

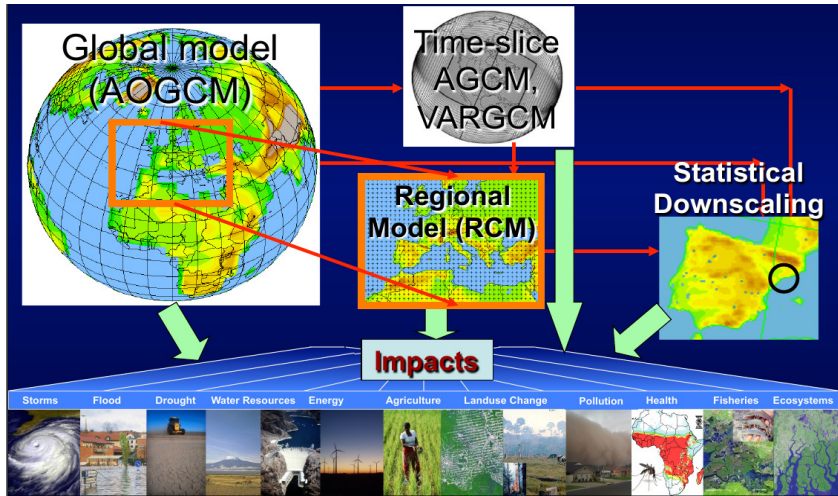
ICTP RegCM

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South Caucasus-Black Sea Regional Climate Conference
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Downscaling regional climate information for impact assessment studies



Strategy Motivation: The resolution of GCMs

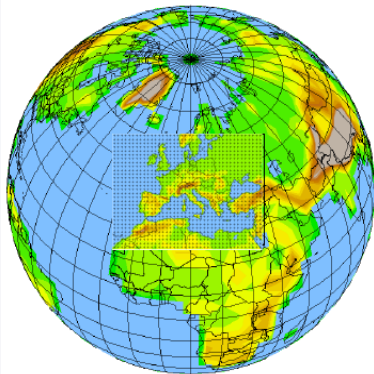
Motivation: The resolution of GCMs is still too coarse to capture regional and local climate processes.

Technique: Regional Climate Model (RCM) is one way nested within a GCM in order to locally increase the model resolution.

- **Atmospheric** Initial conditions (IC) and lateral boundary conditions (LBC) for the RCM are obtained from the GCM (Climate projection) or Reanalysis (perfect LBC Hindcast).
- **Climate** boundary conditions are the same of the driving GCM : the RCPs in CMIP5

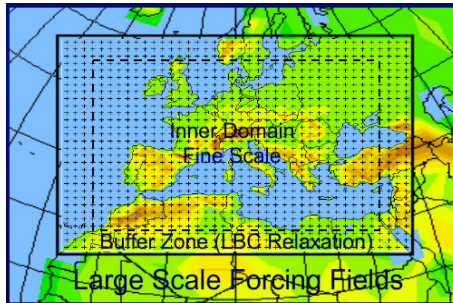
Strategy: The GCM simulates the response of the general circulation to the large scale forcings, the RCM simulates the effect of sub-GCM-grid scale forcings and provides fine scale regional information

- **Technique borrowed from NWP**



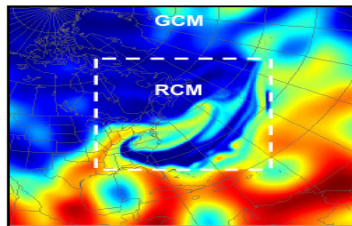
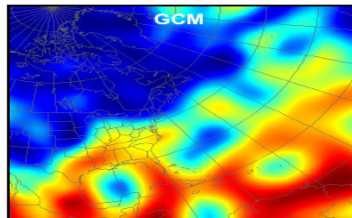
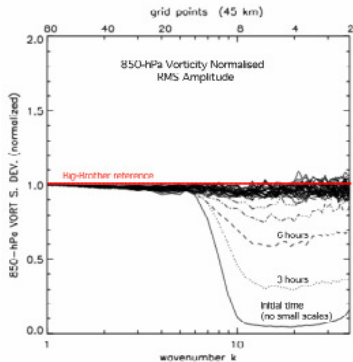
Lateral boundary conditions

$$\frac{\partial \alpha}{\partial t} = F(n)F_1 \times (\alpha_{LBC} - \alpha_{mod}) - F(n)F_2 \times \Delta_2(\alpha_{LBC} - \alpha_{mod})$$



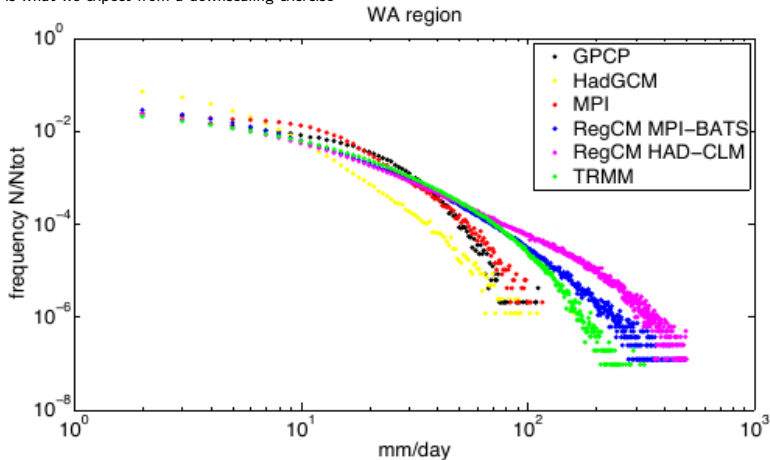
Dynamical Downscaling

Dynamical Downscaling: Generation of small scales by a high-resolution RCM driven by low-resolution GCM data (See 900 hPa specific humidity right) (From R. Laprise)



Added value: Extremes Daily precip PDFs over WA

The GCM is close to the coarse resolution data, the RCMs to the high resolution data
This is what we expect from a downscaling exercise



Some key projects and literature

- **Review papers:** Giorgi and Mearns (1991), McGregor (1997), Giorgi and Mearns (1999), Giorgi et al. (IPCC 2001), Leung et al. (2003), Mearns et al. (2003), Wang et al. (2004), Giorgi (2006), Rummukainen (2010)
- **European projects:** PRUDENCE, AMMA, ENSEMBLES, CECILIA, CLARIS, ACQWA
- **Intercomparison projects:** RMIP, NARCCAP, NEWBALTIC, ARCMIP, PLATIN, ARC, NAMAP, QUIRCS, Transferability
- **Special issues:** JGR 1999; JMSJ 2004; TAC 2006; CC 2007; MAP 2004, 2008; CCH 2006; MET.-ZEIT. 2008; CR 2012; CC 2014.

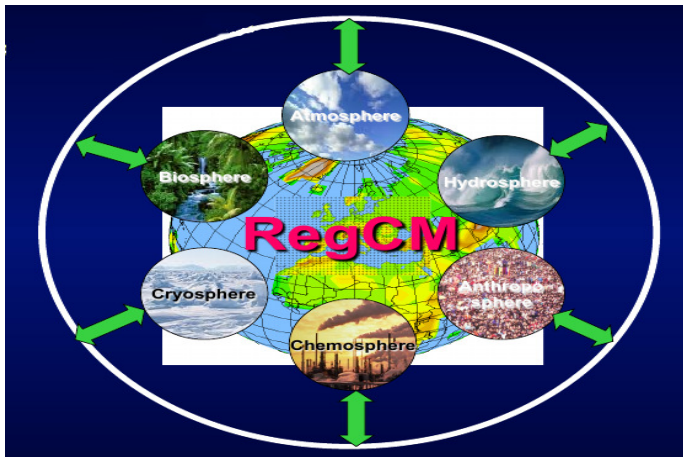
Regional Climate Modeling - Advantages

- **Physically based downscaling**
 - Comprehensive climate modeling system
- **Wide variety of applications**
 - Process studies
 - Paleoclimate
 - Climate change
 - Seasonal prediction
- **High resolution through multiple nesting**
 - currently <10 to 50 km grid interval

Regional Climate Modeling - Limitations

- One-way nesting
 - No regional-to-global feedbacks
- Technical issues in the nesting technique
 - Domain, LBC procedure, physics, etc.
- Not intended to correct systematic errors in the large scale forcing fields
 - Always analyse first the forcing fields
- *Computationally demanding*

Towards the development of a regional Earth System Model



The RegCM regional climate model system

- RegCM1 (1989)
 - Dickinson et al. (1989), Giorgi and Bates (1989)
- RegCM2 (1993)
 - Giorgi et al. (1993a,b)
- RegCM2.5 (1999)
 - Giorgi and Mearns (1999)
- RegCM3 (2007)
 - Pal et al. (2007)
- RegCM4 (2012)
 - Giorgi et al. (2012)

The ESP RegCM and Regional Climate research NETwork, RegCNET



The ICTP regional climate model system

RegCM4 (Giorgi et al. 2012, CR SI 2012)

- Dynamics:
 - Hydrostatic (Giorgi et al. 1993a,b)
 - Non-hydrostatic (MM5 core)
- Radiation:
 - CCM3 (Kiehl 1996)
 - RRTM (Solmon)
- Large-Scale Precipitation:
 - SUBEX (Pal et al 2000)
 - Explicit microphysics (Nogherotto, WSM5)
- Cumulus convection:
 - Anthes-Kuo (1977)
 - Grell (1993)
 - MIT (Emanuel 1991)
 - Tiedtke (1989) (4 schemes)
 - Kain-Fritsch (1990), Kain (2004)
 - Mixed and shallow convection
- Planetary boundary layer:
 - Modified Holtslag, Holtslag (1990)
 - UW-PBL (O'Brien et al. 2011)
- Land Surface:
 - BATS (Dickinson et al 1993)
 - SUB-BATS (Giorgi et al 2003)
 - CLM3.5 (Steiner et al. 2009)
 - CLM4.5 (Oleson et al. 2012)
- Ocean Fluxes
 - BATS (Dickinson et al 1993)
 - Zeng (Zeng et al. 1998)
 - Diurnal SST
 - Fully coupled Ocean Model (MIT or ROMS)
- Configuration
 - Adaptable to any region
 - Tropical belt configuration

Coupled Components

- Coupled ocean
 - MIT ocean model (Artale et al. 2010)
 - ROMS (Ratnam et al. 2009)
- Interactive lake
 - 1D thermal lake mode reactivated (Hostetler et al. 1994; Small et al. 1999)
- Interactive biosphere
 - Available in CLM4.5
- Interactive hydrology
 - CHYM hydrological model
- Aerosols:
 - OC-BC-SO₄ (Solmon et al 2005)
 - Dust (Zakey et al 2006)
 - Sea Salt (Zakey et al. 2009)
- Gas phase chemistry:
 - Various schemes and solvers tested
 - CBMZ + Sillmann solver implemented (Shalaby et al. 2012)

RegCM domains used

