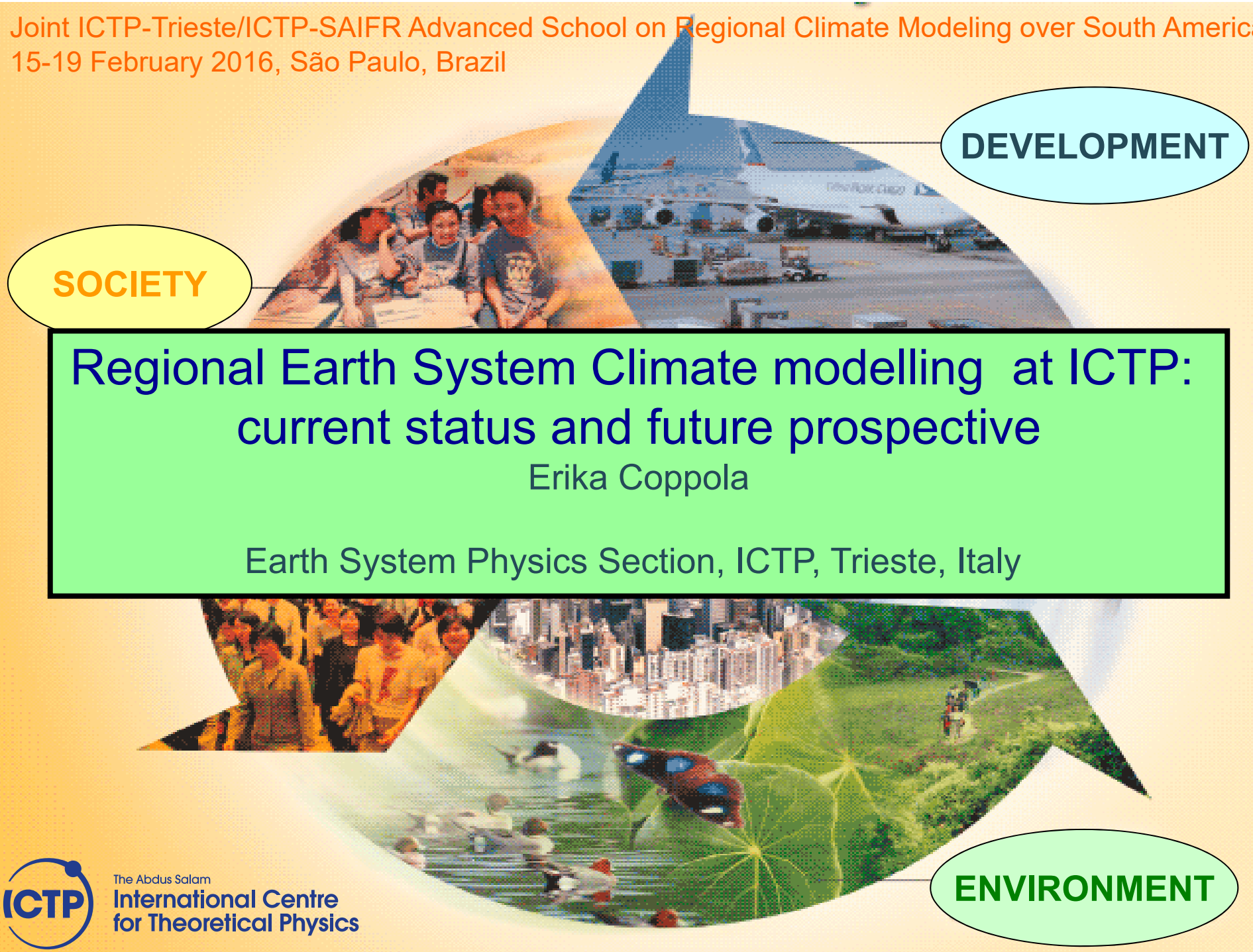
Joint ICTP-Trieste/ICTP-SAIFR Advanced School on Regional Climate Modeling over South America
15-19 February 2016, São Paulo, Brazil

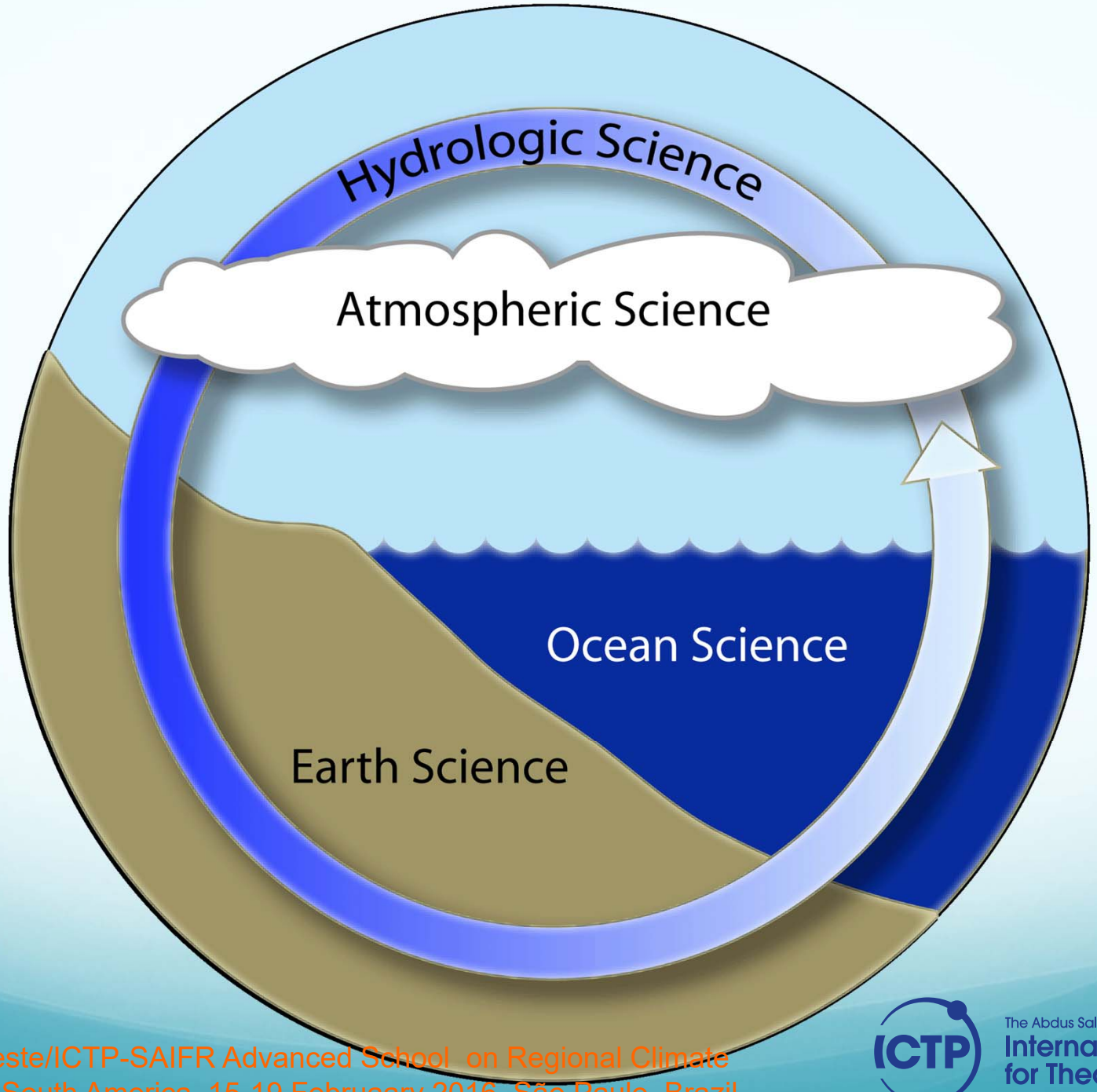


Regional Earth System Climate modelling at ICTP: current status and future prospective

Erika Coppola

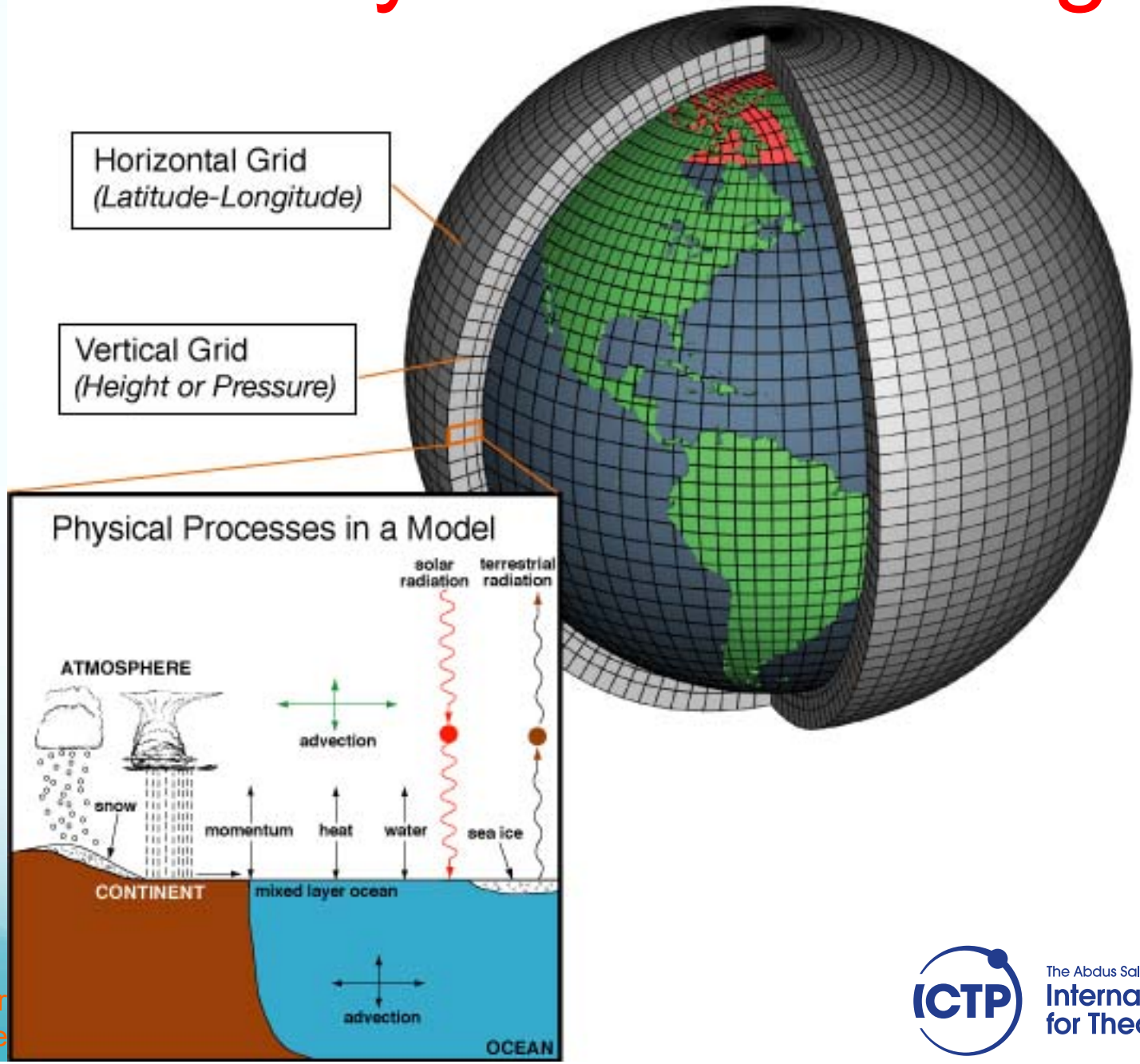
Earth System Physics Section, ICTP, Trieste, Italy

The Abdus Salam International Centre for Theoretical Physics


Hydrologic Science
Atmospheric Science
Ocean Science
Earth Science

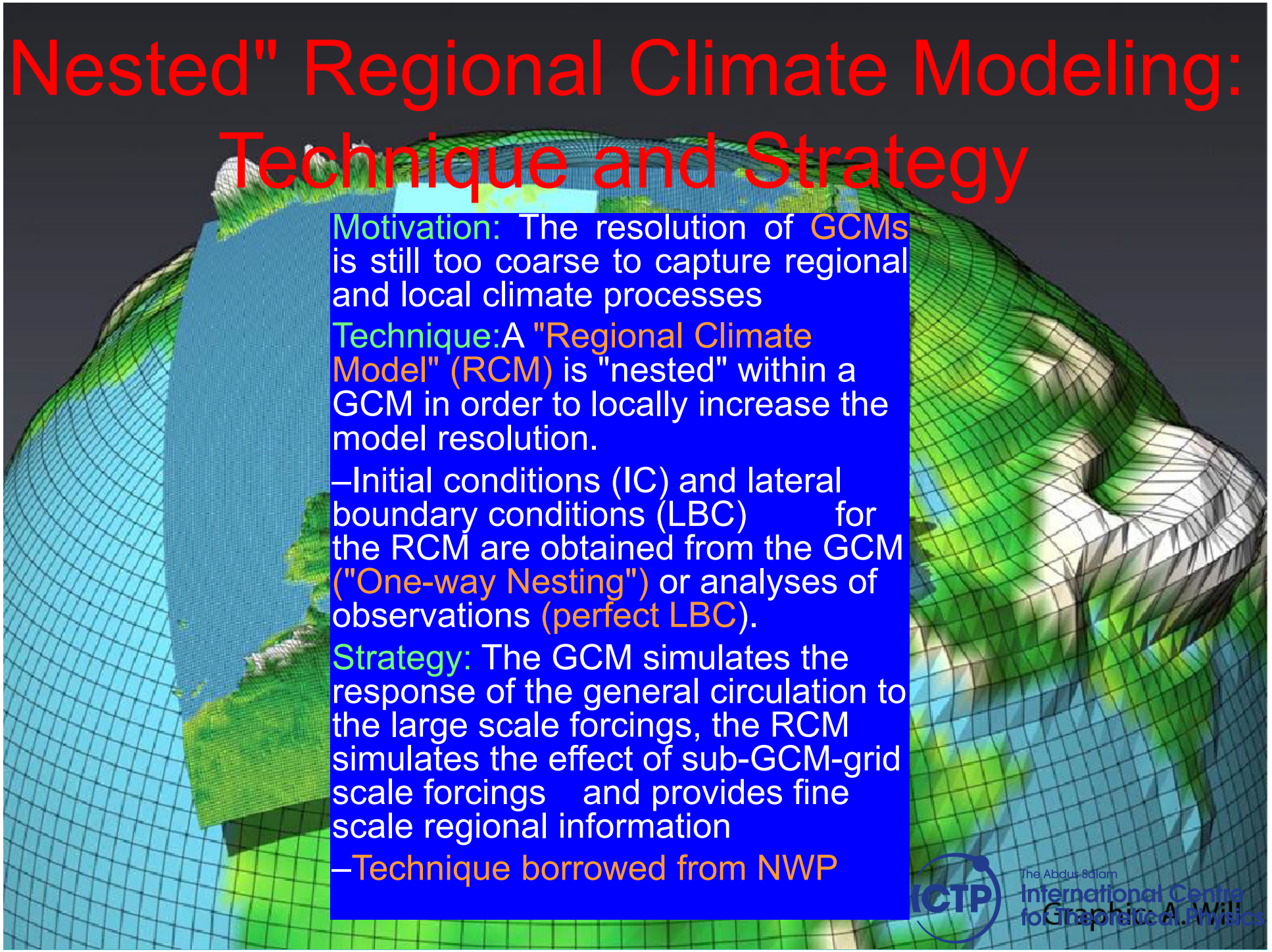
Earth System model

Earth System modelling



Earth System model

"Nested" Regional Climate Modeling: Technique and Strategy



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

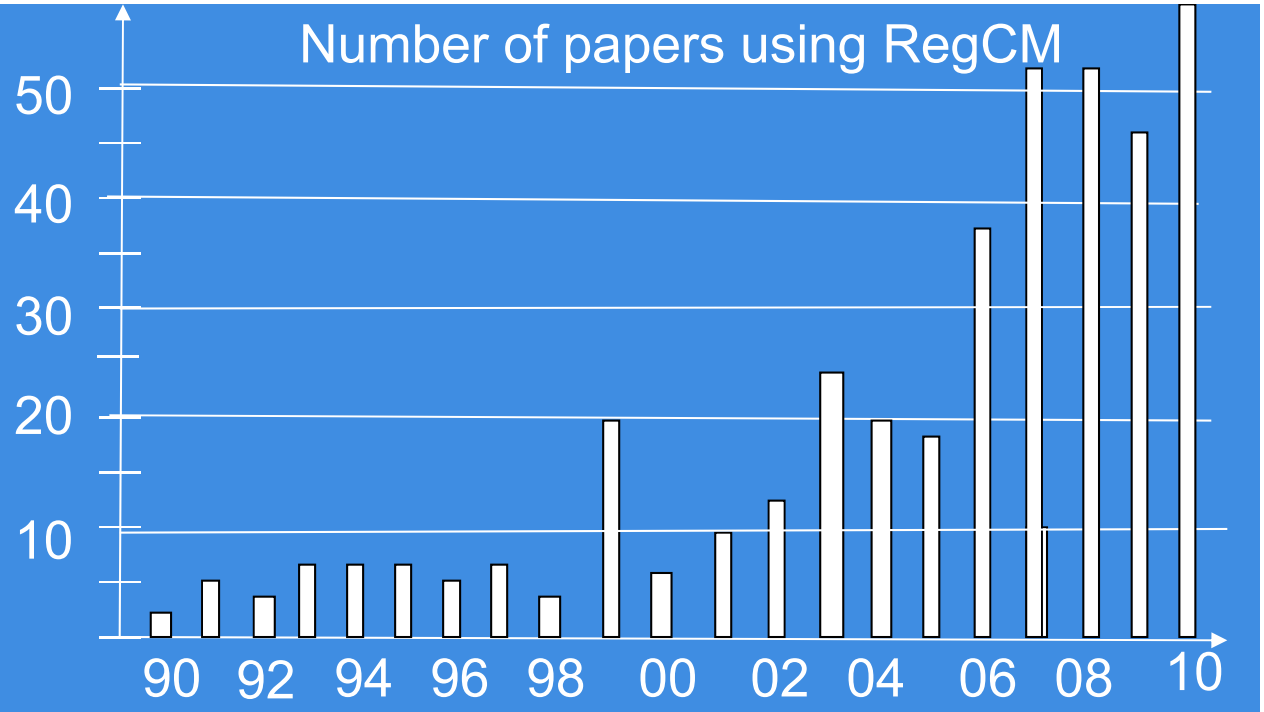
Technique:A "Regional Climate Model" (RCM) is "nested" within a GCM in order to locally increase the model resolution.

–Initial conditions (IC) and lateral boundary conditions (LBC) for the RCM are obtained from the GCM ("One-way Nesting") or analyses of observations (perfect LBC).

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

The RegCM System



Release of new version

RegCM4

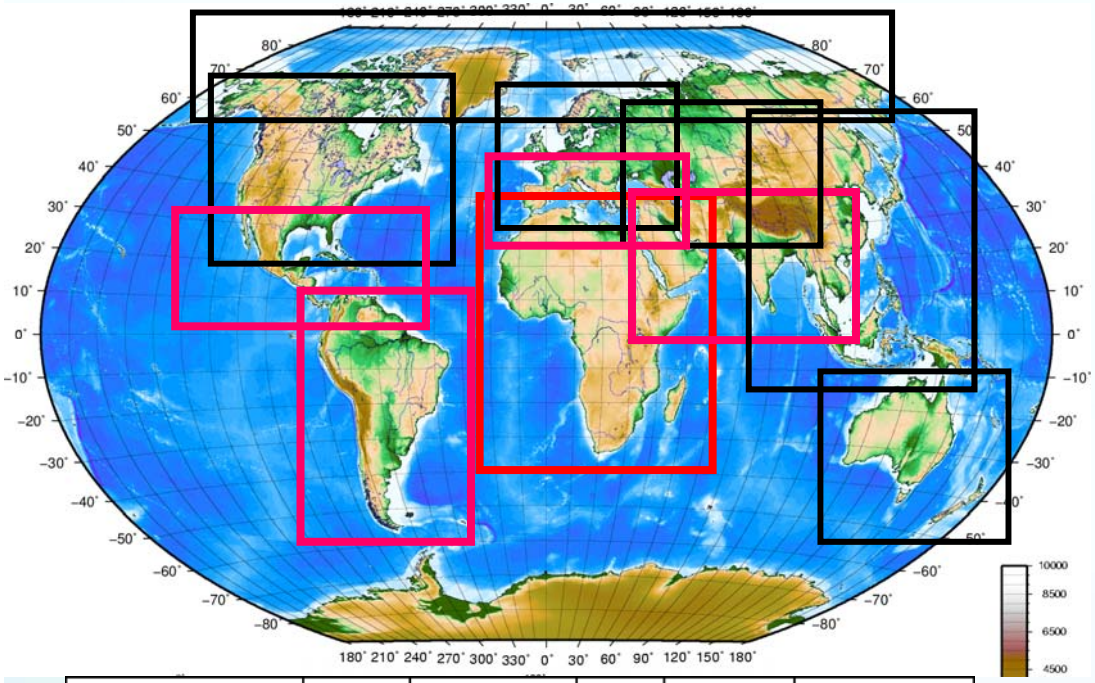
About 3000 downloads since June 2010

Countries where RegCM is used

RegCM training workshops:
ICTP, June 2010
Turunc, Turkey, August 2010
New Delhi, India, December 2010
Amman, Jordan, March 2011
Agua Calientes, Mexico, 2014
ICTP, May 2012
ICTP, May 2014
ICTP,May 2016
Strengthening of the model software development and user support team

Joint
Mode
ional
Paulo, Brazil

RegCM for CORDEX CREMA experiments



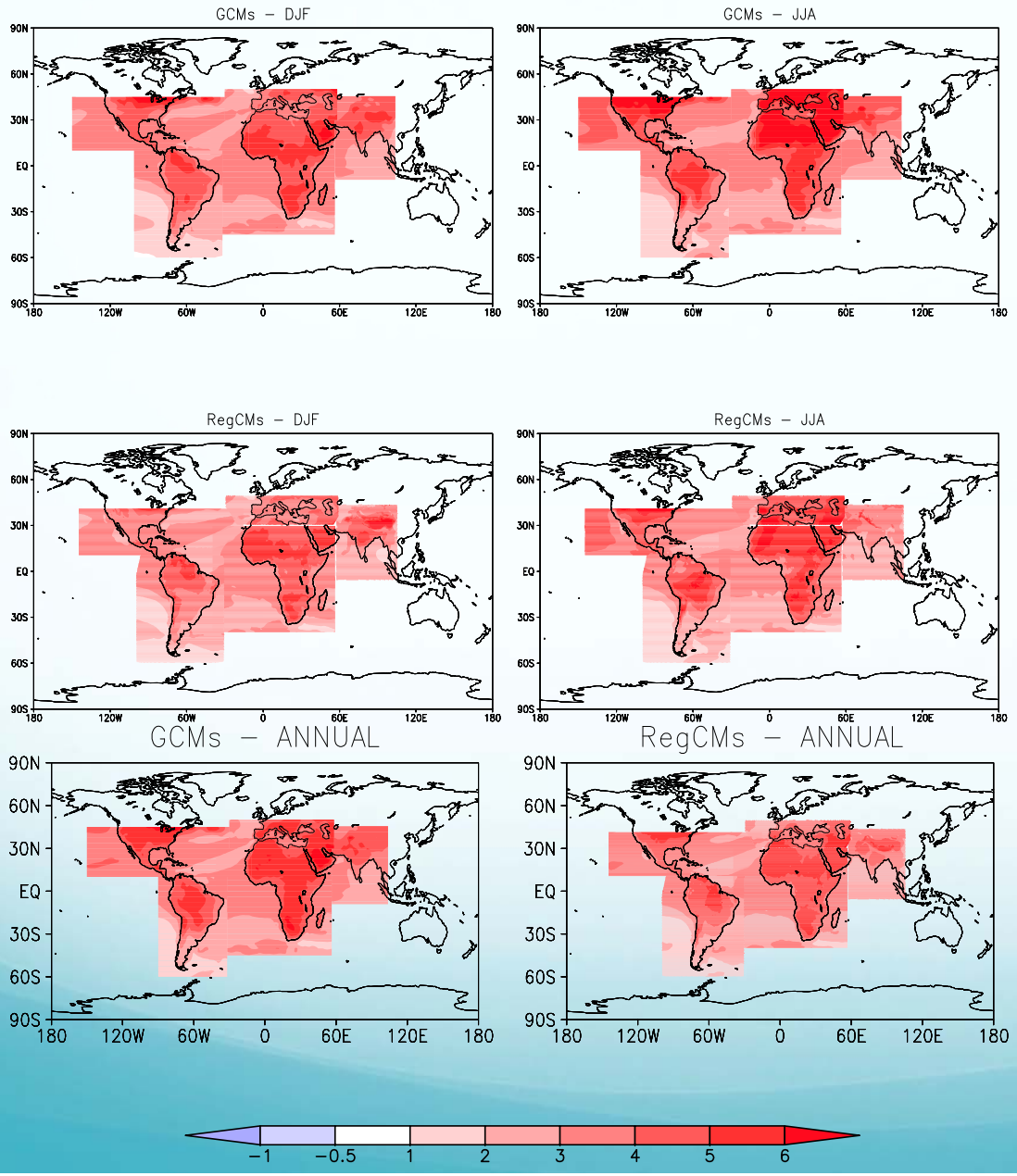
- 33 scenario simulations were completed, each extending from 1970 to 2100
- 1976-2005 being used as reference for the assessment of the model present day climate

	Africa	C America	India	Med	S. America
HAD-CLM-GE	2			1	
HAD-CLM-E		2			2
HAD-BATS-G		2			
HAD-BATS-GE				1	2
MPI-CLM-E		1	1		1
MPI-BATS-G	1	1			
MPI-BATS-GE				1	
MPI-CLM-GE				1	
GFDL-CLM-E			2		1
GFDL-CLM-EG			2		

Temperature change RCP8.5 (2070/2100-1976/2005)

GCM

RegCM



- values exceeding 5 degrees in the inner continental interiors
- RegCM ensemble shows lower amounts of warming by several tenths of a degree
- CLM scheme generally exhibits less sensitivity to increased GHG forcing than BATS

Coppola et al. (2013)

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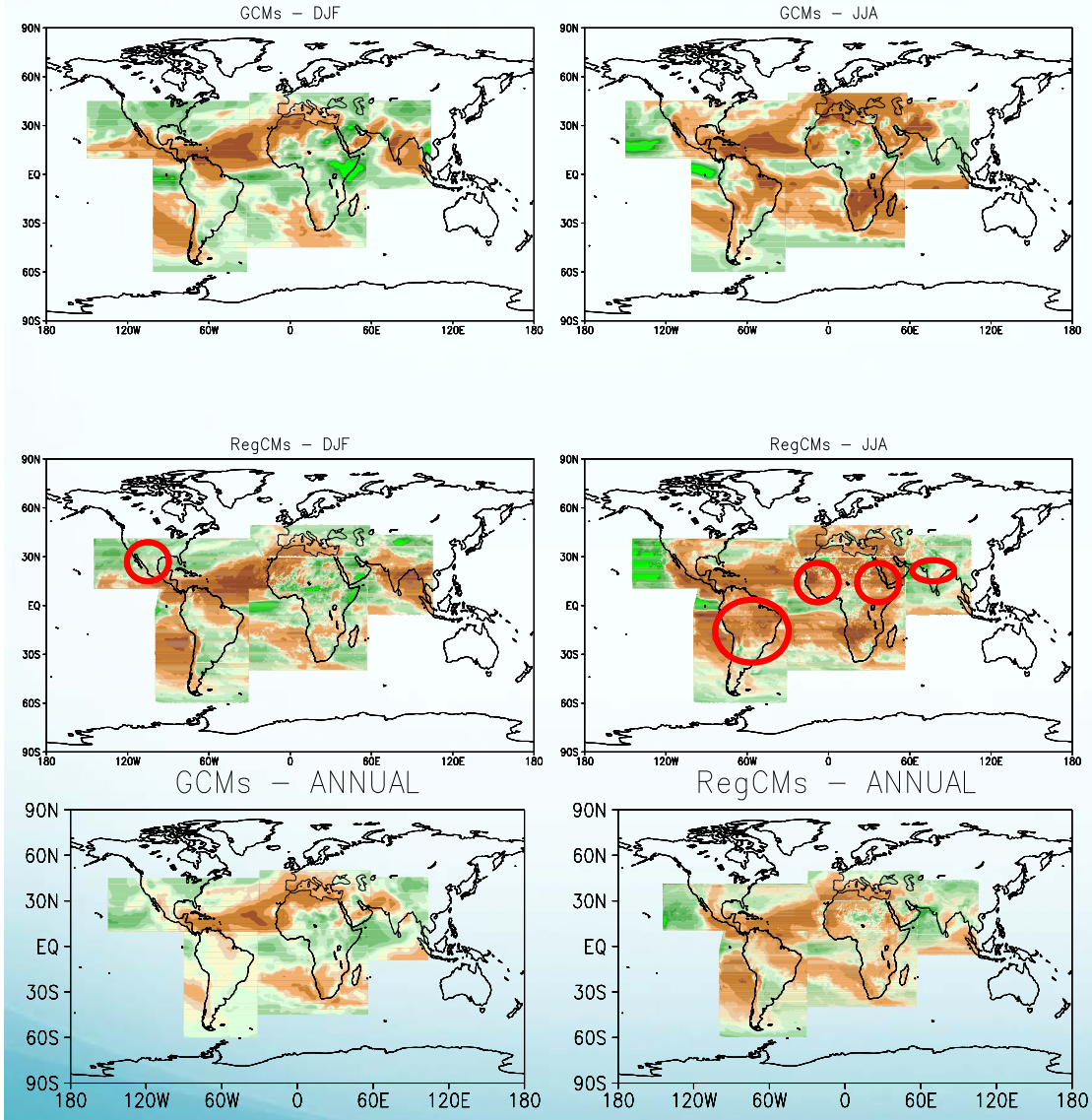
Precipitation change RCP8.5 (2070/2100-1976/2005)

GCM

RegCM



- The forcing of the driving GCMs on the large scale patterns of change simulated by the RCMs is evident from the similarities in the large scale structure of the changes
- important regional differences between GCM and RegCM ○ (different descriptions by the models of land-atmosphere interactions, response to SST changes and local topographical forcings)

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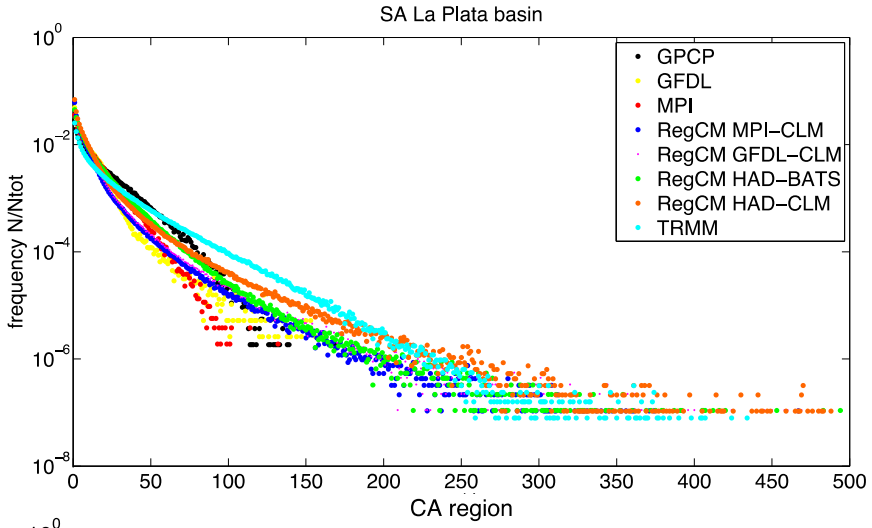
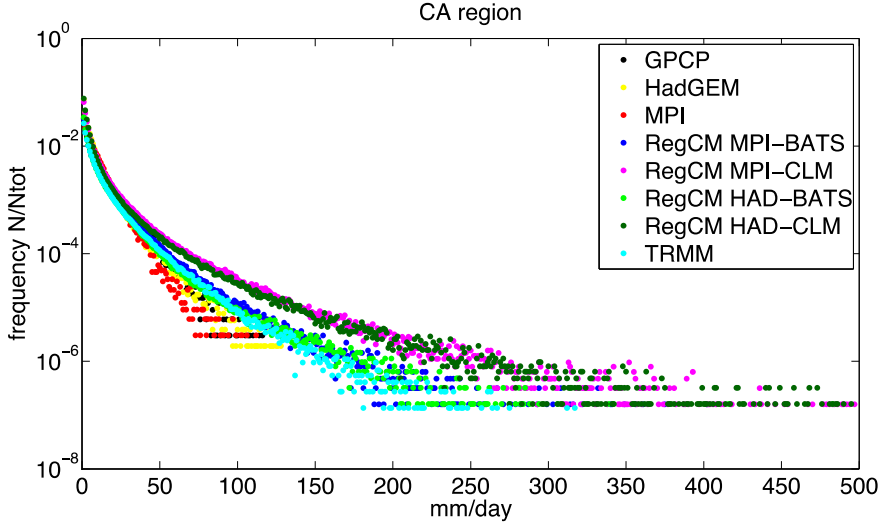
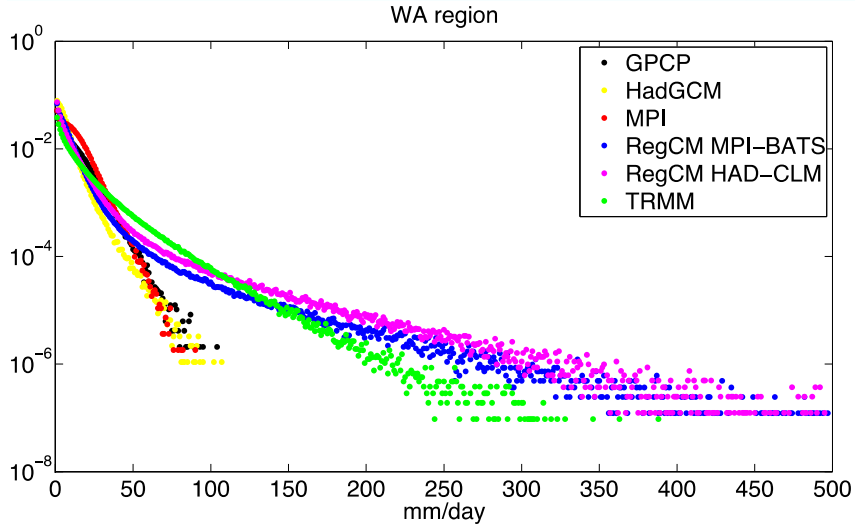
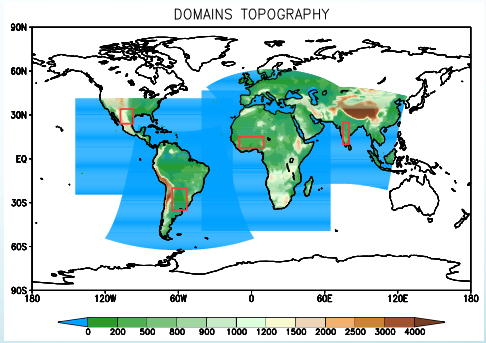
Added value of RCM





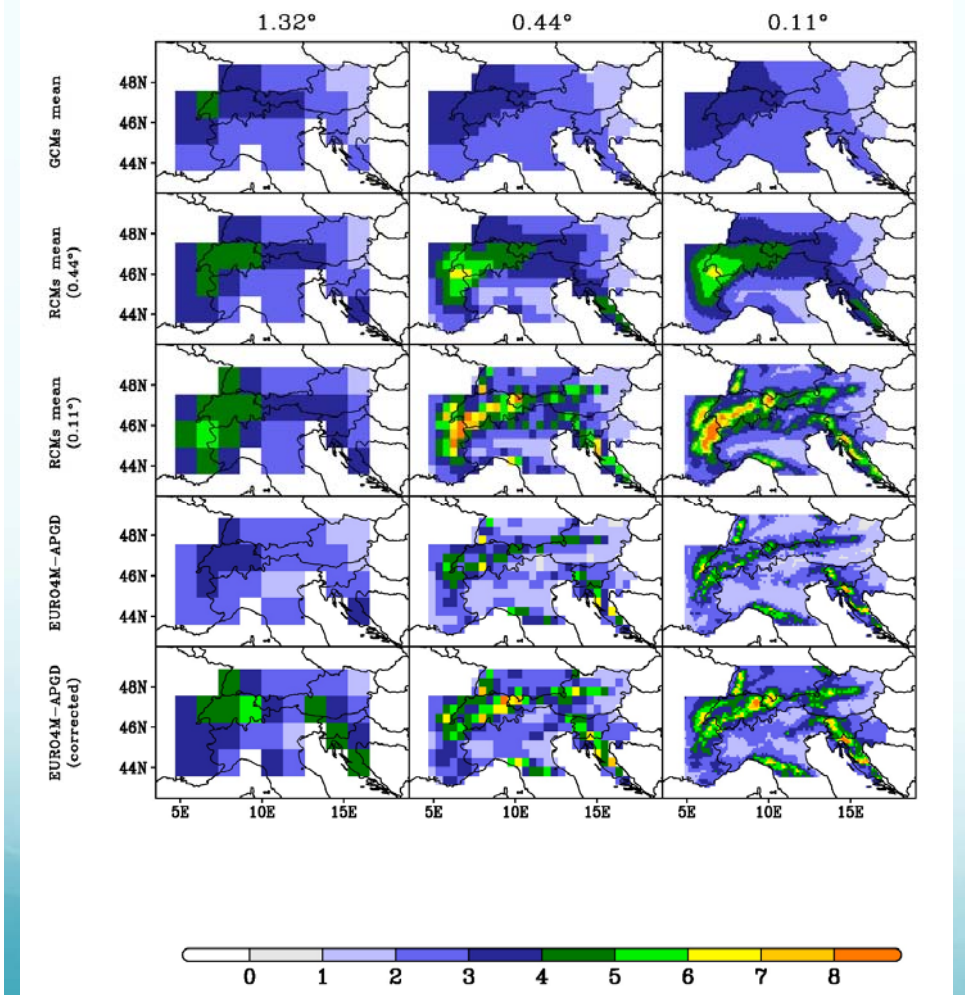




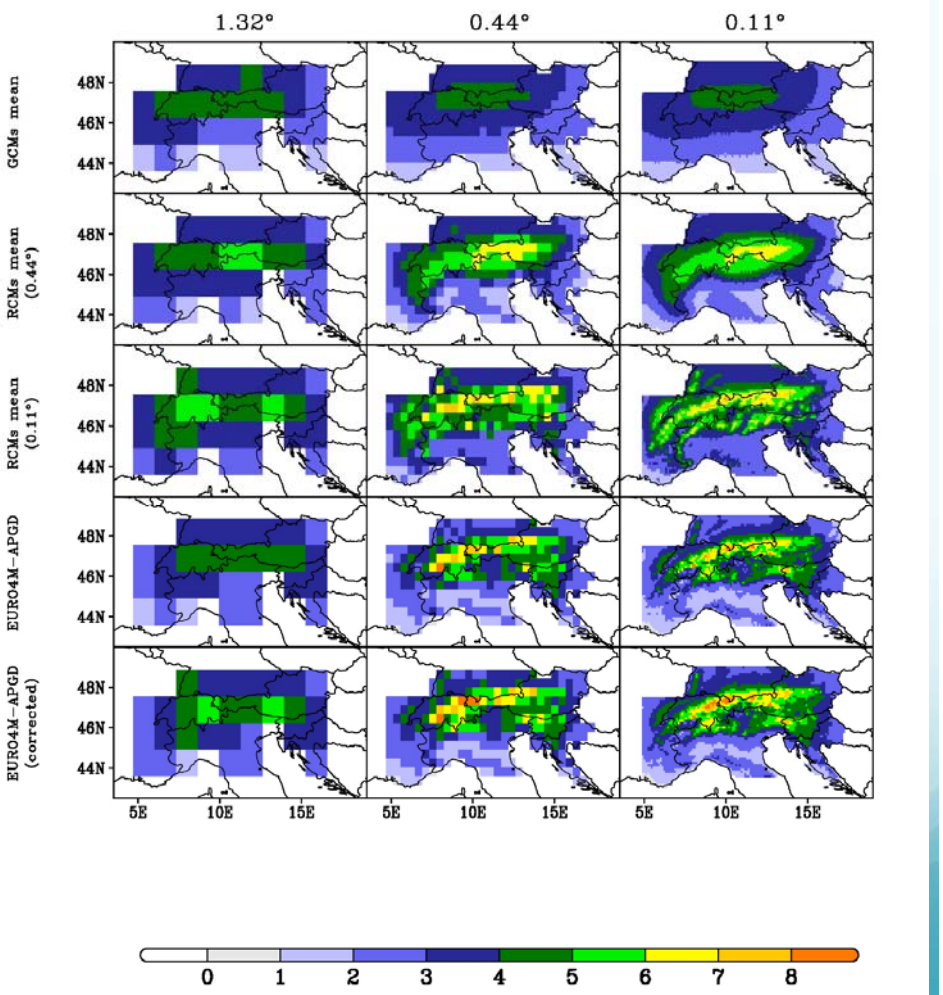
Giorgi et al. (2013)

Euro and Med CORDEX

Winter (DJF)

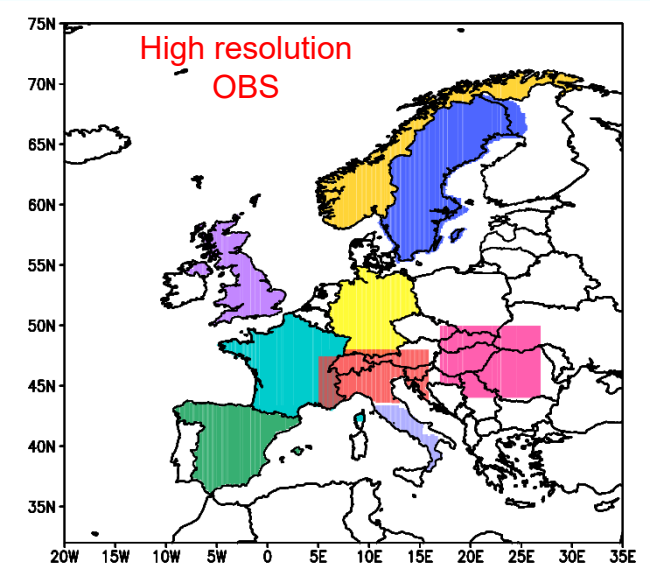


Summer (JJA)



Torma, C., Giorgi F., Coppola E. Added value of regional climate modeling over areas characterized by complex terrain- Precipitation over the Alps., Geophysical Research-atmospheres

Euro and Med CORDEX



Fantini et al., Assessment of multiple daily precipitation statistics in ERA-Interim driven Med-CORDEX and EURO-CORDEX experiments against high resolution observations . Submitted to *Climate Dynamics* Med-CORDEX special issue.

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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: PIRCS, 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

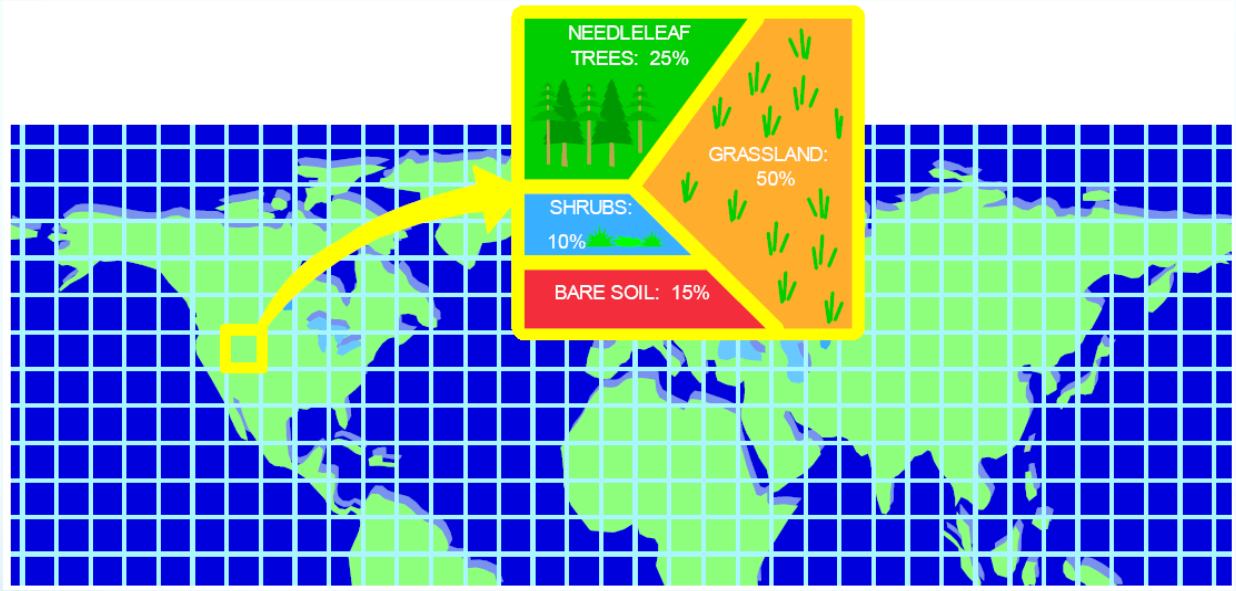
- Physically based downscaling
  - Comprehensive climate modeling system
- Wide variety of applications
  - Process studies
  - Paleoclimate
  - Climate change
  - Seasonal prediction
- High resolution through multiple nesting (currently <10 to 50 km grid interval)

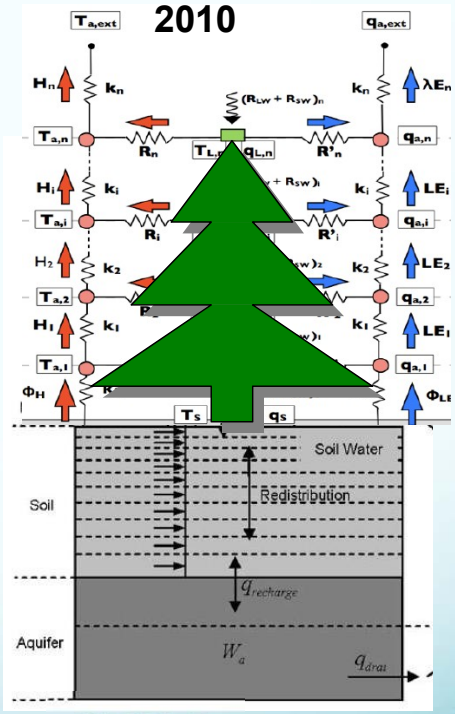
Regional Climate Modeling
Limitation

- 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

Earth System model

Land Surface Modelling





CLM4.5:

CLM4.5

Oleson et al., 2013

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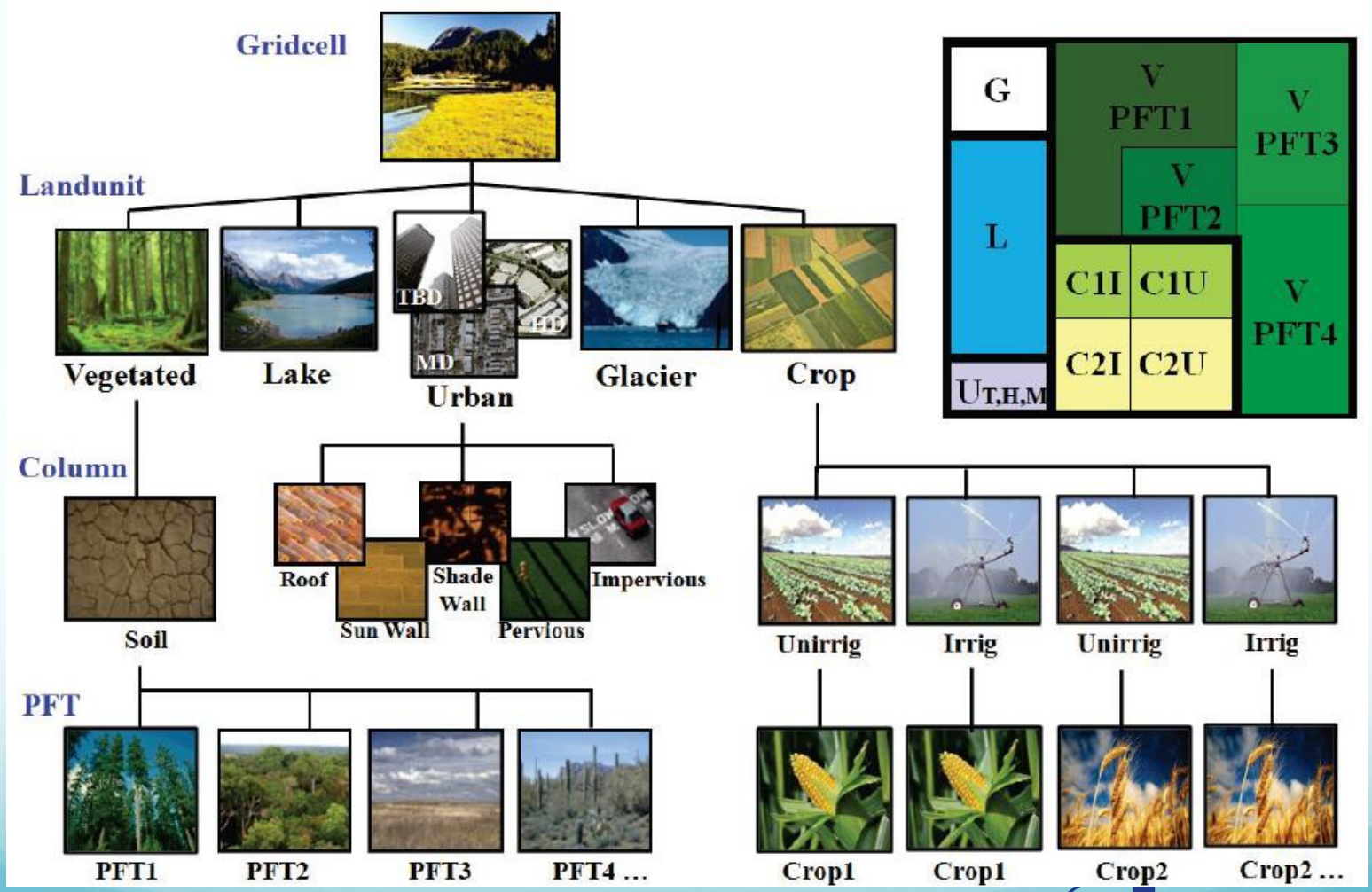
Subgrid hierarchy of tiles: an example

(Oleson et al., 2013)



3rd generation: Photosynthesis model

- Stomatal conductance explicitly related to photosynthetic assimilation using Ball-Berry conductance model (Collatz et al. 1991):

$$g_{stom} = m \frac{A}{c_s} h_s p + b$$

m	empirical coefficient derived from observations
A	photosynthetic assimilation
c_s	CO_2 concentration at the leaf surface
h_s	relative humidity at the leaf surface
p	atmospheric pressure
b	minimum value of g_{stom}

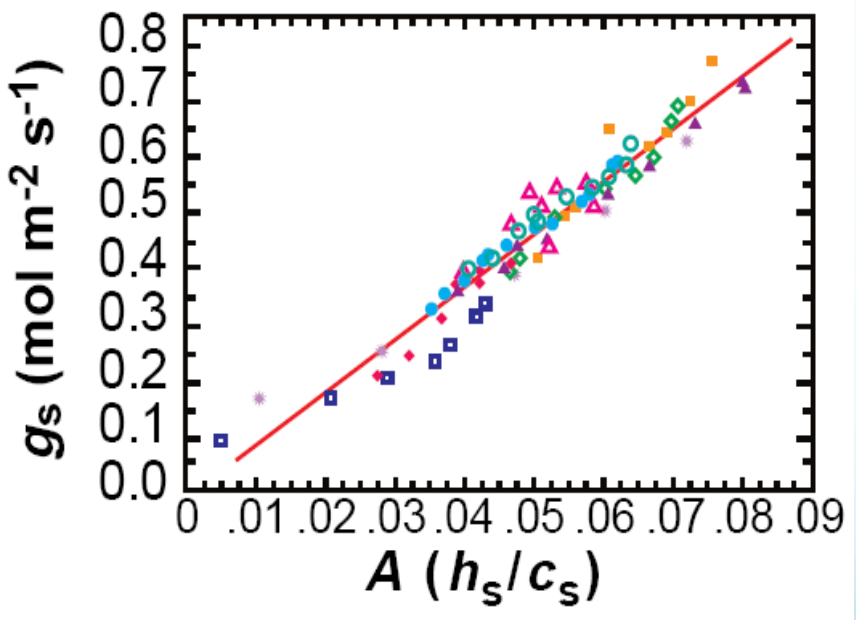
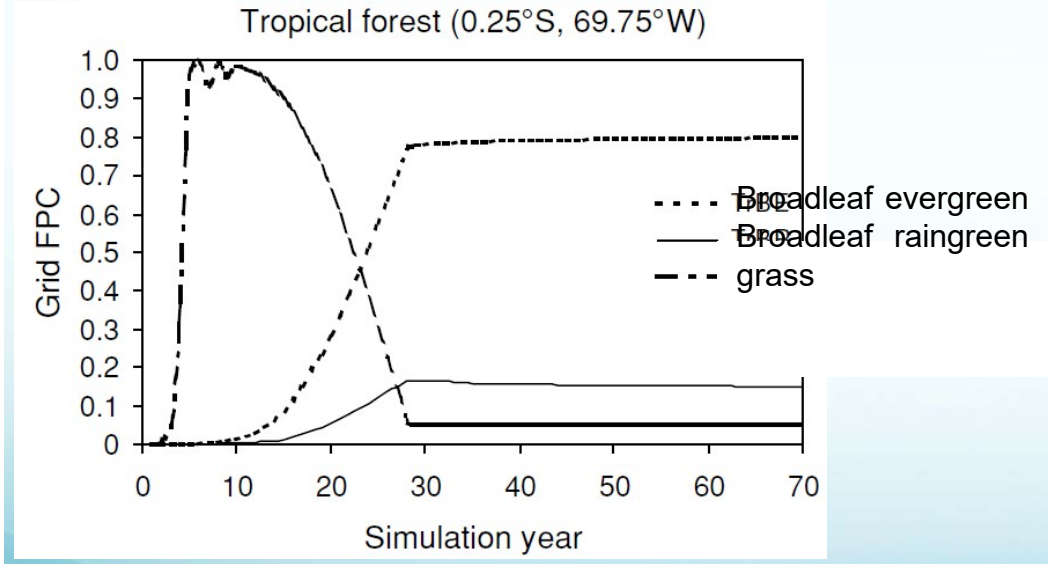


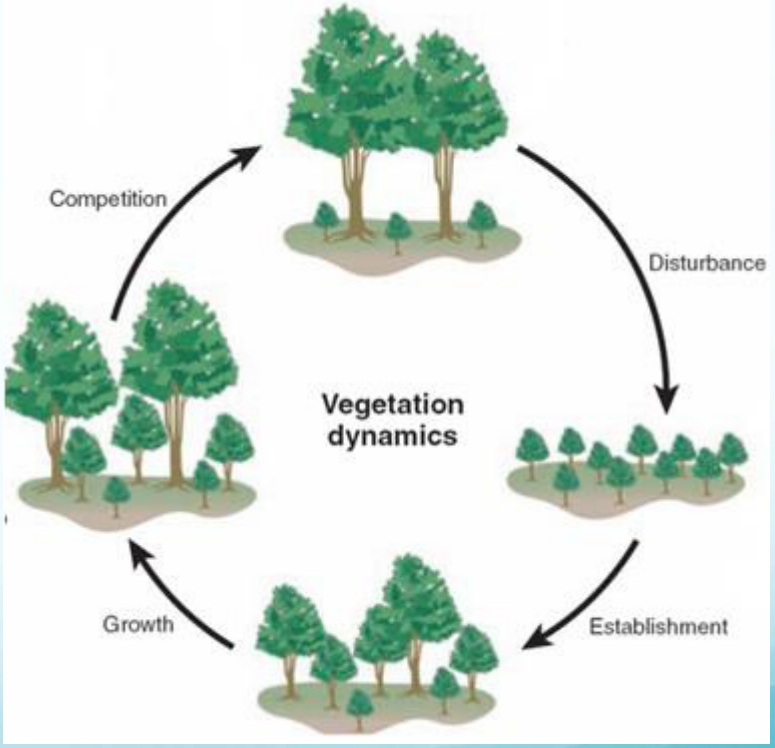
Figure Sellers et al., 1997

Concepts of dynamic vegetation models

- Use Plant Functional Type (PFT) instead of biomes
- Competition for light, water and nutrients
- Successional dynamics



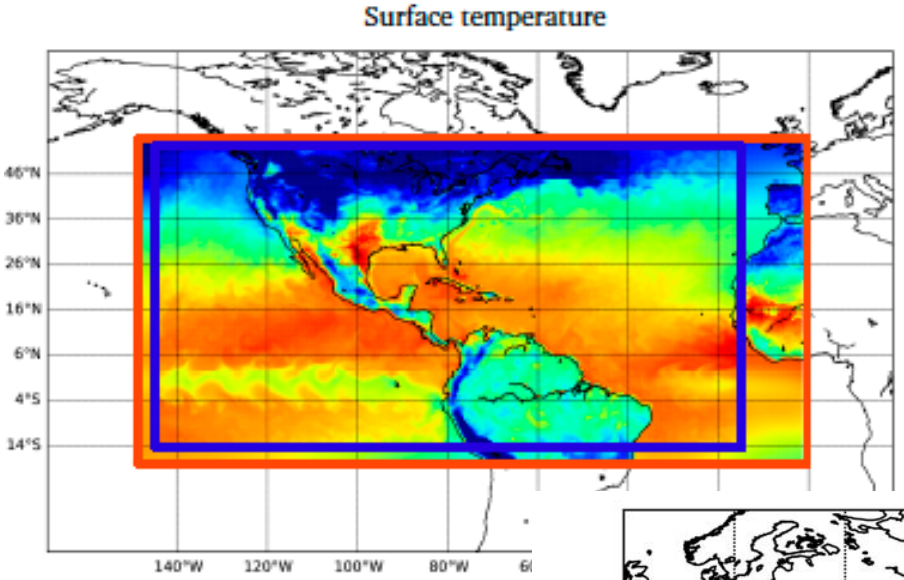
Sitch et al., 2003

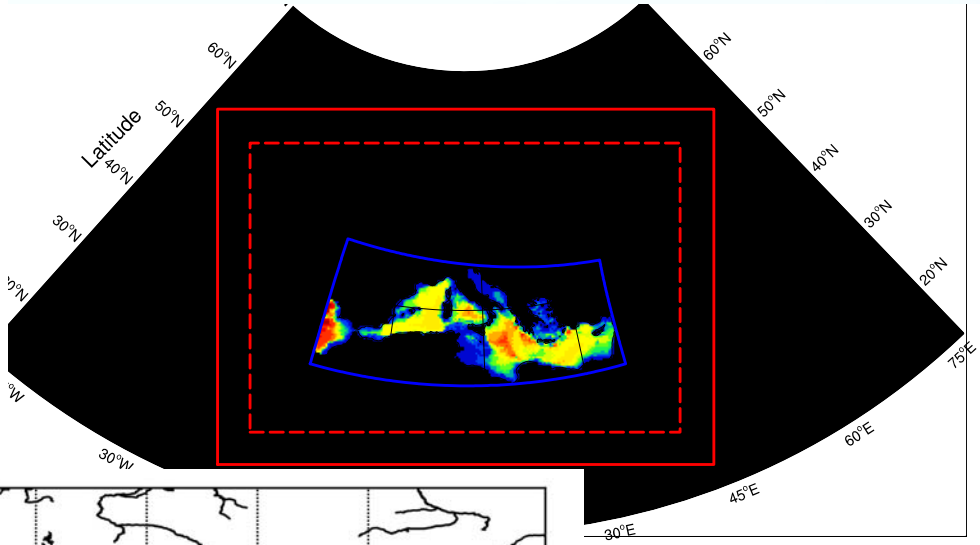


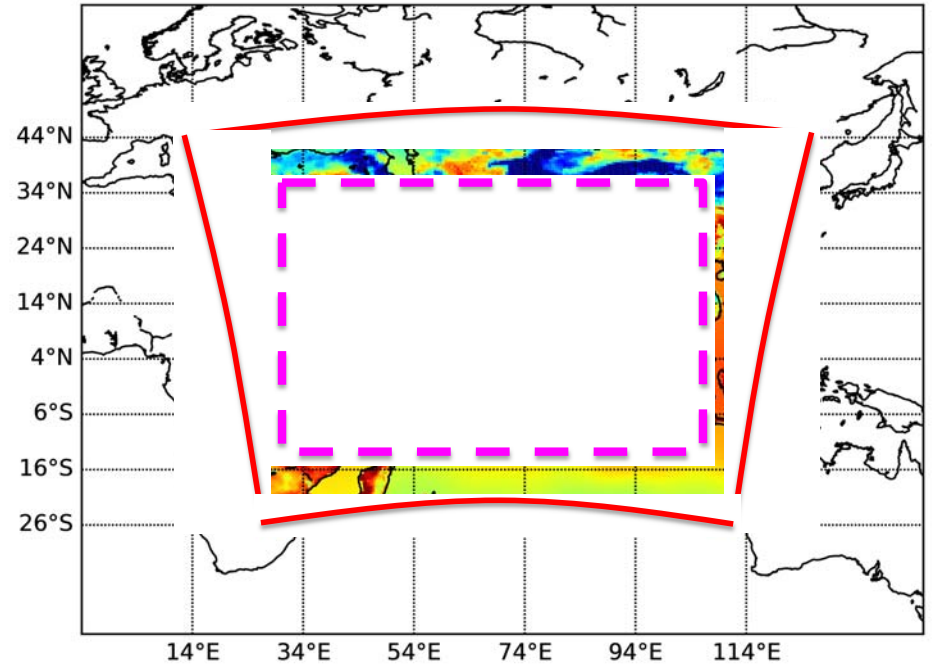
Bonan, 2008

Earth System model

MIT GCM







Joint ICTP-Trieste/ICTP-SAIFR
Modeling over South America.

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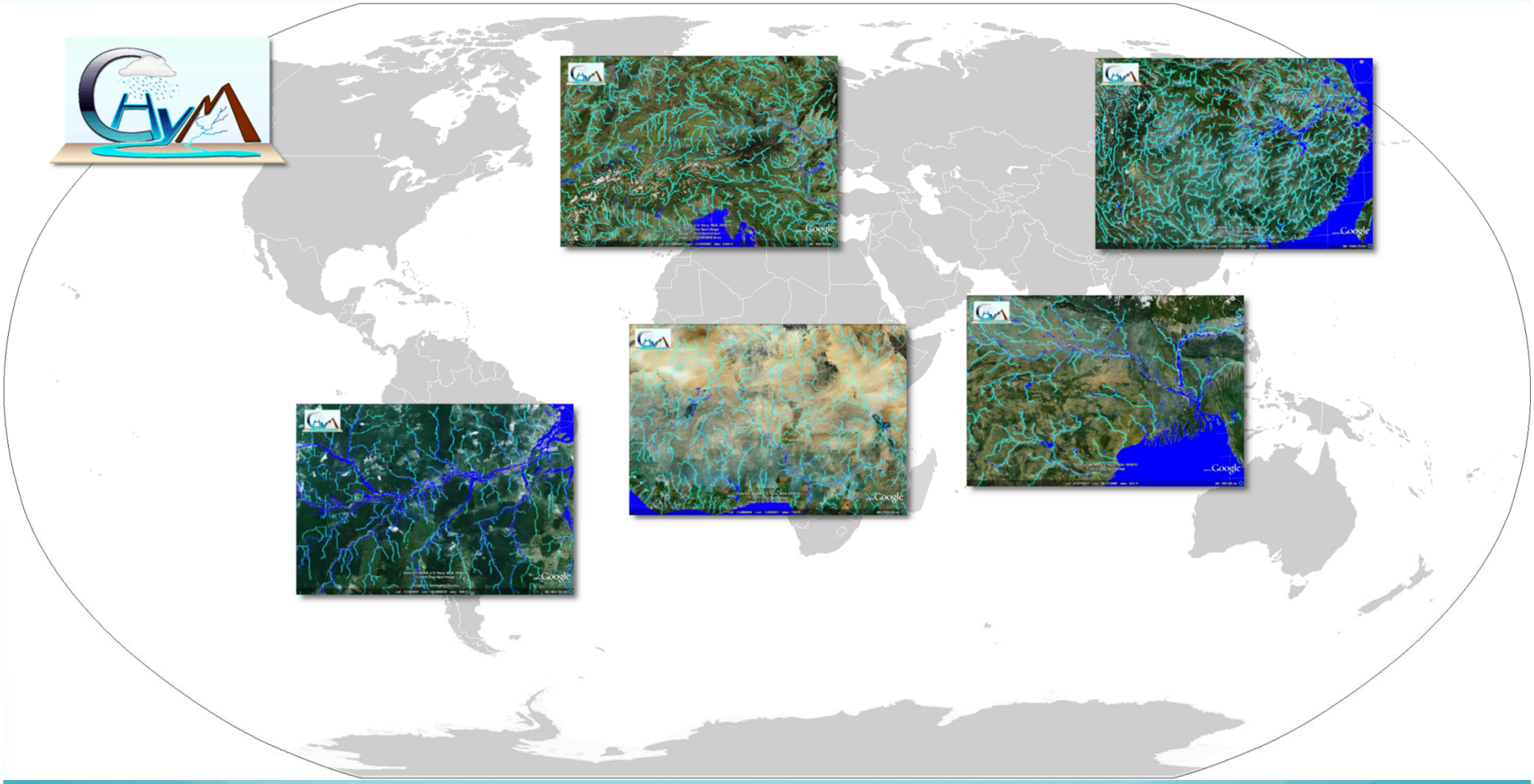
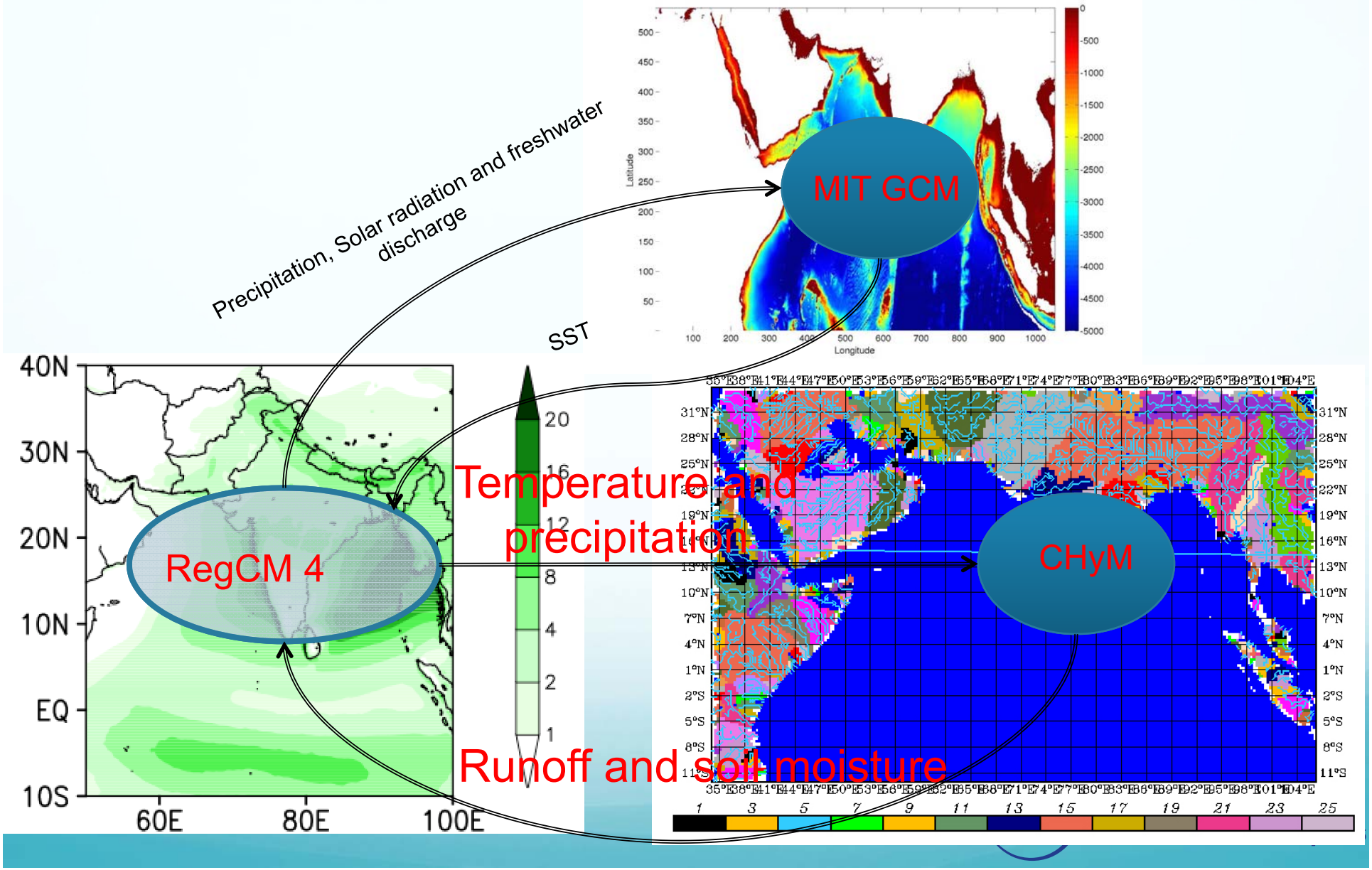
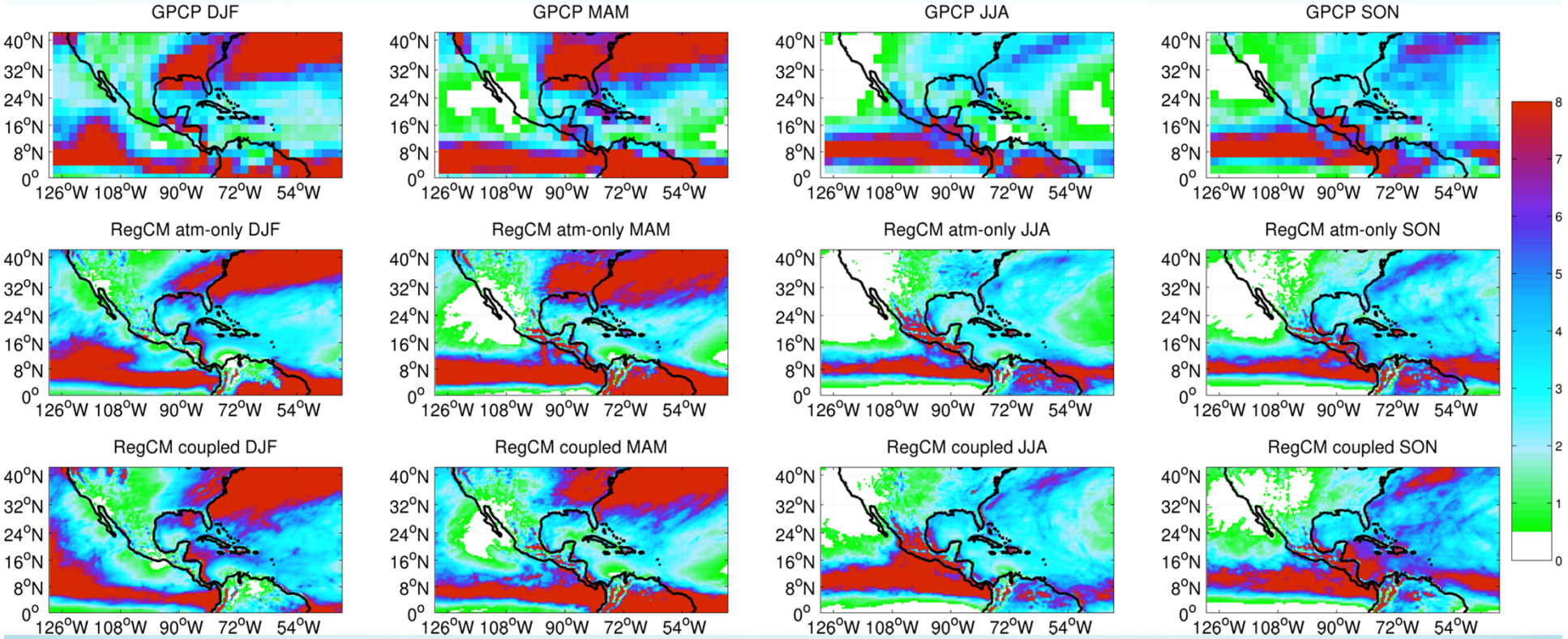
CHyM Hydrological model

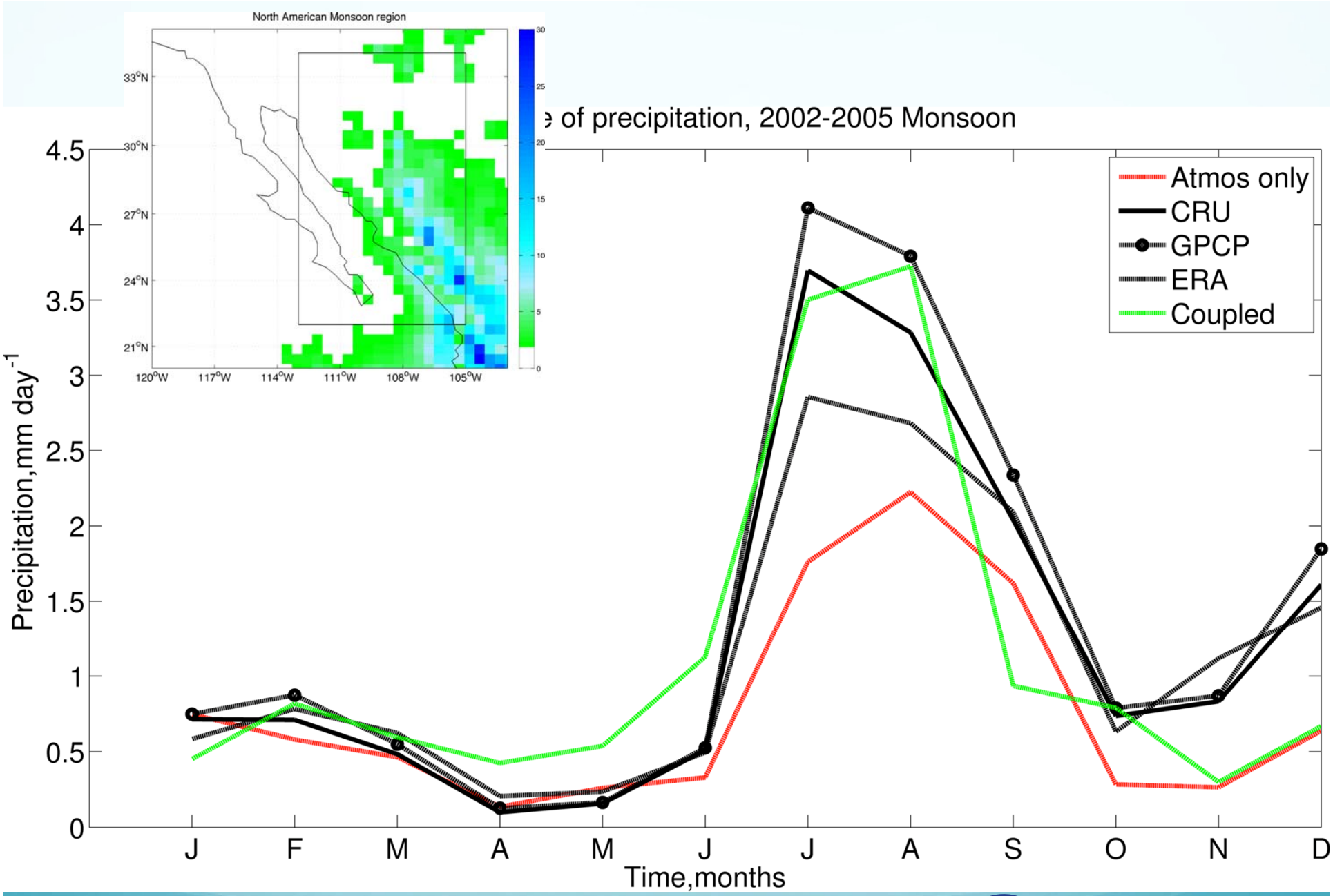


Regional Earth System Model

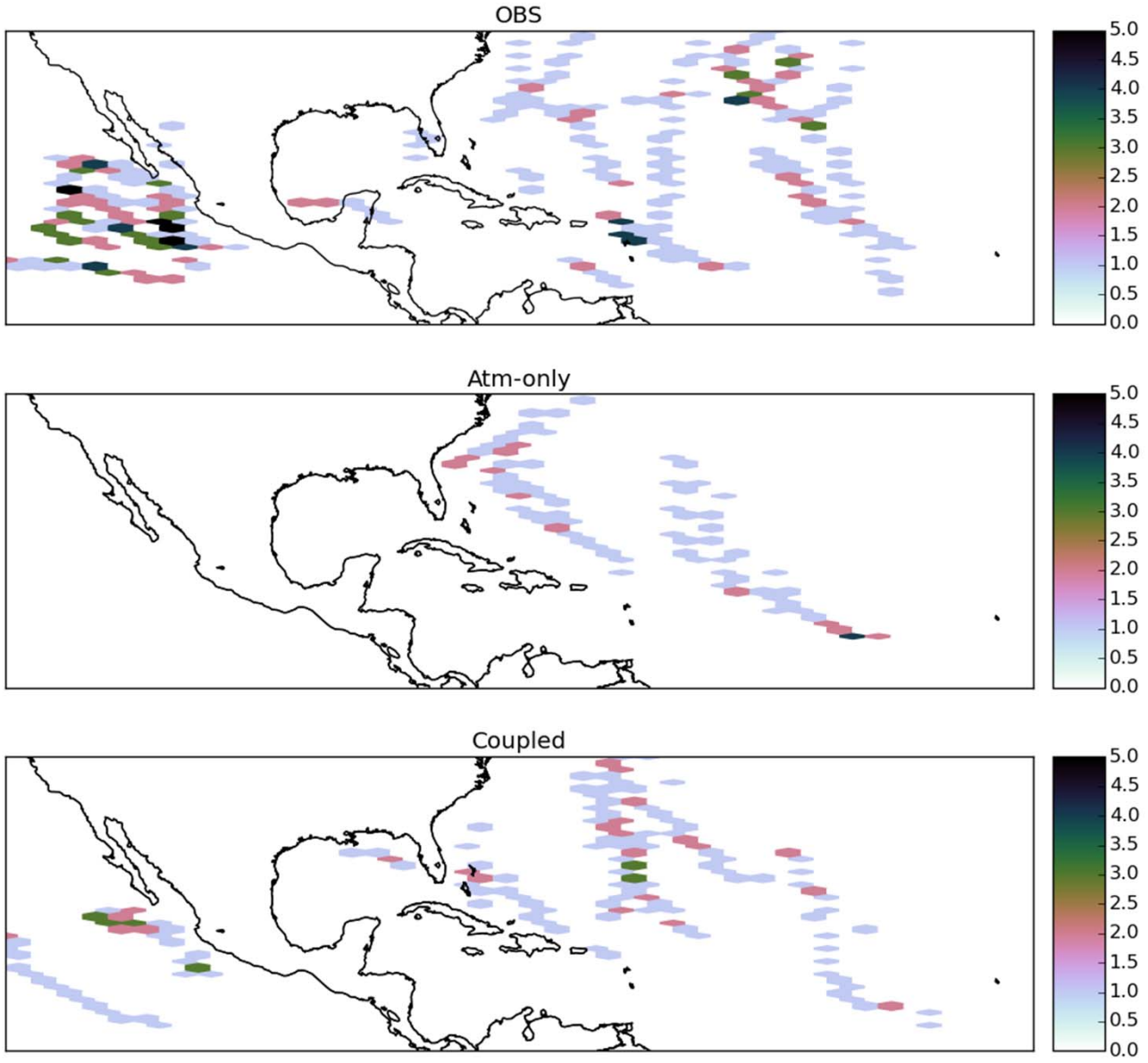


CA precipitation

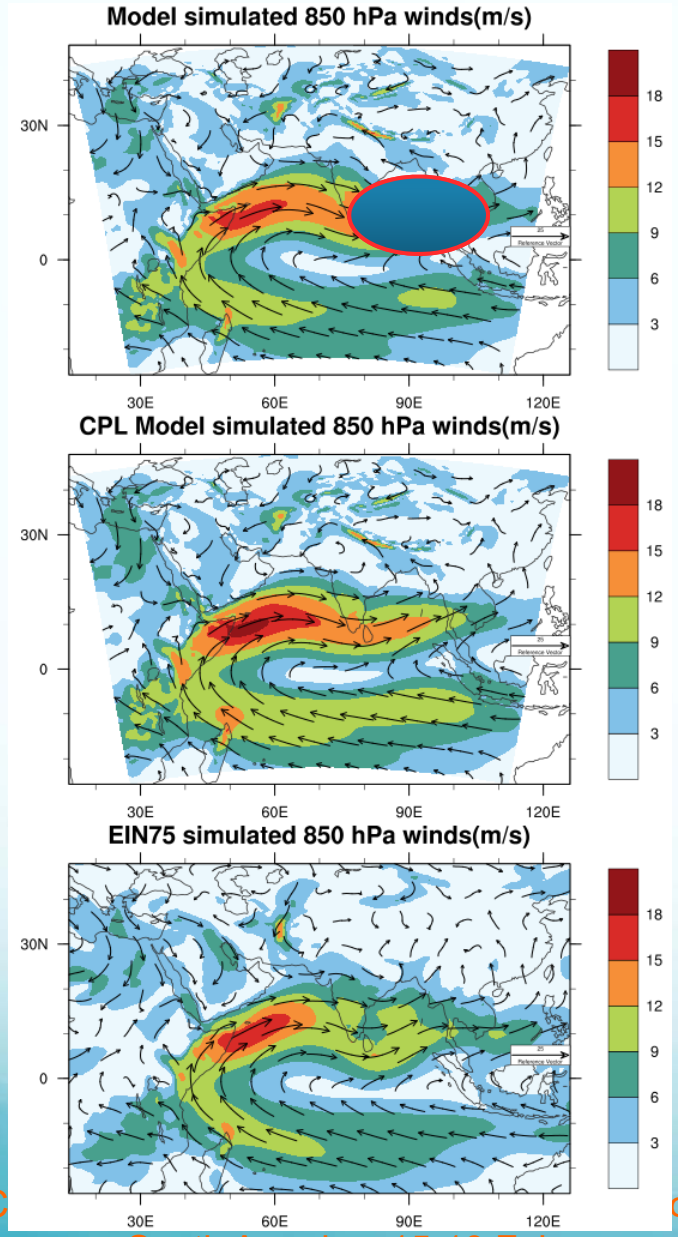



North American Monsoon region
33°N
30°N
27°N
24°N
21°N
120°W
117°W
114°W
111°W
108°W
105°W
30
25
20
15
10
5
0
e of precipitation, 2002-2005 Monsoon
Atmos only
CRU
GPCP
ERA
Coupled
Precipitation,mm day-1
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
J
F
M
A
M
J
J
A
S
O
N
D
Time,months

Cyclone density



The circulation pattern JJAS

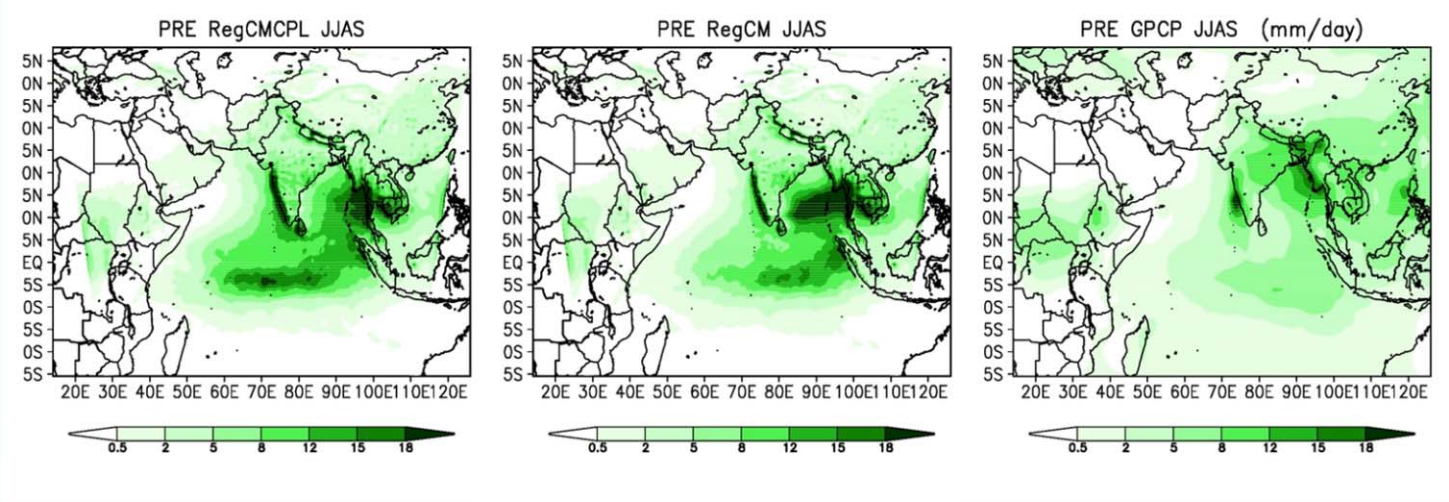


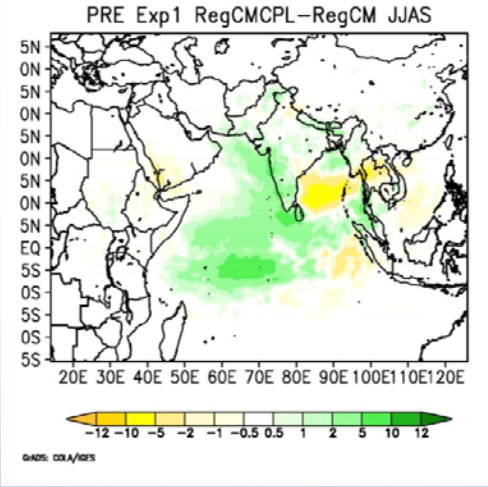
ATM stand alone

Coupled model

ERA-interim

India precipitation

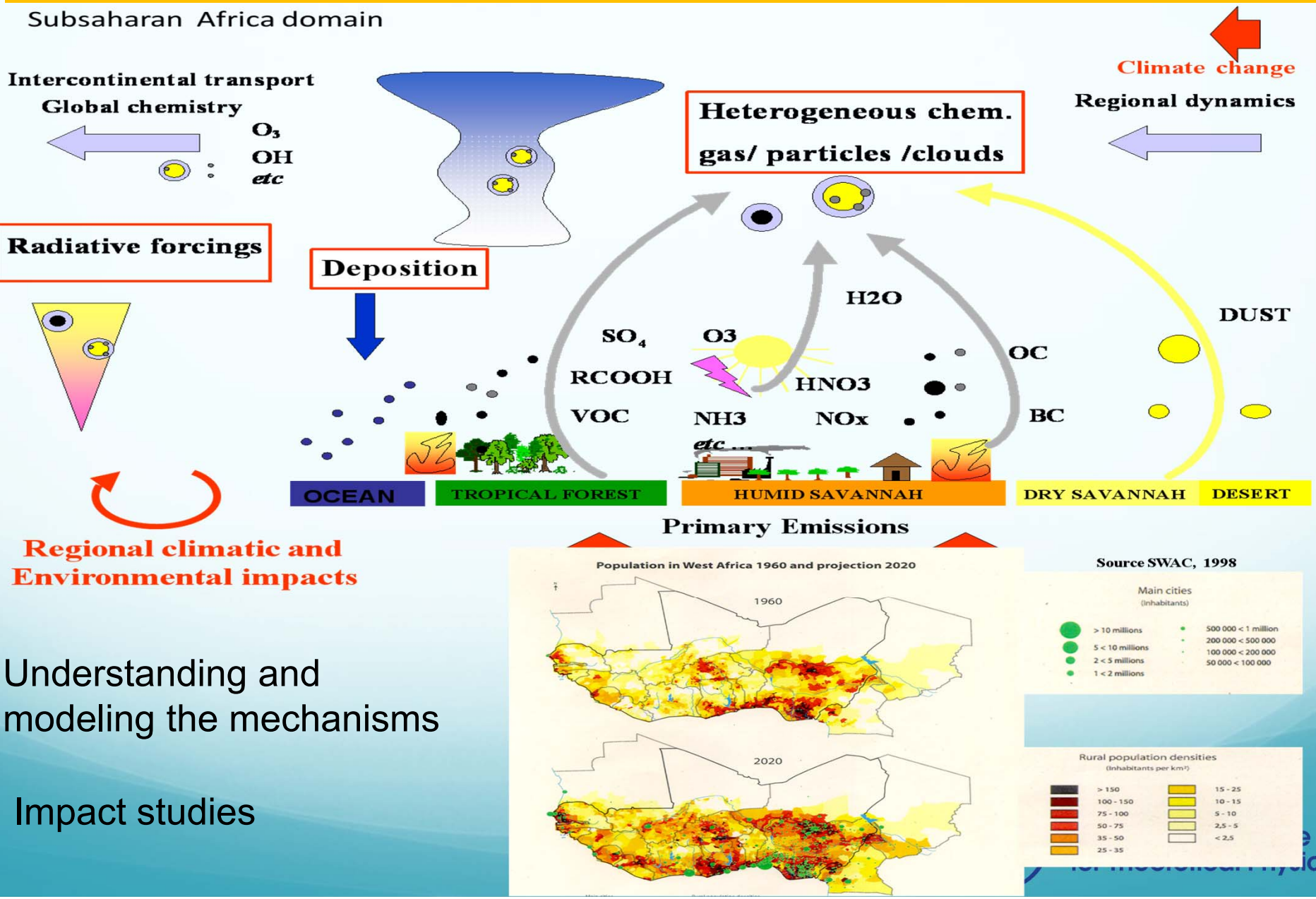




Earth System model


Chemistry-climate interactions
Tianjin
Yellow River
200 km

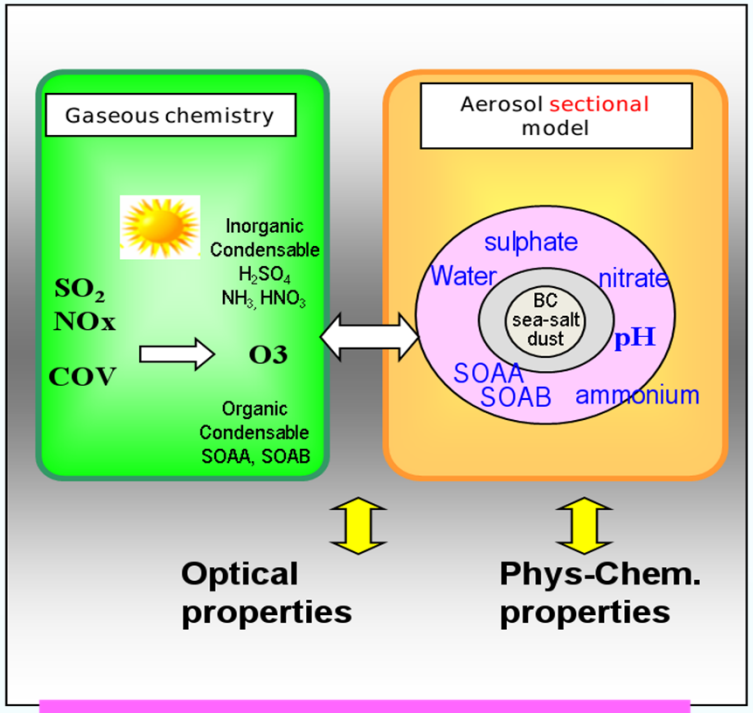
Interaction between atmospheric chemistry, climate, and biogeochemical cylces in a changing environment.



Understanding and modeling the mechanisms

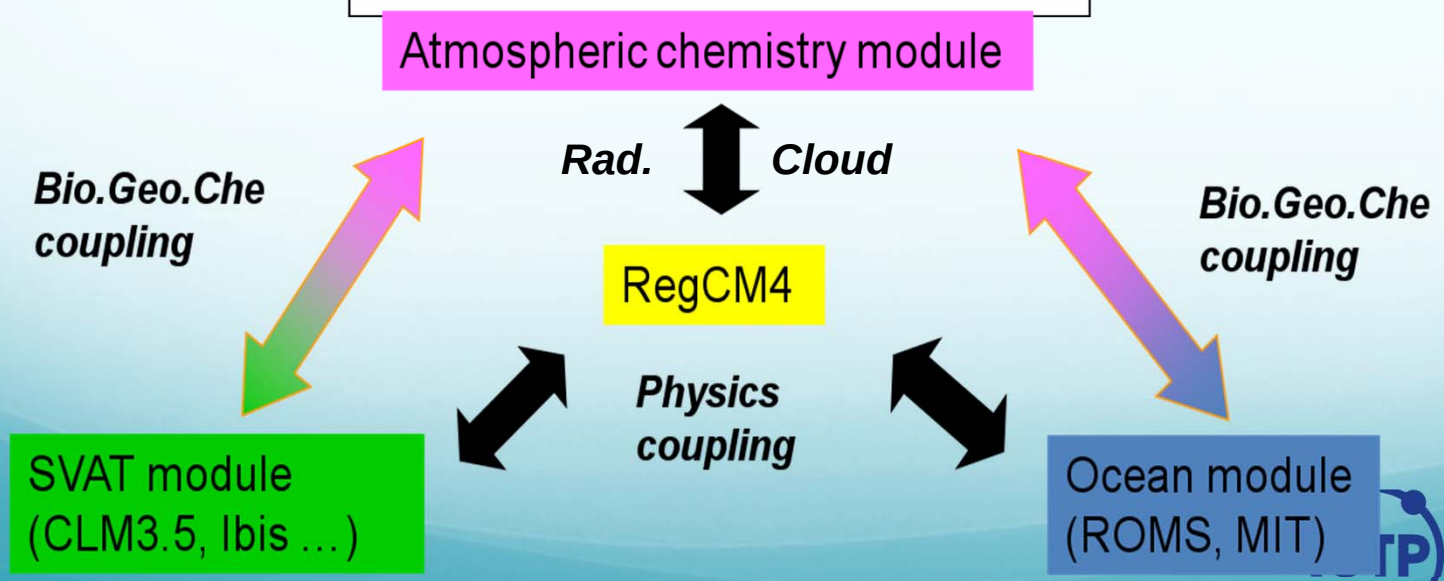
Impact studies

Model developments …



External Collaborations.

Univ of Michigan
DMI, Cophenaghen
LA, CNRS, Toulouse
JRC, Ispra
Egyptian Met. Aut.
…



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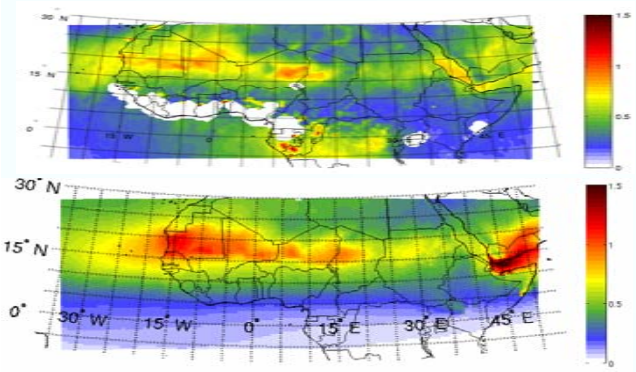
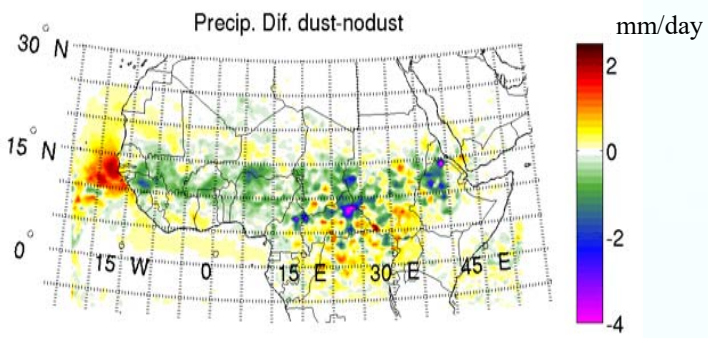
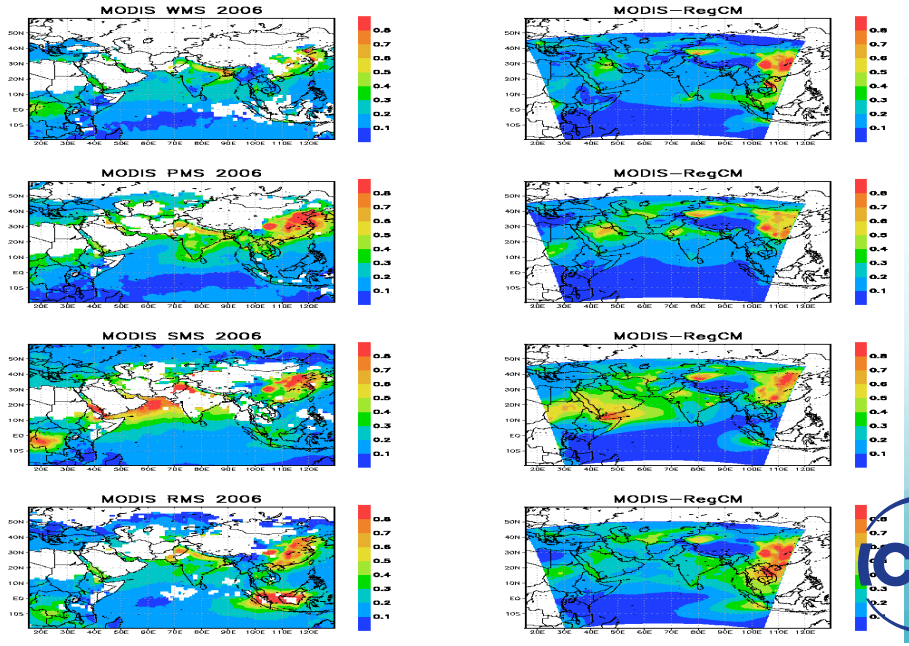
Examples of studies

- Aerosols impacts over Africa (Dust and Biomass burning)
  Solmon et al., 2008; 2011 ; Tummon et al., 2010; Malavelle et al., 2011





- The paprika project : impact of absorbing aerosol deposition on snow in the Hymalayas (Post doc : Vijayakumar S Nair)



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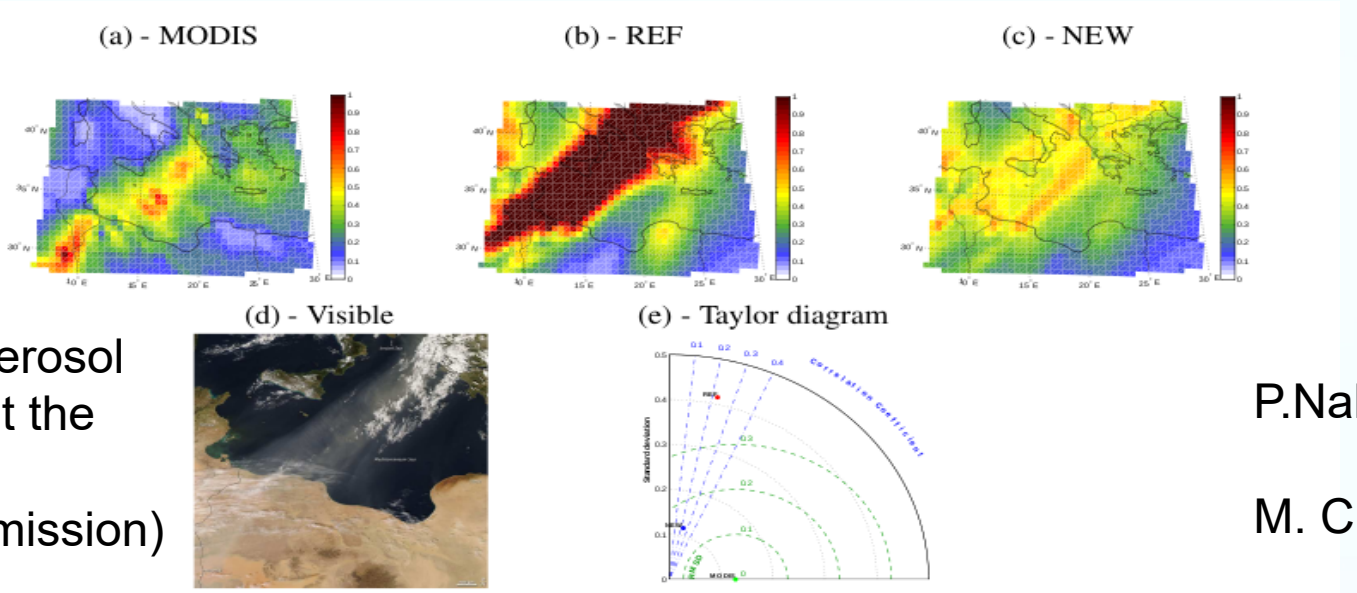
- Aerosols impacts on Euro / Mediterranean climate
  (proj. : MEGAPOLI, CharMex/HyMEx, P.Nabat, M. Chiacciho)



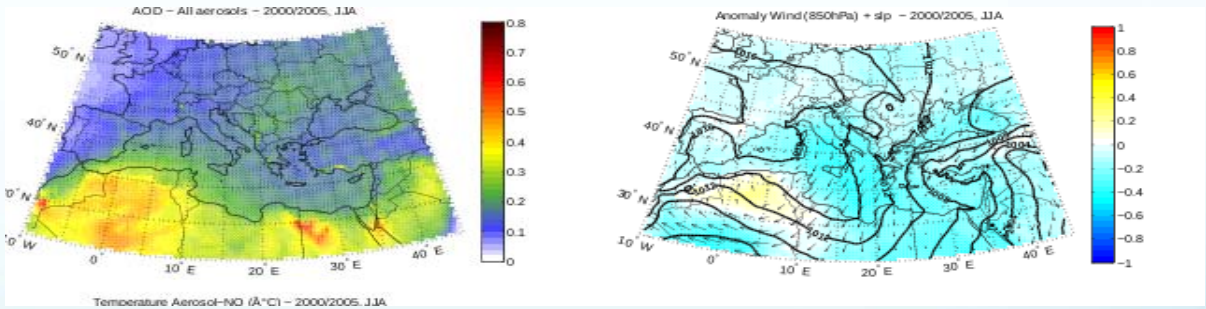
Improving the aerosol scheme at event the scale
(eg here dust emission)

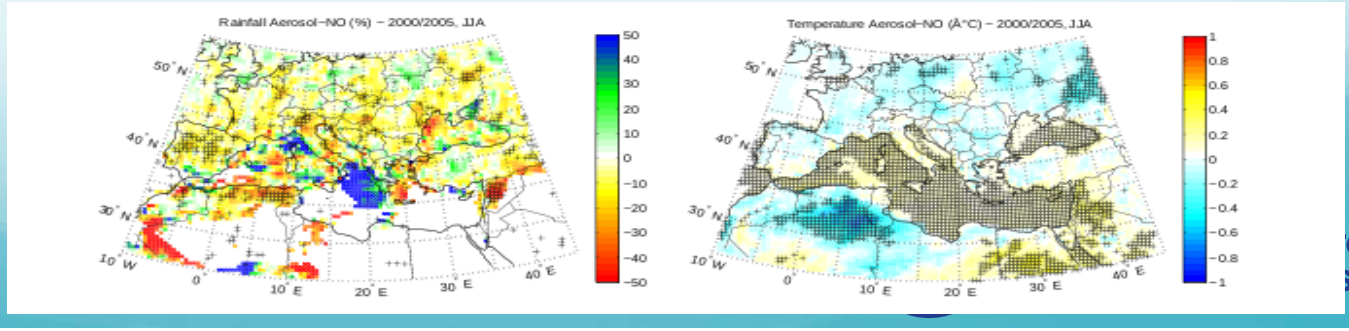
P.Nabat

M. Chiaccio

Impact of aerosol on radiative budget and hydrological cycle.

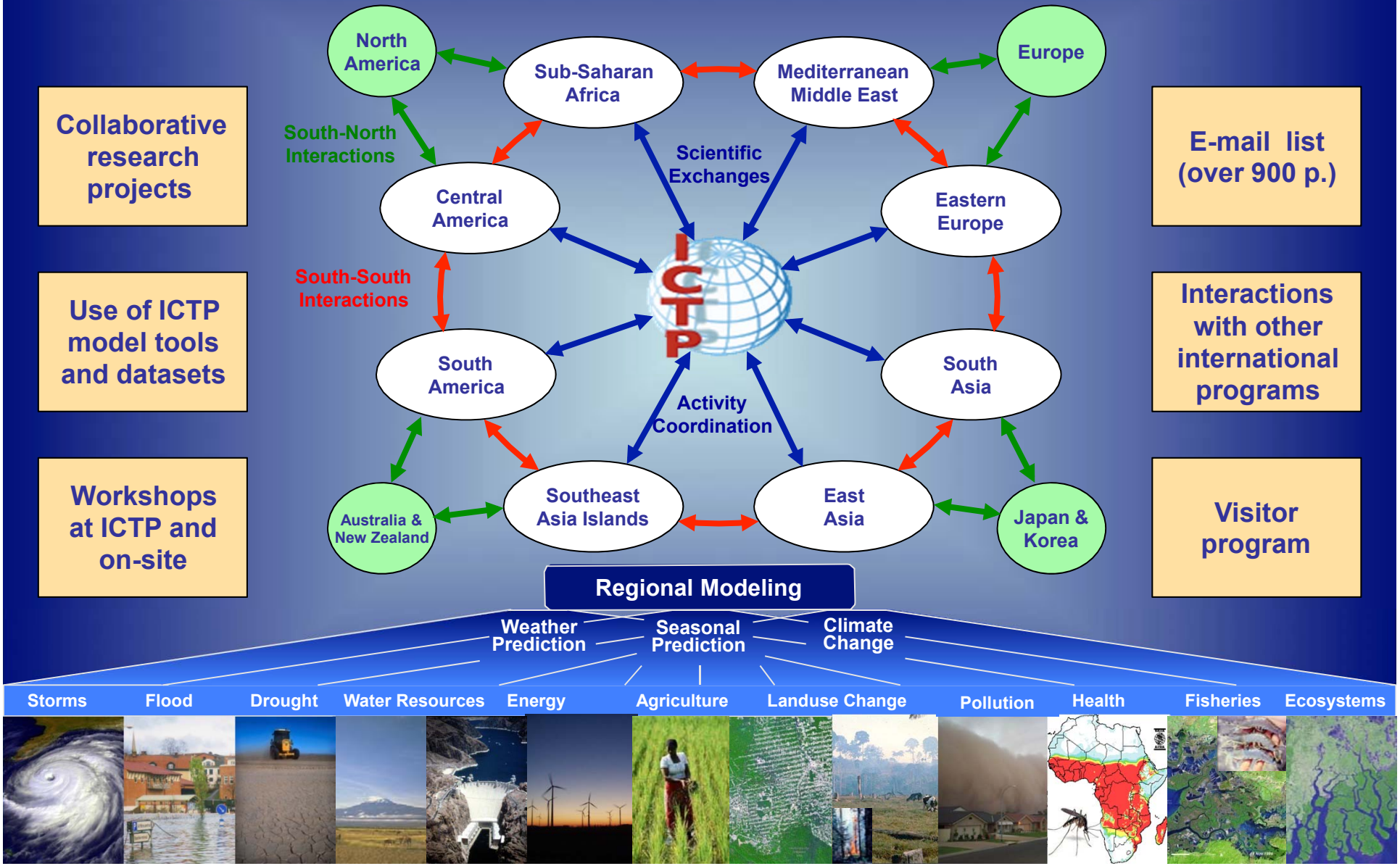
Impact of aerosol deposition on marine ecosystems





Earth System model

The ESP RegCM and Regional Climate research NETwork, RegCNET



Collaborative research projects

Use of ICTP model tools and datasets

Workshops at ICTP and on-site

E-mail list (over 900 p.)

Interactions with other international programs

Visitor program

What ‘s next?

Atmosphere

- Decoupling of convection time step and integration time step to speed up the model Done

Target : 12 km projections over all the COORDEX domain for the COORDEX phase 2

- Non hydrostatic version of the model : RegCM5 Done

Ocean-Hydro-Chem

- Benchmark simulations over all the 3 coupled domains.
- Scenario simulations over the coupled Indian domain
- Fully coupled 12km RCSM simulation over the Med-CORDEX domain: ocean-atm-land-river + realistic 2D spatial, seasonal, trend variability of aerosols + GHG

Joint ICTP-Trieste/ICTP-SAIFR Advanced School on Regional Climate Modeling over South America
15-19 SEptember 2016, São Paulo, Brazil

Thank you

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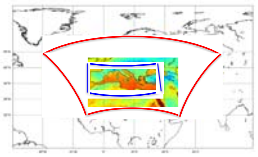
www.ictp.it

8th ICTP WORKSHOP ON THE THEORY AND USE OF

REGIONAL CLIMATE MODELS

23 May - 3 June 2016
Miramare, Trieste, Italy

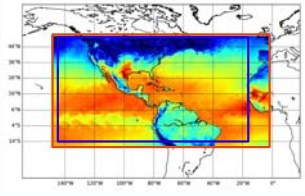


The Abdus Salam International Centre for Theoretical Physics (ICTP) is organizing its **"Eighth ICTP Workshop on The Theory and Use of Regional Climate Models"** to be held on 23 May - 3 June 2016 in Trieste, Italy.

The directors of the Workshop are **F. Giorgi** (ICTP, Italy), **E. Coppola** (ICTP, Italy), **T. Cavazos** (CICESE, Mexico), **X. Gao** (CMA, China).

Regional climate models (**RCMs**) are widely used tools to produce high resolution climate information at regional scales, and can be run at resolutions of a few km which allow explicit description of convection processes. The ICTP regional climate modeling system, **RegCM**, is one of the most used **RCMs** worldwide. Its latest version, **RegCM4**, has been recently augmented in several aspects, in particular towards the application of the model to very high resolution (convection permitting simulations). Among the main model improvements in this direction are the implementation of non-hydrostatic dynamics, the refinement of an advanced explicit cloud microphysics scheme and the full coupling with the **MIT** ocean model, the **CHYM** hydrological model, the **CLM4.5** land-surface model including interactive vegetation and an augmented version of a chemistry/aerosol module.

As in previous workshops of this series, this event will provide lectures and extensive hands-on sessions on the theory of regional climate change and regional climate modeling as well as on the use of the **RegCM4** modeling system. The focus of the present workshop will be on the application of the **RegCM4** to high resolution experiments, in particular within the framework of the international program **CORDEX** (**CO**ordinated **R**egional **D**ownscaling **EX**periment). During the workshop, the new features of the model will be described and tested, and a new version of the model will be released. In addition the contribution of the **RegCM** community to the next phase of the **CORDEX** program will be discussed. The workshop will also include a special session on the interactions between air quality, climate processes and climate change in diverse region of the world under the framework of the **EU REQUA** (Regional climate-air quality interactions) project.



The workshop is also aimed at providing a forum for current and future model users to discuss relevant issues and formulate needs and priorities for further model development and dissemination. A limited number of participants are envisioned, with proven experience in climate modeling and a strong interest in using the **RegCM4** system for regional climate studies.

Participation:
The workshop is intended for scientists and graduate students working in the areas of Atmospheric Physics and Dynamics, Climatology, Oceanography, Physics and Mathematics. It is open to scientists from all member countries of the United Nations, UNESCO and IAEA. The activity will be conducted in English. Limited funding (including travel grants) for participation in the conference is available for scientists from developing countries. No registration fee is required.

How to apply for Participation:
The on-line application form can be accessed at ICTP activity website:

http://indico.ictp.it/event/7613

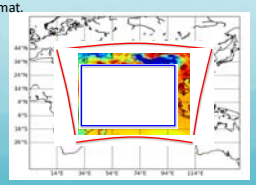
Once in the website, comprehensive instructions will guide you step-by-step, on how to fill out and submit the application form. Please send all fill attachments in Word or PDF format.

Contact Information:

Phone: +39 040 2240 426, **E-mail:** smr2831@ictp.it

ICTP Home page: http://www.ictp.it

November 2015



Directors:

F. Giorgi
(ICTP, Italy)

E. Coppola
(ICTP, Italy)

T. Cavazos
(CICESE, Mexico)

X. Gao
(IPA/CAS, China)

Invited Speakers

N. Ban (ETH, Switzerland)
M. Bukovsky (NCAR, USA)
L. Caporaso (CMCC, Italy)
R. Farneti (ICTP, Italy)
I. Guettler (DHMZ, Croatia
E. S. Im (MIT- SMART, Singapore)
R. Porfirio da Rocha (U. Sao Paulo, Brazil)
F. Stordhal (U. Oslo, Norway)
M. B. Sylla (WASCAL, Burkina Faso)
U.U. Turuncoglu (ITU, Turkey)
N. van Lipzig (KU Leuven, Belgium)
P. Zanis (U. Thessaloniki)

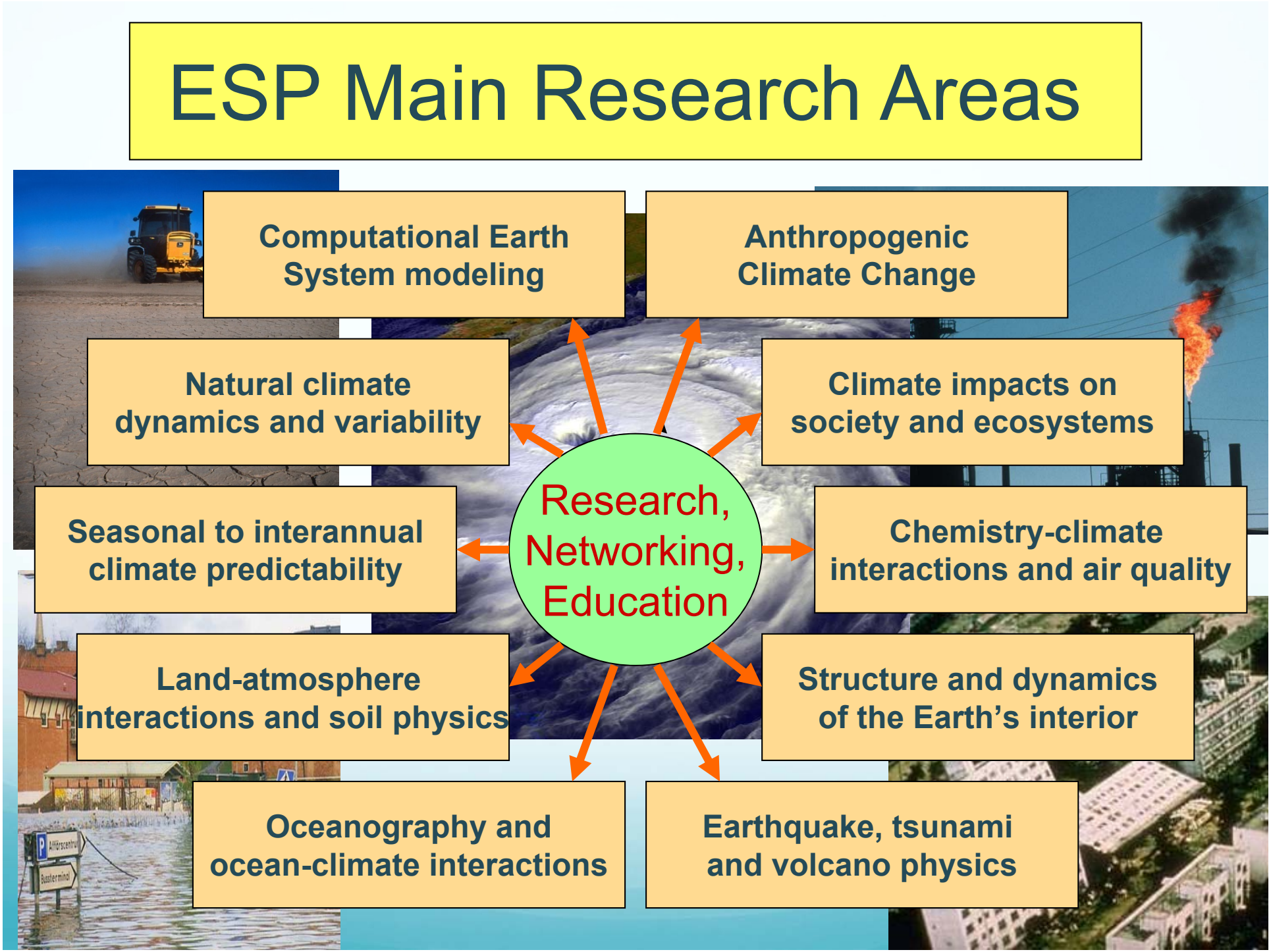
Laboratory Instructors:

G. Giuliani (ICTP)
L. Mariotti (ICTP)
U.U. Turuncoglu (ITU, Turkey)
C. Torma (ICTP)
R. Fuentes Franco (ICTP)
R. Farneti (ICTP)
F. Di Sante (ICTP)
F. Solmon (ICTP)

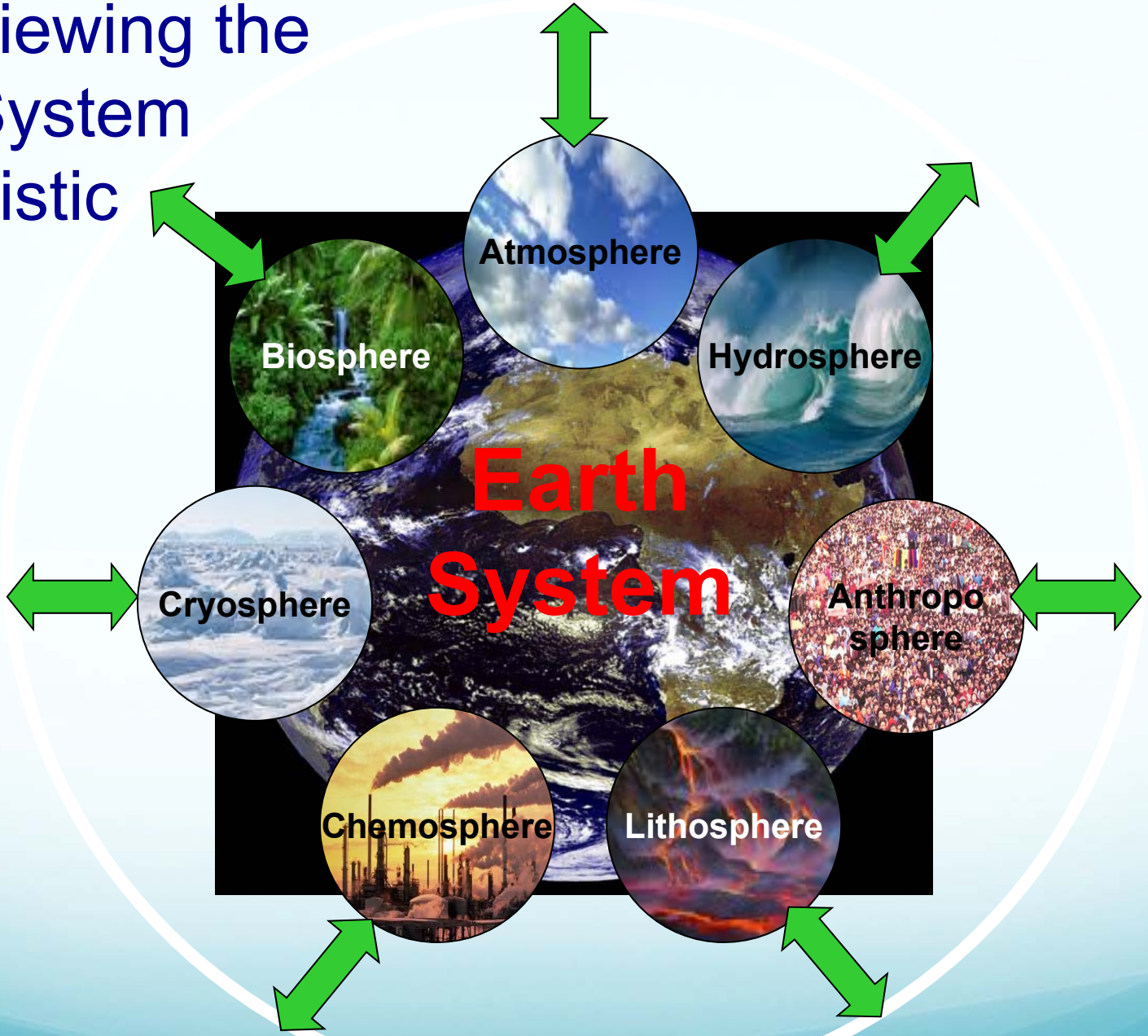
APPLICATION DEADLINE

29 February 2016

ESP Main Research Areas

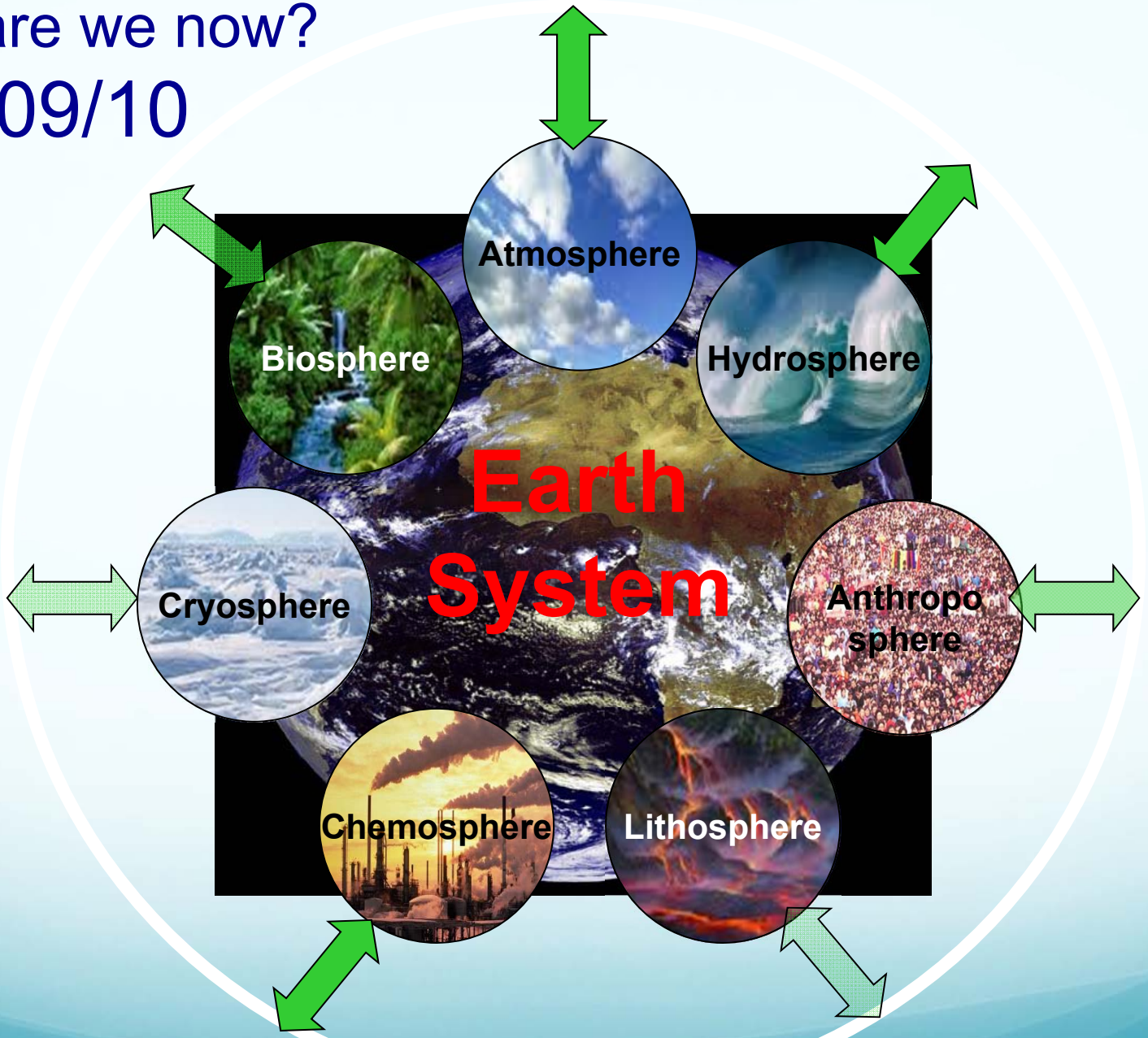


ESP: Viewing the Earth System in a holistic way



Where are we now?

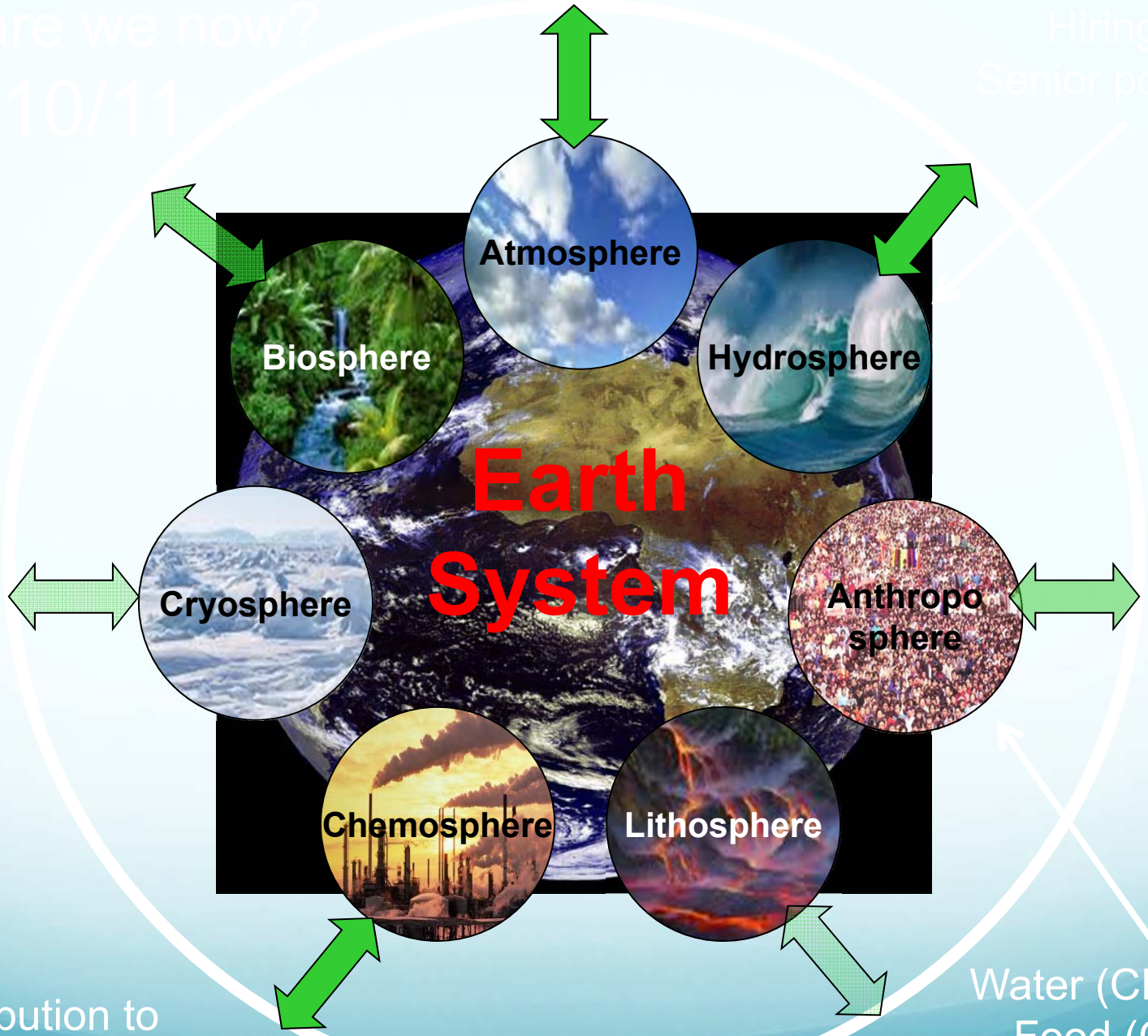
2009/10



Where are we now?

2010/11

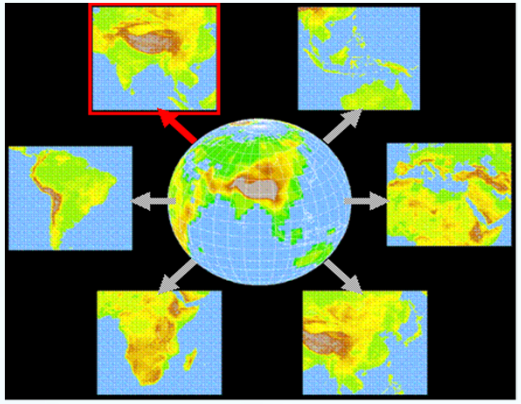
Hiring of
Senior post-doc



Contribution to
the ICTP HPC cluster

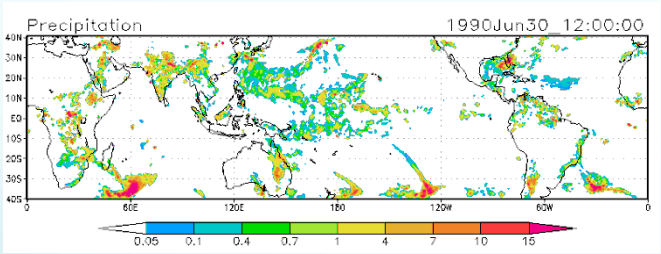
Water (CR,PAPR)
Food (CR,ILLY)
Health (HF, ATOPICA)

Computational Earth System modeling

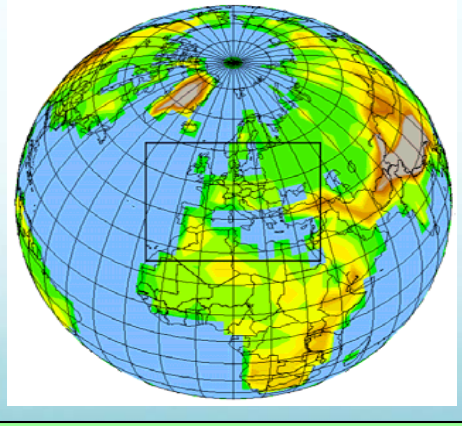


Regional Earth System Modeling (RegCM)

Global Earth System Modeling (ECHAM, SPEEDY)



RegCM Tropical Band



Computing resources:
Local cluster (ARGO)
SISSA cluster
CINECA
ECMWF

Developing flexible and economical tools for developing country needs