37th Session of the
Working Group on Numerical Experimentation (WGNE)
8-10 November 2022
NCAR, Boulder, CO, USA

Model development overview at INPE/CPTEC

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Thanks to S. Freitas, R. Buss de Souza, E. Giarolla, R. Camayo, L. F. Sapucci,
J. G. de Mattos, G. Araújo and many others
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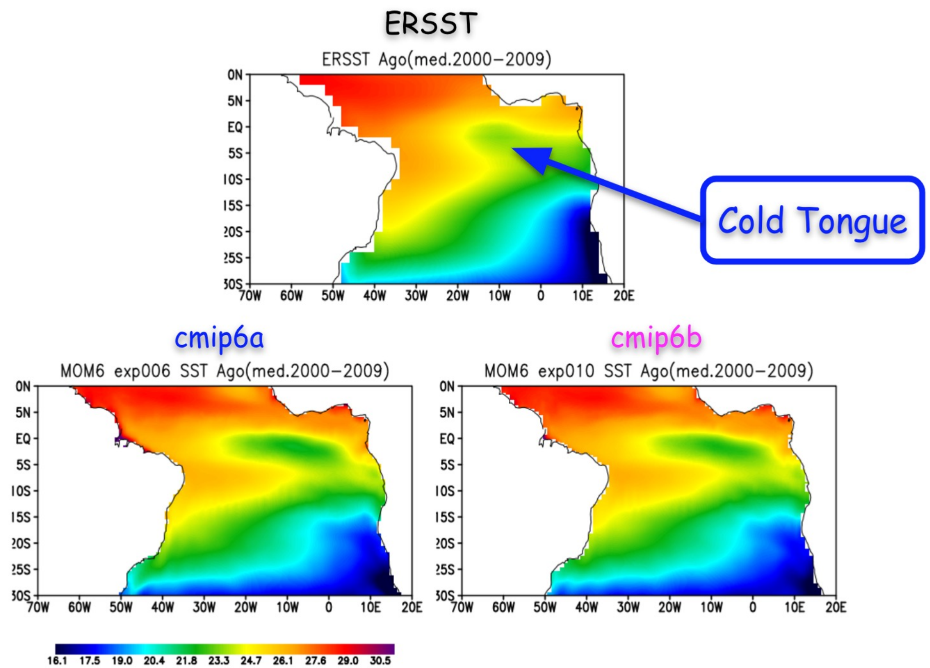
10 Nov 2022

Ocean and Cryosphere Modeling Group

Main Experiments	Experiment names		
	cmip6a	cmip6b	g0.25
Zonal grid size (degrees)	1°	1°	1/4°
Meridional grid size (degrees)	1/4° (Eq.- 10°) 1/4° → 1° (10° - 45°) 1° → 1/2° (45° - 90°)	1/4° (Eq.- 10°) 1/4° → 1° (10° - 45°) 1° → 1/2° (45° - 90°)	1/4°
Vertical resolution	49 layers	63 layers	63 layers
Time extension	~360 years	~360 years	~40 years
Atmos forcing fields	CORE datasets from Large and Yeager	CORE datasets from Large and Yeager, GFS* (*testing phase)	CORE datasets from Large and Yeager

Sample results



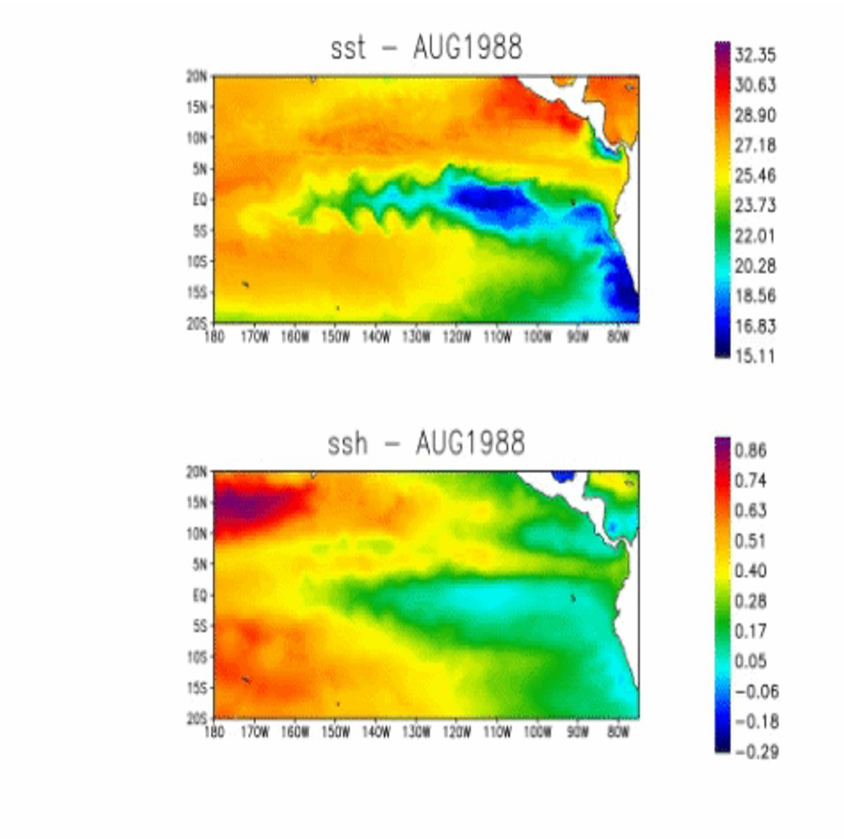
cmip6a and cmip6b, cold tongue

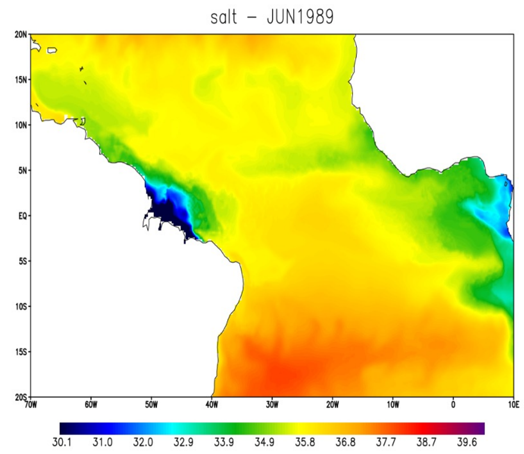
Courtesy: Emanuel Giarolla et al.

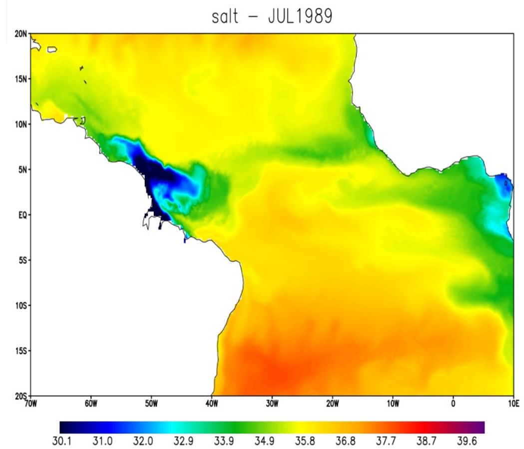
Ocean and Cryosphere Modeling Group

Sample results

g0.25, Amazon river freshwater runoff







g0.25, SST – SSH sample

Courtesy: Emanuel Giarolla et

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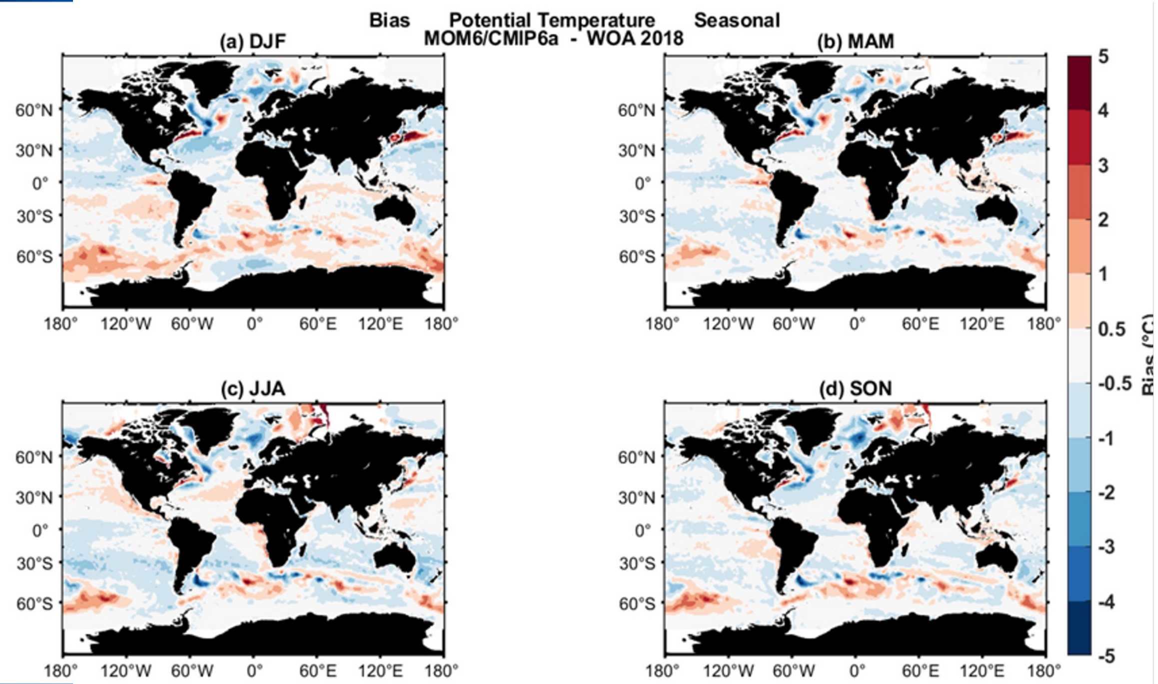
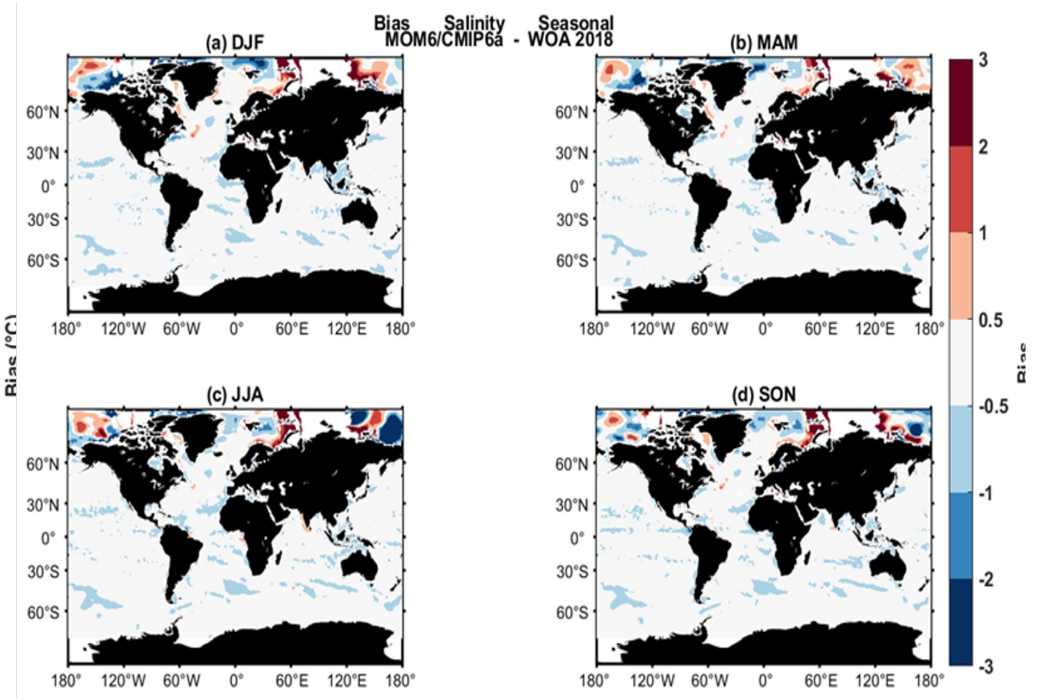
Model Assessment: MOM6 - WOA2018 (Sea Surface Potential Temperature)



Model Assessment: MOM6 - WOA2018 (Sea Surface Salinity)



Courtesy: Emanuel Giarolla et al

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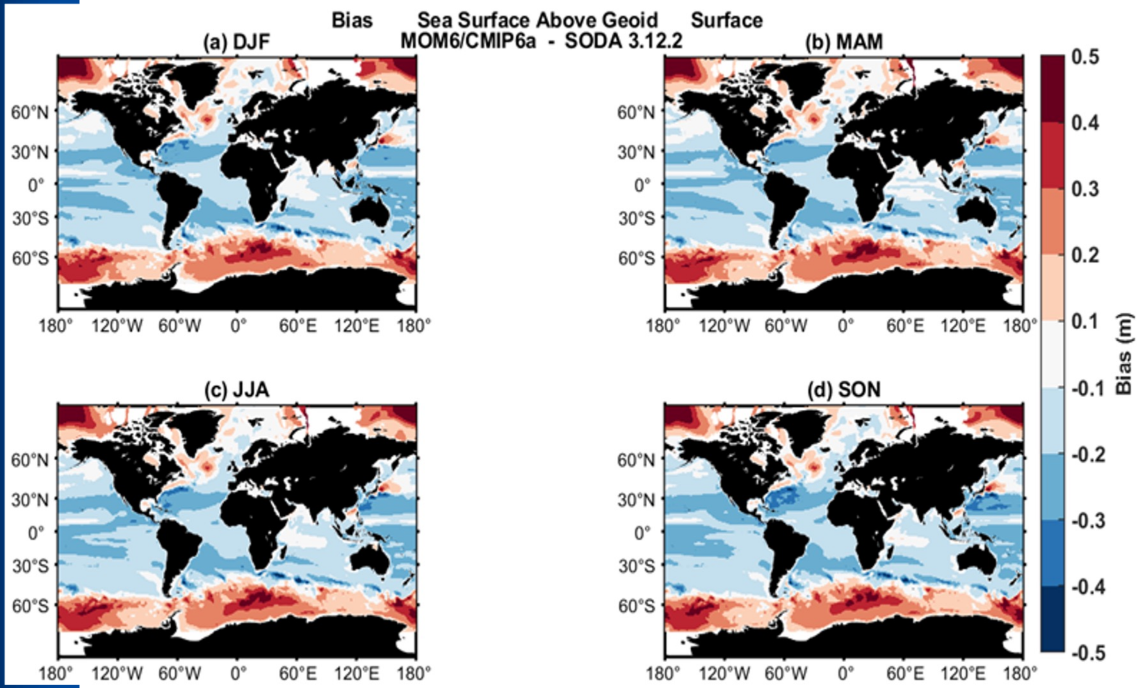
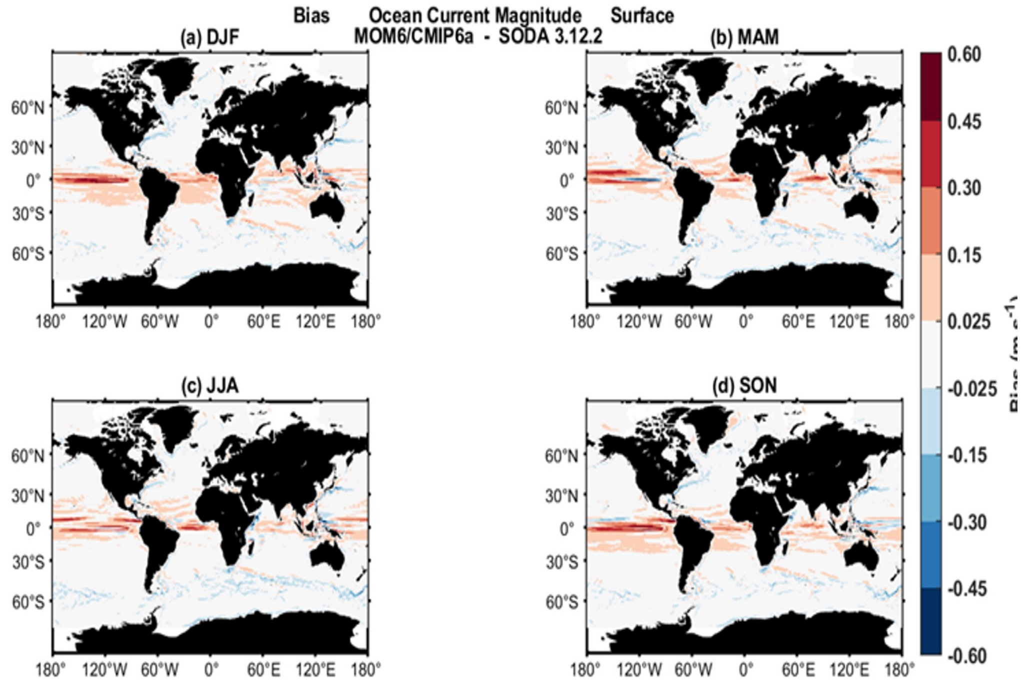
Model Assessment: MOM6 - SODA3.12.2
(Sea Surface Height Above Geoid)



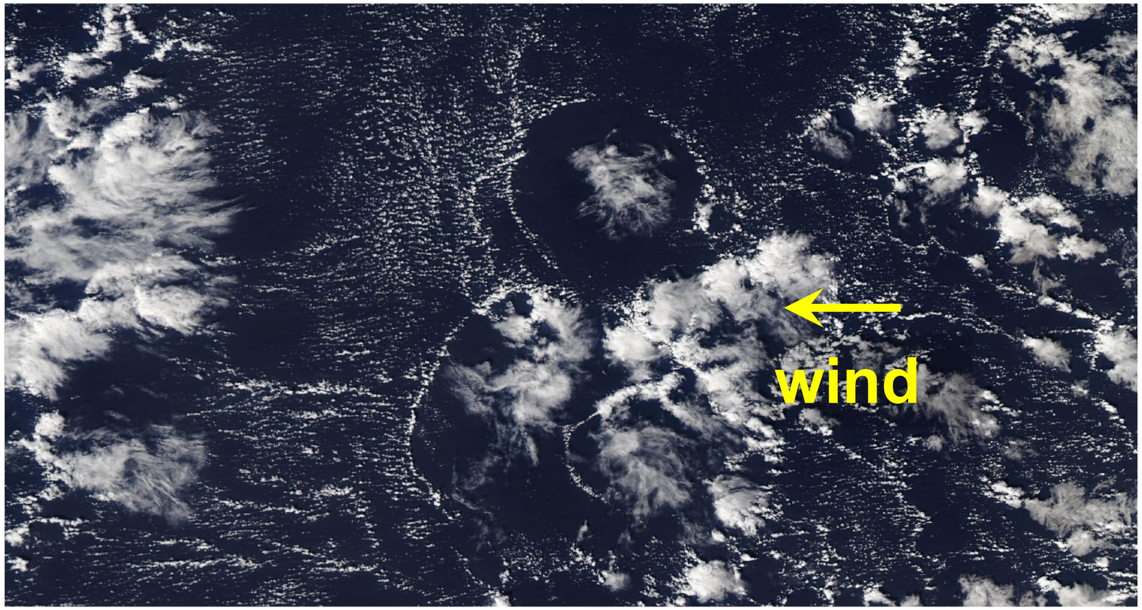
Model Assessment: MOM6 - SODA3.12.2
(Sea Surface Current Magnitude)



Courtesy: Emanuel Giarolla et al.

Atmospheric Modeling Group

Towards a representation of essential aspects of evaporation-driven cold-pools in the Grell-Freitas convection parameterization



Courtesy: Saulo Freitas

Including representation of cold-pools related processes in a convection parameterization:

- Might be useful by introducing spatial-temporal correlations between convective events (memory)
- Might help the diurnal cycle of precipitation
- Might help cloud organization (clustering, lifetime, and propagation) in a GCM
- Should improve the SGS emission estimation of sea salt, dust aerosols

Atmospheric Modeling Group

A sub-grid parameterization to account for effects of cold-pools in further triggering convection

Bx is a new prognostic variable which are advected by the 3-d wind as a scalar

Cold-pools are destroyed by surface fluxes and mixing with the environment air. We will not try to explicitly include those processes

They will all be represented by and 'sink term' in terms of the exponential decay with a prescribed lifetime

Courtesy: Saulo Freitas

Definition of Buoyancy-Excess (B_x)

$$B_x = -(H_d - \tilde{H}), \text{ where } \begin{cases} H_d & \text{downdraft MSE} \\ \tilde{H} & \text{environment MSE} \end{cases}$$

Prognostic Equation: $$\frac{\partial B_x}{\partial t} = adv(B_x) + diff(B_x) + S + R$$

source term $S = \delta_d B_x$, where δ_d is the downdraft detrainment mass flux

sink term $R = -\frac{B_x}{\tau}$, τ is the cold pool lifetime ~ 10^3 - 10^4 seconds

adv and diff are the grid-scale advection and diffusion operators.

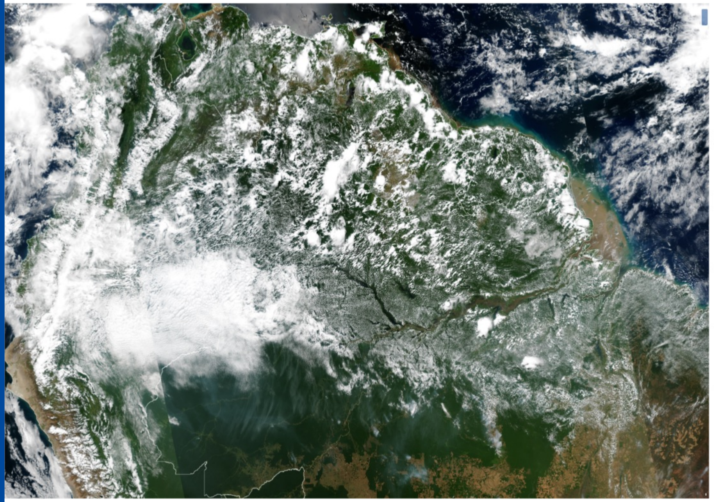
How to connect the buoyancy-excess with the nearby and near-future convection?

An attempt: as a boundary condition for the MSE of the updraft in the propagation direction, serving as an additional source of buoyancy for the convecting air parcels

Atmospheric Modeling Group

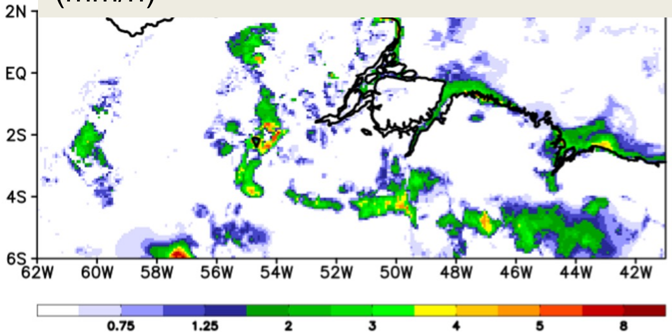
Impact of the cold-pool sub-grid scale parameterization in the simulation of a squall-line in Amazonia

Simulations with GF convection scheme: BRAMS model - grid spacing 8 km x 8 km

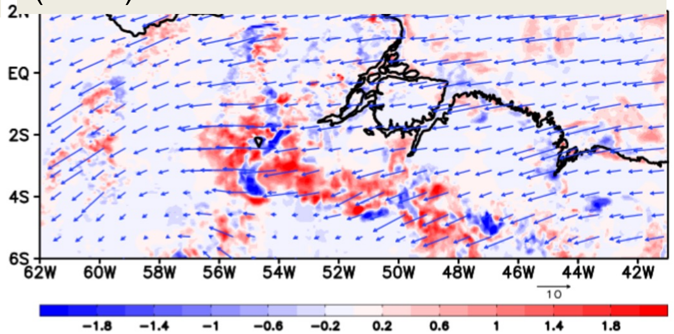


Freitas et al., 2023 (in prep.)

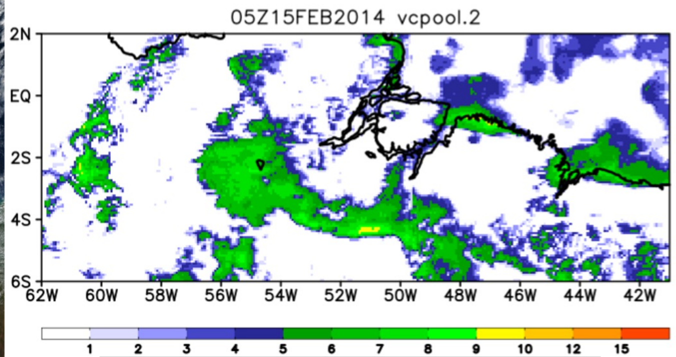
Precipitation rate – Control Experiment (mm/h)



Precipitation rate (cold-pold – control) (mm/h)

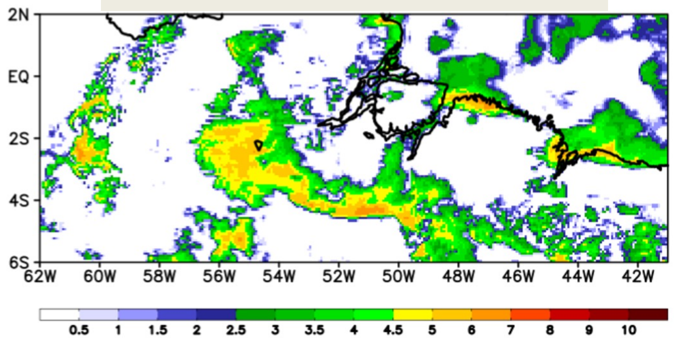


The speed of the density current



$$c_{\text{density}} = K\sqrt{gD\frac{\rho_2 - \rho_1}{\rho_1}} \approx K\sqrt{gD\frac{\theta'}{\overline{\theta}}},$$

The maximum vertical velocity at the leading edge of a density current



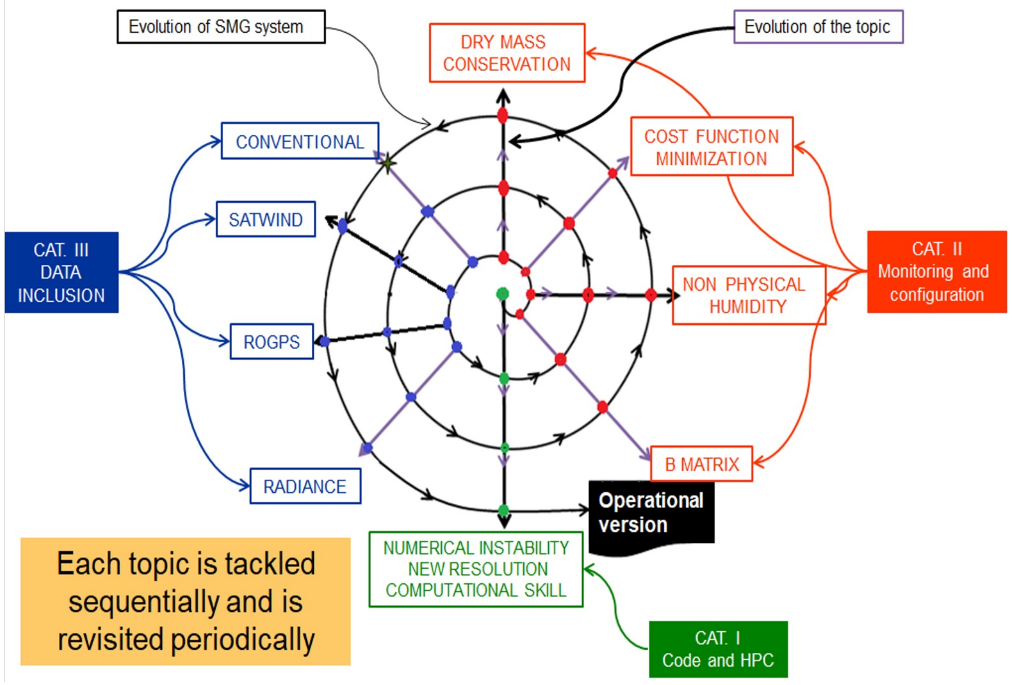
$$w = \sqrt{K^2\frac{g\theta'}{\overline{\theta}}H\sin^2(\alpha)}.$$

Data Assimilation Group

Exciting results obtained with GSI+BAM with hybrid coordinate - operational implementaion in progress

Development strategy (how we handle the lack of human resources):

- Identification of the most relevant components of the assimilation process
- Each component is revised/updated when a essential component is changed
- Each revision of the assimilation system is evaluated against the previous one
- The whole process must involve the atmospheric modeling group



BAM → Brazillian global Atmospheric Model
GSI → Gridpoint Statistical Interpolation

Courtesy: L. F.

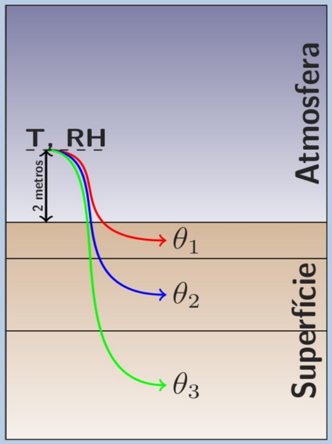
Data Assimilation Group

Future work: Atmospheric and Ocean data assimilation will work on **JEDI -** Joint Effort for Data assimilation Integration

- Land surface assimilation method is the screen level and ASCAT data for soil moisture data assimilation
  - will be developed an operator to use HydroGNSS for soil moisture data assimilation
  - Some studies will be carried out to apply wetlands and river level from the AMAZONIA-1B satellite at INPE's unified model MONAN

RESEARCH PROJECT:

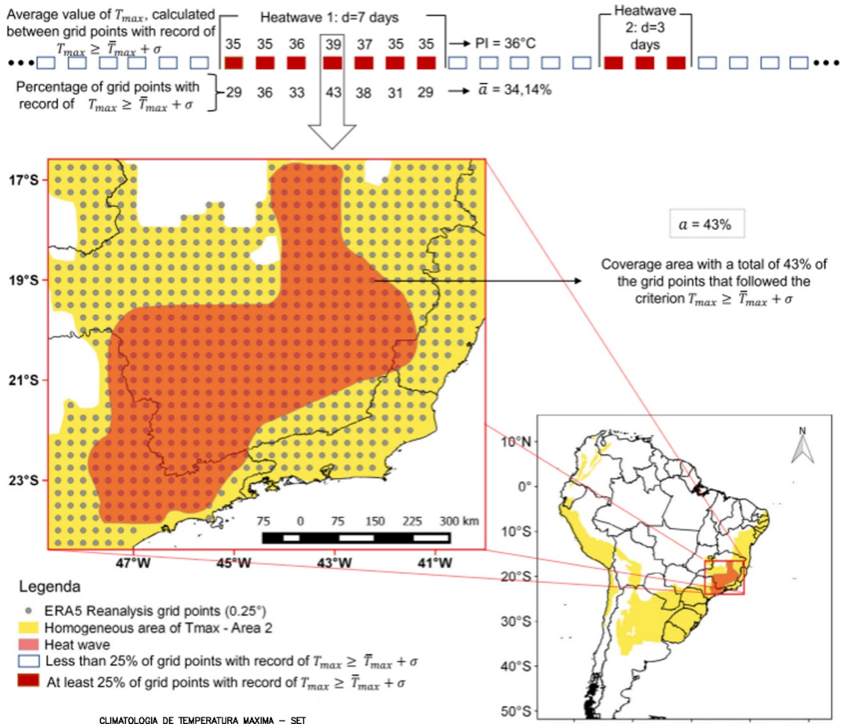
SOIL MOISTURE DATA ASSIMILATION IN NUMERICAL WEATHER AND CLIMATE PREDICTION MODELS

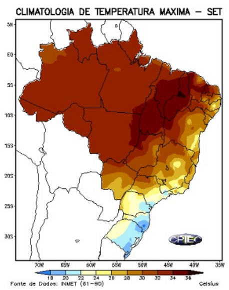


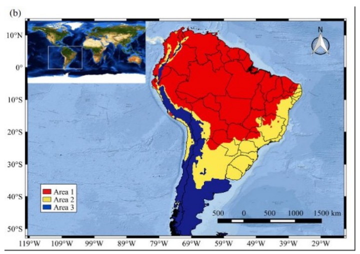
DE MATTOS ET AL.
THANKS TO CNPQ
PROJ Nº 438086/2018-0

Courtesy: L. F. Sapucci & J. G. Mattos

Heatwave and UHI monitoring and forecasting project







Received: 12 January 2022 | Revised: 25 June 2022 | Accepted: 9 August 2022

DOI: 10.1002/joc.7831

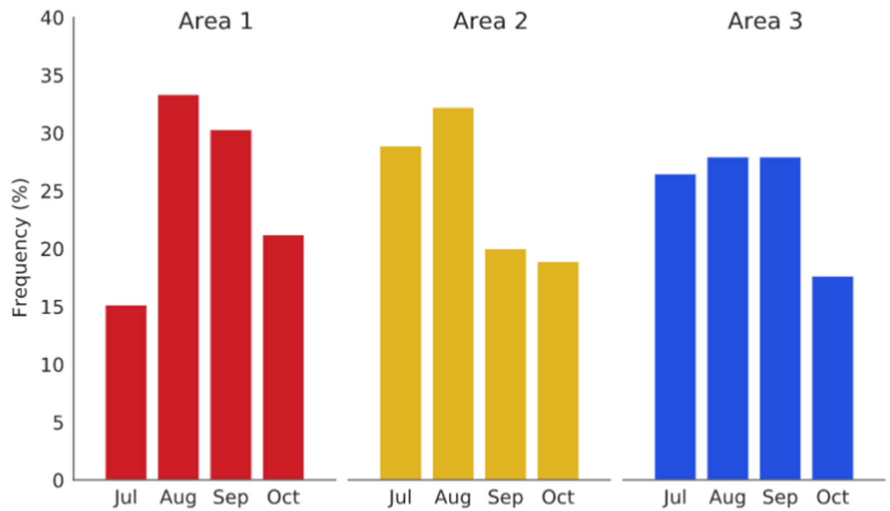
International Journal of Climatology | RMetS

RESEARCH ARTICLE

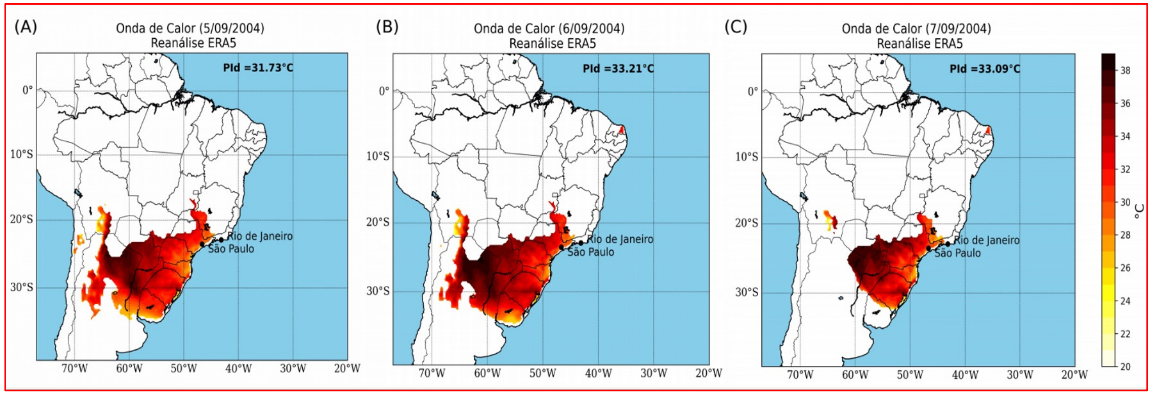
Climatology of heatwaves in South America identified through ERA5 reanalysis data

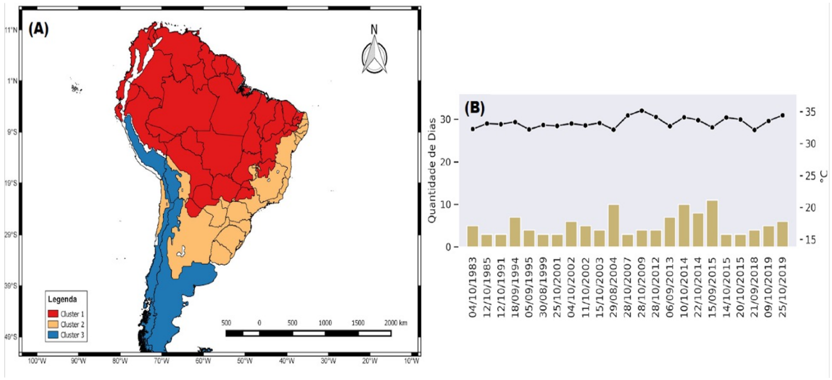
Glícia Ruth Garcia de Araújo[1] | Ariane Frassoni[1] | Luiz Fernando Sapucci[1] | Daniel Bitencourt[2] | Francisco Agustinho de Brito Neto[3]

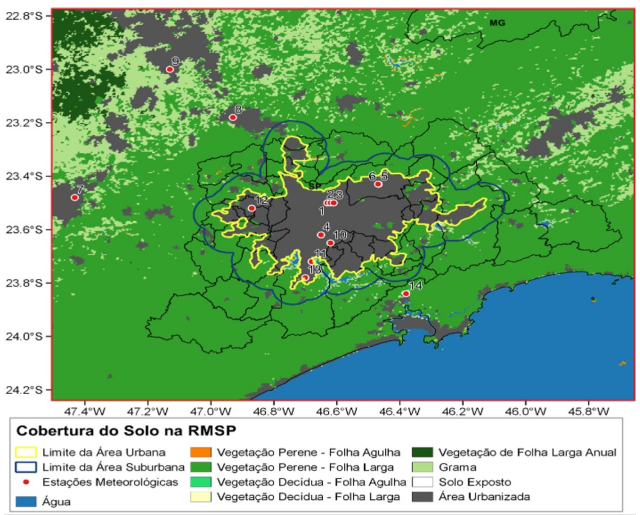
Monthly frequency of heatwaves in percentage for the three homogeneous regions of Tmax

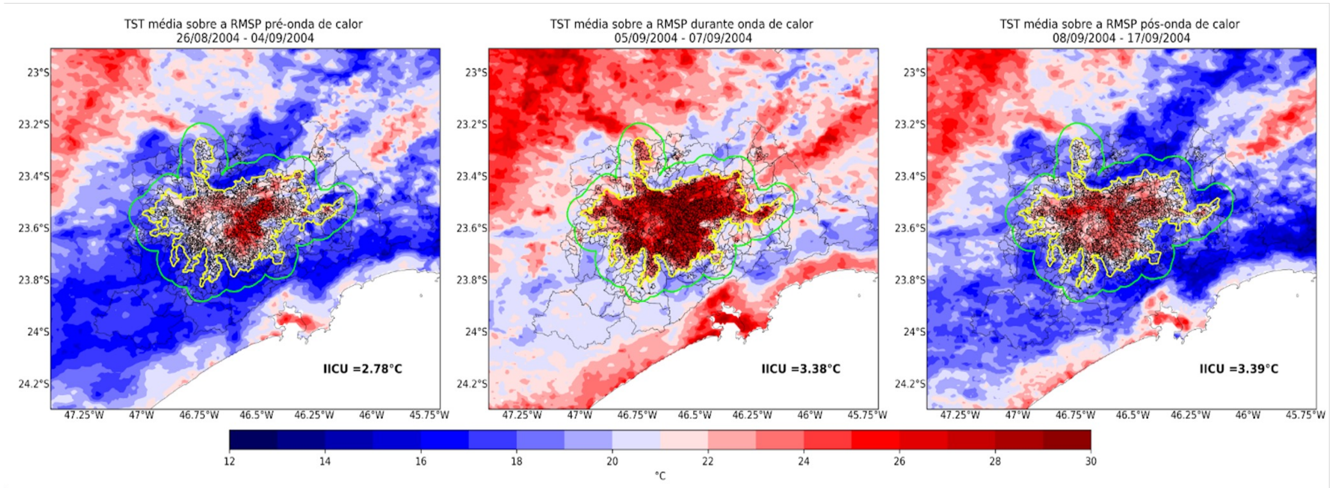


Heatwave and UHI monitoring and forecasting project









Araújo, Frassoni and Sapucci, 2022

Thanks!

WORLD METEOROLOGICAL ORGANIZATION

WCRP World Climate Research Programme

INPE UNIDADE DE PESQUISA DO MCTIC

Questions?