CPTEC
Centro de Previsão de Tempo e Estudos Climáticos

MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

INPE/CPTEC – NOAA Meeting on Weather and Climate Modeling

Silvio Nilo Figueroa/Dirceu Herdies
CPTEC/INPE

Part1. An overview on the CPTEC Global Weather and Climate Modeling System

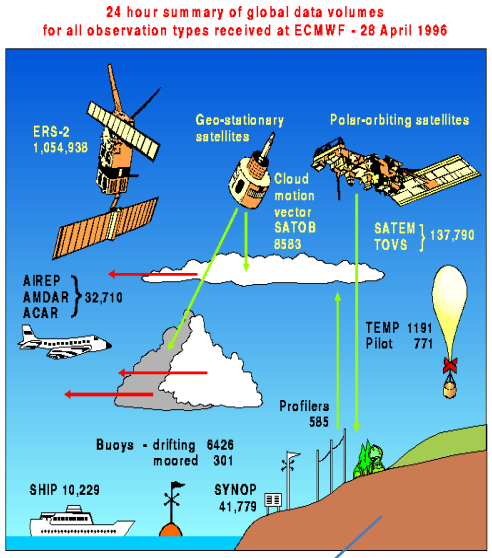
Part2. CPTEC Global Atmospheric Modeling and frontier research topics in Tropical climate Modeling (Teleconnections, Tropical Convection, Andes, etc.)

Cachoeira Paulista, 09/26/2019

We have three serious issues in our global weather and climate modeling

1) We don't have our DAS operational yet
2) Our global model has serious errors over Southern South America (dry bias)
3) We don't have our ESM yet.

CPTEC operational Regional and Global NWP system



DATA

3DVAR

INITIAL CONDITION (CPTEC)

INITIAL CONDITION (from NCEP)

REGIONAL NWP(WRF)
South America: 5 km
3km ???
1km ???

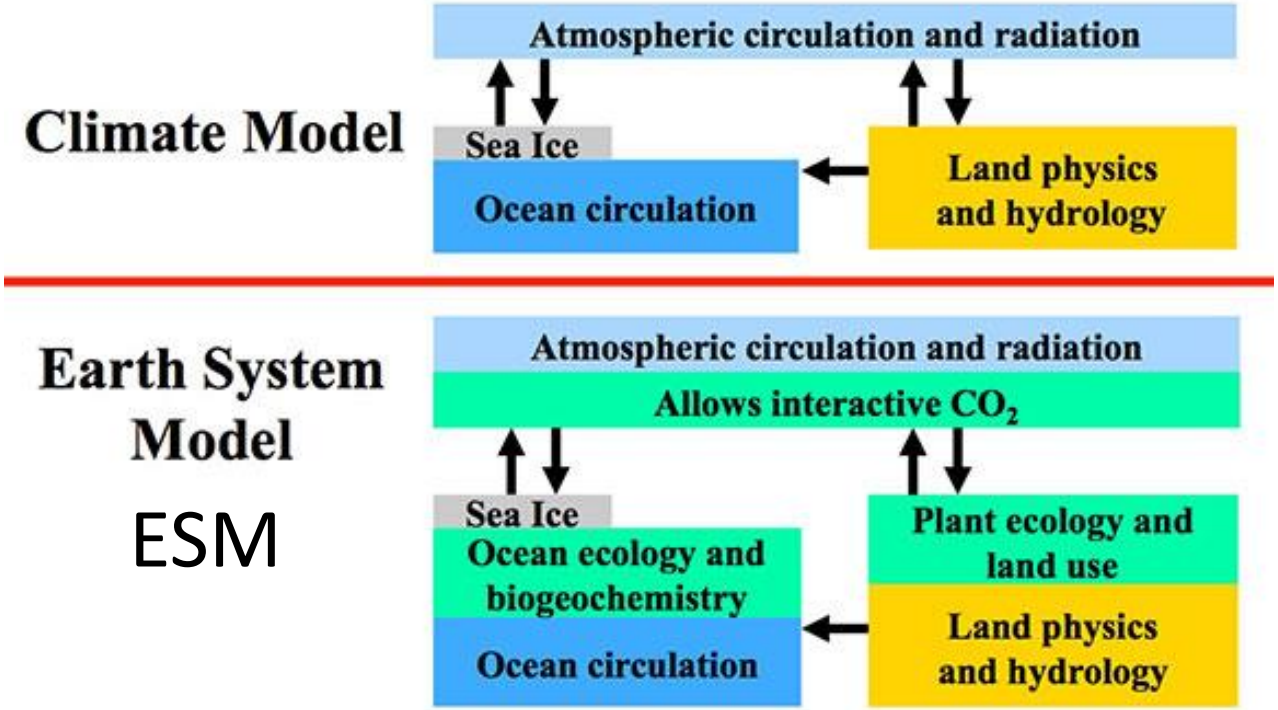
GLOBAL ATMOSPHEIC MODEL (BAM)
20 km (since Jan-1-2016)
9km ????
5km ???

Numerical Weather Prediction (NWP)

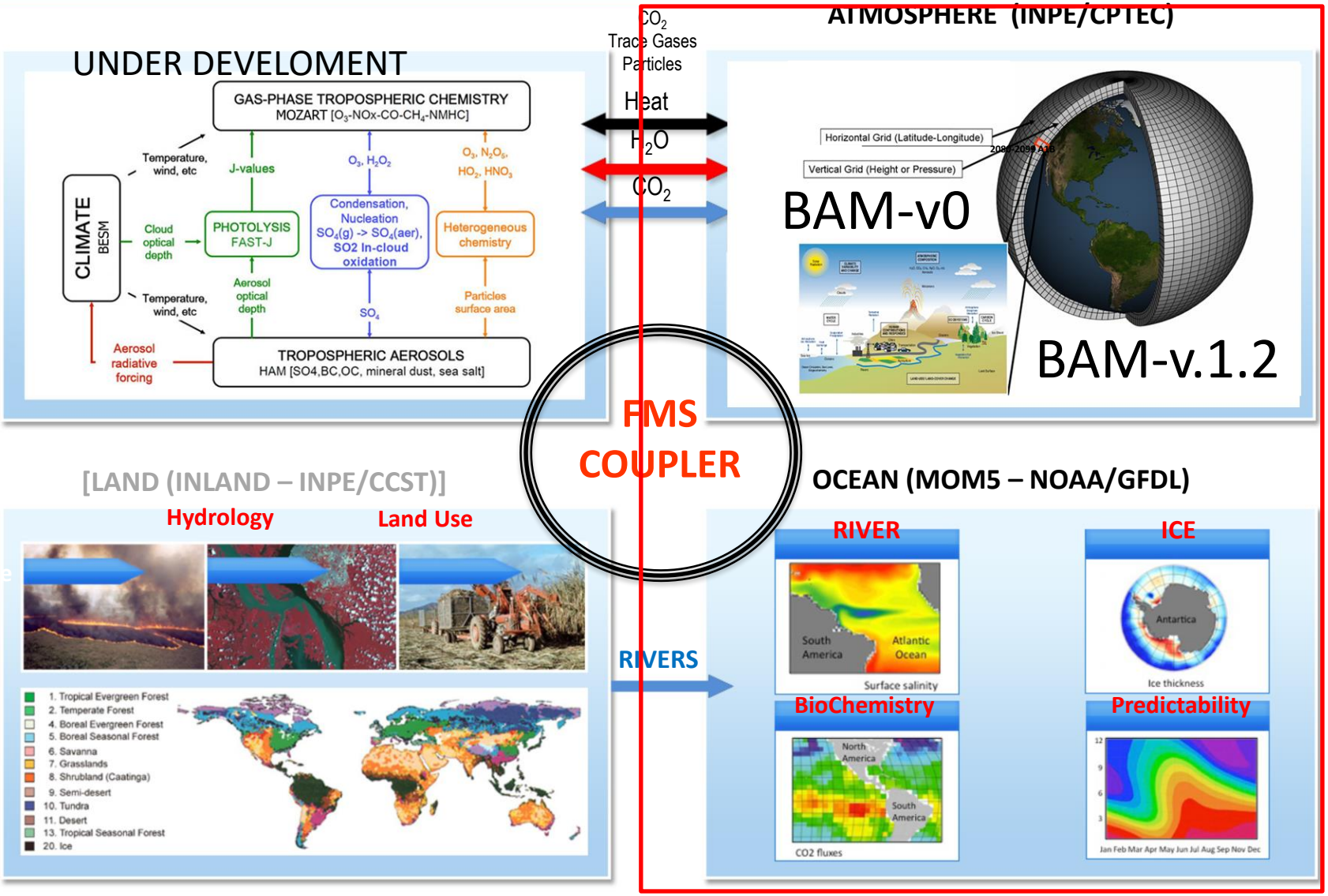
1 dia
2 dias
3 dias
4 dias
5 dias
6 dias
7 dias
8 dias
9 dias
10 dias
11 dias
12 dias
13 dias
14 dias
15 dias

Ensemble prediction (probabilistic)

An Earth System Model (ESM) closes the carbon cycle



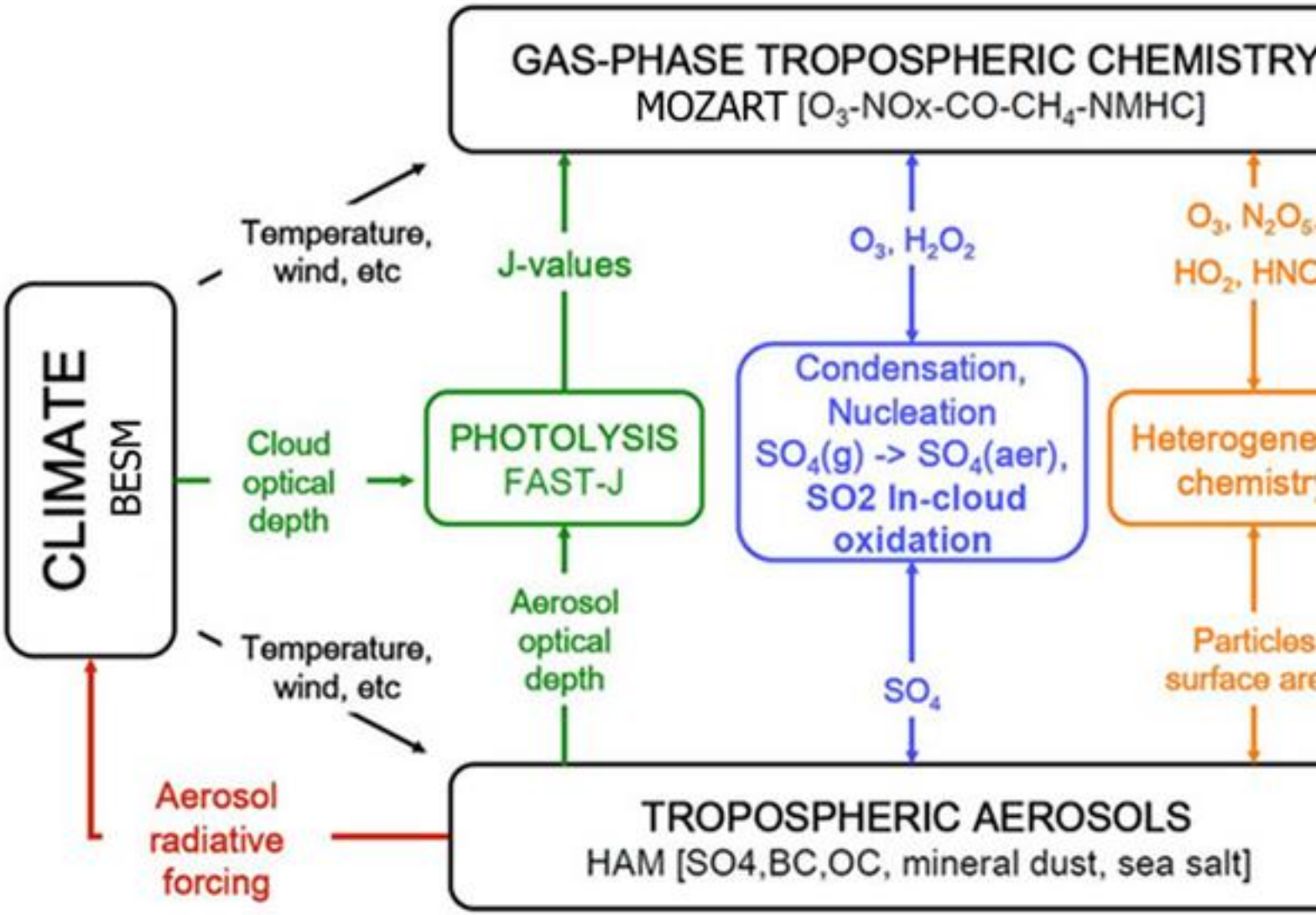
CPTEC COUPLE OCEAN-ATMOSPHERE MODEL
Brazilian Earth System Model (BESM) …..now it is BESM_OA



BESM_OA_2.5= BAM-vo+MOM5

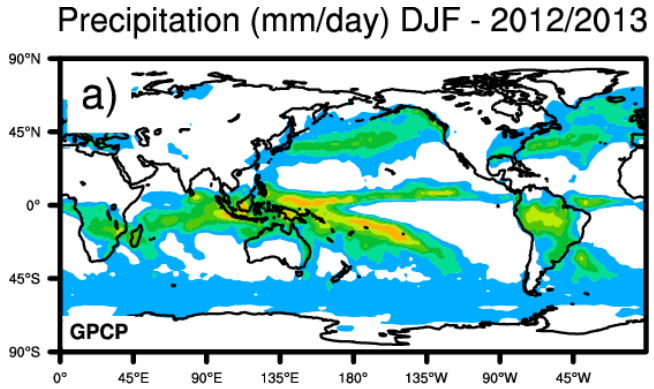
BESM_OA_2.8= BAM-v1+MOM5

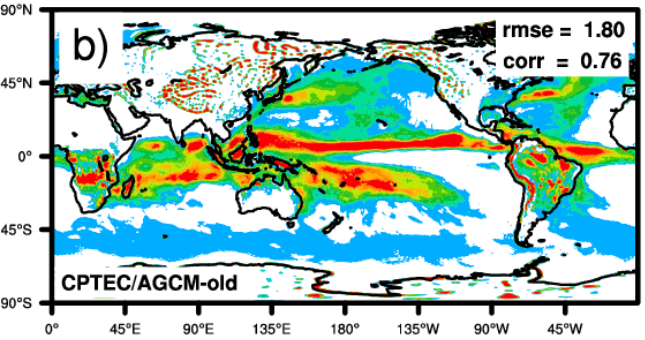
Courtesy: Paulo Nobre

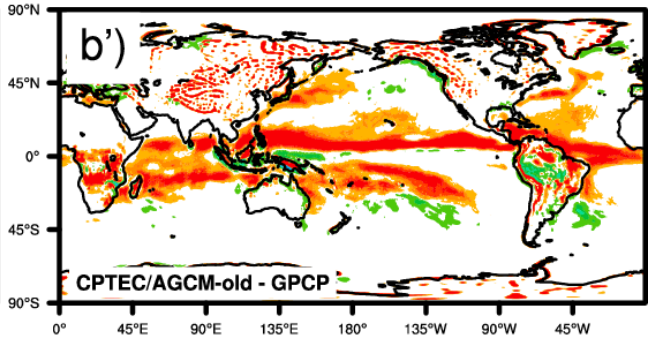

GAS-PHASE TROPOSPHERIC CHEMISTRY
MOZART [O3-NOx-CO-CH4-NMHC]
CLIMATE
BESM
Temperature, wind, etc
J-values
O3, H2O2
O3, N2O5
HO2, HNO
Cloud optical depth
PHOTOLYSIS
FAST-J
Condensation, Nucleation
SO4(g) -> SO4(aer),
SO2 In-cloud oxidation
Heterogene
chemistr
Aerosol optical depth
Particles
surface are
Temperature, wind, etc
SO4
Aerosol radiative forcing
TROPOSPHERIC AEROSOLS
HAM [SO4,BC,OC, mineral dust, sea salt]

DEVELOPMENT OF THE BRAZILIAN GLOBAL ATMOSPHERIC MODEL (BAM) (details in Figueroa et. al 2016)

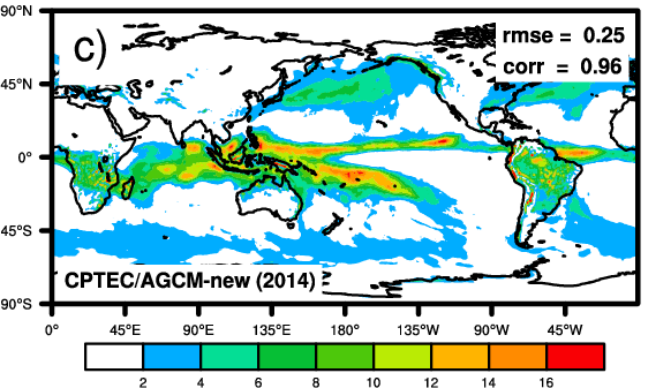
OBSERVED

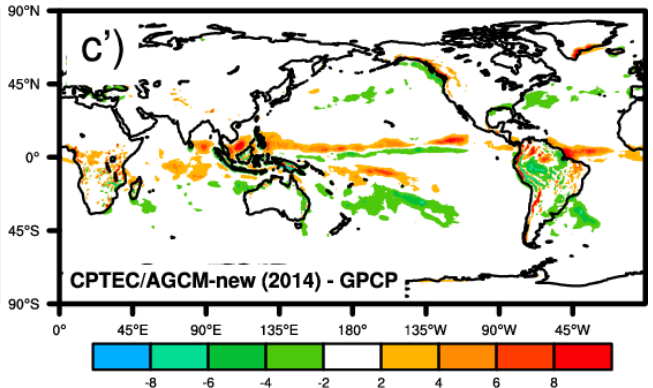






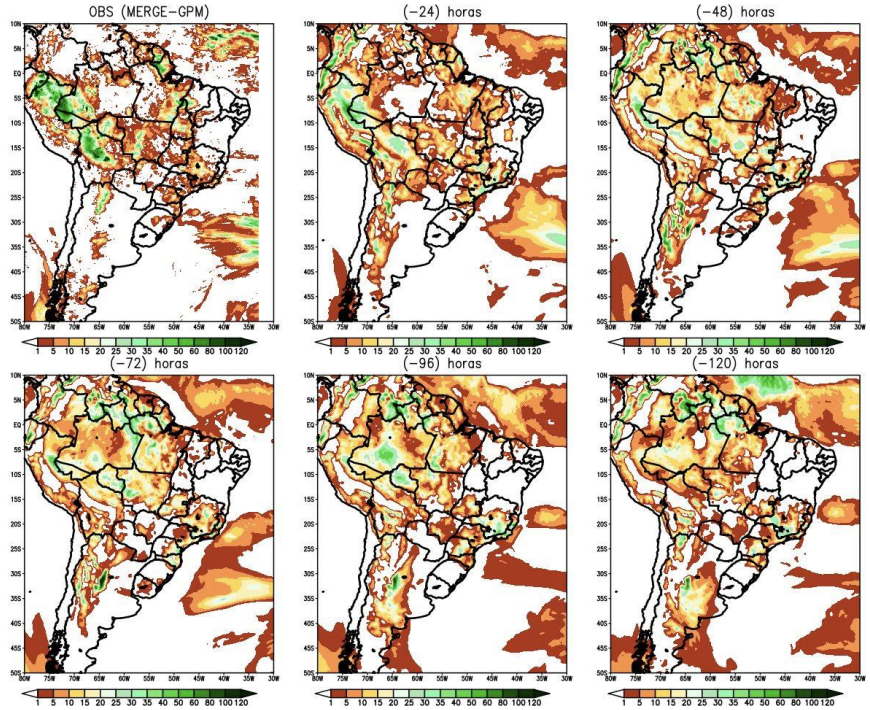
OLD CPTEC AGCM
(originally came from COLA)

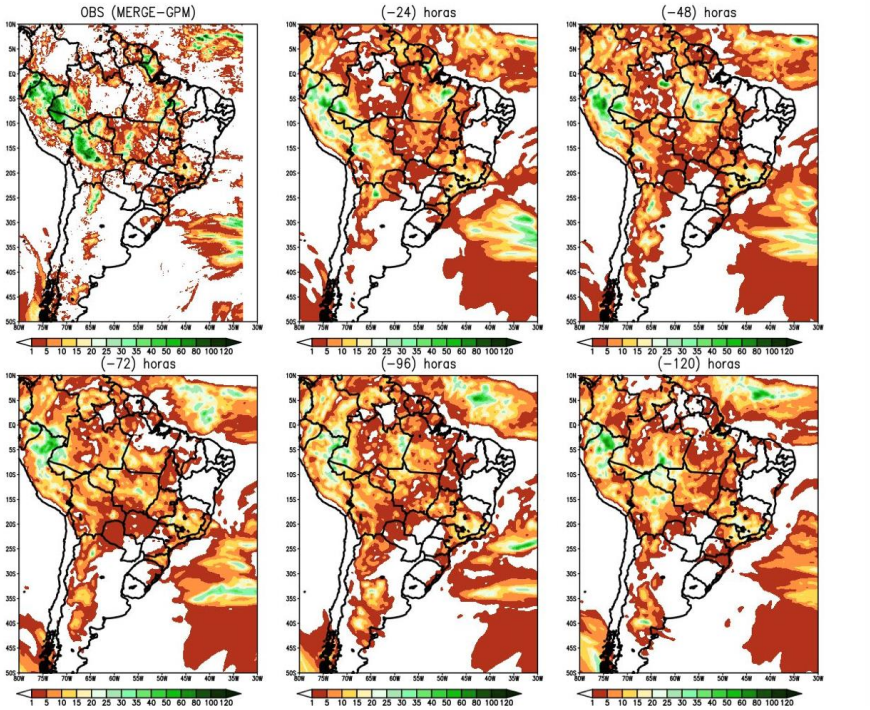




NEW CPTEC AGCM (BAM)
New Dynamic
New physical processes

Comparison between BAM-v1.2 (CPTEC) and GFS (NCEP) operational models





Is it possible to predict the South Atlantic Convergence Zone?

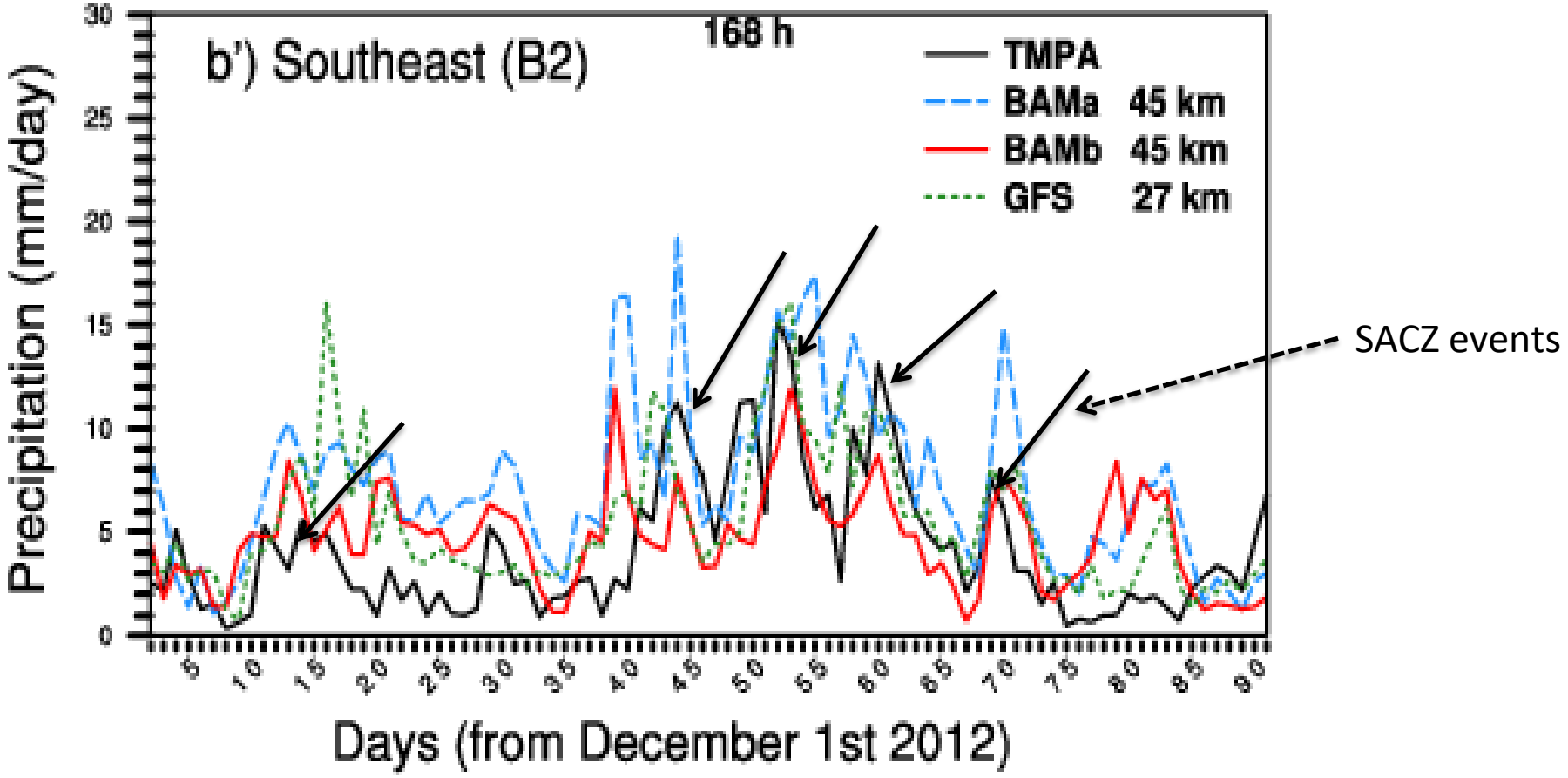


Fig. Daily mean precipitation for the period 01 December 2012 to 28 February 2013 from 168 hours (7 days) forecasts over the Southeast from TMPA and three NWP models indicated in the panel.

SOUTH ATLANTIC CONVERGENCE ZONE (SACZ)

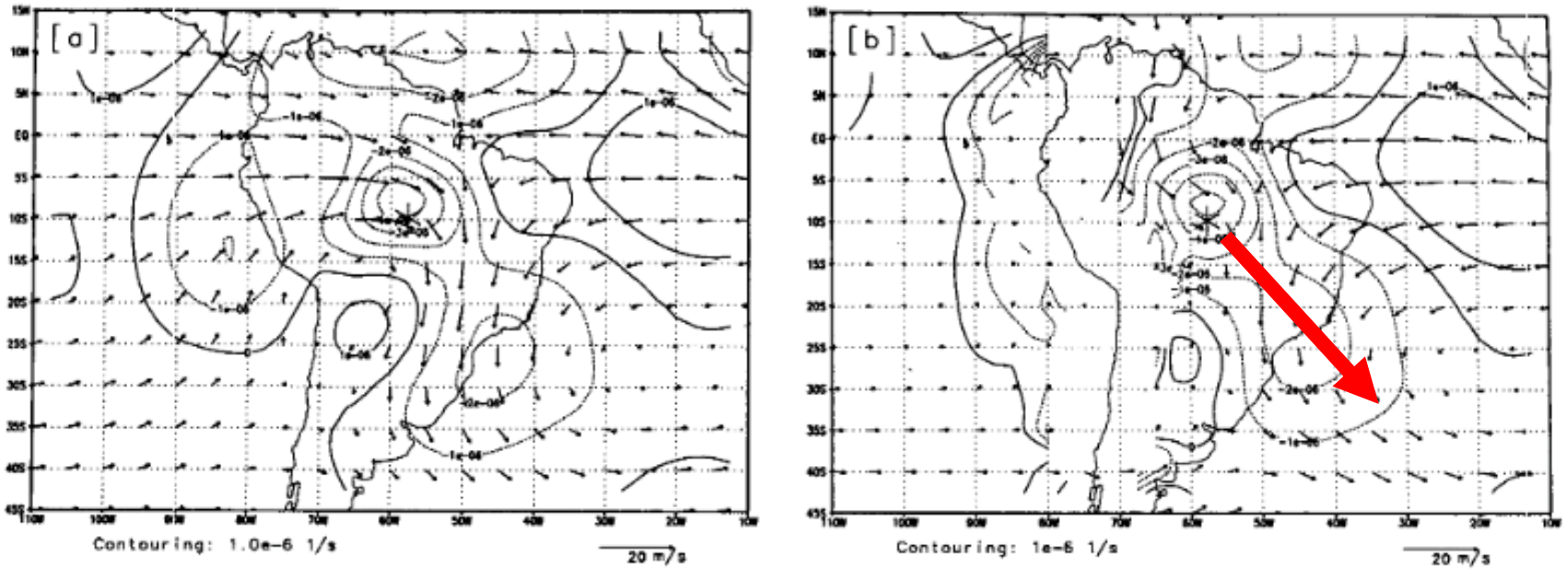
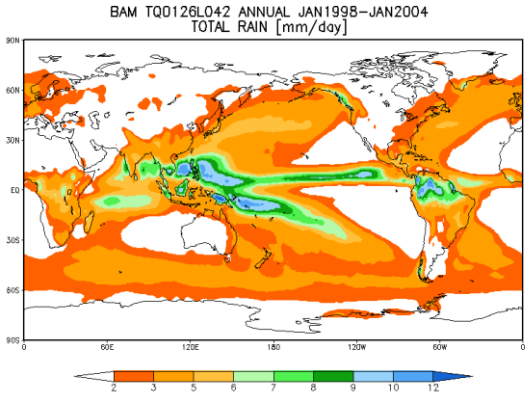


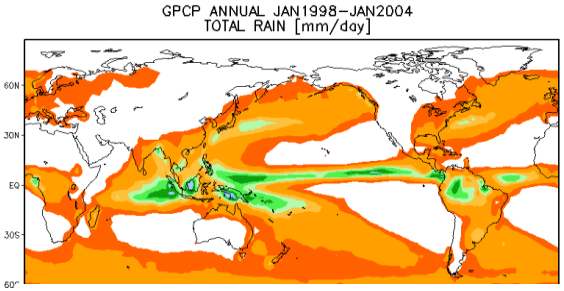
FIG. 10. Vector wind and divergence at 850 hPa in the cases with basic zonal flow: no-mountain case (experiment 3) (a) and mountain case (experiment 4) (b). Asterisk indicates the center of heat source.

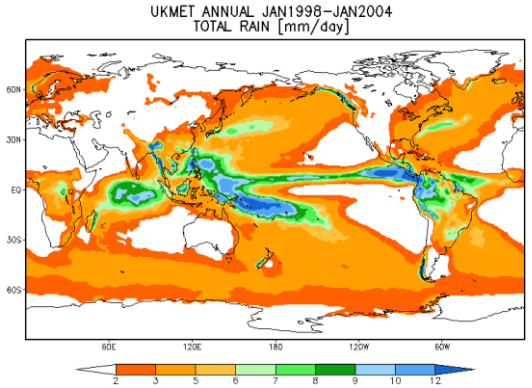
Figueroa et al. 1995

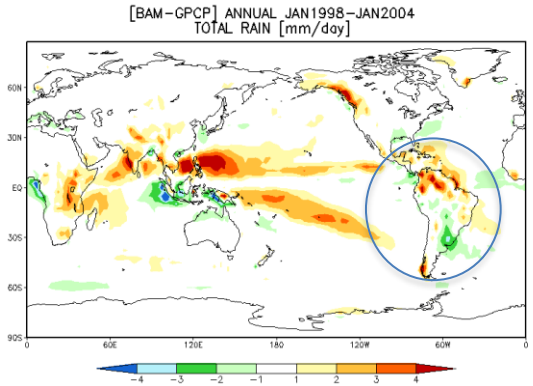
AMIP style simulation
CPTEC and UKMET Global Models

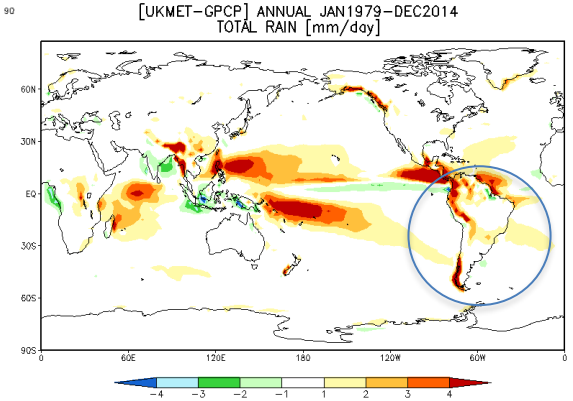
ANNUAL PRECIPITATION

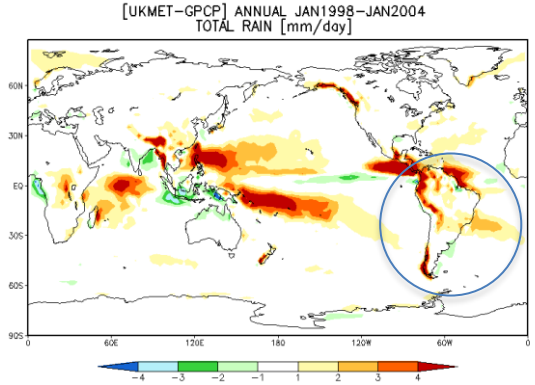












CPTEC: AMIP Style simulation (1998-2004)

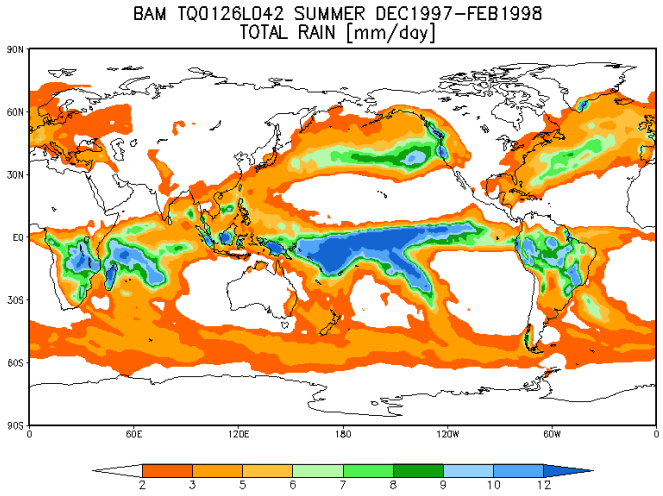
UKMET: AMIP simulation (1979-2014)

UKMET: AMIP simulation (1998-2004)

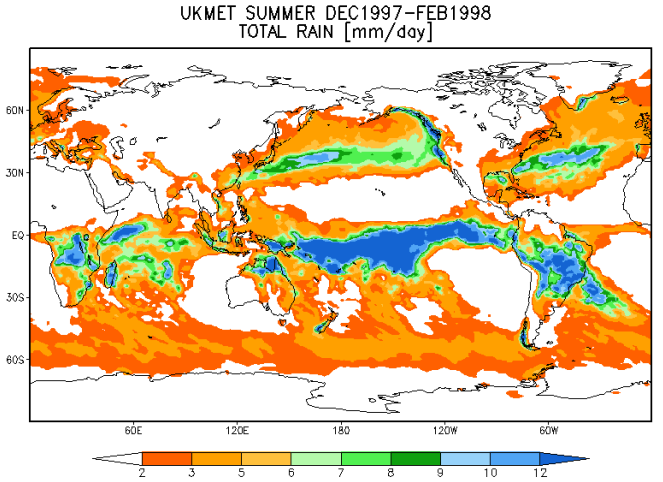
CPTEC. Southern South America

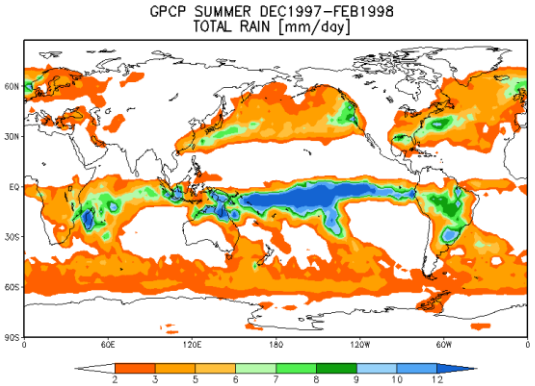
UKMET: SACZ, Andes

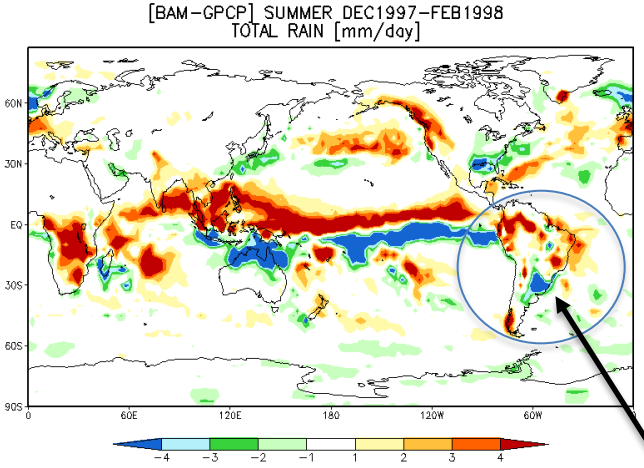
CPTEC:10-year long AMIP style (1995-2004), preliminary results.
UKMET: AMIP simulation (1979-2014)

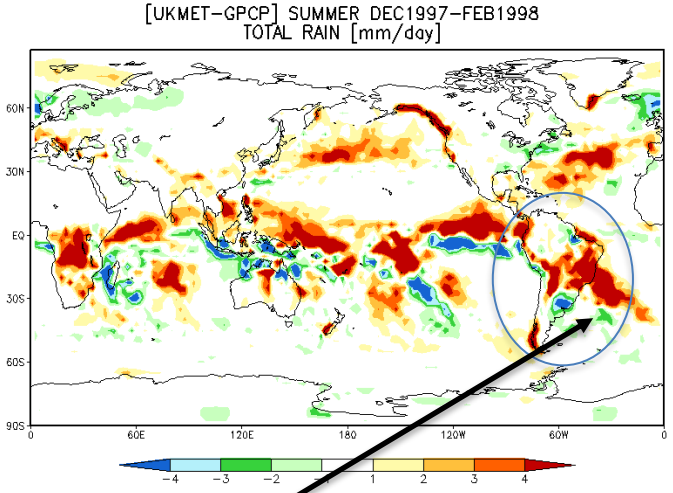


EL NIÑO 97/98









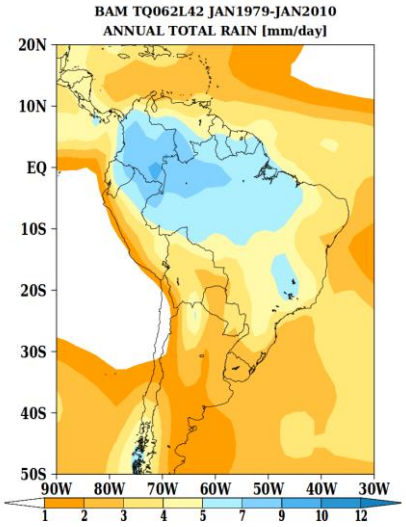
ERRORS

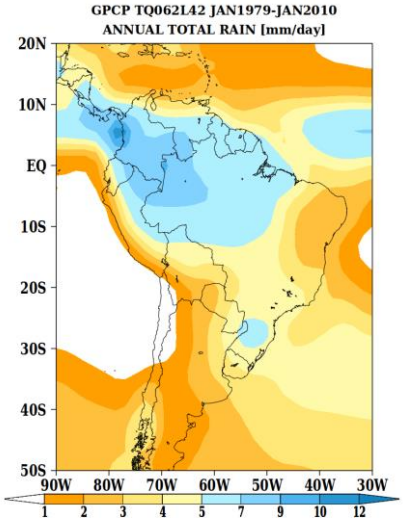
CPTEC. Southern South America

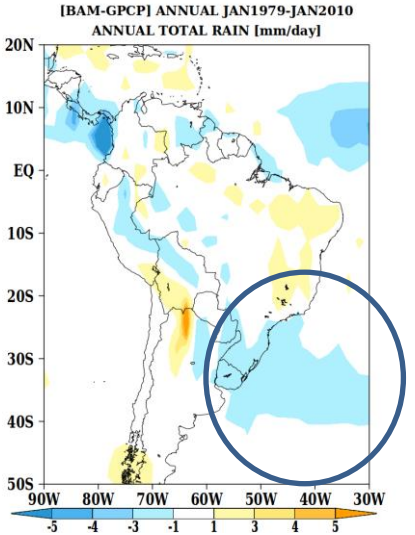
UKMET: Southern South America, SACZ, Andes

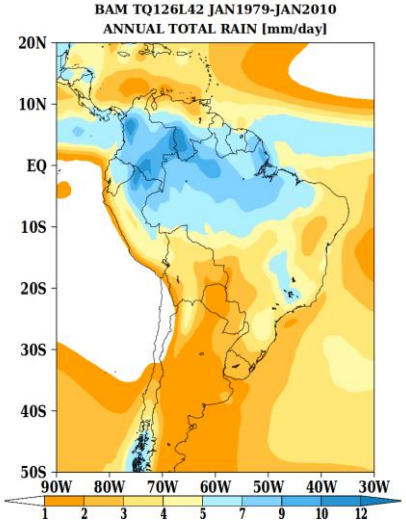
Our global model has serious errors over Southern South America (dry bias)

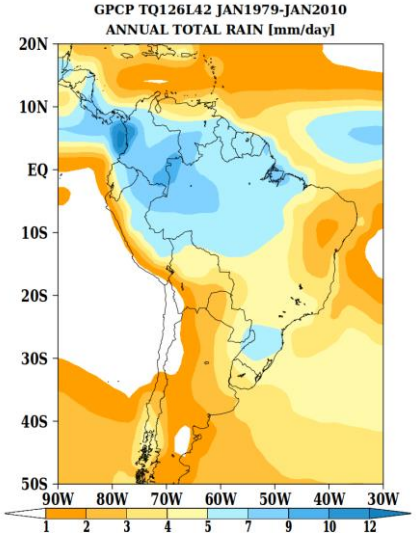
ANNUAL

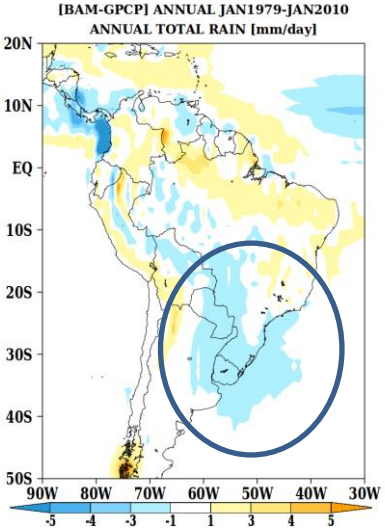


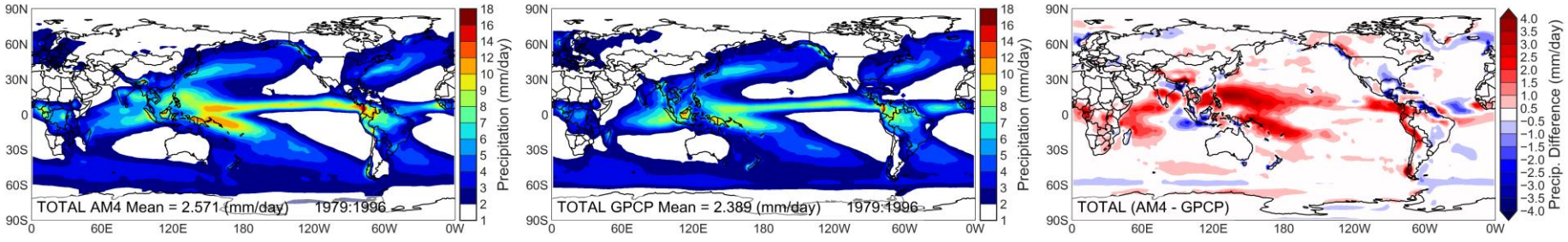




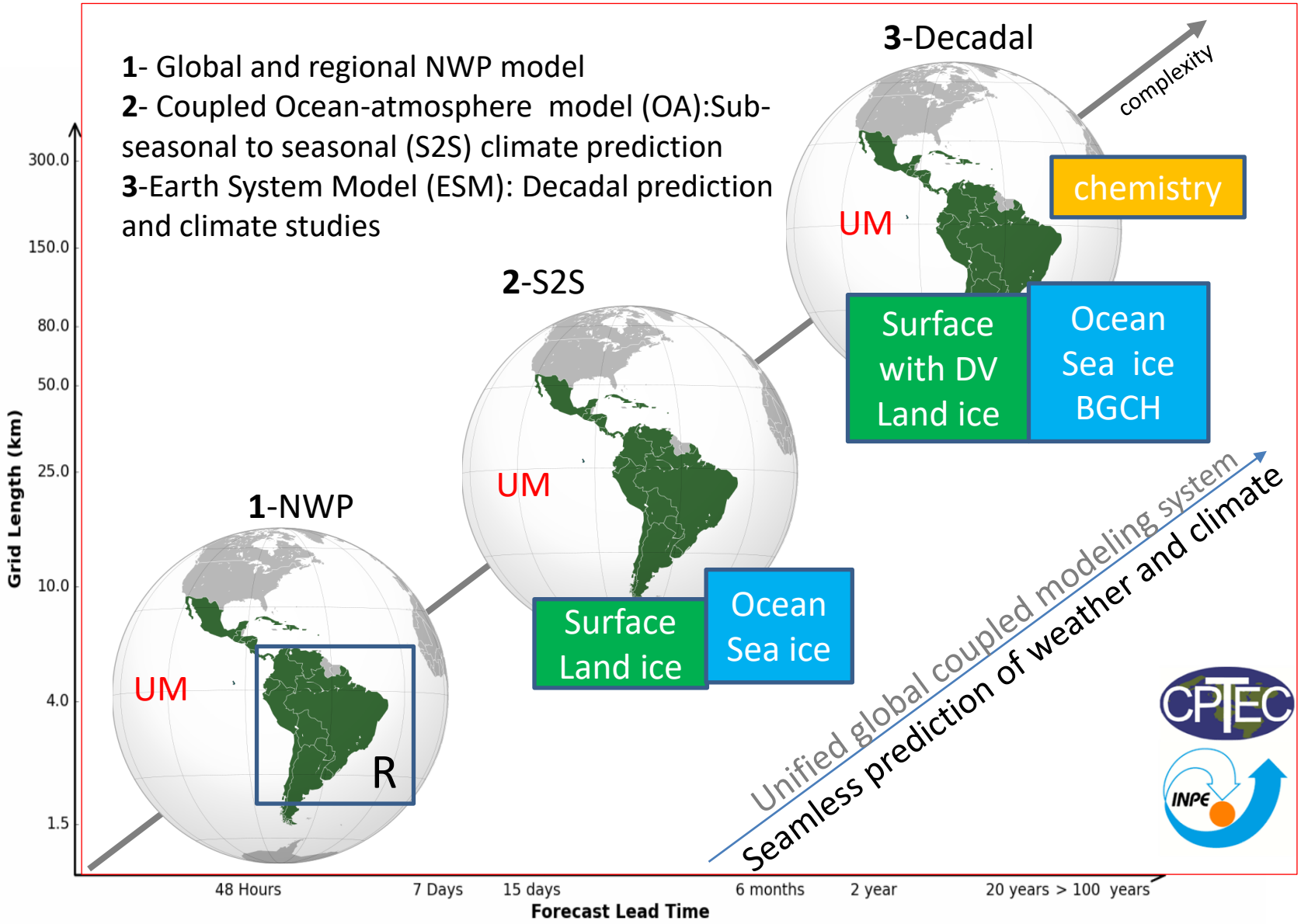







TOTAL AM4 Mean = 2.571 (mm/day) 1979:1996
TOTAL GPCP Mean = 2.389 (mm/day) 1979:1996
TOTAL (AM4 - GPCP)
Precipitation (mm/day)
Precip. Difference (mm/day)
90N
60N
30N
0
30S
60S
90S
0
60E
120E
180
120W
60W
0W
18
16
14
12
10
9
8
7
6
5
4
3
2
1
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
−0.5
−1.0
−1.5
−2.0
−2.5
−3.0
−3.5
−4.0

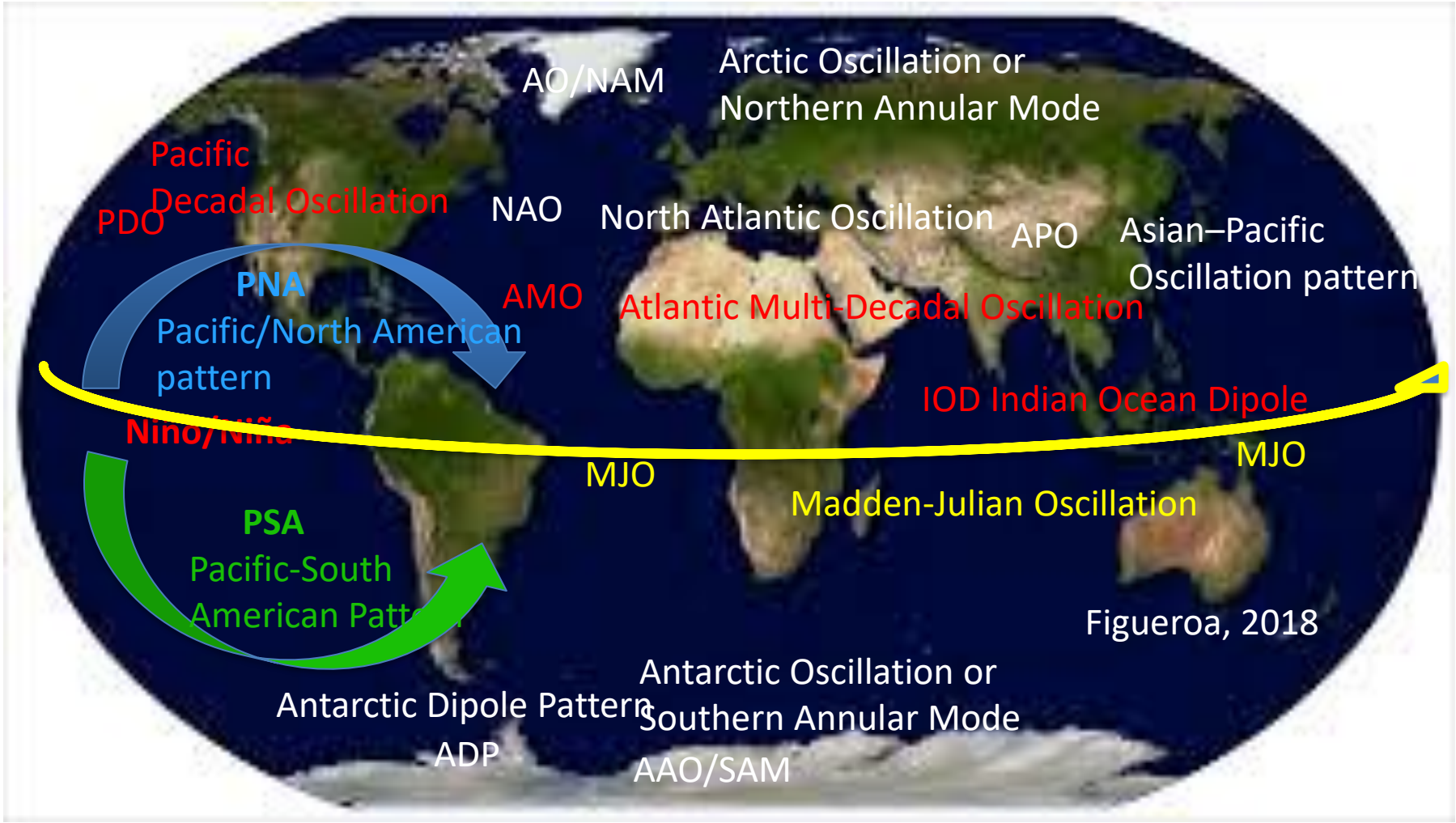
SEAMLESS PREDICTION OF WEATHER AND CLIMATE



Unified Model Global Atmosphere (UM-A)

DIFFERENT TELECONNECTIONS IN THE WORLD (spatial overview)

The most common atmospheric/oceanic oscillations and dipoles in the global system.



GLOBAL CLIMAT MODEL (COUPLED OCEAN_ATMOSPHERE) IS NECESSARY TO UNDERSTAND THE GLOBAL TELECONNECTIONS.

Benefits of the seamless approach

Efficiency

Developing one system for multiple uses reduces development effort and allows improvements made for climate science to be applied in our weather forecasting systems, and vice-versa.

Understanding

Short-range forecasts can be used for learning about error growth and help study the performance of long term climate simulations. Likewise, studying the long-range climatology of the model helps constrain and understand the physical processes used in short-range NWP forecasts.

Robustness

Using the same model for regional and global modelling gives confidence that the driving mechanisms are consistent.

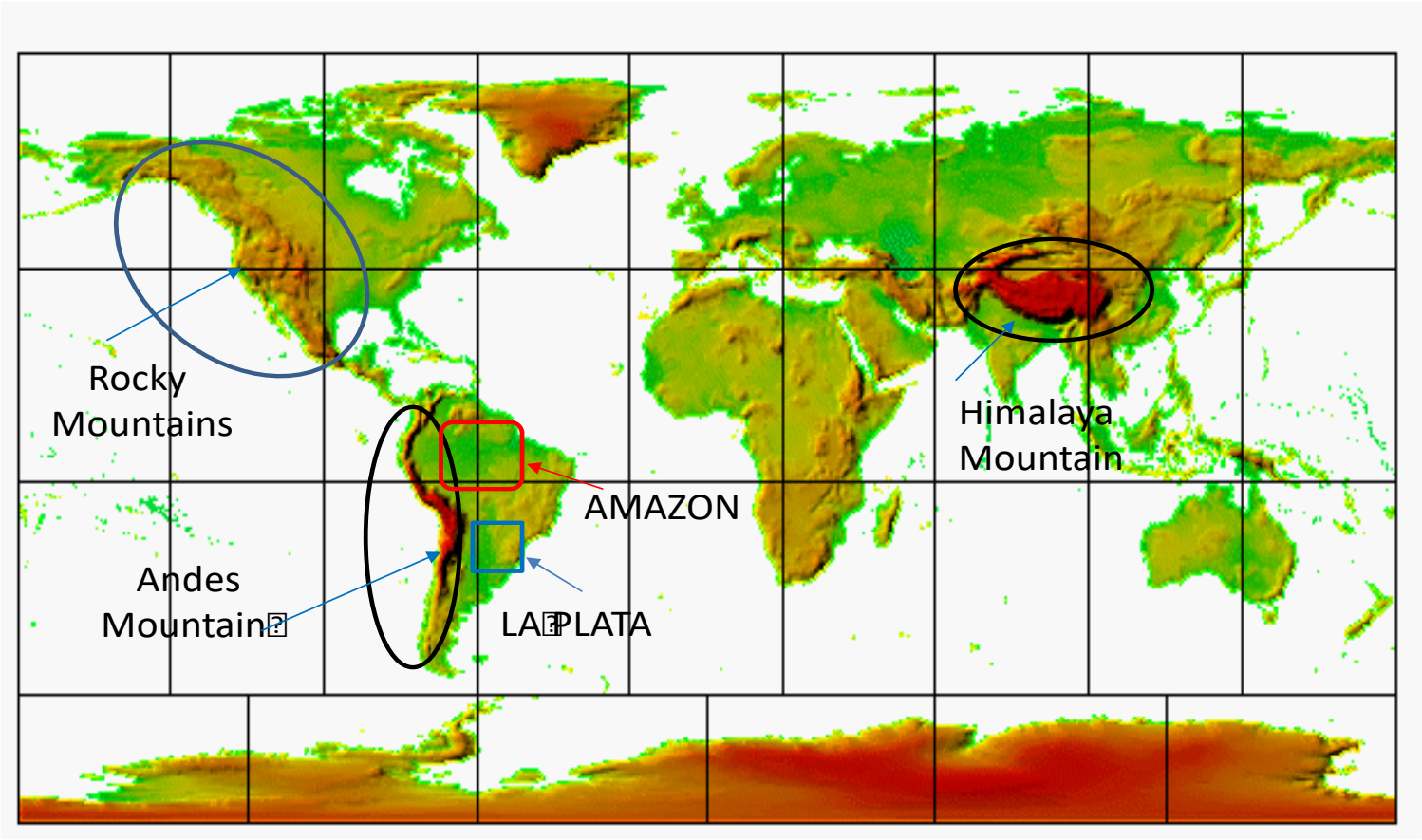
(from Ukmet).

How can we represent realistically the Andes in the Climate Models?.

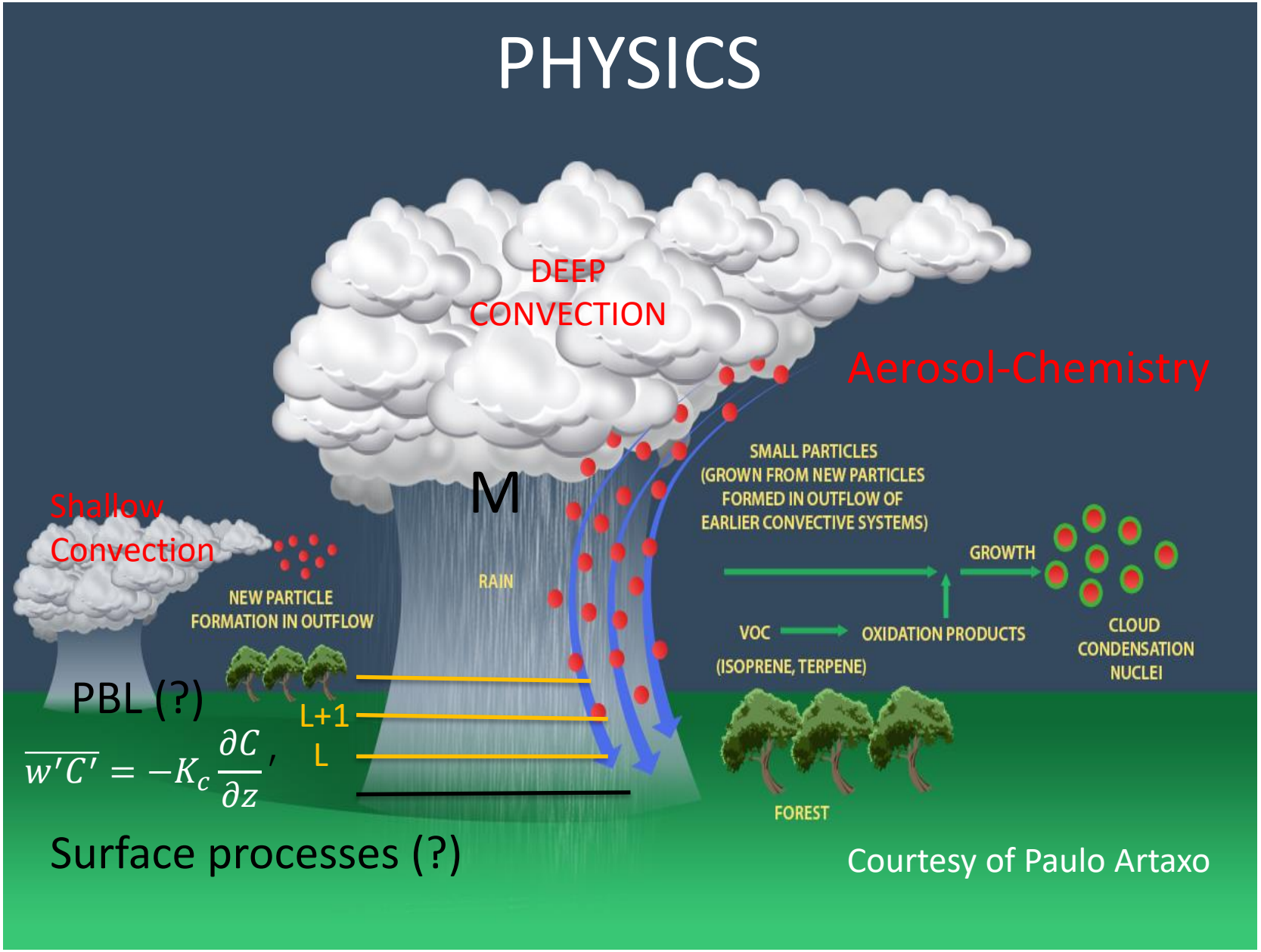
Horizontal dynamic Core
Vertical Coordinate

DYNAMIC CORE FOR COMPLEX MOUNTAINS (eg. ANDES)

GLOBAL TOPOGRAPHY



PHYSICS


DEEP
CONVECTION
Aerosol-Chemistry
M
Shallow
Convection
RAIN
SMALL PARTICLES
(GROWN FROM NEW PARTICLES
FORMED IN OUTFLOW OF
EARLIER CONVECTIVE SYSTEMS)
GROWTH
NEW PARTICLE
FORMATION IN OUTFLOW
VOC
OXIDATION PRODUCTS
(ISOPRENE, TERPENE)
CLOUD
CONDENSATION
NUCLEI
PBL (?)
L+1
L
$\overline{w'C'} = -K_c \frac{\partial C}{\partial z}$,
FOREST
Surface processes (?)
Courtesy of Paulo Artaxo

Mass-flux parameterization approach

$$\varrho \frac{\partial a\chi_c}{\partial t} = -\frac{\partial (M_c \chi_c)}{\partial z} + E\chi_e - D\chi_c - \frac{\partial a\varrho(z)\overline{w'\chi'}^{c}}{\partial z}$$

$$-\varrho \frac{\partial (1-a)\chi_e}{\partial t} = -\frac{\partial (M_c \chi_e)}{\partial z} - E\chi_e + D\chi_c - \frac{\partial (1-a)\varrho(z)\overline{w'\chi'}^{e}}{\partial z}$$

M=?

Mass Flux

$$\varrho \frac{\partial a}{\partial t} = -\frac{\partial M_c}{\partial z} + E - D$$

$\chi \epsilon \{s_l, q_t\}$

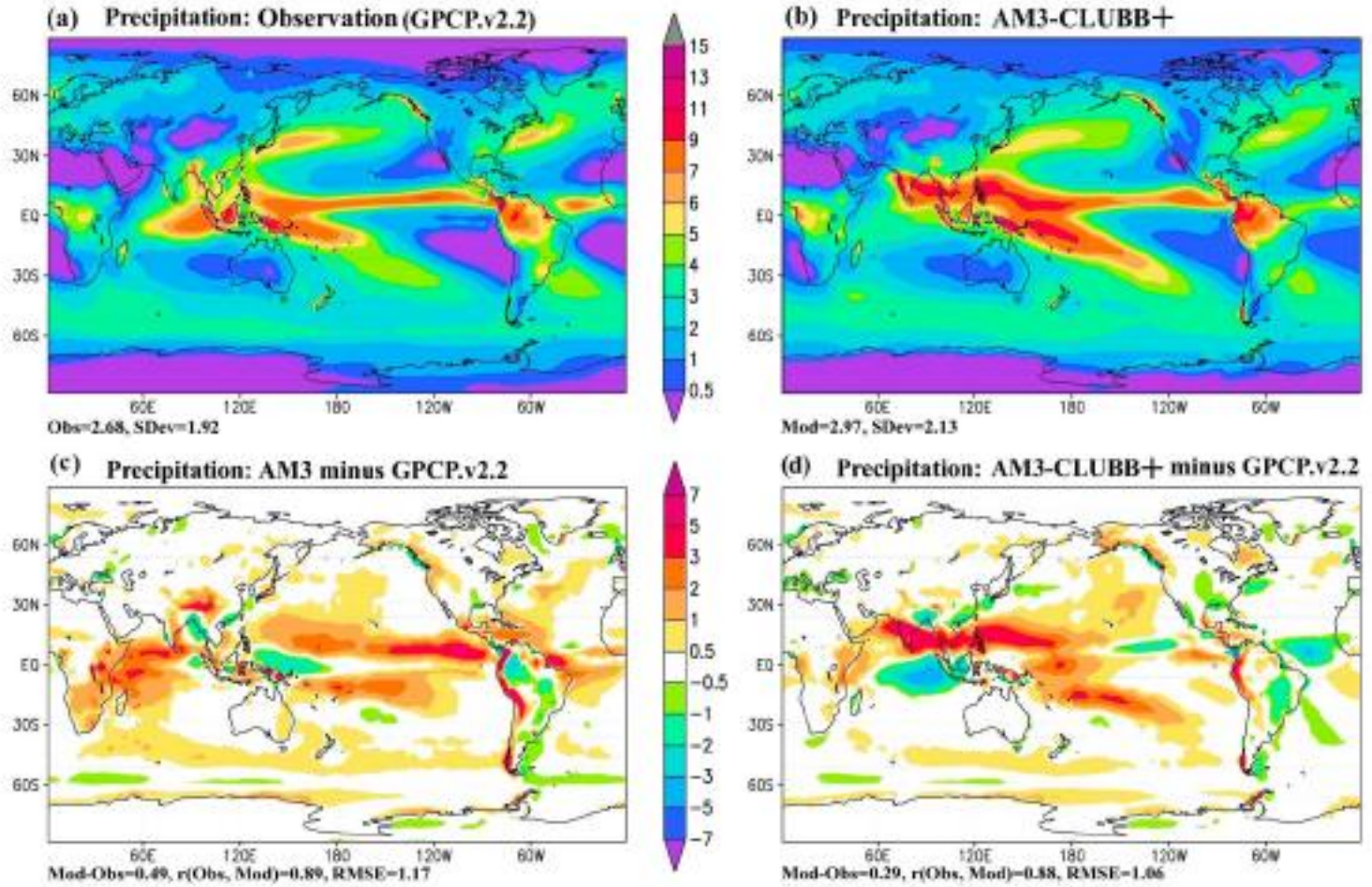
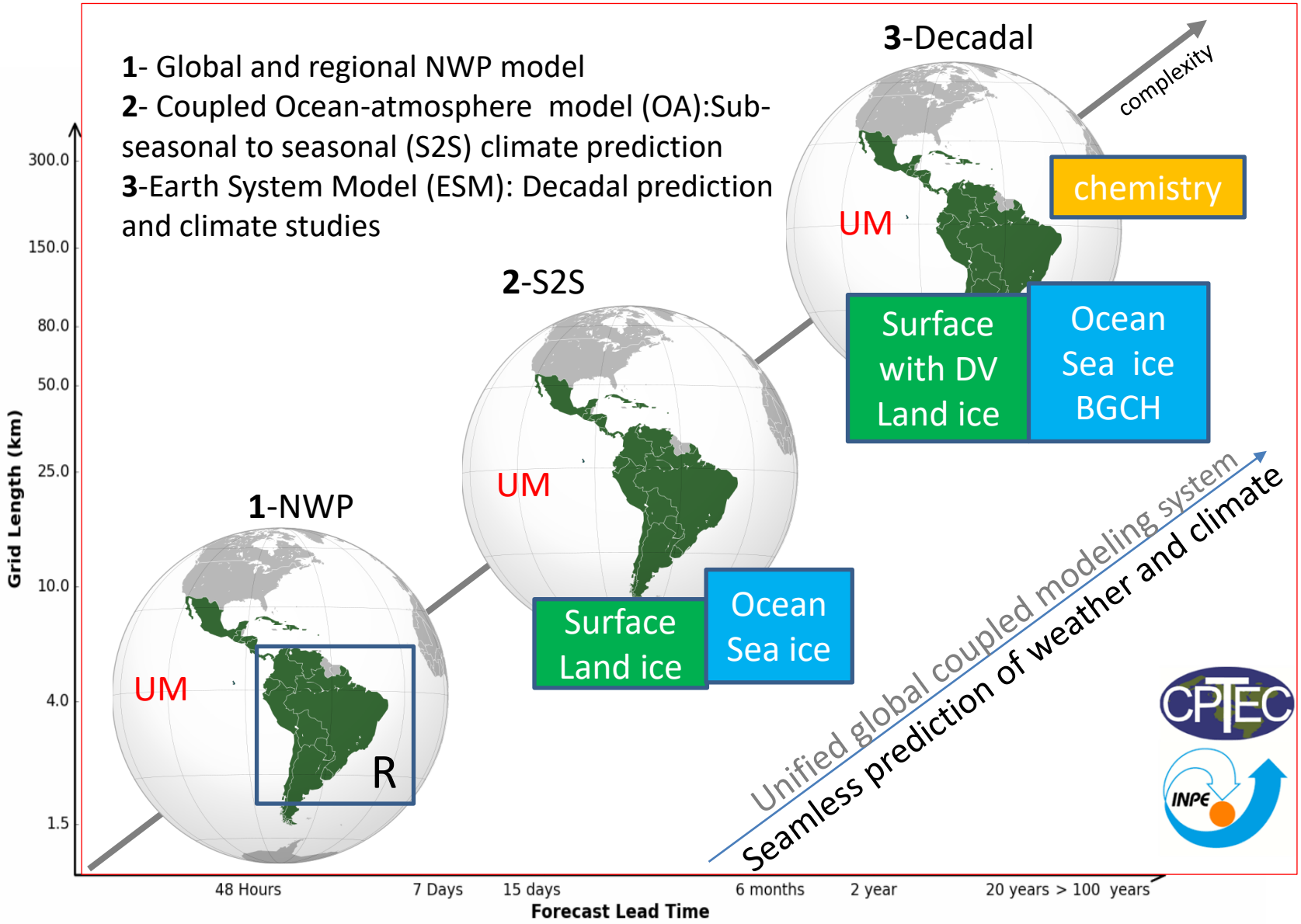


Figure 1. Annual mean precipitation rate (mm d^{-1}) from (a) the version 2 of the Global Precipitation Climatology Project (GPCP.v2.2) [*Adler et al.*, 2003], (b) AM3-CLUBB+, (c) AM3 model bias, and (d) AM3-CLUBB+ model bias, annual mean shortwave cloud forcing (SWCF) model bias from (e) AM3 and (f) AM3-CLUBB+, and longwave cloud forcing (LWCF) model bias from (g) AM3 and (h) AM3-CLUBB+.

SEAMLESS PREDICTION OF WEATHER AND CLIMATE



Unified Model Global Atmosphere (UM-A)

THANKS