



Land surface sub-grid model Giorgi et al. (2003)

- Define a regular fine scale sub-grid for each coarse scale model grid-box.
 - Landuse, topography, and soil texture are characterized on the fine grid.
- Disaggregate climatic fields from the coarse grid to the fine grid (e.g. temperature, water vapor, precipitation).
 - Disaggregation technique based on the elevation differences between the coarse grid and the fine grid.
- Perform BATS surface physics computations on the fine grid.
- Reaggregate the surface fields from the fine grid to the coarse grid.







60-km



• Particles and chemical species considered (12 tracers).

SO ₂ SO ₄ -	BC (soot)		OC (total organic carbon)		DUST (4 bins)				Sea-Salt (2 bins)	
Aqueous and gazeous conversion (Qian et al., 2001)	Hydrophilic (20% at emission)	Hydrophobic (80%at emission)	Hydrophilic (50%at emission)	Hydrophobic(5 0%at emission)	0.01-1 µm	1-2.5 μm	2.5-5 μm	5-20 μm	0.05-1 μm	1.0-10 μm

Qian and Giorgi 1999; Qian et al. 2001; Solmon et al. 2006; Zakey et al. 2006; 2008

Effect of Saharan dust radiative forcing on African monsoon precipitation

MISR AOD

RegCM AOD



JJA Mean precipitation (mm/day)





(DUST -NODUST, JJA precipitation)



Tropical band configuration (Coppola et al. 2011)



RegCM4

TRMM

Precipitation AMJJAS 1998-2002 ERA-Interim LBC





Experimental set-up

- CORDEX domain specifications
- Simulation period
 - 1998-2002 (Availability of TRMM data)
 - ERA-Interim LBC
- Base model configuration same for all domains
 - Mixed convection (Grell/Land Emanuel/Ocean)
 - SUBEX resolved scale precipitation
 - Modified Holtslag PBL
 - BATS
 - CCM3 radiation
- "Customization parameters"
 - Precipitation efficiency (Grell convection)
 - Evaporation rate of falling drops (SUBEX)
 - Autoconversion threshold (SUBEX)
 - Minimum stomatal resistance
- Sensitivity experiments
 - CLM
 - UW-PBL
 - Convection options



Wind and Precipitation



Seasonal cycle of precipitation





Sensitivity of precipitation to convection scheme (Em. Vs. Grell)





Sensitivity of precipitation to land surface scheme (CLM vs. BATS)

Mexico

C. America





Sensitivity of precipitation to convection parameters (wet vs. dry)



Sensitivity of precipitation to convection parameters (Wet vs. Dry)





Sensitivity of precipitation to convection and PBL schemes



Temperature and precipitation bias



Temperature and precipitation annual cycle







Precipitation and wind over East Asia



Conclusions

- Version RegCM4.1 currently being finalized and frozen
- Version RegCM4.2 to be released by the end of 2011
 - Tiedtke convection scheme
 - Final UW_PBL scheme
 - Coupled gas phase chemistry
 - Coupled ROMS
- Further testing and optimization for different CORDEX domains
- Application to different CORDEX domains within the RegCNET community
 - Africa, Europe, S. America, C. America, East Asia, South Asia
- Further test and development of the tropical band configuration
- Planning for the next version of the model
 - Non-hydrostatic dynamics
 - Cloud/aerosol microphysics
 - Earth system component coupling

