ICTP RegCM

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ICTP - Earth System Physics Section

Advanced School on Regional Climate Modeling
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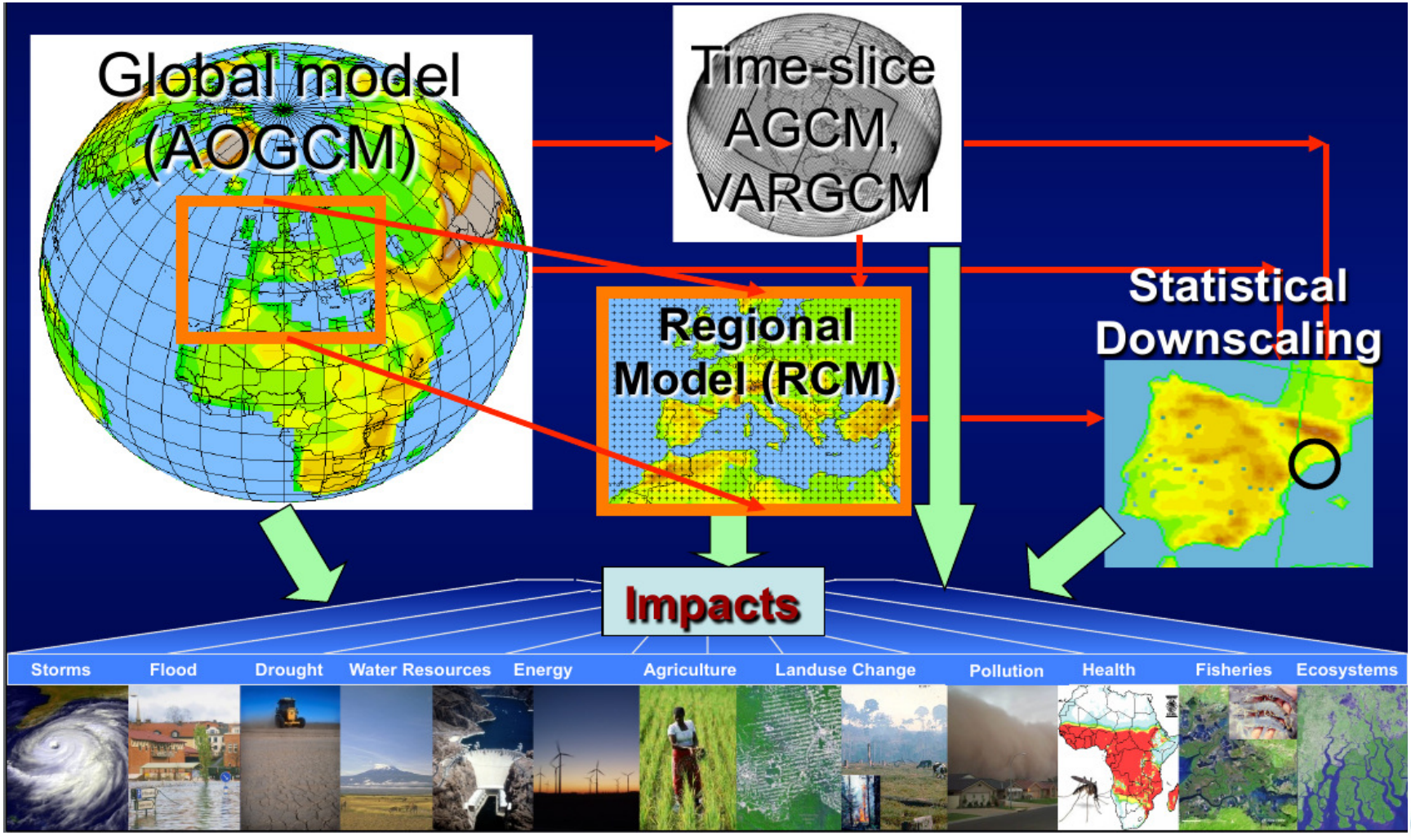
Downscaling regional climate information for impact assessment studies



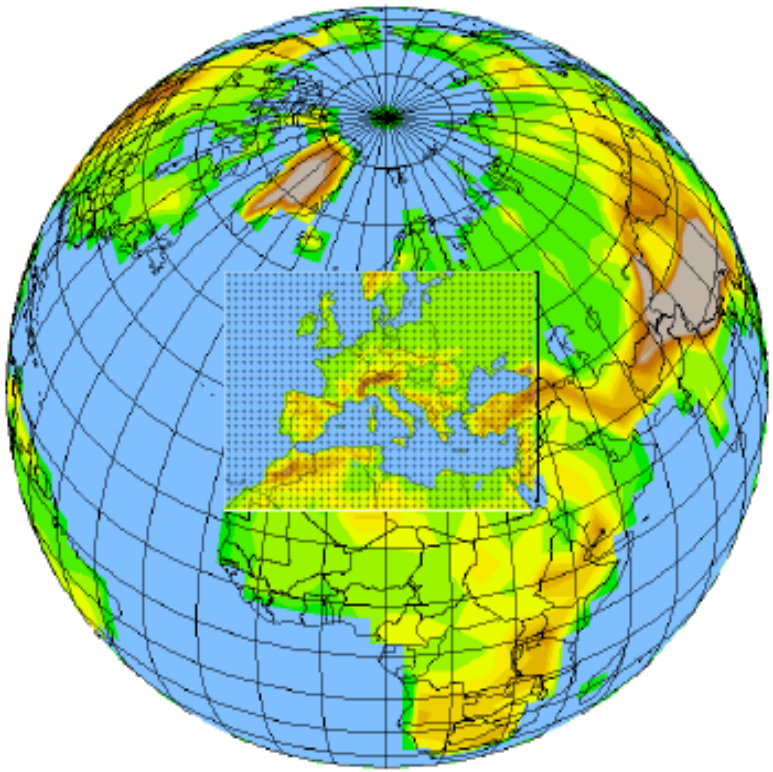
Strategy Motivation: The resolution of GCMs

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

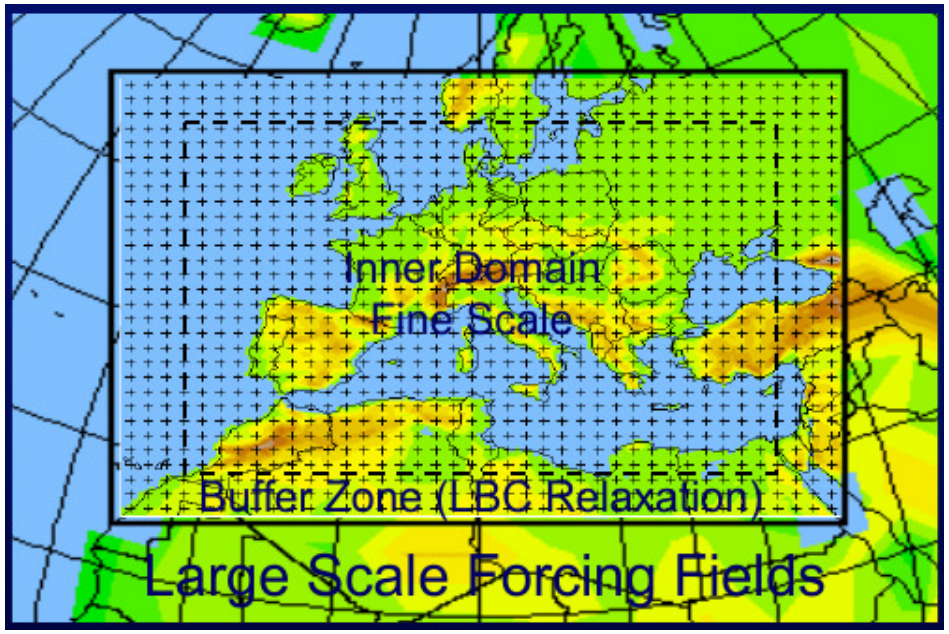
Strategy: The GCM simulates the response of the general circulation to the large scale forcings, the RCM simulates the effect of sub-GCM-grid scale forcings and provides fine scale regional information

- Technique borrowed from NWP



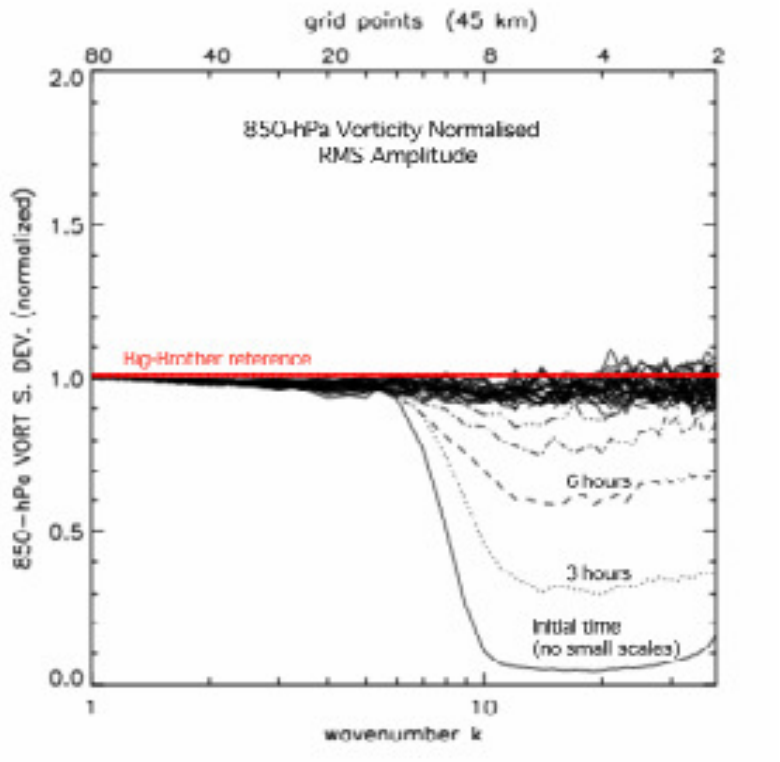
Lateral boundary conditions

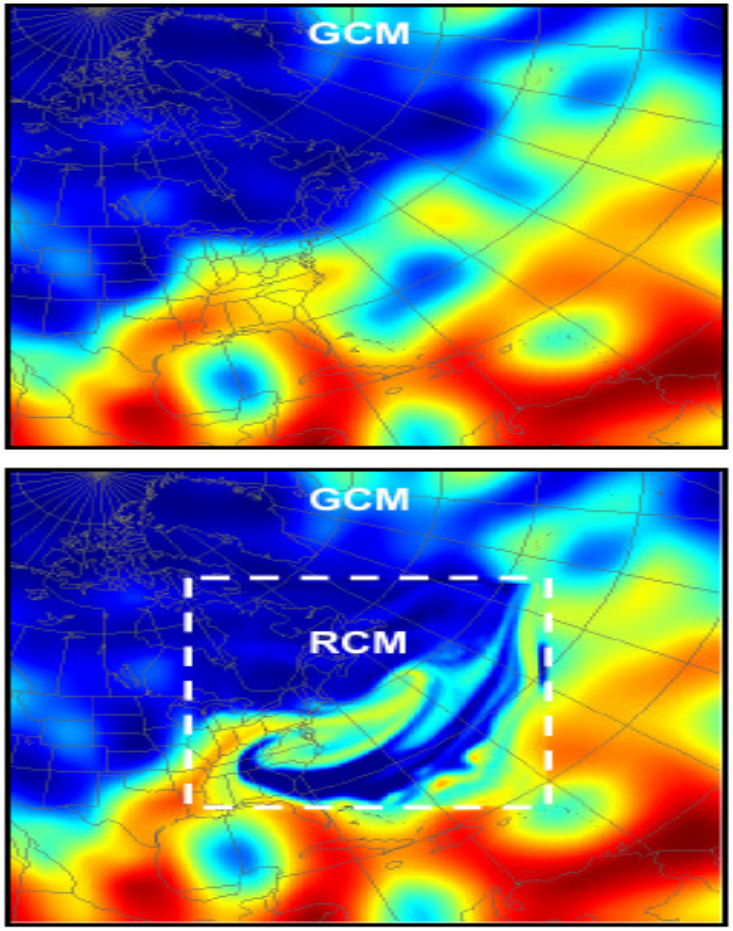
$$\frac{\partial \alpha}{\partial t} = F(n)F_1 \times (\alpha_{LBC} - \alpha_{mod}) - F(n)F_2 \times \Delta_2(\alpha_{LBC} - \alpha_{mod})$$



Dynamical Downscaling

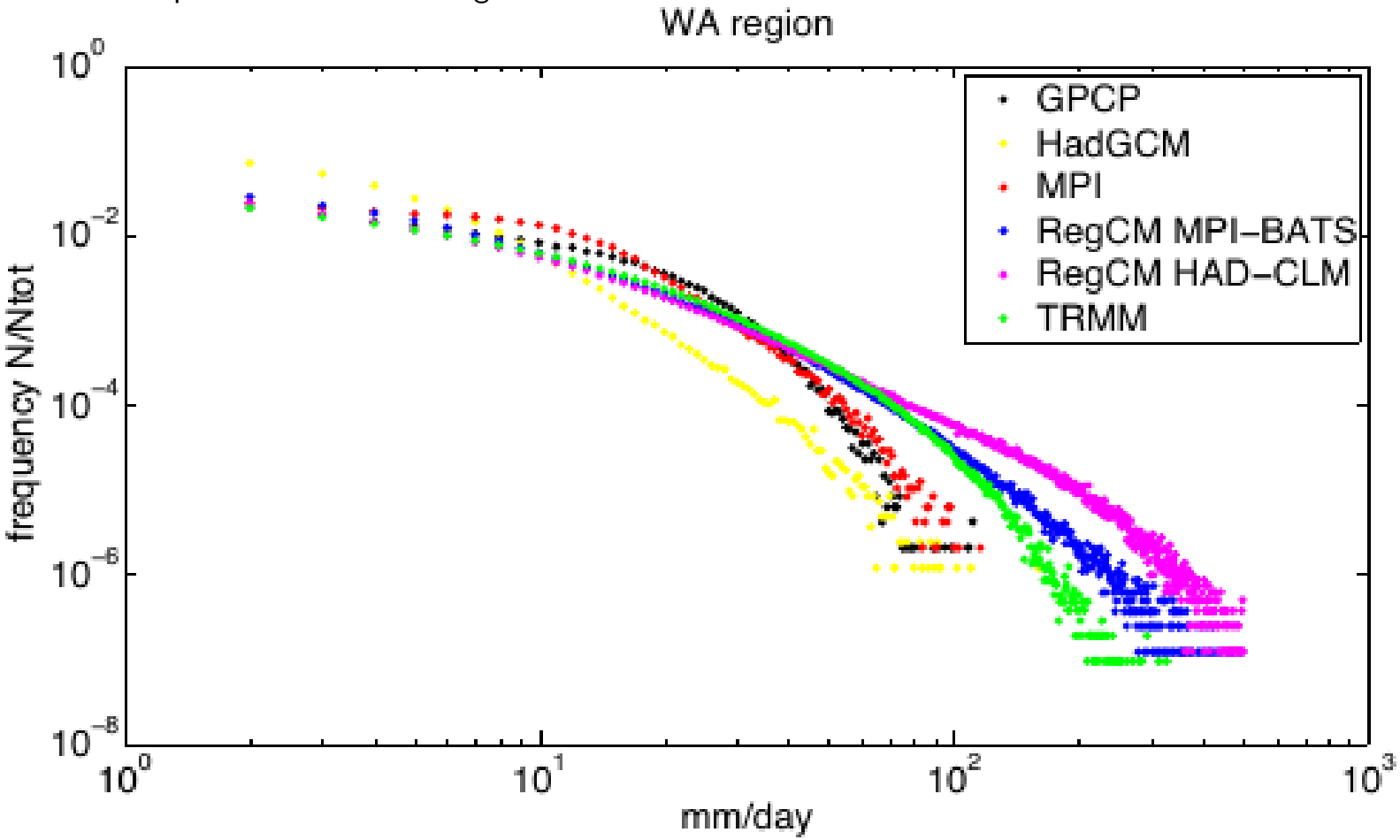
Dynamical Downscaling: Generation of small scales by a high-resolution RCM driven by low-resolution GCM data (See 900 hPa specific humidity right) (From R. Laprise)





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.

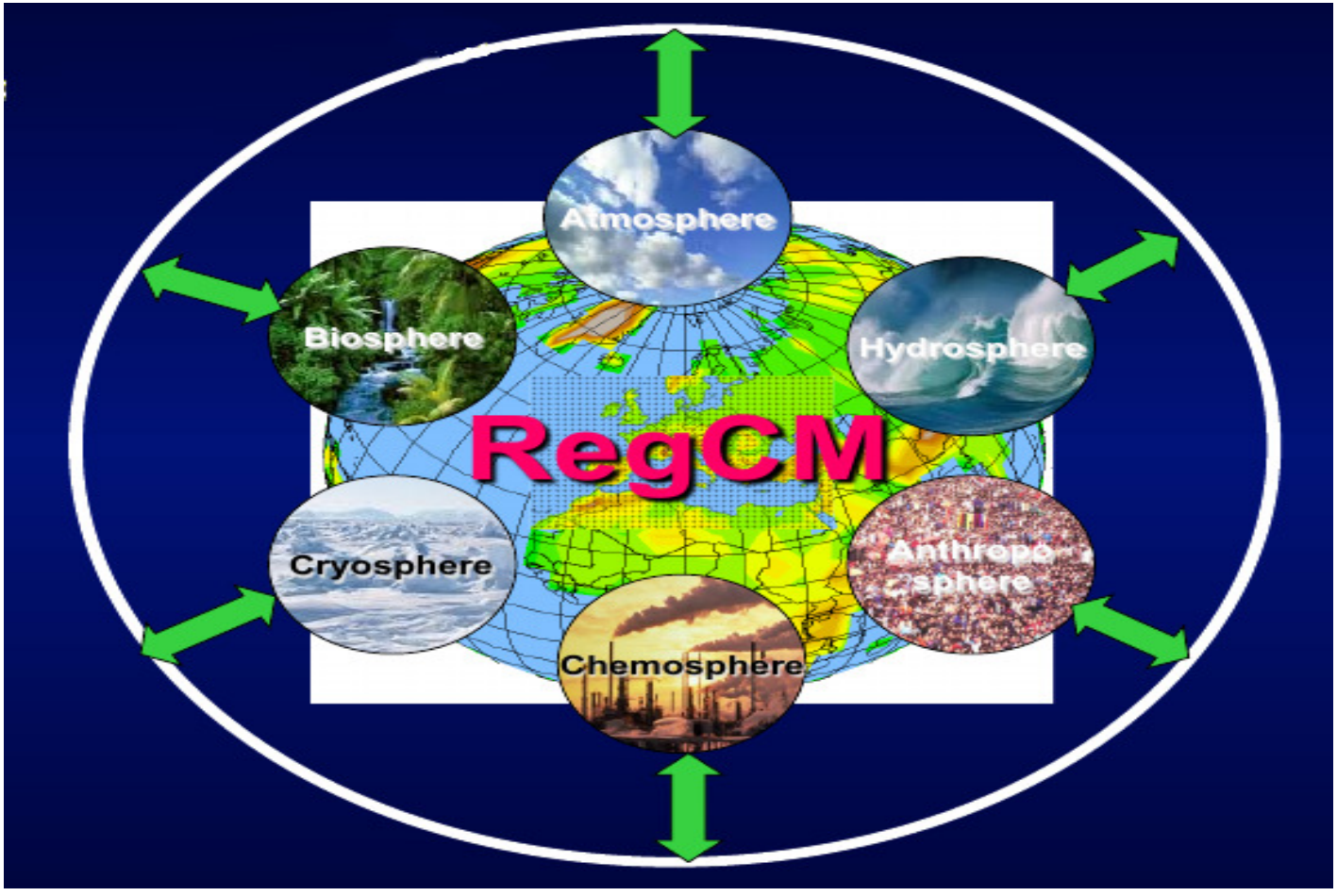
Regional Climate Modeling - Advantages

- 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*

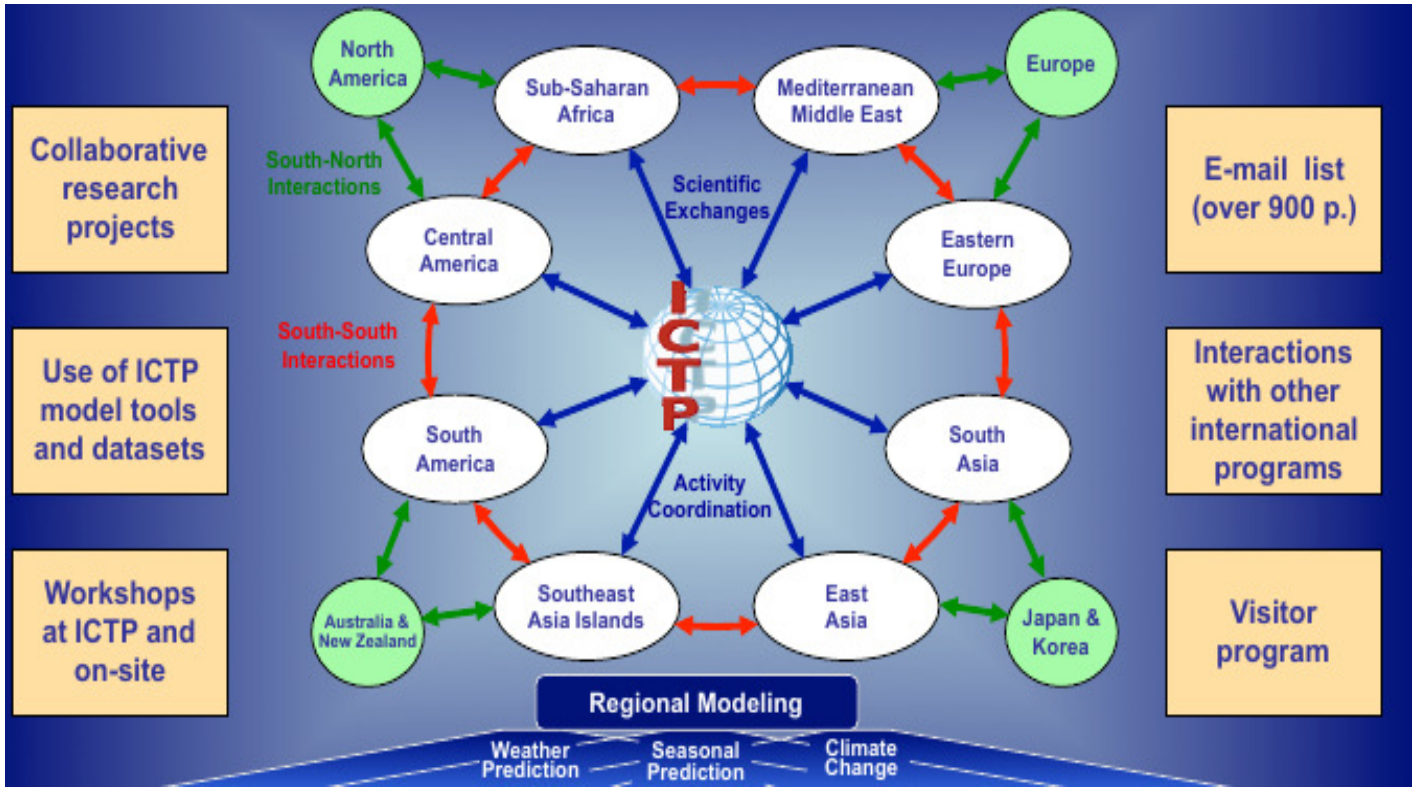
Towards the development of a regional Earth System Model



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 in progress
- Radiation:
  - CCM3 (Kiehl 1996)
  - RRTM (Solmon)
- Large-Scale Precipitaion:
  - SUBEX (Pal et al 2000)
  - Explicit microphysics (Nogherotto)
- Cumulus convection:
  - Grell (1993)
  - Anthes-Kuo (1977)
  - MIT (Emanuel 1991)
  - Tiedtke (1989)
  - Kain-Fritsch (1990), Kain (2004)
  - Mixed 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 available in off line mode
- 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