SOUTH ATLANTIC WAVE CLIMATE UNDER CLIMATE CHANGE IMPACTS

Fabricio Vasconcelos Branco & Bruno Biazeto

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MASTER
METEOROLOGIA APLICADA A SISTEMAS
DE TEMPO REGIONAIS


Laboratório de Oceanografia-Clima-Criosfera
USP
Instituto Oceanográfico - USP

IVAM - OAS

Impacts, Vulnerability and Adaptations for Climate Changes - South Atlantic Ocean

SPONSORED BY PETROBRAS

GOAL

- To obtain regional climate projections for the South Atlantic Ocean in order to understand the regional wave climate, and how it is affected by different emissions scenarios of greenhouse gases in the atmosphere.
- ONGOING TEAM WORK!!!!!

OUTLINE

- general methodology
- challenges
- IPCC model choice
- twentieth century global wave scenario
- briefing of atmospheric downscalling for twentieth century
- briefing of wave downscaling for twentieth century
- next steps

GENERAL METHODOLOGY

GENERAL METHODOLOGY

DATA DOWNLOAD:

- NCEP REANALYSIS
- SODA
- IPCC MODELS
- ~3TB of data

GENERAL METODOLOGY

- DATA DOWNLOAD

  DATA PROCESSING AND ANALYSIS
  - DATA QUALITY CONTROL
  - INTERPOLATION FOR REGULAR GRIDS
  - FORMATTING FOR MODELS INPUT
  - DATA BANK
  - STATISTICS

GENERAL METODOLOGY

- DATA DOWNLOADS
- DATA PROCESSING AND ANALYSIS

  IPCC MODEL CHOICE (MODELS X REANALYSIS OF 20 CENTURY)
  - BIAS
  - RMS
  - CORRELATION
  - VARIANCE
  - TAYLOR DIAGRAM
  - CLIMATOLOGY

GENERAL METODOLOGY

- DATA DOWNLOAD
- DATA PROCESSING AND ANALYSIS
- IPCC MODEL CHOICE

  ATMOSPHERIC DOWNSCALING
  - BRAMS MODEL v.4.2 (Brazilian Regional Atmospheric Modelling System)
  - CONTROL RUNNING OF THE 20 CENTURY (1982 -> 2011)
  - FORCED WITH GLOBAL NCEP REANALYSIS I

GENERAL METODOLOGY

- DATA DOWNLOAD
- DATA PROCESSING AND ANALYSIS
- IPCC MODEL CHOICE
- ATMOSPHERIC DOWNSCALING

GLOBAL WAVE CLIMATE

- Wavewatch III v.3.14 (mpi)
- Global grid
- Winds, Temperature (2m) and Ice coverage from NCEP Reanalysis I - 1982-2011
- SST (OISST)

IPCC MODEL CHOICE

GENERAL METODOLOGY

- DATA DOWNLOAD
- DATA PROCESSING AND ANALYIS
- IPCC MODEL CHOICE
- ATMOSPHERIC DOWNSCALING
- GLOBAL WAVE CLIMATE

  GLOBAL WAVE CLIMATE VALIDATION
  - NDBC Buoy Data
  - Others buoys around the world
  - Satelite data???

IPCC MODEL CHOICE

GENERAL METODOLOGY

- DATA DOWNLOAD
- DATA PROCESSING AND ANALYSIS
- IPCC MODEL CHOICE
- ATMOSPHERIC DOWNSCALING
- GLOBAL WAVE CLIMATE
- GLOBAL WAVE CLIMATE VALIDATION

REGIONAL WAVE CLIMATE

- WW3
- South Atlantic domain
- Winds and Temperature from BRAMS downscaling for 20 century
- Bordered with directional spectrum from the global grid

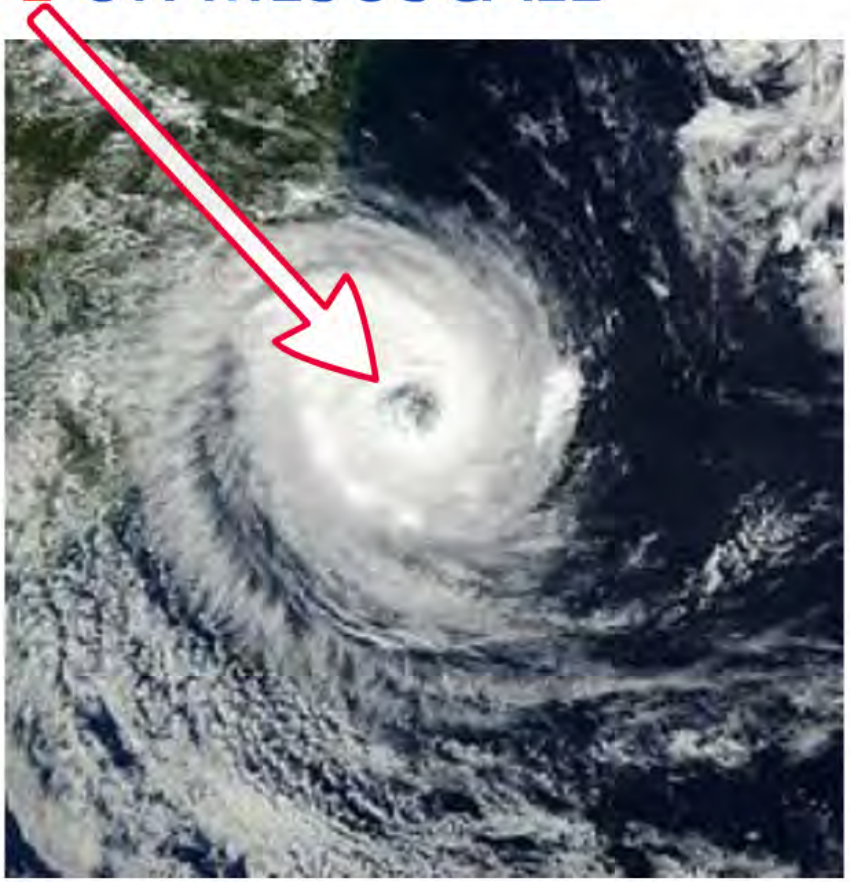
GENERAL METODOLOGY

- DATA DOWNLOAD
- DATA PROCESSING AND ANALYSIS
- IPCC MODEL CHOICE
- ATMOSPHERIC DOWNSCALING (NCEP/CCSM3)
- GLOBAL WAVE CLIMATE (NCEP/CCSM3)
- GLOBAL WAVE CLIMATE VALIDATION
- REGIONAL WAVE CLIMATE
- REGIONAL WAVE CLIMATE VALIDATION
- IPCC SCENARIO I ATMS. DOWNSC.
- IPCC SCENARIO II ATMS. DOWNSC.
- GLOBAL AND REGIONAL FUTURE WAVE CLIMATE FOR BOTH SCENARIOS

CHALLENGE

CLIMATE WORK WITH AN EYE ON MESOSCALE PROCESS:

- TIME RESOLUTION
- DATA VOLUME
- COMPUTING POWER
- DATA PROCESSING



IPCC MODEL CHOICE

- 5 MODELS: GFDL-CM2.1; NCAR-CCSM3.0;ECHAM5/MPI-OM;MIROCC3.2-MedRes; UKMO-HadCM3

Modelo	Resolução Oceano	Resolução Atmosfera	Origem	Referência
NCAR_CCSM3.0	1,125x0,45x40	2,8°x2,8°x26	NCAR (USA)	Collins,W.D. *et al.* (2005)
GFDL_CM2.1	1x1x50	2,5°x2,0°x24	NOAA (USA)	Delworth *et al.* (2006)
MPI_ECHAM5	1x1x40	2,0°x2,0°x31	Max-Planck (Germany)	Roeckner *et al.* (2003)
MIROC3.2_MedRes	1,4x0,94x33	2,8°x2,8°x20	CCSR (Japan)	Hasumi & Emori (2004)
UKMO_HADCM3	1,25x1,25x20	3,75°x2,75°x19	Hadley Centre (UK)	Gordon *et al.* (2000)

IPCC MODEL CHOICE

3 PERIODS:

- 20c3m - 20th century
- sresA2 - pessimistic future
- sresB1 - optmistic future

=> COMPARATIVE STATISTICS

IPCC X REANALYSIS I

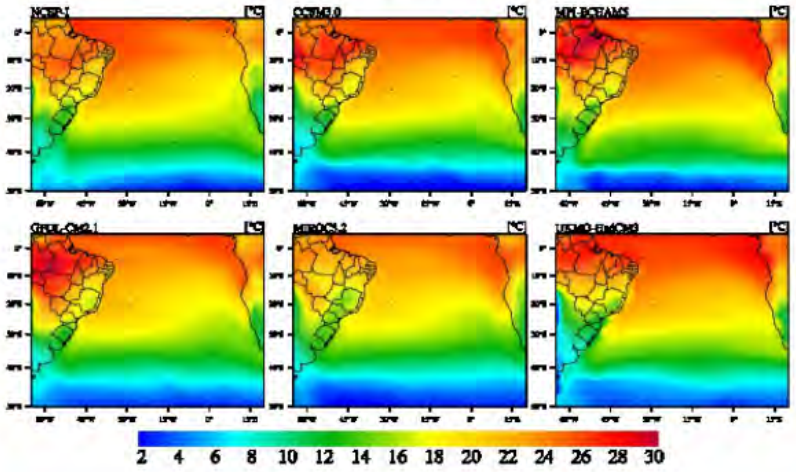
- BIAS
- RMS
- VARIANCE
- CORRELATION
- TAYLOR DIAGRAM

}

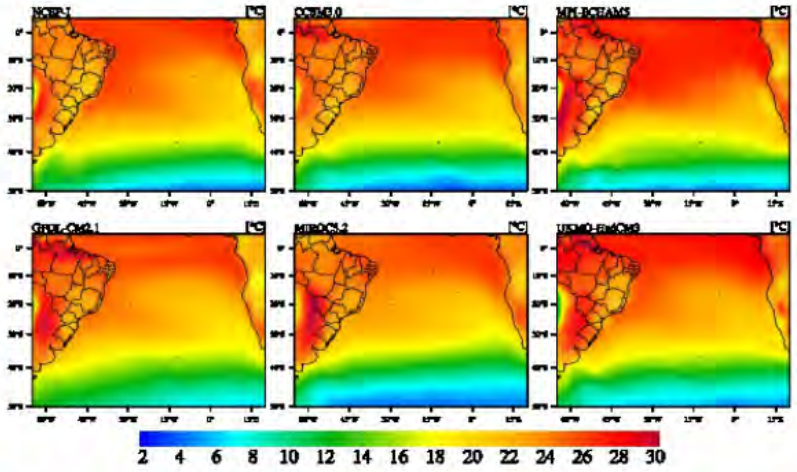
- TEMPERATURE
- SLP
- ZONAL WIND
- MERIDIONAL WIND
- SPECIFIC HUMIDITY

TEMPERATURE

MEDIA: Temperatura do Ar a 2m (JJA 1950 a 1999)

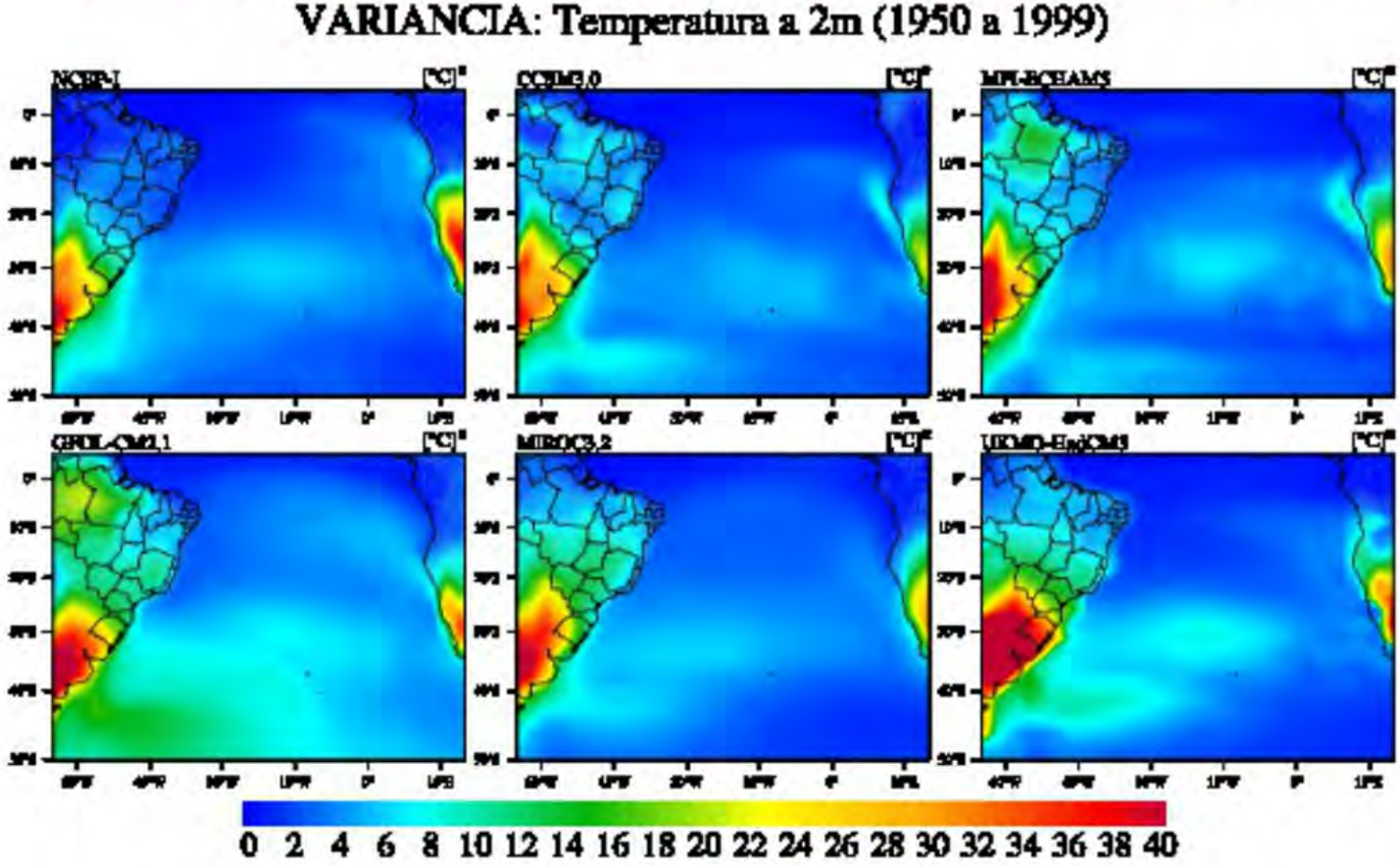


MEDIA: Temperatura do Ar a 2m (DJF 1950 a 1999)



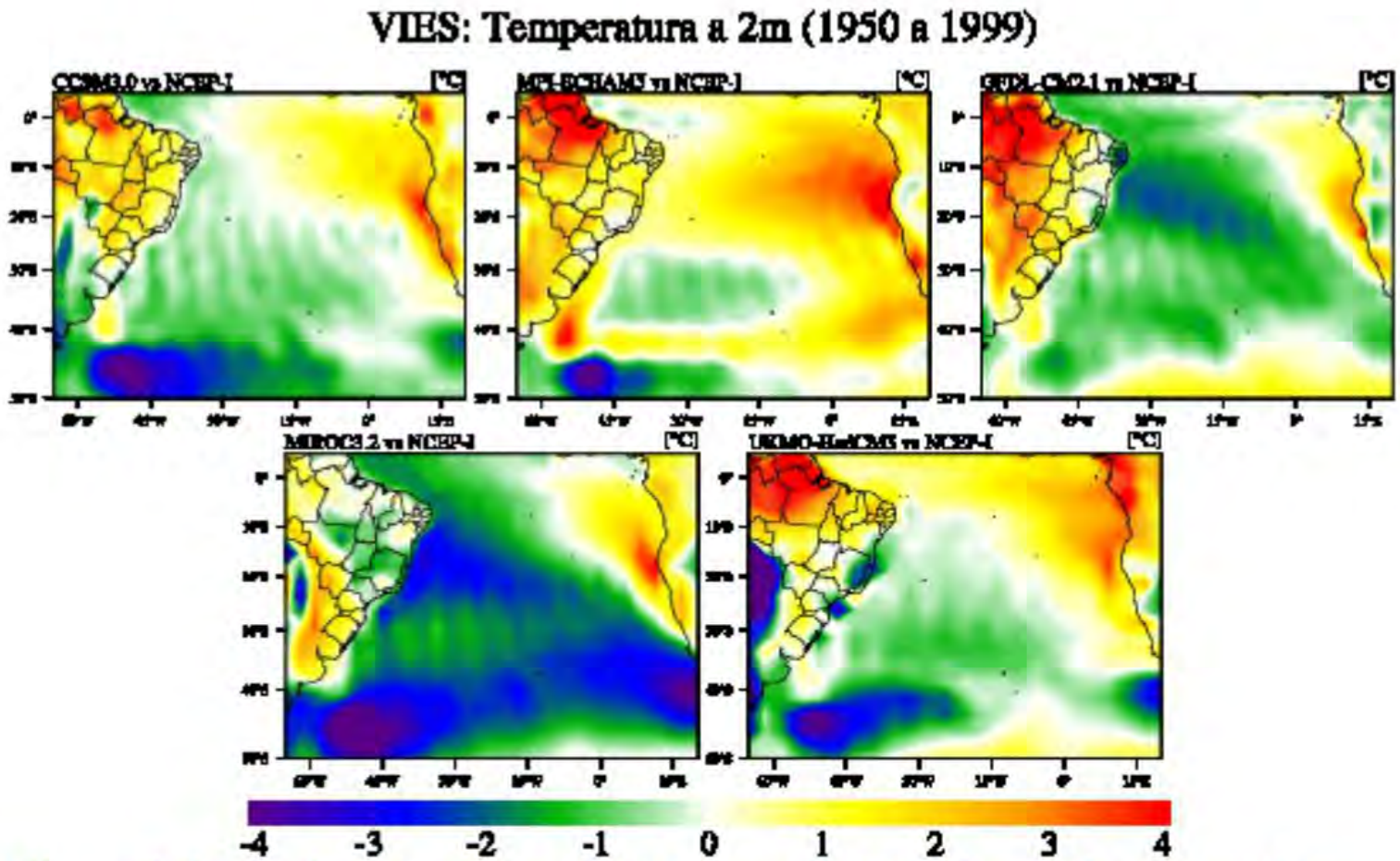
- MODELS WITH SIMILAR FIELDS
- LOW VALUES ON JJA AND HIGHER ON DJF (RIO DA PRATA BASIN)
- OPPOSITE IN THE AMAZON REGION

Temperature Variance



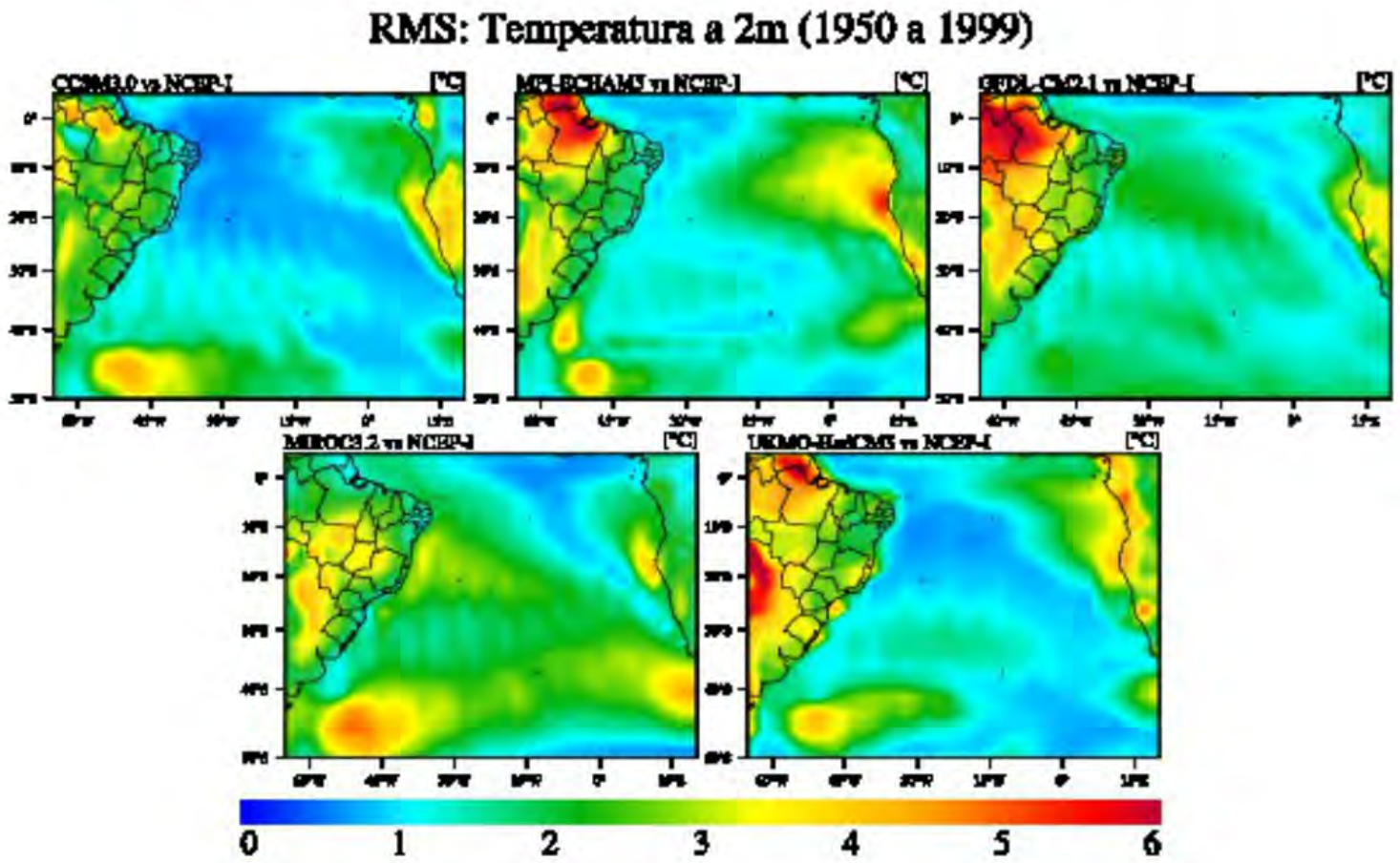
GFDL-CM2.1 and MPI-ECHAM5 with higher values on the Amazon, UKMO-HadCM3 over Rio da Prata River.

TEMPERATURE BIAS



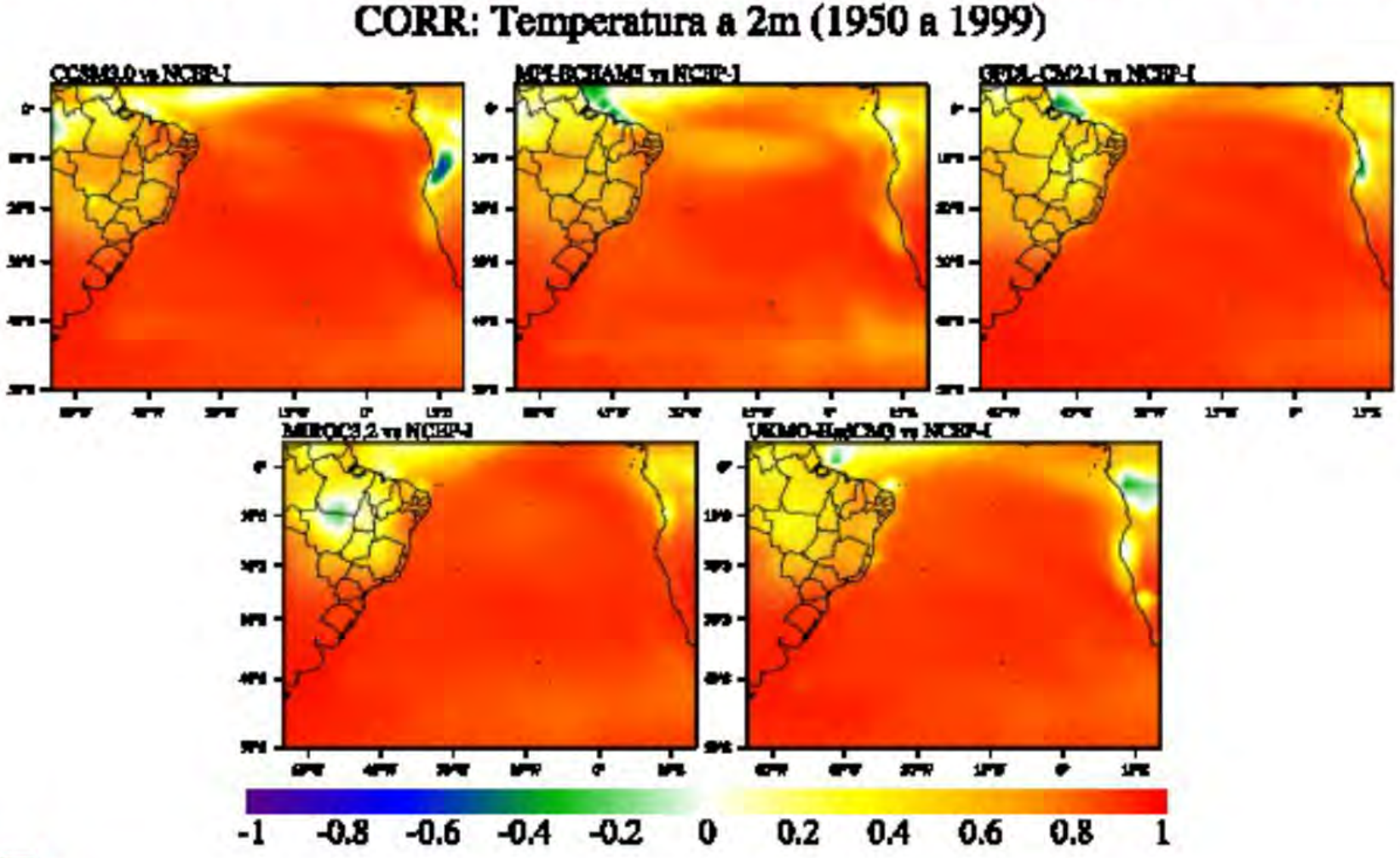
All models underestimate NCEP over SAO. The only exception is MPI-ECHAM5 close to the Brazilian coast.

TEMPERATURE RMS

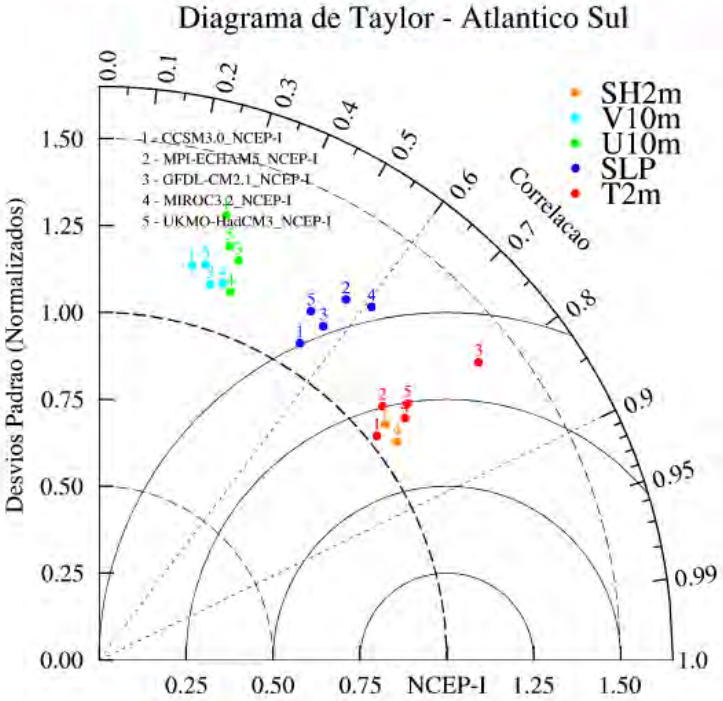


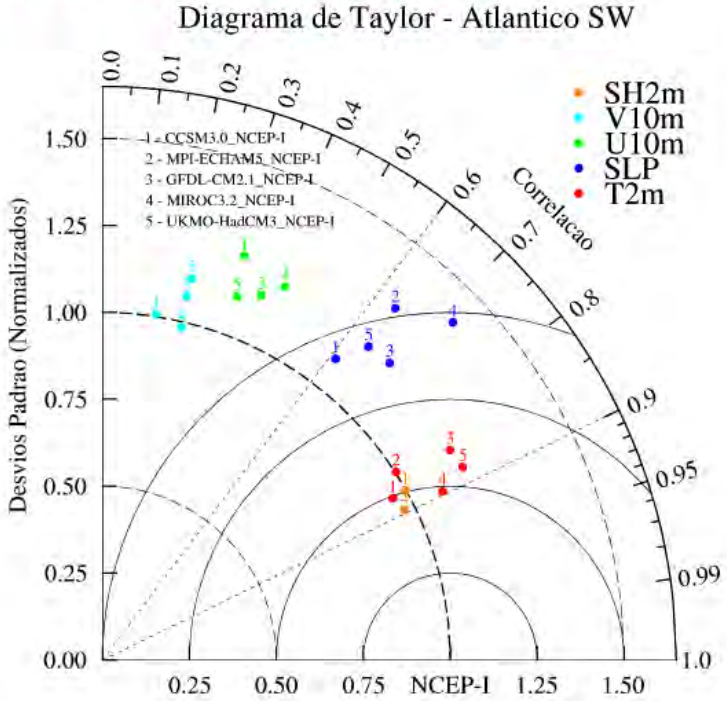
Over SAO and over Brazil CCSM3.0 has better results than the others.

TEMPERATURE CORRELATION



TAYLOR DIAGRAM





- Similar patterns;
- All the models are similar;
- Temperature and humidity have the "best fit".
- CCSM3 and MIROC3.2 have best results.

CHOSEN MODEL:

CCSM3.0

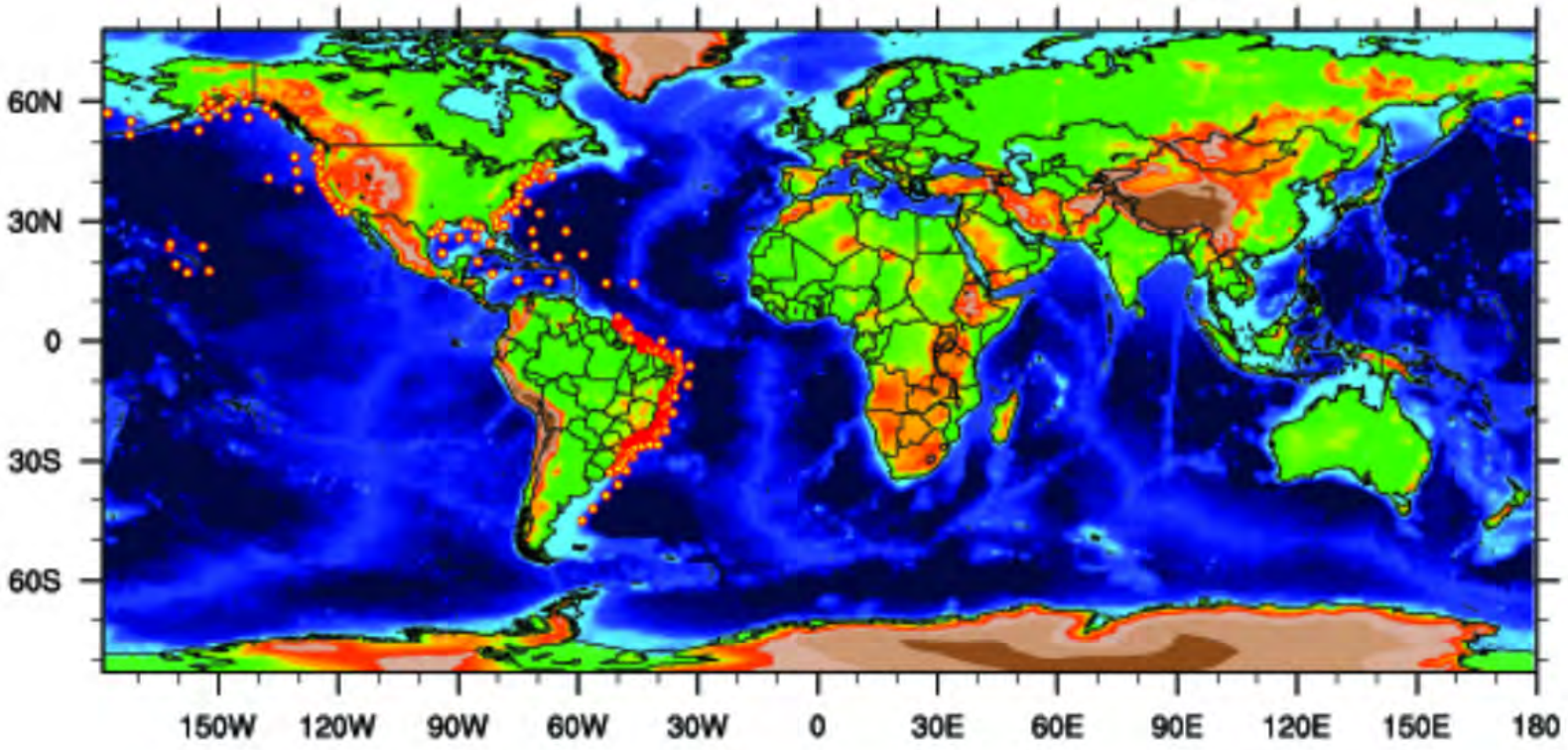
WAVE CLIMATE

icio Vasconcelos E

GLOBAL GRID

Spacial global grid:

- 360 x 161 points
- 1.00 x 1.00 degrees


60N
30N
0
30S
60S
150W
120W
90W
60W
30W
0
30E
60E
90E
120E
150E
180

GLOBAL GRID

- 21 FIELDS
- 373 POINTS LOCATIONS FOR SPECTRA AND TIME SERIES

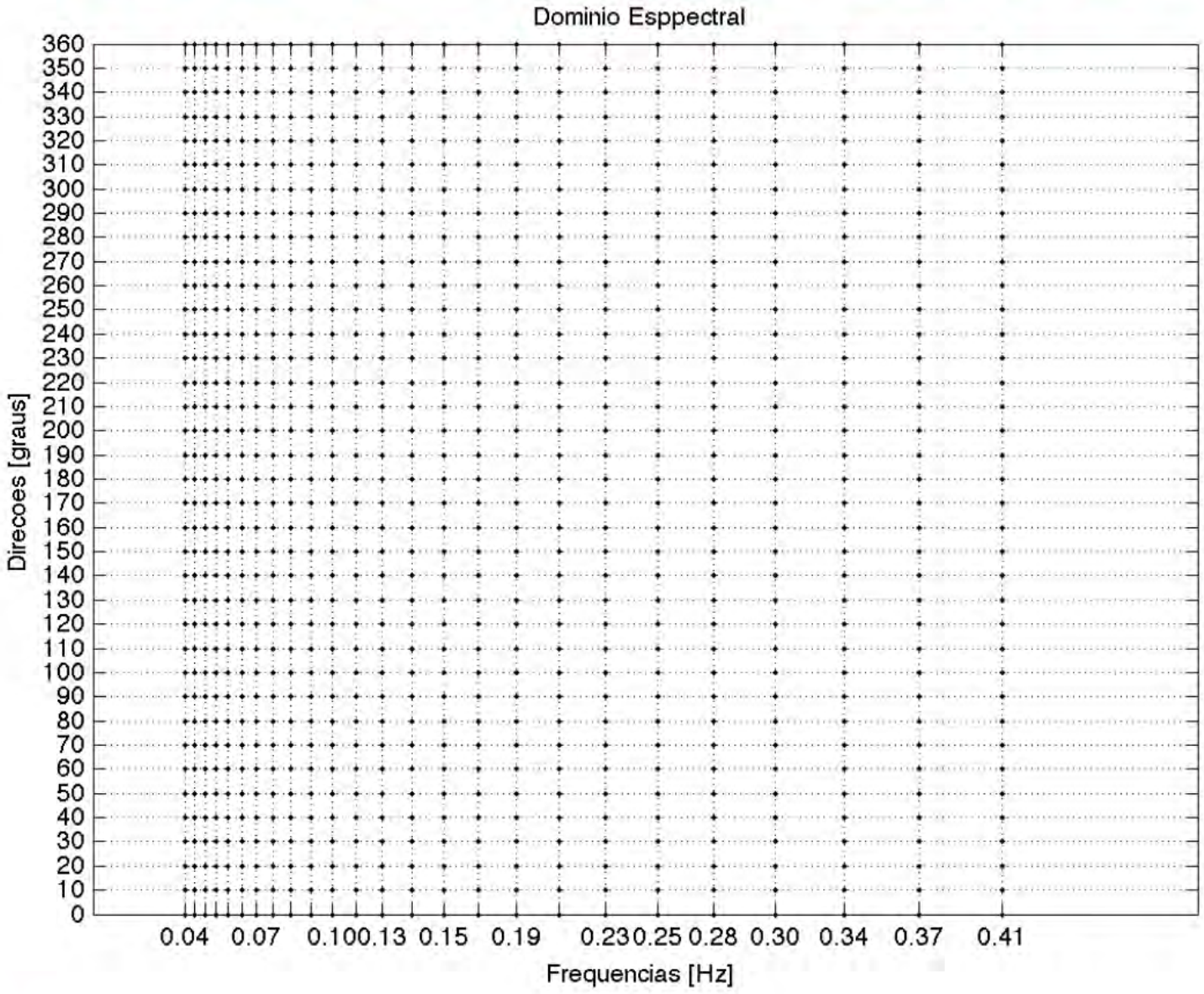
SPECTRAL GRID

- 25 FREQUENCIES
- 36 BIN DIRECTIONS

DJF Significant Height [m] Average - 1982 to 2011

MAM Significant Height [m] Average - 1982 to 2011

SPECTRAL GRID

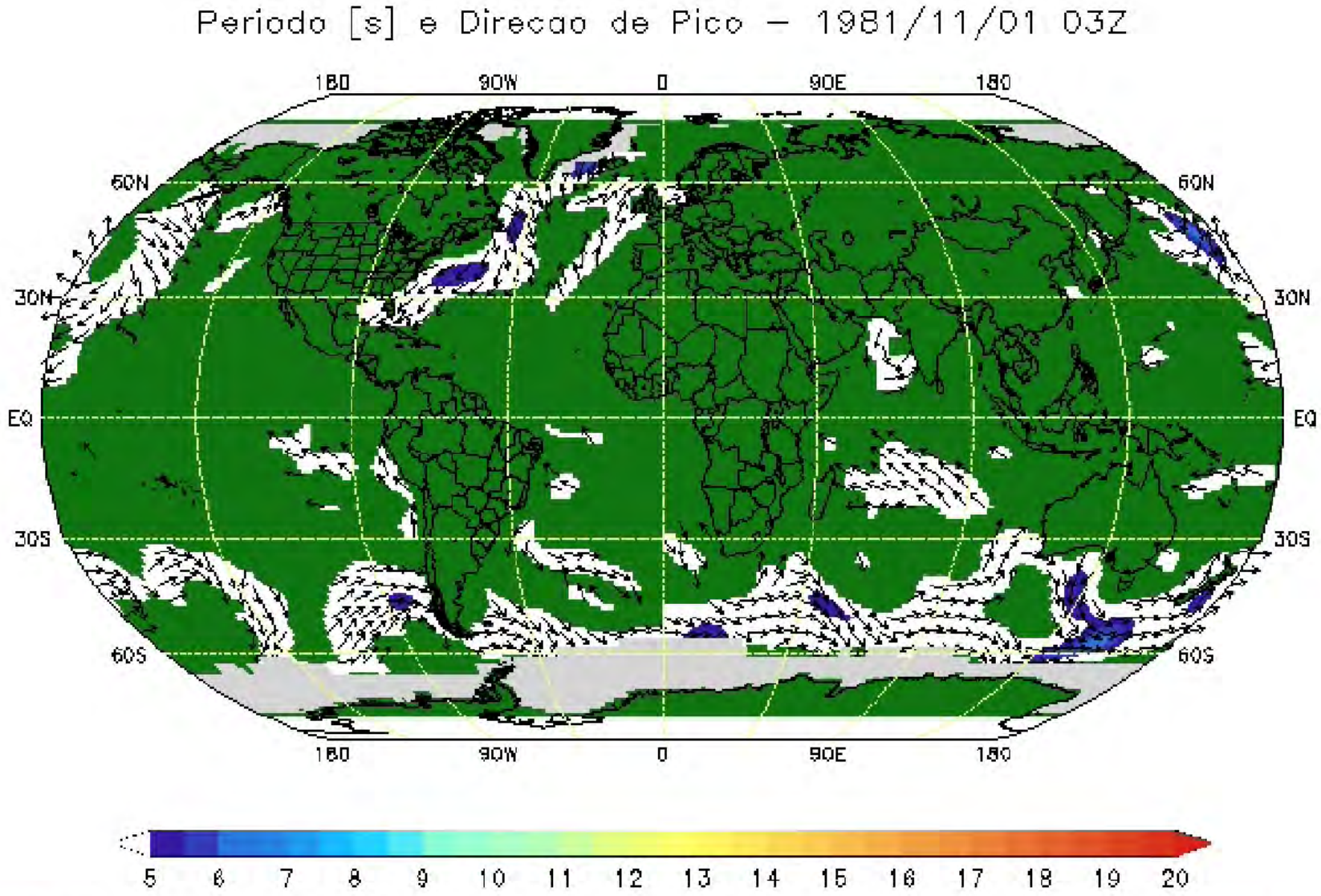


MODEL RUN

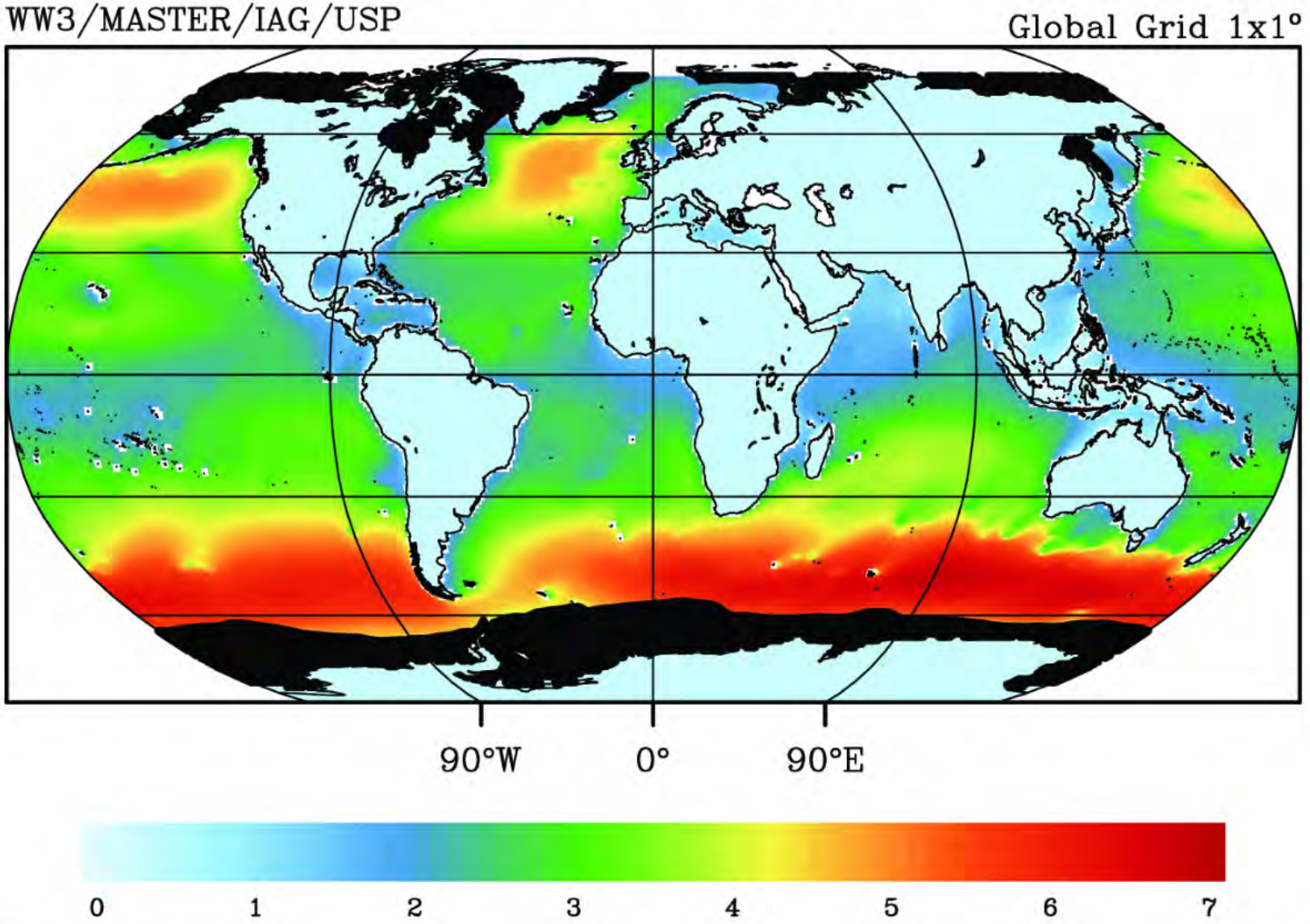
- NOV 81 - DEC31 => SPIN UP
- JAN 82 - DEC 2011 => 30 YEARS
- TIME RESOLUTION: 3 HOURS

WW3 SPIN UP

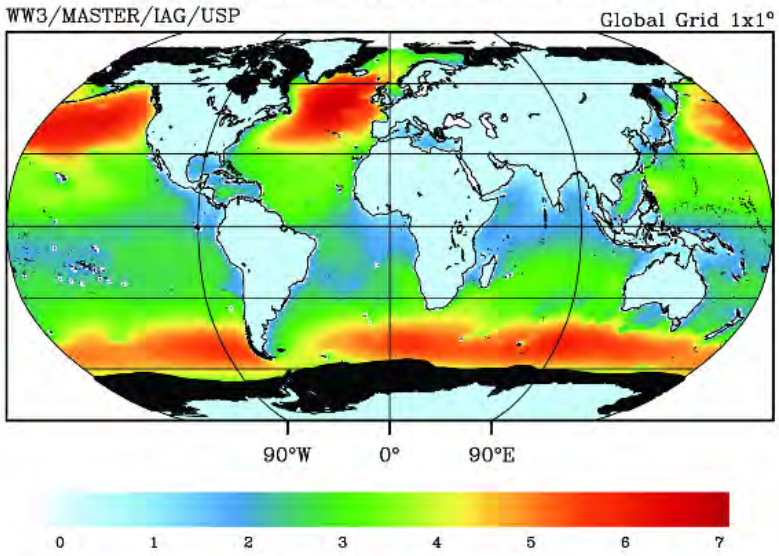
WW3 SPIN UP


Periodo [s] e Direcao de Pico – 1981/11/01 03Z
180
90W
0
90E
180
60N
30N
EQ
30S
60S
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
WAVEWATCH III – MASTER/OC/USP IVAM–OAS
Modelo Global 1.25x1

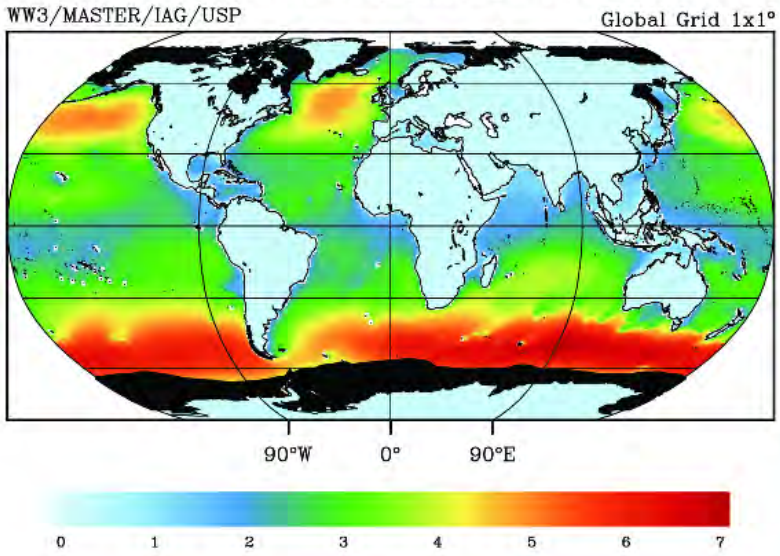
MAM Significant Height [m] Average - 1982 to 2011



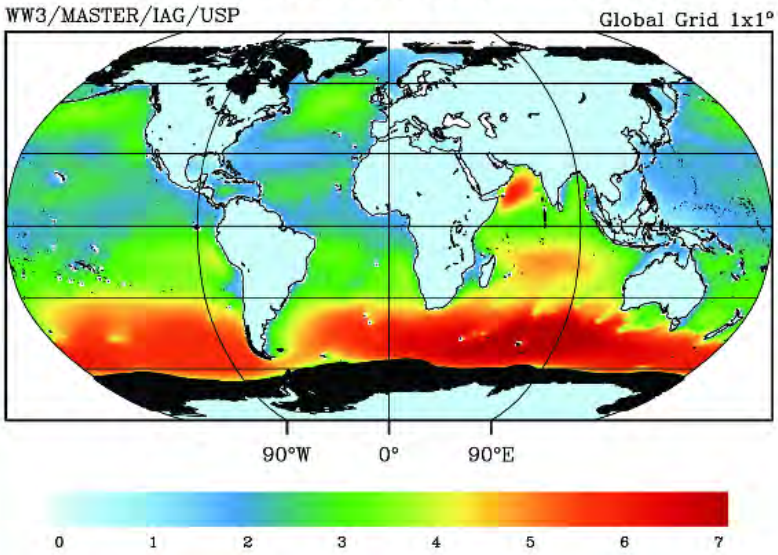
DJF Significant Height [m] Average - 1982 to 2011



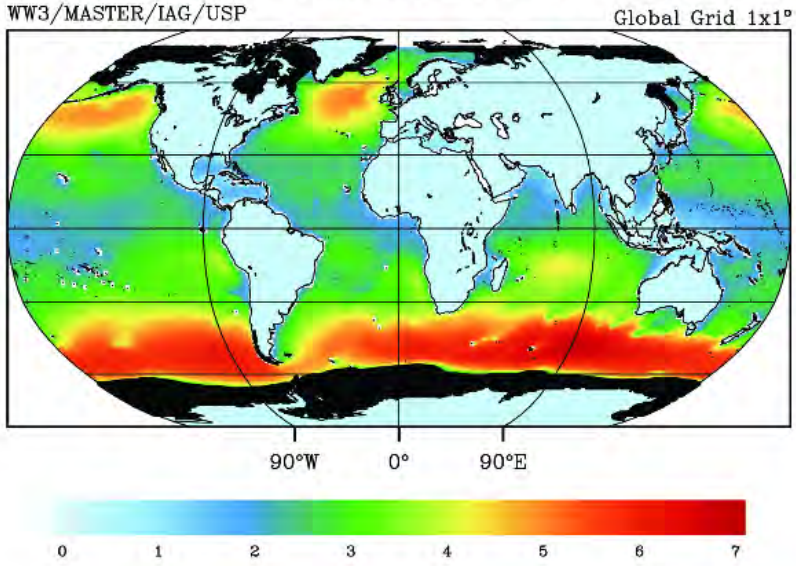
MAM Significant Height [m] Average - 1982 to 2011



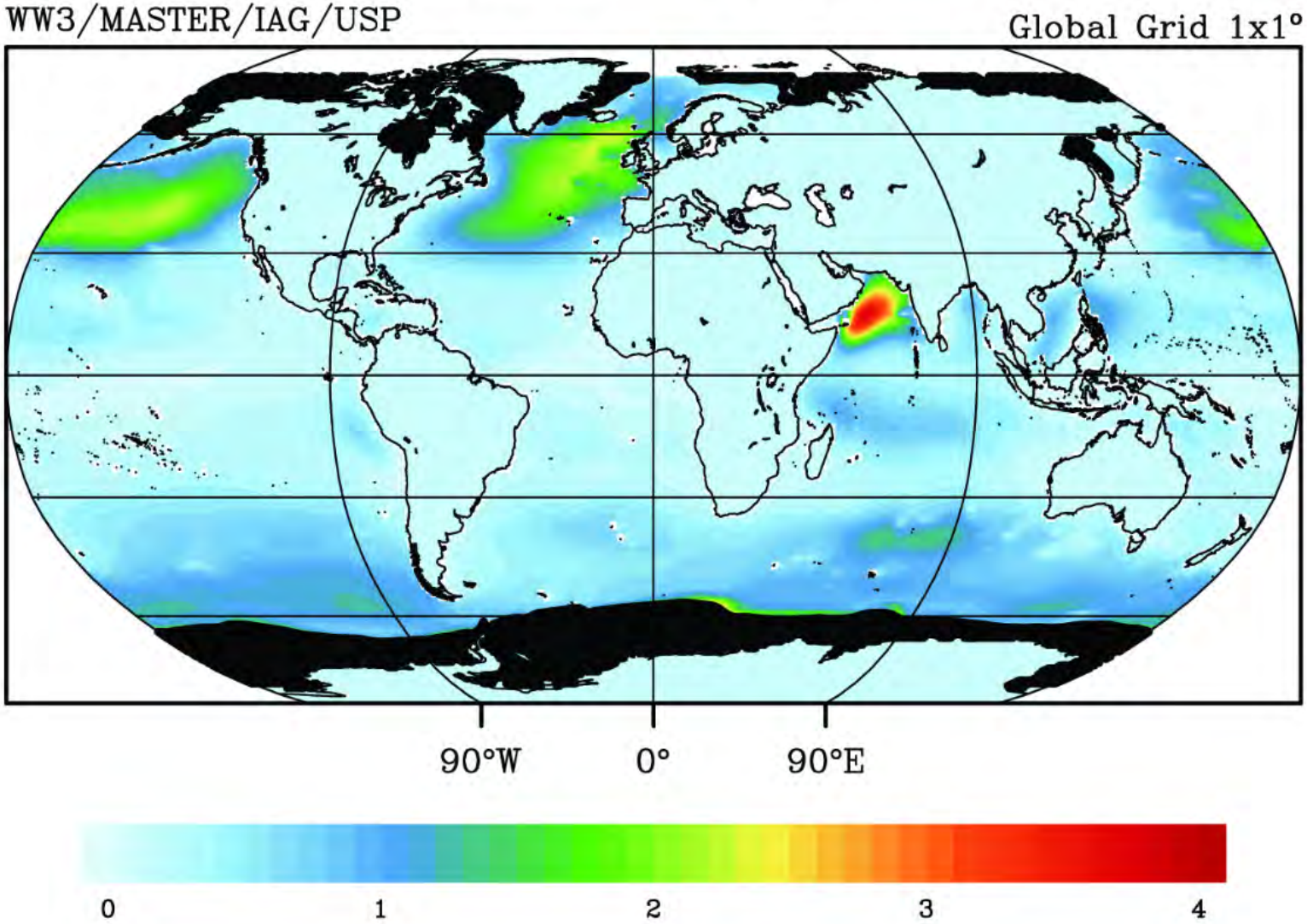
JJA Significant Height [m] Average - 1982 to 2011



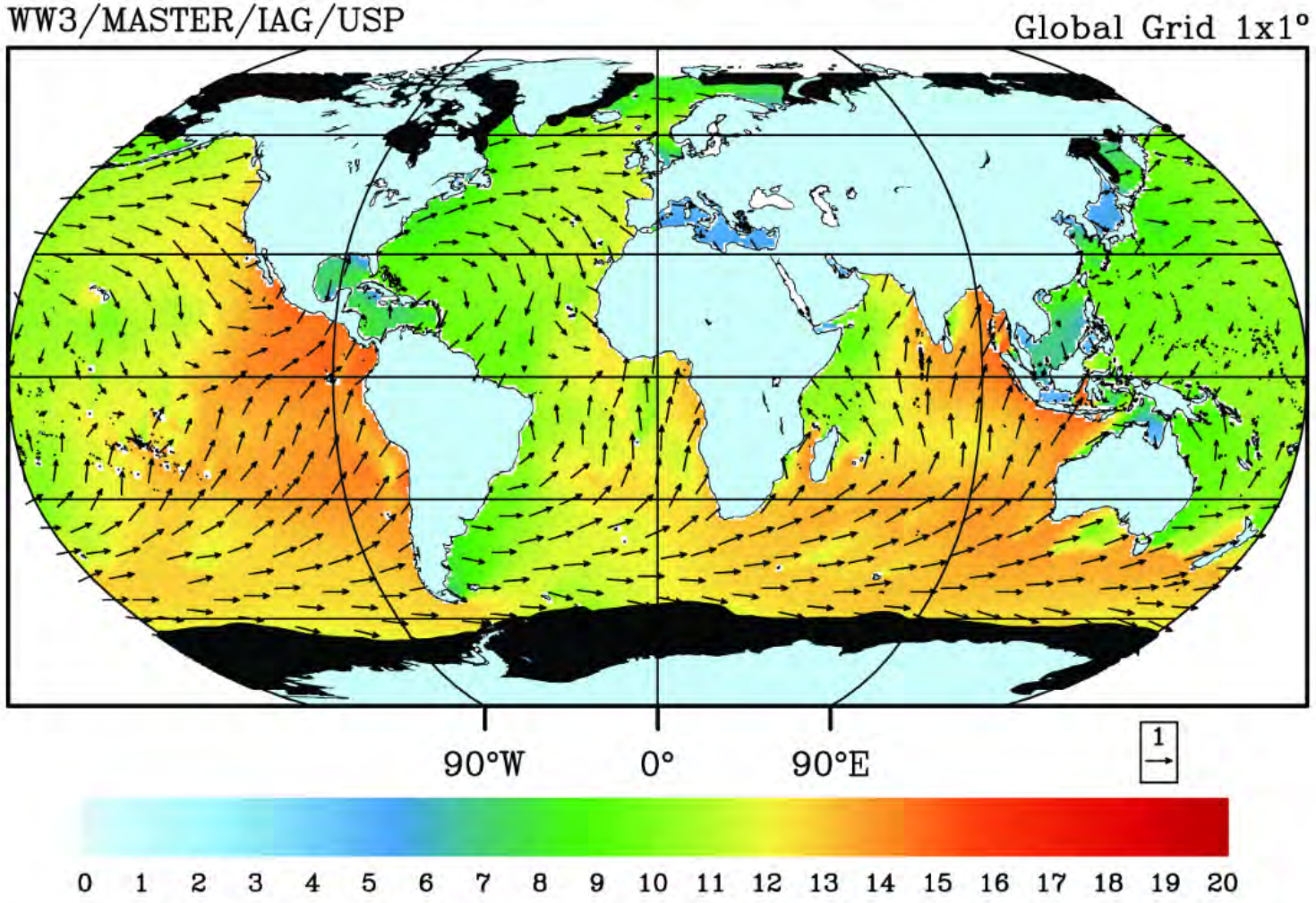
SON Significant Height [m] Average - 1982 to 2011



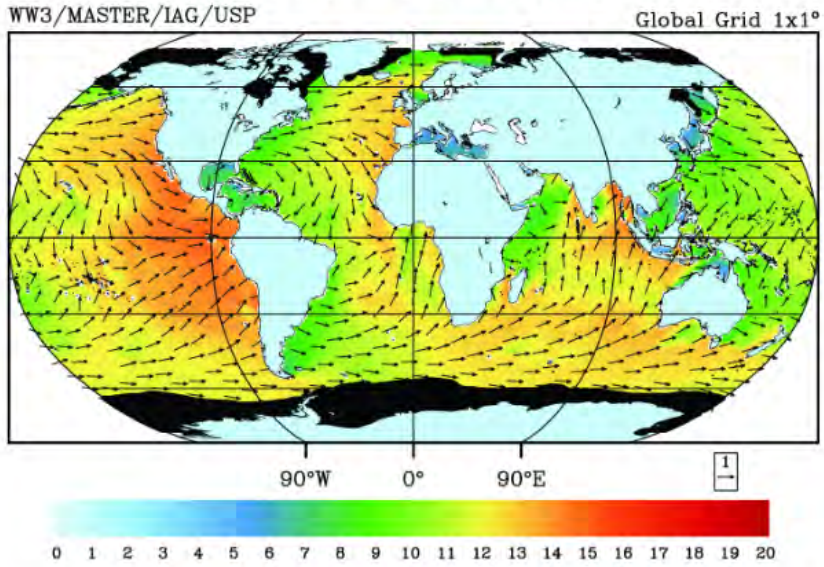
Significant Height Variance - 1982 to 2011



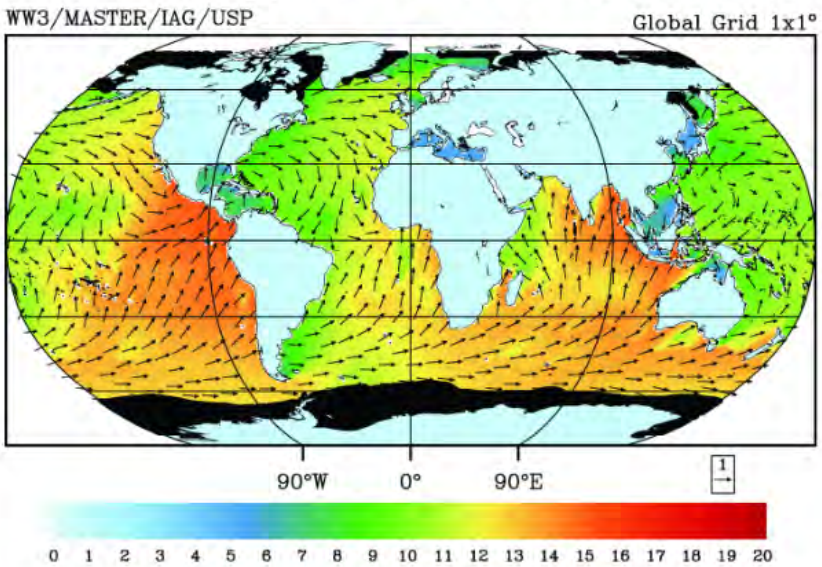
Peak Period [s] and Peak Direction Average- 1982 to 2011



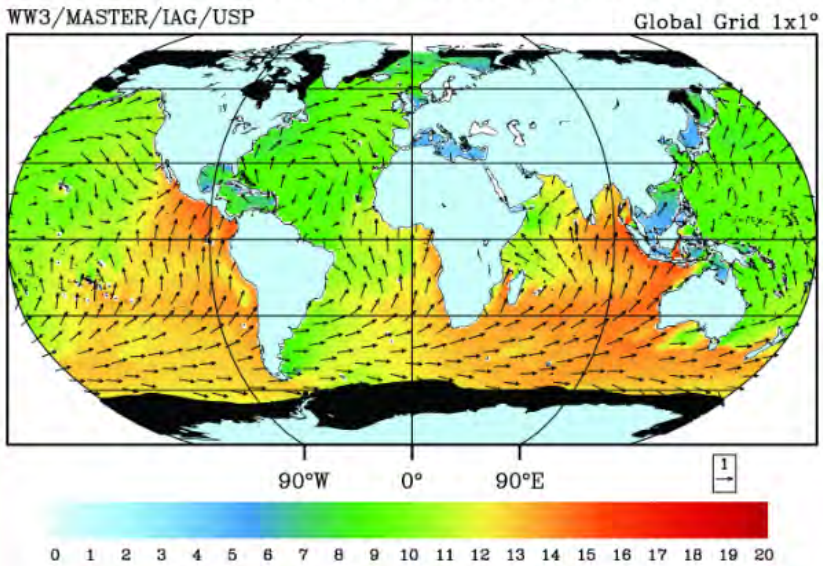
DJF Peak Period [s] and Peak Direction Average - 1982 to 2011



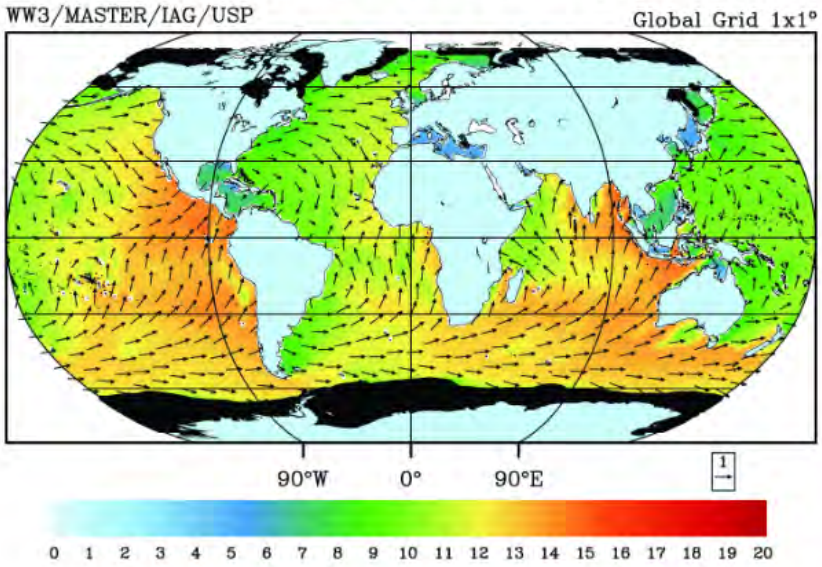
MAM Peak Period [s] and Peak Direction Average - 1982 to 2011



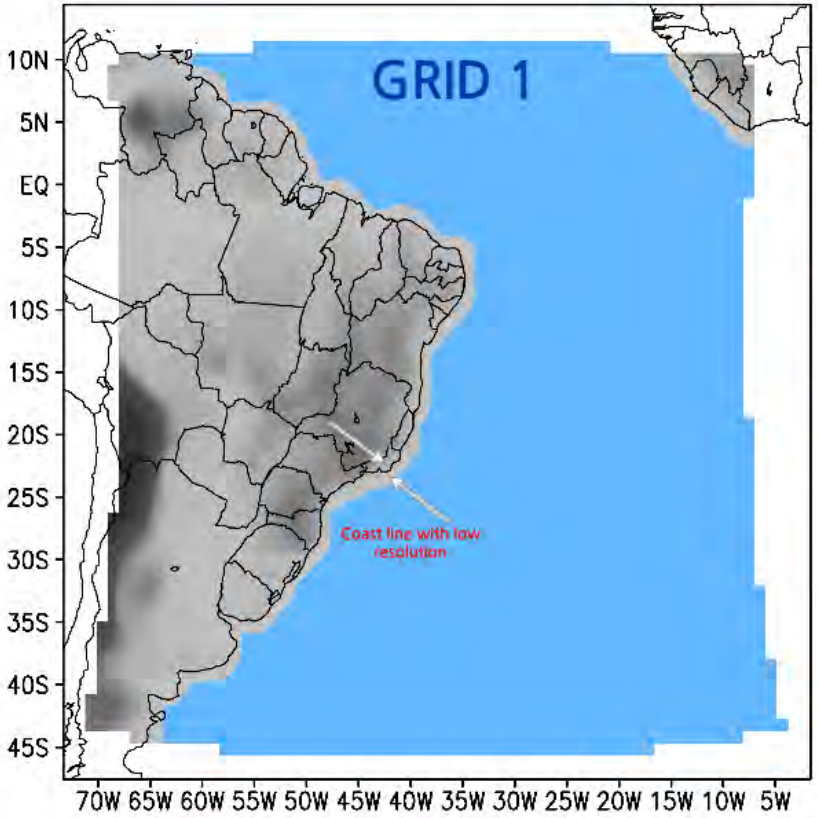
JJA Peak Period [s] and Peak Direction Average - 1982 to 2011



SON Peak Period [s] and Peak Direction Average - 1982 to 2011

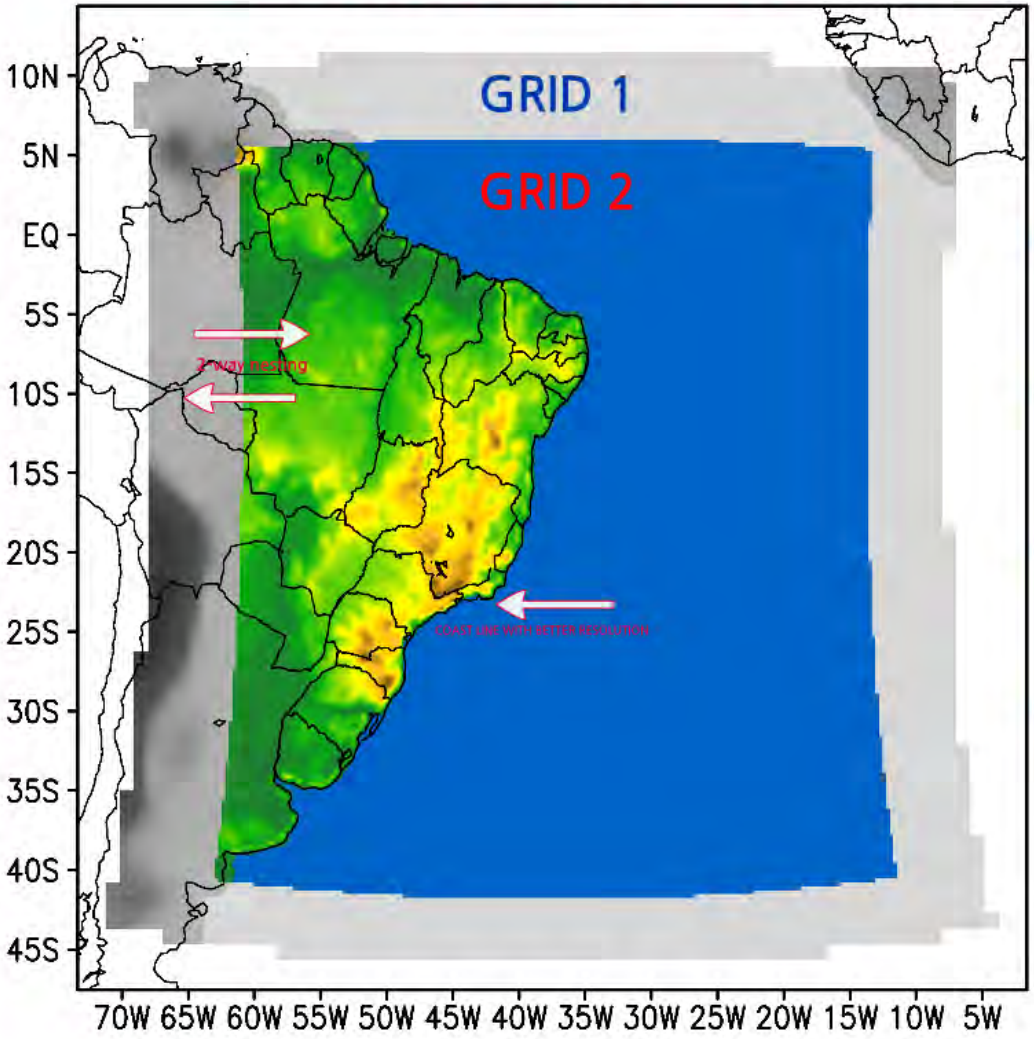


ATMOSPHERIC DOWNSCALING



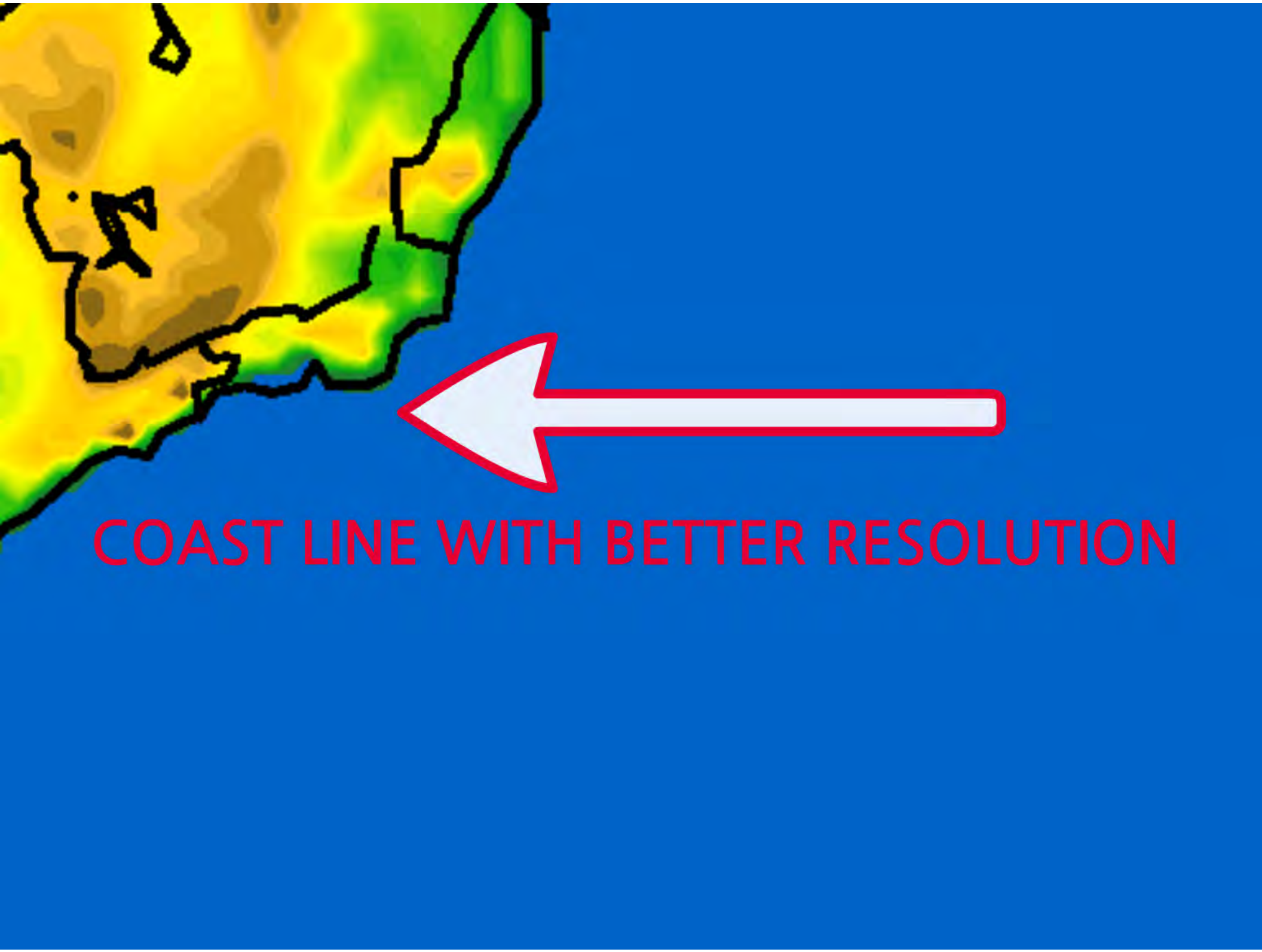
- BRAMS 4.2 - Brazilian Regional Atmospheric Modelling System
- 2 nested grids
- outer grid: 60 X 60 points ~ 1 degree of resolution; 38 vertical levels (better resolution close to surface);
- NCEP Reanalysis I as boundary conditions

ATMOSPHERIC DOWNSCALING



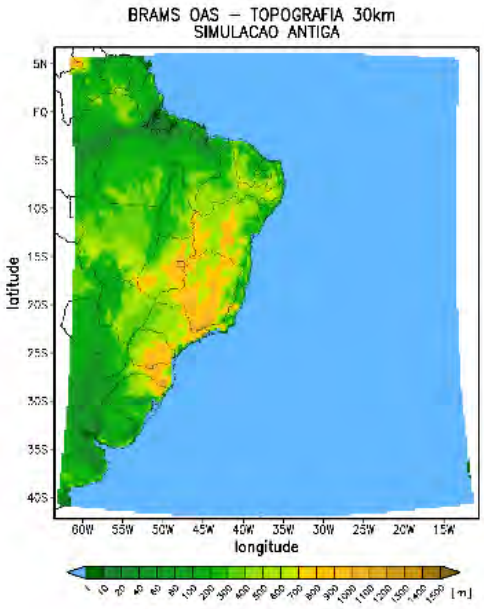
- 200 X 198 points
- ~0.25 degree of resolution
- 38 vertical levels
- 2-way nesting: GRID 1

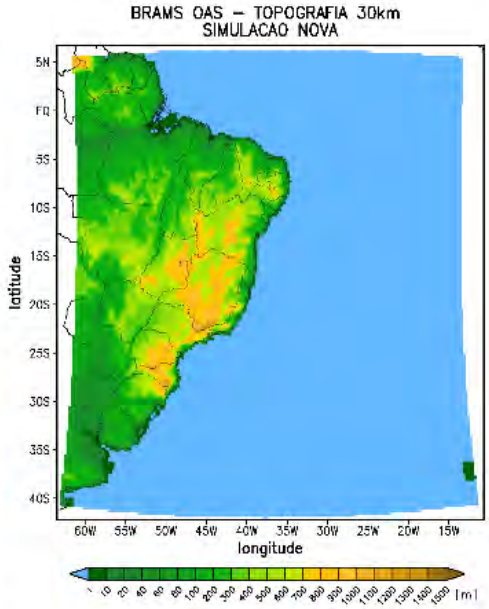

2-way nesting

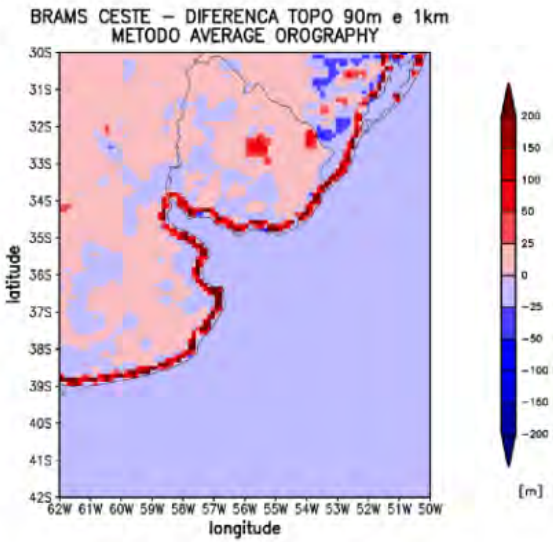

COAST LINE WITH BETTER RESOLUTION

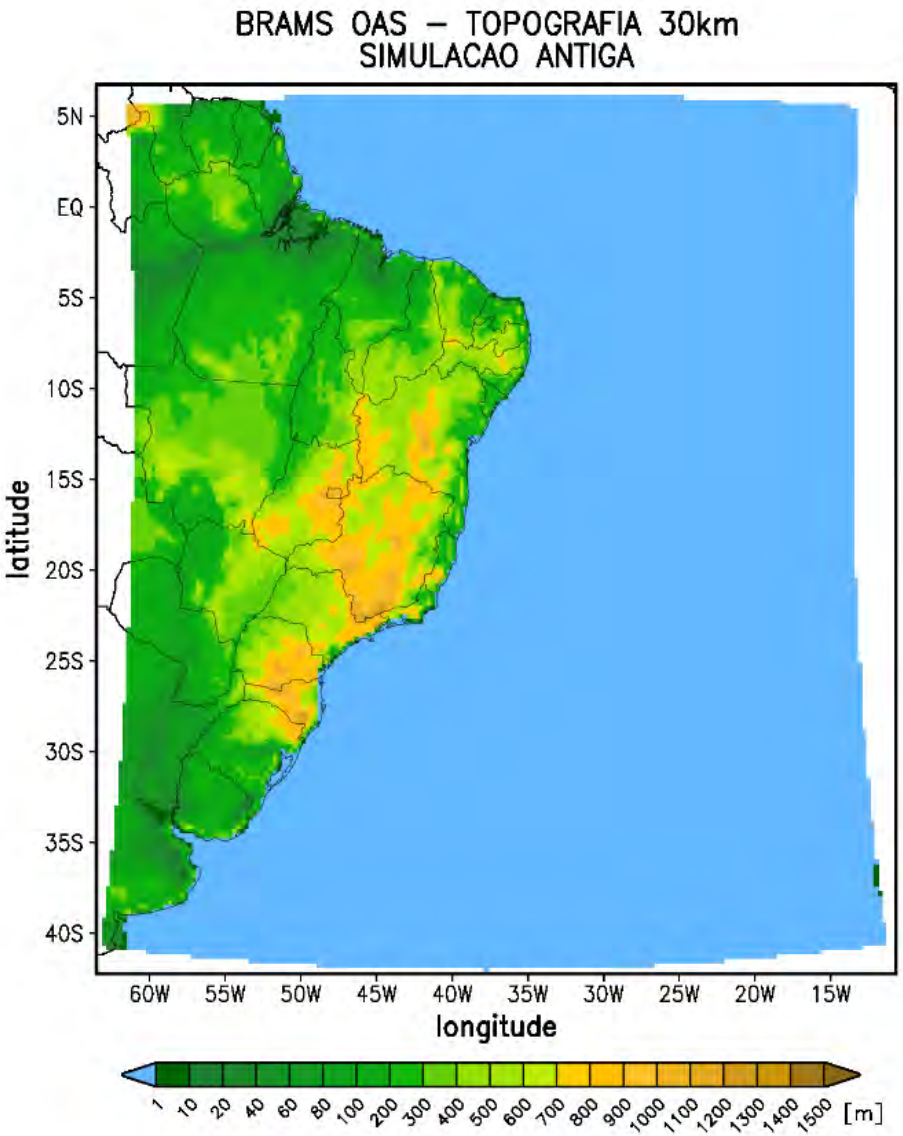
PROBLEM!!!!

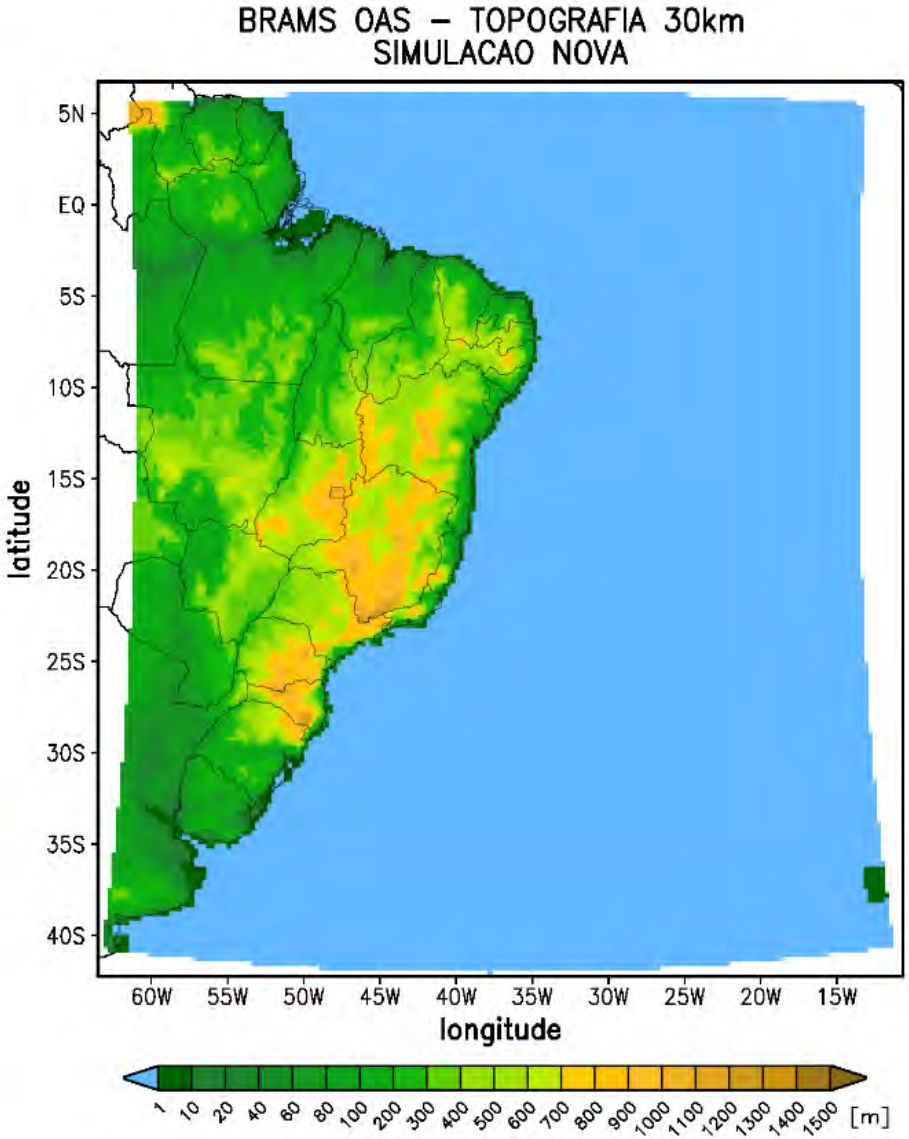
- Detected a topography interpolation problem. This problem makes 30 years of bad downscaling.

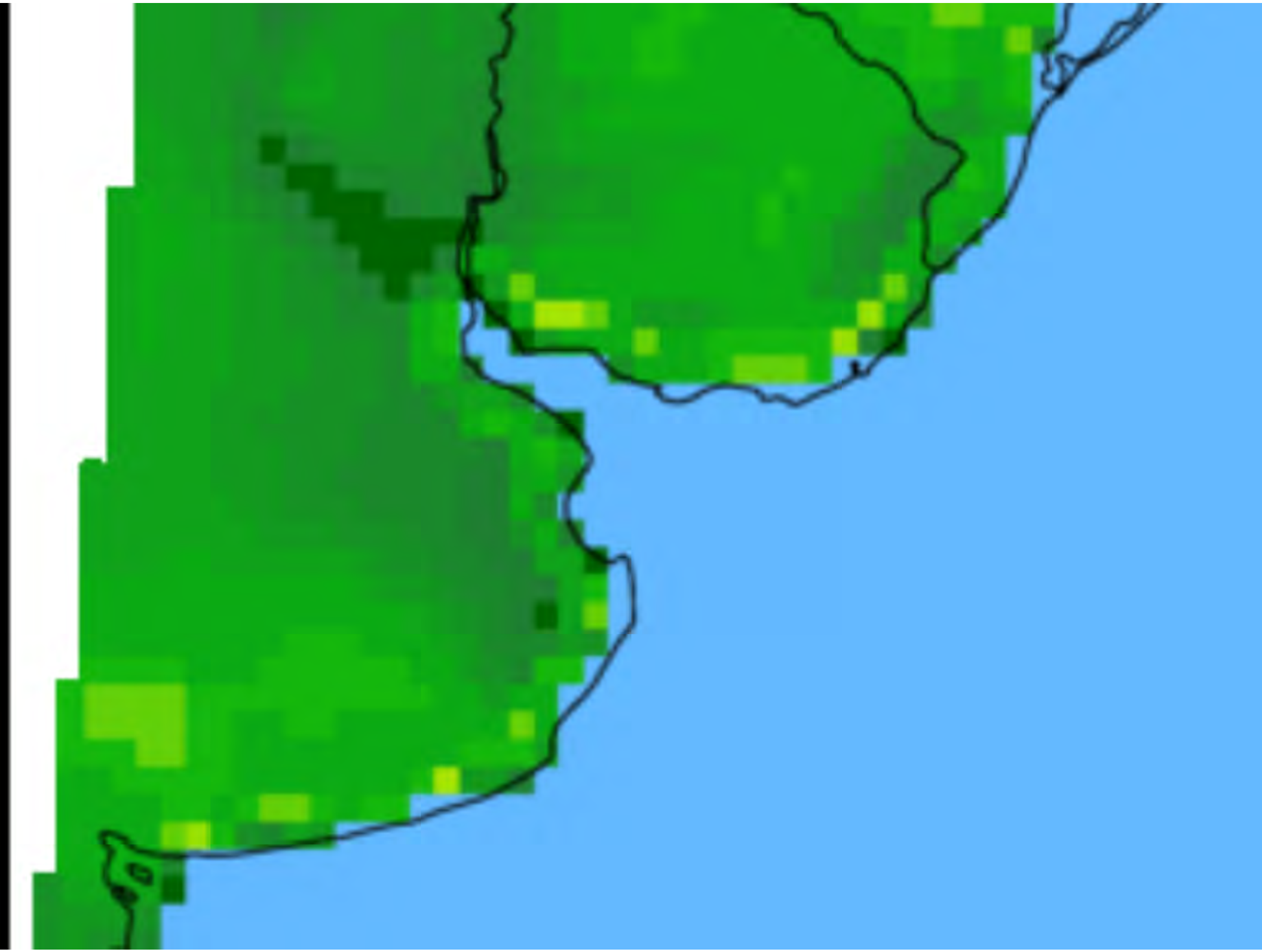


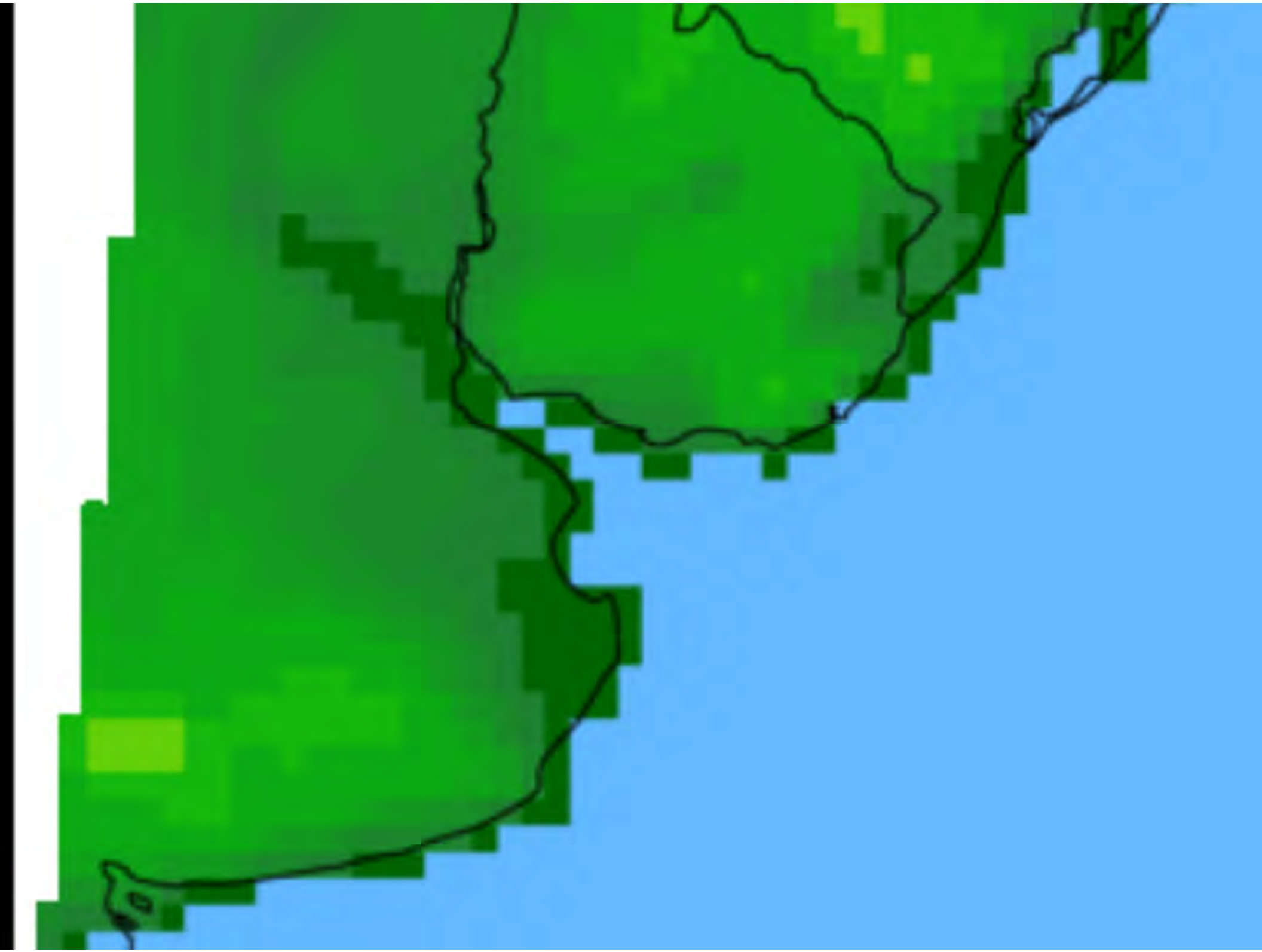


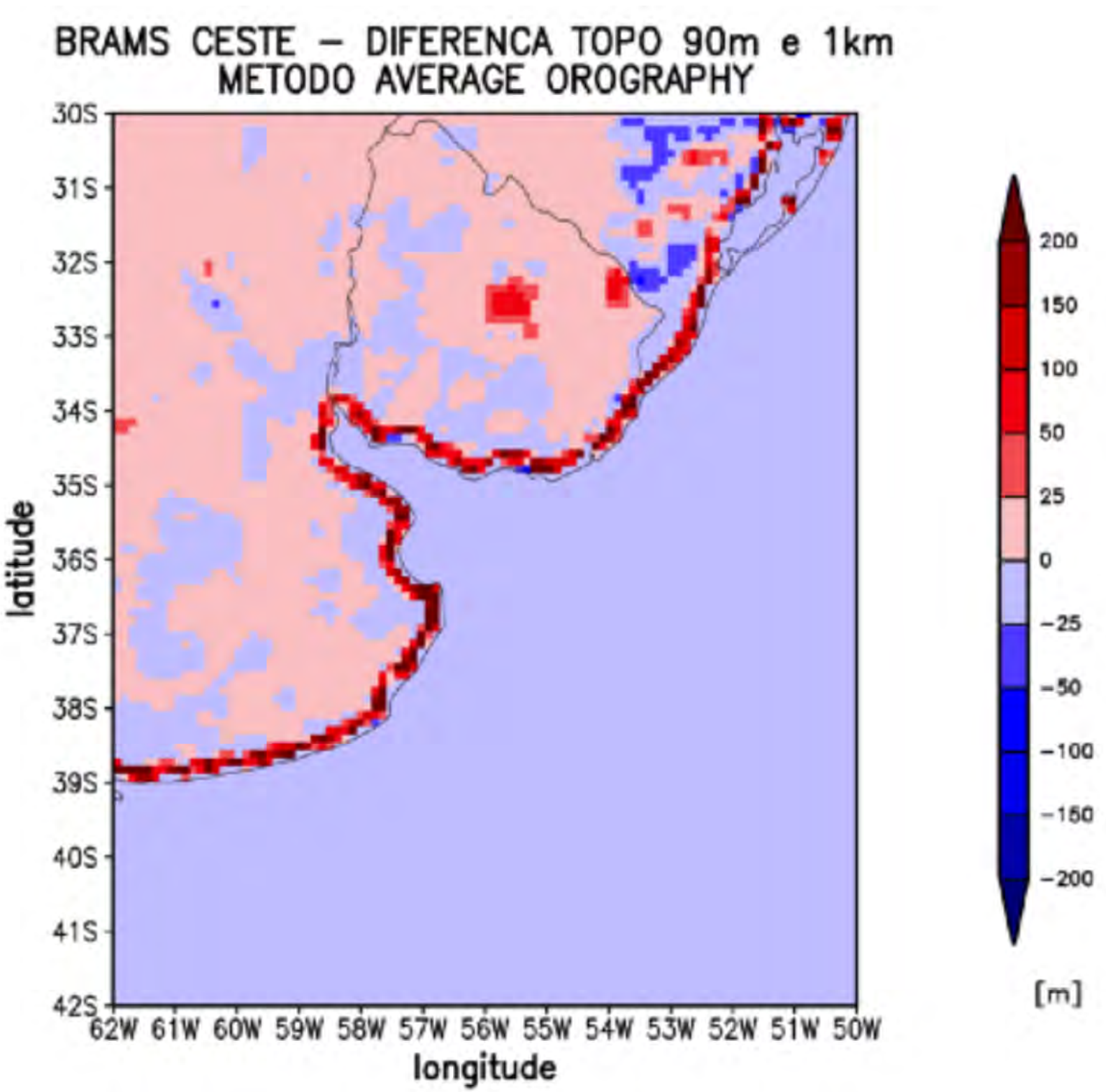



BRAMS OAS – TOPOGRAFIA 30km
SIMULACAO ANTIGA
5N
EQ
5S
10S
15S
20S
25S
30S
35S
40S
latitude
60W
55W
50W
45W
40W
35W
30W
25W
20W
15W
longitude
1
10
20
40
60
80
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
[m]

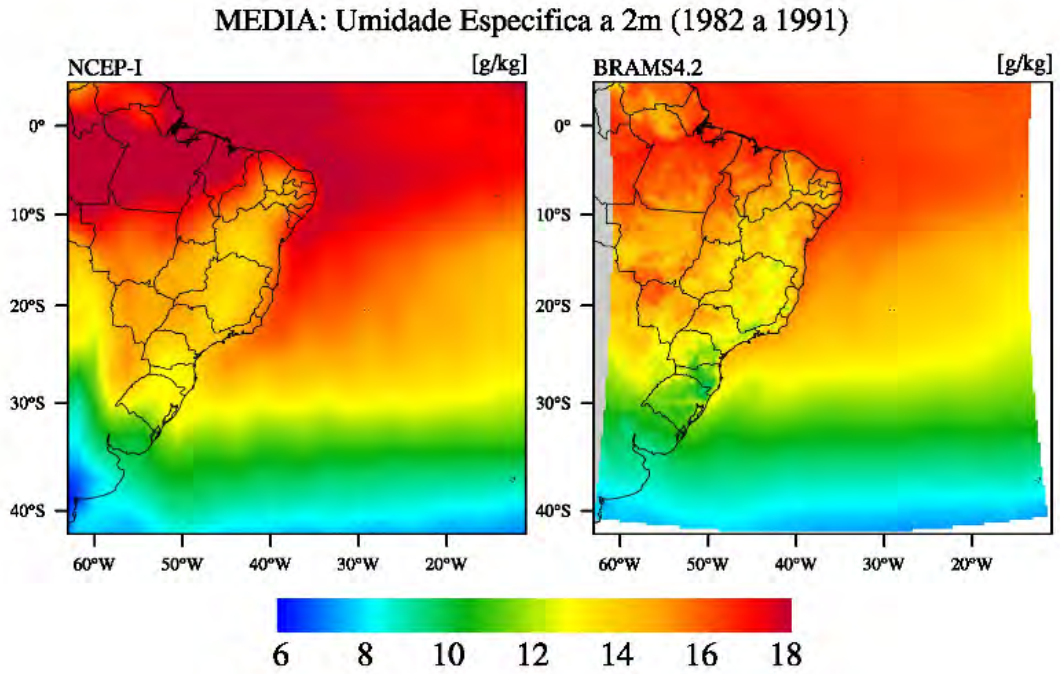

BRAMS OAS – TOPOGRAFIA 30km
SIMULACAO NOVA
5N
EQ
5S
10S
15S
20S
25S
30S
35S
40S
latitude
60W
55W
50W
45W
40W
35W
30W
25W
20W
15W
longitude
1
10
20
40
60
80
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
[m]

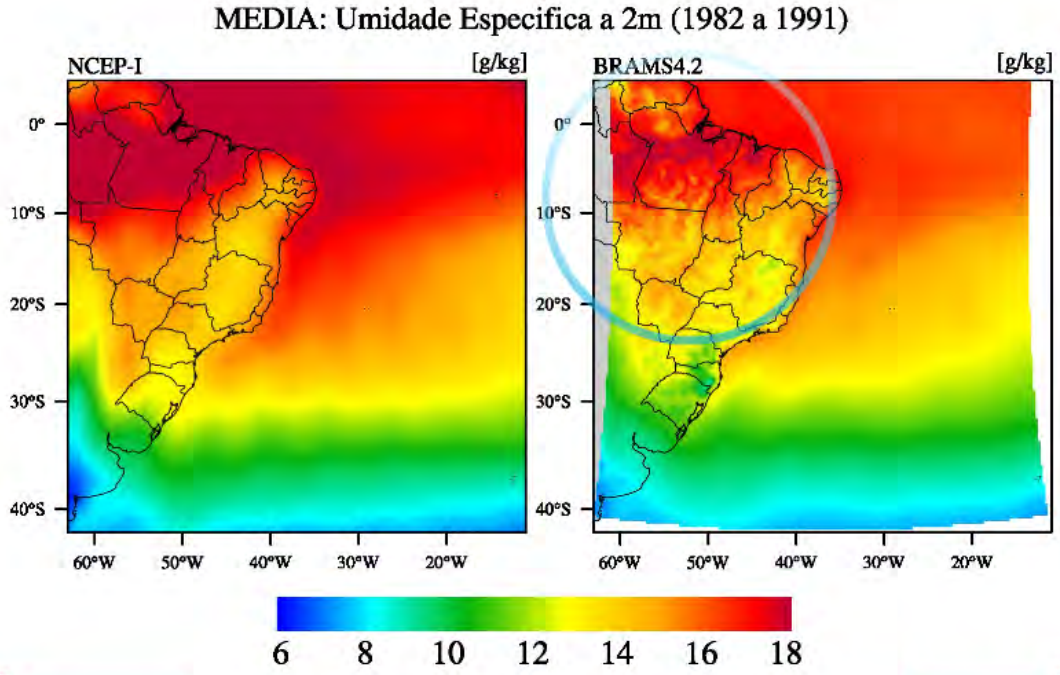





BRAMS CESTE – DIFERENCA TOPO 90m e 1km
METODO AVERAGE OROGRAPHY
30S
31S
32S
33S
34S
35S
36S
37S
38S
39S
40S
41S
42S
latitude
62W 61W 60W 59W 58W 57W 56W 55W 54W 53W 52W 51W 50W
longitude
200
150
100
50
25
0
−25
−50
−100
−150
−200
[m]

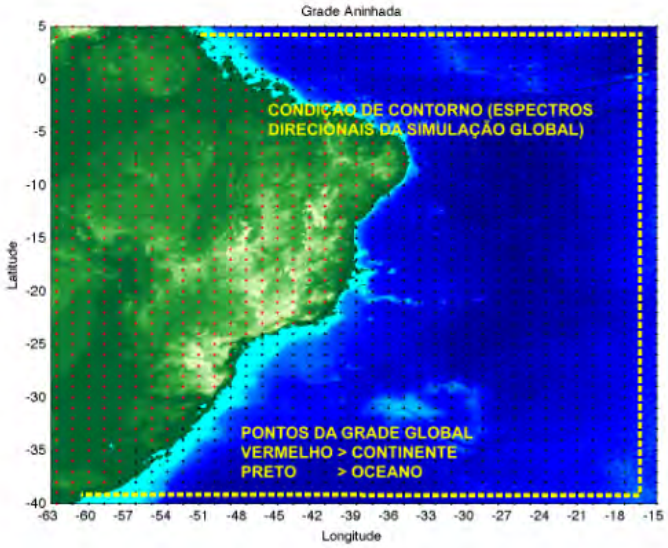
ATMOSPHERIC DOWNSCALING





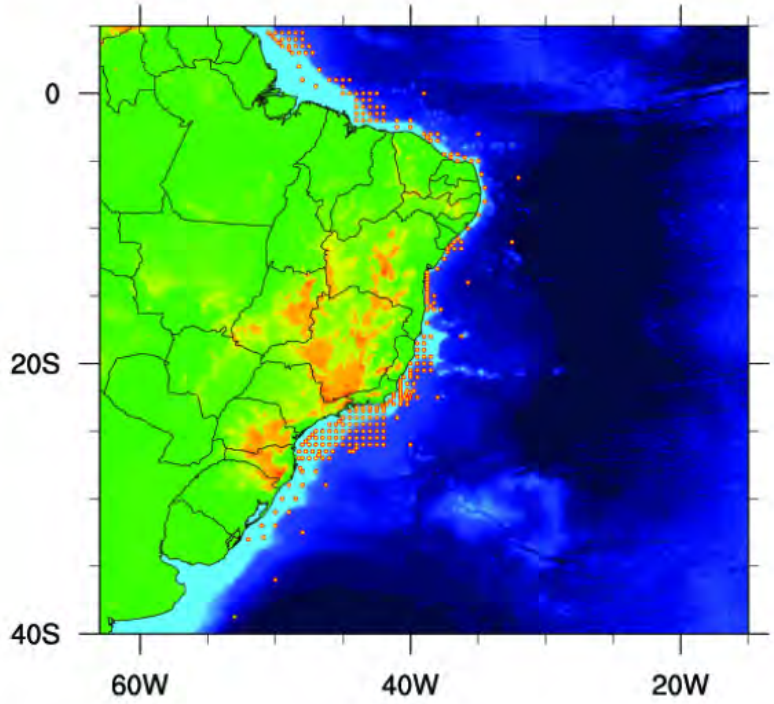
10 days spin up

REGIONAL WAVE CLIMATE AND PROJECTIONS



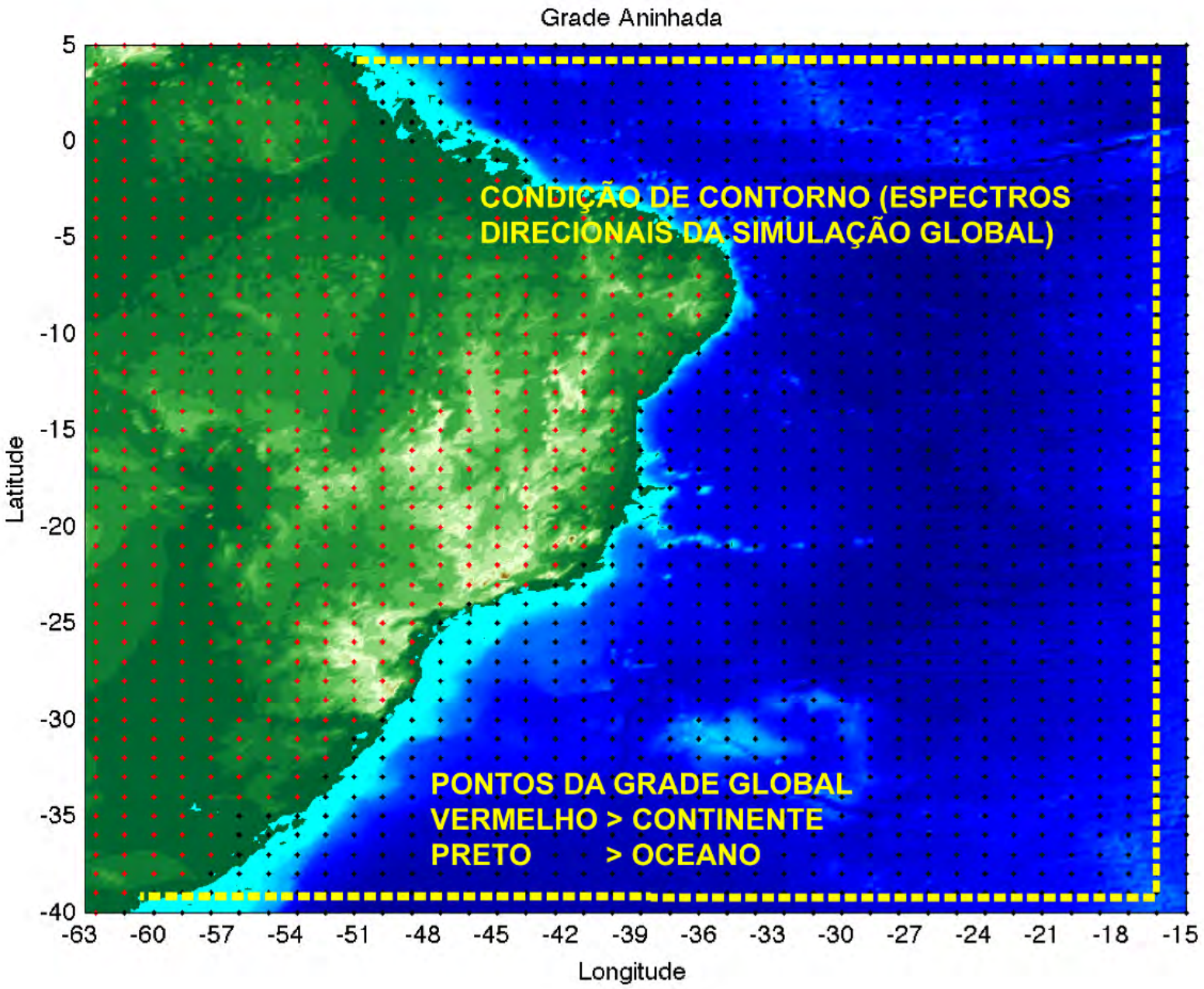
SPACIAL GRID
- 241 X 221 POINTS
- 0.2 X 0.2 DEGREES OF RESOLUTION
- 270 POINTS OUTPUT
- 21 WAVES PARAMETERS
- 3 HOURS TIME RESOLUTION

SPECTRAL GRID AS GLOBAL GRID



NEXT STEPS

VALIDATION OF 20 CENTURY


Grade Aninhada
CONDIÇÃO DE CONTORNO (ESPECTROS DIRECIONAIS DA SIMULAÇÃO GLOBAL)
PONTOS DA GRADE GLOBAL
VERMELHO > CONTINENTE
PRETO > OCEANO
Latitude
Longitude
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-63
-60
-57
-54
-51
-48
-45
-42
-39
-36
-33
-30
-27
-24
-21
-18
-15

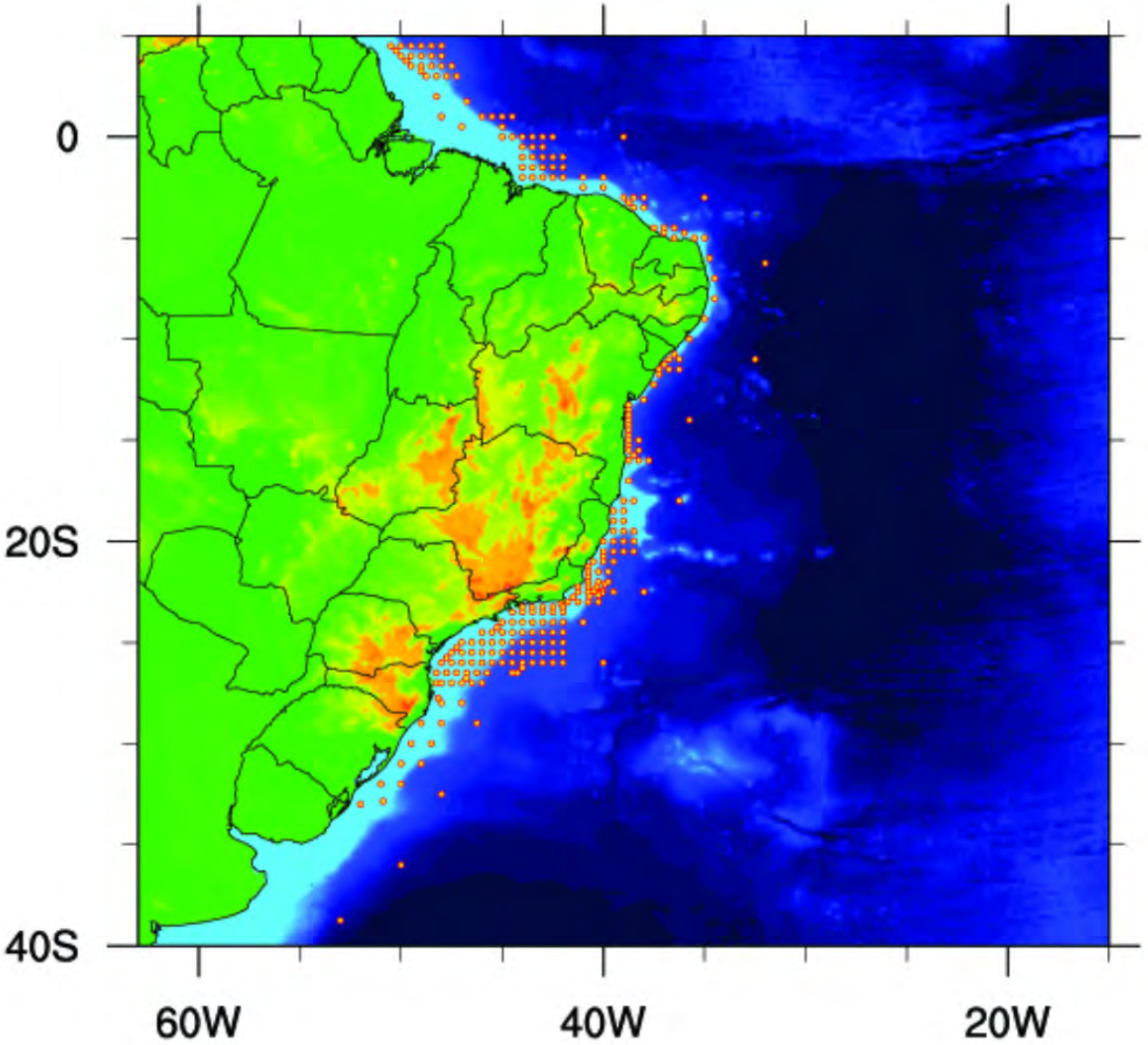
SPACIAL GRID

- 241 X 221 POINTS
- 0.2 X 0.2 DEGREES OF RESOLUTION
- 270 POINTS OUTPUT
- 21 WAVES PARAMETERS
- 3 HOURS TIME RESOLUTION

SPECTRAL GRID AS GLOBAL GRID

S OF

UT
METERS
SOLUTION
LOBAL



NEXT STEPS

- VALIDATION OF 20 CENTURY WAVE CLIMATOLOGY (NDBC)
- FINISH ATMOSPHERIC DOWNS. (20th century - NCEP and CCSM3)
- 20th CENTURY OAS WAVE CLIMATOLOGY
- ATMOSPHERIC PROJECTIONS
- WAVE PROJECTIONS
- FINISH MY PhD!!!!!

THANK YOU